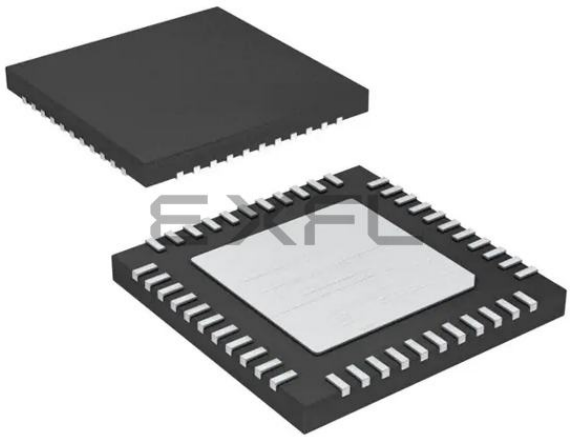
Microchip Technology - PIC24F08KM204T-I/ML Datasheet



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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Obsolete
Core Processor	PIC
Core Size	16-Bit
Speed	32MHz
Connectivity	I²C, IrDA, LINbus, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, LVD, POR, PWM, WDT
Number of I/O	38
Program Memory Size	8KB (2.75K x 24)
Program Memory Type	FLASH
EEPROM Size	512 x 8
RAM Size	2K x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 3.6V
Data Converters	A/D 22x10b/12b; D/A 2x8b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	44-VQFN Exposed Pad
Supplier Device Package	44-QFN (8x8)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic24f08km204t-i-ml

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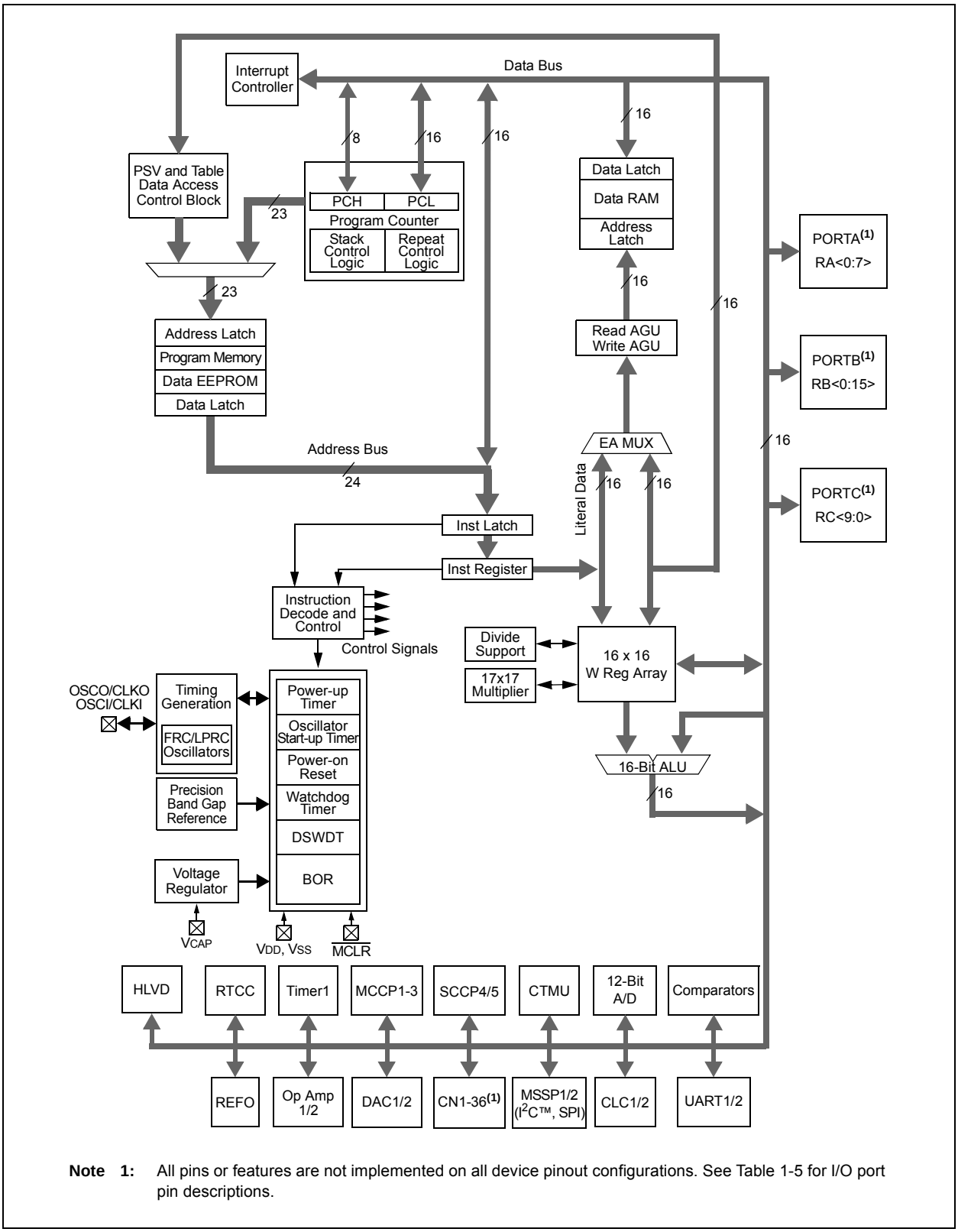
TABLE 1-3: DEVICE FEATURES FOR THE PIC24FV16KM204 FAMILY

Features	PIC24FV16KM204	PIC24FV08KM204	PIC24FV16KM202	PIC24FV08KM202
Operating Frequency	DC-32 MHz			
Program Memory (bytes)	16K	8K	16K	8K
Program Memory (instructions)	5632	2816	5632	2816
Data Memory (bytes)	2048			
Data EEPROM Memory (bytes)	512			
Interrupt Sources (soft vectors/NMI traps)	40 (36/4)			
Voltage Range	2.0-5.5V			
I/O Ports	PORTA<11:7,5:0> PORTB<15:0> PORTC<9:0>		PORTA<7,5:0> PORTB<15:0>	
Total I/O Pins	37		23	
Timers	11 (One 16-bit timer, five MCCPs/SCCPs with up to two 16/32 timers each)			
Capture/Compare/PWM modules MCCP SCCP	 3 2			
Serial Communications MSSP UART	 2 2			
Input Change Notification Interrupt	36		22	
12-Bit Analog-to-Digital Module (input channels)	22		19	
Analog Comparators	3			
8-Bit Digital-to-Analog Converters	2			
Operational Amplifiers	2			
Charge Time Measurement Unit (CTMU)	Yes			
Real-Time Clock and Calendar (RTCC)	Yes			
Configurable Logic Cell (CLC)	2			
Resets (and delays)	POR, BOR, RESET Instruction, $\overline{\text{MCLR}}$, WDT, Illegal Opcode, REPEAT Instruction, Hardware Traps, Configuration Word Mismatch (PWRT, OST, PLL Lock)			
Instruction Set	76 Base Instructions, Multiple Addressing Mode Variations			
Packages	44-Pin QFN/TQFP, 48-Pin UQFN		28-Pin SPDIP/SSOP/SOIC/QFN	

FIGURE 1-1: PIC24FXXXXX FAMILY GENERAL BLOCK DIAGRAMS



Note 1: All pins or features are not implemented on all device pinout configurations. See Table 1-5 for I/O port pin descriptions.

TABLE 1-5: PIC24FV16KM204 FAMILY PINOUT DESCRIPTION (CONTINUED)

Function	F					FV					I/O	Buffer	Description
	Pin Number					Pin Number							
	20-Pin PDIP/ SSOP/ SOIC	28-Pin PDIP/ SSOP/ SOIC	28-Pin QFN	44-Pin QFN/ TQFP	48-Pin UQFN	20-Pin PDIP/ SSOP/ SOIC	28-Pin PDIP/ SSOP/ SOIC	28-Pin QFN	44-Pin QFN/ TQFP	48-Pin UQFN			
SCL1	12	17	14	44	48	12	17	14	44	48	I/O	I2C	MSSP1 I^2C Clock
SDA1	13	18	15	1	1	13	18	15	1	1	I/O	I2C	MSSP1 I^2C Data
SCL2	—	7	4	24	26	—	7	4	24	26	I/O	I2C	MSSP2 I^2C Clock
SDA2	—	6	3	23	25	—	6	3	23	25	I/O	I2C	MSSP2 I^2C Data
SCLKI	10	12	9	34	37	10	12	9	34	37	I	ST	Secondary Clock Digital Input
SOSCI	9	11	8	33	36	9	11	8	33	36	I	ANA	Secondary Oscillator Input
SOSCO	10	12	9	34	37	10	12	9	34	37	I	ANA	Secondary Oscillator Output
T1CK	13	18	15	1	1	13	18	15	1	1	I	ST	Timer1 Digital Input Cock
TCKIA	18	26	23	15	16	18	26	23	15	16	I	ST	MCCP/SCCP Time Base Clock Input A
TCKIB	6	6	3	23	25	6	6	3	23	25	I	ST	MCCP/SCCP Time Base Clock Input B
$\overline{U1CTS}$	12	17	14	44	48	12	17	14	44	48	I	ST	UART1 Clear-To-Send Input
$\overline{U1RTS}$	13	18	15	1	1	13	18	15	1	1	O	—	UART1 Request-To-Send Output
U1BCLK	13	18	15	1	1	13	18	15	1	1	O	—	UART1 16x Baud Rate Clock Output
U1RX	6	6	3	2	2	6	6	3	2	2	I	ST	UART1 Receive
U1TX	11	16	13	3	3	11	16	13	3	3	O	—	UART1 Transmit
$\overline{U2CTS}$	—	12	9	34	37	—	12	9	34	37	I	ST	UART2 Clear-To-Send Input
$\overline{U2RTS}$	—	11	8	33	36	—	11	8	33	36	O	—	UART2 Request-To-Send Output
U2BCLK	13	18	15	1	1	13	18	15	1	1	O	—	UART2 16x Baud Rate Clock Output
U2RX	—	5	2	22	24	—	5	2	22	24	I	ST	UART2 Receive
U2TX	—	4	1	21	23	—	4	1	21	23	O	—	UART2 Transmit
ULPWU	4	4	1	21	23	4	4	1	21	23	I	ANA	Ultra Low-Power Wake-up Input
VCAP	—	—	—	—	—	14	20	17	7	7	P	—	Regulator External Filter Capacitor Connection
VDD	20	28	25	17,28,28	18,30,30	20	28	25	17,28,28	18,30,30	P	—	Device Positive Supply Voltage
VDDCORE	—	—	—	—	—	14	20	17	7	7	P	—	Microcontroller Core Supply Voltage
VPP	1	1	26	18	19	1	1	26	18	19	P	—	High-Voltage Programming Pin
VREF+	2	2	27	19	21	2	2	27	19	21	I	ANA	A/D Reference Voltage Positive Input
VREF-	3	3	28	20	22	3	3	28	20	22	I	ANA	A/D Reference Voltage Negative Input
VSS	19	27	24	16,29,29	17,31,31	19	27	24	16,29,29	17,31,31	P	—	Device Ground Return Voltage

Legend: ANA = Analog level input/output, ST = Schmitt Trigger input buffer, I^2C™ = I^2C/SMBus input buffer

2.0 GUIDELINES FOR GETTING STARTED WITH 16-BIT MICROCONTROLLERS

2.1 Basic Connection Requirements

Getting started with the PIC24FV16KM204 family of 16-bit microcontrollers requires attention to a minimal set of device pin connections before proceeding with development.

The following pins must always be connected:

- All VDD and VSS pins
  (see **Section 2.2 “Power Supply Pins”**)
- All AVDD and AVSS pins, regardless of whether or not the analog device features are used
  (see **Section 2.2 “Power Supply Pins”**)
- $\overline{\text{MCLR}}$ pin
  (see **Section 2.3 “Master Clear (MCLR) Pin”**)
- VCAP pins
  (see **Section 2.4 “Voltage Regulator Pin (VCAP)”**)

These pins must also be connected if they are being used in the end application:

- PGECx/PGEDx pins used for In-Circuit Serial Programming™ (ICSP™) and debugging purposes
  (see **Section 2.5 “ICSP Pins”**)
- OSCI and OSCO pins when an external oscillator source is used
  (see **Section 2.6 “External Oscillator Pins”**)

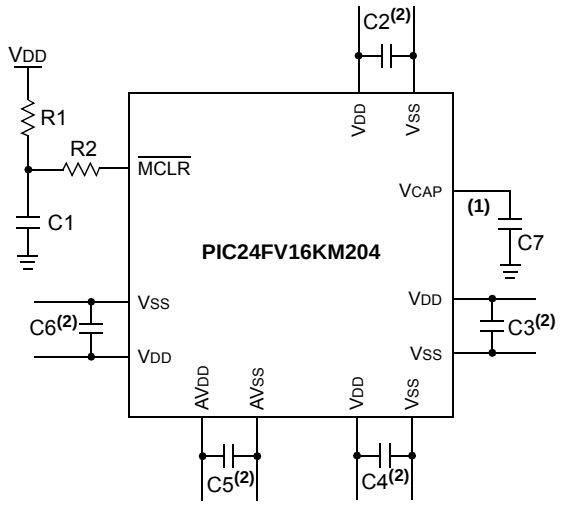
Additionally, the following pins may be required:

- VREF+/VREF- pins are used when external voltage reference for analog modules is implemented

Note:	The AVDD and AVSS pins must always be connected, regardless of whether any of the analog modules are being used.

The minimum mandatory connections are shown in Figure 2-1.

FIGURE 2-1: RECOMMENDED MINIMUM CONNECTIONS



Key (all values are recommendations):

C1 through C6: 0.1 µF, 20V ceramic

C7: 10 µF, 16V tantalum or ceramic

R1: 10 kΩ

R2: 100Ω to 470Ω

Note 1: See **Section 2.4 “Voltage Regulator Pin (VCAP)”** for an explanation of VCAP pin connections.

2: The example shown is for a PIC24F device with five VDD/VSS and AVDD/AVSS pairs. Other devices may have more or less pairs; adjust the number of decoupling capacitors appropriately.

REGISTER 3-2: CORCON: CPU CONTROL REGISTER

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-0
—	—	—	—	—	—	—	—
bit 15							bit 8

U-0	U-0	U-0	U-0	R/C-0, HSC	R/W-0	U-0	U-0
—	—	—	—	IPL3(1)	PSV	—	—
bit 7							bit 0

Legend:	C = Clearable bit	HSC = Hardware Settable/Clearable 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 15-4 **Unimplemented:** Read as '0'

bit 3 **IPL3:** CPU Interrupt Priority Level Status bit(1)
1 = CPU Interrupt Priority Level is greater than 7
0 = CPU Interrupt Priority Level is 7 or less

bit 2 **PSV:** Program Space Visibility in Data Space Enable bit
1 = Program space is visible in Data Space
0 = Program space is not visible in Data Space

bit 1-0 **Unimplemented:** Read as '0'

Note 1: User interrupts are disabled when IPL3 = 1.

3.3 Arithmetic Logic Unit (ALU)

The PIC24F ALU is 16 bits wide and is capable of addition, subtraction, bit shifts and logic operations. Unless otherwise mentioned, arithmetic operations are 2's complement in nature. Depending on the operation, the ALU may affect the values of the Carry (C), Zero (Z), Negative (N), Overflow (OV) and Digit Carry (DC) Status bits in the SR register. The C and DC Status bits operate as Borrow and Digit Borrow bits, respectively, for subtraction operations.

The ALU can perform 8-bit or 16-bit operations, depending on the mode of the instruction that is used. Data for the ALU operation can come from the W register array, or data memory, depending on the addressing mode of the instruction. Likewise, output data from the ALU can be written to the W register array or a data memory location.

The PIC24F CPU incorporates hardware support for both multiplication and division. This includes a dedicated hardware multiplier and support hardware division for 16-bit divisor.

3.3.1 MULTIPLIER

The ALU contains a high-speed, 17-bit x 17-bit multiplier. It supports unsigned, signed or mixed sign operation in several multiplication modes:

- 16-bit x 16-bit signed
- 16-bit x 16-bit unsigned
- 16-bit signed x 5-bit (literal) unsigned
- 16-bit unsigned x 16-bit unsigned
- 16-bit unsigned x 5-bit (literal) unsigned
- 16-bit unsigned x 16-bit signed
- 8-bit unsigned x 8-bit unsigned

TABLE 4-11: SCCP4 REGISTER MAP

File Name	Addr.	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	All Resets
CCP4CON1L(1)	1ACh	CCPON	—	CCPSIDL	r	TMRSYNC	CLKSEL2	CLKSEL1	CLKSEL0	TMRPS1	TMRPS0	T32	CCSEL	MOD3	MOD2	MOD1	MOD0	0000
CCP4CON1H(1)	1AEh	OPSSRC	RTRGEN	—	—	IOPS3	IOPS2	IOPS1	IOPS0	TRIGEN	ONESHOT	ALTSYNC	SYNC4	SYNC3	SYNC2	SYNC1	SYNC0	0000
CCP4CON2L(1)	1B0h	PWMRSEN	ASDGM	—	SSDG	—	—	—	—	ASDG7	ASDG6	ASDG5	ASDG4	ASDG3	ASDG2	ASDG1	ASDG0	0000
CCP4CON2H(1)	1B2h	OENSYNC	—	—	—	—	—	—	OCAEN	ICGSM1	ICGSM0	—	AUXOUT1	AUXOUT0	ICSEL2	ICSEL1	ICSEL0	0100
CCP4CON3H(1)	1B6h	OETRIG	OSCNT2	OSCNT1	OSCNT0	—	—	—	—	—	—	POLACE	—	PSSACE1	PSSACE0	—	—	0000
CCP4STATL(1)	1B8h	—	—	—	—	—	—	—	—	CCPTRIG	TRSET	TRCLR	ASEVT	SCEVT	ICDIS	ICOV	ICBNE	0000
CCP4TMRL(1)	1BCh	SCCP4 Time Base Register Low Word																0000
CCP4TMRH(1)	1BEh	SCCP4 Time Base Register High Word																0000
CCP4PRL(1)	1C0h	SCCP4 Time Base Period Register Low Word																FFFF
CCP4PRH(1)	1C2h	SCCP4 Time Base Period Register High Word																FFFF
CCP4RAL(1)	1C4h	Output Compare 4 Data Word A																0000
CCP4RBL(1)	1C8h	Output Compare 4 Data Word B																0000
CCP4BUFL(1)	1CCh	Input Capture 4 Data Buffer Low Word																0000
CCP4BUFH(1)	1CEh	Input Capture 4 Data Buffer High Word																0000

Legend: x = unknown, u = unchanged, — = unimplemented, q = value depends on condition, r = reserved.
Note 1: These registers are available only on PIC24F(V)16KM2XX devices.

TABLE 4-26: CTMU REGISTER MAP

File Name	Addr.	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	All Resets
CTMUCON1L	35Ah	CTMUEN	—	CTMUSIDL	TGEN	EDGEN	EDGSEQEN	IDISSEN	CTTRIG	ITRIM5	ITRIM4	ITRIM3	ITRIM2	ITRIM1	ITRIM0	IRNG1	IRNG0	0000
CTMUCON1H	35Ch	EDG1MOD	EDG1POL	EDG1SEL3	EDG1SEL2	EDG1SEL1	EDG1SEL0	EDG2STAT	EDG1STAT	EDG2MOD	EDG2POL	EDG2SEL3	EDG2SEL2	EDG2SEL1	EDG2SEL0	—	—	0000
CTMUCON2L	35Eh	—	—	—	—	—	—	—	—	—	—	—	IRSTEN	—	DISCHS2	DISCHS1	DISCHS0	0000

Legend: x = unknown, u = unchanged, — = unimplemented, q = value depends on condition, r = reserved.

TABLE 4-27: ANSEL REGISTER MAP

File Name	Addr.	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	All Resets
ANSA	4E0h	—	—	—	—	—	—	—	—	—	—	—	ANSA4(2)	ANSA3	ANSA2	ANSA1	ANSA0	001F(1)
ANSB	4E2h	ANSB15	ANSB14	ANSB13	ANSB12	—	—	ANSB9	ANSB8	ANSB7	ANSB6(2)	ANSB5(2)	ANSB4	ANSB3(2)	ANSB2	ANSB1	ANSB0	F3FF(1)
ANSC	4E4h	—	—	—	—	—	—	—	—	—	—	—	—	—	ANSC2(2,3)	ANSC1(2,3)	ANSC0(2,3)	0007(1)

Legend: x = unknown, u = unchanged, — = unimplemented, q = value depends on condition, r = reserved.
Note 1: Reset value depends on the device type; the PIC24F16KM204 value is shown.
2: These bits are not implemented in 20-pin devices.
3: These bits are not implemented in 28-pin devices.

TABLE 4-28: REAL-TIME CLOCK AND CALENDAR REGISTER MAP

File Name	Addr.	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	All Resets
ALRMVAL	620h	Alarm Value High Register Window Based on APTR<1:0>																xxxx
ALCFGRPT	622h	ALRMEN	CHIME	AMASK3	AMASK2	AMASK1	AMASK0	ALRMPTR1	ALRMPTR0	ARPT7	ARPT6	ARPT5	ARPT4	ARPT3	ARPT2	ARPT1	ARPT0	0000(1)
RTCVAL	624h	RTCC Value High Register Window Based on RTCPTR<1:0>																xxxx
RCFGCAL	626h	RTCEN	—	RTCWREN	RTCSYNC	HALFSEC	RTCOE	RTCPTR1	RTCPTR0	CAL7	CAL6	CAL5	CAL4	CAL3	CAL2	CAL1	CAL0	0000(1)
RTCPWC	628h	PWCEN	PWCPOL	PWCCPRE	PWCSPRE	RTCCLK1	RTCCLK0	RTCOUT1	RTCOUT0	—	—	—	—	—	—	—	—	0000(1)

Legend: x = unknown, u = unchanged, — = unimplemented, q = value depends on condition, r = reserved.
Note 1: Values are reset only on a VDD POR event.

EXAMPLE 5-5: INITIATING A PROGRAMMING SEQUENCE – ASSEMBLY LANGUAGE CODE

```
        DISI    #5                      ; Block all interrupts
                                          for next 5 instructions
        MOV     #0x55, W0
        MOV     W0, NVMKEY              ; Write the 55 key
        MOV     #0xAA, W1               ;
        MOV     W1, NVMKEY              ; Write the AA key
        BSET    NVMCON, #WR             ; Start the erase sequence
        NOP                             ; 2 NOPs required after setting WR
        NOP                             ;
        BTSC    NVMCON, #15             ; Wait for the sequence to be completed
        BRA     $-2                     ;
```

EXAMPLE 5-6: INITIATING A PROGRAMMING SEQUENCE – 'C' LANGUAGE CODE

```
// C example using MPLAB C30

asm("DISI #5");               // Block all interrupts for next 5 instructions

__builtin_write_NVM();        // Perform unlock sequence and set WR
```

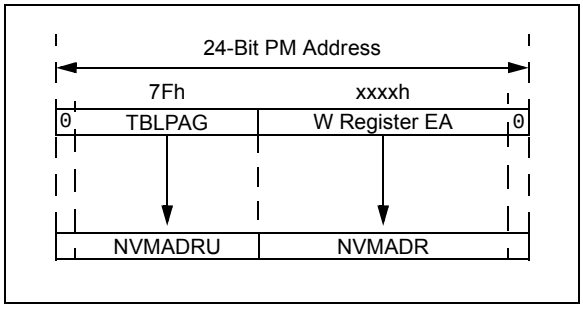
6.3 NVM Address Register

As with Flash program memory, the NVM Address registers, NVMADRU and NVMADR, form the 24-bit Effective Address (EA) of the selected row or word for data EEPROM operations. The NVMADRU register is used to hold the upper 8 bits of the EA, while the NVMADR register is used to hold the lower 16 bits of the EA. These registers are not mapped into the Special Function Register (SFR) space; instead, they directly capture the EA<23:0> of the last Table Write instruction that has been executed and select the data EEPROM row to erase. Figure 6-1 depicts the program memory EA that is formed for programming and erase operations.

Like program memory operations, the Least Significant bit (LSb) of NVMADR is restricted to even addresses. This is because any given address in the data EEPROM space consists of only the lower word of the program memory width; the upper word, including the uppermost "phantom byte", are unavailable. This means that the LSb of a data EEPROM address will always be '0'.

Similarly, the Most Significant bit (MSb) of NVMADRU is always '0', since all addresses lie in the user program space.

FIGURE 6-1: DATA EEPROM ADDRESSING WITH TBLPAG AND NVM ADDRESS REGISTERS



6.4 Data EEPROM Operations

The EEPROM block is accessed using Table Read and Write operations, similar to those used for program memory. The TBLWTH and TBLRDH instructions are not required for data EEPROM operations since the memory is only 16 bits wide (data on the lower address is valid only). The following programming operations can be performed on the data EEPROM:

- Erase one, four or eight words
- Bulk erase the entire data EEPROM
- Write one word
- Read one word

Note 1: Unexpected results will be obtained if the user attempts to read the EEPROM while a programming or erase operation is underway.

2: The XC16 C compiler includes library procedures to automatically perform the Table Read and Table Write operations, manage the Table Pointer and write buffers, and unlock and initiate memory write sequences. This eliminates the need to create assembler macros or time critical routines in C for each application.

The library procedures are used in the code examples detailed in the following sections. General descriptions of each process are provided for users who are not using the XC16 compiler libraries.

10.5 Doze Mode

Generally, changing clock speed and invoking one of the power-saving modes are the preferred strategies for reducing power consumption. There may be circumstances, however, where this is not practical. For example, it may be necessary for an application to maintain uninterrupted synchronous communication, even while it is doing nothing else. Reducing system clock speed may introduce communication errors, while using a power-saving mode may stop communications completely.

Doze mode is a simple and effective alternative method to reduce power consumption while the device is still executing code. In this mode, the system clock continues to operate from the same source and at the same speed. Peripheral modules continue to be clocked at the same speed, while the CPU clock speed is reduced. Synchronization between the two clock domains is maintained, allowing the peripherals to access the SFRs while the CPU executes code at a slower rate.

Doze mode is enabled by setting the DOZEN bit (CLKDIV<11>). The ratio between peripheral and core clock speed is determined by the DOZE<2:0> bits (CLKDIV<14:12>). There are eight possible configurations, from 1:1 to 1:128, with 1:1 being the default.

It is also possible to use Doze mode to selectively reduce power consumption in event driven applications. This allows clock-sensitive functions, such as synchronous communications, to continue without interruption. Meanwhile, the CPU Idles, waiting for something to invoke an interrupt routine. Enabling the automatic return to full-speed CPU operation on interrupts is enabled by setting the ROI bit (CLKDIV<15>). By default, interrupt events have no effect on Doze mode operation.

10.6 Selective Peripheral Module Control

Idle and Doze modes allow users to substantially reduce power consumption by slowing or stopping the CPU clock. Even so, peripheral modules still remain clocked, and thus, consume power. There may be cases where the application needs what these modes do not provide: the allocation of power resources to CPU processing with minimal power consumption from the peripherals.

PIC24F devices address this requirement by allowing peripheral modules to be selectively disabled, reducing or eliminating their power consumption. This can be done with two control bits:

- The Peripheral Enable bit, generically named, “XXXEN”, located in the module’s main control SFR.
- The Peripheral Module Disable (PMD) bit, generically named, “XXXMD”, located in one of the PMDx Control registers.

Both bits have similar functions in enabling or disabling its associated module. Setting the PMDx bits for a module, disables all clock sources to that module, reducing its power consumption to an absolute minimum. In this state, the control and status registers associated with the peripheral will also be disabled, so writes to those registers will have no effect, and read values will be invalid. Many peripheral modules have a corresponding PMDx bit.

In contrast, disabling a module by clearing its XXXEN bit, disables its functionality, but leaves its registers available to be read and written to. Power consumption is reduced, but not by as much as when the PMDx bits are used. Most peripheral modules have an enable bit; exceptions include capture, compare and RTCC.

To achieve more selective power savings, peripheral modules can also be selectively disabled when the device enters Idle mode. This is done through the control bit of the generic name format, “XXXIDL”. By default, all modules that can operate during Idle mode will do so. Using the disable on Idle feature disables the module while in Idle mode, allowing further reduction of power consumption during Idle mode, enhancing power savings for extremely critical power applications.

REGISTER 14-3: SSPxCON1: MSSPx CONTROL REGISTER 1 (SPI MODE)

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-0
—	—	—	—	—	—	—	—
bit 15							bit 8

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
WCOL	SSPOV(1)	SSPEN(2)	CKP	SSPM3(3)	SSPM2(3)	SSPM1(3)	SSPM0(3)
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 15-8 **Unimplemented:** Read as '0'

bit 7 **WCOL:** Write Collision Detect bit
1 = The SSPxBUF register is written while it is still transmitting the previous word (must be cleared in software)
0 = No collision

bit 6 **SSPOV:** Master Synchronous Serial Port Receive Overflow Indicator bit(1)
SPI Slave mode:
1 = A new byte is received while the SSPxBUF register is still holding the previous data. In case of overflow, the data in SSPxSR is lost. Overflow can only occur in Slave mode. The user must read the SSPxBUF, even if only transmitting data, to avoid setting overflow (must be cleared in software).
0 = No overflow

bit 5 **SSPEN:** Master Synchronous Serial Port Enable bit(2)
1 = Enables the serial port and configures SCKx, SDOx, SDIx and $\overline{SSx}$ as serial port pins
0 = Disables the serial port and configures these pins as I/O port pins

bit 4 **CKP:** Clock Polarity Select bit
1 = Idle state for clock is a high level
0 = Idle state for clock is a low level

bit 3-0 **SSPM<3:0>:** Master Synchronous Serial Port Mode Select bits(3)
1010 = SPI Master mode, Clock = FOSC/(2 * ([SSPxADD] + 1))
0101 = SPI Slave mode, Clock = SCKx pin; $\overline{SSx}$ pin control is disabled, $\overline{SSx}$ can be used as an I/O pin
0100 = SPI Slave mode, Clock = SCKx pin; $\overline{SSx}$ pin control is enabled
0011 = SPI Master mode, Clock = TMR2 output/2
0010 = SPI Master mode, Clock = FOSC/32
0001 = SPI Master mode, Clock = FOSC/8
0000 = SPI Master mode, Clock = FOSC/2

Note 1: In Master mode, the overflow bit is not set since each new reception (and transmission) is initiated by writing to the SSPxBUF register.
2: When enabled, these pins must be properly configured as inputs or outputs.
3: Bit combinations not specifically listed here are either reserved or implemented in I^2C™ mode only.

REGISTER 17-5: CLCxGLSH: CLCx GATE LOGIC INPUT SELECT HIGH REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
G4D4T	G4D4N	G4D3T	G4D3N	G4D2T	G4D2N	G4D1T	G4D1N
bit 15							bit 8

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
G3D4T	G3D4N	G3D3T	G3D3N	G3D2T	G3D2N	G3D1T	G3D1N
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 15 **G4D4T:** Gate 4 Data Source 4 True Enable bit
1 = The Data Source 4 inverted signal is enabled for Gate 4
0 = The Data Source 4 inverted signal is disabled for Gate 4

bit 14 **G4D4N:** Gate 4 Data Source 4 Negated Enable bit
1 = The Data Source 4 inverted signal is enabled for Gate 4
0 = The Data Source 4 inverted signal is disabled for Gate 4

bit 13 **G4D3T:** Gate 4 Data Source 3 True Enable bit
1 = The Data Source 3 inverted signal is enabled for Gate 4
0 = The Data Source 3 inverted signal is disabled for Gate 4

bit 12 **G4D3N:** Gate 4 Data Source 3 Negated Enable bit
1 = The Data Source 3 inverted signal is enabled for Gate 4
0 = The Data Source 3 inverted signal is disabled for Gate 4

bit 11 **G4D2T:** Gate 4 Data Source 2 True Enable bit
1 = The Data Source 2 inverted signal is enabled for Gate 4
0 = The Data Source 2 inverted signal is disabled for Gate 4

bit 10 **G4D2N:** Gate 4 Data Source 2 Negated Enable bit
1 = The Data Source 2 inverted signal is enabled for Gate 4
0 = The Data Source 2 inverted signal is disabled for Gate 4

bit 9 **G4D1T:** Gate 4 Data Source 1 True Enable bit
1 = The Data Source 1 inverted signal is enabled for Gate 4
0 = The Data Source 1 inverted signal is disabled for Gate 4

bit 8 **G4D1N:** Gate 4 Data Source 1 Negated Enable bit
1 = The Data Source 1 inverted signal is enabled for Gate 4
0 = The Data Source 1 inverted signal is disabled for Gate 4

bit 7 **G3D4T:** Gate 3 Data Source 4 True Enable bit
1 = The Data Source 4 inverted signal is enabled for Gate 3
0 = The Data Source 4 inverted signal is disabled for Gate 3

bit 6 **G3D4N:** Gate 3 Data Source 4 Negated Enable bit
1 = The Data Source 4 inverted signal is enabled for Gate 3
0 = The Data Source 4 inverted signal is disabled for Gate 3

bit 5 **G3D3T:** Gate 3 Data Source 3 True Enable bit
1 = The Data Source 3 inverted signal is enabled for Gate 3
0 = The Data Source 3 inverted signal is disabled for Gate 3

bit 4 **G3D3N:** Gate 3 Data Source 3 Negated Enable bit
1 = The Data Source 3 inverted signal is enabled for Gate 3
0 = The Data Source 3 inverted signal is disabled for Gate 3

REGISTER 19-5: AD1CHS: A/D SAMPLE SELECT REGISTER

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
CH0NB2	CH0NB1	CH0NB0	CH0SB4	CH0SB3	CH0SB2	CH0SB1	CH0SB0
bit 15							bit 8

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
CH0NA2	CH0NA1	CH0NA0	CH0SA4	CH0SA3	CH0SA2	CH0SA1	CH0SA0
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 15-13 **CH0NB<2:0>:** Sample B Channel 0 Negative Input Select bits
111 = AN6(1)
110 = AN5(2)
101 = AN4
100 = AN3
011 = AN2
010 = AN1
001 = AN0
000 = AVSS

bit 12-8 **CH0SB<4:0>:** S/H Amplifier Positive Input Select for MUX B Multiplexer Setting bits
11111 = Unimplemented, do not use
11110 = AVDD(3)
11101 = AVSS(3)
11100 = Upper guardband rail (0.785 * VDD)
11011 = Lower guardband rail (0.215 * VDD)
11010 = Internal Band Gap Reference (VBG)(3)
11000-11001 = Unimplemented, do not use
10001 = No channels are connected, all inputs are floating (used for CTMU)
10111 = No channels are connected, all inputs are floating (used for CTMU)
10110 = No channels are connected, all inputs are floating (used for CTMU temperature sensor input); does not require the corresponding CTMEN22 (AD1CTMENH<6>) bit)
10101 = Channel 0 positive input is AN21
10100 = Channel 0 positive input is AN20
10011 = Channel 0 positive input is AN19
10010 = Channel 0 positive input is AN18(2)
10001 = Channel 0 positive input is AN17(2)
•
•
•
01001 = Channel 0 positive input is AN9
01000 = Channel 0 positive input is AN8(1)
00111 = Channel 0 positive input is AN7(1)
00110 = Channel 0 positive input is AN6(1)
00101 = Channel 0 positive input is AN5(2)
00100 = Channel 0 positive input is AN4
00011 = Channel 0 positive input is AN3
00010 = Channel 0 positive input is AN2
00001 = Channel 0 positive input is AN1
00000 = Channel 0 positive input is AN0

Note 1: This is implemented on 44-pin devices only.
2: This is implemented on 28-pin and 44-pin devices only.
3: The band gap value used for this input is 2x or 4x the internal VBG, which is selected when PVCFG<1:0> = 1x.

22.0 COMPARATOR MODULE

Note:	This data sheet summarizes the features of this group of PIC24F devices. It is not intended to be a comprehensive reference source. For more information on the Comparator module, refer to the *"PIC24F Family Reference Manual"*, **"Scalable Comparator Module"** (DS39734).

The comparator module provides three dual input comparators. The inputs to the comparator can be configured to use any one of four external analog inputs, as well as a voltage reference input from either the Internal Band Gap Buffer 1 (BGBUF1) or the comparator voltage reference generator.

The comparator outputs may be directly connected to the CxOUT pins. When the respective COE bit equals '1', the I/O pad logic makes the unsynchronized output of the comparator available on the pin.

A simplified block diagram of the module is shown in Figure 22-1. Diagrams of the possible individual comparator configurations are shown in Figure 22-2.

Each comparator has its own control register, CMxCON (Register 22-1), for enabling and configuring its operation. The output and event status of all three comparators is provided in the CMSTAT register (Register 22-2).

FIGURE 22-1: COMPARATOR x MODULE BLOCK DIAGRAM

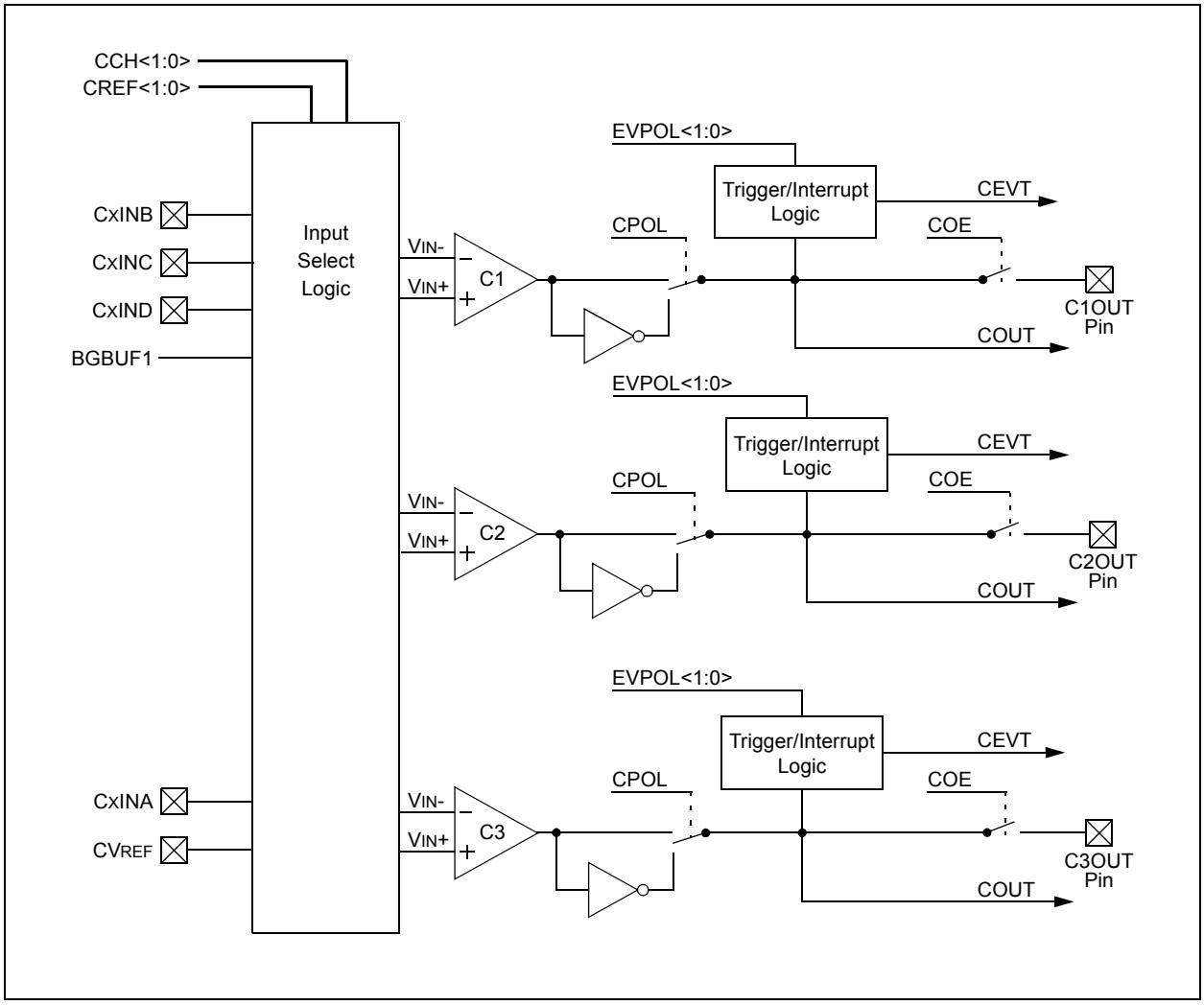
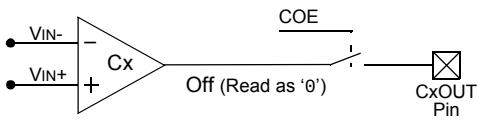
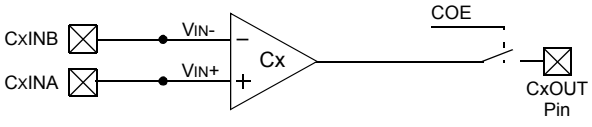


FIGURE 22-2: INDIVIDUAL COMPARATOR CONFIGURATIONS

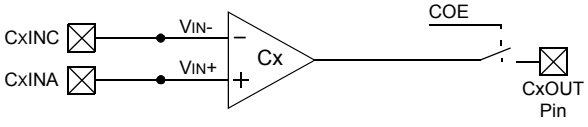
Comparator Off
CON = 0, CREF<1:0> = xx, CCH<1:0> = xx



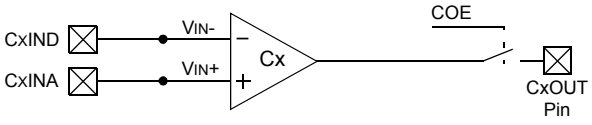
Comparator CxINB > CxINA Compare
CON = 1, CREF<1:0> = 00, CCH<1:0> = 00



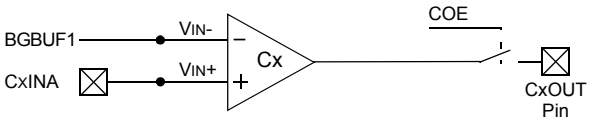
Comparator CxINC > CxINA Compare
CON = 1, CREF<1:0> = 00, CCH<1:0> = 01



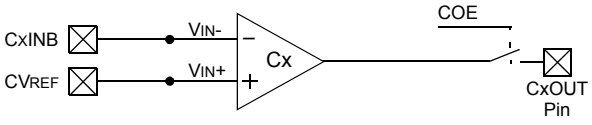
Comparator CxIND > CxINA Compare
CON = 1, CREF<1:0> = 00, CCH<1:0> = 10



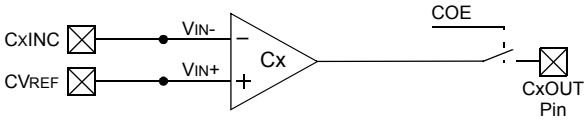
Comparator BGBUF1 > CxINA Compare
CON = 1, CREF<1:0> = 00, CCH<1:0> = 11



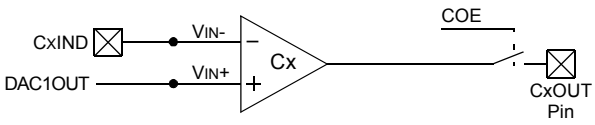
Comparator CxINB > CVREF Compare
CON = 1, CREF<1:0> = 01, CCH<1:0> = 00



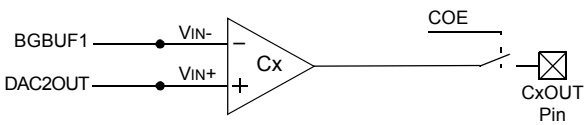
Comparator CxINC > CVREF Compare
CON = 1, CREF<1:0> = 01, CCH<1:0> = 01



Comparator CxIND > DAC1OUT Compare
CON = 1, CREF<1:0> = 10, CCH<1:0> = 10



Comparator BGBUF1 > DAC2OUT Compare
CON = 1, CREF<1:0> = 11, CCH<1:0> = 11



REGISTER 23-1: CVRCON: COMPARATOR VOLTAGE REFERENCE CONTROL REGISTER

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-0
—	—	—	—	—	—	—	—
bit 15							bit 8

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
CVREN	CVROE	CVRSS	CVR4	CVR3	CVR2	CVR1	CVR0
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 15-8 **Unimplemented:** Read as '0'

bit 7 **CVREN:** Comparator Voltage Reference Enable bit
1 = CVREF circuit is powered on
0 = CVREF circuit is powered down

bit 6 **CVROE:** Comparator VREF Output Enable bit
1 = CVREF voltage level is output on the CVREF pin
0 = CVREF voltage level is disconnected from the CVREF pin

bit 5 **CVRSS:** Comparator VREF Source Selection bit
1 = Comparator reference source, CVRSRC = VREF+ – VREF-
0 = Comparator reference source, CVRSRC = AVDD – AVSS

bit 4-0 **CVR<4:0>:** Comparator VREF Value Selection 0 ≤ CVR<4:0> ≤ 31 bits
When CVRSS = 1:
CVREF = (VREF-) + (CVR<4:0>/32) • (VREF+ – VREF-)
When CVRSS = 0:
CVREF = (AVSS) + (CVR<4:0>/32) • (AVDD – AVSS)

The WDT, prescaler and postscaler are reset:

- On any device Reset
- On the completion of a clock switch, whether invoked by software (i.e., setting the OSWEN bit after changing the NOSCx bits) or by hardware (i.e., Fail-Safe Clock Monitor)
- When a PWRSAV instruction is executed (i.e., Sleep or Idle mode is entered)
- When the device exits Sleep or Idle mode to resume normal operation
- By a CLRWDT instruction during normal execution

If the WDT is enabled in hardware (FWDTEN<1:0> = 11), it will continue to run during Sleep or Idle modes. When the WDT time-out occurs, the device will wake and code execution will continue from where the PWRSAV instruction was executed. The corresponding SLEEP or IDLE bit (RCON<3:2>) will need to be cleared in software after the device wakes up.

The WDT Flag bit, WDTO (RCON<4>), is not automatically cleared following a WDT time-out. To detect subsequent WDT events, the flag must be cleared in software.

Note:	The CLRWDT and PWRSAV instructions clear the prescaler and postscaler counts when executed.

25.3.1 WINDOWED OPERATION

The Watchdog Timer has an optional Fixed Window mode of operation. In this Windowed mode, CLRWDT instructions can only reset the WDT during the last 1/4 of the programmed WDT period. A CLRWDT instruction executed before that window causes a WDT Reset, similar to a WDT time-out.

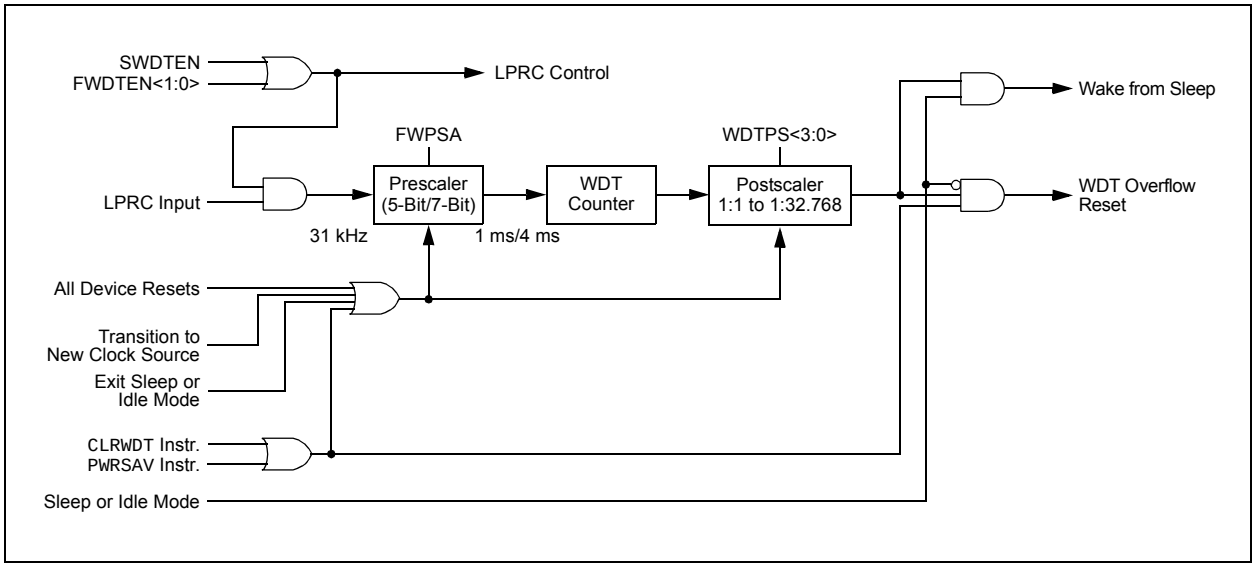
Windowed WDT mode is enabled by programming the Configuration bit, WINDIS (FWDT<6>), to '0'.

25.3.2 CONTROL REGISTER

The WDT is enabled or disabled by the FWDTEN<1:0> Configuration bits. When both of the FWDTEN<1:0> Configuration bits are set, the WDT is always enabled.

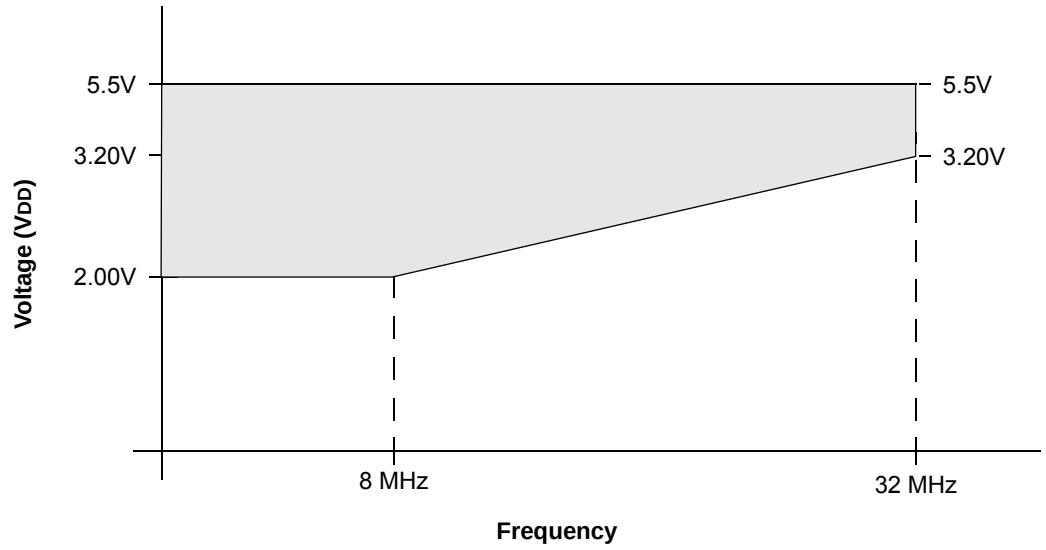
The WDT can be optionally controlled in software when the FWDTEN<1:0> Configuration bits have been programmed to '10'. The WDT is enabled in software by setting the SWDTEN control bit (RCON<5>). The SWDTEN control bit is cleared on any device Reset. The software WDT option allows the user to enable the WDT for critical code segments, and disable the WDT during non-critical segments, for maximum power savings. When the FWDTEN<1:0> bits are set to '01', the WDT is only enabled in Run and Idle modes, and is disabled in Sleep. Software control of the SWDTEN bit (RCON<5>) is disabled with this setting.

FIGURE 25-2: WDT BLOCK DIAGRAM



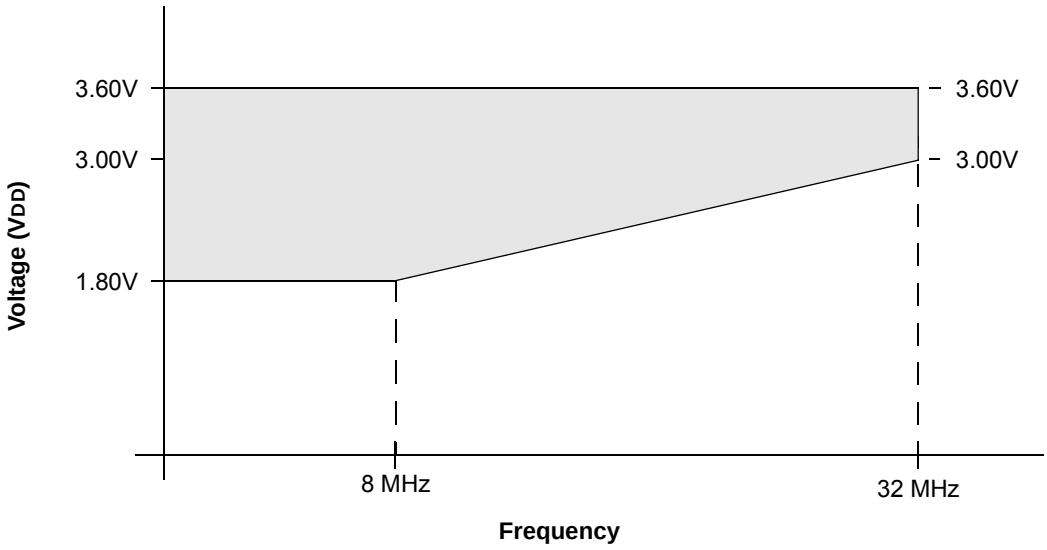
27.1 DC Characteristics

FIGURE 27-1: PIC24FV16KM204 FAMILY VOLTAGE-FREQUENCY GRAPH (INDUSTRIAL)



Note: For frequencies between 8 MHz and 32 MHz, FMAX = 20 MHz * (VDD – 2.0) + 8 MHz.

FIGURE 27-2: PIC24F16KM204 FAMILY VOLTAGE-FREQUENCY GRAPH (INDUSTRIAL)



Note: For frequencies between 8 MHz and 32 MHz, FMAX = 20 MHz * (VDD – 1.8) + 8 MHz.

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