Amplitude Modulation

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What is Modulation

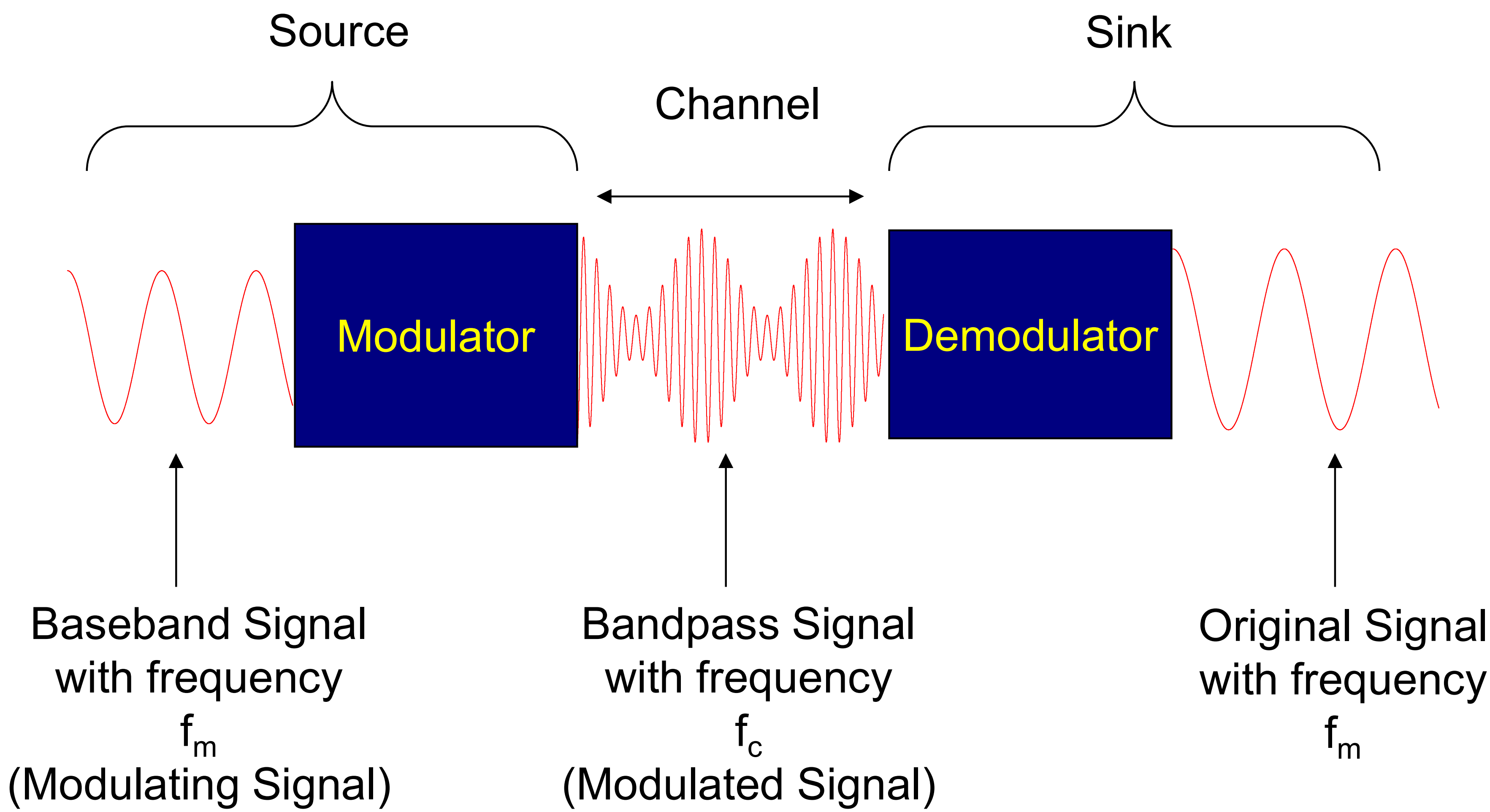
- Modulation
  - In the modulation process, some characteristic of a high-frequency carrier signal (bandpass), is changed according to the instantaneous amplitude of the information (baseband) signal.
- Why Modulation
  - Suitable for signal transmission (distance…etc)
  - Multiple signals transmitted 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.

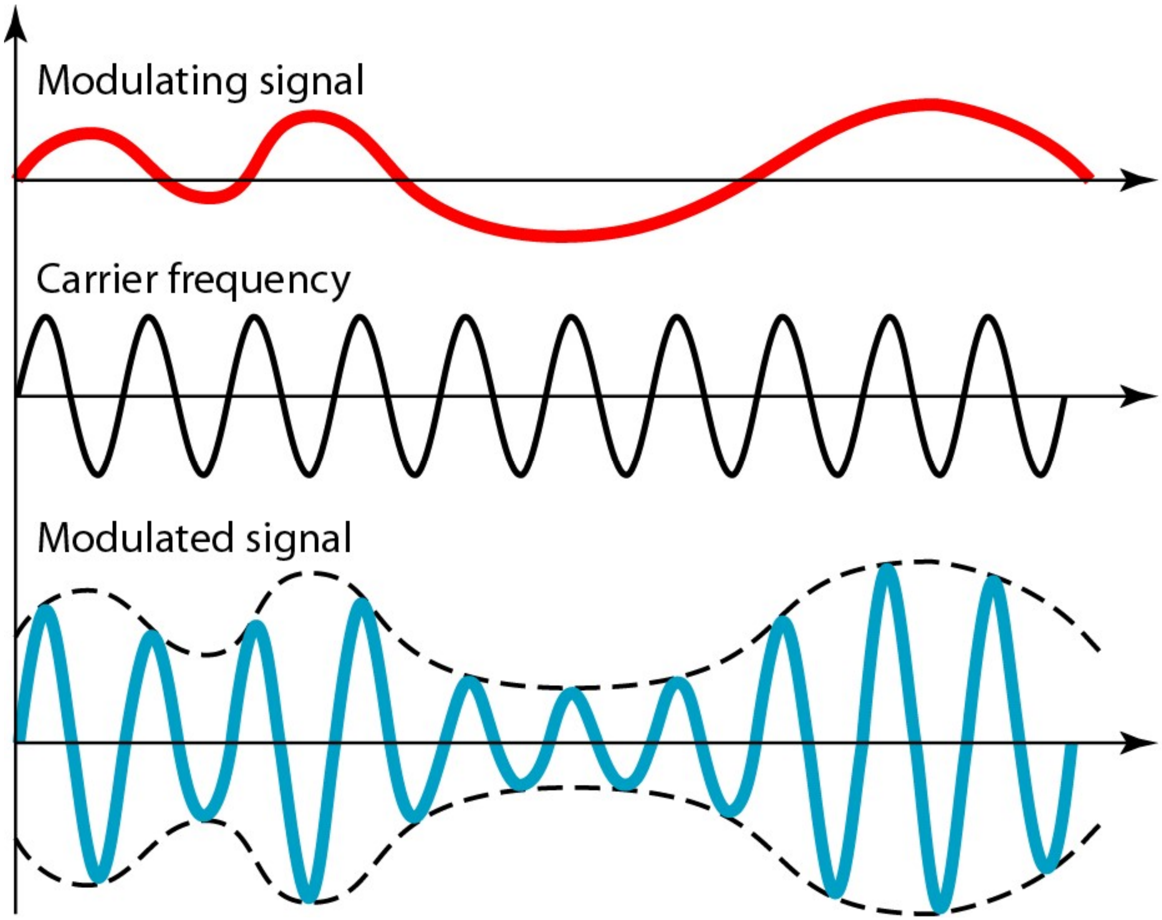
AM Modulation/Demodulation

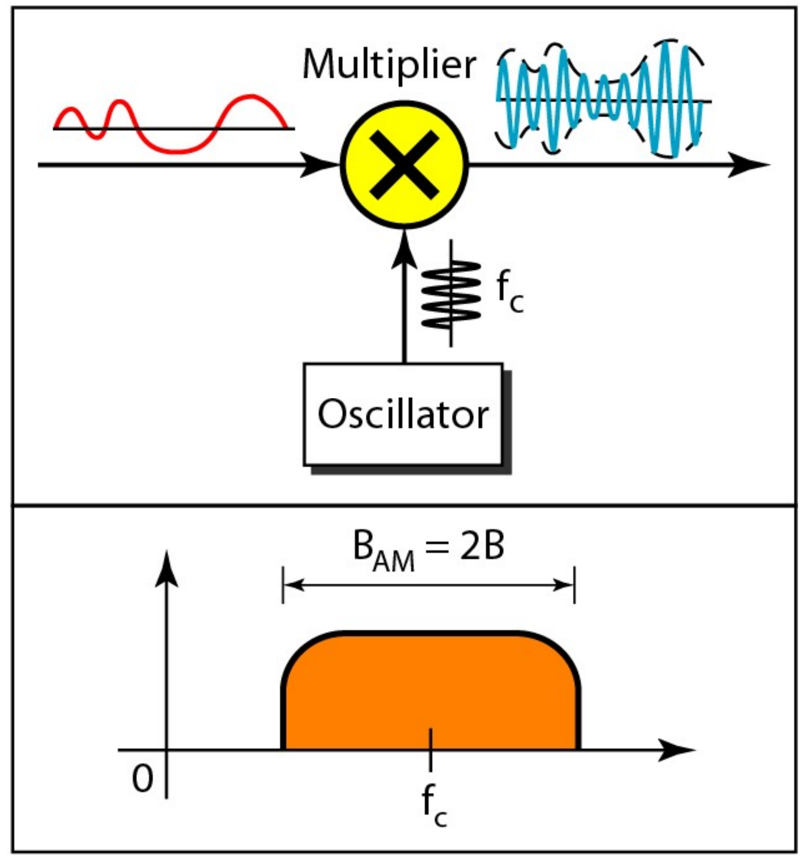


$f_c >> f_m$

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

Example *Amplitude modulation*





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 $\cos(\omega_m t)$

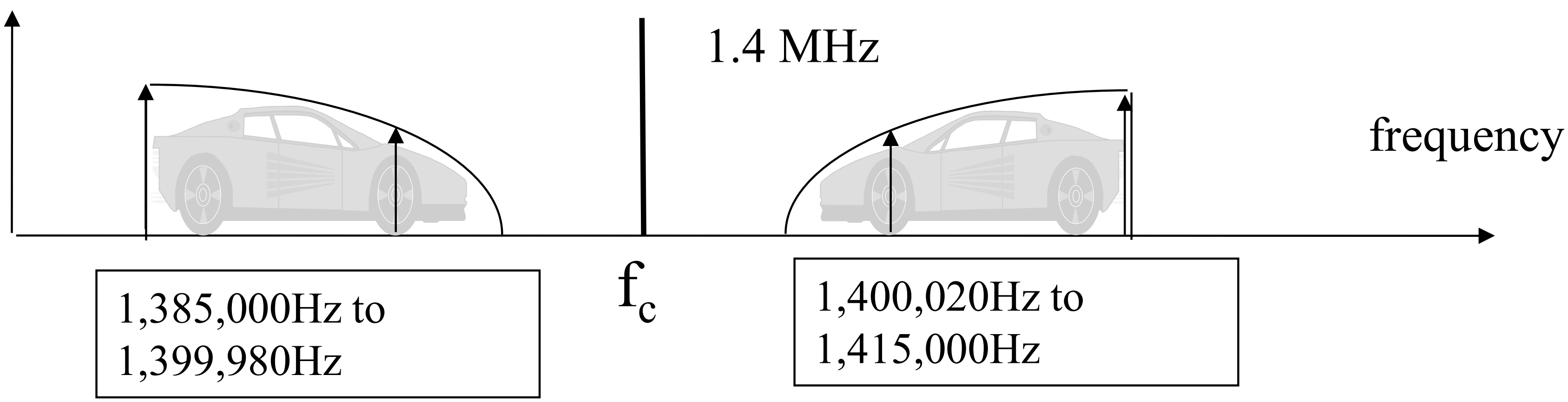
The AM Signal: $s_{AM}(t) = [A_c + m(t)]\cos(2\pi f_c t)$

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?
- 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). Bandwidth: 2x(25K-20)Hz.



Modulation Index of AM Signal

For a sinusoidal message signal $m(t) = A_m \cos(2\pi f_m t)$

Carrier Signal: $\cos(2\pi f_c t)$ DC: A_C

$k = \frac{A_m}{A_c}$

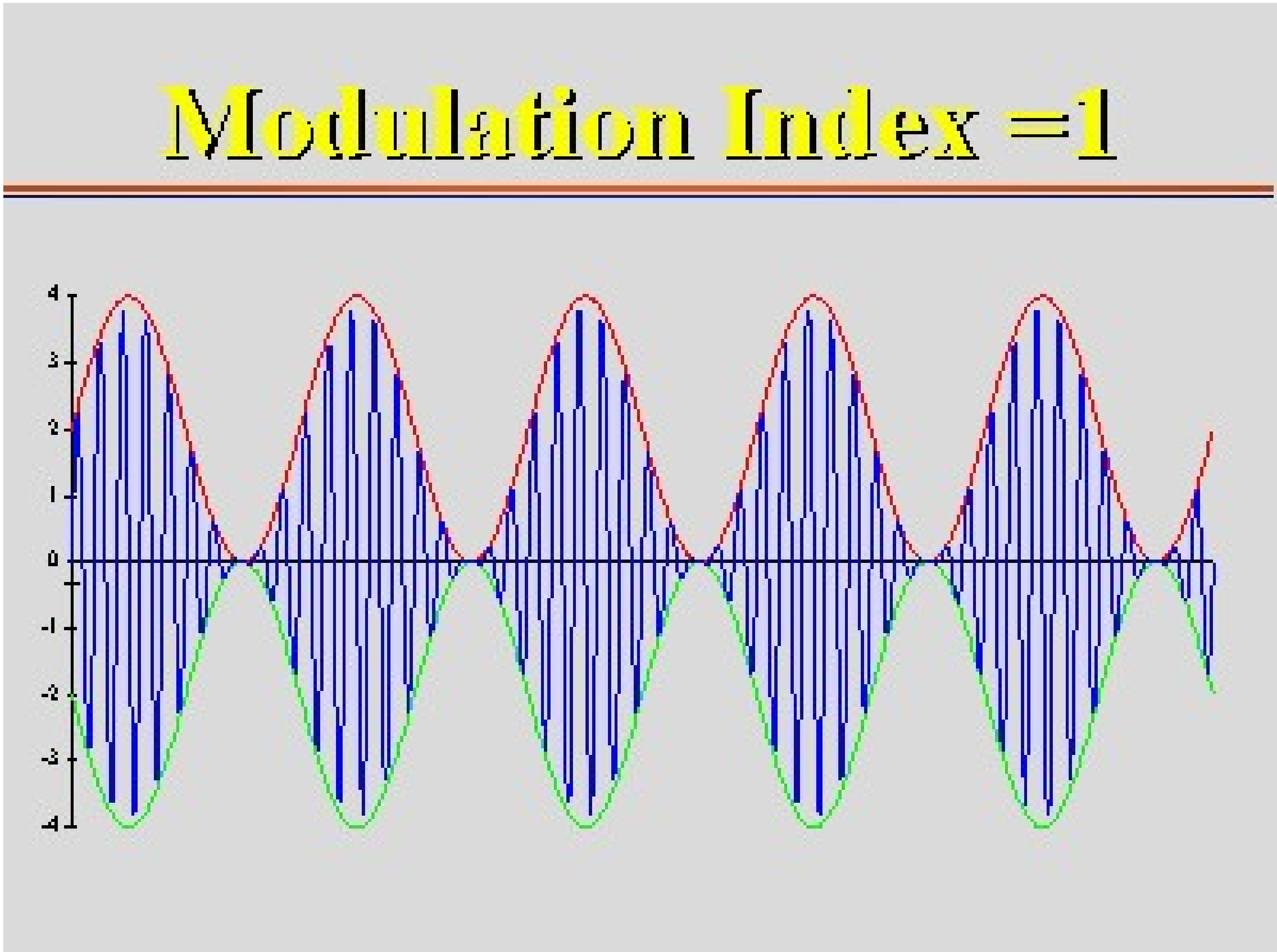
Modulated Signal: $S_{AM}(t) = [A_c + A_m \cos(2\pi f_m t)]\cos(2\pi f_c t)$

$$= A_c[1 + k\cos(2\pi f_m t)]\cos(2\pi f_c t)$$

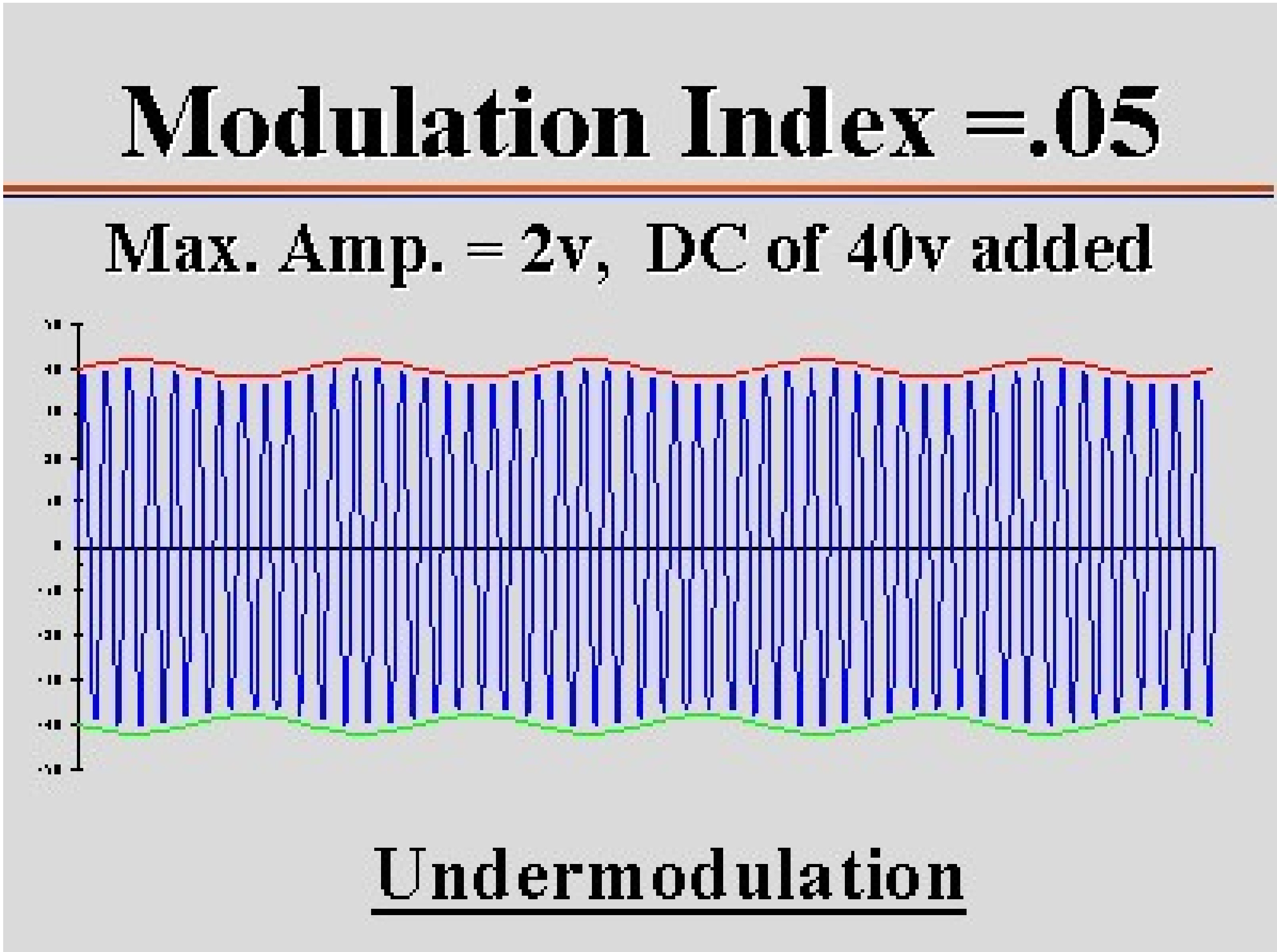
Modulation Index is defined as:

Modulation index k is a measure of the extent to which a carrier voltage is varied by the modulating signal. When k=0 no modulation, when k=1 100% modulation, when k>1 over modulation.

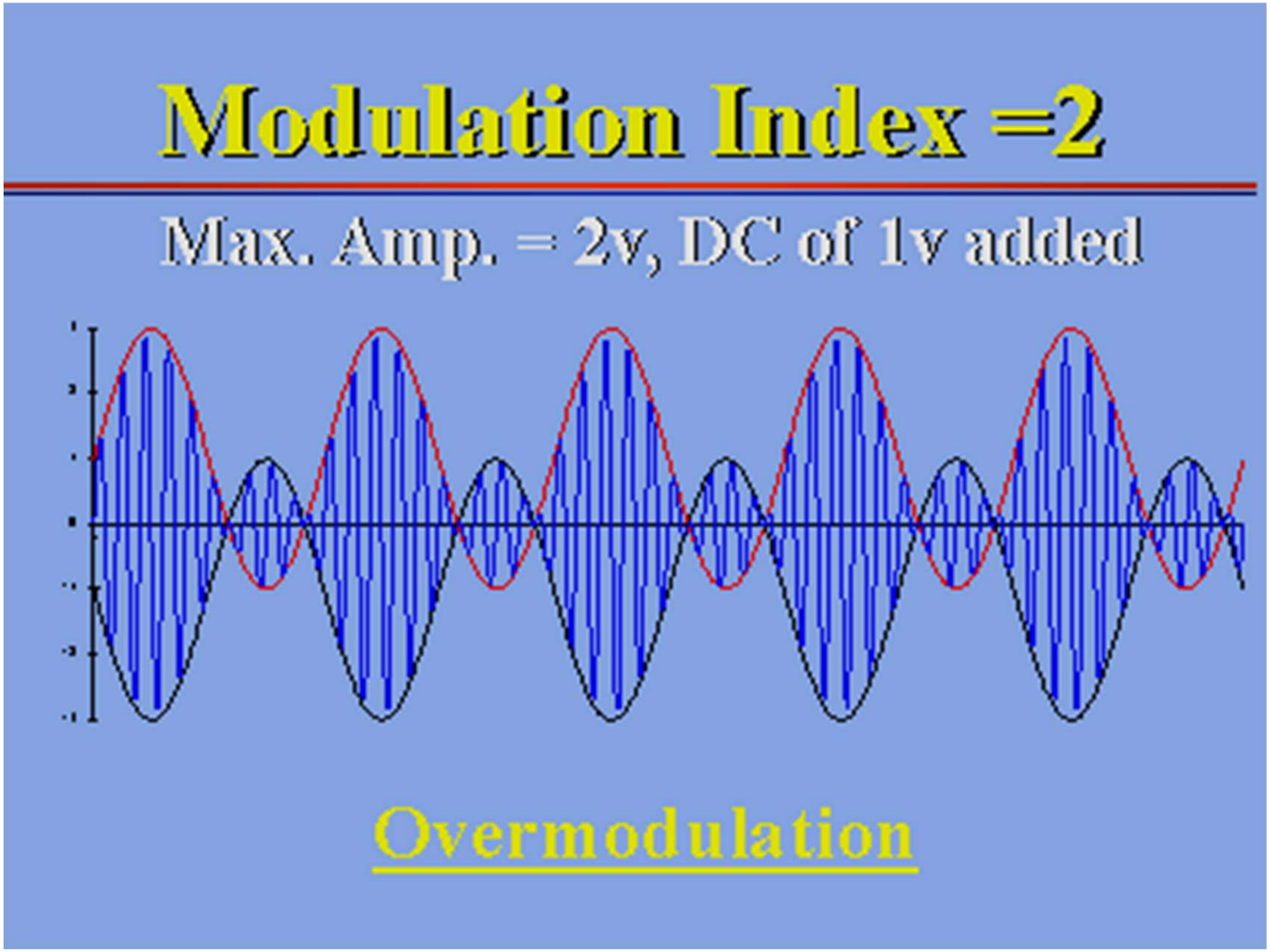
Modulation Index of AM Signal



Modulation Index of AM Signal



Modulation Index of AM Signal



High Percentage Modulation

- It is important to use as high percentage of modulation as possible (k=1) while ensuring that over modulation (k>1) does not occur.
- The sidebands contain the information and have maximum power at 100% modulation.
- Useful equation

$$\mathbf{P_t = P_c(1 + k^2/2)}$$

P_t =Total transmitted power (sidebands and carrier)

P_c = Carrier power