**XMUT310 Communication Engineering**

**Tutorial 2: Amplitude Modulation (AM)**

**Answers are provided for your convenience.**

**Most solutions can be found on Bilibili https://www.bilibili.com/video/BV1Yy4y1z79x and https://www.bilibili.com/video/BV12p4y167BP/ and https://www.bilibili.com/video/BV1kt4y1e7r3**

**Q1**. A modulating signal of frequency 5 kHz and peak voltage of 6 V is used to modulate a carrier of frequency 10 MHz and peak voltage of 10 V. Determine (a) Modulation index, (b) Frequency of LSB and USM, (c) Amplitude of LSB and USB.

(Answers: (a) 60%, (b) 9.995 MHz and 10.005 MHz, (c) 3 V)

**Q2**. For am amplitude modulated wave, the maximum amplitude is found to be 10 V while the minimum amplitude is found to be 6 V. Determine the modulation index (%) and amplitude of original carrier frequency.

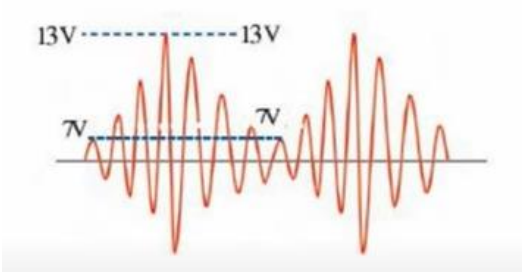
(Answers: 25%, 8V)

**Q3**. If the frequency of 3 kHz signal is to be transmitted through amplitude modulation, which of the following frequency should be used as a carrier frequency?

a. 30 Hz
b. 300 Hz
c. 3000 Hz
d. 3 MHz

(Answer: d)

**Q4**. What will be the modulation index of the following AM wave?




a. 6%
b. 20%
c. 30%
d. 50%

(Answer: c)

**Q5**. A carrier wave of 2 MHz is amplitude modulated by a modulating wave of 2 kHz. Which of the following frequencies will be present in the AM wave?

a. 2 MHz, 2 kHz
b. 2 kHz, 2.002 MHz, 1.998 MHz

c. 2 MHz, 2.002 MHz, 1.998 MHz
d. 2.002 MHz, 1.998 MHz

(Answer: c)

**Q6**. The maximum amplitude of carrier wave is 12 V. What should be the amplitude of modulating signal in order to have a modulation index of 75%?

(Answer: 9 V)

**Q7**. The equation of AM wave is given as $x(t) = 100(1 + 0.6\sin 6280t)\sin(2\pi \times 10^6 t)$. Calculate (a) modulation index, (b) frequency of carrier wave, (c) frequency of modulating wave, (d) frequency of LSB and USB.

(Answers: (a) 60%, (b) 1MHz, (c) 1 kHz, (d) 0.999 MHz and 1.001 MHz)

**Q8**. Find the total modulated power, side power and net modulation index for the AM signal expressed in volts, $y(t) = 10\cos(2\pi \times 10^6 t) + 5\cos(2\pi \times 10^6 t)\cos(2\pi \times 10^3 t) + 2\cos(2\pi \times 10^6 t)\cos(4\pi \times 10^3 t)$.

(Answer: total power = 57.2 5 W, side power = 7.25 W, modulation index = 53.9%)

**Q9**. An amplitude modulated amplifier has radio frequency output of 50 W at 100% modulation index with internal loss in modulator of 10 W.

a. What is the unwanted carrier power?
b. What power output is required from the sideband (baseband signal)?
c. If the percentage modulation is reduced to 75%, how much output is needed from the sideband (baseband signal), assuming that the total transmitted power remains the same?

(Answers: (a) 40 W, (b) 20 W, (c) 13.18 W)

**Q10**. The modulation index of an AM wave is changed from 0 to 1. The transmitted power is

a. Unchanged
b. Halved
c. Increased by 50%
d. Quadrupled

(Answer: c)

**Q11**. An AM wave is given by $y(t) = 10[1 + 0.4\cos(10^3 t) + 0.3\cos(10^4 t)]\cos(2\pi \times 10^6 t)$. The modulation index of the envelope is

a. 0.4
b. 0.5
c. 0.3
d. 0.9

(Answer: b)

**Q12**. The most suitable method for detecting a modulated signal $[2.5 + 5\cos(w_m t)]\cos(w_c t)$ is

a. Envelope detector
b. Synchronous detector
c. Radio detector
d. Both a and b

(Answer: b)

**Q13**. Prove that for an AM, the maximum average power transmitted by AM is 1.5 times the carrier power.

**Q14**. The antenna current of an AM broadcast transmitter, modulated to adepth of 40% by an audio sine wave is 11 amp. It increases to 12 amp as a result of simultaneous modulation by another audio sine wave. Find the modulation index due to this second sine wave.

(Answer: 64.3%)

**Q15**. Determine the efficiency and the percentage of the total power carried by sinusoids of AM wave for tone modulation when $\mu = 1$, 0.5 and 0.3.

(Answers: (a) when $\mu = 1$, efficiency and side power = 33.33%, (b) when $\mu = 0.5$, 11.11%, (c) when $\mu = 0.3$, 4.3%)

**Q16**. Calculate the percentage of power saving by DSB-SC for a modulating index of (a) 100% (b) 50%.

(Answers: (a) 66.67%, (b) 88.88%)

**Q17**. Calculate the percentage of power saving by SSB for a modulating index of (a) 100% (b) 50%.

(Answers: (a) 83.33%, (b) 94.44%)

**Q18**. A message signal $m(t)= \cos 2000\pi t + 4\cos 4000\pi t$ modulates the carrier $c(t) = \cos 2\pi f_c t$ where $f_c$ = 1 MHz to produce an AM signal. For demodulating the generated AM signal using an envelope detector, the time constant RC of the detector circuit should satisfy

a. 0.5 ms < RC < 1 ms
b. 1 us < RC < 0.5 ms
c. RC < 1 us
d. RC > 0.5 ms

(Answer: b)

**Q19**. Suppose that the modulating signal is $m(t) = 2\cos(2\pi f_m t)$ and the carrier signal is $x_c(t) = A_c\cos(2\pi f_c t)$, which one of the following is a conventional AM signal <u>without</u> over-modulation?

a. $x(t) = A_c m(t)\cos(2\pi f_c t)$
b. $x(t) = A_c[1 + m(t)]\cos(2\pi f_c t)$
c. $x(t) = A_c\cos(2\pi f_c t) + A_c/4 m(t)\cos(2\pi f_c t)$
d. $x(t) = A_c\cos(2\pi f_c t)\cos(2\pi f_m t) + A_c\sin(2\pi f_c t)\sin(2\pi f_m t)$

(Answer: c)

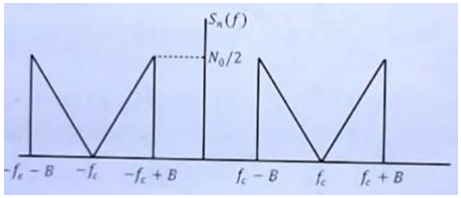
**Q20**. Consider the following AM signal shown here, where $f_m < B$, $x_{AM}(t) = 10(1 + 0.5\sin 2\pi f_m t)\cos 2\pi f_c t$. The average side-band power in W for the AM signal given above is

a. 25

b. 12.5
c. 6.25
d. 3.125

(Answer: c)

**Q21**. The AM signal in Q20 gets added to a noise with power spectral density So(f) given in the figure below. The ratio of average sideband power to mean noise power would be:




a. $25/8N_oB$
b. $25/4N_oB$
c. $25/2N_oB$
d. $25/N_oB$

(Answer: b)

**Q22**. A 1 MHz sinusoid carrier is amplitude modulated by a symmetrical square wave of period 100 usec. Which of the following frequencies will NOT be present in the modulated signal?

a. 900 kHz
b. 1010 kHz
c. 1020 kHz
d. 1030 kHz

(Answer: c)

**Q23**. For a message $m(t)= \cos(2\pi f_m t)$ and carrier of frequency $f_c$ , which of the following represents a single-sideband (SSB) signal?

a. $\cos(2\pi f_m t)\cos(2\pi f_c t)$
b. $\cos(2\pi f_c t)$
c. $\cos[2\pi(f_c+f_m)t]$
d. $[1 + \cos(2\pi f_m t)]\cos(2\pi f_c t)$

(Answer: c)

**Q24**. A message signal given by $m(t) = ½ \cos w_1 t - ½ \sin w_2 t$ is amplitude-modulated with a carrier of frequency $w_c$ to generate $s(t) = [1 + m(t)]\cos w_c t$. What is the power efficiency achieved by this modulation scheme?

a. 8.33%
b. 11.11%
c. 20%
d. 25%

(Answer: c)

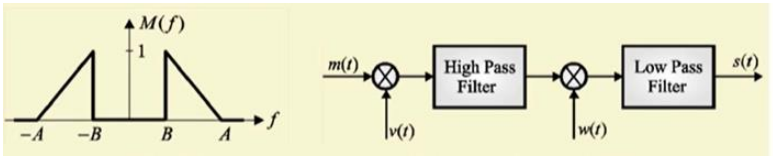
**Q25**. A carrier signal $c(t) = 20 \cos 2\pi 10^6 t$ is modulated by a message signal $m(t) = 20 \cos 8\pi 10^3 t$ to generate DSB-SC, calculate the bandwidth, total power and modulation efficiency.

(Answers: bandwidth = 8 kHz, total power = 100 W, efficiency = 100%)

**Q26**. In a DSB-SC transmission system, if the modulation index is doubled, then the ratio of total sideband power to the carrier power increases by a factor of __?____

(Answer: 4)

**Q27**. In the figure here, M(f) is the Fourier Transform of the message signal m(t) where A = 100 Hz and B = 40 Hz. Given $v(t) = \cos(2\pi f_c t)$ and $w(t) = \cos[2\pi(f_c+A)t]$ where $f_c > A$. The cut-off frequencies of both filters are $f_c$. The bandwidth of the signal s(t) at the output of the modulator is ____ (Hz).




(Answer: 60 Hz)

**Q28**. Which of the following analog modulation scheme requires the minimum transmitted power and minimum channel bandwidth?

a. VSB
b. DSB-SC
c. SSB
d. AM

(Answer: c)

**Q29**. The Hilbert transform of $\cos w_1 t + \sin w_2 t$ is

a. $\sin w_1 t - \cos w_2 t$
b. $\sin w_1 t + \cos w_2 t$
c. $\cos w_1 t - \sin w_2 t$
d. $\sin w_1 t + \sin w_2 t$

(Answer: a)

**Q30**. The amplitude of a sinusoid carrier is modulated by a single sinusoid to obatin the amplitude modulated signal $s(t) = 5\cos 1600\pi t + 20\cos 1800\pi t + 5\cos 2000\pi t$. The value of the modulation index is _____.

(Answer: 0.5)