Lecture 3: FM Transmitters & Receivers

Lecture Plan

- **Review of Previous Lectures**
- **Frequency Modulation – FM Transmitter**
- **FM Demodulation Techniques – FM Receiver**
- **Conclusions & Discussions**

Lecture Notes are available from: http://homepages.unl.ac.uk/~taghizas

Review of Previous Lectures

- **WHAT is Modulation and WHY we Modulate ?**

Modulation is a PROCESS by which the properties of one signal is made to vary the properties of another signal!

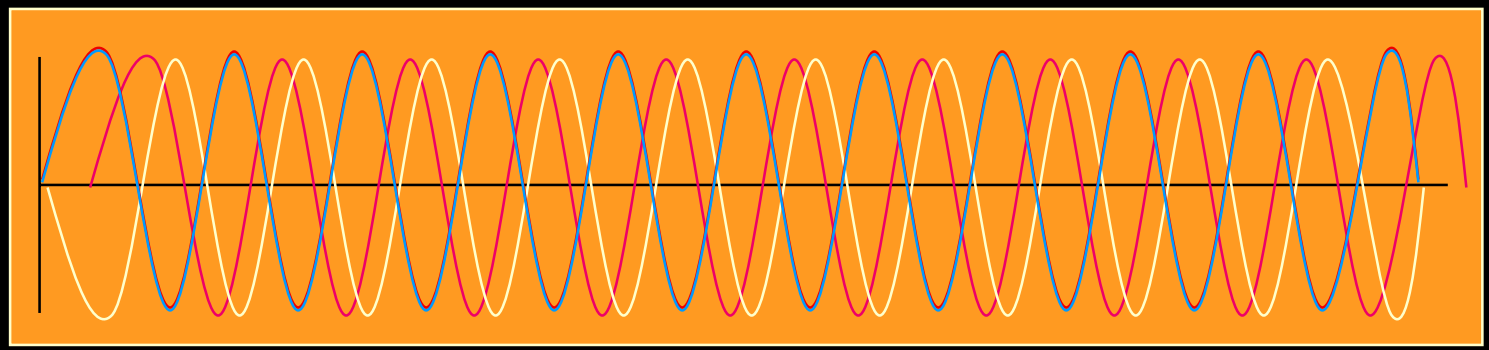
Signals are variation of Electrical Current or Voltages over time.

Signals have basically THREE basic properties

Amplitude Phase Frequency

A Typical Signal: A Sinusoidal Signal

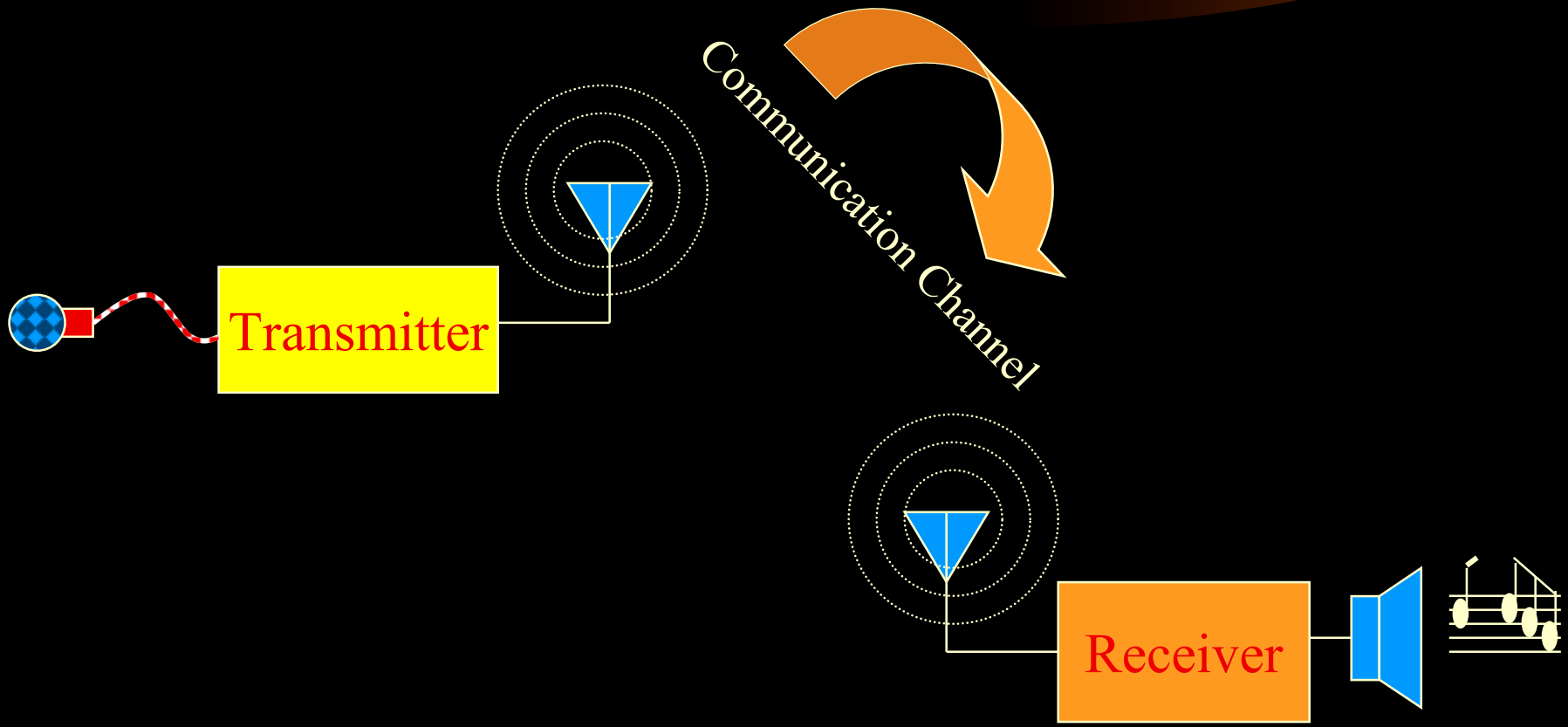
$$x(t) = A\sin(\omega t + \theta)$$



- A: Is the Amplitude
- θ: Is the Phase in Radians
- ω: Is the Frequency in Radians

$\omega = 2\pi f$ *f is the Frequency in Hz*

Why Modulation ?



Contd…

Speech => 300Hz

Wavelength

$$\lambda = \frac{C}{f} = \frac{3 \times 10^8}{300} = 1000 Km$$

Size of the Transmitter Antenna:

$$L = \frac{1}{10} \lambda = 100 Km$$

Contd…

- Reduction in the Size of Antenna
- Multi-Signal Transmission over the same channel
- Less effected by Noise

How To Increase The Frequency?

- **We Select a known signal (e.g. Sinusoidal) and KAKE it TO CARRY the SPEECH signal !**

How?

This is what we call Modulation.

- **We Can Make the Amplitude of the Sinusoid**

To carry it → Amplitude Modulation

- **We Can Make the Frequency of the Sinusoid**

To carry it → Frequency Modulation

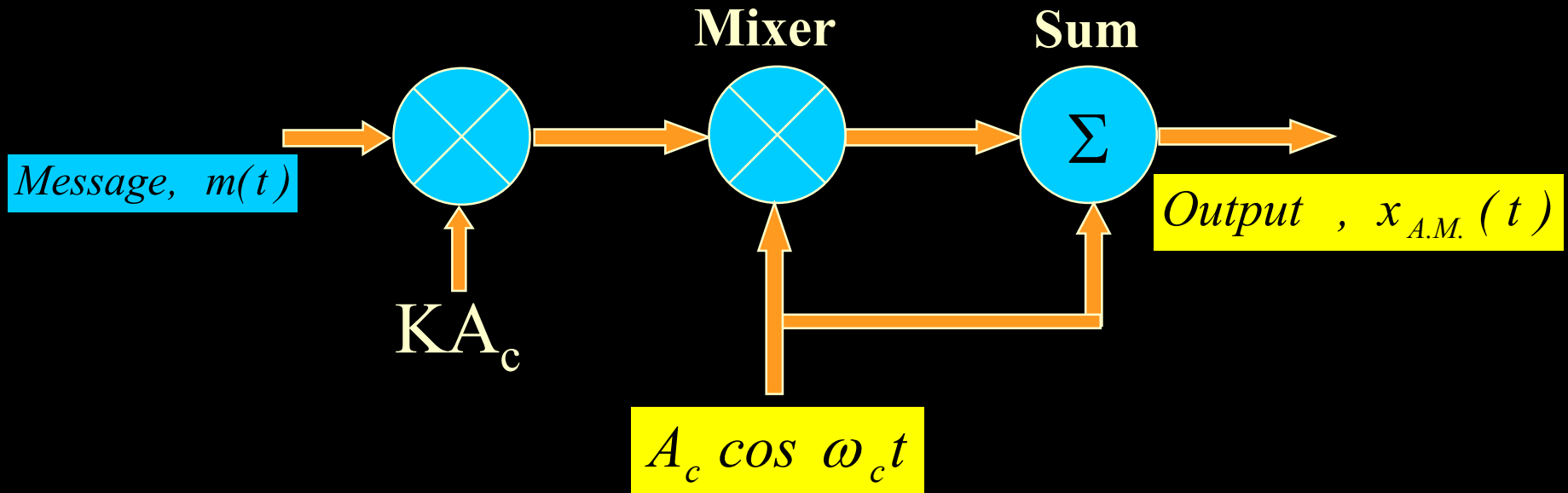
- **We Can Make the Phase of the Sinusoid**

To carry it ----------> Phase Modulation

Amplitude Modulation

$$x_{A.M}(t) = A_c[1 + K\, m(t)]\cos\omega_c t$$

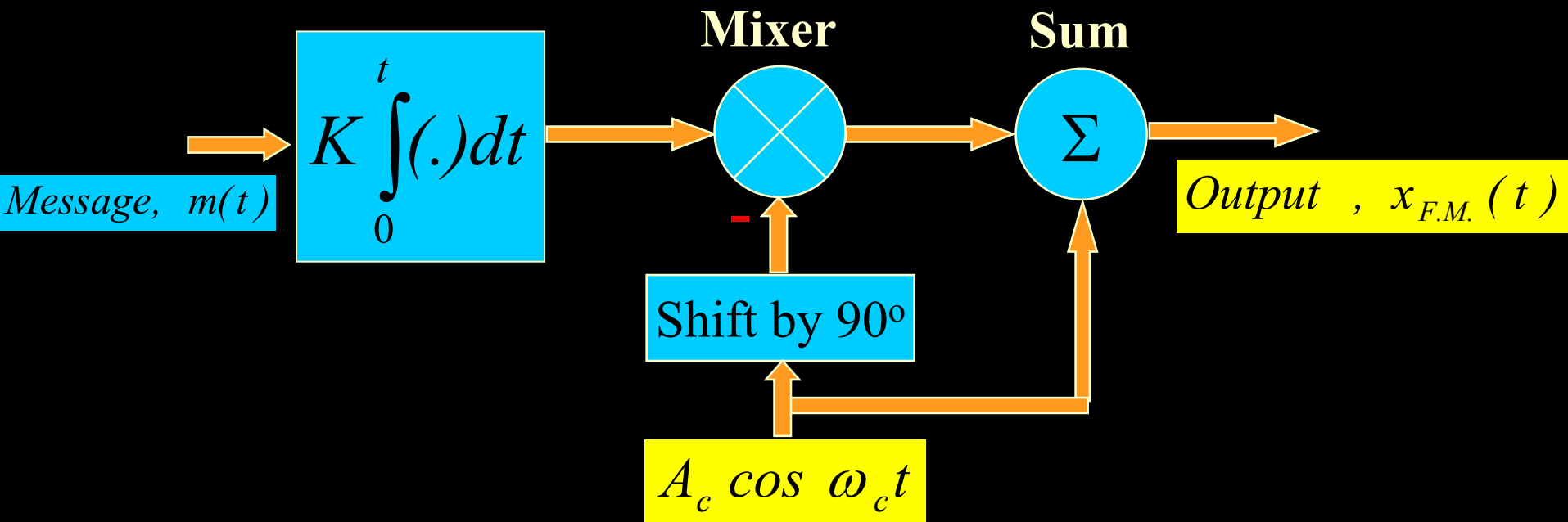
$$= A_c \cos\omega_c t + K\, A_c m(t)\cos\omega_c t$$



Frequency Modulation

$$x_{F.M.}(t) = A_c \cos\left(\omega_c t + K\int_0^t m(t)d(t)\right)$$

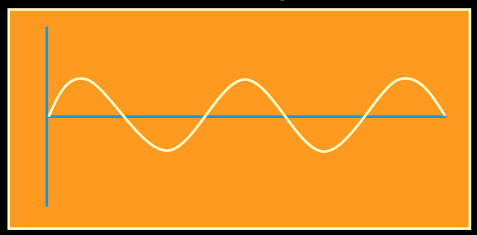
$$x_{F.M.}(t) = A_c \cos\omega_c t - A_c \sin(\omega_c t).K\int_0^t m(t)d(t)$$

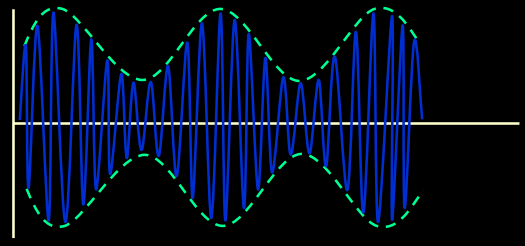


Graphical Illustration

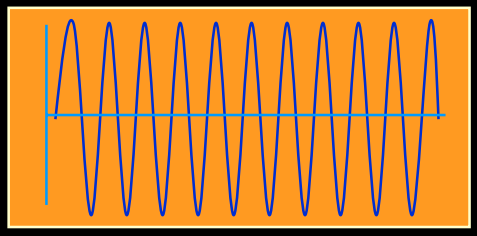
$$x_{A.M}(t) = A_c[1 + K\, m(t)]\cos\omega_c t$$

Message

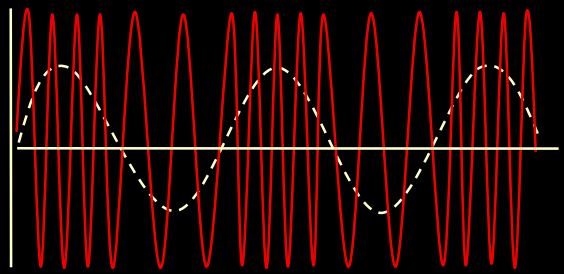




AM Signal



Carrier



FM Signal

$$x_{F.M.}(t) = A_c \cos\ \omega_c t - A_c \sin(\ \omega_c t\ ).\ K \int_0^t m(t)\,d(t)$$

FM Demodulation

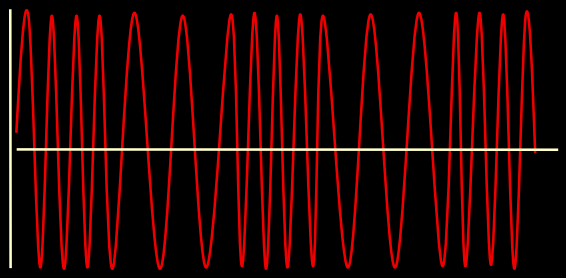
Modulation occurs in the TRANSMITTER Station. We have so far managed to CONVERT our MESSAGE signal, ***m(t)*** into a suitable form for transmission.

What is remaining is to design the **Receiver**. This is called the **Demodulation** Process.

Demodulation is the process that happens in our **RADIOS** – i.e. **the RECEIVER**.

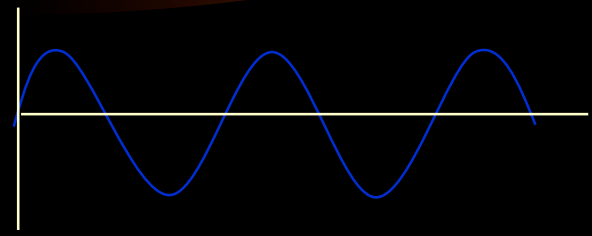
FM Demodulation

The Receiver Antenna detects this:



FM Signal, $x_{FM}(t)$

The Demodulator should generate this:



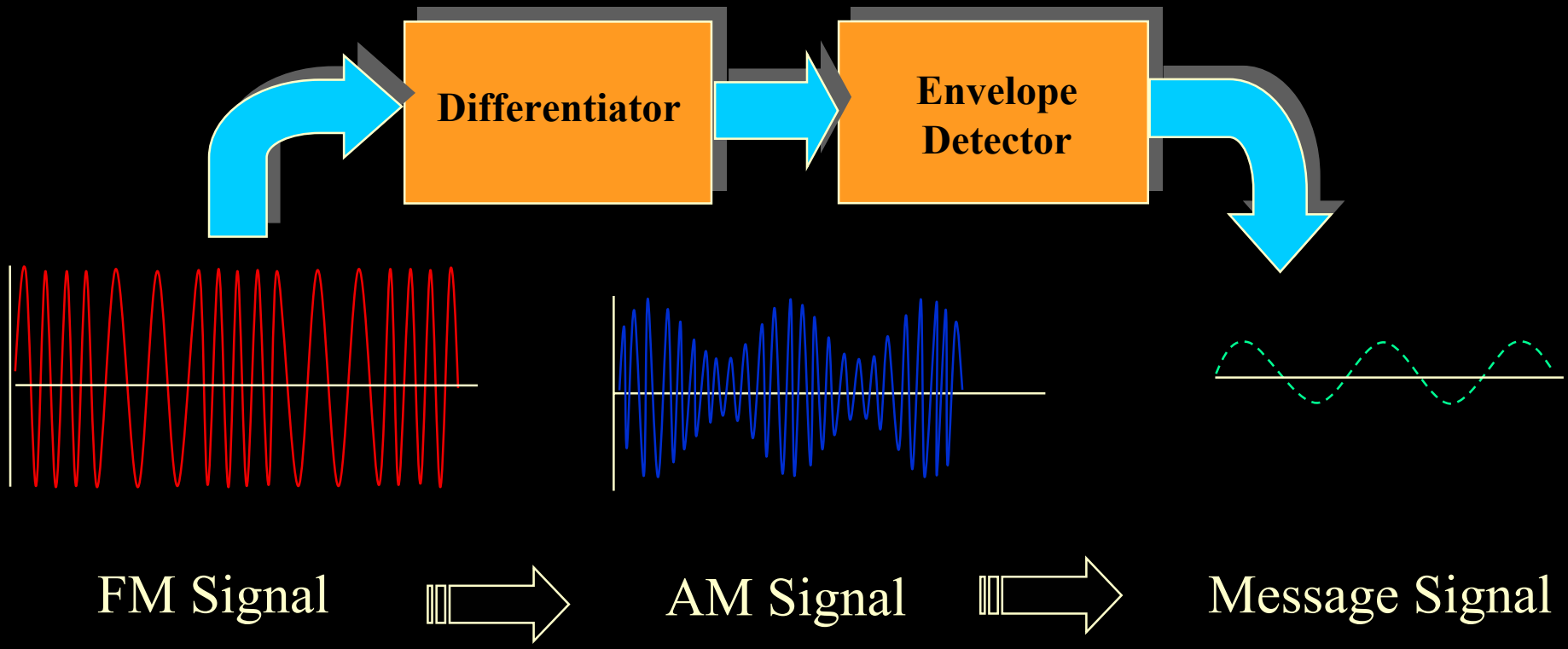
Message Signal, $m(t)$

FM Demodulation Techniques

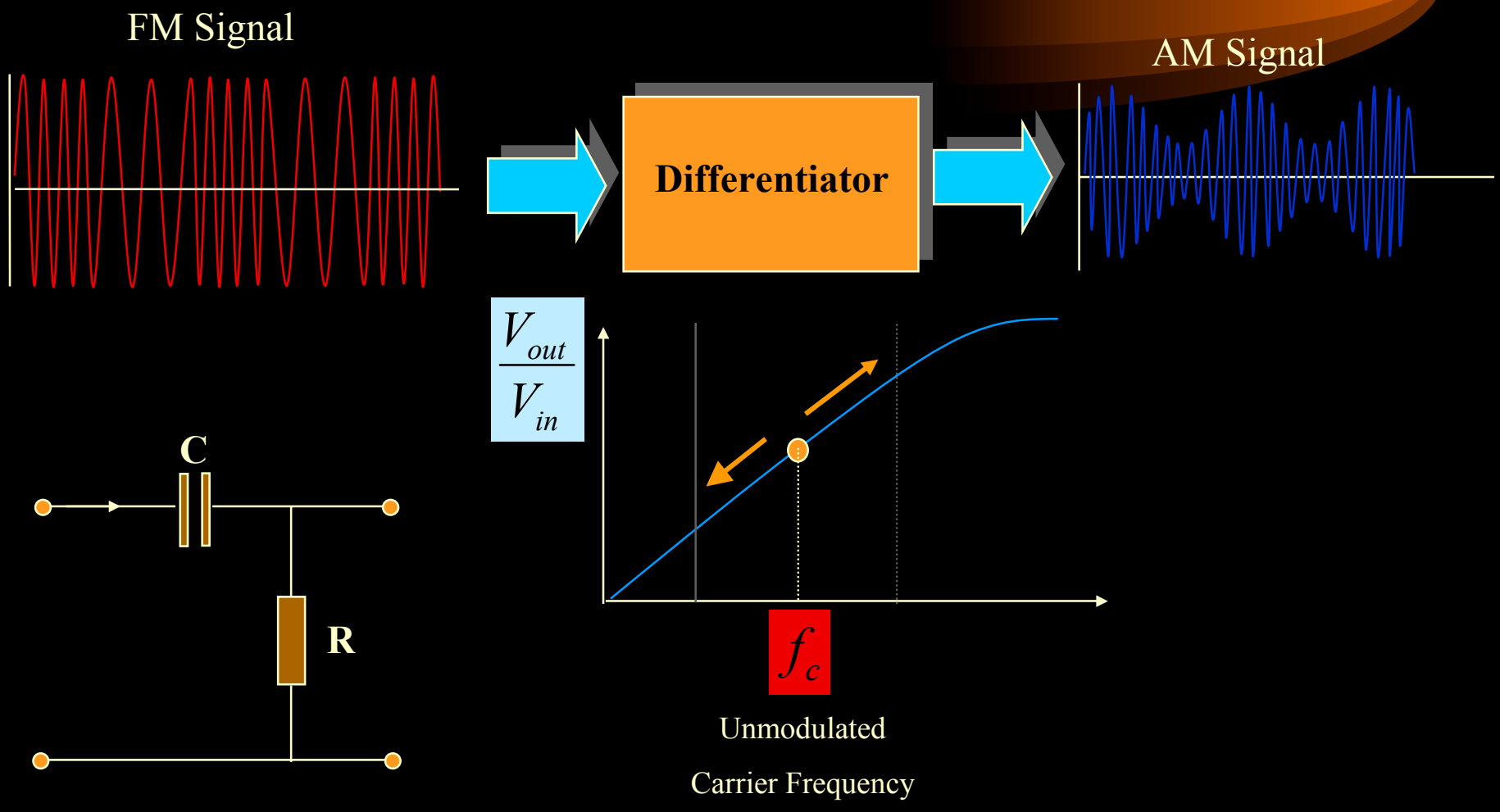
- **FM Discriminator (Slope Detector)**
- **Zero-Crossing FM Detector**
- **Travis Discriminator – Tutorial No.1**
- **Foster-Seeley Discriminator – Tutorial No.1**
- **Phase Locked Loop Detector – Workshop No.1**
- **Ratio Detector – Student Investigation**

FM Discriminator (Slope Detector)

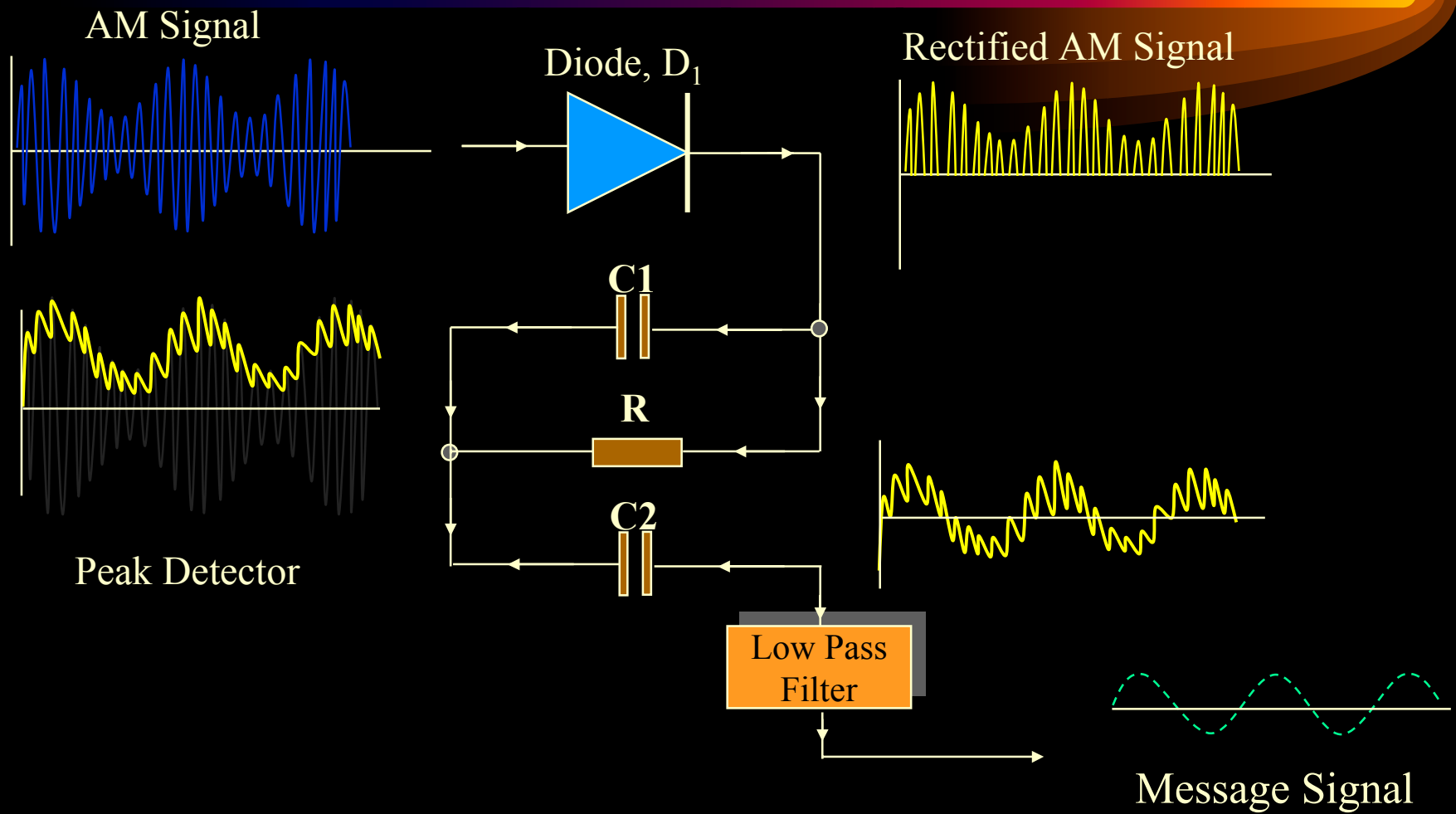
Overall Block Diagram



How Does The Discriminator Works?

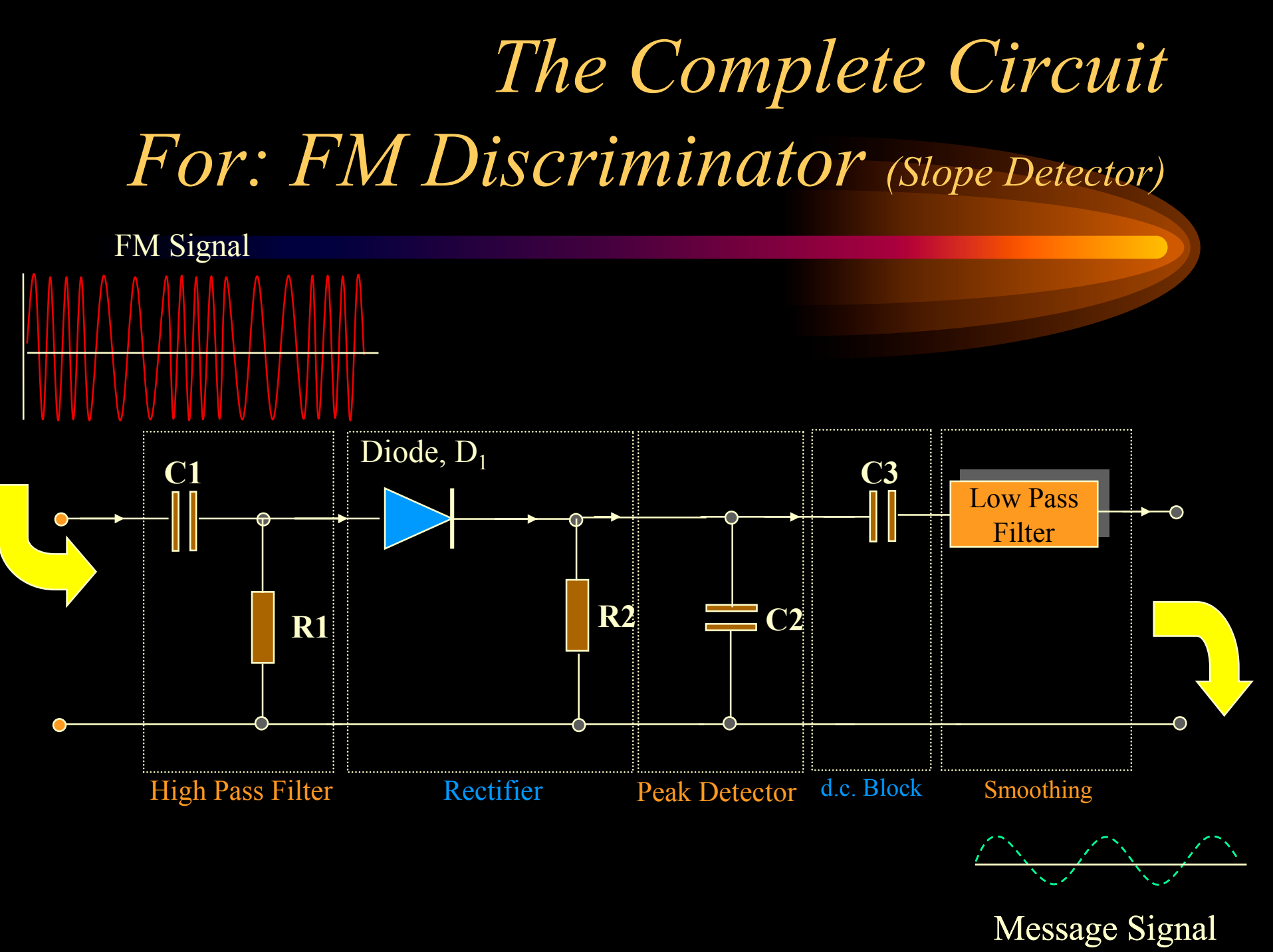


FM Discriminator (Envelope Detection)

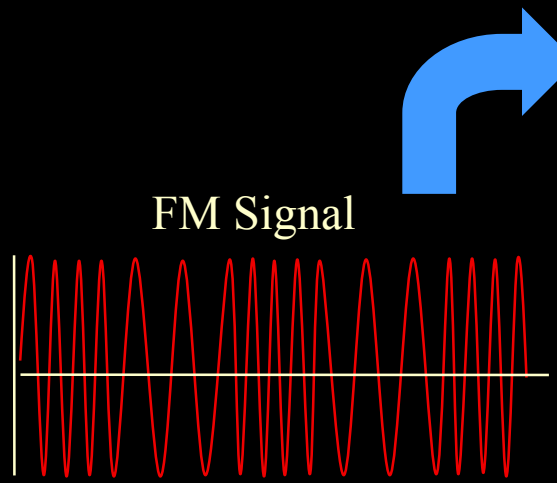


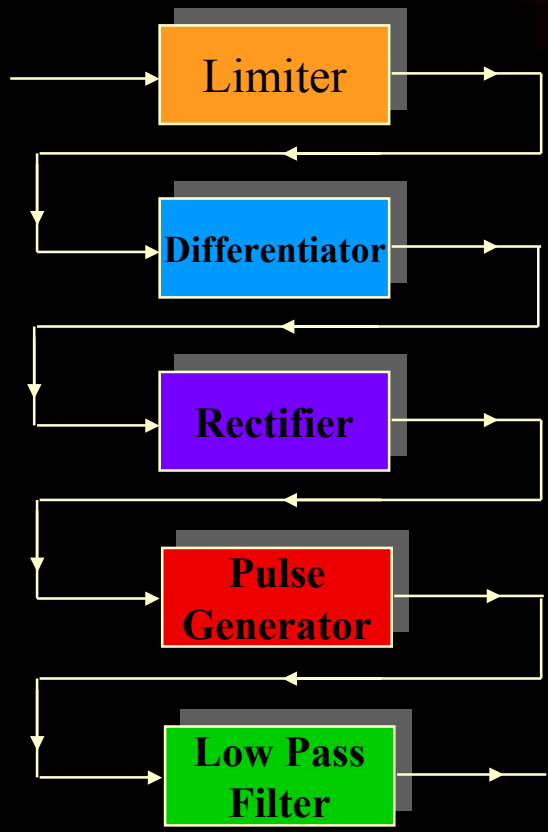
The Complete Circuit

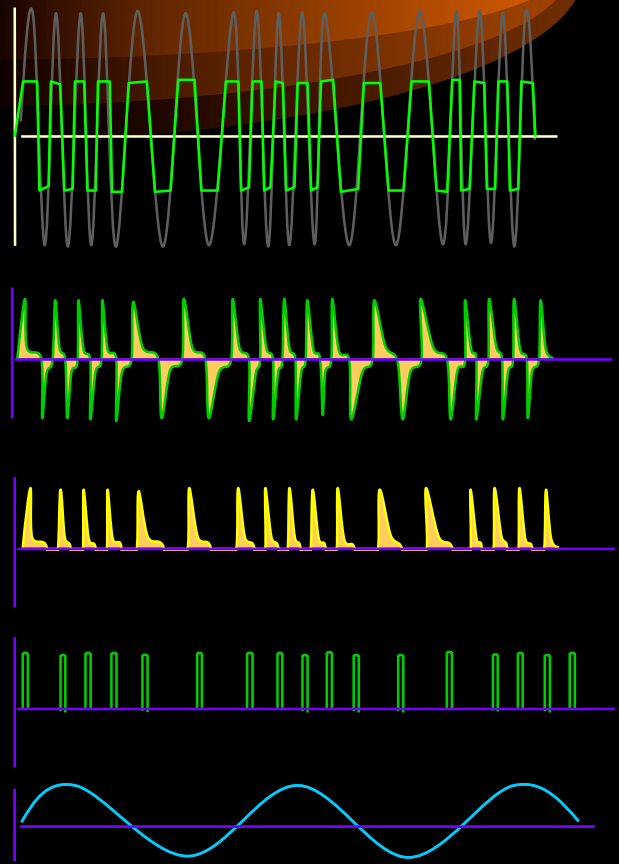
For: FM Discriminator *(Slope Detector)*



FM Demodulation
Zero Crossing Detector

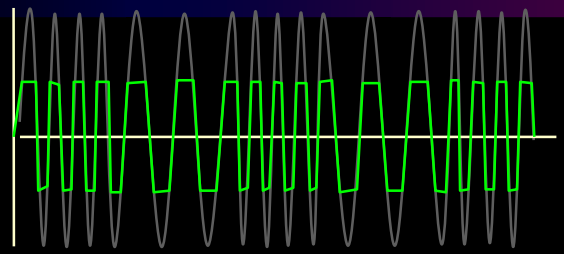


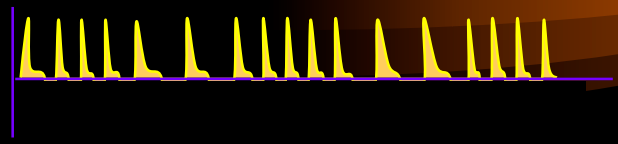




FM Demodulation

Complete Zero Crossing Detector





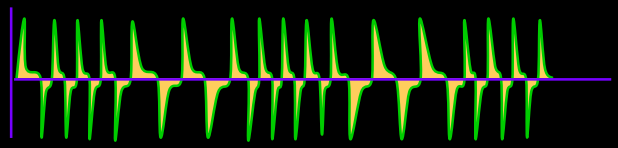
Limiter

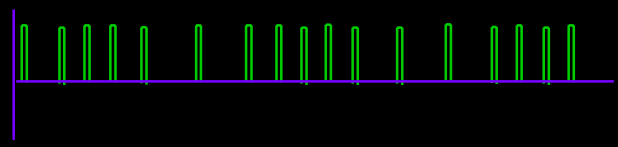
Differentiator

Rectifier

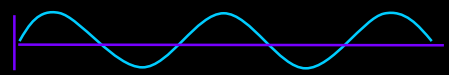
Pulse Generator

Low Pass Filter





FM Signal



Message Signal

Conclusions & Some Observations

- The process of Modulation changes the properties of one signal with respect to another signal.
- Two Examples of Modulation process is AM & FM.
- AM & FM are both very simple to Realize
- AM is more SENSITIVE to noise and interferences than FM
- FM uses 88 MHz to 108MHz band, AM uses 300KHz to 3MHz.

Next Lecture….

All Notes are available from the Web Site

- Effects of Noise in:
  - FM & AM Systems

Note:

Please read the notes from the Web site before the next lecture.

References

- A Detailed list of references which have been used to prepare these notes are available from My Web Site.

- The Workshop for FM will be carried out Next Week.

Finally……

Thank you for Listening