MODULE 5

COMMUNICATION SYSTEM

INTRODUCTION

Communication is the transfer of information from one place to another.

This should be done

- as efficiently as possible
- with as much fidelity/reliability as possible
- as securely as possible

Communication System: Components/subsystems act together to accomplish information transfer/exchange.

ELEMENTS OF COMMUNICATION SYSTEMS

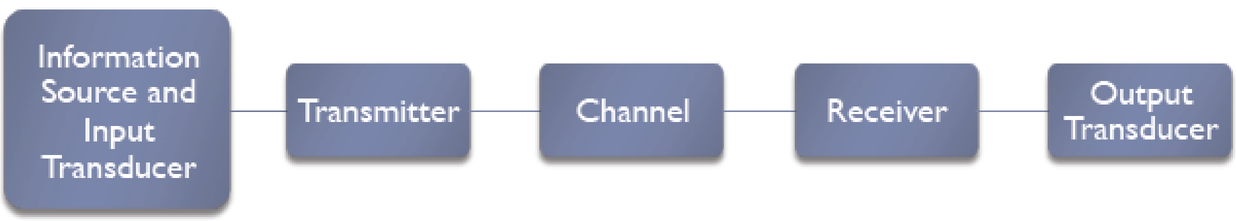

Fig 5.1: Elements of communication systems

Information Source: Audio, image, text, data

Input Transducer: Converts source to electric signal

- Microphone
- Camera
- Keyboard

Output Transducer: Converts electric signal to useable form

- Speaker
- Monitor

Transmitter:

- Converts electrical signal into form suitable for channel
- Modulator
- Amplifier

Channel: Medium used to transfer signal from transmitter to receiver. Point to point or Broadcast

- Wire lines
- Fiber optic cable
- Atmosphere
- Often adds noise / weakens & distorts signal

Transmitter-

It essentially consists of microphone, audio amplifiers, oscillator and modulator. A microphone is a device which converts sound waves into electrical waves. The output of microphone is fed to multistage audio amplifier for raising the strength of weak signal.

The job of amplification is performed by cascaded audio amplifiers. The amplified output from the last audio amplifier is fed to the modulator for rendering the process of modulation.

The function of the oscillation is to produce a high frequency signal called a carrier wave. Usually crystal oscillator is used for the purpose.

The amplified audio signal and carrier waves are fed to the modulator. Here the audio signal is superimposed on the carrier wave in suitable manner. The resultant waves are called modulated waves, and the process is called modulation. The process of modulation permits the transmission of audio signal at the carrier signal (frequency). As the carrier frequency is very high, therefore the audio signal can be transmitted to large distances. The radio waves from the transmitter are fed to the transmitting antenna or aerial from where these are radiated into space.

The transmitting antenna radiates the radio waves in space in all directions. These radio waves travel with the velocity of light $3x10^8$m/sec. The radio waves are electromagnetic waves and possess the same general properties.

Receiver

On reaching the receiving antenna, the radio waves induce tiny emf in it. This small voltage is fed to the radio receiver. Here the radio waves are first amplified and then signal is extracted from them by the process of demodulation. The signal is amplified by audio amplifiers and then fed to the speaker for reproduction into sound waves.

Modulation- The process of changing some characteristics (example amplitude, frequency or phase) of a carrier wave in accordance with the intensity of the signal is known as modulation.

Types of modulation-

1. Amplitude modulation
2. Frequency modulation
3. Phase modulation

1. Amplitude modulation

When the amplitude of high frequency carrier wave is changed in accordance with the intensity of the signal, it is called amplitude modulation.

The following points are to be noted in amplitude modulation.

1. The amplitude of the carrier wave changes according to the intensity of the signal.
2. The amplitude variations of the carrier wave are at the signal frequency f_S.
3. The frequency of the amplitude modulated wave remains the same ie.carrier frequency f_C.

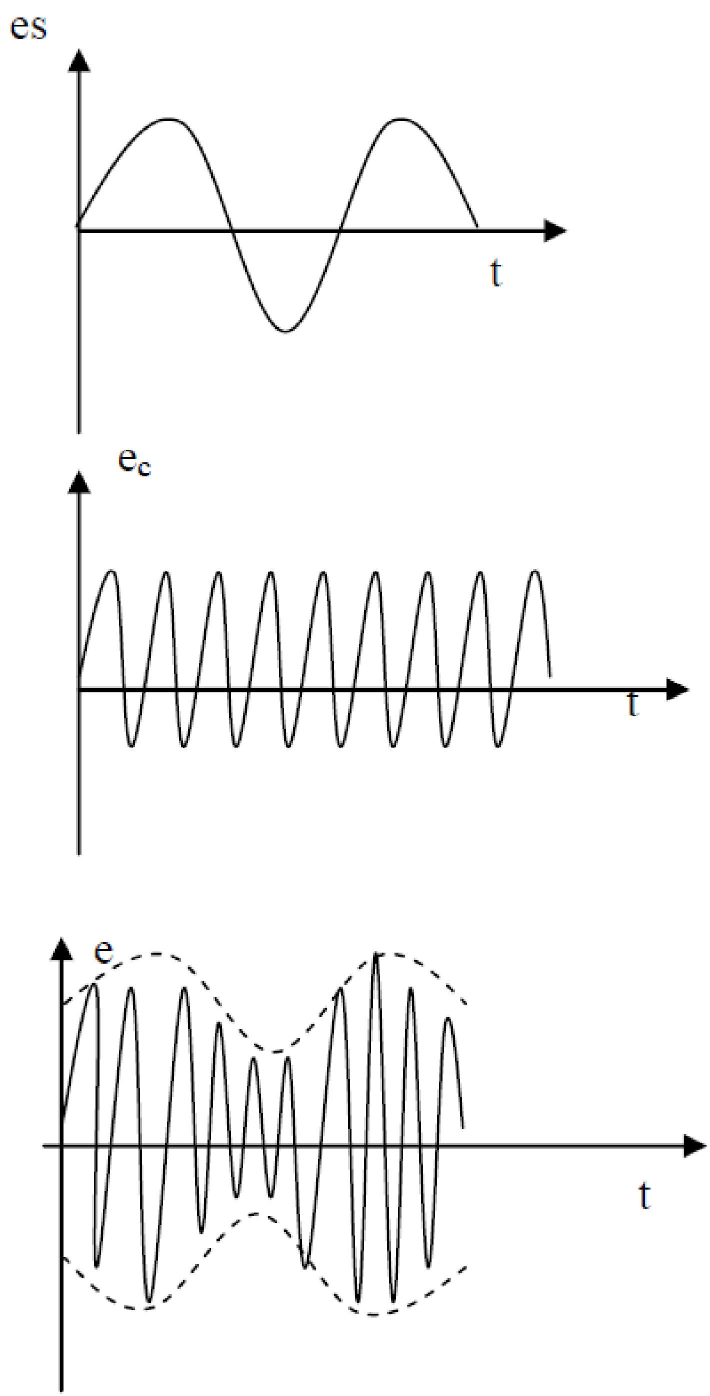

Figure 5.2: AM waveforms

Analysis of amplitude modulated wavesignal

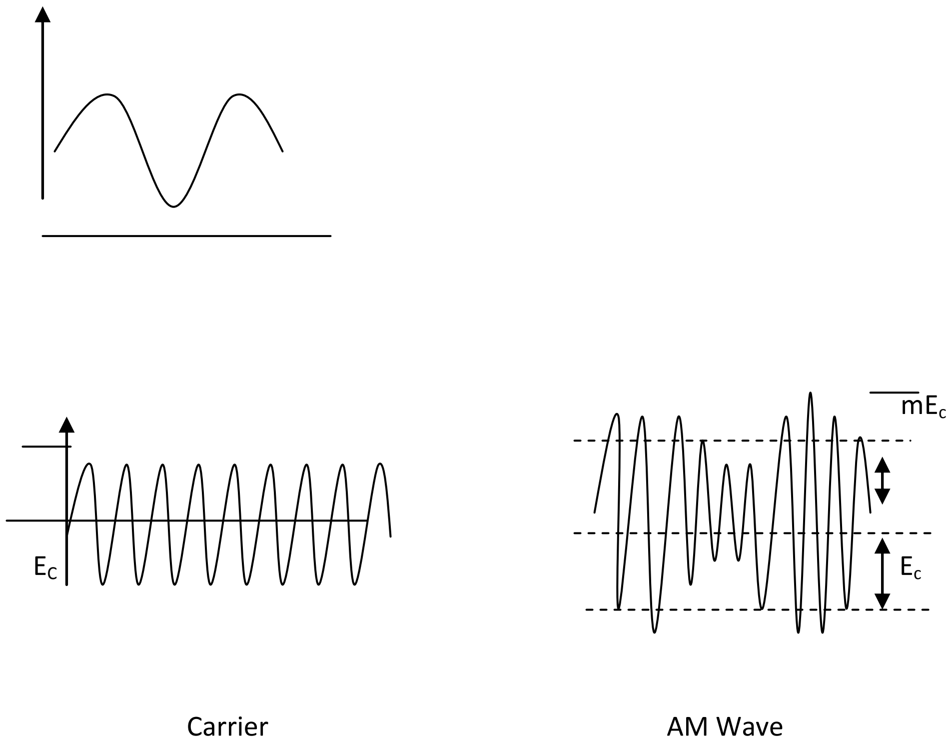

Figure 5.3: AM waveforms

- A carrier wave is represented by $e_c = E_c \cos w_c t$-------------------(1)
  Where e_c ------instantaneous voltage of carrier.

  E_c -----amplitude of carrier.

- In amplitude modulation, the amplitude E_C of the carrier wave is varied in accordance with intensity of the signal as shown in figure.
- Suppose m=modulation index, then change in carrier amplitude $=mE_c$.
  Amplitude or E_{max} of the signal = mE_c.

  $e_s = mE_c \cos w_s t$---------------------------------(2)

  where mE_c is the amplitude of the signal.

  e_s ---------instantaneous voltage of the signal.

The amplitude of the carrier varies at signal frequency fs. Therefore the amplitude of AM wave is given by,

$$E_c + mE_c \cos w_s t = E_c(1+m\cos w_s t)$$

- The instantaneous voltage of AM wave is,
  e = Amplitude x $\cos w_c t$

$$
\begin{aligned}
e &= E_C(1+m\cos w_s t)\cos w_c t \\
&= E_C \cos w_c t + mE_C \cos w_s t \cos w_c t \\
&= E_C \cos w_c t + \frac{mE_C}{2}[2\cos w_s t \cos w_c t] \\
&= E_C \cos w_c t + \frac{mE_c}{2}[\cos(w_c + w_s)t + \cos(w_c - w_s)t] \\
\therefore e &= E_C \cos w_c t + \frac{mE_c}{2}\cos(w_c + w_s)t + \frac{mE_c}{2}\cos(w_c - w_s)t \text{ ------------ } (3)
\end{aligned}
$$

- The AM wave is equivalent ot thesummatoin of theree sinusoidal waves: aone having amplitude E_C and frequency f_c, the second having amplitde $mE_c/2$ and frequency ($f_c + f_s$) and the third having amplitude $mE_c/2$ and frequency $f_c - f_{s.}$.
- The AM wave consists three frequencies viz, f_c, f_c+f_s . The first frequency is the carrier frequency. Thus the process of modulation doesnot change the original carrier frequency but produces two new frequencies f_c+f_s and $f_c - f_{s.}$ which are called sideband frequencies.
- In amplitude modulation the bandwidth is from $f_c - f_{s.}$ to f_c+f_s ie $2f_s$ ie twice the signal frequency.

from equation (3),

$$carrier\ power\ P_C = \frac{\left(\frac{E_c}{\sqrt{2}}\right)^2}{R} = \frac{E_C^2}{2R} ------------(4)$$

$$Total\ power\ of\ sidebands\ P_S = \frac{\left(\frac{mE_C}{2\sqrt{2}}\right)^2}{R} + \frac{\left(\frac{mE_C}{2\sqrt{2}}\right)^2}{R} = \frac{m^2E_C^2}{4R} ---------(5)$$

$$Total\ power\ of\ AM\ wave\ P_T = P_C + P_S$$

$$= \frac{E_C^2}{2R} + \frac{m^2E_C^2}{4R} = \frac{E_C^2}{2R}\left[1 + \frac{m^2}{2}\right]$$

$$= \frac{E_C^2}{2R}\left[\frac{2+m^2}{2}\right] ------------(6)$$

Also fraction of total power carried by sidebands,

$$\frac{P_S}{P_T} = \frac{equn\ (5)}{equn\ (6)} = \frac{m^2}{2+m^2} ----------(7)$$

Frequency modulation

"When the frequency of carrier wave is changed in accordance with the intensity of the signal, it is called frequency modulation‖.

- Here the amplitude of the modulated wave remains the same ie carrier wave amplitude.
- The frequency variations of carrier wave depend upon the instantaneous amplitude of the signal.
- When the signal approaches positive peaks as the B and F, the carrier frequency is increased to maximum and during negative peak, the carrier frequency is reduced to minimum as shown by widely spaced cycles.

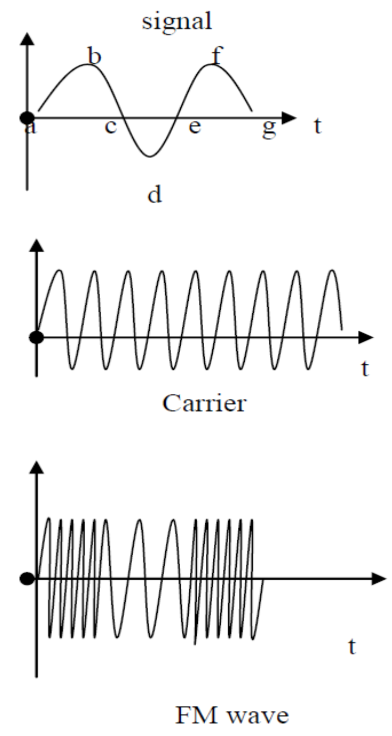

Figure 5.4: FM waveforms

Comparision of AM and FM.

	Amplitude Modulation	**Frequency Modulation**
1	The amplitude of the carrier is varied In accordance with the signal	The frequency of the carrier is varied in accordance with the signal
2	The modulation index _m‘ is <1	The modulation index _β‘ is >1
3	Transmitted power is dependent on modulation index _m‘	Transmitted power is independent on modulation index _β‘
4	Contains only two side bands	Contains multiple side bands
5	Susceptible to noise due to The method of modulation used.	Immune to noise as amplitudes are Clipped
6	Less efficient as carrier contains more power than side	More efficient as it contains more side bands bands and hence more signal power.
7	De-modulation is simple	De-modulation is more complex.

AM diode detector

Fig. below shows a simple diode detector employing a diode and a filter circuit. A detector circuit performs the following two functions.

1. It rectifies the modulated wave.

2. It separates the audio signal from the carrier.

The modulated wave of desired frequency is selected by the parallel tuned circuit L1C1 and is applied to the diode. During positive half cycles of the modulated wave the diode conducts, while during negative half cycles it does not. The result is the output of diode consists of positive half cycle of modulated wave as shown in figure.

- The rectified output consists of r.f. component and the audio signal which cannot be fed to the speaker for sound reproduction. The r.f. component is filtered by the capacitor _C' shunted across the speaker. The value of _C' is large enough to present low reactance to the r.f. component . fc+fs Therefore signal is passed to the speaker

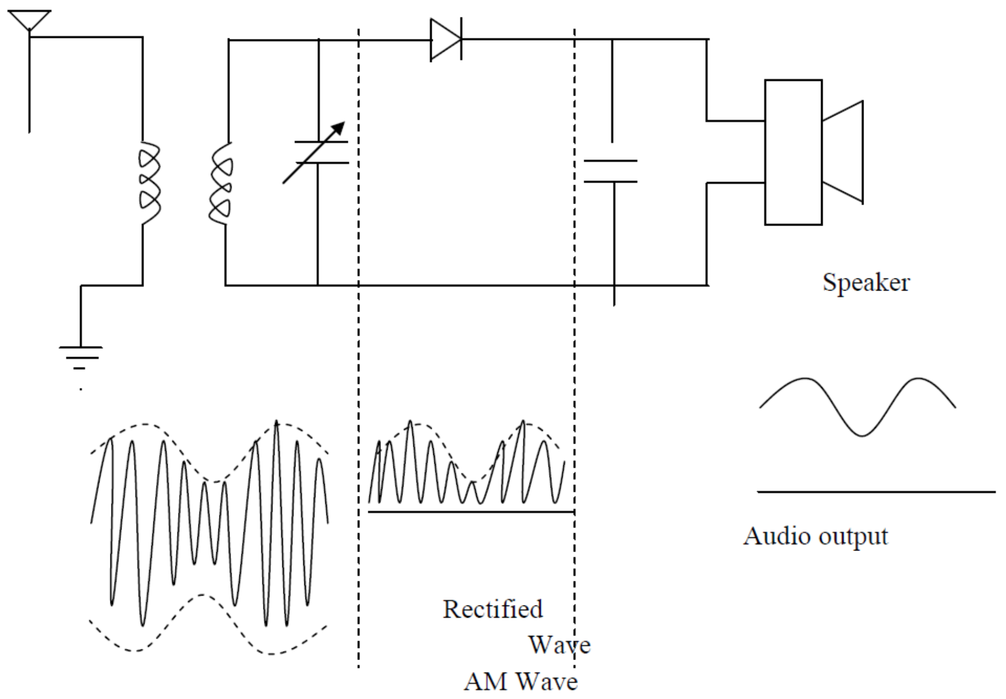

Fig 5.5: AM Diode detector

TRANSDUCERS

INTRODUCTION

A transducer is a device that converts one form of energy to other form. It converts the measured to a usable electrical signal. In other word it is a device that is capable of converting the physical quantity into a proportional electrical quantity such as voltage or current. Transducer contains two parts that are closely related to each other i.e. the sensing element and transduction element. The sensing element is called as the sensor. It is device producing measurable response to change in physical conditions. The transduction element converts the sensor output to suitable electrical form.

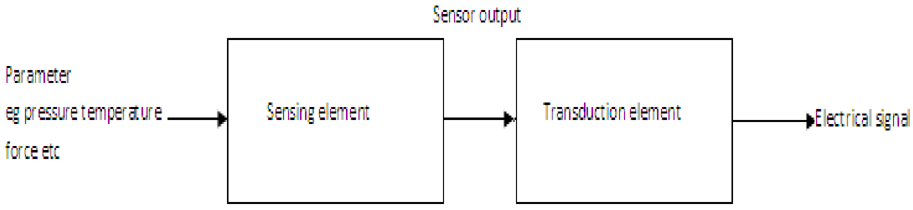

Fig: 5.6: Transducers

Passive Electrical Transducers:

- These transducers need external source of power for their operation. So they are not self generating type transducers.
- A DC power supply or an audio frequency generator is used as an external power source.These transducers produce the output signal in the form of variation in resistance, capacitance, inductance or some other electrical parameter in response to the quantity to be measured.

1. Resistive Transducers

The variable resistance transducers are one of the most commonly used types of transducers. The variable resistance transducers are also called as resistive transducers or resistive sensors. They can be used for measuring various physical quantities like temperature, pressure, displacement, force, vibrations etc. These transducers are usually used as the secondary transducers, where the output from the primary mechanical transducer acts as the input for the variable resistance transducer. The output obtained from it is calibrated against the input quantity and it directly gives the value of the input.

The variable resistance transducer elements work on the principle that the resistance of the conductor is directly proportional to the length of the conductor and inversely proportional to the area of the conductor. Thus if L is the length of the conductor (in m) and A is its area (in m square), its resistance (in ohms) is given by:

$R=\rho l/a$

Where

l -conductor length in m

a – area of crosssection in m^2

ρ – specific resistivity in Ω-m

Resistance Thermometers :

Resistance thermometers, also called resistance temperature detectors (RTDs), are sensors used to measure temperature by correlating the resistance of the RTD element with temperature. Most RTD elements consist of a length of fine coiled wire wrapped around a ceramic or glass core. The element is usually quite fragile, so it is often placed inside a sheathed probe to protect it. The RTD element is made from a pure material, typically platinum, nickel or copper. The material has a predictable change in resistance as the temperature changes and it is this predictable change that is used to determine temperature.

They are slowly replacing the use of thermocouples in many industrial applications below 600 °C, due to higher accuracy and repeatability.

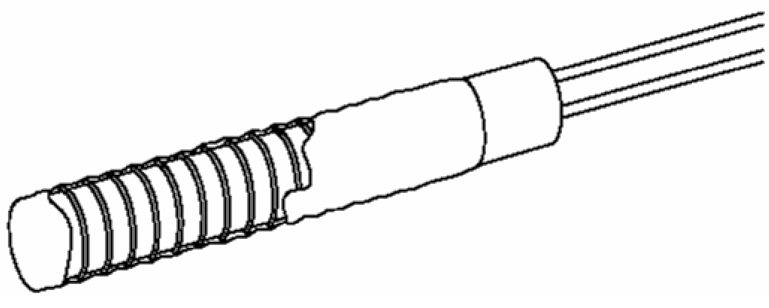

Fig 5.7 : Resistance Thermometers

Thermistor

A **thermistor** is a type of resistor whose resistance varies significantly with temperature, more so than in standard resistors. The word is a portmanteau of *thermal* and *resistor*. Thermistors are widely used as inrush current limiters, temperature sensors, self-resetting overcurrent protectors, and self-regulating heating elements.

$$R = R_0 e^{-B\left(\frac{1}{T_0}-\frac{1}{T}\right)}$$

Where ,

R_0 – resistance at T_0(k)

R - resistance at T(k)

B – constant to be determined experimentally.

For large values of T, we can approximate as

$R = R_0 \exp(\beta/T)$

Linear Variable Differential Transformer

An LVDT, or Linear Variable Differential Transformer, is a transducer that converts a linear displacement or position from a mechanical reference (or zero) into a proportional electrical signal containing hase (for direction) and amplitude information (for distance). The LVDT operation does not require electrical contact between the moving part (probe or core rod assembly) and the transformer, but rather relies on electromagnetic coupling; this and the fact that they operate without any built-in electronic circuitry are the primary reasons why LVDTs have been widely used in applications where long life and high reliability under severe environments are a required, such Military/Aerospace applications.

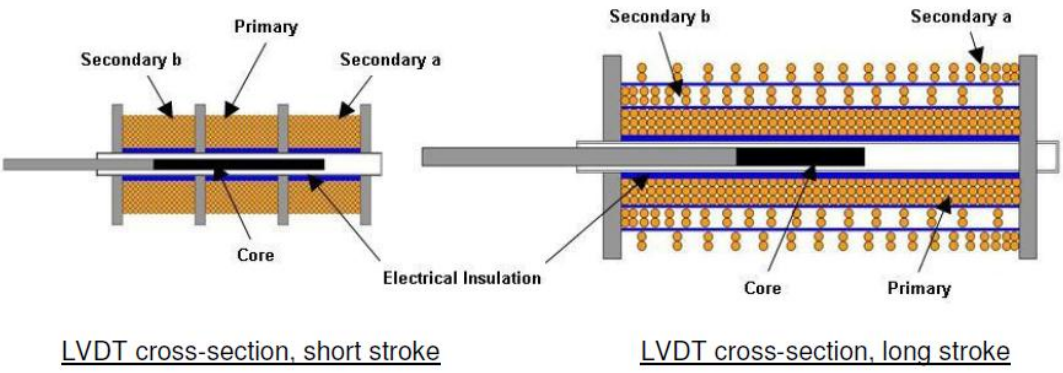

Fig5.8 : Linear Variable Differential Transformer

The LVDT consists of a primary coil (of magnet wire) wound over the whole length of a non-ferromagnetic bore liner (or spool tube) or a cylindrical coil form. Two secondary coils are wound on top of the primary coil for “long stroke” LVDTs (i.e. for actuator main RAM) or each side of the primary coil for “Short stroke” LVDTs (i.e. for electro-hydraulic servo-valve or EHSV). The two secondary windings are typically connected in “opposite series” (or wound in opposite rotational directions). A ferromagnetic core, which length is a fraction of the bore liner length, magnetically couples the primary to the secondary winding turns that are located above the length of the core.

Active electrical transducer

1. **Piezoelectric transducer**

Certain single crystal materials exhibit the following phenomenon: when the crystal is mechanically strained, or when the crystal is deformed by the applica tion of an external stress, electric charges appear on certain of the crystal surfaces; and when the direction of the strain reverses, the polarity of the electric charge is reversed. This is called the direct piezoelectric effect , and the crystals that exhibit it are classed as piezoelectric crystals.

2. **Photoelectric transducer**

Provided is a photoelectric conversion element which suppresses the generation of a reverse current and which has enhanced photoelectric conversion efficiency. The photoelectric conversion element according to the present invention includes at least one support conductive layer, photoelectric conversion layer, porous insulating layer, catalyst layer counter conductive layer, and counter support in series. The photoelectric conversion layer includes a porous semiconductor sub layer containing a semiconductor material and a photosensitizing element adsorbed on the porous semiconductor sub layer. A carrier transport material is placed between the porous insulating layer and the catalyst layer .The porous semiconductor sub layer and the porous insulating layer contain pores. The pores are filled with the carrier transport material .There is no strong bonding force, obtained by deposition by a screen printing process, a vapour deposition process, or a sputtering process, between the porous insulating layer and the catalyst layer .

Recommended Questions

1. What is modulation why it's required?
2. Write short note Amplitude modulation
3. What are diff b/w FM & AM?
4. Explain with neat diagram the principle of Frequency Modulation; write the expressions for an FM wave.
5. Explain with neat diagram the principle of Amplitude Modulation; write the expressions for an AM wave.
6. What are transducers?
7. Explain Passive Electrical Transducers?
8. Explain Active electrical transducer?
9. Explain piezoelectric transducer with a diagram.
10. Explain photoelectric transducer with a diagram.
11. Write a note on Linear Variable Differential Transformer
12. Write a note on Resistive Transducers?
13. Write a note on Resistance Thermometers?