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Department of Electrical and Computer Engineering

Fall 2023 COMPREHENSIVE/BREADTH EXAM

Questions 2/3/4 TTG Area: Comm., Sig. Proc, Ctrls ECGR-4123: Analog and Digital Communications

Unless otherwise noted:
F{} denotes Fourier ; F^{-1}{} denotes inverse Fourier transform
ω denotes frequency in rad/second, f denotes frequency in Hz
$*$ denotes convolution and x*(t) denotes the conjugate of x(t)
$\Delta(t)$ denotes triangle function of width 1 and height 1 centered at t=0
u(t) is unit step

$$G(\omega) = \int_{-\infty}^{\infty} g(t) e^{-j\omega t} dt$$

$$g(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} G(\omega) e^{j\omega t} d\omega$$

***Circle* the Best Answer** **Show All Work Even For Multiple Choice**

1. To avoid aliasing, the signal g(t) = cos(1000πt) + sin(3000πt) should be sampled at a rate greater than

   a) 1 kHz b) 2 kHz c) 3 kHz d) 4 kHz e) none above

2. The dc response of a system with impulse response h(t)= 2δ(t-1) – δ(t-2) is $H(\omega)|_{\omega=0}$ =

   a) -1/2 b) 0 c) 1 d) 2 e) none above

3. The instantaneous frequency of cos(4 t^2) at t=3 is

   a) 6π rad/s b) 6 rad/s c) 24 rad/s d) 48 rad/s e) none above

4. The Fourier transform of x(t)= δ(t) - 3δ(t-3) is X(ω) =

   a) $\delta(\omega) - 2e^{-j3\omega}$ b) $1/(1 - 2\delta(\omega)e^{j3\omega})$ c) $1 - 3e^{-j3\omega}$ d) $\delta(\omega) - 2$ e)none above

5. A signal g(t) = 2 cos(ω_0 t) cos(ω_m t) with $\omega_0 = 10^6$ and $\omega_m = 10^3$ is best described as

   a) VSB b) SSB c) DSB-SC d) AM (DSB-LC)

6. The bandwidth of the signal g(t) = { cos(100π t) + sin(200π t) } cos(1000π t) is

   a) 25 Hz b) 50 Hz c) 100 Hz d) 200 Hz e) none above

Control Number:_____

7. The power of a signal g(t) with autocorrelation $R_g(\tau) = \Delta(\tau/5) + \Delta(\tau/2)$ is

   a) 2 b) 4 c) 7 d) 14 e) none above

8. If a full-scale sinusoid of 21 KHz is sampled by a 9-bit analog-to-digital-converter at a rate of 64,000 samples/second, the signal-to-quantization-noise ratio is:

   a) 49.8 dB b) 55.8 dB c) 61.8 dB d) 73.8 dB e) none above

9. Given a frequency modulated signal $g(t) = 5\cos(\omega_0 t + 5\cos(\omega_m t))$ with carrier frequency ω_o=1000 and modulation frequency ω_m=5, the bandwidth using Carson's rule is

   a) 5 rad/s b) 60 rad/s c) 120 rad/s d) 1005 rad/s e) none above

10. The bandwidth of QAM signal $g(t)= \cos(200\pi t)\sin(4000\pi t) + \cos(50\pi t)\cos(4000\pi t)$ is

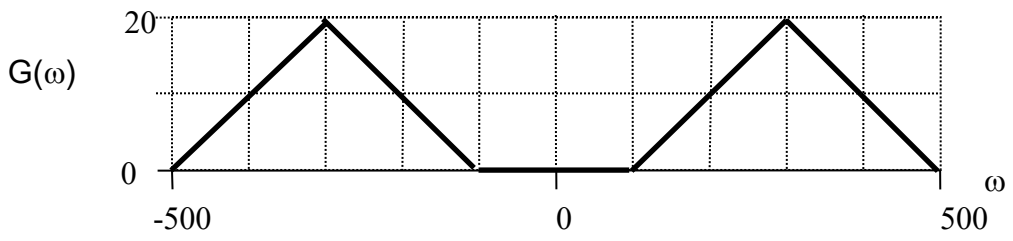
    a) 100 Hz b) 200 Hz c) 400 Hz d) 2100 Hz e) none above

11. For a DSB-SC signal with $g(t)= 8\cos(100\pi t)\sin(3000\pi t)$, the power P_g of the signal g(t) (assume a 1-ohm system) is

    a) 8 W b) 12 W c) 16 W d) 32 W e) none above

12. For the bandpass signal having Fourier transform $G(\omega)$ shown below, the 6 dB bandwidth is

    a) 100 rad/s b) 200 rad/s c) 400 rad/s d) 800 rad/s e) none above



Control Number:_____

13. The frequency modulated signal $g(t) = 50\cos(\omega_0 t + 4\cos(\omega_m t))$ with carrier frequency ω_o=100,000 and modulation frequency ω_m=5,000 is a wideband FM signal.

a) True b) False

14. Given a phase modulated signal $g(t) = 5\cos(\omega_0 t + 0.6\cos(\omega_m t))$ with carrier frequency ω_o=100,000 and modulation frequency ω_m=3, the peak phase deviation is

a) 0.2 rad b) 0.6 rad c) 2 rad d) 1.8 rad e) none above

15. A random voltage between -2 and 3 volts, with uniform distribution, has a mean voltage of

a) 0 b) 1 c) 2 d) 3 e) none above

16. The output of a system is $y(t) = x^3(t)$, where x(t) is the input. If $x(t)=3\cos(20\pi t) + \sin(40\pi t)$, then the highest frequency component of y(t) is

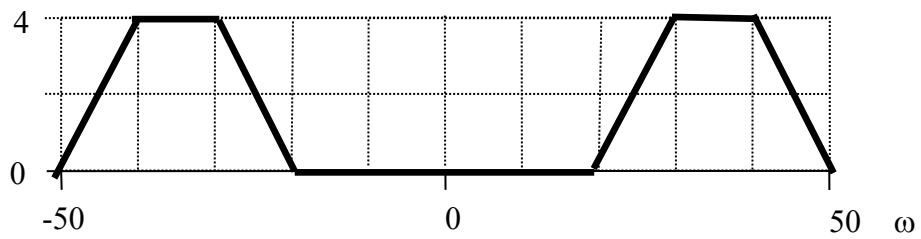
a) 20 Hz b) 40 Hz c) 60 Hz d) 80 Hz d) None above

17. The second ***central*** moment of a random voltage between -1 and 1 volts, with uniform distribution, is

a) $1/\sqrt{12}$ b) 1/12 c) 1/6 d) 1/3 e) none above

18. For signal having power spectral density $S_g(\omega)$ below, the signal power P_g =

a) $20/\pi$ b) $40/\pi$ c) $60/\pi$ d) $80/\pi$ e) none above



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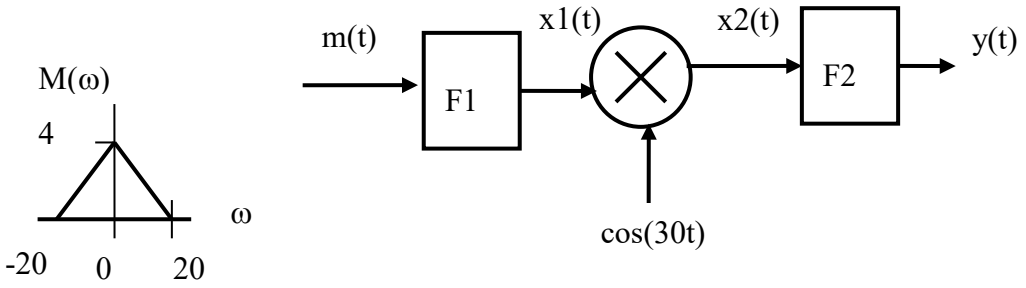
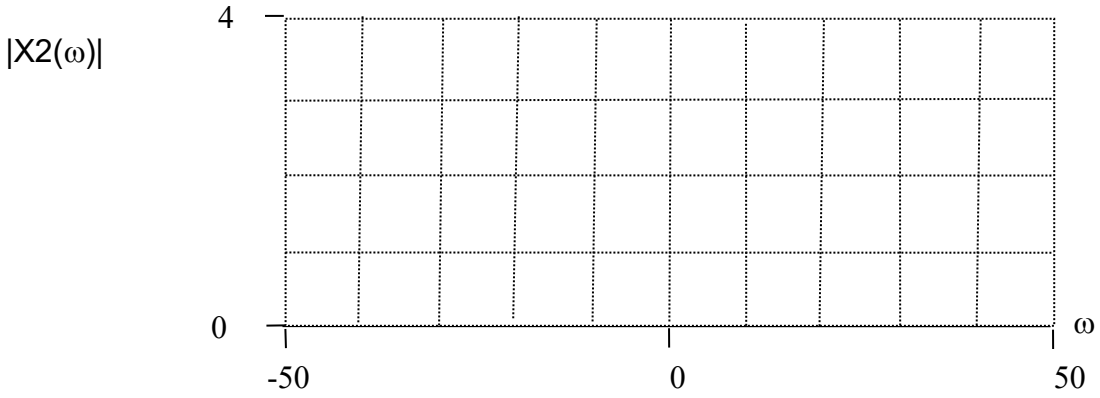


The following questions refer to the above modulator which has an ideal lowpass filter F1 with bandwidth 10 rad/s, and an ideal bandpass filter F2 with bandwidth 20 rad/s at a center frequency of 40 rad/s. The spectrum of m(t) is shown above.

19. Sketch the magnitude of the spectrum, $|X2(\omega)|$.



20. Sketch the magnitude of the output spectrum, $|Y(\omega)|$.