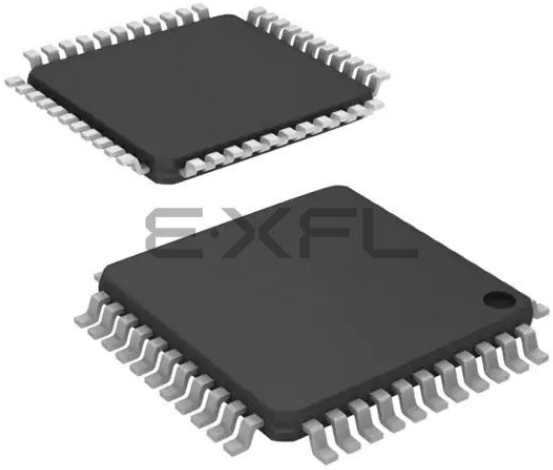

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Details	
Product Status	Obsolete
Core Processor	PIC
Core Size	8-Bit
Speed	4MHz
Connectivity	I²C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	33
Program Memory Size	7KB (4K x 14)
Program Memory Type	OTP
EEPROM Size	-
RAM Size	192 x 8
Voltage - Supply (Vcc/Vdd)	2.5V ~ 6V
Data Converters	A/D 5x8b
Oscillator Type	External
Operating Temperature	0°C ~ 70°C (TA)
Mounting Type	Surface Mount
Package / Case	44-TQFP
Supplier Device Package	44-TQFP (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16lc74a-04-pt

Table of Contents

For register and module descriptions in this data sheet, device legends show which devices apply to those sections. As an example, the legend below would mean that the following section applies only to the PIC16C72, PIC16C73A and PIC16C74A devices.

Applicable Devices						
72	73	73A	74	74A	76	77

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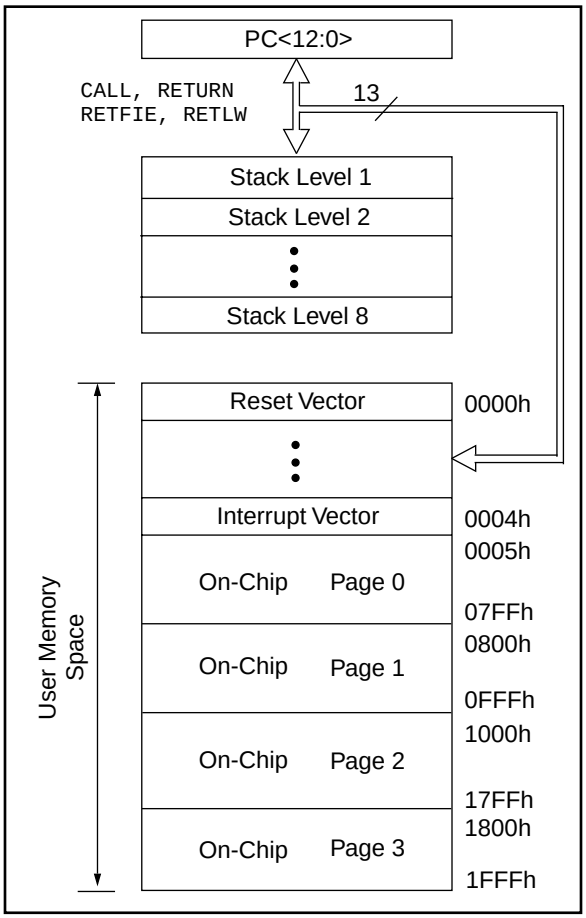
FIGURE 4-3: PIC16C76/77 PROGRAM MEMORY MAP AND STACK



4.2 Data Memory Organization

Applicable Devices						
72	73	73A	74	74A	76	77

The data memory is partitioned into multiple banks which contain the General Purpose Registers and the Special Function Registers. Bits RP1 and RP0 are the bank select bits.

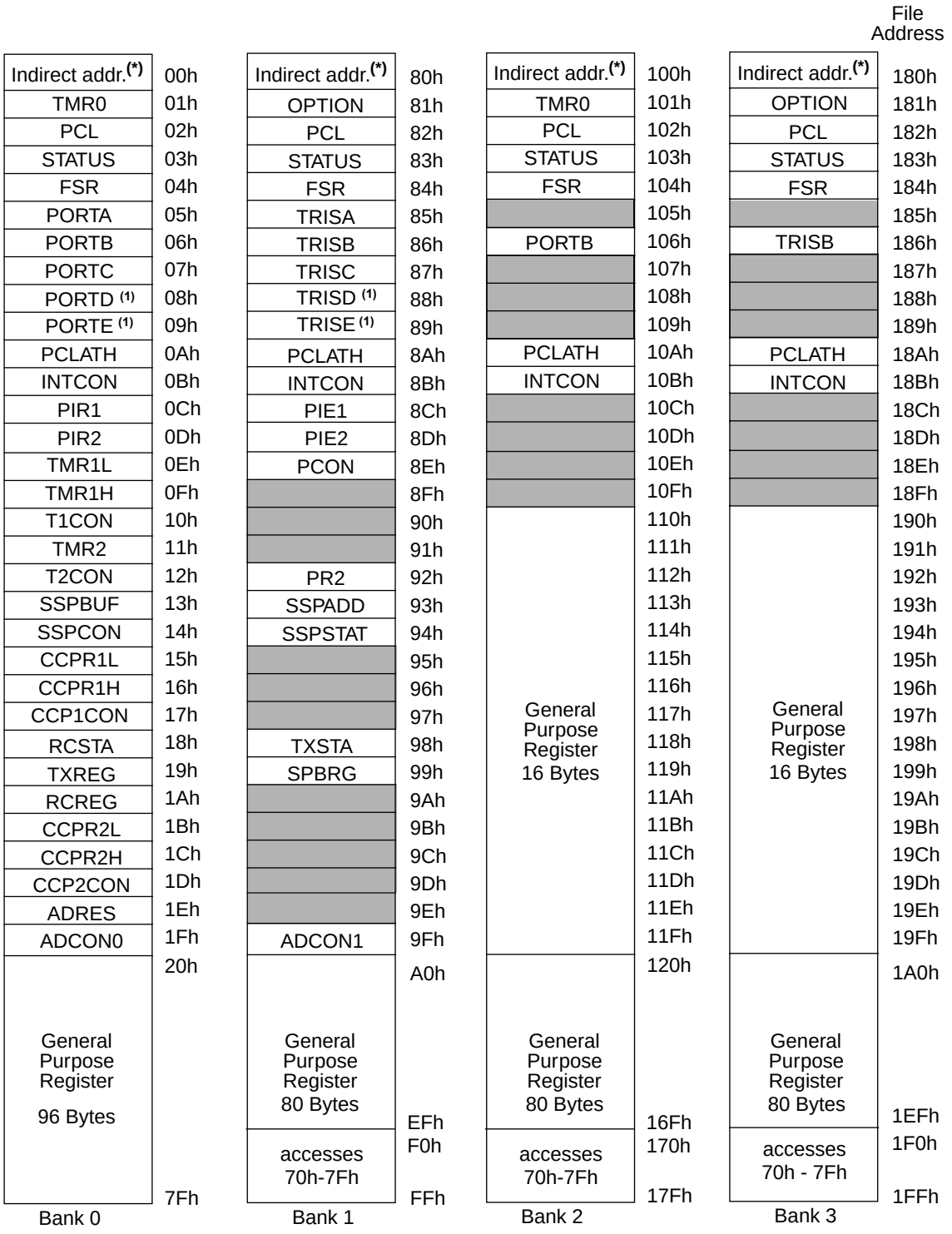
RP1:RP0 (STATUS<6:5>)
= 00 → Bank0
= 01 → Bank1
= 10 → Bank2
= 11 → Bank3

Each bank extends up to 7Fh (128 bytes). The lower locations of each bank are reserved for the Special Function Registers. Above the Special Function Registers are General Purpose Registers, implemented as static RAM. All implemented banks contain special function registers. Some “high use” special function registers from one bank may be mirrored in another bank for code reduction and quicker access.

4.2.1 GENERAL PURPOSE REGISTER FILE

The register file can be accessed either directly, or indirectly through the File Select Register FSR (Section 4.5).

FIGURE 4-6: PIC16C76/77 REGISTER FILE MAP



Unimplemented data memory locations, read as '0'.

* Not a physical register.

Note 1: PORTD, PORTE, TRISD, and TRISE are unimplemented on the PIC16C76, read as '0'.

Note: The upper 16 bytes of data memory in banks 1, 2, and 3 are mapped in Bank 0. This may require relocation of data memory usage in the user application code if upgrading to the PIC16C76/77.

4.2.2.3 INTCON REGISTER

Applicable Devices						
72	73	73A	74	74A	76	77

The INTCON Register is a readable and writable register which contains various enable and flag bits for the TMR0 register overflow, RB Port change and External RB0/INT pin interrupts.

Note: Interrupt flag bits get set when an interrupt condition occurs regardless of the state of its corresponding enable bit or the global enable bit, GIE (INTCON<7>).

FIGURE 4-9: INTCON REGISTER (ADDRESS 0Bh, 8Bh, 10Bh, 18Bh)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-x
GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7: **GIE:**(1) Global Interrupt Enable bit
1 = Enables all un-masked interrupts
0 = Disables all interrupts

bit 6: **PEIE**: Peripheral Interrupt Enable bit
1 = Enables all un-masked peripheral interrupts
0 = Disables all peripheral interrupts

bit 5: **T0IE**: TMR0 Overflow Interrupt Enable bit
1 = Enables the TMR0 interrupt
0 = Disables the TMR0 interrupt

bit 4: **INTE**: RB0/INT External Interrupt Enable bit
1 = Enables the RB0/INT external interrupt
0 = Disables the RB0/INT external interrupt

bit 3: **RBIE**: RB Port Change Interrupt Enable bit
1 = Enables the RB port change interrupt
0 = Disables the RB port change interrupt

bit 2: **T0IF**: TMR0 Overflow Interrupt Flag bit
1 = TMR0 register has overflowed (must be cleared in software)
0 = TMR0 register did not overflow

bit 1: **INTF**: RB0/INT External Interrupt Flag bit
1 = The RB0/INT external interrupt occurred (must be cleared in software)
0 = The RB0/INT external interrupt did not occur

bit 0: **RBIF**: RB Port Change Interrupt Flag bit
1 = At least one of the RB7:RB4 pins changed state (must be cleared in software)
0 = None of the RB7:RB4 pins have changed state

Note 1: For the PIC16C73 and PIC16C74, if an interrupt occurs while the GIE bit is being cleared, the GIE bit may be unintentionally re-enabled by the `RETFIE` instruction in the user's Interrupt Service Routine. Refer to Section 14.5 for a detailed description.

Interrupt flag bits get set when an interrupt condition occurs regardless of the state of its corresponding enable bit or the global enable bit, GIE (INTCON<7>). User software should ensure the appropriate interrupt flag bits are clear prior to enabling an interrupt.

Example 4-1 shows the calling of a subroutine in page 1 of the program memory. This example assumes that PCLATH is saved and restored by the interrupt service routine (if interrupts are used).

EXAMPLE 4-1: CALL OF A SUBROUTINE IN PAGE 1 FROM PAGE 0

```
ORG 0x500
BSF     PCLATH,3  ;Select page 1 (800h-FFFh)
BCF     PCLATH,4  ;Only on >4K devices
CALL    SUB1_P1   ;Call subroutine in
        :         ;page 1 (800h-FFFh)
        :
        :
ORG 0x900
SUB1_P1:          ;called subroutine
        :         ;page 1 (800h-FFFh)
        :
RETURN            ;return to Call subroutine
                  ;in page 0 (000h-7FFh)
```

4.5 Indirect Addressing, INDF and FSR Registers

Applicable Devices						
72	73	73A	74	74A	76	77

The INDF register is not a physical register. Addressing the INDF register will cause indirect addressing.

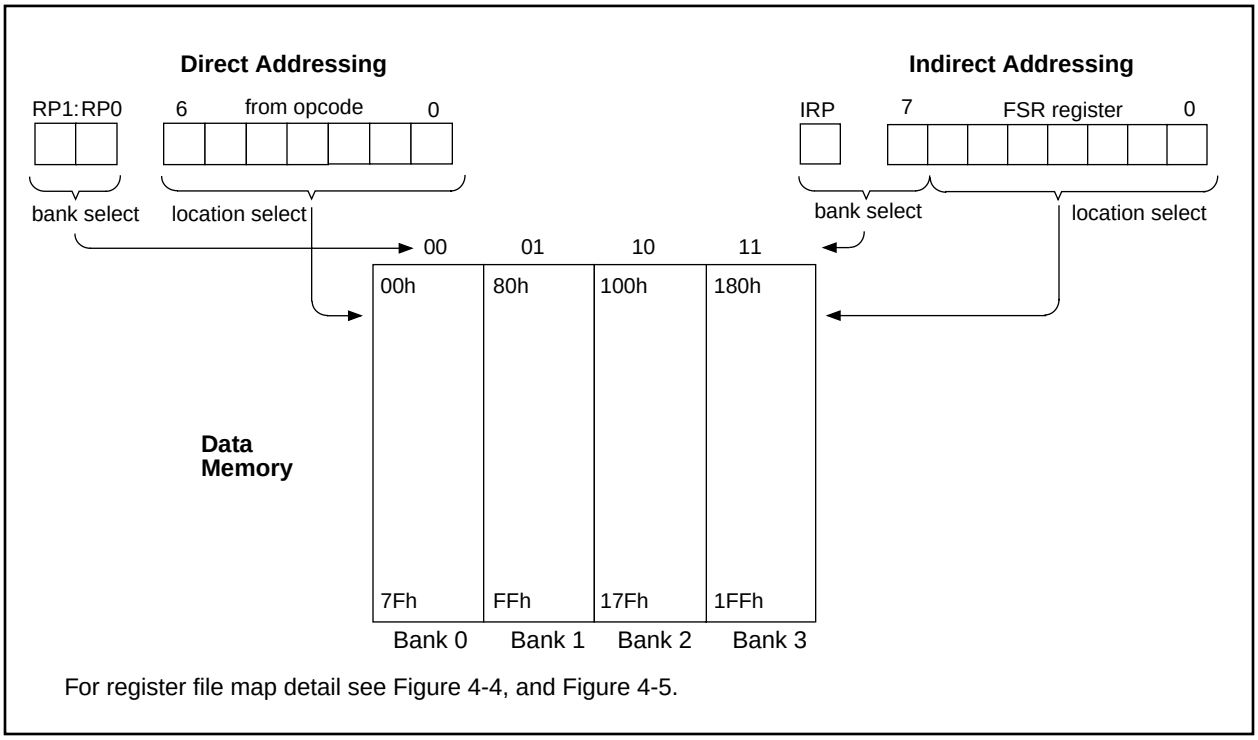
Indirect addressing is possible by using the INDF register. Any instruction using the INDF register actually accesses the register pointed to by the File Select Register, FSR. Reading the INDF register itself indirectly (FSR = '0') will read 00h. Writing to the INDF register indirectly results in a no-operation (although status bits may be affected). An effective 9-bit address is obtained by concatenating the 8-bit FSR register and the IRP bit (STATUS<7>), as shown in Figure 4-18.

A simple program to clear RAM locations 20h-2Fh using indirect addressing is shown in Example 4-2.

EXAMPLE 4-2: INDIRECT ADDRESSING

```
        movlw  0x20   ;initialize pointer
        movwf  FSR    ;to RAM
NEXT    clrf   INDF   ;clear INDF register
        incf   FSR,F  ;inc pointer
        btfss  FSR,4  ;all done?
        goto   NEXT   ;no clear next
CONTINUE
        :              ;yes continue
```

FIGURE 4-18: DIRECT/INDIRECT ADDRESSING



For register file map detail see Figure 4-4, and Figure 4-5.

5.3 PORTC and TRISC Registers

Applicable Devices						
72	73	73A	74	74A	76	77

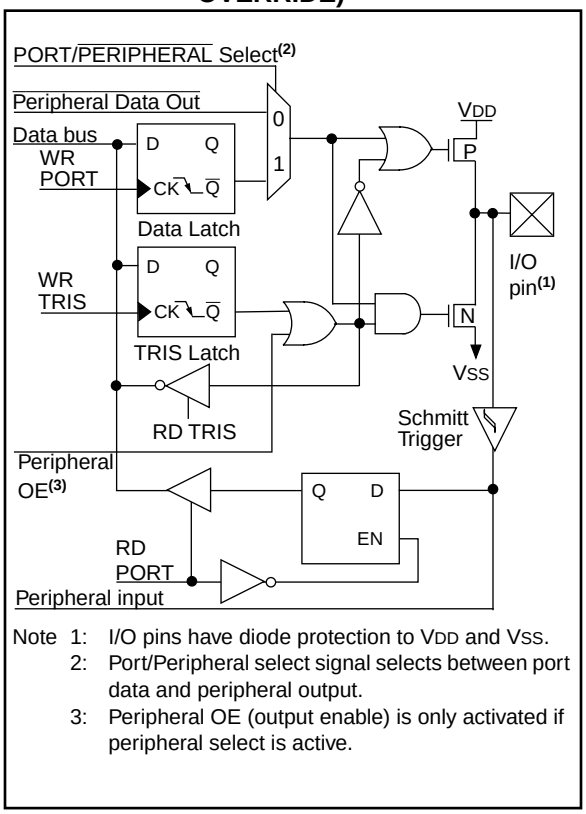
PORTC is an 8-bit bi-directional port. Each pin is individually configurable as an input or output through the TRISC register. PORTC is multiplexed with several peripheral functions (Table 5-5). PORTC pins have Schmitt Trigger input buffers.

When enabling peripheral functions, care should be taken in defining TRIS bits for each PORTC pin. Some peripherals override the TRIS bit to make a pin an output, while other peripherals override the TRIS bit to make a pin an input. Since the TRIS bit override is in effect while the peripheral is enabled, read-modify-write instructions (BSF, BCF, XORWF) with TRISC as destination should be avoided. The user should refer to the corresponding peripheral section for the correct TRIS bit settings.

EXAMPLE 5-3: INITIALIZING PORTC

```
BCF     STATUS, RP0  ; Select Bank 0
BCF     STATUS, RP1  ; PIC16C76/77 only
CLRF    PORTC        ; Initialize PORTC by
                     ; clearing output
                     ; data latches
BSF     STATUS, RP0  ; Select Bank 1
MOVLW   0xCF         ; Value used to
                     ; initialize data
                     ; direction
MOVWF   TRISC        ; Set RC<3:0> as inputs
                     ; RC<5:4> as outputs
                     ; RC<7:6> as inputs
```

FIGURE 5-6: PORTC BLOCK DIAGRAM (PERIPHERAL OUTPUT OVERRIDE)



Note 1: I/O pins have diode protection to VDD and VSS.
2: Port/Peripheral select signal selects between port data and peripheral output.
3: Peripheral OE (output enable) is only activated if peripheral select is active.

TABLE 5-5: PORTC FUNCTIONS

Name	Bit#	Buffer Type	Function
RC0/T1OSO/T1CKI	bit0	ST	Input/output port pin or Timer1 oscillator output/Timer1 clock input
RC1/T1OSI/CCP2(1)	bit1	ST	Input/output port pin or Timer1 oscillator input or Capture2 input/ Compare2 output/PWM2 output
RC2/CCP1	bit2	ST	Input/output port pin or Capture1 input/Compare1 output/PWM1 output
RC3/SCK/SCL	bit3	ST	RC3 can also be the synchronous serial clock for both SPI and I^2C modes.
RC4/SDI/SDA	bit4	ST	RC4 can also be the SPI Data In (SPI mode) or data I/O (I^2C mode).
RC5/SDO	bit5	ST	Input/output port pin or Synchronous Serial Port data output
RC6/TX/CK(2)	bit6	ST	Input/output port pin or USART Asynchronous Transmit, or USART Synchronous Clock
RC7/RX/DT(2)	bit7	ST	Input/output port pin or USART Asynchronous Receive, or USART Synchronous Data

Legend: ST = Schmitt Trigger input
Note 1: The CCP2 multiplexed function is not enabled on the PIC16C72.
2: The TX/CK and RX/DT multiplexed functions are not enabled on the PIC16C72.

5.7 Parallel Slave Port

Applicable Devices						
72	73	73A	74	74A	76	77

PORTD operates as an 8-bit wide Parallel Slave Port, or microprocessor port when control bit PSPMODE (TRISE<4>) is set. In slave mode it is asynchronously readable and writable by the external world through $\overline{RD}$ control input pin RE0/$\overline{RD}$/AN5 and $\overline{WR}$ control input pin RE1/$\overline{WR}$/AN6.

It can directly interface to an 8-bit microprocessor data bus. The external microprocessor can read or write the PORTD latch as an 8-bit latch. Setting bit PSPMODE enables port pin RE0/$\overline{RD}$/AN5 to be the $\overline{RD}$ input, RE1/$\overline{WR}$/AN6 to be the $\overline{WR}$ input and RE2/$\overline{CS}$/AN7 to be the $\overline{CS}$ (chip select) input. For this functionality, the corresponding data direction bits of the TRISE register (TRISE<2:0>) must be configured as inputs (set) and the A/D port configuration bits PCFG2:PCFG0 (ADCON1<2:0>) must be set, which will configure pins RE2:RE0 as digital I/O.

There are actually two 8-bit latches, one for data-out (from the PIC16/17) and one for data input. The user writes 8-bit data to PORTD data latch and reads data from the port pin latch (note that they have the same address). In this mode, the TRISD register is ignored, since the microprocessor is controlling the direction of data flow.

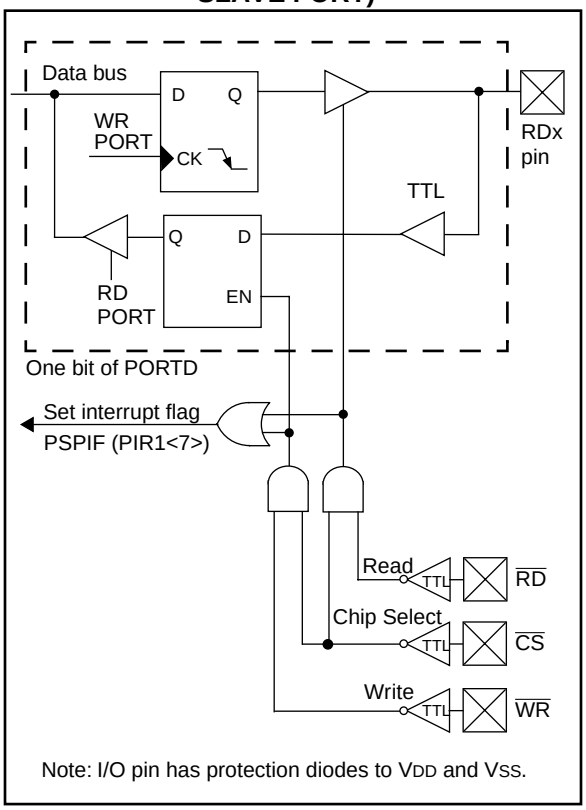
A write to the PSP occurs when both the $\overline{CS}$ and $\overline{WR}$ lines are first detected low. When either the $\overline{CS}$ or $\overline{WR}$ lines become high (level triggered), then the Input Buffer Full status flag bit IBF (TRISE<7>) is set on the Q4 clock cycle, following the next Q2 cycle, to signal the write is complete (Figure 5-12). The interrupt flag bit PSPIF (PIR1<7>) is also set on the same Q4 clock cycle. IBF can only be cleared by reading the PORTD input latch. The input Buffer Overflow status flag bit IBOV (TRISE<5>) is set if a second write to the Parallel Slave Port is attempted when the previous byte has not been read out of the buffer.

A read from the PSP occurs when both the $\overline{CS}$ and $\overline{RD}$ lines are first detected low. The Output Buffer Full status flag bit OBF (TRISE<6>) is cleared immediately (Figure 5-13) indicating that the PORTD latch is waiting to be read by the external bus. When either the $\overline{CS}$ or $\overline{RD}$ pin becomes high (level triggered), the interrupt flag bit PSPIF is set on the Q4 clock cycle, following the next Q2 cycle, indicating that the read is complete. OBF remains low until data is written to PORTD by the user firmware.

When not in Parallel Slave Port mode, the IBF and OBF bits are held clear. However, if flag bit IBOV was previously set, it must be cleared in firmware.

An interrupt is generated and latched into flag bit PSPIF when a read or write operation is completed. PSPIF must be cleared by the user in firmware and the interrupt can be disabled by clearing the interrupt enable bit PSPIE (PIE1<7>).

FIGURE 5-11: PORTD AND PORTE BLOCK DIAGRAM (PARALLEL SLAVE PORT)



Note: I/O pin has protection diodes to V_{DD} and V_{SS}.

10.0 CAPTURE/COMPARE/PWM MODULE(s)

Applicable Devices							
72	73	73A	74	74A	76	77	**CCP1**
72	73	73A	74	74A	76	77	**CCP2**

Each CCP (Capture/Compare/PWM) module contains a 16-bit register which can operate as a 16-bit capture register, as a 16-bit compare register or as a PWM master/slave Duty Cycle register. Both the CCP1 and CCP2 modules are identical in operation, with the exception of the operation of the special event trigger. Table 10-1 and Table 10-2 show the resources and interactions of the CCP module(s). In the following sections, the operation of a CCP module is described with respect to CCP1. CCP2 operates the same as CCP1, except where noted.

CCP1 module:

Capture/Compare/PWM Register1 (CCPR1) is comprised of two 8-bit registers: CCPR1L (low byte) and CCPR1H (high byte). The CCP1CON register controls the operation of CCP1. All are readable and writable.

CCP2 module:

Capture/Compare/PWM Register2 (CCPR2) is comprised of two 8-bit registers: CCPR2L (low byte) and CCPR2H (high byte). The CCP2CON register controls the operation of CCP2. All are readable and writable.

For use of the CCP modules, refer to the Embedded Control Handbook, *"Using the CCP Modules"* (AN594).

TABLE 10-1: CCP MODE - TIMER RESOURCE

CCP Mode	Timer Resource
Capture	Timer1
Compare	Timer1
PWM	Timer2

TABLE 10-2: INTERACTION OF TWO CCP MODULES

CCPx Mode	CCPy Mode	Interaction
Capture	Capture	Same TMR1 time-base.
Capture	Compare	The compare should be configured for the special event trigger, which clears TMR1.
Compare	Compare	The compare(s) should be configured for the special event trigger, which clears TMR1.
PWM	PWM	The PWMs will have the same frequency, and update rate (TMR2 interrupt).
PWM	Capture	None
PWM	Compare	None

10.1.4 CCP PRESCALER

There are four prescaler settings, specified by bits CCP1M3:CCP1M0. Whenever the CCP module is turned off, or the CCP module is not in capture mode, the prescaler counter is cleared. This means that any reset will clear the prescaler counter.

Switching from one capture prescaler to another may generate an interrupt. Also, the prescaler counter will not be cleared, therefore the first capture may be from a non-zero prescaler. Example 10-1 shows the recommended method for switching between capture prescalers. This example also clears the prescaler counter and will not generate the "false" interrupt.

EXAMPLE 10-1: CHANGING BETWEEN CAPTURE PRESCALERS

```
CLRF   CCP1CON      ;Turn CCP module off
MOVLW  NEW_CAPT_PS  ;Load the W reg with
                    ; the new prescaler
                    ; mode value and CCP ON
MOVWF  CCP1CON      ;Load CCP1CON with this
                    ; value
```

10.2 Compare Mode

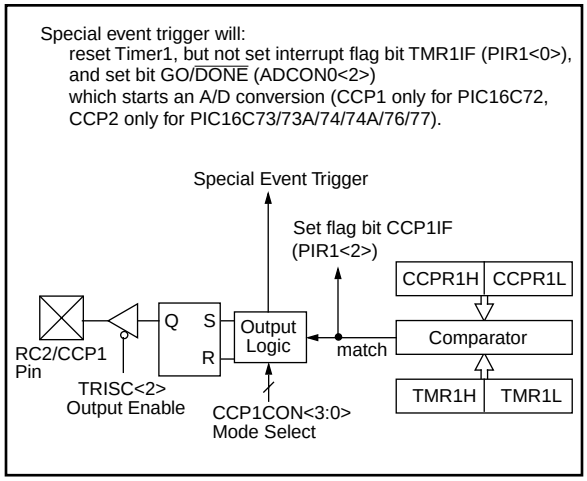
Applicable Devices						
72	73	73A	74	74A	76	77

In Compare mode, the 16-bit CCPR1 register value is constantly compared against the TMR1 register pair value. When a match occurs, the RC2/CCP1 pin is:

- Driven High
- Driven Low
- Remains Unchanged

The action on the pin is based on the value of control bits CCP1M3:CCP1M0 (CCP1CON<3:0>). At the same time, interrupt flag bit CCP1IF is set.

FIGURE 10-3: COMPARE MODE OPERATION BLOCK DIAGRAM



10.2.1 CCP PIN CONFIGURATION

The user must configure the RC2/CCP1 pin as an output by clearing the TRISC<2> bit.

Note:	Clearing the CCP1CON register will force the RC2/CCP1 compare output latch to the default low level. This is not the data latch.

10.2.2 TIMER1 MODE SELECTION

Timer1 must be running in Timer mode or Synchronized Counter mode if the CCP module is using the compare feature. In Asynchronous Counter mode, the compare operation may not work.

10.2.3 SOFTWARE INTERRUPT MODE

When generate software interrupt is chosen the CCP1 pin is not affected. Only a CCP interrupt is generated (if enabled).

10.2.4 SPECIAL EVENT TRIGGER

In this mode, an internal hardware trigger is generated which may be used to initiate an action.

The special event trigger output of CCP1 resets the TMR1 register pair. This allows the CCPR1 register to effectively be a 16-bit programmable period register for Timer1.

The special trigger output of CCP2 resets the TMR1 register pair, and starts an A/D conversion (if the A/D module is enabled).

For the PIC16C72 only, the special event trigger output of CCP1 resets the TMR1 register pair, and starts an A/D conversion (if the A/D module is enabled).

Note:	The special event trigger from the CCP1and CCP2 modules will not set interrupt flag bit TMR1IF (PIR1<0>).

12.1 USART Baud Rate Generator (BRG)

Applicable Devices						
72	73	73A	74	74A	76	77

The BRG supports both the Asynchronous and Synchronous modes of the USART. It is a dedicated 8-bit baud rate generator. The SPBRG register controls the period of a free running 8-bit timer. In asynchronous mode bit BRGH (TXSTA<2>) also controls the baud rate. In synchronous mode bit BRGH is ignored. Table 12-1 shows the formula for computation of the baud rate for different USART modes which only apply in master mode (internal clock).

Given the desired baud rate and Fosc, the nearest integer value for the SPBRG register can be calculated using the formula in Table 12-1. From this, the error in baud rate can be determined.

Example 12-1 shows the calculation of the baud rate error for the following conditions:

FOSC = 16 MHz
Desired Baud Rate = 9600
BRGH = 0
SYNC = 0

EXAMPLE 12-1: CALCULATING BAUD RATE ERROR

Desired Baud rate = Fosc / (64 (X + 1))

9600 = 16000000 /(64 (X + 1))

X = ⌊25.042⌋ = 25

Calculated Baud Rate=16000000 / (64 (25 + 1))

= 9615

$$\text{Error} = \frac{\text{(Calculated Baud Rate - Desired Baud Rate)}}{\text{Desired Baud Rate}}$$

= (9615 - 9600) / 9600

= 0.16%

It may be advantageous to use the high baud rate (BRGH = 1) even for slower baud clocks. This is because the FOSC/(16(X + 1)) equation can reduce the baud rate error in some cases.

Note:	For the PIC16C73/73A/74/74A, the asynchronous high speed mode (BRGH = 1) may experience a high rate of receive errors. It is recommended that BRGH = 0. If you desire a higher baud rate than BRGH = 0 can support, refer to the device errata for additional information, or use the PIC16C76/77.

Writing a new value to the SPBRG register, causes the BRG timer to be reset (or cleared), this ensures the BRG does not wait for a timer overflow before outputting the new baud rate.

TABLE 12-1: BAUD RATE FORMULA

SYNC	BRGH = 0 (Low Speed)	BRGH = 1 (High Speed)
0	(Asynchronous) Baud Rate = FOSC/(64(X+1))	Baud Rate= FOSC/(16(X+1))
1	(Synchronous) Baud Rate = FOSC/(4(X+1))	NA

X = value in SPBRG (0 to 255)

TABLE 12-2: REGISTERS ASSOCIATED WITH BAUD RATE GENERATOR

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Value on all other resets
98h	TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	0000 -010	0000 -010
18h	RCSTA	SPEN	RX9	SREN	CREN	—	FERR	OERR	RX9D	0000 -00x	0000 -00x
99h	SPBRG	Baud Rate Generator Register								0000 0000	0000 0000

Legend: x = unknown, - = unimplemented read as '0'. Shaded cells are not used by the BRG.

12.4 USART Synchronous Slave Mode

Applicable Devices						
72	73	73A	74	74A	76	77

Synchronous slave mode differs from the Master mode in the fact that the shift clock is supplied externally at the RC6/TX/CK pin (instead of being supplied internally in master mode). This allows the device to transfer or receive data while in SLEEP mode. Slave mode is entered by clearing bit CSRC (TXSTA<7>).

12.4.1 USART SYNCHRONOUS SLAVE TRANSMIT

The operation of the synchronous master and slave modes are identical except in the case of the SLEEP mode.

If two words are written to the TXREG and then the SLEEP instruction is executed, the following will occur:

a) The first word will immediately transfer to the TSR register and transmit.
b) The second word will remain in TXREG register.
c) Flag bit TXIF will not be set.
d) When the first word has been shifted out of TSR, the TXREG register will transfer the second word to the TSR and flag bit TXIF will now be set.
e) If enable bit TXIE is set, the interrupt will wake the chip from SLEEP and if the global interrupt is enabled, the program will branch to the interrupt vector (0004h).

Steps to follow when setting up a Synchronous Slave Transmission:

1. Enable the synchronous slave serial port by setting bits SYNC and SPEN and clearing bit CSRC.
2. Clear bits CREN and SREN.
3. If interrupts are desired, then set enable bit TXIE.
4. If 9-bit transmission is desired, then set bit TX9.
5. Enable the transmission by setting enable bit TXEN.
6. If 9-bit transmission is selected, the ninth bit should be loaded in bit TX9D.
7. Start transmission by loading data to the TXREG register.

12.4.2 USART SYNCHRONOUS SLAVE RECEPTION

The operation of the synchronous master and slave modes is identical except in the case of the SLEEP mode. Also, bit SREN is a don't care in slave mode.

If receive is enabled, by setting bit CREN, prior to the SLEEP instruction, then a word may be received during SLEEP. On completely receiving the word, the RSR register will transfer the data to the RCREG register and if enable bit RCIE bit is set, the interrupt generated will wake the chip from SLEEP. If the global interrupt is enabled, the program will branch to the interrupt vector (0004h).

Steps to follow when setting up a Synchronous Slave Reception:

1. Enable the synchronous master serial port by setting bits SYNC and SPEN and clearing bit CSRC.
2. If interrupts are desired, then set enable bit RCIE.
3. If 9-bit reception is desired, then set bit RX9.
4. To enable reception, set enable bit CREN.
5. Flag bit RCIF will be set when reception is complete and an interrupt will be generated, if enable bit RCIE was set.
6. Read the RCSTA register to get the ninth bit (if enabled) and determine if any error occurred during reception.
7. Read the 8-bit received data by reading the RCREG register.
8. If any error occurred, clear the error by clearing bit CREN.

14.2.3 EXTERNAL CRYSTAL OSCILLATOR CIRCUIT

Either a prepackaged oscillator can be used or a simple oscillator circuit with TTL gates can be built. Prepackaged oscillators provide a wide operating range and better stability. A well-designed crystal oscillator will provide good performance with TTL gates. Two types of crystal oscillator circuits can be used; one with series resonance, or one with parallel resonance.

Figure 14-5 shows implementation of a parallel resonant oscillator circuit. The circuit is designed to use the fundamental frequency of the crystal. The 74AS04 inverter performs the 180-degree phase shift that a parallel oscillator requires. The 4.7 kΩ resistor provides the negative feedback for stability. The 10 kΩ potentiometer biases the 74AS04 in the linear region. This could be used for external oscillator designs.

FIGURE 14-5: EXTERNAL PARALLEL RESONANT CRYSTAL OSCILLATOR CIRCUIT

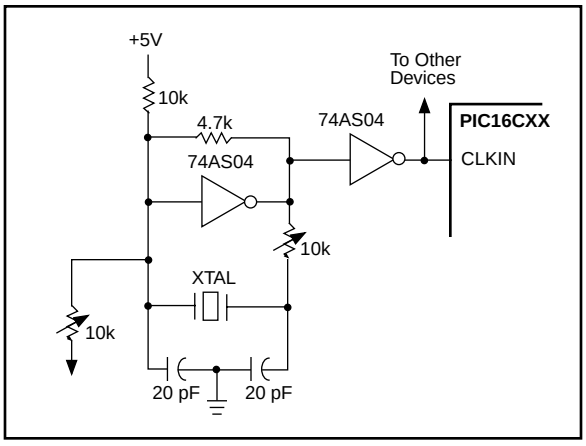
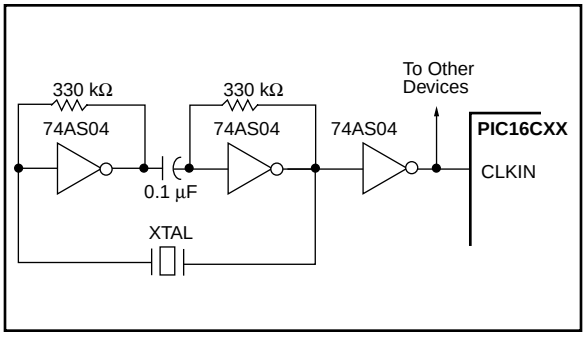


Figure 14-6 shows a series resonant oscillator circuit. This circuit is also designed to use the fundamental frequency of the crystal. The inverter performs a 180-degree phase shift in a series resonant oscillator circuit. The 330 kΩ resistors provide the negative feedback to bias the inverters in their linear region.

FIGURE 14-6: EXTERNAL SERIES RESONANT CRYSTAL OSCILLATOR CIRCUIT



14.2.4 RC OSCILLATOR

For timing insensitive applications the "RC" device option offers additional cost savings. The RC oscillator frequency is a function of the supply voltage, the resistor (Rext) and capacitor (Cext) values, and the operating temperature. In addition to this, the oscillator frequency will vary from unit to unit due to normal process parameter variation. Furthermore, the difference in lead frame capacitance between package types will also affect the oscillation frequency, especially for low Cext values. The user also needs to take into account variation due to tolerance of external R and C components used. Figure 14-7 shows how the R/C combination is connected to the PIC16CXX. For Rext values below 2.2 kΩ, the oscillator operation may become unstable, or stop completely. For very high Rext values (e.g. 1 MΩ), the oscillator becomes sensitive to noise, humidity and leakage. Thus, we recommend to keep Rext between 3 kΩ and 100 kΩ.

Although the oscillator will operate with no external capacitor (Cext = 0 pF), we recommend using values above 20 pF for noise and stability reasons. With no or small external capacitance, the oscillation frequency can vary dramatically due to changes in external capacitances, such as PCB trace capacitance or package lead frame capacitance.

See characterization data for desired device for RC frequency variation from part to part due to normal process variation. The variation is larger for larger R (since leakage current variation will affect RC frequency more for large R) and for smaller C (since variation of input capacitance will affect RC frequency more).

See characterization data for desired device for variation of oscillator frequency due to V_{DD} for given Rext/Cext values as well as frequency variation due to operating temperature for given R, C, and V_{DD} values.

The oscillator frequency, divided by 4, is available on the OSC2/CLKOUT pin, and can be used for test purposes or to synchronize other logic (see Figure 3-4 for waveform).

FIGURE 14-7: RC OSCILLATOR MODE

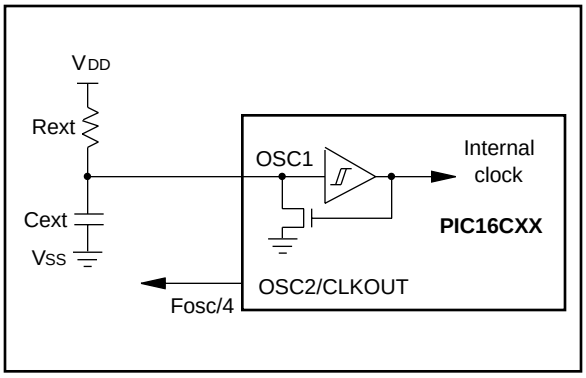
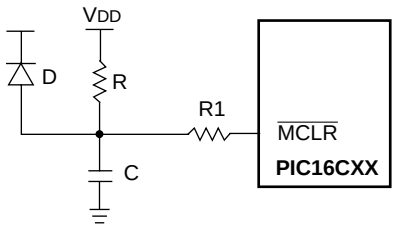


FIGURE 14-13: EXTERNAL POWER-ON RESET CIRCUIT (FOR SLOW VDD POWER-UP)

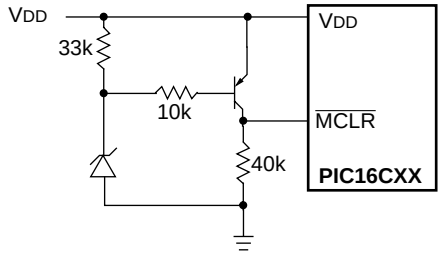


Note 1: External Power-on Reset circuit is required only if VDD power-up slope is too slow. The diode D helps discharge the capacitor quickly when VDD powers down.

2: R < 40 kΩ is recommended to make sure that voltage drop across R does not violate the device's electrical specification.

3: R1 = 100Ω to 1 kΩ will limit any current flowing into MCLR from external capacitor C in the event of MCLR/VPP pin breakdown due to Electrostatic Discharge (ESD) or Electrical Overstress (EOS).

FIGURE 14-14: EXTERNAL BROWN-OUT PROTECTION CIRCUIT 1

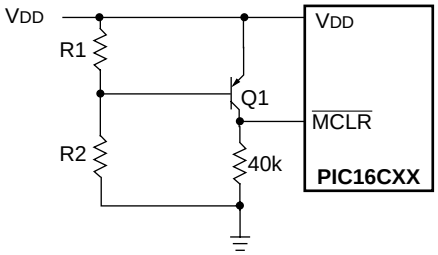


Note 1: This circuit will activate reset when VDD goes below (Vz + 0.7V) where Vz = Zener voltage.

2: Internal brown-out detection on the PIC16C72/73A/74A/76/77 should be disabled when using this circuit.

3: Resistors should be adjusted for the characteristics of the transistor.

FIGURE 14-15: EXTERNAL BROWN-OUT PROTECTION CIRCUIT 2



Note 1: This brown-out circuit is less expensive, albeit less accurate. Transistor Q1 turns off when VDD is below a certain level such that:

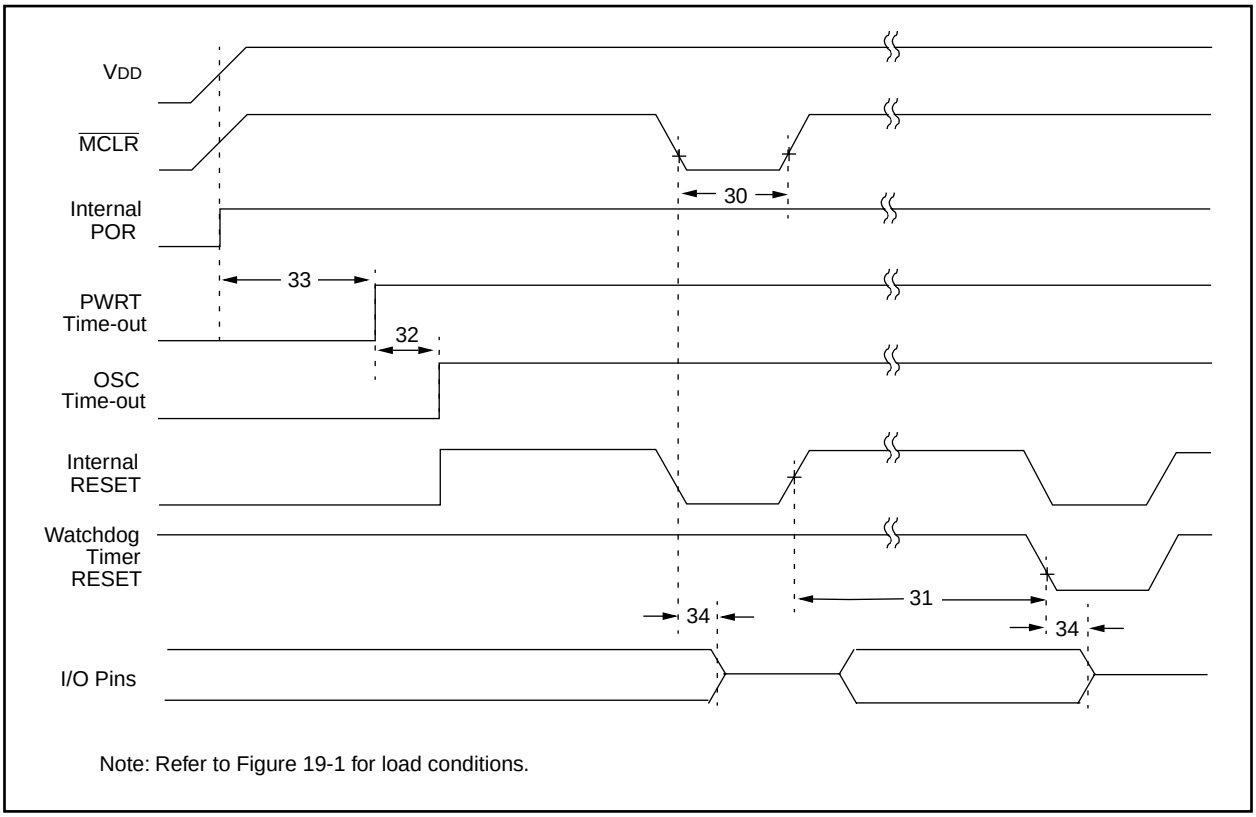
$$V_{DD} \cdot \frac{R1}{R1 + R2} = 0.7V$$

2: Internal brown-out detection on the PIC16C72/73A/74A/76/77 should be disabled when using this circuit.

3: Resistors should be adjusted for the characteristics of the transistor.

Applicable Devices	72	73	73A	74	74A	76	77

FIGURE 19-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING



Note: Refer to Figure 19-1 for load conditions.

FIGURE 19-5: BROWN-OUT RESET TIMING

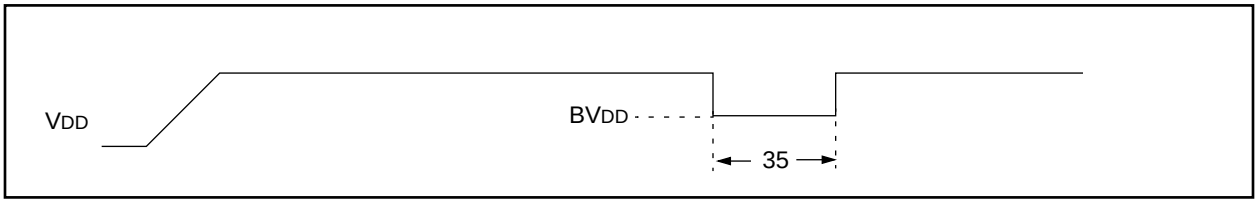


TABLE 19-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER, POWER-UP TIMER, AND BROWN-OUT RESET REQUIREMENTS

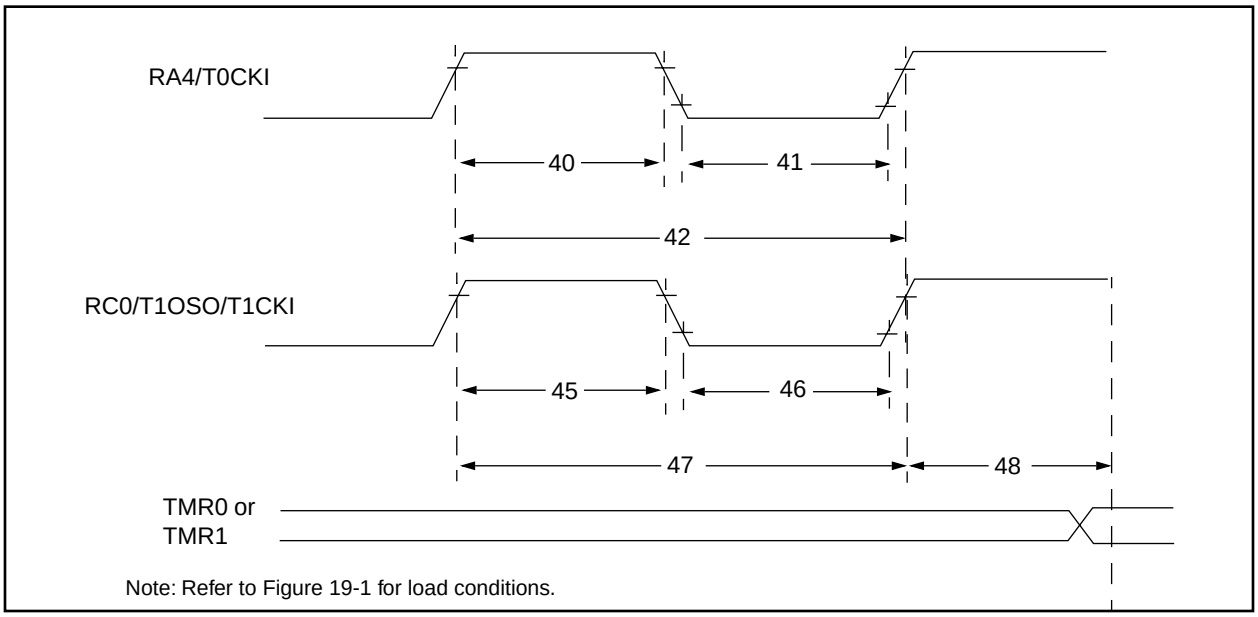
Parameter No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	TmcL	$\overline{MCLR}$ Pulse Width (low)	2	—	—	µs	VDD = 5V, -40˚C to +125˚C
31*	Twdt	Watchdog Timer Time-out Period (No Prescaler)	7	18	33	ms	VDD = 5V, -40˚C to +125˚C
32	Tost	Oscillation Start-up Timer Period	—	1024TOSC	—	—	TOSC = OSC1 period
33*	Tpwrt	Power up Timer Period	28	72	132	ms	VDD = 5V, -40˚C to +125˚C
34	TIOZ	I/O Hi-impedance from $\overline{MCLR}$ Low or Watchdog Timer Reset	—	—	2.1	µs	
35	TBOR	Brown-out Reset pulse width	100	—	—	µs	VDD ≤ BVDD (D005)

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25˚C unless otherwise stated. These parameters are for design guidance only and are not tested.

Applicable Devices	72	73	73A	74	74A	76	77

FIGURE 19-6: TIMER0 AND TIMER1 EXTERNAL CLOCK TIMINGS



Note: Refer to Figure 19-1 for load conditions.

TABLE 19-5: TIMER0 AND TIMER1 EXTERNAL CLOCK REQUIREMENTS

Param No.	Sym	Characteristic			Min	Typ†	Max	Units	Conditions
40*	Tt0H	T0CKI High Pulse Width		No Prescaler	0.5TCY + 20	—	—	ns	Must also meet parameter 42
				With Prescaler	10	—	—	ns	
41*	Tt0L	T0CKI Low Pulse Width		No Prescaler	0.5TCY + 20	—	—	ns	Must also meet parameter 42
				With Prescaler	10	—	—	ns	
42*	Tt0P	T0CKI Period		No Prescaler	TCY + 40	—	—	ns	
				With Prescaler	Greater of: 20 or TCY + 40 / N	—	—	ns	N = prescale value (2, 4, ..., 256)
45*	Tt1H	T1CKI High Time	Synchronous, Prescaler = 1		0.5TCY + 20	—	—	ns	Must also meet parameter 47
			Synchronous, Prescaler = 2,4,8	PIC16**C**7X	15	—	—	ns	
				PIC16**LC**7X	25	—	—	ns	
			Asynchronous	PIC16**C**7X	30	—	—	ns	
				PIC16**LC**7X	50	—	—	ns	
46*	Tt1L	T1CKI Low Time	Synchronous, Prescaler = 1		0.5TCY + 20	—	—	ns	Must also meet parameter 47
			Synchronous, Prescaler = 2,4,8	PIC16**C**7X	15	—	—	ns	
				PIC16**LC**7X	25	—	—	ns	
			Asynchronous	PIC16**C**7X	30	—	—	ns	
				PIC16**LC**7X	50	—	—	ns	
47*	Tt1P	T1CKI input period	Synchronous	PIC16**C**7X	Greater of: 30 OR TCY + 40 / N	—	—	ns	N = prescale value (1, 2, 4, 8)
				PIC16**LC**7X	Greater of: 50 OR TCY + 40 / N				N = prescale value (1, 2, 4, 8)
			Asynchronous	PIC16**C**7X	60	—	—	ns	
				PIC16**LC**7X	100	—	—	ns	
	Ft1	Timer1 oscillator input frequency range (oscillator enabled by setting bit T1OSCEN)			DC	—	200	kHz	
48	TCKEZtmr1	Delay from external clock edge to timer increment			2Tosc	—	7Tosc	—	

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25˚C unless otherwise stated. These parameters are for design guidance only and are not tested.

Applicable Devices	72	73	73A	74	74A	76	77

20.3 DC Characteristics: PIC16C76/77-04 (Commercial, Industrial, Extended) PIC16C76/77-10 (Commercial, Industrial, Extended) PIC16C76/77-20 (Commercial, Industrial, Extended) PIC16LC76/77-04 (Commercial, Industrial)

DC CHARACTERISTICS							**Standard Operating Conditions (unless otherwise stated)** Operating temperature -40°C ≤ TA ≤ +125°C for extended, -40°C ≤ TA ≤ +85°C for industrial and 0°C ≤ TA ≤ +70°C for commercial Operating voltage VDD range as described in DC spec Section 20.1 and Section 20.2.
Param No.	**Characteristic**	**Sym**	**Min**	**Typ †**	**Max**	**Units**	**Conditions**
	Input Low Voltage						
	I/O ports	VIL					
D030	with TTL buffer		VSS	-	0.15VDD	V	For entire VDD range
D030A			VSS	-	0.8V	V	4.5V ≤ VDD ≤ 5.5V
D031	with Schmitt Trigger buffer		VSS	-	0.2VDD	V	
D032	$\overline{MCLR}$, OSC1 (in RC mode)		VSS	-	0.2VDD	V	
D033	OSC1 (in XT, HS and LP)		VSS	-	0.3VDD	V	Note1
	Input High Voltage						
	I/O ports	VIH		-			
D040	with TTL buffer		2.0	-	VDD	V	4.5V ≤ VDD ≤ 5.5V
D040A			0.25VDD + 0.8V	-	VDD	V	For entire VDD range
D041	with Schmitt Trigger buffer		0.8VDD	-	VDD	V	For entire VDD range
D042	$\overline{MCLR}$		0.8VDD	-	VDD	V	
D042A	OSC1 (XT, HS and LP)		0.7VDD	-	VDD	V	Note1
D043	OSC1 (in RC mode)		0.9VDD	-	VDD	V	
D070	PORTB weak pull-up current	IPURB	50	250	400	µA	VDD = 5V, VPIN = VSS
	Input Leakage Current (Notes 2, 3)						
D060	I/O ports	IIL	-	-	±1	µA	Vss ≤ VPIN ≤ VDD, Pin at hi-impedance
D061	$\overline{MCLR}$, RA4/T0CKI		-	-	±5	µA	Vss ≤ VPIN ≤ VDD
D063	OSC1		-	-	±5	µA	Vss ≤ VPIN ≤ VDD, XT, HS and LP osc configuration
	Output Low Voltage						
D080	I/O ports	VOL	-	-	0.6	V	IOL = 8.5 mA, VDD = 4.5V, -40°C to +85°C
D080A			-	-	0.6	V	IOL = 7.0 mA, VDD = 4.5V, -40°C to +125°C
D083	OSC2/CLKOUT (RC osc config)		-	-	0.6	V	IOL = 1.6 mA, VDD = 4.5V, -40°C to +85°C
D083A			-	-	0.6	V	IOL = 1.2 mA, VDD = 4.5V, -40°C to +125°C

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

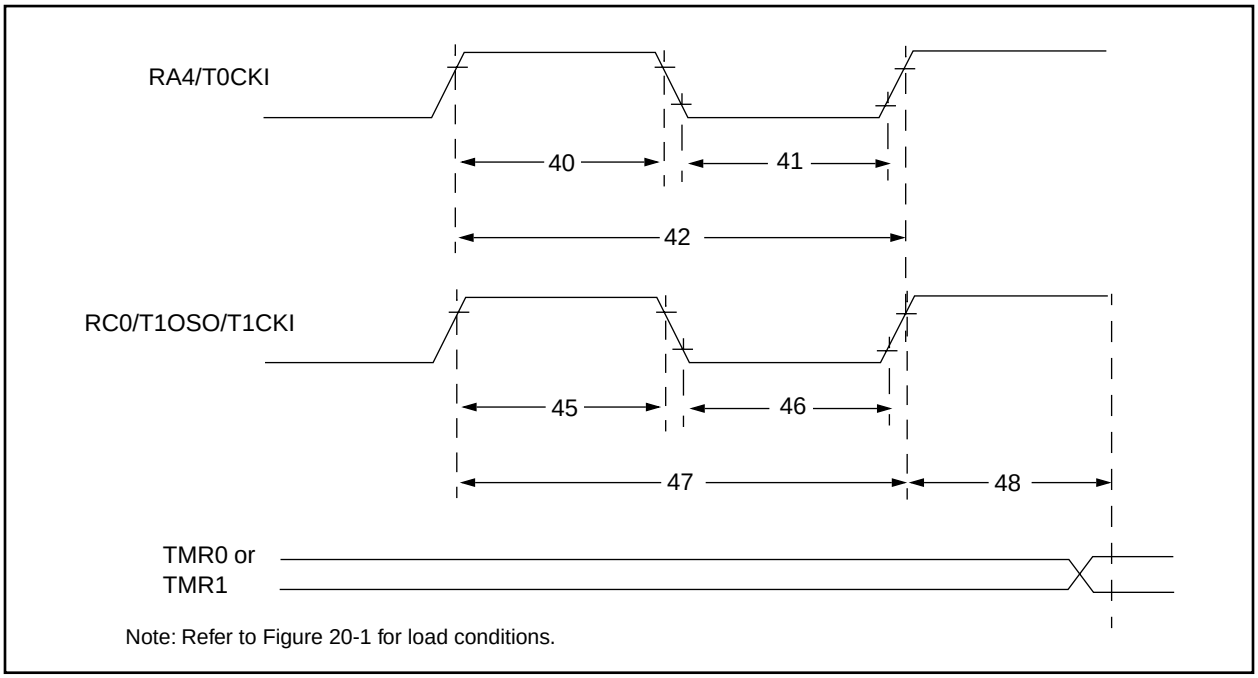
Note 1: In RC oscillator configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the PIC16C7X be driven with external clock in RC mode.

2: The leakage current on the $\overline{MCLR}$ pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current may be measured at different input voltages.

3: Negative current is defined as current sourced by the pin.

Applicable Devices	72	73	73A	74	74A	76	77

FIGURE 20-6: TIMER0 AND TIMER1 EXTERNAL CLOCK TIMINGS



Note: Refer to Figure 20-1 for load conditions.

TABLE 20-5: TIMER0 AND TIMER1 EXTERNAL CLOCK REQUIREMENTS

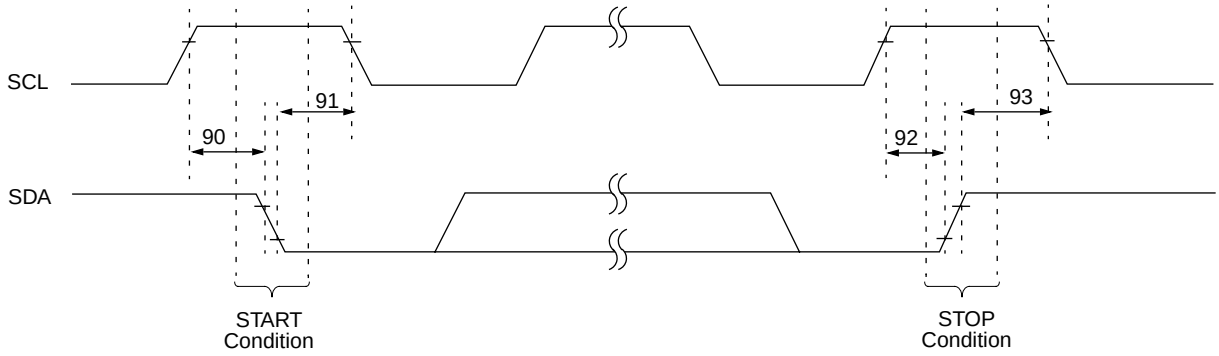
Param No.	Sym	Characteristic			Min	Typ†	Max	Units	Conditions
40*	Tt0H	T0CKI High Pulse Width		No Prescaler	0.5TCY + 20	—	—	ns	Must also meet parameter 42
				With Prescaler	10	—	—	ns	
41*	Tt0L	T0CKI Low Pulse Width		No Prescaler	0.5TCY + 20	—	—	ns	Must also meet parameter 42
				With Prescaler	10	—	—	ns	
42*	Tt0P	T0CKI Period		No Prescaler	TCY + 40	—	—	ns	
				With Prescaler	Greater of: 20 or TCY + 40 / N	—	—	ns	N = prescale value (2, 4, ..., 256)
45*	Tt1H	T1CKI High Time	Synchronous, Prescaler = 1		0.5TCY + 20	—	—	ns	Must also meet parameter 47
			Synchronous, Prescaler = 2,4,8	PIC16**C**7X	15	—	—	ns	
				PIC16**LC**7X	25	—	—	ns	
			Asynchronous	PIC16**C**7X	30	—	—	ns	
				PIC16**LC**7X	50	—	—	ns	
46*	Tt1L	T1CKI Low Time	Synchronous, Prescaler = 1		0.5TCY + 20	—	—	ns	Must also meet parameter 47
			Synchronous, Prescaler = 2,4,8	PIC16**C**7X	15	—	—	ns	
				PIC16**LC**7X	25	—	—	ns	
			Asynchronous	PIC16**C**7X	30	—	—	ns	
				PIC16**LC**7X	50	—	—	ns	
47*	Tt1P	T1CKI input period	Synchronous	PIC16**C**7X	Greater of: 30 OR TCY + 40 / N	—	—	ns	N = prescale value (1, 2, 4, 8)
				PIC16**LC**7X	Greater of: 50 OR TCY + 40 / N				N = prescale value (1, 2, 4, 8)
			Asynchronous	PIC16**C**7X	60	—	—	ns	
				PIC16**LC**7X	100	—	—	ns	
	Ft1	Timer1 oscillator input frequency range (oscillator enabled by setting bit T1OSCEN)			DC	—	200	kHz	
48	TCKEZtmr1	Delay from external clock edge to timer increment			2Tosc	—	7Tosc	—	

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25˚C unless otherwise stated. These parameters are for design guidance only and are not tested.

Applicable Devices	72	73	73A	74	74A	76	77

FIGURE 20-13: I^2C BUS START/STOP BITS TIMING



Note: Refer to Figure 20-1 for load conditions

TABLE 20-9: I^2C BUS START/STOP BITS REQUIREMENTS

Parameter No.	Sym	Characteristic		Min	Typ	Max	Units	Conditions
90	TSU:STA	START condition Setup time	100 kHz mode	4700	—	—	ns	Only relevant for repeated START condition
			400 kHz mode	600	—	—		
91	THD:STA	START condition Hold time	100 kHz mode	4000	—	—	ns	After this period the first clock pulse is generated
			400 kHz mode	600	—	—		
92	TSU:STO	STOP condition Setup time	100 kHz mode	4700	—	—	ns	
			400 kHz mode	600	—	—		
93	THD:STO	STOP condition Hold time	100 kHz mode	4000	—	—	ns	
			400 kHz mode	600	—	—		

Applicable Devices	72	73	73A	74	74A	76	77

FIGURE 21-16: TYPICAL IDD vs. FREQUENCY (RC MODE @ 300 pF, 25°C)

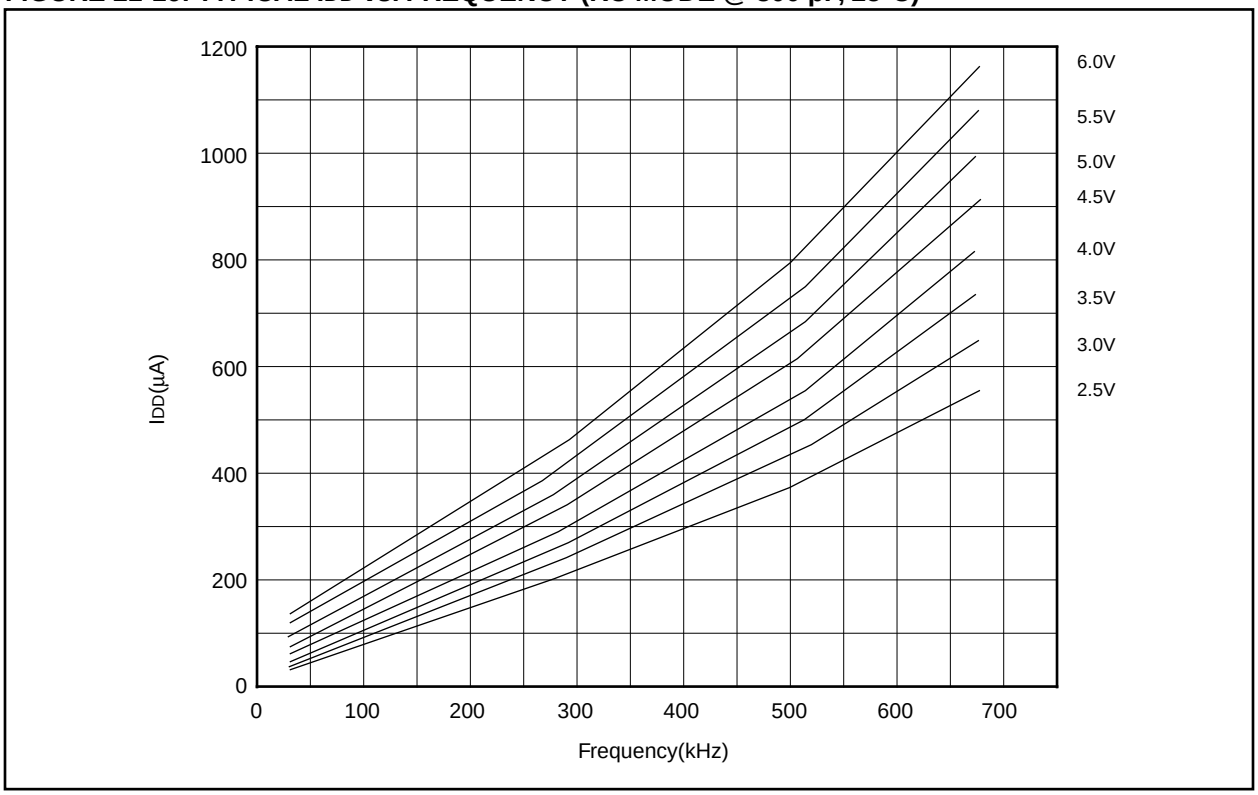
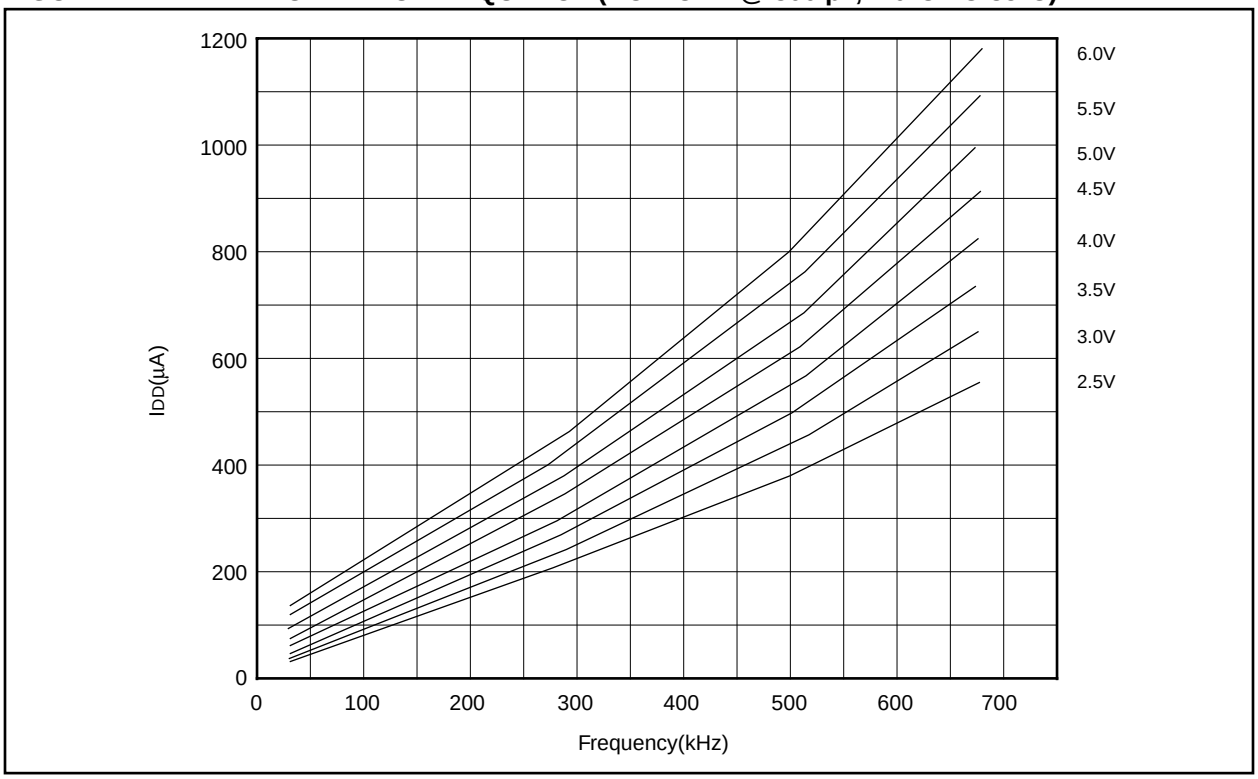


FIGURE 21-17: MAXIMUM IDD vs. FREQUENCY (RC MODE @ 300 pF, -40°C TO 85°C)



Data based on matrix samples. See first page of this section for details.

LIST OF FIGURES