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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	20MHz
Connectivity	-
Peripherals	Brown-out Detect/Reset, LVD, POR, WDT
Number of I/O	11
Program Memory Size	3.5KB (2K x 14)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	128 x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 3.6V
Data Converters	-
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	20-SSOP (0.209", 5.30mm Width)
Supplier Device Package	20-SSOP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16f639-i-ss

20-Pin Diagram

SSOP

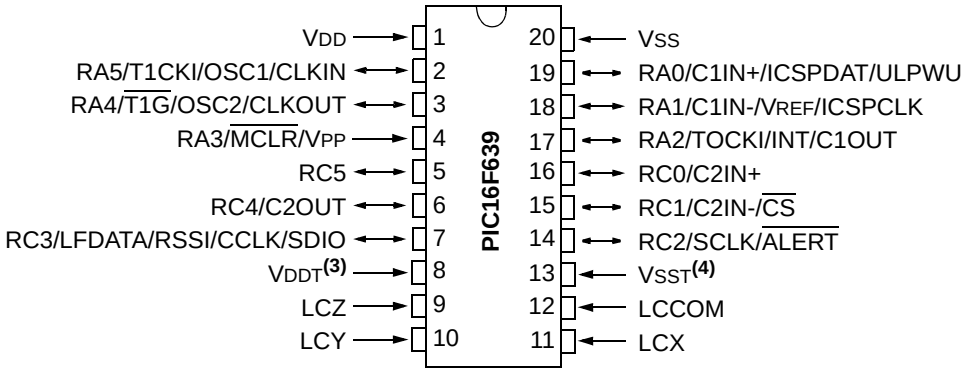


TABLE 4: 20-PIN SUMMARY

I/O	Pin	Analog Front-End	Comparators	Timer	Interrupts	Pull-ups	Basic
RA0	19	—	C1IN+	—	IOC	Y	ICSPDAT/ULPWU
RA1	18	—	C1IN-	—	IOC	Y	VREF/ICSPCLK
RA2	17	—	C1OUT	T0CKI	INT/IOC	Y	—
RA3(1)	4	—	—	—	IOC	Y(2)	MCLR/VPP
RA4	3	—	—	T1G	IOC	Y	OSC2/CLKOUT
RA5	2	—	—	T1CKI	IOC	Y	OSC1/CLKIN
RC0	16	—	C2IN+	—	—	—	—
RC1	15	—	C2IN-	—	—	—	CS
RC2	14	ALERT	—	—	—	—	SCLK
RC3	7	LFDATA/RSSI	—	—	—	—	CCLK/SDIO
RC4	6	—	C2OUT	—	—	—	—
RC5	5	—	—	—	—	—	—
—	8	—	—	—	—	—	VDDT(3)
—	13	—	—	—	—	—	VSST(4)
—	11	LCX	—	—	—	—	—
—	10	LCY	—	—	—	—	—
—	9	LCZ	—	—	—	—	—
—	12	LCCOM	—	—	—	—	—
—	1	—	—	—	—	—	VDD
—	20	—	—	—	—	—	VSS

Note 1: Input only.

2: Only when pin is configured for external MCLR.

3: VDDT is the supply voltage of the Analog Front-End section (PIC16F639 only). VDDT is treated as VDD in this document unless otherwise stated.

4: VSST is the ground reference voltage of the Analog Front-End section (PIC16F639 only). VSST is treated as VSS in this document unless otherwise stated.

TABLE 1-3: PIC16F639 PINOUT DESCRIPTIONS

Name	Function	Input Type	Output Type	Description
LCCOM	LCCOM	AN	—	Common reference for analog inputs.
LCX	LCX	AN	—	125 kHz analog X channel input.
LCY	LCY	AN	—	125 kHz analog Y channel input.
LCZ	LCZ	AN	—	125 kHz analog Z channel input.
RA0/C1IN+/ICSPDAT/ULPWU	RA0	TTL	—	General purpose I/O. Individually controlled interrupt-on-change. Individually enabled pull-up/pull-down. Selectable Ultra Low-Power Wake-up pin.
	C1IN+	AN	—	Comparator1 input – positive.
	ICSPDAT	TTL	CMOS	Serial Programming Data IO.
	ULPWU	AN	—	Ultra Low-Power Wake-up input.
RA1/C1IN-/VREF/ICSPCLK	RA1	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on-change. Individually enabled pull-up/pull-down.
	C1IN-	AN	—	Comparator1 input – negative.
	VREF	AN	—	External voltage reference
	ICSPCLK	ST	—	Serial Programming Clock.
RA2/T0CKI/INT/C1OUT	RA2	ST	CMOS	General purpose I/O. Individually controlled interrupt-on-change. Individually enabled pull-up/pull-down.
	T0CKI	ST	—	External clock for Timer0.
	INT	ST	—	External Interrupt.
	C1OUT	—	CMOS	Comparator1 output.
RA3/$\overline{\text{MCLR}}$/VPP	RA3	TTL	—	General purpose input. Individually controlled interrupt-on-change.
	$\overline{\text{MCLR}}$	ST	—	Master Clear Reset. Pull-up enabled when configured as $\overline{\text{MCLR}}$.
	VPP	HV	—	Programming voltage.
RA4/$\overline{\text{T1G}}$/OSC2/CLKOUT	RA4	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on-change. Individually enabled pull-up/pull-down.
	$\overline{\text{T1G}}$	ST	—	Timer1 gate.
	OSC2	—	XTAL	XTAL connection.
	CLKOUT	—	CMOS	TOSC reference clock.
RA5/T1CKI/OSC1/CLKIN	RA5	TTL	CMOS	General purpose I/O. Individually controlled interrupt-on-change. Individually enabled pull-up/pull-down.
	T1CKI	ST	—	Timer1 clock.
	OSC1	XTAL	—	XTAL connection.
	CLKIN	ST	—	TOSC/4 reference clock.
RC0/C2IN+	RC0	TTL	CMOS	General purpose I/O.
	C2IN+	AN	—	Comparator1 input – positive.
RC1/C2IN-/$\overline{\text{CS}}$	RC1	TTL	CMOS	General purpose I/O.
	C2IN-	AN	—	Comparator1 input – negative.
	$\overline{\text{CS}}$	TTL	—	Chip select input for SPI communication with internal pull-up resistor.
RC2/SCLK/$\overline{\text{ALERT}}$	RC2	TTL	CMOS	General purpose I/O.
	SCLK	TTL	—	Digital clock input for SPI communication.
	$\overline{\text{ALERT}}$	—	OD	Output with internal pull-up resistor for AFE error signal.

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

FIGURE 2-3: PIC12F635 SPECIAL FUNCTION REGISTERS

	File Address		File Address		File Address		File Address
Indirect addr.(1)	00h	Indirect addr.(1)	80h	Accesses 00h-0Bh	100h	Accesses 80h-8Bh	180h
TMR0	01h	OPTION_REG	81h		101h		181h
PCL	02h	PCL	82h		102h		182h
STATUS	03h	STATUS	83h		103h		183h
FSR	04h	FSR	84h		104h		184h
GPIO	05h	TRISIO	85h		105h		185h
	06h		86h		106h		186h
	07h		87h		107h		187h
	08h		88h		108h		188h
	09h		89h		109h		189h
PCLATH	0Ah	PCLATH	8Ah		10Ah		18Ah
INTCON	0Bh	INTCON	8Bh		10Bh		18Bh
PIR1	0Ch	PIE1	8Ch		10Ch		18Ch
	0Dh		8Dh		10Dh		18Dh
TMR1L	0Eh	PCON	8Eh		10Eh		18Eh
TMR1H	0Fh	OSCCON	8Fh		10Fh		18Fh
T1CON	10h	OSCTUNE	90h	CRCON	110h		190h
	11h		91h	CRDAT0(2)	111h		191h
	12h		92h	CRDAT1(2)	112h		192h
	13h		93h	CRDAT2(2)	113h		193h
	14h	LVDCON	94h	CRDAT3(2)	114h		194h
	15h	WPUDA	95h		115h		195h
	16h	IOCA	96h		116h		196h
	17h	WDA	97h		117h		197h
WDTCON	18h		98h		118h		198h
CMCON0	19h	VRCON	99h		119h		199h
CMCON1	1Ah	EEDAT	9Ah		11Ah		19Ah
	1Bh	EEADR	9Bh		11Bh		19Bh
	1Ch	EECON1	9Ch		11Ch		19Ch
	1Dh	EECON2(1)	9Dh		11Dh		19Dh
	1Eh		9Eh		11Eh		19Eh
	1Fh		9Fh		11Fh		19Fh
	20h – 3Fh		A0h – EFh		120h – 16Fh		1A0h – 1EFh
General Purpose Register 64 Bytes	40h – 7Fh	Accesses 70h-7Fh	F0h – FFh	Accesses 70h-7Fh	170h – 17Fh	Accesses Bank 0	1F0h – 1FFh
Bank 0		Bank 1		Bank 2		Bank 3	

Unimplemented data memory locations, read as '0'.

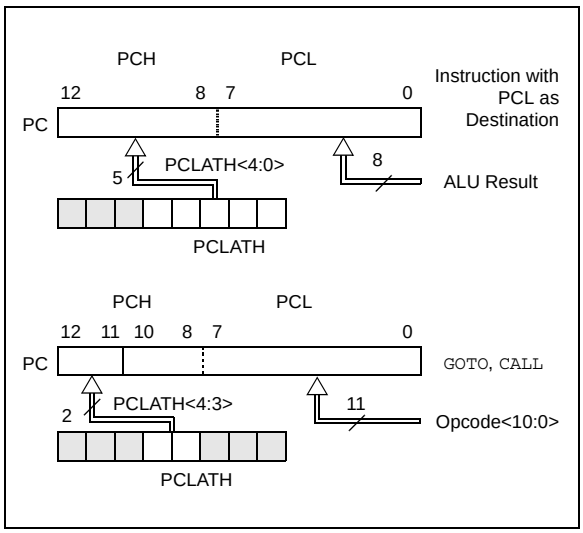
Note 1: Not a physical register.

2: CRDAT<3:0> registers are KEELOQ® hardware peripheral related registers and require the execution of the "KEELOQ® Encoder License Agreement" regarding implementation of the module and access to related registers. The "KEELOQ® Encoder License Agreement" may be accessed through the Microchip web site located at www.microchip.com/KEELOQ or by contacting your local Microchip Sales Representative.

2.3 PCL and PCLATH

The Program Counter (PC) is 13 bits wide. The low byte comes from the PCL register, which is a readable and writable register. The high byte (PC<12:8>) is not directly readable or writable and comes from PCLATH. On any Reset, the PC is cleared. Figure 2-5 shows the two situations for the loading of the PC. The upper example in Figure 2-5 shows how the PC is loaded on a write to PCL (PCLATH<4:0> → PCH). The lower example in Figure 2-5 shows how the PC is loaded during a CALL or GOTO instruction (PCLATH<4:3> → PCH).

FIGURE 2-5: LOADING OF PC IN DIFFERENT SITUATIONS



2.3.1 MODIFYING PCL

Executing any instruction with the PCL register as the destination simultaneously causes the Program Counter PC<12:8> bits (PCH) to be replaced by the contents of the PCLATH register. This allows the entire contents of the program counter to be changed by writing the desired upper 5 bits to the PCLATH register. When the lower 8 bits are written to the PCL register, all 13 bits of the program counter will change to the values contained in the PCLATH register and those being written to the PCL register.

A computed GOTO is accomplished by adding an offset to the program counter (ADDWF PCL). Care should be exercised when jumping into a look-up table or program branch table (computed GOTO) by modifying the PCL register. Assuming that PCLATH is set to the table start address, if the table length is greater than 255 instructions or if the lower 8 bits of the memory address rolls over from 0xFF to 0x00 in the middle of the table, then PCLATH must be incremented for each address rollover that occurs between the table beginning and the target location within the table.

For more information refer to Application Note AN556, "*Implementing a Table Read*" (DS00556).

2.3.2 STACK

The PIC12F635/PIC16F636/639 family has an 8-level x 13-bit wide hardware stack (see Figure 2-1). The stack space is not part of either program or data space and the Stack Pointer is not readable or writable. The PC is PUSHed onto the stack when a CALL instruction is executed or an interrupt causes a branch. The stack is POPed in the event of a RETURN, RETLW or a RETFIE instruction execution. PCLATH is not affected by a PUSH or POP operation.

The stack operates as a circular buffer. This means that after the stack has been PUSHed eight times, the ninth push overwrites the value that was stored from the first push. The tenth push overwrites the second push (and so on).

Note 1:	There are no Status bits to indicate stack overflow or stack underflow conditions.
2:	There are no instructions/mnemonics called PUSH or POP. These are actions that occur from the execution of the CALL, RETURN, RETLW and RETFIE instructions or the vectoring to an interrupt address.

2.4 Indirect Addressing, INDF and FSR Registers

The INDF register is not a physical register. Addressing the INDF register will cause indirect addressing.

Indirect addressing is possible by using the INDF register. Any instruction using the INDF register actually accesses data pointed to by the File Select Register (FSR). Reading INDF itself indirectly will produce 00h. Writing to the INDF register indirectly results in a no operation (although Status bits may be affected). An effective 9-bit address is obtained by concatenating the 8-bit FSR and the IRP bit of the STATUS register, as shown in Figure 2-6.

A simple program to clear RAM location 20h-2Fh using indirect addressing is shown in Example 2-1.

EXAMPLE 2-1: INDIRECT ADDRESSING

```
            MOVLW   0x20    ;initialize pointer
            MOVWF   FSR     ;to RAM
NEXT        CLRF    INDF    ;clear INDF register
            INCF    FSR     ;INC POINTER
            BTFSS   FSR,4   ;all done?
            GOTO    NEXT    ;no clear next
CONTINUE                    ;yes continue
```

REGISTER 5-1: OPTION_REG: OPTION REGISTER

R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
$\overline{\text{RAPU}}$	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0
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 **$\overline{\text{RAPU}}$:** PORTA Pull-up Enable bit
1 = PORTA pull-ups are disabled
0 = PORTA pull-ups are enabled by individual PORT 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 **T0CS:** TMR0 Clock Source Select bit
1 = Transition on T0CKI pin
0 = Internal instruction cycle clock (FOSC/4)

bit 4 **T0SE:** TMR0 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 assigned to the WDT
0 = Prescaler is assigned to the Timer0 module

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

BIT VALUE	TMR0 RATE	WDT RATE
000	1 : 2	1 : 1
001	1 : 4	1 : 2
010	1 : 8	1 : 4
011	1 : 16	1 : 8
100	1 : 32	1 : 16
101	1 : 64	1 : 32
110	1 : 128	1 : 64
111	1 : 256	1 : 128

Note 1: A dedicated 16-bit WDT postscaler is available. See **Section 12.11 "Watchdog Timer (WDT)"** for more information.

TABLE 5-1: SUMMARY OF REGISTERS ASSOCIATED WITH TIMER0

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
TMR0	Timer0 Module Register								xxxx xxxx	uuuu uuuu
INTCON	GIE	PEIE	T0IE	INTE	RAIE	T0IF	INTF	RAIF	0000 000x	0000 000x
OPTION_REG	$\overline{\text{RAPU}}$	INTEDG	T0CS	T0SE	PSA	PS2	PS1	PS0	1111 1111	1111 1111
TRISA	—	—	TRISA5	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	--11 1111	--11 1111

Legend: – = Unimplemented locations, read as '0', u = unchanged, x = unknown. Shaded cells are not used by the Timer0 module.

7.2 Analog Input Connection Considerations

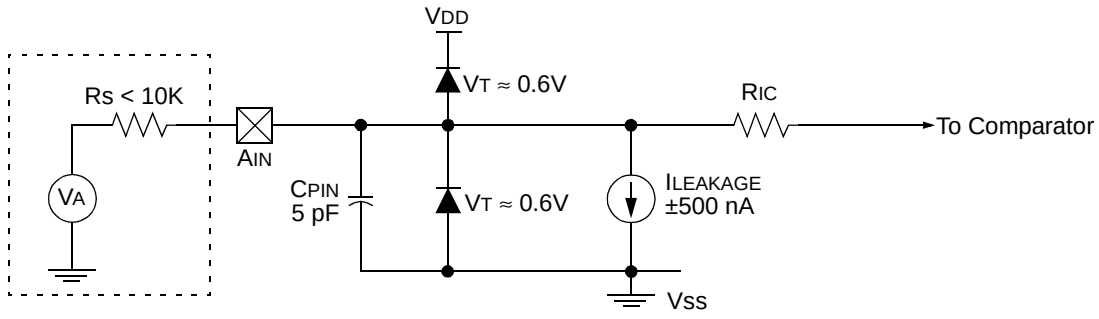
A simplified circuit for an analog input is shown in Figure 7-5. Since the analog input pins share their connection with a digital input, they have reverse biased ESD protection diodes to VDD and VSS. The analog input, therefore, must be between VSS and VDD. If the input voltage deviates from this range by more than 0.6V in either direction, one of the diodes is forward biased and a latch-up may occur.

A maximum source impedance of 10 kΩ is recommended for the analog sources. Also, any external component connected to an analog input pin, such as a capacitor or a Zener diode, should have very little leakage current to minimize inaccuracies introduced.

Note 1: When reading a PORT register, all pins configured as analog inputs will read as a '0'. Pins configured as digital inputs will convert as an analog input, according to the input specification.

2: Analog levels on any pin defined as a digital input, may cause the input buffer to consume more current than is specified.

FIGURE 7-5: ANALOG INPUT MODEL



Legend: CPIN = Input Capacitance
ILEAKAGE = Leakage Current at the pin due to various junctions
RIC = Interconnect Resistance
RS = Source Impedance
VA = Analog Voltage
VT = Threshold Voltage

7.5 Comparator Response Time

The comparator output is indeterminate for a period of time after the change of an input source or the selection of a new reference voltage. This period is referred to as the response time. The response time of the comparator differs from the settling time of the voltage reference. Therefore, both of these times must be considered when determining the total response time to a comparator input change. See the Comparator and Voltage Specifications in **Section 15.0 "Electrical Specifications"** for more details.

7.6 Comparator Interrupt Operation

The comparator interrupt flag is set whenever there is a change in the output value of the comparator. Changes are recognized by means of a mismatch circuit which consists of two latches and an exclusive-or gate (see Figures 7-8 and 7-9). One latch is updated with the comparator output level when the CMCON0 register is read. This latch retains the value until the next read of the CMCON0 register or the occurrence of a Reset. The other latch of the mismatch circuit is updated on every Q1 system clock. A mismatch condition will occur when a comparator output change is clocked through the second latch on the Q1 clock cycle. The mismatch condition will persist, holding the CxIF bit of the PIR1 register true, until either the CMCON0 register is read or the comparator output returns to the previous state.

Note:	A write operation to the CMCON0 register will also clear the mismatch condition because all writes include a read operation at the beginning of the write cycle.

Software will need to maintain information about the status of the comparator output to determine the actual change that has occurred.

The CxIF bit of the PIR1 register, is the comparator interrupt flag. This bit must be reset in software by clearing it to '0'. Since it is also possible to write a '1' to this register, a simulated interrupt may be initiated.

The CxIE bit of the PIE1 register and the PEIE and GIE bits of the INTCON register must all be set to enable comparator interrupts. If any of these bits are cleared, the interrupt is not enabled, although the CxIF bit of the PIR1 register will still be set if an interrupt condition occurs.

The user, in the Interrupt Service Routine, can clear the interrupt in the following manner:

a) Any read or write of CMCON0. This will end the mismatch condition. See Figures 7-8 and 7-9.
b) Clear the CxIF interrupt flag.

A persistent mismatch condition will preclude clearing the CxIF interrupt flag. Reading CMCON0 will end the mismatch condition and allow the CxIF bit to be cleared.

Note:	If a change in the CMCON0 register (CxOUT) should occur when a read operation is being executed (start of the Q2 cycle), then the CxIF interrupt flag may not get set.

REGISTER 7-2: CMCON0: COMPARATOR CONFIGURATION REGISTER (PIC16F636/639)

R-0	R-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
C2OUT	C1OUT	C2INV	C1INV	CIS	CM2	CM1	CM0
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 **C2OUT:** Comparator 2 Output bit

When C2INV = 0:
1 = C2 V_{IN}+ > C2 V_{IN}-
0 = C2 V_{IN}+ < C2 V_{IN}-

When C2INV = 1:
1 = C2 V_{IN}+ < C2 V_{IN}-
0 = C2 V_{IN}+ > C2 V_{IN}-

bit 6 **C1OUT:** Comparator 1 Output bit

When C1INV = 0:
1 = C1 V_{IN}+ > C1 V_{IN}-
0 = C1 V_{IN}+ < C1 V_{IN}-

When C1INV = 1:
1 = C1 V_{IN}+ < C1 V_{IN}-
0 = C1 V_{IN}+ > C1 V_{IN}-

bit 5 **C2INV:** Comparator 2 Output Inversion bit

1 = C2 output inverted
0 = C2 output not inverted

bit 4 **C1INV:** Comparator 1 Output Inversion bit

1 = C1 Output inverted
0 = C1 Output not inverted

bit 3 **CIS:** Comparator Input Switch bit

When CM<2:0> = 010:

1 = C1IN+ connects to C1 V_{IN}-
C2IN+ connects to C2 V_{IN}-
0 = C1IN- connects to C1 V_{IN}-
C2IN- connects to C2 V_{IN}-

When CM<2:0> = 001:
1 = C1IN+ connects to C1 V_{IN}-
0 = C1IN- connects to C1 V_{IN}-

bit 2-0 **CM<2:0>:** Comparator Mode bits (See Figure 7-5)

000 = Comparators off. CxIN pins are configured as analog
001 = Three inputs multiplexed to two comparators
010 = Four inputs multiplexed to two comparators
011 = Two common reference comparators
100 = Two independent comparators
101 = One independent comparator
110 = Two comparators with outputs and common reference
111 = Comparators off. CxIN pins are configured as digital I/O

TABLE 11-1: TYPICAL OUTPUT ENABLE FILTER TIMING

OEH <1:0>	OEL <1:0>	TOEH (ms)	TOEL (ms)	TOET (ms)
01	00	1	1	3
01	01	1	1	3
01	10	1	2	4
01	11	1	4	6
10	00	2	1	4
10	01	2	1	4
10	10	2	2	5
10	11	2	4	8
11	00	4	1	6
11	01	4	1	6
11	10	4	2	8
11	11	4	4	10
00	xx	Filter Disabled		

Note 1: Typical at room temperature and VDD = 3.0V, 32 kHz oscillator.

TOEH is measured from the rising edge of the demodulator output to the first falling edge. The pulse width must fall within TOEH ≤ *t* ≤ TOET.

TOEL is measured from the falling edge of the demodulator output to the rising edge of the next pulse. The pulse width must fall within TOEL ≤ *t* ≤ TOET.

TOET is measured from rising edge to the next rising edge (i.e., the sum of TOEH and TOEL). The pulse width must be *t* ≤ TOET. If the Configuration Register 0 (Register 11-1), OEL<8:7> is set to '00', then TOEH must not exceed TOET and TOEL must not exceed TINACT.

The filter will reset, requiring a complete new successive high and low period to enable LFDATA, under the following conditions.

- The received high is not greater than the configured minimum TOEH value.
- During TOEH, a loss of signal > 56 µs. A loss of signal < 56 µs may or may not cause a filter Reset.
- The received low is not greater than the configured minimum TOEL value.
- The received sequence exceeds the maximum TOET value:
  - TOEH + TOEL > TOET
  - or TOEH > TOET
  - or TOEL > TOET
- A Soft Reset SPI command is received.

If the filter resets due to a long high (TOEH > TOET), the high-pulse timer will not begin timing again until after a gap of TE and another low-to-high transition occurs on the demodulator output.

Disabling the output enable filter disables the TOEH and TOEL requirement and the AFE passes all received LF data. See Figure 11-10, Figure 11-11 and Figure 11-12 for examples.

When viewed from an application perspective, from the pin input, the actual output enable filter timing must factor in the analog delays in the input path (such as demodulator charge and discharge times).

- **TOEH** - TDR + TDF
- **TOEL** + TDR - TDF

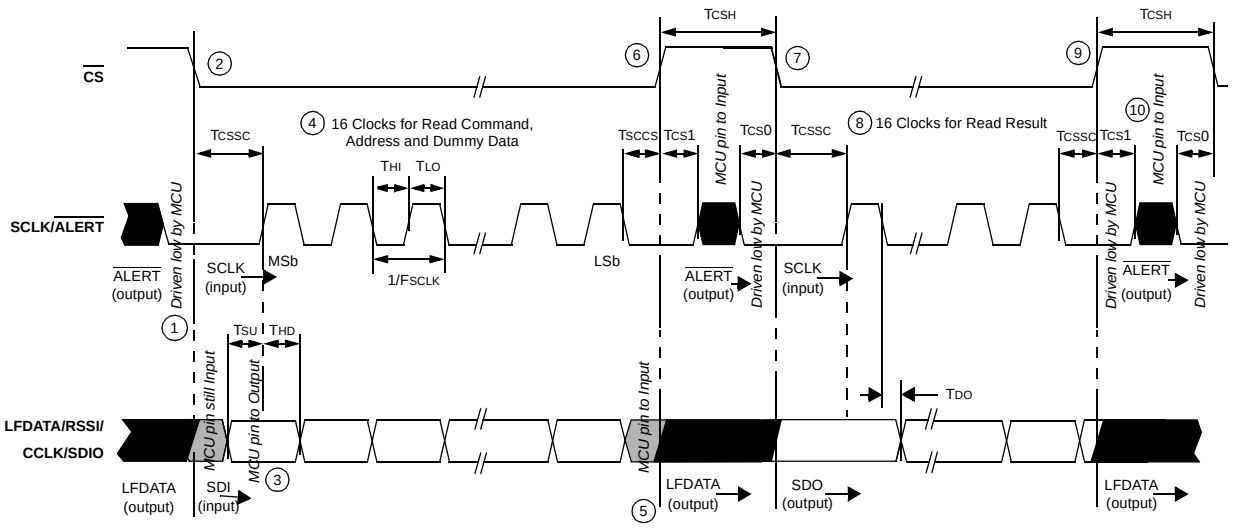
The output enable filter starts immediately after TGAP, the gap after AGC stabilization period.

11.16 Input Sensitivity Control

The AFE is designed to have typical input sensitivity of 3 mVPP. This means any input signal with amplitude greater than 3 mVPP can be detected. The AFE's internal AGC loop regulates the detecting signal amplitude when the input level is greater than approximately 20 mVPP. This signal amplitude is called "AGC-active level". The AGC loop regulates the input voltage so that the input signal amplitude range will be kept within the linear range of the detection circuits without saturation. The AGC Active Status bit AGCACT<5>, in the AFE Status Register 7 (Register 11-8) is set if the AGC loop regulates the input voltage.

Table 11-2 shows the input sensitivity comparison when the AGCSIG option is used. When AGCSIG option bit is set, the demodulated output is available only when the AGC loop is active (see Table 11-1). The AFE has also input sensitivity reduction options per each channel. The Configuration Register 3 (Register 11-4), Configuration Register 4 (Register 11-5) and Configuration Register 5 (Register 11-6) have the option to reduce the channel gains from 0 dB to approximately -30 dB.

FIGURE 11-18: SPI READ SEQUENCE



MCU SPI Read Details:

1. Drive the AFE's open collector $\overline{ALERT}$ output low.
   - To ensure no false clocks occur when $\overline{CS}$ drops.
2. Drop $\overline{CS}$
   - AFE SCLK/$\overline{ALERT}$ becomes SCLK input.
   - LFDATA/RSSI/CCLK/SDIO becomes SDI input.
3. Change LFDATA/RSSI/CCLK/SDIO connected pin to output.
   - Driving SPI data.
4. Clock in 16-bit SPI Read sequence.
   - Command, address and dummy data.
5. Change LFDATA/RSSI/CCLK/SDIO connected pin to input.
6. Raise $\overline{CS}$ to complete the SPI Read entry of command and address.
7. Drop $\overline{CS}$.
   - AFE SCLK/$\overline{ALERT}$ becomes SCLK input.
   - LFDATA/RSSI/CCLK/SDIO becomes SDO output.
8. Clock out 16-bit SPI Read result.
   - First seven bits clocked-out are dummy bits.
   - Next eight bits are the Configuration register data.
   - The last bit is the Configuration register row parity bit.
9. Raise $\overline{CS}$ to complete the SPI Read.
10. Change SCLK/$\overline{ALERT}$ back to input.

Note: The TCSH is considered as one clock. Therefore, the Configuration register data appears at 6th clock after TCSH.

REGISTER 11-2: CONFIGURATION REGISTER 1

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
DATOUT1	DATOUT0	LCXTUN5	LCXTUN4	LCXTUN3	LCXTUN2	LCXTUN1	LCXTUN0	R1PAR
bit 8								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 8-7 **DATOUT<1:0>:** LFDATA Output type bit
00 = Demodulated output
01 = Carrier Clock output
10 = RSSI output
11 = RSSI output

bit 6-1 **LCXTUN<5:0>:** LCX Tuning Capacitance bit
000000 = +0 pF (Default)
:
111111 = +63 pF

bit 0 **R1PAR**: Register Parity Bit – set/cleared so the 9-bit register contains odd parity – an odd number of set bits

REGISTER 11-3: CONFIGURATION REGISTER 2

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
RSSIFET	CLKDIV	LCYTUN5	LCYTUN4	LCYTUN3	LCYTUN2	LCYTUN1	LCYTUN0	R2PAR
bit 8								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 8 **RSSIFET**: Pull-down MOSFET on LFDATA pad bit (controllable by user in the RSSI mode only)
1 = Pull-down RSSI MOSFET on
0 = Pull-down RSSI MOSFET off

bit 7 **CLKDIV:** Carrier Clock Divide-by bit
1 = Carrier Clock/4
0 = Carrier Clock/1

bit 6-1 **LCYTUN<5:0>:** LCY Tuning Capacitance bit
000000 = +0 pF (Default)
:
111111 = +63 pF

bit 0 **R2PAR**: Register Parity Bit – set/cleared so the 9-bit register contains odd parity – an odd number of set bits

12.2 Reset

The PIC12F635/PIC16F636/639 differentiates between various kinds of Reset:

a) Power-on Reset (POR)
b) Wake-up Reset (WUR)
c) WDT Reset during normal operation
d) WDT Reset during Sleep
e) $\overline{\text{MCLR}}$ Reset during normal operation
f) $\overline{\text{MCLR}}$ Reset during Sleep
g) Brown-out Reset (BOR)

Some registers are not affected in any Reset condition; their status is unknown on POR and unchanged in any other Reset. Most other registers are reset to a "Reset state" on:

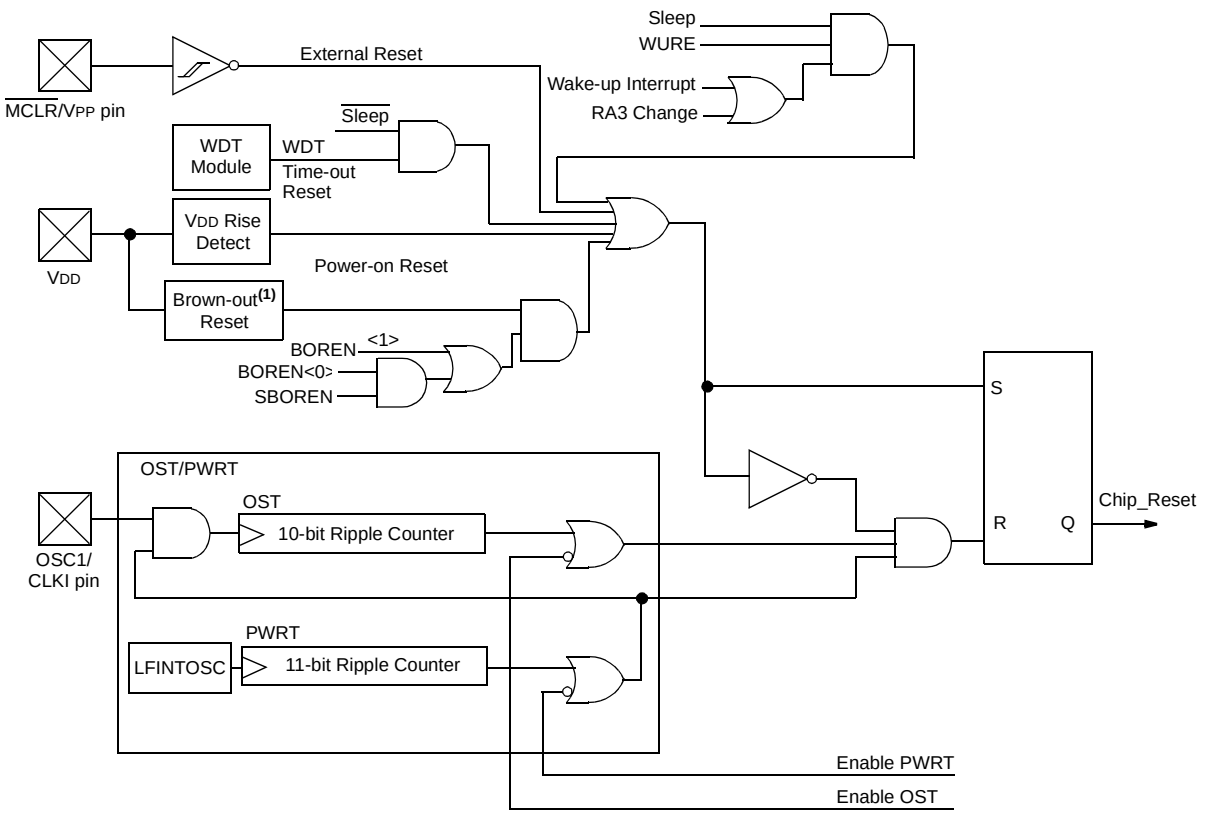
- Power-on Reset
- $\overline{\text{MCLR}}$ Reset
- $\overline{\text{MCLR}}$ Reset during Sleep
- WDT Reset
- Brown-out Reset

They are not affected by a WDT wake-up since this is viewed as the resumption of normal operation. $\overline{\text{TO}}$ and $\overline{\text{PD}}$ bits are set or cleared differently in different Reset situations, as indicated in Table 12-3. These bits are used in software to determine the nature of the Reset. See Table 12-4 for a full description of Reset states of all registers.

A simplified block diagram of the On-Chip Reset Circuit is shown in Figure 12-1.

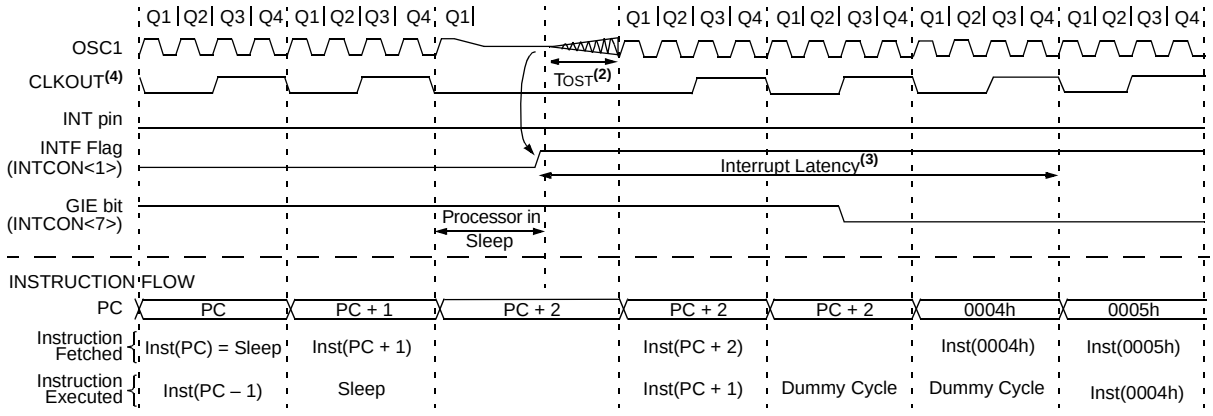
The $\overline{\text{MCLR}}$ Reset path has a noise filter to detect and ignore small pulses. See **Section 15.0 "Electrical Specifications"** for pulse width specifications.

FIGURE 12-1: SIMPLIFIED BLOCK DIAGRAM OF ON-CHIP RESET CIRCUIT



Note 1: Refer to the Configuration Word register (Register 12-1).

FIGURE 12-10: WAKE-UP FROM SLEEP THROUGH INTERRUPT



Note 1: XT, HS or LP Oscillator mode assumed.

2: TOST = 1024 TOSC (drawing not to scale). This delay does not apply to EC and RC Oscillator modes.

3: GIE = 1 assumed. In this case after wake-up, the processor jumps to 0004h. If GIE = 0, execution will continue in-line.

4: CLKOUT is not available in XT, HS, LP or EC Oscillator modes, but shown here for timing reference.

12.13 Code Protection

If the code protection bit(s) have not been programmed, the on-chip program memory can be read out using ICSP for verification purposes.

Note:	The entire data EEPROM and Flash program memory will be erased when the code protection is turned off. See the *"*PIC12F6XX/16F6XX *Memory Programming Specification"* (DS41204) for more information.

12.14 ID Locations

Four memory locations (2000h-2003h) are designated as ID locations where the user can store checksum or other code identification numbers. These locations are not accessible during normal execution but are readable and writable during Program/Verify mode. Only the Least Significant 7 bits of the ID locations are used.

14.7 MPLAB ICE 2000 High-Performance In-Circuit Emulator

The MPLAB ICE 2000 In-Circuit Emulator is intended to provide the product development engineer with a complete microcontroller design tool set for PIC microcontrollers. Software control of the MPLAB ICE 2000 In-Circuit Emulator is advanced by the MPLAB Integrated Development Environment, which allows editing, building, downloading and source debugging from a single environment.

The MPLAB ICE 2000 is a full-featured emulator system with enhanced trace, trigger and data monitoring features. Interchangeable processor modules allow the system to be easily reconfigured for emulation of different processors. The architecture of the MPLAB ICE 2000 In-Circuit Emulator allows expansion to support new PIC microcontrollers.

The MPLAB ICE 2000 In-Circuit Emulator system has been designed as a real-time emulation system with advanced features that are typically found on more expensive development tools. The PC platform and Microsoft® Windows® 32-bit operating system were chosen to best make these features available in a simple, unified application.

14.8 MPLAB REAL ICE In-Circuit Emulator System

MPLAB REAL ICE In-Circuit Emulator System is Microchip's next generation high-speed emulator for Microchip Flash DSC® and MCU devices. It debugs and programs PIC® and dsPIC® Flash microcontrollers with the easy-to-use, powerful graphical user interface of the MPLAB Integrated Development Environment (IDE), included with each kit.

The MPLAB REAL ICE probe is connected to the design engineer's PC using a high-speed USB 2.0 interface and is connected to the target with either a connector compatible with the popular MPLAB ICD 2 system (RJ11) or with the new high speed, noise tolerant, low-voltage differential signal (LVDS) interconnection (CAT5).

MPLAB REAL ICE is field upgradeable through future firmware downloads in MPLAB IDE. In upcoming releases of MPLAB IDE, new devices will be supported, and new features will be added, such as software breakpoints and assembly code trace. MPLAB REAL ICE offers significant advantages over competitive emulators including low-cost, full-speed emulation, real-time variable watches, trace analysis, complex breakpoints, a ruggedized probe interface and long (up to three meters) interconnection cables.

14.9 MPLAB ICD 2 In-Circuit Debugger

Microchip's In-Circuit Debugger, MPLAB ICD 2, is a powerful, low-cost, run-time development tool, connecting to the host PC via an RS-232 or high-speed USB interface. This tool is based on the Flash PIC MCUs and can be used to develop for these and other PIC MCUs and dsPIC DSCs. The MPLAB ICD 2 utilizes the in-circuit debugging capability built into the Flash devices. This feature, along with Microchip's In-Circuit Serial Programming™ (ICSP™) protocol, offers cost-effective, in-circuit Flash debugging from the graphical user interface of the MPLAB Integrated Development Environment. This enables a designer to develop and debug source code by setting breakpoints, single stepping and watching variables, and CPU status and peripheral registers. Running at full speed enables testing hardware and applications in real time. MPLAB ICD 2 also serves as a development programmer for selected PIC devices.

14.10 MPLAB PM3 Device Programmer

The MPLAB PM3 Device Programmer is a universal, CE compliant device programmer with programmable voltage verification at V_{DDMIN} and V_{DDMAX} for maximum reliability. It features a large LCD display (128 x 64) for menus and error messages and a modular, detachable socket assembly to support various package types. The ICSP™ cable assembly is included as a standard item. In Stand-Alone mode, the MPLAB PM3 Device Programmer can read, verify and program PIC devices without a PC connection. It can also set code protection in this mode. The MPLAB PM3 connects to the host PC via an RS-232 or USB cable. The MPLAB PM3 has high-speed communications and optimized algorithms for quick programming of large memory devices and incorporates an SD/MMC card for file storage and secure data applications.

15.3 DC Characteristics: PIC12F635/PIC16F636-E (Extended) (Continued)

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +125°C for extended					
Param No.	Sym	Device Characteristics	Min	Typ†	Max	Units	Conditions	
							VDD	Note
D020	IPD	**Power-down Base Current(4)**	—	0.15	1.2	µA	2.0	WDT, BOR, Comparators, VREF and T1OSC disabled
			—	0.20	1.5	µA	3.0	
			—	0.35	1.8	µA	5.0	
D021			—	1.0	17.5	µA	2.0	WDT Current(1)
			—	2.0	19	µA	3.0	
			—	3.0	22	µA	5.0	
D022A			—	42	60	µA	3.0	BOR Current(1)
			—	85	122	µA	5.0	
D022B			—	22	48	µA	2.0	PLVD Current
			—	25	55	µA	3.0	
			—	33	65	µA	5.0	
D023			—	32.3	45	µA	2.0	Comparator Current(1)
			—	60	78	µA	3.0	
			—	120	160	µA	5.0	
D024A			—	30	36	µA	2.0	CVREF Current(1) (high-range)
			—	45	55	µA	3.0	
			—	75	95	µA	5.0	
D024B			—	39	47	µA	2.0	CVREF Current(1) (low-range)
			—	59	72	µA	3.0	
			—	98	124	µA	5.0	
D025			—	4.5	25	µA	2.0	T1OSC Current(3)
			—	5.0	30	µA	3.0	
			—	6.0	40	µA	5.0	

† Data in "Typ" column is at 5.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

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; 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: The peripheral current is the sum of the base IDD or IPD and the additional current consumed when this peripheral is enabled. The peripheral Δ current can be determined by subtracting the base IDD or IPD current from this limit. Max values should be used when calculating total current consumption.

4: The power-down current in Sleep mode does not depend on the oscillator type. Power-down current is measured with the part in Sleep mode, with all I/O pins in high-impedance state and tied to VDD.

15.4 DC Characteristics: PIC12F635/PIC16F636-I (Industrial) PIC12F635/PIC16F636-E (Extended) (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**
	VOH	**Output High Voltage**					
D090		I/O ports	VDD – 0.7	—	—	V	IOH = -3.0 mA, VDD = 4.5V (Ind.)
D092		OSC2/CLKOUT (RC mode)	VDD – 0.7	—	—	V	IOH = -1.3 mA, VDD = 4.5V (Ind.) IOH = -1.0 mA, VDD = 4.5V (Ext.)
D100	IULP	**Ultra Low-power Wake-up Current**	—	200	—	nA	
		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	
		Data EEPROM Memory					
D120	ED	Byte Endurance	100K	1M	—	E/W	-40°C ≤ TA ≤ +85°C
D120A	ED	Byte Endurance	10K	100K	—	E/W	+85°C ≤ TA ≤ +125°C
D121	VDRW	VDD for Read/Write	VMIN	—	5.5	V	Using EECON1 to read/write VMIN = Minimum operating voltage
D122	TDEW	Erase/Write cycle time	—	5	6	ms	
D123	TRETD	Characteristic Retention	40	—	—	Year	Provided no other specifications are violated
D124	TREF	Number of Total Erase/Write Cycles before Refresh(4)	1M	10M	—	E/W	-40°C ≤ TA ≤ +85°C
		Program Flash Memory					
D130	EP	Cell Endurance	10K	100K	—	E/W	-40°C ≤ TA ≤ +85°C
D130A	ED	Cell Endurance	1K	10K	—	E/W	+85°C ≤ TA ≤ +125°C
D131	VPR	VDD for Read	VMIN	—	5.5	V	VMIN = Minimum operating voltage
D132	VPEW	VDD for Erase/Write	4.5	—	5.5	V	
D133	TPEW	Erase/Write cycle time	—	2	2.5	ms	
D134	TRETD	Characteristic Retention	40	—	—	Year	Provided no other specifications are violated

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5.0V, 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 $\overline{\text{MCLR}}$ 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: See **Section 9.4.1 "Using the Data EEPROM"** for additional information.

15.8 Thermal Considerations

Standard Operating Conditions (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +125°C						
Param No.	**Sym**	**Characteristic**		**Typ**	**Units**	**Conditions**
TH01	θJA	Thermal Resistance Junction to Ambient	PIC12F635	84.6	°C/W	8-pin PDIP package
				163.0	°C/W	8-pin SOIC package
				52.4	°C/W	8-pin DFN 4x4x0.9 mm package
				52.4	°C/W	8-pin DFN-S 6x5 mm package
			PIC16F636	69.8	°C/W	14-pin PDIP package
				85.0	°C/W	14-pin SOIC package
				100.4	°C/W	14-pin TSSOP package
				46.3	°C/W	16-pin QFN 4x0.9mm package
			PIC16F639	108.1	°C/W	20-pin SSOP package
TH02	θJC	Thermal Resistance Junction to Case	PIC12F635	41.2	°C/W	8-pin PDIP package
				38.8	°C/W	8-pin SOIC package
				3.0	°C/W	8-pin DFN 4x4x0.9 mm package
				3.0	°C/W	8-pin DFN-S 6x5 mm package
			PIC16F636	32.5	°C/W	14-pin PDIP package
				31.0	°C/W	14-pin SOIC package
				31.7	°C/W	14-pin TSSOP package
				2.6	°C/W	16-pin QFN 4x0.9mm package
			PIC16F639	32.2	°C/W	20-pin SSOP package
TH03	TJ	Junction Temperature		150	°C	For derated power calculations
TH04	PD	Power Dissipation		—	W	PD = PINTERNAL + PI/O
TH05	PINTERNAL	Internal Power Dissipation		—	W	PINTERNAL = IDD x VDD **(NOTE 1)**
TH06	PI/O	I/O Power Dissipation		—	W	PI/O = Σ (IOL * VOL) + Σ (IOH * (VDD - VOH))
TH07	PDER	Derated Power		—	W	PDER = (TJ - TA)/θJA **(NOTE 2, 3)**

Note 1: IDD is current to run the chip alone without driving any load on the output pins.

2: TA = Ambient Temperature.

3: Maximum allowable power dissipation is the lower value of either the absolute maximum total power dissipation or derated power (PDER).

FIGURE 16-18: MAXIMUM WDT I_{PD} vs. V_{DD} OVER TEMPERATURE

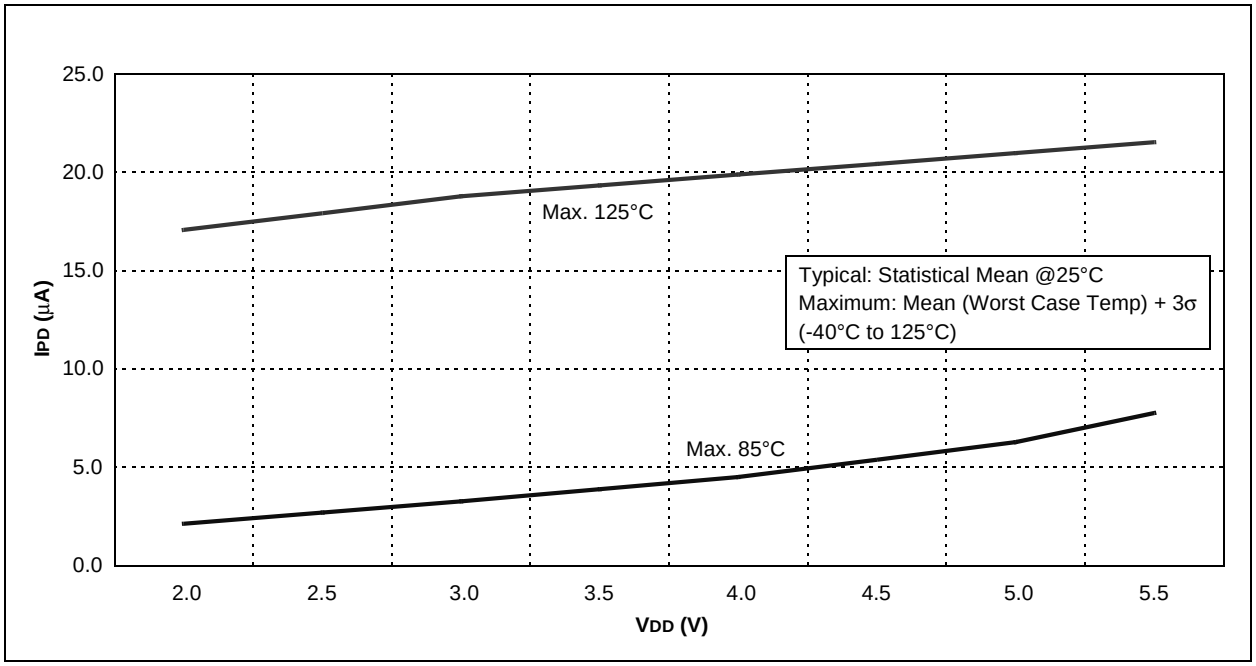


FIGURE 16-19: WDT PERIOD vs. V_{DD} OVER TEMPERATURE

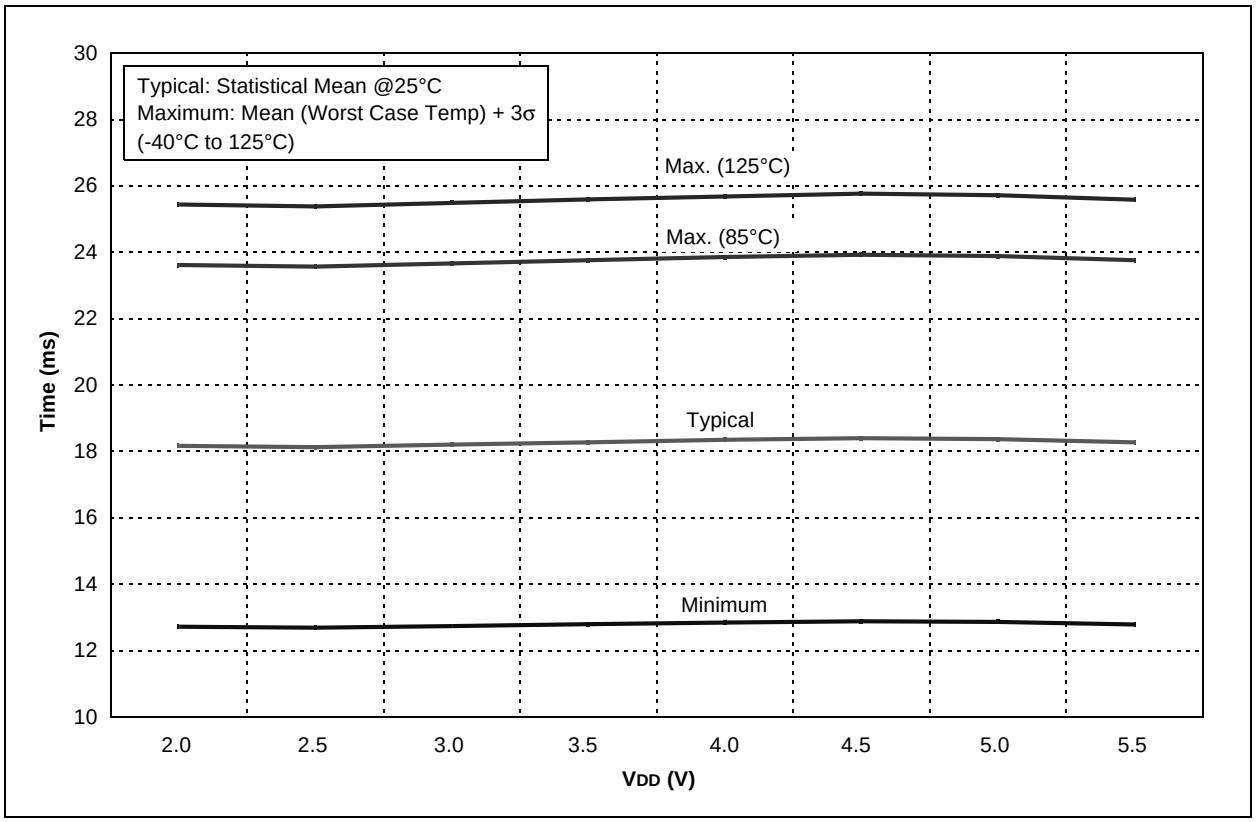


FIGURE 16-30: COMPARATOR RESPONSE TIME (RISING EDGE)

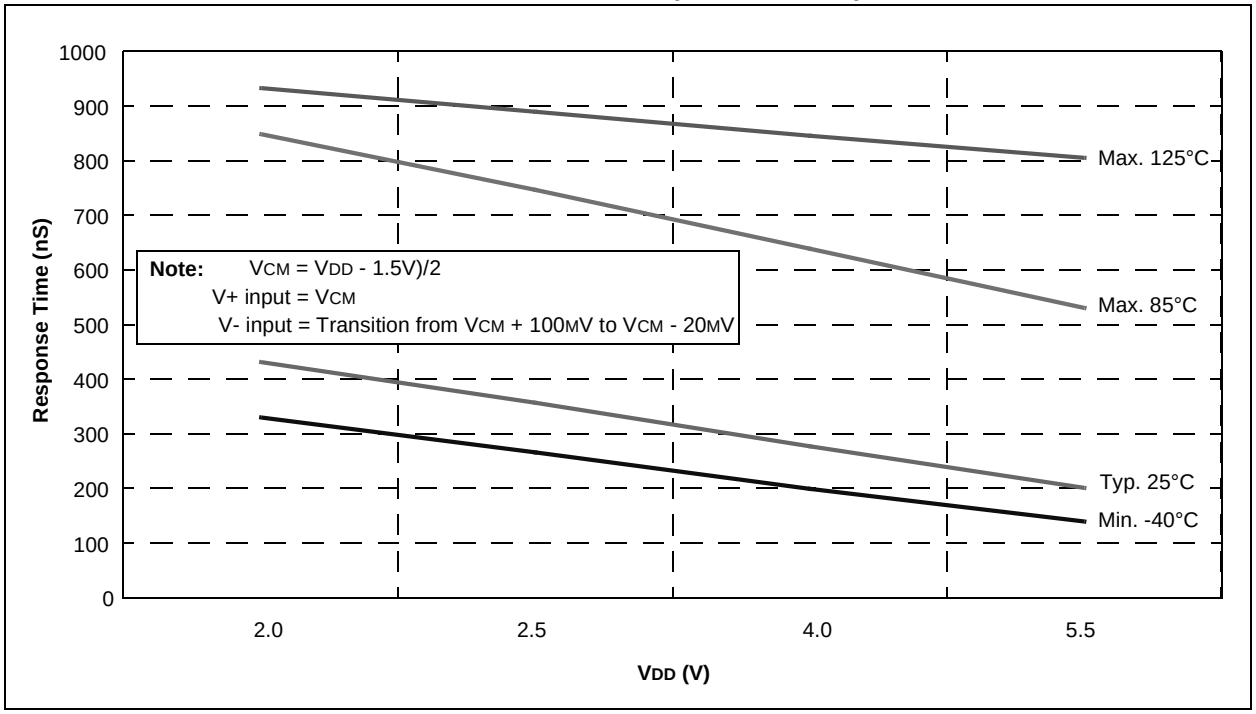


FIGURE 16-31: COMPARATOR RESPONSE TIME (FALLING EDGE)