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

Applications of "[Embedded - Microcontrollers](#)"

Details

Product Status	Active
Core Processor	8051
Core Size	8-Bit
Speed	50MHz
Connectivity	SMBus (2-Wire/I ² C), SPI, UART/USART
Peripherals	POR, PWM, Temp Sensor, WDT
Number of I/O	25
Program Memory Size	8KB (8K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	1.25K x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 5.25V
Data Converters	A/D 25x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°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/c8051f545-imr

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SFR Definition 5.4. ADC0CF: ADC0 Configuration

Bit	7	6	5	4	3	2	1	0
Name	AD0SC[4:0]					AD0RPT[1:0]		GAINEN
Type	R/W					R/W	R/W	R/W
Reset	1	1	1	1	1	0	0	0

SFR Address = 0xBC; SFR Page = 0x00

Bit	Name	Function
7:3	AD0SC[4:0]	ADC0 SAR Conversion Clock Period Bits. SAR Conversion clock is derived from system clock by the following equation, where AD0SC refers to the 5-bit value held in bits AD0SC4–0. SAR Conversion clock requirements are given in the ADC specification table BURSTEN = 0: FCLK is the current system clock BURSTEN = 1: FCLK is a maximum of 30 MHz, independent of the current system clock.. $AD0SC = \frac{FCLK}{CLK_{SAR}} - 1$ Note: Round up the result of the calculation for AD0SC
2:1	A0RPT[1:0]	ADC0 Repeat Count Controls the number of conversions taken and accumulated between ADC0 End of Conversion (ADCINT) and ADC0 Window Comparator (ADCWINT) interrupts. A convert start is required for each conversion unless Burst Mode is enabled. In Burst Mode, a single convert start can initiate multiple self-timed conversions. Results in both modes are accumulated in the ADC0H:ADC0L register. When AD0RPT1–0 are set to a value other than '00', the AD0LJST bit in the ADC0CN register must be set to '0' (right justified). 00: 1 conversion is performed. 01: 4 conversions are performed and accumulated. 10: 8 conversions are performed and accumulated. 11: 16 conversions are performed and accumulated.
0	GAINEN	Gain Enable Bit. Controls the gain programming. Refer to Section “5.3. Selectable Gain” on page 35 for information about using this bit.

SFR Definition 7.1. REF0CN: Reference Control

Bit	7	6	5	4	3	2	1	0
Name			ZTCEN	REFLV	REFSL	TEMPE	BIASE	REFBE
Type	R	R	R	R	R/W	R/W	R/W	R/W
Reset	0	0	0	0	0	0	0	0

SFR Address = 0xD1; SFR Page = 0x00

Bit	Name	Function
7:6	Unused	Read = 00b; Write = don't care.
5	ZTCEN	Zero Temperature Coefficient Bias Enable Bit. This bit must be set to 1b before entering oscillator suspend mode. 0: ZeroTC Bias Generator automatically enabled when required. 1: ZeroTC Bias Generator forced on.
4	REFLV	Voltage Reference Output Level Select. This bit selects the output voltage level for the internal voltage reference 0: Internal voltage reference set to 1.5 V. 1: Internal voltage reference set to 2.20 V.
3	REFSL	Voltage Reference Select. This bit selects the ADCs voltage reference. 0: V_{REF} pin used as voltage reference. 1: V_{DD} used as voltage reference.
2	TEMPE	Temperature Sensor Enable Bit. 0: Internal Temperature Sensor off. 1: Internal Temperature Sensor on.
1	BIASE	Internal Analog Bias Generator Enable Bit. 0: Internal Bias Generator off. 1: Internal Bias Generator on.
0	REFBE	On-chip Reference Buffer Enable Bit. 0: On-chip Reference Buffer off. 1: On-chip Reference Buffer on. Internal voltage reference driven on the V_{REF} pin.

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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 = 0x9B; SFR Page = 0x00

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)

SFR Definition 8.3. CPT1CN: Comparator1 Control

Bit	7	6	5	4	3	2	1	0
Name	CP1EN	CP1OUT	CP1RIF	CP1FIF	CP1HYP[1:0]		CP1HYN[1:0]	
Type	R/W	R	R/W	R/W	R/W		R/W	
Reset	0	0	0	0	0	0	0	0

SFR Address = 0x9D; SFR Page = 0x00

Bit	Name	Function
7	CP1EN	Comparator1 Enable Bit. 0: Comparator1 Disabled. 1: Comparator1 Enabled.
6	CP1OUT	Comparator1 Output State Flag. 0: Voltage on CP1+ < CP1−. 1: Voltage on CP1+ > CP1−.
5	CP1RIF	Comparator1 Rising-Edge Flag. Must be cleared by software. 0: No Comparator1 Rising Edge has occurred since this flag was last cleared. 1: Comparator1 Rising Edge has occurred.
4	CP1FIF	Comparator1 Falling-Edge Flag. Must be cleared by software. 0: No Comparator1 Falling-Edge has occurred since this flag was last cleared. 1: Comparator1 Falling-Edge has occurred.
3:2	CP1HYP[1:0]	Comparator1 Positive Hysteresis Control Bits. 00: Positive Hysteresis Disabled. 01: Positive Hysteresis = 5 mV. 10: Positive Hysteresis = 10 mV. 11: Positive Hysteresis = 20 mV.
1:0	CP1HYN[1:0]	Comparator1 Negative Hysteresis Control Bits. 00: Negative Hysteresis Disabled. 01: Negative Hysteresis = 5 mV. 10: Negative Hysteresis = 10 mV. 11: Negative Hysteresis = 20 mV.

10. CIP-51 Microcontroller

The MCU system controller core is the CIP-51 microcontroller. The CIP-51 is fully compatible with the MCS-51™ instruction set; standard 803x/805x assemblers and compilers can be used to develop software. The MCU family has a superset of all the peripherals included with a standard 8051. The CIP-51 also includes on-chip debug hardware (see description in Section 25), and interfaces directly with the analog and digital subsystems providing a complete data acquisition or control-system solution in a single integrated circuit.

The CIP-51 Microcontroller core implements the standard 8051 organization and peripherals as well as additional custom peripherals and functions to extend its capability (see Figure 10.1 for a block diagram). The CIP-51 includes the following features:

- Fully Compatible with MCS-51 Instruction Set
- 50 MIPS Peak Throughput with 50 MHz Clock
- 0 to 50 MHz Clock Frequency
- Extended Interrupt Handler
- Reset Input
- Power Management Modes
- On-chip Debug Logic
- Program and Data Memory Security

10.1. Performance

The CIP-51 employs a pipelined architecture that greatly increases its instruction throughput over the standard 8051 architecture. In a standard 8051, all instructions except for MUL and DIV take 12 or 24 system clock cycles to execute, and usually have a maximum system clock of 12 MHz. By contrast, the CIP-51 core executes 70% of its instructions in one or two system clock cycles, with no instructions taking more than eight system clock cycles.

11. Memory Organization

The memory organization of the CIP-51 System Controller is similar to that of a standard 8051. There are two separate memory spaces: program memory and data memory. Program and data memory share the same address space but are accessed via different instruction types. The memory organization is shown in Figure 11.1

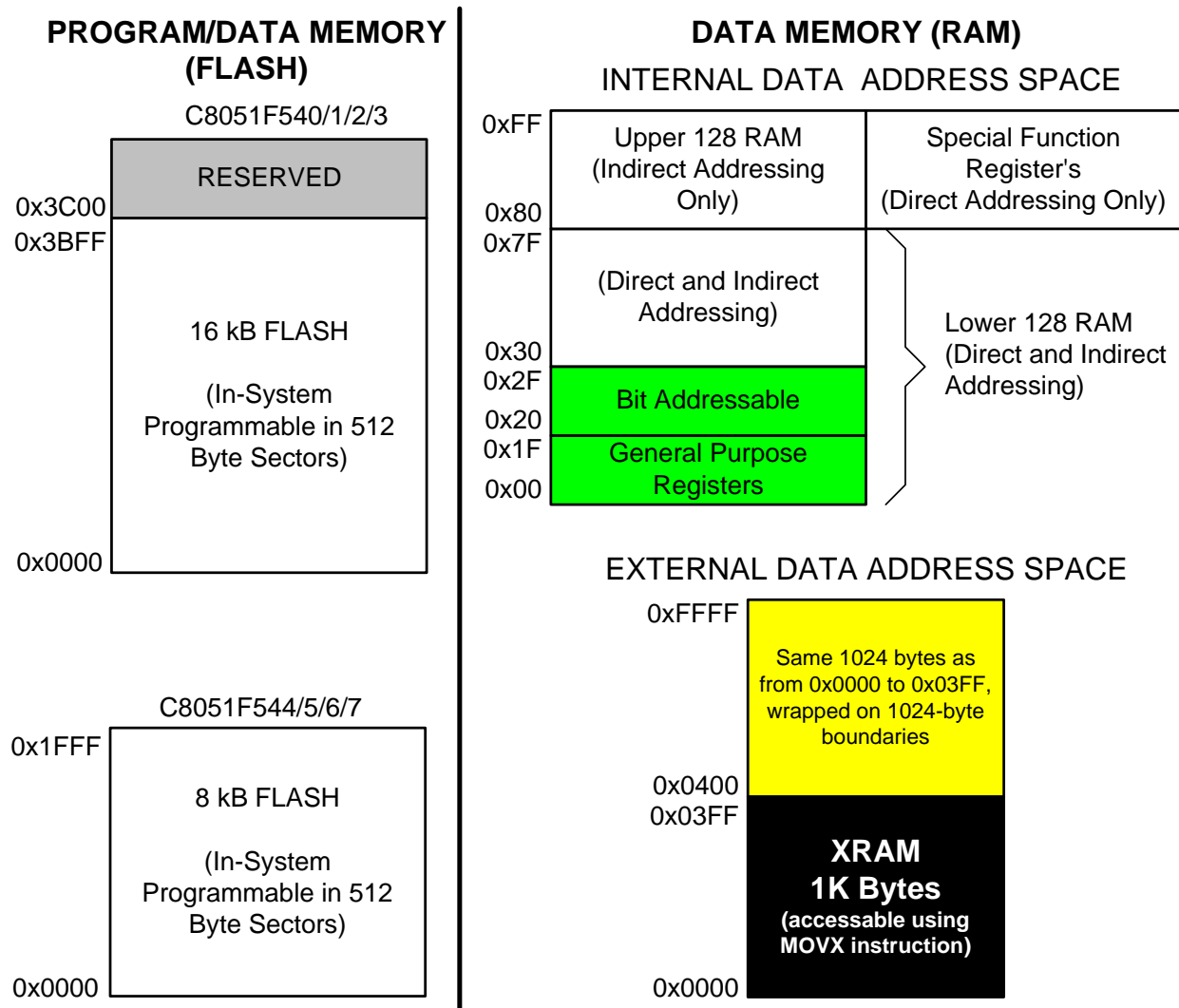


Figure 11.1. C8051F54x Memory Map

11.1. Program Memory

The CIP-51 core has a 64 kB program memory space. The C8051F54x devices implement 16 kB or 8 kB of this program memory space as in-system, re-programmable Flash memory, organized in a contiguous block from addresses 0x0000 to 0x3FFF in 16 kB devices and addresses 0x0000 to 0x1FFF in 8 kB devices. The address 0x3BFF in 16 kB devices and 0x1FFF in 8 kB devices serves as the security lock byte for the device. Addresses above 0x3BFF are reserved in the 16 kB devices.

13.1.1. Interrupt Priorities

Each interrupt source can be individually programmed to one of two priority levels: low or high. A low priority interrupt service routine can be preempted by a high priority interrupt. A high priority interrupt cannot be preempted. Each interrupt has an associated interrupt priority bit in an SFR (IE, EIP1, or EIP2) used to configure its priority level. Low priority is the default. If two interrupts are recognized simultaneously, the interrupt with the higher priority is serviced first. If both interrupts have the same priority level, a fixed priority order is used to arbitrate, given in Table 13.1.

13.1.2. Interrupt Latency

Interrupt response time depends on the state of the CPU when the interrupt occurs. Pending interrupts are sampled and priority decoded each system clock cycle. Therefore, the fastest possible response time is 5 system clock cycles: 1 clock cycle to detect the interrupt and 4 clock cycles to complete the LCALL to the ISR. If an interrupt is pending when a RETI is executed, a single instruction is executed before an LCALL is made to service the pending interrupt. Therefore, the maximum response time for an interrupt (when no other interrupt is currently being serviced or the new interrupt is of greater priority) occurs when the CPU is performing an RETI instruction followed by a DIV as the next instruction. In this case, the response time is 18 system clock cycles: 1 clock cycle to detect the interrupt, 5 clock cycles to execute the RETI, 8 clock cycles to complete the DIV instruction and 4 clock cycles to execute the LCALL to the ISR. If the CPU is executing an ISR for an interrupt with equal or higher priority, the new interrupt will not be serviced until the current ISR completes, including the RETI and following instruction.

SFR Definition 17.6. 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. <table><tr><th>XFCN</th><th>Crystal Mode</th><th>RC Mode</th><th>C Mode</th></tr><tr><td>000</td><td>$f \leq 32 \text{ kHz}$</td><td>$f \leq 25 \text{ kHz}$</td><td>K Factor = 0.87</td></tr><tr><td>001</td><td>$32 \text{ kHz} < f \leq 84 \text{ kHz}$</td><td>$25 \text{ kHz} < f \leq 50 \text{ kHz}$</td><td>K Factor = 2.6</td></tr><tr><td>010</td><td>$84 \text{ kHz} < f \leq 225 \text{ kHz}$</td><td>$50 \text{ kHz} < f \leq 100 \text{ kHz}$</td><td>K Factor = 7.7</td></tr><tr><td>011</td><td>$225 \text{ kHz} < f \leq 590 \text{ kHz}$</td><td>$100 \text{ kHz} < f \leq 200 \text{ kHz}$</td><td>K Factor = 22</td></tr><tr><td>100</td><td>$590 \text{ kHz} < f \leq 1.5 \text{ MHz}$</td><td>$200 \text{ kHz} < f \leq 400 \text{ kHz}$</td><td>K Factor = 65</td></tr><tr><td>101</td><td>$1.5 \text{ MHz} < f \leq 4 \text{ MHz}$</td><td>$400 \text{ kHz} < f \leq 800 \text{ kHz}$</td><td>K Factor = 180</td></tr><tr><td>110</td><td>$4 \text{ MHz} < f \leq 10 \text{ MHz}$</td><td>$800 \text{ kHz} < f \leq 1.6 \text{ MHz}$</td><td>K Factor = 664</td></tr><tr><td>111</td><td>$10 \text{ MHz} < f \leq 30 \text{ MHz}$</td><td>$1.6 \text{ MHz} < f \leq 3.2 \text{ MHz}$</td><td>K Factor = 1590</td></tr></table>	XFCN	Crystal Mode	RC Mode	C Mode	000	$f \leq 32 \text{ kHz}$	$f \leq 25 \text{ kHz}$	K Factor = 0.87	001	$32 \text{ kHz} < f \leq 84 \text{ kHz}$	$25 \text{ kHz} < f \leq 50 \text{ kHz}$	K Factor = 2.6	010	$84 \text{ kHz} < f \leq 225 \text{ kHz}$	$50 \text{ kHz} < f \leq 100 \text{ kHz}$	K Factor = 7.7	011	$225 \text{ kHz} < f \leq 590 \text{ kHz}$	$100 \text{ kHz} < f \leq 200 \text{ kHz}$	K Factor = 22	100	$590 \text{ kHz} < f \leq 1.5 \text{ MHz}$	$200 \text{ kHz} < f \leq 400 \text{ kHz}$	K Factor = 65	101	$1.5 \text{ MHz} < f \leq 4 \text{ MHz}$	$400 \text{ kHz} < f \leq 800 \text{ kHz}$	K Factor = 180	110	$4 \text{ MHz} < f \leq 10 \text{ MHz}$	$800 \text{ kHz} < f \leq 1.6 \text{ MHz}$	K Factor = 664	111	$10 \text{ MHz} < f \leq 30 \text{ MHz}$	$1.6 \text{ MHz} < f \leq 3.2 \text{ MHz}$	K Factor = 1590
XFCN	Crystal Mode	RC Mode	C Mode																																			
000	$f \leq 32 \text{ kHz}$	$f \leq 25 \text{ kHz}$	K Factor = 0.87																																			
001	$32 \text{ kHz} < f \leq 84 \text{ kHz}$	$25 \text{ kHz} < f \leq 50 \text{ kHz}$	K Factor = 2.6																																			
010	$84 \text{ kHz} < f \leq 225 \text{ kHz}$	$50 \text{ kHz} < f \leq 100 \text{ kHz}$	K Factor = 7.7																																			
011	$225 \text{ kHz} < f \leq 590 \text{ kHz}$	$100 \text{ kHz} < f \leq 200 \text{ kHz}$	K Factor = 22																																			
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111	$10 \text{ MHz} < f \leq 30 \text{ MHz}$	$1.6 \text{ MHz} < f \leq 3.2 \text{ MHz}$	K Factor = 1590																																			

Port	P0								P1								P2								P3
Special Function Signals	VREF	CNVSTR	XTAL1	XTAL2									ALE	/RD	/WR		P2.2-P2.7, P3.0 only available on the 32-pin packages								
PIN I/O	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0
UART_TX																									
UART_RX																									
SCK																									
MISO																									
MOSI																									
NSS																									
SDA																									
SCL																									
CP0																									
CP0A																									
CP1																									
CP1A																									
SYSCCLK																									
CEX0																									
CEX1																									
CEX2																									
CEX3																									
CEX4																									
CEX5																									
ECI																									
T0																									
T1																									
LIN_TX																									
LIN_RX																									
	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	P0SKIP[0:7]								P1SKIP[0:7]								P2SKIP[0:7]								P3SKIP[0]

Figure 18.4. Crossbar Priority Decoder in Example Configuration

18.4. Port I/O Initialization

Port I/O initialization consists of the following steps:

1. Select the input mode (analog or digital) for all Port pins, using the Port Input Mode register (PnMDIN).
2. Select the output mode (open-drain or push-pull) for all Port pins, using the Port Output Mode register (PnMDOUT).
3. Select any pins to be skipped by the I/O Crossbar using the Port Skip registers (PnSKIP).
4. Assign Port pins to desired peripherals.
5. Enable the Crossbar (XBARE = 1).

All Port pins must be configured as either analog or digital inputs. Any pins to be used as Comparator or ADC inputs should be configured as an analog inputs. When a pin is configured as an analog input, its weak pullup, digital driver, and digital receiver are disabled. This process saves power and reduces noise on the analog input. Pins configured as digital inputs may still be used by analog peripherals; however this practice is not recommended.

Additionally, all analog input pins should be configured to be skipped by the Crossbar (accomplished by setting the associated bits in PnSKIP). Port input mode is set in the PnMDIN register, where a 1 indicates a digital input, and a 0 indicates an analog input. All pins default to digital inputs on reset. See SFR Definition 18.13 for the PnMDIN register details.

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LIN Register Definition 19.7. LIN0ERR: LIN0 Error Register

Bit	7	6	5	4	3	2	1	0
Name				SYNCH	PRTY	TOUT	CHK	BITERR
Type	R	R	R	R	R	R	R	R
Reset	0	0	0	0	0	0	0	0

Indirect Address = 0x0A

Bit	Name	Function
7:5	Unused	Read = 000b; Write = Don't Care
4	SYNCH	Synchronization Error Bit (slave mode only). 0: No error with the SYNCH FIELD has been detected. 1: Edges of the SYNCH FIELD are outside of the maximum tolerance.
3	PRTY	Parity Error Bit (slave mode only). 0: No parity error has been detected. 1: A parity error has been detected.
2	TOUT	Timeout Error Bit. 0: A timeout error has not been detected. 1: A timeout error has been detected. This error is detected whenever one of the following conditions is met: <ul style="list-style-type: none">• The master is expecting data from a slave and the slave does not respond.• The slave is expecting data but no data is transmitted on the bus.• A frame is not finished within the maximum frame length.• The application does not set the DTACK bit (LIN0CTRL.4) or STOP bit (LIN0CTRL.7) until the end of the reception of the first byte after the identifier.
1	CHK	Checksum Error Bit. 0: Checksum error has not been detected. 1: Checksum error has been detected.
0	BITERR	Bit Transmission Error Bit. 0: No error in transmission has been detected. 1: The bit value monitored during transmission is different than the bit value sent.

LIN Register Definition 19.8. LIN0SIZE: LIN0 Message Size Register

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

Indirect Address = 0x0B

Bit	Name	Function
7	ENHCHK	Checksum Selection Bit. 0: Use the classic, specification 1.3 compliant checksum. Checksum covers the data bytes. 1: Use the enhanced, specification 2.0 compliant checksum. Checksum covers data bytes and protected identifier.
6:4	Unused	Read = 000b; Write = Don't Care
3:0	LINSIZE[3:0]	Data Field Size. 0000: 0 data bytes 0001: 1 data byte 0010: 2 data bytes 0011: 3 data bytes 0100: 4 data bytes 0101: 5 data bytes 0110: 6 data bytes 0111: 7 data bytes 1000: 8 data bytes 1001-1110: RESERVED 1111: Use the ID[1:0] bits (LIN0ID[5:4]) to determine the data length.

20.4.2. SMB0CN Control Register

SMB0CN is used to control the interface and to provide status information (see SFR Definition 20.2). The higher four bits of SMB0CN (MASTER, TXMODE, STA, and STO) form a status vector that can be used to jump to service routines. MASTER indicates whether a device is the master or slave during the current transfer. TXMODE indicates whether the device is transmitting or receiving data for the current byte.

STA and STO indicate that a START and/or STOP has been detected or generated since the last SMBus interrupt. STA and STO are also used to generate START and STOP conditions when operating as a master. Writing a 1 to STA will cause the SMBus interface to enter Master Mode and generate a START when the bus becomes free (STA is not cleared by hardware after the START is generated). Writing a 1 to STO while in Master Mode will cause the interface to generate a STOP and end the current transfer after the next ACK cycle. If STO and STA are both set (while in Master Mode), a STOP followed by a START will be generated.

As a receiver, writing the ACK bit defines the outgoing ACK value; as a transmitter, reading the ACK bit indicates the value received during the last ACK cycle. ACKRQ is set each time a byte is received, indicating that an outgoing ACK value is needed. When ACKRQ is set, software should write the desired outgoing value to the ACK bit before clearing SI. A NACK will be generated if software does not write the ACK bit before clearing SI. SDA will reflect the defined ACK value immediately following a write to the ACK bit; however SCL will remain low until SI is cleared. If a received slave address is not acknowledged, further slave events will be ignored until the next START is detected.

The ARBLOST bit indicates that the interface has lost an arbitration. This may occur anytime the interface is transmitting (master or slave). A lost arbitration while operating as a slave indicates a bus error condition. ARBLOST is cleared by hardware each time SI is cleared.

The SI bit (SMBus Interrupt Flag) is set at the beginning and end of each transfer, after each byte frame, or when an arbitration is lost; see Table 20.3 for more details.

Important Note About the SI Bit: The SMBus interface is stalled while SI is set; thus SCL is held low, and the bus is stalled until software clears SI.

20.5.3. Write Sequence (Slave)

During a write sequence, an SMBus master writes data to a slave device. The slave in this transfer will be a receiver during the address byte, and a receiver during all data bytes. When slave events are enabled (INH = 0), the interface enters Slave Receiver Mode when a START followed by a slave address and direction bit (WRITE in this case) is received. Upon entering Slave Receiver Mode, an interrupt is generated and the ACKRQ bit is set. The software must respond to the received slave address with an ACK, or ignore the received slave address with a NACK.

If the received slave address is ignored, slave interrupts will be inhibited until the next START is detected. If the received slave address is acknowledged, zero or more data bytes are received. Software must write the ACK bit at that time to ACK or NACK the received byte.

The interface exits Slave Receiver Mode after receiving a STOP. Note that the interface will switch to Slave Transmitter Mode if SMB0DAT is written while an active Slave Receiver. Figure 20.7 shows a typical slave write sequence. Two received data bytes are shown, though any number of bytes may be received. Notice that the 'data byte transferred' interrupts occur **before** the ACK in this mode.

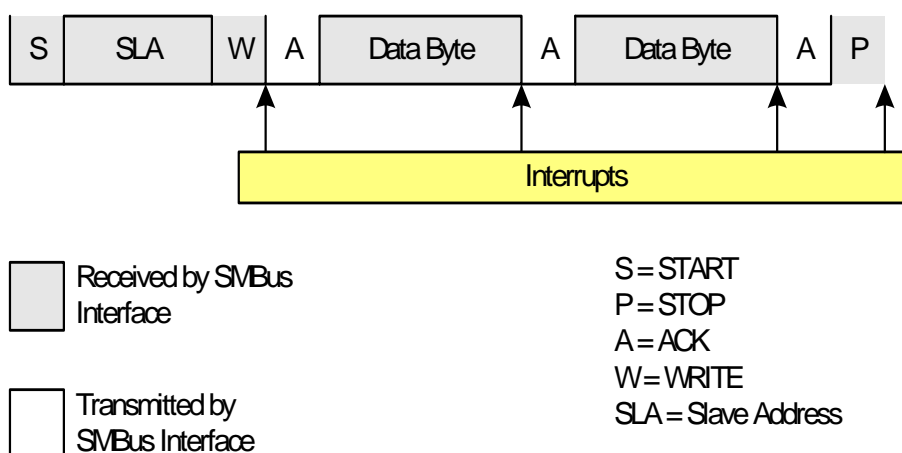


Figure 20.7. Typical Slave Write Sequence

Table 20.4. SMBus Status Decoding

Mode	Values Read				Current SMBus State	Typical Response Options	Values to Write			Next Status Vector Expected
	Status Vector	ACKRQ	ARBLOST	ACK			STA	STO	ACK	
Master Transmitter	1110	0	0	X	A master START was generated.	Load slave address + R/W into SMB0DAT.	0	0	X	1100
	1100	0	0	0	A master data or address byte was transmitted; NACK received.	Set STA to restart transfer.	1	0	X	1110
						Abort transfer.	0	1	X	—
	0	0	1	1	A master data or address byte was transmitted; ACK received.	Load next data byte into SMB0DAT.	0	0	X	1100
						End transfer with STOP.	0	1	X	—
						End transfer with STOP and start another transfer.	1	1	X	—
						Send repeated START.	1	0	X	1110
						Switch to Master Receiver Mode (clear SI without writing new data to SMB0DAT).	0	0	X	1000
Master Receiver	1000	1	0	X	A master data byte was received; ACK requested.	Acknowledge received byte; Read SMB0DAT.	0	0	1	1000
						Send NACK to indicate last byte, and send STOP.	0	1	0	—
						Send NACK to indicate last byte, and send STOP followed by START.	1	1	0	1110
						Send ACK followed by repeated START.	1	0	1	1110
						Send NACK to indicate last byte, and send repeated START.	1	0	0	1110
						Send ACK and switch to Master Transmitter Mode (write to SMB0DAT before clearing SI).	0	0	1	1100
						Send NACK and switch to Master Transmitter Mode (write to SMB0DAT before clearing SI).	0	0	0	1100

Table 22.1. SPI Slave Timing Parameters

Parameter	Description	Min	Max	Units
Master Mode Timing * (See Figure 22.8 and Figure 22.9)				
T_{MCKH}	SCK High Time	$1 \times T_{SYSCLK}$	—	ns
T_{MCKL}	SCK Low Time	$1 \times T_{SYSCLK}$	—	ns
T_{MIS}	MISO Valid to SCK Shift Edge	$1 \times T_{SYSCLK} + 20$	—	ns
T_{MIH}	SCK Shift Edge to MISO Change	0	—	ns
Slave Mode Timing * (See Figure 22.10 and Figure 22.11)				
T_{SE}	NSS Falling to First SCK Edge	$2 \times T_{SYSCLK}$	—	ns
T_{SD}	Last SCK Edge to NSS Rising	$2 \times T_{SYSCLK}$	—	ns
T_{SEZ}	NSS Falling to MISO Valid	—	$4 \times T_{SYSCLK}$	ns
T_{SDZ}	NSS Rising to MISO High-Z	—	$4 \times T_{SYSCLK}$	ns
T_{CKH}	SCK High Time	$5 \times T_{SYSCLK}$	—	ns
T_{CKL}	SCK Low Time	$5 \times T_{SYSCLK}$	—	ns
T_{SIS}	MOSI Valid to SCK Sample Edge	$2 \times T_{SYSCLK}$	—	ns
T_{SIH}	SCK Sample Edge to MOSI Change	$2 \times T_{SYSCLK}$	—	ns
T_{SOH}	SCK Shift Edge to MISO Change	—	$4 \times T_{SYSCLK}$	ns
T_{SLH}	Last SCK Edge to MISO Change (CKPHA = 1 ONLY)	$6 \times T_{SYSCLK}$	$8 \times T_{SYSCLK}$	ns
*Note: T_{SYSCLK} is equal to one period of the device system clock (SYSCLK).				

SFR Definition 23.13. TMR3CN: Timer 3 Control

Bit	7	6	5	4	3	2	1	0
Name	TF3H	TF3L	TF3LEN	TF3CEN	T3SPLIT	TR3		T3XCLK
Type	R/W	R/W	R/W	R/W	R/W	R/W	R	R/W
Reset	0	0	0	0	0	0	0	0

SFR Address = 0x91; SFR Page = 0x00

Bit	Name	Function
7	TF3H	Timer 3 High Byte Overflow Flag. Set by hardware when the Timer 3 high byte overflows from 0xFF to 0x00. In 16 bit mode, this will occur when Timer 3 overflows from 0xFFFF to 0x0000. When the Timer 3 interrupt is enabled, setting this bit causes the CPU to vector to the Timer 3 interrupt service routine. This bit is not automatically cleared by hardware.
6	TF3L	Timer 3 Low Byte Overflow Flag. Set by hardware when the Timer 3 low byte overflows from 0xFF to 0x00. TF3L will be set when the low byte overflows regardless of the Timer 3 mode. This bit is not automatically cleared by hardware.
5	TF3LEN	Timer 3 Low Byte Interrupt Enable. When set to 1, this bit enables Timer 3 Low Byte interrupts. If Timer 3 interrupts are also enabled, an interrupt will be generated when the low byte of Timer 3 overflows.
4	TF3CEN	Timer 3 Capture Mode Enable. 0: Timer 3 Capture Mode is disabled. 1: Timer 3 Capture Mode is enabled.
3	T3SPLIT	Timer 3 Split Mode Enable. When this bit is set, Timer 3 operates as two 8-bit timers with auto-reload. 0: Timer 3 operates in 16-bit auto-reload mode. 1: Timer 3 operates as two 8-bit auto-reload timers.
2	TR3	Timer 3 Run Control. Timer 3 is enabled by setting this bit to 1. In 8-bit mode, this bit enables/disables TMR3H only; TMR3L is always enabled in split mode.
1	Unused	Read = 0b; Write = Don't Care
0	T3XCLK	Timer 3 External Clock Select. This bit selects the external clock source for Timer 3. If Timer 3 is in 8-bit mode, this bit selects the external oscillator clock source for both timer bytes. However, the Timer 3 Clock Select bits (T3MH and T3ML in register CKCON) may still be used to select between the external clock and the system clock for either timer. 0: Timer 3 clock is the system clock divided by 12. 1: Timer 3 clock is the external clock divided by 8 (synchronized with SYSCLK).

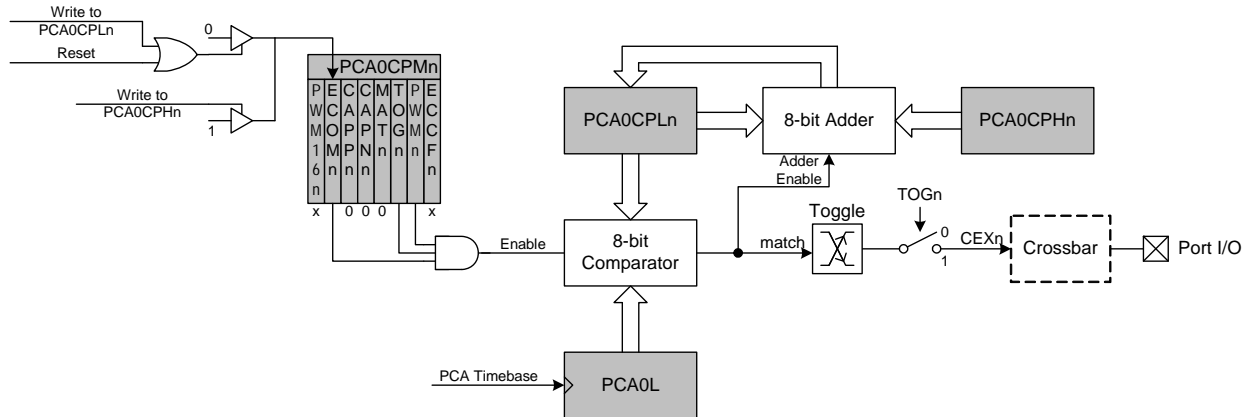


Figure 24.7. PCA Frequency Output Mode

24.3.5. 8-bit, 9-bit, 10-bit and 11-bit Pulse Width Modulator Modes

Each module can be used independently to generate a pulse width modulated (PWM) output on its associated CEXn pin. The frequency of the output is dependent on the timebase for the PCA counter/timer, and the setting of the PWM cycle length (8, 9, 10 or 11-bits). For backwards-compatibility with the 8-bit PWM mode available on other devices, the 8-bit PWM mode operates slightly different than 9, 10 and 11-bit PWM modes. **It is important to note that all channels configured for 8/9/10/11-bit PWM mode will use the same cycle length.** It is not possible to configure one channel for 8-bit PWM mode and another for 11-bit mode (for example). However, other PCA channels can be configured to Pin Capture, High-Speed Output, Software Timer, Frequency Output, or 16-bit PWM mode independently.

24.3.5.1. 8-bit Pulse Width Modulator Mode

The duty cycle of the PWM output signal in 8-bit PWM mode is varied using the module's PCA0CPLn capture/compare register. When the value in the low byte of the PCA counter/timer (PCA0L) is equal to the value in PCA0CPLn, the output on the CEXn pin will be set. When the count value in PCA0L overflows, the CEXn output will be reset (see Figure 24.8). Also, when the counter/timer low byte (PCA0L) overflows from 0xFF to 0x00, PCA0CPLn is reloaded automatically with the value stored in the module's capture/compare high byte (PCA0CPHn) without software intervention. Setting the ECOMn and PWMn bits in the PCA0CPMn register, and setting the CLSEL bits in register PCA0PWM to 00b enables 8-Bit Pulse Width Modulator mode. If the MATn bit is set to 1, the CCFn flag for the module will be set each time an 8-bit comparator match (rising edge) occurs. The COVF flag in PCA0PWM can be used to detect the overflow (falling edge), which will occur every 256 PCA clock cycles. The duty cycle for 8-Bit PWM Mode is given in Equation 24.2.

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.

$$\text{Duty Cycle} = \frac{(256 - \text{PCA0CPHn})}{256}$$

Equation 24.2. 8-Bit PWM Duty Cycle

Using Equation 24.2, the largest duty cycle is 100% (PCA0CPHn = 0), and the smallest duty cycle is 0.39% (PCA0CPHn = 0xFF). A 0% duty cycle may be generated by clearing the ECOMn bit to 0.

Table 24.3. Watchdog Timer Timeout Intervals¹

System Clock (Hz)	PCA0CPL5	Timeout Interval (ms)
24,000,000	255	32.8
24,000,000	128	16.5
24,000,000	32	4.2
3,000,000	255	262.1
3,000,000	128	132.1
3,000,000	32	33.8
187,500 ²	255	4194
187,500 ²	128	2114
187,500 ²	32	541
Notes: <ol style="list-style-type: none">1. Assumes SYSCLK/12 as the PCA clock source, and a PCA0L value of 0x00 at the update time.2. Internal SYSCLK reset frequency = Internal Oscillator divided by 128.		