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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 ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	20-SOIC (0.295", 7.50mm Width)
Supplier Device Package	20-SOIC
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16hv785-e-so

3.4 Internal Clock Modes

The PIC16F785/HV785 has two independent, internal oscillators that can be configured or selected as the system clock source.

1. The **HFINTOSC** (High-frequency Internal Oscillator) is factory calibrated and operates at 8 MHz. The frequency of the HFINTOSC can be user adjusted ±12% via software using the OSCTUNE register (Register 3-1).
2. The **LFINTOSC** (Low-frequency Internal Oscillator) is uncalibrated and operates at approximately 31 kHz.

The system clock speed can be selected via software using the Internal Oscillator Frequency Select (IRCF) bits.

The system clock can be selected between external or internal clock sources via the System Clock Selection (SCS) bit (see **Section 3.5 "Clock Switching"**).

3.4.1 INTRC AND INTRCIO MODES

The INTRC and INTRCIO modes configure the internal oscillators as the system clock source when the device is programmed using the Oscillator Selection (FOSC) bits in the Configuration Word (Register 12-1).

In **INTRC** mode, the OSC1 pin is available for general purpose I/O. The OSC2/CLKOUT pin outputs the selected internal oscillator frequency divided by 4. The CLKOUT signal may be used to provide a clock for external circuitry, synchronization, calibration, test or other application requirements.

In **INTRCIO** mode, the OSC1 and OSC2 pins are available for general purpose I/O.

3.4.2 HFINTOSC

The High-frequency Internal Oscillator (HFINTOSC) is a factory calibrated 8 MHz internal clock source. The frequency of the HFINTOSC can be altered approximately ±12% via software using the OSCTUNE register (Register 3-1).

The output of the HFINTOSC connects to a postscaler and multiplexer (see Figure 3-1). One of seven frequencies can be selected via software using the IRCF bits (see **Section 3.4.4 "Frequency Select Bits (IRCF)"**).

The HFINTOSC is enabled by selecting any frequency between 8 MHz and 125 kHz (IRCF ≠ 000) as the system clock source (SCS = 1) or when Two-Speed Start-up is enabled (IESO = 1 and IRCF ≠ 000).

The HF Internal Oscillator (HTS) bit, in the OSCCON Register, indicates whether the HFINTOSC is stable or not.

3.4.2.1 Calibration Bits

The 8 MHz High-frequency Internal Oscillator (HFINTOSC) is factory calibrated. The HFINTOSC calibration bits are stored in the Calibration Word (CALIB) located in program memory location 2008h. The Calibration Word is not erased using the specified bulk erase sequence in the "*PIC16F785/HV785 Memory Programming Specification*" (DS41237) and does not require reprogramming. Reference the "*PIC16F785/HV785 Memory Programming Specification*" (DS41237) for more information on the Calibration Word register.

Note:	Address 2008h is beyond the user program memory space. It belongs to the special Configuration Memory space (2000h-3FFFh), which can be accessed only during programming. See "*PIC16F785/HV785 Memory Programming Specification*" (DS41237) for more information.

3.4.3 LFINTOSC

The Low-frequency Internal Oscillator (LFINTOSC) is an uncalibrated (approximate) 31 kHz internal clock source.

The output of the LFINTOSC connects to a postscaler and multiplexer (see Figure 3-1). 31 kHz can be selected via software using the IRCF bits (see **Section 3.4.4 "Frequency Select Bits (IRCF)"**). The LFINTOSC is also the frequency for the Power-up Timer (PWRT), Watchdog Timer (WDT) and Fail-Safe Clock Monitor (FSCM).

The LFINTOSC is enabled by selecting 31 kHz (IRCF = 000) as the system clock source (SCS = 1), or when any of the following are enabled:

- Two-Speed Start-up (IESO = 1 and IRCF = 000)
- Power-up Timer (PWRT)
- Watchdog Timer (WDT)
- Fail-Safe Clock Monitor (FSCM)

The LF Internal Oscillator (LTS) bit, in the OSCCON register, indicates whether the LFINTOSC is stable or not.

3.4.4 FREQUENCY SELECT BITS (IRCF)

The output of the 8 MHz HFINTOSC and 31 kHz LFINTOSC connect to a postscaler and multiplexer (see Figure 3-1). The Internal Oscillator Frequency select bits IRCF<2:0> in the OSCCON Register select the frequency output of the internal oscillators. One of eight frequencies can be selected via software:

- 8 MHz
- 4 MHz (Default after Reset)
- 2 MHz
- 1 MHz
- 500 kHz
- 250 kHz
- 125 kHz
- 31 kHz

Note:	Following any Reset, the IRCF bits are set to '110' and the frequency selection is forced to 4 MHz. The user can modify the IRCF bits to select a different frequency.

3.4.5 HF AND LF INTOSC CLOCK SWITCH TIMING

When switching between the LFINTOSC and the HFINTOSC, the new oscillator may already be shut down to save power. If this is the case, there is a 10 μs delay after the IRCF bits are modified before the frequency selection takes place. The LTS/HTS bits will reflect the current active status of the LFINTOSC and the HFINTOSC oscillators. The timing of a frequency selection is as follows:

1. IRCF bits are modified.
2. If the new clock is shut down, a 10 μs clock start-up delay is started.
3. Clock switch circuitry waits for a falling edge of the current clock.
4. CLKOUT is held low and the clock switch circuitry waits for a rising edge in the new clock.
5. CLKOUT is now connected with the new clock. HTS/LTS bits are updated as required.
6. Clock switch is complete.

If the internal oscillator speed selected is between 8 MHz and 125 kHz, there is no start-up delay before the new frequency is selected. This is because the old and the new frequencies are derived from the HFINTOSC via the postscaler and multiplexer.

Note:	Care must be taken to ensure an invalid voltage or frequency selection is not selected. An example of an invalid configuration is selecting 8 MHz when V_{DD} is 2.0V.

REGISTER 4-2: TRISA: PORTA TRI-STATE REGISTER

U-0	U-0	R/W-1	R/W-1	R-1	R/W-1	R/W-1	R/W-1
—	—	TRISA5(2)	TRISA4(2)	TRISA3(1)	TRISA2	TRISA1	TRISA0
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 5-0 **TRISA<5:0>:** PORTA Tri-State Control bit(1), (2)
1 = PORTA pin configured as an input (tri-stated)
0 = PORTA pin configured as an output

bit 0 **C:** Carry/$\overline{\text{Borrow}}$ bit (ADDWF, ADDLW, SUBLW, SUBWF instructions)(1)
1 = A carry-out from the Most Significant bit of the result occurred
0 = No carry-out from the Most Significant bit of the result occurred

Note 1: TRISA<3> always reads '1'.

2: TRISA<5:4> always reads '1' in XT, HS and LP OSC modes.

4.2 Additional Pin Functions

Every PORTA pin on the PIC16F785/HV785 has an interrupt-on-change option and a weak pull-up option. The next three sections describe these functions.

4.2.1 WEAK PULL-UPS

Each of the PORTA pins has an individually configurable internal weak pull-up. Control bits WPUAx enable or disable each pull-up. Refer to Register 4-3. Each weak pull-up is automatically turned off when the port pin is configured as an output. The pull-ups are disabled on a Power-on Reset by the $\overline{\text{RAPU}}$ bit in the (OPTION Register. The weak pull-up on RA3 is automatically enabled when RA3 is configured as $\overline{\text{MCLR}}$.

REGISTER 4-3: WPUA: WEAK PULL-UP REGISTER

U-0	U-0	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1	R/W-1
—	—	WPUA5(4)	WPUA4(4)	WPUA3(3)	WPUA2	WPUA1	WPUA0
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 5-0 **WPUA<5:0>:** Weak Pull-up Register bits
1 = Pull-up enabled
0 = Pull-up disabled

Note 1: Global $\overline{\text{RAPU}}$ must be enabled for individual pull-ups to be enabled.

2: The weak pull-up device is automatically disabled if the pin is in Output mode (TRISA = 0).

3: The RA3 pull-up is automatically enabled when configured as $\overline{\text{MCLR}}$ in the Configuration Word.

4: WPUA<5:4> always reads '1' in XT, HS and LP OSC modes.

7.0 TIMER2 MODULE

The Timer2 module timer is an 8-bit timer with the following features:

- 8-bit timer (TMR2 register)
- 8-bit period register (PR2)
- Readable and writable (both registers)
- Software programmable prescaler (1:1, 1:4, 1:16)
- Software programmable postscaler (1:1 to 1:16 by 1's)
- Interrupt on TMR2 match with PR2

Timer2 has a control register shown in Register 7-1. TMR2 can be shut-off by clearing control bit TMR2ON, of the T2CON Register, to minimize power consumption. Figure 7-1 is a simplified block diagram of the Timer2 module. The prescaler and postscaler selection of Timer2 are controlled by this register.

7.1 Timer2 Operation

Timer2 can be used as the PWM time base for the PWM mode of the CCP module. The TMR2 register is readable and writable, and is cleared on any device Reset. The input clock (FOSC/4) has a prescale option of 1:1, 1:4 or 1:16, selected by control bits T2CKPS<1:0> of the T2CON Register. The match output of TMR2 goes through a 4-bit postscaler (which gives a 1:1 to 1:16 scaling inclusive) to generate a TMR2 interrupt (latched in flag bit TMR2IF), of the PIR1 Register.

The prescaler and postscaler counters are cleared when any of the following occurs:

- A write to the TMR2 register
- A write to the T2CON register
- Any device Reset (Power-on Reset, $\overline{\text{MCLR}}$ Reset, Watchdog Timer Reset or Brown-out Reset)

TMR2 is not cleared when T2CON is written.

REGISTER 7-1: T2CON: TIMER2 CONTROL REGISTER

U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	TOUTPS3	TOUTPS2	TOUTPS1	TOUTPS0	TMR2ON	T2CKPS1	T2CKPS0
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 **Unimplemented:** Read as '0'

bit 6-3 **TOUTPS<3:0>:** Timer2 Output Postscale Select bits

0000 = 1:1 Postscale
0001 = 1:2 Postscale
•
•
•
1111 = 1:16 Postscale

bit 2 **TMR2ON:** Timer2 On bit

1 = Timer2 is on
0 = Timer2 is off

bit 1-0 **T2CKPS<1:0>:** Timer2 Clock Prescale Select bits

00 = Prescaler is 1
01 = Prescaler is 4
1x = Prescaler is 16

Note 1: For $\overline{\text{Borrow}}$, the polarity is reversed. A subtraction is executed by adding the two's complement of the second operand. For rotate (RRF, RLF) instructions, this bit is loaded with either the high-order or low-order bit of the source register.

8.0 CAPTURE/COMPARE/PWM (CCP) MODULE

The Capture/Compare/PWM (CCP) module contains a 16-bit register which can operate as a:

- 16-bit Capture register
- 16-bit Compare register
- PWM Master/Slave Duty Cycle register

Capture/Compare/PWM Register 1 (CCPR1) is comprised of two 8-bit registers: CCPR1L (low byte) and CCPR1H (high byte). The CCP1CON register controls the operation of CCP. The special event trigger is generated by a compare match and will clear both TMR1H and TMR1L registers.

TABLE 8-1: CCP MODE – TIMER RESOURCES REQUIRED

CCP Mode	Timer Resource
Capture	Timer1
Compare	Timer1
PWM	Timer2

REGISTER 8-1: CCP1CON: CCP OPERATION REGISTER

U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
—	—	DC1B1	DC1B0	CCP1M3	CCP1M2	CCP1M1	CCP1M0
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 5-4 **DC1B<1:0>:** PWM Duty Cycle Least Significant bits

Capture mode:
Unused

Compare mode:
Unused

PWM mode:
These bits are the two LSbs of the PWM duty cycle. The eight MSbs are found in CCPR1L.

bit 3-0 **CCP1M<3:0>:** CCP Mode Select bits

0000 = Capture/Compare/PWM off (resets CCP module)
0001 = Unused (reserved)
0010 = Compare mode, toggle output on match (CCP1IF bit is set)
0011 = Unused (reserved)
0100 = Capture mode, every falling edge
0101 = Capture mode, every rising edge
0110 = Capture mode, every 4th rising edge
0111 = Capture mode, every 16th rising edge
1000 = Compare mode, set output on match (CCP1IF bit is set)
1001 = Compare mode, clear output on match (CCP1IF bit is set)
1010 = Compare mode, generate software interrupt on match (CCP1IF bit is set, CCP1 pin is unaffected)
1011 = Compare mode, trigger special event (CCP1IF bit is set; TMR1 is reset, and A/D conversion is started if the A/D module is enabled. CCP1 pin is unaffected.)
110x = PWM mode: CCP1 output is high true.
111x = PWM mode: CCP1 output is low true.

Note 1: For $\overline{\text{Borrow}}$, the polarity is reversed. A subtraction is executed by adding the two’s complement of the second operand. For rotate (RRF, RLF) instructions, this bit is loaded with either the high-order or low-order bit of the source register.

9.0 COMPARATOR MODULE

The Comparator module has two separate voltage comparators: Comparator 1 (C1) and Comparator 2 (C2).

Each comparator offers the following list of features:

- Control and Configuration register
- Comparator output available externally
- Programmable output polarity
- Interrupt-on-change flags
- Wake-up from Sleep
- Configurable as feedback input to the PWM
- Programmable four input multiplexer
- Programmable two input reference selections
- Programmable speed/power
- Output synchronization to Timer1 clock input (Comparator C2 only)

9.1 Control Registers

Both comparators have separate control and Configuration registers: CM1CON0 for C1 and CM2CON0 for C2. In addition, Comparator C2 has a second control register, CM2CON1, for synchronization control and simultaneous reading of both comparator outputs.

9.1.1 COMPARATOR C1 CONTROL REGISTER

The CM1CON0 register (shown in Register 9-1) contains the control and Status bits for the following:

- Comparator enable
- Comparator input selection
- Comparator reference selection
- Output mode
- Comparator speed

Setting C1ON (CM1CON0<7>) enables Comparator C1 for operation.

Bits C1CH<1:0> of the CM1CON0 Register select the comparator input from the four analog pins AN<7:5,1>.

Note:	To use AN<7:5,1> as analog inputs the appropriate bits must be programmed to '1' in the ANSEL0 register.

Setting C1R of the CM1CON0 Register selects the C1VREF output of the comparator voltage reference module as the reference voltage for the comparator. Clearing C1R selects the C1IN+ input on the RA0/AN0/C1IN+/ICSPDAT pin.

The output of the comparator is available internally via the C1OUT flag of the CM1CON0 Register. To make the output available for an external connection, the C1OE bit of the CM1CON0 Register must be set.

The polarity of the comparator output can be inverted by setting the C1POL bit of the CM1CON0 Register. Clearing C1POL results in a non-inverted output.

A complete table showing the output state versus input conditions and the polarity bit is shown in Table 9-1.

TABLE 9-1: C1 OUTPUT STATE VERSUS INPUT CONDITIONS

Input Condition	C1POL	C1OUT
C1VN > C1VP	0	0
C1VN < C1VP	0	1
C1VN > C1VP	1	1
C1VN < C1VP	1	0

Note 1:	The internal output of the comparator is latched at the end of each instruction cycle. External outputs are not latched.
2:	The C1 interrupt will operate correctly with C1OE set or cleared.
3:	To output C1 on RA2/AN2/T0CKI/INT/C1OUT:(C1OE = 1) and (C1ON = 1) and (TRISA<2> = 0).

C1SP of the CM1CON0 Register configures the speed of the comparator. When C1SP is set, the comparator operates at its normal speed. Clearing C1SP operates the comparator in a slower, low-power mode.

9.1.2 COMPARATOR C2 CONTROL REGISTERS

The CM2CON0 register is a functional copy of the CM1CON0 register described in **Section 9.1.1 "Comparator C1 Control Register"**. A second control register, CM2CON1, is also present for control of an additional synchronizing feature, as well as mirrors of both comparator outputs.

9.1.2.1 Control Register CM2CON0

The CM2CON0 register, shown in Register 9-2, contains the control and Status bits for Comparator C2.

Setting C2ON of the CM2CON0 Register enables Comparator C2 for operation.

Bits C2CH<1:0> of the CM2CON0 Register select the comparator input from the four analog pins, AN<7:5,1>.

Note:	To use AN<7:5,1> as analog inputs, the appropriate bits must be programmed to 1 in the ANSEL0 register.

C2R of the CM2CON0 Register selects the reference to be used with the comparator. Setting C2R of the CM2CON0 Register selects the C2VREF output of the comparator voltage reference module as the reference voltage for the comparator. Clearing C2R selects the C2IN+ input on the RC0/AN4/C2IN+ pin.

The output of the comparator is available internally via the C2OUT bit of the CM2CON0 Register. To make the output available for an external connection, the C2OE bit of the CM2CON0 Register must be set.

The comparator output, C2OUT, can be inverted by setting the C2POL bit of the CM2CON0 Register. Clearing C2POL results in a non-inverted output.

A complete table showing the output state versus input conditions and the polarity bit is shown in Table 9-2.

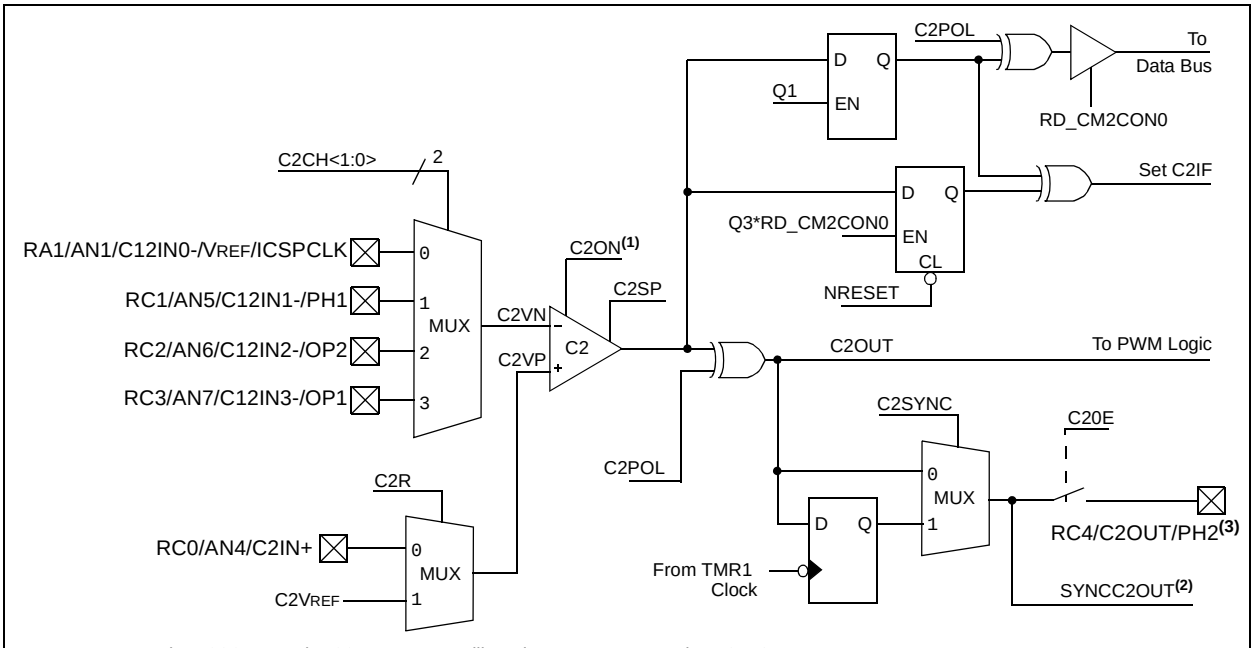
TABLE 9-2: C2 OUTPUT STATE VERSUS INPUT CONDITIONS

Input Condition	C2POL	C2OUT
C2VN > C2VP	0	0
C2VN < C2VP	0	1
C2VN > C2VP	1	1
C2VN < C2VP	1	0

Note 1:	The internal output of the comparator is latched at the end of each instruction cycle. External outputs are not latched.
2:	The C2 interrupt will operate correctly with C2OE set or cleared. An external output is not required for the C2 interrupt.
3:	For C2 output on RC4/C2OUT/PH2: (C2OE = 1) and (C2ON = 1) and (TRISA<4> = 0).

C2SP of the CM2CON0 Register configures the speed of the comparator. When C2SP is set, the comparator operates at its normal speed. Clearing C2SP operates the comparator in low-power mode.

FIGURE 9-2: COMPARATOR C2 SIMPLIFIED BLOCK DIAGRAM



Note 1: When C2ON = 0, the C2 comparator will produce a '0' output to the XOR Gate.
2: Timer1 gate control (see Figure 6-1).
3: Output shown for reference only. For more detail, see Figure 4-13.

NOTES:

NOTES:

REGISTER 13-2: PWMCLK: PWM CLOCK 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
PWMASE	PWMP1	PWMP0	PER4	PER3	PER2	PER1	PER0
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 **PWMASE:** PWM Auto-Shutdown Event Status bit
0 = PWM outputs are operating
1 = A shutdown event has occured. PWM outputs are inactive.

bit 6-5 **PWMP<1:0>:** PWM Clock Prescaler bits
00 = pwm_clk = FOSC ÷ 1
01 = pwm_clk = FOSC ÷ 2
10 = pwm_clk = FOSC ÷ 4
11 = pwm_clk = FOSC ÷ 8

bit 4-0 **PER<4:0>:** PWM Period bits
00000 = Not used. (Period = 1/pwm_clk)
00001 = Period = 2/pwm_clk2
0•••• = •••
01111 = Period = 16/pwm_clk
10000 = Period = 17/pwm_clk
1•••• = •••
11110 = Period = 31/pwm_clk
11111 = Period = 32/pwm_clk

13.9 Complementary Output Mode

The Two-Phase PWM module may be configured to operate in a Complementary Output mode where PH1 and PH2 are always 180 degrees out-of-phase (see Figure 13-5). Three complementary modes are available and are selected by the COMOD<1:0> bits in the PWMCON1 register (see Register 13-5). The difference between the modes is the method by which the PH1 and PH2 outputs switch from the active to the inactive state during the PWM period.

In Complementary mode, there are three methods by which the duty cycle can be controlled. These modes are selected with the COMOD<1:0> bits (see Register 13-5). In each of these modes, the duty cycle is started when the pwm_count = PWMPH1<4:0> and terminates on one of the following:

- Feedback through C1 or C2
- When the pwm_count equals PWMPH1<4:0>
- Combined feedback and pwm_count match

When COMOD<1:0> = 01, the duty cycle is controlled only by feedback through comparator C1 or C2. In this mode, the active drive cycle starts when pwm_count equals PWMPH1<4:0> and terminates when comparator C1's output goes high (if enabled by PWMPH1<5> = 1) or when comparator C2 output goes high (if enabled by PWMPH1<6> = 1).

When COMOD<1:0> = 10, the duty cycle is controlled only by the PWM Phase counter. In this mode, the active drive cycle starts when the pwm_count equals PWMPH1<4:0> and terminates when the pwm_count equals PWMPH2<4:0>. For example, free running 50% duty cycle can be accomplished by setting COMOD<1:0> = 10 and choosing appropriate values for PWMPH1<4:0> and PWMPH2<4:0>.

When COMOD<1:0> = 11, the duty cycle is controlled by the phase counter or feedback through comparator C1 or C2. For example, in this mode, the maximum duty cycle is determined by the values of PWMPH1<4:0> (duty cycle start) and PWMPH2<4:0> (duty cycle end). The duty cycle can be terminated earlier than the maximum by feedback through comparator C1 or C2.

13.9.1 DEAD BAND CONTROL

The Complementary Output mode facilitates driving series connected MOSFET drivers by providing dead band drive timing between each phase output (see Figure 13-6). Dead band times are selectable by the CMDLY<4:0> bits of the PWMCON1 register. Delays from 0 to 155 nanoseconds (typical) with a resolution of 5 nanoseconds (typical) are available.

13.9.2 OVERLAP CONTROL

Overlap timing can be accomplished by configuring the Complementary mode for the desired output polarity and overlap time (as dead time) then swapping the output connections and inverting the outputs. For example, to configure a complementary drive for 55 ns of overlap and an active-high drive output on PH1 and an active-low drive output on PH2, set the PWM control registers as follows:

- Connect PH1 driver to PH2 output
- Connect PH2 driver to PH1 output
- Initialize PORTC<1> to 1 (PH2 driver off)
- Initialize PORTC<4> to 0 (PH1 driver off)
- Set TRISC<1,4> to 0 for output
- Set PWMPH1<POL> to 1 (Inverted PH1)
- Set PWMPH2<POL> to 1 (Non-Inverted PH2)
- Set PWMCON1 for 55 ns delay and desired termination (comparator, count or both)
- Set PWMCON0 desired SYNC and auto-shutdown configuration and to enable PH1 and PH2

13.9.3 SHUTDOWN IN COMPLEMENTARY MODE

During shutdown the PH1 and PH2 complementary outputs are forced to their inactive states (see Figure 13-5). When shutdown ceases the PWM outputs revert to their start-up states for the first cycle which is PH1 inactive (output undriven) and PH2 active (output driven).

15.0 SPECIAL FEATURES OF THE CPU

The PIC16F785/HV785 has a host of features intended to maximize system reliability, minimize cost through elimination of external components, provide power saving features and offer code protection.

These features are:

- Reset:
  - Power-on Reset (POR)
  - Power-up Timer (PWRT)
  - Oscillator Start-up Timer (OST)
  - Brown-out Reset (BOR)
- Interrupts
- Watchdog Timer (WDT)
- Oscillator selection
- Sleep
- Code protection
- ID Locations
- In-Circuit Serial Programming™ (ICSP™)

The PIC16F785/HV785 has two timers that offer necessary delays on power-up. One is the Oscillator Start-up Timer (OST), intended to keep the chip in Reset until the crystal oscillator is stable. The other is the Power-up Timer (PWRT), which provides a fixed delay of 64 ms (nominal) on power-up only, designed to keep the part in Reset while the power supply stabilizes. There is also circuitry to reset the device if a brown-out occurs, which can use the Power-up Timer to provide at least a 64 ms Reset. With these three functions on-chip, most applications need no external Reset circuitry.

The Sleep mode is designed to offer a very low-current Power-down mode. The user can wake-up from Sleep through an external Reset, Watchdog Timer Wake-up or interrupt.

Several oscillator options are also made available to allow the part to fit the application. The INTOSC option saves system cost, while the LP crystal option saves power. A set of configuration bits are used to select various options (see Register 15.2).

15.1 Configuration Bits

The configuration bits can be programmed (read as '0'), or left unprogrammed (read as '1') to select various device configurations as shown in Register 15.2. These bits are mapped in program memory location 2007h.

Note:	Address 2007h is beyond the user program memory space. It belongs to the special configuration memory space (2000h-3FFFh), which can be accessed only during programming. See "*PIC16F785/HV785 Memory Programming Specification*" (DS41237) for more information.

TABLE 15-4: INITIALIZATION CONDITION FOR REGISTERS (CONTINUED)

Register	Address	Power-on Reset	$\overline{\text{MCLR}}$ Reset WDT Reset Brown-out Reset(1)	Wake-up from Sleep through interrupt Wake-up from Sleep through WDT Time-out
VRCON	99h	000- 0000	000- 0000	uuu- uuuu
EEDAT	9Ah	0000 0000	0000 0000	uuuu uuuu
EEADR	9Bh	0000 0000	0000 0000	uuuu uuuu
EECON1	9Ch	---- x000	---- q000	---- uuuu
EECON2	9Dh	---- ----	---- ----	---- ----
ADRESL	9Eh	xxxx xxxx	uuuu uuuu	uuuu uuuu
ADCON1	9Fh	-000 ----	-000 ----	-uuu ----
PWMCON1	110h	-000 0000	-000 0000	-uuu uuuu
PWMCON0	111h	0000 0000	0000 0000	uuuu uuuu
PWMCLK	112h	0000 0000	0000 0000	uuuu uuuu
PWMPH1	113h	0000 0000	0000 0000	uuuu uuuu
PWMPH2	114h	0000 0000	0000 0000	uuuu uuuu
CM1CON0	119h	0000 0000	0000 0000	uuuu uuuu
CM2CON0	11Ah	0000 0000	0000 0000	uuuu uuuu
CM2CON1	11Bh	00-- --10	00-- --10	uu-- --uu
OPA1CON	11Ch	0--- ----	0--- ----	u--- ----
OPA2CON	11Dh	0--- ----	0--- ----	u--- ----

Legend: u = unchanged, x = unknown, – = unimplemented bit, reads as '0', q = value depends on condition.

Note 1: If V_{DD} goes too low, Power-on Reset will be activated and registers will be affected differently.

2: One or more bits in INTCON and/or PIR1 will be affected (to cause wake-up).

3: When the wake-up is due to an interrupt and the GIE bit is set, the PC is loaded with the interrupt vector (0004h).

4: See Table 15-5 for Reset value for specific condition.

5: If Reset was due to brown-out, then bit 0 = 0. All other Resets will cause bit 0 = u.

6: Analog channels read 0 but data latches are unknown.

7: Analog channels read 0 but data latches are unchanged.

15.3.1 RA2/AN2/T0CKI/INT/C1OUT INTERRUPT

External interrupt on RA2/AN2/T0CKI/INT/C1OUT pin is edge-triggered; either rising, if INTEDG bit of the OPTION Register is set, or falling, if INTEDG bit is clear. When a valid edge appears on the RA2/AN2/T0CKI/INT/C1OUT pin, the INTF bit of the INTCON Register is set. This interrupt can be disabled by clearing the INTE control bit of the INTCON Register. The INTF bit must be cleared in software in the Interrupt Service Routine before re-enabling this interrupt. The RA2/AN2/T0CKI/INT/C1OUT interrupt can wake-up the processor from Sleep if the INTE bit was set prior to going into Sleep. The status of the GIE bit decides whether or not the processor branches to the interrupt vector following wake-up (0004h). See **Section 15.6 "Power-Down Mode (Sleep)"** for details on Sleep and Figure 15-10 for timing of wake-up from Sleep through RA2/AN2/T0CKI/INT/C1OUT interrupt.

Note:	The ANSEL0 (91h), and ANSEL1 (93h) registers must be initialized to configure an analog channel as a digital input. Pins configured as analog inputs will read '0'.

15.3.2 TMR0 INTERRUPT

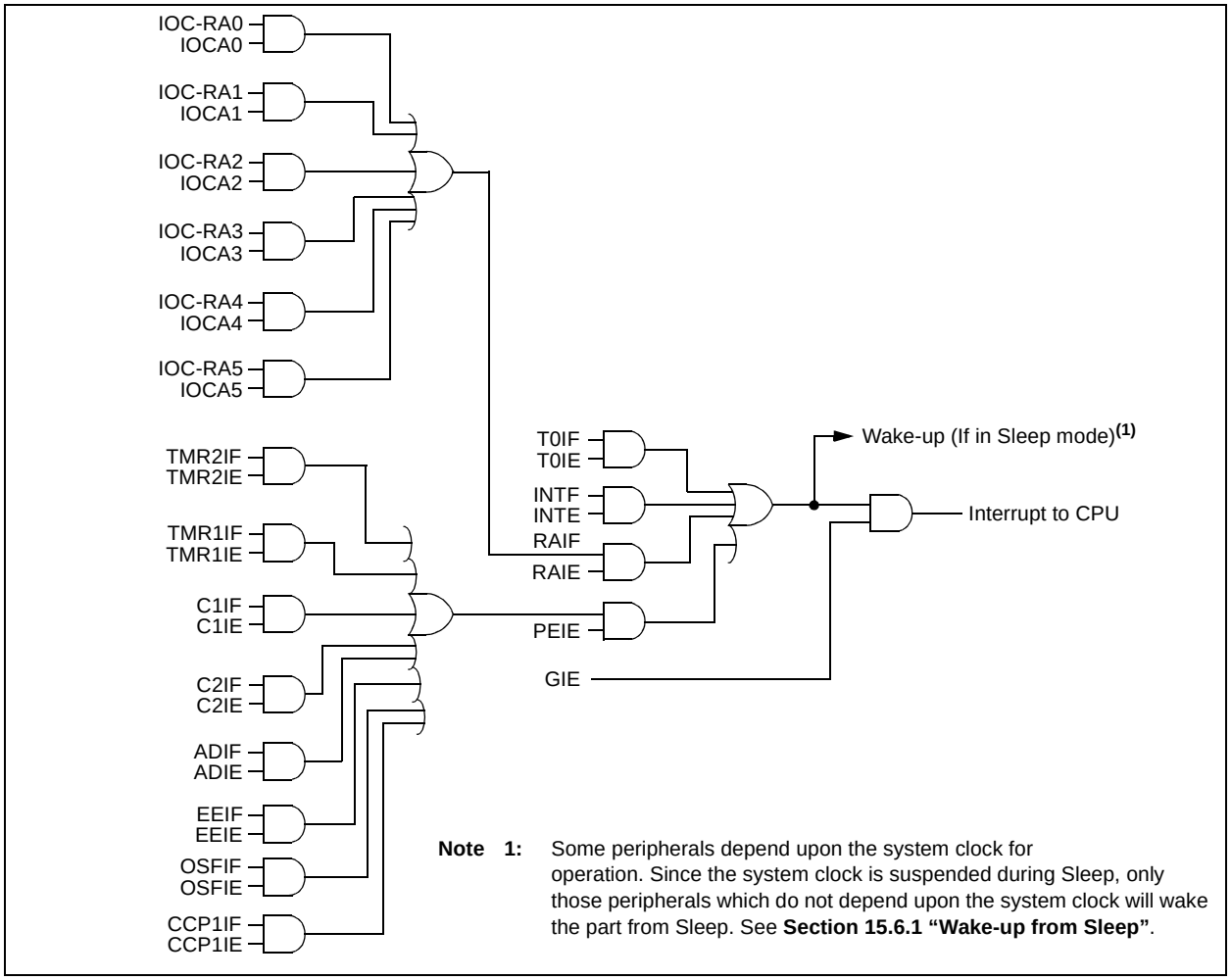
An overflow (FFh → 00h) in the TMR0 register will set the T0IF bit of the INTCON Register. The interrupt can be enabled/disabled by setting/clearing T0IE bit of the INTCON Register. See **Section 5.0 "Timer0 Module"** for operation of the Timer0 module.

15.3.3 PORTA INTERRUPT

An input change on PORTA change sets the RAIF of the INTCON Register bit. The interrupt can be enabled/disabled by setting/clearing the RAIE bit of the INTCON Register. Plus, individual pins can be configured through the IOCA register.

Note:	If a change on the I/O pin should occur when the read operation is being executed (start of the Q2 cycle), then the RAIF interrupt flag may not get set.

FIGURE 15-7: INTERRUPT LOGIC



Note 1: Some peripherals depend upon the system clock for operation. Since the system clock is suspended during Sleep, only those peripherals which do not depend upon the system clock will wake the part from Sleep. See **Section 15.6.1 "Wake-up from Sleep"**.

IORLW **Inclusive OR Literal with W**

Syntax:	[*label*] IORLW k
Operands:	$0 \le k \le 255$
Operation:	(W) .OR. k → (W)
Status Affected:	Z
Description:	The contents of the W register are OR'ed with the eight-bit literal 'k'. The result is placed in the W register.

IORWF **Inclusive OR W with f**

Syntax:	[*label*] IORWF f,d
Operands:	$0 \le f \le 127$ $d \in [0,1]$
Operation:	(W) .OR. (f) → (destination)
Status Affected:	Z
Description:	Inclusive OR the W register with register 'f'. If 'd' is '0', the result is placed in the W register. If 'd' is '1', the result is placed back in register 'f'.

MOVF **Move f**

Syntax:	[*label*] MOVF f,d
Operands:	$0 \le f \le 127$ $d \in [0,1]$
Operation:	(f) → (dest)
Status Affected:	Z
Encoding:	00 | 1000 | dfff | ffff
Description:	The contents of register 'f' is moved to a destination dependent upon the status of 'd'. If 'd' = 0, destination is W register. If 'd' = 1, the destination is file register 'f' itself. 'd' = 1 is useful to test a file register since status flag Z is affected.

MOVLW **Move Literal to W**

Syntax:	[*label*] MOVLW k
Operands:	$0 \le k \le 255$
Operation:	k → (W)
Status Affected:	None
Encoding:	11 | 00xx | kkkk | kkkk
Description:	The eight-bit literal 'k' is loaded into W register. The "don't cares" will assemble as 0's.

MOVWF **Move W to f**

Syntax:	[*label*] MOVWF f
Operands:	$0 \le f \le 127$
Operation:	(W) → (f)
Status Affected:	None
Encoding:	00 | 0000 | 1fff | ffff
Description:	Move data from W register to register 'f'.

NOP **No Operation**

Syntax:	[*label*] NOP
Operands:	None
Operation:	No operation
Status Affected:	None
Encoding:	00 | 0000 | 0xx0 | 0000
Description:	No operation.

19.4 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**
	VIL	**Input Low Voltage**					
		I/O ports					
D030		with TTL buffer	VSS	—	0.8	V	4.5V ≤ VDD ≤ 5.5V
D030A			VSS	—	0.15 VDD	V	Otherwise
D031		with Schmitt Trigger buffer	VSS	—	0.2 VDD	V	Entire range
D032		$\overline{MCLR}$, OSC1 (RC mode)(1)	VSS	—	0.2 VDD	V	
D033		OSC1 (XT and LP modes)	VSS	—	0.3	V	
D033A		OSC1 (HS mode)	VSS	—	0.3 VDD	V	
	VIH	**Input High Voltage**					
		I/O ports		—			
D040		with TTL buffer	2.0	—	VDD	V	4.5V ≤ VDD ≤ 5.5V
D040A			(0.25 VDD + 0.8)	—	VDD	V	Otherwise
D041		with Schmitt Trigger buffer	0.8 VDD	—	VDD	V	Entire range
D042		$\overline{MCLR}$	0.8 VDD	—	VDD	V	
D043		OSC1 (XT and LP modes)	1.6	—	VDD	V	
D043A		OSC1 (HS mode)	0.7 VDD	—	VDD	V	
D043B		OSC1 (RC mode)	0.9 VDD	—	VDD	V	**(Note 1)**
D070	IPUR	**PORTA Weak Pull-up Current**	50*	250	400*	µA	VDD = 5.0V, VPIN = VSS
	IIL	**Input Leakage Current(2)**					
D060		I/O ports	—	±0.1	±1	µA	VSS ≤ VPIN ≤ VDD, Pin at high-impedance
D060A		Analog inputs	—	±0.1	±1	µA	VSS ≤ VPIN ≤ VDD
D060B		VREF	—	±0.1	±1	µA	VSS ≤ VPIN ≤ VDD
D061		$\overline{MCLR}$(3)	—	±0.1	±5	µA	VSS ≤ VPIN ≤ VDD
D063		OSC1	—	±0.1	±5	µA	VSS ≤ VPIN ≤ VDD, XT, HS and LP osc configuration
	VOL	**Output Low Voltage**					
D080		I/O ports	—	—	0.6	V	IOL = 8.5 mA, VDD = 4.5V
D083		OSC2/CLKOUT (RC mode)	—	—	0.6	V	IOL = 1.6 mA, VDD = 4.5V (Ind.) IOL = 1.2 mA, VDD = 4.5V (Ext.)
	VOH	**Output High Voltage**					
D090		I/O ports	VDD – 0.7	—	—	V	IOH = -3.0 mA, VDD = 4.5V
D092		OSC2/CLKOUT (RC mode)	VDD – 0.7	—	—	V	IOH = -1.3 mA, VDD = 4.5V (Ind.) IOH = -1.0 mA, VDD = 4.5V (Ext.)
D193*	VOD	**Open-Drain High Voltage**	—	—	8.5	V	RB6 pin

* 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.

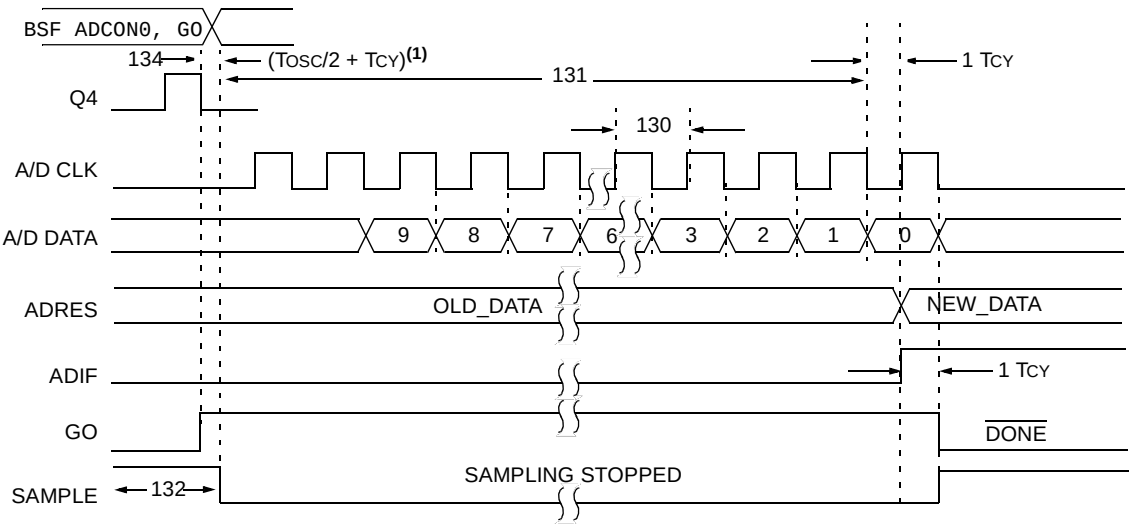
Note 1: In RC oscillator configuration, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended to use an external clock in RC mode.

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

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

4: See **Section 14.4.1 "Using the Data EEPROM"** on page 105.

FIGURE 19-10: PIC16F785/HV785 A/D CONVERSION TIMING (SLEEP MODE)



Note 1: If the A/D clock source is selected as RC, a time of TCY is added before the A/D clock starts. This allows the SLEEP instruction to be executed.

TABLE 19-17: PIC16F785/HV785 A/D CONVERSION REQUIREMENTS (SLEEP MODE)

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
130	TAD	A/D Internal RC Oscillator Period	3.0*	6.0	9.0*	µs	ADCS<1:0> = 11 (RC mode) At VDD = 2.5V
			2.0*	4.0	6.0*	µs	At VDD = 5.0V
131	TCNV	Conversion Time (not including Acquisition Time)(1)	—	11	—	TAD	
132	TACQ	Acquisition Time	**(Note 2)**	11.5	—	µs	
			5*	—	—	µs	The minimum time is the amplifier settling time. This may be used if the "new" input voltage has not changed by more than 1 LSb (i.e., 4.1 mV @ 4.096V) from the last sampled voltage (as stored on CHOLD).
134	TGO	Q4 to A/D Clock Start	—	TOSC/2 + TCY	—	—	If the A/D clock source is selected as RC, a time of TCY is added before the A/D clock starts. This allows the SLEEP instruction to be executed.

* 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: ADRES register may be read on the following TCY cycle.

2: See Table 12-1 for minimum conditions.

FIGURE 20-10: IDD vs. VDD OVER FOSC (LFINTOSC MODE, 31 kHz)

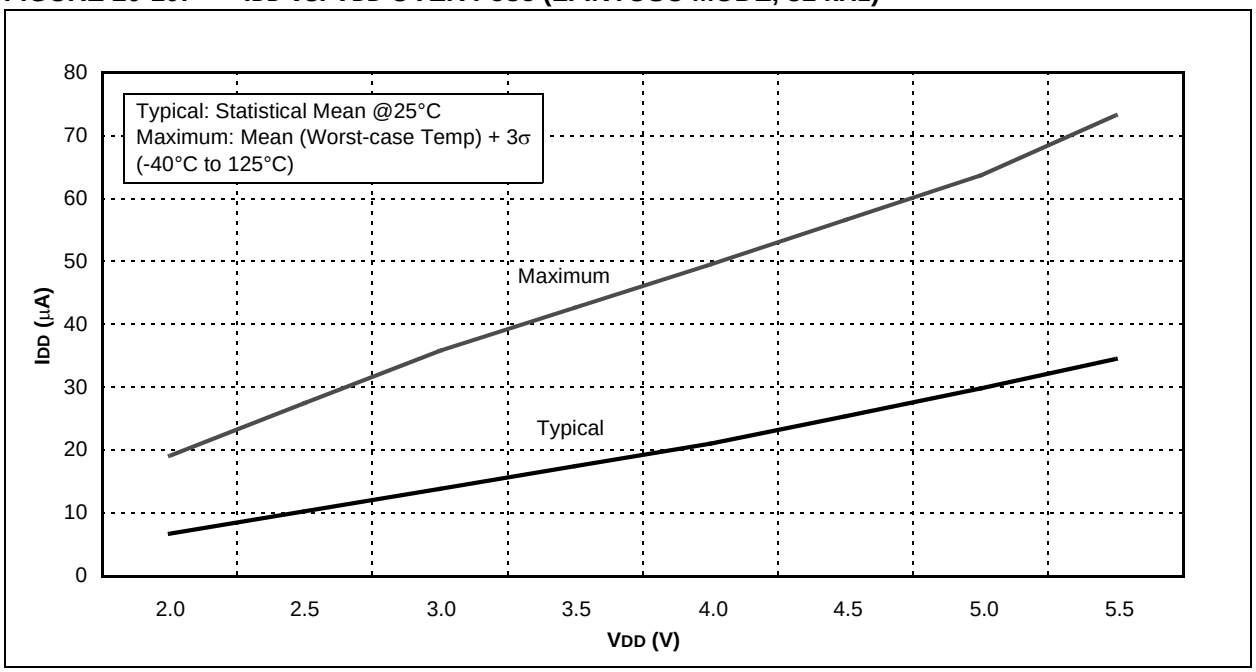


FIGURE 20-11: TYPICAL IDD vs. FOSC OVER VDD (HFINTOSC MODE)

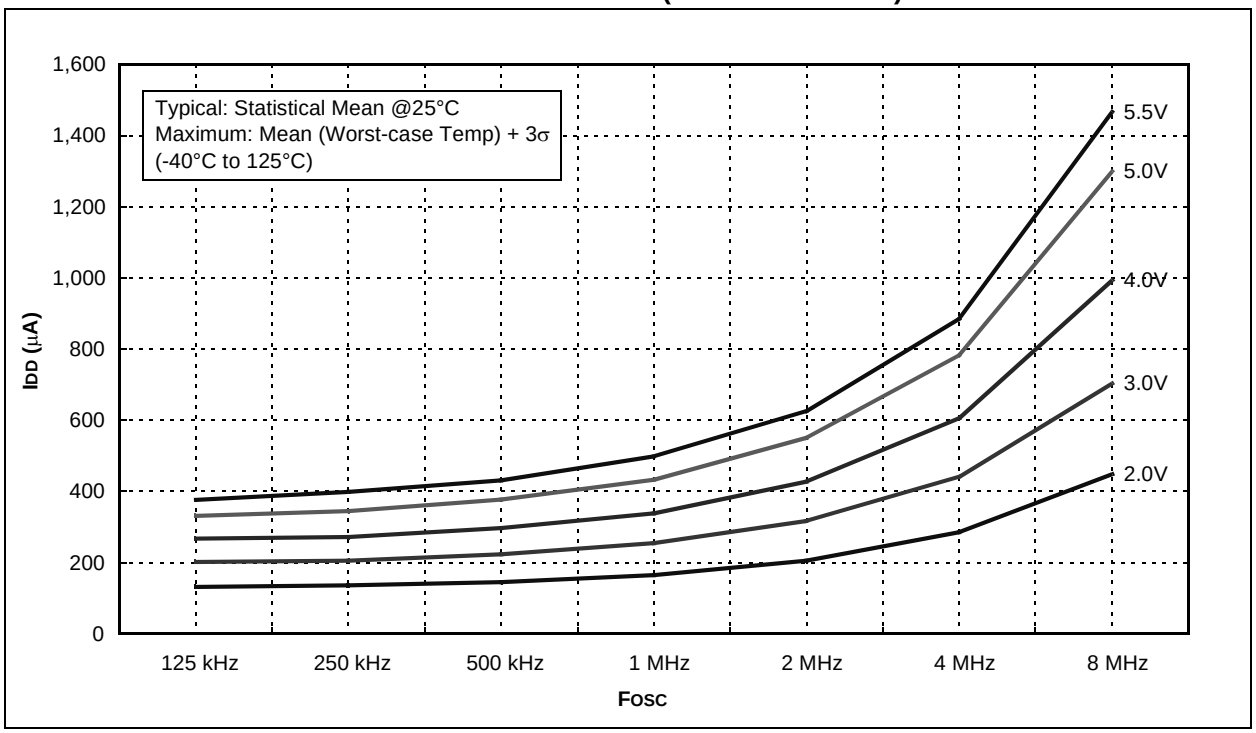


FIGURE 20-34: TYPICAL HFINTOSC FREQUENCY CHANGE vs. VDD (25°C)

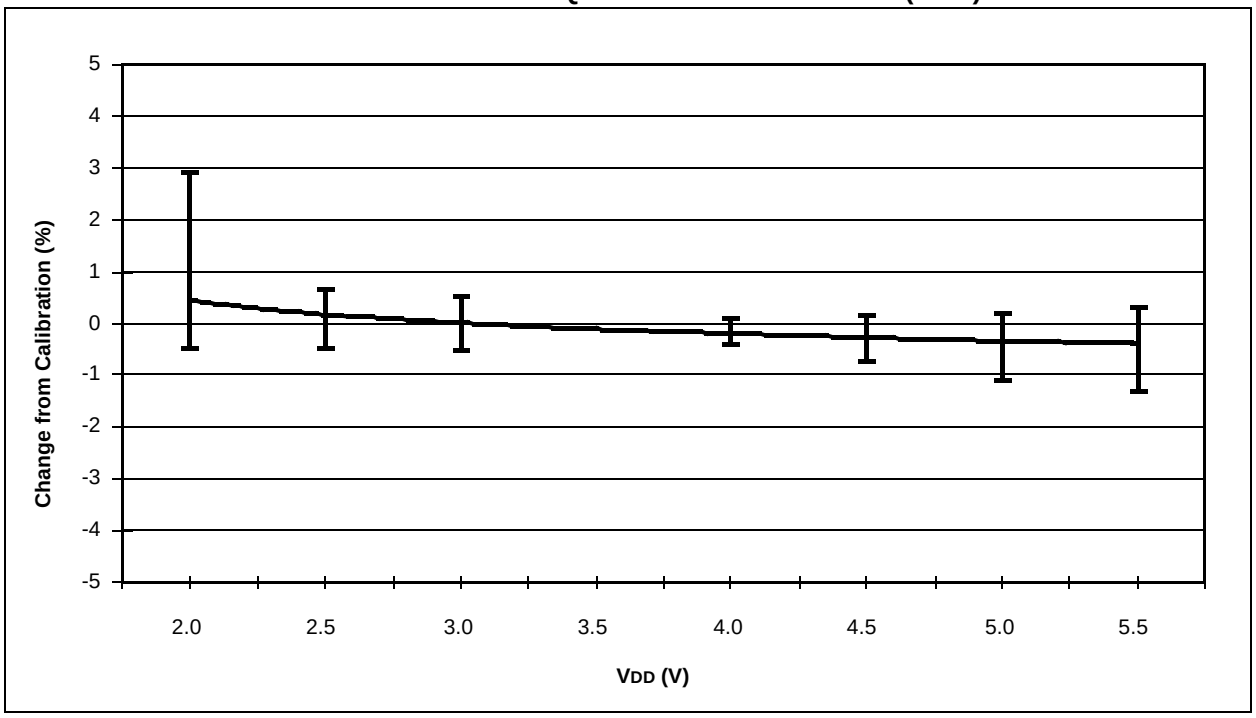
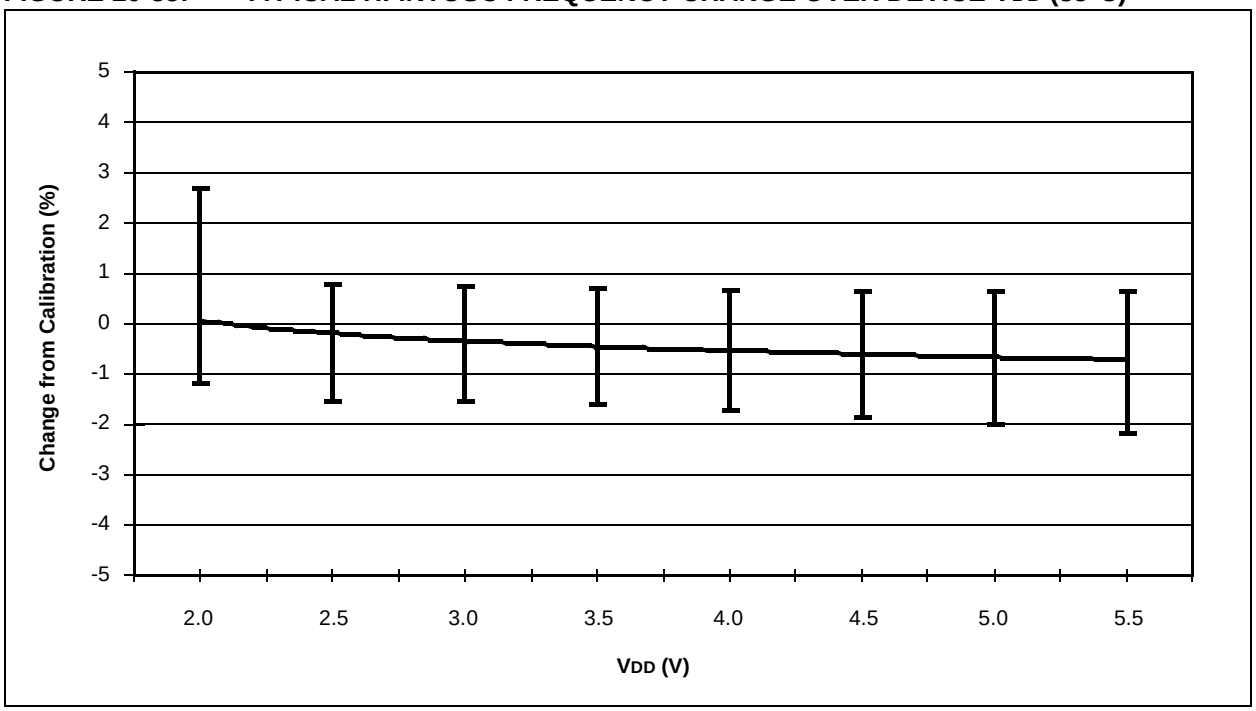


FIGURE 20-35: TYPICAL HFINTOSC FREQUENCY CHANGE OVER DEVICE VDD (85°C)



V

W

X