Problem Set 3

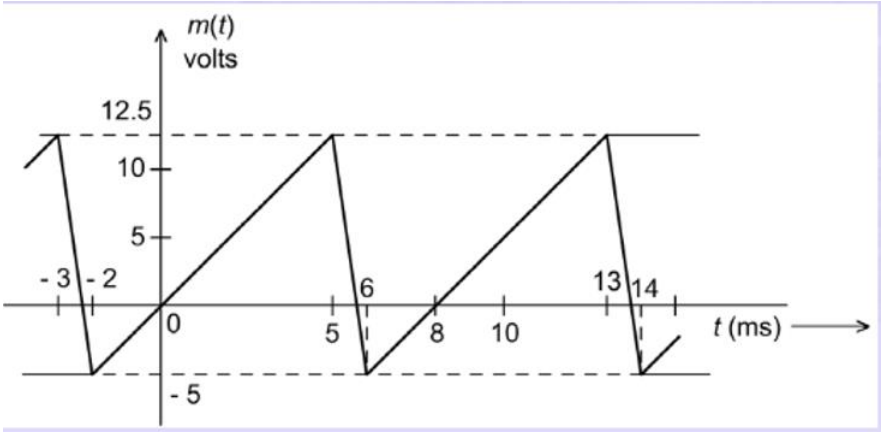
Angle Modulation

1. An angle modulated signal is given by

$$s(t) = \cos\left[2\pi\left(2\times10^{6}t + 30\sin(150t) + 40\cos(150t)\right)\right]$$

   a. Find the carrier frequency
   b. Find m(t) if this is a PM signal with k_p=1rad/V
   c. Find the instantaneous frequency.
   d. If this is an FM signal, propose a structure to recover m(t) from s(t).

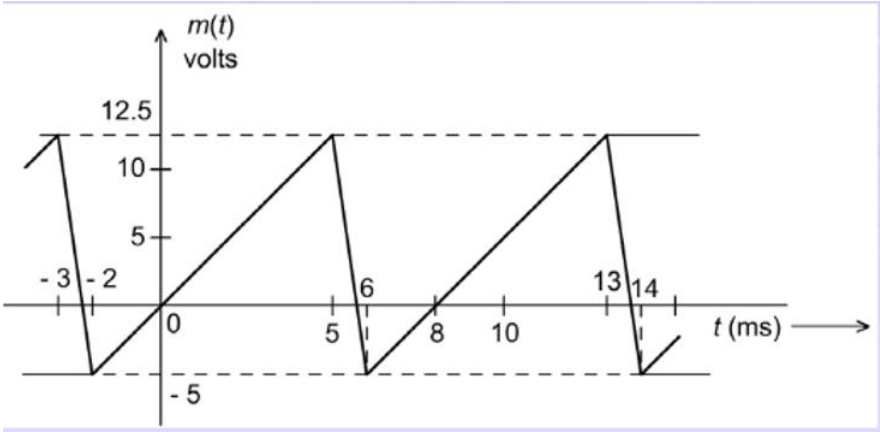
2. The periodic signal m(t) is applied to an FM modulator with a carrier frequency of 100KZ and k_f=1KHz/V.



   a. Find the maximum and minimum values of the frequency of the modulated signal.
   b. Sketch the frequency deviation from the unmodulated carrier as a function of time.

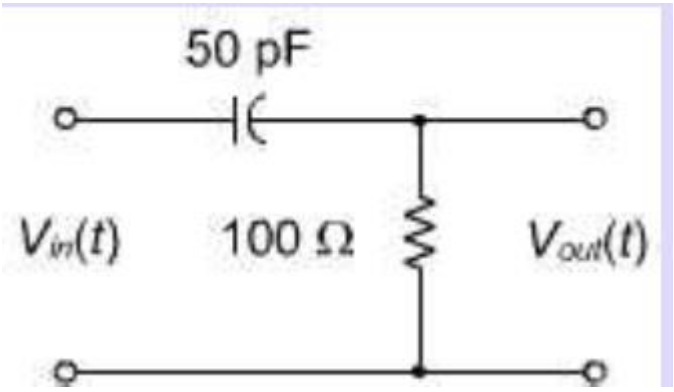
3. A periodic signal $m(t)$ angle modulates a very high frequency carrier. Let the modulated signal be given by, $s(t) = A_c \cos\left[2\pi\times10^{8}t + k_p m(t)\right]$,

where m(t) is as shown in the figure below.



If $(f_i)_{max} - (f_i)_{min}$ is to be 100 kHz show that $k_p = 10\pi$ rad/volt.

4. Let $M(f) = 0.01rect(\frac{f}{100})$ and $f_c = 10^6 Hz$. It is given that $k_f = 250$ Hz/V and $A_f = 4\ V$. Sketch $S(f)$ for a narrow band FM signal.
5. Consider the RC network shown in the figure below. For the values of *R* and *C* given, show that for frequencies around 1.0 MHz, this can act as a differentiator



6.

An FM signal is given by

$$\varphi(t) = 10 \cos (2\pi\ 10^6 t + 5 \sin 2\pi\ 10^3 t).$$

a. Find the 98% bandwidth of the FM signal by considering significant frequency terms.

b. Estimate the bandwidth using Carson's rule

7. **An FM signal $\varphi_{FM}(t) = 5 \cos (2\pi\, 10^6 t + \sin 20{,}000\, \pi t)$ is input a square-law nonlinearity (with the characteristic: $y = 2x^2$, where x is the input and y the output). The output of the nonlinearity y(t) is filtered by an ideal band pass filter with center frequency 2.03 MHz and bandwidth 10 kHz to produce the final output z(t). Determine z(t) and sketch its magnitude spectrum.**

8. We want to transmit two voice signals, each with frequency spectrum ranging in (0 KHz, 5 KHz) over a channel operating in the range of (100 KHz-120 KHz).
   a. Draw the block diagram for the transmitter that uses amplitude modulation to multiplex these two signals. Specify the necessary carrier frequencies for the two baseband signals.
   b. Draw the block diagram for the receiver to demultiplex the two signals and bring back each signal to its baseband. Specify the cut-off frequencies of any filter used.