UNIT - II

Embedded Hardware Design

Analog and digital electronic Components:-

Analog electronic components:- Various analog electronic components are commonly used in designing the hardware of an embedded system. The role of some of these components is explained as follows,

1. **Resistor:-** Resistor is a current limitting device and is commonly used to interface LED's and buzzer's with the port pins of a micro controller in an embedded application.

2. **Transistor:-** Transistors are popularly used in embedded applications for performing switching and amplification functions. when transistor acts as a switch, it remains either in ON (or) in OFF state. whereas in amplification application, a transistor always remains in ON state. For switching and driving circuits in embedded systems NPN transistor in Common emitter configuration is used extensively. Examples of such circuits are relays, buzzers and stepper motor driving circuits.

3. Capacitor :- Capacitors are generally used in signal filtering and resonating circuits for performing implementation of reset circuits, matching of circuits for RF designs, decoupling of power supply in embedded applications. various types of Capacitors that are widely used in embedded hardware design are electrolytic capacitors, Ceramic capacitors, and tantalum capacitors.

4. Diode :- the most commonly used diodes in embedded hardware circuits are P-N junction diodes, schottky diodes and zener diodes. A schottky diode acts similar to a P-N junction diode, but has low forward voltage drop of the order of 0.15V to 0.45V when compared to a P-N junction diode whose forward voltage drop is of the order of 0.7V to 1.7V, also it has a very small current switching time when compared to a P-N junction diode. A zener diode in forward biased condition acts as P-N junction diode & is used in voltage clamping applications. various other functions performed by a diode in an embedded system are reverse polarity protection, voltage rectification, free-wheeling of current produced in inductive circuits etc...

* Digital electronic components :- the various digital electronic components used in embedded system development are as follows.

1. open collector and tristate output
2. logic gates
3. Buffer
4. Latch
5. Decoder
6. Encoder
7. Multiplexer
8. De-multiplexer
9. Combinational circuits
10. Sequential circuits.

open collector and Tristate output :- open collector is employed in embedded system due to the following reasons,

(i) with the open collector, the additional interface circuits are eliminated.
(ii) the open collector output lines are used to build "wired AND" and "wired OR"
(iii) Multi drop connection (connecting more than one open collector output to a single line) is supported by it.

* The below figure shows open collector o/p configuration.

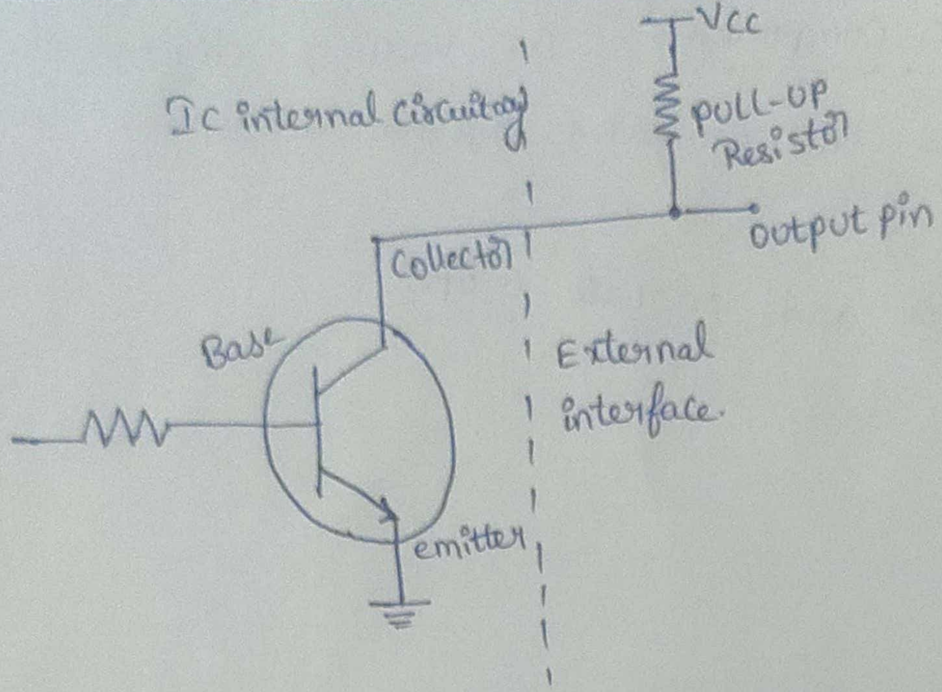

fig:- Configuration of open collector.

* the tristate output allows more devices to share a common bus.

* for the remaining digital electronic components please refer your "DICA material."

Examples of various I/O Devices :-

I/O Device type	Example
1. Serial Input	- Audio Input, video Input, Dial tone, Network Input, transceiver Input, Scanner, Remote i/p and serial I/o bus I/p.

2. Serial output – Audio output, video O/P, Dialing number, N/w O/P, Remote TV Control, transceiver O/P, multi-processor communication and serial I/O bus O/P.

3. Serial UART Input – Keypad, mouse, Keyboard, modem, character Inputs on Serial line.

4. serial UART output – modem, printer, character O/P's on serial line.

5. parallel port single bit I/P – (i) Completion of a revolution of a wheel.
   (ii) acheiving preset pressure in a boiler.
   (iii) exceeding the upper limit of the permitted weight over the pan of an electronic balance.

6. parallel port single bit output – (i) PWM O/P for DAC, which controls liquid level, temperature, pressure, speed (or) angular position of a rotating shaft (or) a d.c motor control.

7. parallel port Input - (i) ADC input from liquid level measuring sensor (or) temperature sensor (or) pressure sensor (or) speed sensor.

8. parallel port output - (i) Multi lane LCD display matrix unit in a cellular phone to display on the screen the phone number, time, messages, character Inputs (or) pictogram bit-images (or) E-mail (or) webpage.

Serial Communication Devices:- [modes]

* There are three modes of serial Communication devices. they are (i) synchronous mode
(ii) iso synchronous mode
(iii) Asynchronous. mode.

Synchronous Communication:- The communication in which data byte is transmitted (or) received at fixed intervals of time along with constant phase differences is known as "synchronous communication". the data bits are transmitted with in a constant maximum time interval.

* An example of synchronous serial communication is frames sent over a LAN. Frames of data communicate with the time interval between each frame remaining constant.
* There are two characteristics of synchronous communication are as follows.

(i) Frames maintain a uniform phase difference i.e; the frames are in complete synchronization with each other. The synchronous communication does not allow handshaking (source and destination exchange signals before communication of data) among the serial transmitter and receiver port within the communication interval.

(ii) The clock ticking must always be present in order to transmit serial data bytes. Frames sent over a LAN, inter processor communication in a microprocessor system are the examples of synchronous serial communication.

Iso-synchronous communication:- It is a special type of synchronous communication in which the data bytes are sent (or) received at maximum variable time intervals with uniform phase differences.

* the "voice over Internet protocol" (VOIP) system is an example for Iso- synchronous communication.

Asynchronous Communication:- Asynchronous communication is defined as the communication in which data bytes are sent (or) received at variable intervals of time.

Characteristics:-

(i) frames in asynchronous communication doesnot maintain uniform phase difference i.e; frames are not synchronized. It is in between handshaking of txer and receiver ports.

(ii) NO clock rate information is transmitted along with the serial data and thereby the receiver clock does not maintain identical frequency and phase difference with the transmitter clock.

⇒ Examples of asynchronous communication are keypad communication, RS 232C communication b/w UART devices and comm. over a telephone line.

Serial Communication devices:- Serial Communication is the process of transmitting data bit by bit over a communication path.

* there are three ways by which serial communication takes place. They are.

(i) synchronous Communication

(ii) Iso- synchronous Communication

(iii) Asynchronous Communication.

* The various serial Communication devices which supports serial Communication are,

(i) RS232 | RS 485

(ii) USART

(iii) HDLC

(iv) X.25

(v) ATM

(vi) DSL

(vii) ADSL

(viii) UART

UART :- (universal Asynchronous Receive Transmit):-

* UART stands for universal Asynchronous Receive transmit. It is designed to convert data from serial form to parallel form and viceversa.

* It can be used as a medium of Communication b/w the processor and RS232 port. There are two units in UART namely receiver unit and transmitter unit. A serial data is given as input to the receiver unit that produces parallel data to processor. On the other hand transmitter unit

accepts the processors output data that is in the parallel format, thus producing the data in serial form. In addition the data is attached with a start bit, stop bits and a parity bit. Most of the micro controllers contain UART present on their chip.

* Even though the voltage level of the UART most be converted in order to match the standard RS232 voltage level. Hence a level shifter is employed between UART and RS232 as illustrated in figure.

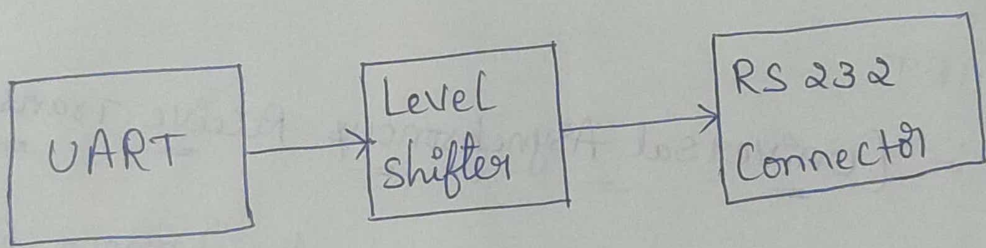

figure:- Interfacing UART to RS232 Connector.

* The operating voltage of UART is 5 volts, this voltage is then converted to a voltage level that matches RS232 through the level shifter and the signals are transmitted to it.
* The RS 232 standard supports connectivity upto 19.2 meters of distance.

* The rate of data transmission (i.e; data rate) provided by UART varries according to the type of UART chip employed and its clock frequency.
* The IC's used for level shifter are MAX 3222, MAX 3241. Maximum processors along with Digital signal processors (DSP) contain UART present on their chip.

Parallel port Devices:-

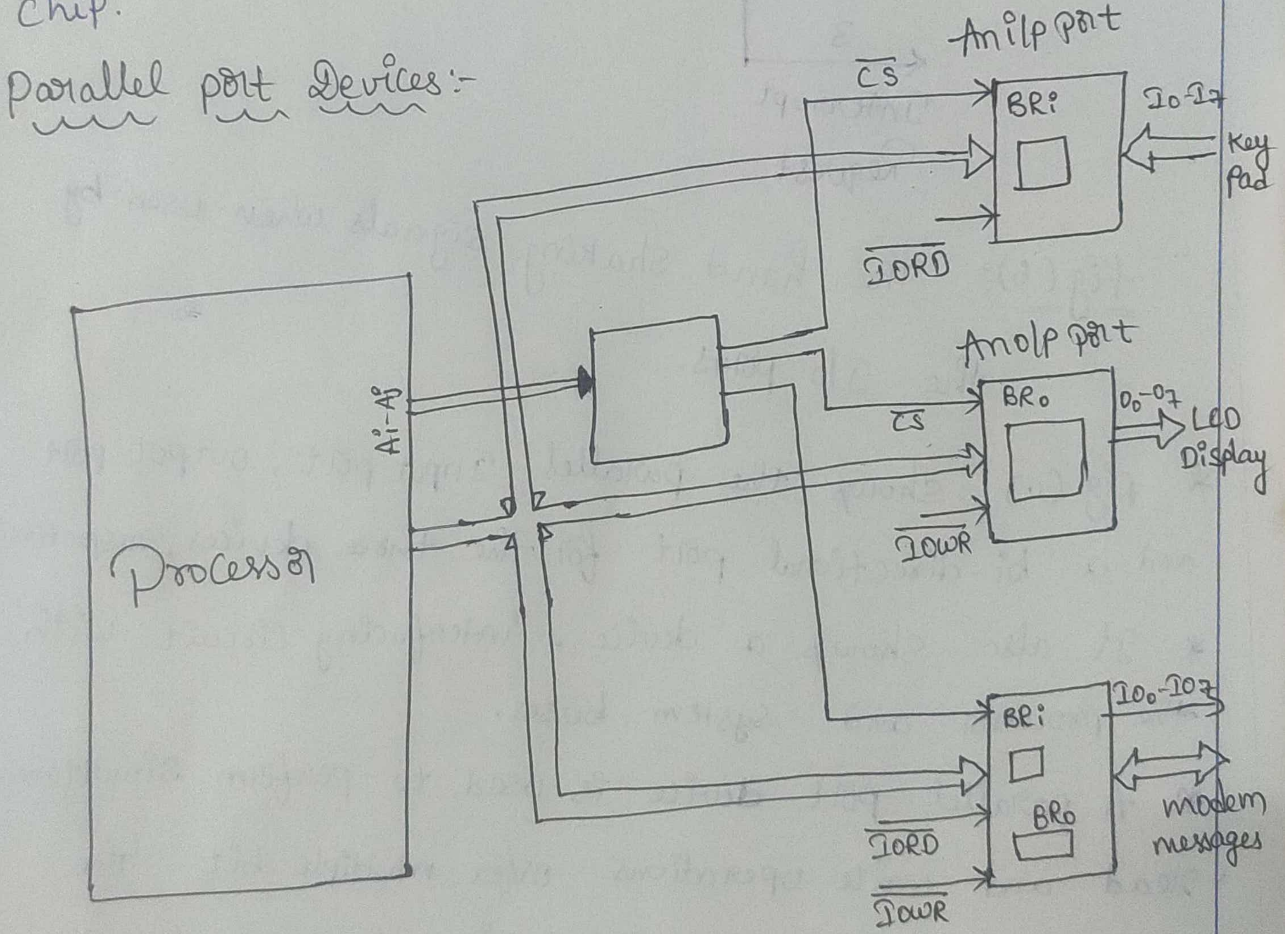

fig (a):- parallel input port, output port and a bidirectional port for connecting the device.

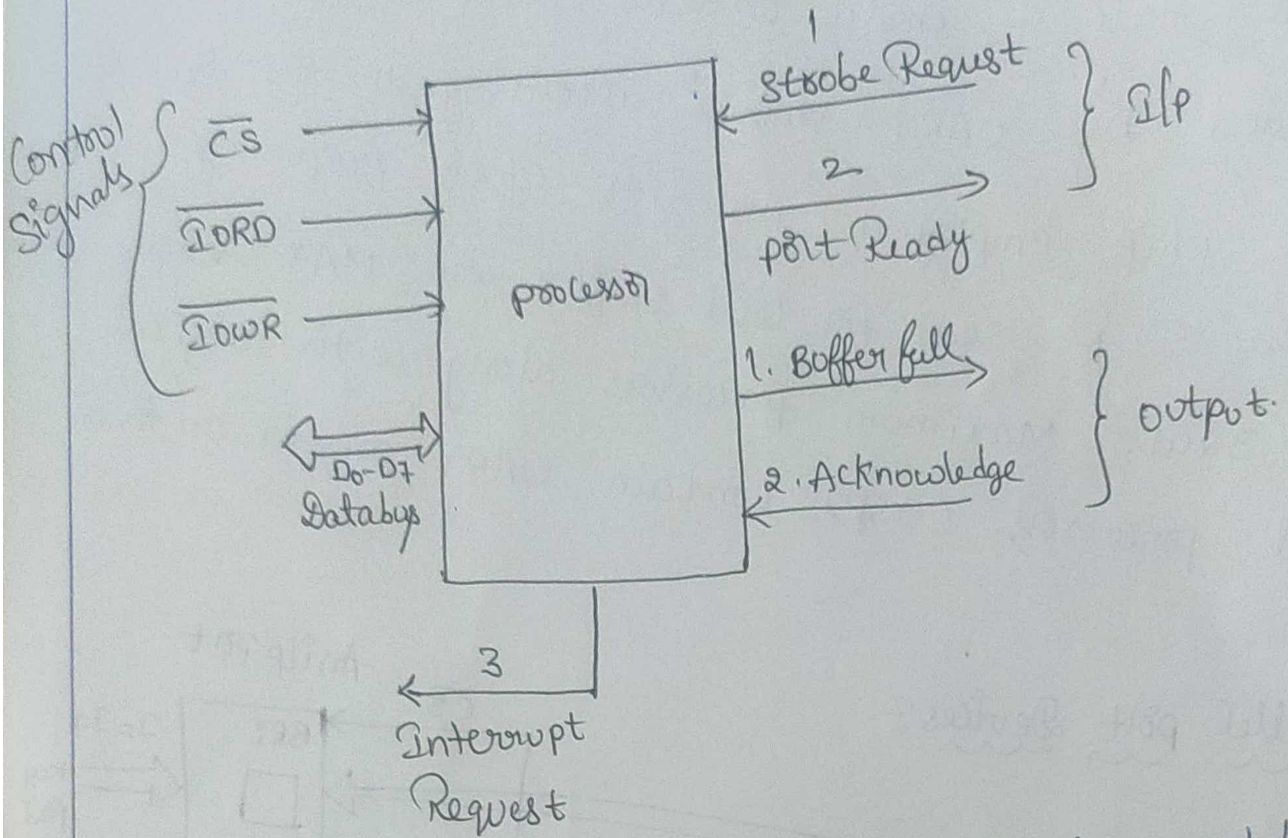

fig (b):- The hand shaking signals when used by the I/O ports.

* fig (a) shows the parallel input port, output port and a bi-directional port for the three devices, respectively.
* It also shows a device - interfacing circuit with the processor and system buses.
* A parallel port device is used to perform simultaneous read and write operations over multiple bit. The Capacitive effect of parallel wires has the following major impacts on the communication.

(i) It tends to decrease the distance of parallel Communication.

(ii) The bits under going transitions at the other end experience a delay in their transmission due to high capacitance of parallel wires.

(iii) The Large amount of capacitance generate noise and cross talk among the parallel wires.

for these reasons, Parallel ports are used for short distance communication.

* It can be observed from above figure that the port I_0 to I_7 are inputs to the Key pad Controller, o/p ports O_0 to O_7 are output bits to LCD display output controller. the above figure depicts that.

(i) Status pin → Input status signal to external ckt

(ii) BR_i and BR_o → Input and output data buffers at bidirectional IO port.

(iii) A_i and A_j → Address ports connected to device through a port address decoder.

(iv) $\overline{IORD}$ & $\overline{IOWR}$ → Control signal for read and write operation in case of 8086 processor.

(v) $\overline{RD}$ & $\overline{WR}$ → Memory Read and write signals used to map IO's.

(vi) $\overline{CS}$ → Control signal from o/p to external ckt.

wireless devices (or) wireless communication using different protocals:-

* The wireless devices after suitably modulating the data bits, useg either Infrared (IR) (or) Radio frequencies for their operation.

(i) Infrared frequency (IR):- the IR transmitter Communicates over LOS (Line of sight) and employs a photo transistor at the receiver side, in order to detect the IR Rays. TV Remote Controller, robotic systems are the major application domains of IR Communication. the IR devices make use of IRDA protocal for Communication purposes.

* Frequency Hopping is employed is bluetooth as more number of devices need to communicate in limited number of frequency bands. The data bits are modulated and demodulated as per protocal specification.

(ii) Radio frequencies:-

* These frequencies provide both short and long distance Communications. The source and receivers employ antenna to send and receive signals. A modulator and demodulator is also used in order to transmit data

over RF frequencies.

* The most Commonly used protocals in wireless devices are bluetooth, IRDA (Infrared Data Association), 802.11, zigbee.

* The below table illustrates the various frequency bands used by radio frequency wireless devices.

wireless Device protocal	Carrier Frequency.
Bluetooth / zigbee	2.4 GHZ / 900 MHZ
Mobile CDMA	2GHZ
Mobile GSM	890-915 / 1710-1785 / 1850-1910 MHZ

Advantages of wireless Devices :- the transmission system use wireless devices for data transmission, these wireless devices offer number of advantags. Few of them are,

(i) Low cost :- As the wireless devices does not employ cables in their design, the cost required for the implementation of these devices is very much less than when Compared to wired devices.

(ii) Mobility :- the device can be moved easily with in the wireless range. It is more suitable for non-reachable places such as hilly (or) river line (or) rural areas.

(iii) Support more no. of users :- wireless devices support more no. of users in a particular range, as they do not limit the slots available in a system.

(iv) Flexibility :- wireless devices are flexible in adhoc situations where there is a need for additional work station.

(v) Easy Installation :- since no cables are used, the wireless devices are installed without any difficulty.

(vi) Support temperory N/w setup :- wireless devices are ideal for temperory n/w setup.

Timer and Counting Devices :- Timer cum Counting device is used to count both irregular and regular events occuring at the i/p port of the device. It is both time and counting device and performs the following two operations.

(a) It counts the inputs occuring due to irregular time intervals and

(b) It counts clock input pulses occuring at regular intervals of time.

The device functions as either a timer or a counter depending on the input(or) status bit of a timing device register.

* It is necessary to include atleast one timing device in a system which generates interrupts for each clock ticks.

Hard ware timer:- The hard ware timer is used as a system clock to generate "num ticks" number of system clock ticks before system interrupts. A clock -out signal provides input from the processor to the hard ware timer and the system clock is activated depending on the "num-ticks" defined at the timer.

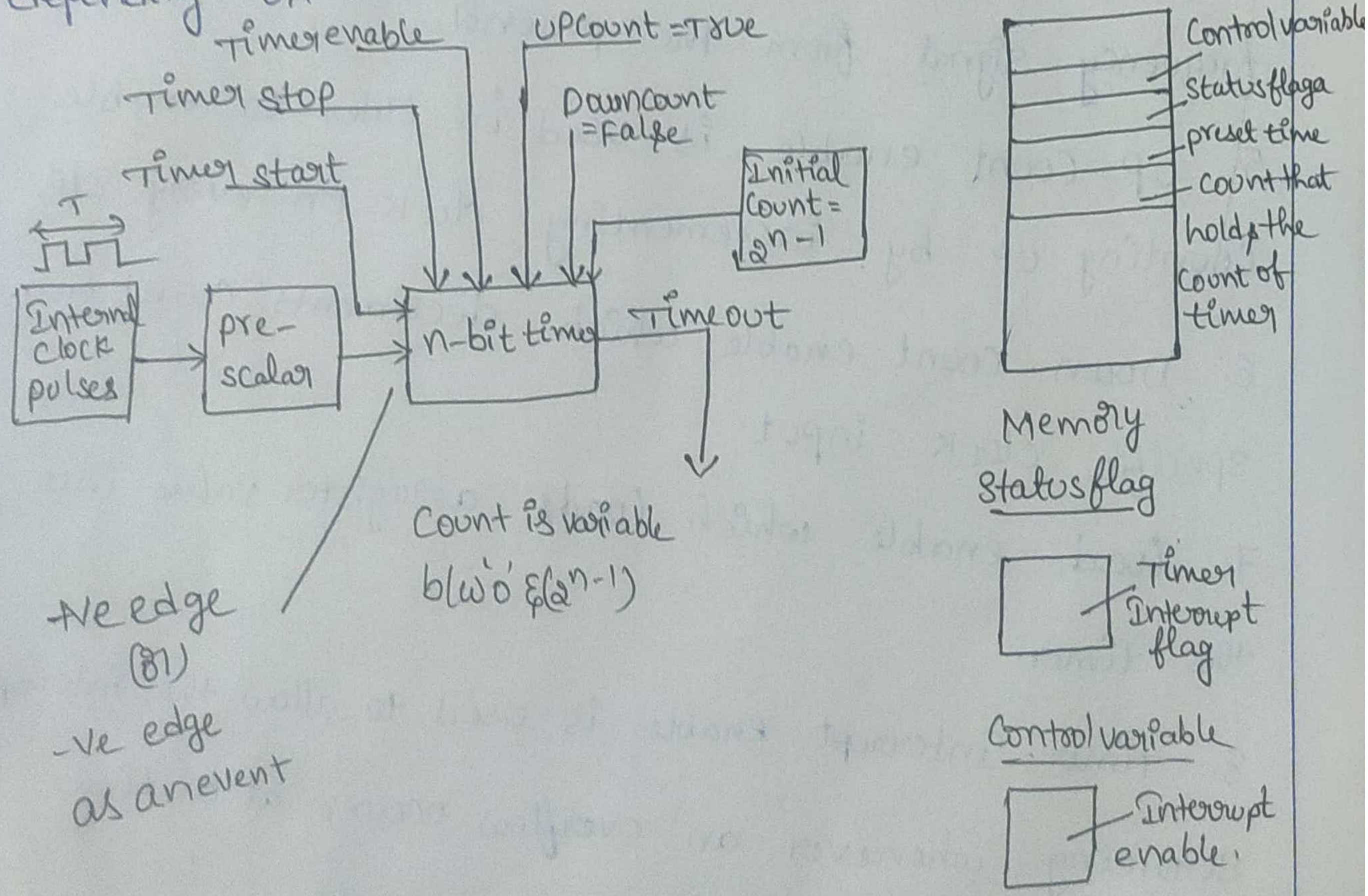

fig:- Hard ware timer Device.

* the above figure depicts that an hardware timer Consists of a Control bits (based on hardware signals and its associated bit at Control register). They are,

1. Timer enable is used to activate a timer device.
2. Timer Start which starts counting at each clock Input.
3. Timer stop from the next clock pulse is used in order to stop counting.
4. prescaling bits are used to divide the clock-out frequency signal from the processor.
5. UP-Count enable is used in order to enable Counting up by incrementing clock on every I/P.
6. Down-Count enable which decrements Count on a specific clock input.
7. Load enable which loads a register value into the timer.
8. Timer-Interrupt enable is used to allow the interrupt servicing whenever an overflow occurs at a timer.

Software Timer :- The input to the software timer (SWT) is the system clock ticks which generate interrupt (a) at periodic intervals of time in accordance with the count - value set. All the software timers present in the activated list employ the same common input of system clock ticks. On reaching a time-out (i.e; count value = 0) all the SWTs set a status flag in the system.

* These timers are also used as virtual timing Devices. Fig(2) shows the control and status bits in software timer device.

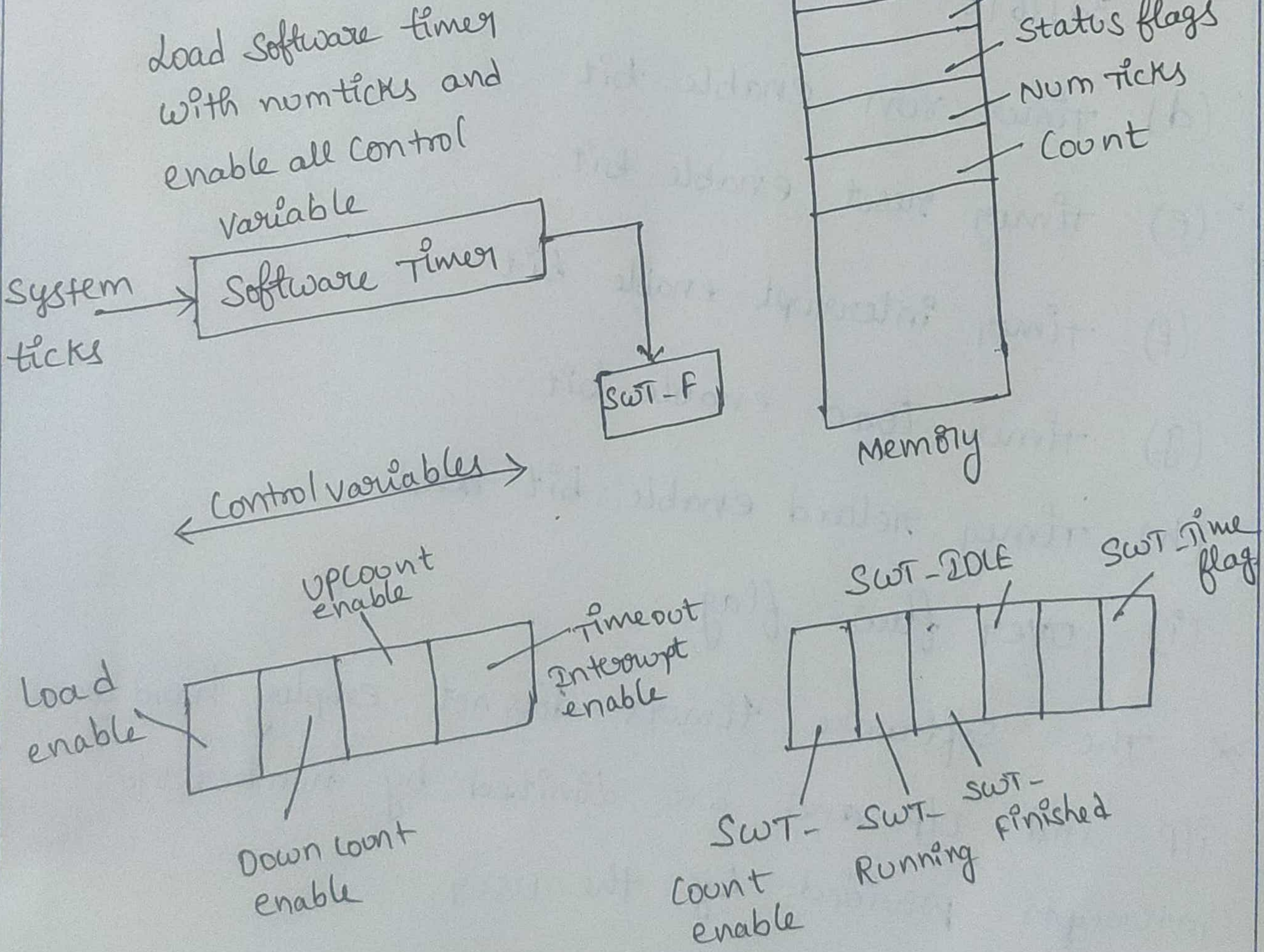

fig:- Software Timer Device.

* Control bits in SWT are set based on the applications and SWT consists of a number of control bits and a time-out status flag in each timer device and functions similar to the hardware timer device.

The various available control bit variables and status flag in a software timer are :.

(a) Reset value 32/16/8.

(b) Initial load value 32/10/8.

(c) Count - value, maximum value and minimum value 32/16/8.

(d) timer run enable bit.

(e) timer reset enable bit.

(f) Timer interrupt enable bit.

(g) timer load enable bit.

(h) Timer reload enable bit and

(i) over flow - flag.

* The software timers does not employ hardware i/p and o/p and are limited by number of interrupts provided by the user.

Watch Dog Timer (WDT) :- A timing device set for a predefined interval of time for occorance of an event is known as watch dog timer. the device generates the time-out signal if no event occurs in the specified interval of time.

* For instance, Consider that a set of events must occur within a time period of 100ms. If the task is accomplished in the specified time, the WDT (watch Dog Timer) gets disabled and stops Counting. on the other hand, if the system fails to accomplish its tasks the WDT (watch Dog timer) generates interrupts after predefined time (i.e; 100ms) and executes a routine that runs.

1. watch-dog timer Can be either a programmed Software task (or) a micro Controller.
2. In mobile phones, WDT's save power when there is no GUI Interaction within a specified time it turnoffs the display. An interval is set to turnoff the display is 15, 20 (or) 25 sec in a mobile phone.
3. In Case of temperature control systems, if the Controller fails to switch off the current in a given

time, the current automatically gets switched off and a warning signal is issued by indicating failure of the Controller.

4. In mobile phones, beep sound is used to attract attention of user when menu is not selected with in a specified time interval.

* It is a hardware timer for monitoring the firmware execution. If firmware execution doesnot complete due to malfunctioning with in the time required by watch dog to reach maximum Count. The Counter will generate reset pulse and this will reset the processor.

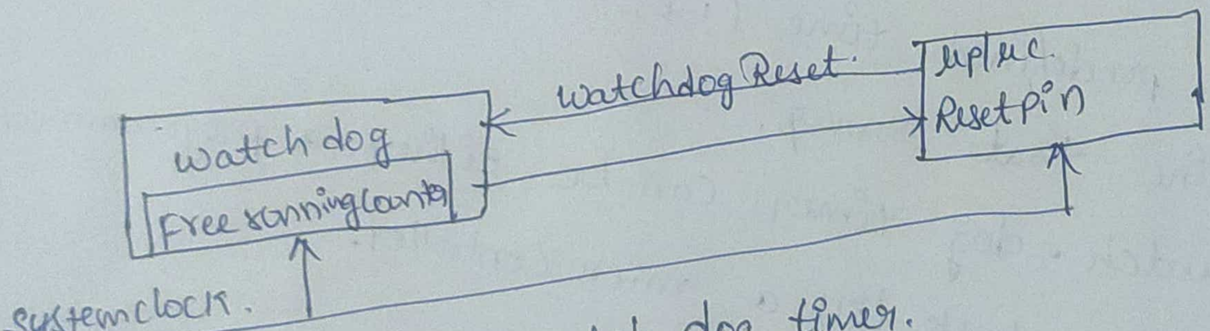

fig:- watch dog timer.

Real time clock :- It is a system Component responsible for keeping the track of time. RTC holds informs like current time 12 hours / 24 hours format.

* It works even if the power supply is off. It contains a micro chip holding time and data related informed and back up battery cell for functioning in the absence of power.

* A clock which generates interrupts continuously at a regular intervals on each clock ticks is known as Real time clock (RTC). After occurance of each time-out (or) overflow of the clock, an interrupt service routine always gets executed in the system. The real time clock once initiated cannot be either stopped (or) modified with another value. Use of Real time clock (RTC) in a system preserves both current time and dates. It also enables to initiate return of control to the system after a preset clock period.