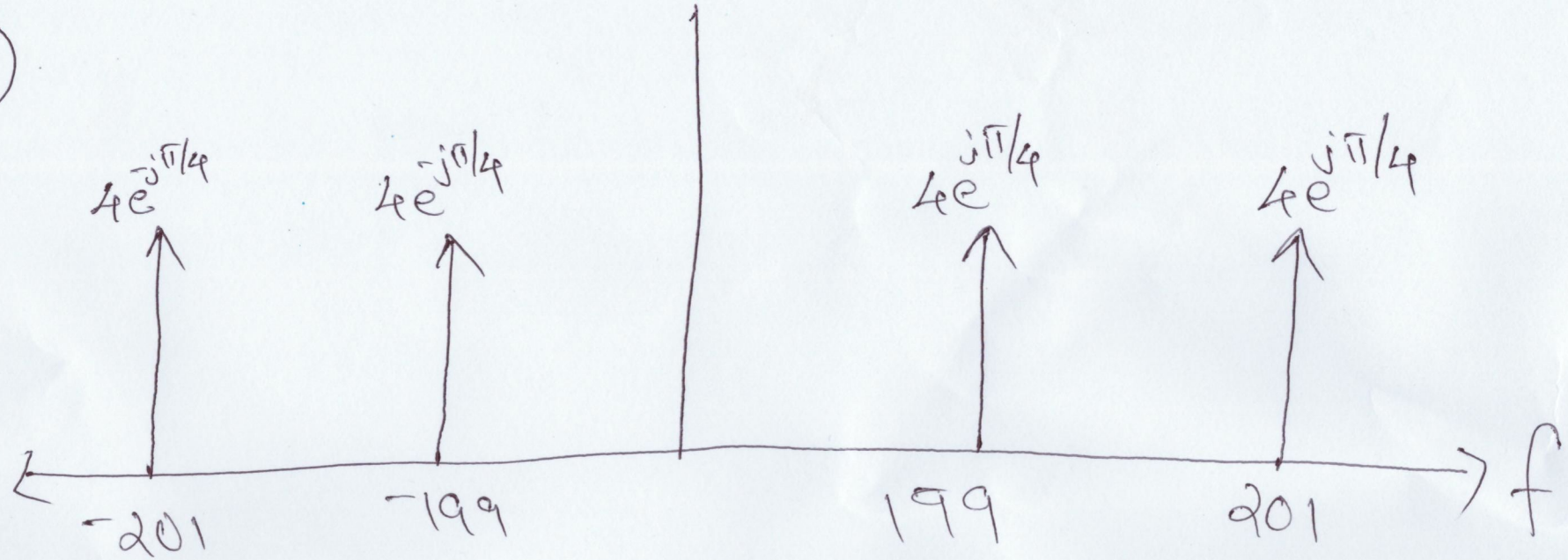
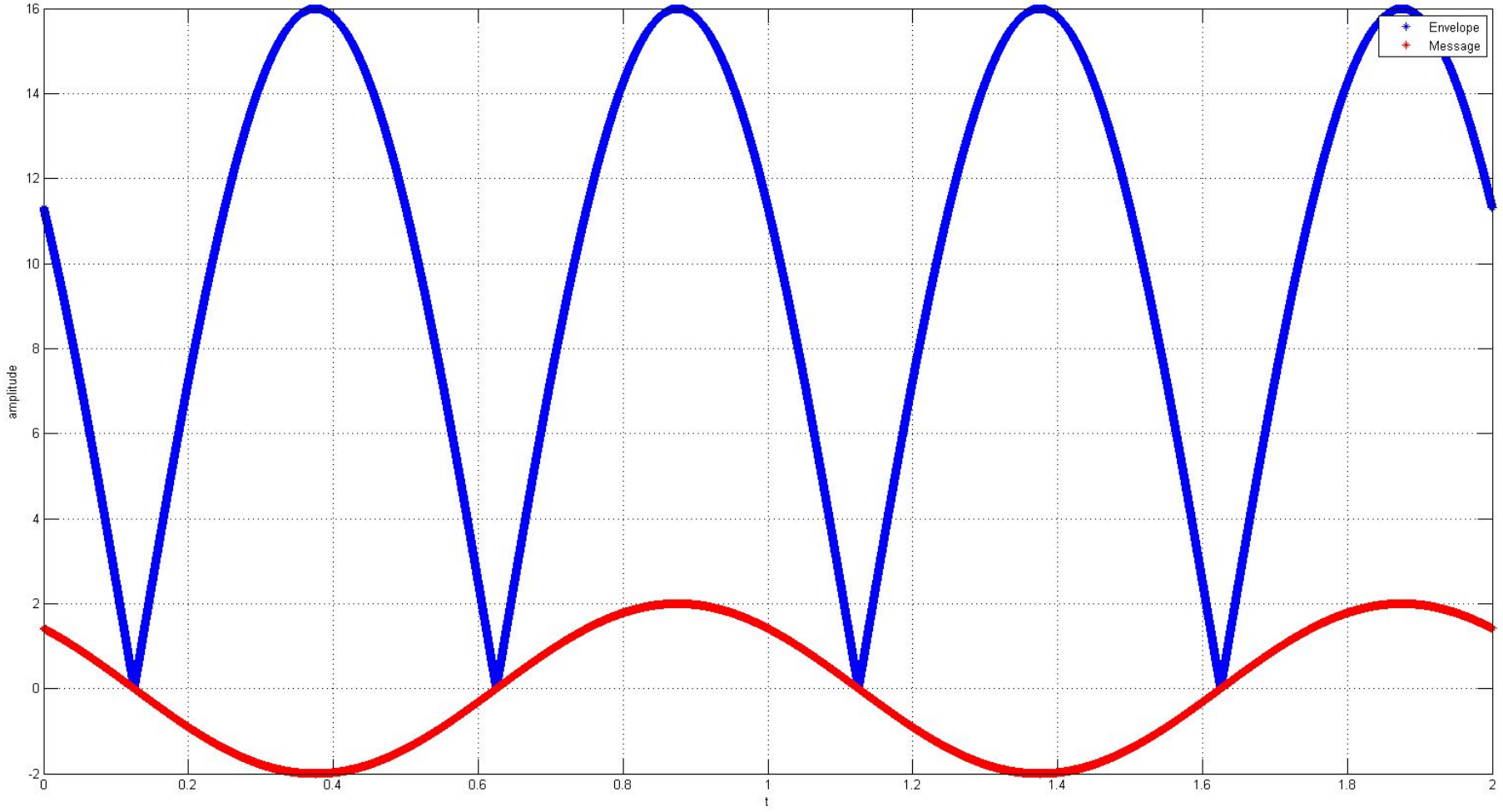
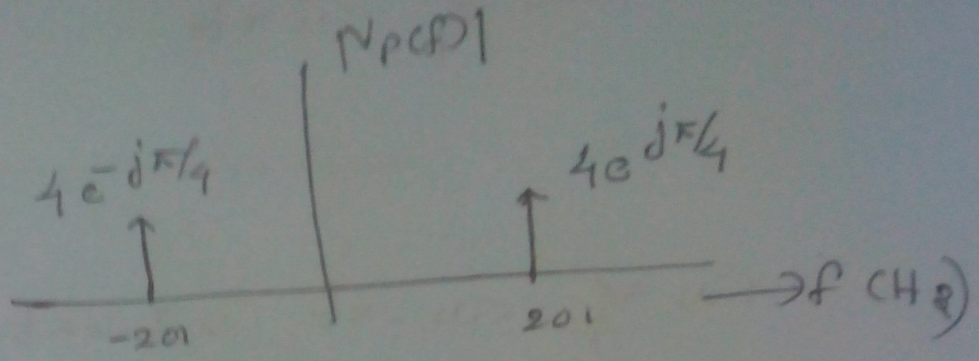
1 a)



$$\text{Power} = 4^3 \cdot 4 = \underline{\underline{64}}$$


Envelope
Message
amplitude
t
16
14
12
10
8
6
4
2
0
-2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

1) after high pass filtering u(t), the spectrum is



So $v_p(t) = 4\cos(20 \times 2\pi t + \pi/4)$

$= 4\cos(400\pi t + (2\pi t + \pi/4))$

$\Rightarrow v_c(t) = 4\cos(2\pi t + \pi/4)$

$v_s(t) = 4\sin(2\pi t + \pi/4)$

The envelope is this 1Hz (low freq) component and can be sketched easily

Q.2. a).

$$m(t) = 3\cos(2\pi t) + 4\sin(6\pi t)$$

(*) (**)

Unit of t is milliseconds.

~~f_1 is given by~~

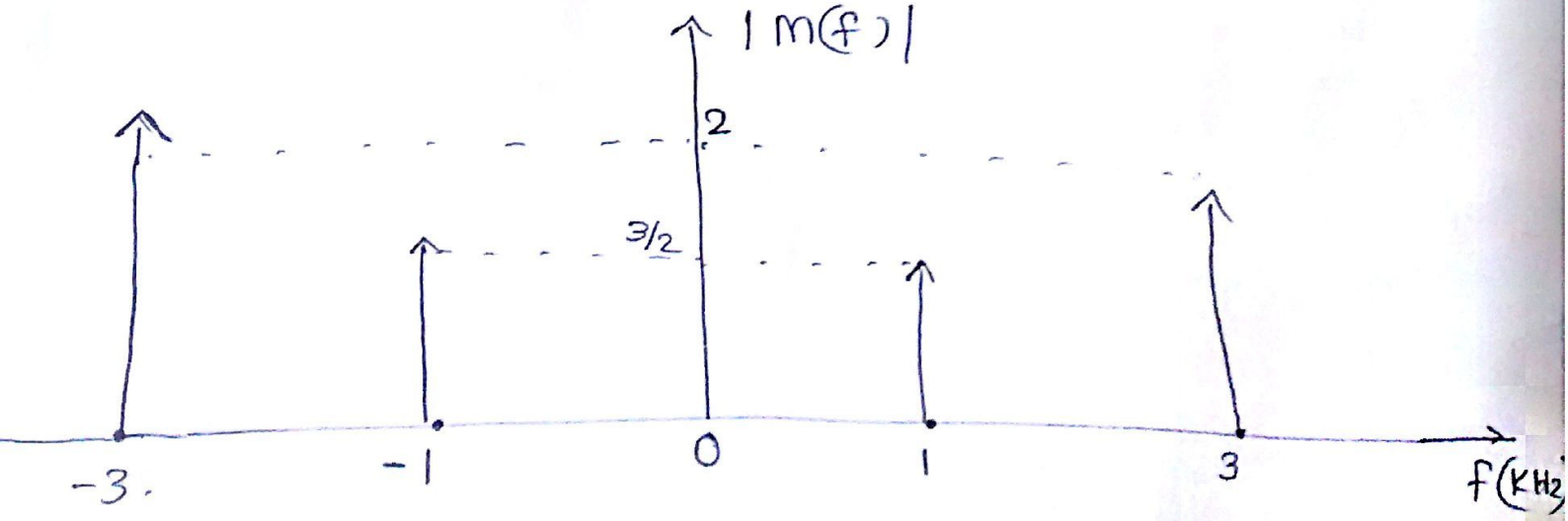
time for one complete cycle in (*) is 1 ms $\Rightarrow f_1 = 1$ KHz.

" " " " " in (**) is $\frac{1}{3}$ ms $\Rightarrow f_2 = 3$ KHz.

Hence.

$$M(f) = \frac{3}{2}\delta(f-f_1) + \frac{3}{2}\delta(f+f_1).$$

$$+2\,\frac{\delta(f-f_2) - \delta(f+f_2)}{j}$$



Band width = 6 KHz.

2)

b) $$m_n(t) = \frac{m(t)}{\left| \min_t m(t) \right|}$$

$$\min_t m(t) = \min_t \left(3\cos 2\pi t + 4 \sin 6\pi t \right)$$

$$= -6.62$$

$$m_n(t) = 0.4532 \cos(2\pi t) + 0.6042 \sin(6\pi t)$$

c) $a_{mod} = 0.5$

$$\Rightarrow u_{AM}(t) = A_c \left(1 + a_{mod} m_n(t)\right) \cos(2\pi f_c t)$$

$$= A_c \left(1 + 0.5 \left(0.4532 \cos(2\pi t) + 0.6042 \sin 6\pi t \right) \right) \cos 2\pi f_c t$$

$$u_{AM}(t) = A_c \left(1 + 0.2266 \cos(2\pi t) + 0.3021 \sin(6\pi t) \right) \cos 2\pi f_c t$$

2 (d)

$$m_n(t) = 0.4532 \cos(2\pi t) + 0.6042 \sin(6\pi t)$$

$$\overline{m_n^2} = \frac{1}{2}(0.4532)^2 + \frac{1}{2}(0.6042)^2$$

$$= 0.1026 + 0.1825$$

$$= 0.2851$$

$$\eta_{AM} = \frac{a_{mod}^2 \times \overline{m_n^2}}{1 + a_{mod}^2 \, \overline{m_n^2}}$$

(Here $a_{mod} = 1/2$)

$$= \frac{\left(\frac{1}{2}\right)^2 \times 0.2851}{1 + \left(\frac{1}{2}\right)^2 \times 0.2851}$$

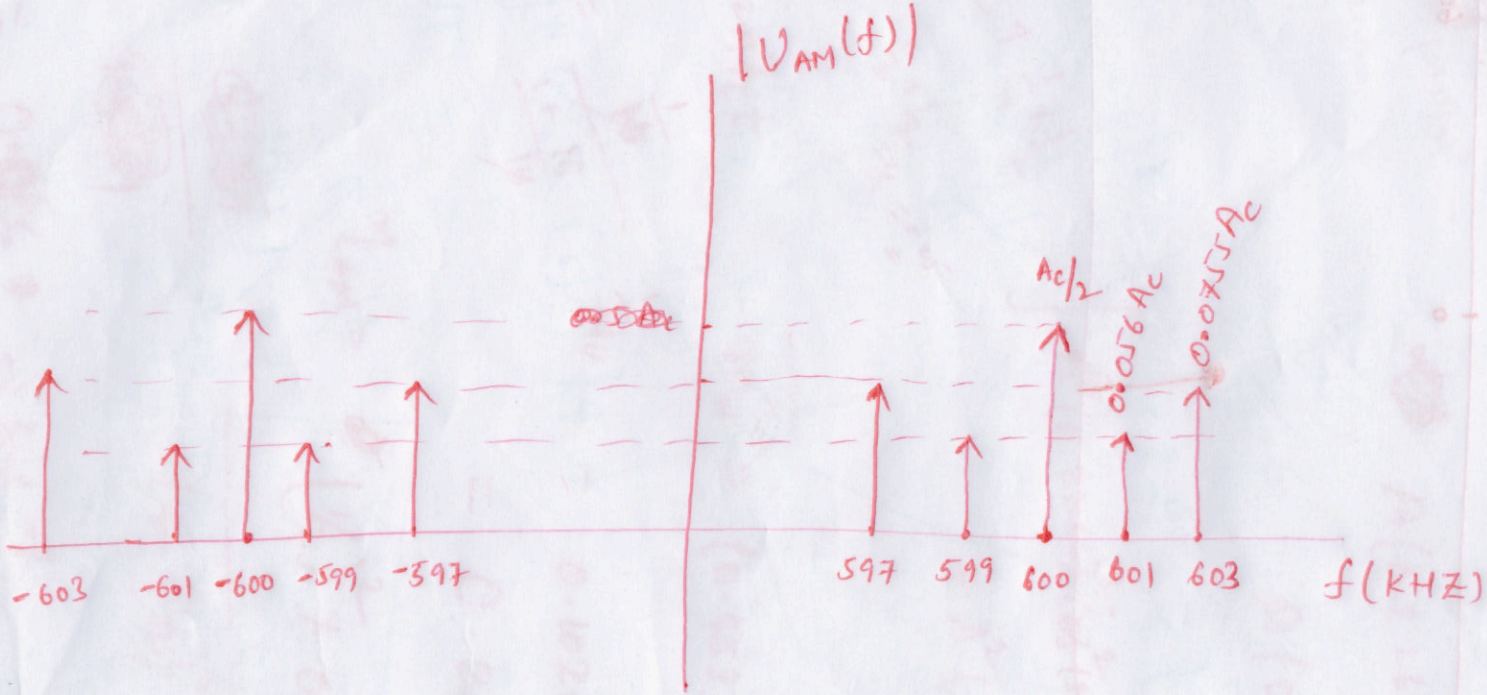
$$= 0.066$$

$\Rightarrow$ 6.6% (Power efficiency)

(2e)

Carrier freq = 600 kHz

$m_n(t) = 0.4532 \cos(2\pi t) + 0.6042 \sin(6\pi t)$



$\frac{A_c}{4} \times a_{mod}^{1/2} \times 0.453$

$= 0.05$

$\frac{A_c}{4} \times a_{mod} \times 0.604$

$= 0.075$

2(f). Bandwidth of message signal $B = 1/3$ KHz

$$f_c = 600 \text{ KHz}.$$

$$R = 50\Omega$$

We know that for an envelope detector

$$\frac{1}{f_c} << RC << \frac{1}{B}$$

$$\frac{1}{600\times10^3} << 50C << \frac{1}{1/3\times10^3}$$

$$\boxed{33.33\text{ nF} << C << 300\text{ uF}}$$

3a

$m(t) = \cos(2\pi f_m t + \phi)$ **DSB-SC**

$u_p(t) = A\, m(t) \cos 2\pi f_c t$ $\quad f_c > f_m$

Spectra of corresponding LSB and USB.

Passband signal: $u_{p\,DSB}(t) = A\, m(t) \cos 2\pi f_c t$

$= A \cdot \cos(2\pi f_m t + \phi) \cos(2\pi f_c t)$

$= A \cdot [\cos(2\pi f_m t)\cos\phi - \sin(2\pi f_m t)\cdot\sin\phi] \times \cos 2\pi f_c t$

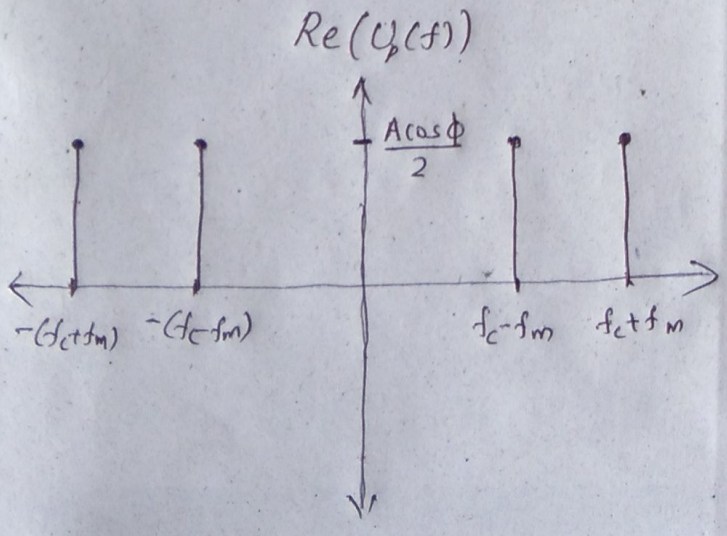
$= A\cos\phi\,(\cos 2\pi f_m t \cdot \cos 2\pi f_c t) - A\sin\phi\,(\sin 2\pi f_m t \cdot \cos 2\pi f_c t)$

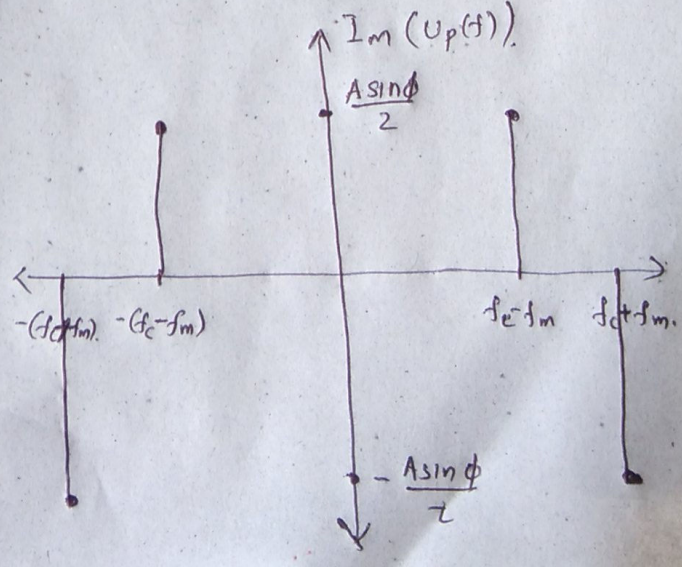
$= \frac{A\cos\phi}{2}\left[\cos(2\pi(f_c - f_m)t) + \cos(2\pi(f_c + f_m)t)\right]$

$- \frac{A\sin\phi}{2}\left[\sin(2\pi(f_m + f_c)t) + \sin(2\pi(f_m - f_c)t)\right]$

$= \frac{A\cos\phi}{2}\cos(2\pi(f_c - f_m)t) + \frac{A\cos\phi}{2}\cos(2\pi(f_c + f_m)t) - \frac{A\sin\phi}{2}\sin(2\pi(f_m + f_c)t)$

$+ \frac{A\sin\phi}{2}\sin(2\pi(f_c - f_m)t)$





3) b $m(t) = \cos(2\pi f_m t + \phi)$

$U_p(t) = A \cdot m(t) \cos 2\pi f_c t$

$U_p(t) = A \cos(2\pi f_m t + \phi) \cos(2\pi f_c t)$

$= \frac{A}{2}[\cos(2\pi f_c t + 2\pi f_m t + \phi) + \cos(2\pi f_c t - 2\pi f_m t - \phi)]$

$U_p(t) = \frac{A}{2}\cos(2\pi t(f_c + f_m) + \phi) + \frac{A}{2}\cos(2\pi t(f_c - f_m) - \phi)$

The first term here is the USB term,
2nd term here is the LSB term

$USB = \frac{A}{2}\cos(2\pi t(f_c + f_m) + \phi)$

$LSB = \frac{A}{2}\cos(2\pi t(f_c - f_m) - \phi)$