

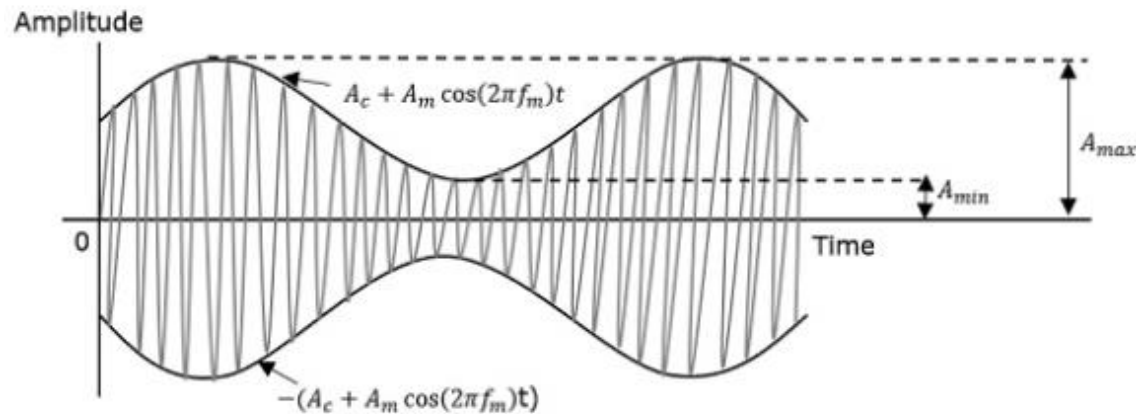
MODULATION INDEX & POWER IN AM SYSTEMS

EEN 462 – ANALOGUE COMMUNICATION

Monday, November 10, 2025

WHAT IS MODULATION INDEX?

1. **Modulation index (also called modulation depth /factor)** is a measure of how much the amplitude of the carrier wave is varied by the modulating signal.
2. **Modulation Index is defined as the ratio of the amplitude of the modulating signal (or message) to the amplitude of the carrier signal.**



$$\text{Modulation Index, } m_a = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$$

POWER CONTAINED IN AM SYSTEM

1. If the modulating signal and carrier signal are respectively

$$x_m(t) = A_m \sin \omega_m t \text{ and } x_c(t) = A_c \sin \omega_c t$$

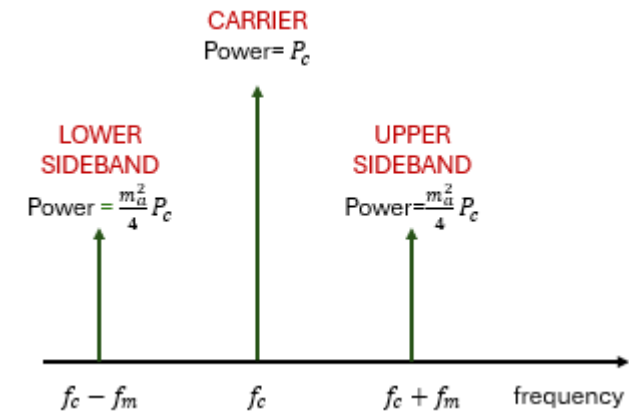
2. Then the modulated signal can be written as

$$x(t) = A_c \sin \omega_c t + \frac{m_a A_c}{2} [\cos(\omega_c - \omega_m)t + \cos(\omega_c + \omega_m)t]$$

3. From the equation, we get the following

- Power in the carrier, $P_c = A_c^2$
- Power in the Lower Side-Band(LSB) = $(\frac{m_a A_c}{2})^2 = \frac{m_a^2}{4} A_c^2 = \frac{m_a^2}{4} P_c$
- Power in the Upper Side-Band(USB) = $(\frac{m_a A_c}{2})^2 = \frac{m_a^2}{4} A_c^2 = \frac{m_a^2}{4} P_c$
- Total power, $P_t = \text{Power in Carrier} + \text{Power in LSB} + \text{Power in USB}$

$$\begin{aligned} &= P_c + \frac{m_a^2}{4} P_c + \frac{m_a^2}{4} P_c \\ &= P_c \left(1 + \frac{m_a^2}{2} \right) \end{aligned}$$



POWER SAVING IN DIFFERENT AM SYSTEMS /01

1. We have power expression in AM system given by

$$P_t = P_c \left(1 + \frac{m_a^2}{2} \right)$$

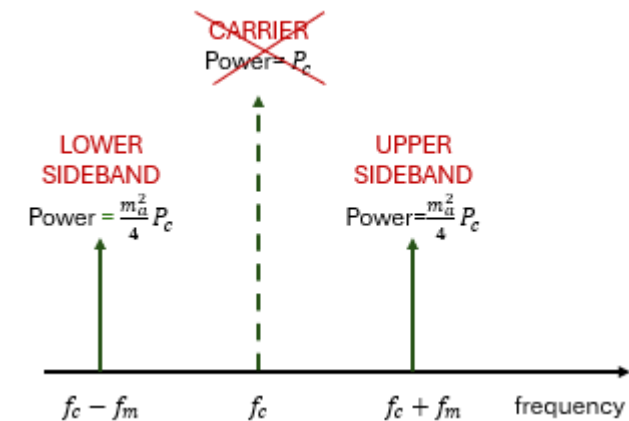
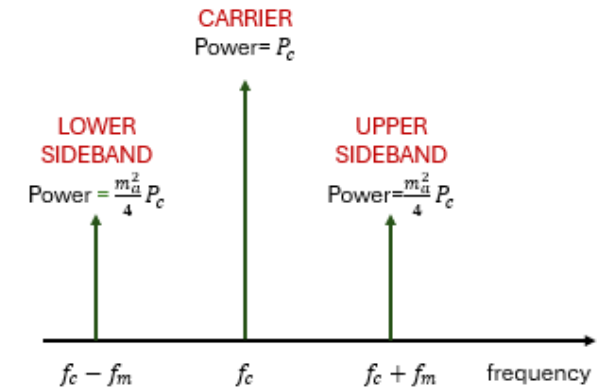
2. **CASE 1: AM DOUBLE SIDEBAND WITHOUT SUPPRESSION**

$$\text{If } m_a = 1 \text{ then } P_t = \frac{3P_c}{2}$$

3. **CASE 2: AM DOUBLE SIDEBAND SUPPRESSED CARRIER (DSB-SC)**

- If $m_a = 1$ then $P_t = \frac{P_c}{2}$
- Power saving is P_c since the carrier is suppressed
- Power saving compared with case without suppression is therefore:

$$\text{Saving} = \frac{\text{Power saved}}{\text{Power without suppression}} = \frac{P_c \times 100}{3P_c/2} = 67\%$$

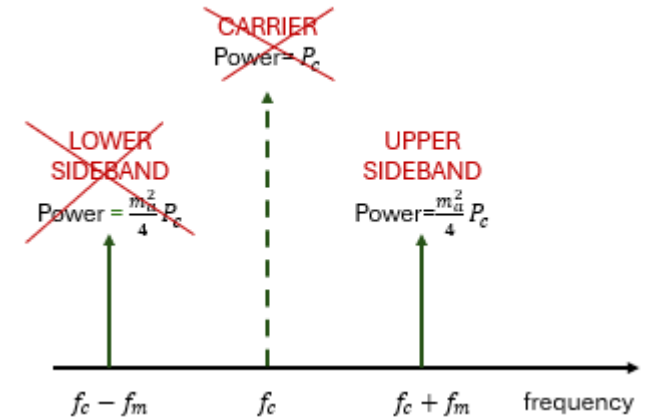


POWER SAVING IN DIFFERENT AM SYSTEMS /03

3. CASE 3: AM SINGLE SIDEBAND SUPPRESSED CARRIER (DSB-SC)

- If $m_a = 1$ then $P_t = \frac{P_c}{4}$
- Power saving is $P_c + \frac{P_c}{4} = \frac{5P_c}{4}$ since the carrier is suppressed
- Power saving compared with case without suppression is therefore:

$$\text{Saving} = \frac{\text{Power saved}}{\text{Power without suppression}} = \frac{\frac{5P_c}{4} \times 100}{3P_c/2} = 83\%$$



WORKED EXAMPLE

A modulating signal $m(t) = 10\sin(2\pi \times 10^3 t)$ is used to modulate a carrier $c(t) = 20\sin(2\pi \times 10^4 t)$. Determine the following:

- (a) Modulation index
- (b) Percentage modulation
- (c) Frequencies of LSB and USB
- (d) Amplitudes of LSB and USB
- (e) Bandwidth of modulated signal

WORKED EXAMPLE SOLUTION

1. We can write the modulating signal, $m(t) = 10\sin(2\pi \times 10^3 t)$ as $v_m \sin(2\pi \times f_m t)$
2. Similarly, we can write the carrier signal $c(t) = 20\sin(2\pi \times 10^4 t)$ as $c(t) = A_c \sin(2\pi \times f_c t)$
3. Using the above variables, we can infer the following:
 - (a) Modulation index $m_a = \frac{v_m}{A_c} = \frac{10}{20} = 0.5$
 - (b) percentage modulation $= 100 \times m_a = 50\%$
 - (c) frequencies of LSB and USB are $10^4 \pm 10^3$ i.e 9KHz and 11 KHz
 - (d) Amplitudes of LSB and USB are given by $\frac{m_a A_c}{2} = \frac{0.5 \times 20}{2} = 5$ Volts
 - (e) Bandwidth of modulated signal $= 2 \times f_m = 2 \times 1000 = 2000$ Hz