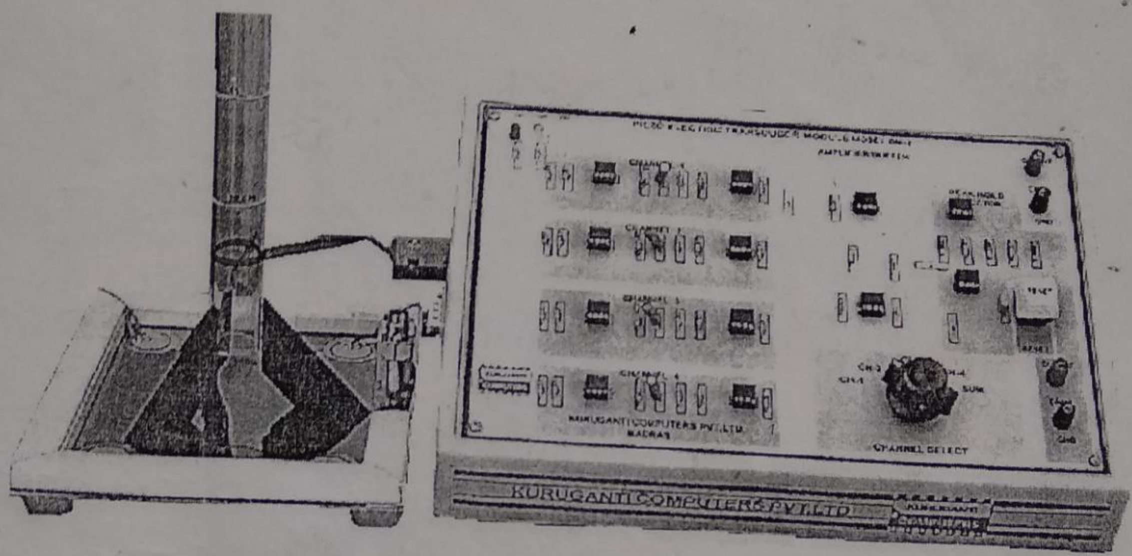
KURUGANTI COMPUTERS

PIEZO ELECTRIC TRANSDUCER
MODEL DM -2

The Piezo electric transducer is one, which changes its state from mechanical energy to electric energy or vice versa. For example, a) when a Piezo electric crystal is subjected to mechanical vibrations, an electrical output is produced. This principle is used for measuring the vibrations in a mechanical fixture. b) When a Piezo electric crystal is excited electrically, the output is mechanical. This principle is used in audio buzzers.

Piezo electric crystals are used in seismic instruments. There are several electrical and mechanical considerations to design a Piezo for a specific application.

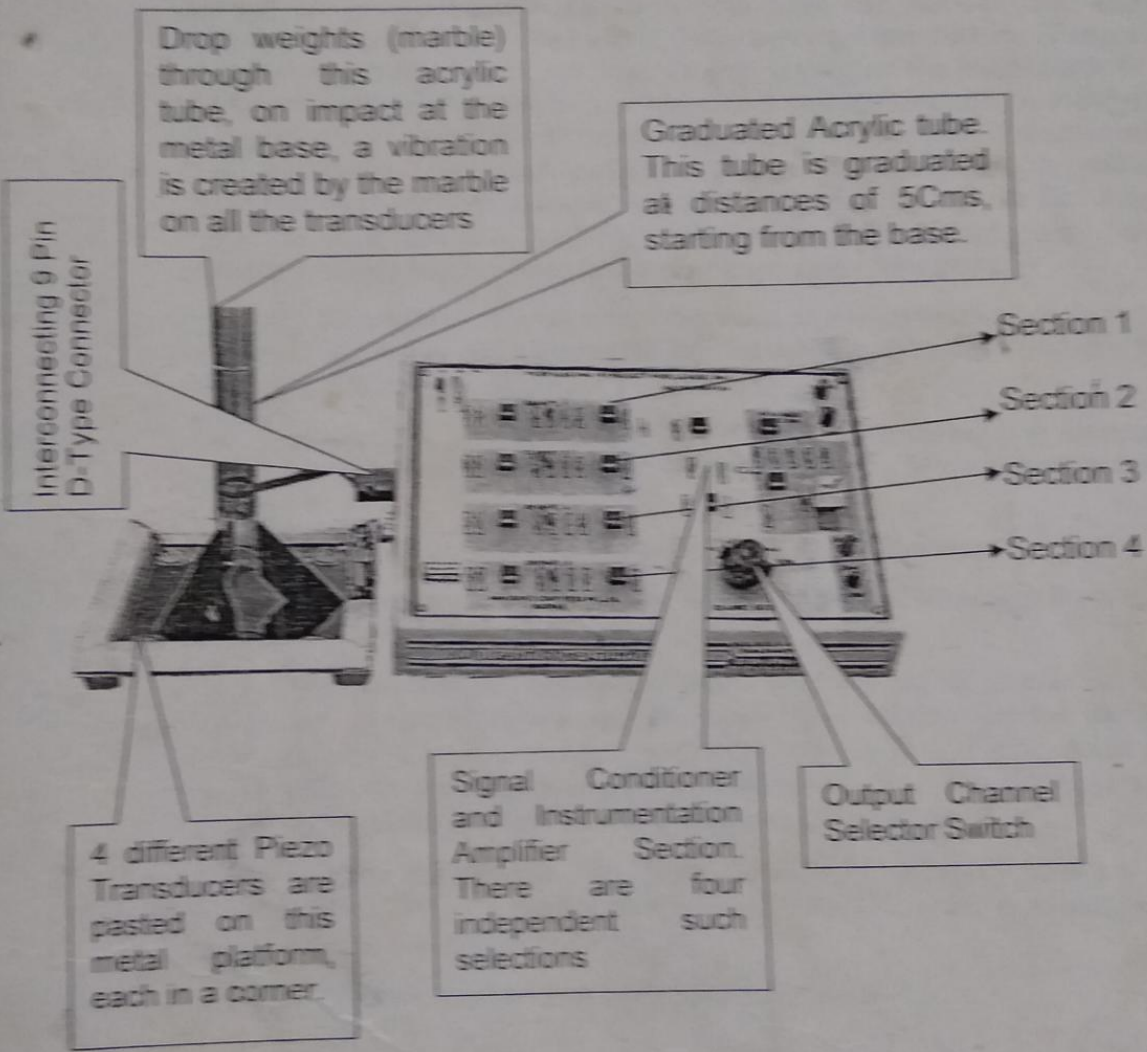


In this trainer, four Piezo electric crystals are used. These are placed on a metallic platform on four sides of the plate. This is kept adjacent to the measuring instrument (trainer). Each is separated by a distance of 3 to 4 inches. Four high –input impedence amplifiers are used input amplifiers. Output of each piezo electric crystal is connected as input at its input terminals. This is followed by a signal conditioning circuit using an OpAmp. This amplifier is called as buffer amplifier. This setup constitutes an amplifier section for one crystall. There are 4 such independent amplifier sections.

The outputs of all the amplifiers are connected to a summing amplifier followed by a sample and hold amplifier, through a switch selector. Two separate sets of terminals aer provided on the front panel for measurements. They are one before sample and hold amplifier , the other set after sample and hold amplifier. In order to create a measured quantity, of mechanical vibration, in terms of electrical output, a mechanical metal platfrom jig is provided. Using this jig it would be possible to drop 20gm weight (using a glass marble) from different heights.

It is be possible to make **qualitative study only**. Often it is hard to reproduce the same set of readings for a given mechanical vibration. This is because; the place at which the

How to assemble the instrument for the first time:-



1. Refer diagram.
2. Identify
   a) Transducer assembly metal platform.
   b) Measuring instrument
   c) An acrylic tube Jig
   d) 9 pin D-type interconnecting cable.

Step 1. Connect 9 pin D-type connector from transducer assembly platform to the instrument.

Step 2. Place the acrylic tube on the platform such that the triangular legs are resting on the transducer platform. This tube has semi-circular slots made in the tube at an interval of 5 Cms, starting from bottom. This can be placed on the platform, with triangle legs resting on the metal platform. Slots are made on this acrylic tube, so that a visiting card can be inserted in the slot, such that when a marble is pushed from top, the card prevents from falling on the metal platform. When you are ready to make measurement, you can remove this card such that the marble can drop on to the metal platform, creating a vibration on all the transducers. This vibration can be measured in terms of voltage using a multimeter.

Step 3. Connect a multimeter at the output terminals of the instrument at sample and hold terminals and switch ON the multimeter. Set the voltmeter to read 2V DC full scale deflection.

Step 4. Turn the channel selector switch to position 1by rotating the selector switch extreme counter clockwise position, to measure the output of first transducer.

Step 5. Turn ON the instrument. An LED will glow on the instrument.

Step 6. Insert a visiting card in one of the slots say at 30Cm height from the bottom of the transducer platform.

Step 7. Drop a marble from top of the acrylic tube. This will not fall directly on the transducer platform, because of the obstruction caused by the visiting card. When this card is removed suddenly, the marble will drop down on to the platform, causing a mechanical vibration. You are supposed to measure the voltage when the marble falls on the platform.

Note: Repeatability is hard to achieve, as Piezo transducers pick up smallest of tremors. More over this is a demonstration instrument to show a mechanical vibration is converted into an electric output.

Repeat step 6 and 7 for different heights and record your observations.

Experiment 2

Step 1. Turn the channel selector switch to position 2 by rotating the selector switch one step clockwise from extreme counter clockwise position, to measure the output of second transducer.

In this experiment we will observe, the output voltages for other channels, namely 2nd channel. You can repeat step 4 to 7 as above and record your observations.

Piezoelectric pressure transducers are widely used for the measurement of rapidly varying pressure as well as shock pressures. They provide flat frequency response from 1 Hz to 20 kHz, the natural frequency being of the order of 50kHz. The lead-zirconate-type ceramic crystals have much higher sensitivities than quartz elements. The transducers can operate over a wide temperature range without appreciable temperature induced errors. Quartz devices can be used over a temperature range of -200□ to + 300□C; whereas ceramic devices are limited to + 100□ C. Sometimes the output is affected by relatively little known pyroelectric effects. These devices find application in aeronautics, turbines, pumps, hydraulics, and acoustics.

The various configurations under which the PZT (piezoelectric transducer) material can be employed for pressure (force) measurements are given in Fig. 7.16. The shape of the element may be a disc, plate, or tube, which may be operated under normal, transverse, or shear modes. Beam and disc-shaped bimorph types are also quite popular ~~in certain~~ applications.

In practical transducers, it is possible to stack a number of identical plates one above the other.electrically connected in series or in parallel. In this case, the charge sensitivity qp increased by a factor equal merit and remains constant indicating the mode effectiveness. The sensitivities, static capacitance, and natural frequencies for a number of configurations of the PZT –5A lead zirconate elements shown in Fig.7.16 are given in Table 7.2. It may be noted that the plate undergoing transverse compression is similar to that in direct compression, but the d31 constant replaces d33, thereby reducing the sensitivity by a factor of two or three. The bending modes invariably use elements of bimorph construction. These consist of two similar plates with conducting plating on the upper and lower faces, which are connected mechanically and electrically along their common surface. They are polarized along its thickness. By appropriate electrical connection, the potential differences may be added. Alternatively, by using plates polarized in opposite directions, an added output can be obtained across the outer surfaces.

It would appear that the mode with the highest charge sensitivity-natural frequency-product is the only one that need be considered, but with the limitations imposed by transducer size, it is often not possible to obtain sufficiently high sensitivity using this mode. In such circumstances, a mode with lower with value of qpfo may be chosen sacrificing the natural frequency.

Table 7.2 shows that a disc or plate under bimorph configuration in normal compression gives the largest value of qpfo. For direct-pressure measurement, the normal compressive mode and the bimorph disc in the bending mode are the best. A typical complete assembly of a normal compressive mode transducer is as shown in fig7.17

mechanical vibration created w.r.t the actual distance from the transducer makes lot of difference. Hence it is very difficiuilt to get same reading repeatedly.

Specifications:-

- Transducer : 4 numbers of Piezo transducers placed on a jig.
- Selector : 4-position selector switch is used to check the output from each transducer.
- Output : Two separate sets of output terminals are provided. a) Output directly from signal conditioner, b) from sample and hold also.
- Jig : Included.
- Built-in Power Supply.

Piezo Electric Transducer

The Piezo-electric transducer is a demonstration instrument. In the Piezo electric transducer trainer, when an externally applied force, entering the transducer through its base platform, on which the transducers are mounted, The transducer produces an e.m.f across the crystal proportional to the magnitude of applied pressure. This property is used in the trainer to demonstrate the principle of Piezo-electric transducer.

This property of piezo electricity has been utilized in the design of pressure transducers, where in the mechanical stress is generated by the diaphragm subjected to pressure. The stress distribution in the crystal will depend not only on the load applied but also the manner in which this is applied, and also upon the size and shape of the sensing element. Piezo-electric transducer find wide application in the measurement of acceleration and force. The performance of a crystal element depends upon the magnitude of the crystal's piezo electric constants.

The important parameters considered are sensitivity, natural frequency, non-linearity, hysteresis, temperature effects, acceleration response, and cross sensitivity. The performance of a crystal element depends upon the magnitude of the crystal's piezoelectric constants. In addition, other related properties are relative permitivity, the natural time constant of the material, the elastic constants, density, and the change of piezoelectric constants with temperature.

Although a very large number of materials are piezoelectric, the most popular ones having significant values of piezoelectric constants and sensitivity are natural quartz, Rochelle salt, ADP, and a variety of synthetic ceramic materials like barium-titanate and lead-zirconatetitanate. Of these, natural quartz is the most stable device for many applications. It has lower temperature sensitivity and, a higher resistively, thus giving an inherently long time constant, which permits static calibration. Further, it exhibits good linearity over a wide range of stress levels with very low hysteresis. On the other hand, piezoelectric ceramics have considerably higher sensitivity and wide adaptability, though the temperature characteristics are poor. The design of both pressure transducers and associated electronic circuitry is affected by the choice of the sensing element materials, although the basic design approach is similar in all piezoelectric materials.

Experiment 3 and 4 will be similar to experiment 2. The only difference is that channel selector is rotated to position 3 in experiment 3 and to position 4 in fourth experiment. There is no other difference otherwise.

Note: You can connect a CRO at the output terminals before sample and hold, keeping the sweep to the lowest rate say at 200mS or less and voltage switch to 1V DC per division range. Whenever a marble is dropped, the beam will swing instantaneously to approximately 1 to 2.5V and drop back automatically. This demonstrates that the output will not last longer.

Sum Output:

There is a fifth position for the channel selector switch. This is summing switch. In this position the output will be half of sum of all the voltages recorded by all the transducers. This position has no significant experiment value except a sum output is also provided.

Piezo Electric Transducer circuit as in setup