MT3000
Capacitive Controller

Reference Guide

MicroTouch®

Document Title*: MT3000 Capacitive Controller Reference Guide*
Document Number: 19-236, Version 2.0

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About This Manual

This reference manual, directed to developers of touchscreen systems, provides installation and configuration information for the MicroTouch MT3000 capacitive touchscreen controller.

This document includes information on integrating the MT3000 controller into your design, communicating with the controller, installing the TouchWare user interface software, and troubleshooting setup problems. It also includes a complete description of the firmware commands, a guide to interpreting status LED conditions, and a table of controller specifications.

MicroTouch Support Services

MicroTouch provides extensive support services through our technical support organization. You can contact technical support by telephone, fax, or electronic mail, or obtain updated information and drivers on the World Wide Web.

MicroTouch Technical Support

Technical Support by telephone is available:

- 24 hours a day, Monday through Friday (excluding holidays)
- 9:00 a.m. to 5:00 p.m. Eastern Standard Time, Saturday and Sunday (excluding holidays)

The Technical Support Hot Line number is: 978-659-9200

Whenever you contact Technical Support, please be ready to provide the following information:

- Part numbers of your controller and sensor
- Version number of your MicroTouch TouchWare
- Make and model of your personal computer
- Name and version number of your operating system
- Type of mouse connected to your system
- List of other peripherals connected to your system
- List of application software installed on your system

You can also submit a written description of the problem to MicroTouch Technical Support at any time by sending a fax or electronic mail.

- Technical Support Fax: 978-659-9400
- Technical Support E-Mail: support@microtouch.com

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http://www.microtouch.com

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C H A P T E R 1

Integrating the MT3000 Controller

The MicroTouch MT3000 controller offers an economical, high performance solution for capacitive touch applications. Its compact design makes for easy integration into flat panel displays and mobile devices.

The MT3000 controller works with all the leading operating systems and is backed by the MicroTouch guarantee of worldwide support.

This chapter covers the following MT3000 controller specifications:

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

Overview of the MT3000 Touchscreen Controller

The MT3000 touchscreen controller and touchscreen are supplied as a matched set. A 25-point linearization procedure has been performed to determine the physical properties of the screen, and the data is stored in the NovRAM of the controller that ships with the screen.

The controller and touchscreen are shipped mated by the flex cable with a serialized label on the sensor, the controller, and over the connector to identify them as a matched set. If the connection needs to be broken during the integration process, the components can be matched again by serial number.

The MT3000 is a compact controller with a standard RS-232 serial interface. It measures 1.3 x 2.4 inches with a total height profile of 0.4 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 MT3000 has a touchscreen connector, a serial cable connector, and a power connector. Refer to Figure 1 for connector locations and to Figure 2 for the overall dimensions.

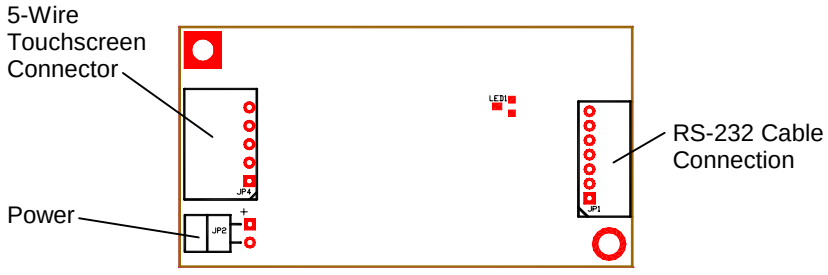


Figure 1 MT3000 Connector Locations

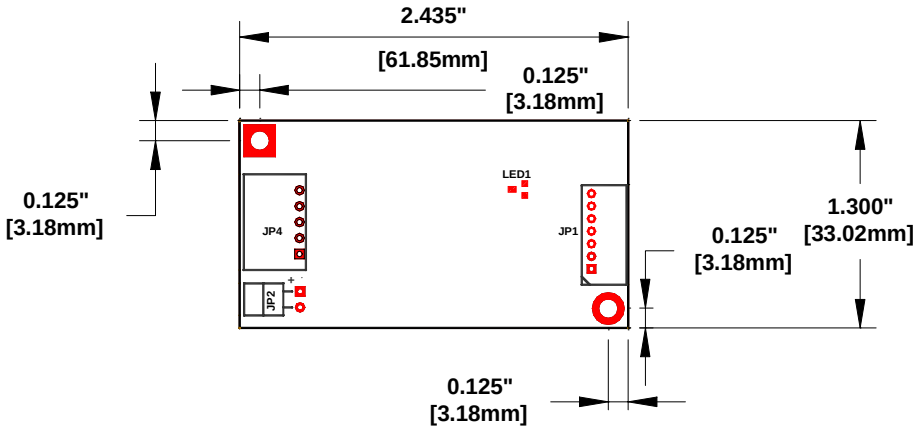


Figure 2 MT3000 Overall Dimensions

To properly integrate and test the MT3000 controller, you need the following items:

- A MicroTouch capacitive touchscreen and MT3000, mated as a linearized set. The touchscreens are available in a variety of sizes.
- A method of establishing the serial data communication between the controller and your system. You can use the standard MicroTouch RS-232 serial cable (P/N 7310101), or you can build your own cable.
- A method of supplying power to the controller. There are several options available including a cable connection to the 0.2 inch power connector (JP2) or supplying power through the serial cable.
- A touchscreen driver with a 2–point calibration routine available to the end user.

Note: You can use TouchWare, which includes the touchscreen device driver and utilities software.

Mounting the MT3000 Controller

You can easily mount the MT3000 controller using standard 4-40 machine screws and washers through the two existing mounting holes. All the components and the connectors are mounted on the top side of the PC board to reduce the overall profile and to minimize clearance requirements. Figure 3 shows the connector locations and identifies which of the mounting holes requires grounding.

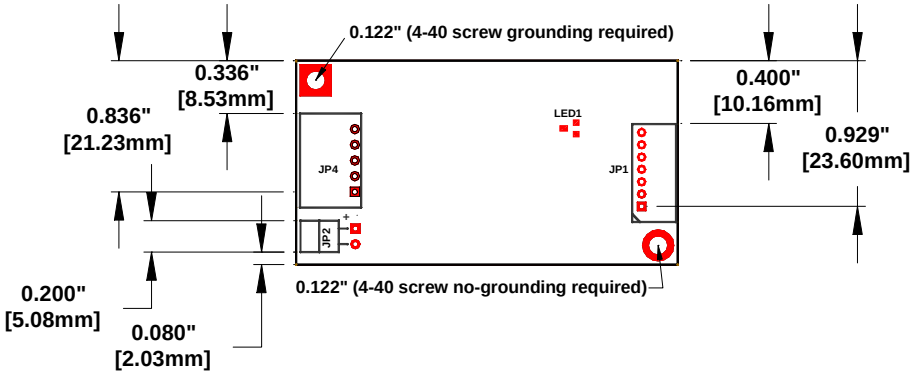


Figure 3 Connector Locations and Mounting Holes

When you mount the MT3000 controller, remember the following important rules:

- Always mount the controller internally. You can orient the components up or down, but turn the board so that the flex cable is not twisted 180°. If possible, mount the controller with the component side visible so you can monitor the status of the LED.
- Ground the controller. Mount it to a metal chassis surface if possible. If you must mount it to a non-metal surface, be sure to attach a ground wire as described in the last paragraph of this section.
- Maintain a clearance of at least 1/8 inch from the highest projection on the controller to the chassis.
- Try to find a mounting area that is away from heat sources and EMI noise generators such as power supplies and backlight (or CRT) drive electronics.

- Route the touchscreen flex cable around the display and plug it into the controller connector (JP4). The cable is supplied mated to the controller and taped over with a part number sticker. If you must disconnect the cable during assembly, ensure that the controller is re-mated to the sensor with the same serial number.

To avoid malfunctions or damage due to electrostatic discharge (ESD), make sure you properly ground the controller through the mounting hole shown in Figure 3. Ideally, you should mount the controller to a metal chassis surface that is properly grounded using metal screws and standoffs.

If you use plastic screws, or if you mount the controller to a non-metal surface, you must connect the mounting hole *nearest the touchscreen connector* (JP4) to a grounded location. See Figure 3. Be sure to route the wire to the nearest grounded location, and keep the wire dimensions as short and as thick as possible. MicroTouch recommends that you use braided ground cable with a flat lug crimped at both ends.

Connecting the Touchscreen Cable

The touchscreen connector (JP4) is a 5-pin AMP 103634-5, locking right angle male connector with pins on 0.1 inch centers.

The MT3000 controller supports exiting the flex cable in any direction from the touchscreen– from the top, bottom, left or right. The standard configuration is with the flex cable exiting from the right side of the sensor, (3 o'clock position) when viewed from the front.

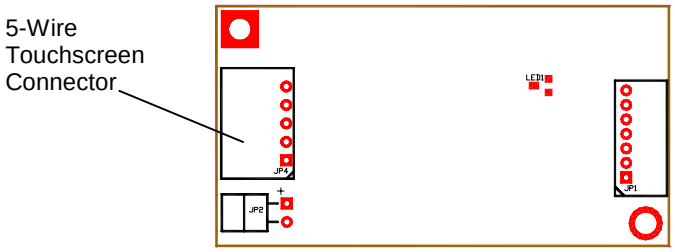


Figure 4 Touchscreen Connector

If you exit from another direction, the controller firmware automatically determines the pinout configuration when you calibrate the touchscreen with TouchWare or your equivalent software. This permits flexibility in orienting the sensor and in mounting the controller to conform to your hardware requirements.

The automatic pinout configuration feature resides in the controller and is independent of the driver you are using.

MicroTouch can provide software for performing a 25–point linearization procedure by the customer, although this is not required with a mated controller and sensor.

Caution: If you are equipped to perform a 25–point linearization and decide to do so, you must orient the sensor with the tail exiting to the right during the procedure. After linearization, you can re-orient the screen as required by your OEM design.

Establishing the Data Connection

The MT3000 controller requires that an RS-232 serial communication cable be attached to connector JP1.

You can use a standard MicroTouch RS-232 cable (P/N 7310101). You may need a 9-pin to 25-pin adapter if the only available communication (COM) port on your PC has 25 pins. One end of this cable plugs into the RS-232 connector (JP1) on the MT3000 controller (Figure 5). The other end, which has a 9-pin D connector, plugs into a COM port on your PC, directly or through the adapter. Table 1 describes the interconnections for the MicroTouch RS-232 cable.

For OEM designs, you can build your own cable using a 7-pin Molex connector (51004-0700) to mate to the JP1 connector, and design your own connector or hard-wired configuration at the other end.

As an option, MicroTouch can supply a controller with the RS232 transceiver removed and bypassed to allow a direct serial 5V logic interface.

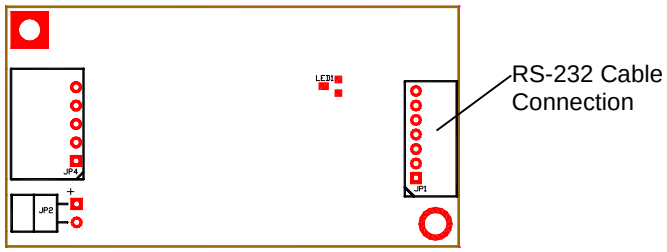


Figure 5 Data Connection

Table 1 COM Cable for MT3000 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 DSR	—	None	
7	Request to Send (RTS)		Black	1	Request to Send (RTS)
8	Clear to Send (CTS)		Green	4	Clear to Send (CTS)
Sleeve			White	6	DC power jack (+5 VDC)
Pin			—	7	Cable shield connected to ground. DC power jack ground
Shell			—	7	Chassis (earth) ground

Supplying Power to the Controller

You must supply the MT3000 controller with power. You can use internal power (that is, tap power from inside the monitor or PC) or external power.

Note: However you supply power, the source must deliver 70 mA typical, with a maximum ripple and noise of 50mV peak-to-peak.

You can supply power to the MT3000 controller using any of the following methods:

- Internal power into JP2 using +5 volts DC at JP2, pin 1 and power supply ground at JP2, pin 2
- Internal power through a custom serial cable configuration
- External power (+5 volts DC) from a wall-mount power supply
- External power (+5 volts DC) from a keyboard power tap cable

Caution: Do not supply both internal power and external power to the controller. Power from two sources could damage one or both of the power supplies.

Using an Internal Power Supply (+5V) to JP2

You can power the MT3000 at JP2 using a +5 volt DC power source within the system.

▶ To provide power directly to the controller using JP2:

1. Obtain a locking, mating connector for JP2 (Molex housing 22-01-3027 with 08-50-0114 contacts).
2. Attach power and ground to the connector (Pin 1: +5V , Pin 2: Ground). The connector is keyed. Pin 1 has continuity to the trace marked + on the board.
3. Insert locking connector into JP2.

Using a Custom Serial Cable Design

▶ When creating a custom serial cable connection (refer to "Establishing the Data Connection"), you can provide power to the controller through the mating Molex connector:

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

Using an External Wall-Mount Power Supply

If you are using a standard MicroTouch RS-232 serial cable (P/N 7310101), you can use either a 120 volt wall-mount power supply (P/N 19-408) or a 220 volt wall-mount power supply (P/N 19-409).

▶ To connect an external wall-mount power supply:

1. Remove the plastic plug covering the power jack of the 9-pin D connector on the serial cable.
2. Connect a DC power plug to the power jack built into the 9-pin D connector.
3. Plug the power supply into a grounded outlet. The power plug supplies both +5V and ground.

Using a Keyboard Power Tap Cable

If you are using a standard MicroTouch RS-232 serial cable, you can use either a 5-pin IBM AT compatible keyboard power tap cable (MicroTouch P/N 19-356) or a 6-pin IBM PS/2 compatible keyboard power tap cable (P/N 19-357).

▶ To connect a keyboard power tap cable:

1. Disconnect the keyboard cable from the back of your computer.
2. Plug the keyboard cable into the power tap cable.
3. Plug the power tap cable into the keyboard socket on the back of your computer.
4. Remove the plastic plug covering the power jack of the 9-pin D connector on the serial cable.

5. Connect the DC plug from the power tap cable to the jack built into the 9-pin D connector.

Mounting the Touchscreen

There are several methods for mounting the touchscreen depending on your application (CRT displays, LCD modules, flat panel displays, each in a variety of sizes). If you need instructions or recommendations from MicroTouch on how to incorporate a touchscreen into your OEM design, you can order the publication Touchscreen Kits Installation Guide (Document Number 19-215).

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.

The MT3000 controller has a light emitting diode (LED) on the component side of the board that indicates the status of the touchscreen unit.

If it was necessary for you to mount the controller component side down, you can determine the status of the LED from its reflected light off the mounting surface.

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. See the next section for other indications.

Status Light (LED) Diagnostics

MicroTouch controllers are highly reliable units, however there may be occasions when the controller does not perform exactly as you expect. The MT3000 controller provides diagnostic feedback with an LED as shown in Figure 6.

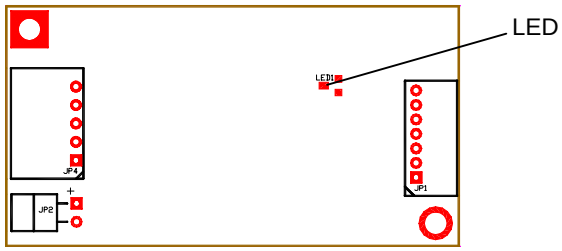


Figure 6 Diagnostic LED (component side)

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 sensor. When you touch the sensor, the LED becomes bright.

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 MT3000 Controller

LED Flashes (per 10 seconds)	**Self-Test Bit** (UV Command)	**Error Description**
1	0	Reserved for future assignment.
2	1	ROM error. Firmware checksum verification error.
3	2	Pulse Width Modulation (PWM) error. Unable to establish PWM operating range at power-up.
4	3	Block 1 NovRAM error. The operating parameters in the controller NovRAM are invalid. Using defaults.
5	4	HDW error. The controller hardware failed (unable to initialize or configure gate array). Non-recoverable error.
6	5	Reserved for future assignment.
7	6	Reserved for future assignment.
8	7	Block 2 NovRAM error. The linearization data in the controller NovRAM is invalid.

Note: Some errors are non-recoverable, meaning that normal touchscreen operation cannot occur. Recoverable errors cause the controller to revert to default values.

What's Next?

You have successfully installed the MT3000 controller and connected the touchscreen to your computer. You are now ready to complete the following tasks:

- Install TouchWare or equivalent software for your touchscreen
- Use the software to calibrate the touchscreen

Installing and Using TouchWare

TouchWare includes the software driver that lets your touchscreen work with your computer. MicroTouch has touchscreen drivers for many operating systems, including Windows 3.1*x*, Windows 95, Windows 98, Windows NT, MS-DOS, and OS-2. Be sure to install the touchscreen software for the operating system you are using.

TouchWare also includes a control panel for setting user touchscreen preferences and diagnostic utilities for isolating problems. For more information on installing and using the touchscreen control panel, refer to the *TouchWare User's Guide*.

Calibrating the Touchscreen

Calibration aligns the touchscreen with the underlying video by defining the dimensions of the image area on the touchscreen, determining the edges of the screen's image, and locating the center of the touchscreen. You must calibrate the touchscreen and test the calibration to ensure its successful operation.

See the *TouchWare User's Guide* for instructions on calibrating your touchscreen.

C H A P T E R 2

Communicating with the MT3000 Controller

This chapter discusses the fundamentals of communicating with the MT3000 controller. The firmware commands, which are usually issued by a driver or utility program on the host system, control the operation of the touchscreen 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

This section describes the default settings for the MT3000 controller.

Communication Parameters

The default operation of the MT3000 controller is N, 7, 2 (no parity, 7 data bits, and 2 stop bits) at 9600 baud. It also can be programmed to work with even/odd parity, 8 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 Decimal is the default format for the MT3000 controller operating at 7 data bits. Format Decimal is provided for compatibility with older designs, *however* MicroTouch recommends that you use Format Tablet for current development because:

- Format Tablet uses only 5 bytes per point and provides the most rapid response time to a touch.
- It is the most efficient and most compact data format, sending approximately 192 packets per second at 9600 baud.
- Format Tablet includes a status byte. The status byte contains information on whether the X/Y coordinate is generated from a touchdown, a touch continuation (when the finger is resting on the screen), or a touch liftoff.
- Format Tablet is supported by all current MicroTouch touchscreen controllers.
- It is the standard for current MicroTouch product development and is the format used by all touchscreen drivers written by MicroTouch.

To use Format Tablet, you must reinitialize the controller to N, 8, 1. See the initialization instructions in the following section: Communicating With the Controller.

Refer also to the Format Tablet command in the firmware reference section that follows.

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 MT3000 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 sensor.

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

MicroTouch recommends that the touchscreen generate an interrupt as each byte in the data stream arrives. Because touchdown and liftoff events are specially coded, your software always knows exactly what the user is doing, provided that 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 this section are those that Microtouch currently uses for development. MicroTouch recommends that you use these commands for MT3000 controller development, however if you need additional commands for compatibility with older designs, you can find the complete command set on the TouchWare CD. Refer to Table 5 in this document and the respective commands in the Touch Controllers Reference Guide on the TouchWare CD.

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 MicroTouch's 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 MicroTouch's 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 received. 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 MT3000 controller for new development, send the sequence of commands shown in Table 3. For controller responses to each of these commands, see the firmware reference section at the end of this document.

Table 3 MT3000 Initialization Command String

Sequence #	Command	Format
1	Reset	<SOH>**R**<CR>
2	AutoBaud Disable	<SOH>**AD**<CR>
3	Parameter Set	<SOH>**PN812**<CR>
4	Format Tablet	<SOH>**FT**<CR>
5	Mode Stream	<SOH>**MS**<CR>
6	Parameter Lock	<SOH>**PL**<CR>

Summary of 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 touchscreen users do *not* have to use firmware commands to use their touch systems. For example, users can use TouchWare or equivalent software to calibrate the touchscreen 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 alters the performance of your touchscreen and can render it inoperable. You should be aware of the results before executing any firmware commands.

To optimize the performance of the MT3000 touchscreen controller and simplify the development of custom drivers, MicroTouch recommends you use the commands listed in Table 4 for current development. Using these commands ensures compatibility with current MicroTouch controllers.

Table 5 lists the additional commands you can find in the Touch Controllers Reference Guide located on the TouchWare CD.

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

Table 4 Firmware Commands for MT3000 Development

Command Name	Code	Description
AutoBaud Disable	AD	Turns OFF the automatic baud rate detection feature.
AutoBaud Enable	AE	Turns ON the automatic baud rate detection feature.
Calibrate Extended	CX	Initiates an interactive, two-point calibration.
Calibrate Raw	CR	Collects the raw X and Y coordinates prior to normal scaling, linearization, and filtering process.
Format Decimal	FD	Outputs the X/Y touch coordinate data as a 9-byte packet in a decimal format. Default for MT3000.
Format Raw	FR	Returns the signal level (amount of touch) of each of the four touchscreen corners in digital format.
Format Tablet	FT	Outputs the X/Y touch coordinate data in a five-byte packet. Preferred for current development.
Mode Status	MT	Sends a touch status byte preceding the X/Y coordinate data sent in response to a Format Decimal or Format Hexadecimal command.
Mode Stream	MS	Sends a continuous stream of X/Y coordinate data when you touch the screen.
Null Command	Z	Queries the controller and waits for a response.
Output Identity	OI	Identifies the controller type and the firmware version.
Parameter Lock	PL	Writes and stores the data format and operating mode of the controller into non-volatile memory (NovRAM).
Parameter Set	P*pds*[*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.
Unit Type Verify	UV	Identifies the touchscreen controller on your system.

Table 5 Additional Commands for Prior Design Compatibility

Command Name	Code	Description
Calibrate Interactive	CI	Initiates an interactive, two-point edge calibration.
Calibrate New	CN	Initiates an interactive, two-point *edge* calibration.
Filter Number	FN*nn*	Sets the number of X/Y values that the controller uses to generate an accurate coordinate after the touchscreen receives an initial touch.
Format Binary [Stream]	FB[S]	Outputs the X/Y touch coordinate data as a five byte packet in a binary (or binary stream) format.
Format Hexadecimal	FH	Outputs the X/Y touch coordinate data as a nine byte packet in a hexadecimal format.
Format Zone	FZ	Outputs the X/Y touch coordinate data as a five byte packet and indicates whether the touch occurred inside or outside the calibration area.
Frequency Adjust	<Ctrl> C F*nn*	Lets you change the operating frequency of the sensor drive signal (DRVOUT) that is fed from the controller to the sensor and drives the sensor output.
Get Parameter Block	GP	Returns all power-up and run time parameters used by the controller.
Mode Down/Up	MDU	Send one X/Y coordinate for each touchdown and each liftoff on the touchscreen.
Mode Inactive	MI	Sends no X/Y coordinates when the screen is touched.
Mode Point	MP	Sends a single X/Y coordinate for each touchdown.
Mode Polled	MQ	Sends an X/Y coordinate only when requested by the host system and only when a user touches the screen.
Output Status	OS	Causes the controller to report the status of its hardware.

Command Name	Code	Description
Set Parameter Block	SP	Sets all power-up and run time parameters used by the controller.
Sensitivity Set	SE*n*	Changes the sensitivity of the touchscreen.

AutoBaud Disable

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

Description: Turns off the automatic baud rate detection feature.

When you disable AutoBaud, the controller maintains the communication rate currently set in non-volatile RAM (NovRAM). The controller continues to use this communication rate until you change it with either the Parameter Set command or the AutoBaud Enable command.

AutoBaud Enable is the factory default for some touchscreen controllers. However, because this automatic feature is limited to the communication rate, MicroTouch recommends that you issue an AutoBaud Disable command to turn off the AutoBaud feature. After you disable AutoBaud, send a Parameter Set command to change the communication parameters (parity, number of data bits, number of stop bits, and baud rate).

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

AutoBaud Enable

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

Description: Turns on the automatic baud rate detection feature.

When you enable AutoBaud, the controller changes its communication rate to that of the next command from the host system. Thereafter, the controller sets its communication rate to the first command received from the host system after powering on the unit.

Although the AutoBaud Enable command sets the communication rate, it does not automatically set the parity, the number of data bits, and the number of stop bits. The controller cannot communicate with the host system unless all communication parameters are the same.

AutoBaud Enable is the factory default for some touchscreen controllers. However, because this automatic feature is limited to the communication rate, MicroTouch recommends that you issue an AutoBaud Disable command to turn off the AutoBaud feature. After you disable AutoBaud, send a Parameter Set command to change the communication parameters (parity, number of data bits, number of stop bits, and baud rate).

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

Calibrate Extended

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

Description: Initiates an interactive, two-point calibration.

During the calibration process, you define the active area of the touchscreen 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.

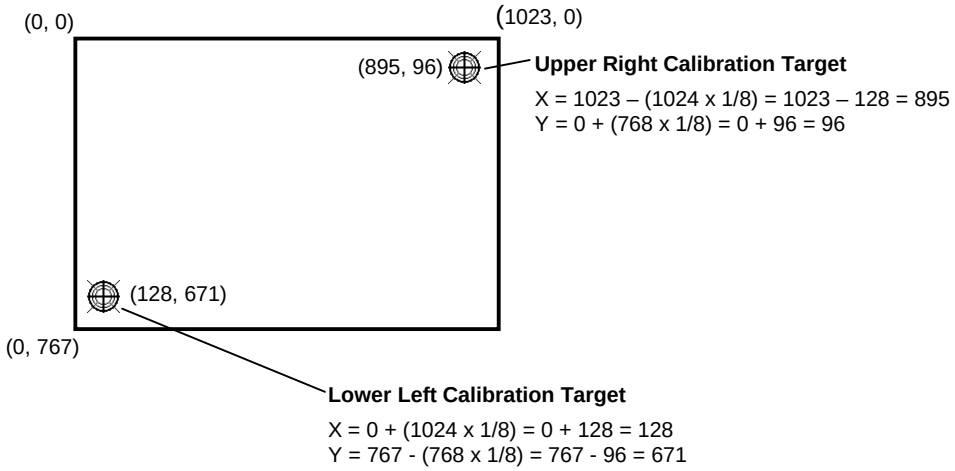
Determining Target Areas

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 (0,767) and the second calibration target inward from the upper right corner (1023,0). The following illustration shows how the calibration targets are calculated.



Note: The example in this discussion is in *video* terms, with the origin (0, 0) in the upper left corner of the screen. Examples from the *controller's* perspective, however, place the origin at the lower left corner of the screen.

You can adjust the default calibration points using the Set Parameter Block command. For more information, contact MicroTouch Technical Support.

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, users can touch the screen, move their finger to the target, hold for one second, and then lift off their finger. 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 touchscreen any time the video display changes or gets repositioned.
- You can cancel a calibration at any time by issuing a Reset command.

Calibrate Extended Procedure

▶ To use the CX command:

1. Enter the Calibrate Extended (CX) command.

   The controller sends an 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, try touching the screen 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>. If you receive a negative response, try touching the screen again.

Touching the two valid calibration points results in a successful calibration. If either calibration point is invalid, the calibration fails. The MT3000 controller restores the factory default calibration if the Calibrate Extended failed.

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, try touching the target area 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 prior to the normal scaling, linearization, and filtering processes. The controller sends the coordinates whenever a touch is detected and continues to send a stream of data as long as a finger remains in contact with the touchscreen.

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.

MicroTouch uses the Calibrate Raw command during manufacturing and testing, and recommends you use this command for diagnostics when you want raw data. Use the Calibrate Extended command for standard interactive, two-point calibration.

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

After the controller is in Calibrate Raw mode, touching the screen causes the controller to return a response in the following format:

SXxYy

where:

S = Status byte; first byte of data. Refer to Table 6.

Xx = X (horizontal) coordinate data; second and third bytes of data

Yy = Y (vertical) coordinate data; fourth and fifth bytes of data.

	MSB*				Bits			LSB*
Data Sequence	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**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 6 describes the meaning of the bits in the status byte (Byte 1).

Table 6. Calibrate Raw Status Bits

Bit	Description	Values
S0 – S5	Reserved	—
S6	Proximity (touch state)	1 = Touchscreen is being touched (a touchdown or a continued touch). 0 = Touchscreen 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.

Format Decimal

Note: *MicroTouch provides this command for compatibility with older touchscreen controllers. To ensure compatibility with all existing and future MicroTouch controllers, do not use this command when developing your touch drivers and applications.*

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

Description: Outputs the X/Y touch coordinate data as a 9-byte packet in a decimal format. The packet includes the following 9 bytes:

- 1 header byte
- 3 bytes of X coordinate data
- An ASCII comma
- 3 bytes of Y coordinate data
- A terminator byte

Data is sent as a string of decimal ASCII characters (0 to 9). The output range for both the X and Y data is 000 to 999.

When activated, Format Decimal resets the Mode Status to report the standard <SOH> header. If the last format command was Format Binary, then Format Decimal sets the output mode to Mode Stream.

Format Decimal, which sends approximately 106 packets per second at 9600 baud, is not as efficient as Format Tablet. Format Decimal does not contain touchdown and liftoff information unless you also use the Mode Status command.

Format Hexadecimal is the same as Format Decimal except the controller returns the X/Y coordinates in hexadecimal instead of decimal.

Format Tablet, which sends approximately 192 packets per second at 9600 baud, is the most efficient packet. It also contains touchdown and liftoff information. Format Tablet is the standard for MicroTouch product development.

Response: <SOH>**0**<CR>

After the controller is in Format Decimal mode, touching the screen causes the controller to return a response in the following format:

<HDR>*Xxx*,*Yyy*<CR>

where:

<HDR>	=	Start-of-header (Hex 01). If you send a Mode Status command after a Format Decimal command, this first byte becomes a status byte. The status byte defines whether the X/Y coordinates are generated from a touchdown, a touch continuation (when the finger is resting on the screen), or a touch liftoff. For more details, refer to the Mode Status command later in this chapter.
Xxx	=	X (horizontal) coordinate data. Total of 3 bytes.
	=	ASCII comma that separates the X and Y coordinate data.
Yyy	=	Y (vertical) coordinate data. Total of 3 bytes.
<CR>	=	Terminator (Hex 0D).

Format Raw

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

Description: Returns the signal level (amount of touch) of each of the four touchscreen corners in digital format. The returned values are not corrected for offset and stray values. However, you can obtain the offset and stray values using the Get Parameter Block command. For more information, refer to the description of the Get Parameter Block command later in this chapter.

The Format Raw data is a 7-byte packet that includes 1 status byte and 6 bytes of binary corner data. The data format for the packet is fixed in order to provide the most efficient transfer of data. The first byte of each packet always has its high bit (Bit 7) set to provide synchronization with the host system. Each corner value is 10 bits, which are delivered in 2 bytes, and has a range of 0 to 1023.

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 touchscreen operation.

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

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

<7-byte-packet><7-byte-packet>...<7-byte-packet>...

Byte	Bits 0 – 7	
1	b0 – b3:	Drive level (amount of signal sent from controller)
	b4 – b6:	Reserved
	b7:	Synchronization bit (Always 1)
2	b0 – b2:	3 most significant bits of upper left (UL) corner
	b3:	Always 0
	b4 – b6:	3 most significant bits of lower left (LL) corner
	b7:	Always 0
3	b0 – b2:	3 most significant bits of lower right (LR) corner
	b3:	Always 0
	b4 – b6:	3 most significant bits of upper right (UR) corner
	b7:	Always 0
4	b0 – b6:	7 least significant bits of lower left (LL) corner
	b7:	Always 0
5	b0 – b6:	7 least significant bits of upper left (UL) corner
	b7:	Always 0
6	b0 – b6:	7 least significant bits of upper right (UR) corner
	b7:	Always 0
7	b0 – b6:	7 least significant bits of lower right (LR) corner
	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 touchscreen 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.

Format Tablet is the most efficient packet (sends approximately 162 packets per second at 9600 baud). It also contains touchdown and liftoff information. Format Tablet is the standard for MicroTouch product development.

For comparison, Format Hexadecimal and Format Decimal (which send approximately 106 packets per second at 9600 baud) are not as efficient as Format Tablet. These data formats do not contain touchdown and liftoff information unless you also use the Mode Status command.

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

After the controller is 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 7.

Xx = X (horizontal) coordinate data; second and third bytes of data.

Yy = Y (vertical) coordinate data; fourth and fifth bytes of data.

	MSB*			Bits				LSB*
Data Sequence	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**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 7 defines the status bits (Byte 1) for the Format Tablet data.

Table 7. Format Tablet Status Bits

Bit	Description	Values
S0	Switch 1 status	For the TouchPen only. 1 = Switch is on (pressed). 0 = Switch is off.
S1	Switch 2 status	
S2 – S5	Reserved	—
S6	Proximity (touch state)	1 = Touchscreen is being touched (a touchdown or a continued touch). 0 = Touchscreen 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 Status

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

Description: Sends a touch status byte preceding the X, Y coordinate data sent in response to a Format Decimal or Format Hexadecimal command. The format of the data depends on the last format command received by the controller.

By default, Format Decimal and Format Hexadecimal send a 9-byte data packet. The first byte is the header byte. If you use the Mode Status command, the first byte becomes a status byte. This status byte defines whether the X, Y coordinates are generated from a touchdown, a touch continuation (when the finger is resting on the screen), or a touch liftoff.

MicroTouch recommends that you use the Mode Status command in conjunction with Format Decimal and Format Hexadecimal so that the touch data includes status information in the packet header byte. By default, Format Decimal and Format Hexadecimal do not contain the status information in the header byte.

Note: You should always send the format command (Decimal and Hexadecimal) first, and then send the Mode Status command.

You do not need to send a Mode Status command if you are using Format Tablet, Format Binary, or Format Binary Stream.

- The Format Tablet protocol automatically includes status information in the first byte of data.
- Format Binary and Format Binary Stream automatically issue a Mode Status command.

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

If the controller is in Format Decimal or Format Hexadecimal mode and you receive a positive response to Mode Status, touching the screen causes the controller to return the following response:

<*Status*>*Xxx*,*Yyy*<CR>

where:

<*Status*> = Defines how the X, Y coordinates are generated, where:

^Y (Hex 19) is a touchdown (first position of finger on the screen).

^\ (Hex 1C) is a continued touch (position of finger remains on the screen).

^R (Hex 18) is a touch liftoff (last position of finger on the screen).

Xxx = X (horizontal) coordinate data. Total of 3 bytes.

= ASCII comma that separates the X and Y coordinate data.

Yyy = Y (vertical) coordinate data. Total of 3 bytes.

<CR> = Terminator (Hex 0D).

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.

Format Raw automatically uses Mode Stream to send X/Y coordinate data.

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

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 identifier, which describes the controller type and the firmware version number. The output identity for the MT3000 controller is A30630 or A30670 for APAC.

Response: <SOH>*CcXxxx*<CR>

where:

Cc = Two ASCII characters that describe the type of MicroTouch controller.

A3 = Excalibur
MT3000
Serial/SMT2
Serial/SMT3V
PC Bus SMT3V

Xxxx = Four ASCII characters that indicate the firmware version number in decimal format. The first two characters represent the version number; the last two characters represent the revision level. For example, 0660 means Version 6, Revision 6 (that is, 6.6).

Parameter Lock

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

Description: Writes and stores the data format and operating mode of the controller into non-volatile memory (NovRAM).

Any time you make changes to the data format or the operating mode, you should issue a Parameter Lock command to store the new settings to the NovRAM. Therefore, the settings are not lost when the unit is powered down.

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

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:

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

For example, using PROCOMM, you enter <Ctrl A>PN815<CR> to set the communication rate to 1200. However, PROCOMM does not support 1200 baud. The controller will now pass data at 1200 baud, but the host system will not be able to read the data. The controller will expect to receive all commands at 1200 baud and will not recognize any attempts to change the communication rate. The controller is effectively locked up. If AutoBaud is enabled, you can correct this situation by a power-down/power-up sequence. If AutoBaud is disabled, you need to use Microcal or another terminal application to set the communication rate at the new values.

The communication rates that can be set with the AutoBaud command are the same as the rates you can set with the Parameter Set command. Therefore, the AutoBaud command no longer finds 7200, 3600, 2000, 1800, 600, 300, 200, 150, 135, and 110 baud. Also, some MicroTouch controllers do not support the AutoBaud command.

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 and Calibrate Raw commands and returns the controller to normal operation.

MicroTouch 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 MicroTouch factory default parameters from ROM to the non-volatile memory (NovRAM) and then executes a Reset command.

Table 8 lists the factory defaults for the MT3000 controller. The Restore Defaults command is useful in situations where inadvertent commands to the controller have rendered the touchscreen inoperative.

Table 8 MT3000 Factory Default Settings

Operating Parameter	Default
Baud Rate	9600
Serial Communication Settings	N, 7, 2
Data Format	Format Decimal
Operating Mode	Mode Stream
Return to Factory Calibration	Yes

The Restore Defaults command requires approximately 75 to 100 milliseconds, plus the execution time of the Reset command (225 to 800 milliseconds). Therefore, the application program should wait and be sure it receives the command response before issuing another command to the controller.

After you issue a Restore Defaults command, calibrate your touchscreen using the Calibrate Extended command.

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: Refer to the Unit Type command in the Touch Controller's Reference Guide on the TouchWare CD for a description of the 8-character identity string. The Unit Type command and the Unit Type Verify command return the same information.

A P P E N D I X A

MT3000 Controller Specifications

MT3000 Controller:	Programmable CMOS small format-size controller
Circuit Board Dimensions:	1.3 in. x 2.4 in. (33 mm x 61 mm)
Power Requirements:	+5 VDC (70 mA typical), 50 mV peak-to-peak maximum ripple and noise
Operating Temperature:	0 to 60 degrees C
Storage Temperature:	-40 to +85 degrees C
Relative Humidity:	90% at 60 degrees C
Optional RS-232 Cable:	8' shielded cable with 9-pin D connector for serial port; 9-pin to 25-pin adapter available
Output Port:	Bi-directional asynchronous RS-232 serial communication
Port Parameters:	No parity, 7 data bits, 2 stop bits, 9600 baud (N, 7, 2, 9600)
Electrostatic Protection:	±20KV air and ±8KV contact discharge to screen (per IEC 801-2)
Regulatory Approvals:	UL, FCC-B, and CE compliant

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