Narrowband and Broadband Discrimination with a Spectrum Analyzer or EMI Receiver

WERNER SCHAEFER
SCHAEFER ASSOCIATES
wernerschaefer@comcast.net

Content

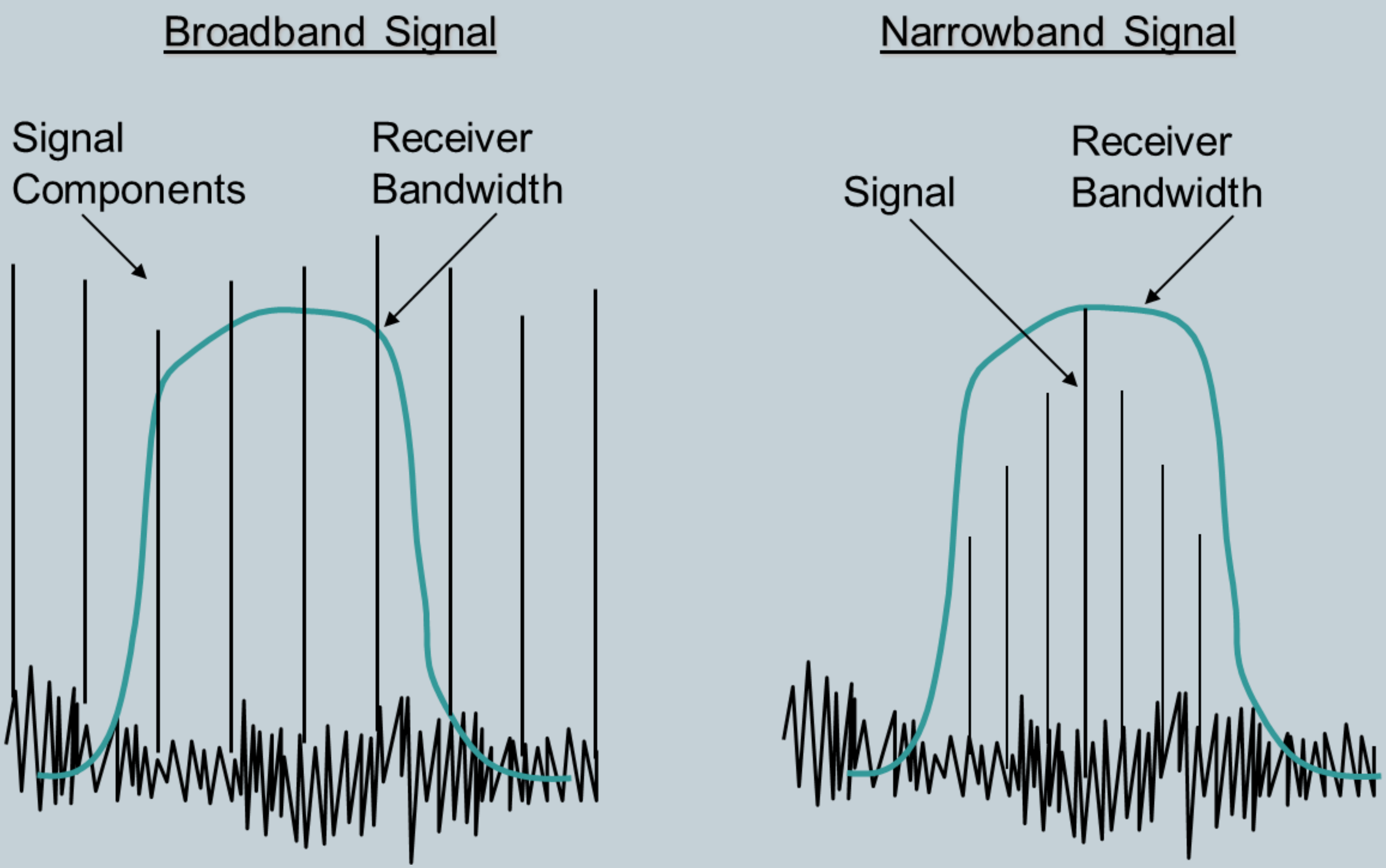
Introduction

- In EMI two main signal categories are of particular interest: narrowband and broadband signals
- Narrowband and broadband signals usually represent a different interference potential for radio services or susceptible devices, which results, in some standards, in different limits (e.g., automotive, MIL-STDs)
- Very often interference spectra contain both narrowband and broadband signals, which cannot be easily discerned by just observing the display of the measuring instrument
- Proper measurement techniques are required that allow the discrimination of narrowband and broadband signals, for example to correctly the frequency of emissions.

Introduction

- The IEV defines a narrowband disturbance as: "*an electromagnetic disturbance, or component thereof, which has a bandwidth less than or equal to that of a particular measuring apparatus, receiver or susceptible device*"
- Analogous to this definition, a broadband signal is defined as "*an electromagnetic disturbance, or component thereof, which has a bandwidth greater than that of a particular measuring apparatus, receiver or susceptible device.*"
- The resolution bandwidth of the instrument is used to discriminate between narrowband and broadband signals. This means, if the bandwidth is changed, the signal classification could change as well!

Introduction



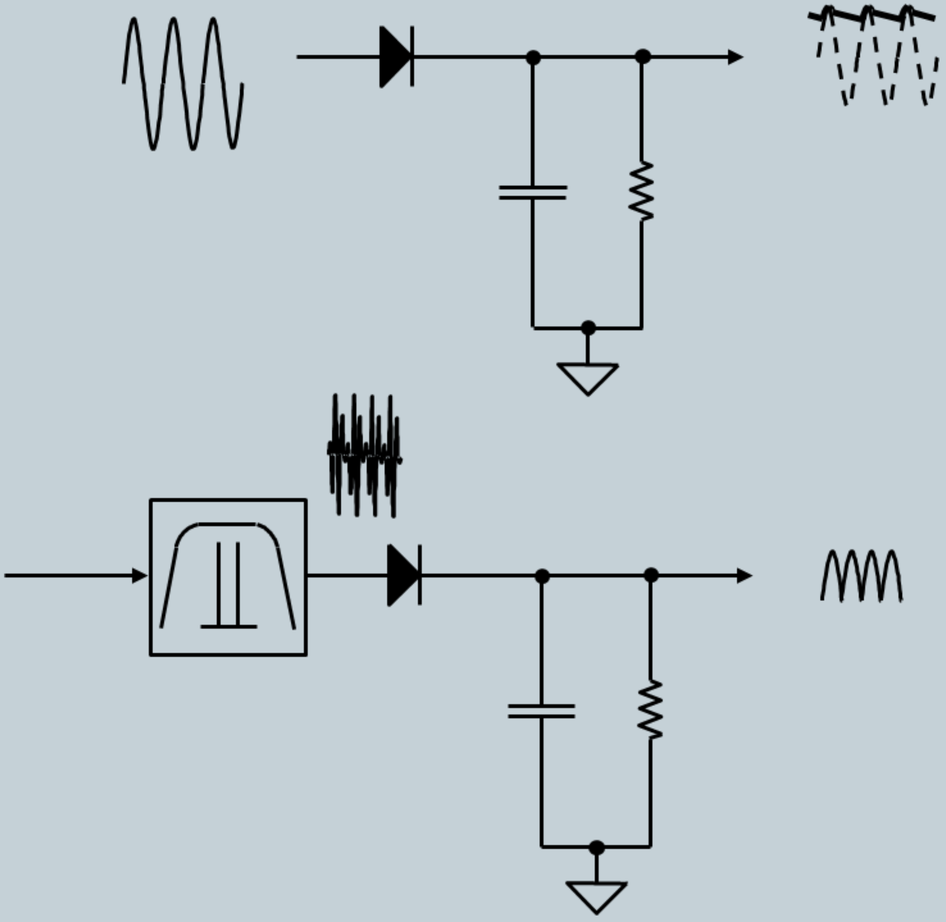
The role of the instrument IF section

- Modern spectrum analyzers and EMI receivers are based on a super-heterodyne principle
- Unknown signals are down-converted to a fixed IF, at which most of the filtering, amplification and signal processing occurs
- The IF filter (“Resolution Bandwidth”) filters out the desired response that represents the unknown signal at the input of the instrument and suppresses all other mixing responses
- After filtering the signal is amplified (“log/lin”), detected (“Peak or Average”), possibly filtered again (“Video Filter”) and finally displayed (graphically or numerically)

The role of the instrument IF section

- IF signals are converted to a low frequency or DC signal using an envelope detector
- The upper frequency is determined by the detection circuit elements
- The envelope detector, in its simplest form, consists of a diode followed by an RC combination
- The time constants of the detector are chosen such that the voltage across the capacitor equals the peak value of the IF signal at all times (requires a fast charge and slow discharge time)
- If there is only one signal in the passband of the IF filter, the detector output will be a constant DC voltage

The role of the instrument IF section



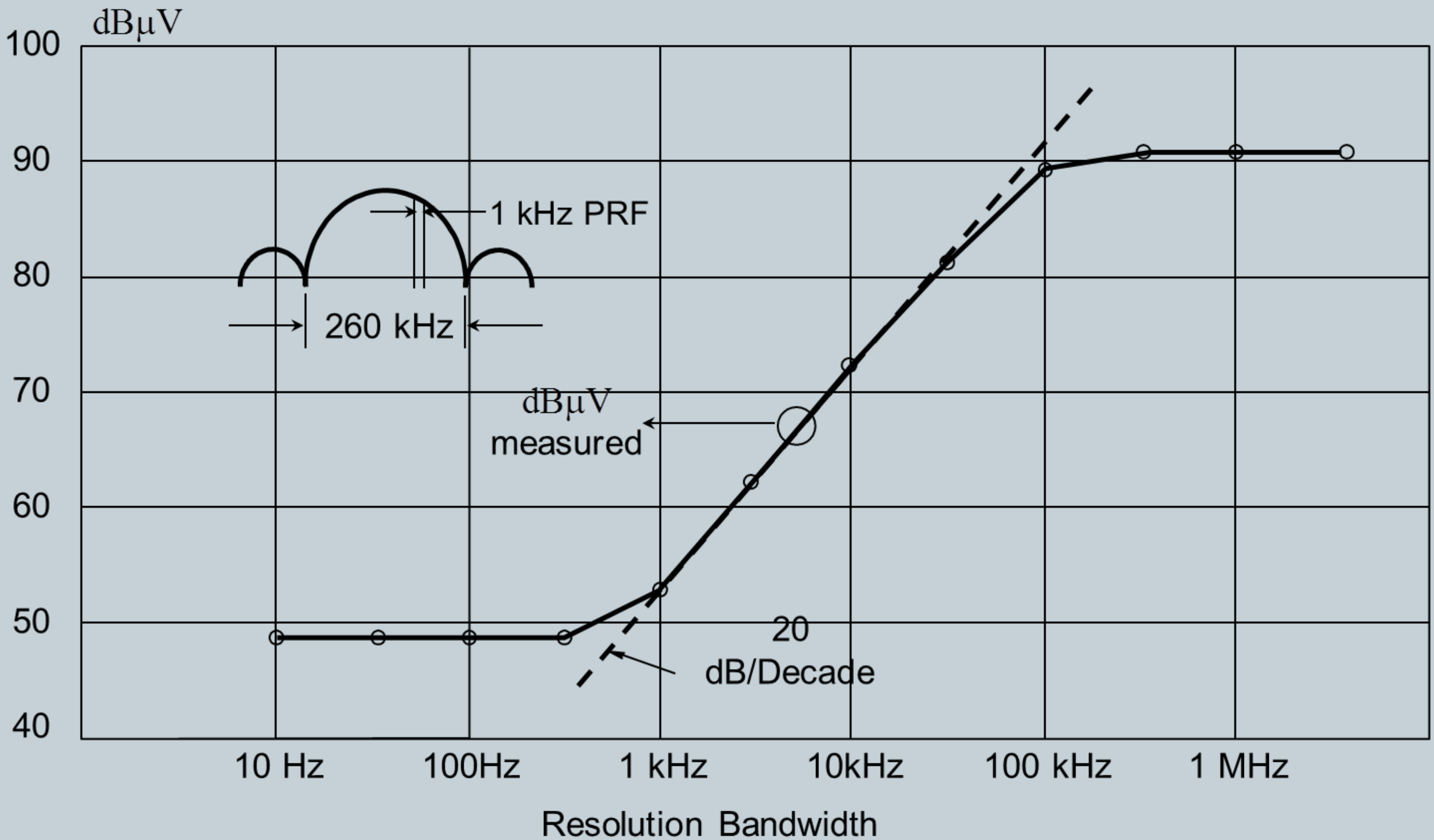
The role of the instrument IF section

- Multiple signals within the IF filter passband interact with each other (as vectors) and the envelope will vary in accordance with the overall phase change of all signals
- The maximum rate at which the envelope of the signal can change is determined by the resolution bandwidth
- Specific instrument settings like selected detectors, resolution bandwidths and sweep time settings have an impact on the displayed result, dependent on the characteristic of the signal to be measured

Resolution bandwidth test

- Resolution bandwidth is the reference for discrimination between narrowband and broadband signals
- Some standards suggest that an amplitude change of a certain value, due to a change of the resolution bandwidth, indicates the presence of a broadband signal
- This test however is of limited usefulness and further information about the signal to be measured (i.e., PRF) is required to avoid erroneous test results and conclusions
- This method provides only conclusive results if a CW is being measured

Resolution bandwidth test



Peak vs. Average detection test

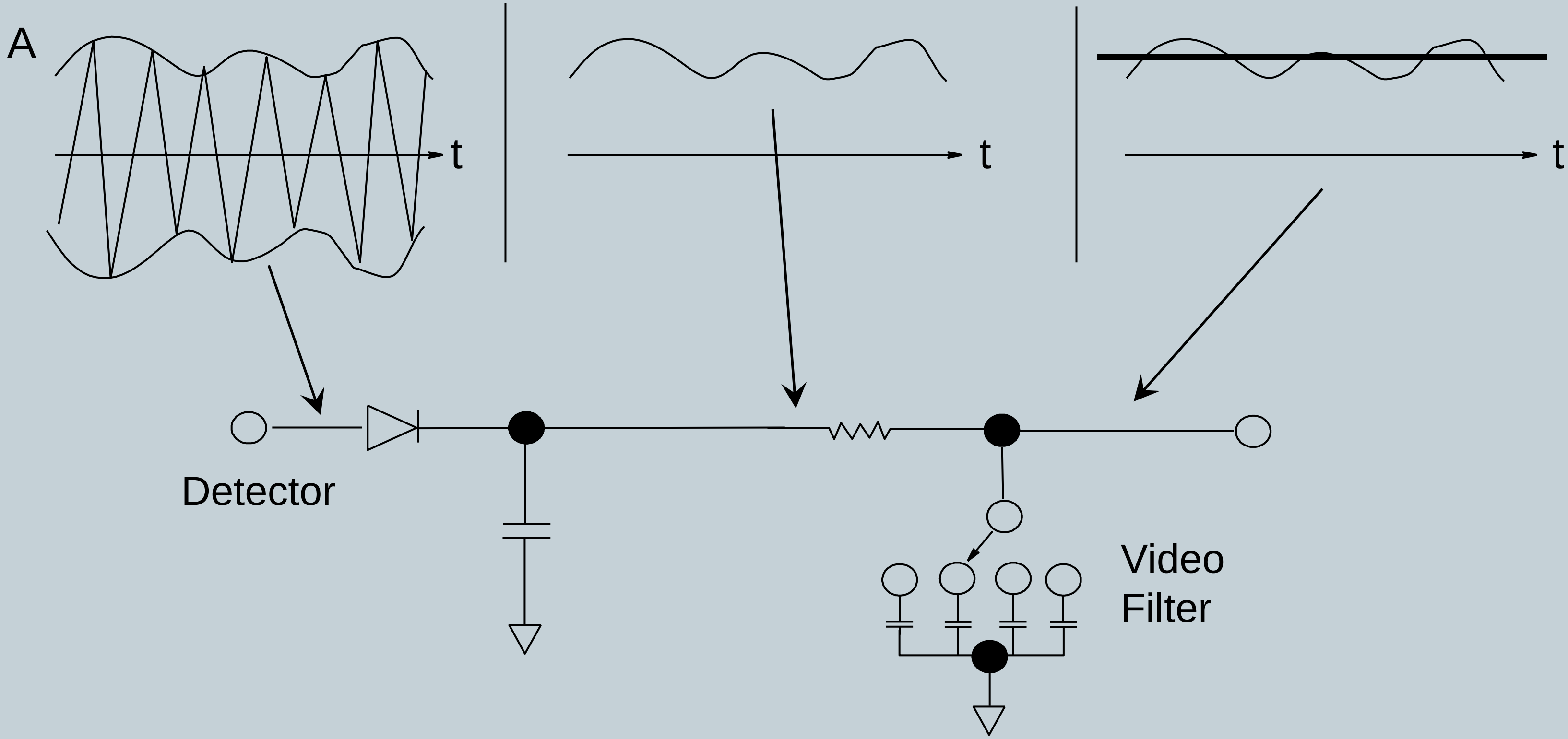
- This test involves two measurements, using the same instrument settings but peak and average detection
- Some standards like CISPR 25 specify an amplitude difference between the peak and average detected value that is used to determine if a signal is broadband or narrowband in nature
- If the amplitude difference is larger than the stated value, the signal is considered broadband, otherwise narrowband.

Peak vs. Average detection test

- This method is very suitable and easy to apply. However, the discrimination value may be different for various standards.
- The envelope detector will determine the maximum signal levels in the IF. A low pass filter can be used to determine the average (i.e., DC term) of the signal to be measured.

Peak vs. Average detection test

Average detection using video filtering



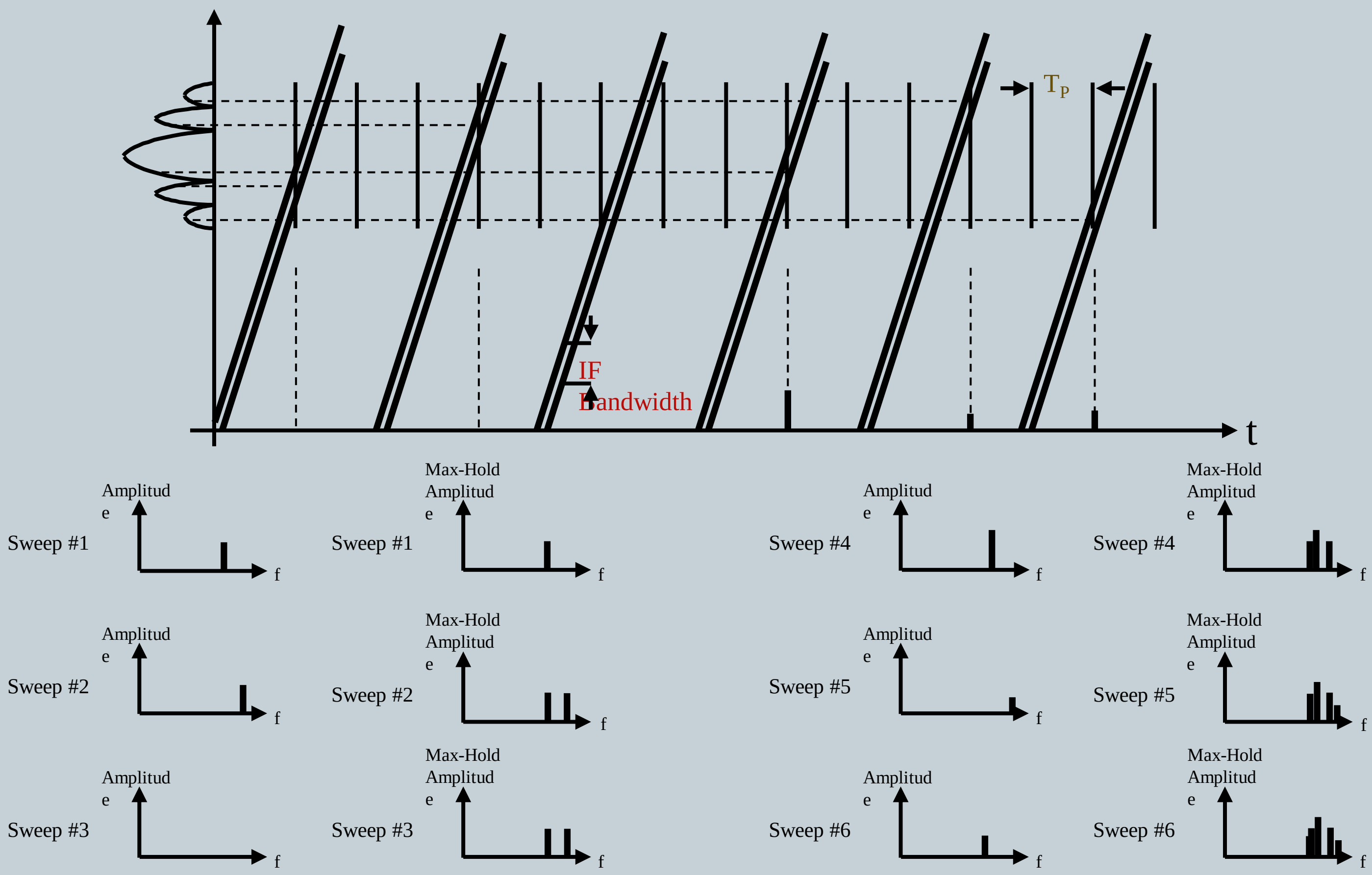
Sweep time test

- The presence of broadband signals is easily determined when using a scanning receiver, since moving responses are very visible
- Their actual location on the display depend on the relationship of the pulse period and the sweep time setting of the instrument
- The measured amplitude at the detection instant is determined by the envelope of the pulse spectrum and represents the impulse response of the receiver to the input signal

Sweep time test

- The PRF of a broadband signal cannot be determined from the display directly (e.g., with a Δ marker function) since the responses represent individual pulses, separated by the pulse period
- The PRF is to be calculated from the measured period and a single sweep is not sufficient to interpret the results correctly

Sweep time test



Sweep time test

- Narrower measurement spans and slower sweep times will lead to more intercepted pulses
- This will allow the sin(x)/x envelope to be traced out over a period of time and thus simplify the determination of broadband signals
- A scanning receiver or spectrum analyzer will display a response every 1/PRF seconds with an amplitude proportional to the spectrum envelope

Sweep time test

- A change in sweep time will therefore affect the location of these responses on the display – for broadband signals. Narrowband signals will be displayed at the same location, independent of the sweep time.
- A change is span will also affect the spacing of broadband responses, but not affect the position of narrowband responses on the display

Tuning test

- Some older EMC standards like MIL-STD 461 propose a tuning test for the discrimination between narrowband and broadband signals
- This test involves a change of the receiver tuning frequency by one or two impulse bandwidths to either side of the original tuning frequency while observing the resulting amplitude change
- The amplitude change is then compared to a criterion (e.g., 3 dB or 6 dB) to determine the signal characteristics

Tuning test

- If the amplitude observed changes are greater than the stated criterion the signal is considered narrowband
- The method can provide inconclusive results when the observed amplitude changes are not both below or above the decision criterion

Summary

- Four main methods were presented for the determination of narrowband and broadband signals:

Discrimination Method	Narrowband	Broadband
Bandwidth test	No change in amplitude	Change in amplitude
Peak vs. average test	No change in amplitude	Change in amplitude
Sweep time test	No change in response spacing	Change in response spacing
Tuning test	Δ amplitude > 3 dB (6 dB)	Δ amplitude < 3 dB (6 dB)