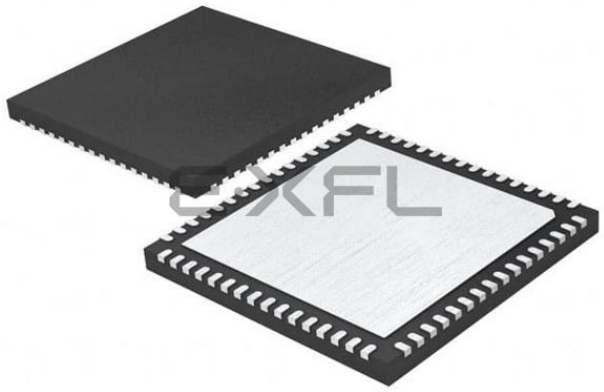

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What is "Embedded - Microcontrollers"?

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

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	64MHz
Connectivity	I²C, LINbus, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, LVD, POR, PWM, WDT
Number of I/O	53
Program Memory Size	64KB (32K x 16)
Program Memory Type	FLASH
EEPROM Size	1K x 8
RAM Size	4K x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 5.5V
Data Converters	A/D 16x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	64-VFQFN Exposed Pad
Supplier Device Package	64-VQFN (9x9)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic18f66k22-i-mrrsl

TABLE 1-1: DEVICE FEATURES FOR THE PIC18F6XK22 (64-PIN DEVICES)

Features	PIC18F65K22	PIC18F66K22	PIC18F67K22
Operating Frequency	DC – 64 MHz		
Program Memory (Bytes)	32K	64K	128K
Program Memory (Instructions)	16,384	32,768	65,536
Data Memory (Bytes)	2K	4K	4K
Interrupt Sources	42	48	
I/O Ports	Ports A, B, C, D, E, F, G		
Parallel Communications	Parallel Slave Port (PSP)		
Timers	8	11	
Comparators	3		
CTMU	Yes		
RTCC	Yes		
Capture/Compare/PWM (CCP) Modules	5	7	7
Enhanced CCP (ECCP) Modules	3		
Serial Communications	Two MSSPs and two Enhanced USARTs (EUSART)		
12-Bit Analog-to-Digital Module	16 Input Channels		
Resets (and Delays)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow, $\overline{\text{MCLR}}$, WDT (PWRT, OST)		
Instruction Set	75 Instructions, 83 with Extended Instruction Set Enabled		
Packages	64-Pin QFN, 64-Pin TQFP		

TABLE 1-2: DEVICE FEATURES FOR THE PIC18F8XK22 (80-PIN DEVICES)

Features	PIC18F85K22	PIC18F86K22	PIC18F87K22
Operating Frequency	DC – 64 MHz		
Program Memory (Bytes)	32K	64K	128K
	(Up to 2 Mbytes with Extended Memory)		
Program Memory (Instructions)	16,384	32,768	65,536
Data Memory (Bytes)	2K	4K	4K
Interrupt Sources	42	48	
I/O Ports	Ports A, B, C, D, E, F, G, H, J		
Parallel Communications	Parallel Slave Port (PSP)		
Timers	8	11	
Comparators	3		
CTMU	Yes		
RTCC	Yes		
Capture/Compare/PWM (CCP) Modules	5	7	7
Enhanced CCP (ECCP) Modules	3		
Serial Communications	Two MSSPs and 2 Enhanced USARTs (EUSART)		
12-Bit Analog-to-Digital Module	24 Input Channels		
Resets (and Delays)	POR, BOR, RESET Instruction, Stack Full, Stack Underflow, $\overline{\text{MCLR}}$, WDT (PWRT, OST)		
Instruction Set	75 Instructions, 83 with Extended Instruction Set Enabled		
Packages	80-Pin TQFP		

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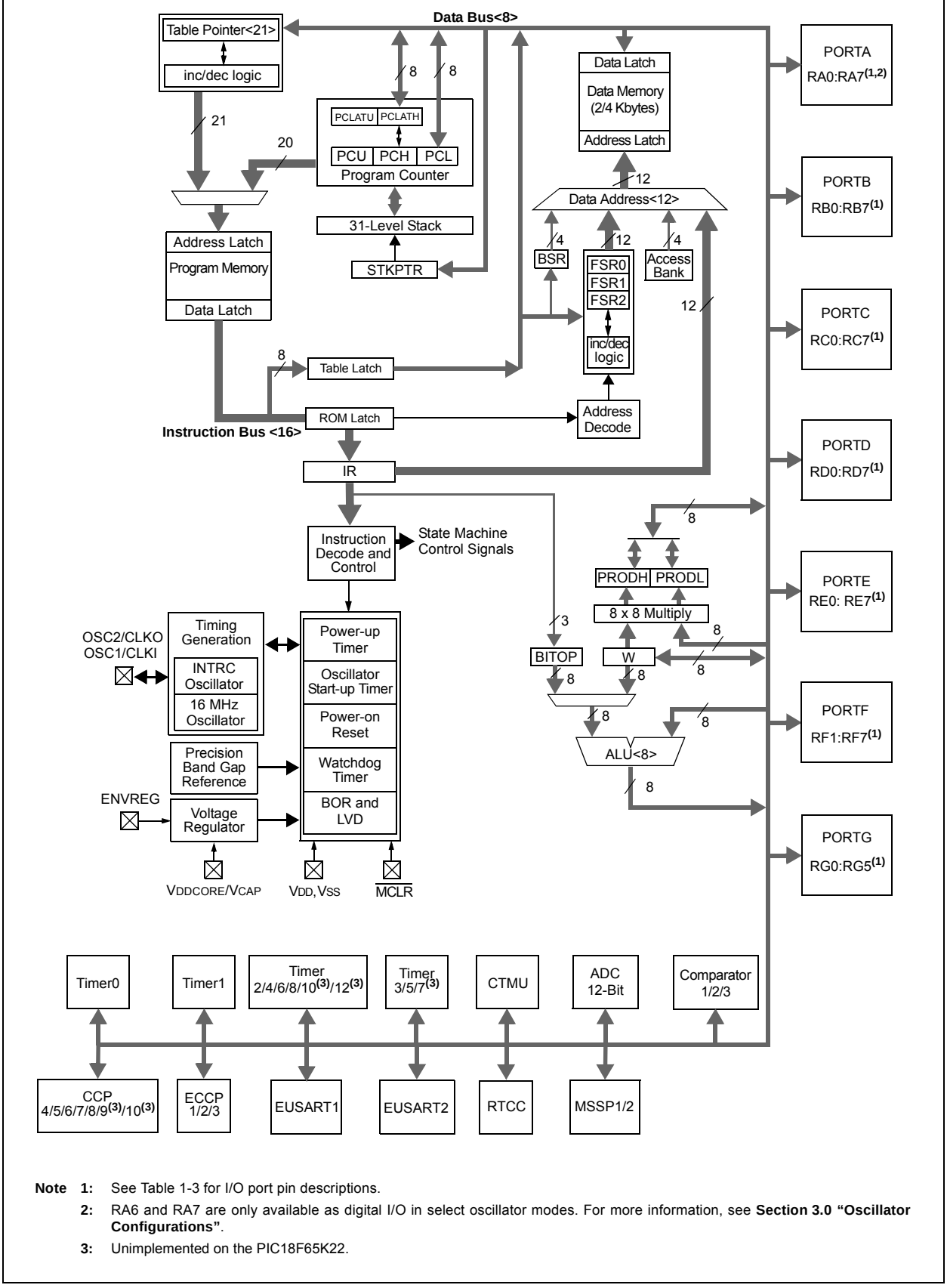
FIGURE 1-1: PIC18F6XK22 (64-PIN) BLOCK DIAGRAM



Note 1: See Table 1-3 for I/O port pin descriptions.

2: RA6 and RA7 are only available as digital I/O in select oscillator modes. For more information, see **Section 3.0 "Oscillator Configurations"**.

3: Unimplemented on the PIC18F65K22.

TABLE 1-4: PIC18F8XK22 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number	Pin Type	Buffer Type	Description
	TQFP			
				PORTJ is a bidirectional I/O port.
RJ0/ALE	62			
RJ0		I/O	ST	Digital I/O.
ALE		O	—	External memory address latch enable.
RJ1/$\overline{OE}$	61			
RJ1		I/O	ST	Digital I/O.
$\overline{OE}$		O	—	External memory output enable.
RJ2/$\overline{WRL}$	60			
RJ2		I/O	ST	Digital I/O.
$\overline{WRL}$		O	—	External memory write low control.
RJ3/$\overline{WRH}$	59			
RJ3		I/O	ST	Digital I/O.
$\overline{WRH}$		O	—	External memory high control.
RJ4/BA0	39			
RJ4		I/O	ST	Digital I/O.
BA0		O	—	External Memory Byte Address 0 control
RJ5/$\overline{CE}$	40			
RJ5		I/O	ST	Digital I/O
$\overline{CE}$		O	—	External memory chip enable control.
RJ6/$\overline{LB}$	41			
RJ6		I/O	ST	Digital I/O.
$\overline{LB}$		O	—	External memory low byte control.
RJ7/$\overline{UB}$	42			
RJ7		I/O	ST	Digital I/O.
$\overline{UB}$		O	—	External memory high byte control.
VSS	11, 31, 51, 70	P	—	Ground reference for logic and I/O pins.
VDD	32, 48, 71	P	—	Positive supply for logic and I/O pins.
AVSS	26	P	—	Ground reference for analog modules.
AVDD	25	P	—	Positive supply for analog modules.
ENVREG	24	I	ST	Enable for on-chip voltage regulator.
VDDCORE/VCAP	12			Core logic power or external filter capacitor connection.
VDDCORE				
VCAP		P	—	External filter capacitor connection (regulator enabled/disabled).

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; Analog = Analog input; I = Input; O = Output; P = Power; OD = Open-Drain (no P diode to VDD); I^2C = I^2C™/SMBus

Note 1: Default assignment for ECCP2 when the CCP2MX Configuration bit is set.

2: Alternate assignment for ECCP2 when the CCP2MX Configuration bit is cleared.

3: Not available on PIC18F65K22 and PIC18F85K22 devices.

4: PSP is available only in Microcontroller mode.

5: The CC6, CCP7, CCP8 and CCP9 pin placement depends on the setting of the ECCPMX Configuration bit (CONFIG3H<1>).

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2.4.1 CONSIDERATIONS FOR CERAMIC CAPACITORS

In recent years, large value, low-voltage, surface-mount ceramic capacitors have become very cost effective in sizes up to a few tens of microfarad. The low-ESR, small physical size and other properties make ceramic capacitors very attractive in many types of applications.

Ceramic capacitors are suitable for use with the internal voltage regulator of this microcontroller. However, some care is needed in selecting the capacitor to ensure that it maintains sufficient capacitance over the intended operating range of the application.

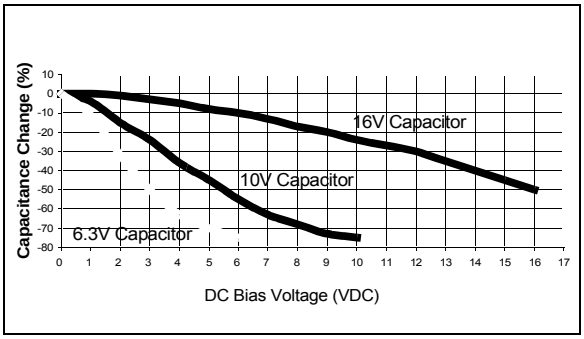
Typical low-cost, 10 μF ceramic capacitors are available in X5R, X7R and Y5V dielectric ratings (other types are also available, but are less common). The initial tolerance specifications for these types of capacitors are often specified as ±10% to ±20% (X5R and X7R), or -20%/+80% (Y5V). However, the effective capacitance that these capacitors provide in an application circuit will also vary based on additional factors, such as the applied DC bias voltage and the temperature. The total in-circuit tolerance is, therefore, much wider than the initial tolerance specification.

The X5R and X7R capacitors typically exhibit satisfactory temperature stability (ex: ±15% over a wide temperature range, but consult the manufacturer's data sheets for exact specifications). However, Y5V capacitors typically have extreme temperature tolerance specifications of +22%/-82%. Due to the extreme temperature tolerance, a 10 μF nominal rated Y5V type capacitor may not deliver enough total capacitance to meet minimum internal voltage regulator stability and transient response requirements. Therefore, Y5V capacitors are not recommended for use with the internal regulator if the application must operate over a wide temperature range.

In addition to temperature tolerance, the effective capacitance of large value ceramic capacitors can vary substantially, based on the amount of DC voltage applied to the capacitor. This effect can be very significant, but is often overlooked or is not always documented.

A typical DC bias voltage vs. capacitance graph for X7R type and Y5V type capacitors is shown in Figure 2-4.

FIGURE 2-4: DC BIAS VOLTAGE vs. CAPACITANCE CHARACTERISTICS



When selecting a ceramic capacitor to be used with the internal voltage regulator, it is suggested to select a high-voltage rating, so that the operating voltage is a small percentage of the maximum rated capacitor voltage. For example, choose a ceramic capacitor rated at 16V for the 2.5V core voltage. Suggested capacitors are shown in Table 2-1.

2.5 ICSP Pins

The PGC and PGD pins are used for In-Circuit Serial Programming™ (ICSP™) and debugging purposes. It is recommended to keep the trace length between the ICSP connector and the ICSP pins on the device as short as possible. If the ICSP connector is expected to experience an ESD event, a series resistor is recommended, with the value in the range of a few tens of ohms, not to exceed 100Ω.

Pull-up resistors, series diodes and capacitors on the PGC and PGD pins are not recommended as they will interfere with the programmer/debugger communications to the device. If such discrete components are an application requirement, they should be removed from the circuit during programming and debugging. Alternatively, refer to the AC/DC characteristics and timing requirements information in the respective device Flash programming specification for information on capacitive loading limits, and pin input voltage high (V_{IH}) and input low (V_{IL}) requirements.

For device emulation, ensure that the "Communication Channel Select" (i.e., PGCx/PGDx pins), programmed into the device, matches the physical connections for the ICSP to the Microchip debugger/emulator tool.

For more information on available Microchip development tools connection requirements, refer to **Section 30.0 "Development Support"**.

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NOTES:

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REGISTER 5-1: RCON: RESET CONTROL REGISTER

R/W-0	R/W-1	R/W-1	R/W-1	R-1	R-1	R/W-0	R/W-0
IPEN	SBOREN	$\overline{CM}$	$\overline{RI}$	$\overline{TO}$	$\overline{PD}$	$\overline{POR}$	$\overline{BOR}$
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 **IPEN:** Interrupt Priority Enable bit
1 = Enable priority levels on interrupts
0 = Disable priority levels on interrupts (PIC16CXXX Compatibility mode)

bit 6 **SBOREN:** BOR Software Enable bit
If BOREN<1:0> = 01:
1 = BOR is enabled
0 = BOR is disabled
If BOREN<1:0> = 00, 10 or 11:
Bit is disabled and read as '0'.

bit 5 **$\overline{CM}$:** Configuration Mismatch Flag bit
1 = A Configuration Mismatch Reset has not occurred
0 = A Configuration Mismatch Reset has occurred (must be set in software after a Configuration Mismatch Reset occurs)

bit 4 **$\overline{RI}$:** RESET Instruction Flag bit
1 = The RESET instruction was not executed (set by firmware only)
0 = The RESET instruction was executed causing a device Reset (must be set in software after a Brown-out Reset occurs)

bit 3 **$\overline{TO}$:** Watchdog Time-out Flag bit
1 = Set by power-up, CLRWDT instruction or SLEEP instruction
0 = A WDT time-out occurred

bit 2 **$\overline{PD}$:** Power-Down Detection Flag bit
1 = Set by power-up or by the CLRWDT instruction
0 = Set by execution of the SLEEP instruction

bit 1 **$\overline{POR}$:** Power-on Reset Status bit
1 = A Power-on Reset has not occurred (set by firmware only)
0 = A Power-on Reset occurred (must be set in software after a Power-on Reset occurs)

bit 0 **$\overline{BOR}$:** Brown-out Reset Status bit
1 = A Brown-out Reset has not occurred (set by firmware only)
0 = A Brown-out Reset occurred (must be set in software after a Brown-out Reset occurs)

Note 1: It is recommended that the $\overline{POR}$ bit be set after a Power-on Reset has been detected, so that subsequent Power-on Resets may be detected.

2: Brown-out Reset is said to have occurred when $\overline{BOR}$ is '0' and $\overline{POR}$ is '1' (assuming that $\overline{POR}$ was set to '1' by software immediately after a Power-on Reset).

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TABLE 6-1: SPECIAL FUNCTION REGISTER MAP FOR PIC18F87K22 FAMILY (CONTINUED)

Addr.	Name	Addr.	Name	Addr.	Name	Addr.	Name
F3Fh	TMR7H(3)	F32h	TMR12(3)	F25h	ANCON0	F18h	PMD1
F3Eh	TMR7L(3)	F31h	PR12(3)	F24h	ANCON1	F17h	PMD2
F3Dh	T7CON(3)	F30h	T12CON(3)	F23h	ANCON2	F16h	PMD3
F3Ch	T7GCON(3)	F2Fh	CM2CON	F22h	RCSTA2		
F3Bh	TMR6	F2Eh	CM3CON	F21h	TXSTA2		
F3Ah	PR6	F2Dh	CCPTMRS0	F20h	BAUDCON2		
F39H	T6CON	F2Ch	CCPTMRS1	F1Fh	SPBRGH2		
F38h	TMR8	F2Bh	CCPTMRS2	F1Eh	SPBRG2		
F37h	PR8	F2Ah	REFOCON	F1Dh	RCREG2		
F36h	T8CON	F29H	ODCON1	F1Ch	TXREG2		
F35h	TMR10(3)	F28h	ODCON2	F1Bh	PSTR2CON		
F34h	PR10(3)	F27h	ODCON3	F1Ah	PSTR3CON		
F33h	T10CON(3)	F26h	MEMCON(3)	F19h	PMD0		

Note 1: This is not a physical register.
2: Unimplemented on 64-pin devices (PIC18F6XK22), read as '0'.
3: This register is not available on devices with a program memory of 32 Kbytes (PIC18FX5K22).
4: Addresses, F16h through F5Fh, are also used by SFRs, but are not part of the Access RAM. To access these registers, users must always load the proper BSR value.

TABLE 6-2: PIC18F87K22 FAMILY REGISTER FILE SUMMARY

Address	File Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on POR, BOR
FFFh	TOSU	—	—	—	Top-of-Stack Upper Byte (TOS<20:16>)					---0 0000
FFEh	TOSH	Top-of-Stack High Byte (TOS<15:8>)								0000 0000
FFDh	TOSL	Top-of-Stack Low Byte (TOS<7:0>)								0000 0000
FFCh	STKPTR	STKFUL	STKUNF	—	Return Stack Pointer					uu-0 0000
FFBh	PCLATU	—	—	—	Holding Register for PC<20:16>					---0 0000
FFAh	PCLATH	Holding Register for PC<15:8>								0000 0000
FF9h	PCL	PC Low Byte (PC<7:0>)								0000 0000
FF8h	TBLPTRU	—	—	bit 21	Program Memory Table Pointer Upper Byte (TBLPTR<20:16>)					--00 0000
FF7h	TBLPTRH	Program Memory Table Pointer High Byte (TBLPTR<15:8>)								0000 0000
FF6h	TBLPTRL	Program Memory Table Pointer Low Byte (TBLPTR<7:0>)								0000 0000
FF5h	TABLAT	Program Memory Table Latch								0000 0000
FF4h	PRODH	Product Register High Byte								xxxx xxxx
FF3h	PRODL	Product Register Low Byte								xxxx xxxx
FF2h	INTCON	GIE/GIEH	PEIE/GIEL	TMR0IE	INT0IE	RBIE	TMR0IF	INT0IF	RBIF	0000 000x
FF1h	INTCON2	$\overline{\text{RBPU}}$	INTEDG0	INTEDG1	INTEDG2	INTEDG3	TMR0IP	INT3IP	RBIP	1111 1111
FF0h	INTCON3	INT2IP	INT1IP	INT3IE	INT2IE	INT1IE	INT3IF	INT2IF	INT1IF	1100 0000
FEFh	INDF0	Uses contents of FSR0 to address data memory – value of FSR0 not changed (not a physical register)								---- ----
FEEh	POSTINC0	Uses contents of FSR0 to address data memory – value of FSR0 post-incremented (not a physical register)								---- ----
FEDh	POSTDEC0	Uses contents of FSR0 to address data memory – value of FSR0 post-decremented (not a physical register)								---- ----
FECh	PREINC0	Uses contents of FSR0 to address data memory – value of FSR0 pre-incremented (not a physical register)								---- ----
FEBh	PLUSW0	Uses contents of FSR0 to address data memory – value of FSR0 pre-incremented (not a physical register) – value of FSR0 offset by W								---- ----
FEAh	FSR0H	—	—	—	—	Indirect Data Memory Address Pointer 0 High				---- 0000
FE9h	FSR0L	Indirect Data Memory Address Pointer 0 Low Byte								xxxx xxxx
FE8h	WREG	Working Register								xxxx xxxx
FE7h	INDF1	Uses contents of FSR1 to address data memory – value of FSR1 not changed (not a physical register)								---- ----

Note 1: This bit is available when Master Clear is disabled (MCLRE = 0). When MCLRE is set, the bit is unimplemented.
2: Unimplemented on 64-pin devices (PIC18F6XK22), read as '0'.
3: Unimplemented on devices with a program memory of 32 Kbytes (PIC18FX5K22).

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NOTES:

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REGISTER 11-8: PIR5: PERIPHERAL INTERRUPT REQUEST (FLAG) REGISTER 5

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
TMR7GIF(1)	TMR12IF(1)	TMR10IF(1)	TMR8IF	TMR7IF(1)	TMR6IF	TMR5IF	TMR4IF
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 **TMR7GIF:** TMR7 Gate Interrupt Flag bits(1)
1 = TMR gate interrupt occurred (bit must be cleared in software)
0 = No TMR gate interrupt occurred

bit 6 **TMR12IF:** TMR12 to PR12 Match Interrupt Flag bit(1)
1 = TMR12 to PR12 match occurred (must be cleared in software)
0 = No TMR12 to PR12 match occurred

bit 5 **TMR10IF:** TMR10 to PR10 Match Interrupt Flag bit(1)
1 = TMR10 to PR10 match occurred (must be cleared in software)
0 = No TMR10 to PR10 match occurred

bit 4 **TMR8IF:** TMR8 to PR8 Match Interrupt Flag bit
1 = TMR8 to PR8 match occurred (must be cleared in software)
0 = No TMR8 to PR8 match occurred

bit 3 **TMR7IF:** TMR7 Overflow Interrupt Flag bit(1)
1 = TMR7 register overflowed (must be cleared in software)
0 = TMR7 register did not overflow

bit 2 **TMR6IF:** TMR6 to PR6 Match Interrupt Flag bit
1 = TMR6 to PR6 match occurred (must be cleared in software)
0 = No TMR6 to PR6 match occurred

bit 1 **TMR5IF:** TMR5 Overflow Interrupt Flag bit
1 = TMR5 register overflowed (must be cleared in software)
0 = TMR5 register did not overflow

bit 0 **TMR4IF:** TMR4 to PR4 Match Interrupt Flag bit
1 = TMR4 to PR4 match occurred (must be cleared in software)
0 = No TMR4 to PR4 match occurred

Note 1: Unimplemented on devices with a program memory of 32 Kbytes (PIC18FX5K22).

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TABLE 12-15: PORTH FUNCTIONS (CONTINUED)

Pin Name	Function	TRIS Setting	I/O	I/O Type	Description
RH4/CCP9/ P3C/AN12/ C2INC	RH4	0	O	DIG	LATH<4> data output.
		1	I	ST	PORTH<4> data input.
	CCP9	0	O	DIG	CCP9 compare/PWM output; takes priority over port data.
		1	I	ST	CCP9 capture input.
	P3C	0	O	—	ECCP3 PWM Output C. May be configured for tri-state during Enhanced PWM.
	AN12	1	I	ANA	A/D Input Channel 12. Default input configuration on POR; does not affect digital input.
	C2INC	x	I	ANA	Comparator 2 Input C.
RH5/CCP8/ P3B/AN13/ C2IND	RH5	0	O	DIG	LATH<5> data output.
		1	I	ST	PORTH<5> data input.
	CCP8	0	O	DIG	CCP8 compare/PWM output; takes priority over port data.
		1	I	ST	CCP8 capture input.
	P3B	0	O	—	ECCP3 PWM Output B. May be configured for tri-state during Enhanced PWM.
	AN13	1	I	ANA	A/D Input Channel 13. Default input configuration on POR; does not affect digital input.
	C2IND	x	I	ANA	Comparator 2 Input D.
RH6/CCP7/ P1C/AN14/ C1INC	RH6	0	O	DIG	LATH<6> data output.
		1	I	ST	PORTH<6> data input.
	CCP7	0	O	DIG	CCP7 compare/PWM output; takes priority over port data.
		1	I	ST	CCP7 capture input.
	P1C	0	O	—	ECCP1 PWM Output C. May be configured for tri-state during Enhanced PWM.
	AN14	1	I	ANA	A/D Input Channel 14. Default input configuration on POR; does not affect digital input.
	C1INC	x	I	ANA	Comparator 1 Input C.
RH7/CCP6/ P1B/AN15	RH7	0	O	DIG	LATH<7> data output.
		1	I	ST	PORTH<7> data input.
	CCP6	0	O	DIG	CCP6 compare/PWM output; takes priority over port data.
		1	I	ST	CCP6 capture input.
	P1B	0	O	—	ECCP1 PWM Output B. May be configured for tri-state during Enhanced PWM.
	AN15	1	I	ANA	A/D Input Channel 15. Default input configuration on POR; does not affect digital input.

Legend: O = Output, I = Input, ANA = Analog Signal, DIG = Digital Output, ST = Schmitt Trigger Buffer Input,
x = Don't care (TRIS bit does not affect port direction or is overridden for this option).

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16.0 TIMER3/5/7 MODULES

The Timer3/5/7 timer/counter modules incorporate these features:

- Software-selectable operation as a 16-bit timer or counter
- Readable and writable eight-bit registers (TMRxH and TMRxL)
- Selectable clock source (internal or external) with device clock or SOSC oscillator internal options
- Interrupt-on-overflow
- Module Reset on ECCP Special Event Trigger

Timer7 is unimplemented for devices with a program memory of 32 Kbytes (PIC18FX5K22).

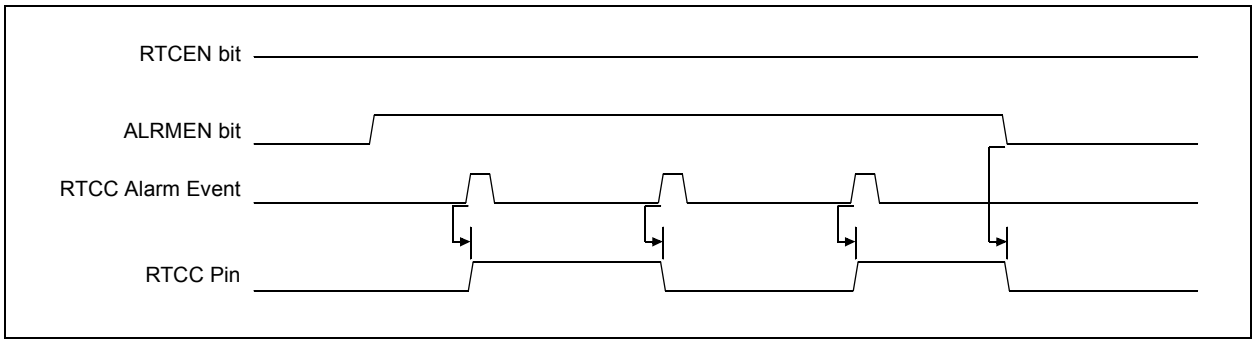
Note: Throughout this section, generic references are used for register and bit names that are the same – except for an 'x' variable that indicates the item's association with the Timer3, Timer5 or Timer7 module. For example, the control register is named TxCON and refers to T3CON, T5CON and T7CON.

A simplified block diagram of the Timer3/5/7 module is shown in Figure 16-1.

The Timer3/5/7 module is controlled through the TxCON register (Register 16-1). It also selects the clock source options for the ECCP modules. (For more information, see **Section 20.1.1 "ECCP Module and Timer Resources"**.)

The FOSC clock source should not be used with the ECCP capture/compare features. If the timer will be used with the capture or compare features, always select one of the other timer clocking options.

FIGURE 18-6: TIMER PULSE GENERATION



18.4 Sleep Mode

The timer and alarm continue to operate while in Sleep mode. The operation of the alarm is not affected by Sleep, as an alarm event can always wake up the CPU.

The Idle mode does not affect the operation of the timer or alarm.

18.5 Reset

18.5.1 DEVICE RESET

When a device Reset occurs, the ALRMRPT register is forced to its Reset state, causing the alarm to be disabled (if enabled prior to the Reset). If the RTCC was enabled, it will continue to operate when a basic device Reset occurs.

18.5.2 POWER-ON RESET (POR)

The RTCCFG and ALRMRPT registers are reset only on a POR. Once the device exits the POR state, the clock registers should be reloaded with the desired values.

The timer prescaler values can be reset only by writing to the SECONDS register. No device Reset can affect the prescalers.

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20.0 ENHANCED CAPTURE/COMPARE/PWM (ECCP) MODULE

PIC18F87K22 family devices have three Enhanced Capture/Compare/PWM (ECCP) modules: ECCP1, ECCP2 and ECCP3. These modules contain a 16-bit register, which can operate as a 16-bit Capture register, a 16-bit Compare register or a PWM Master/Slave Duty Cycle register. These ECCP modules are upward compatible with CCP.

Note:	Throughout this section, generic references are used for register and bit names that are the same, except for an 'x' variable that indicates the item's association with the ECCP1, ECCP2 or ECCP3 module. For example, the control register is named CCPxCON and refers to CCP1CON, CCP2CON and CCP3CON.

ECCP1, ECCP2 and ECCP3 are implemented as standard CCP modules with Enhanced PWM capabilities. These include:

- Provision for two or four output channels
- Output Steering modes
- Programmable polarity
- Programmable dead-band control
- Automatic shutdown and restart

The enhanced features are discussed in detail in **Section 20.4 "PWM (Enhanced Mode)"**.

The ECCP1, ECCP2 and ECCP3 modules use the control registers: CCP1CON, CCP2CON and CCP3CON. The control registers, CCP4CON through CCP10CON, are for the modules, CCP4 through CCP10.

20.4 PWM (Enhanced Mode)

The Enhanced PWM mode can generate a PWM signal on up to four different output pins with up to 10 bits of resolution. It can do this through four different PWM Output modes:

- Single PWM
- Half-Bridge PWM
- Full-Bridge PWM, Forward mode
- Full-Bridge PWM, Reverse mode

To select an Enhanced PWM mode, the PxM bits of the CCPxCON register must be set appropriately.

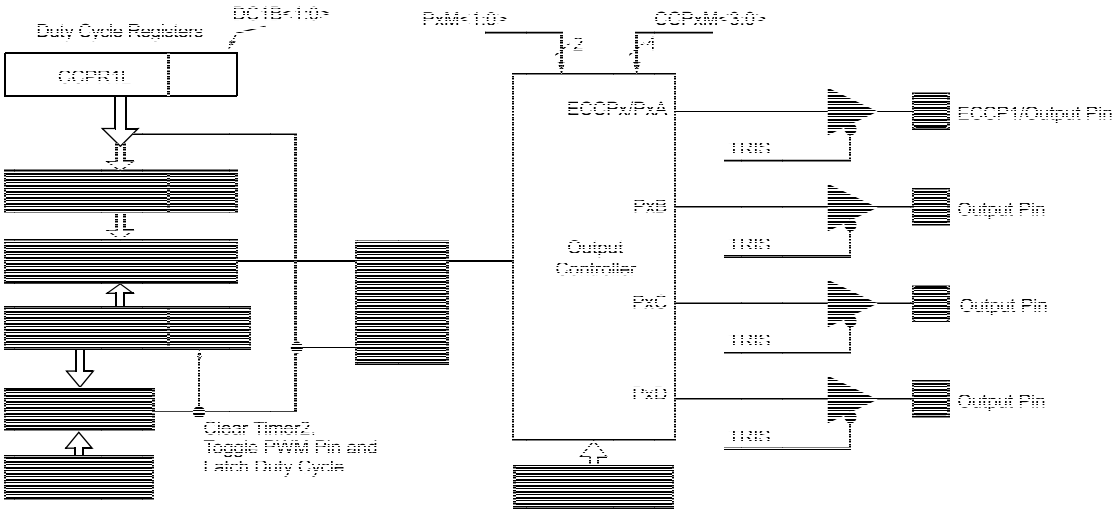
The PWM outputs are multiplexed with I/O pins and are designated: PxA, PxB, PxC and PxD. The polarity of the PWM pins is configurable and is selected by setting the CCPxM bits in the CCPxCON register appropriately.

Table 20-1 provides the pin assignments for each Enhanced PWM mode.

Figure 20-3 provides an example of a simplified block diagram of the Enhanced PWM module.

Note:	To prevent the generation of an incomplete waveform when the PWM is first enabled, the ECCP module waits until the start of a new PWM period before generating a PWM signal.

FIGURE 20-3: EXAMPLE SIMPLIFIED BLOCK DIAGRAM OF THE ENHANCED PWM MODE

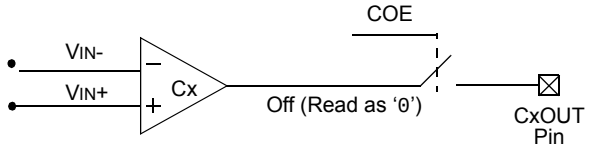


Note 1: The 8-bit TMR2 register is concatenated with the 2-bit internal Q clock, or 2 bits of the prescaler to create the 10-bit time base.

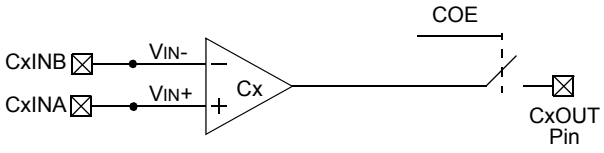
Note 1:	The TRIS register value for each PWM output must be configured appropriately.
2:	Any pin not used by an Enhanced PWM mode is available for alternate pin functions.

FIGURE 24-4: COMPARATOR CONFIGURATIONS

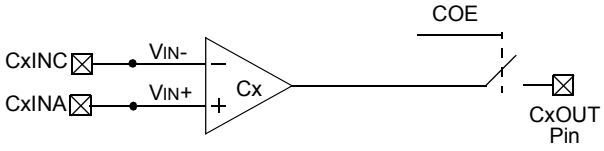
Comparator Off
CON = 0, CREF = x, CCH<1:0> = xx



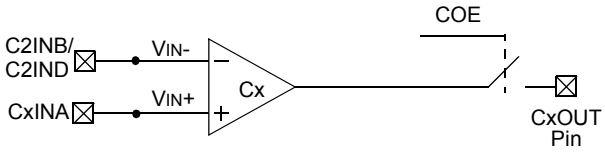
Comparator CxINB > CxINA Compare
CON = 1, CREF = 0, CCH<1:0> = 00



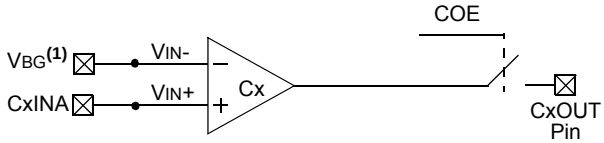
Comparator CxINC > CxINA Compare(2,3)
CON = 1, CREF = 0, CCH<1:0> = 01



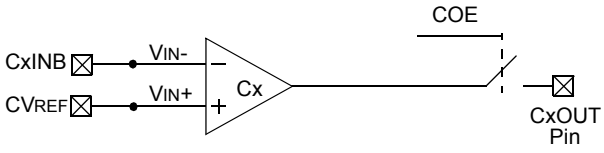
Comparator CxIND > CxINA Compare(3)
CON = 1, CREF = 0, CCH<1:0> = 10



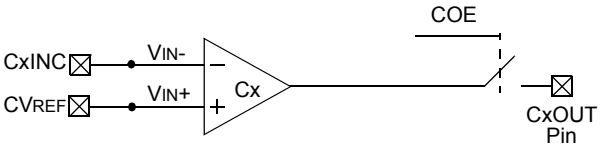
Comparator VIRV > CxINA Compare
CON = 1, CREF = 0, CCH<1:0> = 11



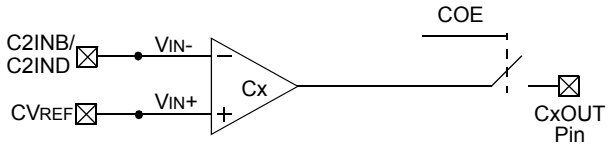
Comparator CxINB > CVREF Compare
CON = 1, CREF = 1, CCH<1:0> = 00



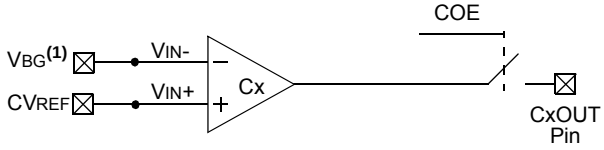
Comparator CxINC > CVREF Compare(2,3)
CON = 1, CREF = 1, CCH<1:0> = 01



Comparator CxIND > CVREF Compare(3)
CON = 1, CREF = 1, CCH<1:0> = 10



Comparator VIRV > CVREF Compare
CON = 1, CREF = 1, CCH<1:0> = 11



Note 1: VBG is the Internal Reference Voltage (1.024V nominal).
2: Configuration is unavailable for CM1CON on 64-pin devices (PIC18F6XK22).
3: Configuration is unavailable for CM2CON on 64-pin devices (PIC18F6XK22).

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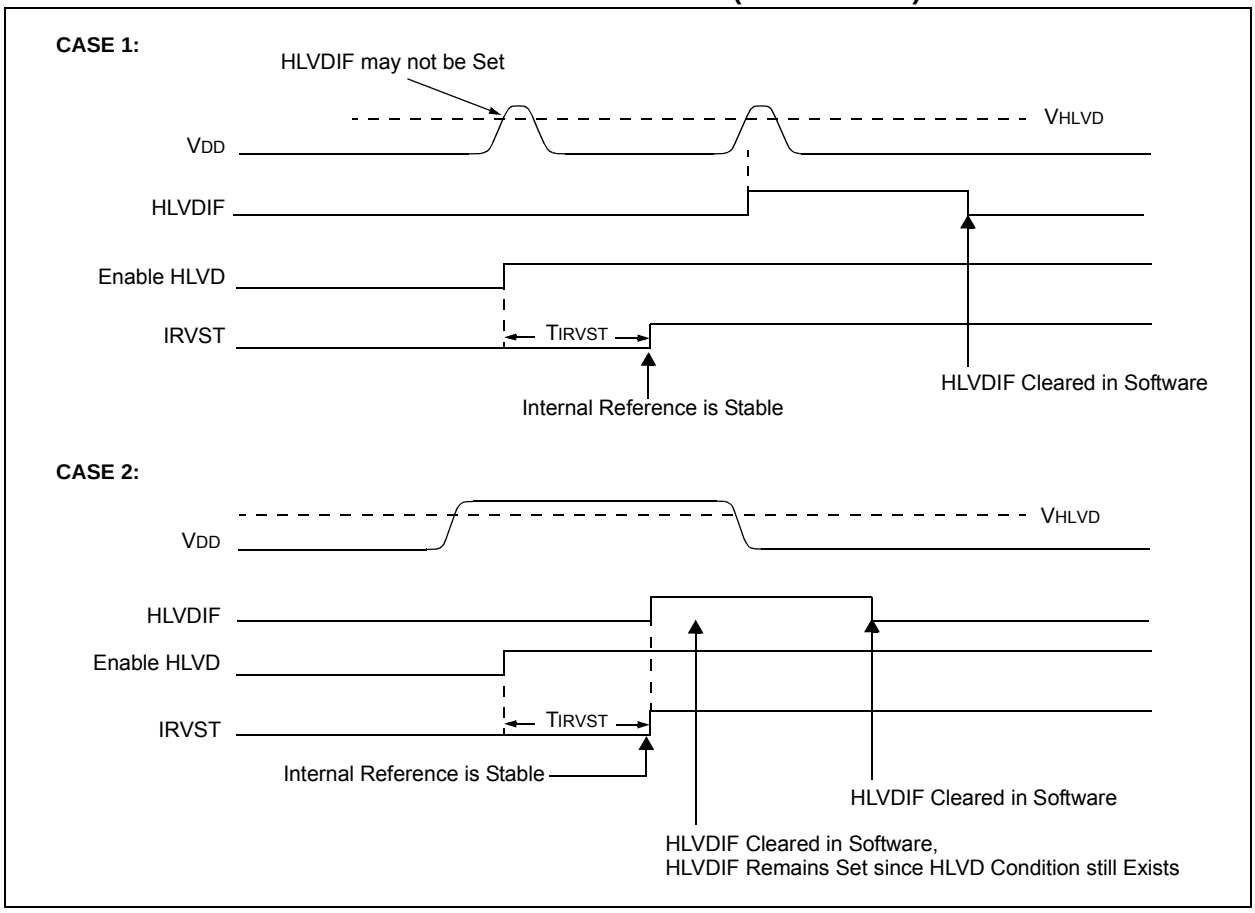
FIGURE 26-3: HIGH-VOLTAGE DETECT OPERATION (VDIRMAG = 1)

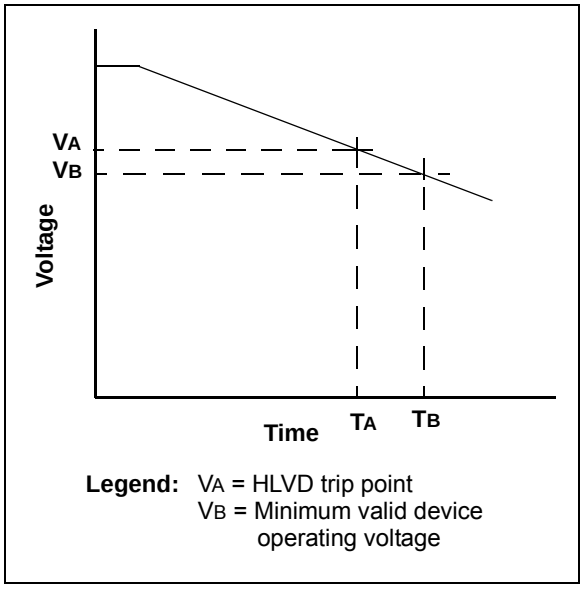


26.5 Applications

In many applications, it is desirable to detect a drop below, or rise above, a particular voltage threshold. For example, the HLVD module could be periodically enabled to detect Universal Serial Bus (USB) attach or detach. This assumes the device is powered by a lower voltage source than the USB when detached. An attach would indicate a High-Voltage Detect from, for example, 3.3V to 5V (the voltage on USB) and vice versa for a detach. This feature could save a design a few extra components and an attach signal (input pin).

For general battery applications, Figure 26-4 shows a possible voltage curve. Over time, the device voltage decreases. When the device voltage reaches voltage, VA, the HLVD logic generates an interrupt at time, TA. The interrupt could cause the execution of an Interrupt Service Routine (ISR), which would allow the application to perform “housekeeping tasks” and a controlled shutdown before the device voltage exits the valid operating range at TB. This would give the application a time window, represented by the difference between TA and TB, to safely exit.

FIGURE 26-4: TYPICAL LOW-VOLTAGE DETECT APPLICATION



REGISTER 28-2: CONFIG1H: CONFIGURATION REGISTER 1 HIGH (BYTE ADDRESS 300001h)

R/P-0	R/P-0	U-0	U-0	R/P-1	R/P-0	R/P-0	R/P-0
IESO	FCMEN	—	PLLCFG(1)	FOSC3(2)	FOSC2(2)	FOSC1(2)	FOSC0(2)
bit 7							bit 0

Legend:	P = Programmable bit		
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 **IESO:** Internal/External Oscillator Switchover bit
1 = Two-Speed Start-up is enabled
0 = Two-Speed Start-up is disabled

bit 6 **FCMEN:** Fail-Safe Clock Monitor Enable bit
1 = Fail-Safe Clock Monitor is enabled
0 = Fail-Safe Clock Monitor is disabled

bit 5 **Unimplemented:** Read as '0'

bit 4 **PLLCFG:** 4x PLL Enable bit(1)
1 = Oscillator is multiplied by 4
0 = Oscillator is used directly

bit 3-0 **FOSC<3:0>:** Oscillator Selection bits(2)
1101 = EC1, EC oscillator **(low power, DC-160 kHz)**
1100 = EC1IO, EC oscillator with CLKOUT function on RA6 **(low power, DC-160 kHz)**
1011 = EC2, EC oscillator **(medium power, 160 kHz-16 MHz)**
1010 = EC2IO, EC oscillator with CLKOUT function on RA6 **(medium power, DC-160 kHz-16 MHz)**
1001 = INTIO1, internal RC oscillator with CLKOUT function on RA6
1000 = INTIO2, internal RC oscillator
0111 = RC, external RC oscillator
0110 = RCIO, external RC oscillator with CKLOUT function on RA6
0101 = EC3, EC oscillator **(high power, 4 MHz-64 MHz)**
0100 = EC3IO, EC oscillator with CLKOUT function on RA6 **(high power, 4 MHz-64 MHz)**
0011 = HS1, HS oscillator **(medium power, 4 MHz-16 MHz)**
0010 = HS2, HS oscillator **(high power, 16 MHz-25 MHz)**
0001 = XT oscillator
0000 = LP oscillator

Note 1: Not valid for the INTIOx PLL mode.
2: INTIO + PLL can be enabled only by the PLLEN bit (OSCTUNE<6>). Other PLL modes can be enabled by either the PLLEN bit or the PLLCFG (CONFIG1H<4>) bit.

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31.2 DC Characteristics: Power-Down and Supply Current PIC18F87K22 Family (Industrial/Extended) (Continued)

PIC18F87K22 Family (Industrial/Extended)		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**	**Typ**	**Max**	**Units**	**Conditions**		
	Supply Current (IDD) Cont.(2,3)						
	All devices	130	390	µA	-40°C	VDD = 1.8V(4) Regulator Disabled	FOSC = 1 MHz (**PRI_RUN** mode, EC oscillator)
		130	390	µA	+25°C		
		130	390	µA	+85°C		
		250	500	µA	+125ºC		
	All devices	270	790	µA	-40°C	VDD = 3.3V(4) Regulator Disabled	
		270	790	µA	+25°C		
		270	790	µA	+85°C		
		400	900	µA	+125ºC		
	All devices	430	990	µA	-40°C	VDD = 5V(5) Regulator Enabled	
		450	980	µA	+25°C		
		460	980	µA	+85°C		
		600	1300	µA	+125ºC		
	All devices	430	860	µA	-40°C	VDD = 1.8V(4) Regulator Disabled	FOSC = 4 MHz (**PRI_RUN** mode, EC oscillator)
		530	900	µA	+25°C		
		490	880	µA	+85°C		
		750	1600	µA	+125ºC		
	All devices	850	1750	µA	-40°C	VDD = 3.3V(4) Regulator Disabled	
		850	1700	µA	+25°C		
		850	1800	µA	+85°C		
		1150	2400	µA	+125ºC		
	All devices	1.1	2.7	mA	-40°C	VDD = 5V(5) Regulator Enabled	
		1.1	2.6	mA	+25°C		
		1.1	2.6	mA	+85°C		
		2.0	4.0	mA	+125ºC		
	All devices	12	19	mA	-40°C	VDD = 3.3V(4) Regulator Disabled	FOSC = 64 MHz (**PRI_RUN** mode, EC oscillator)
		12	19	mA	+25°C		
		12	19	mA	+85°C		
		13	22	mA	+125ºC(6)		
	All devices	13	20	mA	-40°C	VDD = 5V(4) Regulator Enabled	
		13	20	mA	+25°C		
		13	20	mA	+85°C		
		14	23	mA	+125ºC(6)		

Note 1: 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 a high-impedance state and tied to VDD or VSS, and all features that add delta current are disabled (such as WDT, SOSC oscillator, BOR, etc.).

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

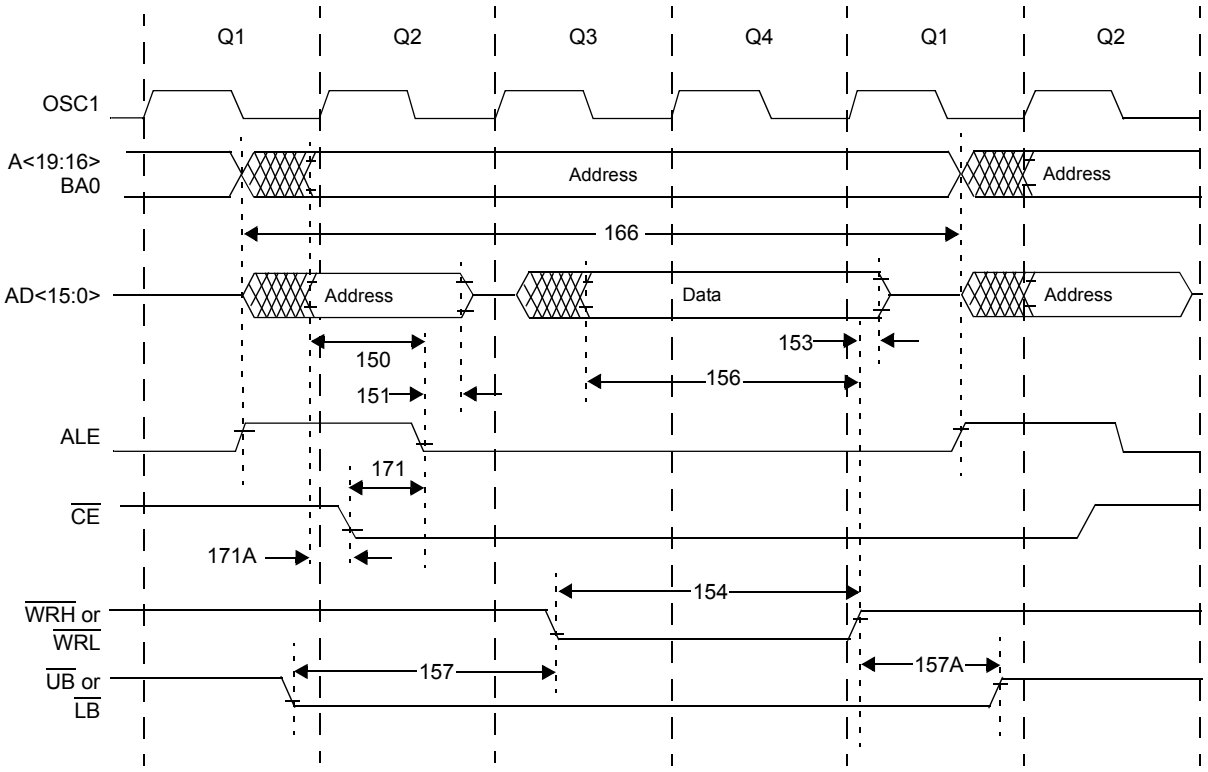
3: Standard, low-cost 32 kHz crystals have an operating temperature range of -10°C to +70°C. Extended temperature crystals are available at a much higher cost.

4: Voltage regulator disabled (ENVREG = 0, tied to VSS, $\overline{\text{RETEN}}$ (CONFIG1L<0>) = 1).

5: Voltage regulator enabled (ENVREG = 1, tied to VDD, SRETEN (WDTCON<4>) = 1 and $\overline{\text{RETEN}}$ (CONFIG1L<0>) = 0).

6: 48 MHz, maximum frequency at +125ºC.

FIGURE 31-8: PROGRAM MEMORY WRITE TIMING DIAGRAM



Operating Conditions: 2.0V < VCC < 3.6V, -40°C < TA < +125°C unless otherwise stated.

TABLE 31-12: PROGRAM MEMORY WRITE TIMING REQUIREMENTS

Param. No	Symbol	Characteristics	Min	Typ	Max	Units
150	TadV2alL	Address Out Valid to ALE ↓ (address setup time)	0.25 TCY – 10	—	—	ns
151	TalL2adl	ALE ↓ to Address Out Invalid (address hold time)	5	—	—	ns
153	TwrH2adl	$\overline{WRn}$ ↑ to Data Out Invalid (data hold time)	5	—	—	ns
154	TwrL	$\overline{WRn}$ Pulse Width	0.5 TCY – 5	0.5 TCY	—	ns
156	TadV2wrH	Data Valid before $\overline{WRn}$ ↑ (data setup time)	0.5 TCY – 10	—	—	ns
157	TbsV2wrL	Byte Select Valid before $\overline{WRn}$ ↓ (byte select setup time)	0.25 TCY	—	—	ns
157A	TwrH2bsI	$\overline{WRn}$ ↑ to Byte Select Invalid (byte select hold time)	0.125 TCY – 5	—	—	ns
166	TalH2alH	ALE ↑ to ALE ↑ (cycle time)	—	TCY	—	ns
171	TalH2csL	Chip Enable Active to ALE ↓	0.25 TCY – 20	—	—	ns
171A	TubL2oeH	AD Valid to Chip Enable Active	—	—	10	ns

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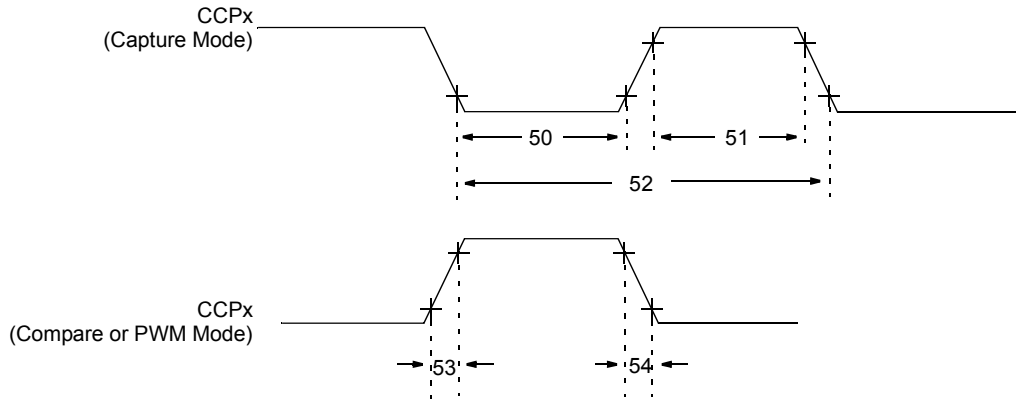
FIGURE 31-13: CAPTURE/COMPARE/PWM TIMINGS (ECCP1, ECCP2 MODULES)



Note: Refer to Figure 31-3 for load conditions.

TABLE 31-16: CAPTURE/COMPARE/PWM REQUIREMENTS (ECCP1, ECCP2 MODULES)

Param No.	Symbol	Characteristic		Min	Max	Units	Conditions
50	TccL	CCPx Input Low Time	No prescaler	0.5 TCY + 20	—	ns	
			With prescaler	10	—	ns	
51	TccH	CCPx Input High Time	No prescaler	0.5 TCY + 20	—	ns	
			With prescaler	10	—	ns	
52	TccP	CCPx Input Period		$\frac{3\ T_{CY} + 40}{N}$	—	ns	N = prescale value (1, 4 or 16)
53	TccR	CCPx Output Fall Time		—	25	ns	
54	TccF	CCPx Output Fall Time		—	25	ns	