5 ULTRASONICS

→ human audibility limit is in between 20Hz & 20KHz.

→ Accoustic waves having frequency below 20Hz are Infrasonics

→ Accoustic waves whose frequency is above 20KHz. are called ultrasonics.

Detection of ultrasonics

1) Piezo-electric Detector:-

→ using piezo-electric effect presence of ultrasonic waves can be detected.

→ ultrasonic waves are applied to opposite faces of ~~an~~ a piezo-electric crystal. From the perpendicular faces of the ~~crystal~~ crystal an a.c potential is developed. From these ac potential we can detect the presence of ultrasonics.

2) Thermal Detector Method:-

→ A fine platinum wire is moved in a medium of ultrasonics.

→ Temperature change takes place at Nodes and it remains constant at Anti-Nodes.

→ Resistance varies w.r.t the changes in Temperature

→ so resistance changes at Nodes and remains constant at Anti Nodes.

→ The change in resistance is determined by a sensitive bridge arrangement.

3, Sensitive Flame Method.

→ A sensitive flame is moved in a medium of ultrasonics.

→ Due to compressions & rarefactions flickering takes place for the flame at Nodes.

→ But at Anti Nodes the flame remains stationary.

4, Kundt's tube method:-

→ Kundt's tube can be used for the detection of ultrasonics.

Piezo Electric effect.

→ When a Mechanical stress or pressure is applied across the opposite faces of certain crystals ~~seeb~~, a potential difference is developed across the perpendicular ~~cry~~ faces. This phenomenon is called piezo electric effect.

→ crystals which exhibit pieso-electric effect are called pieso electric crystals.

→ quartz, toermalline, Rochelle salt are examples of pieso electric crystals.

Production of ultrasonics using pieso electric ~~cry~~ effect:-

→ (First write what is pieso electric effect from previous topic)

→ converse of pieso electric effect is used for the production of ultrasonics.

→ ie, when a.c potential is applied across the opposite faces of a pieso electric crystal, ultrasonic waves are generated from the perpendicular faces.

→ when the natural frequency and forced frequency becomes equal Resonance ~~is~~ takes place. This result vibration of the crystal in largest amplitudes. It generates ultrasonic waves.

[Draw / Refer figures from Text Page No: 383]

Tank circuit of experimental circuit :-

→ The ac potential to be applied is produced using a tank circuit.

→ It consists of an Inductance coil 'L' and a variable capacitor 'C'.

→ The frequency of a.c Potential to be applied is given by

$$\omega = \frac{1}{2\pi\sqrt{LC}} \quad \text{— (1)}$$

→ The arrangement consists of a quartz crystal placed between two metallic places. It is connected parallell to the tank circuit containing L & C. one end of tank circuit is connected to collector of the transistor.

→ The power is supplied from Vcc through R.F choke. RF choke prevents the intermixing between ac & dc. R1 & R2 provides proper biasing to the base.

Working:

→ When Key K is pressed ac potential is produced from tank circuit. This ac is applied across the quartz crystal.

→ The quartz crystal starts vibrating. The variable capacitor C is adjusted so that natural frequency of forced frequency of the crystal becomes equal. Resonce is attained.

→ The crystal starts vibrating in largest amplitudes. It generates ultrasonic waves.

Theory :-

Natural frequency of the crystal is given by

$$\nu = \frac{1}{2l}\sqrt{Y/\rho} \quad \text{—(1)}$$

$V = \nu\lambda$

$$\nu = \frac{V}{\lambda} = \frac{1}{2l}\sqrt{Y/\rho}$$

Forced frequency is given by

$$\nu = \frac{1}{2\pi\sqrt{(L_1+L_2)C}} \quad \text{—(2)}$$

When these two becomes equal Resonce is attained It generates ultrasonic waves.

Magnetostriction.

Principle:- When a ferromagnetic rod is placed in a changing magnetic field, the length of the rod increases and decreases suddenly. ie, the rods starts vibrating. It is used for the production of ultrasonics.

Apparatus:-

[Draw/Refer figure, Page No: 386 of Text]

→ Important part is a ferromagnetic Rod 'R' which is fixed at the middle.

→ The rod contains two coils L_1 & L_2 at the opposite ends of the rods.

→ The coil L_1 is connected to a variable capacitor C which forms the tank circuit. It is connected to the collector of the transistor.

→ The coil L_2 is connected to the base and emitter of the transistor.

Working:-

→ Key K is closed, then a current flows through coil L_1. Hence a magnetic field is induced.

→ This magnetic field changes the length of rod due magnetostriction.

→ This changes the magnetic flux across L_2 and emf is induced across L_2.

→ since L_2 is connected to the base and emitter of transistor, It increase the forward bias to sustain the oscillations of the tank circuit.

→ The oscillations/vibrations of the rod produces ultrasonic waves.

Theory:-

Natural frequency of the rod is given by

$$\nu = \frac{1}{2l}\sqrt{Y/\rho} \quad \text{—(1)}$$

$V = \nu\lambda$

$$\nu = \frac{V}{\lambda} = \frac{1}{2l}\sqrt{Y/\rho}$$

Forced frequency is given by

$$\nu = \frac{1}{2\pi\sqrt{LC}} \quad \text{—(2)}$$

when these two becomes equal, Resonance is attained. It generates ultrasonic waves.

Application of ultrasonics.

1, NDT - Non Destructive Testing :—

[Refer/Draw Image/Figure from Text - Page No. 389]

→ NDT is a method of Testing without any destruction of the materials and without any obstruction of their future use.

→ It is used for testing flaws, cracks, breakings, cavity, air pockets, imperfections etc.

→ If a flaw is present in a metal block, the incident signal due to change in media at the flaw, undergoes partial reflection and partial transmission. The transmitted ray reflects from the bottom layer of metal block.

→ The output is connected to a CRO.

→ If flaw is present we will get three signal at the monitor of CRO. They are input signal, reflected signal, transmitted signal.

→ If flaw is absent the output of CRO contains only two signal across CRO monitor. They are incident and transmitted and then reflected from bottom separation.

→ From the time periods for the peaks the depth of cavity $d = V(t_1 - t_2)$ can be calculated.

Depth of sea

→ Ultrasonic waves can be used for detecting the depth of sea.

→ Device used for this is called SONAR - Sound operated Navigation and Ranging.

→ In this case the time interval between sending the wave and recieving back the reflected wave from the bottom of sea is recorded.

→ Depth is calculated using the equation

$$V = \frac{2d}{t}$$

Velocity & wavelength of ultrasonics using ultrasonic diffractometer.

[Draw figure from Text, page No: 394]

→ Consider a quartz crystal Q placed between two metal plates. The two metal plates are connected with the terminals of an R.F oscillator.

→ The entire arrangement is placed at the bottom of a rectangular glass chamber. A reflector "R" is placed attached at the ~~bottom~~ top of chamber.

→ The glass chamber is filled with Kerosene or CCl4.

→ When the oscillator works, the quartz crystal starts oscillating. These oscillations are propagated towards the top side and reflected back by the reflector.

→ It forms stationary waves or standing waves which contains nodes and Anti-nodes.

→ So it forms an acoustic grating.

→ Using this arrangement velocity 'v' and wavelength 'λ' can be determined.

Working of ultrasonic diffractometer

→ The acoustic grating is mounted on a grating table. Light from a sodium vapour lamp is allowed to fall on the acoustic grating.

→ The nodes and Anti nodes acts as line & spacing in the case of a plane transmission grating.

→ Diffraction takes place and diffracted beam is observed through a telescope.

→ First Direct image is observed through the telescope.

→ Then R.F oscillator is switched on and the frequency of R.F oscillator varies from 2 to 5 MHz. Then the crystal starts vibrating and Resonance is attained. As a result ultrasonic waves are produced.

→ These waves moves towards the reflected objective ~~intern generates node~~ and is reflected. It forms nodes & Antinodes. Arrangement behaves like an accoustic grating.

→ On either side of central maxima Principal maxima are obtained.

→ The telescope is turned towards the left side principal maxima and the cross wire is adjusted with the principal maxima of first order. MSR & VSR are noted and total reading is calculated.

→ Like the telescope is turned towards the first order principal maxima on Right side and total reading is calculated.

→ From these two readings 2θ is calculated and θ is calculated.

→ The value of "d", distance b/w successive nodes or Antinodes is calculated by the equation $d \sin\theta = n\lambda$ ——(1).

→ wavelength of ultrasonic waves is determined by the equation

$$\lambda_a = 2d \quad \text{——} (2)$$

→ Velocity of ultrasonic wave is determined by the equation

$$\boxed{V = \omega \lambda_a}$$

Knowing the frequency ω of the oscillator, velocity 'V' can be determined.