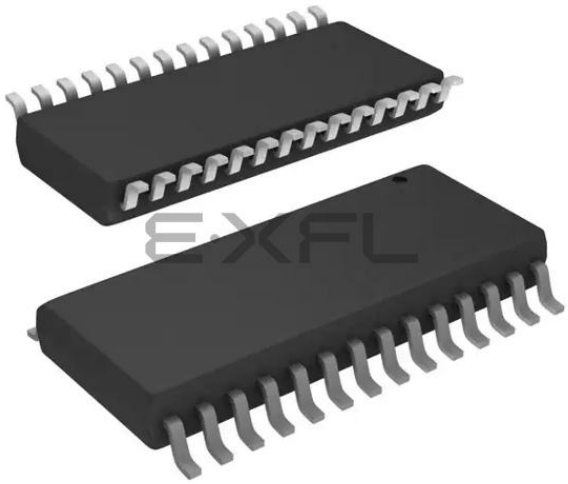
Microchip Technology - PIC16LF1936-I/SO Datasheet



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What is "Embedded - Microcontrollers"?

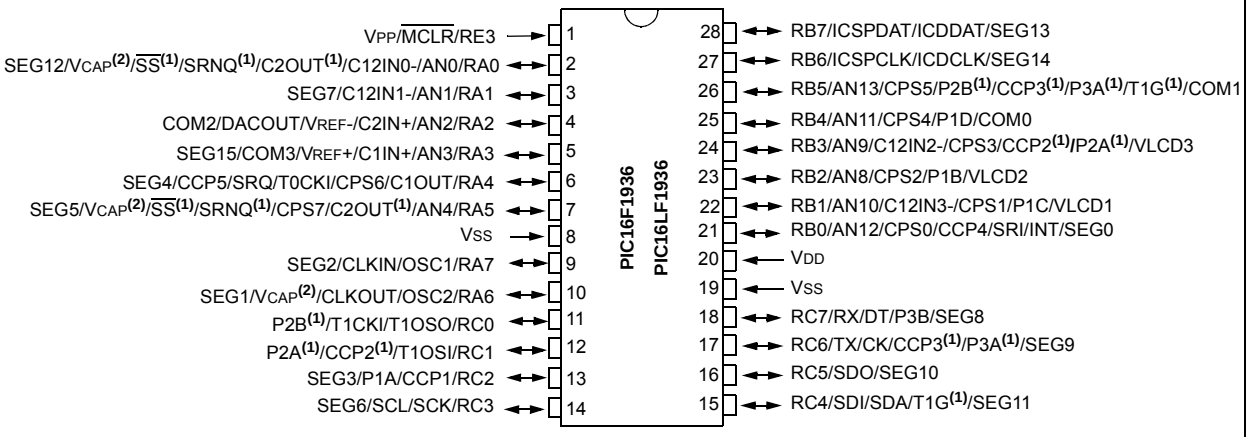
"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" 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	14KB (8K x 14)
Program Memory Type	FLASH
EEPROM Size	256 x 8
RAM Size	512 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-SOIC (0.295", 7.50mm Width)
Supplier Device Package	28-SOIC
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16lf1936-i-so

Pin Diagram – 28-Pin SPDIP/SOIC/SSOP (PIC16(L)F1936)

28-pin SPDIP, SOIC, SSOP



Note 1: Pin function is selectable via the APFCON register.

2: PIC16F1936 devices only.

TABLE 3-11: PIC16(L)F1934/6/7 MEMORY MAP, BANK 31

Bank 31	
F8Ch	Unimplemented Read as '0'
FE3h	
FE4h	STATUS_SHAD
FE5h	WREG_SHAD
FE6h	BSR_SHAD
FE7h	PCLATH_SHAD
FE8h	FSR0L_SHAD
FE9h	FSR0H_SHAD
FEAh	FSR1L_SHAD
FEBh	FSR1H_SHAD
FECh	—
FEDh	STKPTR
FEEh	TOSL
FEFh	TOSH

Legend: = Unimplemented data memory locations, read as '0'.

3.2.6 SPECIAL FUNCTION REGISTERS SUMMARY

The Special Function Register Summary for the device family are as follows:

Device	Bank(s)	Page No.
PIC16(L)F1934/6/7	0	39
	1	40
	2	41
	3	42
	4	43
	5	44
	6	45
	7	46
	8	47
	9-14	48
	15	49
	16-30	51
	31	52

TABLE 3-12: SPECIAL FUNCTION REGISTER SUMMARY (CONTINUED)

Address	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
Bank 8											
400h(2)	INDF0	Addressing this location uses contents of FSR0H/FSR0L to address data memory (not a physical register)								xxxx xxxx	xxxx xxxx
401h(2)	INDF1	Addressing this location uses contents of FSR1H/FSR1L to address data memory (not a physical register)								xxxx xxxx	xxxx xxxx
402h(2)	PCL	Program Counter (PC) Least Significant Byte								0000 0000	0000 0000
403h(2)	STATUS	—	—	—	$\overline{TO}$	$\overline{PD}$	Z	DC	C	---1 1000	---q quuu
404h(2)	FSR0L	Indirect Data Memory Address 0 Low Pointer								0000 0000	uuuu uuuu
405h(2)	FSR0H	Indirect Data Memory Address 0 High Pointer								0000 0000	0000 0000
406h(2)	FSR1L	Indirect Data Memory Address 1 Low Pointer								0000 0000	uuuu uuuu
407h(2)	FSR1H	Indirect Data Memory Address 1 High Pointer								0000 0000	0000 0000
408h(2)	BSR	—	—	—	BSR<4:0>					---0 0000	---0 0000
409h(2)	WREG	Working Register								0000 0000	uuuu uuuu
40Ah(1, 2)	PCLATH	—	Write Buffer for the upper 7 bits of the Program Counter							-000 0000	-000 0000
40Bh(2)	INTCON	GIE	PEIE	TMR0IE	INTE	IOCIE	TMR0IF	INTF	IOCIF	0000 0000	0000 0000
40Ch	—	Unimplemented								—	—
40Dh	—	Unimplemented								—	—
40Eh	—	Unimplemented								—	—
40Fh	—	Unimplemented								—	—
410h	—	Unimplemented								—	—
411h	—	Unimplemented								—	—
412h	—	Unimplemented								—	—
413h	—	Unimplemented								—	—
414h	—	Unimplemented								—	—
415h	TMR4	Timer4 Module Register								0000 0000	0000 0000
416h	PR4	Timer4 Period Register								1111 1111	1111 1111
417h	T4CON	—	T4OUTPS<3:0>				TMR4ON	T4CKPS<1:0>		-000 0000	-000 0000
418h	—	Unimplemented								—	—
419h	—	Unimplemented								—	—
41Ah	—	Unimplemented								—	—
41Bh	—	Unimplemented								—	—
41Ch	TMR6	Timer6 Module Register								0000 0000	0000 0000
41Dh	PR6	Timer6 Period Register								1111 1111	1111 1111
41Eh	T6CON	—	T6OUTPS<3:0>				TMR6ON	T6CKPS<1:0>		-000 0000	-000 0000
41Fh	—	Unimplemented								—	—

Legend: x = unknown, u = unchanged, q = value depends on condition, - = unimplemented, read as '0', r = reserved. Shaded locations are unimplemented, read as '0'.

Note 1: The upper byte of the program counter is not directly accessible. PCLATH is a holding register for the PC<14:8>, whose contents are transferred to the upper byte of the program counter.

2: These registers can be addressed from any bank.

3: These registers/bits are not implemented on PIC16(L)F1936 devices, read as '0'.

4: Unimplemented, read as '1'.

TABLE 3-12: SPECIAL FUNCTION REGISTER SUMMARY (CONTINUED)

Address	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
Bank 15 (Continued)											
7A6h	LCDDATA6	SEG7 COM2	SEG6 COM2	SEG5 COM2	SEG4 COM2	SEG3 COM2	SEG2 COM2	SEG1 COM2	SEG0 COM2	xxxx xxxx	uuuu uuuu
7A7h	LCDDATA7	SEG15 COM2	SEG14 COM2	SEG13 COM2	SEG12 COM2	SEG11 COM2	SEG10 COM2	SEG9 COM2	SEG8 COM2	xxxx xxxx	uuuu uuuu
7A8h	LCDDATA8(3)	SEG23 COM2	SEG22 COM2	SEG21 COM2	SEG20 COM2	SEG19 COM2	SEG18 COM2	SEG17 COM2	SEG16 COM2	xxxx xxxx	uuuu uuuu
7A9h	LCDDATA9	SEG7 COM3	SEG6 COM3	SEG5 COM3	SEG4 COM3	SEG3 COM3	SEG2 COM3	SEG1 COM3	SEG0 COM3	xxxx xxxx	uuuu uuuu
7AAh	LCDDATA10	SEG15 COM3	SEG14 COM3	SEG13 COM3	SEG12 COM3	SEG11 COM3	SEG10 COM3	SEG9 COM3	SEG8 COM3	xxxx xxxx	uuuu uuuu
7ABh	LCDDATA11(3)	SEG23 COM3	SEG22 COM3	SEG21 COM3	SEG20 COM3	SEG19 COM3	SEG18 COM3	SEG17 COM3	SEG16 COM3	xxxx xxxx	uuuu uuuu
7ACh — 7EFh	—	Unimplemented								—	—

Legend: x = unknown, u = unchanged, q = value depends on condition, - = unimplemented, read as '0', r = reserved. Shaded locations are unimplemented, read as '0'.

Note 1: The upper byte of the program counter is not directly accessible. PCLATH is a holding register for the PC<14:8>, whose contents are transferred to the upper byte of the program counter.

2: These registers can be addressed from any bank.

3: These registers/bits are not implemented on PIC16(L)F1936 devices, read as '0'.

4: Unimplemented, read as '1'.

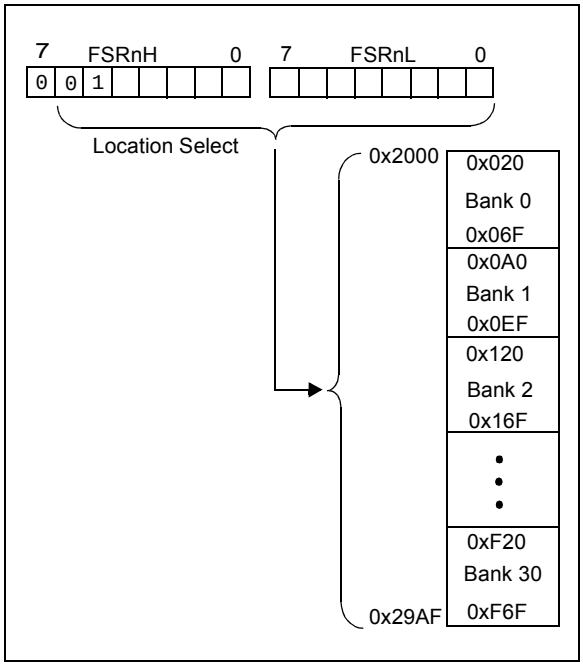
3.5.2 LINEAR DATA MEMORY

The linear data memory is the region from FSR address 0x2000 to FSR address 0x29AF. This region is a virtual region that points back to the 80-byte blocks of GPR memory in all the banks.

Unimplemented memory reads as 0x00. Use of the linear data memory region allows buffers to be larger than 80 bytes because incrementing the FSR beyond one bank will go directly to the GPR memory of the next bank.

The 16 bytes of common memory are not included in the linear data memory region.

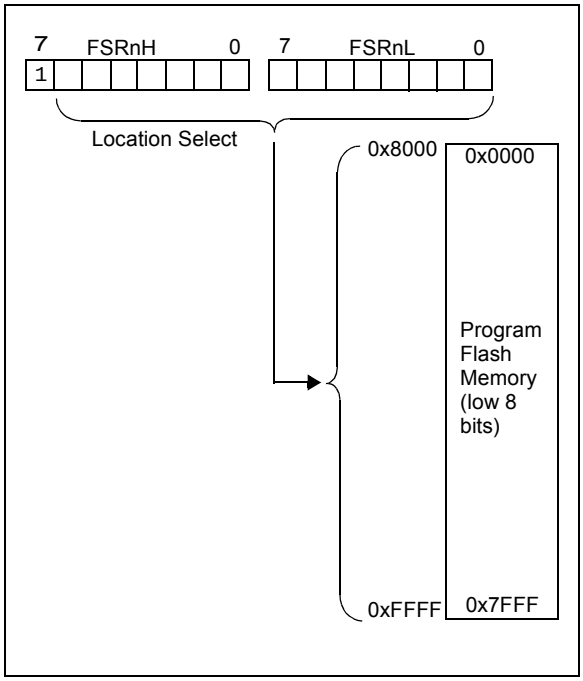
FIGURE 3-11: LINEAR DATA MEMORY MAP



3.5.3 PROGRAM FLASH MEMORY

To make constant data access easier, the entire program Flash memory is mapped to the upper half of the FSR address space. When the MSB of FSRnH is set, the lower 15 bits are the address in program memory which will be accessed through INDF. Only the lower 8 bits of each memory location is accessible via INDF. Writing to the program Flash memory cannot be accomplished via the FSR/INDF interface. All instructions that access program Flash memory via the FSR/INDF interface will require one additional instruction cycle to complete.

FIGURE 3-12: PROGRAM FLASH MEMORY MAP



REGISTER 4-1: CONFIGURATION WORD 1 (CONTINUED)

bit 2-0 **FOSC<2:0>:** Oscillator Selection bits
- 111 = ECH: External Clock, High-Power mode: CLKIN on RA7/OSC1/CLKIN
- 110 = ECM: External Clock, Medium-Power mode: CLKIN on RA7/OSC1/CLKIN
- 101 = ECL: External Clock, Low-Power mode: CLKIN on RA7/OSC1/CLKIN
- 100 = INTOSC oscillator: I/O function on RA7/OSC1/CLKIN
- 011 = EXTRC oscillator: RC function on RA7/OSC1/CLKIN
- 010 = HS oscillator: High-speed crystal/resonator on RA6/OSC2/CLKOUT pin and RA7/OSC1/CLKIN
- 001 = XT oscillator: Crystal/resonator on RA6/OSC2/CLKOUT pin and RA7/OSC1/CLKIN
- 000 = LP oscillator: Low-power crystal on RA6/OSC2/CLKOUT pin and RA7/OSC1/CLKIN

Note 1: Enabling Brown-out Reset does not automatically enable Power-up Timer.
2: The entire data EEPROM will be erased when the code protection is turned off during an erase.
3: The entire program memory will be erased when the code protection is turned off.

REGISTER 15-5: ADRESH: ADC RESULT REGISTER HIGH (ADRESH) ADFM = 1

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
—	—	—	—	—	—	ADRES<9:8>	
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 7-2 **Reserved**: Do not use.

bit 1-0 **ADRES<9:8>**: ADC Result Register bits
Upper 2 bits of 10-bit conversion result

REGISTER 15-6: ADRESL: ADC RESULT REGISTER LOW (ADRESL) ADFM = 1

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
ADRES<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 **ADRES<7:0>**: ADC Result Register bits
Lower 8 bits of 10-bit conversion result

16.0 TEMPERATURE INDICATOR MODULE

This family of devices is equipped with a temperature circuit designed to measure the operating temperature of the silicon die. The circuit's range of operating temperature falls between -40°C and +85°C. The output is a voltage that is proportional to the device temperature. The output of the temperature indicator is internally connected to the device ADC.

The circuit may be used as a temperature threshold detector or a more accurate temperature indicator, depending on the level of calibration performed. A one-point calibration allows the circuit to indicate a temperature closely surrounding that point. A two-point calibration allows the circuit to sense the entire range of temperature more accurately. Reference Application Note AN1333, "*Use and Calibration of the Internal Temperature Indicator*" (DS01333) for more details regarding the calibration process.

16.1 Circuit Operation

Figure 16-1 shows a simplified block diagram of the temperature circuit. The proportional voltage output is achieved by measuring the forward voltage drop across multiple silicon junctions.

Equation 16-1 describes the output characteristics of the temperature indicator.

EQUATION 16-1: VOUT RANGES

High Range: $V_{OUT} = V_{DD} - 4V_T$

Low Range: $V_{OUT} = V_{DD} - 2V_T$

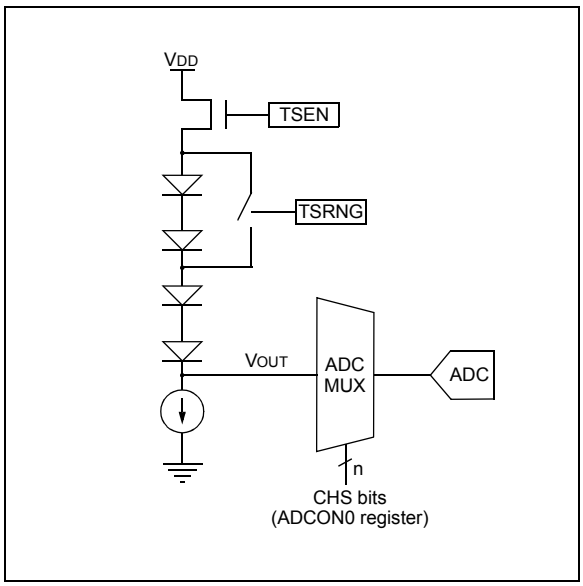
The temperature sense circuit is integrated with the Fixed Voltage Reference (FVR) module. See **Section 14.0 "Fixed Voltage Reference (FVR)"** for more information.

The circuit is enabled by setting the TSEN bit of the FVRCON register. When disabled, the circuit draws no current.

The circuit operates in either high or low range. The high range, selected by setting the TSRNG bit of the FVRCON register, provides a wider output voltage. This provides more resolution over the temperature range, but may be less consistent from part to part. This range requires a higher bias voltage to operate and thus, a higher VDD is needed.

The low range is selected by clearing the TSRNG bit of the FVRCON register. The low range generates a lower voltage drop and thus, a lower bias voltage is needed to operate the circuit. The low range is provided for low voltage operation.

FIGURE 16-1: TEMPERATURE CIRCUIT DIAGRAM



16.2 Minimum Operating VDD vs. Minimum Sensing Temperature

When the temperature circuit is operated in low range, the device may be operated at any operating voltage that is within specifications.

When the temperature circuit is operated in high range, the device operating voltage, VDD, must be high enough to ensure that the temperature circuit is correctly biased.

Table 16-1 shows the recommended minimum VDD vs. range setting.

TABLE 16-1: RECOMMENDED VDD VS. RANGE

Min. VDD, TSRNG = 1	Min. VDD, TSRNG = 0
3.6V	1.8V

16.3 Temperature Output

The output of the circuit is measured using the internal Analog-to-Digital Converter. A channel is reserved for the temperature circuit output. Refer to **Section 16.0 "Analog-to-Digital Converter (ADC) Module"** for detailed information.

16.4 ADC Acquisition Time

To ensure accurate temperature measurements, the user must wait at least 200 μs after the ADC input multiplexer is connected to the temperature indicator output before the conversion is performed. In addition, the user must wait 200 μs between sequential conversions of the temperature indicator output.

22.5 Timer2/4/6 Control Register

REGISTER 22-1: TXCON: TIMER2/TIMER4/TIMER6 CONTROL REGISTER

U-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
—	TOUTPS<3:0>				TMRxON	TxCKPS<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 **Unimplemented:** Read as '0'

bit 6-3 **TOUTPS<3:0>:** Timer Output Postscaler Select bits

0000 = 1:1 Postscaler
0001 = 1:2 Postscaler
0010 = 1:3 Postscaler
0011 = 1:4 Postscaler
0100 = 1:5 Postscaler
0101 = 1:6 Postscaler
0110 = 1:7 Postscaler
0111 = 1:8 Postscaler
1000 = 1:9 Postscaler
1001 = 1:10 Postscaler
1010 = 1:11 Postscaler
1011 = 1:12 Postscaler
1100 = 1:13 Postscaler
1101 = 1:14 Postscaler
1110 = 1:15 Postscaler
1111 = 1:16 Postscaler

bit 2 **TMRxON:** Timerx On bit

1 = Timerx is on
0 = Timerx is off

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

00 = Prescaler is 1
01 = Prescaler is 4
10 = Prescaler is 16
11 = Prescaler is 64

23.4.2 FULL-BRIDGE MODE

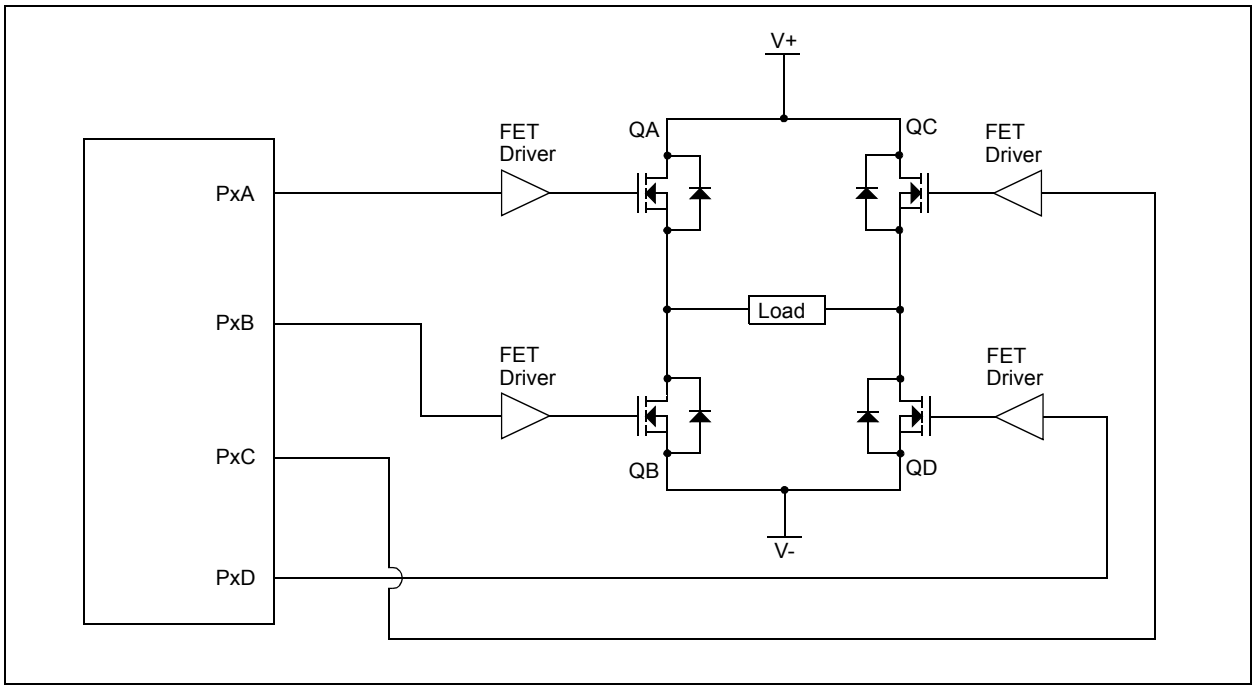
In Full-Bridge mode, all four pins are used as outputs. An example of Full-Bridge application is shown in Figure 23-10.

In the Forward mode, pin CCPx/PxA is driven to its active state, pin PxD is modulated, while PxB and PxC will be driven to their inactive state as shown in Figure 23-11.

In the Reverse mode, PxC is driven to its active state, pin PxB is modulated, while PxA and PxD will be driven to their inactive state as shown Figure 23-11.

PxA, PxB, PxC and PxD outputs are multiplexed with the PORT data latches. The associated TRIS bits must be cleared to configure the PxA, PxB, PxC and PxD pins as outputs.

FIGURE 23-10: EXAMPLE OF FULL-BRIDGE APPLICATION



24.2 SPI Mode Overview

The Serial Peripheral Interface (SPI) bus is a synchronous serial data communication bus that operates in Full-Duplex mode. Devices communicate in a master/slave environment where the master device initiates the communication. A slave device is controlled through a Chip Select known as Slave Select.

The SPI bus specifies four signal connections:

- Serial Clock (SCK)
- Serial Data Out (SDO)
- Serial Data In (SDI)
- Slave Select ($\overline{SS}$)

Figure 24-1 shows the block diagram of the MSSP module when operating in SPI Mode.

The SPI bus operates with a single master device and one or more slave devices. When multiple slave devices are used, an independent Slave Select connection is required from the master device to each slave device.

Figure 24-4 shows a typical connection between a master device and multiple slave devices.

The master selects only one slave at a time. Most slave devices have tri-state outputs so their output signal appears disconnected from the bus when they are not selected.

Transmissions involve two shift registers, eight bits in size, one in the master and one in the slave. With either the master or the slave device, data is always shifted out one bit at a time, with the Most Significant bit (MSb) shifted out first. At the same time, a new Least Significant bit (LSb) is shifted into the same register.

Figure 24-5 shows a typical connection between two processors configured as master and slave devices.

Data is shifted out of both shift registers on the programmed clock edge and latched on the opposite edge of the clock.

The master device transmits information out on its SDO output pin which is connected to, and received by, the slave's SDI input pin. The slave device transmits information out on its SDO output pin, which is connected to, and received by, the master's SDI input pin.

To begin communication, the master device first sends out the clock signal. Both the master and the slave devices should be configured for the same clock polarity.

The master device starts a transmission by sending out the MSb from its shift register. The slave device reads this bit from that same line and saves it into the LSb position of its shift register.

During each SPI clock cycle, a full-duplex data transmission occurs. This means that while the master device is sending out the MSb from its shift register (on its SDO pin) and the slave device is reading this bit and saving it as the LSb of its shift register, that the slave device is also sending out the MSb from its shift register (on its SDO pin) and the master device is reading this bit and saving it as the LSb of its shift register.

After 8 bits have been shifted out, the master and slave have exchanged register values.

If there is more data to exchange, the shift registers are loaded with new data and the process repeats itself.

Whether the data is meaningful or not (dummy data), depends on the application software. This leads to three scenarios for data transmission:

- Master sends useful data and slave sends dummy data.
- Master sends useful data and slave sends useful data.
- Master sends dummy data and slave sends useful data.

Transmissions may involve any number of clock cycles. When there is no more data to be transmitted, the master stops sending the clock signal and it deselects the slave.

Every slave device connected to the bus that has not been selected through its slave select line must disregard the clock and transmission signals and must not transmit out any data of its own.

FIGURE 24-19: I²C SLAVE, 7-BIT ADDRESS, TRANSMISSION (AHEN = 1)

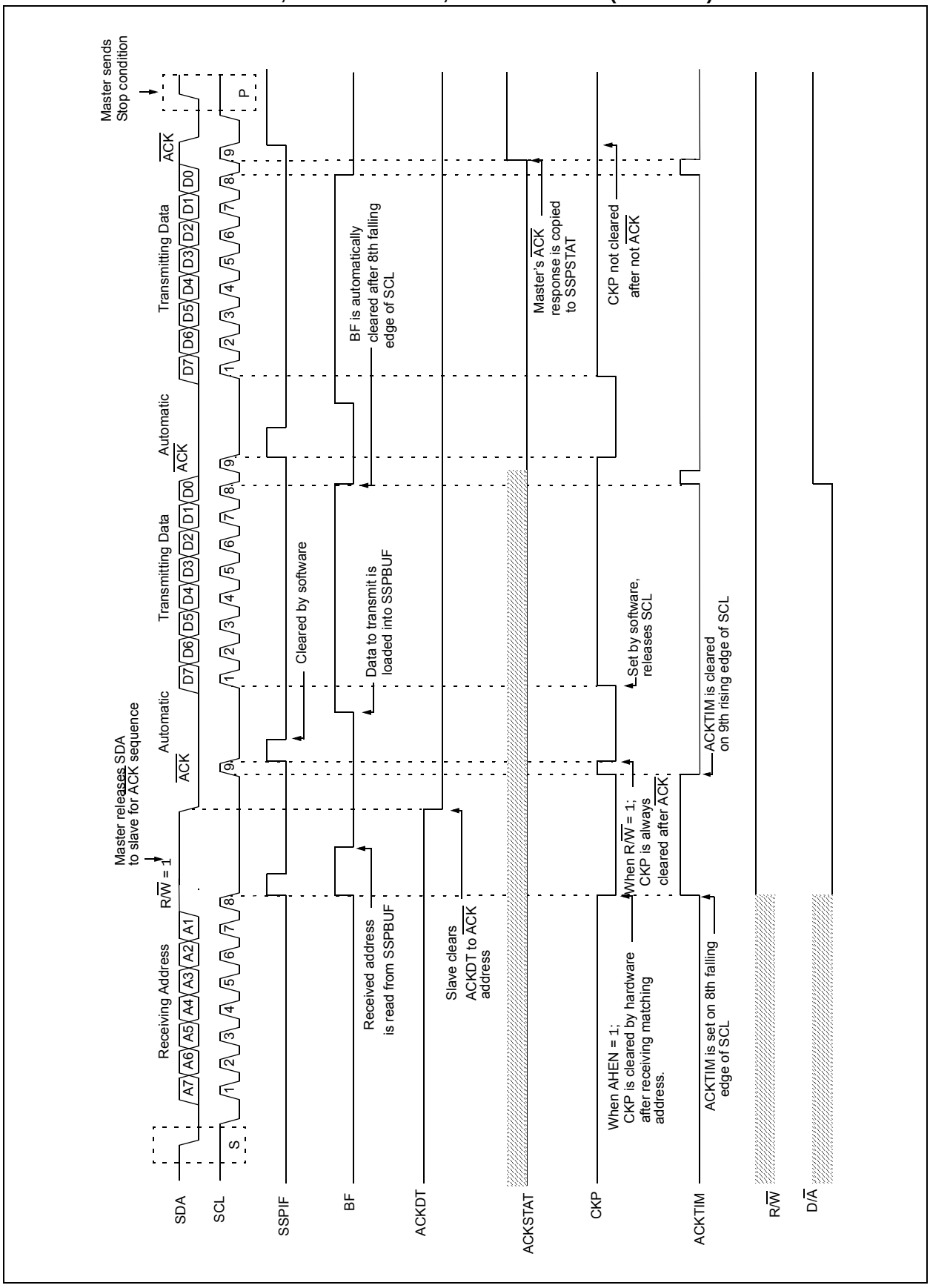
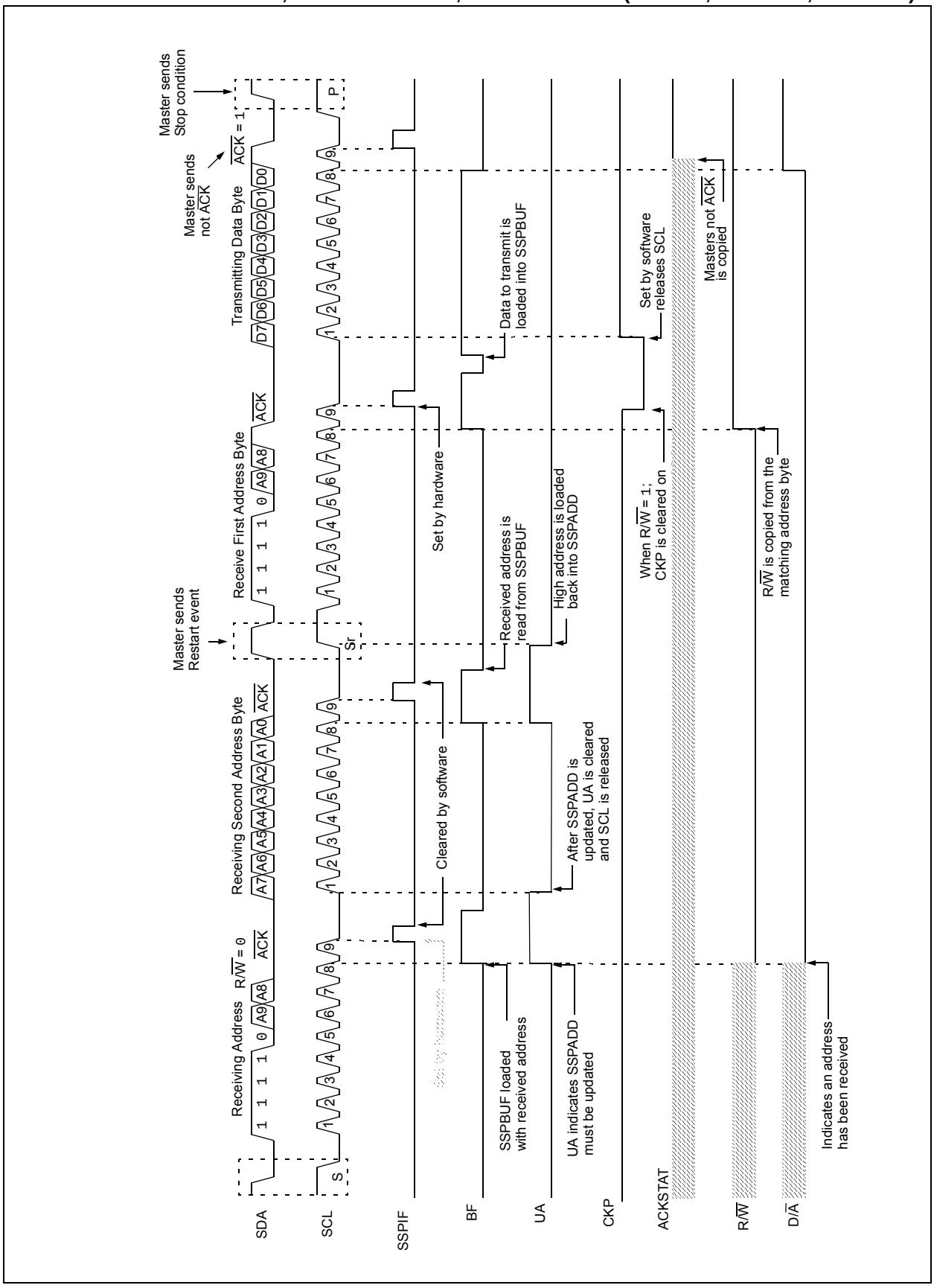


FIGURE 24-22: I²C SLAVE, 10-BIT ADDRESS, TRANSMISSION (SEN = 0, AHEN = 0, DHEN = 0)



24.6.5 I²C MASTER MODE REPEATED START CONDITION TIMING

A Repeated Start condition 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

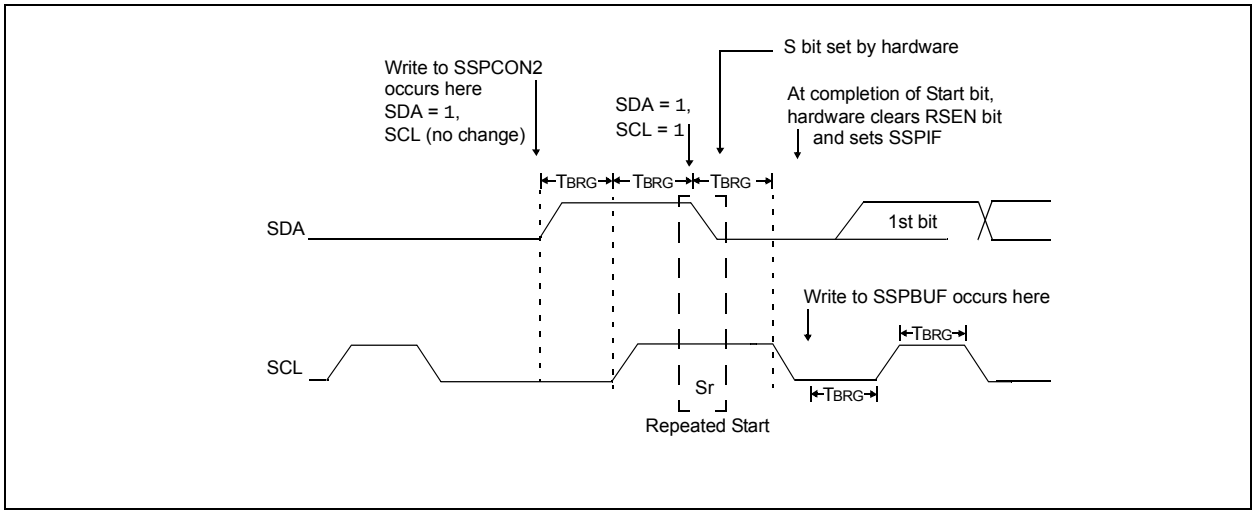
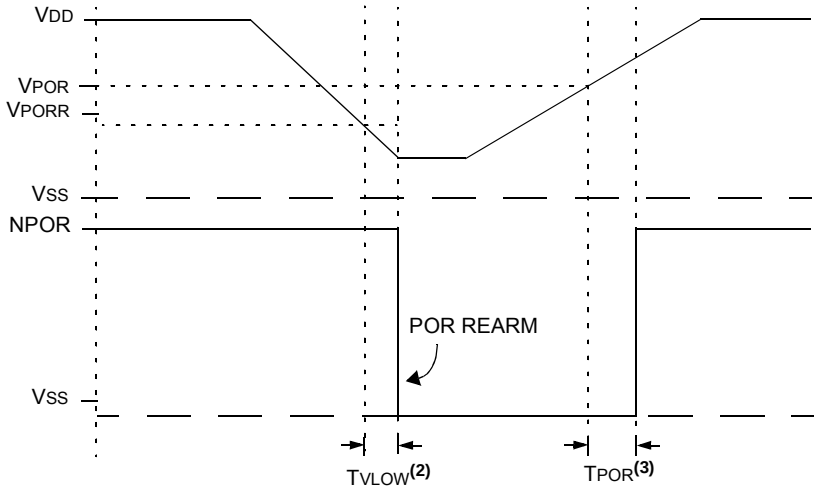


FIGURE 30-4: POR AND POR REARM WITH SLOW RISING VDD



Note 1: When NPOR is low, the device is held in Reset.
2: TPOR 1 μs typical.
3: TVLOW 2.7 μs typical.

30.8 AC Characteristics: PIC16(L)F1934/6/7-I/E

FIGURE 30-6: CLOCK TIMING

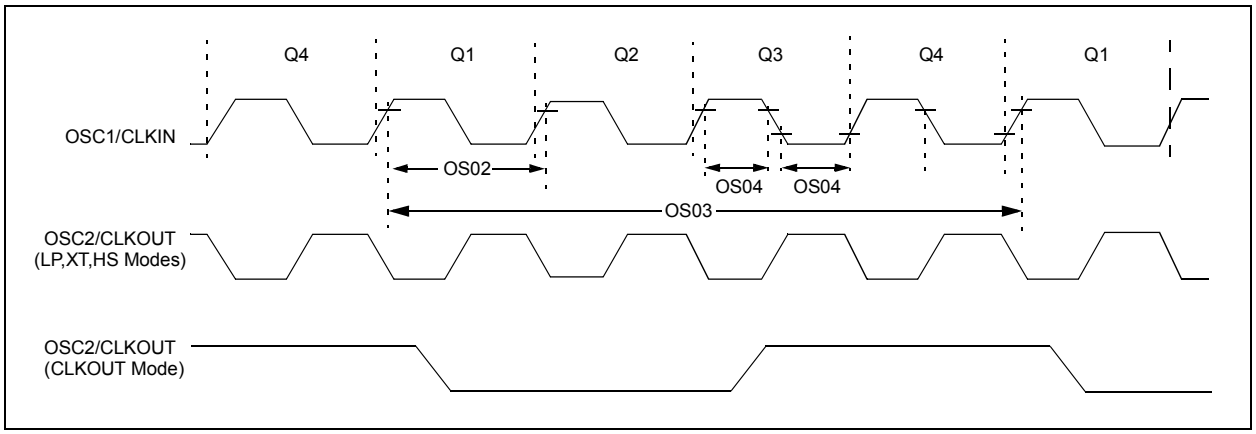


TABLE 30-1: CLOCK OSCILLATOR TIMING REQUIREMENTS

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.

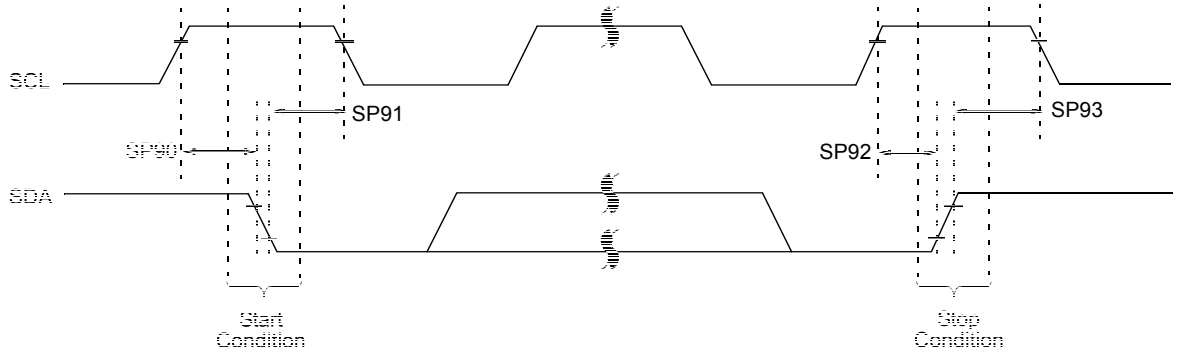
TABLE 30-14: SPI MODE REQUIREMENTS

Param No.	Symbol	Characteristic		Min.	Typ†	Max.	Units	Conditions
SP70*	TssL2scH, TssL2scL	$\overline{SS}\downarrow$ 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	$\overline{SS}\uparrow$ 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 $\overline{SS}\downarrow$ edge		—	—	50	ns	
SP83*	TscH2ssH, TscL2ssH	$\overline{SS}\uparrow$ 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



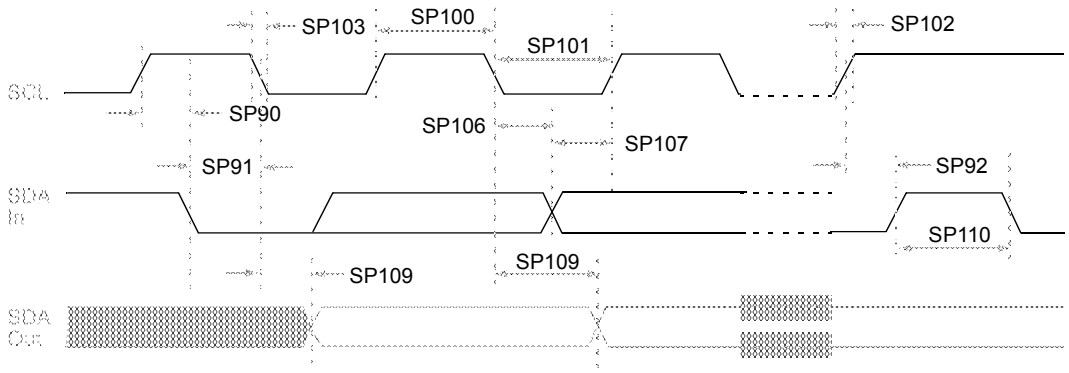
Note: Refer to Figure 30-5 for load conditions.

TABLE 30-15: I²C™ BUS START/STOP BITS REQUIREMENTS

Param No.	Symbol	Characteristic		Min.	Typ	Max.	Units	Conditions
SP90*	TSU:STA	Start condition Setup time	100 kHz mode	4700	—	—	ns	Only relevant for Repeated Start condition
			400 kHz mode	600	—	—		
SP91*	THD:STA	Start condition Hold time	100 kHz mode	4000	—	—	ns	After this period, the first clock pulse is generated
			400 kHz mode	600	—	—		
SP92*	TSU:STO	Stop condition Setup time	100 kHz mode	4700	—	—	ns	
			400 kHz mode	600	—	—		
SP93	THD:STO	Stop condition Hold time	100 kHz mode	4000	—	—	ns	
			400 kHz mode	600	—	—		

* These parameters are characterized but not tested.

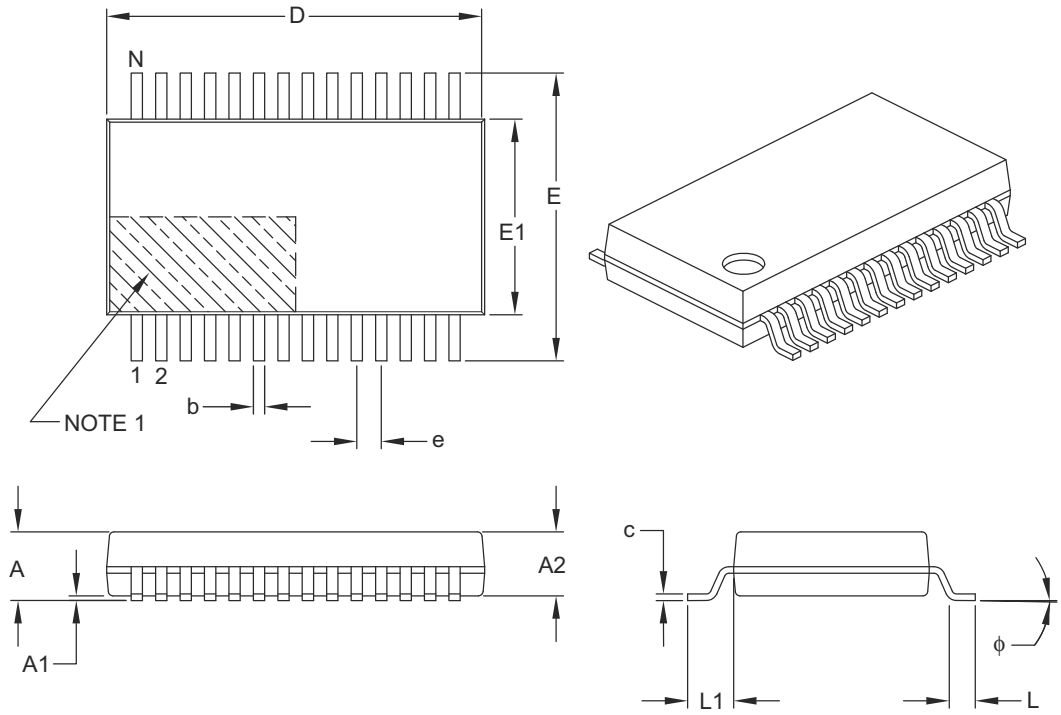
FIGURE 30-21: I²C™ BUS DATA TIMING



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

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:

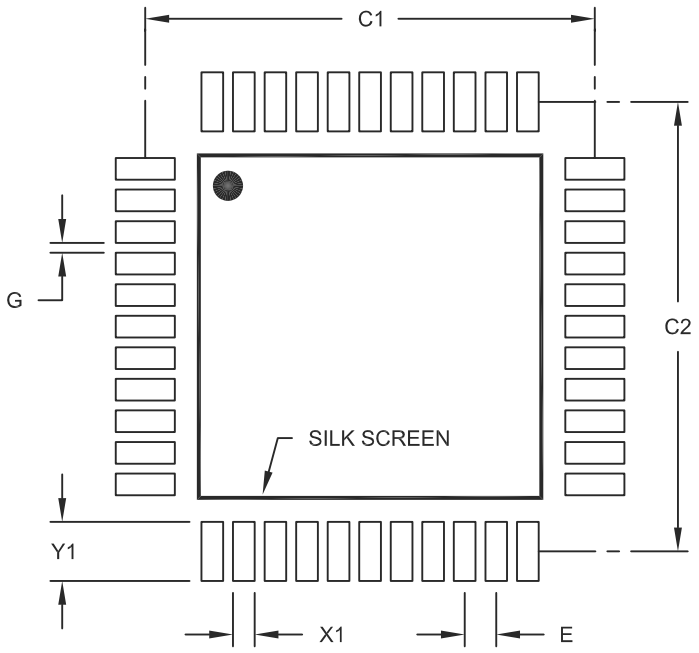
1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.20 mm per side.
3. Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-073B

44-Lead Plastic Thin Quad Flatpack (PT) – 10x10x1 mm Body, 2.00 mm [TQFP]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		0.80 BSC	
Contact Pad Spacing	C1		11.40	
Contact Pad Spacing	C2		11.40	
Contact Pad Width (X44)	X1			0.55
Contact Pad Length (X44)	Y1			1.50
Distance Between Pads	G	0.25		

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2076A