

PIC16(L)F1934/1936/1937 Family Silicon Errata and Data Sheet Clarification

The PIC16(L)F1934/1936/1937 family devices that you have received conform functionally to the current Device Data Sheet (DS41364E), except for the anomalies described in this document.

The silicon issues discussed in the following pages are for silicon revisions with the Device and Revision IDs listed in [Table 1](#). The silicon issues are summarized in [Table 2](#).


The errata described in this document will be addressed in future revisions of the PIC16(L)F1934/1936/1937 silicon.

Note: This document summarizes all silicon errata issues from all revisions of silicon, previous as well as current. Only the issues indicated in the last column of [Table 2](#) apply to the current silicon revision (**A8**).

Data Sheet clarifications and corrections start on [page 10](#), following the discussion of silicon issues.

The silicon revision level can be identified using the current version of MPLAB® IDE and Microchip's programmers, debuggers, and emulation tools, which are available at the Microchip corporate web site (www.microchip.com).

For example, to identify the silicon revision level using MPLAB IDE in conjunction with a hardware debugger:

1. Using the appropriate interface, connect the device to the hardware debugger.
2. Open an MPLAB IDE project.
3. Configure the MPLAB IDE project for the appropriate device and hardware debugger.
4. Based on the version of MPLAB IDE you are using, do one of the following:
 - a) For MPLAB IDE 8, select *Programmer > Reconnect*.
 - b) For MPLAB X IDE, select *Window > Dashboard* and click the **Refresh Debug Tool Status** icon ().
5. Depending on the development tool used, the part number *and* Device Revision ID value appear in the **Output** window.

Note: If you are unable to extract the silicon revision level, please contact your local Microchip sales office for assistance.

The DEVREV values for the various PIC16(L)F1934/1936/1937 silicon revisions are shown in [Table 1](#).

TABLE 1: SILICON DEVREV VALUES

Part Number	DEVICE ID<13:0> ^{(1),(2)}						
	DEV<8:0>	Revision ID for Silicon Revision					
		A2	A3	A5	A6	A7	A8
PIC16F1934	10 0011 010	0 0010	0 0011	0 0101	0 0110	0 0111	0 1000
PIC16LF1934	10 0100 010	0 0010	0 0011	0 0101	0 0110	0 0111	0 1000
PIC16F1936	10 0011 011	0 0010	0 0011	0 0101	0 0110	0 0111	0 1000
PIC16LF1936	10 0100 011	0 0010	0 0011	0 0101	0 0110	0 0111	0 1000
PIC16F1937	10 0011 100	0 0010	0 0011	0 0101	0 0110	0 0111	0 1000
PIC16LF1937	10 0100 100	0 0010	0 0011	0 0101	0 0110	0 0111	0 1000

- Note 1:** The Device ID is located in the configuration memory at address 8006h.
- Note 2:** Refer to the “*PIC16F193X/LF193X and PIC16F194X/LF194X Memory Programming Specification*” (DS41397) for detailed information on Device and Revision IDs for your specific device.

PIC16(L)F1934/1936/1937

TABLE 2: SILICON ISSUE SUMMARY

Module	Feature	Item Number	Issue Summary	Affected Revisions ⁽¹⁾					
				A2	A3	A5	A6	A7	A8
Data EE Memory	Memory Endurance	1.1	Erase/Write Endurance limited.	X	X	X			
Data EE Memory	Writes	1.2	Min. VDD for writes.	X	X	X	X	X	X
Program Flash Memory (PFM)	Endurance	2.1	Erase/Write Endurance limited.	X	X	X			
Program Flash Memory (PFM)	Writes	2.2	Min. VDD for writes.	X	X	X	X	X	X
Capture Compare PWM (CCP)	PWM Dead-Band Delay	3.1	Unpredictable waveforms.	X	X	X	X	X	X
Capture Compare PWM (CCP)	ECCP2 Switching	3.2	PWM outputs.	X	X	X	X	X	X
Capture Compare PWM (CCP)	ECCP2 Changing Direction	3.3	Outputs will improperly go active.	X	X	X	X	X	X
Capture Compare PWM (CCP)	Capture mode	3.4	Capture will be triggered.	X	X	X	X	X	X
Capture Compare PWM (CCP)	ECCPx Dead-Time Delay	3.5	Dead-band delay.	X	X	X	X	X	X
Capture Compare PWM (CCP)	PWM with Pulse Steering	3.6	PWM output.	X	X	X	X	X	X
Capture Compare PWM (CCP)	Capture mode	3.7	Capture will be triggered.	X	X	X	X	X	X
Brown-Out Reset (BOR)	Threshold	4.1	Voltage level.	X					
ADC	ADC Conversion	5.1	ADC conversion may not complete.	X	X	X			
Oscillator	HS Oscillator	6.1	HS oscillator min. VDD.	X	X	X			
Enhanced Capture Compare PWM (ECCP)	Enhanced PWM	7.1	PWM 0% duty-cycle direction change.	X	X	X	X	X	X
Enhanced Capture Compare PWM (ECCP)	Enhanced PWM	7.2	PWM 0% duty-cycle port steering.	X	X	X	X	X	X
Timer1	Timer0 Gate Source	8.1	Toggle mode works improperly.	X	X	X	X	X	X
Timer1	Timer1 Gate Toggle mode	8.2	T1 gate flip-flop does not clear.	X	X	X	X	X	X
LDO	Minimum VDD above 85°C	9.1	Minimum operating VDD for the PIC16F193X devices at TA > 85°C.	X	X	X	X	X	X
Enhanced Universal Synchronous Asynchronous Receiver (EUSART)	Auto-Baud Detect	10.1	Auto-Baud Detect may store incorrect count value in the SPBRG registers.	X	X	X	X	X	

Note 1: Only those issues indicated in the last column apply to the current silicon revision.

Silicon Errata Issues

Note: This document summarizes all silicon errata issues from all revisions of silicon, previous as well as current. Only the issues indicated by the shaded column in the following tables apply to the current silicon revision (A8).

1. Module: Data EE Memory

1.1 Data EE Memory Endurance

The typical write/erase endurance of the data EE memory is limited to 10k cycles.

Work around

Use error correction method that stores data in multiple locations.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X					

1.2 Data EE Write at Min. VDD

The minimum voltage required for a data EE write operation is 2.0 volts.

Work around

None.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

2. Module: Program Flash Memory (PFM)

2.1 Program Flash Memory Endurance

The typical write/erase endurance of the PFM is limited to 1k cycles when VDD is above 3.0 volts. Endurance degrades when VDD is below 3V.

Work around

Use an error correction method that stores data in multiple locations.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X					

2.2 Program Flash Memory Writes at Min. VDD

The minimum voltage required for a PFM write operation is 2.0V.

Work around

None.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

3. Module: Capture Compare PWM (CCP)

3.1 Dead-Band Delay

With the ECCP configured for PWM Half-Bridge mode and a dead-band delay greater than or equal to the PWM duty cycle; unpredictable waveforms will result.

Work around

Make sure the dead-band delay is always less than the PWM duty cycle.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

3.2 ECCP2 Switching Between Single, Half-Bridge and Full-Bridge PWM modes

Switching PWM mode during the current PWM cycle by modifying the P2M<1:0> bits in the CCP2CON register will cause the PWM outputs to switch immediately and not on the start of the next PWM cycle.

Work around

None.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

3.3 ECCP2 Changing Direction in Full-Bridge PWM modes

When changing direction, the active and modulated outputs will improperly go active at the same time and the dead time does not occur, which can lead to large shoot-through currents.

Work around

None.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

PIC16(L)F1934/1936/1937

3.4 Capture mode Selected while CCPx Pin is Held High

If the module is configured to capture on the first rising edge and the CCPx pin is high at this time, a capture will be triggered.

Work around

Clear the CCP interrupt flag ($CCPxIF = 0$) immediately after configuring the module for a capture event.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

3.5 ECCPx Dead-Time Delay in Half-Bridge mode

In Half-Bridge mode, the dead-band delay is 1 TOSC longer than calculated for the first PWM cycle and 1.5 TOSC for following cycles.

Work around

None.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

3.6 PWM with Pulse Steering

Disabling a PWM output during a PWM cycle will cause the output to end 1 TOSC time earlier than expected.

Work around

None.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

3.7 Capture mode Selected while CCPx Pin is Held Low

If the module is configured to capture on the first falling edge and the CCPx pin is low at this time, a capture will be triggered.

Work around

Clear the CCP interrupt flag ($CCPxIF = 0$) immediately after configuring the module for a capture event.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

4. Module: Brown-Out Reset (BOR)

4.1 Brown-Out Threshold

Configuring the BOR for 2.5V operation, the Reset will typically occur at 2.7V.

Work around

None.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X							

5. Module: ADC

5.1 Analog-to-Digital Conversion

An ADC conversion may not complete under these conditions:

1. When FOSC is greater than 8 MHz and it is the clock source used for the ADC converter.
2. The ADC is operating from its dedicated internal FRC oscillator and the device is not in Sleep mode (any FOSC frequency).

When this occurs, the ADC Interrupt Flag (ADIF) does not get set, the GO/DONE bit does not get cleared, and the conversion result does not get loaded into the ADRESH and ADRESL result registers.

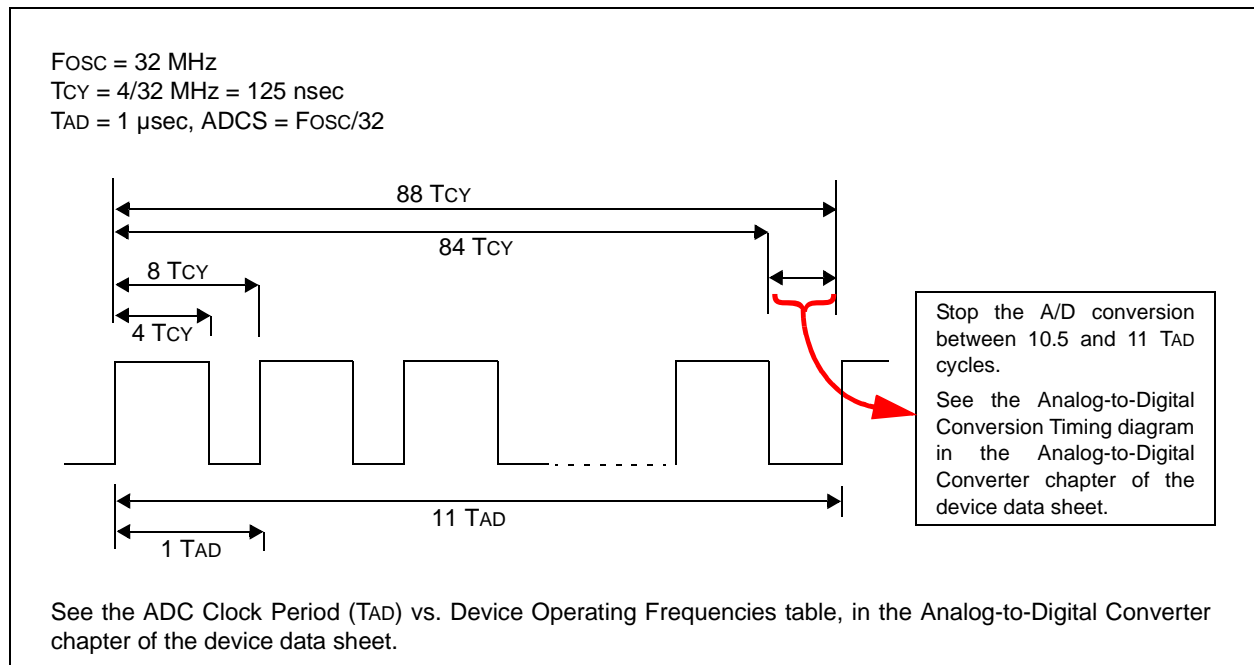
Work around

Method 1: Select the system clock, FOSC, as the ADC clock source and reduce the FOSC frequency to 8 MHz or less when performing ADC conversions.

Method 2: Select the dedicated FRC oscillator as the ADC conversion clock source and perform all conversions with the device in Sleep.

Method 3: This method is provided if the application cannot use Sleep mode and requires continuous operation at frequencies above 8 MHz. This method requires early termination of an ADC conversion. Provide a fixed time delay in software to stop the A-to-D conversion manually, after all 10 bits are converted, but before the conversion would complete automatically. The conversion is stopped by clearing the GO/DONE bit in software. The GO/DONE bit must be cleared during the last ½ TAD cycle, before the conversion would have completed automatically. Refer to [Figure 1](#) for details.

FIGURE 1: INSTRUCTION CYCLE DELAY CALCULATION EXAMPLE



In [Figure 1](#), 88 instruction cycles (TCY) will be required to complete the full conversion. Each TAD cycle consists of 8 TCY periods. A fixed delay is provided to stop the A/D conversion after 86 instruction cycles and terminate the conversion at the correct time as shown in the figure above.

PIC16(L)F1934/1936/1937

Note: The exact delay time will depend on the TAD divisor (ADCS) selection. The Tcy counts shown in the timing diagram above apply to this example only. Refer to [Table 3](#) for the required delay counts for other configurations.

EXAMPLE 1: CODE EXAMPLE OF INSTRUCTION CYCLE DELAY

```
BSF    ADCON0, ADGO    ; Start ADC conversion
                        ; Provide 86
                        ; instruction cycle
                        ; delay here
BCF    ADCON0, ADGO    ; Terminate the
                        ; conversion manually
MOVF   ADRESH, W      ; Read conversion
                        ; result
```

For other combinations of FOSC, TAD values and Instruction cycle delay counts, refer to [Table 3](#).

TABLE 3: INSTRUCTION CYCLE DELAY COUNTS BY TAD SELECTION

TAD	Instruction Cycle Delay Counts
Fosc/64	172
Fosc/32	86
Fosc/16	43

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X					

6. Module: Oscillator

6.1 HS Oscillator

The HS oscillator requires a minimum voltage of 3.0 volts (at 65°C or less) to operate at 20 MHz.

Work around

None.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X					

7. Module: Enhanced Capture Compare PWM (ECCP)

7.1 Enhanced PWM

When the PWM is configured for Full-Bridge mode and the duty cycle is set to 0%, writing the Pxm<1:0> bits to change the direction has no effect on PxA and PxC outputs.

Work around

Increase the duty cycle to a value greater than 0% before changing directions.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

7.2 Enhanced PWM

In PWM mode, when the duty cycle is set to 0% and the STRxSYNC bit is set, writing the STRxA, STRxB, STRxC and the STRxD bits to enable/disable steering to port pins has no effect on the outputs.

Work around

Increase the duty cycle to a value greater than 0% before enabling/disabling steering to port pins.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

PIC16(L)F1934/1936/1937

8. Module: Timer1

8.1 Timer1 Gate Toggle mode with Timer0 as Gate Source

Timer1 Gate Toggle mode provides unexpected results when Timer0 overflow is selected as the Timer1 gate source. We do not recommend using Timer0 overflow as the Timer1 gate source while in Timer1 Gate Toggle mode or when Toggle mode is used in conjunction with Timer1 Gate Single-Pulse mode.

Work around

None.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

8.2 Timer1 Gate Toggle mode

When Timer1 Gate Toggle mode is enabled, it is possible to measure the full-cycle length of a Timer1 gate signal. To perform this function, the Timer1 gate source is routed through a flip-flop that changes state on every incrementing edge of the gate signal. Timer1 Gate Toggle mode is enabled by setting the T1GTM bit of the T1GCON register. When working properly, clearing either the T1GTM bit or the TMR1ON bit would also clear the output value of this flip-flop, and hold it clear. This is done in order to control which edge is being measured. The issue that exists is that clearing the TMR1ON bit does not clear the output value of the flip-flop and hold it clear.

Work around

Clear the T1GTM bit in the T1GCON register to clear and hold clear the output value of the flip-flop.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

9. Module: LDO

9.1 Minimum VDD above 85°C

The minimum voltage required for the PIC16F193X devices is 3.5 volts for temperatures above 85°C.

Note: This issue only applies to the PIC16F193X devices operating in the Extended temperature range. The PIC16LF193X devices are not affected.

Work around

None.

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X	X		

PIC16(L)F1934/1936/1937

10. Module: Enhanced Universal Synchronous Asynchronous Receiver (EUSART)

10.1 Auto-Baud Detect

When using automatic baud detection (ABDEN), on occasion, an incorrect count value can be stored at the end of auto-baud detection in the SPBRGH:SPBRGL (SPBRG) registers. The SPBRG value may be off by several counts. This condition happens sporadically when the device clock frequency drifts to a frequency where the

SPBRG value oscillates between two different values. The issue is present regardless of the baud rate Configuration bit settings.

Work around

When using auto-baud, it is a good practice to always verify the obtained value of SPBRG, to ensure it remains within the application specifications. Two recommended methods are shown below.

For additional auto-baud information, see Technical Brief TB3069, "Use of Auto-Baud for Reception of LIN Serial Communications Devices: Mid-Range and Enhanced Mid-Range".

EXAMPLE 2: METHOD 1 – EUSART AUTO-BAUD DETECT WORK AROUND

In firmware, define default, minimum and maximum auto-baud (SPBRG) values according to the application requirements.

For example, if the application runs at 9600 baud at 16 MHz then, the default SPBRG value would be (assuming 16-bit/Asynchronous mode) 0x67. The minimum and maximum allowed values can be calculated based on the application. In this example, a +/-5% tolerance is required, so tolerance is $0x67 * 5\% = 0x05$.

```
#define SPBRG_16BIT    *((*int)&SPBRG;           // define location for 16-bit SPBRG value

const int DEFAULT_BAUD = 0x0067;               // Default Auto-Baud value
const int TOL = 0x05;                          // Baud Rate % tolerance
const int MIN_BAUD = DEFAULT_BAUD - TOL;       // Minimum Auto-Baud Limit
const int MAX_BAUD = DEFAULT_BAUD + TOL;       // Maximum Auto-Baud Limit
.
.
.
ABDEN = 1;                                     // Start Auto-Baud
while (ABDEN);                                // Wait until Auto-Baud completes

if((SPBRG_16BIT > MAX_BAUD) || (SPBRG_16BIT < MIN_BAUD))
{
    SPBRG_16BIT = DEFAULT_BAUD;               // Compare if value is within limits
                                           // if out of spec, use DEFAULT_BAUD
}
.
.
.
// if in spec, continue using the
// Auto-Baud value in SPBRG
```


PIC16(L)F1934/1936/1937

EXAMPLE 3: METHOD 2 – EUSART AUTO-BAUD DETECT WORK AROUND

Similar to Method 1, define default, minimum and maximum auto-baud (SPBRG) values. In firmware, compute a running average of SPBRG. If the new SPBRG value falls outside the minimum or maximum limits, then use the current running average value (Average_Baud), otherwise use the auto-baud SPBRG value and calculate a new running average.

For example, if the application runs at 9600 baud at 16 MHz then, the default SPBRG value would be (assuming 16-bit/ Asynchronous mode) 0x67. The minimum and maximum allowed values can be calculated based on the application. In this example, a +/-5% tolerance is required, so tolerance is $0x67 * 5\% = 0x05$.

```
#define SPBRG_16BIT    *((*int)&SPBRG;                // define location for 16-bit SPBRG value

const int DEFAULT_BAUD = 0x0067;                    // Default Auto-Baud value
const int TOL = 0x05;                               // Baud Rate % tolerance
const int MIN_BAUD = DEFAULT_BAUD - TOL;           // Minimum Auto-Baud Limit
const int MAX_BAUD = DEFAULT_BAUD + TOL;           // Maximum Auto-Baud Limit

int Average_Baud;                                    // Define Average_Baud variable
int Integrator;                                      // Define Integrator variable
.
.
.
Average_Baud = DEFAULT_BAUD;                        // Set initial average Baud rate
Integrator = DEFAULT_BAUD*15;                       // The running 16 count average
.
.
.
ABDEN = 1;                                          // Start Auto-Baud
while (ABDEN);                                     // Wait until Auto-Baud completes

Integrator+ = SPBRG_16BIT;
Average_Baud = Integrator/16;
if((SPBRG_16BIT > MAX_BAUD)|| (SPBRG_16BIT < MIN_BAUD))
{
    SPBRG_16BIT = Average_Baud;                    // Check if value is within limits
                                                    // If out of spec, use previous average
}
else
{
    Integrator+ = SPBRG_16BIT;                      // If in spec, calculate the running
                                                    // average but continue using the
    Average_Baud = Integrator/16;                  // Auto-Baud value in SPBRG
    Integrator- = Average_Baud;
}
.
.
.
```

Affected Silicon Revisions

A2	A3	A5	A6	A7	A8		
X	X	X	X	X			

PIC16(L)F1934/1936/1937

Data Sheet Clarifications

The following typographic corrections and clarifications are to be noted for the latest version of the device data sheet (DS41364E):

Note: Corrections are shown in bold . Where possible, the original bold text formatting has been removed for clarity.

1. Module: Oscillator

5.5 Fail-Safe Clock Monitor

5.5.3 FAIL-SAFE CONDITION CLEARING

The Fail-Safe condition is cleared after a Reset, executing a `SLEEP` instruction or changing the SCS bits of the `OSCCON` register. When the SCS bits are changed, the OST is restarted. While the OST is running, the device continues to operate from the `INTOSC` selected in `OSCCON`. When the OST times out, the Fail-Safe condition is cleared **after successfully switching to the external clock source. The `OSFIF` bit should be cleared prior to switching to the external clock source. If the Fail-Safe condition still exists, the `OSFIF` flag will again become set by hardware.**

APPENDIX A: DOCUMENT REVISION HISTORY

Rev A Document (9/2009)

Initial release of this document.

Rev B Document (1/2010)

Added silicon revision A5.

Rev C Document (5/2010)

Added Modules 5, 6, 7 and 8.

Data Sheet Clarifications: Added Modules 1 and 2.

Rev D Document (6/2010)

Added Silicon Revision A6.

Rev E Document (7/2010)

Revised Module 5.1; Added Module 8.2; Other minor corrections.

Rev F Document (9/2010)

Added Module 9, LDO.

Rev G Document (9/2011)

Added Silicon Revision A7.

Data Sheet Clarifications: Removed Modules 1 and 2.

Rev H Document (2/2012)

Updated Table 1; Added Module 6.2, 6.3 and 6.4;
Added Module 10, EUSART; Other minor corrections.

Data Sheet Clarifications: Added Module 1, Oscillator.

Rev J Document (7/2012)

Added MPLAB X IDE; Removed the Clock Switching module.

Rev K Document (7/2012)

Added silicon revision A8; Removed Modules 6.2 and 6.3.

PIC16(L)F1934/1936/1937

NOTES:

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 guarantee the security of their code. Code protection does not mean that we are guaranteeing 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.

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.

Trademarks

The Microchip name and logo, the Microchip logo, dsPIC, KEELOQ, KEELOQ logo, MPLAB, PIC, PICmicro, PICSTART, PIC³² logo, rfPIC and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MXDEV, MXLAB, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Application Maestro, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniscient Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICKit, PICtail, REAL ICE, rfLAB, Select Mode, Total Endurance, TSHARC, UniWinDriver, WiperLock 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.

All other trademarks mentioned herein are property of their respective companies.

© 2009-2012, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.

ISBN: 978-1-62076-466-4

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, KEELOQ[®] 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.

**QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
= ISO/TS 16949 =**



MICROCHIP

Worldwide Sales and Service

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

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

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

Cleveland
Independence, OH
Tel: 216-447-0464
Fax: 216-447-0643

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

Detroit
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

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

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

Santa Clara
Santa Clara, CA
Tel: 408-961-6444
Fax: 408-961-6445

Toronto
Mississauga, Ontario,
Canada
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon
Hong Kong
Tel: 852-2401-1200
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8569-7000
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Chongqing
Tel: 86-23-8980-9588
Fax: 86-23-8980-9500

China - Hangzhou
Tel: 86-571-2819-3187
Fax: 86-571-2819-3189

China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4123

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

Japan - Osaka
Tel: 81-66-152-7160
Fax: 81-66-152-9310

Japan - Yokohama
Tel: 81-45-471-6166
Fax: 81-45-471-6122

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-5778-366
Fax: 886-3-5770-955

Taiwan - Kaohsiung
Tel: 886-7-536-4818
Fax: 886-7-330-9305

Taiwan - Taipei
Tel: 886-2-2500-6610
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

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

UK - Wokingham
Tel: 44-118-921-5869
Fax: 44-118-921-5820

11/29/11