1. Consider the narrowband FM signal $A_c\cos\left(2\pi f_c t+\beta\sin\left(2\pi f_m t\right)\right)$ passed through a non-linear device with output given as $a\left(s\left(t\right)\right)^5$. If this output is filtered with a bandpass filter centered at the highest multiple of carrier frequency, what is the resulting FM signal
   a. $\frac{aA_c^2}{2}\cos\left(4\pi f_c t+2\beta\sin\left(2\pi f_m t\right)\right)$
   b. $\frac{aA_c^3}{4}\cos\left(6\pi f_c t+3\beta\sin\left(2\pi f_m t\right)\right)$
   c. $\frac{aA_c^4}{8}\cos\left(8\pi f_c t+4\beta\sin\left(2\pi f_m t\right)\right)$
   d. $\frac{aA_c^5}{16}\cos\left(10\pi f_c t+5\beta\sin\left(2\pi f_m t\right)\right)$

   Ans d
2. An angle-modulated signal *s*(*t*) corresponding to a sinusoidal message signal with maximum frequency deviation 10 Hz is passed through a non-linear device with output $a\left(s\left(t\right)\right)^n$ followed by filtering with a bandpass filter centered at the highest multiple of carrier frequency to yield the final signal $x_c\left(t\right)=10\cos\left(2\pi\times10^7 t+0.2\sin\left(10^3\pi t\right)\right)$. The value of the constant *n* is,
   a. 2
   b. 4
   c. 6
   d. 10

   Ans d
3. Consider the FM signal $x_c\left(t\right)=\cos\left(2\pi\times10^7 t+0.5\sin\left(10^3\pi t\right)\right)$. What is the minimum bandwidth which contains 99% of the signal power
   a. f_m
   b. $2f_m$
   c. $3\,f_m$
   d. $5\,f_m$

   Ans a
4. Consider the FM signal $x_c\left(t\right)=\sin\left(2\pi\times f_c t+\beta\sin\left(2\pi f_m t\right)\right)$. Its spectrum is
   a. $\sum_{n=-\infty}^{\infty}J_n\left(\beta\right)\left(\delta\left(f-f_c-nf_m\right)+\delta\left(f+f_c+nf_m\right)\right)$
   b. $\sum_{n=-\infty}^{\infty}J_n\left(\beta\right)\left(\frac{j}{2}\delta\left(f-f_c-nf_m\right)+\frac{j}{2}\delta\left(f+f_c+nf_m\right)\right)$

c. $\sum_{n=-\infty}^{\infty} J_n(\beta)\left(\frac{j}{2}\delta(f - f_c - nf_m) + \frac{j}{2}\delta(f - f_c + nf_m)\right)$

d. $\sum_{n=-\infty}^{\infty} J_n(\beta)\left(-\frac{j}{2}\delta(f - f_c - nf_m) + \frac{j}{2}\delta(f + f_c + nf_m)\right)$

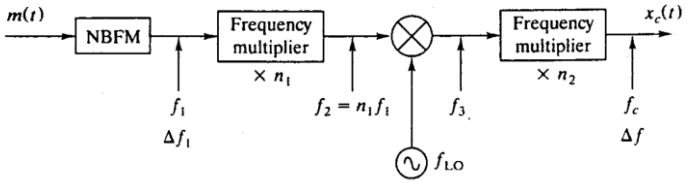
Ans d

5. Consider a 40 MHz carrier frequency-modulated by a sinusoidal signal with maximum frequency deviation of 500 KHz. Find the approximate bandwidth of the FM signal if the frequency of the message signal is 1 KHz
   a. 2 MHz
   b. 10 MHz
   c. 1 MHz
   d. 5 MHz

   Ans c
6. Consider a 40 MHz carrier frequency-modulated by a sinusoidal signal with maximum frequency deviation of 500 KHz. Find the approximate bandwidth of the FM signal if the frequency of the message signal is 500 KHz
   a. 2 MHz
   b. 10 MHz
   c. 1 MHz
   d. 5 MHz

   Ans a
7. Consider a 40 MHz carrier frequency-modulated by a sinusoidal signal with maximum frequency deviation of 500 KHz. Find the approximate bandwidth of the FM signal if the frequency of the message signal is 5 MHz
   a. 2 MHz
   b. 10 MHz
   c. 1 MHz
   d. 5 MHz

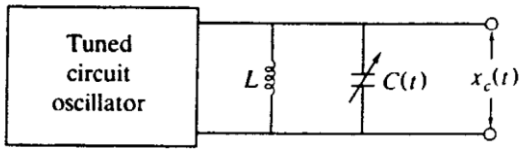
   Ans b
8. A block diagram of a 2 stage indirect FM transmitter is shown in figure below. NBFM stands for Narrowband FM. The crystal oscillator frequency is 400 KHz and the maximum phase deviation is 0.5 for the NBFM signal. The input message frequency ranges from 100 Hz to 20 KHz. After bandpass filtering corresponding to the lower carrier frequency at the output of the second stage, the resulting carrier frequency at the output is 200 MHz and maximum frequency deviation is 150 KHz. Given $n_1 = 50$, what is the frequency of the local oscillator?



a. 3.33 MHz
b. 6 MHz
c. 9.33 MHz
d. 12.0 MHz

Ans c

9. Consider the parallel resonant circuit shown below with the capacitance of the variable capacitor given as $1\mu F - 10^{-8} m(t)$, where $m(t)$ is the message signal which varies slowly with max $|m(t)| << 1$. Using a suitable approximation, what is the resulting carrier frequency and sensitivity K_f of the resulting frequency modulated signal $x_c(t)$.



a. 2.78 KHz, 15.85
b. 3.23 KHz, 11.23
c. 4.53 KHz, 9.37
d. 5.03 KHz, 25.16

Ans d

10. Consider a periodic impulse train with time period $T_s = 1/f_s$. Its spectrum is given as,

a. $f_s \sum_{n=-\infty}^{\infty} \cos(2\pi(f + nf_s))$
b. $f_s \delta(f)$
c. 1
d. $f_s \sum_{n=-\infty}^{\infty} \delta(f - nf_s)$

Ans d