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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	24
Program Memory Size	16KB (5.5K 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 19x10b/12b; D/A 2x8b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	28-SSOP (0.209", 5.30mm Width)
Supplier Device Package	28-SSOP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic24f16km202-e-ss

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			
RB9	13	18	15	1	1	13	18	15	1	1	I/O	ST	PORTB Pins
RB10	—	21	18	8	9	—	21	18	8	9	I/O	ST	PORTB Pins
RB11	—	22	19	9	10	—	22	19	9	10	I/O	ST	PORTB Pins
RB12	15	23	20	10	11	15	23	20	10	11	I/O	ST	PORTB Pins
RB13	16	24	21	11	12	16	24	21	11	12	I/O	ST	PORTB Pins
RB14	17	25	22	14	15	17	25	22	14	15	I/O	ST	PORTB Pins
RB15	18	26	23	15	16	18	26	23	15	16	I/O	ST	PORTB Pins
RC0	—	—	—	25	27	—	—	—	25	27	I/O	ST	PORTC Pins
RC1	—	—	—	26	28	—	—	—	26	28	I/O	ST	PORTC Pins
RC2	—	—	—	27	29	—	—	—	27	29	I/O	ST	PORTC Pins
RC3	—	—	—	36	39	—	—	—	36	39	I/O	ST	PORTC Pins
RC4	—	—	—	37	40	—	—	—	37	40	I/O	ST	PORTC Pins
RC5	—	—	—	38	41	—	—	—	38	41	I/O	ST	PORTC Pins
RC6	—	—	—	2	2	—	—	—	2	2	I/O	ST	PORTC Pins
RC7	—	—	—	3	3	—	—	—	3	3	I/O	ST	PORTC Pins
RC8	—	—	—	4	4	—	—	—	4	4	I/O	ST	PORTC Pins
RC9	—	—	—	5	5	—	—	—	5	5	I/O	ST	PORTC Pins
REFO	18	26	23	15	16	18	26	23	15	16	O	—	Reference Clock Output
RTCC	—	25	22	14	15	—	25	22	14	15	O	—	Real-Time Clock/Calendar Output
SCK1	15	22	19	9	10	15	22	19	9	10	I/O	ST	MSSP1 SPI Clock
SDI1	17	21	18	8	9	17	21	18	8	9	I	ST	MSSP1 SPI Data Input
SDO1	16	24	21	11	12	16	24	21	11	12	O	—	MSSP1 SPI Data Output
$\overline{SS1}$	18	26	23	15	16	18	26	23	15	16	I	ST	MSSP1 SPI Slave Select Input
SCK2	—	14	11	38	41	—	14	11	38	41	I/O	ST	MSSP2 SPI Clock
SDI2	—	19	16	36	39	—	19	16	36	39	I	ST	MSSP2 SPI Data Input
SDO2	—	15	12	37	40	—	15	12	37	40	O	—	MSSP2 SPI Data Output
$\overline{SS2}$	—	23	20	35	38	—	23	20	35	38	I	ST	MSSP2 SPI Slave Select Input

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

NOTES:

TABLE 4-4: ICN 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
CNPD1	56h	CN15PDE(1,2)	CN14PDE	CN13PDE	CN12PDE	CN11PDE	CN10PDE(2)	CN9PDE(1,2)	—	CN7PDE(1,2)	CN6PDE	CN5PDE	CN4PDE	CN3PDE	CN2PDE	CN1PDE	CN0PDE	0000
CNPD2	58h	CN31PDE(2)	CN30PDE	CN29PDE	CN28PDE(2)	CN27PDE(1,2)	CN26PDE(2)	CN25PDE(2)	CN24PDE(1,2)	CN23PDE	CN22PDE	CN21PDE	CN20PDE(2)	CN19PDE(2)	CN18PDE(2)	CN17PDE(2)	CN16PDE(1,2)	0000
CNPD3	5Ah	—	—	—	—	—	—	—	—	—	—	—	CN36PDE(2)	CN35PDE(2)	CN34PDE(2)	CN33PDE(2)	CN32PDE(2)	0000
CNEN1	62h	CN15IE(1,2)	CN14IE	CN13IE	CN12IE	CN11IE	CN10IE(2)	CN9IE(1,2)	—	CN7IE(1,2)	CN6IE	CN5IE	CN4IE	CN3IE	CN2IE	CN1IE	CN0IE	0000
CNEN2	64h	CN31IE(2)	CN30IE	CN29IE	CN28IE(2)	CN27IE(1,2)	CN26IE(2)	CN25IE(2)	CN24IE(1,2)	CN23IE	CN22IE	CN21IE	CN20IE(2)	CN19IE(2)	CN18IE(2)	CN17IE(2)	CN16IE(1,2)	0000
CNEN3	66h	—	—	—	—	—	—	—	—	—	—	—	CN36IE(2)	CN35IE(2)	CN34IE(2)	CN33IE(2)	CN32IE(2)	0000
CNPU1	6Eh	CN15PUE(1,2)	CN14PUE	CN13PUE	CN12PUE	CN11PUE	CN10PUE(2)	CN9PUE(1,2)	—	CN7PUE(1,2)	CN6PUE	CN5PUE	CN4PUE	CN3PUE	CN2PUE	CN1PUE	CN0PUE	0000
CNPU2	70h	CN31PUE(2)	CN30PUE	CN29PUE	CN28PUE(2)	CN27PUE(1,2)	CN26PUE(2)	CN25PUE(2)	CN24PUE(1,2)	CN23PUE	CN22PUE	CN21PUE	CN20PUE(2)	CN19PUE(2)	CN18PUE(2)	CN17PUE(2)	CN16PUE(1,2)	0000
CNPU3	72h	—	—	—	—	—	—	—	—	—	—	—	CN36PUE(2)	CN35PUE(2)	CN34PUE(2)	CN33PUE(2)	CN32PUE(2)	0000

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

Note 1: These bits are available only on 28-pin devices

2: These bits are available only on 44-pin devices

TABLE 4-13: MSSP1 (I^2C™/SPI) 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
SSP1BUF	200h	—	—	—	—	—	—	—	—	MSSP1 Receive Buffer/Transmit Register								00xx
SSP1CON1	202h	—	—	—	—	—	—	—	—	WCOL	SSPOV	SSPEN	CKP	SSPM3	SSPM2	SSPM1	SSPM0	0000
SSP1CON2	204h	—	—	—	—	—	—	—	—	GCEN	ACKSTAT	ACKDT	ACKEN	RCEN	PEN	RSEN	SEN	0000
SSP1CON3	206h	—	—	—	—	—	—	—	—	ACKTIM	PCIE	SCIE	BOEN	SDAHT	SBCDE	AHEN	DHEN	0000
SSP1STAT	208h	—	—	—	—	—	—	—	—	SMP	CKE	D/$\overline{A}$	P	S	R/$\overline{W}$	UA	BF	0000
SSP1ADD	20Ah	—	—	—	—	—	—	—	—	MSSP1 Address Register in I^2C Slave Mode MSSP1 Baud Rate Reload Register in I^2C Master Mode								0000
SSP1MSK	20Ch	—	—	—	—	—	—	—	—	MSK7	MSK6	MSK5	MSK4	MSK3	MSK2	MSK1	MSK0	00FF

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

TABLE 4-14: MSSP2 (I^2C™/SPI) 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
SSP2BUF(1)	210h	—	—	—	—	—	—	—	—	MSSP2 Receive Buffer/Transmit Register								00xx
SSP2CON1(1)	212h	—	—	—	—	—	—	—	—	WCOL	SSPOV	SSPEN	CKP	SSPM3	SSPM2	SSPM1	SSPM0	0000
SSP2CON2(1)	214h	—	—	—	—	—	—	—	—	GCEN	ACKSTAT	ACKDT	ACKEN	RCEN	PEN	RSEN	SEN	0000
SSP2CON3(1)	216h	—	—	—	—	—	—	—	—	ACKTIM	PCIE	SCIE	BOEN	SDAHT	SBCDE	AHEN	DHEN	0000
SSP2STAT(1)	218h	—	—	—	—	—	—	—	—	SMP	CKE	D/$\overline{A}$	P	S	R/$\overline{W}$	UA	BF	0000
SSP2ADD(1)	21Ah	—	—	—	—	—	—	—	—	MSSP2 Address Register in I^2C Slave Mode MSSP2 Baud Rate Reload Register in I^2C Master Mode								0000
SSP2MSK(1)	21Ch	—	—	—	—	—	—	—	—	MSK7	MSK6	MSK5	MSK4	MSK3	MSK2	MSK1	MSK0	00FF

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.

5.5.1 PROGRAMMING ALGORITHM FOR FLASH PROGRAM MEMORY

The user can program one row of Flash program memory at a time by erasing the programmable row. The general process is:

1. Read a row of program memory (32 instructions) and store in data RAM.
2. Update the program data in RAM with the desired new data.
3. Erase a row (see Example 5-1):
   a) Set the NVMOPx bits (NVMCON<5:0>) to '011000' to configure for row erase. Set the ERASE (NVMCON<6>) and WREN (NVMCON<14>) bits.
   b) Write the starting address of the block to be erased into the TBLPAG and W registers.
   c) Write 55h to NVMKEY.
   d) Write AAh to NVMKEY.
   e) Set the WR bit (NVMCON<15>). The erase cycle begins and the CPU stalls for the duration of the erase cycle. When the erase is done, the WR bit is cleared automatically.
4. Write the first 32 instructions from data RAM into the program memory buffers (see Example 5-1).
5. Write the program block to Flash memory:
   a) Set the NVMOPx bits to '000100' to configure for row programming. Clear the ERASE bit and set the WREN bit.
   b) Write 55h to NVMKEY.
   c) Write AAh to NVMKEY.
   d) Set the WR bit. The programming cycle begins and the CPU stalls for the duration of the write cycle. When the write to Flash memory is done, the WR bit is cleared automatically.

For protection against accidental operations, the write initiate sequence for NVMKEY must be used to allow any erase or program operation to proceed. After the programming command has been executed, the user must wait for the programming time until programming is complete. The two instructions following the start of the programming sequence should be NOPs, as displayed in Example 5-5.

EXAMPLE 5-1: ERASING A PROGRAM MEMORY ROW – ASSEMBLY LANGUAGE CODE

```
; Set up NVMCON for row erase operation
        MOV     #0x4058, W0                 ;
        MOV     W0, NVMCON                  ; Initialize NVMCON
; Init pointer to row to be ERASED
        MOV     #tblpage(PROG_ADDR), W0     ;
        MOV     W0, TBLPAG                  ; Initialize PM Page Boundary SFR
        MOV     #tbloffset(PROG_ADDR), W0   ; Initialize in-page EA[15:0] pointer
        TBLWTL  W0, [W0]                    ; Set base address of erase block
        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                                 ; Insert two NOPs after the erase
        NOP                                 ; command is asserted
```

EXAMPLE 5-2: ERASING A PROGRAM MEMORY ROW – 'C' LANGUAGE CODE

```
// C example using MPLAB C30

int __attribute__ ((space(auto_psv))) progAddr = 0x1234;    // Variable located in Pgm Memory, declared as a
                                                            // global variable
    unsigned int offset;

//Set up pointer to the first memory location to be written

    TBLPAG = __builtin_tblpage(&progAddr);                  // Initialize PM Page Boundary SFR
    offset = __builtin_tbloffset(&progAddr);                // Initialize lower word of address

    __builtin_tblwtl(offset, 0x0000);                       // Set base address of erase block
                                                            // with dummy latch write

    NVMCON = 0x4058;                                        // Initialize NVMCON

    asm("DISI #5");                                         // Block all interrupts for next 5 instructions
    __builtin_write_NVM();                                  // C30 function to perform unlock
                                                            // sequence and set WR
```

REGISTER 8-6: IFS1: INTERRUPT FLAG STATUS REGISTER 1

R/W-0, HS	R/W-0, HS	R/W-0, HS	R/W-0, HS	R/W-0, HS	U-0	U-0	U-0
U2TXIF	U2RXIF	INT2IF	CCT4IF	CCT3IF	—	—	—
bit 15							bit 8

U-0	R/W-0, HS	U-0	R/W-0, HS	R/W-0, HS	R/W-0, HS	R/W-0, HS	R/W-0, HS
—	CCP5IF	—	INT1IF	CNIF	CMIF	BCL1IF	SSP1IF
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 **U2TXIF:** UART2 Transmitter Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 14 **U2RXIF:** UART2 Receiver Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 13 **INT2IF:** External Interrupt 2 Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 12 **CCT4IF:** Capture/Compare 4 Timer Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 11 **CCT3IF:** Capture/Compare 3 Timer Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 10-7 **Unimplemented:** Read as '0'

bit 6 **CCP5IF:** Capture/Compare 5 Event Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

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

bit 4 **INT1IF:** External Interrupt 1 Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 3 **CNIF:** Input Change Notification Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 2 **CMIF:** Comparator Interrupt Flag Status Bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 1 **BCL1IF:** MSSP1 I^2C™ Bus Collision Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

bit 0 **SI2C1IF:** MSSP1 SPI/I^2C Event Interrupt Flag Status bit
1 = Interrupt request has occurred
0 = Interrupt request has not occurred

REGISTER 8-28: IPC12: INTERRUPT PRIORITY CONTROL REGISTER 12

U-0	U-0	U-0	U-0	U-0	R/W-1	R/W-0	R/W-0
—	—	—	—	—	BCL2IP2	BCL2IP1	BCL2IP0
bit 15							bit 8

U-0	R/W-1	R/W-0	R/W-0	U-0	U-0	U-0	U-0
—	SSP2IP2	SSP2IP1	SSP2IP0	—	—	—	—
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 15-11 **Unimplemented:** Read as '0'

bit 10-8 **BCL2IP<2:0>:** MSSP2 I^{2}C™ Bus Collision 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 **SSP2IP<2:0>:** MSSP2 SPI/I^{2}C 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'

9.0 OSCILLATOR CONFIGURATION

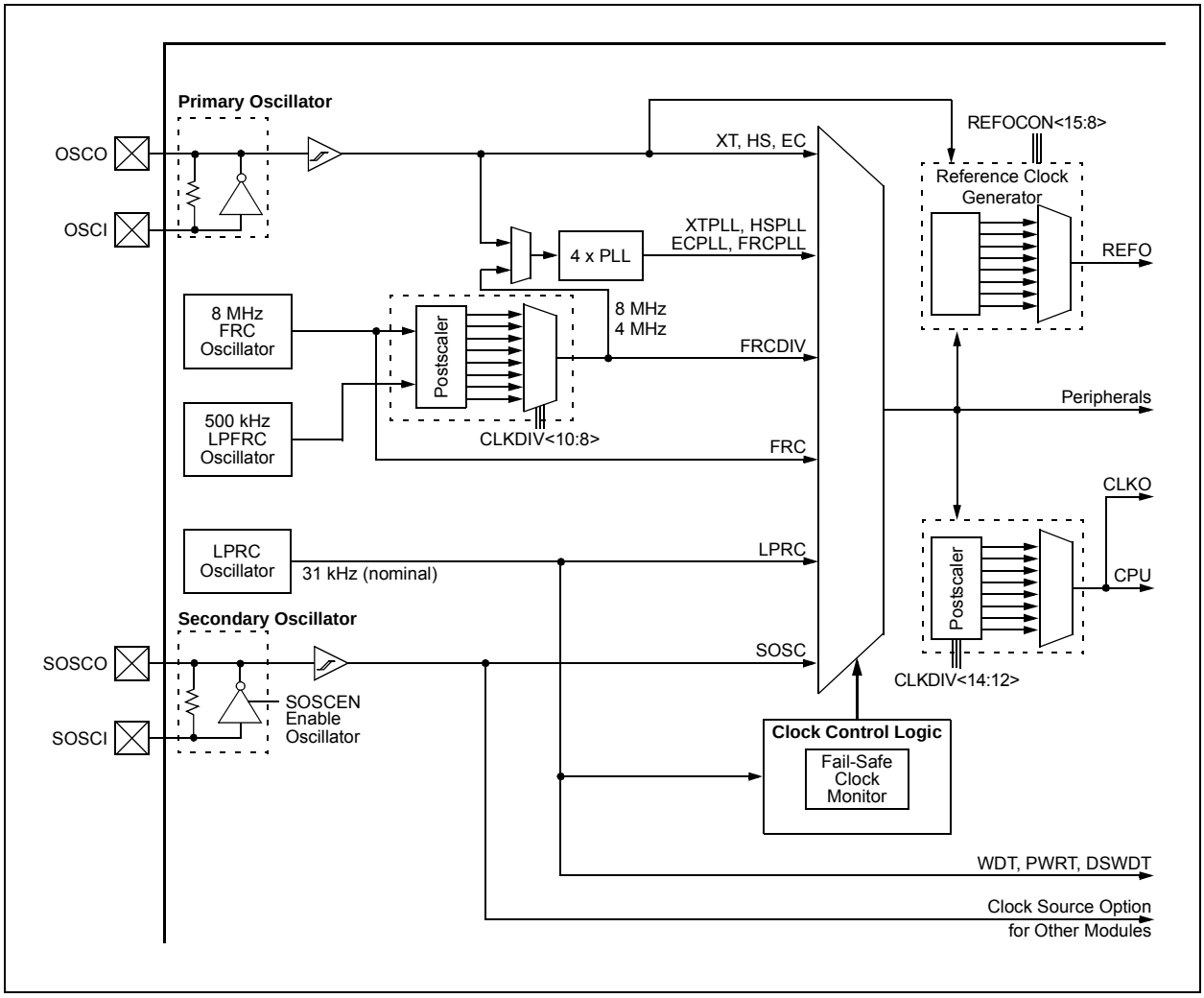
Note: This data sheet summarizes the features of this group of PIC24F devices. It is not intended to be a comprehensive reference source. For more information on oscillator configuration, refer to the *"PIC24F Family Reference Manual"*, **"Oscillator with 500 kHz Low-Power FRC"** (DS39726).

The oscillator system for the PIC24FV16KM204 family of devices has the following features:

- A total of five external and internal oscillator options as clock sources, providing 11 different clock modes.
- On-chip 4x Phase Locked Loop (PLL) to boost internal operating frequency on select internal and external oscillator sources.
- Software-controllable switching between various clock sources.
- Software-controllable postscaler for selective clocking of CPU for system power savings.
- System frequency range declaration bits for External Clock (EC) mode. When using an EC source, the current consumption is reduced by setting the declaration bits to the expected frequency range.
- A Fail-Safe Clock Monitor (FSCM) that detects clock failure and permits safe application recovery or shutdown.

A simplified diagram of the oscillator system is shown in Figure 9-1.

FIGURE 9-1: PIC24FXXXXX FAMILY CLOCK DIAGRAM



11.1.1 OPEN-DRAIN CONFIGURATION

In addition to the PORT, LAT and TRIS registers for data control, each port pin can also be individually configured for either digital or open-drain output. This is controlled by the Open-Drain Control register, ODCx, associated with each port. Setting any of the bits configures the corresponding pin to act as an open-drain output.

The maximum open-drain voltage allowed is the same as the maximum VIH specification.

11.2 Configuring Analog Port Pins

The use of the ANSx and TRISx registers controls the operation of the A/D port pins. The port pins that are desired as analog inputs must have their corresponding TRISx bit set (input). If the TRISx bit is cleared (output), the digital output level (VOH or VOL) will be converted.

When reading the PORTx register, all pins configured as analog input channels will read as cleared (a low level). Analog levels on any pin that is defined as a digital input (including the ANx pins) may cause the input buffer to consume current that exceeds the device specifications.

11.2.1 ANALOG SELECTION REGISTER

I/O pins with shared analog functionality, such as A/D inputs and comparator inputs, must have their digital inputs shut off when analog functionality is used. Note that analog functionality includes an analog voltage being applied to the pin externally.

To allow for analog control, the ANSx registers are provided. There is one ANSx register for each port (ANSA, ANSB and ANSC). Within each ANSx register, there is a bit for each pin that shares analog functionality with the digital I/O functionality.

If a particular pin does not have an analog function, that bit is unimplemented. See Register 11-1 to Register 11-3 for implementation.

REGISTER 11-1: ANSA: PORTA ANALOG SELECTION 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	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
—	—	—	ANSA4(1)	ANSA3	ANSA2	ANSA1	ANSA0
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 15-5 **Unimplemented:** Read as ‘0’

bit 4-0 **ANSA<4:0>:** Analog Select Control bits(1)

1 = Digital input buffer is not active (use for analog input)
0 = Digital input buffer is active

Note 1: The ANSA4 bit is not available on 20-pin devices.

REGISTER 14-2: SSPxSTAT: MSSPx STATUS REGISTER (I^2C™ 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	D/$\overline{A}$	P(1)	S(1)	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:** Slew Rate Control bit
In Master or Slave mode:
1 = Slew rate control is disabled for Standard Speed mode (100 kHz and 1 MHz)
0 = Slew rate control is enabled for High-Speed mode (400 kHz)

bit 6 **CKE:** SMBus Select bit
In Master or Slave mode:
1 = Enables SMBus-specific inputs
0 = Disables SMBus-specific inputs

bit 5 **D/$\overline{A}$:** Data/$\overline{Address}$ bit
In Master mode:
Reserved.
In Slave mode:
1 = Indicates that the last byte received or transmitted was data
0 = Indicates that the last byte received or transmitted was address

bit 4 **P:** Stop bit(1)
1 = Indicates that a Stop bit has been detected last
0 = Stop bit was not detected last

bit 3 **S:** Start bit(1)
1 = Indicates that a Start bit has been detected last
0 = Start bit was not detected last

bit 2 **R/$\overline{W}$:** Read/$\overline{Write}$ Information bit
In Slave mode:(2)
1 = Read
0 = Write
In Master mode:(3)
1 = Transmit is in progress
0 = Transmit is not in progress

bit 1 **UA:** Update Address bit (10-Bit Slave mode only)
1 = Indicates that the user needs to update the address in the SSPxADD register
0 = Address does not need to be updated

Note 1: This bit is cleared on Reset and when SSPEN is cleared.

2: This bit holds the R/$\overline{W}$ bit information following the last address match. This bit is only valid from the address match to the next Start bit, Stop bit or not $\overline{ACK}$ bit.

3: ORing this bit with SEN, RSEN, PEN, RCEN or ACKEN will indicate if the MSSPx is in Active mode.

15.2 Transmitting in 8-Bit Data Mode

1. Set up the UARTx:
   a) Write the appropriate values for data, parity and Stop bits.
   b) Write the appropriate baud rate value to the UxBRG register.
   c) Set up transmit and receive interrupt enable and priority bits.
2. Enable the UARTx.
3. Set the UTXEN bit (causes a transmit interrupt, two cycles after being set).
4. Write the data byte to the lower byte of the UxTXREG word. The value will be immediately transferred to the Transmit Shift Register (TSR) and the serial bit stream will start shifting out with the next rising edge of the baud clock.
5. Alternately, the data byte may be transferred while UTXEN = 0, and then, the user may set UTXEN. This will cause the serial bit stream to begin immediately, because the baud clock will start from a cleared state.
6. A transmit interrupt will be generated as per interrupt control bit, UTXISELx.

15.3 Transmitting in 9-Bit Data Mode

1. Set up the UARTx (as described in **Section 15.2 "Transmitting in 8-Bit Data Mode"**).
2. Enable the UARTx.
3. Set the UTXEN bit (causes a transmit interrupt, two cycles after being set).
4. Write UxTXREG as a 16-bit value only.
5. A word write to UxTXREG triggers the transfer of the 9-bit data to the TSR. The serial bit stream will start shifting out with the first rising edge of the baud clock.
6. A transmit interrupt will be generated as per the setting of control bit, UTXISELx.

15.4 Break and Sync Transmit Sequence

The following sequence will send a message frame header, made up of a Break, followed by an Auto-Baud Sync byte.

1. Configure the UARTx for the desired mode.
2. Set UTXEN and UTXBRK – this sets up the Break character.
3. Load the UxTXREG with a dummy character to initiate transmission (value is ignored).
4. Write '55h' to UxTXREG – loads the Sync character into the transmit FIFO.
5. After the Break has been sent, the UTXBRK bit is reset by hardware. The Sync character now transmits.

15.5 Receiving in 8-Bit or 9-Bit Data Mode

1. Set up the UARTx (as described in **Section 15.2 "Transmitting in 8-Bit Data Mode"**).
2. Enable the UARTx.
3. A receive interrupt will be generated when one or more data characters have been received, as per interrupt control bit, URXISELx.
4. Read the OERR bit to determine if an overrun error has occurred. The OERR bit must be reset in software.
5. Read UxRXREG.

The act of reading the UxRXREG character will move the next character to the top of the receive FIFO, including a new set of PERR and FERR values.

15.6 Operation of $\overline{\text{UxCTS}}$ and $\overline{\text{UxRTS}}$ Control Pins

UARTx Clear-To-Send ($\overline{\text{UxCTS}}$) and Request-To-Send ($\overline{\text{UxRTS}}$) are the two hardware controlled pins that are associated with the UARTx module. These two pins allow the UARTx to operate in Simplex and Flow Control modes. They are implemented to control the transmission and reception between the Data Terminal Equipment (DTE). The UEN<1:0> bits in the UxMODE register configure these pins.

15.7 Infrared Support

The UARTx module provides two types of infrared UARTx support: one is the IrDA clock output to support an external IrDA encoder and decoder device (legacy module support), and the other is the full implementation of the IrDA encoder and decoder.

As the IrDA modes require a 16x baud clock, they will only work when the BRGH bit (UxMODE<3>) is '0'.

15.7.1 EXTERNAL IrDA SUPPORT – IrDA CLOCK OUTPUT

To support external IrDA encoder and decoder devices, the UxBCLK pin (same as the $\overline{\text{UxRTS}}$ pin) can be configured to generate the 16x baud clock. When UEN<1:0> = 11, the UxBCLK pin will output the 16x baud clock if the UARTx module is enabled; it can be used to support the IrDA codec chip.

15.7.2 BUILT-IN IrDA ENCODER AND DECODER

The UARTx has full implementation of the IrDA encoder and decoder as part of the UARTx module. The built-in IrDA encoder and decoder functionality is enabled using the IREN bit (UxMODE<12>). When enabled (IREN = 1), the receive pin (UxRX) acts as the input from the infrared receiver. The transmit pin (UxTX) acts as the output to the infrared transmitter.

REGISTER 19-4: AD1CON5: A/D CONTROL REGISTER 5

R/W-0	R/W-0	R/W-0	R/W-0	r-0	U-0	R/W-0	R/W-0
ASEN(1)	LPEN	CTMREQ	BGREQ	r	—	ASINT1	ASINT0
bit 15							bit 8

U-0	U-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	—	—	WM1	WM0	CM1	CM0
bit 7							bit 0

Legend:	r = Reserved 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 **ASEN:** A/D Auto-Scan Enable bit(1)
- 1 = Auto-scan is enabled
- 0 = Auto-scan is disabled

bit 14 **LPEN:** A/D Low-Power Enable bit
- 1 = Returns to Low-Power mode after scan
- 0 = Remains in Full-Power mode after scan

bit 13 **CTMREQ:** CTMU Request bit
- 1 = CTMU is enabled when the A/D is enabled and active
- 0 = CTMU is not enabled by the A/D

bit 12 **BGREQ:** Band Gap Request bit
- 1 = Band gap is enabled when the A/D is enabled and active
- 0 = Band gap is not enabled by the A/D

bit 11 **Reserved:** Maintain as '0'

bit 10 **Unimplemented:** Read as '0'

bit 9-8 **ASINT<1:0>:** Auto-Scan (Threshold Detect) Interrupt Mode bits
- 11 = Interrupt after a Threshold Detect sequence has completed and a valid compare has occurred
- 10 = Interrupt after a valid compare has occurred
- 01 = Interrupt after a Threshold Detect sequence has completed
- 00 = No interrupt

bit 7-4 **Unimplemented:** Read as '0'

bit 3-2 **WM<1:0>:** A/D Write Mode bits
- 11 = Reserved
- 10 = Auto-compare only (conversion results are not saved, but interrupts are generated when a valid match, as defined by the CMx and ASINTx bits, occurs)
- 01 = Convert and save (conversion results are saved to locations as determined by the register bits when a match, as defined by the CMx bits, occurs)
- 00 = Legacy operation (conversion data is saved to a location determined by the buffer register bits)

bit 1-0 **CM<1:0>:** A/D Compare Mode bits
- 11 = Outside Window mode (valid match occurs if the conversion result is outside of the window defined by the corresponding buffer pair)
- 10 = Inside Window mode (valid match occurs if the conversion result is inside the window defined by the corresponding buffer pair)
- 01 = Greater Than mode (valid match occurs if the result is greater than the value in the corresponding buffer register)
- 00 = Less Than mode (valid match occurs if the result is less than the value in the corresponding buffer register)

Note 1: When using auto-scan with Threshold Detect (ASEN = 1), do not configure the sample clock source to Auto-Convert mode (SSRC<3:0> = 7). Any other available SSRC selection is valid. To use auto-convert as the sample clock source (SSRC<3:0> = 7), make sure ASEN is cleared.

20.0 8-BIT DIGITAL-TO-ANALOG CONVERTER (DAC)

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, refer to the *"PIC24F Family Reference Manual"*. Device-specific information in this data sheet supersedes the information in the *"PIC24F Family Reference Manual"*.

PIC24FV16KM204 family devices include two 8-bit Digital-to-Analog Converters (DACs) for generating analog outputs from digital data. A simplified block diagram for a single DAC is shown in Figure 20-1. Both of the DACs are identical.

The DAC generates an analog output voltage based on the digital input code, according to the formula:

$$V_{DAC} = \frac{V_{DACREF} \times DACxDAT}{256}$$

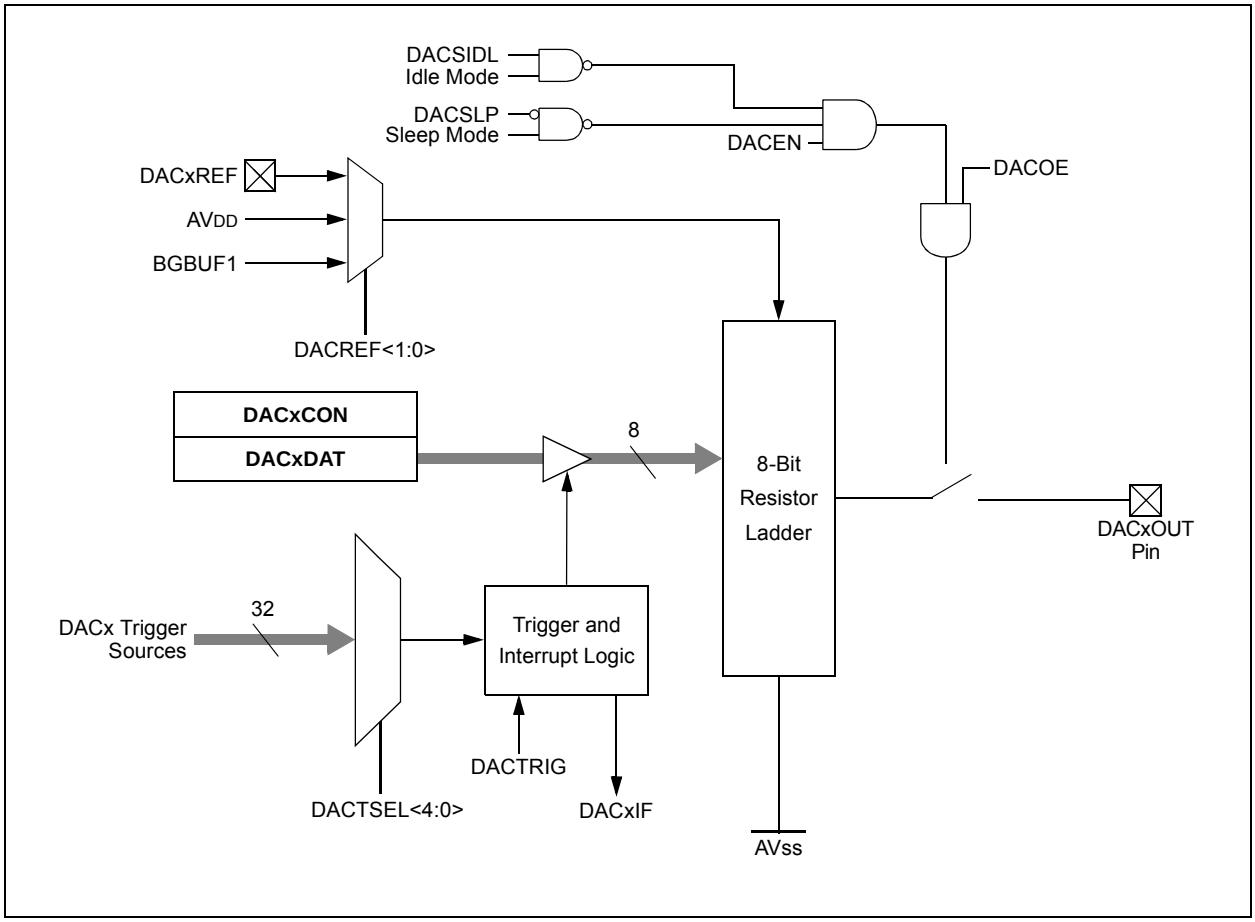
where V_{DAC} is the analog output voltage and V_{DACREF} is the reference voltage selected by DACREF<1:0>.

Each DAC includes these features:

- Precision 8-bit resistor ladder for high accuracy
- Fast settling time, supporting 1 Msps effective sampling rates
- Buffered output voltage
- Three user-selectable voltage reference options
- Multiple conversion Trigger options, plus a manual convert-on-write option
- Left and right justified input data options
- User-selectable Sleep and Idle mode operation

When using the DAC, it is recommended to set the ANSx and TRISx bits for the DACx output pin to configure it as an analog output. See **Section 11.2 "Configuring Analog Port Pins"** for more information.

FIGURE 20-1: SINGLE DACx SIMPLIFIED BLOCK DIAGRAM



24.3 Pulse Generation and Delay

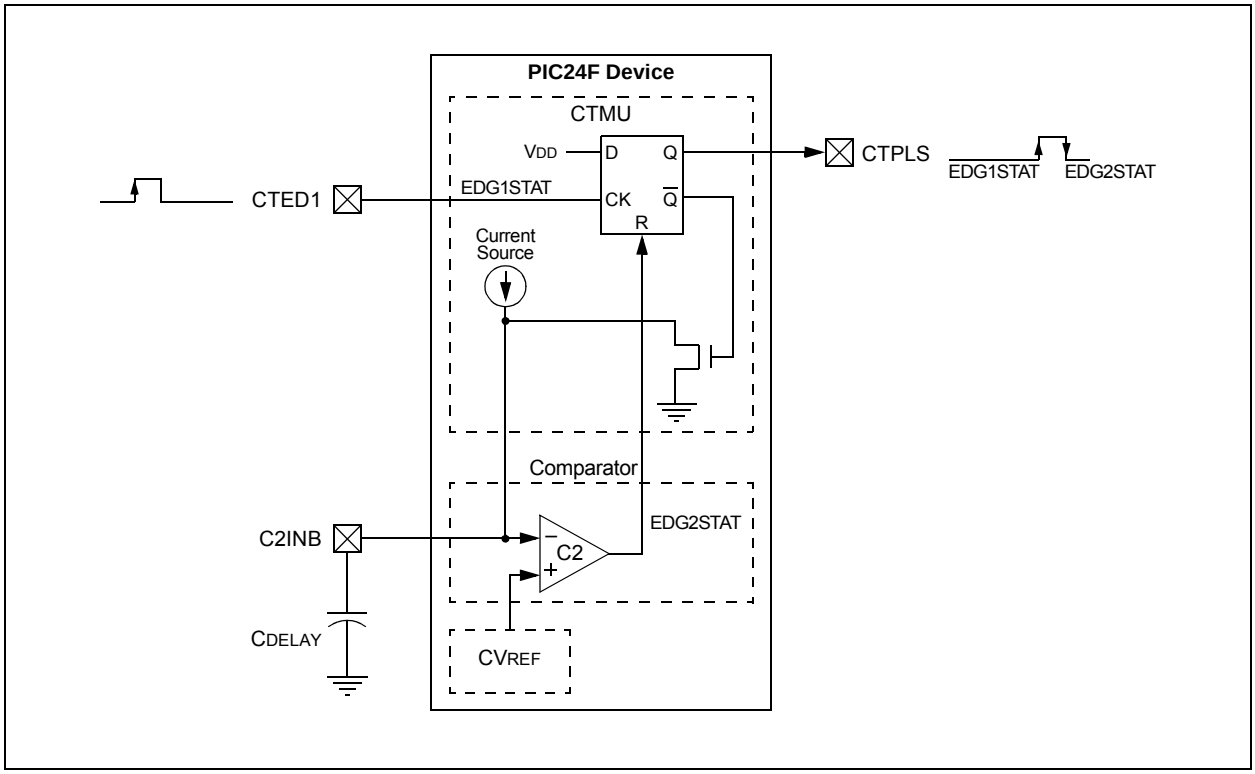
The CTMU module can also generate an output pulse with edges that are not synchronous with the device's system clock. More specifically, it can generate a pulse with a programmable delay from an edge event input to the module.

When the module is configured for pulse generation delay by setting the TGEN bit (CTMUCON1L<12>), the internal current source is connected to the B input of Comparator 2. A Capacitor (CDELAY) is connected to the Comparator 2 pin, C2INB, and the Comparator Voltage Reference, CVREF, is connected to C2INA. CVREF is then configured for a specific trip point. The module begins to charge CDELAY when an edge event is detected. While CVREF is greater than the voltage on CDELAY, the CTPLS pin is high.

When the voltage on CDELAY equals CVREF, CTPLS goes low. With Comparator 2 configured as the second edge, this stops the CTMU from charging. In this state event, the CTMU automatically connects to ground. The IDISSEN bit doesn't need to be set and cleared before the next CTPLS cycle.

Figure 24-3 illustrates the external connections for pulse generation, as well as the relationship of the different analog modules required. While CTED1 is shown as the input pulse source, other options are available. A detailed discussion on pulse generation with the CTMU module is provided in the "*PIC24F Family Reference Manual*".

FIGURE 24-3: TYPICAL CONNECTIONS AND INTERNAL CONFIGURATION FOR PULSE DELAY GENERATION



REGISTER 25-9: DEVREV: DEVICE REVISION REGISTER

U-0	U-0	U-0	U-0	U-0	U-0	U-0	U-0
—	—	—	—	—	—	—	—
bit 23							bit 16

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	R	R	R
—	—	—	—	REV3	REV2	REV1	REV0
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 23-4 **Unimplemented:** Read as ‘0’

bit 3-0 **REV<3:0>:** Minor Revision Identifier bits

27.0 ELECTRICAL CHARACTERISTICS

This section provides an overview of the PIC24FV16KM204 family electrical characteristics. Additional information will be provided in future revisions of this document as it becomes available.

Absolute maximum ratings for the PIC24FV16KM204 family are listed below. Exposure to these maximum rating conditions for extended periods may affect device reliability. Functional operation of the device at these, or any other conditions above the parameters indicated in the operation listings of this specification, is not implied.

Absolute Maximum Ratings(†)

Ambient temperature under bias ..... -40°C to +125°C
Storage temperature ..... -65°C to +150°C
Voltage on V_{DD} with respect to V_{SS} (PIC24FXXKMXXX) ..... -0.3V to +4.5V
Voltage on V_{DD} with respect to V_{SS} (PIC24FVXXKMXXX) ..... -0.3V to +6.5V
Voltage on any combined analog and digital pin with respect to V_{SS} ..... -0.3V to (V_{DD} + 0.3V)
Voltage on any digital only pin with respect to V_{SS} ..... -0.3V to (V_{DD} + 0.3V)
Voltage on $\overline{MCLR}/V_{PP}$ pin with respect to V_{SS} ..... -0.3V to +9.0V
Maximum current out of V_{SS} pin ..... 300 mA
Maximum current into V_{DD} pin(1) ..... 250 mA
Maximum output current sunk by any I/O pin ..... 25 mA
Maximum output current sourced by any I/O pin ..... 25 mA
Maximum current sunk by all ports ..... 200 mA
Maximum current sourced by all ports(1) ..... 200 mA

Note 1: Maximum allowable current is a function of device maximum power dissipation (see Table 27-1).

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

FIGURE 27-9: BROWN-OUT RESET CHARACTERISTICS

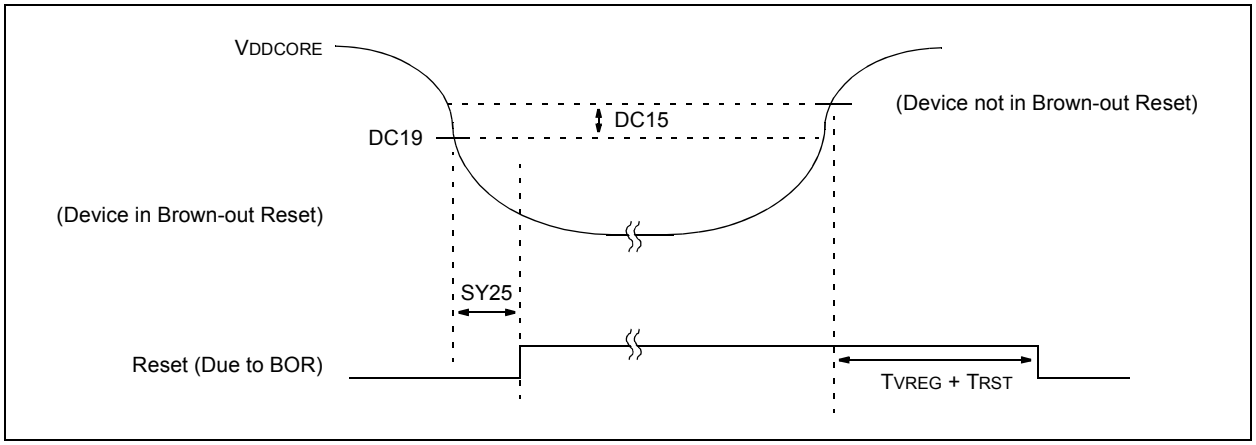


TABLE 27-25: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER, POWER-UP TIMER AND BROWN-OUT RESET TIMING REQUIREMENTS

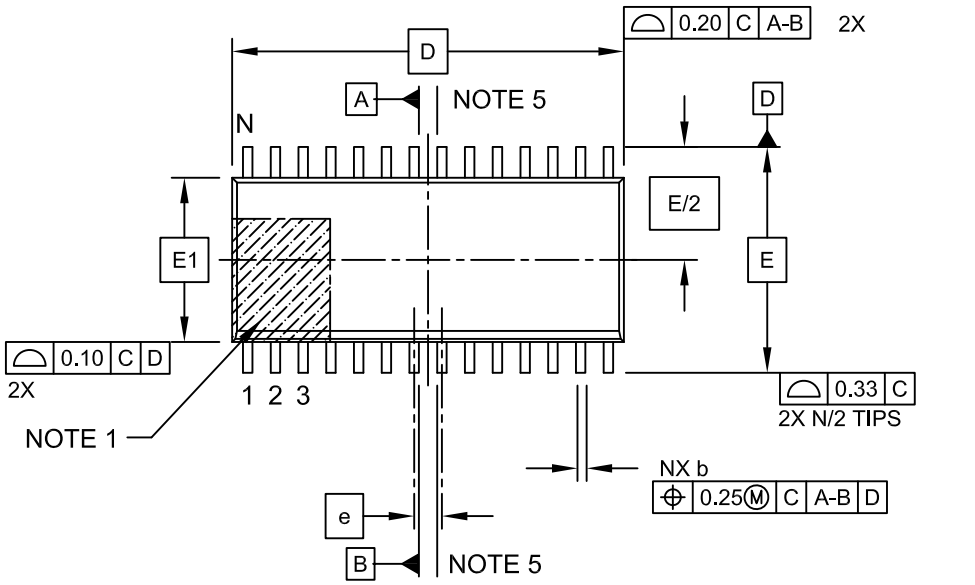
AC CHARACTERISTICS			Standard Operating Conditions: 1.8V to 3.6V (PIC24F16KM204) 2.0V to 5.5V (PIC24FV16KM204) Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended				
Param No.	**Symbol**	**Characteristic**	**Min.**	**Typ(1)**	**Max.**	**Units**	**Conditions**
SY10	TmcL	MCLR Pulse Width (low)	2	—	—	µs	
SY11	TPWRT	Power-up Timer Period	50	64	90	ms	
SY12	TPOR	Power-on Reset Delay	1	5	10	µs	
SY13	TIOZ	I/O High-Impedance from MCLR Low or Watchdog Timer Reset	—	—	100	ns	
SY20	TWDT	Watchdog Timer Time-out Period	0.85	1.0	1.15	ms	1.32 prescaler
			3.4	4.0	4.6	ms	1:128 prescaler
SY25	TBOR	Brown-out Reset Pulse Width	1	—	—	µs	
SY35	TFSCM	Fail-Safe Clock Monitor Delay	—	2.0	2.3	µs	
SY45	TRST	Internal State Reset Time	—	5	—	µs	
SY50	TVREG	On-Chip Voltage Regulator Output Delay	—	10	—	µs	**(Note 2)**
SY55	TLOCK	PLL Start-up Time	—	100	—	µs	
SY65	TOST	Oscillator Start-up Time	—	1024	—	TOSC	
SY71	TPM	Program Memory Wake-up Time	—	1	—	µs	Sleep wake-up with PMSLP = 0
SY72	TLVR	Low-Voltage Regulator Wake-up Time	—	250	—	µs	

Note 1: Data in "Typ" column is at 3.3V, +25°C unless otherwise stated.

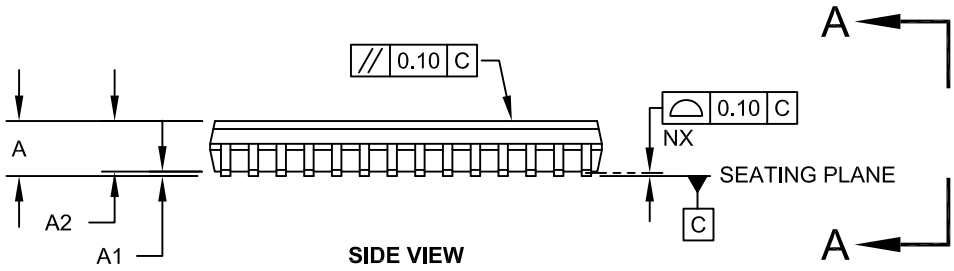
2: This applies to PIC24FV16KMXXX devices only.

28-Lead Plastic Small Outline (SO) - Wide, 7.50 mm Body [SOIC]

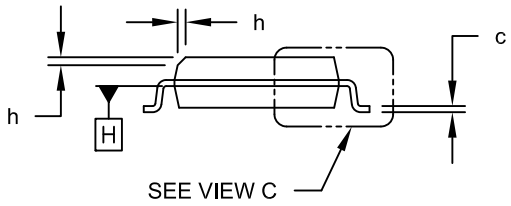
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



TOP VIEW



SIDE VIEW



VIEW A-A

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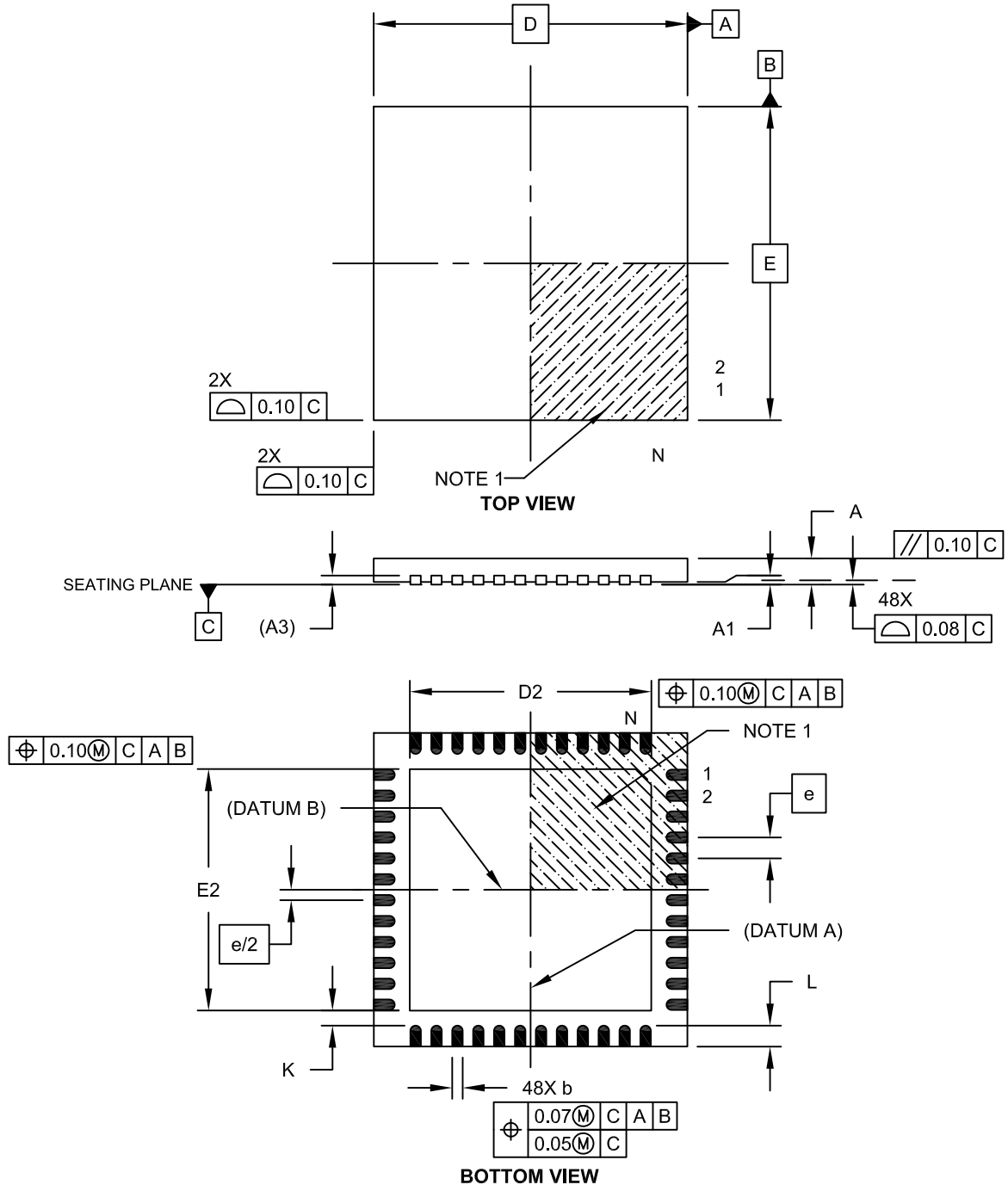
48-Lead Plastic Ultra Thin Quad Flat, No Lead Package (MV) – 6x6x0.5 mm Body [UQFN]

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



Microchip Technology Drawing C04-153A Sheet 1 of 2

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