

*. Introduction :

Wave analyser measures the relative amplitude of single-frequency components in a complex or distorted waveform. This can also be regarded as a frequency component that can be selected and its amplitude can be determined.

The signal to be analysed is applied first to the input attenuator. Here the meter range switch is set on the front panel. Then the signal is given to the driver amplifier, the output of the driver amplifier is given to a high-Q active filter. The filter consists of a cascaded arrangement of RC resonant sections and after amplifiers. The passband of the total filter section is covered in a decade steps over the entire audio range by switching capacitors in the RC sections. Polystyrene capacitors with good tolerance are used for selecting the frequency ranges. Precision potentiometers are used to tune the filter to any desired frequency within the selected pass band.

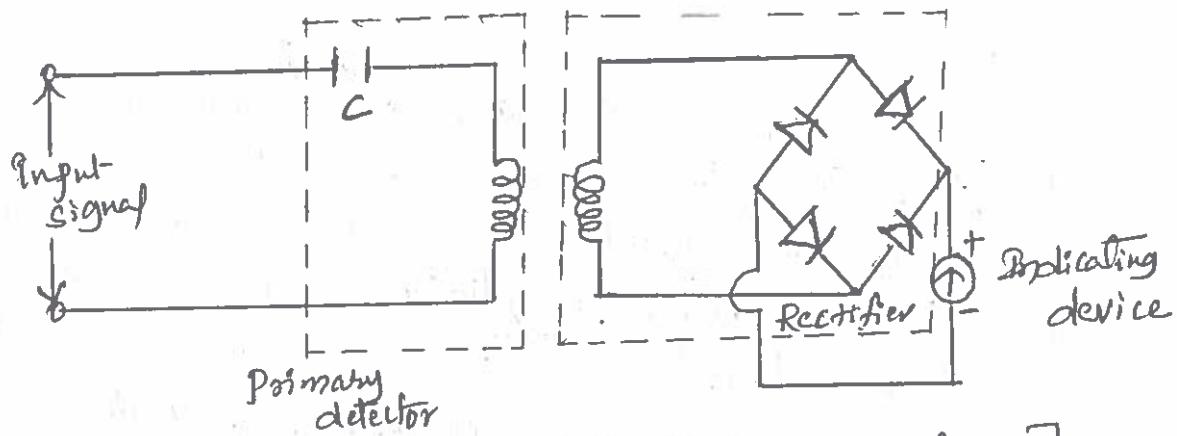
*. Basic Wave Analyzer :

A basic wave analyzer consists of a primary detector, which is a simple LC circuit. The LC circuit is adjusted for resonance at the frequency of the particular harmonic component to be measured.

The intermediate stage is a full wave rectifier, to obtain the average value of the input signal. The indicating device is a simple dc voltmeter that is calibrated to read

the peak value of the sinusoidal input voltage. (2)

Since the LC circuit is tuned to a single frequency, it passes only the frequency to which it is tuned and rejects all other frequencies. A number of tuned filters, connected to the indicating device through a selector switch, would be required for a useful wave analyzer.



* AF Wave Analyzer [frequency Selective Wave Analyzer]:

The wave analyzer consists of a very narrow pass-band filter section which can be tuned to a particular frequency within the audible frequency range ($20\text{ Hz} - 20\text{ kHz}$). The block diagram of wave analyzer is shown below.

The complex wave to be analyzed is passed through an adjustable attenuator which serves as a range multiplier and permits a large range of signal amplitudes to be analyzed without loading the amplifier. (3)

The output of an attenuator is then fed to a selective amplifier, which amplifies the selected frequency. The driver amplifier applies the attenuated input signal to a high-Q active filter. This high-Q active filter is a low pass filter which allows the frequency which is selected to pass and rejects all others. The magnitude of this selected frequency is indicated by the meter and the filter section identifies the frequency of the component.

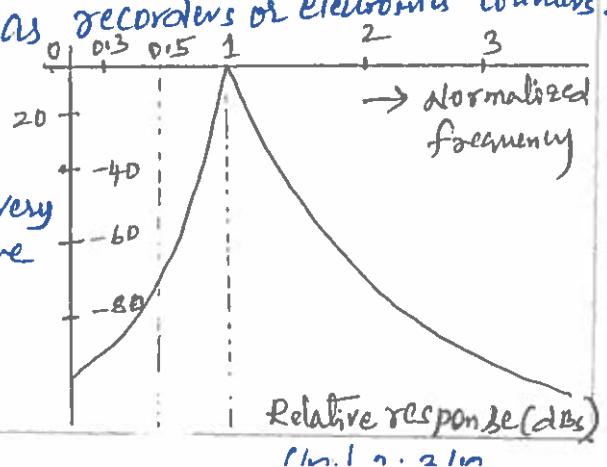
The filter section consists of a cascaded RC resonant circuit and amplifiers. For selecting the frequency range, the capacitors generally used are of the closed tolerance polystyrene type and the resistances used are precision potentiometers.

The capacitors are used for range changing and the potentiometer is used to change the frequency within the selected pass-band. Hence this wave analyzer is called a frequency selective voltmeter.

The selected signal output from the filter amplifier stage is applied to the meter circuit and to an untuned buffer amplifier. The main function of the buffer amplifier is to drive output devices such as recorders or electronic counters.

The wave analyzer must have extremely low input distortion.

The bandwidth of the instrument is very narrow, typically about 1% of the selective band.



* HF Wave Analyzer :-

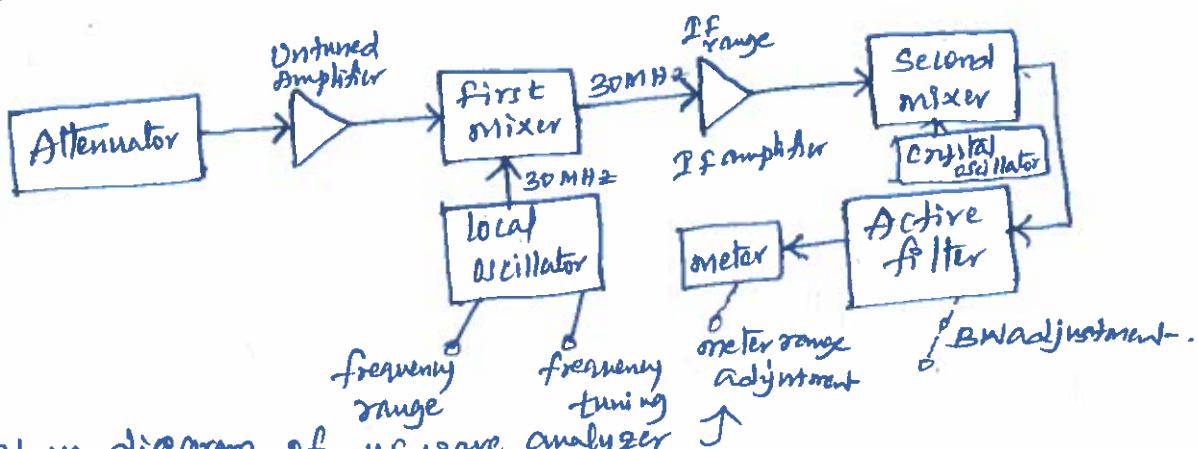
(4)

* Frequency Mixers :-

In a Super heterodyne receiver, the input - Amplitude modulated (AM) and radio frequency (RF) signal carriers have to be combined with ~~and~~ a locally generated RF signal in order to produce a signal at a new carrier frequency (IF) ~~shortly~~. Two methods are available.

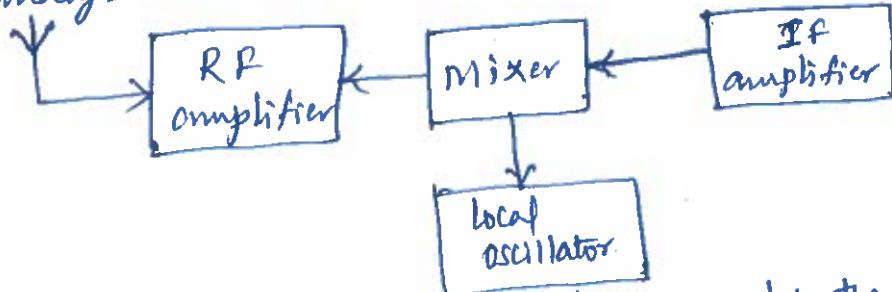
1. Multiplication type in a wave device.

2. Addition type in a non-wave device.



Block diagram of HF wave analyzer

Below diagram shows simplified block diagram of High Frequency Wave Analyzer.



From the simplified block diagram, let the local oscillator voltage be $V_0 \cos \omega_0 t$. Using a device with square law characteristics, $E_C = EV_b^2$; E_C - Collector voltage & E_b - base voltage

$$E_C = EV_b^2 ; E_C - \text{Collector voltage} \& E_b - \text{base voltage}$$

$$V_0 = V_0 \cos \omega_0 t + V_c (1 + m_a \cos \omega_m t) \cos \omega_0 t .$$

An amplified-modulated AM wave is the input to an RF amplifier.

The output of the device will give a large number of RF components including $(\omega_0 - \omega_c)$, $(\omega_0 + \omega_c)$, $(\omega_0 - \omega_c \pm \omega_p)$, $(\omega_0 + \omega_c \pm \omega_p)$ and so on. (5)

If the output load is tuned to $(\omega_c - \omega_c)$, the only significant voltage across is given by,

$$i_t = KV_c V_o \left[\cos(\omega_0 - \omega_c) t + \frac{\omega_0}{2} \cos(\omega_0 - \omega_c + \omega_p) t \right]$$

* Harmonic Distortion Analyzers :

There are three types of Harmonic Distortion (HD) Circuits, they are as follows:

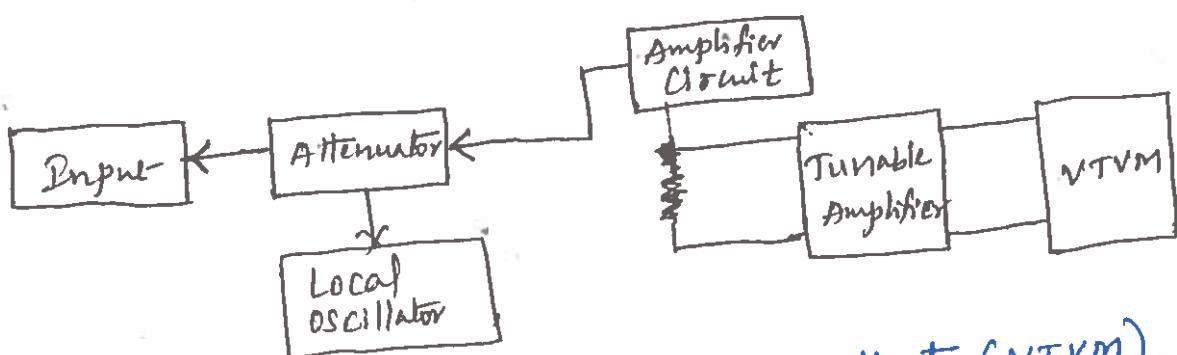
- 1.) Tunable Selective Circuit
- 2.) Heterodyne type

- 3.) Distortion measuring component (which suppresses the product frequency & measures RMS values of the distortion component)

Harmonic Distortion: It is defined as the ratio of harmonic to fundamental when a (theoretically) pure sine wave is reconstructed.

1.) Tunable Selective Circuit :

The complex wave to be analyzed is passed through an adjustable attenuator and is then applied to the selective amplifier, which is tuned to the frequency component to be determined as shown below.



The output is indicated by a Vacuum tube voltmeter (VTVM).

If the amplifier has a constant gain over all frequencies,

the attenuator can be set so that the VTVM gives 100% deflection for the fundamental frequency and the harmonics are expressed (magnitude) as a fraction of fundamental amplitude. The system can be calibrated using a standard signal generator.

A tuned amplifier is generally a resonance-tuned amplifier.

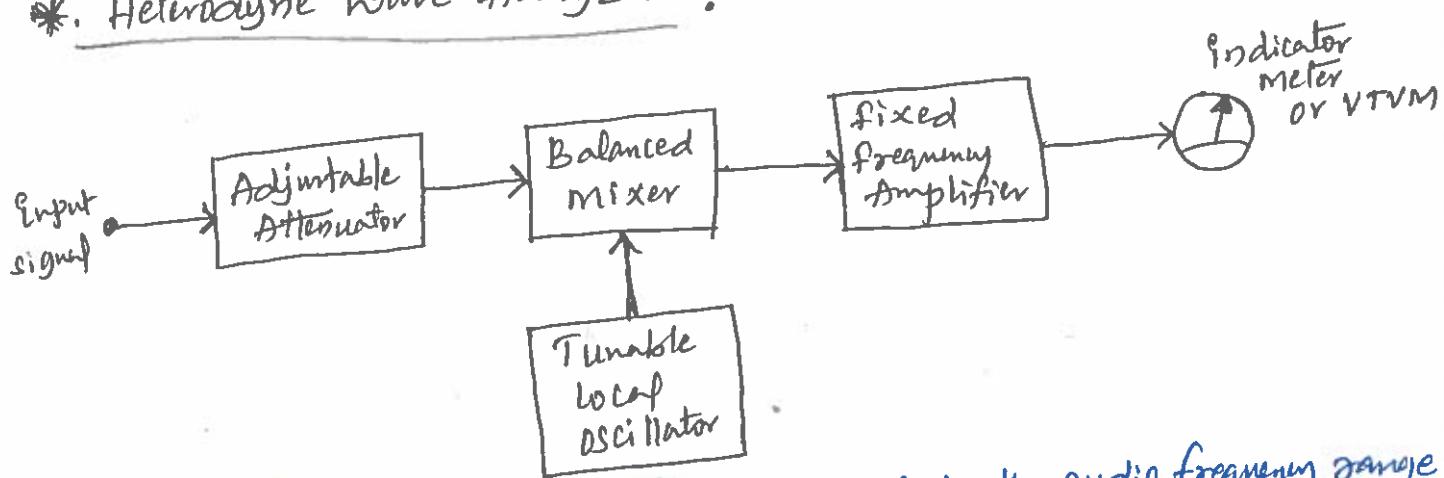
The advantage is that the gain can be totalized at a high frequency and can be made independent of frequency.

Disadvantage:

- 1.) At low frequencies the sizes of L and C are large.
- 2.) Harmonics of signal frequencies are very close to each other. Therefore, it is difficult to distinguish between them.

Harmonic: A harmonic is a signal or wave whose frequency is an integral multiple of the frequency of some reference signal or wave.

* Heterodyne Wave Analyzer :



Wave analyzers are useful for measurement in the audio frequency range only. For measurement in the RF range and above (MHz range), an ordinary wave analyzer cannot be used.

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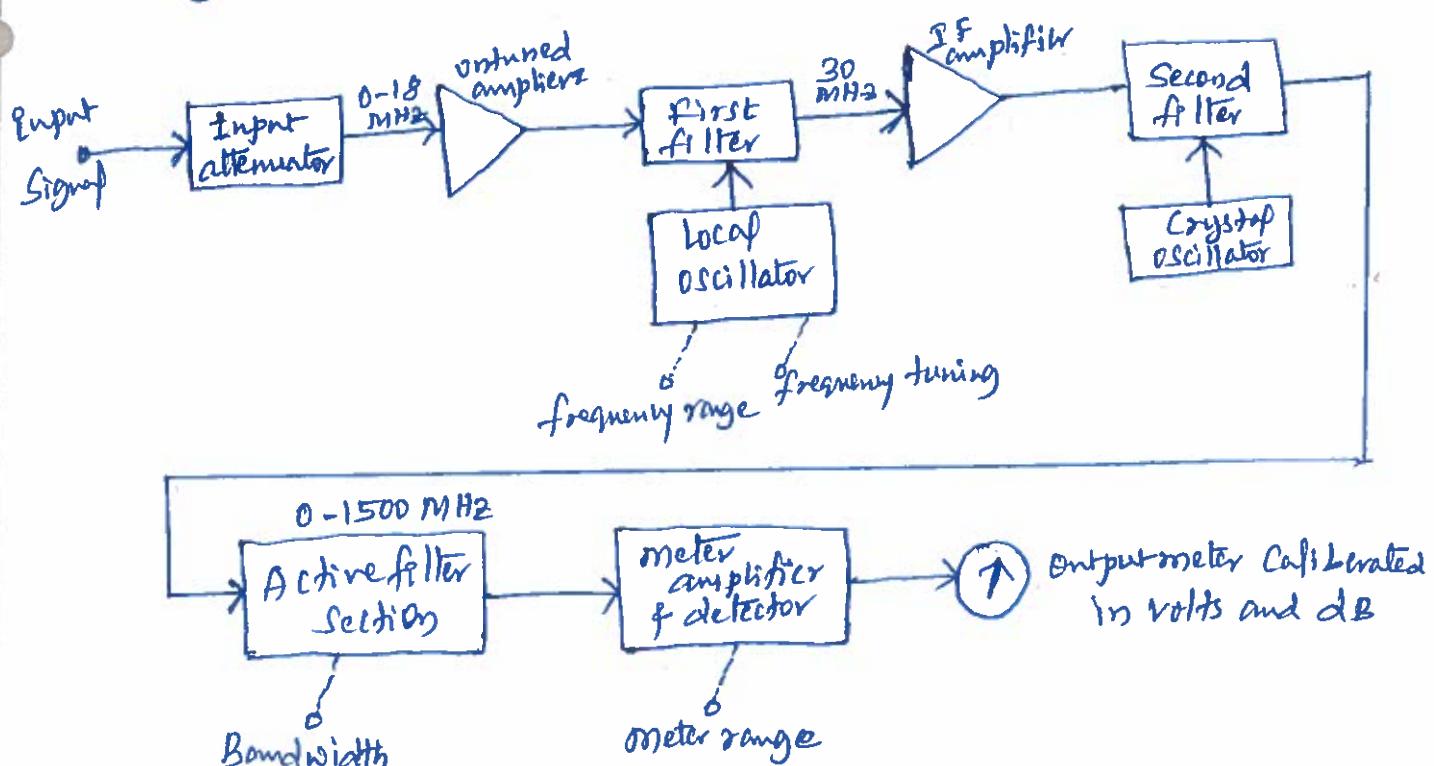
Hence, special type of wave analyzers working on the principle of heterodyning (mixing) are used. These wave analyzers are known as Heterodyne wave analyzers.

In this wave analyzer, the input signal to be analyzed is heterodyned with the signal from the internal tunable local oscillator in the mixer stage to produce a higher IF frequency.

By tuning the local oscillator frequency, various signal frequency components can be shifted within the pass-band of the IF amplifier. The output of the 2F amplifier is rectified and applied to the meter circuit.

The amplitude of the unknown component is indicated by the VTVM or output meter and it is calibrated by means of signals of known amplitude.

The block schematic of the wave analyzer using the heterodyning principle is shown below



The operating frequency range of this instrument is from 10 KHz to 18 MHz in 18 overlapping bands, selected by the frequency range control of the local oscillator. The bandwidth is controlled by an active filter and can be selected at 200, 1000 and 3000 Hz. (8)

The input signal enters the instrument through a probe connector, this probe connector contains a unity gain isolation amplifier. After suitable attenuation, the input signal is heterodyned in the mixer stage with the signal from the local oscillator.

The output of the mixer forms an IF that is uniformly amplified by the 30 MHz IF amplifier, this amplified IF signal is then mixed again with a 30 MHz crystal oscillator signal, which results in information centred around a zero frequency.

An active filter with controlled bandwidth and symmetrical slopes of 72 dB per octave, then passes the selected component to the filter amplifier and the detector circuit. The output from the meter detector can be read on a decibel scale or can be applied to a recording device.

* Spectrum Analyzer :

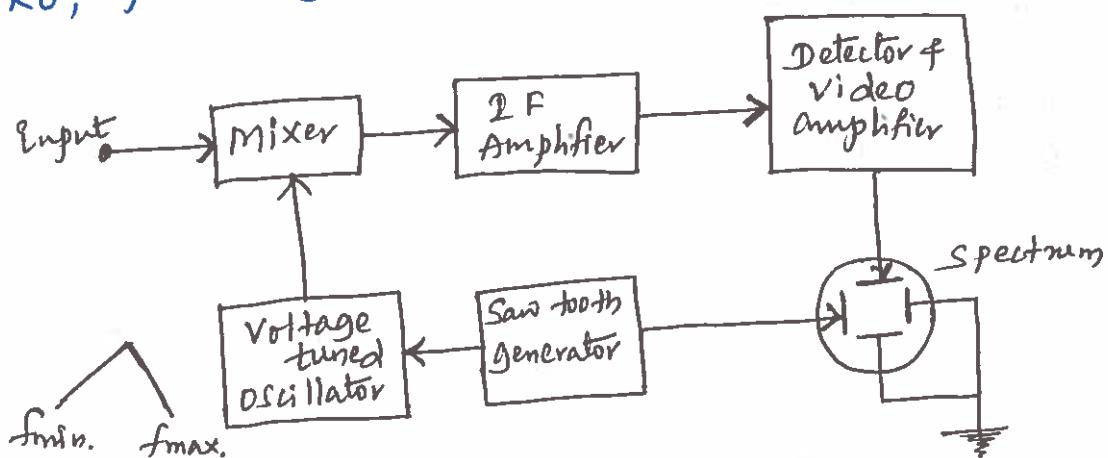
The block diagram basic spectrum analyzer using swept receiver design is as shown.

The sawtooth generator provides the sawtooth voltage which drives the horizontal axis element of the scope and this sawtooth voltage is the frequency controlled element of the voltage tuned oscillator.

As the oscillator sweeps from f_{\min} to f_{\max} of its frequency band at a linear recurring rate, it beats

With the frequency component of the input signal and ⑨ produce an IF, whenever a frequency component is met during its sweep. The frequency component and voltage tuned oscillator frequency beats together to produce a different frequency, i.e., IF.

The IF corresponding to the component is amplified and detected if necessary, and then applied to the vertical plates of the CRO, producing a display of amplitude v/s frequency.



One of the ~~principle~~ principle applications of spectrum analyzers has been in the study of the RF spectrum produced in microwave instruments.

In a microwave instrument, the horizontal axis can display as a wide range as 2-3 GHz, for a broad survey and as narrow as 30 KHz.

The frequency range covered by this instrument is from 1 MHz to 40 MHz.

*. Power Analyzers:

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Power analyzers are used for,

- 1.) Testing and verifying correct operation of motors
- 2.) Checking transformer efficiency
- 3.) Verifying power-supply performance
- 4.) Measuring the effect of neutral current.

These features include harmonic analysis, power measurements, and pulse width modulation (PWM) motor drive triggering. These instruments can also be used as oscilloscopes, which enable troubleshooting and verification of complicated electronic control circuits controlling the high-voltage power electronic circuits.

These instruments can also be used as digital multimeters with a data logger. ~~some model~~

*. Capacitance - Voltage Meters:

* Oscillators :

(11)

Signal sources are described by several names:

- 1) oscillators
- 2) Test oscillators
- 3) Signal generators.

They differ depending upon the design and application.

An oscillator is the basic element common to all the sources.

A test oscillator is a calibrated attenuator and an output monitor.

A signal generator is usually reserved for oscillators with ~~a~~ modulation capability.

Considerations in choosing an oscillator:

- 1) frequency range - it should be capable of producing wide range of frequencies, from a low frequency to a very high frequency i.e., 1 Hz to 30 MHz.
- 2) Output voltage - sufficient range is available to be seen.
- 3) Dial resolution & accuracy - when the dial is ~~repeatedly~~ set to a particular value, the same frequency is obtained.
- 4) Frequency stability - It is the ability to maintain the selected frequency over a period of time.
- 5) Amplitude stability - Amplitude is to remain constant when frequency is changed.
- 6) Distortion - It is undesirable.

* Signal generators :

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Generation of signals is an important aspect in electronic circuits and troubleshooting.

They are widely used in testing electronic circuits, systems and components. A signal generator must be capable of producing stable signals over a wide range of frequencies from a few Hz to even the GHz range. The amplitude must be variable, and attenuators are usually provided to change the amplitude.

The signal generated from the instrument must be free from distortion. Amplitude and frequency stability with variation in temperature must be good.

The types of signal generators are as follows:

1.) Standard Signal Generator - This instrument produces sinusoidal waveforms in AF and RF ranges. This is an oscillator with a modulation capability.

2.) Oscillators - These are available in the AF and RF ranges separately with variable amplitude & frequency.

3.) Test oscillator - It is an oscillator circuit with a calibrated attenuator and an output monitor.

4.) Function Generator - The instrument capable of generating square, triangular, ramp, pulse and sine waves or some of these different types of waveforms in addition to the sine wave such an instrument is called Signal Generator.

5.) Pulse Generator - Rectangular waveforms with variable duty cycles, variable frequency and amplitude are produced in this instrument.

6.) Sweep Generator - Ramp waveforms with variable slopes are produced by this instrument.

* AF Signal Generators :

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The Sine wave is very important and is widely used in electronic Circuits. Therefore most of the signal generators are sine wave generators, these are commercially known as oscillators.

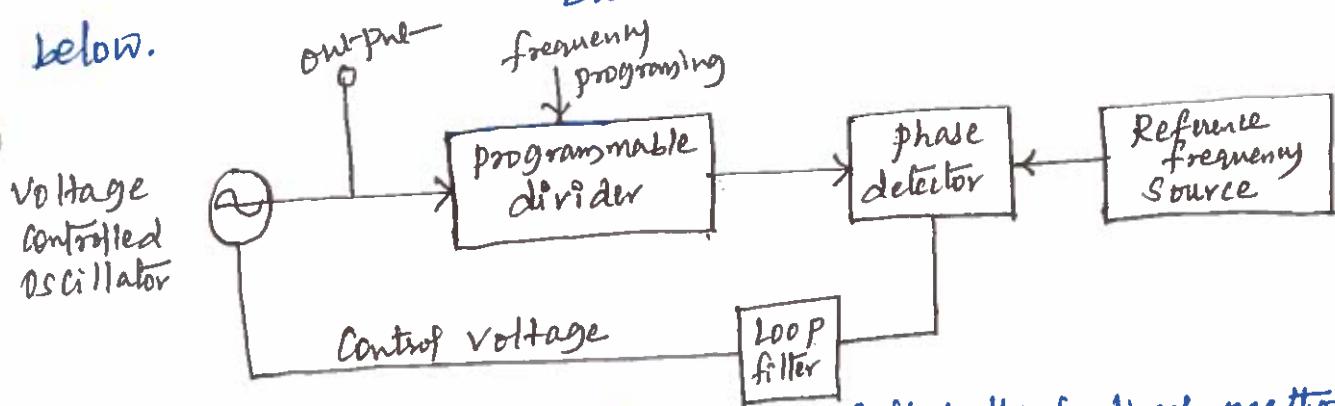
The ~~freq~~ frequency range of this instrument is few Hz to few MHz and in some cases to the GHz range.

Depending on the frequency range, specifications, and cost, the instrument may employ the RC phase shift oscillator circuit, or Colpitts oscillator circuit, or Hartley oscillator circuit to generate the sine wave.

An attenuator is used to vary the amplitude levels in the low and high ranges.

* RF Signal Generator : [PLL-based Signal Generator]

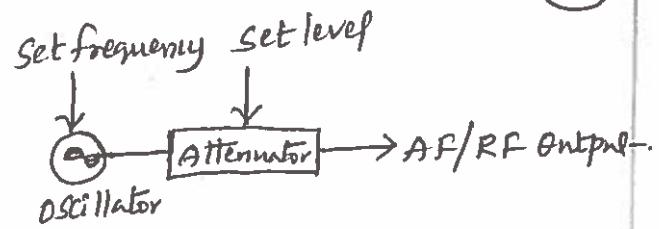
Block schematic of this instrument is shown below.



This method of frequency synthesis is called the indirect method. Here the phase lock loop (PLL) technique is employed.

Voltage controlled oscillator (VCO) : It is the source of output frequency and can be tuned electronically.

Programmable divider : It is a logic element that divides the frequency of the VCO by an integer that can be entered through a microprocessor or programming switches.



phase detector: It provides an analog output that is a function of the phase angle between the two inputs. (14)

Reference source: It is a very accurate and stable frequency source such as a quartz crystal oscillator.

The crystal oscillator works in the frequency range of 1-10 MHz.

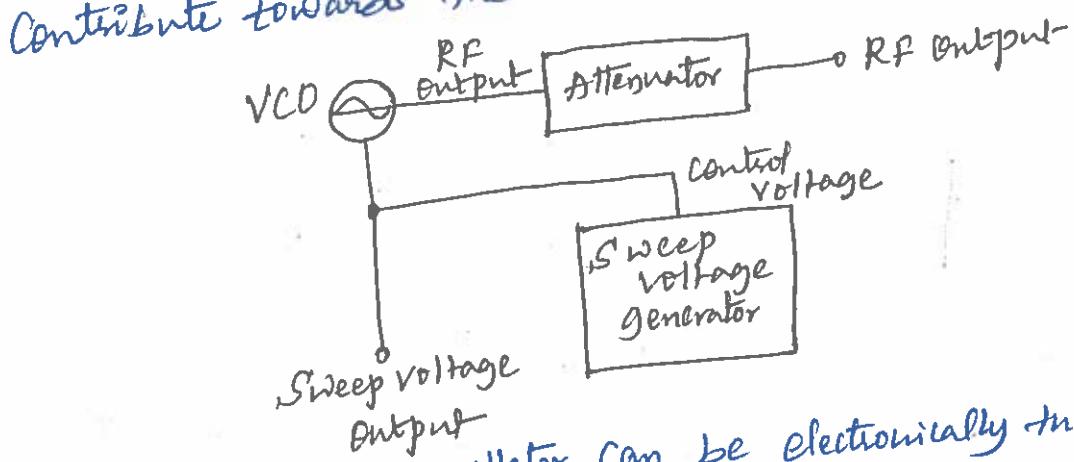
Loop filter: It is an analog filter which ensures ~~stable~~ and noise free operations.

The output of the programmable divider is fed to the phase detector and is compared to the phase of the reference frequency. The output of phase detector is returned to the VCO and any variation in phase could be corrected so that frequency would be equal to the reference frequency.

A VCO would be equal to the reference frequency.

* Sweep frequency generator:

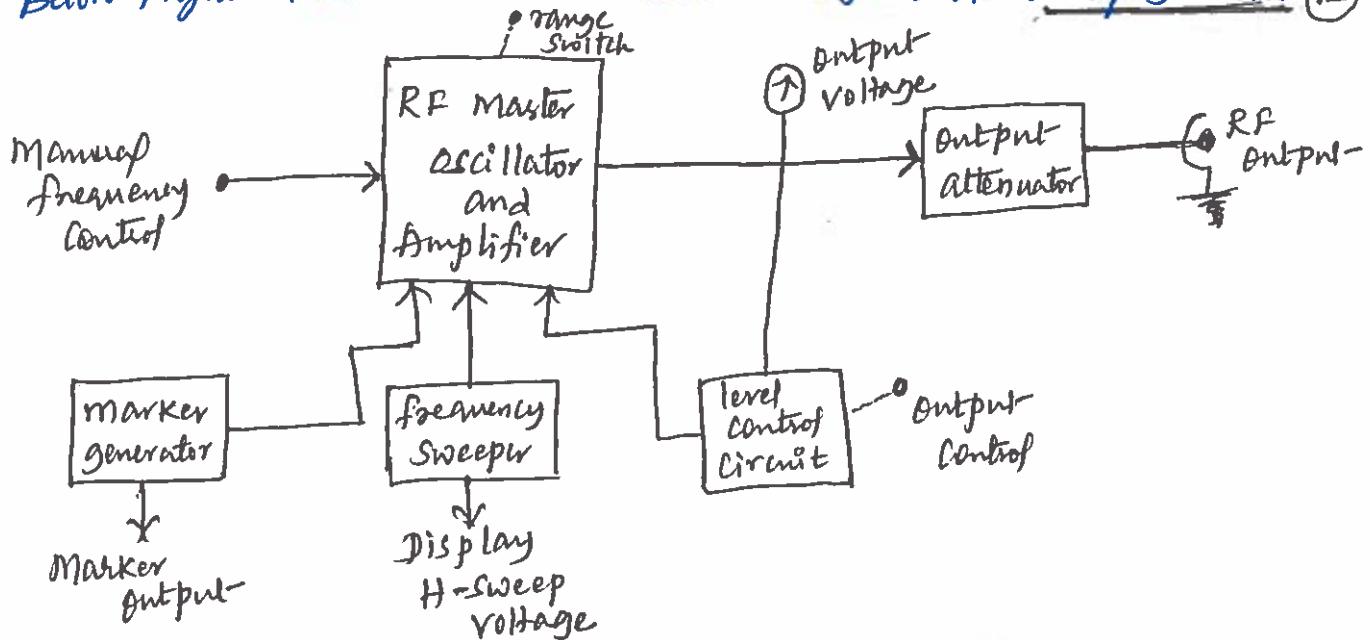
Solid state variable capacitance diodes contribute towards the development of sweep frequency generator.



A sweep generator oscillator can be electronically tuned.

A sweep voltage generator is supplied within a generator to provide the frequency sweep.

Below figure shows a basic block diagram of a sweep generator. (15)



It provides a sinusoidal output voltage whose frequency varies smoothly and continuously over an entire frequency band, usually at an audio rate.

The process of frequency modulation is done electronically by using the modulating voltage to vary the reactance of the oscillator tank circuit component, and mechanically by means of a motor driven capacitor.

The frequency sweeper provides a variable modulating voltage which causes the capacitance of the master oscillator to vary. Sweep rate could be of the order of 20 sweeps/second and a manual control allows independent adjustments of the oscillator resonant frequency.

The frequency to identify a frequency interval, the marker generator provides half sinusoidal waveforms at any frequency within the sweep range.

The automatic level control circuit is a closed loop feedback system which monitors the RF level at some point in the measurement system.

* pulse and square Wave Generators:

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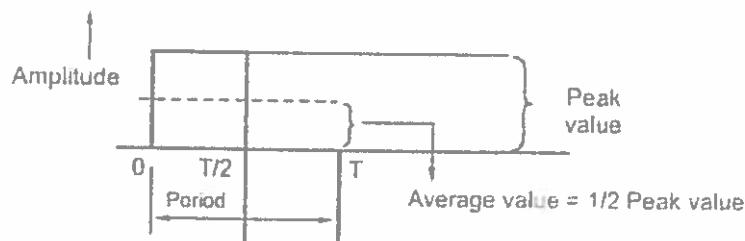


Normal pulse voltage applied to diode is reverse bias
Normal forward voltage over diode produces high voltages and
these voltages can be stored
Capacitors make it possible to convert the
AC waveform into a constant voltage at output but
it must be taken care that the voltage does not
exceed the maximum voltage value which is
also known as breakdown voltage because after
which damage may be caused to the diode. The peak
voltage is determined by the time constant of the
circuit and hence it is required to have a large
capacitor and small resistance. When the voltage
is increased the current through the diode will
also increase and hence the power dissipation
will also increase. So the diode must be
designed such that it can handle the power
dissipation.

PULSE & SQUARE WAVE GENERATOR:

The square wave generator and pulse generator are generally used as measuring devices in combination with the oscilloscope. The basic difference between square wave generator and pulse generator is in the duty cycle. The duty cycle is defined as the ratio of average value of a pulse over one cycle to the peak value. It is also defined as ratio of the pulse width to the period of one cycle.

$$\text{Duty cycle} = \frac{\text{Pulse width}}{\text{Pulse period}}$$



The average value is half of peak value. Both the average value and peak value are inversely proportional to time duration. The average value of a pulse is given as,

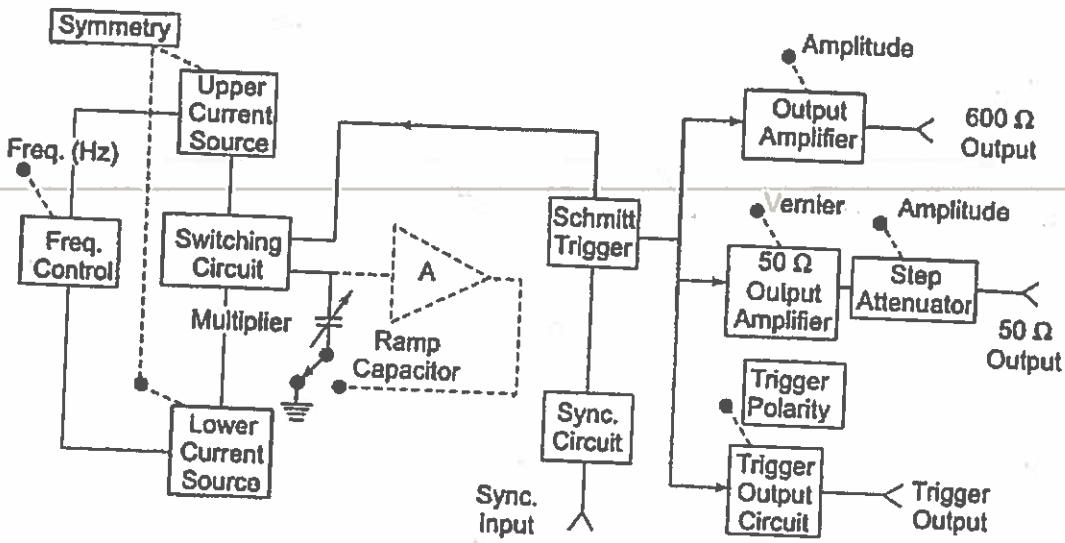
$$\text{Average value} = 1/2 \text{ Peak value}$$

Duty cycle of square wave = 0.5

Thus square wave generator produces an output voltage with equal ON and OFF periods as duty cycle is 0.5 or 50% as the frequency of oscillation is varied. Then we can state that irrespective of the frequency of operation, the positive and negative half cycles extend over half of the total period.

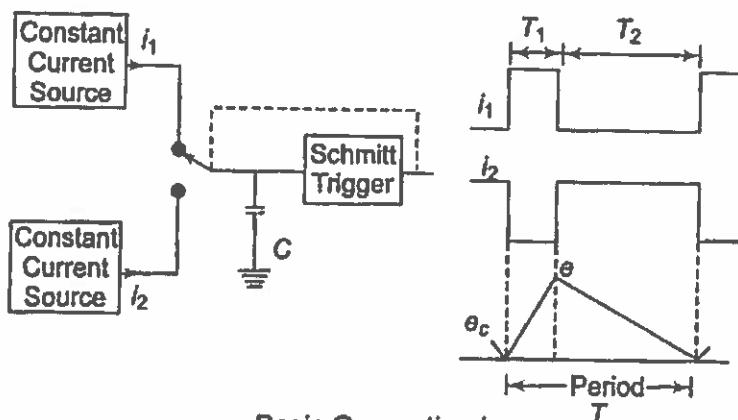
The basic circuit for pulse generation is the asymmetrical multi-vibrator. A laboratory type square wave and pulse generator is shown in Fig.

The frequency range of the instrument is covered in seven decade steps from 1 Hz to 10 MHz, with a linearly calibrated dial for continuous adjustment on all ranges.



Block Diagram of a Pulse Generator

The duty cycle can be varied from 25 – 75%. Two independent outputs are available, a $50\ \Omega$ source that supplies pulses with a rise and fall time of 5 ns at 5 V peak amplitude and a $600\ \Omega$ source which supplies pulses with a rise and fall time of 70 ns at 30 V peak amplitude. The instrument can be operated as a free-running generator, or it can be synchronized with external signals.



Basic Generating Loop

The upper current source supplies a constant current to the capacitor and the capacitor voltage increases linearly. When the positive slope of the ramp voltage reaches the upper limit set by the internal circuit components, the Schmitt trigger changes state. The trigger circuit output becomes negative and reverses the condition of the current switch. The capacitor discharges linearly, controlled by the lower current source. When the negative ramp reaches a predetermined lower level, the Schmitt trigger switches back to its original state. The entire process is then repeated. The ratio i_1/i_2 determines the duty cycle, and is controlled by symmetry control. The sum of i_1 and i_2 determines the frequency. The size of the capacitor is selected by the multiplier switch.

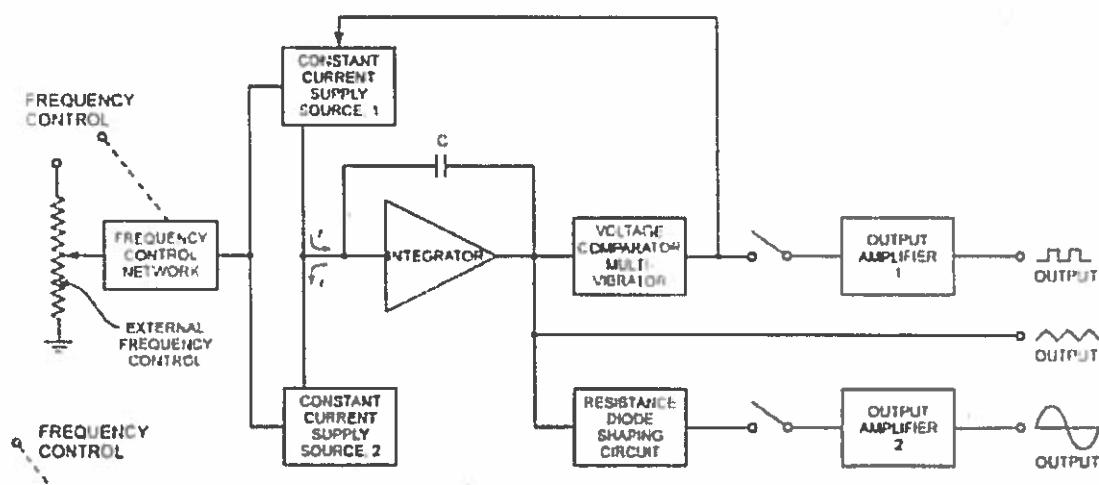
Function Generators:

A function generator is a signal source that has the capability of producing different types of waveforms as its output signal. The most common output waveforms are sine-waves, triangular waves, square waves, and sawtooth waves. The frequencies of such waveforms may be adjusted from a fraction of a hertz to several hundred kHz.

Actually, the function generators are very versatile instruments as they are capable of producing a wide variety of waveforms and frequencies. In fact, each of the waveforms they generate is particularly suitable for a different group of applications. The uses of sinusoidal outputs and square-wave outputs have already been described in the earlier Arts. The triangular-wave and sawtooth wave outputs of function generators are commonly used for those applications which need a signal that increases (or reduces) at a specific linear rate. They are also used in driving sweep oscillators in oscilloscopes and the X-axis of X-Y recorders.

Many function generators are also capable of generating two different waveforms simultaneously (from different output terminals, of course). This can be a useful feature when two generated signals are required for a particular application. For instance, by providing a square wave for linearity measurements in an audio-system, a simultaneous sawtooth output may be used to drive the horizontal deflection amplifier of an oscilloscope, providing a visual display of the measurement result. For another example, a triangular-wave and a sine-wave of equal frequencies can be produced simultaneously. If the zero crossings of both the waves are made to occur at the same time, a linearly varying waveform is available which can be started at the point of zero phase of a sine-wave.

Function Generator Working & Block Diagram



Block Diagram of Function Generator

Function Generator Block Diagram

Another important feature of some function generators is their capability of phase-locking to an external signal source. One function generator may be used to phase lock a second function generator and the two output signals can be displaced in phase by an adjustable amount. In addition, one function generator may be phase locked to a harmonic of the sine-wave of another function generator. By adjustment of the phase and the amplitude of the harmonics, almost any waveform may be produced by the summation of the fundamental frequency generated by one function generator and the harmonic generated by the other function generator. The function generator can also be phase locked to an accurate frequency standard, and all its output waveforms will have the same frequency, stability, and accuracy as the standard.

The block diagram of a function generator is given in the figure. In this instrument, the frequency is controlled by varying the magnitude of the current that drives the integrator. This instrument provides different types of waveforms (such as sinusoidal, triangular and square waves) as its output signal with a frequency range of 0.01 Hz to 100 kHz.

The frequency controlled voltage regulates two current supply sources. Current supply source 1 supplies a constant current to the integrator whose output voltage rises linearly with time. An increase or decrease in the current increases or reduces the slope of the output voltage and thus controls the frequency.

The voltage comparator multivibrator changes state at a predetermined maximum level, of the integrator output voltage. This change cuts-off the current supply from supply source 1 and switches to the supply source 2. The current supply source 2 supplies a reverse current to the integrator so that its output drops linearly with time. When the output attains a predetermined level, the voltage comparator again changes state and switches on to the current supply source. The output of the integrator is a triangular wave whose frequency depends on the current supplied by the constant current supply sources. The comparator output provides a square wave of the same frequency as output. The resistance diode network changes the slope of the triangular wave as its amplitude changes and produces a sinusoidal wave with less than 1% distortion.