Introduction

This document is the hardware user's guide of AVR® Functional Safety board based on ATtiny3217 microcontroller (MCU). It gives details about the overall board design and the hardware function blocks. The AVR Functional Safety board is designed to easily demonstrate and evaluate the safety and reliability peripherals on ATtiny3217 MCU and firmware based safety features, such as:

- Watchdog Timer (WDT)
- Cyclic Redundancy Check (CRC)
- Brown-out Detection (BOD)
- Voltage Level Monitoring (VLM)
- Power-on Reset (POR)
- Timer/Counter Type D (TCD) Fault Detection
- Class B Self Tests
Features

- Core Independent Operation Using Configurable Custom Logic (CCL) and 16-bit Timer/Counter Type A to Create a Heartbeat Signal
- Core Independent Cyclic Redundancy Check Memory Scan (CRCSCAN)
- Core Independent Operation Using 12-bit Timer/Counter Type D (TCD) to Drive a Fan Motor
- Core Independent TCD Fault Handling Using Event System (EVSYS), Analog Comparator (AC) and Digital-to-Analog Converter (DAC)
- Using Charlieplexing Technique to Drive a Large Number of LEDs with a Low Number of Pins, Using 16-bit Timer/Counter Type B (TCB) and Priority Interrupt
- Demonstrating Core Independent Watchdog Timer (WDT) in Window mode
- Demonstrating Real-Time Counter Periodic Interrupt (RTC) (PIT)
- Board Controller with (PTC) Touch Slider to Adjust the Voltage to ATtiny3217, Demonstrating Voltage Level Monitor (VLM) Interrupt, Brown-out Detector (BOD) and Power-on Reset (POR)
- On-board Mini Embedded Debugger (mEDBG) for Programming and Debugging.
# Table of Contents

Introduction......................................................................................................................1

Features.......................................................................................................................... 2

1. Overview....................................................................................................................4
   1.1. Block Diagram..............................................................................................................4
   1.2. Board Overview...........................................................................................................5

2. Design Documents and Related Links...................................................................... 6

3. Quick Start.................................................................................................................7

4. Hardware Blocks....................................................................................................... 8
   4.1. Target MCU Peripherals...............................................................................................8
   4.2. Board Controller Peripherals......................................................................................11
   4.3. Mini Embedded Debugger Implementation...............................................................16

5. Revision History.......................................................................................................19

The Microchip Web Site................................................................................................ 20

Customer Change Notification Service........................................................................20

Customer Support......................................................................................................... 20

Microchip Devices Code Protection Feature................................................................. 20

Legal Notice...................................................................................................................21

Trademarks................................................................................................................... 21

Quality Management System Certified by DNV..............................................................22

Worldwide Sales and Service........................................................................................23
1. Overview

1.1 Block Diagram
There are three MCUs on this board:

- **Target MCU - ATtiny3217:**
  - The main MCU that demonstrates the safety and reliability functions.
- **Board controller - ATtiny1617:**
  - It simulates external conditions to trigger the target MCU safety and reliability functions.
- **Mini Embedded Debugger:**
  - On-board debugger and programmer for target MCU and board controller.

Depending on different safety and reliability functions, the hardware design can be divided into the following function blocks:

- Reset Register and Class B status
- Operation Voltage
- Window Watchdog Timer
- Cyclic Redundancy Check
- Fault Detection Using Event System

These function blocks are clearly noted on the top side of the AVR Functional Safety board. Refer to Figure 1-2 for more details.

The block diagram of the AVR Functional Safety board can be seen below.

**Figure 1-1. AVR® Functional Safety Board Block Diagram**
1.2 Board Overview

Here is a brief overview of the AVR Functional Safety board.

**Figure 1-2. AVR® Functional Safety Board Overview - Top Side**

**Figure 1-3. AVR® Functional Safety Board Overview - Bottom Side**
2. Design Documents and Related Links

The design documents and relevant links are available here:

- **AVR Functional Safety website**: Board information, the latest documents and design files.
- **microchipDIRECT**: Where to buy this board online.
- **ATtiny3217 website**: Target MCU information, documentation and development tools, etc.
- **ATtiny1617 website**: Board controller MCU information, documentation and development tools, etc.
3. **Quick Start**

The AVR Functional Safety board is powered by a 5.0V USB voltage. The on-board programming and debugging function relies on the same USB connection. Refer to [Mini Embedded Debugger Implementation](#) for more information about programming and debugging.

Steps to start exploring the AVR Functional Safety board:

1. Download and install Atmel Studio.
2. Launch Atmel Studio.
3. Connect a USB cable (Standard-A to Micro-B or Micro-AB) between the PC and the USB port on the board.

When the AVR Functional Safety board is connected to the computer for the first time, the operating system will perform a driver software installation. The drivers for the board are included with Atmel Studio. Once the driver is successfully installed and the board is correctly powered, it will be automatically detected and recognized as a mEDBG tool by Atmel Studio.

Before using the board with default firmware, calibrating the board first is recommended. The calibration steps are listed on the backside of the board as shown in [Figure 1-3](#).
4. Hardware Blocks

In this chapter, the hardware designs are described in detail. There are three MCUs on this board and different hardware peripherals are built around them, so this chapter is further divided into three sections according to the MCU and peripheral connections.

4.1 Target MCU Peripherals

ATtiny3217 is the target MCU on the AVR Functional Safetyboard. All the safety and reliability functions demonstrated on this board are from ATtiny3217 MCU. The hardware peripherals around the target MCU are designed for the user to trigger different abnormal conditions, so that the reaction of each safety and reliability module can be easily observed.

4.1.1 Charlieplexed LEDs

On this board, there are 19 LEDs Charlieplexed and driven by only five I/O pins. On this board, PC0, PC1, PC2, PC3 and PC4 are used to drive these LEDs. Compared with traditional LED connection method, Charlieplexing saves a lot of I/O pins. In theory, five I/O pins can drive up to 20 LEDs. More details about Charlieplexing can be found here: https://en.wikipedia.org/wiki/Charlieplexing.

Below are the names of 19 LEDs and their functions.

Table 4-1. Charlieplexed LEDs

<table>
<thead>
<tr>
<th>LED Description</th>
<th>LED Name</th>
<th>LED Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED1</td>
<td>D2</td>
<td>Power-on Reset</td>
</tr>
<tr>
<td>LED2</td>
<td>D3</td>
<td>Brown-out Reset</td>
</tr>
<tr>
<td>LED3</td>
<td>D5</td>
<td>External Reset</td>
</tr>
<tr>
<td>LED4</td>
<td>D6</td>
<td>Watchdog Reset</td>
</tr>
<tr>
<td>LED5</td>
<td>D9</td>
<td>Software Reset</td>
</tr>
<tr>
<td>LED6</td>
<td>D10</td>
<td>UPDI Reset</td>
</tr>
<tr>
<td>LED7</td>
<td>D15</td>
<td>Watchdog Timer Indicator</td>
</tr>
<tr>
<td>LED8</td>
<td>D16</td>
<td>Watchdog Timer Indicator</td>
</tr>
<tr>
<td>LED9</td>
<td>D7</td>
<td>Watchdog Timer Indicator</td>
</tr>
<tr>
<td>LED10</td>
<td>D8</td>
<td>Watchdog Timer Indicator</td>
</tr>
<tr>
<td>LED11</td>
<td>D14</td>
<td>Watchdog Timer Indicator</td>
</tr>
<tr>
<td>LED12</td>
<td>D11</td>
<td>Watchdog Timer Indicator</td>
</tr>
<tr>
<td>LED13</td>
<td>D20</td>
<td>Watchdog Timer Indicator</td>
</tr>
<tr>
<td>LED14</td>
<td>D17</td>
<td>Watchdog Timer Indicator</td>
</tr>
<tr>
<td>LED15</td>
<td>D12</td>
<td>Watchdog Timer Cleared</td>
</tr>
<tr>
<td>LED16</td>
<td>D13</td>
<td>CRCSCAN Error</td>
</tr>
<tr>
<td>LED17</td>
<td>D18</td>
<td>TCD Fault Detected</td>
</tr>
</tbody>
</table>
The schematic of Charlieplexed LEDs is shown below.

**Figure 4-1. LED Charlieplexing**

<table>
<thead>
<tr>
<th>LED Description</th>
<th>LED Name</th>
<th>LED Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED18</td>
<td>D19</td>
<td>Class B Fail</td>
</tr>
<tr>
<td>LED19</td>
<td>D21</td>
<td>Class B OK</td>
</tr>
</tbody>
</table>

**4.1.2 Heartbeat LED**

There is an LED on this board simulating a heartbeat pattern. It is connected to the Configurable Custom Logical (CCL) output pin, so that the heartbeat pattern is easily generated with the timer/counter and the CCL without the intervention of the CPU. This LED is ON when the connected I/O pin output is low.

**Table 4-2. Heartbeat LED**

<table>
<thead>
<tr>
<th>ATtiny3217 Pin</th>
<th>Pin Function</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB4</td>
<td>Heartbeat LED D4</td>
<td>LUT0-OUT on alternative pin</td>
</tr>
</tbody>
</table>
4.1.3 Buttons
There are three mechanical buttons on this board. They are used to trigger different target MCU actions. Their functions are listed below.

Table 4-3. Buttons

<table>
<thead>
<tr>
<th>ATtiny3217 Pin</th>
<th>Pin Function</th>
<th>Button Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB5</td>
<td>SW1</td>
<td>Clear Watchdog (WDT)</td>
</tr>
<tr>
<td>PB6</td>
<td>SW2</td>
<td>Start/Stop Fan</td>
</tr>
<tr>
<td>PB7</td>
<td>SW3</td>
<td>Modify Flash Memory Bit</td>
</tr>
</tbody>
</table>

The buttons are implemented to be low active. When a button is pressed, a low level can be detected on the connected I/O pin.

Their connection is shown below.

Figure 4-3. Buttons

4.1.4 Fan
A small DC fan is attached on this board. It is driven by a MOSFET via an I/O pin control. The fan motor current is amplified by an op amp MCP6002 and fed back to the ATtiny3217 Analog Comparator (AC) input. If the current is above safety value (For example, the fan motor is forced to stop by putting a finger on it) then the fan control signal will be stopped immediately thanks to a Timer/Counter Type D (TCD)
fault control function. According to different input modes, fault detection puts TCD outputs into a predefined state without CPU intervention.

Please see below the table with details on the fan control pin and on the current detection pin connection.

Table 4-4. FAN Control

<table>
<thead>
<tr>
<th>ATtiny3217 Pin</th>
<th>Pin Function</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA4</td>
<td>Fan MOSFET control</td>
<td>WOA of TCD0</td>
</tr>
<tr>
<td>PA7</td>
<td>Fan current detect</td>
<td>AC0 positive input</td>
</tr>
</tbody>
</table>

Below is the fan control schematic.

Figure 4-4. Fan

4.2 Board Controller Peripherals

The purpose of the board controller is to simulate different external conditions to trigger different safety and reliability functions of the target MCU. There are several hardware blocks built around the board controller to make this easier. On this board, an ATtiny1617 is used as the board controller.

4.2.1 Variable Target Voltage

A simple variable voltage circuit is designed to generate the target MCU V<sub>CC</sub>. Ideally, it varies between 0~5V if the MOSFET on-resistance is considered as 0Ω. The board controller, ATtiny1617, controls the ON/OFF and output level of this variable voltage. The pin functions are listed below.

Table 4-5. Variable Target Voltage

<table>
<thead>
<tr>
<th>ATtiny1617 Pin</th>
<th>Pin Function</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA6</td>
<td>Controls variable voltage level</td>
<td>DAC output</td>
</tr>
<tr>
<td>PA7</td>
<td>Controls ON/OFF of voltage</td>
<td>I/O output</td>
</tr>
</tbody>
</table>
The controlled variable voltage circuit is shown below.

**Figure 4-5. Variable Target Voltage**

4.2.2 Touch Slider

A touch slider is implemented on this board for an easy user input. It is based on the Peripheral Touch Controller (PTC) module in ATtiny1617. On this board, the touch slider is implemented with four self-capacitance sensors (Y-line). For further information about PTC touch usage, refer to QTouch® Modular Library User's Guide and Glossary of Touch Terms. In default firmware, this slider is used to control the output voltage of Variable Target Voltage.

The connection of touch slider is shown below.

**Table 4-6. Touch Slider**

<table>
<thead>
<tr>
<th>ATtiny1617 Pin</th>
<th>Pin Function</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC0</td>
<td>Touch slider sensor 1</td>
<td>PTC Y6</td>
</tr>
<tr>
<td>PC1</td>
<td>Touch slider sensor 2</td>
<td>PTC Y7</td>
</tr>
<tr>
<td>PC2</td>
<td>Touch slider sensor 3</td>
<td>PTC Y8</td>
</tr>
<tr>
<td>PC3</td>
<td>Touch slider sensor 4</td>
<td>PTC Y9</td>
</tr>
</tbody>
</table>
4.2.3 Status LED

Four LEDs are controlled by a board controller to indicate the target MCU voltage described in Variable Target Voltage. There are four segments of the target MCU voltage. These LEDs are designed to be low active.

Table 4-7. Status LED

<table>
<thead>
<tr>
<th>ATtiny1617 Pin</th>
<th>Pin Functions</th>
<th>Target MCU Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB2</td>
<td>D22</td>
<td>Normal voltage</td>
</tr>
<tr>
<td>PB3</td>
<td>D23</td>
<td>15% above BOD level</td>
</tr>
</tbody>
</table>
### Level Shifter

As the voltage of the target MCU is controlled by the board controller, the voltage between them can be different. Level shifters are used to make sure that the MCUs can talk to each other when they operate under different voltages. The UPDI pin and mEDBG UART pins are also connected via level shifter, thus the target MCU can be programmed and debugged under any working voltage. The following pins are connected via level shifters.

Refer to the table below for more details.

#### Table 4-8. Pin Connections via Level Shifter

<table>
<thead>
<tr>
<th>ATtiny1617 Pin</th>
<th>ATtiny3217 Pin</th>
<th>mEDBG Pin</th>
<th>Pin Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB0</td>
<td>PB0</td>
<td>--</td>
<td>I²C SCL</td>
</tr>
<tr>
<td>PB1</td>
<td>PB1</td>
<td>--</td>
<td>I²C SDA</td>
</tr>
<tr>
<td>PB6</td>
<td>PA6</td>
<td>--</td>
<td>Target BOD indicator</td>
</tr>
<tr>
<td>PB7</td>
<td>PA2</td>
<td>--</td>
<td>Target VLM indicator</td>
</tr>
<tr>
<td>--</td>
<td>PB2</td>
<td>PD2</td>
<td>UART Tx</td>
</tr>
<tr>
<td>--</td>
<td>PB3</td>
<td>PD3</td>
<td>UART Rx</td>
</tr>
<tr>
<td>--</td>
<td>PA0</td>
<td>PE6</td>
<td>mEDBG UPDI</td>
</tr>
</tbody>
</table>
4.2.5 Reserved Interfaces

The SPI and I²C pins are also reserved on two unmounted headers. The user can use them conveniently if such functions are necessary.

Table 4-9. Reserved Interfaces

<table>
<thead>
<tr>
<th>ATtiny1617 Pin</th>
<th>Pin Function</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA1</td>
<td>SPI MOSI</td>
<td>Board controller SPI interface</td>
</tr>
<tr>
<td>PA2</td>
<td>SPI MISO</td>
<td></td>
</tr>
</tbody>
</table>
### ATtiny1617 Pin

<table>
<thead>
<tr>
<th>ATtiny1617 Pin</th>
<th>Pin Function</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA3</td>
<td>SPI SCK</td>
<td></td>
</tr>
<tr>
<td>PA4</td>
<td>SPI SS</td>
<td></td>
</tr>
<tr>
<td>PB0</td>
<td>I²C SCL</td>
<td>Board controller I²C interface</td>
</tr>
<tr>
<td>PB1</td>
<td>I²C SDA</td>
<td></td>
</tr>
</tbody>
</table>

#### Figure 4-10. Reserved Interface

---

**4.3 Mini Embedded Debugger Implementation**

On the AVR Functional Safety board, the Mini Embedded Debugger (mEDBG) is used as an easy way to program and debug the target MCU. It features a virtual COM port for serial communication to a host PC. Atmel Studio can be used as a front end for the mEDBG.

**4.3.1 Mini Embedded Debugger**

The AVR Functional Safety board contains the Mini Embedded Debugger (mEDBG) for on-board programming. The mEDBG is a composite USB device of two interfaces: a debugger and a virtual COM port.

Together with Atmel Studio, the mEDBG debugger interface can program the ATtiny3217. On AVR Functional Safety board, the UPDI interface is connected between the mEDBG and the ATtiny3217.

The virtual COM port is connected to a UART on the ATtiny3217 and provides an easy way to communicate with the target application through the terminal software. It offers variable baud rate, parity, and Stop bit settings.

**Note:** The settings on the ATtiny3217 must match the settings given in the terminal software.

**Info:** The virtual COM port in the mEDBG requires the terminal software to set the Data Terminal Ready (DTR) signal to enable the UART pins connected to the ATtiny3217. If the DTR signal is not enabled, the UART pins on the mEDBG are kept in high-z (tri-state) rendering the COM port unusable. The DTR signal is automatically set by some terminal software, but it may have to be manually enabled in the target terminal.
The mEDBG controls one status LED on the AVR Functional Safety board. The table below shows how the LED is controlled in different operation modes.

Table 4-10. mEDBG LED Control

<table>
<thead>
<tr>
<th>Operation mode</th>
<th>Status LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power-up</td>
<td>LED is briefly lit</td>
</tr>
<tr>
<td>Normal operation</td>
<td>LED is not lit</td>
</tr>
<tr>
<td>Programming</td>
<td>Activity indicator; the LED flashes when programming/debugging with the mEDBG</td>
</tr>
</tbody>
</table>

4.3.2 UPDI Interface

The Unified Program and Debug Interface (UPDI) uses one pin to communicate with the target. The actual connection of UPDI line between mEDBG and MCU is decided by UPDI Selection.

Table 4-11. UPDI Interface

<table>
<thead>
<tr>
<th>ATtiny3217</th>
<th>ATtiny1617</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA0 (default connection)</td>
<td>PA0</td>
<td>UPDI/RESET</td>
</tr>
</tbody>
</table>

4.3.2.1 UPDI Selection

On this board, both the target MCU ATtiny3217 and the board controller ATtiny1617 use the same programming and debugging interface (UPDI). It is supported by the on-board program and debug chip mEDBG. An UPDI selection circuit is used to switch the UPDI lines between these two MCUs. By default, the mEDBG UPDI interface is connected to ATtiny3217. To program and debug ATtiny1617, the hardware has to be modified by the user.

Table 4-12. UPDI selection

<table>
<thead>
<tr>
<th>UPDI Line Target</th>
<th>Hardware Connection</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATtiny3217</td>
<td>TP29 and TP30 open circuit</td>
<td>Default</td>
</tr>
<tr>
<td>ATtiny1617</td>
<td>TP29 and TP30 short circuit</td>
<td>Modified by user</td>
</tr>
</tbody>
</table>

Figure 4-11. UPDI Selection
4.3.3 Virtual COM Port

The Mini Embedded Debugger (mEDBG) acts as a virtual COM port gateway by using the ATtiny3217 UART pins. As the target MCU may work at different voltage with mEDBG, the pins are connected via a Level Shifter.

Table 4-13. Virtual COM Port

<table>
<thead>
<tr>
<th>ATtiny3217 Pin</th>
<th>Pin Function</th>
<th>mEDBG Pin Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB2</td>
<td>UART Tx</td>
<td>mEDBG CDC Rx</td>
</tr>
<tr>
<td>PB3</td>
<td>UART Rx</td>
<td>mEDBG CDC Tx</td>
</tr>
</tbody>
</table>
## 5. Revision History

<table>
<thead>
<tr>
<th>Doc Rev.</th>
<th>Date</th>
<th>Comments</th>
</tr>
</thead>
</table>

© 2018 Microchip Technology Inc.
The Microchip Web Site

Microchip provides online support via our web site at http://www.microchip.com/. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **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 (FAQ), technical support requests, online discussion groups, Microchip consultant 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

Customer Change Notification Service

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


Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or Field Application Engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site at: http://www.microchip.com/support

Microchip Devices Code Protection Feature

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

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip’s Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
• Neither Microchip nor any other semiconductor manufacturer can assure the security of their code. Code protection does not mean that we are assuring the product as “unbreakable.”

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip’s code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Legal Notice

Information contained in this publication regarding device applications and the like 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. 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 ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. 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, AnyRate, AVR, AVR logo, AVR Freaks, BeaconThings, BitCloud, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, Heldo, JukeBlox, KeeLoq, KeeLoq logo, Kleer, LANCheck, LINK MD, maXStylus, maXTouch, MediaLB, megaAVR, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, Prochip Designer, QTorch, RightTouch, SAM-BA, SpyNIC, SST, SST Logo, SuperFlash, tinyAVR, UNI/O, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

ClockWorks, The Embedded Control Solutions Company, EtherSynch, Hyper Speed Control, HyperLight Load, IntellIMOS, mTouch, Precision Edge, and Quiet-Wire are registered trademarks of Microchip Technology Incorporated in the U.S.A.


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

Silicon Storage Technology is a registered trademark 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.

All other trademarks mentioned herein are property of their respective companies.
ISO/TS 16949
Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company’s quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip’s quality system for the design and manufacture of development systems is ISO 9001:2000 certified.
Americas

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

Asia/Pacific

Australia - Sydney
Tel: 61-2-9868-6733

China - Beijing
Tel: 86-10-8569-7000

China - Chengdu
Tel: 86-28-8665-5511

China - Chongqing
Tel: 86-23-8980-9588

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115

China - Hong Kong SAR
Tel: 852-2943-5100

China - Nanjing
Tel: 86-25-8473-2460

China - Qingdao
Tel: 86-602-8502-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xian
Tel: 86-29-8933-7252

China - Xiamen
Tel: 86-592-2388138

China - Zuhai
Tel: 86-756-3210040

India - Bangalore
Tel: 91-80-3090-4444

India - New Delhi
Tel: 91-11-4160-8631

India - Pune
Tel: 91-20-4121-0141

Japan - Osaka
Tel: 81-6-6152-7160

Japan - Tokyo
Tel: 81-3-6880-3770

Korea - Daegu
Tel: 82-53-744-4301

Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
Tel: 60-3-7651-7906

Malaysia - Penang
Tel: 60-4-227-8870

Philippines - Manila
Tel: 63-2-634-9065

Singapore
Tel: 65-6334-8870

Taiwan - Hsin Chu
Tel: 886-3-577-8366

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600

Thailand - Bangkok
Tel: 66-2-694-1351

Vietnam - Ho Chi Minh
Tel: 84-29-5448-2100

Europe

Austria - Wels
Tel: 43-7242-2244-39

Denmark - Copenhagen
Tel: 45-4450-2828

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-376400

Germany - Hellbronn
Tel: 49-7111-67-3636

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0

Germany - Rosenberg
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

Italy - Milan
Tel: 39-0331-742611

Italy - Padova
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399

Norway - Trondheim
Tel: 47-7289-7561

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

Spain - Madrid
Tel: 34-91-708-08-90

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800

Fax: 44-118-921-5820

© 2018 Microchip Technology Inc.