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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	Not For New Designs
Core Processor	8051
Core Size	8-Bit
Speed	20MHz
Connectivity	SMBus (2-Wire/I²C), SPI, UART/USART
Peripherals	Brown-out Detect/Reset, POR, PWM, Temp Sensor, WDT
Number of I/O	16
Program Memory Size	32KB (32K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	256 x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 3.6V
Data Converters	A/D 8x10b; D/A 2x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	48-TQFP
Supplier Device Package	48-TQFP (7x7)
Purchase URL	https://www.e-xfl.com/product-detail/silicon-labs/c8051f011-gqr

1.3. JTAG Debug and Boundary Scan

The C8051F000 family has on-chip JTAG and debug circuitry that provide *non-intrusive, full speed, in-circuit debug using the production part installed in the end application* using the four-pin JTAG I/F. The JTAG port is fully compliant to IEEE 1149.1, providing full boundary scan for test and manufacturing purposes.

Silicon Labs' debug system supports inspection and modification of memory and registers, breakpoints, watchpoints, a stack monitor, and single stepping. No additional target RAM, program memory, timers, or communications channels are required. All the digital and analog peripherals are functional and work correctly while debugging. All the peripherals (except for the ADC) are stalled when the MCU is halted, during single stepping, or at a breakpoint in order to keep them in sync.

The C8051F000DK, C8051F005DK, C8051F010DK, and C8051F015DK are development kits with all the hardware and software necessary to develop application code and perform in-circuit debug with the C8051F000/1/2, F005/6/7, F010/1/2, and F015/6/7 MCUs respectively. The kit includes software with a developer's studio and debugger, an integrated 8051 assembler, and an RS-232 to JTAG protocol translator module referred to as the EC. It also has a target application board with the associated MCU installed and a large prototyping area, plus the RS-232 and JTAG cables, and wall-mount power supply. The Development Kit requires a Windows 95/98/NT/2000/XP computer with one available RS-232 serial port. As shown in Figure 1.7, the PC is connected via RS-232 to the EC. A six-inch ribbon cable connects the EC to the user's application board, picking up the four JTAG pins and VDD and GND. The EC takes its power from the application board. It requires roughly 20mA at 2.7-3.6V. For applications where there is not sufficient power available from the target board, the provided power supply can be connected directly to the EC.

This is a vastly superior configuration for developing and debugging embedded applications compared to standard MCU Emulators, which use on-board "ICE Chips" and target cables and require the MCU in the application board to be socketed. Silicon Labs' debug environment both increases ease of use and preserves the performance of the precision analog peripherals.

Figure 1.7. Debug Environment Diagram

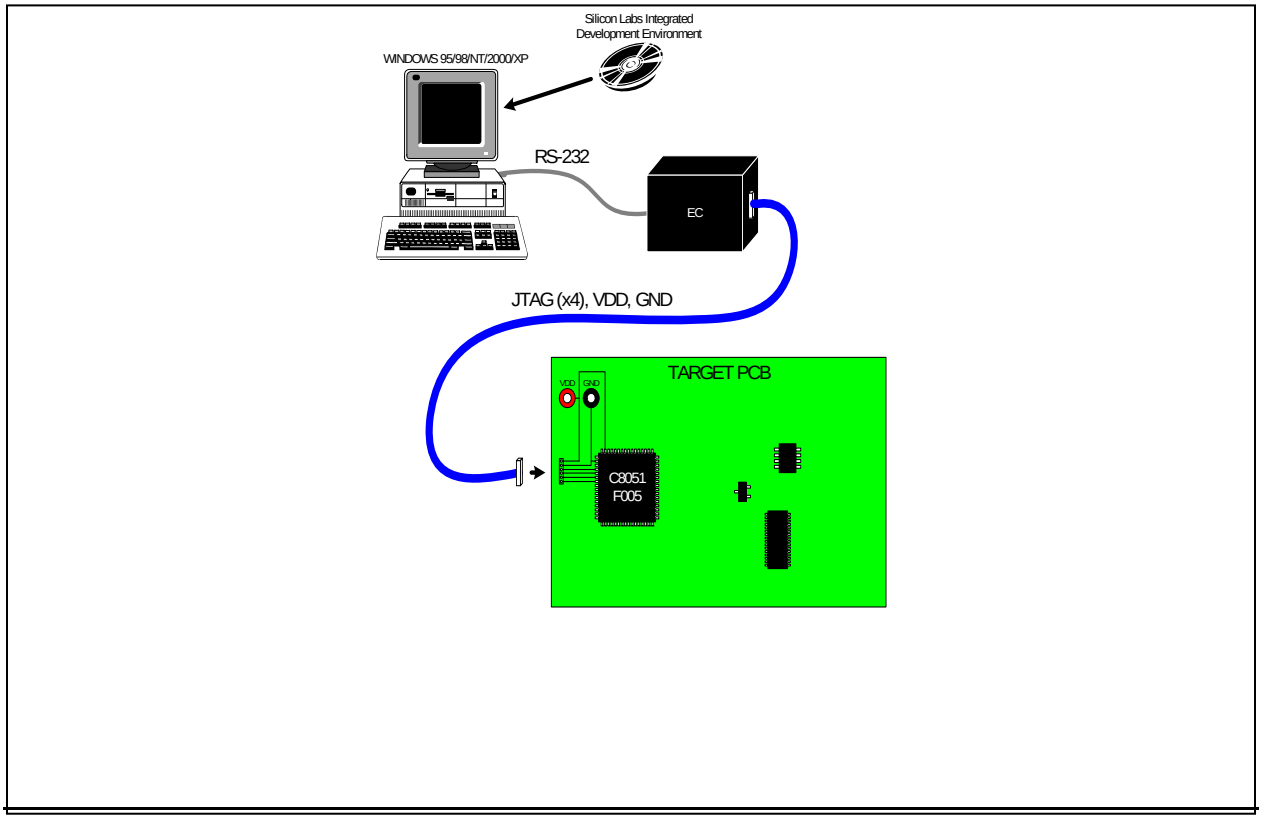


Figure 4.5. LQFP-32 Pinout Diagram

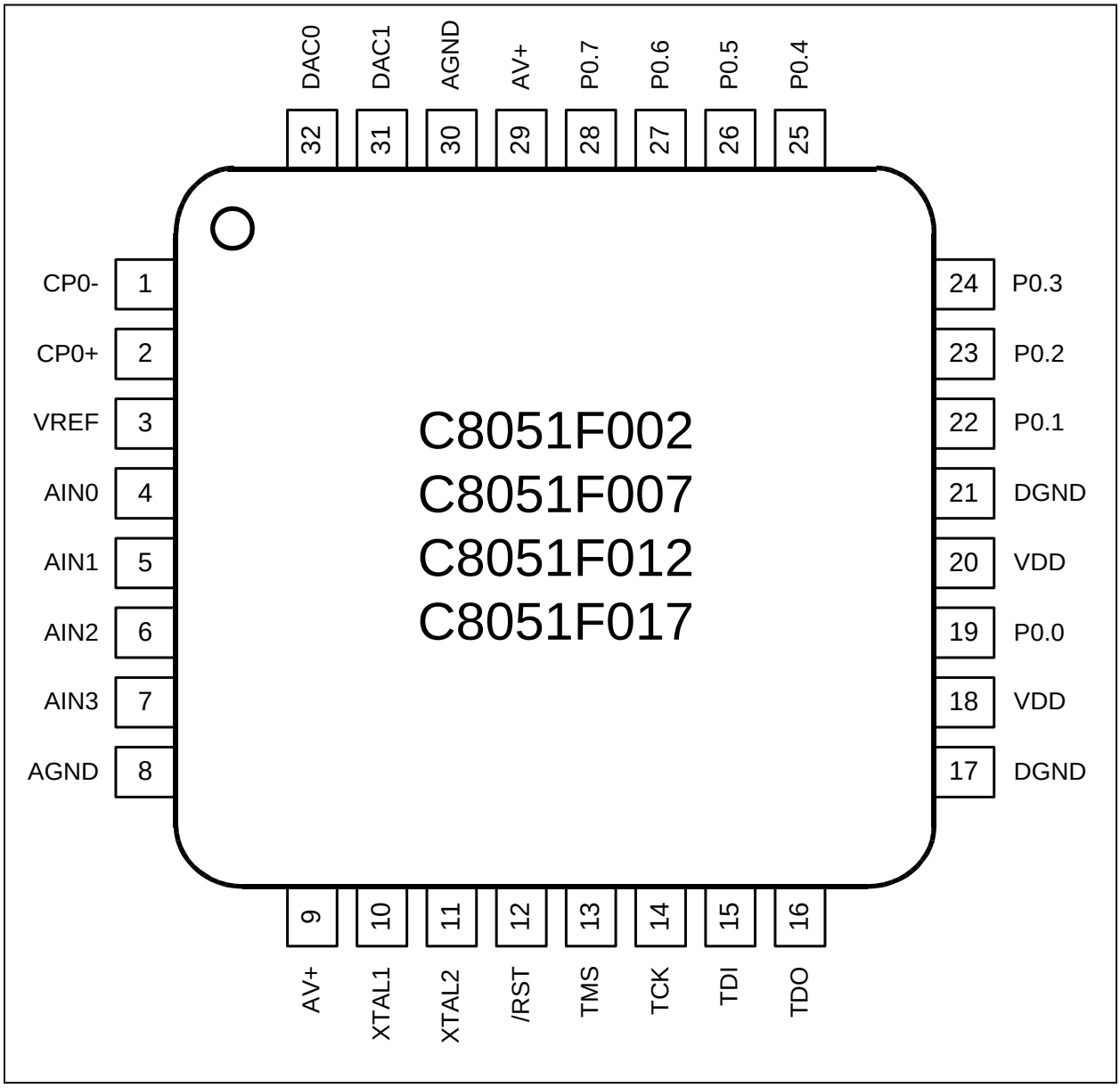


Figure 5.6. ADC0CF: ADC Configuration Register (C8051F00x)

R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	Reset Value
ADCSC2	ADCSC1	ADCSC0	-	-	AMPGN2	AMPGN1	AMPGN0	01100000
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	SFR Address: 0xBC

Bits7-5: ADCSC2-0: ADC SAR Conversion Clock Period Bits
000: SAR Conversion Clock = 1 System Clock
001: SAR Conversion Clock = 2 System Clocks
010: SAR Conversion Clock = 4 System Clocks
011: SAR Conversion Clock = 8 System Clocks
1xx: SAR Conversion Clock = 16 Systems Clocks
(Note: the SAR Conversion Clock should be ≤ 2MHz)
Bits4-3: UNUSED. Read = 00b; Write = don't care
Bits2-0: AMPGN2-0: ADC Internal Amplifier Gain
000: Gain = 1
001: Gain = 2
010: Gain = 4
011: Gain = 8
10x: Gain = 16
11x: Gain = 0.5

Table 5.1. 12-Bit ADC Electrical Characteristics

VDD = 3.0V, AV+ = 3.0V, VREF = 2.40V (REFBE=0), PGA Gain = 1, -40°C to +85°C unless otherwise specified.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
DC ACCURACY					
Resolution			12		bits
Integral Nonlinearity				± 1	LSB
Differential Nonlinearity	Guaranteed Monotonic			± 1	LSB
Offset Error			-3 ± 1		LSB
Full Scale Error	Differential mode		-7 ± 3		LSB
Offset Temperature Coefficient			± 0.25		ppm/°C
DYNAMIC PERFORMANCE (10kHz sine-wave input, 0 to –1dB of full scale, 100ksps)					
Signal-to-Noise Plus Distortion		66	69		dB
Total Harmonic Distortion	Up to the 5th harmonic		-75		dB
Spurious-Free Dynamic Range			80		dB
CONVERSION RATE					
Conversion Time in SAR Clocks		16			clocks
SAR Clock Frequency	C8051F000, ‘F001, ‘F002 C8051F005, ‘F006, ‘F007			2.0 2.5	MHz MHz
Track/Hold Acquisition Time		1.5			µs
Throughput Rate				100	ksps
ANALOG INPUTS					
Voltage Conversion Range	Single-ended Mode (AINn – AGND) Differential Mode |(AINn+) – (AINm-)|	0		VREF - 1LSB	V
Input Voltage	Any AINn pin	AGND		AV+	V
Input Capacitance			10		pF
TEMPERATURE SENSOR					
Linearity			± 0.20		°C
Absolute Accuracy			± 3		°C
Gain	PGA Gain = 1		2.86		mV/°C
Gain Error (±1σ)	PGA Gain = 1		± 33.5		µV/°C
Offset	PGA Gain = 1, Temp = 0°C		776		mV
Offset Error (±1σ)	PGA Gain = 1, Temp = 0°C		± 8.51		mV
POWER SPECIFICATIONS					
Power Supply Current (AV+ supplied to ADC)	Operating Mode, 100ksps		450	900	µA
Power Supply Rejection			± 0.3		mV/V

Figure 6.3. Temperature Sensor Transfer Function

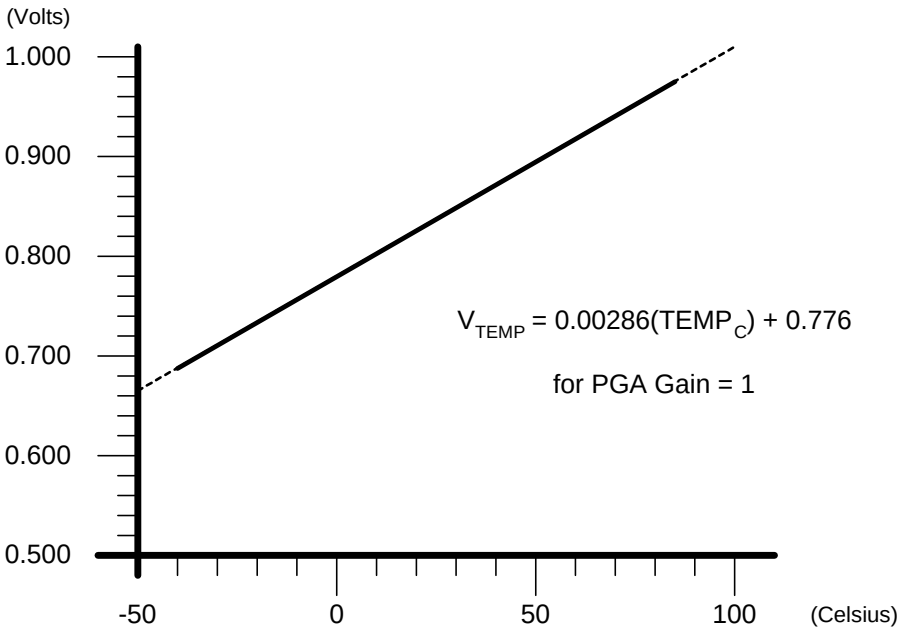


Figure 6.4. AMX0CF: AMUX Configuration Register (C8051F01x)

R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	Reset Value
-	-	-	-	AIN67IC	AIN45IC	AIN23IC	AIN01IC	00000000
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	SFR Address: 0xBA

Bits7-4: UNUSED. Read = 0000b; Write = don't care
Bit3: AIN67IC: AIN6, AIN7 Input Pair Configuration Bit
0: AIN6 and AIN7 are independent singled-ended inputs
1: AIN6, AIN7 are (respectively) +, - differential input pair
Bit2: AIN45IC: AIN4, AIN5 Input Pair Configuration Bit
0: AIN4 and AIN5 are independent singled-ended inputs
1: AIN4, AIN5 are (respectively) +, - differential input pair
Bit1: AIN23IC: AIN2, AIN3 Input Pair Configuration Bit
0: AIN2 and AIN3 are independent singled-ended inputs
1: AIN2, AIN3 are (respectively) +, - differential input pair
Bit0: AIN01IC: AIN0, AIN1 Input Pair Configuration Bit
0: AIN0 and AIN1 are independent singled-ended inputs
1: AIN0, AIN1 are (respectively) +, - differential input pair

NOTE: The ADC Data Word is in 2's complement format for channels configured as differential.

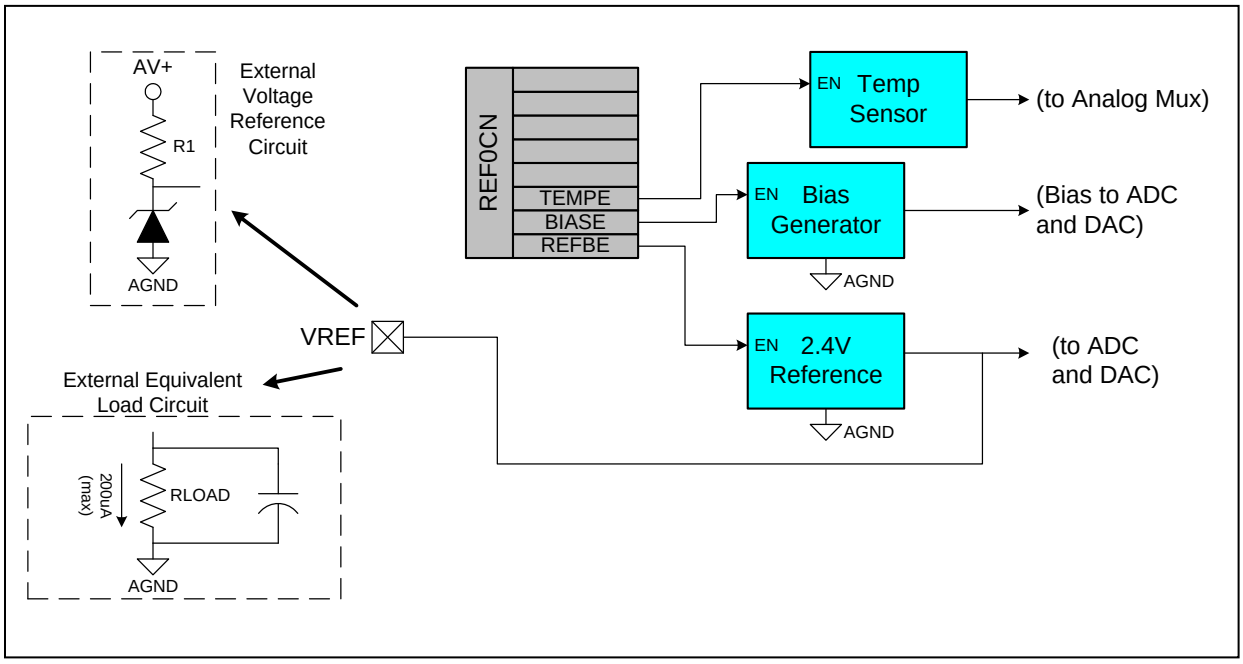
9. VOLTAGE REFERENCE

The voltage reference circuit consists of a 1.2V, 15ppm/°C (typical) bandgap voltage reference generator and a gain-of-two output buffer amplifier. The reference voltage on VREF can be connected to external devices in the system, as long as the maximum load seen by the VREF pin is less than 200µA to AGND (see Figure 9.1).

If a different reference voltage is required, an external reference can be connected to the VREF pin and the internal bandgap and buffer amplifier disabled in software. The external reference voltage must still be less than AV+ - 0.3V. The Reference Control Register, REF0CN (defined in Figure 9.2), provides the means to enable or disable the bandgap and buffer amplifier. The BIASE bit in REF0CN enables the bias circuitry for the ADC and DACs while the REFBE bit enables the bandgap reference and buffer amplifier which drive the VREF pin. When disabled, the supply current drawn by the bandgap and buffer amplifier falls to less than 1uA (typical) and the output of the buffer amplifier enters a high impedance state. If the internal bandgap is used as the reference voltage generator, BIASE and REFBE must both be set to 1. If an external reference is used, REFBE must be set to 0 and BIASE must be set to 1. If neither the ADC nor the DAC are being used, both of these bits can be set to 0 to conserve power. The electrical specifications for the Voltage Reference are given in Table 9.1.

The temperature sensor connects to the highest order input of the A/D converter's input multiplexer (see Figure 5.1 and Figure 5.5 for details). The TEMPE bit within REF0CN enables and disables the temperature sensor. While disabled, the temperature sensor defaults to a high impedance state and any A/D measurements performed on the sensor while disabled result in meaningless data.

Figure 9.1. Voltage Reference Functional Block Diagram



Mnemonic	Description	Bytes	Clock Cycles
RR A	Rotate A right	1	1
RRC A	Rotate A right through carry	1	1
SWAP A	Swap nibbles of A	1	1
DATA TRANSFER			
MOV A,Rn	Move register to A	1	1
MOV A,direct	Move direct byte to A	2	2
MOV A,@Ri	Move indirect RAM to A	1	2
MOV A,#data	Move immediate to A	2	2
MOV Rn,A	Move A to register	1	1
MOV Rn,direct	Move direct byte to register	2	2
MOV Rn,#data	Move immediate to register	2	2
MOV direct,A	Move A to direct byte	2	2
MOV direct,Rn	Move register to direct byte	2	2
MOV direct,direct	Move direct byte to direct	3	3
MOV direct,@Ri	Move indirect RAM to direct byte	2	2
MOV direct,#data	Move immediate to direct byte	3	3
MOV @Ri,A	Move A to indirect RAM	1	2
MOV @Ri,direct	Move direct byte to indirect RAM	2	2
MOV @Ri,#data	Move immediate to indirect RAM	2	2
MOV DPTR,#data16	Load data pointer with 16-bit constant	3	3
MOVC A,@A+DPTR	Move code byte relative DPTR to A	1	3
MOVC A,@A+PC	Move code byte relative PC to A	1	3
MOVX A,@Ri	Move external data (8-bit address) to A	1	3
MOVX @Ri,A	Move A to external data (8-bit address)	1	3
MOVX A,@DPTR	Move external data (16-bit address) to A	1	3
MOVX @DPTR,A	Move A to external data (16-bit address)	1	3
PUSH direct	Push direct byte onto stack	2	2
POP direct	Pop direct byte from stack	2	2
XCH A,Rn	Exchange register with A	1	1
XCH A,direct	Exchange direct byte with A	2	2
XCH A,@Ri	Exchange indirect RAM with A	1	2
XCHD A,@Ri	Exchange low nibble of indirect RAM with A	1	2
BOOLEAN MANIPULATION			
CLR C	Clear carry	1	1
CLR bit	Clear direct bit	2	2
SETB C	Set carry	1	1
SETB bit	Set direct bit	2	2
CPL C	Complement carry	1	1
CPL bit	Complement direct bit	2	2
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
JC rel	Jump if carry is set	2	2/3
JNC rel	Jump if carry not set	2	2/3
JB bit,rel	Jump if direct bit is set	3	3/4
JNB bit,rel	Jump if direct bit is not set	3	3/4
JBC bit,rel	Jump if direct bit is set and clear bit	3	3/4

Figure 10.6. PSW: Program Status Word

R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	Reset Value
CY	AC	F0	RS1	RS0	OV	F1	PARITY	00000000
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0 (bit addressable)	SFR Address: 0xD0

Bit7: CY: Carry Flag.
This bit is set when the last arithmetic operation results in a carry (addition) or a borrow (subtraction). It is cleared to 0 by all other arithmetic operations.

Bit6: AC: Auxiliary Carry Flag.
This bit is set when the last arithmetic operation results in a carry into (addition) or a borrow from (subtraction) the high order nibble. It is cleared to 0 by all other arithmetic operations.

Bit5: F0: User Flag 0.
This is a bit-addressable, general purpose flag for use under software control.

Bits4-3: RS1-RS0: Register Bank Select.
These bits select which register bank is used during register accesses.

RS1	RS0	Register Bank	Address
0	0	0	0x00-0x07
0	1	1	0x08-0x0F
1	0	2	0x10-0x17
1	1	3	0x18-0x1F

Note: Any instruction which changes the RS1-RS0 bits must not be immediately followed by the “MOV Rn, A” instruction.

Bit2: OV: Overflow Flag.
This bit is set to 1 under the following circumstances:

- An ADD, ADDC, or SUBB instruction causes a sign-change overflow.
- A MUL instruction results in an overflow (result is greater than 255) .
- A DIV instruction causes a divide-by-zero condition.

The OV bit is cleared to 0 by the ADD, ADDC, SUBB, MUL, and DIV instructions in all other cases.

Bit1: F1: User Flag 1.
This is a bit-addressable, general purpose flag for use under software control.

Bit0: PARITY: Parity Flag.
(Read only)
This bit is set to 1 if the sum of the eight bits in the accumulator is odd and cleared if the sum is even.

13.8.1. Watchdog Usage

The WDT consists of a 21-bit timer running from the programmed system clock. The timer measures the period between specific writes to its control register. If this period exceeds the programmed limit, a WDT reset is generated. The WDT can be enabled and disabled as needed in software, or can be permanently enabled if desired. Watchdog features are controlled via the Watchdog Timer Control Register (WDTCN) shown in Figure 13.3.

Enable/Reset WDT

The watchdog timer is both enabled and the countdown restarted by writing 0xA5 to the WDTCN register. The user's application software should include periodic writes of 0xA5 to WDTCN as needed to prevent a watchdog timer overflow. The WDT is enabled and restarted as a result of any system reset.

Disable WDT

Writing 0xDE followed by 0xAD to the WDTCN register disables the WDT. The following code segment illustrates disabling the WDT.

```
CLR   EA          ; disable all interrupts
MOV   WDTCN,#0DEh ; disable software
MOV   WDTCN,#0ADh ; watchdog timer
SETB  EA          ; re-enable interrupts
```

The writes of 0xDE and 0xAD must occur within 4 clock cycles of each other, or the disable operation is ignored. Interrupts should be disabled during this procedure to avoid delay between the two writes.

Disable WDT Lockout

Writing 0xFF to WDTCN locks out the disable feature. Once locked out, the disable operation is ignored until the next system reset. Writing 0xFF does not enable or reset the watchdog timer. Applications always intending to use the watchdog should write 0xFF to WDTCN in their initialization code.

Setting WDT Interval

WDTCN.[2:0] control the watchdog timeout interval. The interval is given by the following equation:

$$4^{3+WDTCN[2:0]} \times T_{SYSCLK}\text{ , (where } T_{SYSCLK} \text{ is the system clock period).}$$

For a 2MHz system clock, this provides an interval range of 0.032msec to 524msec. WDTCN.7 must be a 0 when setting this interval. Reading WDTCN returns the programmed interval. WDTCN.[2:0] is 111b after a system reset.

Figure 13.3. WDTCN: Watchdog Timer Control Register

R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	Reset Value
								xxxxx111
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	SFR Address: 0xFF

Bits7-0: WDT Control
Writing 0xA5 both enables and reloads the WDT.
Writing 0xDE followed within 4 clocks by 0xAD disables the WDT.
Writing 0xFF locks out the disable feature.

Bit4: Watchdog Status Bit (when Read)
Reading the WDTCN.[4] bit indicates the Watchdog Timer Status.
0: WDT is inactive
1: WDT is active

Bits2-0: Watchdog Timeout Interval Bits
The WDTCN.[2:0] bits set the Watchdog Timeout Interval. When writing these bits, WDTCN.7 must be set to 0.

Figure 15.13. P3: Port3 Register

R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	Reset Value
P3.7	P3.6	P3.5	P3.4	P3.3	P3.2	P3.1	P3.0	11111111
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0 (bit addressable)	SFR Address: 0xB0

Bits7-0: P3.[7:0]
(Write)
0: Logic Low Output.
1: Logic High Output (high-impedance if corresponding PRT3CF.n bit = 0)
(Read)
0: P3.n is logic low.
1: P3.n is logic high.

Figure 15.14. PRT3CF: Port3 Configuration Register

R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	Reset Value
								00000000
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	SFR Address: 0xA7

Bits7-0: PRT3CF.[7:0]: Output Configuration Bits for P3.7-P3.0 (respectively)
0: Corresponding P3.n Output mode is Open-Drain.
1: Corresponding P3.n Output mode is Push-Pull.

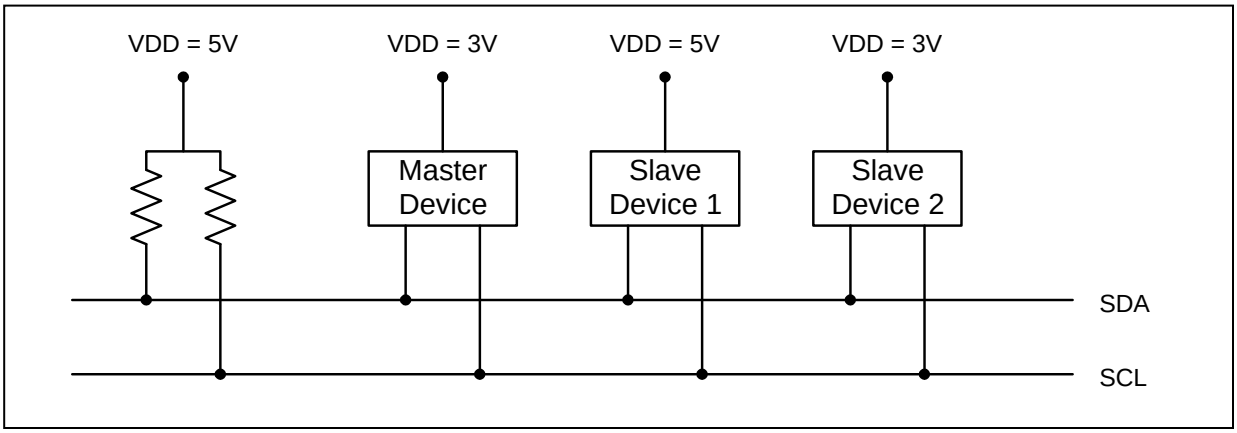
Table 15.2. Port I/O DC Electrical Characteristics

VDD = 2.7 to 3.6V, -40°C to +85°C unless otherwise specified.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Output High Voltage	I_{OH} = -10uA, Port I/O push-pull I_{OH} = -3mA, Port I/O push-pull I_{OH} = -10mA, Port I/O push-pull	VDD – 0.1 VDD – 0.7	 VDD – 0.8		V
Output Low Voltage	I_{OL} = 10uA I_{OL} = 8.5mA I_{OL} = 25mA		 1.0	0.1 0.6	V
Input High Voltage		0.7 x VDD			V
Input Low Voltage				0.3 x VDD	V
Input Leakage Current	DGND < Port Pin < VDD, Pin Tri-state Weak Pull-up Off Weak Pull-up On		 30	 ±1	µA
Capacitive Loading			5		pF

Figure 16.2 shows a typical SMBus configuration. The SMBus interface will work at any voltage between 3.0V and 5.0V and different devices on the bus may operate at different voltage levels. The SCL (serial clock) and SDA (serial data) lines are bi-directional. They must be connected to a positive power supply voltage through a pull-up resistor or similar circuit. When the bus is free, both lines are pulled high. Every device connected to the bus must have an open-drain or open-collector output for both the SCL and SDA lines. The maximum number of devices on the bus is limited only by the requirement that the rise and fall times on the bus will not exceed 300ns and 1000ns, respectively.

Figure 16.2. Typical SMBus Configuration



16.1. Supporting Documents

It is assumed the reader is familiar with or has access to the following supporting documents:

1. *The I²C-bus and how to use it (including specifications)*, Philips Semiconductor.
2. *The I²C-Bus Specification -- Version 2.0*, Philips Semiconductor.
3. *System Management Bus Specification -- Version 1.1*, SBS Implementers Forum.

16.6.1. Control Register

The SMBus Control register SMB0CN is used to configure and control the SMBus interface. All of the bits in the register can be read or written by software. Two of the control bits are also affected by the SMBus hardware. The Serial Interrupt flag (SI, SMB0CN.3) is set to logic 1 by the hardware when a valid serial interrupt condition occurs. It can only be cleared by software. The Stop flag (STO, SMB0CN.4) is cleared to logic 0 by hardware when a STOP condition is present on the bus.

Setting the ENSMB flag to logic 1 enables the SMBus interface. Clearing the ENSMB flag to logic 0 disables the SMBus interface and removes it from the bus. Momentarily clearing the ENSMB flag and then resetting it to logic 1 will reset a SMBus communication. However, ENSMB should not be used to temporarily remove a device from the bus since the bus state information will be lost. Instead, the Assert Acknowledge (AA) flag should be used to temporarily remove the device from the bus (see description of AA flag below).

Setting the Start flag (STA, SMB0CN.5) to logic 1 will put the SMBus in a master mode. If the bus is free, the SMBus hardware will generate a START condition. If the bus is not free, the SMBus hardware waits for a STOP condition to free the bus and then generates a START condition after a 5µs delay per the SMB0CR value. (In accordance with the SMBus protocol, the SMBus interface also considers the bus free if the bus is idle for 50µs and no STOP condition was recognized.) If STA is set to logic 1 while the SMBus is in master mode and one or more bytes have been transferred, a repeated START condition will be generated. To ensure proper operation, the STO flag should be explicitly cleared before setting STA to a logic 1.

When the Stop flag (STO, SMB0CN.4) is set to logic 1 while the SMBus interface is in master mode, the hardware generates a STOP condition on the SMBus. In a slave mode, the STO flag may be used to recover from an error condition. In this case, a STOP condition is not generated on the SMBus, but the SMBus hardware behaves as if a STOP condition has been received and enters the “not addressed” slave receiver mode. The SMBus hardware automatically clears the STO flag to logic 0 when a STOP condition is detected on the bus.

The Serial Interrupt flag (SI, SMB0CN.3) is set to logic 1 by hardware when the SMBus interface enters one of 27 possible states. If interrupts are enabled for the SMBus interface, an interrupt request is generated when the SI flag is set. The SI flag must be cleared by software. While SI is set to logic 1, the clock-low period of the serial clock will be stretched and the serial transfer is suspended.

The Assert Acknowledge flag (AA, SMB0CN.2) is used to set the level of the SDA line during the acknowledge clock cycle on the SCL line. Setting the AA flag to logic 1 will cause an ACKNOWLEDGE (low level on SDA) to be sent during the acknowledge cycle if the device has been addressed. Setting the AA flag to logic 0 will cause a NOT ACKNOWLEDGE (high level on SDA) to be sent during acknowledge cycle. After the transmission of a byte in slave mode, the slave can be temporarily removed from the bus by clearing the AA flag. The slave’s own address and general call address will be ignored. To resume operation on the bus, the AA flag must be reset to logic 1 to allow the slave’s address to be recognized.

Setting the SMBus Free Timer Enable bit (FTE, SMB0CN.1) to logic 1 enables the SMBus Free Timeout feature. If SCL and SDA remain high for the SMBus Free Timeout given in the SMBus Clock Rate Register (Figure 16.5), the bus will be considered free and a Start will be generated if pending. The bus free period should be greater than 50µs.

Setting the SMBus timeout enable bit (TOE, SMB0CN.0) to logic 1 enables Timer 3 to count up when the SCL line is low and Timer 3 is enabled. If Timer 3 overflows, a Timer 3 interrupt will be generated, which will alert the CPU that a SMBus SCL low timeout has occurred.

in an “off-line” state. In a multiple-master environment, the system controller should check the state of the SLVSEL flag (SPI0CN.2) to ensure the bus is free before setting the MSTEN bit and initiating a data transfer.

17.3. Serial Clock Timing

As shown in Figure 17.4, four combinations of serial clock phase and polarity can be selected using the clock control bits in the SPI Configuration Register (SPI0CFG). The CKPHA bit (SPI0CFG.7) selects one of two clock phases (edge used to latch the data). The CKPOL bit (SPI0CFG.6) 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. Note: the SPI should be disabled (by clearing the SPIEN bit, SPI0CN.0) while changing the clock phase and polarity.

The SPI Clock Rate Register (SPI0CKR) as shown in Figure 17.7 controls the master mode serial clock frequency. This register is ignored when operating in slave mode.

Figure 17.4. Data/Clock Timing Diagram

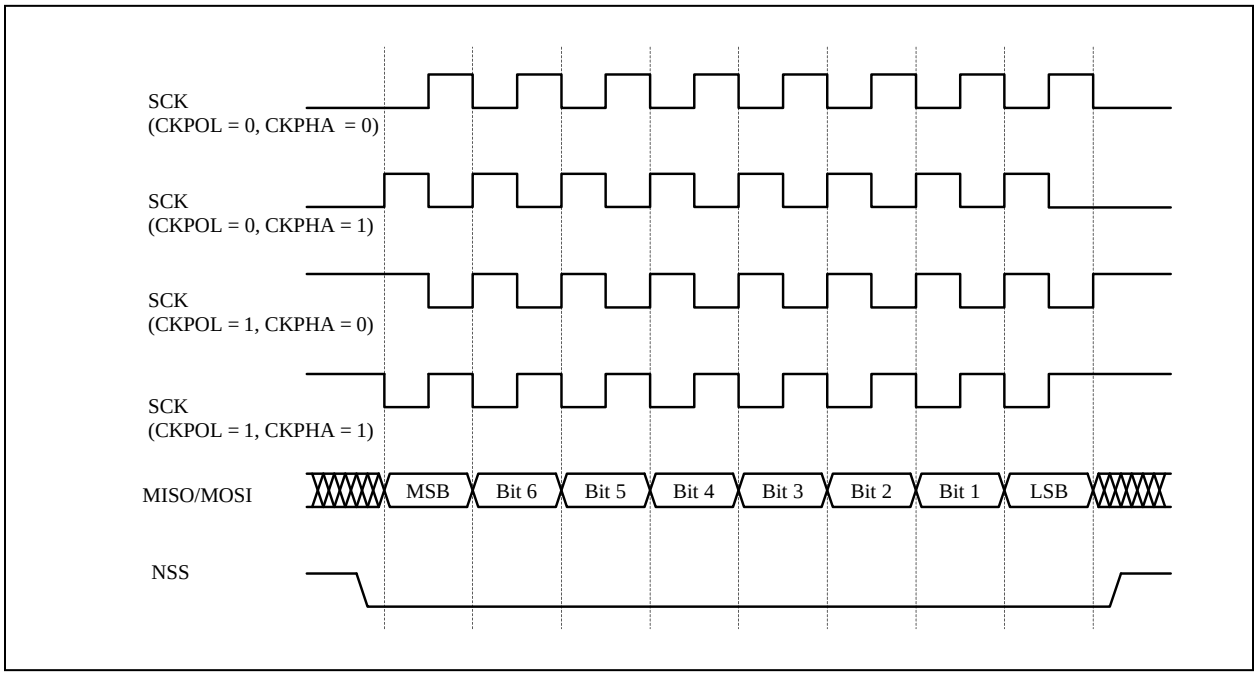


Figure 17.7. SPI0CKR: SPI Clock Rate Register

R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	Reset Value
SCR7	SCR6	SCR5	SCR4	SCR3	SCR2	SCR1	SCR0	00000000
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	SFR Address: 0x9D

Bits7-0: SCR7-SCR0: SPI Clock Rate
These bits determine the frequency of the SCK output when the SPI module is configured for master mode operation. The SCK clock frequency is a divided down version of the system clock, and is given in the following equations:

$f_{SCK} = 0.5 * f_{SYSCLK} / (SPI0CKR + 1)$, for $0 \leq SPI0CKR \leq 255$,

Figure 17.8. SPI0DAT: SPI Data Register

R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	Reset Value
								00000000
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	SFR Address: 0x9B

Bits7-0: SPI0DAT: SPI0 Transmit and Receive Data.
The SPI0DAT register is used to transmit and receive SPI data. Writing data to SPI0DAT places the data immediately into the shift register and initiates a transfer when in Master Mode. A read of SPI0DAT returns the contents of the receive buffer.

18.1. UART Operational Modes

The UART provides four operating modes (one synchronous and three asynchronous) selected by setting configuration bits in the SCON register. These four modes offer different baud rates and communication protocols. The four modes are summarized in Table 18.1 below. Detailed descriptions follow.

Table 18.1. UART Modes

Mode	Synchronization	Baud Clock	Data Bits	Start/Stop Bits
0	Synchronous	SYSCLK/12	8	None
1	Asynchronous	Timer 1 or Timer 2 Overflow	8	1 Start, 1 Stop
2	Asynchronous	SYSCLK/32 or SYSCLK/64	9	1 Start, 1 Stop
3	Asynchronous	Timer 1 or Timer 2 Overflow	9	1 Start, 1 Stop

18.1.1. Mode 0: Synchronous Mode

Mode 0 provides synchronous, half-duplex communication. Serial data is transmitted and received on the RX pin. The TX pin provides the shift clock for both transmit and receive. The MCU must be the master since it generates the shift clock for transmission in both directions (see the interconnect diagram in Figure 18.2).

Eight data bits are transmitted/received, LSB first (see the timing diagram in Figure 18.3). Data transmission begins when an instruction writes a data byte to the SBUF register. The TI Transmit Interrupt Flag (SCON.1) is set at the end of the eighth bit time. Data reception begins when the REN Receive Enable bit (SCON.4) is set to logic 1 and the RI Receive Interrupt Flag (SCON.0) is cleared. One cycle after the eighth bit is shifted in, the RI flag is set and reception stops until software clears the RI bit. An interrupt will occur if enabled when either TI or RI is set.

The Mode 0 baud rate is the system clock frequency divided by twelve. RX is forced to open-drain in mode 0, and an external pull-up will typically be required.

Figure 18.2. UART Mode 0 Interconnect

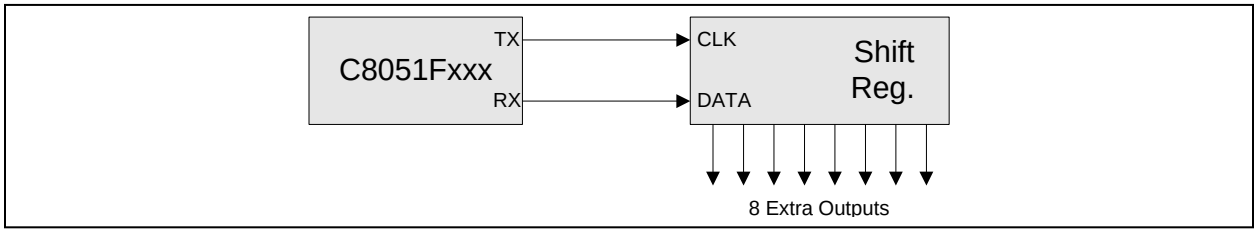
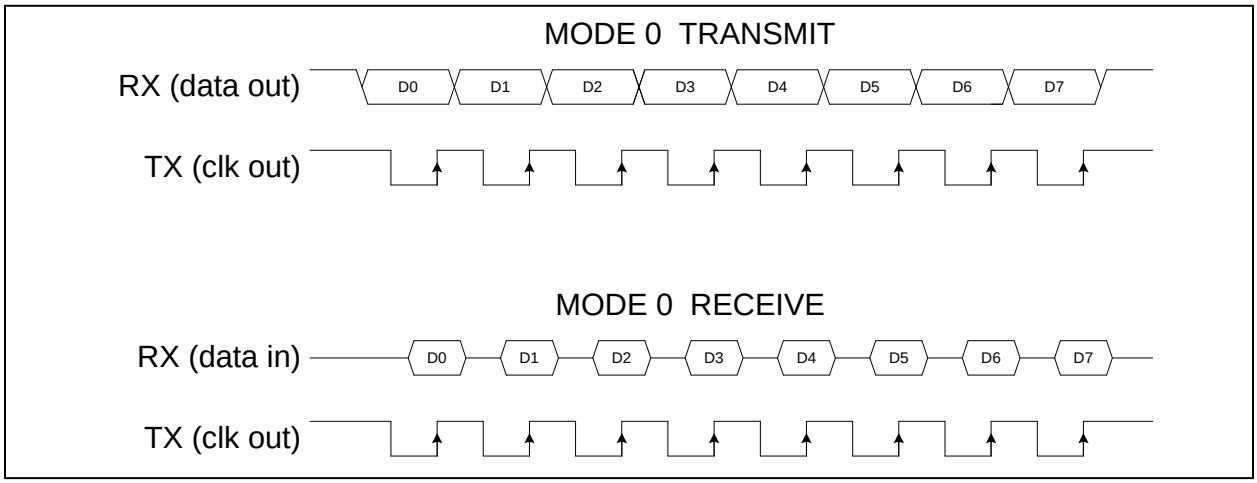


Figure 18.3. UART Mode 0 Timing Diagram



18.2. Multiprocessor Communications

Modes 2 and 3 support multiprocessor communication between a master processor and one or more slave processors by special use of the ninth data bit. When a master processor wants to transmit to one or more slaves, it first sends an address byte to select the target(s). An address byte differs from a data byte in that its ninth bit is logic 1; in a data byte, the ninth bit is always set to logic 0.

Setting the SM2 bit (SCON.5) of a slave processor configures its UART such that when a stop bit is received, the UART will generate an interrupt only if the ninth bit is logic one (RB8 = 1) signifying an address byte has been received. In the UART's interrupt handler, software will compare the received address with the slave's own assigned 8-bit address. If the addresses match, the slave will clear its SM2 bit to enable interrupts on the reception of the following data byte(s). Slaves that weren't addressed leave their SM2 bits set and do not generate interrupts on the reception of the following data bytes, thereby ignoring the data. Once the entire message is received, the addressed slave resets its SM2 bit to ignore all transmissions until it receives the next address byte.

Multiple addresses can be assigned to a single slave and/or a single address can be assigned to multiple slaves, thereby enabling "broadcast" transmissions to more than one slave simultaneously. The master processor can be configured to receive all transmissions or a protocol can be implemented such that the master/slave role is temporarily reversed to enable half-duplex transmission between the original master and slave(s).

Figure 18.7. UART Multi-Processor Mode Interconnect Diagram

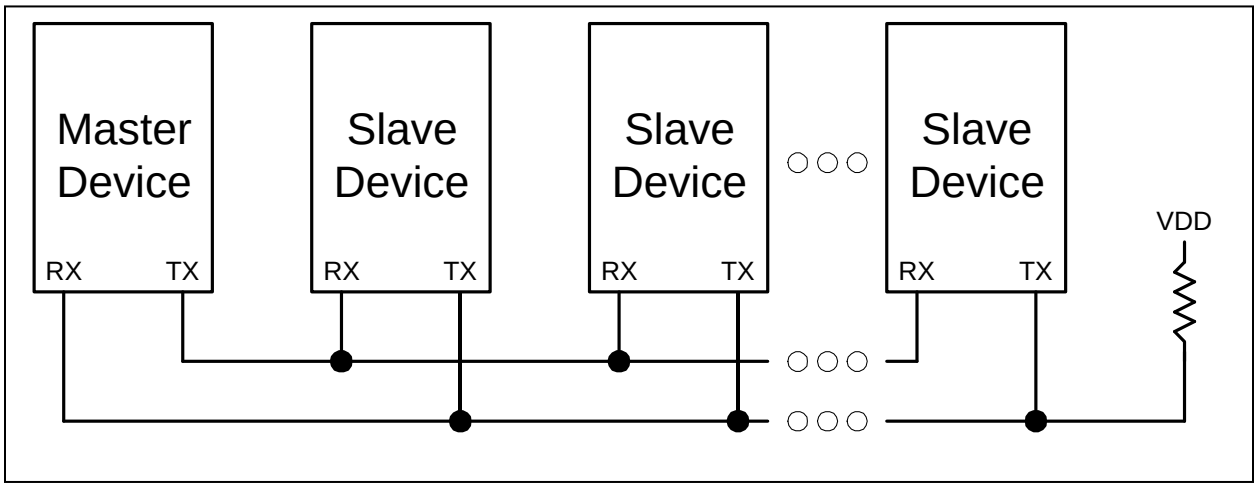


Figure 19.5. TMOD: Timer Mode Register

R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	Reset Value
GATE1	C/T1	T1M1	T1M0	GATE0	C/T0	T0M1	T0M0	00000000
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	SFR Address: 0x89

Bit7: GATE1: Timer 1 Gate Control.
0: Timer 1 enabled when TR1 = 1 irrespective of /INT1 logic level.
1: Timer 1 enabled only when TR1 = 1 AND /INT1 = logic level one.

Bit6: C/T1: Counter/Timer 1 Select.
0: Timer Function: Timer 1 incremented by clock defined by T1M bit (CKCON.4).
1: Counter Function: Timer 1 incremented by high-to-low transitions on external input pin (T1).

Bits5-4: T1M1-T1M0: Timer 1 Mode Select.
These bits select the Timer 1 operation mode.

T1M1	T1M0	Mode
0	0	Mode 0: 13-bit counter/timer
0	1	Mode 1: 16-bit counter/timer
1	0	Mode 2: 8-bit counter/timer with auto-reload
1	1	Mode 3: Timer 1 Inactive/stopped

Bit3: GATE0: Timer 0 Gate Control.
0: Timer 0 enabled when TR0 = 1 irrespective of /INT0 logic level.
1: Timer 0 enabled only when TR0 = 1 AND /INT0 = logic level one.

Bit2: C/T0: Counter/Timer Select.
0: Timer Function: Timer 0 incremented by clock defined by T0M bit (CKCON.3).
1: Counter Function: Timer 0 incremented by high-to-low transitions on external input pin (T0).

Bits1-0: T0M1-T0M0: Timer 0 Mode Select.
These bits select the Timer 0 operation mode.

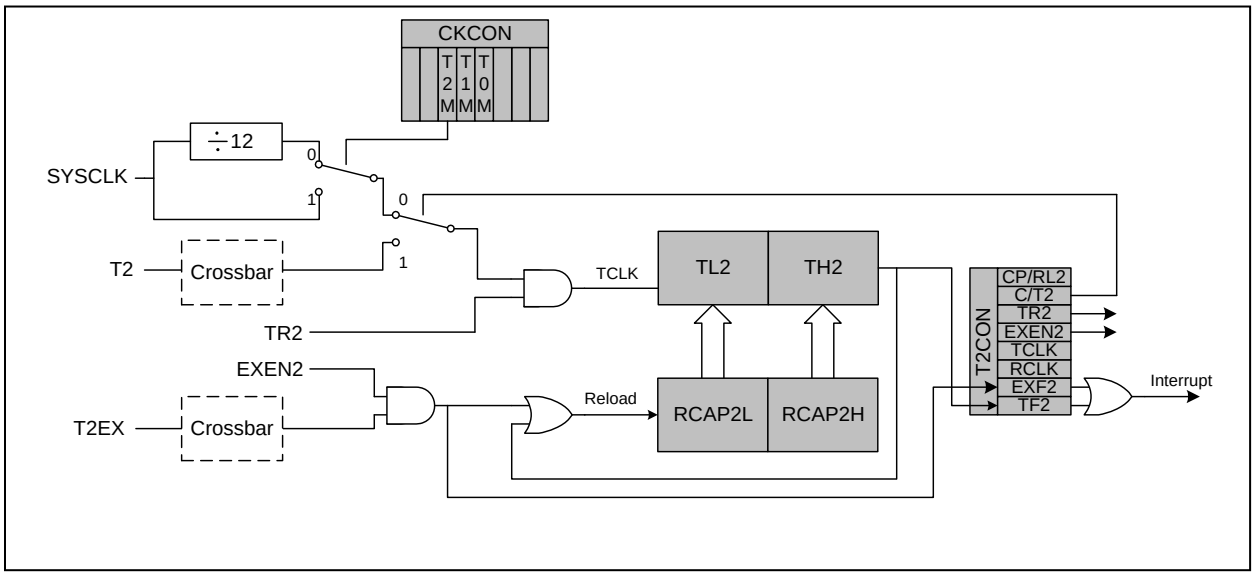
T0M1	T0M0	Mode
0	0	Mode 0: 13-bit counter/timer
0	1	Mode 1: 16-bit counter/timer
1	0	Mode 2: 8-bit counter/timer with auto-reload
1	1	Mode 3: Two 8-bit counter/timers

19.2.2. Mode 1: 16-bit Counter/Timer with Auto-Reload

The Counter/Timer with Auto-Reload mode sets the TF2 timer overflow flag when the counter/timer register overflows from 0xFFFF to 0x0000. An interrupt is generated if enabled. On overflow, the 16-bit value held in the two capture registers (RCAP2H, RCAP2L) is automatically loaded into the counter/timer register and the timer is restarted.

Counter/Timer with Auto-Reload mode is selected by clearing the CP/RL2 bit. Setting TR2 to logic 1 enables and starts the timer. Timer 2 can use either the system clock or transitions on an external input pin as its clock source, as specified by the C/T2 bit. If EXEN2 is set to logic 1, a high-to-low transition on T2EX will also cause Timer 2 to be reloaded. If EXEN2 is cleared, transitions on T2EX will be ignored.

Figure 19.12. T2 Mode 1 Block Diagram



21.3. Debug Support

Each MCU has on-chip JTAG and debug circuitry that provide *non-intrusive, full speed, in-circuit debug using the production part installed in the end application* using the four pin JTAG I/F. Silicon Labs' debug system supports inspection and modification of memory and registers, setting breakpoints, watchpoints, single stepping, and run and halt commands. No additional target RAM, program memory, or communications channels are required. All the digital and analog peripherals are functional and work correctly (remain in sync) while debugging. The WDT is disabled when the MCU is halted during single stepping or at a breakpoint.

The C8051F000DK, C8051F005DK, C8051F010DK, and C8051F015DK are development kits with all the hardware and software necessary to develop application code and perform in-circuit debugging with each MCU in the C8051F000 family. Each kit includes an Integrated Development Environment (IDE) which has a debugger and integrated 8051 assembler. It has an RS-232 to JTAG protocol translator module referred to as the EC. There is also a target application board with a C8051F000, F005, F010, or F015 installed and with a large prototyping area. The kit also includes RS-232 and JTAG cables, and wall-mount power supply.