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Principles of Communication Systems
Chapter 3 (part 2): FM Transmitter & Receiver

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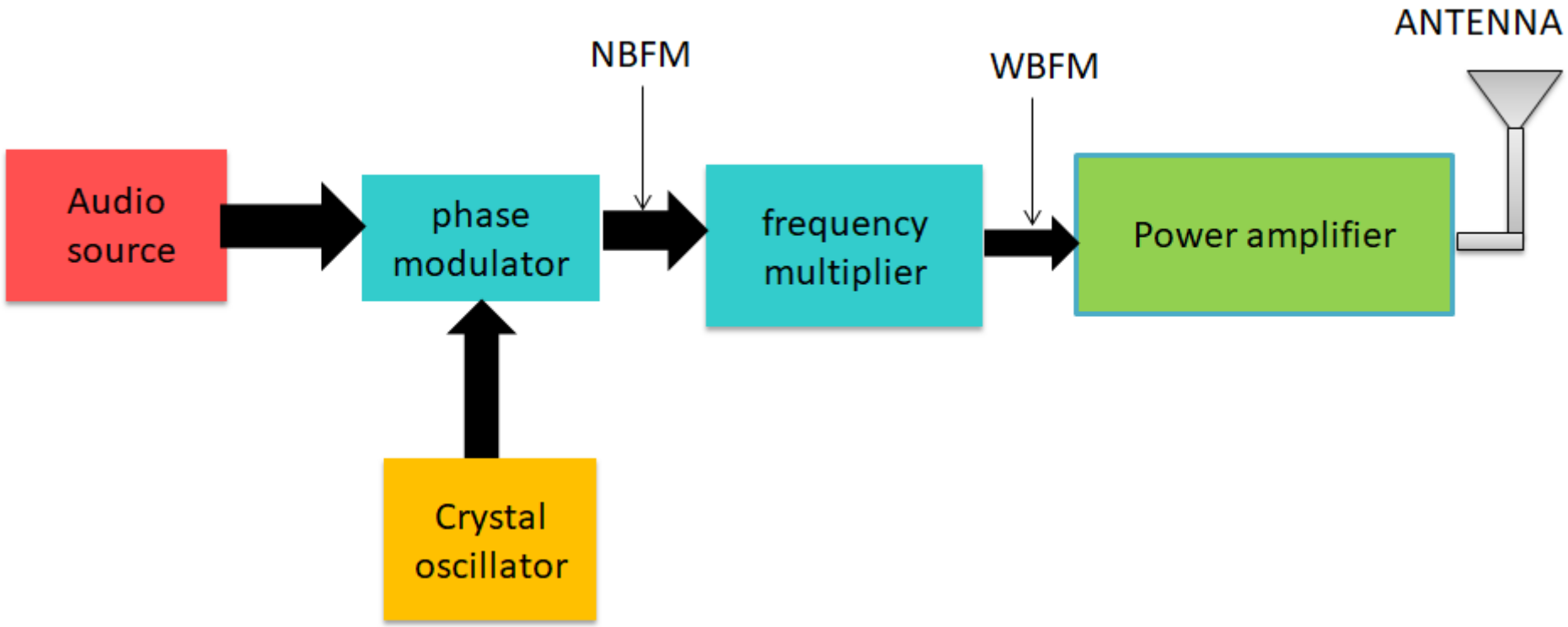
Lesson Outcomes

- By the end of this topics students should be able to:
  - Explain how FM transmitters and receivers operate
  - Describe how FM overcomes noise

FM Transmitter



Description

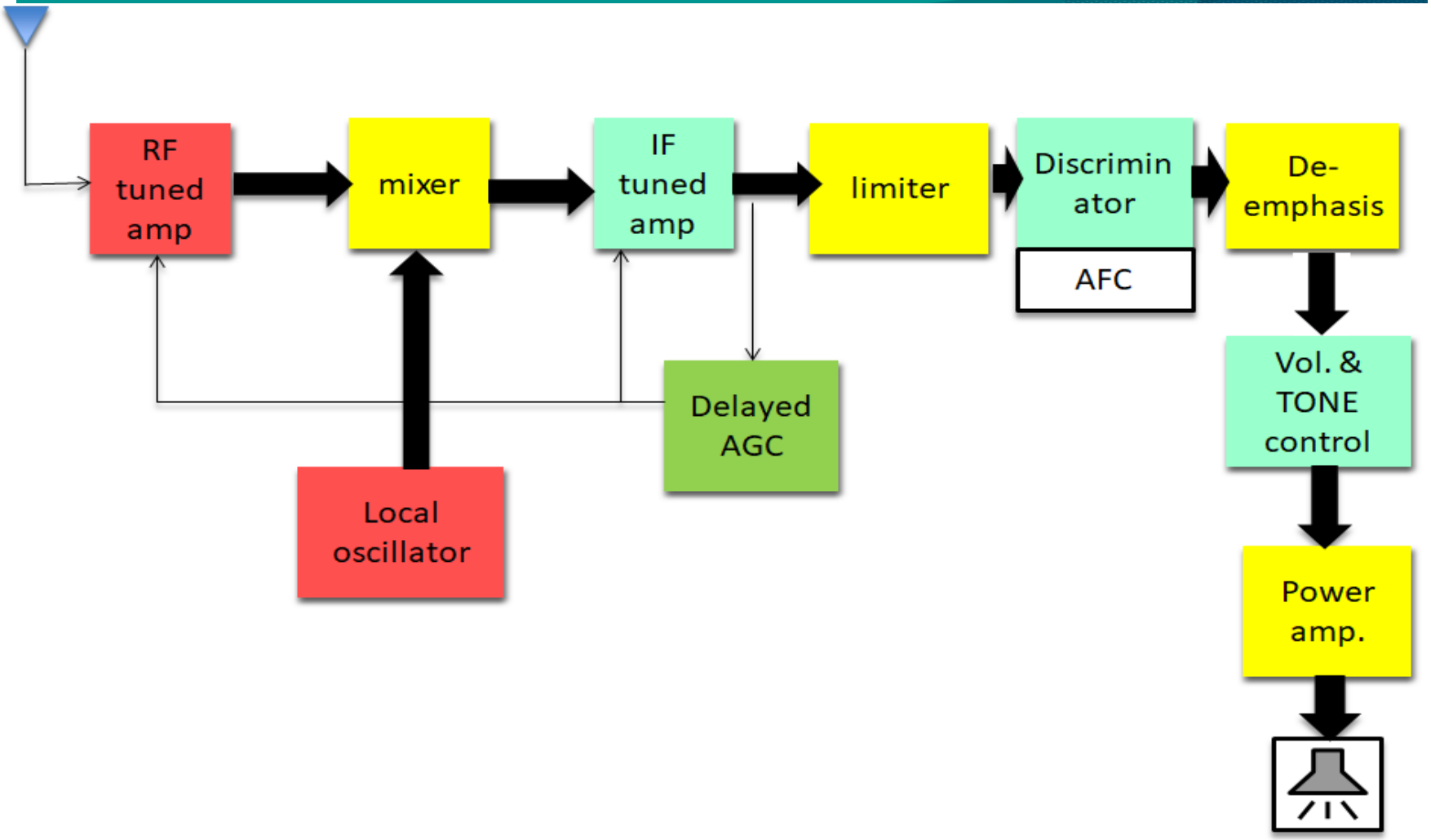
Crystal oscillator: Crystal oscillator generates carrier signal.

Phase modulator: Modulates carrier signal and input signal. The output is a narrowband FM signal.

Frequency multiplier: Increase frequency deviation and carrier signal frequency to the desired level.

Power amplifier: Increase the power level to the signal before passes through the antenna.

FM Receiver


RF tuned amp
mixer
IF tuned amp
limiter
Discrimin ator
AFC
De-emphasis
Vol. & TONE control
Power amp.
Delayed AGC
Local oscillator

Description (cont.)

RF tuned amplifier: Minimise noise level

Mixers: Mix the frequency modulated signal with signal generated by local oscillator. The central frequency are is change but deviation remains constant

Intermediate frequency amplifier: Provides most of the gain and bandwidth requirement of the receiver.

Limiters: Limiters allows certain frequency range to pass and block other signals

Discriminator: Converts FM into AM.

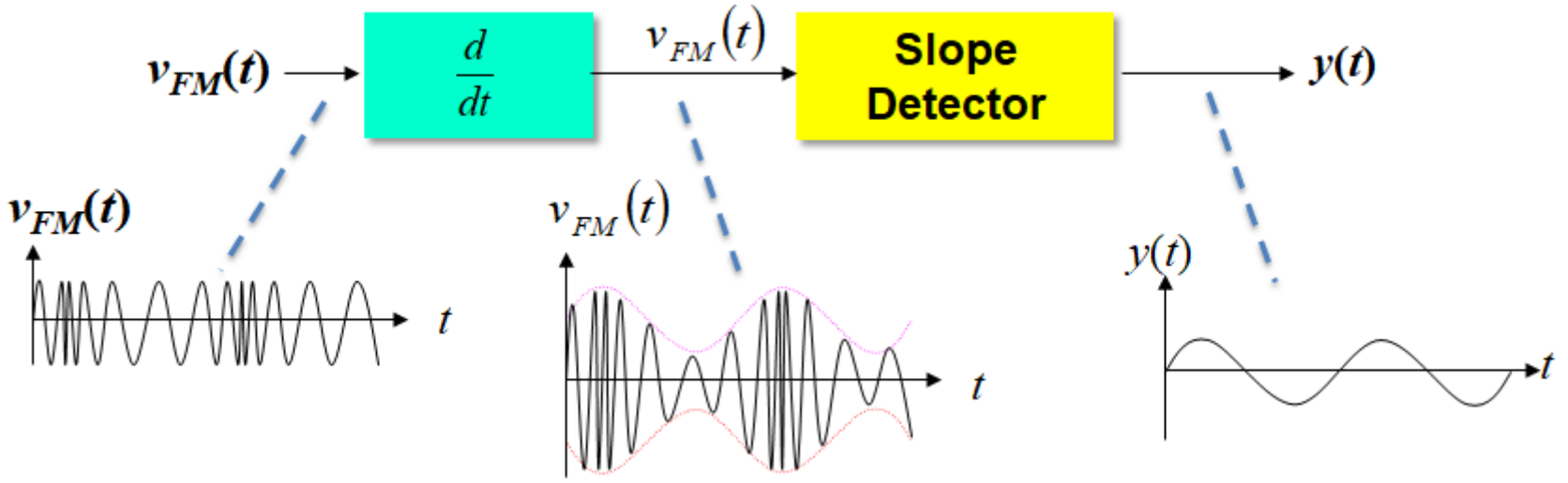
De-emphasis: The artificial boosting given to the higher modulating frequencies

Vol & tone controller: Controls the efficiency of audio signal.

Power amplifier: Gives the required power level to the signal which passes through the loudspeaker.

Discriminator

Discriminator (or slope detection) converts FM signal to AM signal and then by using AM demodulation circuit is to get back the information signal.



Frequency modulators

Two common types of frequency modulator

Varactor modulator

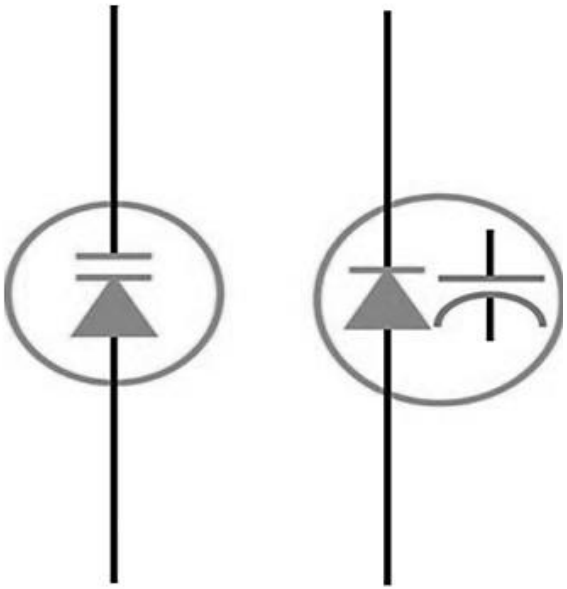
- Uses either:
  - LC oscillator: the carrier frequency can be changed by varying either the inductance or capacitance.
  - Crystal Oscillator: the frequency is fixed by the crystal

Reactance Modulator

- uses a transistor amplifier that acts like either a variable capacitor or an inductor.

Varactor Modulator

- All diodes exhibit variable capacitance.
- Varactors are designed to optimize this characteristic.
- Reverse-biased diode acts like a small capacitor:
  - The P- and N-type materials act as the two plates of the capacitor.
  - The depletion region acts as the dielectric material.
  - The width of the depletion layer determines the width of the dielectric and, therefore the amount of capacitance.



Reactance Modulator

- **Reactance modulator** works by using transistor amplifier as variable capacitor or an inductor.
- When the circuit is connected across the tuned circuit of an oscillator, the oscillator frequency can be varied by applying the modulating signal to the amplifier.
- Reactance modulators can produce frequency deviation over a wide range.
- Reactance modulators are highly linear, so distortion is minimal.

A Reactance Modulator

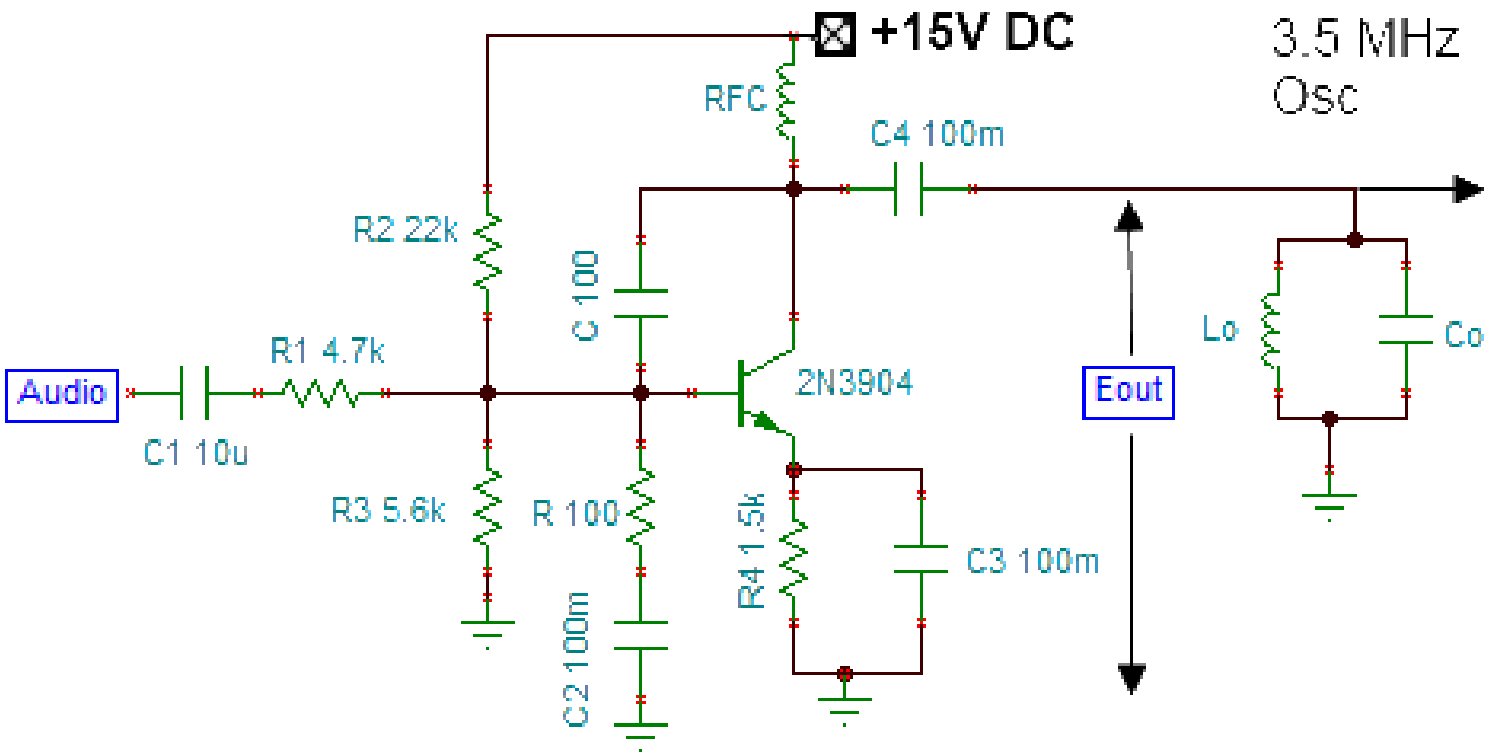
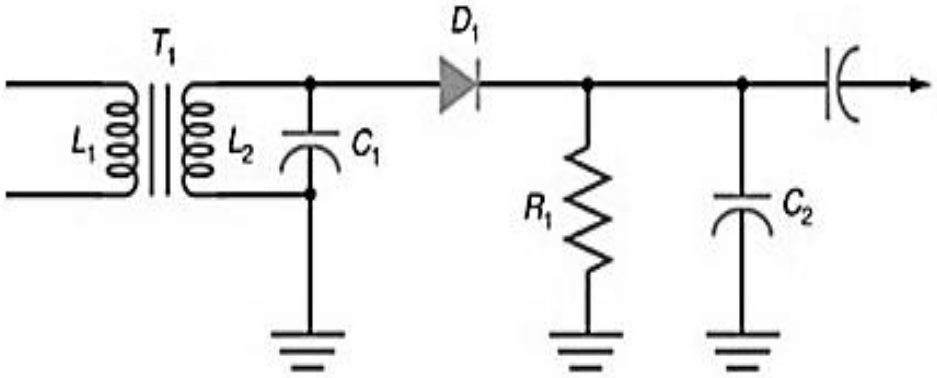


Image source: https://et.wikipedia.org/wiki/Fail:Reaktiivmodulaator.png

Frequency Demodulators

- Slope Detector
- Pulse-Averaging Discriminators
- Quadrature Detector
- Phase-Locked Loop Detector

Slope Detector

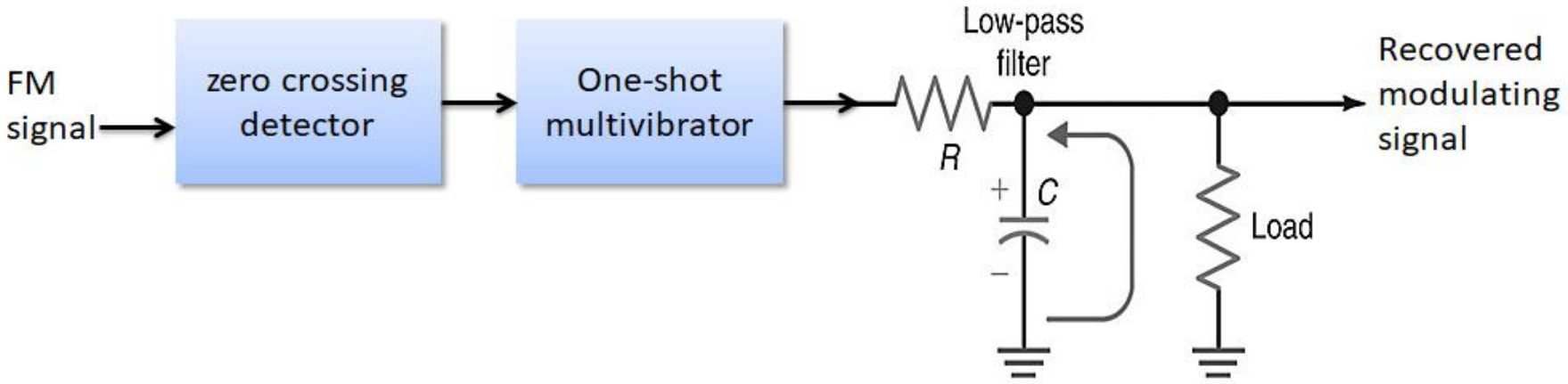


- **Slope detector** uses tuned circuit and a diode detector to convert frequency variations into voltage variations.

- The main difficulty with slope detectors is tuning them.

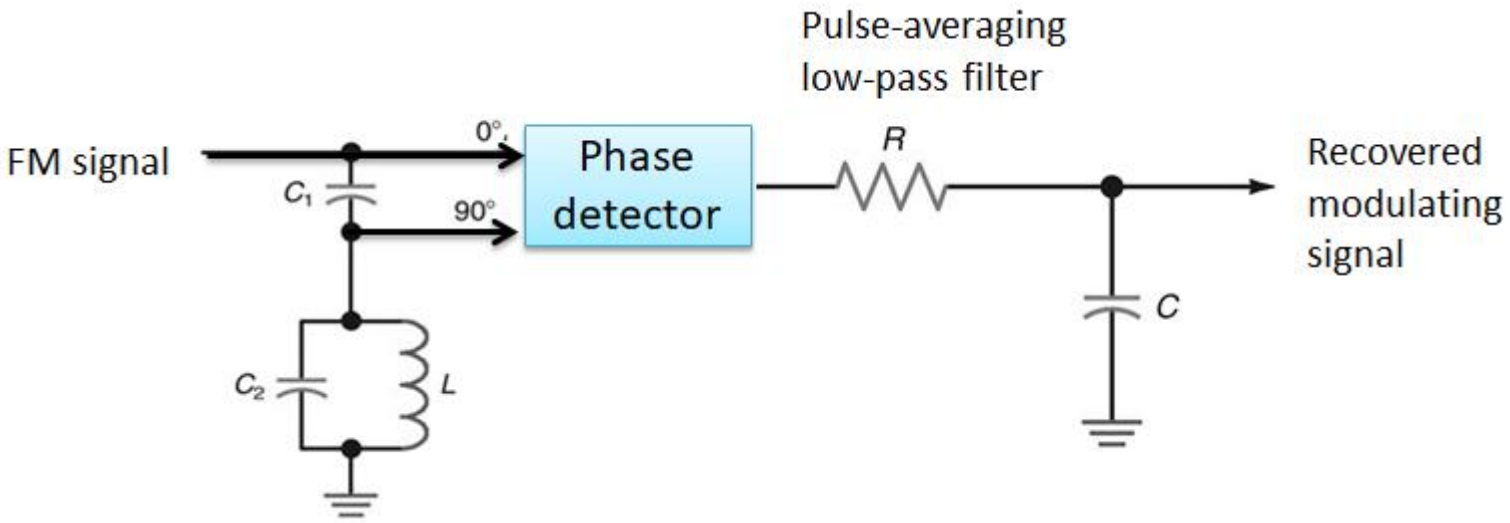
Pulse-Averaging Discriminators

- Consists of a zero crossing detector, a one shot multi vibrator and a low-pass filter.
- A very high-quality frequency demodulator.
- This discriminator is used in many electronic products.



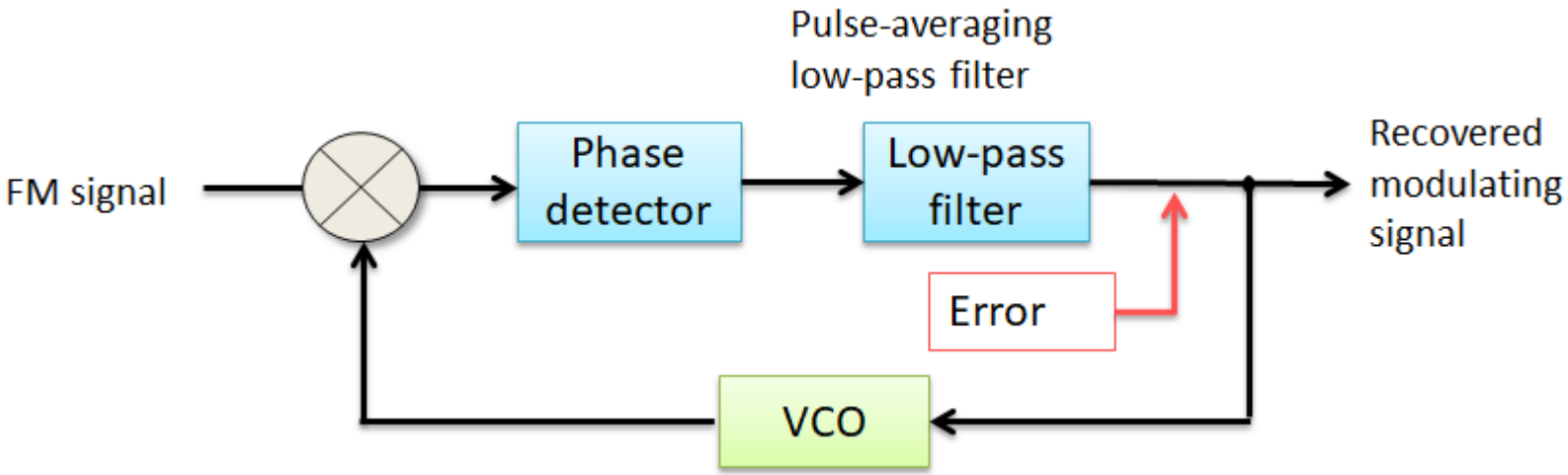
Quadrature Detector

- Most widely used FM demodulator.
- Uses a phase-shift circuit to produce a phase shift of 90 degrees at the unmodulated carrier frequency.



Phase-Locked Loops

- Phase-locked loop (PLL) is a frequency-sensitive feedback control circuit used in frequency demodulation
- PLLs have three basic elements: Phase detector, Low-pass filter, Voltage-controlled oscillator (VCO)

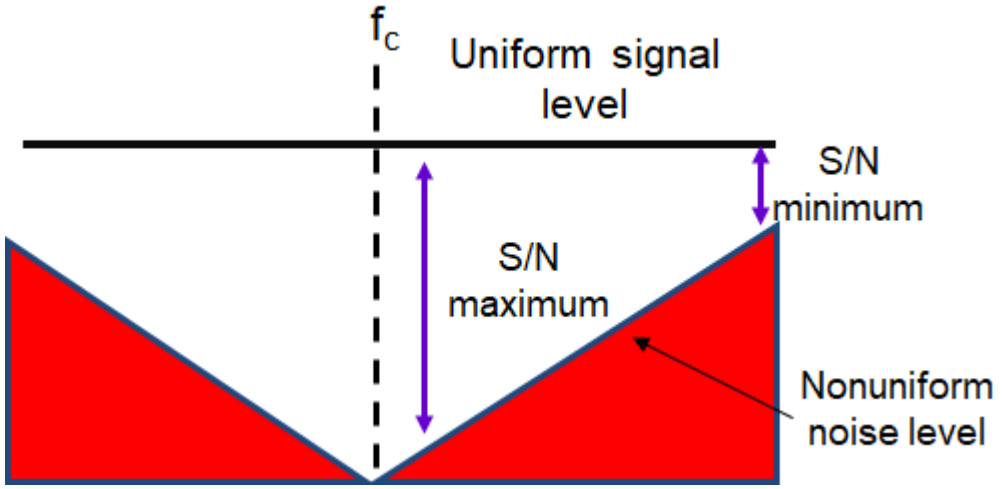


Noise in FM

- Noise is interference that affect information signal.
- In FM, modulated signals have a constant amplitude.
- At receiver, limiter circuits clipped any amplitude variations that may exist on the received signal.
- Information content of the FM signal is not affected since it is contained by the frequency variations, not amplitude of the received signal.

Noise and Angle Modulation

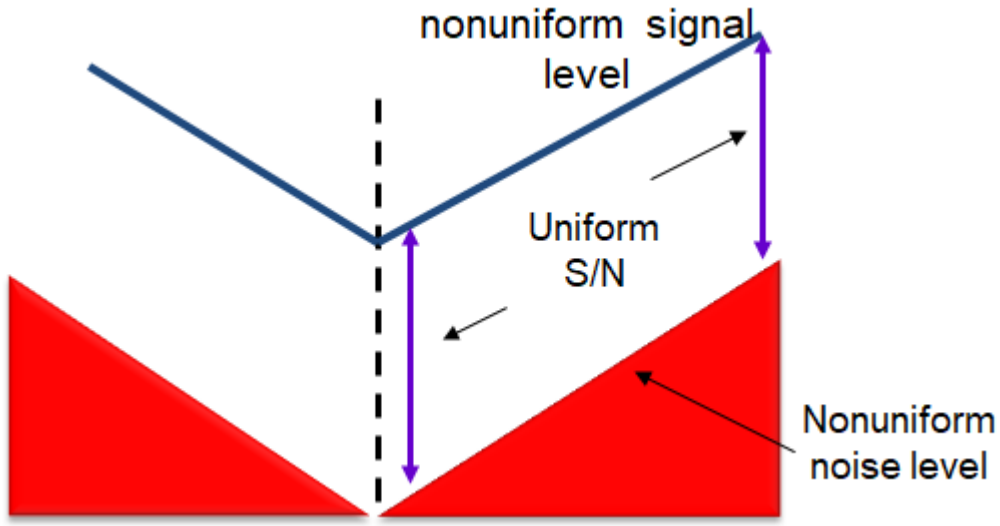
- Noise distribution in FM is non-uniform.
- Higher frequencies suffers more noise than the lower frequencies.
- Higher frequencies also have lower amplitudes compared to lower frequencies.
- Consequently, the Signal to noise ratio is also non-uniform.
- The SNR for higher-modulating frequencies are lower than the SNR for the lower frequencies.



Without preemphasis

Pre-emphasis & De-emphasis

- Solution: the high-frequency modulating signals are emphasized or boosted in amplitude of the transmitter prior to performing modulation and then deemphasized or attenuated during demodulation at receiver.



With preemphasis

Pre-emphasis & De-emphasis

PRE-EMPHASIS

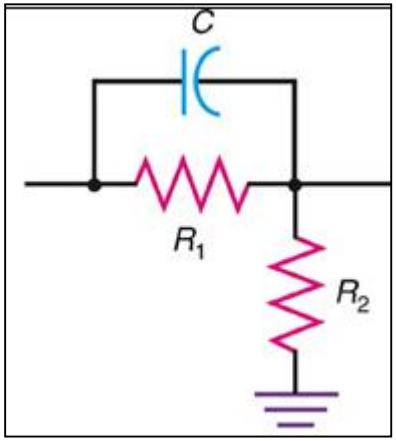
- The amplitudes of higher frequencies components of input signal are increased before it modulate the carrier
- Therefore will be less affected to noise.
- Preemphasis Network –> High-Pass Filter (Differentiator)

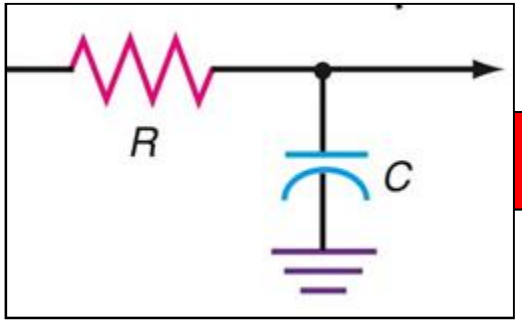
DE-EMPHASIS

- Deemphasis – returns the frequency response to its normal flat level.
- Deemphasis Network -> Low-Pass Filter (Integrator)

Pre-emphasis & De-emphasis circuits

Pre-emphasis





De-emphasis

FM Application

- Radio broadcasting
- Two way mobile radio
- Microwave communication
- TV sound transmission
- Cellular radio communication
- Satellite communication

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