EEE206 2011-12 solutions

Q1

a.

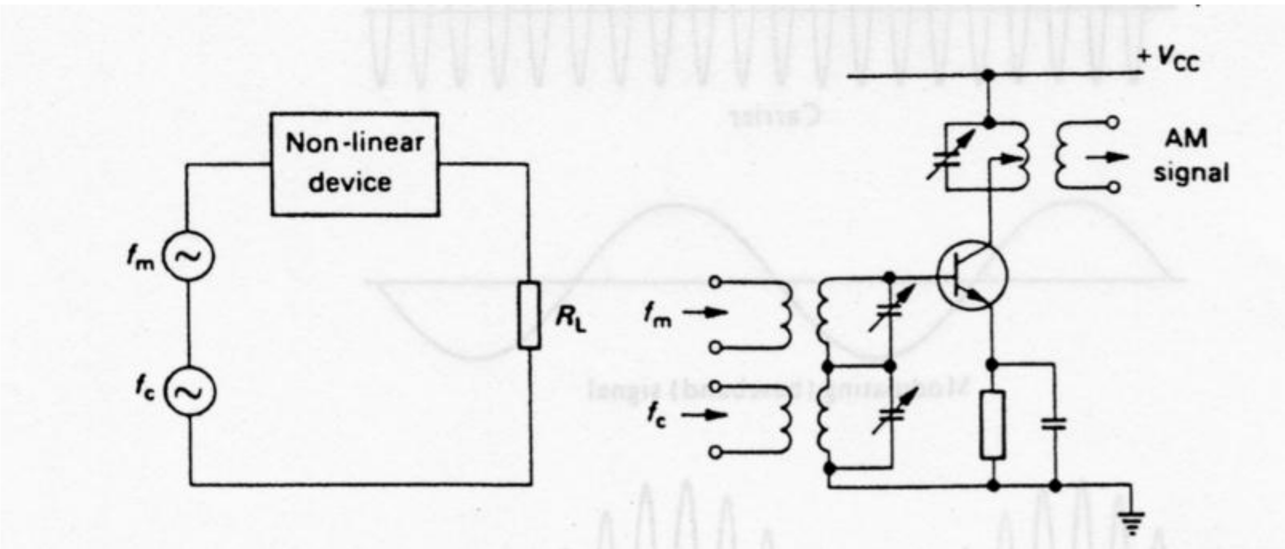
Answers should include any of the following (1 mark for each):-

- Improved S/N
- Efficient radiation due to antenna size
- Enables multiplexing
- Each user can be allocated a different channel

b. The proof below should be given showing that all the components of AMDSB are present

$$V_{AM} = Vc(1 + m\sin(\omega_m t))\sin(\omega_c t)$$
$$V_{AM} = Vc\sin(\omega_c t) + Vcm\sin(\omega_m t)\sin(\omega_c t)$$
$$\sin(\omega_m t)\sin(\omega_c t) = \frac{1}{2}\left(\cos((\omega_c - \omega_m)t - \cos((\omega_c + \omega_m)t)\right)$$
$$V_{AM} = Vc\sin(\omega_c t) + \frac{Vcm}{2}\left(\cos((\omega_c - \omega_m)t - \cos((\omega_c + \omega_m)t)\right)$$

c. Either of the below circuits will do or any other that the student devise as long as it is clear that AM DSB is the output



d.

Total signal is below

$2 + 3\cdot\sqrt{2}\cdot\sin(wc\cdot t) + 2\cdot\sqrt{2}\cdot\sin(wm\cdot t) + 1.8\sin(wc\cdot t)^2 + 2.4\sin(wc\cdot t)\cdot\sin(wm\cdot t) + .8\sin(wm\cdot t)^2$ (2 marks)

Hence the AMDSB signal is

$3\cdot\sqrt{2}\cdot\sin(wc\cdot t) + 2.4\sin(wc\cdot t)\cdot\sin(wm\cdot t)$

And the modulation index is

$\frac{2.4}{\left(3.\cdot\sqrt{2}\right)} = 0.566$ (1 mark)

Frequencies present are below

0Hz (0.5 marks)

3kHz (0.5 marks)

6kHz (0.5 marks)

2MHz (0.5 marks)

4MHz (0.5 marks)

1997kHz and 2003kHz (0.5 marks)

e. $mt = \sqrt{m_1^2 + m_2^2}$ (2 marks)

mt=sqrt(0.566^2 +0.3^2)=0.64 (2 marks)

Q2.

a. 1 mark for any of the following

In AM, the carrier amplitude is varied whereas in FM the carrier frequency is varied

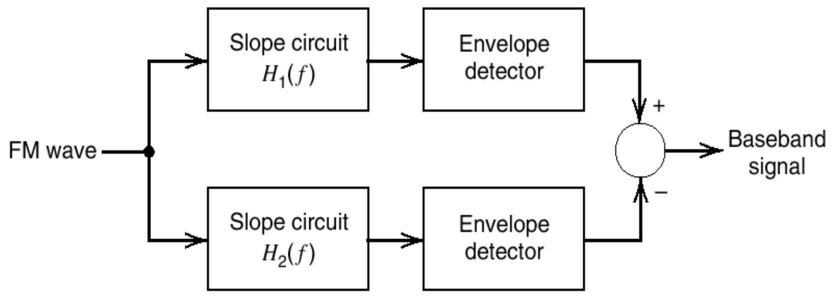
AM produces two sets of sidebands and is said to be a narrowband system. FM produces a large set of sidebands and is a broad band system

FM gives a better signal to noise ratio than AM under similar operating conditions

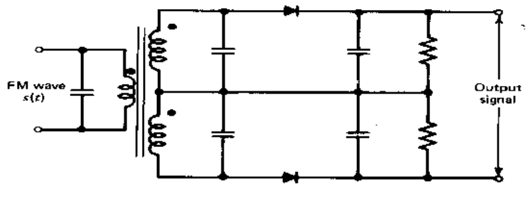
FM systems are more sophisticated and expensive than AM systems

In AM increase depth of modulation increases sideband power and hence total transmitted power. In FM total transmitted power remains constant, increase depth of modulation increases bandwidth

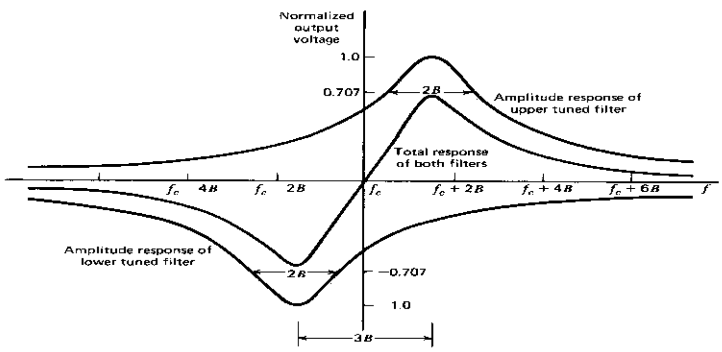
b. A *limiter* is often used to ensure the received signal is constant in amplitude before it enters the *discriminator* or *detector*. (2 marks)



(2 marks)



(b)



(c)

(3 marks) Do not need the detail included in the graph just the concept of a linear slope c.

Total average power is Pt=V^2/2R=100^2/(2*50**)=100W** (1 marks)

Modulation index is 3.7, hence J(0)=-0.399, J(1)=0.054 and J(2)=0.428

Power in carrier Pc=Pt*J(0)^2=100*(-0.399)^2**=15.9W** (2 marks)

Power in 1st sidebands P1=Pc*2*J(1)^2=100*2*0.054^2=**0.58W** (2 marks)

Power in 2nd sidebands P2=Pc*2*J(2)^2=100*2*0.428^2=**36.6W** (2 marks)

According to Carson's rule BW=2(dF+fm)

From the equation fm=127*10^3/2/pi=20.2kHz

Hence, dF=3.7*20.2k=75kHz

Hence, BW=2(75+20.2)=190.4kHz (3 marks)

Q3.

a. 2 marks to be awarded for each of the figures below, or equivalent figures/ descriptions. Important steps to show are PAM+saw tooth waveform, clipped by a reference level to form PWM and then falling edge creates PPM.

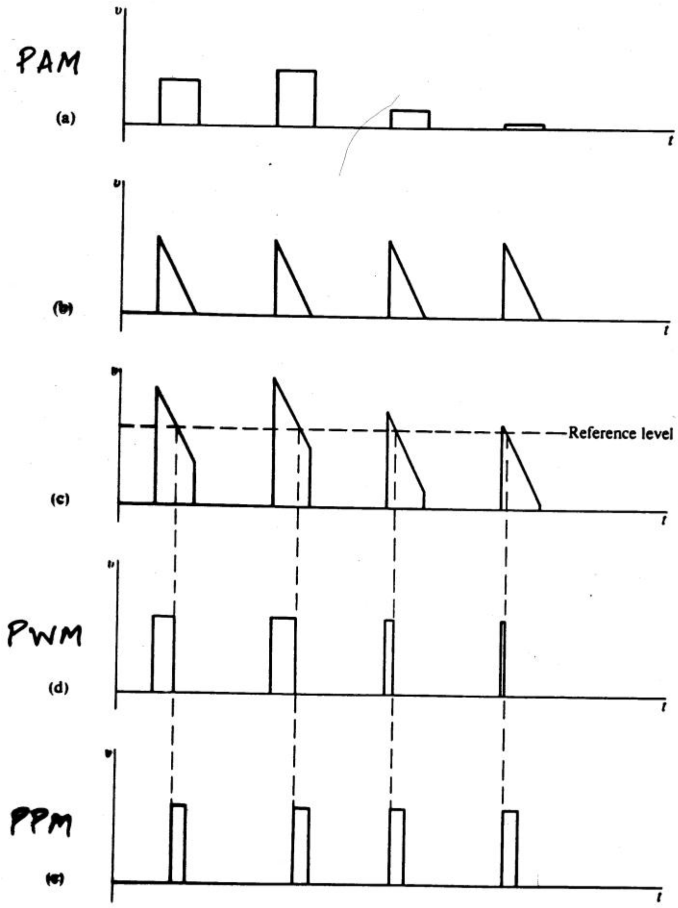


Fig. 3.4 Production of p.w.m. and p.p.m. signals: (a) p.a.m. signal; (b) periodic ramp; (c) sum of p.a.m. signal and ramp; (d) p.w.m. signal; (e) p.p.m. signal.

b.

Number of pixels = 1920*1080 =2073600 (1 mark)

Number of bits per pixel = 10*3 = 30 (1 mark)

Number of bits per frame = 2073600*30 =62208000 (1 mark)

Bit rate = 62208000*24 = 1.48Gbits/s (1 mark)

$$C = B\log_2\left(1+S/N\right)$$

$$B = \frac{C}{\log_2\left(1+S/N\right)} = \frac{1.48*10^9}{\log_2(1+1000)} = \frac{1.48*10^9}{9.97} = 149MHz$$ (2 marks)

c.

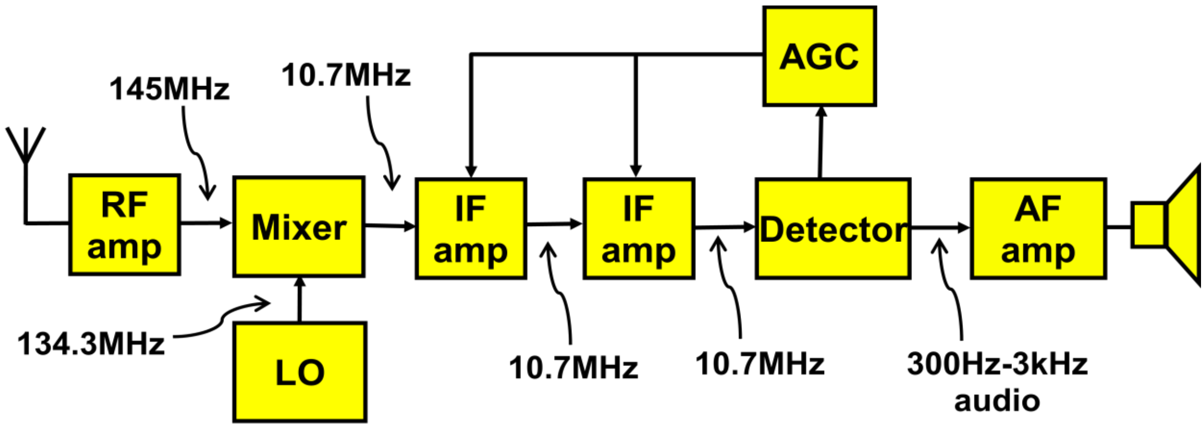
Clearly these bit rates are not achievable using standard download rates. (1 mark)

Methods to reduce bit rate are (Up to 3 marks maximum are given for any of the below):-

- Reduce HDTV spec i.e. use 720i/720p (1 mark)
- Reduce the frame rate (1 mark)
- Use compression (1 mark)
- Reduce bits per colour (1 mark)

4.

a. A diagram similar to that below will attract full marks



2 marks for the RF amp and mixer/LO.

2 marks for IF amp/detector with AGC and AF amp

2 marks for illustrating that LO changes the frequency of the RF to a lower frequency.

b.

$f_{LO1}>f_{sig}$ hence, f_{LO1}-950=70

f_{LO1}=1020MHz

$f_{image\ 1}$=70+1020=1090MHz **(2 marks)**

f_{LO2}<70MHz, hence 70- f_{LO2}=10

f_{LO2}= 60MHz

$f_{image\ 2}$= 60-10 = 50MHz **(2 marks)**

Signals entering mixer 1, which can interfere with IF2 are:-

$f_{image\ 3}$-f_{LO1}=50 and f_{LO1}- $f_{image\ 4}$ =50

$f_{image\ 3}$ =1070MHz

$f_{image\ 4}$ =970MHz **(3 marks)**

c.

$$\text{IFRR} = \sqrt{1 + Q^2x^2}$$

$$x = \frac{f_{image}}{f_{sig}} - \frac{f_{sig}}{f_{image}}$$

Important image frequencies are the ones from the antenna end only, hence 1090, 1070 and 970MHz are important.

x1=1.147-0.872=0.275 (1 mark)

x2=1.126-0.888=0.238 (1 mark)

x3=1.021-0.979=0.042 (1 mark)

IFRR1=$\sqrt{1 + Q^2x^2} = \sqrt{1 + 30^2 0.275^2 =} \; 8.3 = 18.3dB$ (1 mark)

IFRR2=$\sqrt{1 + Q^2x^2} = \sqrt{1 + 30^2 0.238^2 =} \; 7.2 = 17.1dB$ (1 mark)

IFRR3=$\sqrt{1 + Q^2x^2} = \sqrt{1 + 30^2 0.042^2 =} \; 1.6 = 4.1dB$ (1 mark)