3M

EX II Serial Controllers Reference Guide

EX II 1710SC
EX II 1720SC
EX II 1750SC
EX II 7720SC

3M Touch Systems

Read and understand all safety information
contained in this document before using this product.

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Introduction

3M Touch Systems offers several advanced controllers designed for reliability and easy installation. Each controller provides superior performance and delivers excellent stability, sensitivity, accuracy, and fast response.

This reference manual, directed to developers of touch screen systems, provides installation and configuration information for the 3M Touch Systems EX II serial capacitive touch screen controller. This document includes information on integrating the EX II controller into your design, communicating with the controller, installing the TouchWare or MT 7 software user interface, and troubleshooting setup problems. It also includes a complete description of the firmware commands, a guide to interpreting status LED conditions, and controller specifications.

3M Touch Systems is committed to being a premier supplier in touch systems throughout the world. As a 3M Touch Systems customer, you are aware that we have strong internal programs that meet or exceed environmental regulations of our customers and the regions in which we conduct business.

As such, our approach to the European Union Directives 2002/96/EC (WEEE) and 2002/95/EC (RoHS) (the directives) is being addressed in the same rigorous manner. To ensure compliance with the directives, we are pleased to provide this RoHS compliant product.

What You Need to Know

This document assumes you are familiar with firmware commands and how to use them. Executing some commands may alter the performance of your touch product. You should be aware of the results of using these commands before executing them.

Important Safety Information

Read and understand all safety information before using this product. Follow all instructions marked on the product and described in this document. Pay close attention to the following installation warnings and safety precautions.

Intended Use
The EX II controller was designed to enable touch in conjunction with other 3M Touch Systems products and was tested to replace an existing serial controller. This controller is intended for internal use only and is not designed for use in hazardous locations.

⚠ **DANGER**
To avoid the risk of fire and/or explosion which will result in serious injury or death:
• Do not install or use this product in a hazardous location.

⚠ **WARNING**
To avoid the risk of electric shock which could result in serious injury or death:
• Do not use a damaged power supply.
• Do not use a power cord that is frayed or otherwise damaged.
⚠ **WARNING**
To avoid the risk of fire and/or explosion which could result in serious injury or property damage:
• Do not install or use this product in a hazardous location.
• Do not use this product in any outdoor environment unless NEMA (or other similar) standards, such as IP rating, are followed.

⚠ **CAUTION**
To reduce the risks associated with improper disposal, which if not avoided may result in minor or moderate injury from ground water contamination:
• Dispose of components in accordance with local, state, and federal regulations.
To avoid the potentially hazardous situations associated with the use of isopropyl alcohol which may result in minor or moderate injury or property damage:
• Follow all instructions and recommendations in the manufacturer's Material Safety Data Sheet and product label.

Explanation of Symbols

⚠ Attention: Read accompanying documentation

Touch Screen Care and Cleaning

The touch screen requires very little maintenance. 3M Touch Systems, Inc. recommends that you periodically clean the glass touch screen surface.

Typically, an isopropyl alcohol and water solution ratio of 50:50 is the best cleaning agent for your touch screen. You can also use straight isopropyl alcohol. In addition, 3M Screen and Keyboard Cleaner CL680 has been tested and approved for this use.

⚠ **CAUTION**

> To avoid the potentially hazardous situations associated with the use of alcohol or other solvents which may result in minor or moderate injury or property damage:
> - Follow all instructions and recommendations in the manufacturer's Material Safety Data Sheet and product label.
> - Be sure to follow solvent manufacturer's precautions and directions for use when using any solvents
> - It is important to avoid using any caustic chemicals on the touch screen. Do not use any vinegar-based solutions.

Apply the cleaner with a soft, lint-free cloth. Avoid using gritty cloths.

Always dampen the cloth and then clean the screen. Be sure to spray the cleaning liquid onto the cloth, not the screen, so that drips do not seep inside the display or stain the bezel.

Always handle the touch screen with care. Do not pull or stress cables.

Contacting Technical Support

3M Touch Systems, Inc. is committed to helping you get the most out of your touch screen by providing extensive Technical Support. Visit the 3M Touch Systems, Inc. website at http://www.3Mtouch.com/, where you can download touch screen software and drivers, obtain regularly updated technical documentation on 3M Touch Systems, Inc. products, and learn more about our company.

Whenever you contact Technical Support, please provide the following information:
- Display manufacturer and model number
- Touch screen part number and serial number
- Current driver version
- Operating system used
- Information on additional peripherals

Technical Support is available Monday through Friday 8 a.m. to 8 p.m. US Eastern Standard Time – 9 a.m. to 5 p.m. throughout Europe. Limited call back service is available Saturdays and Sundays 9 a.m. to 5 p.m.

You can contact 3M Touch Systems, Inc. Technical Support (US only -- Eastern Standard Time) by calling the hot line, sending email or a fax.
- Technical Support Hot Line: 978-659-9200
- Technical Support Fax: 978-659-9400
- Toll Free: 1-866-407-6666
- Email: US-TS-techsupport@mmm.com

3M Touch Systems, Inc. Worldwide Offices

Contact information for all offices can be accessed through the website: http://www.3Mtouch.com/.

Integrating the EX II Controllers

The 3M Touch Systems EX II controller provides a drop-in replacement for an existing controller with wide dynamic range, increased noise immunity, wide operating temperature stability, reprogrammability using software utilities and improved capability in ungrounded environments.

The EX II 1700SC and 7720SC series capacitive controller firmware is optimized for Cleartek II touch screens integrated in the latest flat panel displays.

This chapter covers the following EX II controller specifications:

- Cable connections
- Mounting requirements
- Power requirements and options
- Status LED codes

Overview of the EX II Touch Screen Controllers

The EX II controllers and touch screens are supplied separately. A 25-point linearization procedure has been performed to determine the physical properties of the touch screen, and the data is stored in a 2D bar code label attached to the touch screen flex cable.

- The EX II 1710SC and 1750SC are available in N81 Format Tablet either cased or uncased for external or internal mounting.
- The EX II 1720SC is available in N72 Format Tablet either cased or uncased for external or internal mounting.
- The EX II 7720SC is available in N81 Format Tablet uncased without cable for mounting within a custom chassis.

To integrate and test the EX II controller, you need the following items:

- A 3M Touch Systems capacitive touch screen. The touch screens are available in a variety of sizes.

- A method of establishing the serial data communication between the controller and your system. The standard 3M Touch Systems RS-232 serial cable (P/N 7310101) is recommended.

- A method of supplying power to the controller -- either internal or external.

- A touch screen driver with a calibration routine.

> **Note:** You can use either TouchWare or MT 7 software, which include the touch screen device driver and utilities software as the software interface.

EX II 17xxSC Dimensions

The EX II 17xxSC cased version measures 2.5 x 3.75 inches with a total height of approximately 1 inch when the touch screen cable is attached. The cased version comes with a standard serial cable.

The EX II 17xxSC uncased version measures 2.25 x 3.6 inches with a total height profile of 0.5 inches from the thru hole pins on the trace side of the board to the top of the highest component on the opposite side. The EX II 17xxSC has a NOVRAM touch screen connector and a serial cable connector.

Figure 1. EX II 17xxSC Overall Dimensions
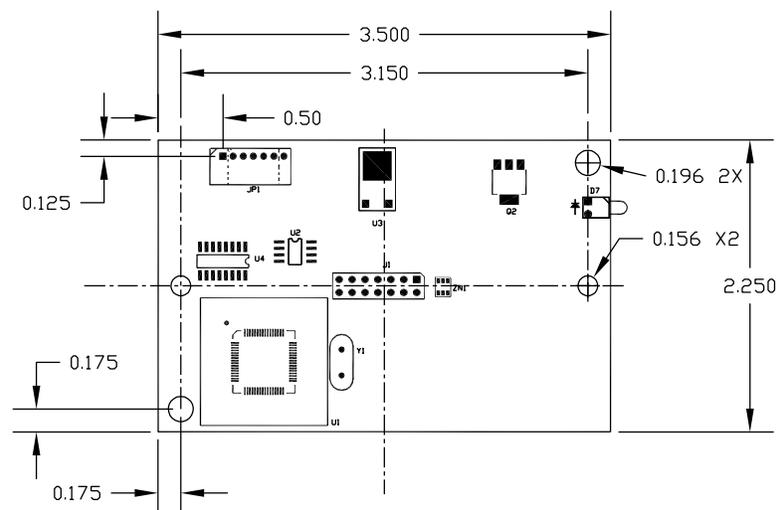
EX II 7720SC Dimensions

The EX II 7720SC controller measures 1.3 x 2.6 inches with a total height profile of 0.38 inches from the thru hole pins on the trace side of the board to the top of the highest component on the opposite side. The EX II 7720SC has a 5-pin touch screen connector and a serial cable connector.

Figure 2. EX II 7720SC Overall Dimensions
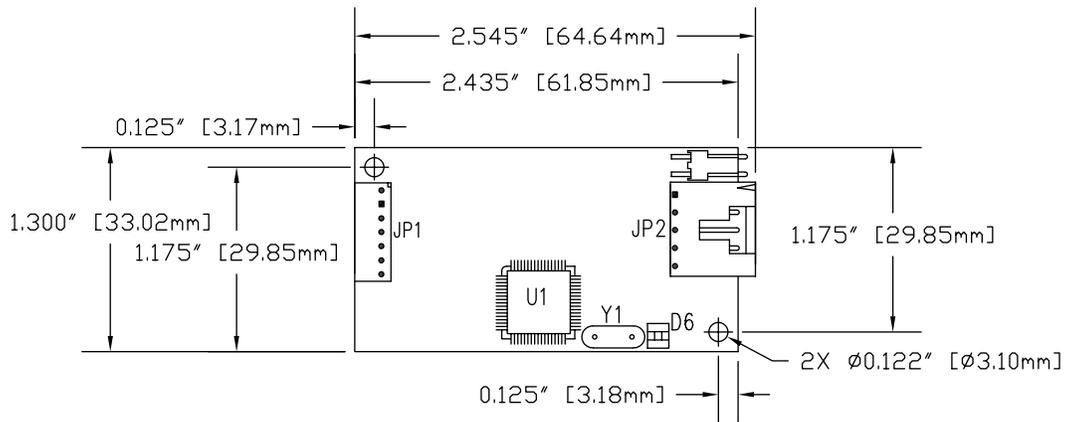
Handling and ESD Protection

When mounting the touch screen and controller, use normal precautions for handling electrostatic sensitive devices. The EX II controllers have internal protection to ±27 kV for ESD discharges to the touch screen (not to the controller directly) that may occur during normal operation of the touch screen. Refer to Appendix A for further specifications.

Establishing the Data Connection

The EX II controllers require that an RS-232 serial communication cable be attached to connector JP1.

You can use a standard 3M Touch Systems RS-232 cable (P/N 7310101) or an equivalent interconnect. One end of this cable plugs into the RS-232 connector (JP1) on the controller. The other end, which has a 9-pin D connector, plugs directly into a serial COM port on your PC. Table 1 describes the interconnections for the 3M Touch Systems RS-232 cable.

Table 1 COM Cable for EX II 17xxSC and 77xxSC Controller

PC Side (9-Pin D)			Wire	Controller Side (7-Pin Molex)	
Pin	RS-232 Assigned	Jumpered to:	Color	Pin	Description
1	Data Carrier Detect (DCD)	4 and 6 DTR and DSR	—	None	
2	Receive Data (RXD)		Brown	2	Transmit Data (TXD)
3	Transmit Data (TXD)		Red	3	Receive Data (RXD)
4	Data Terminal Ready (DTR)	1 and 6 DCD and DSR	—	None	
5	Signal Ground		Blue	5	Power supply ground
6	Data Set Ready (DSR)	1 and 4 DCD and DTR	—	None	
7	Request to Send (RTS)		Black	1	Request to Send (RTS)
8	Clear to Send (CTS)		Green	4	Clear to Send (CTS)
9	Not Used				Do not ground
Sleeve			White	6	DC power jack (+5 VDC)
Pin			—	7	Cable shield connected to ground. DC power jack ground
Shell			—	7	Chassis (earth) ground

Mounting the Controller

The uncased controller is mounted internally. Choose a convenient spot away from high-voltage, high power cables and electronics. Use 4-40 metal screws to mount the controller using the two diagonal mounting holes in the board. The controller is mounted in line with the touch screen cable exit point to minimize cable flexing. The controller is mounted behind or on the side of the display on stand offs to allow room for the touch screen cable connector. Refer to Figure 1 for more details on controller mounting.

Supplying Power to the Controller

You must supply the EX II controller with power. You can use internal power (that is, tap power from inside the monitor or PC) or external power.

However you supply power, the source must deliver 85 mA typical (110 mA maximum), with a maximum ripple and noise of 50mV peak-to-peak.

> ⚠ **CAUTION**
>
> **To avoid possible damage to the controller,** you must provide a path for electrostatic discharge. The controller-mounting hole near the touch screen connector should be used to connect to chassis safety ground and must be attached by the shortest possible route to a good earth return (chassis) in all applications.

You can supply power to the ClearTek II controller using any of the following methods. The voltage input can vary from +5VDC to +12VDC. Exact specifications can be found in the appendices.

- (EX II 7720SC only) Internal power +5V to +12 V DC though the 2-pin power input connector pin 2 (+5V to 12 V) and pin 1 (RTN). A square pin indicator on the bottom of the board marks pin 1.
- Internal power (+5V to +12V DC) through a custom serial cable configuration.
- External power (+5 V DC) from a wall-mount power supply.

Note: To avoid possible damage to one or both of the power supplies, do not supply both internal power and external power to the controller. Power from two sources could cause damage.

Using an Internal Power Supply (+5V to +12V) to JP3

Provide power directly to the controller using JP3 (Molex 22-05-3021). Use a mating 2-pin connector and connect Pin 2 to power (between +5V and +12V) and Pin 1 to the return. (Mating connector is the Molex housing 22-01-3027 with 08-50-0114 contacts).

Using a Custom Serial Cable Design

When creating a custom serial cable connection, you can provide power to the controller through the mating Molex connector: (refer to Table 12 for more information on actual cable connections).

1. Obtain a 7-pin Molex connector 51004-0700.
2. Attach power and ground to the connector, (Pin 6: +5V to +12V, Pin 7: Ground).

Using an External Wall-Mount Power Supply

If you are using a standard 3M Touch Systems RS-232 serial cable (P/N 7310101), consult your applications engineer for power supply specifications.

Mounting the Touch Screen

There are several methods for mounting the touch screen depending on your application (CRT displays or flat panel displays, each in a variety of sizes). If you need instructions or recommendations from 3M Touch Systems on how to incorporate a touch screen into your design, refer to the *ClearTek II Touch Screen Integration Guide* (P/N 19-278v02). All 3M Touch Systems documentation is available from the corporate website at www.3Mtouch.com.

Turning On Your System

Before you turn on your custom system, ensure that all cables are connected properly and that the controller is properly mounted. Be sure to tighten all cable connector screws.

To start up your system:

1. Turn on your monitor and computer.
2. Adjust the contrast and brightness to suit your personal preference and working environment.

3. Adjust the horizontal and vertical position controls on the monitor to center the image on the screen.

Status Light (LED) Diagnostics

3M Touch Systems controllers are highly reliable units; however, there may be occasions when the controller does not perform exactly as you expected. The EX II controller provides diagnostic feedback with a light emitting diode (LED) on the component side of the board that indicates the status of the touch screen unit.

If the LED is on, and remains dimly lit, the controller has power and is operating properly. If the LED is off, the controller is not receiving power.

When you power-up the unit, the LED is bright until the controller start-up sequence is completed. Following start-up, the LED becomes dim and remains dim as long as you do not touch the touch screen. When you touch the touch screen, the LED becomes bright as long as a touch is detected.

A flashing (or blinking) LED during power-up indicates the controller's power-on self-test failed. Refer to Table 2 for a description of each error code.

Table 2 LED Diagnostic Codes for EX II Controllers

Flashes	Error Description	What to do...
1	Reserved.	
2	Reserved.	
3	Setup error. Unable to establish operating range at power-up. Nonrecoverable error.	Replace controller. If error reoccurs, might be a touch screen problem.
4	Controller NOVRAM error. The operating parameters in the controller NOVRAM are invalid. Using defaults.	Restore defaults. If fault persists, replace controller. If error reoccurs, might be a touch screen or cable problem.
5	HDW error. The controller hardware failed (unable to initialize or load program). Nonrecoverable error.	Replace controller.
6	Reserved.	
7	Cable NOVRAM error. The linearization data in the cable NOVRAM is invalid.	At startup, the cable NOVRAM error will flash the LED until the controller receives any valid command from host.
8	Controller NOVRAM error. The controller linearization data in NOVRAM is invalid.	Replace touch screen or perform a 25-point linearization. Contact Technical Support.
9	Reserved	
10	Controller EEPROM not formatted	Reload program code
11	Invalid controller block 5	Not applicable to serial controller.
12	Invalid controller block 6	Restore defaults if possible, otherwise replace controller.

Installing Software

Both TouchWare and MT 7 software include the software driver that enables your touch screen to work with your computer. 3M Touch Systems has touch screen drivers for many operating systems, including Windows XP, XP embedded, 2000, 9X, Windows Me, Windows CE, and Windows NT 4.0 (refer to the website for a complete listing). You must be sure to install the touch screen software for your operating system.

Both TouchWare and MT 7 software include a control panel for setting your touch screen preferences and a diagnostic utility. If you are experiencing problems with the touch screen, you can use the diagnostic utilities provided to locate the touch screen controller and test the touch screen.

For more information on connecting your cables and installing and using the touch screen control panel and utilities, refer to either the *TouchWare Software User Guide* or the *MT 7 Software User Guide* available on the corporate website at www.3Mtouch.com.

EX II Controller Communications

This chapter discusses the fundamentals of communicating with the EX II controller. The firmware commands, which are usually issued by a driver or utility program on the host system, control the operation of the touch screen controller, however developers can enter these commands directly. This chapter:

- Describes the controller default settings.
- Lists the recommended firmware commands for current development.
- Describes how to use each of these commands.
- References additional commands developers may need to use.

The description of each command includes the command syntax, the default value, how the command works, and the expected response from the controller.

Controller Default Settings

Communication Parameters

The default operation of the EX II controllers is N81 (no parity, 8 data bits, and 1 stop bits) at 9600 baud. The EX II 1720SC can be programmed to work with even/odd parity, 7 data bits, and 1 or 2 stop bits.

Data Format

Data format refers to the type of packet the controller uses to send the X/Y touch coordinates to the host system. Format Tablet is the default format for the EX II controller. In Format Tablet, the controller sends 5 bytes per point and provides the most rapid response time to a touch.

- Format Tablet is supported by all current 3M Touch Systems touch screen controllers.
- It is the standard for current 3M Touch Systems product development and is the format used by all touch screen drivers written by 3M Touch Systems.

Refer to the Format Tablet command in the firmware reference section. Note that both TouchWare and MT 7 software automatically set communications parameters to N81.

Operating Mode

The *operating mode* specifies the conditions under which the controller sends the X/Y touch coordinates (input data packet) to the host system.

Mode Stream is the default operating mode for the EX II controller. In Mode Stream, the controller sends a continuous stream of data packets when the screen is touched. The controller sends the data as long as a touch continues on the touch screen.

Because Mode Stream sends touch data continually, it is the most versatile mode, and it provides the best response time and overall feel.

3M Touch Systems recommends that the touch screen driver generate an interrupt as each packet in the data stream arrives. Because touchdown and liftoff events are specially coded, your software always knows exactly what the user is doing, if the interrupts are sent as recommended. This enables instant feedback and prevents data loss.

Communicating with the Controller

This section provides information on sending firmware commands to the controller and interpreting the responses that the controller returns.

The commands listed in the following table are those that 3M Touch Systems currently uses for development. 3M Touch Systems recommends that you use only these commands for EX II controller development.

Commands to the controller are sent on the signal **Receive Data** (RXD) line as a serial data stream. For each command it receives, the controller sends a response to the host on the signal **Transmit Data** (TXD) line also as a serial data stream.

Sending Commands to the Controller

When you send a command to the controller, you must use the correct command format. The general format of a command is as follows:

<Header>Command<Terminator>

Note: The following descriptions of header, command, and terminator, use 3M Touch Systems terminal emulator key sequences. You may need to enter the sequence in a different format, depending on your emulator.

The *header* is the first character in the command string and is the ASCII start-of-header control character SOH. The hexadecimal code for the ASCII SOH control character is 01. To start the command sequence, use the key combination Ctrl A (^A). If you are working with an IBM PC compatible system, the Ctrl A key combination immediately returns an ASCII ☺ character.

The *command*, which always follows the header, consists of ASCII uppercase letters and numbers only (printable characters).

The *terminator* is the last character of each command string and is an ASCII carriage return CR. An ASCII CR control character is 0D hexadecimal. To enter a carriage return, ending the command sequence, use Enter or the key combination Ctrl M (^M).

This chapter lists each command as a string of ASCII control characters and printable characters consisting of a header, the command, and a terminator as follows:

<SOH>*Command*<CR>

Receiving Responses from the Controller

After executing a command, the controller returns a response or acknowledgment to the host system. Each controller response consists of a header, the command response, and a terminator in the following format:

<Header>Command Response<Terminator>

Note: The following descriptions of header, response, and terminator, use 3M Touch Systems terminal emulator key sequences. The format of controller responses varies depending on the terminal emulation mode you are using.

The *header* is the first character in the response string and is the ASCII start-of-header control character SOH. The hexadecimal code for the ASCII SOH control character is 01. If you are working with an IBM PC compatible system in terminal mode, the SOH control character returns a ☺ character to the screen.

The *response*, which always follows the header, is a range of ASCII characters depending on the type of command sent. Responses can be in many forms. For example, one standard response is **0** (ASCII character 'zero' or 30 hexadecimal). This response indicates a successful command completion for most commands, while it indicates a failed completion for other commands. See the firmware reference section for a description of what the response indicates for *each* particular command.

Another standard response is **1** (ASCII character 'one' or 31 hexadecimal). In most cases, this response indicates the command failed. The controller received an invalid command that it could not execute.

Some possible reasons for a command failure include:

- The command was not formatted correctly.
- The system parameters were not set up to allow command execution.
- The controller does not support the command.

The *terminator* is the last character of each response string and is an ASCII carriage return CR. The hexadecimal code for the ASCII CR control character is 0D hexadecimal. The value returned in the response will be the ASCII control character for a carriage return, displayed on the screen as the cursor moving to the next line.

In this chapter, responses are shown as a string of ASCII characters consisting of a header, the response, and a terminator as follows:

<SOH>*Response*<CR>

Controller Initialization

To initialize the EX II controller for new development, 3M Touch Systems recommends that the host system issue a Reset command whenever the host system is powered on and is attempting to establish communication with the controller.

Firmware Commands

Developers may use this information when writing touch applications, developing custom drivers or touch configurations, or testing their touch systems. Developers can use firmware commands to initialize the controller, select operating modes, specify data formats, and execute diagnostic functions.

Most touch screen users do *not* have to use firmware commands to use their touch systems. For example, users can use either TouchWare or MT 7 software to calibrate the touch screen or to determine the controller type and firmware version.

Caution: This document assumes you are familiar with firmware commands and how to use them. Executing some commands may alter the performance of your touch screen and render it inoperable. You should be aware of the results before executing any firmware commands.

To optimize the performance of the Cleartek II touch screen controller and simplify the development of custom drivers, 3M Touch Systems recommends you use the commands listed in Table 3 for current development. Using these commands ensures compatibility with all 3M Touch Systems controllers.

Note: When you enter commands in terminal mode, precede each command with <CTRL> A to enter the start of header.

Table 3 Firmware Commands for EX II Development

Command	Code	Description
Calibrate Extended	CX	Initiates an interactive 2-point calibration.
Calibrate Raw	CR	Collects the raw X and Y coordinates before normal scaling, linearization, and filtering process.
Diagnostic	DX	Determines if there is a problem with the touch screen.
Format Raw	FR	Returns the signal level (amount of touch) of each of the four touch screen corners in digital format.
Format Tablet	FT	Outputs the X/Y touch coordinate data in a five-byte packet. Preferred for current development.
Mode Stream	MS	Sends a continuous stream of X/Y coordinate data when you touch the screen.
Name	NM	Returns a controller identifier string.
Null Command	Z	Queries the controller and waits for a response.
Output Identity	OI	Identifies the controller type and the firmware version.
Parameter Set	Ppds[b]	Lets you adjust the communication parameters (parity, data bits, and stop bits) of the controller.
Reset	R	Initializes the hardware and the firmware, causes the controller to stop sending data, and recalculates the environmental conditions.
Restore Defaults	RD	Returns the controller to the factory default operating parameters. Note: the serial port is reset to N81 format tablet and 2-point calibration is lost.
Unit Type Verify	UV	Identifies the touch screen controller on your system.

Calibrate Extended

Syntax: <SOH>**CX**<CR>

> **Note:** This command should not be used when TouchWare or MT 7 software is being used. The CX command will interfere with the auto orientation algorithm. To calibrate, use the 2- or 4-point calibration in TouchWare or MT 7 software.

Description: Initiates an interactive 2-point calibration.

During the calibration process, you define the active area of the touch screen by mapping locations to an absolute X/Y coordinate system. You touch two *target areas* on the screen. Touching the target areas sends the X/Y coordinates for those touch points to the controller. The controller calculates all other touch points based on these two points.

The Calibrate Extended command sets the calibration targets (points) inward from the corner of the video image. Setting the targets inward makes the calibration process easier and more accurate.

Guidelines for Calibrate Extended

Here are several guidelines for using the Calibrate Extended command:

- The controller uses the data immediately before liftoff to register a calibration touch. Therefore, you can touch the screen, move your finger to the target, hold for a few seconds, and then lift off. Instructing users to touch this way results in a more accurate calibration.

- The controller stores the data in non-volatile memory (NOVRAM). Therefore, you do not have to calibrate the screen each time you power on the system. You should, however, recalibrate the touch screen any time the video display changes size or resolution.
- You can restart calibration at any time during this sequence by issuing a Reset command and reissuing a CX command.

Determining Target Areas

The default calibration targets (points) are located 12.5% (1/8) inward from the corners of the video image. For example, suppose the display resolution of your monitor is 1024 x 768. The Calibrate Extended command calculates the amount to move inward as follows:

- Amount to move inward in the X direction: 1024 x 1/8 = 128
- Amount to move inward in the Y direction: 768 x 1/8 = 96

The Calibrate Extended command then positions the first calibration target inward from the lower left corner and the second calibration target inward from the upper right corner. The following illustration shows how the calibration targets are calculated.

*The coordinates are in *video* terms, with the origin (0, 0) in the upper left corner of the screen. Examples from the

(0, 0)

(1023, 0) [1024, 1024]*

(895, 96) ⊕ — **Upper Right Calibration Target**

X = 1023 − (1024 x 1/8) = 1023 − 128 = 895
Y = 0 + (768 x 1/8) = 0 + 96 = 96

⊕ (128, 671)

[1024, 0]*

(0, 767) [0,0]*

Lower Left Calibration Target

X = 0 + (1024 x 1/8) = 0 + 128 = 128
Y = 767 - (768 x 1/8) = 767 - 96 = 671
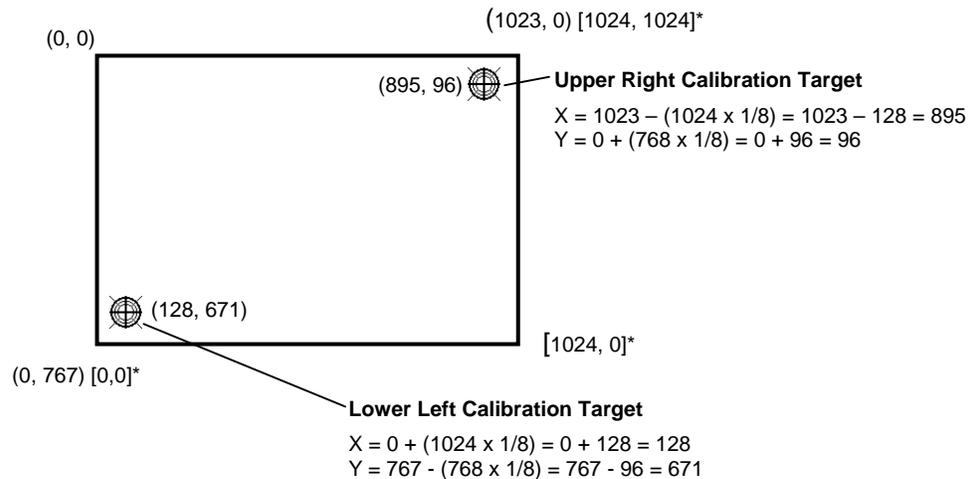
controller's perspective, however, place the origin at the lower left corner of the screen (numbers in brackets). The controller outputs 0 to 1024 on both axes independent of display screen resolution.

Calibrate Extended Procedure

To use the CX command:

1. Enter the Calibrate Extended (CX) command. The controller sends an initial acknowledgment of <SOH>0<CR>.

2. Touch the screen at a lower left target, which is located 12.5% (1/8) in from the corner of the video image. The controller returns an acknowledgment of <SOH>1<CR>. This is a positive response. If you receive a negative response <SOH>0<CR>, you can cancel the calibration by issuing a Rest command and then start over again.

3. Touch the screen at an upper right target, which is located 12.5% (1/8) in from the corner of the video image. The controller returns an acknowledgment of <SOH>1<CR>. This is a positive response. If you receive a negative response, you must start over again.

Touching the two valid calibration points results in a successful calibration. If either calibration point is invalid, the calibration fails. The EX II 1700SC and 7720SC controller restores the previous calibration values. If the Calibrate Extended failed, repeat the CX process.

Response: <SOH>1<CR>   Positive response.

Indicates that the controller received a valid touch coordinate (point) when the target was touched. Two valid touch points indicate a successful calibration.

<SOH>**0**<CR>   Negative response

Indicates that the touch point is out of range of the expected target area. If you receive a negative response, you must start over again.

No Response

Indicates that the user did not touch the target long enough to provide an accurate calibration point.

Calibrate Raw

Syntax: <SOH>**CR**<CR>

Description: Allows the collection of raw (signed) X and Y coordinates before the normal scaling, linearization, and filtering processes. The controller sends a continuous stream of data in Calibrate Raw mode.

The Calibrate Raw data is a 5-byte packet that includes 1 status byte and 4 bytes of binary X/Y coordinate data. Each X/Y coordinate includes 10 binary bits and 1 sign bit. The 10 bits represent coordinates within a range of -1024 to +1023.

To use the Calibrate Raw command, the controller and host system must be in an 8-bit data communication mode. The Calibrate Raw command returns a negative response if the controller is not using an 8-bit communication mode. To end Calibrate Raw mode, issue a Reset command.

3M Touch Systems uses the Calibrate Raw command during manufacturing and testing, and recommends you only use this command for diagnostics when you want raw data.

Response: <SOH>**0**<CR>   Positive response.

After the controller is in Calibrate Raw mode, the controller returns a response in the following format:

SXxYy where:

S = Status byte, first byte of data. Refer to Table 4.
Xx = X (horizontal) coordinate data; second and third bytes of data
Yy = Y (vertical) coordinate data; fourth and fifth bytes of data.

Table 4 Data Sequence

Data Sequence	MSB* 7	6	Bits 5	4	3	2	1	LSB* 0
S- Byte 1	1	S6	Reserved					
X- Byte 2	0	X3	X2	X1	X0	Reserved		
x- Byte 3	0	Xs**	X9	X8	X7	X6	X5	X4
Y- Byte 4	0	Y3	Y2	Y1	Y0	Reserved		
y- Byte 5	0	Ys**	Y9	Y8	Y7	Y6	Y5	Y4

*MSB = Most Significant Bit, LSB = Least Significant Bit
** s = sign bit

Table 5 describes the meaning of the bits in the status byte (Byte 1).

Table 5 Calibrate Raw Status Bits

Bit	Description	Values
S0 – S5	Reserved	—
S6	Proximity (touch state)	1 = Touch screen is being touched (a touchdown or a continued touch). 0 = Touch screen is not being touched (a touch liftoff or inactive). When the proximity bit changes from 1 to 0 (touch liftoff), the controller outputs one final set of X/Y coordinate data with the bit equal to 0 and the X/Y coordinate data equal to the last touch point.
S7	Packet synchronization	Always 1.

Diagnostic Command

Syntax: <SOH>**DX**<CR>

Description: This command requests the controller to check for touch screen failures such as broken corners, broken wires, etc.

Response: <SOH>**0**<CR>   Positive response.
                    <SOH>**1**<CR>   Command not supported.
                    <SOH>**2**<CR>   Failure detected.

Format Raw

Syntax: <SOH>**FR**<CR>

Description: Returns the signal level (amount of touch) of each of the four touch screen corners in digital format. The returned values are not corrected for stray values.

The Format Raw data is a 41-byte packet that includes 1 status byte and 40 bytes of binary corner data. The first byte of each packet always has its high bit (Bit 7) set to provide synchronization with the host system. Refer to Table 6 for General Packet Formats. Each corner data is composed of a pair of 32-bit I and Q values, which are delivered in 10 bytes.

I and Q are complex touch currents as measured in phase and 90 degrees out of phase with the corner drive signal. Refer to Table 7 for I/Q Corner Components.

To use the Format Raw command, the controller and host system must be in an 8-bit data communication mode. The Format Raw command returns a negative response if the controller is not using an 8-bit communication mode.

To terminate Format Raw, issue a Reset command. The controller may return several bytes of data between the time you issue a Reset command and the controller receives it. You can either scan the data stream for the Reset acknowledgment, or you can ignore the response to the first Reset command and then issue a second Reset after approximately 10 seconds has passed.

Use the Format Raw command for diagnostics. Use Format Tablet for standard touch screen operation.

Response: <SOH>**0**<CR>   Positive response.

After the controller is in Format Raw mode, the controller returns a continuous response in the following format:

<41-byte-packet><41-byte-packet>...<41-byte-packet>...

Table 6 General Packet Format

Byte	Bits 0 – 7
1	b0 – b6: Reserved b7: Synchronization bit (Always 1)
2-6	I component of upper left (UL) corner
7-11	Q component of upper left (UL) corner
12-16	I component of upper right (UR) corner
17-21	Q component of upper right (UR) corner
22-26	I component of lower left (LL) corner
27-31	Q component of lower left (LL) corner
32-36	I component of lower right (LR) corner
37-41	Q component of lower right (LR) corner

Table 7 I/Q Corner Component

Byte	Bits 0 – 7
N	b0 – b6: bits 25-31 of respective I/Q corner data b7: Always 0
N+1	b0 – b6: bits 18-24 of respective I/Q corner data b7: Always 0
N+2	b0 – b6: bits 11-17 of respective I/Q corner data b7: Always 0
N+3	b0 – b6: bits 4-10 of respective I/Q corner data b7: Always 0
N+4	b0 – b3: bits 0-3 of respective I/Q corner data b4 – b7: Always 0

Format Tablet

Syntax: <SOH>**FT**<CR>

Description: Outputs the X/Y touch coordinate data in a 5-byte packet. The packet includes 1 status
byte and 4 bytes of binary X/Y coordinate data. The protocol also establishes the X and Y
coordinate output as 14 binary bits providing a range of 0 to 16,383.

The low order bits $(X3 – X0$ and $Y3 – Y0)$ are not significant in a 1024 by 1024 touch
screen because data can fluctuate with each touch, and therefore may not be completely
accurate.

To use Format Tablet, the controller and host system must be in an 8-bit data
communication mode. The Format Tablet command returns a negative response if the
controller is in 7-bit format.

Response: <SOH>**0**<CR>   Positive response.

With the controller in Format Tablet mode, touching the screen causes the controller to
return a response in the following format:

SXxYy

S   = Status byte, first byte of data. Refer to Table 8.
Xx = X (horizontal) coordinate data; second and third bytes of data.
Yy = Y (vertical) coordinate data; fourth and fifth bytes of data.

Table 8 Data Sequence

Data Sequence		MSB* 7	6	5	Bits 4	3	2	1	LSB* 0
S	Byte 1	1	S6	S5	S4	S3	S2	S1	S0
X	Byte 2	0	X6	X5	X4	X3	X2	X1	X0
x	Byte 3	0	X13	X12	X11	X10	X9	X8	X7
Y	Byte 4	0	Y6	Y5	Y4	Y3	Y2	Y1	Y0
y	Byte 5	0	Y13	Y12	Y11	Y10	Y9	Y8	Y7

*MSB = Most Significant Bit, LSB = Least Significant Bit

Table 9 defines the status bits (Byte 1) for the Format Tablet data.

Table 9 Format Tablet Status Bits

Bit	Description	Values
S0 – S5	Reserved	—
S6	Proximity (touch state)	1 = Touch screen is being touched (a touchdown or a continued touch). 0 = Touch screen is not being touched (a touch liftoff or inactive). When the proximity bit changes from 1 to 0 (touch liftoff), the controller outputs one final set of X/Y coordinate data with the bit equal to 0 and the X/Y coordinate data equal to the last touch point.
S7	Packet synchronization	Always 1.

Mode Stream

Syntax: <SOH>**MS**<CR>

Description: Sends a continuous stream of X/Y coordinate data when you touch the screen. The controller continues to send data as long as you touch the screen. The controller sends the data even if the touch is stationary and unchanging.

The format of the coordinate data depends on the last format command received by the controller.

Response: <SOH>**0**<CR>   Positive response.

Name Command

Syntax: <SOH>**NM**<CR>

Description: This command returns a string of characters to help identify the controller. The string contains the controller model number and current firmware revision number (e.g., EXII-7720 Rev. 3.0) The content and format of this command can change and therefore is not intended for normal customer use.

Null Command

Syntax: <SOH>**Z**<CR>

Description: Queries the controller and waits for a response.

                Use Z to determine that you are communicating with the controller or to make sure that a
                utility is communicating with the controller. Using this command does not affect the
                controller's current operating parameters.

Response: <SOH>**0**<CR>   Positive response.

Output Identity

Syntax: <SOH>**OI**<CR>

Description: Returns a 6-character random identifier, which describes the controller type and the
                firmware version number.

Response: <SOH>*CcXxxx*<CR>

                where:

                Cc   = Two ASCII characters that describe the type of 3M Touch Systems controller.
                Xxxx = Four ASCII characters that indicate a build identifier.

Parameter Set

Syntax: <SOH>**P***pds*[*b*]<CR>

                where:

                P   = Parity type
                          N = No parity
                          O = Odd parity
                          E = Even parity
                D   = Number of data bits (**7** or **8**).
                S   = Number of stop bits (**1** or **2**)
                B   = Communication rate
                          1 = 19200 baud   **4** = 2400 baud
                          2 =   9600 baud   **5** = 1200 baud
                          3 =   4800 baud

Description: Lets you adjust the communication parameters (parity, data bits, and stop bits) of the
                controller. Optionally, you can change the communication rate by appending an
                additional character to the command string. Upon execution of the Parameter Set
                command, the controller automatically stores the new settings, the current operating
                mode, and the current data format in NOVRAM.

                The communication parameters of the host system must match the present settings of the
                controller when the command is given for it to be accepted and the changes implemented.

The process of changing the parameters takes three steps:

- The host system must first communicate with the controller using a matched set of parameters.
- The Parameter Set command is issued with the new parameters to the controller. The new settings take effect immediately.
- The host system must be changed to the new parameters in order to communicate with the controller again.

Examples: <SOH>PN813<CR>   Sets the serial line to no parity, eight data bits, one stop bit, and 4800 baud.

                <SOH>PN81<CR>   Sets the parity, data bits, and stop bits; leaves the baud at its previous value.

Caution: The settings are immediately written to NOVRAM, and all future communication must occur at the new values. It is possible to set the parameters to values that prevent future communication with the controller.

Response: <SOH>**0**<CR>   Positive response.

Reset

Syntax: <SOH>**R**<CR>

Description: Initializes the hardware and the firmware, causes the controller to stop sending data, and recalculates the environmental conditions (for example, stray and offset values). The Reset command also cancels the Format Raw, Calibrate Raw, and Calibrate Extended commands and returns the controller to normal operation.

                3M Touch Systems recommends that the host system issue a Reset command whenever the host system is powered on and is attempting to establish communication with the controller.

                The amount of time needed to execute a Reset command ranges from 225 milliseconds to 800 milliseconds. Therefore, the application program should wait and be sure it receives the command response before issuing another command to the controller following the reset.

Response: <SOH>**0**<CR>   Positive response.

Restore Defaults

Syntax: <SOH>**RD**<CR>

Description: Returns to the factory default operating parameters. The Restore Defaults command
copies the 3M Touch Systems factory default parameters from ROM to the non-volatile
memory (NOVRAM) and then executes a Reset command.

Table 10 lists the factory defaults for the EX II controller. The Restore Defaults
command is useful in situations where inadvertent commands to the controller have
rendered the touch screen inoperative.

Table 10 EX II Factory Default Settings

Operating Parameter	Default
Baud Rate	9600
Serial Communication Settings	N, 8, 1[1]
Data Format	Format Tablet
Operating Mode	Mode Stream
Return to Factory Calibration	Yes

The Restore Defaults command requires approximately 1.8 seconds. Therefore, the
application program should wait the maximum amount of time and be sure it receives the
command response before issuing another command to the controller.

Note: After you issue a Restore Defaults command, you must recalibrate your touch
screen using a 2-point calibration.

Response: <SOH>**0**<CR>   Positive response.

Unit Type Verify

Syntax: <SOH>**UV**<CR

Description: Responds with an 8-character identity string. This string identifies the type of controller
currently attached to the system, lists the features supported by the controller, and outputs
the status of the controller hardware (a self-test code).

Response: Returns an identification code up to 8 ASCII characters in the following format:

<SOH>*TtFfffSs*<CR>

where:
Tt   =   Two ASCII characters that identify the controller type.
QM = Serial controller
Ffff   =   Four ASCII characters that indicate the features supported by the
controller.
R= Indicates a resistive controller

---

[1] The EX II 1720SC controller operates at N, 7, 2.

V= Indicates the serial controller

****= Indicates no additional features configured

Ss = Two ASCII characters that provide status information about the controller hardware. The two characters represent one byte. Each character is in the range 0 to 9 and A to F.

Table 2 defines the meaning of each bit (LED minus 1) in the status byte. Each bit can be set to 1 or 0, where:

1 = Error

0 = No error

00 = No diagnostic errors (normal response)

APPENDIX A

EX II 17xxSC Controller Specifications

This section provides controller specifications such as power requirements, environmental requirements, and cable connectors.

The EX II 17xxSC controller is a compact (3.5 x 2.25 x 0.3 inches), RS-232 serial controller. This controller can be internally mounted in your monitor, or enclosed in a molded plastic case (3.75 x 2.5 x 0.9 inches) and mounted to the back or side of your monitor.

The following figures show the overall dimensions of the EX II 17xxSC controller and the locations of the mounting holes and connectors.
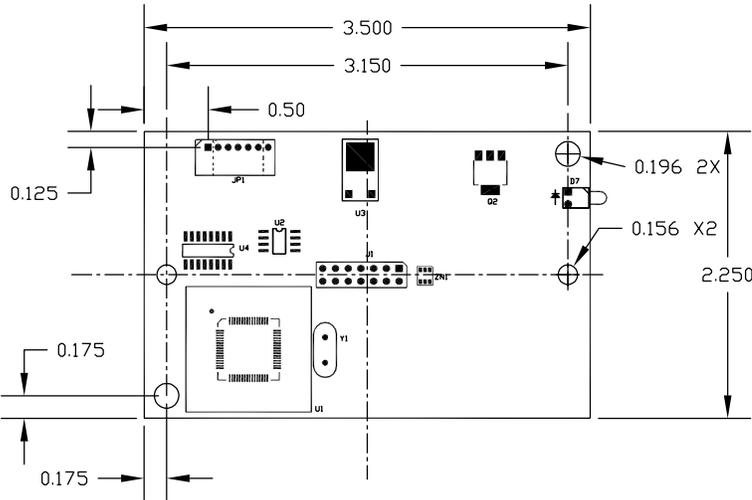

**Figure 3 Uncased EX II 17xxSC Touch Screen Controller**
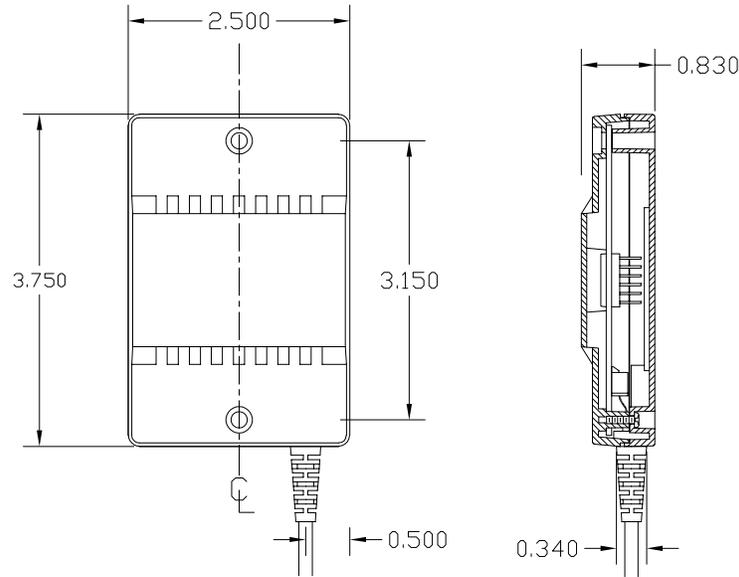
Figure 4 Cased EX II 17xxSC Touch Screen Controller

Technical Specifications

The controller specifications listed below were validated in test systems containing 3M Touch Systems components. These specifications may not be valid if configured with components from suppliers other than 3M Touch Systems. All components in the manufacture of electronic controllers are RoHS Directive compliant (2002/95/EC).

Physical Dimensions

Uncased	3.50 in. x 2.30 in. x 0.45 in.	(88.9 mm x 58.4 mm x 11.4 mm)
Cased	3.75 in. x 2.50 in. x 0.90 in.	(95.3 mm x 63.5 mm x 22.9 mm)

Board Level Functions

Power
- 5 VDC (80 mA typical, 100 mA maximum); $\pm$ 5% regulation 50 mV_{pp} maximum ripple and noise
- 12 VDC (85 mA typical, 100 mA maximum); $\pm$ 10% regulation 50 mV_{pp} maximum ripple and noise

Regulatory Requirements

CE		Compliant
Radiated Emissions – EN 55022:1998	Class B	Compliant
AC Mains Conducted Emissions – EN 55022:1998	Class B	Compliant
Telco Lines Conducted Emissions	N/A	N/A
FCC Class B / CISPR22 Class B	Class B	Compliant
VCCI Class B ITE Emissions (Japan)	Class B	Compliant

AS/NZS 3548:1995/CISPR 22 Class B ITE Emissions (Aus.) Class B			Compliant
RFI – EN 61000-4-3 / ENV 50140		Class A	Compliant
CRFI – EN 61000-4-6	N/A	Cable < 3 meters long	
	Class A	< 80% Screen Area	
	Class B	≥ 80% Screen Area	N/A
EFT (Burst Immunity) – EN 61000-4-4	Class B		Compliant
ESD Susceptibility – IEC 61000-4-2	Class 1		Compliant
Surge – EN 61000-4-5	Class B		Compliant
Harmonics – EN 61000-3-2	Class A		Compliant
Flicker – EN 61000-3-3			Compliant
Power Frequency Magnetic Field – EN 61000-4-8	Class A		Compliant
Voltage Dips – EN 61000-4-11	Class B	< 5% V	
	Class C	< 70% VCompliant	
Voltage Interruptions – EN 61000-4-11	Class C		Compliant
UL/cUL			Compliant

Ambient Operating and Storage Environmental Conditions

All Humidity is Non-Condensing

Operating Temperature Range   - 40 °C to +70 °C

Operating Humidity Range < 36° C 0-95% RH

                                        ≥ 36 °C

Storage Temperature Range   - 50 °C to +85 °C

Storage Humidity Range   < 36°C 0-80% RH

                                        ≥ 36 °C

Performance and Reliability

Minimum Touch Duration   As low as 3 msec.

Touch Resolution – (Maximum addressable coordinates generated by the controller) 16K x 16K

ESD Susceptibility -

±8 kV Contact Discharge[*] – Class 2 per section 9 of IEC 61000-4-2   Compliant

   1 false touch allowed

±27 kV Air Discharge[*] – Class 1 per section 9 of IEC 61000-4-2   Compliant

        Normal Operation – No false touches

* ESD discharges to a 3M Touch Systems touch screen connected to the controller

MTBF (by MIL Std. 217F Calculation)> 740,000 Hours

Touch System Parameters

Accuracy vs. Dynamic Temperature Change   Maintains 1% Accuracy

(tested at 0 deg. C to 60 deg. C with a 0.5 deg. C/minute temperature ramp)

Touch Screen Compatibility   3M Touch Systems Capacitive Touch Screens

Communications Protocol   Serial RS 232

Female Connector on the Touch Screen Cable

The touch screen cable has a 12-pin (2 x 6) dual row female connector that plugs into the controller. Table 11 describes the pins on this connector. The touch screen connector always exits towards the serial cable.

Table 11 Touch Screen Cable Connector for EX II 17xxSC Controllers

Pin	Wire Color	Description
1	———	NOVRAM interface
2	———	NOVRAM interface
3	———	NOVRAM interface
4	———	+5 VDC
5	Gray	Power supply ground
6	Green	Chassis (earth) ground
7	Orange	+12V input
8	Brown Cable shield/drain wire	Connects to the flex tail shield, which must not be grounded because the EX II 17xxSC drives the flex tail shield with an AC waveform.
9	White	Upper right (UR) corner
10	Red	Lower right (LR) corner
11	Black	Upper left (UL) corner
12	Blue	Lower left (LL) corner

Communication Connector

All EX II 17xxSC controllers have an attached RS-232 communication cable with a 9-pin D female connector. Table 12 describes the pins for this cable, which connects to a serial communication (COM) port on the PC. A 9-pin to 25-pin adapter is available.

Table 12 COM Connector for *EX II 1700SC* Controllers

| 9-pin D	7-pin Molex	Wire Color	Description
1	No connection	———	Data Carrier Detect (DCD). Connected to DTR and DSR.
2	2	Brown	Transmit Data (TXD). Pin 2 is the controller's output to the host.
3	3	Red	Receive Data (RXD). Pin 3 is the controller's receive from the host.
4	No connection	———	Data Terminal Ready (DTR). Connected to DSR and DCD.
5	5	Blue	Power supply ground.
6	No connection	———	Data Set Ready (DSR). Connected to DTR and DCD.
7	1	Black	Request To Send (RTS). Connected to CTS.
8	4	Green	Clear To Send (CTS). Connected to RTS.
9	Not used		
Sleeve	6	White	DC power jack (+5 VDC).
Pin	7	———	Cable shield connected to ground. DC power jack (ground).
Shell	7	———	Chassis (earth) ground.

APPENDIX B

EX II 7720SC Controller Specifications

This section provides controller specifications such as power requirements, environmental requirements, and cable connectors. The EX II 7720SC controller is a compact RS-232 serial controller. This controller can be internally mounted in your monitor.

The following figures show the overall dimensions of the EX II 7720SC controller and the locations of the mounting holes and connectors.

Figure 4 EX II 7720SC Touch Screen Controller
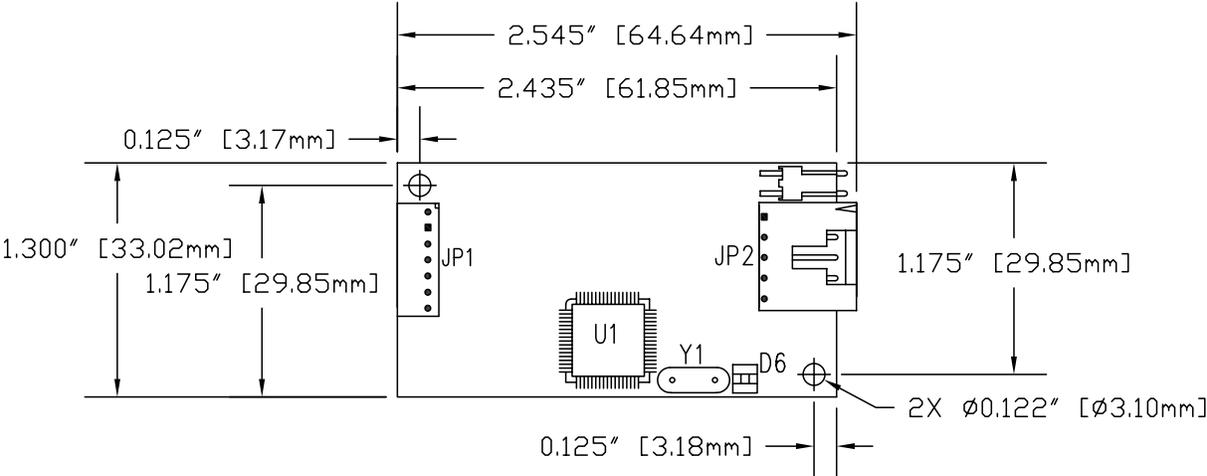
Touch Screen Cable Connections

The touch screen cable has a 5-pin single row locking female connector that plugs into the controller. Table 13 describes the pins on this connector.

Table 13 Touch Screen Cable Connector for EX II 7720SC Controllers

Pin	Wire Color	Description
3	Cable shield/drain wire	Connects to the flex tail shield, which must *not* be grounded because the EX II 7720SC drives the flex tail shield with an AC waveform.
1		Upper left (UL) corner
2		Upper right (UR) corner
4		Lower right (LR) corner
5		Lower left (LL) corner

Communication Connector

You will need a method of establishing the serial data communication between the controller and your system. You can build your own or purchase the standard 3M Touch Systems RS-232 serial cable (P/N 7310101). Table 14 describes the pins for this cable, which connects to a serial communication (COM) port on the PC.

Table 14 COM Connector for EX II 7720SC Controllers

9-pin D	7-pin Molex	Wire Color	Description
1	No connection	———	Data Carrier Detect (DCD). Connected to DTR and DSR.
2	2	Brown	Transmit Data (TXD). Pin 2 is the controller's output to the host.
3	3	Red	Receive Data (RXD). Pin 3 is the controller's receive from the host.
4	No connection	———	Data Terminal Ready (DTR). Connected to DSR and DCD.
5	5	Blue	Power supply ground.
6	No connection	———	Data Set Ready (DSR). Connected to DTR and DCD.
7	1	Black	Request To Send (RTS). Connected to CTS.
8	4	Green	Clear To Send (CTS). Connected to RTS.
9	Not used		
Sleeve	6	White	DC power jack (+5 VDC).
Pin	7	Shield	Cable shield connected to ground. DC power jack (ground).
Shell	7	———	Chassis (earth) ground.

Technical Specifications

The controller specifications listed below were validated in test systems containing 3M Touch Systems components. These specifications may not be valid if configured with components from suppliers other than 3M Touch Systems. All components in the manufacture of electronic controllers are RoHS Directive compliant (2002/95/EC).

Physical Dimensions

Uncased	2.55 in. x 1.30 in. x 0.45 in.	(65.0 mm x 33.0 mm x 11.4 mm)

Board Level Functions

Power   5 to 12 VDC (85 mA typical, 110 mA maximum); ± 5% regulation 50 mV$_{pp}$ maximum ripple and noise

Regulatory Requirements

CE		Compliant
Radiated Emissions – EN 55022:1998	Class B	Compliant
AC Mains Conducted Emissions – EN 55022:1998	Class B	Compliant
Telco Lines Conducted Emissions	N/A	N/A
FCC Class B / CISPR22 Class B	Class B	Compliant
VCCI Class B ITE Emissions (Japan)	Class B	Compliant
AS/NZS 3548:1995/CISPR 22 Class B ITE Emissions (Aus.)	Class B	Compliant
RFI – EN 61000-4-3 / ENV 50140	Class A	Compliant
CRFI – EN 61000-4-6	N/A	Cable < 3 meters long
	Class A	< 80% Screen Area
	Class B	≥ 80% Screen Area N/A
EFT (Burst Immunity) – EN 61000-4-4	Class B	Compliant
ESD Susceptibility – IEC 61000-4-2	Class 1	Compliant
Surge – EN 61000-4-5	Class B	Compliant
Harmonics – EN 61000-3-2	Class A	Compliant
Flicker – EN 61000-3-3		Compliant
Power Frequency Magnetic Field – EN 61000-4-8	Class A	Compliant
Voltage Dips – EN 61000-4-11	Class B	< 5% V
	Class C	< 70% V Compliant
Voltage Interruptions – EN 61000-4-11	Class C	Compliant
UL/cUL		Compliant

Ambient Operating and Storage Environmental Conditions

All Humidity is Non-Condensing	
Operating Temperature Range	- 40 °C to +70 °C
Operating Humidity Range	<36° C 0-95% RH
	≥ 36 °C
Storage Temperature Range	- 50 °C to +85 °C
Storage Humidity Range	< 36°C 0-80% RH

$\geq 36\ °C$

Performance and Reliability

Minimum Touch Duration   As low as 3 msec.

Touch Resolution – (Maximum addressable coordinates generated by the controller) 16K x 16K

ESD Susceptibility -

±8 kV Contact Discharge[*] – Class 2 per section 9 of IEC 61000-4-2   Compliant

   1 false touch allowed

±27 kV Air Discharge[*] – Class 1 per section 9 of IEC 61000-4-2   Compliant

   Normal Operation – No false touches

* ESD discharges to a 3M Touch Systems touch screen connected to the controller

MTBF (by MIL Std. 217F Calculation)> 700,000 Hours

Touch System Parameters

Accuracy vs. Dynamic Temperature Change   Maintains 1% Accuracy

(tested at 0 deg. C to 60 deg. C with a 0.5 deg. C/minute temperature ramp)

Touch Screen Compatibility   3M Touch Systems Capacitive Touch Screens

Communications Protocol   Serial RS 232