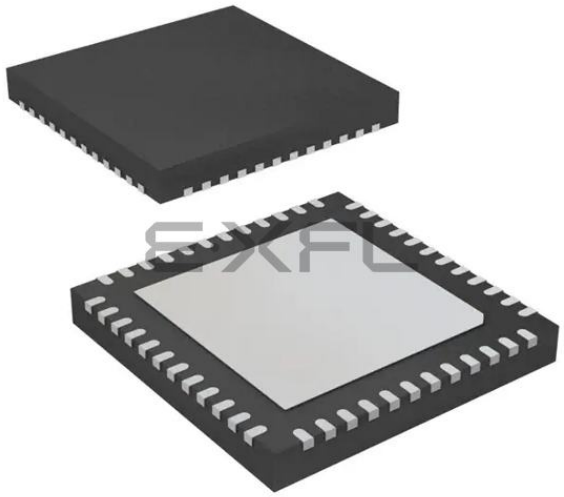


Welcome to E-XFL.COM

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	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	48-UFQFN Exposed Pad
Supplier Device Package	48-UQFN (6x6)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic24f08km204t-i-mv

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

NOTES:

3.3.2 DIVIDER

The divide block supports 32-bit/16-bit and 16-bit/16-bit signed and unsigned integer divide operations with the following data sizes:

1. 32-bit signed/16-bit signed divide
2. 32-bit unsigned/16-bit unsigned divide
3. 16-bit signed/16-bit signed divide
4. 16-bit unsigned/16-bit unsigned divide

The quotient for all divide instructions ends up in W0 and the remainder in W1. Sixteen-bit signed and unsigned DIV instructions can specify any W register for both the 16-bit divisor (Wn), and any W register (aligned) pair (W(m + 1):Wm) for the 32-bit dividend. The divide algorithm takes one cycle per bit of divisor, so both 32-bit/16-bit and 16-bit/16-bit instructions take the same number of cycles to execute.

3.3.3 MULTI-BIT SHIFT SUPPORT

The PIC24F ALU supports both single bit and single-cycle, multi-bit arithmetic and logic shifts. Multi-bit shifts are implemented using a shifter block, capable of performing up to a 15-bit arithmetic right shift, or up to a 15-bit left shift, in a single cycle. All multi-bit shift instructions only support Register Direct Addressing for both the operand source and result destination.

A full summary of instructions that use the shift operation is provided in Table 3-2.

TABLE 3-2: INSTRUCTIONS THAT USE THE SINGLE AND MULTI-BIT SHIFT OPERATION

Instruction	Description
ASR	Arithmetic shift right source register by one or more bits.
SL	Shift left source register by one or more bits.
LSR	Logical shift right source register by one or more bits.

4.0 MEMORY ORGANIZATION

As with Harvard architecture devices, the PIC24F microcontrollers feature separate program and data memory space and busing. This architecture also allows the direct access of program memory from the Data Space (DS) during code execution.

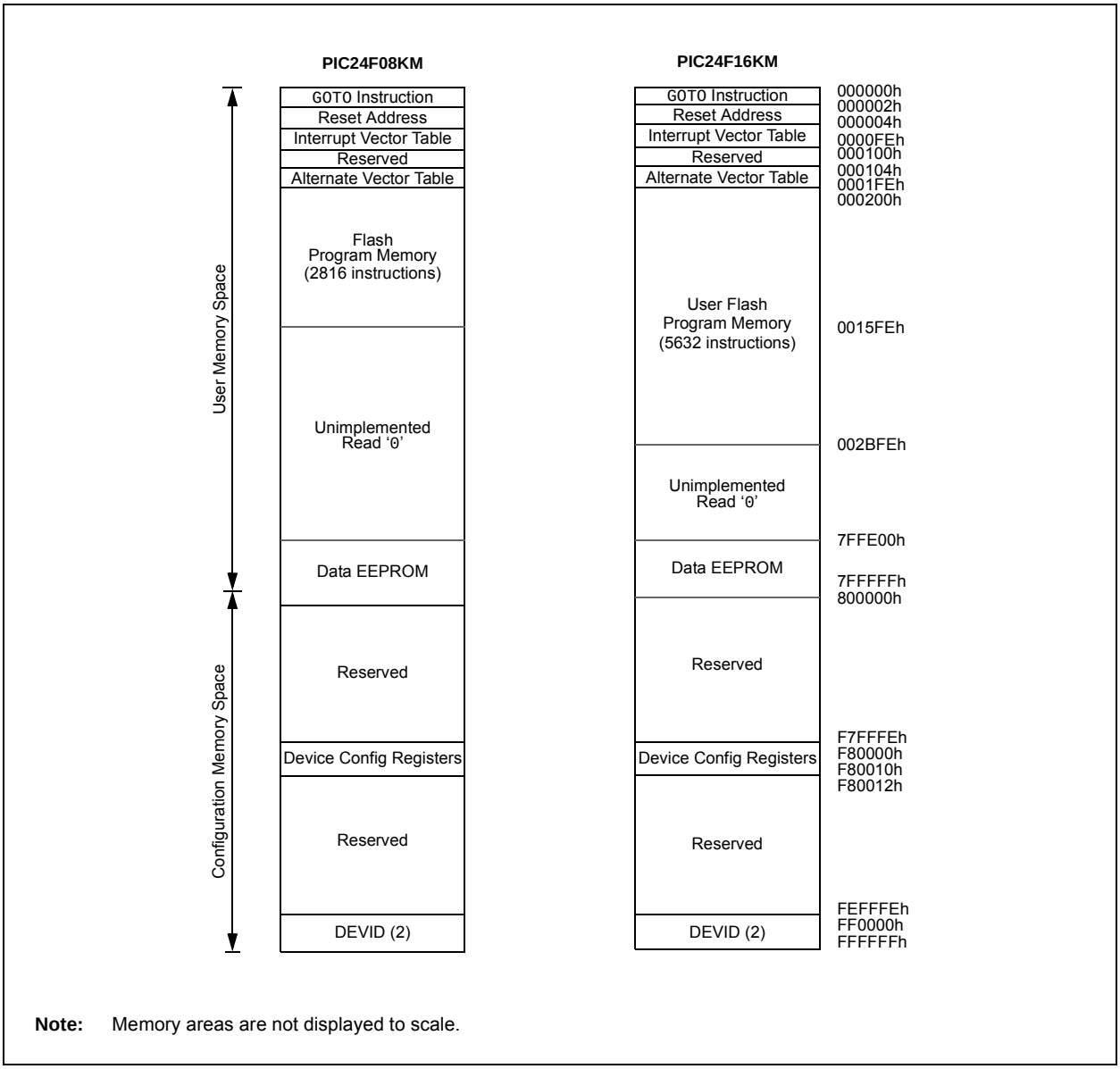
4.1 Program Address Space

The program address memory space of the PIC24F devices is 4M instructions. The space is addressable by a 24-bit value derived from either the 23-bit Program Counter (PC) during program execution, or from a table operation or Data Space remapping, as described in **Section 4.3 "Interfacing Program and Data Memory Spaces"**.

The user access to the program memory space is restricted to the lower half of the address range (000000h to 7FFFFFh). The exception is the use of TBLRD/TBLWT operations, which use TBLPAG<7> to permit access to the Configuration bits and Device ID sections of the configuration memory space.

Memory maps for the PIC24FV16KM204 family of devices are displayed in Figure 4-1.

FIGURE 4-1: PROGRAM SPACE MEMORY MAP FOR PIC24FXXXXX FAMILY DEVICES



Note: Memory areas are not displayed to scale.

TABLE 4-3: CPU CORE REGISTERS 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
WREG0	0h	WREG0																0000
WREG1	2h	WREG1																0000
WREG2	4h	WREG2																0000
WREG3	6h	WREG3																0000
WREG4	8h	WREG4																0000
WREG5	Ah	WREG5																0000
WREG6	Ch	WREG6																0000
WREG7	Eh	WREG7																0000
WREG8	10h	WREG8																0000
WREG9	12h	WREG9																0000
WREG10	14h	WREG10																0000
WREG11	16h	WREG11																0000
WREG12	18h	WREG12																0000
WREG13	1Ah	WREG13																0000
WREG14	1Ch	WREG14																0000
WREG15	1Eh	WREG15																0800
SPLIM	20h	SPLIM Register																xxxx
PCL	2Eh	PCL Register																0000
PCH	30h	—	—	—	—	—	—	—	—	PCH7	PCH6	PCH5	PCH4	PCH3	PCH2	PCH1	PCH0	0000
TBLPAG	32h	—	—	—	—	—	—	—	—	TBLPAG7	TBLPAG6	TBLPAG5	TBLPAG4	TBLPAG3	TBLPAG2	TBLPAG1	TBLPAG0	0000
PSVPAG	34h	—	—	—	—	—	—	—	—	PSVPAG7	PSVPAG6	PSVPAG5	PSVPAG4	PSVPAG3	PSVPAG2	PSVPAG1	PSVPAG0	0000
RCOUNT	36h	RCOUNT Register																xxxx
SR	42h	—	—	—	—	—	—	—	DC	IPL2	IPL1	IPL0	RA	N	OV	Z	C	0000
CORCON	44h	—	—	—	—	—	—	—	—	—	—	—	—	IPL3	PSV	—	—	0000
DISICNT	52h	—	—	DISICNT13	DISICNT12	DISICNT11	DISICNT10	DISICNT9	DISICNT8	DISICNT7	DISICNT6	DISICNT5	DISICNT4	DISICNT3	DISICNT2	DISICNT1	DISICNT0	xxxx

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

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.

4.2.5 SOFTWARE STACK

In addition to its use as a working register, the W15 register in PIC24F devices is also used as a Software Stack Pointer. The pointer always points to the first available free word and grows from lower to higher addresses. It pre-decrements for stack pops and post-increments for stack pushes, as depicted in Figure 4-4.

For a PC push during any CALL instruction, the MSB of the PC is zero-extended before the push, ensuring that the MSB is always clear.

Note:	A PC push during exception processing will concatenate the SRL register to the MSB of the PC prior to the push.

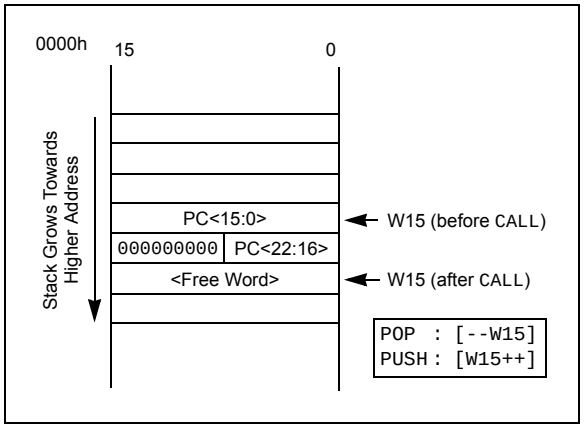
The Stack Pointer Limit Value (SPLIM) register, associated with the Stack Pointer, sets an upper address boundary for the stack. SPLIM is uninitialized at Reset. As is the case for the Stack Pointer, SPLIM<0> is forced to '0' as all stack operations must be word-aligned. Whenever an EA is generated using W15 as a source or destination pointer, the resulting address is compared with the value in SPLIM. If the contents of the Stack Pointer (W15) and the SPLIM register are equal, and a push operation is performed, a stack error trap will not occur. The stack error trap will occur on a subsequent push operation.

Thus, for example, if it is desirable to cause a stack error trap when the stack grows beyond address, 0DF6 in RAM, initialize the SPLIM with the value, 0DF4.

Similarly, a Stack Pointer underflow (stack error) trap is generated when the Stack Pointer address is found to be less than 0800h. This prevents the stack from interfering with the Special Function Register (SFR) space.

Note:	A write to the SPLIM register should not be immediately followed by an indirect read operation using W15.

FIGURE 4-4: CALL STACK FRAME



4.3 Interfacing Program and Data Memory Spaces

The PIC24F architecture uses a 24-bit-wide program space and 16-bit-wide Data Space (DS). The architecture is also a modified Harvard scheme, meaning that data can also be present in the program space. To use this data successfully, it must be accessed in a way that preserves the alignment of information in both spaces.

Apart from the normal execution, the PIC24F architecture provides two methods by which the program space can be accessed during operation:

- Using table instructions to access individual bytes or words anywhere in the program space
- Remapping a portion of the program space into the Data Space, PSV

Table instructions allow an application to read or write small areas of the program memory. This makes the method ideal for accessing data tables that need to be updated from time to time. It also allows access to all bytes of the program word. The remapping method allows an application to access a large block of data on a read-only basis, which is ideal for look ups from a large table of static data. It can only access the least significant word (lsw) of the program word.

4.3.1 ADDRESSING PROGRAM SPACE

Since the address ranges for the data and program spaces are 16 and 24 bits, respectively, a method is needed to create a 23-bit or 24-bit program address from 16-bit data registers. The solution depends on the interface method to be used.

For table operations, the 8-bit Table Memory Page Address register (TBLPAG) is used to define a 32K word region within the program space. This is concatenated with a 16-bit EA to arrive at a full 24-bit program space address. In this format, the Most Significant bit (MSb) of TBLPAG is used to determine if the operation occurs in the user memory (TBLPAG<7> = 0) or the configuration memory (TBLPAG<7> = 1).

For remapping operations, the 8-bit Program Space Visibility Page Address register (PSVPAG) is used to define a 16K word page in the program space. When the MSb of the EA is '1', PSVPAG is concatenated with the lower 15 bits of the EA to form a 23-bit program space address. Unlike the table operations, this limits remapping operations strictly to the user memory area.

See Table 4-35 and Figure 4-5 to know how the program EA is created for table operations and remapping accesses from the data EA. Here, P<23:0> refers to a program space word, whereas D<15:0> refers to a Data Space word.

REGISTER 8-10: IFS5: INTERRUPT FLAG STATUS REGISTER 5

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	U-0	U-0	U-0	R/W-0, HS
—	—	—	—	—	—	—	ULPWUIF
bit 7							bit 0

Legend:	HS = Hardware Settable 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 15-1 **Unimplemented:** Read as '0'

bit 0 **ULPWUIF:** Ultra Low-Power Wake-up Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

REGISTER 8-11: IFS6: INTERRUPT FLAG STATUS REGISTER 6

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	U-0	U-0	R/W-0, HS	R/W-0, HS
—	—	—	—	—	—	CLC2IF	CLC1IF
bit 7							bit 0

Legend:	HS = Hardware Settable 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 15-2 **Unimplemented:** Read as '0'

bit 1 **CLC2IF:** Configurable Logic Cell 2 Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 0 **CLC1IF:** Configurable Logic Cell 1 Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

REGISTER 8-20: IPC1: INTERRUPT PRIORITY CONTROL REGISTER 1

U-0	R/W-1	R/W-0	R/W-0	U-0	R/W-1	R/W-0	R/W-0
—	CCT1IP2	CCT1IP1	CCT1IP0	—	CCP4IP2	CCP4IP1	CCP4IP0
bit 15							bit 8

U-0	R/W-1	R/W-0	R/W-0	U-0	U-0	U-0	U-0
—	CCP3IP2	CCP3IP1	CCP3IP0	—	—	—	—
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 **Unimplemented:** Read as ‘0’

bit 14-12 **CCT1IP<2:0>:** Capture/Compare 1 Timer Interrupt Priority bits
111 = Interrupt is Priority 7 (highest priority interrupt)
•
•
•
001 = Interrupt is Priority 1
000 = Interrupt source is disabled

bit 11 **Unimplemented:** Read as ‘0’

bit 10-8 **CCP4IP<2:0>:** Capture/Compare 4 Event Interrupt Priority bits
111 = Interrupt is Priority 7 (highest priority interrupt)
•
•
•
001 = Interrupt is Priority 1
000 = Interrupt source is disabled

bit 7 **Unimplemented:** Read as ‘0’

bit 6-4 **CCP3IP<2:0>:** Capture/Compare 3 Event Interrupt Priority bits
111 = Interrupt is Priority 7 (highest priority interrupt)
•
•
•
001 = Interrupt is Priority 1
000 = Interrupt source is disabled

bit 3-0 **Unimplemented:** Read as ‘0’

REGISTER 9-2: CLKDIV: CLOCK DIVIDER REGISTER

R/W-0	R/W-0	R/W-1	R/W-1	R/W-0	R/W-0	R/W-0	R/W-1
ROI	DOZE2	DOZE1	DOZE0	DOZEN(1)	RCDIV2	RCDIV1	RCDIV0
bit 15							bit 8

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-0
—	—	—	—	—	—	—	—
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 **ROI:** Recover on Interrupt bit
1 = Interrupts clear the DOZEN bit, and reset the CPU and peripheral clock ratio to 1:1
0 = Interrupts have no effect on the DOZEN bit

bit 14-12 **DOZE<2:0>:** CPU and Peripheral Clock Ratio Select bits
111 = 1:128
110 = 1:64
101 = 1:32
100 = 1:16
011 = 1:8
010 = 1:4
001 = 1:2
000 = 1:1

bit 11 **DOZEN:** Doze Enable bit(1)
1 = DOZE<2:0> bits specify the CPU and peripheral clock ratio
0 = CPU and peripheral clock ratio are set to 1:1

bit 10-8 **RCDIV<2:0>:** FRC Postscaler Select bits
When COSC<2:0> (OSCCON<14:12>) = 111:
111 = 31.25 kHz (divide-by-256)
110 = 125 kHz (divide-by-64)
101 = 250 kHz (divide-by-32)
100 = 500 kHz (divide-by-16)
011 = 1 MHz (divide-by-8)
010 = 2 MHz (divide-by-4)
001 = 4 MHz (divide-by-2) – default
000 = 8 MHz (divide-by-1)
When COSC<2:0> (OSCCON<14:12>) = 110:
111 = 1.95 kHz (divide-by-256)
110 = 7.81 kHz (divide-by-64)
101 = 15.62 kHz (divide-by-32)
100 = 31.25 kHz (divide-by-16)
011 = 62.5 kHz (divide-by-8)
010 = 125 kHz (divide-by-4)
001 = 250 kHz (divide-by-2) – default
000 = 500 kHz (divide-by-1)

bit 7-0 **Unimplemented:** Read as '0'

Note 1: This bit is automatically cleared when the ROI bit is set and an interrupt occurs.

10.4 Voltage Regulator-Based Power-Saving Features

The PIC24FV16KM204 family series devices have a voltage regulator that has the ability to alter functionality to provide power savings. The on-chip regulator is made up of two basic modules: the Voltage Regulator (VREG) and the Retention Regulator (RETREG). With the combination of VREG and RETREG, the following power modes are available:

10.4.1 RUN MODE

In Run mode, the main VREG is providing a regulated voltage with enough current to supply a device running at full speed and the device is not in Sleep mode. The RETREG may or may not be running, but is unused.

10.4.2 SLEEP MODE

In Sleep mode, the device is in Sleep and the main VREG is providing a regulated voltage to the core. By default, in Sleep mode, the regulator enters a low-power standby state which consumes reduced quiescent current. The PMSLP bit (RCON<8>) controls the regulator state in Sleep mode. If the PMSLP bit is set, the program Flash memory will stay powered on during Sleep mode and the regulator will stay in its full-power mode.

10.4.3 RETENTION REGULATOR

The Retention Regulator, sometimes referred to as the low-voltage regulator, is designed to provide power to the core at a lower voltage than the standard voltage regulator, while consuming significantly lower quiescent current. Refer to **Section 27.0 "Electrical Characteristics"** for the voltage output range of the RETREG. This regulator is only used in Sleep mode, and has limited output current to maintain the RAM and provide power for limited peripherals, such as the WDT, while the device is in Sleep. It is controlled by the RETCFG Configuration bit (FPOR<2>) and in firmware by the RETEN bit (RCON<12>). RETCFG must be programmed (= 0) and the RETEN bit must be set (= 1) for the Retention Regulator to be enabled.

10.4.4 RETENTION SLEEP MODE

In Retention Sleep mode, the device is in Sleep and all regulated voltage is provided solely by the RETREG, while the main VREG is disabled. Consequently, this mode provides the lowest Sleep power consumption, but has a trade-off of a longer wake-up time. The low-voltage Sleep wake-up time is longer than Sleep mode due to the extra time required to re-enable the VREG and raise the V_{DDCORE} supply rail back to normal regulated levels.

Note:	The PIC24F16KM204 family devices do not have any internal voltage regulation, and therefore, do not support Retention Sleep mode.

TABLE 10-1: VOLTAGE REGULATION CONFIGURATION SETTINGS FOR PIC24FXXXXX FAMILY DEVICES

RETCFG Bit (FPOR<2>)	RETEN Bit (RCON<12>	PMSLP Bit (RCON<8>)	Power Mode During Sleep	Description
0	0	1	Sleep	VREG mode (normal) is unchanged during Sleep. RETREG is unused.
0	0	0	Sleep (Standby)	VREG goes to Low-Power Standby mode during Sleep. RETREG is unused.
0	1	0	Retention Sleep	VREG is off during Sleep. RETREG is enabled and provides Sleep voltage regulation.
1	x	1	Sleep	VREG mode (normal) is unchanged during Sleep. RETREG is disabled at all times.
1	x	0	Sleep (Standby)	VREG goes to Low-Power Standby mode during Sleep. RETREG is disabled at all times.

REGISTER 14-1: SSPxSTAT: MSSPx STATUS REGISTER (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-0	R-0	R-0	R-0	R-0	R-0
SMP	CKE(1)	D/$\overline{A}$	P	S	R/$\overline{W}$	UA	BF
bit 7							bit 0

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

bit 15-8 **Unimplemented:** Read as '0'

bit 7 **SMP:** Sample bit
SPI Master mode:
1 = Input data is sampled at the end of data output time
0 = Input data is sampled at the middle of data output time
SPI Slave mode:
SMP must be cleared when SPI is used in Slave mode.

bit 6 **CKE:** SPI Clock Select bit(1)
1 = Transmit occurs on transition from active to Idle clock state
0 = Transmit occurs on transition from Idle to active clock state

bit 5 **D/$\overline{A}$:** Data/$\overline{\text{Address}}$ bit
Used in I^{2}C™ mode only.

bit 4 **P:** Stop bit
Used in I^{2}C mode only. This bit is cleared when the MSSPx module is disabled; SSPEN bit is cleared.

bit 3 **S:** Start bit
Used in I^{2}C mode only.

bit 2 **R/$\overline{W}$:** Read/$\overline{\text{Write}}$ Information bit
Used in I^{2}C mode only.

bit 1 **UA:** Update Address bit
Used in I^{2}C mode only.

bit 0 **BF:** Buffer Full Status bit
1 = Receive is complete, SSPxBUF is full
0 = Receive is not complete, SSPxBUF is empty

Note 1: Polarity of clock state is set by the CKP bit (SSPxCON1<4>).

REGISTER 14-8: SSPxADD: MSSPx SLAVE ADDRESS/BAUD RATE GENERATOR 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
ADD7	ADD6	ADD5	ADD4	ADD3	ADD2	ADD1	ADD0
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 7-0 **ADD<7:0>:** Slave Address/Baud Rate Generator Value bits

SPI Master and I²C™ Master modes:
Reload value for the Baud Rate Generator. Clock period is (([SPxADD] + 1) * 2)/FOSC.

I²C Slave modes:
Represents 7 or 8 bits of the slave address, depending on the addressing mode used:

7-Bit mode: Address is ADD<7:1>; ADD<0> is ignored.

10-Bit LSb mode: ADD<7:0> are the Least Significant bits of the address.

10-Bit MSb mode: ADD<2:1> are the two Most Significant bits of the address; ADD<7:3> are always '11110' as a specification requirement; ADD<0> is ignored.

REGISTER 14-9: SSPxMSK: I²C™ SLAVE ADDRESS MASK REGISTER

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

R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
MSK7	MSK6	MSK5	MSK4	MSK3	MSK2	MSK1	MSK0(1)
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 7-0 **MSK<7:0>:** Slave Address Mask Select bits(1)

1 = Masking of corresponding bit of SSPxADD is enabled
0 = Masking of corresponding bit of SSPxADD is disabled

Note 1: MSK0 is not used as a mask bit in 7-bit addressing.

16.2 RTCC Module Registers

The RTCC module registers are organized into three categories:

- RTCC Control Registers
- RTCC Value Registers
- Alarm Value Registers

16.2.1 REGISTER MAPPING

To limit the register interface, the RTCC Timer and Alarm Time registers are accessed through corresponding register pointers. The RTCC Value register window (RTCVALH and RTCVALL) uses the RTCPTRx bits (RCFGCAL<9:8>) to select the desired Timer register pair (see Table 16-1).

By writing the RTCVALH byte, the RTCC Pointer value, the RTCPTR<1:0> bits decrement by one until they reach '00'. Once they reach '00', the MINUTES and SECONDS value will be accessible through RTCVALH and RTCVALL until the pointer value is manually changed.

TABLE 16-1: RTCVAL REGISTER MAPPING

RTCPTR<1:0>	RTCC Value Register Window	
	RTCVAL<15:8>	RTCVAL<7:0>
00	MINUTES	SECONDS
01	WEEKDAY	HOURS
10	MONTH	DAY
11	—	YEAR

The Alarm Value register window (ALRMVALH and ALRMVALL) uses the ALRMPTRx bits (ALCFGRPT<9:8>) to select the desired Alarm register pair (see Table 16-2).

By writing the ALRMVALH byte, the ALRMPTR<1:0> bits (Alarm Pointer value) decrement by one until they reach '00'. Once they reach '00', the ALRMMIN and ALRMSEC value will be accessible through ALRMVALH and ALRMVALL, until the pointer value is manually changed.

TABLE 16-2: ALRMVAL REGISTER MAPPING

ALRMPTR <1:0>	Alarm Value Register Window	
	ALRMVALH<15:8>	ALRMVALL<7:0>
00	ALRMMIN	ALRMSEC
01	ALRMWD	ALRMHR
10	ALRMMNTH	ALRMDAY
11	PWCSTAB	PWCSAMP

Considering that the 16-bit core does not distinguish between 8-bit and 16-bit read operations, the user must be aware that when reading either the ALRMVALH or ALRMVALL bytes, the ALRMPTR<1:0> value will be decremented. The same applies to the RTCVALH or RTCVALL bytes with the RTCPTR<1:0> being decremented.

Note: This only applies to read operations and not write operations.

16.2.2 WRITE LOCK

In order to perform a write to any of the RTCC Timer registers, the RTCWREN bit (RCFGCAL<13>) must be set (see Example 16-1 and Example 16-2).

Note: To avoid accidental writes to the timer, it is recommended that the RTCWREN bit (RCFGCAL<13>) is kept clear at any other time. For the RTCWREN bit to be set, there is only one instruction cycle time window allowed between the 55h/AA sequence and the setting of RTCWREN. Therefore, it is recommended that code follow the procedure in Example 16-2.

16.2.3 SELECTING RTCC CLOCK SOURCE

There are four reference source clock options that can be selected for the RTCC using the RTCCLK<1:0> bits (RTCPWC<11:10>): 00 = Secondary Oscillator, 01 = LPRC, 10 = 50 Hz External Clock and 11 = 60 Hz External Clock.

EXAMPLE 16-1: SETTING THE RTCWREN BIT IN ASSEMBLY

```
push    w7              ; Store W7 and W8 values on the stack.
push    w8
disi    #5              ; Disable interrupts until sequence is complete.
mov     #0x55, w7       ; Write 0x55 unlock value to NVMKEY.
mov     w7, NVMKEY
mov     #0xAA, w8       ; Write 0xAA unlock value to NVMKEY.
mov     w8, NVMKEY
bset    RCFGCAL, #13    ; Set the RTCWREN bit.
pop     w8              ; Restore the original W register values from the stack.
pop     w7
```

EXAMPLE 16-2: SETTING THE RTCWREN BIT IN 'C'

```
//This builtin function executes implements the unlock sequence and sets
//the RTCWREN bit.
__builtin_write_RTCWEN();
```

REGISTER 21-1: AMPxCON: OP AMP x CONTROL REGISTER(1)

R/W-0	U-0	R/W-0	R/W-0	U-0	U-0	U-0	U-0
AMPEN	—	AMPSIDL	AMPSLP	—	—	—	—
bit 15							bit 8

R/W-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
SPDSEL	—	NINSEL2	NINSEL1	NINSEL0	PINSEL2	PINSEL1	PINSEL0
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 **AMPEN:** Op Amp x Control Module Enable bit
1 = Module is enabled
0 = Module is disabled

bit 14 **Unimplemented:** Read as '0'

bit 13 **AMPSIDL:** Op Amp x Peripheral Stop in Idle Mode bit
1 = Discontinues module operation when device enters Idle mode
0 = Continues module operation in Idle mode

bit 12 **AMPSLP:** Op Amp x Peripheral Enabled in Sleep Mode bit
1 = Continues module operation when device enters Sleep mode
0 = Discontinues module operation in Sleep mode

bit 11-8 **Unimplemented:** Read as '0'

bit 7 **SPDSEL:** Op Amp x Power/Speed Select bit
1 = Higher power and bandwidth (faster response time)
0 = Lower power and bandwidth (slower response time)

bit 6 **Unimplemented:** Read as '0'

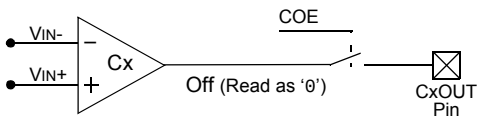
bit 5-3 **NINSEL<2:0>:** Negative Op Amp Input Select bits
111 = Reserved; do not use
110 = Reserved; do not use
101 = Op amp negative input is connected to the op amp output (voltage follower)
100 = Reserved; do not use
011 = Reserved; do not use
010 = Op amp negative input is connected to the OAxIND pin
001 = Op amp negative input is connected to the OAxINB pin
000 = Op amp negative input is connected to AVSS

bit 2-0 **PINSEL<2:0>:** Positive Op Amp Input Select bits
111 = Op amp positive input is connected to the output of the A/D input multiplexer
110 = Reserved; do not use
101 = Op amp positive input is connected to the DAC1 output for OA1 (DAC2 output for OA2)
100 = Reserved; do not use
011 = Reserved; do not use
010 = Op amp positive input is connected to the OAxINC pin
001 = Op amp positive input is connected to the OAxINA pin
000 = Op amp positive input is connected to AVSS

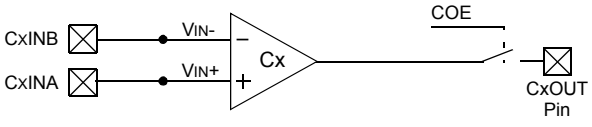
Note 1: This register is available only on PIC24F(V)16KM2XX devices.

FIGURE 22-2: INDIVIDUAL COMPARATOR CONFIGURATIONS

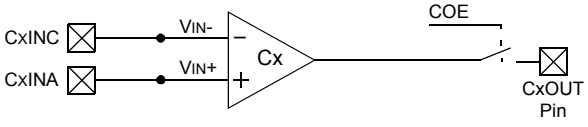
Comparator Off
CON = 0, CREF<1:0> = xx, CCH<1:0> = xx



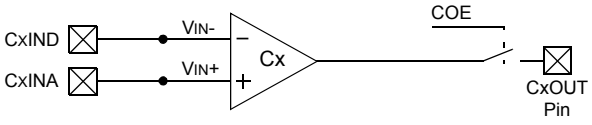
Comparator CxINB > CxINA Compare
CON = 1, CREF<1:0> = 00, CCH<1:0> = 00



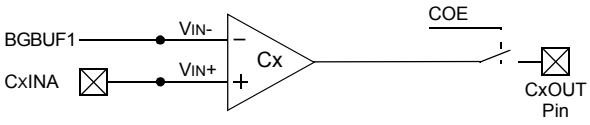
Comparator CxINC > CxINA Compare
CON = 1, CREF<1:0> = 00, CCH<1:0> = 01



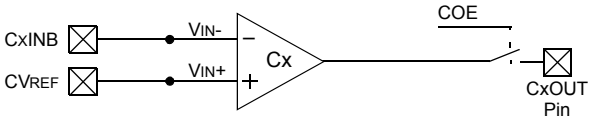
Comparator CxIND > CxINA Compare
CON = 1, CREF<1:0> = 00, CCH<1:0> = 10



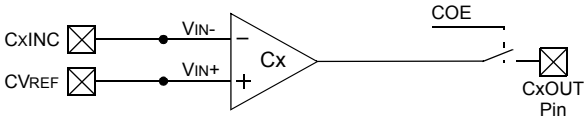
Comparator BGBUF1 > CxINA Compare
CON = 1, CREF<1:0> = 00, CCH<1:0> = 11



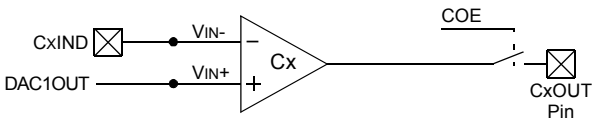
Comparator CxINB > CVREF Compare
CON = 1, CREF<1:0> = 01, CCH<1:0> = 00



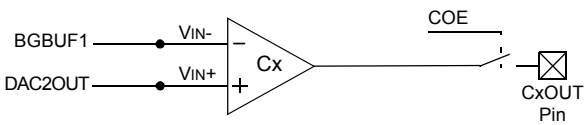
Comparator CxINC > CVREF Compare
CON = 1, CREF<1:0> = 01, CCH<1:0> = 01



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 24-1: CTMUCON1L: CTMU CONTROL 1 LOW REGISTER (CONTINUED)

bit 1-0 **IRNG<1:0>:** Current Source Range Select bits
11 = 100 × Base Current
10 = 10 × Base Current
01 = Base Current Level (0.55 µA nominal)
00 = 1000 × Base Current

TABLE 27-7: DC CHARACTERISTICS: IDLE CURRENT (IIDLE)

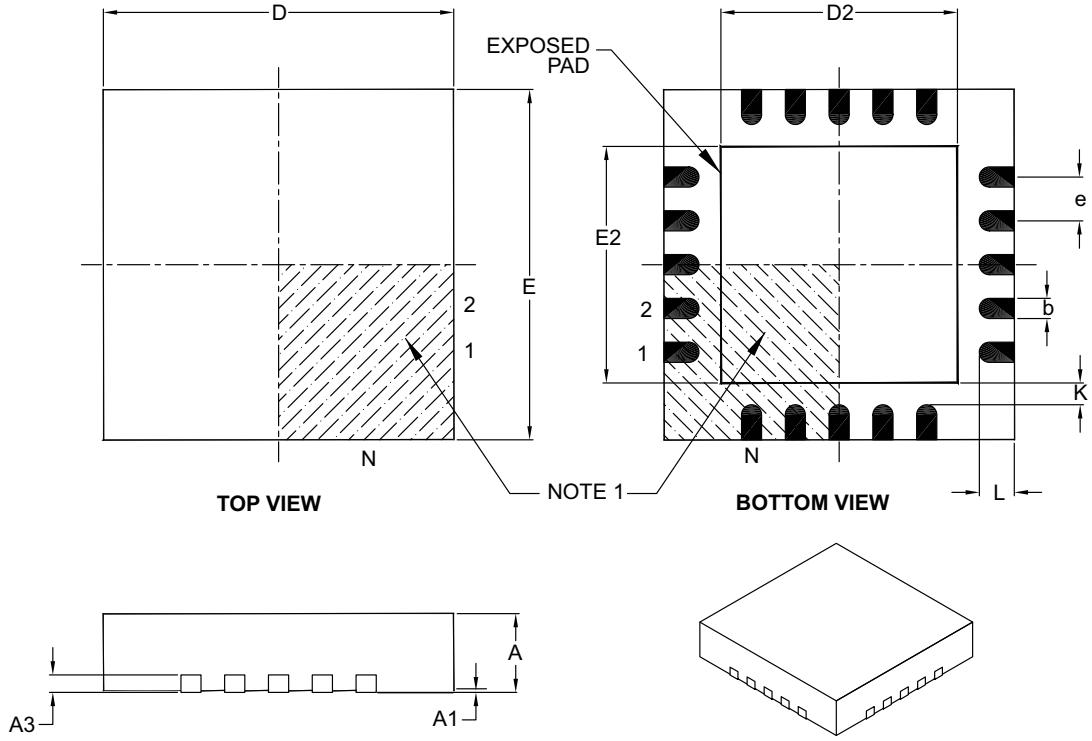
DC CHARACTERISTICS		Standard Operating Conditions: 1.8V to 3.6V (PIC24F16KMXXX) 2.0V to 5.5V (PIC24FV16KMXXX) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Parameter No.	**Device**	**Typical**	**Max**	**Units**	**Conditions**	
Idle Current (IIDLE)						
DC40	PIC24FV16KMXXX	120	200	µA	2.0V	0.5 MIPS, FOSC = 1 MHz(1)
		160	430	µA	5.0V	
	PIC24F16KMXXX	50	100	µA	1.8V	
		90	370	µA	3.3V	
DC42	PIC24FV16KMXXX	165	—	µA	2.0V	1 MIPS, FOSC = 2 MHz(1)
		260	—	µA	5.0V	
	PIC24F16KMXXX	95	—	µA	1.8V	
		180	—	µA	3.3V	
DC44	PIC24FV16KMXXX	3.1	6.5	mA	5.0V	16 MIPS, FOSC = 32 MHz(1)
	PIC24F16KMXXX	2.9	6.0	mA	3.3V	
DC46	PIC24FV16KMXXX	0.65	—	mA	2.0V	FRC (4 MIPS), FOSC = 8 MHz
		1.0	—	mA	5.0V	
	PIC24F16KMXXX	0.55	—	mA	1.8V	
		1.0	—	mA	3.3V	
DC50	PIC24FV16KMXXX	42	200	µA	2.0V	LPRC (15.5 KIPS), FOSC = 31 kHz
		65	225	µA	5.0V	
	PIC24F16KMXXX	2.2	18	µA	1.8V	
		4.0	40	µA	3.3V	

Legend: Unshaded rows represent PIC24F16KMXXX devices and shaded rows represent PIC24FV16KMXXX devices.

Note 1: The oscillator is in External Clock mode (FOSCSEL<2:0> = 010, FOSC<1:0> = 00).

20-Lead Plastic Quad Flat, No Lead Package (ML) – 4x4x0.9 mm Body [QFN]

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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		20	
Pitch	e		0.50 BSC	
Overall Height	A	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Contact Thickness	A3		0.20 REF	
Overall Width	E		4.00 BSC	
Exposed Pad Width	E2	2.60	2.70	2.80
Overall Length	D		4.00 BSC	
Exposed Pad Length	D2	2.60	2.70	2.80
Contact Width	b	0.18	0.25	0.30
Contact Length	L	0.30	0.40	0.50
Contact-to-Exposed Pad	K	0.20	–	–

Notes:

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

BSC: Basic Dimension. Theoretically exact value shown without tolerances.
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-126B

NOTES: