PRACTICAL - 3

DIGITAL COMMUNICATION (EC-209)

Aim

- To study and observe Amplitude Modulation:
  - DSB (Conventional AM)
  - DSB-SC
- Observe the effect of varying the modulation index ($m<1$, $m>1$ and $m=1$)
- Also observe the Trapezoidal Method of determining Modulation Index

What is Modulation

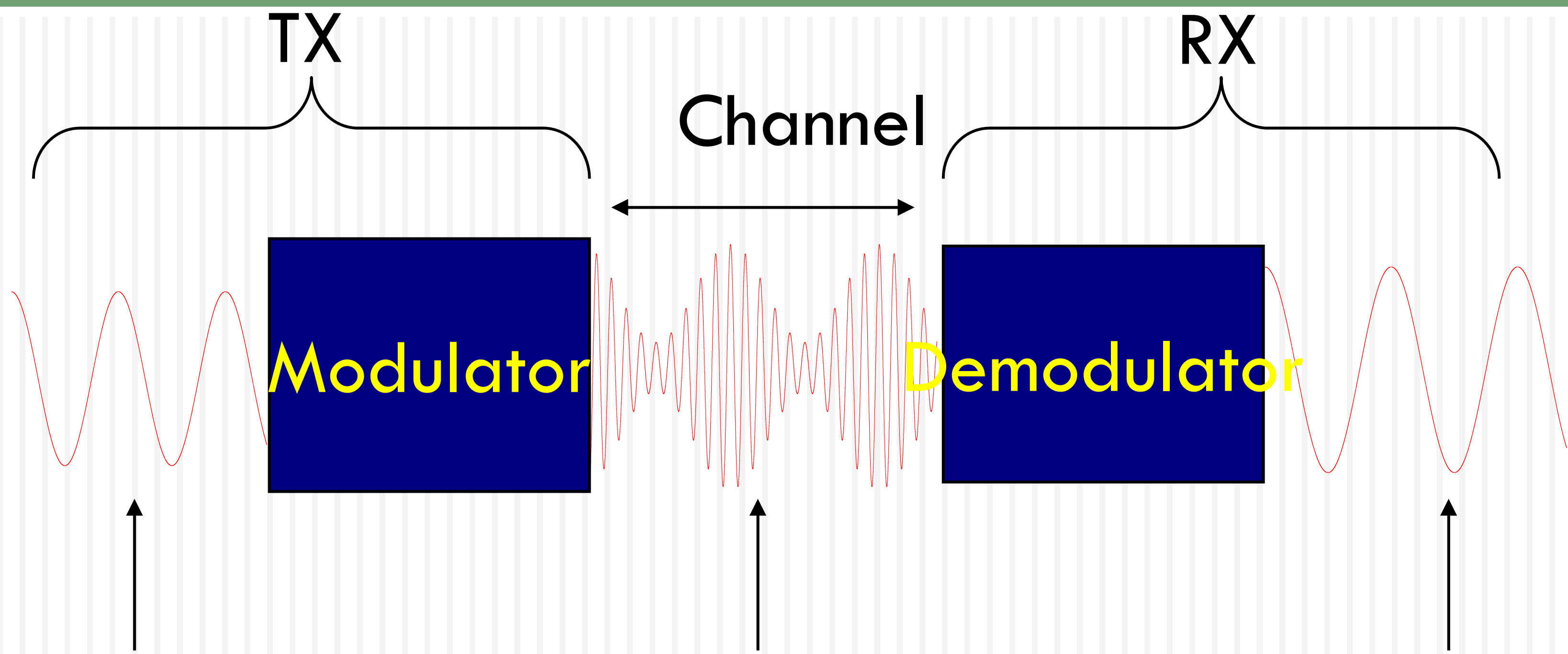
- <u>Modulation</u>
  - In the modulation process, some characteristic of a high-frequency carrier signal (bandpass), is changed according to the instantaneous amplitude of the information (baseband) signal.
- <u>Why Modulation</u>
  - Suitable for signal transmission (distance…etc)
  - Multiple signals transmitted on the same channel
  - Capacitive or inductive devices require high frequency AC input (carrier) to operate.
  - Stability and noise rejection

About Modulation

- Application Examples
  - broadcasting of both audio and video signals.
  - Mobile radio communications, such as cell phone.

- Basic Modulation Types
  - Amplitude Modulation: changes the amplitude.
  - Frequency Modulation: changes the frequency.
  - Phase Modulation: changes the phase.

AM Modulation/Demodulation



Baseband Signal with frequency fm (Modulating Signal)

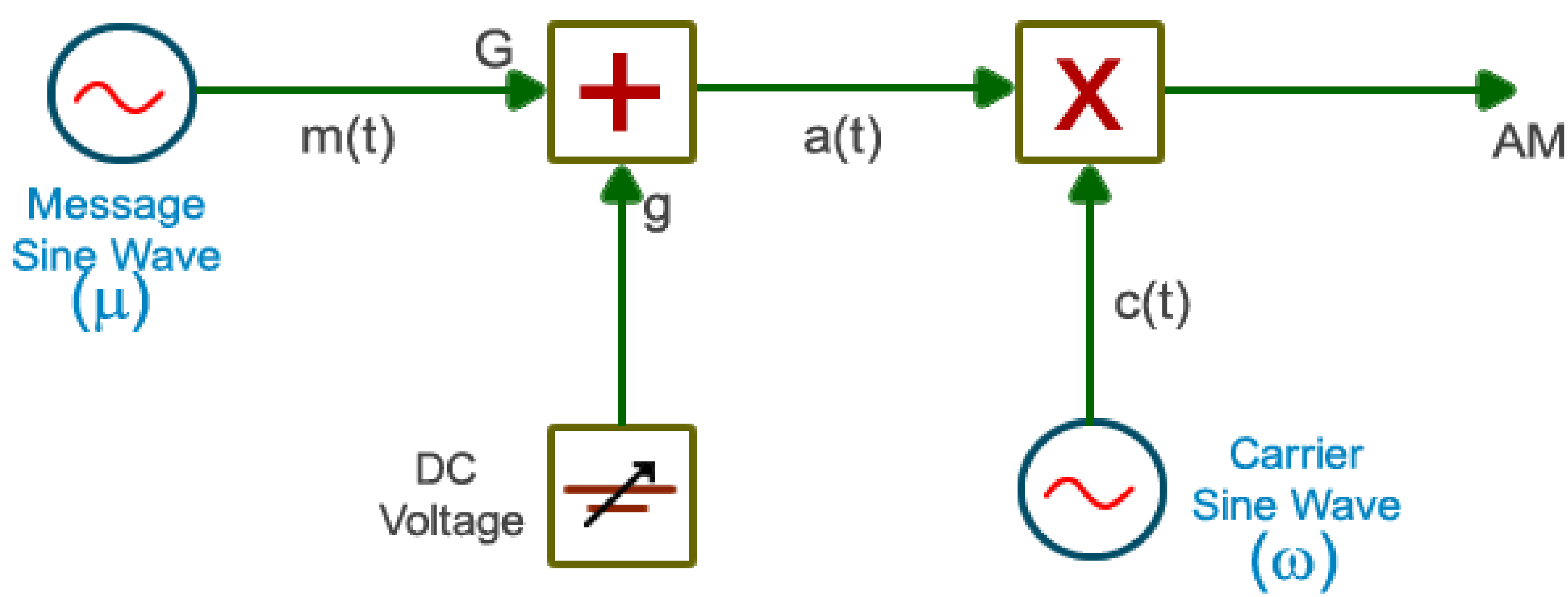
Bandpass Signal with frequency fc (Modulated Signal)

Original Signal with frequency fm

fc >> fm

Voice: 300-3400Hz GSM Cell phone: 900/1800MHz

AM Block Diagram



Amplitude Modulation

- The amplitude of high-carrier signal is varied according to the instantaneous amplitude of the modulating message signal m(t).

Carrier Signal: $\cos(2\pi f_c t)$ or $\cos(\omega_c t)$

Modulating Message Signal: $m(t): \quad \cos(2\pi f_m t)$ or $\cos(\omega_m t)$

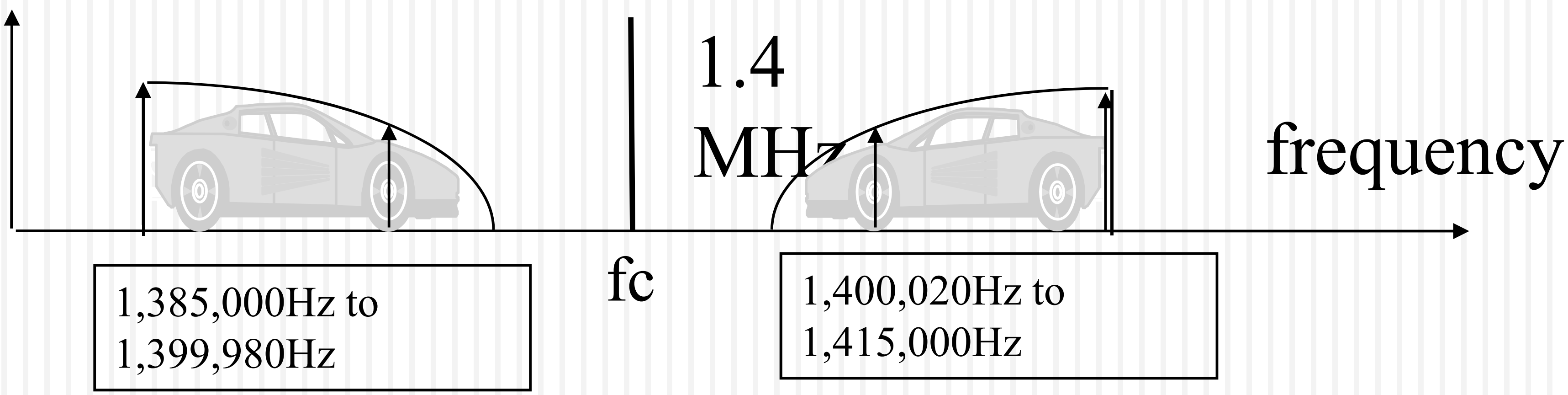
The AM Signal: $s_{AM}(t) = [A_c + m(t)]\cos(2\pi f_c t)$

Amplitude Modulation

- The AM signal is generated using a multiplier.
- All info is carried in the amplitude of the carrier, AM carrier signal has time-varying envelope.
- In frequency domain the AM waveform are the lower-side frequency/band (f_c - f_m), the carrier frequency f_c, the upper-side frequency/band (f_c + f_m).

AM Modulation – Example

- The information signal is usually not a single frequency but a range of frequencies (band). For example, frequencies from 20Hz to 15KHz. If we use a carrier of 1.4MHz, what will be the AM spectrum?



Modulation Index of AM Signal

Measurement of 'm'

The magnitude of **'m'** can be measured directly from the AM display itself.

Maximum and minimum amplitudes of the transmission signal's envelope determine the modulation depth:

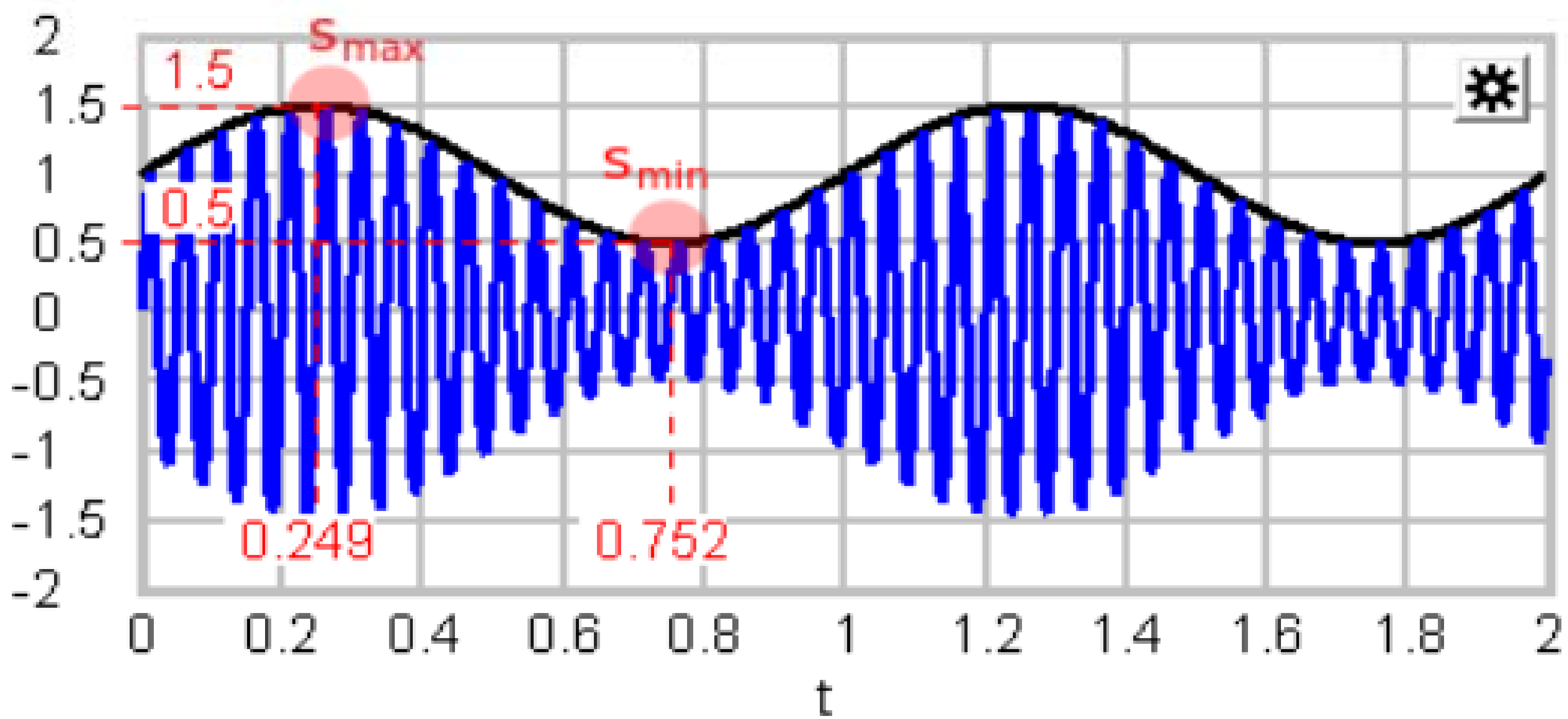
Modulation index, $a_m = \dfrac{E_m}{E_c}$ ....(1)

Maximum amplitude of modulated wave, $a = E_c + E_m$ ....(2)

Minimum amplitude of modulated wave, $b = E_c - E_m$ ....(3)

From (2) and (3), $E_c = \dfrac{a+b}{2}$, $E_m = \dfrac{a-b}{2}$

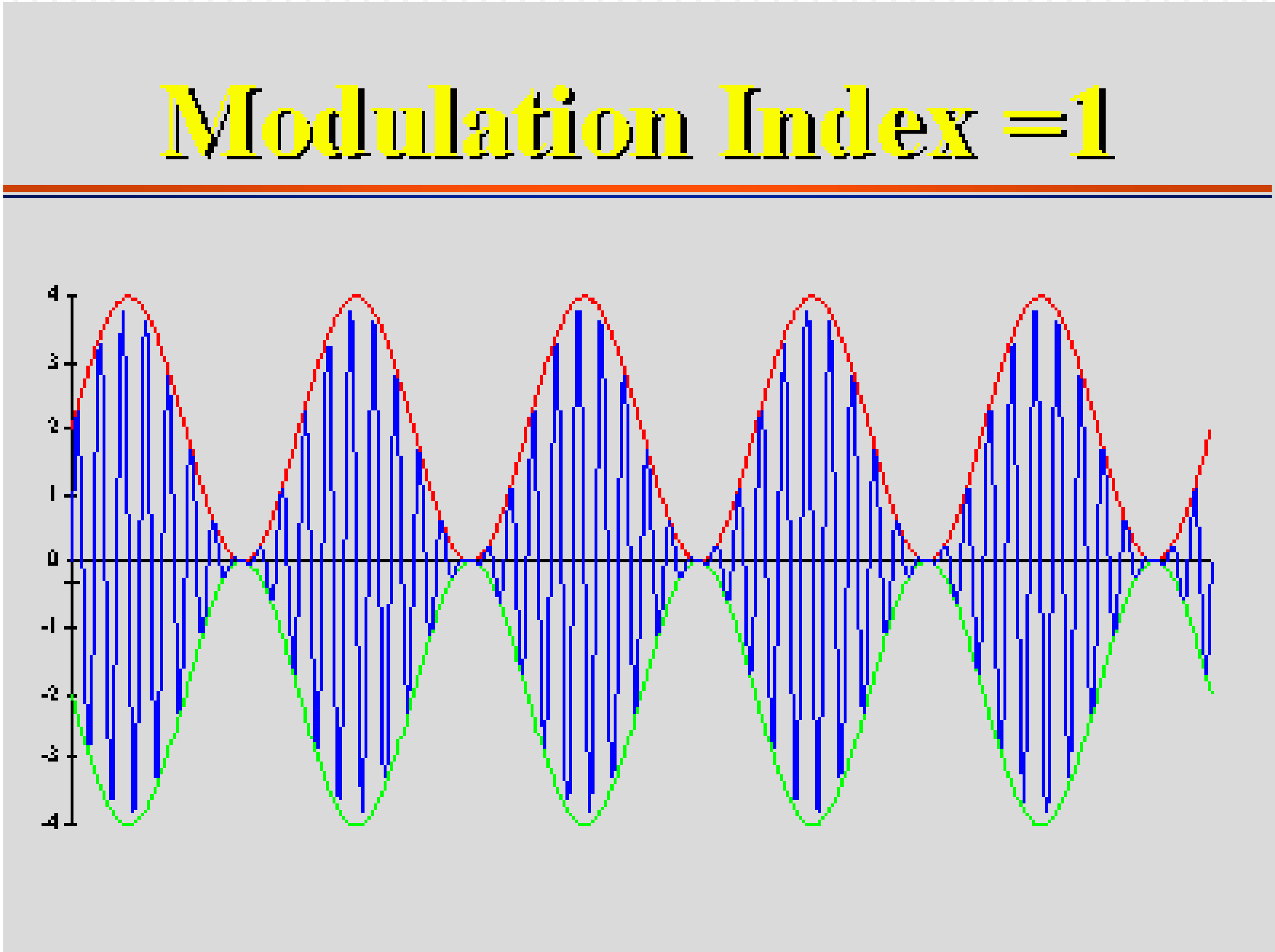
$\therefore$ From (1), modulation index, $a_m = \dfrac{E_m}{E_c} = \dfrac{(a-b)/2}{(a+b)/2} = \dfrac{a-b}{a+b}$



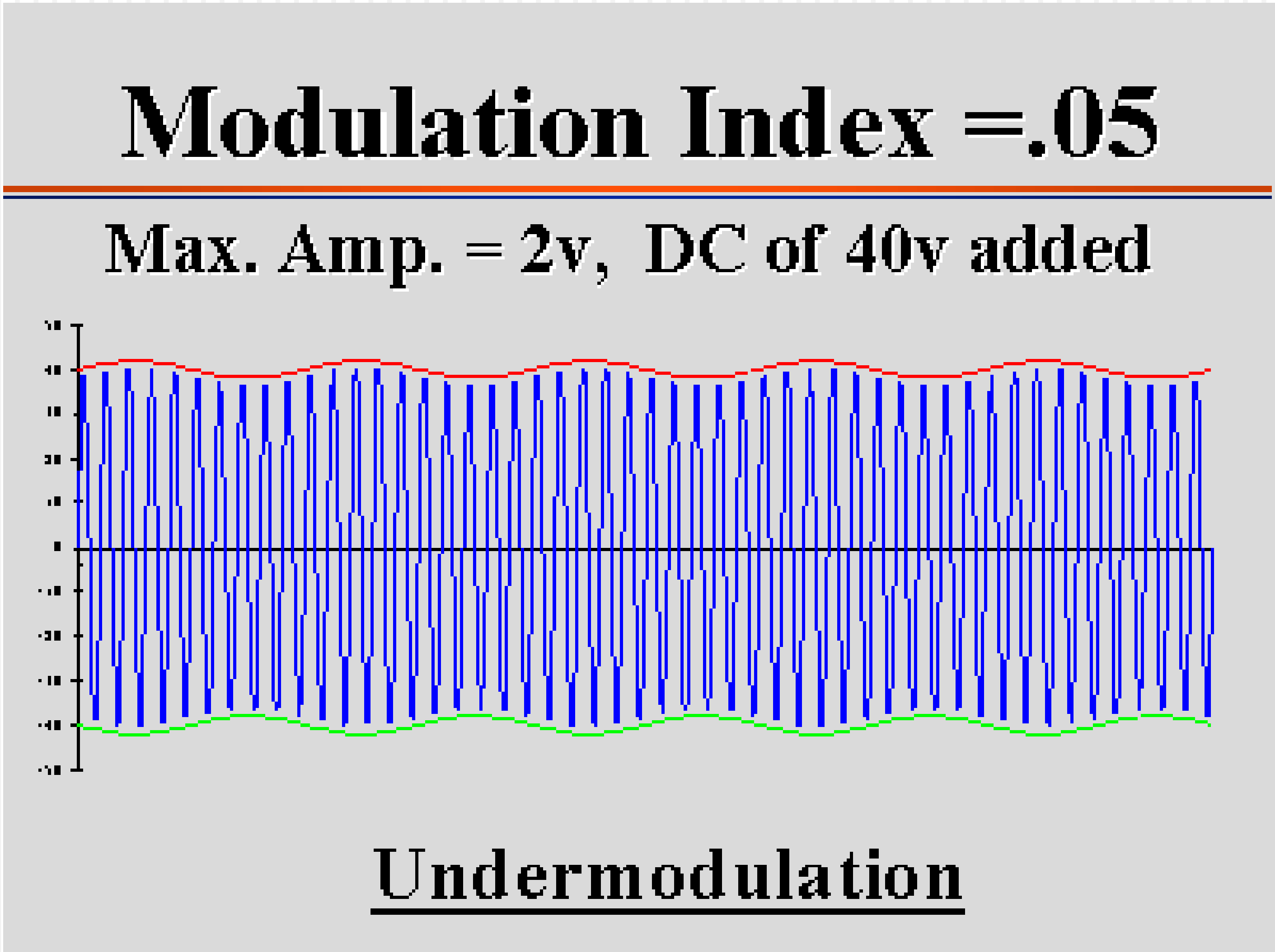
$$m = \frac{s_{\max} - s_{\min}}{s_{\max} + s_{\min}}$$

=1.5-
0.5/1.5+0.5
= 0.5

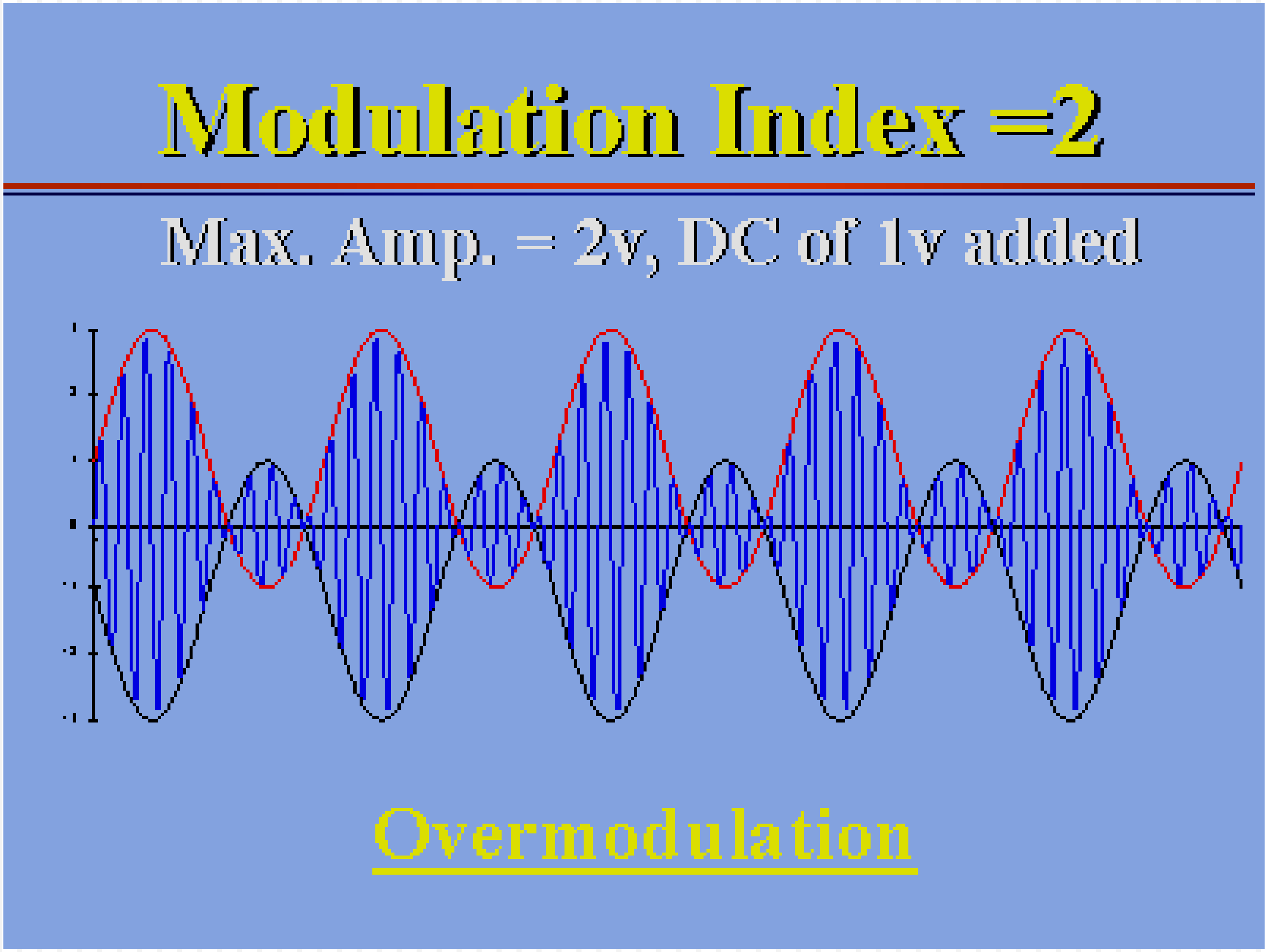
Modulation Index of AM Signal



Modulation Index of AM Signal

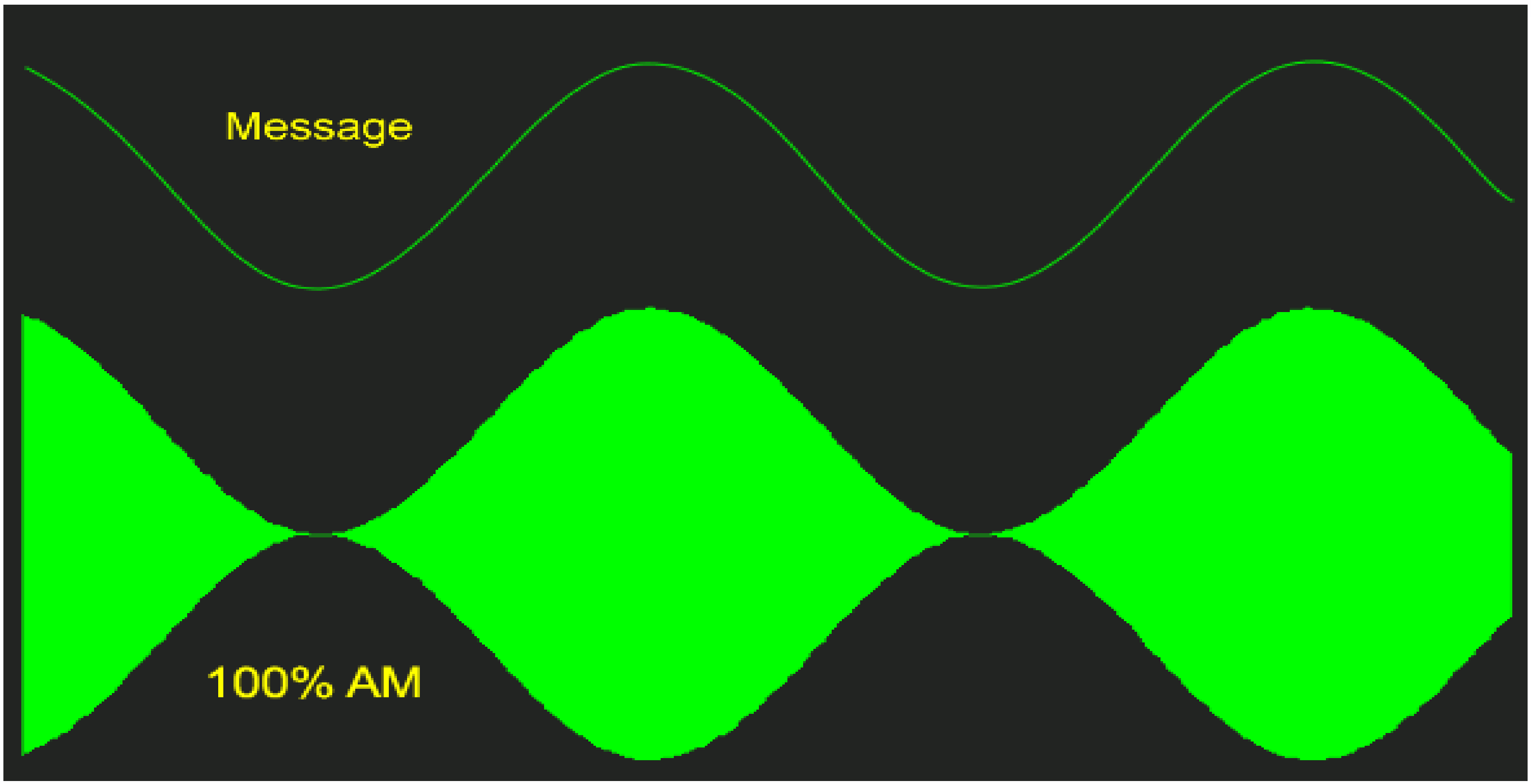


Modulation Index of AM Signal

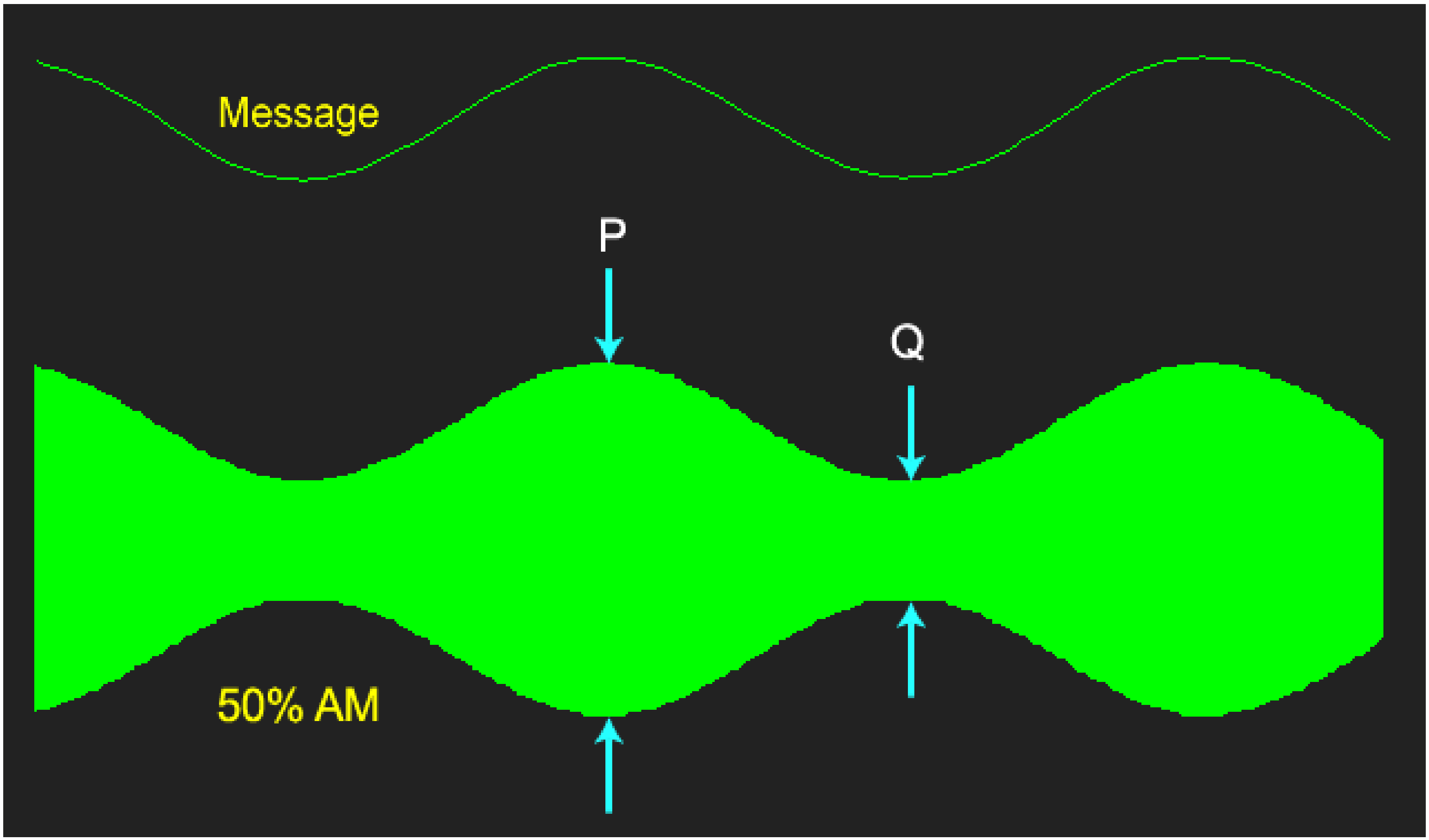


Display on Oscilloscope For Different Modulation indexes

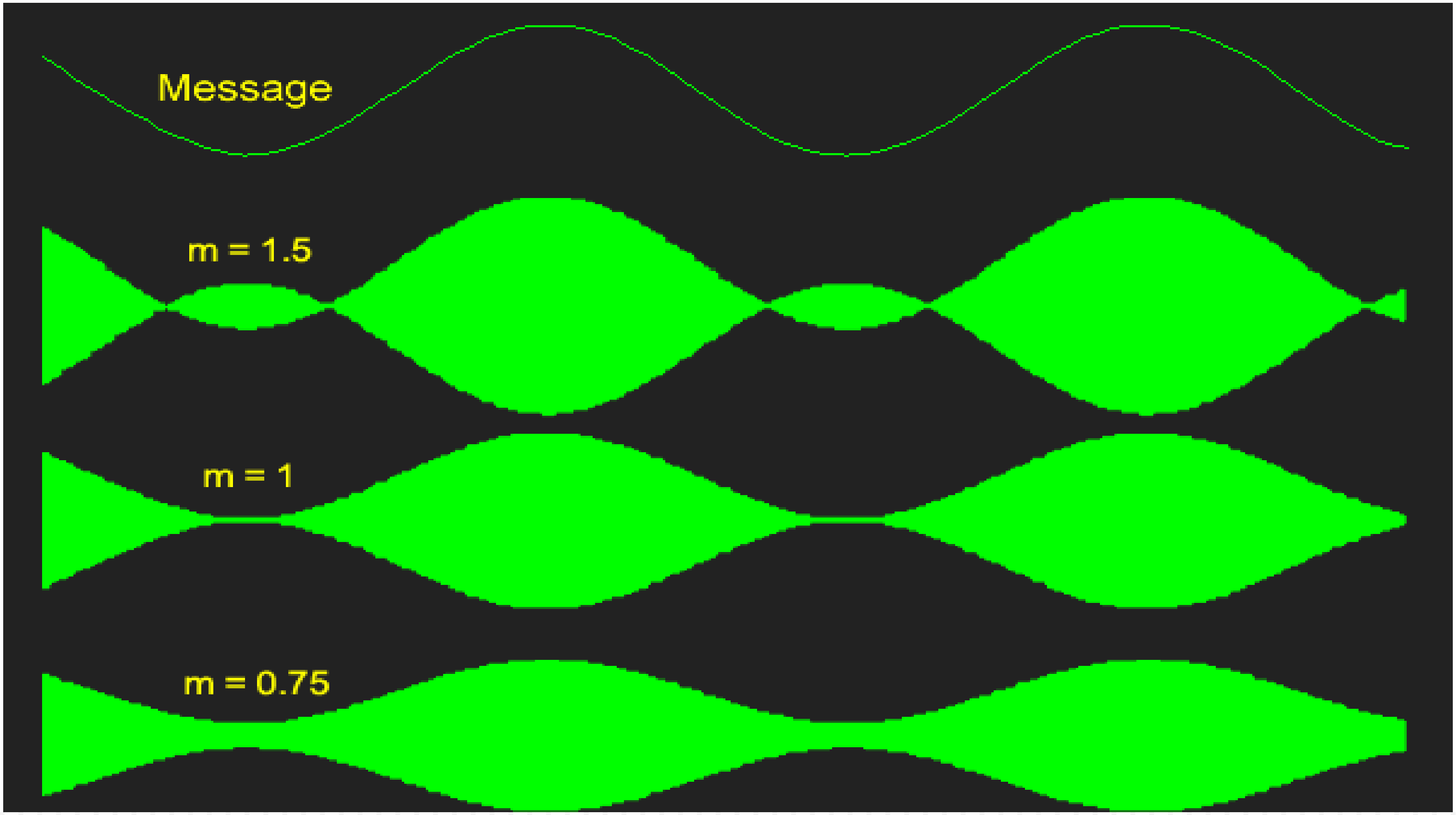
m=1



m<1



m>1



Trapezoidal Method

for finding

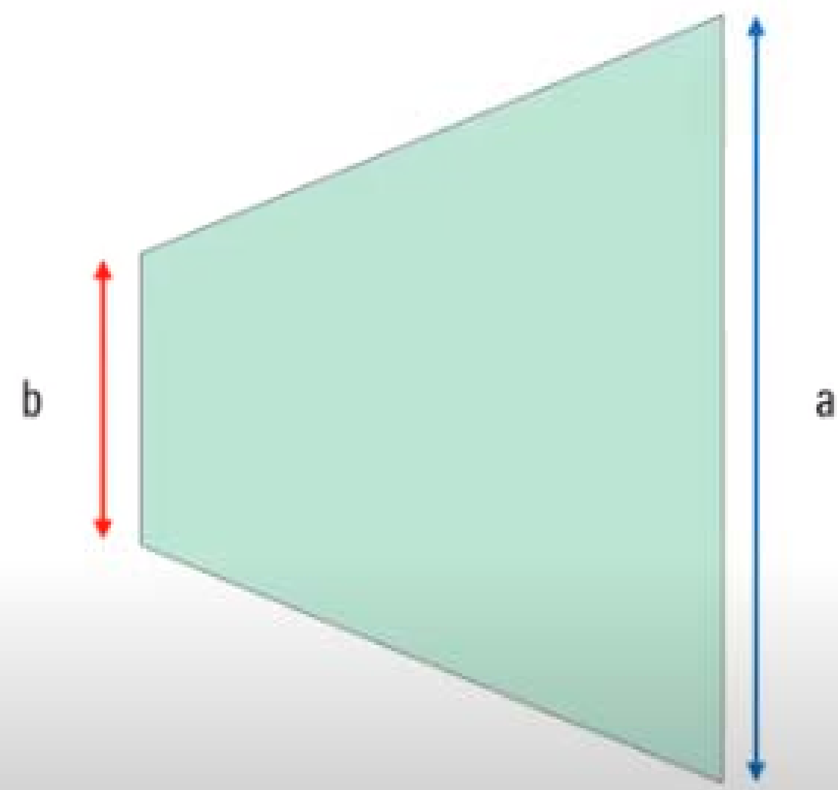
Modulation Index

Flow Chart (To Find Entropy of an Image)

Calculating m in the time domain

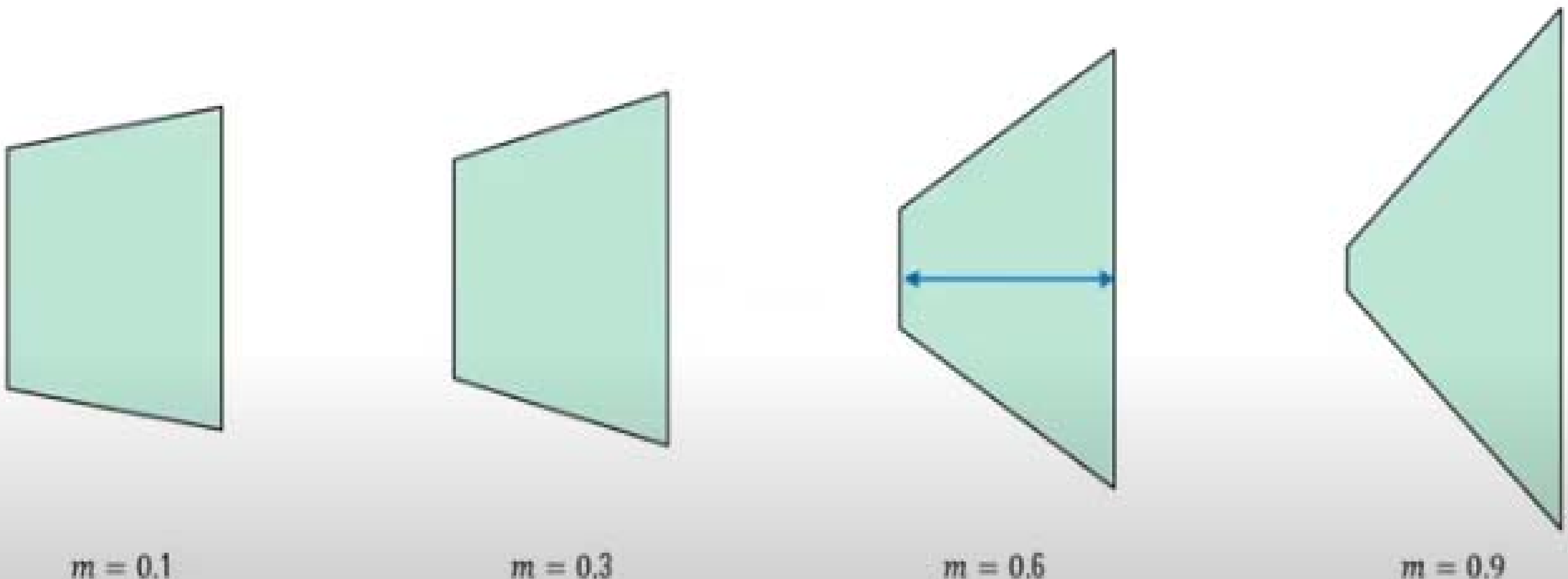
- We can calculate *m* in the time domain using an oscilloscope and the trapezoid method
- The scope is placed in in XY mode
  - X : modulating signal
  - Y : modulated signal
- Modulation index is then calculated from the vertical edge lengths using :

$$m = \frac{a - b}{a + b}$$



Different Cases of ‘m’

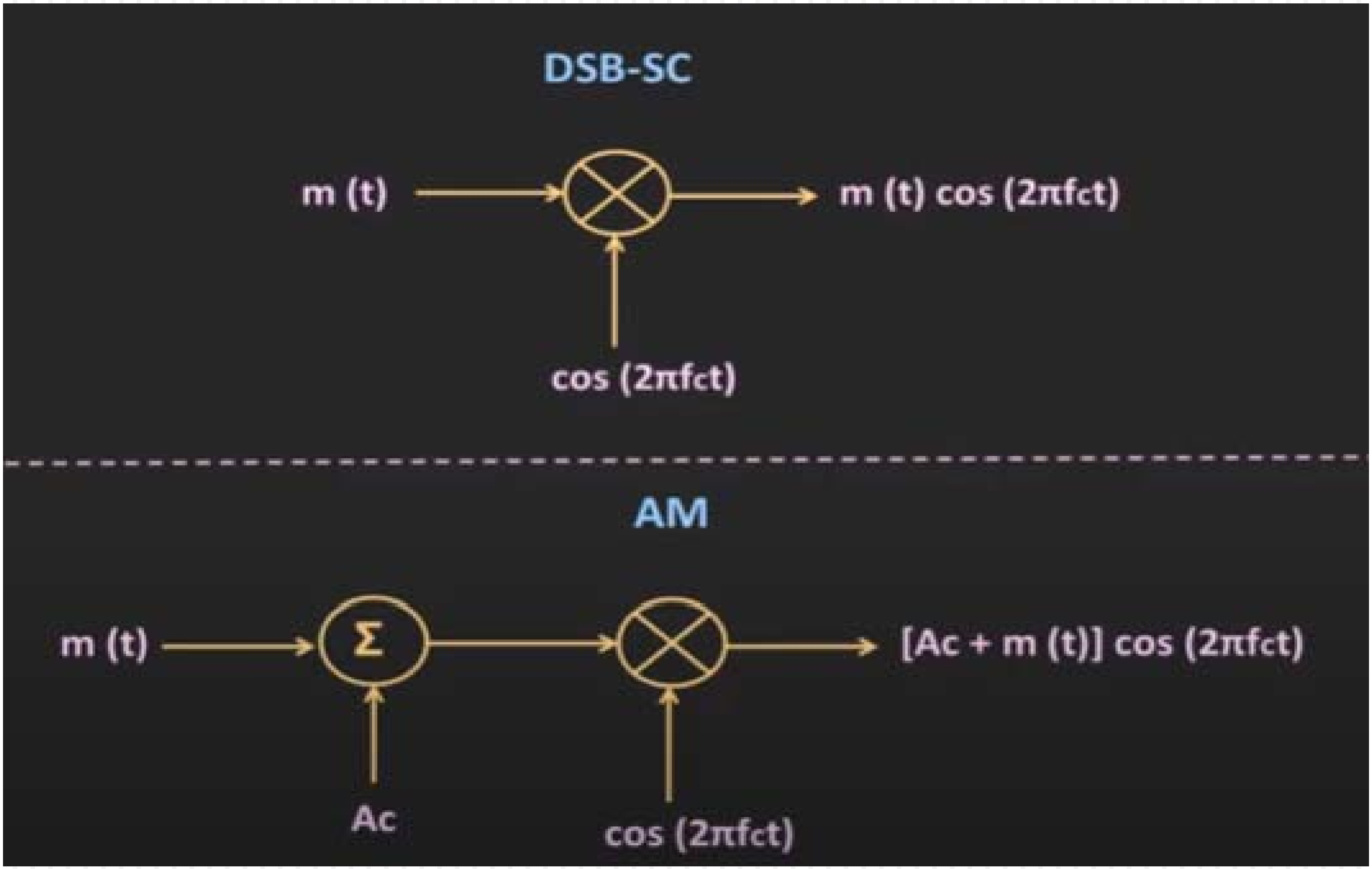
- As modulation index (m) increases, the ratio between the vertical trapezoid edges increases
  - The trapezoid width is unaffected by modulation depth

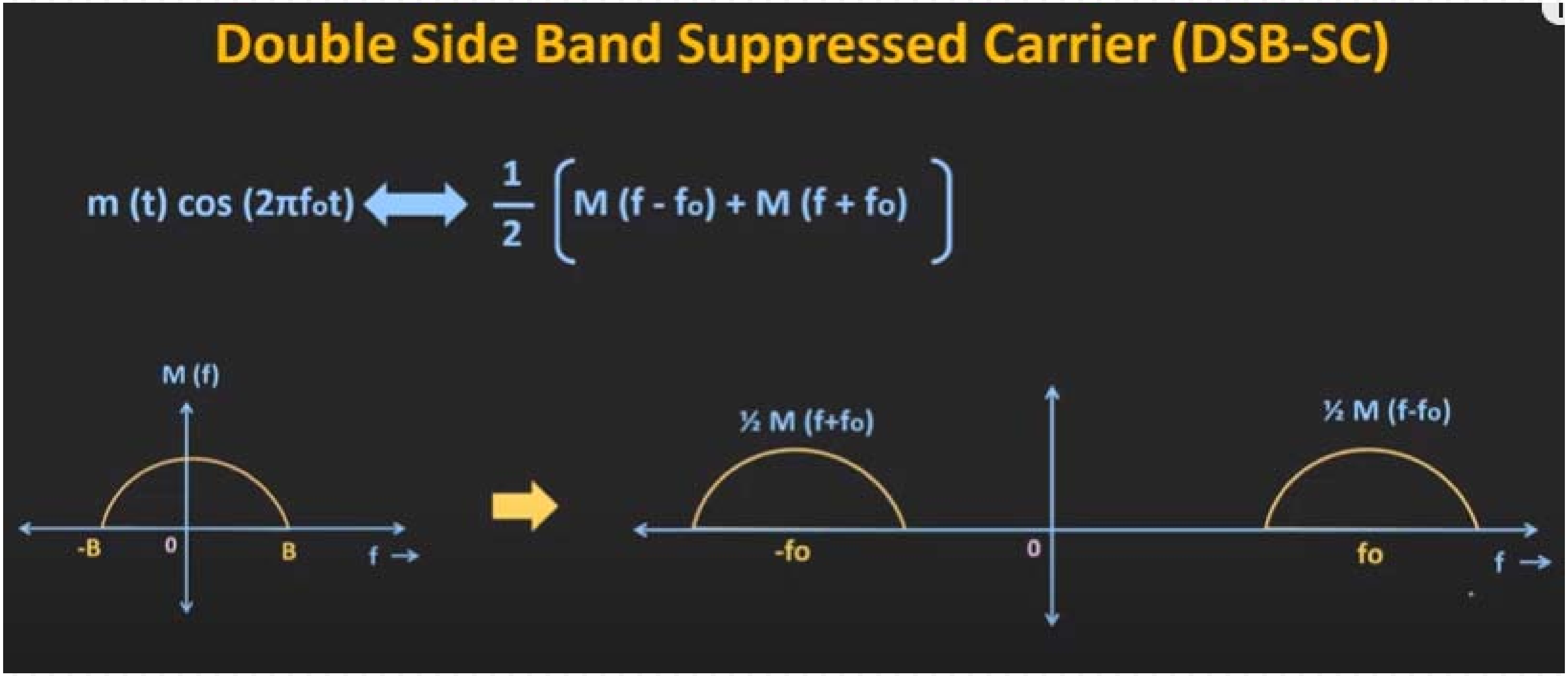


Double Side-Band Suppressed Carrier

DSB-SC

DSB - SC

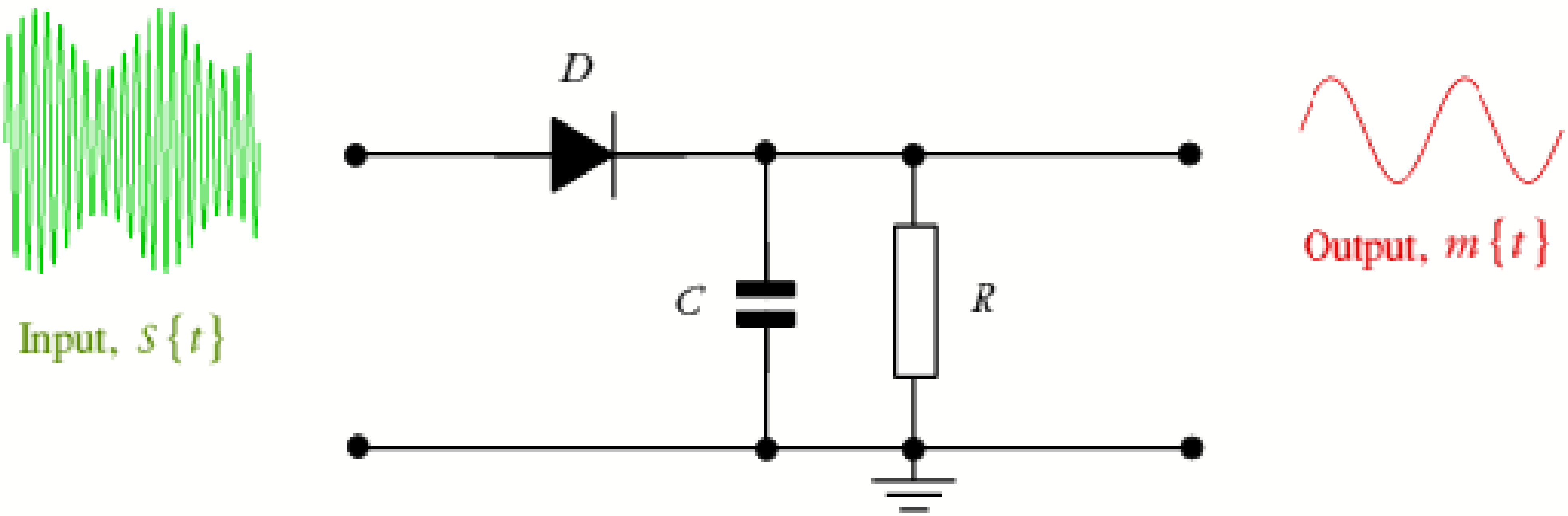

DSB-SC
m (t)
m (t) cos (2πfct)
cos (2πfct)
AM
m (t)
Σ
[Ac + m (t)] cos (2πfct)
Ac
cos (2πfct)



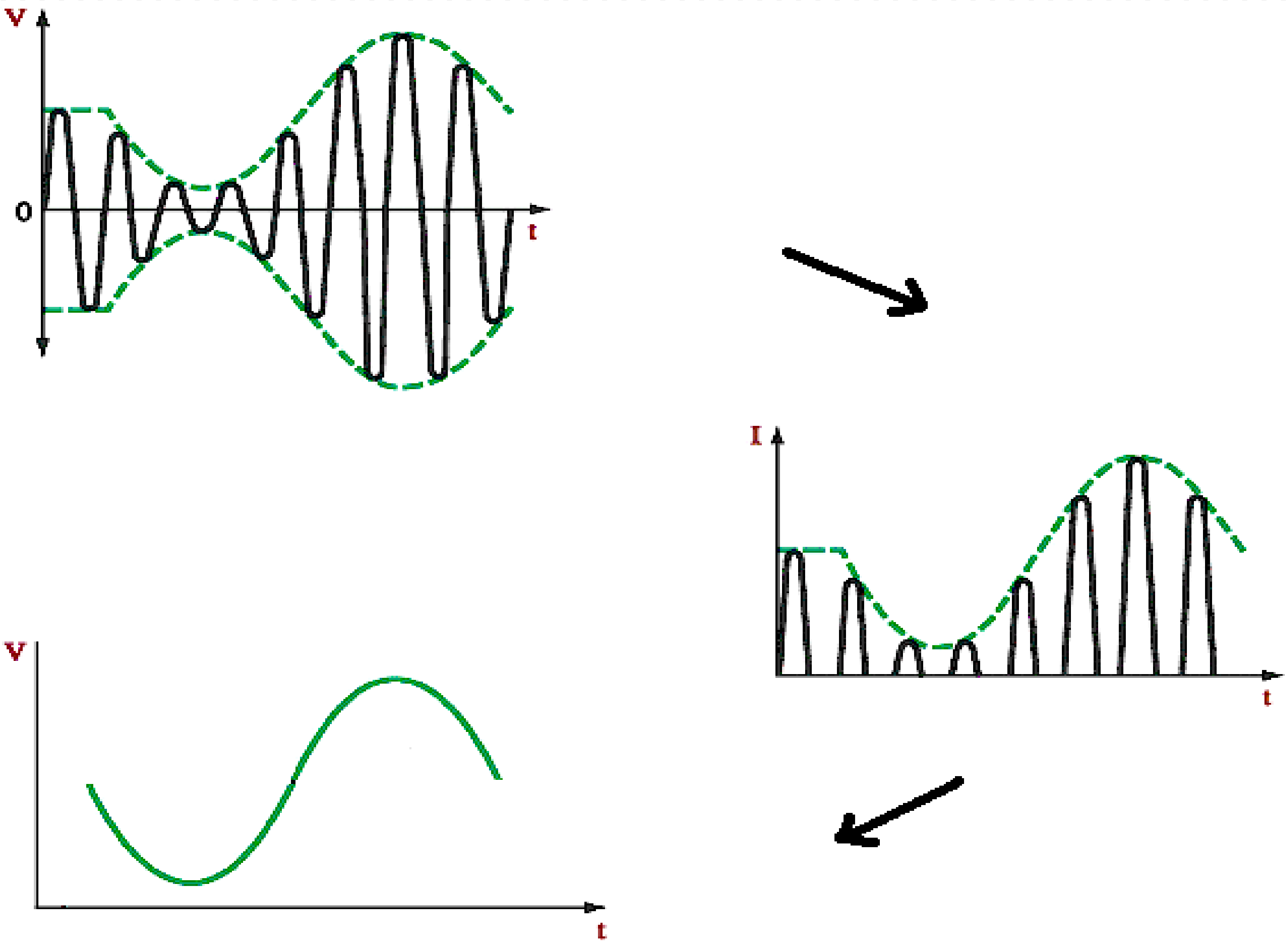
Double Side Band Suppressed Carrier (DSB-SC)
m (t) cos (2πfot) ⟺ 1/2 [M (f - fo) + M (f + fo)]
M (f)
-B
0
B
f →
½ M (f+fo)
½ M (f-fo)
-fo
0
fo
f →

Demodulation Methods

Envelope/Diode AM Detector



Envelope Detector



Simulation Links

https://www.etti.unibw.de/labalive/experiment/am/

To Be Continued…