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**The Hardware Interface for a DeeCO Touch Screen Terminal
in a Technician Maintenance Application**

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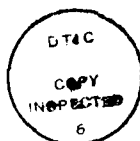
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THE HARDWARE INTERFACE FOR A DEECO TOUCH SCREEN TERMINAL IN A TECHNICIAN MAINTENANCE APPLICATION

1.0 INTRODUCTION

This report describes the hardware interface required to integrate a Digital Electronics Corporation (DeeCO) touch screen Model #M3EL512x256PS (electroluminescent display with touch sensor) through a remote connection to a computer workstation, Sun Microsystems, Inc. Model # 3/110. This was done as part of a project which added a touch sensitive menu interface to a technician's assister artificial intelligence software package, allowing computer interactions without a keyboard. In the anticipated application, a central computer, at a remote location, will be connected via data lines to a terminal interface. The touch screen terminal allows the technician to carry the unit to his workspace, connect it to the central computer using a serial data line, and enter information and commands by activating highlighted areas on the display. The work performed integrates the touch screen in two separate configurations. The first configuration, seen in Fig. 1, used a DEC VT320 to connect to the serial port described in the first configuration. The touch screen was connected to the printer port of the VT320. Interfacing the touch screen to the VT320 allows the user to communicate with a host computer through both the terminal and touch screen, taking advantage of the graphics and touch sensor capabilities of the DeeCO display, while maintaining a standard terminal interface. The second configuration, seen in Fig. 2, used a serial data port to connect the touch screen directly to a VAX 11/780 that was connected via ethernet to the intended host computer, the SUN 3/110. The pertinent characteristics of both configurations will be described, along with the terminals, settings and hardware requirements of the interface. It should however be noted that, while hardware specific information relative to the demonstration is presented, the concept of a remotely located touch sensitive interface to a computer connected via data line is generally applicable to many maintenance functions and system configurations.

1.1 DeeCO Display Controller with IR Touch Panel Hardware Characteristics

The touch screen used in this project is a DeeCO electroluminescent display. The display module (M3) is compact; the overall dimensions are 10.278" W X 5.958" H X 1.980" D, with a flat display area of 7.68" W X 3.84" H. The display resolution is 512 pixels by 256 pixels, with each pixel being 0.015" in width and height. Display color is yellow-orange. The display controller board (C3) accepts commands from the host and drives the display. The controller uses the ANSI 3.64 standard for encoding information and commands for computer peripherals. The most common implementation of the ANSI 3.64 standard is a DEC VT100 terminal. The controller emulates the functions of the VT100 terminal by using a command subset of the ANSI 3.64 standard which is similar to the command subset used by the VT100. The VT100 and the display controller use intersecting subsets of the ANSI standard. The

data format required by the display controller consists of one start bit, 8 data bits, and one stop bit, with no parity check. The controller board has both parallel and serial connectors for interfacing with a host. Both the parallel and serial connectors on the controller board are 26-pin connectors. In this application of the touch screen display, only the serial port was used to interface to the host computer.

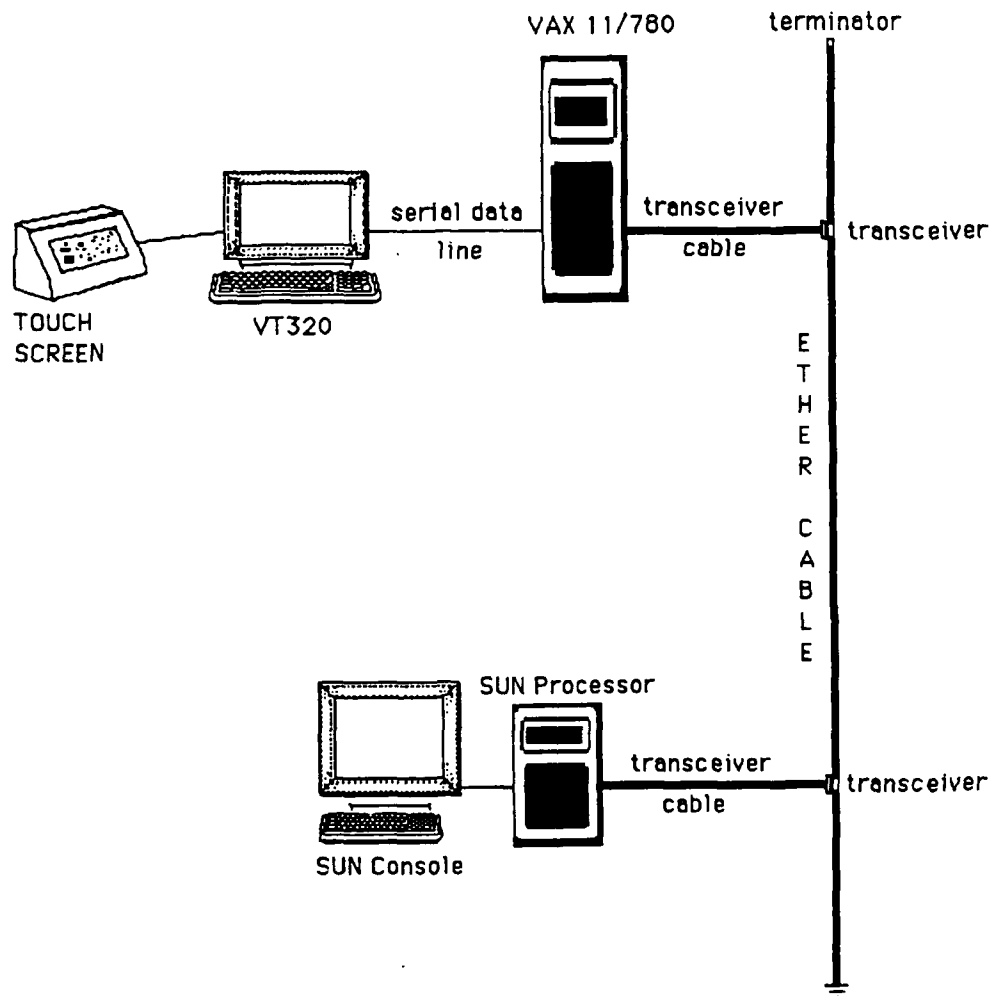


Figure 1. Network configuration for dual display system.

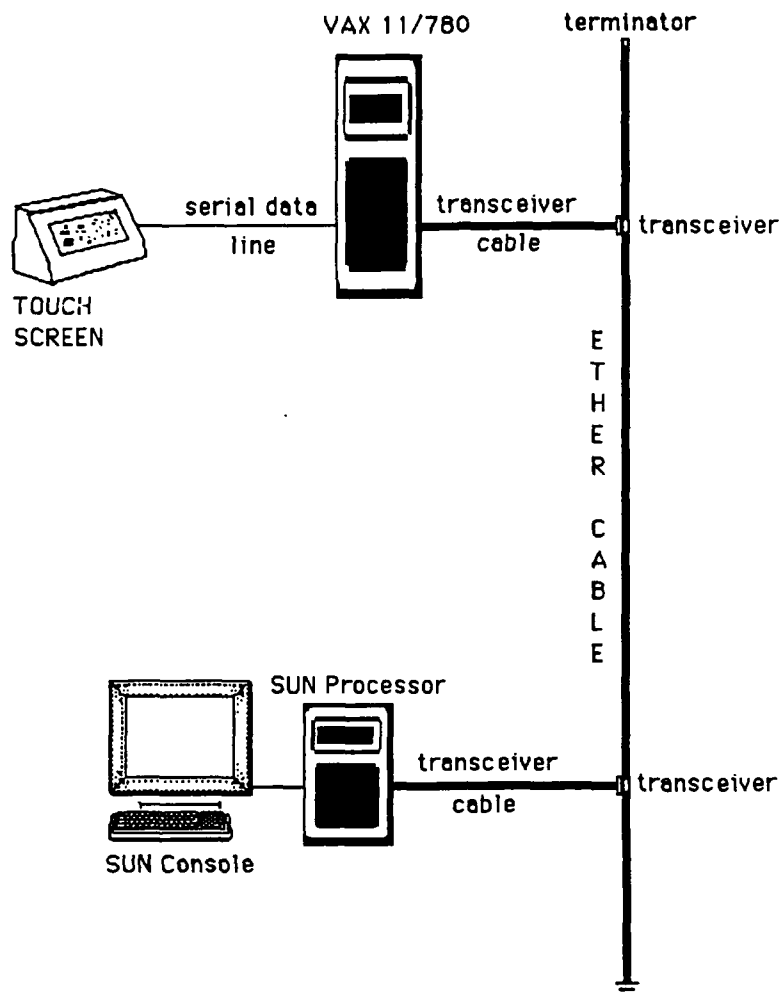


Figure 2. Network configuration for system using only the touch screen display.

An adapter cable, Fig. 3, (DeeCO P/N 6701) is used to interface the controller board to the chassis, which requires a 25-pin D-Sub connector. The 25-pin connector is required for hardware connections to the host computer in the application. A keyboard port is provided on the display controller board; the connector is a 5 pin single line, 100" AMP#640440-5. An adapter cable (DeeCO P/N 6700) is used to interface the keyboard port to the chassis and provide a standard IBM PC DIN connector. The use of the IBM PC keyboard is optional.

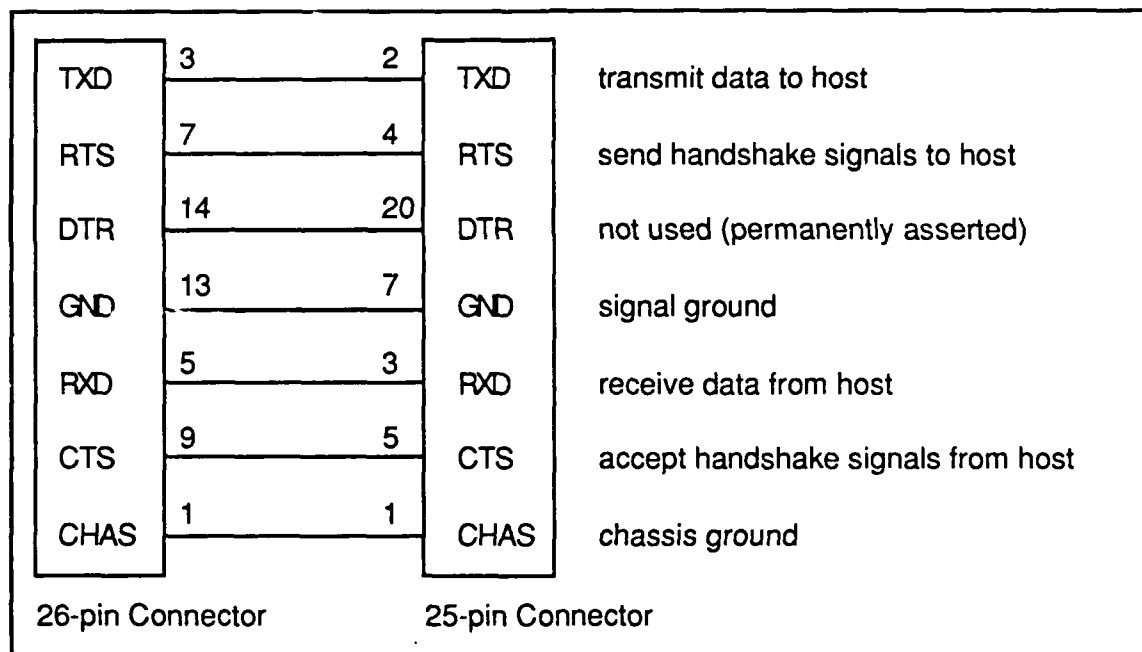


Figure 3. Adapter cable for the touch screen.¹

There are six possible baud rates that the user may select for the touch screen display in serial mode: 300, 1200, 2400, 4800, 9600, and 19200. The baud rate is selected by orienting the physical connections to jumpers E1, E2, and E3, on the controller board, according to Fig. 4.

A DeeCO SealTouch infrared touch sensor is mounted to the display panel to register the activation of areas designated, in software, as being touch sensitive. The touch sensor has infrared emitters and detectors in the bezel of the display panel. The touch sensor is controlled by the infrared controller board attached to the display controller board. Both the parallel interface and the serial interface can be used to transmit data between the infrared controller and the display controller. When the parallel interface is used to connect the infrared and display controllers, the host computer is connected to the display controller through the serial port. The display controller routes the appropriate commands from the host computer to the infrared controller. The serial interface to the infrared controller allows the host computer to communicate directly with the infrared controller, bypassing the display controller. This configuration requires two serial port connections from the host computer and process coordination in system software. The use of the parallel interface for the display and infrared controllers was sufficient for the needs of this project.

¹Digital Electronics Corporation, M3 Module Applications Manual (Hayward, CA: DeeCO, 1989) p. 55

E3	E2	E1	Baud Rate
0	0	0	Parallel
0	0	1	300
0	1	0	1200
0	1	1	2400
1	0	0	4800
1	0	1	9600
1	1	0	19200

Figure 4. Jumpers for setting the touch screen baud rate.²

1.1.1 Terminal Features

The touch screen display provides the same capability to present standard ASCII characters as a VT100 type terminal. Character graphics are implemented using the ANSI 3.64 standard for terminal control and presentation. ANSI compatible commands are used for the control features used in the graphic presentation of touch sensitive buttons, described later in this section.

The touch screen display has access to a binary command mode that was used in an earlier model, C2 controller, in addition to the normal ASCII mode and ANSI display controls of the C3 controller. The C2 controller mode uses binary commands for display control. The advantage of the binary command mode is that it allows access to graphics complexity that may be beyond the ANSI mode. The reader should refer to the DeeCO manual for specific application requirements. In the initial phase of this effort use of the ANSI controls and graphics were sufficient to demonstrate the capabilities of the display, however as the software is enhanced, the graphics available in the command mode may be necessary.

Three modes of interaction with the touch sensor are available to the user. First it has a touch sensitive keyboard which is displayed in the lower half of the screen. The keyboard is toggled on and off by touching the lower right corner of the screen. The keyboard is an image on the screen. The touch screen provides audiovisual feedback to the user to indicate that a "key" has been touched. The feedback is in the form of a "beep" sound and the key becoming highlighted. The second mode allows user-defined, touch sensitive rectangular buttons (with labels) to be displayed. When a button is touched, it sends the user defined response. In addition, the audiovisual feedback used to indicate a "key" activation in keyboard mode is used in the button mode. Buttons can be stored as "pages" of buttons, where each page is one full screen of buttons. Buttons may be used for switching from one

²Ibid., p. 57

page to another. These pages of buttons are convenient for menus--the user can touch buttons instead of typing responses. Since this project involved touch sensitive menus, this was the main option used. In the third option, the coordinates of a touch are reported and the touch may be tracked. The third mode was not used in the application.

1.2 The DEC VT320 Hardware Characteristics

The VT320 consists of a controller, input/output ports and a CRT display. The CRT requires most of the space used by the terminal; the overall dimensions are 12.25" W X 9.87" H X 12.3" D. The display area is a 14" flat screen. The resolution of the display is: horizontal, 127 pixels/inch and vertical, 47.625 pixels/inch. The controller uses the ANSI 3.64 standard for encoding information and commands for computer peripherals. It is very similar to the VT100 and VT200 series of terminals and can emulate each, but it also has added features. Numerous data formats are allowed through the selections in the setup menu. The setup menus are more extensive than either the VT100 or VT200 series, because the VT300 series allows all of the configurations allowed in the earlier members of the VT series. These setups are controllable through manual selection via the keyboard or through software access. One feature that is new to the VT300 series is the access to a printer controller mode, in the terminal setup, which allows bidirectional traffic of information from a device attached to the printer port to the host computer. This feature facilitated the achievement of one of the project goals, to allow the touch screen display to interact with the host computer while attached to the printer port of the VT320 terminal. Earlier members of the VT series only used the printer port as an output from the controller.

The VT320 has two serial ports: one functions as the port to the host computer; the other is the printer port. Both ports require a 6-pin modular (phone-style) connector (DEC-423 interface), see Fig. 5. The ports can independently be set to ten different baud rates for both transmitting and receiving data; the possible baud rates are: 75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, and 19200.

1.2.1 VT320 Terminal Features

The VT320 terminal provides the capability to present standard ASCII characters, control characters and special multinational characters that are available as an option to the user. Character graphics are implemented using the ANSI 3.64 standard for terminal control and presentation. There are several enhancements over the VT100 series but most of these are hardware related features that are not readily apparent to the user.

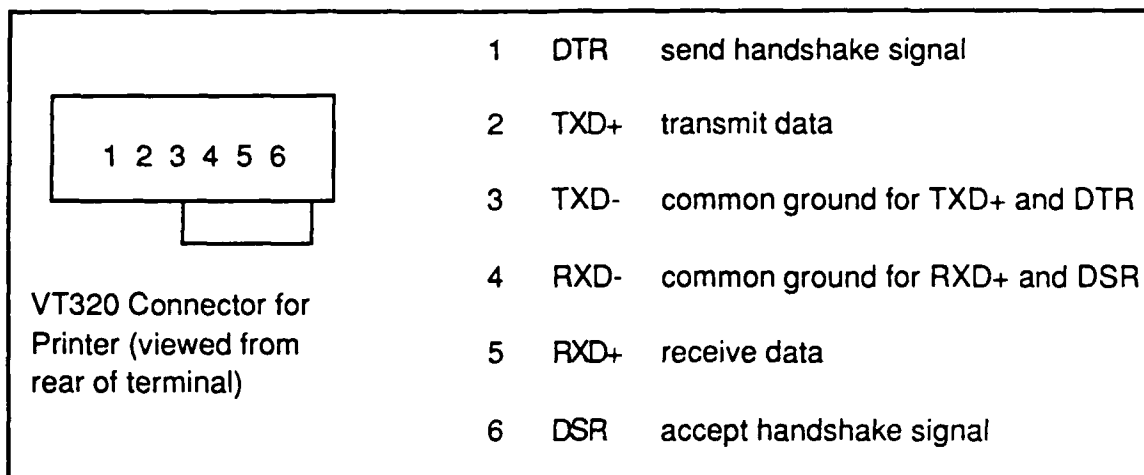


Figure 5. VT320 serial port interface.³

2.0 HARDWARE INTERFACE

There were two configurations used for the presentation of a user touch screen interface. One configuration used both the VT320 terminal and the touch screen. The purpose of this configuration was intended for an implementation at a workstation environment such as possibly a depot repair facility. The intent for this configuration was to allow a repair technician the capability to interact with the host computer and have multiple screens of information presented for different forms of information, i.e. the VT320 could present text information while the touch screen display would be used to present graphic information and provide a touch screen interface for the user. The software is organized so that either text or graphic information could be held on its respective screen, until it is no longer needed, without interfering with the operation of the other display. This configuration could also be implemented as a training aid for ship's technicians when no maintenance actions are required.

The other configuration uses only the touch screen display as the terminal connected to the host computer. The purpose of this configuration is to optimize the user's ability to interact with the host computer in the cramped nonuniform work spaces where most maintenance actions are required. In this configuration the user is able to carry the terminal and connect at serial ports throughout the work area. All interactions that are required can be performed through touch buttons and the touch sensitive keyboard. The display presents both text and graphic information to the user. Primarily, this configuration would be used in a maintenance environment, but the single display could also be used in the workstation environment described for the other configuration.

³Digital Equipment Corporation, Installing and Using the VT320 Video Terminal (Maynard, MA: DEC, 1987) pp. 58-59

2.1 Dual Display Configuration for Depot Maintenance

The dual display configuration requires software to control the action of each display. This requirement means that several functions in software send control commands to both the VT320 and the touch screen display. There are also other software control commands to control the display of touch buttons on the touch screen. The software information is presented in a companion report on the software requirements.

The hardware requirements presented cover cabling configurations and handshaking. The cables used conform to the RS-232 standard for serial data communications. The pin configurations are described. The handshaking was performed using both hardware and software.

2.1.1 Hardware Requirements

The hardware required for the dual display configuration are: a port to the host computer, the VT320 terminal, the touch screen display and serial cable connectors. The serial cable connectors will be described in this section, since the other items have already been discussed.

There are only two cables required to provide the hardware interface: the cable from the host computer serial port to the data port of the VT320, and the cable from the VT320 printer port to the serial port on the touch screen display.

2.1.1.1 Interface of the VT320 to Host Computer

The interface for the VT320 data port is the 6-pin modular socket described in Fig. 5. The interface for the host computer serial port is a 25-pin D-Sub connector. The host computer uses: pin 2, as transmit; pin 3, as receive; and pin 7, as ground. The VT320 port uses: pin 2, as transmit; pin 4, as ground; and pin 5, as receive. A DEC Connect Office Cable BC16E-10, with 25-pin adapter (H8571-F) was used to provide the connection to the host port. The configuration is shown in Fig. 6.

2.1.1.2 Interface of the VT320 to Touch Screen Display

The interface for the VT320 printer port is the 6-pin modular socket described in Fig. 5. The interface for the touch screen display serial port is a 25-pin D-Sub connector. The VT320 port uses: pin 2, as transmit; pin 4, as ground; and pin 5, as receive. The DeeCO display serial port uses: pin 2, as transmit; pin 3, as receive; and pin 7, as ground. A DEC Connect Office Cable BC16E-10, with 25-pin adapter (H8571-F), was used to provide the connection to the touch screen display serial port. In addition, hardware handshaking can be employed. In this case additional pins are used. The VT320 uses pin 1, as data terminal ready, and pin 6, as data set ready. The touch screen display serial port uses pin 4, as request to send, and pin 5, as clear to send. If hardware handshaking is not employed, then pins 1 and 6 must be shorted together, otherwise the VT320 will be unable to recognize that a printer is connected. The connections made in this last manner will also make it impossible for

the VT320 to recognize that the touch screen display is not connected, or not operational. Both hardware configurations are shown in Fig. 7.

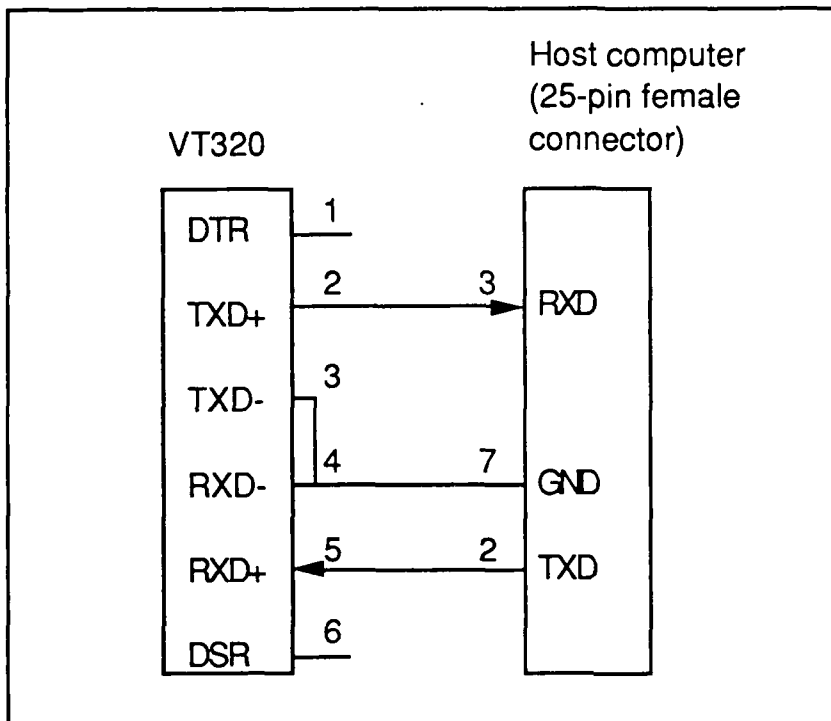


Figure 6. VT320 terminal to host computer hardware cable configuration.

2.1.1.3 Handshaking

Handshaking is a means by which a device can send or receive a signal regarding readiness for transmissions. In many devices (like printers and terminals), incoming data is sent to a buffer to await processing. If data continues to arrive after the buffer becomes full, that data will be lost. A device which does handshaking will send a message, when its buffer is almost full, to stop the transmission until the buffer is again ready to receive data.

The touch screen has two ways to perform handshaking. Hardware handshaking requires that the "request to send" (RTS) and "clear to send" (CTS) lines are connected (as shown in Fig. 7). The touch screen sends handshaking signals over the RTS line to the "data set ready" (DSR). The input buffer of the display controller holds 256 bytes. When it is 80% full, RTS will be deasserted. This signals the host to stop transmitting. When the buffer contents are reduced to 20% of capacity, RTS is asserted and the host may resume transmitting. The touch screen receives handshaking signals from the host over the CTS line. This allows the host to signal the touch screen to stop transmitting. In practice it is very unlikely that the

touch screen would ever send a high enough rate of data to require the VT320 to assert the DTR.

Software handshaking does not use the RTS and CTS lines. When the input buffer is 80% full, the display controller sends an XOFF message (same as "control-S") over the transmission line (TXD). This causes the host to stop transmitting until the controller sends an XON message (same as "control-Q") when it is ready to receive more data. The touch screen can send these signals to the host, but it is not capable of handling these signals coming from the host. This is reasonable because, while it is very likely that the host would send a large amount of data to the touch screen, it is not very likely that the touch screen would send a large amount of data to the host.

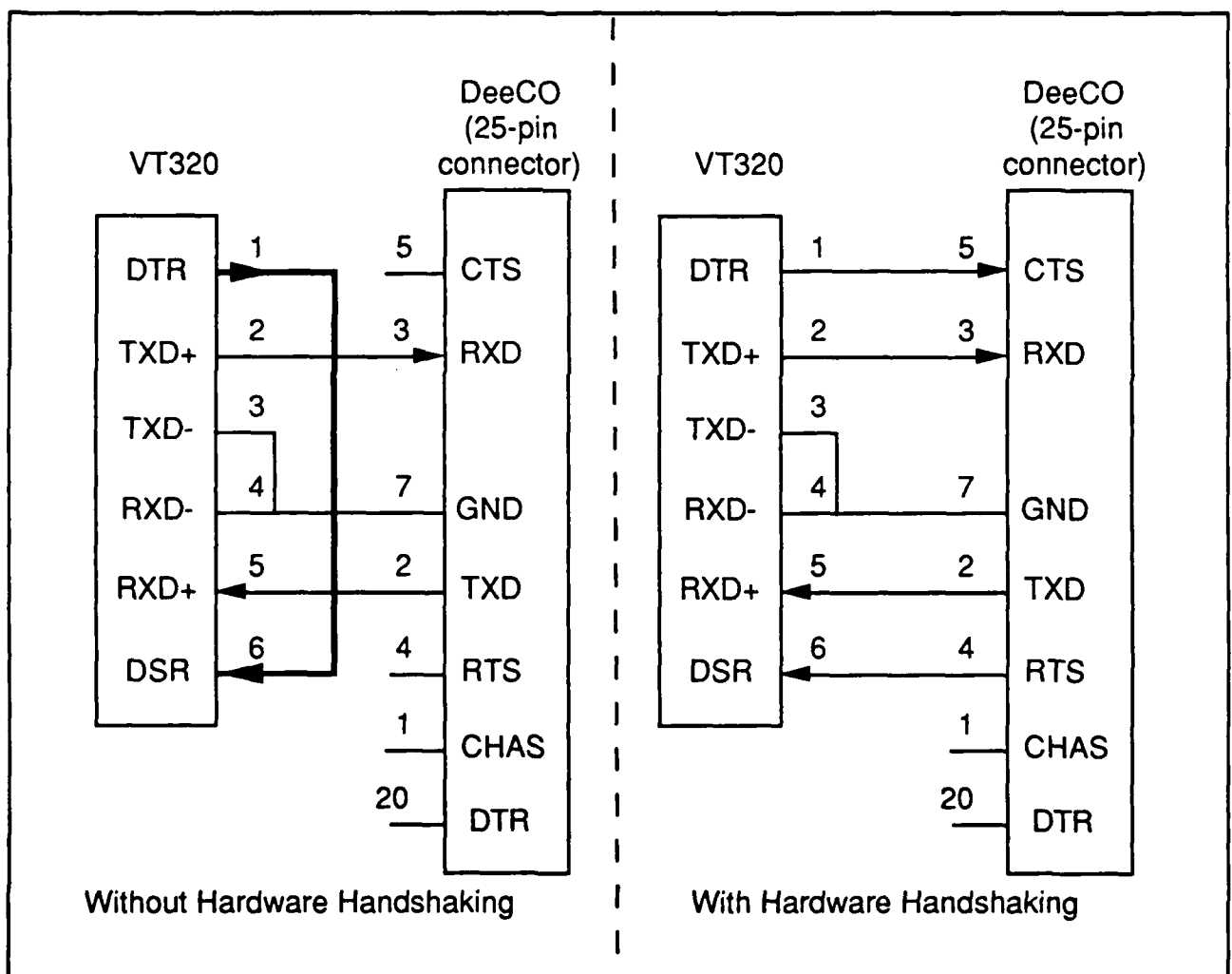


Figure 7. VT320 to touch screen display configuration.⁴

⁴DeeCO, p. 109

In the dual display configuration, both hardware and software handshaking were used to control the data flow between the touch screen display and the VT320. This handshaking only takes effect between the two devices. Another set of handshaking occurs between the VT320 and the host computer (only software handshaking is supported by the host computer.) This is required because each display has its own buffer which must be maintained below the overflow capacity.

The touch screen automatically sends both hardware and software handshaking signals. The hardware handshaking is more effective, especially at higher baud rates, because there is some lag time involved in processing the XON/XOFF commands. There is no option available for changing the point at which the touch screen sends an XOFF.

The VT320 has comparable options for handshaking. Its printer port has two lines for hardware handshaking. It has a "data terminal ready" line (DTR), which it uses to send a message regarding its readiness for sending or receiving data. It has a "data set ready" line (DSR), which it checks to find out whether the printer is ready. For software handshaking, "XON/XOFF" flow control is used between the VT320 and the printer. The terminal can receive an XOFF signal from the printer (when the printer's buffer is almost full) and stop transmitting until an XON signal is received. The terminal can also send XOFF and XON signals to the printer. This operates independently from the "XON/XOFF" between the VT320 and the host.

2.1.2 VT320 Terminal Software Configuration

There are several modes on the VT320 which must be set in order for data from the host to be directed through the printer port to the touch screen and back from the touch screen to the host. Before any communication can take place, the baud rate of the printer port must match the baud rate of the touch screen. In this project, the baud rate of the touch screen was set to 9600 to allow a direct connection to the host computer. The printer port was also set to 9600. Other modes which must be set for proper communication are the bits and parity ("8 bits, no parity"), the stop bit ("1 stop bit"), and the XON/XOFF flow control ("XOFF"). These settings are all done in the printer set-up screen. These settings may not be performed by software running on the host computer; only local control by the user is allowed.

While the other VT320 terminal settings required for interfacing the touch screen with the VT320 may also be chosen through the set-up screens, it is more efficient if they are set automatically by the software. To do this the software being executed by the host must send control sequences to the VT320. One of the settings which must be set by the host is the "controller" print mode. While the VT320 is in this mode, information from the host is displayed on the touch screen and not on the VT320. Another setting required is the "printer to host" mode. This is the mode which allows the touch screen to send information to the host. "Printer to host" mode is only available on the VT300 series; this requires that the terminal mode must be set to "VT300 mode, 8 bit controls" before setting the "printer to host" mode. When access to the touch screen is completed, each mode should be reset; "controller" mode should be turned off, the terminal mode should be reset if it was changed, and "no printer to

host" mode should be set. The control sequences for setting and resetting modes are listed in Fig. 8.

VT320 Mode	Control Sequence
controller mode on	ESC [5 i
controller mode off	ESC [4 i
VT300 mode, 8-bit controls	ESC [6 3 " p
VT100 mode	ESC [6 1 " p
printer to host mode	ESC [? 9 i
no printer to host mode	ESC [? 8 i

Figure 8. Control sequences for interfacing the touch screen with the VT320. (Note: Spaces between characters are for readability and should not be included when sending the control sequences.)⁵

2.1.3 Results

In this project, the touch screen was operated from the printer port of a VT320 terminal by software run on a Sun computer. The touch screen was successfully used to enter software defined commands to the host while connected to the printer port of the VT320. The software could successfully transfer control from the VT320 to the touch screen display. The text display was directed between both the VT320 and the touch screen display. A graphical presentation of a bargraph was displayed on both monitors and compared. The touch screen display provided a sharper presentation of the graphics. The touch screen keyboard was successfully used for entering information, although it required more effort than a normal keyboard, because there was no touch sensation, meaning entries had to be made while looking at the keyboard. It could be toggled on and off to allow full screen display. Another advantage of the dual monitor configuration is that when the VT320 is in printer controller mode its keyboard functions as an auxiliary keyboard for the touch screen.

In application the user defined buttons were displayed on the touch screen display. When activated by a user touch the IR controller would interpret the

⁵DEC, pp. 60-73

activation and pass information to the display controller on which button area was selected. The display controller processes the selection and then transmits, through the data port, the response which was previously defined for the button selection. The information that reaches the SUN is then interpreted as a command relevant to the system software and processes the command.

2.2 Touch Screen Terminal for Field Maintenance

This configuration requires a direct connection from the host computer to the touch screen display. The host computer software performs all of the terminal control for the touch screen display. All information, text, graphics, touch menu commands and keyboard entries, are performed by the display. The hardware requirements presented include the cable configuration description. The cable used conforms to the RS-232 standard for serial data communications. The pin configurations are described. Handshaking was performed by the host computer system software.

2.2.1 Hardware Requirements

The hardware required for the touch screen display configuration is: a port to the host computer, a touch screen display and serial cable connection. The serial cable connection will be described in the following subsection. A single cable is required to provide the hardware interface - the cable from the host computer serial port to the serial port on the touch screen display.

2.2.1.1 Interface of VT320 to Host Computer

The interface for the touch screen display serial port is the 25-pin D-Sub connector described in Fig. 3. The interface for the host computer serial port is a 25-pin D-Sub connector. The host computer uses: pin 2, as transmit; pin 3, as receive; and pin 7, as ground. The DeeCO display serial port uses: pin 2, as transmit; pin 3, as receive; and pin 7, as ground. No hardware handshaking is supported by the host computer so pins 1, 4, 5, and 20, which the touch screen display serial port uses for this purpose, are not connected. The configuration is shown in Fig. 9.

2.2.1.2 Handshaking

The data handshaking which is performed in this hardware configuration is precisely the same as the software handshaking described previously in section 2.1.1.3. This means that as the buffer of the touch screen display fills to 80% of capacity an XOFF is transmitted by the display to the host computer to cease data transmission. When the buffer is then emptied to 20% of capacity then an XON is sent by the touch screen display to the host computer so that data transmission may resume. The touch screen display does not implement the capability to interpret XON/XOFF commands.

2.2.2 Touch Screen Display Software Configuration

There is no unique software requirement needed for this hardware configuration. The system software and application software handle all terminal control without the need for a user to set terminal capabilities. Only the baud rate which is selectable in the touch screen hardware must be maintained at the correct speed. The baud rate used throughout the demonstration of the touch screen display's capabilities was 9600 baud.

2.2.3 Results

The results obtained in this configuration of the hardware were basically the same as those obtained for the dual display configuration. All presentation of data and commands were successfully performed by the touch screen display. The touch button commands and the touch keyboard both functioned properly.

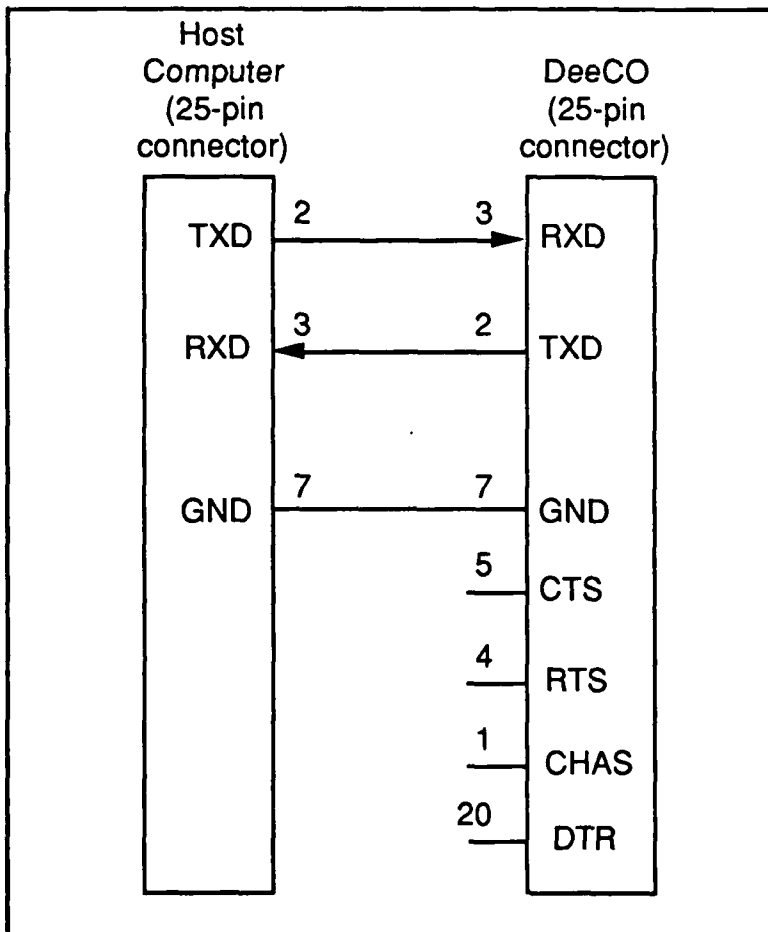


Figure 9. Touch screen display to host computer hardware cable configuration.

3.0 SUMMARY AND CONCLUSIONS

It was shown that the touch screen can be operated from either the printer port of a VT320 terminal or directly from the host computer port. In the dual display configuration software was required to select the proper settings on the VT320 for sending data from the computer to the touch screen and for receiving data back from the touch screen. In the single display configuration, with only the touch screen display, no such software control was required to change the characteristics of the terminal.

In conclusion, both hardware configurations were found to function successfully. All information could be displayed on the displays as expected. In addition, the touch screen display proved to be valuable by providing the capability to enter predefined commands and keyboard entries through the touch screen interface. A negative feature of the DeeCO touch screen display was its poor reliability. Three similar devices were used during the two year development period, and there were controller hardware failures on two of the devices. The incidence of failure in the devices may be coincidental, but actual reliability performance would have to be examined before implementing the DeeCO device in the suggested application. It is expected that some implementation of these or similar hardware configurations will be used in a the Technician's Assister System (TAS) for the SQS-53B sonar system. The TAS uses artificial intelligence techniques to assist the technician in maintenance actions.

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