Operations and Maintenance Manual

Computerized Pavement Condition Survey Unit

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Operation Maintenance Manual
Computerized Pavement Condition Survey Unit

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Conducted in cooperation with the US Department of Transportation
Federal Highway Administration

A computerized field pavement condition survey unit and an IBM PC/XT computer
base office reader and analysis system were developed for use in the pavement manage-
ment program used by WSDOT.

The pavement condition recording and computing device is a microprocessor
controlled, data acquisition and reduction system which uses a combination of
manual inputs and odometer readings to develop pavement condition reports.
These reports are printed on the system printer and written to a standard compact
magnetic tape cartridge along with the raw data for later inclusion in the
Washington State Department of Transportation's pavement management data base.

The device, including all of its attendant equipment, is fully portable
so that it may be used in any motor vehicle that has an odometer pulse generator
(preferably producing approximately 4,000 TTL level counts per mile) and 12 Vdc
power source.

The office system consists of an IBM PC/XT or AT microcomputer with a printer
and a 20 megabyte cartridge tape drive. It also has the software needed to read,
process, analyze and convert the data for direct entry into WSDOT's pavement
management system.

Pavement Management, automated pavement survey equipment, Pavement surface condition survey

Unclassified

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OPERATIONS AND MAINTENANCE MANUAL
COMPUTERIZED PAVEMENT CONDITION
SURVEY UNIT

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Task 6

Washington State Highway Commission
Department of Highways
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U.S. Department of Transportation
Federal Highway Administration

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SECTION I
GENERAL INFORMATION

1.1 Introduction

The time allotted for obtaining pavement condition ratings and to integrate these into a prioritized rehabilitation program for a given road system can be substantially reduced through improved data collection techniques. To gather, record, and process the field data more efficiently, it was necessary to develop a system that would speed up the field data collection process and eliminate the handwritten field coding and office hand entry of the data and allow direct input of the data into the main computer.

To accomplish this the University of Washington developed and built a prototype portable pavement rating device for evaluation by the Washington Department of Transportation. Correlation and operational tests of the prototype were conducted by WSDOT personnel to check operator usability and computer compatibility. These tests were performed by completing actual pavement condition surveys using the current method and the new method of survey. A high degree of correlation was found. The raters became proficient with the new technique of rating rather quickly. Computer compatibility was tested with the application of real data to the main computer and checking the usability of the data within the pavement management system computer programs.
1.2 Specification - Field Unit

See the individual manuals for each of the pieces of hardware in question for specific details. The specifications pertaining to the overall field system are as follows:

Operating Temperature: 40 F to 120 F

The unit less the printer has been successfully tested down to 28 degrees Fahrenheit. The manufacturers minimum temperature specification on the tape drive, however, is 40 F and efforts should be made to keep the unit at or above this temperature if possible while in use.

Storage Temperature: 0 F to 150 F

Tape Storage: Unformatted (450 foot tape)
17 Megabytes

Formatted
5 Megabytes
512 Bytes per Record
10500 (512 Byte) Records per Tape

Tape Format - Using 82 samples per 0.1 mile intervals (Default Values) and 10 Sequences

4 Bytes per Sample of Keyboard
2 (512 Byte) Records per 0.1 mile Sequence
20 (512 Byte) Records per Mile
515 Miles Per Tape

Magnetic Tape Cartridges: 3M Scotch P/N DC 300XL or DEI HI REL DATA P/N 301522-2

Power:
12Vdc @ 1.5 Amps w/o tape drive
3.5 Amps with tape drive

Vehicle Speed - Maximum Sampling Rate:
1.3 Supplies and Accessories

The only supplies required for the operation of the field pavement survey unit are the magnetic tape cartridges and the paper for the printer (See Appendices E through I). No other accessories are available or required for the field unit. However, the IBM PC/XT has almost an unlimited number of accessories and a larger hard disk drive maybe required to handle the large amounts of data that are to be collected. Either a single drive with one hundred plus megabytes or a dual 20 megabyte removable hard disk drive is recommended.

Two additional accessories, which are relatively inexpensive but are necessary for doing extensive data analysis are a BASIC compiler and an 8087 math co-processor. These two items will increase the computers performance and will decrease the time required to read and analyze the data.
SECTION II
INSTALLATION

2.1 General

The installation procedure involves the removal of the various components from within the carrying case and the connection of the various elements to the main microprocessor control unit. This includes the connection of the cables for the keyboard, remote transcrack unit, the hand terminal, the odometer connection and the 12 Volt DC power cable. Once all of these leads are connected and the power switch is turned on the control of the system is automatically taken over by the hand terminal. At this point the simple menu items displayed on the hand terminal will direct the operator through the setup and control of the system.

2.2 Power Requirements

The only power requirements for the use of the pavement survey unit is 12 Volts direct current at approximately 3.5 Amperes maximum. There is also an internal battery back up on part of the system RAM (internal Random Access Memory). This unit is good for approximately 10 years and retains the initial input variables and set parameters, along with pertinent information associated with the operation of the equipment. This means that the operator does not need to re-enter all of the setup information every time the system is turned on and off.
2.3 Front Panel Connections

There are four front panel connections associated with the setting up of the pavement survey unit. These are the 50 pin ribbon cable on the keyboard and the cables from the hand terminal, the remote transverse crack and odometer, and the main power cable. All connectors are polarized. It is impossible to plug a cable in wrong or into a wrong receptacle (See Figure 4).

2.4 Keyboard

All that is required for the installation of the keyboard is to plug the 50 pin connector attached to the unit into its receptacle on the lower lefthand corner of the pavement survey unit (See Figure 4).

2.5 Hand Terminal

The hand terminal is a full ASCII terminal with all the capabilities of a regular computer terminal except for the fact that it is limited to four sixteen character lines of display. It also has four programmable special function keys across the top of the unit. These keys are used extensively in the setup and control of the pavement survey unit.

The hand terminal is powered from the microprocessor control unit and must be plugged in to be operational. It will come on automatically when the microprocessor control unit is switched on.
2.6 Tape Cartridge Drive

The tape cartridge must be placed into the vertical slot on the righthand side of the microprocessor control unit with the metal side of the tape cartridge facing away from the connectors. The cartridge is aligned with the guiding framework and slid firmly and completely into the slot. It should only protrude about 3/4 of inch. The tape can be installed before the power is turned on and can be left in the instrument when it is closed up. Installing the cartridge before the unit is powered up will prevent the tape from being rewound when the power is turned on. This can save time and possible problems and is recommended while in regular use.

2.7 Printer

The only installation associated with the printer is the paper roll. The face of the printer slides out to give access. The factory instruction procedure should be followed, (See the manual, Appendix I).

2.8 Odometer

The odometer input used by the microprocessor control unit for distance and position calculations is connected into the system via the remote transverse crack connector. The coiled cable coming from the remote transverse crack connector joins into a male-female jumper connection which ties into the vehicles
distance measuring equipment without interfering with its normal operation. The cable stretches to give about six feet of distance between the microprocessor control unit and the vehicle's distance measuring equipment display.

Be sure that the power to the vehicle's distance measuring equipment is turned off before the jumper is installed or else the microprocessor control unit and/or the distance measuring equipment may be damaged. The jumper is wired for the Transwave distance measuring equipment (Model NK-1200, See Appendix E and Figure 16). If any other type of equipment is used check to see that the ground wire is connected to the shield and that the logic signal is TTL compatible and on pin 5. The manufacturer's manual provided with the unit used for the prototype development did not give the proper pin outs for this connector. Therefore, take caution and be sure that it is wired into the system properly. Any configuration changes on the other pins will not affect the operation of the system.
SECTION III
OPERATION

3.1 General

The operation of the field unit is controlled through the hand terminal and a series of menu items. The hand terminal is limited to four lines of sixteen characters each and thus leads to some nesting of the different menu lists and items (See Figure 1). However, the hand terminal is only required during initial set up procedures under most circumstances and thus lends itself well to this type of control.

Alphanumeric data can also be entered into the unit during or between runs. This is a little cumbersome with this type of terminal but is still practical. Any type of ASCII terminal or portable microcomputer unit could be adapted for use with the field unit if large amounts of alphanumeric data are required. Each interval (usually 0.1 miles) can contain up to 300 bytes (ASCII characters) of alphanumeric information in addition to the surface condition data. This is about 19 lines of text on the hand terminal.

The operation of the field pavement survey unit is as follows: The power is turned on once all leads have been installed (See section II). The control is automatically switched to the hand terminal and the initial menu is displayed on the LCD screen (See Figure 1 & Section 6.2). The set up data is entered and the system is initiated by pressing the START and ENTER keys.
(See Section 3.8 below). The unit will begin collecting data when the vehicle reaches the BEGIN MILE or immediately if the BEGIN MILE and the ODOMETER are set to the same value. The BEGIN MILE, END MILE and the ODOMETER readings will be displayed continuously on the hand terminal once the system is initiated.

The system is connected directly to the vehicles' odometer output, which is its primary control signal. Once the unit begins to collect data, a red LED will flash on the face of the keyboard (See Figure 2). The unit will automatically sample all of the keys on the keyboard (except the five left most CONTROL KEYS) and store the status of each key on tape at the rate or spacing specified during the set up procedure (samples per interval, See Figure 1 & Section 6.2).

The data sequence is defined as the distance between the BEGIN and END MILE marks. The begin mile - end mile sequence is then divided into intervals, which are usually selected to be one tenth of a mile. Associated with each interval is a 300 byte alphanumeric data storage area on the tape. Up to the 300 bytes of data can be entered at the beginning of each sequence or at any one of the intervals within the sequence. To enter alphanumeric data at an interval break, the vehicle must be stopped and the PAUSE and ENTER keys must be pressed on the CONTROL KEYS section of the keyboard. A menu will appear instructing the operator to press F1 to enter the information. When completed, the menu will direct the operator to push the F2 key to begin normal operation again (See Figure 1).
The vehicle speed that can be obtained while still collecting valid data is dependent on the number of samples per interval and the initial length. Under default operations (82 samples per tenth mile interval) the maximum speed is approximately 50 mph.

The use of the printer at present requires that the vehicle come to a stop at the end of each interval to eliminate any or all data loss. The system still functions properly if not stopped. However, a number of samples will be lost at the beginning of each interval. Future modifications will eliminate this problem by putting a buffer on the printer.

3.2 Front Panel

The only controls associated with the front panel which are relevant for the operation of the field unit is the on-off switch, the printer controls, the installation of the magnetic tape cartridge and the power plug. Once the unit has been plugged into the cigarette lighter of the vehicle or attached directly to the battery using the clip leads that are provide with the unit, turn on the power switch and control will be automatically transferred to the hand terminal. This takes about 5 seconds while the system goes through some self checks. If the unit does not appear to function properly, the system can be reset by turning the power switch off and back on again. The data that has been entered will not be lost since the memory unit associated with the system set up is backed up by an internal battery and
will not have to be reentered. The clock will have to be reset if
desired, however. If the problem persists, try resetting the non-
volatile memory (See Figure 1 & Section 6.2).

3.3 Keyboard

The keyboard is the primary data entry device. It is also
used to start and stop the system and to control some of the tape
functions or operations. The keyboard is separated into seven
different sections. The first is the CONTROL KEYS section. This
section is used to start and stop the actual data collection, to
manually place an extra end of file (EOF) on the tape, to control
the pavement exempt function and for the selection of the
pavement type.

Once the initializing or set up data associated with the hand
terminal operation has been completed the unit will display a
message that control has been transferred to the control rating
panel (CRP) or keyboard and request that you press the START or
STOP button (See Figure 1). Once these keys have been pressed the
unit will begin sampling at the specified BEGIN MILE or
immediately if the ODOMETER reading and the BEGIN MILE reading
are the same. The unit will start at the END MILE and count in
reverse if the sign in front of the interval variable is set to
negative.

The PAV EXMT. (pavement exempt) key is used to exclude or
stop automatic data entry by the system while still maintaining
the proper mileage count. This function is used to eliminate
things like bridges or pavement sections that are not to be included in the final data.

The BST/ACP key is used to select the type of pavement that is being surveyed. This key can be changed while data is being automatically collected.

The second section of the keyboard is the SPECIAL FUNCTION KEYS. In general, these keys can be used for any function that the operator desires. The first two keys are push on - push off and will record data continuously while the LED (key) is on. The last three are momentary on (reset by the microprocessor unit), which means they will record a single value to the tape each time they are pushed. These keys are generally used for counting or for flagging significant points of interest. At present, the F1 key is being used in conjunction with the PATCHING section to indicate FULL DEPTH patching. This function was left out of the initial design specifications and will be added to future units just below the existing BST and ACP keys on the right side of the PATCHING section.

The normal use of the SPECIAL FUNCTION KEYS would be to specify, in the alphanumeric data entry mode, the desired function of each key. Then when the tape is read and analyzed the operator of the IBM PC/XT system can read this information and interpret the data accordingly.

The next five sections make up the main data entry portion of the keyboard. The exact use and function of these keys is defined in section 6.4. In general they function similar to the
categories on the original field survey forms used in previous manual pavement survey procedures. These keys are sampled automatically at the preset sampling interval and the operator simply presses the keys from the moving vehicle as he observes the different distress features in or on the roadway.

3.4 Hand Terminal

The hand terminal is powered directly from the microcomputer control unit and comes on with the main power switch. The unit is a standard ASCII computer terminal other than it is limited to four lines of sixteen characters each and that the keyboard is much smaller and has its own unique control procedures. See the reference manual in Appendix G for details on how to operate this unit. Its only function is to operate as a terminal and to allow the operator to enter the data to the microprocessor control unit which is required to control and operate the overall field pavement survey system.

3.5 Tape Cartridge Drive

Most functions of the tape cartridge drive are controlled automatically by the microprocessor control unit. The tape is manually inserted into the tape cartridge vertical slot on the righthand side of the field unit front panel (See Figure 3). If the power is on the tape will automatically rewind and position itself at the beginning of tape on track one. If the operator would like to start at the position he last stopped, the tape
should be left in the drive or replaced before the power is turned on.

Minimal tape control is supplied under the hand terminal control. This includes the option to define whether or not you are making a new run if a new run is selected the system will rewind the tape before you begin the next sequence (See Figure 1). The system places a double EOF at the end of the tape automatically after each data sequence or at the end of the last successfully completed tape operation.

There can be more than one double EOF on a tape, therefore the operator may need to search the tape to determine the location of the last end of tape. If a problem should occur or if the operator would like to be able to find his location on the tape at a later time he can manually put a double EOF on the tape by pressing the EOF key followed by the ENTER key twice.

3.6 Printer

The printer is controlled through the hand terminal control menu and is either turned on or off (See figure 1). When off the printer plays no role in the operation of the field equipment. In the on status the printer will print a summary report at the end of each interval. This report lists the accumulated number of points associated with each of the CRP sections.
3.7 Odometer

The odometer signal is the only item that has to be supplied by the operator other than the 12Vdc power and the tape cartridges and printer paper. This signal must be TTL compatible and corresponds to the number of counts per mile in the set up menu list (See Figure 1 and Section 3.8). The unit can be calibrated to whatever input frequency that is provided.

To calibrate the unit follow the instructions in the menu (See Figure 1). Once in the calibrate mode the calibration process is initiated by pressing the START key followed by the ENTER key, at a known mile post. The calibration process is completed by pressing the STOP key followed by the ENTER key at a second known mile post. The system will ask for the distance traveled and from this will compute the odometer factor and store this in memory. Record this value manually when going through the input parameters. It will have to be reentered if and when the system is re-initialized.

3.8 Menu Driven Control System (See Figure 1)

When the system is first turned on, the Hand Terminal will go through a five second self test sequence to check out its own functions. At the same time the microprocessor control unit is running through a series of its own self tests. If everything is in working order, the hand terminal will display the MAIN MENU (See Figure 1 & Section 6.2). If the system does not display the
Main Menu after 10 seconds or a different menu shows, turn the power switch off and on and try again. If it still does not work, try resetting the non-volatile memory or refer to section 7.1.

The hand terminal has four special function keys F1, F2, F3, and F4. These keys are used to operate the menu control system. The acronym above each special function key or the menu itself defines the operation of that particular key for that particular menu operation, (see Figures 1 and 3).

MAIN MENU

This is the most basic menu item. It is the first menu to come on when power is applied and the final menu prior to starting the unit. The user is faced with three options:

F1 System Setup
F2 System Ready
F3 System Init.

System Setup - F1

This is used to enter the initial set up data or to change, check, or calibrate the odometer before starting a sequence. Selection of this item will send the hand terminal to MENU 2. The vehicle must be stopped while entering all input variables.

System Ready - F2

This is used when the operator is satisfied with all the system parameters. After selecting this option, the hand terminal
will ask if this is going on a new tape. If so, the tape will be rewound before continuing on, otherwise the system will start with the tape at its present position. Whenever a tape is inserted into the unit with the power on, it is automatically rewound. Therefore, if the tape is not to be rewound insert the tape before switching on the power. After selecting the tape option the hand terminal will display:

Control By CRP
START to Begin
STOP to End

This is to remind the operator that the hand terminal is no longer in control and that the CRP is now waiting for the operator to react. If the operator wishes to return control to the hand terminal to change something before starting, pressing the STOP key followed by the ENTER key on the CRP. The MAIN MENU will appear and nothing will be written to the tape. Once START is pressed followed by the ENTER key, the hand terminal will display the BEGIN MILE, END MILE and the ODOMETER reading, which is updated continuously prior to sampling and once every interval thereafter. This updating is done following all other computer operations. Therefore, the value displayed on the terminal will be somewhat greater than the actual 0.1 mile interval value. The system will begin sampling as defined by the control variables.

System Initiate

This is used to reinitialize the system. It is a good
practice to use this function from time to time, especially when first turning the system on. Since the system is designed to retain the previous information and system parameters after the power is turned off, the memory will tend to collect unnecessary values which could affect the operation of the system. A good example of this would be if the last user pulled out the tape while it was running, crashing the system. Reinitializing the system will reset the computer's memory, reload all the default values, change parameters for the actual values, and then reset the system's hardware and connections.

MENU 2 (F1 in MAIN MENU 1)

This menu gives the operator the choice of whether to look at or reset the parameters, calibrate the odometer, or exit back to the main menu. After selecting this option the terminal will display:

F1 Parameter
F2 Odometer CAL

Parameter - F1

This option is used if the operator wishes to change or look at any parameters, or enter any comments into the comment buffer. The selection of this option will send the hand terminal to MENU 3.

Odometer CAL - F2

This option is used to calibrate the odometer. See section
5.2 for the use of this option. Any exits from within the calibration section will always return to Menu 2.

MENU 3 (F1 in MENU 2)

In this menu the operator has the choice of working with the system parameters or using the comment section. Pressing the Exit (F4) will return the hand terminal back to the Main Menu. The terminal will display the following:

F1 Change Param
F2 Update Param
F3 Comments

Change Param - F1

This option is used to display and/or change any of the system parameters or sequence information which will be written on the tape and control the system. There are three classes of parameters; A) Those parameters which must have a value for the system to run a sequence and are loaded with a default value when the system is initialized, B) Those parameters which are not needed for a successful run of a sequence but are still loaded with a default value when the system is initialized, and C) Those parameters which are used only for information that is written on the sequence header and interval summaries. They will not affect the operation of the system and are set to question marks when the system is initialized.

There are 14 parameters which the operator may page through by pressing either the PRV (F1) or the NXT (F2) keys. The items wrap around so that pressing NXT at the end of the parameters
will take the operator back to the beginning, and pressing PRV at the beginning will take the operator to the end of the parameters. Pressing EXT (F4) at any time will return the operator back to Menu 3 and any changes that were made will be entered into the computer's memory. The following is a list of the menu items:

<table>
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<th>Parameter</th>
<th>Class</th>
<th>Default Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM CODE/RECORD No.</td>
<td>Class C</td>
<td>Default ????</td>
</tr>
</tbody>
</table>

This is arbitrary and can be used at the operators discretion for tape and/or sequence identification.

TEAM ID            Class C Default ??..??

Used for the initials of a two man team. Example, John Doe and Harvey Smith would be entered as JD.HS.

DATE                Class B Default 01/01/85

The date is stored in memory when power is turned off, however, it is not updated. To enter the date simply enter the desired numbers from the hand terminal's keyboard. Follow the instructions above the function keys or use the backspace key on the terminal to edit the input.

CURRENT TIME - 24 hour clock Class B Default 00:00:00

In this menu item is a SET (F3) function which is used to
set the time. After power is removed the time is lost and will return as a random time if the system is not first initialized. To enter the time simply enter the desired numbers from the hand terminal's keyboard. Follow the instructions above the function keys or use the backspace key on the terminal to edit the input. Press the function key below SET on the terminal to enter the time.

DISTRICT-STATE ROUTE-CLASS Class C Default ?????.?

CONTROL SECTION/SEQUENCE Class C Default ?????.???

The use of these input variables is self explanatory and relate to WSDOT's highway classification and labeling system.

LANE Class C Default ?

Used for indicating which lane is being checked. To indicate both lanes, enter a "1". Use a "2" for the left lane and a "3" for the right.

ODOMETER FACTOR Class A Default 4100

This number represents the number of positive pulse transitions given by the distance measuring equipment sensor in one mile. This number may vary slightly from vehicle to vehicle or from factors such as tire wear. Use the odometer calibration to find the exact value for the vehicle which is to be used (See Section 3.7 and 6.7). The odometer factor can be entered manually or computed and stored automatically using the odometer calibration procedure. Once a calibration has been run, the
number that is obtained should be recorded so that it can be entered by hand if and when the non-volatile memory is reset (Initialized). The default value is close to the actual number.

ODOMETER READING  Class A  Default 000.0000

This reading is used to reference the vehicle from the Begin and End mile locations. Usually this would be equal to a mile post number where the vehicle is sitting when the system is setup.

BEGIN MILE  Class A  Default 000.0000

The defined point where the system will start sampling the data keys and write the data on tape.

END MILE  Class A  Default 001.0000

The defined point where the system will stop collecting data, write what data it has collected to tape, and return control to the hand terminal with the MAIN MENU.

INTERVAL DIRECTION/LENGTH  Class A  Default +0.1000

This is the length of the individual intervals. The number is preceded by a "+" or "-" sign to indicate whether the system is to go from the BEGIN MILE to the END MILE or reverse (to increment or decrement the mile counter). An example of decrementing would be if the vehicle turned around and went the
opposite direction for another sequence for the other side of the road.

**NUMBER of SAMPLES per INTERVAL**  Class A  Default 82

This determines how many times per interval the system will sample the CRP for data. This number must be an even multiple of the odometer factor, and if it isn’t, the system will recompute the numbers entered and automatically select the closest even set of values.

The algorithm used for computing the actual number of samples per interval from the values entered is as follows:

Let

\[ \text{ODFACT} = \text{Odometer factor} \, \text{(Number of signal pulses per mile produced by the odometer)} \]

\[ \text{NSAMP} = \text{Number of samples per interval requested} \]

\[ \text{INTLEN} = \text{Interval length requested} \]

Then, the factor

\[ \text{COUNFAC} = \frac{(\text{ODFACT})(\text{INTLEN})}{(\text{NSAMP})} \]

rounded to the nearest integer gives the number of pulses between any two scans (or samples). Because of this "rounding off", NSAMP will have to be adjusted as follows:

\[ \text{NSAMP} \rightarrow \text{NSAMP'} = \frac{(\text{ODFACT})(\text{INTLEN})}{(\text{COUNFAC})} \text{ rounded off to the nearest integer. Rounding off of NSAMP’ will result in a new interval length given by,} \]
INTLEN ----> INTLEN' = (NSAMP')(COUNFAC) / (ODFACT)

PRINTER ON/OFF         Class B        Default OFF

This controls the option to have a report of sample accumulations printed out at the end of each interval. At present, if this option is selected, the operator will have to drive much slower towards the end of each interval to avoid loosing data on the beginning of the next interval. A print buffer is to be added to the system which will eliminate this problem.

3.9 IBM PC/XT Computer System

The IBM PC/XT computer system is an integral part of the overall pavement survey system. It is used to read, edit and display the data from the tapes that are recorded in the field. It also has the software required to do the initial data averaging and file development required to get the data into the interpreting program in their overall pavement management system.

This system consists of an IBM PC/XT with a printer and a Digi-Data Corporation model 6450 cartridge tape drive. Also, software has been developed to control the tape drive, to read, edit and analyze the data and to put the data in a form that can be entered directly pavement management system.
Users Guide For Pavement Survey Unit Software

TDRIV is a program designed to read data tapes from the field pavement survey unit. In addition to displaying the sequence and interval summaries, TDRIV can display individual samples or compute severity, extent and deduct values for the different intervals.

Starting TDRIV

TDRIV is located on the hard disk in directory \DOT, so to make running and loading easier, it is a good idea to move into this directory before running the program. To change into \DOT, type

```
    cd \dot <cr>
```

If, however, you want the files you create while running TDRIV to end up in a directory other than \DOT then you should go to that directory instead and use a different form of the load command discussed below.

Since TDRIV is (presently) written in interpreted BASIC, the first step in running it is to load the BASIC interpreter. This is done with the statement:

```
    basic /c:1000 /s:1000 <cr>
```

where <cr> indicates a carriage return. You should now see a welcome message from BASIC. Next type

```
    load "tdriv.bas" <cr>
```
from within the directory \DOT or

    load "c:\dot\tdriv.bas" <cr>

from any other directory. You should see an "Ok," prompt when
this is completed.

To actually start the program, simply type

    run <cr>

TDRIV's opening menu should now appear.

When you are done running TDRIV and are back at the BASIC
command level (the "Ok," prompt) type

    system <cr>

to return to PC-DOS.

Running TDRIV

All of the functions in TDRIV are accessed from a main menu,
(the one that comes up when the program is first started). The
following sections will cover each option in detail.

1) Set Track

The cartridge tapes are formatted such that there are four
logical tracks per tape. The set track function changes the
track that the tape drive looks at and hence provides an easy way
to skip a quarter of the tape at a time. One word of warning
though, the tracks are arranged on the tape in a serpentine
fashion so that the end of track one is at the beginning of track
two, etc. This means that if you are at the beginning of track one and switch to track two, you will be at the very end of track two and doing any sort of read operation will push you over onto track three. See Section 3.5, 6.5 and Appendix H.

2) Rewind Tape

This will move to the beginning of track one and read the first sequence header, positioning you at sequence one, interval one.

3) Search for Summary

This will search through the tape sequentially from the current position looking for either the next interval summary record or a specific summary, if you gave it an interval number (See Section 6.5). This is a handy way to move long distances forward in a sequence.

One current problem involves trying to search past a tape error. The drive's search routine will return an error code and leave the tape positioned before the error, so that resubmitting the search will only reveal the same error. As of now, no simple way has been found to gain access to data in a sequence that was recorded with a tape error. The data in the following sequences is still good and accessible.

4) Read Current Header

This will read the current sequence header. If the tape is currently positioned in the first sequence then this command
behaves exactly like (2) and rewind the tape. Its main use occurs when the tape is positioned on some sequence other than the first. It can then be used either to recover from a "tape position lost" error without losing track of what sequence it was on or as a fast way to back up. As an example, if the current position was sequence 5, interval 40 (S5I40) and you wanted to move to interval 20 in the same sequence (S5I20) the fastest way to do it would be to read the current header (4) and then search for summary number 20 (3).

5) Dump Interval to Disk

This will dump all the data for a single interval to a disk file of the user's choice, one sample per line.

6) Display Individual Samples

This option allows you to see which keys were depressed for each sample during an interval. The samples are displayed 20 at a time, with blanks representing no data, question marks representing invalid or default data and various mnemonic symbols (such as Sp for spalling, etc., See Appendix A and Section 6.5) representing valid data. After each screen of data you may enter either a carriage return to see the next 20 samples, a specific sample number to see 20 samples starting with that number, or a minus one (-1) to return to the main menu. You will be returned to the main menu automatically when all samples in an interval have been displayed.
7) Space Forward Interval

8) Reverse Space Interval

The forward/reverse space interval function will reposition the tape to the end of the following/preceding interval and then display the interval summary. Should the end/beginning of a sequence be encountered, the sequence header will be read and displayed.

9) Compute Summary Statistics

This will compute the severity, extent and deduct values for the current interval, and then display them to the screen following the interval summary. This operation entails a large amount of data manipulation an number crunching. The speed of these operations can be increased substantially by the use of a BASIC compiler and an 8087 math co-processor. Also, the amount of data being collected may become a consideration. An IBM PC/AT would also greatly improve performance. There are also co-processor type boards for the XT which can greatly improve its performance for a relatively low cost.

A new option is also available but the software modification have yet to be added. That is, at present the field system computes and stores the accumulated data associated with the severity, extent and deduct calculations. This mode will use these values directly and will be added to the IBM software by late spring and will substantially enhance the overall performance of this system.
10) Forward Space Sequence (file)
11) Reverse Space Sequence

The forward/reverse space sequence function moves to the beginning of the following/preceding sequence and reads and displays the sequence header.

12) Retension Tape

Spins the tape cartridge from one end to the other to even out the tape tension. This can sometimes cure intermittent tape errors, if the tape has been sitting for a while or has undergone a great deal of stop and start motion.

13) Autosummary of Current Sequence

This function computes severities, extents and deduct values for all intervals in the current sequence and writes the data into two files. The two file are referred to as the header and the data files.

\(<\text{type}><\text{state}_\text{route}><\text{dir}><\text{beg}_\text{mile}>.\text{DAT}\)

where \(<\text{type}>\) is either H or D for header and data files respectively, \(<\text{state}_\text{route}>::\) is the state route number, \(<\text{dir}>::\) is the direction of travel (either P or M for increasing or decreasing mile number) and \(<\text{beg}_\text{mile}>::\) is the beginning milepost number. These two files are the two required for input to the dBase programs for later manipulation.

14) Stop

Stops the program and returns you to the basic command level.
Common Errors and Problems

Probably the most common error is caused by the tape drive not being properly set or reset. If the tape drive has not been used since it has been turned on (the SELECT light is off), TDRIV will probably halt with an "I/O error in 550" message. The cause of this error has not been determined, but its occurrence causes the SELECT light to go on and hence prevents this problem repetition. Just type run again to restart the program and all should work well.

Another common problem is the program "hanging" and not returning to the menu on the first function selected. This is most likely caused by the tape drive being turned off or a connector having fallen off. Press CTRL and BREAK at the same time to halt the program, then check the switches and connectors before trying again.

Another error manifests itself with an "Illegal function call in 35" message. This probably means that you forgot the "/c:1000 /s:1000" parameters on the BASIC invocation.

dBASE program documentation

To load data files into dBase for the very first time, from within dBase type (you must have the dBASE III dot prompt on the screen).
do load <cr>

and answer the questions.

To load the .DBF files back into dBase at a later time, type

Clear All
select1
use H______ alias header
select 2
use D______ alias sevext
select 3
use A______ alias aved

where the last two lines load the averaged data base and are completely optional.

To average severity and extent values over intervals and store the results in another database, type.

do ave <cr>

and answer the questions.

TREE STRUCTURE

DIRECTORY PATH LISTING FOR VOLUME CDRIVEDOS

Path: \DBASE
Sub-directories: None

Contains dBase III & command files

Path: \SYSFILES.DOS
Sub-directories: None

System files
Path: \DOT

Sub-directories: PROGS

BASIC tape reading programs

Path: \DOT\PROGS

Sub-directories: None

Original source for INTERP, etc.

Path: \COMM

Sub-directories: IBM3101

Communications software

XTK

SPF

Path: \COMM\IBM3101

Sub-directories: None

IBM3101 emulator program

Path: \COMM\XTK

Sub-directories: None

Crosstalk XVI (general purpose)

Path: \COMM\SPF

Sub-directories: None

SPF with communications module

Path: \WPROS

Sub-directories: None

Wordstar word processor (overlay files

must be in your current directory as well)

Also contains document files

Path: \FOR

Sub-directories: None

Microsoft FORTRAN (plus working versions

of INTERP, etc.)

Path: \UTIL

Sub-directories: None

General purpose homebrew utilities

Path: \F77

Sub-directories: None

DRI FORTRAN77 compiler
SECTION IV
MAINTENANCE

4.1 General

The maintenance of the field equipment is limited to the tape drive, the keyboard and the printer. The other items are relatively maintenance free as long as everything is kept clean and dry. Consult the individual manufacturers manuals for the maintenance of the various items in the IBM PC/XT system.

4.2 Microcomputer Unit

This unit should not be removed or tampered with by other than a qualified electronics technician. There is no real maintenance required other than keeping the connectors clean and replaced if required. There is a fuse on the front panel that should be checked and replaced if the unit fails to come on when power is applied to the unit.

4.3 Keyboard

This unit should be kept clean and dry. It would be a good practice to periodically disassemble the unit and remove the three PCB cards and front cover and clean the unit with a freon spray and/or compressed air. By removing the six socket head cap screws on the cable end of the unit the complete assembly can be removed and disassembled. The individual keys are soldered to the top board and can be easily replaced if needed.
4.4 Hand Terminal

The hand terminal is environmentally sealed and should not require maintenance. However, the manufacturer's manual should be studied carefully before using the unit.

4.5 Tape Cartridge Drive

The tape heads and surrounding area should be cleaned periodically using a series of clean cotton or foam swabs and alcohol. It is also generally recommended that the metal surfaces and the tape head be demagnetized at regular intervals, please consult the manual and/or the factory before doing this operation.

4.6 Printer

The paper will have to be replaced as needed, please consult the manual, see appendix I. The front panel pulls out to give access to the paper spindle. Cleaning of this area periodically is also recommended.

4.7 IBM PC/XT Computer System

Consult the applicable manufacturer's literature for the maintenance of this equipment.
SECTION V
CALIBRATION

5.1 General

The only calibration associated with the overall system is in the field pavement survey unit. This calibration is used to determine the exact number of counts per mile that are given out by the odometer unit. This unit is mounted on the vehicle and is connected directly to the microprocessor control unit through the front panel (See Figure 4).

5.2 Odometer Calibration

The calibration of the odometer requires having a stretch of road with known mile post marks. The operator selects the odometer calibration option from the hand terminal (See MENU 2, & Figure 1), the hand terminal will then remind the operator to press the START key (followed by the ENTER key) when the vehicle is at the beginning mile post. When the vehicle comes to the end of the section or final mile post the operator presses the STOP key (again followed by ENTER). The pressing of the ENTER initiates the action, therefore, the START or STOP key can be pushed in advance and the ENTER key used to mark or start the action. The hand terminal will then ask for the distance travelled to the nearest tenth of a mile. Once entered the hand terminal will return the operator to Menu 2 and the system will automatically log the new value for the Odometer Factor into the parameter section of it's memory.
SECTION VI
THEORY OF OPERATION

6.1 General

The pavement condition recording and computing device is a microprocessor-controlled, data acquisition and reduction system which uses a combination of manual inputs and an odometer readings to develop pavement condition reports. These reports are printed on the system printer and written to a standard magnetic tape cartridge along with the raw data for later inclusion in the Washington State Department of Transportation (WSDOT) pavement management data base (WSPMS).

The device, including all of its attendant equipment, is fully portable and can be used in any motor vehicle that has an odometer pulse generator (preferably producing approximately 4,000 TTL level counts per mile) and 12 Vdc power source.

6.2 Microcomputer Control Unit

This is the main component and consists of a microprocessor-based control unit with power supply, input digital signal capability and input/output communication ports. A control rating panel (CRP), a hand terminal, remote transcrack unit, a tape drive and a printer are all connected to this unit. This complete system is housed in a portable moisture resistant case.
6.3 Control Rating Panel - Keyboard

The rating portion of the CRP regulates the monitoring of the pavement defect data. The CRP maintains a running evaluation of the pavement condition. The microprocessor control unit then samples (scans) these inputs at a fixed distance interval (approximately 4,000 scans per mile or any even integer division thereof). It records this raw information on magnetic tape along with the data accumulations for each input variable and any desired alphanumeric text. The terminal also displays the BEGIN MILE, END MILE and the ODOMETER READING, while data is being collected.

Control Keys

The starting sequence will allow the automatic initiation of a test run. The odometer must be set to a known milepost prior to the start of the test run. When the odometer is incremented or decremented to the starting mile value, data collection automatically begins. **The BEGIN MILE is always numerically less than the END MILE.** In the decrementing direction, the value keyed in as END MILE will start the data collection. Auto start cannot be modified while collecting data, but it can be deactivated by pressing the STOP plus the ENTER key on the CRP.

A plus or minus sign in front of the interval value will select whether the odometer will increment or decrement. When in the decrement mode, the END MILE value is considered the start of the measuring sequence and the BEGIN MILE the finish.
The BST/ACP key (push on-push off) records the pavement type as ACP when not activated (light off) and BST when activated (light on).

The STOP key followed by the ENTER key (momentary contact) will halt data collection, terminate the run, and print out and record the accumulated data.

The PAV'T EXEMPT key (push-on-push-off) halts data collection while activated (light on) and resume data collection when deactivated (light off). The odometer continues working through this phase and results in a normal run with fewer samples for that particular interval. This is used to exclude unwanted roadway sections such as bridge decks. The PAV EXMT and the BST/ACP keys are both turned off by either pressing the key again or when the computer resets the CRP at start up.

The END OF FILE key places an end of file (EOF) mark on the tape each time this key and the ENTER key is pushed. This is used for tape control. If problems occur a double EOF on the tape will allow the repositioning of the tape back to this position.

The PAUSE key will return the menu control back to the operator and allow for parameter modification, updating, report generation, addition of comments to that tape interval and system restart.

The STOP, PAUSE, and START keys are tied together so that only one of these keys will be on at a time. The only way to turn off any one of these keys is to press one of the others or
when the computer resets the CRP. When any of these keys are pressed the ENTER key will light up to remind the operator to press ENTER. This must be done before the actual function is performed by the microprocessor unit.

The EOF (End of File) key is a push-on-push-off key which will also light the ENTER key. The ENTER key is to get the computers attention so that if the EOF, STOP, PAUSE, or START keys were pressed by accident, the operator could change the situation before the computer reacted. If the EOF was pressed by accident, pressing it again will turn it off, the ENTER key will stay on but pressing it will only turn the light off. After the computer has recognized the ENTER key and the key which turned it on, the computer will toggle the Ent. STRB line which will turn off the ENTER key light and the EOF if it was pressed. The computer will not turn the STOP, PAUSE, or START lights off, however, so that the operator will know which mode the system is in at all times. The PAV EXMT. and the BST/ACP keys will not affect the ENTER key.

Special Function Keys

The special function keys are user definable keys and can be used for anything the operator wishes. To use these keys the operator simply defines what they are to be used for in the comment section and proceeds as defined. The first two keys (F1 & F2) are push on-push off keys, that is, their status is recorded to tape continuously whether on or off. The last three (F3, F4, & F5) are momentary-on keys and are used for counting
items such as pot holes or for flagging purposes.

The F3, F4, and F5 keys will stay on until the computer reads them, after which the computer will toggle the M STRB line which will turn them off. This assures the operator that the data has been read. If the vehicle stops in the middle of a sequence and one of these three keys are pressed, they will stay on until the vehicle moves forward enough for the system to take another sample of the keyboard. When the vehicle is moving at a reasonable speed, this interaction between the keys and the computer will be such that the keys will appear to be a momentary switches. The transcrack keys also function in this same way.

Control Rating Keys

The rating portion of the CRP is divided into five distinct, visually-separated, rating categories. The categories are laid out from left to right as follows: Alligator cracking, longitudinal cracking, transverse cracking, patching, and raveling or flushing.

The four "CLR" buttons are used to clear or deactivate any defect keys that are in the active status, but will not erase any of the accumulated data in the memory registers. All keys have LED lights in them to indicate active status ("on"). The CLR key will light if an invalid selection has been made in that category.
A hand held rating device is included for the counting of transverse cracks by the driver. The device is identical to the "TRANS CRACK" section on the keyboard and is connected to the main panel through a front panel connector and a six foot long expandable cord.

The CRP is scanned and data stored to tape and accumulated in memory at up to the odometer factor rate per mile. This depends on the input variables, samples per interval and interval length. The BEGIN MILE - END MILE sequence is separated into intervals of any desired length.

The keyboard (CRP) contains three printed circuit boards (PCB's), a housing and a front panel with keys (See Figures 2, 6 - 9 & 12 - 15). The top PCB supports only the switches (keys) and the LEDs (Light Emitting Diodes) for the individual keys. The second board consists of two parts. The main part is the circuitry which handles the switch debounce for the data switches and the LED drivers. The second part is the circuitry for the control switches. This includes the logic circuitry for these switches. The third board consists of the logic circuitry for the data switches and the buffers for the signals going to and coming from the microprocessor control unit.

Each key has its own set of logic circuitry consisting of a flip-flop and a delay buffer (See Figures 15 and 16). Through jumpers on the board the switch can be made to function as a momentary push-on, a momentary push-on with computer reset, or a push-on-push-off type switch. Each switch can be set or reset by the computer (all keys at once) and can be cleared by any
selected clear key or the pressing of another data key in the respective category.

Control Rating Panel Defect Categories

The ALLIGATOR CRACKING and the LONGITUDINAL CRACKING categories each have five keys. At least one key must be activated in either category to indicate a defect. Two keys can be activated at the same time under alligator or longitudinal cracking to indicate defects in each wheel path. Under longitudinal cracking, any combination of these two keys can occur because of multiple cracks. If the "+1" key is pushed, it will duplicate the greatest severity that is active in that category. Activating the "+1" key under alligator cracking indicates two simultaneous defects at the same severity as the key activated in the left hand column. Each time the computer scans the panel, it records the active condition shown on the panel; one count per activity. If the "+1" is active, then the most severe condition indicated gets two counts.

All these keys are push-on-push-off keys (except for the CLR keys). When the CLR key is pressed, all the keys in its category will turn off. If the +1 is pressed by itself or if the HL, >1/4, and the SP are all on at the same time, the CLR key will light up to indicate that this is an invalid situation. Pressing the unwanted key again or the CLR key will remedy the situation.

The severity (S), extent (E) and deduct value (D) are
calculated as follows:

Alligator Cracking Formulas

\[
S_{AC} = \frac{C_1 + 2C_2 + 3C_3}{C_1 + C_2 + C_3}
\]

(Round to nearest 10th)

\[
E_{AC} = \frac{2(C_1 + C_2 + C_3) + 1}{N_s}
\]

(rounded to nearest 10th after checking \(E\) for limits)

\[
D_{AC} = 15(S_{AC} - 1) + 10(E_{AC} - 1) + 10
\]

(Deduct)

\[
= 5(3S_{AC} + 2E_{AC} - 3)
\]

\(C_1\) = counts of "HL" (hairline) severity in each wheel path

\(C_2\) = counts of ">1/4" (over 1/4") severity in each wheel path

\(C_3\) = counts of "SP" (spalling) severity in each wheel path

\(N_s\) = Number of times panel scanned in rated length

If \(C_1 + C_2 + C = 0\), then print "(0.0, 0.0)"

If \(E < 1.03\), then print "(0.0, 0.0)"

If \(E > 4.0\), then \(E = 4.0\)

Longitudinal Cracking

\[
S_{LC} = \frac{C_1 + 2C_2 + 3C_3}{C_1 + C_2 + C_3}
\]

(Round to nearest 10th)

\[
E_{LC} = \frac{C_1 + C_2 + C_3 + 1}{N_s}
\]

(round to nearest 10th after checking \(E < 1.10\))
\[ D_{LC} = 10[(S_{LC} - 1) + (E_{LC} - 1)] + 5 \]
\[ = 10(S_{LC} + E_{LC}) - 15 \]

\( C_1 \) = Counts of "HL" severity along 1 or more cracks
\( C_2 \) = Counts of ">1/4" severity along 1 or more cracks
\( C_3 \) = Counts of "SP" severity along 1 or more cracks
\( N_s \) = Number of times panel scanned in rated length
If \( C_1 + C_2 + C_3 = 0 \), then print "(0.0, 0.0)"
If \( E < 1.01 \), then print "(0.0, 0.0)"
Each crack is counted separately.

The TRANSVERSE CRACKING category has three keys. Each push of a key will count one in the computer at that particular severity. The computer will only scan this category for severity and the data is sent directly to the computer as it is counted.

All these keys are push-on-stay-on keys with computer reset. They are tied together so that only one can be on at a time and it will stay on until the computer reads it and shuts it off. They are, therefore, used to count individual cracks.

The severity \((S_{rc})\), extent \((E_{rc})\) and deduct value \((D)\) are calculated as follows:

\[ S_{rc} = \frac{N_1 + 2N_2 + 3N_3}{N_1 + N_2 + N_3} \quad \text{(round to nearest 10th)} \]
\[ E_{tc} = 0.78 + \frac{22N}{L} \quad \text{(round to nearest 10th after checking for } E<1.00) \]

\[ D_{tc} = 5[(S_{tc} - 1) + (E_{tc} - 1) + 1] \quad \text{(Deduct)} \]

\[ = 5(S_{tc} + E_{tc} - 1) \]

\[ N = N_1 + N_2 + N_3 \]

\[ N_1 = \text{Number of "HL" cracks} \]

\[ N_2 = \text{Number of "}>1/4" cracks} \]

\[ N_3 = \text{Number of "SP" cracks} \]

If \[ E>3.0 \], then make \[ E = 3.0 \]

If \[ E<1.00 \], then print "(0.0, 0.0)"

\[ L = \text{length of section in feet.} \]

The PATCHING category has seven keys. The left column is used to measure extent when combined with distance and the right column is for severity. In each column, not more than one key can be active at one time. If another key is pushed when one is already active, the new one will then become active and cancel the other.

At present the Fl key is being used to indicate full depth patching and operates independently from the other keys in this category (This will be changed in future units). If a key is pressed in one column but not pressed in the other, the CLR key will light up to indicate that this is an invalid situation. Pressing a key in the other column or the CLR key will remedy this situation.
The severity \( (S_{PA}) \), extent \( (E_{PA}) \) and deduct value \( (D) \) are
calculated as follows:

\[
S_{PA} = \frac{B + 2A + 3A'}{B + A + A'} \quad \text{(round to nearest 10th)}
\]

\[
E_{PA} = 0.92 + \frac{2.08 (B + A)}{N_s} \quad \text{(round to nearest 10th after}
\text{checking for } E < 1.00)
\]

\[
D_{PA} = 10[(S_{PA} - 1) + (E_{PA} - 1) + 1] \quad \text{(deduct)}
\]

\[
= 10(S_{PA} + E_{PA} - 1)
\]

\[
B = C_{B1/4} + 2C_{B1/2} + 3C_{B3/4} + 4C_{BF}
\]

\[
A = C_{A1/4} + 2C_{A1/2} + 3C_{A3/4} + 4C_{AF}
\]

\[
A' = C_{A'1/4} + 2C_{A'1/2} + 3C_{A'3/4} + 4C_{A'F}
\]

\[
C_{B1/4} = \text{Counts for 1/4 lane BST patching}
\]

\[
C_x = \text{counts if activated button when scanned } N_s \text{ times}
\]

\[
N_s = \text{Numbers of times scanned in}
\]

\[
B = \text{BST, } A = \text{ACP, } A' = \text{ACP(full depth), F = Full width}
\]

\[
y = \text{portion of lane width}
\]

\[
C = \text{Accumulated counts}
\]

If \( E > 3.0 \), then make \( E = 3.0 \)

If \( E < 1.00 \), then print "(0.0, 0.0)"

If \( B + A = 0 \), then print "(0.0, 0.0)"

The RAVELING or FLUSHING category has nine keys. The left
column defines the defect, the middle the severity, and the right
the extent. In each column, not more than one key can be active at any one time. If another key is pushed when one is already active, the new one will then become active and cancel the other. If there is a key pressed in one or two columns but not all three, the CLR key will light to show that this is an invalid condition. Pressing a key in each column or pressing the CLR key will remedy this situation.

The severity (S), and extent (E) are calculated as follows:

\[
SR_A = \frac{SR_1 + 2SR_2 + 3SR_3}{N_a} \quad \text{(round to nearest 10th)}
\]

\[
SF_L = \frac{SF_1 + 2SF_2 + 3SF_3}{N_a}
\]

\[
ER_A = \frac{ER_1 + 2ER_2 + 3ER_3}{N_a} \quad \text{(round to nearest 10th)}
\]

\[
EF_L = \frac{EF_1 + 2EF_2 + 3EF_3}{N_a}
\]

\[
SR_1 = \text{Accumulated counts at "slight" severity}
\]

\[
SR_2 = \text{Accumulated counts at "moderate" severity}
\]

\[
SR_3 = \text{Accumulated counts at severe" severity}
\]

\[
N_a = \text{Number of times scanned in rated length}
\]

\[
ER_1 = \text{Accumulated counts at "localized" extent}
\]

\[
ER_2 = \text{Accumulated counts at "wheel path" extent}
\]

\[
ER_3 = \text{Accumulated counts at "entire lane" extent}
\]

53
6.4 Hand Terminal

The hand terminal is a full ASCII terminal (regular computer terminal) except it is limited to four lines of sixteen characters each. It also has four programmable special function keys, which are used extensively for program control. The acronym above each key or the F1, F2, F3, or F4 specification in the menu text defines there individual functions.

Menu Variables

The control portion of the system allows input of project data as well as controlling the sequencing of a test. This control function is performed by using the hand held terminal with menu driven data input and the control key functions on the CRP.

The following is a description of the individual variables that are entered from the hand terminal (See Figure 1).

1. SYSTEM CD/REC:
   This is a user definable input and is meant for sequence identification purposes.

2. TEAM INITIALS:
   Two sets of two alpha-values are provided for entering two raters initials.

3. DATE: Month-day-year (00-00-00).
4. CURRENT TIME: - 24 Hour clock

5. DISTRICT/SIGN ROUTE/FUNCTIONAL CLASS:
District = one digit, sign route = up to three digits, functional class = one digit (0-000-0).

6. CONTROL SECTION/CONTROL SECTION SEQUENCE:
Control section = four digits, control section sequence = three digits (0000-000).

7. LANE: Both = 1, right = 2, left = 3 (0).

8. ODOMETER FACTOR:
This is the number of counts per mile generated by the odometer.

9. ODOMETER READING:
The current odometer reading is displayed on the hand terminal while data is being collected and is entered manually.

10. BEGIN MILE:
Normal operation will trigger data collection at this preset mileage if the direction is incrementing; data collection will end at this mileage if the direction is decrementing.

11. END MILE:
Data collection will automatically end at this preset mileage and record the data to tape. If the printer option is active a report is generated. Normal operation will
trigger data collection at this preset mileage if the direction is decrementing. A sequence is defined as the distance between the BEGIN MILE and the END MILE.

12. INTERVAL:
A preset distance interval at which the system will automatically terminate the relative accumulations and record this information to tape. If the print option is on a summary report is generated. Also a plus or minus sign in front of this variable controls whether the counting is incremented or decremented.

13. SAMPLES/INTERVAL:
This defines the resolution between samples.

14. PRINTER ON/OFF:
Activates or deactivates the printer option.

All of the above items are held in the memory after entry. The memory items are held until erased or modified. This part of the memory is non-volatile and will not be altered by unplugging or turning the unit off and on.

6.5 Tape Cartridge Drive

Most of cartridge tape control is handled automatically by the system software. The tape cartridge is rewound upon insertion (if the power is on) and positioned at the beginning of tape and on track one or it can be allowed to continue from the current tape position (the operator must be aware of which track he is on and set the system to the proper track if necessary). Also the
tape can be positioned at a double end of file mark which is automatically placed at the end of a tape if and when a data collection sequence has been completed or the system has been shut down. Also, the operator can place a double end of file on the tape using the keyboard. This is used for limited tape control. This will also allow for more efficient use of individual tapes. A software tape reset feature is provided to reinitialize a new tape when first starting a sequence of measurements. The filling of a tape with data or the removal of a tape sounds an audible alarm and initiates a menu sequence on the hand terminal. This allows for efficient tape management and control.

The tape drive is used for storing both the raw data and information which is important for keeping track of the data. When the system is first turned on the computer will set up the tape controller board (See Figure 5) for proper parity and bit count. Then the system will check the tape drive for its present status to verify that proper communications have been set up. If a status byte is not received the system will send the message "PLEASE TOGGLE THE POWER" to the hand terminal. After the parameters have been entered and the tape has been positioned to where the operator wishes, and the START button has been pushed, the system will write a 512 byte record at the beginning of the tape called the Sequence Header. This information is used to identify one sequence from another and is in the following format:

<table>
<thead>
<tr>
<th>STARTING</th>
<th>NO. of</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYTE #</td>
<td>BYTES</td>
</tr>
<tr>
<td>0</td>
<td>8</td>
</tr>
</tbody>
</table>

DESCRIPTION
ASCII word "HEADER ". Used for locating
the Sequence Header when reading the tape.

8 2 Zeros
10 1 The calculated number of records needed for one interval.
11 5 Zeros
16 4 ASCII System Code and Record
20 4 ASCII Team Letters
24 6 ASCII Date (Month/Day/Year)
30 6 ASCII Time (Hours/Minutes/Seconds)
36 1 ASCII District
37 3 ASCII State Route
40 1 ASCII Functional Class
41 4 ASCII Control Section
45 3 ASCII Control sequence
48 1 ASCII Lane
49 4 Odometer Reading *
53 5 Length of interval, the first byte is going to be either an ASCII "+" or "-". *
58 4 Odometer Factor *
62 4 Begin Mile *
66 4 End Mile *
70 40 Zeros
110 2 Number of samples per interval
112 4 Zeros
116 8 ASCII word "COMMENT "
124 300 Comment Buffer
424 88 Accumulations

* A hexadecimal number represented as hh.hh. Where hh is a two byte hex number representing either the integer number or the decimal number in 10 thousandths. Ex 10.20 would represent the decimal number 256.512.

As the system collects data it writes it to the tape drive in 512 byte records. At the end of every interval (defined by the operator) the system will fill the remaining part of the current record with zeros. If there are less records than the calculated number of records per interval, the system will write blank records to the tape until there are enough records. This condition would result from extensive use of the pavement exempt key.

The system is now ready to write the Interval Summary record. The format is very similar to the Sequence Header and is as follows:

STARTING NO. OF
BYTE #  BYTES DESCRIPTION
0 8 ASCII word "SUMMARY ".

58
Interval Sequence Number

The calculated number of records needed for one interval.

Zeros

ASCII System Code and Record

ASCII Team Letters

ASCII Date (Month/Day/Year)

ASCII Time (Hours/Minutes/Seconds)

ASCII District

ASCII State Route

ASCII Functional Class

ASCII Control Section

ASCII Control Sequence

ASCII Lane

Odometer Reading *

Length of interval, the first byte is going to be either an ASCII "+" or "-". *

Odometer Factor *

Begin Mile *

End Mile *

Alligator Crack Severity **

Alligator Crack Extent **

Longitudinal Crack Severity **

Longitudinal Crack Extent **

Zeros

Patching Severity **

Patching Extent **

Ravelling Severity **

Ravelling Extent **

Flushing Severity **

Flushing Extent **

Flag Button #1

Flag Button #2

Flag Button #3

Flag Button #4

Flag Button #5

Transverse Crack HL

Transverse Crack >1/4

Transverse Crack SP

Number of samples per interval

Zeros

ASCII word "COMMENT "

Comment Buffer

Accumulations

* A hexadecimal number represented as hh.hh. Where hh is a two byte hex number representing either the integer number or the decimal number in 10 thousandths. Ex 10.20 would represent the decimal number 256.0512.

** A hexadecimal number represented as h.h. Where h is a one byte hex number representing either the integer number or the decimal number in tenths.

When the END MILE is reached or the STOP key is pressed
(followed by the ENTER key) the system will write the last summary to tape followed by a file mark to indicate the end of the sequence.

6.6 Printer

The printer is a twenty column serial printer and is driven directly by the microprocessor control unit. It is turned on in the setup menu and is used to print a summary report of the accumulated data associated with each defect category.

6.7 Odometer Circuitry

An odometer which is an automotive industry standard unit, giving approximately 4,000 TTL level positive transitions per mile is required. The actual number of pulses can be anything, the greater the number the more accurate the distance measurements and the greater the number of samples per interval that are possible (within limits). This device must be mounted on the vehicle and can be calibrated by the microprocessor control unit.

6.8 IBM PC/XT Computer System

Please consult the IBM PC/XT system and service manuals for this information. If there are still any questions, call your IBM representative.
SECTION VII
TROUBLESHOOTING

7.1 General

In general the manufacturers manual pertaining to the specific component in question should be referenced when troubleshooting a given problem. The primary components covered in this section are those that have been custom designed and/or built for this piece of equipment.

7.2 Microprocessor Control Unit

When the system is first turned on, the computer goes through a series of checks and tests to check for proper operation of all components. If something is wrong, one or more of the following will happen:

1) The microprocessor control unit gives off a constant "beep beep".

   Problem: The hand terminal is either not hooked up or else the hand terminal connector is poorly seated. The beeping will stop as soon as the hand terminal is hooked up and functioning properly.

2) Hand terminal displays:
   The CRP is not Responding Right
   Fl Restart
Problem: The CRP is either not hooked up or else the connector is poorly seated. After checking everything, press the F1 key on the hand terminal to have the system check again.

3) Hand terminal displays:

REMOTE TC not
Connected
F1 Test Again
F2 Continue

Problem: The Remote Trans. Crack/Odometer input unit is either not hooked up or else the connector is poorly seated. After checking everything press the F1 key on the hand terminal to have the system check again. If you are turning on the system where you don’t need the remote transcrack unit (eg. menu familiarization), press F2 on the hand terminal and the system will ignore this problem.

4) Hand terminal displays:

Check If Tape Is
Secured Right
F1 Restart

Problem: The system was either started without a tape in the tape drive or else the tape was not inserted properly. Pull the tape out all the way then firmly push it straight into the tape drive. Press F1 on the hand terminal to check again.
5) Hand terminal displays:

Tape Is Set For
Write Protect
F1 Restart

Problem: The tape cartridge itself is set so that nothing can be written onto the tape. Pull out the tape and first verify that the tape does not already contain information which should not be lost. Then, looking at the top of the tape on the upper left corner, there is a small tab with an arrow pointing to the word "SAFE". Rotate the tab until it points away from the word "SAFE" (180 degrees), reinsert the tape, and press F1 on the hand terminal for the system to check again.

6) Hand terminal display:

Tape Drive Needs Servicing
F1 Restart

Problem: The tape drive is not properly communicating with the computer. Check for something obvious such as foreign objects in the drive. If pressing F1 on the hand terminal keeps returning you to this message, then the instrument needs to be checked out by a qualified service facility.

7) Hand terminal displays:
Problem: This usually occurs when the tape drive has been interrupted before fully completing an operation (e.g. pulling the tape out in the middle of an active test sequence).

If the system continues to indicate one of the problems mentioned, then the system needs to be checked out by a qualified service facility and servicing should not be attempted while in the field. If a problem occurs that is not mentioned above, check the troubleshooting procedures in the following sections which cover specific items. As a last resort try turning the power on and off and reinitialize the system from the hand terminal.

7.3 Keyboard

Key Replacement

To replace a key, it must be desoldered from the board. Some of the keys are in group of threes. If this is so the entire group will need to be replaced. It can be replaced with another group of three or else three single keys. There is a small slot on the top of the key where the key label may be removed from the old key and inserted into the new one. The mounting holes on the circuit board are polarized so that the keys can be mounted only when positioned the correct way.

Key LED Replacement
To replace a key LED, the switch has to be removed first. When mounting the new LED, be sure that the top of the LED is 3/10 of an inch from the circuit board. This will give the maximum light output and still give enough clearance for switch movement.

Key and Lamp Troubleshooting

Except for continuity checks, the first circuit board (keyboard) should be checked with the second board attached to supply proper voltage levels. Check each LED by supplying +5V to the proper input signal line on the second board.

Logic Board

If the computer indicates that the CRP is not communicating correctly and the connector has been verified to be seated securely, then there is a high probability that the problem is in the logic board. Check both the buffers and the key flip-flops.

7.4 Odometer Circuitry

The odometer circuitry is located on the interface board. If the odometer signal is present at the connector but not effecting the system when it should, verify that the system is enabling the odometer input by placing a high on pin 13 of U3 and that the signal is on pins 11 and 12 of U3.
SECTION VIII

SCHEMATICS, DRAWINGS AND FIGURES
Figure 1 HAND TERMINAL MENU
FLOW CHART
Figure 3  Hand Terminal Layout
PAVEMENT SURVEY SYSTEM BLOCK DIAGRAM

Figure 5 Pavement Survey System Block Diagram
CRP BLOCK DIAGRAM

Figure 6 CRP Block Diagram
Figure 7  CRP Keyboard Top Plate Construction Detail
Figure 8  CRP Housing - Construction Detail
Figure 9  CRP Remote Construction Detail
Figure 12  CRP Keyboard PCB Layout - Keyboard
APPENDIX A

GLOSSARY AND ABBREVIATIONS
AL - Alligator Crack
ACP - Asphalt Concrete Pavement
BM - Beginning mile post.
BST - Bituminous Surface Treatment

CLASS A, B, C - There are three classes of parameters; A) Those parameters which must have a value for the system to run a sequence and are loaded with a default value when the system is initialized; B) Those parameters which are not needed for a successful run of a sequence, but are still loaded with a default value when the system is initialized, and C) those parameters which are used only for information.

CLR - Clear all keys in this section of CRP

CRP - Control-Rating Panel
The hand held keyboard used for entering road fault conditions and controlling basic program execution. Also referred to as the Keyboard.

EM - Ending milepost.
Enter - Used to enter control command on CRP

EOF - End of File

F - Flushing

FULL - Full depth

HL - Hairline

HT - Hand Terminal

F1-F2 - Special Function keys - push-on push-off operation. These keys are counted for each sample until they are released

F3-F4 - Special Function keys - momentary on operation. Reset by the computer each time they are sampled.

Header - Refers to the information put on the tape preceding the actual data record.

Internal Summary - This is the accumulated data summary of the individual surface condition data which is
stored internally on the magnetic tape.

Keyboard - The data entry panel used to enter the surface condition data.

Lane - The actual traffic lane being surveyed.

LOC - Location

LN - Longitudinal Crack

MCU - Microcomputer Control Unit

The main instrument package which houses the computer system, printer, tape drive, and front connectors.

MO - Moderate

PAUSE - Returns control of MCU back to the HT during data sampling.

PAV EXMT - Pavement Exempt

R - Raveling

Record - A 512 byte block of information on the tape which could either be default data, a sequence header, or an interval summary.

RTC - Remote Transverse Crack

The hand held unit containing three push-buttons used for entering transverse crack information remote from the CRP.

R/F - Raveling/Flushing

Sequence

An operator defined section of data on tape which is all the road default data accumulated between the Begin Mile and either the End Mile or the point where the operator pushed the STOP button.

A sequence is always preceded by a 512 byte information header and ended with a file mark on the tape.

STOP - Stops data sampling.

START - Start data sampling.

SE - Severe

SL - Slight
SP - Spalling
TC - Transverse Crack
The interconnections details between the keyboard and the control unit are given below.

**660 BOARD**

<table>
<thead>
<tr>
<th>PIN #</th>
<th>PORT-BIT</th>
<th>ASSIGNED FUNCTION (ALL ARE INPUT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>49</td>
<td>1A-RDY</td>
<td>Control #1 (Enter)</td>
</tr>
<tr>
<td>47</td>
<td>1A-STB</td>
<td>Control #3 (Stop)</td>
</tr>
<tr>
<td>45</td>
<td>1A-0</td>
<td>Allig. Crack HL</td>
</tr>
<tr>
<td>50</td>
<td>1A-1</td>
<td>Allig. Crack (&gt;1/4)</td>
</tr>
<tr>
<td>48</td>
<td>1A-2</td>
<td>Allig. Crack SP</td>
</tr>
<tr>
<td>46</td>
<td>1A-3</td>
<td>Allig. Crack +1</td>
</tr>
<tr>
<td>44</td>
<td>1A-4</td>
<td>Allig. Valid Data *</td>
</tr>
<tr>
<td>43</td>
<td>1A-5</td>
<td>Trans. Crack HL</td>
</tr>
<tr>
<td>41</td>
<td>1A-6</td>
<td>Trans. Crack (&gt;1/4)</td>
</tr>
<tr>
<td>42</td>
<td>1A-7</td>
<td>Trans. Crack SP</td>
</tr>
<tr>
<td>35</td>
<td>1B-RDY</td>
<td>Control #5 (Start)</td>
</tr>
<tr>
<td>33</td>
<td>1B-STB</td>
<td>Control #2 (EOF)</td>
</tr>
<tr>
<td>31</td>
<td>1B-0</td>
<td>Control #10 (Flag #3)</td>
</tr>
<tr>
<td>29</td>
<td>1B-1</td>
<td>C 1B-2 Control #12 (Flag #5)</td>
</tr>
<tr>
<td>32</td>
<td>1B-3</td>
<td>Patching #1</td>
</tr>
<tr>
<td>34</td>
<td>1B-4</td>
<td>Patching #2</td>
</tr>
<tr>
<td>36</td>
<td>1B-5</td>
<td>Patching #3</td>
</tr>
<tr>
<td>37</td>
<td>1B-6</td>
<td>Patching ACP/BST **</td>
</tr>
<tr>
<td>40</td>
<td>1B-7</td>
<td>Patching Valid Data *</td>
</tr>
<tr>
<td>2</td>
<td>2A-RDY</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2A-STB</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2A-0</td>
<td>RAV/Flush #1</td>
</tr>
<tr>
<td>3</td>
<td>2A-1</td>
<td>RAV/Flush #2</td>
</tr>
<tr>
<td>5</td>
<td>2A-2</td>
<td>RAV/Flush #3</td>
</tr>
<tr>
<td>7</td>
<td>2A-3</td>
<td>RAV/Flush #4</td>
</tr>
<tr>
<td>9</td>
<td>2A-4</td>
<td>RAV/Flush R/F ***</td>
</tr>
<tr>
<td>10</td>
<td>2A-5</td>
<td>RAV/Flush Valid Data *</td>
</tr>
<tr>
<td>12</td>
<td>2A-6</td>
<td>Control #8 (Flag #1)</td>
</tr>
<tr>
<td>11</td>
<td>2A-7</td>
<td>Control #9 (Flag #2)</td>
</tr>
<tr>
<td>16</td>
<td>2B-RDY</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>2B-STB</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>2B-0</td>
<td>Long. Crack HL</td>
</tr>
<tr>
<td>22</td>
<td>2B-1</td>
<td>Long. Crack (&gt;1/4)</td>
</tr>
<tr>
<td>21</td>
<td>2B-2</td>
<td>Long. Crack SP</td>
</tr>
<tr>
<td>19</td>
<td>2B-3</td>
<td>Long. Crack +1</td>
</tr>
<tr>
<td>17</td>
<td>2B-4</td>
<td>Long. Crack Valid Data *</td>
</tr>
<tr>
<td>15</td>
<td>2B-5</td>
<td>Control #6 (Pavement exempt)</td>
</tr>
<tr>
<td>14</td>
<td>2B-6</td>
<td>Control #4 (Pause)</td>
</tr>
<tr>
<td>13</td>
<td>2B-7</td>
<td>Control #7 (BST/ACP)</td>
</tr>
</tbody>
</table>

* Low = Valid    High = Invalid
** Low = BST    High = ACP
*** Low = Raveling   High = Flushing
RCA P/N CDP - 185600 BOARD - P-10

<table>
<thead>
<tr>
<th>PIN #</th>
<th>PORT BIT</th>
<th>GNDED FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>A-RDY</td>
<td>*</td>
</tr>
<tr>
<td>27</td>
<td>A-STB</td>
<td>*</td>
</tr>
<tr>
<td>25</td>
<td>A-0</td>
<td>ODOMETER ENABLE</td>
</tr>
<tr>
<td>23</td>
<td>A-1</td>
<td>MASTER SET</td>
</tr>
<tr>
<td>21</td>
<td>A-2</td>
<td>MASTER_RESET</td>
</tr>
<tr>
<td>19</td>
<td>A-3</td>
<td>MASTER STROBE TO Q-LINE ENABLE</td>
</tr>
<tr>
<td>17</td>
<td>A-4</td>
<td>ENTER KEY STROBE</td>
</tr>
<tr>
<td>15</td>
<td>A-5</td>
<td>BUZZER</td>
</tr>
<tr>
<td>13</td>
<td>A-6</td>
<td>*</td>
</tr>
<tr>
<td>11</td>
<td>A-7</td>
<td>*</td>
</tr>
<tr>
<td>9</td>
<td>B-RDY</td>
<td>*</td>
</tr>
<tr>
<td>7</td>
<td>B-STB</td>
<td>*</td>
</tr>
<tr>
<td>5</td>
<td>B-0</td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td>B-1</td>
<td>*</td>
</tr>
<tr>
<td>1</td>
<td>B-2</td>
<td>*</td>
</tr>
<tr>
<td>4</td>
<td>B-3</td>
<td>*</td>
</tr>
<tr>
<td>6</td>
<td>B-4</td>
<td>*</td>
</tr>
<tr>
<td>8</td>
<td>B-5</td>
<td>*</td>
</tr>
<tr>
<td>10</td>
<td>B-6</td>
<td>REM TO CONNECTED</td>
</tr>
<tr>
<td>12</td>
<td>B-7</td>
<td>HAND CONTROLLER CONNECTED</td>
</tr>
</tbody>
</table>

* NOT ASSIGNED

NOTES

1. When A-3 is low, the CRP can then be strobed by pulsing the Q-Line.
2. When A-0 is low, the 1805 counter can receive clock pulses via the BF-2 line.
3. A-4 is used to clear the ENTER and EOF keys.
<table>
<thead>
<tr>
<th>PIN #</th>
<th>SIGNAL NAME</th>
<th>REMARKS</th>
<th>SIGNAL DIRECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Longit. HL</td>
<td>SW 4-1</td>
<td>Out</td>
</tr>
<tr>
<td>2</td>
<td>Longit. &gt;1/4</td>
<td>SW 4-2</td>
<td>Out</td>
</tr>
<tr>
<td>3</td>
<td>Longit. SP</td>
<td>SW 4-3</td>
<td>Out</td>
</tr>
<tr>
<td>4</td>
<td>Allig. +1</td>
<td>SW 2-1</td>
<td>Out</td>
</tr>
<tr>
<td>5</td>
<td>Allig. HL</td>
<td>SW 1-1</td>
<td>Out</td>
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**NOTES:**
- D-SW – Output of Debouncer
- L-OUT – Output of LED Driver
- OUT – Output of F/F
- SW – Switch output
- NC – Not connected
### CONNECTORS P5/J5 - P8/J8

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<td>SW 13-3 D-SW</td>
<td>SW 13-4 D-SW</td>
</tr>
<tr>
<td>5</td>
<td>SW 7-1 OUT</td>
<td>SW 9-4 D-SW</td>
<td>SW 12-1 D-SW</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>SW 7-2 OUT</td>
<td>SW 12-2 D-SW</td>
<td></td>
<td></td>
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<tr>
<td>7</td>
<td>SW 7-3 OUT</td>
<td>SW 12-3 D-SW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>NC</td>
<td>NC</td>
<td>CLR-9</td>
<td>SW</td>
</tr>
<tr>
<td>9</td>
<td>NC</td>
<td>NC</td>
<td>GROUND</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>SW 4-1 OUT</td>
<td>SET LINE</td>
<td>CLR-12</td>
<td>SW 14-3 OUT</td>
</tr>
<tr>
<td>11</td>
<td>SW 4-2 OUT</td>
<td>CTRL-1</td>
<td>SW 14-2 OUT</td>
<td>SW 14-1 OUT</td>
</tr>
<tr>
<td>12</td>
<td>SW 4-3 OUT</td>
<td>CTRL-2</td>
<td>SW 13-3 OUT</td>
<td>STROBE LINE</td>
</tr>
<tr>
<td>13</td>
<td>ENT STRB IN</td>
<td>CTRL-3</td>
<td>SW 13-2 OUT</td>
<td>RESET LINE</td>
</tr>
<tr>
<td>14</td>
<td>+5V POWER</td>
<td>CTRL-4</td>
<td>SW 13-1 OUT</td>
<td></td>
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<tr>
<td>15</td>
<td></td>
<td>CTRL-5</td>
<td></td>
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<tr>
<td>16</td>
<td></td>
<td>CLR LED OP#4</td>
<td></td>
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<tr>
<td>17</td>
<td></td>
<td>CLR LED OP#3</td>
<td></td>
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<tr>
<td>18</td>
<td></td>
<td>STROBE LINE</td>
<td></td>
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<td>19</td>
<td></td>
<td>RESET LINE</td>
<td></td>
<td></td>
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<tr>
<td>20</td>
<td>SW 5-1 D-SW</td>
<td>SW 10-2 OUT</td>
<td></td>
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<tr>
<td>21</td>
<td>SW 1-2 D-SW</td>
<td>SW 10-1 OUT</td>
<td></td>
<td></td>
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<td>SW 1-1 D-SW</td>
<td>SW 12-2 OUT</td>
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<tr>
<td>23</td>
<td>CTR-3 OUT</td>
<td>SW 9-4 OUT</td>
<td></td>
<td></td>
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<tr>
<td>24</td>
<td>CTR-4 OUT</td>
<td>SW 9-3 OUT</td>
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<td>25</td>
<td>CTR-5 OUT</td>
<td>SW 9-2 OUT</td>
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<td>26</td>
<td>CTR-6 OUT</td>
<td>SW 9-1 OUT</td>
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<tr>
<td>27</td>
<td></td>
<td>+5V POWER</td>
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<tr>
<td>28</td>
<td></td>
<td>SW 7-3 D-SW</td>
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<td></td>
<td>SW 7-2 D-SW</td>
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<td></td>
<td>SW 7-1 D-SW</td>
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<td>SET LINE</td>
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<td>35</td>
<td></td>
<td>LONG VALID IN</td>
<td></td>
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<td>36</td>
<td></td>
<td>PATCH VALID IN</td>
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<td>37</td>
<td></td>
<td>CLR-4</td>
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<td>38</td>
<td></td>
<td>RAV/FL VALID IN</td>
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<td>CTR-7</td>
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<td></td>
<td>CTR-8</td>
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<tr>
<td>41</td>
<td></td>
<td>CLR LED OP#1</td>
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<tr>
<td>42</td>
<td></td>
<td>CLR LED OP#2</td>
<td></td>
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<tr>
<td>43</td>
<td></td>
<td>STROBE LINE</td>
<td></td>
<td></td>
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<tr>
<td>44</td>
<td></td>
<td>RESET LINE</td>
<td></td>
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<tr>
<td>45</td>
<td></td>
<td>CTR-9</td>
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<td>46</td>
<td></td>
<td>CTR-10</td>
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<td>47</td>
<td></td>
<td>CTR-11</td>
<td></td>
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<tr>
<td>48</td>
<td></td>
<td>CTR-12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>49</td>
<td></td>
<td>NOTE D-SW - Output of Debouncer</td>
<td>L-OUT - Output of LED Driver</td>
<td>OUT - Output of F/F SW - Switch output NC - Not connected</td>
</tr>
<tr>
<td>50</td>
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TDRIV Users Guide

TDRIV is a program designed to read data tapes from the prototype PMS data recorder. In addition to displaying the sequence and interval summaries, TDRIV can display individual samples or compute severity, extent and deduct values for intervals.

Starting TDRIV

TDRIV is located on the hard disk in directory \DOT, so to make running and loading easier, it is usually a good idea to move yourself into this directory before running the program. To change into \DOT, type

    cd \dot <cr>

If, however, you want the files you create while running TDRIV to end up in a directory other than \DOT then you should go to that directory instead and use a different form of the load command discussed below.

Since TDRIV is (presently) written in interpreted BASIC, the first step in running it is to load the BASIC interpreter. This is done with the statement

    basic /c:1000 /s:1000 <cr>

where <cr> indicates a carriage return. You should now see a welcome message from BASIC. Next type

    load "tdriv.bas" <cr>
from within directory \DOT or

    load "c:\dot\tdriv.bas" <cr>

from any other directory. You should see an "Ok," prompt when
this is completed.

To actually start the program, simply type

    run <cr>

TDRIV's opening menu should now appear.

When you are done running TDRIV and are back at the BASIC
command level (the "Ok," prompt) type

    system <cr>

to return to PC-DOS.
Running TDRIV

All of the functions in TDRIV are accessed from a main menu. (the one that comes up when the program is first started) The following sections will cover each option in detail.

1) set track

The cartridge tapes are formatted such that there are four logical tracks per tape. The set track function changes the track that the tape drive looks at and hence provides an easy way to skip a quarter of the tape at a time. One word of warning though, the tracks are arranged on the tape in a serpentine fashion so that the end of track one is at the beginning of track two, etc. This means that if you are at the beginning of track one and switch to track two, you will be at the very end of track two and doing any sort of read operation will push you over onto track three.

2) rewind tape

This will move to the beginning of track one and read the first sequence header, positioning you at sequence one, interval one.

3) search for summary

This will search through the tape sequentially from the current position looking for either the next interval summary record or a specific summary, if you gave it an interval number. This is a handy way to move long distances forward in a sequence.
One current problem involves trying to search past a tape error. The drive's search routine will return an error code and leave the tape positioned before the error, so that resubmitting the search will only reveal the same error. As of now, no simple way has been found to gain access to data in a sequence that was recorded after a tape error occurred.

4) read current header

This will read the current sequence header. If the tape is currently positioned in the first sequence then this command behaves exactly like (2) rewind. Its main use occurs when the tape is positioned on some sequence other than the first. It can then be used either to recover from a "tape position lost" error without losing track of what sequence it was on or as a fast way to back up. As an example, if the current position was sequence 5, interval 40 (S5I40) and you wanted to move to interval 20 in the same sequence (S5I20) the fastest way to do it would be to (4) read the current header and then (3) search for summary number 20.

5) dump interval to disk

This will dump all the data for a single interval to a disk file of the user's choice, one sample per line.

6) display individual samples

This option allows you to see which buttons were depressed for each sample during an interval. The samples are displayed 20
at a time, with blanks representing no data, question marks representing invalid data and various mnemonic symbols (such as Sp for spalling, etc.) representing valid data. After each screen of data you may enter either a carriage return to see the next 20 samples, a specific sample number to see 20 samples starting with that one, or a minus one (-1) to return to the main menu. You will be returned to the main menu automatically when all samples in an interval have been displayed.

7) space forward interval

8) reverse space interval

The forward/reverse space interval function will reposition the tape to the end of the following/preceding interval and then display the interval summary. Should the end/beginning of a sequence be encountered, the sequence header will be read.

9) compute summary statistics

This will compute the severity, extent and deduct values for the current interval, and then display them to the screen following the interval summary.

10) forward space sequence (file)

11) reverse space sequence

The forward/reverse space sequence function moves to the beginning of the following/preceding sequence and reads and displays the sequence header.
12) tension tape

Spins the tape cartridge from one end to the other to even out tape tension. This can sometimes cure intermittent tape errors, if the tape has been sitting for a while or has undergone a great deal of stop and start motion.

13) autosummary of current sequence

This function computes severities, extents and deduct values for all intervals in the current sequence and writes the data into two files. The files names are

<type><state_route><dir><beg_mile>.DAT

where <type> is either H or D for header and data files respectively, <state_route> is the state route number, <dir> is the direction of travel (either P or M for increasing or decreasing mile number) and <beg_mile> is the beginning milepost number. These two files are the two required for input to dBase for later manipulation.

14) stop

Stops the program and returns you to the basic command level.
Common Errors and Problems

Probably the most common error is caused by the tape drive not being awake. If the tape drive has not been used since it has been turned on (the SELECT light is off), TDRIV will probably halt with an "I/O error in 550" message. The cause of this error has not been determined, but its occurrence causes the SELECT light to go on and hence prevents its repetition. Just type run again to restart the program and all should work well.

Another common problem is the program "hanging" and not returning to the menu on the first function selected. This is most likely caused by the tape drive being turned off or a connector having fallen off. Press CTRL and BREAK at the same time to halt the program, then check the switches and connectors before trying again.

Another error manifests itself with an "Illegal function call in 35" message. This probably means that you forgot the "/c:1000 /s:1000" parameters on the BASIC invocation.

DBASE program documentation

To load data files into dBase for the very first time, from within dBase type

do load <cr>

and answer the questions.

To load the .DBF files back into dBase at a later time, type

clear databases
select 1
use H______ alias header
select 2
use D______ alias sevext
select 3
use A______ alias aved

where the last two lines load the averaged database and are completely optional.

To average severity and extent values over intervals and store the results in another database, type:

do ave <cr>

and answer the questions.
TREE STRUCTURE

DIRECTORY PATH LISTING FOR VOLUME CDRIVEDOS

Path:  \DBASE
Sub-directories:  None

Contains dBase III & command files

Path:  \SYSFILES.DOS
Sub-directories:  None

System files

Path:  \DOT
Sub-directories:  PROGS

BASIC tape reading programs

Path:  \DOT\PROGS
Sub-directories:  None

Original source for INTERP, etc.

Path:  \COMM
Sub-directories:  IBM3101
XTK
SPF

Communications software

Path:  \COMM\IBM3101
Sub-directories:  None

IBM3101 emulator program

Path:  \COMM\XTK
Sub-directories:  None

Crosstalk XVI (general purpose)

Path:  \COMM\SPF
Sub-directories:  None

SPF with communications module
Path: \WPROS
Sub-directories: None
Wordstar word processor (overlay files must be in your current directory as well)
Also contains document files
Path: \FOR
Sub-directories: None
Microsoft FORTRAN (plus working versions of INTERP, etc.)
Path: \UTIL
Sub-directories: None
General purpose homebrew utilities
Path: \F77
Sub-directories: None
DRI FORTRAN77 compiler
10 DEFINT A-Z
15 PRINT "Program TDRIV for reading pavement survey tapes"
20 REM when entering basic, type basic /c:1000 /s:1000
25 DIM RBUF(600) : MRPERF=0 : CURREC=1
30 S=512
35 OPEN "com1:9600,n,8,2,rs,cs,d$" AS #1 LEN=S+4
40 REM preset track and pa
45 TRACK = 1 : PA = 0
50 PRINT: PRINT: PRINT "1 set track"
55 PRINT "2 rewind tape"
60 PRINT "3 search for summary"
65 PRINT "4 read current header"
70 PRINT "5 dump interval to disk"
75 PRINT "6 display individual samples"
80 PRINT "7 space forward interval"
85 PRINT "8 reverse space interval"
90 PRINT "9 compute summary statistics"
95 PRINT "10 forward space sequence (file)"
100 PRINT "11 reverse space sequence"
101 PRINT "12 retention tape"
104 PRINT "13 autosummary of current sequence"
105 PRINT "14 stop"
110 INPUT "enter choice ", MENU: PRINT
115 IF MENU = 14 OR MENU = (1 THEN PRINT "***invalid entry": GOTO 50
120 IF MENU = 14 THEN PRINT "goodbye": STOP
125 ON MENU GOSUB 1000,2000,3000,4000,5000,6000,7000,8000,9000,10000,11000,12000,13000
130 GOTO 50
300 REM code to do fake floating point to ASCII conversion
305 DEF FNITOA$(I) = CHR$(I + ASC("0") )
310 FLSTSTR$ = " "
312 IF RBUF(PTR) > 12 THEN MIDS(FLSTSTR$,1,4):="????" : GOTO 337
315 ITEMP = 256*RBUF(PTR) + RBUF(PTR+1)
320 IVAL=ITEMP MOD 10: MIDS(FLSTSTR$,4):=FNITOA$(IVAL)
325 IVAL = (ITEMP\10) MOD 10: IF ITEMP > 9 THEN MIDS(FLSTSTR$,3):=FNITOA$(IVAL)
330 IVAL = (ITEMP\100) MOD 10: IF ITEMP > 99 THEN MIDS(FLSTSTR$,2):=FNITOA$(IVAL)
335 IVAL = (ITEMP\1000) MOD 10: IF ITEMP > 999 THEN MIDS(FLSTSTR$,1):=FNITOA$(IVAL)
340 IF RBUF(PTR+2) > 39 THEN MIDS(FLSTSTR$,6,4):="????" : GOTO 370
340 ITEM= 256*RBUF(PTR+2) + RBUF(PTR+3)
345 IVAL = ITEMP MOD 10: MIDS(FLSTSTR$,9):=FNITOA$(IVAL)
350 IVAL = (ITEMP\10) MOD 10: IF ITEMP > 9 THEN MIDS(FLSTSTR$,8):=FNITOA$(IVAL)
355 IVAL = (ITEMP\100) MOD 10: IF ITEMP > 99 THEN MIDS(FLSTSTR$,7):=FNITOA$(IVAL)
360 IVAL = (ITEMP\1000) MOD 10: IF ITEMP > 999 THEN MIDS(FLSTSTR$,6):=FNITOA$(IVAL)
370 RETURN
400 REM routine to read a record and handle EDTrack
410 CA = 1 : GOSUB 500
420 IF ECODE = 0 THEN RETURN
430 IF (DS AND 4) = 0 THEN RETURN
440 IF TRACK > 4 THEN TRACK=TRACK+1 : GOTO 410
450 RETURN
500 REM routine to talk to the tape drive
505 MA=(TRACK)+1 OR \&H80
506 IF S=\&124 THEN II=\&H10 ELSE IF S=\&2048 THEN II=\&H10 ELSE IF S=\&3072 THEN II=\&H20 ELSE IF S=\&4096 THEN II=\&H30 ELSE IF S=\&8192 THEN II=\&H50
507 MA = MA OR II
510 POKE VARPTR(\&1)+188,MA
515 POKE VARPTR(\&1)+189,PA
520 POKE VARPTR(\&1)+190,CA
525 PUT \&I,3
530 IF CA = 11 THEN GOTO 550
535 FOR II=1 TO 16
540 POKE VARPTR(\&1)+187+II, ASC(MID$(HAR$(\&H,II,1)) : NEXT II
545 POKE VARPTR(\&1)+187+17,191 : PUT \&I,17
550 GET \&I,2
555 DS=PEEK(VARPTR(\&1)+180)
560 IS=PEEK(VARPTR(\&1)+189)
565 IF IS AND 40 THEN ECODE=1 ELSE ECODE=0
570 PRINT: PRINT USING "##:##":"ds = ",HEX$(DS),"h is ",HEX$(IS),"h"
575 IF ECODE () 0 THEN PRINT USING "####":"code = ",ECODE,"d"
580 PRINT
585 RETURN
600 REM routine to read data
610 GET \&I,5
620 TPTR=VARPTR(\&1)+197
630 FOR II=1 TO S
640 RBUF(II)=PEEK(TPTR+II)
650 NEXT II
660 RETURN
675 REM routine to clear com buffer
680 IF LOC(I,0) THEN RETURN
685 GET \&I,1,LOC(1)
690 GOTO 680
700 REM this routine will forward space SPCNT records, come hell, high water
705 REM or end of track. Errors are returned with SPCNT = -1
710 IF SPCNT=0 THEN PRINT "***Error, negative space count":RETURN
715 WHILE SPCNT=0
720 CA:4 : GOSUB 500 'forward space record
725 IF ECODE = 0 THEN GOTO 760 'if no errors then jump
730 IF (DS AND 64) = 0 THEN GOSUB 900:SPCNT=-1:RETURN 'unrecoverable error
735 IF (DS AND 64) = 0 THEN GOTO 750 'jump on NOT end of track
740 IF TRACK < 4 THEN TRACK=TRACK+1 :GOTO 720
745 PRINT "***end of tape!***":SPCNT=-1:RETURN
750 PRINT "***Unexpected file mark!***": GOSUB 4080 :SPCNT=-1:RETURN
755 SPCNT=SPCNT-1
760 WEND
770 RETURN
800 REM routine to reverse space SPCNT records, similar to above
805 IF SPCNT=0 THEN SPCNT=-1: PRINT "***Error, negative space count":RETURN
810 WHILE SPCNT=0
815 CA:6 : GOSUB 500 'reverse space record
820 IF ECODE = 0 THEN GOTO 860 'if no errors then jump
825 IF (DS AND 64) = 0 THEN GOSUB 900:SPCNT=-1:RETURN 'unknown type error
830 IF (DS AND 0)=0 THEN GOTO 845 'jump if not 80Track
835 IF TRACK > 1 THEN TRACK=TRACK-1 :GOTO 815
840 PRINT "***Beginning of tape!***":SPCNT=-1:GOSUB 4500 :RETURN
845 PRINT "***Unexpected file mark***" 'so step forward and read header
CA=4 : GOSUB 500 : GOSUB 4080 : SPCNT=-1: RETURN
860 SPCNT=SPCNT-1
865 WEND
870 RETURN
900 REM routine to issue discouraging message and damage global variables
910 PRINT
920 PRINT "***Tape Position Lost***"
930 PRINT "(next command must be either search, rewind or a file command)"
940 PRINT
950 CURREC=-1
960 GOSUB 675 'clear comm buffer
970 RETURN
1000 REM routine to set track on tape drive
1010 PRINT
1020 PRINT "current track is": TRACK
1030 INPUT "enter new track": TEMP
1040 IF (TEMP < 1) OR (TEMP > 4) THEN PRINT : PRINT "***invalid track": TEMP : GOTO 1010
1045 TRACK = TEMP
1050 CURREC = -1
1060 RETURN
2000 REM routine to rewind tape
2010 TRACK = 1
2020 CA = 72 'send status bytes relative to 80tape
2030 GOSUB 500
2040 PRINT
2060 GOSUB 4080 'read the first header record
2070 RETURN
3000 REM routine to search for and display a summary record
3005 INPUT "enter a specific interval number or (CR) for next summary": INTNO
3010 MASK$ = "SUMMARY ????????"
3015 IF INTNO > 0 THEN MIDS(MASK$,9,2)=CHR$(INTNO/256)+CHR$(INTNO MOD 256)
3020 PRINT :FOR I=1 TO 16: PRINT HEX$(ASC(MIDS(MASK$[I,I]))): NEXT I
3025 PRINT ";
3030 FOR I=1 TO 16
3031 J=ASC(MIDS(MASK$,I))
3032 IF (((J)31) AND (J[127])) THEN PRINT CHR$(J): ELSE PRINT ";
3033 NEXT I
3035 HEADSUM$="SUM": PRINT
3040 CA = 11 : GOSUB 500 'search for record
3045 IF DS AND 64 THEN PRINT"***filemark detected":GOSUB 4080:RETURN
3050 IF ECODE () 0 THEN GOSUB 900 : RETURN 'abort if unable to read
3055 GOSUB 600 'load into rbuff)
3200 TITLE$="" : FOR CPRTR=1 TO 8
3205 MIDS(TITLE$,CPRTR) = CHR$(RBUFF(CPRTR))
3210 NEXT CPRTR
3215 MISPPOS=0 : CURREC = NPERF+2
3220 IF TITLE$ = "SUMMARY" THEN GOTO 3400
3225 MISPPOS=-1 : CURREC = -1
3230 PRINT USING "&&&": "***expecting 'SUMMARY', found ":TITLE$,""
3235 GOSUB 900 : RETURN 'scream and die
3400 RECOMP=0 'flag for what to display
3405 DEF FNCRS(JJ):CHR$(RBUFF(JJ))
3410 NULLS$="": DSHS$="": WS$="WS": DOTS$="": CS$="": EPS$="I"
3415 FORMS$="&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&&'&&FORM2="&!!": FORM3="&!!": FORM4="&!!!":
3425 FORMS$="#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B#B##
3685 LSET FS:="TIME flag 2 on": PRINT USING FORM$;FS,NULL$,F2
3690 IF RECONP=0 THEN FS:=256*BUF PTR+BUF PTR+1: PTR:=PTR+2
3695 LSET FS:="TIME flag 3 on": PRINT USING FORM$;FS,NULL$,F3
3700 IF RECONP=0 THEN FS:=256*BUF PTR+BUF PTR+1: PTR:=PTR+2
3705 LSET FS:="TIME flag 4 on": PRINT USING FORM$;FS,NULL$,F4
3710 IF RECONP=0 THEN FS:=256*BUF PTR+BUF PTR+1: PTR:=PTR+2
3715 LSET FS:="TIME flag 5 on": PRINT USING FORM$;FS,NULL$,F5
3720 IF RECONP=1 THEN PTR:=PTR+10
3725 PRINT FS:=SPACE(152): LSET FS:="Transverse crack count HL"
3730 IF RECONP=1 THEN PRINT USING FORM$:FS,NULL$,TCH1 ELSE PRINT USING FORM$:FS,NULL$,BUF PTR+256+BUF PTR+1
3735 PTR:=PTR+2
3740 LSET FS:="\1/4"
3745 IF RECONP=1 THEN PRINT USING FORM$:FS,NULL$,TCH2 ELSE PRINT USING FORM$:FS,NULL$,BUF PTR+256+BUF PTR+1
3750 PTR:=PTR+2
3755 LSET FS:="SP"
3760 IF RECONP=1 THEN PRINT USING FORM$:FS,NULL$,TCH3 ELSE PRINT USING FORM$:FS,NULL$,BUF PTR+256+BUF PTR+1
3765 PTR:=PTR+2
3770 N1:=BUF PTR+256+BUF PTR+1:PTR:=PTR+2
3775 N2:=BUF PTR+256+BUF PTR+1:PTR:=PTR+2
3780 N3:=BUF PTR+256+BUF PTR+1:PTR:=PTR+2
3785 FS:="Comments": FS;
3790 PRINT USING FORM$:FS;
3795 WHILE PTR<5 AND (BUF PTR)<>26
3800 PRINT USING FORM$:CHR$(BUF PTR);
3805 PTR:=PTR+1
3810 WEND
3820 PRINT CHR$(13):CHR$(10):
3825 INPUT "Enter (cr) to continue",1
3830 RETURN
4000 REM routine to read the current header and display it
4010 CA:=7
4020 GOSUB 500 "reverse to filemark"
4030 IF ECODE = 0 THEN GOTO 4070 "jump if no errors"
4040 IF (DS AND 0) = 0 THEN GOSUB 900:RETURN "aborted if confused"
4050 IF TRACK = 1 THEN TRACK = TRACK - 1:GOTO 4010
4060 GOTO 4080
4070 CA:=4: GOSUB 500 "step over filemark"
4080 REM entry point for many other routines that want to read a header
4090 CS:=1: GOSUB 500 "read header"
4095 IF ECODE = 0 THEN GOTO 4130
4100 IF (DS AND 4) = 0 THEN GOSUB 900 :RETURN "abort if error is not EOF"
4110 IF TRACK < 4 THEN TRACK=TRACK+1: GOTO 4080 "inc track and try again"
4120 GOSUB 900 :RETURN "if we can't figure out what kind of error it was, abort"
4130 GOSUB 600 "load header into rbuf()"
4500 REM test to see if this is indeed a header record
4510 MISPOS:=0 : TITLES=""
4520 FOR CPtr:=1 TO 8
4530 MIDS(TITLES,CPtr):CHR$(BUF PTR(CPtr))
4540 NEXT CPtr
4550 IF TITLES = "HEADER" THEN GOTO 4580
4560 PRINT USING "&amp;";";";expecting 'HEADER ', found '",TITLES",""
4570 MISPOS:=1 : GOSUB 900 :RETURN 'crap out and die"
4580 REM now we know this is a header, so determine NRPERF and pretend
4590 REM that it's a summary for the purposes of displaying it.
4600 NRPERF := BUF PTR(9)
4605 NSAMP = 256*RBUF(10) + RBUF(11)
4607 IF AUTOSUM=1 THEN CURREC=1: RETURN 'thats all we want for autosummary
4610 HEADSUMS="HEAD"
4620 GOSUB 3400 ' go to summary displaying routine with early return flag set
4630 CURREC=1
4640 PRINT : PRINT : INPUT "hit (CR) to continue",I
4650 RETURN
5000 REM routine to write data from a single interval to disk
5010 IF CURREC < 0 THEN GOSUB 900 : RETURN
5020 SPN1 = CURREC - 1
5030 GOSUB 600 'back space to first data record
5035 IF SPNT () = 0 THEN GOSUB 900 : RETURN
5040 INPUT "enter the output file name ",FNAME$
5050 OPEN FNAME$ FOR OUTPUT AS #2
5060 CURREC = 1 : J = NRPERF+1
5070 IF CURREC-J THEN PRINT "write completed with ",CURREC-1," records": GOTO 5200
5080 CA = 1 : GOSUB 500 'read record
5090 IF ECODE(10) THEN GOSUB 5150 'jump on error
5100 GOSUB 600 'load data into rbuff
5105 IF CURREC(NRPERF) THEN N=S ELSE N=(NSAMP*4) MOD S
5110 FOR I=1 TO N STEP 4
5120 PRINT #2, USING "### ### ### ###"; RBUF(I),RBUF(I+1),RBUF(I+2),RBUF(I+3)
5130 NEXT I
5140 PRINT "record ",CURREC,"written": CURREC=CURREC+1 : GOTO 5070
5150 REM cleanup code for read errors
5160 PRINT "###read error on tape, disregarding record ",CURREC
5170 GOSUB 675 'clear buffer
5180 CURREC=CURREC+1 : GOTO 5070
5200 REM code to close files and go home
5210 CLOSE #2
5220 RETURN
6000 REM routine to display individual samples
6005 IF CURREC = -1 THEN GOSUB 900 : RETURN
6010 SPN1=CURREC-1 : GOSUB 600 'CURREC=1 'reverse to first data record
6015 IF SPNT () = 0 THEN GOSUB 900 :RETURN 'abort if unable to position
6020 PTR = 1
6025 IF CURREC > NRPERF THEN RETURN
6030 GOSUB 400 'read record
6035 IF ECODE () = 0 THEN RETURN 'abort if unable to read
6040 CURREC = CURREC + 1
6045 MORE=1
6050 I=1:PRINT "Sam. | Allig. | Longit. | Trans. | Patching | Rav/Flush | Pav | RSI/ | Flags"
6055 PRINT " | | | | | | | |"
6060 PRINT " | | | | | | | |"
6065 MSAM=((CURREC-2)*128+PTR-1)/4+1: BYTE1A=RBUF(PTR): BYTE1B=RBUF(PTR+1)
6070 BYTE2A=RBUF(PTR+2):BYTE2B=RBUF(PTR+3)
6075 REM code to display information to screen
6080 AS=":
6090 IF BYTE1A AND 1 THEN MID$(AS,5,1)="H" 'alligator cracks
6095 IF BYTE1A AND 2 THEN MID$(AS,6,1)="H"
6095 IF BYTE1A AND 4 THEN MID$(AS,7,1)="S"
6100 IF BYTE1A AND 8 THEN MID$(AS,8,1)="S"
6105 IF BYTE1A AND 16 THEN MID$(AS,9,4)="???
6110 IF BYTE2B AND 1 THEN MID$(AS,14,1)="H" 'longitudinal cracks

110
6115 IF BYTE2B AND 2 THEN MID$(AS,15,1)="\""
6120 IF BYTE2B AND 4 THEN MID$(AS,16,1)="\"S\"
6125 IF BYTE2B AND 8 THEN MID$(AS,17,1)="\"\"
6130 IF BYTE2B AND 16 THEN MID$(AS,14,4)="?????"
6135 REM transverse cracks
6140 TEMP = BYTE1A AND 224
6145 IF TEMP = 0 THEN MID$(AS,24,1)="\" ELSE IF TEMP = 32 THEN MID$(AS,24,4)="H.L.\" ELSE IF TEMP = 64 THEN MID$(AS,24,4)="\"/4\" ELSE
6150 REM patching
6155 TEMP=(BYTE1B \ 8) AND 7 'isolate three bits
6160 IF TEMP = 1 THEN MID$(AS,33,3)="\"1/4\" ELSE IF TEMP = 2 THEN MID$(AS,33,3)="\"1/2\" ELSE IF TEMP = 3 THEN MID$(AS,33,3)="\"3/4\" ELSE IF TEMP = 4 THEN MID$(AS,33,3)="\"8\" ELSE IF TEMP = 5 THEN MID$(AS,33,3)="\"28\" ELSE IF TEMP = 6 THEN MID$(AS,33,3)="\"9\" ELSE IF TEMP = 7 THEN MID$(AS,33,3)="\"K\" ELSE
6165 IF BYTE1B AND 64 THEN MID$(AS,36,1)="\"A\" ELSE MID$(AS,36,1)="\"B\"
6170 IF BYTE1B AND 128 THEN MID$(AS,33,6)="????? ?"
6175 IF (BYTE1B AND 240) = 0 THEN MID$(AS,33,6)="\" 'watch for no data
6180 REM raveling and flushing
6185 IF BYTE2A AND 16 THEN MID$(AS,44,1)="\"F\" ELSE MID$(AS,44,1)="\"R"
6190 TEMP BYTE2A AND 3
6195 IF TEMP = 1 THEN MID$(AS,46,2)="\"Si\" ELSE IF TEMP = 2 THEN MID$(AS,46,2)="\"No\" ELSE IF TEMP = 3 THEN MID$(AS,46,2)="\"So\"
6200 TEMP=(BYTE2A\4) AND 3
6205 IF TEMP = 1 THEN MID$(AS,49,3)="\"Loc\" ELSE IF TEMP = 2 THEN MID$(AS,49,4)="\"W.P.\" ELSE IF TEMP = 3 THEN MID$(AS,49,3)="\"Ent"
6215 IF BYTE2A AND 32 THEN MID$(AS,44,0)="\" ?? ?? ??"
6220 IF BYTE2A AND 63 = 0 THEN MID$(AS,44,8)="\" 'test for no data
6225 IF BYTE2B AND 32 THEN MID$(AS,56,1)="\"*
6230 IF BYTE2B AND 128 THEN MID$(AS,61,3)="\"ACP\" ELSE MID$(AS,61,3)="\"BST"
6235 IF BYTE2A AND 64 THEN MID$(AS,69,1)="\"1"
6240 IF BYTE2A AND 128 THEN MID$(AS,70,1)="\"2"
6245 IF BYTE1B AND 1 THEN MID$(AS,71,1)="\"3"
6250 IF BYTE1B AND 2 THEN MID$(AS,72,1)="\"4"
6255 IF BYTE1B AND 4 THEN MID$(AS,73,1)="\"5"
6260 PRINT USING "\"###\"; NSAH; AS
6265 PTR=PTR+4: I=I+1
6270 IF I=20 AND PTR=(S-3) AND NSAM=NSAMP THEN GOTO 6065
6275 INPUT "enter sample to see a specific sample, (cr) to continue, -1 to stop": MORE
6280 IF MORE=0 THEN IF NSAM=NSAMP THEN RETURN ELSE IF PTR=(S-3) THEN GOTO 6050 ELSE PTR=1: GOTO 6020
6285 IF MORE=0 THEN RETURN
6290 IF MORE=NSAMP THEN PRINT "*** Sample number too high ***": MORE=0: GOTO 6275
6295 NSAM MORE = MORE=1 'wants to see sample number NSAM
6300 NREC= NSAM\(S\4) +1 'calculate what record we need to read
6305 I=0
6310 IF NREC = (CURREC - 1) THEN GOTO 6345
6315 I=1
6320 IF NREC = CURREC THEN GOTO 6345
6325 IF NREC < CURREC THEN SPCNT-CURREC-NREC : GOSUB 800
6330 IF NREC > CURREC THEN SPCNT=NRRC-CURREC : GOSUB 700
6335 IF SPCNT = 0 THEN GOSUB 900 : RETURN
6340 CURREC = NREC
6345 PTR= NREC-1 - S*(NREC-1) + 1 'align ptr to point into proper spot
6350 IF I = 0 THEN GOTO 6050 ELSE GOTO 6020
6355 PRINT "***Glitch!!!***": PRINT
6360 RETURN
7000 REM routine to forward space by one "interval", which is NRRF+1 records
7001 REM long. If the positioning is successful then the summary
7002 REM record will be read and displayed and the current record pointer
7003 REM will be left at NRRF+2.
7010 IF CURREC = (O THEN GOSUB 900 : RETURN 'abort if tape position is unknown
7020 SPCNT = NRPERF + NRPERF + 2 - CURREC
7030 GOSUB 700 'forward space to summary record
7040 IF SPCNT(10 THEN RETURN 'abort if unable to position
7050 CA-1 : GOSUB 500 'read summary
7060 IF ECODE = 0 THEN GOTO 7100
7070 IF (DS AND 4) = 0 THEN GOSUB 990: RETURN 'error but not end of track
7080 IF TRACK (< 4 THEN TRACK-TRACK+1 : GOTO 7050
7090 GOSUB 990: RETURN 'end of tape, most likely
7100 GOSUB 600 'load into rbuf()
7110 MISPOS = 0 'not mispositioned
7115 HEADSUM$: "SUM"
7120 GOSUB 3200 'display summary
7130 IF MISPOS=-1 THEN PRINT "***not on summary record***":GOSUB 990: RETURN
7140 CURREC:=NRPERF+2
7150 RETURN
8000 REM routine to reverse space by one interval, similar to above
8010 IF CURREC < 0 THEN GOSUB 990:RETURN 'abort if lost
8020 SPCNT = CURREC
8030 GOSUB 800 'reverse space to summary record
8040 IF SPCNT(10 THEN RETURN 'abort if unable to position
8050 CA-1 : GOSUB 500 'read summary
8060 IF ECODE = 0 THEN GOTO 8100
8070 IF (DS AND 4) = 0 THEN GOSUB 990: RETURN 'error but not end of track
8080 IF TRACK (< 4 THEN TRACK-TRACK+1 : GOTO 8050
8090 GOSUB 990: RETURN 'end of tape, most likely
8100 GOSUB 600 'load into rbuf()
8110 MISPOS = 0 'not mispositioned
8115 HEADSUM$: "SUM"
8120 GOSUB 3200 'display summary
8130 IF MISPOS=-1 THEN PRINT "***not on summary record***":GOSUB 990: RETURN
8140 CURREC:=NRPERF+2
8150 RETURN
9000 REM routine to recompute summary values from raw data in data blocks
9070 IF CURREC ( 0 THEN GOSUB 990: RETURN 'abort if lost
9080 SPCNT-CURREC-1 : GOSUB 800 'backspace to start of data
9090 IF SPCNT(10 THEN RETURN 'return if unable to position
9095 MEXMPT = 0 'number of samples with pavement exempt active
9100 FOR I:=1 TO NRPERF 'loop on data blocks
9110 CA-1 : GOSUB 500 'read data block
9120 IF ECODE = 0 THEN GOTO 9160 'jump if no errors
9130 IF (DS AND 4) = 0 THEN GOTO 9150 'jump if not E0track
9140 IF TRACK (< 4 THEN TRACK-TRACK+1 : GOTO 9110 'try next track
9150 PRINT "###unexpected filemark error###": GOSUB 990 : RETURN
9160 PRINT "Tallying block","of","NRPERF,"Please wait."
9170 GOSUB 600 'read data block into rbuf()
9180 FOR PTR:=1 TO 5 STEP 4
9190 BYTE=1: RBUF(PTR)
9200 BYTE=1: RBUF(PTR+1)
9210 BYT9220: RBUF(PTR+2)
9220 BYT9230: RBUF(PTR+3)
9225 IF BYT9230: AND 32 THEN NEXMEMT = NEXMEMT+1: GOTO 9500
9230 REM code to tally up counts of bad road from the four bytes of raw data
9240 IF BYT9250: AND 16 THEN GOTO 9290 'check for bad alligators
9250 IF BYT9260: AND 1 THEN AC1 = AC1+1
9260 IF BYT9270: AND 4 THEN AC3 = AC3+1
9270 IF BYT9280: AND 8 THEN IF BYT9290: AND 4 THEN AC1 = AC1+1 ELSE IF BYT92A0: AND 2 THEN AC2 = AC2+1 ELSE AC1 = AC1+1
9290 IF BYT92B0: AND 16 THEN GOTO 9340 'check for bad longit cracks
9300 IF BYT92C0: AND 1 THEN LC1 = LC1+1
9310 IF BYT92D0: AND 2 THEN LC2 = LC2+1
9320 IF BYT92E0: AND 4 THEN LC3 = LC3+1
9330 IF BYT92F0: AND 8 THEN IF BYT9300: AND 4 THEN LC3 = LC3+1 ELSE IF BYT9310: AND 2 THEN LC2 = LC2+1 ELSE LC1 = LC1+1
9340 IF BYT9320: AND 32 THEN TCN1 = TCN1+1
9350 IF BYT9330: AND 64 THEN TCN2 = TCN2+1
9360 IF BYT9340: AND 128 THEN TCN3 = TCN3+1
9370 IF BYT9350: AND 128 THEN GOTO 9400
9380 TEMP = (BYTE9360) AND 7
9390 IF BYT9370: AND 64 THEN PAA = PAA + TEMP ELSE PAB = PAB + TEMP
9400 IF BYT9380: AND 32 THEN GOTO 9450
9410 TEMP = (BYTE9390: AND 4) AND 3
9420 IF BYT93A0: AND 16 THEN SFL1 = SFL1 + TEMP ELSE SRA1 = SRA1 + TEMP
9430 TEMP = (BYTE93B0: AND 4) AND 3
9440 IF BYT93C0: AND 16 THEN EFL1 = EFL1 + TEMP ELSE ERA1 = ERA1 + TEMP
9450 IF BYT93D0: AND 64 THEN F1 = F1 + 1 'flag counters
9460 IF BYT93E0: AND 128 THEN F2 = F2 + 1
9470 IF BYTE93F0: AND 1 THEN F3 = F3 + 1
9480 IF BYTE9400: AND 2 THEN F4 = F4 + 1
9490 IF BYT9410: AND 4 THEN F5 = F5 + 1
9500 NEXT PTR
9510 NEXT I 'tallying done, now compute severities and extents
9520 CA = 1: GOSUB 300 'read summary block
9530 IF ECODE = 0 THEN GOTO 9570 'jump if no errors
9540 IF (DS AND 4) = 0 THEN GOTO 9560 'jump if not E0Track
9550 IF TRACK < 4 THEN TRACK = TRACK+1: GOTO 9520 'try next track
9560 PRINT *** Unexpected filemark error *** : GOSUB 900 : RETURN
9570 GOSUB 600 'load data into rbuf()
9580 CURRCE = NRPET+2
9590 N3 = (SXR8UF(11)+RBUF(116) 'M3, number of samples recorded
9591 NS = N3 - NEXMEMT 'number of unexempted samples
9592 IF NS = 1 THEN NS = 1
9600 LENGTH = (256*RBUF(55)+RBUF(56)+256*RBUF(57)+RBUF(58)+10000) / 5280
9605 IF (AC1+AC2+AC3) = 0 THEN SAC1 = 0 : EAC1 = 0 : GOTO 9640
9610 SAC1 = (AC1+2*AC2+3*AC3)/(AC1+AC2+AC3)
9620 EAC1 = 1.5*(AC1+AC2+AC3)/NS + 1
9630 IF EAC1 < 1.04 THEN EAC1 = 1: SAC1 = 0!
9640 IF EAC1 = 4 THEN EAC1 = 4!
9641 DAC! = 5 # (3*SAC1 + 2*EAC1 - 3)
9642 IF DAC! < 0 THEN DAC! = 0
9645 IF (LC1+LC2+LC3) = 0 THEN SLC1 = 0 : ELC1 = 0 : GOTO 9670
9650 SLC1 = (LC1+2*LC2+3*LC3)/(LC1+LC2+LC3)
9660 ELC1 = (LC1+LC2+LC3)/NS + 1
9670 IF ELC1 < 1.01 THEN ELC1 = 1: SLC1 = 0!
9671 DLC1 = 10 # (SLC1 + ELC1) - 15
9672 IF DLC! ( < 0 THEN DLC! = 0
9675 IF ((TCH1+TCH2+TCH3):0 THEN STCl=0!: ETC!0!: GOTO 9700
9690 STCl=(TCH1+TCH2+TCH3)/(TCH1+TCH2+TCH3)
9690 ETC]=.78 + 22*(TCH1+TCH2+TCH3)/LENGTH!
9700 IF ETC! < 3! THEN ETC! = 3!
9710 IF ETC! ( < 1! THEN ETC! = 0!: STCI=0!
9711 DTC! = 5 * (STC! + ETC! - 1)
9712 IF DTC! ( < 0 THEN DTC! = 0
9715 IF (PAI+PAB+FI)=0 THEN SPAI=0!: EPIA: GOTO 9740
9720 SPA=:(PAI+PAB+34FI)/(PAI+PAB+FI)
9730 EPIA=2*(PAI+PAB+FI)/MS + 1!
9740 IF EPA! ( < 1! THEN EPA! = 0!: SPAI=0!
9750 IF EPA! > 3! THEN EPAI=3!
9751 DPAI = 10 * (SPA! + EPA! - 1)
9752 IF DPAI ( < 0 THEN DPAI = 0
9760 SRAI=SRA/MS: SFL=SF!/MS: ERAI=ERA/MS: EFL=EFL/MS
9765 IF AUTOSUM=1 THEN RETURN
9770 RECOMPl=HEADSUM=SUM’: GOSUB 3405: RECOMPl=’call display routine
9780 RETURN
10000 REM routine to space forward file (sequence)
10010 CA!: 5: GOSUB 500 ’forward space
10020 IF ((CODE=0)AND((DS AND 4)=0): WRITE 10060 0: return if no errors then jump
10030 IF (DS AND 4)=0 THEN GOSUB 900: RETURN ’ bail out if lost
10040 IF TRACKE: ( (4 THEN TRACKE: TRACKE: GOTO 10010 ’step to next track
10050 PRINT **end of tape!!!**: GOSUB 900: RETURN ’ abort on EOTape
10060 MISPOS: 0 ’should now be at header record
10070 GOSUB 4000 ’read and display supposed header record
10080 IF MISPOS = -1 THEN RETURN ’if lost then abort
10090 CURREC=1
10100 RETURN
11000 REM routine to reverse space file (sequence)
11005 1: 0
11010 CAI7: GOSUB 500 ’reverse space
11020 IF ((CODE=0)AND((DS AND 12)=0): GOTO 11055
11025 IF (DS AND 4)=0 THEN GOTO 11010 ”at extreme end of track (EMS)
11030 IF (DS AND 8)=0 THEN GOSUB 900: RETURN ’ bail out if lost
11040 IF TRACKE: 1 THEN TRACKE: TRACKE: GOTO 11010 ’step to previous track
11050 PRINT **beginning of tape!!!*: GOTO 11080 ’step over space command
11055 IF 1: 0 THEN I: 1: GOTO 11010
11060 CA!: 4: GOSUB 500 ’step over filemark
11070 MISPOS: 0 ’should now be at header record
11080 GOSUB 4000 ’read and display supposed header record
11090 IF MISPOS = -1 THEN RETURN ’if lost then abort
11100 CURREC=1
11110 RETURN
12000 REM routine to rotation tape by running it from one end to the other
12010 TRACKE: 2
12020 CA!: 72 ’send status bytes relative to BOT
12030 GOSUB 500
12040 TRACKE: 1
12050 GOSUB 2000 ’rewind and read first header record
12060 RETURN
13000 REM routine to do automated summaries of all intervals in a sequence
13010 AUTOSUM=1
13015 GOSUB 4000 ’read sequence header
13020 IF CUREC=-1 THEN GOTO 13800
13030 FAMES="H"+CHR$(RBUF(38))+CHR$(RBUF(39))+CHR$(RBUF(40))
13031 I = RBUF(63)*256 + RBUF(64)
13032 IF RBUF(54)"H"H28 THEN I:256#RBUF(67) + RBUF(68)
13033 IF RBUF(54):H"H28 THEN SIGNS:="P" ELSE SIGNS:"N"
13034 FAMES = FAMES + SIGNS + MID$(STR$(I),2,3) + ".DAT"
13040 OPEN FAMES FOR OUTPUT AS #2
13060 FOR I=17 TO 49
13070 PRINT #2, CHR$(RBUF(I));
13080 NEXT I
13090 PTR = 50: GOSUB 300 : PRINT #2,FLTSTRGS;CHR$(RBUF(54));
13100 FOR PTR=55 TO 67 STEP 4
13110 GOSUB 300: PRINT #2, FLTSTRGS;
13120 NEXT PTR
13130 PRINT #2,
13131 CLOSE #2
13132 I = INSTR(FAMES,".")
13133 FAMES = "D"+MID$(FAMES,2)
13134 OPEN FAMES FOR OUTPUT AS #2
13140 MINT = 0
13150 GOSUB 9000 'compute summaries
13160 IF CUREC=-1 THEN GOTO 13800 'end if errors
13170 INTMO = 256#RBUF(9) + RBUF(10)
13180 MINT = MINT+1
13190 PRINT "writing summary of interval ",MINT
13191 PTR=50 : GOSUB 300 'put odometer reading into FLTSTRG$
13190 PRINT #2, USING "#### \\
13195 IF HXEXMP = 0 THEN PRINT #2, USING " \####":1! ELSE PRINT #2, USING " \####": NS/NS
13200 CUREC = CUREC - (WRPERF+1) 'increment to next interval
13210 GOTO 13150
13220 REM end of sequence processing
13230 AUTOSUM=0
13240 CLOSE #2
13250 PRINT: PRINT"end of sequence, ";MINT:" intervals summarized": PRINT
13340 GOSUB 900
13350 RETURN
* EXPAND will take an INTERP input data file, load it
* into dBase and expand all the severity and extent fields
* from one column to two.
accept 'What is the data file name?' to rdfname
set console off
store at('.',rdfname) -1 to perpos
store substr(rdfname,1,perpos) to stemname
set console on
use narrow
? 'loading data'
append from &rdfname sdf
use wide
copy structure to &stemname
use &stemname
? 'reformatting data'
append from narrow
use narrow
set safety off
zap
set safety on
use &stemname
? rdfname + ' loaded'
* AVE will average severities and extents over a user
* selected length to a new file
accept "Enter the SR - dir - beg mile code " to fstem
set talk off
if type('fstem') <> 'C'
    ? 'File name must be a character expression'
    return
endif
* first open correct files
close databases
select 1
store "H" + fstem to fname
use &fname alias header
select 2
store "D" + fstem to fname
use &fname alias sevext
select sevext
store "A" + fstem to fname
copy structure to &fname
select 3
use &fname alias aved
* determine how many records to average into one
select header
go 1
average int_length next 1 to il
? "Interval length is " + str(il,5,3) + " miles"
input "Enter averaging window length (in miles) " to aveleng
store int(aveleng/il) to nint
? "Averaging " + str(nint,2,0) + " intervals at a time"
*
* NINT is now the number of intervals (number of records in
* SEVEXT) to average over. The AVERAGE function puts its
* results in memory variables which are then REPLACED into a
* new blank record in AVED, the averaged file. One variable,
* the length fraction, is summed rather than averaged so that
* it can be used with the header file to determine the actual
* length of the averaged segments.
*
select sevext
go 1
do while .not.eof()
currec = recno()
    average next nint to in,od, acs, ace, acd, lcs, lce, lcd, tcs, tce, tcd,
    pas, pae, pad, ras, rae, fls, fle, lf
    go currec
    sum next nint leng_frac to lf
select aved
append blank
replace into new in,od, reading with od, acsew with acs,
    acext with ace, aced with acd, lcsnev with lcs, lcext with lce,
    lced with lcd, tcsew with tcs, tcext with tce, tcowed with tcd
replace pasev with pas, paext with pae, padev with pad, rasev with ras,
raext with rae, flsev with fls, fleaf with fle, lenqfrac with lf
select sevext
if .not.eof()
go recno()+1
endif
enddo
release in, od, acs, ace, acd, lcs, lce, lcd, tcs, tce, tcd, pas, pae, pad,
ras, rae, fls, fle, lf, aveleng, il, nint, currec
set talk on
? str(recno(), 5, 0) + " records averaged"

LOAD.PRG

* This procedure will load the severity and extent and
* header data into dBase files.
set talk off
accept "Enter the State Route - direction - begin mile code, e.g. 123P1 "
accept "Enter the directory, if other than default " to fdif
if len(fdif) > 1
    set path to &fdif
endif
close databases
select 1
use header
store "H" + fstem to fname
copy structure to &fname
use &fname alias header
store fname + ".DAT" to fname
append from &fname sdf
store "D" + fstem to fname
select 2
use sevext
copy structure to &fname
use &fname alias sevext
store fname + ".DAT" to fname
append from &fname sdf
? "Header and data files loaded"
set talk on
APPENDIX D

HARDWARE MANUALS
RCA CMOS Microboard Computer
CDP18S600
RCA CMOS Microboard Computer
CDP18S600

The RCA Microboard Computer CDP18S600 is a versatile computer system on a single 4.5 x 7.5 inch card. It features a CDP1805A CPU with a powerful expanded instruction set, and can run at up to twice the speed of previous RCA CPU cards. The card contains a complete UART driven RS232 or RS422 serial data link with handshaking, and more than 20 lines of programmable parallel I/O ports. Five memory sockets are provided, one populated with a 2-K byte RAM, allowing a total mix of RAM, EPROM or ROM of up to 40 kilobytes. A crystal controlled oscillator, power-on clear circuitry, and a full Microboard expansion interface complete the board.

The CDP18S600 is a powerful stand alone system, but it may be combined with any of the broad line of Microboard components for larger applications. (Not all Microboards at present will run at the higher of the 2 selectable clock speeds of the CDP18S600; consult RCA.) The CDP18S600 is plug-in compatible with the RCA MSI series of Industrial Chassis and with the RCA Microboard Computer Development Systems (MCDS) CDP18S693 and CDP18S694 and Color MCDS CDP18S695 to facilitate hardware and software development. It can

Features
- Low power static CMOS — requires 20 mA (typ.)*
- Operable from a single 5 volt supply
- High noise immunity
- 2.46 or 4.92 MHz crystal clock
- Compatible with RCA MSI series Industrial Chassis and 1800-based development systems
- Stand alone capability
- 2 kilobytes of read/write memory — socketed
- Sockets for up to 40 kilobytes of ROM, EPROM, or byte-wide RAM (including socket above)
- Power-on reset
- 1800 series Microprocessor architecture
- Flexible memory and I/O expansion
- 20 programmable parallel I/O lines, plus 4 testable flag inputs and Q output
- 8-bit counter-timer with prescaler
- UART driven serial I/O
- RS232, RS422, or CMOS level serial interface
- 15 selectable BAUD rates: 50 to 38,400
- Addresses full 64 Kbyte memory space
- 44 pin system interface
- Wide temperature range: -40°C to +85°C.
- Small board size: 4.5 x 7.5 inches

*with CMOS ROM and CMOS level serial interface

Fig. 1 - Block Diagram of RCA CMOS CDP18S600 Microboard Computer
also be used with the RCA Development System CDP-18S008 (CDSIV) and the MicroDisk Development System (MS2000).

Because of its CMOS design and low current requirements, the power supply and cooling requirements are minimal. A complete system, including an RS422 data link, could run from a small plug in power supply such as the CDP18S023.

Component Features

Central Processing Unit: The central processor for the CDP18S600 is the 8-bit silicon gate CMOS RCA CDP1805A. The CDP1805A features 16 general purpose 16-bit registers, any of which can be used as program counter, stack or data pointer, or general data storage. One register serves as a program counter for interrupt servicing, while a second can serve as a DMA pointer for fast I/O transfer of data. If either DMA or interrupt is unused, its register is free for other uses. A versatile 8-bit counter/timer with prescaler, 4 testable flag lines, a single bit testable output port, and several powerful new instructions are also featured.

Memory: The CDP18S600 provides 2 independent banks, one of 4 sockets and one of one. A 6116 CMOS RAM provided in one of the sockets gives 2 Kbytes of read/write storage. All 5 sockets may be loaded with 2716 (2K x 8), 2732 (4K x 8), or 2764 (8K x 8) compatible EPROM's or masked ROM's, or 6116 (2K x 8) or 6264 (8K x 8) compatible RAM's.

Serial I/O: A serial communications interface, driven by a CDP1854A UART, has EIA RS232 and RS422 capability. The data format is software selectable, while 15 BAUD rates, from 50 to 38,400, are selectable by a 4-position DIP switch.

Parallel I/O: 20 programmable input or output lines are provided by a CDP1851 programmable parallel I/O port. Each line can be customized to an input or output under software control, while several may be used to provide handshaking for byte transfer applications. The CPU 'flag and Q lines may also be used as input and output respectively.

Specifications

Memory Capacity
On-board ROM/EPROM/RAM: 5 sockets for up to 40 kilobytes
On-board RAM: 2 kilobytes occupying one of the above sockets

Off-board expansion: Up to 64 kilobytes total memory space

Memory Address Map
On-board RAM: any 2 kilobyte block
On-board ROM/EPROM/RAM: depending on type and quantity of memory, any 2-, 4-, 8-, 16-, or 32-kilobyte block

I/O Capacity
Parallel: 20 lines, each programmable as input or output. 8 of the above are programmable as bidirectional, 4 additional flag inputs and 1 additional bit output.
Serial: Data input and output, and clear to send input and output. Programmable format and switch selectable BAUD rate. RS232, RS422, or CMOS level interface.

Operating Temperature Range
-40°C to +85°C.

Dimensions
4.5 x 7.5 inches (114 x 191 mm)
Board pitch 0.5 inch (12.7 mm) minimum

Power Requirements
(except as noted, 5 volts ± 10%, @ 2.46 or 4.92 MHz)
Without ROM's or serial interface
6 mA in Reset mode (clock independent)
11 or 13 mA in Wait mode, memory access off-board
15 or 23 mA operating all memory access off-board
47 or 53 mA operating every cycle on-board RAM access

With RS422 driver installed (U3)
55 mA additional
With RS232/RS422 receiver installed (U2)
35 mA additional

Optional supplies needed for RS232 driver (U4)
+10 to +15 volts at 8 mA typ.
-5 to -15 volts at 8 mA type.

Connectors
System Interface: Double sided edge fingers, 0.156 inch pitch, 44 conductors
Parallel I/O: Double sided edge fingers, 0.100 inch pitch, 34 conductors
Serial I/O: separate RS422 and RS232 10-pin right angle connectors, 2 row, 0.100 inch spacings (mating headers supplied)

Clock
CPU and Interface: 9.8304 MHz crystal controlled oscillator, divided to 4.9152 or 2.4576 MHz
RCA CMOS Microboard Computer
CDP18S600

Microboard Bus Interface Signals (Connector P1)

The following signals are generated or received by the CDP18S600 CPU Microboard and provide the interface to other Microboard Systems components. For further information on these signals, refer to the data sheet for the CDP1805A (File No. 1370). For a list of the pins and signals for the RCA Microboard Universal Backplane Connector (P1) as used on the CDP18S600, see Table 1.

DB7 through DB0 — Eight bidirectional data bus lines. Taken directly from the CPU bus pins, these lines transfer data among the memory, CPU, and I/O devices.

N0, N1, N2 — Taken directly from the CPU pins, these lines indicate an I/O instruction is being executed. They are derived from the low-order three bits of the N register during an I/O instruction execution only. They are low (false) at all other times. These bits form the primary address identifying the I/O device. Direction of transfer, derived from N3 internal to the CPU, is presented on the MRD line. When high, MRD indicates data transfer from I/O to memory; when low, from memory to I/O.

EFT, EF2, EF3, EF4 — Taken directly to the CPU pins, these inputs can be tested by conditional branch instructions. They, along with INT, DMA1, and DMAO are pulled high (inactive) with resistors. EF1 and EF2, gated by the PIO group address, are used to test the ready state of I/O ports A and B. EF3 and EF4, gated by the UART group address, are used to test the UART interrupt output and the serial data input line. The EF lines may be used to identify the source of an interrupt to the CPU, or they may be used to indicate priority or status.

INT — Taken directly to the CPU pin, the interrupt line causes a transfer of control from the current program counter to register i. Intermups may be inhibited by software. If Interrupt Enable (IE) is set, recognition of INT results in completion of execution of the current instruction, followed by an S3 machine state during which designators X and P are stored in T. Then, X is set to 2, P is set to 1, and IE is reset to 0. The S3 state lasts one machine cycle (eight clocks), after which processing resumes with R1 as program counter.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Mnemonic</th>
<th>Signal Flow</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DMAi-N</td>
<td>In</td>
<td>DMA Input Request</td>
</tr>
<tr>
<td>2</td>
<td>DMAO-N</td>
<td>In</td>
<td>DMA Output</td>
</tr>
<tr>
<td>3</td>
<td>RN1-P</td>
<td>In</td>
<td>Run Utility Request</td>
</tr>
<tr>
<td>4</td>
<td>INT-N</td>
<td>In</td>
<td>Interrupt Request</td>
</tr>
<tr>
<td>5</td>
<td>MRD-N</td>
<td>Out</td>
<td>Memory Read</td>
</tr>
<tr>
<td>6</td>
<td>Q-P</td>
<td>Out</td>
<td>Programmed Output Latch</td>
</tr>
<tr>
<td>7</td>
<td>SCO-P</td>
<td>Out</td>
<td>State Code</td>
</tr>
<tr>
<td>8</td>
<td>SC1-P</td>
<td>Out</td>
<td>State Code</td>
</tr>
<tr>
<td>9</td>
<td>CLEAR-N</td>
<td>In</td>
<td>Clear-Mode Request</td>
</tr>
<tr>
<td>10</td>
<td>WAIT-N</td>
<td>In</td>
<td>Wait-Mode Request</td>
</tr>
<tr>
<td>11</td>
<td>-5V/-15V</td>
<td>—</td>
<td>Auxiliary Power</td>
</tr>
<tr>
<td>12</td>
<td>SPARE</td>
<td>—</td>
<td>Not Assigned</td>
</tr>
<tr>
<td>13</td>
<td>CLOCK OUT</td>
<td>Out</td>
<td>Clock from CPU Osc.</td>
</tr>
<tr>
<td>14</td>
<td>N0-P</td>
<td>Out</td>
<td>I/O Primary Address</td>
</tr>
<tr>
<td>15</td>
<td>N1-P</td>
<td>Out</td>
<td>I/O Primary Address</td>
</tr>
<tr>
<td>16</td>
<td>N2-P</td>
<td>Out</td>
<td>I/O Primary Address</td>
</tr>
<tr>
<td>17</td>
<td>EF1-N</td>
<td>In</td>
<td>External Flag</td>
</tr>
<tr>
<td>18</td>
<td>EF2-N</td>
<td>In</td>
<td>External Flag</td>
</tr>
<tr>
<td>19</td>
<td>EF3-N</td>
<td>In</td>
<td>External Flag</td>
</tr>
<tr>
<td>20</td>
<td>+10V/+15V</td>
<td>—</td>
<td>Auxiliary Power</td>
</tr>
<tr>
<td>21</td>
<td>+5V</td>
<td>—</td>
<td>+5 V dc</td>
</tr>
<tr>
<td>22</td>
<td>GND</td>
<td>—</td>
<td>Digital Ground</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pin</th>
<th>Mnemonic</th>
<th>Signal Flow</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>TPA-P</td>
<td>Out</td>
<td>System Timing Pulse 1</td>
</tr>
<tr>
<td>B</td>
<td>TPB-P</td>
<td>Out</td>
<td>System Timing Pulse 2</td>
</tr>
<tr>
<td>C</td>
<td>DBO-P</td>
<td>In/Out</td>
<td>Data Bus</td>
</tr>
<tr>
<td>D</td>
<td>DB1-P</td>
<td>In/Out</td>
<td>Data Bus</td>
</tr>
<tr>
<td>E</td>
<td>DB2-P</td>
<td>In/Out</td>
<td>Data Bus</td>
</tr>
<tr>
<td>F</td>
<td>DB3-P</td>
<td>In/Out</td>
<td>Data Bus</td>
</tr>
<tr>
<td>G</td>
<td>DB4-P</td>
<td>In/Out</td>
<td>Data Bus</td>
</tr>
<tr>
<td>H</td>
<td>DB5-P</td>
<td>In/Out</td>
<td>Data Bus</td>
</tr>
<tr>
<td>I</td>
<td>DB6-P</td>
<td>In/Out</td>
<td>Data Bus</td>
</tr>
<tr>
<td>J</td>
<td>DB7-P</td>
<td>In/Out</td>
<td>Data Bus</td>
</tr>
<tr>
<td>K</td>
<td>A0-P</td>
<td>Out</td>
<td>Multiplexed Address Bus</td>
</tr>
<tr>
<td>L</td>
<td>A1-P</td>
<td>Out</td>
<td>Multiplexed Address Bus</td>
</tr>
<tr>
<td>M</td>
<td>A2-P</td>
<td>Out</td>
<td>Multiplexed Address Bus</td>
</tr>
<tr>
<td>N</td>
<td>A3-P</td>
<td>Out</td>
<td>Multiplexed Address Bus</td>
</tr>
<tr>
<td>O</td>
<td>A4-P</td>
<td>Out</td>
<td>Multiplexed Address Bus</td>
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<tr>
<td>P</td>
<td>A5-P</td>
<td>Out</td>
<td>Multiplexed Address Bus</td>
</tr>
<tr>
<td>Q</td>
<td>A6-P</td>
<td>Out</td>
<td>Multiplexed Address Bus</td>
</tr>
<tr>
<td>R</td>
<td>A7-P</td>
<td>Out</td>
<td>Multiplexed Address Bus</td>
</tr>
<tr>
<td>S</td>
<td>MWR-N</td>
<td>Out</td>
<td>Memory Write Pulse</td>
</tr>
<tr>
<td>T</td>
<td>EF4-N</td>
<td>In</td>
<td>External Flag</td>
</tr>
<tr>
<td>U</td>
<td>+5V</td>
<td>—</td>
<td>+5 V dc</td>
</tr>
<tr>
<td>V</td>
<td>GND</td>
<td>—</td>
<td>Digital Ground</td>
</tr>
</tbody>
</table>

Note: Signal flow direction is relative to CPU.
Interrupts can result from an external source or from the counter timer. Each can be separately enabled with XIE or CIE instructions.

DMA1, DMA0 — Taken directly to CPU pins and not utilized by the CDP18S600, these lines allow off-board I/O controllers rapid direct memory access. The CPU monitors these data transfers, going into an S2 machine state for each byte transfer. R0 is used as the memory pointer and is automatically incremented each time. Thus, DMA transfers are interleaved with normal processing and no software action is required except to initialize R0 before transfer starts. INT and or an EF may be used to notify the program that a block DMA transfer is completed so that initialization and processing of the data block may be performed. The DMA inputs may be maintained in the true state for contiguous S2 states for the most rapid transfer. In the usual case, however, the DMA request is removed at the TPA of the S2 cycle to obtain a single byte transfer, allowing time for normal processing and for setting up the next byte in the requesting controller. Each S2 state is eight clock cycles in duration.

SC1, SC0 — State code outputs from the CPU which identify the type of machine cycle in progress.

<table>
<thead>
<tr>
<th>State Type</th>
<th>State Code Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>S0 (Fetch)</td>
<td>SC1: L, SC0: L</td>
</tr>
<tr>
<td>S1 (Execute)</td>
<td>SC1: L, SC0: H</td>
</tr>
<tr>
<td>S2 (DMA)</td>
<td>SC1: H, SC0: L</td>
</tr>
<tr>
<td>S3 (Interrupt)</td>
<td>SC1: H, SC0: H</td>
</tr>
</tbody>
</table>

TPA, TPB — Timing pulses generated by the CPU which occur once in each machine cycle. TPA trailing edge is used to latch the high-order memory address. TPB trailing edge is used to latch output data from the data bus.

All I/O cycles should be considered to start at the trailing edge of TPA and end at the trailing edge of TPB. MRD, the N lines, and the A7 through A0 lines are stable during this period. (To provide additional hold time on these lines, the CDP18S600 board latches them at TPB trailing edge, and holds them through the next leading edge of TPA.)

A7 through A0 — Eight memory address lines from the CPU. The 16 memory address bits are multiplexed on this address bus. The high-order eight bits are presented early in each machine cycle and must be latched at the TPA trailing edge. The CDP18S600 buffers, latches, and decodes these bits for the on-board memories. Any external memory must provide its own latches. During the latter part of the cycle, the low-order eight bits are presented on this address bus and need not be latched.

MWR — A WRITE command from the CPU to the memories. Address lines are stable at this time. Actual writing or latching occurs at the trailing edge.

MRD — A READ command from the CPU to the memories and a direction indicator for I/O data transfers. In the I/O instructions it corresponds to N3 (N register, internal to the CPU) which distinguishes I/O inputs from outputs. MRD must be used to condition output drivers in all memory components, or their output buffers, to avoid contention on the data bus. The absence of MWR must not be interpreted as a READ. Early in a write cycle, data are being driven onto the data bus by the CPU or an input device. If a memory allows its outputs to be enabled while MRD is false before MWR appears, bus contention will occur resulting in unnecessary power dissipation and perhaps circuit failures.

Q — A single bit output from the CPU. This bit is set or reset by SEQ (7B) or REF (7A) instructions, and is also reset by CLEAR. It is available both on the Microboard Bus (P1) and on the Parallel I/O connector (P2). Q may also be tested with a branch instruction, or may be toggled from the Counter/Timer.

CLOCK OUT — A 4.9152 or 2.4576 MHz square wave clock provided for general use. It is derived from the 9.8304 MHz on-board crystal controlled oscillator.

WAIT, CLEAR — Two control inputs to the CPU which determine the mode of operation.

<table>
<thead>
<tr>
<th>CLEAR</th>
<th>WAIT</th>
<th>MODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>L</td>
<td>Not allowed</td>
</tr>
<tr>
<td>L</td>
<td>H</td>
<td>Reset</td>
</tr>
<tr>
<td>H</td>
<td>L</td>
<td>Pause</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
<td>Run</td>
</tr>
</tbody>
</table>

The functions of the modes are defined as follows:

RESET: Registers R1, N, Q, counter prescaler, and counter interrupt (CI) are reset. IE, XIE, and CIE are set and 0’s (Vss) are placed on the data bus. TPA and TPB are suppressed while reset is held and the CPU is placed in S1. The state of the counter/timer is unaffected by the RESET operation.

The first machine cycle after termination of reset is an initialization cycle which requires 9 clock pulses. During this cycle the CPU remains in S1, X, P, and then registers X, P, and R0 are reset. Interrupt and DMA
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Servicing is suppressed during the initialization cycle. The next cycle is an S0 or an S2 but never an S1 or S3. In most cases, it is desirable to reset the IE before starting processing. The use of a 71 instruction followed by 00 at memory locations 0000 and 0001 will reset IE which may be set later when the software is able to process interrupt. Power-up reset-run is provided on the CDP18S600 board.

PAUSE: Stops the internal CPU timing generator, freezing the state of the processor. Pause can occur at two points in a machine cycle, on the low-to-high transition of either TPA or TPB. The oscillator continues to run but subsequent clock transitions are ignored (see Fig. 2).

If Pause is entered while in the event counter mode, the appropriate E Flag transitions will continue to decrement the counter.

RUN: May be initiated from the Pause or Reset mode functions. If initiated from Pause, the CPU resumes operation at the point it left off. If paused at TPA, it will resume on the first high-to-low clock transition. If paused at TPB, it will resume on the first low-to-high clock transition (see Fig. 2). When run is initiated from the Reset operation, the first machine cycle following Reset is always the initialization cycle.

**TPA Pause Timing**

```
<table>
<thead>
<tr>
<th>CLOCK</th>
<th>70</th>
<th>71</th>
<th>00</th>
<th>01</th>
<th>PAUSE</th>
<th>10</th>
<th>11</th>
<th>20</th>
<th>21</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPA</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WAIT</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
```

**TPB Pause Timing**

```
<table>
<thead>
<tr>
<th>CLOCK</th>
<th>50</th>
<th>51</th>
<th>60</th>
<th>61</th>
<th>70</th>
<th>71</th>
<th>00</th>
<th>01</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>TPA</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>WAIT</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
```

**Fig. 2 - Pause mode timing waveforms.**

The initialization cycle is then followed by a DMA (S2) cycle or fetch (S0) from location 0000 in memory.

**RNU - Run Utility Software.** A signal supplied to CDP18S600 to force the most significant address true. As a result, the program start is at memory location 8000 instead of 0000. See discussion under Run Utility.

**Counter-Timer and Controls**

The CDP1805A provides an on-chip 8-bit presettable timer-counter. Software control of the counter allows the clock input to be TPA ÷ 32, EF1, EF2, TPA*EF1, or TPA*EF2, in addition to the Decrement-Counter Instruction.

The counter-timer logic shown in Fig. 3 consists of a presettable 8-bit down-counter (Modulo N type), and a conditional divide-by-32 prescaler. After counting down to 01, the counter returns to its initial value at the next count and sets the Timer/Counter Interrupt. It will continue decrementing on subsequent counts. If the counter is preset to 00, a full 256 counts will occur.

During a Load Counter instruction (LDC) if the counter was stopped with a STPC instruction, the counter and its holding register (CH) are loaded with the value in the D register and any previous counter interrupt is cleared. If the LDC is executed when the counter is running, the contents of the D register are loaded into the holding register (CH) only and any previous counter interrupt is not cleared. After counting down to 01, the next count will load the new initial value into the counter, set the Counter Interrupt Latch, and operation will continue.

The timer/counter has the following five programmable modes:

1. **Event Counter 1:** Input to counter is connected to the EF1 terminal. The high-to-low transition decrements the counter.

2. **Event Counter 2:** Input to counter is connected to the EF2 terminal. The high-to-low transition decrements the counter.

3. **Timer:** Input to counter is from the divide-by-32 prescaler clocked by TPA. The prescaler is decremented on the low-to-high transition of TPA. The divide-by-32 prescaler is reset when the counter in in a mode other than the Timer mode or stopped by a STPC.

4. **Pulse Duration Measurement:** Input to counter connected to TPA. Each low-to-high transition of TPA decrements the counter if the input signal at EF1 terminal (gate input) is low. On the transition of EF1 to the positive state, the count is stopped, the mode is cleared, and the interrupt request latched. If the counter underflows while the input is low, interrupt will also be set, but counting will continue.
5. Pulse Duration Measurement 2: Operation is identical to Pulse Duration Measurement 1, except EF2 is used as the gate input.

The modes can be changed without affecting the stored count.

Those modes which use EF1 and EF2 terminals as inputs do not exclude testing these flags for branch instructions.

The Stop Counter (STPC) instruction clears the counter mode and stops counting. The STPC instruction should be executed prior to a GEC instruction, if the counter is in the Event Counter Mode 1 or 2.

In addition to the five programmable modes, the Decrement Counter instruction (DTC) enables the user to count in software. In order to avoid conflict with counting done in the other modes, the instruction should be used only after the mode has been cleared by a Stop Counter instruction.

The Enable Toggle Q instruction (ETQ) connects the Q-line flip-flop to the output of the counter, such that each time the counter decrements from 01 to its next value, the Q output changes state. This action is independent of the counter mode and the Interrupt Enable flip-flops. The Enable Toggle Q condition is cleared by an LDC with the timer/counter stopped, system Reset, or a BCI with C1=1.

On-Board Memory Addressing

All 1800 series processors use a multiplexed address bus: the high byte is output first to be latched with TPA trailing edge, then the low byte is output. The CDP-18S600 also latches the low byte and holds it through the next TPA leading edge. This gives more address hold time after the memory write pulse and TPB. (TPB trailing edge is often used to strobe I/O output data.)

The latched A0 through A10 are sent to each memory socket, while A13 through A15 are decoded for chip selects. A11 and A12 may be used either at the socket or for chip select decoding depending on memory size.

The CDP18S600 provides 2 independent memory "banks", one of 4 sockets and one of 1 socket. Each socket may contain ROM, EPROM, or RAM of 2K x 8, 4K x 8, or 8K x 8 size, the only restriction being that all the memories within one bank be the same size. In addition, each socket may be disabled entirely.

Note that in the following discussion of memory address setting, all links within a given link pack not specifically called out as closed must be removed. Permanent circuit damage could result otherwise. Refer to the Parts List for manufacturers' part no's for Links.

Selecting Memory Type

Each socket, U17 through U21, has an associated 6
pin link pack, LK 6 through LK 10, used to set memory type. The link pack is found near pin 28 of each socket; see figure 4 for socket and link placement. Table II lists link connections needed for each memory type.

Table II: Links for setting memory type.

<table>
<thead>
<tr>
<th>Generic Type</th>
<th>Size</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>6116 RAM</td>
<td>2K x 8</td>
<td>1 - 2</td>
</tr>
<tr>
<td>6264 RAM</td>
<td>8K x 8</td>
<td>1 - 6, 2 - 3</td>
</tr>
<tr>
<td>2716 EPROM</td>
<td>2K x 8</td>
<td>2 - 5</td>
</tr>
<tr>
<td>2732 EPROM</td>
<td>4K x 8</td>
<td>2 - 3</td>
</tr>
<tr>
<td>2764 EPROM</td>
<td>8K x 8</td>
<td>2 - 3, 5 - 6</td>
</tr>
</tbody>
</table>

Note that EPROM's are Intel compatible pinout. Compatible ROM's could be substituted. Note also that a larger memory could be used to fill a smaller "hole," such as using a 6264 as a 4K RAM. Link the socket to fit the memory used, but link the decoder to provide the memory size desired as discussed below.

Note that all memory sockets are 28 pin. When using 24 pin memories, insert the chip so that pins 1, 2, 27, and 28 of the socket are left vacant. The chip should still be facing the same way as the socket.

Setting memory addresses: 1 socket memory bank (U21).

Link packs 11 and 14 (see Fig. 4) set the address of U21. Tables III, IV, and V give link pack 11 and 14 positions for 2K, 4K, and 8K x 8 memory sizes respectively.

Setting memory addresses: 4 socket memory bank (U20, U19, U18, U17)

Link pack 13 (see Fig. 3) sets the addresses of U20, U19, U18, and U17. Tables VI, VII, and VIII give link pack 13 positions for 2K, 4K, and 8K x 8 memory sizes respectively. Note that all link pack 12 links should also be made except when it is desired to disable a socket as discussed below.

Disabling memory sockets

As memory data lines are buffered, simply removing a memory chip will not free up that memory space. See Table IX for disabling each memory socket. As previously mentioned, link packs 6 through 10 are located near pin 28 of sockets U17 through U21.

To avoid floating inputs on the memory decoders, unused memory banks must still have a valid address setup on link packs 13 or 14.

When a socket is disabled, remove the contained memory chip.

Fig. 4 - Links, Connectors, Baud Rate Switch, and Socketed I.C.s.
### Table III: 1 Socket Memory Bank (U21) Linking for 2Kx8 Memory Chips

<table>
<thead>
<tr>
<th>MEMORY ADDRESS</th>
<th>LK14</th>
<th>5 - 6</th>
<th>1 - 2</th>
<th>2 - 3</th>
<th>4 - 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - 3, 5 - 6</td>
<td></td>
<td>7 - 8, 10 - 11, 13 - 14</td>
<td>0000 - 07FF</td>
<td>0800 - 0FFF</td>
<td>1000 - 17FF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - 9, 10 - 11, 13 - 14</td>
<td>2000 - 27FF</td>
<td>2800 - 2FFF</td>
<td>3000 - 37FF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - 8, 11 - 12, 13 - 14</td>
<td>4000 - 47FF</td>
<td>4800 - 4FFF</td>
<td>5000 - 57FF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - 9, 11 - 12, 13 - 14</td>
<td>6000 - 67FF</td>
<td>6800 - 6FFF</td>
<td>7000 - 77FF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - 8, 10 - 11, 14 - 15</td>
<td>8000 - 87FF</td>
<td>8800 - 8FFF</td>
<td>9000 - 97FF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - 9, 10 - 11, 14 - 15</td>
<td>A000 - A7FF</td>
<td>A800 - AFFF</td>
<td>B000 - B7FF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - 8, 11 - 12, 14 - 15</td>
<td>C000 - C7FF</td>
<td>C800 - CFFF</td>
<td>D000 - D7FF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - 9, 11 - 12, 14 - 15</td>
<td>E000 - E7FF</td>
<td>E800 - EFFF</td>
<td>F000 - F7FF</td>
</tr>
</tbody>
</table>

### Table IV: 1 Socket Memory Bank (U21) Linking for 4Kx8 Memory Chips

<table>
<thead>
<tr>
<th>Memory Address</th>
<th>LK11</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2, 5 - 6</td>
<td></td>
</tr>
<tr>
<td>7 - 8, 10 - 11, 13 - 14</td>
<td>0000 - 0FFF</td>
</tr>
<tr>
<td>8 - 9, 10 - 11, 13 - 14</td>
<td>2000 - 2FFF</td>
</tr>
<tr>
<td>7 - 8, 11 - 12, 13 - 14</td>
<td>4000 - 4FFF</td>
</tr>
<tr>
<td>8 - 9, 11 - 12, 13 - 14</td>
<td>6000 - 6FFF</td>
</tr>
<tr>
<td>7 - 8, 10 - 11, 14 - 15</td>
<td>8000 - 8FFF</td>
</tr>
<tr>
<td>8 - 9, 10 - 11, 14 - 15</td>
<td>A000 - AFFF</td>
</tr>
<tr>
<td>7 - 8, 11 - 12, 14 - 15</td>
<td>C000 - CFFF</td>
</tr>
<tr>
<td>8 - 9, 11 - 12, 14 - 15</td>
<td>E000 - EFFF</td>
</tr>
</tbody>
</table>

### Table V: 1 Socket Memory Bank (U21) Linking for 8Kx8 Memory Chips

<table>
<thead>
<tr>
<th>Memory Address</th>
<th>LK11</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2, 4 - 5</td>
<td></td>
</tr>
<tr>
<td>7 - 8, 10 - 11, 13 - 14</td>
<td>0000 - 1FFF</td>
</tr>
<tr>
<td>8 - 9, 10 - 11, 13 - 14</td>
<td>2000 - 3FFF</td>
</tr>
<tr>
<td>7 - 8, 11 - 12, 13 - 14</td>
<td>4000 - 5FFF</td>
</tr>
<tr>
<td>8 - 9, 11 - 12, 13 - 14</td>
<td>6000 - 7FFF</td>
</tr>
<tr>
<td>7 - 8, 10 - 11, 14 - 15</td>
<td>8000 - 9FFF</td>
</tr>
<tr>
<td>8 - 9, 10 - 11, 14 - 15</td>
<td>A000 - BFFF</td>
</tr>
<tr>
<td>7 - 8, 11 - 12, 14 - 15</td>
<td>C000 - DFFF</td>
</tr>
<tr>
<td>8 - 9, 11 - 12, 14 - 15</td>
<td>E000 - FFFF</td>
</tr>
</tbody>
</table>

### Table VI: 4 Socket Memory Bank (U17 - 20) Linking for 2Kx8 Memory Chips

<table>
<thead>
<tr>
<th>Memory Address</th>
<th>Memory Socket</th>
</tr>
</thead>
<tbody>
<tr>
<td>LK13</td>
<td>U20</td>
</tr>
<tr>
<td>10 - 11, 14 - 15, 18 - 19</td>
<td>0000 - 07FF</td>
</tr>
<tr>
<td>11 - 12, 14 - 15, 18 - 19</td>
<td>2000 - 27FF</td>
</tr>
<tr>
<td>10 - 11, 15 - 16, 18 - 19</td>
<td>4000 - 47FF</td>
</tr>
<tr>
<td>11 - 12, 15 - 16, 18 - 19</td>
<td>6000 - 67FF</td>
</tr>
<tr>
<td>10 - 11, 14 - 15, 19 - 20</td>
<td>8000 - 87FF</td>
</tr>
<tr>
<td>11 - 12, 14 - 15, 19 - 20</td>
<td>A000 - A7FF</td>
</tr>
<tr>
<td>10 - 11, 15 - 16, 19 - 20</td>
<td>C000 - C7FF</td>
</tr>
<tr>
<td>11 - 12, 15 - 16, 19 - 20</td>
<td>E000 - E7FF</td>
</tr>
</tbody>
</table>
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Table VII: 4 Socket Memory Bank (U17 - 20) Linking for 4Kx8 Memory Chips

<table>
<thead>
<tr>
<th>Memory Address</th>
<th>Memory Socket</th>
</tr>
</thead>
<tbody>
<tr>
<td>LK13</td>
<td>U20</td>
</tr>
<tr>
<td>14 - 15, 18 - 19</td>
<td>0000 - 0FFF</td>
</tr>
<tr>
<td>15 - 16, 18 - 19</td>
<td>4000 - 4FFF</td>
</tr>
<tr>
<td>14 - 15, 19 - 20</td>
<td>8000 - 8FFF</td>
</tr>
<tr>
<td>15 - 16, 19 - 20</td>
<td>C000 - CFFF</td>
</tr>
</tbody>
</table>

Table VIII: 4 Socket Memory Bank (U17 - 20) Linking for 8Kx8 Memory Chips

<table>
<thead>
<tr>
<th>Memory Address</th>
<th>Memory Socket</th>
</tr>
</thead>
<tbody>
<tr>
<td>LK13</td>
<td>U20</td>
</tr>
<tr>
<td>2 - 3, 7 - 9, 5 - 9, 13 - 17</td>
<td>18 - 19</td>
</tr>
<tr>
<td>19 - 20</td>
<td>8000 - 9FFF</td>
</tr>
</tbody>
</table>

Table IX: Disabling memory sockets

<table>
<thead>
<tr>
<th>Disabled socket</th>
<th>Remove links</th>
<th>Add links</th>
</tr>
</thead>
<tbody>
<tr>
<td>U21</td>
<td>LK 10 and LK 11: all</td>
<td>LK 10: 4 - 5</td>
</tr>
<tr>
<td>U19</td>
<td>LK 8: all, LK 12: 3 - 4</td>
<td>LK 8: 4 - 5</td>
</tr>
<tr>
<td>U18</td>
<td>LK 7: all, LK 12: 5 - 6</td>
<td>LK 7: 4 - 5</td>
</tr>
<tr>
<td>U17</td>
<td>LK 6: all, LK 12: 7 - 8</td>
<td>LK 6: 4 - 5</td>
</tr>
</tbody>
</table>

Input/Output Interfacing

2 Level Addressing

In order to expand the number of I/O addresses available on RCA CDP1800 series microprocessors, a 2 level addressing scheme has been adopted on RCA Microboards. The data output during an “OUT I” (61) instruction is latched by all I/O type Microboards. (This is referred to as a group select or 2 level address.) Boards decode either the lower nibble (bits 0 - 3) in a linear (1 of 4) manner, or the upper nibble in a binary (1 of 16) manner. Each I/O board compares this group number to the number assigned to it, and if the group matches, it can then respond to subsequent output (62 - 67) or input (6A - 6F) instructions. (“INP I” (69) is reserved to read back, where implemented, the last group select address. The CDP18S600 board does not provide this function.)

Both the serial I/O, a CDP1854A UART, and the parallel I/O, a CDP1851 PIO, are enabled by linear group select bits. The UART may occupy either group 1 or 2, while the PIO is fixed in group 8. LK4 sets the UART group address; see figure 4 for location. Table X gives the group select choices. Note that utility programs such as UT70 require the UART to be in group 1.

Table X: UART and PIO group addresses

<table>
<thead>
<tr>
<th>LK4 links</th>
<th>Group</th>
<th>Binary Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2</td>
<td>UART group 1</td>
<td>XXXX 0001</td>
</tr>
<tr>
<td>2 - 3</td>
<td>UART group 2</td>
<td>XXXX 0010</td>
</tr>
<tr>
<td>XXXXX</td>
<td>PIO group 8</td>
<td>XXXX 1000</td>
</tr>
</tbody>
</table>

Note: X = don’t care

Serial I/O

The CDP1854A UART has 4 registers. Once the UART group has been enabled, the registers are addressable as in Table XI below.

Table XI: UART I/O register addresses

| Out 2: | Load transmitter holding register |
| Out 3: | Load control register |
| Inp 2: | Read receiver holding register |
| Inp 3: | Read status register |

The control register sets, among other things, the word length, even odd parity, parity enable, and number of stop bits. RCA utility routines, such as contained in RCA Monitor Program CDP18SUT70, set conditions of no parity, 8 data bits, and 2 stop bits. This setup requires an Out 3 instruction with data of hex 1D. For more information on setting up the UART, refer to the data
sheet for the CD8154A, file number 1193.

The status register (Inp 3) holds transmitter and receiver status information. When bit 7, transmitter holding register empty, is set, it indicates that it is okay to load another output character for transmission. When bit 0, data available, is set, it indicates that a full character has been received and may be read.

The Out 2 instruction outputs data to be transmitted, and the Inp 2 instruction reads data that has been received.

The UART has an interrupt output that can be programmed to respond to several different status conditions; again refer to file 1193. The interrupt signal can be presented to the CPU INT — N or EF3 — N lines through links on LK1. The SDI (serial data in) signal can be sampled on EF4 — N through a third link on LK1; this allows a break condition to be detected (EF4 False). This link must be in place for running MICRODOS or equivalent. See Table XII for LK1 connections and Fig. 4 for LK1 location.

Both EF lines are driven through open collector gates and are disabled by removing the UART group select. The INT line is also open collector, but is not controlled with group select. In a system with multiple interrupts, the source of an interrupt could be determined by enabling group selects until an active flag was found.

### Table XII: LK1 Connections

<table>
<thead>
<tr>
<th>LK1 link</th>
<th>Connects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 12</td>
<td>PIO interrupts to INT — N</td>
</tr>
<tr>
<td>2 - 11</td>
<td>UART interrupt to INT — N</td>
</tr>
<tr>
<td>3 - 10</td>
<td>PIO ARDY line to EF1 — N</td>
</tr>
<tr>
<td>4 - 9</td>
<td>PIO BRDY line to EF2 — N</td>
</tr>
<tr>
<td>5 - 8</td>
<td>UART interrupt to EF3 — N</td>
</tr>
<tr>
<td>6 - 7</td>
<td>UART SDI line to EF4 — N</td>
</tr>
</tbody>
</table>

The UART circuitry provides clear to send (CTS) handshaking as well as serial data input and output (SDI and SDO). Transmitting is stopped if the external CTS input is low (high at the UART). When receiving, the CTS output is lowered in the middle of the first stop bit, and raised again approximately 1/2 of a bit time after the receiver holding register is read. This allows synchronization of sender and receiver. See Table XIII to disable CTS input handshaking. If U2 has been removed, jumper its socket, pins 2 to 4.

### Table XIII: Selecting Serial Interface

<table>
<thead>
<tr>
<th>Interface</th>
<th>LK2 (CTS)</th>
<th>LK3 (SDI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS232</td>
<td>1 - 2</td>
<td>1 - 2</td>
</tr>
<tr>
<td>RS422, unterminated</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>RS422, terminated with 200 Ohms</td>
<td>3 - 4</td>
<td>3 - 4</td>
</tr>
<tr>
<td>Disable (CTS input only)</td>
<td>1 - 2, 3 - 4</td>
<td>—</td>
</tr>
</tbody>
</table>

The serial data and CTS lines may use RS232, RS422, or 0 - 5 volt CMOS signal levels. RS232 uses ± 5 to ± 15 volt single ended signals, while RS422 uses differential 2 volt signal levels. RS422 is intended for transmitting over longer distances or at greater speeds. Note that in RS232 the data is inverted and CTS is active high.

J2 provides the RS232 interface connections; see Table XIV for pin functions, and Fig. 5 for pin placement. U4 is the RS232 driver, and requires auxiliary supplies as outlined in the specifications. For applications where 0 to 5 volt output levels are acceptable, U4 may be removed and pins 1 to 3 and 5 to 7 jumpered. U2 is both the RS232 and RS422 receiver; select interface type by linking LK2 and LK3 as per Table XIII. RS232 and RS422 interfaces cannot be hooked up simultaneously.

J1 provides the RS422 interface. U3 is the RS422 driver while again U2 serves as the receiver. Input signals can be terminated with 200 Ohms to provide matching for longer distance cable runs; see Table XIII. Also see Table XIII to disable CTS input handshaking. When connecting RS422 inputs, the corresponding LK2 or LK3 pin 1 to 2 jumper must be removed; the short could damage the driver.

### Table XIV: J1 (RS422) And J2 (RS232) Pin Functions

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>J1</th>
<th>J2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>- CTS Out</td>
<td>Ground</td>
</tr>
<tr>
<td>2</td>
<td>- Data Out</td>
<td>- Data In</td>
</tr>
<tr>
<td>3</td>
<td>KEY</td>
<td>- Data Out</td>
</tr>
<tr>
<td>4</td>
<td>- CTS In</td>
<td>Tied High</td>
</tr>
<tr>
<td>5</td>
<td>- Data In</td>
<td>KEY</td>
</tr>
<tr>
<td>6</td>
<td>+ Data In</td>
<td>Tied High</td>
</tr>
<tr>
<td>7</td>
<td>+ CTS In</td>
<td>+ CTS Out</td>
</tr>
<tr>
<td>8</td>
<td>Ground</td>
<td>Tied High</td>
</tr>
<tr>
<td>9</td>
<td>+ Data Out</td>
<td>+ CTS In</td>
</tr>
<tr>
<td>10</td>
<td>+ CTS Out</td>
<td>Ground</td>
</tr>
</tbody>
</table>

J1 also provides a CMOS level interface. This allows a
RCA CMOS Microboard
Computer
CDP18S600

low power serial communications link, but with less
noise immunity than either RS232 or RS422. Remove
U2, U3, and U4. Using 0.3 inch jumpers, connect U2
socket pins 2 to 7 and 3 to 6, and U3 socket pins 2 to 7
and 3 to 6. Open all LK2 and LK3 pins. The former
RS422 "+" signal pins now carry the interface, although
CTS is active low. If CTS input handshaking is not
desired, jumper U2 socket pins 2 to 4.
SW1 sets the BAUD rate over a range of 50 to 38,400
bits/second. See Table XV for a list of available BAUD
rates and switch settings.
Parallel I/O
The parallel I/O interface (P2) consists of 20 lines
from a CDP1851 programmable I/O port, the CPU Q
output and 4 flag inputs, clear, all 3 system supplies, and
ground. P2 mates with a 34 conductor, 0.100 inch pitch,
card edge connector. (Not supplied: see parts list for
appropriate connectors.) See Fig. 5 for orientation, and
Table XVI for a list of pin functions.

<table>
<thead>
<tr>
<th>Switch S1</th>
<th>Output Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 3 2 1</td>
<td>Baud*</td>
</tr>
<tr>
<td>C C C C</td>
<td>19200</td>
</tr>
<tr>
<td>C C C O</td>
<td>38400</td>
</tr>
<tr>
<td>C C O C</td>
<td>50</td>
</tr>
<tr>
<td>C C O O</td>
<td>75</td>
</tr>
<tr>
<td>C O C C</td>
<td>134.5</td>
</tr>
<tr>
<td>C O C O</td>
<td>200</td>
</tr>
<tr>
<td>C O O C</td>
<td>600</td>
</tr>
<tr>
<td>C O O O</td>
<td>2400</td>
</tr>
<tr>
<td>O C C C</td>
<td>9600</td>
</tr>
<tr>
<td>O C C O</td>
<td>4800</td>
</tr>
<tr>
<td>O C O C</td>
<td>1800</td>
</tr>
<tr>
<td>O O C C</td>
<td>1200</td>
</tr>
<tr>
<td>O O C O</td>
<td>2400</td>
</tr>
<tr>
<td>O O O C</td>
<td>300</td>
</tr>
<tr>
<td>O O O O</td>
<td>150</td>
</tr>
</tbody>
</table>

*Actual input to UART is 16 times the indicated output rate.
O=Open; C=Closed.

The RCA CDP1851 PIO consists of 2 - 8-bit ports,
each with 2 handshaking lines, as well as internal control
and status registers. The external ports (A and B) can be
programmed as input or output, or one or both can be
set in the bit-programmable mode. In this mode, each
data and handshake line is a direction-programmable
I/O line, and the PIO can generate interrupts on logical
combinations of the data lines. Port A can also be placed
in a bi-directional mode using all 4 handshake lines
(requires port B to be in bit-programmable mode). Ports
can be read back in the output mode, allowing a check
of last byte output.

After first enabling the PIO group select as discussed
previously, the CDP1851 registers may be addressed as
in Table XVII. Note that the RCA Monitor Program
Table XVI: Microboard Computer
Parallel I/O Connector (P2)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Pin</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B2-P</td>
<td>2</td>
<td>GND</td>
</tr>
<tr>
<td>3</td>
<td>B1-P</td>
<td>4</td>
<td>B3-P</td>
</tr>
<tr>
<td>5</td>
<td>B0-P</td>
<td>6</td>
<td>B4-P</td>
</tr>
<tr>
<td>7</td>
<td>BSTB-P</td>
<td>8</td>
<td>B5-P</td>
</tr>
<tr>
<td>9</td>
<td>BRDY-P</td>
<td>10</td>
<td>B6-P</td>
</tr>
<tr>
<td>11</td>
<td>AD7-P</td>
<td>12</td>
<td>B7-P</td>
</tr>
<tr>
<td>13</td>
<td>AD6-P</td>
<td>14</td>
<td>GND</td>
</tr>
<tr>
<td>15</td>
<td>AD5-P</td>
<td>16</td>
<td>CLEAR-N</td>
</tr>
<tr>
<td>17</td>
<td>AD4-P</td>
<td>18</td>
<td>GND</td>
</tr>
<tr>
<td>19</td>
<td>AD3-P</td>
<td>20</td>
<td>Q-P</td>
</tr>
<tr>
<td>21</td>
<td>AD2-P</td>
<td>22</td>
<td>GND</td>
</tr>
<tr>
<td>23</td>
<td>AD1-P</td>
<td>24</td>
<td>EF4-N</td>
</tr>
<tr>
<td>25</td>
<td>AD0-P</td>
<td>26</td>
<td>EF3-N</td>
</tr>
<tr>
<td>27</td>
<td>ASTB-P</td>
<td>28</td>
<td>GND</td>
</tr>
<tr>
<td>29</td>
<td>ARDY-P</td>
<td>30</td>
<td>+5V</td>
</tr>
<tr>
<td>31</td>
<td>EF2-N</td>
<td>32</td>
<td>-5V/-15V</td>
</tr>
<tr>
<td>33</td>
<td>EF1-N</td>
<td>34</td>
<td>+10V/+15V</td>
</tr>
</tbody>
</table>

Setting Modes: The different modes of the PIO can be set by doing an OUT 6 with the data contained in Table XVIII. Note that modes should be set in the order shown: don't set port B as bit programmable then try to set port A as output. Also note that only port A can be bidirectional, and if set so, port B has to be bit programmable.

Table XVIII: Mode set and interrupt enable control words (OUT 6)

<table>
<thead>
<tr>
<th></th>
<th>PORT A</th>
<th>PORT B</th>
<th>BOTH PORTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input</td>
<td>0B</td>
<td>13</td>
<td>1B</td>
</tr>
<tr>
<td>Output</td>
<td>4B</td>
<td>53</td>
<td>5B</td>
</tr>
<tr>
<td>Bit-Programmable</td>
<td>CB*</td>
<td>D3*</td>
<td>DB*</td>
</tr>
<tr>
<td>Bit-Directional</td>
<td>8D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enable Interrupts</td>
<td>81</td>
<td>.89</td>
<td>—</td>
</tr>
<tr>
<td>DisableInterrupts</td>
<td>01</td>
<td>.09</td>
<td>—</td>
</tr>
</tbody>
</table>

*Note: When Bit-Programmable mode is set, a second OUT 6 must follow with data to set bit direction; see text.

Enabling Interrupts: In the following mode discussions, interrupts can be used for a variety of handshaking chores or can result from a programmable logical function of input or output bits. To enable or disable interrupts, the data contained in Table XVIII must be written to the control register (OUT 6). This shouldn't be done until all other setup is accomplished. Reset disables all interrupts. Note that when interrupts are disabled, neither the open collector interrupt drivers nor the interrupt bits in the status register can be active.

Input Mode: The input mode is entered either from reset or by setting it as in Table XVIII. If ASTB or BSTB is high (pulled high by on-board 10 KOhm resistors), then input data can be read continuously. If handshaking is desired, strobing ASTB or BSTB high then low will latch data into port A or B. The leading edge of the strobe will knock down ARDY or BRDY; these signals can then be used to signify "not ready for more data." The trailing edge of the strobe will set the PIO interrupt, if enabled, signalling the CPU to read the data. The leading edge of reading the PIO (INP 3 for port A, INP 2 for port B) will drop the interrupt request from that port, and the trailing edge will set ARDY or BRDY high again.

Since A and B interrupt drivers are tied together, the source must be determined by reading the status register (INP 6 — see Table XIX) or E1F or 2. Status register bit...
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I set or EFI active indicates port A, while bit 0 or EF2 indicates port B. In a non-interrupt driven system, the status bits alone can be used for determining when data is available. Avoid using the flag lines alone unless the strobe pulse is known to be very narrow.

Note that on first entering the input mode, the ARDY and BRDY lines may be low; doing a "dummy" read will set them high. Also note that the STB, RDY, and all data lines have 10 KΩ pullup resistors.

Output Mode: When data is loaded into ports A or B (OUT 3 or 2), the ARDY or BRDY lines go high signifying "data available." The PIO interrupt goes inactive (if the other port isn't interrupting) as well as the EFI or EF2 line. An external device accepting the data should respond by strobing ASTB or BSTB high then low. The strobe leading edge will knock down the ARDY or BRDY lines (EF1 or 2 go inactive), and the trailing edge will set the interrupt request. This signifies "data accepted, ready for more." (Output data can be read back if ASTB or BSTB is high.)

The same methods and precautions as described under input mode should be used for determining interrupt source.

Bit-Programmable Mode: The bit-programmable mode is entered by loading the control register (OUT 6) with the appropriate word from Table XVIII A SECOND LOAD TO THE CONTROL REGISTER MUST FOLLOW with data to program the direction of each bit. Every 0 in the byte will assign that bit position as an input, a 1 as an output. If both ports were set at once (OUT 6, data = hex DB), the second load will set the direction of both ports simultaneously.

Once a port is in the bit-programmable mode, its STB and RDY lines can also be programmed as input or output data lines. (Except when port A is bi-directional; BSTB and BRDY are assigned to it). Table XX gives the control register (OUT 6) bits for setting STB and RDY line use. Bit 1 selects which port is to be acted on. Bit 2 high allows bit 6 to set the RDY line direction, while bit 3 high allows bit 7 to set the STB line direction.

All STB and RDY lines can be read on the status register (INP 6), regardless of programmed direction. See Table XIX.

If STB or RDY are output bits, they can be written with an OUT 6. Bit 1 selects port A or B, bits 4 and 5 are the RDY and STB output data, and the remaining bits are 0's.

Note that ARDY and BRDY are outputs when reset is applied. If connected as inputs, that is to some other driving source, at least 1000 Ohms should be placed in series. This prevents damage by excessive current flow between the RDY output and the external source when reset is applied.

In the bit-programmable mode, the CDP1851 can generate interrupts on logical combinations of input or output bits. Table XXI gives the interrupt control word (OUT 6) bit assignments. Bit 3 selects port A or B, bit 4 indicates if a new interrupt mask is to follow, and bits 5 and 6 select the applicable logic function. When bit 4 is set, A SECOND LOAD TO THE CONTROL REGISTER (OUT 6) MUST FOLLOW. Every bit in the mask that is a 0 feeds the corresponding bit position in the port to the interrupt logic. A mask of hex FF is not allowed.

Once interrupt conditions are set up, interrupts have to be enabled by loading the appropriate control word from Table XVIII. The CPU interrupt signal and/or bits 0 and 1 from the status register can then monitor the logical conditions of the unmasked data bits.

Bidirectional Mode: Only port A can be bidirectional, and only if port B is first placed in the bit-programmable mode. Port A now uses all 4 handshake lines. Table XVIII gives the appropriate control word.

The ASTB and ARDY lines function for input handshaking the same as in the input mode. BSTB and BRDY function as output handshaking, the same as in the output mode, with the addition of BSTB being a 3-state control. With BSTB high, the port A output drivers

<table>
<thead>
<tr>
<th>Bit 7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSTB</td>
<td>BRDY</td>
<td>ASTB</td>
<td>ARDY</td>
<td>A INT.</td>
<td>A INT.</td>
<td>A INT.</td>
<td>B INT.</td>
</tr>
<tr>
<td>Input</td>
<td>Input</td>
<td>Input</td>
<td>Input</td>
<td>Source</td>
<td>Source</td>
<td>Request</td>
<td>Request</td>
</tr>
<tr>
<td>Data</td>
<td>Data</td>
<td>Data</td>
<td>Data</td>
<td>= ASTB</td>
<td>= BSTB</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table XIX: Status Register Bit Assignments (INP 6)
are enabled.

Interrupts and CPU handshaking are the same as if both ports A and B were in use, except only the A interrupt request (status register bit 6) is active. To determine whether an input or output operation caused the interrupt, status register bits 2 and 3 must be checked. See Table XIX.

### Table XXI: Interrupt Control Bit Assignments (Out 6)

<table>
<thead>
<tr>
<th>Bit 7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Select Logic Function</td>
<td>Mask Follows</td>
<td>Port Select</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
| 0 0 = Int. if Any Unmasked Bit is Low  
0 1 = Int. if Any Unmasked Bit is High  
1 0 = Int. if All Unmasked Bits are Low  
1 1 = Int. if All Unmasked Bits are High |

*Note: When Bit 4 is Set, a Second Out 6 Must Follow to Set Interrupt Mask: See Text*

### Setting Clock Speed

There are 2 selectable clock speeds. LK5, pins 1 to 2.

sets 4.9152 MHz, and pins 2 to 3 sets 2.4576 MHz. The selected clock is buffered and available on pin 13 of the backplane.

Not all available Microboards will accept the higher CPU speed. Table XXII gives presently available boards capable of running at the higher speed. Consult RCA for up to date information.

### Table XXII: RCA Microboards with 5 MHz Capability

<table>
<thead>
<tr>
<th>Memory</th>
<th>I/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDP18S628 32/64K RAM/ROM</td>
<td>CDP18S641B UART</td>
</tr>
<tr>
<td>CDP18S630 8K RAM</td>
<td>CDP18S651 Floppy</td>
</tr>
<tr>
<td>CDP18S631 16K RAM</td>
<td>Disk Controller</td>
</tr>
<tr>
<td>CDP18S632 32K RAM</td>
<td>CDP18S655 Real Time Clock</td>
</tr>
<tr>
<td>CDP18S650 Counter/Timer</td>
<td></td>
</tr>
</tbody>
</table>

### Selecting Alternate CPU's

Although supplied with a CDP1805A CPU, any presently available 1800 series CPU may be used. Link 15 pins 1 to 2 and Link 16 allows use of different CPU's, and allow enabling disabling of internal memory on CDP1804's. See Table XXIII for setting Links 15 and 16. (LK15, pins 3 - 4 disables RNU.)
RCA CMOS Microboard Computer
CDP18S600

Table XXIII: RCA CPU Selection

<table>
<thead>
<tr>
<th>CPU</th>
<th>LK15</th>
<th>LK16</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDP1802, 1802A, 1802B</td>
<td>1 - 2</td>
<td>2 - 3, 4 - 5</td>
</tr>
<tr>
<td>CDP1805, 1805A, 1806, 1806A</td>
<td>2 - 3, 4 - 5</td>
<td></td>
</tr>
<tr>
<td>CDP1804A, no internal memory</td>
<td>2 - 3, 4 - 5</td>
<td></td>
</tr>
<tr>
<td>CDP1804A, with internal RAM/ROM</td>
<td>1 - 2, 5 - 6</td>
<td></td>
</tr>
</tbody>
</table>

Note that the RCA CDP1804A with internal memory enabled uses on-chip memory address decoders. The user must make sure that none of the CDP18S600 memory is linked to the same addresses.

Run Utility

The RNU (backplane pin 3) signal is “OR’ed” with address bit 15 for the on-board memory address decoding. RCA utility programs, such as CDP18SUN70, are located at address hex 8000, and can thus be entered from reset if RNU is held high.

RNU is pulled low through a resistor for systems not requiring this function. Noise immunity can be increased by tying RNU low with LK15, pins 3 - 4. Make sure LK15, pins 3 - 4, is open if an active RNU source such as the MS1M40 or CDP18S640A is present in the system.

Power-On Clear

An R - C integrator and a Schmitt trigger provide approximately a 180 MSec long CLEAR-N signal when the +5 volt supply is turned on. This open collector, active low signal appears on the backplane and the parallel interface connector, and is used to initialize the CPU, UART, and PIO. It also disables all memory chip selects, and the CPU, backplane and UART clocks. It does not reset the group select latch, nor stop the oscillator.

The CLEAR-N signal resets the UART interrupt flip-flop, receiver holding register, control and status registers, and sets SDO high (low at the RS232 interface). It also sets both PIO ports to input mode, resets the status register, drops both RDY lines, disables interrupts, and sets the interrupt mask register to all O’s (all bits enabled). It does not reset data already loaded in the PIO.

The CPU clear function has been discussed under “Microboard Bus Interface Signals”.

If an external power-up reset or reset/RUN U source is available, such as on the MSIM40 supply and control module, the on-board power-up clear should be disabled. Link LK17 pins 1 - 2.

Using On-Chip RAM

The 64 byte RAM contained in the CDP1805A CPU (or the CDP1804A when internal decoding is disabled) may be accessed through an external decoder. LK15 pin 2 is the low-active memory enable input. LK 11, pins 6, 1, 3, and 4 are 4 decoded active low chip selects. An unused pin could be jumpered to the CPU memory enable input. See Tables IV, V, or VI for the 1 socket memory bank decoding. The 64 byte RAM will “wrap around” to fill the entire 2, 4, or 8K decoded space.

Installation in Microboard Systems

The CDP18S600 may be installed in the CDP18S008, MS2000, or CDP18S693, 694, or 695 development system, or in the CDP18S670 or MS1 series of industrial chassis. It is intended for use only in systems with a Microboard Universal Backplane. See each system manual for appropriate memory address requirements. The CDP18S600 may be run at its higher clock speed in the RCA MS2000 Micro Disk Development System with the standard board complement, thus increasing throughput. Use in other systems or with non-designated boards requires use of the lower clock speed.
## Linking Summary

### Table XXIV: Summary of System Link Connections

<table>
<thead>
<tr>
<th>Link</th>
<th>Use</th>
<th>Referenced From</th>
</tr>
</thead>
<tbody>
<tr>
<td>LK1</td>
<td>PIO and UART: flags and interrupts</td>
<td>Table XII</td>
</tr>
<tr>
<td>LK2, 3</td>
<td>CTS, SDO: select RS232, RS422</td>
<td>Table XIII</td>
</tr>
<tr>
<td>LK4</td>
<td>Set UART group number</td>
<td>Table X</td>
</tr>
<tr>
<td>LK5</td>
<td>Set CPU clock speed</td>
<td>Setting Clock Speeds</td>
</tr>
<tr>
<td>LK 6 - 10</td>
<td>Set U17 — 21 memory types</td>
<td>Tables II, IX</td>
</tr>
<tr>
<td>LK11, 14</td>
<td>Set U21 memory address</td>
<td>Tables III, IV, V, IX</td>
</tr>
<tr>
<td>LK12, 13</td>
<td>Set U17 — 20 memory addresses</td>
<td>Tables VI, VII, VIII, IX</td>
</tr>
<tr>
<td>LK15</td>
<td>Set CPU type, disable RUN Utility</td>
<td>Table XXIII, Run Utility</td>
</tr>
<tr>
<td>LK16</td>
<td>Set CPU type, use</td>
<td>Table XXIII</td>
</tr>
<tr>
<td>LK17</td>
<td>Disable power-on clear</td>
<td>Power-On Clear</td>
</tr>
</tbody>
</table>

### Parts List

C1, C2, C6, C9 - C15 = 0.1uf, ± 20%, 50V  
C3, C4 = 2.2 uf ± 20%, 20V  
C5 = 47 pf, ± 10%, 200V  
C7 = 10 pF, ± 10%, 200V  
C8 = 39 pF, ± 10%, 200V  
C16 = 4.7 uF, ± 10%, 10V  
CR1 = 1N914B Diode  
R1 = 10 Meg, 1/4W, 5%  
R2 = 3K, 1/4W, 5%  
R3, R5 = 10K, 1/4W, 5%  
R4, R6 = 200 Ohm, 1/4W, 5%  
R7 = 2.2K, 1/4W, 5%  
R8 = 1.8 Meg, 1/4W, 5%  
N1 = 10K, 8-pin resis. network  
N2, N4, N6 = 10K, 10-pin resis. network  
N3 = 10K, 6-pin resis. network  
N5 = 22K, 10-pin resis. network  
Y1 = 9.8304 MHz crystal  
S1 = pos. DIP switch  
J1, J2 = 10-pin rt. angle connector  
Mates with:  
  Header: AMP No. 1-86148-2  
  Contacts: AMP No. 1-87309-4  
  Keying Plug: AMP No. 87077-1  
  (supplied)  
U1 = CDP1851CE  
U2 = 9637ARM EIA Receiver  
U3 = 9638RM EIA Receiver  
U4 = CA3240F  
U5, U6, U9 = CD40107BE  
U7, U10 = CD74HC14E  
U8, U25, U31 = CD74HC75E  
U11 = CDP1854ACE  
U12 = CD74HC164E  
U13 = CD74HC74E  
U14, U26 = CD74HC02E  
U15 = 4702BPC Baud Rate Generator  
U16 = CD74HC245E  
U21 = HM6116P-4 2Kx8 RAM  
U22 = CD74HC27E  
U23 = CD74HC11E  
U24, U27 = CD81866CE  
U28 = CDP1805ACE  
U29 = CD74HC4075E  
U30 = CD74HC373E  
U32 = CD74HC367E  
Card Extractor - MSIA 11  
XU1, XU11, XU28 = Socket, 40-pin  
XU2, XU3, XU4 = Socket, 8-pin  
XU17 - XU21 = Socket, 28-pin  
P2 mates with a variety of 34-pin flat cable connectors such as T & B Ansley 609-3415M, Berg 65764-005, 3M 3463-0001, or equivalent (not supplied)  
Push-on links:  
  AMP No. 531220-3  
  Berg 76264-101  
or equivalent
RCA CMOS Microboard Computer
CDP18S600

Fig. 6 - Microboard Computer CDP18S600 Layout Diagram.
Fig. 7 - Microboard Computer CDP18S600 Logic and Circuit Diagram - Central Processor Unit.
RCA CMOS Microboard Computer
CDP18S600

Fig. 8 - Microboard Computer CDP18S600 Logic and Circuit Diagram - Memory Portion.
Fig. 9 - Microboard Computer CDP18S600 Logic and Circuit Diagram - I/O Portion.
S-5579
Multiply/Divide/Clock Board
Microboard* Compatible

Trademark of RCA
SYSASSIST

S-5579 MDU-Clock

Features
- Microsecond math processing
- 32 x 32 bit multiply operation
- 64/32 bit divide operation
- Time and date clock
- "Watchdog" timer reset
- Low power CMOS circuitry
- Alarm interrupt
- Timebase interrupt or flag
- Powerdown mode with automatic powerup
- External timer outputs
- External power connections
- 74HCxx devices permit highspeed bus operation

The Sysassist S-5579 Math Clock Board is a CMOS Microboard* compatible function board. The board is designed to be used with any of the extensive assortment of CMOS Microboards available from RCA. The S-5579 consists of both math and clock chips, providing a variety of features useful in a wide range of systems.

The S-5579 can be configured with 1 to 4 CDP1855 multiply/divide chips for math functions from 8x8 to 32x32 bits. Most configurations complete an operation in less than one microprocessor bus cycle. The math operations are fast enough for most real-time control applications, including proportional control and velocity control loops in industrial machinery and robots.

The CDP1879 clock chip provides complete crystal-controlled clock functions suitable for time and date functions on larger systems, as well as providing real-time interrupts for smaller dedicated control systems. A special power-down feature is provided with complete power switching for up to one amp per supply (5,15, -15) provided on the S-5579. An external power connector maintains clock power, permitting automatic power-up at a preset time. In remote data logging and telemetry applications, the math capability provides extremely rapid processing of data, which in conjunction with the power-down feature can provide low system duty cycles and low power consumptions. A “Wired-Or” input is provided which can override the power-down state if there are external conditions which require immediate attention. An automatic reset function is provided to periodically reset the processor in systems where program failure is unacceptable; the period is under software control. In systems where volatile memory must be maintained, a wait generator is provided which reduces power without turning off the system bus; a battery-backed RAM board is available from RCA if desired.

**S-5579 BLOCK DIAGRAM**

*Fig. 1 — Math-Clock Block Diagram.*
## S-5579 Link Tables

### NUMBER OF MUDs

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1-4</td>
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<td>OPEN</td>
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</tr>
<tr>
<td></td>
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<td>OPEN</td>
<td>2-3</td>
<td>OPEN</td>
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</table>

### GROUP SELECTS LINK 8

<table>
<thead>
<tr>
<th></th>
<th>00-70H</th>
<th>6-10</th>
<th>SHORTED</th>
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<tbody>
<tr>
<td></td>
<td>4-12</td>
<td>OPEN</td>
<td></td>
</tr>
<tr>
<td>80-FFH</td>
<td>4-12</td>
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<td></td>
</tr>
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<td>6-10</td>
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<table>
<thead>
<tr>
<th>1 of 8</th>
<th>PIN</th>
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<tr>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>POWERDOWN</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>MATH SELECT</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>CLOCK SELECT</td>
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<td>4</td>
<td>5</td>
<td>WAIT GENERATE</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
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</tr>
<tr>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>6</td>
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### MATH CLOCK PRESCALER LINK 5

<table>
<thead>
<tr>
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<th>SHORTED</th>
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<tbody>
<tr>
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</tr>
<tr>
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<td>3-4</td>
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### DEVICE SELECTS AT LINK 8

<table>
<thead>
<tr>
<th>PIN</th>
<th>DEVICE</th>
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<tbody>
<tr>
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<td>18</td>
<td>MATH</td>
</tr>
<tr>
<td>17</td>
<td>CLOCK</td>
</tr>
<tr>
<td>16</td>
<td>WAIT GENERATOR</td>
</tr>
</tbody>
</table>

### OVERFLOW FLAG LINK 9

| O.F. to INT | 1-10 | SHORTED |
| O.F. to EF1 | 2-9  | SHORTED |
| O.F. to EF2 | 3-8  | SHORTED |
| O.F. to EF3 | 4-7  | SHORTED |
| O.F. to EF4 | 5-6  | SHORTED |

### WAIT RELEASE SOURCE LINK 7

<table>
<thead>
<tr>
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<td>INT</td>
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### 1879 CLOCK PULSE DESTINATION LINK 10

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<tbody>
<tr>
<td>EF1</td>
<td>4-7</td>
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<td></td>
</tr>
<tr>
<td>EF2</td>
<td>3-8</td>
<td>SHORTED</td>
<td></td>
</tr>
<tr>
<td>EF3</td>
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<td>SHORTED</td>
<td></td>
</tr>
<tr>
<td>EF4</td>
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</table>

### WAIT FUNCTION LINK 12

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<td>CLEAR</td>
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<tr>
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### 1879 INTERRUPT DESTINATION LINK 11

<table>
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<th>SHORTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>EF1</td>
<td>2-11</td>
<td>SHORTED</td>
<td></td>
</tr>
<tr>
<td>EF2</td>
<td>3-10</td>
<td>SHORTED</td>
<td></td>
</tr>
<tr>
<td>EF3</td>
<td>4-9</td>
<td>SHORTED</td>
<td></td>
</tr>
<tr>
<td>EF4</td>
<td>5-8</td>
<td>SHORTED</td>
<td></td>
</tr>
<tr>
<td>CLR</td>
<td>6-7</td>
<td>SHORTED</td>
<td></td>
</tr>
</tbody>
</table>
Parts List

U1, 14, 16 = 74HC04
U2, 3, 12 = 40107
U4 = 74HC74
U5 = 1879
U67, 8, 9 = CDP1855
U10 = 74HC32
U11 = 74HC164
U13 = 74HC175
U15 = 74HC00
U17 = 74HC08
U18, 19 = CDP1857
U20 = 74HC138
U21 = 4050
CR1, 2, 3, 4 = 1N4001
Q1, 2, 4 = 2N6732
Q3, 5 = 2N6731
RN1 = 20K
RN2, 3 = 100K
R1 = 1M, 1/4W
R2 = 479 ohms, 1/4W
R3 = 4.7K, 1/4W
R4, 6, 13 = 1K, 1/4W
R5, 9, 10, 11, 14, 15 = 20K, 1/4W
R7, 8, 12 = 10K, 1/4W
R16 = 100K, 1/4W
C1 = 22µF @16v
C2-8, C10-12 = 0.1 @50v
C9 = .001µF
C13 = 22µF @ 16v
Y1 = 32.768 KHz
P2 = RIGHT ANGLE HEADER

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SYSASSIST INC.

610 W. SIERRA AVE.
COTATI, CA 94928
RCA COSMAC Microboard Combination Memory and I/O Module

CDP18S660
RCA COSMAC Microboard
Combination Memory and I/O Module
CDP18S660

The RCA COSMAC Microboard Memory and I/O Module CDP18S660 is a versatile expansion module combining RAM, ROM, and I/O lines. It contains two kilobytes of static CMOS RAM (4 MWS5114's), four on-board sockets for read-only memory (up to 8 kilobytes of EPROM or mask-programmable ROM), two CMOS programmable interfaces (CDP1851's), plus address latches and decoders and I/O latches and decoders. Address and data lines are buffered to minimize loading of the Microboard bus interface.

Specifications

Memory Capacity
On-board RAM: 2 kilobytes (4 CMOS static RAM's, 1024 x 4, MWS5114)
On-board ROM/EPROM: 4 sockets for up to 8 kilobytes (CDP1834, 2708, 2758, 2716)

Memory Address Map
On-board RAM: Any two 1-kilobyte blocks within any even 4-kilobyte block
On-board ROM/EPROM: Depending on type and quantity of ROM's, any 1-, 2-, 4-, or 8-kilobyte block

I/O Capacity
40 parallel lines programmable as input, output, or bidirectional

Operating Temperature Range
0°C to 70°C

Dimensions
4.5 inches x 7.5 inches (114.3 x 190.5 mm)
Board pitch 0.5 inch (12.7 mm) minimum

Power Requirements
With CMOS ROM's: +5 V at 8 mA, typical operating

Features

- Low-power static CMOS
- Operable from single 5-volt supply
- High noise immunity
- Compatible with COSMAC Development Systems
- 2 kilobytes of read-write memory
- Sockets for 4/8 kilobytes of ROM/PROM
- 40 programmable I/O lines
- 44-pin system interface
- Expandable by use of COSMAC Microboard Universal Backplane
- Small board size: 4.5 x 7.5 inches
- RAM and ROM independently assignable within memory space
- Assignable I/O addresses
- Member of extensive Microboard family
- Simple system interface
- Temperature range: 0°C to 70°C

Connectors
System Interface: Edge fingers, 44 pins on 0.156-inch centers
I/O: Edge fingers, 50 pins on 0.100-inch centers

Microboard Bus Interface Signals
(Connector P1)

The following signals are generated or received by the RCA COSMAC Microboard Combination Memory and I/O Module CDP18S660. For further information on
these signals, refer to the data sheet for the CDP1802 (File No. 1023) and to the User Manual for the CDP1802 COSMAC Microprocessor, MPM-201.

DB7 through DB0
Eight bidirectional data bus lines. Taken directly from the Microboard Universal Backplane to the CDP1851 I/O devices, but buffered from the ROM and RAM memories by CDP1856's; these lines are used to transfer data between memory, CPU, and I/O devices.

A7 through A0
Eight memory address lines on which the high and low address bytes are multiplexed. The high-address byte is latched at the TPA trailing edge and used by the on-board decoders to select the appropriate block of memory.

TPA, TPB
Timing pulses generated by the CPU which occur once in each machine cycle. TPA trailing edge is used to latch the high-order memory address. TPB trailing edge is used to latch output data from the data bus.

MWR
A WRITE command from the CPU to the memories. Address lines are stable at this time. Actual writing or latching occurs at the trailing edge.

MRD
A READ command from the CPU to the memories and a direction indicator for I/O data transfers. In the I/O instructions it corresponds to N3 (N register, internal to the CPU) which distinguishes I/O inputs from outputs. MRD must be used to condition output drivers in all memory components, or their output buffers, to avoid contention on the data bus. The absence of MWR must not be interpreted as a READ. Early in a write cycle, data are being driven onto the data bus by the CPU or an input device. If a memory allows its outputs to be enabled while MRD is false before MWR appears, bus contention will occur resulting in unnecessary power dissipation and perhaps circuit failures. Operation using the Micronmonitor CDP185030 is impossible unless MRD is properly used to condition data output.

EF1, EF2, EF3, EF4
Four external flags taken to the CPU by way of the Microboard Universal Backplane. These flags can be tested in software by conditional branch instructions.

N0, N1, N2
Taken directly from the Microboard Universal Backplane, these lines indicate an I/O instruction is being executed. They are derived from the low-order three bits of the N register during an I/O instruction execution only. They are low (false) at all other times. These bits form the primary address identifying the I/O device. Direction of transfer, derived from N3 internal to the CPU, is presented on the MRD line. When high, MRD indicates data transfer from the I/O to memory; when low, from memory to I/O.

INT
Connected to the Microboard Universal Backplane via optional links and driven by transmission gates, INT originates in the CDP1851 I/O devices. Interrupt causes a transfer of control from the current program counter to register 1. Interrupts may be inhibited by software. If Interrupt Enable (IE) is set, recognition of INT results in a completion of execution of the current instruction followed by an S3 machine state during which designators X and P are stored in CPU register T. Then, X is set to 2, P is set to 1, and IE is reset to 0. The S3 state lasts one machine cycle (eight clocks), after which processing resumes with R1 as the program counter.

RNU
Run Utility Software. This signal is supplied to force the most significant address bit true. As a result, the program start is at memory location 8000 instead of 0000.

CLEAR
This input signal is used on the RCA COSMAC Microboard Module CDP185660 to reset the ports on both CDP1851's to the input mode and to reset the status register, A RDY, B RDY, and interrupt enable (disabling interrupts).

On-Board Memory Addressing
The high-order eight memory address bits are latched, decoded, and used for generating chip selects for on-board memories. A system of links is provided for placing RAM or ROM in the desired area of the 64-kilobyte address space. As an alternative, DIP switches can be readily installed in place of links that may require frequent changing.

RAM Address
The RAM on the CDP185660 is two kilobytes of static CMOS RAM. The four high-order address bits (A15, A14, A13, A12) are latched and decoded, and a set of eight links is provided so that RAM can be positioned in any even 4-kilobyte block. The next two address bits (A11, A10) are further decoded, and a set of four links is provided to allow RAM to occupy any two
RCA COSMAC Microboard Combination Memory and I/O Module CDP18S660

1-kilobyte blocks within the selected 4-kilobyte block. The board is shipped prelinked with RAM occupying 2 kilobytes of contiguous memory from 9000 to 97FF. To alter this configuration, the user should cut connections 6:11 and 3:14 in link LK33 and connections 4:5 and 3:6 in link LK16 and then install jumpers in accordance with Tables I and II.

ROM Address

Four 24-pin sockets are provided for user-programmed ROM's. Four ROM types are suitable: CDP1834 (1 kilobyte), 2708 (1 kilobyte), 2758 (1 kilobyte), and 2716 (2 kilobytes, Intel pin-out). The CDP1834 mask-programmable ROM can be used in combination with any of the other three types. No other combination may be used. One to four ROM devices may be used.

Two types of links are provided to select the desired ROM configuration. The first link type is for accommodating the type of ROM selected. The second link type is for selecting the memory address space to be occupied by ROM.

Links LK24 and LK39 are 10-pin and 8-pin dual-in-line arrangements, respectively, with preprinted links to accommodate the CDP1834 or 2708 ROM's. Table III gives the connections required for each ROM type.

Links LK34 and LK35 are 16-pin dual-in-line arrangements. Link LK34 provides the high-order four address bits decoded so that two links or jumpers place sockets XU22 and XU23 in any 4-kilobyte block within the 64-kilobyte memory address space. Link LK35 does the same for sockets XU20 and XU21. Links LK34 and LK35 are prelinked so that ROM occupies 4 kilobytes of contiguous memory from 1000 to 1FFF. To alter the ROM address configuration, the user should cut pin connections 1:16 and 6:11 in links LK34 and LK35 and install jumpers in accordance with Table I.

To avoid having floating inputs to the gates, both links LK34 and LK35 should always have two jumpers. For example, if sockets XU20 and XU21 are unused, LK35 may be jumpered the same as LK34. Otherwise, spurious chip selects may be generated, turning on the three-state data buffers and causing interference with normal processing.

For 1-kilobyte ROM's such as the CDP1834, 2708, or 2758, links LK34 and LK35 should be jumpered identically in accordance with Table I. Then, ROM's should be installed in sockets XU23, XU21, XU22, and XU20, in that order, starting with the lowest-address ROM.

For 2-kilobyte ROM's (2716), links LK34 and LK35 should be jumpered independently in accordance with Table I for the required two 4-kilobyte blocks. Then, socket XU23 is the low 2 kilobytes and socket XU22 is the high 2 kilobytes of the 4-kilobyte block as set in LK34. Similarly, socket XU21 is the low 2 kilobytes and socket XU20 is the high 2 kilobytes of the 4-kilobyte block set in LK35.

Table I — 4-Kilobyte Link Connections

<table>
<thead>
<tr>
<th>4-Kilobyte Address Space</th>
<th>Link LK33, LK34 or LK35 Pin Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000-0FFF</td>
<td>1:16, 5:12</td>
</tr>
<tr>
<td>11000-1FFF</td>
<td>1:16, 6:11</td>
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<tr>
<td>2000-2FFF</td>
<td>1:16, 7:10</td>
</tr>
<tr>
<td>3000-3FFF</td>
<td>1:16, 8:9</td>
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<td>4000-4FFF</td>
<td>2:15, 5:12</td>
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<tr>
<td>5000-5FFF</td>
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<tr>
<td>6000-6FFF</td>
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<tr>
<td>7000-7FFF</td>
<td>2:15, 8:9</td>
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<tr>
<td>8000-8FFF</td>
<td>3:14, 5:12</td>
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<tr>
<td>9000-9FFF</td>
<td>3:14, 6:11</td>
</tr>
<tr>
<td>A000-AFFF</td>
<td>3:14, 7:10</td>
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<tr>
<td>B000-BFFF</td>
<td>3:14, 8:9</td>
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<tr>
<td>C000-CFFF</td>
<td>4:13, 5:12</td>
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<td>4:13, 6:11</td>
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<tr>
<td>E000-EFFF</td>
<td>4:13, 7:10</td>
</tr>
<tr>
<td>F000-FFFF</td>
<td>4:13, 8:9</td>
</tr>
</tbody>
</table>

LK33 is associated with the 2-kilobyte RAM
LK34 is associated with ROM sockets XU23 and XU22
LK35 is associated with ROM sockets XU21 and XU20
†Prewired ROM location on LK34 and LK35
†Prewired RAM location on LK33

Table II — RAM 1-Kilobyte Link Connections

(2 required)

<table>
<thead>
<tr>
<th>1-Kilobyte Address Space</th>
<th>Link LK16 Pin Connections</th>
<th>RAM Locations</th>
</tr>
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<tbody>
<tr>
<td>X000-X3FF</td>
<td>*4:5</td>
<td>U12, U14</td>
</tr>
<tr>
<td>X400-X7FF</td>
<td>*3:6</td>
<td>U13, U15</td>
</tr>
<tr>
<td>X800-XBFF</td>
<td>2:7</td>
<td>U12, U14</td>
</tr>
<tr>
<td>XC00-XFFF</td>
<td>1:8</td>
<td>U13, U15</td>
</tr>
</tbody>
</table>

X denotes any one 4-kilobyte block (X = 0 to F), as fixed by link LK33
*Prewired links
### Table III — ROM Type Selection Links

<table>
<thead>
<tr>
<th>Link</th>
<th>LK24 Pins</th>
<th>CDP1834*</th>
<th>2708*</th>
<th>2758</th>
<th>2716</th>
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<tbody>
<tr>
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<td></td>
<td>OPEN</td>
<td>SHORTED</td>
<td>OPEN</td>
<td>SHORTED</td>
</tr>
<tr>
<td>2:9</td>
<td></td>
<td>X</td>
<td>SHORTED</td>
<td>OPEN</td>
<td>OPEN</td>
</tr>
<tr>
<td>3:8</td>
<td></td>
<td>X</td>
<td>OPEN</td>
<td>SHORTED</td>
<td>OPEN</td>
</tr>
<tr>
<td>4:7</td>
<td></td>
<td>X</td>
<td>OPEN</td>
<td>OPEN</td>
<td>OPEN</td>
</tr>
<tr>
<td>5:6</td>
<td></td>
<td>X</td>
<td>SHORTED</td>
<td>OPEN</td>
<td>OPEN</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Link</th>
<th>LK39 Pins</th>
<th>1:8</th>
<th>2:7</th>
<th>3:6</th>
<th>4:5</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>OPEN</td>
<td>SHORTED</td>
<td>OPEN</td>
<td>SHORTED</td>
</tr>
<tr>
<td></td>
<td></td>
<td>OPEN</td>
<td>OPEN</td>
<td>OPEN</td>
<td>OPEN</td>
</tr>
</tbody>
</table>

*X = don't care; Links LK24 and LK39 are prewired to accept CDP1834 or 2708.

2716. If all links are set up for the 2-kilobyte ROM's as shown in Table III for LK24 and LK39, and if LK34 and LK35 are set up for different 4-kilobyte blocks, then a 1-kilobyte ROM in socket XU23 will occupy the two lower 1-kilobyte segments of the 4-kilobyte block. In other words, its 1 kilobyte will "wrap" through the lower 2 kilobytes of the 4-kilobyte block. If it is in socket XU22, it will wrap through the upper 2 kilobytes of the 4-kilobyte block. A 2-kilobyte ROM may be placed in either socket XU23 or socket XU22 while the other is occupied by a 1-kilobyte ROM. Socket XU21 (low 2 kilobytes) and socket XU20 (high 2 kilobytes) may be used in the same manner.

Note: When 2708 ROM's are used, the Microboard Universal Backplane must supply +12 volts on pin P1-20 and -5 volts on pin P1-11.

### I/O Operation

#### Two-Level I/O Addressing Conventions

During the I/O instruction, the CPU presents the low-order three bits of its N register on the N2, N1, and N0 lines.  N3 generates the MRD signal to indicate the direction of data flow.  Thus, the instructions 61 through 67 and 69 through 6F provide seven output and seven input commands.  These instructions may be interpreted by the system as either different commands to the same I/O device or as I/O commands to different devices as addressed by the N lines.

In a larger system more addresses are needed.  In the Microboard system the following conventions are established:

1. The 61 output instruction is used to transmit a group number.  The output data byte is latched and decoded by any Microboard module in the system having an I/O function.

2. The group number is divided into two parts, the lower four bits being a one-of-four encoding and the higher four bits being binary encoded.  Thus, the number of addresses provided is 15 binary-encoded plus 4 individual lines, times the six commands left after reserving the 61 and 69.  The total of useful I/O addresses is 114.

3. The 69 instruction is reserved for reading the latched output of the 61 instruction.  The CDP18S660, however, does not provide this feature.

The use of the two halves of the group number must be independent and exclusive.  That is, the high-order bits must be zero when any of the low-order bits is used, and the low-order bits must be zero when the high-order bits are used. Once a group is set up, subsequent 62-through-67 and 6A-through-6F instructions are recognized only by the devices assigned to that group number.

The CDP18S660 encodes the high four bits of the transmitted group number to select both CDP1851 programmable I/O interfaces. Each CDP1851 is assigned its own unique group number by jumpering the pin connections in link LK25 as shown in Table IV. The board is shipped prelinked with group number 10 assigned to U1 and group number 20 assigned to U2.
RCA COSMAC Microboard
Combination Memory and I/O Module
CDP18S660

Table IV — I/O Group Selects

<table>
<thead>
<tr>
<th>Group Number</th>
<th>LK25 Pin Connections</th>
<th>U1</th>
<th>U2</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>*1:16</td>
<td>1:15</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>2:16</td>
<td>*2:15</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>3:16</td>
<td>3:15</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>4:16</td>
<td>4:15</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>5:16</td>
<td>5:15</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>6:16</td>
<td>6:15</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>7:16</td>
<td>7:15</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>8:16</td>
<td>8:15</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>9:16</td>
<td>9:15</td>
<td></td>
</tr>
<tr>
<td>A0</td>
<td>10:16</td>
<td>10:15</td>
<td></td>
</tr>
<tr>
<td>B0</td>
<td>11:16</td>
<td>11:15</td>
<td></td>
</tr>
<tr>
<td>C0</td>
<td>12:16</td>
<td>12:15</td>
<td></td>
</tr>
<tr>
<td>D0</td>
<td>13:16</td>
<td>13:15</td>
<td></td>
</tr>
<tr>
<td>E0</td>
<td>14:16</td>
<td>14:15</td>
<td></td>
</tr>
</tbody>
</table>

*Prewired links

I/O Interface

The I/O interface consists of 40 lines provided on connector P2. Each CDP18S51 programmable I/O interface generates 20 lines: 8 lines for port A, 8 lines for port B, and 4 handshaking lines. These lines may be programmed as input, output, or bidirectional individually or as a block. The P2 connector also provides a logic ground and +5 volts to be used as a reference.

For more detailed information on the Programmable I/O Interface CDP18S51, refer to the data sheet for that device (File No. 1056).

As previously described, each CDP18S51 is assigned to a unique group number by jumpering the proper pin connections in link LK25 (see Table IV). The CDP18S51 designated U1 is prelinked for I/O group 10. The CDP18S51 designated U2 is prelinked for I/O group 20. Therefore, in order to enable access, a 61 output instruction with data = 1016 or 2016 is required before read, write, or control I/O may be performed.

Signals 1A RDY, 1B RDY, 2A RDY, and 2B RDY conditioned by the group select can generate flags EF1 through EF4 by jumpering the appropriate pin connections in link LK11 (see Table V). The board is shipped prelinked so that the selection of U1 conditions 1A RDY and 1B RDY, causing the generation of EF1 and EF2, respectively. Similarly, the selection of U2 conditions 2A RDY and 2B RDY, also causing the generation of EF1 and EF2 respectively.

Interrupts can be generated by signals 1 INTA and 1 INTB by jumpering link LK8. Signals 2 INTA and 2 INTB can also be used to generate interrupts by jumpering link LK7. If both links are jumpered, any of the signals 1 INTA, 1 INTB, 2 INTA, or 2 INTB will generate an interrupt.

Once the group select is accomplished, N1 and N2 are used to address the selected CDP18S51. The following read and write instructions are used to access data, status, and command registers.

62 - Write to control register
64 - Write to Port A data register (if A is an output)
66 - Write to Port B data register (if B is an output)
6A - Read status register
6C - Read Port A data register (if A is an input)
6E - Read Port B data register (if B is an input)

Using the Ready Lines for Data Synchronization

When the group select for U1 is set, Port 1A and Port 1B RDY lines are presented to the CPU EF1 and EF2 lines as prelinked. When the group select for U2 is set, Port 2A and Port 2B RDY lines are presented to the CPU EF1 and EF2 lines as prelinked. For altering the CPU flag selection, see Table V. Note that there is a logic reversal: when RDY is true, the EF is false. A test for RDY true might use the BI instruction (34) which would take the branch if RDY were false. Even though these RDY lines are primarily intended for "handshaking" with the device on the other end of the cable, they are useful for synchronizing data transfer between the CDP18S51 and the CPU.

When a port designated as an output port is loaded, RDY goes true. When the receiving device takes the data, it transmits STB which removes RDY. The software can then test RDY until it is false (EF1 or EF2 true) and load the next output byte. When a port is designated as an input port, reading the data sets RDY, and the transmitting device resets RDY when it transmits data and STB. Again, the software tests to see if RDY is false and reads the input byte. In this case, a dummy read after reset is necessary to raise the first RDY.

Table V — CPU Flag Generation (Link LK11)

<table>
<thead>
<tr>
<th>CDP18S51 Signal Causing Flag Generation</th>
<th>Link LK11 Pin Connection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EF1</td>
</tr>
<tr>
<td>1A RDY</td>
<td>*8:9</td>
</tr>
<tr>
<td>1B RDY</td>
<td></td>
</tr>
<tr>
<td>2A RDY</td>
<td>*4:13</td>
</tr>
<tr>
<td>2B RDY</td>
<td></td>
</tr>
</tbody>
</table>

*Prewired links
Note that if the remote device is passive, such as a display or a set of points, handshaking is not necessary. The output port may be loaded at any time to change data without acknowledgment from the remote device. Similarly, the input port may be read at any time to store the current state of the input lines.

Using the Interrupt Line for Data Synchronization

If links LK7 and LK8 are jumpered, 1 INTA, 1 INTB, 2 INTA, or 2 INTB generates INT to the CPU. INT is not conditioned by the group select. INT is set by the remote sending device STB to acknowledge an output port and is reset by loading an output port. Similarly, INT is set by the remote device sending STB to load an input port and is reset by reading the input port. Table VI summarizes the actions of READY and INT for input and output modes.

The software can find the source of the interrupt by setting the appropriate group select and then either testing the RDY lines or reading the status byte. Depending on the group select, the low-order two bits of the status byte are:

\[
b_{0}=1 \text{ INTA or 2 INTA}; \quad b_{1}=1 \text{ INTB or 2 INTB.}
\]

Bidirectional Mode

In each CDP1851, Port A may be programmed to be bidirectional. In this case, Port B must be programmed to be in the bit-programmable mode, to be described later. In the bidirectional mode, A RDY and A STB become A INPUT RDY and A INPUT STB; BRDY becomes A OUTPUT RDY, and B STB becomes A OUTPUT STB. Each of the eight lines AD0-AD7 may transmit data in both directions, using the input handshaking lines to synchronize inputs and the output handshaking lines for the output data. Operation is much the same as for independent input and output ports except that data is gated into AD0-AD7 only when the OUTPUT STB line is raised. In summary, Port A in the bidirectional mode is an output port and an input port sharing the same eight data lines, each having a set of handshaking lines.

Bit-Programmable Mode

In each CDP1851, both Port A and Port B are capable of being programmed to be in the bit-programmable mode. Port B must be in this mode if Port A is in the bidirectional mode. In the bit-programmable mode, each line in AD0-AD7 and B0-B7 is programmed to be either input or output. In addition, the handshaking lines are programmed to be input or output lines unless Port A is bidirectional, in which case it uses all four handshaking lines. The handshaking lines, when used as data lines, are accessed by a write control for output lines and read status for input lines. The other eight lines in each port are accessed by the usual read and write data instructions.

Interrupts are generated when an input line goes true except that the former handshaking lines cannot generate interrupts. The bits may be individually masked as not to generate interrupts. The interrupt control word selects one of the two interrupt rules, AND or OR. The AND rule results in an interrupt only when all unmasked lines are true. The OR rule results in an interrupt when any unmasked line is true. The interrupt control word also defines the input lines as logically true when high or logically true when low.

<table>
<thead>
<tr>
<th>Table VI — READY and INTERRUPT Actions for Input and Output Modes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>READY</strong></td>
</tr>
<tr>
<td>Set by</td>
</tr>
<tr>
<td>Reset by</td>
</tr>
<tr>
<td><strong>INTERRUPT</strong></td>
</tr>
<tr>
<td>Set by</td>
</tr>
<tr>
<td>Reset by</td>
</tr>
</tbody>
</table>
RCA COSMAC Microboard
Combination Memory and I/O Module
CDP18S660

Pin Terminals and Signals
for the RCA COSMAC Universal Backplane
Connector (P1)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>TPA-P</td>
</tr>
<tr>
<td>B</td>
<td>TPB-P</td>
</tr>
<tr>
<td>C</td>
<td>DB0-P</td>
</tr>
<tr>
<td>D</td>
<td>DB1-P</td>
</tr>
<tr>
<td>E</td>
<td>DB2-P</td>
</tr>
<tr>
<td>F</td>
<td>DB3-P</td>
</tr>
<tr>
<td>H</td>
<td>DB4-P</td>
</tr>
<tr>
<td>J</td>
<td>DB5-P</td>
</tr>
<tr>
<td>K</td>
<td>DB6-P</td>
</tr>
<tr>
<td>L</td>
<td>DB7-P</td>
</tr>
<tr>
<td>M</td>
<td>A0-P</td>
</tr>
<tr>
<td>N</td>
<td>A1-P</td>
</tr>
<tr>
<td>P</td>
<td>A2-P</td>
</tr>
<tr>
<td>R</td>
<td>A3-P</td>
</tr>
<tr>
<td>S</td>
<td>A4-P</td>
</tr>
<tr>
<td>T</td>
<td>A5-P</td>
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<tr>
<td>U</td>
<td>A6-P</td>
</tr>
<tr>
<td>V</td>
<td>A7-P</td>
</tr>
<tr>
<td>W</td>
<td>MWR-N</td>
</tr>
<tr>
<td>X</td>
<td>EF4-N</td>
</tr>
<tr>
<td>Y</td>
<td>+5V</td>
</tr>
<tr>
<td>Z</td>
<td>GND</td>
</tr>
</tbody>
</table>

*Signals used on RCA COSMAC Microboard
Combination Memory and I/O
Module CDP18S660

Pin Terminals and Signals for the
Microboard I/O Connector (P2)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2A STB-P</td>
</tr>
<tr>
<td>2</td>
<td>2A RDY-P</td>
</tr>
<tr>
<td>3</td>
<td>2AD1-P</td>
</tr>
<tr>
<td>4</td>
<td>2AD0-P</td>
</tr>
<tr>
<td>5</td>
<td>2AD2-P</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
</tr>
<tr>
<td>7</td>
<td>2AD3-P</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
</tr>
<tr>
<td>9</td>
<td>2AD4-P</td>
</tr>
<tr>
<td>10</td>
<td>2AD5-P</td>
</tr>
<tr>
<td>11</td>
<td>2AD7-P</td>
</tr>
<tr>
<td>12</td>
<td>2AD6-P</td>
</tr>
<tr>
<td>13</td>
<td>2B7-P</td>
</tr>
<tr>
<td>14</td>
<td>2B6-P</td>
</tr>
<tr>
<td>15</td>
<td>2B5-P</td>
</tr>
<tr>
<td>16</td>
<td>2B RDY-P</td>
</tr>
<tr>
<td>17</td>
<td>2B4-P</td>
</tr>
<tr>
<td>18</td>
<td>2B STB-P</td>
</tr>
<tr>
<td>19</td>
<td>2B3-P</td>
</tr>
<tr>
<td>20</td>
<td>2B0-P</td>
</tr>
<tr>
<td>21</td>
<td>2B2-P</td>
</tr>
<tr>
<td>22</td>
<td>2B1-P</td>
</tr>
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<td>23</td>
<td>GND</td>
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<tr>
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<td>27</td>
<td>GND</td>
</tr>
<tr>
<td>28</td>
<td>GND</td>
</tr>
<tr>
<td>29</td>
<td>1B1-P</td>
</tr>
<tr>
<td>30</td>
<td>1B2-P</td>
</tr>
<tr>
<td>31</td>
<td>1B0-P</td>
</tr>
<tr>
<td>32</td>
<td>1B3-P</td>
</tr>
<tr>
<td>33</td>
<td>1B STB-P</td>
</tr>
<tr>
<td>34</td>
<td>1B4-P</td>
</tr>
<tr>
<td>35</td>
<td>1B RDY-P</td>
</tr>
<tr>
<td>36</td>
<td>1B5-P</td>
</tr>
<tr>
<td>37</td>
<td>1B6-P</td>
</tr>
<tr>
<td>38</td>
<td>GND</td>
</tr>
<tr>
<td>39</td>
<td>+5V</td>
</tr>
<tr>
<td>40</td>
<td>1B7-P</td>
</tr>
<tr>
<td>41</td>
<td>1AD6-P</td>
</tr>
<tr>
<td>42</td>
<td>1AD7-P</td>
</tr>
<tr>
<td>43</td>
<td>1AD5-P</td>
</tr>
<tr>
<td>44</td>
<td>1AD4-P</td>
</tr>
<tr>
<td>45</td>
<td>1AD0-P</td>
</tr>
<tr>
<td>46</td>
<td>1AD3-P</td>
</tr>
<tr>
<td>47</td>
<td>1A STB-P</td>
</tr>
<tr>
<td>48</td>
<td>1AD2-P</td>
</tr>
<tr>
<td>49</td>
<td>1A RYD-P</td>
</tr>
<tr>
<td>50</td>
<td>1AD1-P</td>
</tr>
</tbody>
</table>

NOTE: The signals on connector P2 come from the two CDP1851 Programmable I/O Interfaces. For electrical characteristics refer to the data sheet for the CDP1851 (File No. 1056).
Parts List

C1, C2, C3 = 15 μF, 20 V
C4, C5 = 0.1 μF, 50 V
R1 = 22 kΩ, ¼ W
U1, U2 = CDP1851CE
U3 = CD4071BE
U4, U10 = CD4016BE
U5 = CD4011BE
U6, U30 = resistor module 22 kΩ
U9, U19 = CD4001BE
U12-U15 = MWS5114E
U17 = CDP1866CE
U18, U40 = CD4050BE
U26 = CD4514BE
U27, U31 = CDP1855CE
U28, U29 = CD4012BE
U32 = CDP1859CE
U36 = CD4067CE
U37, U41 = CD4069BE
U42 = CD4673BE
XU1, XU2 = 40-pin socket
XU20-XU23 = 24-pin socket

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Logic diagram of Microboard Combination Memory and I/O Module CDP18S660 — memory portions.
Logic diagram of Microboard Combination Memory and I/O Module CDP18S660 — I/O portions.
RCA Microboard UART Interface

CDP18S641B

The RCA Microboard UART (Universal Asynchronous Receiver Transmitter) Interface Module CDP18S641B is a parallel-to-serial I/O data controller utilizing the RCA CDP1854A UART. The CDP18S641B is designed for use in a Microboard computer system. The CDP18S641B provides an efficient byte interface to the system while serial data are transmitted and received at the remote interface. Baud rates from 110 to 19,200 are switch-selectable. It provides for full-duplex operation.

The CDP18S641B also provides two-level I/O address latching and decoding on board, with selectable addresses for flexible system configurations.

The CDP18S641B is plug-in compatible with the RCA MSJ Series of Industrial Chassis and with RCA Microboard Computer Development Systems (MCDS) CDP18S693 and CDP18S694 and Color CMCDS CDP18S695 to facilitate hardware and software development. It can also be used with RCA Prototyping Systems CDP18S691 and CDP18S692, and RCA Development Systems CDP18S005 (CDSII) and CDP18S007 (CDSIII).

Specifications

**UART**
CDP1854A, programmed mode.

**Parity**
Even or odd, or inhibited.

**Stop Bits**
One or two.

**Word Length**
5, 6, 7, or 8 bits.

**Baud Rate**
Crystal-controlled, switch-selectable for 55, 110, 150, 300, 600, 1200, 2400, 4800, 9600, or 19,200 baud.

**Addressing**
I/O space, link-selectable for both N codes and I/O group number.

**Serial Interface**
20-ma loop or RS232C.

**Operating-Temperature Range**
-40°C to +85°C

**Power Requirements**

<table>
<thead>
<tr>
<th>Voltage (V)</th>
<th>With EIA RS232C Terminal</th>
<th>With 20-ma Loop Terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>+5</td>
<td>2 mA</td>
<td>2 mA</td>
</tr>
<tr>
<td>-5 to -15</td>
<td>7.5 mA</td>
<td>38 mA</td>
</tr>
<tr>
<td>+12 to +15</td>
<td>8.5 mA</td>
<td>40 mA</td>
</tr>
</tbody>
</table>

Features

- Low-power static CMOS
- High noise immunity
- Small board size (4.5 x 7.5 inches)
- Member of extensive Microboard family
- Compatible with RCA MSI Series of Industrial Chassis and RCA 1800-Series Development Systems

**Flexible address assignment**

**Selectable baud rate**

**Selectable serial interface: RS232C or 20-ma loop**

**Paper-tape-reader run control**

**Temperature range: -40°C to +85°C**

Connectors

System interface: Edge fingers, 44 pins on 0.156-inch centers.
Serial interface: Two right-angle 10-pin headers
housing — AMP 1-86148-2
contact — AMP 86016-1
keying plug — AMP 87077-1

Dimensions

4.5 inches x 7.5 inches (114.3 x 190.5 mm);
Board pitch - 0.5 inch (12.7 mm) minimum.

Block diagram of RCA Microboard UART Interface CDP18S641B.
Microboard Bus Interface Signals (Connector P1)

The following signals are generated or received by the RCA Microboard UART Interface Module CDP18S641B and provide the interface to other Microboard System components. For further information on these signals, refer to the data sheet for the CDP1802 (File No. 1305) and to the User Manual for the CDP1802 COSMAC Microprocessor, MPM-201.

Table I provides a list of the pins and the signals for the RCA Universal Backplane Connector signals marked with an asterisk (*) are those used on the RCA Microboard UART CDP18S641B.

DB7 through DB0 — These eight bidirectional data bus lines communicate directly with the CDP1854A UART, which has internal controls to establish direction and timing. In addition, DB7 to set the paper-tape-reader control, and DB7 through DB0 are used, through a system of optional links, to define the I/O group chosen for this board.

N0, N1, N2 — The N lines, which define the primary I/O address, are wired to a CDP1853 decoder. The CDP-1853 outputs 7 through 1 are connected through optional links to the CDP1854A UART.

MRD — The Memory Read line is used by the CDP1854A UART to identify proper direction of data flow on the bidirectional data bus. When true, this line indicates that data are being read from memory and, therefore, written to the bidirectional data bus. When this line is true, the direction is reversed when MRD is false.

TPA — This timing pulse is used only by the N decoder to set its output enable at the trailing edge of TPA.

TPB — This timing pulse is used by the CDP1854A UART to latch data written to it. It is also used by the N decoder to terminate its output enable at the trailing edge of TPB.

INT — This signal may be connected by optional link LK24 pins 1 and 14 to the INT output from the CDP1854A UART. This signal is buffered by a transmission gate so that wired-“OR” connection may be made with other devices driving the backplane INT line.

EF1, EF2, EF3, EF4 — Links are provided (link LK24) so that these flag lines may be wired to outputs from the CDP1854A UART. The outputs are Data Available (DA), Transmitter Holding Register Empty (THRE),

### Table I — Pin Terminals and Signals for the RCA Universal Backplane Connector (P1)

<table>
<thead>
<tr>
<th>Pin</th>
<th>Mnemonic</th>
<th>Wire Side</th>
<th>Component Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>TPA-P</td>
<td>Out</td>
<td>1 DMAi-N</td>
</tr>
<tr>
<td>B</td>
<td>TPB-P</td>
<td>Out</td>
<td>2 DMAO-N</td>
</tr>
<tr>
<td>C</td>
<td>DB0-P</td>
<td>In/Out</td>
<td>3 RNU-P</td>
</tr>
<tr>
<td>D</td>
<td>DB1-P</td>
<td>In/Out</td>
<td>4 INT-N</td>
</tr>
<tr>
<td>E</td>
<td>DB2-P</td>
<td>In/Out</td>
<td>5 MRD-N</td>
</tr>
<tr>
<td>F</td>
<td>DB3-P</td>
<td>In/Out</td>
<td>6 Q-P</td>
</tr>
<tr>
<td>G</td>
<td>DB4-P</td>
<td>In/Out</td>
<td>7 SCO-P</td>
</tr>
<tr>
<td>H</td>
<td>DB5-P</td>
<td>In/Out</td>
<td>8 SCI-P</td>
</tr>
<tr>
<td>I</td>
<td>DB6-P</td>
<td>In/Out</td>
<td>9 CLEAR-N</td>
</tr>
<tr>
<td>J</td>
<td>DB7-P</td>
<td>In/Out</td>
<td>10 WAIT-N</td>
</tr>
<tr>
<td>K</td>
<td>A0-P</td>
<td>Out</td>
<td>11 -5V/-15V</td>
</tr>
<tr>
<td>L</td>
<td>A1-P</td>
<td>Out</td>
<td>12 SPARE</td>
</tr>
<tr>
<td>M</td>
<td>A2-P</td>
<td>Out</td>
<td>13 CLOCK OUT</td>
</tr>
<tr>
<td>N</td>
<td>A3-P</td>
<td>Out</td>
<td>14 N0-P</td>
</tr>
<tr>
<td>P</td>
<td>A4-P</td>
<td>Out</td>
<td>15 N1-P</td>
</tr>
<tr>
<td>R</td>
<td>A5-P</td>
<td>Out</td>
<td>16 N2-P</td>
</tr>
<tr>
<td>S</td>
<td>A6-P</td>
<td>Out</td>
<td>17 EF1-N</td>
</tr>
<tr>
<td>T</td>
<td>A7-P</td>
<td>Out</td>
<td>18 EF2-N</td>
</tr>
<tr>
<td>U</td>
<td>MWR-N</td>
<td>Out</td>
<td>19 EF3-N</td>
</tr>
<tr>
<td>V</td>
<td>EF4-N</td>
<td>In</td>
<td>20 +12V/+15V</td>
</tr>
<tr>
<td>X</td>
<td>V+5V</td>
<td>—</td>
<td>21 +5 V</td>
</tr>
<tr>
<td>Y</td>
<td>GND</td>
<td>—</td>
<td>22 GND</td>
</tr>
</tbody>
</table>

*Signals used on RCA Microboard UART Interface CDP18S641B.

†Signal flow is with respect to the CPU board.
reading status from the UART, if the user does not wish to connect the links for status or interrupt. Connections for selecting interrupt or any of the status bits may be identified on the logic diagram.

**Installation in the RCA Development Systems CDP18S005 (CDS II) and CDP18S007 (CDS III)**

Installation in the CDS II (CDP18S005) or the CDS III (CDP18S007) is the same as for installation in a Microboard computer system except that the Development System backplane must have certain signals wired to the UART location. The user should select an empty slot in the I/O section (slots 19 and 20 should be avoided), and then install the following wires in that slot.

- Pin 9 to pin 13: RESET-OP
- Pin 14 to Slot 13 pin 14: N0-P
- Pin 15 to Slot 13 pin 15: N1-P
- Pin 16 to Slot 13 pin 16: N2-P

---

**Table II — I/O Group Select Link Connections**

<table>
<thead>
<tr>
<th>I/O Group</th>
<th>LK5</th>
<th>LK14</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-16</td>
<td>3-14</td>
</tr>
<tr>
<td>01</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>02*</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>04</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>08</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>10</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>20</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>30</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>40</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>50</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>60</td>
<td>O</td>
<td>O</td>
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<tr>
<td>70</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>80</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>90</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>A0</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>B0</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>C0</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>D0</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>E0</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>F0</td>
<td>O</td>
<td>O</td>
</tr>
</tbody>
</table>

*Group 02 is preprinted. O = Open S = Shorted
RCA Microboard UART Interface

CDP18S641B

Layout diagram of RCA Microboard UART Interface Module CDP18S641B.
Logic diagram of RCA Microboard UART Interface Module CDP18S641B.

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RCA Microboard UART Interface
CDP18S641B

Parts List
C1, C2, C3 = 15 µF, 50 V
C4 = 0.33 µF, 50 V
C5 = 39 pF,
C6 = 10 pF,
CR1 — CR8 = 1N914
J1, J2 = connector, right angle (mates with connector comprised of housing — AMP 1-86148-2, contact —AMP 86016-1, keying plug — AMP 87077-1, or equivalent)
R2 = 10 MΩ, ¼ W
R3-R8, R19 = 22 kΩ, ¼ W
R9, R14 = 910 Ω, ¼ W
R10, R15 = 10 kΩ, ¼ W
R11, R16 = 47 kΩ, ¼ W
R12 = 4.7 kΩ, ¼ W
R13 = 470 Ω, ¼ W
R17 = 4.3 kΩ, ¼ W
R18 = 560 Ω, ¼ W
S1 = 7-position DIP
U1 = CD4072BE
U2 = CD4071BE
U3, U8 = CA3140E
U4 = CD4059AE
U6 = 74HC20
U7, U13 = CA324E
U9 = 74HC04
U15, U19 = CD4069BE
U10 = CDP1854ACE
U11 = CD4013BE
U12 = CD4049BE
U16 = CD4098BE
U17 = 74HC00
U21 = 74HC138
U22 = CD4017AE
U23, U24, U25 = CD40107
Y1 = 1.8432-MHz crystal
RCA Microboard UART Interface
CDP18S641B

Overrun Error or Parity Error (OE/PE), Framing Error (FE), and Serial Data In (SDI).

CLEAR — This signal provides an initialization signal for the CDP1854A UART and resets the paper-tape-motor control.

Operation

The operation of the RCA Microboard UART Interface CDP18S641B can be understood by reference to the logic diagrams. Reference should also be made to the technical data sheet (File No. 1193) for the CDP1854A UART (U10 on the logic diagram) for Mode 1 operation details.

The crystal-controlled oscillator circuit and the divide-by-N counter CD4059AE (U4) provide a clock for the UART at a frequency 16 times the rate selected by the user via the baud rate switch (S1), as required by the UART.

Switch position 1 and one of the switch positions 2 through 7 must be closed (down) to select the baud rate as marked. Switch position 1 may be opened (up) to divide the indicated baud rate by 2.

The clear-to-send-in signal CTS-IN from the connector J2 to the UART may be left floating, if desired, and it will assume the true state at the UART. The clear-to-send-out signal CTS-OUT is driven by the data available signal DA from the UART with a trailing edge delay. This signal may be used for handshaking, for example, between two UART modules. This output may be made true all the time by changing link LK18 to the A position.

Any communication with the UART Interface CDP18S641B or with any Microboard I/O Controller, must be started by the transmittal of the I/O group select number assigned to the controller. The system software transmits the group number by issuing an OUT1 (61h) command whose data is the group number desired. This group number then stays selected until another OUT1 command supersedes it. Group number assignment details are given in the next section on Installation.

To operate the paper-tape reader, the system software should issue an output instruction 67 with the data byte containing a 1 in bit seven (most significant bit). The CD4096BEJ-K flip-flop (U16) is triggered to the set state by this command, making the signal PT RDR low, thus enabling the tape reader. As soon as the reader starts to transmit data, the signal Serial Data In (SDI) causes the J-K flip-flop (U16) to be triggered to the reset state. As a result, one byte is transmitted to the UART and the tape is stopped before the next byte. Another 67 instruction, therefore, must be issued for each successive byte.

Installation in a Microboard Computer System

Installation of the Microboard UART Interface CDP18S641B in a Microboard Computer System requires only the setting of the proper baud rate switch (S1), as marked, unless the preselected addresses are not appropriate. The preselected addresses are as follows:

<table>
<thead>
<tr>
<th>I/O GROUP</th>
<th>DATA INPUT</th>
<th>DATA OUTPUT</th>
<th>STATUS INPUT</th>
<th>CONTROL OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 02h</td>
<td>+ INP2 (6a, e)</td>
<td>+ OUT2 (62, e)</td>
<td>+ INP3 (6b, a)</td>
<td>+ OUT3 (63, e)</td>
</tr>
</tbody>
</table>

FLAG AND INTERRUPT LINES ARE OPEN

A system of link positions is provided so that the user can select variations of the above functions. The links are arranged and numbered in a DIP configuration for ease of identification and to allow installation of DIP switches, headers, or other aids in the event frequent changes are anticipated.

For changes in the I/O group assignment, refer to Table II for links LK5 and LK14.

The primary addresses for data transfer and status/control transfer are prewired for Input/Output 2 and Input/Output 3, respectively. Should different I/O instructions be required, Link LK20 should be wired as follows.

For data transfer, wire link LK20 pin 4 to:

- Pin 11 + INP 2, OUT 2
- Pin 9 + INP 3, OUT 3
- Pin 14 + INP 4, OUT 4
- Pin 12 + INP 5, OUT 5
- Pin 10 + INP 6, OUT 6
- Pin 8 + INP 7, OUT 7

For status in or control out, wire link LK20 pin 6 to:

- Pin 11 = INP 2, OUT 2
- Pin 9 = INP 3, OUT 3
- Pin 14 = INP 4, OUT 4
- Pin 12 = INP 5, OUT 5
- Pin 10 = INP 6, OUT 6
- Pin 8 = INP 7, OUT 7

Link LK24 provides a means of connecting the UART interrupt to the system interrupt, as well as the UART status bits to the external flags EF1 through EF4 of the system. The interrupt is then unconditioned, but the flags are enabled by the group select. Thus, an interrupt-identification polling scheme may be implemented by system software. Polling may also be accomplished by
RCA Microboard
Industrial Chassis Series

End bezel allows side panel removal for access.

Deluxe chassis in 7 sizes from 4 to 25 slots.

Plug-in-front-access power-supply modules.

Protective covers for front wiring.

Rugged steel and aluminum construction.

Accepts any number of Microboards.

How to Solve Your Packaging Problem

MB-8
RCA Microboard
Industrial Chassis Series

RCA’s Microboard Industrial chassis series includes 21 chassis easily convertible, through a broad line of versatile accessories, to hundreds of different customer-selectable configurations for mounting on a rack, backwall, or desk, or in custom equipment. They range from a simple backplane with connectors for four boards to a fully enclosed chassis with room for a plug-in power supply and 24 boards. Other sizes hold 8, 12, 16, 20, or 24 boards. Each unit can be customized with accessories to give you exactly what you want in a chassis.

**Rugged** — designed to stand up to tough industrial environments
**Flexible** — for system prototyping design and redesign
**Attractive** — desk-top configuration enhances any office
**Versatile** — mountable on 19” EIA rack, on backwall, or on surface
**Accessible** — provides front or side access to controls
**Efficient** — sizes available to accommodate up to 24 cards
**Easy to Use** — Microboard Universal Backplane
**Compact** — small CMOS Microboards, no bulky fans

**Table 1** —
Product Designations of RCA COSMAC Microboard Industrial Chassis Series and Associated Accessories.

<table>
<thead>
<tr>
<th>Chassis</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSI 800</td>
<td>Standard chassis</td>
</tr>
<tr>
<td>MSI 8800</td>
<td>Deluxe chassis</td>
</tr>
<tr>
<td>MSI 8000</td>
<td>Backplanes with connectors</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accessories</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSIA 0100</td>
<td>Solid top and bottom covers</td>
</tr>
<tr>
<td>MSIA 0200</td>
<td>Perforated top and bottom covers</td>
</tr>
<tr>
<td>MSIA 0300</td>
<td>Solid rear panels</td>
</tr>
<tr>
<td>MSIA 0400</td>
<td>Front panel guards</td>
</tr>
<tr>
<td>MSIA 06</td>
<td>Mounting angle brackets</td>
</tr>
<tr>
<td>MSIA 07</td>
<td>End bezels (handles)</td>
</tr>
<tr>
<td>MSIA 08</td>
<td>Four-card front panel</td>
</tr>
<tr>
<td>MSIA 10</td>
<td>Cable conduit</td>
</tr>
<tr>
<td>MSIA 11</td>
<td>Card extractor</td>
</tr>
</tbody>
</table>

Flexibility with Style —
Deluxe Chassis MSI 8825
Includes all accessories shown

Photo A — Deluxe chassis MSI 8825 with angle brackets positioned for flush mounting in a 19-inch rack.

Photo B — Deluxe chassis MSI 8825 with front panel guard and angle brackets positioned for recessed mounting in 19-inch rack.

Photo C — Deluxe chassis MSI 8825 with front panel guard and angle brackets positioned for backwall mounting.

Photo D — Deluxe chassis MSI 8825 with end bezels (handles) and front panel guard for desk top use.

Photo E — Deluxe chassis MSI 8825 with end bezels (handles) and front panel guard. End panel removed to show CDP185640 display and control Microboard module (available separately) in end position for access to controls.
The RCA COSMAC Microboard Industrial Chassis Series provides the designer with extremely flexible means of mounting, connecting, and enclosing the broad line of standard RCA Microboards as well as the newly developed RCA MSI-series Industrial Microboard products. The three series of industrial chassis available provide the user with both a wide range of option levels and a wide choice in the number of Microboard slots. One chassis series comprises a bare 44-pin Microboard backplane (MSI 8000); the second comprises a functional but unadorned chassis (MSI 800); the third comprises a complete chassis system that is fully enclosed, looks at home on a desk top, but is also rack or backwall mountable (MSI 8800). The Deluxe MSI 8800 series is the optimum starting point for packaging design.

Accessories are available to build the MSI 800 series at any option level up to that of the MSI 8800 series. See Tables I and II for model designations of the various chassis and accessories.

The basic unit of all series is 2.4 inches wide and accepts four Microboards (4.5 x 7.5 inches) on 0.6 inch pitch. Each series is available in 1 to 7 unit widths, with space for up to 24 Microboards. The 7-unit-wide model has a 25th connector dedicated to a plug-in power supply. The supply can mount in any other chassis, but occupies four slots.

The Standard MSI 825 (with optional MSIA 06 angle brackets) or the Deluxe MSI 8825 (angle brackets included) can be mounted in a 19-inch EIA rack, taking only 5-1/4-inch panel height. Flush or recessed mounting is possible. The brackets may also be used for backwall mounting of any of the MSI 800 or 8800 series chassis. See photos A, B, C, and K.*

The Deluxe MSI 8800 series is supplied with end bezels/carrying handles for portable or desk top use. The cover plate(s) under the end bezels may be omitted for access to the end card. This access allows the use of boards such as the CDP18S640 Control and Display Module or CDP18S480 PROM Programmer Module while the rest of the system is kept enclosed. See photos E and N. The end bezels are available as accessories for the Standard MSI 800 series.

*Photos G through P are on the back cover.

---

### Features

- Rugged steel/aluminum frame — protective coating
- Microboard Universal Backplane
- Gold plated card edge connectors
- 0.062 inch FR4 epoxy backplane
- 4, 8, 12, 16, 20, 24, or 25 card slots
- Full-length card guides
- Extractor rails
- Access slots for ribbon cable
- Ample room within chassis for internal cabling
- Fully enclosed (MSI 8800)
- Rack or backwall mounting: only 5-1/4-inches high x 10.08 inches deep
- Flush or recessed rack mounting
- Protective see-through cover for wiring (MSI 8800)
- Desk-top use with carrying handles/end bezels (MSI 8800)
- Optional accessibility of end card (MSI 8800)
- Optional plug-in power supply (MSIM 40 or MSIM 40E)
- Optional power I/O interface module MSIM 20
- Connector for external supply
- Many accessories available: customize the chassis as needed
- Optional rack-mount wire trough front-panel wiring

---

### Table II — Designation Numbers for the Various Chassis

<table>
<thead>
<tr>
<th>No. of Slots:</th>
<th>Standard Chassis</th>
<th>Deluxe Chassis</th>
<th>Backplanes With Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>MSI 804</td>
<td>MSI 8804</td>
<td>MSI 8004</td>
</tr>
<tr>
<td>8</td>
<td>MSI 808</td>
<td>MSI 8808</td>
<td>MSI 8008</td>
</tr>
<tr>
<td>12</td>
<td>MSI 812</td>
<td>MSI 8812</td>
<td>MSI 8012</td>
</tr>
<tr>
<td>16</td>
<td>MSI 816</td>
<td>MSI 8816</td>
<td>MSI 8016</td>
</tr>
<tr>
<td>20</td>
<td>MSI 820</td>
<td>MSI 8820</td>
<td>MSI 8020</td>
</tr>
<tr>
<td>24</td>
<td>MSI 824</td>
<td>MSI 8824</td>
<td>MSI 8024</td>
</tr>
<tr>
<td>25</td>
<td>MSI 825</td>
<td>MSI 8825</td>
<td>MSI 8025</td>
</tr>
</tbody>
</table>
MSI 800 Series:
Standard Chassis

The MSI 800 series standard chassis have card guides and chassis added to the MSI 8000 series backplanes. See photo L and M. Front and rear aluminum extrusions have an anodine finish and are mounted to painted steel side pieces to give considerable structural strength. Spacer strips slide into the extrusions to locate full-length snap-in card guides. The connector tabs of the MSI 8000 backplane series slide into the rear extrusions, and nut plates slide into the front extrusions. Both are held captive by the side pieces. The nut plates provide for the mounting of MSI series industrial Microboards or matching MSIA 08 blank front panels. See Fig. 1 for dimensions.

A power supply connector is supplied loose with each chassis. For information see page 7. The chassis is electrically isolated from the Microboard backplane but may readily be grounded by connecting pin 22 or Z to a convenient chassis screw.

The side pieces have an entry slot for cable access to the front of the Microboards, but are reversible front to rear. If it is desired to mount and access the power-supply connector from the outside of the chassis, the left side piece should be reversed so that the entry slot is towards the rear.

Stick-on rubber feet are provided for desk-top use and are supplied loose.

A number strip along the inside of the bottom front extrusion identifies slot positions.

If the Microboards to be inserted in the chassis contain mounted standoffs, see the discussion under accessories for standoff removal. The standoffs will not clear the full-length card guides.

The MSI 800 series chassis will take any of the options listed in Table IV to bring it up partially or fully to the MSI 8800 deluxe chassis. Figs. 2 and 3 show mounting of optional accessories. Photo F shows a MSI 812 with available accessories. Refer to Fig. 4 for dimensions with optional end bezels or angle brackets. The MSI 825, which has slots for 24 Microboards, dedicates four additional right-most slots to power supply use.

Fig. 1 — Standard chassis MSI 800 series dimensions.
With Flexibility

Industrial Chassis Series

Fig. 2 — Standard chassis MSI 800 series assembly cutaway.

Fig. 3 — Standard chassis MSI 800 series optional end assembly.
MSI 8800 Series Deluxe Chassis

The MSI 8800 series deluxe chassis have full covers and a variety of mounting options added to the standard MSI 800 series. The MSI 8800 series comes assembled with slide-in solid top and bottom covers, screw-fastened front and rear panels, a standoff mounted see-through front panel guard, and two carrying handle/end bezels. Photo D shows an MSI 8825 setup for desk-top use. See Fig. 4 for dimensions, and Table IV for a listing of accessories supplied with the MSI 8800 series.

Two mounting angle brackets are included (loose) to allow flush or recessed mounting from the front or the rear of the chassis. The MSI 8825 may be mounted in a 5-1/4-inch opening of a 19-inch rack and may have either the chassis front or the protective wiring cover flush with the rack front. As in the MSI 800 series, rubber feet and a power-supply connector are supplied loose. See the discussion under accessories for removal of standoffs from Microboard modules.

Both the end bezels and steel side plates may be left in place, or one or the other may be omitted. With only the end bezels in place, the chassis becomes a good basis for a desk-top development system. The left-most position might mount a CDP18S480 PROM Programmer or CDP18S640 Control and Display Module. See photos E and N. Access to the right-most socket solder side would be useful for board development. Note that for the MSI 8825, the right-most socket is only for power supply use and will not operate Microboards.

The front panel guard supplied is one unit width (2.4-inch) smaller than the chassis width. This space is to provide access to the supply power switch (if used). The MSI-8804 is not supplied with a front panel guard. Guards of any unit width may be bought as options.

---

![Diagram of MSI 8800 Series Deluxe Chassis](image)

**Table IV**

<table>
<thead>
<tr>
<th>PART NO.</th>
<th>DIM A</th>
<th>DIM B</th>
<th>DIM C</th>
</tr>
</thead>
<tbody>
<tr>
<td>INCHES</td>
<td>mm</td>
<td>INCHES</td>
<td>mm</td>
</tr>
<tr>
<td>MSI 8804</td>
<td>11.1</td>
<td>3.5</td>
<td>4.1</td>
</tr>
<tr>
<td>MSI 8809</td>
<td>9.3</td>
<td>1.2</td>
<td>4.3</td>
</tr>
<tr>
<td>MSI 8812</td>
<td>6.2</td>
<td>1.6</td>
<td>3.6</td>
</tr>
<tr>
<td>MSI 8816</td>
<td>12.3</td>
<td>3.1</td>
<td>4.2</td>
</tr>
<tr>
<td>MSI 8820</td>
<td>14.7</td>
<td>3.7</td>
<td>4.7</td>
</tr>
<tr>
<td>MSI 8824</td>
<td>17.1</td>
<td>4.3</td>
<td>5.3</td>
</tr>
<tr>
<td>MSI 8825</td>
<td>19.5</td>
<td>4.95</td>
<td>6.75</td>
</tr>
</tbody>
</table>

*NOTE: IF SIDE PLATE IS REMOVED, DECREASE DIM A BY 0.5 INCHES (2.5 mm).*

---

**Fig. 4 — Deluxe chassis MSI 8800 series dimensions.**
MSI 8000 Series: Backplane With Connectors

Each of the MSI 8000 series chassis consists of a backplane (See photo G) with 44-pin, 0.156-inch pitch card edge connectors on 0.6-inch centers. For dimensions, all pins having the same designations are bussed together. Pins 22 and Z (Microboard ground) and 21 and Y (+5 volt) are heavily bussed. See Table III for Microboard backplane pin assignments.

A five-hole pattern on 0.156-inch centers is provided at the extreme left side of the backplane for mounting a power-supply connector. Backplane pins 11 (-15 volts), 12 (spare), and 20 (+15 volts), as well as +5 volts and ground, are wired to this location. See Fig. 6 for connector details. The power supply connector is supplied loose.

The MSI 8025, 25-card backplane, occupies the same space as a 28-card version would. Connectors 25, 26, and 27 are omitted, however, and the 28th connector is wired only for plug-in power supply connections.

Connector positions are numbered left to right as seen from the connector side, and connector pins are numbered top to bottom: 1-22 on the left, A-Z on the right. Microboards are to be mounted with components facing left.

### Table III: Microboard Backplane Pin Assignments

<table>
<thead>
<tr>
<th>Pin</th>
<th>Signal</th>
<th>Pin</th>
<th>Signal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DMA1-N</td>
<td>A</td>
<td>TPA-P</td>
</tr>
<tr>
<td>2</td>
<td>DMA2-N</td>
<td>B</td>
<td>TPB-P</td>
</tr>
<tr>
<td>3</td>
<td>RNU-P</td>
<td>C</td>
<td>DB0-P</td>
</tr>
<tr>
<td>4</td>
<td>INT-N</td>
<td>D</td>
<td>DB1-P</td>
</tr>
<tr>
<td>5</td>
<td>MRD-N</td>
<td>E</td>
<td>DB2-P</td>
</tr>
<tr>
<td>6</td>
<td>Q-P</td>
<td>F</td>
<td>DB3-P</td>
</tr>
<tr>
<td>7</td>
<td>SC0-P</td>
<td>H</td>
<td>DB4-P</td>
</tr>
<tr>
<td>8</td>
<td>SC1-P</td>
<td>J</td>
<td>DB5-P</td>
</tr>
<tr>
<td>9</td>
<td>CLEAR-N</td>
<td>K</td>
<td>DB6-P</td>
</tr>
<tr>
<td>10</td>
<td>WAIT-N</td>
<td>L</td>
<td>DB7-P</td>
</tr>
<tr>
<td>11</td>
<td>-15 V</td>
<td>M</td>
<td>A0-P</td>
</tr>
<tr>
<td>12</td>
<td>SPARE</td>
<td>N</td>
<td>A1-P</td>
</tr>
<tr>
<td>13</td>
<td>CLOCK OUT</td>
<td>P</td>
<td>A2-P</td>
</tr>
<tr>
<td>14</td>
<td>N0-P</td>
<td>R</td>
<td>A3-P</td>
</tr>
<tr>
<td>15</td>
<td>N1-P</td>
<td>S</td>
<td>A4-P</td>
</tr>
<tr>
<td>16</td>
<td>N2-P</td>
<td>T</td>
<td>A5-P</td>
</tr>
<tr>
<td>17</td>
<td>EF1-N</td>
<td>U</td>
<td>A6-P</td>
</tr>
<tr>
<td>18</td>
<td>EF2-N</td>
<td>V</td>
<td>A7-P</td>
</tr>
<tr>
<td>19</td>
<td>EF3-N</td>
<td>W</td>
<td>MWR-N</td>
</tr>
<tr>
<td>20</td>
<td>+15 V</td>
<td>X</td>
<td>EF4-N</td>
</tr>
<tr>
<td>21</td>
<td>+5 V</td>
<td>Y</td>
<td>+5 V</td>
</tr>
<tr>
<td>22</td>
<td>GND</td>
<td>Z</td>
<td>GND</td>
</tr>
</tbody>
</table>

**Fig. 5 — Backplane MSI 8000 series dimensions.**

**Fig. 6 — Power supply connector.**
**MSIA Accessory Series**

Table IV lists the accessory part numbers versus the chassis that they fit. Parts that are standard on the Deluxe MSI 8800 series are marked "S"; those that are available optionally to fit are marked "O". Any part marked "S" or "O" will also fit the corresponding Standard MSI 800 series chassis. Table V gives condensed description of each accessory. Accessories are normally supplied in quantities of 10.

MSIA 0100 series solid top or bottom covers or MSI 0200 series perforated top or bottom covers slide into slots in the front and rear extrusion (See Fig. 2). To mount the cover, one end bezel and/or slide plate must be removed. Only one end plate should be removed at one time and the chassis should not be stressed when the end plate is off.

Note that MSI 0400 series front panel guards are normally supplied one size smaller than the corresponding chassis (except MSI 8804), but may be used at any size up to the width of the chassis.

The MSIA 0300 series of rear panels can be mounted on the front to replace one or more MSIA 08 front panels. An access slot for front entry of cables is thus provided. When a MSIA 0300 series panel is mounted in the rear of a MSI 800 series chassis, a side panel must be removed to insert top and bottom slide-in nut plates with the panel.

The MSIA 10 cable conduit is a 19-inch rack mount wiring guide that occupies 1-3/4 inches of rack space. It has a snap-off aluminum cover and is recessed so that the cover is flush with the rack front. See photo K. It may be used with a MSI 8825 or MSI 825 chassis with angle brackets to guide wiring to the front surface of the chassis. The chassis should be mounted in the recessed position.

Depending on the date of manufacture, Microboards may be equipped with standoffs. These standoffs are unnecessary for Microboards installed in the Industrial Chassis Series and should be removed because they may not clear the full-length card guides. If the spacer is a drive pin inside a nylon sleeve, heat the head of the pin for several seconds with a hot soldering iron, and remove the sleeve with pliers. The pin is then free to drop out. Do not use cutters on the pins; they are hardened and will damage cutters or fly apart suddenly.

The MSIA 11 card extractor consists of an ejector cam and a snap-on retaining ring. This card extractor is to be inserted through the hole at the top corner of a Microboard and the retaining ring snapped over its pin. The ring is marked "up" for the side away from the board. The ejector cam can be mounted on the bottom corner of the Microboard if the top is not clear, but extra care may be needed to remove and insert the Microboard. The card extractor mounts in a 0.1-inch hole that is 0.15 inch from both the end and the side of the Microboard.

Figs. 7 through 14 give the dimensions for the optional accessories.

---

### Table IV — Accessory Table — MSI 8800 Series.

<table>
<thead>
<tr>
<th>Chassis</th>
<th>Front Panel Guard</th>
<th>Angle Brackets</th>
<th>End Bezel</th>
<th>Rear Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MSI 04*</td>
<td>MSIA 06, N=2</td>
<td>MSIA 07, N=2</td>
<td>MSIA 03*</td>
</tr>
<tr>
<td>MSI 8804</td>
<td>08</td>
<td>04 08 12 16 20 24 25</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>MSI 8808</td>
<td>S, N = 1</td>
<td>O</td>
<td>S S</td>
<td>S</td>
</tr>
<tr>
<td>MSI 8812</td>
<td>S, N = 2</td>
<td>S</td>
<td>S</td>
<td>S O S</td>
</tr>
<tr>
<td>MSI 8816</td>
<td>S, N = 3</td>
<td>O S O</td>
<td>S</td>
<td>S O S</td>
</tr>
<tr>
<td>MSI 8820</td>
<td>S, N = 4</td>
<td>O O S O</td>
<td>S</td>
<td>S O O S</td>
</tr>
<tr>
<td>MSI 8824</td>
<td>S, N = 5</td>
<td>O O O S O</td>
<td>S</td>
<td>S O O O S</td>
</tr>
<tr>
<td>MSI 8825</td>
<td>S, N = 6</td>
<td>O O O O O S O</td>
<td>S</td>
<td>S O O O O S</td>
</tr>
<tr>
<td>MSI 8827</td>
<td>S, N = 7</td>
<td>O</td>
<td>S</td>
<td>S</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chassis</th>
<th>Solid Top/Bottom Cover</th>
<th>Perforated Top/Bottom Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MSI 01*</td>
<td>MSI 02*</td>
</tr>
<tr>
<td>MSI 8804</td>
<td>08 04 08 12 16 20 24 25</td>
<td>04 08 12 16 20 24 25</td>
</tr>
<tr>
<td>MSI 8808</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>MSI 8812</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>MSI 8816</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>MSI 8820</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>MSI 8824</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>MSI 8825</td>
<td>S</td>
<td>S</td>
</tr>
</tbody>
</table>

Notes:
- N = Number of these accessories supplied, otherwise N = 1
- S = Standard
- O = Optional — any rear panel
- MSI 0300 series marked S or O will fit on front of chassis

*The last two digits of these designations are one of 04, 08, 12, 16, 20, 24, or 25 depending on size.*
For Versatility

Table V — Condensed Description of Accessories for RCA COSMAC Microboard Industrial Chassis Series. See Photos F and K for accessory photographs.

<table>
<thead>
<tr>
<th>Part Designation</th>
<th>Name</th>
<th>Material</th>
<th>Finish</th>
<th>Fig. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSIA 0100*</td>
<td>Solid Cover (Top or Bottom)</td>
<td>Aluminum</td>
<td>Yellow-Bronze</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alodine (inside)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Black Paint (outside)</td>
<td></td>
</tr>
<tr>
<td>MSIA 0200*</td>
<td>Perforated Cover</td>
<td>Aluminum</td>
<td>Yellow-Bronze</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alodine (inside)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Black Paint (outside)</td>
<td></td>
</tr>
<tr>
<td>MSIA 0300*</td>
<td>Rear Panel</td>
<td>Aluminum</td>
<td>Yellow-Bronze</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alodine</td>
<td></td>
</tr>
<tr>
<td>MSIA 0400*</td>
<td>Front Panel Guard</td>
<td>Plastic</td>
<td>Gray Transparent</td>
<td>9</td>
</tr>
<tr>
<td>MSIA 06</td>
<td>Angle Bracket</td>
<td>Steel</td>
<td>Black Paint</td>
<td>10</td>
</tr>
<tr>
<td>MSIA 07</td>
<td>End/Bezel/Handle</td>
<td>Plastic</td>
<td>Black Paint</td>
<td>11</td>
</tr>
<tr>
<td>(non-conductive)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSIA 08</td>
<td>Front Panel (4 card)</td>
<td>Aluminum</td>
<td>Yellow-Bronze</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Alodine</td>
<td></td>
</tr>
<tr>
<td>MSIA 10</td>
<td>Cable Conduit: Cover</td>
<td>Aluminum</td>
<td>Yellow-Bronze</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Duct</td>
<td>Plastic</td>
<td>Alodine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>End Brackets</td>
<td>Steel</td>
<td>Dark Gray</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Black Paint</td>
<td></td>
</tr>
<tr>
<td>MSIA 11</td>
<td>Card Extractor</td>
<td>Nylon</td>
<td>White</td>
<td>14</td>
</tr>
</tbody>
</table>

*The last two digits of these designations are one of 04, 08, 12, 16, 20, 24, or 25 depending on size.

Fig. 7 — MSIA 0100. MSIA 0200 series solid or perforated top and bottom covers.

Fig. 8 — MSIA 0300 series rear panels.
Fig. 9 — MSIA 0400 series front panel guards.

Fig. 11 — MSIA 07 end bezels.

Fig. 13 — MSIA 10 cable conduit.

Fig. 10 — MSIA 06 mounting angle brackets.

Fig. 12 — MSIA 08 4-card front panel.

Fig. 14 — MSIA 11 card extractor.
Optional Plug-In Modules

The RCA Microboard I/O Module Card MSIM 20 mounts in a 4-slot segment of the Industrial Chassis Series and has a mating 4-slot cover with barrier strips for making power connections. The card mounts up to 8 industry standard optically isolated power modules in any mix of AC or DC, input or output signals. LED's mounted on the front panel provide a visual indication of channel activity.

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The RCA Industrial Microboard Power Supplies MSIM 40 and MSIM 40E are self-contained line-access switching supplies that plug into any RCA Industrial Series Chassis. They occupy 4 card slots and are complete with power cord, circuit breaker, switch, and power-on light. Operate with either 110 or 220 volts AC and provide logic (5 volts) and analog (+/-15 volts) voltages. They feature a power-down circuit for detecting impending power supply loss.

Photo F — Standard 12-card chassis MSI 812 with available accessories identified with call outs.
RCA Microboard
Industrial Chassis Series

Photo G — Three representative standard chassis. Shown are MSI 825, MSI 812, and MSI 804.

Photo L — Interior of standard 4-card chassis MSI 804. Left side panel is removed to display interior card guides and backplane.

Photo H — MSI 8000 series of backplanes and connectors. Shown are MSI 8004, MSI 8008, MSI 8012, MSI 8016, MSI 8020, MSI 8024, and MSI 8025.

Photo I — Standard 12-card chassis MSI 812 with optional mounting angle brackets in place for flush mounting. Other optional accessories shown are the solid and perforated top and bottom covers, a solid rear panel, a front panel guard with 4 standoffs, and two end bezels (handles).

Photo N — Standard 16-card chassis MSI 816 in typical desk-top configuration. Optional end bezels are added and left side panel is removed to provide access to PROM programmer module in end position.

Photo J — Standard 12-card chassis MSI 812 with slotted side panels removed and optional end bezels mounted in place. Optional front panel guard with standoffs, solid and perforated top and bottom covers, and mounting angle brackets are shown unmounted.

Photo O — Deluxe 25-card chassis MSI 8825 showing all supplied components.

Photo K — Deluxe 25-card chassis MSI 8825 and cable conduit MSI 10 with cover removed mounted on simulated 19-inch rack.

Photo P — Deluxe 16-card chassis MSI 8816 showing all supplied components.
FEATURES

- Data retention in the absence of power
- Data security provided by automatic write protection during power failure
- Direct replacement for volatile 2K x 8 Byte Wide Static RAM
- +5 Volt only Read/Write
- Unlimited write cycles
- CMOS - 440 MW active; 5.5 MW standby
- 24-Pin Dual in Line package, JEDEC pinout
- Read cycle time equals write cycle time
- High performance

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Access Time</th>
<th>R/W Cycle Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>MK48202-25</td>
<td>250 nsec</td>
<td>250 nsec</td>
</tr>
<tr>
<td>MK48202-20</td>
<td>200 nsec</td>
<td>200 nsec</td>
</tr>
<tr>
<td>MK48202-15</td>
<td>150 nsec</td>
<td>150 nsec</td>
</tr>
</tbody>
</table>

DESCRIPTION

The MK48202 is a 16,384-bit, Non-Volatile Static RAM, organized 2K x 8 using HCMOS and an integral Lithium energy source. The ZEROPOWER™ RAM has all the sought-after characteristics of a CMOS static RAM, with the important added benefit of data being retained in the absence of power. Data retention current is so small that a miniature Lithium cell contained within the package provides an energy source to preserve data. Extraordinary low current drain has been attained by the use of a full CMOS memory cell, novel analog support circuitry, and carefully controlled junction leakage by an all implanted

PIN NAMES

<table>
<thead>
<tr>
<th>A0 - A10</th>
<th>Address Inputs</th>
<th>VCC</th>
<th>Power (+5 V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ė</td>
<td>Chip Enable</td>
<td>W</td>
<td>Write Enable</td>
</tr>
<tr>
<td>GND</td>
<td>Ground</td>
<td>G</td>
<td>Output Enable</td>
</tr>
<tr>
<td>DQ0 - DQ7</td>
<td>Data In/Data Out</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PIN CONNECTIONS

Figure 1

BLOCK DIAGRAM

Figure 2

TRUTH TABLE

<table>
<thead>
<tr>
<th>VCC</th>
<th>Ė</th>
<th>Ĝ</th>
<th>Ė</th>
<th>MODE</th>
<th>DQ</th>
<th>POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤5.5 volts</td>
<td>VIL</td>
<td>VIL</td>
<td>VIL</td>
<td>Deselect</td>
<td>High Z</td>
<td>Standby</td>
</tr>
<tr>
<td>≥4.75 volts</td>
<td>VIL</td>
<td>VIL</td>
<td>VIL</td>
<td>Write</td>
<td>DIN</td>
<td>Active</td>
</tr>
<tr>
<td>&lt;4.5 volts</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Read</td>
<td>DOUT</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Read</td>
<td>High Z</td>
<td>Active</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>Write Protect</td>
<td>High</td>
<td>Zero</td>
</tr>
</tbody>
</table>
CMOS process. Safeguards against inadvertent data loss have been incorporated to maintain data integrity during the uncertain operating environment associated with power-up and power-down transients. The ZEROPOWER RAM can replace existing 2K x 8 static RAM, directly conforming to the popular Byte Wide 24-pin DIP package (JEDEC). MK48202 also matches the pinning of 2716 EPROM and 2K x 8 EPROM. Like other static RAM, there is no limit on the number of write cycles that can be performed. Since the access time, read cycle, and write cycle are less than 250 ns and require +5 volts only, no additional support circuitry is needed to interface to a microprocessor.

OPERATION

Read Mode

The MK48202 is in the Read Mode whenever W (Write Enable) is high and E (Chip Enable) is low, providing a ripple-through access of data from eight of 16,384 locations in the static storage array. Thus, the unique address specified by the 11 Address Inputs (A11) defines which one of 2048 bytes of data is to be accessed.

Valid data will be available to the eight Data Output Drivers within tAA after the last address input signal is stable, providing that the E and G (Output Enable) access times are satisfied. If E or G access times are not met, data access will be measured from the limiting parameter (tCEA or tCGA) rather than the address. The state of the eight Data I/O signals is controlled by the E and G control signals. The data lines may be in an indeterminate state between tOH and tAA, but the data lines will always have valid data at tAA.

Write Mode

The MK48202 is in the Write Mode whenever the W and E inputs are in the low state. The latter occurring falling edge of either W or E will determine the start of the Write Cycle. Therefore, tAS, tWD, and tCEW are referenced to the latter occurring edge of E or W. The Write Cycle is terminated by the earlier rising edge of E or W. The addresses must be held valid throughout the cycle. W must return to the high state for a minimum of tWR prior to the initiation of another cycle. If the output bus has been enabled (E and G low), then W will disable the outputs in tWEZ from its falling edge; however, care must be taken to avoid a potential bus contention. Data-In must be valid tDS prior to the rising edge of E or W and must remain valid for tOH after the rising edge of E or W.

Data Retention Mode

The ZEROPOWER RAM provides full functional capability for VCC above 4.75 volts, guarantees write protection for VCC less than 4.50 volts, maintains data in the absence of VCC, and needs no additional support circuitry. The block diagram shown in Figure 7 illustrates this self-contained solution.

The MK48202 constantly monitors VCC. Should the supply voltage decay, the RAM will automatically write-protect itself in the VCC range between 4.75 and 4.50 volts (Figure 6). Once VCC falls below 4.50 volts, all inputs to the RAM become "DON'T CARE" (−0.3 ≤ VIL ≤ 5.5 volts), and all outputs are high impedance.

As VCC falls below approximately 3.0 volts, the power switching circuit connects one of two Lithium cells that supply the power necessary to retain data. A decision as to which cell to use is made on the basis of highest voltage. The redundant Lithium cells are independent rather than parallel, to enhance reliability. (Furthermore, each cell comes from a different manufacturing lot.) In the data retention mode, junction leakage (Ij) is the only current requirement: Leakage, typically 300 pA, is supplied from a Lithium cell.

During power-up, when VCC rises above approximately 3.0 volts, the power switching circuit connects external VCC to the RAM and disconnects the Lithium cell. As VCC rises from 4.50 to 4.75 volts, the Lithium cells are checked; if the voltage in either cell is below 2.0 V, a flag will be set. Normal RAM operation can resume after VCC exceeds 4.75 volts. The flag can be checked on the first write cycle after a power-up. This first write cycle will not be executed if either Lithium cell has been depleted, thereby warning of an impending data loss.
**ABSOLUTE MAXIMUM RATINGS**

Voltage on any pin relative to \( V_{SS} \) ........................................ -0.3 V to 7.0 V
Operating Temperature \( T_A \) (Ambient) ........................................ 0°C to +70°C
Storage Temperature (Ambient) ........................................ -20°C to +70°C
Power Dissipation ........................................ 1 Watt
Output Current ........................................ 20 mA

*Stresses greater than those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

**CAUTION:** Under no conditions can the "Absolute Maximum Rating" for the voltage on any pin be exceeded since it will cause permanent damage. Specifically, do not perform the "standard" continuity test on any input or output pin, i.e. do not force these pins below -0.3 V DC.

**RECOMMENDED D.C. OPERATING CONDITIONS**

\((0°C \leq T_A \leq +70°C)\)

<table>
<thead>
<tr>
<th>SYM</th>
<th>PARAMETER</th>
<th>MIN</th>
<th>MAX</th>
<th>UNITS</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V_{CC})</td>
<td>Supply Voltage</td>
<td>4.75</td>
<td>5.50</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>GND</td>
<td>Supply Voltage</td>
<td>0</td>
<td>0</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>(V_{IH})</td>
<td>Logic &quot;1&quot; Voltage All Inputs</td>
<td>2.2</td>
<td>(V_{CC} + 0.5 ) V</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>(V_{IL})</td>
<td>Logic &quot;0&quot; Voltage All Inputs</td>
<td>-0.3</td>
<td>0.8</td>
<td>V</td>
<td>1,6</td>
</tr>
</tbody>
</table>

**DC ELECTRICAL CHARACTERISTICS**

\((0°C \leq T_A \leq +70°C) (V_{CC} = 5.0 \text{ volts} + 10\% - 5\%)\)

<table>
<thead>
<tr>
<th>SYM</th>
<th>PARAMETER</th>
<th>MIN</th>
<th>MAX</th>
<th>UNITS</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>(I_{CC1})</td>
<td>Average (V_{CC}) Power Supply Current</td>
<td>80</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(I_{CC2})</td>
<td>TTL Standby Current ((E = V_{IH}))</td>
<td>3</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(I_{CC3})</td>
<td>CMOS Standby Current ((E \geq V_{CC} - 0.2 ) V)</td>
<td>1</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(I_{IL})</td>
<td>Input Leakage Current (Any Input)</td>
<td>-1</td>
<td>+1</td>
<td>(\mu)A</td>
<td>2</td>
</tr>
<tr>
<td>(I_{OL})</td>
<td>Output Leakage Current</td>
<td>-5</td>
<td>+5</td>
<td>(\mu)A</td>
<td>2</td>
</tr>
<tr>
<td>(V_{OH})</td>
<td>Output Logic &quot;1&quot; Voltage ((I_{OUT} = -1.0 ) mA)</td>
<td>2.4</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(V_{OL})</td>
<td>Output Logic &quot;0&quot; Voltage ((I_{OUT} = 2.1 ) mA)</td>
<td>0.4</td>
<td>V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**AC ELECTRICAL CHARACTERISTICS**

\((0°C \leq T_A \leq +70°C) (V_{CC} = 5.0 \text{ V} + 10\% - 5\%)\)

<table>
<thead>
<tr>
<th>SYM</th>
<th>PARAMETER</th>
<th>MK48Z02-15</th>
<th>MK48Z02-20</th>
<th>MK48Z02-25</th>
</tr>
</thead>
<tbody>
<tr>
<td>(t_{RC})</td>
<td>Read Cycle Time</td>
<td>150</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>(t_{AA})</td>
<td>Address Access Time</td>
<td>150</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>(t_{CEA})</td>
<td>Chip Enable Access Time</td>
<td>150</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>(t_{CEZ})</td>
<td>Chip Enable Data Off Time</td>
<td>35</td>
<td>40</td>
<td>50</td>
</tr>
<tr>
<td>(t_{OEA})</td>
<td>Output Enable Access Time</td>
<td>55</td>
<td>65</td>
<td>75</td>
</tr>
<tr>
<td>(t_{OEZ})</td>
<td>Output Enable Data Off Time</td>
<td>35</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>
AC ELECTRICAL CHARACTERISTICS (Cont.)

(0°C ≤ TA ≤ +70°C) (VCC = 5.0 V ± 10% - 5%)

<table>
<thead>
<tr>
<th>SYM</th>
<th>PARAMETER</th>
<th>MK48Z02-15</th>
<th>MK48Z02-20</th>
<th>MK48Z02-25</th>
</tr>
</thead>
<tbody>
<tr>
<td>tOH</td>
<td>Output Hold from Address Change</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>tWC</td>
<td>Write Cycle Time</td>
<td>150</td>
<td>200</td>
<td>250</td>
</tr>
<tr>
<td>tAS</td>
<td>Address Setup Time</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>tCEW</td>
<td>Chip Enable to End of Write</td>
<td>90</td>
<td>120</td>
<td>160</td>
</tr>
<tr>
<td>tAVE</td>
<td>Address Valid to End of Write</td>
<td>120</td>
<td>140</td>
<td>180</td>
</tr>
<tr>
<td>tWD</td>
<td>Write Pulse Width</td>
<td>90</td>
<td>120</td>
<td>160</td>
</tr>
<tr>
<td>tWR</td>
<td>Write Recovery Time</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>tWEZ</td>
<td>Write Enable Data Off Time</td>
<td>50</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>tDS</td>
<td>Data Setup Time</td>
<td>40</td>
<td>60</td>
<td>100</td>
</tr>
<tr>
<td>tDH</td>
<td>Data Hold Time</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

CAPACITANCE (TA = 25°C)

<table>
<thead>
<tr>
<th>SYM</th>
<th>PARAMETER</th>
<th>MAX</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Capacitance on all pins (except D/Q)</td>
<td>7 pF</td>
<td>9</td>
</tr>
<tr>
<td>CD/Q</td>
<td>Capacitance on D/Q pins</td>
<td>10 pF</td>
<td>4.9</td>
</tr>
</tbody>
</table>

NOTES:
1. All voltages referenced to GND.
2. Measured with GND ≤ VIL ≤ VCC and outputs deselected.
3. Measured with load as shown in Figure 3.
4. Output buffer is deselected.
5. ICC1 measured with outputs open.
6. Negative spikes of -1.0 volts allowed for up to 10 ns once per cycle.
7. See MK48Z02 Reliability Report for statistical data on accelerated operational life studies and methods of predicting data retention time (tDR).
8. Each MK48Z02 is marked with a 4 digit data code XXYY, XX designates the year of manufacture and YY designates the week in that year. Example 8340 would be interpreted as year 1983 week 40 or September 29, 1983. The expected tDR is defined as starting at date of manufacture and proceeding without interruption.
9. Effective capacitance calculated from the equation \( C = \frac{\Delta t}{\Delta V} \) with \( \Delta V = 3 \) volts and power supply at nominal level.

OUTPUT LOAD DIAGRAM

Figure 3

![Diagram](image)

A.C. TEST CONDITIONS

Input Levels:
0.6 V to 2.4 V

Transition Times:
5 ns

Input and Output Timing Reference Levels:
0.8V or 2.2 V
**POWER-DOWN, POWER-UP CONDITIONS**  
Figure 6

![Diagram showing power-down and power-up conditions](image)

**POWER-DOWN/POWER-UP TIMING**  
\(0^\circ C \leq T_A \leq +70^\circ C\)

<table>
<thead>
<tr>
<th>SYM</th>
<th>PARAMETER</th>
<th>MIN</th>
<th>MAX</th>
<th>UNITS</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>(t_{PD})</td>
<td>(E) or (\bar{W}) at (V_{IH}) before Power Down</td>
<td>0</td>
<td></td>
<td>(\mu S)</td>
<td></td>
</tr>
<tr>
<td>(t_F)</td>
<td>(V_{CC}) slew from 4.75 V to 4.50 V ((E) or (\bar{W}) at (V_{IH}))</td>
<td>300</td>
<td></td>
<td>(\mu S)</td>
<td></td>
</tr>
<tr>
<td>(t_{FB})</td>
<td>(V_{CC}) slew from 4.50 V to 3.0 V</td>
<td>10</td>
<td></td>
<td>(\mu S)</td>
<td></td>
</tr>
<tr>
<td>(t_{RB})</td>
<td>(V_{CC}) slew from 3.0 V to 4.50 V</td>
<td>1</td>
<td></td>
<td>(\mu S)</td>
<td></td>
</tr>
<tr>
<td>(t_R)</td>
<td>(V_{CC}) slew from 4.50 V to 4.75 V ((E) or (\bar{W}) at (V_{IH}))</td>
<td>0</td>
<td></td>
<td>(\mu S)</td>
<td></td>
</tr>
<tr>
<td>(t_{REC})</td>
<td>(E) or (\bar{W}) at (V_{IH}) after Power Up</td>
<td>2</td>
<td></td>
<td>ms</td>
<td></td>
</tr>
</tbody>
</table>

\((T_A = 25^\circ C)\)

<table>
<thead>
<tr>
<th>SYM</th>
<th>PARAMETER</th>
<th>MIN</th>
<th>MAX</th>
<th>UNITS</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>(t_{DR})</td>
<td>Expected Data Retention Time</td>
<td>10</td>
<td></td>
<td>years</td>
<td>7.8</td>
</tr>
</tbody>
</table>

**WARNING:**  
Under no circumstances are negative undershoots, of any amplitude, allowed when device is in battery backup mode.
ZEROPOWER RAM FUNCTIONAL DIAGRAM

Figure 7
## ORDERING INFORMATION

<table>
<thead>
<tr>
<th>PART NO.</th>
<th>ACCESS TIME</th>
<th>PACKAGE TYPE</th>
<th>TEMPERATURE RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>MK48Z02B-15</td>
<td>150 ns</td>
<td>Plastic</td>
<td>0° to 70°C</td>
</tr>
<tr>
<td>MK48Z02B-20</td>
<td>200 ns</td>
<td>Plastic</td>
<td>0° to 70°C</td>
</tr>
<tr>
<td>MK48Z02B-25</td>
<td>250 ns</td>
<td>Plastic</td>
<td>0° to 70°C</td>
</tr>
</tbody>
</table>

## PACKAGE DESCRIPTION

**B Package**
24 Pin

### Diagram

![Diagram of B Package 24 Pin](image)

### Notes:

1. Lead finish is to be specified on the detail specifications.
2. Overall length includes .010 in. flash on either end of the package.
3. Package standoff to be measured per JEDEC requirements.
4. Measured from centerline to centerline at lead tips.
5. When the solder lead finish is specified, the maximum limit shall be increased by .003 in.

---

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270-272 Avenue de Tervuren (BTE21). B-1150 Brussels, Belgium:

Phone: 762.18.80

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30 to 100 Watt High Performance DC-DC Converters

APPLICATIONS
Telecommunications
Data Acquisition
Robotics
Remote Systems
Process Control
Battery Operated Systems
Uninterruptable Power Systems
Test Instrumentation
Ground Support Equipment
Commercial and Military

DESIGN FEATURES
WIDE 2:1 INPUT RANGES
INPUT: 9-18VDC, 18-36VDC,
and 36-72VDC

EXTERNAL SYNC: User can externally synchronize the DCS to a system clock. This feature will improve the overall system signal-to-noise ratio as all internal switching of the converter will be “locked” to a system rate. In the event of loss of internal sync, the DCS will “free run” on its own internal oscillator.

EXTERNAL DISABLE: Remote TTL turnoff for power conservation. In the “disable” mode the DCS dissipates less than 0.75 watts.

DISPLAY INDICATORS: 4 LED’s provide indication of status modes. The indicators can simplify system troubleshooting.

SOFTSTART: Designed to gradually increase the duty cycle of the pulse-width-modulation (PWM) from zero to its normal operating point. This softstart eliminates voltage transients and limits inrush current during startup.

HIGH EFFICIENCY: Typically 71% (80% max)—which does not vary more than 3% over the full 2:1 input range.

PARALLEL OPERATION: The DCS series may be connected in parallel for increased current capability.

POWER DESIGN: All models have been designed to provide up to 80% of full output power from any individual output up to the full power rating of the unit. Not only are nominal ratings shown, but “absolute maximum” is indicated for multiple outputs. The designer is not restricted to the ratings shown but can use the DCS up to maximum indicated in models chart provided that rated “power” is not exceeded.

INPUT TO OUTPUT ISOLATION: 1000VDC Typical.

FULLY REGULATED OUTPUTS: Provision has been made for the derived outputs to be fully regulated. This option improves the line and load regulation by a factor of 10 and virtually eliminates typical cross regulation interaction between the primary and derived outputs.

REMOTE SENSE: Remote sense on the primary output compensates for IR drop of up to 0.5V. Internal sensing is automatic if remote sense lines are either open or shorted.

SHOCK AND VIBRATION: Option available to vibration of up to 5g’s.

GENERAL DESCRIPTION
The DCS series is a complete family of DC to DC converters ranging from 30 to 100 Watts of power. There are more than 100 models which are available in single, dual, or triple outputs; and input can be selected from three 2:1 ranges of 9-18VDC, 18-36VDC, or 36-72VDC. Each power rating is available with outputs of +5, +3.3, +15, +24, +28, ±12, ±15, and ±18VDC.

The DCS series was designed to meet the needs of a design engineer rather than just matching competitive model types currently available. By incorporating features such as external synchronization provision, external disable, display status indicators, semi-regulated and fully regulated outputs, and high efficiency, the DCS series provides the user with a system component far superior to conventional DC to DC converters.
DCS Theory of Operation

The DCS series of 30-, 50-, and 100-watt DC-DC converters was first introduced in late 1981. Since its introduction, this series has been expanded and improved upon so that today it offers the Design Engineer a price/performance ratio unmatched in the industry. Many of the 136 different models have been used in applications such as telecommunications, process control, vehicle-mounted instrumentation, and oil exploration — wherever performance, quality, and systems features are required.

The DCS series utilizes the "forward converter" type of topology as opposed to a "fly-back" scheme due to the inherent lower noise produced on the output.

In a forward converter (see Block Diagram), the transistor switch produces a pulse train whose amplitude varies according to the input line and whose width is modulated by means of a master control to maintain a constant output. This pulse train is fed into the transformer and integrated by the LC filter. The output voltage is sensed and fed back into the master control which varies the "on" time of the power transistor, thereby controlling the amount of power that is fed into the integrator.

Although the forward converter comprises the major element in the DCS block diagram as shown, the power train is only a portion of the total power supply. One of the most important parts is what we call the "logic card" which controls an independent bias supply as well as the forward converter.

A master timing generator feeds a clock signal into portions of the logic card, one portion of which controls an independent bias supply. This "power supply within a power supply" is independent of the main output. It is there solely to provide housekeeping power on both sides of the isolation barrier and to allow for proper operation of all the complex circuits without their having to be dependent upon outside phenomena such as short circuit, overvoltage, turn on, or turn off conditions.

There is sufficient reserve in the bias power supply to keep the logic card up for some time after the power for the main power switches ceases to be there. The bias supply is very important in that it allows us to do these things without having to affect the main loop. It also provides well-regulated power from which to operate many other functions without becoming a victim of a sloppy internal power supply. In addition, this scheme is more efficient than using a series-pass power supply as a means of maintaining housekeeping power.

The master control of the logic card has an optically isolated error amplifier which uses a high-quality operational amplifier in the temperature compensated precision voltage reference. Similarly, the overvoltage circuit employs an optically isolated, independent error-detection scheme that is not tied to the remote sense lines as are the overvoltage types of protection found on many competitive units. It also does not rely on the same feedback path as the error amplifier; therefore, if there were something wrong with the error amplifier, the overvoltage has a redundant path to over-ride it and shut down the supply. This alternate path is only used in the condition of overvoltage: therefore, its components are not subject to any stress, per se, as they are all in an "off" position until the fault occurs.

The output error amplifier has also been designed to provide zero volts on the output in the event of fault. Other design considerations include a disable scheme which is optically isolated through the overvoltage circuit and a sync circuit that is optically isolated from the timing generator.

Disable is referenced to output low, and is connected via the over voltage circuit. The disable terminal forces the unit into standby status. When a +5 V source of 20 mA is applied to that terminal, no limiting is required. When higher voltages are used, please limit current to 20 mA. Upon application of the disable voltage the following sequence of events occurs:

1. ≈50 ms: Terminates output modulation.
2. ≈100 ms: Terminates internal modulation functions.
3. ≈500 ms: Reduces internal current drain, illuminates standby LED.

The external sync is a port into the timing generator by which a square-wave timing signal can be fed to move the switching frequency of the power converter either plus or minus 10%. This particular feature is unusual in that the converter can be made to move over or under its default frequency. Most synchronization schemes only allow them to move in one direction, usually only up in frequency.
The logic card itself has many fault-detection schemes employed throughout. Conditions such as overload, overvoltage, stand-by, power off, and power on, all initiate a soft-start cycle. In soft-start, the output is increased in a slow controlled fashion, instead of being allowed to rise as fast as it can leading to the possibility of overshoot. Once the output voltage has risen to its near nominal value, the error amplifier will take control of the output voltage and will maintain it at its preset value.

In the event of a signal requiring the total shutdown of the logic card (in other words, disable housekeeping functions within the converter are terminated in a sequence-controlled fashion. First, the main power switch is turned off, then the bias supply is turned off, and finally the timing generator is shut off. Even the internal start-up supply, which is a series-pass regulator driven off the input voltage, is shut down so there are no internal housekeeping requirements other than that required to light the LED on the front panel. This allows for very low stand-by currents (in most cases, less than ½ watt dissipation).

The DCS Block Diagram shows the derived outputs (outputs 2 & 3) as being windings off the main power transformer fed into separate filter inductors and capacitors. This scheme as shown is known as a "semi-regulated output". It provides good line regulation and a reasonably good load regulation, depending upon the requirement. If you can tolerate a 5-10% deviation in total voltage and can always provide a minimum load of 10% of the nominal rated output of that channel, semi-regulated models can offer distinct cost advantages. For applications where tighter regulation is required, Intronic offers a fully regulated option. The 30 and 50 watt series use a screw-pass type regulation scheme while the 100 watt units use a pulse-width modulation scheme (PWM) to control the derived output voltage. This frees us from the dissipation-limited linear regulators that work well on lower power units. The 100-watt series is available with fully regulated outputs only.

The DCS series is a switching power supply which has a sensing and control network to regulate the outputs to the limits of the specification. Sensing must be done to accomplish this task. To accomplish this, a minimum preload of 10% is required on all outputs. Below this preload condition on the primary output, the terminal derived output voltages(s) of a DCS could be 0VDC. Additionally, the derived output voltage(s) will increase to a clamp limit below a preload condition on the derived outputs (see Figure 5). Intronic could have installed a preload inside the DCS at the output terminals.

However, the trade-off of efficiency for this condition is not in the user's best interest. Without a preload, all outputs will fall outside specified limits.

Remote or four wire sensing (Figure 6a) provides complete compensation for DC voltage drops in the connecting cables. Power leads should be twisted and run together. Shield sense leads and route for minimum noise pickup. If the positive output is grounded, the negative sense lead should be shielded. If the output is floating, shield both sense leads and connect shield to chassis ground. Capacitor (Ct) is suggested to reduce output impedance and prevent instability. Ct should be approximately 100μF/D per amperage.

Remote with multiple loads (Figure 5b) is used to decouple the output from the DCS's primary output. The DCS series can be floated at a DC potential above ground. The DCS series can be floated at a DC voltage of 500VDC maximum.

It is important to note that the high efficiency of the DCS series is maintained over the entire 2:1 input range. The efficiency varies less than 3% over this range. The 100-watt unit, which incorporates the PWM regulation scheme offers a remarkable 75% efficiency even though the derived outputs are fully regulated. Consider what this means: the DCS 100-watt, single-output units only dissipate 35 watts internally vs. 100 watts on comparable units that operate at 50% efficiency! This is a factor of 3:1 over many units presently sold today.

1. Graph based on normalized efficiency of 0.71% at full load.
2. Graph is approximate. Actual performance will depend on the number of outputs, loading distribution, and regulation options.
General Specifications

Range of input voltage for which unit will operate per the specifications.

Maximum deviation of the DC output voltage from its nominal value as set by the factory.

Adjustment range of primary output using potentiometers in front panel.

The ability to sense the output voltage of the supply at the load. This allows compensation for "IR" voltage drops in the power bus.

The percent change in the output voltage as the input voltage varies within its specified limits.

The percent change in the output voltage as the load current varies within its specified limits.

Ratio of the output power to the input power. Usually specified at full load and nominal line voltage.

Minimum load required to keep output within specified limits.

A crowbar or other circuit which limits the output voltage when a preset limit is exceeded.

A monitoring circuit which automatically limits the output current when an overload occurs. There are two common types:

1) "Fold Back" - will decrease or fold back the output current to 50% of rated I_{max}.

2) Straight line or constant - will limit the output overcurrent to a constant maximum of 120-160% of rated I_{max}.

The maximum DC voltage which may be applied between input and output without causing damage.

Same as above except voltage is applied between primary and derived outputs.

INPUT VOLTAGE RANGE:
9-18VDC 18-36VDC 36-72VDC

OUTPUT VOLTAGE/CURRENT:
(See Page 8)

PRESET ACCURACY:
±1% (primary or main channel)
±5% (derived or auxiliary channel)

EXTERNAL ADJUSTMENT:
±5% Primary Output (Typical)

REMOTE SENSE:
0.5VDC Minimum
(See Fig. C)

LINE REGULATION:
0.2% over full 2:1 input range

LOAD REGULATION:
Primary Output: 0.2% (10% to 100% load)
Derived Outputs: 1%-5%
(See Fig. B)

EFFICIENCY:
71% typical (depends on model)
Varies <3% over 2:1 input range

MINIMUM LOAD:
10% on all primary and semi-regulated derived outputs.

PROTECTION MODES:
Input Polarity: Reverse diode shunt with series internal input fuse

Output Overvoltage: 5V outputs limited to 6.2VDC. All other outputs clamp limited to 130% of rating — recovery automatic.

Output Overcurrent: Straight line current limit at 120% of rating — recovery automatic.
(See Page 8)

ISOLATION:
Input to Output: 1000VDC
Primary to Derived: 500VDC
NOISE:
15mV_{pp} (Bandwidth 5Hz-20kHz) or 0.3% of output, whichever is greater.
50mV_{pp} (5Hz-10kHz) or 1% of output, whichever is greater.
(See Fig. H)

REFLECTED INPUT RIPPLE:
10% of I_{max} (RMS)

TRANSIENT RESPONSE:
Primary Output:
1) Load ≤ 50% to 100% or 100% to 50% maximum deviation ≤ 2.0% nominal Vout. Response time ≤ 300μsec to 0.5% nominal Vout.
2) Load 10% to 100% or 100% to 10% maximum deviation ≤ 3%. Response time ≤ 500μsec to 0.5% nominal Vout.
Derived Output:
1) Load ≤ 50% to 100% or 100% to 50% maximum deviation ≤ 10% nominal Vout. Response ≤ 800μsec to 0.5% nominal Vout.
2) Load ≤ 10% to 100% or 100% to 10% maximum deviation ≤ 30% nominal Vout. Response ≤ 2msec to 0.5% nominal Vout.

OSCILLATOR SYNC:
TTL 20mA sink current required. Sync frequency 18-22kHz.
(See Fig. E)

EXTERNAL DISABLE:
TTL high or current source with 20mA capability. Input power at nominal input voltage less than 0.75W in disable mode. (See Fig. F)

PARALLEL OPERATION: Yes
(See Fig. G)

SOFTSTART: Yes, occurs when:
1) Power is turned on.
2) Disable command removed.
3) Input returns from OV condition.
4) Removal of current limit condition.

TEMPERATURE RATINGS:
Operation: -20°C to +80°C
(Base Plate)
Storage: -40°C to +85°C

TEMPERATURE COEFFICIENT:
Primary Output: 0.01%/°C
Derived Output: 0.2%/°C

An AC voltage which rides on the DC output voltage measured within the bandwidth specified.

The peak-to-peak AC current that is "reflected back" to the input lines by switching pulses generated by the converter.

The amount of time required for the output voltage to settle within the regulation limit specified after a step change in output load current.

The ability to synchronize the internal oscillator to an external clock. This is very helpful in telecommunications applications or where the suppression of beat frequencies is essential (See Figure D).

The ability to "shut down" the converter. Very helpful when long periods of inactivity are anticipated (See Figure E).

Limits the in-rush current during various turn-on modes by varying the duty cycle of a pulse-width-modulator. This is important when other devices are connected to the same input bus.

The range of temperature that the unit will operate within specification in a free air environment. Typical temperature rise is 15°C.

The average change in output voltage as temperature varies from +25°C to the limits specified.
OSCILLATOR SYNCHRONIZATION

The DCS runs at a switching frequency of approx. 20kHz. To synchronize the DCS with a system clock, the input to the sync terminal must be a current sink of 10-15mA. Typically, an open collector will suffice. The sync range can be varied ±10% from the norm. Consult factory for higher sync frequency.

Note: 1. I = 10-20mA min.
2. Q₁ = 2N2222 or equivalent.

EXTERNAL DISABLE

DISABLE Figure F

The user must provide a 40mA current source with at least 1.5 volts of compliance as shown. If this feature is not to be used, the disable terminal may either be left open or tied to RTN.

Note: 1. DCS disables when S₁ is closed.

NOISE MEASUREMENT

When measuring noise, keep impedance low to minimize pick-up of common-mode switching noise (radiated and conducted at the output). Suggested measurement set-up is shown.

Note: Ripple = 2 × scope reading.

DISPLAY INDICATORS

Note: ADJ Out 2 and 3 on 100 W units only.

DISPLAY FUNCTIONS

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>RUN (Green)</th>
<th>STANDBY (Amber)</th>
<th>OVERLOAD (Red)</th>
<th>OVP (Red)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUT OVP</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>ON</td>
</tr>
<tr>
<td>OUTPUT OVERLOAD</td>
<td>ON</td>
<td>OFF</td>
<td>ON</td>
<td>OFF</td>
</tr>
<tr>
<td>DISABLE</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
<tr>
<td>NORMAL OPERATION</td>
<td>ON</td>
<td>OFF</td>
<td>OFF</td>
<td>OFF</td>
</tr>
</tbody>
</table>
MECHANICAL DIMENSIONS
INCHES (mm)

<table>
<thead>
<tr>
<th></th>
<th>30 WATT</th>
<th>50 WATT</th>
<th>100 WATT</th>
<th></th>
<th>30 WATT</th>
<th>50 WATT</th>
<th>100 WATT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.50(14.0)</td>
<td>8.60(21.9)</td>
<td>9.00(22.9)</td>
<td>R</td>
<td>1.24(3.1)</td>
<td>1.35(3.4)</td>
<td>1.20(3.0)</td>
</tr>
<tr>
<td>B</td>
<td>4.52(11.5)</td>
<td>6.22(15.8)</td>
<td>6.50(16.5)</td>
<td>S</td>
<td>0.82(20.4)</td>
<td>0.93(23.6)</td>
<td>0.90(23.0)</td>
</tr>
<tr>
<td>C</td>
<td>1.55(3.9)</td>
<td>2.09(5.3)</td>
<td>2.20(5.6)</td>
<td>T</td>
<td>0.25(6.4)</td>
<td>0.35(8.9)</td>
<td>0.34(8.7)</td>
</tr>
<tr>
<td>D</td>
<td>5.80(14.7)</td>
<td>8.10(20.6)</td>
<td>N/A</td>
<td>U</td>
<td>0.80(20.3)</td>
<td>0.80(20.3)</td>
<td>0.80(20.3)</td>
</tr>
<tr>
<td>E</td>
<td>0.45(11.4)</td>
<td>1.10(28.0)</td>
<td>N/A</td>
<td>V</td>
<td>1.15(29.2)</td>
<td>1.15(29.2)</td>
<td>1.15(29.2)</td>
</tr>
<tr>
<td>F</td>
<td>0.77(19.6)</td>
<td>1.05(26.7)</td>
<td>N/A</td>
<td>W</td>
<td>2.09(52.7)</td>
<td>2.09(52.7)</td>
<td>2.09(52.7)</td>
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<tr>
<td>G</td>
<td>6.00(15.2)</td>
<td>7.40(18.7)</td>
<td>7.50(19.1)</td>
<td>X</td>
<td>3.15(79.9)</td>
<td>3.15(79.9)</td>
<td>3.15(79.9)</td>
</tr>
<tr>
<td>H</td>
<td>0.25(6.4)</td>
<td>0.25(6.4)</td>
<td>0.90(22.9)</td>
<td>Y</td>
<td>0.20(5.1)</td>
<td>0.20(5.1)</td>
<td>0.20(5.1)</td>
</tr>
<tr>
<td>J</td>
<td>3.70(93.9)</td>
<td>3.70(93.9)</td>
<td>3.70(93.9)</td>
<td>AA</td>
<td>N/A</td>
<td>N/A</td>
<td>2.50(63.5)</td>
</tr>
<tr>
<td>K</td>
<td>0.28(7.1)</td>
<td>0.28(7.1)</td>
<td>0.40(10.2)</td>
<td>BB</td>
<td>N/A</td>
<td>N/A</td>
<td>2.50(63.5)</td>
</tr>
<tr>
<td>L</td>
<td>0.32(8.1)</td>
<td>0.32(8.1)</td>
<td>0.52(13.2)</td>
<td>CC</td>
<td>N/A</td>
<td>N/A</td>
<td>1.85(47.0)</td>
</tr>
<tr>
<td>M</td>
<td>0.64(16.2)</td>
<td>0.64(16.2)</td>
<td>1.12(28.4)</td>
<td>DD</td>
<td>N/A</td>
<td>N/A</td>
<td>0.45(11.4)</td>
</tr>
<tr>
<td>N</td>
<td>0.33(8.4)</td>
<td>0.80(20.3)</td>
<td>0.54(13.7)</td>
<td>EE</td>
<td>N/A</td>
<td>N/A</td>
<td>2.06(52.7)</td>
</tr>
<tr>
<td>P</td>
<td>3.50(88.9)</td>
<td>3.50(88.9)</td>
<td>4.25(107.9)</td>
<td>FF</td>
<td>N/A</td>
<td>N/A</td>
<td>2.60(66.0)</td>
</tr>
</tbody>
</table>

APPROXIMATE WEIGHTS
30 WATT: 11 lbs. 6 oz. 50 WATT: 21 lbs. 6 oz. 100 WATT: 2 lbs. 8 oz.

OUTPUT/CONNECTOR DESIGNATION TABLE

<table>
<thead>
<tr>
<th>MODEL CODES</th>
<th>OUTPUT VOLTAGES</th>
<th>Output 1</th>
<th>Output 2</th>
<th>Output 3</th>
<th>Output 1</th>
<th>Output 2</th>
<th>Output 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+5</td>
<td>+5</td>
<td>+5</td>
<td>+5</td>
<td>+5</td>
<td>+5</td>
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</tr>
<tr>
<td>2</td>
<td>+12</td>
<td>+12</td>
<td>+12</td>
<td>+12</td>
<td>+12</td>
<td>+12</td>
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</tr>
<tr>
<td>3</td>
<td>+15</td>
<td>+15</td>
<td>+15</td>
<td>+15</td>
<td>+15</td>
<td>+15</td>
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</tr>
<tr>
<td>4</td>
<td>+24</td>
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<td>+24</td>
<td>+24</td>
<td>+24</td>
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</tr>
<tr>
<td>6</td>
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</tr>
<tr>
<td>7</td>
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</tr>
<tr>
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</tr>
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<td>9</td>
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<td>±24</td>
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<tr>
<td>10</td>
<td>±+ 12</td>
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<td>±+ 12</td>
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<tr>
<td>11</td>
<td>±+ 15</td>
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</tr>
<tr>
<td>12</td>
<td>±+ 24</td>
<td>±+ 24</td>
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<tr>
<td>13</td>
<td>±+ 28</td>
<td>±+ 28</td>
<td>±+ 28</td>
<td>±+ 28</td>
<td>±+ 28</td>
<td>±+ 28</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>±± 12</td>
<td>±± 12</td>
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<td>±± 12</td>
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<td>17</td>
<td>±± 28</td>
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</tbody>
</table>

CONNECTORS
(30 & 50 Watt Models)

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Function 30/450W units</th>
<th>Terminal</th>
<th>Function 30/450W units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+Vin</td>
<td>7</td>
<td>Out 2</td>
</tr>
<tr>
<td>2</td>
<td>-Vin</td>
<td>8</td>
<td>Derived Output</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Return (Out #2 &amp; #3 Common)</td>
</tr>
<tr>
<td>3</td>
<td>+Out 1 Sense</td>
<td>9</td>
<td>Out 3</td>
</tr>
<tr>
<td>4</td>
<td>+Out 1</td>
<td>10</td>
<td>Sync</td>
</tr>
<tr>
<td>5</td>
<td>-Out 1</td>
<td>11</td>
<td>Disable</td>
</tr>
<tr>
<td>6</td>
<td>-Out 1 Sense</td>
<td>12</td>
<td>Case</td>
</tr>
</tbody>
</table>

Terminal | Function 100W units | Terminal | Function 100W units |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+Vin</td>
<td>9</td>
<td>Out 2 Sense</td>
</tr>
<tr>
<td>2</td>
<td>+Vin</td>
<td>10</td>
<td>Out 2</td>
</tr>
<tr>
<td>3</td>
<td>-Vin</td>
<td>11</td>
<td>Out 2/3 Com.</td>
</tr>
<tr>
<td>4</td>
<td>-Vin</td>
<td>12</td>
<td>Out 2/3 Com.</td>
</tr>
<tr>
<td>5</td>
<td>+Out 1 Sense</td>
<td>13</td>
<td>Out 3 Sense</td>
</tr>
<tr>
<td>6</td>
<td>+Out 1</td>
<td>14</td>
<td>Out 3</td>
</tr>
<tr>
<td>7</td>
<td>-Out 1 Sense</td>
<td>15</td>
<td>Sync</td>
</tr>
<tr>
<td>8</td>
<td>-Out 1</td>
<td>16</td>
<td>Disable</td>
</tr>
</tbody>
</table>

Note: 1. Shorting bars provided on terminal blocks are nickel steel. Do not try to pass large currents through these as "IR" drops will occur.
2. Make sure all terminal screws are tight during operation. Locking washers are recommended.
**ORDERING GUIDE**

**INPUT CODES**

<table>
<thead>
<tr>
<th>CODE</th>
<th>INPUT RANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9-15VDC (except 10W)</td>
</tr>
<tr>
<td>2</td>
<td>36-17VDC</td>
</tr>
</tbody>
</table>

**ORDERING EXAMPLE**

DCS 50-317

50 watt DCS
18-38VDC Input
+5VDC, ±15VDC Outputs

*100W Series available in fully-regulated version only*

**OPTION CODES**

<table>
<thead>
<tr>
<th>OPTION</th>
<th>CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully regulated derived outputs</td>
<td>2</td>
</tr>
<tr>
<td>±15VDC, ±32VDC (&lt;10% each)</td>
<td>4</td>
</tr>
<tr>
<td>Extended input range consular factory</td>
<td>5</td>
</tr>
</tbody>
</table>

**OUTPUT CODES**

**30-WATT SERIES**

<table>
<thead>
<tr>
<th>OUTPUT VOLTAGE (V)</th>
<th>OUTPUT CURRENT (mA)</th>
<th>PRICE (d$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nom.</td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>+5VDC</td>
<td>6A</td>
<td>6A</td>
</tr>
<tr>
<td>+12VDC</td>
<td>2.5A</td>
<td>2.5A</td>
</tr>
<tr>
<td>+15VDC</td>
<td>2A</td>
<td>2A</td>
</tr>
<tr>
<td>+24VDC</td>
<td>1.25A</td>
<td>1.25A</td>
</tr>
<tr>
<td>+28VDC</td>
<td>1A</td>
<td>1A</td>
</tr>
</tbody>
</table>

**50-WATT SERIES**

<table>
<thead>
<tr>
<th>OUTPUT VOLTAGE (V)</th>
<th>OUTPUT CURRENT (mA)</th>
<th>PRICE (d$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nom.</td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>+5VDC</td>
<td>10A</td>
<td>10A</td>
</tr>
<tr>
<td>+12VDC</td>
<td>4A</td>
<td>4A</td>
</tr>
<tr>
<td>+15VDC</td>
<td>3.3A</td>
<td>3.3A</td>
</tr>
<tr>
<td>+24VDC</td>
<td>2A</td>
<td>2A</td>
</tr>
<tr>
<td>+28VDC</td>
<td>1.8A</td>
<td>1.8A</td>
</tr>
</tbody>
</table>

**100-WATT SERIES**

<table>
<thead>
<tr>
<th>OUTPUT VOLTAGE (V)</th>
<th>OUTPUT CURRENT (mA)</th>
<th>PRICE (d$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nom.</td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>+5VDC</td>
<td>20A</td>
<td>20A</td>
</tr>
<tr>
<td>+12VDC</td>
<td>8A</td>
<td>8A</td>
</tr>
<tr>
<td>+15VDC</td>
<td>6.6A</td>
<td>6.6A</td>
</tr>
<tr>
<td>+24VDC</td>
<td>4A</td>
<td>4A</td>
</tr>
<tr>
<td>+28VDC</td>
<td>3.6A</td>
<td>3.6A</td>
</tr>
</tbody>
</table>

**TRIPLE OUTPUTS**

<table>
<thead>
<tr>
<th>OUTPUT VOLTAGE (V)</th>
<th>OUTPUT CURRENT (mA)</th>
<th>PRICE (d$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nom.</td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>+5VDC</td>
<td>3A</td>
<td>3A</td>
</tr>
<tr>
<td>+12VDC</td>
<td>0.9A</td>
<td>0.9A</td>
</tr>
<tr>
<td>+15VDC</td>
<td>0.72A</td>
<td>0.72A</td>
</tr>
<tr>
<td>+24VDC</td>
<td>0.6A</td>
<td>0.6A</td>
</tr>
</tbody>
</table>

**57 Chapel Street, Newton, Massachusetts 02158, U.S.A.**

Prices & specifications subject to change without notice.
Introduction

Each model in the NK-1200 Series of vehicle installed distance measuring instruments is a powerful microcomputer controlled device with many programmed instructions. Full use of these instruments can be acquired within a short learning and familiarization period. Each model has a built-in TEST MODE feature that simulates sensor signals as though the vehicle is travelling at about 34 m.p.h. While parked, you can use the TEST MODE of operation to become acquainted with the instrument. Depending upon the model, it may take several hours to become totally familiar with the instrument before its full capability can be appreciated. This small investment of time will be repaid 100 fold in more efficient measurements and data collection.

Your instrument was designed by electronic engineers who have had years of experience in actual field measurements of thousands of miles of highway, and actually designed the first electronic distance measurement (EDM) in 1976. Using the latest "state of the Art" in microprocessor technology, we have been able to incorporate the features and capabilities requested by highway and communication engineers.

To accommodate all the features demanded by many engineers and, at the same time, allow a selection for those requiring only basic distance measuring applications, the NK-1200 Series is available in four (4) models: NK-1201 through NK-1203/P. The operational procedures of each model is described in this manual.

Please keep in mind that each instrument can be up-graded to a higher level without having to purchase a complete new instrument. As an example: if you purchased an NK-1201 and later find a need for the features and capabilities of our NK-1203/P, your 1201 can be up-graded to a 1203/P for the difference in the current list price plus a flat $50.00 conversion fee.
Mounting The NK Instrument

Select a suitable location on top of the dashboard and attach the VELCRO strips by removing the self-adhesive protective covering. A matching VELCRO strip is attached to the bottom of the instrument. Each strip should be pressed firmly in place and allowed to set for five minutes prior to mating. Keep in mind that the operator should have a direct line of sight to the display and keyboard. This may require that the instrument be mounted at a slight angle towards the operator.

Plug the cable into the instrument and decide how much slack you will require. There is adequate cable to allow a passenger to hold and operate the instrument if desirable. In the area where the steering column goes through the firewall you can normally find an opening to the engine compartment without having to drill a special hole (speedometer cable, vehicle wiring harness, etc.).

Wiring

1. The location for mounting the terminal block will be under the hood on the left front inner fender.

2. Route all wiring as far as possible from any spark plug wires and ignition coil.

3. Terminate the wiring as shown in Figure M-6. After completion, refer to the OPERATING PROCEDURES SECTION for calibration and operational procedures.
Wiring For Both Transwave And Nu-Metrics Instruments

In many instances, it may be desirable to equip a car to accept both the Transwave NK-1200 Series Instrument and the Nu-Metrics DM1. However, the Transwave instruments provide the power to the sensor directly from the measuring instrument so when the instrument is OFF (or out of the vehicle) no power is going to the sensor.

With the Nu-Metrics instrument, power to the sensor is supplied by a separate wire connected after the ignition key. In this installation, the sensor is ON anytime the vehicle is being driven.

In order to be able to use both brands in the same vehicle, each instrument wiring harness must be installed as shown in FIGURE 6-7. Keep in mind that the orange wire in the NK harness is "HOT," when the NK is turned on. For this reason, you must tape the terminal lug to insure the orange wire does not short to metal or any other wire. Contact of the bare terminal lug will create a direct short which will damage the instrument.

Transmission Sensor Installation—G.M. Vehicles

1. Remove speedometer cable at the vehicle's transmission. Attach sensor into the transmission using one inch nut. Make sure sensor cable is facing away from the road surface and the exhaust pipe. Insert speedometer cable into back of sensor. Adaptor nut is provided for different thread diameters of the cable.

2. Route the sensor wire to the NK terminal block making sure the wire is not near the exhaust pipe or manifold. Attach leads to terminal block as shown in Figure 1.

NOTE: On G.M. Vehicles equipped with Cruise Control, sensor can be attached to the upper most outlet of the Cruise Control Unit. Terminate wires as described in Step 2.

NK Wire Functions

1. GREEN—PD SIGNAL
2. WHITE—SENSOR SIGNAL
3. BLACK—GROUND
4. RED—+12 VDC
5. ORANGE—+5VDC TO SENSOR

FIGURE 6-7

If Adaptor Kit is required (Ford and Chrysler vehicles) follow instructions as supplied in the Adaptor Kit, terminate wires as shown in Figure 1.
Section 6 Installation Procedures

Wheel Sensor Installation

Mounting Wheel Targets

Ten (10) stainless steel clamp-on targets are provided; however, the maximum you will use is eight (8). The remaining are extras and should be stored in the glove box of the vehicle, should you need them.

STEP 1.
Jack front of vehicle up and remove left front wheel. Lay wheel face down. Targets will be mounted on side of rim that faces under the vehicle.

STEP 2.
Remove all lead wheel weights from this side of rim and move them to the outside, but in the same relative position.

STEP 3.
It is recommended that the rim be thoroughly cleaned with a degreasing solvent or soap and water.

![Figure M-1](image)

STEP 4.
After the rim is clean, install targets as indicated in Figure M-1. Install the first target on the STEEL CLAMP portion so that the clamp fits between the tire and lip of the wheel rim. The steel clamp holds firmly to the wheel similar to a conventional wheel weight.

NOTE: Caution should be exercised when installing the targets so that the stainless steel portion of the target does not receive a blow (Figure M-2). This could cause the target to separate or could cause non-uniformity in relation to sensor alignment. To install the second target, sight straight across the wheel from the first target and install as described before.

Halfway between #1 and #2 targets, place #3 target. Sight straight across from #3, place #4 target, etc., until all eight (8) targets are installed. When it becomes necessary to remove the tire from the wheel, the targets should be CAREFULLY removed from the wheel prior to attempting tire removal.

Before re-installing targets on wheel, inspect the spring steel clamp portion of the target. Adjust the clamp with pliers if it appears that it was bent excessively during removal. Squeezing the clamp together will insure a firm, positive fit.

![Figure M-2](image)

NOTE: The stainless steel portion of the target should be flush with the clip. If there is some separation of the two (8), a light tapping at Point "A" will insure a flush and even target.
Sensor Mounting And Alignment

**STEP 1.**
Measure the distance from the tie rod end knuckle to the targets. This will give you an idea of how to fashion the bracket for correct scanning of the targets. At this time, you may want to remove the wheel to aid in the installation of the sensor.

**STEP 2.**
Mount the sensor on the bracket near one end (Figure M-3). The other end will be bolted to the tie rod end using the original nut (a new cotter pin is provided). The distance from the tie rod end to the wheel differs from one vehicle to another. You may have to bend the bracket or cut some off. **NOTE:** On one side of the sensor is a nomenclature plate with an LED light – this side of the sensor should face forward for easy viewing when aligning or checking proper operation. If the wheel has been removed, re-mount the wheel and be sure the face of the sensor is scanning 1/8 inch away from each target.

**STEP 3.**
Route the sensor wire through the fender well to engine compartment. Use cable ties to secure excess cable to the tie rod, making sure there is enough slack in wire so when wheel is turned to extreme left or right it will not break.

**STEP 4.**
**IMPORTANT:** After the wheel is securely mounted, carefully inspect the proper rotation of the wheel and align sensor accordingly so that each target passes the face of the sensor by approximately 1/8 inch. Also, inspect brake caliper to ensure targets have adequate clearance.
Sensor Installation
G.M. Vehicles Equipped With Sway Bar

The typical sensor installation shown in Figure M-3 presents some unique problems when applied to late model General Motors Corporation cars. Although, not readily discernible during installation, the sensor may come into contact with the sway bar when the steering is turned and the suspension is compressed. This causes the sensor to be forced into the targets mounted on the wheel rim. As you may well imagine, when this occurs, two terrible consequences may result. First, the targets may be dislodged or torn completely from the wheel requiring replacement of the affected targets. The second (and most expensive) consequence is that the sensor may be knocked from its mounting bracket, either destroying the sensor and/or the bracket.

To remedy this situation, we have found it necessary to mount the sensor from a position behind the lower ball joint, just below the disk brake caliper. (See Figure M-4). This installation requires a bit more time and mechanical ability than the typical installation. However, the problem-free performance that can be achieved more than compensates for the extra effort expended.

Mechanics Of Installation

STEP 1.
The first steps of this installation are, of course, to jack up the left front tire of the vehicle, place a jackstand under the car for safety and remove the wheel. The disk brake pads and caliper must now be removed by taking out the two large Allen head bolts and lifting the pads out. The caliper should be supported with a wire and should NOT be allowed to hang by the brake hose.

STEP 2.
The next step requires the removal of the disk rotor by first removing the wheel bearing dust cover, cotter key, retaining nut and wheel bearings. This now permits the careful removal of the disk rotor and hub assembly which finally exposes the bolt (5/16-20 x 3/4") that we are searching for. It is located just below the brake caliper on your right and is used to fasten a dust cover to the assembly.

STEP 3.
This bolt (5/16-20 x 3/4") should be removed and replaced with a longer bolt (5/16-20 x 1 1/4") complete with nut and lock washer, so that approximately 1/2" protrudes on the engine side of the assembly. This stud now provides the mounting point for the sensor bracket. After the bolt is secured, the bracket and sensor should be securely mounted using the new nut and lock washer.

STEP 4.
As illustrated in Figure M-4, the bracket must be bent at a right angle for proper sensor alignment. Some trial and error will be required to properly position the sensor squarely in front of the targets and must be completed after reassembly of the unit.

STEP 5.
Careful scrutiny must now be used to insure that no part of the sensor comes into contact with the sensor at both stops of the steering travel. Attention should also be directed to the routing of the cable at this time to insure that it will not become entangled in the suspension or steering.

STEP 6.
Reassembly of the unit can now be done by reversing the disassembly sequence. The remainder of the installation can be accomplished as explained in the typical sensor installation.
Typical G.M. Installation

Typical Ford Installation

FIGURE M-4

FIGURE M-5
Section 7 Calibration

Pre-Calibration Procedures

1. Place the "Power On/Off" switch on the front of the instrument to the "On" position. For a period of about one (1) second, the instrument performs a self diagnostic test during which the instrument will remain blank.

2. When first turned on, the instrument will be in the "STOP" position with the Miles and Meters indicator lights (not functional on the 1201) flashing.

Prior to calibrating the NK to a particular vehicle, tire pressure must be assured. Pressure should be the optimum pressure recommended by the tire manufacturer. For continuous accurate measurements, it is important that the pressure be maintained within ± 2 pounds of the pressure used to calibrate the instrument.

Pre-measure a 1,000 foot long and straight road course accurately with a measuring tape. A shorter course can be used if necessary, i.e.: 600 feet, 800 feet, etc.

Mark the pre-measured course at the beginning and the end with an object. Start and stop with markers at the same sight reference.

Example: At the beginning of course, sight out of the window of the vehicle at the marker, using an object on vehicle as reference, i.e. door handle, window post, radio antenna, etc.

Instrument Calibration—NK-1201

1. Place power switch to "ON". The display should indicate a "0" in the right most digit and the unit will be in the "STOP" mode (Indicator Lights flashing).

2. Depress the "CLEAR" key.

3. Depress the "VSC" key. The number "E5" will be shown on the far left digit.
4. On the keyboard, depress the numbers 1000 in sequence. As you enter each number, it will be displayed and move to the left as each subsequent number is depressed. You are now programming the instrument to count one (1) each time it receives a pulse. In essence, you are merely counting the pulses received from the sensor. The LED's should still be flashing, indicating a "STOP" mode.

5. Depress "ENTER". The value (1000) is now entered into the instrument and the display will drop to zero. The "ES" will blink.

6. Release the STOP and drive the pre-measured calibration course starting at the beginning and stopping at the end. Depress STOP again to hold the count.

The digital display will read the total number of pulses acquired over the pre-measured course. Mathematically divide this number into 1000 (or the actual course length used). The result will be the approximate "VSC" calibration number for measuring distance, i.e., pulse counts of 1035 divided into 1000 equals 966.

Enter the "VSC" number in the sequence of: STOP, CLEAR, VSC, key in VSC value, ENTER. Re-drive the pre-measured course and if the measured distance is too low, use a higher "VSC" number, and, if too high, use a lower "VSC" number.

The value of a previously entered "VSC" number can be viewed while in the STOP mode by depressing the "VSC" key. If the value is to be changed, depress CLEAR, key in the new value, depress ENTER. If the value is not changed, depress ENTER to store the value on display back into the instrument.

Once adjustments have been made and the "VSC" program number is established for the vehicle, it is advisable to write down the program number on a piece of tape and affix it to the vehicle dashboard or sun visor. When power to the NK is turned off, the VSC program number is eliminated from the registers and must be re-entered in the computer again each time power is restored. This feature serves as a check to insure that the correct VSC number is being used each time the instrument is operated.

Instrument Calibration - NK-1202, NK-1203, NK-1203/P

Unlike the NK-1201 which requires a manual mathematical calculation for determination of the VSC number, the NK-1202, 1203, and 1203/P will automatically determine its VSC calibration number. The procedure for AUTOMATIC CALIBRATION is as follows:

1. Place power switch to "ON". The display should indicate a zero (0) in the right most digit and the instrument will be in the "STOP" mode (LED's flashing).

2. Depress the "CLEAR" key.

3. Release the "START/STOP" key and drive the pre-measured calibration course. During this period, zero (0) will remain on display and no count will be seen.

4. At end of calibration course, depress "STOP" key.

5. Depress "AUTO VSC", followed by length of the calibration course, i.e., 1000, 800, 723, etc.

6. Depress "ENTER". The instrument will calculate and display the appropriate VSC (calibration) number.

7. Depress "ENTER" again. The VSC value is now entered in to the instrument and the length of the calibration course is verified on display.

8. Depress "CLEAR". The instrument is now ready to measure and display actual distance travelled.

If the VSC (calibration) number has already been established, you can enter this number without going through the automatic calibration procedure as follows:

1. Start/Stop in STOP mode.
2. Depress "CLEAR" key.
3. Depress "AUTO VSC" key.
4. Depress "CLEAR" again.
5. Key in VSC number.
6. Depress "ENTER".

Re-drive the calibration course to verify that the VSC number is correct, and if the measured distance is too low, use a higher VSC number; if too high, use a lower VSC number.

The value of a previously entered "VSC" number can be reviewed while in the STOP mode by depressing the "AUTO VSC" key. If the value is to be changed, depress CLEAR, key in the new value, depress ENTER. If the value is not changed, depress ENTER to store the value on display back into the instrument.

Once adjustments have been made and the "VSC" program number is established for the vehicle, it is advisable to write down the program number on a piece of tape and affix it to the vehicle dashboard or sun visor. When power to the NK is turned off, the VSC program number is eliminated from the registers, and must be re-entered in the computer again each time power is restored. This feature serves as a check to insure that the correct VSC number is being used each time the instrument is operated.
Limited Warranty

A. The Transwave NK-1201 through NK-1203/P instruments are covered by a one-year limited warranty on parts and labor against defects in materials and workmanship. Sensors, targets, cables, connectors, brackets and other hardware is warranted for ninety (90) days.

B. TRANSWAVE CORPORATION warrants each new instrument product manufactured by it to be free from defective material and workmanship and agrees to remedy any such defect or to furnish a new part in exchange for any part of any unit of its manufacture which under normal installation, use and service discloses such defect, provided the unit is returned to our factory or authorized service agent, intact, for examination, with all transportation charges prepaid.

C. This warranty does not extend to any of our products which have been subjected to misuse, neglect, accident, incorrect wiring not our own, improper installation or to use in violation of instructions furnished by us, nor extend to units which have been repaired or altered outside of our factory or authorized service agent.

D. Any part of a unit approved for remedy or exchange hereunder will be remedied or exchanged by the authorized agent or our factory sales division without charge to the owner.

E. This warranty is in lieu of all other warranties expressed or implied and no representative or person is authorized to assume for us any other liability in connection with the sales of our products.

F. TRANSWAVE CORPORATION reserves the right to make improvements in the product specifications at any time without notice.

G. Questions concerning this warranty or any TRANSWAVE CORPORATION product should be directed to either the Sales or Service Department at (412) 628-6370.
Specifications-NK-1201
POWER: 9 to 16 VDC, negative ground, 3.6 watt average.
OPERATING TEMPERATURE: 0 degrees C to +70 degrees C.
DISPLAY: 1.0 ft. to 999,999 ft.
DISTANCE RESOLUTION: ± 1.0 ft.
ACCURACY: ± 1 ft. (display) ± .001 ft. (computation)
KEYBOARD: Touch-Tell 16 Key
PRE-DISTANCE: 0-999,999 feet
SENSOR: Solid State Proximity or Transmission Type
BI-DIRECTIONAL: Compute distance count up or down
DIMENSIONS: 6.1" (W), 6.3" (D), 2.6" (H)
WEIGHT: 14 oz.

Specifications-NK-1202
POWER: 9 to 16 VDC, negative ground, 3.6 watt average
OPERATING TEMPERATURE: 0 degrees C to +70 degrees C.
DISPLAY: 1.0 feet to 999,999 ft.
DISTANCE RESOLUTION: ± 1.0 ft.
ACCURACY: ± 1 ft. (display) ± .001 ft. (computation)
KEYBOARD: Touch-Tell 16 Key
PRE-DISTANCE: 0-999,999 ft., 0-813,440 miles or 0-999,999 kilometers
SENSOR: Solid-State Proximity or Transmission Type
BI-DIRECTIONAL: Compute distance count up or down
UNIT: Automatic Conversion, 0-999,999 ft., 0-999,999 kilometers, 0 - 813.440 miles
VSC (AUTO): Automatic calibration entry
WAYPOINT: Display Hold
SPEED: 0-999 MPH, FPH or FPS
MEMORY: Two digit code (0 - 99), 10 Memory locations
PRINT-MARK: Direct peripheral control
PDI: TTL positive true user selectable duration .01 sec. to 2.55 sec.
DIMENSIONS: 6.1" (W), 6.3" (D), 2.6" (H)
WEIGHT: 14 oz.

Specifications-NK-1203
POWER: 9 to 16 VDC, negative ground, 3.6 watt average
OPERATING TEMPERATURE: 0 degrees C to +70 degrees C
DISPLAY: 1.0 ft. to 999,999 ft.
DISTANCE RESOLUTION: ± 1.0 ft.
ACCURACY: ± 1 ft. (display) ± .001 ft. (computation)
KEYBOARD: Touch-Tell 16 Key
PRE-DISTANCE: 0-999,999 ft., 0-813,440 miles or 0-999,999 kilometers
SENSOR: Solid-State Proximity or Transmission Type
BI-DIRECTIONAL: Compute distance count up or down
UNIT: Automatic Conversion, 0-999,999 ft., 0-999,999 kilometers, 0 - 813.440 miles
VSC (AUTO): Automatic calibration entry
WAYPOINT: Display Hold
SPEED: 0-999 MPH, FPH or FPS
MEMORY: Two digit code (0 - 99), 10 Memory locations
PRINT-MARK: Direct peripheral control
PDI: TTL positive true user selectable duration .01 sec. to 2.55 sec.
DIMENSIONS: 6.1" (W), 6.3" (D), 2.6" (H)
WEIGHT: 14 oz.
Section 8: Warranty And Specs.

Specifications-NK-1203/P

POWER: 9 to 16 VDC @ 20 watts peak

OPERATING TEMPERATURE: 0 degrees C to +70 degrees C

DISPLAY: 1.0 ft. to 999,999 ft.

DISTANCE RESOLUTION: ± 1.0 ft.

ACCURACY: ± 1 ft. (display) ± .001 ft. (computation)

KEYBOARD: Touch-Tell 16 Key

PRE-DISTANCE: 0-999,999 ft., 0-81.0440 miles or 0-999.999 kilometers

SENSOR: Solid-State Proximity or Transmission Type

DI-DIRECTIONAL: Compute distance count up or down

UNIT: Automatic Conversion, 0-999.999 ft., 0-999.999 meters, 0-813.440 miles

VEC (AUTO): Automatic Calibration entry

WAYPOINT: Display hold

SPEED: 0-999 KPH, KPH or FPS

MEMORY: Two digit code (0 - 99), 10 Memory locations

PRINT-MARK: Direct peripheral control

PDI: TTL positive true usable selectable duration .01 sec. to 2.55 sec.

PRINTER: Alpha Numeric Dot Matrix 5 x 7, 16 column

PRINT SPEED: 1 line/Sec.

PAPER: Standard 1.8" W

RIBBON: Inked Cassette

DIMENSIONS: 6.1" (W), 6.3" (H), 2.6" (R)

WEIGHT: 1.2 lbs.
The HT/1000 is an extremely versatile handheld terminal. Much of this flexibility is due to the programmable communications, keyboard, and display options designed into the unit.

With all the features available to the user it is recommended that this manual be thoroughly reviewed prior to integrating the HT/1000 into the user's system.

This manual has been written with a detailed explanation of each operation. Its intent is to quickly and easily familiarize the user with the terminal. In addition, information has been included on the available communications interfaces and on battery life characteristics. We feel that this should facilitate easy integration of the HT/1000 into your system. However, should you require further assistance on any matter, please contact the factory and we will provide you with any support necessary.

HT/1000 VERSIONS

HT/1000 OEM -

Because there are times when the great flexibility of the HT/1000 is not needed, Termiflex has another model, the HT/1000 OEM. This is a simplified version of the HT/1000 available in quantities of 40 and above. The keyboard, display, and interfaces remain the same as the standard model, but the HT/1000 OEM will not have operating batteries, a backup battery, a wide range power supply or user selectable options. The advantage of the HT/1000 OEM is its lower per unit pricing. It is also available with the user customizable keyboard if you wish to make your own nomenclature.

HT/1000K -

The HT/1000K is identical in operation to the HT/1000. This version provides the user with the means to customize the keyboard to suit the projects needs.

When the user receives the terminal, there will be three additional pieces in the carton. One is the write-on layer which the user will apply custom lettering to. The other piece provides the tactile feedback for the membrane switch and protect the custom lettering. The third piece is a transfer lettering kit which can be used to customize the write-on layer. This kit or any other suitable means may be used.
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WARRANTY

Products manufactured by TERMIFLEX CORPORATION are warranted to the original purchaser against defective materials and workmanship for a period of one year from purchase - under normal use and service. This warranty is void where a product has been damaged by accident or abuse, or if the serial number is altered or removed, or if the product has been serviced, or modified by other than an authorized representative of TERMIFLEX CORPORATION.

This is the entire warranty of TERMIFLEX CORPORATION and no other warranties, expressed, implied, or statutory are given.

PROPRIETARY NOTICE

The information in this manual is proprietary information to TERMIFLEX and is intended only as an aid in operating and servicing the equipment. This information may not be used or reproduced without the expressed written permission of TERMIFLEX.

NOTICE

Information contained in this publication is believed to be accurate and reliable. However, responsibility is assured neither for its use nor for any infringement of patents or rights of others that may result from its use. No license is granted by implication or otherwise under any patent or patent right of TERMIFLEX CORPORATION or others. The equipment herein described is sold, leased, or loaned subject to TERMIFLEX Standard Terms and Conditions Of Sale. Prices and specifications subject to change without notice.

WARNING:

This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to correct the interference.
Series 82 Standard Keyboard Modules

One Button Module

Two Button Module

Three Button Module

Six Button Module

For rear views, see page 22.

Stack In Any Array

- 11/16 Inch Button Centers Maintained With Modules Placed Side By Side
- Vertical or Horizontal Mount
- Long Stroke, Wiping Contact
- PC Mountable

Standard Modules
- 1 to 4 Poles Per Button
- Off the Shelf Availability
- Coding Capability
- Choice of Colors and Legend Styles

Lightable Modules
- 1 or 2 Poles Per Button
- Self Legendable
- Mounts Over LED or Lamp
FIGURE 9 – SINGLE PULSE OUTPUT CIRCUIT

FIGURE 10 – MULTIPLE OUTPUT SIGNAL TIMING DIAGRAM

MOTOROLA Semiconductor Products Inc.
TYPICAL APPLICATIONS

ASYMMETRICAL TIMING

In applications where different leading and trailing edge delays are required (such as a fast attack/slow release timmer). Clocks of different frequencies can be gated into the MC14490 as shown in Figure 6. In order to produce a slow attack/fast release circuit leads A and B should be interchanged. The clock out lead can then be used to feed clock signals to the other MC14490 packages where the asymmetrical input/output timing is required.

FIGURE 6 – FAST ATTACK/SLOW RELEASE CIRCUIT

LATCHED OUTPUT

The contents of the Bounce Eliminator can be latched by using several extra gates as shown in Figure 7. If the latch lead is high the clock will be stopped when the output goes low. This will hold the output low even though the input has returned to the high state. Any time the clock is stopped the outputs will be representative of the input signal four clock periods earlier.

FIGURE 7 – LATCHED OUTPUT CIRCUIT

MULTIPLE TIMING SIGNALS

As shown in Figure 8, the Bounce Eliminator circuits can be connected in series. In this configuration each output is delayed by four clock periods relative to its respective input. This configuration may be used to generate multiple timing signals such as a delay line, for programming other timing operations.

One application of the above is shown in Figure 9, where it is required to have a single pulse output for a single operation (make) of the push button or relay contact. This only requires the series connection of two Bounce Eliminator circuits, one inverter, and one NOR gate in order to generate the signal AB as shown in Figures 9 and 10. The signal AB is four clock periods in length. If the inverter is switched to the A output, the pulse AB will be generated upon release or break of the contact. With the use of a few additional parts many different pulses and waveshapes may be generated.

FIGURE 8 – MULTIPLE TIMING CIRCUIT CONNECTIONS

MOTOROLA Semiconductor Products Inc.
FIGURE 4 - TYPICAL "FORM A" CONTACT DEBOUNCE CIRCUIT
(Only One Deboouncer Shown)

OPERATING CHARACTERISTICS

The single most important characteristic of the MC14490 is that it works with a single signal lead as an input, making it directly compatible with mechanical contacts (Form A and B).

The circuit has a built-in pullup resistor on each input. The worst case value of the pullup resistor (determined from the Electrical Characteristics table) is used to calculate the contact wetting current. If more contact current is required, an external resistor may be connected between VDD and the input.

Because of the built-in pullup resistors, the inputs cannot be driven with a single standard CMOS gate when VDD is below 5 V. At this voltage, the input should be driven with paralleled standard gates or by the MC14049 or MC14050 buffers.

The clock input circuit (pin 7) has Schmitt trigger shaping such that proper clocking will occur even with very slow clock edges, eliminating any need for clock preshaping. In addition, other MC14490 oscillator inputs can be driven from a single oscillator output buffered by an MC14050 (see Figure 5). Up to six MC14490s may be driven by a single buffer.

The MC14490 is TTL compatible on both the inputs and the outputs. When VDD is at 4.5 V, the buffered outputs can sink 1.6 mA at 0.4 V. The inputs can be driven with TTL as a result of the internal input pullup resistors.

FIGURE 5 - TYPICAL SINGLE OSCILLATOR DEBOUNCE SYSTEM
THEORY OF OPERATION

The MC14490 Hex Contact Bounce Eliminator is basically a digital integrator. The circuit can integrate both up and down. This enables the circuit to eliminate bounce on both the leading and trailing edges of the signal, shown in the timing diagram of Figure 3.

Each of the six Bounce Eliminators is composed of a 4½-bit register (the integrator) and logic to compare the input with the contents of the shift register, as shown in Figure 4. The shift register requires a series of timing pulses in order to shift the input signal into each shift register location. These timing pulses (the clock signal) are represented in the upper waveform of Figure 3. Each of the six Bounce Eliminator circuits has an internal resistor as shown in Figure 4. A pullup resistor was incorporated rather than a pulldown resistor in order to implement switched ground input signals, such as those coming from relay contacts and push buttons. By switching ground, rather than a power supply lead, system faults (such as shorts to ground on the signal input leads) will not cause excessive currents in the wiring and contacts. Signal lead shorts to ground are much more probable than shorts to a power supply lead.

When the relay contact is open the shift register is loaded with a 1 (positive logic assumed) on each positive edge of the clock signal. To understand the operation, we assume all bits of the shift register are loaded with 1’s and the output is at a 1 or high level.

At clock edge 1 (Figure 3) the input has gone low and a 0 (low level) has been loaded into the first bit or storage location of the shift register. Just after the positive edge of clock 1 the input signal has bounced back to a logic 1. This causes the shift register to be reset to all 1’s in all four bits — thus starting the timing sequence over again.

During clock edges 3 to 6 the input signal has stayed low. Thus a logic 0 has been shifted into all four shift register bits and, as shown, the output goes to a 0 during the positive edge of clock pulse 6.

It should be noted that there is a 3½ to 4½ clock period delay between the clean input signal and output signal. In this example there is a delay of 3.8 clock periods from the beginning of the clean input signal.

After some time period of N clock periods, the contact is opened and at N+7 a 1 is loaded into the first bit. Just after N+7, when the input bounces low, all bits are reset to 0. At N+8 nothing happens because the input and output are low and all bits of the shift register are 0. At time N+9 and thereafter the input signal is a high (1) clean signal. At N+13 the output goes high (1) as a result of four 1’s being shifted into the shift register.

Assuming the input signal is long enough to be clocked through the Bounce Eliminator, the output signal will be no longer or shorter than the clean input signal plus or minus one clock period.

The amount of time distortion between the input and output signals is a function of the difference in bounce characteristics on the edges of the input signal and the clock frequency. Since most relay contacts have more bounce when making as compared to breaking, the overall delay, counting bounce period, will be greater on the leading edge of the input signal than on the trailing edge. Thus, the output signal will be shorter than the input signal — if you include the leading edge bounce in the overall timing calculation.

The only requirement on the clock frequency in order to obtain a bounce free output signal is that four clock periods do not occur while the input signal is in a false state. Referring to Figure 3, a false state is seen to occur three times at the beginning of the input signal. The input signal goes low three times before it finally settles down to a valid low state. The first three low pulses are referred to as false states.

If the user has an available clock signal of the proper frequency, it may be used by connecting it to the oscillator input (pin 7). However, if an external clock is not available the user can place a small capacitor across the oscillator input and output pins in order to start up an internal clock source (as shown in Figure 4). The clock signal at the oscillator output pin may then be used to clock other MC14490 Bounce Eliminator packages. With the use of the MC14490, a large number of signals can be cleaned up, with the requirement of only one small capacitor external to the Hex Bounce Eliminator packages.

FIGURE 3 – TIMING DIAGRAM

![Timing Diagram](image-url)
### ELECTRICAL CHARACTERISTICS (C_L = 50 pF, T_A = 25°C)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>VDD Vdc</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Rise Time All Outputs</td>
<td>1TLH</td>
<td>5.0</td>
<td>180</td>
<td>90</td>
<td>360</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Fall Time Oscillator Output</td>
<td>1THL</td>
<td>5.0</td>
<td>100</td>
<td>90</td>
<td>200</td>
<td>ns</td>
</tr>
<tr>
<td></td>
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<td>10</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td>15</td>
<td></td>
<td>40</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.0</td>
<td>50</td>
<td>40</td>
<td>120</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>50</td>
<td></td>
<td>60</td>
<td></td>
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<td></td>
<td></td>
<td>15</td>
<td>20</td>
<td></td>
<td>40</td>
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</tr>
<tr>
<td>Propagation Delay Time Oscillator Input to</td>
<td>1PHL</td>
<td>5.0</td>
<td>285</td>
<td></td>
<td>570</td>
<td>ns</td>
</tr>
<tr>
<td>Debounce Outputs</td>
<td></td>
<td>10</td>
<td>120</td>
<td></td>
<td>240</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>95</td>
<td></td>
<td>190</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1PLH</td>
<td>5.0</td>
<td>370</td>
<td></td>
<td>740</td>
<td>ns</td>
</tr>
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<td></td>
<td></td>
<td>10</td>
<td>300</td>
<td></td>
<td>600</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>120</td>
<td></td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>Clock Frequency (50% Duty Cycle)</td>
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<td></td>
<td>5.0</td>
<td>2.8</td>
<td>1.4</td>
<td>MHz</td>
</tr>
<tr>
<td>External Clock</td>
<td></td>
<td>10</td>
<td>6</td>
<td>3</td>
<td>12</td>
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<tr>
<td></td>
<td></td>
<td>15</td>
<td>9</td>
<td>4.5</td>
<td>18</td>
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</tr>
<tr>
<td>Setup Time (See Figure 1)</td>
<td></td>
<td></td>
<td>5.0</td>
<td>100</td>
<td>50</td>
<td>ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>80</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td>15</td>
<td>80</td>
<td>30</td>
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<td>Maximum External Clock input</td>
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<td></td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>Rise and Fall Time</td>
<td>1n</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>15</td>
<td></td>
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</tr>
<tr>
<td>Oscillator Frequency</td>
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<td>5.0</td>
<td>1.5</td>
<td></td>
<td>Hz</td>
<td></td>
</tr>
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<td>OSC_OUT</td>
<td></td>
<td>10</td>
<td></td>
<td>4.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C_EXT = 500 pF to 0.1 pF</td>
<td></td>
<td>15</td>
<td></td>
<td>6.5</td>
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<td></td>
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</tbody>
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#### FIGURE 1 – TYPICAL SWITCHING TIME WAVEFORMS

#### FIGURE 2 – AMBIENT TEMPERATURE POWER DERATING
### MAXIMUM RATINGS (Voltages referenced to VSS, Pin 81)

<table>
<thead>
<tr>
<th>Rating</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Supply Voltage</td>
<td>VDD</td>
<td>-0.5 to +18 V</td>
<td></td>
</tr>
<tr>
<td>Input Voltage, All Inputs</td>
<td>Vᵢᵣ</td>
<td>-0.5 to VDD +0.5 V</td>
<td></td>
</tr>
<tr>
<td>DC Current Drain per Input Pin</td>
<td>I₁</td>
<td>10 mA</td>
<td></td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>Tₘ</td>
<td>-55 to +125 °C</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tₜq</td>
<td>-40 to +85 °C</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>Tₛq</td>
<td>-65 to +150 °C</td>
<td></td>
</tr>
</tbody>
</table>

### ELECTRICAL CHARACTERISTICS

#### Output Voltage

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>VDD</th>
<th>Tlow*</th>
<th>25°C</th>
<th>thigh*</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;0&quot; Level</td>
<td>VᵪL</td>
<td>5.0</td>
<td>0.05</td>
<td>0</td>
<td>0.05</td>
<td>V</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>15</td>
<td>0.05</td>
<td>0</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>&quot;1&quot; Level</td>
<td>VᵪH</td>
<td>5.0</td>
<td>4.96</td>
<td>5.0</td>
<td>4.96</td>
<td>V</td>
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<td>9.96</td>
<td>10</td>
<td>9.96</td>
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<td>15</td>
<td>14.96</td>
<td>16</td>
<td>14.96</td>
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#### Input Voltage

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>VDD</th>
<th>Tlow*</th>
<th>25°C</th>
<th>thigh*</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;0&quot; Level</td>
<td>VᵩL</td>
<td>5.0</td>
<td>1.5</td>
<td>2.25</td>
<td>15</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>3.0</td>
<td>4.90</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>4.0</td>
<td>6.75</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>&quot;1&quot; Level</td>
<td>VᵩH</td>
<td>5.0</td>
<td>3.5</td>
<td>2.75</td>
<td>3.5</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>7.0</td>
<td>5.50</td>
<td>7.0</td>
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<td></td>
<td></td>
<td>15</td>
<td>11.0</td>
<td>8.25</td>
<td>11.0</td>
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</table>

#### Output Drive Current Source

<table>
<thead>
<tr>
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<th>Symbol</th>
<th>VDD</th>
<th>Tlow*</th>
<th>25°C</th>
<th>thigh*</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oscillator Output</td>
<td>VᵩH</td>
<td>5.0</td>
<td>0.5</td>
<td>0.15</td>
<td>-0.4</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>0.5</td>
<td>0.15</td>
<td>-0.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>0.5</td>
<td>0.15</td>
<td>-0.4</td>
<td></td>
</tr>
<tr>
<td>Drainage Outputs</td>
<td>VᵩL</td>
<td>5.0</td>
<td>1.5</td>
<td>2.25</td>
<td>15</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>3.0</td>
<td>4.90</td>
<td>3.0</td>
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<td>4.0</td>
<td>6.75</td>
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<tr>
<td>Sink</td>
<td></td>
<td>5.0</td>
<td>3.5</td>
<td>2.75</td>
<td>3.5</td>
<td>V</td>
</tr>
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<td>15</td>
<td>11.0</td>
<td>8.25</td>
<td>11.0</td>
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</table>

#### Input Current

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>VDD</th>
<th>Tlow*</th>
<th>25°C</th>
<th>thigh*</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oscillator Input</td>
<td>IᵩL</td>
<td>5.0</td>
<td>0.36</td>
<td>0.30</td>
<td>0.24</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>0.36</td>
<td>0.30</td>
<td>0.24</td>
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<td>15</td>
<td>0.36</td>
<td>0.30</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Drainage Inputs</td>
<td>IᵩH</td>
<td>5.0</td>
<td>1.6</td>
<td>2.1</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
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<td>10</td>
<td>1.6</td>
<td>2.1</td>
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<td>15</td>
<td>1.6</td>
<td>2.1</td>
<td>1.8</td>
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</table>

#### Output Capacitance

<table>
<thead>
<tr>
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<th>Symbol</th>
<th>VDD</th>
<th>Tlow*</th>
<th>25°C</th>
<th>thigh*</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>f = 10 kHz</td>
<td>CᵩL</td>
<td>15</td>
<td>-300</td>
<td>+300</td>
<td>0</td>
<td>pF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>-250</td>
<td>+250</td>
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#### Capacitive Load Current

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<thead>
<tr>
<th>Characteristic</th>
<th>Symbol</th>
<th>VDD</th>
<th>Tlow*</th>
<th>25°C</th>
<th>thigh*</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>f = 10 kHz</td>
<td>IᵩD</td>
<td>15</td>
<td>-30</td>
<td>0</td>
<td>10</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>-30</td>
<td>0</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

---

*This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields, however, it is advised that normal precautions be taken to avoid application of any voltage higher than the maximum rated voltages to this high impedance circuit. For proper operation, it is recommended that Vᵢᵣ and VᵢᵣH be constrained to the range VSS ≤ Vᵢᵣ ≤ VᵢᵣH ≤ VDD.*

---

**MOTOROLA Semiconductor Products Inc.**
HEX CONTACT BOUNCE ELIMINATOR

The MC14490 is constructed with complementary MOS enhancement mode devices, and is used for the elimination of extraneous level changes that result when interfacing with mechanical contacts. The digital contact bounce eliminator circuit takes an input signal from a bouncing contact and generates a clean digital signal four clock periods after the input has stabilized. The bounce eliminator circuit will remove bounce on both the "make" and the "break" of a contact closure. The clock for operation of the MC14490 is derived from an internal R-C oscillator which requires only an external capacitor to adjust for the desired operating frequency (bounce delay). The clock may also be driven from an external clock source or the oscillator of another MC14490.

- Diode Protection on All Inputs
- Noise immunity = 45% of VDD Typical
- Six Debuffers Per Package
- Internal Pulses on All Data Inputs
- Can Be Used as a Digital Integrator, System Synchronizer, or Delay Line
- Internal Oscillator (R-C), or External Clock Source
- TTL Compatibility of Data Inputs/Outputs
- Digital Input, Debuffers Both "Make" and "Break" Contacts
- Does Not Require "Form C" (Single Pole Double Throw) Input Signal
- Cascadable for Longer Time Delays
- Schmitt Trigger on Clock Input (Pin 7)
- Supply Voltage Range = 3.0 V to 18 V

ORDERING INFORMATION

MC14xxx-Suffix Denotes
L Ceramic Package
P Plastic Package

BLOCK DIAGRAM

- VDD
- A in
- Oscillator
- Two-Phase Clock Generator
- Output
- Identical to Above Stage
- Identical to Above Stage
- Identical to Above Stage
- Identical to Above Stage
- Identical to Above Stage
- Identical to Above Stage
- Identical to Above Stage
- Identical to Above Stage
- Identical to Above Stage
- Identical to Above Stage
- Identical to Above Stage
- Identical to Above Stage
- Identical to Above Stage
Hinged aluminum inner lids are available in all Zero VAL-AN cases to make the upper part of the case into a storage compartment. The inner lid is secured with a special push button latch that has been tested to 200 pounds.

To determine approximate weight of Inner Lid Assembly, multiply the square foot area by .889 lbs. per square foot for .063 cases; 1.27 lbs. per square foot for .090 cases.
CLOSURE, PANEL FLANGE AND INNER LID DETAILS

Special mating gasketed extrusions are used to provide effective sealing of Zero VAL-AN cases. In addition to sealing, these exclusive closures provide effective alignment of the two halves of the case and protection of the seal and hinges from shearing forces. Each of the closure, panel flange and inner lid choices listed below is available on every VAL-AN case. Specify by inserting the indicated code in the basic part number.

Note: For detailed dimensioning of closure extrusions see pages 168-171.

A = Plain.
Weight: 0.063 cases = 0.280 lbs/ft.;
0.090 cases = 0.492 lbs/ft.

B = Plain with inner lid.
Weight (closure only):
0.063 cases = 0.240 lbs/ft.;
0.090 cases = 0.472 lbs/ft.

C = Top flanged with nut plates and flange gasket.
Weight: 0.063 cases = 0.487 lbs/ft.;
0.090 cases = 0.737 lbs/ft.

D = Top Flanged with nut plates, flange gasket and inner lid.
Weight (closure and panel only):
0.063 cases = 0.487 lbs/ft.;
0.090 cases = 0.737 lbs/ft.

E = Medium recessed flange with nut plates and flange gasket.
Weight: 0.063 cases = 0.523 lbs/ft.;
0.090 cases = 0.744 lbs/ft.

F = Medium recessed flange with nut plates, flange gasket and inner lid.
Weight (closure and panel only):
0.063 cases = 0.523 lbs/ft.;
0.090 cases = 0.744 lbs/ft.

G = Deep recessed flange with nut plates and flange gasket.
Weight: 0.063 cases = 0.887 lbs/ft.;

H = Deep recessed flange with nut plates, flange gasket and inner lid.
Weight (closure and panel flange only):
0.063 cases = 0.887 lbs/ft.;
0.090 cases = 1.122 lbs/ft.
**VAL-AN CASES**

Continuous mating gasketed extruded closure. See page 216.

Hinges in 1/4" increments.

Handles meet or exceed military specification. See page 215.

Military specification: see page 219.

Solid feet: see page 218.

Spring loaded latches tested to 400 pounds pull. Are located to insure case integrity. See page 215.

Optional panel flange (with plate nuts, neoprene gasket and free panel template). See page 216.

Choice of manual or automatic pressure relief valve, see page 218.

Hinged latch inner lid assembly. See pages 216-217.

NOTE: Length, width and height are outside dimensions measured at points of tangency of bottom, top and sides.

**MEETS MIL-STD-108**

Zero VAL-AN cases are the result of an intensive design and testing program and will meet or exceed all watertight requirements of MIL-STD-108.

Zero-West: U.S. Government procurement vendor code number 08176

Zero-East: U.S. Government procurement vendor code number 19178

This catalog has been designed to speed and simplify ordering watertight cases to MIL-STD-108. Choose the basic case size, specify combination, transit or instrument case, indicate manual or automatic pressure relief valve, case and lid height and finish desired by inserting the code for each in the basic part number formula below. Cases are supplied without panel. Panels may be ordered separately.

**HOW TO USE THIS CATALOG SECTION**

**Part Number Example**

**HG1DA20C18**

specifies a deep drawn aluminum combination case, 9" x 27", to comply with MIL-STD-108, with one handle, four latches, two hinges, gasketed closure with flush panel flange complete with 10-32 tee wing nut plates and neoprene gasket, hinged and latched inner lid, automatic two-way pressure relief valve, case 5" high, cover 4½" high, painted per MIL-E-15090, Type III, Class 2, light gray semi-gloss enamel.

**CODE**   **CASE TYPE**

1 = Combination Case (No feet on rear except when handle is on front. Latches on case with strikes on cover. Separable hinges).

2 = Transit Case (No feet on rear except when handle is on front. Latches are on cover, strikes on case. Non-separable hinges).

3 = Instrument Case (Feet on rear and bottom in all situations. Separable hinges).

Note: Drawings shown on pages 189-214 are typical subject to the above.
1.1 UNPACKING

Your HT/1000 is ready to operate from the moment you unpack it. Nothing needs to be done to it except plug it into an appropriate mating connector. However, we recommend that you examine the package carefully to be certain everything is there. Included in the box there should be:

a) One HT/1000 Control/Display Unit
b) One HT/1000 User's Manual
c) Six size AA alkaline batteries

OPTIONS

a) One optional cable
b) Six rechargeable nickel cadmium AA batteries
c) One rechargeable battery charger

Install the batteries being careful to observe the polarities. If either the rechargeable battery option or an optional cable were ordered, please refer to the option installation instructions.

When the unit is powered up, the display will go through a self-test of displaying a full screen of each "#", "M", "I", and sounding the buzzer. Then the cursor will either be a solid black block indicating that the unit is waiting for a "CTS" signal (if RS-232-C) or it will be a small open block indicating that the unit is ready to operate. See "Display Operation" for further cursor information.

The default parameters are:

1200 baud
Even Parity
No Echo
Auto Key Repeat
No Parity Error indicate
Display not saved
No flashing characters
Control Characters not displayed

In order to change these parameters, please refer to the software operating specifications.

1.2 OPTION INSTALLATION INSTRUCTIONS

A. RECHARGEABLE BATTERY OPTION

1. Disconnect HT/1000 from any external equipment.
2. Depress OFF button.
3. Loosen the two captive screws at the bottom of the battery access door.
4. Remove battery access door by pulling bottom of door outward, then sliding it toward the bottom of the HT/1000.
5. Carefully remove the six batteries.
6. Replace them with the six enclosed rechargeable cells noting polarity as shown inside of the case.
7. Replace the battery access door by reversing steps 3 and 4.
8. Using a pair of pointed pliers carefully remove and discard the rubber plug from the charger jack at the bottom of the HT/1000.
9. Connect the enclosed charger to the HT/1000 and plug it into a standard wall outlet.
10. Charge the unit for approximately 12-14 hours. Unit may be operated while charging.

WARNING

Never operate unit on charger without batteries installed.

B. CABLE OPTION

1. Disconnect HT/1000 from any external equipment.
2. Depress OFF button.
3. Loosen the four case mounting screws (non-battery access door screws).
4. Carefully lift off the back of the HT/1000 and set it to the right of the unit, being careful not to damage the wiring connecting the case halves.
5. Remove the old cable by carefully squeezing the tab on the connector while pulling the cable away from the printed circuit board. Hold the black connector firmly in place while removing the cable.
6. Install the enclosed new cable.
7. Carefully replace the back of the HT/1000 making certain that the cable exits through the notch in the bottom of the case.
8. Install the four case mounting screws.
1.3 POWER SAVING TIPS

1) When operating from the line power keep Vin as close to 5.0 VDC as possible. Anything higher than that is just wasting power that must be dissipated as heat in the HT/1000.

2) Operate unit at highest baud rate possible. More power is consumed during data transfers than when unit is idle, therefore keep data transfers as brief as possible. (Doesn't matter in RS-422-A)

3) If RTS/CTS are not needed, leave unterminated. Any load on RTS consumes power, and internal circuitry for the HT/1000 CTS circuit allows it to send data to the interfacing equipment (if it's always ready), without any pullups or jumpers on CTS. (Note, this is for RS-232-C only).

4) Especially when operating on batteries, turn off unit when it is not being used.

5) If possible, operate in "Echo" Mode as data is only sent in one direction for each character as opposed to "No Echo" mode where each character sent by the HT/1000 is both sent and received. (See #2).

6) Use the buzzer as infrequently as possible as it consumes a considerable amount of power.

1.4 OFF LINE TEST CONNECTIONS

RS-232-C, RS-422-A, TTL Units

CURRENT LOOP Units

FIGURE 1.1
2.1 Control Keys

The HT/1000 Unit uses a four by eight (32) keyboard. The keyboard uses 28 keys to generate the 128 ASCII Characters. The 4 keys at the top of the unit are used as function keys. The configuration is shown in Fig. 2.1.

Certain keys are used to generate the most commonly used control characters. These keys and an explanation of each key are as follows:

<table>
<thead>
<tr>
<th>KEY</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF</td>
<td>Transmits the Line Feed control character (HEX 0A)</td>
</tr>
<tr>
<td>CR</td>
<td>Transmits the Carriage Return control character (HEX 0D)</td>
</tr>
<tr>
<td>SP</td>
<td>Transmits the ASCII Space character (HEX 20)</td>
</tr>
<tr>
<td>BSP</td>
<td>Transmits the Back Space control character (HEX 08)</td>
</tr>
<tr>
<td>ESC</td>
<td>Transmits the Escape control character (HEX 1B)</td>
</tr>
<tr>
<td>CTRL</td>
<td>Control - This key sets up the control mode of operation. The next key stroke, with the exception of the SPACE key will transmit the control character. If the user depresses the SPACE key the unit looks for a valid control character on the upper right of the keys to be depressed. Once a key is depressed and the character transmitted, the unit will resume normal operation.</td>
</tr>
</tbody>
</table>

![Fig. 2.1 HT/1000 Keypad](image)

**NOTE**

The ON and OFF keys are only functional when the unit is to be powered by the batteries. Otherwise they are ignored. If the unit is operating on batteries and line power is supplied, the unit will automatically switch over to the line supply. It will turn off when the line power is interrupted.
2.2 SPECIAL FUNCTION KEYS

There are two keys in the lower left hand section of the keyboard that are used for special keyboard functions. These functions are as follows:

(Shift Keyboard Left)

This function will shift the keyboard to the Alpha characters on the top left of each key. After the key is transmitted the keyboard will unshift and resume normal operation.

(Shift Keyboard Right)

This function will shift the keyboard to the punctuation characters on the top right of each key. After the key is transmitted the keyboard will unshift and resume normal operation.

This function is selected when the user depresses the shift right key twice. This function will lock the keyboard into the right shift mode. When selected this function will remain engaged until the user selects the shift right key again, unlocking the shift.

This function is selected when the user depresses the shift left key twice. This function will lock the keyboard into the upper left shift mode for each key. This enables the user to send alpha characters thereafter with only one key stroke. This function, when selected, will remain engaged until the user selects the shift left key again, unlocking the shift.

This function is selected by depressing the shift right key then depressing the shift left key. This is used to lock in lower case alpha characters until the unlock is depressed. This function will enable the user to send lower case characters with only a single key stroke. This function will remain engaged until the user depresses the shift left key again, unlocking the keyboard.

2.3 FUNCTION KEYS (F1 to F4)

The purpose of the function keys is to enable the user to program special messages that can be transmitted with only a single keystroke. This function utilizes a buffer that is sixteen (16) characters long.

The total number of characters associated with the function keys cannot be more than 16 characters; that is, if F1 contains 5 characters, F2 contains 3 characters, F3 contains 2 characters, then F4 cannot contain more than 6 characters (i.e., $5+3+2+6=16$ characters).

The function keys can contain any ASCII value from Null (HEX 00) to Del (HEX 7F). The function keys can use any combination of control keys (HEX 00 to HEX 1F) and lower or upper case ASCII characters as well as all of the punctuation characters.

The function keys can be programmed manually or on line from a host system.

The function keys are programmed manually on power up when the user simultaneously depresses the "Shift Left Key" and the "Carriage Return Key" (CR) as power is applied. This sequence forces the unit into the program mode, which is described elsewhere.

To program the function keys a menu called "PGM Function Keys" will appear in the KBD Mode of the programming sequence. This menu is described in detail later.

To program the unit while on line, an ESC sequence is used. This escape sequence is explained in the section entitled "Downline Loading".

If the function keys are not programmed each key will assume a single value. These are:

- F1=DC1 (HEX 11)
- F2=DC2 (HEX 12)
- F3=DC3 (HEX 13)
- F4=DC4 (HEX 14)
NORMAL DISPLAY

The normal display is 64 characters on 4 lines. Characters are input starting at the lower left hand corner of the display and after each line feed or, after the line is filled, the display data shifts upward one line at a time. When display data is shifted past the top line, it is lost. If cursor positioning is used, the characters can be set to any position on the display. When the line is full or a line feed is encountered, the cursor will shift down to the next line (if available); if the cursor is at the bottom of the display, the display will scroll up.

The HT/1000 display has seven types of keyboard input modes which are indicated by seven different cursors as shown in Figure 3.1. These are as follows:

3.1 Normal Mode Cursor - - When in the normal mode, the unit will read keys that are in the unshifted position. That is, all of the numeric keys and some of the punctuation keys will be available from the keyboard. The "Normal Mode Cursor" is displayed as a flashing square block.

3.2 Shift Left Mode Cursor - - When in the shift left mode, the unit will read the alpha keys on the keyboard. The "Shift Left Mode Cursor" is displayed as a flashing square block with the upper left corner removed.

3.3 Shift Right Mode Cursor - - When in the shift right mode the unit will read the punctuation characters on the right side of each key on the keyboard. "Shift Right Mode Cursor" is displayed as a flashing square block with the upper right corner removed.

3.4 Control Mode Cursor - - When the control key (CTRL) is pressed, the unit will shift the keyboard left, to access the alpha keys. The control mode cursor appears as "CT".

3.5 Lower Case Mode Cursor - - When the user presses the lower case key (shift right followed by a shift left), the HT/1000 will display the lower case cursor which is signified by the character "LC". This cursor will act similar to the shift left lock function, which locks the keyboard left, except that this function will transmit lower case alpha characters as long as the keyboard is not unlocked. Pressing the shift left key will unlock the keyboard, the cursor will change to the normal cursor and the keyboard will resume its normal operation.

Characters that are input to the HT/1000 are displayed at the position of the cursor. After each character is input the cursor is incremented to the next location.

3.6 Low Battery Cursor - - This cursor replaces the normal cursor whenever the batteries are in need of replacing or recharging. All other cursors are available to the user.

3.7 Not Clear to Send Cursor - - This cursor replaces the normal cursor whenever the equipment connected to the HT/1000 is not ready to receive data. However the HT/1000 can still receive and display characters.

3.8 Received Characters - - Characters that are input to the HT/1000 are displayed at the position of the cursor. After each character is input the cursor is incremented to the next location.

Control --- If the HT/1000 is not in the "Display Control Characters" mode, upon receipt of the following characters, the HT/1000 will perform as described.

CR - Move the cursor to the left most position of the current line.
LF - Perform a CR, then move cursor down one line. If cursor is already at bottom of screen then move display up one line.
TAB - Move cursor one position to the right. If cursor is at right most position, do nothing.
BS - Move cursor one position to the left. If cursor is at left most position, do nothing.
FF - Clear screen and position cursor to lower left most position.
BEL - Sound the internal buzzer for about ½ second.

Fig. 3.1 Display Cursors
The following escape sequences control the cursor position and the clearing of display characters when transmitted to the HT/1000.

**ESC A Cursor Up**
Moves the cursor up 1 row of characters. The horizontal position is unchanged. If the cursor is at the top of the display, the cursor will remain unchanged.

**ESC B Cursor Down**
Moves the cursor down 1 row of characters. The horizontal position is unchanged. If the cursor is at the bottom of the display, the cursor will remain unchanged.

**ESC C Cursor Right**
Moves the cursor 1 position to the right. If cursor is at the right most position, the cursor will remain at the end of the current line.

**ESC D Cursor Left**
Moves the cursor 1 position to the left. If cursor is at the left most position, the cursor will remain at the beginning of the current line.

**ESC H Home**
Positions the cursor at the lower left most position of the display.

**ESC J Erase to End of Screen**
Erase all characters from the current cursor position to the end of the display. The cursor will remain at the current position.

**ESC K Erase to End of Line**
Erase all characters from the current cursor position to the end of the current line. The cursor will remain at the current position.

**ESC Y (row) (col)**
Positions the cursor to anywhere on the screen by using single ASCII characters as defined below in Table 4-1. Absolute cursor positioning (row) and (col) are single ASCII characters as defined below:

Row = SP (HEX 20) to # (HEX 23)
Col = SP (HEX 20) to / (HEX 2F)

<table>
<thead>
<tr>
<th>ROW</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SP</td>
<td>!</td>
<td>&quot;</td>
<td>#</td>
<td>$</td>
<td>%</td>
<td>&amp;</td>
<td>'</td>
<td>(</td>
<td>)</td>
<td>+</td>
<td>-</td>
<td>.</td>
<td>/</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>SP</td>
<td>49</td>
<td>50</td>
<td>51</td>
<td>52</td>
<td>53</td>
<td>54</td>
<td>55</td>
<td>56</td>
<td>57</td>
<td>58</td>
<td>59</td>
<td>60</td>
<td>61</td>
<td>62</td>
<td>63</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>33</td>
<td>34</td>
<td>35</td>
<td>36</td>
<td>37</td>
<td>38</td>
<td>39</td>
<td>40</td>
<td>41</td>
<td>42</td>
<td>43</td>
<td>44</td>
<td>45</td>
<td>46</td>
<td>47</td>
</tr>
<tr>
<td>3</td>
<td>&quot;</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>21</td>
<td>22</td>
<td>23</td>
<td>24</td>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
<td>29</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>4</td>
<td>#</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>76</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 4-1

**Example:**

Before

After

**ESC Y \(\) \(\)**

The cursor will move to row 3, column 10.

**ESC Y sp -**

The cursor will move to row 1, column 14.
The HT/1000 provides a keyboard program mode through which the user may set up different parameters to run the HT/1000, such as Baud Rate, Parity, Etc. These parameters may be selected through the keyboard program mode or down line loaded. Parameters selected in this mode are permanently stored. The user starts the program sequence by holding down the shift left key and the carriage return key (CR) simultaneously at power up. The HT/1000 will display “Main Menu” on the top line and the following on the bottom line:

“COM DSP KBD EXT”

which are commands to get the user into various modes of programming.

These commands are as follows:

- **COM** HT/1000 Communications options (Baud, Parity, Etc.)
- **DSP** HT/1000 Display options (Flashing Char., Etc.)
- **KBD** HT/1000 Keyboard options (Auto Key Repeat, Etc.)
- **EXT** Exit the HT/1000 programming Mode and begin operation

The commands at the bottom of the display correspond to the function keys (F1-F4) that are at the top of the keyboard. Pressing F1 will perform the “COM” function, F2 will perform the “DSP” function and F3 will perform the “KBD” function. Pressing F4 will exit the programming mode and begin normal operation. Each of these functions will be discussed in detail starting with the COM option.

### 5.1 COM Communications

By pressing the COM (F1) function key the HT/1000 will display the first program of the communications option.

**“BAUD RATE”**

The HT/1000 will display the message “Baud Rate” on the first line of the display, the second line will display a value, which is the Baud Rate currently selected. The unit defaults to 1200 Baud and this will be the value when the unit is first powered up. The bottom line contains “PRV NXT SAV EXT”. These commands will select a value from the appropriate table in memory as follows:

- **PRV** Selects the previous value to be displayed.
- **NXT** Selects the next value to be displayed.
- **SAV** Permanently saves the value presently displayed. After the value is saved, the unit will step to the next mode to be programmed. If the HT/1000 is at the last function to be programmed the unit will return to the “Main Menu”.
- **EXT** Exits the mode that the user is currently in, saves the value displayed and returns to the main menu.

The unit is capable of implementing the following baud rates:

- 19,200
- 9600
- 4800
- 2400
- 1200
- 600
- 300
- 150

The Baud Rates are selected by using the “NXT” (F2) / “PRV” (F1) keys on the keyboard. If the user has stepped to 150 Baud the next “PRV” pressed will display “19,200” Baud, and if the user has stepped back to 19,200 Baud the next “NXT” will display “150” Baud.

**“PARITY”**

The HT/1000 will display the message “Parity” on the top line. The second line will contain the parity default value of “Even”. Parity is displayed by using the “NXT”/“PRV” function keys.

The unit is capable of implementing the following Parities:

- Even
- Odd
- Space
- Mark

If the user has stepped to mark parity the “NXT” will display “EVEN” parity and if the user has stepped back to even parity the “PRV” key will display “MARK” parity.
"MODE"

The HT/1000 will now display the message "MODE" on the top line and the default value of "NO ECHO" on the second line.

Mode assumes the following values -

**ECHO**  
Echo characters to the HT/1000 display as well as transmitting them to the host system. Normally used when host is in half duplex mode.

**NO ECHO**  
Do not echo characters to the HT/1000 display. Transmit only to the host and assume the host will transmit characters back to the HT/1000. Normally used when host is in full duplex mode.

"DISPLAY PARITY ERROR"  
- The HT/1000 will display the message "Display Parity Error" on the top of the display and the default value of "NO" on the second line.

"Display Parity Error" can assume the following values -

**YES**  
The unit will display "PE" when a Parity Error occurs, and will ignore character with Parity Error.

**NO**  
Does Not Display "PE" if parity was incorrect and displays the character received.

"AUDIBLE PARITY ERROR"  
- The HT/1000 will display the message "Audible Parity Error" on the top of the display and the default value of "NO" on the second line.

Audible Parity Error can assume the following values -

**YES**  
The unit will ring a bell for approximately 1/4 of a second when an error occurs.

**NO**  
Does not ring bell if parity is incorrect.

**NOTE:** Both "Audible Parity Error" and "Display Parity Error" can be selected at the same time. Thus, a user can hear as well as see the error.

5.2 DSP - - - Display Options

To enter this function, the HT/1000 has to be in the program mode and at the "Main Menu". This function is selected by pressing the F2 key while at the main menu. The HT/1000 will now go through the display functions. The first function is "Flashing".

"FLASHING"  
The HT/1000 will display "Flashing?" on the top of the display and the default value of "NO" on the second line. Flashing allows the user the option of flashing important messages and/or warning messages to the operator thus enabling the user to quickly notice any errors. Once flashing has been enabled all the user need do is bracket the statement transmitted to the HT/1000 as follows: precede the statement with the control character "SUB" (Control Z/Hex 1A) and end the statement with the control character "CAN" (Control X/Hex 18). All of the characters between "SUB" and "CAN" will now flash. The user can continuously flash the characters by never transmitting the "CAN" character from the host system.

Flashing cannot be enabled when the "Display Control Characters" option described below is selected.

Flashing can assume the following values:

**YES** - - Enable character flashing under the control of host CPU.

**NO** - - Does not flash characters

"DISPLAY CONTROL CHARACTERS"  
The HT/1000 will display the message "DSPLY CTRL CHARS" on the top line and the default value of "NO" on the second line. This option displays all ASCII control characters (HEX 00 to HEX 1F) as a flashing version of the equivalent keyboard character and (HEX 7F) as a left arrow. Therefore, an EOT (Control D/Hex 04) is displayed as a flashing D. The user can distinguish the difference from control characters and normal characters because the control characters will flash at a rate of approximately 2 HZ. This option has priority over the flashing characters option described in the last paragraph. That is, if "Flashing" was selected and display control characters was also selected, then "Display Control Characters" will be the only one used. This allows the user to differentiate between the two options.

"Display Control Characters" can assume the following values:

**YES**  
Enables "Display Control Characters" and disables flashing if it was selected. Flash any character below the HEX value of 1F received from the host. Do not perform CR, LF, etc.

**NO**  
Does not display control characters. Ignore all control characters except those that are executed by the HT/1000 i.e. LF, CR, BKSP, etc.

"SAVE DISPLAY"  
The HT/1000 will display the message "Save Display?" on the top line and default value of "NO" on the second line. This option, when enabled, will save what is currently on display when it is powered down. The display will be saved in the units battery backup memory. This option gives the user the ability to keep messages on the display overnight, over a weekend, etc. When the unit is powered up, the display that was saved will be redisplayed; if the option was not selected the display will be blank on power up.

Save Display can assume the following values:

**YES**  
Enable unit user to save the current display in battery backup memory.
NO --- Do not enable this option. The display is cleared on power up.

5.3 KBD --- Keyboard Operation

To enter this function the HT/1000 has to be in the program mode at the "Main Menu". This function is selected by pressing the F3 function key on the keyboard while at the "Main Menu". The HT/1000 will now go through the keyboard programming function with auto key repeat and is explained in detail as follows:

"AUTO KEY REPEAT" --- The HT/1000 will display the message "Auto Key Repeat" on the top of the display and the default value of "YES" on the second line. This option will allow the user to transmit a key as long as the key is depressed. Once a key is pressed, and after a ½ second delay, a character will be transmitted at a rate of 7 characters a second. The characters will continue to be transmitted until the key is released.

"Auto Key Repeat" can assume the following values:

YES --- Enables auto key repeat, allowing the user to transmit at 7 characters a second as long as the key is held down.

NO --- Does not allow user to continuously transmit; allows only single characters per keystroke.

"MAXIMUM AUTO REPEAT" --- The HT/1000 will display the message "Max Auto Repeat" on the top line of the display and the default value of "YES" on the second line. This option will allow a user to continuously transmit a character once a key is pressed. Once a key is pressed, the HT/1000 will begin transmitting the character under the key, there is no delay as in "Auto Key Repeat" before a key is transmitted. The key will transmit 40 characters a second for baud rates over 300, the unit transmits 15 and 30 characters per second for baud rates 150 and 300 respectively. The unit will continuously transmit until key is released.

"Max Auto Repeat" can assume the following values:

YES --- Enables "Maximum Auto Repeat". Begin transmitting at 40 characters per second with no delay.

NO --- Does not enable "Max Auto Repeat". Allows only single keystrokes.

NOTE: "Auto Key Repeat" and Maximum Auto Repeat are mutually exclusive options. The one that is last selected is the mode that is enabled.

"DISABLE KB SHIFT" --- The HT/1000 will display the message "Disable KB Shift" on the top line and the default value of "NO" on the second line. This option lets the user add three more keys (Control, Left Shift and Right Shift) to his keyboard. If this option is selected, the shifted characters above the keys (alpha and punctuation) cannot be used. (For ease of operator interface, the user may not want to use the shifted characters). The three keys are replaced with the following values:

SHIFT LEFT ---- A
SHIFT RIGHT ---- B
CONTROL KEY (CTRL) ---- C

(Refer to "Special Function Keys" section to help identify these Keys).

"Disable Shift" can assume the following values:

YES --- Disables the Keyboard shift, cannot use the alpha characters or punctuation marks above the keys. Use the default characters.

NO --- Allows shifting of the keyboard to obtain all ASCII characters.

"KEYBOARD AUDIO FEEDBACK" ----

HT/1000 will display the message "Audible Keys" on the top line and the default value of "NO" on the second line. This will let the user select the option of allowing the bell to ring each time a key is depressed.

Keyboard Bell can assume the following values:

YES --- Lets the bell ring when each key is pressed.

NO --- Does not allow bell to ring when each key is pressed.

5.4 "PROGRAM FUNCTION KEYS"

The HT/1000 will display "PGM Function Key" on the top line and "F1" on the second line. The user will also note that the bottom line of the display does not have a "SAV" function. This is because the save function has been moved to the second menu of this option and the user can only exit from this menu. "F1" corresponds to the first function key, "F2", the second function key, etc. The "YES" key that is displayed on the bottom of the display will allow the user to begin operation of programming the function keys. The "NO" key will increment the "F1" on the second line of the display. The "F1" will step to "F2", "F3" and "F4". When the display reads "F4" the next depression of the "NO" key will change the "F4" to an "F1". "Fx" corresponds to which function key the user wishes to program. F1 equals function key F1, F2 equals function key F2, etc. The "EXT" key will return the program to the "MAIN MENU" and the user can program another function or exit from there to the main program flow.

By pressing the "Yes" key, the HT/1000 will enter the function key programming mode. The display will now contain a flashing cursor on the top line, the function key RAM on the second line, 4 up-hats (>) on the third line and four commands on the bottom line. The flashing cursor indicates where the user will start to program the function key that was selected in the previous menu.

5-3
The second line displays all of the function key messages currently contained in the function key RAM. The third line contains a series of up-hats (\(\wedge\)) which are used as separators for each of the messages. The first function key message is between the start of the display and the first up-hat, the second message between the first and second up-hat, the third message between the second and third up-hat and the fourth message between the third up-hat and the fourth up-hat.

The bottom line contains two editing functions, a SAVE function and an EXIT function. The first two functions are used to edit the function key data the user is altering. "BSP" indicates to backspace a character for each key depression and "FSP" indicates to forward space for each key depression. The "SAVE" function will save the contents the user has input on the top line. The contents will be stored in the function key RAM from the first character input to the last character input. The data that remains from the last character to the end of the display will fill in the remainder of the function key RAM. Note that if the user inputs more characters then there is RAM available, the last message could be cut off. If the user inputs less characters then is available the remainder of the RAM will be filled in with either the remainder of the function key RAM or if there is no data in RAM then it will be filled with blanks.

The "EXIT" key will exit this menu and return to the "PGM Function Key" Menu and redisplay the function key "Fx" that was being programmed. The data that the user installed in the HT/100 will not be entered into the function key RAM. This allows the user to exit, if a mistake was made, without worrying if the function key was programmed with bad data.

When the user presses the "SAVE" key, the data displayed is the data saved. The program will return to the "PGM" Function Key" menu and the user can now program another function key or exit back to the main menu.

NOTE: If a key is not programmed it will assume its default values of:

- F1 = DC1 (HEX11)
- F2 = DC2 (HEX12)
- F3 = DC3 (HEX13)
- F4 = DC4 (HEX14)
DOWNLNLIE LOADING

Many options of the HT/1000 may be selected by downline loading of the proper sequence as described below. These options are permanently stored in memory when selected. They may be altered by downline loading at any time.

**Example: ESC(x) (Length) (chars) -- sets-up user definable function keys**

\[
\begin{align*}
\text{IF } x = 1 & \text{ then set-up function key } F1 \\
\text{ IF } x = 2 & \text{ then set-up function key } F2 \\
\text{ IF } x = 3 & \text{ then set-up function key } F3 \\
\text{ IF } x = 4 & \text{ then set-up function key } F4 \\
\end{align*}
\]

\[
\text{Length} = 1 \text{ to } 16 \text{ (16 is total combined characters for all four of the function keys; the length can be broken down to any combination under each of the function keys (F1 - F4) but the maximum is still 16 characters for all of the function keys. The length must be in Hex, (0 to F), with 0 representing 16 and 1 through F representing 1 through 15 respectively.}
\]

Chars = Characters (the message for that function key)  
The number of characters transmitted by each key is determined by the length.

Example: The following sequence will program function key F1 to be "TEST?"

**ESC 1 5 Test?**

Function key F1 will contain the characters "Test?".  
There will be 11 characters available for the rest of the function keys.

**Example:** The following sequence will program F1 thru F4.

\[
\begin{align*}
\text{ESC 1 5 TEST? ESC 2 2 NO ESC 3 3 YES ESC 4 8 TESTING?} \\
F1 = \text{"TEST?"} \\
F2 = \text{"NO"} \\
F3 = \text{"YES"} \\
F4 = \text{"TESTIN"}
\end{align*}
\]

Function key F4 contains only the first 6 characters from the original "TESTING?" as the letter "N" was the 16th character.

The default values of these keys can be found in the Section titled "Program Function Keys".

**ESC P (10 chars) Sets up communication options and other terminal features. The ten characters which follow ESC P control the terminal features as shown below:**

\[
\begin{align*}
\text{BAUD RATE} & = 2 \text{ Chars Defaults } 40 \\
\text{KEYBOARD MODE} & = 2 \text{ Chars Defaults } 01 \\
\text{DISPLAY} & = 2 \text{ Chars Defaults } 00 \\
\text{SPARE} & = 2 \text{ Chars Defaults } 00 \\
\text{COMMUNICATIONS} & = 2 \text{ Chars Defaults } 80 \\
\end{align*}
\]

**ESC P WWWXXYYYZZ**

**ESC P VVVVVVWWWWXXXYYYZZZ**

BAUD RATE KEYBOARD MODE DISPLAY SPARE COMMUNICATIONS LINE CONTROL

All of the ESC P characters must be programmed together. Unlike the function keys, they cannot be individually programmed.

**NOTE:** All values programmed are affected as soon as the characters are transmitted with the exception of Baud Rate, which becomes effective at the next Power Down/Power Up Sequence.

See Tables 1 through 4 in Appendix A for the character values to use for the desired options.

To program the keyboard, display, and communications values, refer to Appendix A.

The following is an example of a typical downloader instruction:

**EXAMPLE:** **ESC P 40012000C1**
This sequence will setup the unit for the following:

1200 BAUD
AUTO KEY REPEAT
NO ECHO
KEYBOARD SHIFT ENABLED
NO FLASHING CHARACTERS
CONTROL CHARACTERS DISPLAYED
ODD PARITY
NO AUDIO FEEDBACK
NO PARTY ERRORS DISPLAYED
AUDIBLE PARITY ERROR INDICATE
DISPLAY NOT SAVED
NO MAX AUTO REPEAT

*NOTE*: When initiating the downline loading command, both the host and terminal must be at the same baud rate and parity.
The HT/1000 performs three separate self tests at every powerup to verify integrity. These tests are a display test, a nondestructive internal memory test (to verify the microprocessor's memory is functional) and a ROM sum check test (to verify the unit has not lost any of its ROM Data). Each are described in detail as follows:

7.1 DISPLAY TEST - The HT/1000 runs a display test to verify that all of the dots are functional. The HT/1000 runs a series of characters through the display, the first is a pound sign (#) followed by an "M" and ending with the character "I". This requires a visual check by the user to verify that all of the dots are functional.

7.2 NONDESTRUCTIVE INTERNAL RAM TEST - The microprocessor contains 128 Bytes of internal RAM that is used for display buffering, flags, counters and function key messages. All of the RAM is utilized for this function and some of the memory cannot be changed once the unit has been programmed. During the self test the unit will read a Byte of data from RAM, complement it, write the data back to the same memory location, read the data back from the same location, complement it again and verify it against the original data for accuracy. The unit will store its original value at the same location, and reread it. The value should be the same. If the values ever differ from each other, the HT/1000 will display a memory error message on the display.

7.3 CHECKSUM TEST - The HT/1000 performs a sum check of the ROM that contains the program. This is done by reading each of the ROM locations and adding it to a register (the carry is not added). Once the addition is done the value is compared against the original value stored. If this value is different the internal memory of the ROM has been altered and the unit is not functioning properly. The HT/1000 will display a ROM checksum error if the unit fails this test.

After all of these tests are run and the unit detects no errors the unit will respond with a small flashing square in the lower left hand corner of the display. This is the HT/1000 cursor and normal operation can now begin.

7.4 RESET BUZZER - During the self test the HT/1000 buzzer will turn on. If it does not do this, or if it does not cease at the end of the self test, then consult the Trouble Shooting section in Appendix B.

**IMPORTANT:** To change the programmed options, the user must depress and hold CR and Shift Left Keys simultaneously through the self-test period. Otherwise, the unit will operate using the last set of options stored in memory.
8.1 BATTERIES:

A) Low Battery Indicator.

The normal cursor will change to a flashing LB character when batteries are in need of recharging or replacing. The alkaline cells should have about 10% of useful life at this time, while the rechargeable cells should have less than 5% of useful life left. Refer to figure 8.1 for battery life. Refer to Figure 8.2 for dimensions of the Battery charger.

One way to have longer battery operation is to install mercury cells. Available from Electronic distributors, they have about 40% longer operating life than alkaline cells. When the LB cursor appears they have less than 3% of useful life left. They are available as ZM9 from Duracell, E9 from Eveready, and T9 from Ray-O-Vac.

B) SHELF LIFE

The shelf life of a battery is drastically affected by storage temperature. However at normal room temperature, typical shelf life is as follows:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>TIME TO 90% CAPACITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALKALINE</td>
<td>4 years</td>
</tr>
<tr>
<td>MERCURY</td>
<td>2 years</td>
</tr>
<tr>
<td>NICKEL CADMIUM</td>
<td>2 weeks</td>
</tr>
</tbody>
</table>

NOTE
The high quality, industrial Ni Cad batteries have an expected life of 1000 charge/discharge cycles, and, in most circumstances, will not require replacement more often than every five years.

C) BACK UP BATTERY

There is an internal battery, not replaceable by users, that maintains information in the internal memory. This battery should have a typical useful life of about 10 years. Should the display ever show the message BAD BACKUP BATT, contact the factory for instructions.

WARNING

Use only the Termillex charger (P/N 51-0014-000), as it has been specifically designed to fulfill the requirements of the HT/1000. Use of any other may cause permanent damage to the HT/1000 and will void your warranty.
### 8.2 HT/1000 INTERFACE_THRESHOLDS

<table>
<thead>
<tr>
<th></th>
<th>INPUT</th>
<th></th>
<th>OUTPUT</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MARK</td>
<td>SPACE</td>
<td>MARK</td>
<td>SPACE</td>
</tr>
<tr>
<td>RS232</td>
<td>$-15.0 , \text{V to } +0.5 , \text{V}$</td>
<td>$+1.4 , \text{to } +15.0 , @ 2, \text{mA}$</td>
<td>$-5.0 , \text{to } -15.0 , \text{V}$</td>
<td>$+5.0 , \text{to } +15 , @ 3, \text{mA}$</td>
</tr>
<tr>
<td>RS422</td>
<td>$-0.20 , \text{V to } -6.0 , \text{V}$</td>
<td>$+0.2 , \text{to } +6.0 , @ 3, \text{mA}$</td>
<td>$-2.0 , \text{to } -5.0 , \text{V}$</td>
<td>$+2.0 , \text{to } +5.0 , @ 40, \text{mA}$</td>
</tr>
<tr>
<td>TTL</td>
<td>$0.0 , \text{V to } +0.5 , \text{V}$</td>
<td>$+1.4 , \text{to } +5.2 , @ 0.1, \text{mA}$</td>
<td>$+0.00 , \text{to } +0.7 , \text{V}$</td>
<td>$+2.4 , \text{to } +5.2 , @ 2, \text{mA}$</td>
</tr>
<tr>
<td>20mA C.L.</td>
<td>$5.0 , \text{to } 25, \text{mA}$</td>
<td>$0.0 , \text{to } 2.5, \text{mA} , @ 150, \text{V}$</td>
<td>$15 , \text{to } 25, \text{mA}$</td>
<td>$0.0 , \text{to } 2.5, \text{mA} , @ 150, \text{V}$</td>
</tr>
</tbody>
</table>

### 8.3 HT/1000 INTERFACE PIN ASSIGNMENTS

<table>
<thead>
<tr>
<th>CONNECTOR</th>
<th>MODULAR</th>
<th>DB 15 25 CIR</th>
<th>DB 15 25 CIR</th>
<th>RS-232</th>
<th>TTL</th>
<th>20mA C.L.</th>
<th>RS-422</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 BLU</td>
<td>7 7 7</td>
<td>GROUND</td>
<td>GROUND</td>
<td>GROUND</td>
<td>GROUND</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 YEL</td>
<td>2 2 2</td>
<td>XMIT DATA</td>
<td>XMIT DATA</td>
<td>LOOP OUT</td>
<td>XMIT DATA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 GRN</td>
<td>3 3 3</td>
<td>RECEV DATA</td>
<td>RECEV DATA</td>
<td>LOOP IN</td>
<td>RECEV DATA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 RED</td>
<td>4 4 4</td>
<td>TFX ROY</td>
<td>N/C</td>
<td>LOOP OUT RTN</td>
<td>XMIT DATA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 BLK</td>
<td>5 5 5</td>
<td>CLR TO SEND</td>
<td>N/C</td>
<td>LOOP IN RTN</td>
<td>RECEV DATA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 WHT</td>
<td>15 9 9</td>
<td>POWER</td>
<td>POWER</td>
<td>POWER</td>
<td>POWER</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For more information on RS-232-C or RS-422-A interfaces, refer to the respective Electronic Industries Association Standards.

Figure 8.3 HT/1000 Outline Drawing
8.4 MECHANICAL

- Weight: 24 oz. (680g)
- Cable Length: 6 feet (1.8m)
- Case Connector: 6 pin modular jack, AMP 520250-3
- Cable Connector: 25 pin, DB-25P

8.5 ENVIRONMENTAL

- Operating Temperature Range: 0°C to +50°C
- Storage Temperature Range: -20°C to +70°C
- Humidity: 95% non-condensing
- Intrinsic Safety: Contact Factory

8.6 PARITY

There are only four possible parities. They are commonly referred to as, Odd; Even; Mark; & Space, or Odd; Even; & bit, No parity; & 7 bit, No parity. Each set is identical and Termix literature conforms to the former nomenclature. A brief description of each type of parity follows:

a) ODD: The total number of bits set to a logical “1” in an ASCII character is examined. If it is odd, the parity bit is cleared (0). If it is even, the parity bit is set (1) thereby making the total number of “1”’s ODD.

b) EVEN: The total number of bits set to a logical “1” in an ASCII character is examined. If it is even, the parity bit is cleared (0). If the total is odd, the parity bit is set (1) thereby making the total number of “1”’s EVEN.

c) MARK: The parity bit is always set (1).

d) SPACE: The parity bit is always cleared (0).

The parity bit is the eighth or most significant bit in the data word as is illustrated in Fig. 8-4.

8.7 CABLE LENGTHS

When discussing cable lengths two different areas should be examined:

A) Power Cable
B) Communication Cable

A) The power cable’s length is limited primarily by the voltage drop per foot of the cable. Therefore, for the HT/1000, a typical drop per 1000 feet is as follows:

<table>
<thead>
<tr>
<th>Wire Gauge</th>
<th>Diameter</th>
<th>Voltage Drop/1000 Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 (19/34)</td>
<td>.67 mm</td>
<td>.70 V/1000 Ft. (304m)</td>
</tr>
<tr>
<td>24 (19/36)</td>
<td>.50 mm</td>
<td>1.05 V/1000 Ft. (304m)</td>
</tr>
<tr>
<td>26 (19/38)</td>
<td>.33 mm</td>
<td>1.72 V/1000 Ft. (304m)</td>
</tr>
</tbody>
</table>

Therefore if you are supplying power from 1000 feet away from the HT/1000 and using 24 gauge wire, you must supply a minimum of 5.8VDC at the source to meet the 4.75V min requirement of the HT/1000. (4.75V + 1.05V = 5.8V)

B) The communication cable’s maximum length is a function of interface, baudrate, and cable capacitance. Typical Values are listed below for 19.200 BPS.

<table>
<thead>
<tr>
<th>Interface</th>
<th>RS-232-C</th>
<th>RS-422-A (W/O termination resistance)</th>
<th>RS-422-A (termination resistance = 100ohm)</th>
<th>TTL</th>
</tr>
</thead>
<tbody>
<tr>
<td>20mA, C.L.</td>
<td>50 Ft</td>
<td>1000 Ft</td>
<td>4000 Ft</td>
<td>25 Ft</td>
</tr>
</tbody>
</table>

1) The 20mA, C.L. interface is also a function of compliance voltage and as such is listed in table 8-1.

![Figure 8-4](image_url)
### 2.0m A. C.L. Ideal maximum cable lengths at 19200 baud

<table>
<thead>
<tr>
<th>COMPLIANCE VOLTAGE</th>
<th>ALPHA #1178 22 GAUGE (.67mm) 7/30 22.6pt/lft</th>
<th>ALPHA #5016 24 GAUGE (5mm) 7/32 20.8pt/lft</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>875 (269m)</td>
<td>950 (292m)</td>
</tr>
<tr>
<td>20</td>
<td>215 (66m)</td>
<td>225 (69m)</td>
</tr>
<tr>
<td>45</td>
<td>95 (29m)</td>
<td>100 (31m)</td>
</tr>
<tr>
<td>145</td>
<td>25 (8m)</td>
<td>30 (9m)</td>
</tr>
</tbody>
</table>

**TABLE 8-1**

### NOTE

1) Compliance Voltage = Applied Voltage - Active Drops.

2) Recommended Usage of Interfaces.

The TTL interface is recommended for use in low noise environments where interconnections can be kept short.

RS-232-C Should be used where only short runs can be used but moderate noise immunity is required.

RS-422-A Can be used over long distances with high noise immunity.

20mA Current Loop can be used over long distances with very good noise immunity and the added advantage of electrical isolation.
# APPENDIX A

## TABLE 1 - BAUD RATE CHARACTER STRING

<table>
<thead>
<tr>
<th>BAUD RATE</th>
<th>CHARACTER STRING</th>
</tr>
</thead>
<tbody>
<tr>
<td>19200</td>
<td>00</td>
</tr>
<tr>
<td>9600</td>
<td>10</td>
</tr>
<tr>
<td>4800</td>
<td>20</td>
</tr>
<tr>
<td>2400</td>
<td>30</td>
</tr>
<tr>
<td>1200</td>
<td>40</td>
</tr>
<tr>
<td>600</td>
<td>50</td>
</tr>
<tr>
<td>300</td>
<td>60</td>
</tr>
<tr>
<td>150</td>
<td>70</td>
</tr>
</tbody>
</table>

## TABLE 2 - KEYBOARD OPTIONS CHARACTER STRING

<table>
<thead>
<tr>
<th>ECHO CHAR ENABLED</th>
<th>KB SHIFT DISABLED</th>
<th>KB AUDIO ENABLED</th>
<th>MAX KEY REPEAT</th>
<th>AUTO KEY REPEAT</th>
<th>CHAR STRING</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>01</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>02</td>
<td></td>
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<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>03</td>
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<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>89</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>8A</td>
<td></td>
<td></td>
</tr>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>8B</td>
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<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>8C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>8D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>8E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>8F</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A-1
### TABLE 3 - DISPLAY OPTIONS CHARACTER STRINGS

<table>
<thead>
<tr>
<th>FLASHING CHARS ENABLED</th>
<th>DISPLAY CONTROL CHARS ENABLED</th>
<th>SAVE DISPLAY ENABLED</th>
<th>CHAR STRING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>00</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td></td>
<td>08</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>X</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>X</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>X</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>X</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>X</td>
<td>A0</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>A8</td>
<td>18</td>
</tr>
</tbody>
</table>

### TABLE 4 - COMMUNICATIONS OPTIONS CHARACTER STRINGS

<table>
<thead>
<tr>
<th>TYPE OF PARITY</th>
<th>DISPLAY PARITY ERROR ENABLED</th>
<th>AUDIO PARITY ERROR ENABLED</th>
<th>CHAR STRING</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPACE</td>
<td></td>
<td>X</td>
<td>00</td>
</tr>
<tr>
<td>SPACE</td>
<td></td>
<td>X</td>
<td>01</td>
</tr>
<tr>
<td>SPACE</td>
<td>X</td>
<td></td>
<td>02</td>
</tr>
<tr>
<td>SPACE</td>
<td>X</td>
<td>X</td>
<td>03</td>
</tr>
<tr>
<td>MARK</td>
<td></td>
<td>X</td>
<td>40</td>
</tr>
<tr>
<td>MARK</td>
<td>X</td>
<td></td>
<td>41</td>
</tr>
<tr>
<td>MARK</td>
<td>X</td>
<td>X</td>
<td>42</td>
</tr>
<tr>
<td>MARK</td>
<td>X</td>
<td>X</td>
<td>43</td>
</tr>
<tr>
<td>EVEN</td>
<td></td>
<td>X</td>
<td>80</td>
</tr>
<tr>
<td>EVEN</td>
<td></td>
<td>X</td>
<td>81</td>
</tr>
<tr>
<td>EVEN</td>
<td>X</td>
<td></td>
<td>82</td>
</tr>
<tr>
<td>EVEN</td>
<td>X</td>
<td>X</td>
<td>83</td>
</tr>
<tr>
<td>ODD</td>
<td></td>
<td>X</td>
<td>C0</td>
</tr>
<tr>
<td>ODD</td>
<td></td>
<td>X</td>
<td>C1</td>
</tr>
<tr>
<td>ODD</td>
<td>X</td>
<td></td>
<td>C2</td>
</tr>
<tr>
<td>ODD</td>
<td>X</td>
<td>X</td>
<td>C3</td>
</tr>
</tbody>
</table>
APPENDIX B

TROUBLE SHOOTING

SYMPTOM

If there is no display or beep @ power-up ........................................ go to step 1
If beep @ power-up does not stop ....................................................... go to step 2
If display shows “Ram Error” ............................................................... go to step 2
If display shows “Rom Error” .............................................................. go to step 2
If display flashes “Bad Backup Battery” ................................................. go to step 2
If cursor remains a large black block .................................................. go to step 3
If interfacing equipment does not receive characters .......................... go to step 4
If unit doesn’t receive characters ....................................................... go to step 5
If display shows garbled message ....................................................... go to step 6
If display shows double characters .................................................... go to step 7
If beeper sounds or PE is displayed with incoming characters .......... go to step 8
<table>
<thead>
<tr>
<th>STEP</th>
<th>PROBABLE CAUSE</th>
<th>TO SOLVE</th>
<th>IF SOLVED</th>
<th>IF NOT SOLVED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bad power Connection</td>
<td>Operate Terminal on battery power</td>
<td>Check Power and ground connections and voltage level.</td>
<td>Go to 11</td>
</tr>
<tr>
<td>2</td>
<td>Bad Reset</td>
<td>Turn off power wait 5 sec., then turn on</td>
<td>Continue using terminal</td>
<td>Go to 11</td>
</tr>
<tr>
<td>3</td>
<td>No clear to send</td>
<td>Install a self-test connector (fig. 1.4)</td>
<td>Be sure pin 5 is high by either leaving it open or shorting 4 to 5</td>
<td>Check the connections on the HT/1000 connector.</td>
</tr>
<tr>
<td>4</td>
<td>Bad Xmit connections</td>
<td>Put terminal in local echo mode, check baud rate &amp; parity, then depress keys</td>
<td>Go to 11</td>
<td>If the Terminal displays characters but still does not transmit then go to step 9</td>
</tr>
<tr>
<td>5</td>
<td>Bad Recv. connections</td>
<td>Check parity &amp; baud rate. Send data from interfacing equipment</td>
<td>If terminal displays characters, continue using terminal</td>
<td>Go to step 9</td>
</tr>
<tr>
<td>6</td>
<td>Incorrect baud rate</td>
<td>Set baud rate &amp; parity to be compatible with interfacing equipment</td>
<td>Continue using terminal</td>
<td>Go to 11</td>
</tr>
<tr>
<td>7</td>
<td>Terminal is set for &quot;echo&quot; in a &quot;no echo&quot; application.</td>
<td>Set Terminal to &quot;no echo&quot; mode</td>
<td>Continue using terminal</td>
<td>Go to 11</td>
</tr>
<tr>
<td>STEP</td>
<td>PROBABLE CAUSE</td>
<td>TO SOLVE</td>
<td>IF SOLVED</td>
<td>IF NOT SOLVED</td>
</tr>
<tr>
<td>------</td>
<td>------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>----------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>8</td>
<td>Incorrect Parity</td>
<td>Set Parity of terminal to be compatible with interfacing equipment</td>
<td>Continue using terminal</td>
<td>Go to 11</td>
</tr>
<tr>
<td>9</td>
<td>Bad I/O connection</td>
<td>Install a self test connector, Fig. 1.4, depress keys</td>
<td>Go to 10</td>
<td>Check connections on the HT/1000 I/O connector</td>
</tr>
<tr>
<td>10</td>
<td>Bad I/O connections on interfacing equipment or incorrect control signals</td>
<td>If being used, check RTS, CTS, DTR on interfacing equipment. Voltage levels should be ±3 to ±15 VDC</td>
<td>Check I/O connections of all control signals and data lines. If 20 ma. current loop is being used, then check current loop sources.</td>
<td>Get control signals to the proper level by the use of jumpers.</td>
</tr>
<tr>
<td>11</td>
<td>Defective Equipment</td>
<td>Call Factory</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Model 70R
RS-232 C COMPATIBLE
TAPE CARTRIDGE SYSTEM
OPERATION MANUAL

0553525-0000   revA110983
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A-4 Power Board Output Connector Pinouts
A-5 Right Side of Interface Board
A-6 Configuration Switch Settings
1 - INTRODUCTION AND INSTALLATION

1.1 SCOPE OF MANUAL. This manual describes the Model 70R, RS-232 Compatible Cartridge Tape System manufactured by Digi-Data Corporation, 8580 Dorsey Run Road, Jessup, MD 20794. 70R Tape Systems consist of a cartridge drive and an interface board mounted in a desk-top chassis. This document describes each component of the 70R system with special emphasis on the RS-232 interface board. After a general description of the equipment and directions for installation, this manual explains all relevant RS-232 I/O signals, 70R tape format and all tape operations. This manual then describes the protocol for issuing commands from the computer and receiving status from the board, and replace the individual components.

1.2 REFERENCE DOCUMENTS. The following documents include more information about aspects of system operation which this document does not describe in detail.

Cartridge Drive Operation Manual, Digi-Data Corporation.

Unrecorded Magnetic Tape Cartridge for Information Interchange, 0.250 inch (6.30 mm), 1600 bpi (63 bpsm), Phase Encoded, ANSI No. X3.55-1977.

EIA RS-232-C -- Interface between data terminal equipment and data communication equipment employing serial binary data interchange.

1.3 DESCRIPTION OF EQUIPMENT.

1.3.1 CARTRIDGE DRIVE. The cartridge tape drive reads and records high density data on cartridges mechanically conforming to ANSI X3.55-1977. (Note that 70R Systems accept 450" and 555" cartridges as well as the 300-foot cartridge described in this specification.) Data is recorded serially on four tracks. For more detailed information, including specifications, recording codes and maintenance procedures, see the cartridge drive operation manual.

1.3.2 DESK TOP CHASSIS. The desk top chassis contains the power supply for the cartridge drive. The drive mounts on the chassis front panel. The front panel also contains the cartridge loading slot, three indicator lights and one pushbutton Rewind switch. The indicators connect to the cartridge drive Options Connector and are described briefly below. (See the cartridge drive manual for a pinout of the Options Connector and complete descriptions of all of the signals.)

1) SELECT: This indicator lights when the cartridge drive is selected (i.e. being addressed).

2) BOT: This indicator lights when the loaded cartridge is physically positioned at or before the Load Point Sensor (LPS) tape hole (logical BOT). (See the cartridge drive manual for more information on cartridge format and tape zones.)

3) SAFE: This indicator lights when the SAFE switch on the loaded cartridge is in the file protected position, thus preventing writing or erasing.

1.3.3 RS-232 INTERFACE BOARD. The RS-232 interface board is microprocessor controlled. It enables the cartridge drive to communicate with a computer or other controller via a standard EIA RS-232 interface port. The interface board decodes serial input sequences to generate the appropriate cartridge drive command lines, and encodes cartridge drive status lines to communicate the required information to the host over the serial line. The board also formats data records as described in chapter 3 of this manual and generates or checks parity on all data bytes. During data transfers, incoming data is loaded into a record-sized buffer until the entire record has been transmitted. The interface board then transfers the data to the cartridge drive, which records it on tape.

In addition to the microprocessor, the design includes 49 integrated circuits. Switch-selectable setups include parity (odd, even, or none), number of stop bits (1, 1.5, or 2), and baud rate (75 to 19200 baud or external clocking to 175K baud).

1.4 INSTALLATION. 70R Tape Systems are shipped already configured to your order. To install the system, simply attach a standard RS-232 cable to the I/O at the back of the chassis (upper right hand corner) and plug in the power cord. If you wish to change any of the options at any time, see Appendix A, figure A-6.
1.5 SPECIFICATIONS.

Operating Environment

40° to 115° F (5° to 45°C) (cartridge limited)
Altitude to 10,000' (3000m)
20% to 80% Relative Humidity (non-condensing)

System Size

5.2 in (13.2 cm) H x 8.95 (22.7) W x 14.7 (37.3) D

System Power Requirements

99 to 132 VAC @ 1.5 A or
198 to 264 VAC @ .75 A;
49 to 400 Hz

Cartridge Drive

4 track serial:
Unidirectional (6410/8310) or
Bidirectional (6420/8320);
6400 bpi IMFM (6410/6420) or
8333 bpi IMFM (8310/8320)

Tape Format

Transfer Rate

Up to 192K bits per second (64xx Series drives)
Up to 312.5K bits per second (83xx Series drives)

Interface Board

Controller to Interface:

True (0) = +3 to -25 VDC
False (1) = -3 to -25 VDC

Interface to Cartridge Drive

True = 0.0 to +0.6 VDC
False = +2.5 to +5.0 VDC

Interface, internal

True = +2.5 to +5.0 VDC
False = 0.0 to +0.7 VDC

Power

+5 VDC @ 2.5A max.
+18 VDC @ 50mA max.
-18 VDC @ 50mA max.
2 - RS-232 INTERFACE

2.1 INTRODUCTION. The RS-232 serial interface transfers data and control signals between the tape system and a host computer or modem. This chapter describes the physical and electrical characteristics of the serial interface, defines relevant signals, and describes RS-232 data format. It also explains cabling both directly to a host computer and to a modem.

2.2 INTERFACE CONVENTIONS. All Digi-Data 70R Tape Systems are fully RS-232 compatible. The interface cable connects to the tape system via a standard 25 pin D-subminiature female connector with all relevant signals located on the proper pins. See figure 2-2.

True (Space, or binary 0) is indicated by +3 VDC to +25 VDC; false (Mark, or binary 1) is indicated by -3 VDC to -25 VDC.

RS-232 transfers data asynchronously and therefore requires an accurate clock. Baud rates may be set on the board or the host can supply an external clock via the RXC and TXC lines. Figure 2-1 illustrates the proper data format. The default state for the data lines is Mark. To signal the beginning of a data character, a single Start bit (Space) at the appropriate baud rate precedes the data. On the eight bit cycles following the Start bit come the eight data bits in the byte, least-significant-bit (LSB) first. If selected, a parity bit follows the most-significant-bit (MSB) of the byte. After the last bit of the byte, whether parity or the MSB, the data line returns to the Mark state for one, one-and-one-half, or two cycles; these cycles are called the Stop bits. Another Start bit precedes the next data byte or, after the last byte of the record, the line remains high.

2.3 CABLES. Shielded data cables must be provided by the user in Radio-Frequency Interference (RFI) sensitive applications. The shield braid of the cable should be attached to the chasses through the jack screw connection at each end of the cable.

70R Tape Systems will use different cables depending on whether they are connected directly to the host computer or to a modem. The two types of cables are described below.

2.3.1 DIRECT CABLES. When cabled directly to a computer 70R Tape Systems only require three I/O signals: Signal Ground, Transmitted Data and Received Data. Note that Transmitted Data from each component must be connected to Received Data from the other. This will require cross-wiring the connector if your system does not perform the crossover internally. If it does, straight-through cables similar to those used with modems will be required. Protective Ground may be connected (depending on applicable safety specifications) but has no effect on the interface. If your system is configured for an external clock, RXC and TXC must also be connected. RXC (External Receiver Clock) and TXC (External Transmitter Clock) are generated by the host system. They clock data at a rate of one clock per bit. Data must be valid on the rising edge of the clock. See figures 2-2 and 2-3.

2.3.2 MODEM CABLES. Modem cables are wired straight-through with no cross-wiring since the modem performs all crossovers internally. The cable must include Transmitted Data, Received Data, Signal Ground, Request to Send, Clear to Send, Data Set Ready, Received Line Signal Detector and Data Terminal Ready. See figure 2-2.

![Figure 2-1, Data Format](image)

Figure 2-1, Data Format

2 - 1
NAME: Protective Ground   PIN: 1   EIA NAME: AA   DIRECTION: Common   USAGE: All
REMARKS: Provides the interface with Protective Ground which is attached to the desk top chassis and the power cord ground as a safety feature to prevent shock.

NAME: Transmitted Data (TD)   PIN: 2   EIA NAME: BA   DIRECTION: Output   USAGE: All
REMARKS: Outputs data from the interface board. It is in the Mark state when no data is being transmitted.

NAME: Received Data (RD)   PIN: 3   EIA NAME: BB   DIRECTION: Input   USAGE: All
REMARKS: Inputs data to the interface board. It is in the Mark state when no data is being received.

NAME: Request to Send (RTS)   PIN: 4   EIA NAME: CA   DIRECTION: Output   USAGE: Modem
REMARKS: Signals to the modem that the interface has data ready for transmission. The modem should respond with CTS when prepared to receive data from the interface.

NAME: Clear to Send (CTS)   PIN: 5   EIA NAME: CB   DIRECTION: Input   USAGE: Modem
REMARKS: Indicates to the interface that the modem is ready to receive data. The interface board will not transmit data unless CTS is true. If CTS is dropped in the middle of a transmission, the interface will finish transmitting the current character and then stop transmission.

NAME: Data Set Ready (DSR)   PIN: 6   EIA NAME: CC   DIRECTION: Input   USAGE: Modem
REMARKS: Indicates that the modem has established a telephone connection. The interface board will not transmit or receive data when DSR is false.

NAME: Signal Ground   PIN: 7   EIA NAME: AB   DIRECTION: Common   USAGE: All
REMARKS: Establishes the common reference ground for all RS-232 signals. It is connected to the tape system power supply; it is also connected to Protective Ground.

NAME: Rec'd Line Signal Detector (RLSD)   PIN: 8   EIA NAME: CF   DIR: Input   USAGE: Modem
REMARKS: Indicates that the modem is ready to transmit data to the interface. The interface board will not accept data if this signal is false. Also known as Data Carrier Detect (DCD). The interface should respond with DTR.

NAME: External Transmitter Clock (TxCl)   PIN: 15   EIA NAME: DB   DIR: Input   USAGE: All
REMARKS: Clocks TD when the baud rate switches are set for external clocking. TxC is generated by the device receiving the data. The clock rate equals the baud rate. Data is shifted out on the mark-to-space transition of each pulse.

NAME: External Receiver Clock (RxCl)   PIN: 17   EIA NAME: DD   DIRECTION: Input   USAGE: All
REMARKS: Clocks RD when the baud rate switches are set for external clocking. RxCl is generated by the device transmitting the data. The clock rate equals the baud rate. Data is shifted in on the mark-to-space transition of each pulse.

NAME: Data Terminal Ready (DTR)   PIN: 20   EIA NAME: CD   DIRECTION: Output   USAGE: Modem
REMARKS: Indicates to the modem that the interface is ready to receive data. DTR comes true in response to RLSD.

Figure 2-2, 70R Interface Connector Signals
Figure 2-3, Data/Clock Timing
3 - TAPE OPERATIONS

3.1 INTRODUCTION. This chapter describes all 70R tape operations. It discusses tape and record format, then explains the sequence of events in each operation. (For more information on these operations at the drive level, see the Cartridge Drive Manual. For information on the cartridge's specifications, see ANSI Specification no. X3.55-1977.)

3.2 RECORD FORMAT.

3.2.1 DATA RECORDS. See figure 3-1 during the following discussion of data record format.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREAMBLE + PRESYNC</td>
<td>Five $8$ hex bytes followed by $8$ hex byte</td>
</tr>
<tr>
<td>SYNC BYTE</td>
<td>FF hex</td>
</tr>
<tr>
<td>RECORD TYPE BYTE</td>
<td>22 hex = Data</td>
</tr>
<tr>
<td>DATA</td>
<td>Number of bytes determined by record length given in MA</td>
</tr>
<tr>
<td>LRCC BYTE</td>
<td>Even parity bit-wise of data</td>
</tr>
<tr>
<td>RECORD TYPE BYTE</td>
<td>22 hex = Data</td>
</tr>
<tr>
<td>POSTAMBLE SEQUENCE</td>
<td>$1$ hex byte followed by five $8$ hex bytes</td>
</tr>
</tbody>
</table>

1.25" nominal (1.2" Minimum) Interrecord Gap

Figure 3-1, Data Record Format

All records begin with a preamble. The preamble enables the read circuits to synchronize on the data before decoding. 70R preambles consist of five $8$ hex bytes followed by $8$ hex. All bytes, including data, are recorded least-significant-bit first, followed by an even parity bit. After the preamble, the software records the Sync Byte (FF hex) and the Record Type Byte (22 hex for data records or 55 hex for filemarks).

Immediately following the record type byte comes the data. The number of bytes in the data block is specified in the Mode Argument (MA). See paragraph 4.3.1. Note that the MA must specify a quantity less than or equal to the length of the buffer on the interface board or data errors will result. See the descriptions of Read and Write operations below for more details.

The Longitudinal Redundancy Check Character (LRCC) byte follows the data. The LRCC is formed from the even horizontal parity of bits $0$ to $7$ of each byte in the data portion of the record (i.e., the even parity of bit $7$ in each data byte is bit $7$ in the LRCC, the even parity of bit $6$ in each data byte is bit $6$ of the LRCC, etc.). Only data bytes are used to calculate the LRCC; the Preamble, Record Type byte and Sync bytes are ignored. Note that although the LRCC will contain a parity bit, this bit is generated from the vertical parity of the LRCC itself rather than from the horizontal parity of all the data parity bits. When writing, the LRCC is generated in software before actually writing the data. During read or read-after-write operations, the LRCC is regenerated in hardware and compared to the LRCC recorded on tape.

After the LRCC, the Record Type Byte (22 hex) is repeated, followed by the postamble ($1$ hex followed by five $8$ hex bytes).

3.2.2 FILEMARKS (EOF RECORDS). End-Of-File records begin with the same preamble and Sync Bytes as data records. They continue with a Record Type Byte (55 hex), followed immediately by a postamble identical to that of data records. See figure 3-2.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREAMBLE + PRESYNC</td>
<td>Five $8$ hex bytes followed by $8$ hex byte</td>
</tr>
<tr>
<td>SYNC BYTE</td>
<td>FF hex</td>
</tr>
<tr>
<td>RECORD TYPE BYTE</td>
<td>55 hex = Filemark</td>
</tr>
<tr>
<td>POSTAMBLE SEQUENCE</td>
<td>$1$ hex byte followed by five $8$ hex bytes</td>
</tr>
</tbody>
</table>

1.25" nominal (1.2" Minimum) Interrecord Gap

Figure 3-2, Filemark Format
3.2.3 RECOMMENDED TAPE FORMAT. Most 70R operations do not require a special tape format (legal recording area, etc.). The Off Line Copy operation, however, requires two consecutive filemarks at the end of data on each track. If the filemarks are missing, causing an abort. We therefore recommend that you perform two Write File Mark operations immediately after writing data records to tape. If you wish to add more data to a track after Copy operation will not find the data following the second filemark. We also recommend initializing tapes by writing two filemarks on the beginning of each track before performing any operations. When you wish to record a track, start at the beginning and overwrite the track does not contain data and does not begin with two filemarks, the Off Line Copy operation will abort.

Note that although they are not required, following these conventions also facilitates Record Search Under Mask and Space Forward Records operations.

3.3 TAPE OPERATIONS. This section describes the sequence of events for each tape operation performed by the 70R Tape System. It focuses especially on the signal flow to and from the interface board.

3.3.1 READ OPERATIONS. The read operation reads a block of data from tape and transmits it to the host. The length of the block is encoded in the Mode Argument (MA). See paragraph 4.3.1. The RS-232 interface board takes the record sent by the cartridge drive, strips off data into its buffer. When the entire record has been loaded, the interface transmits the Drive Status (DS) and Interface Status (IS) bytes to the host (see section 4.4), followed by the data.

If the record on tape is an EOF, the interface does not transfer any data. It signals the host that it has read a filemark by setting bit 6 of the DS byte true. See paragraph 4.4.1.

If the actual length of the record is not the length indicated in the MA, the interface will not transfer any data. It will end the operation and inform the host of the error by setting the Command Status bits in the IS byte (bits 5 and 4) to abort (19).

If an error occurs during a read operation, the interface will backspace over the error record and attempt to reread it. If the reread is successful, the interface ends the operation normally. If the reread is unsuccessful, the interface will keep trying to read the record correctly. If after a total of 10 attempts read errors still occur, the interface will end the operation and inform the host of the error by setting the Command Status bits in the IS byte (bits 5 and 4) to abort (19).

3.3.2 WRITE OPERATIONS. Write operations transfer data from the host to tape. The length of the block is encoded in the Mode Argument (MA). See paragraph 4.3.1. The RS-232 interface board loads the incoming data from the host into an on-board buffer. When the entire data block has been loaded, the interface board formats it as described in paragraph 3.2.1 and transmits it to the drive, which records it on tape.

The read circuitry in the system is still active during write operations. The interface uses the read-after-write data to check that the record was written correctly. As the read data comes from the drive, the interface regenerates the LRCC in hardware. It also checks the parity bits and monitors the DAD (Data Detected) line from the cartridge drive for dropouts. (DAD envelops the read data; if a dropout occurs, DAD will go false. See the cartridge drive manual for more information.) At the end of the record, if there were no LRCC or parity errors and no dropouts, the interface ends the operation and sends the Drive Status (DS) and Interface Status (IS) bytes to the host. See section 4.4. If an error is detected and if the auto-rewrite on error facility is enabled (i.e., if bit 5 of the Command Argument is 0; see paragraph 4.3.3), the drive will backspace over the error record, erase three inches of tape (thereby erasing the error record), and attempt to write the record again. If the rewrite contains an error, the drive backspaces, erases an additional three inches of tape, and tries a third time. The system will rewrite the record up to 10 times. If errors still persist, the system will abort the operation and send the DS and IS bytes to the host. The Command Status bits in the IS byte (bits 5 and 4) will indicate an abort (19). If any of the write attempts is successful, the operation will end normally.

If a write error occurs but bit 5 of the Command Argument (CA) is set, thus disabling the auto-rewrite on error, the interface will terminate the operation after the first attempt and indicate an abort in the Command Status bits of the IS byte (i.e., bits 5 and 4 will be set to 19).
If the number of bytes to be transferred exceeds the length of the buffer on the RS-232 interface board, the drive will write all of the characters in the buffer on tape. It will then append the data block with FF hex until the number of bytes specified in the Mode Argument are recorded. This will cause a read-after-write error: the LRCC on tape was generated from the entire data block (buffer length plus the excess data), but the LRCC generated during reading is from the buffer-length data plus the FF “padding”.

Note that when reading the record on tape, the record length in the MA of the read operation must equal the record length in the MA of the write operation that wrote that record. We recommend using a constant record length for all data transfer operations to help prevent aborts due to faulty MAs. Also, if it is necessary to edit a record (i.e. to rewrite a record in the middle of other records without disturbing the surrounding data), keeping the record length constant will help prevent the edit operation from disrupting the following record. (Note that when editing, bit 5 of the CA should be set to disable the auto-rewrite on error.)

3.3.3 WRITE FILE MARK. Write File Mark operations write an End-Of-File record on tape. The file marks are generated in software on the RS-232 interface board, so no write data is transferred from the host.

To enable the Off Line Copy operation to function properly, two file marks must be written at the end of data on each track (and at the beginning of unrecorded tracks) as described in paragraph 3.2.3, Tape Format. To facilitate this, the Write File Mark command may be executed after the EOS bit (DS bit) is set. Note that if you write consecutive EOF records in the middle of a track, the Off Line Copy operation will not copy anything beyond the second file mark. See paragraph 3.3.8.

3.3.4 SPACE RECORDS. The Space Records operations move the tape in the specified direction (forward or reverse) over a number of records equal to the value stored in the Positional Argument (PA) plus 1. That is, the PA range is 0 to 255; the number of records spaced is 1 to 256. If an EOF record is encountered while spacing, the operation terminates and the Command Status bits of the Interface Status (IS) byte (bits 5 and 4) indicate an abort (10). If you follow the tape format described in paragraph 3.2.3, the Space Forward Records operation will abort normally at the end of each track since the drive will encounter a filemark. Otherwise, the drive will continue spacing to the EOT tape hole (or the BOT tape holes on tracks 2 and 4 of bidirectional [or serpentine] drives; see the cartridge drive manual). When the drive reaches EOT (BOT), it will halt immediately and the drive's BUSY signal to the interface board will go false. This will terminate the operation and set the Command Status bits of the IS byte to Abort.

3.3.5 SPACE FILES. These operations are identical to the corresponding Space Records operations except that they space over file marks rather than records. These operations obviously do not abort on EOF. If the drive reaches EOT (BOT if bidirectional), it will halt immediately and the drive's BUSY signal to the interface board will go false. This will terminate the operation and set the Command Status bits of the Interface Status (IS) byte (bits 5 and 4) to Abort (10).

3.3.6 HIGH SPEED SPACE OPERATIONS. These operations are identical to the corresponding low speed operations except that they are executed at high speed. During High Speed Space Records operations, if the PA equals 0, 1 or 2 (i.e. the drive is to space 1, 2 or 3 records), the interface will automatically execute the operation at low speed. All High Speed Space Files operations are performed at high speed, however. Note that if the system encounters an EOF while performing a High Speed Space Records operation, it will abort. Since the deceleration ramp is longer for high speed than for low speed, the drive will overshoot the interrecord gap into the next tape record. Therefore, whenever a High Speed Search Records operation is aborted because of a filemark, we recommend performing a low speed space file operation in the opposite direction to position the tape properly before proceeding.

3.3.7 SEND CURRENT STATUS. This operation causes the interface to send Drive Status (DS) and Interface Status (IS) bytes to the host as soon as the selected cartridge drive is ready. If this operation is commanded with bit 6 of the Command Argument (CA) set, the drive will rewind and halt at EOT before the interface sends the Status Words.

3.3.8 OFF LINE COPY. The Off Line Copy operation makes a duplicate of a cartridge. You must have two daisy-chained cartridge drives (see the cartridge drive manual) to perform this operation. The source drive must be addressed as unit 1 and the destination drive as unit 2.

When the operation begins, the interface reads the first record on track 1 of the source tape. It checks the length of this record and assumes that all subsequent records will be the same length. The interface then writes the record to drive 2 and reads the next record from drive 1. It copies this record to drive 2, and repeats the procedure until it encounters a file mark.
When the interface detects a file mark on the source tape, it performs a Write File Mark operation to drive 2, then reads the next record on the source tape. If this is a data record, it is copied normally. If it is a second file mark, however, the interface assumes that the two file marks indicate the end of a track. After writing a second file mark on drive 2, the interface increments the track on drive 1 and performs a rewind-then-read operation. When this record is stored, it increments the track on drive 2 and performs a rewind-then-write operation. The Off Line Copy then continues normally on the new track.

When the drive reaches two consecutive file marks on track 4, it rewinds both tapes and ends the operation.

The reread-on-error (paragraph 3.1.1) and rewrite-on-error (paragraph 3.1.2) facilities are usually both active during Off Line Copy. (If bit 5 of the Command Argument (CA) is set, the rewrite-on-error facility is disabled.) Note that if there is a write error, the three inch erased gap produced during the rewrite procedure may push drive 2 past the EWS tape hole before drive 1 passes EWS. If this should happen, when drive 1 attempts to copy the next data record to the same track, an illegal command will occur (a write operation while EWS is true), terminating the Off Line Copy operation.

3.3.9 RECORD SEARCH UNDER MASK. This operation searches the tape for a file beginning with a particular data pattern. This data pattern, or mask, may be up to 512 bytes long. If the mask is less than the full 512 bytes, the end of the mask must be marked with 3F hex. (Note that if this byte is used within the mask the interface board will interpret it as the end of the sequence and will ignore subsequent characters.) The mask is sent to the interface board immediately following the Command Argument (CA) and is loaded into the interface board buffer. Note that ASCII question marks (3F hex) are "wildcards"; they match any other single character.

The interface begins reading the tape (after rewinding if bit 6 of the CA is set) and loading each record into the read data buffer. It compares the first bytes of each record with the mask. If the loaded record does not begin with the mask bytes, it is flushed and the next tape record loaded. When a record is found that does begin with the mask, that record is transmitted to the host as in a read operation. After transmitting the record, the interface ends the operation. Note that if several records begin with the mask bytes only the first record encountered will be identified and transferred during this operation. If a file mark is encountered before finding a matching record, the operation ends and the Command Status bits in the Interface Status (IS) byte (bits 5 and 4) are set to Abort (10).
4 - COMMUNICATING WITH THE 70R TAPE SYSTEM

4.1 INTRODUCTION. This chapter explains how the host and the 70R Tape System interact. Section 4.2 gives an overview of the system I/O sequence during tape operations. Sections 4.3 and 4.4 describe the Input (Command) and Output (Status) Words in detail. See the cartridge drive manual for a description of the drive to interface board I/O.

4.2 I/O SEQUENCE. The operation begins with a one or three byte input sequence plus write data when appropriate. Three byte protocol consists of the Mode Argument (MA) which specifies the data record size, the drive selection, and the track selection; the Positional Argument (PA) which specifies the count to be used by space commands; and the Command Argument (CA) which is the actual instruction. Each of these bytes is described in detail in section 4.3. One byte protocol, consisting only of the CA, may be used when the MA and PA remain the same as in the preceding operation. The interface uses bit 7 of the first byte to arrive to determine whether the command follows three byte or one byte protocol: if the bit is a 1, then the input follows three byte protocol since bit 7 of the MA is always 1; if the bit is a 0, the input follows one byte protocol since bit 7 of the CA is always 0.

During Write and Search Under Mask operations, the host sends the input data immediately following the CA.

The host awaits the interface's response after sending the command sequence and data (if required). When the drive completes the tape operation, the interface sends the two Status Words: Drive Status (DS) which reports the status of the currently selected drive; and Interface Status (IS) which reports the command status, and the currently selected drive and track. These two words are described in detail in section 4.4.

After successful Read and Search Under Mask operations, the read data follows the IS byte.

4.3 INPUT (COMMAND) WORDS. This section defines each bit of the three Input (Command) Words accepted by the RS-232 interface board. The bytes are transmitted with bit 0 (least-significant-bit) first.

4.3.1 MODE ARGUMENT (MA).

<table>
<thead>
<tr>
<th>Bit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Must be 1 to distinguish 3 byte protocol from 1 byte protocol (CA begins with 0)</td>
</tr>
<tr>
<td>6</td>
<td>Data Record Size*</td>
</tr>
<tr>
<td>5</td>
<td>0000 = 1024 bytes</td>
</tr>
<tr>
<td>4</td>
<td>001 = 2048</td>
</tr>
<tr>
<td></td>
<td>010 = 3072</td>
</tr>
<tr>
<td></td>
<td>011 = 4096</td>
</tr>
<tr>
<td></td>
<td>100 = 8192</td>
</tr>
<tr>
<td></td>
<td>101 = 512</td>
</tr>
<tr>
<td></td>
<td>110 = 8208</td>
</tr>
<tr>
<td></td>
<td>111 = 3630</td>
</tr>
<tr>
<td>3</td>
<td>Drive Selection</td>
</tr>
<tr>
<td>2</td>
<td>00 = Drive 1</td>
</tr>
<tr>
<td></td>
<td>01 = Drive 2</td>
</tr>
<tr>
<td></td>
<td>10 = Drive 3</td>
</tr>
<tr>
<td></td>
<td>11 = Drive 4</td>
</tr>
<tr>
<td>1</td>
<td>Track Selection</td>
</tr>
<tr>
<td></td>
<td>00 = ANSI track 1</td>
</tr>
<tr>
<td></td>
<td>01 = ANSI track 2</td>
</tr>
<tr>
<td></td>
<td>10 = ANSI track 3</td>
</tr>
<tr>
<td></td>
<td>11 = ANSI track 4</td>
</tr>
</tbody>
</table>

*Must be less than or equal to interface buffer length or errors will result.

4.3.2 POSITIONAL ARGUMENT (PA).

<table>
<thead>
<tr>
<th>Bit 7 - 0</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Used for Space commands. Contains one less than the number of files or records to be spaced -- values 0 to 255 correspond to 1 to 256 files or records.</td>
</tr>
</tbody>
</table>
4.3.3 COMMAND ARGUMENT (CA).

Bit
7 Must be 0.
6 1 = drive rewinds before executing operation;
   0 = drive executes operation from current tape position.
5 1 = Edit mode (disable auto-rewrite on error)
   0 = Standard mode
4 Reserved (may be either 0 or 1).
3-0 Commands

0000 Rewind if Bit 6 = 1;
     Retransmit block if Bit 6 = 0
0001 Read
0010 Write
0011 Write File Mark
0100 Space Forward Records*
0101 Space Forward Files
0110 Space Reverse Records*
0111 Space Reverse Files
1000 Send Current Status
1001 Off Line Copy
1010 Undefined, sets Illegal Command status (see paragraph 4.4.2)
1011 Record Search Under Mark*
1100 High Speed Space Forward Records*
1101 High Speed Space Forward Files
1110 High Speed Space Reverse Records*
1111 High Speed Space Reverse Files

*Aborts on File Mark

4.4 OUTPUT WORDS. This section defines each bit of the two Output (Status) Words transmitted by the RS-232 interface board. The bytes are transmitted with bit 0 (least-significant-bit) first.

4.4.1 DRIVE STATUS (DS). All bits are high true.

Bit
7 Always 1.
6 File Mark detected.
5 Drive rewinding.
4 Power On and Cartridge in Place.
3 BOT (Tape is positioned at logical Beginning of Tape).
2 EWS (Early Warning Sensed). Indicates that the cartridge is positioned at or beyond the first Early Warning tape hole. Only Write File Mark, Rewind, or Space Reverse operations may be started when this bit is set.
1 FLAG. Indicates that the tape has been rewound since the last operation.
0 Write Enabled. This indicates that the tape is not "SAFE" (not File Protected), thus permitting write operations.
4.4.2 INTERFACE STATUS (IS).

Bit
7 Always 1
6 1 = Data follows
   0 = No data follows
5 Command Status
   00 = Successful operation
   01 = Illegal Command*
   10 = Abort**
   11 = Syntax or Parity Error
4
3 Current Drive
   (Should parallel MA bits 3 and 2)
2
1 Current Track
   (Should parallel MA bits 1 and 0)
0

*Illegal commands include:
1) Space Reverse at EOT or Space Forward at EOT
2) Any write operation on a File Protected cartridge
3) Forward operation (except Write File Mark) past EWS tape hole***
4) Any operation to a drive without a cartridge installed
5) Setting CA bits 3 - 0 equal to 1010

**Abort indicates that a legal command was loaded and execution begun, but
some error caused it to end prematurely. Since tape may have moved
before the operation was rejected, unless you know the exact reason for
the abort and are certain of the tape position, the next command should
be executed relative to EOT (i.e. CA bit 6 = 1).

***Note that if the drive should ever reach true EOT due to a series of re-
written filemarks, no more forward motion will be performed whether a
complete EOF record is written or not. This situation generates an
abort condition.
APPENDIX A - TROUBLESHOOTING AND COMPONENT REPLACEMENT

A.1 INTRODUCTION. This appendix explains how to remove and replace the major components in the desk top chassis. See the cartridge drive manual for further information on servicing the drive.

A.2 OPENING THE DESK TOP CHASSIS.

1) Disconnect the AC supply from the chassis.

WARNING! Electric shock hazard from power supply components will be present if the power cord is not disconnected from the AC supply.

2) Open the chassis by removing the six screws (3 on either side of the enclosure) and lifting the top off the chassis.

A.3 CARTRIDGE DRIVE.

A.3.1 REMOVAL.

1) Unplug the Power Supply cable from the drive's Power Connector (right hand side of the drive as seen from the front panel). See figure A-1. Note the orientation. Do not disconnect the Power Board end of the cable.

2) Unscrew the four screws holding the cartridge drive to the front panel. Place the drive face down in the chassis.

3) Carefully remove the cartridge drive I/O cable and the front panel cables from the Control Board. Lift the drive out of the chassis.

A.3.2 REPLACEMENT.

1) Attach the front panel cable to the Options Connector of the cartridge drive. See the cartridge drive manual for the location of the Options Connector.

2) Plug the I/O cable into the drive I/O connector, with pin 1 toward the center of the board. See figure A-2.

3) Attach the drive to the front panel using the hardware removed earlier. Note that the enclosure is built either for the standard or for the alternate mounting configuration. All 6403 drives use the alternate configuration, along with any drives whose model numbers are suffixed with a "T." All other drives use standard mounting. Drives of one configuration will not mount directly in enclosures built for the other; you may obtain correct replacement mounting brackets from the factory.

4) Attach the cable from the Power Supply Board to the drive's Power Connector, orienting it properly. (Refer to the cartridge drive manual if necessary.)

5) Replace the cover of the chassis, securing it with the six screws removed above.

6) Plug in the AC power cord from the desk top chassis.

Figure A-1, Drive Power Connector
A.4 POWER BOARD.

A.4.1 FAULT ISOLATION. If either the drive or the interface board loses one of its voltages, use the following procedure to determine which device is at fault.

WARNING!

This procedure involves opening the chassis with power connected, producing a shock hazard. Only qualified maintenance personnel taking proper safety precautions should perform this procedure. Hazard exists at filter connections, at AC power inputs and at the voltage range switches.

1) Unplug the affected device’s power cable from the Power Board. Note orientation.

2) Plug in the AC power cord from the chassis.

3) Check the Power Board output pins for the proper voltages. See figure A-4.

---

Figure A-2, Options and I/O Connectors

Figure A-3, Series 70 Power Supply Board Connector Locations

<table>
<thead>
<tr>
<th>PIN</th>
<th>VOLTAGE</th>
<th>PIN</th>
<th>VOLTAGE</th>
<th>PIN</th>
<th>VOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+18/+27</td>
<td>1</td>
<td>+18/+27</td>
<td>1</td>
<td>+18/+27</td>
</tr>
<tr>
<td>2</td>
<td>-18/-27</td>
<td>2</td>
<td>-18/-27</td>
<td>2</td>
<td>-18/-27</td>
</tr>
<tr>
<td>3</td>
<td>GND</td>
<td>3</td>
<td>GND</td>
<td>3</td>
<td>GND</td>
</tr>
<tr>
<td>4</td>
<td>+5V</td>
<td>4</td>
<td>+5V</td>
<td>4</td>
<td>+5V</td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>5</td>
<td>GND</td>
<td>5</td>
<td>GND</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td>6</td>
<td>GND</td>
<td>6</td>
<td>GND</td>
</tr>
</tbody>
</table>

Figure A-4, Power Board Output Connector Pinouts

A - 2
4) If the proper voltages are present on the Power Board, the problem is either with the cable or with the disconnected device. Otherwise, check the fuses on the Power Board. If one has burned open, replace it with a Bussman 3A Fast-Blo fuse or the equivalent. If both fuses are intact, replace the Power Board as described in paragraph A.4.2 and A.4.3.

A.4.2 REMOVAL.

1) Label and disconnect the four quick-disconnect plugs from the Power Board. See Figure A-3.

2) Unscrew the two screws holding the Power Board to the chassis. Lift the board out of the chassis.

3) Unplug the drive's Power Connector and the RS-232 Interface Board Power Connector from the Power Board. See figure A-3.

A.4.3 REPLACEMENT.

1) Place the Power Board in position in the chassis and replace the screws to hold it to the chassis.

2) Replace the quick disconnect connectors from the transformer in their proper locations.

3) Plug in the AC power cord from the chassis.

WARNING! While the chassis is open and plugged in, shock hazard exists. Do not touch capacitor connections, AC power inputs or voltage range switches.

4) Connect a DVM to one of the +5V pins and one of the ground pins on the output connectors (see figure A-4). Adjust potentiometer R8 to obtain +5V 1.05V.

5) Disconnect the DVM and unplug the power cord from the desk top chassis.

6) Connect the drive and interface board power connectors disconnected in step 3, Removal. Be sure to connect them in the proper locations on the Power Connectors of the Power Board. See figure A-3.

7) Replace the cover of the chassis, securing it with the screws removed earlier.

8) Plug in the AC power cord from the desk top chassis.

A.5 RS-232 INTERFACE BOARD.

A.5.1 REMOVAL.

1) Unplug the Power Supply cable from the interface board's power connector.

2) Unscrew the two jack screws holding the interface board to the rear of the chassis. Carefully lift the board from the chassis.

3) Disconnect the cartridge drive I/O cable from the interface board.

A.5.2 CONFIGURATION. A single DIP switch on the lower right hand side of the board sets all options. Using a screwdriver, pencil, or your fingernail, set the switches as desired. See either the silkscreen or figure A-5.

A.5.3 REPLACEMENT.

1) Check that the desired options are selected on the interface board switches. See paragraph A.5.2.

2) Attach the cartridge drive I/O cable to the interface board connector.

3) Place the interface board in position in the chassis. Be sure to seat the board in the guides on the bottom of the chassis. Replace the jack screws, connecting it to the chassis.

4) Reconnect the power connector to the interface board.

5) Replace the cover of the chassis, securing it with the screws removed earlier.

6) Plug in the AC power cord from the desk top chassis.
STOP BITS.
1 Stop Bit  -  -  SW1= off  SW2= on
1.5 Stop Bits  -  -  SW1= on  SW2= off
2 Stop Bits  -  -  SW1= on  SW2= on

PARITY.
Odd Parity  -  -  SW3= off
Even Parity  -  -  SW3= on

Should the Interface check parity?
No  -  -  -  SW4= off
Yes  -  -  -  SW4= on

BAUD RATE.

<table>
<thead>
<tr>
<th>Baud Rate</th>
<th>SW5</th>
<th>SW6</th>
<th>SW7</th>
<th>SW8</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Clock</td>
<td>off</td>
<td>off</td>
<td>off</td>
<td>off</td>
</tr>
<tr>
<td>75</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>off</td>
</tr>
<tr>
<td>110</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>off</td>
</tr>
<tr>
<td>134.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>off</td>
</tr>
<tr>
<td>150</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>off</td>
</tr>
<tr>
<td>300</td>
<td>-</td>
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<td>off</td>
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<td>500</td>
<td>-</td>
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</tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>off</td>
</tr>
<tr>
<td>1800</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>on</td>
</tr>
<tr>
<td>2000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>on</td>
</tr>
<tr>
<td>2400</td>
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<td>-</td>
<td>-</td>
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</tr>
<tr>
<td>3600</td>
<td>-</td>
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<tr>
<td>4800</td>
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</tr>
<tr>
<td>7200</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>on</td>
</tr>
<tr>
<td>9600</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>on</td>
</tr>
<tr>
<td>19200</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>on</td>
</tr>
</tbody>
</table>

Figure A-6, Configuration Switch Settings
Figure A-5, Right Side of Interface Board
APPENDIX B - MAINTENANCE

The drive's head is the only component which comes in direct contact with the tape. A dirty tape head can cause data dropouts and errors during read and write operations. Periodic cleaning assures that dirt or oxide buildup will not interfere with adequate contact and hence data reliability. The following routine should be performed after every eight hours of system use or every week if the system is not used regularly.

1) Remove the cartridge.

2) Moisten a cotton swab with isopropyl alcohol or a commercial head-cleaning solvent. Excessive liquid is not required.

   CAUTION

   DO NOT use carbon tetrachloride or any abrasive or hard object. Use of these will damage the head. Spray type head cleaners are not recommended.

3) Clean the head thoroughly using firm vertical and horizontal strokes.

   CAUTION

   Use reasonable care when cleaning the head. The delicate tach encoder disk is near the head (just above the capstan). While the disk does have a protective shield, it is possible to slip off the head and damage the disk. A damaged disk will result in motor speed variations.

4) Once cleaned, allow time for the solvent to evaporate before loading a tape cartridge.
¾-INCH TAPE CARTRIDGE DRIVE

Models 6410, 6420, 6430, 6440
Models 8310, 8320, 8330, 8340

OPERATION AND MAINTENANCE MANUAL
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      6.3.6 MOTOR/TACH ENCODER ASSEMBLY
      6.3.7 HEAD
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1.2 Head Configuration

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3.3 Controller I/O
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1. GENERAL INFORMATION

1.1 SCOPE. This manual describes how to install, interface, operate and maintain the start/stop cartridge drives designed and manufactured by Digi-Data Corporation, 8580 Dorsey Run Road, Jessup, Maryland 20794, USA. The models covered are described in Figure 1.1.

<table>
<thead>
<tr>
<th>MODEL NUMBER</th>
<th>30 IPS LOW DENSITY</th>
<th>37.5 IPS HIGH DENSITY</th>
<th>SERPENTINE</th>
<th>LOW POWER</th>
</tr>
</thead>
<tbody>
<tr>
<td>6410</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6420</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6430</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6440</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8310</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8320</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>8330</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8340</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1.1, Digi-Data Cartridge Drive Models

1.2 GENERAL DESCRIPTION. Digi-Data Cartridge drives read and record Inverted Modified Frequency Modulation (IMFM) data on cartridges mechanically conforming to ANSI specification X3.55-1977. IMFM data is recorded serially on four tracks by a read-after-write head. Cartridge interchangerability with other Digi-Data cartridge drives depends solely on recording density. (See also section 1.9.) 64xx series drives run at 30 inches per second (IPS) and have a data packing density of 6400 bits per inch (bpi). 83xx series drives run at 37.5 IPS, with a density of 8333 bpi. Series xx30 and xx40 drives are specially designed for battery-power applications (see below). Each is capable of high-speed block-search operations.

The direct-drive motor eliminates belts and pulleys and provides tighter control of tape motion. Speed accuracy is enhanced by the use of an optical tachometer. Tape hole markers are detected by a pulsed infrared LED and filtered sensors to reduce the effects of ambient light. For multiple-drive systems, each drive can be configured to respond to one of eight addresses.

Other features include front mounting, very compact size, and an industry-standard interface on the drive that makes it interchangeable with other cartridge units on the market.

The basic functional units of each drive may be described in three groups:

1) MECHANISM. The mechanism moves the tape under the control of the two circuit boards. In addition to the capstan motor and tachometer, the mechanism contains the read-after-write head, tape hole sensing assembly, and File Protect and Cartridge-In-Place status switches.

2) SERVO BOARD. The Servo Board contains all of the analog electronics. It provides regulated power supplies for the drive, as well as controlling tape motion. It has been computer-optimized to provide high performance at the lowest possible motor power dissipation. The Servo Board also transmits data to the write head, and amplifies and digitizes the signals from the read head. It drives the Tape Hole Detector LED and receives the signals from the Tape Hole Sensors and the File Protect and Cartridge-In-Place switches.

3) CONTROL BOARD. The Control Board contains all of the digital electronics. It remembers the tape position, locking out illegal motion commands. It decodes the select lines, latches and clears all commands at the appropriate times, and gates status signals from the drive to the Controller. The Control Board also formats data, converting NRZ write data from the controller to IMFM data for the drive, and IMFM data from the drive to NRZ data and Read Data Strobes for the controller. All signals leaving the board are sent through open-collector drivers and all inputs are to receivers with hysteresis to provide noise immunity.

In addition to the above, xx30 and xx40 series drives are designed for low power usage from +5 and ±12 volt supplies and to be switched on and off while not reading or writing data. Because of this, there are two major differences in their operation:

1) No Automatic Rewind Sequence (ARS) is performed at the time of powering up, since the drive is intended to be powered down during periods of data inactivity (i.e., between data blocks). ARS is performed when remote rewind commands are received and when a tape is inserted into a powered drive.

2) Rewind and search speeds are lowered to reduce the power required by the motor. See the specifications chart below.
1.3 SPECIFICATIONS.
(common to all models)

DRIVE
Single capstan motor drives roller inside cartridge—no contact between tape and capstan

CAPSTAN SERVO
Velocity feedback from digital tachometer

HEAD TYPE
Dual gap read-during-write with selective erase
(see Fig. 1.2)

MODELS
Models xx10 & xx30 - write Forward only
Models xx20 & xx40 - write Forward on tracks 1, 3
write Reverse on tracks 2, 4

RECORDING MODE
4 Track serial

RECORDING CODE
Inverted modified frequency modulation
Serial by bit

INTERFACE
NRZ (High Density)

PROGRAM TYPE
No Restrictions

DRIVE RELIABILITY
7500 hours Mean Time Between Failures (MTBF)

1.4 SPECIFICATIONS.
(model variable)

CARTRIDGE TYPE

RECORDING DENSITY

DATA TRANSFER RATE

TAPE SPEED, Synchronous
30 IPS (76 cm/s)
Fwd/Rev

TAPE SPEED, Rewind
90 IPS (229 cm/s)

TAPE SPEED, Search
(90 IPS (229 cm/s)
long term, Fwd/Rev)

SPEED VARIATION,*

Synchronous, Max.

Synchronous, Max.

CAPSTAN START/STOP TIME
at synchronous speed

START/STOP TIMING

WAIT DELAY

START/STOP DISTANCE,
Synchronous

START/STOP DISTANCE,
Search

INTERRECORD GAP

START/STOP TIME
to search speed

START/STOP TO SEARCH
TIMING WAIT DELAY

REWIND TIME

<table>
<thead>
<tr>
<th></th>
<th>6410/6420</th>
<th>6430/6440</th>
<th>8310/8320</th>
<th>8330/8340</th>
</tr>
</thead>
<tbody>
<tr>
<td>300', 450' or 555'</td>
<td>Same as 6410/6420</td>
<td>600' only</td>
<td>Same as 6430/6440</td>
<td>Same as 8310/8320</td>
</tr>
<tr>
<td>6400 bpi</td>
<td>Same as 6410/6420</td>
<td>6333 bpi</td>
<td>Same as 6430/6440</td>
<td>Same as 8310/8320</td>
</tr>
<tr>
<td>328 bits per mm</td>
<td>Same as 6410/6420</td>
<td>312,488 bits per sec (8333 bpi @ 37.5 IPS)</td>
<td>Same as 6430/6440</td>
<td>Same as 8310/8320</td>
</tr>
<tr>
<td>30 IPS (76 cm/s)</td>
<td>Same as 6410/6420</td>
<td>37.5 IPS (95.3 cm/s)</td>
<td>Same as 6430/6440</td>
<td>Same as 8310/8320</td>
</tr>
<tr>
<td>90 IPS (229 cm/s)</td>
<td>Same as 6410/6420</td>
<td>60 IPS (152 cm/s)</td>
<td>Same as 6430/6440</td>
<td>Same as 8310/8320</td>
</tr>
<tr>
<td>± 5%</td>
<td>Same as 6410/6420</td>
<td>60 IPS (152 cm/s)</td>
<td>Same as 6430/6440</td>
<td>Same as 8310/8320</td>
</tr>
<tr>
<td>± 5%</td>
<td>Same as 6410/6420</td>
<td>60 IPS (152 cm/s)</td>
<td>Same as 6430/6440</td>
<td>Same as 8310/8320</td>
</tr>
<tr>
<td>± 7% long term</td>
<td>Same as 6410/6420</td>
<td>± 3% long term</td>
<td>Same as 6430/6440</td>
<td>Same as 8310/8320</td>
</tr>
<tr>
<td>± 7% short term</td>
<td>Same as 6410/6420</td>
<td>± 3% short term</td>
<td>Same as 8310/8320</td>
<td></td>
</tr>
<tr>
<td>± 2% long term</td>
<td>Same as 6410/6420</td>
<td>± 1% long term</td>
<td>Same as 8310/8320</td>
<td></td>
</tr>
<tr>
<td>± 3% short term</td>
<td>Same as 6410/6420</td>
<td>± 3% short term</td>
<td>Same as 8310/8320</td>
<td></td>
</tr>
<tr>
<td>30 msec ± 5%</td>
<td>Same as 6410/6420</td>
<td>37.5 msec ± 5%</td>
<td>Same as 8310/8320</td>
<td></td>
</tr>
<tr>
<td>20 msec Read</td>
<td>Same as 6410/6420</td>
<td>25 msec Read</td>
<td>Same as 8310/8320</td>
<td></td>
</tr>
<tr>
<td>40 msec Write, min.</td>
<td>Same as 6410/6420</td>
<td>45 msec Write, min.</td>
<td>Same as 8310/8320</td>
<td></td>
</tr>
<tr>
<td>.375 in. (9.525 mm) ± 10%</td>
<td>Same as 6410/6420</td>
<td>.70 in. (17.86 mm) ± 10%</td>
<td>Same as 8310/8320</td>
<td></td>
</tr>
<tr>
<td>3.4 in. (86.3 mm) nominal</td>
<td>Same as 6410/6420</td>
<td>Same as 6410/6420</td>
<td>Same as 8310/8320</td>
<td></td>
</tr>
<tr>
<td>1.2 in. nominal**</td>
<td>Same as 6410/6420</td>
<td>1.7 in. nominal***</td>
<td>Same as 8310/8320</td>
<td></td>
</tr>
<tr>
<td>90 msec nominal</td>
<td>Same as 6410/6420</td>
<td>Same as 6410/6420</td>
<td>Same as 8310/8320</td>
<td></td>
</tr>
<tr>
<td>100 msec</td>
<td>Same as 6410/6420</td>
<td>Same as 6410/6420</td>
<td>Same as 8310/8320</td>
<td></td>
</tr>
<tr>
<td>60 sec nominal (450 ft. tape)</td>
<td>90 sec maximum (450 ft. tape)</td>
<td>80 sec nominal (600 ft. tape)</td>
<td>120 sec maximum (600 ft. tape)</td>
<td></td>
</tr>
</tbody>
</table>

NOTES:
*Measured per ANSI/ECMA/ISO standards
**During read operations, the drive is capable of reading a minimum Interrecord Gap (IRG) of 1.02 in.
***During read operations, the drive is capable of reading a minimum IRG of 1.4 in.
1.5 VOLTAGE AND CURRENT REQUIREMENTS.

CURRENT REQUIREMENTS IN AMPERES

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>POSITIVE SUPPLY&lt;sup&gt;1&lt;/sup&gt;</th>
<th>NEGATIVE SUPPLY&lt;sup&gt;2&lt;/sup&gt;</th>
<th>REG. +5V DC SUPPLY&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATIC (No Motion)</td>
<td>.13</td>
<td>.07</td>
<td>1.8</td>
</tr>
<tr>
<td>REWIND</td>
<td>.73</td>
<td>.07</td>
<td>1.8</td>
</tr>
<tr>
<td>FORWARD -- Search</td>
<td>.11</td>
<td>.68</td>
<td>1.8</td>
</tr>
<tr>
<td>FORWARD -- Synch.</td>
<td>.11</td>
<td>.53</td>
<td>1.8</td>
</tr>
<tr>
<td>REVERSE -- Synch.</td>
<td>.62</td>
<td>.07</td>
<td>1.8</td>
</tr>
<tr>
<td>FORWARD RAMP -- Synch.</td>
<td>.32*</td>
<td>1.30**</td>
<td>1.8</td>
</tr>
<tr>
<td>REVERSE RAMP -- Synch.</td>
<td>1.30**</td>
<td>.32*</td>
<td>1.8</td>
</tr>
<tr>
<td>FORWARD RAMP -- Search</td>
<td>.32*</td>
<td>1.30**</td>
<td>1.8</td>
</tr>
<tr>
<td>REVERSE RAMP -- Search</td>
<td>1.30**</td>
<td>.32</td>
<td>1.8</td>
</tr>
</tbody>
</table>

| ABSOLUTE MAXIMUM        | 1.50                          | 1.50                         | 3.0                              |

<sup>1</sup> 24V DC Nominal (+18 to +27V DC) for Series xx10 and xx20
<sup>2</sup> 12V DC Nominal (+11 to +14V DC) for Series xx30 and xx40
<sup>3</sup> 24V DC Nominal (+18 to +27V DC) for Series xx10 and xx20
<sup>4</sup> 12V DC Nominal (+11 to +14V DC) for Series xx30 and xx40
<sup>5</sup> DC to 5.25V DC -- applies to all models

*Stop Ramp Current
**Start Ramp Current

General Notes:
- All voltages measured at power connector on drive.
- Start/Stop Ramp Currents are pulses with a pulse width of 30 msec to/from 30 ips, 37.5 msec to/from 37.5 ips, and 90 msec to/from 90 ips.
- The ramp period current peaks do not occur simultaneously. A defective cartridge can increase ramp current to the limit of the input fuse or power supply limit.

1.6 ENVIRONMENTAL SPECIFICATIONS.

TEMPERATURE, Operating + 5° to +45°C, cartridge limited.
TEMPERATURE, Non-Operating -30° to +60°C, hardware + 5° to +45°C, cartridge storage -40° to +45°C, cartridge transportation.
HUMIDITY 20% to 80% non-condensing.
ALTITUDE, Operating 10,000 ft (3000 m) maximum.
ALTITUDE, Non-operating 40,000 ft (12000 m) maximum.
VIBRATION, Operating Tested with 0.5 G, 10 to 60 Hz.
SHOCK, Non-operating Tested with 50G, 10 ms, half sine wave.
OPERATING ATTITUDE Any except with the cartridge loaded directly upward; oxide residue from the head may fall into the cartridge and reduce data reliability when mounted in this position.
DUST RESISTANCE The drive is designed to withstand the dust level of a typical office environment. If used in particularly dusty areas, more frequent cleaning of the head or protecting the equipment with a cover or door is required.
SIZE (max.) 3.5 in (8.9 cm) H x 6.9 in (17.5 cm) W x 5.8 in (14.8 cm) D
WEIGHT (max.) 2.5 lbs (1.13 kg).
1.7 FOUR-TRACK FORMAT

Nominal track width - Read: .020 inch
Nominal track width - Write: .036 inch
Nominal track width - Erase: .048 inch
Nominal track to track spacing: .064 inch
Nominal write to read gap spacing: .300 inch
Nominal write to erase gap spacing: .265 inch (xx10 & xx30)
Nominal write to erase gap spacing: .225 inch (xx20 & xx40)

---baseplate surface---

Models xx10 & xx30
(Standard Head)

Figure 1.2, Head Configuration (Front View). Arrows indicate direction of tape motion for active data transfer.

1.8 ERROR RATES. The error rates listed below are design goals measured at the cartridge drive interface before the formatter or controller performs any error correction. For these measurements, the minimum allowable record consists of 18 data bits. Cartridges must meet ANSI X3.55 specifications while operating in temperatures from 5°C to 45°C with a relative humidity of 20% to 80% and must be full-length certified at full recording density. Errors caused by tape with damaged oxide shall not be included in the error rate unless the damage is caused by the drive during test.

1.8.1 DEFINITIONS.
1) Recoverable Errors - Those existing for less than five retries of writing or reading.
2) Permanent Errors - Those persisting after five reread or rewrite attempts (including an extended erased gap with each rewrite). These errors constitute an equipment failure and are included in the MTBF.

1.8.2 WRITE ERROR RATE. The recoverable write error rate will not exceed one error in 10⁷ bits. The permanent write error rate will not exceed one error in 10⁸ bits.

1.8.3 READ ERROR RATE. When reading a tape with no write errors, the recoverable read error rate will not exceed one error in 10⁷ bits. The permanent read error rate will not exceed one error in 10⁸ bits.

1.9 CARTRIDGE COMPATIBILITY. Due to differences in the magnetic properties of the tapes, it is recommended that only 300-foot, 450-foot, or 555-foot cartridges be used on low density (64xx series) drives and only 600-foot High Density cartridges be used on high density (83xx series) drives.
2) INSTALLATION

2.1 INTRODUCTION. This chapter describes the installation procedures for the drive. (NOTE: Interfacing is described in detail in Chapter 3.)

2.2 INSTALLATION PROCEDURE. Digi-Data Cartridge Drives come completely calibrated and ready to install in a system. No test equipment or technical training is needed. Installation requires only a few simple steps:

1) Plug the cable from the controller onto the interface connector at the rear of the drive, on the Control (lowest) Board. See figure 3.3. Pin number one is indicated by a number on the board. The drive requires a 50-pin connector (3M #3425-7000 or equivalent).

2) Plug the power cable onto the connector on the right side of the Servo (inner) Board. The plug should be keyed so that it can be attached only one way. See section 3.2.3.

3) If the drive is to be installed as one unit per controller, skip to paragraph (4).

The Digi-Data Cartridge Drive is designed so that up to eight units may be daisy-chained (connected in parallel) to one controller. In this type of system, each tape unit must be assigned a number so that the controller can select each individually. As shipped, each drive is configured to be selected as Unit 0. Therefore, in a multiple-drive system, all units after the first must be re-configured to a different select number. This can be done as follows:

A. Turn the drive upside-down, with its front toward you. You will see the Control Board (labeled "82CDC"). At the extreme right side of the board you will find either three 10-ohm resistors, or a DIP switch, labeled "RSL  4 1 2".

RESISTORS: Removing a resistor adds its assigned number to the tape unit select number. For example:

<table>
<thead>
<tr>
<th>Tape Unit as shipped</th>
<th>Remove RSL 1 &amp; 4</th>
<th>Unit # 0</th>
<th>Unit # 1</th>
<th>Unit # 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>DO NOTHING</td>
<td></td>
<td>Unit # 0</td>
<td>Unit # 1</td>
<td>Unit # 5</td>
</tr>
</tbody>
</table>

Determine the Unit Select Number to be assigned to the drive. Using a small pair of wire cutters, clip each resistor close to the board on each end and remove from the board.

SWITCH: Unit Number selection is analogous to the resistor method described above, except that you set the designated switches off instead of removing resistors.

In summary,

<table>
<thead>
<tr>
<th>To Set This Tape Unit Number</th>
<th>Remove These Resistors</th>
<th>OR</th>
<th>Turn These Switches OFF</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>DO NOTHING 1</td>
<td>ALL ON</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>RSL 1</td>
<td>RSL 1</td>
<td>RSL 1</td>
</tr>
<tr>
<td>2</td>
<td>RSL 2</td>
<td>RSL 2</td>
<td>RSL 2</td>
</tr>
<tr>
<td>3</td>
<td>RSL 2 + RSL 1</td>
<td>RSL 2 + RSL 1</td>
<td>RSL 2 + RSL 1</td>
</tr>
<tr>
<td>4</td>
<td>RSL 4</td>
<td>RSL 4</td>
<td>RSL 4</td>
</tr>
<tr>
<td>5</td>
<td>RSL 4 + RSL 1</td>
<td>RSL 4 + RSL 1</td>
<td>RSL 4 + RSL 1</td>
</tr>
<tr>
<td>6</td>
<td>RSL 4 + RSL 2</td>
<td>RSL 4 + RSL 2</td>
<td>RSL 4 + RSL 2</td>
</tr>
<tr>
<td>7</td>
<td>RSL 4 + RSL 2 + RSL 1</td>
<td>RSL 4 + RSL 2 + RSL 1</td>
<td>RSL 4 + RSL 2 + RSL 1</td>
</tr>
</tbody>
</table>

B. For all drives except the LAST in the chain you will also need to change the terminator pack on the Control Board. The Pack is in the socket at location 09B. As shipped, each drive contains a 220/330 terminator (i.e. 220 ohms to +5V and 330 ohms to GND). For all intermediate drives in the chain, lift the pack out of the socket and replace it with a 4.7k-ohm resistor pack (i.e. 4700 ohms to +5V). See section 3.2 for more details.

4) Attach the drive to the housing with four 8-32 screws of the appropriate length (panel thickness + ¼ inch maximum).
3) INTERFACE AND CONTROL

This chapter describes the electrical and physical interface requirements and defines all interface signals.

3.1 ELECTRICAL INTERFACE REQUIREMENTS. The cartridge drive and its controller exchange all information (commands, status, and data) through the drive's interface. All signals are TTL (low true) and pass through dedicated interface lines. For all output signals, line drivers are 7406 open-collector buffers or the equivalent, capable of sinking 40 mA; receivers are 7414 thresholded devices or the equivalent. As shipped, all inputs are terminated in a 220/330 terminator pack (i.e., a 220 Ohm resistor to +5V and a 330 Ohm resistor to ground) to keep the signals from the controller at proper TTL high or low levels. This is correct for solitary drives, but when the system requires that more than one drive be daisy-chained (connected in parallel) to one controller, the terminator on all drives EXCEPT the last in the chain must be changed to a 4.7k Ohm resistor pack. For convenience, the terminator is socket-mounted at location U9B on the Control Board. See Figure 3.1.

![Figure 3.1, Bottom Rear of Drive](image)

The controller should drive all inputs using open-collector circuits capable of sinking at least 30 milliamps while maintaining the logic levels listed below. The recommended interface circuit is shown in Figure 3.2.

- Logic True Level = LOW = 0 to 0.4 VDC
- Logic False Level = HIGH = 2.5 to 5 VDC

![Figure 3.2, Recommended Interface](image)

The minimum recommended pulse width on the interface line (except for DADs) is 500 nanoseconds. Inputs which elicit immediate confirming responses from the drive may be narrower if they go false upon detecting the drive's response. Rise and fall times should not exceed 100 nsec.

3.2 PHYSICAL INTERFACE REQUIREMENTS.

3.2.1 CONTROLLER I/O. The 50 pin male interface plug on the drive is located at the right rear of the Control Board. It mates with 3M Company connector part no. 3425-7000 and cable part no. 3350 50-conductor or equivalents.
3.2.2 OPTIONS CONNECTOR INTERFACE. The 16 pin female interface DIP socket at the rear center of the Control Board mates with standard male DIP connectors.

3.2.3 DRIVE POWER CONNECTOR INTERFACE. The 16 pin male connector on the Servo Board mates with the following AMP Corporation parts or their equivalents:

- Connector - AMP Part No. 1-86148-5 (1 ea)
- Contact Pins - AMP Part No. 86016-4 (13 ea)
- Keying Plugs - AMP Part No. 86286-1 (3 ea)

3.2.3.1 WIRING.

A. Chassis Ground is the physical case of the drive. Servo common returns the unregulated supplies' currents. Logic common returns the +5 VDC current. All three are separate within the drive. All three must be tied together and to ground at a single point within the power supply.

B. Hookup wire size - #22 AWG.

C. See Section 1.5 for power requirements.

3.2.3.2 FUSING. The positive, negative, and +5 VDC power supply lines to the drive should have a Bussman ACC 3A, 250V Fast-Blo (or equivalent) fuse in series with them.
### 3.4 SIGNAL DESCRIPTIONS. (Note: All are TTL Low True.)

<table>
<thead>
<tr>
<th>SIGNAL</th>
<th>NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSY-</td>
<td>BUSY</td>
<td>BUSY, gated by RDY, indicates that the drive is presently moving tape. BUSY goes true when the tape begins moving and remains true approximately 30 msec after the motion command is cleared (37.5 msec in 83xx series drives, and 95 msec during high speed operations) to allow time for the tape to ramp down completely. BUSY will not go true if a REVERSE command is received when the tape is at BOT or if a FORWARD command is received when the tape is at EOT.</td>
</tr>
<tr>
<td>DAD-</td>
<td>DATA DETECTED</td>
<td>DATA DETECTED indicates that valid read data is being received with no interruptions in the data flow. It comes true 20 usec after the beginning of the preamble (in low speed operation) to permit the Control Board to verify that a proper preamble has been received. The signal then remains true for the duration of the data block or until a large (40 usec nom.) dropout occurs. When reading, DAD should be monitored continuously since it may go false momentarily during the middle of a record if a dropout occurs. The controller must therefore take care when backspacing over an error record for rewriting so that it does not interpret the momentary dropout in DAD as an interrecord gap or else the rewrite operation will begin at an incorrect place on tape. During high speed searches, DAD can be monitored to detect data blocks.</td>
</tr>
<tr>
<td>EWS-</td>
<td>EARLY WARNING SENSED</td>
<td>EARLY WARNING, gated by RDY and not rewinding, indicates that the Early Warning tape hole has been passed while moving forward. Between this tape hole and the EOT marker there are 48 inches of tape, 36 inches of which are usable for data recording. EWS remains true until the Early Warning tape hole is passed while moving reverse. The Control Board prevents high speed tape motion (except rewinding) when EARLY WARNING is true. Note that in Low Power models (xx30 and xx40), this signal is false upon power up even if the drive is positioned at or beyond the Early Warning tape hole. At power up, these models do not remember their status nor perform an Auto Rewind Sequence but assume that the tape is positioned between the Load Point and Early Warning markers. It is up to the controller to keep track of the status of these drives; if not, it would be possible to run the tape beyond EOT.</td>
</tr>
<tr>
<td>FLG-</td>
<td>FLAG</td>
<td>FLAG, gated by RDY, indicates that a rewind sequence has been completed, the tape is positioned between the two BOT markers farthest from the take-up hub, and the drive has ramped down. FLAG remains true until the drive executes a forward operation. This signal is false upon power up in Low Power Models (xx30 and xx40), since the drive does not rewind on power up.</td>
</tr>
<tr>
<td>FUP-</td>
<td>FILE UNPROTECTED</td>
<td>FUP, gated by RDY, indicates that the cartridge presently installed can be written on. When false, FUP indicates that the cartridge's file protect switch is in the &quot;SAFE&quot; position.</td>
</tr>
<tr>
<td>FWD-</td>
<td>FORWARD</td>
<td>FORWARD commands the drive to move tape forward at the speed specified by HSP. The drive will execute the command if RDY is true, the drive is not already moving tape, and it is not at EOT. Acceleration and deceleration rates are constant; ramp up and ramp down times are nominally equal. When FORWARD is cleared the servo brakes the motor and the drive ramps down. Another FWD command given during the ramp down time will be executed immediately; a REV command will be executed as soon as the tape stops moving. If FWD is set at the same time as REV, the drive will ramp to a halt and remain halted until one of the commands is cleared.</td>
</tr>
</tbody>
</table>
3.3 SIGNAL LOCATIONS.

3.3.1 CONTROLLER I/O.

<table>
<thead>
<tr>
<th>PIN NO.</th>
<th>SIGNAL</th>
<th>NAME</th>
<th>PIN NO.</th>
<th>SIGNAL</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>SLD-</td>
<td>Selected-</td>
<td>18</td>
<td>RWD-</td>
<td>Rewind-</td>
</tr>
<tr>
<td>4</td>
<td>RDY-</td>
<td>Ready-</td>
<td>20</td>
<td>REV-</td>
<td>Reverse-</td>
</tr>
<tr>
<td>6</td>
<td>WND-</td>
<td>Write Enabled-</td>
<td>22</td>
<td>FWD-</td>
<td>Forward-</td>
</tr>
<tr>
<td>8</td>
<td>FLG-</td>
<td>Flag-</td>
<td>24</td>
<td>HSP-</td>
<td>High Speed</td>
</tr>
<tr>
<td>10</td>
<td>LPS-</td>
<td>Load Point Sensed-</td>
<td>26</td>
<td>WEN-</td>
<td>Write Enable-</td>
</tr>
<tr>
<td>12</td>
<td>FUP-</td>
<td>File Unprotected</td>
<td>28</td>
<td>SL1-</td>
<td>Unit Select 2-0</td>
</tr>
<tr>
<td>14</td>
<td>BSY-</td>
<td>Busy-</td>
<td>30</td>
<td>SL2-</td>
<td>Unit Select 2-1</td>
</tr>
<tr>
<td>16</td>
<td>EWS-</td>
<td>Early Warning Sensed-</td>
<td>32</td>
<td>SL4-</td>
<td>Unit Select 2-2</td>
</tr>
<tr>
<td>36</td>
<td>RNZ-</td>
<td>Read NRZ Data-</td>
<td>34</td>
<td>SLG-</td>
<td>Select Gate</td>
</tr>
<tr>
<td>38</td>
<td>RDS-</td>
<td>Read Data Strobe-</td>
<td>42</td>
<td>WDE-</td>
<td>Write Data Enable-</td>
</tr>
<tr>
<td>40</td>
<td>DAD-</td>
<td>Data Detected-</td>
<td>44</td>
<td>WNZ-</td>
<td>Write NRZ Data-</td>
</tr>
<tr>
<td>48</td>
<td>WDS-</td>
<td>Write Data Strobe-</td>
<td>46</td>
<td>TR2-</td>
<td>Track Select 2-1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>50</td>
<td>TR1-</td>
<td>Track Select 2-0</td>
</tr>
</tbody>
</table>

NOTE: All odd-numbered pins are ground returns for the signals on the following even-numbered pins and are tied together.

3.3.2 OPTIONS CONNECTOR.

<table>
<thead>
<tr>
<th>PIN NO.</th>
<th>SIGNAL</th>
<th>TYPE</th>
<th>SIGNAL NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SL-I</td>
<td>OUTPUT</td>
<td>Selected - Inverted</td>
</tr>
<tr>
<td>5</td>
<td>RWD-I</td>
<td>INPUT</td>
<td>Rewind - Inverted</td>
</tr>
<tr>
<td>6</td>
<td>FIPD-I</td>
<td>OUTPUT</td>
<td>File Protected - Inverted</td>
</tr>
<tr>
<td>7</td>
<td>BSTD-I</td>
<td>OUTPUT</td>
<td>Beginning of Tape - Inverted</td>
</tr>
<tr>
<td>8</td>
<td>BSYD-I</td>
<td>OUTPUT</td>
<td>Drive Busy - Inverted</td>
</tr>
<tr>
<td>9</td>
<td>+5</td>
<td>OUTPUT</td>
<td>+5 Volts</td>
</tr>
<tr>
<td>11</td>
<td>GND</td>
<td></td>
<td>Ground</td>
</tr>
</tbody>
</table>

NOTE: Pins 2, 3, 4, 10, 12, 13, 14, 15, 16 are all unused (No Connection).

3.3.3 DRIVE POWER CONNECTOR.

<table>
<thead>
<tr>
<th>PIN NO.</th>
<th>SIGNAL</th>
<th>SIGNAL NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/C--Key Pin</td>
<td>No Connection (cut off)</td>
</tr>
<tr>
<td>2,10</td>
<td>+ VDC</td>
<td>Positive power supply (24V or 12V)</td>
</tr>
<tr>
<td>3,11</td>
<td>- VDC</td>
<td>Negative power supply (24V or 12V)</td>
</tr>
<tr>
<td>4,12</td>
<td>N/C--Key Pin</td>
<td>No Connection (cut off)</td>
</tr>
<tr>
<td>5,13</td>
<td>SC</td>
<td>Servo common from power supply</td>
</tr>
<tr>
<td>6,14</td>
<td>+5 VDC</td>
<td>Regulated +5 VDC from power supply</td>
</tr>
<tr>
<td>7,15</td>
<td>LC</td>
<td>Logic common from power supply</td>
</tr>
<tr>
<td>8,16</td>
<td>CG</td>
<td>Chassis ground from drive</td>
</tr>
<tr>
<td>9</td>
<td>N/C</td>
<td>no connection</td>
</tr>
</tbody>
</table>
**HSP-** HIGH SPEED

HIGH SPEED commands the servo to move tape at search speed in the direction selected by FWD or REV. High speed motion can only be executed between the Load Point hole (LP) and the Early Warning hole (EW); outside this region the HSP line is ignored. It is not necessary to set HSP to rewind.

Note that xx30 and xx40 drives upon power up do not remember where the tape is positioned. Therefore, it is up to the controller to take care not to issue HSP outside the legal zone.

**LPS-** LOAD POINT SENSED

LOAD POINT, gated by RDY and not rewinding, indicates that the Load Point tape hole has been passed while moving reverse. LPS remains true until the Load Point tape hole is passed while moving forward. The Control Board prevents high speed tape motion (except rewinding) when LOAD POINT is true.

Note that in Low Power models (xx30 and xx40), this signal is false upon power up even if the tape is positioned at or before the Load Point tape hole. At power up, these models do not remember their status nor perform an Auto Rewind Sequence but assume that the tape is positioned between the Load Point and Early Warning markers. It is up to the controller to keep track of the status of these drives; if not, it would be possible to run the tape before BOT.

**RDS-** READ DATA STROBE

The READ DATA STROBE indicates to the controller that the RNZ lines are stable and can be sampled. It occurs once per character period and has a 25% duty cycle. (At 6400 bpi, the character period is 5.2 ± 0.32 usec; 25% duty cycle is 1.3 ± 0.32 usec. At 8333 bpi character period is 3.2 ± 0.32 usec, duty cycle is 800 ± 80 nsec.) RNZ will be stable 200 nsec before RDS and will remain stable for the duration of the strobe. The data may be changed on the trailing edge of RDS or at any time thereafter, but will be stable 200 nsec before the next read strobe.

**RDY-** READY

READY indicates that the drive is powered up, has a cartridge in place, and is selected.

**REV-** REVERSE

REVERSE commands the servo to move tape in the reverse direction at the speed specified by HSP. The drive will execute the command if RDY is true; the drive is not already moving tape, and it is not at BOT. Acceleration and deceleration rates are constant; ramp up and ramp down times are nominally equal. When REVERSE is cleared the servo brakes the motor and the drive ramps down. Another REV command given during ramp down time will be executed immediately; a FWD command will be executed as soon as the tape stops moving. If FWD and REV are set at the same time the drive will ramp to a halt and remain halted until one of the commands is cleared.

xx30 and xx40 drives do not remember their position upon power up, so it may be possible to run these reverse past BOT. See the description of Load Point Sensed, above.

**RNZ-** READ NRZ DATA

READ NRZ DATA is the NRZ read data to the controller. A zero is indicated as a high and a one as a low. RNZ will be stable at least 200 nanoseconds before RDS and will remain stable for the duration of the strobe.

**RWD-** REWIND

REWIND initiates an Automatic Rewind Sequence to BOT. If RDY is true, the command is accepted. All subsequent commands are ignored until the operation is complete. The drive may be deselected during the rewind sequence without affecting the operation.
The controller must maintain proper track selection during all operations. When a drive is selected, the track lines are activated. To avoid any conflict in track selection, the drive must be selected before any other track lines are activated.

The data on the tape must be accurately recorded with the proper format. The data is then read from the tape using the appropriate drive. The data is then processed by the controller and stored in the proper location on the hard disk.

The controller must also maintain proper track selection during all operations. When a drive is selected, the track lines are activated. To avoid any conflict in track selection, the drive must be selected before any other track lines are activated.

The data on the tape must be accurately recorded with the proper format. The data is then read from the tape using the appropriate drive. The data is then processed by the controller and stored in the proper location on the hard disk.

The controller must also maintain proper track selection during all operations. When a drive is selected, the track lines are activated. To avoid any conflict in track selection, the drive must be selected before any other track lines are activated.

The data on the tape must be accurately recorded with the proper format. The data is then read from the tape using the appropriate drive. The data is then processed by the controller and stored in the proper location on the hard disk.
4. TAPE AND DATA FORMATS

4.1 INTRODUCTION. This chapter describes the ANSI Standard for data cartridges (ANSI X3.55-1977) and the IFMFI data format.

4.2 TAPE FORMAT. The tape format is illustrated in figure 4.1. Tape regions are marked by small holes in the tape. These holes are sensed by a pulsed infrared LED and two detectors on the drive. The drive uses the direction of tape motion and the tape hole signals to determine the tape's position and which motion commands are legal.

Beginning of Tape (BOT) is marked by three sets of simultaneous upper and lower holes, beginning 18 inches from the physical beginning of tape and spaced 18 inches apart. Beyond the last set is Load Point (LP), a single upper tape hole. Then follows the main recording area of the tape. Another single upper tape hole signals Early Warning (EW), 48 inches before End of Tape (EOT). The drive's logic distinguishes between the LP and EW by the direction of tape travel and by the last marker hole seen. EOT is marked by three single lower tape holes spaced 18 inches apart, the last of which is 18 inches from the physical end of the tape. BOT and EOT are redundantly marked by three sets of holes each to help ensure that the tape will not be run off the reels.

![Diagram of Tape Format](image)

**Figure 4.1, Tape Format**

Starting from BOT, standard drives begin recording data after the LP hole has been passed while going forward and continue until the EW marker hole. EW serves to signal the controller that data activity must cease soon; all forward motion ends when EOT is reached. Between LP and EW all High and Low Speed and Forward and Reverse operations are allowed; no high speed (except rewind) is permitted beyond EW or before LP to protect the tape. When moving reverse, all motion stops at BOT. Serpentine drives perform the same on tracks 1 and 3, but on tracks 2 and 4 writing and reading is in reverse, so the tape regions are treated oppositely--Starting at EOT, there is no recording before EW, and LP serves to warn that EOT will soon be reached and the tape will stop.

<table>
<thead>
<tr>
<th>TAPE ZONE</th>
<th>LEGAL COMMANDS (Standard Drives)</th>
<th>LEGAL COMMANDS (Serpentine Drives)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOT ZONE</td>
<td>Low Speed Forward -</td>
<td>Low Speed Forward - No Data</td>
</tr>
<tr>
<td></td>
<td>No Data Transfer</td>
<td>Transfer Tracks 1 &amp; 3</td>
</tr>
<tr>
<td>BOT</td>
<td>Low Speed Forward and Reverse -</td>
<td>Low Speed Forward and Reverse -</td>
</tr>
<tr>
<td></td>
<td>No Data Transfer</td>
<td>No Data Transfer Tracks 1 &amp; 3</td>
</tr>
<tr>
<td></td>
<td>Rewind</td>
<td>Rewind</td>
</tr>
<tr>
<td>LPS</td>
<td>High/Low Speed Fwd and Rev</td>
<td>High/Low Speed Fwd and Rev</td>
</tr>
<tr>
<td></td>
<td>Read Forward/Reverse</td>
<td>Read Forward and Reverse</td>
</tr>
<tr>
<td></td>
<td>Rewind</td>
<td>write Forward Tracks 1 &amp; 3</td>
</tr>
<tr>
<td></td>
<td>Rewind</td>
<td>Rewind</td>
</tr>
<tr>
<td></td>
<td>Low Speed Forward and Reverse</td>
<td>Low Speed Forward and Reverse -</td>
</tr>
<tr>
<td></td>
<td>Read Forward and Reverse</td>
<td>No Data Transfer Tracks 2 &amp; 4</td>
</tr>
<tr>
<td>EWS</td>
<td>Write Forward</td>
<td>Read Fwd and Rev Tracks 1 &amp; 3</td>
</tr>
<tr>
<td></td>
<td>Rewind</td>
<td>Write Forward Tracks 2 &amp; 4</td>
</tr>
<tr>
<td>EOT</td>
<td>Low Speed Reverse</td>
<td>Rewind</td>
</tr>
<tr>
<td>EOT ZONE</td>
<td>Read Reverse</td>
<td>Rewind</td>
</tr>
<tr>
<td></td>
<td>Rewind</td>
<td>Rewind</td>
</tr>
</tbody>
</table>

**Figure 4.2, Legal Tape Commands**
4.3 IM FM DATA FORMAT. IM FM is a self-clocking data code. Each Digi-Data Cartridge Drive contains its own IM FM formatting circuitry as part of the Control Board, and is ready to receive data records encoded in NRZ from the controller. A record consists of three parts: preamble, data, and postamble.

Data coding is context sensitive. A zero preceded by a zero is encoded as a magnetic flux transition at the beginning of the bit cell; a zero not preceded by a zero (i.e., at the beginning of the preamble or following a one) does not have a transition associated with it. Ones are always represented as a flux reversal in the center of the bit cell. See figure 4-3 below for sample data and waveforms.

Since transitions may occur both at the beginning and in the middle of a bit cell, the decoding circuits must be synchronized with the data before attempting to read. A preamble therefore precedes the data to provide a standard pattern that the formatter decodes to establish proper timing. Generally, the preamble consists of at least 39 zeros followed by a single one; there is no standard, however, and there is some variation in preamble formats. Digi-Data's IM FM formatting circuitry synchronizes on a minimum of 39 zeros followed by a one to make it compatible with most of the controllers on the market. The controller must send the preamble encoded in NRZ; the Control Board then converts it to IM FM. When reading a preamble, the Control Board synchronizes on the all zeros portion and, after encountering the one at the end of the preamble, transmits the NRZ data and strobe derived from the IM FM data. A postamble follows the data to allow synchronization when reading reverse.

There is no standard for file marks; each controller must generate and decode them based on the manufacturer's specifications. It is recommended that the file mark be at least 100 bits long to allow for proper detection in high speed search mode. The controller is also responsible for generating the appropriate gaps after file marks and at the end of records.

Figure 4-3, Sample Data Waveforms
5) TAPE OPERATIONS

5.1 INTRODUCTION. This chapter describes drive and track selection, data transfer operations, High Speed Searches, and rewinds. It begins with a brief summary of each operation and then explains the controller timing at the interface.

5.2 SUMMARIES OF OPERATIONS.

5.2.1 PREPARING THE DRIVE. Before any tape operation can be executed the controller must select the drive, receive the appropriate status signals and set the track lines.

The controller can individually select each drive connected to it by addressing the unit select lines. Each drive can be configured to respond to a different unit select number (0 - 7). See the chapter on installation, section 2.2 (2).

Before any operation can begin the drive must be selected, and a cartridge must be inserted. This is indicated by the output signal RDY (Ready).

Once a drive is selected and has a cartridge inserted, the track lines should be set. (During rewind track selection is irrelevant.) These lines specify the track to or from which data is to be transferred. The lines must be set before any data transfer or search operation begins and must remain stable throughout the operation. During read operations the track lines should not be changed until the tape halts (BUSY goes false). When changing from write to read, the controller should wait at least 2 milliseconds after WND goes false before changing track selection.

5.2.2 WRITE OPERATIONS. Write Operations receive data from the controller and record it on tape. The drive will receive NRZ data with a Write Data Strobe and convert it to IFM. The data is recorded serially on one of four tracks. Write Operations can only be executed in low speed forward on Standard models, on Serpentine models, writing is forward on tracks 1 and 3, and in reverse on tracks 2 and 4.

To prevent accidental erasure, several internal status signals are required before the Write Operation can be performed. The SAFE switch on the cartridge must be in the unprotected position; this will be indicated by FUP - true. RDY must be true and the track lines must be set. After the track lines are stable Write Enable (WEN) must be set.

Once WEN is set the Write Operation may begin by asserting FWD (Forward). After the drive ramps up to speed (the prerecord delay), the preamble (supplied by the controller) is written on tape. The data follows, ending with the controller-generated postamble.

After the postamble has been written, the controller should wait until the entire postamble has passed the read head to complete the read after write check. After an extended postrecord delay (at least 2.5 usec longer than the read delay) the motion command may be removed. When the tape has halted (BUSY goes false), WEN may be removed. A new track may not be selected until at least 2 usec after WND is cleared; WND is cleared when a motion command is received that would be illegal for writing. That is High Speed (HSF), Rewind (RWD), Reverse (REV) on standard drives; and on Serpentine drives, Reverse on tracks 1 and 3, Forward (FWD) on tracks 2 and 4.

5.2.3 READ OPERATIONS. Read Operations transfer data from tape to the controller. The HPP Formatting circuitry converts the MFM data into NRZ data and Read Data Strobes and strips off the preamble. The drive can read bidirectionally, subject to controller limitations. No high speed read operations may be performed, however.

To initiate a Read Operation, RDY must first be true. The track lines should then be set, followed by the Forward or Reverse motion command. As long as HSF and WEN are not asserted, a read operation will take place. The track lines must be stable or the data will be unreliable. The Read Data is transmitted over the RNZ line. Data Detected (DAD) will be true when the RNZ line is valid and can thus be sampled. The RNZ line should only be sampled while DAD is true. NOTE: During the first 20 usec of the acceleration ramp it is recommended that RNZ not be sampled regardless of the status of DAD. The drive will begin transferring data to the controller immediately following the "one" in the preamble.

To end a Read Operation, the controller should first wait until the last data word is transferred and the postamble is completed. At that point DAD will go false. After a short postrecord delay (less than 100 usec) the controller should either remove the motion command or begin another operation "on-the-fly." Once the tape halts completely (BUSY goes false) the track lines may be changed safely.

5.2.4 HIGH SPEED SEARCH OPERATIONS. The High Speed Search Operation moves tape either Forward or Reverse under controller direction. Generally, the controller monitors DAD and counts how many records pass the read head to determine when to end the operation.
The sequence of commands for a High Speed Search Operation is very similar to a Read Operation, except that HSP is asserted before the motion command. The drive must be selected and RDY must be true; the track must be selected; HSP must then be set; lastly, the motion command must be asserted. When the drive has spaced the appropriate number of records, it should be decelerated and stopped. During deceleration, however, the drive will probably overshoot into the following data blocks; the drive must then return to the correct block. There are many ways to do this, depending on system formats and requirements. One common method is given below.

After spacing the appropriate number of records, remove HSP. Continue counting DADs while the tape ramps to synchronous speed. Once the drive is moving at synchronous speed, decelerate it to a halt at the end of the next data block. It should come to a stop between records. To return to the correct place on tape, space reverse in low speed (to prevent the tape from overshooting the gap again) the number of records passed during the ramp down. Once the tape halts (once again in the gap) the desired data can be read.

5.2.5 REWIND OPERATIONS. The Automatic Rewind Sequence begins with .6 seconds of high speed forward motion (to guarantee clearance of all three BOT markers), followed immediately by high speed reverse to the first BOT marker encountered (i.e. the one farthest from physical beginning of the tape). Once a BOT marker is encountered, the tape ramps down immediately. This is the only operation that can be performed while the track lines are changing.

There are several ways to initiate a rewind sequence. The controller can command a rewind operation by setting RWD low. A Rewind may be initiated manually through the RW input to the Option Connector. A rewind sequence is also executed whenever a cartridge is inserted if the drive is powered up. With Models xx10 and xx20 only, if a cartridge is in place but the drive is not powered up, a rewind will occur when power does come on.

5.3 CONTROLLER TIMING DIAGRAMS. The timing requirements for the major tape operations on each model of the drive are illustrated in the following timing diagrams with comments accompanying them. Note the following conventions:

1. The timing diagrams are drawn from the controller's perspective rather than from the perspective of a specific drive: the status signals shown are for the selected drive. While no drive is selected (e.g. while drive selection is changing) the status signals are not valid.

2. Whenever a signal is invalid (and therefore not to be examined) it is shaded in.

3. All boxed signal names on the timing diagrams represent controller inputs from the drive, and all unboxed signals are controller outputs.

4. All signals are TTL low true.

5. There is no rigid time scale in the drawings; all significant times are labeled. Where dual times are given, the first figure is for 64xx drives, the figure in () is for 83xx drives.

5.3.1 WRITE OPERATIONS. The timing diagram (figure 5.1) for the write operation also includes drive deselection and reselection. Note the following:

1. The track lines must be completely stable before SLG comes true. While the drive is selected, the track lines may only be changed if the drive has not been Write Enabled (WD) for at least 2 milliseconds and if the tape is not moving.

2. While drive selection is changing the status signals should be ignored.

3. WEN is a 300 nanosecond pulse (minimum). The leading edge of WEN sets and latches WD (Write Enabled). The drive remains write enabled until either a high speed or an illegal-for-write motion command is executed. Thus, even though the drive is deselected and then resellected, WD remains latched. Note that when Drive 2 is resellected the track lines must return to TRK 2 because WEN is still latched. Track selection may be changed two milliseconds after WEN is cleared if the tape is not moving.

4. The prerecord delay (delay from FWD to WDA) should be at least 40 milliseconds.

5. DAD should be ignored until the write data transmission begins (at least 40 milliseconds after the FWD motion command). As soon as FWD goes false DAD again should be ignored.

6. After DAD goes false there is a 2.5 millisecond (minimum) post-record delay before FWD is removed.

Write operations performed from BOT (figure 5.2) are identical to normal write operations except that the prerecord delay must extend at least 200 milliseconds after LPS goes false.
5.3.2 READ OPERATIONS. The read operation is shown in figure 5.3. Note the following:

1. While drive selection is changing the status signals should be ignored.

2. DAD should be ignored for at least 20 milliseconds after FWD is asserted. It should be ignored again as soon as FWD goes false.

3. The post-record delay is very short for read operations. The write delay is 2.5 milliseconds (minimum) to produce a sufficiently long interrecord gap; the read delay is very short to ensure that the gap written onto the tape is long enough to allow for deceleration and acceleration into the next record without encountering data.

Read operations performed from BOT are identical to normal read operations except that DAD should be ignored for at least 100 milliseconds after LPS goes false.

5.3.3 HIGH SPEED SEARCH OPERATIONS. Figure 5.4 shows a high speed search following a write operation (WND true). Items to note are:

1. The motion command may be either FWD or REV, with the other held false through the entire operation.

2. The track lines must be stable for the duration of the operation.

3. WND goes false as soon as the motion command is asserted (with HSP true).

4. DAD should be ignored for the first 20 milliseconds after the motion command. The controller may count DADs during the deceleration to enable the drive to place the tape in the correct interrecord gap (not shown).

5.3.4 AUTOMATIC REWIND SEQUENCE. The Automatic Rewind Sequence (see figure 5.5) is shown beginning past the EW tape hole following a write operation (WND true). Items to note are:

1. WND goes false as soon as RWD comes true.

2. RWD is a 300 nanosecond (minimum) pulse. Although the tape moves at high speed, HSP should not be set.

3. EWS and LPS are both suppressed during the rewind until BOT is reached.

4. The Select lines must be stable. The track lines should be changed only after BOT is reached.

5.4 DATA SIGNALS. The following paragraphs discuss timing for the write and read data signals.

5.4.1 WRITE DATA. The write data is input to the drive as NRZ. The relevant signals are shown in figure 5.6. Note the following:

1. The preamble, data, and postamble must be presented already encoded in NRZ.

2. The first zero of the preamble should be on WNZ 200 nanoseconds before WDE. WDE should be cleared on the positive going edge of the last WDS in the postamble.

3. WDS is a 25% duty cycle pulse that occurs once per bit. Data is clocked in on the negative going edge of the strobe.

4. Each bit must be stable on WNZ at least 200 nanoseconds before the clock. It may be changed on or after the positive going edge of WDS but must again be stable 200 nanoseconds before the next clock.

5.4.2 READ DATA. The read data is an output to the controller from the IIMF Formatter. The relevant signals are shown in figure 5.7. Note the following:

1. The IIMF Formatting circuitry is designed to strip the preamble from the data transmitted to the controller. It will always transmit the postamble and a few "garbage" cells after the postamble until DAD goes false.

2. DAD will come true within the first seven zeros of the preamble. DAD will go false after the end of the postamble.

3. RDS is a 25% duty cycle pulse that occurs once per bit. Data is clocked in on the negative going edge of RDS.

4. Each bit will be stable on RNZ at least 200 nanoseconds before the clock. It may be changed on or after the positive going edge of RDS but will again be stable 200 nanoseconds before the next clock.

5 - 3
Figure 5.2, Write From BOT
Figure 5.3, Read Timing Diagram
Figure 5.4, High Speed Search Operation
Figure 5.5, Rewind From EWS
Figure 5.6, Write Waveforms

Figure 5.7, Read Waveforms
6) MAINTENANCE AND CALIBRATION

6.1 INTRODUCTION. This chapter describes the maintenance and repair of the Digi-Data 6400 Series Cartridge Drive. It includes procedures for replacing all printed circuit boards and assemblies.

6.2 MAINTENANCE. The only routine maintenance required by the Cartridge Drive is head cleaning. The procedure below should be performed after every eight hours of system use or every week if the system is not used frequently. The correct procedure is:

1) Remove the cartridge.

2) Moisten a cotton swab with isopropyl alcohol or a commercial head cleaning solvent. Excessive liquid is not required.

   CAUTION DO NOT use carbon tetrachloride or any abrasive. Use of these will damage the head.

3) Clean the tape head thoroughly using firm vertical and horizontal strokes.

4) Once cleaned, allow a few seconds for the solvent to evaporate before loading a cartridge.

6.3 BOARD & ASSEMBLY REPLACEMENT PROCEDURES.

6.3.1 ENTIRE DRIVE. Before any of the replacement procedures can be performed, the drive must be removed from its housing.

1) Disconnect the AC power source.

   WARNING Power supply components in the cartridge drive housing can pose a shock hazard if the AC power is not removed.

2) Remove the four screws holding the drive to its housing.

3) Carefully withdraw the drive as far as possible. If there is an Options Connector on the Control Board, note its orientation and remove it. Then remove the power connector (JP) and the interface cable from the drive.

4) Lift the drive the rest of the way out.

5) To replace the drive, reverse the above procedures. No calibration is necessary.

6.3.2 CONTROL BOARD.

1) If the Control Board is being replaced remove the cable connecting the Control Board to the Servo Board. Pry it off from the ends using a small screwdriver.

2) Remove the screws holding the Control Board to the drive. Detach it from the plastic retainers at the front of the drive by squeezing the ears of the retainers, and lift it out of the drive.

3) To replace, snap the Control Board onto the plastic retainers and tighten the screws. Reattach the cable. No calibration is necessary.

   CAUTION Do not overtighten the screws or they will strip the nylon spacers.

6.3.3 SERVO BOARD.

1) Remove the Control Board.

2) Remove all connectors from the back of the Servo Board.

3) Unscrew the nylon spacers holding the Servo Board to the frame and the two screws holding the heatsink to the baseplate. Lift the board out slightly and detach the motor connector. Remove the board.

4) To replace the board, reverse the above procedure. If a different board has been installed it will be necessary to perform a complete calibration. See section 6.4 for procedures.
Figure 6.1, Parts Locations
6.3.4 TAPE HOLE SENSOR ASSEMBLY.

1) Loosen (do not remove) the screw holding the Tape Hole Sensor Assembly in place. Detach the connector from the Servo Board. Remove the sensor assembly.

2) To replace, place the sensor assembly in position and snug (do not tighten) the screw. Insert a cartridge into the drive to act as a guide. Position the sensor assembly so that the overhanging portion is centered over the window in the cartridge (front edge of the assembly will be parallel to the front edge of the cartridge). Hold it in this position and tighten the screw.

3) Replace the connector. No calibration is necessary.

6.3.5 STATUS (CIP/FIP) SWITCH ASSEMBLY

1) Remove the connector from the Servo Board. Unscrew the two screws from the CIP and FIP switches, being very careful not to lose the washers and nuts underneath the mounting plate. Remove the two switches.

2) To replace, place the CIP and FIP switches in position (actuators to the left) and put the screws in place. Carefully replace the washers and nuts and tighten.

**CAUTION**

Do not overtighten these screws or the plastic switches will break.

3) Replace the connector. Insert a cartridge and check that both switches can be activated. Loosen the screws and adjust the switches position if necessary. No calibration is necessary.

6.3.6 MOTOR/TACH ENCODER ASSEMBLY.

1) Remove the printed circuit boards.

2) Unhook the spring. Loosen the four screws holding the motor gimbals. Rock the gimbals back out of the sockets and remove the Motor/Encoder Assembly. **NOTE:** The gimbals do not have to be removed entirely; simply slide them out of the way.

3) To replace the Motor/Encoder place it into position. Slide the gimbals into place and tighten the four screws. Replace the spring. Replace the printed circuit boards.

4) It will be necessary to adjust the tape speed and ramp times. See section 6.4 for procedures.

6.3.7 HEAD.

1) Remove the printed circuit boards.

2) Remove the two screws holding the head in place from the underside of the top plate. Retain all hardware and plastic shims from under the head. Remove the head.

3) To replace the head, put it into place square to the mounting plate and replace the hardware. The Read and Write portions of the head should extend equally into the tape path. Check that the head body is not shorted to the chassis. Replace all printed circuit boards.

4) It will be necessary to calibrate the Read Amplifier and the Write Circuitry to the new head. See section 6.4 for details.

6.4 CALIBRATION PROCEDURES.

**WARNING!**

While there are no hazardous voltages in the drive itself, performing the following may place the technician near dangerous AC power supply components. Read the manual for the system which contains the cartridge drive before proceeding.

**ADJUSTMENT:** ±5 VR  **LOCATION:** R158  **TEST POINT:** Control Board, JD33/34

**PROCEDURE:** Adjust R158 to obtain 5.00 ±0.05 volts.

**ADJUSTMENT:** FWD Speed  **LOCATION:** R118  **TEST POINT:** Control Board, U48 pin 10

**PROCEDURE:** Install a Master Speed Tape (96.000 KHz signal) in the drive. Issue a FWD command to the drive. Monitoring U48 pin 10 with a frequency meter, adjust R118 for 96 KHz ±1% (±960 Hz). Make only full passes of the tape to keep tape tension controlled and select track 1 or 2 (an inside track) for the most reliable readings.
ADJUSTMENT: Rev Speed  LOCATION: R119  TEST POINT: Control Board, U48-10
PROCEDURE: Exactly the same procedure as for the FWD speed adjustment, except that a reverse command is given to the drive.

ADJUSTMENT: Ramp Time  LOCATION: R117  TEST POINT: Control Bd, U5D pin 17 (trigger) Servo Board, U2 pin 12 (signal)
PROCEDURE: Install a tape cartridge in the drive.
Issue alternating FWD and STOP commands at approximately this rate:
FWD—that 50 msec—STOP—that 40 msec—repeat.
With oscilloscope set to trigger negative, monitor the signal and adjust R117 so that the time from trigger to 90% of maximum value is 27 msec ±1.3 msec.

ADJUSTMENT: Write Circuitry  LOCATION: RP3  TEST POINT: Servo Board, U12, pin 6
PROCEDURE: (NOTE: RP3 is a quad potentiometer with one section for each track.
The adjustment must be performed for each track. The sections correspond to the tracks in this order: rear-track 3, track 2, track 1, track 4-front.)
Write to tape a continuous 11101110 pattern (EE hex).
Trigger the oscilloscope positive on the signal and use the variable time base to produce a waveform like the diagram. It must trigger at the zero axis. You will be adjusting the relative times between the zero-axis crossings of the waveform, absolute time is unimportant.
The first zero-crossing is called 2T; vary the timebase to place this exactly 4 divisions from the trigger point. Adjust RP3 to place the second zero-crossing (4T) at 8.1 divisions. You will have to readjust the timebase to keep 2T at 4 divisions as the adjustment causes both 2T and 4T to move. The diagram shows the final waveform.
(Some drives may have a single pot at RP3; in this case scan all the tracks before adjusting and perform the calibration only using the track with the greatest initial 2T zero-crossing time.)

Figure 6.2. Write Calibration Waveform

ADJUSTMENT: Read Circuitry  LOCATION: R113  TEST POINT: Servo Board, JD23
PROCEDURE: With JD23 (Servo Board) grounded, write high frequency (all ones) to tape.
Scan all 4 tracks while monitoring U12 pin 6. Select the track which shows the lowest peak-to-peak amplitude.
Monitor JD20 (Control Board) and adjust R113 until negative-going pulses begin to occur. Double-check that negative-going pulses are present on the other three tracks as well. Remove ground from JD23.
APPENDIX - APPLICATION NOTES

A1 Cartridges often lose tape tension during shipment, causing tape slippage and data errors. When using a cartridge for the first time or after it has been in storage or has been mishandled (jarring, etc.) retein the tape by performing a high speed forward to EOT and then rewinding to BOT.

A2 Shutting operations and Write-Backspace-Read operations over a single record are not recommended anywhere on the cartridge since they tend to degrade data reliability by loosening tape. If tape tension drops, any deformity in the tape itself (slight wrinkles, bowing, tape hole blemishes cf. Note A3, etc.) will pull the tape away from the head, causing errors. Maintaining tension prevents the tape from pulling away from the head and eliminates these errors. Note A4 gives the recommended write check/error correction procedure.

A3 The BOT and EOT holes on some cartridges may cause deformities at the beginning of track 3 and at the beginning and end of track 4. Since there is a higher incidence of errors in these zones when the tape is not properly tensioned (cf. A2 above), be especially careful to maintain tape tension while performing any type of error correction routine in these regions. Note A4 gives the recommended procedure write check/error correction procedure.

A4 To find and correct write errors the following procedure is recommended.
(1) Perform a read-while-write error check.
(2) If any errors are found, finish writing the record. Backspace 5 to 10 records and then read forward. The controller must know where it is in the data. Be careful not to simply backspace over an incorrectly written record and attempt to rewrite; if a dropout occurred, DAD will go false in the middle of the record, giving the controller a false indication of its location in the data, making it all but impossible to correct the write error, aside from possibly losing tape tension (cf. Note A2 above). Backspacing several records avoids the tension problem, and reading forward after the backspace allows the controller to "find its place" in the data so that it can rewrite the entire incorrect record.
(3) At the beginning of the record containing the error, rewrite the entire record with an extended interrecord gap to skip over the bad portion of tape.

A5 Cartridges have ferromagnetic guide pins which may become magnetized in the presence of strong magnetic fields. Data written on a tape with magnetized pins will be degraded as it moves back and forth and passes over those pins. If any possibility exists that unused cartridges have been subjected to a strong magnetic field, it is recommended that they be degaussed completely prior to recording data on them.
Cartridge Drive Schematic: Write Head
Cartridge Drive Schematic
Map-20S Miniature
Serial Input-20 Column
Alphanumeric-Thermal Printer

- Simple 2-wire data input
- Full 96 character print set
- Quiet inkless thermal printing
- Programmable controls
- Weighs only 4.2 lbs.
- Built-in self test program
- Complete interface electronics for isolated 20 mA current loop and RS 232 C

Extended Size
THE WORLD'S SMALLEST ALPHANUMERIC THERMAL PRINTER.
INTRODUCTION

MEMODYNE’s MAP-20S is a miniature, panel-mounting alphanumeric printer utilizing quiet, non-impact thermal printing for low cost display and instrumentation applications. The MAP-20S (MEMODYNE ALPHANUMERIC PRINTER) features 20-column printing in a self-contained housing including complete control and interface electronics with AC power supply.

The miniature size of the MAP-20S lends itself to a host of new applications.

With outline dimensions of 4.44W x 2.75H x 7.75D in (113x70x197mm) to the rear fuseholder excluding front panel, the MAP-20S uses just 95 cubic inches of space and weighs under 4.2 pounds (1.9kg). The small size is made possible by using an internal dedicated microprocessor for control, timing, character generation, printhead drive and motor stepping and as a UART.

The MAP-20S is expressly designed for smart analytical instruments, process control monitors, industrial data loggers, security systems, hotel management dispatchers, assembly line tally systems, data acquisition systems, aircraft and vehicle systems, telephone and data communications loggers and traffic, environmental and noise data loggers. In addition, the MAP-20S is an ideal, low cost alphanumeric printer for most microprocessor development systems.

The MAP-20S is a self-contained printer systems module and does not require separately-mounted interface electronics, power supplies and bulky cabling.

DESCRIPTION

The MAP-20S prints the full ASCII character set of upper and lower case letters, numerals, punctuation, etc. in 20 column lines across the paper. The internal control electronics of the MAP-20S offer special OEM programming features which would be impossible with an ordinary print mechanism. These features are either data-word or pin-selected and include:

- Print Direction, Buffer Mode, Character Size, Form Feed, Vertical Tab, Horizontal Tab, Backspace, Carriage Return, and Line Feed.

The serial MAP-20S simplifies external wiring to a minimum by requiring only 2 wires for the 20 mA current loop interface. The opto-isolation feature protects against common mode noise and ground loop problems.

The MAP-20S accepts serial input data in ASCII format. Both 20mA loop and RS-232-C electrical levels may be accepted on separate input pins. One character line (up to 20 characters) of input data is stored in an internal input register. Data input must then be halted briefly while the MAP-20S drives the thermal printhead and advances one line. Data is accepted at pin-selectable data rates from 75 to 9600 baud.

The RS-232-C input includes a Data Terminal Ready standard control output to synchronize start-stop data loading from remote sources.

FEATURES

- Needs only 2 wires to interface, simplifies input connections to any computer serial port.
- Includes all internal serial data and drive electronics and AC power supply. No extra electronics required. No bulky additional chassis or cables.
- Miniature 20-column alphanumeric panel-mount thermal printer.
- Internal microprocessor and UART includes 1-line, 20 character input buffer
- Internal or external BAUD rate clock.
- Serial 20 mA TTY current loop input is current direction independent and optoisolated to 300V. Eliminates ground loop noise problems. Permits positioning of the printer hundreds of feet from a computer.
- Standard RS-232-C connector also included.
- 4.2-pound featherweight, 115 lines per min (2 lines/sec) at high baud rates.
- Jumper or logic selected baud rate (75 to 9600) at any bit character length (9, 10, or 11).
- Jumper, logic, or character-selected (SO, SI) EXTENDED CHARACTERS.
- Jumper or logic-selected inverted (TEXT) printing or normal (LISTER) printing.
- Includes switchable dual 115 230 VAC power supply. OEM's stock one version, choice of line cords.
- Electronic End of Paper sensing allows printing to the last inch of paper.
- Internal self test program prints entire character set and is initiated from the front panel switch.
- 5V, 1/2A regulated DC power supply available for use on user’s external electronics.

APPLICATIONS — USE THE MAP-20S FOR:

- Miniature hard copy printer for medical systems, analytical instruments and diagnostic testers.
- Remote Slave Printer Terminal hundreds of feet from data source.
- Multiple-station, daisy-chained message repeater using 2-wire interconnects.
- Portable test and measurement instrumentation for laboratory or field use.
- Serial interface data logger or industrial data acquisition system with terminal at operator’s station remote from hazardous process.
SPECIFICATIONS

GENERAL

The MAP-20S prints alphanumeric information with 120 character columns on an internal roll of paper from externally supplied ASCII encoded characters. The MAP-20S receives both industry standard 20 millamp current loop levels and RS-232-C voltage levels.

The MAP-20S prints all upper and lower case ASCII letters, numbers, punctuation, and special symbols shown in ANSI X3 4-1977 in a 5-column by 7-row dot matrix. The printing is accomplished using a dot-line, thin-film, non-impact ceramic thermal printhead by selectively printing each 20 character-row of the character matrix. After each character-row has been printed, a stepper motor advances the paper. After the entire character-line has been printed, the paper is advanced 4 more character-row spaces, allowing the printed character-line to be immediately viewed.

The printhead design is self-cleaning. Periodic cleaning of the mechanism, printhead, and drive roller with isopropyl alcohol may be required. Cleaning is suggested for dirt accumulation depending on operating conditions.

WEIGHT

with full paper roll
4.2 lb
1.9 kg

DIMENSIONS

Outline (note 1) 4.44 x 2.75 x 7.00 in
112.8 x 69.9 x 177.8 mm
Front Panel 5.25 x 2.81 in
133.4 x 71.4 mm
Front Panel 4.50 x 2.78 in
114.3 x 70.6 mm

ABSOLUTE MAXIMUM RATINGS

Temperature Range (Ta)
Operating 0 to 50 °C
Storage -25 to 85 °C
Relative Humidity (RH) noncondensing 20 to 90%

Input line
Voltage Range (V) 115V 105 to 130 VRMS
230V 210 to 260 VRMS
Frequency Range (F) 47 to 440 Hz

Voltage On Any Pin (with respect to ground)
RX RS232, RX TIMING
DATA TERMINAL READY - 30 to +30 V
RX ILOOP
Maximum common mode 300V
All Other Pins - 0.7 to +6.0 V
Current Through RX ILOOP 50 mA

CHARACTERISTICS

Tamb = 25 °C RH = 50% Vj = 115V
Fj = 60Hz Data Rate = 9600 baud

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<td>Extended Size Char.</td>
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</tr>
<tr>
<td></td>
<td>Diameter</td>
<td>—</td>
<td>0.25</td>
</tr>
<tr>
<td>Internal Baud Clock Error</td>
<td>all baud rates</td>
<td>—</td>
<td>0.5</td>
</tr>
<tr>
<td>Input Register Full</td>
<td>Pulse Width</td>
<td>—</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Repetition Rate</td>
<td>—</td>
<td>13.3</td>
</tr>
<tr>
<td></td>
<td>Print Pulse Width</td>
<td>5.0</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Print Head Life</td>
<td>(note 4)</td>
<td>—</td>
</tr>
</tbody>
</table>

Notes:
1. Outline dimensions are exclusive of front panel, connector, and fuse.
2. The paper will darken with prolonged storage above 60 °C.
3. A high level may be achieved with no connection.
4. Using a random character distribution and Memorystex supplied paper.
I/O SIGNAL DESCRIPTION

CONTROL INPUTS:

NOTE: All printer control inputs contain internal pull-up resistors. A no connection achieves a logic high.

INTERFACE SELECT
- Pin 5 (ILOOP/RS232) Input. One LS TTL and one 75489A load with 4.7K pull-up resistor.
  
Interface Select low is RS232 true. RS232C true, connects the RX RS232C input line to the printer control electronics. Interface Select high is ILOOP true. ILOOP true, connects the RX ILOOP data inputs to the printer control electronics. The state of Interface Select is scanned at power-up and at the end of the self-test sequence.

BAUD CLOCK SOURCE
- Pin 6 (EXT/INT) Input. One LS TTL load with 4.7K pull-up resistor.
  
Baud Clock Source low is INT true. INT true, connects the internal baud rate generator (at a rate determined by Baud Rate Select inputs) to the printer control electronics. Baud Clock Source High is EXT true. EXT true, connects the EXT CLK input to the printer control electronics. The state of Baud Clock Source is scanned at power-up and at the end of the self-test sequence.

CHARACTER LENGTH SELECT
- Pin 13 (CB2) Pin 12 (CB1) Pin 11 (CB0) inputs. One LS TTL load with 4.7K pull-up resistor.
  
The 20S accepts the following character lengths independent of the state of the Character Length Select inputs:

<table>
<thead>
<tr>
<th>TOTAL # OF BITS</th>
<th># OF BITS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>START</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>1</td>
</tr>
</tbody>
</table>

BAUD RATE SELECT
- Pin 21 (BS3), Pin 22 (BS2), Pin 23 (BS1), Pin 24 (BS0) inputs. One LS TTL load with 4.7K pull-up resistor.
  
The Baud Rate Select inputs control the clock rate of the internal baud rate generator according to the following table:

<table>
<thead>
<tr>
<th>BAUD RATE</th>
<th>BS3</th>
<th>BS2</th>
<th>BS1</th>
<th>BS0</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>110</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>150</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>300</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>600</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1200</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2400</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4800</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9600</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The state of Baud Rate Select is scanned at power-up and at the end of the self-test sequence.

CHARACTER SIZE SELECT
- Pin 9 (CS0) Pin 8 (CS1) inputs. One LS TTL load with 4.7K pull-up resistor.

The Character Size Select inputs control the size of the printed character according to the following table:

<table>
<thead>
<tr>
<th>CS1</th>
<th>CS0</th>
<th>CHARACTER SIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>CONTROL CODE SELECTED</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>NORMAL</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>NORMAL</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>EXTENDED</td>
</tr>
</tbody>
</table>

*SO (0E Hex-CTRL N) to extended sized characters
SI (0F Hex-CTRL O) to normal sized characters
The initial state is normal sized characters

A normal size character is 7 dot lines high. An extended size character is 13 dot lines high. The full 96-character print set (both upper and lower case) may be printed normal size or extended size. The state of the Character Size Select input is scanned after each character is received and DTR is true. Character size may change on a character by character basis. Extended size and normal size characters may be mixed on a single line.

PRINT DIRECTION
- Pin 14 (TEXT/LISTER) Input. One MOS input with 6K pull-up resistor.

Print Direction high is TEXT true. With TEXT true, characters appear inverted when viewed at the front panel. When viewing a page of text mode printed, the last line printed is at the bottom of the page. Print Direction low is LISTER true. Lister true places the printer in the list mode. With LISTER true, characters appear non-inverted when viewed at the front panel. When viewing a page of list mode printing, the last line printed is at the top of the page. Print Direction is scanned after the first character of a print line is received and DTR is true. The print direction will only change on a line by line basis.

BUFFER MODE
- Pin 15 (LINE BUFFERED/SINGLE CHARACTER PRINTING) Input. One MOS input with 6K pull-up resistor

Buffer Mode high is LINE BUFFERED true. With LINE BUFFERED TRUE, data characters are printed a line at a time after storing them in the input line buffer. Characters are not printed as they are received. Buffer Mode low is SINGLE CHARACTER PRINTING true. With SINGLE CHARACTER PRINTING true, data characters are printed as they are received, as in keyboard echo applications. Buffer Mode is scanned after the first character of a print line is received and DTR is true. The buffer mode will only change on a line by line basis.

AUXILIARY PRINT
- Pin 25 (PRINT) active low. One pseudo TTL input with 4.7K pull-up resistor.

Print true, prints the characters stored in the line buffer and advances the paper one character line. Holding PRINT active, acts as a remote paper feed after printing one line. When printing a line, PRINT must go inactive before DTR becomes active to insure that a remote paper feed will not occur.
STATUS OUTPUTS:

END OF PAPER
Pin 16 (EOP) Output, active low. A darlington transistor with 4.7K pull-up resistor and one LS/LTL load. EOP active indicates that the paper is within 1 inch of exhaustion. The printer stops when EOP becomes active.

INPUT REGISTER FULL
Pin 2 (IRF) Output, active low. An MOS output with 6K pull-up resistor.

The IRF pulse train indicates that the line buffer is full and any additional printable data characters will be ignored. It begins once the 20th character is placed in the line buffer and continues until:
1. the line is printed
2. the buffer is reset with the Delete (Del 7F Hex) command
3. a character is removed from the buffer with the backspace (BS 08 Hex-CTRL H) command

An IRF pulse is issued following the receipt of a carriage Return (CR 0D Hex-CTRL M). IRF may be wired directly to the PRNT input to automatically initiate printing upon receipt of the 20th character in a line.

DATA TERMINAL READY
Pin 20 (DTR) Output, active high. One RS-232C transmitter DTR true may be used to control switching the user’s data communication equipment to the RX DATA RS232 input.

DTR inactive, indicates the printer is busy and is unable to receive additional data or commands. The user’s data communication equipment must stop data transmission after DTR goes false. The character in transmission may be completed.

DATA INPUTS:

RX ILOOP
Pins 17 and 18 (RX ILOOP) Input active when 20 mA current flowing. A rectified optoisolated current loop receiver.

Serial asynchronous data input selected when Interface Select is high. The baud rate is controlled by Baud Rate Select inputs.

RX RS232
Pin 3 (RX RS232) Input active low. One RS-232C receiver Serial asynchronous input rate, which limits the maximum baud rate. The baud rates are controlled by Baud Rate Select inputs.

TIMING IN:
EXTERNAL X16 BAUD CLOCK
Pin 4 (EXT CLK) Input. One LS/LTL input with 4.7K pull-up resistor

EXT CLK is an alternate source for the serial data baud rate. The EXT CLK rate must be 16 times the baud rate (or bits per second). The maximum baud rate is 9600 baud.

There is no minimum baud rate. EXT CLK is selected by Baud Clock Source input equal to EXT.

TIMING OUT:
RX TIMING
Pin 19 (FXTIM) output. One RS232C transmitter.

RXTIM, when the Baud Clock Source is EXT, is a copy of EXT X16 Baud Clock.

RXTIM, when the Baud Clock Source is INT, is a X16 baud rate clock.

POWER CONNECTIONS:
VCC
Pin 10 (Vcc)

Regulated +5v DC Power supply with 15A available externally.

LOGIC GROUND
Pin 7 (COM)

Power Supply Return.

CHASSIS GROUND
Pin 1 (CGND)

Chassis Ground Connection

A jumper is provided internally which may be removed to break the connection to the connector.

OPERATING MODES

The MAP-20S is a line printer; it prints a 20 character line of 5-column by 7-row dot matrix characters at once. Each character-line is printed on one character-row at a time. In between character-rows, the paper advances one character-row space. To print a character-row, the printhead is energized five times. Once for each column in the character-row. If all twenty dots of a particular column and line require no printing, the printer automatically skips to the next column and/or line. This action dramatically increases print rates for sparse lines.

The MAP-20S recognizes 96 of the 128 7-bit ASCII characters as printable. Of the remaining characters, the following characters are interpreted as control characters:

<table>
<thead>
<tr>
<th>ASCII</th>
<th>HEX</th>
<th>7-bit</th>
<th>KEYBOARD</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUL</td>
<td>00</td>
<td>CTRL</td>
<td>SHIFT P</td>
<td>Null — do nothing</td>
</tr>
<tr>
<td>BS</td>
<td>06</td>
<td>CTRL H</td>
<td></td>
<td>Backspace — Single Character Mode, interpreted as a space. Line Buffer Mode, deletes the previous entry, if the previous entry was the first entry, the buffer is considered empty.</td>
</tr>
<tr>
<td>HT</td>
<td>09</td>
<td>CTRL I</td>
<td></td>
<td>Horizontal Tab — Tab to characters 4, 9 &amp; 15</td>
</tr>
<tr>
<td>LF</td>
<td>0A</td>
<td>CTRL J</td>
<td></td>
<td>Line Feed — advance 1 character line, the contents of the input line buffer are not printed, the next data character will be added to the buffer</td>
</tr>
<tr>
<td>VT</td>
<td>0B</td>
<td>CTRL K</td>
<td></td>
<td>Vertical Tab — advance 5 character lines, the contents of the input line buffer are not printed, the next data character will be added to the buffer</td>
</tr>
<tr>
<td>FF</td>
<td>0C</td>
<td>CTRL L</td>
<td></td>
<td>Form Feed — advance 11 character lines, the contents of the input line buffer are not printed, the next data character will be added to the buffer</td>
</tr>
<tr>
<td>CR</td>
<td>0D</td>
<td>CTRL M</td>
<td></td>
<td>Carriage Return — print the contents of the input line buffer</td>
</tr>
<tr>
<td>SO</td>
<td>0E</td>
<td>CTRL N</td>
<td></td>
<td>Shift Out — to extended size characters</td>
</tr>
<tr>
<td>SI</td>
<td>0F</td>
<td>CTRL O</td>
<td></td>
<td>Shift In — to normal size characters</td>
</tr>
<tr>
<td>DEL</td>
<td>7F</td>
<td>DEL</td>
<td></td>
<td>Delete — reset input line buffer, the buffer is considered empty</td>
</tr>
</tbody>
</table>

All other non-printable characters are interpreted as spaces. The data control characters, in conjunction with the I/O programmable control features, make the MAP-20S a versatile panel mountable printer.

There are 3 ways to initiate a print cycle in a MAP-20S. After the data has been loaded into the input buffer the user may:

1) send a CR (0D Hex)
2) depress the FEED switch
3) strobe the Auxiliary Print input.

To print the contents of the input buffer. In addition, if one desires that the printer automatically print the contents of the input buffer when that buffer is full, simply connect the Input Register Full output to the Auxiliary Print input.
HOW TO LOAD PAPER

1. Depress both front panel slide latches and pull the printer mechanism out of the housing until the mechanism stops.

2. Raise the load bracket by pulling it forward until it latches. This automatically lifts the thermal printhead from the paper drive roller.

3. Pull the remaining paper out from under the printhead. Grasp the empty paper roll and pull it straight along the axle slot and out of the printer assembly.

4. Slide the paper roll axle out of the used paper roll and insert the axle into a new paper roll. DO NOT DISCARD AXLE!

5. Slide the axle (with new paper roll) into the axle slot and seal the axle in the bottom of the slot. Be sure that the paper is threaded from the rear and passes over the paper roll. Paper should be cut straight for easy insertion. Only the outside paper surface is treated for printing.

6. Insert the paper in the slot formed by the paper guide and the printhead until paper appears at the front panel opening. Pull paper through front panel slot. Close the load bracket by pressing it downwards, and check that the EOP LED turns off. If not, the paper is not in the proper paper path.

7. Slide the printer mechanism back into the housing until latching both slide latches. Advance the paper by depressing the Feed switch.

SAMPLE PRINTOUT (ACTUAL SIZE)

```
**#**%W*:**:+:**: 789:1:<>:0:ABCDGHIJK
456789:1:<>:0:ABCDGHIJK
HIJKLMNOPQRSTUVWXYZ
\N^L\abcdefghijklmnopqrstuvwxyz
ANB56789A101:10300
DLSE345451:103008
15678909TX:TH:03008
```

TIMING DIAGRAMS

- MARK
- SPACE
- START
- STOP

TYPICAL CHARACTER LINE TIMING
A single IRF pulse is issued following receipt of a character

TYPICAL SERIAL DATA
1st and 2nd start bit are optional. See Table 10 for detailed description of characters.

TYPICAL PRINT TIMING
220 ± 50 (ms) depends on number of lines and dots to print and character size.
FRONT PANEL

INDICATORS

**EOP** The End of Paper LED indicates when the paper is not in the proper paper path or the printer is out of paper.

**DTR** The Data Terminal Ready LED indicates when the printer is ready to receive an RS-232-C character.

**ON** The Power On LED indicates when the printer is operational.

**F/E** The paper indicator arm displays from Full to Empty the relative amount of paper remaining on the internal supply roll.

CONTROLS

**TEST/FEED** Depressing the switch to Feed performs an Auxiliary Print. Pressing and holding the switch to Test performs internal self-testing function, printing 385 lines. The self-test may be stopped by depressing and holding the switch to Feed. The Baud Clock Source and Baud Rate Select inputs are scanned after a self-test.
APPLICATION NOTE 1
USING THE MAP-20S AS A MESSAGE REPEATER
Several MAP-20S printers may be daisy-chained together using the 20 mA current loop interface to form a multistation remote slave terminal network. All the nodes of the network are driven from one computer port with only two wires. Examples of this class of applications include plant security systems where several stations are linked by MAP-20S printers to give periodic hard-copy printout of plant security and time of day information.

The wiring is very simple and noncritical unless very long distances, high electrical noise, or fast baud rates are involved. Each pair MAP-20S RX ILOOP inputs are hooked in series. Since the MAP-20S ILOOP interface is current direction independent, one need not keep track of current polarity. Care should be taken to insure that the sum of the MAP-20S ILOOP interface voltage drops (approximately 3.7V) do not exceed the compliance of the loop driver.

APPLICATION NOTE 2
TYPICAL RS-232-C INTERCONNECTION
When connecting directly to an RS-232-C terminal, the user is cautioned that many programmable features (both inputs and outputs) are included on the MAP-20S's RS-232-C connector. However, some terminals may use these same pins for RS-232-C functions which are not available on or required for the MAP-20S. It may be necessary to internally disconnect these wires before direct connection to such terminals. A CR character must be sent at least every 20 characters to print the contents of the input buffer. Should the user desire an autotransfer after the 20th received data character, simply connect Pin 2 (IRF) to Pin 25 (Auxiliary Print).

Using the following conventions:

- **CR** = Carriage Return character
- **HT** = Horizontal Tab character (CTRL I)
- **SO** = Shift Out character (CTRL N)
- **SI** = Shift In character (CTRL O)
- **SP** = Space

REQUIRED DATA FLOW

```
  1. CH<TIME<DATE<TSAMPLE
  2. toSP<columnsSP4,9,15,13
  3. SOH<RSORIZONTAL<SPOTS<ABSPSOS<HT<SICR

Let PRINT DIRECTION (pin 16) float.

4. Selectable<SP<SPOINTER<CR>
5. SSPORTION<SP<Inverted
6. printing<Sp<SP<TEXT<SP<CR>
7. applications<SP<Where<CR>
8. lastSPline<SP<printed<SP<
9. atSP<line<SP<bottom<SP<CR
10. theSP<printout<CR>
11. SOSSIZE<SP<SORSP<XSP<EMPHASIS<CR>
12. EXTENDEDSP<CHARACTER<CR
```

TYPICAL MAP-20S PRINTOUT

One must transmit the following characters to print the sample shown. PRINT (pin 25) was connected to IRF (pin 2) causing an autotransfer after the 20th character in a line.

```
  1. **CH** TIME DATE SAMPLE
  2. to columns 4,9,15
```

ORDERING INFORMATION:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAP-20SAC</td>
<td>20 column thermal printer with mating connector, hood and 3 prong U.S. line cord.</td>
</tr>
<tr>
<td>MAP-20SEC</td>
<td>Same as above except with VDE CE7-7/7 (DIN 49441) line cord.</td>
</tr>
<tr>
<td>PT-20B1</td>
<td>Box of 10 rolls of black on white thermal paper. Capacity — 10,000 normal size character lines per roll.</td>
</tr>
</tbody>
</table>