UNIT-2

...gnal Generators :

Signal generator are the sources of electrical signals used for the purpose of testing and Operating different kinds of electrical equipment.

A signal generator provides different types of wave-forms such as sine, triangular, square pulse etc.

Characteristics of Signal Generator (or) Sources :

1. The signal frequency must be stable and well known
2. It should have controllable output amplitude, whose range is from very small values to relatively large values.
3. The output signal of a signal source must be free from distortion.

Different types of Signal generators are

-> Function generator

-> pulse generator

-> pulse frequency generators

Applications of Signal generators :

-> Measuring the frequency response of amplifiers.

-> Alignment of radio receivers.

AF oscillators :

Generally oscillators are sine-wave generators that are both in the radio frequency and audio frequency ranges.

oscillator is an instrument, which provides only a sinus output signal. One of the most useful electrical and electronic measuring instrument is oscillator.

An oscillator may also be known as signal generator function generator or test oscillator, which are based upon the oscillator application or design. A sine wave signal of known amplitude and frequency is generated by an oscillator which is the basic element of all signal sources. oscillators are basically classified into two types. They are.

- Based on the design principle used
- Based on the frequency range.

A function generator is a device, whose output waveforms are sine, square wave, triangular wave and pulse train.

The AF oscillators are divided into two types.

- Fixed frequency AF oscillator
- Variable frequency AF oscillator.

Fixed frequency AF oscillator:

In many cases, a self-contained oscillator circuit is an integral part of the instrument circuitary and is used to generate a signal at home specified audio frequency. Such a fixed frequency might be a 400 Hz signal used for audio testing or a 1000 Hz signal for exciting a bridge circuit.

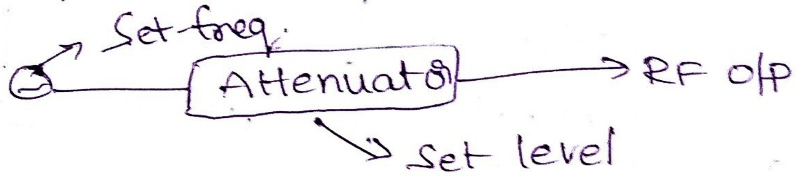
Oscillator at specified audio frequencies are easily generated by the use of an iron core transformer to obtain positive feedback through inductive Coupling between the primary and Secondary windings.

Variable AF oscillator:

A variable AF oscillator for general purpose use in a laboratory should Cover at least the full range of audibility (20 Hz to 20KHz) and should have a fairly Constant pure Sinusoidal wave output over the entire frequency range. Hence, variable frequency AF generators for laboratory use are of the RC feedback oscillator type (or) Beat frequency oscillator type.

Basic Standard Signal generator;

The sine wave generator represents the largest single category of signal generator. This instrument Covers a frequency range from a few hertz to many Giga-Hertz. The Sine wave generator in its Simplest form



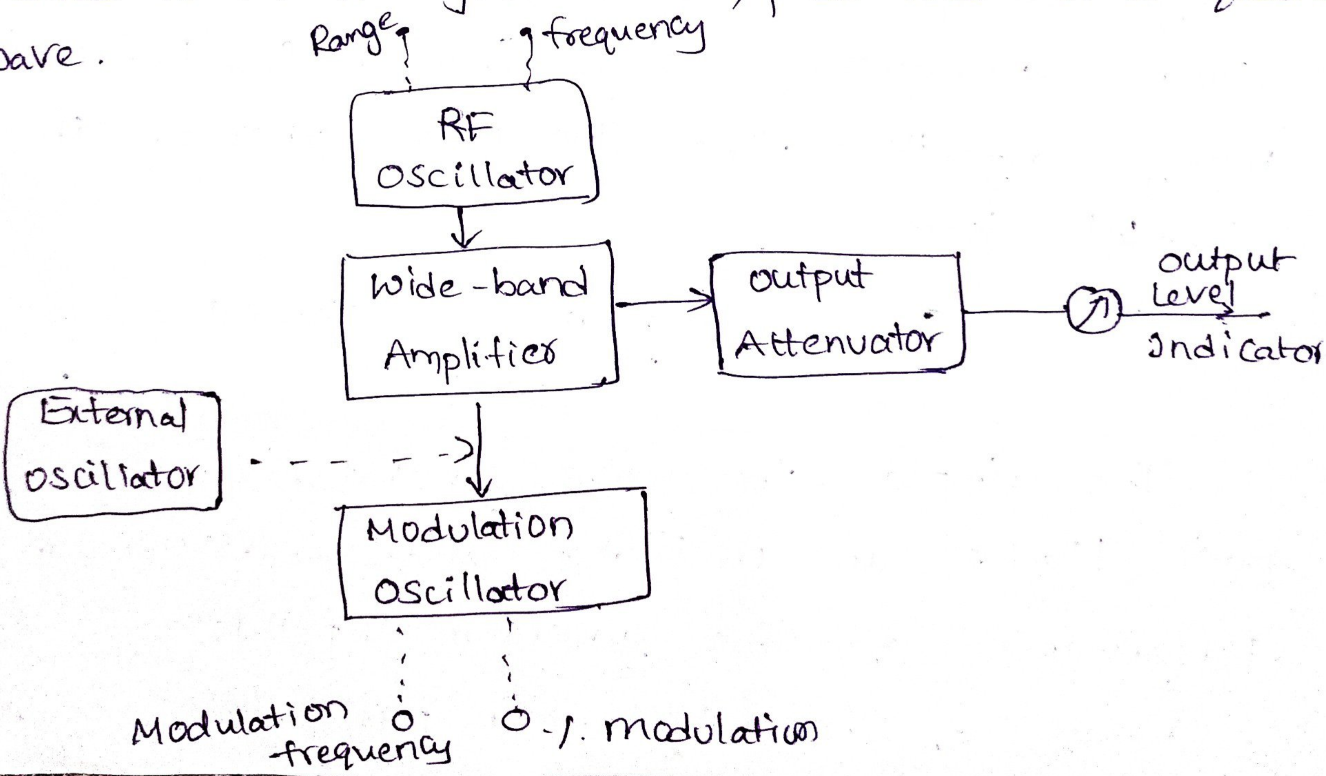
The simple sine wave generator Consists of two basic blocks, an oscillator and an attenuator. The Performance of the generator depends on the success of these two main parts. The accuracy of the frequency, stability and freedom from distortion depends on the design of the oscillator while the amplitude depends on the design of the attenuator.

Standard signal generator:

A standard signal generator produces known and controllable voltages. It is used as power source for the measurement of gain, signal to noise ratio (S/N), band width, standing wave ratio and other properties. It is extensively used in the testing of radio receivers and transmitters.

An Amplitude modulated or frequency modulated signal can be obtained at the output of the generator through a modulation circuit. The modulation of the carrier frequency is indicated by a meter.

The carrier frequency can be modulated with either a sine wave, triangular wave, pulse wave or a square wave.



An oscillator which produces a Constant output over any frequency range Such as a highly stable RF oscillator employing, an LC tank Circuit is used to generate a Carrier frequency. The frequency of oscilla-tions of this Carrier wave/signal Can be adjusted by the frequency range Control and the Vernier dial Setting.

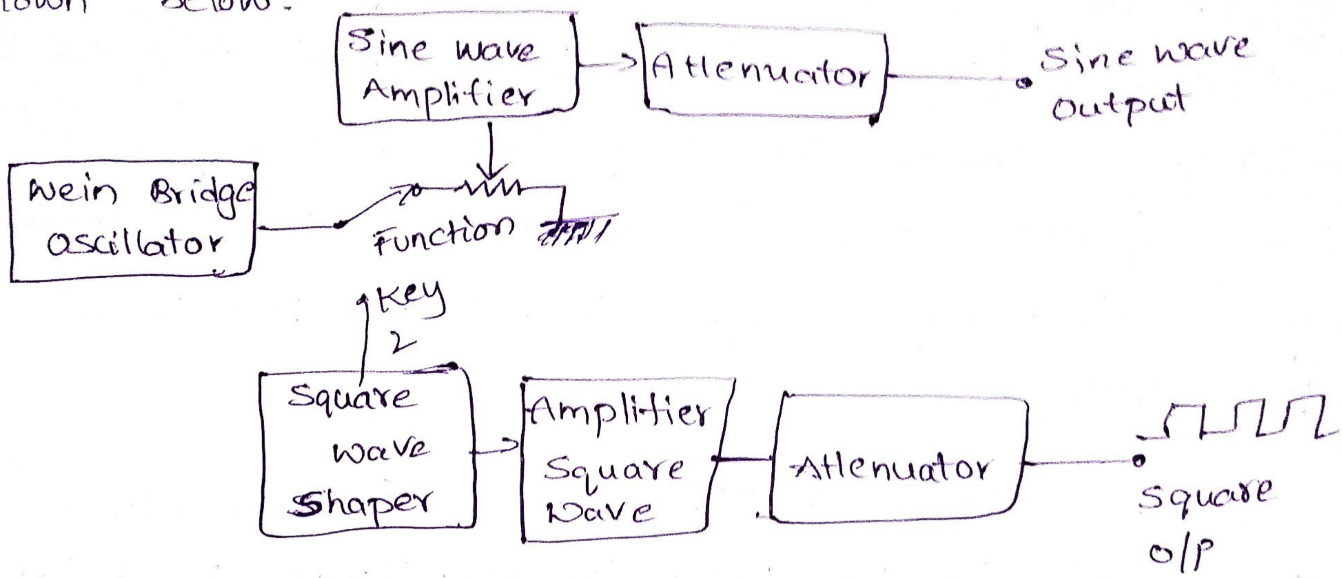
The external oscillator or an internal sine wave generator Can be used for Amplitude modulation of the Carrier Signal. The modulation process is Carried out in an output amplifier circuit. The modulated is fed to the o/p attenuator. finally, the level of the output voltage Can be read through an output meter.

The frequency stability depends on the design of the LC circuit of the RF oscillator. As the frequency range switching is achieved through selection of appropriate Capacitors, the instru-ment requires Some time to stabilize at the new resonant frequency.

AF Sine and Square wave Generator:

As the name Suggest an AF sine and square wave generator produces either sine wave or Square wave output. It employs a wein bridge.

oscillator, sine wave amplifier, square wave shaper, square wave amplifier and attenuator. The schematic block is shown below.



The wien bridge oscillator operates effectively in audio frequency ranges. It produces oscillations whose frequency can be varied by varying the capacitance value of capacitor of the oscillator. Also the freq value can be varied in steps by switching in different values of resistors. The oscillations of wien bridge oscillator are applied to either sine wave amplifier or sine wave amplifier shape through function key is connected to position 1, the output oscillations are connected to sine wave amplifier and then to attenuator. Therfore the oscillations are amplified and then attenuated and a pure sinewave is available at the output. Depending on the requirement the amplitude of this sine wave can be from 5mv to 5v.

When the key is connected to position 2, the oscillations are applied to square wave shape which converts the oscillations into squre wave. The square wave signal is amplified and then attenuated and finally appears as pure square wave at the output.

The front panel of the instrument

-> ON/OFF switch:

-> frequency Multiplier: To choose the frequency range over 5 decades (from 10Hz to 1MHz)

-> Amplitude Multiplier: To attenuate sine wave output in 3 decades (x1, 0.1x, 0.01x)

-> Amplitude: To continuously attenuate the amplitude of square wave output.

-> Variable Amplitude: To continuously attenuate the amplitude of the sine wave output.

-> frequency selector: To select different ranges of frequencies and to vary the frequency in a ration of 1:11

-> Symmetry Control: To adjust the symmetry of square wave from 30% to 70%.

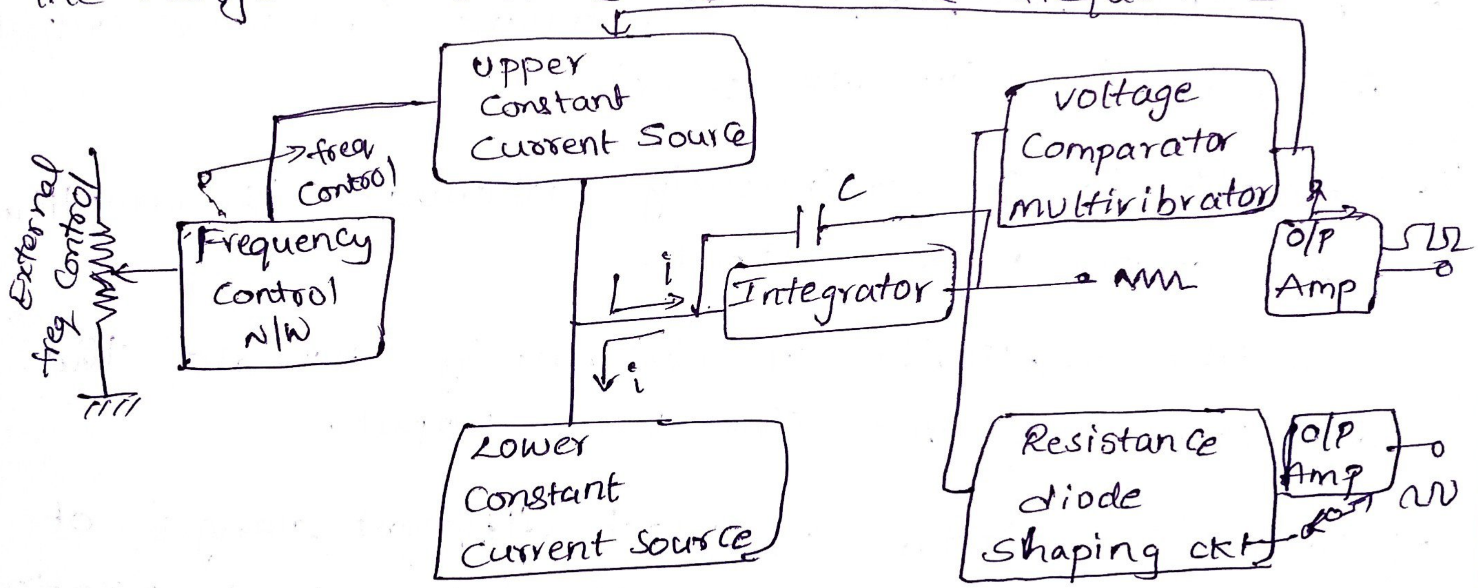
-> Sync: To synchronize the internal signal with external signal.

-> Output Available: This provide sine wave and square wave o/p.

Function generator:

An instrument which provides different types of wave forms whose frequency value can be varied and adjusted over a wide range is refferred to as function generator. A function generator commonly produces sine wave, square wave triangular wave and sawtooth wave. The block diagram representation of a function generator is shown in below.

The device is designed to produce waves in the range of 0.01 Hz to 100 kHz frequencies.



· The frequency control network is governed by the voltage applied externally or the frequency dial provided on the front panel of the device. The output of frequency control network regulates the two current sources i.e upper constant current source. The upper constant current source. The upper constant source provides current of constant.

Constant magnitude to the integrator circuit. Therefore the output voltage of integrator linearly increases with respect to time and its o/p voltage is given by the following equation.

$$\therefore C_{out} = \frac{-1}{C} \int_0^t i\,dt$$

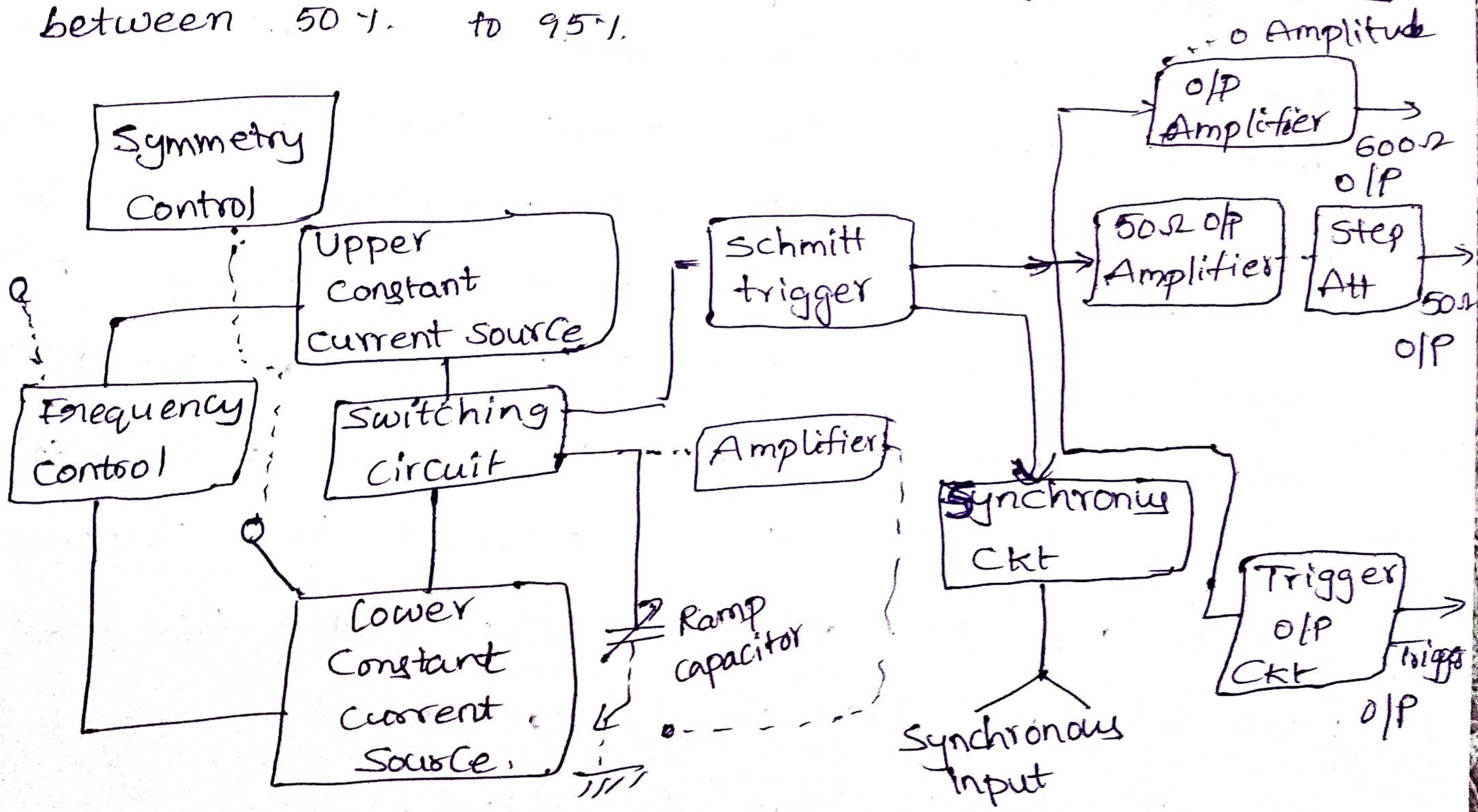
When the o/p current of the upper current source increases, the slope of the integrator. o/p voltage decreases vise versa. As the positive slope of the output voltage of the integrator reaches a predetermined level. the voltage comparator multi-vibrator changes its state. This causes the output of upper current supply to the integrator to cut-off and switch on the lower current source supply to the integrator. Now the lower current source provides a reverse current of constant magnitude to the integrator. The output of voltage comparator multivibrator is square wave whose frequency is same as that of the triangular wave. The output of integrator which is triangu-lar wave is given to the resistance diode shaping circuit. This ckt alters the slope of the triangular wave into amplitude changes and provides sine wave of <1% distortion at the output.

The o/p Section of this instrument Contains Selected Waveforms among the three individually and simultaneously.

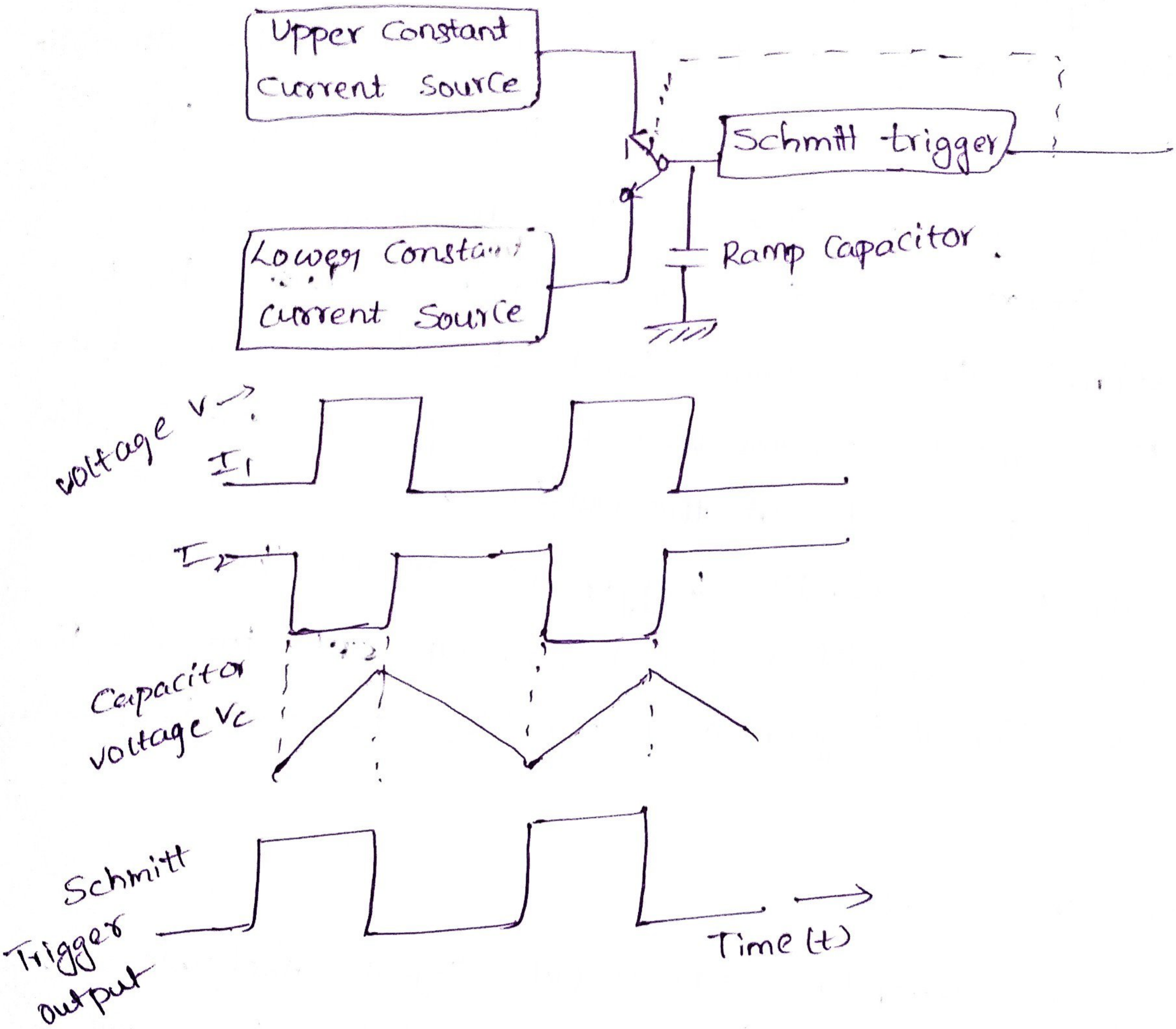
Square pulse generator.

Square wave and pulse generators along with CRO are used as measuring instruments. The o/p of these give quantative as well as qualitative information about the instrument under test. The basic difference between Square wave generator and pulse generator is Concerm with ratio of pulse width to the pulse Period i.e duty cycle.

The duty cycle of a square wave generator is 50% and the duty cycle of a pulse generator varies between 50% to 95%.



This generator can be operated as free-running generator the basic generating loop of this generator is shown above figure. It contains two constant current sources a simple current switch, Schmitt trigger, ramp capacitor.



The upper constant current source provides constant current for charging the ramp ckt capacitor. As the ramp capacitor charges, the ramp voltages increases linearly. As soon as the positively increasing ramp approaches pre determined upper limit that is set by the internal elements of the circuit, the schmitt trigger changes from one state to another. The Schmitt trigger Can be a bistable multivibrator.

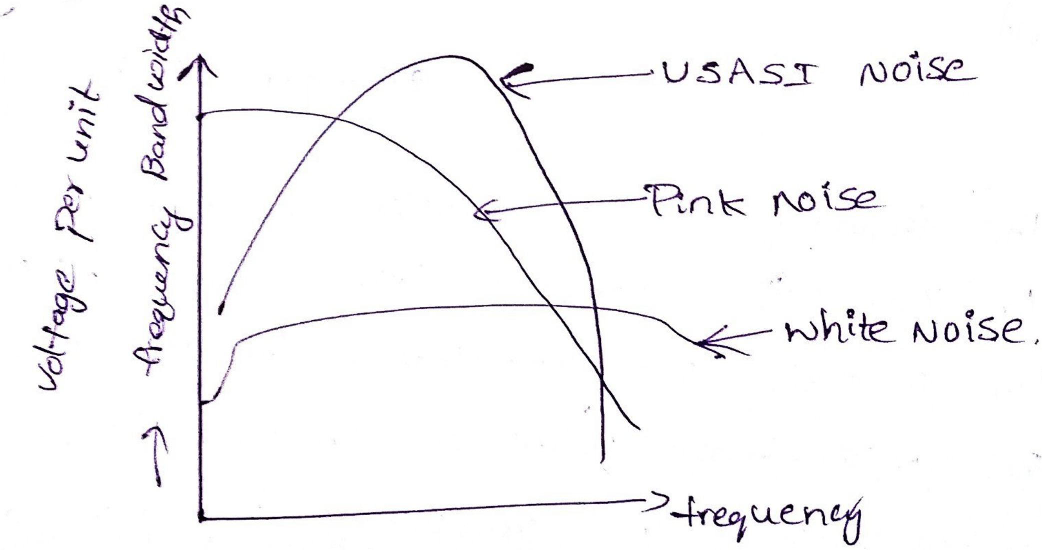
When the schmitt trigger changes its state, its output goes to negative, the current Switch reverse its Condition and the ramp Capacitor discharging linearly Now the lower Constant Current Source Controls this discharging rate. As Soon as the negative ramp voltage approaches the predetermined lower level, the schmitt trigger Comes back to it original state. thus the complete process will be repeated and negative pulses are produced at the output at a Constant rate. The output of Schmitt trigger is applied the 600Ω and 50Ω O/P amplifier. The trigger o/p ckt inverts the O/P of Schmitt trigger and provides positive triggering pulse.

Random Noise Generator:

A generator whose output signal amplitude changes randomly and doesn't Contain any periodic frequency Components is referred to as random noise generator The block diagram of a random noise generator

This instrument doesn't allow several measurements at a single frequency at a time, but it allows only one measurements to express the performances over consists of noise source, amplifier, modulator and noise filter.

The noise source can be a semiconductor noise diode. It produces noise frequencies in the range of 80 to 220 KHz. This noise signal is amplified in the amplifier and then applied to balanced symmetrical modulator, where it is mixed down to the band of audio frequencies. When the output of modulator is given to the filter which controls the bandwidth of the signals and provides ~~the output~~ in the form of noise power spectrum. Here three noise curves are shown below.



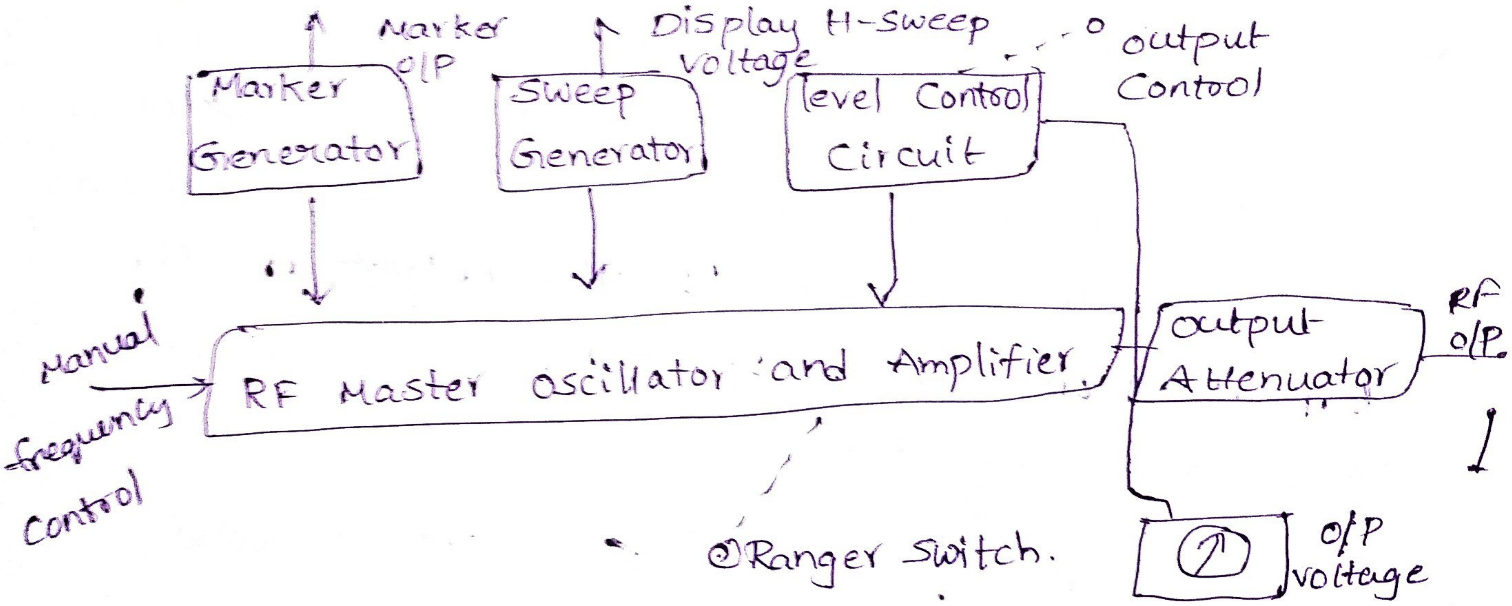
→ white noise covers all frequencies, i.e it has equal power spectral density.

→ Pink noise has a spectrum same as that larger amplitudes at low frequency range.

→ USASI noise Curve is similar to the energy distribution of Speech and music frequencies. It helps in the testing of audio systems such as loud speakers and audio amplifiers

Sweep Generator :

An instrument whose output is a sinusoidal voltage that varies over a complete frequency band slowly and continuously is referred as sweep generator.



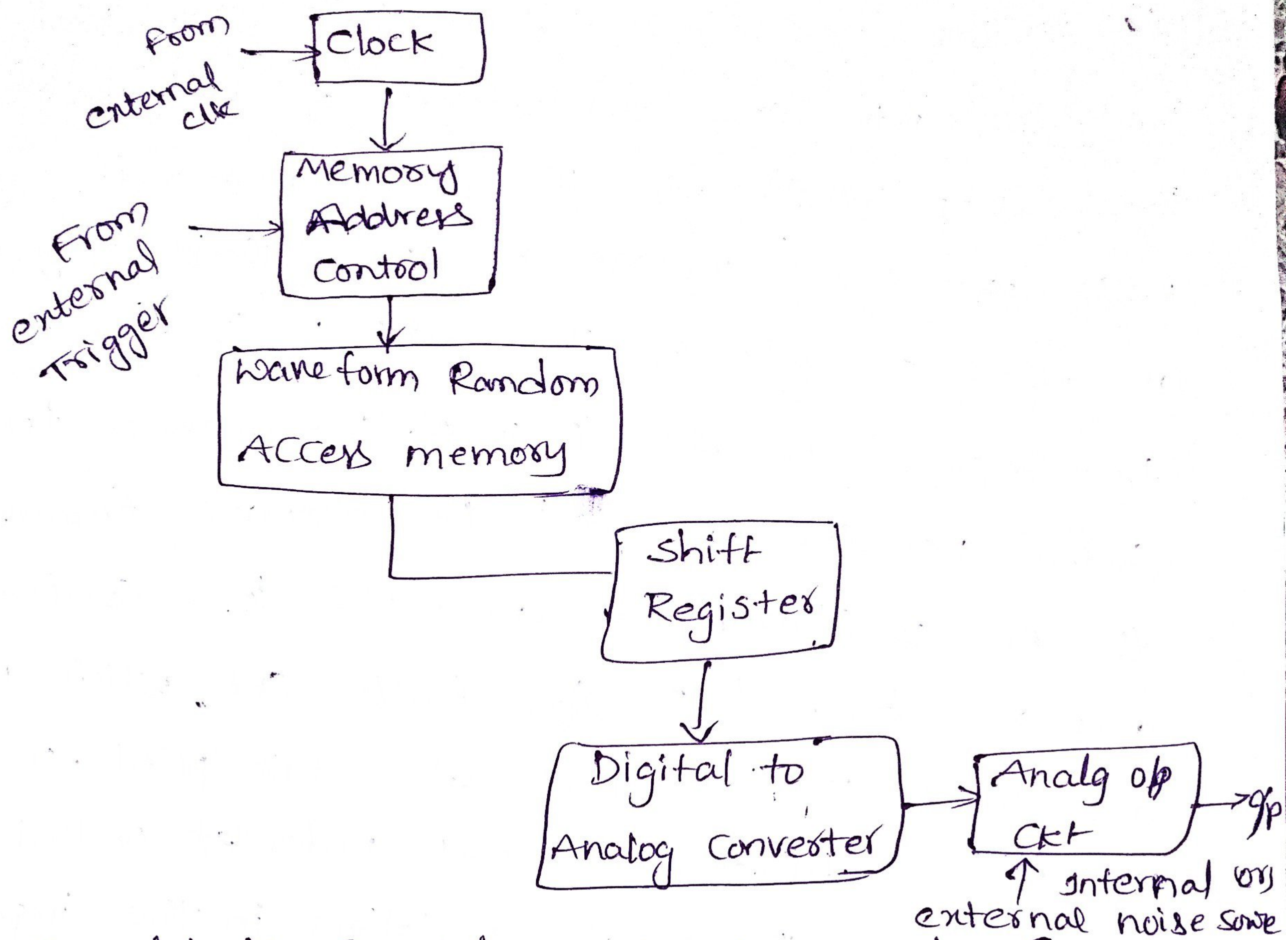
The frequency sweep supplies variable modulating voltage to the RF master oscillator and amplifier circuit. Due to this the capacitance of the oscillator changes. the approximate value of sweep rate is around 20 sweeps/second. The frequency sweeper also supplies a varying sweep voltage signal to the horizontal deflection plates of a cathode ray oscilloscope. ∴ the amplitude of the output of the instrument under test will be locked and displayed on the CRT.

The marker generator Supplies half Sinusoidal Signal to the oscillator at any range of frequencies with in the Sweep range. Also the o/p of marker is Combined with the Sweep voltage of the Cathode ray oscilloscope at alternate Cycles of the sweep ∴ finally it appears Super imposed on the o/p wave. The manual frequency Control permits to adjust the resonant frequency of the RF oscillator. The automatic level Control ckt acts as closed loop feed back ckt, which measures and controls the RF level at certain point. It also maintains the power delivered to ckt under test or load at Constant and independent of the variations in the impedance and frequency

Arbitary wave form Generator:

It is a waveform generator, which generates waveforms based on digital data stored in RAM. This digital data gives the detailed information of the Constantly varying voltage levels of an A.C signal without or with DC content. The basic block diagram of an arbitary waveform generator.

In this type of waveform generator, digital data is stored in wave form random Access memory. In this case a cathode ray oscilloscope is used to measure a waveform



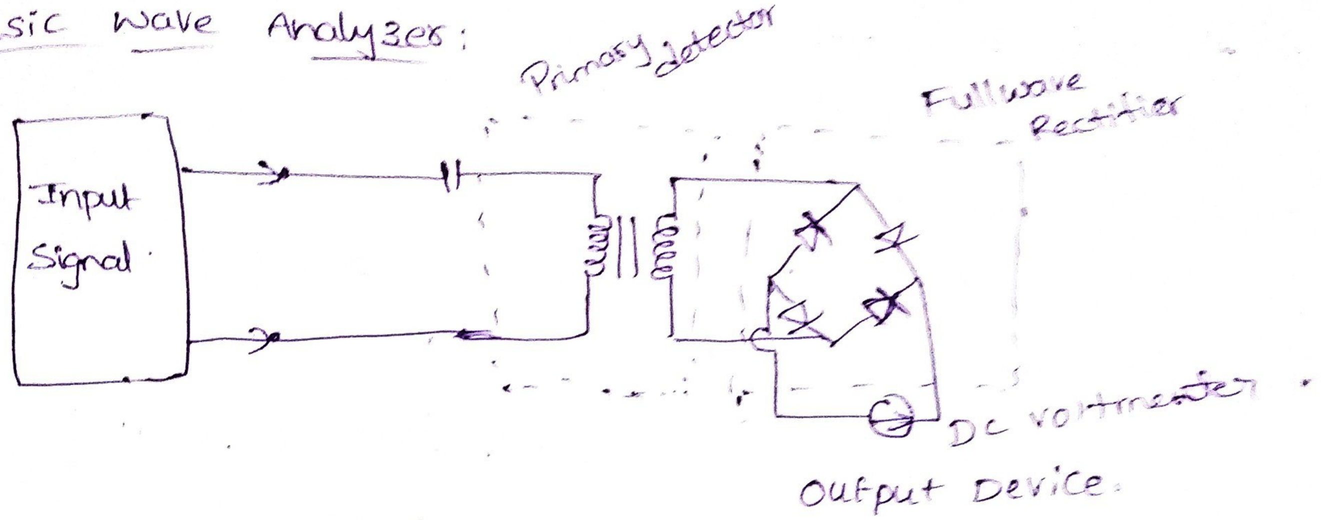
In which the data is sampled. A digital to analog Converter is used to read back the memory location and feeding the data points there by reconstructing the signal at any time. The Nyquist Sampling theorm we know that

$$f_s = 2f_m$$

If above Condition is satisfied then we can achieve better fiedelity.

Wave Analyzers: A wave Analyzer is used to measure the magnitude of different harmonics of any typical wave form (or) it is used to measure relative amplitude of single frequency Components present in a distorted or complex wave-form. This instrument selects a signal of one particular frequency to which it is tuned and rejects all other frequencies ∴ it can be referred to as a frequency Selective voltmeter.

Basic wave Analyzer:



The basic wave Analyzer Contains a primary detector and a rectifier. The primary detector is formed by a simple L·C ckt and it is varied and adjusted for reasonance at a particular frequency signal of the Particular harmonic which is to be analyzed or measured.

The full wave rectifier having four diodes acts as an intermediate stage and is used to achieve the average value of the applied A.c i/p signal. The o/p indicating device is nothing but a D.C voltmeter.

When the signal wave form is applied at the input, the primary detector circuit allows only one particular frequency to which it is tuned and rejects all other frequencies to pass rectifier and the output device.

Applications of wave Analyzer: The wave analyzer is widely applied in following three measurements.

-> electrical measurements

-> Sound measurements

-> vibration Measurements

Based on the frequency ranges used, wave analyzers are divided into two types.

1. frequency selective wave analyzer. (20 Hz to 20 KHz)

2. Heterodyne wave analyzer (10 KHz to 18 MHz)

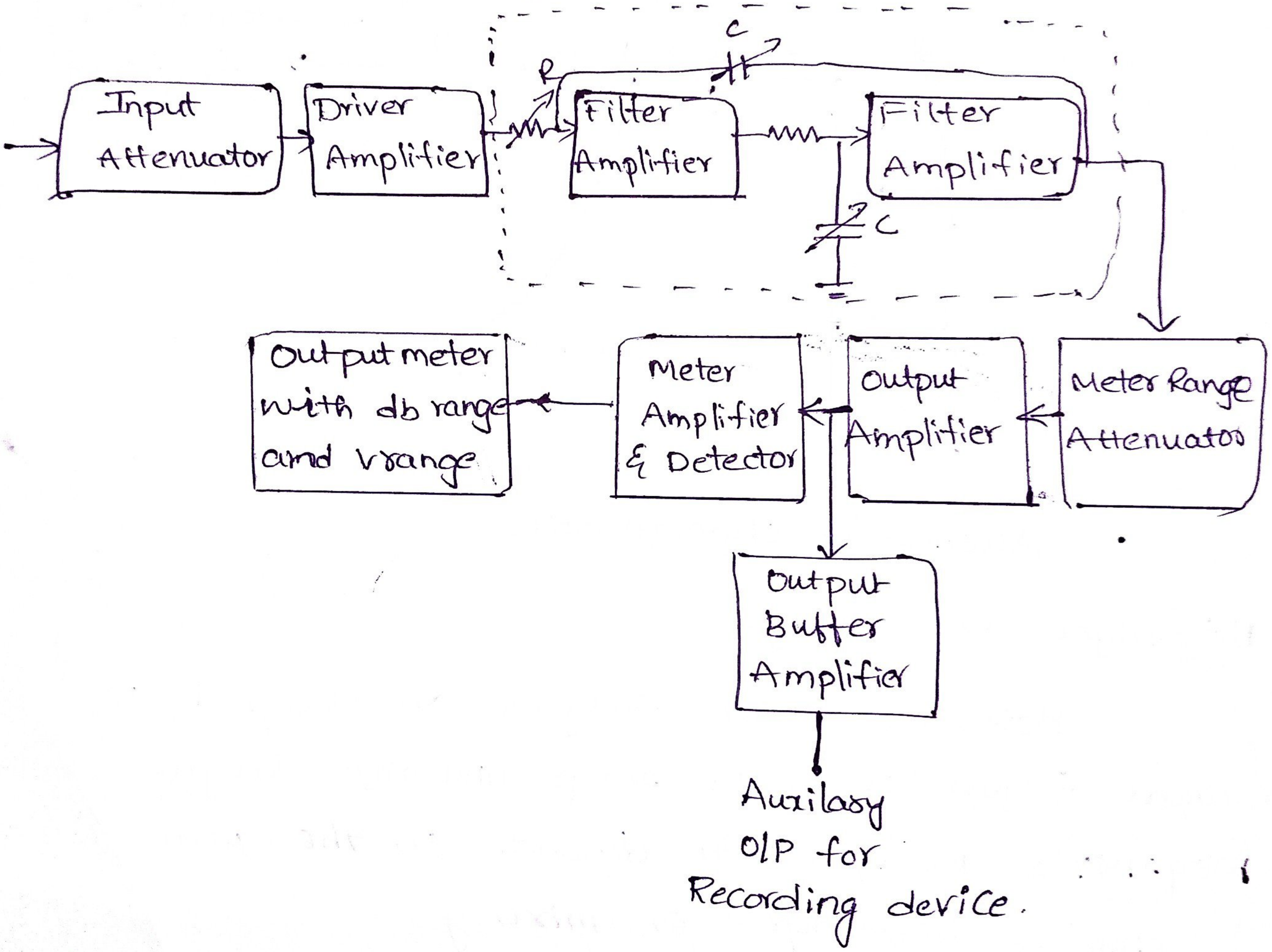
-> frequency Selective wave analyzer:

frequency selective wave analyzer are designed to measure the frequencies of audible range 20 Hz to 20 KHz. This analyzer Consists of a very narrow Pass band filter, that can be tuned to a Particular frequency Component depending on requirement

The block diagram representation of a frequency Component Selective wave Analyzer is shown in below

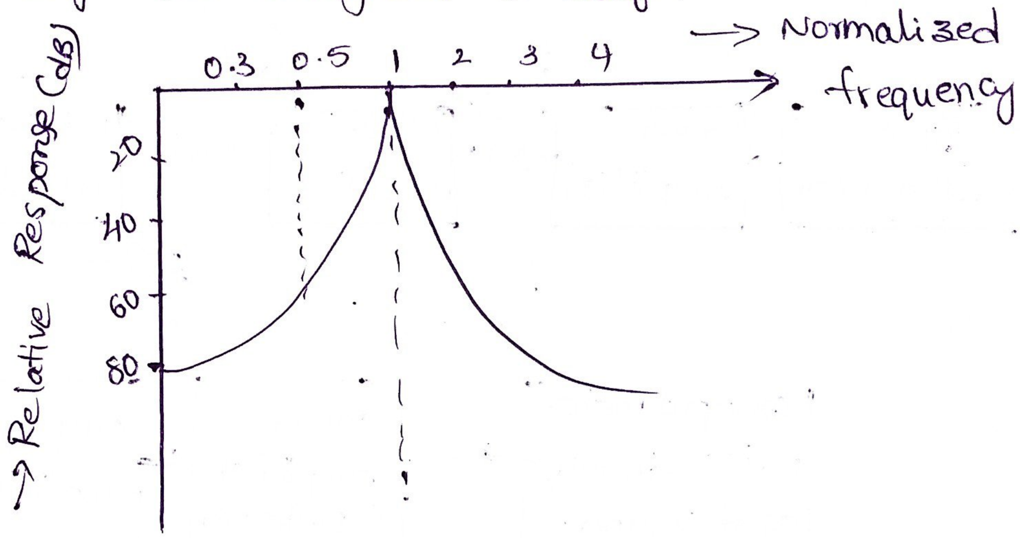
The complex wave-form which is to be analyzed is fed to the input attenuator that Can be adjusted and set by 'meter range' Switch provided on its front pannel. This attenuator allows large range of Signal amplitudes to the selective amplifier.

without loading it. Now, the attenuated o/p is applied to a high Q active filter through driver amplifier ckt. The high Q is a low pass filter that contains RC resonant ckt and filter amplifiers connected in cascade form and allows the selective frequency to pass and rejects the remaining frequencies. The final amplifier supplies the selected frequency signal to the meter which



· Indicates the magnitude of selected frequency and to output buffer amplifier which is employed to drive the electronic counter or recorder or any o/p device.

In this analyzer the resistor are of precision potentiometer type and capacitor are of closed tolerance polystyrene type and these are used to select a particular frequency ranges. Specifically the Capacitors are used to select frequency ranges and the precision Potentiometers are used to tune the filter to any required frequency with in the selective band. This analyzer should have low input distortion that cannot be detected by the anlyzer it self.

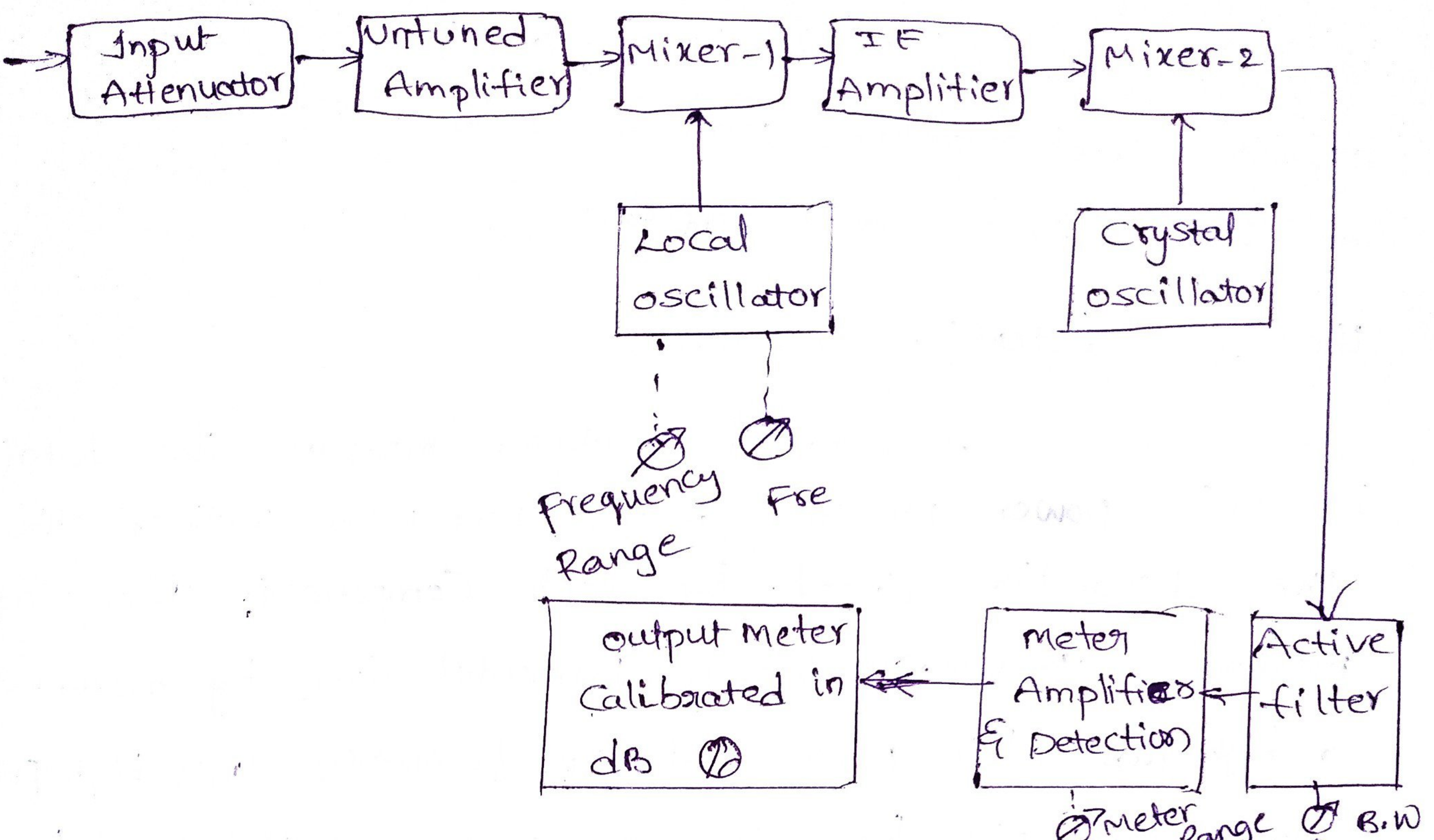


Attenuation characteristics.

Heterodyne wave Analyzer:

Heterodyne wave Analyzer are designed to measure frequencies in RF range and also ranges above megahertz. Its operation depends on the particular principle of heterodyne or mixing.

In this analyzer the input to be analyzed is applied through an attenuator and untuned amplifier before being heterodyned in mixer-1, to a higher IF range with an internal local oscillator



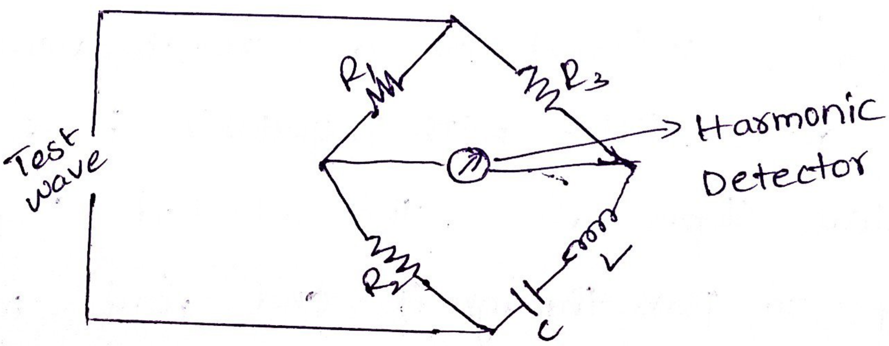
• The O/P frequency such that the frequency should be in the pass band of IF amplifier ∴, the output of the mixer-1 is an intermediate freq signal which is then amplified by 30 MHz IF amplifier. The output of the IF amplifier is again heterodyned with a 30MHz signal coming from a crystal oscillator. Due to this output of Mixer-2 centered on a zero frequency. The sub sequent active filter with adjustable band width and symmetrical slopes allows the selected component of frequency to pass through it and reach meter amplifier and detector whose output can be read by a decibel calibrated scale.

This hetrodyne wave analyzer is also reffered to as a hetrodying tuned voltmeter and operates in the range of 10 KHz to 18 MHz. The band width of the Signal Can be adjusted and controlled with an active filter and can be at 200 Hz, 1000 Hz and 3000 Hz.

Harmonic distortion Analyzer:

A distortion analyzer measures the total harmonic power present in the test wave rather than the distor-tion Caused by each Component. The Simplest method is to supress the fundamental freq by means of a high Pass filter whose cut off frequency. This high pass allows only the harmonics to pass and the total harmo--nic distortion can then be measured. Other types of harmonic distortion analyzers based on fundamental Suppression as follows.

1. Employing a Resonance bridge:



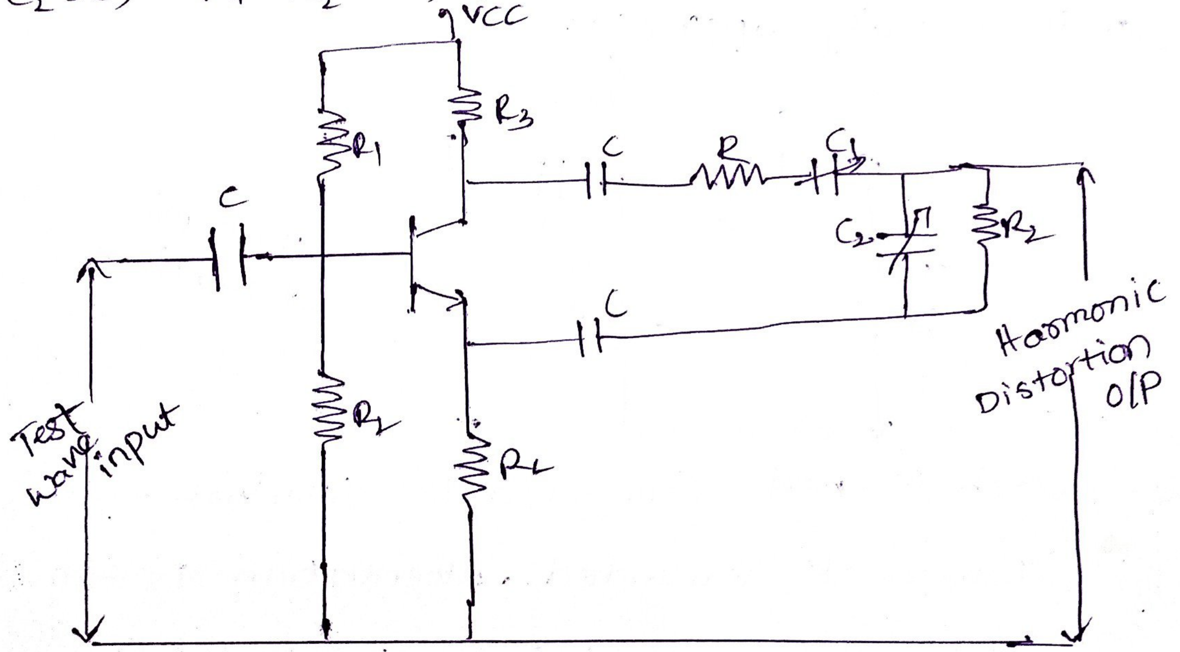
The bridge is balanced for the fundamental frequency i.e L and C tuned to the fundamental frequency

The bridge is unbalanced for the harmonics i.e only harmonic Power will be available at output terminal and can be measured. If the fundamental frequency is changed, the bridge must be balanced again. If L and C are fixed components, then this method is suitable only when the test wave has a fixed frequency. Indicators can be thermocouples or square law VTVMs. This indicates the rms value of all harmonics.

Wien's bridge method:

The bridge is balanced for the fundamental frequency. The fundamental energy is dissipated in the bridge circuit elements. Only the harmonic components reach the output terminals. The harmonic distortion o/p can then be measured with a meter. For balance at the fundamental frequency

$C_1 = C_2 = C$, $R_1 = R_2 = R$, $R_3 = 2R_4$.

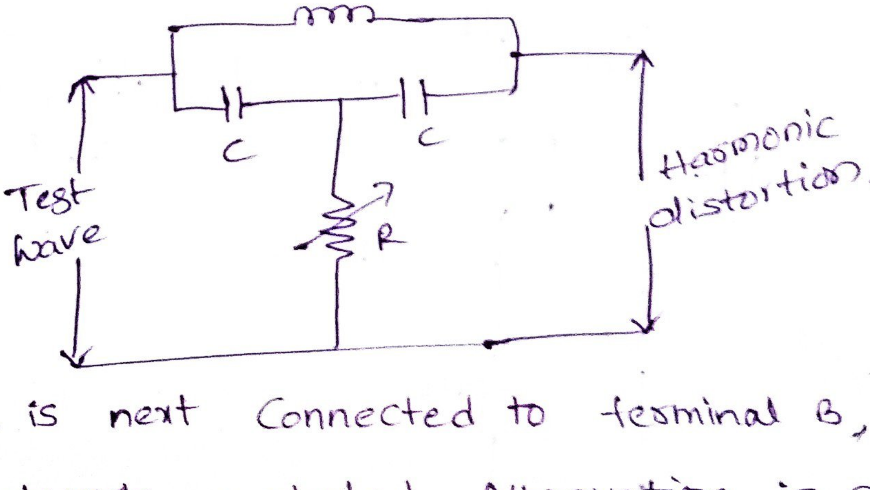


Bridge T-Network method:

The L and C's are tuned to the fundamental frequency and R is adjusted to by pass fundamental frequency. The tank ckt being tuned to the fundamental frequency. the energy will circulate in the tank and is by passed by the resistance. Only harmonic Components will reach the o/p Can be measured by the meter. The Q of the resonant ckt must be at least 3-5

One way of using a bridge T-network is given below.

The Switch S is first Connected to point A So that the attenuator is excluded and the bridge T-network is adjusted for full Suppression of the fundamental frequency i.e minimum o/p minimum o/p indicates that the bridge T-network is tuned to the fundamental frequency and that the fundamental frequency is fully Suppressed.



The switch is next Connected to terminal B, i.e the bridge T-network excluded. Attenuation is adjusted until the Same reading is obtained on the meter. The attenuator reading indicates the total rms distortion.

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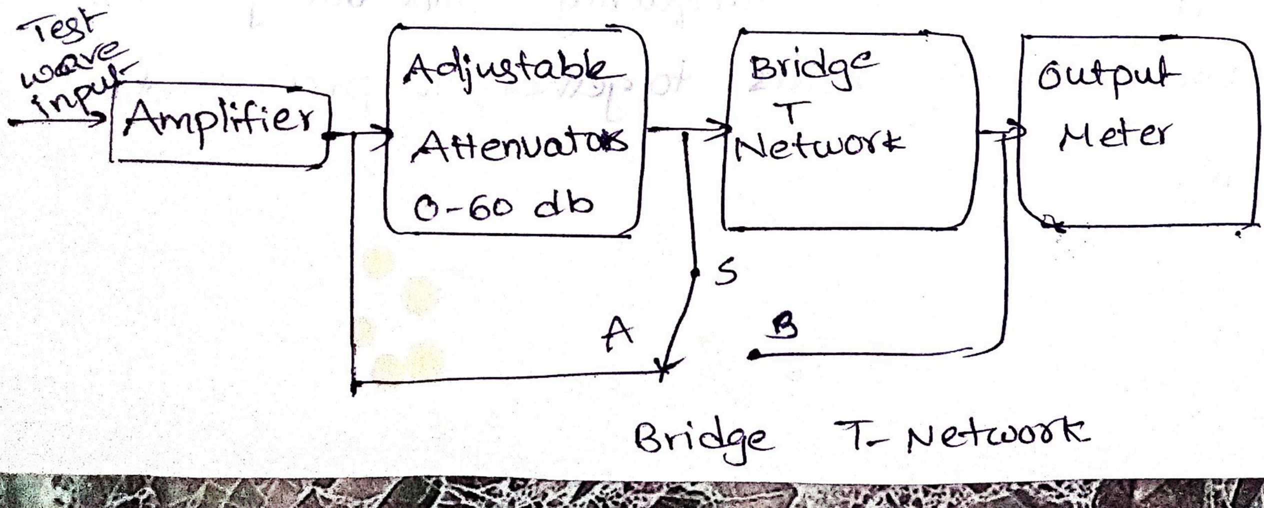
Spectrum Analyzer:

The most common way of observing signals is to display them on an oscilloscope with time as the x-axis. This is the time domain. It is also useful to display signals in the frequency domain. The instrument providing this frequency domain view is the spectrum analyzer.

A spectrum analyzer provides a calibrated graphical display on its CRT, with frequency on the horizontal axis and amplitude on the vertical axis.

Displayed as vertical lines against these coordi-nates are sinusoidal components of which the i/p signal is composed. The height representation the absolute magni-tude and the horizontal location represents the frequency. These instruments provide a display of the frequency spectrum over a given frequency band. Spectrum analyzers use either a parallel filter bank or a swept frequency technique.



Bridge T- Network

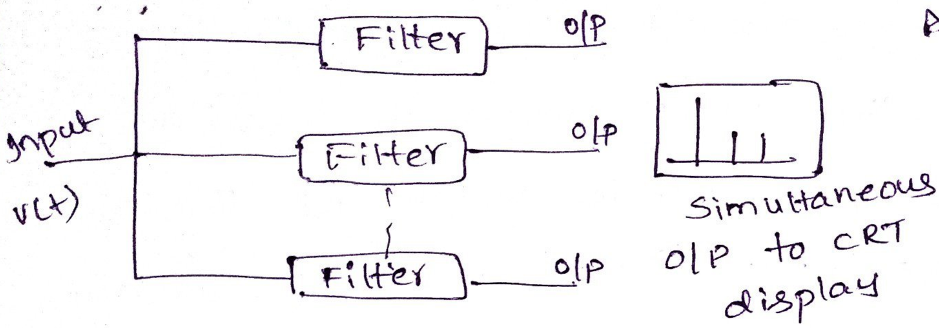
In a parallel filter bank analyzer, the frequency range is covered by a series of filters whose central frequencies and bandwidth are so selected that they overlap each other shown in above figure.

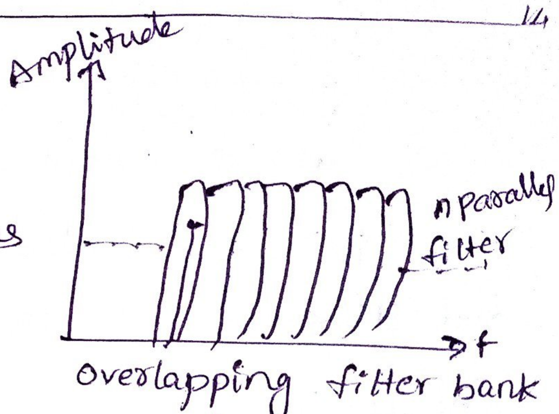
Typically, an audio analyzer will have 32 of these filters, each covering one third of an active. for wide band narrow resolution analysis, particularly at RF or microwave signals, the swept technique is prefered.

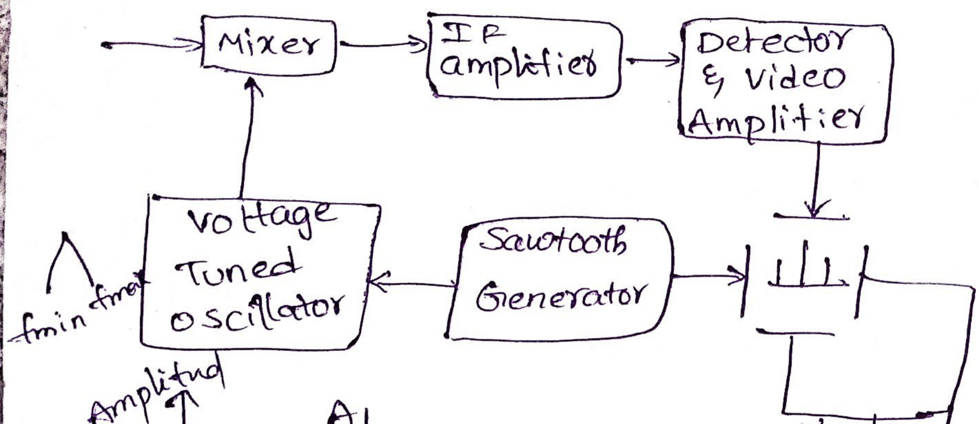
Basic Spectrum Analyzer using swept Receiver Design:

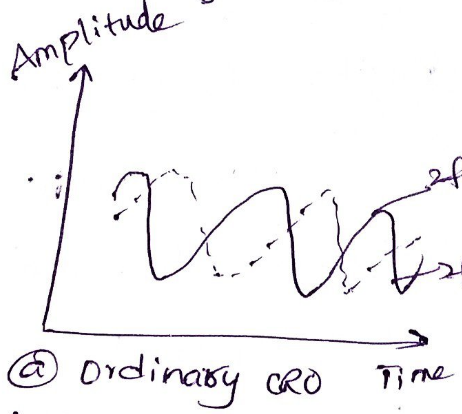
The Sawtooth generator provides the Sawtooth voltage which drives the horizontal axis element of the scope and this sawtooth voltage is the frequency controlled element of the voltage tuned oscillator.

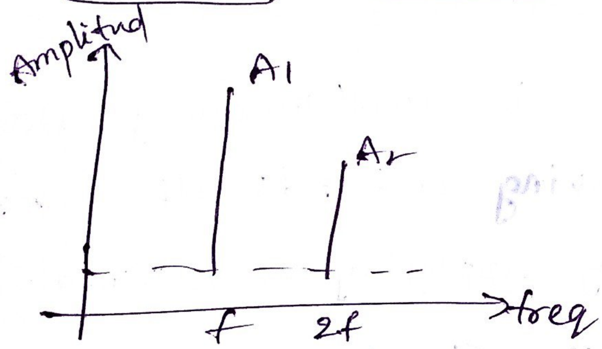
As the oscillator sweeps from f_{min} to f_{max} of its frequency band at a linear recurring rate it beats with the frequency component of the input signal and produce an IF, whenever a frequency component is met during its sweep. The frequency and voltage tuned oscillator frequency beats together to produce different frequency

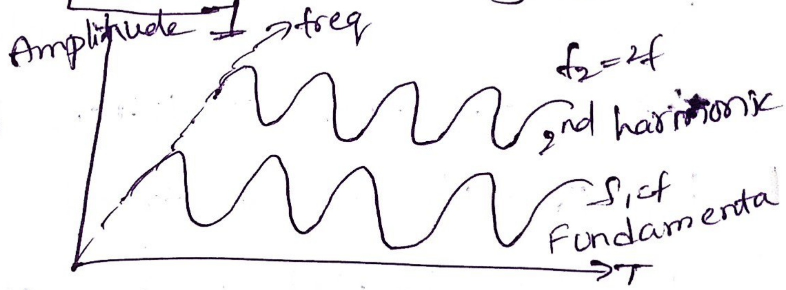












One of the principle applications of spectrum analyzers has been in the study of the RF Spectrum produced in microwave instrument, the horizontal axis can display as a wide range as 2-3 GHz for broad survey as narrow as 30 kHz, for a highly magnified view of any small portion of the Spectrum signals at microwave frequency separated by only a few kHz can be seen individually.

The input signal is fed into a mixer which is driven by a local oscillator. This ocillator is linearly tunable.

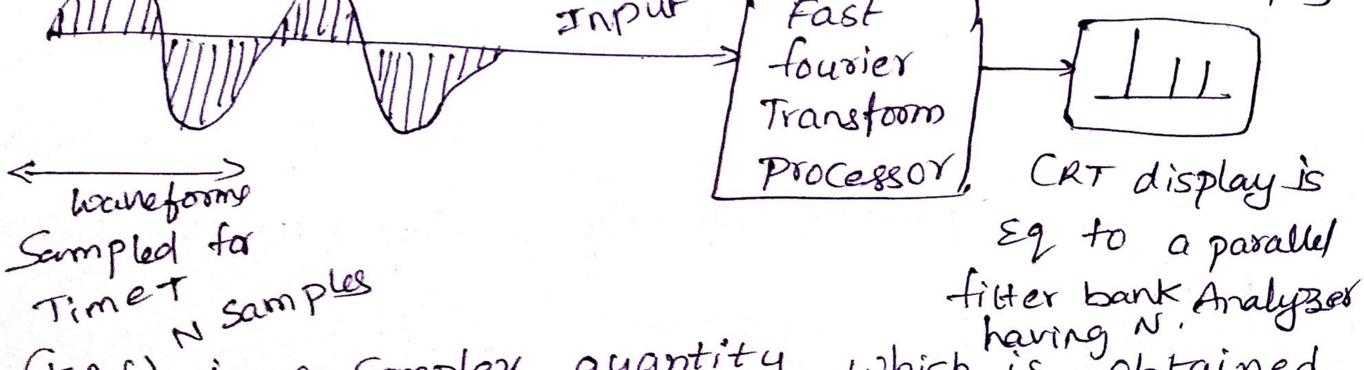
electrically over the range 2-3 GHz. The Mixer provides two Signals at its output that are proportional in amplitude to the input Signal but of frequencies which are the sum and difference of the input Signal and local oscillator frequency.

Digital fourier Analyzer:

The basic principle of a digital fourier analyzer converts the analogue wave-form over time period T into N Samples. The discrete Spectral response $S_x(k\Delta f)$ $k = 1, 2 \ldots N$ which is equivalent to simultaneously obtaining the output from N filters having a bandwidth given by $\Delta f = 1/T$ is obtained by applying a Discreate to the Sampled version of the Signal. The Spectral response

$$S_x(k\Delta f) = \frac{T}{N} \sum_{n=1}^{N} x(n \cdot \Delta t) \exp\left(\frac{-j2\pi kn}{N}\right)$$

where $k = 1, 2, 3 \ldots N$



$S_x(k\Delta f)$ is a Complex quantity, which is obtained by operating on all the Sample $x(n \cdot \Delta t)$ $n = 1, 2, 3 \ldots N$ by the complex factor $\exp[-j(2\pi kn)/N]$.

The discrete inverse transform is given by

$$x(n.\Delta t) = \frac{N}{T} \sum_{n=1}^{N} S_x(k.\Delta f) \exp\frac{(j2\pi kn)}{N}$$

where $n = 1, 2 \ldots N$

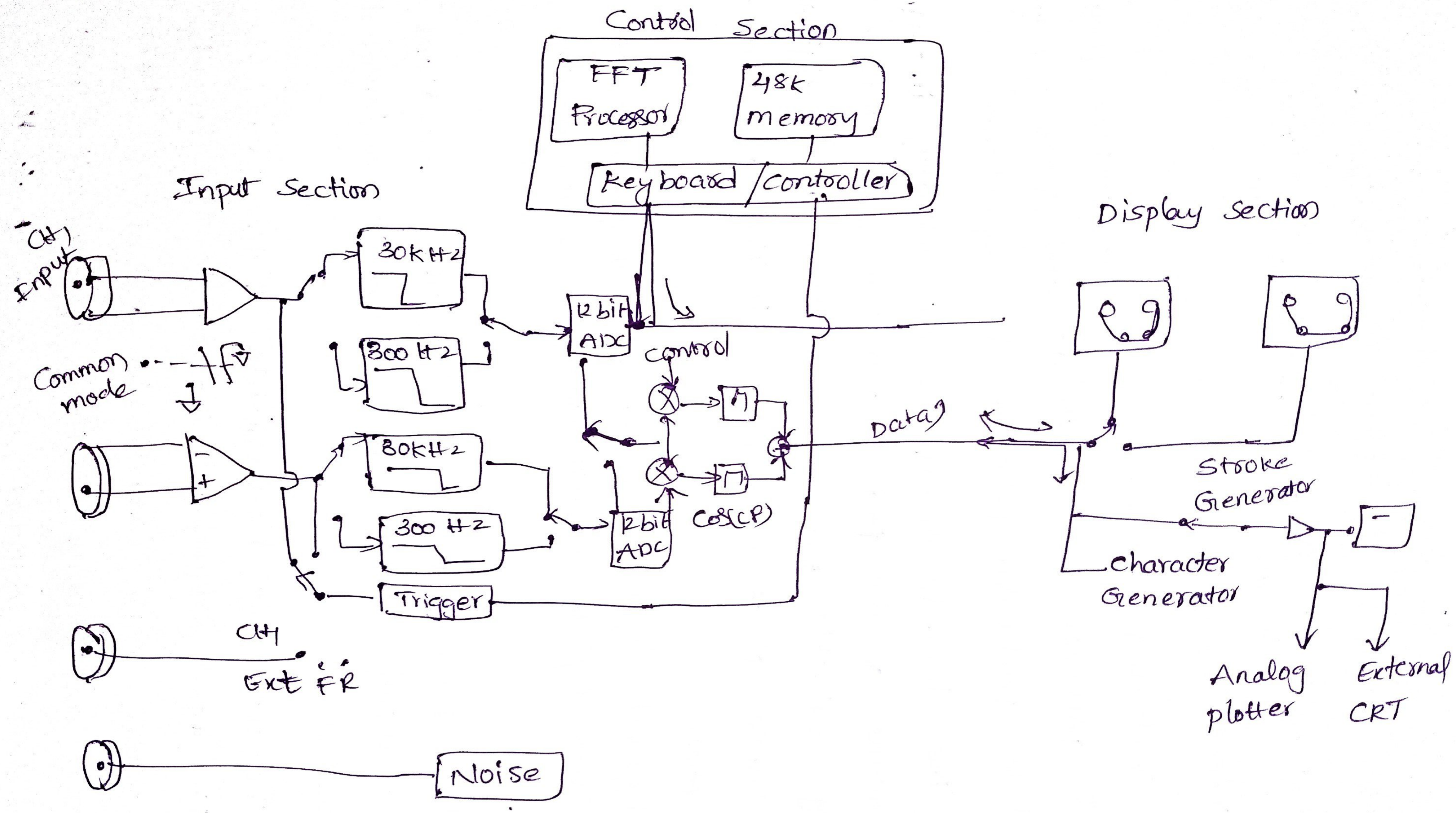
Since $S_x(k.\Delta f)$; $k = 1, 2 \ldots N$ is a complex quantity the DFT provides both amplitude and phase information at a particular point in the spectrum.

The discrete transforms are usually implemented by means of the fast fourier transform which is particullarly suitable for implementation in a digital computer, since N is constrained to the power of 2 i.e $2^{10} = 1024$.

The digital signal analyzer block diagram is shown in below. This digital signal analyzer employs an algorithm.

The block diagram is divided into three sections, namely the input section, the control section and the display section.

The input section consists of two identical channels the input signal is applied to the input amplifier, where it is conditioned and passed through two or more antialiasing filters. the cut off frequencies of these filters are selected with respect to the sampling



Block diagram of a digital signal analyzer.

frequency being used. The 30KHz filter is used with a Sampling rate of 102.4 KHz and the 300 KHz filter with a Sampling rate of 1.024 MHz.

To Convert the signal into digital form, a 12 bit ADC is used. The o/p from the ADC is Connected to a multiplier and a digital filter. For one channel this Can provide the real and imaginary of the linear Spectrum $S_x(f)$ of a time domain Signal.

$$S_x(f) = F(x(t))$$

Where $F(x(t))$ is the fourier transform of $x(t)$. The auto spectrum $G_{xx}(f)$ which Contains no phase information is obtained from $S_x(f)$ as

$$G_{xx}(f) = S_x(f)\, S_x(f)^*$$

Where $S_x(f)^*$ complex Conjugate of $S_x(f)$. The Power Spectrum Density is obtained by normalized the function $G_{xx}(f)$ to a band width of 1Hz, which represents the power in a band width of 1Hz Centered around the frequency f. The inverse fourier Transform of $G_{xx}(f)$ is given by.

$$R_{xx}(\tau) = F^{-1}(G_{xx}(f))$$

$$R_{xx}(\tau) = F^{-1}(S_x(f)\, S_x(f))^*$$

Writing the above equation in terms of the time domain characteristics of the signal $x(t)$, its auto correla-tion function is defined as

$$R_{xx}(\tau) = \lim_{T \to \infty} \frac{1}{T} \int_0^T x(t)\, x(t+\tau)\, dt$$

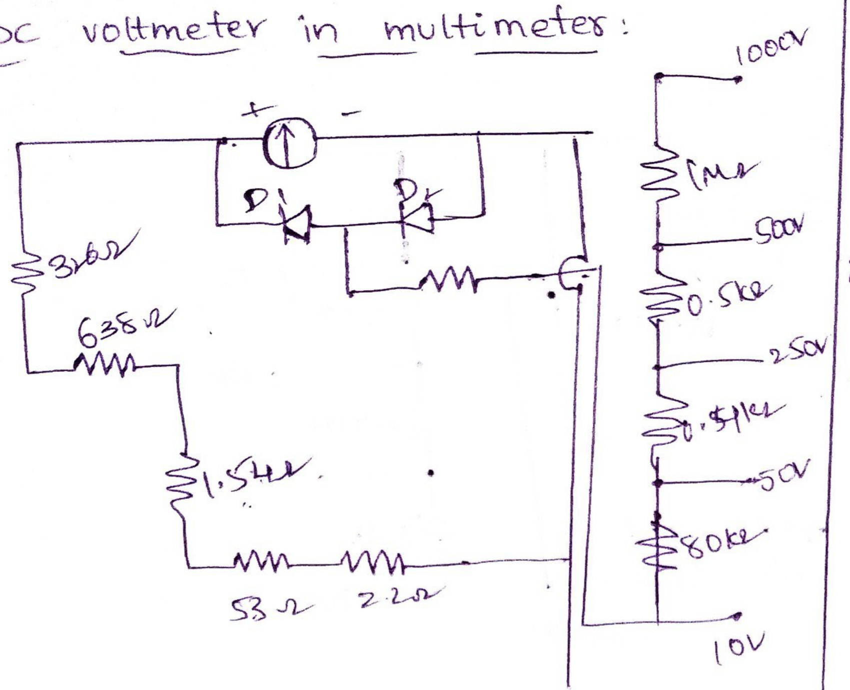
By the use of two channels, the combined properties of the two signals can be obtained

$$G_{yx}(f) = S_y(t)\, S_x(t)^*$$

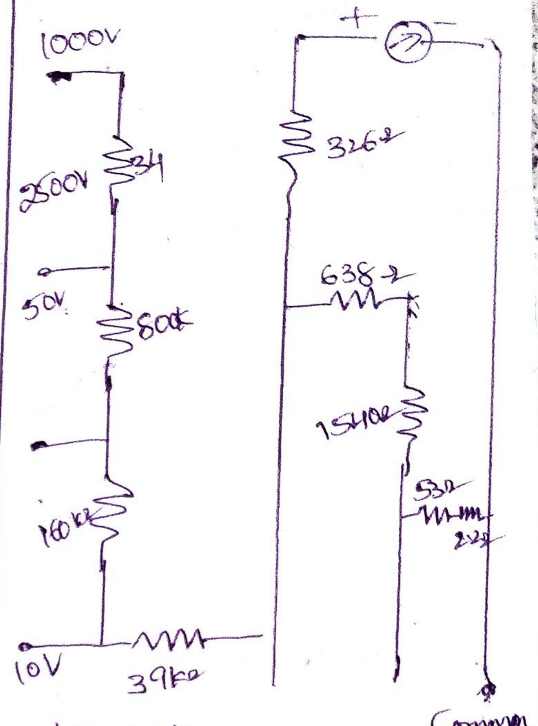
If $x(t)$ represents the input to a system and $y(t)$ the output of the system, then its transfer function $H(f)$ is

$$H(f) = \frac{\overline{G_{yx}(f)}}{\overline{G_{xx}(f)}}$$

AC/DC voltmeter in multimeter:



AC-voltmeter Section of a multimeter



dc-voltmeter.

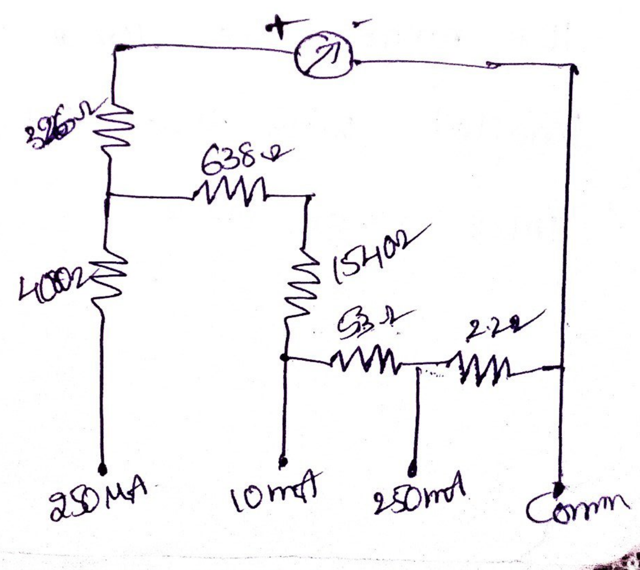
-> To measure AC voltage, the output ac-voltage is rectified by a half wave rectifier before current passes through meter.

-> The other diodes is used for protection

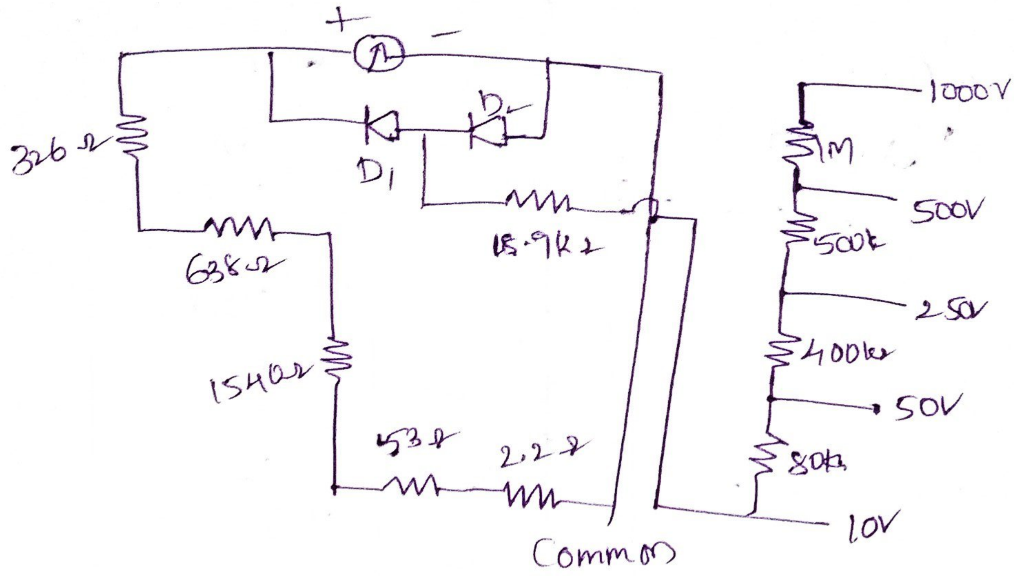
-> The diode Conducts when reverse voltage appears across the diodes, So that current bipasses the meter in reverse direction.

DC ammeter :

-> The figure shows dc ammeter which can measure currents in milli amperes and micro ampers



Ac voltmeter



Ac voltmeter : Ac voltmeter Section of a multimeter To measure ac voltage, the output ac voltage is rectified by a half wave rectifier before the current passes through the meter. Across the meter the other diode serves as protection. The diode conducts when a reverse voltage appears across the diodes so that current by passes the meter in the reverse direction.

Ohmmeter: The ohmmeter Section of a multimeter in the 10K range the 102 Ω resistance is connected in Parallel with the total ckt resistance and in the 1MΩ range 102 Ω meter increase

→ This brings pointer to fullscale deflection position

→ The value of R_1 and R_2 are determined from the value of R_x which gives half the full scale deflection

$$R_h = R_1 + (R_2 \parallel R_m) = R_1 + \frac{R_2 R_m}{R_2 + R_m}$$

R_h = half of full scale deflection resistance

→ The total resistance presented in the battery is $2R_h$ and the battery current needed to supply half deflection is

$$I_h = \frac{V}{2R_h}$$

To produce full scale current the battery current has to be doubled

∴ total current of circuit $I_t = \frac{V}{R_h}$

Shunt current through R_2 is $I_2 = I_t - I_{fsd}$

→ The voltage across shunt is equal to voltage across meter $V_{sh} = V_m$

$$I_2 R_2 = I_{fsd} R_m$$

$$R_2 = \frac{I_{fsd} R_m}{I_2}$$

but $I_2 = I_t - I_{fsd}$ → (2)

eq (2) in (1) ⇒ $R_2 = \frac{I_{fsd} R_m}{I_t - I_{fsd}}$ → (3)

but $I_t = \frac{V}{R_h}$

eq ③ $\Rightarrow$ $R_2 = \frac{I_{fsd} R_m}{V/R_h - I_{fsd}}$ $\frac{I_{fsd} R_m R_h}{V - R_h} = R_2$

but $R_h = R_1 + \frac{R_2 R_m}{R_2 + R_m}$

$\therefore R_1 = R_h - \frac{R_2 R_m}{R_2 + R_m}$

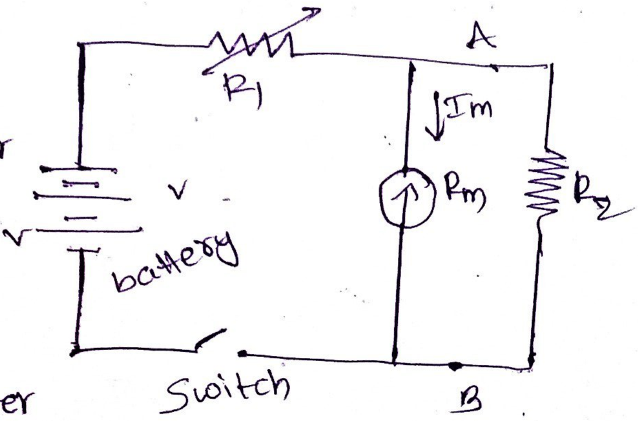
$$R_1 = R_h - \frac{\left(\frac{I_{fsd} R_m R_h}{V - R_h I_{fsd}}\right) R_m}{\left(\frac{I_{fsd} R_m R_h}{V - R_h I_{fsd}}\right) + R_m}$$

$$\boxed{R_1 = R_h - \frac{I_{fsd} R_m R_h}{V}}$$

Thus R_1 & R_2 can be determined.

Shunt type ohmmeter:

→ It consists of a battery in series with an adjustable resistor R_1 and a D'Arsonval movement.



→ The unknown resistance is connected in parallel with meter hence it is shunt type.

fig: shunt type voltmeter