SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME : 23EET206 CONTROL SYSTEMS AND INSTRUMENTATION

II YEAR ECE /III SEMESTER

Unit 5- Oscilloscope, Signal Generator, Signal Analyzer and Data Acquisition System

Topic 4 : Signal Analyzer(Wave and Spectrum)

SPECTRUM ANALYZER

- A spectrum analyzer is a device that measures and displays signal amplitude (strength) as it varies by frequency within its frequency range (spectrum).
- The frequency appears on the horizontal (X) axis, and the amplitude is displayed on the vertical (Y) axis. It looks like an oscilloscope.
- A spectrum analyzer displays a spectrum of signal amplitudes on different frequencies. It enables analysis that determines whether signals fall within required limits. It displays spurious signals, complex waveforms, rare short-duration events and noise. Spectrum analyzers can also analyze transient signals, capture burst transmissions and glitches, and show if stronger signals are masking weaker ones.

FREQUENCY SIGNAL ANALYZER

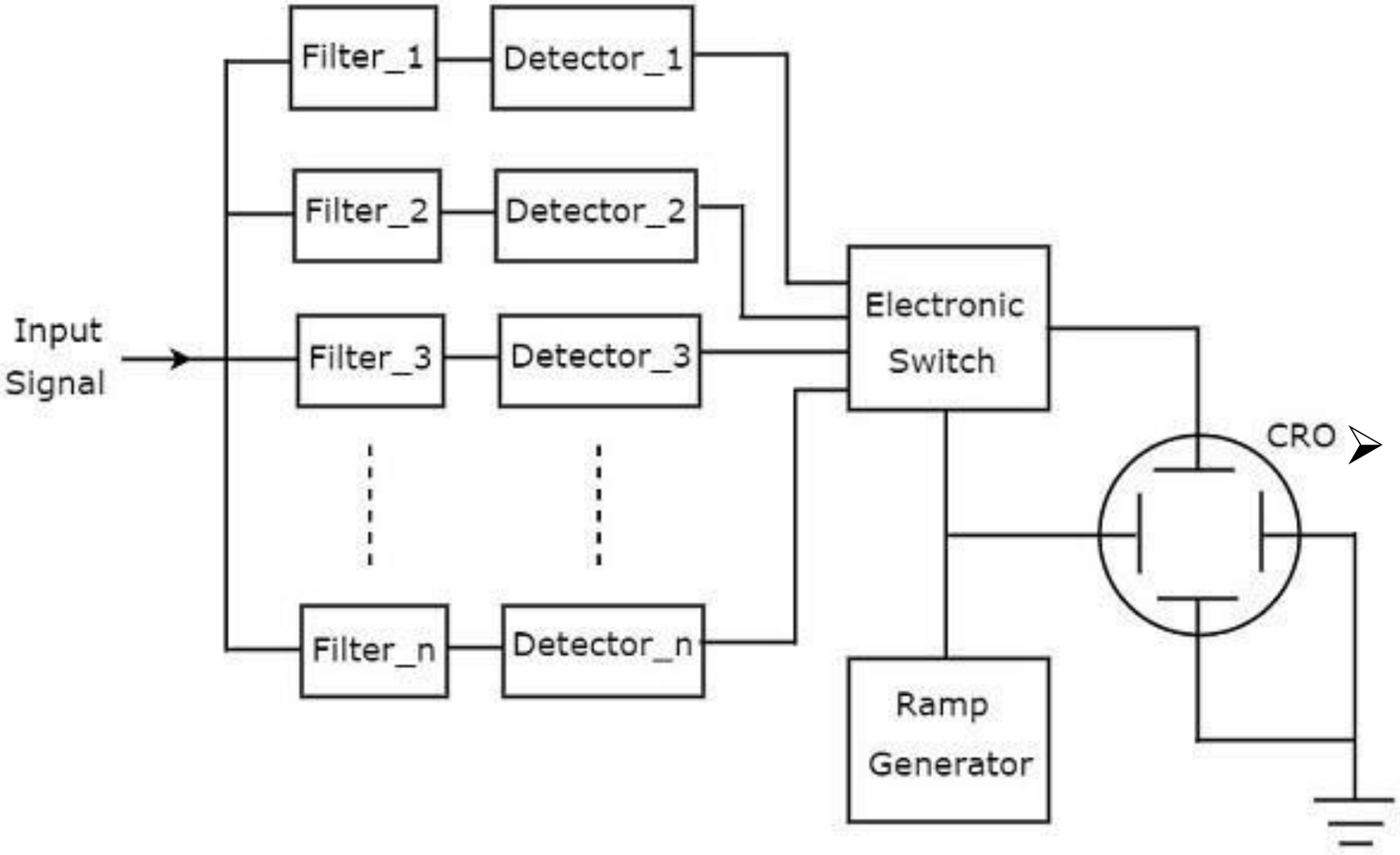
- A frequency signal can be of two range.
  - Audio Frequency Range
  - Radio Frequency Range

- Signal Analyzer can be of two types
  - Wave Analyzer (Suited for Audio Frequency Range)
  - Spectrum Analyzer (Suited for Radio Frequency Range)

SPECTRUM ANALYZER TYPES

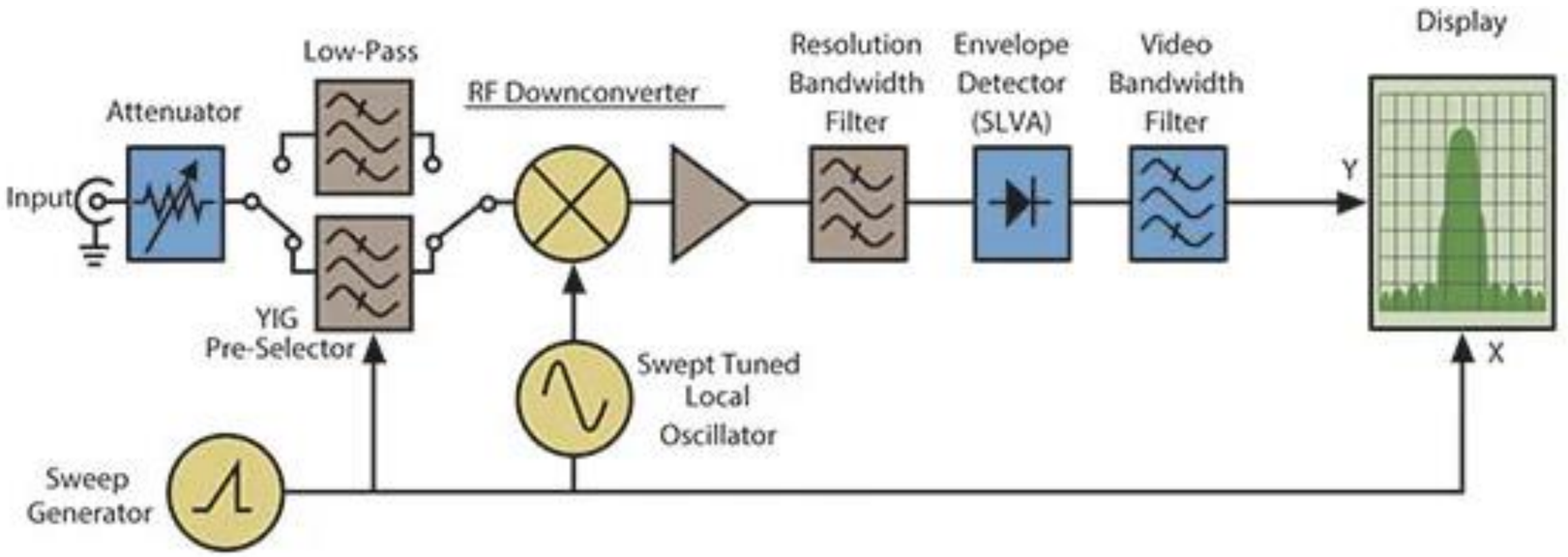
- Vector Signal Analyzer (VSA)
- Filter Bank Spectrum Analyzer or Real-time Spectrum Analyzer (RSA)
- Superheterodyne Spectrum Analyzer or Swept Spectrum Analyzer (SA)

FILTER BANK SPECTRUM ANALYZER



- It has a set of band pass filters and each one is designed for allowing a specific band of frequencies. The output of each band pass filter is given to a corresponding detector.
- All the detector outputs are connected to Electronic switch. This switch allows the detector outputs sequentially to the vertical deflection plate of CRO. So, CRO displays the frequency **spectrum of AF signal** on its CRT screen.

SUPERHETRODYNE SPECTRUM ANALYZER



- The superheterodyne principle is a method to convert incoming radio signals to an intermediate frequency for amplification and filtering.
- The superheterodyne principle works by:
  - **Mixing**: Mixing the radio frequency (RF) signal with a local oscillator (LO) signal to generate an intermediate frequency (IF)
  - **Amplifying**: Amplifying the weak input signal at the IF.
  - **Filtering**: Passing the IF signal through a bandpass filter to reject image frequencies .
  - **Demodulating**: Demodulating the IF signal

SUPERHETRODYNE SPECTRUM ANALYZER

- . The RF input to be analyzed is applied to the input attenuator. After attenuating, the signal is fed to low pass filter.
- The low pass filter suppresses high frequency components and allows low frequency components to pass through it.
- The output of the low pass filter is given to the mixer, where this signal is fixed with the signal coming from voltage controlled or voltage tuned oscillator. This oscillator is tuned over 2 to 3 GHz range.
- The output of the mixer includes two signals whose amplitudes are proportional to the input signal but their frequencies are the sum and difference of the input signal and the frequency of the local oscillator.

SUPERHETRODYNE SPECTRUM ANALYZER

- Since the frequency range of the oscillator is tuned over 2 to 3 GHz, the IF amplifier is tuned to a narrow band of frequencies of about 2 GHz. Therefore only those signals which are separated from the oscillator frequency by 2 GHz are converted to Intermediate Frequency (IF) band.
- This IF signal is amplified by IF amplifier and then rectified by the detector. After completing amplification and rectification the signal is applied to vertical plates of CRO to produce a vertical deflection on the CRT screen. Thus, when the saw tooth signal sweeps, the oscillator also sweeps linearly from minimum to maximum frequency range i.e., from 2 to 3 GHz.
- Here the saw tooth signal is applied not only to the oscillator (to tune the oscillator) but also to the horizontal plates of the CRO to get the frequency axis or horizontal deflection on the CRT screen. On the CRT screen the vertical axis is calibrated in amplitude and the horizontal axis is calibrated in frequency

WAVE ANALYZER

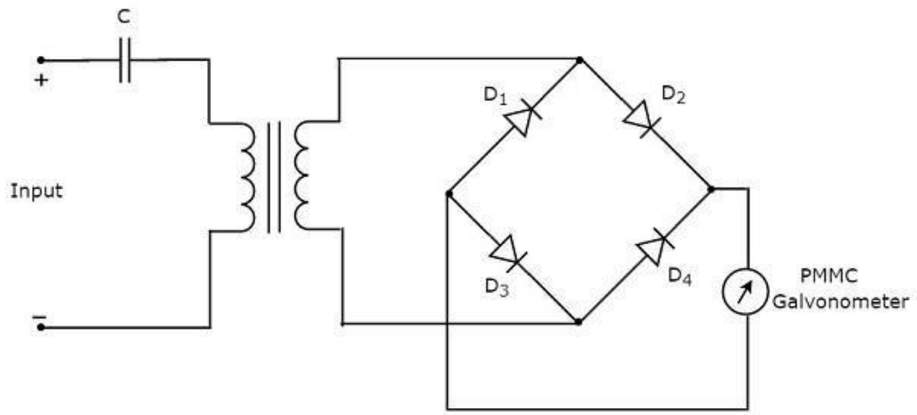
Complex waveform is made up of a fundamental and its harmonics.

- Wave analyzers: Instrument to measure the amplitude of each harmonic or fundamental individually.
- Wave analyzers are also referred to as frequency selective voltmeters, carrier frequency voltmeters, and selective level voltmeters.
- The instrument is tuned to the frequency of one component whose amplitude is measured. This instrument is a narrow band superheterodyne receiver.

WAVE ANALYZER

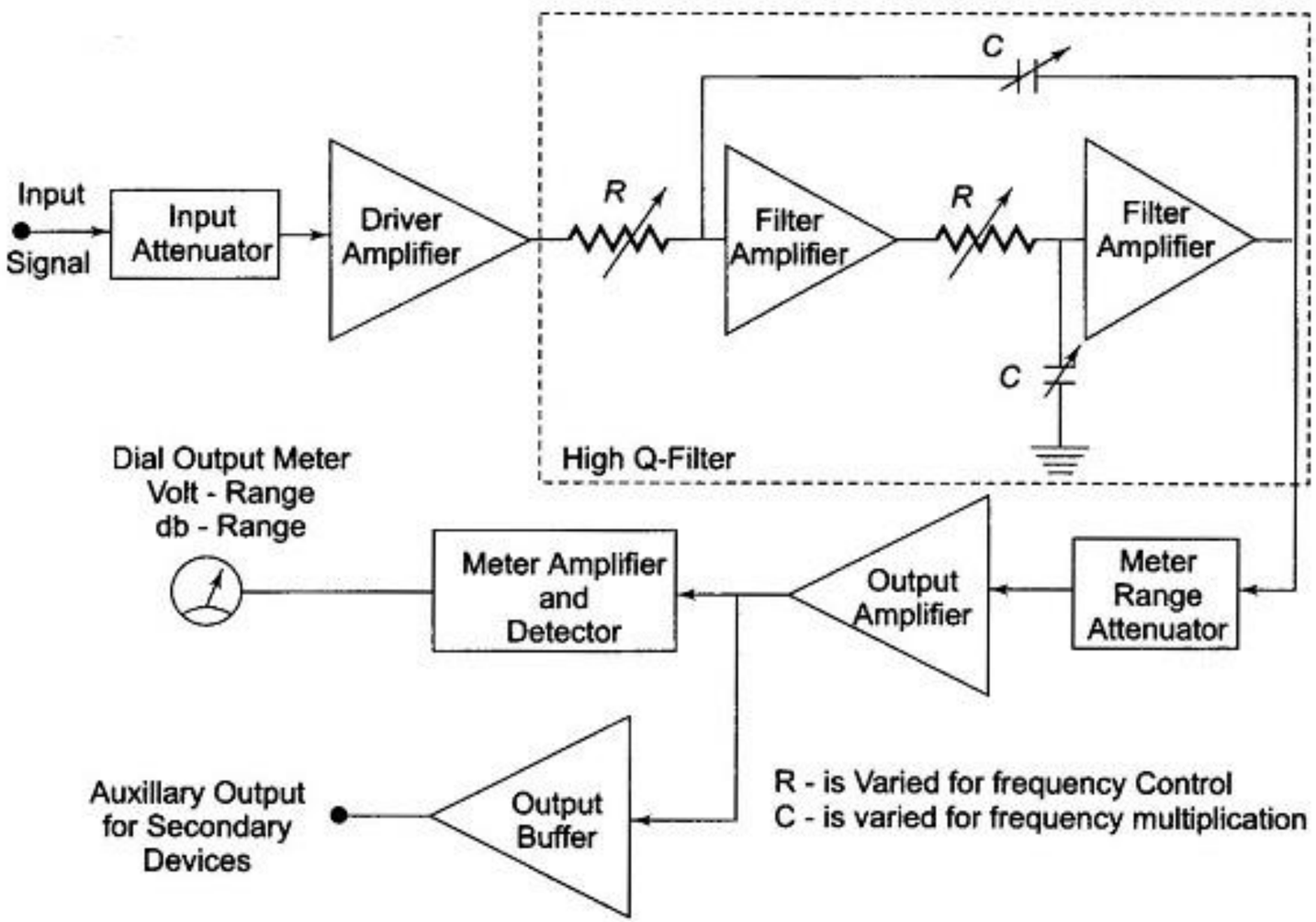
Distortion: When a sinusoidal signal is applied to the input of an ideal linear amplifier, it produces a sinusoidal output waveform. However, in most cases the output waveform is not an exact replica of the input signal because of different types of distortion. The amount by which the output waveform of an amplifier differs from the input waveform is a measure of the distortion introduced by the inherent non-linear characteristics of the active devices.

BASIC WAVE ANALYZER



- Consists of a primary detector with a simple LC circuit.
- LC circuit is adjusted at resonance frequency for the particular harmonic component to be measured.
- LC circuit is tuned to a single frequency and passes only the frequency to which it is tuned and rejects all other frequencies.
- Full wave rectifier (intermediate stage): Obtain the average value of the input signal.
- DC voltmeter (indicating device): Calibrated to read the peak value of the sinusoidal input voltage.

FREQUENCY SELECTIVE WAVE ANALYZER



FREQUENCY SELECTIVE WAVE ANALYZER

- Wave analyzer is a very narrow pass-band filter section which is tuned to a particular frequency within the audible frequency range (20 Hz - 20kHz).
- 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.
- The driver amplifier amplifies the selected frequency and then applies to a high-Q active filter (low pass filter which allows the frequency which is selected to pass and reject all others).

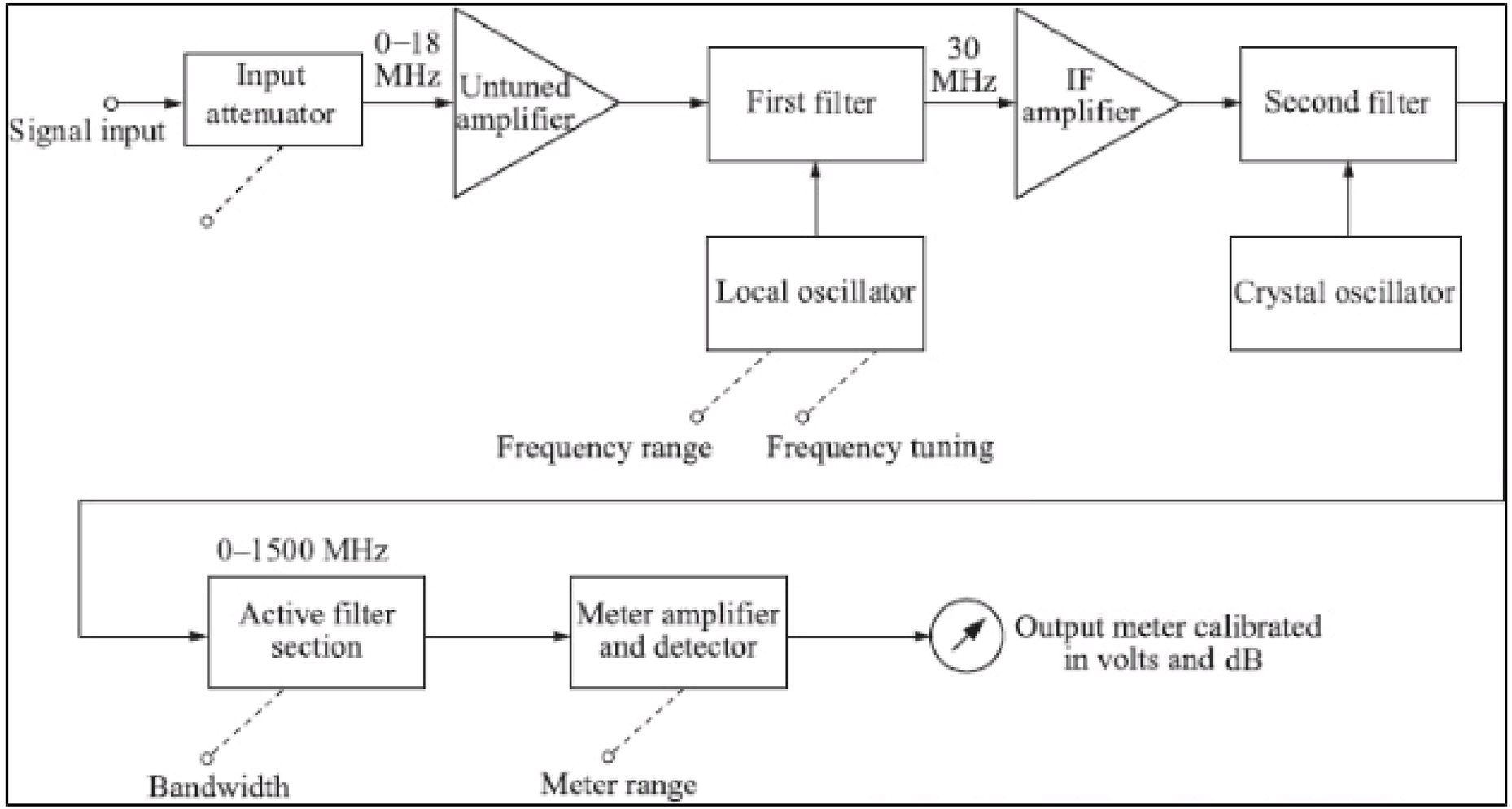
FREQUENCY SELECTIVE WAVE ANALYZER

- Magnitude of this selected frequency is indicated by the meter and the filter section identifies the frequency of the component.
- The filter circuit consists of a cascaded RC resonant circuit and amplifiers.
- 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 also called a Frequency selective voltmeter. (The entire AF range is covered in decade steps by switching capacitors in the RC section).
- The selected signal output from the final amplifier stage is applied to the meter circuit and to an untuned buffer amplifier.

FREQUENCY SELECTIVE WAVE ANALYZER

- The main function of the buffer amplifier is to drive output devices, such as recorders or electronics counters.
- The meter has several voltage ranges as well as decibel scales marked on it. It is driven by an average reading rectifier type detector.

HETRODYNE WAVE ANALYZER



HETRODYNE WAVE ANALYZER

- Wave analyzers are useful for measurement in the audio frequency range only. For measurements in the RF range and above (MHz range), an ordinary wave analyzer cannot be used.
- Hence, special types 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 IF amplifier is rectified and applied to the meter circuit.

HETRODYNE WAVE ANALYZER

- The attenuator provides the required input signal for heterodyning in the first mixer stage, with the signal from a local oscillator having a frequency of 30 - 48MHz.
- The first mixer stage produces an output which is the difference of the local oscillator frequency and the input signal, to produce an IF signal of 30 MHz.
- This IF frequency is uniformly amplified by the IF amplifier which is fed to the second mixer stage, where it is again heterodyned to produce a IF of zero frequency.
- The selected component is then passed to the meter amplifier and detector circuit through an active filter having a controlled band-width.
- The meter detector output can then be read off on a db-calibrated scale, or may be applied to a secondary device such as a recorder.
- This wave analyzer is operated in the RF range of 10kHz - 18 MHz.

References

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2. Sawhney A K., “Course in Electrical, Electronic Measurements and Instrumentation”, Shree Hari Publications, 2021(Unit IV-V).
3. Patranabis D, “Principles of Industrial Instrumentation”, Mc-Graw Hill Education, 3rd Edition, 2017 (Unit IV-V).

Thank You