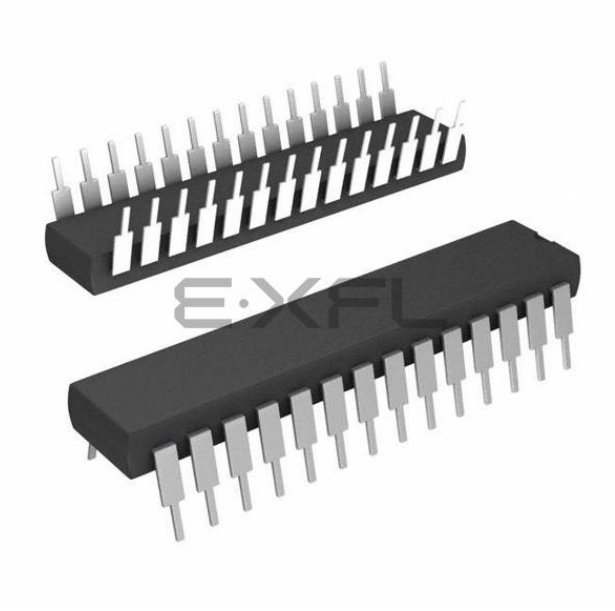

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"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	32MHz
Connectivity	I²C, LINbus, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, LCD, POR, PWM, WDT
Number of I/O	25
Program Memory Size	7KB (4K x 14)
Program Memory Type	FLASH
EEPROM Size	256 x 8
RAM Size	256 x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 3.6V
Data Converters	A/D 11x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Through Hole
Package / Case	28-DIP (0.300", 7.62mm)
Supplier Device Package	28-SPDIP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16lf1933-e-sp

Peripheral Features (Continued):

- Master Synchronous Serial Port (MSSP) with SPI and I^2C™ with:
  - 7-bit address masking
  - SMBus/PMBus™ compatibility
  - Auto-wake-up on start
- Enhanced Universal Synchronous Asynchronous Receiver Transmitter (EUSART)
  - RS-232, RS-485 and LIN compatible
  - Auto-Baud Detect
- SR Latch (555 Timer):
  - Multiple Set/Reset input options
  - Emulates 555 Timer applications
- 2 Comparators:
  - Rail-to-rail inputs/outputs
  - Power mode control
  - Software enable hysteresis
- Voltage Reference module:
  - Fixed Voltage Reference (FVR) with 1.024V, 2.048V and 4.096V output levels
  - 5-bit rail-to-rail resistive DAC with positive and negative reference selection

PIC16(L)F193X/194X Family Types

Device	Data Sheet Index	Program Memory Flash (words)	Data EEPROM (bytes)	Data SRAM (bytes)	I/O's(2)	10-bit ADC (ch)	CapSense (ch)	Comparators	Timers (8/16-bit)	EUSART	MSSP (I^2C™/SPI)	ECCP	CCP	LCD (Com/Seg/Total)	Debug(1)	XLP
PIC16(L)F1933	(1)	4096	256	256	25	11	8	2	4/1	1	1	3	2	4/16/60(3)	I/H	Y
PIC16(L)F1934	(2)	4096	256	256	36	14	16	2	4/1	1	1	3	2	4/24/96	I/H	Y
PIC16(L)F1936	(2)	8192	256	512	25	11	8	2	4/1	1	1	3	2	4/16/60(3)	I/H	Y
PIC16(L)F1937	(2)	8192	256	512	36	14	16	2	4/1	1	1	3	2	4/24/96	I/H	Y
PIC16(L)F1938	(3)	16384	256	1024	25	11	8	2	4/1	1	1	3	2	4/16/60(3)	I/H	Y
PIC16(L)F1939	(3)	16384	256	1024	36	14	16	2	4/1	1	1	3	2	4/24/96	I/H	Y
PIC16(L)F1946	(4)	8192	256	512	54	17	17	3	4/1	2	2	3	2	4/46/184	I	Y
PIC16(L)F1947	(4)	16384	256	1024	54	17	17	3	4/1	2	2	3	2	4/46/184	I	Y

Note 1: I - Debugging, Integrated on Chip; H - Debugging, available using Debug Header.

2: One pin is input-only.

3: COM3 and SEG15 share the same physical pin, therefore SEG15 is not available when using 1/4 multiplex displays.

Data Sheet Index: (Unshaded devices are described in this document.)

1: DS41575 PIC16(L)F1933 Data Sheet, 28-Pin Flash, 8-bit Microcontrollers.

2: DS41364 PIC16(L)F1934/6/7 Data Sheet, 28/40/44-Pin Flash, 8-bit Microcontrollers.

3: DS41574 PIC16(L)F1938/9 Data Sheet, 28/40/44-Pin Flash, 8-bit Microcontrollers.

4: DS41414 PIC16(L)F1946/1947 Data Sheet, 64-Pin Flash, 8-bit Microcontrollers.

Note: For other small form-factor package availability and marking information, please visit **http://www.microchip.com/packaging** or contact your local sales office.

TABLE 3-7: PIC16(L)F1933 MEMORY MAP, BANK 15

Bank 15	
791h	LCDCON
792h	LCDPS
793h	LCDREF
794h	LCDCST
795h	LCDRL
796h	—
797h	—
798h	LCDSE0
799h	LCDSE1
79Ah	—
79Bh	—
79Ch	—
79Dh	—
79Eh	—
79Fh	—
7A0h	LCDDATA0
7A1h	LCDDATA1
7A2h	—
7A3h	LCDDATA3
7A4h	LCDDATA4
7A5h	—
7A6h	LCDDATA6
7A7h	LCDDATA7
7A8h	—
7A9h	LCDDATA9
7AAh	LCDDATA10
7ABh	—
7ACh	—
7ADh	—
7AEh	—
7AFh	—
7B0h	—
7B1h	—
7B2h	—
7B3h	—
7B4h	—
7B5h	—
7B6h	—
7B7h	—
7B8h – 7EFh	Unimplemented Read as '0'

Legend: = Unimplemented data memory locations, read as '0'.

TABLE 3-8: PIC16(L)F1933 MEMORY MAP, BANK 31

Bank 31	
F8Ch – FE3h	Unimplemented Read as '0'
FE4h	STATUS_SHAD
FE5h	WREG_SHAD
FE6h	BSR_SHAD
FE7h	PCLATH_SHAD
FE8h	FSR0L_SHAD
FE9h	FSR0H_SHAD
FEAh	FSR1L_SHAD
FEBh	FSR1H_SHAD
FECh	—
FEDh	STKPTR
FEEh	TOSL
FEFh	TOSH

Legend: = Unimplemented data memory locations, read as '0'.

3.3.5 SPECIAL FUNCTION REGISTERS SUMMARY

The Special Function Register Summary for the device family are as follows:

Device	Bank(s)	Page No.
PIC16(L)F1933	0	25
	1	26
	2	27
	3	28
	4	29
	5	30
	6	31
	7	32
	8	33
	9-14	34
	15	35
	16-30	36
	31	37

TABLE 3-9: SPECIAL FUNCTION REGISTER SUMMARY (CONTINUED)

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on POR, BOR	Value on all other Resets
Bank 3											
180h(2)	INDF0	Addressing this location uses contents of FSR0H/FSR0L to address data memory (not a physical register)								xxxx xxxx	xxxx xxxx
181h(2)	INDF1	Addressing this location uses contents of FSR1H/FSR1L to address data memory (not a physical register)								xxxx xxxx	xxxx xxxx
182h(2)	PCL	Program Counter (PC) Least Significant Byte								0000 0000	0000 0000
183h(2)	STATUS	—	—	—	$\overline{TO}$	$\overline{PD}$	Z	DC	C	---1 1000	---q quuu
184h(2)	FSR0L	Indirect Data Memory Address 0 Low Pointer								0000 0000	uuuu uuuu
185h(2)	FSR0H	Indirect Data Memory Address 0 High Pointer								0000 0000	0000 0000
186h(2)	FSR1L	Indirect Data Memory Address 1 Low Pointer								0000 0000	uuuu uuuu
187h(2)	FSR1H	Indirect Data Memory Address 1 High Pointer								0000 0000	0000 0000
188h(2)	BSR	—	—	—	BSR<4:0>					---0 0000	---0 0000
189h(2)	WREG	Working Register								0000 0000	uuuu uuuu
18Ah(1, 2)	PCLATH	—	Write Buffer for the upper 7 bits of the Program Counter							-000 0000	-000 0000
18Bh(2)	INTCON	GIE	PEIE	TMR0IE	INTE	IOCIE	TMR0IF	INTF	IOCIF	0000 0000	0000 0000
18Ch	ANSELA	—	—	ANSA5	ANSA4	ANSA3	ANSA2	ANSA1	ANSA0	--11 1111	--11 1111
18Dh	ANSELB	—	—	ANSB5	ANSB4	ANSB3	ANSB2	ANSB1	ANSB0	--11 1111	--11 1111
18Eh	—	Unimplemented								—	—
18Fh	—	Unimplemented								—	—
190h	—	Unimplemented								—	—
191h	EEADRL	EEPROM / Program Memory Address Register Low Byte								0000 0000	0000 0000
192h	EEADRH	—(3)	EEPROM / Program Memory Address Register High Byte							1000 0000	1000 0000
193h	EEDATL	EEPROM / Program Memory Read Data Register Low Byte								xxxx xxxx	uuuu uuuu
194h	EEDATH	—	—	EEPROM / Program Memory Read Data Register High Byte						--xx xxxx	--uu uuuu
195h	EECON1	EEPGD	CFGS	LWLO	FREE	WRERR	WREN	WR	RD	0000 x000	0000 q000
196h	EECON2	EEPROM control register 2								0000 0000	0000 0000
197h	—	Unimplemented								—	—
198h	—	Unimplemented								—	—
199h	RCREG	USART Receive Data Register								0000 0000	0000 0000
19Ah	TXREG	USART Transmit Data Register								0000 0000	0000 0000
19Bh	SPBRGL	BRG<7:0>								0000 0000	0000 0000
19Ch	SPBRGH	BRG<15:8>								0000 0000	0000 0000
19Dh	RCSTA	SPEN	RX9	SREN	CREN	ADDEN	FERR	OERR	RX9D	0000 000x	0000 000x
19Eh	TXSTA	CSRC	TX9	TXEN	SYNC	SENDB	BRGH	TRMT	TX9D	0000 0010	0000 0010
19Fh	BAUDCON	ABDOVF	RCIDL	—	SCKP	BRG16	—	WUE	ABDEN	01-0 0-00	01-0 0-00

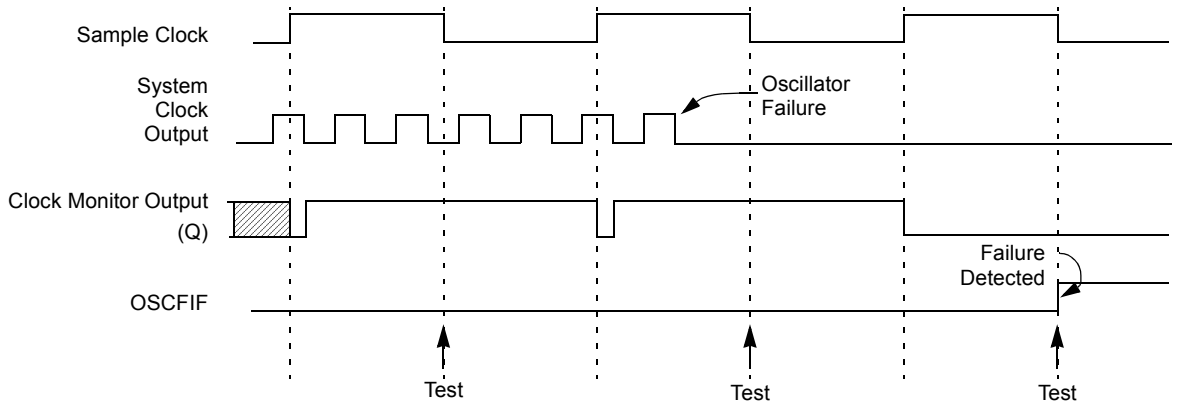
Legend: x = unknown, u = unchanged, q = value depends on condition, - = unimplemented, read as '0', r = reserved. Shaded locations are unimplemented, read as '0'.

Note 1: The upper byte of the program counter is not directly accessible. PCLATH is a holding register for the PC<14:8>, whose contents are transferred to the upper byte of the program counter.

2: These registers can be addressed from any bank.

3: Unimplemented, read as '1'.

FIGURE 5-10: FSCM TIMING DIAGRAM



Note: The system clock is normally at a much higher frequency than the sample clock. The relative frequencies in this example have been chosen for clarity.

5.6 Register Definitions: Oscillator Control

REGISTER 5-1: OSCCON: OSCILLATOR CONTROL REGISTER

R/W-0/0	R/W-0/0	R/W-1/1	R/W-1/1	R/W-1/1	U-0	R/W-0/0	R/W-0/0
SPLLEN	IRCF<3:0>				—	SCS<1:0>	
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7 **SPLLEN:** Software PLL Enable bit
If PLLEN in Configuration Words = 1:
SPLLEN bit is ignored. 4x PLL is always enabled (subject to oscillator requirements)
If PLLEN in Configuration Words = 0:
1 = 4x PLL Is enabled
0 = 4x PLL is disabled

bit 6-3 **IRCF<3:0>:** Internal Oscillator Frequency Select bits
1111 = 16 MHz HF
1110 = 8 MHz or 32 MHz HF(see **Section 5.2.2.1 “HFINTOSC”**)
1101 = 4 MHz HF
1100 = 2 MHz HF
1011 = 1 MHz HF
1010 = 500 kHz HF(1)
1001 = 250 kHz HF(1)
1000 = 125 kHz HF(1)
0111 = 500 kHz MF (default upon Reset)
0110 = 250 kHz MF
0101 = 125 kHz MF
0100 = 62.5 kHz MF
0011 = 31.25 kHz HF(1)
0010 = 31.25 kHz MF
000x = 31 kHz LF

bit 2 **Unimplemented:** Read as ‘0’

bit 1-0 **SCS<1:0>:** System Clock Select bits
1x = Internal oscillator block
01 = Timer1 oscillator
00 = Clock determined by FOSC<2:0> in Configuration Words.

Note 1: Duplicate frequency derived from HFINTOSC.

6.11 Determining the Cause of a Reset

Upon any Reset, multiple bits in the STATUS and PCON register are updated to indicate the cause of the Reset. Table 6-3 and Table 6-4 show the Reset conditions of these registers.

TABLE 6-3: RESET STATUS BITS AND THEIR SIGNIFICANCE

STKOVF	STKUNF	$\overline{\text{RMCLR}}$	$\overline{\text{RI}}$	$\overline{\text{POR}}$	$\overline{\text{BOR}}$	$\overline{\text{TO}}$	$\overline{\text{PD}}$	Condition
0	0	1	1	0	x	1	1	Power-on Reset
0	0	1	1	0	x	0	x	Illegal, $\overline{\text{TO}}$ is set on $\overline{\text{POR}}$
0	0	1	1	0	x	x	0	Illegal, $\overline{\text{PD}}$ is set on $\overline{\text{POR}}$
0	0	1	1	u	0	1	1	Brown-out Reset
u	u	u	u	u	u	0	u	WDT Reset
u	u	u	u	u	u	0	0	WDT Wake-up from Sleep
u	u	u	u	u	u	1	0	Interrupt Wake-up from Sleep
u	u	0	u	u	u	u	u	$\overline{\text{MCLR}}$ Reset during normal operation
u	u	0	u	u	u	1	0	$\overline{\text{MCLR}}$ Reset during Sleep
u	u	u	0	u	u	u	u	RESET Instruction Executed
1	u	u	u	u	u	u	u	Stack Overflow Reset (STVREN = 1)
u	1	u	u	u	u	u	u	Stack Underflow Reset (STVREN = 1)

TABLE 6-4: RESET CONDITION FOR SPECIAL REGISTERS(2)

Condition	Program Counter	STATUS Register	PCON Register
Power-on Reset	0000h	---1 1000	00-- 110x
$\overline{\text{MCLR}}$ Reset during normal operation	0000h	---u uuuu	uu-- 0uuu
$\overline{\text{MCLR}}$ Reset during Sleep	0000h	---1 0uuu	uu-- 0uuu
WDT Reset	0000h	---0 uuuu	uu-- uuuu
WDT Wake-up from Sleep	PC + 1	---0 0uuu	uu-- uuuu
Brown-out Reset	0000h	---1 1uuu	00-- 11u0
Interrupt Wake-up from Sleep	PC + 1(1)	---1 0uuu	uu-- uuuu
RESET Instruction Executed	0000h	---u uuuu	uu-- u0uu
Stack Overflow Reset (STVREN = 1)	0000h	---u uuuu	1u-- uuuu
Stack Underflow Reset (STVREN = 1)	0000h	---u uuuu	u1-- uuuu

Legend: u = unchanged, x = unknown, - = unimplemented bit, reads as '0'.

Note 1: When the wake-up is due to an interrupt and Global Enable bit (GIE) is set, the return address is pushed on the stack and PC is loaded with the interrupt vector (0004h) after execution of PC + 1.

2: If a Status bit is not implemented, that bit will be read as '0'.

TABLE 15-1: ADC CLOCK PERIOD (T_{AD}) VS. DEVICE OPERATING FREQUENCIES

ADC Clock Period (T_{AD})		Device Frequency (F_{OSC}) Device Frequency (F_{OSC})					
ADC Clock Source	**ADCS<2:0>**	**32 MHz**	**20 MHz**	**16 MHz**	**8 MHz**	**4 MHz**	**1 MHz**
Fosc/2	000	62.5ns(2)	100 ns(2)	125 ns(2)	250 ns(2)	500 ns(2)	2.0 μs
Fosc/4	100	125 ns(2)	200 ns(2)	250 ns(2)	500 ns(2)	1.0 μs	4.0 μs
Fosc/8	001	0.5 μs(2)	400 ns(2)	0.5 μs(2)	1.0 μs	2.0 μs	8.0 μs(3)
Fosc/16	101	800 ns	800 ns	1.0 μs	2.0 μs	4.0 μs	16.0 μs(3)
Fosc/32	010	1.0 μs	1.6 μs	2.0 μs	4.0 μs	8.0 μs(3)	32.0 μs(3)
Fosc/64	110	2.0 μs	3.2 μs	4.0 μs	8.0 μs(3)	16.0 μs(3)	64.0 μs(3)
FRC	x11	1.0-6.0 μs(1,4)	1.0-6.0 μs(1,4)	1.0-6.0 μs(1,4)	1.0-6.0 μs(1,4)	1.0-6.0 μs(1,4)	1.0-6.0 μs(1,4)

Legend: Shaded cells are outside of recommended range.

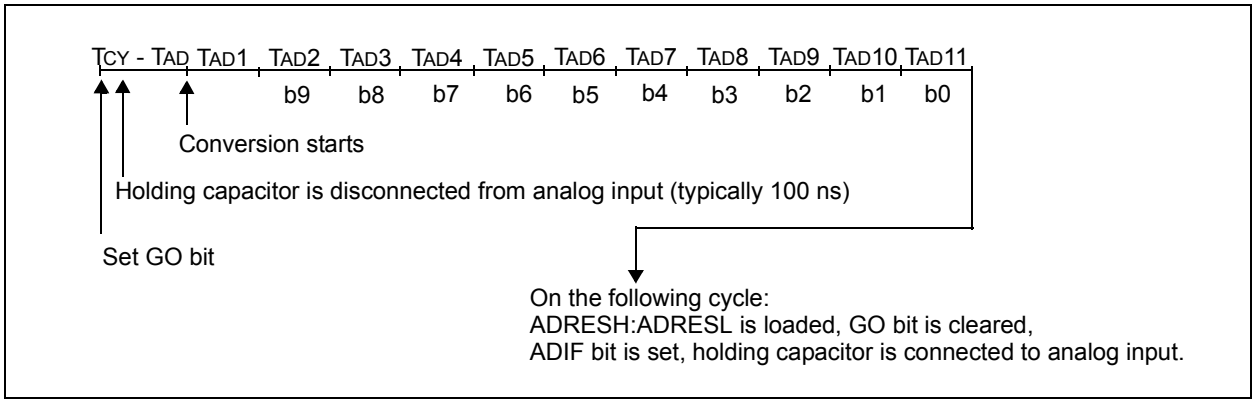
Note 1: The FRC source has a typical TAD time of 1.6 μs for VDD.

2: These values violate the minimum required TAD time.

3: For faster conversion times, the selection of another clock source is recommended.

4: The ADC clock period (TAD) and total ADC conversion time can be minimized when the ADC clock is derived from the system clock FOSC. However, the FRC clock source must be used when conversions are to be performed with the device in Sleep mode.

FIGURE 15-2: ANALOG-TO-DIGITAL CONVERSION T_{AD} CYCLES



20.2 Register Definitions: Option Register

REGISTER 20-1: OPTION_REG: OPTION REGISTER

R/W-1/1	R/W-1/1	R/W-1/1	R/W-1/1	R/W-1/1	R/W-1/1	R/W-1/1	R/W-1/1
$\overline{\text{WPUEN}}$	INTEDG	TMR0CS	TMR0SE	PSA	PS<2:0>		
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
'1' = Bit is set	'0' = Bit is cleared	

bit 7 **$\overline{\text{WPUEN}}$:** Weak Pull-Up Enable bit
1 = All weak pull-ups are disabled (except $\overline{\text{MCLR}}$, if it is enabled)
0 = Weak pull-ups are enabled by individual WPUx latch values

bit 6 **INTEDG:** Interrupt Edge Select bit
1 = Interrupt on rising edge of INT pin
0 = Interrupt on falling edge of INT pin

bit 5 **TMR0CS:** Timer0 Clock Source Select bit
1 = Transition on T0CKI pin
0 = Internal instruction cycle clock (FOSC/4)

bit 4 **TMR0SE:** Timer0 Source Edge Select bit
1 = Increment on high-to-low transition on T0CKI pin
0 = Increment on low-to-high transition on T0CKI pin

bit 3 **PSA:** Prescaler Assignment bit
1 = Prescaler is not assigned to the Timer0 module
0 = Prescaler is assigned to the Timer0 module

bit 2-0 **PS<2:0>:** Prescaler Rate Select bits

Bit Value	Timer0 Rate
000	1 : 2
001	1 : 4
010	1 : 8
011	1 : 16
100	1 : 32
101	1 : 64
110	1 : 128
111	1 : 256

TABLE 20-1: SUMMARY OF REGISTERS ASSOCIATED WITH TIMER0

Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Register on Page
CPSCON0	CPSON	CPSRM	—	—	CPSRNG<1:0>		CPSOUT	T0XCS	311
INTCON	GIE	PEIE	TMR0IE	INTE	IOCIE	TMR0IF	INTF	IOCIF	82
OPTION_REG	$\overline{\text{WPUEN}}$	INTEDG	TMR0CS	TMR0SE	PSA	PS<2:0>			173
TMR0	Timer0 Module Register								171*
TRISA	TRISA7	TRISA6	TRISA5	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	116

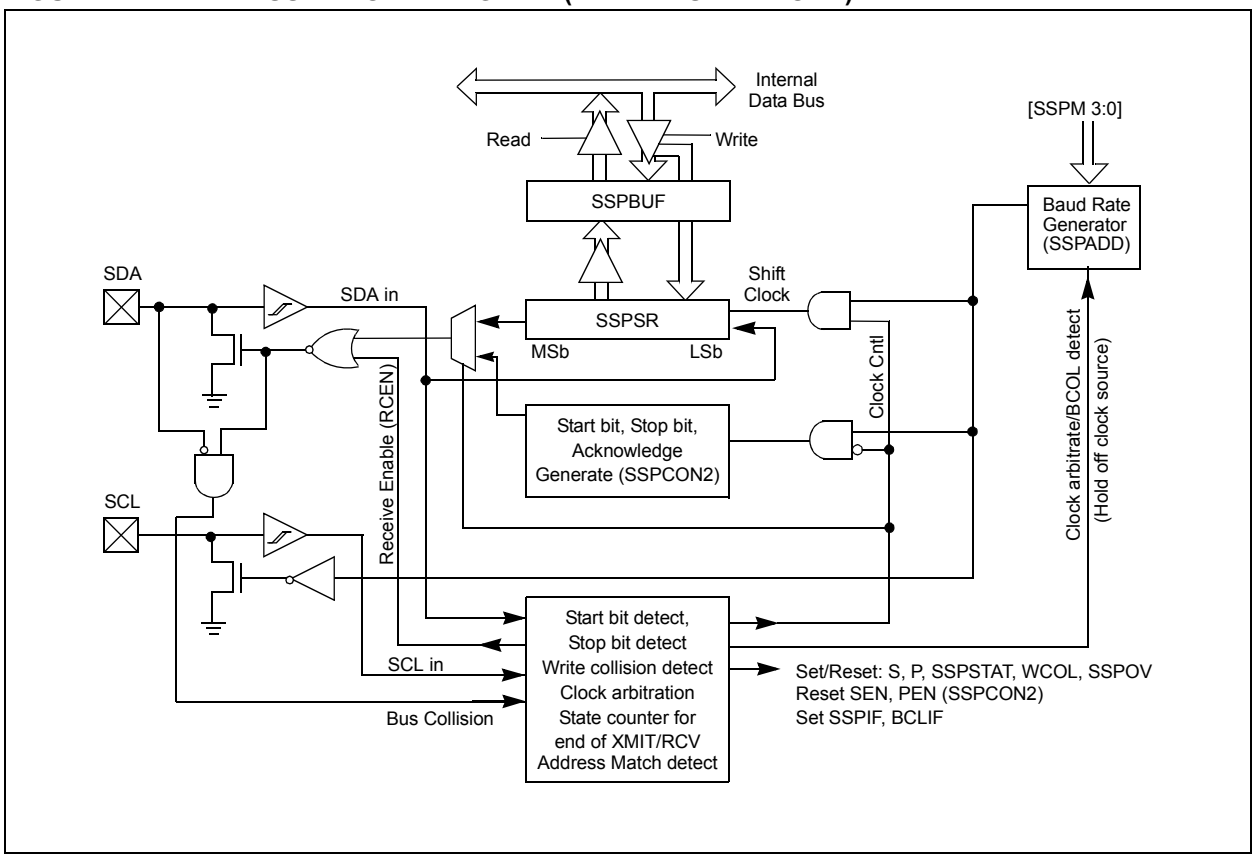
Legend: — = Unimplemented location, read as '0'. Shaded cells are not used by the Timer0 module.
* Page provides register information.

The I²C interface supports the following modes and features:

- Master mode
- Slave mode
- Byte NACKing (Slave mode)
- Limited Multi-master support
- 7-bit and 10-bit addressing
- Start and Stop interrupts
- Interrupt masking
- Clock stretching
- Bus collision detection
- General call address matching
- Address masking
- Address Hold and Data Hold modes
- Selectable SDA hold times

Figure 24-2 is a block diagram of the I²C Interface module in Master mode. Figure 24-3 is a diagram of the I²C Interface module in Slave mode.

FIGURE 24-2: MSSP BLOCK DIAGRAM (I²C™ MASTER MODE)



24.6.13.3 Bus Collision During a Stop Condition

Bus collision occurs during a Stop condition if:

a) After the SDA pin has been deasserted and allowed to float high, SDA is sampled low after the BRG has timed out.

b) After the SCL pin is deasserted, SCL is sampled low before SDA goes high.

The Stop condition begins with SDA asserted low. When SDA is sampled low, the SCL pin is allowed to float. When the pin is sampled high (clock arbitration), the Baud Rate Generator is loaded with SSPADD and counts down to zero. After the BRG times out, SDA is sampled. If SDA is sampled low, a bus collision has occurred. This is due to another master attempting to drive a data '0' (Figure 24-38). If the SCL pin is sampled low before SDA is allowed to float high, a bus collision occurs. This is another case of another master attempting to drive a data '0' (Figure 24-39).

FIGURE 24-38: BUS COLLISION DURING A STOP CONDITION (CASE 1)

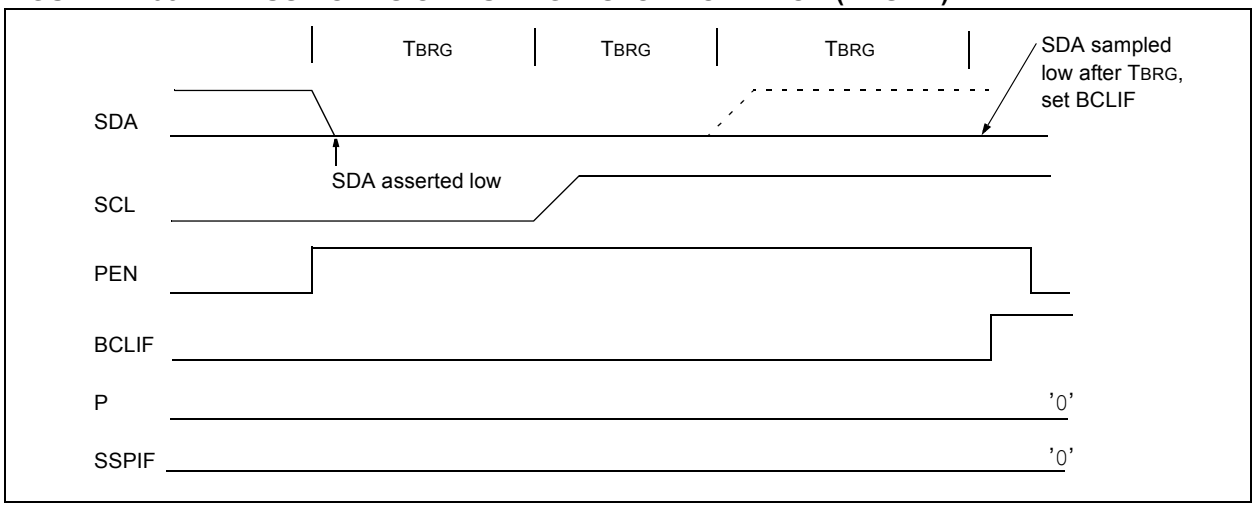


FIGURE 24-39: BUS COLLISION DURING A STOP CONDITION (CASE 2)

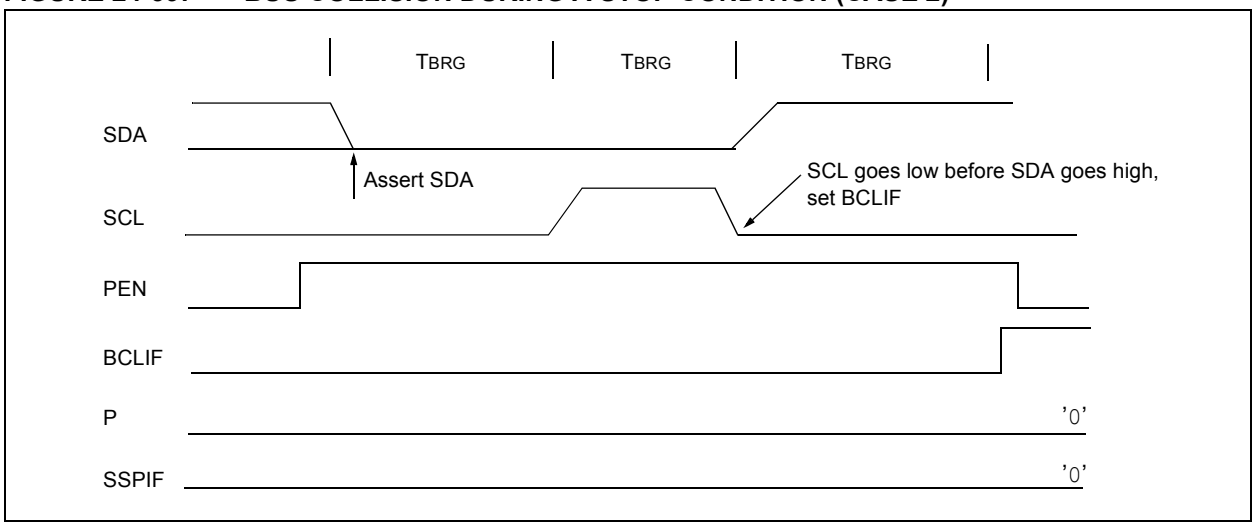
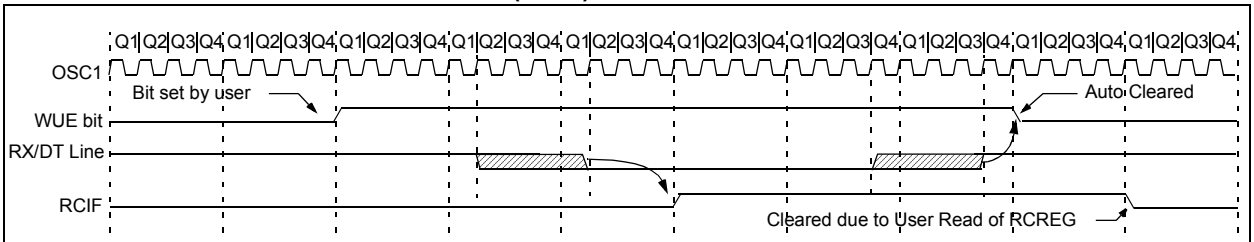
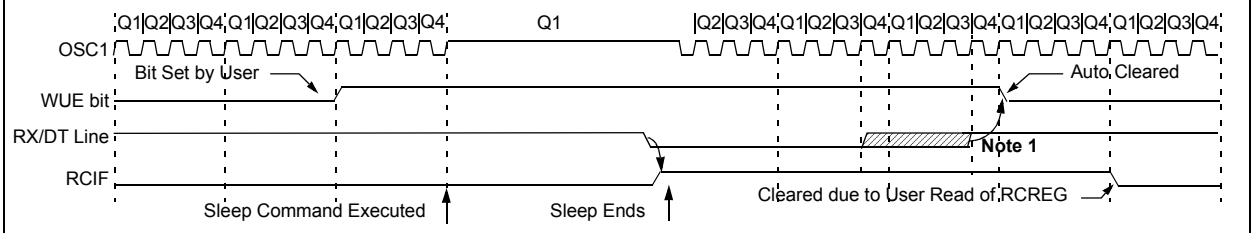


FIGURE 25-7: AUTO-WAKE-UP BIT (WUE) TIMING DURING NORMAL OPERATION



Note 1: The **EUSART** remains in Idle while the WUE bit is set.

FIGURE 25-8: AUTO-WAKE-UP BIT (WUE) TIMINGS DURING SLEEP



Note 1: If the wake-up event requires long oscillator warm-up time, the automatic clearing of the WUE bit can occur while the `stposc` signal is still active. This sequence should not depend on the presence of Q clocks.

2: The **EUSART** remains in Idle while the WUE bit is set.

25.5.1.5 Synchronous Master Reception

Data is received at the RX/DT pin. The RX/DT pin output driver is automatically disabled when the EUSART is configured for synchronous master receive operation.

In Synchronous mode, reception is enabled by setting either the Single Receive Enable bit (SREN of the RCSTA register) or the Continuous Receive Enable bit (CREN of the RCSTA register).

When SREN is set and CREN is clear, only as many clock cycles are generated as there are data bits in a single character. The SREN bit is automatically cleared at the completion of one character. When CREN is set, clocks are continuously generated until CREN is cleared. If CREN is cleared in the middle of a character the CK clock stops immediately and the partial character is discarded. If SREN and CREN are both set, then SREN is cleared at the completion of the first character and CREN takes precedence.

To initiate reception, set either SREN or CREN. Data is sampled at the RX/DT pin on the trailing edge of the TX/CK clock pin and is shifted into the Receive Shift Register (RSR). When a complete character is received into the RSR, the RCIF bit is set and the character is automatically transferred to the two character receive FIFO. The Least Significant eight bits of the top character in the receive FIFO are available in RCREG. The RCIF bit remains set as long as there are unread characters in the receive FIFO.

25.5.1.6 Slave Clock

Synchronous data transfers use a separate clock line, which is synchronous with the data. A device configured as a slave receives the clock on the TX/CK line. The TX/CK pin output driver is automatically disabled when the device is configured for synchronous slave transmit or receive operation. Serial data bits change on the leading edge to ensure they are valid at the trailing edge of each clock. One data bit is transferred for each clock cycle. Only as many clock cycles should be received as there are data bits.

25.5.1.7 Receive Overrun Error

The receive FIFO buffer can hold two characters. An overrun error will be generated if a third character, in its entirety, is received before RCREG is read to access the FIFO. When this happens, the OERR bit of the RCSTA register is set. Previous data in the FIFO will not be overwritten. The two characters in the FIFO buffer can be read, however, no additional characters will be received until the error is cleared. The OERR bit can only be cleared by clearing the overrun condition. If the overrun error occurred when the SREN bit is set and CREN is clear then the error is cleared by reading RCREG. If the overrun occurred when the CREN bit is set then the error condition is cleared by either clearing the CREN bit of the RCSTA register or by clearing the SPEN bit which resets the EUSART.

25.5.1.8 Receiving 9-bit Characters

The EUSART supports 9-bit character reception. When the RX9 bit of the RCSTA register is set the EUSART will shift 9-bits into the RSR for each character received. The RX9D bit of the RCSTA register is the ninth, and Most Significant, data bit of the top unread character in the receive FIFO. When reading 9-bit data from the receive FIFO buffer, the RX9D data bit must be read before reading the eight Least Significant bits from the RCREG.

25.5.1.9 Synchronous Master Reception Set-up:

1. Initialize the SPBRGH, SPBRGL register pair for the appropriate baud rate. Set or clear the BRGH and BRG16 bits, as required, to achieve the desired baud rate.
2. Clear the ANSEL bit for the RX pin (if applicable).
3. Enable the synchronous master serial port by setting bits SYNC, SPEN and CSRC.
4. Ensure bits CREN and SREN are clear.
5. If interrupts are desired, set the RCIE bit of the PIE1 register and the GIE and PEIE bits of the INTCON register.
6. If 9-bit reception is desired, set bit RX9.
7. Start reception by setting the SREN bit or for continuous reception, set the CREN bit.
8. Interrupt flag bit RCIF will be set when reception of a character is complete. An interrupt will be generated if the enable bit RCIE was set.
9. Read the RCSTA register to get the ninth bit (if enabled) and determine if any error occurred during reception.
10. Read the 8-bit received data by reading the RCREG register.
11. If an overrun error occurs, clear the error by either clearing the CREN bit of the RCSTA register or by clearing the SPEN bit which resets the EUSART.

26.4 Current Ranges

The capacitive sensing oscillator can operate within different current ranges, depending on the voltage reference mode and current range selections.

Within each of the two voltage reference modes, there are four current ranges. Selection between the voltage reference modes is controlled by the CPSRM bit of the CPSCON0 register. Clearing this bit selects the fixed voltage references provided by the capacitive sensing oscillator module. Setting this bit selects the variable voltage references supplied by the Fixed Voltage Reference (FVR) module and the Digital-to-Analog Converter (DAC) module. See Section **Section 26.3 "Voltage Reference Modes"** for more information on configuring the voltage references.

Selecting the current range within the voltage reference mode is controlled by configuring the CPSRNG<1:0> bits in the CPSCON0 register. See Table 26-1 for proper current mode selection.

The Noise Detection mode is unique in that it disables the constant current source associated with the selected input pin, but leaves the rest of the oscillator circuitry and pin structure active. This eliminates the oscillation frequency on the analog pin and greatly reduces the current consumed by the oscillator module. When noise is introduced onto the pin, the oscillator is driven at the frequency determined by the noise. This produces a detectable signal at the comparator stage, indicating the presence of activity on the pin.

Figure 26-2 shows a more detailed drawing of the constant current sources and comparators associated with the oscillator and input pin.

TABLE 26-1: CURRENT RANGE MODE SELECTION

CPSRM	Voltage Reference Mode	CPSRNG<1:0>	Current Range(1)
1	Variable	00	Noise Detection
		01	Low
		10	Medium
		11	High
0	Fixed	00	Off
		01	Low
		10	Medium
		11	High

Note 1: See Power-Down Currents (IPD) in **Section 30.0 "Electrical Specifications"** for more information.

27.3 LCD Clock Source Selection

The LCD module has three possible clock sources:

- FOSC/256
- T1OSC
- LFINTOSC

The first clock source is the system clock divided by 256 (FOSC/256). This divider ratio is chosen to provide about 1 kHz output when the system clock is 8 MHz. The divider is not programmable. Instead, the LCD prescaler bits LP<3:0> of the LCDPS register are used to set the LCD frame clock rate.

The second clock source is the T1OSC. This also gives about 1 kHz when a 32.768 kHz crystal is used with the Timer1 oscillator. To use the Timer1 oscillator as a clock source, the T1OSCEN bit of the T1CON register should be set.

The third clock source is the 31 kHz LFINTOSC, which provides approximately 1 kHz output.

The second and third clock sources may be used to continue running the LCD while the processor is in Sleep.

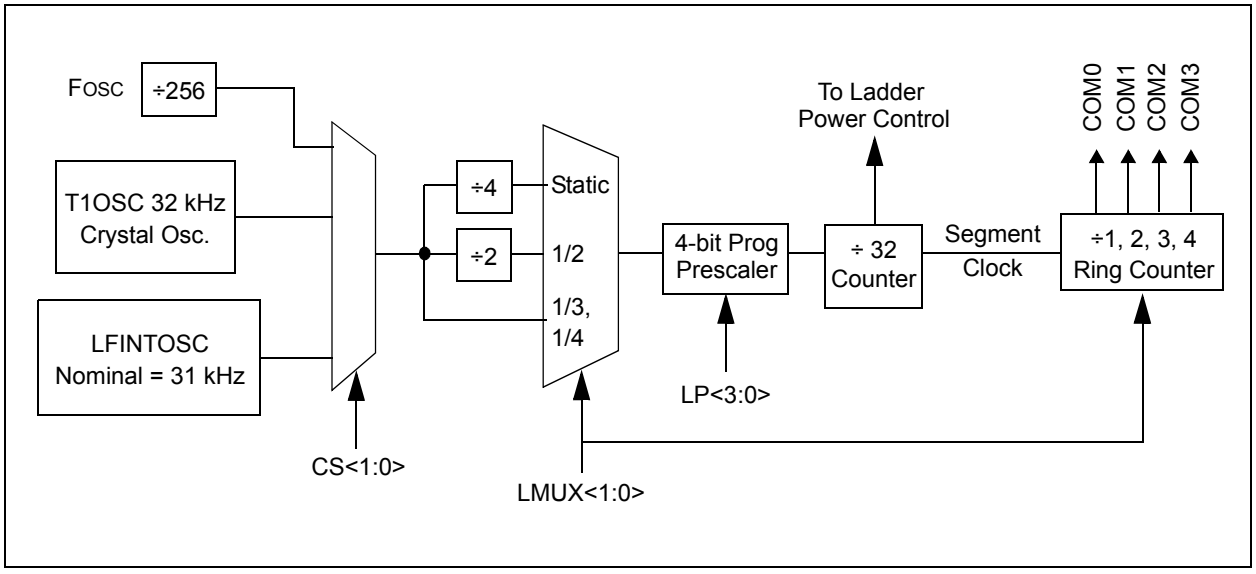
Using bits CS<1:0> of the LCDCON register can select any of these clock sources.

27.3.1 LCD PRESCALER

A 4-bit counter is available as a prescaler for the LCD clock. The prescaler is not directly readable or writable; its value is set by the LP<3:0> bits of the LCDPS register, which determine the prescaler assignment and prescale ratio.

The prescale values are selectable from 1:1 through 1:16.

FIGURE 27-2: LCD CLOCK GENERATION



BCF **Bit Clear f**

Syntax:	[*label*] BCF f,b
Operands:	0 ≤ f ≤ 127 0 ≤ b ≤ 7
Operation:	0 → (f<b>)
Status Affected:	None
Description:	Bit 'b' in register 'f' is cleared.

BRA **Relative Branch**

Syntax:	[*label*] BRA label [*label*] BRA $+k
Operands:	-256 ≤ label - PC + 1 ≤ 255 -256 ≤ k ≤ 255
Operation:	(PC) + 1 + k → PC
Status Affected:	None
Description:	Add the signed 9-bit literal 'k' to the PC. Since the PC will have incremented to fetch the next instruction, the new address will be PC + 1 + k. This instruction is a two-cycle instruction. This branch has a limited range.

BRW **Relative Branch with W**

Syntax:	[*label*] BRW
Operands:	None
Operation:	(PC) + (W) → PC
Status Affected:	None
Description:	Add the contents of W (unsigned) to the PC. Since the PC will have incremented to fetch the next instruction, the new address will be PC + 1 + (W). This instruction is a two-cycle instruction.

BSF **Bit Set f**

Syntax:	[*label*] BSF f,b
Operands:	0 ≤ f ≤ 127 0 ≤ b ≤ 7
Operation:	1 → (f<b>)
Status Affected:	None
Description:	Bit 'b' in register 'f' is set.

BTFSC **Bit Test f, Skip if Clear**

Syntax:	[*label*] BTFSC f,b
Operands:	0 ≤ f ≤ 127 0 ≤ b ≤ 7
Operation:	skip if (f<b>) = 0
Status Affected:	None
Description:	If bit 'b' in register 'f' is '1', the next instruction is executed. If bit 'b', in register 'f', is '0', the next instruction is discarded, and a NOP is executed instead, making this a 2-cycle instruction.

BTFSS **Bit Test f, Skip if Set**

Syntax:	[*label*] BTFSS f,b
Operands:	0 ≤ f ≤ 127 0 ≤ b < 7
Operation:	skip if (f<b>) = 1
Status Affected:	None
Description:	If bit 'b' in register 'f' is '0', the next instruction is executed. If bit 'b' is '1', then the next instruction is discarded and a NOP is executed instead, making this a 2-cycle instruction.

LSLF **Logical Left Shift**

Syntax: [*label*] LSLF f {,d}

Operands: $0 \le f \le 127$
$d \in [0,1]$

Operation: (f<7>) → C
(f<6:0>) → dest<7:1>
0 → dest<0>

Status Affected: C, Z

Description: The contents of register 'f' are shifted one bit to the left through the Carry flag. A '0' is shifted into the LSb. If 'd' is '0', the result is placed in W. If 'd' is '1', the result is stored back in register 'f'.

LSRF **Logical Right Shift**

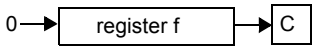
Syntax: [*label*] LSRF f {,d}

Operands: $0 \le f \le 127$
$d \in [0,1]$

Operation: 0 → dest<7>
(f<7:1>) → dest<6:0>,
(f<0>) → C,

Status Affected: C, Z

Description: The contents of register 'f' are shifted one bit to the right through the Carry flag. A '0' is shifted into the MSb. If 'd' is '0', the result is placed in W. If 'd' is '1', the result is stored back in register 'f'.



MOVF **Move f**

Syntax: [*label*] MOVF f,d

Operands: $0 \le f \le 127$
$d \in [0,1]$

Operation: (f) → (dest)

Status Affected: Z

Description: The contents of register f is moved to a destination dependent upon the status of d. If d = 0, destination is W register. If d = 1, the destination is file register f itself. d = 1 is useful to test a file register since status flag Z is affected.

Words: 1

Cycles: 1

Example:

```
MOVF    FSR, 0
```

After Instruction
W = value in FSR register
Z = 1

30.4 DC Characteristics: I/O Ports (Continued)

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤ +125°C for extended				
Param No.	**Sym.**	**Characteristic**	**Min.**	**Typ†**	**Max.**	**Units**	**Conditions**
		Capacitive Loading Specs on Output Pins					
D101*	COSC2	OSC2 pin	—	—	15	pF	In XT, HS and LP modes when external clock is used to drive OSC1
D101A*	CIO	All I/O pins	—	—	50	pF	
		VCAP Capacitor Charging					
D102		Charging current	—	200	—	µA	
D102A		Source/sink capability when charging complete	—	0.0	—	mA	

* These parameters are characterized but not tested.

† Data in "Typ" column is at 3.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: In RC oscillator configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended to use an external clock in RC mode.

2: Negative current is defined as current sourced by the pin.

3: The leakage current on the $\overline{MCLR}$ pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current may be measured at different input voltages.

4: Including OSC2 in CLKOUT mode.

FIGURE 31-41: IPD, CAPACITIVE SENSING (CPS) MODULE, MEDIUM-CURRENT RANGE, CPSRM = 0, CPSRNG = 10, PIC16LF1933 ONLY

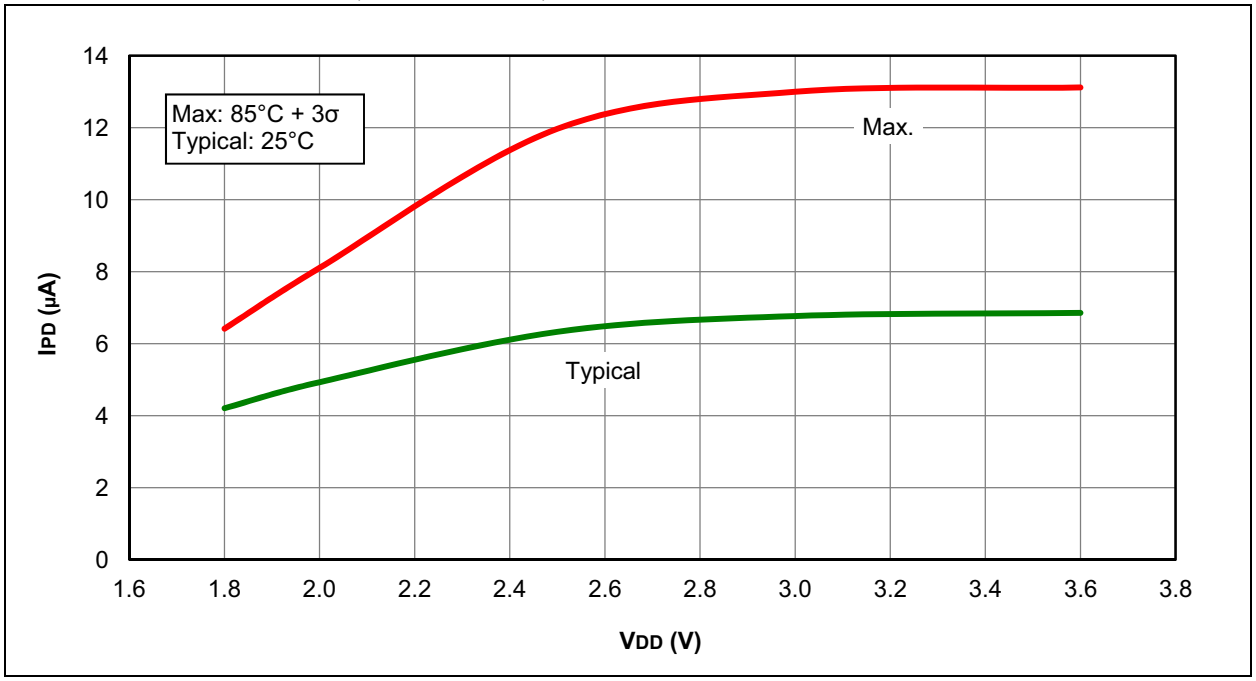
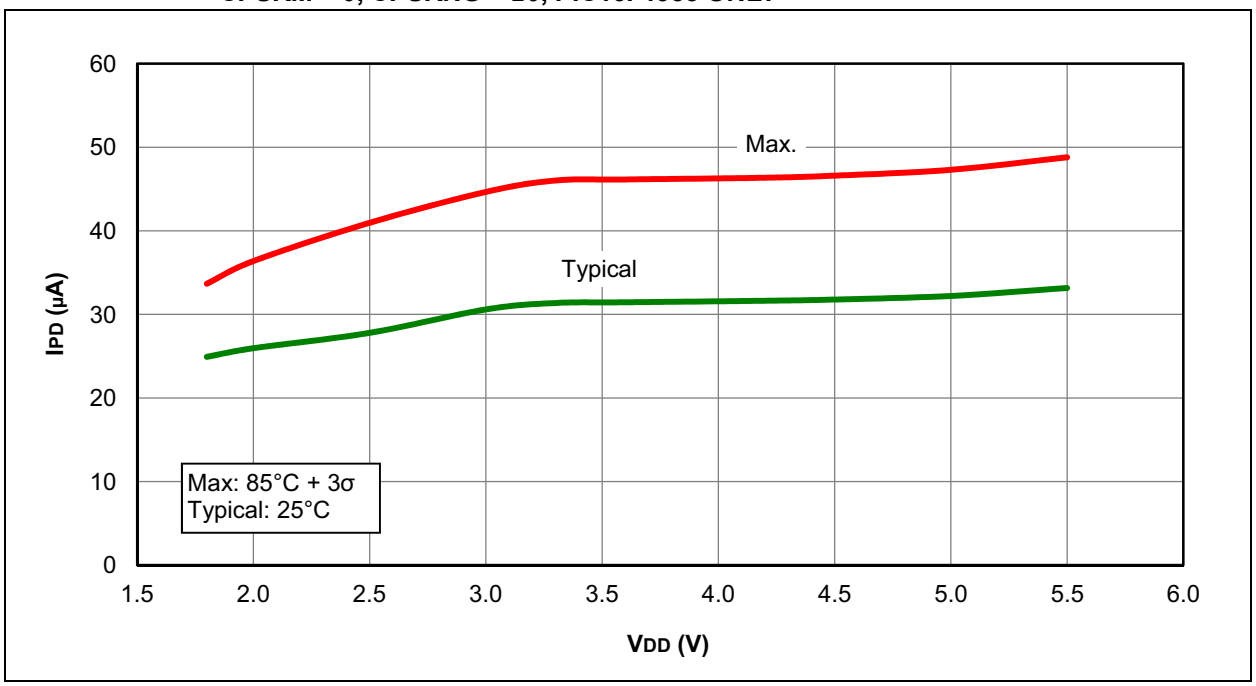


FIGURE 31-42: IPD, CAPACITIVE SENSING (CPS) MODULE, MEDIUM-CURRENT RANGE, CPSRM = 0, CPSRNG = 10, PIC16F1933 ONLY



32.0 DEVELOPMENT SUPPORT

The PIC® microcontrollers and dsPIC® digital signal controllers are supported with a full range of software and hardware development tools:

- Integrated Development Environment
  - MPLAB® IDE Software
- Compilers/Assemblers/Linkers
  - MPLAB C Compiler for Various Device Families
  - HI-TECH C® for Various Device Families
  - MPASM™ Assembler
  - MPLINK™ Object Linker/ MPLIB™ Object Librarian
  - MPLAB Assembler/Linker/Librarian for Various Device Families
- Simulators
  - MPLAB SIM Software Simulator
- Emulators
  - MPLAB REAL ICE™ In-Circuit Emulator
- In-Circuit Debuggers
  - MPLAB ICD 3
  - PICkit™ 3 Debug Express
- Device Programmers
  - PICkit™ 2 Programmer
  - MPLAB PM3 Device Programmer
- Low-Cost Demonstration/Development Boards, Evaluation Kits, and Starter Kits

32.1 MPLAB Integrated Development Environment Software

The MPLAB IDE software brings an ease of software development previously unseen in the 8/16/32-bit microcontroller market. The MPLAB IDE is a Windows® operating system-based application that contains:

- A single graphical interface to all debugging tools
  - Simulator
  - Programmer (sold separately)
  - In-Circuit Emulator (sold separately)
  - In-Circuit Debugger (sold separately)
- A full-featured editor with color-coded context
- A multiple project manager
- Customizable data windows with direct edit of contents
- High-level source code debugging
- Mouse over variable inspection
- Drag and drop variables from source to watch windows
- Extensive on-line help
- Integration of select third party tools, such as IAR C Compilers

The MPLAB IDE allows you to:

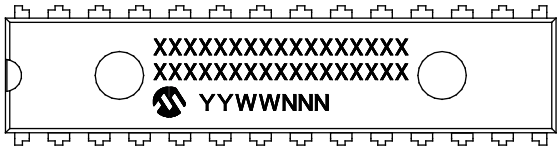
- Edit your source files (either C or assembly)
- One-touch compile or assemble, and download to emulator and simulator tools (automatically updates all project information)
- Debug using:
  - Source files (C or assembly)
  - Mixed C and assembly
  - Machine code

MPLAB IDE supports multiple debugging tools in a single development paradigm, from the cost-effective simulators, through low-cost in-circuit debuggers, to full-featured emulators. This eliminates the learning curve when upgrading to tools with increased flexibility and power.

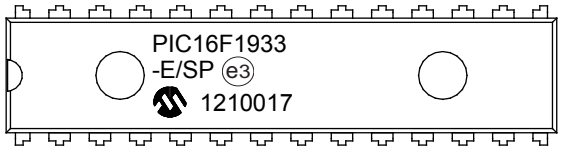
33.0 PACKAGING INFORMATION

33.1 Package Marking Information

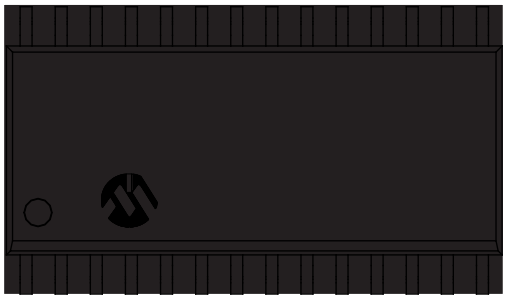
28-Lead SPDIP (.300”)



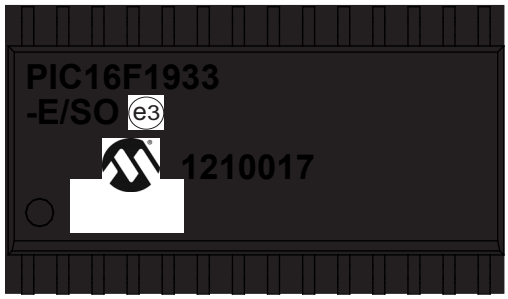
Example



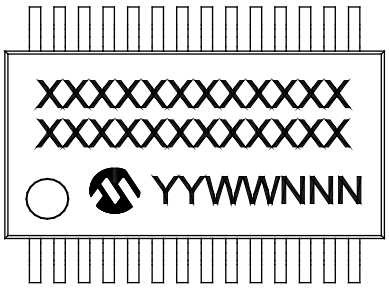
28-Lead SOIC (7.50 mm)



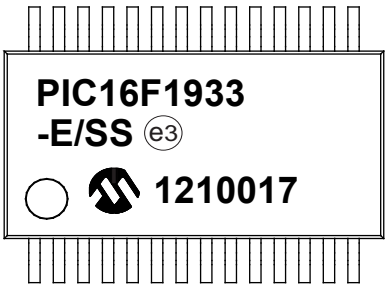
Example



28-Lead SSOP (5.30 mm)



Example



Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

* Standard PICmicro® device marking consists of Microchip part number, year code, week code and traceability code. For PICmicro device marking beyond this, certain price adders apply. Please check with your Microchip Sales Office. For QTP devices, any special marking adders are included in QTP price.