Manual
For
Recorder Model 9240

Revision
11-1-5

Allen Datagraph Systems Inc
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1 Introduction

1.1 Description

The Model 9240 is a two-channel 40 mm thermal strip-chart recorder module. Featuring microprocessor-based electronics and thermal dot array print head, the 9240 can either be operated in stand-alone mode or it can be interfaced to a host computer for additional flexibility. The versatility of the 9240 makes it the ideal chart recorder choice for a variety of applications and systems.

The 9240 hardware consists of three basic modules:

- The paper transport consists of the mechanical housing, drive and print rollers, and a stepper motor drive train for moving the chart paper at any of several calibrated speeds. A paper-out sensor is also provided.
- The 48 mm thermal print head is mounted on the top of the transport mechanism and contains an array of 384 thermal print elements.
- The microprocessor -based control electronics are located on a printed circuit board mounted on the rear of the unit. The controller processes analog and/or digital signal information and controls the operation of the paper transport and print head to produce waveform plots, text, or graphic images on the chart.

1.2 Software Development Kit

The 9240 software development kit can be downloaded from the Allen Datagraph web site at www.allendatagraph.com. Then click on Tech Support and choose the 9240 Recorder topic. The development kit includes a driver and demonstration code that allows user level programs to write to the parallel port of a PC from the Windows XP or Window 2000 operating system. The kit is written in Delphi 6. If you want to make changes to the Delphi source code for the kit or use the Delphi driver installation class, Delphi 6 is required. The kit uses a modified freeware driver developed by http://www.beyondlogic.org/ using the PortTalk module. If you prefer to write in C you can modify the driver installation software supplied by beyond logic to install the Allen Datagraph Port9240 driver by changing the driver name in their code. The driver is compiled by the Windows XP driver development kit. All source code is included in the kit.

1.3 Operating Modes

The 9240 features four distinct operating modes: analog waveform, digital waveform, text, and graphics. At power-up, the recorder enters the analog waveform mode. In stand-alone applications, where the 9240 is not connected to a host computer, only the analog waveform mode is available. For access to the other three operating modes, the 9240 must be interfaced to a host computer.

ANALOG WAVEFORM MODE:

The 9240 reads the two analog signals that are input through the P6 connector, digitizes using the on-board A/D converters, and plots the corresponding waveforms. The chart can be formatted as two separate 20 mm channels, with one analog signal plotted in each channel, or both signals can be plotted together in a single 40 mm channel. Channel 0 includes an optional pre amplifier to allow voltage ranges other then 0 to 5 volts.

DIGITAL WAVEFORM MODE:

Digital data from the host computer is latched into the recorder's C/D Port (command/data interface port), and the corresponding waveforms are then plotted.

TEXT MODE:

The 9240 receives ASCII characters from the host computer through the C/D Port and prints the corresponding text in either horizontal or vertical format.

GRAPHICS MODE:

The recorder accepts "bit mapped" graphics data through the C/D Port and uses the bit patterns to address and control the individual dot elements of the thermal print head. This mode can produce any desired graphics image or pattern on the chart.

1.4 Manual Conventions

The ~ (tilde) character before an electronic signal name indicates that the signal is asserted when at the LOW level. E.g. less then 0.8 volts.

The signal names which have a bar or over score are "true" when LOW.

A signal name with a bar over the top and the same named signal with a ~ prefix are the same signal.

~CMD/DATA Using a ~ in front of part of a name indicates the voltage level to select that name. In the case of ~CMD indicates a low voltage is necessary to select CMD and high voltage is necessary to select DATA.

2 Electrical Connections

2.1 Connector Locations

All electrical connections to the 9240 are made through connectors P6, P5, and P2 on the controller circuit board. These connectors carry analog signals, power supply connections, and digital interface signals respectively. Figure 2.1 shows the location and orientation of these circuit board connectors on the Rev D CPU board. Connector numbers and location differ slightly different in Rev B CPU boards.

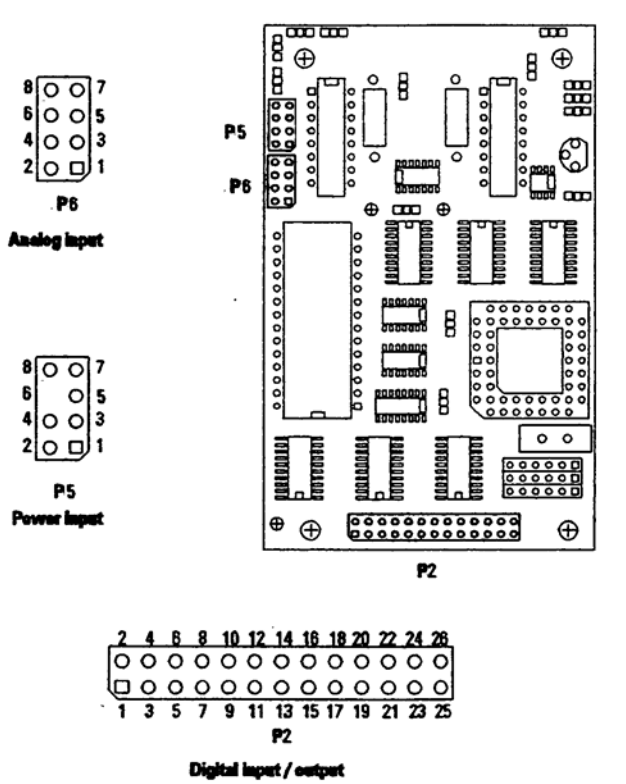


Figure 2-1 9240 Controller Board Signal Connections Table

2.2 Power Supply Connections

Two separate DC power supply voltages are required for correct operation of the 9240:

A regulated 5-volt supply (Vlogic) is required for powering the controller logic and analog circuits.

A separate Vmotor/Vhead supply powers both the chart drive stepper motor and the thermal array print head. Several different Vmotor/Vhead voltages are supported by different versions of the 9240; See Appendix E for the Vmotor/Vhead voltage requirements (listed as "PRINTHEAD VOLTAGE") of your particular unit.

The power supplies are connected to connector P5 on the controller board as shown in Table 2.1.

Table 2.1 Power Supply Connections

P5 Connector Pinout		Power Requirements		
PIN #	DESCRIPTION	SUPPLY	VOLTAGE RANGE	WATTS
1	Vlogic	Vlogic	5.0VDC ±10%	2 W
2	Vlogic GND	Vmotor = Vhead (The same supply is usually used for both head and motor) See Appendix E for nominal Vmotor/Vhead voltage	12V nominal: 11-13.8 VDC 15V nominal: 14- 16VDC 18V nominal: 17 -19 VDC See Rev D note below 11-30V	Vmotor : 5W Vhead : 64W All black printing. If only 192 pixels are ever black then 32W
3	Vmotor/Vhead GND			
4	Vmotor/Vhead GND			
5	Vmotor			
6	(key)			
7	Vhead			
8	Vhead			

Note: The Vhead power supply should never be applied to the 9240 unless the Vlogic supply has been switched ON and the microprocessor has had time to complete its reset cycle- This may be accomplished in either of two ways. With either method, Vmotor is usually switched along with Vhead to save power.

An external timing circuit may be employed to ensure that the V. supply is not enabled until at least two seconds after the Vlogic supply has stabilized to 5 volts. The external circuit must also insure that when the Vlogic supply is switched off the Vhead supply is also immediately disabled

The ~PSEN signal line, located on the P2 digital signal connector, may be used as a control signal to activate an external switch or relay to enable the Vhead supply. The PSEN signal line, described in futher detail in Section 2.3, goes LOW under control of the 9240 microprocessor only when the Vhead supply is actually required for chart motion or printing. ~PSEN stays HIGH at all other times when the Vmotor supply is powered on. This is the preferred method of controlling Vhead. See Figure 2.2 for a typical power supply control circuit using the ~PSEN signal line.

FAILURE TO FOLLOW THESE REQURIMENTS COULD PERMANENTLY DAMAGE THE PRINT HEAD AND MAY VOID THE WARRANTY.

Rev D Board Note: On the revision D board a new power supply circuit has been added. This power supply board converts the Vhead input voltage to 7.5 volts for the new head. As a result of the new power supply board the voltage range requirements of the Vhead has been significantly loosened. If the 9240 you have, has the new power supply board, then the Vhead/Vmotor voltage can be between 11V and 30V with the same number of watts as specified in the table above. In addition the Vhead voltage is now controlled by the ~PSEN line which turns off the head voltage when the printer is not printing. As a result of this change there is no longer a requirement to turn on the Vhead voltage after the Vlogic supply is turned on. They can be powered on at the same time.

Note also that the Vlogic, and Vhead/Vmotor grounds must be tied together at the power supply.

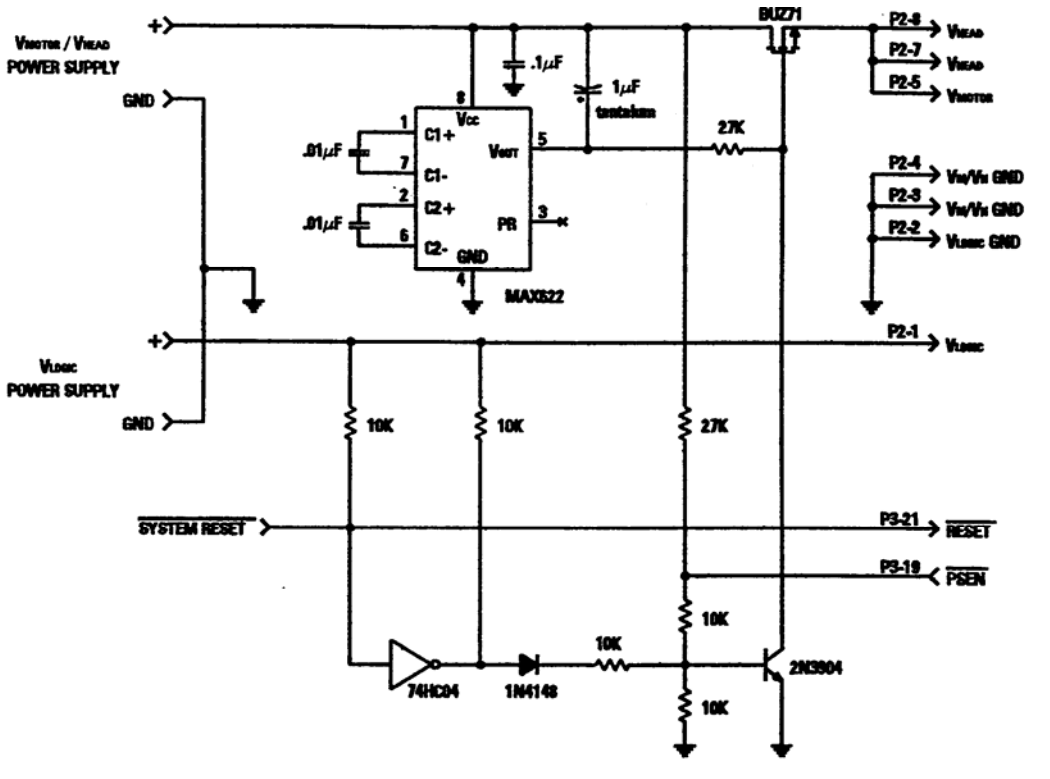


Figure 2-2 Typical Power Supply Control Circuit Using ~PSEN Control Signal

2.3 Analog Signal Connections

In analog waveform mode, the 9240 scans the voltages of the two analog signals inputs and plots the corresponding waveforms on the chart. The signals for channel 0 are fed into P6-1 (signal) and P6-2 (Gnd), while the signals for channel l are fed into P6-5 (signal) and P6-6 (Gnd). Each signal must be a positive voltage with a range of 0 to 5 volts maximum, with 5 volts corresponding to full-scale amplitude of the output plot. Table 2.2 shows the connection of these signals to the analog signal input connector.

Note: Analog signal input lines are NOT over-voltage protected. Ensure that these lines do not experience DC voltages greater than +5 VDC or less than 0 V with respect to GROUND.

FAILURE TO FOLLOW THESE REQUIREMENTS COULD PERMENANTELY DAMAGE THE RECORDER AND MAY VOID THE WARRANTY.

Table 2.2 Analog Signal Connections	
Connector P6	
PIN #	DESCRIPTION
1	Channel 0 input +
2	Channel 0 input -
3	Analog Ground
4	(Reserved)
5	Channel 1 input +
6	Channel 1 input -
7	Analog Ground
8	(Reserved)

2.4 Digital Signal Connections

Connector P2 carries all digital inputs and output signals between the 9240 and the external system. Table 2.3 lists the signals on the P2 connector along with a description of their use. All digital signals are TTL compatible. All input lines have on-board resistors and are pulled HI if left unconnected.

Note: Digital signal lines are NOT over-voltage protected Ensure that these lines do not experience DC voltages greater than +5.5 V or less than -0.7 V with respect to GROUND.

FAILURE TO FOLLOW THESE REQUIREMENTS COULD PERMANENTLY DAMAGE THE RECORDER AND MAY VOID THE WARRANTY.

Four digital input signals (M0-M3) form the "M Port," used exclusively for controlling the 9240 in stand-alone mode. The operation of the M Port is described in Section 3, Stand-Alone Operation.

Input signals D0-D7 form an 8-bit parallel bus. Along with the STROBE, CMD / DATA, W/~A, CHANNEL, and BUSY signals, this bus forms the "C/D Port" to provide a high-speed interface for controlling the 9240 from a host computer. Section 4, "Interfacing the 9240 to a Computer," describes the functions of these signals.

The remaining signals on connector are general-purpose control and status signals and may be used in either stand-alone or computer-driven mode. These signals are described below:

~STEP (P2-10)

This input is provided as an external clock for the chart drive stepper motor. The motor speed selection must be set to SINGLE STEP, either through the M Port (stand-alone mode) or by software command (computer-driven mode). Once the SINGLE STEP speed has been selected, each negative-edge pulse of the STEP line will advance the chart paper 1/18 mm. The maximum motor speed obtainable from the STEP input is 25 mm per second, corresponding to a maximum frequency of 450 Hz.

The ~STEP line can also be used to initiate the 9240's power-on self-test printout. To start a self-test, connect the ~STEP line to logic ground when the power is off then apply power. When the self-test printout begins, disconnect the ~STEP line from ground. See the Self Test Command description in Section 5.5.4 for a description of the self-test printout.

~PSEN (P2-19):

This output line is provided as a means for the 9240 to drive external circuitry for turning the Vhead/Vmotor power supply on and off PSEN goes LOW just before the 9240 starts to print and then HIGH after printing. It is recommended to use this line for efficient power consumption and head protection. See Section 2.1 for details.

~RESET (P2-21):

Bringing this input line LOW initiates a hardware reset of the 9240 and returns it to power-up conditions. RESET should be held LOW a minimum of 50 milliseconds to insure that a reset cycle occurs.

~ALARM (P2-22):

This output signal goes LOW to indicate the presence of any of the following alarm conditions: paper out, print head over-temperature, or self-test failure. Any communication with the 9240 when ALARM is asserted will be lost. The recorder will halt all activity except monitoring of the alarm sensors while the alarm condition persists.

Table 2.3: Digital Signal Connections

Connector. P2				
PIN #	SIGNAL NAME	Direction	FUNCTION. M Port (stand-alone) mode	FUNCTION, C/D Port (computer-driven) mode
1	~STROBE	Input	No connection	Latches D0-D7 & ~CMD/DATA into C/D Port
2-9	DO - D7	Input	No connection	8-bit command / data bus (C/D Port)
10	~STEP	Input	External dock input for chart drive motor (also initiates power-on self-test)	
11	BUSY	Output	no connection	Indicates C/D port busy status
12	CHANNEL	Input	Selects 1 x 40 mm or 2 x 20 mm char format	Specifies channel for digital waveform data
13	W/~A	Input	Triggers event mark	Specifies data type: digital waveform / other
14	~CMD/DATA	Input	No connection	Specifies content of D0-07: command/ data
15 -18	MO - M3	Input	Selects chart speed (M Port)	Must be HIGH for C/D port operation
19	~PSEN	Output	Control signal for external switching of Vhead power supply	
20	(Reserved)		no connection	
21	~RESET	Input	Hardware reset of 9240	
22	~ALARM	Output	Indicates error condition: Paper out, print head over-temperature, or self-test failure.	
23-25	Vlogic Gnd		Ground reference for digital signal	
26	(Reserved)		No connection	

2.5 Preamplifier

The schematic in figure 2.3 shows the configurable preamplifier only available on the Rev D 9240 CPU board. The 9240 is normally shipped with the preamplifier disabled. E.g. JP2 and JP3 installed. To configure the preamplifier you can use the preamp.xls worksheet that is included in the installation directory of the software development kit. After installing Excel and the SDK from the start menu select All Programs -> Allen Datagraph -< 9240 SDK -> Configure Gain of Preamplifier. Using the spreadsheet you can set the minimum and maximum voltage levels to configure the preamp as either an attenuator or an amplifier. To set the gain and offset of the amplifier follow the instructions on the preamp.xls. Install the resistor in R7 ($\pm$ 4K) as calculated by the preamp.xls to set the gain range. With the power off with an ohmmeter set to ohms Ω connect to TP2 and JP1 and set the gain exactly using the gain pot. After setting the gain, power up the 9240 with no analog input signal. Set DVM to DC volts (A V with a flat bar over the top). Connect black to TP3 Gnd and red to TP1 and adjust the zero voltage to the value calculated by preamp.xls. Move the jumper in JP2 to JP1. If very high gains are used you might have to separate the grounds to get a clean signal by removing JP3.

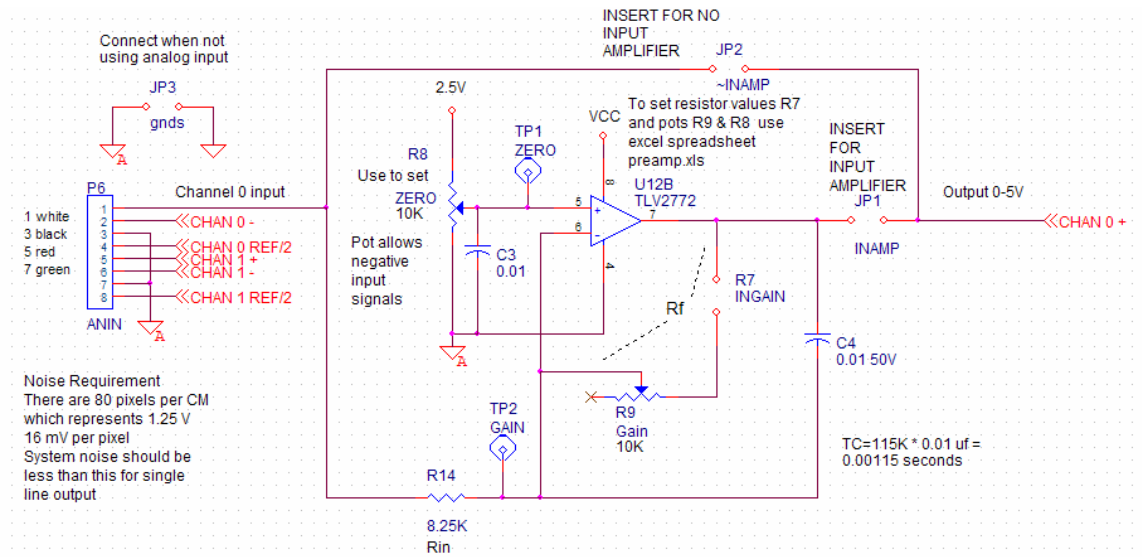


Figure 2-3 Preamplifier Schematic

The analog and logic ground should then be connected in the customers power supply. A gain of 0.3 to 3 should be easy to configure. Higher gains may require an external preamplifier with isolated voltage sources. If desired R7 can be chosen by the customer and Allen Datagraph will install this resistor at the factory. **Note: Ground bouncing caused by the print head turning on amplified by a large gain value in the preamplifier will cause spikes on the waveform if a large (> 40) number of dots on the paper are turned on simultaneously. If you need a large gain you will need to do one of the following: Provide your own preamplifier or do not use a printed grid.**

Use of the preamp will allow any range of analog signals in the range of –10V to 10V with a gain of 0.3 to 3 to be converted to the 0 to 5V range of the A to D converters on the board.

Note: the amplifier above inverts the analog signal input so the top of the range is mapped to 0V and the bottom of the range is mapped to 5V. Software commands from the parallel port can be used to invert the channel data back to normal. This feature can be defaulted on power up to either normal or invert status

E4H 229_{10} Invert Channel 0

E5H 230_{10} Normal Channel 0

3 Stand-Alone Operation

3.1 Configuration Settings

The 9240 is designed for quick setup of analog waveform mode recording without requiring connection to an external computer. The chart format information is permanently set in the program ROM of the 9240's microprocessor. The configuration sheet in Appendix E lists the power-up settings used in stand-alone mode for your particular version of 9240 software. For an illustration of the grid patterns, see Figure 5.1.

The power-up settings are also printed out as part of the power-on self-test. For an explanation of running this self test, refer to the description of the ~STEP signal in Section 2.3. Consult the factory if the self-test printout does not match the configuration sheet or if your application requires custom settings.

3.2 The M Port

In stand-alone operating mode, the M Port, consisting of the four input signal lines M0-M3 (P2 pins 15-18), is used to set the chart speed. Table 3.1 shows the M Port speed selections for the standard 9240 software configuration. The configuration sheet lists the chart speeds for your unit, in order from speed 0 through 7.

Table 3.3.1 M-Port Speed Selection P2					
M3 P2-18	M2 P2-17	M1 P2-16	M0 P2-15	SPEED NUMBER	DEFAULT SPEED*
L	L	L	L	0	5 mm / sec
L	L	L	H	1	10 mm / sec
L	L	H	H	2	25 mm / sec
L	L	H	L	3	50 mm / sec
L	H	L	L	4	5 mm / min
L	H	L	H	5	10 mm / min
L	H	H	H	6	25 mm / min
L	H	H	L	7	50 mm / min
H	L	L	L	Single Step (external dock)	
H	L	L	H	Halt	
H	L	H	L		
H	L	H	H		
H	H	L	L		
H	H	L	H		
H	H	H	L		
H	H	H	H	Ignore M-Port	

*See configuration sheet in Appendix E for speeds used in your version

The M Port inputs may be connected to TTL control signals or mechanically switched to Vlogic GROUND in the user's system to control the 9240-chart speed. Internal pull-up resistors are provided on the M Port inputs, and the controller scans and debounces the inputs continually to provide speed updates.

If M0-M3 are all HIGH, speed selection and other software commands from the C/D Port (host computer interface) will be recognized; otherwise, the C/D Port is ignored. When the M Port inputs select the "HALT" speed, the ~PSEN output (P2-19) goes HIGH to disable the Vhead/Vmotor power supply as described in Sections 2.1 and 2.2; several input combinations are provided for the "HALT" selection to simplify signal encoding. When the "Single Step" speed is selected, the ~STEP input (P2-10) is enabled, allowing the chart to be driven from an external clock See Section 2.3 for details.

3.3 Other Signals

In addition to the M Port, several other signals on the P2 digital I/O connector may be used to control the 9240 in stand-alone operation.. The operation of the general-purpose signals ~PSEN, ~STEP, ~ALARM, and ~RESET signals is described in Section 2.3. Two other signal lines usually associated with the C/D port have alternate functions when used with the M Port in stand-alone mode:

CHANNEL (P2-12):

In stand-alone mode, this signal line selects the channel format used for the analog waveform recording. If CHANNEL is HIGH or not connected, the 1 x 40 mm format is selected, with both analog signals plotted in a single 40 mm channel. If CHANNEL is LOW, the analog data is plotted in two independent 20 mm channels, channel 0 data in the bottom and channel 1 data in the top channel.

W/~A (P2-13):

When the 9240 is in stand-alone mode, pulsing the W/~A input LOW prints an event mark on the chart which signifies some important event in the user's system. The event mark style is listed on the configuration sheet in Appendix E. See Figure 5.2 for an illustration of the event mark styles. If the 2 x 20 mm chart format is selected by bringing the CHANNEL line LOW, the W/~A line triggers event marks in both channels. The LOW-going pulse on W/~A should be at least 1 millisecond long in order to be recognized.

4 Computer-Driven Operation

4.1 C/D Port Signals

For interfacing the 9240 to a host computer, a group of signals known as the C/D Port is provided on the P2 digital I/O connector. Through this interface the host computer can set the 9240 to any of the four operating modes and can transfer data for waveform mode annotation, digital waveform plotting, and text or graphics mode printing. The software command set of the 9240 is described in Section 5.

The C/D Port is a strobed 8-bit parallel input port of an IEEE-1284 parallel printer interface. For computer-driven operation, the M Port pins (P3-15 through P3-18) should be set HIGH or left unconnected. The C/D Port signal functions are defined as follows:

DO-D7 (P2-2 through P2-9):

These lines form the 8-bit input bus for transferring Command and Data bytes to the 9240. The least significant bit is DO (P2-2), while D7 (P2-9) is the most significant bit of each byte.

~CMD/DATA (P2-14):

This input specifies the content of the byte being sent on DO-D7. When ~CMD/DATA is LOW, a 9240 Command byte is being transferred. When ~CMD/DATA is HIGH, a Data byte is being sent, and the W/~A and CHANNEL lines specify the type of Data transfer.

~STROBE (P2-1):

The host computer pulses this input line LOW to transfer Command or Data bytes to the chart recorder. The falling edge of ~STROBE latches the contents of the D0-D7 and ~CMD/DATA lines into the 9240, and sets the BUSY line HIGH.

W/~A (P2-13):

During Data byte transfers (~CMD/DATA = HIGH), the W/~A input line specifies the type of Data byte being sent. When W/~A is HIGH, the Data byte contains digital waveform data to be plotted in the channel specified by the CHANNEL input line. W/~A should be set LOW for all other types of Data transfers. These include character data for text mode printing, bit-image data for graphics mode printing, and annotation text or other command arguments for analog or digital waveform mode operation. The W/~A input has no meaning for Command byte transfers (~CMD/DATA = LOW).

CHANNEL (P2-12):

When Digital Waveform Mode Data bytes are sent to the 9240, the CHANNEL input selects the channel in which the data is to be plotted, LOW for channel 0 data or HIGH for channel 1. CHANNEL has no meaning unless the ~CMD/DATA and W/~A inputs are both HIGH.

BUSY (P2-11):

This handshaking output goes HIGH when the C/D Port is busy. BUSY is set HIGH for each transfer by the falling edge of ~STROBE and goes LOW again when the 9240 has processed the byte and is ready for another one. Note that W/~A and CHANNEL are not latched, these lines must be stable before the start of ~STROBE and remain so until BUSY goes LOW. The BUSY output is also set HIGH for the duration of the 9240 reset cycle or while an ~ALARM condition exists (Section 2.3).

Table 4.1 contains a summary of the types of C/D Port byte transfers and the corresponding required states of the ~CMD/DATA, W/~A, and CHANNEL signals.

Table 4.1 C/D Port Byte Transfers			
Transfer type (contents of DO-D7)	~CMD/DATA	W/~A	CHANNEL
Command	LOW	don't care	don't care
Digital waveform data, channel 0	HIGH	HIGH	LOW
Digital waveform data, channel 1	HIGH	HIGH	HIGH
Non-waveform data (required by some commands.)	HIGH	LOW (waveform modes) don't care (text/graphics modes)	don't care

4.2 Command / Data Byte Transfer Cycle

The procedure for writing a Command or Data Byte to the 9240 is as follows. Figure 4.1 shows the timing of the C/D Port signals for a byte transfer cycle.

Begin with the ~STOBE HIGH. Wait for the BUSY handshake line to go LOW before beginning each write cycle.

Write the desired Command or Data byte information to the 8-bit bus D0-D7.

Write to the ~CMD/DATA, W/~A, and CHANNEL lines to set them the proper levels for the type of byte transfer desired. (See Table 4.1).

While holding the D0-D7 bus, ~CMD/DATA, W/~A, and CHANNEL lines stable, set the ~STROBE line LOW, then HIGH again.

Continue to hold the ~CMD/DATA, W/~A, and CHANNEL lines stable. Wait for BUSY to go low before transferring the next byte to the 9240.

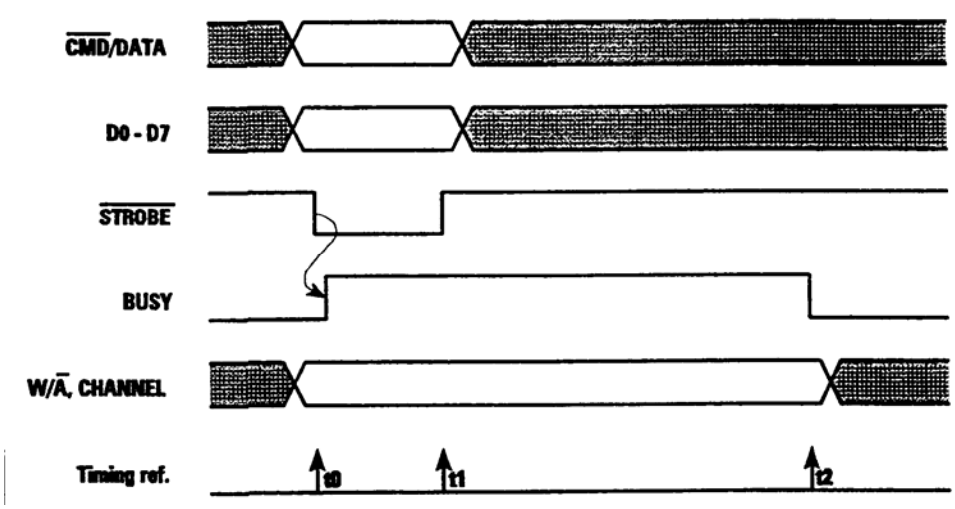


Figure 4-1 C/D Port Signal Timing

Notes:

At time t0, the DO-D7 and ~CMD/DATA tines must be stable. These lines are latched and the BUSY line is set HIGH by the falling edge of ~STROBE.

To prevent false triggering, DO-D7 and ~CMD/DATA should remain stable until after the end of the ~STROBE pulse at t1.

The W/~A and CHANNEL lines are NOT latched and must be held stable at their respective levels before the falling edge of ~STROBE at t0 until after the BUSY line goes L OW at time t2. No further communication can reliably occur until after t2.

5 Software Commands

5.1 Overview

All four 9240 operating modes, Analog Waveform, Digital Waveform, Text, and Graphics, are supported by a set of commands sent via the C/D Port computer interface. A single Command byte transfer enables most recorder functions. Additional Data bytes are sent to the 9240 for plotting or printing in the Digital Waveform, Text, and Graphics Modes, and also for chart annotation in both Analog and Digital Waveform Modes.

All software Command and Data transfers needed for 9240 operation are defined in this chapter. The discussion is organized by operating mode. Analog and Digital Waveform Mode command descriptions are combined in a single section, since these operate in essentially the same manner. Text Mode commands and Graphics Mode commands are each treated in separate sections, and a section of miscellaneous 9240 command concludes the chapter.

5.2 Waveform Mode Commands

The recorder's two waveform plotting modes, Analog Waveform Mode and Digital Waveform Mode, use the same set of software commands and operate identically except in the way that they obtain data for plotting. A curve-smoothing algorithm plots the data traces in either mode.

The command set supports numerous features to control the appearance and content of the chart. The 9240 commands for Waveform Mode are categorized and described in order as follows:

- Waveform Mode Selection Commands
- Chart Speed Commands
- Channel Format and Enable Commands
- Grid Commands
- Print Chart Speed Commands
- Annotation Commands
- Annotation Font Commands
- Reverse Text Command
- Event Marker Commands
- Dither Command

5.2.1 Analog Waveform Mode:

To place 9240 into the Analog Waveform Mode, the following Command byte is sent: E7H 231_{10} Enter Analog Waveform Mode

The 9240 continually scans the analog signals from the P6 connector using the on-board A to D converters, and produces a plot of the corresponding waveforms. This scanning process occurs automatically and requires no intervention by the host computer. A signal voltage of 0 volts is plotted at the bottom of the corresponding channel on the chart. A voltage of 5 volts is plotted at the top of the corresponding channel, an amplitude of 40 or 20mm, depending on the format used. The external analog circuitry must scale the incoming signals as necessary to lie within the recorder's input voltage range.

There are two curve-smoothing algorithms available:

Method 1: Min/Max value during time:

Method 2: Averaging of multiple readings for the A to D converter. The last (2, 4, 8 or 16) A to D conversions are saved. When it is time to calculate a value to place on the recorder these values are averaged. This has the effect of reducing the noise on the waveform by giving up some frequency response.

Selecting the Filter Length chooses the method. If filter length 0 is chosen the Min/Max method is used. If Filter length of 2, 4, 8, or 16 is chosen the Averaging method is used.

E6+N 230 Set Analog Filter Length 0, 2, 4, 8, 16

5.2.2 Digital Waveform Mode:

The following Command byte sets the recorder into Digital Waveform Mode: EBH 232_{10} Enter Digital Waveform mode

In this mode, waveform plots are generated directly from data bytes received from the C/D Port. Each byte is interpreted as an unsigned integer ranging from 0 to 255 decimal (FFH), plotted as zero to full-scale on the chart.

Data bytes for Digital Waveform Mode plotting must be presented on the C/D Port with the ~CMD/DATA and W/~A control lines both HIGH. The CHANNEL input directs plotting of the data to channel 0 of LOW or channel 1 if HIGH. See section 4.1 for use of these control line. Digital waveform data sent in this manner may be freely interspersed in the D/D port with other Command and Data bytes; digital waveform data is placed immediately into the waveform data buffer when received, rather then being placed in the general-purpose command queue. This permits Digital Waveform Mode data to be supplied to the 9240 at a constant sample rate, without appreciable jitter. The SDK sets its priority level to Real Time to minimize the effects of other things occurring while sending waveform data to the 9240 through the parallel port.

The maximum rate at which waveform data can be latched into the recorder is approximately 10k bytes per second (5K bytes per channel if both channels are active). However, the 9240 requires only one data sample per channel between motor steps to plot at its highest possible resolution. The chart is stepped in 1/18mm increments as points are plotted on the chart paper. The number of steps per second is dependent on the chart speed and equals the speed divided by the step size. For instance, at 25 mm/sec., the number of steps per second is 25 divided by 1/18, giving 450 steps/second. This means that at 25 mm/sec., 450 bytes per second for each channel are required to plot at maximum resolution. If data is supplied at a lower rate, the most-recently supplied data will be re-plotted as the chart advances, resulting in a "flat-line" trace on the chart.

Digital Waveform Mode data may also be plotted on a non-real-time basis. Setting the chart speed to Single Step mode, supplying the necessary data points for each waveform channel, and advancing the motor one step after each data update, does this. Section 5.2.3 contains details of the commands to control the chart motor.

5.2.3 Chart Speed Commands

The following commands set the recorder chart speed. The speeds shown are those used for the standard version of the 9240 controller software. The configuration sheet in Appendix E lists the available speeds for your version, in order from speed 0 through speed 7. The ~PSEN signal line, described in Section 2.3, goes LOW when the chart is running at any of the selected speeds, and HIGH when the chart is stopped.

ECH 236_{10} Set Chart Speed 0: 5 mm/second*

EBH 235_{10} Set Chart Speed 1: 10 mm/second*

EAR 234_{10} Set Chart Speed 2: 25 mm/second*

E9H 233_{10} Set Chart Speed 3: 50 mm/second*

F0H 240_{10} Set Chart speed 4: 5 mm/minute*

EFH 239_{10} Set chart speed 5: 10 mm/minute*

EEH 238_{10} Set Chart Speed 6: 25 mm/minute*

EDH 237_{10} Set Chart Speed 7: 50 mm/minute*

FFH 255_{10} Stop chart

The chart drive stepper motor can also be controlled directly, either by an external clock signal (See the ~STEP signal description in Section 2.3), or by software command. First the "Set Chart Speed: Single Step" command is given. Then a series of "Step Motor Once" software commands or low-going pulses on the ~STEP input advance

the chart, 1/18 mm per step. In either waveform mode, all waveform data accumulated since the last step is plotted each time a new step is made. When all steps have been given, the "Stop Chart" command given above should be sent to de-activate the ~PSEN line.

F1H 241_{10} Set Chart Speed: Single Step

F5H 245_{10} Step Motor Once

5.2.4 Channel Format and Enable Commands

The chart may be formatted as a single 40 mm channel or two 20 mm channels. In the 1 x 40 mm chart format, either or both waveform traces are plotted in a single 40 mm channel In the 2 x 20 mm format, a separate 20 mm channel is provided for each waveform. Channel 0 data is plotted on the bottom and channel 1 data is plotted on the top. The following commands establish the channel format used for plotting waveforms.

F3B 243_{10} Set Channel format: 1 x 40 mm

F2H 242_{10} Set Channel format: 2 x 20 mm

With either channel format, the following commands enable or disable the waveform traces individually. When a channel is disabled, the corresponding analog or digital waveform data is ignored.

40H 64_{10} Channel 0 trace OFF

48H 72_{10}, Channel 0 trace ON

41H 65_{10} Channel 1 trace OFF

49H 73_{10} Channel 1 trace ON

See the configuration sheet in Appendix E for the initial power-up settings for chart format and channel enable status.

5.2.5 Grid Commands

Grid Commands specify the chart background patterns for the reproduced waveforms. There are four grid options available, the three patterns shown in Figure 5.1 plus a gird-off option. When the 2 x 20 mm channel format is selected, grids may be specified independently for each channel. In the l x 40 mm format, the grid commands for either channel control the single grid The grid pattern commands are as follows:

60H Grid, Channel 0, Pattern 0: OFF

61H Grid, Channel 1, Pattern 0: OFF

68H Grid, Channel 0, Pattern 1: 5 mm square

69H Grid, Channel 1, Pattern 1: 5 mm square

70H Grid, Channel 0, Pattern 2: 5 mm square, 1 mm divisions

71H Grid, Channel 1, Pattern 2: 5 mm square, l mm divisions

78H Grid, Channel 0, Pattern 3: 5 mm horizontal lines

79H Grid, Channel 1, Pattern 3: 5 mm horizontal lines

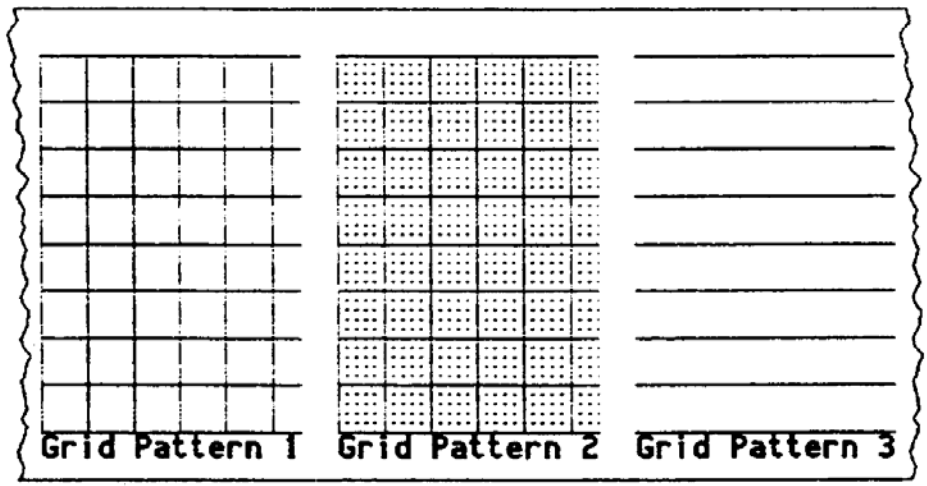


Figure 5-1 Grid Pattern Examples

See the configuration sheet in Appendix E for the initial power-up grid settings. If the power-up settings are for the 1 x 40 mm chart format, the grid pattern specified for channel 0 will control the single 40 mm grid

5.2.6 Print Chart Speed / Logo Commands

The 9240 can automatically print out the current chart speed whenever the waveform mode chart is running. A logo consisting of a customer-defined text string can also be programmed into the 9240's ROM memory and printed out along with the chart speed at periodic intervals. The chart speed / logo annotation is printed above is selected. Printout of the chart speed and logo text may be individually turned on and off by the following software commands:

D1H 209_{10} Print Chart Speed OFF

D0H 208_{10} Print Chart Speed ON

D3H 211_{10} Print Logo OFF

D2H 210_{10} Print Logo ON

The interval at which the speed and logo printout is repeated can also be controlled by means of the following software command The repeat distance is specified in centimeters by the value of the Data byte "Val", which may range from 5 to 255 decimal (05 to FFH). "Val" must be sent as anon-waveform Data byte transfer over the C/D Port, with the ~CMD/DATA line set HIGH and the W/~A line set LOW during the data transfer.

D4H+val 212_{10}+val Set Speed/Logo Print Interval = val**

The configuration sheet in Appendix E lists the initial on-off setting for the initial print speed and logo and the initial repeat interval. If there is no logo text programmed into your version of the 9240 ROM, there will be no entry for logo on-off setting.

5.2.7 Annotation Commands

The 9240 can annotate the waveform with text strings received from the C/D Port as the chart is being plotted. Each string may be up to 80 characters in length and is printed horizontally along the chart. Strings are positioned vertically in any one of 45 locations, referenced from the bottom of the chart in 1 mm increments. Figures 5.2 and 5.3 show these locations in relation to the 1 x 40 mm and 2 x 20 mm chart formats, respectively.

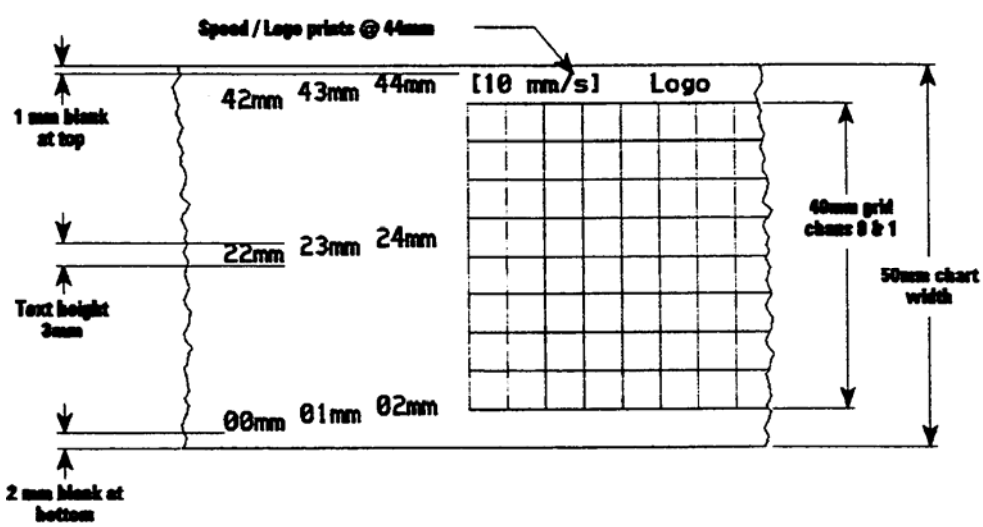


Figure 5-2 Annotation Segment Positions, 1 x 40 mm Channel Format

The annotation commands have the following format:

00H +string 0_{10} +string Annotation @ 0 mm position, text = "string"

through

2CH +string 44_{10} +string Annotation @ 44 mm position, text = "string"

The Command byte of each annotation command is sent in the normal manner on the C/D Port with the ~CMD/DATA line HIGH. This byte may range in value from 0 to 44 decimal (00H - 2CH). Its value specifies the vertical position of the annotation text on the chart, ranging from 0 through 44mm.

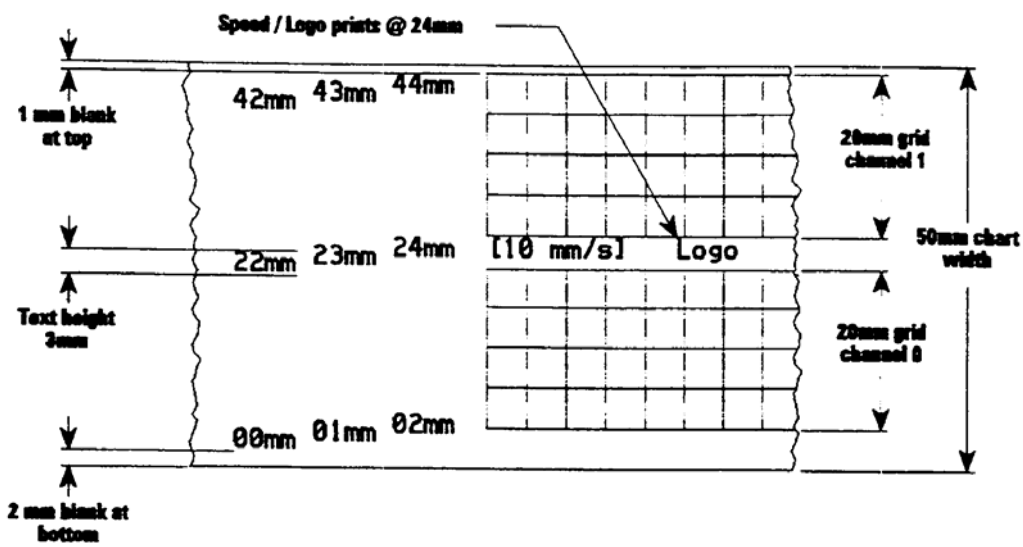
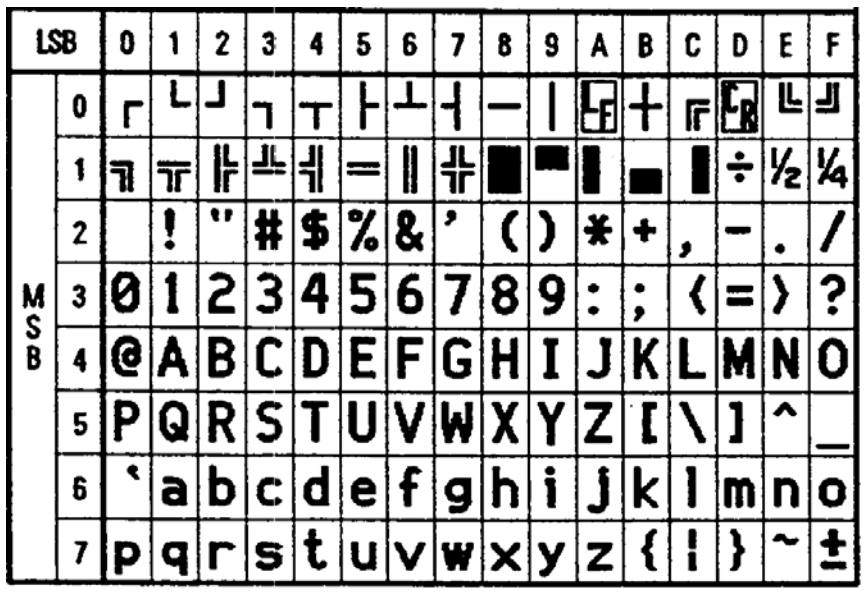


Figure 5-3 Annotation Segment Position, 2 x 20 mm Channel Format

The annotation Command byte is followed by the argument "string," the text string to be printed. This is sent to the C/D port as a series of Data bytes, with the ~CMD/DATA line HIGH and the W/~A line LOW. The string may be up to 80 characters in length. The text characters, any of the ASCII or special graphics characters shown in Table 5.1, are placed into a holding buffer as they are received When the carriage return (CR =13 decimal or 0DH) or line feed (LF =10 decimal or 0AH) character is received, the string buffer is printed at the specified position. If no CR or LF character is sent, the string will be printed automatically when the buffer is filled with 80 characters.



LSB	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
MSB 0	┌	└	┘	┐	┬	├	┴	┤	─	│	LF	┼	╔	CR	╚	╝
1	╗	╦	╠	╩	╣	═	╬	╧	▀	▄	▌	▐	▊	÷	½	¼
2		!	"	#	$	%	&	'	(	)	*	+	,	-	.	/
3	0	1	2	3	4	5	6	7	8	9	:	;	<	=	>	?
4	@	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
5	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_
6	`	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
7	p	q	r	s	t	u	v	w	x	y	z	{	¦	}	~	±

Table 5.1 Character Set

The 9240 maintains four separate buffers for printing annotation, assigning annotation commands to these buffers in a transparent round-robin fashion. Up to three completed annotation strings may be in the process of printing while the fourth buffer is simultaneously receiving data from the host computer. If a fifth annotation command is issued before the text from the first command has finished printing, the buffer containing the text from the first command will be overwritten.

Note: In Digital Waveform Mode, waveform Data bytes may be interspersed freely with the character Data bytes of annotation text. As each byte is received, the state of the W/~A line is used to make this distinction. This mechanism prevents degradation of frequency response in the Digital Waveform Mode when using the annotation function.

Waveform annotation may be printed in any of three high-resolution fonts, with character cell widths of 1, 2, or 3 mm. All character cells are nominally 3 mm high. The annotation font width may be changed by software command The selected font will also be used for printing the chart speed and logo text, as described in Section 5.2.6. For reliable results, the font size should not be changed while annotation text is being printed. The initial power-up font selection for annotation printing is listed in Appendix E.

The annotation font selection commands are as follows:

DDH 221_{10} Set annotation font: 1 mm

DEH 222_{10} Set annotation font: 2 mm

DFH 223_{10} Set annotation font: 3 mm

The following Reverse Text Command reverses the image of all text characters. This command functions as a toggle. Sent once, it changes all subsequent characters to print in reverse (white-on-black) mode; sent again, it reverses to normal (white-on black) printing. This command may be used any time during recorder operation, and affects Text Mode printing as well as all Waveform Mode text. On reset or power-up, the 9240 characters are set to normal (black-on-white) printing. Note: Black backgrounds take more power for Vhead than white backgrounds.

D9 217_{10} Reverse Text: toggle ON/OFF

5.2.8 Event Mark Commands

Commands in this group highlight an area of interest on the cart Four styles of event markers can be generated by the 9240, as shown in Figure 5.4. In the 2 x 20 mm channel format, event marks can be independently generated for each channel. In the l x 40 mm format, the event mark command for either channel may be used.

80H 128_{10} Event, Channel 0, Style 0: bottom tick

81H 129_{10} Event, Channel 1, Style 0: bottom tick

88H 136_{10} Event, Channel 0, Style 1: top tick

89H 137_{10} Event, Channel 1, Style 1: top tick

90H 144_{10} Event, channel 0, Style 2: center tick

91H 145_{10} Event, Channel 1, Style 2: center tick

98H 152_{10} Event, Channel 0, Style 3: across channel

99H 153_{10} Event, Channel 1, Style 3: across channel

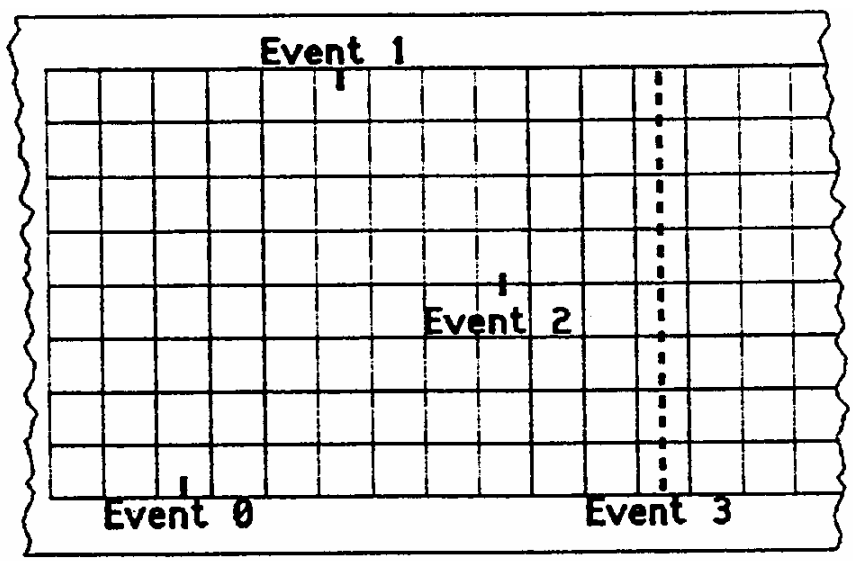


Figure 5-4 Event Mark Examples

5.2.9 Dither Commands

The 9240 incorporates a feature known as dithering which helps prolong the life of the thermal array print head. After every 255 centimeters of waveform mode plotting, the entire print pattern, including grids, signal traces, annotation, and so on, is shifted upward by one chart position. After another 255 cm of operation, the pattern is shifted back This procedure helps equalize wear on the individual print elements, reducing stress on elements that lie on major grid divisions. Dithering operates only in the Analog and Digital Waveform Modes, and can be turned off for applications that use paper with a pre-printed grid or for printing with no grid. The following commands turn the dither feature on and off. Refer to the configuration sheet in Appendix E to see if the dither is initially on or off for your version.

D6H 214_{10} Dither OFF

D5H 213_{10} Dither ON

5.3 Text Mode Commands

The Text Modes allow the 9240 to function as an alphanumeric printer, capable of printing the standard 96 ASCII character set along with 30 special graphics and math characters as shown in Table 5.1. Text can be printed in 1 mm, 2 mm, or 3 mm wide fonts and oriented either vertically or horizontally on the chart. The following commands select the 9240 Text Modes and fonts:

F8H 248_{10} Enter Vertical Text Mode, 1 mm font (48 columns across chart)

F7H 247_{10} Enter Vertical Text Mode, 2 mm font (24 columns across chart)

F6H 246_{10} Enter Vertical Text Mode, 3 mm font (16 columns across chart)

D8H 216_{10} Enter Horizontal Text Mode, l mm font (16 rows along chart)

D7H 215_{10} Enter Horizontal Text Mode, 2 mm font (16 rows along chart)

F4H 244_{10} Enter Horizontal Text Mode, 3 mm font (16 rows along chart)

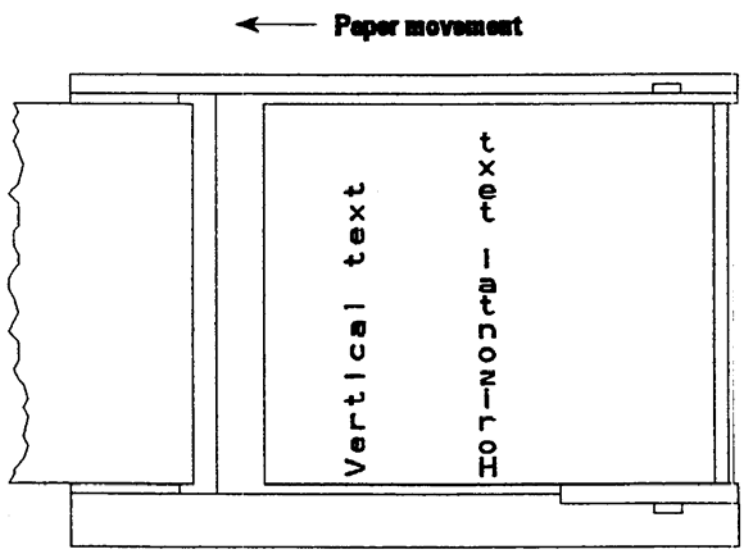


Figure 5-5 Text Mode Character Orientation

Figure 5.5 shows the orientation of the strings "Vertical text" and "Horizontal text" printed in their respective formats using the 3 mm wide fot. Note that the height of the changer cell is 3mm for all three font widths. Note that the vertical format, the text may be read directly as it is printer across the page. Horizontal text string are printed in the same order, but because of the rotation of the characters, they are not readable in the order printed Therefore, horizontal format strings are usually stored as character arrays in the host computer, then indexed one column at a time in reverse row order for printing.

After the desired text mode has been set, characters are sent to the C/D Port as Data bytes with the ~CMD/DATA line HIGH. Received characters are placed in a line buffer. The buffer holds as many characters as will fit across the chart. This amounts to 48, 24, or 16 characters per line for the 1 mm, 2 mm, and 3 mm vertical modes, respectively, or 16 characters per column for all horizontal modes (character height = 3mm). When the line buffer fills, its contents are automatically printed in the selected orientation and size. The chart advances and the line buffer is cleared. Either the carriage return (CR =13 decimal, 0DH) or line feed (LF = 10 decimal, 0A H) character may be sent to print a partially-filled (or blank) line.

Note: The ~PSEN line remains LOW (ACTIVE) continuously while the 9240 is operating in the Text Modes. If this line is used to control the Vmotor/Vhead power supply as described in Section 2.2, the 9240 should be reset during prolonged idle periods. This can be accomplished either by the RESET control signal (see Section 2.4), or by issuing the "Reset 9240" software command (see Section 5.5.1). The appropriate Text Mode command should then be sent before resuming printing.

5.4 Graphics Mode Commands

Graphics Mode produces any arbitrary image or pattern on the chart. The elements of the thermal array print head are individually switched on or off to print the desired image. For each element that is switched on, a black dot is printed at the corresponding point on the chart. By properly selecting which dots are to be turned on and advancing the paper after each row of dots is printed, the image can be created very precisely on the chart. The following command selects the 9240 Graphics Mode:

E20 22610 Enter Graphics Mode

Once the Graphics Mode command has been issued, each dot row of the image is formed by sending 48 Data bytes (~CMD/DATA line HIGH) on the C/D Port. Data bytes sent to the 9240 in Graphics Mode pass directly to the thermal array print head At 8 dots/mm resolution, the 48 data bytes correspond directly to the 48mm print head, 384 dots and 384 bits total per line. Graphics data is oriented ("bit-mapped") across the chart with the least significant bit of the first byte of appearing at the bottom of the chart and the most significant bit of the 48th byte appearing at the top of the chart. See Figure 5.6. Each bit is written with a 1 to turn it ON (black), or with a 0 to turn it OFF (white).

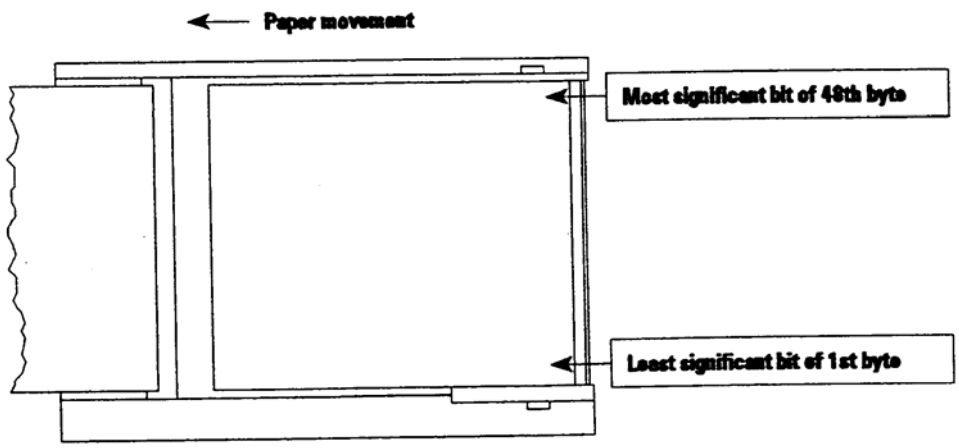


Figure 5-6 Bit-Mapped Graphics Data Orientation

After the 48th Data byte is received, the thermal head is automatically strobed to paint the line of dots. Next, the chart paper must be advanced into position for the next line to be printed. This normally done by issuing the following software command:

F5H 245_{10} Step Motor Once

or by pulsing the ~STEP input line LOW (see Section 2.4). Either of these methods will advance the chart one step, a distance of 1/18mm Since the dot dimension is somewhat larger than 1/8 mm in the direction of paper movement, the chart may be advanced a second time to move the chart a total of 1/9 mm after each row of graphics data is printed A single step between dot rows produces a higher resolution in the chart motion direction. Two steps per row will reduce the amount of time and data needed to print the image.

Note: The ~PSEN line remains LOW (ACTIVE) continuously while the 9240 is in the. Graphics Mode. If this line is used to control the Vmotor/Vhead power supply as described in Section 2.2, the 9240 should be reset during prolonged idle periods. This can be accomplished either by using the ~RESET control signal (see Section 2.4), or by issuing the "Reset 9240" software command (see Section 5.5.1). The "Enter Graphics Mode" command should then be sent to resume graphics printing.

5.5 Miscellaneous Commands

5.5.1 Reset Command

The following command initializes the recorder to the power-up default settings as shown in the configuration sheet in Appendix E. This command also stops the chart and disables the ~PSEN signal line (See Sections 2.2 and 2.4).

F9H 249_{10} Reset 9240

5.5.2 Print Head Control Commands

The following ids enable and disable the 9240 print head. They can be used with the "Set Chart Speed" commands to advance the paper without printing. This capability is useful for loading a new roll of paper or for advancing a completed chart to the exit slot for easy tear off.

FDH 253_{10} Print Head OFF

FCH 252_{10} Print Head ON

5.5.3 Step Motor Once Command

The following command advances the chart one motor step or 1/18 mm. It is used in Graphics Mode to advance the chart after each graphics row is printed (see Section 5.4). It can also be used in the Text Modes to insert additional spacing between character lines. In the Waveform Modes, the "Step Motor Once command can be used along with the "Set Chart Speed. Single Step" command (See Section 5.2.3). In waveform modes, each "Step Motor Once" command prints out one row's worth of data, grids, event marks, annotation, etc., as established, then advances the chart 1/18 mm

F5H 245_{10} Step motor Once

5.5.4 Self Test Command

The following software command initiates the 9240's built-in self test:

FAH 250_{10} Self Test

The self-test function helps confirm that the configuration and operation of the 9240 hardware and software are correct by printing out a test strip. The self-test strip consists of the following.

A header block; This includes the controller ROM software part number and revision. These should be checked against Appendix E to -ensure that the correct software is installed in your 9240

A memory test section

The program ROM (read-only memory) is tested first. The words "ROM test" are printed, then a checksum test routine is performed. If this completed successfully, the words "ROM checksum OK" are printed If the checksum test fails, the ~ALARM signal line on the P2 connector (Section 2.4) goes LOW to indicate a failure, and the ~PSEN signal goes HIGH to disable the Vmotor/Vhead power supply. The 9240 must be powered off and on again or the ~RESET line must be brought LOW to clear this error condition. The Reset software command cannot be used for this purpose, since the C/D Port is disabled by the error condition.

The RAM (read-write memory) is tested next. First the RAM internal to the 9240's microprocessor is tested, then the external RAM chip is tested. These tests operate similarly to the ROM test.

A WAVEFORM mode example using the 1 x 40 mm format with two superimposed waveforms, grid, and sample annotation.

A WAVEFORM mode example using the 2 x 20 mm format with two separate waveforms, grids, event markers, and sample annotation.

HORIZONTAL TEXT mode samples, showing the entire 9240 character set in 1 mm, 2 mm, and 3 mm wide fonts.

VERTICAL TEXT mode samples, showing the character set in 1 mm, 2 mm, and 3 mm wide fonts.

A series of four GRAPHICS mode test patterns. These consist of three checkerboard patterns in 1/4 mm, 1/8 mm, and 3mm sizes, followed by pattern of l mm diagonal bars. These patterns should be examined closely to determine that all the elements of the thermal array print head are functioning correctly.

A configuration summary lists the print head characteristics, chart speeds, fonts, power-up default settings, and other options which apply for the particular software part number used on this unit. Again, these should be verified against the configuration data in Appendix E.

A footer message: "SELF TEST COMPLETE."

The self-test function can also be initiated by grounding the ~STEP input line before powering up the 9240, then removing the ground once the self test printout has begun (see Section 2.4). Immediately after the self-test begins, the BUSY line on the C/D port goes HIGH, indicating that the recorder is unable to accept commands. After the self-test is

finished, the 9240 is reset to the factory default conditions. The BUSY line goes LOW again and the C/D Port becomes active only after the self-test and reset cycle has been successfully completed.

6 Paper Loading

With power removed from the recorder:

- Open the carriage by pulling forward on the finger grip located on the right side of the carriage. Remove the spool remaining from the previous roll of paper.
- Insert the new paper roll onto the paper spindle with the leading edge unrolling from the bottom. Unroll about six inches of paper.
- Pass the unrolled paper over the rubber pressure roller and partially close the carriage.
- Insert the leading edge of the paper into the slot in the front of the carriage. Push the paper into this slot until it emerges from the paper exit slot at the bottom of the carriage platen
- Close the carriage fully.

With power applied to the recorder, chart drive halted due to paper out:

- Open the carriage by pulling forward on the finger grip located on the right side of the carriage. Remove the spool remaining from the previous roll of paper.
- Insert the new paper roll onto the paper spindle with the leading edge unrolling from the bottom. Unroll about six inches of paper.
- Pass the unrolled paper over the rubber pressure roller and close the carriage completely.
- Insert the paper into the slot in the front of the carriage. Continue pushing the paper into the slot until the chart drive starts.

7 Care of the Recorder

The 9240 is designed for minimum preventive maintenance, and normally requires only a simple cleaning. All thermal chart recorder papers leave some residue on the print head heating elements or on the pressure roller. These deposits can be easily removed using a cotton swab moistened with alcohol.

Open the carriage and inspect the print head and pressure roller to see if cleaning is necessary. Recorder usage determines how frequently cleaning is required. If cleaning is required, apply alcohol sparingly to moisten the cotton. Use ONLY isopropyl alcohol -- other solvents may damage the head, roller, or plastic housing. Gently remove any residue by passing the moistened cotton over the area requiring cleaning.

NOTE: Saturating the pressure roller with alcohol may remove lubricants from the rubber.

8 Specifications

See the configuration sheet in Appendix E for the power-up settings for your software version.

8.1 General

Writing method:	Direct thermal array print head
Print head	Width: 48mm
	Resolution: 8 dots/mm (200 dots/inch)
Chart motor:	1.8° stepper motor (18 steps/mm)
Paper:	80 foot roll. 50mm wide, 2.125" diameter max.
Input power:	Logic: 5 VDC ±10%, 2W
	Head/Motor: (See appendix E for nominal voltage)
	12V nominal: 11 to 13.8 VDC
	15V nominal: 14 to 16 VDC
	18V nominal: 16 to 18 VDC
	10 to 64W average, depending on print conditions
	Rev D boards allow Head motor voltage in 11 to 30V range.
Logic Input levels:	HIGH: > +3.6 VDC (5.5V absolute max)
	LOW: < +0.8 VDC (-0.7V absolute min)
Weight:	740 g
Chassis:	Glass-filled polycarbonate
Paper out sensor:	Reflective sensor, TTL output to host

8.2 Waveform Mode

Number of Channels:	2
Channel Formats:	Single 40 mm channel, 1 or 2 overlapping traces
	Dual 20 mm channels, 1 trace per channel
Analog input voltage:	0 to 5VDC voltage swing gives full-scale plot
Frequency response:	DC to >200Hz
Analog to digital conversion:	8 bits, 1300 Hz sample rate
Digital waveform mode:	8 bits, 2 channels
Chart speeds:	5 mm/min. to 50 mm/sec. (See appendix E)
	Single step via software or external clock, 0 to 25 mm/sec.
Speed accuracy:	<±2% of rated speed
Trace algorithm:	Automatic curve smoothing or
	Averaging of multiple Analog to Digital readings.
	Software selectable
Time axis resolution:	18 dots/mm (0 to 25 mm/sec)
	9 dots/mm (50 mm/sec)
Grids:	4 styles: 5 mm, 5 mm w/1 mm subdivisions, 5 mm horizontal, OFF.
	Independently selected for each channel in dual 20 mm channel format.
Event Markers:	4 styles: Top, bottom, center tick, or dashed line full channel. Independently triggered for each channel in dual 20 mm channel format.
Annotation:	Chart speed, logo text and up to 4 user-defined annotation strings active simultaneously. User defined text can be located anywhere on text in 1 mm increments. Selectable 1, 2 or 3 mm fonts.
Dither:	Waveform pattern shifts up/down 1 position every 255cm of plot distance. Software selectable.

8.3 Text Mode

Character size:	Width: 1 mm, 2 mm, or 3 mm. Height: 3 mm.
Formats:	Vertical (16, 24, or 48 columns across chart) Horizontal (16 lines across chart)
Character set:	95 ASCII, 31 graphics/symbol characters
Print speed:	>8 lines/second, 3 x 3mm characters

8.4 Graphics Mode

Method:	Raster bit map, 1 bit per dot, 48 bytes
Print width:	384 dots, 48mm
Resolution:	Chart width axis: 8 dots/mm
Paper movement axis:	18 dots/mm, single step 9 dots/mm, double step

8.5 Digital Control Interface

Signal Levels	TTL compatible:
Inputs:	V_{IH}: 2.0V min, V_{IL}: 0.8V max, $R_{pullup.}$ = 10K ohm Outputs: V_{OH}: 2.4V min, $V_{IL,}$: 0.8V max.
Stand-alone mode:	Analog Waveform mode only.4 motor speed select inputs, (M Port)
Computer-driven mode:	Analog and Digital Waveform, Text, and Graphics modes accessible via software commands. 8-bit parallel Command/Data input port (C/D Port) ~STROBE and BUSY handshake signals ~CMD/DATA, W/~A, CHANNEL select inputs
General-purpose signals:	~ALARM, ~PSEN outputs, ~STEP and ~RESET inputs.

8.6 Environmental

Temperature:	Operating: 0 to +55 ° C
Storage:	-40 to +85'C
Humidity:	5 to 85% RH, without condensation

8.7 Reliability

Thermal Print head:	50 km of paper
Mechanical:	100 km of paper

The products are designed and produced for applications in ordinary electronic equipment (AV equipment, OA equipment, telecommunications equipment, home appliances, amusement equipment, etc). If the product is to be used in devices requiring extremely high reliability (medial equipment, transport equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or operational error may endanger human life and sufficient fail-safe measure, please consult with the Company's sales staff in advance. If product malfunctions may result in serious damage, including that to human life, sufficient fail-safe measures must be taken, including the following:

a. Installation of protection circuits or other protective devices to improve system safety.

b. Installation of redundant circuits in the case of single-circuit or software failure.

The product is designed for use in a standard environment and not in any special environments. Application of the products in a special environment can deteriorate product performance. Accordingly verification and confirmation of product performance, prior to use, is recommended if used under the following conditions:

a. Use in various types of liquid, including water, oils, chemicals, and organic solvents

b. Use outdoors where product is exposed to direct sunlight, or in dusty places.

c. Use in places where products are exposed to sea winds or corrosive gases, including: CL_2, H_2S, NH_3, SO_2 and NO_2

d. Use in places where the product is exposed to static electricity or electromagnetic waves

e. Use in proximity to heat-producing components, plastic cords, or other flammable items

f. Use involving sealing or coating the product with resin or other coatings materials

g. Use involving unclean solder or use of water or water-soluble cleaning; agents for cleaning after soldering

h. Use of the product in places subject to dew condensation

The product is not radiation resistant.

The company is not responsible for any problems resulting from use of the product under conditions not recommended herein.

The company should be notified of any product safety issues. Moreover, the customer should periodically monitor product safety issues.

Appendix A Using The 9240 with A PC

This appendix contains application information for operating the 9240 chart recorder from an IBM-compatible personal computer. The discussion covers hardware interfacing, PC parallel port register functions, data transfers from the PC to the 9240 C/D port, and programming examples which demonstrate all four of the 9240 chart recorder operating modes.

A.1 Interface Cabling

Figure A-1 shows the interface cable connections from a standard IBM-PC compatible parallel printer port to the 9240's P3 digital 1/O connector. Additional connections from the user's system to the 9240, such as the ~PSEN output and the ~R E S E T and ~ST E P inputs to P2, power supply connections to P5, and analog signal connections to P6, are not shown. All register descriptions and programming examples in this application note assume that the cable is used as illustrated below.

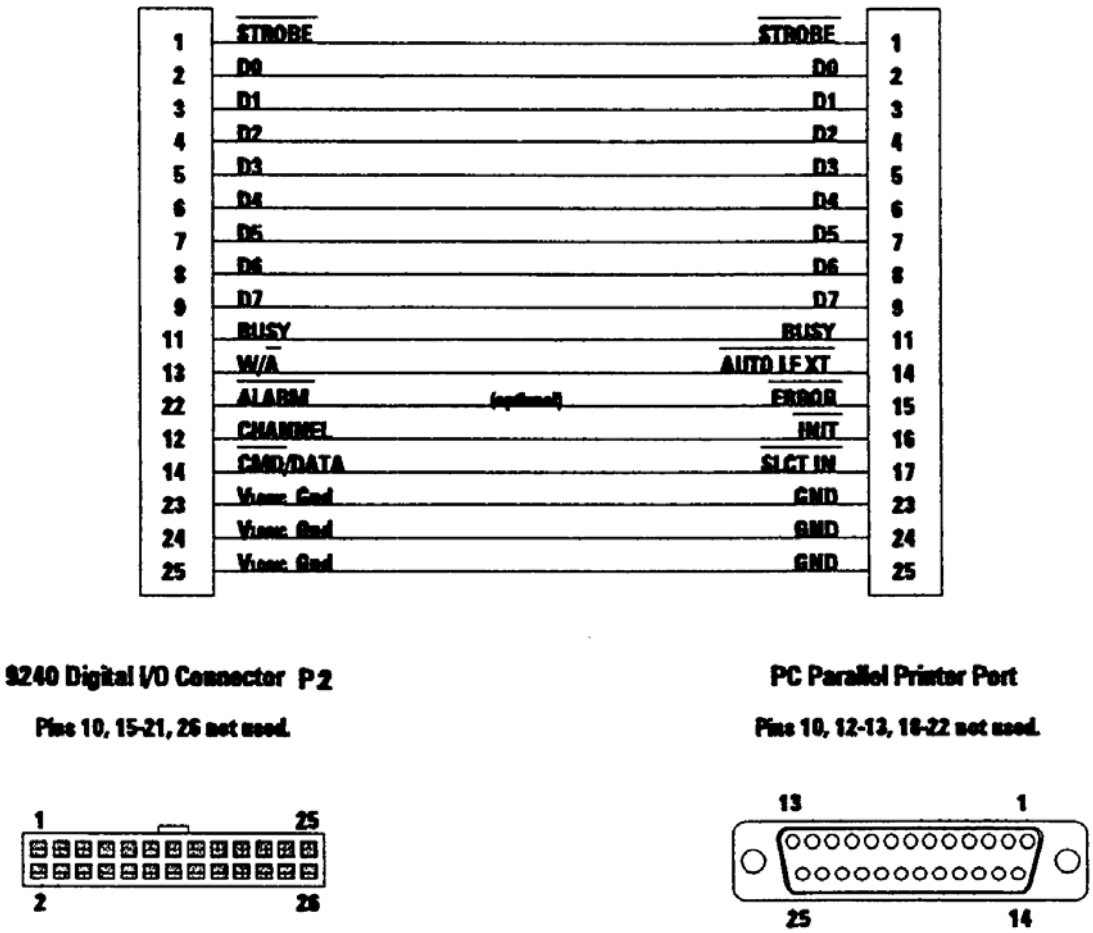


Figure A-1 Interface Cable - 9240 to IBM PC Compatible Parallel Printer Port

A.2 PC Parallel Printer Port Registers

For each parallel printer port in the PC architecture, there are three I/O registers used by software to control the port. With the chart recorder connected to the parallel printer port as shown in Figure A-1, reading and writing these three I/O registers establish control of the 9240. Table A-1 defines the bit functions of the three parallel printer port registers when used with the 9240.

Each parallel printer port has a base address, which may be found by examining the DOS data area of the PC's memory. The base I/O address of printer port LPT1 is stored as two bytes, beginning at memory location 0040:0008 (hex). The base addresses for LPT2, LPT3, and LPT4 are stored consecutively in DOS memory at 0040:000A, 0040:000C, and 0040:000E. These locations are zero if no corresponding parallel port is present.

Table A.1 IBM PC Parallel Port Bit Assignments For Programming 9240

BIT ASSIGNMENTS - PORT A
(Write PC parallel printer port control register @ port base address+2)

Bit	7	6	5	4	3	2	1	0
9240 signal name					~CMD/DATA	CHANNEL	W~A	~STROBE
9240 pin number (connector P2)					14	12	13	1
PC parallel port signal name					~SELECT IN	~TN1T	~AUTO LF XT	~STROBE
PC parallel port pin number					17	16	14	1
Bit polarity	always write 0	always write 0	always write 0	always write 0	*1= CMD 0=DATA	0= CH 0 1=CH1	*0= WAVE 1=ALPHA	*1= ~STB LOW

BIT ASSIGNMENTS - PORT B
(Write PC parallel printer port data register @ port base address)

Bit	7	6	5	4	3	2	1	0
9240 signal name	D7	D6	D5	D4	D3	D2	D1	D0
9240 pin number (connector P2)	9	8	7	6	5	4	3	2
PC parallel port signal name	D7	D6	D5	D4	D3	D2	D1	D0
PC parallel port pin number	9	8	7	6	5	4	3	2
Bit polarity	0= Data bit LOW 1= Data bit HIGH							

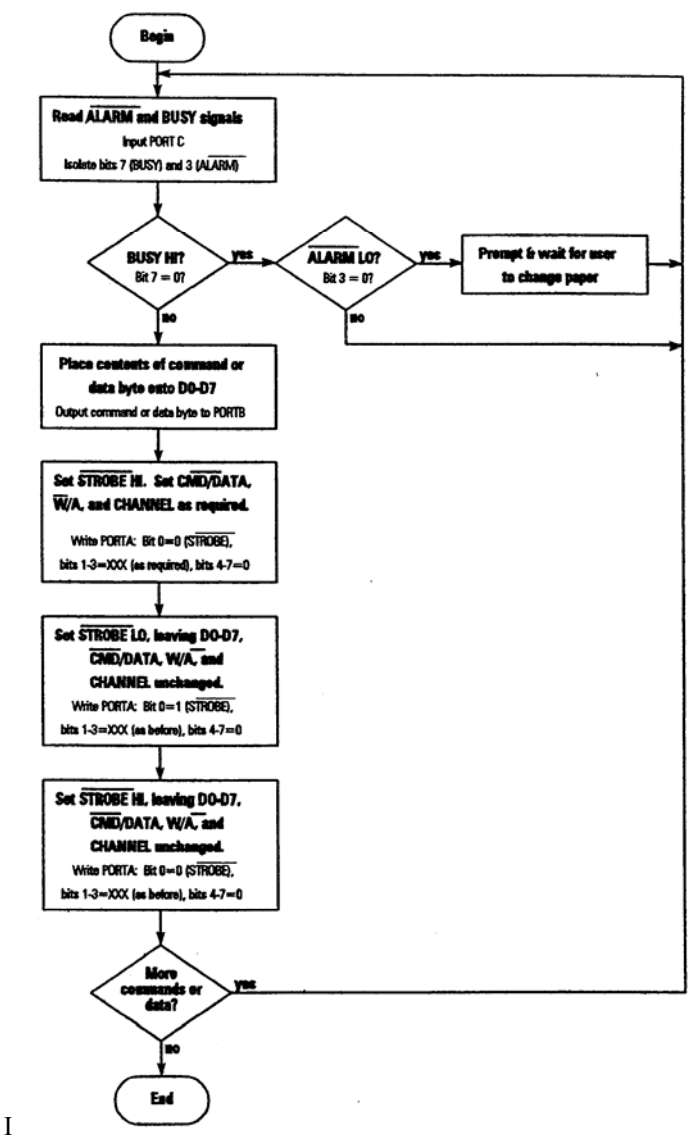
BIT ASSIGNMENTS - PORT C
(Read PC parallel printer port status register @ port base address+1)

Bit	7	6	5	4	3	2	1	0
9240 signal name	BUSY				~ALARM			
9240 pin number (connector P2)	11				22			
PC parallel port signal name	BUSY	~ACK	PAPER OUT	SELECT	~ERROR			
PC parallel port pin number	11	10	12	13	15			
Bit polarity	*0= 9240 Busy	ignored	ignored	ignored	0= 9240 Alarm	ignored	ignored	ignored

* Data bits on PC are inverted by parallel port in PC hardware

A.3 Transferring Commands and Data to the 9240

The sequence of operations required to transfer each Command or Data byte from the PC to the 9240 is shown in flowchart form in Figure A-2. This basic sequence, minus the ~ALARM signal checking, is used in the subroutines "SendCmd", "SendData", "SendWav0", and "SendWav1" in the programming examples given in the following section.



I

Figure A-2 Command / Data Byte Transfer Flowchart

A.4 Programming Examples

The following examples demonstrate programming the 9240 via the C/D Port. All recorder commands and data through are sent to the 9240 using the PC's parallel printer port. The programs are written in Microsoft QBasic, included with MS-DOS versions 5.0 and later. In addition to these examples in Basic a software development kit is available on the Allen Datagraph technical support website at www.allendatagraph.com.

Example A-1 Analog Waveform Mode Programming

This program sample demonstrates simple control of the 9240 Analog Waveform Mode operation. The subroutines illustrate methods of locating the parallel printer port base address, polling the 9240's BUSY handshake output, and transferring commands and data to the recorder. The following software functions are demonstrated:

- Analog Waveform Mode initialization
- Channel format selection: 1 x 40 mm

- Grid selection: 5 mm square grid
- Chart speed selection: 10 mm/sec
- Annotation text generation

```
DECLARE SUB FindLPT1 ()
DECLARE SUB SendCmd (cmd As INTEGER)
DECLARE SUE SendData (dat AS INTEGER)
DECLARE SUB SendText (text AS STRING)
DECLARE SUB WaitNotBusy ()

COMMON SHARED porta AS INTEGER
COMMON SHARED portb AS INTEGER
COMMON SHARED portc AS INTEGER
COMMON SHARED quit As INTEGER

'EXAMPLE A-1: ANALOG WAVEFORM MODE

FindLPT1                        'Set up parallel port addresses
CLS : LOCATE 10, 28     'Display header page PRINT "Analog Waveform
Mode"
LOCATE 11, 30
PRINT "Press ESC to Exit"
quit = 0                        'Clear Quit flag
SendCmd &HF9                    'Reset 9240
SendCmd &HE7                    'Analog waveform mode
SLEEP (1)                       'Delay for slow power supply
SendCmd &HF3                    'single 40mm channel format
SendCmd &H48                    'Channel 0 trace CH
SendCmd &H41                    'Channel 1 trace OFF
SendCmd &H68                    'Grid 5 mm
SendCmd &HEA                    'Set Chart speed 2 (25 mm/sec)
SendCmd 0                       'Annotation @ bottom margin
SendText "Bottom Margin" + CHR$(13)
SendCmd 15                      'Annotation @ 15 mm above bottom margin
SendText "Text @ 15 mm" + CHR$(13)
WHILE quit = 0                  'Run till user presses ESC key
  WaitNotBusy
WEND
quit = 0: SendCmd &HF9  'Reset 9240 to stop
END

'SUBROUTINES

SUB FindLPT1                    'FIND ADDRS OF PARALLEL PORT LPT1
      DEF SEG = &H40            'Base address of LPT1 can be found
      'by peeking £H0040:0008 and :0009
      addr = 256 * PEEK(9) + PEEK(8)
      porta = addr + 2          'Port A = Base addr + 2
      portb = addr
      portc = addr + 1
END SUB

SUB SendCmd (cmd AS INTEGER)  'SEND CCb24AND BYTE TO 9240
```

```
      WaitNotBusy             'Wait for BUSY low or keyboard escape
      IF quit = 0 THEN
            OUT portb, cmd    'Place byte on D0-D7
            OUT porta, 8      'Set ~CMD/DATA low, STROBE high
            OUT porta, 9      'Start STROBE (low)
            OUT porta, 8      'End STROBE (high)
      END IF
END SUB

SUB SendData (dat AS INTEGER) 'SEND NON-WAVEFORM DATA BYTE TO 9240
      WaitNotBusy             'Wait for BUSY low or keyboard escape
      IF guit = 0 THEN
            OUT portb, dat    'Place byte on D0-D7
            OUT porta, 2      'Set ~CMD/DATA, W/A, & STROBE high
            OUT porta, 3      'Start STROBE (low)
            OUT porta, 2      'End STROBE (high)
      END IF
END SUB

SUB SendText (text AS STRING) 'SEND TEXT STRING DATA TO 9240
      length = LEN (text)     'Send each byte using SUB SendData
      IF length > 0 THEN
            FOR i = 1 TO length
                  SendData ASC(MID$(text, i, 1))
            NEXT i
      END IF
END SUB

SUB WaitNotBusy   'WAIT FOR 9240 NOT BUSY OR ESC KEY
      x = 0
      'Loop while BUSY hi and Quit flag clear
      WHILE (x <> 128 AND quit = 0)
            'Set Quit flag if user types ESC
            IF INKEY$ = CHR$(27) THEN quit = 1
            x = INP(portc) AND 128
      WEND
END SUB
```

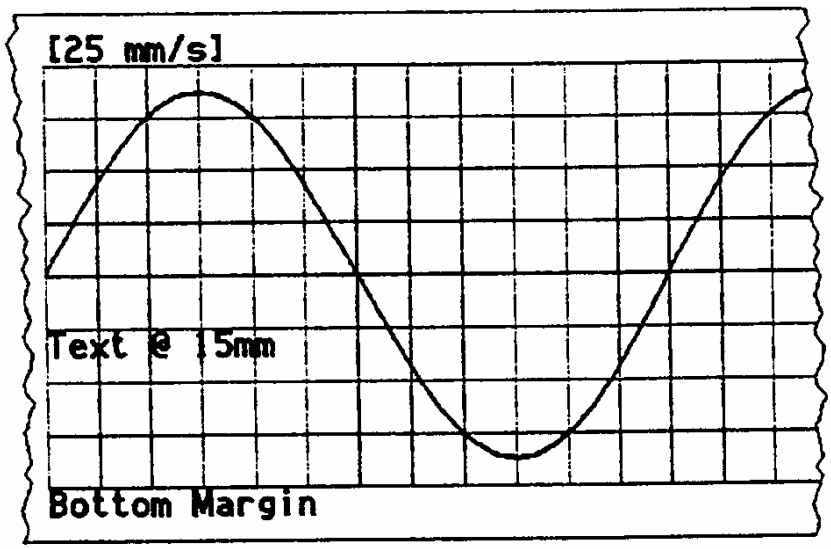


Figure A-3 Example A-1 Output - Analog Waveform Mode Programming

Example A-2 Digital Waveform Mode Programming

This program illustrated Digital Waveform Mode operation. Subroutines to transmit the waveform data are included here; other subroutines not listed here are shown in Example A-1. This sample exercises the following software functions:

- Digital Waveform Mode initialization and data generation
- Channel format selection: 2 x 20 mm
- Grid selection: 5 mm grid with 1 mm subdivisions in channel 0, 5 mm linear grid in channel 1
- Chart speed selection: 25 mm/sec
- Chart speed printout, repeat interval set to 15 cm.

```
DECLARE SUB FindLPT1 ()
DECLARE SUB SendCmd (cad As INTEGER)
DECLARE SUB SendData (dat As INTEGER)
DECLARE SUB SendText (text AS STRING)
DECLARE SUB SendWave0 (wav0 AS INTEGER)
DECLARE SUB SendWavel (wavl AS INTEGER)
DECLARE SUB WaitNotBusy ()
COMMON SHARED ports AS INTEGER
COMMON SHARED portb AS INTEGER
COMMON SHARED portc AS INTEGER
COMMON SHARED quit As INTEGER

' Example A-2: DIGITAL WXVEFORM MODE
FindLPT1                'Set up parallel port addresses
CLS : LOCATE 10, 28     'Display header page PRINT "Digital Waveform
Mode"
LOCATE 11, 30
PRINT "Press ESC to Exit"
quit = 0                        'Clear Quit flag
pi# = 3.141592654#              'Init digital waveform variables
```

```
freq = 2                        'freq = frequency adjustment
deg = 0                         'deg = degree counter
SendCmd &HF9                    'Reset 9240
SendCmd &H48                    'Digital waveform mode
SLEEP (1)                       'Delay for slow power supply
SendCmd &HF2                    'Dual 20 mm channel format
SendCmd &H48                    'Channel 0 trace ON
SendCmd &H49                    'Channel 1 trace ON
SendCmd &H70                    'Channel 0 Grid 5 mm / 1 mm
SendCmd £H79                    'Channel 1 Grid 5 mm horizontal
SendCmd &HEB                    'Set Chart speed 1 (l0 mm/sec)
SendCmd &HD0                    'Print Speed CH
SendCmd &HD2                    'Print speed interval = 15 cm
SendData 15
WHILE quit = 0                  'Run till user presses ESC key
      'w0% = sine wave data for chap 0
      omega = (freq * deg * pi#) / 180
      wO% = 64 * SIN (omega) + 128
      IF deg < 180 THEN 'w1% = square wave data for chan 1
            w1% = 64
      ELSE
            w1% = 192
      END IF
      deg = deg + 1             'update degrees
      IF deg > 359 THEN deg = 0
      SendWave0 w0%             'send digital data to 9240
      SendWavel w1%             '(quit if user presses ESC)
WEND
quit = 0: SendCmd &HF9  'Reset 9240 to stop
END
'SUBROUTINES
'See Example A-1 for text of other subroutines
'SEND CHAN 0 DIGITAL WAVE DATA TO 9240
SUB SendWave0 (wav0 AS INTEGER)
      WaitNotBusy 'Wait for BUSY low or keyboard escape
      IF quit = 0 THEN
            OUT portb, wav0   'Place byte on D0-D7
            'Set c D/DATA & STROBE high, W/A 6 CHANNEL low
            OUT porta, 0
            OUT porta, 1      'Start STROBE (low)
            OUT porta, 0      'End STROBE (high)
      END IF
END SUB


'SEND CHAN 1 DIGITAL WAVEFORK DATA TO 9240
SUB SendWavel (wav1 AS INTEGER)
      WaitNotBusy 'Wait for BUSY low or keyboard escape
      IF quit = 0 THEN
            OUT portb, wav1   'Place byte on D0-D7
            'Set ~CMD/DATA, CHANNEL & ~STROBE high, W/~A low
            OUT porta, 4
            OUT porta, 5      'Start STROBE (low)
            OUT porta, 4      'End STROBE (high)
      END IF
End Sub
```

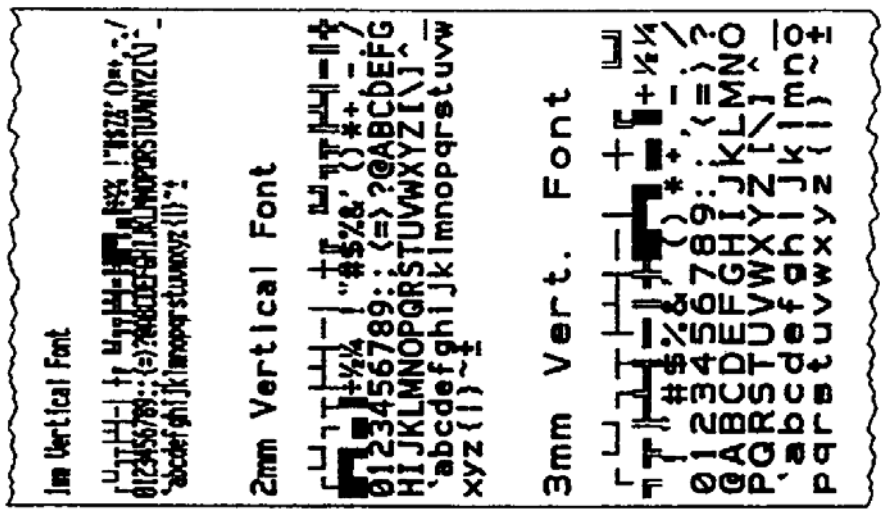


Figure A-4 Example A-2 Output - Digital Waveform Mode Programming

Example A-3 Vertical Text Mode Programming

This example demonstrates 9240 Vertical Text Mode operation. The entire character set is printed out in each of the three font sizes.

```
DECLARE SUB FindLPT1 ()
DECLARE SUB SendCmd (cmd AS INTEGER)
DECLARE SUB SendData (dat AS INTEGER)
DECLARE SUB SendText (text AS STRING)
DECLARE SUB WaitNotBusy ()

COMMON SHARED porta AS INTEGER
COMMON SHARED portb AS INTEGER
COMMON SHARED portc AS INTEGER
COMMON SHARED quit AS INTEGER
'EXAMPLE A-3: VERTICAL TEXT MODES

FindLPT1                'Set up parallel port addresses
charset$ = ""           'init string of all printable chars
FOR i = 0 TO 127
      IF i <> 10 AND i <> 13 THEN
            charset$ = charset$ + CHR$(i)
      ELSE
            'replace chars 10,13 (LF,CR) with spaces
            charset$ = charset$ + " "
      END IF
NEXT i
CLS : LOCATE 10, 29     'Display header page
PRINT "Vertical Text Modes"
LOCATE 11, 30
PRINT "Press ESC to Exit"
quit = 0                'Clear Quit flag
SendCmd &HF9            'Reset 9240
```

```
SendCmd &HF8 '1 mm vertical text mode
SLEEP (1)                'Delay for slow power supply
SendText "l mm Vertical font"
SendData 13: SendData 13 'Print character set
SendText charset$
SendData 13: SendData 13: SendData 13
SendCmd &HF7             '2 mm vertical text mode
SendText "2 mm vertical font"
SendData 13: SendData 13
SendText charset$        'Print character set
SendData 13: SendData 13: SendData 13
SendCmd &EF6             '3 mm vertical text mode
SendText "3 mm Vert. font"
SendData 13: SendData 13
SendText charset$        'Print character set
SendData 13: SendData 13: SendData 13
quit = 0:
SendCmd &HF9             'Reset 9240 to stop
END

'SUBROUTINES 'See Example A-1 for text of subroutines
```

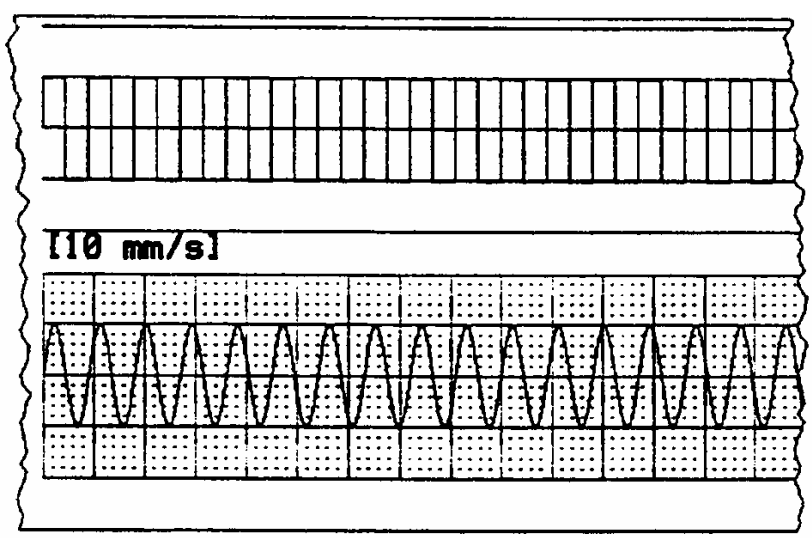


Figure A-5 Example A-3 Output - Vertical Text Mode Programming

Example A-4 Horizontal Text Mode Programming

This program illustrates the Horizontal Text Mode by printing out the character set in all three fonts. The use of an array to control column-by-column printing of lines of horizontal text is demonstrated in the "HorizArray" subroutine.

```
DECLARE SUB FindLPT1 ()
DECLARE SUB HorizArray (fontname AS STRING)
DECLARE SUB SendCmd (cmd As INTEGER)
DECLARE SUB SendData (dat AS INTEGER)
DECLARE SUB WaitNotBusy ()
```

```
COMMON SHARED porta AS INTEGER
COMMON SHARED portb AS INTEGER
COMMON SHARED portc AS INTEGER
COMMON SHARED quit AS INTEGER

'EXAMPLE A-4: HORIZONTAL TEXT MODES

FindLPT1                        'Set up parallel port addresses
CLS : LOCATE 10, 28             'Display header page
PRINT "Horizontal Text Modes"
LOCATE 11, 30
PRINT "Press ESC to Exit"
quit = 0                        'Clear Quit flag
SendCmd &HF9                    'Reset 9240
SendCmd &HD8                    ' l mm vertical text mode
SLEEP (1)                       'Delay for slow power supply
HorizArray "l mm Horiz font"    'Print character set using array
SendData 13: SendData 13: SendData 13
SendCmd &HD7                    ' 2mm vertical text mode
HorizArray "2 mm Horiz font"    'Print character set using array
SendData 13: SendData 13: SendData 13
SendCmd &HF4                    '3mm vertical text mode
HorizArray "3 mm Horiz font"    'Print character set using array
SendData 13: SendData 13: SendData 13
quit = 0: SendCmd &HF9          'Reset 9240 to stop

'SUBROUTINES
'See example A-1 for text of other subroutines

SUB HorizArray (fontname AS STRING)
      ' 16 line of text 03mm high fit across page
      DIM htext (1 TO 16) AS STRING
      FOR row = 1 TO 16         'Init all lines to empty strings
            htext(row) = ""
      NEXT row
      htext(3) = fontname       'Place font name in row 3
      FOR i = 0 TO 7            'Format character set into 8 rows
            row = 5 + I         'Place these in rows 5-12
            FOR col - 0 TO 15 'Add 16 chars to each row
                  ch% = 16 * i + col
                  'Replace LF or CR with SPACE
                  IF ch% = 10 THEN ch% = 32
                  IF ch% = 13 THEN ch% = 32
                  htext(row) = htext(row) + CHR$(ch%)
            NEXT col
      NEXT i
      longest = 0       'Find string length of longest line
      FOR row = 1 TO 16
            rowlen = LEN(htext(row))
            IF rowlen > longest THEN longest = rowlen
      NEXT row
      FOR col = 1 TO longest  'Print array one COLUMN at a time
            'Start each col with char from LAST line
            FOR row = 16 TO 1 STEP -1
                  IF LEN(htext(row)) >= col THEN
                        code% = ASC(MID$(htext(row), col, 1))
```

```
                ELSE
                      'Print space if past end of short line
                      code% = 32
                END IF
                SendData code%
            NEXT row    'end each col with char from FIRST line
      NEXT col    'end of last colon
END SUB
```

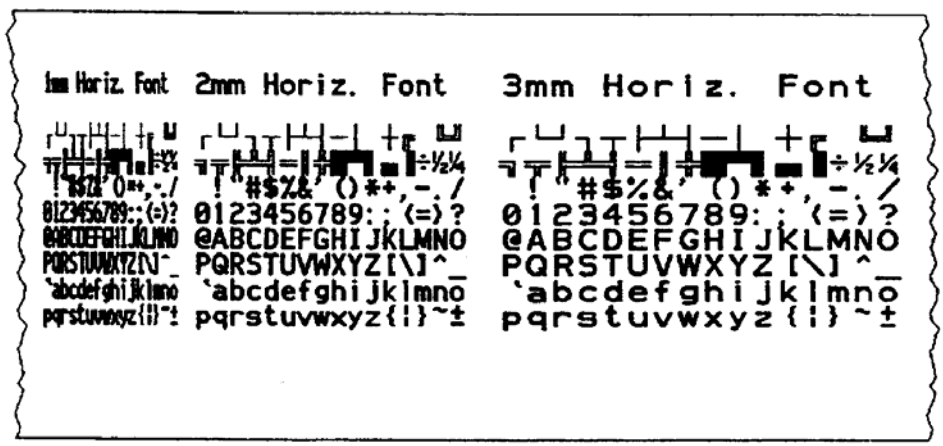


Figure A-6 Example A-4 Output - Horizontal Text Mode Programming

Example A-5 Graphics Mode Programming

This example demonstrates programming techniques for producing an image in the 9240 Graphics Mode. Rows of upward-pointing 4 mm arrows are printed to show the required bit and byte order of the graphics data. The chart motor is double-stepped after each dot row is printed.

```
DECLARE SUB FindLPT1 ()
DECLARE SUB SendCmd (cmd AS INTEGER)
DECLARE SUB SendData (dat AS INTEGER)
DECLARE SUB WaitNotBusy ()

COMMON SHARED porta AS INTEGER
COMMON  SHARED porch AS INTEGER
COMMON  SHARED ports AS INTEGER
COMMON  SHARED quit As INTEGER

'EXAMPLE A-5: GRAPHICS MODE

FindLPT1                'Set up parallel port addresses
CLS : LOCATE 10,  32    'Display by-A-- page PRINT "Graphics Mode"
LOCATE 11,  30
PRINT "Press ESC to Exit"
quit = 0                'Clear Quit flag
SendCmd &HF9            'reset 9240
SendCmd &HE2            'Graphics mode
Sleep(1)                'Delay for slow power supply
WHILE quit = 0          'Run till user presses ESC key
```

```
'Print col of arrows, 16 dot rows/arrow
'Select graphic data for each row
'4 bytes of data (each arrow 4 mm high)
'oriented so arrow points down (to LSB)
FOR row = 0 TO 15
  SELECT CASE row
    CASE 0: byte0% = &H0: byte1% = &H3: byte2% = &H0  : byte3% = &H0
    CASE 1: byte0% = &HC0 : byte1% = &H3   : byte2% = &H0     : byte3% = &H0
    CASE 2: byte0% = &HF0: byte1% = &HFF: byte2% = &HFF: byte3% = &H3F
    CASE 3: byte0% = &HFC : byte1% = &HFF   : byte2% = &HFF   : byte3% = &H3F
    CASE 4: byte0% = &HF0 : byte1% = &HFF   : byte2% = &HFF  : byte3% = &H3F
    CASE 5: byte0% = &HC0 : byte1% = &H3    : byte2% = &H0    : byte3% = &H0
    CASE 6: byte0% = &H0: byte1% = &H3  : byte2% = &H0: byte3% = &H0
    CASE ELSE: byte0% = &H0 : byte1% = &H0    : byte2% = &H0    : byte3% = &H0
  END SELECT
  FOR arrow = 1 TO 12   'send exactly 48 bytes/dot row
    SendData byte0%     '(14 arrows * 4mm high each)
    SendData byte1%
    SendData byte2%
    SendData byte3%
  NEXT arrow
  SendCmd &HF5                'after each dot row, step motor twice
  FOR x = 1 TO 5        '9 dot rows/mm in paper movement axis
  NEXT x                          'short delay (about 1ms) for each
  step
  SendCmd &HF5
  FOR x = 1 TO 5
  NEXT x
NEXT row
WEND
quit = 0: SendCmd &HF9  'Reset 9240 to stop
END

' SUBROUTINES
'See example A-1 for text of subroutines
```

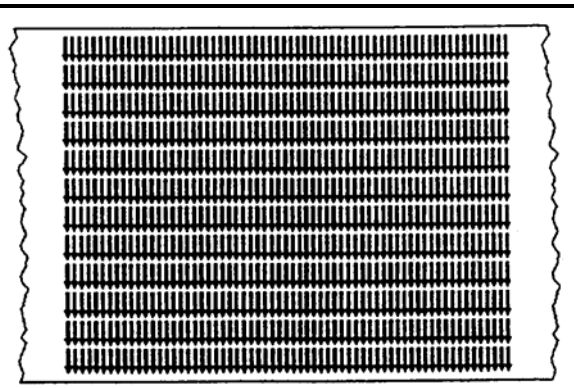


Figure A-7 Example A-5 Output - Graphics Mode Programming

Appendix B Software Command Summary

Table B.1 9240 Software Command Summary			
HEX	DECIMAL	DESCRIPTION	SECTION
00+string thru 2C+string	0+string thru 44+string	Annotation @ 0mm position, text = "sling" Annotation @ 44mm position, text = "string"	5.2.7
40	64	Channel 0 trace OFF	5.2.4
41	65	Channel 1 trace OFF	5.2.4
48	72	Channel 0 trace ON	5.2.4
49	73	Channel 1 trace ON	5.2.4
60	96	Grid, Channel 0, Pattern 0: OFF	5.2.5
61	97	Grid, Channel 1, Pattern 0: OFF	5.2.5
68	104	Grid, Channel 0, Pattern 1: 5 mm square	5.2.5
69	105	Grid, Channel 1, Pattern 1: 5 mm square	5.2.5
70	112	Grid, Channel 0, Pattern 2: 5 mm square, 1 mm divisions	5.2.5
71	113	Grid, Channel 1, Pattern 2: 5mm square, 1 mm divisions	5.2.5
78	120	Grid, Channel 0. Pattern 3: 5 mm horizontal lines	5.2.5
79	121	Grid, Channel 1, Pattern 3: 5 mm horizontal lines	5.2.5
80	128	Event, Channel 0, Style 0: bottom tick	5.2.8
81	129	Event, Channel 1, Style 0: bottom tick	5.2.8
88	136	Event, Channel 0. Style 1: top tick	5.2.8
89	137	Event, Channel 1, Style 1: top tick	5.2.8
90	144	Event, Channel 0, Style 2: center tick	5.2.8
91	145	Event, Channel 1. Style 2: center tick	5.2.8
98	152	Event, Channel 0, Style 3: across channel	5.2.8
99	153	Event, Channel 1. Style 3: across channel	5.2.8
D0	208	Print Chart Speed ON	5.2.6
D1	209	Print Chart Speed OFF	5.2.6
D2	210	Print Logo ON	5.2.6
D3	211	Print Logo OFF	5.2.6
D4+ val	212+ val	Set Chart Speed/ Logo Print interval = va/	5.2.6
D5	213	Dither ON	5.2.9
D6	214	Dither OFF	5.2.9
D7	215	Enter Horizontal Text Mode, 2 mm font	5.3
D8	216	Enter Horizontal Text Mode, 1 mm font	5.3
D9	217	Reverse Text: toggle ON / OFF	5.2.7
DD	221	Set Annotation Font: 1mm	5.2.7
DE	222	Set Annotation font: 2 mm	5.2.7
DF	223	Set Annotation Font: 3 mm	5.2.7
E2	226	Enter Graphics Mode	5.4
E4	229	Invert Channel 0	2.5
E5	230	Normal Channel 0	2.5
E6+N	230	Set Analog Filter Length 0, 2, 4, 8, 16	5.2.1
E7	231	Enter Analog Waveform mode	5.2.1
E8	232	Enter Digital Waveform mode	5.2.2
E9	233	Set Chart Speed 3: 50 mm / sec*	5.2.3
EA	234	Set Chart Speed 2: 25 mm / sec*	5.2.3
EB	235	Set Chart Speed 1:1O mm / sec*	5.2.3
EC	236	Set Chart Speed 0: 5 mm / sec*	5.2.3
ED	237	Set Chart Speed 7: 50 mm / min*	5.2.3
EE	238	Set Chart Speed 6: 25 mm / min*	5.2.3
EF	239	Set Chart Speed 5:10 mm /min*	5.2.3
F0	240	Set Chart Speed 4: 5 mm / min*	5.2.3

HEX	DECIMAL	DESCRIPTION	SECTION
F1	241	Set Chart Speed: Single Step	5.2.3
F2	242	Set Channel Format: 2 x 20 mm	5.2.4
F3	243	Set Channel Format: 1 x 40 mm	5.2.4
F4	244	Enter Horizontal Text Mode, 3 mm font	5.3
F5	245	Step Motor Once	5.2.3, 5.4, 5.5.3
F6	246	Enter Vertical Text Mode, 3 mm font	5.3
F7	247	Enter Vertical Text Mode, 2 mm font	5.3
F8	248	Enter Vertical Text Mode, 1 mm font	5.3
F9	249	Reset 9240	5.5.1
FA	250	Self Test	5.5.4
FC	252	Print Head ON	5.5.2
FD	253	Print Head OFF	5.5.2
FF	255	Set Chart Speed: OFF (stop chart)	5.2.3

Appendix C Allen Datagraph Systems, Inc Warranty

Seller warrants to Buyer that the strip chart recorders shall be free from defects in workmanship and material under normal and proper use and service for the period of one year. The sole and exclusive obligation of Seller under this warranty shall be that the product or products will be free from such defects and will perform in accordance with Seller's specifications and that, upon its failure to do so, Seller shall, as its sole obligation under this warranty, repair or replace it in accordance with the provisions hereinafter stated. THE WARRANTY PERIOD SO SPECIFIED IS COMPUTED FROM THE DATE OF SHIPMENT FROM SELLER. Seller agrees to repair or replace at the place of manufacture, without charge, products which are returned, transportation prepaid, for inspection at Seller's factory within the applicable warranty period plus 30 days provided and inspection of the product or products discloses that the defects are covered by the warranty above specified, and provided also that the product has not been altered or repaired other than by the approved procedures of Seller or has not been subjected to misuse, improper installation or other handling or care which is beyond the control of the Seller.

Product or parts shall not be returned to the Seller's factory or service facility for inspection, replacement or repair without specific written authorization from Seller. No person, including any distributor, dealer, agent or representative of Seller or Buyer is authorized to assume for Seller any liability on its behalf or in its name except to refer to this warranty.

This warranty is made exclusively to the original Buyer only. Further warranties, express or implied, are specifically excluded by Seller for merchandise obtained from anyone other than Seller.

1. Authorization to Return: Prior to returning any defective equipment or parts to Allen Datagraph Systems, Inc., the Buyer must notify Allen Datagraph Systems, Inc. and obtain a written Return authorization. Allen Datagraph will not accept unauthorized returns.

2. Transportation charges: All warranty repairs must be returned to Allen Datagraph prepaid. Buyer is responsible for the return freight also.

3. Packing and insurance: It is the Buyer's responsibility on all returns to ensure that they are properly packaged and returned in the same shipping carton as provided by Allen Datagraph. Shipping damage resulting from returns due to improper packaging void the warranty.

4. No defect found: All strip chart recorders returned for repair undergo extensive testing, Q.C. and handling. A diagnostic charge of $75.00 will be required for any recorders returned for repair and found not to be defective.

5. All units must be returned to Allen Datagraph at the level of assembly at which they were shipped. At no time will Allen Datagraph accept units for repair that are housed or attached to a customer's property.

Our Application Engineers are always available for technical assistance. Call 603-893-1983.

Appendix D Shipping Claims Important

Prior to leaving the Seller's plant, this equipment was thoroughly inspected and tested to ensure that it was in optimum operating condition. Even though extreme care has been taken in packaging this equipment for shipping, rough handling during transit may result in damage. Allen Datagraph's responsibility in regard to this shipment ended upon its delivery to the carrier. Therefore, all claims for loss or damage sustained in transit must be made upon the carrier by you, the consignee. Upon receipt of this shipment, an inspection report should be completed, noting any damage. This report would be used as a basis for any required claims.

It is recommended that the following checks be made upon receipt:

1. Verify that the number of cartons shown on the freight bill or express receipt matches the number of received cartons.

2. Verify that the weight of the shipment matches the weight shown on the receipt.

3. Examine the carton for damage.

4. Inspect the equipment for obvious damage.

5. Run a Self Test strip (Section 2.4).

If no obvious damage is noted upon receipt, an operational check should be performed within 15 days of receipt of your equipment. Although no external damage is apparent, damage may occur during transit due to rough handling. When concealed damage is discovered, a written request for inspection must be made to the carrier's agent within 15 days of the date of delivery. Delay in submitting this request may result in loss of your claim privilege. Do not destroy the shipping carton and packing material as they must be made available for inspection.

The carrier will normally require the return of the equipment to the Seller's plant for inspection and repair. An invoice itemizing all repairs due to physical damage will be returned to you with the equipment. The amount of this invoice then becomes part of your claim.

Appendix E Firmware Part Numbers

p/n	head	width (mm)	voltage	chart 0	chart 1	chart 2	chart 3	chart 4	chart 5	chart 6	chart 7	Chan format	Chan 1	Chan 0 grid	Chan 1 grid	hardware event style	print speed	dither	other	logo	Current Revision	Initial Speed	Filter Length
				5	10	25	50	5	10	25	50												
80000020	Mitsubishi	48	18	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on	5mm/1mm	5mm	3	on,20 cm	on	none	off	D	Off	0
				5	10	25	50	5	10	25	50												
80000040	Rohm	56	18	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 50	on	5mm/1mm	5mm	3	on,20 cm	on	none	off	D	Off	0
				5	10	25	50	5	10	25	50												
80000045	Rohm	56	18	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 50	on	5mm/1mm	5mm/1mm	3	on,20 cm	on	none	off	D	Off	0
				5	10	25	50	5	10	25	50												
80000080	Mitsubishi	48	15	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on	5mm/1mm	5mm	3	on,20 cm	on	none	off	D	Off	0
				5	10	25	50	5	10	25	50												
80000085	Mitsubishi	48	15	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on	off	off	3	on,20 cm	on	none	off	D	Off	0
				5	10	25	50	5	10	25	50		off(1x40)										
80000090	Mitsubishi	48	12	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on(2x20)	off	off	1	off, 20 cm	off	none	off	D	Off	0
				5	10	25	50	5	10	25	50												
80000100	Rohm	48	12	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on	5mm/1mm	5mm	3	on,20 cm	on	none	off	D	Off	0
				256	10	25	50	5	10	20	50												
80000101	Rohm	48	12	mm/min	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on	5mm/1mm	5mm	3	on,20 cm	on	none	off	D	Off	0
				5	10	25	50	5	10	25	50												
80000102	Rohm	48	12	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on	5mm linear	5mm linear	1	on,20 cm	on	none	on, [GK] GPS-200	D	Off	0
				5	10	25	50	5	10	25	50												
80000103	Rohm	48	12	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on	off	5mm	3	on,20 cm	on	none	off	D	Off	0
				5	10	25	50	5	10	25	50		off(1x40)										
80000110	Mitsubishi	48	12	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on(2x20)	5mm/1mm	5mm	3	on,20 cm	off	none	off	D	Off	0
				5	10	25	50	5	10	25	50												
80000120	Mitsubishi	48	12	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on	5mm/1mm	5mm	3	on,20 cm	on	none	off	D	Off	0
				25	5	50	10	1	10	5	50												
80000130	Mitsubishi	48	18	mm/sec	mm/min	mm/sec	mm/min	mm/sec	mm/sec	mm/sec	mm/min	1 x 40	on	5mm/1mm	5mm	3	on,20 cm	on	none	off	D	Off	0
				5	10	25	50	5	10	25	50												
80000140	Rohm	56	24	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 50	on	5mm/1mm	5mm	3	on,20 cm	on	none	off	D	Off	0
				25	5	50	10	5	25	10	50												
80000150	Mitsubishi	48	15	mm/sec	mm/min	mm/sec	mm/min	mm/sec	mm/min	mm/sec	mm/min	1 x 40	on	5mm/1mm	5mm	3	on,20 cm	on	none	off	D	Off	0
				5	10	25	50	5	10	25	50												
80000160	Rohm	48	12	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	off	5mm/1mm	5mm	3	on,20 cm	on	none	off	D	Off	0
				10	5	25	10	1	50	5	50												
80000170	Mitsubishi	48	12	mm/sec	mm/min	mm/sec	mm/min	mm/sec	mm/sec	mm/sec	mm/min	1 x 40	on	off	off	3	on,20 cm	on	none	off	D	Off	0
				5	10	25	50	5	10	25	50												
80000180	Rohm	48	12	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on	5mm/1mm	5mm/1mm	3	off,20 cm	on	none	off	D	Off	0
				0.2	2		10	12	25	50	120												
80000181	Rohm	48	12	mm/min	mm/min	5 mm/min	mm/min	mm/min	mm/min	mm/min	mm/min	1 x 40	on	5mm/1mm	5mm/1mm	3	off,20 cm	on	none	off	D	Off	0
				0.5			5.03	5.01	4.99	4.97										on, Acoustic CardioGraph		Speed	
80000182	Rohm	48	12	cm/sec	1 cm/sec	2.5 cm/sec	cm/sec	cm/sec	cm/sec	cm/sec	5 cm/sec	1 x 40	on	10mm/2mm	10mm/2mm	3	off,20 cm	on	none	Co www.acg-co.com	G	7	4
				0.5			5.03	5.01	4.99	4.97										on, Acoustic CardioGraph		Speed	
80000183	Rohm	48	12	cm/sec	1 cm/sec	2.5 cm/sec	cm/sec	cm/sec	cm/sec	cm/sec	5 cm/sec	1 x 40	on	off	off	3	off,20 cm	on	none	Co www.acg-co.com	E	7	4
				5	10	25	50	5	10	25	50												
80000190	Rohm	48	12	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/min	1 x 40	on	5mm/1mm	5mm/1mm	3	on,20 cm	on	none	on, HI-TECH	D	Off	0
				5	10	25	50	5	10	25	1								custom 3mm				
80000200	Rohm	48	12	mm/sec	mm/sec	mm/sec	mm/sec	mm/min	mm/min	mm/min	mm/sec	1 x 40	on	5mm/1mm	5mm	3	on,20 cm	on	chars	off, Hokanson Logo	D	Off	0

Common Features to all software models

Fonts	1,2,3
Mode	Analog Waveform
Chan 0	on
Wave Mode Font	3mm
Text Mode Font	3mm