Principles of communication systems

EET3202, CUNY City Tech, Fall 2023

Homework #05 (Due on Oct 5)

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Problem 1

Calculate the instantaneous frequency of the following signals.

a) $A\sin(\omega t + \phi)$

b) $\cos(at^2 + bt + c)$

c) $\cos(e^t)$

d) $\cos(\sin(\omega t + \theta))$

e) $\cos(\sqrt{t} + c)$

Problem 2

Find the FM signal corresponding to the following instantaneous frequencies.

a) $w_i = w_c + k_f t$

b) $w_i = w_c + k_f C$

c) $w_i = w_c - \sin(w_m t)$

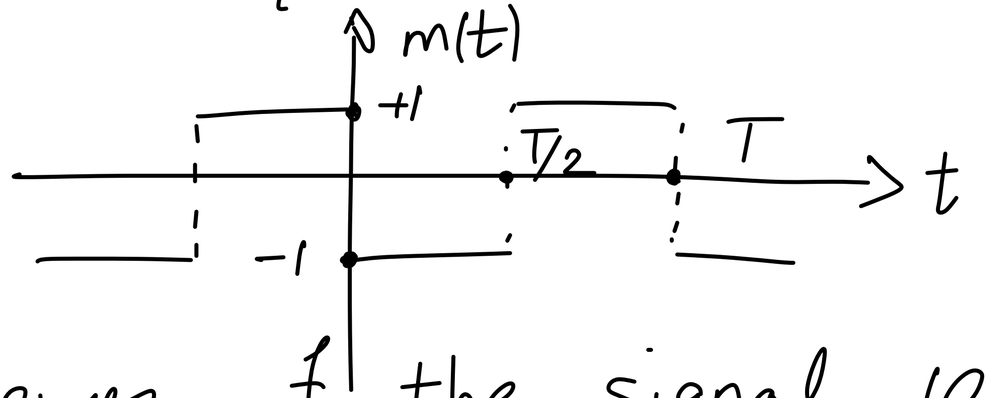
d) $w_i = w_c + k_f u(t - t_0)$

* $u(t - t_0)$ is the unit step function.

Problem 3

The power of an FM signal

Assume we have an FM signal $\varphi_{FM}(t) = A\cos(\theta(t))$ with the instantaneous frequency $\omega_i = \frac{d\theta}{dt} = \omega_c + k_f m(t)$. The message looks like a periodic square wave.



Calculate the power of the signal $\varphi_{FM}(t)$.

* Hint : Calculate the power separately for $m(t)=+1$ and $m(t)=-1$

Problem 4

Power and bandwidth of AM

We have an AM signal where the message is a single tone with frequency $f_m = 3$ kHz and amplitude 1.2 V peak to peak.

a) What is the required DC voltage for a modulation index of $\mu = 1$?

b) Write down the function representing the message+DC.

Problem 4

Power and bandwidth of AM

c) Suppose we modulate a carrier $A\cos(2\pi f_c t)$ with our DC shifted message. What is the final AM signal? ($A = 10$ V, $f_c = 250$ kHz)

d) Calculate the sideband power P_s and the carrier power P_c for the AM signal.

Problem 4

Power and bandwidth of AM

e) calculate the power efficiency?

$$\mu = \frac{P_s}{P_c + P_s}$$

f) what is the bandwidth of our AM signal?

Problem 5

Power and bandwidth of FM

Assume we have the same carrier and message from the last problem but with no DC component. This time we want to generate an FM signal.

a) Assume the FM signal is $\varphi_{FM}(t) = B\cos(\theta(t))$.

Find the value of B and calculate $\theta(t) = w_c t + k_f \int_{-\infty}^{t} m(\alpha)d\alpha$

b) what is the power of $\varphi_{FM}(t)$?

Problem 5

Power and bandwidth of FM

c) Assume $k_f = 2\pi \times 3000$. Calculate the deviation index $\beta = \dfrac{f_{max}[\varphi_{FM}] - f_{min}[\varphi_{FM}]}{\text{Bandwidth of } m(t)}$.

d) what is the bandwidth of $\varphi_{FM}(t)$?

e) Bonus: what is the sideband power, carrier power, and the power efficiency of $\varphi_{FM}(t)$?