

Figure 8.1 In-phase (I), quadrature (Q) signals, and I/Q signals.

$$S_{IQ}(t) = A_I(t) \cos 2\pi f_c \cdot t + A_Q(t) \cdot \sin 2\pi f_c \cdot t$$

QAM \rightarrow $S_{IQ}(t)$ \rightarrow $\text{LO} \cos 2\pi f_c \cdot t$

1)

$$\cos 2\pi f_c t \cdot \sin 2\pi f_c t = A_I(t) \cos 2\pi f_c t \cdot \cos 2\pi f_c t + A_Q(t) \cos 2\pi f_c t \cdot \sin 2\pi f_c t$$

$$\cos A \cdot \cos B = \frac{1}{2} (\cos[B-A] + \cos[A+B])$$

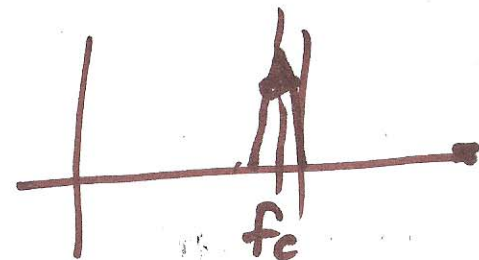
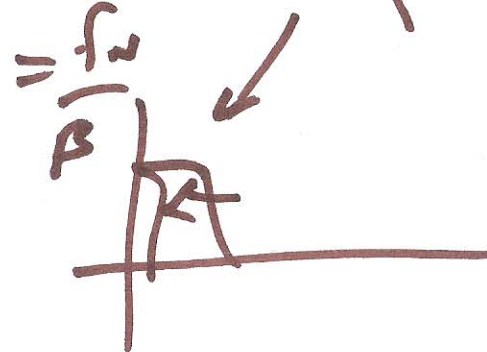
$$\sin B \cdot \cos A = \frac{1}{2} (\sin[B-A] + \sin[A+B])$$

$$A_I(t) \cos 2\pi f_c t \cdot \cos 2\pi f_c t$$

$$= A_I(t) \frac{1}{2} (1 + \cos(2\pi \cdot 2f_c t))$$

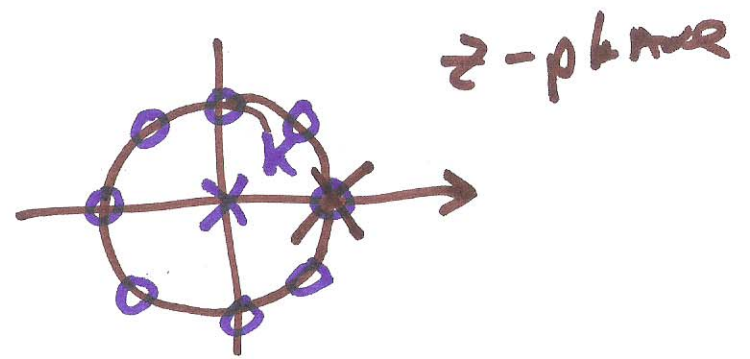


$$OSR = \frac{f_s}{2B}$$



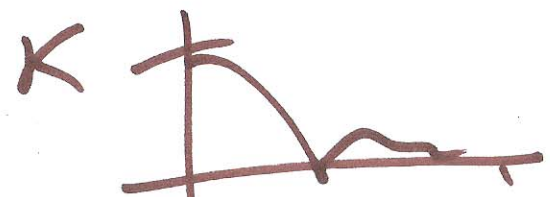
$$\frac{1}{1+z^{-2}}$$

$$\frac{1-z^{-k}}{1-z^{-1}}$$



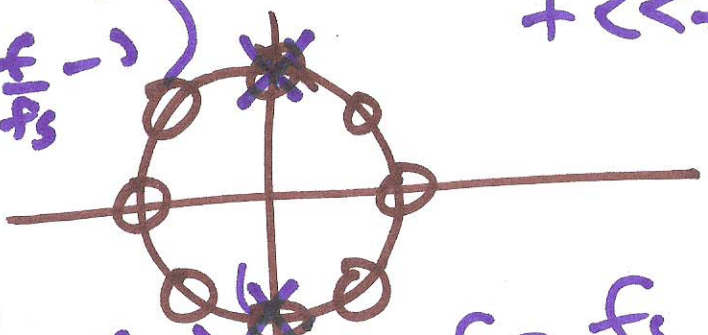
$$\frac{z^2}{z^2+1} \cdot \frac{1-z^{-k}}{1+z^{-2}}$$

$$\frac{1}{1-z^{-1}} \cdot \frac{1+j2\pi f}{f_s} \cdot \frac{z}{z-1} = \frac{1+j2\pi f}{1+j2\pi f - 1}$$



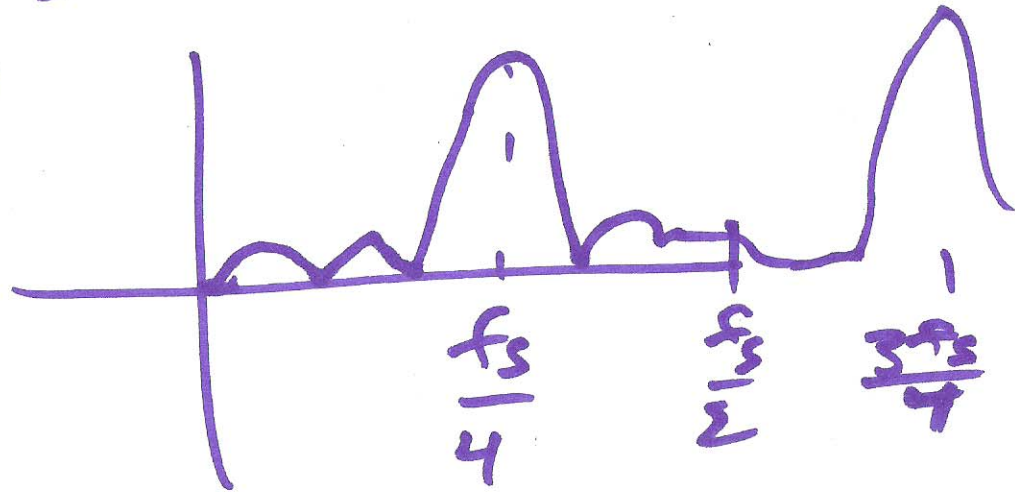
$$(z-j)(z+j) \cdot (1+j2\pi \frac{f}{f_s} - j)$$

$f \ll f_s$

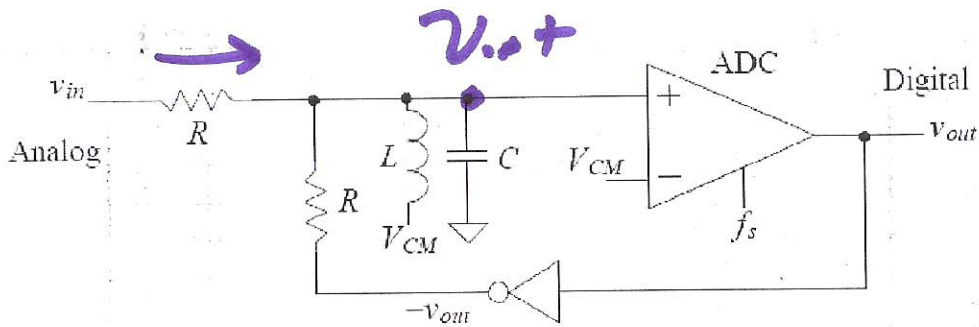


$$1 + j(2\pi \frac{f}{f_s} - 1)$$

$f = \frac{f_s}{2\pi}$



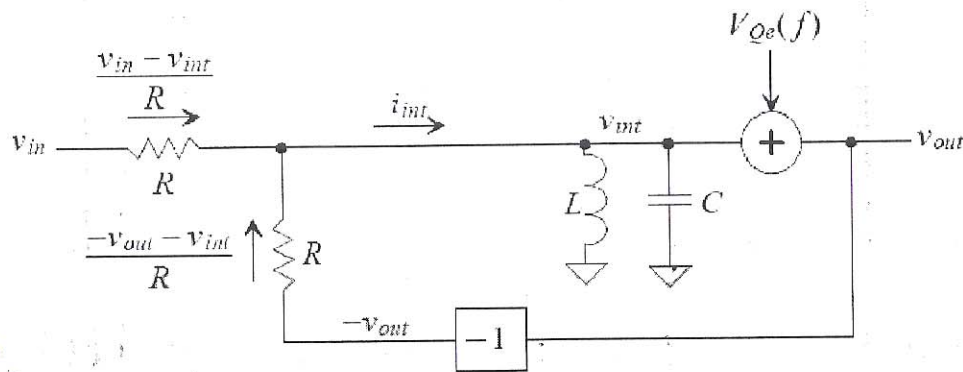
3)



(a) Circuit implementation of a bandpass modulator.

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$\frac{sL \cdot \frac{1}{sC}}{sL + \frac{1}{sC}} = \frac{sL}{1 + s^2LC}$$



(b) Block diagram

Figure 8.2 A bandpass passive NS modulator.

$$V_{out} = \left(\frac{v_{in} - v_{int}}{R} + \frac{-v_{out} - v_{int}}{R} \right) \cdot \frac{\frac{v_{int}}{sL + \frac{1}{sC}} + V_{oe}}{sL + \frac{1}{sC}}$$

4)

$$V_{VT} = \left(\frac{V_{in} - V_{VT}}{R} + \frac{-V_{VT} - V_{in}}{R} \right) \frac{SL}{1 + s^2 LC} + V_{oe}$$

$$V_{VT} (1 + s^2 LC) = V_{oe} (1 + s^2 LC) + \left(\frac{V_{in}}{R} - \frac{V_{VT}}{R} - \frac{2V_{in}}{R} \right) SL$$

$$V_{VT} \left(\frac{SL + R + s^2 LCR}{R} \right) = V_{oe} (1 + s^2 LC) + \frac{SL}{R} \cdot V_{in} - \frac{2SL}{R} V_{VT}$$

$$V_{VT} = \frac{V_{oe} (1 + s^2 LC)}{s^2 LC + \frac{L}{R} \cdot s + 1} + \frac{SL V_{in}}{s^2 LC + \frac{L}{R} \cdot s + 1} + (\dots) V_{in}$$

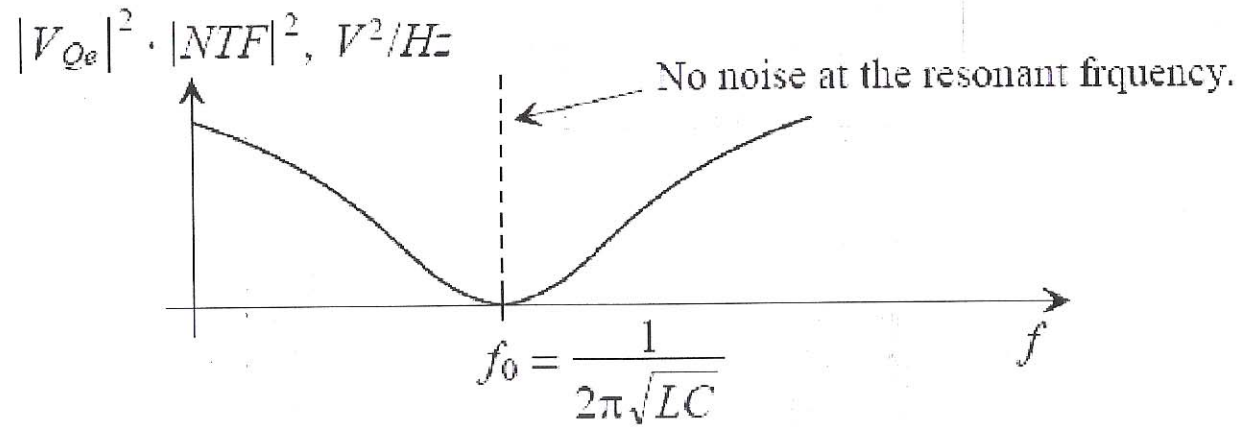
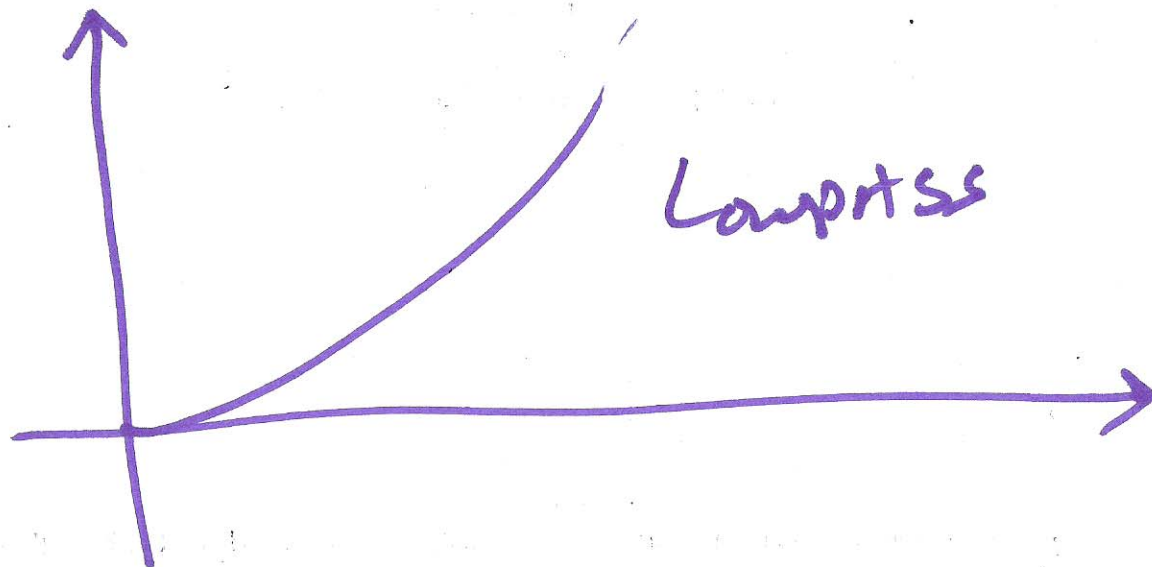


Figure 8.3 Modulation noise spectral density for a bandpass modulator.



6)