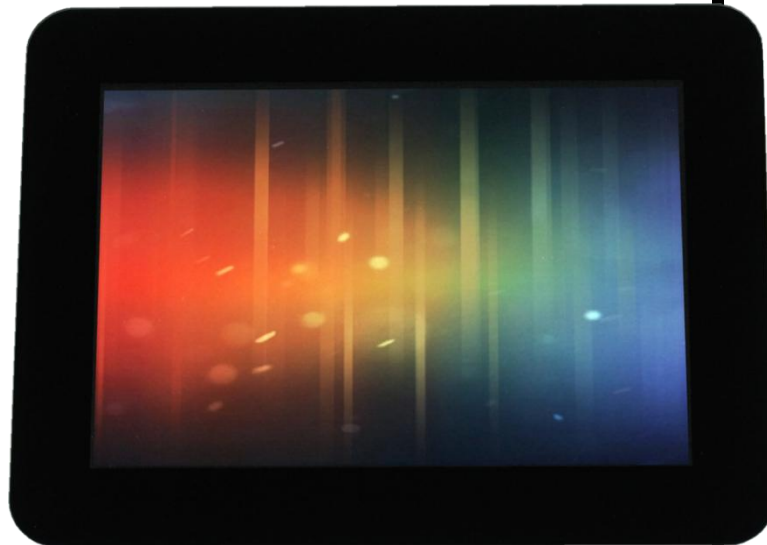


## Features

- Complete Touchscreen Module:
  - Projected Capacitive Multi Touch Controller
  - 3.5in LCD
  - 200 bytes non-volatile serial EEPROM
- Touch:
  - Atmel maXTouch™ mXT112S Touch Controller
  - Supports up to 4 touches
- Display:
  - 320x480 resolution
  - ILI9488 driver IC
  - 30 ms max response time
  - White LED backlight
  - 8-bit MCU parallel interface
- Cover Panel:
  - 1.1mm Soda Lime Glass



## PDA TM3500: 3.5in PCAP Touch Module



Visit <http://www.pdaatl.com/tm3500>  
for the latest information on the TM3500

1410-3-4

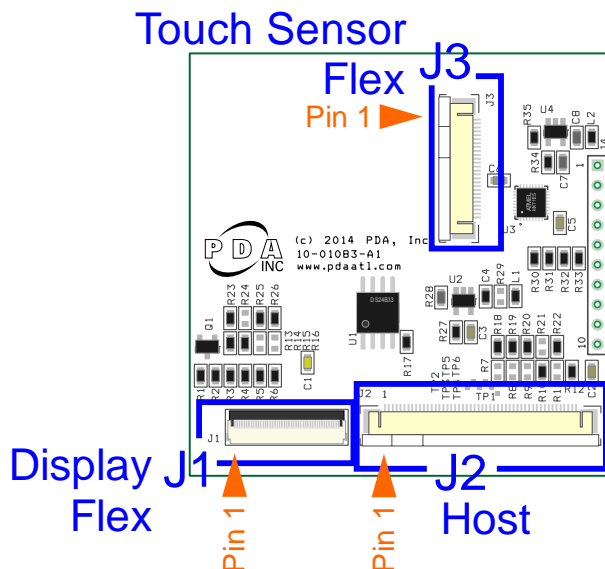
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# 1 Module Overview

## 1.1 PCB Connections



**Figure 1 - PCB Connectors**

NOTE: Insert flex in Host Connector J2 with contacts facing DOWN.

The following notations are used for pin descriptions:

I	Input only	OD	Open drain output
O	Output only, push-pull	P	Ground or power
MXT	maXTouch touchscreen	LCD	LCD Panel
EE	Serial EEPROM		

NOTE: Inputs and output are defined from the standpoint of the Touch Module.

## 1.2 Display Flex Connector J1

Connector J1 connects to the LCD panel flex and carries signals between the Host and the LCD Panel.

Pin	Type	Description
1	P	GND
2	P	LED/K6
3	P	LED/K5
4	P	LED/K4
5	P	LED/K3
6	P	LED/K2
7	P	LED/K1
8	P	LED/A
9	O	IM2
10	O	IM1
11	O	IM0
12	P	VDD_IO
13	P	GND
14	O	LCD_DATA_17
15	O	LCD_DATA_16
16	O	LCD_DATA_15
17	O	LCD_DATA_14
18	O	LCD_DATA_13
19	O	LCD_DATA_12
20	O	LCD_DATA_11
21	O	LCD_DATA_10
22	O	LCD_DATA_9
23	O	LCD_DATA_8

Pin	Type	Description
24	O	LCD_DATA_7
25	O	LCD_DATA_6
26	O	LCD_DATA_5
27	O	LCD_DATA_4
28	O	LCD_DATA_3
29	O	LCD_DATA_2
30	O	LCD_DATA_1
31	O	LCD_DATA_0
32	P	Vdd
33	O	VSYNC
34	O	HSYNC
35	-	N/C
36	O	RDX
37	O	DE
38	O	~RESET
39	O	PCLK
40	O	~SS
41	O	D/CX
42	O	SCK
43	I	MOSI
44	O	MISO
45	P	GND

## 1.3 Host Interface J2

Connector J2 implements Atmel's "XPRO LCD" connector found on various Xplained and Xplained Pro evaluation kits.

It connects to the host and carries signals between the host and (1) the MaXTouch Touch Controller, (2) the LCD Panel, and (3) serial EEPROM.

Suggested Flex (included with the TM3500 kit):

Manufacturer P/N: Wurth Electronics #687 650 100 002

Description: 0.5mm pitch 50 position FFC, Length 100mm

Flex should be inserted in to Connector J2 with contacts facing DOWN towards the PCB.

Pin	Type	Description	MX	TD	EE
1	I/O	One-Wire Interface			•
2	P	GND			
3	I	LCD_DATA_0		•	
4	I	LCD_DATA_1		•	
5	I	LCD_DATA_2		•	
6	I	LCD_DATA_3		•	
7	P	GND			
8	I	LCD_DATA_4		•	
9	I	LCD_DATA_5		•	
10	I	LCD_DATA_6		•	
11	I	LCD_DATA_7		•	
12	P	GND			
13	I	LCD_DATA_8		•	
14	I	LCD_DATA_9		•	
15	I	LCD_DATA_10		•	
16	I	LCD_DATA_11		•	
17	P	GND			
18	I	LCD_DATA_12		•	
19	I	LCD_DATA_13		•	
20	I	LCD_DATA_14		•	
21	I	LCD_DATA_15		•	
22	P	GND			
23	I	LCD_DATA_16		•	
24	I	LCD_DATA_17		•	
25	I	LCD_DATA_18 / TP2		•	

Pin	Type	Description	MX	TD	EE
26	I	LCD_DATA_19 / TP5		•	
27	P	GND			
28	I	LCD_DATA_20 / TP3		•	
29	I	LCD_DATA_21 / TP6		•	
30	I	LCD_DATA_22 / TP4		•	
31	I	LCD_DATA_23 / TP1		•	
32	P	GND			
33	I	PCLK (parallel) / D/CX (SPI)		•	
34	I	VSYNC (parallel) / CS (SPI)		•	
35	I	HSYNC (parallel) / WR (SPI)		•	
36	I	DE (parallel) / RE (SPI)		•	
37	I	SCK		•	
38	I	MOSI		•	
39	O	MISO		•	
40	I	~SS		•	
41	I	DISP		•	
42	I	I <sup>2</sup> C SDA	•		
43	I/O	I <sup>2</sup> C SCL	•		
44	O	~MXT_CHG	•		
45	-	N/C			
46	I	LCD_PWM		•	
47	I	~RESET	•		
48	P	+3.3Vdc			
49	P	+3.3Vdc			
50	P	GND			

## 1.4 Touch Sensor Flex Connector J3

Connector J3 connects to the touch sensor flex and carries signals used by the maXTouch controller to detect input on the touch sensor.

Pin	Type	Description
1	P	GND
2	I/O	X13
3	I/O	X12
4	I/O	X11
5	I/O	X10
6	I/O	X9
7	I/O	X8
8	I/O	X7
9	I/O	X6
10	I/O	X5
11	I/O	X4
12	I/O	X3
13	I/O	X2

Pin	Type	Description
14	I/O	X1
15	I/O	X0
16	P	GND
17	P	GND
18	I/O	Y0
19	I/O	Y1
20	I/O	Y2
21	I/O	Y3
22	I/O	Y4
23	I/O	Y5
24	I/O	Y6
25	I/O	Y7
26	P	GND

## 1.5 Debug Connector J4

Connector J4 carries signals used to debug the maXTouch Touch Controller.

Pin	Type	Description	MXT
1	-	N/C	
2	-	N/C	
3	O	~MXT_CHG	•
4	-	N/C	
5	I	I <sup>2</sup> C SDA	•

Pin	Type	Description	MXT
6	I/O	I <sup>2</sup> C SCL	•
7	P	3.3V	
8	P	GND	
9	O	DBG DATA	•
10	O	DBG CLK	•

## 2 Overview of the 3.5in PCAP Touch Module

### 2.1 Introduction

The TM3500 3.5in PCAP Touch Module is a touchscreen module offering best-in-class projected capacitance multi-touch functionality combined with a 3.5in LCD panel. The module is configured for development and evaluation with several Atmel AVR- and ARM-based evaluation solutions as well as development and integration with a custom host system.

For convenience, this module features a host interface connector for use with hardware supporting the Xplained PRO LCD interface

As shown in Figure 2 below, the module provides host access to several sub-system components to maximize effective integration.

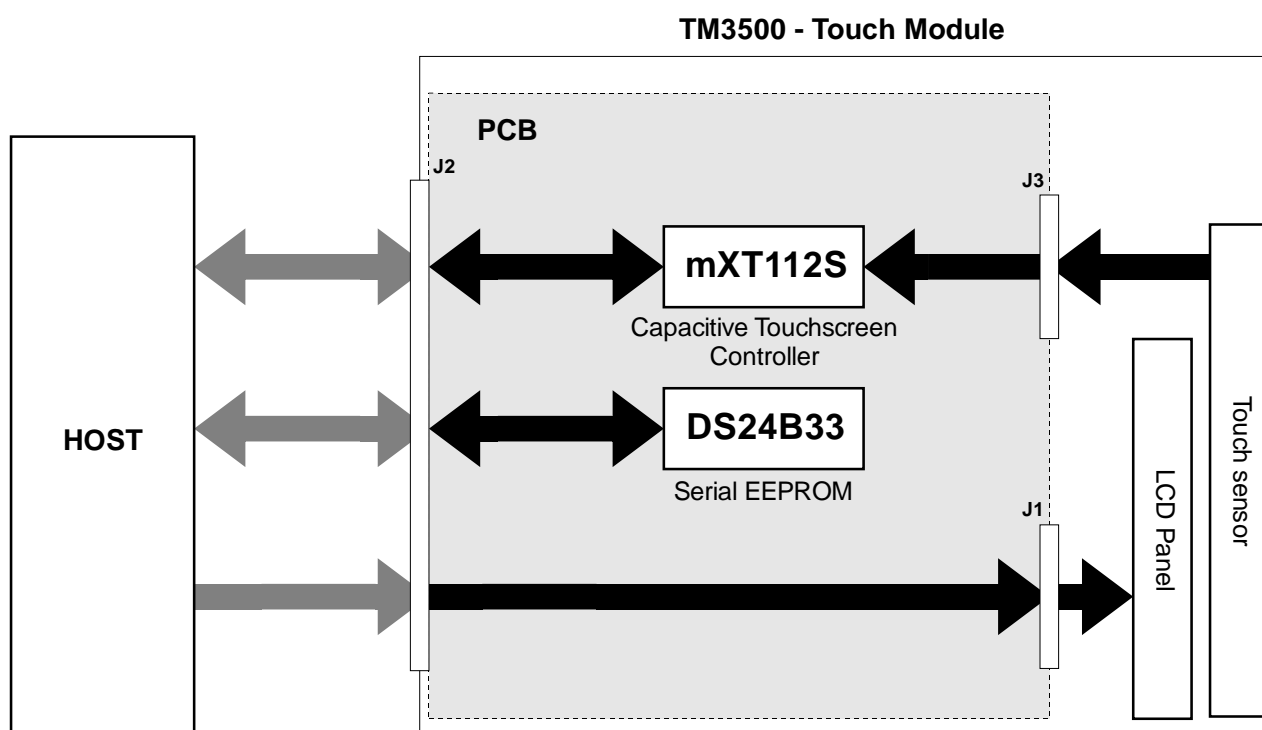


Figure 2 - Functional Block Diagram



## 2.2 Background Concepts

Throughout this document, the functionality of the module sub-system will be outlined and summarized. However, the user is encouraged to refer to the resources and documents below in order to gain a more thorough understanding of each sub-system.

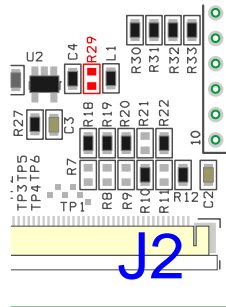
- Atmel maXTouch mXT112S Datasheet ([www.atmel.com](http://www.atmel.com))
- For a basic overview of I<sup>2</sup>C communication, refer to [Section 5](#) of this document
- ILI Technology Corp ILI9488 Driver IC ([www.ilitek.com](http://www.ilitek.com))
- Maxim DS24B33 Datasheet ([www.maximintegrated.com](http://www.maximintegrated.com))

In addition, when developing or evaluating with the Atmel Xplained and Xplained PRO evaluation kits, it is recommended that the user visit [asf.atmel.com](http://asf.atmel.com) and [www.at91.com](http://www.at91.com) which contains a broad range of resources for the EK's and the devices they feature.

Visit [www.pdaatl.com/tm3500](http://www.pdaatl.com/tm3500) for the latest information on this module.

## 2.3 Module Logic Voltage

The module logic voltage is derived from the input supply voltage provided by the host ([Connector J2](#)). This voltage is selectable by optionally populating R29 shown in Figure 3 below.



**Figure 3 - Voltage Selection**

The logic voltages can be selected according to Table 2-1 below.

**Table 2-1 - Logic Voltage Selection**

R29	Direction
0 $\Omega$	3.3V
DNP	<b>2.8V</b>

Note: Factory setting is 2.8V

The interface bus voltage may be adjusted lower (down to 1.8Vdc) if desired. For more information contact PDA.

## 2.4 LCD Panel

The module provides the host with a direct connection from the host ([Connector J2](#)) to the LCD panel interface ([Connector J1](#)). Aside from generating supply voltages for the LED backlight and providing backlight control to the host, no display panel control is performed by the module.

The LCD panel features an ILI 9488 internal driver IC. For further details on interfacing to the ILI9488 contact Precision Design Associates ([www.pdaatl.com](http://www.pdaatl.com)) or ILITEK ([www.ilitek.com](http://www.ilitek.com)). Also, refer to Section 3.2 below for additional resources.

## 2.5 maXTouch Capacitive Touchscreen Controller

The module touch screen interface is based on the Atmel maXTouch mXT112S Touch Controller and operates on the touch sensor at [Connector J3](#).

The touch controller scans the touch sensor and will signal the host with an active low interrupt signal (~MXT\_CHG on [J2](#)) when new touch data is available. Data communication with the maXTouch controller is performed over the I<sup>2</sup>C interface (on [J2](#)). The I<sup>2</sup>C address of the touch controller is fixed at **0x4A** is not configurable.

**NOTE:** The TM3500 has pull-up resistors on the I<sup>2</sup>C SCL (R32) and SDA (R31) lines. A pull-up resistor for the maXTouch ~CHG interrupt signal is located at R33.

### 2.5.1 maXTouch Controller Interface

Details of the maXTouch communication protocol are beyond the scope of this document. However information is provided below to facilitate evaluation and initial development.



**This module is pre-loaded with a configuration already optimized for this touch sensor and panel, so the developer need only focus on interfacing with the device. When developing the maXTouch controller interface during evaluation and host development, care should be taken to avoid changing the maXTouch configuration or committing changes to NV storage on the maXTouch controller.**

To get started with host interface development, the user is *strongly* encouraged to leverage existing code available from the resources outlined in Sections 3.2

## 2.6 Serial EEPROM

The module includes a DS24B33 Serial EEPROM providing 512 bytes of non-volatile storage. Data communication with the EEPROM is performed over a One-Wire Interface. The EEPROM is not used by another subsystem on the touch module and can be freely used by the host system for any purpose. For example, Atmel ARM-based EK's running Linux or Android operating systems use the pre-programmed contents of the EEPROM to identify this module type.



**NOTE:** The user should take care if choosing to overwrite the pre-programmed EEPROM contents. As noted above, certain builds of Linux or Android targeted for the Atmel ARM-based EKs use the EEPROM contents to identify the module and may no longer recognize the module. The user is advised to backup the EEPROM contents before overwriting.

The serial EEPROM is accessed via a one-wire interface (ONE\_WIRE Interface on [J2](#)). Refer to the DS24B33 Datasheet ([www.maximintegrated.com](http://www.maximintegrated.com)) for details.

### 3 Getting Started

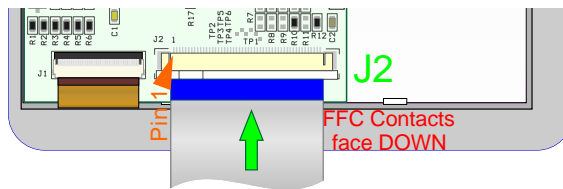
This module was designed for use with a variety of Atmel ARM-based EK's including the SAM4S Xplained Pro and SAMA5D3 Xplained evaluation kits. This provides the fastest way to evaluate the performance of the touchscreen and display.

The following sections provide basic information related to using and evaluating the Touch Module. Visit the Precision Design Associates website ([www.pdaatl.com/tm3500](http://www.pdaatl.com/tm3500)) or Atmel's AT91 Community website ([www.at91.com](http://www.at91.com)) for more information related to this touch module or guidance appropriate for your specific EK.

#### 3.1 Hardware Connections

The module interfaces with the EK board via the Host Interface at flex connector, **J2**. The Flat Flex Cable should be inserted with flex contacts facing DOWN toward the PCB as shown in Figure 4 below.

This interface can be used connected to Atmel evaluation kits that support the "XPRO LCD" connector. Refer to EK documentation to see if this interface is supported by the evaluation hardware and ensure proper matchup of host signals.



## 3.3 Using the Touch Module

### 3.3.1 Evaluating the Touch Module

For effective evaluation of the module's touch sensor and LCD panel, the user is encouraged to try the following applications and tools depending on the desired host OS.

#### 3.3.1.1 Android

Atmel provides prebuilt Android system images for use with some of their ARM evaluation kits which can be used to demonstrate the touch module. Visit the Android4SAM website ([www.at91.com/android4sam](http://www.at91.com/android4sam)) for more details.

Follow the guides on the AT91 Community website or the PDA website for info on how to load the system image onto your evaluation kit hardware.

In addition, the following Android apps are available from Google Play:

[TouchTest](#) by Moonblink

[Dotty](#) by Gerry Steele

[Multitouch Visible Test](#) by Battery Powered Games

[Screen Test](#) by Amberfog

#### 3.3.1.2 Linux

Atmel provides prebuilt Linux system images for use with some of their ARM evaluation kits which can be used to demonstrate the touch module. Visit the Linux4SAM website ([www.at91.com/linux4sam](http://www.at91.com/linux4sam)) for more details.

Some system images include demo UI applications from Qt Timesys and Crank Software. The user can perform simple touch / drawing test using the `ts_test` utility that is part of `tslib`.

Follow the guides on the AT91 Community website or the PDA website for info on how to load the system image onto your evaluation kit hardware.

#### 3.3.1.3 “Bare Metal”

Check the Precision Design Associates website ([www.pdaatl.com/tm3500](http://www.pdaatl.com/tm3500)) for links to demo binaries for use with the TM3500.

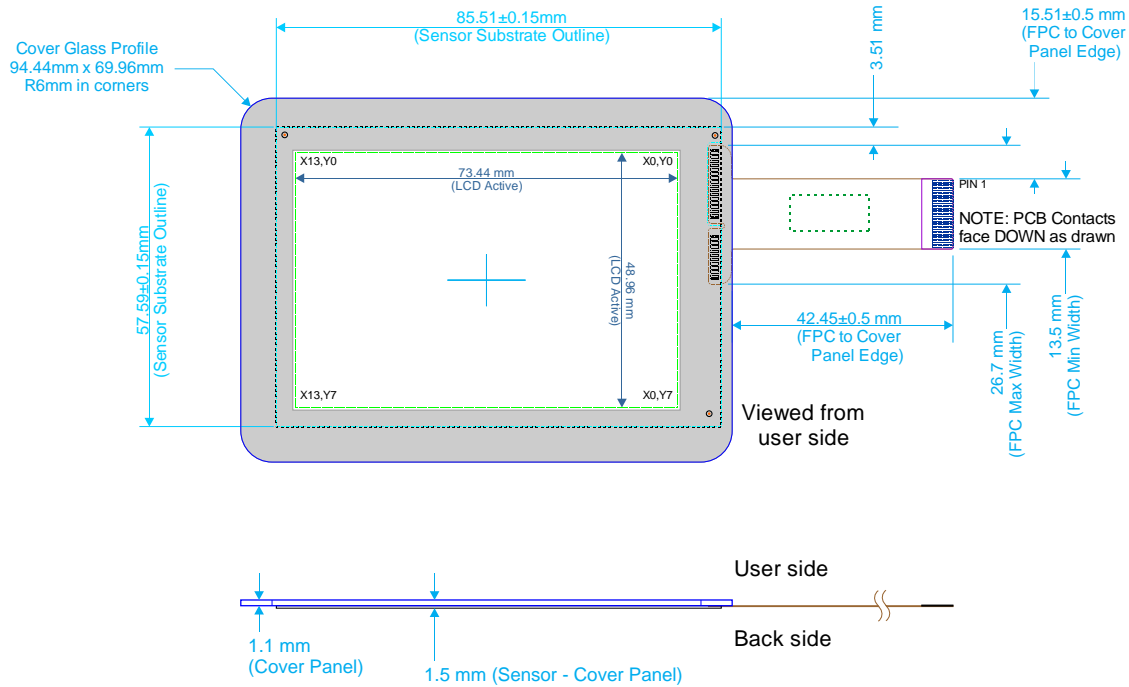
## 4 Specifications

Except where noted, the following specifications apply to the whole TM3500 assembly.

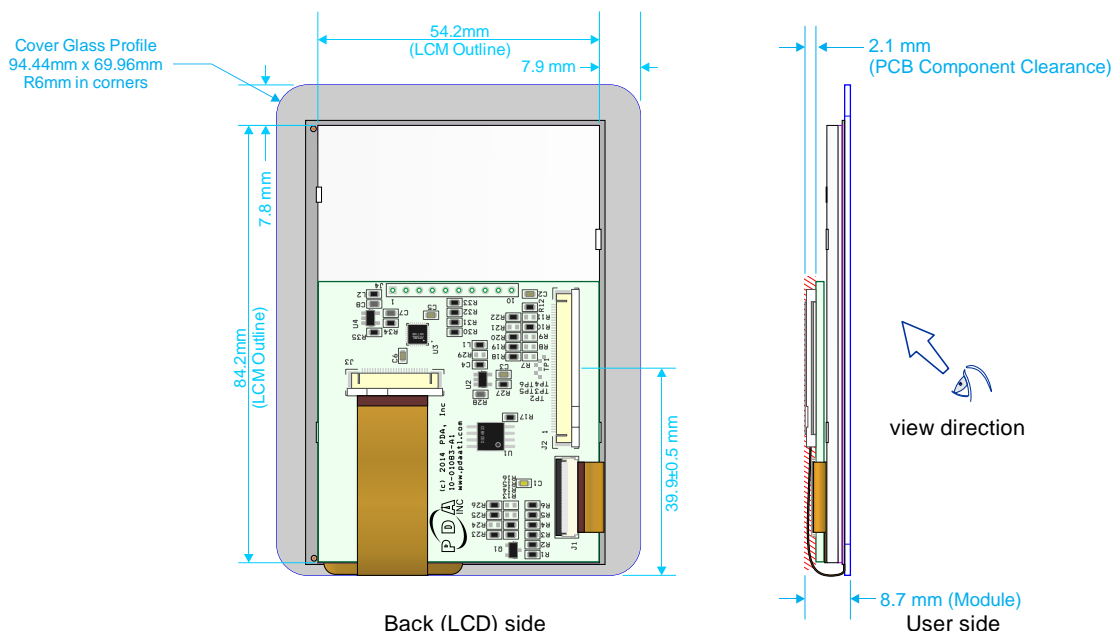
For complete specifications, refer to the datasheets listed in section 2.2 for the various sub-system components outlined in Sections 2.4 through 2.6 or contact PDA.

### 4.1 Mechanical Specifications

Drawings and CAD models available upon request.



Sensor (P/N: 90-00023-A1) may be purchased individually.  
Minimum order quantities apply. Contact PDA for details.



**Figure 6 – Module Dimensions**

## 4.2 Module Parameters

Parameter	Value
Module Size	3.5in
Overall Dimensions	69.96mm (H) x 94.44mm (W) x 8.7mm (T)
Overall Weight	48.8g

## 4.3 Absolute Maximum Specifications

Parameter	Value
Operating temp	0°C to + 70°C
Storage temp	-30°C to + 80°C
Vdd	-0.5 to +6V
Max continuous pin current, any control or drive pin	±40 mA
Voltage forced onto any pin	-0.5V to (Vdd + 0.5) Volts



**CAUTION:** Stresses beyond those listed under *Absolute Maximum Specifications* may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or other conditions beyond those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum specification conditions for extended periods may affect device reliability.

#### 4.4 Recommended Operating Conditions

Parameter	Value
V <sub>in</sub>	3.3V $\pm$ 5 percent
Supply ripple + noise	$\pm$ 20 mV

#### 4.5 DC Specifications

V<sub>in</sub> = 3.3V, V<sub>dd</sub>=2.8VDC, T<sub>a</sub> = recommended range, unless otherwise noted

Parameter	Description	Min	Typ	Max	Units	Notes
V <sub>IL</sub>	Low input logic level	- 0.5	–	0.3 V <sub>dd</sub>	V	1.8V <V <sub>dd</sub> <3.3V
V <sub>HL</sub>	High input logic level	0.7 V <sub>dd</sub>	–	V <sub>dd</sub> + 0.5	V	1.8V <V <sub>dd</sub> <3.3V
V <sub>OL</sub>	Low output voltage	–	–	0.2V <sub>dd</sub>	V	
V <sub>OH</sub>	High output voltage	0.8V <sub>dd</sub>	–	–	V	
I <sub>IL</sub>	Input leakage current	–	–	1	$\mu$ A	

#### 4.6 I2C-compatible Bus Specifications

Parameter	Operation
Touchscreen Controller Address	0x4A
Maximum bus speed (SCL)	400 kHz
I2C Specification	Version 2.1
Bus Voltage	2.8V (Adjustable down to 1.8V – Contact PDA)

#### 4.7 Power Consumption

V <sub>dd</sub> (V)	Mode	I <sub>dd</sub> (mA)
3.3Vdc	mXT112S in Free Run, LCD backlight on maximum intensity	200

## 4.8 LCM Specification


Specifications in this section apply only to the LCD panel.

### 4.8.1 LCM Parameters

Parameter	Value
Display Size	3.5in
LCD Type	$\alpha$ -Si TFT
Display Mode	TN / Transmissive
Resolution	320 x RGB x 480
View Direction (Best Image)	6 O'clock (Portrait, LCD flex end at bottom)
Dimensions	54.16mm (H) x 84.21mm (W) x 2.15mm (T)
Active Area	48.96mm x 73.44mm
Pixel Size	0.153mm x 0.153mm
Pixel Arrangement	Stripe
Display Colors	262K
Interface	8-bit Parallel MCU is used in TM3500
Driver IC	ILI9488
Weight	15.5g



## 4.8.2 LCM Absolute Maximum Specifications

Parameter	Description	Min	Max	Units
$V_{CC}$	Supply Voltage	-0.3	4.6	V
$IOV_{CC}$	IO Supply	-0.3	4.6	V
$V_I$	Input Voltage	- 0.3	$IOV_{CC} + 0.3$	V
$T_{STG}$	Storage temperature	-30	+80	°C
$T_{OP}$	Operating temperature	-20	+70	°C
$H_{STG}$	Storage humidity ( $T_a < 50\text{ °C}$ )	10	90	%RH
	Storage humidity ( $T_a > 60\text{ °C}$ )	10	60	%RH
$H_{OP}$	Operating humidity ( $T_a < 50\text{ °C}$ )	10	90	%RH
	Operating humidity ( $T_a > 60\text{ °C}$ )	10	60	%RH
 <b>CAUTION:</b> Stresses beyond those listed under LCM <i>Absolute Maximum Specifications</i> may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or other conditions beyond those indicated in the operational sections of this specification are not implied. Exposure to absolute maximum specification conditions for extended periods may affect device reliability.				

## 4.8.3 LCM DC Specifications

Parameter	Description	Min	Typ	Max	Units
$V_{CC}$	Power Supply	2.4	2.8	3.3	V
$IOV_{CC}$	IO Supply	1.65	1.8	3.3	V
$V_{IL}$	Low input logic level	- 0.3 $IOV_{CC}$	—	0.3 $IOV_{CC}$	V
$V_{HL}$	High input logic level	0.7 $IOV_{CC}$	—	$IOV_{CC}$	V
$V_{OL}$	Low output voltage	—	—	0.2 $IOV_{CC}$	V
$V_{OH}$	High output voltage	0.8 $IOV_{CC}$	—	—	V

#### 4.8.4 LCM Backlight Specifications

Parameter	Description	Min	Typ	Max	Units
$V_f$	Forward Voltage ( $T_a=25^{\circ}\text{C}$ , $I_f=15\text{mA}$ )	–	3.2	3.5	V
$I_f$	Forward Current ( $T_a=25^{\circ}\text{C}$ , $V_f=3.2\text{A}$ ), per LED	–	20	–	mA
	LED Configuration	6x White LED in parallel			
	Drive method	Constant current			
$L_v$	Luminance	280	300	–	$\text{cd/m}^2$
Avg	Uniformity	80	85	–	%
$\text{CIE}_x$	CIE (X)	0.26	0.28	0.3	
$\text{CIE}_y$	CIE (Y)	0.26	0.28	0.3	
$P_d$	Power Dissipation	–	384	–	mW
$V_{AK}$	Backlight Driving Voltage	–	3.3	3.5	V

#### 4.8.5 LCM Optical Characteristics

Backlight On (Transmissive Mode).

Parameter	Description	Min	Typ	Max	Units
$L_v$	Luminance	280	300	–	$\text{cd/m}^2$
CR	Contrast Ratio	–	300	–	
$T_R$	Response Time (rise: 10% to 90%)	–	10	20	ms
$T_F$	Response Time (fall: 90% to 10%)	–	20	30	ms
$X_R$	Chromaticity: Red	0.586	0.636	0.706	–
$Y_R$		0.281	0.339	0.401	–
$X_G$	Chromaticity: Green	0.251	0.290	0.371	–
$Y_G$		0.569	0.603	0.689	–
$X_B$	Chromaticity: Blue	0.083	0.142	0.203	–
$Y_B$		0.014	0.053	0.134	–
$X_W$	Chromaticity: White	0.2600	0.2900	0.3200	–
$Y_W$		0.2800	0.3100	0.3400	–
-	NTSC Ratio (Gamut)	–	60	–	–

#### 4.9 TM3500 Part Number

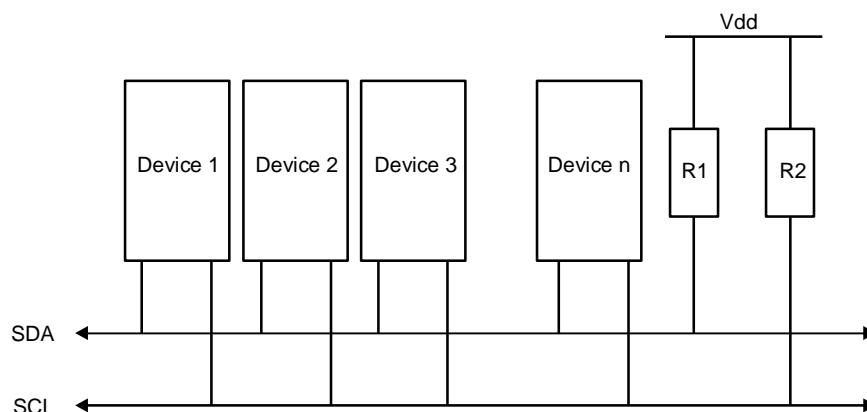
Part Number	Description
90-00035-A0	TM3500: 3.5" Touchscreen Module

## 5 I2C Basics (I2C-compatible Operation)

### 5.1 Interface Bus

The device communicates with the host over an I<sup>2</sup>C-compatible bus, in accordance with version 2.1 of the I<sup>2</sup>C specification. The following sections give an overview of the bus; more detailed information is available from [www.i2c-bus.org](http://www.i2c-bus.org). Devices are connected to the I<sup>2</sup>C-compatible bus as shown in Figure 7 both bus lines are connected to Vdd via pull-up resistors. The bus drivers of all I<sup>2</sup>C-compatible devices must be open-drain type. This implements a wired “AND” function that allows any and all devices to drive the bus, one at a time. A low level on the bus is generated when a device outputs a zero.

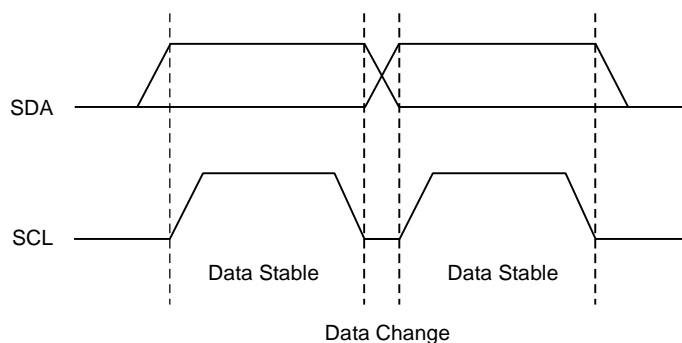
**Figure 7. I<sup>2</sup>C-compatible Interface Bus**



### 5.2 Transferring Data Bits

Each data bit transferred on the bus is accompanied by a pulse on the clock line. The level of the data line must be stable when the clock line is high; the only exception to this rule is for generating START and STOP conditions.

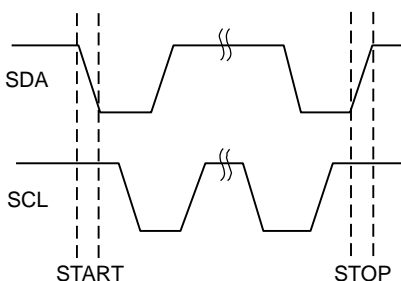
**Figure 8. Data Transfer**



### 5.3 START and STOP Conditions

The host initiates and terminates a data transmission. The transmission is initiated when the host issues a START condition on the bus, and is terminated when the host issues a STOP condition. Between the START and STOP conditions, the bus is considered busy. As shown in Figure 9 START and STOP conditions are signaled by changing the level of the SDA line when the SCL line is high.

### Figure 9. START and STOP Conditions

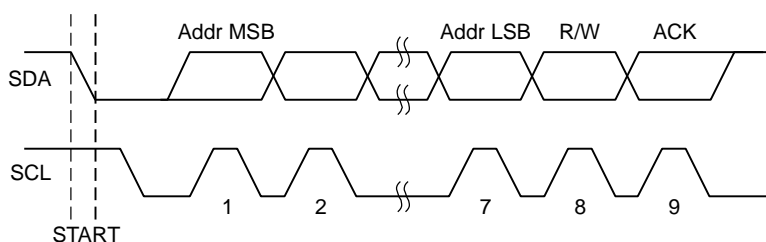


## 5.4 Address Byte Format

All address bytes are 9 bits long. They consist of 7 address bits, one READ/WRITE control bit and an acknowledge bit. If the READ/WRITE bit is set, a read operation is performed. Otherwise a write operation is performed. An address byte consisting of a slave address and a READ or a WRITE bit is called SLA+R or SLA+W, respectively. When the device recognizes that it is being addressed, it acknowledges by pulling SDA low in the ninth SCL (ACK) cycle.

The most significant bit of the address byte is transmitted first.

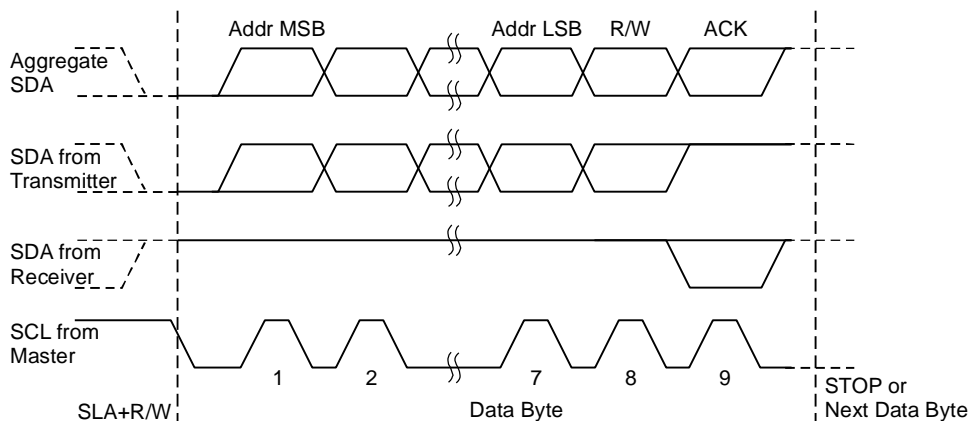
**Figure 10. Address Byte Format**



## 5.5 Data Byte Format

All data bytes are 9 bits long, consisting of 8 data bits and an acknowledge bit. During a data transfer, the host generates the clock and the START and STOP conditions. The slave device is responsible for acknowledging the reception. An acknowledge (ACK) is signaled by the slave device pulling the SDA line low during the ninth SCL cycle. If the slave device leaves the SDA line high, a NACK is signaled.

### Figure 11. Data Byte Format

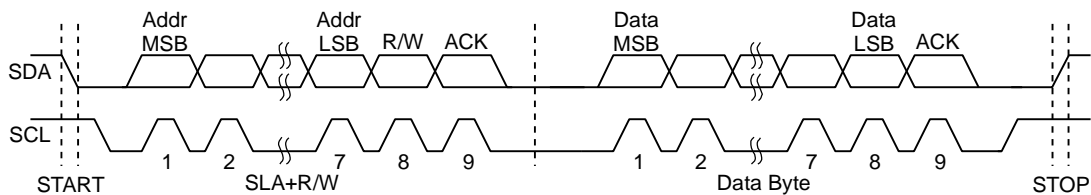


## 5.6 Combining Address and Data Bytes into a Transmission

A transmission consists of a START condition, an SLA+R or SLA+W, one or more data bytes and a STOP condition. The wired “ANDing” of the SCL line is used to implement handshaking between the host and the device. The device extends the SCL low period by pulling the SCL line low whenever it needs extra time for processing between the data transmissions.

Figure 12 shows a typical data transmission. Note that several data bytes can be transmitted between the SLA+R or SLA+W and the STOP.

**Figure 12. Byte Transmission**



## 6 Revision History

Revision No.	History
Rev1404-1-1	Preliminary Draft (limited release)
Rev1410-2-2	Initial Release
Rev1410-3-4	LCD Parameters added to Specification Section (4.7). Figure 7 updated.

## 7 Notes



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