ECE 447 Fall 2025

Lesson 11

Angle Modulation, Part 1

UNITED STATES AIR FORCE ACADEMY

Schedule and Admin

- Schedule
- Admin
  - **Lab 3 Assignment**. Due Lesson 14 - specifically 15 Sep by 2359 via Gradescope upload.
  - HW2 coming next week
  - Skills Review graded. Working on the Labs and HW1...

Review

- DSB-SC: Problem 4.2-7 in textbook

Angle Modulation

- Where is the message in FM or PM? How does that look mathematically?

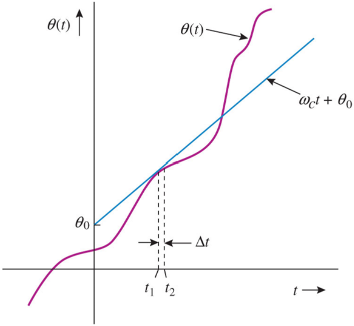
- What is the relationship between frequency and phase?
  Hint: in $\cos(\omega_c t + \theta_0)$, the phase $\theta_0 = \omega_c * \Delta t$ where Δt is the time shift

- Argument of a sinusoid is an angle (phase)

- If we plot $\omega_c t + \theta_0$ vs. t, we get a straight line

- $\frac{d(\omega_c t + \theta_0)}{dt} =$

Angle Modulation



- Now consider a generalized sinusoidal signal: $\varphi(t) = A\cos\theta(t)$, where $\theta(t)$ is the generalized angle (not just a straight line)
- *Instantaneous* frequency: $\omega_i(t) = \frac{d\theta}{dt}$ and $\theta(t) = \int_{-\infty}^{t} \omega_i(\alpha)d\alpha$

Angle Modulation

- PM
  - $\theta(t) = \omega_c t + k_p m(t)$, where k_p is a constant
  - $\varphi_{PM}(t) = A\cos[\omega_c t + k_p m(t)]$
  - $\omega_i(t) = \frac{d\theta}{dt} = \omega_c k_p \dot{m}(t)$
- FM
  - ω_i varies linearly with $m(t)$ or $\omega_i(t) = \omega_c + k_f m(t)$, where k_f is a constant
  - $\theta(t) = \int_{-\infty}^{t} \omega_i(\alpha) d\alpha =$
  - $\varphi_{FM}(t) = A\cos[\omega_c t + k_f \int_{-\infty}^{t} m(\alpha) d\alpha]$
- Power of FM or PM signals?

Computer Simulations

Jupyter Notebook files on Teams