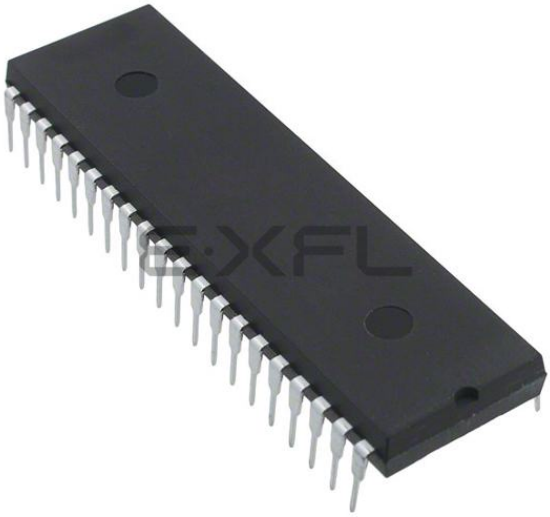

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	40MHz
Connectivity	I²C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, LVD, POR, PWM, WDT
Number of I/O	34
Program Memory Size	32KB (16K x 16)
Program Memory Type	FLASH
EEPROM Size	256 x 8
RAM Size	1.5K x 8
Voltage - Supply (Vcc/Vdd)	4.2V ~ 5.5V
Data Converters	A/D 8x10b
Oscillator Type	External
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Through Hole
Package / Case	40-DIP (0.600", 15.24mm)
Supplier Device Package	40-PDIP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic18f452-i-p

3.0 RESET

The PIC18FXXX differentiates between various kinds of RESET:

a) Power-on Reset (POR)
b) $\overline{\text{MCLR}}$ Reset during normal operation
c) $\overline{\text{MCLR}}$ Reset during SLEEP
d) Watchdog Timer (WDT) Reset (during normal operation)
e) Programmable Brown-out Reset (BOR)
f) `RESET` Instruction
g) Stack Full Reset
h) Stack Underflow Reset

Most registers are unaffected by a RESET. Their status is unknown on POR and unchanged by all other RESETS. The other registers are forced to a "RESET state" on Power-on Reset, $\overline{\text{MCLR}}$, WDT Reset, Brown-out Reset, $\overline{\text{MCLR}}$ Reset during SLEEP and by the `RESET` instruction.

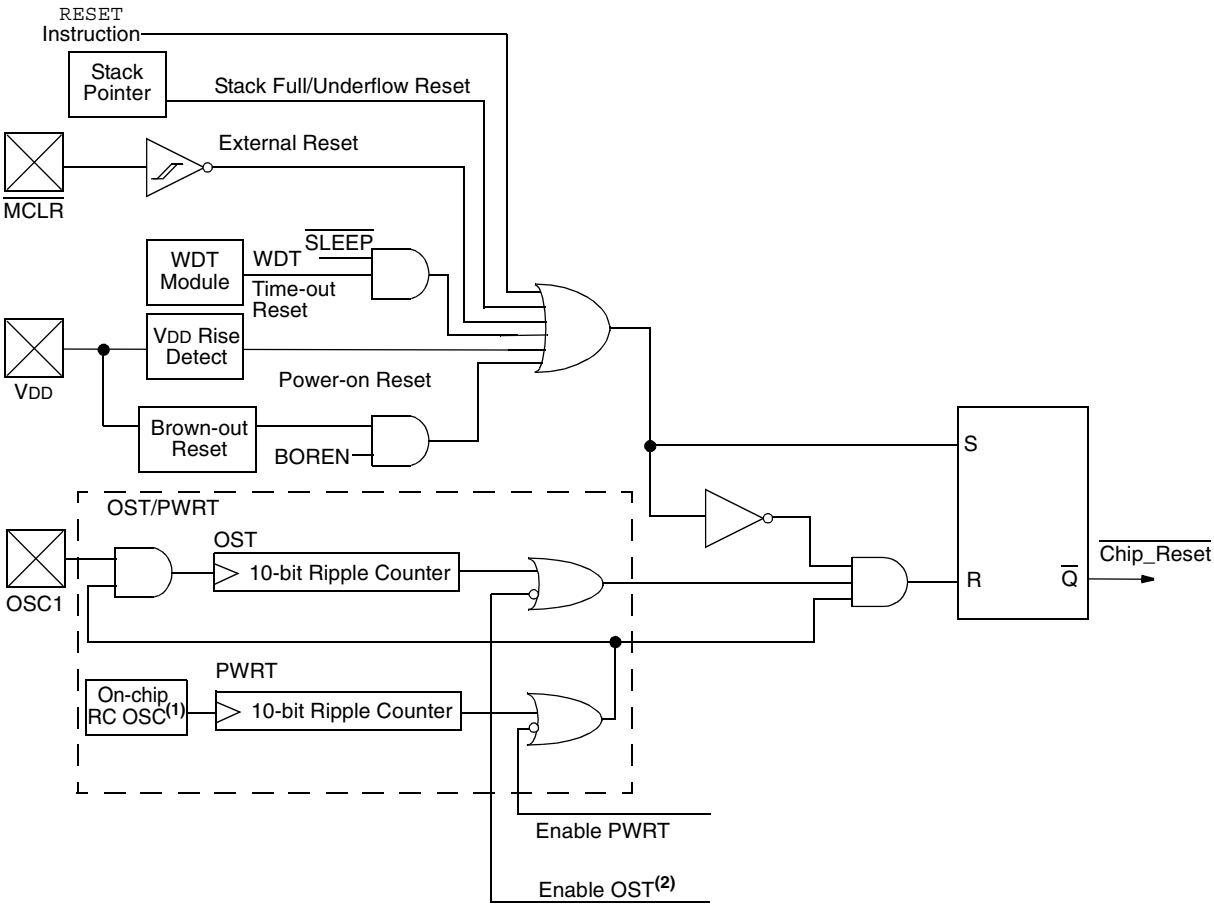
Most registers are not affected by a WDT wake-up, since this is viewed as the resumption of normal operation. Status bits from the RCON register, $\overline{\text{RI}}$, $\overline{\text{TO}}$, $\overline{\text{PD}}$, $\overline{\text{POR}}$ and $\overline{\text{BOR}}$, are set or cleared differently in different RESET situations, as indicated in Table 3-2. These bits are used in software to determine the nature of the RESET. See Table 3-3 for a full description of the RESET states of all registers.

A simplified block diagram of the On-Chip Reset Circuit is shown in Figure 3-1.

The Enhanced MCU devices have a $\overline{\text{MCLR}}$ noise filter in the $\overline{\text{MCLR}}$ Reset path. The filter will detect and ignore small pulses.

The $\overline{\text{MCLR}}$ pin is not driven low by any internal RESETS, including the WDT.

FIGURE 3-1: SIMPLIFIED BLOCK DIAGRAM OF ON-CHIP RESET CIRCUIT



Note 1: This is a separate oscillator from the RC oscillator of the CLKI pin.
2: See Table 3-1 for time-out situations.

NOTES:

TABLE 4-2: REGISTER FILE SUMMARY

File Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on POR, BOR	Details on page:
TOSU	—	—	—	Top-of-Stack upper Byte (TOS<20:16>)					---0 0000	37
TOSH	Top-of-Stack High Byte (TOS<15:8>)								0000 0000	37
TOSL	Top-of-Stack Low Byte (TOS<7:0>)								0000 0000	37
STKPTR	STKFUL	STKUNF	—	Return Stack Pointer					00-0 0000	38
PCLATU	—	—	—	Holding Register for PC<20:16>					---0 0000	39
PCLATH	Holding Register for PC<15:8>								0000 0000	39
PCL	PC Low Byte (PC<7:0>)								0000 0000	39
TBLPTRU	—	—	bit21(2)	Program Memory Table Pointer Upper Byte (TBLPTR<20:16>)					--00 0000	58
TBLPTRH	Program Memory Table Pointer High Byte (TBLPTR<15:8>)								0000 0000	58
TBLPTRL	Program Memory Table Pointer Low Byte (TBLPTR<7:0>)								0000 0000	58
TABLAT	Program Memory Table Latch								0000 0000	58
PRODH	Product Register High Byte								xxxx xxxx	71
PRODL	Product Register Low Byte								xxxx xxxx	71
INTCON	GIE/GIEH	PEIE/GIEL	TMR0IE	INT0IE	RBIE	TMR0IF	INT0IF	RBIF	0000 000x	75
INTCON2	RBPU	INTEDG0	INTEDG1	INTEDG2	—	TMR0IP	—	RBIP	1111 -1-1	76
INTCON3	INT2IP	INT1IP	—	INT2IE	INT1IE	—	INT2IF	INT1IF	11-0 0-00	77
INDF0	Uses contents of FSR0 to address data memory - value of FSR0 not changed (not a physical register)								n/a	50
POSTINC0	Uses contents of FSR0 to address data memory - value of FSR0 post-incremented (not a physical register)								n/a	50
POSTDEC0	Uses contents of FSR0 to address data memory - value of FSR0 post-decremented (not a physical register)								n/a	50
PREINC0	Uses contents of FSR0 to address data memory - value of FSR0 pre-incremented (not a physical register)								n/a	50
PLUSW0	Uses contents of FSR0 to address data memory - value of FSR0 (not a physical register). Offset by value in WREG.								n/a	50
FSR0H	—	—	—	—	Indirect Data Memory Address Pointer 0 High Byte				---- 0000	50
FSR0L	Indirect Data Memory Address Pointer 0 Low Byte								xxxx xxxx	50
WREG	Working Register								xxxx xxxx	n/a
INDF1	Uses contents of FSR1 to address data memory - value of FSR1 not changed (not a physical register)								n/a	50
POSTINC1	Uses contents of FSR1 to address data memory - value of FSR1 post-incremented (not a physical register)								n/a	50
POSTDEC1	Uses contents of FSR1 to address data memory - value of FSR1 post-decremented (not a physical register)								n/a	50
PREINC1	Uses contents of FSR1 to address data memory - value of FSR1 pre-incremented (not a physical register)								n/a	50
PLUSW1	Uses contents of FSR1 to address data memory - value of FSR1 (not a physical register). Offset by value in WREG.								n/a	50
FSR1H	—	—	—	—	Indirect Data Memory Address Pointer 1 High Byte				---- 0000	50
FSR1L	Indirect Data Memory Address Pointer 1 Low Byte								xxxx xxxx	50
BSR	—	—	—	—	Bank Select Register				---- 0000	49
INDF2	Uses contents of FSR2 to address data memory - value of FSR2 not changed (not a physical register)								n/a	50
POSTINC2	Uses contents of FSR2 to address data memory - value of FSR2 post-incremented (not a physical register)								n/a	50
POSTDEC2	Uses contents of FSR2 to address data memory - value of FSR2 post-decremented (not a physical register)								n/a	50
PREINC2	Uses contents of FSR2 to address data memory - value of FSR2 pre-incremented (not a physical register)								n/a	50
PLUSW2	Uses contents of FSR2 to address data memory - value of FSR2 (not a physical register). Offset by value in WREG.								n/a	50
FSR2H	—	—	—	—	Indirect Data Memory Address Pointer 2 High Byte				---- 0000	50
FSR2L	Indirect Data Memory Address Pointer 2 Low Byte								xxxx xxxx	50
STATUS	—	—	—	N	OV	Z	DC	C	---x xxxx	52
TMR0H	Timer0 Register High Byte								0000 0000	105
TMR0L	Timer0 Register Low Byte								xxxx xxxx	105
T0CON	TMR0ON	T08BIT	T0CS	T0SE	PSA	T0PS2	T0PS1	T0PS0	1111 1111	103

Legend: x = unknown, u = unchanged, - = unimplemented, q = value depends on condition

Note 1: RA6 and associated bits are configured as port pins in RCIO and ECIO Oscillator mode only and read '0' in all other Oscillator modes.

2: Bit 21 of the TBLPTRU allows access to the device configuration bits.

3: These registers and bits are reserved on the PIC18F2X2 devices; always maintain these clear.

6.0 DATA EEPROM MEMORY

The Data EEPROM is readable and writable during normal operation over the entire VDD range. The data memory is not directly mapped in the register file space. Instead, it is indirectly addressed through the Special Function Registers (SFR).

There are four SFRs used to read and write the program and data EEPROM memory. These registers are:

- EECON1
- EECON2
- EEDATA
- EEADR

The EEPROM data memory allows byte read and write. When interfacing to the data memory block, EEDATA holds the 8-bit data for read/write and EEADR holds the address of the EEPROM location being accessed. These devices have 256 bytes of data EEPROM with an address range from 0h to FFh.

The EEPROM data memory is rated for high erase/write cycles. A byte write automatically erases the location and writes the new data (erase-before-write). The write time is controlled by an on-chip timer. The write time will vary with voltage and temperature, as well as from chip to chip. Please refer to parameter D122 (Electrical Characteristics, Section 22.0) for exact limits.

6.1 EEADR

The address register can address up to a maximum of 256 bytes of data EEPROM.

6.2 EECON1 and EECON2 Registers

EECON1 is the control register for EEPROM memory accesses.

EECON2 is not a physical register. Reading EECON2 will read all '0's. The EECON2 register is used exclusively in the EEPROM write sequence.

Control bits RD and WR initiate read and write operations, respectively. These bits cannot be cleared, only set, in software. They are cleared in hardware at the completion of the read or write operation. The inability to clear the WR bit in software prevents the accidental or premature termination of a write operation.

The WREN bit, when set, will allow a write operation. On power-up, the WREN bit is clear. The WRERR bit is set when a write operation is interrupted by a $\overline{\text{MCLR}}$ Reset, or a WDT Time-out Reset during normal operation. In these situations, the user can check the WRERR bit and rewrite the location. It is necessary to reload the data and address registers (EEDATA and EEADR), due to the RESET condition forcing the contents of the registers to zero.

Note:	Interrupt flag bit, EEIF in the PIR2 register, is set when write is complete. It must be cleared in software.

9.6 Parallel Slave Port

The Parallel Slave Port is implemented on the 40-pin devices only (PIC18F4X2).

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

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/$\overline{RD}$ to be the $\overline{RD}$ input, RE1/$\overline{WR}$ to be the $\overline{WR}$ input and RE2/$\overline{CS}$ 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). The A/D port configuration bits PCFG2:PCFG0 (ADCON1<2:0>) must be set, which will configure pins RE2:RE0 as digital I/O.

A write to the PSP occurs when both the $\overline{CS}$ and $\overline{WR}$ lines are first detected low. A read from the PSP occurs when both the $\overline{CS}$ and $\overline{RD}$ lines are first detected low.

The PORTE I/O pins become control inputs for the microprocessor port when bit PSPMODE (TRISE<4>) is set. In this mode, the user must make sure that the TRISE<2:0> bits are set (pins are configured as digital inputs), and the ADCON1 is configured for digital I/O. In this mode, the input buffers are TTL.

FIGURE 9-10: PORTD AND PORTE BLOCK DIAGRAM (PARALLEL SLAVE PORT)

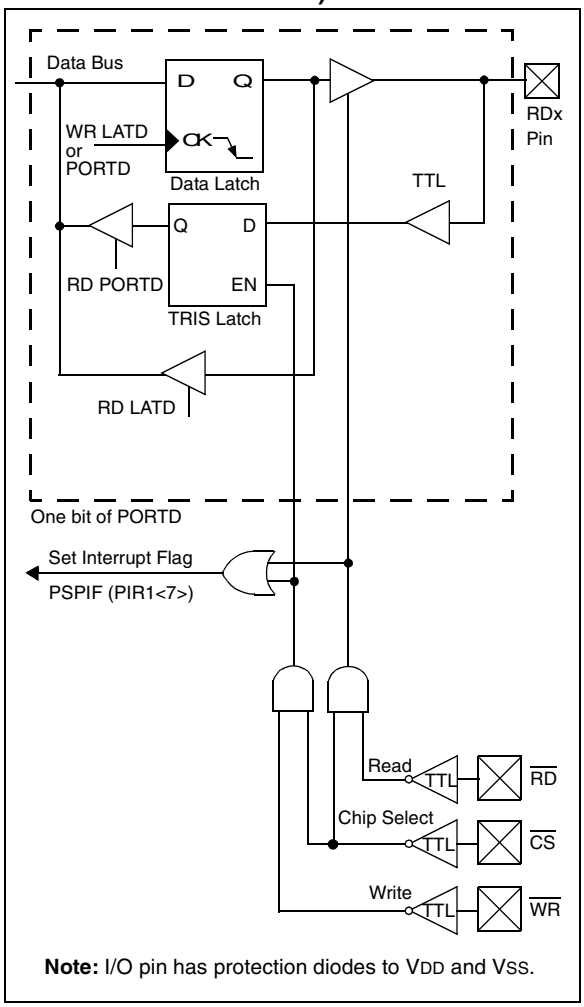
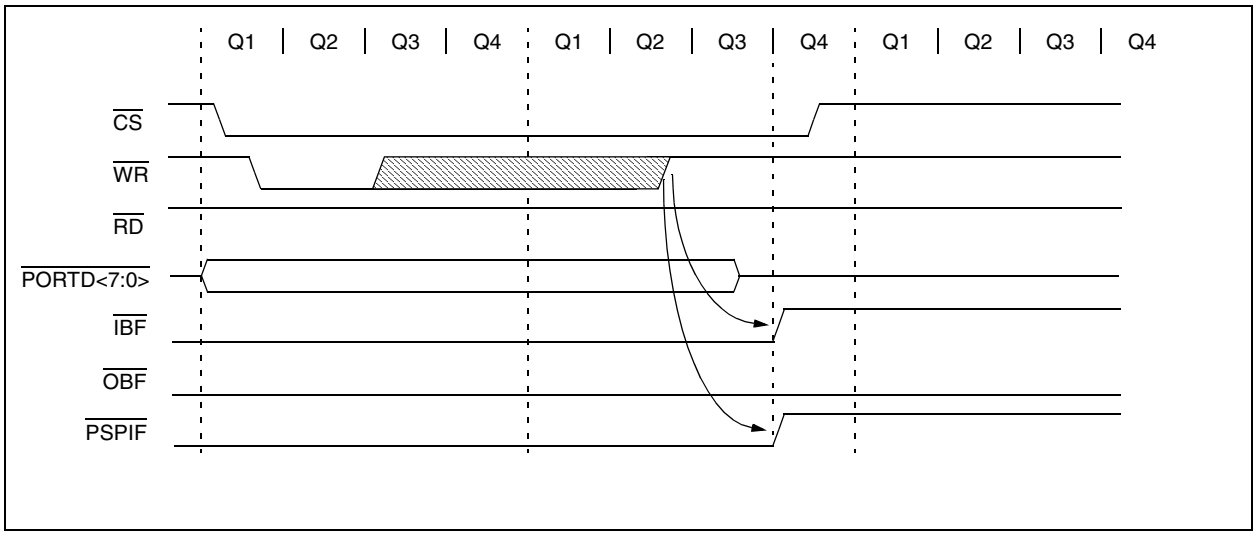


FIGURE 9-11: PARALLEL SLAVE PORT WRITE WAVEFORMS



13.0 TIMER3 MODULE

The Timer3 module timer/counter has the following features:

- 16-bit timer/counter
  (two 8-bit registers; TMR3H and TMR3L)
- Readable and writable (both registers)
- Internal or external clock select
- Interrupt-on-overflow from FFFFh to 0000h
- RESET from CCP module trigger

Figure 13-1 is a simplified block diagram of the Timer3 module.

Register 13-1 shows the Timer3 control register. This register controls the Operating mode of the Timer3 module and sets the CCP clock source.

Register 11-1 shows the Timer1 control register. This register controls the Operating mode of the Timer1 module, as well as contains the Timer1 oscillator enable bit (T1OSCEN), which can be a clock source for Timer3.

REGISTER 13-1: T3CON: TIMER3 CONTROL 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
RD16	T3CCP2	T3CKPS1	T3CKPS0	T3CCP1	$\overline{\text{T3SYNC}}$	TMR3CS	TMR3ON
bit 7							bit 0

bit 7 **RD16:** 16-bit Read/Write Mode Enable bit
1 = Enables register Read/Write of Timer3 in one 16-bit operation
0 = Enables register Read/Write of Timer3 in two 8-bit operations

bit 6-3 **T3CCP2:T3CCP1:** Timer3 and Timer1 to CCPx Enable bits
1x = Timer3 is the clock source for compare/capture CCP modules
01 = Timer3 is the clock source for compare/capture of CCP2,
Timer1 is the clock source for compare/capture of CCP1
00 = Timer1 is the clock source for compare/capture CCP modules

bit 5-4 **T3CKPS1:T3CKPS0**: Timer3 Input Clock Prescale Select bits
11 = 1:8 Prescale value
10 = 1:4 Prescale value
01 = 1:2 Prescale value
00 = 1:1 Prescale value

bit 2 **$\overline{\text{T3SYNC}}$:** Timer3 External Clock Input Synchronization Control bit
(Not usable if the system clock comes from Timer1/Timer3)
When TMR3CS = 1:
1 = Do not synchronize external clock input
0 = Synchronize external clock input
When TMR3CS = 0:
This bit is ignored. Timer3 uses the internal clock when TMR3CS = 0.

bit 1 **TMR3CS:** Timer3 Clock Source Select bit
1 = External clock input from Timer1 oscillator or T1CKI
(on the rising edge after the first falling edge)
0 = Internal clock (FOSC/4)

bit 0 **TMR3ON:** Timer3 On bit
1 = Enables Timer3
0 = Stops Timer3

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

15.3.1 REGISTERS

The MSSP module has four registers for SPI mode operation. These are:

- MSSP Control Register1 (SSPCON1)
- MSSP Status Register (SSPSTAT)
- Serial Receive/Transmit Buffer (SSPBUF)
- MSSP Shift Register (SSPSR) - Not directly accessible

SSPCON1 and SSPSTAT are the control and status registers in SPI mode operation. The SSPCON1 register is readable and writable. The lower 6 bits of the SSPSTAT are read only. The upper two bits of the SSPSTAT are read/write.

SSPSR is the shift register used for shifting data in or out. SSPBUF is the buffer register to which data bytes are written to or read from.

In receive operations, SSPSR and SSPBUF together create a double buffered receiver. When SSPSR receives a complete byte, it is transferred to SSPBUF and the SSPIF interrupt is set.

During transmission, the SSPBUF is not double buffered. A write to SSPBUF will write to both SSPBUF and SSPSR.

REGISTER 15-1: SSPSTAT: MSSP STATUS REGISTER (SPI MODE)

R/W-0	R/W-0	R-0	R-0	R-0	R-0	R-0	R-0
SMP	CKE	D/$\overline{A}$	P	S	R/$\overline{W}$	UA	BF
bit 7							bit 0

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

bit 6 **CKE:** SPI Clock Edge Select
When CKP = 0:
1 = Data transmitted on rising edge of SCK
0 = Data transmitted on falling edge of SCK
When CKP = 1:
1 = Data transmitted on falling edge of SCK
0 = Data transmitted on rising edge of SCK

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

bit 4 **P:** STOP bit
Used in I^2C mode only. This bit is cleared when the MSSP module is disabled, SSPEN is cleared.

bit 3 **S:** START bit
Used in I^2C mode only

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

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

bit 0 **BF:** Buffer Full Status bit (Receive mode only)
1 = Receive complete, SSPBUF is full
0 = Receive not complete, SSPBUF is empty

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

15.3.5 MASTER MODE

The master can initiate the data transfer at any time because it controls the SCK. The master determines when the slave (Processor 2, Figure 15-2) is to broadcast data by the software protocol.

In Master mode, the data is transmitted/received as soon as the SSPBUF register is written to. If the SPI is only going to receive, the SDO output could be disabled (programmed as an input). The SSPSR register will continue to shift in the signal present on the SDI pin at the programmed clock rate. As each byte is received, it will be loaded into the SSPBUF register as if a normal received byte (interrupts and status bits appropriately set). This could be useful in receiver applications as a “Line Activity Monitor” mode.

The clock polarity is selected by appropriately programming the CKP bit (SSPCON1<4>). This then, would give waveforms for SPI communication as shown in Figure 15-3, Figure 15-5, and Figure 15-6, where the MSB is transmitted first. In Master mode, the SPI clock rate (bit rate) is user programmable to be one of the following:

- FOSC/4 (or TCY)
- FOSC/16 (or 4 • TCY)
- FOSC/64 (or 16 • TCY)
- Timer2 output/2

This allows a maximum data rate (at 40 MHz) of 10.00 Mbps.

Figure 15-3 shows the waveforms for Master mode. When the CKE bit is set, the SDO data is valid before there is a clock edge on SCK. The change of the input sample is shown based on the state of the SMP bit. The time when the SSPBUF is loaded with the received data is shown.

FIGURE 15-3: SPI MODE WAVEFORM (MASTER MODE)

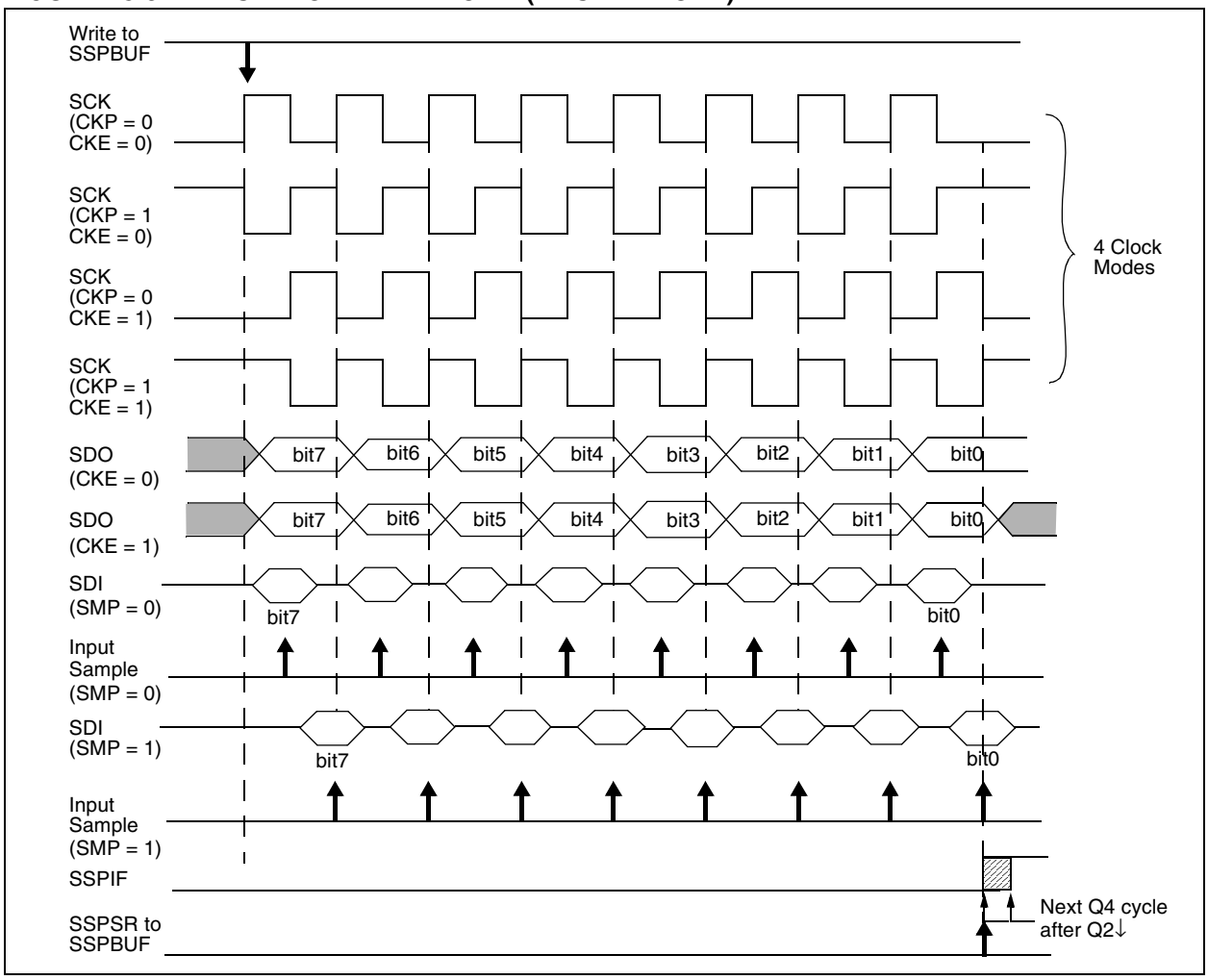


FIGURE 15-10: I²C SLAVE MODE TIMING WITH SEN = 0 (RECEPTION, 10-BIT ADDRESS)

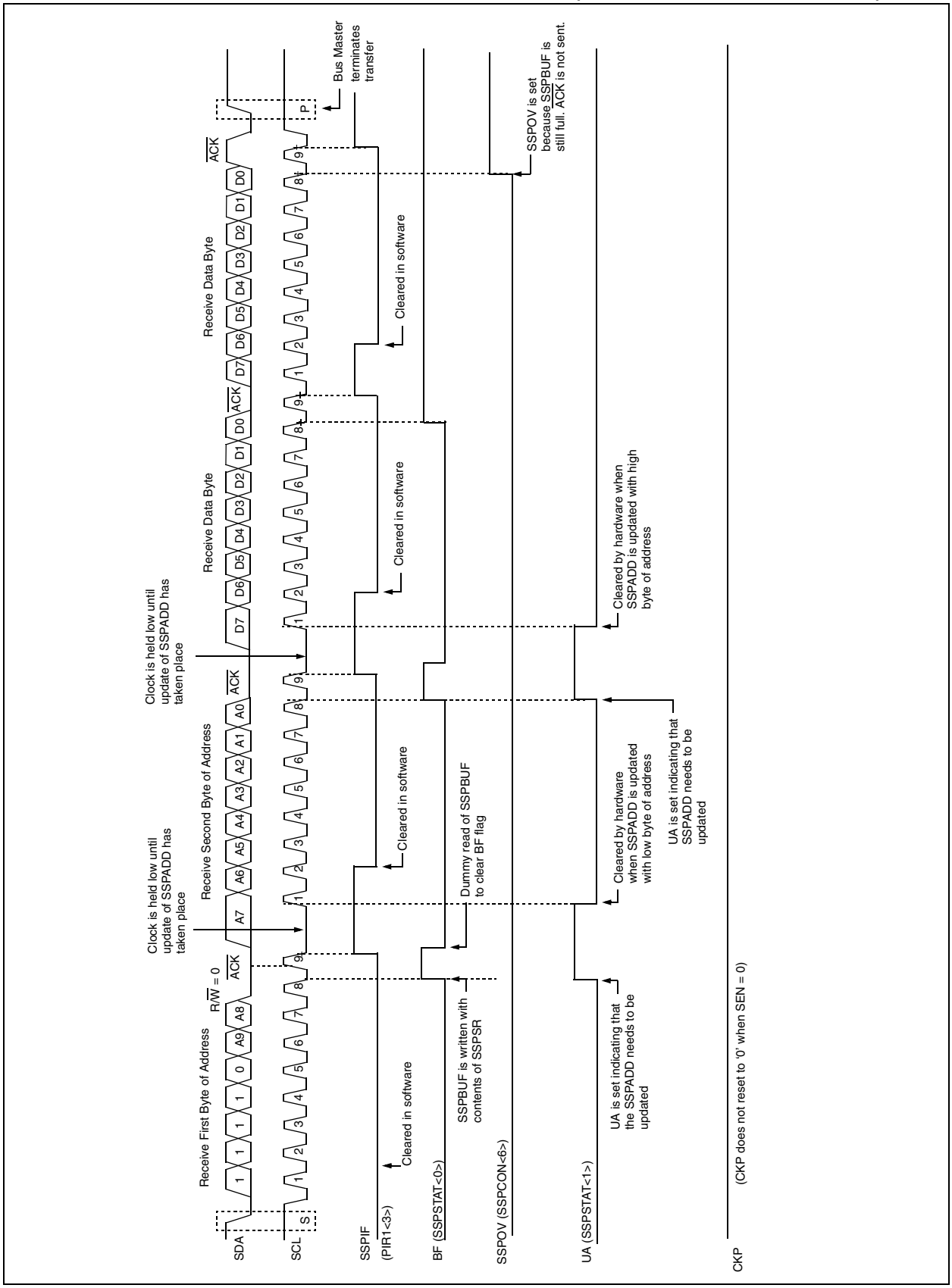


FIGURE 15-11: I²C SLAVE MODE TIMING (TRANSMISSION, 10-BIT ADDRESS)

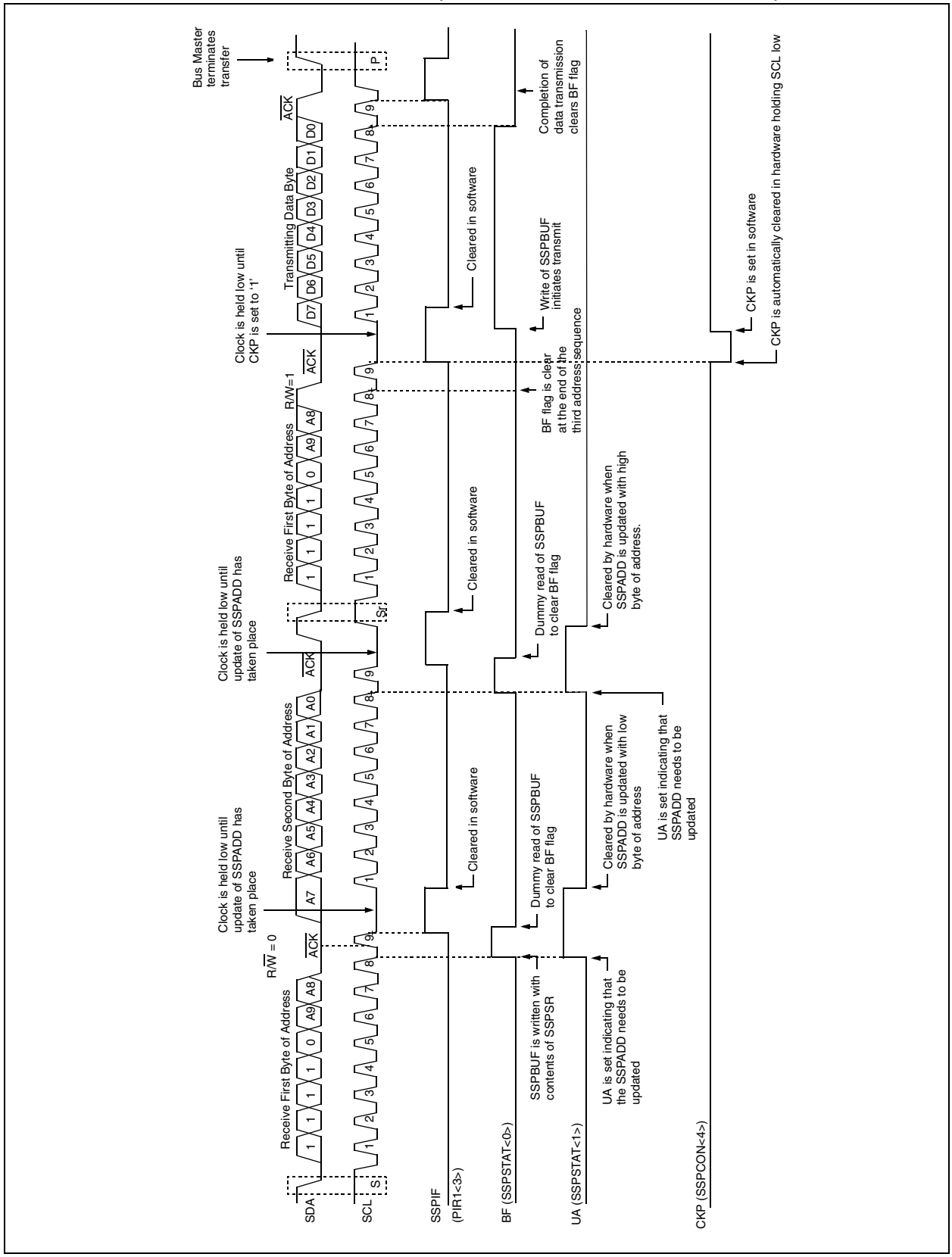


FIGURE 15-13: I^2C SLAVE MODE TIMING WITH SEN = 1 (RECEPTION, 7-BIT ADDRESS)

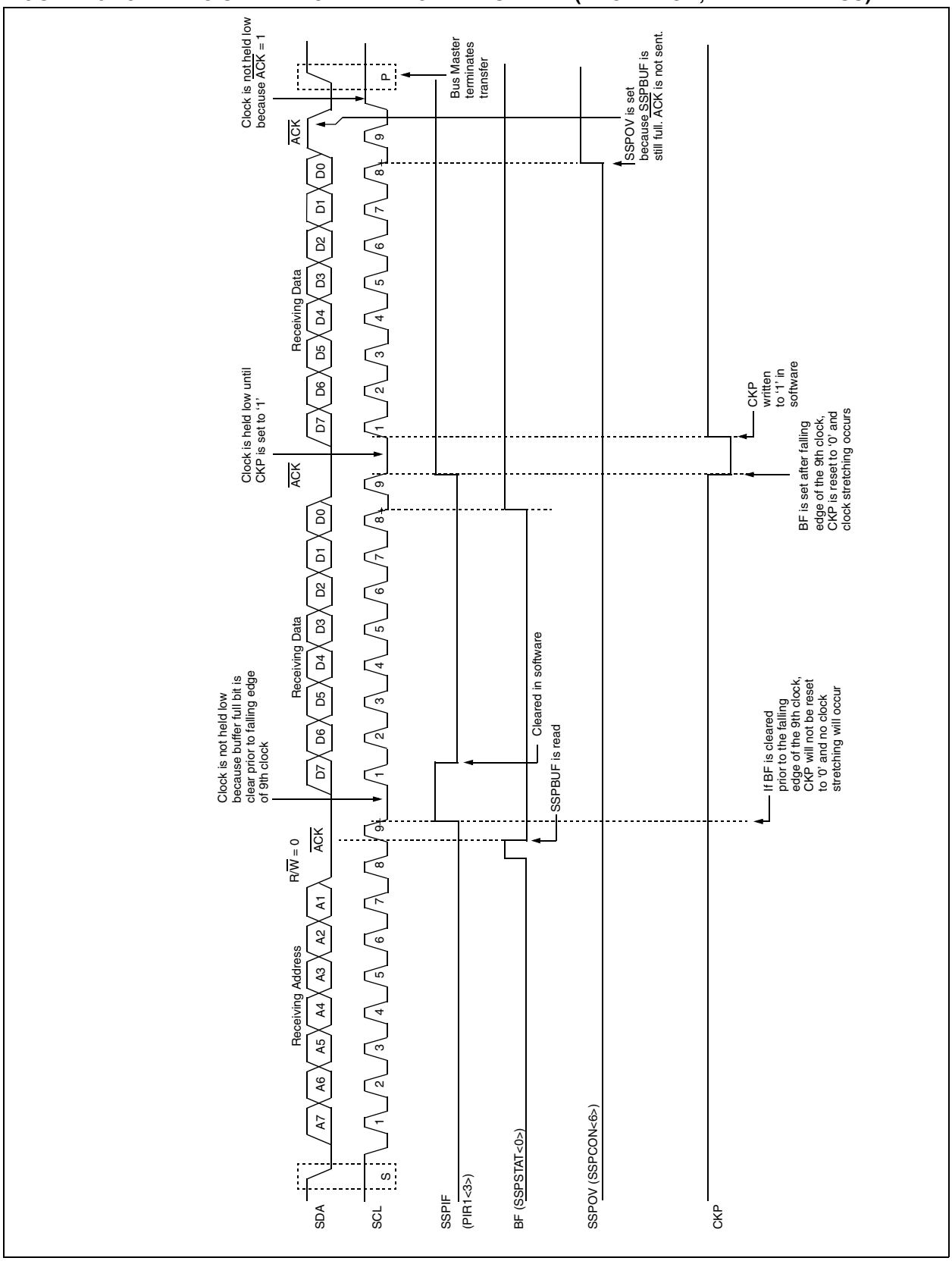
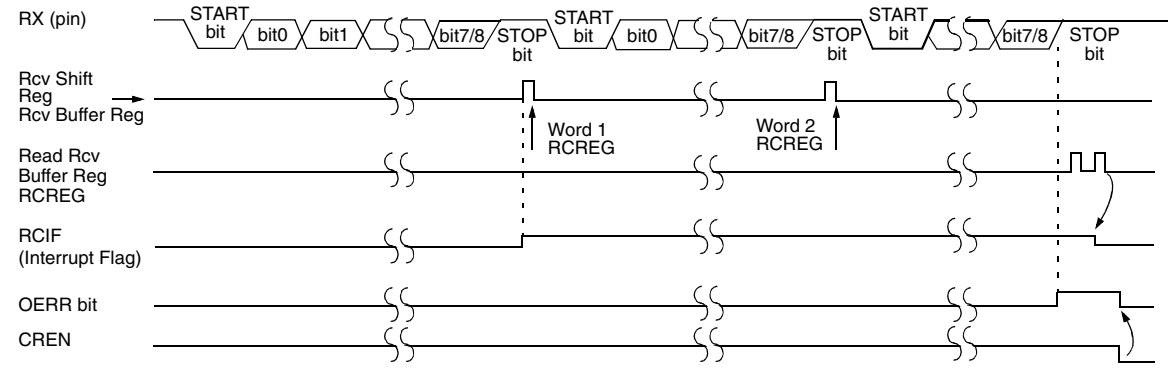


FIGURE 16-5: ASYNCHRONOUS RECEPTION



Note: This timing diagram shows three words appearing on the RX input. The RCREG (receive buffer) is read after the third word, causing the OERR (overrun) bit to be set.

TABLE 16-7: REGISTERS ASSOCIATED WITH ASYNCHRONOUS RECEPTION

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
INTCON	GIE/GIEH	PEIE/ GIEL	TMR0IE	INT0IE	RBIE	TMR0IF	INT0IF	RBIF	0000 000x	0000 000u
PIR1	PSPIF(1)	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	0000 0000	0000 0000
PIE1	PSPIE(1)	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	0000 0000	0000 0000
IPR1	PSPIP(1)	ADIP	RCIP	TXIP	SSPIP	CCP1IP	TMR2IP	TMR1IP	0000 0000	0000 0000
RCSTA	SPEN	RX9	SREN	CREN	ADDEN	FERR	OERR	RX9D	0000 -00x	0000 -00x
RCREG	USART Receive Register								0000 0000	0000 0000
TXSTA	CSRC	TX9	TXEN	SYNC	—	BRGH	TRMT	TX9D	0000 -010	0000 -010
SPBRG	Baud Rate Generator Register								0000 0000	0000 0000

Legend: x = unknown, - = unimplemented locations read as '0'.
Shaded cells are not used for Asynchronous Reception.

Note 1: The PSPIF, PSPIE and PSPIP bits are reserved on the PIC18F2X2 devices; always maintain these bits clear.

20.0 INSTRUCTION SET SUMMARY

The PIC18FXXX instruction set adds many enhancements to the previous PICmicro instruction sets, while maintaining an easy migration from these PICmicro instruction sets.

Most instructions are a single program memory word (16-bits), but there are three instructions that require two program memory locations.

Each single word instruction is a 16-bit word divided into an OPCODE, which specifies the instruction type and one or more operands, which further specify the operation of the instruction.

The instruction set is highly orthogonal and is grouped into four basic categories:

- **Byte-oriented** operations
- **Bit-oriented** operations
- **Literal** operations
- **Control** operations

The PIC18FXXX instruction set summary in Table 20-2 lists **byte-oriented**, **bit-oriented**, **literal** and **control** operations. Table 20-1 shows the opcode field descriptions.

Most **byte-oriented** instructions have three operands:

1. The file register (specified by ‘f’)
2. The destination of the result (specified by ‘d’)
3. The accessed memory (specified by ‘a’)

The file register designator 'f' specifies which file register is to be used by the instruction.

The destination designator ‘d’ specifies where the result of the operation is to be placed. If 'd' is zero, the result is placed in the WREG register. If 'd' is one, the result is placed in the file register specified in the instruction.

All **bit-oriented** instructions have three operands:

1. The file register (specified by ‘f’)
2. The bit in the file register (specified by ‘b’)
3. The accessed memory (specified by ‘a’)

The bit field designator 'b' selects the number of the bit affected by the operation, while the file register designator 'f' represents the number of the file in which the bit is located.

The **literal** instructions may use some of the following operands:

- A literal value to be loaded into a file register (specified by ‘k’)
- The desired FSR register to load the literal value into (specified by ‘f’)
- No operand required (specified by ‘—’)

The **control** instructions may use some of the following operands:

- A program memory address (specified by ‘n’)
- The mode of the Call or Return instructions (specified by ‘s’)
- The mode of the Table Read and Table Write instructions (specified by ‘m’)
- No operand required (specified by ‘—’)

All instructions are a single word, except for three double-word instructions. These three instructions were made double-word instructions so that all the required information is available in these 32 bits. In the second word, the 4-MSbs are 1’s. If this second word is executed as an instruction (by itself), it will execute as a `NOP`.

All single word instructions are executed in a single instruction cycle, unless a conditional test is true or the program counter is changed as a result of the instruction. In these cases, the execution takes two instruction cycles with the additional instruction cycle(s) executed as a `NOP`.

The double-word instructions execute in two instruction cycles.

One instruction cycle consists of four oscillator periods. Thus, for an oscillator frequency of 4 MHz, the normal instruction execution time is 1 μs. If a conditional test is true or the program counter is changed as a result of an instruction, the instruction execution time is 2 μs. Two-word branch instructions (if true) would take 3 μs.

Figure 20-1 shows the general formats that the instructions can have.

All examples use the format `'nnh'` to represent a hexadecimal number, where `'h'` signifies a hexadecimal digit.

The Instruction Set Summary, shown in Table 20-2, lists the instructions recognized by the Microchip Assembler (MPASM™).

Section 20.1 provides a description of each instruction.

TABLE 20-1: OPCODE FIELD DESCRIPTIONS

Field	Description
a	RAM access bit a = 0: RAM location in Access RAM (BSR register is ignored) a = 1: RAM bank is specified by BSR register
bbb	Bit address within an 8-bit file register (0 to 7)
BSR	Bank Select Register. Used to select the current RAM bank.
d	Destination select bit; d = 0: store result in WREG, d = 1: store result in file register f.
dest	Destination either the WREG register or the specified register file location
f	8-bit Register file address (0x00 to 0xFF)
fs	12-bit Register file address (0x000 to 0xFFF). This is the source address.
fd	12-bit Register file address (0x000 to 0xFFF). This is the destination address.
k	Literal field, constant data or label (may be either an 8-bit, 12-bit or a 20-bit value)
label	Label name
mm * *+ *- +*	The mode of the TBLPTR register for the Table Read and Table Write instructions. Only used with Table Read and Table Write instructions: No Change to register (such as TBLPTR with Table reads and writes) Post-Increment register (such as TBLPTR with Table reads and writes) Post-Decrement register (such as TBLPTR with Table reads and writes) Pre-Increment register (such as TBLPTR with Table reads and writes)
n	The relative address (2's complement number) for relative branch instructions, or the direct address for Call/Branch and Return instructions
PRODH	Product of Multiply high byte
PRODL	Product of Multiply low byte
s	Fast Call/Return mode select bit. s = 0: do not update into/from shadow registers s = 1: certain registers loaded into/from shadow registers (Fast mode)
u	Unused or Unchanged
WREG	Working register (accumulator)
x	Don't care (0 or 1) The assembler will generate code with x = 0. It is the recommended form of use for compatibility with all Microchip software tools.
TBLPTR	21-bit Table Pointer (points to a Program Memory location)
TABLAT	8-bit Table Latch
TOS	Top-of-Stack
PC	Program Counter
PCL	Program Counter Low Byte
PCH	Program Counter High Byte
PCLATH	Program Counter High Byte Latch
PCLATU	Program Counter Upper Byte Latch
GIE	Global Interrupt Enable bit
WDT	Watchdog Timer
$\overline{TO}$	Time-out bit
$\overline{PD}$	Power-down bit
C, DC, Z, OV, N	ALU status bits Carry, Digit Carry, Zero, Overflow, Negative
[ ]	Optional
( )	Contents
→	Assigned to
< >	Register bit field
∈	In the set of
italics	User defined term (font is courier)

RCALL **Relative Call**

Syntax: [*label*] RCALL n

Operands: -1024 ≤ n ≤ 1023

Operation: (PC) + 2 → TOS,
(PC) + 2 + 2n → PC

Status Affected: None

Encoding:

1101	1nnn	nnnn	nnnn

Description: Subroutine call with a jump up to 1K from the current location. First, return address (PC+2) is pushed onto the stack. Then, add the 2's complement number '2n' to the PC. Since the PC will have incremented to fetch the next instruction, the new address will be PC+2+2n. This instruction is a two-cycle instruction.

Words: 1

Cycles: 2

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	Read literal 'n' Push PC to stack	Process Data	Write to PC
No operation	No operation	No operation	No operation

Example: `HERE RCALL Jump`

Before Instruction
PC = Address `(HERE)`

After Instruction
PC = Address `(Jump)`
TOS = Address `(HERE+2)`

RESET **Reset**

Syntax: [*label*] RESET

Operands: None

Operation: Reset all registers and flags that are affected by a $\overline{\text{MCLR}}$ Reset.

Status Affected: All

Encoding:

0000	0000	1111	1111

Description: This instruction provides a way to execute a $\overline{\text{MCLR}}$ Reset in software.

Words: 1

Cycles: 1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	Start reset	No operation	No operation

Example: `RESET`

After Instruction
Registers = Reset Value
Flags* = Reset Value

SUBWFB **Subtract W from f with Borrow**

Syntax: [*label*] SUBWFB f [,d [,a]

Operands: $0 \le f \le 255$
$d \in [0,1]$
$a \in [0,1]$

Operation: (f) – (W) – ($\overline{C}$) → dest

Status Affected: N, OV, C, DC, Z

Encoding:

0101	10da	ffff	ffff

Description: Subtract W and the carry flag (borrow) from register 'f' (2's complement method). If 'd' is 0, the result is stored in W. If 'd' is 1, the result is stored back in register 'f' (default). If 'a' is 0, the Access Bank will be selected, overriding the BSR value. If 'a' is 1, then the bank will be selected as per the BSR value (default).

Words: 1

Cycles: 1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	Read register 'f'	Process Data	Write to destination

Example 1:
```
SUBWFB  REG, 1, 0
```
Before Instruction
```
REG  =  0x19    (0001 1001)
W    =  0x0D    (0000 1101)
C    =  1
```
After Instruction
```
REG  =  0x0C    (0000 1011)
W    =  0x0D    (0000 1101)
C    =  1
Z    =  0
N    =  0       ; result is positive
```

Example 2:
```
SUBWFB  REG, 0, 0
```
Before Instruction
```
REG  =  0x1B    (0001 1011)
W    =  0x1A    (0001 1010)
C    =  0
```
After Instruction
```
REG  =  0x1B    (0001 1011)
W    =  0x00
C    =  1
Z    =  1       ; result is zero
N    =  0
```

Example 3:
```
SUBWFB  REG, 1, 0
```
Before Instruction
```
REG  =  0x03    (0000 0011)
W    =  0x0E    (0000 1101)
C    =  1
```
After Instruction
```
REG  =  0xF5    (1111 0100)
                ; [2's comp]
W    =  0x0E    (0000 1101)
C    =  0
Z    =  0
N    =  1       ; result is negative
```

SWAPF **Swap f**

Syntax: [*label*] SWAPF f [,d [,a]

Operands: $0 \le f \le 255$
$d \in [0,1]$
$a \in [0,1]$

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

Status Affected: None

Encoding:

0011	10da	ffff	ffff

Description: The upper and lower nibbles of register 'f' are exchanged. If 'd' is 0, the result is placed in W. If 'd' is 1, the result is placed in register 'f' (default). If 'a' is 0, the Access Bank will be selected, overriding the BSR value. If 'a' is 1, then the bank will be selected as per the BSR value (default).

Words: 1

Cycles: 1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	Read register 'f'	Process Data	Write to destination

Example:
```
SWAPF   REG, 1, 0
```
Before Instruction
```
REG  =  0x53
```
After Instruction
```
REG  =  0x35
```

XORWF **Exclusive OR W with f**

Syntax: [*label*] XORWF f [,d [,a]

Operands: $0 \le f \le 255$
$d \in [0,1]$
$a \in [0,1]$

Operation: (W) .XOR. (f) → dest

Status Affected: N, Z

Encoding:

0001	10da	ffff	ffff

Description: Exclusive OR the contents of W with register 'f'. If 'd' is 0, the result is stored in W. If 'd' is 1, the result is stored back in the register 'f' (default). If 'a' is 0, the Access Bank will be selected, overriding the BSR value. If 'a' is 1, then the bank will be selected as per the BSR value (default).

Words: 1

Cycles: 1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	Read register 'f'	Process Data	Write to destination

Example: `XORWF REG, 1, 0`

Before Instruction
REG = 0xAF
W = 0xB5

After Instruction
REG = 0x1A
W = 0xB5

FIGURE 22-1: PIC18FXX2 VOLTAGE-FREQUENCY GRAPH (INDUSTRIAL)

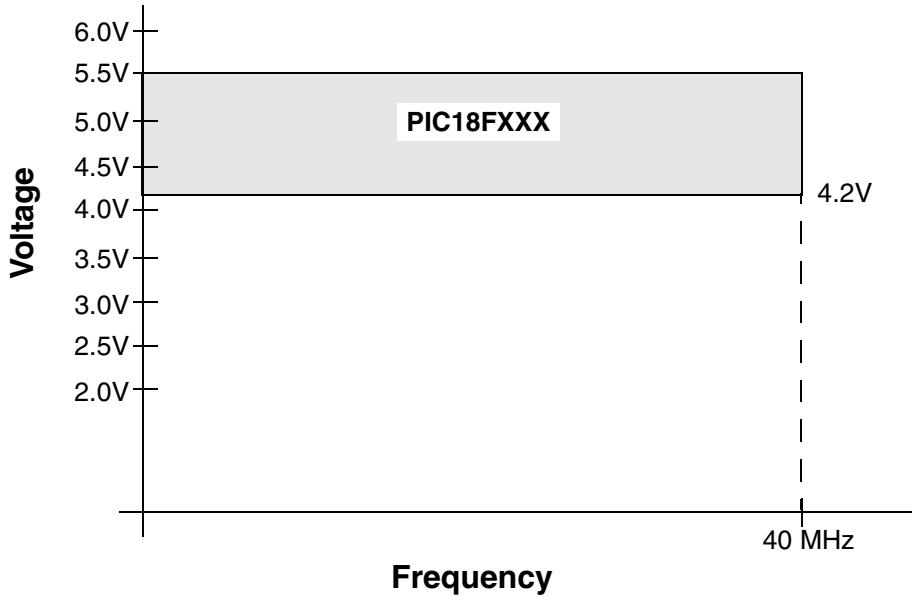
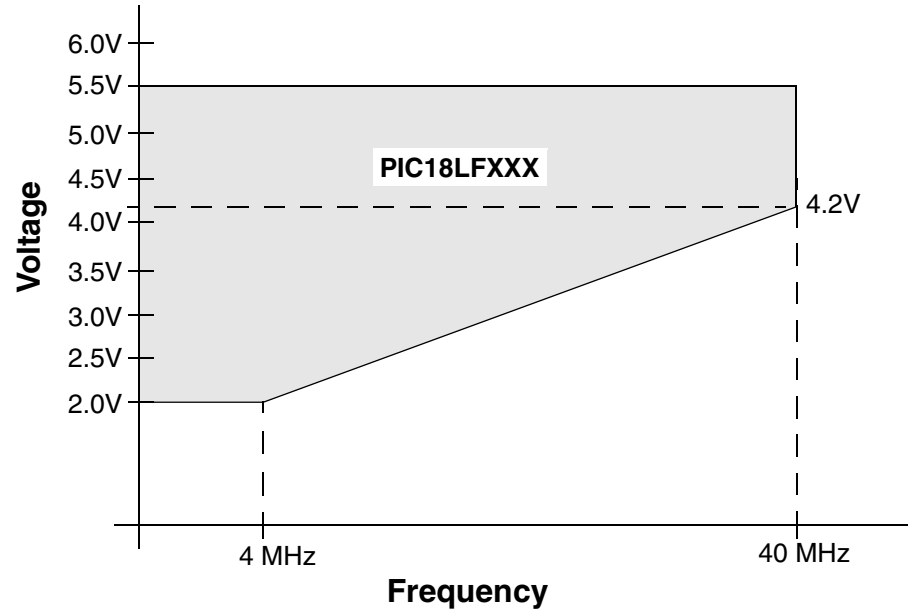


FIGURE 22-2: PIC18LFXX2 VOLTAGE-FREQUENCY GRAPH (INDUSTRIAL)



FMAX = (16.36 MHz/V) (VDDAPPMIN – 2.0V) + 4 MHz

Note: VDDAPPMIN is the minimum voltage of the PICmicro® device in the application.

22.1 DC Characteristics: PIC18FXX2 (Industrial, Extended) PIC18LFXX2 (Industrial) (Continued)

PIC18LFXX2 (Industrial)			**Standard Operating Conditions (unless otherwise stated)** Operating temperature -40°C ≤ TA ≤ +85°C for industrial				
PIC18FXX2 (Industrial, Extended)			**Standard Operating Conditions (unless otherwise stated)** 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**
	IDD	**Supply Current(2,4) (Continued)**					
D010C		PIC18LFXX2	—	10	25	mA	EC, ECIO osc configurations VDD = 4.2V, -40°C to +85°C
D010C		PIC18FXX2	—	10	25	mA	EC, ECIO osc configurations VDD = 4.2V, -40°C to +125°C
D013		PIC18LFXX2	—	.6	2	mA	HS osc configuration FOSC = 4 MHz, VDD = 2.0V
			—	10	15	mA	FOSC = 25 MHz, VDD = 5.5V HS + PLL osc configurations
			—	15	25	mA	FOSC = 10 MHz, VDD = 5.5V
D013		PIC18FXX2	—	10	15	mA	HS osc configuration FOSC = 25 MHz, VDD = 5.5V HS + PLL osc configurations
			—	15	25	mA	FOSC = 10 MHz, VDD = 5.5V
D014		PIC18LFXX2	—	15	55	µA	Timer1 osc configuration FOSC = 32 kHz, VDD = 2.0V
D014		PIC18FXX2	—	—	200	µA	Timer1 osc configuration FOSC = 32 kHz, VDD = 4.2V, -40°C to +85°C
			—	—	250	µA	FOSC = 32 kHz, VDD = 4.2V, -40°C to +125°C
	IPD	**Power-down Current(3)**					
D020		PIC18LFXX2	—	.08	.9	µA	VDD = 2.0V, +25°C
			—	.1	4	µA	VDD = 2.0V, -40°C to +85°C
			—	3	10	µA	VDD = 4.2V, -40°C to +85°C
D020		PIC18FXX2	—	.1	.9	µA	VDD = 4.2V, +25°C
			—	3	10	µA	VDD = 4.2V, -40°C to +85°C
D021B			—	15	25	µA	VDD = 4.2V, -40°C to +125°C

Legend: Shading of rows is to assist in readability of the table.

Note 1: This is the limit to which VDD can be lowered in SLEEP mode, or during a device RESET, without losing RAM data.

2: The supply current is mainly a function of the operating voltage and frequency. Other factors, such as I/O pin loading and switching rate, oscillator type, internal code execution pattern and temperature, also have an impact on the current consumption.

The test conditions for all IDD measurements in active Operation mode are:

OSC1 = external square wave, from rail-to-rail; all I/O pins tri-stated, pulled to VDD

$\overline{MCLR}$ = VDD; WDT enabled/disabled as specified.

3: The power-down current in SLEEP mode does not depend on the oscillator type. Power-down current is measured with the part in SLEEP mode, with all I/O pins in hi-impedance state and tied to VDD or VSS, and all features that add delta current disabled (such as WDT, Timer1 Oscillator, BOR,...).

4: For RC osc configuration, current through REXT is not included. The current through the resistor can be estimated by the formula Ir = VDD/2REXT (mA) with REXT in kOhm.

5: The LVD and BOR modules share a large portion of circuitry. The ΔIBOR and ΔILVD currents are not additive. Once one of these modules is enabled, the other may also be enabled without further penalty.

FIGURE 23-21: TYPICAL, MINIMUM AND MAXIMUM V_{OH} vs. I_{OH} (V_{DD} = 5V, -40°C TO +125°C)

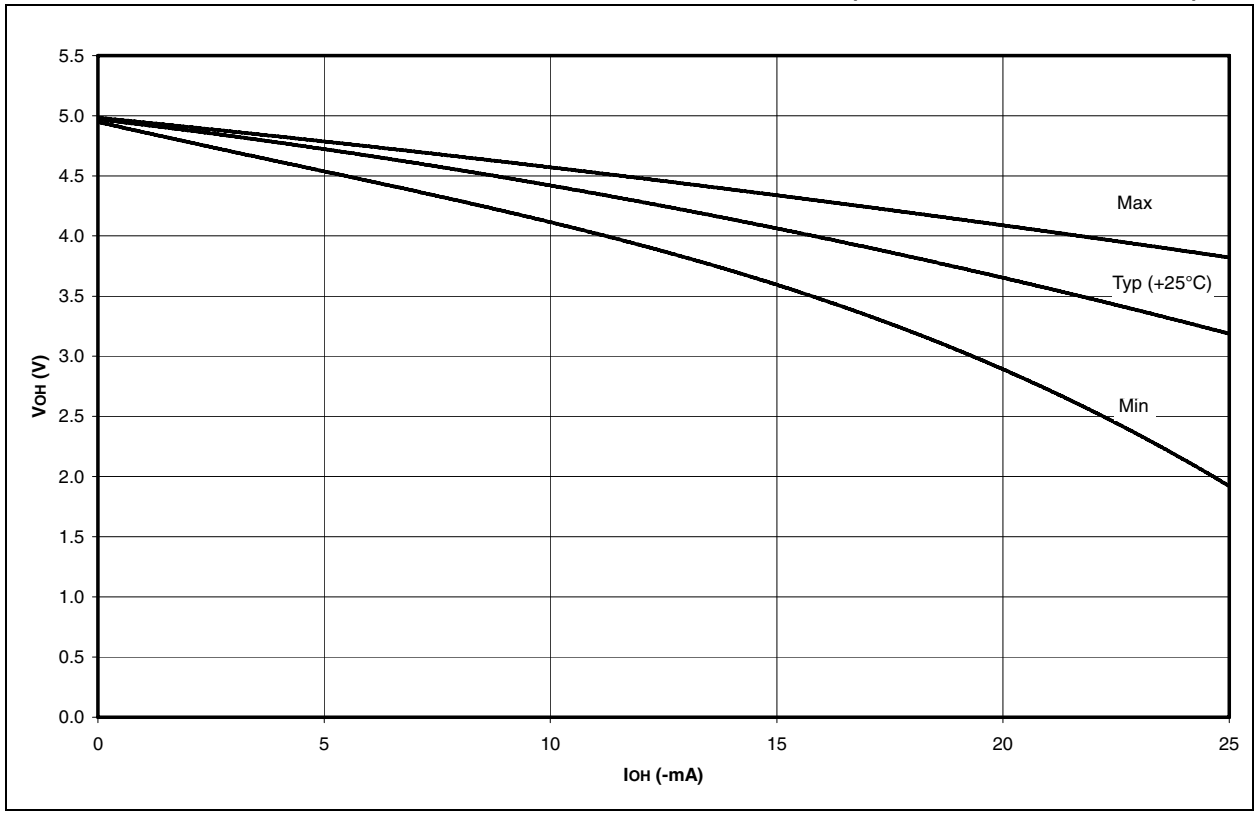


FIGURE 23-22: TYPICAL, MINIMUM AND MAXIMUM V_{OH} vs. I_{OH} (V_{DD} = 3V, -40°C TO +125°C)