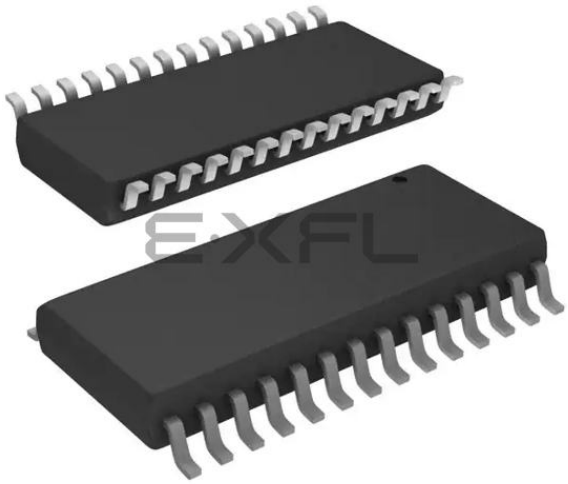

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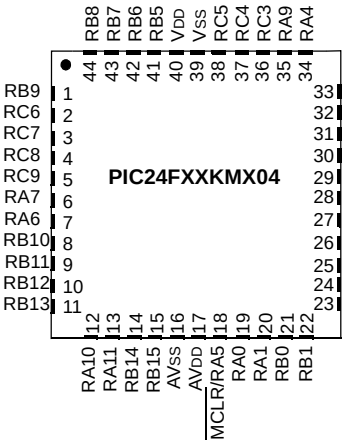
Applications of "Embedded - Microcontrollers"

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	23
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)	2V ~ 5V
Data Converters	A/D 19x10b/12b; D/A 2x8b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	28-SOIC (0.295", 7.50mm Width)
Supplier Device Package	28-SOIC
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic24fv08km202t-i-so

Pin Diagrams (Continued)

44-Pin TQFP/QFN(1)



Pin	Pin Features	
	PIC24FXXKMX04	PIC24FVXXKMX04
1	AN21/SDA1/T1CK/U1RTS/U1BCLK/IC2/ /CLC1O/CTED4/CN21/RB9	
2	U1RX/ /CN18/RC6	
3	U1TX/ /CN17/RC7	
4	/CN20/RC8	
5	IC4/OC2F/CTED7/CN19/RC9	
6	IC1/ / /CTED3/CN9/RA7	
7	/OC1A/CTED1/INT2/CN8/RA6	VCAP or VDDCORE
8	PGED2/SDI1/OC1C/CTED11/CN16/RB10	
9	PGEC2/SCK1/OC2A/CTED9/CN15/RB11	
10	/AN12/HLVDIN/ /CTED2/ CN14/RB12	/AN12/HLVDIN/ /CTED2/INT2/ CN14/RB12
11	/ /AN11/SDO1/OC1D/CTPLS/CN13/RB13	
12	/ /CN35/RA10	
13	/ /CTED8/CN36/RA11	
14	/CVREF/ / /AN10/ / /C1OUT/OCFA/CTED5/INT1/CN12/ RB14	
15	/ /AN9/ /REFO/SS1/TCKIA/CTED6/CN11/RB15	
16	AVSS	
17	AVDD	
18	MCLR/VPP/RA5	
19	CVREF+/VREF+/ /AN0/ /CN2/ RA0	CVREF+/VREF+/ /AN0/ / CTED1/CN2/RA0
20	CVREF-/VREF-/AN1/CN3/RA1	
21	PGED1/AN2/CTCMP/ULPWU/C1IND/ / / /CN4/RB0	
22	PGEC1/ / /AN3/C1INC/ / /CTED12/CN5//RB1	
23	/ /AN4/C1INB/ / /TCKIB/CTED13/CN6/RB2	
24	/AN5/C1INA/ / /CN7/RB3	
25	AN6/CN32/RC0	
26	AN7/CN31/RC1	
27	AN8/CN10/RC2	
28	VDD	
29	VSS	
30	OSCI/CLKI/AN13/CN30/RA2	
31	OSCO/CLKO/AN14/CN29/RA3	
32	OCFB/CN33/RA8	
33	SOSCI/AN15/ / /CN1/RB4	
34	SOSCO/SCLKI/AN16/PWRLCLK/ /CN0/RA4	
35	/CN34/RA9	
36	/CN28/RC3	
37	/CN25/RC4	
38	/CN26/RC5	
39	VSS	
40	VDD	
41	PGED3/AN17/ASDA1/OC1E/CLCINA/CN27/RB5	
42	PGEC3/AN18/ASCL1/OC1F/CLCINB/CN24/RB6	
43	AN19/INT0/CN23/RB7	AN19/ /OC1A/INT0/CN23/RB7
44	AN20/SCL1/U1CTS/C3OUT/OC1B/CTED10/CN22/RB8	

Legend: Values in indicate pin function differences between PIC24F(V)XXKM202 and PIC24F(V)XXKM102 devices.

Note 1: Exposed pad on underside of device is connected to VSS.

1.0 DEVICE OVERVIEW

This document contains device-specific information for the following devices:

The PIC24FV16KM204 family introduces many new analog features to the extreme low-power Microchip devices. This is a 16-bit microcontroller family with a broad peripheral feature set and enhanced computational performance. This family also offers a new migration option for those high-performance applications which may be outgrowing their 8-bit platforms, but do not require the numerical processing power of a Digital Signal Processor (DSC).

1.1 Core Features

1.1.1 16-BIT ARCHITECTURE

Central to all PIC24F devices is the 16-bit modified Harvard architecture, first introduced with Microchip's dsPIC® Digital Signal Controllers. The PIC24F CPU core offers a wide range of enhancements, such as:

- 16-bit data and 24-bit address paths with the ability to move information between data and memory spaces
- Linear Addressing of up to 16 Mbytes (program space) and 16 Kbytes (data)
- A 16-element working register array with built-in software stack support
- A 17 x 17 hardware multiplier with support for integer math
- Hardware support for 32-bit by 16-bit division
- An instruction set that supports multiple addressing modes and is optimized for high-level languages, such as C
- Operational performance up to 16 MIPS

1.1.2 POWER-SAVING TECHNOLOGY

All of the devices in the PIC24FV16KM204 family incorporate a range of features that can significantly reduce power consumption during operation. Key features include:

- On-the-Fly Clock Switching, to allow the device clock to be changed under software control to the Timer1 source or the internal, low-power RC Oscillator during operation, allowing users to incorporate power-saving ideas into their software designs.
- Doze Mode Operation, when timing-sensitive applications, such as serial communications, require the uninterrupted operation of peripherals, the CPU clock speed can be selectively reduced, allowing incremental power savings without missing a beat.
- Instruction-Based Power-Saving Modes, to allow the microcontroller to suspend all operations or selectively shut down its core while leaving its peripherals active with a single instruction in software.

1.1.3 OSCILLATOR OPTIONS AND FEATURES

The PIC24FV16KM204 family offers five different oscillator options, allowing users a range of choices in developing application hardware. These include:

- Two Crystal modes using crystals or ceramic resonators.
- Two External Clock (EC) modes offering the option of a divide-by-2 clock output.
- Two Fast Internal Oscillators (FRCs), one with a nominal 8 MHz output and the other with a nominal 500 kHz output. These outputs can also be divided under software control to provide clock speed as low as 31 kHz or 2 kHz.
- A Phase Locked Loop (PLL) frequency multiplier, available to the external oscillator modes and the 8 MHz FRC Oscillator, which allows clock speeds

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			
OSCI	7	9	6	30	33	7	9	6	30	33	I	ANA	Primary Oscillator Input
OSCO	8	10	7	31	34	8	10	7	31	34	O	ANA	Primary Oscillator Output
PGEC1	5	5	2	22	24	5	5	2	22	24	I/O	ST	ICSP Clock 1
PGED1	4	4	1	21	23	4	4	1	21	23	I/O	ST	ICSP Data 1
PGEC2	2	22	19	9	10	2	22	19	9	10	I/O	ST	ICSP Clock 2
PGED2	3	21	18	8	9	3	21	18	8	9	I/O	ST	ICSP Data 2
PGEC3	10	15	12	42	46	10	15	12	42	46	I/O	ST	ICSP Clock 3
PGED3	9	14	11	41	45	9	14	11	41	45	I/O	ST	ICSP Data 3
PWRLCLK	10	12	9	34	37	10	12	9	34	37	I	ST	RTCC Power Line Clock Input
RA0	2	2	27	19	21	2	2	27	19	21	I/O	ST	PORTA Pins
RA1	3	3	28	20	22	3	3	28	20	22	I/O	ST	PORTA Pins
RA2	7	9	6	30	33	7	9	6	30	33	I/O	ST	PORTA Pins
RA3	8	10	7	31	34	8	10	7	31	34	I/O	ST	PORTA Pins
RA4	10	12	9	34	37	10	12	9	34	37	I/O	ST	PORTA Pins
RA5	1	1	26	18	19	1	1	26	18	19	I/O	ST	PORTA Pins
RA6	14	20	17	7	7	—	—	—	—	—	I/O	ST	PORTA Pins
RA7	—	19	16	6	6	—	19	16	6	6	I/O	ST	PORTA Pins
RA8	—	—	—	32	35	—	—	—	32	35	I/O	ST	PORTA Pins
RA9	—	—	—	35	38	—	—	—	35	38	I/O	ST	PORTA Pins
RA10	—	—	—	12	13	—	—	—	12	13	I/O	ST	PORTA Pins
RA11	—	—	—	13	14	—	—	—	13	14	I/O	ST	PORTA Pins
RB0	4	4	1	21	23	4	4	1	21	23	I/O	ST	PORTB Pins
RB1	5	5	2	22	24	5	5	2	22	24	I/O	ST	PORTB Pins
RB2	6	6	3	23	25	6	6	3	23	25	I/O	ST	PORTB Pins
RB3	—	7	4	24	26	—	7	4	24	26	I/O	ST	PORTB Pins
RB4	9	11	8	33	36	9	11	8	33	36	I/O	ST	PORTB Pins
RB5	—	14	11	41	45	—	14	11	41	45	I/O	ST	PORTB Pins
RB6	—	15	12	42	46	—	15	12	42	46	I/O	ST	PORTB Pins
RB7	11	16	13	43	47	11	16	13	43	47	I/O	ST	PORTB Pins
RB8	12	17	14	44	48	12	17	14	44	48	I/O	ST	PORTB Pins

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

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

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 7-1: RCON: RESET CONTROL REGISTER(1)

R/W-0, HS	R/W-0, HS	R/W-0	R/W-0	U-0	U-0	R/W-0	R/W-0
TRAPR	IOPUWR	SBOREN	RETEN(3)	—	—	CM	PMSLP
bit 15							bit 8

R/W-0, HS	R/W-0, HS	R/W-0, HS	R/W-0, HS	R/W-0, HS	R/W-0, HS	R/W-1, HS	R/W-1, HS
EXTR	SWR	SWDTEN(2)	WDTO	SLEEP	IDLE	BOR	POR
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 **TRAPR:** Trap Reset Flag bit
1 = A Trap Conflict Reset has occurred
0 = A Trap Conflict Reset has not occurred

bit 14 **IOPUWR:** Illegal Opcode or Uninitialized W Access Reset Flag bit
1 = An illegal opcode detection, an illegal address mode or Uninitialized W register used as an Address Pointer caused a Reset
0 = An illegal opcode or Uninitialized W Reset has not occurred

bit 13 **SBOREN:** Software Enable/Disable of BOR bit
1 = BOR is turned on in software
0 = BOR is turned off in software

bit 12 **RETEN:** Retention Sleep Mode(3)
1 = Regulated voltage supply provided by the Retention Regulator (RETREG) during Sleep
0 = Regulated voltage supply provided by the main Voltage Regulator (VREG) during Sleep

bit 11-10 **Unimplemented:** Read as '0'

bit 9 **CM:** Configuration Word Mismatch Reset Flag bit
1 = A Configuration Word Mismatch Reset has occurred
0 = A Configuration Word Mismatch Reset has not occurred

bit 8 **PMSLP:** Program Memory Power During Sleep bit
1 = Program memory bias voltage remains powered during Sleep
0 = Program memory bias voltage is powered down during Sleep and the voltage regulator enters Standby mode

bit 7 **EXTR:** External Reset ($\overline{MCLR}$) Pin bit
1 = A Master Clear (pin) Reset has occurred
0 = A Master Clear (pin) Reset has not occurred

bit 6 **SWR:** Software RESET (Instruction) Flag bit
1 = A RESET instruction has been executed
0 = A RESET instruction has not been executed

bit 5 **SWDTEN:** Software Enable/Disable of WDT bit(2)
1 = WDT is enabled
0 = WDT is disabled

Note 1: All of the Reset status bits may be set or cleared in software. Setting one of these bits in software does not cause a device Reset.

2: If the FWDTEN<1:0> Configuration bits are '11' (unprogrammed), the WDT is always enabled regardless of the SWDTEN bit setting.

3: This is implemented on PIC24FV16KMXXX parts only; not used on PIC24F16KMXXX devices.

REGISTER 8-2: 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(2)	PSV(1)	—	—
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(2)
1 = CPU Interrupt Priority Level is greater than 7
0 = CPU Interrupt Priority Level is 7 or less

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

Note 1: See Register 3-2 for the description of this bit, which is not dedicated to interrupt control functions.

2: The IPL3 bit is concatenated with the IPL<2:0> bits (SR<7:5>) to form the CPU Interrupt Priority Level.

Note: Bit 2 is described in **Section 3.0 "CPU"**.

REGISTER 9-3: OSCTUN: FRC OSCILLATOR TUNE 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	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	TUN5(1)	TUN4(1)	TUN3(1)	TUN2(1)	TUN1(1)	TUN0(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 15-6 **Unimplemented:** Read as '0'

bit 5-0 **TUN<5:0>:** FRC Oscillator Tuning bits(1)

011111 = Maximum frequency deviation
011110
•
•
•
000001
000000 = Center frequency, oscillator is running at factory calibrated frequency
111111
•
•
•
100001
100000 = Minimum frequency deviation

Note 1: Increments or decrements of TUN<5:0> may not change the FRC frequency in equal steps over the FRC tuning range and may not be monotonic.

13.2 General Purpose Timer

Timer mode is selected when CCSEL = 0 and MOD<3:0> = 0000. The timer can function as a 32-bit timer or a dual 16-bit timer, depending on the setting of the T32 bit (Table 13-2).

TABLE 13-2: TIMER OPERATION MODE

T32 (CCPxCON1L<5>)	Operating Mode
0	Dual Timer Mode (16-bit)
1	Timer Mode (32-bit)

Dual 16-Bit Timer mode provides a simple timer function with two independent 16-bit timer/counters. The primary timer uses CCPxTMRL and CCPxPRL. Only the primary timer can interact with other modules on the device. It generates the MCCPx Sync out signals for use by other MCCP modules. It can also use the SYNC<4:0> bits signal generated by other modules.

The secondary timer uses CCPxTMRH and CCPxPRH. It is intended to be used only as a periodic interrupt source for scheduling CPU events. It does not generate an Output Sync/Trigger signal like the primary time base. In Dual Timer mode, the Secondary Timer Period register, CCPxPRH, generates the MCCP Compare Event (CCPxIF) used by many other modules on the device.

The 32-Bit Timer mode uses the CCPxTMRL and CCPxTMRH registers, together, as a single 32-bit timer. When CCPxTMRL overflows, CCPxTMRH increments by one. This mode provides a simple timer function when it is important to track long time periods. Note that the T32 bit (CCPxCON1L<5>) should be set before the CCPxTMRL or CCPxPRH registers are written to initialize the 32-bit timer.

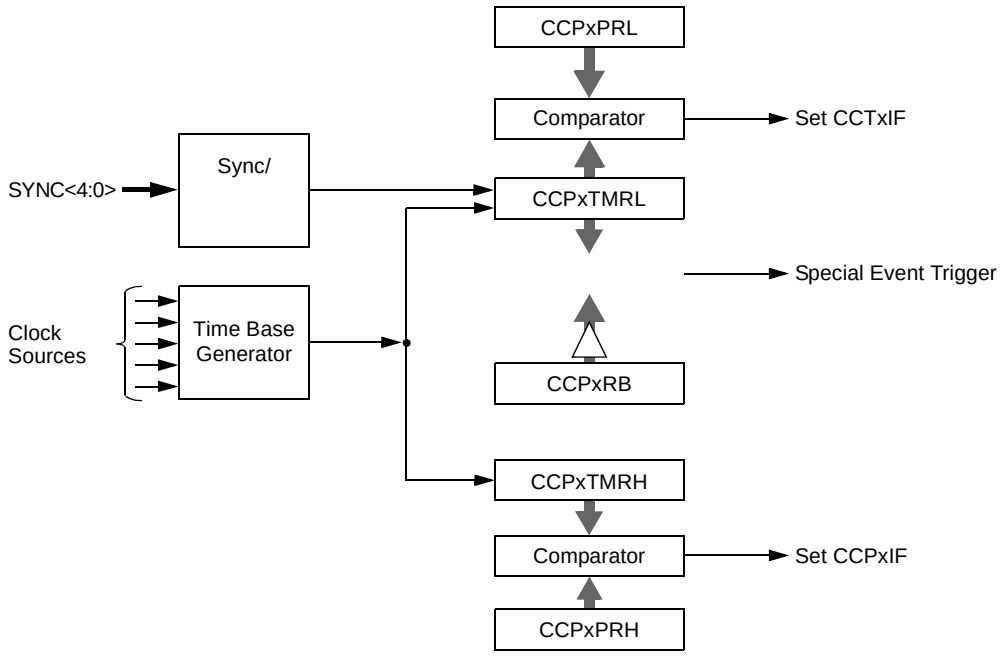
13.2.1 SYNC AND TRIGGER OPERATION

In both 16-bit and 32-bit modes, the timer can also function in either Synchronization (“Sync”) or Trigger operation. Both use the SYNC<4:0> bits (CCPxCON1H<4:0>) to determine the input signal source. The difference is how that signal affects the timer.

In Sync operation, the timer Reset or clear occurs when the input selected by SYNC<4:0> is asserted. The timer immediately begins to count again from zero unless it is held for some other reason. Sync operation is used whenever the TRIGEN bit (CCPxCON1H<7>) is cleared. SYNC<4:0> can have any value except ‘11111’.

In Trigger operation, the timer is held in Reset until the input selected by SYNC<4:0> is asserted; when it occurs, the timer starts counting. Trigger operation is used whenever the TRIGEN bit is set. In Trigger mode, the timer will continue running after a Trigger event as long as the CCPTRIG bit (CCPxSTATL< 7>) is set. To clear CCPTRIG, the TRCLR bit (CCPxSTATL<5>) must be set to clear the Trigger event, reset the timer and hold it at zero until another Trigger event occurs. On PIC24FV16KM204 family devices, Trigger operation can only be used when the system clock is the time base source (CLKSEL<2:0> = 000).

FIGURE 13-3: DUAL 16-BIT TIMER MODE



REGISTER 13-7: CCPxSTATL: CCPx STATUS REGISTER

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

R-0	W1-0	W1-0	R/C-0	R/C-0	R/C-0	R/C-0	R/C-0
CCPTRIG	TRSET	TRCLR	ASEVT	SCEVT	ICDIS	ICOV	ICBNE
bit 7							bit 0

Legend:	C = Clearable bit		
R = Readable bit	W1 = Write ‘1’ only	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 **CCPTRIG:** CCPx Trigger Status bit
1 = Timer has been triggered and is running
0 = Timer has not been triggered and is held in Reset

bit 6 **TRSET:** CCPx Trigger Set Request bit
Write ‘1’ to this location to trigger the timer when TRIGEN = 1 (location always reads as ‘0’).

bit 5 **TRCLR:** CCPx Trigger Clear Request bit
Write ‘1’ to this location to cancel the timer Trigger when TRIGEN = 1 (location always reads as ‘0’).

bit 4 **ASEVT:** CCPx Auto-Shutdown Event Status/Control bit
1 = A shutdown event is in progress; CCPx outputs are in the shutdown state
0 = CCPx outputs operate normally

bit 3 **SCEVT:** Single Edge Compare Event Status bit
1 = A single edge compare event has occurred
0 = A single edge compare event has not occurred

bit 2 **ICDIS:** Input Capture x Disable bit
1 = Event on Input Capture x pin (ICx) does not generate a capture event
0 = Event on Input Capture x pin will generate a capture event

bit 1 **ICOV:** Input Capture x Buffer Overflow Status bit
1 = The Input Capture x FIFO buffer has overflowed
0 = The Input Capture x FIFO buffer has not overflowed

bit 0 **ICBNE:** Input Capture x Buffer Status bit
1 = Input Capture x buffer has data available
0 = Input Capture x buffer is empty

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>).

15.1 UARTx Baud Rate Generator (BRG)

The UARTx module includes a dedicated 16-bit Baud Rate Generator (BRG). The UxBRG register controls the period of a free-running, 16-bit timer. Equation 15-1 provides the formula for computation of the baud rate with BRGH = 0.

EQUATION 15-1: UARTx BAUD RATE WITH BRGH = 0(1)

$$\text{Baud Rate} = \frac{F_{CY}}{16 \cdot (UxBRG + 1)}$$

$$UxBRG = \frac{F_{CY}}{16 \cdot \text{Baud Rate}} - 1$$

Note 1: Based on FCY = FOSC/2; Doze mode and PLL are disabled.

Example 15-1 provides the calculation of the baud rate error for the following conditions:

- FCY = 4 MHz
- Desired Baud Rate = 9600

The maximum baud rate (BRGH = 0) possible is FCY/16 (for UxBRG = 0) and the minimum baud rate possible is FCY/(16 * 65536).

Equation 15-2 shows the formula for computation of the baud rate with BRGH = 1.

EQUATION 15-2: UARTx BAUD RATE WITH BRGH = 1(1)

$$\text{Baud Rate} = \frac{F_{CY}}{4 \cdot (UxBRG + 1)}$$

$$UxBRG = \frac{F_{CY}}{4 \cdot \text{Baud Rate}} - 1$$

Note 1: Based on FCY = FOSC/2; Doze mode and PLL are disabled.

The maximum baud rate (BRGH = 1) possible is FCY/4 (for UxBRG = 0) and the minimum baud rate possible is FCY/(4 * 65536).

Writing a new value to the UxBRG register causes the BRG timer to be reset (cleared). This ensures the BRG does not wait for a timer overflow before generating the new baud rate.

EXAMPLE 15-1: BAUD RATE ERROR CALCULATION (BRGH = 0)(1)

Desired Baud Rate = FCY/(16 (UxBRG + 1))

Solving for UxBRG value:

UxBRG = ((FCY/Desired Baud Rate)/16) – 1
UxBRG = ((4000000/9600)/16) – 1
UxBRG = 25

Calculated Baud Rate = 4000000/(16 (25 + 1))
= 9615

Error = (Calculated Baud Rate – Desired Baud Rate) / Desired Baud Rate
= (9615 – 9600)/9600
= 0.16%

Note 1: Based on FCY = FOSC/2; Doze mode and PLL are disabled.

REGISTER 15-2: UxSTA: UARTx STATUS AND CONTROL REGISTER

R/W-0	R/W-0	R/W-0	U-0	R/W-0, HC	R/W-0	R-0, HSC	R-1, HSC
UTXISEL1	UTXINV	UTXISEL0	—	UTXBRK	UTXEN	UTXBF	TRMT
bit 15							bit 8

R/W-0	R/W-0	R/W-0	R-1, HSC	R-0, HSC	R-0, HSC	R/C-0, HS	R-0, HSC
URXISEL1	URXISEL0	ADDEN	RIDLE	PERR	FERR	OERR	URXDA
bit 7							bit 0

Legend:	HC = Hardware Clearable bit		
HS = Hardware Settable bit	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 15,13 **UTXISEL<1:0>:** UARTx Transmission Interrupt Mode Selection bits
- 11 = Reserved; do not use
- 10 = Interrupt when a character is transferred to the Transmit Shift Register (TSR) and as a result, the transmit buffer becomes empty
- 01 = Interrupt when the last character is shifted out of the Transmit Shift Register; all transmit operations are completed
- 00 = Interrupt when a character is transferred to the Transmit Shift Register (this implies there is at least one character open in the transmit buffer)

bit 14 **UTXINV:** IrDA® Encoder Transmit Polarity Inversion bit

If IREN = 0:
- 1 = UxTX Idle '0'
- 0 = UxTX Idle '1'

If IREN = 1:
- 1 = UxTX Idle '1'
- 0 = UxTX Idle '0'

bit 12 **Unimplemented:** Read as '0'

bit 11 **UTXBRK:** UARTx Transmit Break bit
- 1 = Sends Sync Break on next transmission – Start bit, followed by twelve '0' bits, followed by Stop bit; cleared by hardware upon completion
- 0 = Sync Break transmission is disabled or completed

bit 10 **UTXEN:** UARTx Transmit Enable bit
- 1 = Transmit is enabled; UxTX pin is controlled by UARTx
- 0 = Transmit is disabled; any pending transmission is aborted and the buffer is reset; UxTX pin is controlled by the PORT register

bit 9 **UTXBF:** UARTx Transmit Buffer Full Status bit (read-only)
- 1 = Transmit buffer is full
- 0 = Transmit buffer is not full, at least one more character can be written

bit 8 **TRMT:** Transmit Shift Register Empty bit (read-only)
- 1 = Transmit Shift Register is empty and the transmit buffer is empty (the last transmission has completed)
- 0

16.2.4 RTCC CONTROL REGISTERS

REGISTER 16-1: RCFGCAL: RTCC CALIBRATION AND CONFIGURATION REGISTER(1)

R/W-0	U-0	R/W-0	R-0, HSC	R-0, HSC	R/W-0	R/W-0	R/W-0
RTCEN(2)	—	RTCWREN	RTCSYNC	HALFSEC(3)	RTCOE	RTCPTR1	RTCPTR0
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
CAL7	CAL6	CAL5	CAL4	CAL3	CAL2	CAL1	CAL0
bit 7							bit 0

Legend:	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 **RTCEN:** RTCC Enable bit(2)
1 = RTCC module is enabled
0 = RTCC module is disabled

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

bit 13 **RTCWREN:** RTCC Value Registers Write Enable bit
1 = RTCVALH and RTCVALL registers can be written to by the user
0 = RTCVALH and RTCVALL registers are locked out from being written to by the user

bit 12 **RTCSYNC:** RTCC Value Registers Read Synchronization bit
1 = RTCVALH, RTCVALL and ALCFGRPT registers can change while reading due to a rollover ripple resulting in an invalid data read. If the register is read twice and results in the same data, the data can be assumed to be valid.
0 = RTCVALH, RTCVALL or ALCFGRPT registers can be read without concern over a rollover ripple

bit 11 **HALFSEC:** Half Second Status bit(3)
1 = Second half period of a second
0 = First half period of a second

bit 10 **RTCOE:** RTCC Output Enable bit
1 = RTCC output is enabled
0 = RTCC output is disabled

bit 9-8 **RTCPTR<1:0>:** RTCC Value Register Window Pointer bits
Points to the corresponding RTCC Value registers when reading the RTCVALH and RTCVALL registers. The RTCPTR<1:0> value decrements on every read or write of RTCVALH until it reaches '00'.
RTCVAL<15:8>:
00 = MINUTES
01 = WEEKDAY
10 = MONTH
11 = Reserved
RTCVAL<7:0>:
00 = SECONDS
01 = HOURS
10 = DAY
11 = YEAR

Note 1: The RCFGCAL register is only affected by a POR.
2: A write to the RTCEN bit is only allowed when RTCWREN = 1.
3: This bit is read-only; it is cleared to '0' on a write to the lower half of the MINSEC register.

17.1 Control Registers

The CLCx module is controlled by the following registers:

- CLCxCONL
- CLCxCONH
- CLCxSEL
- CLCxGLSL
- CLCxGLSH

The CLCx Control registers (CLCxCONL and CLCxCONH) are used to enable the module and interrupts, control the output enable bit, select output polarity and select the logic function. The CLCx Control registers also allow the user to control the logic polarity of not only the cell output, but also some intermediate variables.

The CLCx Source Select register (CLCxSEL) allows the user to select up to 4 data input sources using the 4 data input selection multiplexers. Each multiplexer has a list of 8 data sources available.

The CLCx Gate Logic Select registers (CLCxGLSL and CLCxGLSH) allow the user to select which outputs from each of the selection MUXes are used as inputs to the input gates of the logic cell. Each data source MUX outputs both a true and a negated version of its output. All of these 8 signals are enabled, ORed together by the logic cell input gates.

REGISTER 17-1: CLCxCONL: CLCx CONTROL REGISTER (LOW)

R/W-0	U-0	U-0	U-0	R/W-0	R/W-0	U-0	U-0
LCEN	—	—	—	INTP	INTN	—	—
bit 15							bit 8

R-0	R-0	R/W-0	U-0	U-0	R/W-0	R/W-0	R/W-0
LCOE	LCOUT	LCPOL	—	—	MODE2	MODE1	MODE0
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 **LCEN:** CLCx Enable bit
1 = CLCx is enabled and mixing input signals
0 = CLCx is disabled and has logic zero outputs

bit 14-12 **Unimplemented:** Read as ‘0’

bit 11 **INTP:** CLCx Positive Edge Interrupt Enable bit
1 = Interrupt will be generated when a rising edge occurs on LCOUT
0 = Interrupt will not be generated

bit 10 **INTN:** CLCx Negative Edge Interrupt Enable bit
1 = Interrupt will be generated when a falling edge occurs on LCOUT
0 = Interrupt will not be generated

bit 9-8 **Unimplemented:** Read as ‘0’

bit 7 **LCOE:** CLCx Port Enable bit
1 = CLCx port pin output is enabled
0 = CLCx port pin output is disabled

bit 6 **LCOUT:** CLCx Data Output Status bit
1 = CLCx output high
0 = CLCx output low

bit 5 **LCPOL:** CLCx Output Polarity Control bit
1 = The output of the module is inverted
0 = The output of the module is not inverted

bit 4-3 **Unimplemented:** Read as ‘0’

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.

TABLE 27-12: DC CHARACTERISTICS: DATA EEPROM MEMORY

DC 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.	**Sym**	**Characteristic**	**Min**	**Typ(1)**	**Max**	**Units**	**Conditions**
		Data EEPROM Memory					
D140	EPD	Cell Endurance	100,000	—	—	E/W	
D141	VPRD	VDD for Read	VMIN	—	3.6	V	VMIN = Minimum operating voltage
D143A	TIWD	Self-Timed Write Cycle Time	—	4	—	ms	
D143B	TREF	Number of Total Write/Erase Cycles Before Refresh	—	10M	—	E/W	
D144	TRETDD	Characteristic Retention	40	—	—	Year	Provided no other specifications are violated
D145	IDDPD	Supply Current During Programming	—	7	—	mA	

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

TABLE 27-13: DC CHARACTERISTICS: COMPARATOR

DC 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**	**Max**	**Units**	**Conditions**
D300	VIOFF	Input Offset Voltage	—	20	40	mV	
D301	VICM	Input Common-Mode Voltage	0	—	VDD	V	
D302	CMRR	Common-Mode Rejection Ratio	55	—	—	dB	

TABLE 27-14: DC CHARACTERISTICS: COMPARATOR VOLTAGE REFERENCE

DC 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**	**Max**	**Units**	**Conditions**
VRD310	CVRES	Resolution	—	—	VDD/32	LSb	
VRD311	CVRAA	Absolute Accuracy	—	—	1	LSb	AVDD = 3.3V-5.5V
VRD312	CVRUR	Unit Resistor Value (R)	—	2k	—		

27.2 AC Characteristics and Timing Parameters

The information contained in this section defines the PIC24FV16KM204 family AC characteristics and timing parameters.

TABLE 27-18: TEMPERATURE AND VOLTAGE SPECIFICATIONS – AC

AC CHARACTERISTICS	**Standard Operating Conditions: 1.8V to 3.6V** Operating temperature -40°C ≤ TA ≤ +85°C for Industrial -40°C ≤ TA ≤ +125°C for Extended Operating voltage VDD range as described in **Section 27.1 "DC Characteristics"**.

FIGURE 27-5: LOAD CONDITIONS FOR DEVICE TIMING SPECIFICATIONS

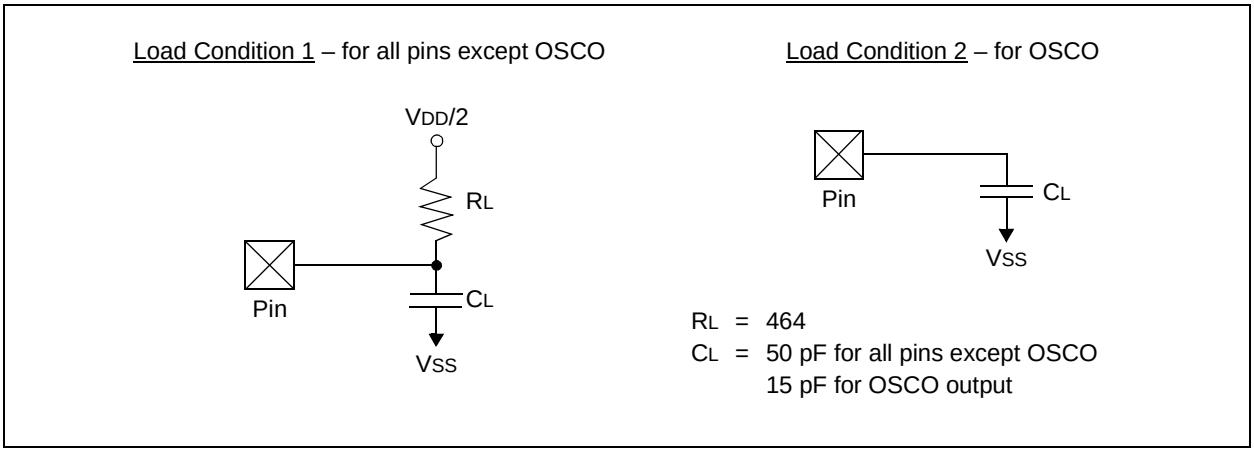


TABLE 27-19: CAPACITIVE LOADING REQUIREMENTS ON OUTPUT PINS

Param No.	Symbol	Characteristic	Min	Typ(1)	Max	Units	Conditions
DO50	COSC2	OSCO/CLKO Pin	—	—	15	pF	In XT and HS modes when External Clock is used to drive OSCI
DO56	CIO	All I/O Pins and OSCO	—	—	50	pF	EC mode
DO58	CB	SCLx, SDAx	—	—	400	pF	In I^2C™ mode

Note 1: Data in "Typ" column is at 3.3V, +25°C unless otherwise stated. Parameters are for design guidance only and are not tested.

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