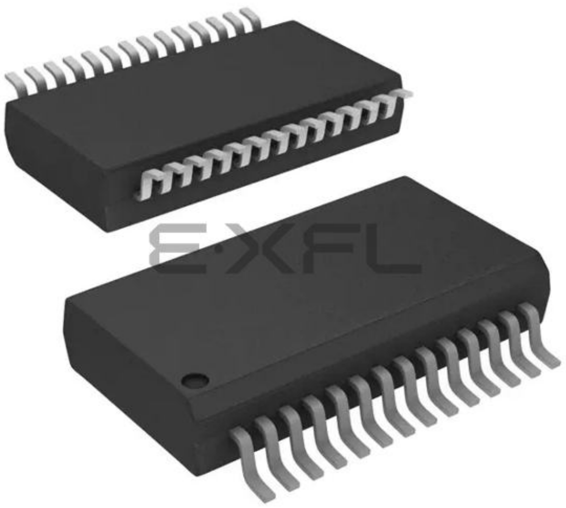

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"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	32MHz
Connectivity	I²C, LINbus, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, LCD, POR, PWM, WDT
Number of I/O	25
Program Memory Size	7KB (4K x 14)
Program Memory Type	FLASH
EEPROM Size	256 x 8
RAM Size	256 x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 3.6V
Data Converters	A/D 11x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	28-SSOP (0.209", 5.30mm Width)
Supplier Device Package	28-SSOP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16lf1933-i-ss

REGISTER 4-2: CONFIG2: CONFIGURATION WORD 2

R/P-1	R/P-1	U-1	R/P-1	R/P-1	R/P-1
LVP(1)	$\overline{\text{DEBUG}}$(3)	—	BORV	STVREN	PLLEN
bit 13					bit 8

U-1	U-1	R/P-1	R/P-1	U-1	U-1	R/P-1	R/P-1
—	—	VCAPEN<1:0>(2)		—	—	WRT<1:0>	
bit 7							bit 0

Legend:		
R = Readable bit	P = Programmable bit	U = Unimplemented bit, read as ‘1’
‘0’ = Bit is cleared	‘1’ = Bit is set	-n = Value when blank or after Bulk Erase

bit 13 **LVP:** Low-Voltage Programming Enable bit(1)
`1` = Low-voltage programming enabled
`0` = High-voltage on $\overline{\text{MCLR}}$ must be used for programming

bit 12 **$\overline{\text{DEBUG}}$:** In-Circuit Debugger Mode bit(3)
`1` = In-Circuit Debugger disabled, ICSPCLK and ICSPDAT are general purpose I/O pins
`0` = In-Circuit Debugger enabled, ICSPCLK and ICSPDAT are dedicated to the debugger

bit 11 **Unimplemented:** Read as ‘`1`’

bit 10 **BORV:** Brown-out Reset Voltage Selection bit(4)
`1` = Brown-out Reset voltage (Vbor), low trip point selected.
`0` = Brown-out Reset voltage (Vbor), high trip point selected.

bit 9 **STVREN:** Stack Overflow/Underflow Reset Enable bit
`1` = Stack Overflow or Underflow will cause a Reset
`0` = Stack Overflow or Underflow will not cause a Reset

bit 8 **PLLEN:** PLL Enable bit
`1` = 4xPLL enabled
`0` = 4xPLL disabled

bit 7-5 **Unimplemented:** Read as ‘`1`’

bit 4 **$\overline{\text{VCAPEN}}$:** Voltage Regulator Capacitor Enable bits(2)
`00` = VCAP functionality is enabled on RA0
`01` = VCAP functionality is enabled on RA5
`10` = VCAP functionality is enabled on RA6
`11` = No capacitor on VCAP pin

bit 3-2 **Unimplemented:** Read as ‘`1`’

bit 1-0 **WRT<1:0>:** Flash Memory Self-Write Protection bits
`00` = VCAP functionality is enabled on RA0
`01` = VCAP functionality is enabled on RA5
`10` = VCAP functionality is enabled on RA6
`11` = No capacitor on VCAP pin

Note 1: The LVP bit cannot be programmed to ‘`0`’ when Programming mode is entered via LVP.
2: Reads as ‘`11`’ on PIC16LF193X only.
3: The $\overline{\text{DEBUG}}$ bit in Configuration Words is managed automatically by device development tools including debuggers and programmers. For normal device operation, this bit should be maintained as a ‘`1`’.
4: See Vbor parameter for specific trip point voltages.

EXAMPLE 11-3: FLASH PROGRAM MEMORY READ

```
* This code block will read 1 word of program
* memory at the memory address:
   PROG_ADDR_HI: PROG_ADDR_LO
*  data will be returned in the variables;
*  PROG_DATA_HI, PROG_DATA_LO

   BANKSEL  EEADRL           ; Select Bank for EEPROM registers
   MOVLW    PROG_ADDR_LO     ;
   MOVWF    EEADRL           ; Store LSB of address
   MOVLW    PROG_ADDR_HI     ;
   MOVWL    EEADRH           ; Store MSB of address

   BCF      EECON1,CFGS      ; Do not select Configuration Space
   BSF      EECON1,EEPGD     ; Select Program Memory
   BCF      INTCON,GIE       ; Disable interrupts
   BSF      EECON1,RD        ; Initiate read
   NOP                       ; Executed (Figure 11-1)
   NOP                       ; Ignored (Figure 11-1)
   BSF      INTCON,GIE       ; Restore interrupts

   MOVF     EEDATL,W         ; Get LSB of word
   MOVWF    PROG_DATA_LO     ; Store in user location
   MOVF     EEDATH,W         ; Get MSB of word
   MOVWF    PROG_DATA_HI     ; Store in user location
```

EXAMPLE 11-5: WRITING TO FLASH PROGRAM MEMORY

```
; This write routine assumes the following:
; 1. The 16 bytes of data are loaded, starting at the address in DATA_ADDR
; 2. Each word of data to be written is made up of two adjacent bytes in DATA_ADDR,
;    stored in little endian format
; 3. A valid starting address (the least significant bits = 000) is loaded in ADDRH:ADDRL
; 4. ADDRH and ADDRL are located in shared data memory 0x70 - 0x7F (common RAM)
;
        BCF         INTCON,GIE      ; Disable ints so required sequences will execute properly
        BANKSEL     EEADRH          ; Bank 3
        MOVF        ADDRH,W         ; Load initial address
        MOVWF       EEADRH          ;
        MOVF        ADDRL,W         ;
        MOVWF       EEADRL          ;
        MOVLW       LOW DATA_ADDR   ; Load initial data address
        MOVWF       FSR0L           ;
        MOVLW       HIGH DATA_ADDR  ; Load initial data address
        MOVWF       FSR0H           ;
        BSF         EECON1,EEPGD    ; Point to program memory
        BCF         EECON1,CFGS     ; Not configuration space
        BSF         EECON1,WREN     ; Enable writes
        BSF         EECON1,LWLO     ; Only Load Write Latches
LOOP
        MOVIW       FSR0++          ; Load first data byte into lower
        MOVWF       EEDATL          ;
        MOVIW       FSR0++          ; Load second data byte into upper
        MOVWF       EEDATH          ;

        MOVF        EEADRL,W        ; Check if lower bits of address are '000'
        XORLW       0x07            ; Check if we're on the last of 8 addresses
        ANDLW       0x07            ;
        BTFSC       STATUS,Z        ; Exit if last of eight words,
        GOTO        START_WRITE     ;

  Required Sequence:
        MOVLW       55h             ; Start of required write sequence:
        MOVWF       EECON2          ; Write 55h
        MOVLW       0AAh            ;
        MOVWF       EECON2          ; Write AAh
        BSF         EECON1,WR       ; Set WR bit to begin write
        NOP                         ; Any instructions here are ignored as processor
                                    ; halts to begin write sequence
        NOP                         ; Processor will stop here and wait for write to complete.

                                    ; After write processor continues with 3rd instruction.

        INCF        EEADRL,F        ; Still loading latches Increment address
        GOTO        LOOP            ; Write next latches

START_WRITE
        BCF         EECON1,LWLO     ; No more loading latches - Actually start Flash program
                                    ; memory write

  Required Sequence:
        MOVLW       55h             ; Start of required write sequence:
        MOVWF       EECON2          ; Write 55h
        MOVLW       0AAh            ;
        MOVWF       EECON2          ; Write AAh
        BSF         EECON1,WR       ; Set WR bit to begin write
        NOP                         ; Any instructions here are ignored as processor
                                    ; halts to begin write sequence
        NOP                         ; Processor will stop here and wait for write complete.

                                    ; after write processor continues with 3rd instruction
        BCF         EECON1,WREN     ; Disable writes
        BSF         INTCON,GIE      ; Enable interrupts
```

11.7 Register Definitions: Data EEPROM Control

REGISTER 11-1: EEDATL: EEPROM DATA LOW BYTE REGISTER

R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u
EEDAT<7:0>							
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7-0 **EEDAT<7:0>**: Read/Write Value for EEPROM Data Byte or Least Significant bits of Program Memory

REGISTER 11-2: EEDATH: EEPROM DATA HIGH BYTE REGISTER

U-0	U-0	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u	R/W-x/u
—	—	EEDAT<13:8>					
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7-6 **Unimplemented:** Read as ‘0’

bit 5-0 **EEDAT<13:8>**: Read/Write Value for Most Significant bits of Program Memory

REGISTER 11-3: EEADRL: EEPROM ADDRESS LOW BYTE REGISTER

R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0
EEADR<7:0>							
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7-0 **EEADR<7:0>**: Specifies the Least Significant bits for Program Memory Address or EEPROM Address

REGISTER 11-4: EEADRH: EEPROM ADDRESS HIGH BYTE REGISTER

U-1	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0
—(1)	EEADR<14:8>						
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7 **Unimplemented:** Read as ‘1’

bit 6-0 **EEADR<14:8>**: Specifies the Most Significant bits for Program Memory Address or EEPROM Address

Note 1: Unimplemented, read as ‘1’.

23.3.7 OPERATION IN SLEEP MODE

In Sleep mode, the TMRx register will not increment and the state of the module will not change. If the CCPx pin is driving a value, it will continue to drive that value. When the device wakes up, TMRx will continue from its previous state.

23.3.8 CHANGES IN SYSTEM CLOCK FREQUENCY

The PWM frequency is derived from the system clock frequency. Any changes in the system clock frequency will result in changes to the PWM frequency. See **Section 5.0 "Oscillator Module (with Fail-Safe Clock Monitor)"** for additional details.

23.3.9 EFFECTS OF RESET

Any Reset will force all ports to Input mode and the CCP registers to their Reset states.

23.3.10 ALTERNATE PIN LOCATIONS

This module incorporates I/O pins that can be moved to other locations with the use of the alternate pin function register, APFCON. To determine which pins can be moved and what their default locations are upon a Reset, see **Section 12.1 "Alternate Pin Function"** for more information.

TABLE 23-8: SUMMARY OF REGISTERS ASSOCIATED WITH STANDARD PWM

Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Register on Page
APFCON	—	CCP3SEL	T1GSEL	P2BSEL	SRNQSEL	C2OUTSEL	SSSEL	CCP2SEL	114
CCPxCON	PxM<1:0>(1)		DCxB<1:0>		CCPxM<3:0>				214
CCPTMRS0	C4TSEL<1:0>		C3TSEL<1:0>		C2TSEL<1:0>		C1TSEL<1:0>		215
CCPTMRS1	—	—	—	—	—	—	C5TSEL<1:0>		215
INTCON	GIE	PEIE	TMR0IE	INTE	IOCIE	TMR0IF	INTF	IOCIF	82
PIE1	TMR1GIE	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	83
PIE2	OSFIE	C2IE	C1IE	EEIE	BCLIE	LCDIE	—	CCP2IE	84
PIE3	—	CCP5IE	CCP4IE	CCP3IE	TMR6IE	—	TMR4IE	—	85
PIR1	TMR1GIF	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	86
PIR2	OSFIF	C2IF	C1IF	EEIF	BCLIF	LCDIF	—	CCP2IF	87
PIR3	—	CCP5IF	CCP4IF	CCP3IF	TMR6IF	—	TMR4IF	—	88
PRx	Timer2/4/6 Period Register								187*
TxCON	—	TxOUTPS<3:0>				TMRxON	TxCKPS<:0>1		189
TMRx	Timer2/4/6 Module Register								187
TRISA	TRISA7	TRISA6	TRISA5	TRISA4	TRISA3	TRISA2	TRISA1	TRISA0	116
TRISB	TRISB7	TRISB6	TRISB5	TRISB4	TRISB3	TRISB2	TRISB1	TRISB0	121
TRISC	TRISC7	TRISC6	TRISC5	TRISC4	TRISC3	TRISC2	TRISC1	TRISC0	125

Legend: — = Unimplemented location, read as '0'. Shaded cells are not used by the PWM.
Note 1: Applies to ECCP modules only.
* Page provides register information.

REGISTER 23-2: CCPTMRS0: PWM TIMER SELECTION CONTROL REGISTER 0

R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0	R/W-0/0
C4TSEL<1:0>		C3TSEL<1:0>		C2TSEL<1:0>		C1TSEL<1:0>	
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7-6 **C4TSEL<1:0>:** CCP4 Timer Selection
11 = Reserved
10 = CCP4 is based off Timer6 in PWM mode
01 = CCP4 is based off Timer4 in PWM mode
00 = CCP4 is based off Timer2 in PWM mode

bit 5-4 **C3TSEL<1:0>:** CCP3 Timer Selection
11 = Reserved
10 = CCP3 is based off Timer6 in PWM mode
01 = CCP3 is based off Timer4 in PWM mode
00 = CCP3 is based off Timer2 in PWM mode

bit 3-2 **C2TSEL<1:0>:** CCP2 Timer Selection
11 = Reserved
10 = CCP2 is based off Timer6 in PWM mode
01 = CCP2 is based off Timer4 in PWM mode
00 = CCP2 is based off Timer2 in PWM mode

bit 1-0 **C1TSEL<1:0>:** CCP1 Timer Selection
11 = Reserved
10 = CCP1 is based off Timer6 in PWM mode
01 = CCP1 is based off Timer4 in PWM mode
00 = CCP1 is based off Timer2 in PWM mode

REGISTER 23-3: CCPTMRS1: PWM TIMER SELECTION CONTROL REGISTER 1

U-0	U-0	U-0	U-0	U-0	U-0	R/W-0/0	R/W-0/0
—	—	—	—	—	—	C5TSEL<1:0>	
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	

bit 7-2 **Unimplemented:** Read as ‘0’

bit 1-0 **C5TSEL<1:0>:** CCP5 Timer Selection bits
11 = Reserved
10 = CCP5 is based off Timer6 in PWM mode
01 = CCP5 is based off Timer4 in PWM mode
00 = CCP5 is based off Timer2 in PWM mode

24.6.5 I2C MASTER MODE REPEATED START CONDITION TIMING

A Repeated Start condition (Figure 24-27) occurs when the RSEN bit of the SSPCON2 register is programmed high and the master state machine is no longer active. When the RSEN bit is set, the SCL pin is asserted low. When the SCL pin is sampled low, the Baud Rate Generator is loaded and begins counting. The SDA pin is released (brought high) for one Baud Rate Generator count (TBRG). When the Baud Rate Generator times out, if SDA is sampled high, the SCL pin will be deasserted (brought high). When SCL is sampled high, the Baud Rate Generator is reloaded and begins counting. SDA and SCL must be sampled high for one TBRG. This action is then followed by assertion of the SDA pin (SDA = 0) for one TBRG while SCL is high. SCL is asserted low. Following this, the RSEN bit of the SSPCON2 register will be automatically cleared and the Baud Rate Generator will not be reloaded, leaving the SDA pin held low. As soon as a Start condition is detected on the SDA and SCL pins, the S bit of the SSPSTAT register will be set. The SSPIF bit will not be set until the Baud Rate Generator has timed out.

Note 1: If RSEN is programmed while any other event is in progress, it will not take effect.

2: A bus collision during the Repeated Start condition occurs if:

- SDA is sampled low when SCL goes from low-to-high.
- SCL goes low before SDA is asserted low. This may indicate that another master is attempting to transmit a data '1'.

FIGURE 24-27: REPEAT START CONDITION WAVEFORM

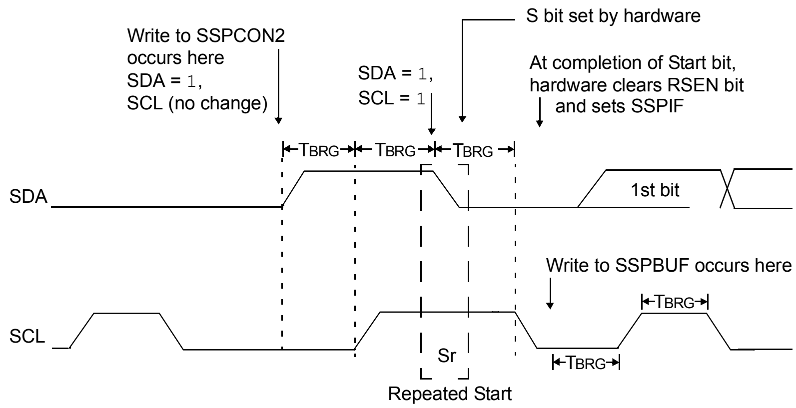
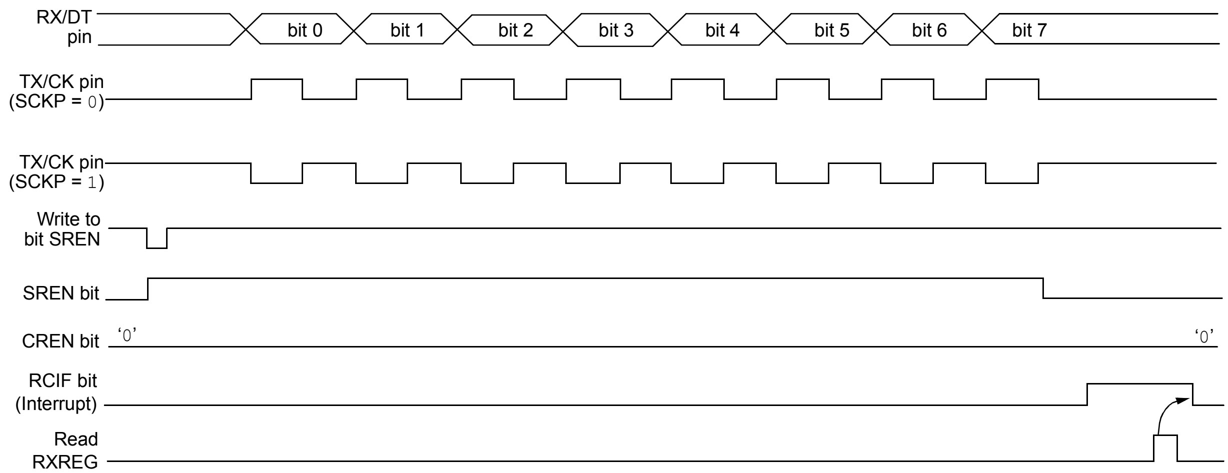


FIGURE 25-12: SYNCHRONOUS RECEPTION (MASTER MODE, SREN)



Note: Timing diagram demonstrates Sync Master mode with bit SREN = 1 and bit BRGH = 0.

TABLE 25-8: SUMMARY OF REGISTERS ASSOCIATED WITH SYNCHRONOUS MASTER RECEPTION

Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Register on Page
BAUDCON	ABDOVF	RCIDL	—	SCKP	BRG16	—	WUE	ABDEN	287
INTCON	GIE	PEIE	TMR0IE	INTE	IOCIE	TMR0IF	INTF	IOCIF	82
PIE1	TMR1GIE	ADIE	RCIE	TXIE	SSPIE	CCP1IE	TMR2IE	TMR1IE	83
PIR1	TMR1GIF	ADIF	RCIF	TXIF	SSPIF	CCP1IF	TMR2IF	TMR1IF	86
RCREG	EUSART Receive Data Register								280*
RCSTA	SPEN	RX9	SREN	CREN	ADDEN	FERR	OERR	RX9D	286
SPBRGL	BRG<7:0>								288*
SPBRGH	BRG<15:8>								288*
TRISC	TRISC7	TRISC6	TRISC5	TRISC4	TRISC3	TRISC2	TRISC1	TRISC0	125
TXSTA	CSRC	TX9	TXEN	SYNC	SENDB	BRGH	TRMT	TX9D	285

Legend: — = unimplemented, read as '0'. Shaded cells are not used for synchronous master reception.
* Page provides register information.

27.1 LCD Registers

The module contains the following registers:

- LCD Control register (LCDCON)
- LCD Phase register (LCDPS)
- LCD Reference Ladder register (LCDRL)
- LCD Contrast Control register (LCDCST)
- LCD Reference Voltage Control register (LCDREF)
- Up to 3 LCD Segment Enable registers (LCDSEn)
- Up to 12 LCD data registers (LCDDATAn)

TABLE 27-1: LCD SEGMENT AND DATA REGISTERS

Device	# of LCD Registers	
	Segment Enable	Data
PIC16(L)F1933	2	8

The LCDCON register (Register 27-1) controls the operation of the LCD driver module. The LCDPS register (Register 27-2) configures the LCD clock source prescaler and the type of waveform; Type-A or Type-B. The LCDSEn registers (Register 27-5) configure the functions of the port pins.

The following LCDSEn registers are available:

- LCDSE0 SE<7:0>
- LCDSE1 SE<15:8>

Once the module is initialized for the LCD panel, the individual bits of the LCDDATAn registers are cleared/set to represent a clear/dark pixel, respectively:

- LCDDATA0 SEG<7:0>COM0
- LCDDATA1 SEG<15:8>COM0
- LCDDATA3 SEG<7:0>COM1
- LCDDATA4 SEG<15:8>COM1
- LCDDATA6 SEG<7:0>COM2
- LCDDATA7 SEG<15:8>COM2
- LCDDATA9 SEG<7:0>COM3
- LCDDATA10 SEG<15:8>COM3

As an example, LCDDATAn is detailed in Register 27-6.

Once the module is configured, the LCDEN bit of the LCDCON register is used to enable or disable the LCD module. The LCD panel can also operate during Sleep by clearing the SLPEN bit of the LCDCON register.

REGISTER 27-3: LCDREF: LCD REFERENCE VOLTAGE CONTROL REGISTER

R/W-0/0	R/W-0/0	R/W-0/0	U-0	R/W-0/0	R/W-0/0	R/W-0/0	U-0
LCDIRE	LCDIRS	LCDIRI	—	VLCD3PE	VLCD2PE	VLCD1PE	—
bit 7							bit 0

Legend:		
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as ‘0’
u = Bit is unchanged	x = Bit is unknown	-n/n = Value at POR and BOR/Value at all other Resets
‘1’ = Bit is set	‘0’ = Bit is cleared	C = Only clearable bit

bit 7 **LCDIRE:** LCD Internal Reference Enable bit
1 = Internal LCD Reference is enabled and connected to the Internal Contrast Control circuit
0 = Internal LCD Reference is disabled

bit 6 **LCDIRS:** LCD Internal Reference Source bit
If LCDIRE = 1:
0 = Internal LCD Contrast Control is powered by V_{DD}
1 = Internal LCD Contrast Control is powered by a 3.072V output of the FVR
If LCDIRE = 0:
Internal LCD Contrast Control is unconnected. LCD bandgap buffer is disabled.

bit 5 **LCDIRI:** LCD Internal Reference Ladder Idle Enable bit
Allows the Internal FVR buffer to shut down when the LCD Reference Ladder is in power mode ‘B’
1 = When the LCD Reference Ladder is in power mode ‘B’, the LCD Internal FVR buffer is disabled
0 = The LCD Internal FVR Buffer ignores the LCD Reference Ladder power mode

bit 4 **Unimplemented:** Read as ‘0’

bit 3 **VLCD3PE:** VLCD3 Pin Enable bit
1 = The VLCD3 pin is connected to the internal bias voltage LCDBIAS3[(1)]
0 = The VLCD3 pin is not connected

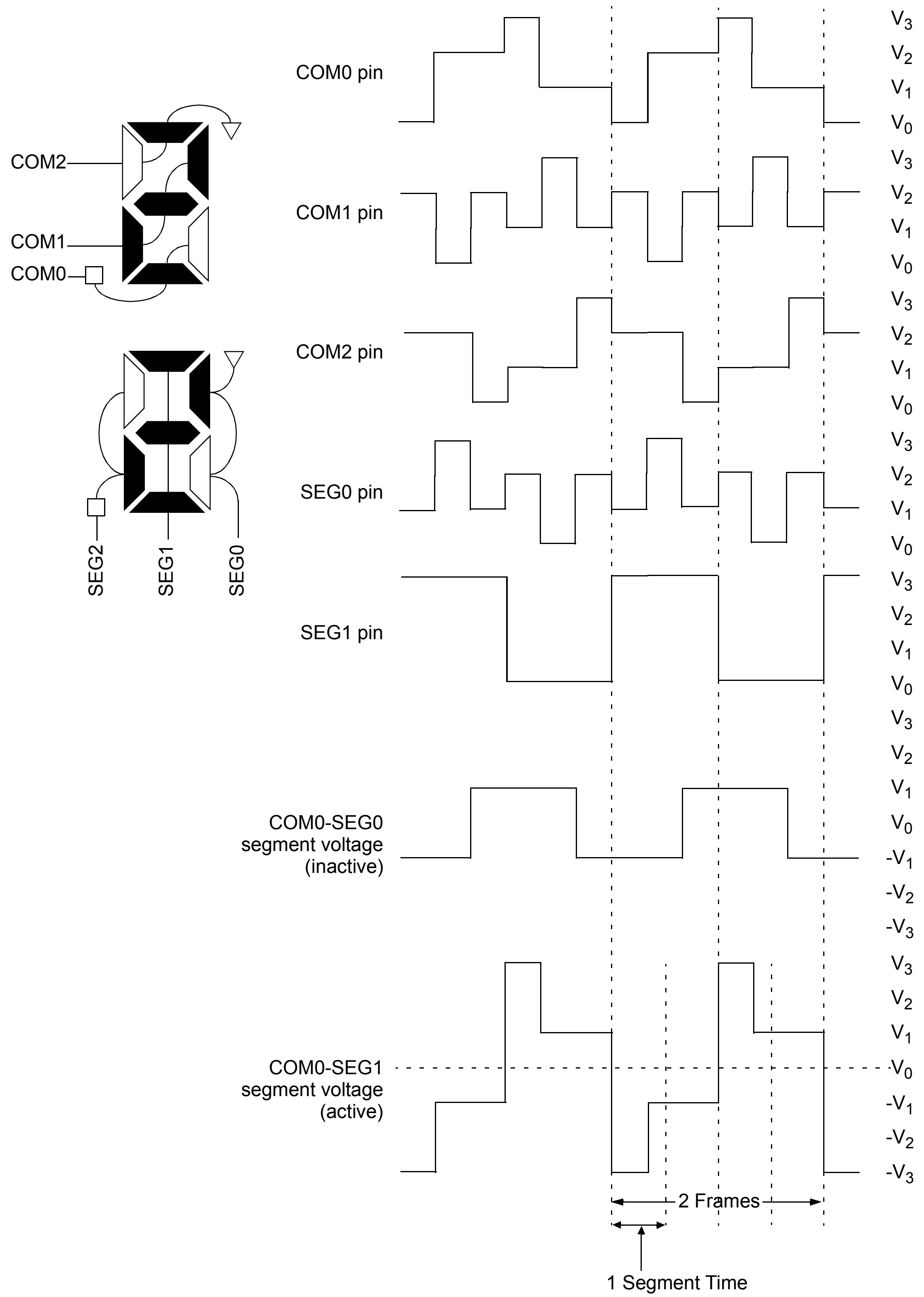
bit 2 **VLCD2PE:** VLCD2 Pin Enable bit
1 = The VLCD2 pin is connected to the internal bias voltage LCDBIAS2[(1)]
0 = The VLCD2 pin is not connected

bit 1 **VLCD1PE:** VLCD1 Pin Enable bit
1 = The VLCD1 pin is connected to the internal bias voltage LCDBIAS1[(1)]
0 = The VLCD1 pin is not connected

bit 0 **Unimplemented:** Read as ‘0’

Note 1: Normal pin controls of TRISx and ANSELx are unaffected.

FIGURE 27-16: TYPE-B WAVEFORMS IN 1/3 MUX, 1/3 BIAS DRIVE



Note: 1 Frame = 2 single segment times.

27.12 Operation During Sleep

The LCD module can operate during Sleep. The selection is controlled by bit SLPEN of the LCDCON register. Setting the SLPEN bit allows the LCD module to go to Sleep. Clearing the SLPEN bit allows the module to continue to operate during Sleep.

If a `SLEEP` instruction is executed and SLPEN = `1`, the LCD module will cease all functions and go into a very low-current consumption mode. The module will stop operation immediately and drive the minimum LCD voltage on both segment and common lines. Figure 27-20 shows this operation.

The LCD module can be configured to operate during Sleep. The selection is controlled by bit SLPEN of the LCDCON register. Clearing SLPEN and correctly configuring the LCD module clock will allow the LCD module to operate during Sleep. Setting SLPEN and correctly executing the LCD module shutdown will disable the LCD module during Sleep and save power.

If a `SLEEP` instruction is executed and SLPEN = `1`, the LCD module will immediately cease all functions, drive the outputs to Vss and go into a very low-current mode. The `SLEEP` instruction should only be executed after the LCD module has been disabled and the current cycle completed, thus ensuring that there are no DC voltages on the glass. To disable the LCD module, clear the LCDEN bit. The LCD module will complete the disabling process after the current frame, clear the LCDA bit and optionally cause an interrupt.

The steps required to properly enter Sleep with the LCD disabled are:

- Clear LCDEN
- Wait for LCDA = `0` either by polling or by interrupt
- Execute `SLEEP`

If SLPEN = `0` and `SLEEP` is executed while the LCD module clock source is FOSC/4, then the LCD module will halt with the pin driving the last LCD voltage pattern. Prolonged exposure to a fixed LCD voltage pattern will cause damage to the LCD glass. To prevent LCD glass damage, either perform the proper LCD module shutdown prior to Sleep, or change the LCD module clock to allow the LCD module to continue operation during Sleep.

If a `SLEEP` instruction is executed and SLPEN = `0` and the LCD module clock is either T1OSC or LFINTOSC, the module will continue to display the current contents of the LCDDATA registers. While in Sleep, the LCD data cannot be changed. If the LCDIE bit is set, the device will wake from Sleep on the next LCD frame boundary. The LCD module current consumption will not decrease in this mode; however, the overall device power consumption will be lower due to the shutdown of the CPU and other peripherals.

Table 27-8 shows the status of the LCD module during a Sleep while using each of the three available clock sources.

Note:	When the LCDEN bit is cleared, the LCD module will be disabled at the completion of frame. At this time, the port pins will revert to digital functionality. To minimize power consumption due to floating digital inputs, the LCD pins should be driven low using the PORT and TRIS registers.

If a `SLEEP` instruction is executed and SLPEN = `0`, the module will continue to display the current contents of the LCDDATA registers. To allow the module to continue operation while in Sleep, the clock source must be either the LFINTOSC or T1OSC external oscillator. While in Sleep, the LCD data cannot be changed. The LCD module current consumption will not decrease in this mode; however, the overall consumption of the device will be lower due to shut down of the core and other peripheral functions.

Table 27-8 shows the status of the LCD module during Sleep while using each of the three available clock sources:

TABLE 27-8: LCD MODULE STATUS DURING SLEEP

Clock Source	SLPEN	Operational During Sleep
T1OSC	0	Yes
	1	No
LFINTOSC	0	Yes
	1	No
FOSC/4	0	No
	1	No

Note:	The LFINTOSC or external T1OSC oscillator must be used to operate the LCD module during Sleep.

If LCD interrupts are being generated (Type-B waveform with a multiplex mode not static) and LCDIE = `1`, the device will awaken from Sleep on the next frame boundary.

29.2 Instruction Descriptions

ADDFSR — Add Literal to FSRn

Syntax:	[*label*] ADDFSR FSRn, k
Operands:	$-32 \leq k \leq 31$ $n \in [0, 1]$
Operation:	$FSR(n) + k \rightarrow FSR(n)$
Status Affected:	None
Description:	The signed 6-bit literal ‘k’ is added to the contents of the FSRnH:FSRnL register pair. FSRn is limited to the range 0000h - FFFFh. Moving beyond these bounds will cause the FSR to wrap-around.

ADDLW — Add literal and W

Syntax:	[*label*] ADDLW k
Operands:	$0 \leq k \leq 255$
Operation:	$(W) + k \rightarrow (W)$
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:	$0 \leq f \leq 127$ $d \in$ [0,1]
Operation:	$(W) + (f) \rightarrow$ (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’.

ADDWFC — ADD W and CARRY bit to f

Syntax:	[*label*] ADDWFC f {,d}
Operands:	$0 \leq f \leq 127$ $d \in$ [0,1]
Operation:	$(W) + (f) + (C) \rightarrow$ dest
Status Affected:	C, DC, Z
Description:	Add W, the Carry flag and data memory location ‘f’. If ‘d’ is ‘0’, the result is placed in W. If ‘d’ is ‘1’, the result is placed in data memory location ‘f’.

ANDLW — AND literal with W

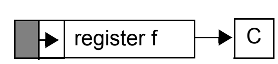
Syntax:	[*label*] ANDLW k
Operands:	$0 \leq k \leq 255$
Operation:	(W) .AND. (k) $\rightarrow$ (W)
Status Affected:	Z
Description:	The contents of W register are AND’ed with the eight-bit literal ‘k’. The result is placed in the W register.

ANDWF — AND W with f

Syntax:	[*label*] ANDWF f,d
Operands:	$0 \leq f \leq 127$ $d \in$ [0,1]
Operation:	(W) .AND. (f) $\rightarrow$ (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’.

ASRF — Arithmetic Right Shift

Syntax:	[*label*] ASRF f {,d}
Operands:	$0 \leq f \leq 127$ $d \in$ [0,1]
Operation:	$(f<7>) \rightarrow dest<7>$ $(f<7:1>) \rightarrow dest<6:0>$, $(f<0>) \rightarrow C$,
Status Affected:	C, Z
Description:	The contents of register ‘f’ are shifted one bit to the right through the Carry flag. The MSb remains unchanged. If ‘d’ is ‘0’, the result is placed in W. If ‘d’ is ‘1’, the result is stored back in register ‘f’.



MOVWI	Move W to INDFn
Syntax:	[*label*] MOVWI ++FSRn [*label*] MOVWI --FSRn [*label*] MOVWI FSRn++ [*label*] MOVWI FSRn-- [*label*] MOVWI k[FSRn]
Operands:	n ∈ [0,1] mm ∈ [00,01, 10, 11] $-32 \leq k \leq 31$
Operation:	W → INDFn Effective address is determined by • FSR + 1 (preincrement) • FSR - 1 (predecrement) • FSR + k (relative offset) After the Move, the FSR value will be either: • FSR + 1 (all increments) • FSR - 1 (all decrements) Unchanged
Status Affected:	None

Mode	Syntax	mm
Preincrement	++FSRn	00
Predecrement	--FSRn	01
Postincrement	FSRn++	10
Postdecrement	FSRn--	11

Description:	This instruction is used to move data between W and one of the indirect registers (INDFn). Before/after this move, the pointer (FSRn) is updated by pre/post incrementing/decrementing it. Note: The INDFn registers are not physical registers. Any instruction that accesses an INDFn register actually accesses the register at the address specified by the FSRn. FSRn is limited to the range 0000h - FFFFh. Incrementing/decrementing it beyond these bounds will cause it to wrap-around. The increment/decrement operation on FSRn WILL NOT affect any Status bits.

NOP	No Operation
Syntax:	[*label*] NOP
Operands:	None
Operation:	No operation
Status Affected:	None
Description:	No operation.
Words:	1
Cycles:	1
Example:	`NOP`

OPTION	Load OPTION_REG Register with W
Syntax:	[*label*] OPTION
Operands:	None
Operation:	(W) → OPTION_REG
Status Affected:	None
Description:	Move data from W register to OPTION_REG register.
Words:	1
Cycles:	1
Example:	`OPTION` Before Instruction OPTION_REG = 0xFF W = 0x4F After Instruction OPTION_REG = 0x4F W = 0x4F

RESET	Software Reset
Syntax:	[*label*] RESET
Operands:	None
Operation:	Execute a device Reset. Resets the $\overline{RI}$ flag of the PCON register.
Status Affected:	None
Description:	This instruction provides a way to execute a hardware Reset by software.

30.8 AC Characteristics: PIC16(L)F1933-I/E

FIGURE 30-6: CLOCK TIMING

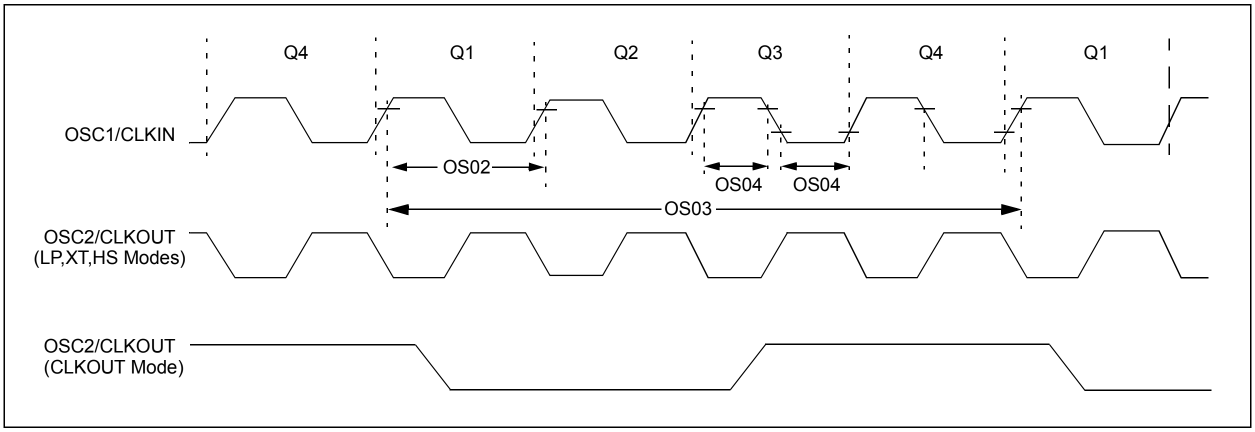


TABLE 30-1: CLOCK OSCILLATOR TIMING REQUIREMENTS

Standard Operating Conditions (unless otherwise stated)
Operating temperature -40°C ≤ TA ≤ +125°C

Param No.	Sym.	Characteristic	Min.	Typ†	Max.	Units	Conditions
OS01	FOSC	External CLKIN Frequency(1)	DC	—	0.5	MHz	EC Oscillator mode (low)
			DC	—	4	MHz	EC Oscillator mode (medium)
			DC	—	20	MHz	EC Oscillator mode (high)
		Oscillator Frequency(1)	—	32.768	—	kHz	LP Oscillator mode
			0.1	—	4	MHz	XT Oscillator mode
			1	—	4	MHz	HS Oscillator mode
			1	—	20	MHz	HS Oscillator mode, VDD > 2.7V
			DC	—	4	MHz	RC Oscillator mode, VDD > 2.0V
OS02	TOSC	External CLKIN Period(1)	27	—	∞	μs	LP Oscillator mode
			250	—	∞	ns	XT Oscillator mode
			50	—	∞	ns	HS Oscillator mode
			50	—	∞	ns	EC Oscillator mode
		Oscillator Period(1)	—	30.5	—	μs	LP Oscillator mode
			250	—	10,000	ns	XT Oscillator mode
			50	—	1,000	ns	HS Oscillator mode
			250	—	—	ns	RC Oscillator mode
OS03	TCY	Instruction Cycle Time(1)	200	TCY	DC	ns	TCY = 4/FOSC
OS04*	TosH, TosL	External CLKIN High, External CLKIN Low	2	—	—	μs	LP oscillator
			100	—	—	ns	XT oscillator
			20	—	—	ns	HS oscillator
OS05*	TosR, TosF	External CLKIN Rise, External CLKIN Fall	0	—	∞	ns	LP oscillator
			0	—	∞	ns	XT oscillator
			0	—	∞	ns	HS oscillator

* These parameters are characterized but not tested.

† Data in "Typ" column is at 3.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: Instruction cycle period (TCY) equals four times the input oscillator time base period. All specified values are based on characterization data for that particular oscillator type under standard operating conditions with the device executing code. Exceeding these specified limits may result in an unstable oscillator operation and/or higher than expected current consumption. All devices are tested to operate at "min" values with an external clock applied to OSC1 pin. When an external clock input is used, the "max" cycle time limit is "DC" (no clock) for all devices.

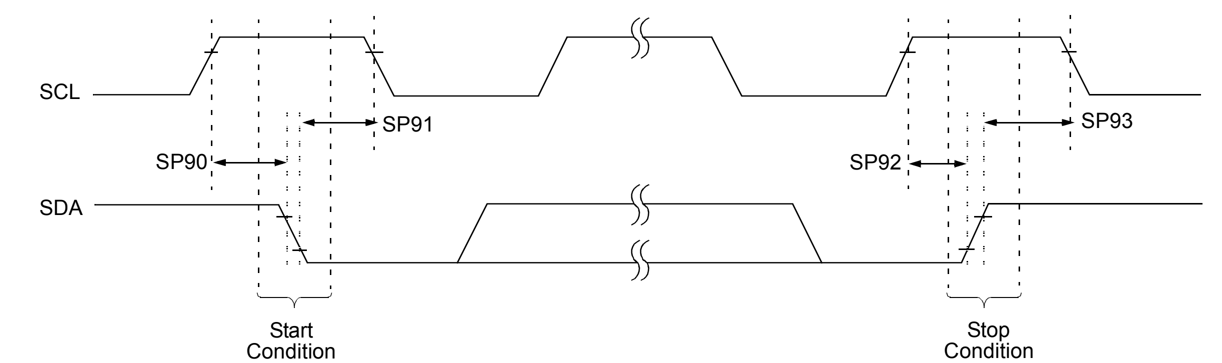
TABLE 30-14: SPI MODE REQUIREMENTS

Param No.	Symbol	Characteristic		Min.	Typ†	Max.	Units	Conditions
SP70*	TssL2scH, TssL2scL	$\overline{SS}$↓ to SCK↓ or SCK↑ input		Tcy	—	—	ns	
SP71*	TscH	SCK input high time (Slave mode)		Tcy + 20	—	—	ns	
SP72*	TscL	SCK input low time (Slave mode)		Tcy + 20	—	—	ns	
SP73*	TdiV2scH, TdiV2scL	Setup time of SDI data input to SCK edge		100	—	—	ns	
SP74*	TscH2diL, TscL2diL	Hold time of SDI data input to SCK edge		100	—	—	ns	
SP75*	TdoR	SDO data output rise time	3.0-5.5V	—	10	25	ns	
			1.8-5.5V	—	25	50	ns	
SP76*	TdoF	SDO data output fall time		—	10	25	ns	
SP77*	TssH2doZ	$\overline{SS}$↑ to SDO output high-impedance		10	—	50	ns	
SP78*	TscR	SCK output rise time (Master mode)	3.0-5.5V	—	10	25	ns	
			1.8-5.5V	—	25	50	ns	
SP79*	TscF	SCK output fall time (Master mode)		—	10	25	ns	
SP80*	TscH2doV, TscL2doV	SDO data output valid after SCK edge	3.0-5.5V	—	—	50	ns	
			1.8-5.5V	—	—	145	ns	
SP81*	TdoV2scH, TdoV2scL	SDO data output setup to SCK edge		Tcy	—	—	ns	
SP82*	TssL2doV	SDO data output valid after $\overline{SS}$↓ edge		—	—	50	ns	
SP83*	TscH2ssH, TscL2ssH	$\overline{SS}$ ↑ after SCK edge		1.5Tcy + 40	—	—	ns	

* These parameters are characterized but not tested.

† Data in “Typ” column is at 3.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

FIGURE 30-20: I²C™ BUS START/STOP BITS TIMING



Note: Refer to Figure 30-5 for load conditions.

FIGURE 31-19: IDD, MFINTOSC MODE, FOSC = 500 kHz, PIC16LF1933 ONLY

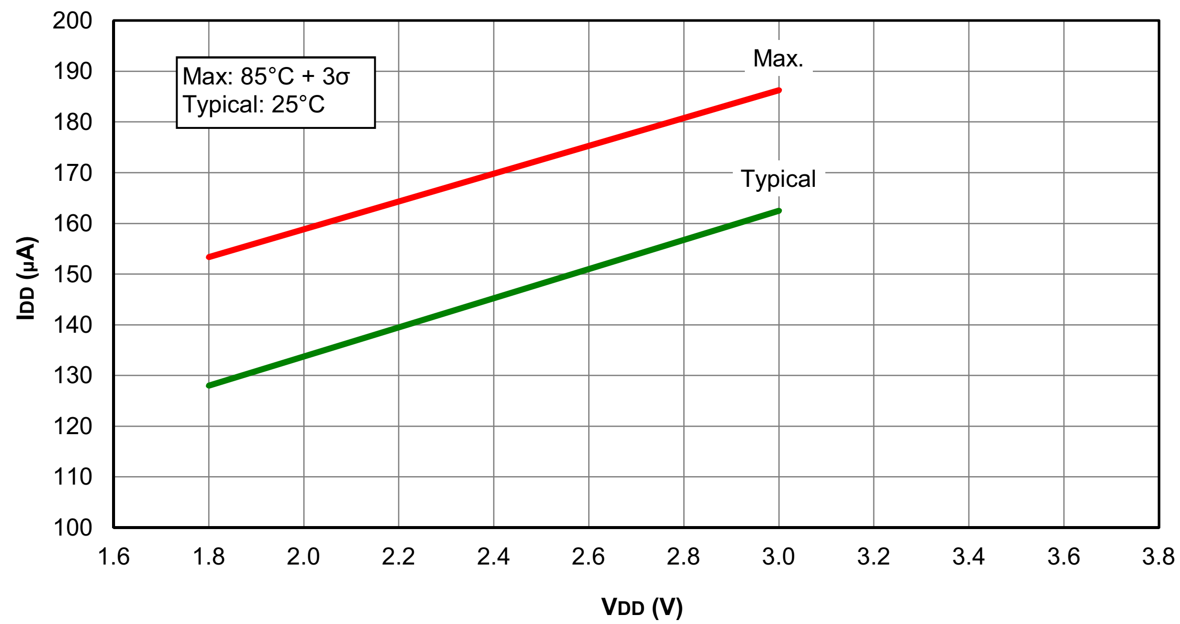


FIGURE 31-20: IDD, MFINTOSC MODE, FOSC = 500 kHz, PIC16F1933 ONLY

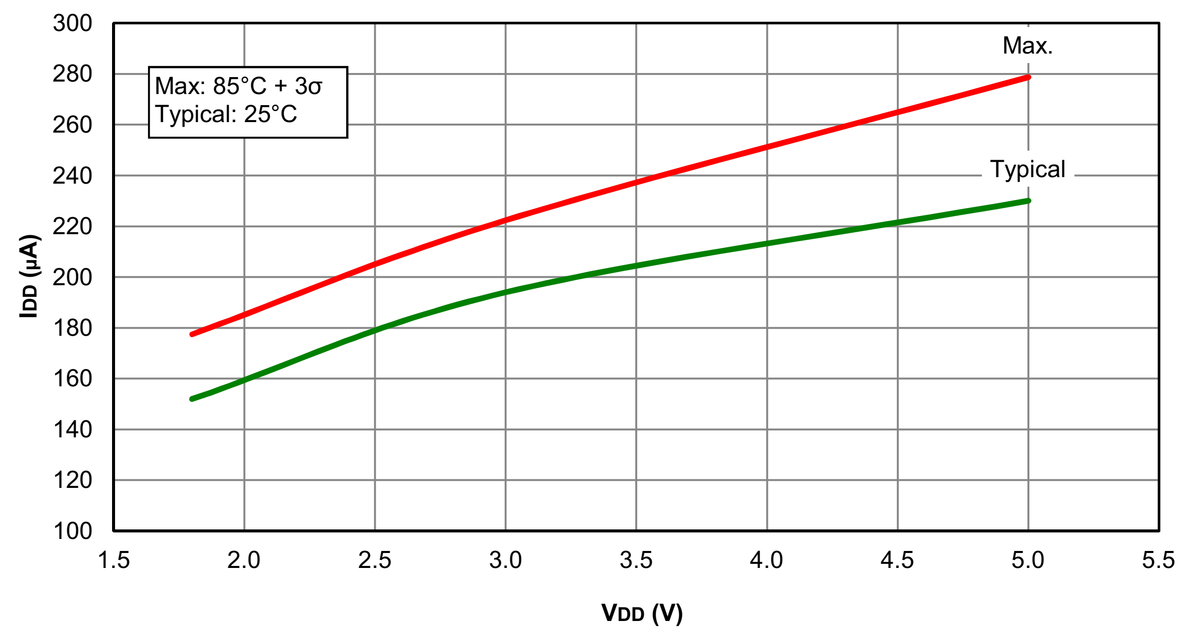


FIGURE 31-63: COMPARATOR HYSTERESIS, NORMAL-POWER MODE, CxSP = 1, CxHYS = 1

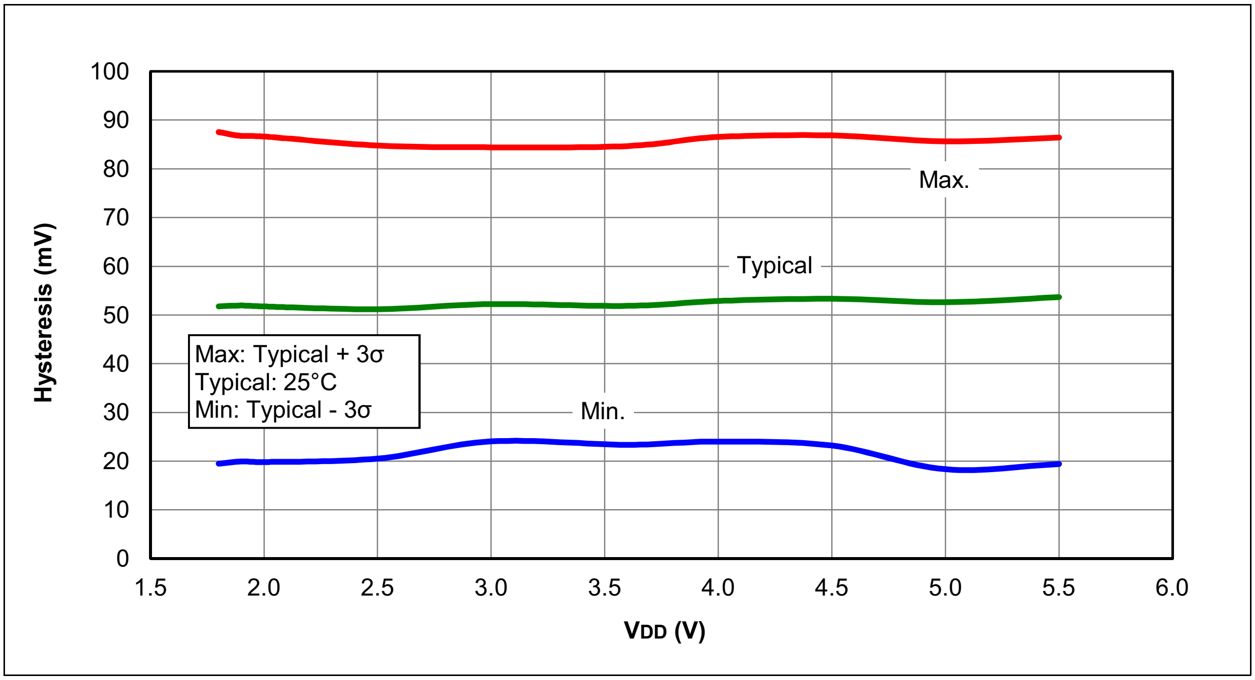
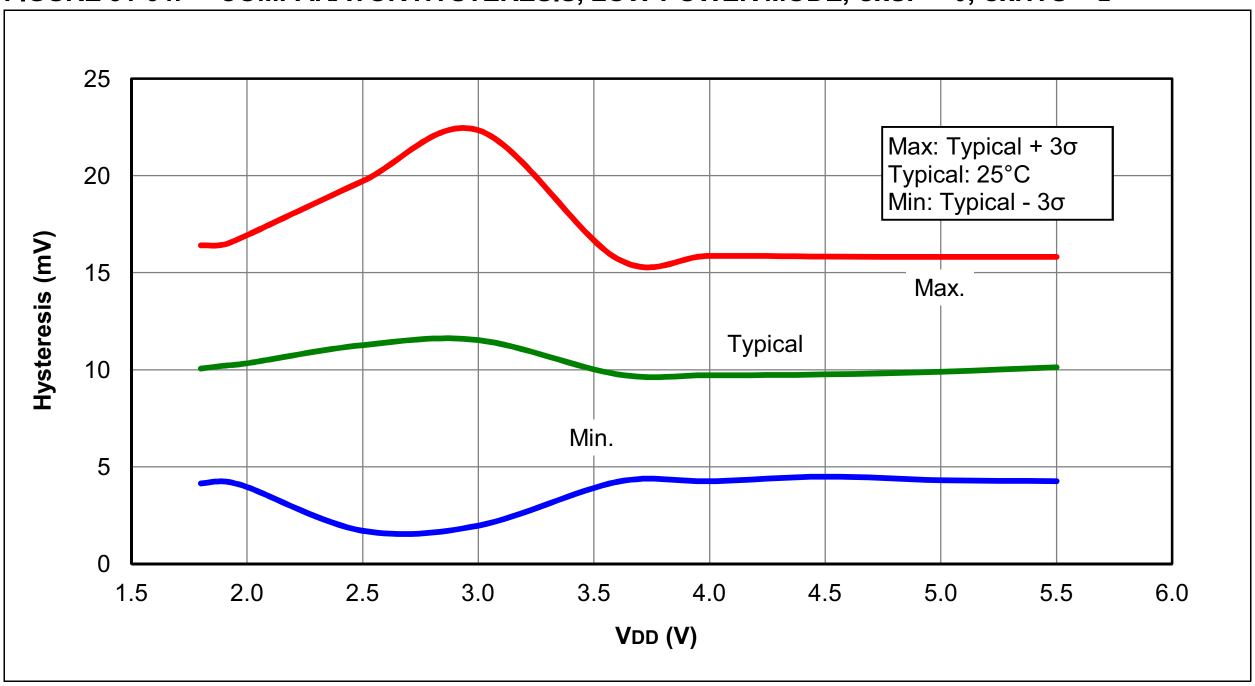
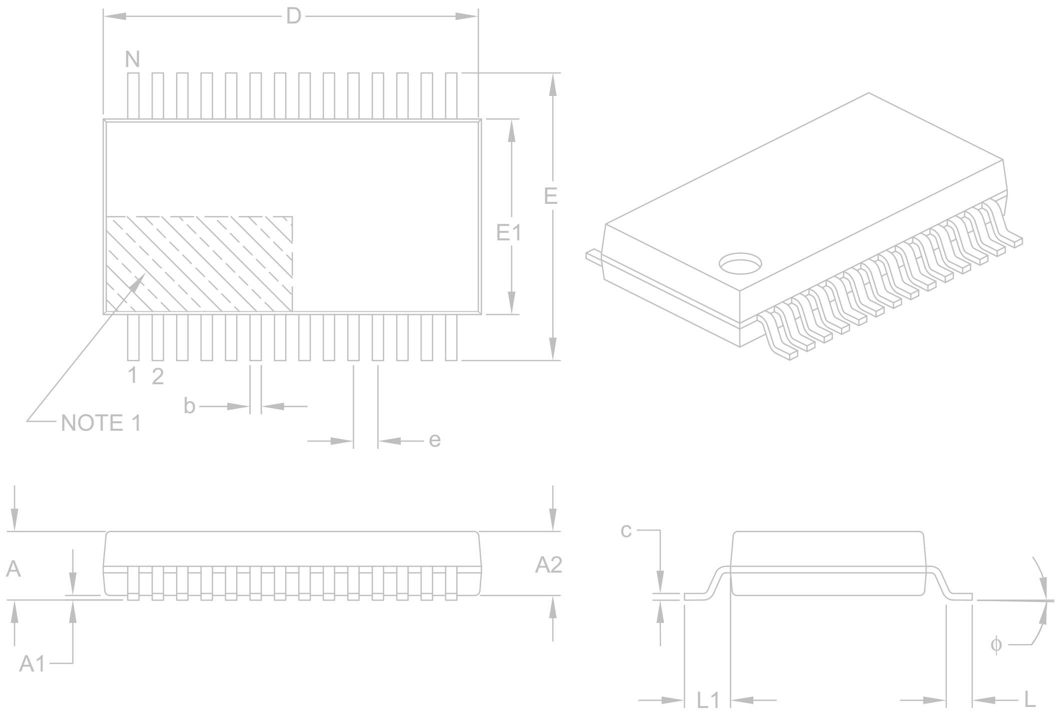


FIGURE 31-64: COMPARATOR HYSTERESIS, LOW-POWER MODE, CxSP = 0, CxHYS = 1



28-Lead Plastic Shrink Small Outline (SS) – 5.30 mm Body [SSOP]

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N	28		
Pitch	e	0.65 BSC		
Overall Height	A	–	–	2.00
Molded Package Thickness	A2	1.65	1.75	1.85
Standoff	A1	0.05	–	–
Overall Width	E	7.40	7.80	8.20
Molded Package Width	E1	5.00	5.30	5.60
Overall Length	D	9.90	10.20	10.50
Foot Length	L	0.55	0.75	0.95
Footprint	L1	1.25 REF		
Lead Thickness	c	0.09	–	0.25
Foot Angle	φ	0°	4°	8°
Lead Width	b	0.22	–	0.38

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.20 mm per side.
3. Dimensioning and tolerancing per ASME Y14.5M.

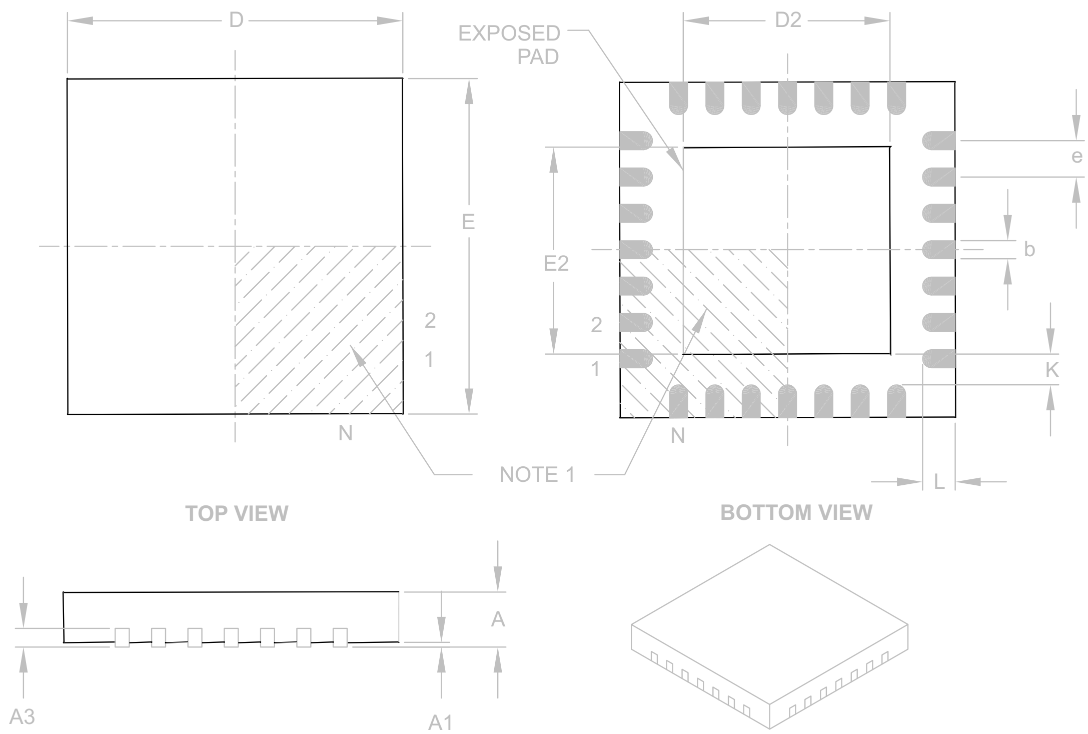
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-073B

28-Lead Plastic Quad Flat, No Lead Package (ML) – 6x6 mm Body [QFN] with 0.55 mm Contact Length

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N		28	
Pitch	e		0.65 BSC	
Overall Height	A	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Contact Thickness	A3		0.20 REF	
Overall Width	E		6.00 BSC	
Exposed Pad Width	E2	3.65	3.70	4.20
Overall Length	D		6.00 BSC	
Exposed Pad Length	D2	3.65	3.70	4.20
Contact Width	b	0.23	0.30	0.35
Contact Length	L	0.50	0.55	0.70
Contact-to-Exposed Pad	K	0.20	–	–

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated.
3. Dimensioning and tolerancing per ASME Y14.5M.

   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-105B