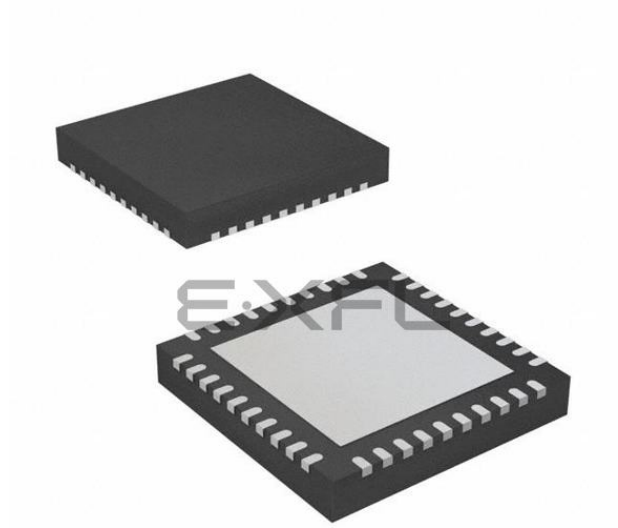

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Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	8051
Core Size	8-Bit
Speed	50MHz
Connectivity	EBI/EMI, SMBus (2-Wire/I²C), LINbus, SPI, UART/USART
Peripherals	POR, PWM, Temp Sensor, WDT
Number of I/O	33
Program Memory Size	16KB (16K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	2.25K x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 5.25V
Data Converters	A/D 32x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	40-VFQFN Exposed Pad
Supplier Device Package	40-QFN (6x6)
Purchase URL	https://www.e-xfl.com/product-detail/silicon-labs/c8051f574-im

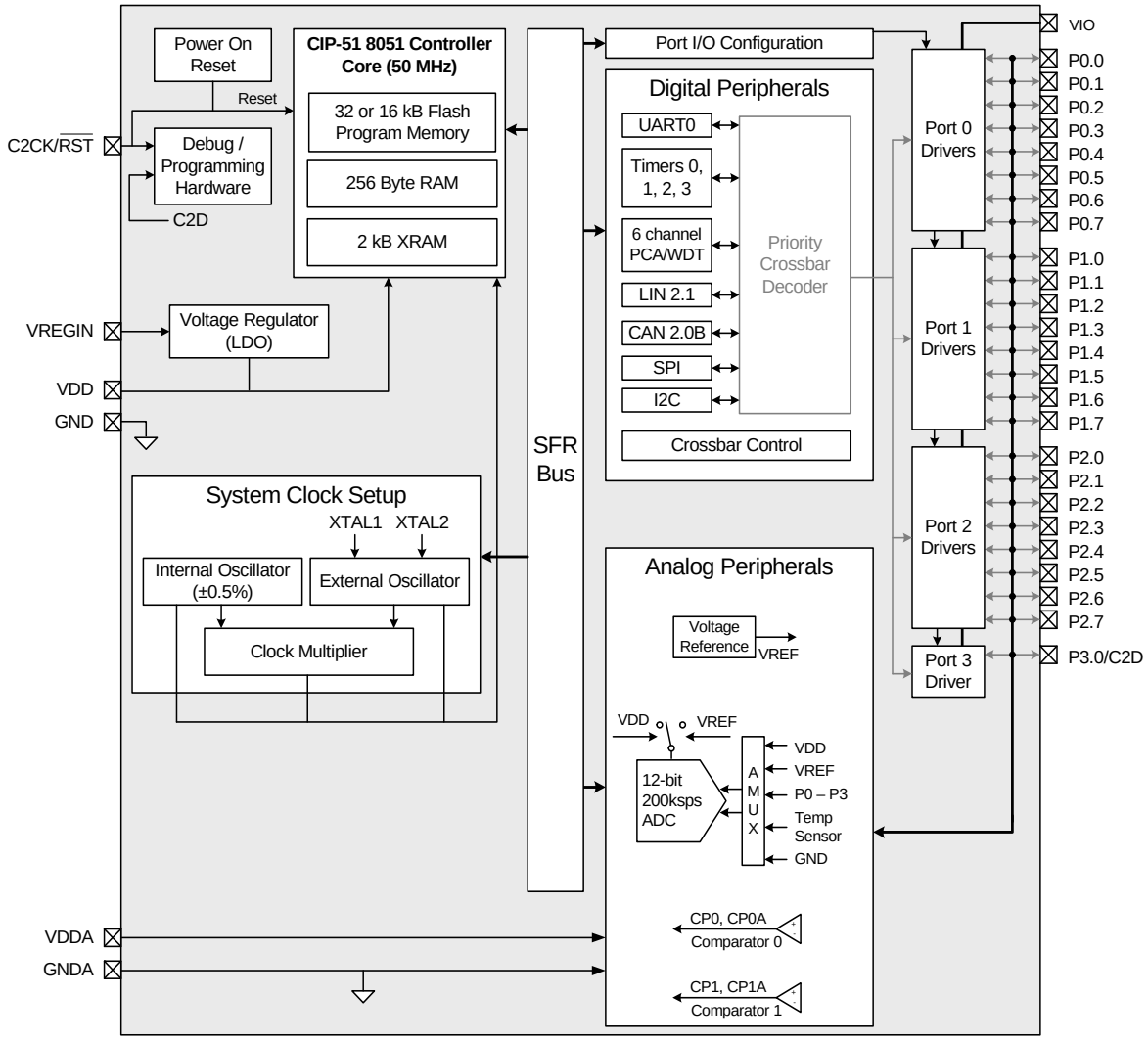

Figure 1.2. C8051F560-7 (32-pin) Block Diagram

3. Pin Definitions

Table 3.1. Pin Definitions for the C8051F55x/56x/57x

Name	Pin 40-pin packages	Pin 32-pin packages	Pin 24-pin packages	Type	Description
VDD	4	4	3		Digital Supply Voltage. Must be connected.
GND	6	6	4		Digital Ground. Must be connected.
VDDA	5	5	—		Analog Supply Voltage. Must be connected.
GNDA	7	7	5		Analog Ground. Must be connected.
VREGIN	3	3	2		Voltage Regulator Input
VIO	2	2	1		Port I/O Supply Voltage. Must be connected.
$\overline{\text{RST}}$/ C2CK	10	10	8	D I/O D I/O	Device Reset. Open-drain output of internal POR or V_{DD} Monitor. Clock signal for the C2 Debug Interface.
P4.0/ C2D	9	—	—	D I/O or A In D I/O	Port 4.0. See SFR Definition 19.28. Bi-directional data signal for the C2 Debug Interface.
P3.0/ C2D		9	—	D I/O or A In D I/O	Port 3.0. See SFR Definition 19.24. Bi-directional data signal for the C2 Debug Interface.
P2.1/ C2D		—	7	D I/O or A In D I/O	Port 2.1. See SFR Definition 19.20. Bi-directional data signal for the C2 Debug Interface.
P0.0	8	8	6	D I/O or A In	Port 0.0. See SFR Definition 19.12.
P0.1	1	1	24	D I/O or A In	Port 0.1
P0.2	40	32	23	D I/O or A In	Port 0.2
P0.3	39	31	22	D I/O or A In	Port 0.3
P0.4	38	30	21	D I/O or A In	Port 0.4
P0.5	37	29	20	D I/O or A In	Port 0.5
P0.6	36	28	19	D I/O or A In	Port 0.6
P0.7	35	27	18	D I/O or A In	Port 0.7

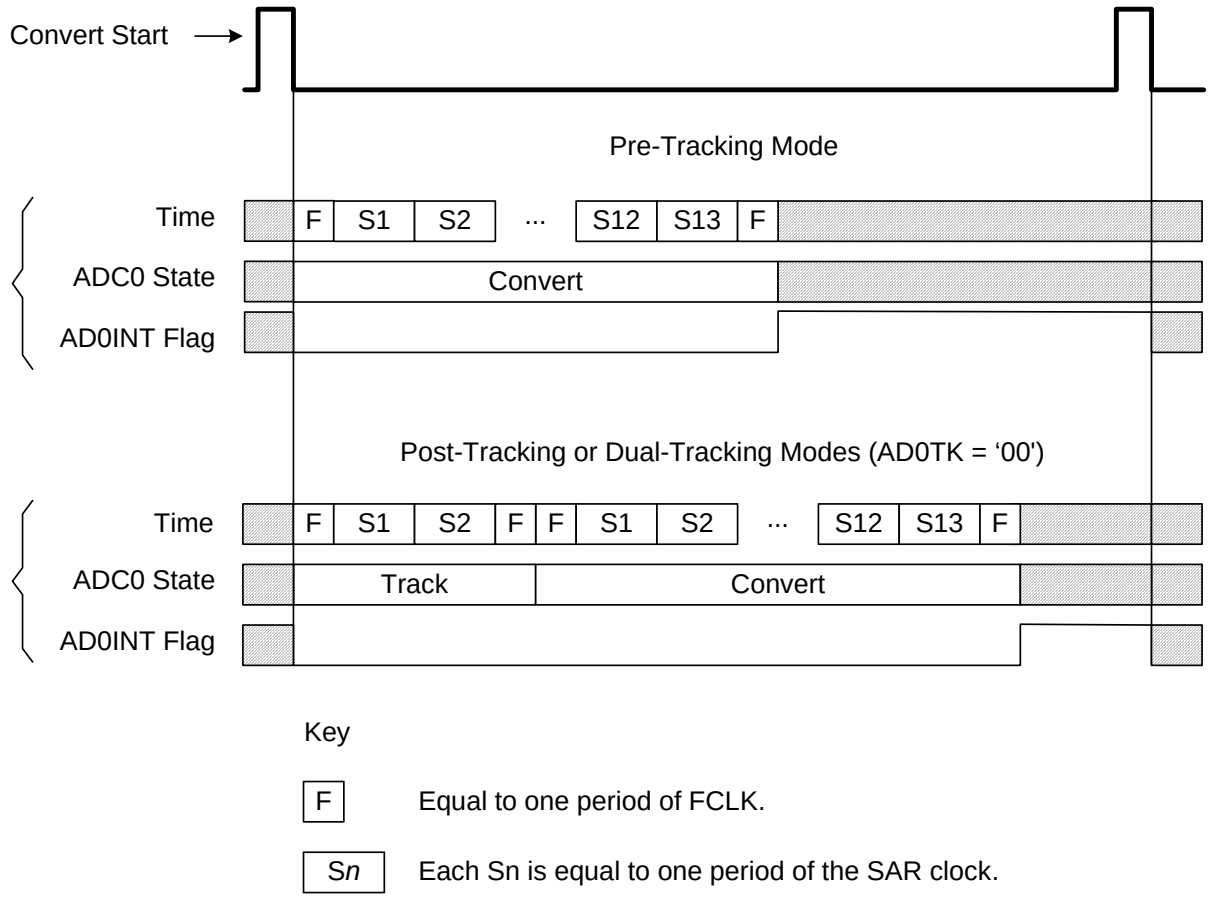

Figure 6.3. 12-Bit ADC Tracking Mode Example

6.1.4. Burst Mode

Burst Mode is a power saving feature that allows ADC0 to remain in a very low power state between conversions. When Burst Mode is enabled, ADC0 wakes from a very low power state, accumulates 1, 4, 8, or 16 samples using an internal Burst Mode clock (approximately 25 MHz), then re-enters a very low power state. Since the Burst Mode clock is independent of the system clock, ADC0 can perform multiple conversions then enter a very low power state within a single system clock cycle, even if the system clock is slow (e.g., 32.768 kHz), or suspended.

Burst Mode is enabled by setting BURSTEN to logic 1. When in Burst Mode, AD0EN controls the ADC0 idle power state (i.e. the state ADC0 enters when not tracking or performing conversions). If AD0EN is set to logic 0, ADC0 is powered down after each burst. If AD0EN is set to logic 1, ADC0 remains enabled after each burst. On each convert start signal, ADC0 is awakened from its Idle Power State. If ADC0 is powered down, it will automatically power up and wait the programmable Power-up Time controlled by the AD0PWR bits. Otherwise, ADC0 will start tracking and converting immediately. Figure 6.4 shows an example of Burst Mode Operation with a slow system clock and a repeat count of 4.

Important Note: When Burst Mode is enabled, only Post-Tracking and Dual-Tracking modes can be used.

When Burst Mode is enabled, a single convert start will initiate a number of conversions equal to the repeat count. When Burst Mode is disabled, a convert start is required to initiate each conversion. In both modes, the ADC0 End of Conversion Interrupt Flag (AD0INT) will be set after “repeat count” conversions have

7. Voltage Reference

The Voltage reference multiplexer on the C8051F55x/56x/57x devices is configurable to use an externally connected voltage reference, the on-chip reference voltage generator routed to the VREF pin, or the V_{DD} power supply voltage (see Figure 7.1). The REFSL bit in the Reference Control register (REF0CN, SFR Definition 7.1) selects the reference source for the ADC. For an external source or the on-chip reference, REFSL should be set to 0 to select the VREF pin. To use V_{DD} as the reference source, REFSL should be set to 1.

The BIASE bit enables the internal voltage bias generator, which is used by the ADC, Temperature Sensor, and internal oscillator. This bias is automatically enabled when any peripheral which requires it is enabled, and it does not need to be enabled manually. The bias generator may be enabled manually by writing a 1 to the BIASE bit in register REF0CN. The electrical specifications for the voltage reference circuit are given in Table 5.11.

The on-chip voltage reference circuit consists of a temperature stable bandgap voltage reference generator and a gain-of-two output buffer amplifier. The output voltage is selectable between 1.5 V and 2.25 V. The on-chip voltage reference can be driven on the VREF pin by setting the REFBE bit in register REF0CN to a 1. The maximum load seen by the VREF pin must be less than 200 µA to GND. Bypass capacitors of 0.1 µF and 4.7 µF are recommended from the VREF pin to GND. If the on-chip reference is not used, the REFBE bit should be cleared to 0. Electrical specifications for the on-chip voltage reference are given in Table 5.11.

Important Note about the VREF Pin: When using either an external voltage reference or the on-chip reference circuitry, the VREF pin should be configured as an analog pin and skipped by the Digital Crossbar. Refer to Section “19. Port Input/Output” on page 169 for the location of the VREF pin, as well as details of how to configure the pin in analog mode and to be skipped by the crossbar. If VDD is selected as the voltage reference in the REF0CN register and the ADC is enabled in the ADC0CN register, the P0.0/VREF pin cannot operate as a general purpose I/O pin in open-drain mode. With the above settings, this pin can operate in push-pull output mode or as an analog input.

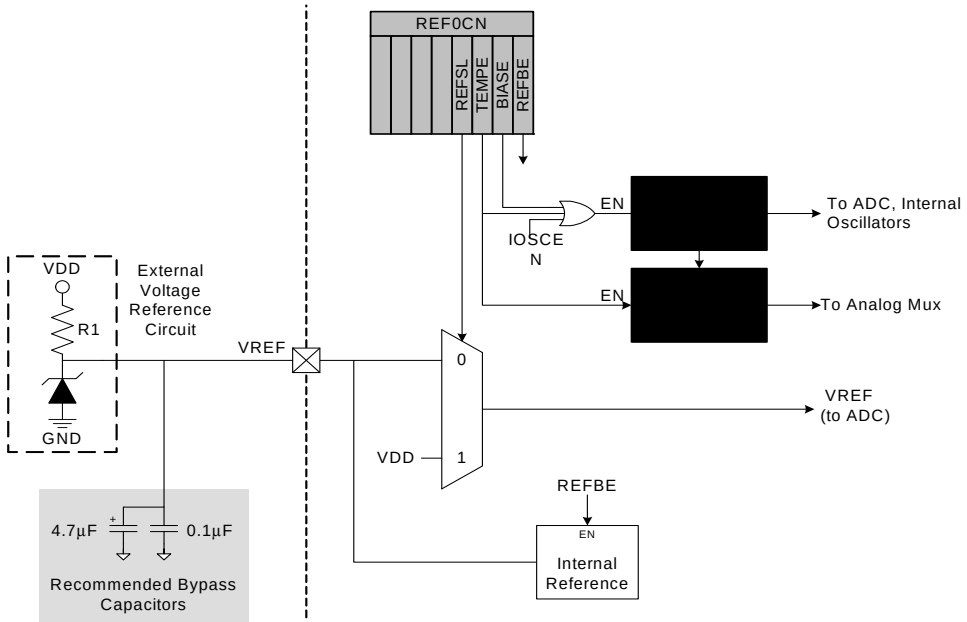

Figure 7.1. Voltage Reference Functional Block Diagram

SFR Definition 8.5. CPT0MX: Comparator0 MUX Selection

Bit	7	6	5	4	3	2	1	0
Name	CMX0N[3:0]				CMX0P[3:0]			
Type	R/W				R/W			
Reset	0	1	1	1	0	1	1	1

SFR Address = 0x9C; SFR Page = 0x00

Bit	Name	Function
7:4	CMX0N[3:0]	**Comparator0 Negative Input MUX Selection.** 0000: P0.1 0001: P0.3 0010: P0.5 0011: P0.7 0100: P1.1 0101: P1.3 0110: P1.5 0111: P1.7 1000: P2.1 1001: P2.3 (only available on 40-pin and 32-pin devices) 1010: P2.5 (only available on 40-pin and 32-pin devices) 1011: P2.7 (only available on 40-pin and 32-pin devices) 1100–1111: None
3:0	CMX0P[3:0]	**Comparator0 Positive Input MUX Selection.** 0000: P0.0 0001: P0.2 0010: P0.4 0011: P0.6 0100: P1.0 0101: P1.2 0110: P1.4 0111: P1.6 1000: P2.0 1001: P2.2 (only available on 40-pin and 32-pin devices) 1010: P2.4 (only available on 40-pin and 32-pin devices) 1011: P2.6 (only available on 40-pin and 32-pin devices) 1100–1111: None

SFR Definition 8.6. CPT1MX: Comparator1 MUX Selection

Bit	7	6	5	4	3	2	1	0
Name	CMX1N[3:0]				CMX1P[3:0]			
Type	R/W				R/W			
Reset	0	1	1	1	0	1	1	1

SFR Address = 0x9F; SFR Page = 0x00

Bit	Name	Function
7:4	CMX1N[3:0]	**Comparator1 Negative Input MUX Selection.** 0000: P0.1 0001: P0.3 0010: P0.5 0011: P0.7 0100: P1.1 0101: P1.3 0110: P1.5 0111: P1.7 1000: P2.1 1001: P2.3 (only available on 40-pin and 32-pin devices) 1010: P2.5 (only available on 40-pin and 32-pin devices) 1011: P2.7 (only available on 40-pin and 32-pin devices) 1100–1111: None
3:0	CMX1P[3:0]	**Comparator1 Positive Input MUX Selection.** 0000: P0.0 0001: P0.2 0010: P0.4 0011: P0.6 0100: P1.0 0101: P1.2 0110: P1.4 0111: P1.6 1000: P2.0 1001: P2.2 (only available on 40-pin and 32-pin devices) 1010: P2.4 (only available on 40-pin and 32-pin devices) 1011: P2.6 (only available on 40-pin and 32-pin devices) 1100–1111: None

9. Voltage Regulator (REG0)

C8051F55x/56x/57x devices include an on-chip low dropout voltage regulator (REG0). The input to REG0 at the V_{REGIN} pin can be as high as 5.25 V. The output can be selected by software to 2.1 V or 2.6 V. When enabled, the output of REG0 appears on the V_{DD} pin, powers the microcontroller core, and can be used to power external devices. On reset, REG0 is enabled and can be disabled by software.

The Voltage regulator can generate an interrupt (if enabled by EREG0, EIE2.0) that is triggered whenever the V_{REGIN} input voltage drops below the dropout threshold voltage. This dropout interrupt has no pending flag and the recommended procedure to use it is as follows:

1. Wait enough time to ensure the V_{REGIN} input voltage is stable
2. Enable the dropout interrupt (EREG0, EIE2.0) and select the proper priority (PREG0, EIP2.0)
3. If triggered, inside the interrupt disable it (clear EREG0, EIE2.0), execute all procedures necessary to protect your application (put it in a safe mode and leave the interrupt now disabled.
4. In the main application, now running in the safe mode, regularly checks the DROPOUT bit (REG0CN.0). Once it is cleared by the regulator hardware the application can enable the interrupt again (EREG0, EIE1.6) and return to the normal mode operation.

The input (V_{REGIN}) and output (V_{DD}) of the voltage regulator should both be bypassed with a large capacitor (4.7 µF + 0.1 µF) to ground as shown in Figure 9.1. This capacitor will eliminate power spikes and provide any immediate power required by the microcontroller. The settling time associated with the voltage regulator is shown in Table 5.8 on page 43.

Note: The output of the internal voltage regulator is calibrated by the MCU immediately after any reset event. The output of the un-calibrated internal regulator could be below the high threshold setting of the V_{DD} Monitor. If this is the case *and* the V_{DD} Monitor is set to the high threshold setting *and* if the MCU receives a non-power on reset (POR), the MCU will remain in reset until a POR occurs (i.e., V_{DD} Monitor will keep the device in reset). A POR will force the V_{DD} Monitor to the low threshold setting which is guaranteed to be below the un-calibrated output of the internal regulator. The device will then exit reset and resume normal operation. It is for this reason Silicon Labs strongly recommends that the V_{DD} Monitor is always left in the low threshold setting (i.e. default value upon POR).

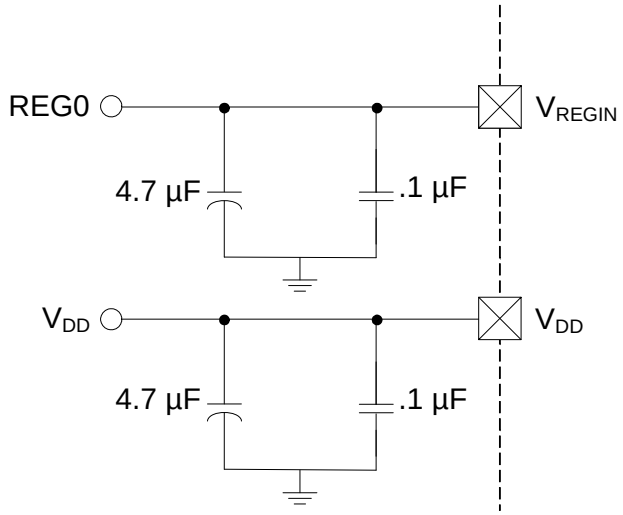

Figure 9.1. External Capacitors for Voltage Regulator Input/Output—Regulator Enabled

C8051F55x/56x/57x.

11.2.1.1. General Purpose Registers

The lower 32 bytes of data memory, locations 0x00 through 0x1F, may be addressed as four banks of general-purpose registers. Each bank consists of eight byte-wide registers designated R0 through R7. Only one of these banks may be enabled at a time. Two bits in the program status word, RS0 (PSW.3) and RS1 (PSW.4), select the active register bank (see description of the PSW in SFR Definition 10.6). This allows fast context switching when entering subroutines and interrupt service routines. Indirect addressing modes use registers R0 and R1 as index registers.

11.2.1.2. Bit Addressable Locations

In addition to direct access to data memory organized as bytes, the sixteen data memory locations at 0x20 through 0x2F are also accessible as 128 individually addressable bits. Each bit has a bit address from 0x00 to 0x7F. Bit 0 of the byte at 0x20 has bit address 0x00 while bit7 of the byte at 0x20 has bit address 0x07. Bit 7 of the byte at 0x2F has bit address 0x7F. A bit access is distinguished from a full byte access by the type of instruction used (bit source or destination operands as opposed to a byte source or destination).

The MCS-51™ assembly language allows an alternate notation for bit addressing of the form XX.B where XX is the byte address and B is the bit position within the byte. For example, the instruction:

```
MOV    C, 22.3h
```

moves the Boolean value at 0x13 (bit 3 of the byte at location 0x22) into the Carry flag.

11.2.1.3. Stack

A programmer's stack can be located anywhere in the 256-byte data memory. The stack area is designated using the Stack Pointer (SP) SFR. The SP will point to the last location used. The next value pushed on the stack is placed at SP+1 and then SP is incremented. A reset initializes the stack pointer to location 0x07. Therefore, the first value pushed on the stack is placed at location 0x08, which is also the first register (R0) of register bank 1. Thus, if more than one register bank is to be used, the SP should be initialized to a location in the data memory not being used for data storage. The stack depth can extend up to 256 bytes.

Table 12.3. Special Function Registers (Continued)

SFRs are listed in alphabetical order. All undefined SFR locations are reserved

Register	Address	Description	Page
SMB0CF	0xC1	SMBus0 Configuration	224
SMB0CN	0xC0	SMBus0 Control	226
SMB0DAT	0xC2	SMBus0 Data	228
SMOD0	0xA9	UART0 Mode	243
SN0	0xF9	Serial Number 0	91
SN1	0xFA	Serial Number 1	91
SN2	0xFB	Serial Number 2	91
SN3	0xFC	Serial Number 3	91
SP	0x81	Stack Pointer	89
SPI0CFG	0xA1	SPI0 Configuration	253
SPI0CKR	0xA2	SPI0 Clock Rate Control	255
SPI0CN	0xF8	SPI0 Control	254
SPI0DAT	0xA3	SPI0 Data	255
TCON	0x88	Timer/Counter Control	265
TH0	0x8C	Timer/Counter 0 High	268
TH1	0x8D	Timer/Counter 1 High	268
TL0	0x8A	Timer/Counter 0 Low	267
TL1	0x8B	Timer/Counter 1 Low	267
TMOD	0x89	Timer/Counter Mode	266
TMR2CN	0xC8	Timer/Counter 2 Control	272
TMR2H	0xCD	Timer/Counter 2 High	274
TMR2L	0xCC	Timer/Counter 2 Low	274
TMR2RLH	0xCB	Timer/Counter 2 Reload High	273
TMR2RLL	0xCA	Timer/Counter 2 Reload Low	273
TMR3CN	0x91	Timer/Counter 3 Control	278
TMR3H	0x95	Timer/Counter 3 High	280
TMR3L	0x94	Timer/Counter 3 Low	280
TMR3RLH	0x93	Timer/Counter 3 Reload High	279
TMR3RLL	0x92	Timer/Counter 3 Reload Low	279
VDM0CN	0xFF	V_{DD} Monitor Control	141
XBR0	0xE1	Port I/O Crossbar Control 0	176
XBR1	0xE2	Port I/O Crossbar Control 1	177
XBR2	0xC7	Port I/O Crossbar Control 2	178

17.2. Configuring the External Memory Interface

Configuring the External Memory Interface consists of four steps:

1. Configure the Output Modes of the associated port pins as either push-pull or open-drain (push-pull is most common), and skip the associated pins in the crossbar.
2. Configure Port latches to “park” the EMIF pins in a dormant state (usually by setting them to logic 1).
3. Select the memory mode (on-chip only, split mode without bank select, split mode with bank select, or off-chip only).
4. Set up timing to interface with off-chip memory or peripherals.

Each of these four steps is explained in detail in the following sections. The Port selection and Mode bits are located in the EMI0CF register shown in SFR Definition .

17.3. Port Configuration

The External Memory Interface appears on Ports 1, 2 and 3 when it is used for off-chip memory access. These ports are multiplexed so that low-order address lines are shared with the data lines. When the EMIF is used, the Crossbar should be configured to skip over the /RD control line (P1.6) and the /WR control line (P1.7) using the P1SKIP register and also skip over the ALE control line (P1.5). For more information about configuring the Crossbar, see Section “19.6. Special Function Registers for Accessing and Configuring Port I/O” on page 183. The EMIF pinout is shown inTable 17.1 on page 146.

The External Memory Interface claims the associated Port pins for memory operations ONLY during the execution of an off-chip MOVX instruction. Once the MOVX instruction has completed, control of the Port pins reverts to the Port latches or to the Crossbar settings for those pins. See Section “19. Port Input/Output” on page 169 for more information about the Crossbar and Port operation and configuration. **The Port latches should be explicitly configured to “park” the External Memory Interface pins in a dormant state, most commonly by setting them to a logic 1**.

During the execution of the MOVX instruction, the External Memory Interface will explicitly disable the drivers on all Port pins that are acting as Inputs (Data[7:0] during a READ operation, for example). The Output mode of the Port pins (whether the pin is configured as Open-Drain or Push-Pull) is unaffected by the External Memory Interface operation, and remains controlled by the PnMDOUT registers. In most cases, the output modes of all EMIF pins should be configured for push-pull mode.

SFR Definition 18.3. OSCICRS: Internal Oscillator Coarse Calibration

Bit	7	6	5	4	3	2	1	0
Name		OSCICRS[6:0]						
Type	R	R/W						
Reset	0	Varies	Varies	Varies	Varies	Varies	Varies	Varies

SFR Address = 0xA2; SFR Page = 0x0F

Bit	Name	Function
7	Unused	Read = 0; Write = Don't Care
6:0	OSCICRS[6:0]	**Internal Oscillator Coarse Calibration Bits.** These bits determine the internal oscillator period. When set to 0000000b, the internal oscillator operates at its slowest setting. When set to 1111111b, the internal oscillator operates at its fastest setting. The reset value is factory calibrated to generate an internal oscillator frequency of 24 MHz.

SFR Definition 18.4. OSCIFIN: Internal Oscillator Fine Calibration

Bit	7	6	5	4	3	2	1	0
			OSCIFIN[5:0]					
Type	R	R	R/W					
Reset	0	0	Varies	Varies	Varies	Varies	Varies	Varies

SFR Address = 0x9E; SFR Page = 0x0F

Bit	Name	Function
7:6	Unused	Read = 00b; Write = Don't Care
5:0	OSCIFIN[5:0]	**Internal Oscillator Fine Calibration Bits.** These bits are fine adjustment for the internal oscillator period. The reset value is factory calibrated to generate an internal oscillator frequency of 24 MHz.

SFR Definition 18.6. OSCXCN: External Oscillator Control

Bit	7	6	5	4	3	2	1	0
Name	XTLVLD	XOSCMD[2:0]				XFCN[2:0]		
Type	R	R/W			R	R/W		
Reset	0	0	0	0	0	0	0	0

SFR Address = 0x9F; SFR Page = 0x0F

Bit	Name	Function
7	XTLVLD	**Crystal Oscillator Valid Flag.** (Read only when XOSCMD = 11x.) 0: Crystal Oscillator is unused or not yet stable. 1: Crystal Oscillator is running and stable.
6:4	XOSCMD[2:0]	**External Oscillator Mode Select.** 00x: External Oscillator circuit off. 010: External CMOS Clock Mode. 011: External CMOS Clock Mode with divide by 2 stage. 100: RC Oscillator Mode. 101: Capacitor Oscillator Mode. 110: Crystal Oscillator Mode. 111: Crystal Oscillator Mode with divide by 2 stage.
3	Unused	Read = 0b; Write =0b
2:0	XFCN[2:0]	**External Oscillator Frequency Control Bits.** Set according to the desired frequency for Crystal or RC mode. Set according to the desired K Factor for C mode.

XFCN	Crystal Mode	RC Mode	C Mode
000	f ≤ 32 kHz	f ≤ 25 kHz	K Factor = 0.87
001	32 kHz < f ≤ 84 kHz	25 kHz < f ≤ 50 kHz	K Factor = 2.6
010	84 kHz < f ≤ 225 kHz	50 kHz < f ≤ 100 kHz	K Factor = 7.7
011	225 kHz < f ≤ 590 kHz	100 kHz < f ≤ 200 kHz	K Factor = 22
100	590 kHz < f ≤ 1.5 MHz	200 kHz < f ≤ 400 kHz	K Factor = 65
101	1.5 MHz < f ≤ 4 MHz	400 kHz < f ≤ 800 kHz	K Factor = 180
110	4 MHz < f ≤ 10 MHz	800 kHz < f ≤ 1.6 MHz	K Factor = 664
111	10 MHz < f ≤ 30 MHz	1.6 MHz < f ≤ 3.2 MHz	K Factor = 1590

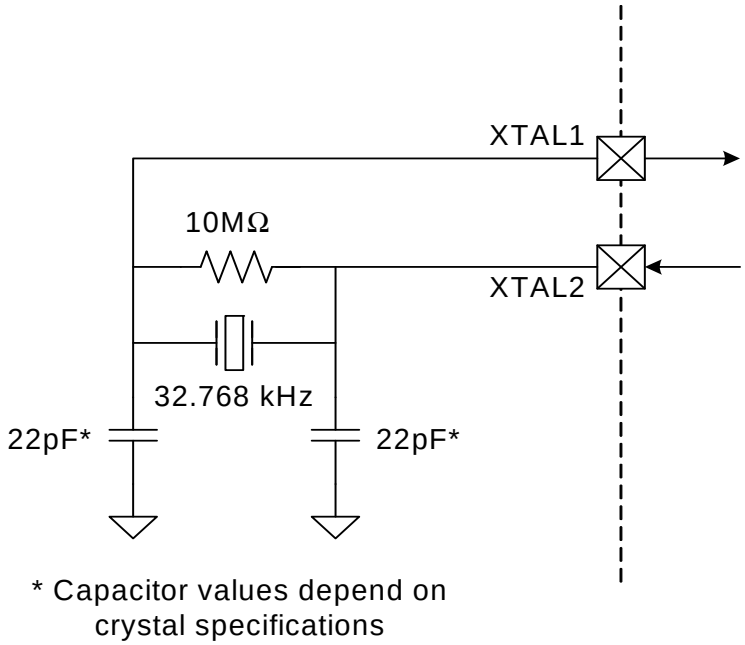

Figure 18.3. External 32.768 kHz Quartz Crystal Oscillator Connection Diagram

18.4.2. External RC Example

If an RC network is used as an external oscillator source for the MCU, the circuit should be configured as shown in Figure 18.1, Option 2. The capacitor should be no greater than 100 pF; however for very small capacitors, the total capacitance may be dominated by parasitic capacitance in the PCB layout. To determine the required External Oscillator Frequency Control value (XFCN) in the OSCXCN Register, first select the RC network value to produce the desired frequency of oscillation, according to Equation 18.1, where f = the frequency of oscillation in MHz, C = the capacitor value in pF, and R = the pull-up resistor value in kΩ.

$$f = 1.23 \times 10^3 / (R \times C)$$

Equation 18.1. RC Mode Oscillator Frequency

For example: If the frequency desired is 100 kHz, let R = 246 kΩ and C = 50 pF:

f = 1.23(10^3)/RC = 1.23(10^3)/[246 x 50] = 0.1 MHz = 100 kHz

Referring to the table in SFR Definition 18.6, the required XFCN setting is 010b.

18.4.3. External Capacitor Example

If a capacitor is used as an external oscillator for the MCU, the circuit should be configured as shown in Figure 18.1, Option 3. The capacitor should be no greater than 100 pF; however for very small capacitors, the total capacitance may be dominated by parasitic capacitance in the PCB layout. To determine the required External Oscillator Frequency Control value (XFCN) in the OSCXCN Register, select the capacitor to be used and find the frequency of oscillation according to Equation , where f = the frequency of oscillation in MHz, C = the capacitor value in pF, and V_{DD} = the MCU power supply in Volts.

SFR Definition 19.25. P3MDIN: Port 3 Input Mode

Bit	7	6	5	4	3	2	1	0
Name	P3MDIN[7:0]							
Type	R/W							
Reset	1	1	1	1	1	1	1	1

SFR Address = 0xF4; SFR Page = 0x0F

Bit	Name	Function
7:0	P3MDIN[7:0]	**Analog Configuration Bits for P3.7–P3.0 (respectively).** Port pins configured for analog mode have their weak pull-up and digital receiver disabled. For analog mode, the pin also needs to be configured for open-drain mode in the P3MDOUT register. 0: Corresponding P3.n pin is configured for analog mode. 1: Corresponding P3.n pin is not configured for analog mode.
Note: P3.0 is available on 40-pin and 32-pin packages. P3.1-P3.7 are available on 40-pin packages		

SFR Definition 19.26. P3MDOUT: Port 3 Output Mode

Bit	7	6	5	4	3	2	1	0
Name	P3MDOUT[7:0]							
Type	R/W							
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xAE; SFR Page = 0x0F

Bit	Name	Function
7:0	P3MDOUT[7:0]	**Output Configuration Bits for P3.7–P3.0 (respectively).** These bits are ignored if the corresponding bit in register P3MDIN is logic 0. 0: Corresponding P3.n Output is open-drain. 1: Corresponding P3.n Output is push-pull.
Note: P3.0 is available on 40-pin and 32-pin packages. P3.1-P3.7 are available on 40-pin packages		

SFR Definition 22.2. SMB0CN: SMBus Control

Bit	7	6	5	4	3	2	1	0
Name	MASTER	TXMODE	STA	STO	ACKRQ	ARBLOST	ACK	SI
Type	R	R	R/W	R/W	R	R	R/W	R/W
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xC0; Bit-Addressable; SFR Page =0x00

Bit	Name	Description	Read	Write
7	MASTER	**SMBus Master/Slave Indicator.** This read-only bit indicates when the SMBus is operating as a master.	0: SMBus operating in slave mode. 1: SMBus operating in master mode.	N/A
6	TXMODE	**SMBus Transmit Mode Indicator.** This read-only bit indicates when the SMBus is operating as a transmitter.	0: SMBus in Receiver Mode. 1: SMBus in Transmitter Mode.	N/A
5	STA	**SMBus Start Flag.**	0: No Start or repeated Start detected. 1: Start or repeated Start detected.	0: No Start generated. 1: When Configured as a Master, initiates a START or repeated START.
4	STO	**SMBus Stop Flag.**	0: No Stop condition detected. 1: Stop condition detected (if in Slave Mode) or pending (if in Master Mode).	0: No STOP condition is transmitted. 1: When configured as a Master, causes a STOP condition to be transmitted after the next ACK cycle. Cleared by Hardware.
3	ACKRQ	**SMBus Acknowledge Request.**	0: No Ack requested 1: ACK requested	N/A
2	ARBLOST	**SMBus Arbitration Lost Indicator.**	0: No arbitration error. 1: Arbitration Lost	N/A
1	ACK	**SMBus Acknowledge.**	0: NACK received. 1: ACK received.	0: Send NACK 1: Send ACK
0	SI	**SMBus Interrupt Flag.** This bit is set by hardware under the conditions listed in Table 15.3. SI must be cleared by software. While SI is set, SCL is held low and the SMBus is stalled.	0: No interrupt pending 1: Interrupt Pending	0: Clear interrupt, and initiate next state machine event. 1: Force interrupt.

24.3. SPI0 Slave Mode Operation

When SPI0 is enabled and not configured as a master, it will operate as a SPI slave. As a slave, bytes are shifted in through the MOSI pin and out through the MISO pin by a master device controlling the SCK signal. A bit counter in the SPI0 logic counts SCK edges. When 8 bits have been shifted through the shift register, the SPIF flag is set to logic 1, and the byte is copied into the receive buffer. Data is read from the receive buffer by reading SPI0DAT. A slave device cannot initiate transfers. Data to be transferred to the master device is pre-loaded into the shift register by writing to SPI0DAT. Writes to SPI0DAT are double-buffered, and are placed in the transmit buffer first. If the shift register is empty, the contents of the transmit buffer will immediately be transferred into the shift register. When the shift register already contains data, the SPI will load the shift register with the transmit buffer's contents after the last SCK edge of the next (or current) SPI transfer.

When configured as a slave, SPI0 can be configured for 4-wire or 3-wire operation. The default, 4-wire slave mode, is active when NSSMD1 (SPI0CN.3) = 0 and NSSMD0 (SPI0CN.2) = 1. In 4-wire mode, the NSS signal is routed to a port pin and configured as a digital input. SPI0 is enabled when NSS is logic 0, and disabled when NSS is logic 1. The bit counter is reset on a falling edge of NSS. Note that the NSS signal must be driven low at least 2 system clocks before the first active edge of SCK for each byte transfer. Figure 24.4 shows a connection diagram between two slave devices in 4-wire slave mode and a master device.

3-wire slave mode is active when NSSMD1 (SPI0CN.3) = 0 and NSSMD0 (SPI0CN.2) = 0. NSS is not used in this mode, and is not mapped to an external port pin through the crossbar. Since there is no way of uniquely addressing the device in 3-wire slave mode, SPI0 must be the only slave device present on the bus. It is important to note that in 3-wire slave mode there is no external means of resetting the bit counter that determines when a full byte has been received. The bit counter can only be reset by disabling and re-enabling SPI0 with the SPIEN bit. Figure 24.3 shows a connection diagram between a slave device in 3-wire slave mode and a master device.

24.4. SPI0 Interrupt Sources

When SPI0 interrupts are enabled, the following four flags will generate an interrupt when they are set to logic 1:

All of the following bits must be cleared by software.

1. The SPI Interrupt Flag, SPIF (SPI0CN.7) is set to logic 1 at the end of each byte transfer. This flag can occur in all SPI0 modes.
2. The Write Collision Flag, WCOL (SPI0CN.6) is set to logic 1 if a write to SPI0DAT is attempted when the transmit buffer has not been emptied to the SPI shift register. When this occurs, the write to SPI0DAT will be ignored, and the transmit buffer will not be written.This flag can occur in all SPI0 modes.
3. The Mode Fault Flag MODF (SPI0CN.5) is set to logic 1 when SPI0 is configured as a master, and for multi-master mode and the NSS pin is pulled low. When a Mode Fault occurs, the MSTEN and SPIEN bits in SPI0CN are set to logic 0 to disable SPI0 and allow another master device to access the bus.
4. The Receive Overrun Flag RXOVRN (SPI0CN.4) is set to logic 1 when configured as a slave, and a transfer is completed and the receive buffer still holds an unread byte from a previous transfer. The new byte is not transferred to the receive buffer, allowing the previously received data byte to be read. The data byte which caused the overrun is lost.

24.5. Serial Clock Phase and Polarity

Four combinations of serial clock phase and polarity can be selected using the clock control bits in the SPI0 Configuration Register (SPI0CFG). The CKPHA bit (SPI0CFG.5) selects one of two clock phases (edge used to latch the data). The CKPOL bit (SPI0CFG.4) selects between an active-high or active-low clock. Both master and slave devices must be configured to use the same clock phase and polarity. SPI0 should be disabled (by clearing the SPIEN bit, SPI0CN.0) when changing the clock phase or polarity. The clock and data line relationships for master mode are shown in Figure 24.5. For slave mode, the clock and data relationships are shown in Figure 24.6 and Figure 24.7. CKPHA must be set to 0 on both the master and slave SPI when communicating between two of the following devices: C8051F04x, C8051F06x, C8051F12x, C8051F31x, C8051F32x, and C8051F33x.

The SPI0 Clock Rate Register (SPI0CKR) as shown in SFR Definition 24.3 controls the master mode serial clock frequency. This register is ignored when operating in slave mode. When the SPI is configured as a master, the maximum data transfer rate (bits/sec) is one-half the system clock frequency or 12.5 MHz, whichever is slower. When the SPI is configured as a slave, the maximum data transfer rate (bits/sec) for full-duplex operation is 1/10 the system clock frequency, provided that the master issues SCK, NSS (in 4-wire slave mode), and the serial input data synchronously with the slave's system clock. If the master issues SCK, NSS, and the serial input data asynchronously, the maximum data transfer rate (bits/sec) must be less than 1/10 the system clock frequency. In the special case where the master only wants to transmit data to the slave and does not need to receive data from the slave (i.e. half-duplex operation), the SPI slave can receive data at a maximum data transfer rate (bits/sec) of 1/4 the system clock frequency. This is provided that the master issues SCK, NSS, and the serial input data synchronously with the slave's system clock.

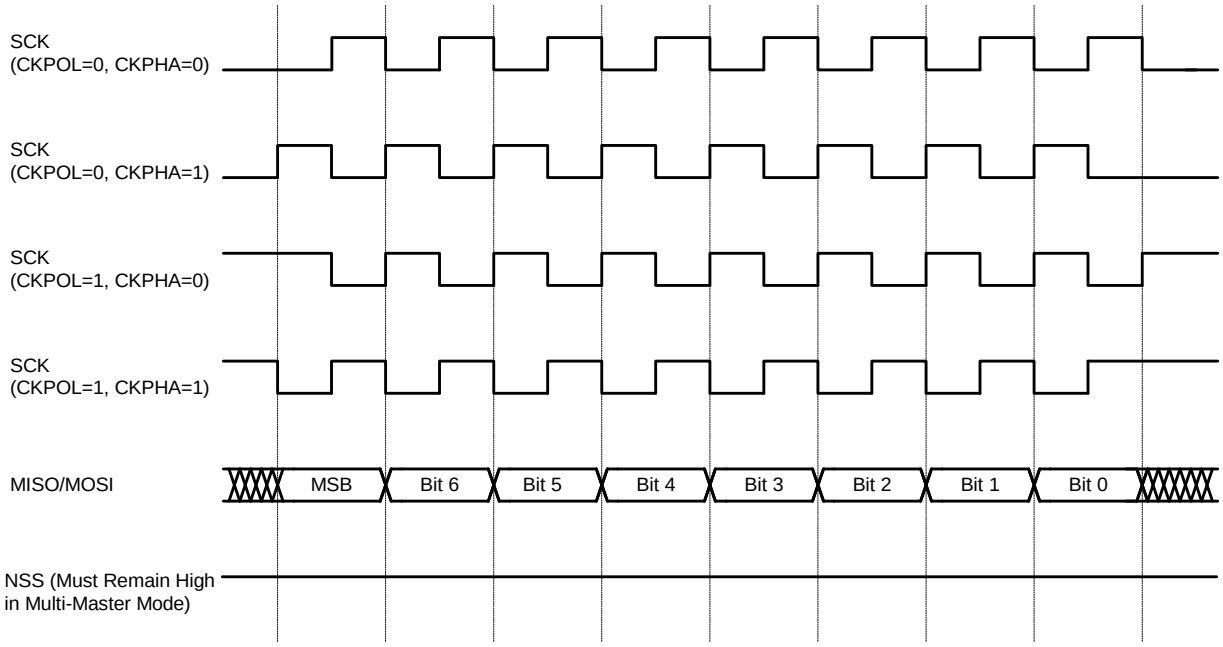

Figure 24.5. Master Mode Data/Clock Timing

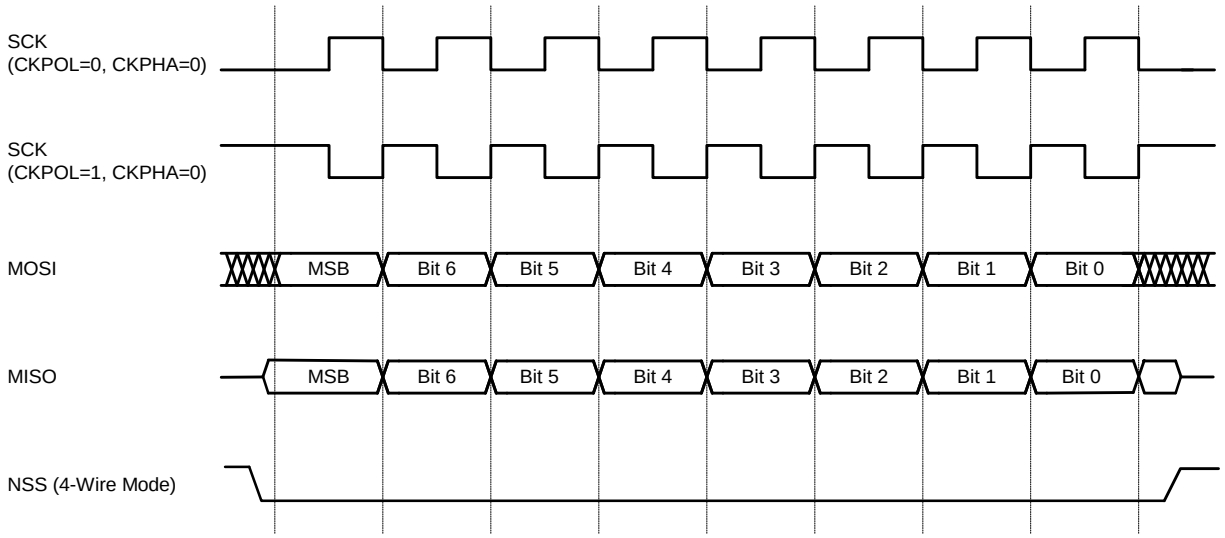

Figure 24.6. Slave Mode Data/Clock Timing (CKPHA = 0)

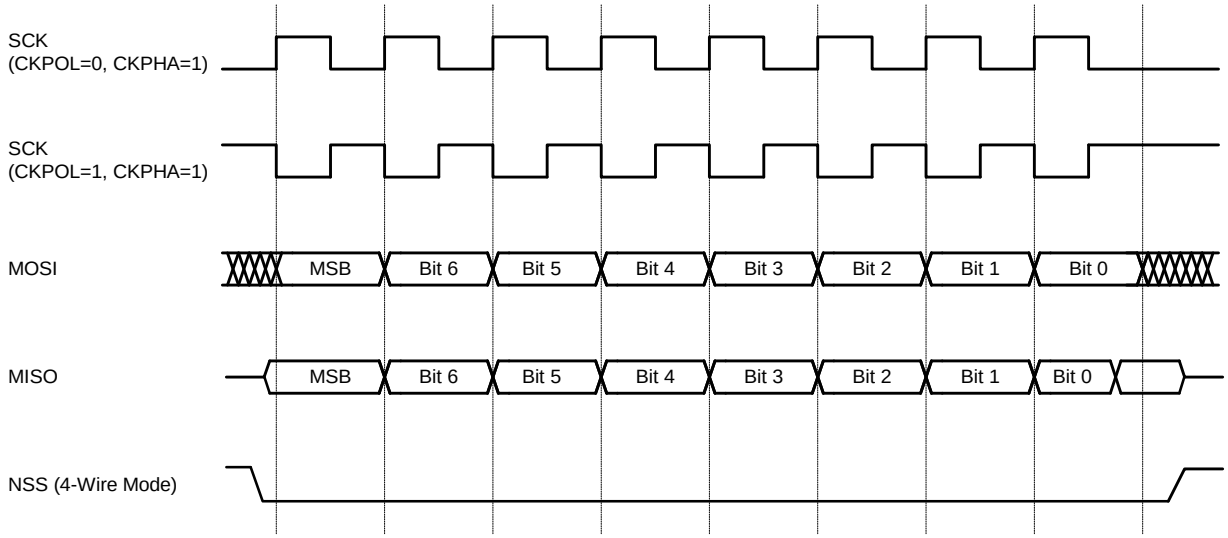

Figure 24.7. Slave Mode Data/Clock Timing (CKPHA = 1)

24.6. SPI Special Function Registers

SPI0 is accessed and controlled through four special function registers in the system controller: SPI0CN Control Register, SPI0DAT Data Register, SPI0CFG Configuration Register, and SPI0CKR Clock Rate Register. The four special function registers related to the operation of the SPI0 Bus are described in the following figures.

T3MH	T3XCLK	TMR3H Clock Source
0	0	SYSCLK/12
0	1	External Clock/8
1	X	SYSCLK

T3ML	T3XCLK	TMR3L Clock Source
0	0	SYSCLK/12
0	1	External Clock/8
1	X	SYSCLK

The TF3H bit is set when TMR3H overflows from 0xFF to 0x00; the TF3L bit is set when TMR3L overflows from 0xFF to 0x00. When Timer 3 interrupts are enabled, an interrupt is generated each time TMR3H overflows. If Timer 3 interrupts are enabled and TF3LEN (TMR3CN.5) is set, an interrupt is generated each time either TMR3L or TMR3H overflows. When TF3LEN is enabled, software must check the TF3H and TF3L flags to determine the source of the Timer 3 interrupt. The TF3H and TF3L interrupt flags are not cleared by hardware and must be manually cleared by software.

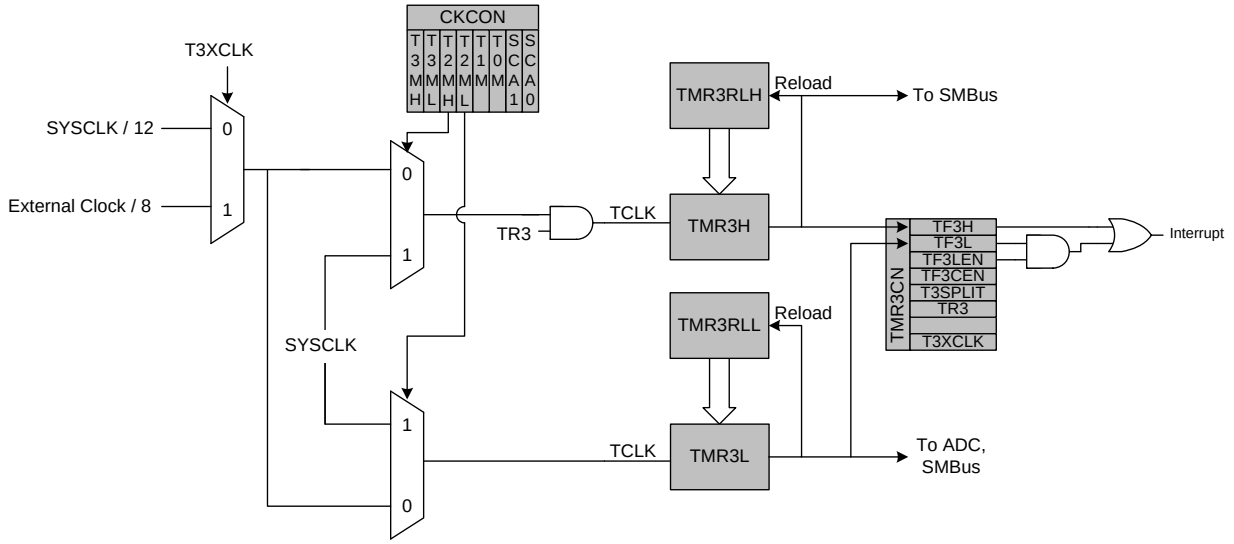

Figure 25.8. Timer 3 8-Bit Mode Block Diagram

25.3.3. External Oscillator Capture Mode

Capture Mode allows the external oscillator to be measured against the system clock. Timer 3 can be clocked from the system clock, or the system clock divided by 12, depending on the T3ML (CKCON.6), and T3XCLK bits. When a capture event is generated, the contents of Timer 3 (TMR3H:TMR3L) are loaded into the Timer 3 reload registers (TMR3RLH:TMR3RLL) and the TF3H flag is set. A capture event is generated by the falling edge of the clock source being measured, which is the external oscillator/8. By recording the difference between two successive timer capture values, the external oscillator frequency can be determined with respect to the Timer 3 clock. The Timer 3 clock should be much faster than the capture clock to achieve an accurate reading. Timer 3 should be in 16-bit auto-reload mode when using Capture Mode.

If the SYSCLK is 24 MHz and the difference between two successive captures is 5861, then the external clock frequency is as follows:

24 MHz/(5861/8) = 0.032754 MHz or 32.754 kHz

This mode allows software to determine the external oscillator frequency when an RC network or capacitor is used to generate the clock source.

27.2. C2 Pin Sharing

The C2 protocol allows the C2 pins to be shared with user functions so that in-system debugging and Flash programming may be performed. This is possible because C2 communication is typically performed when the device is in the halt state, where all on-chip peripherals and user software are stalled. In this halted state, the C2 interface can safely ‘borrow’ the C2CK (RST) and C2D pins. In most applications, external resistors are required to isolate C2 interface traffic from the user application. A typical isolation configuration is shown in Figure 27.1.

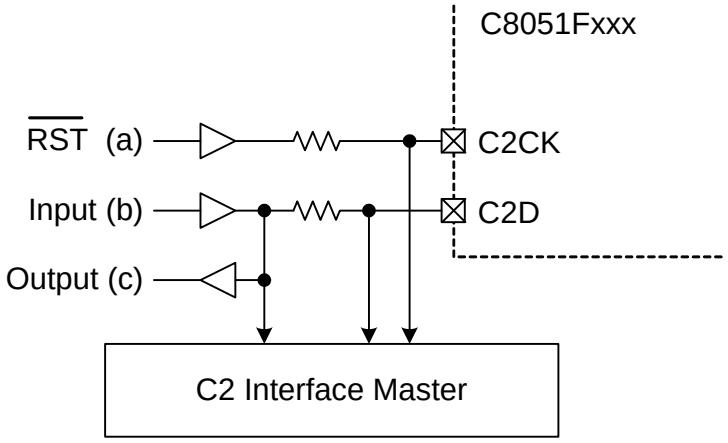

Figure 27.1. Typical C2 Pin Sharing

The configuration in Figure 27.1 assumes the following:

1. The user input (b) cannot change state while the target device is halted.
2. The RST pin on the target device is used as an input only.

Additional resistors may be necessary depending on the specific application.