



UNIVERSITY OF ENERGY AND NATURAL RESOURCES, SUNYANI

SCHOOL OF ENGINEERING

DEPARTMENT OF COMPUTER AND ELECTRICAL ENGINEERING

LEVEL 300, END OF FIRST SEMESTER EXAMINATION, 2018/2019

Bachelor of Science (Electrical and Electronics Engineering)

ELNG 307: Analog and Digital Communications

December, 2018

Time: 2 Hrs : 45 Mins

**Materials required:** Non-programmable calculator, pen, pencil, eraser, and ruler**Instructions:** Answer all questions in SECTION A and TWO (2) in SECTION B.**SECTION A – ANSWER ALL QUESTIONS.**

*Shade well the letter corresponding to the correct option on the Shading Answer Sheet provided. Any correct answer carries 0.5 marks.*

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| <p>1. The biggest disadvantage of PCM is ____ .</p> <ul style="list-style-type: none"> <li>A. Its inability to handle analog signals</li> <li>B. The high error rate which its quantizing noise introduces</li> <li>C. Its incompatibility with TDM</li> <li>D. The large bandwidths that are required for it</li> </ul> <p>2. Maximum allowable frequency swing in FM broadcasting is _____</p> <ul style="list-style-type: none"> <li>A. 10 kHz</li> <li>B. 15 kHz</li> <li>C. 25 kHz</li> <li>D. 75 kHz</li> </ul> <p>3. Which of these is not a characteristic of frequency modulated carrier?</p> <ul style="list-style-type: none"> <li>A. The higher the modulating amplitude, the greater is the amount of frequency shift away from the resting frequency</li> <li>B. The amplitude of the FM modulated carrier remains constant as the amplitude of the modulating source varies</li> <li>C. As the amplitude of the modulating source decreases, the frequency of the carrier decreases</li> <li>D. The amplitude of the carrier varies as the frequency of the modulating signal increases</li> </ul> <p>4. The peak difference between the modulated carrier and the frequency of the carrier is known as the _____</p> | <p>A. Frequency deviation<br/>B. Modulation index<br/>C. Modulation sensitivity factor<br/>D. None of the above</p> <p>A commercial FM broadcast station operates on a frequency of 97.1 MHz. On a modulation peak, the frequency increases to 97.13 MHz. (Question 5)</p> <p>5. Determine the frequency deviation</p> <ul style="list-style-type: none"> <li>A. +75 kHz</li> <li>B. +30 kHz</li> <li>C. +15 kHz</li> <li>D. -200 kHz</li> </ul> <p>6. The Hartley Shannon theorem sets a limit on the _____.</p> <ul style="list-style-type: none"> <li>A. Highest frequency that may be sent over a given channel</li> <li>B. Maximum capacity of a channel with a given noise level</li> <li>C. Maximum number of coding levels in a channel with a given noise level</li> <li>D. Maximum number of quantizing levels in a channel of a given bandwidth</li> </ul> <p>7. Determine the modulation index when a 97.1 MHz carrier frequency is modulated by a 10 kHz audio signal source. The frequency deviation produced is <math>\pm 40</math> kHz.</p> <ul style="list-style-type: none"> <li>A. 0.04</li> <li>B. 4</li> <li>C. 1</li> <li>D. 0.25</li> </ul> |
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8. The sidebands generated in FM are spaced on both sides of the carrier at frequency intervals equal to the \_\_\_\_\_  
 A. Modulating frequency and its multiples  
 B. Twice the highest frequency in the modulating signal  
 C. Frequency of the modulating signal  
 D. None of the above
9. The modulation system that only affects the amplitude of the carrier signal is termed \_\_\_\_\_  
 A. Pulse modulation  
 B. Minimum shift keying  
 C. Linear modulation  
 D. Exponential modulation
10. \_\_\_\_\_ is that when any signal is multiplied by a sinusoidal signal of frequency  $f_c$ , the resulting signal has a spectrum like the original, but translated out to frequency  $\pm f_c$ .  
 A. Frequency translation  
 B. Fourier transformation  
 C. Multiplexing  
 D. Signal modulation
11. The recovery of baseband signal from transmitted signal is \_\_\_\_\_  
 A. Demultiplexing  
 B. Passband multiplexing  
 C. Demodulation  
 D. Translation
12. Which of the following is the odd one out in the choice of modulation techniques used in communication system?  
 A. The amount of bandwidth allocated  
 B. Channel characteristics  
 C. Effective Radiated Power (ERP) of the antenna  
 D. Types of noise and/or interference the signal will encounter during transmission
13. Which of the following fundamental parameter(s) control(s) the rate and quality of information transmission?  
 A. Distortion and interference due to non-ideal nature of the channel  
 B. The channel bandwidth  $B$  and the signal power  $S$ .

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- C. The type of modulation techniques used  
 D. The receiver effectively synchronizing with the transmitter
14. If a signal  $x(t)$  with amplitude  $A$ , is such that the condition below is true, then the signal is best described as \_\_\_\_\_  
 $0 < E_x < \infty; P = 0; V_p \rightarrow 0$  as  $|t| \rightarrow \infty$   
 A. Power type  
 B. Energy type  
 C. Discrete type  
 D. Random type
15. In digital communication, the block responsible to convert the information source to a binary form is \_\_\_\_\_.  
 A. Channel encoder  
 B. Digital modulator  
 C. Source encoder  
 D. Channel decoder
16. Carrier phase reversal occurs \_\_\_\_\_  
 A. For all  $t$ ,  $|1 + k_a m(t)| > 1$  and whenever  $1 + k_a m(t)$  crosses the time axis.  
 B. For all  $t$ ,  $|k_a m(t)| > 1$  and whenever  $k_a m(t)$  crosses the time axis.  
 C. For all  $t$ ,  $1 < |1 + k_a m(t)| < \mu$  and whenever  $1 + k_a m(t)$  crosses the time axis.  
 D. For all  $t$ ,  $|k_a m(t)| > 1$  and whenever  $1 + k_a m(t)$  crosses the time axis.
17. Distortion caused by over-modulation produces \_\_\_\_\_  
 A. Inter-symbol interference  
 B. Channel interference  
 C. Attenuation  
 D. None of the above
18. To effectively detect the envelope of an DSB-SC wave one of the conditions below should be satisfied.  
 A.  $A_c \ll A_m$   
 B.  $f_c \approx f_m$  and  $\phi_c = 0$   
 C.  $f_m \gg f_c$   
 D.  $W \ll f_c$

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19. Digital signals \_\_\_\_\_.  
A. Do not provide a continuous set of values  
B. Present values as discrete steps  
C. Can utilize decimal or binary systems  
D. All of the above
20. The frequency spectrum of an *DSB-FC* contains the following except  
A. A component at  $f_c$   
B. Sidebands at  $f_c + f_m$  and  $f_c - f_m$   
C. Sidebands at  $f_c \pm nf_m$ ;  $n = 1, 2, \dots$   
D. A and C
21. When FM carrier is modulated, the frequency of the carrier varies by an amount that is proportional to \_\_\_\_\_ at a rate determined by the modulation frequency  
A. Frequency of the modulating waveform  
B. Amplitude of the modulating waveform  
C. Frequency of the carrier waveform  
D. Amplitude and deviation of the modulating waveform
22. The percentage of the total power of the modulated signal that conveys information is called \_\_\_\_\_  
A. Power efficiency  
B. Percentage modulation  
C. Phase reversal factor  
D. Modulator's sensitivity factor
23. In linear modulation, the intelligent signal is conveyed in \_\_\_\_\_  
A. The amplitude of the transmitted signal  
B. The sideband components of the transmitted wave  
C. The phase deviation modulated signal  
D. None of the above
24. The output of DSB-SC received signal after LPF filtering is  $y_l(t) = \frac{1}{2} A_c m(t) \cos(\phi_c - \phi)$ . To effectively recover the intelligent signal, it is required that the receiver is in sync with the transmitter by employing the following except.
- A. Phase-locked loop (PLL)  
B. Discriminator circuit  
C. A pilot tone related to  $f_c$   
D. B and C
25. What communication technique or modulation scheme make use of channel noise as an added advantage?  
A. Asynchronous shift key modulation  
B. Vestigial sideband modulation  
C. Spread-spectrum  
D. Wideband Frequency modulation
26. Which of these is true about periodic signal based on Parseval's theorem?  
I. If a periodic signal is power signal, then, it means that every term of the Fourier series is also power signal as the original.  
II. The power of the signal is equal to the powers of its Fourier series.  
III. The total power of the signal is equal to the sum of the powers of the first term, and the second term squared of the Fourier series component for all even functions of the signal.  
IV. Fourier series of the signal is mutually orthogonal  
A. I only  
B. All except II and IV  
C. All except III  
D. II, III, and IV
27. In \_\_\_\_\_ the amplitude and power of non-linear modulated signal do not change with modulation scheme used.  
A. Angle modulation  
B. Linear modulation  
C. Quadrature modulation  
D. None of the above
28. Which of these analog modulation schemes trade bandwidth for noise immunity?  
A. Vestigial sideband modulation  
B. Single sideband full carrier modulation  
C. Wideband FM modulation  
D. Old short-wave (SW) modulation

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29. Narrowband FM and AM share a lot of similarities except that _____	34. Sampling that defies Nyquist criterion leads to _____
A. The lower side frequencies are $180^\circ$ out of phase. B. The upper side frequencies are $180^\circ$ out of phase. C. The sideband frequencies are $180^\circ$ out of phase. D. None of the above	A. Aliasing B. Band splatter C. Splatter D. Over-modulation
30. An FM signal can be generated from a PM modulator by including _____	35. Which modulation scheme maintains fixed amplitude and width?
A. A differentiator before the PM modulator B. A differentiator after the PM modulator C. An Integrator before the PM modulator  D. An Integrator after the PM modulator	A. Pulse phase modulation B. Pulse width modulation C. Phase modulation D. Pulse position modulation
31. An intelligence signal is amplified by a 65% efficient amplifier before being combined with a 250W carrier to generate an AM signal. If it is desired to operate at 100% modulation, what must be the DC input power to the final intelligence signal's amplifier?	36. The difference between actual and coded value (midpoint) is referred to as the quantization error?
A. 384.6 W B. 192.3 W C. 162.5 W D. 83.3 W	A. Sampling error B. Transmission bit rate C. Resolution D. Quantization
For an AM DSB-FC wave with a peak unmodulated carrier voltage $V_c = 10$ V, frequency of 100kHz, a load resistor of $R_L = 10 \Omega$ , frequency of modulating signal of 10 kHz and $m = 1$ , determine the following (Question 32 and 33):	37. The unwanted phenomenon in telecommunication where the previous symbols have similar effect as noise resulting in less reliable communication is _____.
32. Total power of the modulated wave	A. Quantization error B. Synchronization error C. Self-synchronization D. Intersymbol interference
A. 5 W B. 1.25 W C. 7.5 W D. 2.5 W	38. A rectangular-pulse polar baseband signal is used to modulate an RF carrier in FSK. If the baseband signal has a data rate of 200 kbps and the two RF frequencies are 215 kHz apart, determine the bandwidth.
33. The percentage of power saved when DSB-SC is used	A. 350 kHz B. 830 kHz C. 615 kHz D. 700 kHz
A. 16.67 % B. 66.67 % C. 57.14 % D. 28.58 %	39. Indicate the <i>false</i> statement. The need for modulation can best be exemplified by the following.
	A. Antenna lengths will be approximately $A/4$ long B. An antenna in the standard broadcast AM band is 4876.8 m C. All sound is concentrated from 20 Hz to 20 kHz D. A message is composed of unpredictable variations in both amplitude and frequency

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40. For an FSK modulator with space, rest, and mark frequencies of 60, 70, and 80 MHz, respectively and an input bit rate of 20 Mbps. Determine the modulation index.
- 4.0
  - 3.5
  - 1.0
  - 0.5
41. The sum of three signals  $P_1, P_2$  and  $P_3$  with power levels given by 0 dBm, +3 dBm and -6 dBm is \_\_\_\_\_. *(Ans: 3.25 mW)*
- 3.25 mW
  - 57.29 dB
  - 11.79 dB
  - 5.12 dBm
42. In FM system, if the carrier is modulated above 100%, distortion and spurious sidebands \_\_\_\_\_. *(Ans: Affects the received signal)*
- Affects the received signal
  - Interfere with other adjacent channels even with guard band spacing of channels
  - Produces what is called sideband splatter
- Does not produce any adverse effect on the modulated signal

A commercial AM station is broadcasting with an average transmitted power of 10 kW. The modulation index is set at 0.707 for a sinusoidal message signal. Find the following (Question 43 and 44):

43. The average power in the carrier component of the transmitted power
- 55 kW
  - 7.4 kW
  - 8 kW
  - 12.5 kW
44. The transmission power efficiency
- 19.99 %
  - 20.00 %
  - 33.33 %
  - 41.42 %
45. In Linear Modulation technique, all operations performed on the signal are linear hence \_\_\_\_\_ is applicable.

- A. Peak frequency deviation  
 B. Phase modulation  
 C. Convolution  
 D. None of the above
46. Given a sine wave modulating signal, PM modulated wave appears to be frequency modulated by cosine modulating wave.
- True
  - False
47. \_\_\_\_\_ is obtained when the modulation index is larger as compared to one radian or  $\phi_c(t)$ .
- Vestigial Sideband
  - Distortion signal
  - Wideband FM
  - Diagonal clipping
48. A wideband angle-modulated wave spectrum consists of \_\_\_\_\_. *(Ans: Carrier component plus upper and lower sidebands only)*
- Carrier component plus upper and lower sidebands only
  - Carrier component plus upper sideband only
  - Carrier component plus an infinite number of sidebands
  - None of the above
49. In an Exponential modulation technique, the number of significant spectral components is a function of message amplitude.
- True
  - False
50. For a given FM system, the minimum bandwidth is greatest when the maximum \_\_\_\_\_ is produced by the maximum modulating signal frequency. *(Ans:  $n = \frac{\Delta f}{2\pi f_m}$ )*
- Frequency deviation
  - Modulation index
  - Deviation ratio
  - Transmission power
51. By definition, deviation ratio is the \_\_\_\_\_ modulation index and is equal to the maximum peak \_\_\_\_\_ divided by the maximum modulating signal frequency.
- Worst-case; modulation index
  - Worst-case; frequency deviation
  - Best-case; modulation index
  - Modulation index; worst-case

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52. \_\_\_\_\_ is the difference between the analog signal and the closest available digital value at each sampling instant from the A/D converter.
- A. Diagonal clipping
  - B. Distortion
  - C. Aliasing
  - D. Quantization error
53. A convenient way of recovering the original analog signal from a sampled version is by using \_\_\_\_\_.  
A. An Envelope detector  
B. A low pass filter (LPF)  
C. An Impulse sampler  
D. All the above
54. To avoid distortion in PAM, the sampling rate should be \_\_\_\_\_ the signal frequency.  
A. At least twice  
B. Half  
C. Same as  
D. None of the above
55. In data communication, \_\_\_\_\_ pertains to processes that require timing coordination to be successful, such as voice and digital video transmission.  
A. Isochronous  
B. Synchronous  
C. Asynchronous  
D. All the above
56. The superior performance of FM compared to AM in the presence of noise is due to \_\_\_\_\_.  
A. Constant amplitude in the modulated signal  
B. Modulation index of FM can be larger than unity  
C. Frequency dependent effect of noise in case of FM  
D. All of the above

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57. The usefulness of pre-emphasis and deemphasis is to improve the performance of modulation system in the presence of noise by
- A. Emphasizing high frequency amplitude values of modulating signal
  - B. Emphasizing low frequency amplitude values of modulating signal
  - C. Emphasizing carrier frequency amplitude values
  - D. Emphasizing carrier frequency itself
58. Quantizing noise occurs in \_\_\_\_\_.  
A. Time division multiplex  
B. Frequency division multiplex  
C. Pulse code modulation  
D. Pulse width modulation
59. Indicate which of the following pulse modulation system analog.  
A. PCM  
B. Differential PCM  
C. PWM  
D. Delta
60. The Shannon Hartley Law \_\_\_\_\_.  
A. Refers to distortion  
B. Defines bandwidth  
C. Describes signaling rates  
D. Refers to noise
61. In a communications system, noise is most likely to affect the signal \_\_\_\_\_.  
A. At the transmitter  
B. In the channel  
C. In the information source  
D. All of the above
62. At the destination Under sampling causes \_\_\_\_\_.  
A. Interference  
B. Intersymbol interference  
C. Aliasing  
D. All of the above

(f<sub>out</sub> + f<sub>c</sub>)

**QUESTION ONE [15 MARKS]**

- A. Draw a block diagram of a typical digital communication system. Briefly explain what any three block does in the communication process. [4 marks]
- B. An ordinary AM modulated wave with an output wave that changes by  $\pm 7.5$  V is represented by the following equation

$$s(t) = 20 \sin(2\pi 500 \times 10^3 t) - 3.75 \cos(2\pi 510 \times 10^3 t) + 3.75 \cos(2\pi 490 \times 10^3 t)$$

Based on the information given,

$\times f_m$

$$\mu = \frac{A_m}{A_c}$$

$f_c - f_L = 10$

- Determine the modulation index,  $m$  and percent modulation. [1 mark]
- Determine the peak amplitude of the modulated carrier, upper and lower side frequency voltages. [2 marks]
- Determine the maximum and minimum amplitude of the envelope. [2 marks]
- Sketch and label the output envelope. [2 marks]

- C. A single-toned message of 25 kHz is frequency modulated onto a carrier of 75 kHz. The peak frequency deviation is set to be 10 kHz. What is the modulated index of the FM signal thus obtained?

- Write the time-domain expression for the FM signal in (a).  $\beta = \frac{\Delta f}{f_m}$  [1 mark]
- What is the peak phase deviation? [1 mark]
- What is the approximate bandwidth of the FM signal? [1 mark]

$$f_m = 25 \text{ Hz}$$

$$f_c = 75 \text{ Hz}$$

$$\Delta f = 10 \text{ KHz}$$

$$A_c (s \cdot t (\cos \omega_m t + \frac{\Delta f}{\omega_m} (\sin \omega_m t)))$$

**QUESTION TWO [15 MARKS]**

- A. A single toned message,  $m(t) = 4 \sin(2\pi \times 100t)$ , where time measured in seconds, is amplitude modulated onto a carrier  $c(t) = 20 \cos(\omega_c t)$ . The carrier frequency is  $f_c = 15$  kHz.

- Sketch a diagram of a scheme to achieve this DSB-FC modulation. Include numerical values for any gains used. [3 marks]
- What is the power in the modulated signal? [1 mark]
- The signal is to be demodulated using a Coherent detector. Sketch a block diagram showing a Coherent detector. [2 marks]

- B. A DSB-SC signal,  $s(t) = A_c m(t) \cos(\omega_c t)$ , with a message bandwidth of  $W$ , is transmitted over

AWGN channel with two-sided noise power spectral density of  $N_0/2$ .

- Write an expression for the transmitted power. [1 mark]
  - Derive an expression for the signal-to-noise ratio (SNR) on the channel. [2 marks]
  - What is AWGN channel? [1 mark]
- C. i) Briefly describe two methods that can be used to generate Wideband FM. [2 marks]
- ii) Explain with appropriate spectrum diagram(s) how VSB is generated from DSB-SC waveform. [3 marks]



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 $\Delta f_m$   
 $f_m$
  - A. Frequency deviation  
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