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UNIT - 2

EMBEDDED HARDWARE DESIGN:

Review of Analog and digital electronic components, I/O types and examples, Serial communication devices, Parallel device ports, Wireless devices, Timer and counting devices, Watchdog timer, Real time clock.

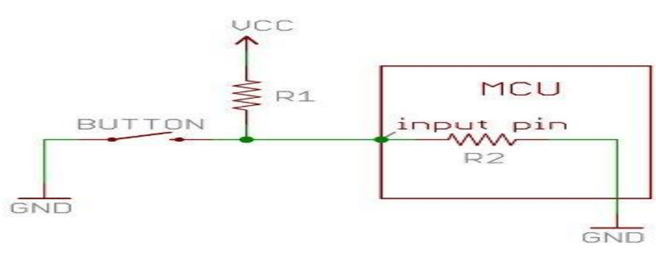
Analog Electronic Components

Resistors, Capacitors, Diodes, Transistors are the commonly used analog electronic components in embedded hardware design.

Resistor:

- The Resistor is a most commonly used component in many electronic circuits and electronic devices.
- The main function of the resistor is, it restricts the flow of current to other components.
- Interfacing of LEDs, Buzzer etc, with the port pins of Microcontroller through current limiting resistors is a typical example for the usage of resistors.
- Pull-up and pull-down resistors are frequently used in interfacing devices like interfacing a switch to microcontroller.
- Most of the microcontrollers have inbuilt programmable pull up/pull down resistors.

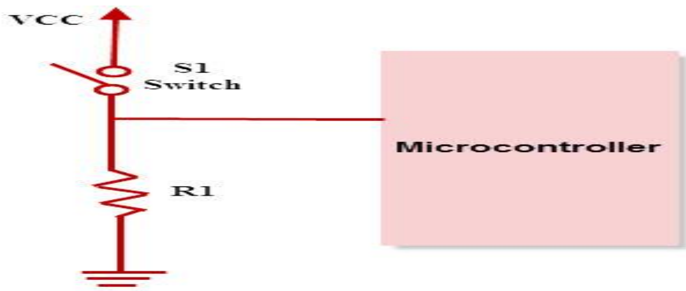
Pull-up Resistor: With a pull up resistor, the input pin will read a high state when the button is not pressed, thus the input pin reads close to VCC. When the button is pressed, it connects the input pin directly to ground. The current flows through the resistor to ground, thus the input pin reads the low state



Pull down resistor:

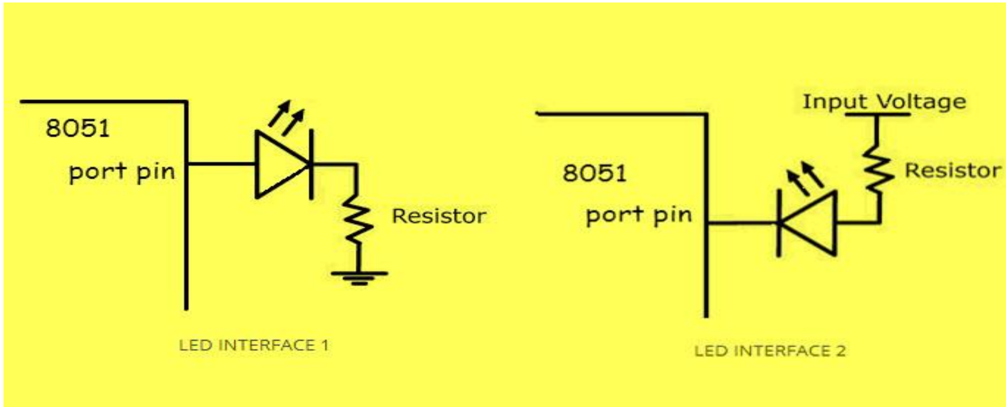
- Pull down resistors pull the pin to a low value. Pull-down resistors are connected between a particular pin on a microcontroller and the ground terminal.

- An example of a pull down resistor is a digital circuit shown in the figure below. A switch is connected between the VCC and the microcontroller pin.
- When the switch is closed in the circuit, the input of the microcontroller is logic 1,but when the switch is open in a circuit, the pull down resistor pulls down the input voltage to the ground (logic 0 or logic low value).



Example: Light Emitting Diode(LED)

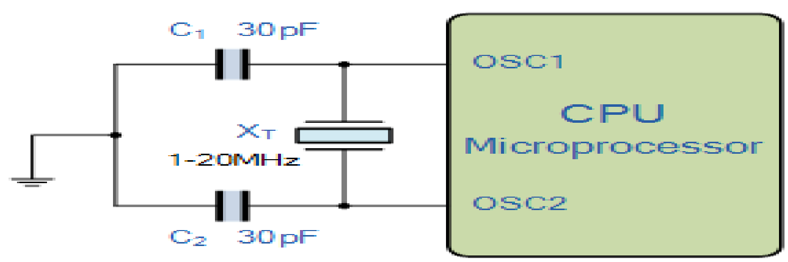
- The light emitting diode is an important output device for visual indication in any embedded system.LED can be used as an indicator for the status of various signals or situations.
- Typical examples of LEDs are indicating the presence of power conditions like Device On, Battery low or charging of battery for a battery operated handheld embedded devices. For proper functioning of LED, the anode of it should be connected to Positive terminal of the supply and cathode to the negative terminal of the supply voltage.
- The current flowing through the LED should be limited to a value below the maximum current that it can conduct. LEDs can be interfaced to the port pin of the processor/ controller in two ways. In the first method the anode is directly connected to the port pin and the port pin drives the LED. In this approach the port pin drives current to the LED when the port pin is at logic High(Logic '1').
- In the second method, the cathode of the LED is connected to the port pin of the processor/ controller and the anode to the supply voltage through a current limiting resistor. The LED is turned on when the port pin is at logic low.



Capacitor:

A capacitor is a device that stores electric charge in electric field. The electric energy stored in such capacitors maintains the information during the temporary loss of power.(capacitors store charge and act like a battery).

- Capacitors have many important applications. They are used, for example, in digital circuits so that information stored in large computer memories is not lost during a momentary electric power failure.
- Capacitors play an even more important role as filters to divert spurious electric signals and thereby prevent damage to sensitive components and circuits caused by electric surges.



- To obtain a very high stability quartz crystal is generally used as frequency determining device.
- Capacitors are used to damp out the oscillations in the output.
- Inductors store the energy for the limited time. As the inductors store the energy in the form of magnetic field, it will collapse when we remove the power supply.
- The most common application of tank circuits is **tuning** radio transmitters and receivers. For example, when tuning a radio to a particular station, the LC circuits are set at resonance for that particular carrier frequency.

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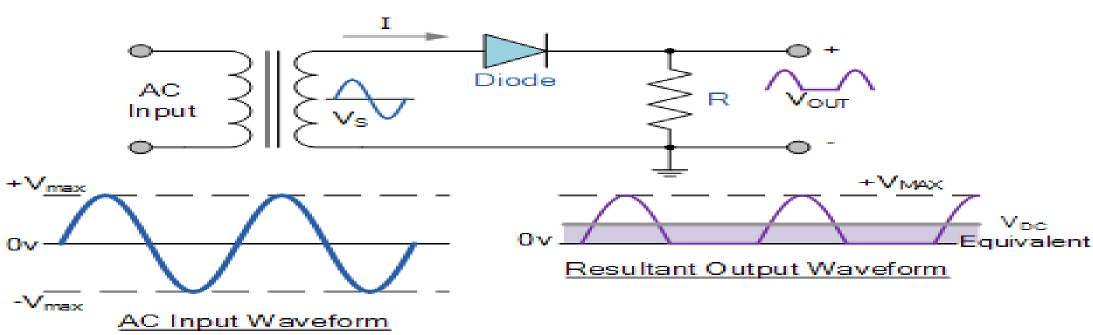
Diode:

Semiconductor device with two terminals, typically allowing the flow of current in one direction only.

- Examples: PN junction diode, schottky diode, Zener diode are the more commonly used diodes in embedded hardware circuits.
- It is normally used for voltage clamping applications, voltage rectification, Brown out protection circuit.
- The main application of p-n junction **diode** is in rectification circuits. These circuits are **used** to describe the conversion of a.c signals to d.c in power supplies.
- During each "positive" half cycle of the AC sine wave, the diode is *forward biased* as the anode is positive with respect to the cathode resulting in current flowing through the diode.
- During each "negative" half cycle of the AC sinusoidal input waveform, the diode is *reverse biased* as the anode is negative with respect to the cathode. Therefore, NO current flows through the diode or circuit. Then in the negative half cycle of the supply, no current flows in the load resistor as no voltage appears across it so therefore, Vout = 0.



Brown out protection circuit:

- Many microcontrollers have a protection circuit which detects when the supply voltage goes below the level required for reliable operation, and puts the device into a reset state to ensure proper startup when power returns. This action is called a "Brown Out Reset".
- It is essential for battery powered devices since there are greater chances for the battery voltage to drop below the required threshold.
- If the processor does not have a built in Brown out detection circuit, the same can be implemented externally.

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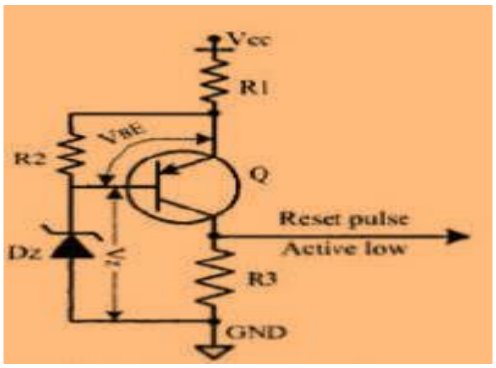
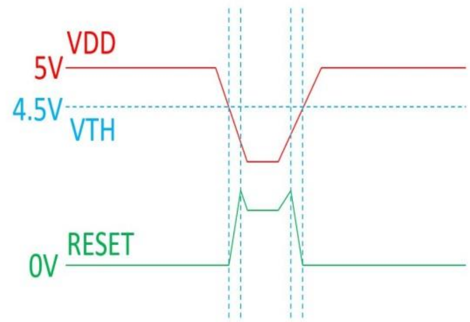
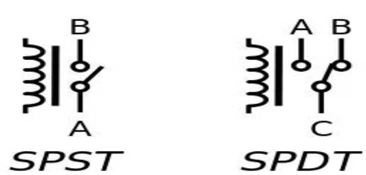
- Microprocessor supervisor IC s like DS1232 from Dallas Semiconductor also provides the Brown out protection circuit. The Zener diode and the transistor forms the heart of the circuit. The transistor conducts always when the supply voltage Vcc is greater than the sum of Vbe and Vz(zener voltage).The transistor stops conducting when the supply voltage falls below the sum of Vbe and Vz.



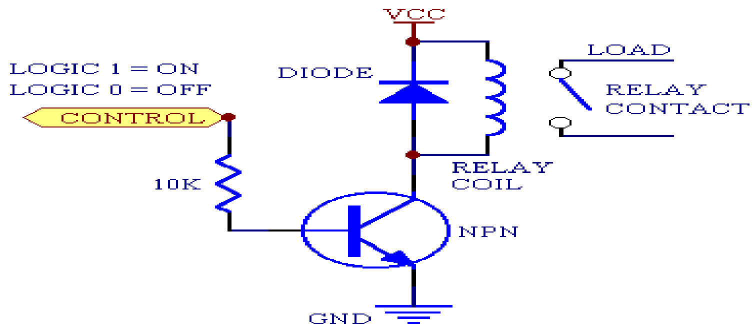


<u>Transistor:</u> Transistors in embedded applications are used for switching or amplification purposes. In switching applications the transistor is either in On or OFF state.

- Ex: Relay is an electro mechanical device. In embedded application, the Relay unit acts as dynamic path selectors for signals and power. The Relay unit contains a relay coil made up of insulated wire on a metal core with one or more contacts.
- Relay works on Electromagnetic principle. When voltage is applied to the relay coil, current flows through the coil, which in turn generates the magnetic field. The magnetic field attracts the armature and moves the contact point. The relays are available in different configurations such as
- Single Pole Single Throw normally open
- Single Pole Double Throw



- The Relay is normally controlled using a Relay driver circuit connected to the port pin of the processor/controller. A transistor is used for building the relay driver circuit. The diode is used for protecting the relay and the transistor.



DIGITAL ELECTRONIC COMPONENTS

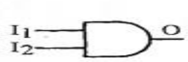
- Digital electronics deal with digital or discrete signals.
- Microprocessors, microcontrollers and system on chips (SoCs) work on digital principles.
- Embedded systems employ various digital electronic circuits for 'Glue logic' implementation.
- 'Glue logic' is the custom digital electronic circuitry required to achieve compatible interface between two different integrated circuit chips.
- Address decoders, latches, encoders/decoders, etc. are examples for glue logic circuits.
- Transistor Transistor Logic (TTL), Complementary Metal Oxide Semiconductor (CMOS) logic etc. are some of the standards describing the electrical characteristics of digital signals in a digital system.

Logic Gates:

Logic gates are the building blocks of digital circuits. Logic gates control the flow of digital information by performing a logical operation of the input signals. Depending on the logical operation, the logic gates used in digital design are classified into-AND, OR, XOR, NOT, NAND, NOR and XNOR. The logical relationship between the output signal and the input signals for a logic gate is represented using a truth table.

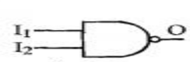
AND Gate –Truth Table

I_1	I_2	O
0	0	0
0	1	0
1	0	0
1	1	1



NAND Gate –Truth Table

I_1	I_2	O
0	0	1
0	1	1
1	0	1
1	1	0

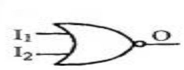


OR Gate –Truth Table

I_1	I_2	O
0	0	0
0	1	1
1	0	1
1	1	1

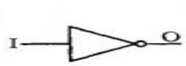
NOR Gate –Truth Table

I_1	I_2	O
0	0	1
0	1	0
1	0	0
1	1	0



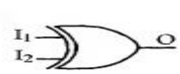
NOT Gate –Truth Table

I	O
0	1
1	0



XOR Gate –Truth Table

I_1	I_2	O
0	0	0
0	1	1
1	0	1
1	1	0



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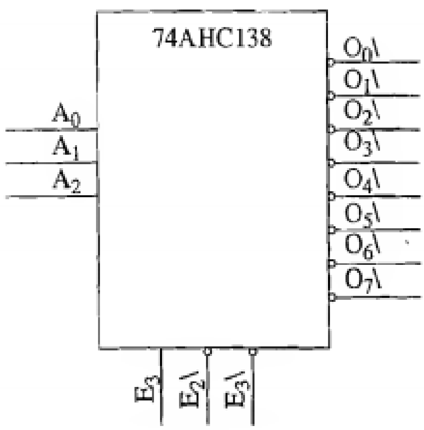
Decoder:

A decoder is a logic circuit which generates all the possible combinations of the input signals. Decoders are named with their input line numbers and the possible combinations of the input as output. Examples are 2 to 4 decoder, 3 to 8 decoder and 4 to 16 decoder. The 3 to 8 decoder contains 3 input signal lines and it is possible to have 8 different configurations with the 3 lines (000 to 111 in the input line cor¬ responds to 0 to 7 in the output line). Depending on the input signal, the corresponding output line is asserted. For example, for the input state 001, the output line 2 is asserted. Decoders are mainly used for address decoding and chip select signal generation in electronic circuits and are available as integrated circuits. 74LS138/74AHC138 is an example for 3 to 8 decoder IC.

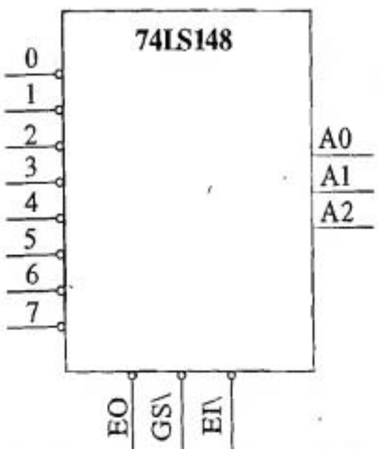


Input						Output							
A_2	A_1	A_0	$E_1\backslash$	$E_2\backslash$	$E_3\backslash$	$O_0\backslash$	$O_1\backslash$	$O_2\backslash$	$O_3\backslash$	$O_4\backslash$	$O_5\backslash$	$O_6\backslash$	$O_7\backslash$
0	0	0	0	0	1	0	1	1	1	1	1	1	1
0	0	1	0	0	1	1	0	1	1	1	1	1	1
0	1	0	0	0	1	1	1	0	1	1	1	1	1
0	1	1	0	0	1	1	1	1	0	1	1	1	1
1	0	0	0	0	1	1	1	1	1	0	1	1	1
1	0	1	0	0	1	1	1	1	1	1	0	1	1
1	1	0	0	0	1	1	1	1	1	1	1	0	1
1	1	1	0	0	1	1	1	1	1	1	1	1	0

The decoder output is enabled only when the ‘Output Enable’ signal lines El\, E2\ and E3 are at logic levels 0,0 and 1 respectively. If the output-enable signals are not at the required logic state, all the output lines are forced to the inactive (High) state. The output line corresponding to the input state is asserted ‘Low’ when the ‘Output Enable’ signal lines are at the required logic state (Here E1\=E2\=0 and E3 =1). The output line can be directly connected to the chip select pin of a device, if the chip select logic of the device is active low.

Encoder:

An encoder performs the reverse operation of decoder. The encoder encodes the corresponding input state to a particular output format. The binary encoder encodes the input to the corresponding binary format. Encoders are named with their input line numbers and the encoder output format. Examples are 4 to 2 encoder, 8 to 3 encoder and 16 to 4 encoder. The 8 to 3 encoder contains 8 input signal lines and it is possible to generate a 3 bit binary output corresponding to the input (e.g. inputs 0 to 7 are encoded to binary 111 to 000 in the output lines). The corresponding output line is asserted in accordance with the input signals. For example, if the input line 1 is asserted, the output lines AO, A1 and A2 are asserted as 0,1 and 1 respectively. Encoders are mainly used for address decoding and chip select signal generation in electronic circuits and are available as integrated circuits. 74F148/74LS148 is an example of 8 to 3 encoder IC. Figure illustrates the 74F148/74LS148 encoder and the function table .

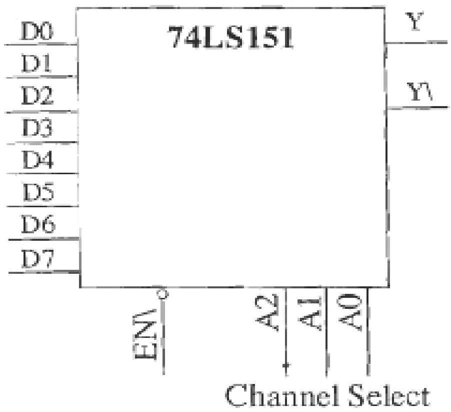


Input									Output				
7	6	5	4	3	2	1	0	E1	GS	E0	A2	A1	A0
1	1	1	1	1	1	1	0	0	0	1	1	1	1
1	1	1	1	1	1	0	1	0	0	1	1	1	0
1	1	1	1	1	0	1	1	0	0	1	1	0	1
1	1	1	1	0	1	1	1	0	0	1	1	0	0
1	1	1	0	1	1	1	1	0	0	1	0	1	1
1	1	0	1	1	1	1	1	0	0	1	0	1	0
1	0	1	1	1	1	1	1	0	0	1	0	0	1
0	1	1	1	1	1	1	1	0	0	1	0	0	0

The encoder output is enabled only when the 'Enable Input (El)' signal line is at logic 0. A 'High' on the Enable Input (El) forces all outputs to the inactive (High) state and allows new data to settle without producing erroneous information at the outputs. The group signal (GS) is active-Low when any input is Low: this indicates when any input is active. The Enable Output (EO) is active-Low when all inputs are at logic 'High'. 74LS148/74F148 is a priority encoder and it provides priority encoding of the inputs to ensure that only the highest order data line is encoded when multiple data lines are asserted

Multiplexer (MUX):

A multiplexer (MUX) can be considered as a digital switch which connects one input line from a set of input lines, to an output line at a given point of time. It contains multiple input lines and a single output line. The inputs of a MUX are said to be multiplexed. It is possible to connect one input with the output line at a time. The input line is selected through the MUX control lines. 74S151 is an example for 8 to 1 multiplexer IC. Figure illustrates the 74S151 multiplexer and the function table for it



Input				Output	
A2	A1	A0	EN\	Y	Y\
0	0	0	0	D0	D0\
0	0	1	0	D1	D1\
0	1	0	0	D2	D2\
0	1	1	0	D3	D3\
1	0	0	0	D4	D4\
1	0	1	0	D5	D5\
1	1	0	0	D6	D6\
1	1	1	0	D7	D7\
x	x	x	1	0	1

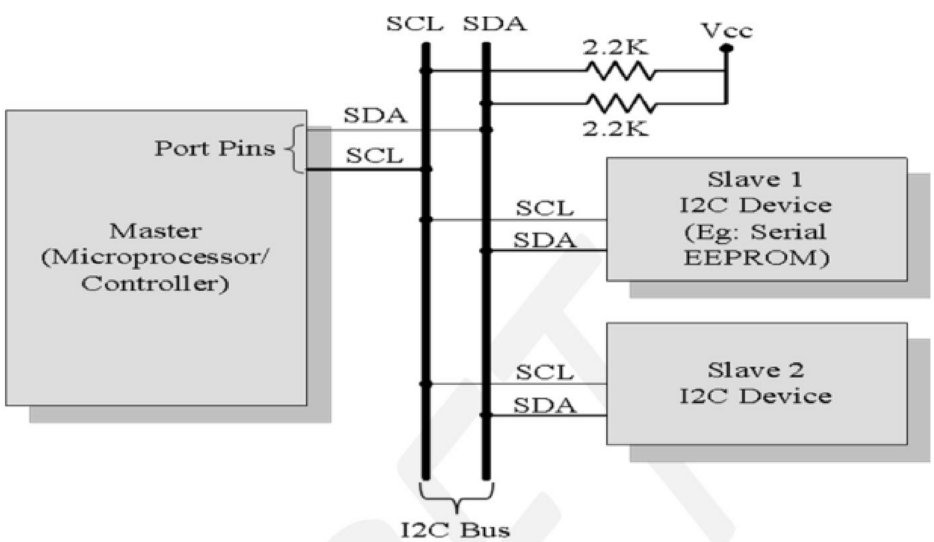
x: Don't care

The multiplexer is enabled only when the 'Enable signal (EN)' line is at logic 0. A 'High' on the EN line forces the output to the inactive (Low) state. The input signal is switched to the output line through the channel select control lines A2, A1 and AO. In order to select a particular input line, apply its binary equivalent to the channel select lines AO, A1 and A2 (e.g. set A2A1A0 as 000 for selecting Input DO, and as 001 for selecting channel Dl, etc.)

Serial communication Devices

I2C (Inter Integrated Circuit) Bus:

- Inter Integrated Circuit Bus (I2C - Pronounced „I square C‟) is a synchronous bi-directional half duplex (one-directional communication at a given point of time) two wire serial interface bus.
- The concept of I2C bus was developed by „Philips Semiconductors‟ in the early 1980‟s. The original intention of I2C was to provide an easy way of connection between a microprocessor/microcontroller system and the peripheral chips in Television sets
- The I2C bus is comprised of two bus lines, namely; Serial Clock – SCL and Serial Data – SDA.



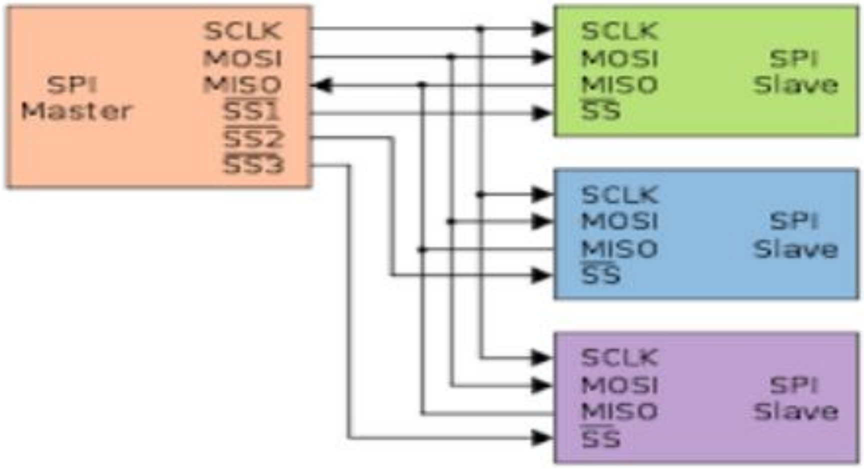
SCL line is responsible for generating synchronization clock pulses and SDA is responsible for transmitting the serial data across devices.

The sequence of operation for communicating with an I2C slave device is:

1. Master device pulls the clock line (SCL) of the bus to „HIGH‟
2. Master device pulls the data line (SDA) „LOW‟, when the SCL line is at logic „HIGH‟ (This is the Start condition for data transfer).
3. Master sends the address (7 bit or 10 bit wide) of the "Slave‟ device to which it wants to communicate, over the SDA line.
4. Clock Pulses are generated at the SCL line for synchronizing the bit reception by the slave device.
5. Slave devices connected to the bus compares the address received with the address assigned to them
6. The Slave device with the address requested by the master device responds by sending an acknowledge bit (Bit value =1) over the SDA line
7. Upon receiving the acknowledge bit, master sends the 8bit data to the slave device over SDA line, if the requested operation is "Write to device‟.
8. If the requested operation is "Read from device‟, the slave device sends data to the master over the SDA line.
9. Master waits for the acknowledgement bit from the device upon byte transfer complete for a write operation and sends an acknowledge bit to the slave device for a read operation
10. Master terminates the transfer by pulling the SDA line „HIGH‟ when the clock line SCL is at logic "HIGH‟ (Indicating the "STOP‟ condition).

Serial Peripheral Interface (SPI) Bus:

- The Serial Peripheral Interface Bus (SPI) is a synchronous bi-directional full duplex four wire serial interface bus. The concept of SPI is introduced by Motorola.
- SPI is a single master multislave system. It is possible to have a system where more than one SPI device can be master, provided the condition only one master device is active at any given point of time, is satisfied.
- SPI is used to send data between Microcontrollers and small peripherals such as shift registers, sensors, and SD cards.



SPI requires four signal lines for communication. They are:

1. Master Out Slave In (MOSI): Signal line carrying the data from master to slave device

2. Master In Slave Out (MISO): Signal line carrying the data from slave to master device.

3. Serial Clock (SCLK): Signal line carrying the clock signals

4. Slave Select (SS): Signal line for slave device select. It is an active low signal.

The master device is responsible for generating the clock signal. Master device selects the required slave device by asserting the corresponding slave devices slave select signal 'LOW‟. The data out line (MISO) of all the slave devices when not selected floats at high impedance state. The serial data transmission through SPI Bus is fully configurable. SPI devices contain certain set of registers for holding these configurations. The Serial Peripheral Control Register holds the various configuration parameters like¬ master/slave selection for the device, baudrate selection for communication, clock signal control etc. The status register holds the status of various conditions for transmission and reception.SPI works on the principle of 'Shift Register‟. The master and slave devices contain a special shift register for the data to transmit or receive.

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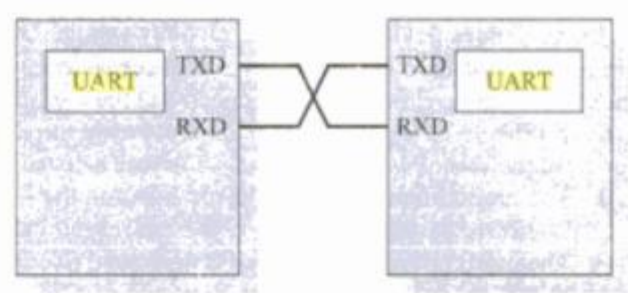
UART(Universal Asynchronous Receiver Transmitter:

- Universal Asynchronous Receiver Transmitter (UART) based data transmission is an asynchronous form of serial data transmission.
- UART based serial data transmission doesn't require a clock signal to synchronise the transmitting end arid receiving end for transmission.
- Instead it relies upon the pre-defined agreement between the transmitting device and receiving device. The serial communication settings (Baudrate, number of bits per byte, parity, number of start bits and stop bit and flow control) for both transmitter and receiver should be set as identical.
- The start and stop of communication is indicated through inserting special bits in the data stream. While sending a byte of data, a start bit is added first and a stop bit is added at the end of the bit stream.
- The least significant bit of the data byte follows the 'start' bit.
- For proper communication, the 'Transmit line' of the sending device should be connected to the 'Receive line' of the receiving device

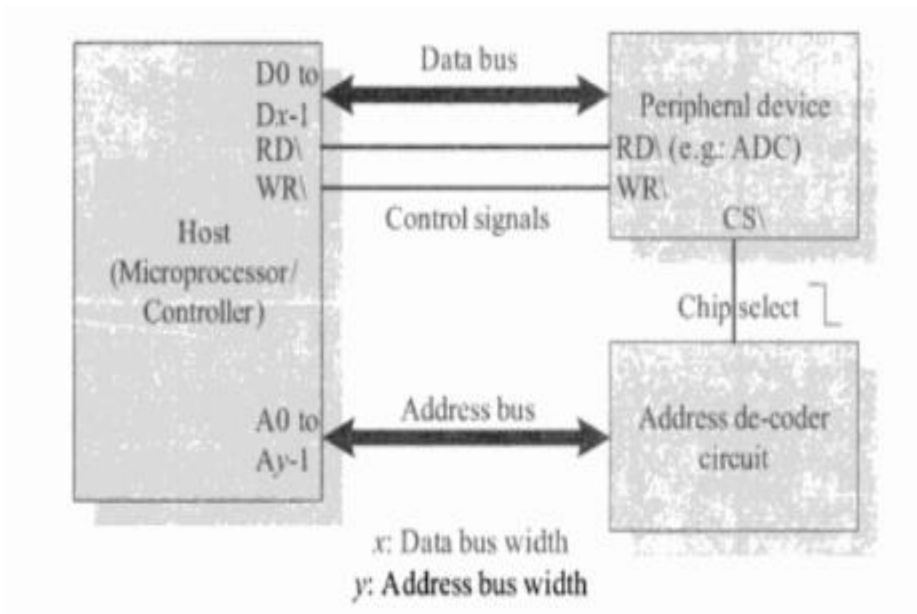


TXD: Transmitter line
RXD: Receiver line

PARALLEL DEVICE PORTS

- The on-board parallel interface is normally used for communicating with peripheral devices which are memory mapped to the host of the system.
- The host processor/controller of the embedded system contains a parallel bus and the device which supports parallel bus can directly connect to this bus system.
- The communication through the parallel bus is controlled by the control signal interface between the device and the host. The 'Control Signals' for communication includes 'Read/ Write' signal and device select signal.
- The device normally contains a device select line and the device becomes active only when this line is asserted by the host processor. The direction of data transfer (Host to Device or Device to Host) can be controlled through the control signal lines for 'Read' and 'Write'.

- Only the host processor has control over the 'Read' and 'Write' control signals.
- The device is normally memory mapped to the host processor and a range of address is assigned to it. An address decoder circuit is used for generating the chip select signal for the device.
- When the address selected by the processor is within the range assigned for the device, the decoder circuit activates the chip select line and thereby the device becomes active.
- The processor then can read or write from or to the device by asserting the corresponding control line (RD\ and WR\ respectively).



Parallel Interface Bus

Wireless communication devices

The different wireless communication services that are widely used inEmbedded systems are

1.Bluetooth

2. WI-FI

3.ZIGBEE

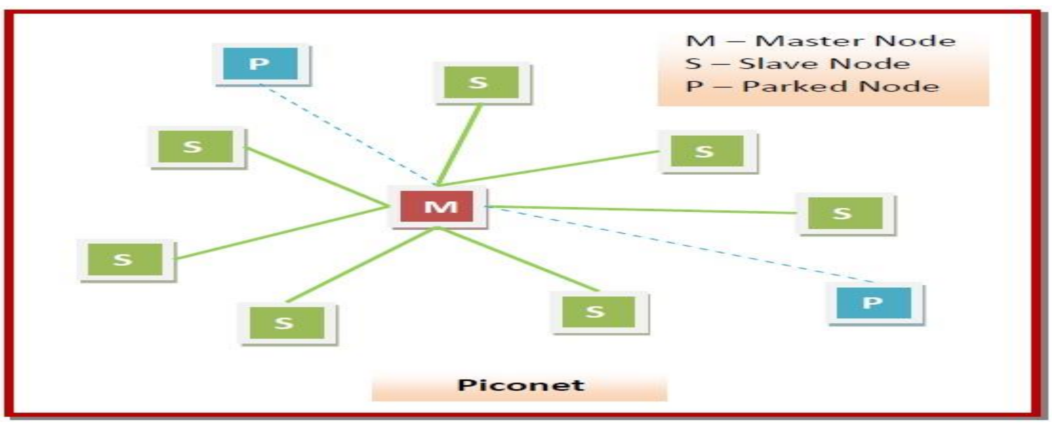
4.GPRS(general Packet Radio service)

BLUETOOTH:

- Bluetooth is a low cost, low power, short range wireless technology for data and voice communication. Bluetooth is first proposed by Ericsson in 1994.
- Bluetooth operates at 2.4GHz of Radio frequency spectrum.
- It supports a data rate of 1Mbps and a range of approximately 30 feet for data communication.
- Bluetooth communication has two essential parts
  - A) Physical part: which is responsible for the physical transmission of data between devices supporting Bluetooth communication.
  - B) Protocol Part: which is responsible for defining the rules of communication.
- Bluetooth supports point to point(Device to Device) and Point to Multi point(Device to Multiple devices) wireless communication.
- The Bluetooth can function as Master or Slave. When a network is formed with one Bluetooth as master and more than one device as slave it is called as Piconet.
- A Piconet has a maximum of seven slave devices.
- Bluetooth is a favourite for sort range of data communication. It is popular among cell phone users as they are the easiest communication for transferring Ringtones, Music files, Pictures between Neighbouring Bluetooth enables phones.

There are two types of Bluetooth networks −

- Piconets
- Scatternets



- Piconets are small Bluetooth networks, formed by at most 8 stations, one of which is the master node and the rest slave nodes (maximum of 7 slaves).
- Master node is the primary station that manages the small network. The slave stations are secondary stations that are synchronized with the primary station.

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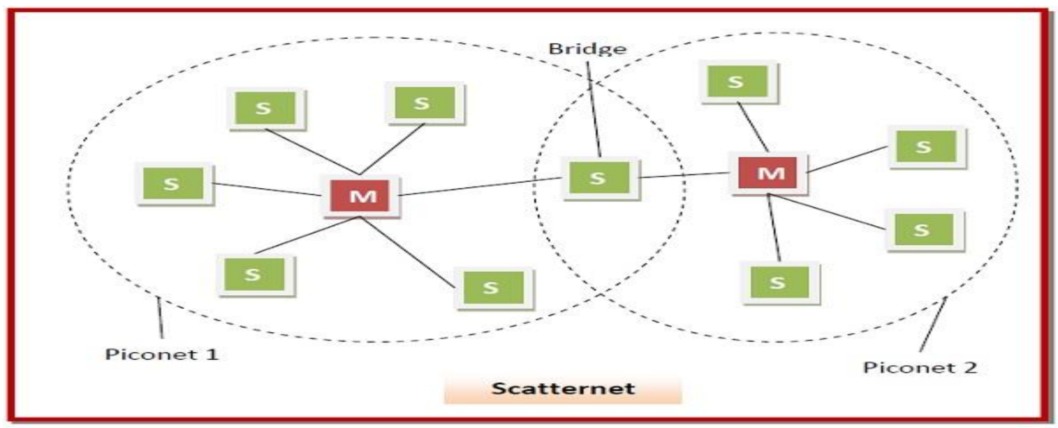
- Communication can take place between a master node and a slave node in either one-to-one or one-to-many manner. However, no direct communication takes place between slaves.
- Each station, whether master or slave, is associated with a 48-bit fixed device address.
- Besides the seven active slaves, there can be parked nodes. The only work that they can do is respond to a beacon frame for activation from the master node.

Scatternodes:

- A scatternet is an interconnected collection of two or more piconets. They are formed when a node in a piconet, whether a master or a slave, acts as a slave in another piconet. This node is called the bridge between the two piconets, which connects the individual piconets to form the scatternet.



Wi-Fi(Wireless Fidelity)

- Wi-Fi is the popular wireless communication technique for networked communication of devices.
- Wi-Fi follows the IEEE 802.11 standard. It supports IP(Internet Protocol) based communication.
- In an IP based communication each device is identified by an IP address, which is unique to each device on the network.
- The Internet Protocol (IP) is a protocol, or set of rules, for routing and addressing packets of data so that they can travel across networks and arrive at the correct destination.
- Wi-Fi based communication requires an intermediate agent called Wi-Fi router to mange the communications.

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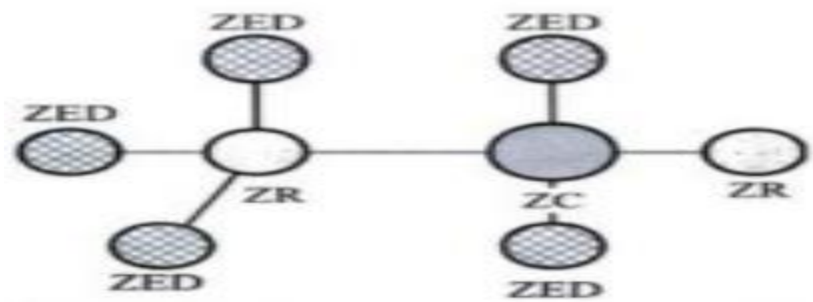
- The Wi-Fi router is responsible for access to a network, assigning the IP address to device on the network, routing the data packets to intended devices on the network.
- The wi-fi enabled devices contain a wireless adaptor for transmitting and receiving data in the form of radio signals through an antenna.
- The Wi-Fi supports data rates ranging from 1Mbps to 150Mbps, and the range of 100 to 300 feet.
- The most common way for users to connect to the Internet wirelessly is with a wireless (Wi-Fi) router. Usually these routers look like small boxes with short antennas to help broadcast signal throughout a home or an office. The farther a user is from the Wi-Fi router, the weaker the signal is. So there are usually multiple wireless routers placed throughout the workspace, in an array allowing for extended Internet coverage.

Zigbee

- Zigbee is a low power, low cost, wireless network communication.
- It is targeted for low data rate and secure applications for wireless personal area network. Zigbee operates worldwide at the unlicensed bands of Radio spectrum mainly at 2.4GHz, 902 to 928 MHz.
- it supports a distance of 100 to 200 metres and a data rate of 20 to 250 Kbps.
- Zigbee coordinator (ZC): The zigbee coordinator act as the root of the Zigbee network. The ZC is responsible for initiating the Zigbee network and it has the capability to store the information about the network.
- Zigbee Router(ZR): Responsible for passing information from device to another device or to another ZR.

- Zigbee end device(ZED): The device which is having the zigbee functionality for data communication.



GENERAL PACKET RADIO SERVICE(GPRS)

- GPRS is a communication technique for transferring data over a mobile communication network like GSM.
- Data is sent as packets in GPRS communication. The transmitting device splits the data into several related packets. At the receiving end the data is reconstructed by combining the received data packets.
- GPRS supports a maximum transfer rate of 171.2Kbps. The GPRS communication divides the channel in to 8 time slots and transmits the data over the available channel.
- GPRS is mainly used in mobile enabled devices for data communication. GPRS is a old technology and now it is replaced with new generation like EDGE etc, which offers higher bandwidth for communication.

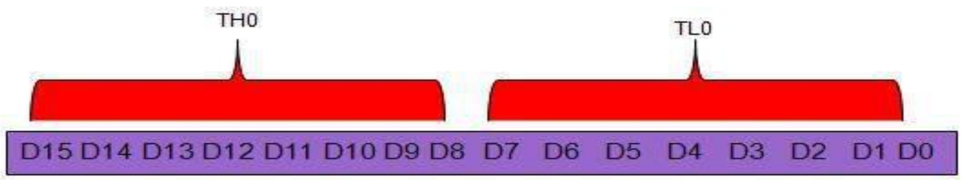
TIMER AND COUNTING DEVICES

- A timer is a specialized type of clock which is used to measure time intervals. A timer that counts from zero upwards for measuring time elapsed is often called a stopwatch. A timer is used for producing the precise time delay.
- In Embedded systems the timers can also be used as counters to count events happening outside the microcontroller. The counters are used to store the number of times a particular event occurred.

Timer 0 Register:

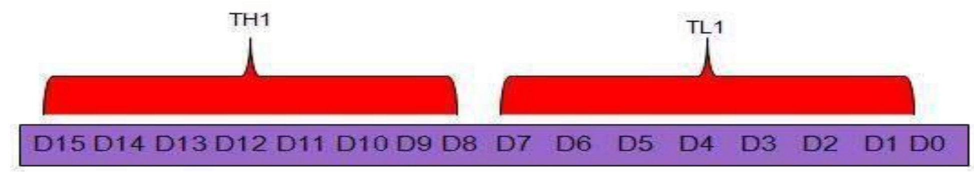
- The 16-bit register of Timer 0 is accessed as low- and high-byte. The low-byte register is called TL0 (Timer 0 low byte) and the high-byte register is called TH0 (Timer 0 high byte).

- These registers can be accessed like any other register.
- For example, the instruction MOV TL0, #4H moves the value into the low-byte of Timer 0.



Timer 1 Register:

- The 16-bit register of Timer 1 is accessed as low- and high-byte. The low-byte register is called TL1 (Timer 1 low byte) and the high-byte register is called TH1 (Timer 1 high byte).
- These registers can be accessed like any other register. For example, the instruction MOV TL1, #4H moves the value into the low-byte of Timer 1.



TMOD (Timer Mode) Register

- This timer register is used to set various timer modes in timer0 and timer1. In this 8-bit TMOD register, 4 lower bits are set aside for timer0 and the 4 upper bits are used for timer1. For each timer, the lower 2 bits are used to set the timer mode while the remaining 2 upper bits are used to specify the operation.

GATE	$C/\bar{T}$	M1	M0	GATE	$C/\bar{T}$	M1	M0
Timer1				Timer0			

Fig. TMOD Register

GATE: This bit is used for choice of Software are Hardware start and stop of timer. If Gate=1, we can start and stop the timer using hardware, and if Gate=0, the start and stop can be done using software instructions such as SETB TRO(start the timer), CLR TRO(stop the timer).

C/T: This bit decides whether the timer is used as time delay generator or as an event counter.

C/T=0, used as timer for delay purpose.

C/T=1, used as counter to count the number of events.

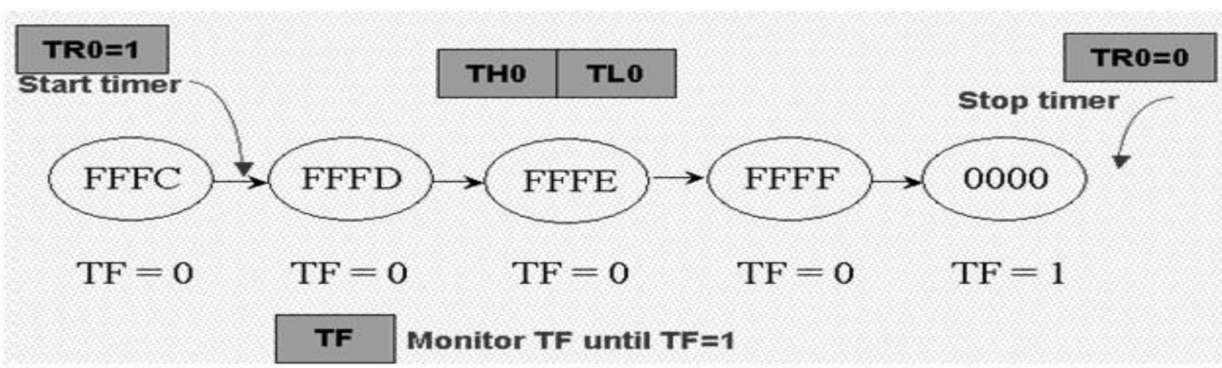
MODE Bits M1, M0:

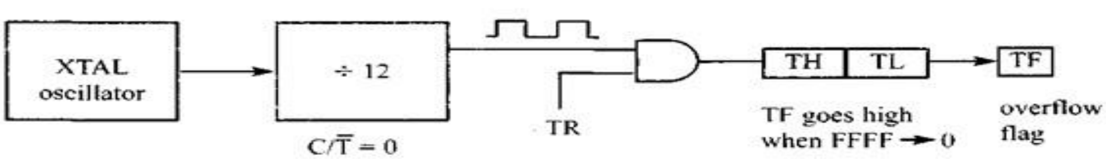
- The last two bits for each timer i.e. M1 and M0 are used to select the timer mode. 8051 has 4 timer modes which are given below.

M1 / M2

M1	M2	Mode
0	0	13-bit timer mode.
0	1	16-bit timer mode.
1	0	8-bit auto reload mode.
1	1	Spilt mode.

For time delay,the timer use the clock source of the crystal frequency of the crystal attached to 8051. The frequency for the timer will be 1/12th of the frequency of the external crystal attached.





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  The Timer control register is used to start and stop the timer and also to detect the status whether the timer is over flown or not.

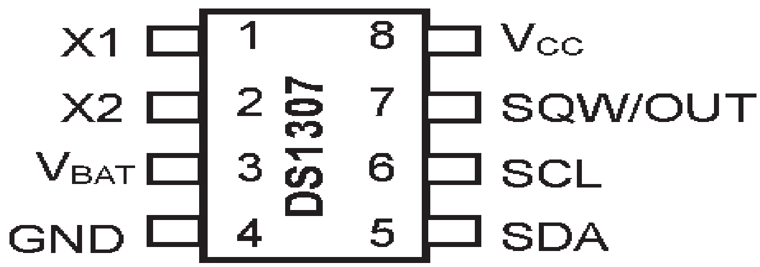
- **TF1: Timer 1 overflow bit** : Set by the hardware when the timer/counter overflows.
- **TR1: Timer 1 Run control bit**. Set/cleared by software to turn Timer/Counter ON/ OFF.
- **TF0: Timer 0 overflow bit:** Set by the hardware when the timer/counter overflows.
- **TR0: Timer 0 run control bit:** Set/ cleared by software to turn Timer/ Counter ON/OFF.
- **IE1: External Interrupt 1 Edge flag**: set by the hardware when the external interrupt is detected.
- **IT1: External Interrupt 1 type control bit**: Set/ cleared to specify external edge/level triggered.
- **IE0: External Interrupt 0 edge flag**: Set by the hardware when the external interrupt is detected.
- **IT0: External Interrupt 0 type control bit**: Set/cleared to specify external edge/ level triggered.

REAL TIME CLOCK (RTC)

- Real Time clock is a system component responsible for keeping the track of time. RTC holds information like current time(In Hours, Minutes and Seconds) in 12hr format or 24 hour format, date , month, year, day of the week, etc.
- So, it is the one which supplies timing reference to the system. RTC is intended to function even in the absence of power. RTC are available in the form of Integrated circuits from different semiconductor manufactures likes Maxim /Dallas, ST Microelectronics etc.
- It is microchip for holding the time and date related information and backup battery cell for functioning in the absence of the power.
- The RTC is interfaced to the processor or controller of the embedded system. For Operating system based embedded devices, a timing reference is essential for synchronizing the operations of OS kernel [Process management, Time management, Memory management] etc.
- The DS1307 is a low-power clock/calendar with a battery backup SRAM. The clock/calendar provides seconds, minutes, hours, day, date, month and year qualified data.

- The main advantage of RTC is that they have an arrangement of battery backup which keeps the clock/calendar running even if there is power failure.
- We can find these RTCs in many applications like embedded systems and computer mother boards, etc.

Pin diagram:



- **Pin 1, 2:** Connections for standard 32.768 kHz quartz crystal. The internal oscillator circuitry is intended for operation with a crystal. A crystal oscillator is an electronic oscillator circuit that is used for creating an electrical signal with a given frequency. These oscillators are used to provide clock to the Microprocessor/Microcontroller.
- **Pin 3**: Battery input for any standard 3V lithium cell or other energy source. Battery voltage should be between 2V and 3.5V for suitable operation. A lithium battery with 48mAhr or greater will backup the DS1307 for more than 10 years in the absence of power.
- **Pin 4:** Ground.
- **Pin 5:** Serial data input/output. The input/output for the I2C serial interface is the SDA, which requires a pull up resistor to pull the voltage to 5v.
- **Pin 6:** Serial clock input. It is the I2C interface clock input and is used in data synchronization.
- **Pin 7:** Square wave/output driver. When enabled, the SQWE bit set to 1, the SQW/OUT pin outputs one of four square-wave frequencies (1Hz, 4 kHz, 8 kHz, and 32 kHz).
- **Pin 8:** Primary power supply. When voltage is applied within normal limits, the device is fully accessible and data can be written and read.

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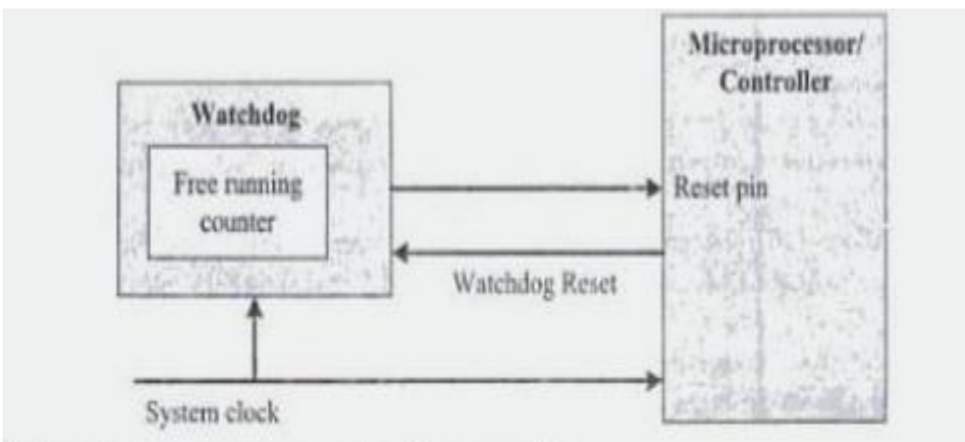
WATCH DOG TIMER (WDT)

In desktop Windows systems, if we feel our application is behaving in an abnormal way or if the system hangs up, we have the 'Ctrl + Alt + Del' to come out of the situation. What if it happens to our embedded system? Do we really have a 'Ctrl + Alt + Del' to take control of the situation? Of course not ⊗, but we have a watchdog to monitor the firmware execution and reset the system processor/microcontroller when the program execution hangs up. A watchdog timer, or simply a watchdog, is a hardware timer for monitoring the firmware execution. Depending on the internal implementation, the watchdog timer increments or decrements a free running counter with each clock pulse and generates a reset signal to reset the processor if the count reaches zero for a down counting watchdog, or the highest count value for an upcounting watchdog. If the watchdog counter is in the enabled state, the firmware can write a zero (for upcounting watchdog implementation) to it before starting the execution of a piece of code (subroutine or portion of code which is susceptible to execution hang up) and the watchdog will start counting. If the firmware execution doesn't complete due to malfunctioning, within the time required by the watchdog to reach the maximum count, the counter will generate a reset pulse and this will reset the processor (if it is connected to the reset line of the processor). If the firmware execution completes before the expiration of the watchdog timer you can reset the count by writing a 0 (for an upcounting watchdog timer) to the watchdog timer register. Most of the processors implement watchdog as a built-in component and provides status register to control the watchdog timer (like enabling and disabling watchdog functioning) and watchdog timer register for writing the count value. .



Watchdog timer for firmware execution supervision