

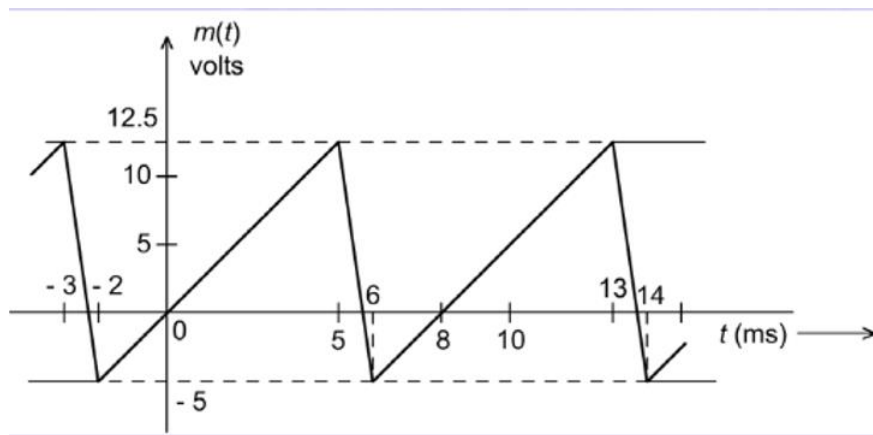
Problem Set 3

Angle Modulation

1. An angle modulated signal is given by

$$s(t) = \cos \left[2\pi \left(2 \times 10^6 t + 30 \sin(150t) + 40 \cos(150t) \right) \right]$$

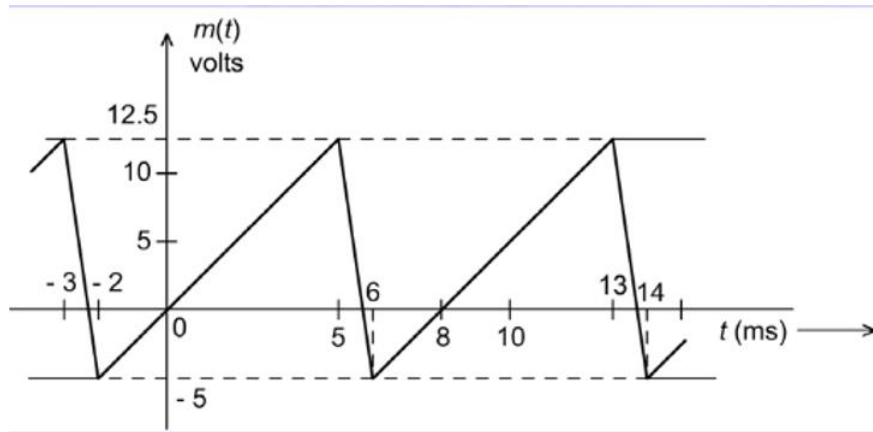
- a. Find the carrier frequency
 - b. Find $m(t)$ if this is a PM signal with $k_p=1\text{rad/V}$
 - c. Find the instantaneous frequency.
 - d. If this is an FM signal, propose a structure to recover $m(t)$ from $s(t)$.
2. The periodic signal $m(t)$ is applied to an FM modulator with a carrier frequency of 100KZ and $k_f=1\text{KHz/V}$.



- 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.

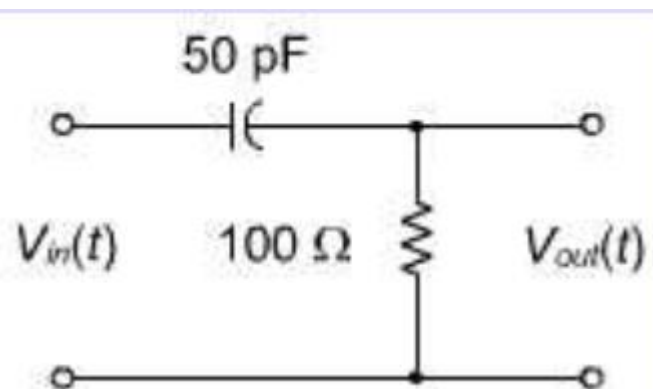
A periodic signal $m(t)$ angle modulates a very high frequency carrier. Let the modulated signal be given by, $s(t) = A_c \cos \left[2\pi \times 10^8 t + k_p m(t) \right]$,

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 $M(f) = 0.01 \text{rect}(\frac{f}{100})$ and $f_c = 10^6 \text{ Hz}$. It is given that $k_f = 250 \text{ Hz/V}$ and $A_f = 4 \text{ V}$. 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

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

- 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 $\phi_{\text{FM}}(t) = 5 \cos(2\pi 10^6 t + \sin 20,000 \pi t)$ 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.