3M™ MicroTouch™ Controller EX111 HID Reference Guide

For EX111 HID

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

MicroTouch™

3M

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CHAPTER 1

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 guide, designed for developers of touch systems, provides installation and configuration information for the 3M™ MicroTouch™ EX111 HID surface capacitive touch controller. This document includes information on integrating the EX111 HID controller into your design, communicating with the controller, installing the MT 7 software user interface, and troubleshooting setup problems. It also includes a complete description of the firmware commands 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.

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, understand and follow 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 USB controller was designed to enable surface capacitive touch in conjunction with other 3M™ MicroTouch™ sensor products and was tested to replace an existing USB controller. This controller is intended for internal mounting only and is not suitable for use in hazardous locations.

Explanation of Signal Word Consequences
⚠ **WARNING:** Indicates a potentially hazardous situation, which, if not avoided, could result in death or serious injury and/or property damage.   ⚠ **CAUTION:** Indicates a potentially hazardous situation, which, if not avoided, may result in minor or moderate injury and/or property damage.   **CAUTION:** Indicates a potentially hazardous situation, which, if not avoided, may result in property damage.

⚠ **WARNING**
To reduce the risk of fire and/or explosion which could result in serious injury or death: Do not install or use this product in a hazardous location.   **To reduce the risk of fire and/or explosion which could result in serious injury or property damage:**   Do not use this product in any outdoor environment unless NEMA standards (or similar standards such as IP rating) are followed.   **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.

⚠ **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 federal, state and local regulations.
To reduce the risk of possible environmental contamination which may result in minor or moderate injury: Dispose of the display in accordance with federal, state and local regulations.   **To reduce the risk of 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.

Sensor Care and Cleaning

The sensor requires very little maintenance. 3M Touch Systems recommends that you periodically clean the glass 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. 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 sensor.
- 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.
- Apply the cleaner with a soft, lint-free cloth. Avoid using gritty cloths.
- Always handle the sensor with care. Do not pull on or stress flex tail.

3M Touch Systems Support Services

3M Touch Systems provides extensive support services through our website and technical support organization. Visit the 3M Touch Systems website at http://www.3M.com\touch, where you can download touch software and drivers, obtain regularly updated technical documentation on 3M Touch Systems products, and learn more about our company.

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

Technical Support is available Monday through Friday 8:30 a.m. to 5:30 p.m. with limited call back service after 5:30 p.m. until 8:00 p.m. US Eastern Standard Time – 9 a.m. to 5 p.m. throughout Europe.

You can contact 3M Touch Systems 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 (Option 3)
- Email: US-TS-techsupport@mmm.com

Contact 3M Touch Systems

Contact information for all offices can be found on our website at:
http://www.3M.com\touch/

CHAPTER 2

Integrating the 3M™ MicroTouch™ EX111 HID Controller

Overview

The 3M MicroTouch™ EX111 HID controller provides a drop-in replacement for an existing controller. It features wide dynamic range, increased noise immunity, wide operating temperature stability, reprogrammability using software utilities and improved capability in ungrounded environments.

The firmware for the EX111 USB controller is optimized for the Surface Capacitive touch sensors integrated in the latest displays.

This chapter covers the following EX111 HID controller specifications:
- Cable connections
- Mounting requirements
- Power requirements and options
- Status LED codes

Note: For complete specifications for this EX111 HID controller, refer to the appendices at the end of this manual.

The EX111 HID controller is available uncased without cable for mounting within a custom chassis.

The EX II ASIC has a built-in Universal Serial Bus (USB) full speed interface. A full speed USB interface has a data rate of 12 Mb/s. The USB core in the ASIC was designed to USB specification revision 1.1 but is forward compatible with revision 2.0.

A 25-point linearization procedure has been performed to determine the physical properties of the touch sensor, and the data is stored in a 2D bar code label attached to the touch sensor flex tail.

To integrate and test the EX111 HID controller, you need the following items:

- A 3M Touch Systems surface capacitive touch sensor (available in a variety of sizes).

- A method of establishing the USB data communication between the controller and your system. The standard 3M Touch Systems USB cable (P/N 7319420) is recommended for this device.

- The controller will operate with the standard USB +5V bus power.

- A driver and a calibration program.

Handling and ESD Protection

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

Establishing the Data Connection

The EX111 HID controller requires a 3M Touch Systems USB communication cable (P/N 7319420) or an equivalent interconnect. One end of this cable plugs into the USB connector (JP1) on the EX111 HID controller. The other end plugs into a USB port on your PC with a Type-A connector. When creating a custom cable, use the Molex 51004-0500 mating connector. The following table describes the interconnections of the 3M Touch Systems USB cable.

Table 1. USB Cable for EX111 HID Controller

PC Side (USB Type A)		Wire	Controller Side (5-Pin Molex)	
Pin	USB Assigned	Color	Pin	Description
1	+5Vdc (VBUS)	Red	1	+5Vdc VBUS input power
2	Data (DN)	Gray	2	Data (DN) differential pair
3	Data (DP)	Green	3	Data (DP) differential pair
4	0V	Black	4	Power return
5	Cable Shield Shell	Charcoal Gray	5	Outer cable shield around signal and power lines. Chassis (earth) ground

Touch Sensor Connection

The touch sensor flex tail has a 5-pin single row female connector that plugs into the EX111 HID controller with a right side tail exit. The following table describes the pins on this connector.

Table 2. Touch Sensor Flex Tail Connector for EX111 HID Controller

Pin	Description
1	Upper left (UL) corner
2	Upper right (UR) corner
3	Connects to the flex tail shield, which must not be grounded because the EX111 HID drives the flex tail shield with an AC waveform.
4	Lower right (LR) corner
5	Lower left (LL) corner

Mounting the Controller

The controller is designed for internal mounting only. Choose a convenient spot away from high-voltage, high power cables and electronics. Use 4-40 (or M3 metric) metal screws to mount the controller using the two diagonal mounting holes in the board. The controller should be mounted in line with the touch sensor cable exit point to minimize cable flexing. The controller should be mounted internally behind or on the side of the display on stand offs to allow room for the touch sensor cable connector.

Avoid awkward electrical connections by ensuring that the tail and controller are aligned such that the tail remains straight (90°), not pulled or twisted in an odd angle from the touch sensor.

Figure 1. Recommendation for Tail Connection

Recommended:
Wrap tail smoothly

Not recommended:
Do not twist the tail
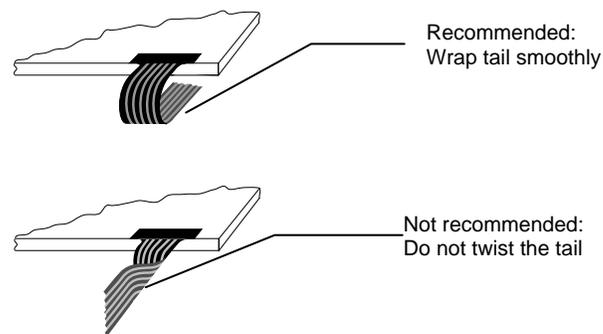
If necessary, to make the touch sensor cable reach to the controller location, you can extend the length of the tail with a one-to-one, shielded, flat ribbon cable extender. The connector must be compatible with the connector manufacturer, i.e., Amp should connect to Amp. Be sure to use tin compatible contact pins.

Supplying Power to the Controller

The controller is designed to use USB bus power (that is, take power from the USB port). The source must deliver 75 mA typical (100 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 sensor 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.

Mounting the Touch Sensor

There are several methods for mounting the touch sensor to the flat panel display depending on your application. If you need instructions or recommendations from 3M Touch Systems on how to incorporate a touch sensor into your design, refer to the *3M^{TM} MicroTouch^{TM} System 3250EX Integration* Guide (P/N 19-278). 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.

To start up your system:

1. Turn on your display 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 display to center the image on the sensor.

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 controller provides diagnostic feedback with a light emitting diode (LED) on the component side of the board that indicates the status of the touch sensor 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 or USB communications have stopped and the controller is in suspend mode.

The LED indicator also provides visual indication of the controller's internal self-tests by flashing or blinking a code that may be interpreted using the following table. The test results are also returned as part of the USB status report. Those bits that result in a flashing error code are repeated in the table.

Some errors are fatal -- that is, normal touch sensor operation cannot occur. Others errors may simply cause "default conditions" to be assumed and touch sensor operation may proceed. An example of a non-fatal error is when default operating conditions are restored due to an incorrect NOVRAM checksum: in this case, operation continues using factory default conditions (as if a Restore Defaults Request had been issued).

Table 3. LED Diagnostic Codes for EX111 HID Controller

Self Test Condition	LED Flashes	Self Test Bit	Description	What to do...
RAM Data ERROR[2]	1	0	Data side checksum error	Reload program code.
RAM Code ERROR[2]	2	1	Firmware EEPROM checksum verification error	Reload program code.
STRAY ERROR[1]	3	2	Unable to initialize stray cancellation	Replace controller. If error reoccurs, might be a touch sensor problem.
NOV ERROR[3]	4	3	Parameters invalid (using defaults)	Restore defaults. If fault persists, replace controller. If error reoccurs, might be a touch sensor or cable problem.
HDW ERROR[1]	5	4	Controller hardware failure (phase/gain initialization)	Cycle power. If fault persists, replace controller.
Reserved	6	5	Reserved	
Reserved	7	6	Reserved	
NOV2 ERROR	8	7	Controller NOVRAM linearization data invalid	Replace touch sensor or perform a 25-point linearization. Contact Technical Support.
Reserved	9	8	Not used	
EEPROM Error[2]	10	9	EEPROM is not working	Reload program code.
NOV5 ERROR	11	10	Controller ID is not valid	Restore defaults. If fault persists, replace controller.
NOV6 ERROR	12	11	Interface configuration values are not valid	Reload defaults. If fault persists, replace controller.
NOV7 ERROR	13	12	Touch configuration values are not valid	Restore defaults. If fault persists, replace controller.
Reserved	14	13	Reserved	
Resistance ERROR	15	14	Touch sensor resistance is out of supported range	Cycle power. If fault persists, replace touch sensor.
Backplane ERROR	16	15	Low resistance path from backplane to touch sensor	Cycle power. If fault persists, replace touch sensor.
Corner ERROR	17	16	Corner drive offset level is too high	Cycle power. If fault persists, replace controller.
Fixed Cal ERROR	18	17	Fixed 2-point cal error high	Cycle power. If fault persists, replace controller.

Note 1: this is a fatal error.
Note 2: this error is detected by the ROM code
Note 3: indicates that the EEPROM is not formatted when given by the ROM code

Installing Software

Since this is a HID (human interface device) compatible controller, the controller will operate independent of a 3M™ MicroTouch™ driver. This controller supports USB HID for direct communication. You must obtain a HID calibration utility from the 3M Touch Systems website.

Additional 3M Touch Systems documentation is available from the corporate website at www.3Mtouch.com.

CHAPTER 3

3M™ MicroTouch™ EX111 HID Controller Communications

This chapter discusses the fundamentals of communicating with the EX111 HID controller. The firmware commands, which are usually issued by a driver or utility program on the host system, control the operation of the controller. This chapter lists the recommended firmware commands and describes how to use each of these commands.

Overview of USB HID Firmware Commands

Developers may use these USB commands when writing touch applications, developing custom drivers or touch configurations, or testing their touch systems. Developers can issue commands to initialize the controller, select operating modes, and execute diagnostic functions.

Note: This document assumes you are familiar with USB standards and modes of communication with USB HID devices, as well as firmware commands and how to use them. Executing some commands may alter the performance of your touch sensor and render it inoperable. You should be aware of the results before executing any firmware commands.

To optimize the performance of the EX111 HID controller and simplify the development of custom drivers, 3M Touch Systems recommends you use the commands listed in this chapter for current development.

Communication Basics

This section provides information on sending firmware commands to the controller and interpreting the responses that the controller returns. The default operation of the EX111 HID controller is USB HID 1.1 at 12 MHz.

The USB command set is implemented by using vendor HID Get Feature and Set Feature commands. The computer can send requests to the controller to change how it operates or receives information about the controller. The controller issues a synchronous report in response to some of these requests. The controller also issues asynchronous reports automatically to the computer upon touch.

You need to know the product ID (0003H) and the vendor ID (0596H) to write your own driver. These values are required for identifying the controller.

The EX111 HID command set conforms to the HID protocol. The HID protocol allows the EX controller to be used with operating systems that support HID. The only required software is a calibration tool used for aligning the touch sensor to the display. This calibration tool is available from 3M Touch Systems.

Receiving Reports from the Controller

The controller sends a variety of reports to the computer. The first byte of each report is the Report ID that defines the structure and content of the report. The controller sends some reports as a direct response to a computer request (synchronous). The controller will also send some reports as the result of an external event, such as a touch (asynchronous).

USB Command Set

The USB command set is implemented by using HID Get Feature and Set Feature commands. The various requests and reports are grouped together by report size under a common feature ID.

The following commands are currently used by 3M Touch Systems for optimal communications. 3M Touch Systems recommends that you use only these commands for EX111 HID controller communications.

Sending Commands to the Controller

To send a command, the program must construct a USB request packet. The request format is described in the following table. This is known as the setup stage. Any data appended immediately after the setup stage is referred to as the data stage.

If using Windows, you may want to use the Set and Get Feature functions, respectively HidD_SetFeature and HidD_GetFeature. The buffers for these routines are the data stages of the requests. Note that HidD_GetFeature requires you to populate the first byte of the buffer with the desired report ID.

Table 4. Request Format

Offset	Field	Size	Value	Description

0	bmRequestType	1	d0100001	Characteristics of request [direction, type, recipient]
				D7: Data Transfer Direction
				        0 = Host-to-device
				        1 = Device-to-host
				D6…5 Type
				        0 = Standard
				        1 = Class
				        2 = Vendor
				        3 = Reserved
				D4…0 Recipient
				        0 = Device
				        1 = Interface
				        2 = Endpoint
				        3 = Other
				        4…31 = Reserved

1	bRequest	1	0xXX	HID request [Get report (0x01) or Set report (0x09)]
2	wValue	2	0x03XX	Command parameters where XX is the feature report ID
4	wIndex	2	0	Must be 0 (zero)
6	wLength	2	0xXXXX	Number of bytes in the data stage

Note that the device stalls endpoint 0 if it cannot process a request. If you are writing your own driver it is your responsibility to reestablish communications. 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.

Controller Initialization

To initialize the EX111 HID controller, 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.

Touch Reports

The EX111 HID controller sends a touch report to the host computer when a user interacts with the touch sensor. Usually this is handled by the operating system's HID software. Most applications will not use these reports. However, if you are writing a custom driver or possibly a diagnostics program, your program will process these reports.

Under normal circumstances, the controller sends the HID coordinate data report (report 1 for mouse HID controllers). If you use a custom driver, it should recognize this report and translate it into mouse events. Depending on how you design your custom driver, diagnostic programs may also have access to this report.

If you use the operating system's HID driver, an application does not have access to this report. Instead, your application must change how the controller reports touches. In this case, the application should send an Asynchronous Report Enable request to place the controller in the synchronous coordinates mode and then issue a series of Get Touch Report Utility requests to obtain the touch report. Details on this are given in the Get Touch Report Utility and Asynchronous Report Enable requests.

HID Mouse Coordinate Data Report

This report is sent by the mouse HID touch controller whenever there is some touch event (touchdown, drag, or liftoff) indicating some user action. It reports the state of the touch (contact, no contact) and the position of the touch on the sensor. Unlike the standard MicroTouch coordinate system, the EX111 HID controller uses the HID standard and treats the upper left corner as the origin, coordinate (0, 0).

This is an asynchronous report that is normally enabled for the mouse HID controller. It must be disabled when utility reports are being accessed with the Get Touch Report Utility requests. See the Asynchronous Report Enable request for details on how to disable this report.

Table 5. HID Mouse Coordinate Data Report

Offset	Field	Size	Value	Description
0	Report ID	1	0x01	HID ID number
1	Reserved	1	0xXX	Reserved
2	Status	1	dddddddd	Touch State bit mask D7-D1: reserved D0: 1 = button 1 pressed (contact)
3	X Compensated	2	0xXXXX	0-0x03FF
5	Y Compensated	2	0xXXXX	0-0x03FF
7	X Raw	2	0xXXXX	0-0xFFFF
9	Y Raw	2	0xXXXX	0-0xFFFF
11	Not Used	6	0x00	Not Used

A driver should use the compensated X and Y coordinates when determining touch location. These coordinates reflect the calibration of the touch sensor and benefit from MicroTouch algorithms that improve the accuracy of the touch sensor.

When the user initially touches the touch sensor, the D0 bit (button 1) is set to 1. The controller continues to send reports with this bit set as long as the user maintains contact. When the user breaks contact, the controller sends one report with D0 set to 0 at the last known location of the previous contact. At all other times, when the user is not interacting with the touch sensor, the controller does not send this report.

Although the details of interfacing with various operating systems differ, generally the first contact report should be treated as a mouse button down event, the following contact reports as mouse drag events, and the final no contact report as a mouse button up event.

Get Touch Report Utility

Some applications need to monitor touch locations directly from the controller. If you are using a standard Windows HID driver, the HID Coordinate Data Reports are not available. You can use the Get Touch Report Utility request to monitor touch events.

Before using the Get Touch Report Utility you must first disable the HID Coordinate Data reports. Use the Asynchronous Report Enable request to disable the reports. In this mode, touch is effectively disabled if you are using the standard HID driver.

Once the HID Coordinate Data reports are disabled, you can issue the Get Touch Report Utility request as often as you want. When you finish monitoring touch, the Asynchronous Report Enable request should be used to enable normal touch reporting.

Table 6. Setup Stage for Get Touch Report Utility Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0xA1	Device-to-host
1	bRequest	1	0x01	Get Report
2	wValue	2	0x0303	Coordinate Data Feature Report
4	wIndex	2	0	Target - Interface
6	wLength	2	8	Length of the data stage

Response

The device stalls endpoint 0 if the request cannot be processed successfully.

The data stage of this request is almost identical to the HID Mouse Coordinate Data Report. Refer to the previous section for details on how to interpret the data stage.

Table 7. Data Stage for Get Touch Report Utility Request – Coordinate Data Report

Offset	Field	Size	Value	Description
0	Report ID	1	0x03	HID ID number
1	Loop Counter	1	0xXX	Report synchronization
2	Status	1	dddddddd	Touch State bit mask D7-D1: reserved D0: 1 = contact, 0 = no contact
3	X Compensated	2	0xXXXX	0-0x03FF
5	Y Compensated	2	0xXXXX	0-0x03FF
7	X Raw	2	0xXXXX	0-0xFFFF
9	Y Raw	2	0xXXXX	0-0xFFFF
11	Not Used	6	0x00	Not Used

Basic Commands

These commands provide basic support for software control over the touch controller and include:
- Calibration
- Controller Status

- Reset
- Restore Defaults
- Controller ID
- Asynchronous Report Enable
- Change Mode
- Write Parameter
- Write Parameter Index
- Read Parameter
- Set Frequency
- Set Frequency Index
- Get Frequency

Calibration

This is a request to perform a 2-point calibration. The calibration can be performed at points inset from the lower left and upper right corners (extended calibration) or it can be done at those corners. This is equivalent to the Calibrate Extended (12.5% insets from the lower left and upper right corners) and Calibrate New (lower left and upper right corners) commands used by the 3M Touch Systems serial controllers. The 2-point calibration defines the active area of the touch sensor by mapping two targets displayed on the video image to absolute X and Y coordinates on the touch sensor.

Table 8. Setup Stage for Calibration Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0x21	Characteristics (host-to-device)
1	bRequest	1	9	Set Report
2	wValue	2	0x0310	Report type – Feature; Report ID – 8-byte data
4	wIndex	2	0x0000	Target - interface
6	wLength	2	8	Report length

Table 9. Data Stage for Calibration Request

Offset	Field	Size	Value	Description
0	Report ID	1	0x10	8-byte data reports
1	Report Sub-type	1	0x11	Calibration
2	Cal Type	1	0xXX	Calibration type
3-7	Not Used	5	0x0000	Reserved

Response

The device stalls endpoint 0 if the request cannot be processed successfully.

When the request is processed successfully, a positive USB acknowledge (zero length data packet) is sent.

The host should issue status requests to determine the status of this request. A command status of 1 indicates that the controller is waiting for a touch in the lower left quadrant. A status of 2 indicates that the lower left touch has been completed and the controller is waiting for a touch in the upper right quadrant. A status of 3 indicates that the upper right touch has been completed. A status of 0 indicates that the request has failed. A soft reset command should be sent if the host wishes to terminate calibration.

Determining Target Areas

The default calibration targets (points) are located 12.5% (1/8) inward from the lower left and upper right corners of the video image. For example, suppose the display resolution of your Windows-based display 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 for a Windows-based system. Your operating system may be different.

Figure 2. Calibration Target Locations

(0, 0) [0, 0]*

(1023, 0) [16K, 0]*

(895, 96)

Upper Right Calibration Target
X = 1023 – (1024 x 1/8) = 1023 – 128 = 895
Y = 0 + (768 x 1/8) = 0 + 96 = 96

Lower Left Calibration Target
X = 0 + (1024 x 1/8) = 0 + 128 = 128
Y = 767 - (768 x 1/8) = 767 - 96 = 671

(128, 671)

(0, 767) [0, 16K]*

(1023, 767) [16K, 16K]*
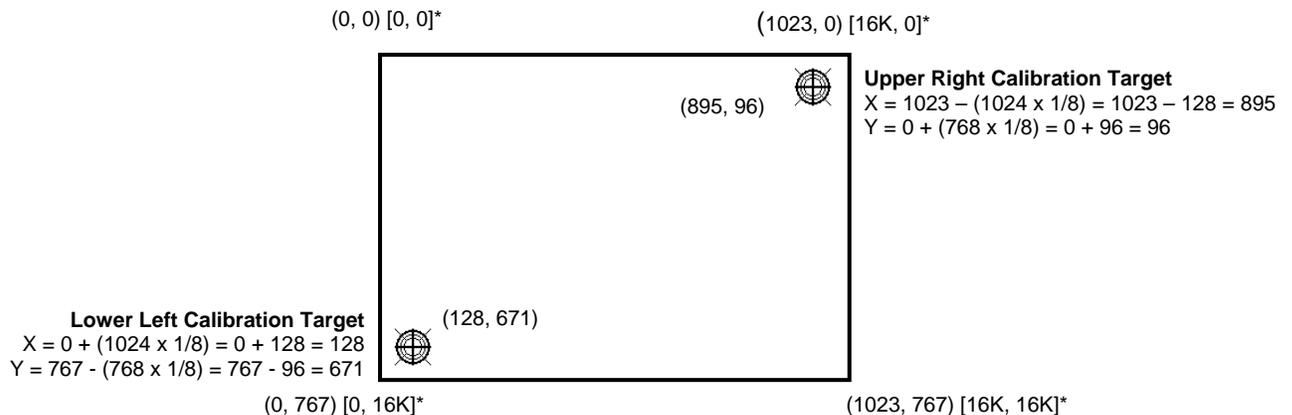
*Both the video (0, 0) and controller [0, 0] coordinates origin are in the upper left corner of the sensor. The controller outputs 0 to 16K on both axes independent of display screen resolution.

Controller Status

This is a request to send information that indicates the status of the controller. Use this request to determine whether there were any power on check errors and whether the last request was completed successfully.

The Controller Status Request is used to poll the controller for command completion when a previous USB request involved a controller reset. Refer to the Reset Request for additional details.

Table 10. Setup Stage for Controller Status Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0xA1	Device to host
1	bRequest	1	0x01	Get Report
2	wValue	2	0x0380	Report Type - Feature; Report ID – Status
4	wIndex	2	0x0000	Target - Interface
6	wLength	2	0x0014	Length of the data stage

Response

The device stalls endpoint 0 if the request cannot be processed successfully.

The status report is sent by the controller in the data stage.

Table 11. Data Stage for Controller Status Request – Status Report

Offset	Field	Size	Value	Description
0	Report ID	1	0x80	Report ID number
1	POC Status	2	0xXXXX	Power On Check Status
3	Cmd Status	1	0xXX	Status of last command
4	Touch Status	1	0xXX	Finger Up/Down
5	Asynch Reports	2	0xXXXX	Active asynchronous reports
7	Reserved	2	0xXXXX	Reserved
9	Extended POC Status	2	0xXXXX	Additional Power On Check Status
11	Touch Mode	1	0xXX	1– streaming, 3 – down/up
12	Filler	8	8 bytes	Future expansion

Power-On Check (POC) and Extended POC Status

Various systems are checked when the controller first starts. If any failures in these systems are detected, a POC flag is set. The POC and Extended POC status fields report the state of these flags.

A failure in the POC also causes a flashing pattern in the controller's diagnostic LEDs. Refer to Table 3 for more details on LED Status descriptions. The Self Test Bit column of the table corresponds with the bit positions in the status words. Bits 0 through 15 are in POC Status, while bits 16 through 31 are in Extended POC Status.

Command Status

The command status contains the status of the last command request. This field is used to determine whether the last request was processed successfully. It is also used to track the progress of a multiple-stage request, such as calibration.

The Controller Status request does not affect the contents of this field. The successful or unsuccessful processing of a previous Controller Status request does not cause the command status field to change.

Table 12. Valid Command Status Field Entries

Response	Description
0x00	Failure in command processing
0x01	Command being processed
0x02	First stage processing complete for multiple-stage commands
0x03	Command complete
0x04	Soft reset occurred
0x05	Hard reset occurred

Touch Status

The touch status indicates whether the sensor is currently being touched. This is a bit field, with bit 0 set to one when there is a touch or to zero when there is not a touch. All other bits are reserved for future use.

Asynchronous Reports

This field shows the enabled asynchronous reports. If a report is enabled, its corresponding bit is set.

Table 13. Active Asynchronous Reports

Bit Number	Description
0	HID Mouse Report
1–15	Reserved

Reset Request

This request performs a controller reset. There are 3 types of resets that can be issued. The soft reset initializes a subset of the controller's parameters. This is mainly used to force a recalculation of the controller's environmental values, such as stray compensation.

A hard reset results in the controller re-initializing all run-time parameters and ASIC registers. This is required for changes that are made with the Set Parameter request to take effect.

A reboot to EEPROM is the same as a hard reset except that it takes the additional step of reloading the program code from EEPROM.

Table 14. Setup Stage for Reset Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0x21	Characteristics (host-to-device)
1	bRequest	1	9	Set Report
2	wValue	2	0x0310	Report type – Feature; Report ID – 8-byte data
4	wIndex	2	0x0000	Target – interface
6	wLength	2	8	Report length

Table 15. Data Stage for Reset Request

Offset	Field	Size	Value	Description
0	Report ID	1	0x10	8-byte data reports
1	Report Sub-type	1	0x12	Reset
2	Reset Type	1	0xXX	1 - soft reset 2 – hard reset 5 – reboot EEPROM
3-7	Not Used	5	0x0000	Reserved

Response

The device stalls endpoint 0 if the request cannot be processed successfully.

When the request is processed successfully, a positive USB acknowledge (zero length data packet) is sent.

Since the time to complete the soft reset can be more than 500 ms, the device acknowledges the request before it is completed. The host must issue a status request to determine whether the reset request was completed. The command status field of the status report will be set to "command in progress" while the soft reset is occurring. The field will change to "soft reset occurred" when the reset has completed. Any other request issued while the reset is still in progress will be rejected.

The hard reset and reboot to EEPROM are executed immediately upon decoding of this request. The reset sequence begins by simulating a device disconnect from the host. This disconnect causes the driver to unload and will result in any handles to the driver that an application may have becoming invalid. An application should handle an unplug event.

A re-connect is then performed and the device must re-enumerate its connection with the host. Because of this, a response to the request cannot be sent prior to, or even after, the beginning of the reset sequence. The host should issue status and ID requests after the reset has completed to verify whether this request was handled properly by the device. The status request should be used to determine when the hard reset occurred. The ID request is used to verify that the controller is now in the desired mode by looking at the contents of the controller type field.

Restore Defaults

This request restores the default values in the controller to the factory presets. You must recalibrate after this command since this request also restores the calibration settings and touch sensor orientation.

Table 16. Setup Stage for Restore Defaults Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0x21	Characteristics (host-to-device)
1	bRequest	1	9	Set Report
2	wValue	2	0x0310	Report type – Feature; Report ID – 8-byte data
4	wIndex	2	0x0000	Target – interface
6	wLength	2	8	Report length

Table 17. Data Stage for Restore Defaults Request

Offset	Field	Size	Value	Description
0	Report ID	1	0x10	8-byte data reports
1	Report Sub-type	1	0x13	Restore Defaults
2	EEPROM Type	1	0	Reserved
3	Block Number	1	0	Reserved
4-7	Not Used	4	0x0000	Reserved

Response

The device stalls endpoint zero if it cannot process this request. The request will fail if any of the fields are not set correctly.

When the request is processed successfully, a positive USB acknowledge (zero length data packet) is sent.

A soft reset will be done at the completion of this request. Because of this, the controller must be polled to determine when the reset is done (see Reset Request for details).

Controller ID

This is a request to get information about the front end processor, including the controller type, firmware revision level, and the memory checksums.

Table 18. Setup Stage for Controller ID Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0xA1	Characteristics (device-to-host)
1	bRequest	1	0x01	Get Report
2	wValue	2	0x0381	Report Type - Feature; Report ID – Controller ID
4	wIndex	2	0x0000	Target - Interface
6	wLength	2	0x1A	Size of ID report

Response

The device stalls endpoint 0 if the request cannot be processed successfully.

The report sent by the controller in the data stage contains information describing the controller, including its type, firmware revision, special features, and the ROM checksum.

All multi-byte quantities in this report are sent LSB first.

Table 19. Data Stage for Controller ID Request – Controller ID Report

Offset	Field	Size	Value	Description
0	Report ID	1	0x81	Report ID number
1	Controller type	2	0x4D33	Indicates the type of controller (M3)
3	FW major revision	1	0xXX	Firmware major revision level
4	FW minor revision	1	0xXX	Firmware minor revision level
5	Reserved	1	0xXX	Reserved
6	Constants Checksum	2	0xXXXX	RAM constants checksum
8	Max Param Write	2	0x0040	Maximum data for Read Parameter request
10	Reserved	8	0xXX	Reserved
18	Code Checksum	4	0xXXXXXXXX	RAM program code checksum
22	ASIC type	2	0x0103	ASIC type
24	Reserved	2	0xXXXX	Reserved

Note: If you received an identifier of M0, you should contact Technical Support for assistance.

Max Parameter Write

This is the largest transfer that can take place. This only affects the Read and Write Parameter requests.

ASIC Type

This indicates the type and version of the ASIC in the controller. The high byte is used to note major ASIC changes, such as a new ASIC family, and the low byte indicates changes within a family. A setting of 0x01 for the high byte indicates the EX II ASIC. A low byte of 0x03 indicates Rev C of the ASIC.

Asynchronous Report Enable

This request starts or stops the sending of various asynchronous endpoint 1 reports. Once enabled, the touch controller sends an asynchronous report whenever data is available.

When the report information is no longer needed, a request to turn the report off can be made. The firmware defaults to sending report 1 after power-up or reset for a HID standard (mouse) controller. All other asynchronous reports are de-activated.

Table 20. Setup Stage for Asynchronous Report Enable Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0x21	Characteristics (host-to-device)
1	bRequest	1	9	Set Report
2	wValue	2	0x0310	Report type- Feature; Report ID – 8 byte
4	wIndex	2	0x0000	Target – Interface
6	wLength	2	8	Report length

Table 21. Data Stage for Asynchronous Report Enable Request

Offset	Field	Size	Value	Description
0	Report ID	1	0x10	8-byte data report
1	Report Sub-type	1	0x10	Set Asynchronous report
2	Activate	1	0xXX	0x00 – deactivate report 0x01 – activate report 0x02 – deactivate all 0x03 – activate default
3	Report Num	1	0xXX	Asynchronous report number
4 - 7	Not Used		0x00	Reserved

The Activate field in the data stage indicates whether the output of a specific asynchronous report should be turned on or off. A zero turns the report specified in the Report Num field off and a 1 turns it on. A setting of 2 turns off all asynchronous reports. A setting of 3 enables the default asynchronous reports, as specified in non-volatile configuration memory.

The Report Num field is used to select the asynchronous report number. Only report 1 is valid.

Response

The device stalls endpoint 0 if the request cannot be processed successfully.

When the request is processed successfully, a positive USB acknowledge (zero length data packet) is sent.

Change Mode

Generally, the controller sends coordinate data to the host computer in the streaming mode. What this means is that the controller periodically sends updated position information while a touch is maintained on the touch sensor. New data is sent even if the touch remains stationary and unchanging.

Another available operating mode is the Down/Up mode. In this mode, the controller sends one coordinate when the sensor is first touched, sends no data while the touch is maintained, and sends a second coordinate when the touch is removed. The second coordinate is the last touch position prior to the removal of the touch.

This request allows you to change between the touch operating modes.

Table 22. Setup Stage for Change Mode Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0x21	Characteristics (host-to-device)
1	bRequest	1	9	Set Report
2	wValue	2	0x0310	Report type- Feature; Report ID – 8 byte
4	wIndex	2	0x0000	Target - Interface
6	wLength	2	8	Report length

Table 23. Data Stage for Change Mode Request

Offset	Field	Size	Value	Description
0	Report ID	1	0x10	8-byte data report
1	Report Sub-type	1	0x17	Change mode
2	Mode	1	0x00	Default
			0x03	Down/Up
			0x01	Streaming
3	Flags	1	0x00	Temporary change
			0x01	Permanent change
4 - 7	Not Used		0x00	Reserved

Notes

Permanent changes are saved in non-volatile memory and remain in effect after a reboot or power-cycle. Temporary changes are lost when either of these events occurs. A soft reset does not affect temporary mode changes.

Response

The device stalls endpoint 0 if the request cannot be processed successfully.

When the request is processed successfully, a positive USB acknowledge (zero length data packet) is sent.

Parameter Access

There is some information and configuration data available in the EX111 HID controller. This is accessed as parameters. This section describes how to set and read parameters.

The following table contains a list of supported parameters and the settings necessary to properly access the parameters. Note that some parameters may only be read. Attempting to set these parameters will fail.

Table 24. Available Parameters

Parameter		Size	Description
Name	**Number**	**(bytes)**	

Sensor Orientation	1	2	Where the lower left corner of the display maps to the sensor.
			    0000 – Upper Right (9:00)
			    0001 – Lower Right (6:00)
			    0002 – Upper Left (12:00)
			    0003 – Lower Left (Standard, not rotated, 3:00)

Controller Serial Number	2	4	Serial number assigned by software. Generally used for multi-display support.
2-pt. Cal Coefficients	3	8	Controller calibration data
Default Async Reports	4	2	Bit 0 – HID mouse report enabled
Copyright String	101	52 [2]	Copyright, e.g. "Copyright (c) 2007 3M. All Rights Reserved."
Build String	102	46 [2]	Build Date, e.g. "EX DOWNLOAD BUILD 0310 - 2008/10/02.16:23"

Note: All strings are NULL terminated ASCII strings. The strings are packed 2-characters per word and the routine that is retrieving the data can only retrieve words. Strings are padded with an extra NULL, if necessary, to make the number of bytes even.

Write Parameter

This is a request to modify the contents of a configuration parameter. String parameters cannot be modified.

The request uses parameter numbers to determine what data is being requested and where the data is located. Refer to Table 25 for details about the parameters.

Either this request or a Write Parameter Index request must be issued prior to a Read Parameter request. This request sets up the memory access information that is used by the Read Parameter request.

A Hard Reset request should be sent after the Write Parameter request completes. This is to ensure that all parameter changes will take effect. There are some parameters that have runtime copies or that are used to derive other runtime parameters. Many of these are only updated when the system is power cycled or a Hard Reset occurs. Note that a soft reset does not update these parameters. This is an intentional design feature to allow temporary changes made by the user, such as changing the touch mode, to remain in place after a soft reset.

Table 25. Setup Stage for Write Parameter Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0x21	Characteristics (host-to-device)
1	bRequest	1	9	Set Report
2	wValue	2	0x0320	Report type – Feature; Report ID – 8+64 byte data

Offset	Field	Size	Value	Description
4	wIndex	2	0x0000	Target - interface
6	wLength	2	0x48	Report length

Table 26. Data Stage for Write Parameter Request

Offset	Field	Size	Value	Description
0	Report ID	1	0x20	8 + 64-byte data reports
1	Report Sub-type	1	0x20	Write Parameter
2	Parameter Request	2	0x0030	Must be H'30
4	Parameter Number	2	0xXXXX	Parameter Number
6	Size	1	0xXX	Size (bytes) of the parameter to be written
7	Reserved	1	0x00	Reserved
8	Data		0x40	Parameter data

Data Phase

The first 8 bytes of the data stage specify the request that is being made and the location of the parameters that are to be changed. The last 64 bytes are the new settings for the parameters.

For the first 8 bytes of the data stage, all multi-byte fields are sent LSB first. This corresponds with how USB normally handles words and double words. For the Data field (offset 8+) however, all values are sent as if they are individual bytes. Any words or double words must be sent MSB first. This corresponds with how data is stored in the controller. This eliminates the need for the controller to determine the type of each variable in a block and reverse the byte order when a multi-byte variable is encountered. USB is little endian, while the microprocessor is big endian.

The report is always 72 bytes long (8 setup bytes + 64 data bytes). If fewer than 64 bytes of data are being set, the extra bytes in the report are ignored.

Response

If the command cannot be processed, the device stalls endpoint 0. The command cannot be processed if the parameter number is not valid. It cannot be processed if more data is requested than is contained in the parameter.

When the request is processed successfully, a positive USB acknowledge (zero length data packet) is sent.

Write Parameter Index

This is a request to set the access information for parameter data requests. Either this request or a Write Parameter request must be issued prior to a Read Parameter request. This request identifies the parameter number and the parameter size to be accessed by a subsequent Read Parameter request. Refer to Table 25 for available parameters.

Table 27. Setup Stage for Write Parameter Index Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0x21	Characteristics (host-to-device)
1	bRequest	1	9	Set Report
2	wValue	2	0x0310	Report type – Feature; Report ID – 8-byte data
4	wIndex	2	0x0000	Target - interface
6	wLength	2	8	Report length

Table 28. Data Stage for Write Parameter Index Request

Offset	Field	Size	Value	Description
0	Report ID	1	0x10	8-byte data reports
1	Report Sub-type	1	0x16	Set Parameter Index
2	Parameter Request	2	0x0030	Reserved
4	Parameter Number	2	0xXXXX	Parameter Number
6	Size (bytes)	1	0xXX	The amount of data to retrieve
7	Reserved	1	0x00	Reserved

Response

If the command cannot be processed, the device stalls endpoint 0. The command cannot be processed if the parameter number is not valid. It cannot be processed if more data is requested than is contained in the parameter.

When the request is processed successfully, a positive USB acknowledge (zero length data packet) is sent.

Read Parameter Request

This is a request to retrieve the contents of a configuration parameter or string.

The request only specifies that a Read Parameter report is being requested. It cannot specify what contents (parameter values) are required within the report. This must be set up by a previous Write Parameter or Write Parameter Index request.

The request uses parameter numbers to determine what data is being requested and where that data is located.

Table 29. Setup Stage for Read Parameter Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0xA1	Characteristics (device-to-host)
1	bRequest	1	0x01	Get Report

Offset	Field	Size	Value	Description
2	wValue	2	0x0320	Report Type – Feature; Report ID – Read Parameter
4	wIndex	2	0x0000	Target Interface
6	wLength	2	0x48	Length of the Parameter Data report

Response

If the command cannot be processed, the device stalls endpoint 0. The command cannot be processed if the memory access information was not set previously by a successful Write Parameter or Write Parameter Index request.

The data stage contains the parameter report returned by the controller.

Table 30. Data Stage for Read Parameter Request – Parameter Report

Offset	Field	Size	Value	Description
0	Report ID	1	0x20	Report ID number
1	Report Sub ID	1	0x20	Read Parameter Number report
2	Parameter Request	2	0x0030	Always H'30
4	Parameter Number	2	0xXXXX	Number that represents the parameter being referenced
6	Size	1	0xXX	Size of the parameter being retrieved
7	Reserved	1	0x00	Reserved for future use
8	Parameter Data	64	varies	The requested parameter data

The first 8-bytes echo the memory access information that was set by a previous Write Parameter or Write Parameter Index request. These settings should be used to verify that you are getting the results for the desired parameter. The size field also indicates how many of the last 64-bytes contain the requested data. The unused bytes are set to zero.

Frequency

The controller drives the touch sensor with an AC waveform. The frequency of the sensor drive signal (operating frequency), should not be the same as any frequency, or second or third harmonics of any frequency, in close proximity to the sensor. The frequency requests provide access to the operating frequency settings and allow you to change those settings if necessary. The following table lists the available frequencies and the corresponding EX settings (Frequency Select).

Table 31. Frequency Settings

Frequency Select (hex)	Operating Frequency (kHz)
1B	109
1F	96
23	85
27	77
2B	70
2F	64

Frequency Select (hex)	Operating Frequency (kHz)
33	60
37	56
3B	52
3F	49
43	46
47	44

Set Frequency Request

This is a request to modify the operating frequency of the controller. Refer to Table 32 for a list of the available Frequency Select values and their corresponding operating frequencies.

Either this request or a Set Frequency Index request must be issued prior to a Get Frequency request. This is necessary in order to set up the frequency access information.

Table 32. Setup Stage for Set Frequency Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0x21	Characteristics (host-to-device)
1	bRequest	1	9	Set Report
2	wValue	2	0x0310	Report type – Feature; Report ID – 8-byte data
4	wIndex	2	0x0000	Target - interface
6	wLength	2	0x0008	Report length

Table 33. Data Stage for Set Frequency Request

Offset	Field	Size	Value	Description
0	Report ID	1	0x10	8-byte data report
1	Report Sub-type	1	0x14	Set frequency
2	Reserved	1	0x00	Reserved
3	Reserved	1	0x00	Reserved
4	Frequency	2	0xXXXX	Frequency Select
6 - 7	Not Used	2	0x00	Reserved

Response

If the command cannot be processed, the device stalls endpoint 0. The command cannot be processed if the fields in the data stage are not correct. It cannot be processed if anything other than 8 bytes is sent by the host in the Data stage.

When the request is processed successfully, a positive USB acknowledge (zero length data packet) is sent.

Set Frequency Index

This request sets up some access information related to the controller operating frequency.

Either this request or a Set Frequency request must be issued prior to a Get Frequency request. This is necessary in order to set up the frequency access information.

Table 34. Setup Stage for Set Frequency Index

Offset	Field	Size	Value	Description
0	bmRequestType	1	0x21	Characteristics (host-to-device)
1	bRequest	1	9	Set Report
2	wValue	2	0x0310	Report type- Feature; Report ID – 8 byte
4	wIndex	2	0x0000	Target - Interface
6	wLength	2	8	Report length

Table 35. Data Stage for Set Frequency Index Request

Offset	Field	Size	Value	Description
0	Report ID	1	0x10	8-byte data report
1	Report Sub-type	1	0x15	Set Frequency Index
2	Reserved	1	0x00	Reserved
3	Reserved	1	0x00	Reserved
4 - 7	Not Used	4	0x00	Reserved

Response

If the command cannot be processed, the device stalls endpoint 0. The command cannot be processed if the fields in the data stage are not correct. It cannot be processed if anything other than 8 bytes is sent by the host in the Data stage.

When the request is processed successfully, a positive USB acknowledge (zero length data packet) is sent.

Get Frequency

This is a request to read the operating frequency of the controller to the host.

The request only specifies that a Frequency report is being requested. It cannot specify what frequency setting is required within the report. This must be set up by a previous Set Frequency or Set Frequency Index request. Refer to Table 32 for a list of the available Frequency Select values and their corresponding operating frequencies.

Table 36. Setup Stage for Get Frequency Request

Offset	Field	Size	Value	Description
0	bmRequestType	1	0xA1	Characteristics (device-to-host)
1	bRequest	1	0x01	Get Report
2	wValue	2	0x0310	Report Type – Feature; Report ID - Frequency
4	wIndex	2	0x0000	Target Interface
6	wLength	2	0x08	Length of the Frequency Data report

Response

If the command cannot be processed, the device stalls endpoint 0. The command cannot be processed if the frequency access information was not set previously by a successful Set Frequency or Set Frequency Index request.

The controller sends a Frequency Data report in the data stage. The frequency data is treated as if it is a single word, so USB will send the LSB first.

**Table 37. Data Stage for the Get Frequency Request – Frequency Report**

Offset	Field	Size	Value	Description
0	Report ID	1	0x10	Report ID number
1	Frequency	2	0xXXXX	Frequency Select
2-7	Not Used	5	0x00	Reserved

APPENDIX A

EX111 HID Controller Specifications

This section provides controller specifications such as power requirements, environmental requirements, and cable connectors. The EX111 HID controller is a compact USB controller. This controller can be internally mounted in your display.

The EX111 HID controller has a touch sensor connector (JP2) and a USB cable connector (JP1). The uncased controller measures approximately 1.3 x 2.6 inches with a total height of approximately 0.38-inch from the thru hole pins on the trace side of the board to the top of the highest component on the opposite side. The following figure shows the overall dimensions of the EX111 HID controller and the locations of the mounting holes and connectors.

Figure 3. EX111 HID Controller Overall Dimensions
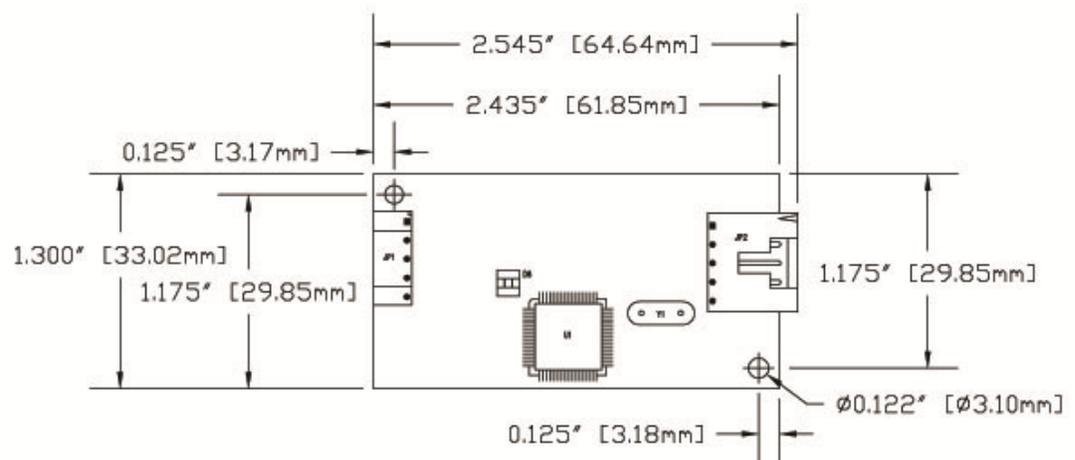
Technical Specifications

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 VDC (75 mA typical, 100 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
RFI – EN 61000-4-3 / ENV 50140	Class A		Compliant
CRFI – EN 61000-4-6	N/A	Cable < 3 meters long	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	N/A		
Voltage Dips – EN 61000-4-11	Class B	< 5% V	
	Class C	< 70% V	Compliant
Voltage Interruptions – EN 61000-4-11	Class C		Compliant
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
UL/cUL			Compliant

Ambient Operating and Storage Environmental Conditions

Note: All humidity is non-condensing

Operating Temperature Range		- 40 °C to +70 °C
Operating Humidity Range	<36° C 0-90% RH	≥ 36 °C (see Figure 4)
Storage Temperature Range		- 50 °C to +85 °C
Storage Humidity Range	< 36°C 0-90% RH	≥ 36 °C (see Figure 4)

Performance and Reliability

Minimum Touch Duration	Typically 5.4 msec
Touch Resolution – (Maximum addressable coordinates generated by the controller)	16K x 16K
ESD Susceptibility[1]-	
±8 kV Contact Discharge – Class 2 per section 9 of IEC 61000-4-2 1 false touch allowed	Compliant
±27 kV Air Discharge – Class 1 per section 9 of IEC 61000-4-2 Normal Operation – No false touches	Compliant
MTBF (by MIL Std. 217F Calculation)	700,000 Hours

Touch System Parameters

Accuracy vs. Dynamic Temperature Change	Maintains 99.0% True Position Accuracy
(Tested at 0 deg. C to 60 deg. C with a 0.5 deg. C/minute temperature ramp)	
Touch Sensor Compatibility	3M Touch Systems Surface Capacitive Touch Sensors
Communications Protocol	USB HID

[1] ESD discharges to a 3M Touch Systems touch sensor connected to the controller

Figure 4. Storage and Operating Temperature with Humidity Conditions