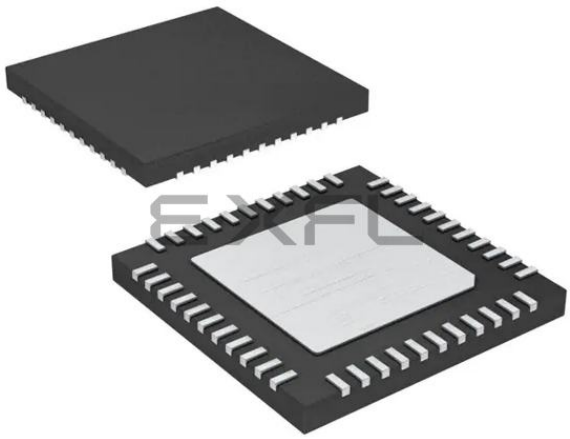

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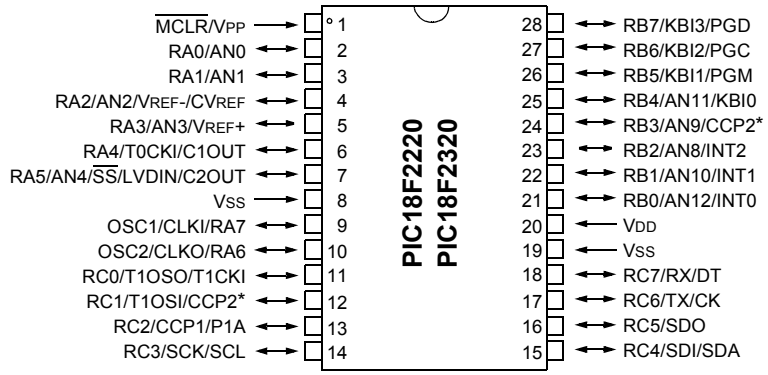
Applications of "Embedded - Microcontrollers"

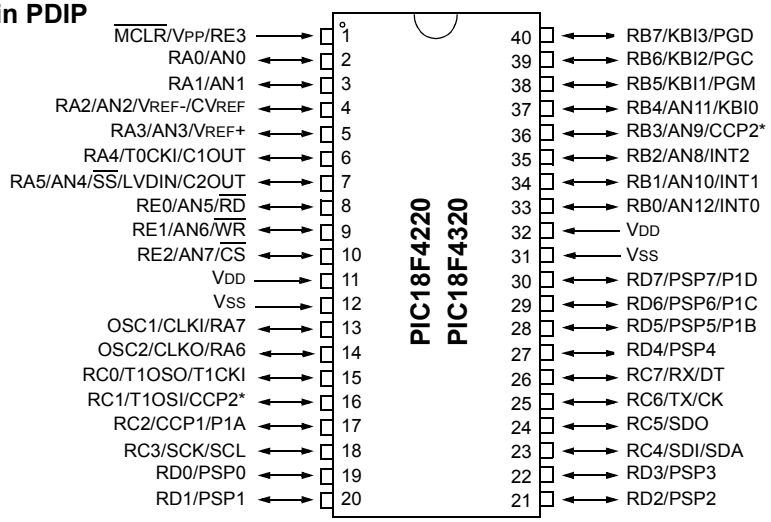
Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	40MHz
Connectivity	I²C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, LVD, POR, PWM, WDT
Number of I/O	36
Program Memory Size	4KB (2K x 16)
Program Memory Type	FLASH
EEPROM Size	256 x 8
RAM Size	512 x 8
Voltage - Supply (Vcc/Vdd)	4.2V ~ 5.5V
Data Converters	A/D 13x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	44-VQFN Exposed Pad
Supplier Device Package	44-QFN (8x8)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic18f4220-i-ml

Pin Diagrams

28-Pin SPDIP, SOIC



40-Pin PDIP



* RB3 is the alternate pin for the CCP2 pin multiplexing.

Note: Pin compatible with 40-pin PIC16C7X devices.

TABLE 1-3: PIC18F4220/4320 PINOUT I/O DESCRIPTIONS

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	TQFP	QFN			
MCLR/VPP/RE3	1	18	18			Master Clear (input) or programming voltage (input).
MCLR				I	ST	Master Clear (Reset) input. This pin is an active-low Reset to the device.
VPP				P		Programming voltage input.
RE3				I	ST	Digital input.
OSC1/CLKI/RA7	13	30	32			Oscillator crystal or external clock input.
OSC1				I	ST	Oscillator crystal input or external clock source input. ST buffer when configured in RC mode, CMOS otherwise.
CLKI				I	CMOS	External clock source input. Always associated with pin function OSC1. (See related OSC1/CLKI, OSC2/CLKO pins.)
RA7				I/O	TTL	General purpose I/O pin.
OSC2/CLKO/RA6	14	31	33			Oscillator crystal or clock output.
OSC2				O	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO				O	—	In RC mode, OSC2 pin outputs CLKO which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
RA6				I/O	TTL	General purpose I/O pin.
						PORTA is a bidirectional I/O port.
RA0/AN0	2	19	19			
RA0				I/O	TTL	Digital I/O.
AN0				I	Analog	Analog input 0.
RA1/AN1	3	20	20			
RA1				I/O	TTL	Digital I/O.
AN1				I	Analog	Analog input 1.
RA2/AN2/VREF-/CVREF	4	21	21			
RA2				I/O	TTL	Digital I/O.
AN2				I	Analog	Analog input 2.
VREF-				I	Analog	A/D reference voltage (low) input.
CVREF				O	Analog	Comparator reference voltage output.
RA3/AN3/VREF+	5	22	22			
RA3				I/O	TTL	Digital I/O.
AN3				I	Analog	Analog input 3.
VREF+				I	Analog	A/D reference voltage (high) input.
RA4/T0CKI/C1OUT	6	23	23			
RA4				I/O	ST/OD	Digital I/O. Open drain when configured as output.
T0CKI				I	ST	Timer0 external clock input.
C1OUT				O	—	Comparator 1 output.
RA5/AN4/SS/LVDIN/C2OUT	7	24	24			
RA5				I/O	TTL	Digital I/O.
AN4				I	Analog	Analog input 4.
SS				I	TTL	SPI slave select input.
LVDIN				I	Analog	Low-Voltage Detect input.
C2OUT				O	—	Comparator 2 output.
RA6						See the OSC2/CLKO/RA6 pin.
RA7						See the OSC1/CLKI/RA7 pin.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power; OD = Open-drain (no diode to VDD)

Note 1: Alternate assignment for CCP2 when CCP2MX is cleared.

2: Default assignment for CCP2 when CCP2MX (CONFIG3H<0>) is set.

3.3.1 PRI_IDLE MODE

This mode is unique among the three low-power Idle modes in that it does not disable the primary system clock. For timing sensitive applications, this allows for the fastest resumption of device operation, with its more accurate primary clock source, since the clock source does not have to “warm up” or transition from another oscillator.

PRI_IDLE mode is entered by setting the IDLEN bit, clearing the SCS bits and executing a `SLEEP` instruction. Although the CPU is disabled, the peripherals continue to be clocked from the primary clock source specified in Configuration Register 1H. The OSTS bit remains set in PRI_IDLE mode (see Figure 3-3).

When a wake-up event occurs, the CPU is clocked from the primary clock source. A delay of approximately 10 μs is required between the wake-up event and when code execution starts. This is required to allow the CPU to become ready to execute instructions. After the wake-up, the OSTS bit remains set. The IDLEN and SCS bits are not affected by the wake-up (see Figure 3-4).

FIGURE 3-3: TRANSITION TIMING TO PRI_IDLE MODE

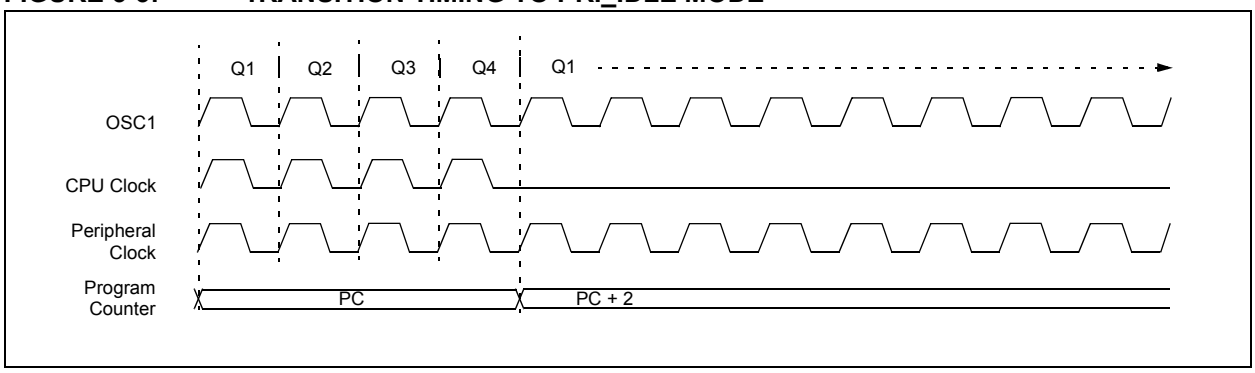
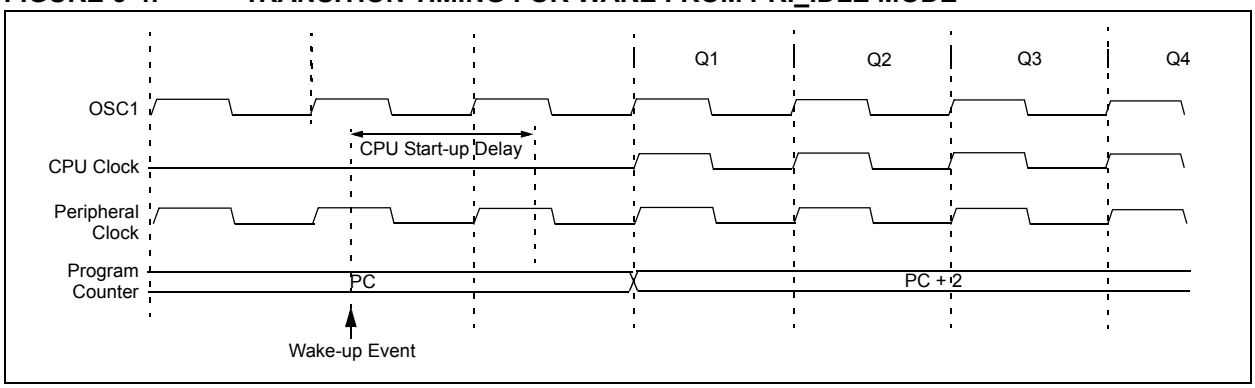


FIGURE 3-4: TRANSITION TIMING FOR WAKE FROM PRI_IDLE MODE

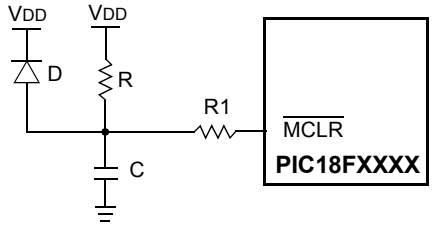


4.1 Power-on Reset (POR)

A Power-on Reset pulse is generated on-chip when VDD rise is detected. To take advantage of the POR circuitry, just tie the MCLR pin through a resistor (1k to 10 kΩ) to VDD. This will eliminate external RC components usually needed to create a Power-on Reset delay. A minimum rise rate for VDD is specified (parameter D004). For a slow rise time, see Figure 4-2.

When the device starts normal operation (i.e., exits the Reset condition), device operating parameters (voltage, frequency, temperature, etc.) must be met to ensure operation. If these conditions are not met, the device must be held in Reset until the operating conditions are met.

FIGURE 4-2: EXTERNAL POWER-ON RESET CIRCUIT (FOR SLOW VDD POWER-UP)



Note 1: External Power-on Reset circuit is required only if the VDD power-up slope is too slow. The diode D helps discharge the capacitor quickly when VDD powers down.

2: R < 40 kΩ is recommended to make sure that the voltage drop across R does not violate the device's electrical specification.

3: R1 ≥ 1 kΩ will limit any current flowing into MCLR from external capacitor C, in the event of MCLR/VPP pin breakdown, due to Electrostatic Discharge (ESD) or Electrical Overstress (EOS).

4.2 Power-up Timer (PWRT)

The Power-up Timer (PWRT) of the PIC18F2X20/4X20 devices is an 11-bit counter, which uses the INTRC source as the clock input. This yields a count of 2048 x 32 μs = 65.6 ms. While the PWRT is counting, the device is held in Reset.

The power-up time delay depends on the INTRC clock and will vary from chip-to-chip due to temperature and process variation. See DC parameter #33 for details.

The PWRT is enabled by clearing Configuration bit, PWRTEN.

4.3 Oscillator Start-up Timer (OST)

The Oscillator Start-up Timer (OST) provides a 1024 oscillator cycle (from OSC1 input) delay after the PWRT delay is over (parameter #33). This ensures that the crystal oscillator or resonator has started and stabilized.

The OST time-out is invoked only for XT, LP, HS and HSPLL modes and only on Power-on Reset, or on exit from most power-managed modes.

4.4 PLL Lock Time-out

With the PLL enabled in its PLL mode, the time-out sequence following a Power-on Reset is slightly different from other oscillator modes. A portion of the Power-up Timer is used to provide a fixed time-out that is sufficient for the PLL to lock to the main oscillator frequency. This PLL lock time-out (TPLL) is typically 2 ms and follows the oscillator start-up time-out.

4.5 Brown-out Reset (BOR)

A Configuration bit, BOREN, can disable (if clear/programmed) or enable (if set) the Brown-out Reset circuitry. If VDD falls below VBOR (parameter D005) for greater than TBOR (parameter #35), the brown-out situation will reset the chip. A Reset may not occur if VDD falls below VBOR for less than TBOR. The chip will remain in Brown-out Reset until VDD rises above VBOR. If the Power-up Timer is enabled, it will be invoked after VDD rises above VBOR; it then will keep the chip in Reset for an additional time delay TPWRT (parameter #33). If VDD drops below VBOR while the Power-up Timer is running, the chip will go back into a Brown-out Reset and the Power-up Timer will be initialized. Once VDD rises above VBOR, the Power-up Timer will execute the additional time delay. Enabling BOR Reset does not automatically enable the PWRT.

4.6 Time-out Sequence

On power-up, the time-out sequence is as follows: First, after the POR pulse has cleared, PWRT time-out is invoked (if enabled). Then, the OST is activated. The total time-out will vary based on oscillator configuration and the status of the PWRT. For example, in RC mode with the PWRT disabled, there will be no time-out at all. Figure 4-3, Figure 4-4, Figure 4-5, Figure 4-6 and Figure 4-7 depict time-out sequences on power-up.

Since the time-outs occur from the POR pulse, if MCLR is kept low long enough, all time-outs will expire. Bringing MCLR high will begin execution immediately (Figure 4-5). This is useful for testing purposes or to synchronize more than one PIC18FXXXX device operating in parallel.

Table 4-2 shows the Reset conditions for some Special Function Registers, while Table 4-3 shows the Reset conditions for all the registers.

TABLE 10-1: PORTA FUNCTIONS

Name	Bit#	Buffer	Function
RA0/AN0	bit 0	TTL	Input/output or analog input.
RA1/AN1	bit 1	TTL	Input/output or analog input.
RA2/AN2/VREF-/CVREF	bit 2	TTL	Input/output, analog input, VREF- or comparator VREF output.
RA3/AN3/VREF+	bit 3	TTL	Input/output, analog input or VREF+.
RA4/T0CKI/C1OUT	bit 4	ST	Input/output, external clock input for Timer0 or Comparator 1 output. Output is open-drain type.
RA5/AN4/$\overline{SS}$/LVDIN/C2OUT	bit 5	TTL	Input/output, analog input, slave select input for Master Synchronous Serial Port, Low-Voltage Detect input or Comparator 2 output.
OSC2/CLKO/RA6	bit 6	TTL	OSC2, clock output or I/O pin.
OSC1/CLKI/RA7	bit 7	TTL	OSC1, clock input or I/O pin.

Legend: TTL = TTL input, ST = Schmitt Trigger input

TABLE 10-2: SUMMARY OF REGISTERS ASSOCIATED WITH PORTA

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
PORTA	RA7(1)	RA6(1)	RA5	RA4	RA3	RA2	RA1	RA0	xx0x 0000	uu0u 0000
LATA	LATA7(1)	LATA6(1)	LATA Data Latch Register						xxxx xxxx	uuuu uuuu
TRISA	TRISA7(1)	TRISA6(1)	PORTA Data Direction Register						1111 1111	1111 1111
ADCON1	—	—	VCFG1	VCFG0	PCFG3	PCFG2	PCFG1	PCFG0	--00 0000	--00 0000
CMCON	C2OUT	C1OUT	C2INV	C1INV	CIS	CM2	CM1	CM0	0000 0111	0000 0111
CVRCON	CVREN	CVROE	CVRR	—	CVR3	CVR2	CVR1	CVR0	000- 0000	000- 0000

Legend: x = unknown, u = unchanged, - = unimplemented locations read as '0'. Shaded cells are not used by PORTA.

Note 1: RA7:RA6 and their associated latch and data direction bits are enabled as I/O pins based on oscillator configuration; otherwise, they are read as '0'.

EXAMPLE 12-1: IMPLEMENTING A REAL-TIME CLOCK USING A TIMER1 INTERRUPT SERVICE

```
RTCinit
            MOVLW   0x80            ; Preload TMR1 register pair
            MOVWF   TMR1H           ; for 1 second overflow
            CLRF    TMR1L
            MOVLW   b'00001111'     ; Configure for external clock,
            MOVWF   T1OSC           ; Asynchronous operation, external oscillator
            CLRF    secs            ; Initialize timekeeping registers
            CLRF    mins            ;
            MOVLW   .12
            MOVWF   hours
            BSF     PIE1, TMR1IE    ; Enable Timer1 interrupt
            RETURN
RTCisr
            BSF     TMR1H,7         ; Preload for 1 sec overflow
            BCF     PIR1,TMR1IF     ; Clear interrupt flag
            INCF    secs,F          ; Increment seconds
            MOVLW   .59             ; 60 seconds elapsed?
            CPFSGT  secs
            RETURN                  ; No, done
            CLRF    secs            ; Clear seconds
            INCF    mins,F          ; Increment minutes
            MOVLW   .59             ; 60 minutes elapsed?
            CPFSGT  mins
            RETURN                  ; No, done
            CLRF    mins            ; clear minutes
            INCF    hours,F         ; Increment hours
            MOVLW   .23             ; 24 hours elapsed?
            CPFSGT  hours
            RETURN                  ; No, done
            MOVLW   .01             ; Reset hours to 1
            MOVWF   hours
            RETURN                  ; Done
```

TABLE 12-2: REGISTERS ASSOCIATED WITH TIMER1 AS A TIMER/COUNTER

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
INTCON	GIE/GIEH	PEIE/GIEL	TMR0IE	INT0IE	RBIE	TMR0IF	INT0IF	RBIF	0000 000x	0000 000u
PIR1	PSPIF(1)	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
PIE1	PSPIE(1)	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
IPR1	PSPIP(1)	ADIP	RCIP	TXIP	SSPIP	CCP1IP	TMR2IP	TMR1IP	1111 1111	1111 1111
TMR1L	Timer1 Low Byte Register								xxxx xxxx	uuuu uuuu
TMR1H	Timer1 High Byte Register								xxxx xxxx	uuuu uuuu
T1CON	RD16	T1RUN	T1CKPS1	T1CKPS0	T1OSCEN	T1SYNC	TMR1CS	TMR1ON	0000 0000	u0uu uuuu

Legend: x = unknown, u = unchanged, – = unimplemented, read as '0'. Shaded cells are not used by the Timer1 module.
Note 1: The PSPIF, PSPIE and PSPIP bits are reserved on the PIC18F2X20 devices; always maintain these bits clear.

15.1 CCP1 Module

Capture/Compare/PWM Register 1 (CCPR1) is comprised of two 8-bit registers: CCPR1L (low byte) and CCPR1H (high byte). The CCP1CON register controls the operation of CCP1. All are readable and writable.

TABLE 15-1: CCP MODE - TIMER RESOURCE

CCP Mode	Timer Resource
Capture	Timer1 or Timer3
Compare	Timer1 or Timer3
PWM	Timer2

15.2 CCP2 Module

Capture/Compare/PWM Register 2 (CCPR2) is comprised of two 8-bit registers: CCPR2L (low byte) and CCPR2H (high byte). The CCP2CON register controls the operation of CCP2. All are readable and writable.

CCP2 functions identically to CCP1 except for the enhanced PWM modes offered by CCP2

TABLE 15-2: INTERACTION OF TWO CCP MODULES

CCPx Mode	CCPy Mode	Interaction
Capture	Capture	TMR1 or TMR3 time base. Time base can be different for each CCP.
Capture	Compare	The compare could be configured for the Special Event Trigger which clears either TMR1 or TMR3 depending upon which time base is used.
Compare	Compare	The compare(s) could be configured for the Special Event Trigger which clears TMR1 or TMR3 depending upon which time base is used.
PWM	PWM	The PWMs will have the same frequency and update rate (TMR2 interrupt).
PWM	Capture	None.
PWM	Compare	None.

REGISTER 17-3: SSPSTAT: MSSP STATUS REGISTER (I²C™ MODE)

R/W-0	R/W-0	R-0	R-0	R-0	R-0	R-0	R-0
SMP	CKE	D/$\overline{A}$	P(1)	S(2)	R/$\overline{W}$	UA	BF
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7 **SMP:** Slew Rate Control bit

In Master or Slave mode:
1 = Slew rate control disabled
0 = Slew rate control enabled

bit 6 **CKE:** SMBus Select bit

In Master or Slave mode:
1 = Enable SMBus specific inputs
0 = Disable SMBus specific inputs

bit 5 **D/$\overline{A}$:** Data/$\overline{\text{Address}}$ bit

In Master mode:
Reserved.

In Slave mode:
1 = Indicates that the last byte received or transmitted was data
0 = Indicates that the last byte received or transmitted was address

bit 4 **P:** Stop bit(1)

1 = Indicates that a Stop bit has been detected last
0 = Stop bit was not detected last

bit 3 **S:** Start bit(2)

1 = Indicates that a Start bit has been detected last
0 = Start bit was not detected last

bit 2 **R/$\overline{W}$:** Read/$\overline{\text{Write}}$ bit Information (I²C mode only)

In Slave mode:(3)
1 = Read
0 = Write

In Master mode:(4)
1 = Transmit is in progress
0 = Transmit is not in progress

bit 1 **UA:** Update Address bit (10-Bit Slave mode only)

1 = Indicates that the user needs to update the address in the SSPADD register
0 = Address does not need to be updated

bit 0 **BF:** Buffer Full Status bit

In Transmit mode:
1 = Data transmit in progress (does not include the $\overline{\text{ACK}}$ and Stop bits), SSPBUF is full
0 = Data transmit complete (does not include the $\overline{\text{ACK}}$ and Stop bits), SSPBUF is empty

In Receive mode:
1 = Receive complete, SSPBUF is full
0 = Receive not complete, SSPBUF is empty

Note 1: This bit is cleared on Reset when SSPEN is cleared or a Start bit has been detected.

2: This bit is cleared on Reset when SSPEN is cleared or a Stop bit has been detected.

3: This bit holds the R/W bit information following the last address match. This bit is only valid from the address match to the next Start bit, Stop bit or not $\overline{\text{ACK}}$ bit.

4: ORing this bit with the SSPCON2 bits, SEN, RSEN, PEN, RCEN or ACKEN will indicate if the MSSP is in Idle mode.

REGISTER 17-5: SSPCON2: MSSP CONTROL REGISTER 2 (I^2C™ MODE)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
GCEN	ACKSTAT	ACKDT(1)	ACKEN	RCEN	PEN	RSEN	SEN
bit 7							bit 0

Legend:			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'	
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown

bit 7 **GCEN:** General Call Enable bit (Slave mode only)
1 = Enable interrupt when a general call address (0000h) is received in the SSPSR
0 = General call address disabled

bit 6 **ACKSTAT:** Acknowledge Status bit (Master Transmit mode only)
1 = Acknowledge was not received from slave
0 = Acknowledge was received from slave

bit 5 **ACKDT:** Acknowledge Data bit (Master Receive mode only)(1)
1 = Not Acknowledge
0 = Acknowledge

bit 4 **ACKEN:** Acknowledge Sequence Enable bit (Master Receive mode only)
1 = Initiate Acknowledge sequence on SDA and SCL pins and transmit ACKDT data bit. Automatically cleared by hardware.
0 = Acknowledge sequence Idle

bit 3 **RCEN:** Receive Enable bit (Master Receive mode only)
1 = Enables Receive mode for I^2C
0 = Receive Idle

bit 2 **PEN:** Stop Condition Enable bit (Master mode only)
1 = Initiate Stop condition on SDA and SCL pins. Automatically cleared by hardware.
0 = Stop condition Idle

bit 1 **RSEN:** Repeated Start Condition Enabled bit (Master mode only)
1 = Initiate Repeated Start condition on SDA and SCL pins. Automatically cleared by hardware.
0 = Repeated Start condition Idle

bit 0 **SEN:** Start Condition Enabled/Stretch Enabled bit
In Master mode:
1 = Initiate Start condition on SDA and SCL pins. Automatically cleared by hardware.
0 = Start condition Idle
In Slave mode:
1 = Clock stretching is enabled for both Slave Transmit and Slave Receive (stretch enabled)
0 = Clock stretching is disabled

Note 1: Value that will be transmitted when the user initiates an Acknowledge sequence at the end of a receive.

FIGURE 18-2: ASYNCHRONOUS TRANSMISSION

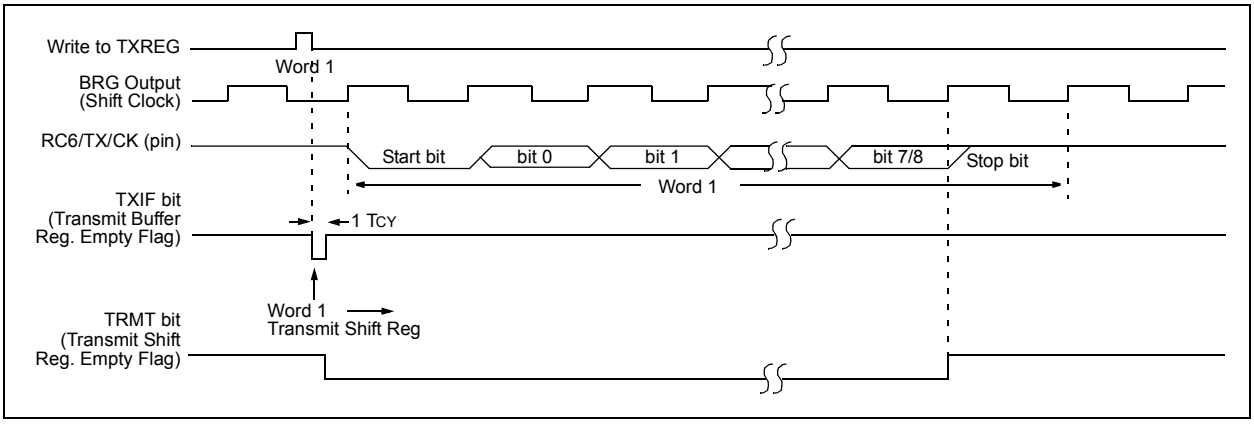
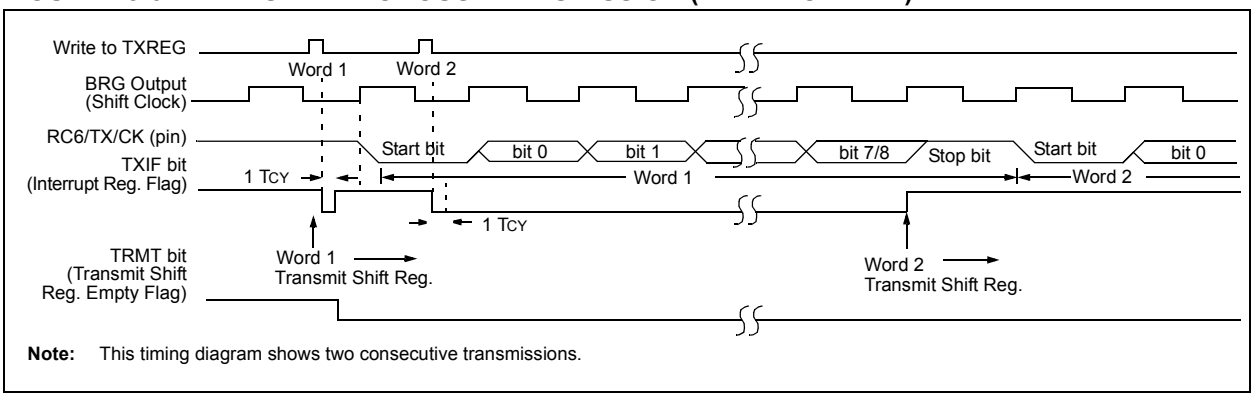


FIGURE 18-3: ASYNCHRONOUS TRANSMISSION (BACK TO BACK)



Note: This timing diagram shows two consecutive transmissions.

TABLE 18-6: REGISTERS ASSOCIATED WITH ASYNCHRONOUS TRANSMISSION

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
INTCON	GIE/GIEH	PEIE/GIEL	TMR0IE	INT0IE	RBIE	TMR0IF	INT0IF	RBIF	0000 000x	0000 000u
PIR1	PSPIF(1)	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
PIE1	PSPIE(1)	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
IPR1	PSPIP(1)	ADIP	RCIP	TXIP	SSPIP	CCP1IP	TMR2IP	TMR1IP	1111 1111	1111 1111
RCSTA	SPEN	RX9	SREN	CREN	ADDEN	FERR	OERR	RX9D	0000 000x	0000 000x
TXREG	USART Transmit Register								0000 0000	0000 0000
TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	0000 -010	0000 -010
SPBRG	Baud Rate Generator Register								0000 0000	0000 0000

Legend: x = unknown, - = unimplemented locations read as '0'. Shaded cells are not used for asynchronous transmission.

Note 1: The PSPIF, PSPIE and PSPIP bits are reserved on the PIC18F2X20 devices; always maintain these bits clear.

The value in the ADRESH/ADRESL registers is not modified for a Power-on Reset. The ADRESH/ADRESL registers will contain unknown data after a Power-on Reset.

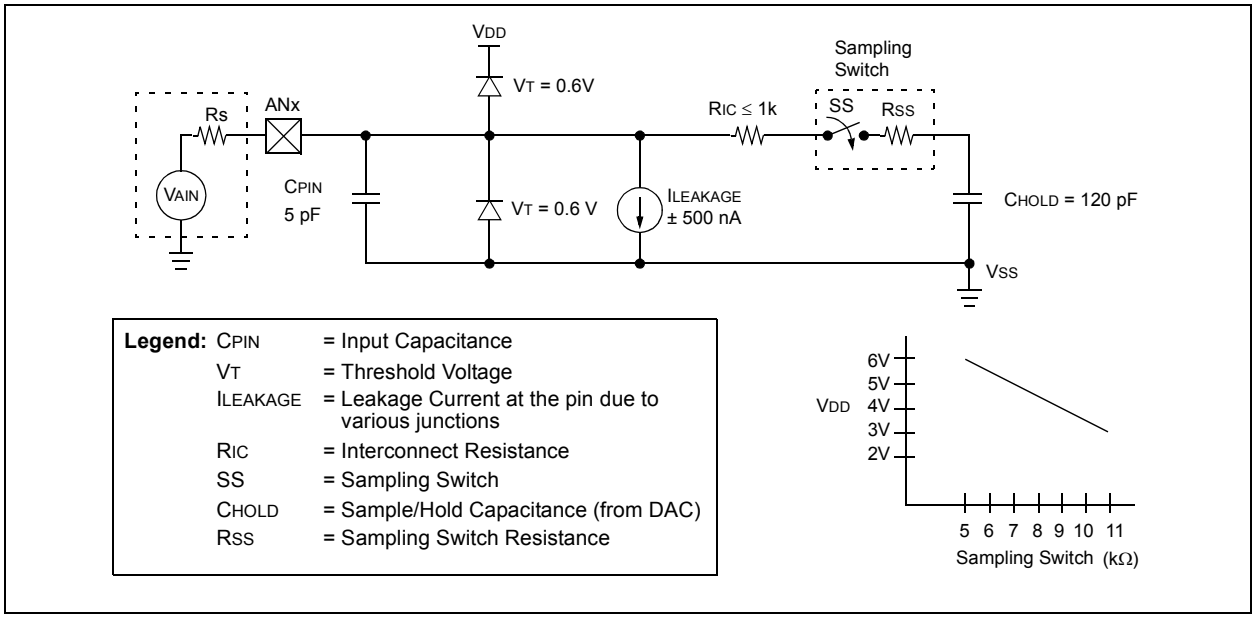
After the A/D module has been configured as desired, the selected channel must be acquired before the conversion is started. The analog input channels must have their corresponding TRIS bits selected as an input. To determine acquisition time, see **Section 19.1 "A/D Acquisition Requirements"**. After this acquisition time has elapsed, the A/D conversion can be started. An acquisition time can be programmed to occur between setting the GO/$\overline{\text{DONE}}$ bit and the actual start of the conversion.

The following steps should be followed to do an A/D conversion:

1. Configure the A/D module:
   - Configure analog pins, voltage reference and digital I/O (ADCON1)
   - Select A/D input channel (ADCON0)
   - Select A/D acquisition time (ADCON2)
   - Select A/D conversion clock (ADCON2)
   - Turn on A/D module (ADCON0)
2. Configure A/D interrupt (if desired):
   - Clear ADIF bit
   - Set ADIE bit
   - Set GIE bit
3. Wait the required acquisition time (if required).
4. Start conversion:
   - Set GO/$\overline{\text{DONE}}$ bit (ADCON0 register)
5. Wait for A/D conversion to complete, by either:
   - Polling for the GO/$\overline{\text{DONE}}$ bit to be cleared

   OR
   - Waiting for the A/D interrupt
6. Read A/D Result registers (ADRESH:ADRESL); clear bit ADIF if required.
7. For next conversion, go to step 1 or step 2, as required. The A/D conversion time per bit is defined as TAD. A minimum wait of 2 TAD is required before next acquisition starts.

FIGURE 19-2: ANALOG INPUT MODEL



NOTES:

ANDWF **AND W with f**

Syntax: [*label*] ANDWF f [,d [,a]]

Operands: $0 \le f \le 255$
$d \in [0,1]$
$a \in [0,1]$

Operation: (W) .AND. (f) → dest

Status Affected: N, Z

Encoding:

0001	01da	ffff	ffff

Description: The contents of W are AND'ed with register 'f'. If 'd' is '0', the result is stored in W. If 'd' is '1', the result is stored back in register 'f' (default). If 'a' is '0', the Access Bank will be selected. If 'a' is '1', the BSR will not be overridden (default).

Words: 1

Cycles: 1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	Read register 'f'	Process Data	Write to destination

Example: `ANDWF REG, W`

Before Instruction
W = 0x17
REG = 0xC2

After Instruction
W = 0x02
REG = 0xC2

BC **Branch if Carry**

Syntax: [*label*] BC n

Operands: $-128 \le n \le 127$

Operation: if Carry bit is '1',
(PC) + 2 + 2n → PC

Status Affected: None

Encoding:

1110	0010	nnnn	nnnn

Description: If the Carry bit is '1', then the program will branch.
The 2's complement number '2n' is added to the PC. Since the PC will have incremented to fetch the next instruction, the new address will be PC + 2 + 2n. This instruction is then a two-cycle instruction.

Words: 1

Cycles: 1(2)

Q Cycle Activity:
If Jump:

Q1	Q2	Q3	Q4
Decode	Read literal 'n'	Process Data	Write to PC
No operation	No operation	No operation	No operation

If No Jump:

Q1	Q2	Q3	Q4
Decode	Read literal 'n'	Process Data	No operation

Example: `HERE BC JUMP`

Before Instruction
PC = address `(HERE)`

After Instruction
If Carry = 1;
PC = address `(JUMP)`
If Carry = 0;
PC = address `(HERE + 2)`

NEGF **Negate f**

Syntax: [*label*] NEGF f [,a]

Operands: $0 \le f \le 255$
$a \in [0,1]$

Operation: $(\overline{f}) + 1 \rightarrow f$

Status Affected: N, OV, C, DC, Z

Encoding:

0110	110a	ffff	ffff

Description: Location 'f' is negated using two's complement. The result is placed in the data memory location 'f'. If 'a' is '0', the Access Bank will be selected, overriding the BSR value. If 'a' = 1, then the bank will be selected as per the BSR value.

Words: 1

Cycles: 1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	Read register 'f'	Process Data	Write register 'f'

Example: `NEGF REG, 1`

Before Instruction
REG = 0011 1010 [0x3A]
After Instruction
REG = 1100 0110 [0xC6]

NOP **No Operation**

Syntax: [*label*] NOP

Operands: None

Operation: No operation

Status Affected: None

Encoding:

0000 1111	0000 xxxx	0000 xxxx	0000 xxxx

Description: No operation.

Words: 1

Cycles: 1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	No operation	No operation	No operation

Example:

None.

TBLWT **Table Write**

Syntax: [*label*] TBLWT (*; *+; *-; +*)

Operands: None

Operation: if TBLWT*,
(TABLAT) → Holding Register,
TBLPTR - No Change;
if TBLWT*+,
(TABLAT) → Holding Register,
(TBLPTR) +1 → TBLPTR;
if TBLWT*-,
(TABLAT) → Holding Register,
(TBLPTR) -1 → TBLPTR;
if TBLWT+*,
(TBLPTR) +1 → TBLPTR,
(TABLAT) → Holding Register

Status Affected: None

Encoding:

0000	0000	0000	11nn nn=0 * =1 *+ =2 *- =3 +*

Description: This instruction uses the 3 LSBs of TBLPTR to determine which of the 8 holding registers the TABLAT is written to. The holding registers are used to program the contents of Program Memory (P.M.). (Refer to **Section 6.0 "Flash Program Memory"** for additional details on programming Flash memory.)
The TBLPTR (a 21-bit pointer) points to each byte in the program memory. TBLPTR has a 2 MByte address range. The LSb of the TBLPTR selects which byte of the program memory location to access.

TBLPTR[0] = 0: Least Significant Byte of Program Memory Word

TBLPTR[0] = 1: Most Significant Byte of Program Memory Word

The TBLWT instruction can modify the value of TBLPTR as follows:

- no change
- post-increment
- post-decrement
- pre-increment

TBLWT Table Write (Continued)

Words: 1

Cycles: 2

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	No operation	No operation	No operation
No operation	No operation (Read TABLAT)	No operation	No operation (Write to Holding Register)

Example1: `TBLWT *+;`

Before Instruction
TABLAT = 0x55
TBLPTR = 0x00A356
HOLDING REGISTER (0x00A356) = 0xFF

After Instructions (table write completion)
TABLAT = 0x55
TBLPTR = 0x00A357
HOLDING REGISTER (0x00A356) = 0x55

Example 2: `TBLWT +*;`

Before Instruction
TABLAT = 0x34
TBLPTR = 0x01389A
HOLDING REGISTER (0x01389A) = 0xFF
HOLDING REGISTER (0x01389B) = 0xFF

After Instruction (table write completion)
TABLAT = 0x34
TBLPTR = 0x01389B
HOLDING REGISTER (0x01389A) = 0xFF
HOLDING REGISTER (0x01389B) = 0x34

26.4.3 TIMING DIAGRAMS AND SPECIFICATIONS

FIGURE 26-6: EXTERNAL CLOCK TIMING (ALL MODES EXCEPT PLL)

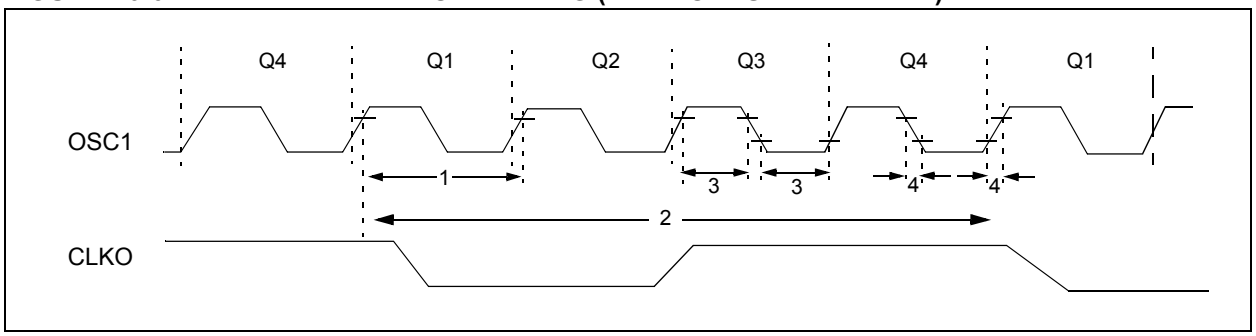


TABLE 26-6: EXTERNAL CLOCK TIMING REQUIREMENTS

Param. No.	Symbol	Characteristic	Min	Max	Units	Conditions
1A	FOSC	External CLKI Frequency(1)	DC	40	MHz	EC, ECIO (industrial)
			DC	25	MHz	EC, ECIO (extended)
		Oscillator Frequency(1)	DC	4	MHz	RC osc
			0.1	1	MHz	XT osc
			4	25	MHz	HS osc
			4	10	MHz	HS + PLL osc (industrial)
			4	6.25	MHz	HS + PLL osc (extended)
			5	33	kHz	LP Osc mode
1	TOSC	External CLKI Period(1)	25	—	ns	EC, ECIO (industrial)
			40	—	ns	EC, ECIO (extended)
		Oscillator Period(1)	250	—	ns	RC osc
			1	—	μs	XT osc
			40	250	ns	HS osc
			100	250	ns	HS + PLL osc (industrial)
			160	250	ns	HS + PLL osc (extended)
			30	—	μs	LP osc
2	TCY	Instruction Cycle Time(1)	100	—	ns	TCY = 4/FOSC (industrial)
			160	—	ns	TCY = 4/FOSC (extended)
3	TOSL, TOSH	External Clock in (OSC1) High or Low Time	30	—	ns	XT osc
			2.5	—	μs	LP osc
			10	—	ns	HS osc
4	TOSR, TOSF	External Clock in (OSC1) Rise or Fall Time	—	20	ns	XT osc
			—	50	ns	LP osc
			—	7.5	ns	HS osc

Note 1: Instruction cycle period (TCY) equals four times the input oscillator time base period for all configurations except PLL. All specified values are based on characterization data for that particular oscillator type under standard operating conditions with the device executing code. Exceeding these specified limits may result in an unstable oscillator operation and/or higher than expected current consumption. All devices are tested to operate at “min.” values with an external clock applied to the OSC1/CLKI pin. When an external clock input is used, the “max.” cycle time limit is “DC” (no clock) for all devices.

TABLE 26-19: I²C™ BUS DATA REQUIREMENTS (SLAVE MODE)

Param. No.	Symbol	Characteristic		Min	Max	Units	Conditions
100	THIGH	Clock High Time	100 kHz mode	4.0	—	μs	PIC18FXX20 must operate at a minimum of 1.5 MHz
			400 kHz mode	0.6	—	μs	PIC18FXX20 must operate at a minimum of 10 MHz
			MSSP module	1.5 TCY	—		
101	TLOW	Clock Low Time	100 kHz mode	4.7	—	μs	PIC18FXX20 must operate at a minimum of 1.5 MHz
			400 kHz mode	1.3	—	μs	PIC18FXX20 must operate at a minimum of 10 MHz
			MSSP module	1.5 TCY	—		
102	TR	SDA and SCL Rise Time	100 kHz mode	—	1000	ns	
			400 kHz mode	20 + 0.1 CB	300	ns	CB is specified to be from 10 to 400 pF
103	TF	SDA and SCL Fall Time	100 kHz mode	—	300	ns	
			400 kHz mode	20 + 0.1 CB	300	ns	CB is specified to be from 10 to 400 pF
90	TSU:STA	Start Condition Setup Time	100 kHz mode	4.7	—	μs	Only relevant for Repeated Start condition
			400 kHz mode	0.6	—	μs	
91	THD:STA	Start Condition Hold Time	100 kHz mode	4.0	—	μs	After this period, the first clock pulse is generated
			400 kHz mode	0.6	—	μs	
106	THD:DAT	Data Input Hold Time	100 kHz mode	0	—	ns	
			400 kHz mode	0	0.9	μs	
107	TSU:DAT	Data Input Setup Time	100 kHz mode	250	—	ns	**(Note 2)**
			400 kHz mode	100	—	ns	
92	TSU:STO	Stop Condition Setup Time	100 kHz mode	4.7	—	μs	
			400 kHz mode	0.6	—	μs	
109	TAA	Output Valid from Clock	100 kHz mode	—	3500	ns	**(Note 1)**
			400 kHz mode	—	—	ns	
110	TBUF	Bus Free Time	100 kHz mode	4.7	—	μs	Time the bus must be free before a new transmission can start
			400 kHz mode	1.3	—	μs	
D102	CB	Bus Capacitive Loading		—	400	pF	

Note 1: As a transmitter, the device must provide this internal minimum delay time to bridge the undefined region (min. 300 ns) of the falling edge of SCL to avoid unintended generation of Start or Stop conditions.

2: A fast mode I²C bus device can be used in a standard mode I²C bus system but the requirement, TSU:DAT ≥ 250 ns, must then be met. This will automatically be the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line, TR max. + TSU:DAT = 1000 + 250 = 1250 ns (according to the standard mode I²C bus specification), before the SCL line is released.

FIGURE 27-7: MAXIMUM IDD vs. FOSC OVER VDD PRI_RUN, EC MODE, -40°C TO +125°C

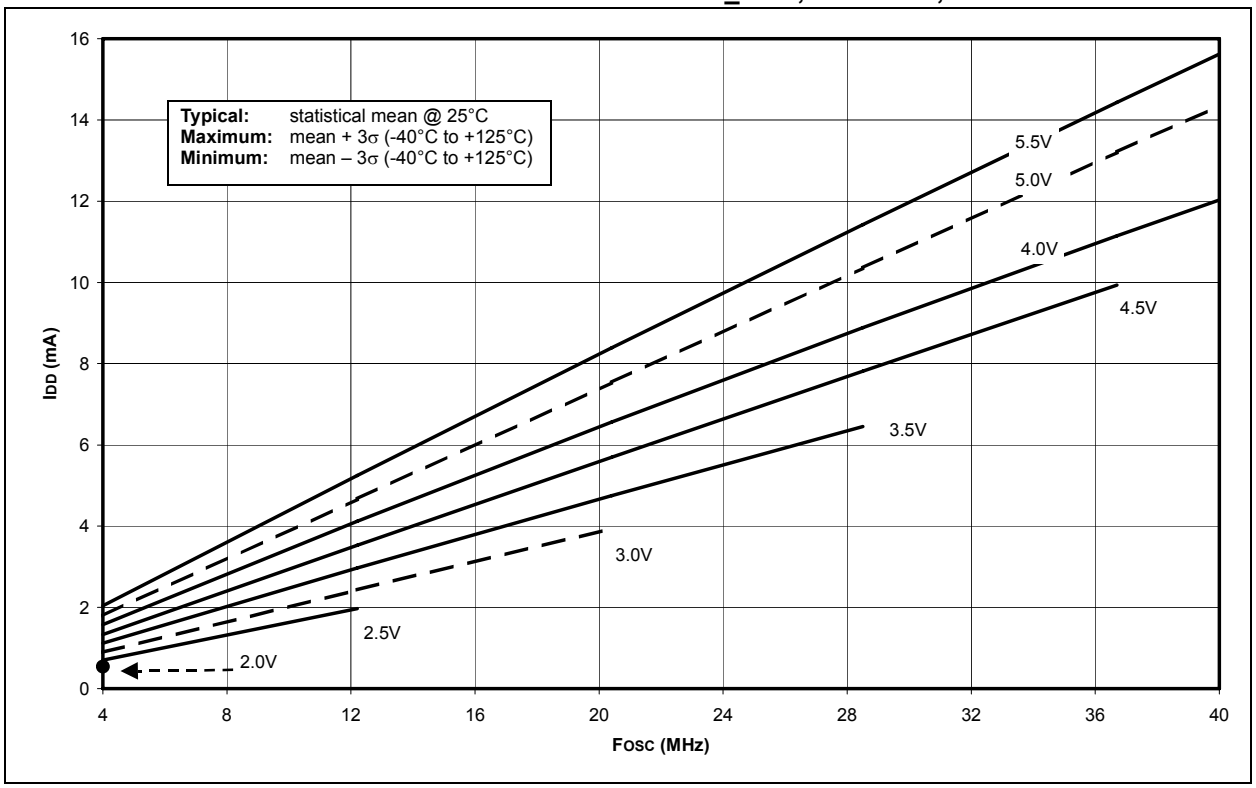


FIGURE 27-8: TYPICAL IDD vs. FOSC OVER VDD PRI_IDLE, EC MODE, +25°C

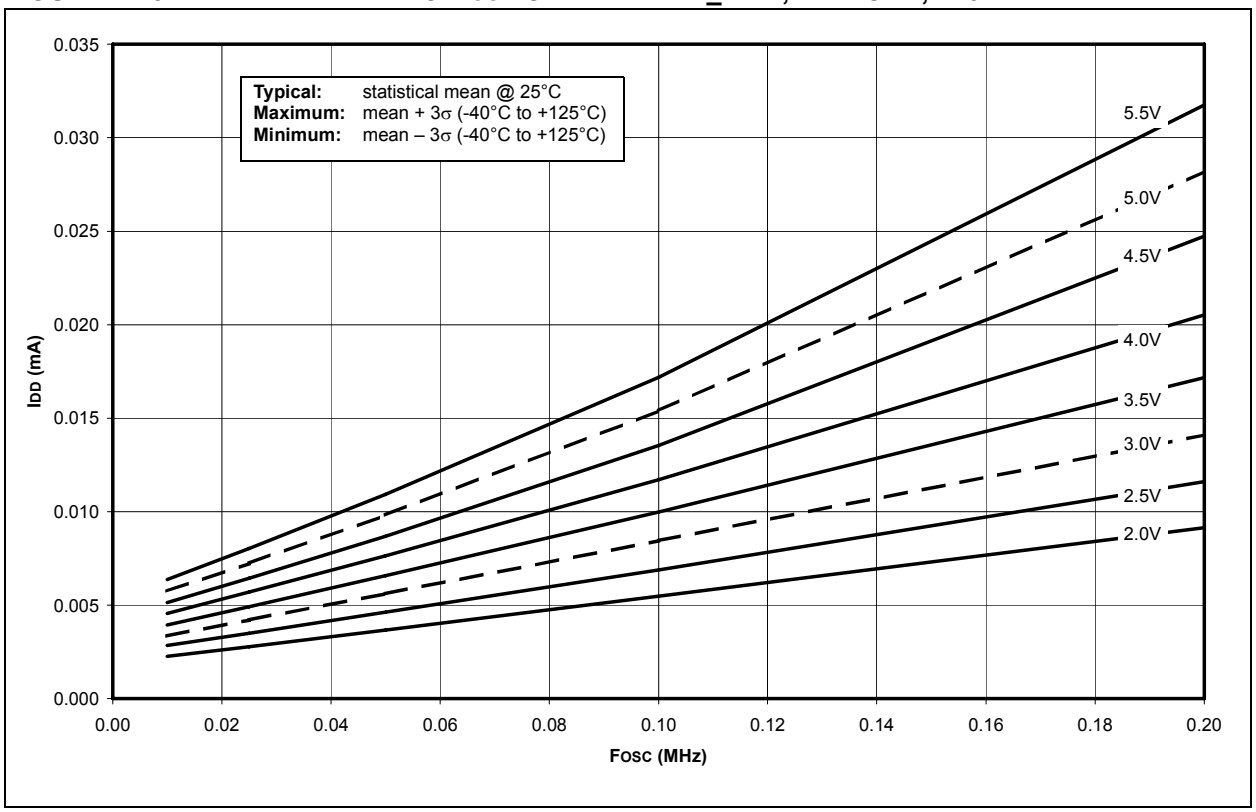


FIGURE 27-27: V_{OL} vs. I_{OL} OVER TEMPERATURE (-40°C TO +125°C), V_{DD} = 5.0V

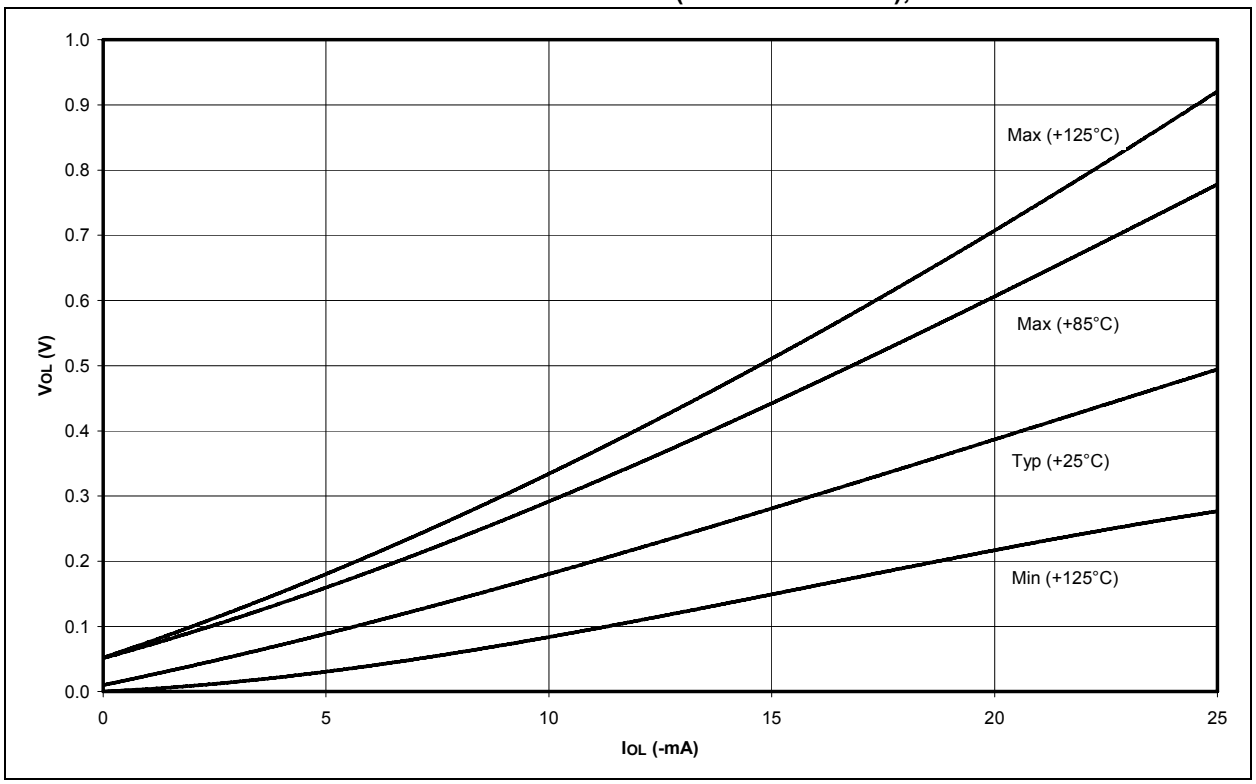
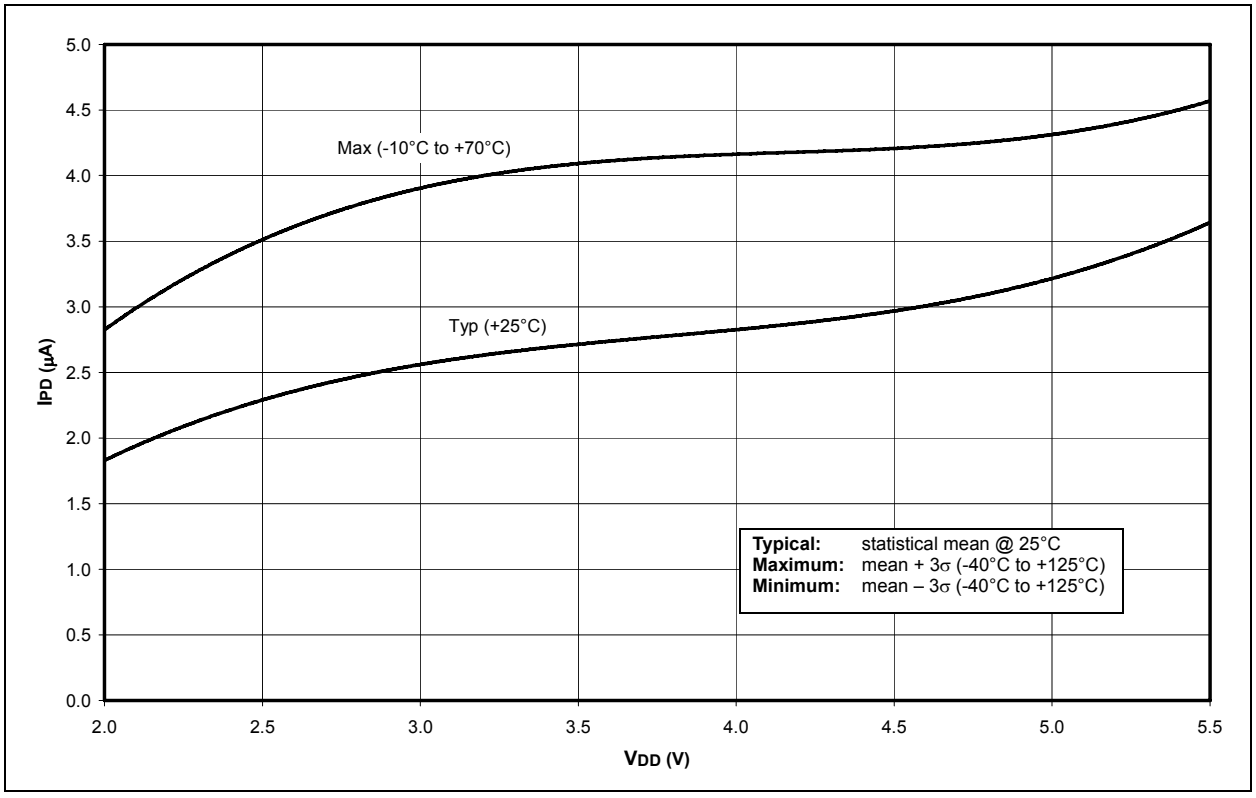


FIGURE 27-28: Δ I_{PD} TIMER1 OSCILLATOR, -10°C TO +70°C SLEEP MODE, TMR1 COUNTER DISABLED



NOTES: