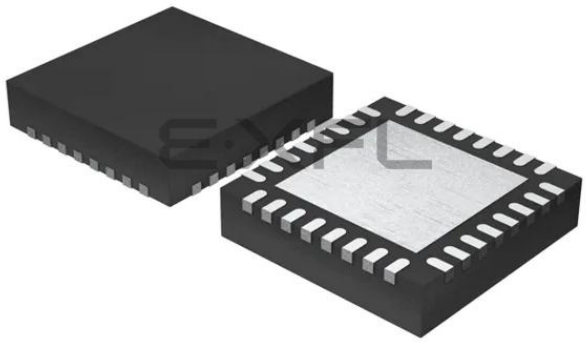

Welcome to E-XFL.COM

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	8051
Core Size	8-Bit
Speed	48 MIPS
Connectivity	I²C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, Temp Sensor, WDT
Number of I/O	25
Program Memory Size	32KB (32K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	2.25K x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 5.25V
Data Converters	A/D 21x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	32-VFQFN Exposed Pad
Supplier Device Package	32-QFN (5x5)
Purchase URL	https://www.e-xfl.com/product-detail/silicon-labs/c8051f38b-b-gm

List of Figures

Figure 1.1. C8051F388/A Block Diagram 17
Figure 1.2. C8051F389/B Block Diagram 18
Figure 3.1. TQFP-48 (C8051F388/A) Pinout Diagram (Top View) 24
Figure 3.2. TQFP-48 Package Diagram 25
Figure 3.3. TQFP-48 Recommended PCB Land Pattern 26
Figure 3.4. LQFP-32 (C8051F389/B) Pinout Diagram (Top View) 27
Figure 3.5. LQFP-32 Package Diagram 28
Figure 3.6. LQFP-32 Recommended PCB Land Pattern 29
Figure 3.7. QFN-32 (C8051F389/B) Pinout Diagram (Top View) 30
Figure 3.8. QFN-32 Package Drawing 31
Figure 3.9. QFN-32 Recommended PCB Land Pattern 32
Figure 4.1. Connection Diagram with Voltage Regulator Used 33
Figure 4.2. Connection Diagram with Voltage Regulator Not Used 33
Figure 6.1. ADC0 Functional Block Diagram 42
Figure 6.2. Typical Temperature Sensor Transfer Function 44
Figure 6.3. Temperature Sensor Error with 1-Point Calibration 45
Figure 6.4. 10-Bit ADC Track and Conversion Example Timing 47
Figure 6.5. ADC0 Equivalent Input Circuits 48
Figure 6.6. ADC Window Compare Example: Right-Justified Data 54
Figure 6.7. ADC Window Compare Example: Left-Justified Data 54
Figure 7.1. Voltage Reference Functional Block Diagram 58
Figure 8.1. Comparator0 Functional Block Diagram 60
Figure 8.2. Comparator1 Functional Block Diagram 61
Figure 8.3. Comparator Hysteresis Plot 62
Figure 8.4. Comparator Input Multiplexer Block Diagram 67
Figure 11.1. CIP-51 Block Diagram 75
Figure 13.1. On-Chip Memory Map for 64 kB Devices (C8051F388/9) 85
Figure 13.2. On-Chip Memory Map for 32 kB Devices (C8051F38A/B) 86
Figure 14.1. Multiplexed Configuration Example 92
Figure 14.2. Non-multiplexed Configuration Example 93
Figure 14.3. EMIF Operating Modes 94
Figure 14.4. Non-Multiplexed 16-bit MOVX Timing 98
Figure 14.5. Non-Multiplexed 8-bit MOVX without Bank Select Timing 99
Figure 14.6. Non-Multiplexed 8-bit MOVX with Bank Select Timing 100
Figure 14.7. Multiplexed 16-bit MOVX Timing 101
Figure 14.8. Multiplexed 8-bit MOVX without Bank Select Timing 102
Figure 14.9. Multiplexed 8-bit MOVX with Bank Select Timing 103
Figure 17.1. Reset Sources 123
Figure 17.2. Power-On and VDD Monitor Reset Timing 124
Figure 18.1. Flash Program Memory Map and Security Byte 131
Figure 19.1. Oscillator Options 136
Figure 19.2. External Crystal Example 144
Figure 20.1. Port I/O Functional Block Diagram (Port 0 through Port 3) 147

6.4.1. Window Detector Example

Figure 6.6 shows two example window comparisons for right-justified, single-ended data, with ADC0LTH:ADC0LTL = 0x0080 (128d) and ADC0GTH:ADC0GTL = 0x0040 (64d). The input voltage can range from 0 to VREF x (1023/1024) with respect to GND, and is represented by a 10-bit unsigned integer value. In the left example, an AD0WINT interrupt will be generated if the ADC0 conversion word (ADC0H:ADC0L) is within the range defined by ADC0GTH:ADC0GTL and ADC0LTH:ADC0LTL (if 0x0040 < ADC0H:ADC0L < 0x0080). In the right example, and AD0WINT interrupt will be generated if the ADC0 conversion word is outside of the range defined by the ADC0GT and ADC0LT registers (if ADC0H:ADC0L < 0x0040 or ADC0H:ADC0L > 0x0080). Figure 6.7 shows an example using left-justified data with the same comparison values.

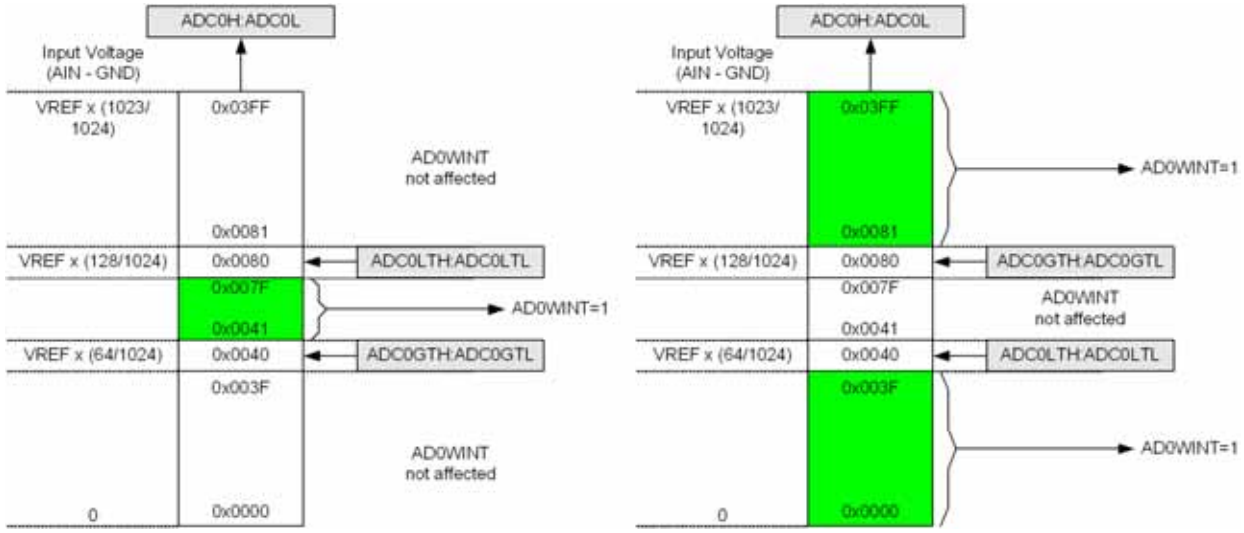

Figure 6.6. ADC Window Compare Example: Right-Justified Data

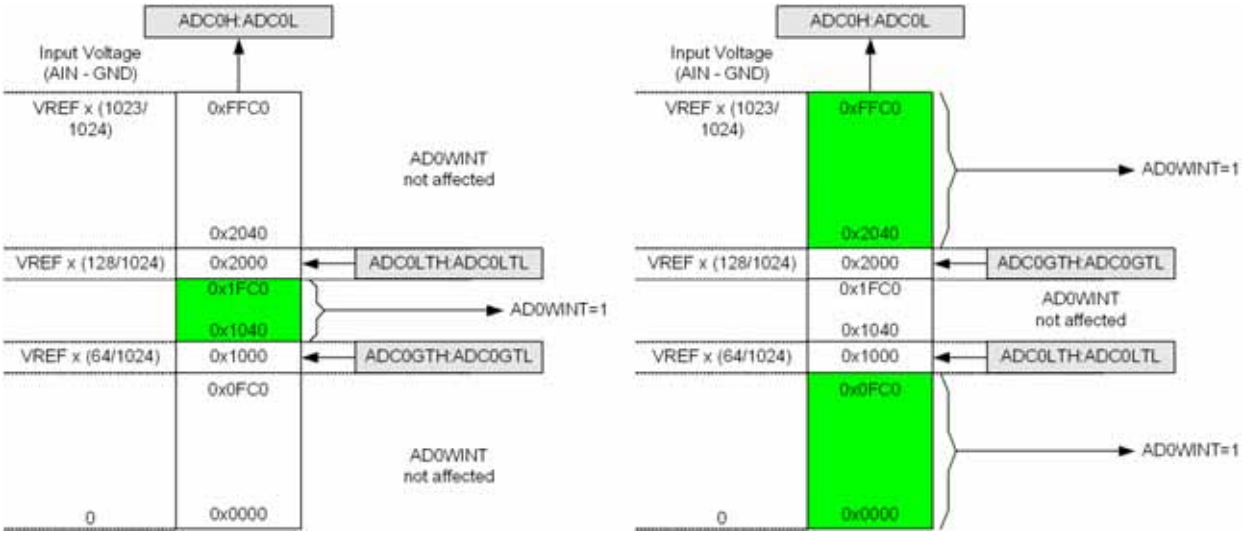

Figure 6.7. ADC Window Compare Example: Left-Justified Data

SFR Definition 8.2. CPT0MD: Comparator0 Mode Selection

Bit	7	6	5	4	3	2	1	0
Name			CP0RIE	CP0FIE			CP0MD[1:0]	
Type	R	R	R/W	R/W	R	R	R/W	
Reset	0	0	0	0	0	0	1	0

SFR Address = 0x9D; SFR Page = All Pages

Bit	Name	Function
7:6	Unused	Read = 00b, Write = don't care.
5	CP0RIE	**Comparator0 Rising-Edge Interrupt Enable.** 0: Comparator0 Rising-edge interrupt disabled. 1: Comparator0 Rising-edge interrupt enabled.
4	CP0FIE	**Comparator0 Falling-Edge Interrupt Enable.** 0: Comparator0 Falling-edge interrupt disabled. 1: Comparator0 Falling-edge interrupt enabled.
3:2	Unused	Read = 00b, Write = don't care.
1:0	CP0MD[1:0]	**Comparator0 Mode Select.** These bits affect the response time and power consumption for Comparator0. 00: Mode 0 (Fastest Response Time, Highest Power Consumption) 01: Mode 1 10: Mode 2 11: Mode 3 (Slowest Response Time, Lowest Power Consumption)

Table 11.1. CIP-51 Instruction Set Summary (Continued)

Mnemonic	Description	Bytes	Clock Cycles
ANL C, bit	AND direct bit to Carry	2	2
ANL C, /bit	AND complement of direct bit to Carry	2	2
ORL C, bit	OR direct bit to carry	2	2
ORL C, /bit	OR complement of direct bit to Carry	2	2
MOV C, bit	Move direct bit to Carry	2	2
MOV bit, C	Move Carry to direct bit	2	2
Program Flow Timings are listed with the PFE on and FLRT = 0. Extra cycles are required for branches if FLRT = 1.			
JC rel	Jump if Carry is set	2	2/4
JNC rel	Jump if Carry is not set	2	2/4
JB bit, rel	Jump if direct bit is set	3	3/5
JNB bit, rel	Jump if direct bit is not set	3	3/5
JBC bit, rel	Jump if direct bit is set and clear bit	3	3/5
ACALL addr11	Absolute subroutine call	2	4
LCALL addr16	Long subroutine call	3	5
RET	Return from subroutine	1	6
RETI	Return from interrupt	1	6
AJMP addr11	Absolute jump	2	4
LJMP addr16	Long jump	3	5
SJMP rel	Short jump (relative address)	2	4
JMP @A+DPTR	Jump indirect relative to DPTR	1	4
JZ rel	Jump if A equals zero	2	2/4
JNZ rel	Jump if A does not equal zero	2	2/4
CJNE A, direct, rel	Compare direct byte to A and jump if not equal	3	4/6
CJNE A, #data, rel	Compare immediate to A and jump if not equal	3	3/5
CJNE Rn, #data, rel	Compare immediate to Register and jump if not equal	3	3/5
CJNE @Ri, #data, rel	Compare immediate to indirect and jump if not equal	3	4/6
DJNZ Rn, rel	Decrement Register and jump if not zero	2	2/4
DJNZ direct, rel	Decrement direct byte and jump if not zero	3	3/5
NOP	No operation	1	1

Notes on Registers, Operands and Addressing Modes:
Rn - Register R0–R7 of the currently selected register bank. **@Ri** - Data RAM location addressed indirectly through R0 or R1. **rel** - 8-bit, signed (two's complement) offset relative to the first byte of the following instruction. Used by SJMP and all conditional jumps. **direct** - 8-bit internal data location's address. This could be a direct-access Data RAM location (0x00–0x7F) or an SFR (0x80–0xFF). **#data** - 8-bit constant **#data16** - 16-bit constant **bit** - Direct-accessed bit in Data RAM or SFR **addr11** - 11-bit destination address used by ACALL and AJMP. The destination must be within the same 2 kB page of program memory as the first byte of the following instruction. **addr16** - 16-bit destination address used by LCALL and LJMP. The destination may be anywhere within the 8 kB program memory space. There is one unused opcode (0xA5) that performs the same function as NOP. All mnemonics copyrighted © Intel Corporation 1980.

12. Prefetch Engine

The C8051F388/9/A/B family of devices incorporate a 2-byte prefetch engine. Because the access time of the Flash memory is 40 ns, and the minimum instruction time is roughly 20 ns, the prefetch engine is necessary for full-speed code execution. Instructions are read from Flash memory two bytes at a time by the prefetch engine and given to the CIP-51 processor core to execute. When running linear code (code without any jumps or branches), the prefetch engine allows instructions to be executed at full speed. When a code branch occurs, the processor may be stalled for up to two clock cycles while the next set of code bytes is retrieved from Flash memory. It is recommended that the prefetch be used for optimal code execution timing.

Note: The prefetch engine can be disabled when the device is in suspend mode to save power.

SFR Definition 12.1. PFE0CN: Prefetch Engine Control

Bit	7	6	5	4	3	2	1	0
Name			PFEN					FLBWE
Type	R	R	R/W	R	R	R	R	R/W
Reset	0	0	1	0	0	0	0	0

SFR Address = 0xAF; SFR Page = All Pages

Bit	Name	Function
7:6	Unused	Read = 00b, Write = don't care.
5	PFEN	**Prefetch Enable.** This bit enables the prefetch engine. 0: Prefetch engine is disabled. 1: Prefetch engine is enabled.
4:1	Unused	Read = 0000b. Write = don't care.
0	FLBWE	**Flash Block Write Enable.** This bit allows block writes to Flash memory from software. 0: Each byte of a software Flash write is written individually. 1: Flash bytes are written in groups of two.

14.6.2.3. 8-bit MOVX with Bank Select: EMI0CF[4:2] = 010

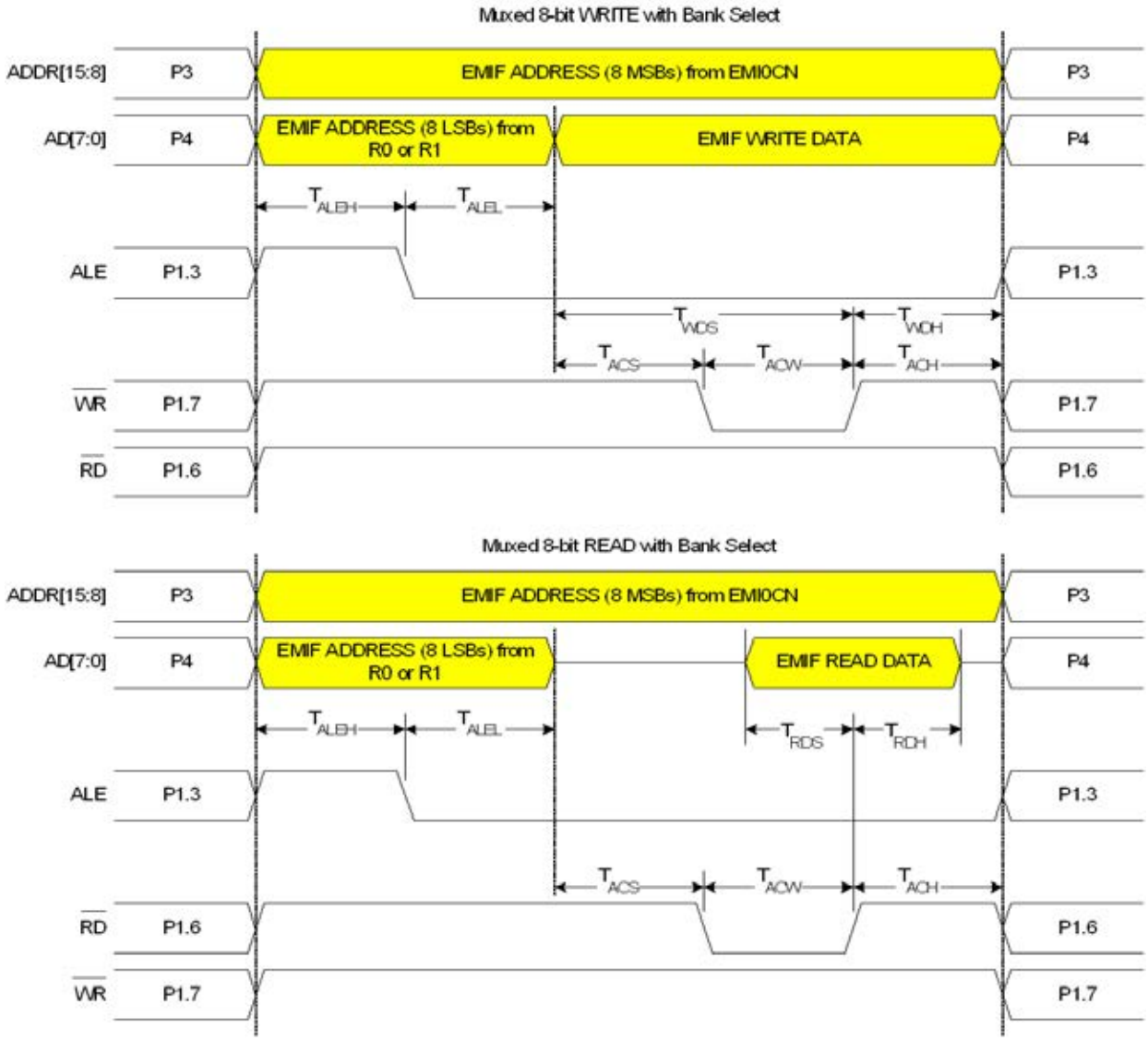

Figure 14.9. Multiplexed 8-bit MOVX with Bank Select Timing

17.6. PCA Watchdog Timer Reset

The programmable Watchdog Timer (WDT) function of the Programmable Counter Array (PCA) can be used to prevent software from running out of control during a system malfunction. The PCA WDT function can be enabled or disabled by software as described in Section “26.4. Watchdog Timer Mode” on page 269; the WDT is enabled and clocked by SYSCLK / 12 following any reset. If a system malfunction prevents user software from updating the WDT, a reset is generated and the WDTRSF bit (RSTSRC.5) is set to 1. The state of the $\overline{\text{RST}}$ pin is unaffected by this reset.

17.7. Flash Error Reset

If a Flash program read, write, or erase operation targets an illegal address, a system reset is generated. This may occur due to any of the following:

- Programming hardware attempts to write or erase a Flash location which is above the user code space address limit.
- A Flash read from firmware is attempted above user code space. This occurs when a MOVC operation is attempted above the user code space address limit.
- A Program read is attempted above user code space. This occurs when user code attempts to branch to an address above the user code space address limit.
- A Flash read, write, or erase attempt is restricted due to a Flash security setting.
- A Flash write or erase is attempted when the V_{DD} monitor is not enabled.

The FERROR bit (RSTSRC.6) is set following a Flash error reset. The state of the $\overline{\text{RST}}$ pin is unaffected by this reset.

17.8. Software Reset

Software may force a reset by writing a 1 to the SWRSF bit (RSTSRC.4). The SWRSF bit will read 1 following a software forced reset. The state of the $\overline{\text{RST}}$ pin is unaffected by this reset.

20. Port Input/Output

Digital and analog resources are available through 40 I/O pins (C8051F388/A) or 25 I/O pins (C8051F389/B). Port pins are organized as shown in Figure 20.1. Each of the Port pins can be defined as general-purpose I/O (GPIO) or analog input; Port pins P0.0-P3.7 can be assigned to one of the internal digital resources as shown in Figure 20.3. The designer has complete control over which functions are assigned, limited only by the number of physical I/O pins. This resource assignment flexibility is achieved through the use of a Priority Crossbar Decoder. Note that the state of a Port I/O pin can always be read in the corresponding Port latch, regardless of the Crossbar settings.

The Crossbar assigns the selected internal digital resources to the I/O pins based on the Priority Decoder (Figure 20.3 and Figure 20.4). The registers XBR0, XBR1, and XBR2 defined in SFR Definition 20.1, SFR Definition 20.2, and SFR Definition 20.3, are used to select internal digital functions.

All Port I/Os are 5 V tolerant (refer to Figure 20.2 for the Port cell circuit). The Port I/O cells are configured as either push-pull or open-drain in the Port Output Mode registers (PnMDOUT, where n = 0,1,2,3,4).

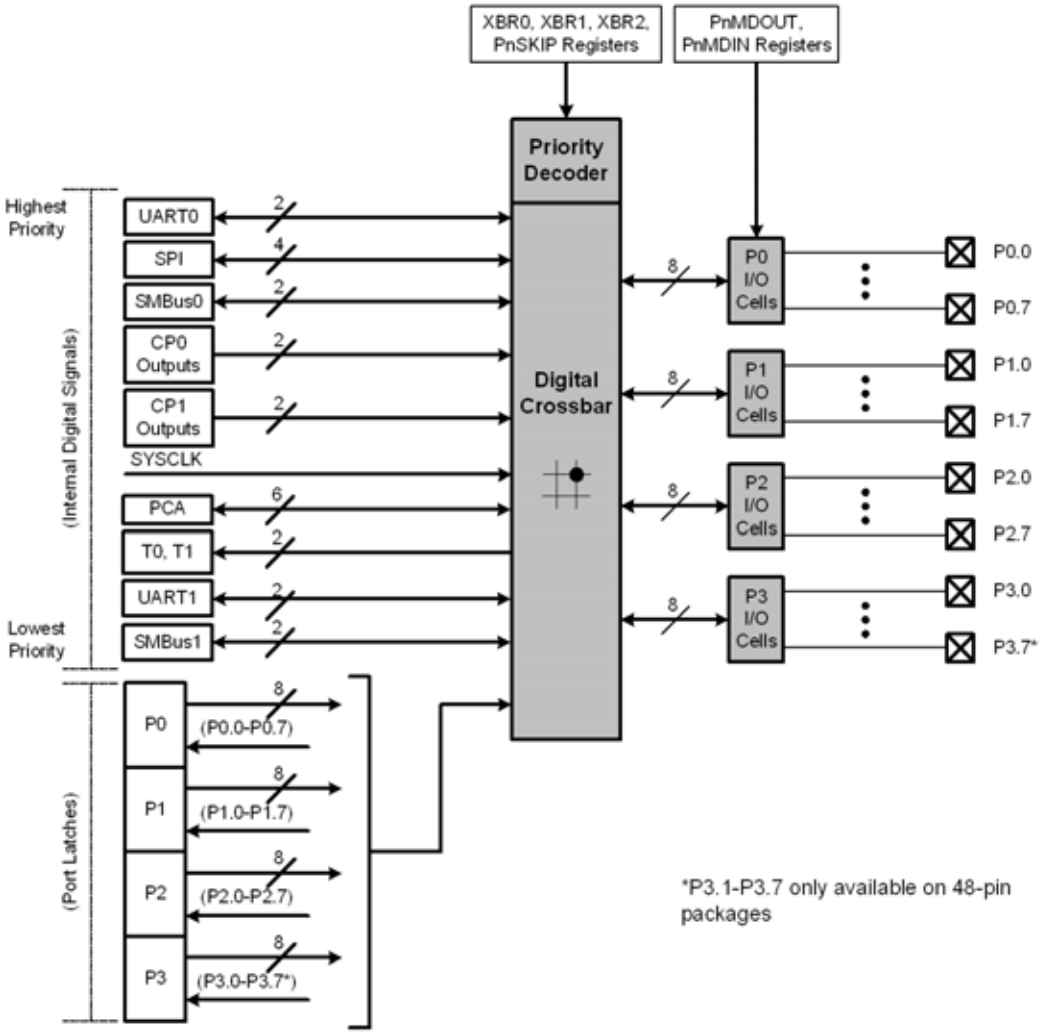

Figure 20.1. Port I/O Functional Block Diagram (Port 0 through Port 3)

21. SMBus0 and SMBus1 (I^2C Compatible)

The SMBus I/O interface is a two-wire, bi-directional serial bus. The SMBus is compliant with the System Management Bus Specification, version 1.1, and compatible with the I^2C serial bus. The C8051F388/9/A/B devices contain two SMBus interfaces, SMBus0 and SMBus1.

Reads and writes to the SMBus by the system controller are byte oriented with the SMBus interface autonomously controlling the serial transfer of the data. Data can be transferred at up to 1/20th of the system clock as a master or slave (this can be faster than allowed by the SMBus specification, depending on the system clock used). A method of extending the clock-low duration is available to accommodate devices with different speed capabilities on the same bus.

The SMBus may operate as a master and/or slave, and may function on a bus with multiple masters. The SMBus provides control of SDA (serial data), SCL (serial clock) generation and synchronization, arbitration logic, and START/STOP control and generation. The SMBus peripherals can be fully driven by software (i.e., software accepts/rejects slave addresses, and generates ACKs), or hardware slave address recognition and automatic ACK generation can be enabled to minimize software overhead. A block diagram of the SMBus0 peripheral and the associated SFRs is shown in Figure 21.1. SMBus1 is identical, with the exception of the available timer options for the clock source, and the timer used to implement the SCL low timeout feature. Refer to the specific SFR definitions for more details.

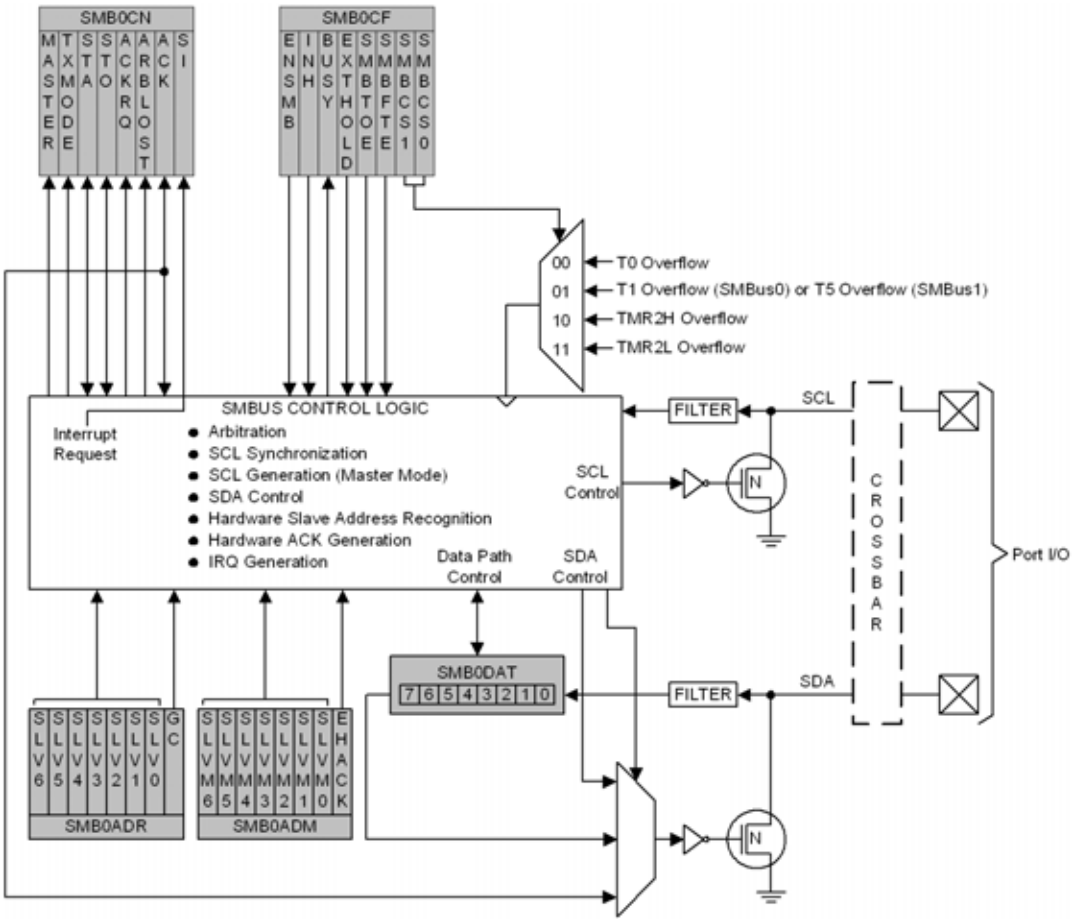

Figure 21.1. SMBus Block Diagram

SFR Definition 21.11. SMB1DAT: SMBus Data

Bit	7	6	5	4	3	2	1	0
Name	SMB1DAT[7:0]							
Type	R/W							
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xC2; SFR Page = F

Bit	Name	Function
7:0	SMB1DAT[7:0]	**SMBus1 Data.** The SMB1DAT register contains a byte of data to be transmitted on the SMBus1 serial interface or a byte that has just been received on the SMBus1 serial interface. The CPU can read from or write to this register whenever the SI1 serial interrupt flag (SMB1CN.0) is set to logic 1. The serial data in the register remains stable as long as the SI1 flag is set. When the SI1 flag is not set, the system may be in the process of shifting data in/out and the CPU should not attempt to access this register.

SFR Definition 23.1. SCON1: UART1 Control

Bit	7	6	5	4	3	2	1	0
Name	OVR1	PERR1	THRE1	REN1	TBX1	RBX1	TI1	RI1
Type	R/W	R/W	R	R/W	R/W	R/W	R/W	R/W
Reset	0	0	1	0	0	0	0	0

SFR Address = 0xD2; SFR Page = All Pages

Bit	Name	Function
7	OVR1	**Receive FIFO Overrun Flag.** This bit indicates a receive FIFO overrun condition, where an incoming character is discarded due to a full FIFO. This bit must be cleared to 0 by software. 0: Receive FIFO Overrun has not occurred. 1: Receive FIFO Overrun has occurred.
6	PERR1	**Parity Error Flag.** When parity is enabled, this bit indicates that a parity error has occurred. It is set to 1 when the parity of the oldest byte in the FIFO does not match the selected Parity Type. This bit must be cleared to 0 by software. 0: Parity Error has not occurred. 1: Parity Error has occurred.
5	THRE1	**Transmit Holding Register Empty Flag.** 0: Transmit Holding Register not Empty - do not write to SBUF1. 1: Transmit Holding Register Empty - it is safe to write to SBUF1.
4	REN1	**Receive Enable.** This bit enables/disables the UART receiver. When disabled, bytes can still be read from the receive FIFO. 0: UART1 reception disabled. 1: UART1 reception enabled.
3	TBX1	**Extra Transmission Bit.** The logic level of this bit will be assigned to the extra transmission bit when XBE1 = 1. This bit is not used when Parity is enabled.
2	RBX1	**Extra Receive Bit.** RBX1 is assigned the value of the extra bit when XBE1 = 1. If XBE1 is cleared to 0, RBX1 is assigned the logic level of the first stop bit. This bit is not valid when Parity is enabled.
1	TI1	**Transmit Interrupt Flag.** Set to a 1 by hardware after data has been transmitted at the beginning of the STOP bit. When the UART1 interrupt is enabled, setting this bit causes the CPU to vector to the UART1 interrupt service routine. This bit must be cleared manually by software.
0	RI1	**Receive Interrupt Flag.** Set to 1 by hardware when a byte of data has been received by UART1 (set at the STOP bit sampling time). When the UART1 interrupt is enabled, setting this bit to 1 causes the CPU to vector to the UART1 interrupt service routine. This bit must be cleared manually by software. Note that RI1 will remain set to '1' as long as there is still data in the UART FIFO. After the last byte has been shifted from the FIFO to SBUF1, RI1 can be cleared.

1 at the end of the transfer. If interrupts are enabled, an interrupt request is generated when the SPIF flag is set. While the SPI0 master transfers data to a slave on the MOSI line, the addressed SPI slave device simultaneously transfers the contents of its shift register to the SPI master on the MISO line in a full-duplex operation. Therefore, the SPIF flag serves as both a transmit-complete and receive-data-ready flag. The data byte received from the slave is transferred MSB-first into the master's shift register. When a byte is fully shifted into the register, it is moved to the receive buffer where it can be read by the processor by reading SPI0DAT.

When configured as a master, SPI0 can operate in one of three different modes: multi-master mode, 3-wire single-master mode, and 4-wire single-master mode. The default, multi-master mode is active when NSSMD1 (SPI0CN.3) = 0 and NSSMD0 (SPI0CN.2) = 1. In this mode, NSS is an input to the device, and is used to disable the master SPI0 when another master is accessing the bus. When NSS is pulled low in this mode, MSTEN (SPI0CN.6) and SPIEN (SPI0CN.0) are set to 0 to disable the SPI master device, and a Mode Fault is generated (MODF, SPI0CN.5 = 1). Mode Fault will generate an interrupt if enabled. SPI0 must be manually re-enabled in software under these circumstances. In multi-master systems, devices will typically default to being slave devices while they are not acting as the system master device. In multi-master mode, slave devices can be addressed individually (if needed) using general-purpose I/O pins. Figure 24.2 shows a connection diagram between two master devices in multiple-master mode.

3-wire single-master mode is active when NSSMD1 (SPI0CN.3) = 0 and NSSMD0 (SPI0CN.2) = 0. In this mode, NSS is not used, and is not mapped to an external port pin through the crossbar. Any slave devices that must be addressed in this mode should be selected using general-purpose I/O pins. Figure 24.3 shows a connection diagram between a master device in 3-wire master mode and a slave device.

4-wire single-master mode is active when NSSMD1 (SPI0CN.3) = 1. In this mode, NSS is configured as an output pin, and can be used as a slave-select signal for a single SPI device. In this mode, the output value of NSS is controlled (in software) with the bit NSSMD0 (SPI0CN.2). Additional slave devices can be addressed using general-purpose I/O pins. Figure 24.4 shows a connection diagram for a master device in 4-wire master mode and two slave devices.

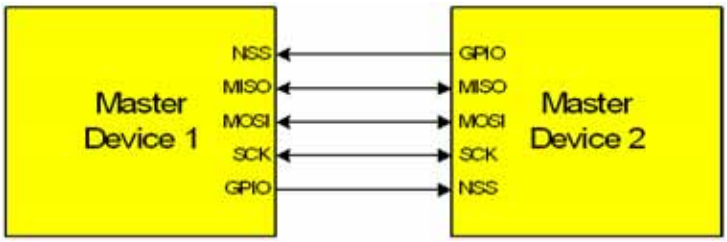

Figure 24.2. Multiple-Master Mode Connection Diagram

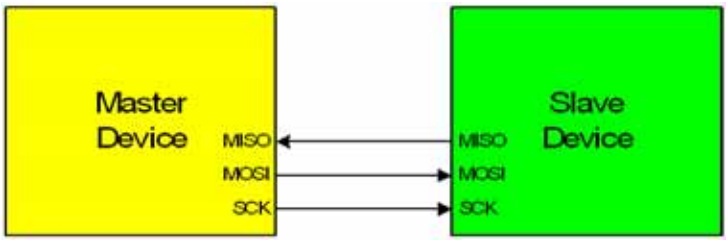

Figure 24.3. 3-Wire Single Master and 3-Wire Single Slave Mode Connection Diagram

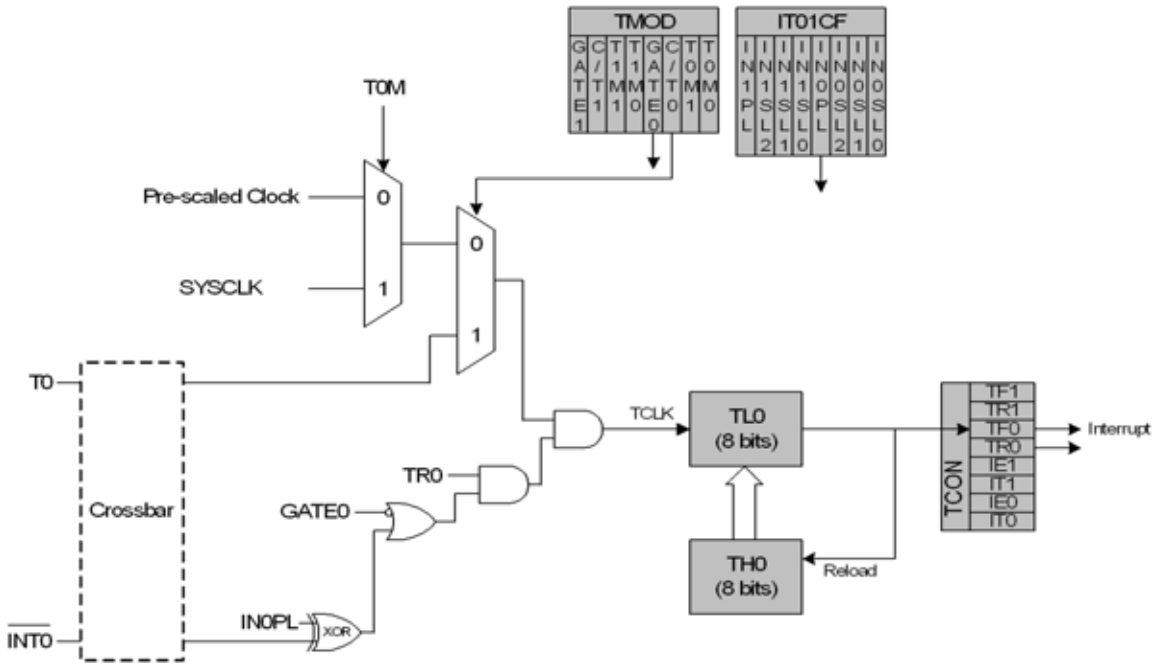

Figure 25.2. T0 Mode 2 Block Diagram

25.1.4. Mode 3: Two 8-bit Counter/Timers (Timer 0 Only)

In Mode 3, Timer 0 is configured as two separate 8-bit counter/timers held in TL0 and TH0. The counter/timer in TL0 is controlled using the Timer 0 control/status bits in TCON and TMOD: TR0, C/T0, GATE0 and TF0. TL0 can use either the system clock or an external input signal as its timebase. The TH0 register is restricted to a timer function sourced by the system clock or prescaled clock. TH0 is enabled using the Timer 1 run control bit TR1. TH0 sets the Timer 1 overflow flag TF1 on overflow and thus controls the Timer 1 interrupt.

Timer 1 is inactive in Mode 3. When Timer 0 is operating in Mode 3, Timer 1 can be operated in Modes 0, 1 or 2, but cannot be clocked by external signals nor set the TF1 flag and generate an interrupt. However, the Timer 1 overflow can be used to generate baud rates or overflow conditions for other peripherals. While Timer 0 is operating in Mode 3, Timer 1 run control is handled through its mode settings. To run Timer 1 while Timer 0 is in Mode 3, set the Timer 1 Mode as 0, 1, or 2. To disable Timer 1, configure it for Mode 3.

SFR Definition 25.7. TH0: Timer 0 High Byte

Bit	7	6	5	4	3	2	1	0
Name	TH0[7:0]							
Type	R/W							
Reset	0	0	0	0	0	0	0	0

SFR Address = 0x8C; SFR Page = All Pages

Bit	Name	Function
7:0	TH0[7:0]	**Timer 0 High Byte.** The TH0 register is the high byte of the 16-bit Timer 0.

SFR Definition 25.8. TH1: Timer 1 High Byte

Bit	7	6	5	4	3	2	1	0
Name	TH1[7:0]							
Type	R/W							
Reset	0	0	0	0	0	0	0	0

SFR Address = 0x8D; SFR Page = All Pages

Bit	Name	Function
7:0	TH1[7:0]	**Timer 1 High Byte.** The TH1 register is the high byte of the 16-bit Timer 1.

SFR Definition 25.13. TMR2H Timer 2 High Byte

Bit	7	6	5	4	3	2	1	0
Name	TMR2H[7:0]							
Type	R/W							
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xCD; SFR Page = 0

Bit	Name	Function
7:0	TMR2H[7:0]	**Timer 2 Low Byte.** In 16-bit mode, the TMR2H register contains the high byte of the 16-bit Timer 2. In 8-bit mode, TMR2H contains the 8-bit high byte timer value.

25.3. Timer 3

Timer 3 is a 16-bit timer formed by two 8-bit SFRs: TMR3L (low byte) and TMR3H (high byte). Timer 3 may operate in 16-bit auto-reload mode, (split) 8-bit auto-reload mode, or Low-Frequency Oscillator (LFO) Rising Edge capture mode. The Timer 3 operation mode is defined by the T3SPLIT (TMR3CN.3), T3CE (TMR3CN.4) bits, and T3CSS (TMR3CN.1) bits.

Timer 3 may be clocked by the system clock, the system clock divided by 12, or the external oscillator source divided by 8. The external clock mode is ideal for real-time clock (RTC) functionality, where the internal oscillator drives the system clock while Timer 3 (and/or the PCA) is clocked by an external precision oscillator. Note that the external oscillator source divided by 8 is synchronized with the system clock.

25.3.1. 16-bit Timer with Auto-Reload

When T3SPLIT (TMR3CN.3) is zero, Timer 3 operates as a 16-bit timer with auto-reload. Timer 3 can be clocked by SYSCLK, SYSCLK divided by 12, or the external oscillator clock source divided by 8. As the 16-bit timer register increments and overflows from 0xFFFF to 0x0000, the 16-bit value in the Timer 3 reload registers (TMR3RLH and TMR3RLL) is loaded into the Timer 3 register as shown in Figure 25.8, and the Timer 3 High Byte Overflow Flag (TMR3CN.7) is set. If Timer 3 interrupts are enabled (if EIE1.7 is set), an interrupt will be generated on each Timer 3 overflow. Additionally, if Timer 3 interrupts are enabled and the TF3LEN bit is set (TMR3CN.5), an interrupt will be generated each time the lower 8 bits (TMR3L) overflow from 0xFF to 0x00.

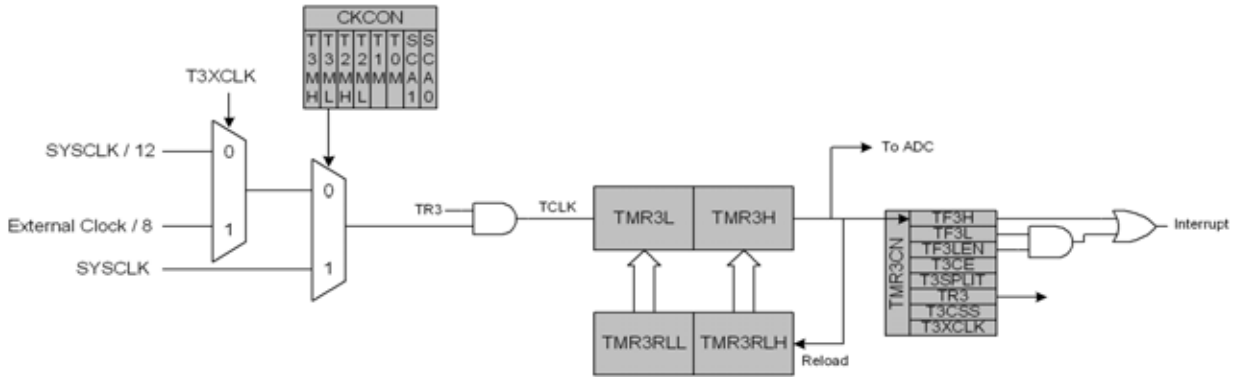

Figure 25.8. Timer 3 16-Bit Mode Block Diagram

25.3.2. 8-bit Timers with Auto-Reload

When T3SPLIT is 1 and T3CE = 0, Timer 3 operates as two 8-bit timers (TMR3H and TMR3L). Both 8-bit timers operate in auto-reload mode as shown in Figure 25.9. TMR3RLL holds the reload value for TMR3L; TMR3RLH holds the reload value for TMR3H. The TR3 bit in TMR3CN handles the run control for TMR3H. TMR3L is always running when configured for 8-bit Mode.

Each 8-bit timer may be configured to use SYSCLK, SYSCLK divided by 12, or the external oscillator clock source divided by 8. The Timer 3 Clock Select bits (T3MH and T3ML in CKCON) select either SYSCLK or the clock defined by the Timer 3 External Clock Select bit (T3XCLK in TMR3CN), as follows:

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.

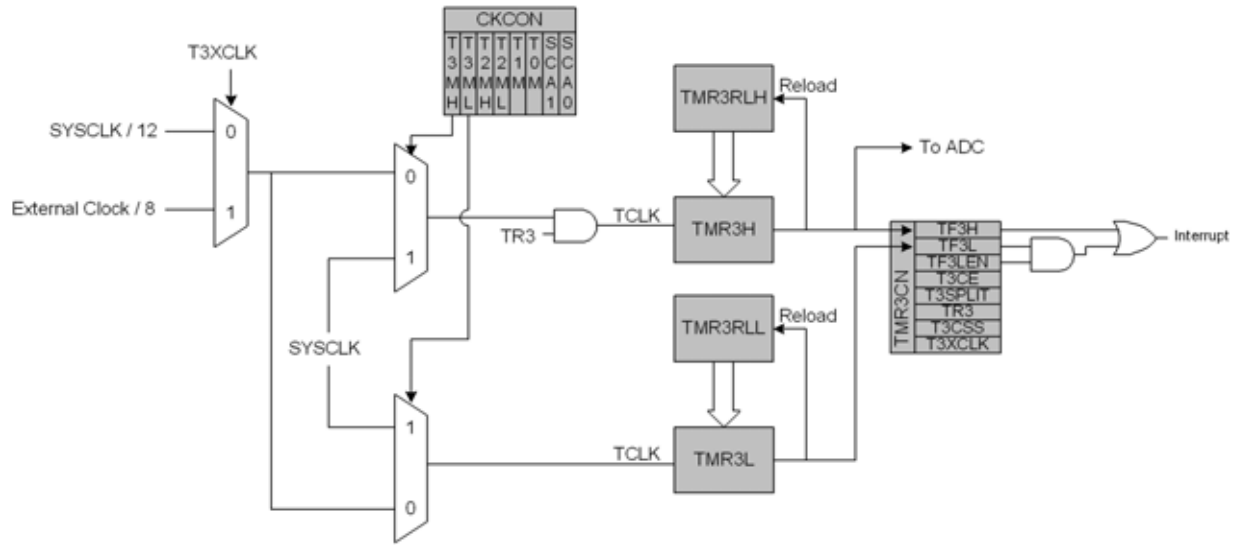

Figure 25.9. Timer 3 8-Bit Mode Block Diagram

25.3.3. Timer 3 Capture Modes: LFO Falling Edge

When T3CE = 1, Timer 3 will operate in a special capture mode with the LFO (T3CSS is set to 1). The LFO falling-edge capture mode can be used to calibrate the internal Low-Frequency Oscillator against the internal High-Frequency Oscillator or an external clock source. When T3SPLIT = 0, Timer 3 counts up and overflows from 0xFFFF to 0x0000. Each time a capture event is received, the contents of the Timer 3 registers (TMR3H:TMR3L) are latched into the Timer 3 Reload registers (TMR3RLH:TMR3RLL). A Timer 3 interrupt is generated if enabled.

26.1. PCA Counter/Timer

The 16-bit PCA counter/timer consists of two 8-bit SFRs: PCA0L and PCA0H. PCA0H is the high byte (MSB) of the 16-bit counter/timer and PCA0L is the low byte (LSB). Reading PCA0L automatically latches the value of PCA0H into a “snapshot” register; the following PCA0H read accesses this “snapshot” register. **Reading the PCA0L register first guarantees an accurate reading of the entire 16-bit PCA0 counter.** Reading PCA0H or PCA0L does not disturb the counter operation. The CPS2–CPS0 bits in the PCA0MD register select the timebase for the counter/timer as shown in Table 26.1.

When the counter/timer overflows from 0xFFFF to 0x0000, the Counter Overflow Flag (CF) in PCA0MD is set to logic 1 and an interrupt request is generated if CF interrupts are enabled. Setting the ECF bit in PCA0MD to logic 1 enables the CF flag to generate an interrupt request. The CF bit is not automatically cleared by hardware when the CPU vectors to the interrupt service routine, and must be cleared by software. Clearing the CIDL bit in the PCA0MD register allows the PCA to continue normal operation while the CPU is in Idle mode.

Table 26.1. PCA Timebase Input Options

CPS2	CPS1	CPS0	Timebase
0	0	0	System clock divided by 12
0	0	1	System clock divided by 4
0	1	0	Timer 0 overflow
0	1	1	High-to-low transitions on ECI (max rate = system clock divided by 4)
1	0	0	System clock
1	0	1	External oscillator source divided by 8*
1	1	x	Reserved
Note: External oscillator source divided by 8 is synchronized with the system clock.			

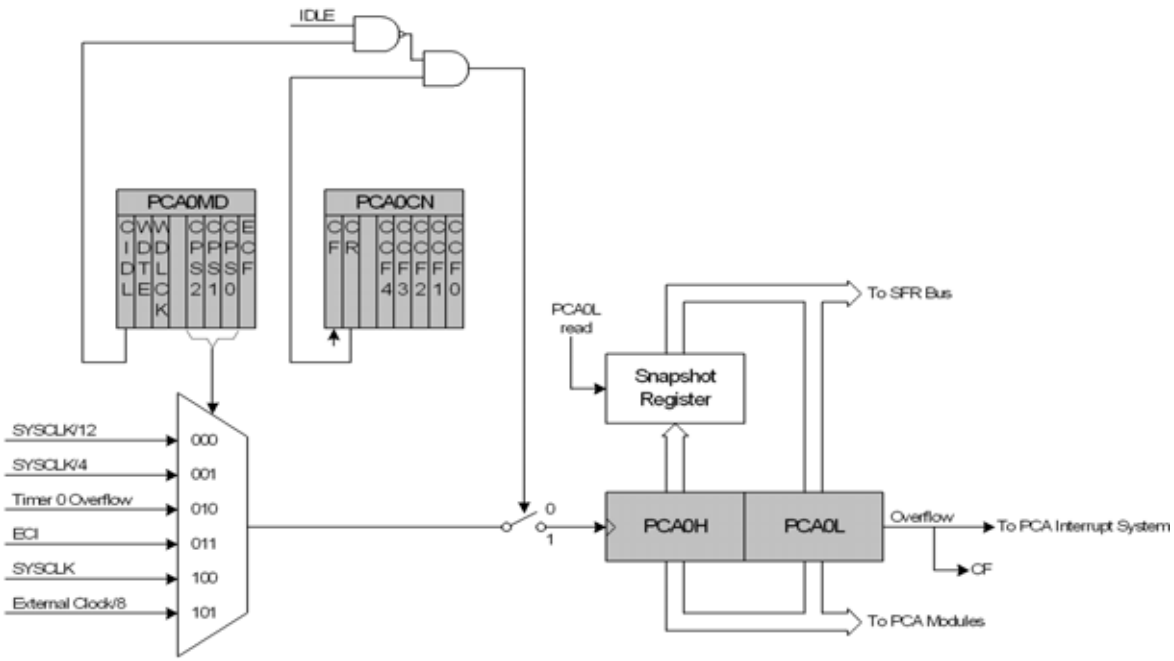

Figure 26.2. PCA Counter/Timer Block Diagram

26.3.3. High-Speed Output Mode

In High-Speed Output mode, a module's associated CEXn pin is toggled each time a match occurs between the PCA Counter and the module's 16-bit capture/compare register (PCA0CPHn and PCA0CPLn). When a match occurs, the Capture/Compare Flag (CCFn) in PCA0CN is set to logic 1. An interrupt request is generated if the CCFn interrupt for that module is enabled. The CCFn bit is not automatically cleared by hardware when the CPU vectors to the interrupt service routine, and must be cleared by software. Setting the TOGn, MATn, and ECOMn bits in the PCA0CPMn register enables the High-Speed Output mode. If ECOMn is cleared, the associated pin will retain its state, and not toggle on the next match event.

Important Note About Capture/Compare Registers: When writing a 16-bit value to the PCA0 Capture/Compare registers, the low byte should always be written first. Writing to PCA0CPLn clears the ECOMn bit to 0; writing to PCA0CPHn sets ECOMn to 1.

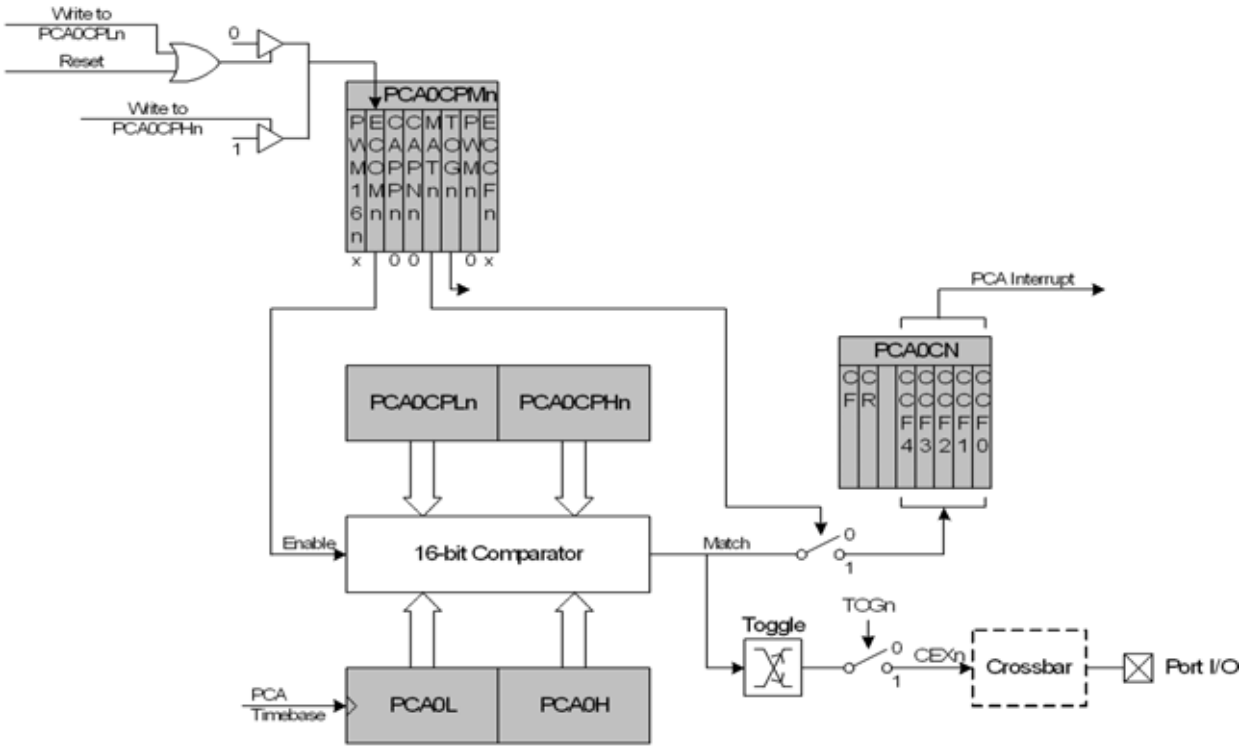

Figure 26.6. PCA High-Speed Output Mode Diagram