EE309(S2): Microprocessors

Spring 2025

[Week#6 Slides]

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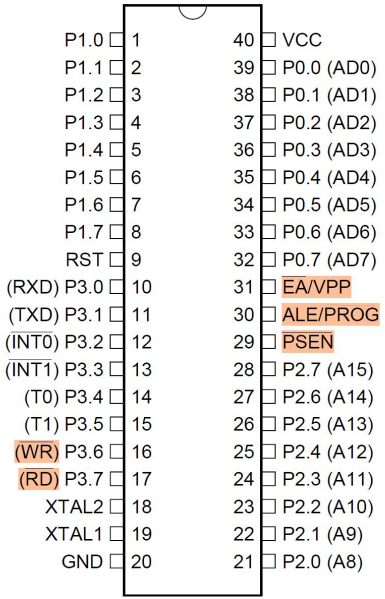
Serial Port Modes



The serial port can operate in 4 modes:

Mode 0: Serial data enters and exits through RXD. TXD outputs the shift clock. 8 bits are transmitted/received: 8 data bits (LSB first). The baud rate is fixed at 1/12 the oscillator frequency.

Mode 1: 10 bits are transmitted (through TXD) or received (through RXD): a start bit (0), 8 data bits (LSB first), and a stop bit (1). On receive, the stop bit goes into RB8 in Special Function Register SCON. The baud rate is variable.

Mode 2: 11 bits are transmitted (through TXD) or received (through RXD): a start bit (0), 8 data bits (LSB first), a programmable 9th data bit, and a stop bit (1). On transmit, the 9th data bit (TB8 in SCON) can be assigned the value of 0 or 1. Or, for example, the parity bit (P, in the PSW) could be moved into TB8. On receive, the 9th data bit goes into RB8 in Special Function register SCON, while the stop bit is ignored. The baud rate is programmable to either 1/32 or 1/64 the oscillator frequency.

Mode 3: 11 bits are transmitted (through TXD) or received (through RXD): a start bit (0), 8 data bits (LSB first), a programmable 9th data bit and a stop bit (1). In fact, Mode 3 is the same as Mode 2 in all respects except the baud rate. The baud rate in Mode 3 is variable.

Courtesy: 8051 Manual

Serial Port Modes

Mode	Functionality	Baud Rate	Description
0	8-bit shift register	Fixed (1/12 of oscillator)	Synchronous serial communication
1	8-bit UART	Variable (Timer 1 overflow)	Standard asynchronous UART communication
2	9-bit UART (fixed baud rate)	Fixed (1/32 or 1/64 of oscillator)	Multiprocessor communication with fixed baud rate
3	9-bit UART (variable baud rate)	Variable (Timer 1 overflow)	Multiprocessor communication with variable baud rate

Courtesy: 8051 Manual

SFRs Related to Serial Port in 8051

	Bit Addressable	8 Bytes Non-bit Addressable							
F8h									FFh
F0h	B								F7h
E8h									EFh
E0h	ACC								E7h
D8h									DFh
D0h	PSW								D7h
C8h	(T2CON)		(RCAP2L)	(RCAP2H)	(TL2)	(TH2)			CFh
C0h									C7h
B8h	IP								BFh
B0h	P3								B7h
A8h	IE								AFh
A0h	P2								A7h
98h	SCON	SBUF							9Fh
90h	P1								97h
88h	TCON	TMOD	TL0	TL1	TH0	TH1	AUXR	CKCON	8Fh
80h	P0	SP	DPL	DPH				PCON	87h
	0/8	**1/9**	**2/A**	**3/B**	**4/C**	**5/D**	**6/E**	**7/F**	

Note: Reserved

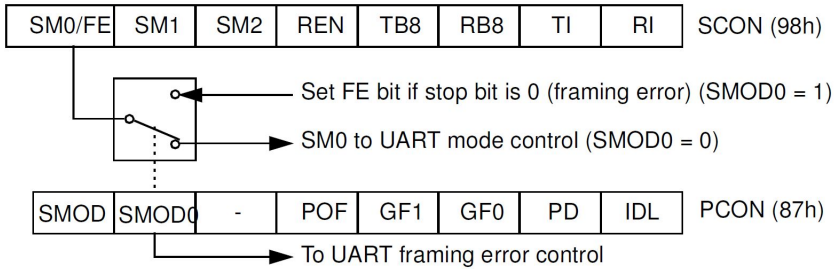
PCON Register

Table 2-25. PCON Register
PCON - Power Control Register (87h)

7	6	5	4	3	2	1	0
SMOD1	SMOD0	-	POF	GF1	GF0	PD	IDL

Bit Number	Bit Mnemonic	Description
7	SMOD1	**Serial port Mode bit 1 for UART** Set to select double baud rate in mode 1, 2 or 3.
6	SMOD0	Serial port Mode bit 0 for UART Cleared to select SM0 bit in SCON register. Set to select FE bit in SCON register.
5	-	**Reserved** The value read from this bit is indeterminate. Do not set this bit.
4	POF	**Power-Off Flag** Cleared to recognize next reset type. Set by hardware when VCC rises from 0 to its nominal voltage. Can also be set by software.
3	GF1	**General purpose Flag** Cleared by user for general purpose usage. Set by user for general purpose usage.
2	GF0	**General purpose Flag** Cleared by user for general purpose usage. Set by user for general purpose usage.
1	PD	**Power-Down mode bit** Cleared by hardware when reset occurs. Set to enter power-down mode.
0	IDL	**Idle mode bit** Cleared by hardware when interrupt or reset occurs. Set to enter idle mode.

Figure 2-25. Framing Error Block Diagram



SCON Register

Table 2-19. SCON Register
SCON - Serial Control Register (98h)

7	6	5	4	3	2	1	0
FE/SM0	SM1	SM2	REN	TB8	RB8	TI	RI

Bit Number	Bit Mnemonic	Description
7	FE	**Framing Error bit (SMOD0=1)** Clear to reset the error state, not cleared by a valid stop bit. Set by hardware when an invalid stop bit is detected. SMOD0 must be set to enable access to the FE bit
	SM0	**Serial port Mode bit 0** Refer to SM1 for serial port mode selection. SMOD0 must be cleared to enable access to the SM0 bit
6	SM1	Serial port Mode bit 1 SM0 SM1 Mode Description Baud Rate 0 0 0 Shift Register $F_{CPU\ PERIPH}/6$ 0 1 1 8-bit UART Variable 1 0 2 9-bit UART $F_{CPU\ PERIPH}/32$ or /16 1 1 3 9-bit UART Variable
5	SM2	Serial port Mode 2 bit / Multiprocessor Communication Enable bit Clear to disable multiprocessor communication feature. Set to enable multiprocessor communication feature in mode 2 and 3, and eventually mode 1. This bit should be cleared in mode 0.
4	REN	**Reception Enable bit** Clear to disable serial reception. Set to enable serial reception.
3	TB8	Transmitter Bit 8 / Ninth bit to transmit in modes 2 and 3. o transmit a logic 0 in the 9th bit. Set to transmit a logic 1 in the 9th bit.
2	RB8	**Receiver Bit 8 / Ninth bit received in modes 2 and 3** Cleared by hardware if 9th bit received is a logic 0. Set by hardware if 9th bit received is a logic 1. In mode 1, if SM2 = 0, RB8 is the received stop bit. In mode 0 RB8 is not used.
1	TI	**Transmit Interrupt flag** Clear to acknowledge interrupt. Set by hardware at the end of the 8th bit time in mode 0 or at the beginning of the stop bit in the other modes.
0	RI	**Receive Interrupt flag** Clear to acknowledge interrupt. Set by hardware at the end of the 8th bit time in mode 0, see Figure 2-26. and Figure 2-27. in the other modes.

Reset Value = 0000 0000b
Bit addressable

Transmitting from Serial Port in 8051

Configure Timer 1 for Baud Rate Generation:

- Use Timer 1 in Mode 2 (8-bit auto-reload mode) to generate the baud rate for serial communication.
- Load the appropriate value into the TH1 register to set the desired baud rate.

Configure the Serial Port:

- Set up the SCON (Serial Control) register to select the desired serial communication mode (typically Mode 1 for 8-bit UART).

Enable Timer 1:

- Start Timer 1 by setting the TR1 (Timer 1 Run) bit in the TCON (Timer Control) register.

Enable Serial Interrupt (Optional):

- If you want to use serial interrupts, enable the serial interrupt by setting the ES (Enable Serial) bit in the IE (Interrupt Enable) register and enable global interrupts by setting the EA (Enable All) bit.

Write Data Transmission Routine:

- Write a routine to load data into the SBUF (Serial Buffer) register for transmission.
- Wait for the TI (Transmit Interrupt) flag to be set, indicating that transmission is complete, then clear the TI flag.

Receiving from Serial Port in 8051

Configure Timer 1 for Baud Rate Generation:

- Use Timer 1 in Mode 2 (8-bit auto-reload mode) to generate the baud rate for serial communication.
- Load the appropriate value into the TH1 register to set the desired baud rate.

Configure the Serial Port:

- Set up the SCON (Serial Control) register to select the desired serial communication mode (typically Mode 1 for 8-bit UART).
- Enable serial reception by setting the REN (Receive Enable) bit.

Enable Timer 1:

- Start Timer 1 by setting the TR1 (Timer 1 Run) bit in the TCON (Timer Control) register.

Enable Serial Interrupt (Optional):

- If you want to use serial interrupts, enable the serial interrupt by setting the ES (Enable Serial) bit in the IE (Interrupt Enable) register and enable global interrupts by setting the EA (Enable All) bit.

Write Data Reception Routine:

- Write a routine to read data from the SBUF (Serial Buffer) register upon receiving.
- Clear the RI (Receive Interrupt) flag after reading the data.

Serial Port Baud Rate in 8051

Baud Rate Calculation:

$$\text{Baud Rate} = \frac{2^{SMOD} \times f_{oscillator}}{12 \times 32 \times (256 - TH1)}$$

where:

- SMOD is a bit in the PCON (Power Control) register that doubles the baud rate when set.
- f_oscillator is the crystal oscillator frequency (in Hz) commonly used in the 8051.
- 12 is the division factor (12 clock cycles per machine cycle).
- TH1 is the value loaded into the Timer1 high byte register.

Example: To configure the baud rate of 9600 bps using a 11.0592 MHz crystal oscillator:

- SMOD = 0 (not doubling the baud rate)
- Crystal oscillator frequency = 12,000,000 Hz
- Timer1 in Mode 2 with TH1 (auto-reload) value = 0FDH