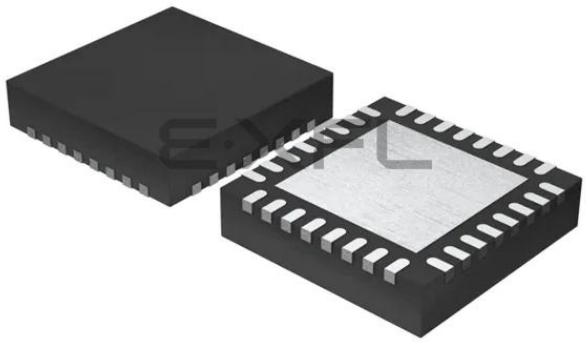

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What is "Embedded - Microcontrollers"?

"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	8051
Core Size	8-Bit
Speed	48 MIPS
Connectivity	I²C, SPI, UART/USART, USB
Peripherals	Brown-out Detect/Reset, POR, PWM, Temp Sensor, WDT
Number of I/O	25
Program Memory Size	16KB (16K 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/c8051f38c-gm

1. System Overview

C8051F380/1/2/3/4/5/6/7/C devices are fully integrated mixed-signal System-on-a-Chip MCUs. Highlighted features are listed below. Refer to Table 1.1 for specific product feature selection.

- High-speed pipelined 8051-compatible microcontroller core (up to 48 MIPS)
- In-system, full-speed, non-intrusive debug interface (on-chip)
- Universal Serial Bus (USB) Function Controller with eight flexible endpoint pipes, integrated transceiver, and 1 kB FIFO RAM
- Supply Voltage Regulator
- True 10-bit 500 ksps differential / single-ended ADC with analog multiplexer
- On-chip Voltage Reference and Temperature Sensor
- On-chip Voltage Comparators (2)
- Precision internal calibrated 48 MHz internal oscillator
- Internal low-frequency oscillator for additional power savings
- Up to 64 kB of on-chip Flash memory
- Up to 4352 Bytes of on-chip RAM (256 + 4 kB)
- External Memory Interface (EMIF) available on 48-pin versions.
- 2 I^2C/SMBus, 2 UARTs, and Enhanced SPI serial interfaces implemented in hardware
- Four general-purpose 16-bit timers
- Programmable Counter/Timer Array (PCA) with five capture/compare modules and Watchdog Timer function
- On-chip Power-On Reset, V_{DD} Monitor, and Missing Clock Detector
- Up to 40 Port I/O (5 V tolerant)

With on-chip Power-On Reset, V_{DD} monitor, Voltage Regulator, Watchdog Timer, and clock oscillator, C8051F380/1/2/3/4/5/6/7/C devices are truly stand-alone System-on-a-Chip solutions. The Flash memory can be reprogrammed in-circuit, providing non-volatile data storage, and also allowing field upgrades of the 8051 firmware. User software has complete control of all peripherals, and may individually shut down any or all peripherals for power savings.

The on-chip Silicon Labs 2-Wire (C2) Development Interface allows non-intrusive (uses no on-chip resources), full speed, in-circuit debugging using the production MCU installed in the final application. This debug logic supports inspection and modification of memory and registers, setting breakpoints, single stepping, run and halt commands. All analog and digital peripherals are fully functional while debugging using C2. The two C2 interface pins can be shared with user functions, allowing in-system debugging without occupying package pins.

Each device is specified for 2.7–5.25 V operation over the industrial temperature range (–40 to +85 °C). For voltages above 3.6 V, the on-chip Voltage Regulator must be used. A minimum of 3.0 V is required for USB communication. The Port I/O and $\overline{RST}$ pins are tolerant of input signals up to 5 V. C8051F380/1/2/3/4/5/6/7/C devices are available in 48-pin TQFP, 32-pin LQFP, or 32-pin QFN packages. See Table 1.1, “Product Selection Guide,” on page 17 for feature and package choices.

Table 5.5. Internal Voltage Regulator Electrical Characteristics
–40 to +85 °C unless otherwise specified.

Parameter	Test Condition	Min	Typ	Max	Unit
Voltage Regulator (REG0)					
Input Voltage Range[1]		2.7	—	5.25	V
Output Voltage (V_{DD})[2]	Output Current = 1 to 100 mA	3.0	3.3	3.6	V
Output Current[2]		—	—	100	mA
Dropout Voltage (V_{DO})[3]		—	1	—	mV/mA
Voltage Regulator (REG1)					
Input Voltage Range		1.8	—	3.6	V

Notes:
1. Input range specified for regulation. When an external regulator is used, should be tied to V_{DD}.
2. Output current is total regulator output, including any current required by the C8051F380/1/2/3/4/5/6/7/C.
3. The minimum input voltage is 2.70 V or V_{DD} + V_{DO} (max load), whichever is greater.

Table 5.6. Flash Electrical Characteristics

Parameter	Test Condition	Min	Typ	Max	Unit
Flash Size	C8051F380/1/4/5* C8051F382/3/6/7	65536* 32768	—	—	Bytes Bytes
Endurance		10k	100k	—	Erase/Write
Erase Cycle Time	25 MHz System Clock	10	15	22.5	ms
Write Cycle Time	25 MHz System Clock	10	15	20	µs

Notes:
1. 1024 bytes at location 0xFC00 to 0xFFFF are not available for program storage.
2. Data Retention Information is published in the Quarterly Quality and Reliability Report.

Table 5.14. USB Transceiver Electrical Characteristics

V_{DD} = 3.0 V to 3.6 V, –40 to +85 °C unless otherwise specified.

Parameter	Test Condition	Min	Typ	Max	Unit
Transmitter					
Output High Voltage (V_{OH})		2.8	—	—	V
Output Low Voltage (V_{OL})		—	—	0.8	V
VBUS Detection Input Low Voltage		—	—	1.0	V
VBUS Detection Input High Voltage		3.0	—	—	V
Output Crossover Point (V_{CRS})		1.3	—	2.0	V
Output Impedance (Z_{DRV})	Driving High Driving Low	— —	38 38	— —	W
Pull-up Resistance (R_{PU})	Full Speed (D+ Pull-up) Low Speed (D– Pull-up)	1.425	1.5	1.575	kΩ
Output Rise Time (T_R)	Low Speed Full Speed	75 4	— —	300 20	ns
Output Fall Time (T_F)	Low Speed Full Speed	75 4	— —	300 20	ns
Receiver					
Differential Input Sensitivity (V_{DI})	| (D+) – (D–) |	0.2	—	—	V
Differential Input Common Mode Range (V_{CM})		0.8	—	2.5	V
Input Leakage Current (I_L)	Pullups Disabled	—	<1.0	—	µA

Note: Refer to the USB Specification for timing diagrams and symbol definitions.

14.7.1.3. 8-bit MOVX with Bank Select: EMI0CF[4:2] = 110

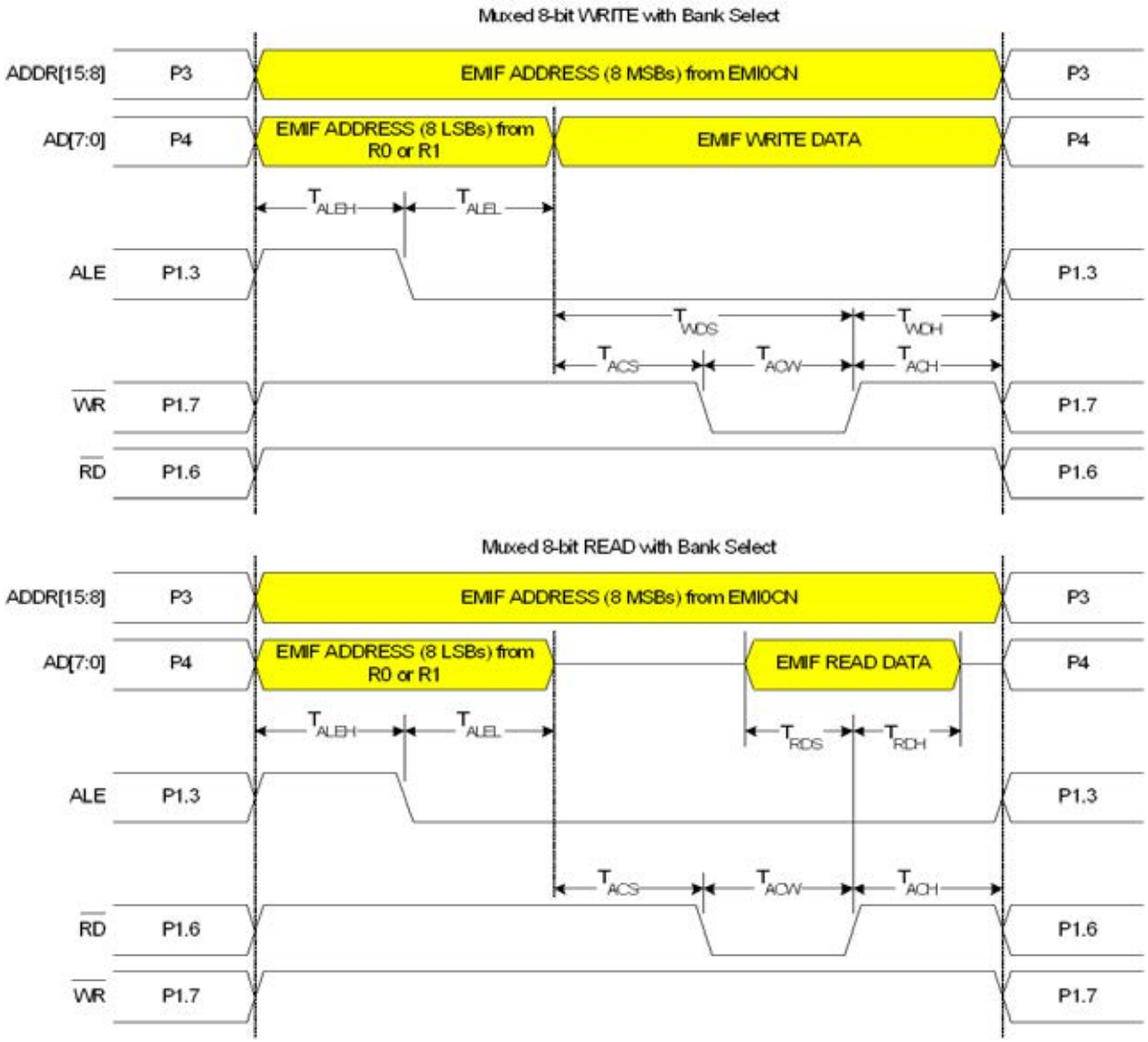


Figure 14.7. Non-multiplexed 8-bit MOVX with Bank Select Timing

SFR Definition 16.7. IT01CF: $\overline{\text{INT0}}$/$\overline{\text{INT1}}$ Configuration

Bit	7	6	5	4	3	2	1	0
Name	IN1PL	IN1SL[2:0]			IN0PL	IN0SL[2:0]		
Type	R/W	R/W			R/W	R/W		
Reset	0	0	0	0	0	0	0	1

SFR Address = 0xE4; SFR Page = 0

Bit	Name	Function
7	IN1PL	**$\overline{\text{INT1}}$ Polarity.** 0: $\overline{\text{INT1}}$ input is active low. 1: $\overline{\text{INT1}}$ input is active high.
6:4	IN1SL[2:0]	**$\overline{\text{INT1}}$ Port Pin Selection Bits.** These bits select which Port pin is assigned to $\overline{\text{INT1}}$. Note that this pin assignment is independent of the Crossbar; $\overline{\text{INT1}}$ will monitor the assigned Port pin without disturbing the peripheral that has been assigned the Port pin via the Crossbar. The Crossbar will not assign the Port pin to a peripheral if it is configured to skip the selected pin. 000: Select P0.0 001: Select P0.1 010: Select P0.2 011: Select P0.3 100: Select P0.4 101: Select P0.5 110: Select P0.6 111: Select P0.7
3	IN0PL	**$\overline{\text{INT0}}$ Polarity.** 0: $\overline{\text{INT0}}$ input is active low. 1: $\overline{\text{INT0}}$ input is active high.
2:0	IN0SL[2:0]	**$\overline{\text{INT0}}$ Port Pin Selection Bits.** These bits select which Port pin is assigned to $\overline{\text{INT0}}$. Note that this pin assignment is independent of the Crossbar; $\overline{\text{INT0}}$ will monitor the assigned Port pin without disturbing the peripheral that has been assigned the Port pin via the Crossbar. The Crossbar will not assign the Port pin to a peripheral if it is configured to skip the selected pin. 000: Select P0.0 001: Select P0.1 010: Select P0.2 011: Select P0.3 100: Select P0.4 101: Select P0.5 110: Select P0.6 111: Select P0.7

SFR Definition 19.3. OSCICN: Internal H-F Oscillator Control

Bit	7	6	5	4	3	2	1	0
Name	IOSCEN	IFRDY	SUSPEND				IFCN[1:0]	
Type	R/W	R	R/W	R	R	R	R/W	
Reset	1	1	0	0	0	0	0	0

SFR Address = 0xB2; SFR Page = All Pages

Bit	Name	Function
7	IOSCEN	**Internal H-F Oscillator Enable Bit.** 0: Internal H-F Oscillator Disabled. 1: Internal H-F Oscillator Enabled.
6	IFRDY	**Internal H-F Oscillator Frequency Ready Flag.** 0: Internal H-F Oscillator is not running at programmed frequency. 1: Internal H-F Oscillator is running at programmed frequency.
5	SUSPEND	**Internal Oscillator Suspend Enable Bit.** Setting this bit to logic 1 places the internal oscillator in SUSPEND mode. The internal oscillator resumes operation when one of the SUSPEND mode awakening events occurs.
4:2	Unused	Read = 000b; Write = don't care
1:0	IFCN[1:0]	**Internal H-F Oscillator Frequency Divider Control Bits.** The Internal H-F Oscillator is divided by the IFCN bit setting after a divide-by-4 stage. 00: SYSCLK can be derived from Internal H-F Oscillator divided by 8 (1.5 MHz). 01: SYSCLK can be derived from Internal H-F Oscillator divided by 4 (3 MHz). 10: SYSCLK can be derived from Internal H-F Oscillator divided by 2 (6 MHz). 11: SYSCLK can be derived from Internal H-F Oscillator divided by 1 (12 MHz).

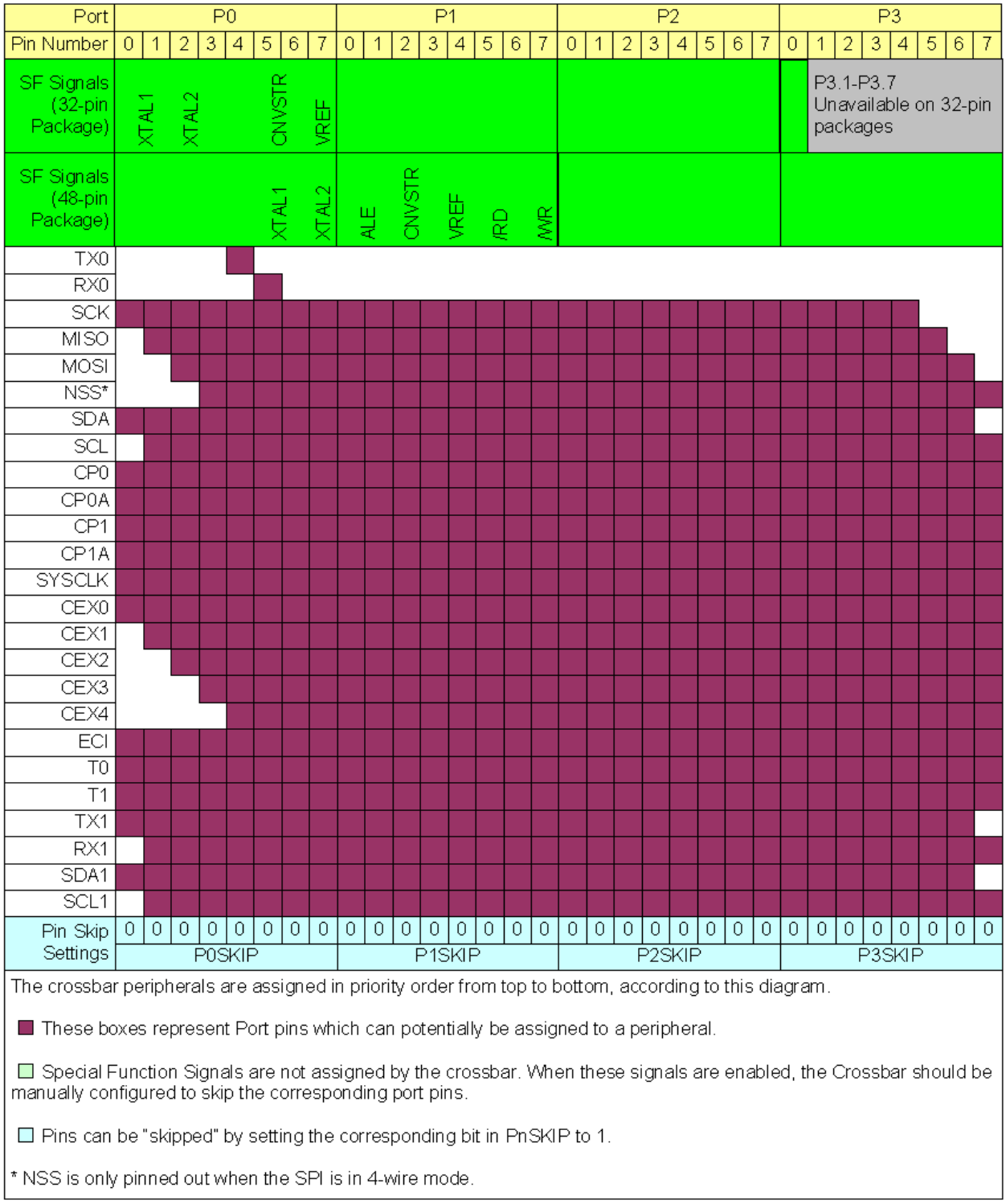


Figure 20.3. Peripheral Availability on Port I/O Pins

SFR Definition 20.20. P4: Port 4

Bit	7	6	5	4	3	2	1	0
Name	P4[7:0]							
Type	R/W							
Reset	1	1	1	1	1	1	1	1

SFR Address = 0xC7; SFR Page = All Pages

Bit	Name	Description	Write	Read
7:0	P4[7:0]	**Port 4 Data.** Sets the Port latch logic value or reads the Port pin logic state in Port cells configured for digital I/O.	0: Set output latch to logic LOW. 1: Set output latch to logic HIGH.	0: P4.n Port pin is logic LOW. 1: P4.n Port pin is logic HIGH.

SFR Definition 20.21. P4MDIN: Port 4 Input Mode

Bit	7	6	5	4	3	2	1	0
Name	P4MDIN[7:0]							
Type	R/W							
Reset	1	1	1	1	1	1	1	1

SFR Address = 0xF5; SFR Page = All Pages

Bit	Name	Function
7:0	P4MDIN[7:0]	**Analog Configuration Bits for P4.7–P4.0 (respectively).** Port pins configured for analog mode have their weak pullup, digital driver, and digital receiver disabled. 0: Corresponding P4.n pin is configured for analog mode. 1: Corresponding P4.n pin is not configured for analog mode.

USB Register Definition 21.16. CMIE: USB0 Common Interrupt Enable

Bit	7	6	5	4	3	2	1	0
Name					SOFE	RSTINTE	RSUINTE	SUSINTE
Type	R	R	R	R	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	1	1	0

USB Register Address = 0x0B

Bit	Name	Function
7:4	Unused	Read = 0000b. Write = don't care.
3	SOFE	**Start of Frame Interrupt Enable.** 0: SOF interrupt disabled. 1: SOF interrupt enabled.
2	RSTINTE	**Reset Interrupt Enable.** 0: Reset interrupt disabled. 1: Reset interrupt enabled.
1	RSUINTE	**Resume Interrupt Enable.** 0: Resume interrupt disabled. 1: Resume interrupt enabled.
0	SUSINTE	**Suspend Interrupt Enable.** 0: Suspend interrupt disabled. 1: Suspend interrupt enabled.

USB Register Definition 21.18. E0CNT: USB0 Endpoint0 Data Count

Bit	7	6	5	4	3	2	1	0
Name		E0CNT[6:0]						
Type	R	R						
Reset	0	0	0	0	0	0	0	0

USB Register Address = 0x16

Bit	Name	Function
7	Unused	Read = 0b. Write = don't care.
6:0	E0CNT[6:0]	**Endpoint 0 Data Count.** This 7-bit number indicates the number of received data bytes in the Endpoint 0 FIFO. This number is only valid while bit OPRDY is a 1.

21.11. Configuring Endpoints1-3

Endpoints1-3 are configured and controlled through their own sets of the following control/status registers: IN registers EINCSRL and EINCSRH, and OUT registers EOUTCSRL and EOUTCSRH. Only one set of endpoint control/status registers is mapped into the USB register address space at a time, defined by the contents of the INDEX register (USB Register Definition 21.4).

Endpoints1-3 can be configured as IN, OUT, or both IN/OUT (Split Mode) as described in Section 21.5.1. The endpoint mode (Split/Normal) is selected via the SPLIT bit in register EINCSRH.

When SPLIT = 1, the corresponding endpoint FIFO is split, and both IN and OUT pipes are available.

When SPLIT = 0, the corresponding endpoint functions as either IN or OUT; the endpoint direction is selected by the DIRSEL bit in register EINCSRH.

Endpoints1-3 can be disabled individually by the corresponding bits in the ENABLE register. When an Endpoint is disabled, it will not respond to bus traffic or stall the bus. All Endpoints are enabled by default.

USB Register Definition 21.19. EENABLE: USB0 Endpoint Enable

Bit	7	6	5	4	3	2	1	0
Name					EEN3	EEN2	EEN1	
Type	R	R	R	R	R/W	R/W	R/W	R/W
Reset	1	1	1	1	1	1	1	1

USB Register Address = 0x1E

Bit	Name	Function
7:4	Unused	Read = 1111b. Write = don't care.
3	EEN3	**Endpoint 3 Enable.** This bit enables/disables Endpoint 3. 0: Endpoint 3 is disabled (no NACK, ACK, or STALL on the USB network). 1: Endpoint 3 is enabled (normal).
2	EEN2	**Endpoint 2 Enable.** This bit enables/disables Endpoint 2. 0: Endpoint 2 is disabled (no NACK, ACK, or STALL on the USB network). 1: Endpoint 2 is enabled (normal).
1	EEN1	**Endpoint 1 Enable.** This bit enables/disables Endpoint 1. 0: Endpoint 1 is disabled (no NACK, ACK, or STALL on the USB network). 1: Endpoint 1 is enabled (normal).
0	Reserved	Must Write 1b.

21.12. Controlling Endpoints1-3 IN

Endpoints1-3 IN are managed via USB registers EINCSRL and EINCSRH. All IN endpoints can be used for Interrupt, Bulk, or Isochronous transfers. Isochronous (ISO) mode is enabled by writing 1 to the ISO bit in register EINCSRH. Bulk and Interrupt transfers are handled identically by hardware.

An Endpoint1-3 IN interrupt is generated by any of the following conditions:

1. An IN packet is successfully transferred to the host.
2. Software writes 1 to the FLUSH bit (EINCSRL.3) when the target FIFO is not empty.
3. Hardware generates a STALL condition.

21.12.1. Endpoints1-3 IN Interrupt or Bulk Mode

When the ISO bit (EINCSRH.6) = 0 the target endpoint operates in Bulk or Interrupt Mode. Once an endpoint has been configured to operate in Bulk/Interrupt IN mode (typically following an Endpoint0 SET_INTERFACE command), firmware should load an IN packet into the endpoint IN FIFO and set the INPRDY bit (EINCSRL.0). Upon reception of an IN token, hardware will transmit the data, clear the INPRDY bit, and generate an interrupt.

Writing 1 to INPRDY without writing any data to the endpoint FIFO will cause a zero-length packet to be transmitted upon reception of the next IN token.

USB Register Definition 21.23. EOUTCSRH: USB0 OUT Endpoint Control High Byte

Bit	7	6	5	4	3	2	1	0
Name	DBOEN	ISO						
Type	R/W	R/W	R	R	R	R	R	R
Reset	0	0	0	0	0	0	0	0

USB Register Address = 0x15

Bit	Name	Function
7	DBOEN	**Double-buffer Enable.** 0: Double-buffering disabled for the selected OUT endpoint. 1: Double-buffering enabled for the selected OUT endpoint.
6	ISO	**Isochronous Transfer Enable.** This bit enables/disables isochronous transfers on the current endpoint. 0: Endpoint configured for bulk/interrupt transfers. 1: Endpoint configured for isochronous transfers.
5:0	Unused	Read = 000000b. Write = don't care.

USB Register Definition 21.24. EOUTCNTL: USB0 OUT Endpoint Count Low

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

USB Register Address = 0x16

Bit	Name	Function
7:0	EOCL[7:0]	**OUT Endpoint Count Low Byte.** EOCL holds the lower 8-bits of the 10-bit number of data bytes in the last received packet in the current OUT endpoint FIFO. This number is only valid while OPRDY = 1.

SFR Definition 22.3. SMBTC: SMBus Timing Control

Bit	7	6	5	4	3	2	1	0
Name					SMB1SDD[1:0]		SMB0SDD[1:0]	
Type	R	R	R	R	R/W		R/W	
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xB9; SFR Page = F

Bit	Name	Function
7:4	Unused	Read = 0000b; Write = don't care.
3:2	SMB1SDD[1:0]	**SMBus1 Start Detection Window** These bits increase the hold time requirement between SDA falling and SCL falling for START detection. 00: No additional hold time requirement (0-1 SYSCLK). 01: Increase hold time window to 2-3 SYSCLKs. 10: Increase hold time window to 4-5 SYSCLKs. 11: Increase hold time window to 8-9 SYSCLKs.
1:0	SMB0SDD[1:0]	**SMBus0 Start Detection Window** These bits increase the hold time requirement between SDA falling and SCL falling for START detection. 00: No additional hold time window (0-1 SYSCLK). 01: Increase hold time window to 2-3 SYSCLKs. 10: Increase hold time window to 4-5 SYSCLKs. 11: Increase hold time window to 8-9 SYSCLKs.

SFR Definition 22.4. SMB0CN: SMBus Control

Bit	7	6	5	4	3	2	1	0
Name	MASTER0	TXMODE0	STA0	STO0	ACKRQ0	ARBLOST0	ACK0	SI0
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; SFR Page = 0; Bit-Addressable

Bit	Name	Description	Read	Write
7	MASTER0	**SMBus0 Master/Slave Indicator.** This read-only bit indicates when the SMBus0 is operating as a master.	0: SMBus0 operating in slave mode. 1: SMBus0 operating in master mode.	N/A
6	TXMODE0	**SMBus0 Transmit Mode Indicator.** This read-only bit indicates when the SMBus0 is operating as a transmitter.	0: SMBus0 in Receiver Mode. 1: SMBus0 in Transmitter Mode.	N/A
5	STA0	**SMBus0 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	STO0	**SMBus0 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	ACKRQ0	**SMBus0 Acknowledge Request.**	0: No ACK requested 1: ACK requested	N/A
2	ARBLOST0	**SMBus0 Arbitration Lost Indicator.**	0: No arbitration error. 1: Arbitration Lost	N/A
1	ACK0	**SMBus0 Acknowledge.**	0: NACK received. 1: ACK received.	0: Send NACK 1: Send ACK
0	SI0	**SMBus0 Interrupt Flag.** This bit is set by hardware under the conditions listed in Table 15.3. SI0 must be cleared by software. While SI0 is set, SCL0 is held low and the SMBus0 is stalled.	0: No interrupt pending 1: Interrupt Pending	0: Clear interrupt, and initiate next state machine event. 1: Force interrupt.

SFR Definition 22.9. SMB1ADM: SMBus1 Slave Address Mask

Bit	7	6	5	4	3	2	1	0
Name	SLVM1[6:0]							EHACK1
Type	R/W							R/W
Reset	1	1	1	1	1	1	1	0

SFR Address = 0xCE; SFR Page = F

Bit	Name	Function
7:1	SLVM1[6:0]	**SMBus1 Slave Address Mask.** Defines which bits of register SMB1ADR are compared with an incoming address byte, and which bits are ignored. Any bit set to 1 in SLVM1[6:0] enables comparisons with the corresponding bit in SLV1[6:0]. Bits set to 0 are ignored (can be either 0 or 1 in the incoming address).
0	EHACK1	**Hardware Acknowledge Enable.** Enables hardware acknowledgement of slave address and received data bytes. 0: Firmware must manually acknowledge all incoming address and data bytes. 1: Automatic Slave Address Recognition and Hardware Acknowledge is Enabled.

SFR Definition 23.2. SBUF0: Serial (UART0) Port Data Buffer

Bit	7	6	5	4	3	2	1	0
Name	SBUF0[7:0]							
Type	R/W							
Reset	0	0	0	0	0	0	0	0

SFR Address = 0x99; SFR Page = All Pages

Bit	Name	Function
7:0	SBUF0[7:0]	**Serial Data Buffer Bits 7–0 (MSB–LSB).** This SFR accesses two registers; a transmit shift register and a receive latch register. When data is written to SBUF0, it goes to the transmit shift register and is held for serial transmission. Writing a byte to SBUF0 initiates the transmission. A read of SBUF0 returns the contents of the receive latch.

Table 23.1. Timer Settings for Standard Baud Rates Using Internal Oscillator

	Target Baud Rate (bps)	Actual Baud Rate (bps)	Baud Rate Error	Oscillator Divide Factor	Timer Clock Source	SCA1-SCA0 (pre-scale select*	T1M	Timer 1 Reload Value (hex)
SYSCLK = 12 MHz	230400	230769	0.16%	52	SYSCLK	XX	1	0xE6
	115200	115385	0.16%	104	SYSCLK	XX	1	0xCC
	57600	57692	0.16%	208	SYSCLK	XX	1	0x98
	28800	28846	0.16%	416	SYSCLK	XX	1	0x30
	14400	14423	0.16%	832	SYSCLK / 4	01	0	0x98
	9600	9615	0.16%	1248	SYSCLK / 4	01	0	0x64
	2400	2404	0.16%	4992	SYSCLK / 12	00	0	0x30
	1200	1202	0.16%	9984	SYSCLK / 48	10	0	0x98
SYSCLK = 24 MHz	230400	230769	0.16%	104	SYSCLK	XX	1	0xCC
	115200	115385	0.16%	208	SYSCLK	XX	1	0x98
	57600	57692	0.16%	416	SYSCLK	XX	1	0x30
	28800	28846	0.16%	832	SYSCLK / 4	01	0	0x98
	14400	14423	0.16%	1664	SYSCLK / 4	01	0	0x30
	9600	9615	0.16%	2496	SYSCLK / 12	00	0	0x98
	2400	2404	0.16%	9984	SYSCLK / 48	10	0	0x98
	1200	1202	0.16%	19968	SYSCLK / 48	10	0	0x30
SYSCLK = 48 MHz	230400	230769	0.16%	208	SYSCLK	XX	1	0x98
	115200	115385	0.16%	416	SYSCLK	XX	1	0x30
	57600	57692	0.16%	832	SYSCLK / 4	01	0	0x98
	28800	28846	0.16%	1664	SYSCLK / 4	01	0	0x30
	14400	14388	0.08%	3336	SYSCLK / 12	00	0	0x75
	9600	9615	0.16%	4992	SYSCLK / 12	00	0	0x30
	2400	2404	0.16%	19968	SYSCLK / 48	10	0	0x30

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 25.2 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 25.3 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 25.4 shows a connection diagram for a master device in 4-wire master mode and two slave devices.

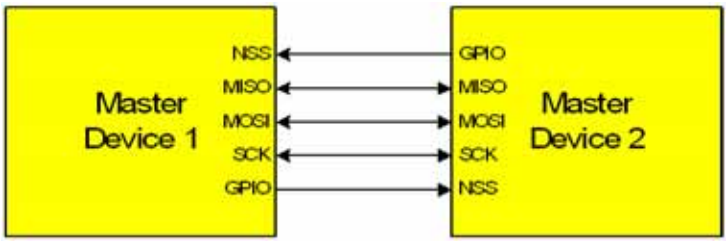


Figure 25.2. Multiple-Master Mode Connection Diagram

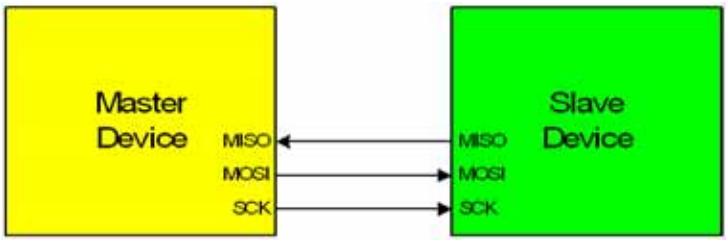
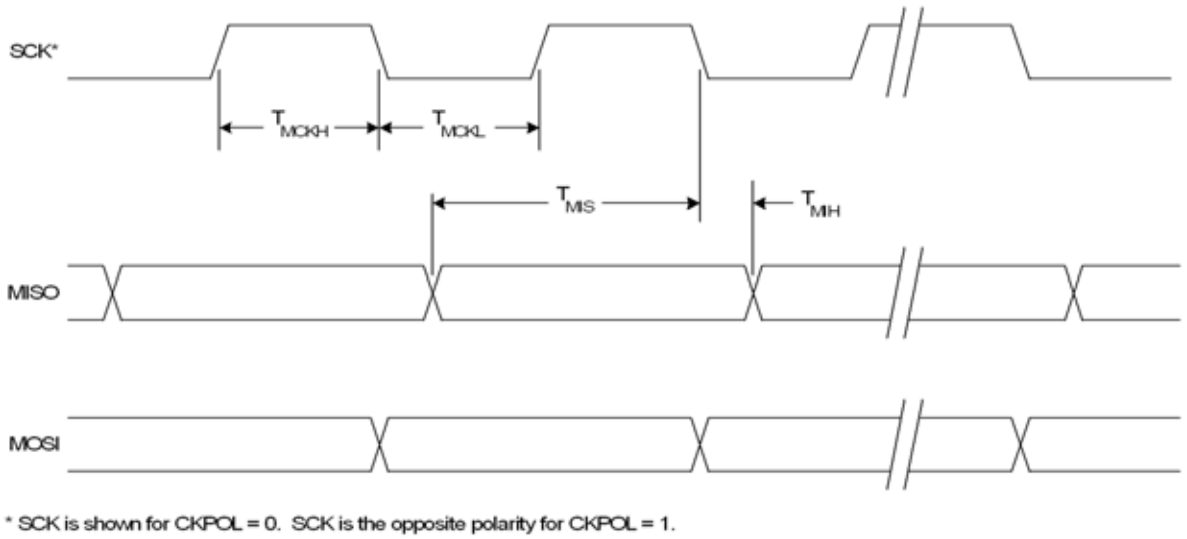
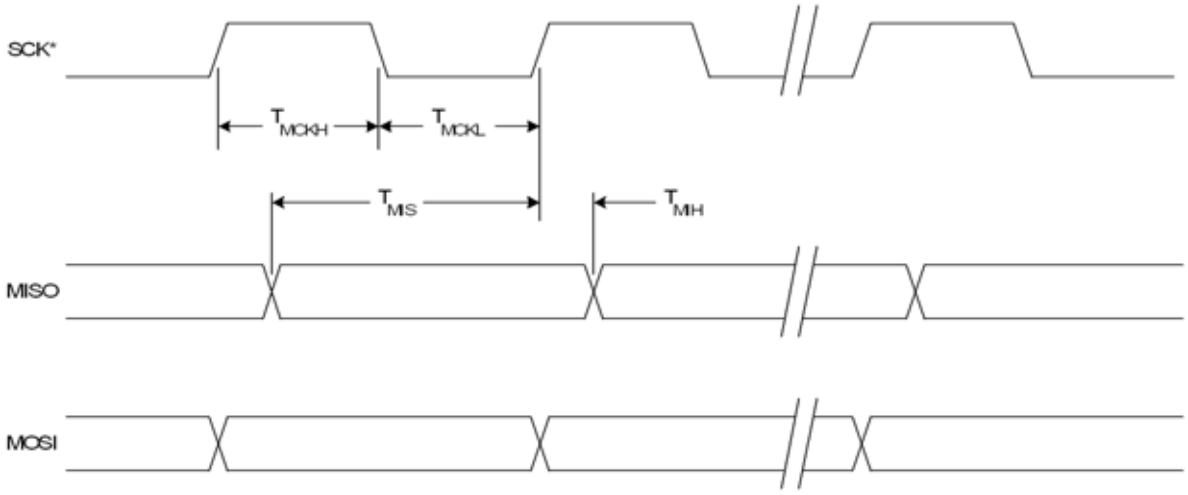


Figure 25.3. 3-Wire Single Master and 3-Wire Single Slave Mode Connection Diagram



* SCK is shown for CKPOL = 0. SCK is the opposite polarity for CKPOL = 1.

Figure 25.8. SPI Master Timing (CKPHA = 0)



* SCK is shown for CKPOL = 0. SCK is the opposite polarity for CKPOL = 1.

Figure 25.9. SPI Master Timing (CKPHA = 1)

26.3.2. 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 26.9. 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.

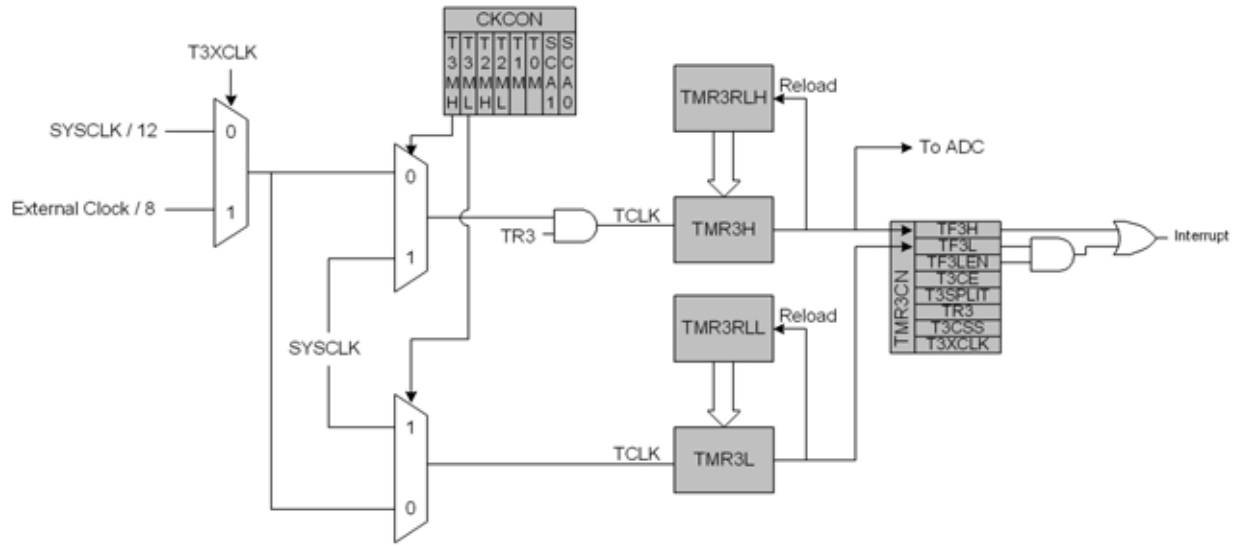


Figure 26.9. Timer 3 8-Bit Mode Block Diagram

26.3.3. Timer 3 Capture Modes: USB Start-of-Frame or LFO Falling Edge

When T3CE = 1, Timer 3 will operate in one of two special capture modes. The capture event can be selected between a USB Start-of-Frame (SOF) capture, and a Low-Frequency Oscillator (LFO) Falling Edge capture, using the T3CSS bit. The USB SOF capture mode can be used to calibrate the system clock or external oscillator against the known USB host SOF clock. 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.