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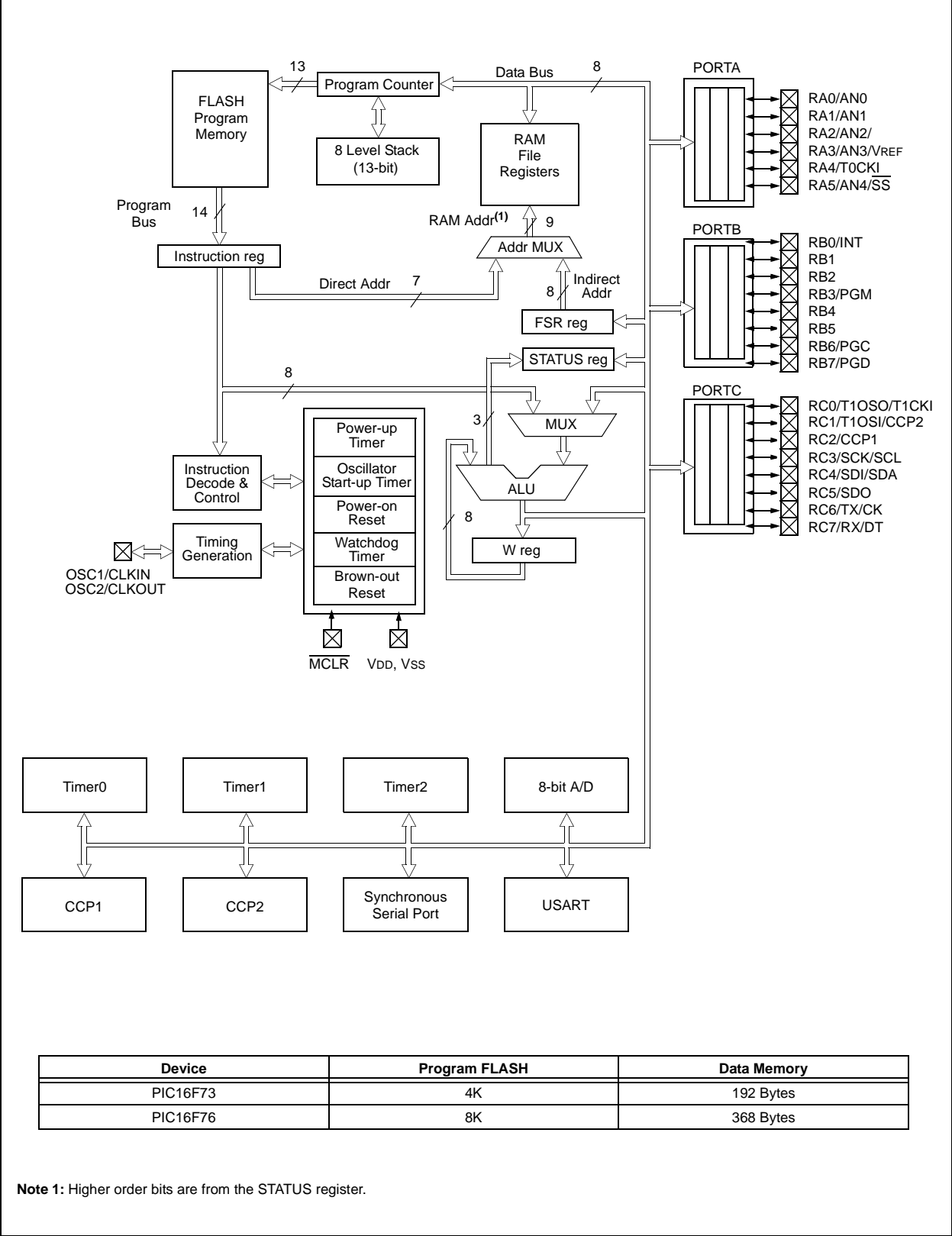
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Details

Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	20MHz
Connectivity	I ² C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	22
Program Memory Size	14KB (8K x 14)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	368 x 8
Voltage - Supply (Vcc/Vdd)	4V ~ 5.5V
Data Converters	A/D 5x8b
Oscillator Type	External
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	28-VQFN Exposed Pad
Supplier Device Package	28-QFN (6x6)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16f76-i-ml

PIC16F7X

FIGURE 1-1: PIC16F73 AND PIC16F76 BLOCK DIAGRAM



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2.2.2 SPECIAL FUNCTION REGISTERS

The Special Function Registers are registers used by the CPU and peripheral modules for controlling the desired operation of the device. These registers are implemented as static RAM. A list of these registers is given in Table 2-1.

The Special Function Registers can be classified into two sets: core (CPU) and peripheral. Those registers associated with the core functions are described in detail in this section. Those related to the operation of the peripheral features are described in detail in the peripheral feature section.

TABLE 2-1: SPECIAL FUNCTION REGISTER SUMMARY

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on: POR, BOR	Details on page
Bank 0											
00h ⁽⁴⁾	INDF	Addressing this location uses contents of FSR to address data memory (not a physical register)								0000 0000	27, 96
01h	TMR0	Timer0 Module Register								xxxx xxxx	45, 96
02h ⁽⁴⁾	PCL	Program Counter (PC) Least Significant Byte								0000 0000	26, 96
03h ⁽⁴⁾	STATUS	IRP	RP1	RP0	\overline{TO}	\overline{PD}	Z	DC	C	0001 1xxxx	19, 96
04h ⁽⁴⁾	FSR	Indirect Data Memory Address Pointer								xxxx xxxx	27, 96
05h	PORTA	—	—	PORTA Data Latch when written: PORTA pins when read						--0x 0000	32, 96
06h	PORTB	PORTB Data Latch when written: PORTB pins when read								xxxx xxxx	34, 96
07h	PORTC	PORTC Data Latch when written: PORTC pins when read								xxxx xxxx	35, 96
08h ⁽⁵⁾	PORTD	PORTD Data Latch when written: PORTD pins when read								xxxx xxxx	36, 96
09h ⁽⁵⁾	PORTE	—	—	—	—	—	RE2	RE1	RE0	---- -xxxx	39, 96
0Ah ^(1,4)	PCLATH	—	—	—	Write Buffer for the upper 5 bits of the Program Counter					---0 0000	26, 96
0Bh ⁽⁴⁾	INTCON	GIE	PEIE	TMR0IE	INTE	RBIE	TMR0IF	INTF	RBIF	0000 000x	21, 96
0Ch	PIR1	PSPIF ⁽³⁾	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	23, 96
0Dh	PIR2	—	—	—	—	—	—	—	CCP2IF	---- ---0	24, 96
0Eh	TMR1L	Holding Register for the Least Significant Byte of the 16-bit TMR1 Register								xxxx xxxx	50, 96
0Fh	TMR1H	Holding Register for the Most Significant Byte of the 16-bit TMR1 Register								xxxx xxxx	50, 96
10h	T1CON	—	—	T1CKPS1	T1CKPS0	T1OSCEN	$\overline{T1SYNC}$	TMR1CS	TMR1ON	--00 0000	47, 96
11h	TMR2	Timer2 Module Register								0000 0000	52, 96
12h	T2CON	—	TOUTPS3	TOUTPS2	TOUTPS	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0	-000 0000	52, 96
13h	SSPBUF	Synchronous Serial Port Receive Buffer/Transmit Register								xxxx xxxx	64, 68, 96
14h	SSPCON	WCOL	SSPOV	SSPEN	CKP	SSPM3	SSPM2	SSPM1	SSPM0	0000 0000	61, 96
15h	CCPR1L	Capture/Compare/PWM Register1 (LSB)								xxxx xxxx	56, 96
16h	CCPR1H	Capture/Compare/PWM Register1 (MSB)								xxxx xxxx	56, 96
17h	CCP1CON	—	—	CCP1X	CCP1Y	CCP1M3	CCP1M2	CCP1M1	CCP1M0	--00 0000	54, 96
18h	RCSTA	SPEN	RX9	SREN	CREN	—	FERR	OERR	RX9D	0000 -00x	70, 96
19h	TXREG	USART Transmit Data Register								0000 0000	74, 96
1Ah	RCREG	USART Receive Data Register								0000 0000	76, 96
1Bh	CCPR2L	Capture/Compare/PWM Register2 (LSB)								xxxx xxxx	58, 96
1Ch	CCPR2H	Capture/Compare/PWM Register2 (MSB)								xxxx xxxx	58, 96
1Dh	CCP2CON	—	—	CCP2X	CCP2Y	CCP2M3	CCP2M2	CCP2M1	CCP2M0	--00 0000	54, 96
1Eh	ADRES	A/D Result Register Byte								xxxx xxxx	88, 96
1Fh	ADCON0	ADCS1	ADCS0	CHS2	CHS1	CHS0	$\frac{GO}{DONE}$	—	ADON	0000 00-0	83, 96

Legend: x = unknown, u = unchanged, q = value depends on condition, - = unimplemented, read as '0', r = reserved.
Shaded locations are unimplemented, read as '0'.

- Note 1:** The upper byte of the program counter is not directly accessible. PCLATH is a holding register for the PC<12:8>, whose contents are transferred to the upper byte of the program counter during branches (CALL or GOTO).
- 2:** Other (non power-up) RESETS include external RESET through MCLR and Watchdog Timer Reset.
- 3:** Bits PSPIE and PSPIF are reserved on the 28-pin devices; always maintain these bits clear.
- 4:** These registers can be addressed from any bank.
- 5:** PORTD, PORTE, TRISD, and TRISE are not physically implemented on the 28-pin devices, read as '0'.
- 6:** This bit always reads as a '1'.

TABLE 4-9: PORTE FUNCTIONS

Name	Bit#	Buffer Type	Function
RE0/ $\overline{\text{RD}}$ /AN5	bit0	ST/TTL ⁽¹⁾	Input/output port pin or read control input in Parallel Slave Port mode or analog input. For $\overline{\text{RD}}$ (PSP mode): 1 = IDLE 0 = Read operation. Contents of PORTD register output to PORTD I/O pins (if chip selected).
RE1/ $\overline{\text{WR}}$ /AN6	bit1	ST/TTL ⁽¹⁾	Input/output port pin or write control input in Parallel Slave Port mode or analog input. For $\overline{\text{WR}}$ (PSP mode): 1 = IDLE 0 = Write operation. Value of PORTD I/O pins latched into PORTD register (if chip selected).
RE2/ $\overline{\text{CS}}$ /AN7	bit2	ST/TTL ⁽¹⁾	Input/output port pin or chip select control input in Parallel Slave Port mode or analog input. For $\overline{\text{CS}}$ (PSP mode): 1 = Device is not selected 0 = Device is selected

Legend: ST = Schmitt Trigger input, TTL = TTL input

Note 1: Input buffers are Schmitt Triggers when in I/O mode and TTL buffers when in Parallel Slave Port mode.

TABLE 4-10: SUMMARY OF REGISTERS ASSOCIATED WITH PORTE

Addr	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
09h	PORTE	—	—	—	—	—	RE2	RE1	RE0	---- -xxx	---- -uuu
89h	TRISE	IBF	OBF	IBOV	PSPMODE	—	PORTE Data Direction bits			0000 -111	0000 -111
9Fh	ADCON1	—	—	—	—	—	PCFG2	PCFG1	PCFG0	---- -000	---- -000

Legend: x = unknown, u = unchanged, - = unimplemented, read as '0'. Shaded cells are not used by PORTE.

A read from the PSP occurs when both the $\overline{\text{CS}}$ and $\overline{\text{RD}}$ lines are detected low. The data in the PORTD output latch is output to the PORTD pins. The Output Buffer Full (OBF) status flag bit (TRISE<6>) is cleared immediately (Figure 4-10), indicating that the PORTD latch is being read, or has been read by the external bus. If firmware writes new data to the output latch during this time, it is immediately output to the PORTD pins, but OBF will remain cleared.

When not in PSP mode, the IBF and OBF bits are held clear. Flag bit IBOV remains unchanged. The PSPIF bit must be cleared by the user in firmware; the interrupt can be disabled by clearing the interrupt enable bit PSPIE (PIE1<7>).

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NOTES:

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REGISTER 8-1: CCP1CON REGISTER/CCP2CON REGISTER (ADDRESS: 17h/1Dh)

U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	CCPxX	CCPxY	CCPxM3	CCPxM2	CCPxM1	CCPxM0
bit 7		bit 0					

bit 7-6 **Unimplemented:** Read as '0'

bit 5-4 **CCPxX:CCPxY:** PWM Least Significant bits

Capture mode:

Unused

Compare mode:

Unused

PWM mode:

These bits are the two LSbs of the PWM duty cycle. The eight MSbs are found in CCPRxL.

bit 3-0 **CCPxM3:CCPxM0:** CCPx Mode Select bits

0000 = Capture/Compare/PWM disabled (resets CCPx module)

0100 = Capture mode, every falling edge

0101 = Capture mode, every rising edge

0110 = Capture mode, every 4th rising edge

0111 = Capture mode, every 16th rising edge

1000 = Compare mode, set output on match (CCPxIF bit is set)

1001 = Compare mode, clear output on match (CCPxIF bit is set)

1010 = Compare mode, generate software interrupt on match (CCPxIF bit is set, CCPx pin is unaffected)

1011 = Compare mode, trigger special event (CCPxIF bit is set, CCPx pin is unaffected); CCP1 clears Timer1; CCP2 clears Timer1 and starts an A/D conversion (if A/D module is enabled)

11xx = PWM mode

Legend:

R = Readable bit

W = Writable bit

U = Unimplemented bit, read as '0'

- n = Value at POR reset

'1' = Bit is set

'0' = Bit is cleared

x = Bit is unknown

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REGISTER 9-1: SSPSTAT: SYNC SERIAL PORT STATUS REGISTER (ADDRESS 94h)

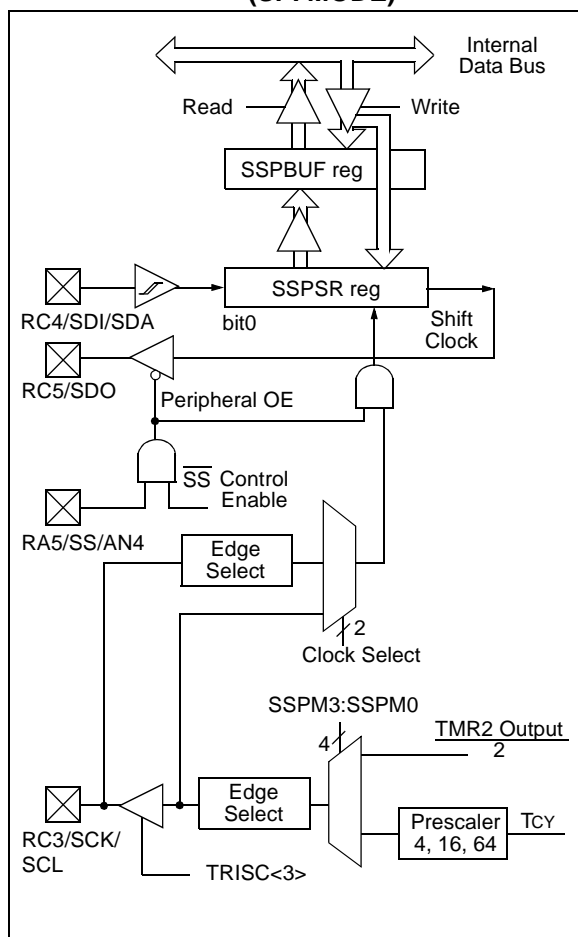
R/W-0	R/W-0	R-0	R-0	R-0	R-0	R-0	R-0
SMP	CKE	D/A	P	S	R/W	UA	BF
bit 7						bit 0	

- bit 7 **SMP:** SPI Data Input Sample Phase bit
SPI Master mode:
 1 = Input data sampled at end of data output time
 0 = Input data sampled at middle of data output time (Microwire®)
SPI Slave mode:
 SMP must be cleared when SPI is used in Slave mode
I²C mode:
 This bit must be maintained clear
- bit 6 **CKE:** SPI Clock Edge Select bit (Figure 9-2, Figure 9-3, and Figure 9-4)
SPI mode, CKP = 0:
 1 = Data transmitted on rising edge of SCK (Microwire® alternate)
 0 = Data transmitted on falling edge of SCK
SPI mode, CKP = 1:
 1 = Data transmitted on falling edge of SCK (Microwire® default)
 0 = Data transmitted on rising edge of SCK
I²C mode:
 This bit must be maintained clear
- bit 5 **D/A:** Data/Address bit (I²C mode only)
 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 (I²C mode only)
 This bit is cleared when the SSP module is disabled, or when the START bit is detected last. SSPEN is cleared.
 1 = Indicates that a STOP bit has been detected last (this bit is '0' on RESET)
 0 = STOP bit was not detected last
- bit 3 **S:** START bit (I²C mode only)
 This bit is cleared when the SSP module is disabled, or when the STOP bit is detected last. SSPEN is cleared.
 1 = Indicates that a START bit has been detected last (this bit is '0' on RESET)
 0 = START bit was not detected last
- bit 2 **R/W:** Read/Write bit Information (I²C mode only)
 This bit holds the R/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 ACK bit.
 1 = Read
 0 = Write
- bit 1 **UA:** Update Address bit (10-bit I²C mode only)
 1 = Indicates that the user needs to update the address in the SSPADD register
 0 = Address does not need to be updated
- bit 0 **BF:** Buffer Full Status bit
Receive (SPI and I²C modes):
 1 = Receive complete, SSPBUF is full
 0 = Receive not complete, SSPBUF is empty
Transmit (I²C mode only):
 1 = Transmit in progress, SSPBUF is full
 0 = Transmit complete, SSPBUF is empty

Legend:

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

FIGURE 9-1: SSP BLOCK DIAGRAM (SPI MODE)



To enable the serial port, SSP enable bit, SSPEN (SSPCON<5>) must be set. To reset or reconfigure SPI mode, clear bit SSPEN, re-initialize the SSPCON register, and then set bit SSPEN. This configures the SDI, SDO, SCK, and \overline{SS} pins as serial port pins. For the pins to behave as the serial port function, they must have their data direction bits (in the TRISC register) appropriately programmed. That is:

- SDI must have TRISC<4> set
- SDO must have TRISC<5> cleared
- SCK (Master mode) must have TRISC<3> cleared
- SCK (Slave mode) must have TRISC<3> set
- \overline{SS} must have TRISA<5> set and ADCON must be configured such that RA5 is a digital I/O

Note 1: When the SPI is in Slave mode with \overline{SS} pin control enabled (SSPCON<3:0> = 0100), the SPI module will reset if the \overline{SS} pin is set to VDD.

2: If the SPI is used in Slave mode with CKE = '1', then the \overline{SS} pin control must be enabled.

3: When the SPI is in Slave mode with \overline{SS} pin control enabled (SSPCON<3:0> = '0100'), the state of the \overline{SS} pin can affect the state read back from the TRISC<5> bit. The Peripheral OE signal from the SSP module into PORTC controls the state that is read back from the TRISC<5> bit (see Section 4.3 for information on PORTC). If Read-Modify-Write instructions, such as BSF are performed on the TRISC register while the \overline{SS} pin is high, this will cause the TRISC<5> bit to be set, thus disabling the SDO output.

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9.3.2 MASTER MODE

Master mode of operation is supported in firmware using interrupt generation on the detection of the START and STOP conditions. The STOP (P) and START (S) bits are cleared from a RESET or when the SSP module is disabled. The STOP (P) and START (S) bits will toggle based on the START and STOP conditions. Control of the I²C bus may be taken when the P bit is set, or the bus is IDLE and both the S and P bits are clear.

In Master mode, the SCL and SDA lines are manipulated by clearing the corresponding TRISC<4:3> bit(s). The output level is always low, irrespective of the value(s) in PORTC<4:3>. So when transmitting data, a '1' data bit must have the TRISC<4> bit set (input) and a '0' data bit must have the TRISC<4> bit cleared (output). The same scenario is true for the SCL line with the TRISC<3> bit. Pull-up resistors must be provided externally to the SCL and SDA pins for proper operation of the I²C module.

The following events will cause SSP Interrupt Flag bit, SSPIF, to be set (SSP Interrupt will occur if enabled):

- START condition
- STOP condition
- Data transfer byte transmitted/received

Master mode of operation can be done with either the Slave mode IDLE (SSPM3:SSPM0 = 1011), or with the Slave active. When both Master and Slave modes are enabled, the software needs to differentiate the source(s) of the interrupt.

9.3.3 MULTI-MASTER MODE

In Multi-Master mode, the interrupt generation on the detection of the START and STOP conditions, allows the determination of when the bus is free. The STOP (P) and START (S) bits are cleared from a RESET or when the SSP module is disabled. The STOP (P) and START (S) bits will toggle based on the START and STOP conditions. Control of the I²C bus may be taken when bit P (SSPSTAT<4>) is set, or the bus is IDLE and both the S and P bits clear. When the bus is busy, enabling the SSP Interrupt will generate the interrupt when the STOP condition occurs.

In Multi-Master operation, the SDA line must be monitored to see if the signal level is the expected output level. This check only needs to be done when a high level is output. If a high level is expected and a low level is present, the device needs to release the SDA and SCL lines (set TRISC<4:3>). There are two stages where this arbitration can be lost, these are:

- Address Transfer
- Data Transfer

When the slave logic is enabled, the slave continues to receive. If arbitration was lost during the address transfer stage, communication to the device may be in progress. If addressed, an ACK pulse will be generated. If arbitration was lost during the data transfer stage, the device will need to retransfer the data at a later time.

TABLE 9-3: REGISTERS ASSOCIATED WITH I²C OPERATION

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
0Bh, 8Bh, 10Bh, 18Bh	INTCON	GIE	PEIE	TMR0IE	INTE	RBIE	TMR0IF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF ⁽¹⁾	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
8Ch	PIE1	PSPIE ⁽¹⁾	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
13h	SSPBUF	Synchronous Serial Port Receive Buffer/Transmit Register								xxxx xxxx	uuuu uuuu
93h	SSPAD	Synchronous Serial Port (I ² C mode) Address Register								0000 0000	0000 0000
14h	SSPCON	WCOL	SSPOV	SSPEN	CKP	SSPM3	SSPM2	SSPM1	SSPM0	0000 0000	0000 0000
94h	SSPSTAT	SMP ⁽²⁾	CKE ⁽²⁾	D/A	P	S	R/W	UA	BF	0000 0000	0000 0000
87h	TRISC	PORTC Data Direction Register								1111 1111	1111 1111

Legend: x = unknown, u = unchanged, - = unimplemented locations read as '0'. Shaded cells are not used by SSP module in I²C mode.

Note 1: PSPIF and PSPIE are reserved on the PIC16F73/76; always maintain these bits clear.

2: Maintain these bits clear in I²C mode.

10.2.2 USART ASYNCHRONOUS RECEIVER

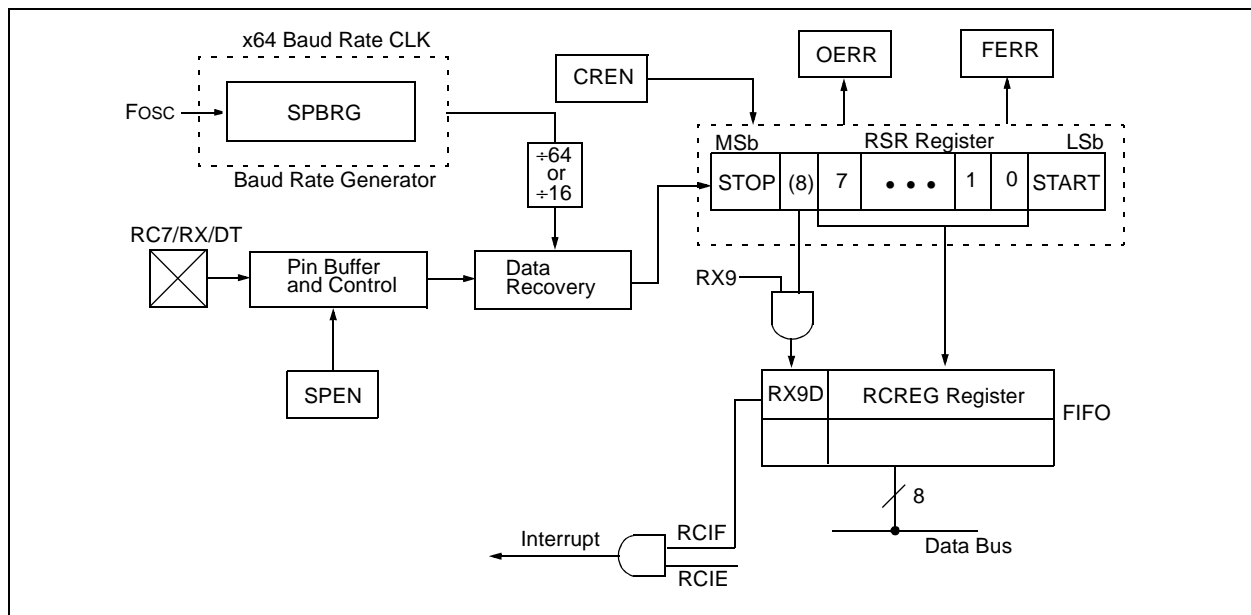
The receiver block diagram is shown in Figure 10-4. The data is received on the RC7/RX/DT pin and drives the data recovery block. The data recovery block is actually a high speed shifter operating at x16 times the baud rate, whereas the main receive serial shifter operates at the bit rate, or at FOSC.

Once Asynchronous mode is selected, reception is enabled by setting bit CREN (RCSTA<4>).

The heart of the receiver is the receive (serial) shift register (RSR). After sampling the STOP bit, the received data in the RSR is transferred to the RCREG register (if it is empty). If the transfer is complete, flag bit RCIF (PIR1<5>) is set. The actual interrupt can be enabled/disabled by setting/clearing enable bit RCIE (PIE1<5>). Flag bit RCIF is a read only bit which is cleared by the hardware. It is cleared when the RCREG register has been read and is empty. The RCREG is a double buffered register (i.e., it is a two deep FIFO). It

is possible for two bytes of data to be received and transferred to the RCREG FIFO and a third byte to begin shifting to the RSR register. On the detection of the STOP bit of the third byte, if the RCREG register is still full, the overrun error bit OERR (RCSTA<1>) will be set. The word in the RSR will be lost. The RCREG register can be read twice to retrieve the two bytes in the FIFO. Overrun bit OERR has to be cleared in software. This is done by resetting the receive logic (CREN is cleared and then set). If bit OERR is set, transfers from the RSR register to the RCREG register are inhibited and no further data will be received, therefore, it is essential to clear error bit OERR if it is set. Framing error bit FERR (RCSTA<2>) is set if a STOP bit is detected as clear. Bit FERR and the 9th receive bit are buffered the same way as the receive data. Reading the RCREG will load bits RX9D and FERR with new values, therefore, it is essential for the user to read the RCSTA register before reading RCREG register, in order not to lose the old FERR and RX9D information.

FIGURE 10-4: USART RECEIVE BLOCK DIAGRAM



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11.7 Use of the CCP Trigger

An A/D conversion can be started by the “special event trigger” of the CCP2 module. This requires that the CCP2M3:CCP2M0 bits (CCP2CON<3:0>) be programmed as 1011 and that the A/D module is enabled (ADON bit is set). When the trigger occurs, the GO/DONE bit will be set, starting the A/D conversion, and the Timer1 counter will be reset to zero. Timer1 is reset to automatically repeat the A/D acquisition period

with minimal software overhead (moving the ADRES to the desired location). The appropriate analog input channel must be selected and an appropriate acquisition time should pass before the “special event trigger” sets the GO/DONE bit (starts a conversion).

If the A/D module is not enabled (ADON is cleared), then the “special event trigger” will be ignored by the A/D module, but will still reset the Timer1 counter.

TABLE 11-2: SUMMARY OF A/D REGISTERS

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
0Bh, 8Bh, 10Bh, 18Bh	INTCON	GIE	PEIE	TMR0IE	INTE	RBIE	TMR0IF	INTF	RBIF	0000 000x	0000 000u
0Ch	PIR1	PSPIF ⁽¹⁾	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
0Dh	PIR2	—	—	—	—	—	—	—	CCP2IF	---- --0	---- --0
8Ch	PIE1	PSPIE ⁽¹⁾	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
8Dh	PIE2	—	—	—	—	—	—	—	CCP2IE	---- --0	---- --0
1Eh	ADRES	A/D Result Register								xxxx xxxx	uuuu uuuu
1Fh	ADCON0	ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/DONE	—	ADON	0000 00-0	0000 00-0
9Fh	ADCON1	—	—	—	—	—	PCFG2	PCFG1	PCFG0	---- -000	---- -000
05h	PORTA	—	—	RA5	RA4	RA3	RA2	RA1	RA0	--0x 0000	--0u 0000
85h	TRISA	—	—	PORTA Data Direction Register						--11 1111	--11 1111
09h	PORTE ⁽²⁾	—	—	—	—	—	RE2	RE1	RE0	---- -xxx	---- -uuu
89h	TRISE ⁽²⁾	IBF	OBF	IBOV	PSPMODE	—	PORTE Data Direction Bits			0000 -111	0000 -111

Legend: x = unknown, u = unchanged, - = unimplemented, read as '0'. Shaded cells are not used for A/D conversion.

Note 1: Bits PSPIE and PSPIF are reserved on the PIC16F73/76; always maintain these bits clear.

Note 2: These registers are reserved on the PIC16F73/76.

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TABLE 13-2: PIC16F7X INSTRUCTION SET

Mnemonic, Operands		Description	Cycles	14-Bit Opcode				Status Affected	Notes
				MSb		LSb			
BYTE-ORIENTED FILE REGISTER OPERATIONS									
ADDWF	f, d	Add W and f	1	00	0111	dfff	ffff	C,DC,Z	1,2
ANDWF	f, d	AND W with f	1	00	0101	dfff	ffff	Z	1,2
CLRF	f	Clear f	1	00	0001	1fff	ffff	Z	2
CLRW	-	Clear W	1	00	0001	0xxx	xxxx	Z	
COMF	f, d	Complement f	1	00	1001	dfff	ffff	Z	1,2
DECf	f, d	Decrement f	1	00	0011	dfff	ffff	Z	1,2
DECFSZ	f, d	Decrement f, Skip if 0	1(2)	00	1011	dfff	ffff		1,2,3
INCF	f, d	Increment f	1	00	1010	dfff	ffff	Z	1,2
INCFSZ	f, d	Increment f, Skip if 0	1(2)	00	1111	dfff	ffff		1,2,3
IORWF	f, d	Inclusive OR W with f	1	00	0100	dfff	ffff	Z	1,2
MOVF	f, d	Move f	1	00	1000	dfff	ffff	Z	1,2
MOVWF	f	Move W to f	1	00	0000	1fff	ffff		
NOP	-	No Operation	1	00	0000	0xx0	0000		
RLF	f, d	Rotate Left f through Carry	1	00	1101	dfff	ffff	C	1,2
RRF	f, d	Rotate Right f through Carry	1	00	1100	dfff	ffff	C	1,2
SUBWF	f, d	Subtract W from f	1	00	0010	dfff	ffff	C,DC,Z	1,2
SWAPF	f, d	Swap nibbles in f	1	00	1110	dfff	ffff		1,2
XORWF	f, d	Exclusive OR W with f	1	00	0110	dfff	ffff	Z	1,2
BIT-ORIENTED FILE REGISTER OPERATIONS									
BCF	f, b	Bit Clear f	1	01	00bb	bfff	ffff		1,2
BSF	f, b	Bit Set f	1	01	01bb	bfff	ffff		1,2
BTFSC	f, b	Bit Test f, Skip if Clear	1 (2)	01	10bb	bfff	ffff		3
BTFSS	f, b	Bit Test f, Skip if Set	1 (2)	01	11bb	bfff	ffff		3
LITERAL AND CONTROL OPERATIONS									
ADDLW	k	Add literal and W	1	11	111x	kkkk	kkkk	C,DC,Z	
ANDLW	k	AND literal with W	1	11	1001	kkkk	kkkk	Z	
CALL	k	Call subroutine	2	10	0kkk	kkkk	kkkk		
CLRWDT	-	Clear Watchdog Timer	1	00	0000	0110	0100	$\overline{TO}, \overline{PD}$	
GOTO	k	Go to address	2	10	1kkk	kkkk	kkkk		
IORLW	k	Inclusive OR literal with W	1	11	1000	kkkk	kkkk	Z	
MOVLW	k	Move literal to W	1	11	00xx	kkkk	kkkk		
RETFIE	-	Return from interrupt	2	00	0000	0000	1001		
RETLW	k	Return with literal in W	2	11	01xx	kkkk	kkkk		
RETURN	-	Return from Subroutine	2	00	0000	0000	1000		
SLEEP	-	Go into Standby mode	1	00	0000	0110	0011	$\overline{TO}, \overline{PD}$	
SUBLW	k	Subtract W from literal	1	11	110x	kkkk	kkkk	C,DC,Z	
XORLW	k	Exclusive OR literal with W	1	11	1010	kkkk	kkkk	Z	

- Note 1:** When an I/O register is modified as a function of itself (e.g., `MOVF PORTB, 1`), the value used will be that value present on the pins themselves. For example, if the data latch is '1' for a pin configured as input and is driven low by an external device, the data will be written back with a '0'.
- 2:** If this instruction is executed on the TMR0 register (and, where applicable, d = 1), the prescaler will be cleared if assigned to the Timer0 module.
- 3:** If Program Counter (PC) is modified, or a conditional test is true, the instruction requires two cycles. The second cycle is executed as a NOP.

Note: Additional information on the mid-range instruction set is available in the PICmicro™ Mid-Range MCU Family Reference Manual (DS33023).

13.2 Instruction Descriptions

ADDLW Add Literal and W

Syntax: [*label*] ADDLW *k*

Operands: $0 \leq k \leq 255$

Operation: $(W) + k \rightarrow (W)$

Status Affected: C, DC, Z

Description: The contents of the W register are added to the eight-bit literal 'k' and the result is placed in the W register.

ADDWF Add W and f

Syntax: [*label*] ADDWF *f*,*d*

Operands: $0 \leq f \leq 127$
 $d \in [0,1]$

Operation: $(W) + (f) \rightarrow (\text{destination})$

Status Affected: C, DC, Z

Description: Add the contents of the W register with register 'f'. If 'd' is 0, the result is stored in the W register. If 'd' is 1, the result is stored back in register 'f'.

ANDLW AND Literal with W

Syntax: [*label*] ANDLW *k*

Operands: $0 \leq k \leq 255$

Operation: $(W) .\text{AND.} (k) \rightarrow (W)$

Status Affected: Z

Description: The contents of W register are AND'd with the eight-bit literal 'k'. The result is placed in the W register.

ANDWF AND W with f

Syntax: [*label*] ANDWF *f*,*d*

Operands: $0 \leq f \leq 127$
 $d \in [0,1]$

Operation: $(W) .\text{AND.} (f) \rightarrow (\text{destination})$

Status Affected: Z

Description: AND the W register with register 'f'. If 'd' is 0, the result is stored in the W register. If 'd' is 1, the result is stored back in register 'f'.

BCF Bit Clear f

Syntax: [*label*] BCF *f*,*b*

Operands: $0 \leq f \leq 127$
 $0 \leq b \leq 7$

Operation: $0 \rightarrow (f)$

Status Affected: None

Description: Bit 'b' in register 'f' is cleared.

BSF Bit Set f

Syntax: [*label*] BSF *f*,*b*

Operands: $0 \leq f \leq 127$
 $0 \leq b \leq 7$

Operation: $1 \rightarrow (f)$

Status Affected: None

Description: Bit 'b' in register 'f' is set.

BTFSS Bit Test f, Skip if Set

Syntax: [*label*] BTFSS *f*,*b*

Operands: $0 \leq f \leq 127$
 $0 \leq b < 7$

Operation: skip if $(f) = 1$

Status Affected: None

Description: If bit 'b' in register 'f' is '0', the next instruction is executed. If bit 'b' is '1', then the next instruction is discarded and a NOP is executed instead, making this a 2TCY instruction.

BTFSC Bit Test, Skip if Clear

Syntax: [*label*] BTFSC *f*,*b*

Operands: $0 \leq f \leq 127$
 $0 \leq b \leq 7$

Operation: skip if $(f) = 0$

Status Affected: None

Description: If bit 'b' in register 'f' is '1', the next instruction is executed. If bit 'b', in register 'f', is '0', the next instruction is discarded, and a NOP is executed instead, making this a 2TCY instruction.

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SWAPF **Swap Nibbles in f**

Syntax: [*label*] SWAPF f,d

Operands: $0 \leq f \leq 127$
 $d \in [0,1]$

Operation: (f<3:0>) → (destination<7:4>),
 (f<7:4>) → (destination<3:0>)

Status Affected: None

Description: The upper and lower nibbles of register 'f' are exchanged. If 'd' is 0, the result is placed in the W register. If 'd' is 1, the result is placed in register 'f'.

XORWF **Exclusive OR W with f**

Syntax: [*label*] XORWF f,d

Operands: $0 \leq f \leq 127$
 $d \in [0,1]$

Operation: (W) .XOR. (f) → (destination)

Status Affected: Z

Description: Exclusive OR the contents of the W register with register 'f'. If 'd' is 0, the result is stored in the W register. If 'd' is 1, the result is stored back in register 'f'.

XORLW **Exclusive OR Literal with W**

Syntax: [*label*] XORLW k

Operands: $0 \leq k \leq 255$

Operation: (W) .XOR. k → (W)

Status Affected: Z

Description: The contents of the W register are XOR'ed with the eight-bit literal 'k'. The result is placed in the W register.

14.4 MPLINK Object Linker/ MPLIB Object Librarian

The MPLINK object linker combines relocatable objects created by the MPASM assembler and the MPLAB C17 and MPLAB C18 C compilers. It can also link relocatable objects from pre-compiled libraries, using directives from a linker script.

The MPLIB object librarian is a librarian for pre-compiled code to be used with the MPLINK object linker. When a routine from a library is called from another source file, only the modules that contain that routine will be linked in with the application. This allows large libraries to be used efficiently in many different applications. The MPLIB object librarian manages the creation and modification of library files.

The MPLINK object linker features include:

- Integration with MPASM assembler and MPLAB C17 and MPLAB C18 C compilers.
- Allows all memory areas to be defined as sections to provide link-time flexibility.

The MPLIB object librarian features include:

- Easier linking because single libraries can be included instead of many smaller files.
- Helps keep code maintainable by grouping related modules together.
- Allows libraries to be created and modules to be added, listed, replaced, deleted or extracted.

14.5 MPLAB SIM Software Simulator

The MPLAB SIM software simulator allows code development in a PC-hosted environment by simulating the PICmicro series microcontrollers on an instruction level. On any given instruction, the data areas can be examined or modified and stimuli can be applied from a file, or user-defined key press, to any of the pins. The execution can be performed in single step, execute until break, or trace mode.

The MPLAB SIM simulator fully supports symbolic debugging using the MPLAB C17 and the MPLAB C18 C compilers and the MPASM assembler. The software simulator offers the flexibility to develop and debug code outside of the laboratory environment, making it an excellent multi-project software development tool.

14.6 MPLAB ICE High Performance Universal In-Circuit Emulator with MPLAB IDE

The MPLAB ICE universal in-circuit emulator is intended to provide the product development engineer with a complete microcontroller design tool set for PICmicro microcontrollers (MCUs). Software control of the MPLAB ICE in-circuit emulator is provided by the MPLAB Integrated Development Environment (IDE), which allows editing, building, downloading and source debugging from a single environment.

The MPLAB ICE 2000 is a full-featured emulator system with enhanced trace, trigger and data monitoring features. Interchangeable processor modules allow the system to be easily reconfigured for emulation of different processors. The universal architecture of the MPLAB ICE in-circuit emulator allows expansion to support new PICmicro microcontrollers.

The MPLAB ICE in-circuit emulator system has been designed as a real-time emulation system, with advanced features that are generally found on more expensive development tools. The PC platform and Microsoft® Windows environment were chosen to best make these features available to you, the end user.

14.7 ICEPIC In-Circuit Emulator

The ICEPIC low cost, in-circuit emulator is a solution for the Microchip Technology PIC16C5X, PIC16C6X, PIC16C7X and PIC16CXXX families of 8-bit One-Time-Programmable (OTP) microcontrollers. The modular system can support different subsets of PIC16C5X or PIC16CXXX products through the use of interchangeable personality modules, or daughter boards. The emulator is capable of emulating without target application circuitry being present.

TABLE 14-1: DEVELOPMENT TOOLS FROM MICROCHIP

	PIC12CXX	PIC1400	PIC16C5X	PIC16C6X	PIC16CXX	PIC16C7X	PIC16C7XX	PIC16C8X	PIC16F8XX	PIC16C9XX	PIC17C4X	PIC17C7XX	PIC18CXX2	PIC18FXX	24CXX/ 25CXX/ 93CXX	HC5XX	MCRFXX	MCP2510
Software Tools	MPLAB® Integrated Development Environment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	MPLAB® C17 C Compiler										✓	✓	✓	✓				
	MPLAB® C18 C Compiler												✓	✓				
Emulators	MPASM™ Assembler/ MPLINK™ Object Linker	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	MPLAB® ICE In-Circuit Emulator	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	ICEPIC™ In-Circuit Emulator	✓		✓	✓		✓	✓		✓								
Debugger	MPLAB® ICD In-Circuit Debugger				✓		✓		✓					✓				
Programmers	PICSTART® Plus Entry Level Development Programmer	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
	PRO MATE® II Universal Device Programmer	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		
Demo Boards and Eval Kits	PICDEM™ 1 Demonstration Board		✓					✓			✓							
	PICDEM™ 2 Demonstration Board				✓								✓	✓				
	PICDEM™ 3 Demonstration Board									✓								
	PICDEM™ 14A Demonstration Board		✓															
	PICDEM™ 17 Demonstration Board											✓						
	KEELOQ® Evaluation Kit															✓		
	KEELOQ® Transponder Kit															✓		
	microID™ Programmer's Kit																✓	
	125 kHz microID™ Developer's Kit																✓	
	125 kHz Anticollision microID™ Developer's Kit																✓	
	13.56 MHz Anticollision microID™ Developer's Kit																✓	
	MCP2510 CAN Developer's Kit																✓	✓

* Contact the Microchip Technology Inc. web site at www.microchip.com for information on how to use the MPLAB® ICD In-Circuit Debugger (DV164001) with PIC16C62, 63, 64, 65, 72, 73, 74, 76, 77.
 ** Contact Microchip Technology Inc. for availability date.
 † Development tool is available on select devices.

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TABLE 15-9: I²C BUS DATA REQUIREMENTS

Param. No.	Symbol	Characteristic		Min	Max	Units	Conditions
100*	THIGH	Clock high time	100 kHz mode	4.0	—	μs	Device must operate at a minimum of 1.5 MHz
			400 kHz mode	0.6	—	μs	Device must operate at a minimum of 10 MHz
			SSP Module	1.5T _{CY}	—		
101*	TLOW	Clock low time	100 kHz mode	4.7	—	μs	Device must operate at a minimum of 1.5 MHz
			400 kHz mode	1.3	—	μs	Device must operate at a minimum of 10 MHz
			SSP Module	1.5T _{CY}	—		
102*	TR	SDA and SCL rise time	100 kHz mode	—	1000	ns	
			400 kHz mode	20 + 0.1C _B	300	ns	C _B is specified to be from 10 - 400 pF
103*	TF	SDA and SCL fall time	100 kHz mode	—	300	ns	
			400 kHz mode	20 + 0.1C _B	300	ns	C _B is specified to be from 10 - 400 pF
90*	TSU:STA	START condition setup time	100 kHz mode	4.7	—	μs	Only relevant for Repeated START condition
			400 kHz mode	0.6	—	μs	
91*	THD:STA	START condition hold time	100 kHz mode	4.0	—	μs	After this period the first clock pulse is generated
			400 kHz mode	0.6	—	μs	
106*	THD:DAT	Data input hold time	100 kHz mode	0	—	ns	
			400 kHz mode	0	0.9	μs	
107*	TSU:DAT	Data input setup time	100 kHz mode	250	—	ns	(Note 2)
			400 kHz mode	100	—	ns	
92*	TSU:STO	STOP condition setup time	100 kHz mode	4.7	—	μs	
			400 kHz mode	0.6	—	μs	
109*	TAA	Output valid from clock	100 kHz mode	—	3500	ns	(Note 1)
			400 kHz mode	—	—	ns	
110*	TBUF	Bus free time	100 kHz mode	4.7	—	μs	Time the bus must be free before a new transmission can start
			400 kHz mode	1.3	—	μs	
	C _B	Bus capacitive loading		—	400	pF	

* These parameters are characterized but not tested.

- Note 1:** As a transmitter, the device must provide this internal minimum delay time to bridge the undefined region (min. 300 ns) of the falling edge of SCL to avoid unintended generation of START or STOP conditions.
- Note 2:** A Fast mode (400 kHz) I²C bus device can be used in a Standard mode (100 kHz) I²C bus system, but the requirement TSU:DAT ≥ 250 ns must then be met. This will automatically be the case if the device does not stretch the LOW period of the SCL signal. If such a device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line TR max. + TSU:DAT = 1000 + 250 = 1250 ns (according to the Standard mode I²C bus specification), before the SCL line is released.

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FIGURE 16-11: ΔI_{BOR} vs. V_{DD} OVER TEMPERATURE

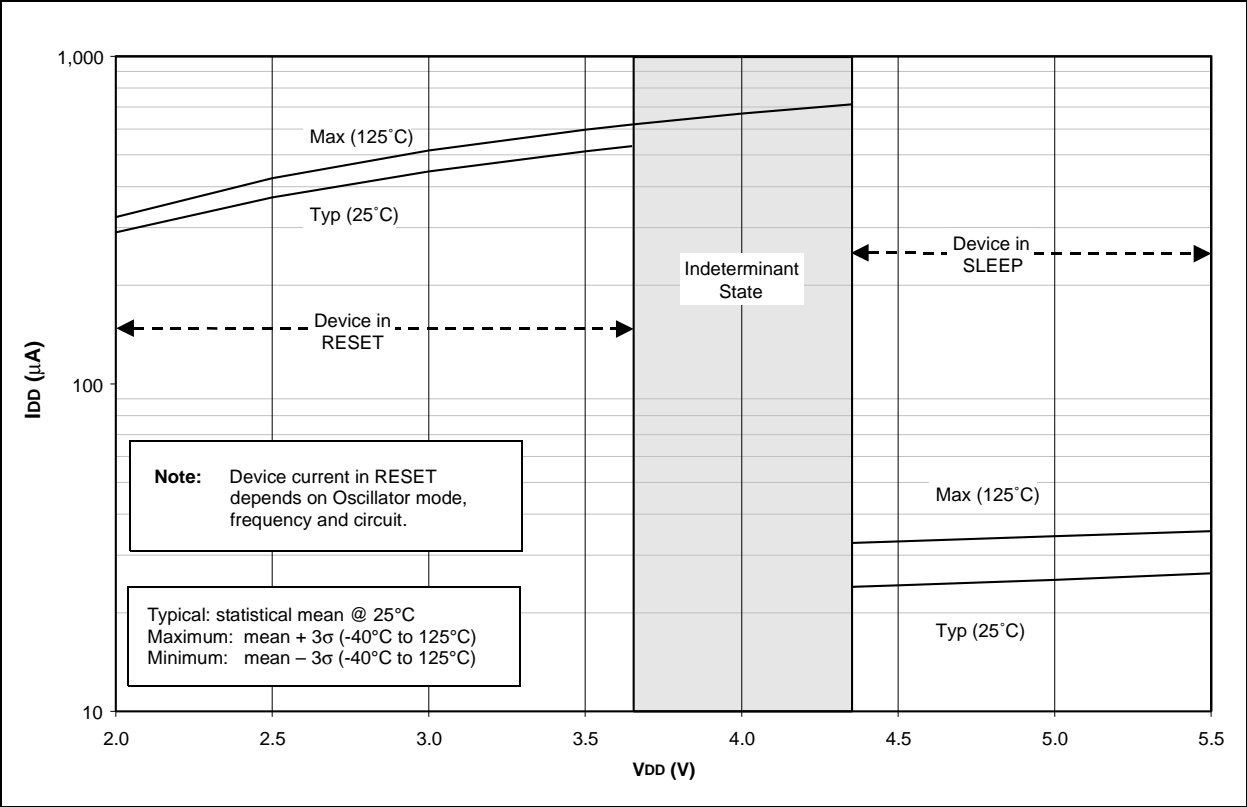
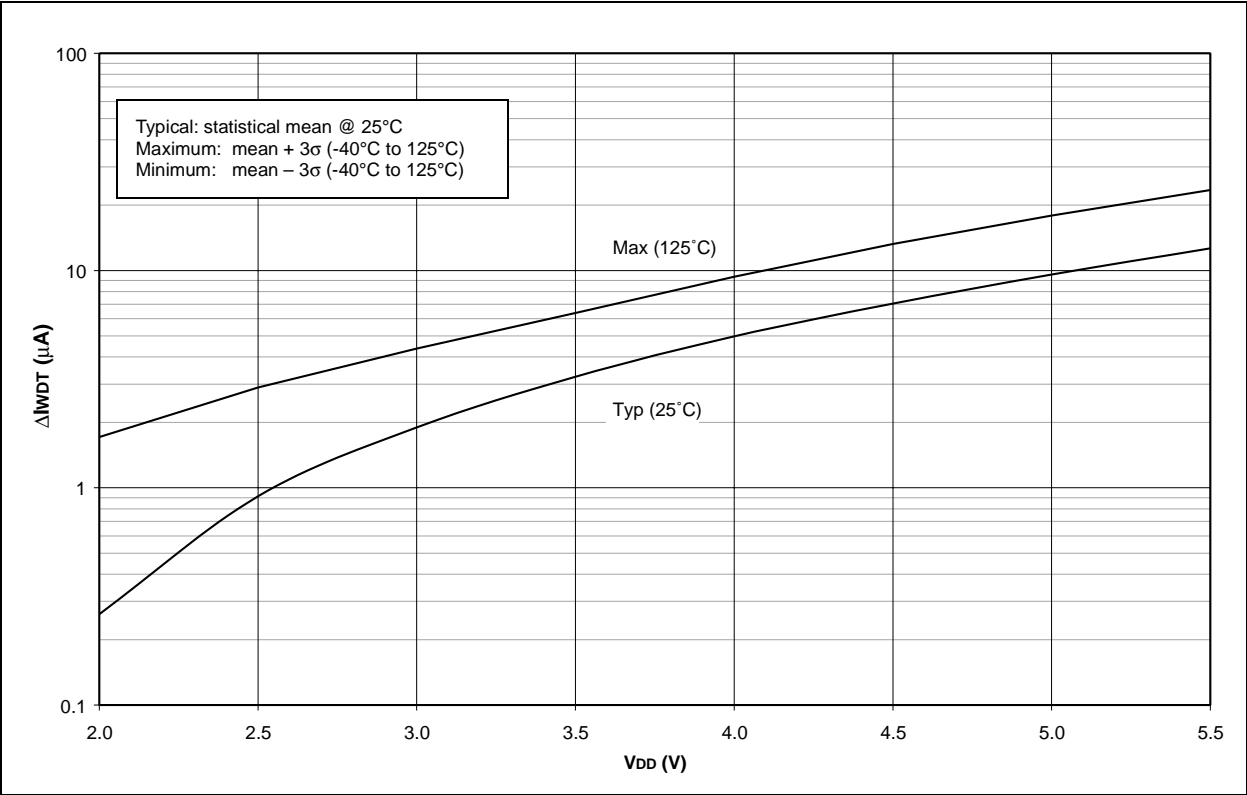


FIGURE 16-12: TYPICAL AND MAXIMUM ΔI_{WDT} vs. V_{DD} OVER TEMPERATURE



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FIGURE 16-19: MINIMUM AND MAXIMUM V_{IN} vs. V_{DD} , (TTL INPUT, -40°C TO 125°C)

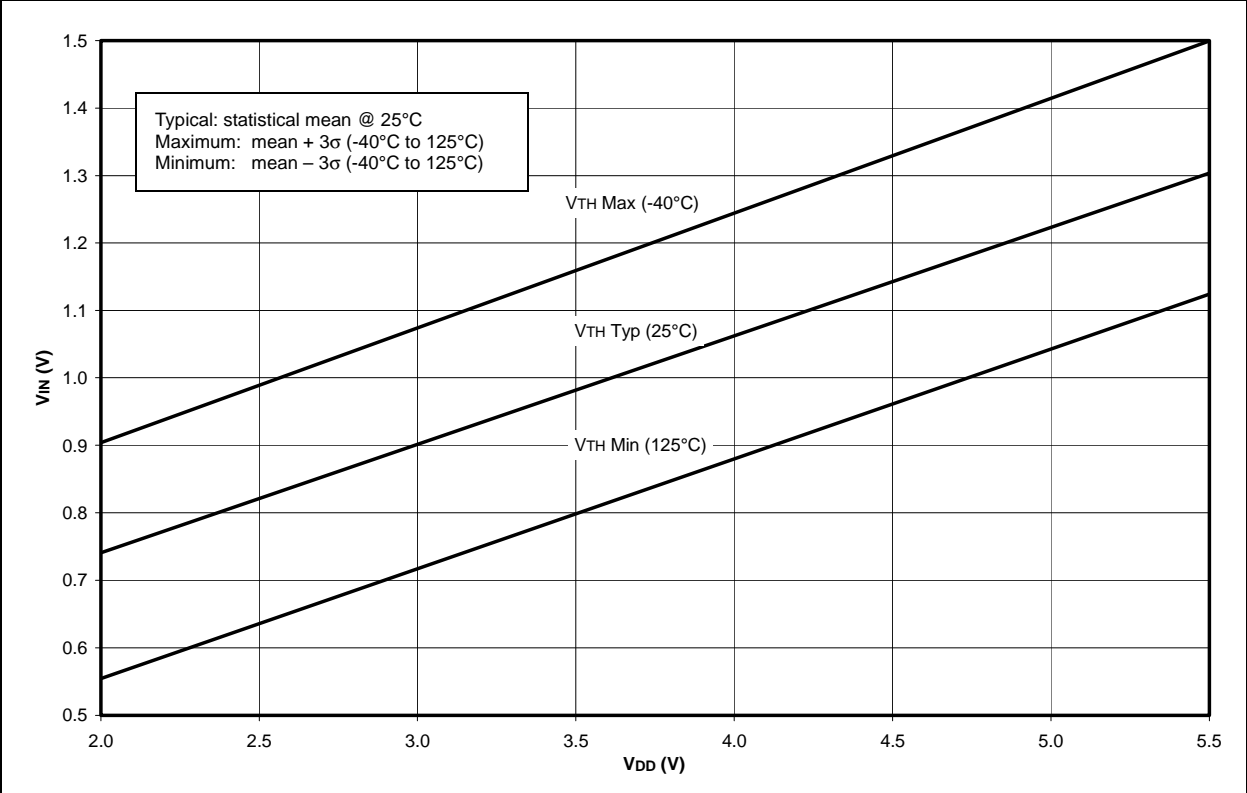
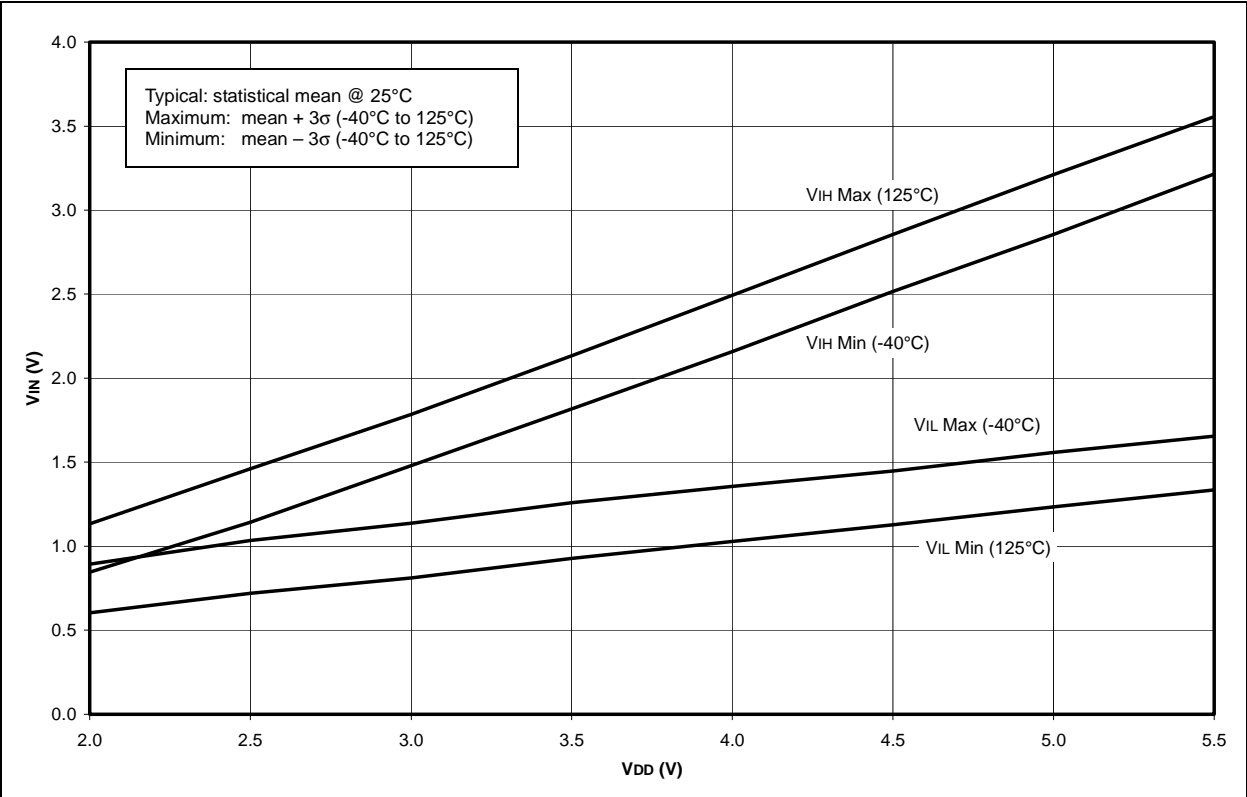


FIGURE 16-20: MINIMUM AND MAXIMUM V_{IN} vs. V_{DD} (ST INPUT, -40°C TO 125°C)



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