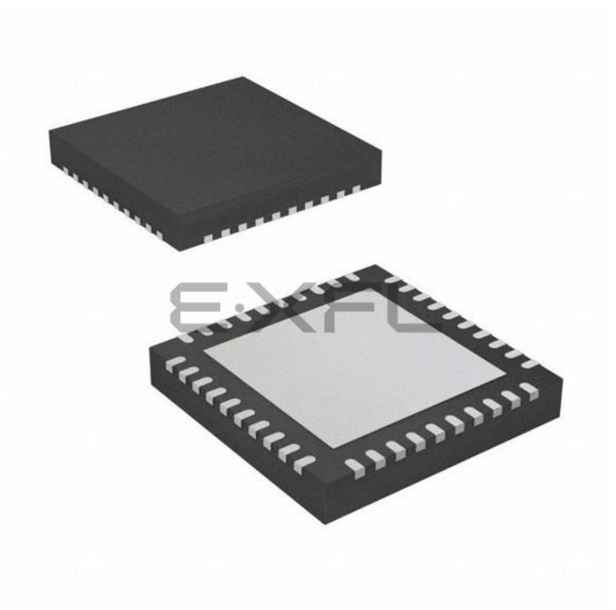

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	20MHz
Connectivity	I²C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	36
Program Memory Size	14KB (8K x 14)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	368 x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 3.6V
Data Converters	A/D 14x8b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	40-UFQFN Exposed Pad
Supplier Device Package	40-UQFN (5x5)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16lf727-e-mv

TABLE 1-1: PIC16(L)F722/3/4/6/7 PINOUT DESCRIPTION

Name	Function	Input Type	Output Type	Description
RA0/AN0/$\overline{SS}$/VCAP	RA0	TTL	CMOS	General purpose I/O.
	AN0	AN	—	A/D Channel 0 input.
	$\overline{SS}$	ST	—	Slave Select input.
	VCAP	Power	Power	Filter capacitor for Voltage Regulator (PIC16F72X only).
RA1/AN1	RA1	TTL	CMOS	General purpose I/O.
	AN1	AN	—	A/D Channel 1 input.
RA2/AN2	RA2	TTL	CMOS	General purpose I/O.
	AN2	AN	—	A/D Channel 2 input.
RA3/AN3/VREF	RA3	TTL	CMOS	General purpose I/O.
	AN3	AN	—	A/D Channel 3 input.
	VREF	AN	—	A/D Voltage Reference input.
RA4/CPS6/T0CKI	RA4	TTL	CMOS	General purpose I/O.
	CPS6	AN	—	Capacitive sensing input 6.
	T0CKI	ST	—	Timer0 clock input.
RA5/AN4/CPS7/$\overline{SS}$/VCAP	RA5	TTL	CMOS	General purpose I/O.
	AN4	AN	—	A/D Channel 4 input.
	CPS7	AN	—	Capacitive sensing input 7.
	$\overline{SS}$	ST	—	Slave Select input.
	VCAP	Power	Power	Filter capacitor for Voltage Regulator (PIC16F72X only).
RA6/OSC2/CLKOUT/VCAP	RA6	TTL	CMOS	General purpose I/O.
	OSC2	—	XTAL	Crystal/Resonator (LP, XT, HS modes).
	CLKOUT	—	CMOS	FOSC/4 output.
	VCAP	Power	Power	Filter capacitor for Voltage Regulator (PIC16F72X only).
RA7/OSC1/CLKIN	RA7	TTL	CMOS	General purpose I/O.
	OSC1	XTAL	—	Crystal/Resonator (LP, XT, HS modes).
	CLKIN	CMOS	—	External clock input (EC mode).
	CLKIN	ST	—	RC oscillator connection (RC mode).
RB0/AN12/CPS0/INT	RB0	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on-change. Individually enabled pull-up.
	AN12	AN	—	A/D Channel 12 input.
	CPS0	AN	—	Capacitive sensing input 0.
	INT	ST	—	External interrupt.
RB1/AN10/CPS1	RB1	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on-change. Individually enabled pull-up.
	AN10	AN	—	A/D Channel 10 input.
	CPS1	AN	—	Capacitive sensing input 1.
RB2/AN8/CPS2	RB2	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on-change. Individually enabled pull-up.
	AN8	AN	—	A/D Channel 8 input.
	CPS2	AN	—	Capacitive sensing input 2.
RB3/AN9/CPS3/CCP2	RB3	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on-change. Individually enabled pull-up.
	AN9	AN	—	A/D Channel 9 input.
	CPS3	AN	—	Capacitive sensing input 3.
	CCP2	ST	CMOS	Capture/Compare/PWM2.

Legend: AN = Analog input or output; CMOS = CMOS compatible input or output; OD = Open Drain; TTL = TTL compatible input; ST = Schmitt Trigger input with CMOS levels; I^2C = Schmitt Trigger input with I^2C; HV = High Voltage; XTAL = Crystal levels

TABLE 6-3: SUMMARY OF REGISTERS ASSOCIATED WITH PORTC

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
APFCON	—	—	—	—	—	—	SSSEL	CCP2SEL	`---- --00`	`---- --00`
CCP1CON	—	—	DC1B1	DC1B0	CCP1M3	CCP1M2	CCP1M1	CCP1M0	`--00 0000`	`--00 0000`
CCP2CON	—	—	DC2B1	DC2B0	CCP2M3	CCP2M2	CCP2M1	CCP2M0	`--00 0000`	`--00 0000`
PORTC	RC7	RC6	RC5	RC4	RC3	RC2	RC1	RC0	`xxxx xxxx`	`xxxx xxxx`
RCSTA	SPEN	RX9	SREN	CREN	ADDEN	FERR	OERR	RX9D	`0000 000x`	`0000 000x`
SSPCON	WCOL	SSPOV	SSPEN	CKP	SSPM3	SSPM2	SSPM1	SSPM0	`0000 0000`	`0000 0000`
SSPSTAT	SMP	CKE	D/$\overline{\text{A}}$	P	S	R/$\overline{\text{W}}$	UA	BF	`0000 0000`	`0000 0000`
T1CON	TMR1CS1	TMR1CS0	T1CKPS1	T1CKPS0	T1OSCEN	$\overline{\text{T1SYNC}}$	—	TMR1ON	`0000 00-0`	`uuuu uu-u`
TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	`0000 -010`	`0000 -010`
TRISC	TRISC7	TRISC6	TRISC5	TRISC4	TRISC3	TRISC2	TRISC1	TRISC0	`1111 1111`	`1111 1111`

Legend: x = unknown, u = unchanged, - = unimplemented locations read as ‘0’. Shaded cells are not used by Port C.

REGISTER 6-17: ANSELE: PORTE ANALOG SELECT REGISTER

U-0	U-0	U-0	U-0	U-0	R/W-1	R/W-1	R/W-1
—	—	—	—	—	ANSE2(2)	ANSE1(2)	ANSE0(2)
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 7-3 **Unimplemented:** Read as ‘0’

bit 2-0 **ANSE<2:0>**: Analog Select between Analog or Digital Function on Pins RE<2:0>, respectively
0 = Digital I/O. Pin is assigned to port or Digital special function.
1 = Analog input. Pin is assigned as analog input(1). Digital Input buffer disabled.

Note 1: When setting a pin to an analog input, the corresponding TRIS bit must be set to Input mode in order to allow external control of the voltage on the pin.
2: ANSELE register is not implemented on the PIC16F722/723/726/PIC16LF722/723/726. Read as ‘0’

TABLE 6-5: SUMMARY OF REGISTERS ASSOCIATED WITH PORTE

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
ADCON0	—	—	CHS3	CHS2	CHS1	CHS0	GO/$\overline{DONE}$	ADON	--00 0000	--00 0000
ANSELE	—	—	—	—	—	ANSE2	ANSE1	ANSE0	---- -111	---- -111
PORTE	—	—	—	—	RE3	RE2	RE1	RE0	---- xxxx	---- xxxx
TRISE	—	—	—	—	TRISE3(2)	TRISE2(1)	TRISE1(1)	TRISE0(1)	---- 1111	---- 1111

Legend: x = unknown, u = unchanged, – = unimplemented locations read as ‘0’. Shaded cells are not used by PORTE
Note 1: These registers are not implemented on the PIC16F722/723/726/PIC16LF722/723/726 devices, read as ‘0’.
2: This bit is always ‘1’ as RE3 is input only.

7.0 OSCILLATOR MODULE

7.1 Overview

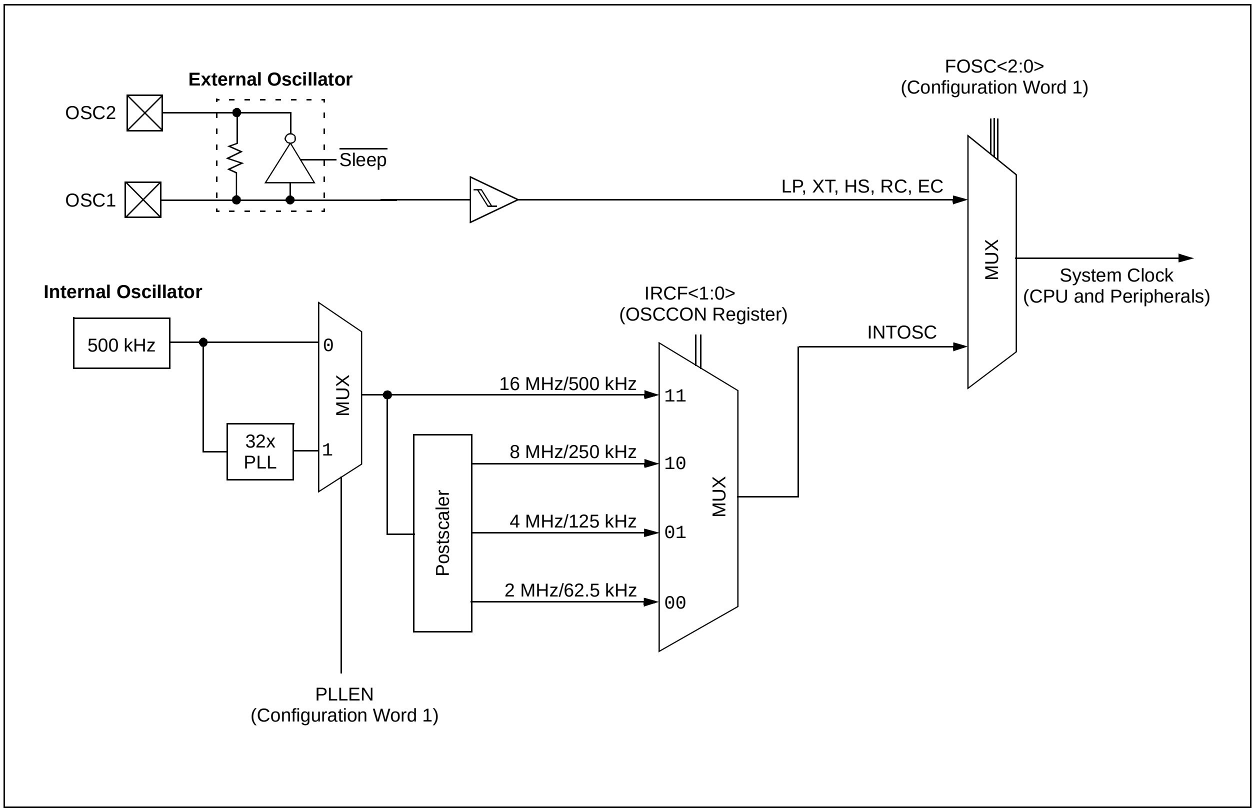
The oscillator module has a wide variety of clock sources and selection features that allow it to be used in a wide range of applications while maximizing performance and minimizing power consumption. Figure 7-1 illustrates a block diagram of the oscillator module.

Clock sources can be configured from external oscillators, quartz crystal resonators, ceramic resonators and Resistor-Capacitor (RC) circuits. In addition, the system can be configured to use an internal calibrated high-frequency oscillator as clock source, with a choice of selectable speeds via software.

Clock source modes are configured by the FOSC bits in Configuration Word 1 (CONFIG1). The oscillator module can be configured for one of eight modes of operation.

1. RC – External Resistor-Capacitor (RC) with FOSC/4 output on OSC2/CLKOUT.
2. RCIO – External Resistor-Capacitor (RC) with I/O on OSC2/CLKOUT.
3. INTOSC – Internal oscillator with FOSC/4 output on OSC2 and I/O on OSC1/CLKIN.
4. INTOSCIO – Internal oscillator with I/O on OSC1/CLKIN and OSC2/CLKOUT.
5. EC – External clock with I/O on OSC2/CLKOUT.
6. HS – High Gain Crystal or Ceramic Resonator mode.
7. XT – Medium Gain Crystal or Ceramic Resonator Oscillator mode.
8. LP – Low-Power Crystal mode.

FIGURE 7-1: SIMPLIFIED PIC® MCU CLOCK SOURCE BLOCK DIAGRAM



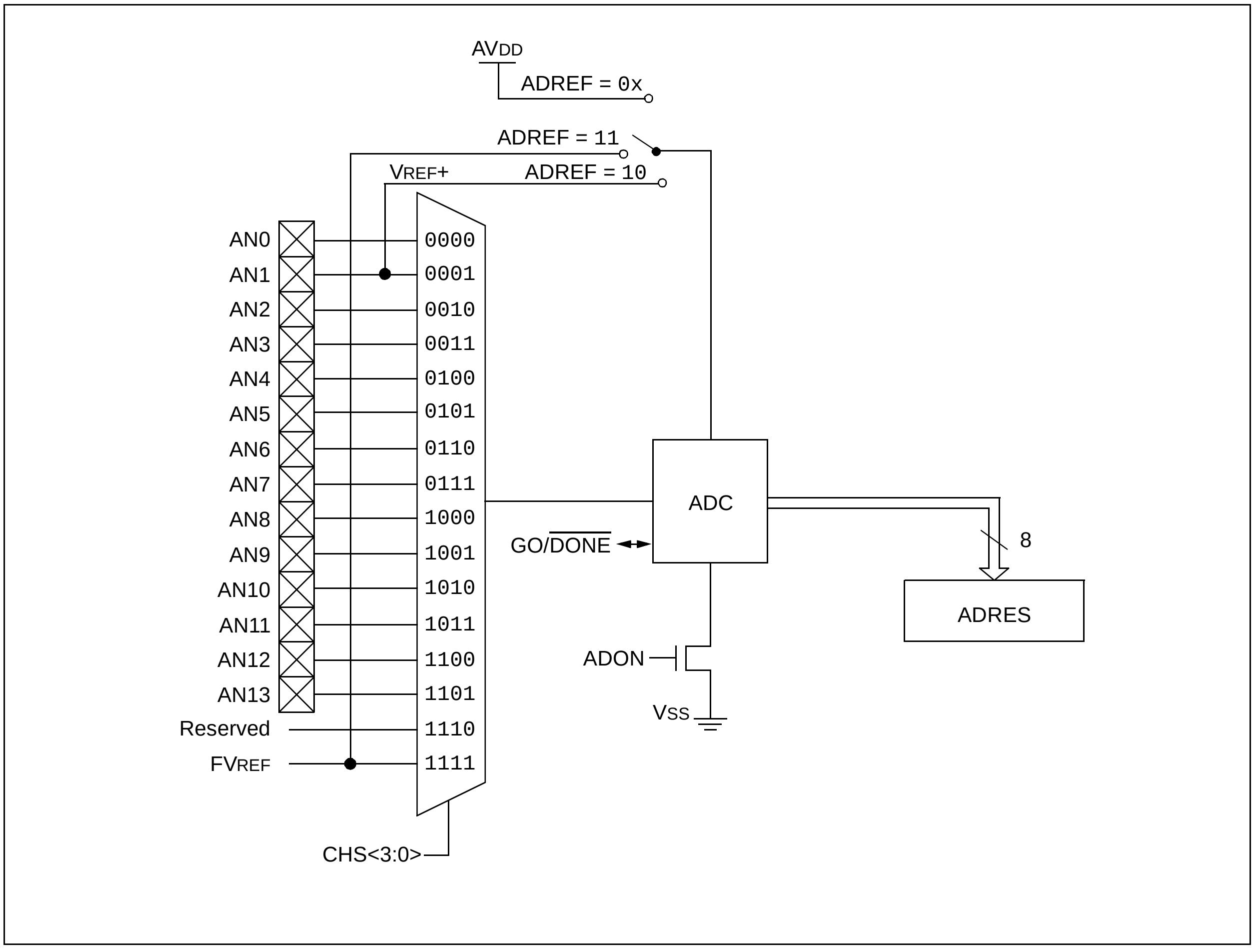
9.0 ANALOG-TO-DIGITAL CONVERTER (ADC) MODULE

The Analog-to-Digital Converter (ADC) allows conversion of an analog input signal to a 8-bit binary representation of that signal. This device uses analog inputs, which are multiplexed into a single sample and hold circuit. The output of the sample and hold is connected to the input of the converter. The converter generates a 8-bit binary result via successive approximation and stores the conversion result into the ADC result register (ADRES). Figure 9-1 shows the block diagram of the ADC.

The ADC voltage reference is software selectable to be either internally generated or externally supplied.

The ADC can generate an interrupt upon completion of a conversion. This interrupt can be used to wake-up the device from Sleep.

FIGURE 9-1: ADC BLOCK DIAGRAM



9.1.5 INTERRUPTS

The ADC module allows for the ability to generate an interrupt upon completion of an Analog-to-Digital conversion. The ADC interrupt flag is the ADIF bit in the PIR1 register. The ADC interrupt enable is the ADIE bit in the PIE1 register. The ADIF bit must be cleared in software.

> **Note 1:** The ADIF bit is set at the completion of every conversion, regardless of whether or not the ADC interrupt is enabled.
>
> **2:** The ADC operates during Sleep only when the FRC oscillator is selected.

This interrupt can be generated while the device is operating or while in Sleep. If the device is in Sleep, the interrupt will wake-up the device. Upon waking from Sleep, the next instruction following the SLEEP instruction is always executed. If the user is attempting to wake-up from Sleep and resume in-line code execution, the GIE and PEIE bits of the INTCON register must be disabled. If the GIE and PEIE bits of the INTCON register are enabled, execution will switch to the Interrupt Service Routine.

Please refer to **Section 9.1.5 “Interrupts”** for more information.

9.2 ADC Operation

9.2.1 STARTING A CONVERSION

To enable the ADC module, the ADON bit of the ADCON0 register must be set to a ‘1’. Setting the GO/$\overline{\text{DONE}}$ bit of the ADCON0 register to a ‘1’ will start the Analog-to-Digital conversion.

> **Note:** The GO/$\overline{\text{DONE}}$ bit should not be set in the same instruction that turns on the ADC. Refer to **Section 9.2.6 “A/D Conversion Procedure”**.

9.2.2 COMPLETION OF A CONVERSION

When the conversion is complete, the ADC module will:

- Clear the GO/$\overline{\text{DONE}}$ bit
- Set the ADIF Interrupt Flag bit
- Update the ADRES register with new conversion result

9.2.3 TERMINATING A CONVERSION

If a conversion must be terminated before completion, the GO/$\overline{\text{DONE}}$ bit can be cleared in software. The ADRES register will be updated with the partially complete Analog-to-Digital conversion sample. Incomplete bits will match the last bit converted.

> **Note:** A device Reset forces all registers to their Reset state. Thus, the ADC module is turned off and any pending conversion is terminated.

9.2.4 ADC OPERATION DURING SLEEP

The ADC module can operate during Sleep. This requires the ADC clock source to be set to the FRC option. When the FRC clock source is selected, the ADC waits one additional instruction before starting the conversion. This allows the SLEEP instruction to be executed, which can reduce system noise during the conversion. If the ADC interrupt is enabled, the device will wake-up from Sleep when the conversion completes. If the ADC interrupt is disabled, the ADC module is turned off after the conversion completes, although the ADON bit remains set.

When the ADC clock source is something other than FRC, a SLEEP instruction causes the present conversion to be aborted and the ADC module is turned off, although the ADON bit remains set.

9.2.5 SPECIAL EVENT TRIGGER

The Special Event Trigger of the CCP module allows periodic ADC measurements without software intervention. When this trigger occurs, the GO/$\overline{\text{DONE}}$ bit is set by hardware and the Timer1 counter resets to zero.

Using the Special Event Trigger does not assure proper ADC timing. It is the user’s responsibility to ensure that the ADC timing requirements are met.

Refer to **Section 15.0 “Capture/Compare/PWM (CCP) Module”** for more information.

9.2.7 ADC REGISTER DEFINITIONS

The following registers are used to control the operation of the ADC.

REGISTER 9-1: ADCON0: A/D CONTROL REGISTER 0

U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	CHS3	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	ADON
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 7-6 **Unimplemented:** Read as ‘0’

bit 5-2 **CHS<3:0>:** Analog Channel Select bits
- 0000 = AN0
- 0001 = AN1
- 0010 = AN2
- 0011 = AN3
- 0100 = AN4
- 0101 = AN5
- 0110 = AN6
- 0111 = AN7
- 1000 = AN8
- 1001 = AN9
- 1010 = AN10
- 1011 = AN11
- 1100 = AN12
- 1101 = AN13
- 1110 = Reserved
- 1111 = Fixed Voltage Reference (FVREF)

bit 1 **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit
- 1 = A/D conversion cycle in progress. Setting this bit starts an A/D conversion cycle.
  This bit is automatically cleared by hardware when the A/D conversion has completed.
- 0 = A/D conversion completed/not in progress

bit 0 **ADON:** ADC Enable bit
- 1 = ADC is enabled
- 0 = ADC is disabled and consumes no operating current

TABLE 9-2: SUMMARY OF ASSOCIATED ADC REGISTERS

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
ADCON0	—	—	CHS3	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	ADON	--00 0000	--00 0000
ADCON1	—	ADCS2	ADCS1	ADCS0	—	—	ADREF1	ADREF0	-000 --00	-000 --00
ANSELA	—	—	ANSA5	ANSA4	ANSA3	ANSA2	ANSA1	ANSA0	--11 1111	--11 1111
ANSELB	—	—	ANSB5	ANSB4	ANSB3	ANSB2	ANSB1	ANSB0	--11 1111	--11 1111
ANSELE	—	—	—	—	—	ANSE2	ANSE1	ANSE0	---- -111	---- -111
ADRES	A/D Result Register Byte								xxxx xxxx	uuuu uuuu
CCP2CON	—	—	DC2B1	DC2B0	CCP2M3	CCP2M2	CCP2M1	CCP2M0	--00 0000	--00 0000
FVRCON	FVRRDY	FVREN	—	—	—	—	ADFVR1	ADFVR0	q0-- --00	q0-- --00
INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000x
PIE1	TMR1GIE	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
PIR1	TMR1GIF	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
TRISA	TRISA7	TRISA6	TRISA5	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	1111 1111	1111 1111
TRISB	TRISB7	TRISB6	TRISB5	TRISB4	TRISB3	TRISB2	TRISB1	TRISB0	1111 1111	1111 1111
TRISE	—	—	—	—	TRISE3	TRISE2	TRISE1	TRISE0	---- 1111	---- 1111

Legend: x = unknown, u = unchanged, – = unimplemented read as ‘0’, q = value depends on condition. Shaded cells are not used for ADC module.

12.6 Timer1 Gate

Timer1 can be configured to count freely or the count can be enabled and disabled using Timer1 Gate circuitry. This is also referred to as Timer1 Gate Count Enable.

Timer1 Gate can also be driven by multiple selectable sources.

12.6.1 TIMER1 GATE COUNT ENABLE

The Timer1 Gate is enabled by setting the TMR1GE bit of the T1GCON register. The polarity of the Timer1 Gate is configured using the T1GPOL bit of the T1GCON register.

When Timer1 Gate (T1G) input is active, Timer1 will increment on the rising edge of the Timer1 clock source. When Timer1 Gate input is inactive, no incrementing will occur and Timer1 will hold the current count. See Figure 12-3 for timing details.

TABLE 12-3: TIMER1 GATE ENABLE SELECTIONS

T1CLK	T1GPOL	T1G	Timer1 Operation
↑	0	0	Counts
↑	0	1	Holds Count
↑	1	0	Holds Count
↑	1	1	Counts

12.6.2 TIMER1 GATE SOURCE SELECTION

The Timer1 Gate source can be selected from one of four different sources. Source selection is controlled by the T1GSS bits of the T1GCON register. The polarity for each available source is also selectable. Polarity selection is controlled by the T1GPOL bit of the T1GCON register.

TABLE 12-4: TIMER1 GATE SOURCES

T1GSS	Timer1 Gate Source
00	Timer1 Gate Pin
01	Overflow of Timer0 (TMR0 increments from FFh to 00h)
10	Timer2 match PR2 (TMR2 increments to match PR2)
11	Count Enabled by WDT Overflow (Watchdog Time-out interval expired)

12.6.2.1 T1G Pin Gate Operation

The T1G pin is one source for Timer1 Gate Control. It can be used to supply an external source to the Timer1 Gate circuitry.

12.6.2.2 Timer0 Overflow Gate Operation

When Timer0 increments from FFh to 00h, a low-to-high pulse will automatically be generated and internally supplied to the Timer1 Gate circuitry.

12.6.2.3 Timer2 Match Gate Operation

The TMR2 register will increment until it matches the value in the PR2 register. On the very next increment cycle, TMR2 will be reset to 00h. When this Reset occurs, a low-to-high pulse will automatically be generated and internally supplied to the Timer1 Gate circuitry.

12.6.2.4 Watchdog Overflow Gate Operation

The Watchdog Timer oscillator, prescaler and counter will be automatically turned on when TMR1GE = 1 and T1GSS selects the WDT as a gate source for Timer1 (T1GSS = 11). TMR1ON does not factor into the oscillator, prescaler and counter enable. See Table 12-5.

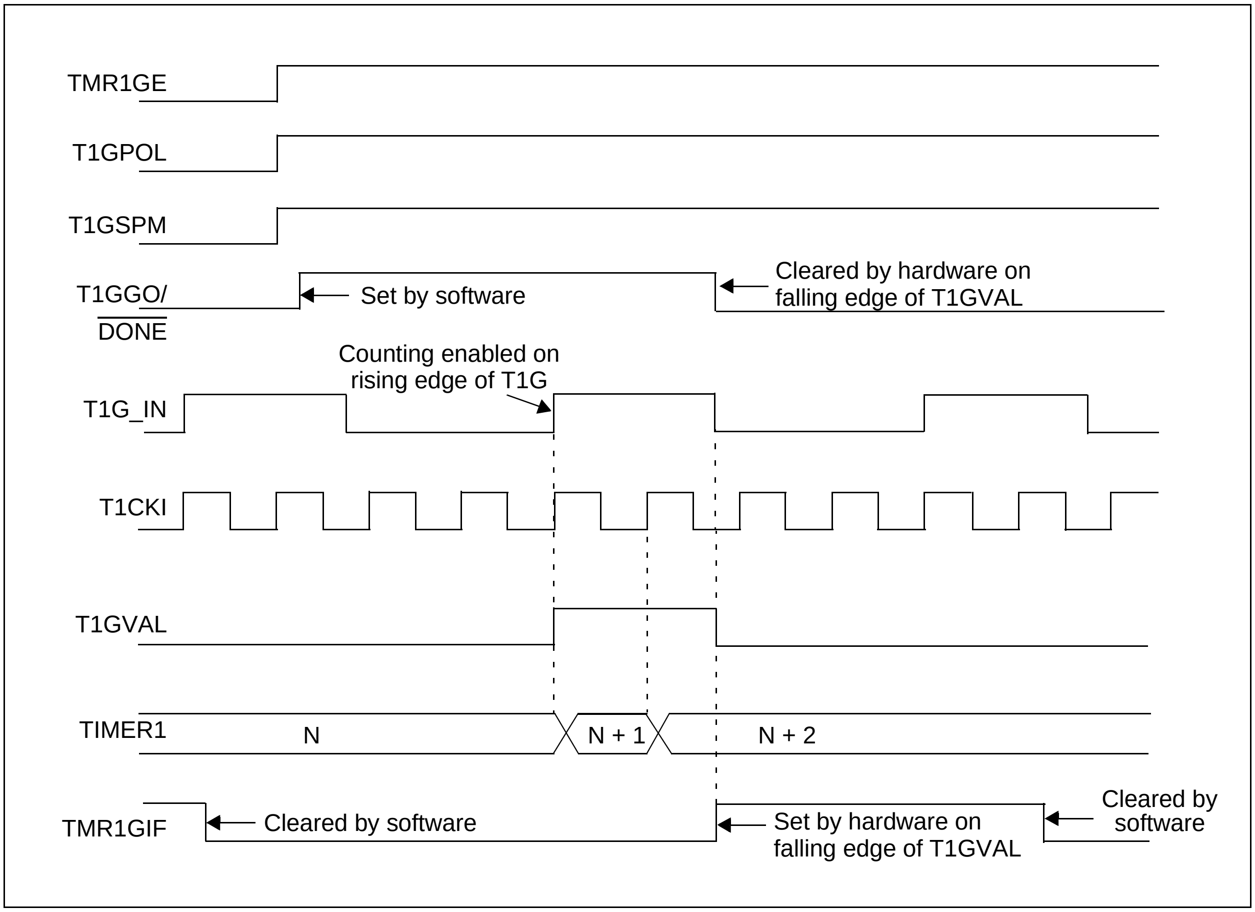
The PSA and PS bits of the OPTION register still control what time-out interval is selected. Changing the prescaler during operation may result in a spurious capture.

Enabling the Watchdog Timer oscillator does not automatically enable a Watchdog Reset or Wake-up from Sleep upon counter overflow.

> **Note:** When using the WDT as a gate source for Timer1, operations that clear the Watchdog Timer (`CLRWDT`, `SLEEP` instructions) will affect the time interval being measured for capacitive sensing. This includes waking from Sleep. All other interrupts that might wake the device from Sleep should be disabled to prevent them from disturbing the measurement period.

As the gate signal coming from the WDT counter will generate different pulse widths depending on if the WDT is enabled, when the `CLRWDT` instruction is executed, and so on, Toggle mode must be used. A specific sequence is required to put the device into the correct state to capture the next WDT counter interval.

FIGURE 12-5: TIMER1 GATE SINGLE-PULSE MODE



14.1 Analog MUX

The capacitive sensing module can monitor up to 16 inputs. The capacitive sensing inputs are defined as CPS<15:0>. To determine if a frequency change has occurred the user must:

- Select the appropriate CPS pin by setting the CPSCH<3:0> bits of the CPSCON1 register
- Set the corresponding ANSEL bit
- Set the corresponding TRIS bit
- Run the software algorithm

Selection of the CPSx pin while the module is enabled will cause the capacitive sensing oscillator to be on the CPSx pin. Failure to set the corresponding ANSEL and TRIS bits can cause the capacitive sensing oscillator to stop, leading to false frequency readings.

14.2 Capacitive Sensing Oscillator

The capacitive sensing oscillator consists of a constant current source and a constant current sink, to produce a triangle waveform. The CPSOUT bit of the CPSCON0 register shows the status of the capacitive sensing oscillator, whether it is a sinking or sourcing current. The oscillator is designed to drive a capacitive load (single PCB pad) and at the same time, be a clock source to either Timer0 or Timer1. The oscillator has three different current settings as defined by CPSRNG<1:0> of the CPSCON0 register. The different current settings for the oscillator serve two purposes:

- Maximize the number of counts in a timer for a fixed time base
- Maximize the count differential in the timer during a change in frequency

14.3 Timer resources

To measure the change in frequency of the capacitive sensing oscillator, a fixed time base is required. For the period of the fixed time base, the capacitive sensing oscillator is used to clock either Timer0 or Timer1. The frequency of the capacitive sensing oscillator is equal to the number of counts in the timer divided by the period of the fixed time base.

14.4 Fixed Time Base

To measure the frequency of the capacitive sensing oscillator, a fixed time base is required. Any timer resource or software loop can be used to establish the fixed time base. It is up to the end user to determine the method in which the fixed time base is generated.

Note:	The fixed time base can not be generated by timer resource the capacitive sensing oscillator is clocking.

14.4.1 TIMER0

To select Timer0 as the timer resource for the capacitive sensing module:

- Set the T0XCS bit of the CPSCON0 register
- Clear the T0CS bit of the OPTION register

When Timer0 is chosen as the timer resource, the capacitive sensing oscillator will be the clock source for Timer0. Refer to **Section 11.0 "Timer0 Module"** for additional information.

14.4.2 TIMER1

To select Timer1 as the timer resource for the capacitive sensing module, set the TMR1CS<1:0> of the T1CON register to '11'. When Timer1 is chosen as the timer resource, the capacitive sensing oscillator will be the clock source for Timer1. Because the Timer1 module has a gate control, developing a time base for the frequency measurement can be simplified using either:

- The Timer0 overflow flag
- The Timer2 overflow flag
- The WDT overflow flag

It is recommend that one of these flags, in conjunction with the toggle mode of the Timer1 Gate, is used to develop the fixed time base required by the software portion of the capacitive sensing module. Refer to **Section 12.0 "Timer1 Module with Gate Control"** for additional information.

TABLE 14-1: TIMER1 ENABLE FUNCTION

TMR1ON	TMR1GE	Timer1 Operation
0	0	Off
0	1	Off
1	0	On
1	1	Count Enabled by input

REGISTER 14-2: CPSCON1: CAPACITIVE SENSING CONTROL REGISTER 1

U-0	U-0	U-0	U-0	R/W-0(2)	R/W-0	R/W-0	R/W-0
—	—	—	—	CPSCH3	CPSCH2	CPSCH1	CPSCH0
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 7-4 **Unimplemented:** Read as ‘0’

bit 3-0 **CPSCH<3:0>:** Capacitive Sensing Channel Select bits

If CPSON = 0:

These bits are ignored. No channel is selected.

If CPSON = 1:

0000 = channel 0, (CPS0)
0001 = channel 1, (CPS1)
0010 = channel 2, (CPS2)
0011 = channel 3, (CPS3)
0100 = channel 4, (CPS4)
0101 = channel 5, (CPS5)
0110 = channel 6, (CPS6)
0111 = channel 7, (CPS7)
1000 = channel 8, (CPS8(1))
1001 = channel 9, (CPS9(1))
1010 = channel 10, (CPS10(1))
1011 = channel 11, (CPS11(1))
1100 = channel 12, (CPS12(1))
1101 = channel 13, (CPS13(1))
1110 = channel 14, (CPS14(1))
1111 = channel 15, (CPS15(1))

Note 1: These channels are not implemented on the PIC16F722/723/726/PIC16LF722/723/726.

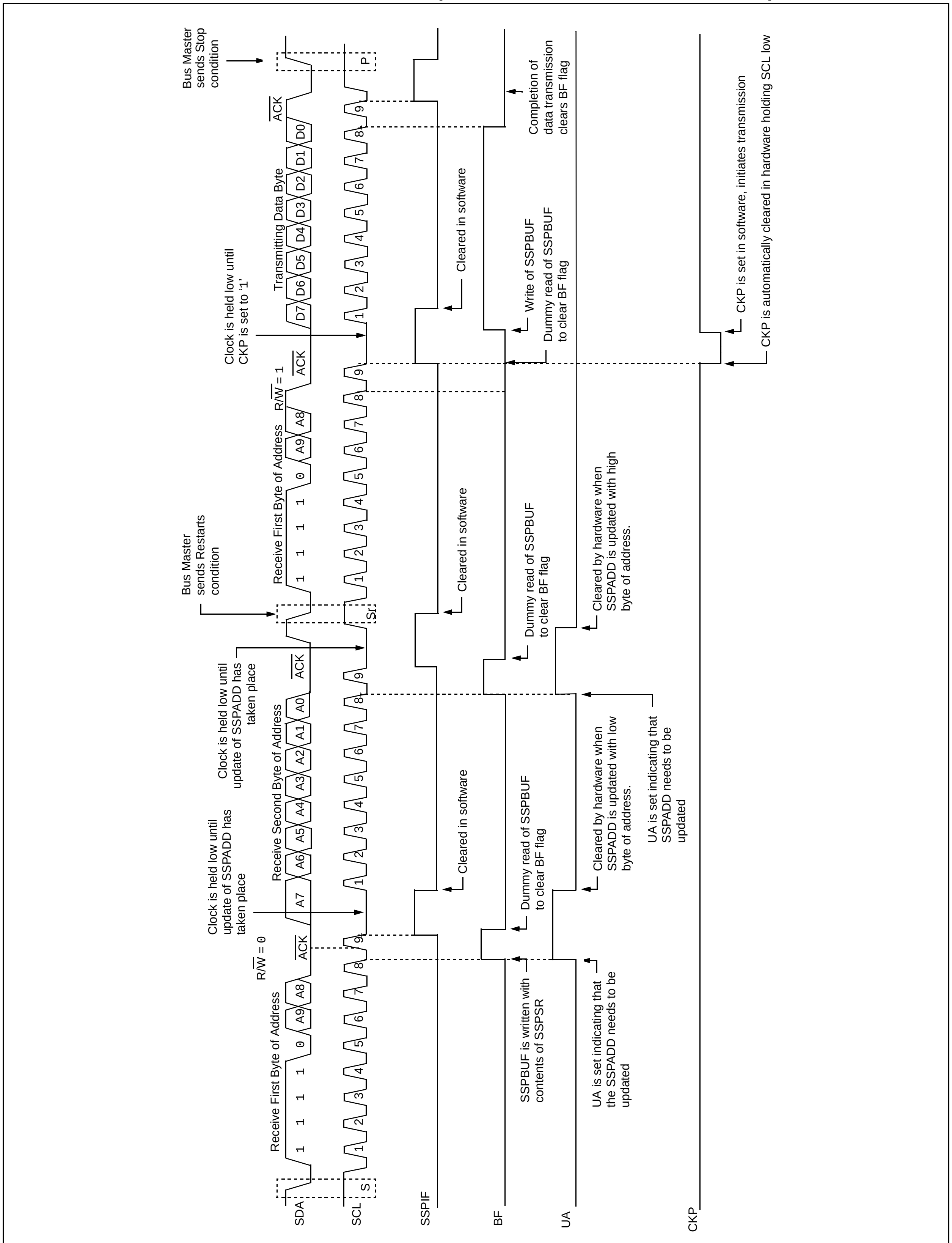
2: This bit is not implemented on PIC16F722/723/726/PIC16LF722/723/726, Read as ‘0’

TABLE 14-2: SUMMARY OF REGISTERS ASSOCIATED WITH CAPACITIVE SENSING

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
ANSELA	—	—	ANSA5	ANSA4	ANSA3	ANSA2	ANSA1	ANSA0	--11 1111	--11 1111
ANSELB	—	—	ANSB5	ANSB4	ANSB3	ANSB2	ANSB1	ANSB0	--11 1111	--11 1111
ANSELD	ANSD7	ANSD6	ANSD5	ANSD4	ANSD3	ANSD2	ANSD1	ANSD0	1111 1111	1111 1111
OPTION_REG	$\overline{\text{RBPU}}$	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111
PIE1	TMR1GIE	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
PIR1	TMR1GIF	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
T1CON	TMR1CS1	TMR1CS0	T1CKPS1	T1CKPS0	T1OSCEN	$\overline{\text{T1SYNC}}$	—	TMR1ON	0000 00-0	0000 00-0
T2CON	—	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0	-000 0000	-000 0000
TRISA	TRISA7	TRISA6	TRISA5	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	1111 1111	1111 1111
TRISB	TRISB7	TRISB6	TRISB5	TRISB4	TRISB3	TRISB2	TRISB1	TRISB0	1111 1111	1111 1111
TRISD	TRISD7	TRISD6	TRISD5	TRISD4	TRISD3	TRISD2	TRISD1	TRISD0	1111 1111	1111 1111

Legend: - = Unimplemented locations, read as ‘0’, u = unchanged, x = unknown. Shaded cells are not used by the capacitive sensing module.

FIGURE 17-13: I²C SLAVE MODE TIMING (TRANSMISSION 10-BIT ADDRESS)



23.2 DC Characteristics: PIC16(L)F722/3/4/6/7-I/E (Industrial, Extended) (Continued)

PIC16LF722/3/4/6/7			Standard Operating Conditions (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤ +125°C for extended				
PIC16F722/3/4/6/7			**Standard Operating Conditions (unless otherwise stated)** Operating temperature -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤ +125°C for extended				
Param No.	**Device Characteristics**	**Min.**	**Typ†**	**Max.**	**Units**	**Conditions**	
						VDD	**Note**
	Supply Current (IDD)[1, 2]						
D014		—	290	330	μA	1.8	FOSC = 4 MHz EC Oscillator mode
		—	460	500	μA	3.0	
D014		—	300	430	μA	1.8	FOSC = 4 MHz EC Oscillator mode **(Note 5)**
		—	450	655	μA	3.0	
		—	500	730	μA	5.0	
D015		—	100	130	μA	1.8	FOSC = 500 kHz MFINTOSC mode
		—	120	150	μA	3.0	
D015		—	115	195	μA	1.8	FOSC = 500 kHz MFINTOSC mode **(Note 5)**
		—	135	200	μA	3.0	
		—	150	220	μA	5.0	
D016		—	650	800	μA	1.8	FOSC = 8 MHz HFINTOSC mode
		—	1000	1200	μA	3.0	
D016		—	625	850	μA	1.8	FOSC = 8 MHz HFINTOSC mode **(Note 5)**
		—	1000	1200	μA	3.0	
		—	1100	1500	μA	5.0	
D017		—	1.0	1.2	mA	1.8	FOSC = 16 MHz HFINTOSC mode
		—	1.5	1.85	mA	3.0	
D017		—	1	1.2	mA	1.8	FOSC = 16 MHz HFINTOSC mode **(Note 5)**
		—	1.5	1.7	mA	3.0	
		—	1.7	2.1	mA	5.0	
D018		—	210	240	μA	1.8	FOSC = 4 MHz EXTRC mode **(Note 3, Note 5)**
		—	340	380	μA	3.0	
D018		—	225	320	μA	1.8	FOSC = 4 MHz EXTRC mode **(Note 3, Note 5)**
		—	360	445	μA	3.0	
		—	410	650	μA	5.0	
D019		—	1.6	1.9	mA	3.0	FOSC = 20 MHz HS Oscillator mode
		—	2.0	2.8	mA	3.6	
D019		—	1.6	2	mA	3.0	FOSC = 20 MHz HS Oscillator mode **(Note 5)**
		—	1.9	3.2	mA	5.0	

Note 1: The test conditions for all IDD measurements in active operation mode are: OSC1 = external square wave, from rail-to-rail; all I/O pins tri-stated, pulled to VDD; $\overline{\text{MCLR}}$ = VDD; WDT disabled.

2: The supply current is mainly a function of the operating voltage and frequency. Other factors, such as I/O pin loading and switching rate, oscillator type, internal code execution pattern and temperature, also have an impact on the current consumption.

3: For RC oscillator configurations, current through REXT is not included. The current through the resistor can be extended by the formula IR = VDD/2REXT (mA) with REXT in kΩ.

4: FVR and BOR are disabled.

5: 0.1 μF capacitor on VCAP (RA0).

TABLE 23-1: CLOCK OSCILLATOR TIMING REQUIREMENTS

Standard Operating Conditions (unless otherwise stated)
Operating temperature -40°C ≤ TA ≤ +125°C

Param No.	Sym.	Characteristic	Min.	Typ†	Max.	Units	Conditions
OS01	FOSC	External CLKIN Frequency(1)	DC	—	37	kHz	LP Oscillator mode
			DC	—	4	MHz	XT Oscillator mode
			DC	—	20	MHz	HS Oscillator mode
			DC	—	20	MHz	EC Oscillator mode
		Oscillator Frequency(1)	—	32.768	—	kHz	LP Oscillator mode
			0.1	—	4	MHz	XT Oscillator mode
			1	—	20	MHz	HS Oscillator mode
			DC	—	4	MHz	RC Oscillator mode
OS02	TOSC	External CLKIN Period(1)	27	—	∞	μs	LP Oscillator mode
			250	—	∞	ns	XT Oscillator mode
			50	—	∞	ns	HS Oscillator mode
			50	—	∞	ns	EC Oscillator mode
		Oscillator Period(1)	—	30.5	—	μs	LP Oscillator mode
			250	—	10,000	ns	XT Oscillator mode
			50	—	1,000	ns	HS Oscillator mode
			250	—	—	ns	RC Oscillator mode
OS03	TCY	Instruction Cycle Time(1)	200	TCY	DC	ns	TCY = 4/FOSC
OS04*	TosH, TosL	External CLKIN High, External CLKIN Low	2	—	—	μs	LP oscillator
			100	—	—	ns	XT oscillator
			20	—	—	ns	HS oscillator
OS05*	TosR, TosF	External CLKIN Rise, External CLKIN Fall	0	—	∞	ns	LP oscillator
			0	—	∞	ns	XT oscillator
			0	—	∞	ns	HS oscillator

* 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: Instruction cycle period (TCY) equals four times the input oscillator time base period. 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 OSC1 pin. When an external clock input is used, the “max” cycle time limit is “DC” (no clock) for all devices.

FIGURE 24-7: PIC16F722/3/4/6/7 TYPICAL IDD vs. VDD OVER FOSC, EXTRC MODE, VCAP = 0.1 µF

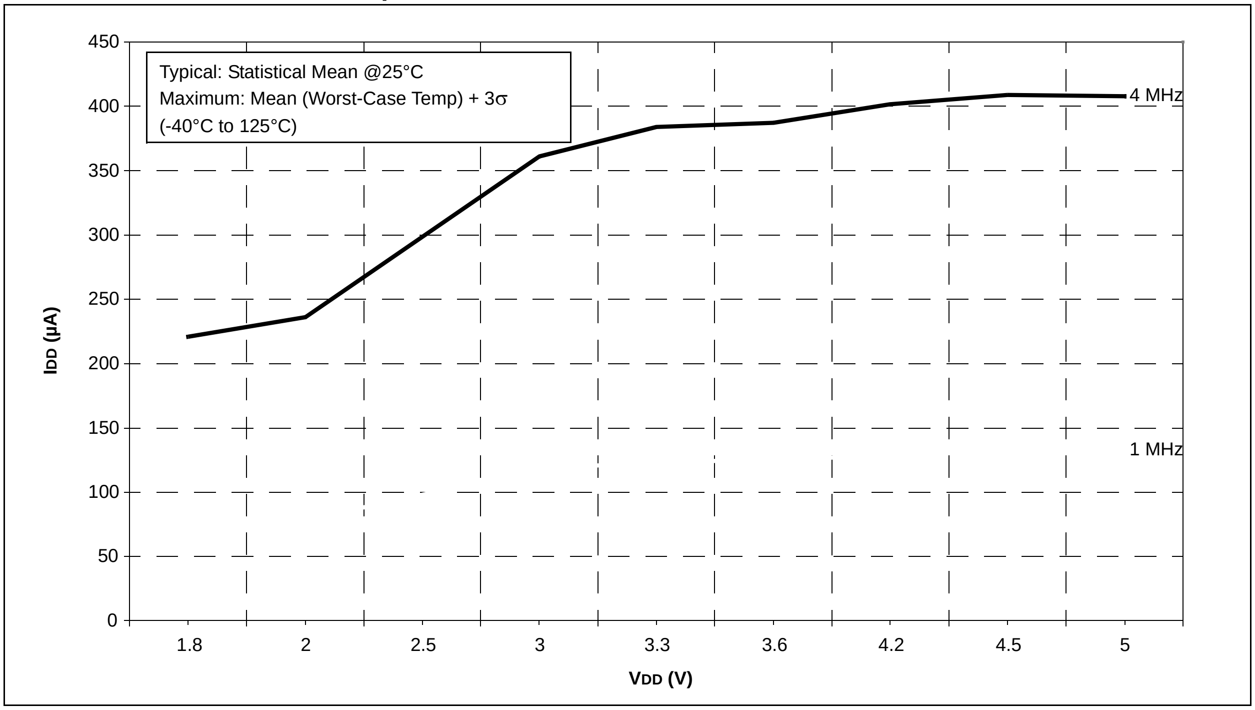


FIGURE 24-8: PIC16LF722/3/4/6/7 TYPICAL IDD vs. VDD OVER FOSC, EXTRC MODE

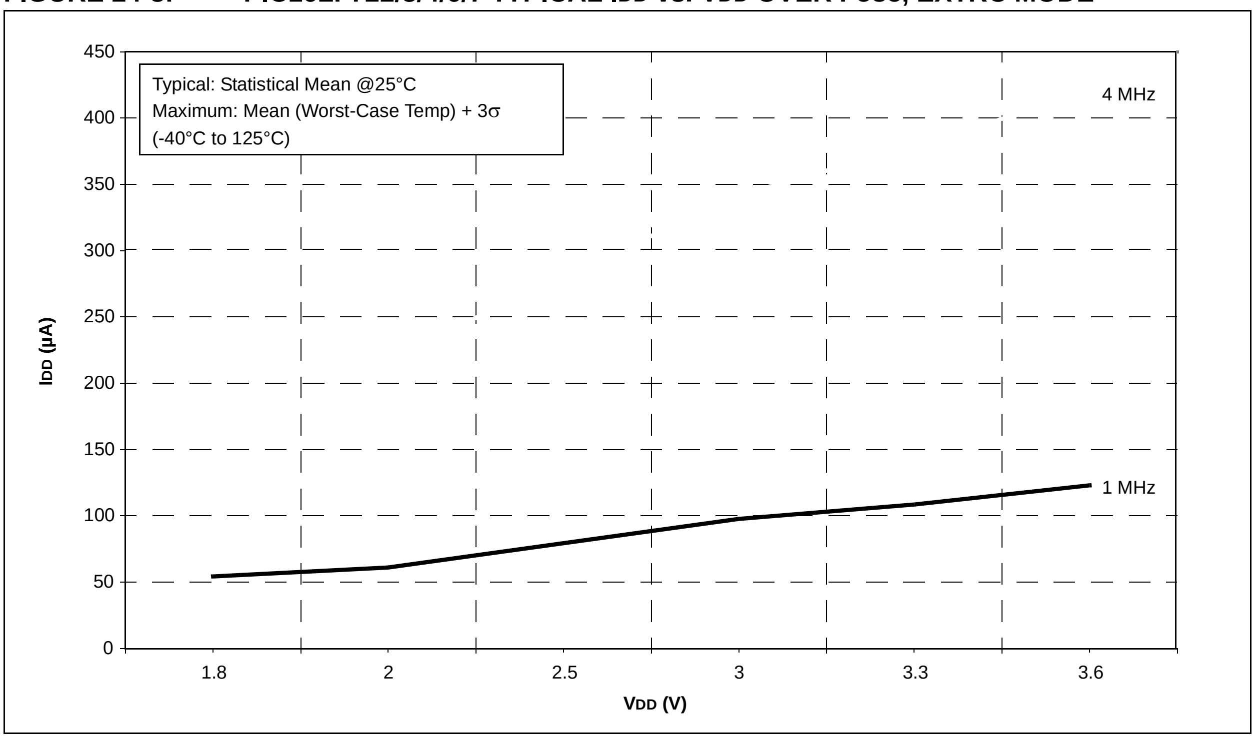


FIGURE 24-39: PIC16F722/3/4/6/7 CAP SENSE LOW POWER IPD vs. VDD, VCAP = 0.1 µF

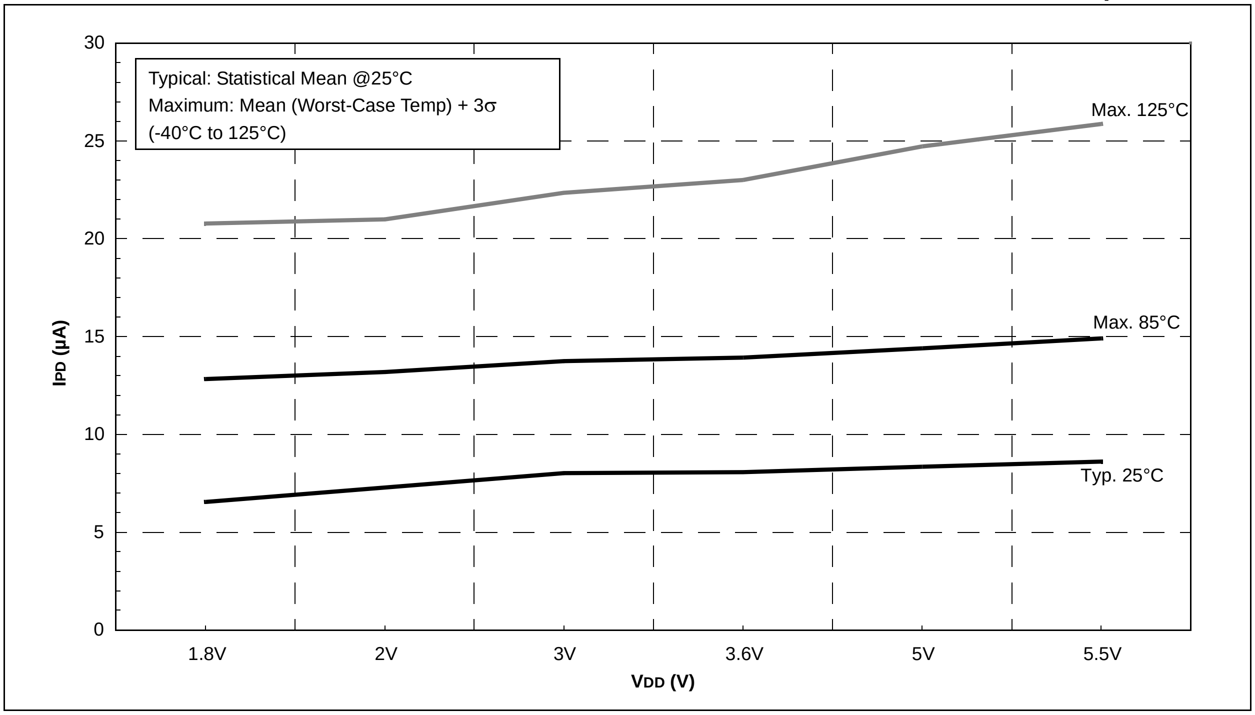
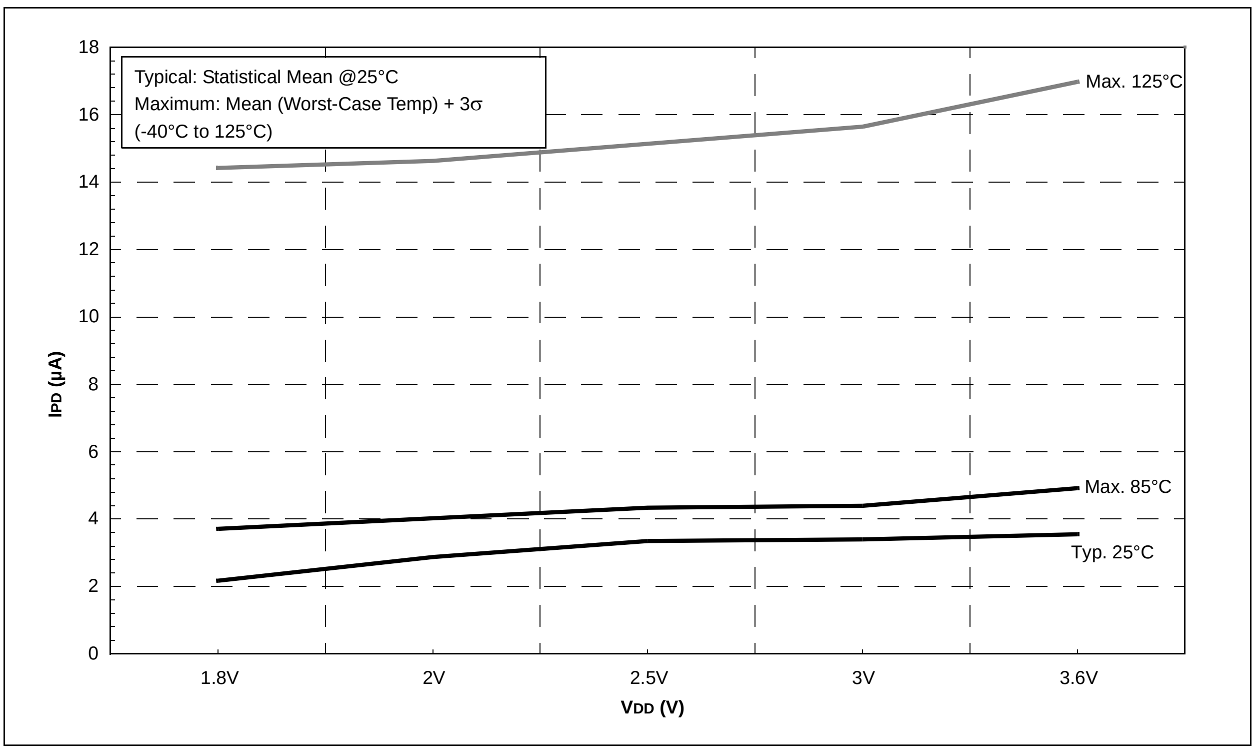
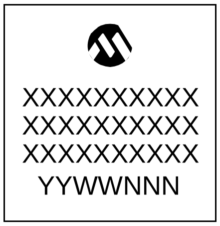


FIGURE 24-40: PIC16LF722/3/4/6/7 CAP SENSE LOW POWER IPD vs. VDD

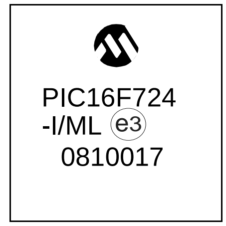


Package Marking Information (Continued)

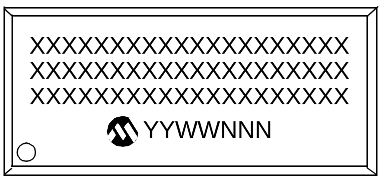
44-Lead QFN



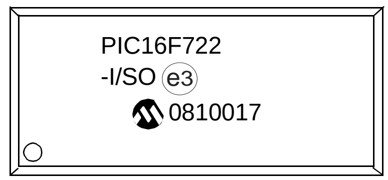
Example



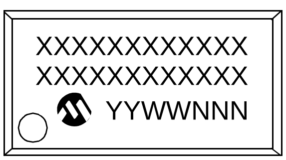
28-Lead SOIC



Example

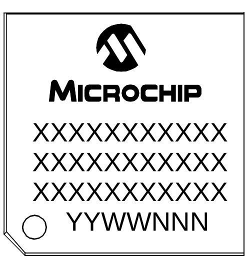


28-Lead SSOP

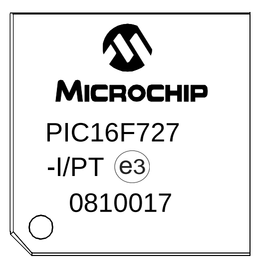


Example

44-Lead TQFP



Example

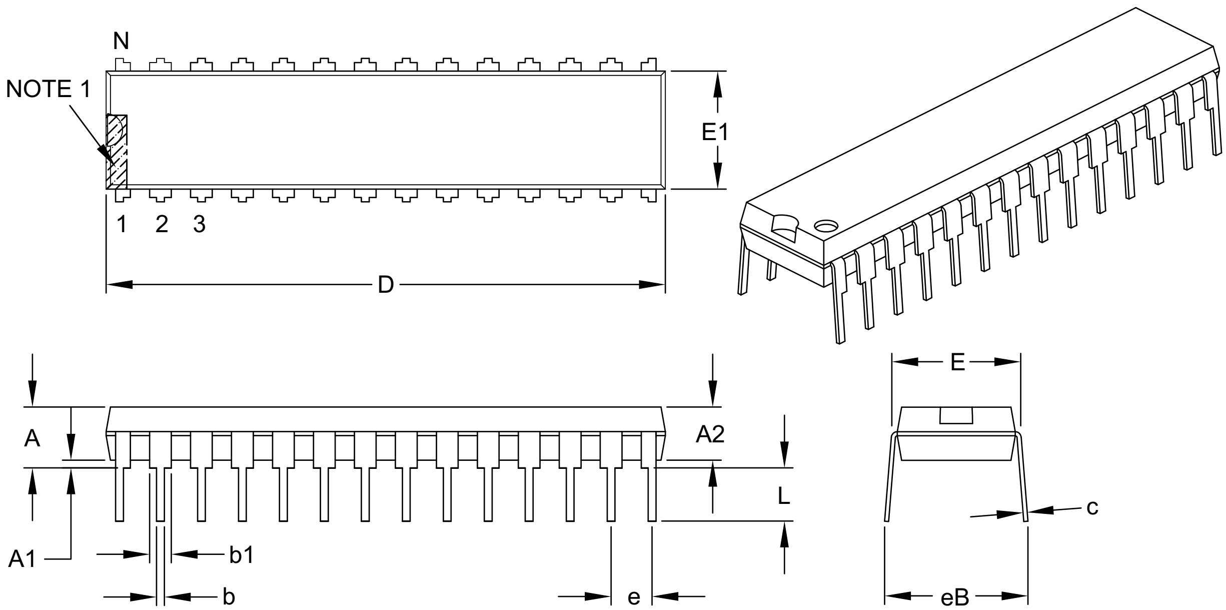


25.2 Package Details

The following sections give the technical details of the packages.

28-Lead Skinny Plastic Dual In-Line (SP) – 300 mil Body [SPDIP]

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		INCHES		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		28	
Pitch	e		.100 BSC	
Top to Seating Plane	A	–	–	.200
Molded Package Thickness	A2	.120	.135	.150
Base to Seating Plane	A1	.015	–	–
Shoulder to Shoulder Width	E	.290	.310	.335
Molded Package Width	E1	.240	.285	.295
Overall Length	D	1.345	1.365	1.400
Tip to Seating Plane	L	.110	.130	.150
Lead Thickness	c	.008	.010	.015
Upper Lead Width	b1	.040	.050	.070
Lower Lead Width	b	.014	.018	.022
Overall Row Spacing §	eB	–	–	.430

Notes:

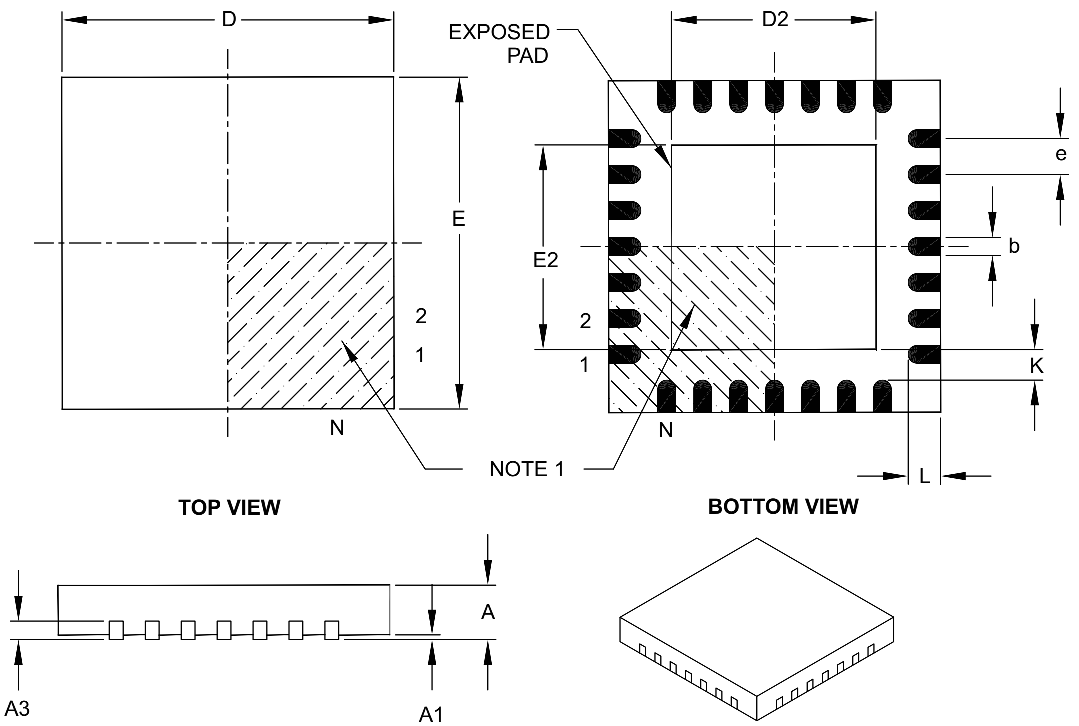
1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic.
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
4. Dimensioning and tolerancing per ASME Y14.5M.

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-070B

28-Lead Plastic Quad Flat, No Lead Package (ML) – 6x6 mm Body [QFN] with 0.55 mm Contact Length

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		28	
Pitch	e		0.65 BSC	
Overall Height	A	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Contact Thickness	A3		0.20 REF	
Overall Width	E		6.00 BSC	
Exposed Pad Width	E2	3.65	3.70	4.20
Overall Length	D		6.00 BSC	
Exposed Pad Length	D2	3.65	3.70	4.20
Contact Width	b	0.23	0.30	0.35
Contact Length	L	0.50	0.55	0.70
Contact-to-Exposed Pad	K	0.20	–	–

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated.
3. Dimensioning and tolerancing per ASME Y14.5M.

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-105B