EEEN 462 – ANALOGUE COMMUNICATION

PHASE MODULATION (PM) - TEST YOUR KNOWLEDGE

MULTIPLE CHOICE QUESTIONS

1. **Phase Modulation (PM) is a type of .....**
   a) Amplitude modulation
   b) Frequency modulation
   c) Angle modulation
   d) Pulse modulation
   Answer: c) Angle modulation

2. **In PM, the instantaneous phase deviation is proportional to .....**
   a) The amplitude of the modulating signal
   b) The frequency of the modulating signal
   c) The integral of the modulating signal
   d) The derivative of the modulating signal
   Answer: a) The amplitude of the modulating signal

3. **The mathematical expression for a PM wave is .....**
   a) Accos(2πfct+kpm(t))$A\cos(2\pi fct+kpm(t))$
   b) Accos(2πfct+kf∫m(t)dt)$A\cos(2\pi fct+kf\int m(t)dt)$
   c) Accos(2πfct+ϕ0)$A\cos(2\pi fct+\phi 0)$
   d) Accos(2πfct+kpdm(t)dt)$A\cos(2\pi fct+kpdtdm(t))$
   Answer: a) Accos(2πfct+kpm(t))$A\cos(2\pi fct+kpm(t))$

4. **The modulation index in PM depends on .....**
   a) Carrier frequency only
   b) Modulating signal amplitude only
   c) Both amplitude and frequency of the modulating signal
   d) None of the above
   Answer: b) Modulating signal amplitude only

5. **PM is similar to Frequency Modulation (FM) when .....**
   a) The modulating signal is integrated before modulation
   b) The modulating signal is differentiated before modulation
   c) The carrier frequency is varied
   d) The phase deviation is zero
   Answer: b) The modulating signal is differentiated before modulation

6. **The bandwidth of a PM signal depends on.....**
   a) Only the carrier frequency

b) Only the modulating signal frequency
c) Both the modulation index and modulating frequency
d) None of the above
Answer: c) Both the modulation index and modulating frequency

7. **Carson's rule is used to estimate the bandwidth of .....**
   a) AM signals
   b) PM and FM signals
   c) PCM signals
   d) DSB-SC signals
   Answer: b) PM and FM signals

8. **For a PM signal with a sinusoidal modulating signal, the phase deviation is given by .....**
   a) Δϕ=kpAmΔϕ=$kpAm$
   b) Δϕ=kfAmΔϕ=$kfAm$
   c) Δϕ=kp/fmΔϕ=kp/fm
   d) Δϕ=kf/fmΔϕ=kf/fm
   Answer: a) Δϕ=kpAmΔϕ=$kpAm$

9. **The modulation index (β) in PM is defined as .....**
   a) β=Δϕβ=Δϕ
   b) β=Δf/fmβ=Δf/fm
   c) β=Δf·fmβ=Δ$f{\cdot}fm$
   d) β=kp/fmβ=kp/fm
   Answer: a) β=Δϕβ=Δϕ

10. **Compared to FM, PM is more susceptible to .....**
    a) Amplitude noise
    b) Phase noise
    c) Frequency drift
    d) All of the above
    Answer: b) Phase noise

SECTION B: SHORT ANSWER QUESTIONS

11. **Define Phase Modulation (PM).**
    Answer: PM is a modulation technique where the phase of the carrier signal varies in proportion to the instantaneous amplitude of the modulating signal while keeping frequency and amplitude constant.

12. **Write the mathematical expression of a PM wave.**
    Answer: s(t)=Accos(2πfct+kpm(t))$s(t)=A\cos(2\pi f_c t+k_p m(t))$

13. **What is the difference between PM and FM?**
    Answer: In PM, phase deviation is proportional to the modulating signal, whereas in FM, frequency deviation is proportional to the modulating signal.

14. **Explain the term "phase deviation" in PM.**
    Answer: Phase deviation (ΔϕΔϕ) is the maximum change in phase of the carrier due to modulation, given by Δϕ=kp·max|m(t)|Δϕ=kp·max|m(t)|.

15. **How does the bandwidth of a PM signal vary with modulation index?**
    Answer: Bandwidth increases with modulation index, following Carson's rule: BW≈2(β+1)fmBW≈2(β+1)fm.

16. **Why is PM considered a nonlinear modulation technique?**
    Answer: Because the modulated signal's frequency components are not simple linear translations of the baseband signal.

17. **What is the effect of increasing the modulating signal frequency in PM?**
    Answer: The bandwidth increases, but the phase deviation remains unchanged.

18. **Compare the noise immunity of PM and AM.**
    Answer: PM has better noise immunity than AM because it encodes information in phase variations rather than amplitude.

19. **What is the role of the phase modulator in a communication system?**
    Answer: It varies the carrier's phase in accordance with the modulating signal for transmission.

20. **List two applications of PM.**
    Answer:
    - Digital communication (e.g., BPSK, QPSK)
    - Wireless data transmission

SECTION C: NUMERICAL PROBLEMS

21. **A PM signal has kp=2 rad/Vkp=2rad/V and m(t)=3cos(2π×103t)m(t)=3cos(2π×103t). Find the phase deviation.**
    Solution:
    Δϕ=kp·Am=2×3=6 radΔϕ=kp·Am=2×3=6rad

22. **A PM signal has β=4β=4 and fm=1 kHzfm=1kHz. Estimate its bandwidth using Carson's rule.**
    Solution:
    BW≈2(β+1)fm=2(4+1)×1 kHz=10 kHzBW≈2(β+1)fm=2(4+1)×1kHz=10kHz

23. **Given s(t)=10cos(2π×106t+5sin(2π×103t))s(t)=10cos(2π×106t+5sin(2π×103t)), find ΔϕΔϕ.**
    Solution:
    Δϕ=5 radΔϕ=5rad

24. **If m(t)=2cos(2π×500t)m(t)=2cos(2π×500t) modulates a carrier with kp=1.5 rad/Vkp=1.5rad/V, find the instantaneous phase.**
    Solution:
    ϕ(t)=2πfct+kpm(t)=2πfct+3cos(2π×500t)ϕ(t)=2πfct+kpm(t)=2πfct+3cos(2π×500t)

25. **A PM signal has β=2β=2 and fc=100 MHzfc=100MHz. If fm=5 kHzfm=5kHz, find the frequency deviation.**
    Solution:
    Δf=β·fm=2×5 kHz=10 kHzΔf=β·fm=2×5kHz=10kHz

SECTION D: CONCEPTUAL QUESTIONS

26. **Explain how PM can be generated using a VCO (Voltage-Controlled Oscillator).**
    Answer: A VCO produces an output signal whose frequency depends on the input voltage. If the modulating signal is first integrated and then applied to the VCO, the output will be a PM signal.

27. **Compare PM and FM in terms of bandwidth efficiency.**
    Answer: FM generally has better bandwidth efficiency for high modulation indices, whereas PM requires more bandwidth for the same deviation.

28. **Why is demodulation of PM more complex than AM?**
    Answer: PM requires phase-sensitive detectors (e.g., PLLs) to recover the original signal, whereas AM can be demodulated using simple envelope detectors.

29. **Discuss the impact of noise on PM signals.**
    Answer: Noise affects PM by introducing random phase variations, leading to distortion. However, PM is less susceptible to amplitude noise compared to AM.

30. **How can PM be converted into FM and vice versa?**
    Answer:
    - **PM to FM:** Differentiate the modulating signal before phase modulation.
    - **FM to PM:** Integrate the modulating signal before frequency modulation.