

PIC18F87J50 Family Silicon Errata and Data Sheet Clarification

The PIC18F87J50 family devices that you have received conform functionally to the current Device Data Sheet (DS39775C), 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 PIC18F87J50 family 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 (A4).

Data Sheet clarifications and corrections start on [page 6](#), 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 PIC18F87J50 family silicon revisions are shown in [Table 1](#).

TABLE 1: SILICON DEVREV VALUES

Part Number	Device ID ⁽¹⁾	Revision ID for Silicon Revision ⁽²⁾		
		A2	A3	A4
PIC18F65J50	410Xh	2h	3h	4h
PIC18F66J50	414Xh			
PIC18F66J55	416Xh			
PIC18F67J50	418Xh			
PIC18F85J50	41AXh			
PIC18F86J50	41EXh			
PIC18F86J55	420Xh			
PIC18F87J50	422Xh			

Note 1: The Device IDs (DEVID and DEVREV) are located at the last two implemented addresses of configuration memory space. They are shown in hexadecimal in the format "DEVID DEVREV".

2: Refer to the "PIC18F6XJXX/8XJXX Family Flash Microcontroller Programming Specification" (DS39644) for detailed information on Device and Revision IDs for your specific device.

PIC18F87J50 FAMILY

TABLE 2: SILICON ISSUE SUMMARY

Module	Feature	Item Number	Issue Summary	Affected Revisions ⁽¹⁾		
				A2	A3	A4
MSSP (I ² C™ Slave)	I ² C™ Slave	1.	With I ² C slave reception, need to read data promptly.	X	X	X
MSSP (I ² C™ Master)	I ² C Master	2.	With I ² C Master mode, narrow clock width upon slave clock stretch.	X	X	X
Enhanced Universal Synchronous Asynchronous Receiver Transmitter (EUSART)	Interrupts	3.	If interrupts are enabled, 2 Tcy delay needed after re-enabling the module.	X	X	X
MSSP	SPI Master mode	4.	SPI master, write collision for Fosc/64 and Timer2/2.	X	X	X
I/O (PORTH)	RH0, RH1	5.	In certain cases, PMP can override RH0 and RH1.	X	X	X
Timer1/3	Interrupt	6.	When the timer is operated in Asynchronous External Input mode, unexpected interrupt flag generation may occur.	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 (A4).

1. Module: MSSP (I²C™ Slave)

When configured for I²C™ slave reception, the MSSP module may not receive the correct data, in extremely rare cases. This occurs only if the Serial Receive/Transmit Buffer Register (SSPBUF) is not read after the SSPIF interrupt (PIR1<3>) has occurred, but before the first rising clock edge of the next byte being received.

Work around

The issue can be resolved in either of these ways:

- Prior to the I²C slave reception, enable the clock stretching feature.
This is done by setting the SEN bit (SSPCON2<0>).
- Each time the SSPIF is set, read the SSPBUF before the first rising clock edge of the next byte being received.

Affected Silicon Revisions

A2	A3	A4					
X	X	X					

2. Module: MSSP (I²C™ Master)

When in I²C Master mode, if the slave performs clock stretching, the first clock pulse after the slave releases the SCL line may be narrower than the configured clock width. This may result in the slave missing the first clock in the next transmission/reception.

Work around

The clock pulse will be the normal width if the slave does not perform clock stretching.

Affected Silicon Revisions

A2	A3	A4					
X	X	X					

3. Module: Enhanced Universal Synchronous Asynchronous Receiver Transmitter (EUSART)

In rare situations, when interrupts are enabled, unexpected results may occur if:

- The EUSART is disabled (SPEN bit (RCSTAx<7>) = 0)
- The EUSART is re-enabled (RCSTAx<7> = 1)
- A 2-cycle instruction is executed immediately after enabling the module (setting SPEN, CREN or TXEN = 1)

Work around

Add a 2 Tcy delay after any instruction that re-enables the EUSART module (ex: sets SPEN = 1). See [Example 1](#).

EXAMPLE 1: RE-ENABLING A EUSART MODULE

```
;Initial conditions: SPEN = 0 (module disabled)
;To re-enable the module:
;Re-Initialize TXSTAx, BAUDCONx, SPBRGx, SPBRGHx registers (if needed)
;Re-Initialize RCSTAx register (if needed), but do not set SPEN = 1 yet

;Now enable the module, but add a 2-Tcy delay before executing any two-cycle
;instructions
bsf    RCSTA1, SPEN ;or RCSTA2 if EUSART2
nop    ;1 Tcy delay
nop    ;1 Tcy delay (two total)

;CPU may now execute 2 cycle instructions
```

Affected Silicon Revisions

A2	A3	A4					
X	X	X					

PIC18F87J50 FAMILY

4. Module: MSSP

With MSSP1 or MSSP2 in SPI Master mode, the $F_{osc}/64$ or Timer2/2 clock rate enabled and $CKE = 0$, a write collision may occur if SSPBUF is loaded immediately after the transfer is complete. A delay may be required before writing SSPBUF, after the MSSP Interrupt Flag bit (SSPIF) is set or the Buffer Full bit (BF) is set. If the delay is insufficiently short, a write collision may occur as indicated by the WCOL bit being set.

Work around

Add a software delay of one SCK period after detecting the completed transfer and prior to updating the SSPBUF contents.

Affected Silicon Revisions

A2	A3	A4					
X	X	X					

5. Module: I/O (PORTH)

When the Parallel Master Port (PMP) module is enabled ($PMCONH<7> = 1$) and the PMPMX bit is clear ($CONFIG3L<2> = 0$), the PMP module can, under certain conditions, override firmware control over the RH0 and RH1 general purpose I/O (GPIO) pins.

The RH0 and RH1 pins will function normally and can still be used as standard GPIO if the PMP is disabled or the PMPMX Configuration bit is set.

This issue only applies to the 80-pin devices (PIC18F85J50, PIC18F86J50, PIC18F86J55 and PIC18F87J50).

Work around

None.

Affected Silicon Revisions

A2	A3	A4					
X	X	X					

6. Module: Timer1/3

When Timer1 or Timer3 is operated in Asynchronous External Input mode, unexpected interrupt flag generation may occur if an external clock edge arrives too soon following a firmware write to the TMRxH:TMRxL registers. An unexpected interrupt flag event may also occur when enabling the module or switching from Synchronous to Asynchronous mode.

Work around

This issue only applies when operating the timer in Asynchronous mode. Whenever possible, operate the timer module in Synchronous mode to avoid spurious timer interrupts.

If Asynchronous mode must be used in the application, potential strategies to mitigate the issue may include any of the following:

- Design the firmware so it does not rely on the TMRxIF flag or keep the respective interrupt disabled. The timer still counts normally and does not reset to 0x0000 when the spurious interrupt flag event is generated.
- Design the firmware so that it does not write to the TMRxH:TMRxL registers or does not periodically disable/enable the timer, or switch modes. Reading from the timer does not trigger the spurious interrupt flag events.
- If the firmware must use the timer interrupts and must write to the timer (or disable/enable, or mode switch the timer), implement code to suppress the spurious interrupt event, should it occur. This can be achieved by following the process shown in [Example 2](#).

EXAMPLE 2: ASYNCHRONOUS TIMER MODE WORK AROUND TO AVOID SPURIOUS INTERRUPT

```
//Timer1 update procedure in asynchronous mode
//The code below uses Timer1 as example

T1CONbits.TMR1ON = 0;           //Stop timer from incrementing
PIE1bits.TMR1IE = 0;           //Temporarily disable Timer1 interrupt vectoring
TMR1H = 0x00;                  //Update timer value
TMR1L = 0x00;
T1CONbits.TMR1ON = 1;          //Turn on timer

//Now wait at least two full T1CKI periods + 2TCY before re-enabling Timer1 interrupts.
//Depending upon clock edge timing relative to TMR1H/TMR1L firmware write operation,
//a spurious TMR1IF flag event may sometimes assert. If this happens, to suppress
//the actual interrupt vectoring, the TMR1IE bit should be kept clear until
//after the "window of opportunity" (for the spurious interrupt flag event has passed).
//After the window is passed, no further spurious interrupts occur, at least
//until the next timer write (or mode switch/enable event).

while(TMR1L < 0x02);           //Wait for 2 timer increments more than the Updated Timer
                                //value (indicating more than 2 full T1CKI clock periods elapsed)
NOP();                          //Wait two more instruction cycles
NOP();
PIR1bits.TMR1IF = 0;           //Clear TMR1IF flag, in case it was spuriously set
PIE1bits.TMR1IE = 1;           //Now re-enable interrupt vectoring for timer 1
```

Affected Silicon Revisions

A2	A3	A4					
X	X	X					

PIC18F87J50 FAMILY

Data Sheet Clarifications

The following typographic corrections and clarifications are to be noted for the latest version of the device data sheet (DS39775C):

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

1. Module: Table 28-1: Memory Programming Requirements

On page 430, parameter D132B is renamed, and the minimum and maximum voltage levels and conditions column of the Self-Timed Erase or Write for VDD and VDDCORE for are included. The TWE parameter number and conditions column are changed.

The changed content is indicated in bold text in [Table 28-1](#):

TABLE 28-1: MEMORY PROGRAMMING REQUIREMENTS

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for industrial				
Param No.	Sym.	Characteristic	Min.	Typ†	Max.	Units	Conditions
		Program Flash Memory					
D130	EP	Cell Endurance	10K	—	—	E/W	-40°C to +85°C V _{MIN} = Minimum operating voltage
D131	VPR	VDDCORE for Read	V _{MIN}	—	3.6	V	
D132	VPEW	Voltage for Self-Timed Erase or Write					
		VDD	2.35	—	3.6	V	ENVREG tied to VDD
		VDDCORE	2.25	—	2.7	V	ENVREG tied to Vss
D133A	TIW	Self-Timed Write Cycle Time	—	2.8	—	ms	Provided no other specifications are violated
D133B	TIE	Self-Timed Page Erase Cycle Time	—	33.0	—	ms	
D134	TRETD	Characteristic Retention	20	—	—	Year	
D135	IDDP	Supply Current during Programming	—	10	—	mA	
D140	TWE	Writes per Erase Cycle	—	—	1	—	For each physical address

† Data in “Typ” column is at 3.3V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

PIC18F87J50 FAMILY

2. Module: Table 28-2: Comparator Specifications

On page 431, the maximum Input Offset Voltage (parameter D300) is changed to ± 25 mV.

The parameter numbers for TRESP and TMC2OV are changed to D303 and D304, respectively.

A new parameter number, D305, for VIRV is added.

The changed/append content is indicated in bold text in [Table 28-2](#).

3. Module: Table 28-4: Internal Voltage Regulator Specifications

On page 431, additional comments are provided to help guide selection of an external capacitor.

The changed/append content is indicated in bold text in [Table 28-4](#).

TABLE 28-2: COMPARATOR SPECIFICATIONS

Operating Conditions: $3.0V < V_{DD} < 3.6V$, $-40^{\circ}C < T_A < +85^{\circ}C$ (unless otherwise stated)							
Param No.	Sym.	Characteristics	Min.	Typ.	Max.	Units	Comments
D300	VIOFF	Input Offset Voltage	—	± 5.0	± 25	mV	
D301	VICM	Input Common Mode Voltage	0	—	$AV_{DD} - 1.5$	V	
D302	CMRR	Common Mode Rejection Ratio	55	—	—	dB	
D303	TRESP	Response Time ⁽¹⁾	—	150	400	ns	
D304	TMC2OV	Comparator Mode Change to Output Valid	—	—	10	μs	
D305	VIRV	Internal Reference Voltage	—	1.2	—	V	

Note 1: Response time measured with one comparator input at $(V_{DD} - 1.5)/2$, while the other input transitions from VSS to VDD.

TABLE 28-4: INTERNAL VOLTAGE REGULATOR SPECIFICATIONS

Operating Conditions: $-40^{\circ}C < T_A < +85^{\circ}C$ (unless otherwise stated)							
Param No.	Sym.	Characteristics	Min.	Typ.	Max.	Units	Comments
	VRGOUT	Regulator Output Voltage	2.45	2.5	—	V	V_{DD} , ENVREG = 3.0V
	CEFC	External Filter Capacitor Value ⁽¹⁾	4.7 ⁽²⁾	10	—	μF	Capacitor must be low series resistance ($< 5\Omega$)

Note 1: CEFC applies when the internal regulator is enabled (ENVREG = VDD). When the regulator is disabled (ENVREG = VSS), there is no minimum or maximum capacitance, but good supply rail bypassing should still be practiced.

2: If the regulator is enabled and the VDD supply rail has moderate ripple voltage, it is recommended that more than the minimum CEFC be used.

PIC18F87J50 FAMILY

4. Module: Section 28.3 “DC Characteristics: PIC18F87J50 Family (Industrial)”

The changed content is indicated in bold text in the “**DC CHARACTERISTICS**” table.

On page 428, the characteristics and conditions of the Input Leakage Current are updated for the Analog (D060) and included for the Digital (D060A) I/O ports.

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for industrial			
Param No.	Symbol	Characteristic	Min	Max	Units	Conditions
D030 D030A D031 D032 D033 D033A D034	V_{IL}	Input Low Voltage All I/O ports: with TTL buffer with Schmitt Trigger buffer $\overline{\text{MCLR}}$ OSC1 OSC1 T1CKI	V_{SS} — V_{SS} V_{SS} V_{SS} V_{SS} V_{SS}	$0.15 V_{DD}$ 0.8 $0.2 V_{DD}$ $0.2 V_{DD}$ $0.3 V_{DD}$ $0.2 V_{DD}$ 0.3	V V V V V V V	$V_{DD} < 3.3\text{V}$ $3.3\text{V} \leq V_{DD} \leq 3.6\text{V}$ HS, HSPLL modes EC, ECPLL modes
D040 D040A D041 Dxxx DxxxA Dxxx D042 D043 D043A D044	V_{IH}	Input High Voltage I/O ports with non 5.5V tolerance:⁽²⁾ with TTL buffer with Schmitt Trigger buffer I/O ports with 5.5V tolerance:⁽²⁾ with TTL buffer with Schmitt Trigger buffer $\overline{\text{MCLR}}$ OSC1 OSC1 T1CKI	$0.25 V_{DD} + 0.8\text{V}$ 2.0 $0.8 V_{DD}$ $0.25 V_{DD} + 0.8\text{V}$ 2.0 $0.8 V_{DD}$ $0.8 V_{DD}$ $0.7 V_{DD}$ $0.8 V_{DD}$ 1.6	V_{DD} V_{DD} V_{DD} 5.5 5.5 5.5 V_{DD} V_{DD} V_{DD} V_{DD}	V V V V V V V V V V	$V_{DD} < 3.3\text{V}$ $3.3\text{V} \leq V_{DD} \leq 3.6\text{V}$ $V_{DD} < 3.3\text{V}$ $3.3\text{V} \leq V_{DD} \leq 3.6\text{V}$ HS, HSPLL modes EC, ECPLL modes
D060 D060A D061 D063	I_{IL}	Input Leakage Current⁽¹⁾ I/O ports with non 5.5V tolerance:⁽²⁾ I/O ports with 5.5V tolerance:⁽²⁾ $\overline{\text{MCLR}}$ OSC1	— — — —	± 1 ± 1 ± 1 ± 5	μA μA μA μA	$V_{SS} \leq V_{PIN} \leq V_{DD}$, Pin at high-impedance $V_{SS} \leq V_{PIN} \leq 5.5\text{V}$, Pin at high-impedance $V_{SS} \leq V_{PIN} \leq V_{DD}$ $V_{SS} \leq V_{PIN} \leq V_{DD}$

Note 1: Negative current is defined as current sourced by the pin.

2: Refer to Table 10-1 for the pins that have corresponding tolerance limits.

5. Module: Section 19.3 “SPI Mode” and Section 19.4 “I²C™ Mode”

In **Section 19.3 “SPI Mode”** on page 231 and **Section 19.4 “I²C™ Mode”** on page 241, the following note is added to describe the procedure to disable the MSSP module:

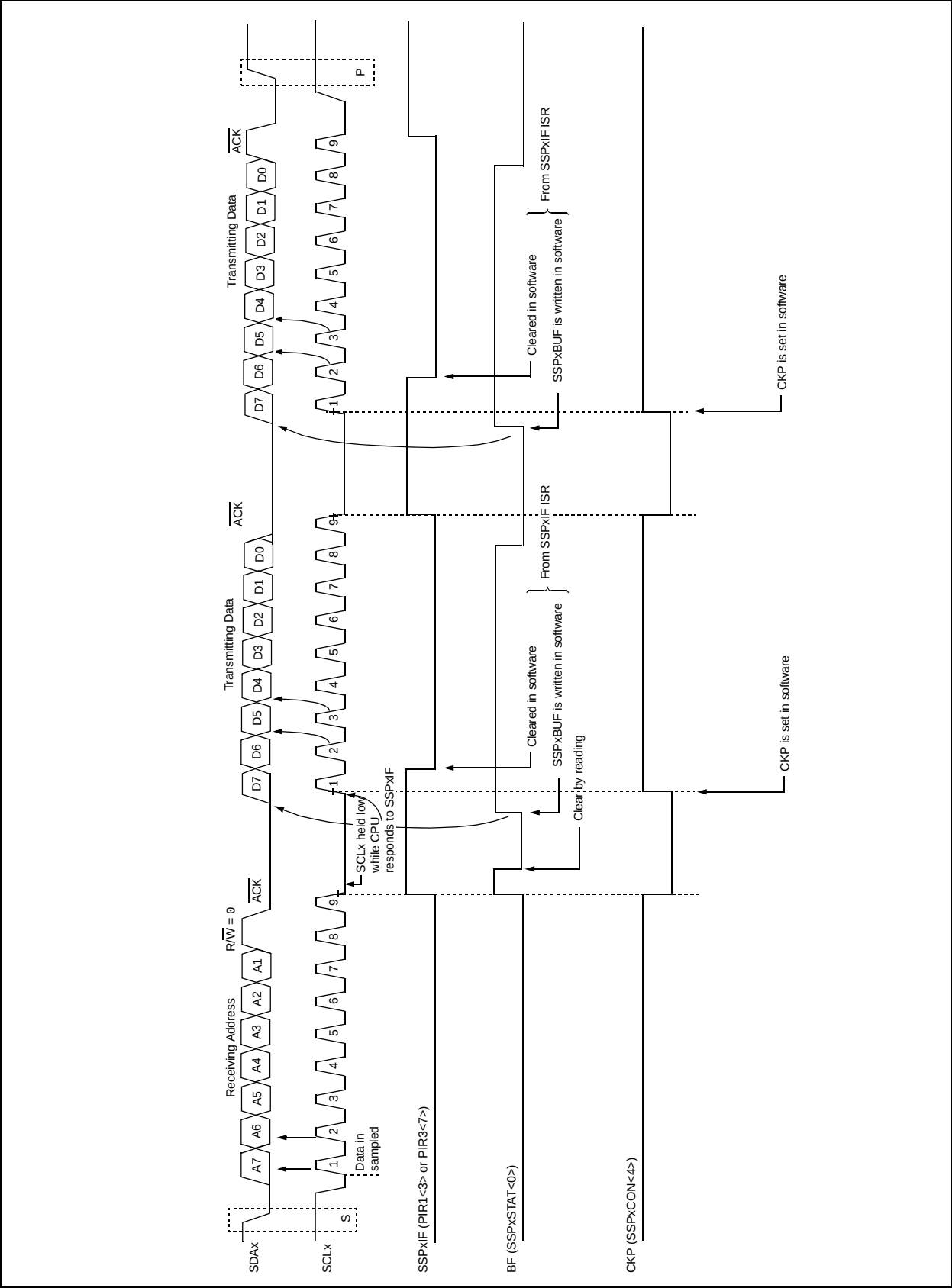
Note: Disabling the MSSP module by clearing the SSPEN bit (SSPxCON1<5>) may not reset the module. It is recommended to clear the SSPxSTAT, SSPxCON1 and SSPxCON2 registers and select the mode prior to setting the SSPEN bit to enable the MSSP module.
--

6. Module: Figure 19-10: I²C™ Slave Mode Timing (Transmission, 7-Bit Address)

On page 252, the figure is replaced with the new timing diagram provided in [Figure 19-10](#).

PIC18F87J50 FAMILY

FIGURE 19-10: I²C™ SLAVE MODE TIMING (TRANSMISSION, 7-BIT ADDRESS)



7. Module: **Figure 19-24: I²C™ Master Mode Waveform (Reception, 7-Bit Address)**

On page 269, the condition, $R/\overline{W}$, when the Acknowledge signal (ACK) is received from the slave, after transmitting the address to the slave, is changed to '1'.

The changed value is indicated in bold text in [Figure 19-24](#).

8. Module: MSSP (SPI Master)

In **Section 19.3.6, “Master Mode,”** the following content is added:

When used in Timer2 Output/2 mode, the SPI bit rate can be configured using the PR2 Period register and the Timer2 prescaler.

To operate in this mode, firmware must first initialize and enable the Timer2 module before it can be used with the MSSP. Once enabled, the Timer2 module is free running and mostly independent of the MSSP module.

Writing to the SSPxBUF register will not clear the current TMR2 value in hardware. This can result in an unpredictable SPI transmit MSb bit width, depending on how close the TMR2 register was to the PR2 match condition at the moment that the firmware wrote to SSPxBUF.

To avoid the unpredictable MSb bit width, initialize the TMR2 register to a known value when writing to SSPxBUF. An example procedure, which provides predictable bit widths (only needed in the Timer2/2 mode), is given in [Example 3](#). The example procedure demonstrates operation with MSSP1, but the concepts apply equally to MSSP2.

EXAMPLE 3: LOADING SSPxBUF WITH THE TIMER2/2 CLOCK MODE

```
TransmitSPI:
BCF    PIR1, SSP1IF    ;Make sure interrupt flag is clear (may have been set from previous
                        ;transmission)
MOVWF  SSP1BUF, W      ;Perform read, even if the data in SSPBUF is not important
MOVWF  RXDATA          ;Save previously received byte in user RAM, if the data is meaningful
BCF    T2CON, TMR2ON   ;Turn off timer when loading SSPBUF
CLRF   TMR2            ;Set timer to a known state
MOVWF  TXDATA, W       ;WREG = Contents of TXDATA (user data to send)
MOVWF  SSP1BUF          ;Load data to send into transmit buffer
BSF    T2CON, TMR2ON   ;Start timer to begin transmission

WaitComplete:          ;Loop until data has finished transmitting
BTFSS  PIR1, SSP1IF    ;Interrupt flag set when transmit is complete
BRA    WaitComplete
```

9. Module: OSCTUNE Register

The second paragraph of **Section 2.2.5.1 “OSCTUNE Register”** is modified as indicated:

When the OSCTUNE register is modified, the INTOSC frequency begins shifting to the new value. The INTOSC clock stabilizes within 1 ms.

Code execution continues during this shift. There is no indication that the shift has occurred.

PIC18F87J50 FAMILY

APPENDIX A: DOCUMENT REVISION HISTORY

Rev A Document (9/2009)

Initial release of the combined, silicon errata/data sheet clarification document. New silicon issues 4 (MSSP) and 5 (I/O – PORTH). New data sheet clarifications 8 (MSSP – SPI Master) and 9 (OSCTUNE Register).

This document replaces these errata documents:

- DS80321B, “PIC18F87J50 Family Rev. A2 Silicon Errata”
- DS80415A, “PIC18F87J50 Family Rev. A3 Silicon Errata”
- DS80409B, “PIC18F87J50 Family Data Sheet Errata”.

Rev B Document (7/2014)

Updated errata to new format; Added Module 6, Timer1/3, to Silicon Errata Issues section; Other minor corrections.

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, FlashFlex, flexPWR, JukeBlox, KEELoQ, KEELoQ logo, Klear, LANCheck, MediaLB, MOST, MOST logo, MPLAB, OptoLyzer, PIC, PICSTART, PIC³² logo, RightTouch, SpyNIC, SST, SST Logo, SuperFlash and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

The Embedded Control Solutions Company and mTouch are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, BodyCom, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, ECAN, In-Circuit Serial Programming, ICSP, Inter-Chip Connectivity, KlearNet, KlearNet logo, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, RightTouch logo, REAL ICE, SQI, Serial Quad I/O, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, 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.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

GestIC is a registered trademarks 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.

© 2009-2014, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

ISBN: 978-1-63276-433-1

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
= 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, 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.

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

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

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

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

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

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110

Canada - Toronto
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: 852-2943-5100
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: 86-571-8792-8115
Fax: 86-571-8792-8116

China - Hong Kong SAR
Tel: 852-2943-5100
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: 86-755-8864-2200
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: 91-20-3019-1500

Japan - Osaka
Tel: 81-6-6152-7160
Fax: 81-6-6152-9310

Japan - Tokyo
Tel: 81-3-6880-3770
Fax: 81-3-6880-3771

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: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600
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 - Dusseldorf
Tel: 49-2129-3766400

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

Germany - Pforzheim
Tel: 49-7231-424750

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

Italy - Venice
Tel: 39-049-7625286

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

Poland - Warsaw
Tel: 48-22-3325737

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

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

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820