(Q3) $f_f = 1 \times 10^6$ Hz, $f_m = 100$ Hz, $f' = 1.1 \times 10^6$ Hz

$$x(t) = \cos(2\pi f_f t)\cdot\cos(\beta\sin(2\pi f_m t)) - \sin(2\pi f_f t)\cdot\sin(\beta\sin(2\pi f_m t)).$$

$$\approx \cos(2\pi f_f t) - \beta\sin(2\pi f_m t)\cdot\sin(2\pi f_f t).$$

writing this as complex exponentials:

$$x(t) = \frac{e^{j2\pi f_f t} + e^{-j2\pi f_f t}}{2} + -\beta\sin(2\pi f_m t)\cdot\sin(2\pi f_f t).$$

$$= \frac{e^{j2\pi f_f t} + e^{-j2\pi f_f t}}{2} - \beta\,\frac{e^{j2\pi f_m t} - e^{-j2\pi f_m t}}{2j} \times \frac{e^{j2\pi f_f t} - e^{-j2\pi f_f t}}{2j}$$

$$= \frac{e^{j2\pi f_f t} + e^{-j2\pi f_f t}}{2} + \frac{\beta}{4}\left\{ e^{j2\pi(f_m+f_f)t} - e^{-j2\pi(f_f-f_m)t} - e^{j2\pi(f_f-f_m)t} + e^{-j2\pi(f_f+f_m)t} \right\}$$

after filtering

$$f(t) = \frac{e^{j2\pi f_f t} + e^{-j2\pi f_f t}}{2} + \frac{\beta}{4}\left\{ e^{j2\pi(f_m+f_f)t} + e^{-j2\pi(f_f+f_m)t} \right\}.$$

in order to find the complex baseband, consider the +ive freq. part. Then the spectrum is given by

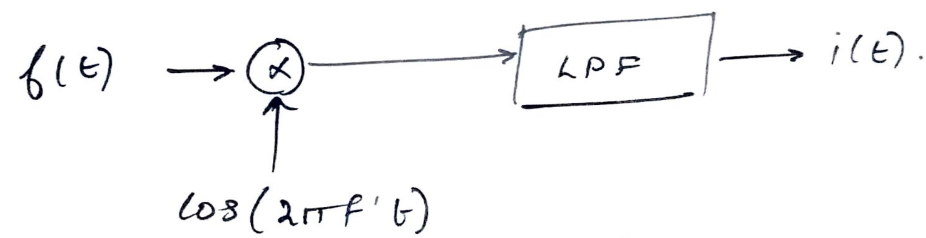
$$\frac{e^{j2\pi f_f t}}{2} + \frac{\beta}{4}\, e^{j2\pi(f_m+f_f)t}$$

using $f' = 1.1$ MHz.

$$e^{j2\pi f' t}\left(\underbrace{\frac{e^{j2\pi(f_f - f')t}}{2} + \frac{\beta}{4} e^{j2\pi(f_m + f_f - f')t}}_{\text{complex baseband.}}\right)$$

$$\frac{1}{2}\cos 2\pi(f_f - f')t + j\frac{1}{2}\sin(2\pi(f_f - f)t)$$
$$+\frac{\beta}{4}\cos(2\pi(f_f + f_m - f')t) + \frac{\beta j}{4}\sin(2\pi(f_f + f_m - f')t).$$

how to calculate $i(t)$.



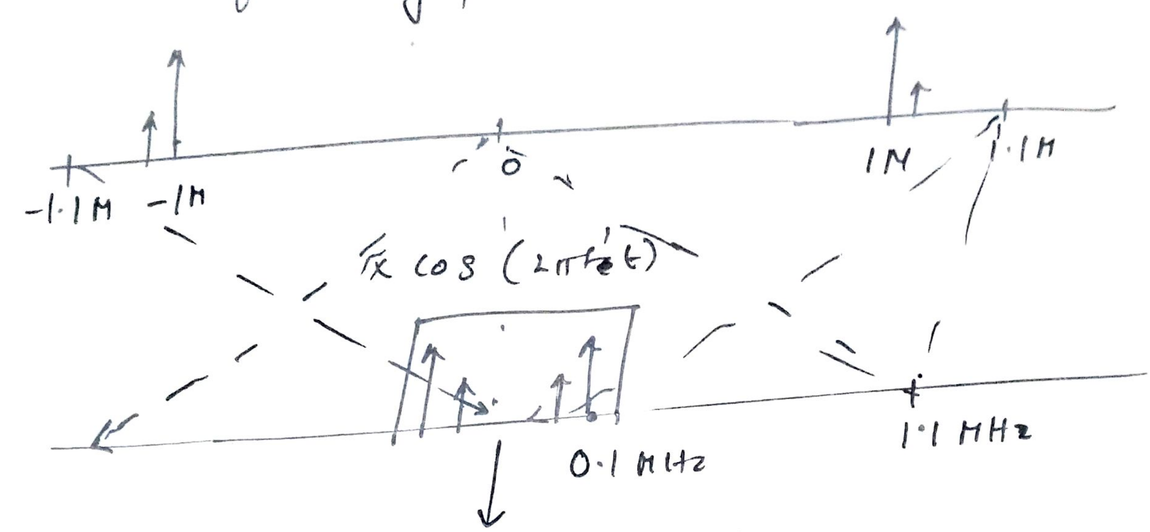
$$f(t) = \frac{e^{j2\pi f_f t} + e^{-j2\pi f_f t}}{2} + \frac{\beta}{4}\left\{e^{j2\pi(f_f + f_m)t} + e^{-j2\pi(f_f + f_m)t}\right\}$$

$f(t) \times \cos(2\pi f' t)$

$$= \frac{1}{4}\left\{e^{j2\pi(f_f + f')t} + e^{j2\pi(f_f - f')t} + e^{-j2\pi(f_f + f')t} + e^{-j2\pi(f_f - f')t}\right\}$$
$$+ \frac{\beta}{8}\left\{e^{j2\pi(f_f + f_m + f')t} + e^{j2\pi(f_f + f_m - f')t} + e^{-j2\pi(f_f + f_m - f')t} + e^{-j2\pi(f_f + f_m + f')t}\right\}$$

Now this gets LPFed by a filter of cutoff 100 kHz.
Assume brickwall passes 100 kHz.

Intuition from mag plot



This is LPFed.

$$f(t) \times \cos(2\pi f' t) = f(t) \cdot \frac{e^{j2\pi f' t} + e^{-j2\pi f' t}}{2}$$

- $f_f + f'$ terms will get cutoff.

$f_f - f' = -100k$. and $f_f + f_m - f' = -100k + f_m$.

$$i(t) = \frac{1}{4}\left(e^{j2\pi(f'-f_f)t} + e^{-j2\pi(f'-f_f)t}\right)$$
$$+ \frac{\beta}{8}\left(e^{j2\pi(f'-f_f-f_m)t} + e^{-j2\pi(f'-f_f-f_m)t}\right)$$
$$= \frac{1}{2}\cos(2\pi(f'-f_f)t) + \frac{\beta}{4}\cos(2\pi(f'-f_f-f_m)t).$$

compare with complex BB result obtained earlier.