5.5" 4-Lane MIPI 720p LCD Display Module With maXTouch® Technology

AC40T08A

Preface

The MPU32-MIPI-DISPLAY-720P with maXTouch® technology (AC40T08A) is designed to evaluate the Microchip graphics display solution and graphics library for 32-bit microcontrollers and microprocessors.

This AC40T08A is electrically and mechanically compatible with Microchip MPU Curiosity boards.

The figure below illustrates the AC40T08A maXTouch display module.

1. Introduction

This section describes the features of the Microchip AC40T08A and provides an overview of the 5.5" 4-Lane MIPI 720p LCD Display Module kit.

1.1 Features

The key features of the Microchip AC40T08A kit are:

- Display
  - 5.5-inch display module
  - Himax HX8394-F LCD driver
  - LCD 720 x 1280 resolution
  - 4-lane MIPI serial interface
- Backlight
  - Microchip MIC2289 white LED backlight driver
- Touch
  - Microchip mXT336UD maXTouch capacitive touch screen controller
  - Support for up to 10 touches
  - 1.1 mm soda-lime glass
- Power Supply
  - Microchip MIC23150 buck regulator for 3.3V generation
- Hardware Identification System
  - Programmed Microchip 24AA014H 1-Kbit I²C EEPROM

Kit contents

- One 5.5-inch display module with its control board
- One 34-way flexible flat cable (FFC)

1.2 Kit Overview

The Microchip 5.5" 4-Lane MIPI 720p LCD Display Module kit is an extension board for Microchip MPU Curiosity boards, with 720 x 1280 MIPI LCD resolution and a capacitive touch sensor with a maXTouch controller. The LCD is composed of the following interfaces:

- A four-lane MIPI interface
- An I²C interface for maxTouch controller and EEPROM identification and communications
- A digital backlight brightness control
- Static GPIO for the LCD module control (Module Enable, Display Control and Global Reset)

1.3 Additional Resources

For additional information, refer to the information available via these links:

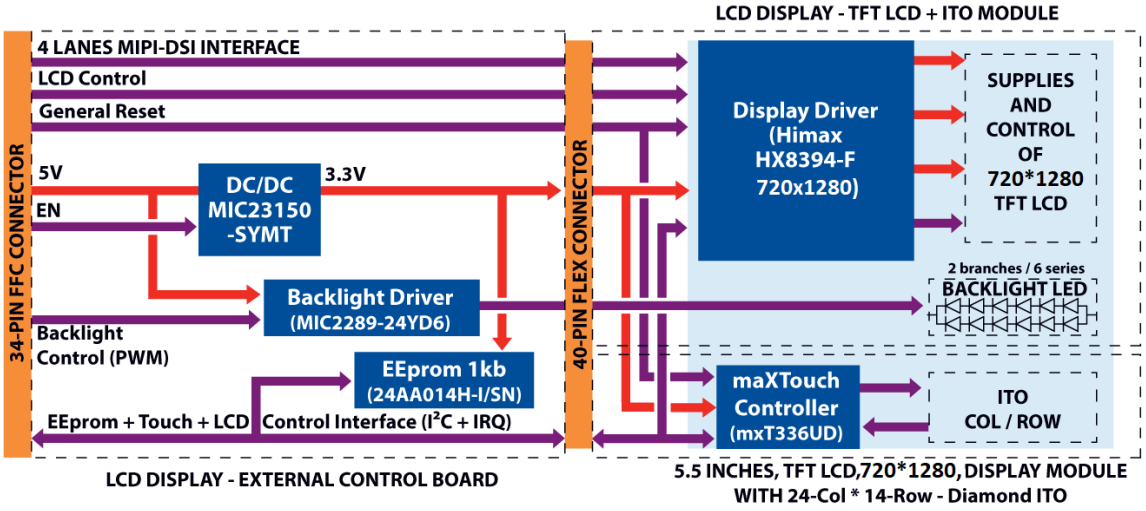
- Himax HX8394-F LCD Driver IC (www.himax.com.tw)
- Microchip mXT336UD maXTouch® Capacitive Touchscreen Controller (www.microchip.com/en-us/product/ATMXT336UD)
- Microchip MIC2289 White LED backlight driver (www.microchip.com/en-us/product/MIC2289)
- Microchip MIC23150 Synchronous Buck Regulator (www.microchip.com/en-us/product/MIC23150)
- Microchip 24AA014H 1 Kbit I²C Serial EEPROM (www.microchip.com/en-us/product/24AA014H)

2. LCD Module Overview

This section covers the specifications of the AC40T08A kit and provides a high-level description of the board's major components and interfaces.

2.1 Block Diagram

Figure 2-1. AC40T08A Block Diagram

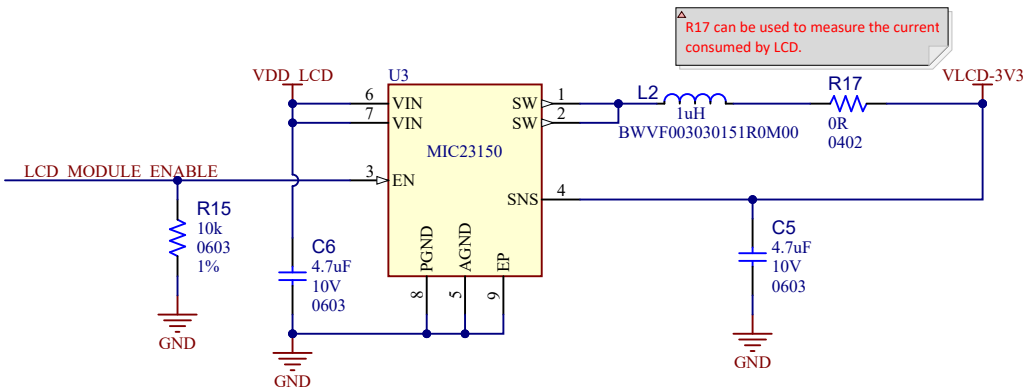


2.2 System Power-On/Power-Off

VDD_LCD is a 5V power input from the external processor board. It must be converted to the 3.3V VLCD_3V3 power rail for the EEPROM memory and the MIPI display.

The MIC23150 is implemented, which is a synchronous Buck regulator with a HyperLight Load® mode. HyperLight Load technology provides high efficiency at light loads and ultra-fast transient response, making it suitable for supplying processor core voltages.

Figure 2-2. System Power-On/Power-Off



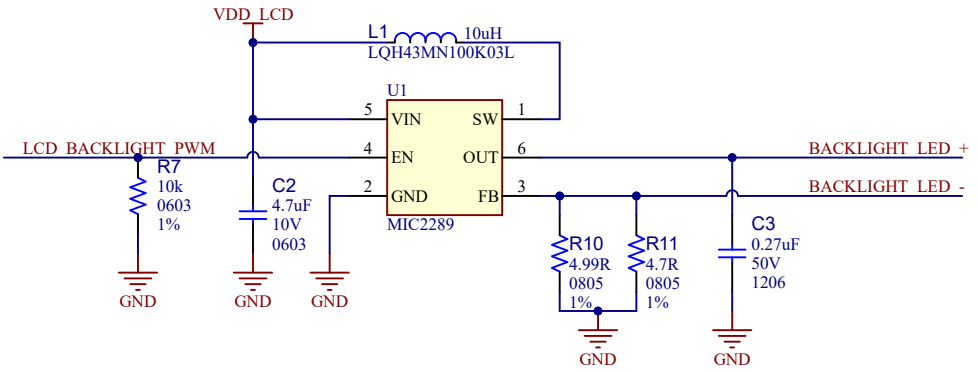
2.3 Backlight Control

The backlight management of the LCD module is ensured by a Microchip MIC2289 PWM boost-switching regulator optimized for constant-current white LED driver applications.

The MIC2289 implements a constant frequency 1.2 MHz PWM control scheme. The added benefit of the constant-frequency PWM scheme, in comparison to the variable-frequency one, is the significantly lower noise and input ripple injected into the input power source.

For more details on the MIC2289 backlight driver, see Additional Resources.

Figure 2-3. MIC2289 Backlight Driver Schematic



By default, after MPU NRST is released, the backlight driver is off and a command on LCD_BACKLIGHT_PWM must be applied to power on the LCD module backlight.

2.4 maXTouch® Capacitive Touchscreen Controller

The module's touch screen interface is based on the Microchip maXTouch mXT336UD Touch Controller and operates on the touch sensor at connector J2. The touch controller scans the touch sensor and signals the host with an active-low interrupt signal (MXT_IRQ on J1) when new touch data is available.

Data communication with the maXTouch controller is performed via the I2C interface (LCD_I²C_DATA and LCD_I²C_CLK on J1). The I2C address of the touch controller is fixed at 0x4A and is not configurable.

Important: The maXTouch has no pull-up resistors featured on the I²C Bus (LCD_I²C_DATA and LCD_I²C_CLK) or its interrupt line (MXT_IRQ). They must be featured on the host board driving the display

Details of the maXTouch communication protocol are beyond the scope of this document. This module is pre-loaded with a configuration already optimized for the maXTouch touch sensor and panel, hence the developer will 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 non-volatile storage on the maXTouch controller. To start with host interface development, users need to leverage the existing code available from Linux which is available at www.microchip.com/linux for more details or from MPLAB® Harmony, which is available at www.microchip.com/mplab/mplab-harmony.

For additional information regarding maXTouch devices, refer to www.microchip.com.

2.5 LCD Module Identification With EEPROM

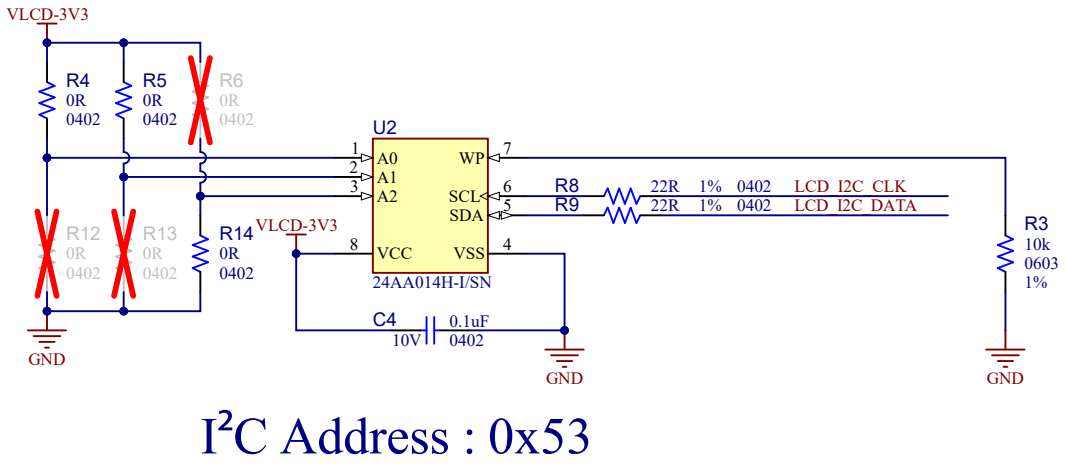
The 5.5" 4-Lane MIPI 720p LCD Display Module kit embeds a 24AA014H 1-Kbit EEPROM used for LCD module identification.

The Microchip 24AA014H is a 1-Kbit serial EEPROM with operation down to 1.7V. The device is organized as a single block of 128 x 8-bit memory with a 2-wire serial interface. Low-current design

permits operation with maximum standby and active currents of only 1 µA and 400 µA, respectively. The device has a page write capability of up to 16 bytes of data.

For more details on the 24AA014H EEPROM memory, refer to Additional Resources.

Figure 2-4. 24AA014H Module Identification Schematic



Important: The 24AA014H EEPROM is accessible through the I²C bus at 0x53 address. No other components with the same I²C address can be connected on the same bus.

Important: It is recommended not to erase the data stored in the 24AA014H EEPROM. This data is necessary at the system level for the LCD module identification.
The data contained is a 42-byte word described in the table below.

Table 2-1. EEPROM Memory Mapping

Byte(s) N°(1)	Type	Information	Default Value
[0]	Decimal	Number of bytes	0x2A (42 bytes)
[5:2]	ASCII String [4]	Microchip division	0x4D505520 (MPU)
[8:7]	ASCII String [2]	Manufacturer country	0x434E (CN)
[21:10]	ASCII String [12]	Ordering code	0x414334305430384120202020 (AC40T08A)
[32:23]	ASCII String [10]	Main device embeds	0x48583833393420202020 (HX8394)
[34]	Decimal	Manufacturing code (year)	0x18 (2024)(2)
[35]	Decimal	Manufacturing code (week)	0x0A (Week 10)(2)
[37]	ASCII String [1]	Hardware revision	0x31 (Revision 1)
[39]	ASCII String [1]	Mapping revision	0x41 (Revision A)
[41]	Hexa Data	CRC-8 checksum	N/A

Notes:

1. Unspecified bytes are used as data separators and contain the value 0x2D.
2. These values are examples and may vary, depending on the batch.

3. Connecting AC40T08A to a Microchip MPU Curiosity Board

The AC40T08A can be easily mounted on the MIPI display-capable Microchip MPU Curiosity boards. A connection using a flexible flat cable (FFC), which is contained in the box with the display, is necessary to control the LCD module by software.

Important: In this section, the Curiosity board pictured is just an example. Refer to the respective host board documentation for more information about connection details, cables and accessories.

Four connectors are used between the LCD module and the Microchip MPU Curiosity board for the mechanical connection, thus ensuring stability of the ensemble.

3.1 Microchip MPU Curiosity Board Connector

Microchip MPU Curiosity boards are evaluation platforms that provide a full Microchip embedded microprocessor experience to users. This platform consists of a series of microcontrollers and extension boards, which are supported by Linux and/or by MPLAB® X IDE, MPLAB Harmony drivers, demo code, etc.

The AC40T08A is connected to the MPU host board with an FFC to the J1 connector, the schematic and pinout of which are described below.

Figure 3-1. Microchip MPU Curiosity Board Connector Schematic

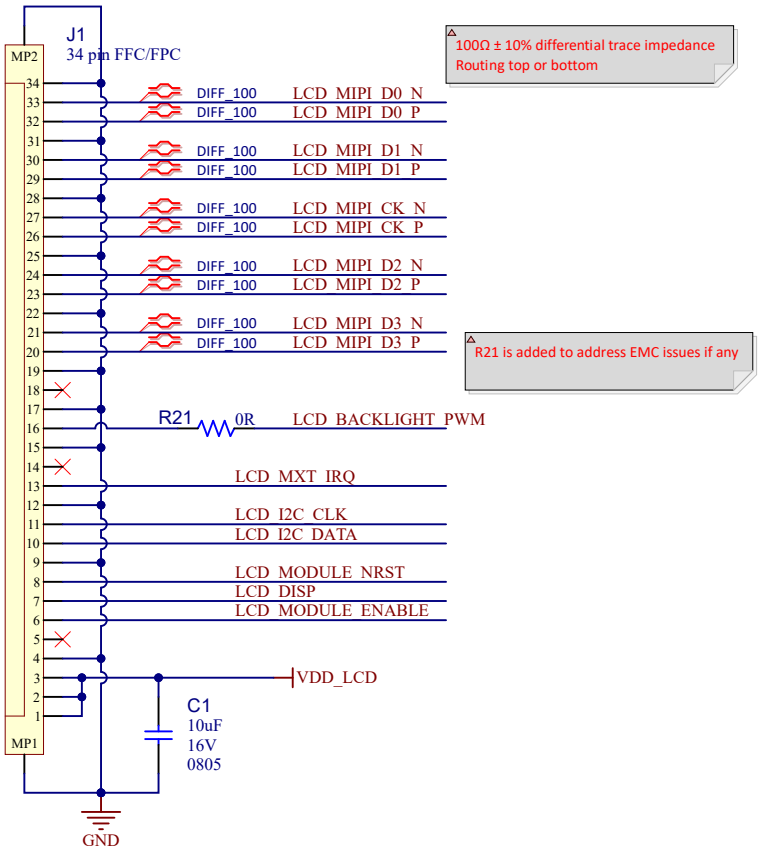


Table 3-1. Microchip MPU Curiosity Board Connector Pinout

Pin Number	Signal Name	I/O Type	Description
33	LCD_MIPI_D0_N	Input	Negative MIPI Differential Data Line 0
32	LCD_MIPI_D0_P	Input	Positive MIPI Differential Data Line 0
30	LCD_MIPI_D1_N	Input	Negative MIPI Differential Data Line 1
29	LCD_MIPI_D1_P	Input	Positive MIPI Differential Data Line 1
27	LCD_MIPI_CK_N	Input	Negative MIPI Differential Clock Line
26	LCD_MIPI_CK_P	Input	Positive MIPI Differential Clock Line
24	LCD_MIPI_D2_N	Input	Negative MIPI Differential Data Line 2
23	LCD_MIPI_D2_P	Input	Positive MIPI Differential Data Line 2
21	LCD_MIPI_D3_N	Input	Negative MIPI Differential Data Line 3
20	LCD_MIPI_D3_P	Input	Positive MIPI Differential Data Line 3
16	LCD_BACKLIGHT_PWM	Input	Backlight Driver Control
13	LCD_MXT_IRQ	Output	Touch Screen Controller Interrupt
11	LCD_I2C_CLK	Input	Touch Screen Controller I²C Clock Line
10	LCD_I2C_DATA	Bidir	Touch Screen Controller I²C Data Line
8	LCD_MODULE_NRST	Input	LCD Module General Reset Line (LCD Driver, Touch Screen Controller)
7	LCD_DISP	Input	LCD Driver Enable
6	LCD_MODULE_EN	Input	LCD Module Enable
18,14,5	NC	NC	Not Connected
3, 2, 1	VDD_LCD	Power	LCD Module 5V Main Supply
34,31, 28, 25, 22, 19, 17, 15, 12, 9, 4	GND	Power	Ground Supply

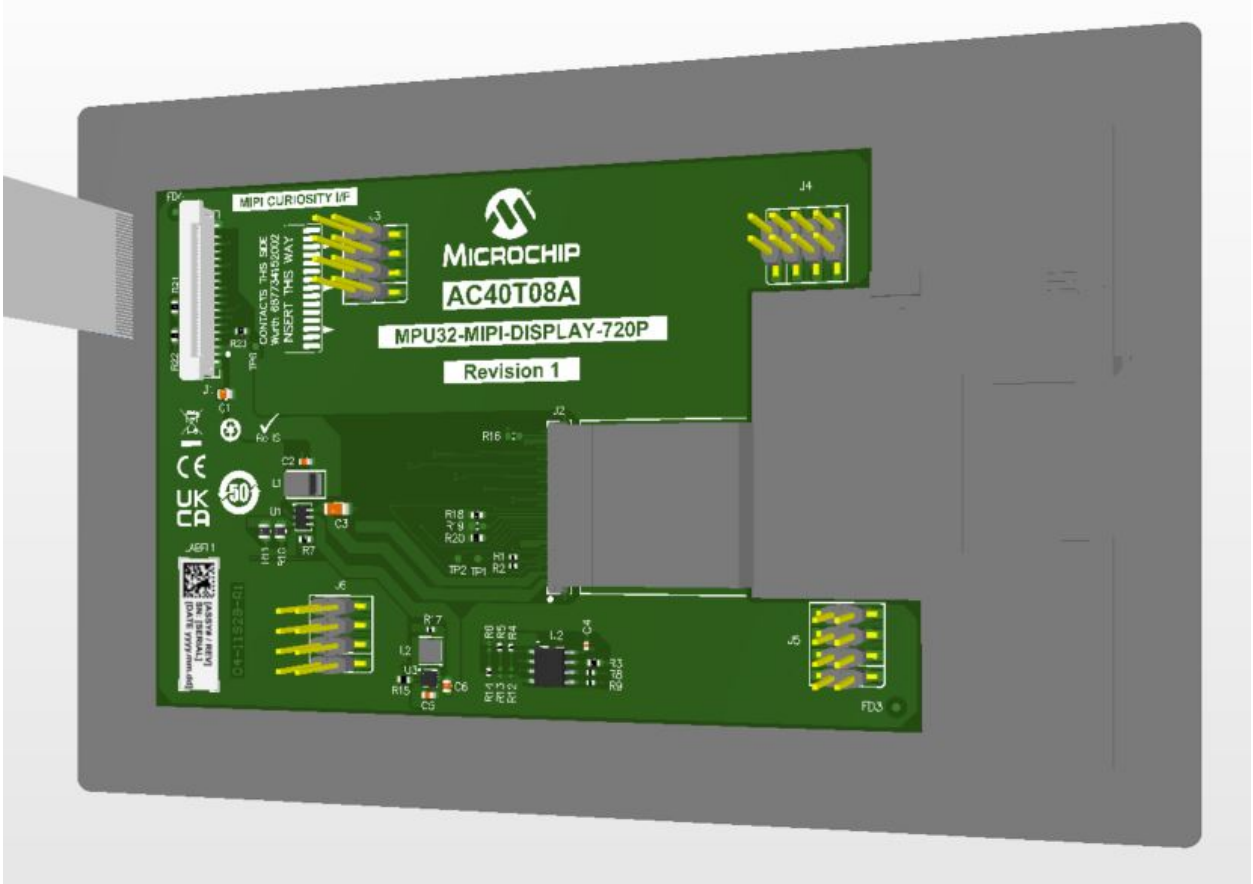
3.2 Connecting the LCD Module to the Curiosity Board

3.2.1 Connecting the Flexible Flat Cable (FFC)

To connect the LCD module to the host board using the flexible flat cable (FFC), follow the sequence below:

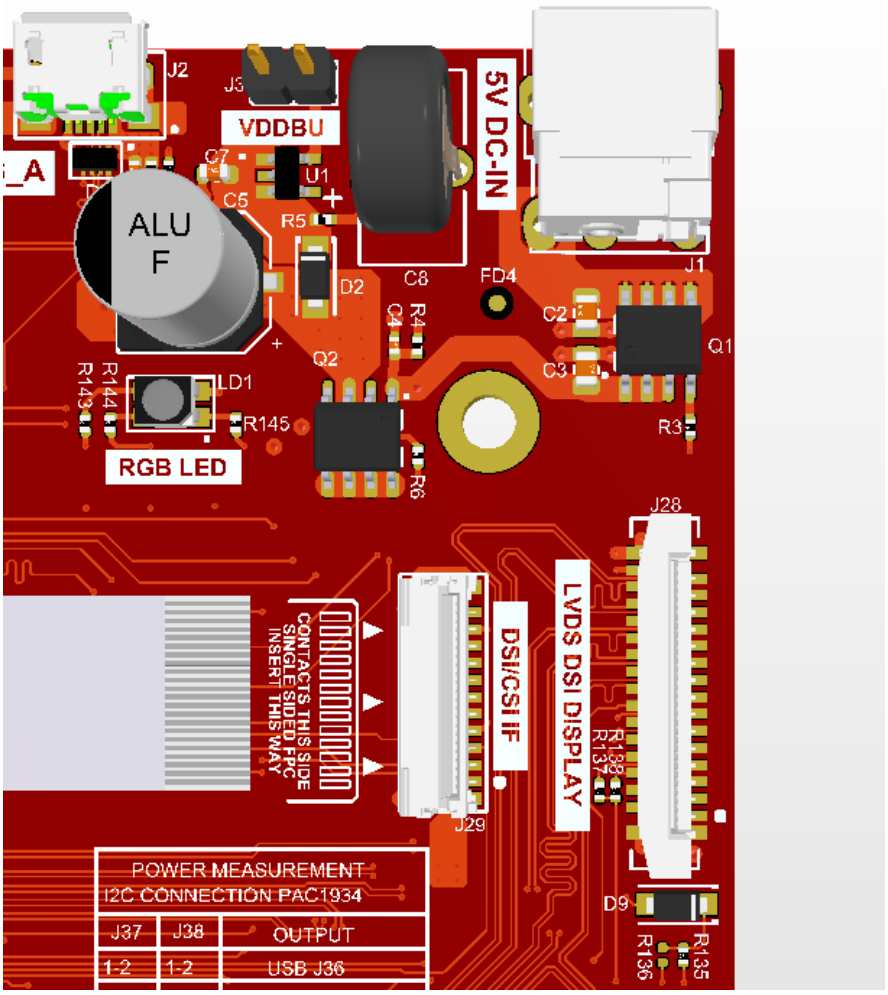
- First :
  - Connect the FFC to the LCD module as illustrated in Figure 3-2.
  - Ensure that the metallic fingers of the FFC are facing towards the interior of the board when the FFC is inserted in the header J1, as shown in Figure 3-2.
  - Verify that Pin 1 of the FFC is aligned with Pin 1 of the J1 connector of the AC40T08A board.

Figure 3-2. Connecting the FFC to the LCD Module



- Second:
  - Connect the FFC to the host board as illustrated in Figure 3-3.
  - Ensure that the FFC metallic fingers are facing towards the outside of the board when it is inserted in the connector, as shown in Figure 3-3.
  - Verify that Pin 1 of the FFC is aligned with Pin 1 of the connector.

Figure 3-3. Connecting the FFC to the Curiosity Board



3.2.2 Mechanical Connection of the LCD Module with the Curiosity Board

Once the FFC connecting the board to the module is in place, follow the steps below to position the AC40T08A correctly on the Curiosity board.

1. Position the LCD module so that the four 2x4-pin headers (circled in red) are above the Curiosity board headers (circled in white) as illustrated in Figure 3-4 below.
2. Be sure that the FFC connecting the two boards is not twisted.
3. Push the LCD module headers into the Curiosity board headers as shown in Figure 3-5.
4. Make sure that all headers are perfectly aligned and mated in the Curiosity board sockets.

Figure 3-4. Positioning the LCD Module

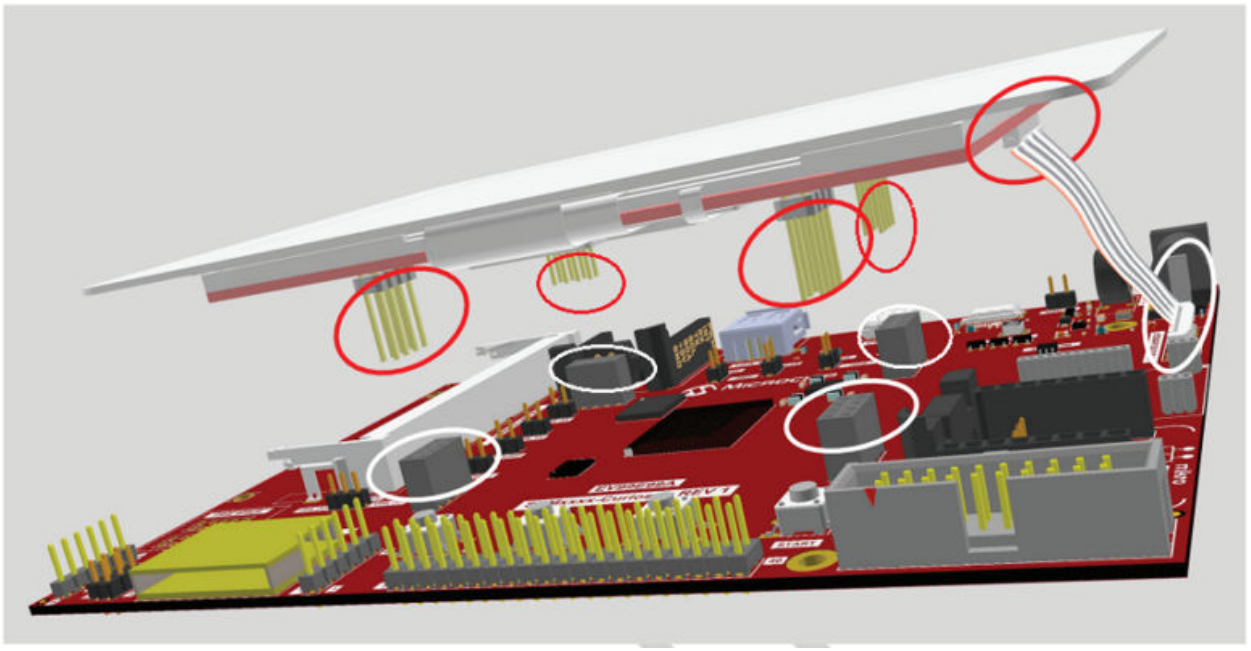
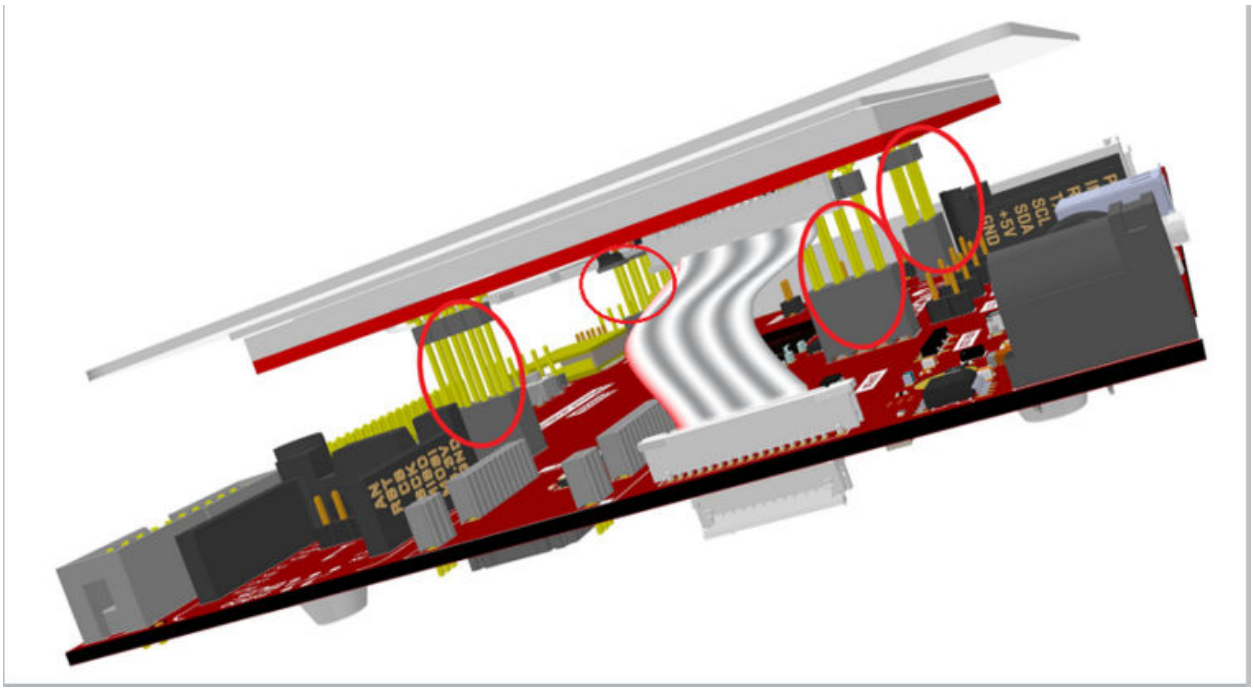


Figure 3-5. Correct Placement of the LCD Module



4. LCD Module Specifications

Table 4-1. Module Parameters

Parameter	Value
LCD Module size	5.5 inches
Overall dimensions	97 mm (H) 152 mm (W) 20 mm (T)
Overall weight	152g ± 5g

Table 4-2. Absolute Maximum Specifications

Parameter	Value
Operating temperature	-20°C to +70°C
Storage temperature	-30°C to +80°C
VDD_LCD	-0.3 to +3.6V
Maximum continuous pin current, any control or drive pin	±20 mA
Voltage forced onto any pin	-0.5V to +3.6V

Important: Stresses beyond those listed in the above table may cause permanent damage to the device. This is a stress rating only and the functional operation of the device under these conditions or others 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.

Table 4-3. Recommended Operating Conditions

Parameter	Value
VDD_LCD (LCD Module input voltage)	5V ± 250 mV
Supply ripple + noise	±100 mV

Table 4-4. DC Specifications

Parameter	Description	Min.	Typ.	Max.	Unit	Conditions
V_{IL}	Low-Input logic level (I²C, LCD_DISP, NRST)	-0.5	–	0.3 VDDIO	V	3.2V < VDDIO < 3.4V
V_{IH}	High-Input logic level (I²C, LCD_DISP, NRST)	0.7 VDDIO	–	–	V	3.2V < VDDIO < 3.4V
V_{OL}	Low-Output logic level (MXT_IRQ, I²C)	–	–	0.2 VDDIO	V	3.2V < VDDIO < 3.4V
V_{OH}	High-Output logic level (MXT_IRQ, I²C)	0.8 VDDIO	–	–	V	3.2V < VDDIO < 3.4V
V_{IL}	Low-Input logic level (LCD_MODULE_EN)	–	–	0.5	V	4.75V < VDD_LCD < 5.25V
V_{IH}	High-Input logic level (LCD_MODULE_EN)	0.5	0.8	1.2	V	4.75V < VDD_LCD < 5.25V
V_{IL}	Low-Input logic level (LCD_BACKLIGHT_PWM)	–	–	0.4	V	4.75V < VDD_LCD < 5.25V
V_{IH}	High-Input logic level (LCD_BACKLIGHT_PWM)	1.1	–	–	V	4.75V < VDD_LCD < 5.25V

Table 4-5. I2C Compatible Bus Specifications

Parameter	Operation
Touchscreen controller address	0x4A
EEPROM memory address	0x53
Maximum bus speed (SCL)	400 kHz
Bus voltage	3.3V

Table 4-6. LCD Panel Specifications

Parameter	Value
Display size	5.5 inches
LCD type	TFT/Normally Black
Display mode	Transmissive
Resolution	720 x 1280
View direction	FREE
Dimensions	129.11 mm (L) x 70.84 mm (H) x 1.63 mm (T)
Active area	120.96 mm x 68.04 mm
Pixel size	0.0945 mm x 0.0945 mm
Pixel arrangement	Vertical Stripe
Display colors	16.7M

Table 4-7. Backlight Specifications

Parameter	Description	Min.	Typ.	Max.	Units
V_F	Forward voltage (T_A = 25°C, I_F = Typ)	16.8	18.6	20.4	V
I_F	Forward current (T_A = 25°C)	–	40	--	mA
	LED configuration	2 branches of 6x white LEDs in series			
L_V	Luminance	–	300	–	cd/m²
P_d	Maximum power dissipation	–	–	800	mW
V_{AK}	Backlight driving voltage	4.75	5	5.25	V

5. Schematics

Figure 5-1. AC40T08A Block Diagram

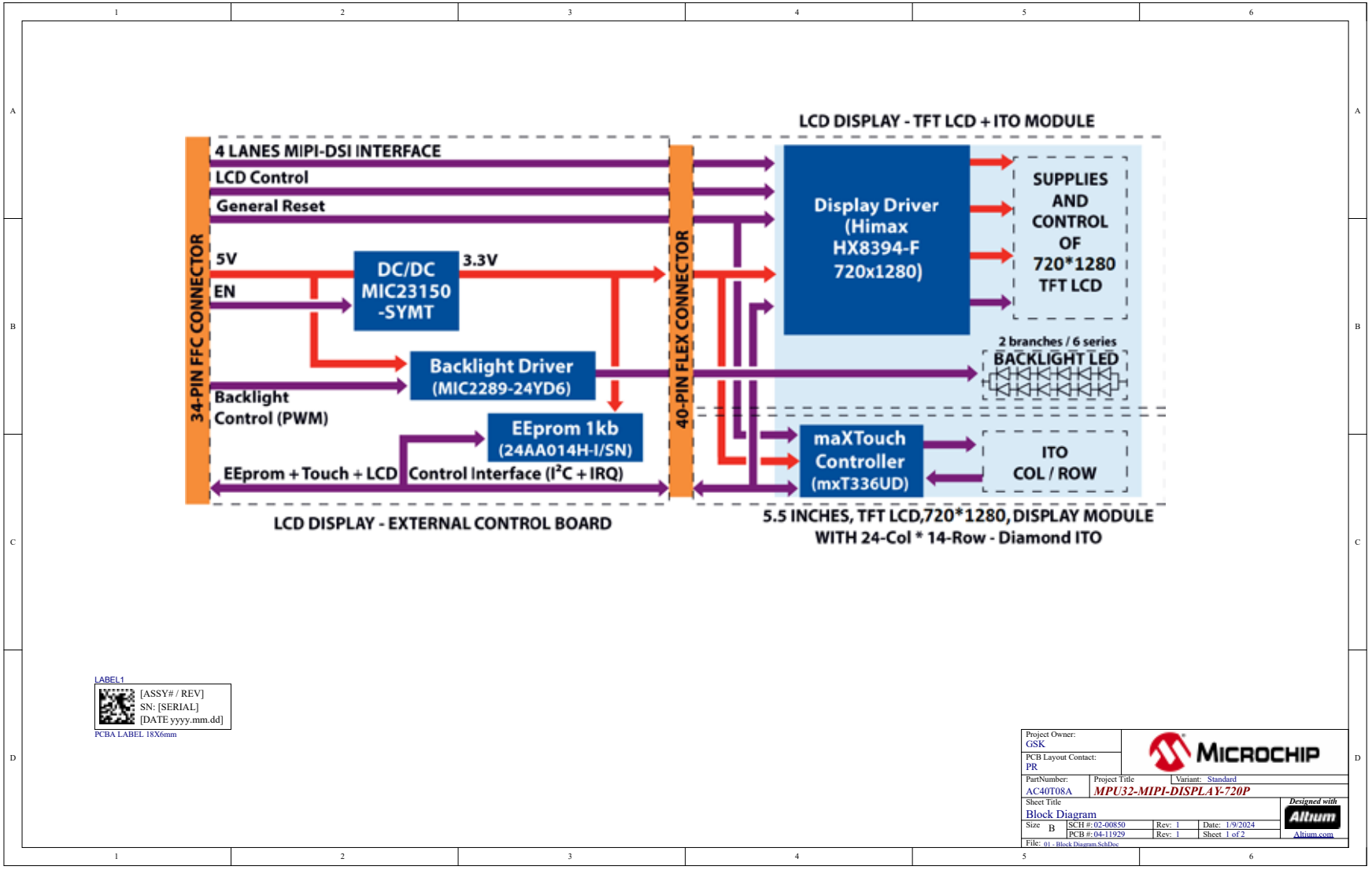
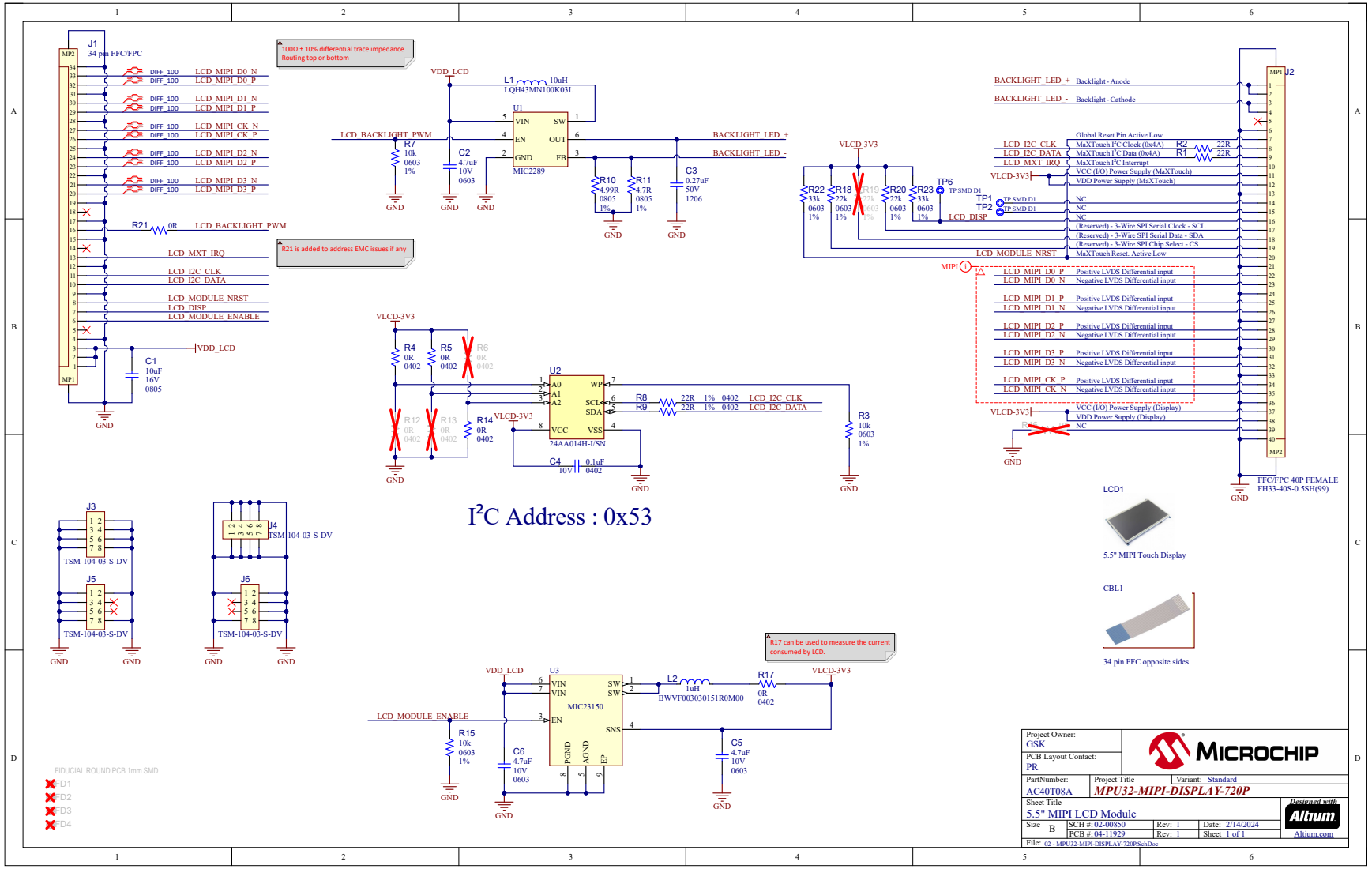


Figure 5-2. AC40T08A Display Schematic



6. Ordering Information

Ordering Code	Board Marking
AC40T08A	AC40T08A MPU32-MIPI-DISPLAY-720P

7. Revision History

7.1 Rev. A - 04/2024

Changes
First issue.

Microchip Information

The Microchip Website

Microchip provides online support via our website at www.microchip.com/. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip design partner program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Product Change Notification Service

Microchip's product change notification service helps keep customers current on Microchip products. Subscribers will receive email notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, go to www.microchip.com/pcn and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Embedded Solutions Engineer (ESE)
- Technical Support

Customers should contact their distributor, representative or ESE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in this document.

Technical support is available through the website at: www.microchip.com/support

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable". Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.

Legal Notice

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure

that your application meets with your specifications. Contact your local Microchip sales office for additional support or, obtain additional support at www.microchip.com/en-us/support/design-help/client-support-services.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL, OR CONSEQUENTIAL LOSS, DAMAGE, COST, OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION.

Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, CryptoMemory, CryptoRF, dsPIC, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Kleer, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AgileSwitch, ClockWorks, The Embedded Control Solutions Company, EtherSynch, Flashtec, Hyper Speed Control, HyperLight Load, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, TimeCesium, TimeHub, TimePictra, TimeProvider, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, Augmented Switching, BlueSky, BodyCom, Clockstudio, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, Espresso T1S, EtherGREEN, EyeOpen, GridTime, IdealBridge, IGaT, In-Circuit Serial Programming, ICSP, INICnet, Intelligent Paralleling, IntelliMOS, Inter-Chip Connectivity, JitterBlocker, Knob-on-Display, MarginLink, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, mSiC, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, Power MOS IV, Power MOS 7, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, RTAX, RTG4, SAM-ICE, Serial Quad I/O, simpleMAP, SimpliPHY, SmartBuffer, SmartHLS, SMART-I.S., storClad, SQI, SuperSwitcher, SuperSwitcher II, Switchtec, SynchroPHY, Total Endurance, Trusted Time, TSHARC, Turing, USBCheck, VariSense, VectorBlox, VeriPHY, ViewSpan, WiperLock, XpressConnect, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

ISBN: 978-1-6683-4367-8

Quality Management System

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
Corporate Office	**Australia - Sydney**	**India - Bangalore**	**Austria - Wels**
2355 West Chandler Blvd.	Tel: 61-2-9868-6733	Tel: 91-80-3090-4444	Tel: 43-7242-2244-39
Chandler, AZ 85224-6199	**China - Beijing**	**India - New Delhi**	Fax: 43-7242-2244-393
Tel: 480-792-7200	Tel: 86-10-8569-7000	Tel: 91-11-4160-8631	**Denmark - Copenhagen**
Fax: 480-792-7277	**China - Chengdu**	**India - Pune**	Tel: 45-4485-5910
Technical Support:	Tel: 86-28-8665-5511	Tel: 91-20-4121-0141	Fax: 45-4485-2829
www.microchip.com/support	**China - Chongqing**	**Japan - Osaka**	**Finland - Espoo**
Web Address:	Tel: 86-23-8980-9588	Tel: 81-6-6152-7160	Tel: 358-9-4520-820
www.microchip.com	**China - Dongguan**	**Japan - Tokyo**	**France - Paris**
Atlanta	Tel: 86-769-8702-9880	Tel: 81-3-6880- 3770	Tel: 33-1-69-53-63-20
Duluth, GA	**China - Guangzhou**	**Korea - Daegu**	Fax: 33-1-69-30-90-79
Tel: 678-957-9614	Tel: 86-20-8755-8029	Tel: 82-53-744-4301	**Germany - Garching**
Fax: 678-957-1455	**China - Hangzhou**	**Korea - Seoul**	Tel: 49-8931-9700
Austin, TX	Tel: 86-571-8792-8115	Tel: 82-2-554-7200	**Germany - Haan**
Tel: 512-257-3370	**China - Hong Kong SAR**	**Malaysia - Kuala Lumpur**	Tel: 49-2129-3766400
Boston	Tel: 852-2943-5100	Tel: 60-3-7651-7906	**Germany - Heilbronn**
Westborough, MA	**China - Nanjing**	**Malaysia - Penang**	Tel: 49-7131-72400
Tel: 774-760-0087	Tel: 86-25-8473-2460	Tel: 60-4-227-8870	**Germany - Karlsruhe**
Fax: 774-760-0088	**China - Qingdao**	**Philippines - Manila**	Tel: 49-721-625370
Chicago	Tel: 86-532-8502-7355	Tel: 63-2-634-9065	**Germany - Munich**
Itasca, IL	**China - Shanghai**	**Singapore**	Tel: 49-89-627-144-0
Tel: 630-285-0071	Tel: 86-21-3326-8000	Tel: 65-6334-8870	Fax: 49-89-627-144-44
Fax: 630-285-0075	**China - Shenyang**	**Taiwan - Hsin Chu**	**Germany - Rosenheim**
Dallas	Tel: 86-24-2334-2829	Tel: 886-3-577-8366	Tel: 49-8031-354-560
Addison, TX	**China - Shenzhen**	**Taiwan - Kaohsiung**	**Israel - Hod Hasharon**
Tel: 972-818-7423	Tel: 86-755-8864-2200	Tel: 886-7-213-7830	Tel: 972-9-775-5100
Fax: 972-818-2924	**China - Suzhou**	**Taiwan - Taipei**	**Italy - Milan**
Detroit	Tel: 86-186-6233-1526	Tel: 886-2-2508-8600	Tel: 39-0331-742611
Novi, MI	**China - Wuhan**	**Thailand - Bangkok**	Fax: 39-0331-466781
Tel: 248-848-4000	Tel: 86-27-5980-5300	Tel: 66-2-694-1351	**Italy - Padova**
Houston, TX	**China - Xian**	**Vietnam - Ho Chi Minh**	Tel: 39-049-7625286
Tel: 281-894-5983	Tel: 86-29-8833-7252	Tel: 84-28-5448-2100	**Netherlands - Drunen**
Indianapolis	**China - Xiamen**		Tel: 31-416-690399
Noblesville, IN	Tel: 86-592-2388138		Fax: 31-416-690340
Tel: 317-773-8323	**China - Zhuhai**		**Norway - Trondheim**
Fax: 317-773-5453	Tel: 86-756-3210040		Tel: 47-72884388
Tel: 317-536-2380			**Poland - Warsaw**
Los Angeles			Tel: 48-22-3325737
Mission Viejo, CA			**Romania - Bucharest**
Tel: 949-462-9523			Tel: 40-21-407-87-50
Fax: 949-462-9608			**Spain - Madrid**
Tel: 951-273-7800			Tel: 34-91-708-08-90
Raleigh, NC			Fax: 34-91-708-08-91
Tel: 919-844-7510			**Sweden - Gothenberg**
New York, NY			Tel: 46-31-704-60-40
Tel: 631-435-6000			**Sweden - Stockholm**
San Jose, CA			Tel: 46-8-5090-4654
Tel: 408-735-9110			**UK - Wokingham**
Tel: 408-436-4270			Tel: 44-118-921-5800
Canada - Toronto			Fax: 44-118-921-5820
Tel: 905-695-1980			
Fax: 905-695-2078			