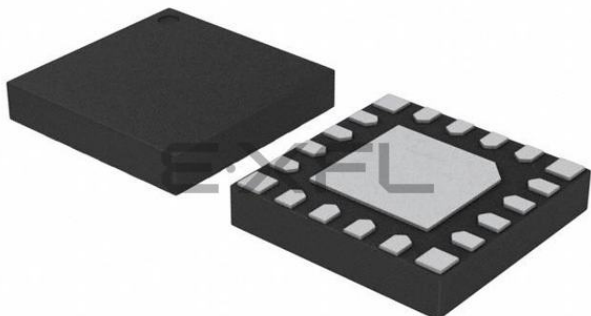




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Details

Product Status	Obsolete
Core Processor	CIP-51 8051
Core Size	8-Bit
Speed	25MHz
Connectivity	SMBus (2-Wire/I ² C), SPI, UART/USART
Peripherals	Brown-out Detect/Reset, Cap Sense, POR, PWM, Temp Sensor, WDT
Number of I/O	16
Program Memory Size	8KB (8K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	512 x 8
Voltage - Supply (Vcc/Vdd)	1.8V ~ 3.6V
Data Converters	A/D 9x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	20-UFQFN Exposed Pad
Supplier Device Package	20-QFN (3x3)
Purchase URL	https://www.e-xfl.com/product-detail/silicon-labs/c8051f990-gm

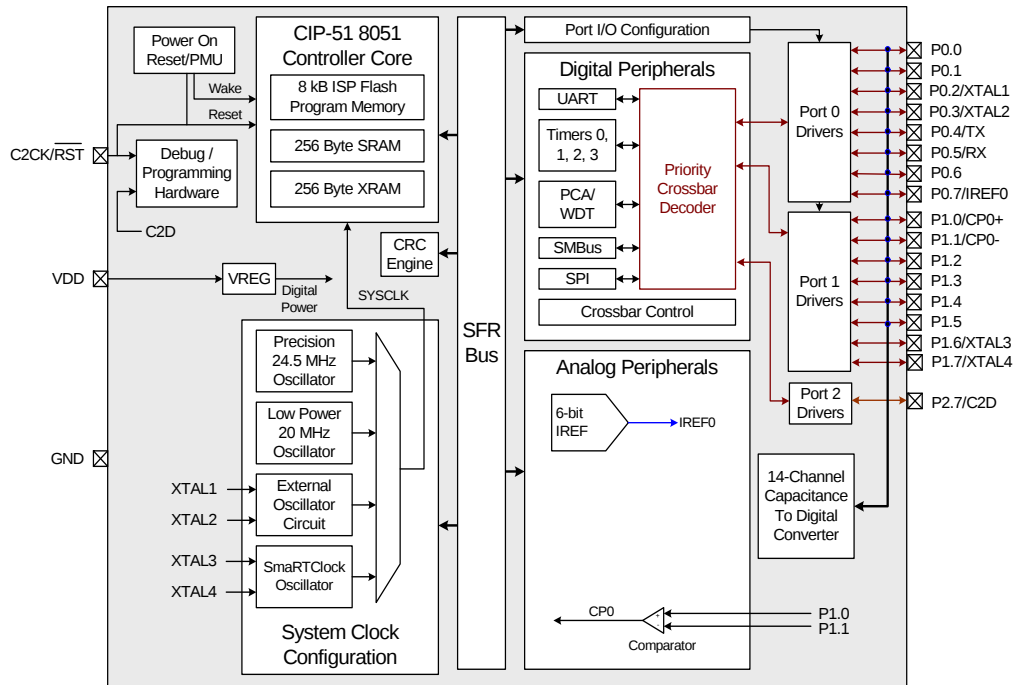


Figure 1.13. C8051F997 Block Diagram

5.1. Output Code Formatting

The registers ADC0H and ADC0L contain the high and low bytes of the output conversion code from the ADC at the completion of each conversion. Data can be right-justified or left-justified, depending on the setting of the AD0SJST[2:0]. When the repeat count is set to 1, conversion codes are represented as 10-bit unsigned integers. Inputs are measured from 0 to $V_{REF} \times 1023/1024$. Example codes are shown below for both right-justified and left-justified data. Unused bits in the ADC0H and ADC0L registers are set to 0.

Input Voltage	Right-Justified ADC0H:ADC0L (AD0SJST = 000)	Left-Justified ADC0H:ADC0L (AD0SJST = 100)
$V_{REF} \times 1023/1024$	0x03FF	0xFFC0
$V_{REF} \times 512/1024$	0x0200	0x8000
$V_{REF} \times 256/1024$	0x0100	0x4000
0	0x0000	0x0000

When the repeat count is greater than 1, the output conversion code represents the accumulated result of the conversions performed and is updated after the last conversion in the series is finished. Sets of 4, 8, 16, 32, or 64 consecutive samples can be accumulated and represented in unsigned integer format. The repeat count can be selected using the AD0RPT bits in the ADC0AC register. When a repeat count is higher than 1, the ADC output must be right-justified (AD0SJST = 0xx); unused bits in the ADC0H and ADC0L registers are set to 0. The example below shows the right-justified result for various input voltages and repeat counts. Notice that accumulating 2^n samples is equivalent to left-shifting by n bit positions when all samples returned from the ADC have the same value.

Input Voltage	Repeat Count = 4	Repeat Count = 16	Repeat Count = 64
$V_{REF} \times 1023/1024$	0x0FFC	0x3FF0	0xFFC0
$V_{REF} \times 512/1024$	0x0800	0x2000	0x8000
$V_{REF} \times 511/1024$	0x07FC	0x1FF0	0x7FC0
0	0x0000	0x0000	0x0000

The AD0SJST bits can be used to format the contents of the 16-bit accumulator. The accumulated result can be shifted right by 1, 2, or 3 bit positions. Based on the principles of oversampling and averaging, the effective ADC resolution increases by 1 bit each time the oversampling rate is increased by a factor of 4. The example below shows how to increase the effective ADC resolution by 1, 2, and 3 bits to obtain an effective ADC resolution of 11-bit, 12-bit, or 13-bit respectively without CPU intervention.

Input Voltage	Repeat Count = 4 Shift Right = 1 11-Bit Result	Repeat Count = 16 Shift Right = 2 12-Bit Result	Repeat Count = 64 Shift Right = 3 13-Bit Result
$V_{REF} \times 1023/1024$	0x07F7	0x0FFC	0x1FF8
$V_{REF} \times 512/1024$	0x0400	0x0800	0x1000
$V_{REF} \times 511/1024$	0x03FE	0x04FC	0x0FF8
0	0x0000	0x0000	0x0000

5.2. Modes of Operation

ADC0 has a maximum conversion speed of 300 ksps in 10-bit mode. The ADC0 conversion clock (SARCLK) is a divided version of the system clock when burst mode is disabled (BURSTEN = 0), or a divided version of the low power oscillator when burst mode is enabled (BURSEN = 1). The clock divide value is determined by the AD0SC bits in the ADC0CF register.

5.2.1. Starting a Conversion

A conversion can be initiated in one of five ways, depending on the programmed states of the ADC0 Start of Conversion Mode bits (AD0CM2–0) in register ADC0CN. Conversions may be initiated by one of the following:

1. Writing a 1 to the AD0BUSY bit of register ADC0CN
2. A Timer 0 overflow (i.e., timed continuous conversions)
3. A Timer 2 overflow
4. A Timer 3 overflow
5. A rising edge on the CNVSTR input signal (pin P0.6)

Writing a 1 to AD0BUSY provides software control of ADC0 whereby conversions are performed "on-demand". During conversion, the AD0BUSY bit is set to logic 1 and reset to logic 0 when the conversion is complete. The falling edge of AD0BUSY triggers an interrupt (when enabled) and sets the ADC0 interrupt flag (AD0INT). When polling for ADC conversion completions, the ADC0 interrupt flag (AD0INT) should be used. Converted data is available in the ADC0 data registers, ADC0H:ADC0L, when bit AD0INT is logic 1. When Timer 2 or Timer 3 overflows are used as the conversion source, Low Byte overflows are used if Timer 2/3 is in 8-bit mode; High byte overflows are used if Timer 2/3 is in 16-bit mode. See "25. Timers" on page 278 for timer configuration.

Important Note About Using CNVSTR: The CNVSTR input pin also functions as Port pin P0.6. When the CNVSTR input is used as the ADC0 conversion source, Port pin P0.6 should be skipped by the Digital Crossbar. To configure the Crossbar to skip P0.6, set to 1 Bit 6 in register P0SKIP. See "21. Port Input/Output" on page 215 for details on Port I/O configuration.

5.6.1. Window Detector In Single-Ended Mode

Figure 5.5 shows two example window comparisons for right-justified data, with $ADC0LTH:ADC0LTL = 0x0080$ (128d) and $ADC0GTH:ADC0GTL = 0x0040$ (64d). The input voltage can range from 0 to $VREF \times (1023/1024)$ with respect to GND, and is represented by a 10-bit unsigned integer value. In the left example, an $AD0WINT$ interrupt will be generated if the $ADC0$ conversion word ($ADC0H:ADC0L$) is within the range defined by $ADC0GTH:ADC0GTL$ and $ADC0LTH:ADC0LTL$ (if $0x0040 < ADC0H:ADC0L < 0x0080$). In the right example, an $AD0WINT$ interrupt will be generated if the $ADC0$ conversion word is outside of the range defined by the $ADC0GT$ and $ADC0LT$ registers (if $ADC0H:ADC0L < 0x0040$ or $ADC0H:ADC0L > 0x0080$). Figure 5.6 shows an example using left-justified data with the same comparison values.

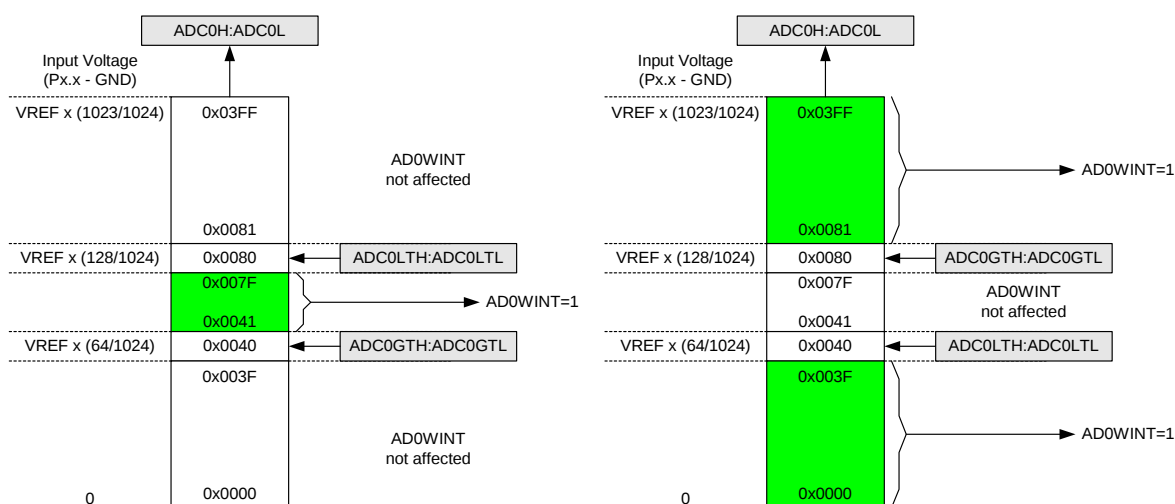


Figure 5.5. ADC Window Compare Example: Right-Justified Single-Ended Data

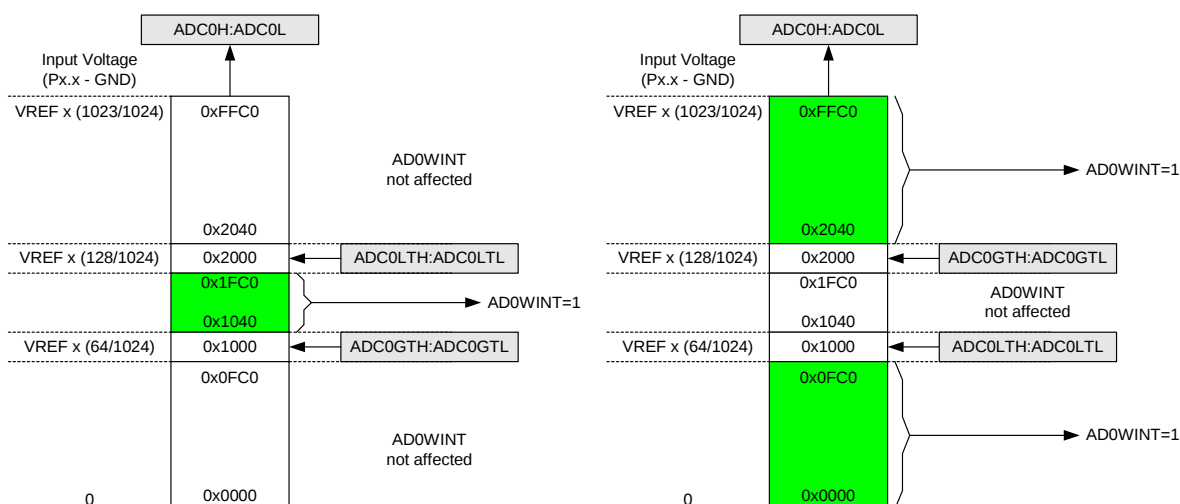


Figure 5.6. ADC Window Compare Example: Left-Justified Single-Ended Data

5.6.2. ADC0 Specifications

See “4. Electrical Characteristics” on page 48 for a detailed listing of $ADC0$ specifications.

C8051F99x-C8051F98x

8.4. CS0 Multiple Channel Enable

CS0 has the capability of measuring the total capacitance of multiple channels using a single conversion. When the multiple channel feature is enabled ($CS0MCEN = 1$), Channels selected by $CS0SCAN0/1$ are internally shorted together and the combined node is selected as the CS0 input. This mode can be used to detect a capacitance change on multiple channels using a single conversion and is useful for implementing “wake-on-multiple channels”.

8.5. CS0 Gain Adjustment

The gain of the CS0 circuit can be adjusted in integer increments from 1x to 8x (8x is the default). High gain gives the best sensitivity and resolution for small capacitors, such as those typically implemented as touch-sensitive PCB features. To measure larger capacitance values, the gain should be lowered accordingly. The bits $CS0CG[2:0]$ in register $CS0MD$ set the gain value.

8.6. Wake from Suspend

CS0 has the capability of waking the device from a low power suspend mode upon detection of a “touch” using the digital comparator. When the $CS0SMEN$ is set to 1, CS0 may also wake up the device after an end of scan event when $CS0CM[2:0]$ are set to 101b or after each conversion when $CS0CM[2:0]$ are set to 110b or 111b. If the accumulate feature is enabled, the device wakes up after all samples have been accumulated. The $CS0WOI$ bit in the $CS0MD1$ register can be used to configure desire wake from suspend behavior.

8.7. Using CS0 in Applications that Utilize Sleep Mode

To achieve maximum power efficiency, CS0 should be enabled only when taking a conversion and disabled at all other times. CS0 must be disabled by software prior to entering Sleep Mode.

8.9. Automatic Scanning (Method 2—CS0SMEN = 1)

When CS0SMEN is enabled, CS0 uses an alternate autoscanning method that uses the contents of CS0SCAN0 and CS0SCAN1 to determine which channels to include in the scan. This maximizes flexibility for application development and can result in more power efficient scanning. The following procedure can be used to configure the device for Automatic Scanning with CS0SMEN = 1.

1. Set the CS0SMEN bit to 1.
2. Select the start of conversion mode (CS0CM[2:0]) if not already configured. Mode 101b is the mode of choice for most systems.
3. Configure the CS0SCAN0 and CS0SCAN1 registers to enable channels in the scan.
4. Configure the CS0THH:CS0THL digital comparator threshold and polarity.
5. Enable wake from suspend on end of scan (CS0WOI = 1) if this functionality is desired.
6. Set CS0SS to point to the first channel in the scan. Note: CS0SS uses the same bit mapping as the CS0MX register.
7. Issue a start of conversion (BUSY = 1).
8. Enable the CS0 Wakeup Source and place the device in Suspend mode (optional).

If using Mode 101b, scanning will stop once a “touch” has been detected using the digital comparator. The CS0MX register will contain the channel mux value of the channel that caused the interrupt. Setting the busy bit when servicing the interrupt will cause the scan to continue where it left off. Scanning will also stop after all channels have been sampled and no “touches” have been detected. If the CS0WOI bit is set, a wake from suspend event will be generated. Note: When automatic scanning is enabled, the contents of the CS0MX register are only valid when the digital comparator interrupt is set and BUSY = 0.

8.10. CS0 Comparator

The CS0 comparator compares the latest capacitive sense conversion result with the value stored in CS0THH:CS0THL. If the result is less than or equal to the stored value, the CS0CMPF bit(CS0CN:0) is set to 0. If the result is greater than the stored value, CS0CMPF is set to 1.

If the CS0 conversion accumulator is configured to accumulate multiple conversions, a comparison will not be made until the last conversion has been accumulated.

An interrupt will be generated if CS0 greater-than comparator interrupts are enabled by setting the ECSDC bit (EIE2.5) when the comparator sets CS0CMPF to 1.

If auto-scan is running when the comparator sets the CS0CMPF bit, no further auto-scan initiated conversions will start until firmware sets CS0BUSY to 1.

A CS0 greater-than comparator event can wake a device from suspend mode. This feature is useful in systems configured to continuously sample one or more capacitive sense channels. The device will remain in the low-power suspend state until the captured value of one of the scanned channels causes a CS0 greater-than comparator event to occur. It is not necessary to have CS0 comparator interrupts enabled in order to wake a device from suspend with a greater-than event.

For a summary of behavior with different CS0 comparator, auto-scan, and auto accumulator settings, please see Table 8.1.

SFR Definition 8.11. CS0MD1: Capacitive Sense Mode 1

Bit	7	6	5	4	3	2	1	0
Name	Reserved	CS0POL	CS0DR		CS0WOI	CS0CG[2:0]		
Type	R/W					R/W	R/W	R/W
Reset	0	0	0	0	0	1	1	1

SFR Page = 0x0; SFR Address = 0xAF

Bit	Name	Description
7	Reserved	Must write 0.
6	CS0POL	CS0 Digital Comparator Polarity Select. 0: The digital comparator generates an interrupt if the conversion is greater than the threshold. 1: The digital comparator generates an interrupt if the conversion is less than or equal to the threshold.
5:4	CS0DR[1:0]	CS0 Double Reset Select. These bits adjust the secondary CS0 reset time. For most touch-sensitive switches, the default (fastest) value is sufficient. See the discussion in Section 8.13 for more information. 00: No additional time is used for secondary reset. 01: An additional 0.75 μ s is used for secondary reset. 10: An additional 1.5 μ s is used for secondary reset. 11: An additional 2.25 μ s is used for secondary reset.
3	CS0WOI	CS0 Wake on Interrupt Configuration. 0: Wake-up event generated on digital comparator interrupt only. 1: Wake-up event generated on end of scan or digital comparator interrupt.
2:0	CS0CG[2:0]	CS0 Capacitance Gain Select. These bits select the gain applied to the capacitance measurement. Lower gain values increase the size of the capacitance that can be measured with the CS0 module. The capacitance gain is equivalent to CS0CG[2:0] + 1. 000: Gain = 1x 001: Gain = 2x 010: Gain = 3x 011: Gain = 4x 100: Gain = 5x 101: Gain = 6x 110: Gain = 7x 111: Gain = 8x (default)

Notes on Registers, Operands and Addressing Modes:

Rn—Register R0–R7 of the currently selected register bank.

@Ri—Data RAM location addressed indirectly through R0 or R1.

rel—8-bit, signed (twos complement) offset relative to the first byte of the following instruction. Used by SJMP and all conditional jumps.

direct—8-bit internal data location's address. This could be a direct-access Data RAM location (0x00–0x7F) or an SFR (0x80–0xFF).

#data—8-bit constant

#data16—16-bit constant

bit—Direct-accessed bit in Data RAM or SFR

addr11—11-bit destination address used by ACALL and AJMP. The destination must be within the same 2 kB page of program memory as the first byte of the following instruction.

addr16—16-bit destination address used by LCALL and LJMP. The destination may be anywhere within the 8 kB program memory space.

There is one unused opcode (0xA5) that performs the same function as NOP.
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11. On-Chip XRAM

The C8051F99x-C8051F98x MCUs include on-chip RAM mapped into the external data memory space (XRAM). The external memory space may be accessed using the external move instruction (MOVX) with the target address specified in either the data pointer (DPTR), or with the target address low byte in R0 or R1. On C8051F99x-C8051F98x devices, the target address high byte is a don't care.

When using the MOVX instruction to access on-chip RAM, no additional initialization is required and the MOVX instruction execution time is as specified in the CIP-51 chapter.

Important Note: MOVX write operations can be configured to target Flash memory, instead of XRAM. See Section “14. Flash Memory” on page 150 for more details. The MOVX instruction accesses XRAM by default.

Important Note: On device reset or upon waking up from Sleep mode, address 0x0000 of external memory may be overwritten by an indeterminate value. The indeterminate value is 0x00 in most situations. A dummy variable should be placed at address 0x0000 in external memory to ensure that the application firmware does not store any data that needs to be retained during sleep or reset at this memory location.

11.1. Accessing XRAM

The XRAM memory space is accessed using the MOVX instruction. The MOVX instruction has two forms, both of which use an indirect addressing method. The first method uses the Data Pointer, DPTR, a 16-bit register which contains the effective address of the XRAM location to be read from or written to. The second method uses R0 or R1 to generate the effective XRAM address. Examples of both of these methods are given below.

11.1.1. 16-Bit MOVX Example

The 16-bit form of the MOVX instruction accesses the memory location pointed to by the contents of the DPTR register. The following series of instructions reads the value of the byte at address 0x1234 into the accumulator A:

```
MOV    DPTR, #0034h      ; load DPTR with 16-bit address to read (0x0034)
MOVX   A, @DPTR          ; load contents of 0x0034 into accumulator A
```

The above example uses the 16-bit immediate MOV instruction to set the contents of DPTR. Alternately, the DPTR can be accessed through the SFR registers DPH, which contains the upper 8-bits of DPTR, and DPL, which contains the lower 8-bits of DPTR.

11.1.2. 8-Bit MOVX Example

The 8-bit form of the MOVX instruction uses the contents of R0 or R1 to determine the 8-bits of the effective address to be accessed. The following series of instructions read the contents of the byte at address 0x0034 into the accumulator A.

```
MOV    R0, #34h          ; load low byte of address into R0 (or R1)
MOVX   A, @R0            ; load contents of 0x0034 into accumulator A
```

14.5. Flash Write and Erase Guidelines

Any system which contains routines which write or erase Flash memory from software involves some risk that the write or erase routines will execute unintentionally if the CPU is operating outside its specified operating range of V_{DD} , system clock frequency, or temperature. This accidental execution of Flash modifying code can result in alteration of Flash memory contents causing a system failure that is only recoverable by re-Flashing the code in the device.

To help prevent the accidental modification of Flash by firmware, the V_{DD} Monitor must be enabled and enabled as a reset source on C8051F99x-C8051F98x devices for the Flash to be successfully modified. **If either the V_{DD} Monitor or the V_{DD} Monitor reset source is not enabled, a Flash Error Device Reset will be generated when the firmware attempts to modify the Flash.**

The following guidelines are recommended for any system that contains routines which write or erase Flash from code.

14.5.1. V_{DD} Maintenance and the V_{DD} Monitor

1. If the system power supply is subject to voltage or current "spikes," add sufficient transient protection devices to the power supply to ensure that the supply voltages listed in the Absolute Maximum Ratings table are not exceeded.
2. Make certain that the minimum V_{DD} rise time specification of 1 ms is met. If the system cannot meet this rise time specification, then add an external V_{DD} brownout circuit to the RST pin of the device that holds the device in reset until V_{DD} reaches the minimum device operating voltage and re-asserts RST if V_{DD} drops below the minimum device operating voltage.
3. Keep the on-chip V_{DD} Monitor enabled and enable the V_{DD} Monitor as a reset source as early in code as possible. This should be the first set of instructions executed after the Reset Vector. For C-based systems, this will involve modifying the startup code added by the C compiler. See your compiler documentation for more details. Make certain that there are no delays in software between enabling the V_{DD} Monitor and enabling the V_{DD} Monitor as a reset source. Code examples showing this can be found in "AN201: Writing to Flash from Firmware," available from the Silicon Laboratories website.

Notes:

1. On C8051F99x-C8051F98x devices, both the V_{DD} Monitor and the V_{DD} Monitor reset source must be enabled to write or erase Flash without generating a Flash Error Device Reset.
2. On C8051F99x-C8051F98x devices, both the V_{DD} Monitor and the V_{DD} Monitor reset source are enabled by hardware after a power-on reset.
4. As an added precaution, explicitly enable the V_{DD} Monitor and enable the V_{DD} Monitor as a reset source inside the functions that write and erase Flash memory. The V_{DD} Monitor enable instructions should be placed just after the instruction to set PSWE to a 1, but before the Flash write or erase operation instruction.
5. Make certain that all writes to the RSTSRC (Reset Sources) register use direct assignment operators and explicitly DO NOT use the bit-wise operators (such as AND or OR). For example, "RSTSRC = 0x02" is correct, but "RSTSRC |= 0x02" is incorrect.
6. Make certain that all writes to the RSTSRC register explicitly set the PORSF bit to a 1. Areas to check are initialization code which enables other reset sources, such as the Missing Clock Detector or Comparator, for example, and instructions which force a Software Reset. A global search on "RSTSRC" can quickly verify this.

15.2. Idle Mode

Setting the Idle Mode Select bit (PCON.0) causes the CIP-51 to halt the CPU and enter Idle mode as soon as the instruction that sets the bit completes execution. All internal registers and memory maintain their original data. All analog and digital peripherals can remain active during Idle mode.

Note: To ensure the MCU enters a low power state upon entry into Idle Mode, the one-shot circuit should be enabled by clearing the BYPASS bit (FLSCL.6).

Idle mode is terminated when an enabled interrupt is asserted or a reset occurs. The assertion of an enabled interrupt will cause the Idle Mode Selection bit (PCON.0) to be cleared and the CPU to resume operation. The pending interrupt will be serviced and the next instruction to be executed after the return from interrupt (RETI) will be the instruction immediately following the one that set the Idle Mode Select bit. If Idle mode is terminated by an internal or external reset, the CIP-51 performs a normal reset sequence and begins program execution at address 0x0000.

If enabled, the Watchdog Timer (WDT) will eventually cause an internal watchdog reset and thereby terminate the Idle mode. This feature protects the system from an unintended permanent shutdown in the event of an inadvertent write to the PCON register. If this behavior is not desired, the WDT may be disabled by software prior to entering the idle mode if the WDT was initially configured to allow this operation. This provides the opportunity for additional power savings, allowing the system to remain in the idle mode indefinitely, waiting for an external stimulus to wake up the system. Refer to Section “18.6. PCA Watchdog Timer Reset” on page 185 for more information on the use and configuration of the WDT.

15.3. Stop Mode

Setting the Stop Mode Select bit (PCON.1) causes the CIP-51 to enter stop mode as soon as the instruction that sets the bit completes execution. In stop mode the precision internal oscillator and CPU are stopped; the state of the low power oscillator and the external oscillator circuit is not affected. Each analog peripheral (including the external oscillator circuit) may be shut down individually prior to entering stop mode. Stop mode can only be terminated by an internal or external reset. On reset, the CIP-51 performs the normal reset sequence and begins program execution at address 0x0000.

If enabled, the Missing Clock Detector will cause an internal reset and thereby terminate the Stop mode. The Missing Clock Detector should be disabled if the CPU is to be put to in STOP mode for longer than the MCD timeout.

Stop mode is a legacy 8051 power mode; it will not result in optimal power savings. Sleep or suspend mode will provide more power savings if the MCU needs to be inactive for a long period of time.

Note: To ensure the MCU enters a low power state upon entry into Stop Mode, the one-shot circuit should be enabled by clearing the BYPASS bit (FLSCL.6).

18. Reset Sources

Reset circuitry allows the controller to be easily placed in a predefined default condition. On entry to this reset state, the following occur:

- CIP-51 halts program execution
- Special Function Registers (SFRs) are initialized to their defined reset values
- External Port pins are forced to a known state
- Interrupts and timers are disabled

All SFRs are reset to the predefined values noted in the SFR descriptions. The contents of RAM are unaffected during a reset; any previously stored data is preserved as long as power is not lost. Since the stack pointer SFR is reset, the stack is effectively lost, even though the data on the stack is not altered.

The Port I/O latches are reset to 0xFF (all logic ones) in open-drain mode. Weak pullups are enabled during and after the reset. For power-on resets, the $\overline{\text{RST}}$ pin is high-impedance with the weak pull-up off until the device exits the reset state. For V_{DD} Monitor resets, the $\overline{\text{RST}}$ pin is driven low until the device exits the reset state.

On exit from the reset state, the program counter (PC) is reset, and the system clock defaults to an internal oscillator. Refer to Section “19. Clocking Sources” on page 188 for information on selecting and configuring the system clock source. The Watchdog Timer is enabled with the system clock divided by 12 as its clock source (Section “26.4. Watchdog Timer Mode” on page 311 details the use of the Watchdog Timer). Program execution begins at location 0x0000.

Important Note: On device reset or upon waking up from Sleep mode, address 0x0000 of external memory may be overwritten by an indeterminate value. The indeterminate value is 0x00 in most situations. A dummy variable should be placed at address 0x0000 in external memory to ensure that the application firmware does not store any data that needs to be retained during sleep or reset at this memory location.

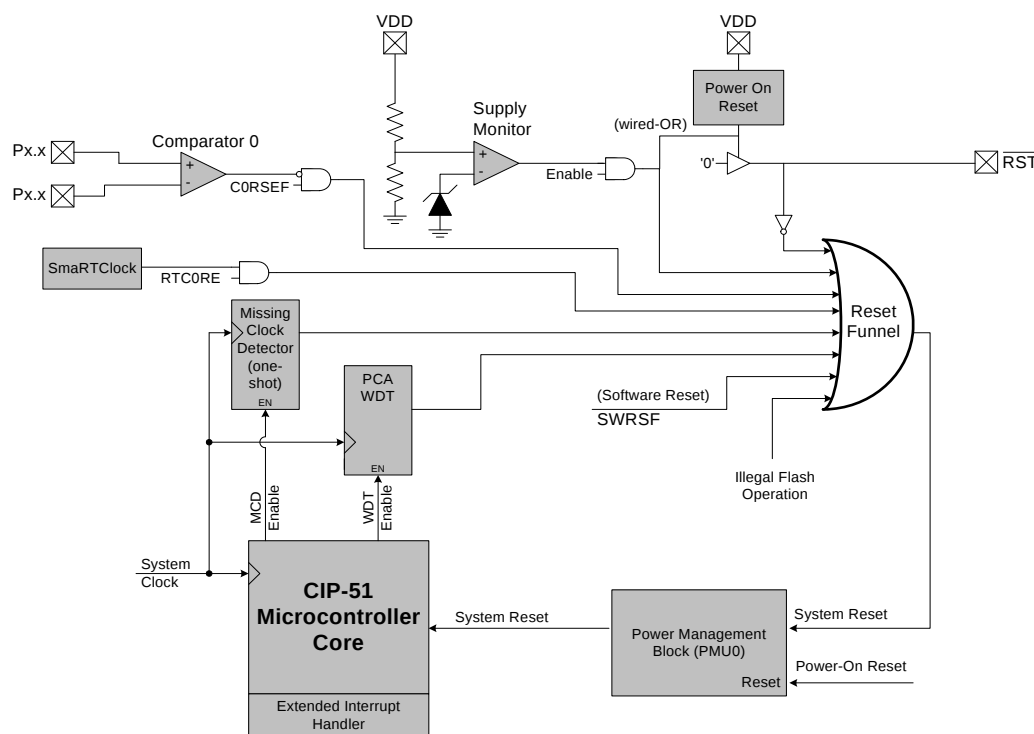


Figure 18.1. Reset Sources

19. Clocking Sources

C8051F99x-C8051F98x devices include a programmable precision internal oscillator, an external oscillator drive circuit, a low power internal oscillator, and a SmartClock real time clock oscillator. The precision internal oscillator can be enabled/disabled and calibrated using the OSCICN and OSCICL registers, as shown in Figure 19.1. The external oscillator can be configured using the OSCXCN register. The low power internal oscillator is automatically enabled and disabled when selected and deselected as a clock source. SmartClock operation is described in the SmartClock oscillator chapter.

The system clock (SYSCLK) can be derived from the precision internal oscillator, external oscillator, low power internal oscillator, low power internal oscillator divided by 8, or SmartClock oscillator. The global clock divider can generate a system clock that is 1, 2, 4, 8, 16, 32, 64, or 128 times slower than the selected input clock source. Oscillator electrical specifications can be found in the Electrical Specifications Chapter.

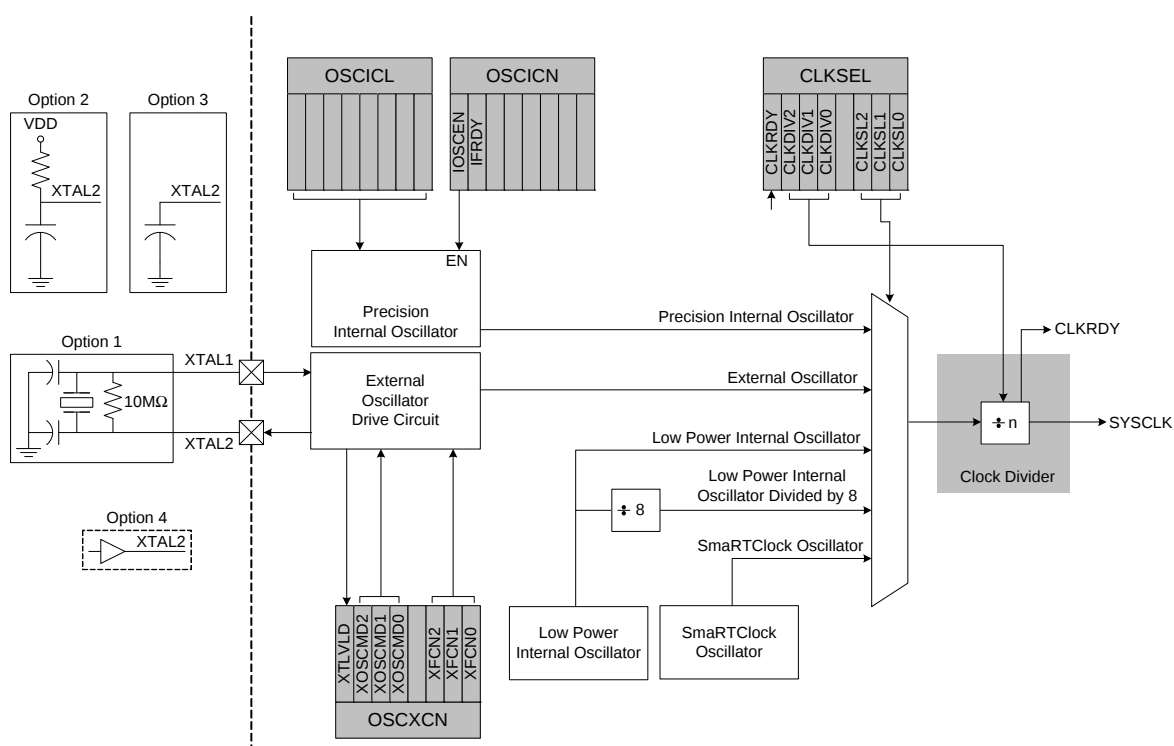


Figure 19.1. Clocking Sources Block Diagram

The proper way of changing the system clock when both the clock source and the clock divide value are being changed is as follows:

If switching from a fast “undivided” clock to a slower “undivided” clock:

1. Change the clock divide value.
2. Poll for CLKRDY > 1.
3. Change the clock source.

If switching from a slow “undivided” clock to a faster “undivided” clock:

1. Change the clock source.
2. Change the clock divide value.
3. Poll for CLKRDY > 1.

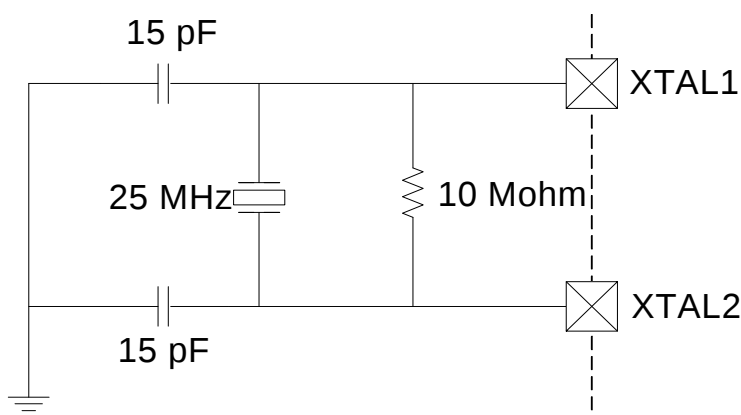


Figure 19.2. 25 MHz External Crystal Example

Important Note on External Crystals: Crystal oscillator circuits are quite sensitive to PCB layout. The crystal should be placed as close as possible to the XTAL pins on the device. The traces should be as short as possible and shielded with ground plane from any other traces which could introduce noise or interference.

When using an external crystal, the external oscillator drive circuit must be configured by software for *Crystal Oscillator Mode* or *Crystal Oscillator Mode with divide by 2 stage*. The divide by 2 stage ensures that the clock derived from the external oscillator has a duty cycle of 50%. The External Oscillator Frequency Control value (XFCN) must also be specified based on the crystal frequency. The selection should be based on Table 19.1. For example, a 25 MHz crystal requires an XFCN setting of 111b.

Table 19.1. Recommended XFCN Settings for Crystal Mode

XFCN	Crystal Frequency	Bias Current	Typical Supply Current (VDD = 2.4 V)
000	$f \leq 20 \text{ kHz}$	0.5 μA	3.0 μA , $f = 32.768 \text{ kHz}$
001	$20 \text{ kHz} < f \leq 58 \text{ kHz}$	1.5 μA	4.8 μA , $f = 32.768 \text{ kHz}$
010	$58 \text{ kHz} < f \leq 155 \text{ kHz}$	4.8 μA	9.6 μA , $f = 32.768 \text{ kHz}$
011	$155 \text{ kHz} < f \leq 415 \text{ kHz}$	14 μA	28 μA , $f = 400 \text{ kHz}$
100	$415 \text{ kHz} < f \leq 1.1 \text{ MHz}$	40 μA	71 μA , $f = 400 \text{ kHz}$
101	$1.1 \text{ MHz} < f \leq 3.1 \text{ MHz}$	120 μA	193 μA , $f = 400 \text{ kHz}$
110	$3.1 \text{ MHz} < f \leq 8.2 \text{ MHz}$	550 μA	940 μA , $f = 8 \text{ MHz}$
111	$8.2 \text{ MHz} < f \leq 25 \text{ MHz}$	2.6 mA	3.9 mA, $f = 25 \text{ MHz}$

When the crystal oscillator is first enabled, the external oscillator valid detector allows software to determine when the external system clock has stabilized. Switching to the external oscillator before the crystal oscillator has stabilized can result in unpredictable behavior. The recommended procedure for starting the crystal is as follows:

1. Configure XTAL1 and XTAL2 for analog I/O and disable the digital output drivers.
2. Configure and enable the external oscillator.
3. Poll for $\text{XTLVLD} \geq 1$.
4. Switch the system clock to the external oscillator.

20.2.6. Missing SmarTClock Detector

The missing SmarTClock detector is a one-shot circuit enabled by setting MCLKEN (RTC0CN.6) to 1. When the SmarTClock Missing Clock Detector is enabled, OSCFAIL (RTC0CN.5) is set by hardware if SmarTClock oscillator remains high or low for more than 100 μ s.

A SmarTClock Missing Clock detector timeout can trigger an interrupt, wake the device from a low power mode, or reset the device. See Section “13. Interrupt Handler” on page 138, Section “15. Power Management” on page 162, and Section “18. Reset Sources” on page 181 for more information.

Note: The SmarTClock Missing Clock Detector should be disabled when making changes to the oscillator settings in RTC0XCN.

20.2.7. SmarTClock Oscillator Crystal Valid Detector

The SmarTClock oscillator crystal valid detector is an oscillation amplitude detector circuit used during crystal startup to determine when oscillation has started and is nearly stable. The output of this detector can be read from the CLKVLD bit (RTX0XCN.4).

Notes:

1. The CLKVLD bit has a blanking interval of 2 ms. During the first 2 ms after turning on the crystal oscillator, the output of CLKVLD is not valid.
2. This SmarTClock crystal valid detector (CLKVLD) is not intended for detecting an oscillator failure. The missing SmarTClock detector (CLKFAIL) should be used for this purpose.

20.3. SmarTClock Timer and Alarm Function

The SmarTClock timer is a 32-bit counter that, when running (RTC0TR = 1), is incremented every SmarTClock oscillator cycle. The timer has an alarm function that can be set to generate an interrupt, wake the device from a low power mode, or reset the device at a specific time. See Section “13. Interrupt Handler” on page 138, Section “15. Power Management” on page 162, and Section “18. Reset Sources” on page 181 for more information.

The SmarTClock timer includes an Auto Reset feature, which automatically resets the timer to zero one SmarTClock cycle after the alarm signal is deasserted. When using Auto Reset, the Alarm match value should always be set to 2 counts less than the desired match value. When using the LFO in combination with Auto Reset, the right-justified Alarm match value should be set to 4 counts less than the desired match value. Auto Reset can be enabled by writing a 1 to ALRM (RTC0CN.2).

20.3.1. Setting and Reading the SmarTClock Timer Value

The 32-bit SmarTClock timer can be set or read using the six CAPTUREn internal registers. Note that the timer does not need to be stopped before reading or setting its value. The following steps can be used to set the timer value:

1. Write the desired 32-bit set value to the CAPTUREn registers.
2. Write 1 to RTC0SET. This will transfer the contents of the CAPTUREn registers to the SmarTClock timer.
3. Operation is complete when RTC0SET is cleared to 0 by hardware.

The following steps can be used to read the current timer value:

1. Write 1 to RTC0CAP. This will transfer the contents of the timer to the CAPTUREn registers.
2. Poll RTC0CAP until it is cleared to 0 by hardware.
3. A snapshot of the timer value can be read from the CAPTUREn registers

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Internal Register Definition 20.4. RTC0CN: SmaRTClock Control

Bit	7	6	5	4	3	2	1	0
Name	RTC0EN	MCLKEN	OSCFail	RTC0TR	RTC0AEN	ALRM	RTC0SET	RTC0CAP
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W
Reset	0	0	Varies	0	0	0	0	0

SmaRTClock Address = 0x04

SmartClock Address 0x04

Bit	Name	Function		
7	RTC0EN	SmaRTClock Enable. Enables/disables the SmaRTClock oscillator and associated bias currents. 0: SmaRTClock oscillator disabled. 1: SmaRTClock oscillator enabled.		
6	MCLKEN	Missing SmaRTClock Detector Enable. Enables/disables the missing SmaRTClock detector. 0: Missing SmaRTClock detector disabled. 1: Missing SmaRTClock detector enabled.		
5	OSCFAIL	SmaRTClock Oscillator Fail Event Flag. Set by hardware when a missing SmaRTClock detector timeout occurs. Must be cleared by software. The value of this bit is not defined when the SmaRTClock oscillator is disabled.		
4	RTC0TR	SmaRTClock Timer Run Control. Controls if the SmaRTClock timer is running or stopped (holds current value). 0: SmaRTClock timer is stopped. 1: SmaRTClock timer is running.		
3	RTC0AEN	SmaRTClock Alarm Enable. Enables/disables the SmaRTClock alarm function. Also clears the ALRM flag. 0: SmaRTClock alarm disabled. 1: SmaRTClock alarm enabled.		
2	ALRM	SmaRTClock Alarm Event Flag and Auto Reset Enable. Reads return the state of the alarm event flag. Writes enable/disable the Auto Reset function.	Read: 0: SmaRTClock alarm event flag is de-asserted. 1: SmaRTClock alarm event flag is asserted.	Write: 0: Disable Auto Reset. 1: Enable Auto Reset.
1	RTC0SET	SmaRTClock Timer Set. Writing 1 initiates a SmaRTClock timer set operation. This bit is cleared to 0 by hardware to indicate that the timer set operation is complete.		
0	RTC0CAP	SmaRTClock Timer Capture. Writing 1 initiates a SmaRTClock timer capture operation. This bit is cleared to 0 by hardware to indicate that the timer capture operation is complete.		
Note: The ALRM flag will remain asserted for a maximum of one SmaRTClock cycle. See Section “Power Management” on page 162 for information on how to capture a SmaRTClock Alarm event using a flag which is not automatically cleared by hardware.				

21. Port Input/Output

Digital and analog resources are available through 16 or 17 I/O pins. Port pins are organized as three byte-wide ports. Port pins P0.0–P1.7 can be defined as digital or analog I/O. Digital I/O pins can be assigned to one of the internal digital resources or used as general purpose I/O (GPIO). Analog I/O pins are used by the internal analog resources. P2.7 can be used as GPIO and is shared with the C2 Interface Data signal (C2D). See Section “27. C2 Interface” on page 319 for more details.

The designer has complete control over which digital and analog functions are assigned to individual Port pins, limited only by the number of physical I/O pins. This resource assignment flexibility is achieved through the use of a Priority Crossbar Decoder. See Section 21.3 for more information on the Crossbar.

All Port I/Os can tolerate voltages up to the supply rail when used as digital inputs or open-drain outputs. For Port I/Os configured as push-pull outputs, current is sourced from the V_{DD} supply. Port I/Os used for analog functions can operate up to the V_{DD} supply voltage. See Section 21.1 for more information on Port I/O operating modes and the electrical specifications chapter for detailed electrical specifications.

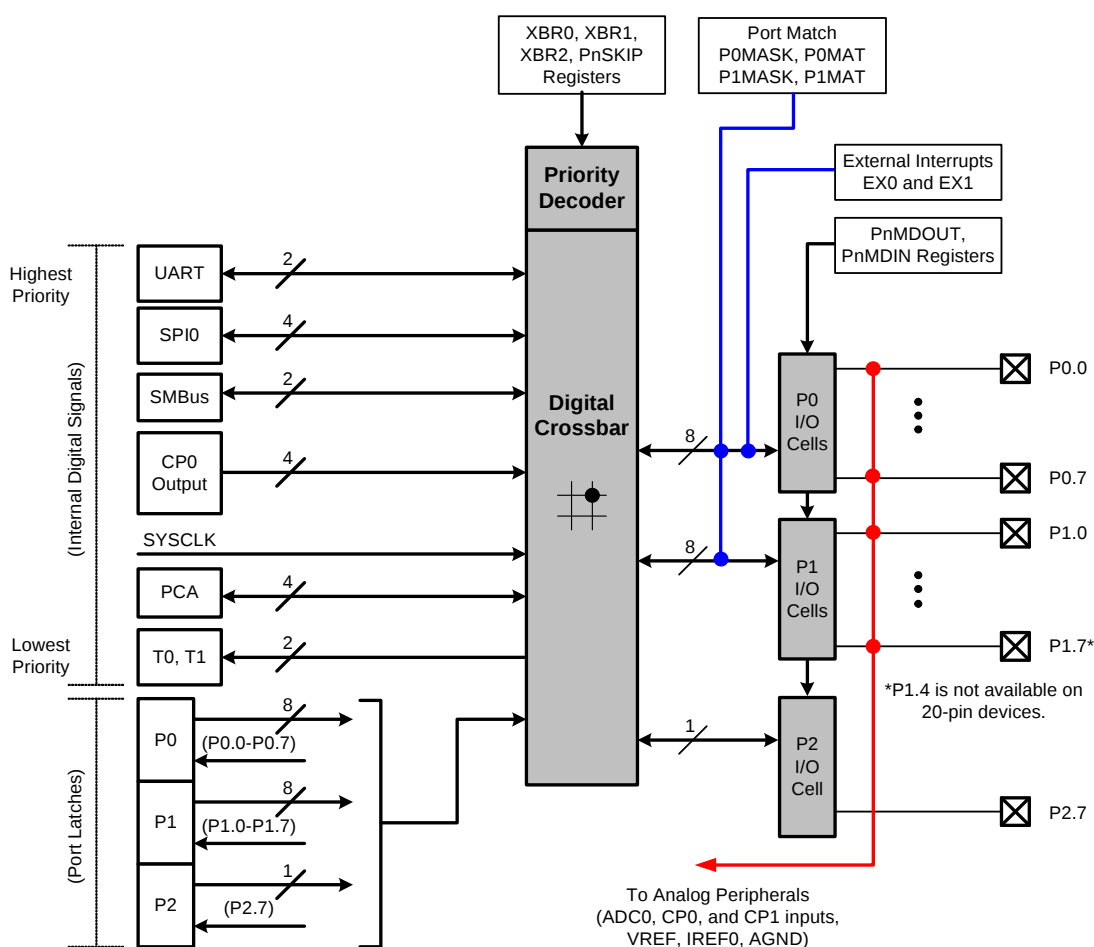


Figure 21.1. Port I/O Functional Block Diagram

SFR Definition 21.8. P0: Port0

Bit	7	6	5	4	3	2	1	0
Name	P0[7:0]							
Type	R/W							
Reset	1	1	1	1	1	1	1	1

SFR Page = All; SFR Address = 0x80; Bit-Addressable

Bit	Name	Description	Write	Read
7:0	P0[7:0]	Port 0 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: P0.n Port pin is logic LOW. 1: P0.n Port pin is logic HIGH.

SFR Definition 21.9. P0SKIP: Port0 Skip

Bit	7	6	5	4	3	2	1	0
Name	P0SKIP[7:0]							
Type	R/W							
Reset	0	0	0	0	0	0	0	0

SFR Page= 0x0; SFR Address = 0xD4

Bit	Name	Function
7:0	P0SKIP[7:0]	Port 0 Crossbar Skip Enable Bits. These bits select Port 0 pins to be skipped by the Crossbar Decoder. Port pins used for analog, special functions or GPIO should be skipped by the Crossbar. 0: Corresponding P0.n pin is not skipped by the Crossbar. 1: Corresponding P0.n pin is skipped by the Crossbar.

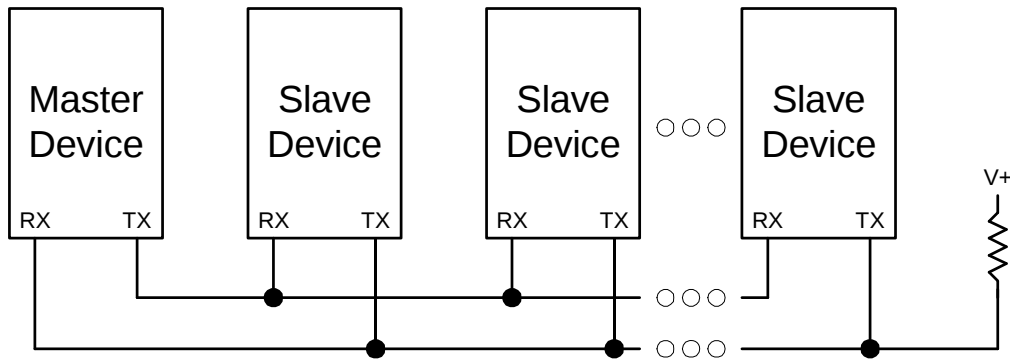


Figure 23.6. UART Multi-Processor Mode Interconnect Diagram

26.3.1. Edge-triggered Capture Mode

In this mode, a valid transition on the CEX_n pin causes the PCA to capture the value of the PCA counter/timer and load it into the corresponding module's 16-bit capture/compare register (PCA0CPL_n and PCA0CPH_n). The CAPP_n and CAPN_n bits in the PCA0CPM_n register are used to select the type of transition that triggers the capture: low-to-high transition (positive edge), high-to-low transition (negative edge), or either transition (positive or negative edge). When a capture occurs, the Capture/Compare Flag (CCF_n) in PCA0CN is set to logic 1. An interrupt request is generated if the CCF_n interrupt for that module is enabled. The CCF_n bit is not automatically cleared by hardware when the CPU vectors to the interrupt service routine, and must be cleared by software. If both CAPP_n and CAPN_n bits are set to logic 1, then the state of the Port pin associated with CEX_n can be read directly to determine whether a rising-edge or falling-edge caused the capture.

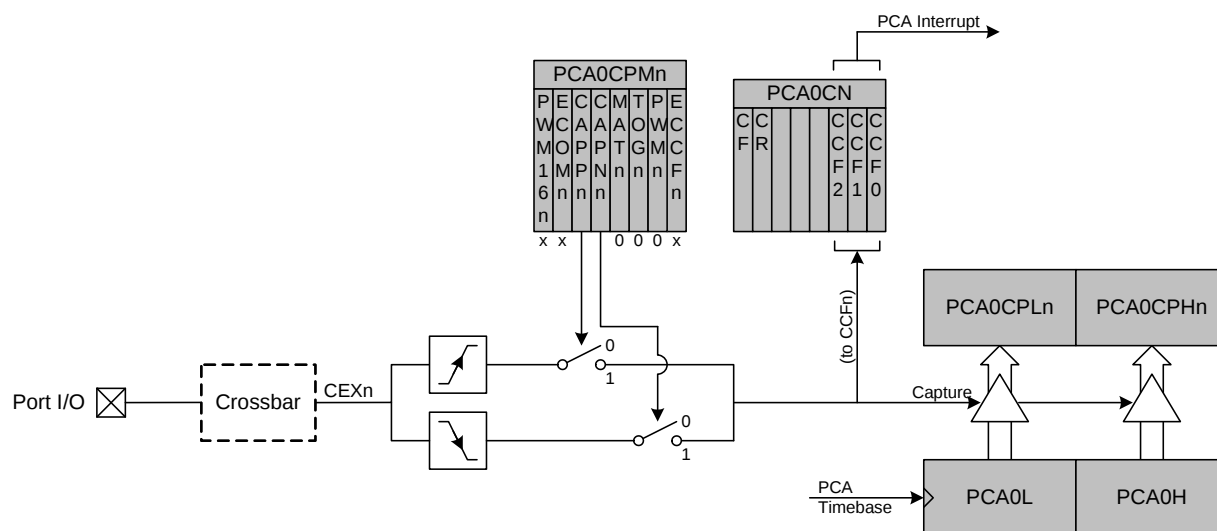


Figure 26.4. PCA Capture Mode Diagram

Note: The CEX_n input signal must remain high or low for at least 2 system clock cycles to be recognized by the hardware.