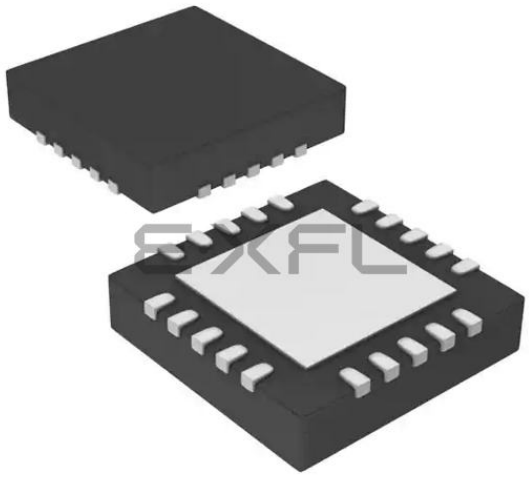

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	20MHz
Connectivity	-
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	17
Program Memory Size	3.5KB (2K x 14)
Program Memory Type	FLASH
EEPROM Size	256 x 8
RAM Size	128 x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 5.5V
Data Converters	A/D 14x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	20-VFQFN Exposed Pad
Supplier Device Package	20-QFN (4x4)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16f785-i-ml

Device	Program Memory	Data Memory		I/O	10-bit A/D (ch)	Op Amps	Comparators	CCP	Two-Phase PWM	Timers 8/16-bit	Shunt Reg.
	Flash (words)	SRAM (bytes)	EEPROM (bytes)								
PIC16F785	2048	128	256	17+1	12+2	2	2	1	1	2/1	0
PIC16HV785	2048	128	256	17+1	12+2	2	2	1	1	2/1	1

Dual in Line Pin Diagram

20-pin PDIP, SOIC, SSOP

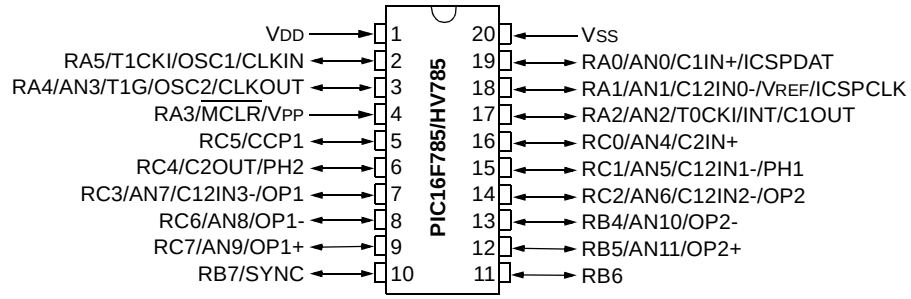


TABLE 1: DUAL IN LINE PIN SUMMARY

I/O	Pin	Analog	Comp.	Op Amps	PWM	Timers	CCP	Interrupt	Pull-ups	Basic
RA0	19	AN0	C1IN+	—	—	—	—	IOC	Y	ICSPDAT
RA1	18	AN1/VREF	C12IN0-	—	—	—	—	IOC	Y	ICSPCLK
RA2	17	AN2	C1OUT	—	—	T0CKI	—	INT/IOC	Y	—
RA3(1)	4	—	—	—	—	—	—	IOC	Y	MCLR/VPP
RA4	3	AN3	—	—	—	T1G	—	IOC	Y	OSC2/CLKOUT
RA5	2	—	—	—	—	T1CKI	—	IOC	Y	OSC1/CLKIN
RB4	13	AN10	—	OP2-	—	—	—	—	—	—
RB5	12	AN11	—	OP2+	—	—	—	—	—	—
RB6(2)	11	—	—	—	—	—	—	—	—	—
RB7	10	—	—	—	SYNC	—	—	—	—	—
RC0	16	AN4	C2IN+	—	—	—	—	—	—	—
RC1	15	AN5	C12IN1-	—	PH1	—	—	—	—	—
RC2	14	AN6	C12IN2-	OP2	—	—	—	—	—	—
RC3	7	AN7	C12IN3-	OP1	—	—	—	—	—	—
RC4	6	—	C2OUT	—	PH2	—	—	—	—	—
RC5	5	—	—	—	—	—	CCP1	—	—	—
RC6	8	AN8	—	OP1-	—	—	—	—	—	—
RC7	9	AN9	—	OP1+	—	—	—	—	—	—
—	1	—	—	—	—	—	—	—	—	VDD
—	20	—	—	—	—	—	—	—	—	VSS

Note 1: Input only.

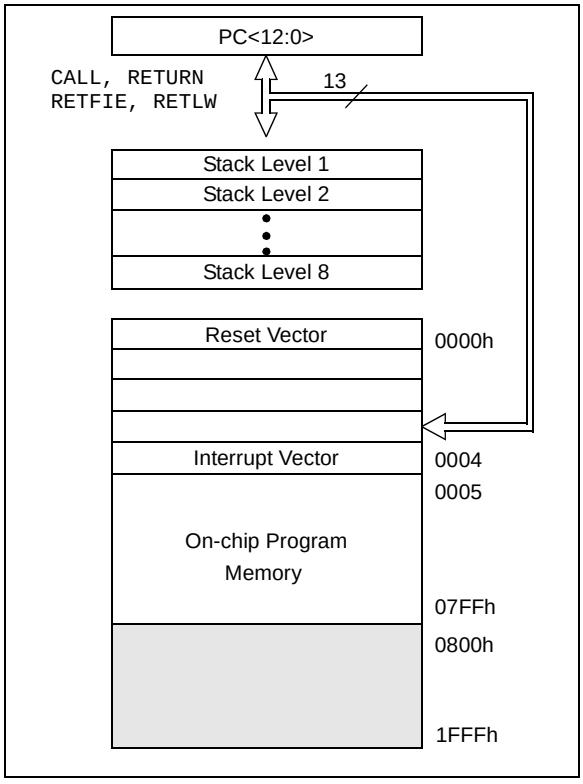
2: Open drain.

2.0 MEMORY ORGANIZATION

2.1 Program Memory Organization

The PIC16F785/HV785 has a 13-bit program counter capable of addressing an 8k x 14 program memory space. Only the first 2k x 14 (0000h-07FFh) for the PIC16F785/HV785 is physically implemented. Accessing a location above these boundaries will cause a wrap around within the first 2k x 14 space. The Reset vector is at 0000h and the interrupt vector is at 0004h (see Figure 2-1).

FIGURE 2-1: PROGRAM MEMORY MAP AND STACK FOR THE PIC16F785/HV785



2.2 Data Memory Organization

The data memory (see Figure 2-2) is partitioned into four banks, which contain the General Purpose Registers (GPR) and the Special Function Registers (SFR). The Special Function Registers are located in the first 32 locations of each bank. Register locations 20h-7Fh in Bank 0 and A0h-BFh in Bank 1 are General Purpose Registers, implemented as static RAM. The last sixteen register locations in Bank 1 (F0h-FFh), Bank 2 (170h-17Fh), and Bank 3 (1F0h-1FFh) point to addresses 70h-7Fh in Bank 0. All other RAM is unimplemented and returns '0' when read.

Seven address bits are required to access any location in a data memory bank. Two additional bits are required to access the four banks. When data memory is accessed directly, the seven Least Significant address bits are contained within the opcode and the two Most Significant bits are contained in the STATUS register. RP0 and RP1 bits of the STATUS register are the two Most Significant data memory address bits and are also known as the bank select bits. Table 2-1 lists how to access the four banks of registers.

TABLE 2-1: BANK SELECTION

	RP1	RP0
Bank 0	0	0
Bank 1	0	1
Bank 2	1	0
Bank 3	1	1

2.2.1 GENERAL PURPOSE REGISTER FILE

The register file banks are organized as 128 x 8 in the PIC16F785/HV785. Each register is accessed, either directly, by seven address bits within the opcode, or indirectly, through the File Select Register (FSR). When the FSR is used to access data memory, the eight Least Significant data memory address bits are contained in the FSR and the ninth Most Significant address bit is contained in the IRP bit in the STATUS Register. (see **Section 2.4 "Indirect Addressing, INDF and FSR Registers"**).

2.2.2 SPECIAL FUNCTION REGISTERS

The Special Function Registers are registers used by the CPU and peripheral functions for controlling the desired operation of the device (see Table 2-2). These registers are static RAM.

The special registers can be classified into two sets: core and peripheral. The Special Function Registers associated with the "core" are described in this section. Those related to the operation of the peripheral features are described in the section of that peripheral feature.

FIGURE 2-2: DATA MEMORY MAP OF THE PIC16F785/HV785

Bank 0	File Address	Bank 1	File Address	Bank 2	File Address	Bank 3	File Address
Indirect addr.(1)	00h	Indirect addr.(1)	80h	Indirect addr.(1)	100h	Indirect addr.(1)	180h
TMR0	01h	OPTION_REG	81h	TMR0	101h	OPTION_REG	181h
PCL	02h	PCL	82h	PCL	102h	PCL	182h
STATUS	03h	STATUS	83h	STATUS	103h	STATUS	183h
FSR	04h	FSR	84h	FSR	104h	FSR	184h
PORTA	05h	TRISA	85h	PORTA	105h	TRISA	185h
PORTB	06h	TRISB	86h	PORTB	106h	TRISB	186h
PORTC	07h	TRISC	87h	PORTC	107h	TRISC	187h
	08h		88h		108h		188h
	09h		89h		109h		189h
PCLATH	0Ah	PCLATH	8Ah	PCLATH	10Ah	PCLATH	18Ah
INTCON	0Bh	INTCON	8Bh	INTCON	10Bh	INTCON	18Bh
PIR1	0Ch	PIE1	8Ch		10Ch	PIE1	18Ch
	0Dh		8Dh		10Dh		18Dh
TMR1L	0Eh	PCON	8Eh		10Eh		18Eh
TMR1H	0Fh	OSCCON	8Fh		10Fh		18Fh
T1CON	10h	OSCTUNE	90h	PWMCON1	110h		190h
TMR2	11h	ANSEL0	91h	PWMCON0	111h		191h
T2CON	12h	PR2	92h	PWMCLK	112h		192h
CCPR1L	13h	ANSEL1	93h	PWMPH1	113h		193h
CCPR1H	14h		94h	PWMPH2	114h		194h
CCP1CON	15h	WPUA	95h		115h		195h
	16h	IOCA	96h		116h		196h
	17h		97h		117h		197h
WDTCON	18h	REFCON	98h		118h		198h
	19h	VRCON	99h	CM1CON0	119h		199h
	1Ah	EEDAT	9Ah	CM2CON0	11Ah		19Ah
	1Bh	EEADR	9Bh	CM2CON1	11Bh		19Bh
	1Ch	EECON1	9Ch	OPA1CON	11Ch		19Ch
	1Dh	EECON2(1)	9Dh	OPA2CON	11Dh		19Dh
ADRESH	1Eh	ADRESL	9Eh		11Eh		19Eh
ADCON0	1Fh	ADCON1	9Fh		11Fh		19Fh
General Purpose Register 96 Bytes	20h–6Fh	General Purpose Register 32 Bytes	A0h–BFh		120h–16Fh		1A0h–1EFh
	70h–7Fh	accesses Bank 0	C0h–EFh	accesses Bank 0	170h–17Fh	accesses Bank 0	1F0h–1FFh
			F0h–FFh				

Unimplemented data memory locations, read as '0'.

Note 1: Not a physical register.

3.4.2.2 OSCTUNE Register

The HFINTOSC is factory calibrated but can be adjusted in software by writing to the OSCTUNE register (Register 3-1).

The OSCTUNE register has a nominal tuning range of ±12%. The default value of the OSCTUNE register is '0'. The value is a 5-bit two's complement number. Due to process variation, the monotonicity and frequency step cannot be specified.

When the OSCTUNE register is modified, the HFINTOSC frequency will begin shifting to the new frequency. The HFINTOSC clock will stabilize within 1 ms. Code execution continues during this shift. There is no indication that the shift has occurred.

OSCTUNE does not affect the LFINTOSC frequency. Operation of features that depend on the LFINTOSC clock source frequency, such as the Power-up Timer (PWRT), Watchdog Timer (WDT), Fail-Safe Clock Monitor (FSCM) and peripherals, are *not* affected by the change in frequency.

REGISTER 3-1: OSCTUNE: OSCILLATOR TUNING REGISTER

U-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	—	TUN4	TUN3	TUN2	TUN1	TUN0
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 7-5 **Unimplemented:** Read as '0'

bit 4-0 **TUN<4:0>:** Frequency Tuning bits

01111 = Maximum frequency
01110 =
•
•
•
00001 =
00000 = Center frequency. Oscillator module is running at the calibrated frequency.
11111 =
•
•
•
10000 = Minimum frequency

4.4.1.5 RC2/AN6/C12IN2-/OP2

The RC2 is configurable to function as one of the following:

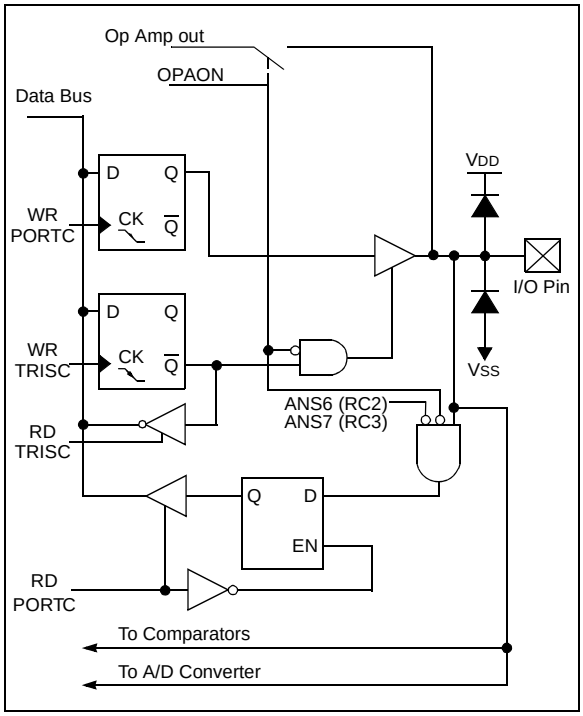
- General purpose I/O
- Analog input for the A/D Converter
- Analog input to Comparators 1 and 2
- Analog output from Op Amp 2

4.4.1.6 RC3/AN7/C12IN3-/OP1

The RC3 is configurable to function as one of the following:

- General purpose I/O
- Analog input for the A/D Converter
- Analog input to Comparators 1 and 2
- Analog output for Op Amp 1

FIGURE 4-12: BLOCK DIAGRAM OF RC2 AND RC3

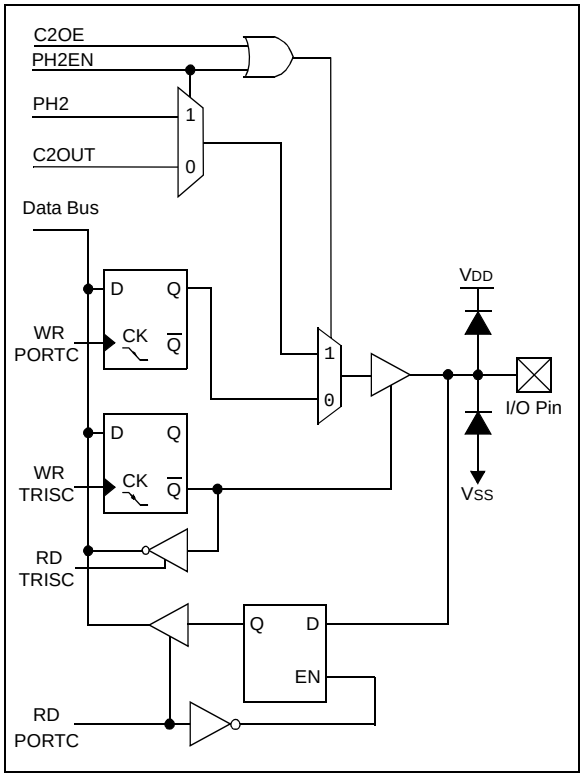


4.4.1.7 RC4/C2OUT/PH2

The RC4 is configurable to function as one of the following:

- General purpose I/O
- Digital output from Comparator 2
- Digital output from the Two-Phase PWM

FIGURE 4-13: BLOCK DIAGRAM OF RC4



6.5 Timer1 Operation in Asynchronous Counter Mode

If control bit $\overline{\text{T1SYNC}}$ of the T1CON Register is set, the external clock input is not synchronized. The timer continues to increment asynchronous to the internal phase clocks. The timer will continue to run during Sleep and can generate an interrupt on overflow, which will wake-up the processor. However, special precautions in software are needed to read/write the timer (**Section 6.5.1 "Reading and Writing Timer1 in Asynchronous Counter Mode"**).

Note:	The ANSEL0 (91h) register must be initialized to configure an analog channel as a digital input. Pins configured as analog inputs will read '0'.

6.5.1 READING AND WRITING TIMER1 IN ASYNCHRONOUS COUNTER MODE

Reading TMR1H or TMR1L while the timer is running from an external asynchronous clock will ensure a valid read (taken care of in hardware). However, the user should keep in mind that reading the 16-bit timer in two 8-bit values itself, poses certain problems, since the timer may overflow between the reads.

For writes, it is recommended that the user simply stop the timer and write the desired values. A write contention may occur by writing to the timer registers, while the register is incrementing. This may produce an unpredictable value in the timer register.

6.6 Timer1 Oscillator

A crystal oscillator circuit is built-in between pins OSC1 (input) and OSC2 (amplifier output). It is enabled by setting control bit T1OSCEN of the T1CON Register. The oscillator is a low power oscillator rated for 32.768 kHz. It will continue to run during Sleep. It is primarily intended for a 32.768 kHz tuning fork crystal.

The Timer1 oscillator is shared with the system LP oscillator. Thus, Timer1 can use this mode only when the primary system clock is also the LP oscillator or is derived from the internal oscillator. As with the system LP oscillator, the user must provide a software time delay to ensure proper oscillator start-up.

Sleep mode will not disable the system clock when the system clock and Timer1 share the LP oscillator.

TRISA<5> and TRISA<4> bits are set when the Timer1 oscillator is enabled. RA5 and RA4 read as '0' and TRISA<5> and TRISA<4> bits read as '1'.

Note:	The oscillator requires a start-up and stabilization time before use. Thus, T1OSCEN should be set and a suitable delay observed prior to enabling Timer1.

6.7 Timer1 Operation During Sleep

Timer1 can only operate during Sleep when setup in Asynchronous Counter mode. In this mode, an external crystal or clock source can be used to increment the counter. To setup the timer to wake the device:

- Timer1 of the T1CON Register must be on
- TMR1IE bit of the PIE1 Register must be set
- PEIE bit of the INTCON Register must be set

The device will wake-up on an overflow. If the GIE bit of the INTCON Register is set, the device will wake-up and jump to the Interrupt Service Routine (0004h) on an overflow. If the GIE bit is clear, execution will continue with the next instruction.

TABLE 6-1: REGISTERS ASSOCIATED WITH TIMER1

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
ANSEL0	ANS7	ANS6	ANS5	ANS4	ANS3	ANS2	ANS1	ANS0	1111 1111	1111 1111
CM2CON1	MC1OUT	MC2OUT	—	—	—	—	T1GSS	C2SYNC	00-- --10	00-- --10
INTCON	GIE	PEIE	T0IE	INTE	RAIE	T0IF	INTF	RAIF	0000 0000	0000 0000
PIE1	EEIE	ADIE	CCP1IE	C2IE	C1IE	OSFIE	TMR2IE	TMR1IE	0000 0000	0000 0000
PIR1	EEIF	ADIF	CCP1IF	C2IF	C1IF	OSFIF	TMR2IF	TMR1IF	0000 0000	0000 0000
T1CON	T1GINV	TMR1GE	T1CKPS1	T1CKPS0	T1OSCEN	$\overline{\text{T1SYNC}}$	TMR1CS	TMR1ON	0000 0000	uuuu uuuu
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

Legend: – x = unknown, u = unchanged, – = unimplemented, read as '0'. Shaded cells are not used by the Timer1 module.

11.3 Effects of a Reset

A device Reset forces all registers to their Reset state. This disables both op amps.

11.4 OPA Module Performance

Common AC and DC performance specifications for the OPA module:

- Common Mode Voltage Range
- Leakage Current
- Input Offset Voltage
- Open Loop Gain
- Gain Bandwidth Product (GBWP)

Common mode voltage range is the specified voltage range for the OPA+ and OPA- inputs, for which the OPA module will perform to within its specifications. The OPA module is designed to operate with input voltages between 0 and V_{DD}-1.4V. Behavior for common mode voltages greater than V_{DD}-1.4V, or below 0V, are beyond the normal operating range.

Leakage current is a measure of the small source or sink currents on the OPA+ and OPA- inputs. To minimize the effect of leakage currents, the effective impedances connected to the OPA+ and OPA- inputs should be kept as small as possible and equal.

Input offset voltage is a measure of the voltage difference between the OPA+ and OPA- inputs in a closed loop circuit with the OPA in its linear region. The offset voltage will appear as a DC offset in the output equal to the input offset voltage, multiplied by the gain of the circuit. The input offset voltage is also affected by the common mode voltage.

Open loop gain is the ratio of the output voltage to the differential input voltage, (OPA+) - (OPA-). The gain is greatest at DC and falls off with frequency.

Gain Bandwidth Product or GBWP is the frequency at which the open loop gain falls off to 0 dB.

11.5 Effects of Sleep

When enabled, the op amps continue to operate and consume current while the processor is in Sleep mode.

TABLE 11-1: REGISTERS ASSOCIATED WITH THE OPA MODULE

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
ANSEL0	ANS7	ANS6	ANS5	ANS4	ANS3	ANS2	ANS1	ANS0	1111 1111	1111 1111
ANSEL1	—	—	—	—	ANS11	ANS10	ANS9	ANS8	---- 1111	---- 1111
OPA1CON	OPAON	—	—	—	—	—	—	—	0--- ----	0--- ----
OPA2CON	OPAON	—	—	—	—	—	—	—	0--- ----	0--- ----
TRISB	TRISB7	TRISB6	TRISB5	TRISB4	—	—	—	—	1111 ----	1111 ----
TRISC	TRISC7	TRISC6	TRISC5	TRISC4	TRISC3	TRISC2	TRISC1	TRISC0	1111 1111	1111 1111

Legend: x = unknown, u = unchanged, - = unimplemented, read as '0'. Shaded cells are not used for the OPA module.

12.1.7 CONFIGURING THE A/D

After the A/D module has been configured as desired, the selected channel must be acquired before the conversion is started. The analog input channels must have their corresponding TRIS bits selected as inputs.

To determine sample time, see Table 19-16 and Table 19-17. After this sample time has elapsed, the A/D conversion can be started.

These steps should be followed for an A/D conversion:

1. Configure the A/D module:
   - Configure analog/digital I/O (ANSx)
   - Select A/D conversion clock in the ADCON1 Register
   - Configure voltage reference in the ADCON0 Register
   - Select A/D input channel in the ADCON0 Register
   - Select result format in the ADCON0 Register
   - Turn on A/D module in the ADCON0 Register
2. Configure A/D interrupt (if desired):
   - Clear ADIF bit of the PIR1 Register
   - Set ADIE bit of the PIE1 Register
   - Set PEIE and GIE bits of the INTCON Register
3. Wait the required acquisition time.
4. Start conversion:
   - Set GO/$\overline{\text{DONE}}$ bit (ADCON0<1>)
5. Wait for A/D conversion to complete, by either:
   - Polling for the GO/$\overline{\text{DONE}}$ bit to be cleared (with interrupts disabled); OR
   - Waiting for the A/D interrupt
6. Read A/D Result register pair (ADRESH:ADRESL), clear bit ADIF if required.
7. For next conversion, go to step 1 or step 2 as required. The A/D conversion time per bit is defined as T_{AD}. A minimum wait of 2 T_{AD} is required before the next acquisition starts.

EXAMPLE 12-1: A/D CONVERSION

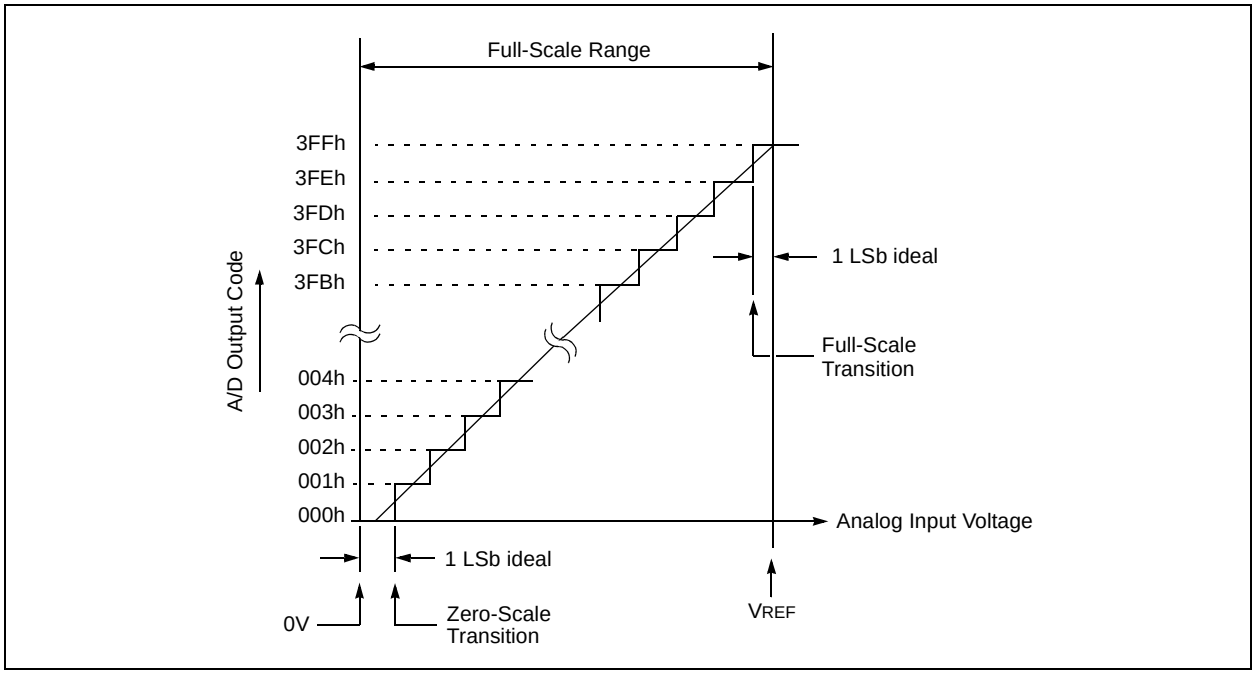
```
;This code block configures the A/D
;for polling, Vdd reference, R/C clock
;and RA0 input.
;
;Conversion start and wait for complete
;polling code included.
;
 BCF    STATUS,RP1  ;Bank 1
 BSF    STATUS,RP0  ;
 MOVLW  B'01110000' ;A/D RC clock
 MOVWF  ADCON1
 BSF    TRISA,0     ;Set RA0 to input
 BSF    ANSEL0,0    ;Set RA0 to analog
 BCF    STATUS,RP0  ;Bank 0
 MOVLW  B'10000001' ;Right, Vdd Vref, AN0
 MOVWF  ADCON0
 CALL   SampleTime  ;Wait min sample time
 BSF    ADCON0,GO   ;Start conversion
 BTFSC  ADCON0,GO   ;Is conversion done?
 GOTO   $-1         ;No, test again
 MOVF   ADRESH,W    ;Read upper 2 bits
 MOVWF  RESULTHI
 BSF    STATUS,RP0  ;Bank 1
 MOVF   ADRESL,W    ;Read lower 8 bits
 BCF    STATUS,RP0  ;Bank 0
 MOVWF  RESULTLO
```

12.3 A/D Operation During Sleep

The A/D Converter module can operate during Sleep. This requires the A/D clock source to be set to the FRC option. When the RC clock source is selected, the A/D waits one instruction before starting the conversion. This allows the SLEEP instruction to be executed, thus eliminating much of the switching noise from the conversion. When the conversion is complete, the GO/DONE bit is cleared and the result is loaded into the ADRESH:ADRESL registers. If the A/D interrupt is enabled (ADIE and PEIE bits set), the device awakens from Sleep. If the GIE bit of the INTCON Register is set, the program counter is set to the interrupt vector (0004h). If GIE is clear, the next instruction is executed. If the A/D interrupt is not enabled, the A/D module is turned off, although the ADON bit remains set.

When the A/D clock source is something other than RC, a SLEEP instruction causes the present conversion to be aborted and the A/D module is turned off. The ADON bit remains set.

FIGURE 12-5: A/D TRANSFER FUNCTION



17.2 Instruction Descriptions

ADDLW	Add Literal and W
Syntax:	[*label*] ADDLW k
Operands:	$0 \le k \le 255$
Operation:	(W) + k → (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:	$0 \le f \le 127$ $d \in [0,1]$
Operation:	(W) + (f) → (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:	$0 \le k \le 255$
Operation:	(W) .AND. (k) → (W)
Status Affected:	Z
Description:	The contents of W register are AND'ed 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:	$0 \le f \le 127$ $d \in [0,1]$
Operation:	(W) .AND. (f) → (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:	$0 \le f \le 127$ $0 \le b \le 7$
Operation:	0 → (f<b>)
Status Affected:	None
Description:	Bit 'b' in register 'f' is cleared.

BSF	Bit Set f
Syntax:	[*label*] BSF f,b
Operands:	$0 \le f \le 127$ $0 \le b \le 7$
Operation:	1 → (f<b>)
Status Affected:	None
Description:	Bit 'b' in register 'f' is set.

18.11 PICSTART Plus Development Programmer

The PICSTART Plus Development Programmer is an easy-to-use, low-cost, prototype programmer. It connects to the PC via a COM (RS-232) port. MPLAB Integrated Development Environment software makes using the programmer simple and efficient. The PICSTART Plus Development Programmer supports most PIC devices in DIP packages up to 40 pins. Larger pin count devices, such as the PIC16C92X and PIC17C76X, may be supported with an adapter socket. The PICSTART Plus Development Programmer is CE compliant.

18.12 PICkit 2 Development Programmer

The PICkit™ 2 Development Programmer is a low-cost programmer and selected Flash device debugger with an easy-to-use interface for programming many of Microchip's baseline, mid-range and PIC18F families of Flash memory microcontrollers. The PICkit 2 Starter Kit includes a prototyping development board, twelve sequential lessons, software and HI-TECH's PICC™ Lite C compiler, and is designed to help get up to speed quickly using PIC® microcontrollers. The kit provides everything needed to program, evaluate and develop applications using Microchip's powerful, mid-range Flash memory family of microcontrollers.

18.13 Demonstration, Development and Evaluation Boards

A wide variety of demonstration, development and evaluation boards for various PIC MCUs and dsPIC DSCs allows quick application development on fully functional systems. Most boards include prototyping areas for adding custom circuitry and provide application firmware and source code for examination and modification.

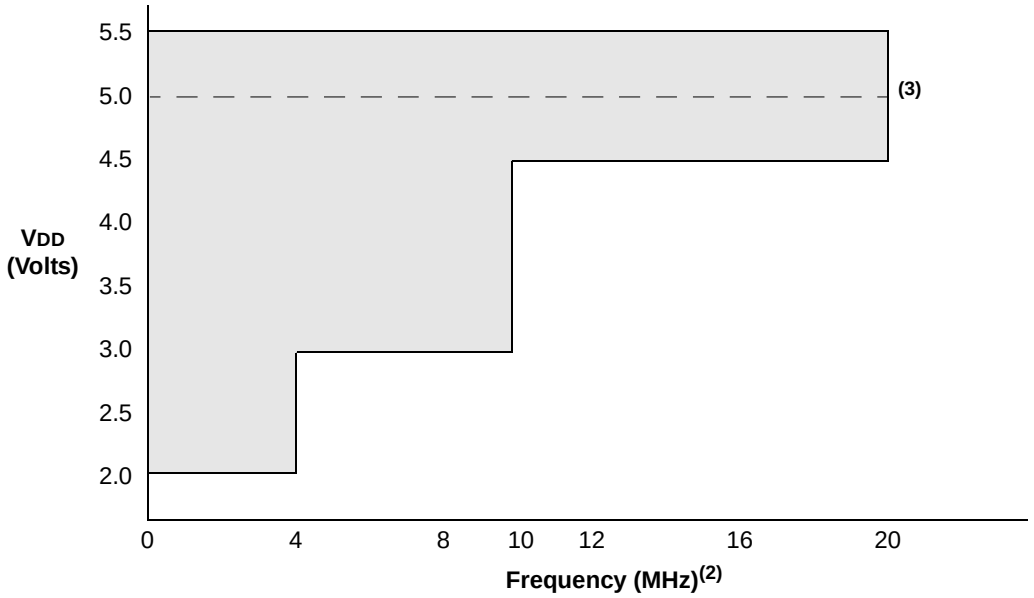
The boards support a variety of features, including LEDs, temperature sensors, switches, speakers, RS-232 interfaces, LCD displays, potentiometers and additional EEPROM memory.

The demonstration and development boards can be used in teaching environments, for prototyping custom circuits and for learning about various microcontroller applications.

In addition to the PICDEM™ and dsPICDEM™ demonstration/development board series of circuits, Microchip has a line of evaluation kits and demonstration software for analog filter design, KEELOQ® security ICs, CAN, IrDA®, PowerSmart battery management, SEEVAL® evaluation system, Sigma-Delta ADC, flow rate sensing, plus many more.

Check the Microchip web page (www.microchip.com) for the complete list of demonstration, development and evaluation kits.

FIGURE 19-1: PIC16F785/HV785 WITH ANALOG DISABLED VOLTAGE-FREQUENCY GRAPH, -40°C ≤ TA ≤ +125°C(2)



Note 1: The shaded region indicates the permissible combinations of voltage and frequency.

2: Frequency denotes system clock frequency. When using the HFINTOSC the system clock is after the postscaler.

3: The internal shunt regulator of the PIC16HV785 keeps VDD at or below 5.0V (nominal).

19.1 DC Characteristics: PIC16F785/HV785-I (Industrial), PIC16F785/HV785-E (Extended)

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**
	VDD	**Supply Voltage(2)**					FOSC ≤ 4 MHz:
D001			2.0	—	5.5	V	PIC16F785 with A/D off
D001A			2.2	—	5.5	V	PIC16F785 with A/D on, 0°C to +125°C
D001B			2.5	—	5.5	V	PIC16F785 with A/D on, -40°C to +125°C
D001C			3.0	—	5.5	V	4 MHz ≤ FOSC ≤ 10 MHz
D001D			4.5	—	5.5	V	10 MHz ≤ FOSC ≤ 20 MHz
D002	VDR	**RAM Data Retention Voltage(1)**	1.5*	—	—	V	Device in Sleep mode
D003	VPOR	VDD voltage above which the internal **POR releases**	—	1.8	—	V	See **Section 15.2.1 "Power-On Reset"** for details.
D003A	VPARM	VDD voltage below which the internal **POR rearms**	—	1.0	—	V	See **Section 15.2.1 "Power-On Reset"** for details.
D004	SVDD	VDD **Rise Rate** to ensure internal Power-on Reset signal	0.05*	—	—	V/ms	See **Section 15.2.1 "Power-On Reset"** for details.
D005	VBOR	**Brown-out Reset**	—	2.1	—	V	

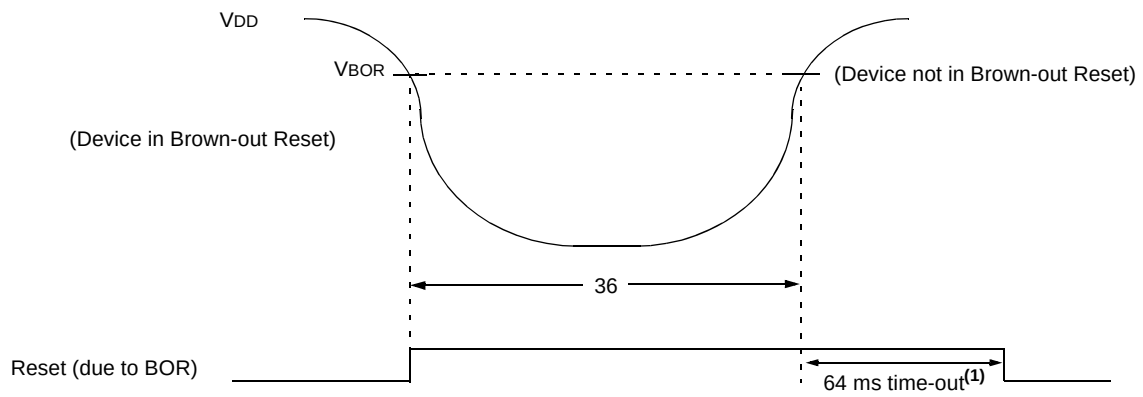
* These parameters are characterized but not tested.

† 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: This is the limit to which VDD can be lowered in Sleep mode without losing RAM data.

2: Maximum supply voltage is VSHUNT for PIC16HV785 device (see Table 19-14).

FIGURE 19-6: BROWN-OUT RESET TIMING AND CHARACTERISTICS



Note 1: 64 ms delay only if $\overline{\text{PWRTE}}$ bit in Configuration Word is programmed to '0'.

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

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	TMCL	$\overline{\text{MCLR}}$ Pulse Width (low)	2 11	— 18	— 24	µs µs	VDD = 5.0V, -40°C to +85°C Extended temperature
31	TWDT	Watchdog Timer Time-out Period (No Prescaler)	10 10	17 17	25 30	ms ms	VDD = 5.0V, -40°C to +85°C Extended temperature
32	TOST	Oscillation Start-up Timer Period	—	1024 TOSC	—	—	TOSC = OSC1 period
33*	TPWRT	Power-up Timer Period	28*	64	132*	ms	VDD = 5.0V, -40°C to +85°C
34	TIOZ	I/O High-impedance from $\overline{\text{MCLR}}$ Low or Watchdog Timer Reset	—	—	2.0	µs	
35	VBOR	Brown-out Reset Voltage	2.025	—	2.175	V	
36	TBOR	Brown-out Reset Pulse Width	100*	—	—	µs	VDD ≤ VBOR (D005)

* These parameters are characterized but not tested.

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

NOTES:

FIGURE 20-2: MAXIMUM IDD vs. FOSC OVER VDD (EC MODE)

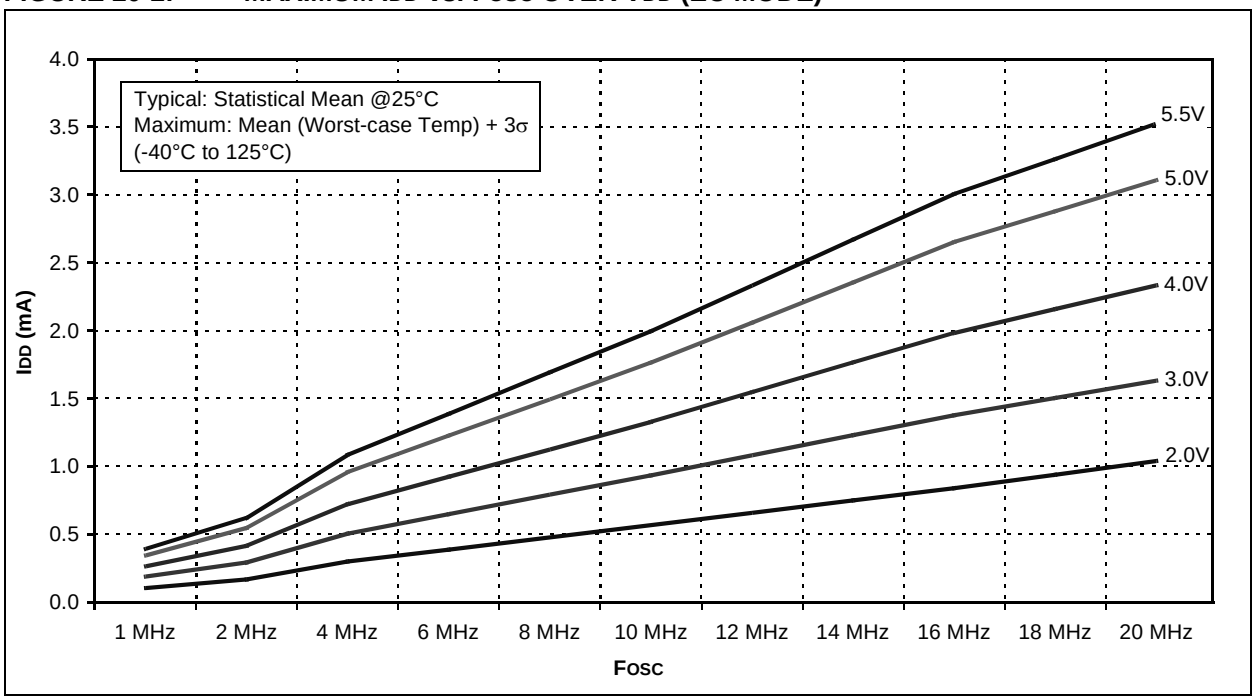
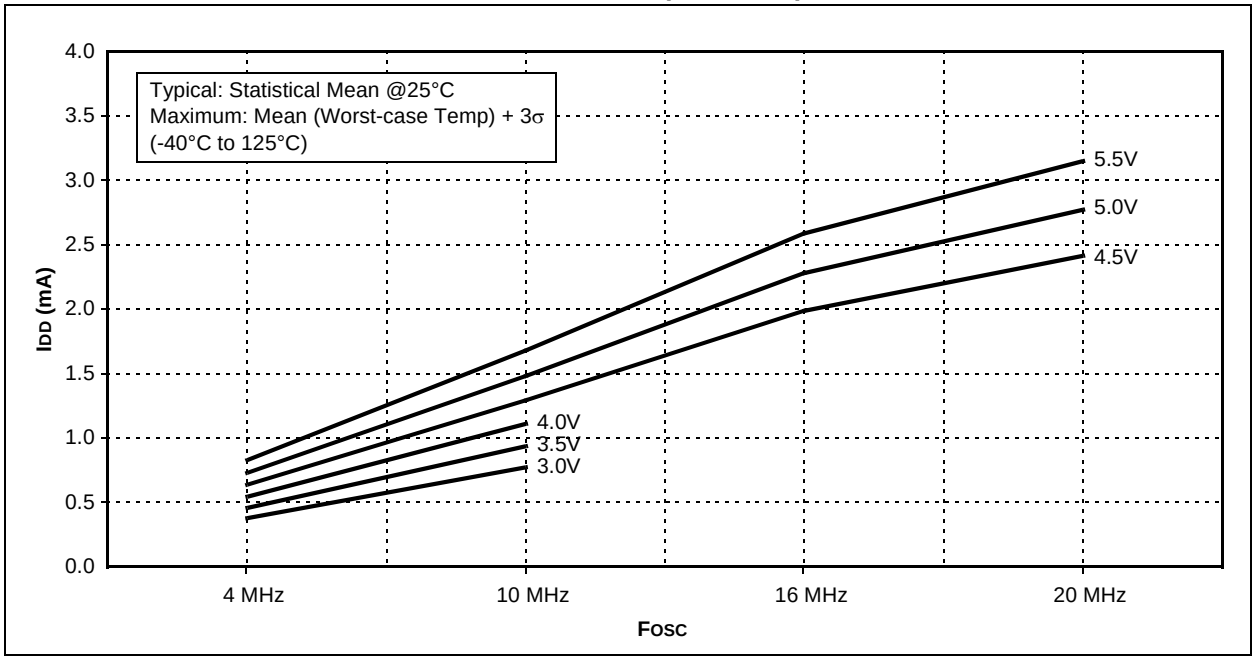


FIGURE 20-3: TYPICAL IDD vs. FOSC OVER VDD (HS MODE)



INDEX

V

W

X

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