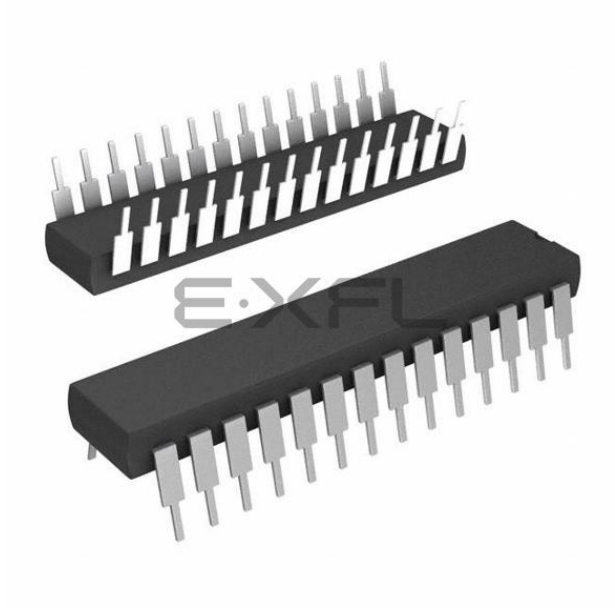

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	4MHz
Connectivity	I²C, SPI
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	22
Program Memory Size	3.5KB (2K x 14)
Program Memory Type	OTP
EEPROM Size	-
RAM Size	128 x 8
Voltage - Supply (Vcc/Vdd)	2.5V ~ 5.5V
Data Converters	A/D 5x8b
Oscillator Type	External
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Through Hole
Package / Case	28-DIP (0.300", 7.62mm)
Supplier Device Package	28-SPDIP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16lc72a-04i-sp

2.2 Data Memory Organization

The data memory is partitioned into multiple banks which contain the General Purpose Registers and the Special Function Registers. Bits RP1 and RP0 are the bank select bits.

RP1(1)	RP0

(STATUS<6:5>)

= 00 → Bank0
= 01 → Bank1
= 10 → Bank2 (not implemented)
= 11 → Bank3 (not implemented)

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

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. Some “high use” Special Function Registers from one bank may be mirrored in another bank for code reduction and quicker access.

2.2.1 GENERAL PURPOSE REGISTER FILE

The register file can be accessed either directly, or indirectly through the File Select Register FSR (Section 2.5).

FIGURE 2-2: REGISTER FILE MAP

File Address	Bank 0	Bank 1	File Address
00h	INDF(1)	INDF(1)	80h
01h	TMR0	OPTION_REG	81h
02h	PCL	PCL	82h
03h	STATUS	STATUS	83h
04h	FSR	FSR	84h
05h	PORTA	TRISA	85h
06h	PORTB	TRISB	86h
07h	PORTC	TRISC	87h
08h	—	—	88h
09h	—	—	89h
0Ah	PCLATH	PCLATH	8Ah
0Bh	INTCON	INTCON	8Bh
0Ch	PIR1	PIE1	8Ch
0Dh	—	—	8Dh
0Eh	TMR1L	PCON	8Eh
0Fh	TMR1H	—	8Fh
10h	T1CON	—	90h
11h	TMR2	—	91h
12h	T2CON	PR2	92h
13h	SSPBUF	SSPADD	93h
14h	SSPCON	SSPSTAT	94h
15h	CCPR1L	—	95h
16h	CCPR1H	—	96h
17h	CCP1CON	—	97h
18h	—	—	98h
19h	—	—	99h
1Ah	—	—	9Ah
1Bh	—	—	9Bh
1Ch	—	—	9Ch
1Dh	—	—	9Dh
1Eh	ADRES(2)	—	9Eh
1Fh	ADCON0(2)	ADCON1(2)	9Fh
20h	General Purpose Registers	General Purpose Registers	A0h
			BFh
		—	C0h
		—	
7Fh		—	FFh

Unimplemented data memory locations, read as '0'.

Note 1: Not a physical register.
2: These registers are not implemented on the PIC16C62B, read as '0'.

2.2.2.1 STATUS REGISTER

The STATUS register, shown in Register 2-1, contains the arithmetic status of the ALU, the RESET status and the bank select bits for data memory.

The STATUS register can be the destination for any instruction, as with any other register. If the STATUS register is the destination for an instruction that affects the Z, DC or C bits, the write to these three bits is disabled. These bits are set or cleared according to the device logic. The $\overline{TO}$ and $\overline{PD}$ bits are not writable. The result of an instruction with the STATUS register as destination may be different than intended.

For example, `CLRF STATUS` will clear the upper-three bits and set the Z bit. This leaves the STATUS register as `000u u1uu` (where `u` = unchanged).

It is recommended, therefore, that only `BCF`, `BSF`, `SWAPF` and `MOVWF` instructions are used to alter the STATUS register, because these instructions do not affect the Z, C or DC bits from the STATUS register. For other instructions, not affecting any status bits, see the "Instruction Set Summary."

Note 1: The IRP and RP1 bits are reserved. Maintain these bits clear to ensure upward compatibility with future products.

Note 2: The C and DC bits operate as a $\overline{borrow}$ and $\overline{digit\ borrow}$ bit, respectively, in subtraction. See the `SUBLW` and `SUBWF` instructions.

REGISTER 2-1: STATUS REGISTER (ADDRESS 03h, 83h)

R/W-0	R/W-0	R/W-0	R-1	R-1	R/W-x	R/W-x	R/W-x
IRP	RP1	RP0	$\overline{TO}$	$\overline{PD}$	Z	DC	C
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7: **IRP**: Register Bank Select bit (used for indirect addressing)
(reserved, maintain clear)

bit 6-5: **RP1:RP0**: Register Bank Select bits (used for direct addressing)
`01` = Bank 1 (80h - FFh)
`00` = Bank 0 (00h - 7Fh)
Each bank is 128 bytes
Note: RP1 is reserved, maintain clear

bit 4: **$\overline{TO}$**: Time-out bit
`1` = After power-up, `CLRWDT` instruction, or `SLEEP` instruction
`0` = A WDT time-out occurred

bit 3: **$\overline{PD}$**: Power-down bit
`1` = After power-up or by the `CLRWDT` instruction
`0` = By execution of the `SLEEP` instruction

bit 2: **Z**: Zero bit
`1` = The result of an arithmetic or logic operation is zero
`0` = The result of an arithmetic or logic operation is not zero

bit 1: **DC**: Digit carry/$\overline{borrow}$ bit (`ADDWF`, `ADDLW`, `SUBLW`, `SUBWF` instructions) (for $\overline{borrow}$, the polarity is reversed)
`1` = A carry-out from the 4th low order bit of the result occurred
`0` = No carry-out from the 4th low order bit of the result

bit 0: **C**: Carry/$\overline{borrow}$ bit (`ADDWF`, `ADDLW`, `SUBLW`, `SUBWF` instructions) (for $\overline{borrow}$, the polarity is reversed)
`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: For $\overline{borrow}$, 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 or low order bit of the source register.

2.2.2.6 PCON REGISTER

The Power Control register (PCON) contains flag bits to allow differentiation between a Power-on Reset (POR), Brown-Out Reset (BOR) and resets from other sources. .

Note:	On Power-on Reset, the state of the $\overline{BOR}$ bit is unknown and is not predictable. If the BODEN bit in the configuration word is set, the user must first set the BOR bit on a POR, and check it on subsequent resets. If BOR is cleared while POR remains set, a Brown-out reset has occurred. If the BODEN bit is clear, the BOR bit may be ignored.

REGISTER 2-6: PCON REGISTER (ADDRESS 8Eh)

U-0	U-0	U-0	U-0	U-0	U-0	R/W-0	R/W-q
—	—	—	—	—	—	$\overline{POR}$	$\overline{BOR}$
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7-2: **Unimplemented:** Read as '0'

bit 1: **$\overline{POR}$**: Power-on Reset Status bit
1 = No Power-on Reset occurred
0 = A Power-on Reset occurred (must be set in software after a Power-on Reset occurs)

bit 0: **$\overline{BOR}$**: Brown-out Reset Status bit
1 = No Brown-out Reset occurred
0 = A Brown-out Reset occurred (must be set in software after a Brown-out Reset occurs)

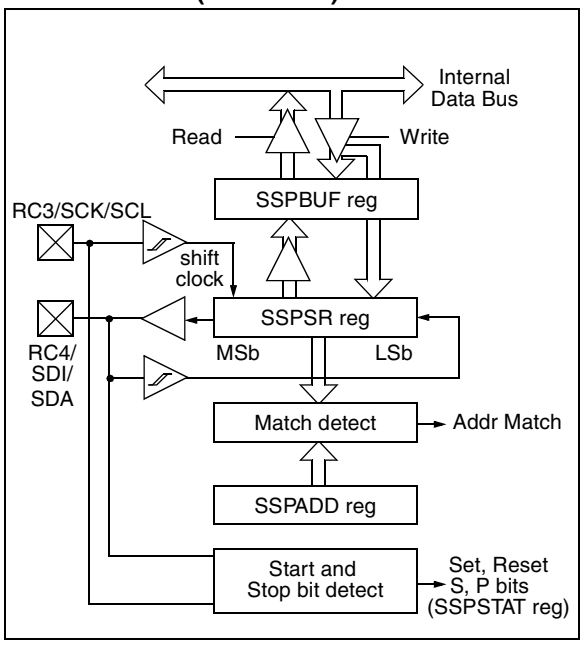
8.3 SSP I²C Operation

The SSP module in I²C mode fully implements all slave functions, except general call support, and provides interrupts on start and stop bits in hardware to support firmware implementations of the master functions. The SSP module implements the standard mode specifications, as well as 7-bit and 10-bit addressing.

Two pins are used for data transfer. These are the RC3/SCK/SCL pin, which is the clock (SCL), and the RC4/SDI/SDA pin, which is the data (SDA). The user must configure these pins as inputs or outputs through the TRISC<4:3> bits.

The SSP module functions are enabled by setting SSP Enable bit SSPEN (SSPCON<5>).

FIGURE 8-2: SSP BLOCK DIAGRAM (I²C MODE)



The SSP module has five registers for I²C operation. These are the:

- SSP Control Register (SSPCON)
- SSP Status Register (SSPSTAT)
- Serial Receive/Transmit Buffer (SSPBUF)
- SSP Shift Register (SSPSR) - Not accessible
- SSP Address Register (SSPADD)

The SSPCON register allows control of the I²C operation. Four mode selection bits (SSPCON<3:0>) allow one of the following I²C modes to be selected:

- I²C Slave mode (7-bit address)
- I²C Slave mode (10-bit address)
- I²C Slave mode (7-bit address), with start and stop bit interrupts enabled for firmware master mode support
- I²C Slave mode (10-bit address), with start and stop bit interrupts enabled for firmware master mode support
- I²C start and stop bit interrupts enabled for firmware master mode support, slave mode idle

Selection of any I²C mode, with the SSPEN bit set, forces the SCL and SDA pins to be operated as open drain outputs, provided these pins are programmed to inputs by setting the appropriate TRISC bits.

Additional information on SSP I²C operation may be found in the PIC® MCU Mid-Range Reference Manual, (DS33023).

8.3.1 SLAVE MODE

In slave mode, the SCL and SDA pins must be configured as inputs (TRISC<4:3> set). The SSP module will override the input state with the output data when required (slave-transmitter).

When an address is matched or the data transfer after an address match is received, the hardware automatically will generate the acknowledge ($\overline{ACK}$) pulse, and load the SSPBUF register with the received value in the SSPSR register.

There are certain conditions that will cause the SSP module not to give this $\overline{ACK}$ pulse. This happens if either of the following conditions occur:

a) The buffer full bit BF (SSPSTAT<0>) was set before the transfer was completed.

b) The overflow bit SSPOV (SSPCON<6>) was set before the transfer was completed.

In this case, the SSPSR register value is not loaded into the SSPBUF, but bit SSPIF (PIR1<3>) is set. Table 8-2 shows what happens when a data transfer byte is received, given the status of bits BF and SSPOV. The shaded cells show the condition where user software did not properly clear the overflow condition. Flag bit BF is cleared by reading the SSPBUF register, while bit SSPOV is cleared through software.

The SCL clock input must have a minimum high and low for proper operation. The high and low times of the I²C specification, as well as the requirement of the SSP module, is shown in timing parameter #100, THIGH, and parameter #101, TLOW.

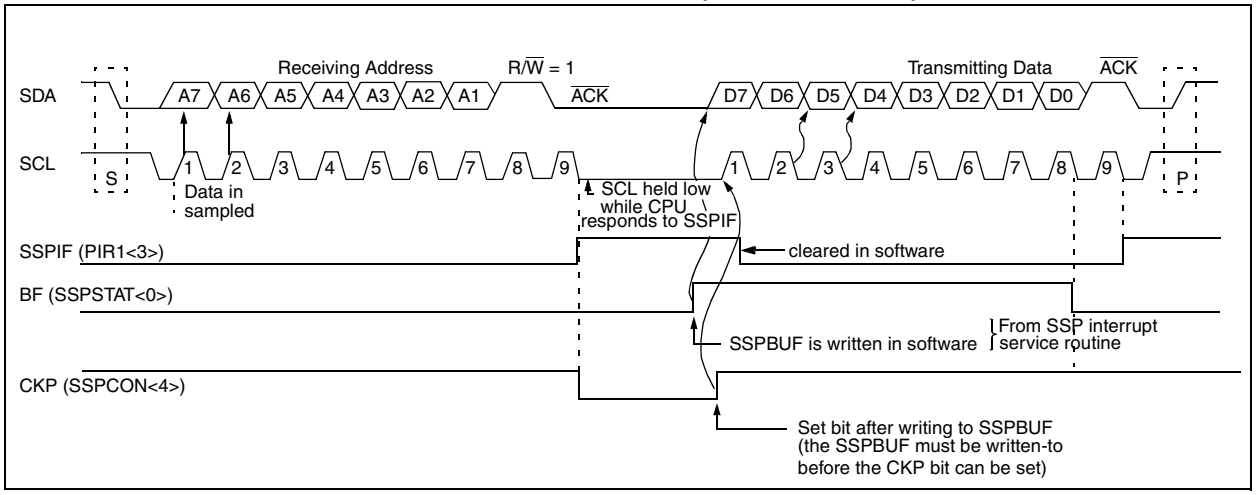
8.3.1.3 TRANSMISSION

When the R/$\overline{W}$ bit of the incoming address byte is set and an address match occurs, the R/$\overline{W}$ bit of the SSPSTAT register is set. The received address is loaded into the SSPBUF register. The $\overline{ACK}$ pulse will be sent on the ninth bit and the CKP will be cleared by hardware, holding SCL low. Slave devices cause the master to wait by holding the SCL line low. The transmit data is loaded into the SSPBUF register, which in turn loads the SSPSR register. When bit CKP (SSPCON<4>) is set, pin RC3/SCK/SCL releases SCL. When the SCL line goes high, the master may resume operating the SCL line and receiving data. The master must monitor the SCL pin prior to asserting another clock pulse. The slave devices may be holding off the master by stretching the clock. The eight data bits are shifted out on the falling edge of the SCL input. This ensures that the SDA signal is valid during the SCL high time (Figure 8-4).

An SSP interrupt is generated for each data transfer byte. Flag bit SSPIF must be cleared in software, and the SSPSTAT register used to determine the status of the byte. Flag bit SSPIF is set on the falling edge of the ninth clock pulse.

As a slave-transmitter, the $\overline{ACK}$ pulse from the master-receiver is latched on the rising edge of the ninth SCL input pulse. If the SDA line was high (not $\overline{ACK}$), then the data transfer is complete. When the $\overline{ACK}$ is latched by the slave, the slave logic is reset (resets SSPSTAT register) and the slave then monitors for another occurrence of the START bit. If the SDA line was low ($\overline{ACK}$), the transmit data must be loaded into the SSPBUF register, which also loads the SSPSR register. Then pin RC3/SCK/SCL should be enabled by setting bit CKP.

FIGURE 8-4: I²C WAVEFORMS FOR TRANSMISSION (7-BIT ADDRESS)



9.0 ANALOG-TO-DIGITAL CONVERTER (A/D) MODULE

Note: This section applies to the PIC16C72A only.

The analog-to-digital (A/D) converter module has five input channels.

The A/D allows conversion of an analog input signal to a corresponding 8-bit digital number (refer to Application Note AN546 for use of A/D Converter). The output of the sample and hold is the input into the converter, which generates the result via successive approximation. The analog reference voltage is software selectable to either the device's positive supply voltage (V_{DD}) or the voltage level on the RA3/AN3/V_{REF} pin.

The A/D converter has the feature of being able to operate while the device is in SLEEP mode. To operate in sleep, the A/D conversion clock must be derived from the A/D's internal RC oscillator.

Additional information on the A/D module is available in the PIC® MCU Mid-Range Reference Manual, (DS33023).

The A/D module has three registers. These registers are:

- A/D Result Register (ADRES)
- A/D Control Register 0 (ADCON0)
- A/D Control Register 1 (ADCON1)

A device reset forces all registers to their reset state. This forces the A/D module to be turned off, and any conversion is aborted.

The ADCON0 register, shown in Figure 9-1, controls the operation of the A/D module. The ADCON1 register, shown in Figure 9-2, configures the functions of the port pins. The port pins can be configured as analog inputs (RA3 can also be a voltage reference) or as digital I/O.

REGISTER 9-1: ADCON0 REGISTER (ADDRESS 1Fh)

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	—	ADON
bit7							bit0

R = Readable bit
W = Writable bit
U = Unimplemented bit, read as '0'
- n = Value at POR reset

bit 7-6: **ADCS1:ADCS0:** A/D Conversion Clock Select bits
00 = F_{OSC}/2
01 = F_{OSC}/8
10 = F_{OSC}/32
11 = F_{RC} (clock derived from an internal RC oscillator)

bit 5-3: **CHS2:CHS0**: Analog Channel Select bits
000 = channel 0, (RA0/AN0)
001 = channel 1, (RA1/AN1)
010 = channel 2, (RA2/AN2)
011 = channel 3, (RA3/AN3)
100 = channel 4, (RA5/AN4)

bit 2: **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit

If ADON = 1
1 = A/D conversion in progress (setting this bit starts the A/D conversion)
0 = A/D conversion not in progress (This bit is automatically cleared by hardware when the A/D conversion is complete)

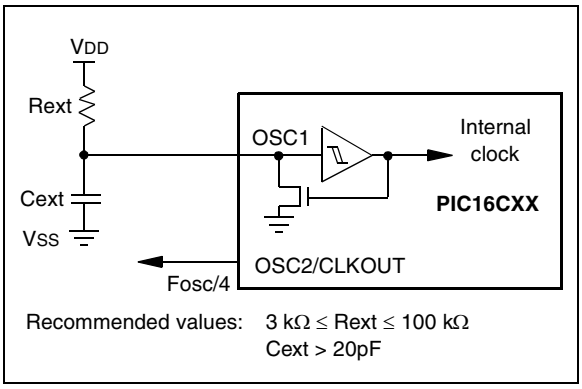
bit 1: **Unimplemented**: Read as '0'

bit 0: **ADON**: A/D On bit
1 = A/D converter module is operating
0 = A/D converter module is shutoff and consumes no operating current

10.2.3 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 10-4 shows how the R/C combination is connected to the PIC16CXXX.

FIGURE 10-4: RC OSCILLATOR MODE



10.3 Reset

The PIC16CXXX differentiates between various kinds of reset:

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

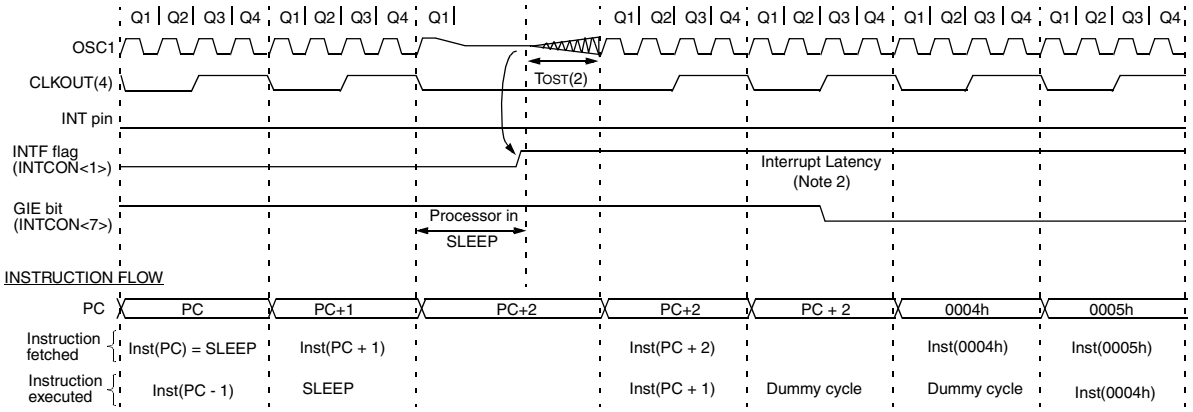
Some registers are not affected in any reset condition; their status is unknown on POR and unchanged by any other reset. Most other registers are reset to a “reset state” on Power-on Reset (POR), on the $\overline{\text{MCLR}}$ and WDT Reset, on $\overline{\text{MCLR}}$ reset during SLEEP, and on Brown-out Reset (BOR). They are not affected by a WDT Wake-up from SLEEP, which is viewed as the resumption of normal operation. The $\overline{\text{TO}}$ and $\overline{\text{PD}}$ bits are set or cleared depending on the reset situation, as indicated in Table 10-4. These bits are used in software to determine the nature of the reset. See Table 10-6 for a full description of reset states of all registers.

A simplified block diagram of the on-chip reset circuit is shown in Figure 10-5.

The PIC devices have a $\overline{\text{MCLR}}$ noise filter in the $\overline{\text{MCLR}}$ reset path. The filter will ignore small pulses. However, a valid $\overline{\text{MCLR}}$ pulse must meet the minimum pulse width (TmcL, Specification #30).

No internal reset source (WDT, BOR, POR) willdrive the $\overline{\text{MCLR}}$ pin low.

FIGURE 10-10: WAKE-UP FROM SLEEP THROUGH INTERRUPT



Note 1: XT, HS or LP oscillator mode assumed.
2: TOST = 1024TOSC (drawing not to scale) This delay will not be there for RC osc mode.
3: GIE = '1' assumed. In this case after wake- up, the processor jumps to the interrupt routine. If GIE = '0', execution will continue in-line.
4: CLKOUT is not available in these osc modes, but shown here for timing reference.

10.14 Program Verification/Code Protection

If the code protection bits have not been programmed, the on-chip program memory can be read out for verification purposes.

Note:	Microchip does not recommend code protecting windowed devices.

10.15 ID Locations

Four memory locations (2000h - 2003h) are designated as ID locations where the user can store checksum or other code-identification numbers. These locations are not accessible during normal execution, but are readable and writable during program/verify. It is recommended that only the 4 least significant bits of the ID location are used.

For ROM devices, these values are submitted along with the ROM code.

10.16 In-Circuit Serial Programming™

PIC16CXXX microcontrollers can be serially programmed while in the end application circuit. This is simply done with two lines for clock and data, and three more lines for power, ground and the programming voltage. This allows customers to manufacture boards with unprogrammed devices, and then program the microcontroller just before shipping the product. This also allows the most recent firmware or a custom firmware to be programmed.

For complete details of serial programming, please refer to the In-Circuit Serial Programming (ICSP™) Guide, DS30277.

BTFSS	Bit Test f, Skip if Set
Syntax:	[*label*] BTFSS f,b
Operands:	0 ≤ f ≤ 127 0 ≤ b < 7
Operation:	skip if (f<b>) = 1
Status Affected:	None
Description:	If bit 'b' in register 'f' is '0', then the next instruction is executed. If bit 'b' is '1', then the next instruction is discarded and a NOP is executed instead, making this a 2TCY instruction.

BTFSC	Bit Test, 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', then the next instruction is executed. If bit 'b' in register 'f' is '0', then the next instruction is discarded, and a NOP is executed instead, making this a 2TCY instruction.

CALL	Call Subroutine
Syntax:	[*label*] CALL k
Operands:	0 ≤ k ≤ 2047
Operation:	(PC)+ 1→ TOS, k → PC<10:0>, (PCLATH<4:3>) → PC<12:11>
Status Affected:	None
Description:	Call Subroutine. First, return address (PC+1) is pushed onto the stack. The eleven bit immediate address is loaded into PC bits <10:0>. The upper bits of the PC are loaded from PCLATH. CALL is a two cycle instruction.

CLRF	Clear f
Syntax:	[*label*] CLRF f
Operands:	0 ≤ f ≤ 127
Operation:	00h → (f) 1 → Z
Status Affected:	Z
Description:	The contents of register 'f' are cleared and the Z bit is set.

CLRW	Clear W
Syntax:	[*label*] CLRW
Operands:	None
Operation:	00h → (W) 1 → Z
Status Affected:	Z
Description:	W register is cleared. Zero bit (Z) is set.

CLRWDT	Clear Watchdog Timer
Syntax:	[*label*] CLRWDT
Operands:	None
Operation:	00h → WDT 0 → WDT prescaler, 1 → $\overline{TO}$ 1 → $\overline{PD}$
Status Affected:	$\overline{TO}$, $\overline{PD}$
Description:	CLRWDT instruction resets the Watchdog Timer. It also resets the prescaler of the WDT. Status bits $\overline{TO}$ and $\overline{PD}$ are set.

and test the sample code. In addition, PICDEM-17 supports down-loading of programs to and executing out of external FLASH memory on board. The PICDEM-17 is also usable with the MPLAB-ICE or PICMASTER emulator, and all of the sample programs can be run and modified using either emulator. Additionally, a generous prototype area is available for user hardware.

12.17 SEEVAL Evaluation and Programming System

The SEEVAL SEEPROM Designer's Kit supports all Microchip 2-wire and 3-wire Serial EEPROMs. The kit includes everything necessary to read, write, erase or program special features of any Microchip SEEPROM product including Smart Serials™ and secure serials. The Total Endurance™ Disk is included to aid in trade-off analysis and reliability calculations. The total kit can significantly reduce time-to-market and result in an optimized system.

12.18 KEELOQ Evaluation and Programming Tools

KEELOQ evaluation and programming tools support Microchips HCS Secure Data Products. The HCS evaluation kit includes an LCD display to show changing codes, a decoder to decode transmissions, and a programming interface to program test transmitters.

13.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings (†)

Ambient temperature under bias ..... -55°C to +125°C

Storage temperature ..... -65°C to +150°C

Voltage on any pin with respect to V_{SS} (except V_{DD}, $\overline{MCLR}$, and RA4) ..... -0.3V to (V_{DD} + 0.3V)

Voltage on V_{DD} with respect to V_{SS} ..... -0.3V to +7.5V

Voltage on $\overline{MCLR}$ with respect to V_{SS} (Note 2) ..... 0V to +13.25V

Voltage on RA4 with respect to Vss ..... 0V to +8.5V

Total power dissipation (Note 1) 1.0W

Maximum current out of V_{SS} pin ..... 300 mA

Maximum current into V_{DD} pin ..... 250 mA

Input clamp current, I_{IK} (V_I < 0 or V_I > V_{DD}) ..... ±20 mA

Output clamp current, I_{OK} (V_O < 0 or V_O > V_{DD}) ..... ±20 mA

Maximum output current sunk by any I/O pin ..... 25 mA

Maximum output current sourced by any I/O pin ..... 25 mA

Maximum current sunk by PORTA and PORTB (combined) ..... 200 mA

Maximum current sourced by PORTA and PORTB (combined) ..... 200 mA

Maximum current sunk by PORTC ..... 200 mA

Maximum current sourced by PORTC ..... 200 mA

Note 1: Power dissipation is calculated as follows: $P_{dis} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD}-V_{OH}) \times I_{OH}\} + \sum(V_{ol} \times I_{OL})$

2: Voltage spikes below V_{SS} at the $\overline{MCLR}/V_{PP}$ pin, inducing currents greater than 80 mA, may cause latch-up. Thus, a series resistor of 50-100Ω should be used when applying a "low" level to the $\overline{MCLR}/V_{PP}$ pin, rather than pulling this pin directly to V_{SS}.

† NOTICE: Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

13.1 DC Characteristics: PIC16C62B/72A-04 (Commercial, Industrial, Extended) PIC16C62B/72A-20 (Commercial, Industrial, Extended)

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature 0°C ≤ TA ≤ +70°C for commercial -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤+125°C for extended				
Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
D001 D001A	VDD	Supply Voltage	4.0 4.5 VBOR*	- - -	5.5 5.5 5.5	V V V	XT, RC and LP osc mode HS osc mode BOR enabled (Note 7)
D002*	VDR	RAM Data Retention **Voltage** (Note 1)	-	1.5	-	V	
D003	VPOR	**VDD Start Voltage** to ensure internal Power-on Reset signal	-	VSS	-	V	See section on Power-on Reset for details
D004* D004A*	SVDD	**VDD Rise Rate** to ensure internal Power-on Reset signal	0.05 TBD	- -	- -	V/ms	PWRT enabled ($\overline{\text{PWRTE}}$ bit clear) PWRT disabled ($\overline{\text{PWRTE}}$ bit set) See section on Power-on Reset for details
D005	VBOR	Brown-out Reset voltage trip point	3.65	-	4.35	V	BODEN bit set
D010 D013	IDD	**Supply Current** (Note 2, 5)	- -	2.7 10	5 20	mA mA	XT, RC osc modes FOSC = 4 MHz, VDD = 5.5V (Note 4) HS osc mode FOSC = 20 MHz, VDD = 5.5V
D020 D021 D021B	IPD	**Power-down Current** (Note 3, 5)	- - - -	10.5 1.5 1.5 2.5	42 16 19 19	µA µA µA µA	VDD = 4.0V, WDT enabled,-40°C to +85°C VDD = 4.0V, WDT disabled, 0°C to +70°C VDD = 4.0V, WDT disabled,-40°C to +85°C VDD = 4.0V, WDT disabled,-40°C to +125°C
D022* D022A*	ΔIWDT ΔIBOR	Module Differential Current (Note 6) Watchdog Timer Brown-out Reset	- -	6.0 TBD	20 200	µA µA	WDTE BIT SET, VDD = 4.0V BODEN bit set, VDD = 5.0V

* 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.

Note 1: This is the limit to which VDD can be lowered without losing RAM data.

2: The supply current is mainly a function of the operating voltage and frequency. Other factors such as I/O pin loading and switching rate, oscillator type, internal code execution pattern, and temperature also have an impact on the current consumption.
The test conditions for all IDD measurements in active operation mode are:
OSC1 = external square wave, from rail to rail; all I/O pins tristated, pulled to VDD,
$\overline{\text{MCLR}}$ = VDD; WDT enabled/disabled as specified.

3: The power-down current in SLEEP mode does not depend on the oscillator type. Power-down current is measured with the part in SLEEP mode, with all I/O pins in hi-impedance state and tied to VDD and VSS.

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

5: Timer1 oscillator (when enabled) adds approximately 20 µA to the specification. This value is from characterization and is for design guidance only. This is not tested.

6: The Δ current is the additional current consumed when this peripheral is enabled. This current should be added to the base IDD or IPD measurement.

7: This is the voltage where the device enters the Brown-out Reset. When BOR is enabled, the device will perform a brown-out reset when VDD falls below VBOR.

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature 0°C ≤ TA ≤ +70°C for commercial -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤+125°C for extended Operating voltage VDD range as described in DC spec Section 13.1 and Section 13.2				
Param No.	**Sym**	**Characteristic**	**Min**	**Typ†**	**Max**	**Units**	**Conditions**
D083		OSC2/CLKOUT (RC osc mode)	-	-	0.6	V	IOL = 7.0 mA, VDD = 4.5V, -40°C to +125°C
			-	-	0.6	V	IOL = 1.6 mA, VDD = 4.5V, -40°C to +85°C
			-	-	0.6	V	IOL = 1.2 mA, VDD = 4.5V, -40°C to +125°C
		Output High Voltage					
D090	VOH	I/O ports (Note 3)	VDD-0.7	-	-	V	IOH = -3.0 mA, VDD = 4.5V, -40°C to +85°C
			VDD-0.7	-	-	V	IOH = -2.5 mA, VDD = 4.5V, -40°C to +125°C
D092		OSC2/CLKOUT (RC osc mode)	VDD-0.7	-	-	V	IOH = -1.3 mA, VDD = 4.5V, -40°C to +85°C
			VDD-0.7	-	-	V	IOH = -1.0 mA, VDD = 4.5V, -40°C to +125°C
D150*	VOD	**Open-Drain High Voltage**	-	-	8.5	V	RA4 pin
		Capacitive Loading Specs on Output Pins					
D100	COSC2	OSC2 pin	-	-	15	pF	In XT, HS and LP modes when external clock is used to drive OSC1.
D101	CIO	All I/O pins and OSC2 (in RC mode)	-	-	50	pF	
D102	Cb	SCL, SDA in I^2C mode	-	-	400	pF	

* 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.

Note 1: In RC oscillator mode, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the device be driven with external clock in RC mode.

2: The leakage current on the $\overline{MCLR}$/VPP 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.

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

FIGURE 13-11: EXAMPLE SPI MASTER MODE TIMING (CKE = 0)

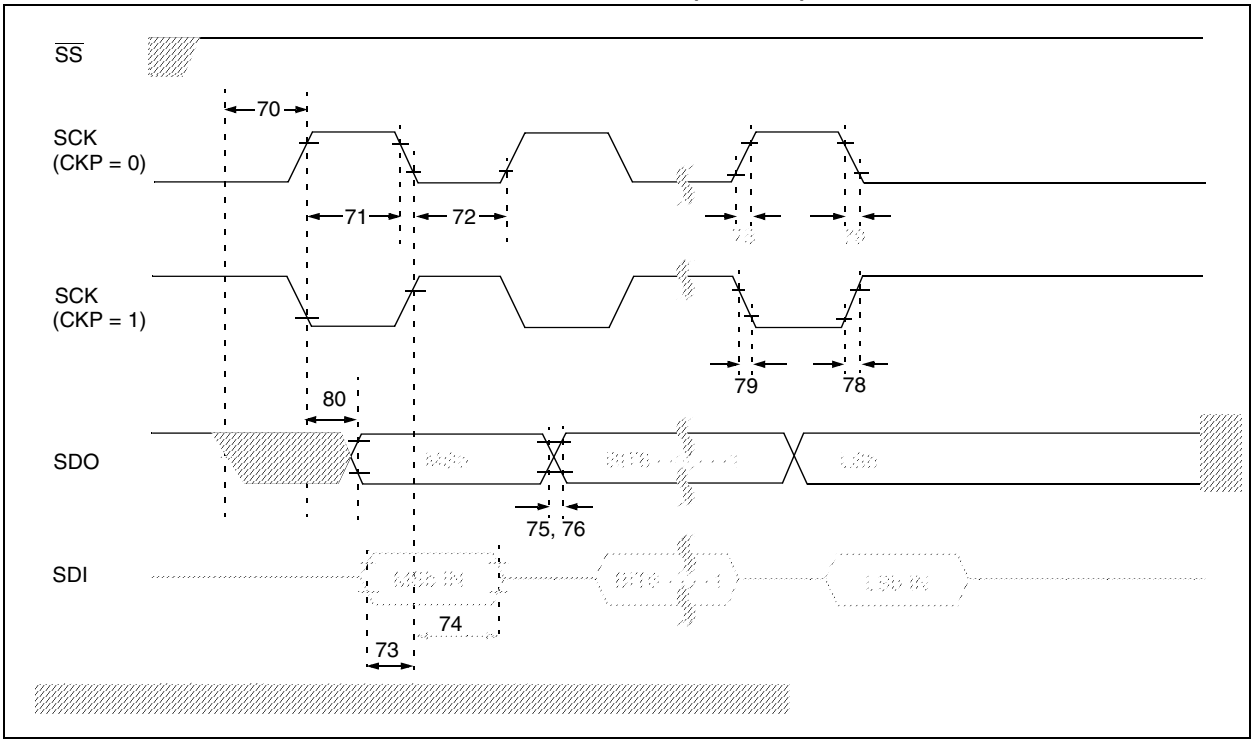


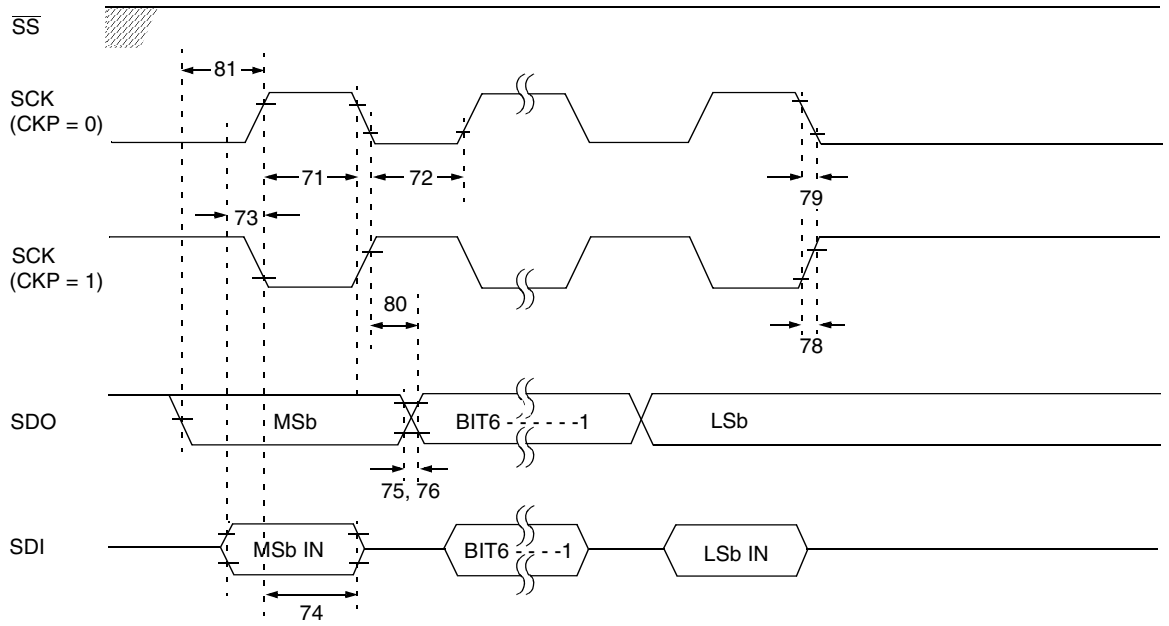
TABLE 13-7: EXAMPLE SPI MODE REQUIREMENTS (MASTER MODE, CKE = 0)

Param. No.	Symbol	Characteristic		Min	Typ†	Max	Units	Conditions
70	TssL2scH, TssL2scL	$\overline{SS}$↓ to SCK↓ or SCK↑ input		TCY	—	—	ns	
71	TscH	SCK input high time (slave mode)	Continuous	1.25TCY + 30	—	—	ns	
71A			Single Byte	40	—	—	ns	Note 1
72	TscL	SCK input low time (slave mode)	Continuous	1.25TCY + 30	—	—	ns	
72A			Single Byte	40	—	—	ns	Note 1
73	TdiV2scH, TdiV2scL	Setup time of SDI data input to SCK edge		100	—	—	ns	
73A	TB2B	Last clock edge of Byte1 to the 1st clock edge of Byte2		1.5TCY + 40	—	—	ns	Note 1
74	TscH2diL, TscL2diL	Hold time of SDI data input to SCK edge		100	—	—	ns	
75	TdoR	SDO data output rise time	**PIC16CXX**	—	10	25	ns	
			PIC16LCXX	—	20	45	ns	
76	TdoF	SDO data output fall time		—	10	25	ns	
78	TscR	SCK output rise time (master mode)	**PIC16CXX**	—	10	25	ns	
			PIC16LCXX	—	20	45	ns	
79	TscF	SCK output fall time (master mode)		—	10	25	ns	
80	TscH2doV, TscL2doV	SDO data output valid after SCK edge	**PIC16CXX**	—	—	50	ns	
			PIC16LCXX	—	—	100	ns	

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

Note 1: Specification 73A is only required if specifications 71A and 72A are used.

FIGURE 13-12: EXAMPLE SPI MASTER MODE TIMING (CKE = 1)



Note: Refer to Figure 13-4 for load conditions.

TABLE 13-8: EXAMPLE SPI MODE REQUIREMENTS (MASTER MODE, CKE = 1)

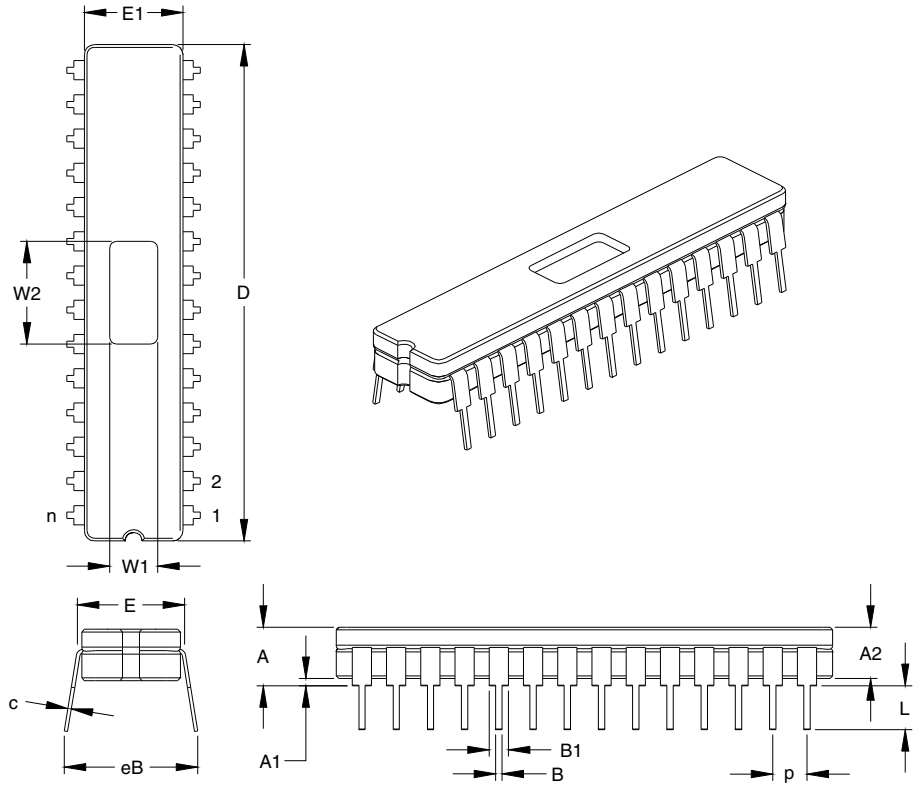
Param. No.	Symbol	Characteristic		Min	Typ†	Max	Units	Conditions
71	TscH	SCK input high time (slave mode)	Continuous	1.25TCY + 30	—	—	ns	
71A			Single Byte	40	—	—	ns	Note 1
72	TscL	SCK input low time (slave mode)	Continuous	1.25TCY + 30	—	—	ns	
72A			Single Byte	40	—	—	ns	Note 1
73	TdiV2scH, TdiV2scL	Setup time of SDI data input to SCK edge		100	—	—	ns	
73A	TB2B	Last clock edge of Byte1 to the 1st clock edge of Byte2		1.5TCY + 40	—	—	ns	Note 1
74	TscH2diL, TscL2diL	Hold time of SDI data input to SCK edge		100	—	—	ns	
75	TdoR	SDO data output rise time	**PIC16CXX**	—	10	25	ns	
			PIC16LCXX		20	45	ns	
76	TdoF	SDO data output fall time		—	10	25	ns	
78	TscR	SCK output rise time (master mode)	**PIC16CXX**	—	10	25	ns	
			PIC16LCXX		20	45	ns	
79	TscF	SCK output fall time (master mode)		—	10	25	ns	
80	TscH2doV, TscL2doV	SDO data output valid after SCK edge	**PIC16CXX**	—	—	50	ns	
			PIC16LCXX		—	100	ns	
81	TdoV2scH, TdoV2scL	SDO data output setup to SCK edge		TCY	—	—	ns	

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

Note 1: Specification 73A is only required if specifications 71A and 72A are used.

NOTES:

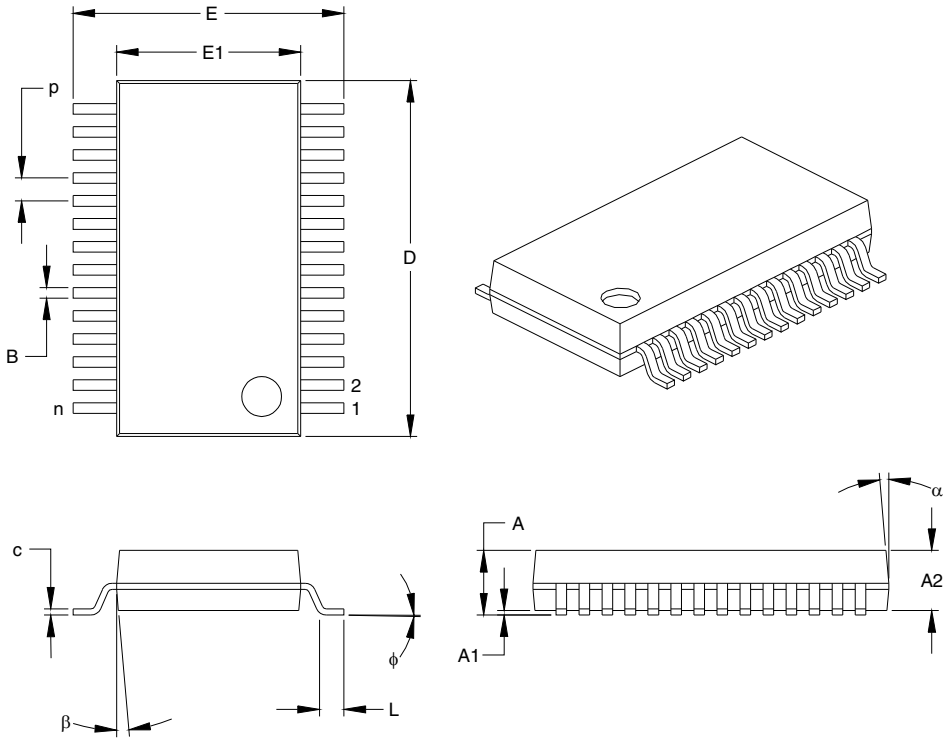
15.3 28-Lead Ceramic Dual In-line with Window (JW) – 300 mil (CERDIP)



Units		INCHES*			MILLIMETERS		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		28			28	
Pitch	p		.100			2.54	
Top to Seating Plane	A	.170	.183	.195	4.32	4.64	4.95
Ceramic Package Height	A2	.155	.160	.165	3.94	4.06	4.19
Standoff	A1	.015	.023	.030	0.38	0.57	0.76
Shoulder to Shoulder Width	E	.300	.313	.325	7.62	7.94	8.26
Ceramic Pkg. Width	E1	.285	.290	.295	7.24	7.37	7.49
Overall Length	D	1.430	1.458	1.485	36.32	37.02	37.72
Tip to Seating Plane	L	.135	.140	.145	3.43	3.56	3.68
Lead Thickness	c	.008	.010	.012	0.20	0.25	0.30
Upper Lead Width	B1	.050	.058	.065	1.27	1.46	1.65
Lower Lead Width	B	.016	.019	.021	0.41	0.47	0.53
Overall Row Spacing	eB	.345	.385	.425	8.76	9.78	10.80
Window Width	W1	.130	.140	.150	3.30	3.56	3.81
Window Length	W2	.290	.300	.310	7.37	7.62	7.87

*Controlling Parameter
JEDEC Equivalent: MO-058
Drawing No. C04-080

15.5 28-Lead Plastic Shrink Small Outline (SS) – 209 mil, 5.30 mm (SSOP)



Units		INCHES			MILLIMETERS*		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		28			28	
Pitch	p		.026			0.66	
Overall Height	A	.068	.073	.078	1.73	1.85	1.98
Molded Package Thickness	A2	.064	.068	.072	1.63	1.73	1.83
Standoff	A1	.002	.006	.010	0.05	0.15	0.25
Overall Width	E	.299	.309	.319	7.59	7.85	8.10
Molded Package Width	E1	.201	.207	.212	5.11	5.25	5.38
Overall Length	D	.396	.402	.407	10.06	10.20	10.34
Foot Length	L	.022	.030	.037	0.56	0.75	0.94
Lead Thickness	c	.004	.007	.010	0.10	0.18	0.25
Foot Angle	φ	0	4	8	0.00	101.60	203.20
Lead Width	B	.010	.013	.015	0.25	0.32	0.38
Mold Draft Angle Top	α	0	5	10	0	5	10
Mold Draft Angle Bottom	β	0	5	10	0	5	10

*Controlling Parameter

Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010” (0.254mm) per side.

JEDEC Equivalent: MS-150

Drawing No. C04-073

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., PIC16CXXX).

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 PIC16CXX 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. Code protection scheme is enhanced such that portions of the program memory can be protected, while the remainder is unprotected.
18. Brown-out protection circuitry has been added. Controlled by configuration word bit BODEN. 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 PIC16CXXX, 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.

