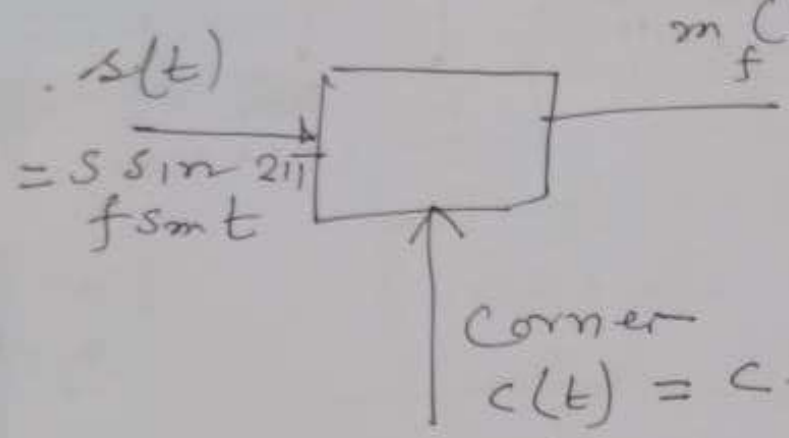
1 Frequency Modulation



$* \; m_f(t) = C \sin\left(2\pi\left(f_c + k_f S(t)\right)\right)$

~~$= C \sin (2\pi (f_c + k_f S \sin 2\pi$~~

$= C \sin\left(2\pi\left(f_c + k_f S \sin 2\pi f_s m t\right) t\right)$

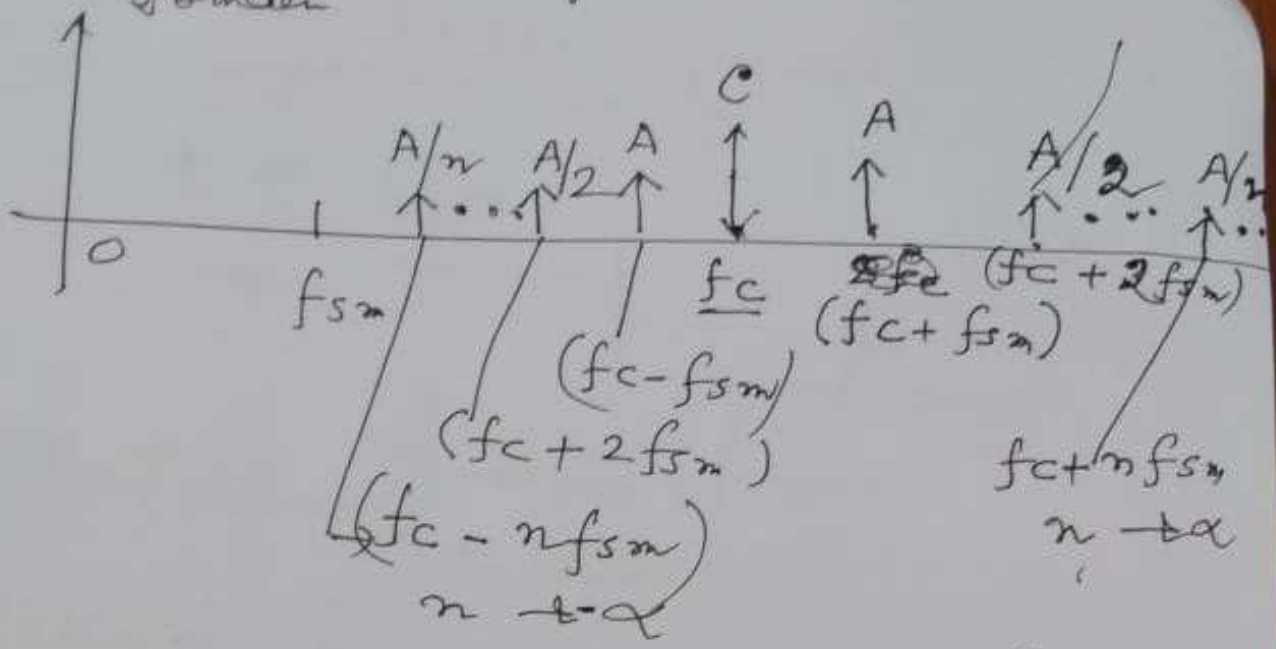
$\Rightarrow$ A sin function within a sine function.

$\Rightarrow$ So analysis can be done by simple trigonometric process.

$\Rightarrow$ Solution for $m(t)$ in time domain I have gone through very complicated higher Engineering mathematics whose result is being presented in next page in frequency domain.

m(t)
in frequency domain

(1)



(2) A = Amplitude of the first frequency above fsm (or below) Frequency is modulated signal

Ideal Bw of m(t) ⇒

$= (fc + nfsm) - (fc - nfsm)$

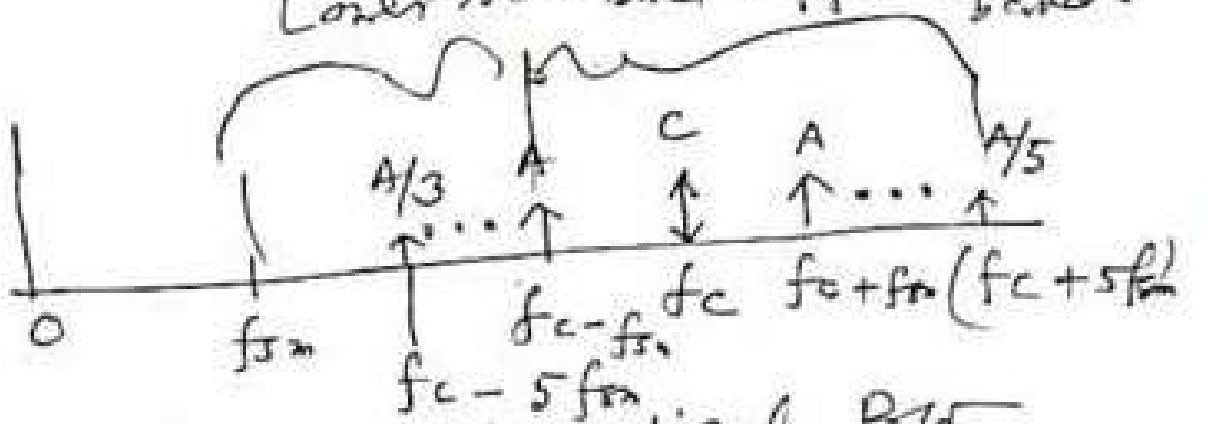
$= 2nfsm \quad n \to \infty$

$= \infty$.

(3) But we see as n increases the Amplitude decreases. Inverse,

⇒ as n increases power decreases inversely as n^2

(4) It has been practically observed that with $n > 5$ the power is so small that frequency above $n = 5$ can be neglected.



Effective or practical BW

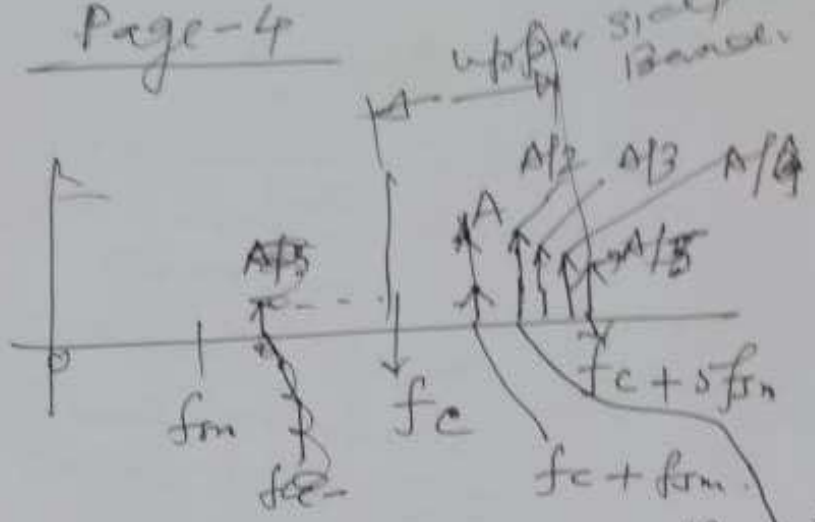
$$BW_e = (f_c + 5f_m) - (f_c - 5f_m)$$

$$= 10 f_m.$$

(5) Now with very insignificant loss of quality either the lower or upper side band can be transmitted, like Amplitude modulation

(6) Assume that we shall transmit upper side band for FDM (Frequency Division Multiplexing) to create many channels

(07)



(08) Therefore BW for transmission purpose

$$= (fc + 5fsm) - (fc)$$

$$= 5fsm$$

(09) fc Music $fsm = 20\,KHz$

Therefore Bandwidth of Music channel for FM = 100 KHz.

(10) For AM transmission Bandwidth fc AM channel = 20 KHz.

(11) Then why we go fc FM with 5 times channel BW? Because total number of channels over a given BW of space will be very lesser.

(12) We shall choose FM for quality music.

In AM both signal $s(t)$ and noise signal changes the amplitude of the carrier but frequency of carrier is not changed.

(13) After demodulation at receiver the noise will come along with the music signal $s(t)$ which can not be seperated.

(14) In FM, the noise will change the Amplitude of the carrier but signal $s(t)$ will change the frequency.

(15) So after demodulation, the noise can be filtered out from the signal.

(16) So the quality of music signal is very good in FM.

(1) The transmission Range of AM music is medium wave range.

(2) Transmission of FM music is from 90 MHz to 108 MHz (in HF High frequency or HF range)

Problem FDM in FM

Earlier example:

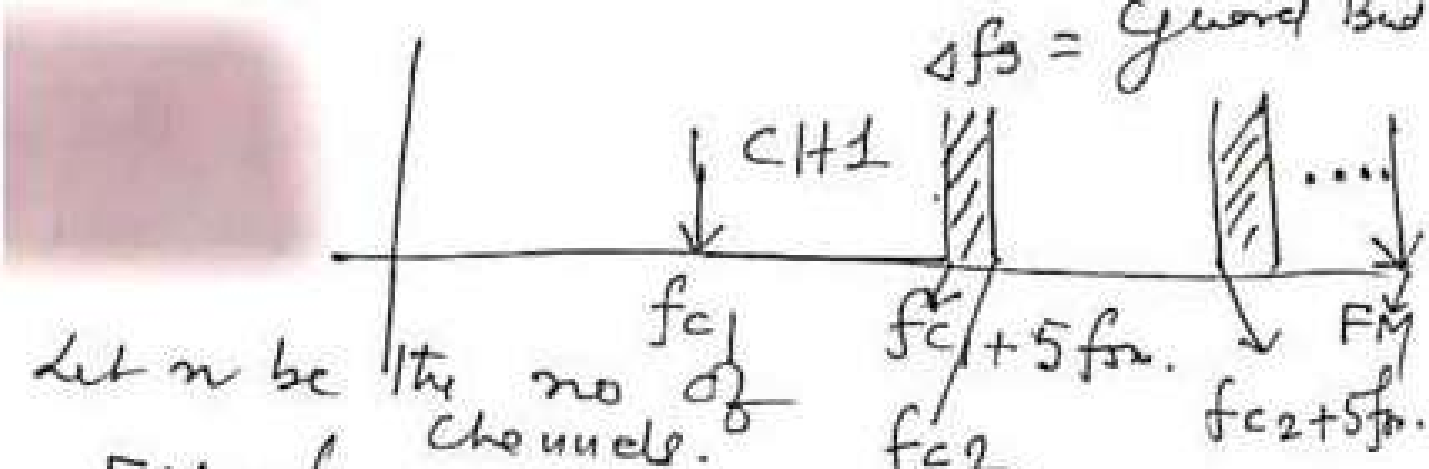
(i) Lowest comp = 400 KHz

(ii) BW of music signal = 20 KHz.

guard Band = 2 KHz.

(iii) highest frequency allocated FM = 2 MHz

(iv) Upper side Band is used.



Let n be the no of channels.

FM - f_{c1} = $n \times 5f_m + (n-1)\Delta f_g$

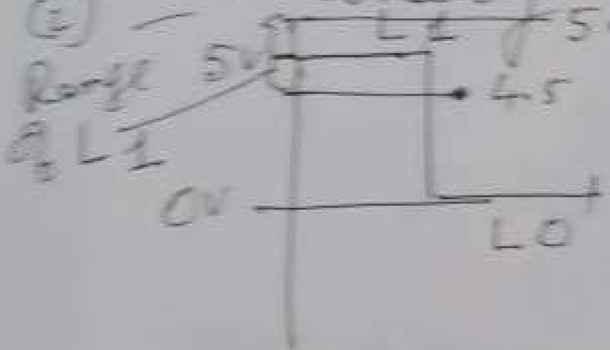
Calculate n and take floor value.

Analog vs Digital Transmission. Page-66

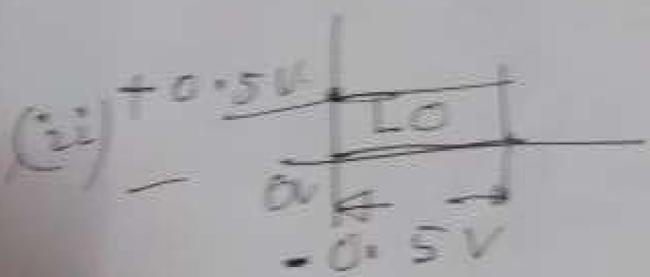
Quality of transmission of digital signal is much better than the analog signal & other benefits.

Why?

(1) Digital signal after some distance of propagation can be regenerated to its original form. Which the analog signal .

(i)


$L1 = 5V \pm .5V$ (Logical 1)

(ii)


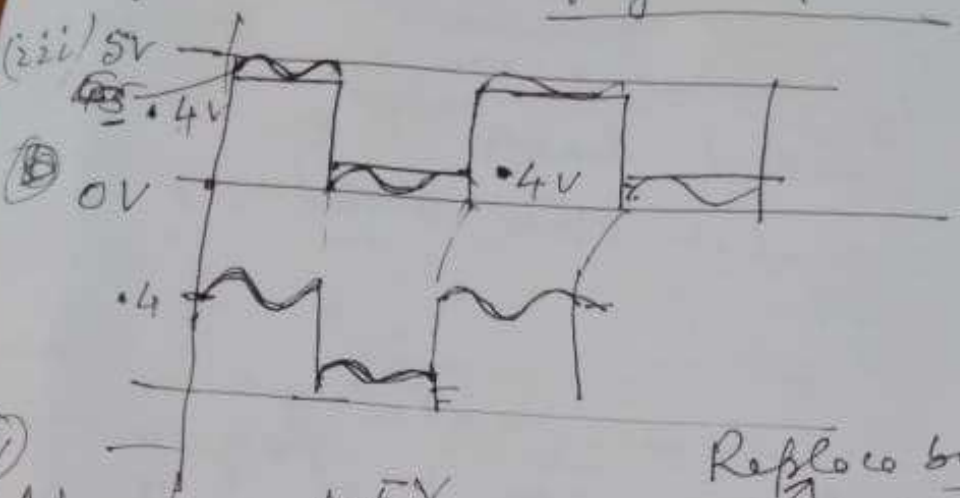
$L0 = 0 \pm .5V$

Suppose our transmission sequence is 1010...

L1 effected by $-.4V$ to noise.

and L0 effect $+.4V$ noise.

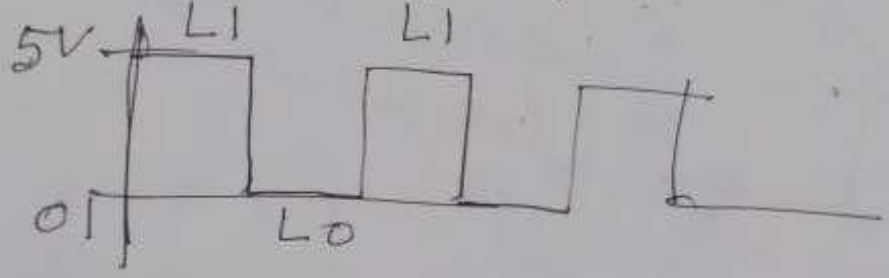
(iii) 5V
.4V
0V
.4V
.4
2V



At receiver $4.5V \leq$ Voltage $\Rightarrow$ Reflow by $\Rightarrow L1$

Reflow

Voltage $< .5V \Rightarrow L0$



(iv) Then Amplified to compensate for power Loss.

(2) —

(3) —

(4) —