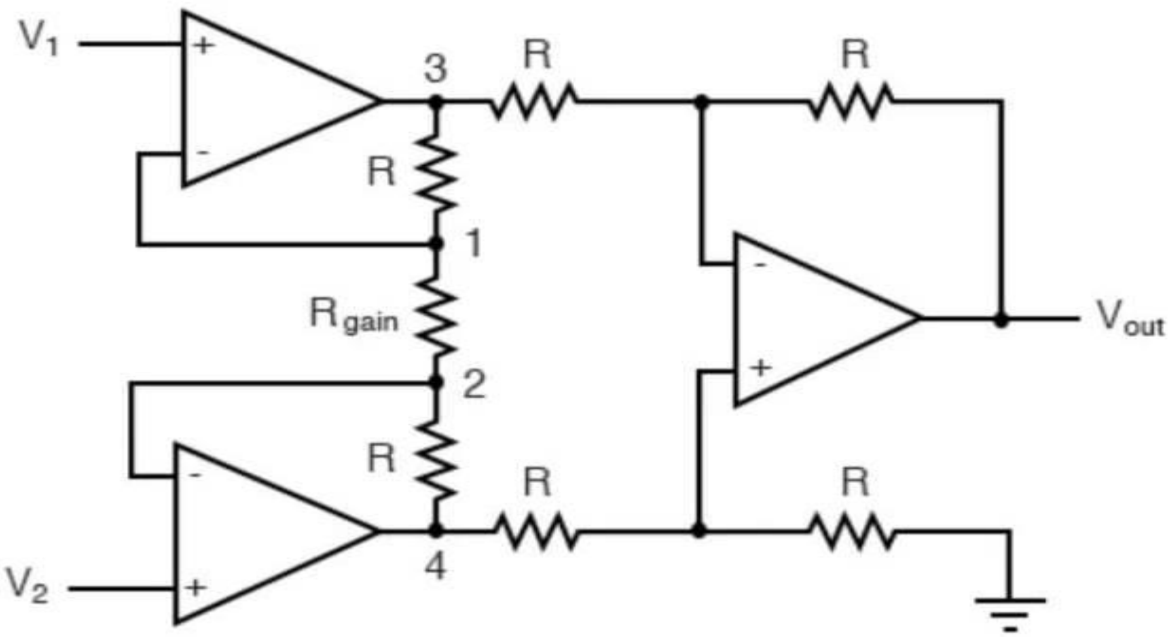
Unit -5, Signal Generators & Analytical Instruments ,(08 Periods)

Definition:-

> Instrumentation amplifiers are **precision**, integrated operational amplifiers that have differential input and single-ended or differential output. Some of their key features include very high common mode rejection ratio (CMRR), high open loop gain, low DC offset, low drift, low input impedance, and low noise.



Understanding the Instrumentation Amplifier Circuit

This intimidating circuit is constructed from a buffered differential amplifier stage with three new resistors linking the two buffer circuits together. Consider all resistors to be of equal value except for R_{gain}.

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The negative feedback of the upper-left op-amp causes the voltage at point 1 (top of R_{gain}) to be equal to V_1. Likewise, the voltage at point 2 (bottom of R_{gain}) is held to a value equal to V_2. This establishes a voltage drop across R_{gain} equal to the voltage difference between V_1 and V_2. That voltage drop causes a current through R_{gain}, and since the feedback loops of the two input op-amps draw no current, that same amount of current through R_{gain} must be going through the two "R" resistors above and below it.

This produces a voltage drop between points 3 and 4 equal to:

$$V_{3\text{-}4} = (V_2 - V_1)(1 + \frac{2R}{R_{gain}})$$

The regular differential amplifier on the right-hand side of the circuit then takes this voltage drop between points 3 and 4 and amplifies it by a gain of 1 (assuming again that all "R" resistors are of equal value).

Yes, we could still change the overall gain by changing the values of some of the other resistors, but this would necessitate *balanced* resistor value changes for the circuit to remain symmetrical. Please note that the lowest gain possible with the above circuit is obtained with R_{gain} completely open (infinite resistance), and that gain value is 1.

REVIEW:

- An *instrumentation amplifier* is a differential op-amp circuit providing high input impedances with ease of gain adjustment through the variation of a single resistor.

Advantages of the Instrumentation Amplifier

Though this looks like a cumbersome way to build a differential amplifier, it has the distinct advantages of possessing extremely high input impedances on the V_1 and V_2 inputs (because they connect straight into the noninverting inputs of their respective op-amps), and adjustable gain that can be set by a single resistor.

Manipulating the above formula a bit, we have a general expression for overall voltage gain in the instrumentation amplifier:

$$A_V = (1 + \frac{2R}{R_{gain}})$$

Though it may not be obvious by looking at the schematic, we can change the differential gain of the instrumentation amplifier simply by changing the value of one resistor: R_{gain}.

Applications of Distortion Meter

1. Distortion meters are being widely used now a days especially in music industry. To make the sound more pleasing and musical, many frequencies are eliminated and some are enhanced as well. For eliminating the unwanted frequencies we use a distortion meter.

2. Distortion meters also find extensive uses in electrical circuits now a days. As mentioned earlier they are used to eliminate the distortions in the currents and voltages which can also prove fatal in some cases.

3. Many advance electrical machines use distortion meters to compensate for the current distortions so that the expensive appliance can be saved from damage due to these distortions.

This was all for now. To know about more such devices do give this blog a visit in upcoming days because I have many other informative articles coming for you my friends.

How to use a distortion meter?

Now that we are familiar with the basics of harmonic distortion, and also the fact that a distortion meter is used for the detection and measurement of such frequencies, what lies next?

So once the frequencies are detected, the distortion meter now acts such that it works to eliminate the effect of such frequencies. For this purpose it has the option to set certain predefined parameters, so that any frequencies which lie outside these set of parameters are eliminated and not allowed to pass along with the original signal. The original signal can then be produced at the output in whatever way it is required.

So in short a distortion meter not only detects and measures the distortion in our signal frequencies but also works to overcome or eliminate them.

What is a distortion meter used for? Now distortion meter is such a device which measures detects the frequencies which are responsible for producing harmonic distortion in our signal. So the first question that needs to be answered is that what is harmonic distortion?

Harmonic distortion

Harmonic distortion is the distortion in our signal that is produced by the additional frequencies generated in the signal. These frequencies are nothing but multiples of the original frequency of our signal. Harmonic distortion occurs not only in sound waves, as that is the most commonly used example.

It also occurs in electrical signals, that is, when a current is passing through a circuit, it can induce vibrations in the circuit and the vibrations produced would obviously be some multiple of the current signal frequency. Hence these vibrations can cause

The above block diagram consists of mainly **two paths**. Those are upper path and lower path. Upper path is used to produce AF sine wave and the lower path is used to produce AF square wave.

Wien bridge oscillator will produce a sine wave in the range of audio frequencies. Based on the requirement, we can connect the output of Wien bridge oscillator to either upper path or lower path by a switch.

The upper path consists of the blocks like sine wave amplifier and attenuator. If the switch is used to connect the output of Wien bridge oscillator to upper path, it will produce a desired **AF sine wave** at the output of upper path.

The lower path consists of the following blocks: square wave shaper, square wave amplifier, and attenuator. The square wave shaper converts the sine wave into a square wave. If the switch is used to connect the output of Wien bridge oscillator to lower path, then it will produce a desired **AF square wave** at the output of lower path. In this way, the block diagram that we considered can be used to produce either AF sine wave or AF square wave based on the requirement.

Integrator present in the above block diagram, gets constant current alternately from upper and lower current sources for equal amount of time repeatedly. So, the integrator will produce two types of output for the same time repeatedly –

- The output voltage of an integrator **increases linearly** with respect to time for the period during which integrator gets current from upper current source.
- The output voltage of an integrator **decreases linearly** with respect to time for the period during which integrator gets current from lower current source.

In this way, the integrator present in above block diagram will produce a **triangular wave**.

Square Wave & Sine Wave

The output of integrator, i.e. the triangular wave is applied as an input to two other blocks as shown in above block diagram in order to get the square wave and sine wave respectively. Let us discuss about these two one by one.

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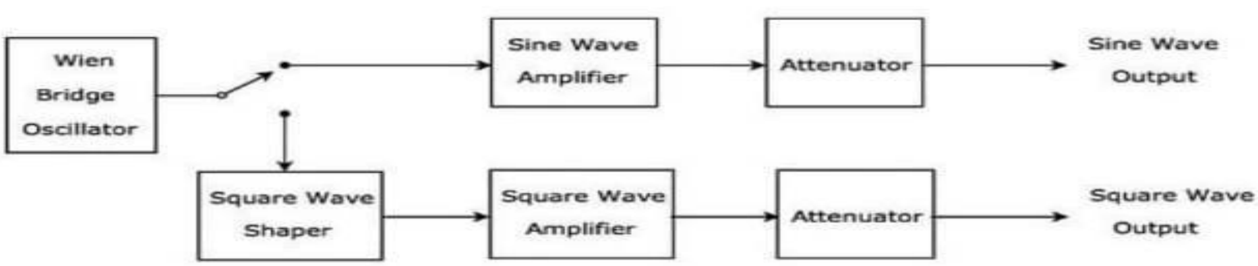
Signal generator is an electronic equipment that provides standard test signals like sine wave, square wave, triangular wave and etc. It is also called an oscillator, since it produces periodic signals.

The signal generator, which produces the periodic signal having a frequency of Audio Frequency (AF) range is called **AF signal generator**. the range of audio frequencies is 20Hz to 20KHz.

AF Sine and Square Wave Generator

The AF signal generator, which generates either sine wave or square wave in the range of audio frequencies based on the requirement is called AF Sine and Square wave generator. Its **block diagram**is shown in below figure.



The above block diagram consists of mainly **two paths**. Those are upper path and lower path. Upper path is used to produce AF sine wave and the lower

The triangular wave has positive slope and negative slope alternately for equal amount of time repeatedly. So, the **voltage comparator multi vibrator** present in above block diagram will produce the following two types of output for equal amount of time repeatedly.

- One type of constant **(higher) voltage** at the output of voltage comparator multi vibrator for the period during which the voltage comparator multi vibrator gets the positive slope of the triangular wave.
- Another type of constant **(lower) voltage** at the output of voltage comparator multi vibrator for the period during which the voltage comparator multi vibrator gets the negative slope of the triangular wave.

The voltage comparator multi vibrator present in above block diagram will produce a **square wave**. If the amplitude of the square wave that is produced at the output of voltage comparator multi vibrator is not sufficient, then it can be amplified to the required value by using a square wave amplifier.

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The **sine wave shaping circuit** will produce a sine wave output from the triangular input wave. Basically, this circuit consists of a diode resistance network. If the amplitude of the sine wave produced at the output of sine wave shaping circuit is insufficient, then it can be amplified to the required value by using sine wave amplifier.

Harmonic distortion

Harmonic distortion is the distortion in our signal that is produced by the additional frequencies generated in the signal. These frequencies are nothing but multiples of the original frequency of our signal. Harmonic distortion occurs not only in sound waves, as that is the most commonly used example.

It also occurs in electrical signals, that is, when a current is passing through a circuit, it can induce vibrations in the circuit and the vibrations produced would obviously be some multiple of the current signal frequency. Hence these vibrations can cause distortion in our original signal. This distortion in current can lead to many problems like voltage fluctuation etc.

The importance of an **instrumentation amplifier** is that it can reduce unwanted noise that is picked up by the circuit. The ability to reject noise or unwanted signals common to all IC pins is called the common-mode rejection ratio (CMRR). **Instrumentation amplifiers** are very useful due to their high CMRR.