ECE 321 – PRINCIPLES OF COMMUNICATIONS

CONTINUOUS ASSESSMENT TEST 1

Tuesday 2, December 2025

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1. In a matched impedance system, an amplifier produces an output voltage of 4 volts when the input voltage is 200mV. What is the voltage gain in dB?

◯ 20 dB

◯ 26 dB

◯ 6 dB

◯ 13 dB

The voltage ratio is 4/0.2 = 20. Using the formula $20log_{10}20$ ≈26 dB.

2. A receiver detects a signal power of -75dBm and the noise floor is measured at -95dBm. What is the Signal-to-Noise Ratio (SNR) in dB?

◯ 1.26 dB

◯ 170 dB

◯ 20 dB

◯ 20 dB

3. What is the maximum theoretical power efficiency of standard AM?

◯ %

◯ 33.3%

◯ 50%

◯ 66.7%

The efficiency of AM is calculated as:

$\eta = [\mu^2 / (2 + \mu^2)] \times 100\%$

Efficiency is maximized when μ = 1 (critical modulation):

$\eta_{max} = [1^2 / (2 + 1^2)] \times 100\% = (1/3) \times 100\% \approx 33.3\%$

This efficiency limit is due to the carrier component, which contains two-thirds of the total power but carries no information. The sidebands contain the actual information but only use one-third of the power at maximum modulation.

4. An AM transmitter produces a carrier signal of 500 kHz with an amplitude of 20V. It is modulated by a 5 kHz sinusoidal signal with a modulation index of 0.8. What is the amplitude of the lower sideband?

◯ 4V

◯ 6V

◯ 8V

- ◯ 10V

For an AM signal, the amplitude of each sideband is given by:

$A_{sb} = (m \times A_c) / 2$

Where:

m = modulation index = 0.8

A_c = carrier amplitude = 20V

Substituting the values:

$A_{sb} = (0.8 \times 20) / 2 = 16 / 2 = 8V$

Both the upper and lower sidebands have the same amplitude of 8V. The carrier frequency (500 kHz) and modulating frequency (5 kHz) don't affect the amplitude calculation

5. A 1 MHz carrier is amplitude modulated by a 400 Hz sine wave, resulting in upper and lower sideband frequencies. If the AM signal is passed through a bandpass filter that only allows frequencies between 999.5 kHz and 1000.5 kHz, which components will be present at the output?

- ◯ Carrier only
- ◯ Carrier and lower sideband
- ◯ Carrier and upper sideband
- ◯ All components (carrier and both sidebands)

For an AM signal with carrier frequency f_c = 1 MHz = 1000 kHz and modulating frequency f_m = 400 Hz = 0.4 kHz:

Upper sideband (USB) frequency = $f_c + f_m$ = 1000 + 0.4 = 1000.4 kHz

Lower sideband (LSB) frequency = f_c - fm = 1000 - 0.4 = 999.6 kHz

The bandpass filter allows frequencies between 999.5 kHz and 1000.5 kHz.

Comparing frequencies:

• Carrier: 1000 kHz (within passband)

• USB: 1000.4 kHz (within passband)

• LSB: 999.6 kHz (within passband)

All three components fall within the filter's passband, so all will be present at the output.

6. An FM signal has a carrier frequency of 100 MHz and is modulated by a sinusoidal signal of 5 kHz. The frequency deviation is 75 kHz. What is the modulation index (β) of this FM signal?

- ◯ 0.067
- ◯ 1.33
- ◯ 15
- ◯ 0.75

The modulation index (β) for FM is calculated as:

$\beta = \Delta f / f_m$

where Δf is the frequency deviation (75 kHz) and f_m is the modulating frequency (5 kHz).

β = 75 kHz / 5 kHz = 15

The carrier frequency (100 MHz) is not needed for this calculation

7. An FM broadcast transmitter operates with a peak frequency deviation of 75 kHz and a maximum modulating frequency of 15 kHz. Using Carson's rule, what is the approximate bandwidth required for this FM signal?

- ◯ 90 kHz
- ◯ 150 kHz
- ◯ 180 kHz
- ◯ 210 kHz

Carson's rule provides an estimate for FM bandwidth:

$$BW \approx 2(\Delta f + f_m)$$

where Δf is the peak frequency deviation (75 kHz) and f_m is the maximum modulating frequency (15 kHz).

$$BW \approx 2(75 \text{ kHz} + 15 \text{ kHz}) = 2(90 \text{ kHz}) = 180 \text{ kHz}$$

For commercial FM broadcasting, the bandwidth is typically 200 kHz, which aligns with this calculation.

8. A 10 MHz carrier is frequency modulated by a sinusoidal signal of 2 kHz, producing a frequency deviation of 10 kHz. What is the bandwidth occupied by the significant sidebands (using the universal curve or Bessel functions approach for β = 5)?

- ◯ 4 kHz
- ◯ 20 kHz
- ◯ 24 kHz
- ◯ 40 kHz

First, calculate the modulation index:

$$\beta = \Delta f / f_m = 10 \text{ kHz} / 2 \text{ kHz} = 5$$

For β = 5, Bessel functions show significant sidebands up to approximately $n = \beta + 1 = 6$ pairs of sidebands. The bandwidth can be calculated as:

$$BW \approx 2 \times n \times f_m \approx 2 \times 6 \times 2 \text{ kHz} = 24 \text{ kHz}$$

However, for higher β values, a more accurate approach using the universal curve gives:

$$BW \approx 2(\Delta f + f_m) = 2(10 \text{ kHz} + 2 \text{ kHz}) = 24 \text{ kHz}$$

But wait, for β = 5, the actual number of significant sidebands (from Bessel tables) is about 8 (n=8), giving:

$$BW \approx 2 \times 8 \times 2 \text{ kHz} = 32 \text{ kHz}$$

The most accurate answer among options is 40 kHz, which accounts for more sidebands.

9(1) The bandwidth of a QAM signal is ....

- ◯ Twice the bandwidth of the baseband signal
- ◯ The same as the bandwidth of the baseband signal
- ◯ Half the bandwidth of the baseband signal
- ◯ Four times the bandwidth of the baseband signal

The same as the bandwidth of the baseband signal (for analog QAM, the bandwidth is the same as the baseband because both signals are transmitted in the same bandwidth by using quadrature carriers).

9(2) Which of the following is an advantage of using QAM?

- ◯ It requires less bandwidth than single-sideband modulation
- ◯ It allows two independent signals to be transmitted over the same frequency band
- ◯ It is simpler to implement than amplitude modulation
- ◯ It is less susceptible to noise than frequency modulation

10. An FM system has a modulation index of 5 when the modulating frequency is 5 kHz. If the modulating frequency is increased to 10 kHz while keeping the deviation constant, what is the new modulation index and approximate bandwidth (using Carson's rule)?

- ◯ β = 2.5, BW = 30 kHz
- ◯ β = 5, BW = 60 kHz
- ◯ β = 2.5, BW = 70 kHz
- ◯ β = 10, BW = 120 kHz

First, find the frequency deviation from the initial condition:

$$\beta_1 = \Delta f / f_{m1} = 5$$

$$\Delta f = \beta_1 \times f_{m1} = 5 \times 5 \text{ kHz} = 25 \text{ kHz}$$

The deviation remains constant at 25 kHz. The new modulation index with f_{m2} = 10 kHz is:

$$\beta_2 = \Delta f / f_{m2} = 25 \text{ kHz} / 10 \text{ kHz} = 2.5$$

Using Carson's rule for the new bandwidth:

$$BW \approx 2(\Delta f + f_{m2}) = 2(25 \text{ kHz} + 10 \text{ kHz}) = 2(35 \text{ kHz}) = 70 \text{ kHz}$$

So the new modulation index is 2.5 and the approximate bandwidth is 70 kHz.

11. An AM signal has total power of 1500 W with 80% modulation. If converted to SSB with the same modulation, what would be the approximate power saving?

- ◯ 83.3%

◯ 66.7%

◯ 50%

◯ 33.3%

$P_{total} = P_{carrier} + P_{sidebands} = P_c (1 + m^2/2)$

We know P_{total} = 1500 W, so:

$1500 = P_c (1 + 0.8^2/2) = P_c (1 + 0.32) = 1.32 P_c$

$P_c = 1500 / 1.32 \approx 1136.36$ W

The sideband power is:

$P_{sidebands} = P_{total} - P_c = 1500 - 1136.36 \approx 363.64$ W

12. Why does a mono FM receiver (which only decodes the 0-15 kHz (L+R) signal) typically have a better signal-to-noise ratio (SNR) for the same received RF signal strength compared to a stereo receiver decoding full L & R channels?

◯ The mono receiver uses a narrower IF bandwidth, rejecting more noise.

◯ In stereo, the (L-R) information is transmitted via a DSB-SC AM subcarrier, which is more susceptible to noise than the (L+R) FM signal. The de-emphasis filter also has less effect on the higher frequency noise in the (L-R) band.

◯ The 19 kHz pilot tone interferes with the audio in stereo mode.

◯ Stereo receivers have inferior RF amplifier stages.

The (L+R) signal benefits from FM's inherent noise suppression. The (L-R) signal, however, is encoded as AM on the 38 kHz subcarrier, which has no such noise advantage. During demodulation, the 23-53 kHz band containing the (L-R) DSB-SC signal is more affected by high-frequency noise, and the standard 75 μs de-emphasis applied to the final audio does little to attenuate the noise folded down from this higher baseband frequency range. This results in a ~22 dB worse SNR in stereo mode, which is why stations often boost modulation on stereo material.

13. For a television system with 525 total lines per frame, 40 lines lost during vertical retrace, and a frame rate of 30 Hz, what is the approximate horizontal line frequency?

◯ 15.75 kHz

◯ 31.5 kHz

◯ 45.5 kHz

◯ 7.8 kHz

Active lines per frame = Total lines − Lost lines = 525 − 40 = 485 lines (Note: This detail is sometimes given, but the horizontal frequency is based on **total lines**).

Horizontal line frequency = Total lines per frame × Frame rate
= 525 lines × 30 frames/s = 15,750 Hz = 15.75 kHz.

The lost lines are part of the total line count; they occur during vertical blanking and are included in the line frequency calculation.

14: In a 2:1 interlaced scanning system with a frame rate of 30 Hz and 600 total lines per frame, how many complete frames are displayed per second, and how many fields per second?

- ◯ 30 frames, 30 fields
- ◯ 30 frames, 60 fields
- ◯ 60 frames, 60 fields
- ◯ 15 frames, 30 fields

> 2:1 interlaced: Two fields per frame.
>
> Frame rate = 30 Hz → 30 frames/sec.
>
> Field rate = 2 × frame rate = 60 fields/sec.

15. Which photometric unit measures luminous flux per unit area?

- ◯ Candela
- ◯ Lumen
- ◯ Lux
- ◯ Foot-candle

> Lux is the SI unit of illuminance, measuring luminous flux per unit area. One lux is equal to one lumen per square meter. This unit quantifies how much luminous flux is spread over a given surface area.

16. In a telephone exchange, an average call lasts 3 minutes, and the exchange handles 200 calls during the busiest hour. What is the traffic intensity in Erlangs?

- ◯ 10 Erlangs
- ◯ 600 Erlangs
- ◯ 3.33 Erlangs
- ◯ 200 Erlangs

> Traffic intensity in Erlangs is calculated as:
>
> $A = (\lambda \times h) / 3600$
>
> Where:
> λ = number of calls in the busy hour = 200 calls/hour
> h = average call holding time in seconds = 3 minutes × 60 = 180 seconds
>
> Therefore:
> $A = (200 \times 180) / 3600 = 36{,}000 / 3600 = 10$ Erlangs
>
> An Erlang represents one continuous circuit occupied for one hour. So 10 Erlangs means an average of 10 circuits are continuously occupied during the busy hour.