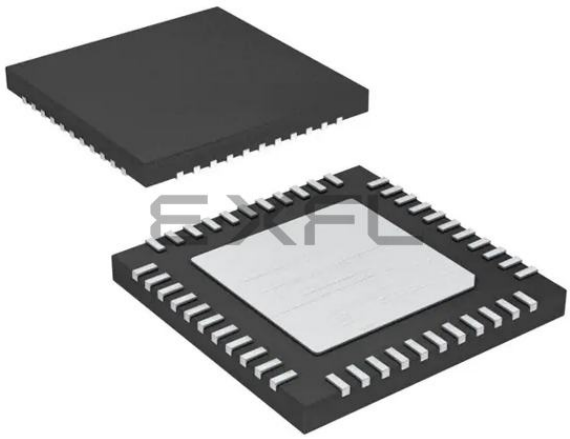

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Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	40MHz
Connectivity	I²C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, LVD, POR, PWM, WDT
Number of I/O	36
Program Memory Size	8KB (4K x 16)
Program Memory Type	FLASH
EEPROM Size	256 x 8
RAM Size	512 x 8
Voltage - Supply (Vcc/Vdd)	4.2V ~ 5.5V
Data Converters	A/D 13x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	44-VQFN Exposed Pad
Supplier Device Package	44-QFN (8x8)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic18f4320t-i-ml

TABLE 1-2: PIC18F2220/2320 PINOUT I/O DESCRIPTIONS

Pin Name	Pin Number		Pin Type	Buffer Type	Description
	PDIP	SOIC			
MCLR/VPP	1	1			Master Clear (input) or programming voltage (input).
MCLR			I	ST	Master Clear (Reset) input. This pin is an active-low Reset to the device.
VPP			P		Programming voltage input.
OSC1/CLKI/RA7	9	9			Oscillator crystal or external clock input.
OSC1			I	ST	Oscillator crystal input or external clock source input. ST buffer when configured in RC mode, CMOS otherwise.
CLKI			I	CMOS	External clock source input. Always associated with pin function OSC1. (See related OSC1/CLKI, OSC2/CLKO pins.)
RA7			I/O	TTL	General purpose I/O pin.
OSC2/CLKO/RA6	10	10			Oscillator crystal or clock output.
OSC2			O	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO			O	—	In RC mode, OSC2 pin outputs CLKO which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
RA6			I/O	TTL	General purpose I/O pin.
					PORTA is a bidirectional I/O port.
RA0/AN0	2	2			
RA0			I/O	TTL	Digital I/O.
AN0			I	Analog	Analog input 0.
RA1/AN1	3	3			
RA1			I/O	TTL	Digital I/O.
AN1			I	Analog	Analog input 1.
RA2/AN2/VREF-/CVREF	4	4			
RA2			I/O	TTL	Digital I/O.
AN2			I	Analog	Analog input 2.
VREF-			I	Analog	A/D reference voltage (low) input.
CVREF			O	Analog	Comparator reference voltage output.
RA3/AN3/VREF+	5	5			
RA3			I/O	TTL	Digital I/O.
AN3			I	Analog	Analog input 3.
VREF+			I	Analog	A/D reference voltage (high) input.
RA4/T0CKI/C1OUT	6	6			
RA4			I/O	ST/OD	Digital I/O. Open drain when configured as output.
T0CKI			I	ST	Timer0 external clock input.
C1OUT			O	—	Comparator 1 output.
RA5/AN4/SS/LVDIN/C2OUT	7	7			
RA5			I/O	TTL	Digital I/O.
AN4			I	Analog	Analog input 4.
SS			I	TTL	SPI slave select input.
LVDIN			I	Analog	Low-Voltage Detect input.
C2OUT			O	—	Comparator 2 output.
RA6					See the OSC2/CLKO/RA6 pin.
RA7					See the OSC1/CLKI/RA7 pin.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power; OD = Open-drain (no diode to VDD)

Note 1: Alternate assignment for CCP2 when CCP2MX is cleared.

2: Default assignment for CCP2 when CCP2MX (CONFIG3H<0>) is set.

TABLE 1-2: PIC18F2220/2320 PINOUT I/O DESCRIPTIONS (CONTINUED)

Pin Name	Pin Number		Pin Type	Buffer Type	Description
	PDIP	SOIC			
					PORTC is a bidirectional I/O port.
RC0/T1OSO/T1CKI	11	11			
RC0			I/O	ST	Digital I/O.
T1OSO			O	—	Timer1 oscillator output.
T1CKI			I	ST	Timer1/Timer3 external clock input.
RC1/T1OSI/CCP2	12	12			
RC1			I/O	ST	Digital I/O.
T1OSI			I	CMOS	Timer1 oscillator input.
CCP2(2)			I/O	ST	Capture 2 input, Compare 2 output, PWM2 output.
RC2/CCP1/P1A	13	13			
RC2			I/O	ST	Digital I/O.
CCP1			I/O	ST	Capture 1 input/Compare 1 output/PWM1 output.
P1A			O	—	Enhanced CCP1 output.
RC3/SCK/SCL	14	14			
RC3			I/O	ST	Digital I/O.
SCK			I/O	ST	Synchronous serial clock input/output for SPI mode.
SCL			I/O	ST	Synchronous serial clock input/output for I^2C™ mode.
RC4/SDI/SDA	15	15			
RC4			I/O	ST	Digital I/O.
SDI			I	ST	SPI data in.
SDA			I/O	ST	I^2C data I/O.
RC5/SDO	16	16			
RC5			I/O	ST	Digital I/O.
SDO			O	—	SPI data out.
RC6/TX/CK	17	17			
RC6			I/O	ST	Digital I/O.
TX			O	—	USART asynchronous transmit.
CK			I/O	ST	USART synchronous clock (see related RX/DT).
RC7/RX/DT	18	18			
RC7			I/O	ST	Digital I/O.
RX			I	ST	USART asynchronous receive.
DT			I/O	ST	USART synchronous data (see related TX/CK).
VSS	8, 19	8, 19	P	—	Ground reference for logic and I/O pins.
VDD	20	20	P	—	Positive supply for logic and I/O pins.

Legend: TTL = TTL compatible input
CMOS = CMOS compatible input or output
ST = Schmitt Trigger input with CMOS levels
I = Input
O = Output
P = Power
OD = Open-drain (no diode to VDD)

Note 1: Alternate assignment for CCP2 when CCP2MX is cleared.

2: Default assignment for CCP2 when CCP2MX (CONFIG3H<0>) is set.

TABLE 1-3: PIC18F4220/4320 PINOUT I/O DESCRIPTIONS

Pin Name	Pin Number			Pin Type	Buffer Type	Description
	PDIP	TQFP	QFN			
MCLR/VPP/RE3	1	18	18			Master Clear (input) or programming voltage (input).
MCLR				I	ST	Master Clear (Reset) input. This pin is an active-low Reset to the device.
VPP				P		Programming voltage input.
RE3				I	ST	Digital input.
OSC1/CLKI/RA7	13	30	32			Oscillator crystal or external clock input.
OSC1				I	ST	Oscillator crystal input or external clock source input. ST buffer when configured in RC mode, CMOS otherwise.
CLKI				I	CMOS	External clock source input. Always associated with pin function OSC1. (See related OSC1/CLKI, OSC2/CLKO pins.)
RA7				I/O	TTL	General purpose I/O pin.
OSC2/CLKO/RA6	14	31	33			Oscillator crystal or clock output.
OSC2				O	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
CLKO				O	—	In RC mode, OSC2 pin outputs CLKO which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
RA6				I/O	TTL	General purpose I/O pin.
						PORTA is a bidirectional I/O port.
RA0/AN0	2	19	19			
RA0				I/O	TTL	Digital I/O.
AN0				I	Analog	Analog input 0.
RA1/AN1	3	20	20			
RA1				I/O	TTL	Digital I/O.
AN1				I	Analog	Analog input 1.
RA2/AN2/VREF-/CVREF	4	21	21			
RA2				I/O	TTL	Digital I/O.
AN2				I	Analog	Analog input 2.
VREF-				I	Analog	A/D reference voltage (low) input.
CVREF				O	Analog	Comparator reference voltage output.
RA3/AN3/VREF+	5	22	22			
RA3				I/O	TTL	Digital I/O.
AN3				I	Analog	Analog input 3.
VREF+				I	Analog	A/D reference voltage (high) input.
RA4/T0CKI/C1OUT	6	23	23			
RA4				I/O	ST/OD	Digital I/O. Open drain when configured as output.
T0CKI				I	ST	Timer0 external clock input.
C1OUT				O	—	Comparator 1 output.
RA5/AN4/SS/LVDIN/C2OUT	7	24	24			
RA5				I/O	TTL	Digital I/O.
AN4				I	Analog	Analog input 4.
SS				I	TTL	SPI slave select input.
LVDIN				I	Analog	Low-Voltage Detect input.
C2OUT				O	—	Comparator 2 output.
RA6						See the OSC2/CLKO/RA6 pin.
RA7						See the OSC1/CLKI/RA7 pin.

Legend: TTL = TTL compatible input; CMOS = CMOS compatible input or output; ST = Schmitt Trigger input with CMOS levels; I = Input; O = Output; P = Power; OD = Open-drain (no diode to VDD)

Note 1: Alternate assignment for CCP2 when CCP2MX is cleared.

2: Default assignment for CCP2 when CCP2MX (CONFIG3H<0>) is set.

2.7.2 OSCILLATOR TRANSITIONS

The PIC18F2X20/4X20 devices contain circuitry to prevent clocking “glitches” when switching between clock sources. A short pause in the system clock occurs during the clock switch. The length of this pause is between 8 and 9 clock periods of the new clock source. This ensures that the new clock source is stable and that its pulse width will not be less than the shortest pulse width of the two clock sources.

Clock transitions are discussed in greater detail in **Section 3.1.2 “Entering Power-Managed Modes”**.

2.8 Effects of Power-Managed Modes on the Various Clock Sources

When the device executes a SLEEP instruction, the system is switched to one of the power-managed modes, depending on the state of the IDLEN and SCS1:SCS0 bits of the OSCCON register. See **Section 3.0 “Power-Managed Modes”** for details.

When PRI_IDLE mode is selected, the designated primary oscillator continues to run without interruption. For all other power-managed modes, the oscillator using the OSC1 pin is disabled. The OSC1 pin (and OSC2 pin, if used by the oscillator) will stop oscillating.

In secondary clock modes (SEC_RUN and SEC_IDLE), the Timer1 oscillator is operating and providing the system clock. The Timer1 oscillator may also run in all power-managed modes if required to clock Timer1 or Timer3.

In internal oscillator modes (RC_RUN and RC_IDLE), the internal oscillator block provides the system clock source. The INTRC output can be used directly to provide the system clock and may be enabled to support various special features, regardless of the power-managed mode (see **Section 23.2 “Watchdog Timer (WDT)”** through **Section 23.4 “Fail-Safe Clock Monitor”**). The INTOSC output at 8 MHz may be used directly to clock the system or may be divided down first. The INTOSC output is disabled if the system clock is provided directly from the INTRC output.

If the Sleep mode is selected, all clock sources are stopped. Since all the transistor switching currents have been stopped, Sleep mode achieves the lowest current consumption of the device (only leakage currents).

Enabling any on-chip feature that will operate during Sleep will increase the current consumed during Sleep. The INTRC is required to support WDT operation. The Timer1 oscillator may be operating to support a Real-Time Clock. Other features may be operating that do not require a system clock source (i.e., MSSP slave, PSP, INTx pins, A/D conversions and others).

2.9 Power-up Delays

Power-up delays are controlled by two timers so that no external Reset circuitry is required for most applications. The delays ensure that the device is kept in Reset until the device power supply is stable under normal circumstances and the primary clock is operating and stable. For additional information on power-up delays, see **Section 4.1 “Power-on Reset (POR)”** through **Section 4.5 “Brown-out Reset (BOR)”**.

The first timer is the Power-up Timer (PWRT) which provides a fixed delay on power-up (parameter 33, Table 26-10), if enabled, in Configuration Register 2L. The second timer is the Oscillator Start-up Timer (OST), intended to keep the chip in Reset until the crystal oscillator is stable (LP, XT and HS modes). The OST does this by counting 1024 oscillator cycles before allowing the oscillator to clock the device.

When the HSPLL Oscillator mode is selected, the device is kept in Reset for an additional 2 ms, following the HS mode OST delay, so the PLL can lock to the incoming clock frequency.

There is a delay of 5 to 10 μs, following POR, while the controller becomes ready to execute instructions. This delay runs concurrently with any other delays. This may be the only delay that occurs when any of the EC, RC or INTIO modes are used as the primary clock source.

TABLE 2-3: OSC1 AND OSC2 PIN STATES IN SLEEP MODE

OSC Mode	OSC1 Pin	OSC2 Pin
RC, INTIO1	Floating, external resistor should pull high	At logic low (clock/4 output)
RCIO, INTIO2	Floating, external resistor should pull high	Configured as PORTA, bit 6
ECIO	Floating, pulled by external clock	Configured as PORTA, bit 6
EC	Floating, pulled by external clock	At logic low (clock/4 output)
LP, XT, and HS	Feedback inverter disabled at quiescent voltage level	Feedback inverter disabled at quiescent voltage level

Note: See Table 4-1 in **Section 4.0 “Reset”** for time-outs due to Sleep and $\overline{\text{MCLR}}$ Reset.

3.1.2 ENTERING POWER-MANAGED MODES

In general, entry, exit and switching between power-managed clock sources requires clock source switching. In each case, the sequence of events is the same.

Any change in the power-managed mode begins with loading the OSCCON register and executing a SLEEP instruction. The SCS1:SCS0 bits select one of three power-managed clock sources; the primary clock (as defined in Configuration Register 1H), the secondary clock (the Timer1 oscillator) and the internal oscillator block (used in RC modes). Modifying the SCS bits will have no effect until a SLEEP instruction is executed. Entry to the power-managed mode is triggered by the execution of a SLEEP instruction.

Figure 3-5 shows how the system is clocked while switching from the primary clock to the Timer1 oscillator. When the SLEEP instruction is executed, clocks to the device are stopped at the beginning of the next instruction cycle. Eight clock cycles from the new clock source are counted to synchronize with the new clock source. After eight clock pulses from the new clock source are counted, clocks from the new clock source resume clocking the system. The actual length of the pause is between eight and nine clock periods from the new clock source. This ensures that the new clock source is stable and that its pulse width will not be less than the shortest pulse width of the two clock sources.

Three bits indicate the current clock source: OSTS and IOFS in the OSCCON register and T1RUN in the T1CON register. Only one of these bits will be set while in a power-managed mode other than PRI_RUN. When the OSTS bit is set, the primary clock is providing the system clock. When the IOFS bit is set, the INTOSC output is providing a stable 8 MHz clock source and is providing the system clock. When the T1RUN bit is set, the Timer1 oscillator is providing the system clock. If none of these bits are set, then either the INTRC clock source is clocking the system or the INTOSC source is not yet stable.

If the internal oscillator block is configured as the primary clock source in Configuration Register 1H, then both the OSTS and IOFS bits may be set when in PRI_RUN or PRI_IDLE modes. This indicates that the primary clock (INTOSC output) is generating a stable 8 MHz output. Entering a power-managed RC mode (same frequency) would clear the OSTS bit.

Note 1: Caution should be used when modifying a single IRCF bit. If V_{DD} is less than 3V, it is possible to select a higher clock speed than is supported by the low V_{DD}. Improper device operation may result if the V_{DD}/F_{OSC} specifications are violated.

2: Executing a SLEEP instruction does not necessarily place the device into Sleep mode; executing a SLEEP instruction is simply a trigger to place the controller into a power-managed mode selected by the OSCCON register, one of which is Sleep mode.

3.1.3 MULTIPLE SLEEP COMMANDS

The power-managed mode that is invoked with the SLEEP instruction is determined by the settings of the IDLEN and SCS bits at the time the instruction is executed. If another SLEEP instruction is executed, the device will enter the power-managed mode specified by these same bits at that time. If the bits have changed, the device will enter the new power-managed mode specified by the new bit settings.

3.1.4 COMPARISONS BETWEEN RUN AND IDLE MODES

Clock source selection for the Run modes is identical to the corresponding Idle modes. When a SLEEP instruction is executed, the SCS bits in the OSCCON register are used to switch to a different clock source. As a result, if there is a change of clock source at the time a SLEEP instruction is executed, a clock switch will occur.

In Idle modes, the CPU is not clocked and is not running. In Run modes, the CPU is clocked and executing code. This difference modifies the operation of the WDT when it times out. In Idle modes, a WDT time-out results in a wake from power-managed modes. In Run modes, a WDT time-out results in a WDT Reset (see Table 3-2).

During a wake-up from an Idle mode, the CPU starts executing code by entering the corresponding Run mode until the primary clock becomes ready. When the primary clock becomes ready, the clock source is automatically switched to the primary clock. The IDLEN and SCS bits are unchanged during and after the wake-up.

Figure 3-2 shows how the system is clocked during the clock source switch. The example assumes the device was in SEC_IDLE or SEC_RUN mode when a wake is triggered (the primary clock was configured in HSPLL mode).

TABLE 4-3: INITIALIZATION CONDITIONS FOR ALL REGISTERS

Register	Applicable Devices				Power-on Reset, Brown-out Reset	MCLR Resets WDT Reset RESET Instruction Stack Resets	Wake-up via WDT or Interrupt
TOSU	2220	2320	4220	4320	---0 0000	---0 0000	---0 uuuu(3)
TOSH	2220	2320	4220	4320	0000 0000	0000 0000	uuuu uuuu(3)
TOSL	2220	2320	4220	4320	0000 0000	0000 0000	uuuu uuuu(3)
STKPTR	2220	2320	4220	4320	uu-0 0000	00-0 0000	uu-u uuuu(3)
PCLATU	2220	2320	4220	4320	---0 0000	---0 0000	---u uuuu
PCLATH	2220	2320	4220	4320	0000 0000	0000 0000	uuuu uuuu
PCL	2220	2320	4220	4320	0000 0000	0000 0000	PC + 2(2)
TBLPTRU	2220	2320	4220	4320	--00 0000	--00 0000	--uu uuuu
TBLPTRH	2220	2320	4220	4320	0000 0000	0000 0000	uuuu uuuu
TBLPTRL	2220	2320	4220	4320	0000 0000	0000 0000	uuuu uuuu
TABLAT	2220	2320	4220	4320	0000 0000	0000 0000	uuuu uuuu
PRODH	2220	2320	4220	4320	xxxx xxxx	uuuu uuuu	uuuu uuuu
PRODL	2220	2320	4220	4320	xxxx xxxx	uuuu uuuu	uuuu uuuu
INTCON	2220	2320	4220	4320	0000 000x	0000 000u	uuuu uuuu(1)
INTCON2	2220	2320	4220	4320	1111 -1-1	1111 -1-1	uuuu -u-u(1)
INTCON3	2220	2320	4220	4320	11-0 0-00	11-0 0-00	uu-u u-uu(1)
INDF0	2220	2320	4220	4320	N/A	N/A	N/A
POSTINC0	2220	2320	4220	4320	N/A	N/A	N/A
POSTDEC0	2220	2320	4220	4320	N/A	N/A	N/A
PREINC0	2220	2320	4220	4320	N/A	N/A	N/A
PLUSW0	2220	2320	4220	4320	N/A	N/A	N/A
FSR0H	2220	2320	4220	4320	---- xxxx	---- uuuu	---- uuuu
FSR0L	2220	2320	4220	4320	xxxx xxxx	uuuu uuuu	uuuu uuuu
WREG	2220	2320	4220	4320	xxxx xxxx	uuuu uuuu	uuuu uuuu
INDF1	2220	2320	4220	4320	N/A	N/A	N/A
POSTINC1	2220	2320	4220	4320	N/A	N/A	N/A
POSTDEC1	2220	2320	4220	4320	N/A	N/A	N/A
PREINC1	2220	2320	4220	4320	N/A	N/A	N/A
PLUSW1	2220	2320	4220	4320	N/A	N/A	N/A

Legend: u = unchanged, x = unknown, - = unimplemented bit, read as '0', q = value depends on condition. Shaded cells indicate conditions do not apply for the designated device.

Note 1: One or more bits in the INTCONx or PIRx registers will be affected (to cause wake-up).

2: When the wake-up is due to an interrupt and the GIEL or GIEH bit is set, the PC is loaded with the interrupt vector (0008h or 0018h).

3: When the wake-up is due to an interrupt and the GIEL or GIEH bit is set, the TOSU, TOSH and TOSL are updated with the current value of the PC. The STKPTR is modified to point to the next location in the hardware stack.

4: See Table 4-2 for Reset value for specific condition.

5: Bits 6 and 7 of PORTA, LATA and TRISA are enabled, depending on the oscillator mode selected. When not enabled as PORTA pins, they are disabled and read '0'.

5.0 MEMORY ORGANIZATION

There are three memory types in enhanced MCU devices. These memory types are:

- Program Memory
- Data RAM
- Data EEPROM

Data and program memory use separate busses which allow for concurrent access of these types.

Additional detailed information for Flash program memory and data EEPROM is provided in **Section 6.0 "Flash Program Memory"** and **Section 7.0 "Data EEPROM Memory"**, respectively.

5.1 Program Memory Organization

A 21-bit program counter is capable of addressing the 2-Mbyte program memory space. Accessing a location between the physically implemented memory and the 2-Mbyte address will cause a read of all '0's (a NOP instruction).

The PIC18F2220 and PIC18F4220 each have 4 Kbytes of Flash memory and can store up to 2,048 single-word instructions.

The PIC18F2320 and PIC18F4320 each have 8 Kbytes of Flash memory and can store up to 4,096 single-word instructions.

The Reset vector address is at 0000h and the interrupt vector addresses are at 0008h and 0018h.

The Program Memory Maps for PIC18F2220/4220 and PIC18F2320/4320 devices are shown in Figure 5-1 and Figure 5-2, respectively.

FIGURE 5-1: PROGRAM MEMORY MAP AND STACK FOR PIC18F2220/4220

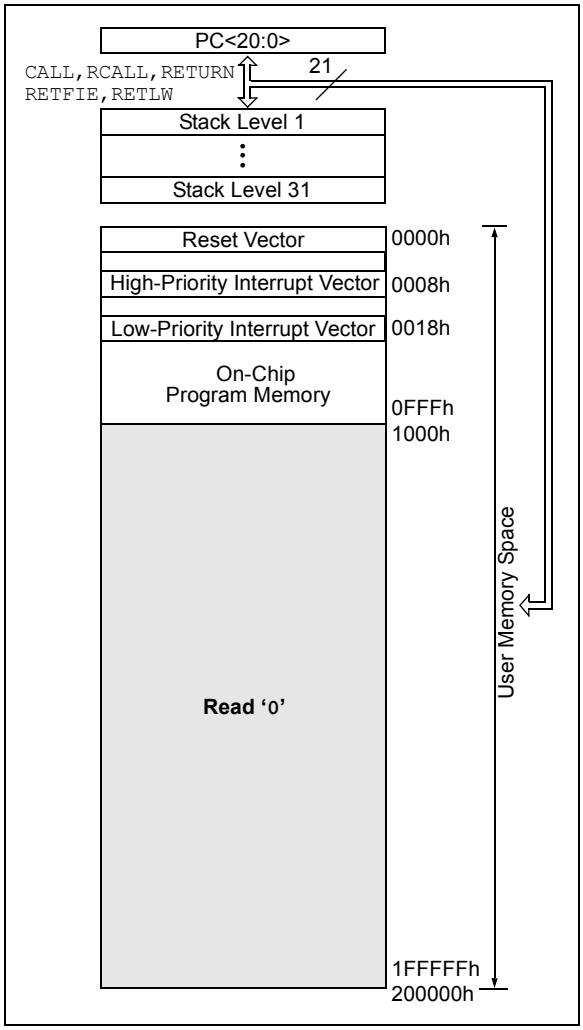


FIGURE 5-2: PROGRAM MEMORY MAP AND STACK FOR PIC18F2320/4320

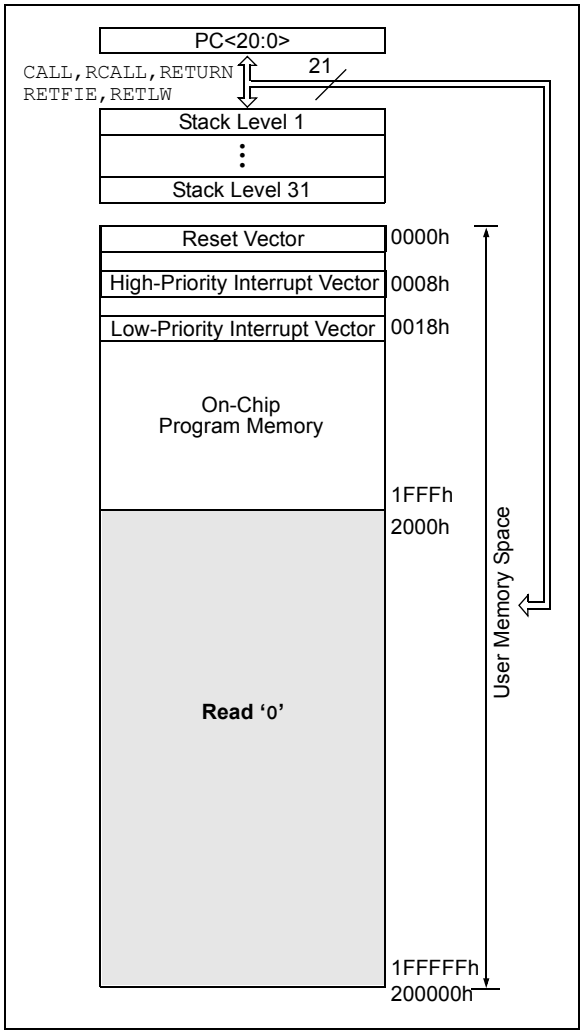
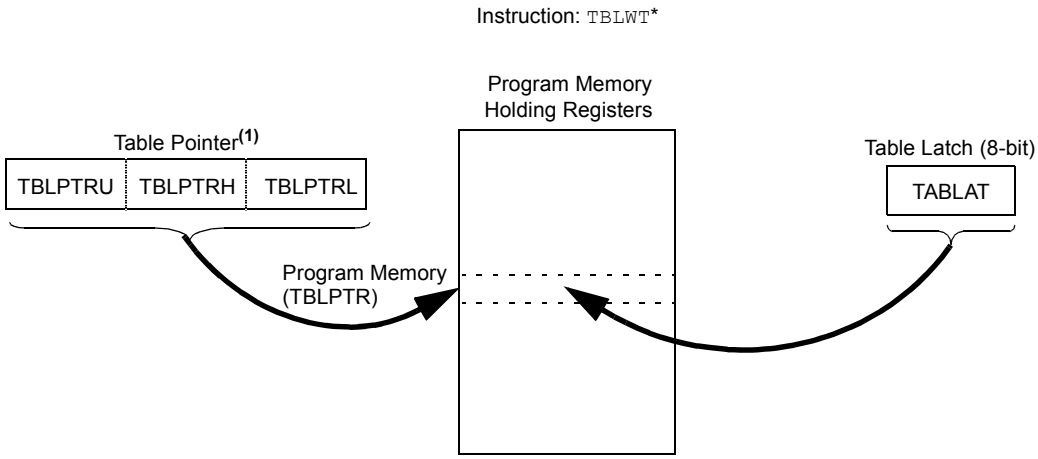


FIGURE 6-2: TABLE WRITE OPERATION



Note 1: Table Pointer actually points to one of eight holding registers, the address of which is determined by TBLPTRL<2:0>. The process for physically writing data to the program memory array is discussed in **Section 6.5 "Writing to Flash Program Memory"**.

6.2 Control Registers

Several control registers are used in conjunction with the TBLRD and TBLWT instructions. These include the:

- EECON1 register
- EECON2 register
- TABLAT register
- TBLPTR registers

6.2.1 EECON1 AND EECON2 REGISTERS

EECON1 is the control register for memory accesses.

EECON2 is not a physical register. Reading EECON2 will read all '0's. The EECON2 register is used exclusively in the memory write and erase sequences.

Control bit, EEPGD, determines if the access will be to program or data EEPROM memory. When clear, operations will access the data EEPROM memory. When set, program memory is accessed.

Control bit, CFGS, determines if the access will be to the Configuration registers or to program memory/data EEPROM memory. When set, subsequent operations access Configuration registers. When CFGS is clear, the EEPGD bit selects either program Flash or data EEPROM memory.

The FREE bit controls program memory erase operations. When the FREE bit is set, the erase operation is initiated on the next WR command. When FREE is clear, only writes are enabled.

The WREN bit enables and disables erase and write operations. When set, erase and write operations are allowed. When clear, erase and write operations are disabled – the WR bit cannot be set while the WREN bit is clear. This process helps to prevent accidental writes to memory due to errant (unexpected) code execution.

Firmware should keep the WREN bit clear at all times except when starting erase or write operations. Once firmware has set the WR bit, the WREN bit may be cleared. Clearing the WREN bit will not affect the operation in progress.

The WRERR bit is set when a write operation is interrupted by a Reset. In these situations, the user can check the WRERR bit and rewrite the location. It will be necessary to reload the data and address registers (EEDATA and EEADR) as these registers have cleared as a result of the Reset.

Control bits, RD and WR, start read and erase/write operations, respectively. These bits are set by firmware and cleared by hardware at the completion of the operation.

The RD bit cannot be set when accessing program memory (EEPGD = 1). Program memory is read using table read instructions. See **Section 6.3 "Reading the Flash Program Memory"** regarding table reads.

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

9.5 RCON Register

The RCON register contains bits used to determine the cause of the last Reset or wake-up from power-managed mode. RCON also contains the bit that enables interrupt priorities (IPEN).

REGISTER 9-10: RCON: RESET CONTROL REGISTER

R/W-0	U-0	U-0	R/W-1	R-1	R-1	R/W-0	R/W-0
IPEN	—	—	$\overline{RI}$	$\overline{TO}$	$\overline{PD}$	$\overline{POR}$	$\overline{BOR}$
bit 7							bit 0

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

bit 7 **IPEN:** Interrupt Priority Enable bit
1 = Enable priority levels on interrupts
0 = Disable priority levels on interrupts (PIC16CXXX Compatibility mode)

bit 6-5 **Unimplemented:** Read as '0'

bit 4 **$\overline{RI}$:** RESET Instruction Flag bit
1 = The RESET instruction was not executed (set by firmware only)
0 = The RESET instruction was executed causing a device Reset (must be set in software after a Brown-out Reset occurs)

bit 3 **$\overline{TO}$:** Watchdog Time-out Flag bit
1 = Set by power-up, CLRWDT instruction or SLEEP instruction
0 = A WDT time-out occurred

bit 2 **$\overline{PD}$:** Power-Down Detection Flag bit
1 = Set by power-up or by the CLRWDT instruction
0 = Cleared by execution of the SLEEP instruction

bit 1 **$\overline{POR}$:** Power-on Reset Status bit
1 = A Power-on Reset has not occurred (set by firmware only)
0 = A Power-on Reset occurred (must be set in software after a Power-on Reset occurs)

bit 0 **$\overline{BOR}$:** Brown-out Reset Status bit
1 = A Brown-out Reset has not occurred (set by firmware only)
0 = A Brown-out Reset occurred (must be set in software after a Brown-out Reset occurs)

TABLE 15-3: REGISTERS ASSOCIATED WITH CAPTURE, COMPARE, TIMER1 AND TIMER3

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	1111 1111	1111 1111
TRISC	PORTC Data Direction Register								1111 1111	1111 1111
TMR1L	Holding Register for the Least Significant Byte of the 16-bit TMR1 Register								xxxx xxxx	uuuu uuuu
TMR1H	Holding Register for the Most Significant Byte of the 16-bit TMR1 Register								xxxx xxxx	uuuu uuuu
T1CON	RD16	T1RUN	T1CKPS1	T1CKPS0	T1OSCEN	$\overline{\text{T1SYNC}}$	TMR1CS	TMR1ON	0000 0000	uuuu uuuu
CCPR1L	Capture/Compare/PWM Register 1 (LSB)								xxxx xxxx	uuuu uuuu
CCPR1H	Capture/Compare/PWM Register 1 (MSB)								xxxx xxxx	uuuu uuuu
CCP1CON	—	—	DC1B1	DC1B0	CCP1M3	CCP1M2	CCP1M1	CCP1M0	--00 0000	--00 0000
CCPR2L	Capture/Compare/PWM Register 2 (LSB)								xxxx xxxx	uuuu uuuu
CCPR2H	Capture/Compare/PWM Register 2 (MSB)								xxxx xxxx	uuuu uuuu
CCP2CON	—	—	DC2B1	DC2B0	CCP2M3	CCP2M2	CCP2M1	CCP2M0	--00 0000	--00 0000
PIR2	OSCFIF	CMIF	—	EEIF	BCLIF	LVDIF	TMR3IF	CCP2IF	00-0 0000	00-0 0000
PIE2	OSCFIE	CMIE	—	EEIE	BCLIE	LVDIE	TMR3IE	CCP2IE	00-0 0000	00-0 0000
IPR2	OSCFIP	CMIP	—	EEIP	BCLIP	LVDIP	TMR3IP	CCP2IP	11-1 1111	11-1 1111
TMR3L	Holding Register for the Least Significant Byte of the 16-bit TMR3 Register								xxxx xxxx	uuuu uuuu
TMR3H	Holding Register for the Most Significant Byte of the 16-bit TMR3 Register								xxxx xxxx	uuuu uuuu
T3CON	RD16	T3CCP2	T3CKPS1	T3CKPS0	T3CCP1	$\overline{\text{T3SYNC}}$	TMR3CS	TMR3ON	0000 0000	uuuu uuuu

Legend: x = unknown, u = unchanged, - = unimplemented, read as '0'. Shaded cells are not used by Capture and Timer1.
Note 1: These bits are reserved on the PIC18F2X20 devices; always maintain these bits clear.

19.0 10-BIT ANALOG-TO-DIGITAL CONVERTER (A/D) MODULE

The Analog-to-Digital (A/D) converter module has 10 inputs for the PIC18F2X20 devices and 13 for the PIC18F4X20 devices. This module allows conversion of an analog input signal to a corresponding 10-bit digital number.

A new feature for the A/D converter is the addition of programmable acquisition time. This feature allows the user to select a new channel for conversion and setting the GO/DONE bit immediately. When the GO/DONE bit is set, the selected channel is sampled for the programmed acquisition time before a conversion is actually started. This removes the firmware overhead that may have been required to allow for an acquisition (sampling) period (see Register 19-3 and **Section 19.3 "Selecting and Configuring Automatic Acquisition Time"**).

The module has five registers:

- A/D Result High Register (ADRESH)
- A/D Result Low Register (ADRESL)
- A/D Control Register 0 (ADCON0)
- A/D Control Register 1 (ADCON1)
- A/D Control Register 2 (ADCON2)

The ADCON0 register, shown in Register 19-1, controls the operation of the A/D module. The ADCON1 register, shown in Register 19-2, configures the functions of the port pins. The ADCON2 register, shown in Register 19-3, configures the A/D clock source, programmed acquisition time and justification.

REGISTER 19-1: ADCON0: A/D CONTROL REGISTER 0

U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	CHS3	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	ADON
bit 7							bit 0

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

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

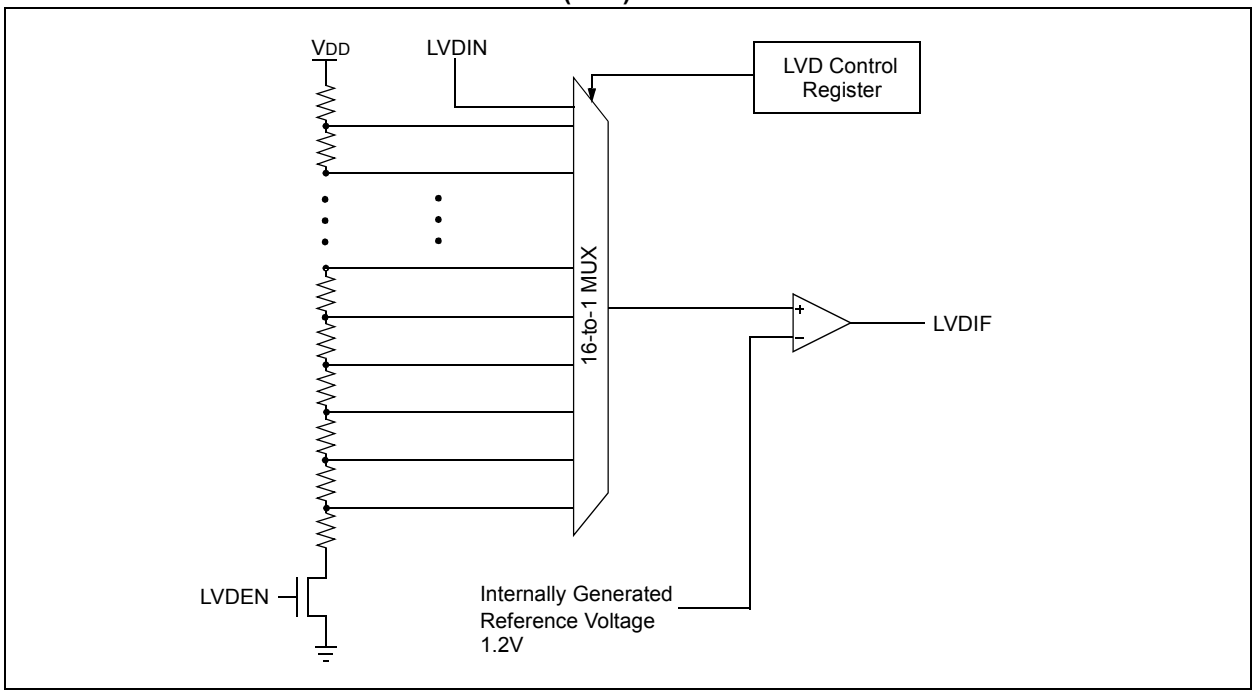
bit 5-2 **CHS3:CHS0:** Analog Channel Select bits
0000 = Channel 0 (AN0)
0001 = Channel 1 (AN1)
0010 = Channel 2 (AN2)
0011 = Channel 3 (AN3)
0100 = Channel 4 (AN4)
0101 = Channel 5 (AN5)**(1,2)**
0110 = Channel 6 (AN6)**(1,2)**
0111 = Channel 7 (AN7)**(1,2)**
1000 = Channel 8 (AN8)
1001 = Channel 9 (AN9)
1010 = Channel 10 (AN10)
1011 = Channel 11 (AN11)
1100 = Channel 12 (AN12)
1101 = Unimplemented**(2)**
1110 = Unimplemented**(2)**
1111 = Unimplemented**(2)**

bit 1 **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit
When ADON = 1:
1 = A/D conversion in progress
0 = A/D Idle

bit 0 **ADON:** A/D On bit
1 = A/D converter module is enabled
0 = A/D converter module is disabled

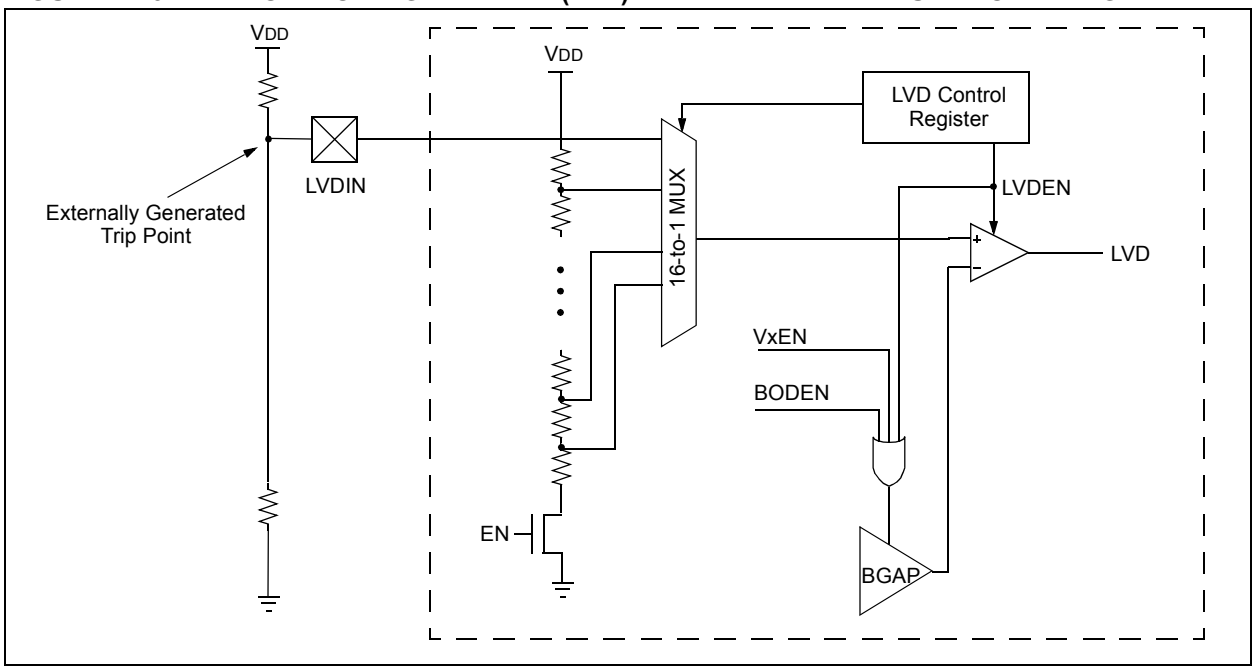
Note 1: These channels are not implemented on the PIC18F2X20 (28-pin) devices.
2: Performing a conversion on unimplemented channels returns full-scale results.

FIGURE 22-2: LOW-VOLTAGE DETECT (LVD) BLOCK DIAGRAM



The LVD module has an additional feature that allows the user to supply the sense voltage to the module from an external source. This mode is enabled when bits LVDL3:LVDL0 are set to '1111'. In this state, the comparator input is multiplexed from the external input pin, LVDIN (Figure 22-3). This gives users flexibility because it allows them to configure the Low-Voltage Detect interrupt to occur at any voltage in the valid operating range.

FIGURE 22-3: LOW-VOLTAGE DETECT (LVD) WITH EXTERNAL INPUT BLOCK DIAGRAM



MOVLW **Move Literal to W**

Syntax: [*label*] MOVLW k

Operands: $0 \le k \le 255$

Operation: $k \rightarrow W$

Status Affected: None

Encoding:

0000	1110	kkkk	kkkk

Description: The eight-bit literal 'k' is loaded into W.

Words: 1

Cycles: 1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	Read literal 'k'	Process Data	Write to W

Example: `MOVLW 0x5A`

After Instruction

W = 0x5A

MOVWF **Move W to f**

Syntax: [*label*] MOVWF f [,a]

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

Operation: $(W) \rightarrow f$

Status Affected: None

Encoding:

0110	111a	ffff	ffff

Description: Move data from W to register 'f'. Location 'f' can be anywhere in the 256-byte bank. If 'a' is '0', the Access Bank will be selected, overriding the BSR value. If 'a' = 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 register 'f'

Example: `MOVWF REG`

Before Instruction

W = 0x4F
REG = 0xFF

After Instruction

W = 0x4F
REG = 0x4F

MULLW **Multiply Literal with W**

Syntax: [*label*] MULLW k

Operands: $0 \le k \le 255$

Operation: (W) x k → PRODH:PRODL

Status Affected: None

Encoding:

0000	1101	kkkk	kkkk

Description: An unsigned multiplication is carried out between the contents of W and the 8-bit literal 'k'. The 16-bit result is placed in PRODH:PRODL register pair. PRODH contains the high byte. W is unchanged. None of the Status flags are affected. Note that neither overflow nor carry is possible in this operation. A zero result is possible but not detected.

Words: 1

Cycles: 1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	Read literal 'k'	Process Data	Write registers PRODH: PRODL

Example: `MULLW 0xC4`

Before Instruction

W = 0xE2
PRODH = ?
PRODL = ?

After Instruction

W = 0xE2
PRODH = 0xAD
PRODL = 0x08

MULWF **Multiply W with f**

Syntax: [*label*] MULWF f [,a]

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

Operation: (W) x (f) → PRODH:PRODL

Status Affected: None

Encoding:

0000	001a	ffff	ffff

Description: An unsigned multiplication is carried out between the contents of W and the register file location 'f'. The 16-bit result is stored in the PRODH:PRODL register pair. PRODH contains the high byte. Both W and 'f' are unchanged. None of the Status flags are affected. Note that neither overflow nor carry is possible in this operation. A zero result is possible but not detected. If 'a' is '0', the Access Bank will be selected, overriding the BSR value. If 'a'= 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 registers PRODH: PRODL

Example: `MULWF REG`

Before Instruction

W = 0xC4
REG = 0xB5
PRODH = ?
PRODL = ?

After Instruction

W = 0xC4
REG = 0xB5
PRODH = 0x8A
PRODL = 0x94

NEGF **Negate f**

Syntax: [*label*] NEGF f [,a]

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

Operation: $(\overline{f}) + 1 \rightarrow f$

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

Encoding:

0110	110a	ffff	ffff

Description: Location 'f' is negated using two's complement. The result is placed in the data memory location 'f'. If 'a' is '0', the Access Bank will be selected, overriding the BSR value. If 'a' = 1, then the bank will be selected as per the BSR value.

Words: 1

Cycles: 1

Q Cycle Activity:

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

Example: `NEGF REG, 1`

Before Instruction
REG = 0011 1010 [0x3A]
After Instruction
REG = 1100 0110 [0xC6]

NOP **No Operation**

Syntax: [*label*] NOP

Operands: None

Operation: No operation

Status Affected: None

Encoding:

0000 1111	0000 xxxx	0000 xxxx	0000 xxxx

Description: No operation.

Words: 1

Cycles: 1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	No operation	No operation	No operation

Example:

None.

SUBLW **Subtract W from Literal**

Syntax: [*label*] SUBLW k

Operands: $0 \le k \le 255$

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

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

Encoding:

0000	1000	kkkk	kkkk

Description: W is subtracted from the eight-bit literal 'k'. The result is placed in W.

Words: 1

Cycles: 1

Q Cycle Activity:

Q1	Q2	Q3	Q4
Decode	Read literal 'k'	Process Data	Write to W

Example 1: `SUBLW 0x02`

Before Instruction
W = 1
C = ?

After Instruction
W = 1
C = 1 ; result is positive
Z = 0
N = 0

Example 2: `SUBLW 0x02`

Before Instruction
W = 2
C = ?

After Instruction
W = 0
C = 1 ; result is zero
Z = 1
N = 0

Example 3: `SUBLW 0x02`

Before Instruction
W = 3
C = ?

After Instruction
W = FF ; (2's complement)
C = 0 ; result is negative
Z = 0
N = 1

SUBWF **Subtract W from f**

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

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

Operation: $(f) - (W) \rightarrow dest$

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

Encoding:

0101	11da	ffff	ffff

Description: Subtract W 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: `SUBWF REG`

Before Instruction
REG = 3
W = 2
C = ?

After Instruction
REG = 1
W = 2
C = 1 ; result is positive
Z = 0
N = 0

Example 2: `SUBWF REG, W`

Before Instruction
REG = 2
W = 2
C = ?

After Instruction
REG = 2
W = 0
C = 1 ; result is zero
Z = 1
N = 0

Example 3: `SUBWF REG`

Before Instruction
REG = 0x01
W = 0x02
C = ?

After Instruction
REG = 0xFFh ;(2's complement)
W = 0x02
C = 0x00 ; result is negative
Z = 0x00
N = 0x01

TABLE 26-1: MEMORY PROGRAMMING REQUIREMENTS

DC Characteristics			Standard Operating Conditions (unless otherwise stated) Operating temperature -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤ +125°C for extended				
Param No.	**Sym**	**Characteristic**	**Min**	**Typ†**	**Max**	**Units**	**Conditions**
		Internal Program Memory Programming Specifications					
D110	VPP	Voltage on $\overline{\text{MCLR}}$/VPP pin	9.00	—	13.25	V	**(Note 2)**
D112	IPP	Current into $\overline{\text{MCLR}}$/VPP pin	—	—	300	μA	
D113	IDDP	Supply Current during Programming	—	—	1.0	mA	
		Data EEPROM Memory					
D120	ED	Byte Endurance	100K 10K	1M 100K	— —	E/W E/W	-40°C to +85°C -40°C to +125°C
D121	VDRW	VDD for Read/Write	VMIN	—	5.5	V	Using EECON to read/write VMIN = Minimum operating voltage
D122	TDEW	Erase/Write Cycle Time	—	4	—	ms	
D123	TRETD	Characteristic Retention	40	—	—	Year	Provided no other specifications are violated
D124	TREF	Number of Total Erase/Write Cycles before Refresh(1)	1M 100K	10M 1M	— —	E/W E/W	-40°C to +85°C -40°C to +125°C
		Program Flash Memory					
D130	EP	Cell Endurance	10K 1K	100K 10K	— —	E/W E/W	-40°C to +85°C -40°C to +125°C
D131	VPR	VDD for Read	VMIN	—	5.5	V	VMIN = Minimum operating voltage
D132	VIE	VDD for Block Erase	4.5	—	5.5	V	Using ICSP port
D132A	VIW	VDD for Externally Timed Erase or Write	4.5	—	5.5	V	Using ICSP port
D132B	VPEW	VDD for Self-Timed Write	VMIN	—	5.5	V	VMIN = Minimum operating voltage
D133	TIE	ICSP Block Erase Cycle Time	—	4	—	ms	VDD > 4.5V
D133A	TIW	ICSP Erase or Write Cycle Time (externally timed)	1	—	—	ms	VDD > 4.5V
D133A	TIW	Self-Timed Write Cycle Time	—	2	—	ms	
D134	TRETD	Characteristic Retention	40	—	—	Year	Provided no other specifications are violated

† Data in "Typ" column is at 5.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: Refer to **Section 7.8 "Using the Data EEPROM"** for a more detailed discussion on data EEPROM endurance.

2: Required only if Low-Voltage Programming is disabled.

FIGURE 27-5: MAXIMUM IDD vs. FOSC OVER VDD PRI_RUN, EC MODE, -40°C TO +125°C

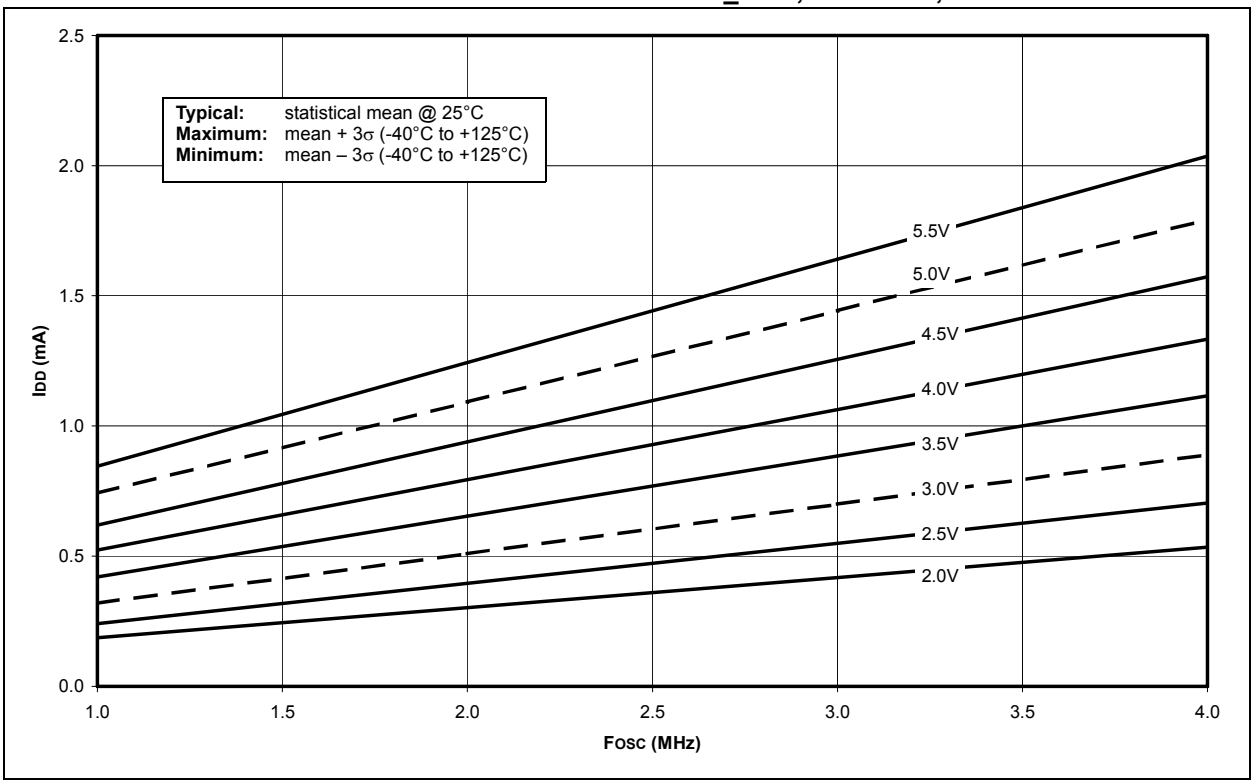
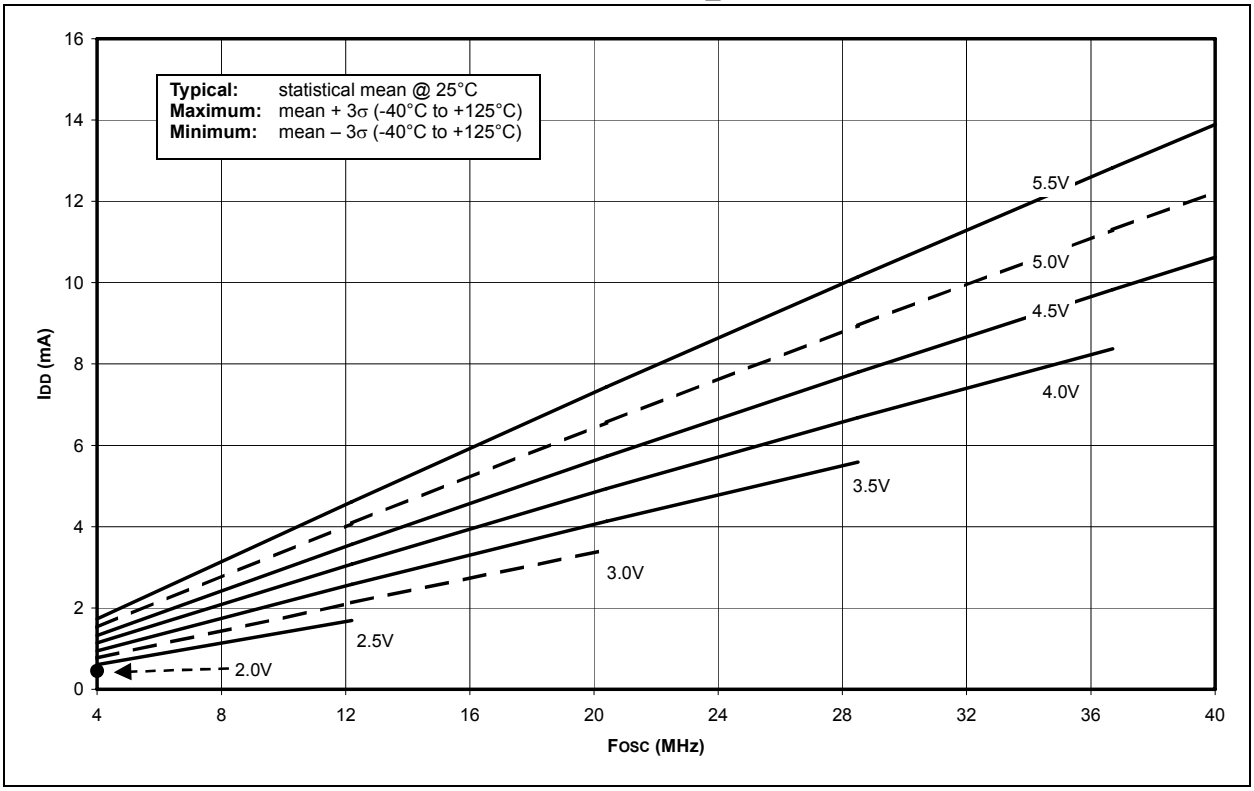


FIGURE 27-6: TYPICAL IDD vs. FOSC OVER VDD PRI_RUN, EC MODE, +25°C



APPENDIX A: REVISION HISTORY

Revision A (June 2002)

Original data sheet for PIC18F2X20/4X20 devices.

Revision B (October 2002)

This revision includes major changes to **Section 2.0 "Oscillator Configurations"** and **Section 3.0 "Power-Managed Modes"**, updates to the Electrical Specifications in **Section 26.0 "Electrical Characteristics"** and minor corrections to the data sheet text.

Revision C (October 2003)

This revision includes updates to the Electrical Specifications in **Section 26.0 "Electrical Characteristics"** and to the DC Characteristics Graphs and Charts in **Section 27.0 "DC and AC Characteristics Graphs and Tables"** and minor corrections to the data sheet text.

Revision D (October 2006)

This revision includes updates to the packaging diagrams.

Revision E (January 2007)

This revision includes updates to the packaging diagrams.

Revision F (February 2007)

This revision includes updates to the packaging diagrams.

Revision G (December 2007)

- Modified OSCTUNE register data and added OSCTUN2 register data to **Section 2.6 "Internal Oscillator Block"** and Table 4-3 and Table 5-1.
- Changed Brown-out Voltage values in **Section 26.1 "DC Characteristics: Supply Voltage PIC18F2220/2320/4220/4320 (Industrial) PIC18LF2220/2320/4220/4320 (Industrial)"**.
- Updated low-voltage detect values in Table 26-4.
- Removed RE3 pin references for PIC18F2220/2320 devices in **Section 1.0 "Device Overview"**, **Section 5.0 "Memory Organization"**, **Section 10.0 "I/O Ports"**, **Section 19.0 "10-bit Analog-to-Digital Converter (A/D) Module"** and **Section 23.0 "Special Features of the CPU"**.
- Made minor changes to **Section 17.3.3 "Enabling SPI I/O"**; Table 1-2, Table 1-3, Table 3-3, Table 12-1 and Table 26-2; Figure 12-3 and Figure 16-1; Example 10-1 and Example 10-2; and Table 21-1 and Table 23-1.

NOTES: