Amplitude Modulation and Frequency Modulation problems

1. Determine from Figure 1:
   (a) Modulation Index
   (b) The frequency of the modulating signal, assuming $f_c = 45$ kHz
   (c) The carrier power (for a 75 Ω load)
   (d) The Power in one sideband (for a 75 Ω load)
   (e) Total power dissipated (for a 75 Ω load)
   (f) The carrier power as a percentage of the total
   (g) The bandwidth required to transmit this signal
   (h) The spectrum of a SSB SC-AM signal with the same message and carrier frequencies
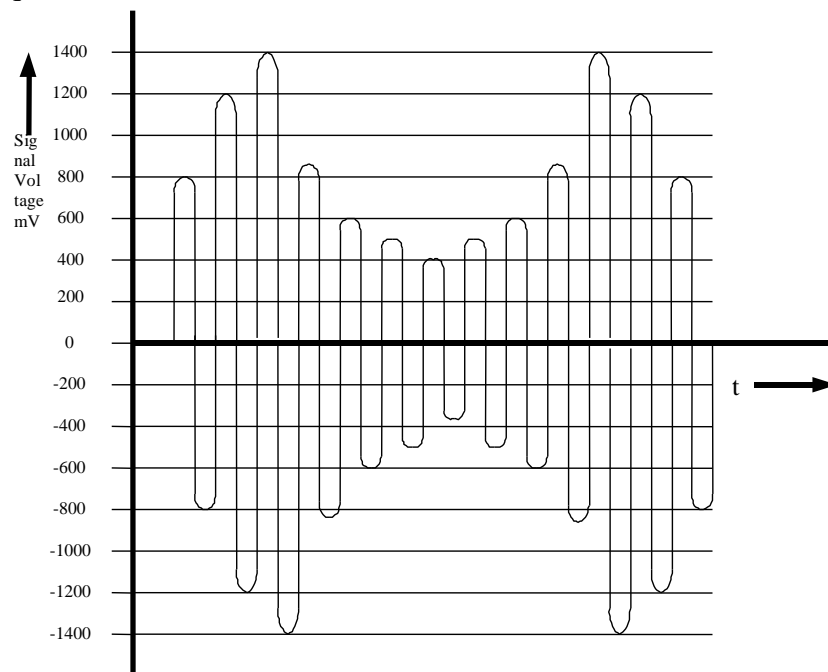

Figure 1

2. The peak amplitude of an unmodulated 40kHz cosine carrier signal is 100V. This is then modulated by a 10kHz cosine tone to an index of 50%:
   (a) Sketch the signal over a 0.2 millisecond period
   (b) Sketch the frequency spectrum of this AM signal. Include the frequency and peak voltage of each component
   (c) Write the mathematical expression of this signal in a form that shows the carrier, lower sideband and upper sideband (Again include the actual numerical frequencies and peak voltages)
   (d) Determine the bandwidth required to transmit the signal
   (e) Calculate the power delivered to a 50 Ω load for the following:
       i. P_C
       ii. P_{USB}
       iii. P_{total}

3. The instantaneous voltage of a frequency modulated signal is given by:

$$v(t) = V_c \sin\left(2\pi 10^7 t + 37.5 \sin\left(2\pi 12.6 \times 10^3 t\right)\right)$$

Determine the carrier frequency, the modulating signal frequency and the peak frequency deviation.

4. Two approximations for the bandwidth of wideband and narrowband FM are given as:

$$B = 2.(\beta + 1).f_m \qquad \text{for} \qquad \beta \gg 1 \qquad \text{(Wideband FM)}$$
$$B = 2 f_m \qquad \text{for} \qquad \beta \ll 1 \qquad \text{(Narrowband FM)}$$

Consider frequency modulation of a 10 MHz carrier by a 5 kHz tone that has a deviation of:

        i.   1.25 kHz
       ii.   40 kHz

(a) Calculate and sketch the frequency spectrum for the Narrowband case
(b) Check the accuracy of the bandwidth of the predicted by the above eqations for both Narrowband and Wideband cases.