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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	13
Program Memory Size	3.5KB (2K x 14)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	128 x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 5.5V
Data Converters	A/D 4x8b
Oscillator Type	External
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	20-SSOP (0.209", 5.30mm Width)
Supplier Device Package	20-SSOP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16f716t-i-ss

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TABLE 1-1: PIC16F716 PINOUT DESCRIPTION

Name	Function	Input Type	Output Type	Description
$\overline{MCLR}$/VPP	$\overline{MCLR}$	ST	—	Master clear (Reset) input. This pin is an active-low Reset to the device.
	VPP	P	—	Programming voltage input
OSC1/CLKIN	OSC1	XTAL	—	Oscillator crystal input
	CLKIN	CMOS	—	External clock source input
	CLKIN	ST	—	RC Oscillator mode
OSC2/CLKOUT	OSC2	XTAL	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode.
	CLKOUT	—	CMOS	In RC mode, OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
RA0/AN0	RA0	TTL	CMOS	Bidirectional I/O
	AN0	AN	—	Analog Channel 0 input
RA1/AN1	RA1	TTL	CMOS	Bidirectional I/O
	AN1	AN	—	Analog Channel 1 input
RA2/AN2	RA2	TTL	CMOS	Bidirectional I/O
	AN2	AN	—	Analog Channel 2 input
RA3/AN3/VREF	RA3	TTL	CMOS	Bidirectional I/O
	AN3	AN	—	Analog Channel 3 input
	VREF	AN	—	A/D reference voltage input
RA4/T0CKI	RA4	ST	OD	Bidirectional I/O. Open drain when configured as output.
	T0CKI	ST	—	Timer0 external clock input
RB0/INT/$\overline{ECCPAS2}$	RB0	TTL	CMOS	Bidirectional I/O. Programmable weak pull-up.
	INT	ST	—	External Interrupt
	$\overline{ECCPAS2}$	ST	—	ECCP Auto-Shutdown pin
RB1/T1OSO/T1CKI	RB1	TTL	CMOS	Bidirectional I/O. Programmable weak pull-up.
	T1OSO	—	XTAL	Timer1 oscillator output. Connects to crystal in Oscillator mode.
	T1CKI	ST	—	Timer1 external clock input
RB2/T1OSI	RB2	TTL	CMOS	Bidirectional I/O. Programmable weak pull-up.
	T1OSI	XTAL	—	Timer1 oscillator input. Connects to crystal in Oscillator mode.
RB3/CCP1/P1A	RB3	TTL	CMOS	Bidirectional I/O. Programmable weak pull-up.
	CCP1	ST	CMOS	Capture1 input, Compare1 output, PWM1 output.
	P1A	—	CMOS	PWM P1A output
RB4/$\overline{ECCPAS0}$	RB4	TTL	CMOS	Bidirectional I/O. Programmable weak pull-up. Interrupt-on-change.
	$\overline{ECCPAS0}$	ST	—	ECCP Auto-Shutdown pin
RB5/P1B	RB5	TTL	CMOS	Bidirectional I/O. Programmable weak pull-up. Interrupt-on-change.
	P1B	—	CMOS	PWM P1B output
RB6/P1C	RB6	TTL	CMOS	Bidirectional I/O. Programmable weak pull-up. Interrupt-on-change. ST input when used as ICSP programming clock.
	P1C	—	CMOS	PWM P1C output
RB7/P1D	RB7	TTL	CMOS	Bidirectional I/O. Programmable weak pull-up. Interrupt-on-change. ST input when used as ICSP programming data.
	P1D	—	CMOS	PWM P1D output
VSS	VSS	P	—	Ground reference for logic and I/O pins.
VDD	VDD	P	—	Positive supply for logic and I/O pins.

Legend: I = Input, O = Output, P = Power, AN = Analog input or output, TTL = TTL compatible input, XTAL = Crystal, OD = Open drain, ST = Schmitt Trigger input with CMOS levels, CMOS = CMOS compatible input or output

2.0 MEMORY ORGANIZATION

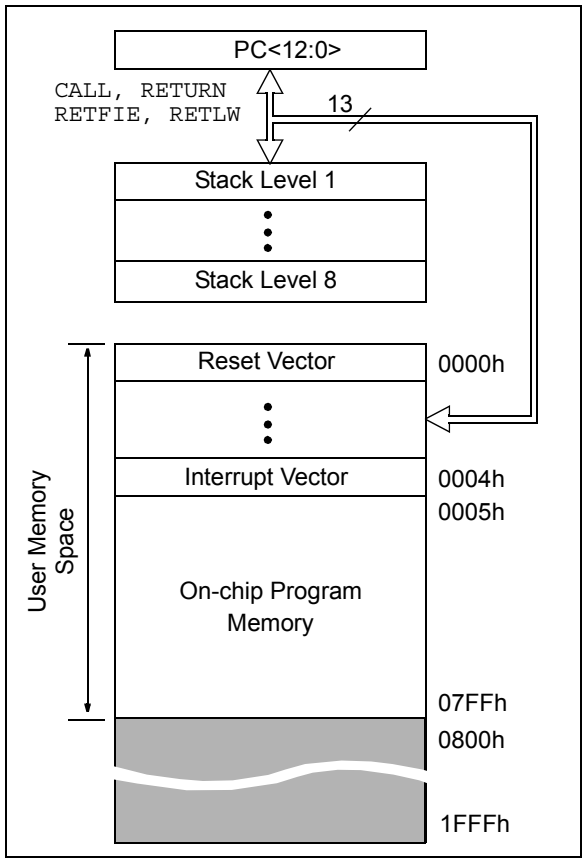
There are two memory blocks in the PIC16F716 device. Each block (program memory and data memory) has its own bus so that concurrent access can occur.

2.1 Program Memory Organization

The PIC16F716 has a 13-bit program counter capable of addressing an 8K x 14 program memory space. The PIC16F716 has 2K x 14 words of program memory. Accessing a location above the physically implemented address will cause a wrap-around.

The Reset vector is at 0000h and the interrupt vector is at 0004h.

FIGURE 2-1: PROGRAM MEMORY MAP AND STACK OF PIC16F716



2.2 Data Memory Organization

The data memory is partitioned into multiple banks which contain the General Purpose Registers (GPR) and the Special Function Registers (SFR). Bits RP1 and RP0 of the STATUS register are the bank select bits.

RP<1:0>(1) (Status<6:5>)	Bank
00	0
01	1
10	2(2)
11	3(2)

Note 1: Maintain Status bit 6 clear to ensure upward compatibility with future products.

2: Not implemented

Each bank extends up to 7Fh (128 bytes). The lower locations of each bank are reserved for the Special Function Registers. Above the Special Function Registers are General Purpose Registers, implemented as static RAM. All implemented banks contain Special Function Registers. The upper 16 bytes of GPR space and some “high use” Special Function Registers in Bank 0 are mirrored in Bank 1 for code reduction and quicker access.

3.0 I/O PORTS

Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin.

3.1 PORTA and the TRISA Register

PORTA is a 5-bit wide bidirectional port. The corresponding data direction register is TRISA. Setting a TRISA bit (= 1) will make the corresponding PORTA pin an input (i.e., put the corresponding output driver in a High-impedance mode). Clearing a TRISA bit (= 0) will make the corresponding PORTA pin an output (i.e., put the contents of the output latch on the selected pin).

Reading the PORTA register reads the status of the pins, whereas writing to it will write to the PORT latch. All write operations are read-modify-write operations. Therefore, a write to a port implies that the port pins are read, the value is modified and then written to the PORT data latch.

Pin RA4 is multiplexed with the Timer0 module clock input to become the RA4/T0CKI pin. The RA4/T0CKI pin is a Schmitt Trigger input and an open drain output. All other RA port pins have TTL input levels and full CMOS output drivers.

PORTA pins, RA<3:0>, are multiplexed with analog inputs and analog VREF input. The operation of each pin is selected by clearing/setting the control bits in the ADCON1 register (A/D Control Register 1).

Note:	On a Power-on Reset, these pins are configured as analog inputs and read as '0'.

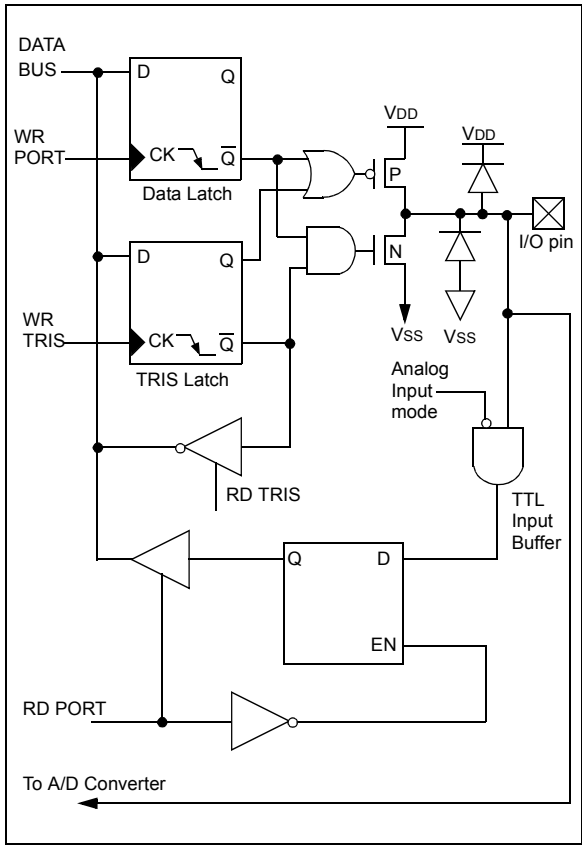
The TRISA register controls the direction of the RA pins, even when they are being used as analog inputs. The user must ensure the bits in the TRISA register are maintained set when using them as analog inputs.

Note:	Setting RA3:0 to output while in Analog mode will force pins to output contents of data latch.

EXAMPLE 3-1: INITIALIZING PORTA

```
BCF    STATUS, RP0   ;
CLRF   PORTA         ;Initialize PORTA by
                     ;clearing output
                     ;data latches
BSF    STATUS, RP0   ;Select Bank 1
MOVLW  0xEF          ;Value used to
                     ;initialize data
                     ;direction
MOVWF  TRISA         ;Set RA<3:0> as inputs
                     ;RA<4> as outputs
BCF    STATUS, RP0   ;Return to Bank 0
```

FIGURE 3-1: BLOCK DIAGRAM OF RA<3:0>



NOTES:

7.1.5 INTERRUPTS

The ADC module allows for the ability to generate an interrupt upon completion of an Analog-to-Digital conversion. The ADC interrupt flag is the ADIF bit in the PIR1 register. The ADC interrupt enable is the ADIE bit in the PIE1 register. The ADIF bit must be cleared in software.

Note:	The ADIF bit is set at the completion of every conversion, regardless of whether or not the ADC interrupt is enabled.

This interrupt can be generated while the device is operating or while in Sleep. If the device is in Sleep, the interrupt will wake-up the device. Upon waking from Sleep, the next instruction following the `SLEEP` instruction is always executed. If the user is attempting to wake-up from Sleep and resume in-line code execution, the global interrupt must be disabled. If the global interrupt is enabled, execution will switch to the Interrupt Service Routine.

Please see **Section 7.1.5 "Interrupts"** for more information.

8.3.8 ENHANCED PWM AUTO-SHUTDOWN MODE

The PWM mode supports an Auto-Shutdown mode that will disable the PWM outputs when an external shutdown event occurs. Auto-Shutdown mode places the PWM output pins into a predetermined state. This mode is used to help prevent the PWM from damaging the application.

The auto-shutdown sources are selected using the ECCPASx bits of the ECCPAS register. A shutdown event may be generated by:

- A logic '0' on the INT pin
- Setting the ECCPASE bit in firmware

A shutdown condition is indicated by the ECCPASE (Auto-Shutdown Event Status) bit of the ECCPAS register. If the bit is a '0', the PWM pins are operating normally. If the bit is a '1', the PWM outputs are in the shutdown state. Refer to Figure 8-5.

When a shutdown event occurs, two things happen:

The ECCPASE bit is set to '1'. The ECCPASE will remain set until cleared in firmware or an auto-restart occurs (see **Section 8.3.9 "Auto-Restart Mode"**).

The enabled PWM pins are asynchronously placed in their shutdown states. The PWM output pins are grouped into pairs [P1A/P1C] and [P1B/P1D]. The state of each pin pair is determined by the PSSAC and PSSBD bits of the ECCPAS register. Each pin pair may be placed into one of three states:

- Drive logic '1'
- Drive logic '0'
- Tri-state (high-impedance)

FIGURE 8-5: AUTO-SHUTDOWN BLOCK DIAGRAM

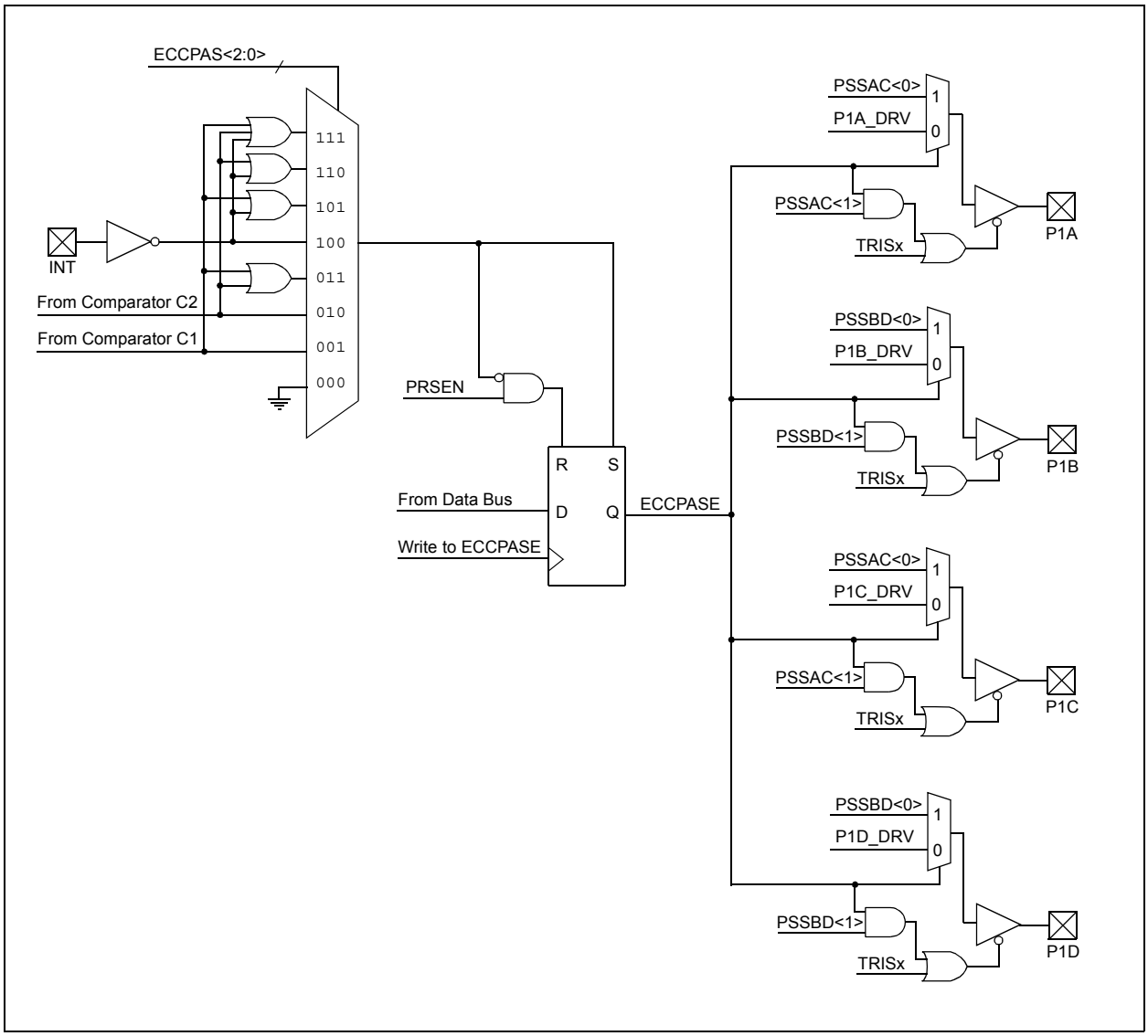
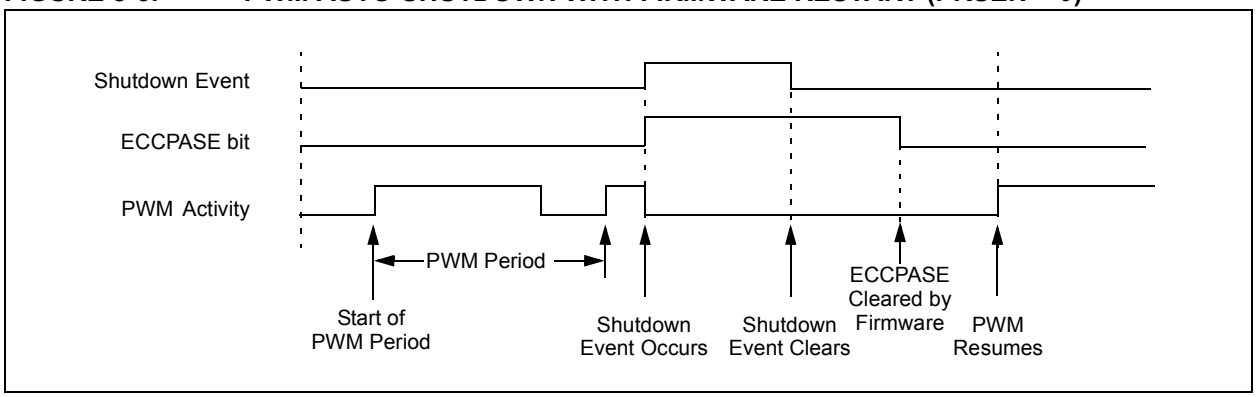


FIGURE 8-6: PWM AUTO-SHUTDOWN WITH FIRMWARE RESTART (PRSEN = 0)

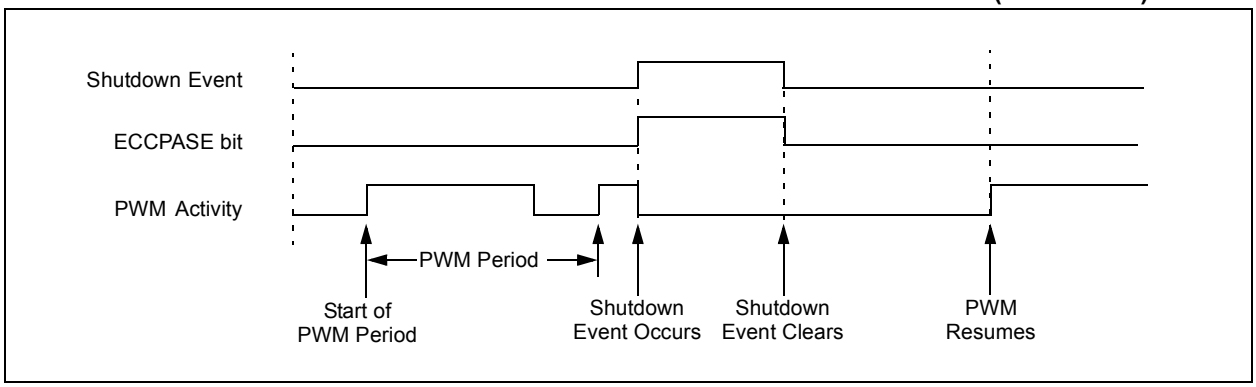


8.3.9 AUTO-RESTART MODE

The Enhanced PWM can be configured to automatically restart the PWM signal once the auto-shutdown condition has been removed. Auto-restart is enabled by setting the PRSEN bit in the PWM1CON register.

If auto-restart is enabled, the ECCPASE bit will remain set as long as the auto-shutdown condition is active. When the auto-shutdown condition is removed, the ECCPASE bit will be cleared via hardware and normal operation will resume.

FIGURE 8-7: PWM AUTO-SHUTDOWN WITH AUTO-RESTART ENABLED (PRSEN = 1)



REGISTER 8-3: PWM1CON: ENHANCED PWM 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
PRSEN	PDC6	PDC5	PDC4	PDC3	PDC2	PDC1	PDC0
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 **PRSEN:** PWM Restart Enable bit

1 = Upon auto-shutdown, the ECCPASE bit clears automatically once the shutdown event goes away; the PWM restarts automatically

0 = Upon auto-shutdown, ECCPASE must be cleared in software to restart the PWM

bit 6-0 **PDC<6:0>:** PWM Delay Count bits

PDCn = Number of FOSC/4 (4 * TOSC) cycles between the scheduled time when a PWM signal **should** transition active and the **actual** time it transitions active

TABLE 8-6: REGISTERS ASSOCIATED WITH PWM

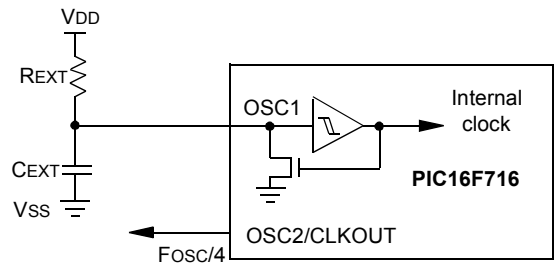
Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Value on POR, BOR	Value on all other Resets
CCPR1L	Capture/Compare/PWM Register 1 (LSB)								xxxx xxxx	xxxx xxxx
CCPR1H	Capture/Compare/PWM Register 1 (MSB)								xxxx xxxx	xxxx xxxx
CCP1CON	P1M1	P1M0	DC1B1	DC1B0	CCP1M3	CCP1M2	CCP1M1	CCP1M0	0000 0000	0000 0000
ECCPAS	ECCPASE	ECCPAS2	—	ECCPAS0	PSSAC1	PSSAC0	PSSBD1	PSSBD0	00-0 0000	00-0 0000
INTCON	GIE	PEIE	T0IE	INTE	RBIE	T0IF	INTF	RBIF	0000 000x	0000 000x
PIE1	—	ADIE	—	—	—	CCP1IE	TMR2IE	TMR1IE	-0-- -000	-0-- -000
PIR1	—	ADIF	—	—	—	CCP1IF	TMR2IF	TMR1IF	-0-- 0000	-0-- -000
PR2	Timer2 Period Register								1111 1111	1111 1111
PWM1CON	PRSEN	PDC6	PDC5	PDC4	PDC3	PDC2	PDC1	PDC0	0000 0000	0000 0000
TMR1L	Holding Register for the Least Significant Byte of the 16-bit TMR1 Register								xxxx xxxx	xxxx xxxx
TMR1H	Holding Register for the Most Significant Byte of the 16-bit TMR1 Register								xxxx xxxx	xxxx xxxx
TMR2	Timer2 Module's Register								0000 0000	0000 0000
TRISB	TRISB7	TRISB6	TRISB5	TRISB4	TRISB3	TRISB2	TRISB1	TRISB0	1111 1111	1111 1111

Legend: – = Unimplemented locations, read as '0', u = unchanged, x = unknown. Shaded cells are not used by the PWM.

9.2.3 RC OSCILLATOR

For timing insensitive applications, the "RC" device option offers additional cost savings. The RC oscillator frequency is a function of the supply voltage, the resistor (REXT) and capacitor (CEXT) values and the operating temperature. In addition to this, the oscillator frequency will vary from unit-to-unit due to normal process parameter variation. Furthermore, the difference in lead frame capacitance between package types will also affect the oscillation frequency, especially for low CEXT values. The user also needs to take into account variation due to tolerance of external R and C components used. Figure 9-3 shows how the R/C combination is connected to the PIC16F716.

FIGURE 9-3: RC OSCILLATOR MODE



Recommended values:

3 kΩ ≤ REXT ≤ 100 kΩ (VDD ≥ 3.0V)

10 kΩ ≤ REXT ≤ 100 kΩ (VDD ≥ 3.0V)

CEXT > 20 pF

9.3 Reset

The PIC16F716 differentiates between various kinds of Reset:

- Power-on Reset (POR)
- $\overline{MCLR}$ Reset during normal operation
- $\overline{MCLR}$ Reset during Sleep
- WDT Reset (during normal operation)
- WDT Wake-up (during Sleep)
- Brown-out Reset (BOR)

Some registers are not affected in any Reset condition; their status is unknown on POR and unchanged in any other Reset. Most other registers are reset to a "Reset state" on Power-on Reset (POR), on the $\overline{MCLR}$ and WDT Reset, on $\overline{MCLR}$ Reset during Sleep and Brown-out Reset (BOR). They are not affected by a WDT Wake-up, which is viewed as the resumption of normal operation. The $\overline{TO}$ and $\overline{PD}$ bits are set or cleared differently in different Reset situations as indicated in Table 9-4. These bits are used in software to determine the nature of the Reset. See Table 9-6 for a full description of Reset states of all registers.

A simplified block diagram of the On-chip Reset circuit is shown in Figure 9-5.

The PIC® microcontrollers have an $\overline{MCLR}$ noise filter in the $\overline{MCLR}$ Reset path. The filter will detect and ignore small pulses.

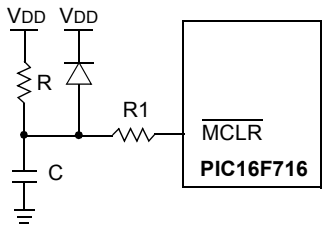
It should be noted that a WDT Reset does not drive the $\overline{MCLR}$ pin low.

9.4 Power-On Reset (POR)

A Power-on Reset pulse is generated on-chip when VDD rise is detected. To take advantage of the POR, just tie the $\overline{MCLR}$ pin directly (or through a resistor) to VDD. This will eliminate external RC components usually needed to create a Power-on Reset. A maximum rise time for VDD is specified (parameter D004). For a slow rise time, see Figure 9-4.

When the device starts normal operation (exits the Reset condition), device operating parameters (voltage, frequency, temperature,...) must be met to ensure operation. If these conditions are not met, the device must be held in Reset until the operating conditions are met. Brown-out Reset may be used to meet the start-up conditions.

FIGURE 9-4: EXTERNAL POWER-ON RESET CIRCUIT (FOR SLOW VDD POWER-UP)



Note 1: External Power-on Reset circuit is required only if VDD power-up slope is too slow. The diode D helps discharge the capacitor quickly when VDD powers down.

2: R < 40 kΩ is recommended to make sure that voltage drop across R does not violate the device's electrical specification.

3: R1 = 100Ω to 1 kΩ will limit any current flowing into $\overline{MCLR}$ from external capacitor C in the event of $\overline{MCLR}$/VPP pin breakdown due to Electrostatic Discharge (ESD) or Electrical Overstress (EOS).

TABLE 9-6: INITIALIZATION CONDITIONS FOR ALL REGISTERS OF THE PIC16F716

Register	Power-on Reset, Brown-out Reset	$\overline{\text{MCLR}}$ Resets WDT Reset	Wake-up via WDT or Interrupt
W	xxxx xxxx	uuuu uuuu	uuuu uuuu
INDF	N/A	N/A	N/A
TMR0	xxxx xxxx	uuuu uuuu	uuuu uuuu
PCL	0000h	0000h	PC + 1(2)
STATUS	0001 1xxx	000q quuu(3)	uuuq quuu(3)
FSR	xxxx xxxx	uuuu uuuu	uuuu uuuu
PORTA(4), (5), (6)	--xx 0000	--xx 0000	--uu uuuu
PORTB(4), (5)	xxxx xxxx	uuuu uuuu	uuuu uuuu
PCLATH	---0 0000	---0 0000	---u uuuu
INTCON	0000 -00x	0000 -00u	uuuu -uuu(1)
PIR1	-0-- -000	-0-- -000	-u-- -uuu(1)
TMR1L	xxxx xxxx	uuuu uuuu	uuuu uuuu
TMR1H	xxxx xxxx	uuuu uuuu	uuuu uuuu
T1CON	--00 0000	--uu uuuu	--uu uuuu
TMR2	0000 0000	0000 0000	uuuu uuuu
T2CON	-000 0000	-000 0000	-uuu uuuu
CCPR1L	xxxx xxxx	uuuu uuuu	uuuu uuuu
CCPR1H	xxxx xxxx	uuuu uuuu	uuuu uuuu
CCP1CON	0000 0000	0000 0000	uuuu uuuu
PWM1CON	0000 0000	0000 0000	uuuu uuuu
ECCPAS	00-0 0000	00-0 0000	u-uu uuuu
ADRES	xxxx xxxx	uuuu uuuu	uuuu uuuu
ADCON0	0000 0000	0000 0000	uuuu uuuu
OPTION_REG	1111 1111	1111 1111	uuuu uuuu
TRISA	--11 1111	--11 1111	--uu uuuu
TRISB	1111 1111	1111 1111	uuuu uuuu
PIE1	-0-- -000	-0-- -000	-u-- -uuu
PCON	---- --qq	---- --uu	---- --uu
PR2	1111 1111	1111 1111	uuuu uuuu
ADCON1	---- -000	---- -000	---- -uuu

Legend: u = unchanged, x = unknown, - = unimplemented bit, read as '0', q = value depends on condition

Note 1: One or more bits in INTCON and/or PIR1 will be affected (to cause wake-up).

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

3: See Table 9-5 for Reset value for specific condition.

4: On any device Reset, these pins are configured as inputs.

5: This is the value that will be in the port output latch.

6: Output latches are unknown or unchanged. Analog inputs default to analog and read '0'.

10.2 Instruction Descriptions

ADDLW	Add literal and W
Syntax:	[*label*] ADDLW k
Operands:	0 ≤ k ≤ 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 ≤ f ≤ 127 d ∈ [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 ≤ k ≤ 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 ≤ f ≤ 127 d ∈ [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 ≤ f ≤ 127 0 ≤ b ≤ 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 ≤ f ≤ 127 0 ≤ b ≤ 7
Operation:	1 → (f<b>)
Status Affected:	None
Description:	Bit 'b' in register 'f' is set.

BTFSC	Bit Test f, Skip if Clear
Syntax:	[*label*] BTFSC f,b
Operands:	0 ≤ f ≤ 127 0 ≤ b ≤ 7
Operation:	skip if (f<b>) = 0
Status Affected:	None
Description:	If bit 'b' in register 'f' is '1', the next instruction is executed. If bit 'b', in register 'f', is '0', the next instruction is discarded, and a NOP is executed instead, making this a two-cycle instruction.

12.5 AC (Timing) Characteristics

12.5.1 TIMING PARAMETER SYMBOLOGY

The timing parameter symbols have been created using one of the following formats:

1. TppS2ppS
2. TppS

T			
F	Frequency	T	Time

Lowercase letters (pp) and their meanings:

pp			
cc	CCP1	osc	OSC1
ck	CLKOUT	rd	$\overline{RD}$
cs	$\overline{CS}$	rw	$\overline{RD}$ or $\overline{WR}$
di	SDI	sc	SCK
do	SDO	ss	$\overline{SS}$
dt	Data in	t0	T0CKI
io	I/O port	t1	T1CKI
mc	$\overline{MCLR}$	wr	$\overline{WR}$

Uppercase letters and their meanings:

S			
F	Fall	P	Period
H	High	R	Rise
I	Invalid (High-impedance)	V	Valid
L	Low	Z	High-impedance

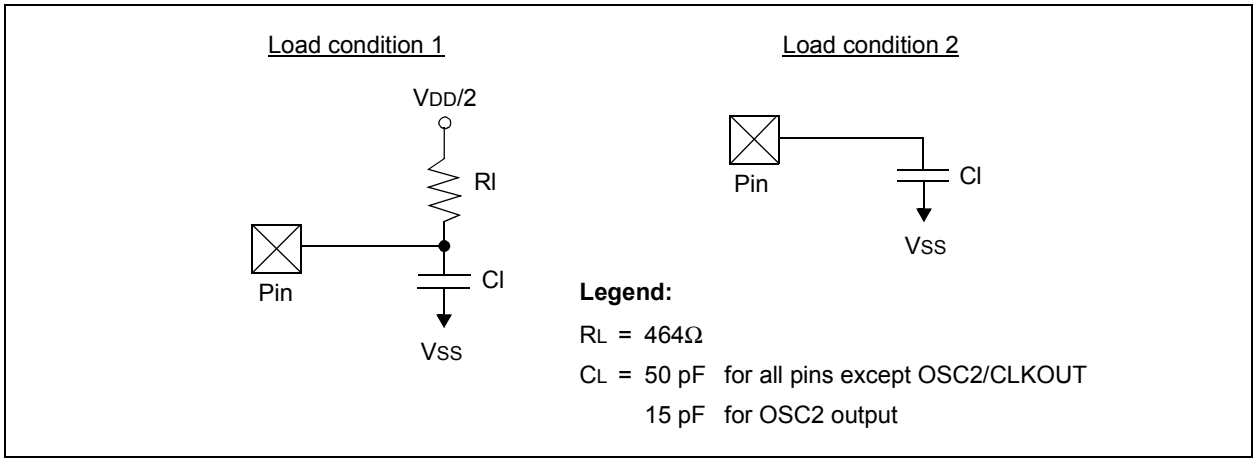
12.5.2 TIMING CONDITIONS

The temperature and voltages specified in Table 12-1 apply to all timing specifications, unless otherwise noted. Figure 12-3 specifies the load conditions for the timing specifications.

TABLE 12-1: TEMPERATURE AND VOLTAGE SPECIFICATIONS - AC

AC CHARACTERISTICS	**Standard Operating Conditions (unless otherwise stated)** Operating temperature -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤ +125°C for extended Operating voltage VDD range as described in DC spec **Section 12.1 "DC Characteristics: PIC16F716 (Industrial, Extended)"** and **Section 12.4 "DC Characteristics: PIC16F716 (Industrial, Extended)"**. LC parts operate for commercial/industrial temp's only.

FIGURE 12-3: LOAD CONDITIONS FOR DEVICE TIMING SPECIFICATIONS



12.5.3 TIMING DIAGRAMS AND SPECIFICATIONS

FIGURE 12-4: EXTERNAL CLOCK TIMING

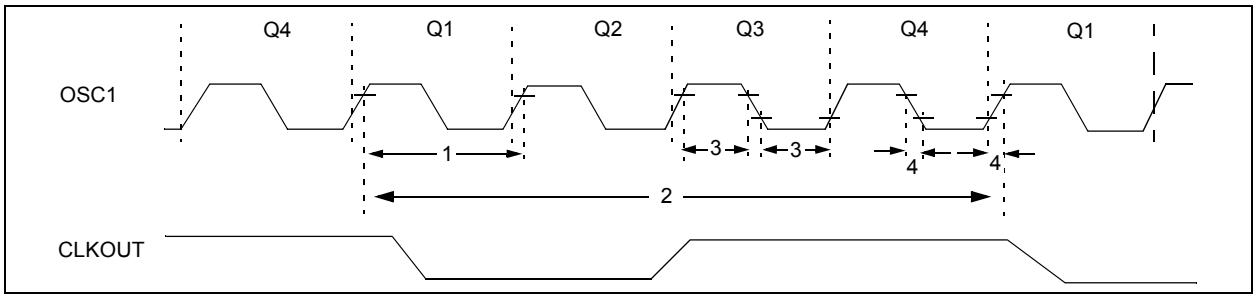
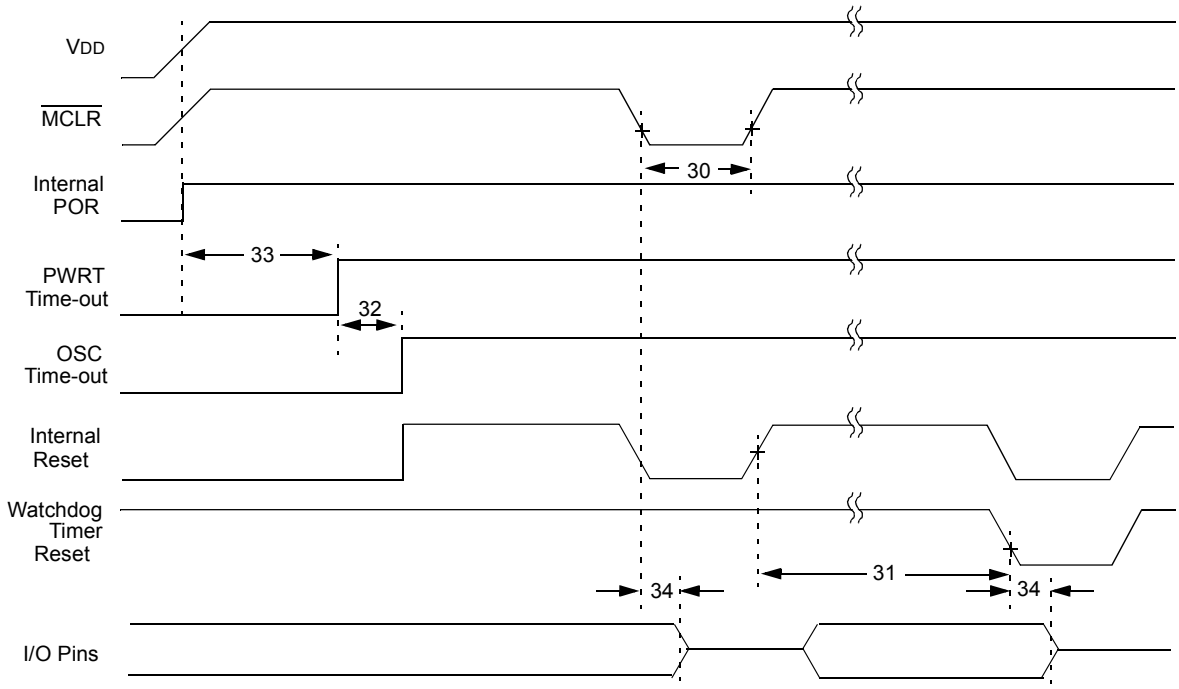


FIGURE 12-6: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING(1)



Note 1: Refer to Figure 12-3 for load conditions.

FIGURE 12-7: BROWN-OUT RESET TIMING

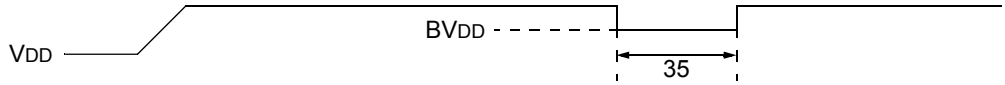


TABLE 12-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER, POWER-UP TIMER, AND BROWN-OUT RESET REQUIREMENTS

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	TMCL	$\overline{\text{MCLR}}$ Pulse Width (low)	2	—	—	µs	VDD = 5V, -40°C to +125°C
31*	TWDT	Watchdog Timer Time-out Period (No Prescaler)	7	18	33	ms	VDD = 5V, -40°C to +85°C
			TBD	TBD	TBD	ms	VDD = 5V, +85°C to +125°C
32	TOST	Oscillation Start-up Timer Period	—	1024 TOSC	—	—	TOSC = OSC1 period
33*	TPWRT	Power-up Timer Period	28	72	132	ms	VDD = 5V, -40°C to +85°C
			TBD	TBD	TBD	ms	VDD = 5V, +85°C to +125°C
34	TIOZ	I/O high-impedance from $\overline{\text{MCLR}}$ Low or WDT Reset	—	—	2.1	µs	
35	TBOR	Brown-out Reset Pulse Width	100	—	—	µs	VDD ≤ BVDD (D005)

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

FIGURE 13-14: MAXIMUM WDT IPD vs. VDD OVER TEMPERATURE

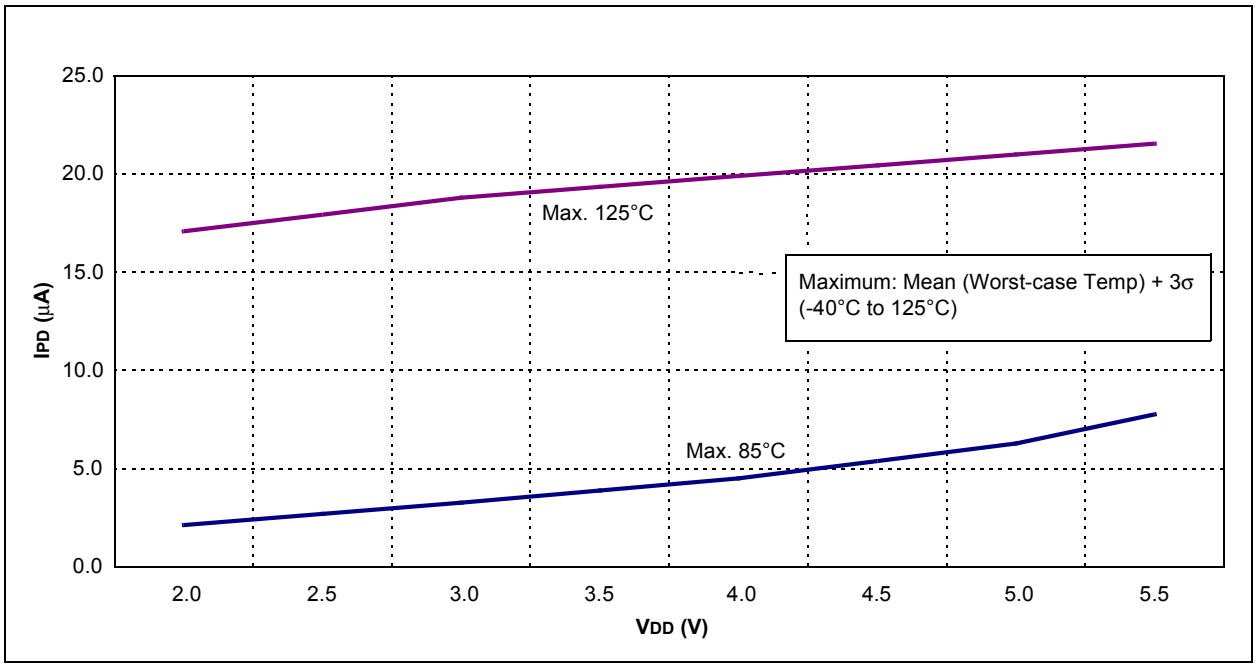
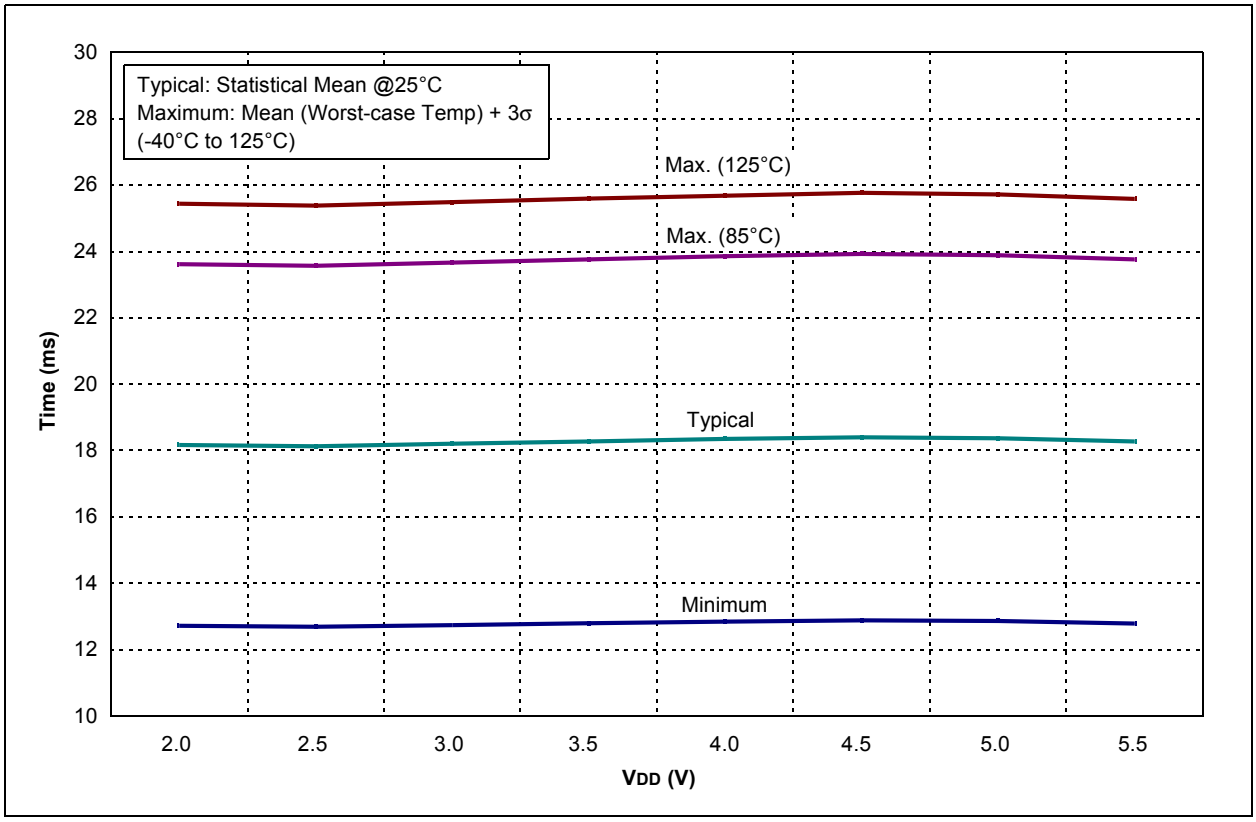


FIGURE 13-15: WDT PERIOD vs. VDD OVER TEMPERATURE



APPENDIX A: REVISION HISTORY

Revision A (June 2003)

Original data sheet. However, the device described in this data sheet are upgrades to PIC16C716.

Revision B (February 2007)

Updated with current formats and added Characterization Data. Replaced Package Drawings.

APPENDIX B: CONVERSION CONSIDERATIONS

This is a Flash program memory version of the PIC16C716 device. Refer to the migration document, DS40059, for more information about differences between the PIC16F716 and PIC16C716.

APPENDIX C: MIGRATION FROM BASE-LINE TO MID-RANGE DEVICES

This section discusses how to migrate from a baseline device (i.e., PIC16C5X) to a mid-range device (i.e., PIC16F716).

The following are the list of modifications over the PIC16C5X microcontroller family:

1. Instruction word length is increased to 14-bits. This allows larger page sizes both in program memory (2K now as opposed to 512 before) and register file (128 bytes now versus 32 bytes before).
2. A PC high latch register (PCLATH) is added to handle program memory paging. Bits PA2, PA1, PA0 are removed from STATUS register.
3. Data memory paging is redefined slightly. STATUS register is modified.
4. Four new instructions have been added: `RETURN, RETFIE, ADDLW`, and `SUBLW`. Two instructions `TRIS` and `OPTION` are being phased out although they are kept for compatibility with PIC16C5X.
5. OPTION_REG and TRIS registers are made addressable.
6. Interrupt capability is added. Interrupt vector is at 0004h.
7. Stack size is increased to 8 deep.
8. Reset vector is changed to 0000h.
9. Reset of all registers is revisited. Five different Reset (and wake-up) types are recognized. Registers are reset differently.
10. Wake-up from Sleep through interrupt is added.
11. Two separate timers, Oscillator Start-up Timer (OST) and Power-up Timer (PWRT) are included for more reliable power-up. These timers are invoked selectively to avoid unnecessary delays on power-up and wake-up.
12. PORTB has weak pull-ups and interrupt-on-change feature.
13. T0CKI pin is also a port pin (RA4) now.
14. FSR is made a full eight-bit register.
15. “In-circuit serial programming” is made possible. The user can program PIC16F716 devices using only five pins: V_{DD}, V_{SS}, $\overline{MCLR}/V_{PP}$, RB6 (clock) and RB7 (data in/out).
16. PCON STATUS register is added with a Power-on Reset Status bit ($\overline{POR}$).
17. Brown-out protection circuitry has been added. Controlled by Configuration Word bits BOREN and BORV. Brown-out Reset ensures the device is placed in a Reset condition if V_{DD} dips below a fixed setpoint.

To convert code written for PIC16C5X to PIC16F716, the user should take the following steps:

1. Remove any program memory page select operations (PA2, PA1, PA0 bits) for `CALL`, `GOTO`.
2. Revisit any computed jump operations (write to PC or add to PC, etc.) to make sure page bits are set properly under the new scheme.
3. Eliminate any data memory page switching. Redefine data variables to reallocate them.
4. Verify all writes to STATUS, OPTION, and FSR registers since these have changed.
5. Change Reset vector to 0000h

.

Note 1: This device has been designed to perform to the parameters of its data sheet. It has been tested to an electrical specification designed to determine its conformance with these parameters. Due to process differences in the manufacture of this device, this device may have different performance characteristics than its earlier version. These differences may cause this device to perform differently in your application than the earlier version of this device.

2: The user should verify that the device oscillator starts and performs as expected. Adjusting the loading capacitor values and/or the Oscillator mode may be required.

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