EEE206 Examination Solutions May 2011

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Question 1

(a) Baseband signal is the message or data to be sent
Carrier wave is high frequency wave onto which the baseband signal is modulated.

2 marks

(b) Low frequency signal travels further, costs less but has less bandwidth.
Components such as antennas will be larger for low frequency system. **3 marks**

(c) Sketch spectrum of DSB and SSB signals and explain each.

DSB takes up too much bandwidth and is not power efficient but receiver costs are low.

5 marks

(d)

(i) Total power = $P_c(1 + m^2/2) = 2.1 \times 10^3$ when m = 1

Hence $\boldsymbol{P_c =}$ ***1400 watts***

2marks

(ii) m = 0.5 Power in one sideband = $m^2 P_c/4 = 0.25 \times 1.4 \times 10^3 / 4 =$ 87.5 watts

If P_{RC} is power in the reduced carrier, $10 \log_{10}(P_c / P_{RC}) = 26$, hence $P_{RC} = 1400/400 = 3.5$ watts

Total power radiated is thus 87.5 + 3.5 = ***91 watts***

4 marks

$m_1 = 0.5$, $m_2 = 0.35$, Hence effective m = $\sqrt{(0.5^2 + 0.35^2)} = 0.61$

Total radiated power = $1400 \times (1 + 0.61^2/2)$ = ***1660.4 watts*** **4 marks**

Question 2

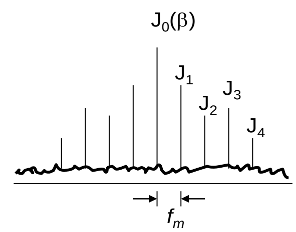
(a)

Frequency Modulation

$$v(t)\big|_{FM} = A\cos\left[\int \omega_i \cdot dt\right] = A\cos\left[\omega_c t + k_\omega \int M(t)\cdot dt\right]$$

$$= A\cos\left[\omega_c t + \frac{k_\omega B}{\omega_m}\sin\omega_m t\right]$$

$$= A\cos\left[\omega_c t + \frac{\Delta f}{f_m}\sin\omega_m t\right]$$



$\Delta f = Bk_\omega / 2\pi$ = frequency deviation

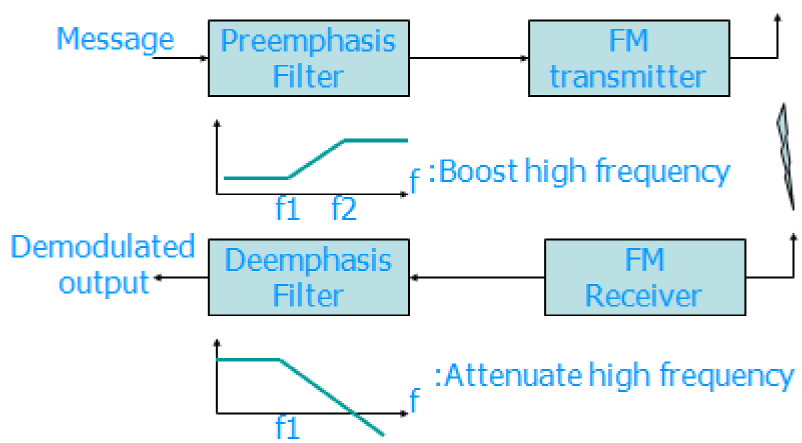
$\beta = \dfrac{\Delta f}{f_m}$ = modulation index (FM)

6 marks

(b)

Preemphasis and Deemphasis

- To increase SNR



4 marks

(c) $f_c = 101.4 \times 10^6$, $f_s = 8000$, $\Lambda f = 75000$

(i) Carrier swing = 2 Λf = 150 kHz
(ii) $f_{max} = f_c + \Lambda f$ = 101.475 MHz, $f_{min} = f_c - \Lambda f$ = 101.325 MHz

(iii) modulation index $\beta = \Lambda f / f_s = 75/8 = 9.375$

(iv) Carson's rule BW = $2(\beta + 1) f_s = 2(9.375 + 1) \times 8000$ = 166 kHz.

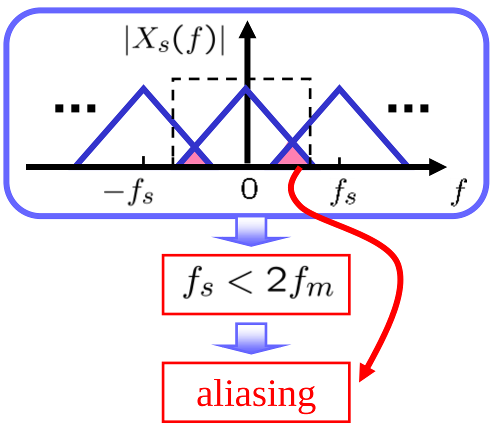
<u>8 marks</u>

This is wideband FM as $\beta > 0.3$

<u>2 marks</u>

Question 3

(a) Sampling theorem – min 2 samples at highest signal frequency



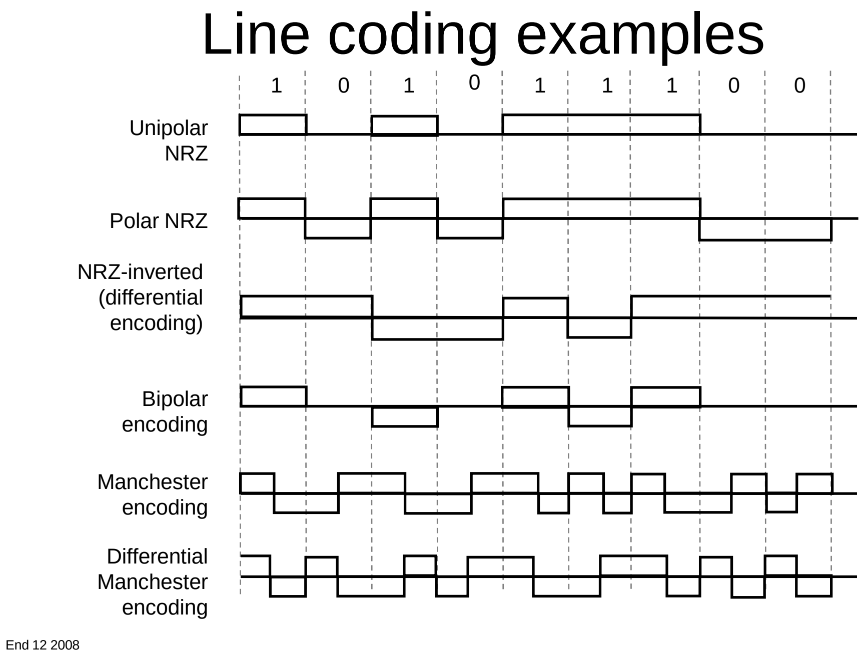
Aliasing

<u>4 marks</u>

(b)
LINE CODING _ baseband transmission

To transmit information through physical channels, binary 0s and 1s such as PCM sequences (codewords) for example have no timing information - can be transformed to pulses (waveforms) called Line Codes which can be more efficient in transmitting data. There are two major categories: return to zero (RZ) (returns to zero at end of bit - timing information) and non return to zero (NRZ) which has no timing information.

- Mapping of binary information sequence into the digital signal that enters the channel
  - Ex. "1" maps to +A square pulse; "0" to –A pulse **<u>4 marks</u>**



<u>2 marks</u>

(c)

$$C = B\log_2(1+\frac{S}{N})$$

C = information carrying capacity of the channel in bits / sec
B = bandwidth in Hz
S = signal power in watts
N = noise power in watts **4 marks**

S/N = 30 dB $\equiv$ 1000

C = 20000 $\log_2$ (1 + 1000) [$\log_2(x) = \log_{10}(x)/\log_{10}(2)$]

= 20000 x 9.968 = <u>199360 bits/sec</u> **<u>2 marks</u>**

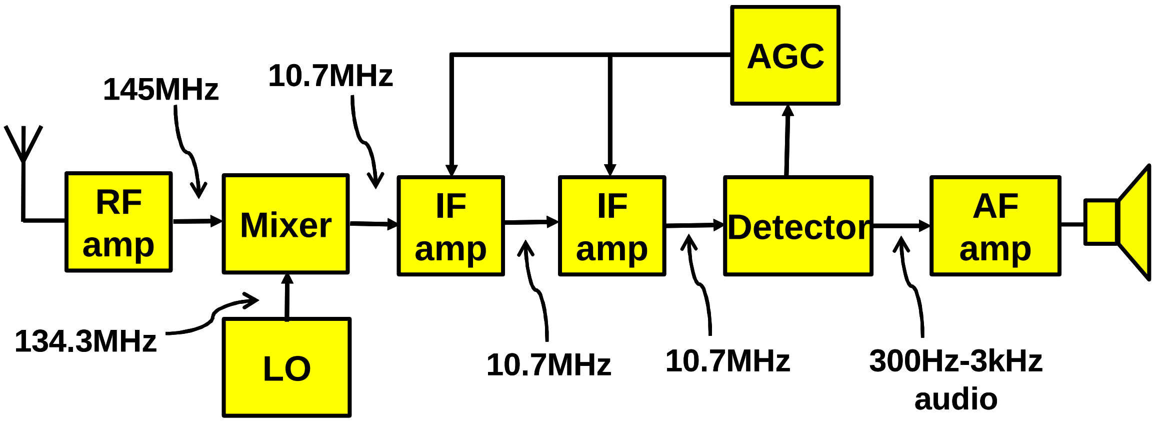
If the S/N in a 40 kHz bandwidth is 1000 this is equivalent to a noise power of 1 mW when the signal power is 1000 mW. The signal power is unchanged when the bandwidth is doubled but when the bandwidth is doubled, so is the noise power.

$\therefore$ C = 40000 $\log_2$ (1 + 1000/2)

= 40000 $\log_2$ (501) = <u>358780 bits/sec</u> **<u>4 marks</u>**

Question 4

(a)



Tunable RF input frequency f_{RF} is converted to a single IF f_{IF} frequency by a tunable Local Oscillator (LO) f_{LO}

Mixer converts RF frequency to a lower frequency, the IF or intermediate frequency, that is easier to manipulate

IF frequency?

Standard frequencies are preferred 455kHz, 1.4MHz, 10.7MHz, 21.4MHz, 45MHz, 70MHz

Standard crystal and ceramic filters are low cost

Multiple tuned filter circuits are used to get selectivity in the IF

At high RF frequencies it is impossible to make sufficiently narrow filters for narrow band signals

…but we can do it at a lower IF

Amplifiers that work over wide frequency ranges (and with AGC) are difficult to make

But relatively simple for one fixed IF frequency

8 marks

(b) **Image is 2x IF away from the wanted frequency**

- Larger IF frequency makes suppression of image easier
- Too low an IF and the RF input filters are too difficult
- LO radiation is also a problem if it leaks up the antenna

4 marks

(c)

$f_{LO} = 900 - 70 = 830$ MHz.

$\therefore$ f image = 830 - 70 = 760 MHz. (1st IF image)

2nd IF = 10 MHz and 2nd LO > 70

i.e. $-\underset{\substack{\uparrow \\ 70}}{f_{sig}} + LO = 10$ $\therefore$ f 2nd LO = 80 MHz.

Then would have f 2nd image = 70 + 20 = 90 MHz.

Input signals causing 2nd IF
image problems

$\therefore$ $f_2 - 830 = 90$ Hence f_2 = 920 MHz

$830 - f_3 = 90$ Hence f3 = 740 MHz

8 marks