PHY-SE-4014
BASIC INSTRUMENTATION SKILLS
Unit V: Signal Generators and Analysis Instruments (Lectures 4)

SIGNAL GENERATOR

Definition: A signal generator is an equipment that is used to produce signals of varying amplitude and frequency. It is usually a source for generating sinusoidal signals. However, it can also produce a signal in the form of a square wave, triangular wave or sawtooth wave etc.
The adjustable frequency range of the generated signal falls between a **few Hz and MHz**. While the amplitude can be adjusted from some millivolts to volts.

How a signal generator differs from an oscillator???????????

*An oscillator also generates **sinusoidal and non-sinusoidal waveforms**. But, a signal generator holds the ability to modulate the output signal with another signal.*

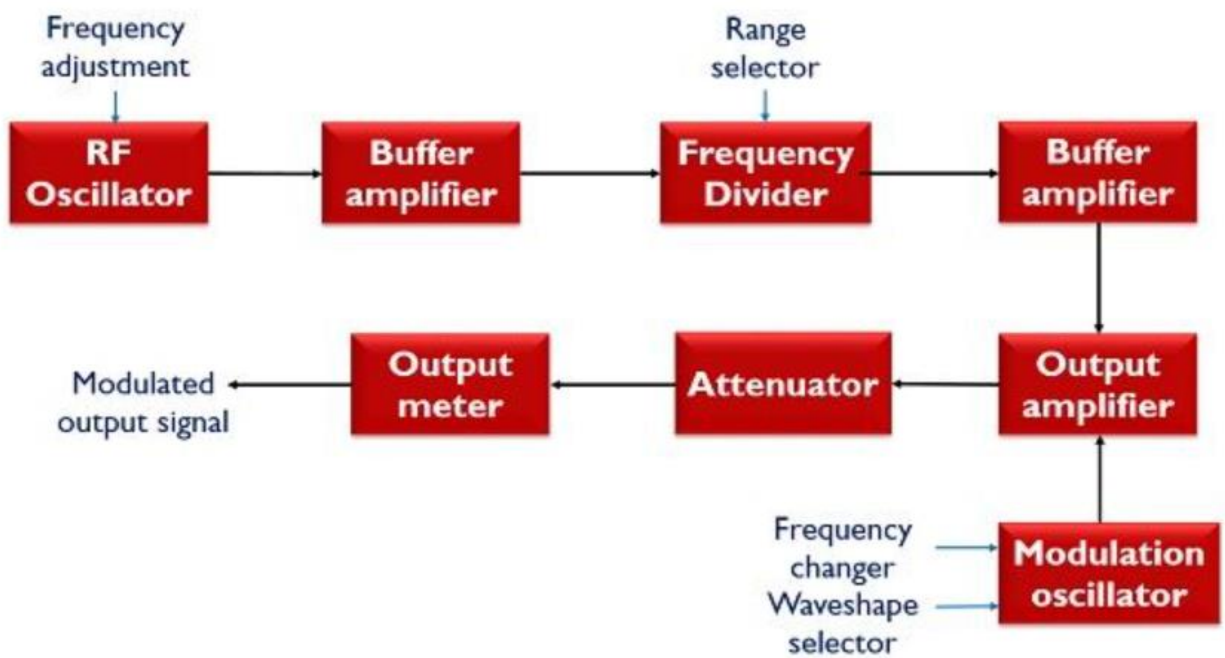
USE OF THE SIGNAL GENERATOR

The major use of the signal generator is to provide proper signals for the purpose of testing, calibrating or troubleshooting of electronic circuits.

Usually, the signal generated (output) can be amplitude or frequency modulated. However, it is not necessary that every time only the modulated signal is produced.

BLOCK DIAGRAM AND WORKING OF SIGNAL GENERATOR

The figure here shows the block diagram representation of an AM(Amplitude **M**odulated**) signal generator**:



Block diagram of Signal Generator

In the above figure, it is clearly seen that an **RF oscillator** is placed at the beginning of the arrangement. This oscillator **generates a carrier signal having a frequency range** 100 KHz to 30 MHz**. The frequency of this carrier signal can be varied by making use of a selector switch**.

Also, a **modulation oscillator** is placed that produces a modulating signal. As we can see in the above figure that two input lines are provided in this modulation oscillator. One is for frequency or amplitude adjustment and other is for the selection of waveform.

This waveform selector is basically used to have sinusoidal or non-sinusoidal waveforms at the output.

The radio frequency carrier signal through a **buffer amplifier** (its use: *the buffer amplifier acts as an isolator in order to provide good isolation between the oscillator and output amplifier. This reduces the effects of distortion in the generated signal.)* is fed to an **output amplifier** along with the modulating frequency signal. This output amplifier is a wideband amplifier.

So, the generated signal gets amplified in the output amplifier

This amplified output is then given to an **attenuator**. The reason for providing the output voltage to an attenuator is to adjust the voltage of the signal generated at the output in the range of **1 μV to 0.1 V**.

In the case of low-frequency signals, either resistive or waveguide attenuators are used. However, in the case of high-frequency signal waveguide attenuators are used.

REQUIREMENTS OF A SIGNAL GENERATOR

- It must produce a signal of stable amplitude.
- The frequency of the waveform should be controllable.
- The generated signal must be free from harmonics and distortion.

So, from the above discussion, we can clearly say that a signal generator is able to produce modulated signals of different waveforms

TYPES OF SIGNAL GENERATOR

Signal generators are majorly classified as follows:

1. **Function generator**
2. **Sweep frequency generator**
3. **Pulse generator**

Function generator:

Function generators are electronic devices that generate repetitive non-sinusoidal waveforms. They are commonly used to create test signals for measuring and adjusting electronic equipment.

They generate various types of waveforms at its output like a sinusoidal wave, sawtooth wave, a triangular wave, square wave etc. It offers variable frequency in the range of few Hz to several KHz.

The generation of a variety of waveforms proves its versatility as various waveforms are utilized in different applications.

Sometimes different waveforms (generally 2) can also be generated at the same time by a function generator.

IT'S USE:

Function generators are typically used in electronics to generate various waveforms; they are also beneficial in acoustics, seismology, and geophysics applications.

Sweep frequency generator:

It is a type of signal generator that has the ability to generate variable frequency sinusoidal waveform. Basically, in a sweep frequency generator, the output frequency automatically varies between 2 selected values.

But, in this case, the amplitude of the signal is kept constant with the variation on frequency.

Its frequency range has 3 bands i.e., 0.001 Hz to 100 KHz, 100 KHz to 1500 MHz and 1200 GHz.

Pulse generator:

A pulse generator is a compact electronic device that generates voltage, current, or power pulses.

Thus they produce pulsed waveform at its output. More specifically, this type of generators produces rectangular pulses at its output.

Pulse generators use a clock signal or some other source of periodic timing to generate a train of identical pulses.

These pulses occur by an external event, such as pressing a button or turning on a light switch.

Either analog, digital or combination of the two techniques can be utilized by the pulse generator. By varying the width of the pulses various forms of pulsed signals can be achieved.

IT'S USE:

Pulse generators are valuable in testing and measurement instruments and industrial control applications such as switching appliances on and off under program control.

Pulse Generators are sound in industrial, scientific, and medical areas to provide a clean and precise source of electronic pulses

These devices are helpful in medical equipment to measure heart rates and other vital functions.

RADIO FREQUENCY (RF) SIGNAL GENERATORS:

A radio frequency (RF) signal generator is an electronic device that generates electromagnetic signals in the RF (radio frequency) portion of the spectrum.

RF signal generators are helpful in terms of testing and troubleshooting purposes, especially in the development stages of consumer electronics devices, such as mobile phones.

RF signal generators have two primary uses:

1. Generating a carrier signal for electronics testing and
2. Calibration of a source of modulated RF signals for electronic component failure analysis.

RF signal generators produce sinusoidal and pulse-modulated RF signals with an arbitrary waveform and modulation. It makes RF signal generators a valuable tool for testing many devices, including wireless receivers from cell phones to Wi-Fi receivers

DISTORTION FACTOR OR TOTAL HARMONIC DISTORTION (THD)

Harmonic distortion tends to widen the frequency spectrum of the output emissions from a device by adding signals at multiples of the input frequency. Hence it distorts the original signal.

THD is a measurement of the harmonic distortion present in a signal.

THD or distortion factor is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency.

The THD is usually expressed in percent or in dB relative to the fundamental as distortion attenuation.

In audio systems, **lower distortion means** the components in a loudspeaker, amplifier or microphone or other equipment produce a more accurate reproduction of an audio recording.

MATHEMATICAL EXPRESSION:

When a sinusoidal signal of frequency **ω** passes through a non-ideal, non-linear device, additional content is added at multiples **nω** (harmonics) of the original frequency. THD is a measure of that additional signal content not present in the input signal.

- If we want to know the **contribution of the original frequency with respect to its harmonics** , then the **measurement of THD is most commonly defined** as the ratio of the **RMS** (Root Mean Square) amplitude of a set of higher harmonic frequencies(i.e., 2nd, 3rd, 4th…….and so on) to the RMS amplitude of the first harmonic, or fundamental frequency and is represented by **THD_F.**

$$\mathrm{THD_F} = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \cdots}}{V_1}$$

Where V_1 is the RMS value of the fundamental component(1st harmonic) and V_2, V_3, V_4…… are the RMS value of the 2nd, 3rd ,4th harmonics and so on.

Measurements for calculating the THD are made at the output of a device under specified conditions.

A variant definition uses the fundamental plus harmonics as the reference, though usage is discouraged.

$$\mathrm{THD_R} = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \cdots}}{\sqrt{V_1^2 + V_2^2 + V_3^2 + \cdots}} = \frac{\mathrm{THD_F}}{\sqrt{1 + \mathrm{THD_F^2}}}$$

These can be distinguished as **$\mathrm{THD_F}$** (for "fundamental"), and **$\mathrm{THD_R}$** (for "root mean square").

DISTORTION FACTOR METER

Distortion meter (or more precisely distortion factor meter) is an electronic measuring instrument which displays the amount of distortion added to the original signal by an electronic circuit.

A distortion factor meter is actually a level-meter with two switchable parallel circuits at the input. The first circuit measures the total signal at the output of a system. (For low distortion levels this will be almost equal to fundamental). That value is adjusted to read 100% or, equivalently, to 0 dB. The second circuit is a high pass filter which removes (as much as practical) the fundamental frequency. This can be a notch filter, one which passes all but the fundamental, with negligible attenuation at other frequencies (including whatever harmonics might be present). Alternatively, if the distortion products are at higher frequencies, a high-pass filter can be used if its cutoff rate is sufficiently steep to not affect the expected distortion products. The output of the filter is measured as a percentage of the fundamental, and the reported value will be the distortion value.