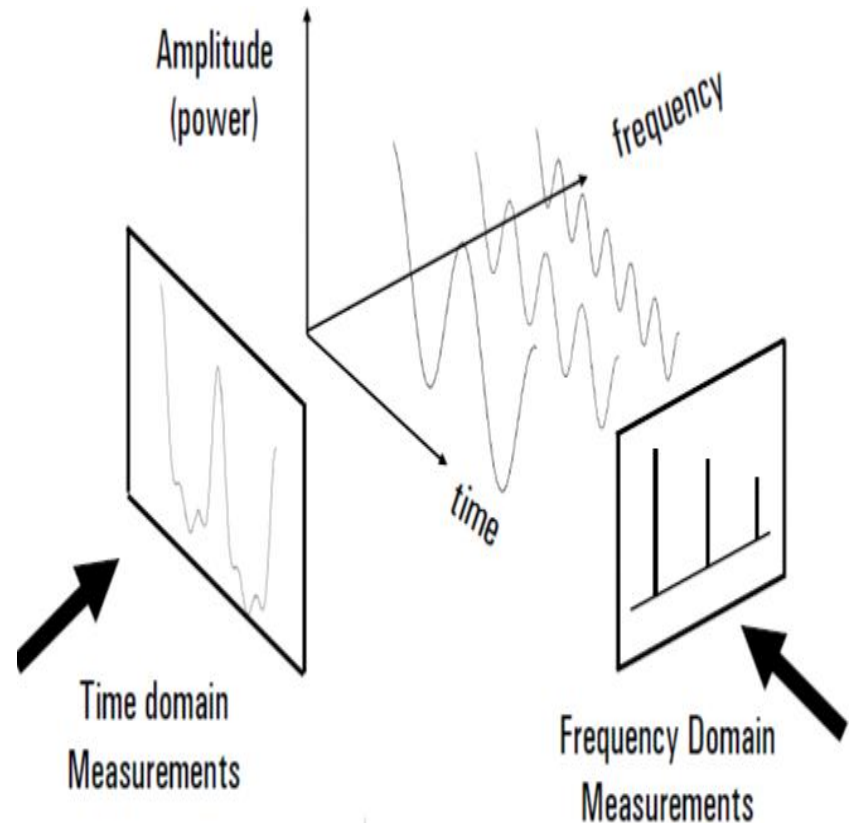# SPECTRUM ANALYZER

# Introduction

- A **spectrum analyzer** measures the amplitude of an input signal versus frequency within the full frequency range of the instrument
- The spectrum analyzer is to the frequency domain where as the oscilloscope is to the time domain

- In the frequency domain, complex signals are separated into their frequency components, and the level at each frequency is displayed

- Spectrum analyzer greatly reduces the amount of noise present in the measurement and also ensure there's no interference from neighbouring frequencies.

# SPECTRUM ANALYZERS

- The problems associated with non-real-time analysis in the frequency domain can be eliminated by using a spectrum analyzer. A spectrum analyzer is a real-time analyzer, which means that it simultaneously displays the amplitude of all the signals in the frequency range of the analyzer.

- Spectrum analyzers, like wave analyzers, provide information about the voltage or energy of a signal as a function of frequency. Unlike wave analyzers. spectrum analyzers provide a graphical display on a CRT. A block diagram of an audio spectrum analyzer.

# SPECTRUM ANALYZERS

- The real-time, or multichannel. analyzer is basically a set of stagger-tuned bandpass filters connected through an electronic scan switch to a CRT. The composite amplitude of the signal within each filters bandwidth is displayed as a function of the overall frequency range of the filter.

- Therefore, the frequency range of the instrument is limited by the number of filters and their bandwidth. The electronic switch sequentially connects the filter outputs to the CRT.

# SPECTRUM ANALYZERS

- Horizontal deflection is obtained from the scan generator, which has a saw tooth output that is nic switch
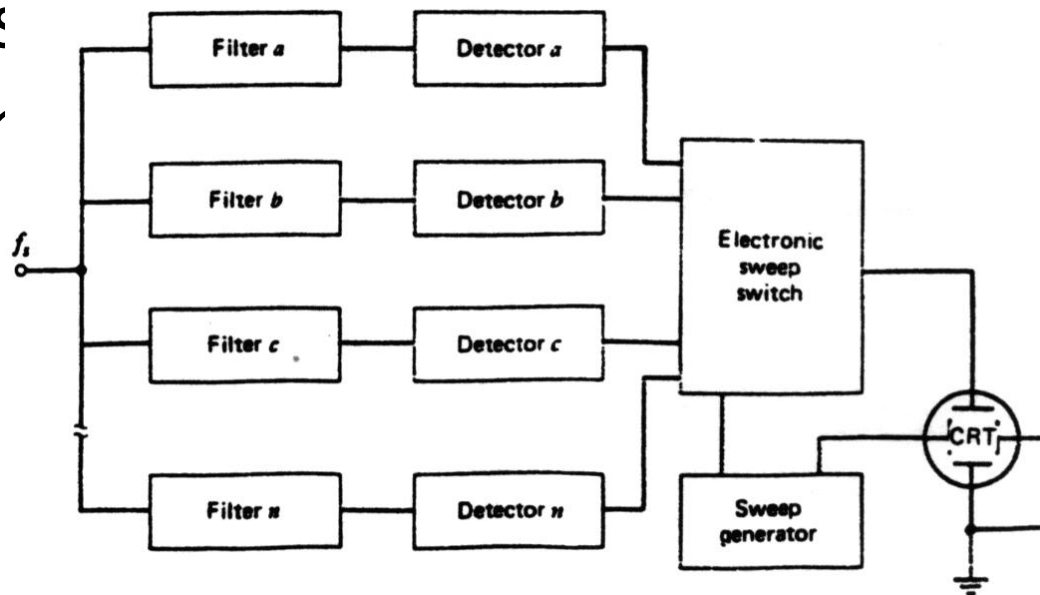


**Fig. 7 Block diagram of an audio spectrum analyzer.**

# SPECTRUM ANALYZERS

- Such analyzers are usually restricted to audio-frequency applications and may employ as many as 32 filters. The bandwidth of each filter is generally made very narrow for good resolution.

- The relationship between a time-domain presentation on the CRT of an oscilloscope and a frequency-domain presentation on the CRT of a spectrum analyzer is shown in the three-dimensional drawing in Fig8.

# SPECTRUM ANALYZERS

Spectrum analyzers are used to obtain a wide variety of information from various kinds of signals, including the following.

- Spectral purity of continuous-wave (CW) signals.
- Percentage of modulation of amplitude-modulated (AM) signals.
- Deviation of frequency-modulated (FM) signals.
- Noise such as impulse and random noise.
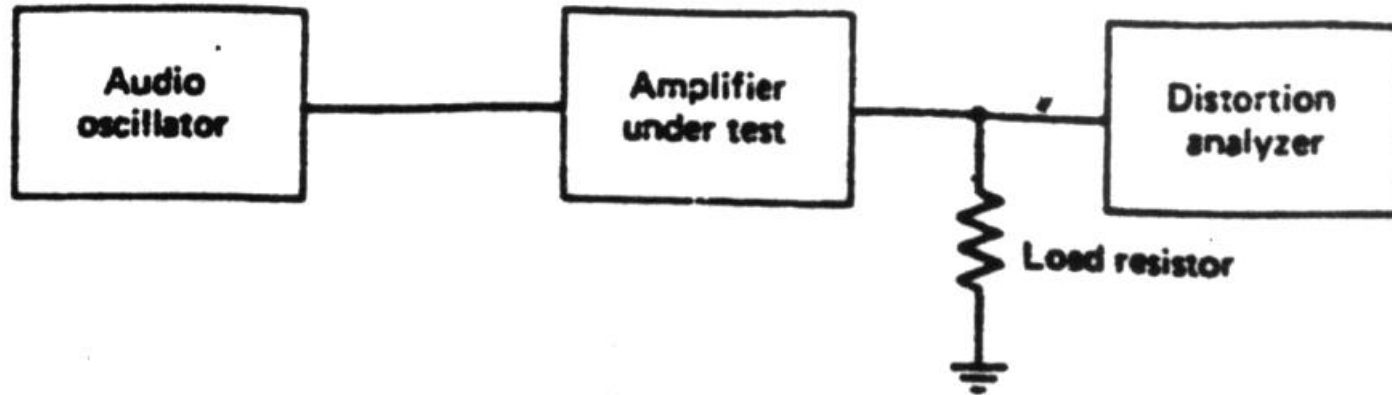- Filter frequency response.

# DISTORTION OF AN AMPLIFIER



**Fig. 11 Test setup to measure the total harmonic distortion of an amplifies.**

# DISTORTION OF AN AMPLIFIER

- waveform is applied to the amplifier. The output of the amplifier is applied directly to the distortion analyzer which measures the total harmonic distortion.

- In the field of microwave communications, in which pulsed oscillators are widely used. spectrum analyzers are an important tool. They also find wide application in analyzing the performance of AM and FM transmitters.

- Spectrum analyzers and Fourier analyzers are widely used in applications requiring very low frequencies in the fields of biomedical electronics, geological surveying. and oceanography. They are also used in analyzing air and water pollution.

# SPECTRUM ANALYZER TO MEASURE INTERMODULATION DISTORTION

- The spectrum analyzer can be used to measure the intermodulation distortion, as shown in the circuit in Fig14. The frequency of the audio oscillator is normally at
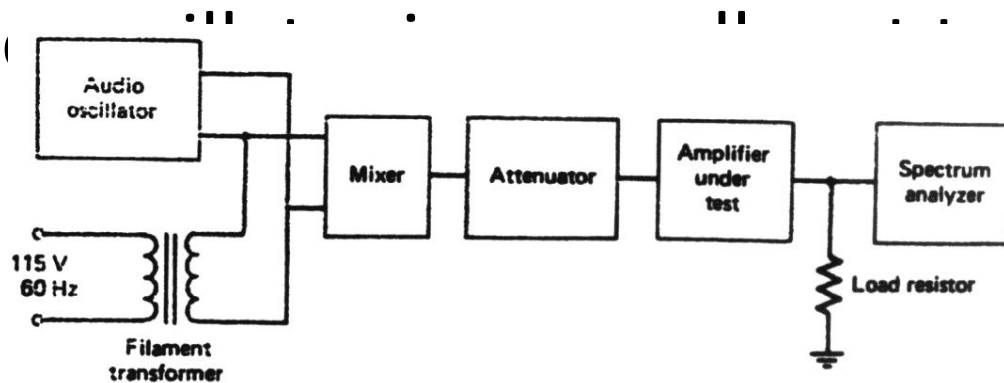
6 kHz.



**Fig.14 Using the spectrum analyzer to measure intermodulation distortion.**

# SPECTRUM ANALYZER TO MEASURE INTERMODULATION DISTORTION

- If the nonlinearity of the circuit is significant. the modulation of the higher-frequency signal by the lower-frequency signal will produce the familiar amplitude modulation waveform as shown in Fig13. The percentage of intermodulation distortion is computed as

$$IMD = \frac{M-m}{M-m} \; x \, 100\%$$

**where**

IMD = the intermodulation distortion expressed as a percentage

M = the peak-to-peak modulated signal

m= the minimum value of the modulated waveform

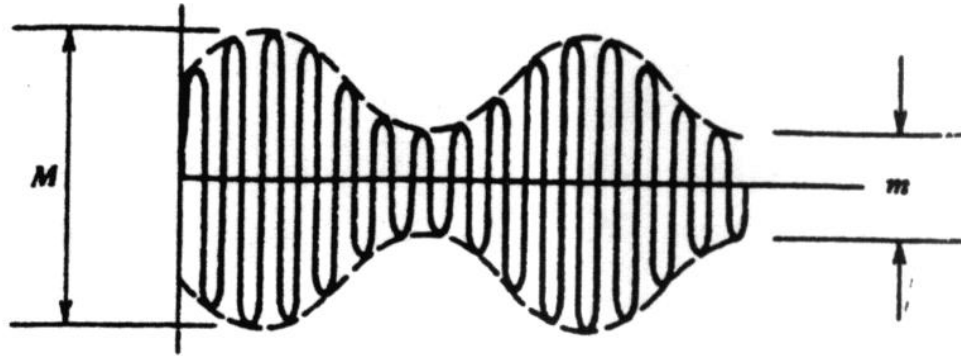# WAVEFORM PRODUCED BY INTERMODULATION DISTORTION



**Fig. 13 Amplitude-modulated waveform produced by intermodulation distortion.**

# Types

- The most common spectrum analyzer measurements are: **modulation, distortion,** and **noise**

- Spectrum analyzer types are:
  - ➢ **Swept tuned spectrum analyzer** : It sweeps across the frequency range, displaying all the frequency components present. This enables measurements to be made over a large dynamic range and wide frequency range.
  - ➢ **FFT based spectrum analyzer** : The FFT analyzer takes a time-domain signal, digitizes it using digital sampling, and then applies the mathematics required to convert it to the frequency domain. The result is displayed as a spectrum.

# Swept tuned spectrum analyzer
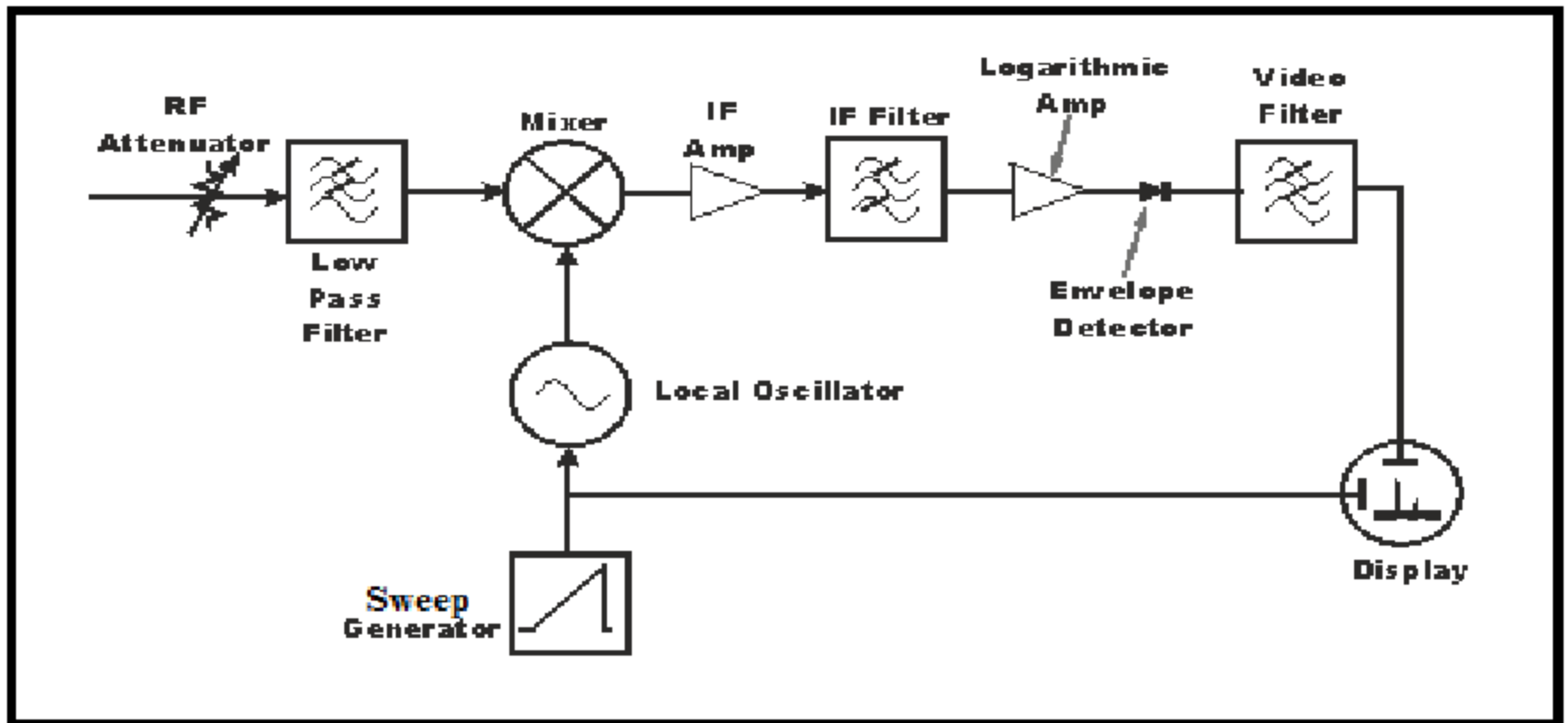


- The major components in a spectrum analyzer are the RF input attenuator, mixer, IF (Intermediate Frequency) gain, IF filter, detector, video filter, local oscillator, sweep generator, and LCD display.

# Input attenuator and mixer

• Its purpose is to adjust the level of the signal entering the mixer to its optimum level. If the signal level is too high, the readings fall outside the display, but also the mixer performance may not be optimum.

**RF INPUT ATTENUATOR**
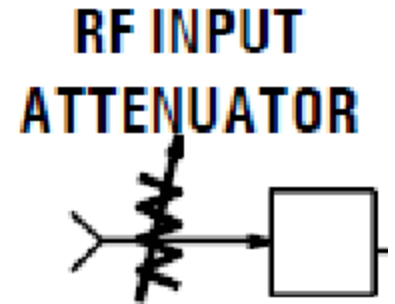
• A mixer is a three-port device that converts a signal from one frequency to another (sometimes called a frequency translation device)
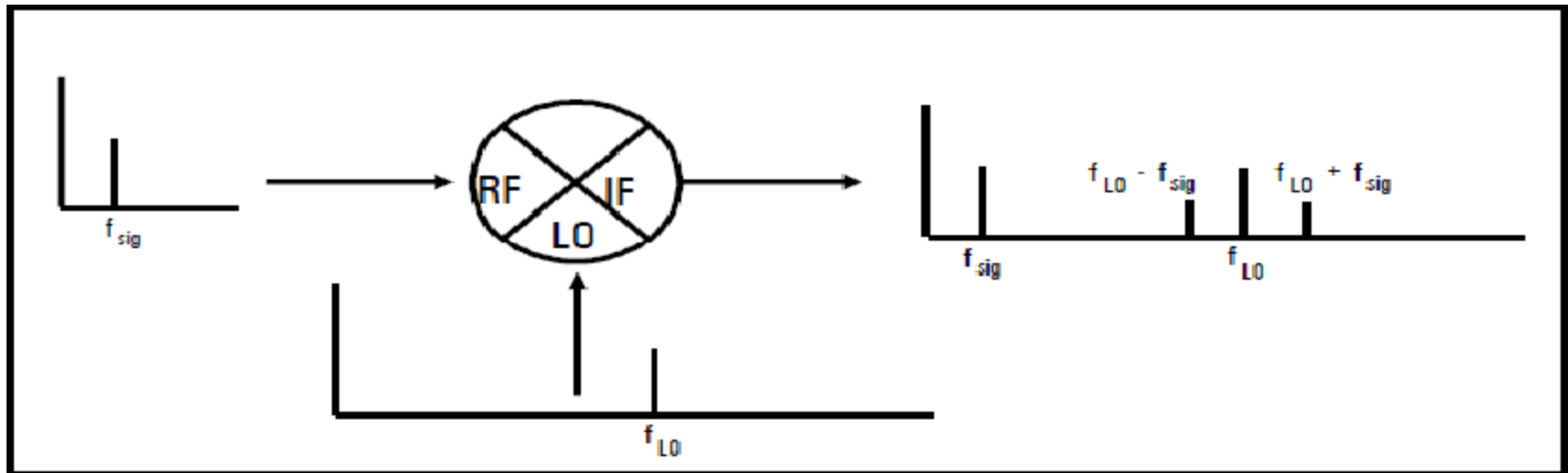
# Gain , filter and detector

**IF GAIN**



•   IF stages provide the required level of gain. It has to be used in conjunction with the RF gain control. Too high a level of IF gain will increase the front end noise level which may result in low level signals being masked.

**IF FILTER**



•   The IF filter is a band pass filter which is used as the "window" for detecting signals. It's bandwidth is also called the resolution bandwidth (RBW) of the analyzer and can be changed via the front panel of the analyzer.

**DETECTOR**



•   The analyzer must covert the IF signal to a baseband or video signal so it can be digitized and then viewed on the analyzer display. This is accomplished with an envelope detector whose video output is then digitized with an analog-to digital converter (ADC).
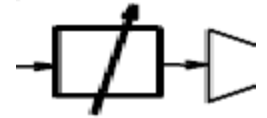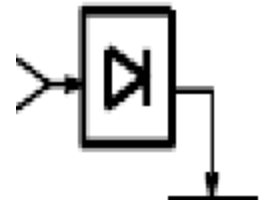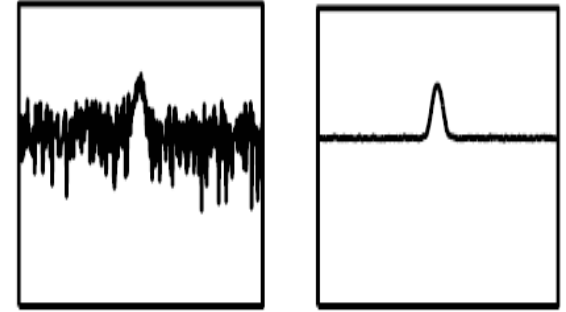
# Video filter, LO, SG and ADC

• The video filter is a low-pass filter that is located after the envelope detector and before the ADC. This filter determines the bandwidth of the video amplifier, and is used to average or smooth the trace seen on the screen.



• The local oscillator (LO) must be capable of being tuned over a very wide range of frequencies to enable the analyzer to scan over the required range. The sweep generator actually tunes the LO so that its frequency changes in proportion to the ramp voltage. The video signal by the ADC is also synchronized with the sweep generator to create the frequency domain on the x-axis.
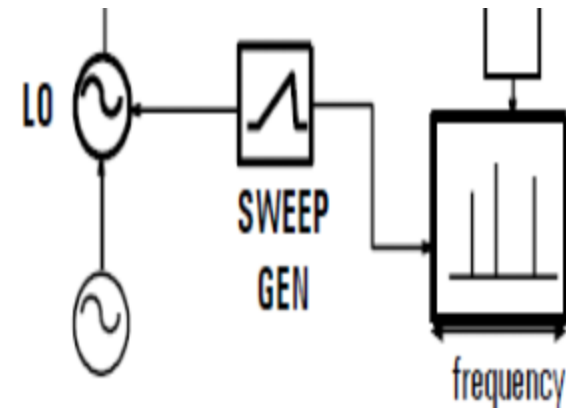
# Front Panel

- The three primary hard keys on any spectrum analyzer are: frequency, amplitude, and span

- Other important control functions include setting the resolution- bandwidth, sweep time, input attenuator and video bandwidth

- Most analyzers allow you to enter values by either punching in the value on the number pad, or by "dialing" up or down to the desired value using the front panel knob

Primary functions
(Frequency, Amplitude, Span)

Softkeys

Control functions
(RBW, sweep time, VBW)

RF Input

Numeric keypad
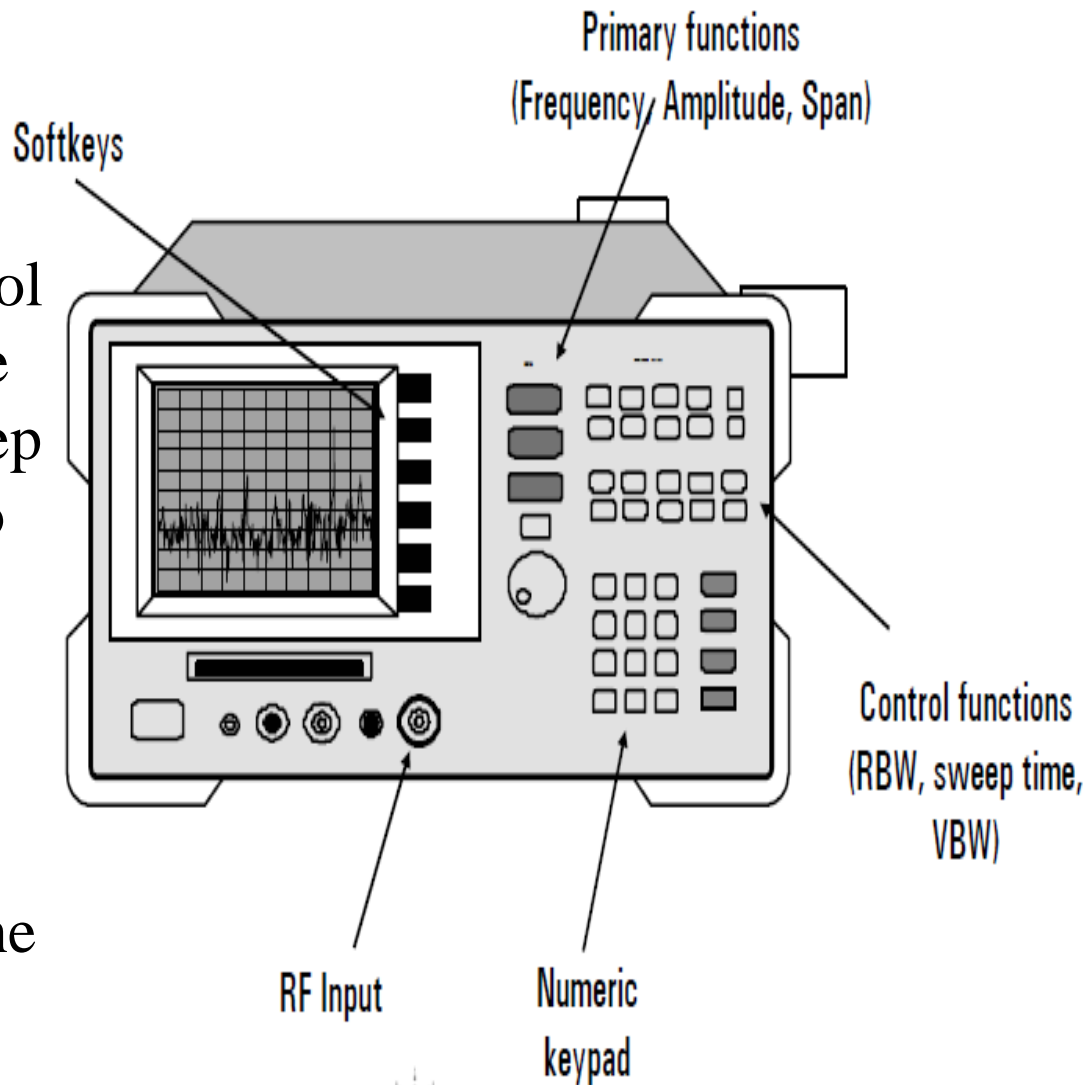
# Advantages and disadvantages

- Advantages :

  ➢Able to operate over wide frequency range
  ➢Wide bandwidth
  ➢Not as expensive as other spectrum analyzer technologies

- Disadvantages:

  ➢Cannot measure phase
  ➢Cannot measure transient events

# Summary

- Spectrum analyzer measures the signal amplitude v/s frequency.
- The most common spectrum analyzer measurements are: modulation, distortion, and noise
- Two types of Spectrum analyzer are

  Swept tuned spectrum analyzer and

  FFT based spectrum analyzer
- The major components in a spectrum analyzer are the RF input attenuator, mixer, IF (Intermediate Frequency) gain, IF filter, detector, video filter, local oscillator, sweep generator, and LCD display.
- Can operate over wide frequency range and it is not expensive as other spectrum analyzers
- Cannot measure phase and transient events