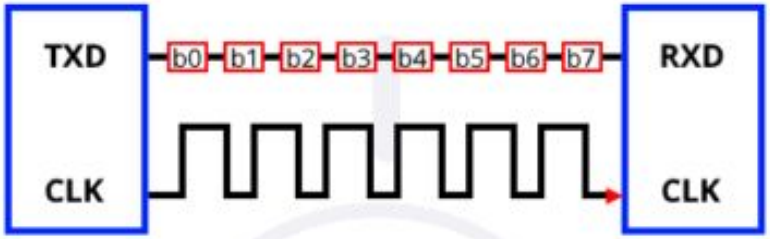
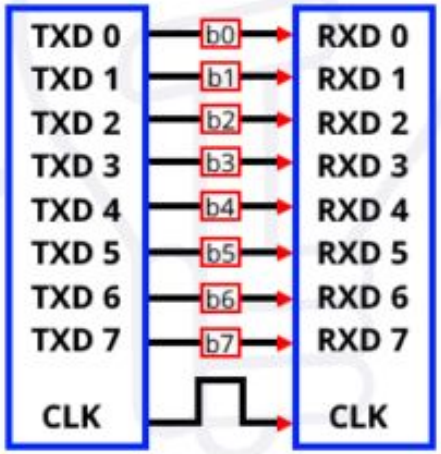
UART
(Universal Asynchronous Receiver Transmitter)

SERIAL PORT

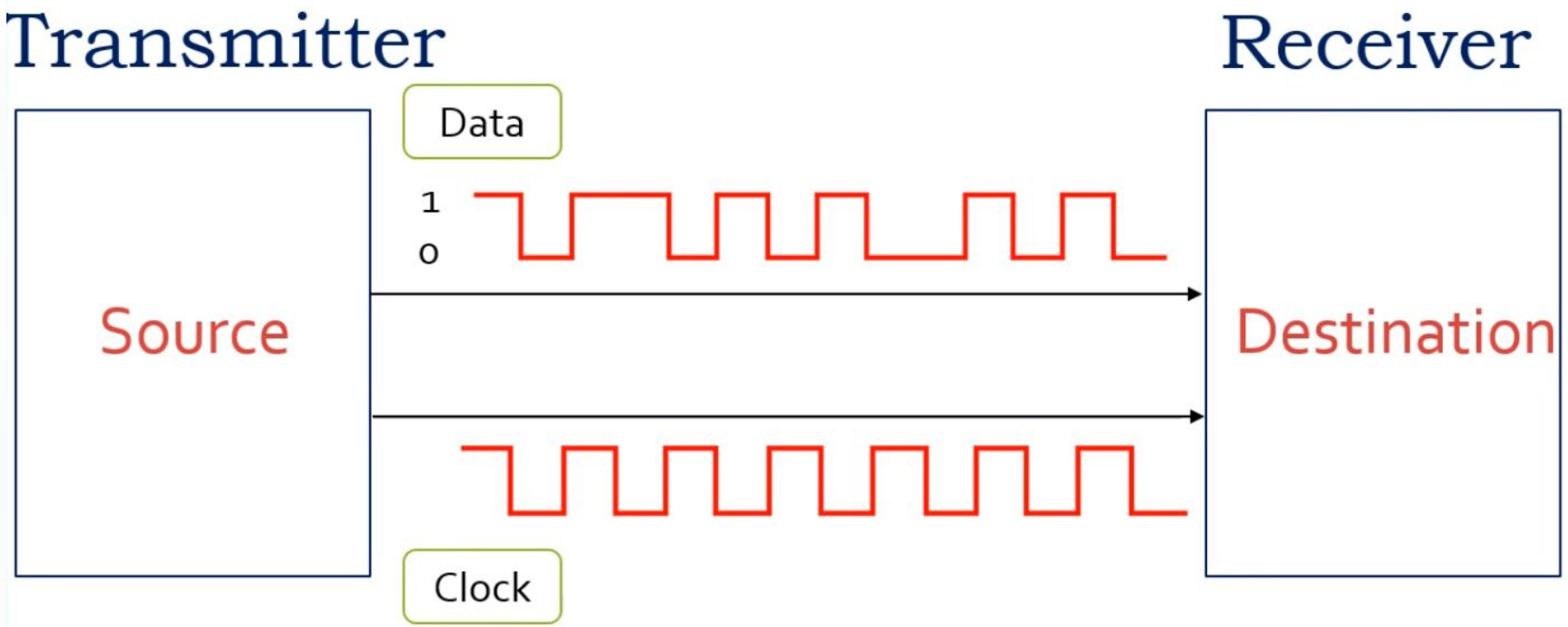


Serial Communication

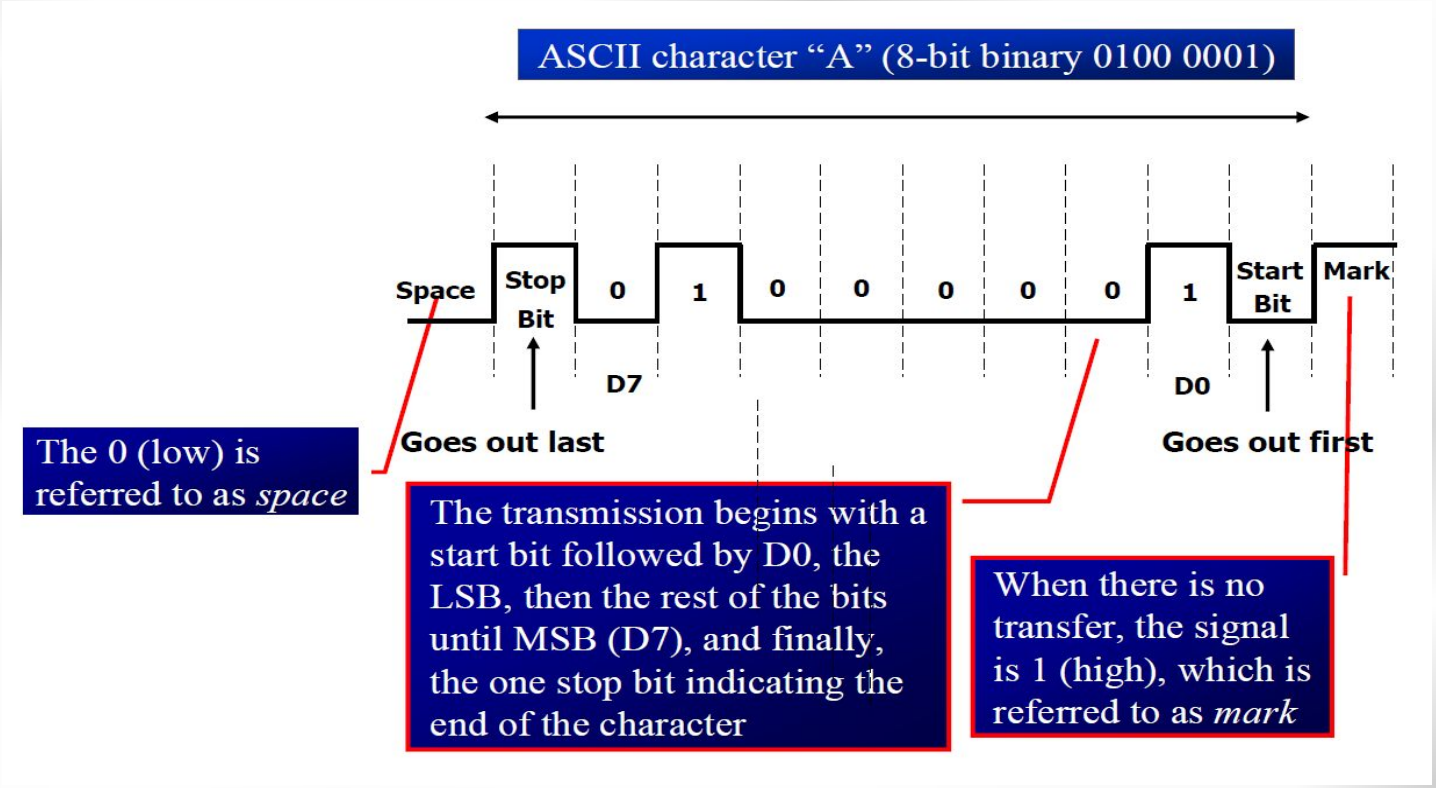


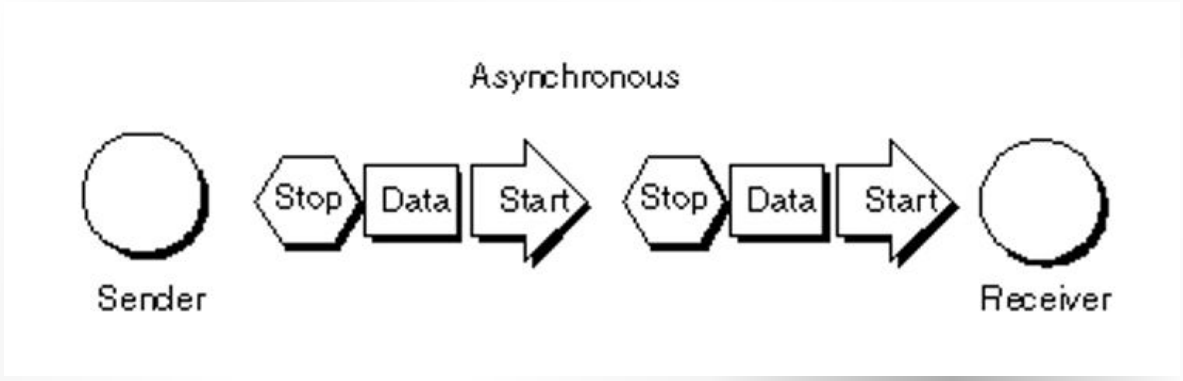
Parallel Communication

Synchronous :



Asynchronous – Start & Stop Bit

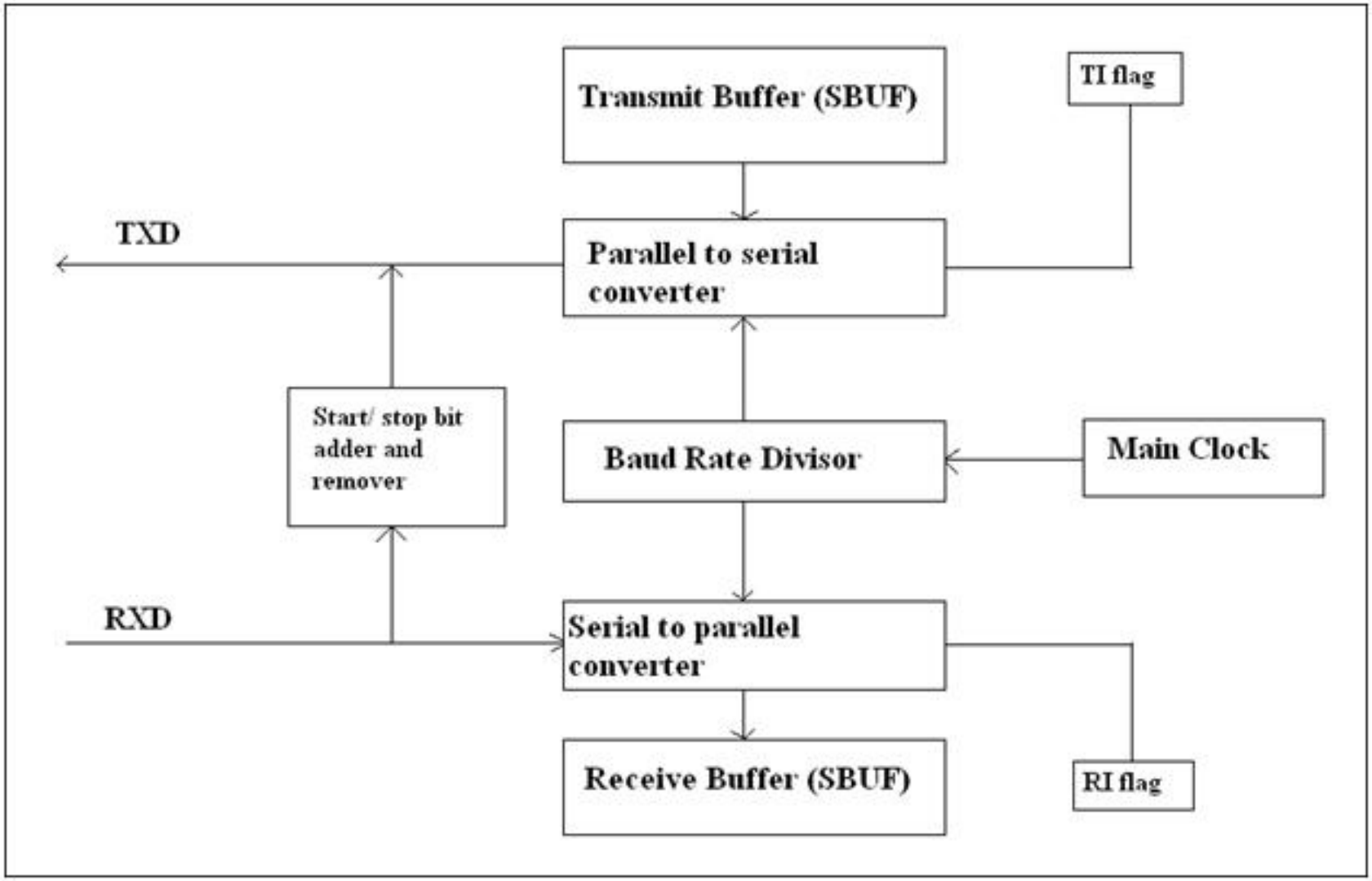




Asynchronous – Start & Stop Bit

- Asynchronous serial communication is widely used for character-oriented transmissions
  - Each character is placed in between start and stop bits, this is called framing.
  - **The start bit is always one bit, but the stop bit can be one or two bits**
  - **The start bit is always a 0 (low) and the stop bit(s) is 1 (high)**
- Synchronous serial communication is widely used for block-oriented transmissions

UART - Serial port block diagram

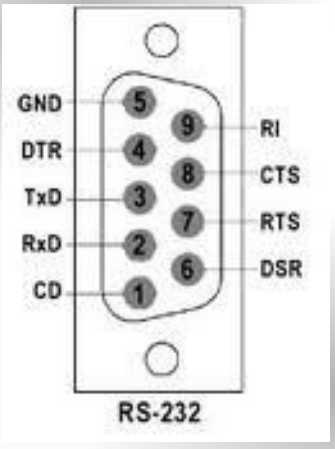


- During Transmission, the character(A) is placed in the SBUF(transmit), then parallel data is converted to serial, start bit/stop bit added and then sent through TxD pin assigned with a baud rate.

- During Receiving, the character is received via RxD pin, start/stop bit is removed, the serial data is converted to parallel and placed in receive buffer(SBUF) assigned with a baud rate.

- Three Special function registers (SFRs) are used for serial communication.

- SBUF :
  - ✔ Two dedicated, 8 – bit registers to hold the data
  - ✔ Transmit (writing the data into SBUF)
  - ✔ Receive (reading the data)



SCON :

Controls the data communication

PCON :

Controls the data transfer rates(bps)

Pin RxD (P3.0) & Pin TxD (P3.1) are used for data transfer

Registers related to Serial Communication

1. SBUF Register
2. SCON register
3. PCON Register

SBUF Register

- SBUF is an 8-bit register used solely for serial communication.
- For a byte data to be transferred via the TxD line, it must be placed in the SBUF register.
- The moment a byte is written into SBUF, it is framed with the start and stop bits and transferred serially via the TxD line.
- SBUF holds the byte of data when it is received by 8051 RxD line.
- When the bits are received serially via RxD, the 8051 deframes it by eliminating the stop and start bits, making a byte out of the data received, and then placing it in SBUF.

SCON (Serial control) register

SM0 (SCON.7) : Mode specifier

SM1 (SCON.6) : Mode specifier

SM2 (SCON.5) : Multi-processor communication enable

REN (SCON.4) : Receive enable (This bit must be set to receive characters)

TB8 (SCON.3) : Programmable error check bit during Transmit (optional)

RB8 (SCON.2) : Programmable error check bit during receive (optional)

TI (SCON.1) : Transmit flag (Set when a byte has been transmitted)

RI (SCON.0) : Receive flag (Set when a byte has been received)

Modes of operation

SM0	SM1	MODE	Operation	Baud rate
0	0	**0**	shift register	Fixed (xtal/12) (Synchronous)
0	1	**1**	***8 bit UART***	Variable (timer1)
1	0	**2**	***9 bit UART***	Fixed (xtal/32 or xtal/64)
1	1	**3**	***9 bit UART***	Variable (timer1)

SERIAL COMMUNICA-TION PROGRAMMING (cont')

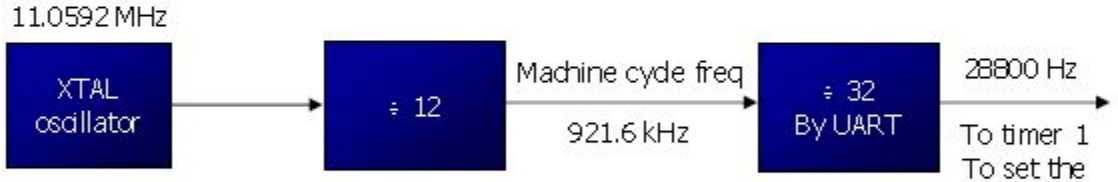
With XTAL = 11.0592 MHz, find the TH1 value needed to have the following baud rates. (a) 9600 (b) 2400 (c) 1200

Solution:

The machine cycle frequency of 8051 = 11.0592 / 12 = 921.6 kHz, and 921.6 kHz / 32 = 28,800 Hz is frequency by UART to timer 1 to set baud rate.

(a) 28,800 / 3 = 9600 where -3 = FD (hex) is loaded into TH1
(b) 28,800 / 12 = 2400 where -12 = F4 (hex) is loaded into TH1
(c) 28,800 / 24 = 1200 where -24 = E8 (hex) is loaded into TH1

Notice that dividing 1/12 of the crystal frequency by 32 is the default value upon activation of the 8051 RESET pin.



Baud Rate	TH1 (Decimal)	TH1 (Hex)
9600	-3	FD
4800	-6	FA
2400	-12	F4
1200	-24	E8

TF is set to 1 every 12 ticks, so it functions as a frequency divider

Doubling Baud Rate

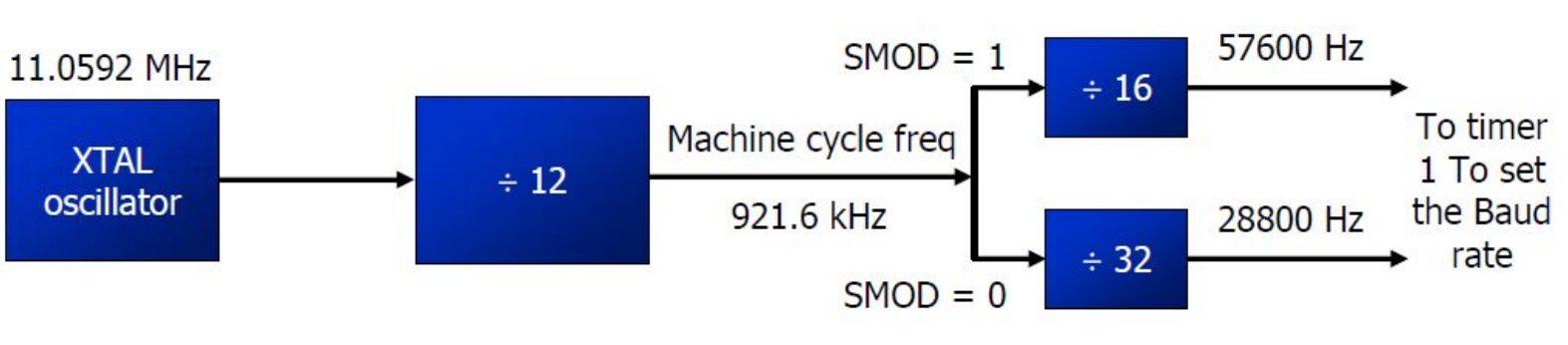
- There are two ways to increase the baud rate of data transfer
  1. **By using a higher frequency crystal**
  2. **By changing a bit in the PCON register**

- **PCON register** is an 8-bit register.

SMOD	--	--	--	GF1	GF0	PD	IDL

  - When 8051 is powered up, **SMOD** is zero.
  - **We can set it to high** by software and thereby **double** the baud rate.

Doubling Baud Rate (cont…)



Baud Rate comparison for SMOD=0 and SMOD=1

TH1	(Decimal)	(Hex)	SMOD=0	SMOD=1
	-3	FD	9600	19200
	-6	FA	4800	9600
	-12	F4	2400	4800
	-24	E8	1200	2400