16/11/23

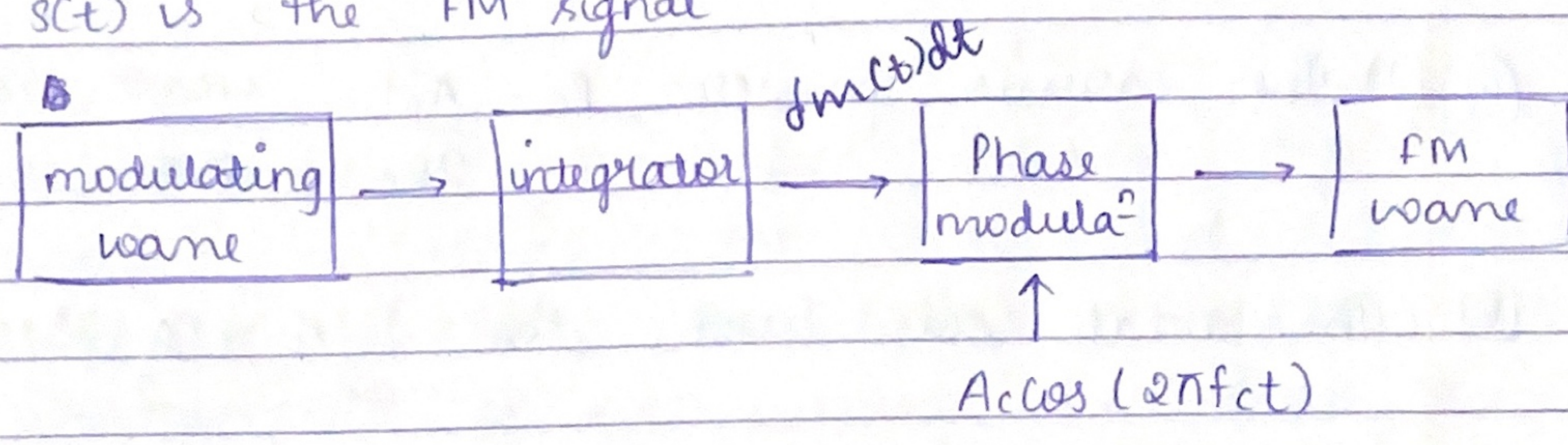
Master Tutorial - 01

(5) Identify a suitable analog modulation technique to transmit an audio signal for long distance requiring min. bandwidth, & explain with approo^n expressions & block diagram.

→ For transmitting an audio signal over a long distance while requiring minimum BW, FM is a suitable analog modulation technique. FM is known for its resistance to amplitude variations & ability to provide high quality audio transmission.

$$S(t) = A_c \cos(2\pi f_c t + 2\pi K_f \int_0^t m(T)\, dT)$$

- S(t) is the FM signal



$$S(t) = A_c \cos(2\pi f_c t + K_p \int m(t)\, dt$$

(a) Message signal source (Audio input) : Represents the audio signal to be transmitted.

(b) Voltage controlled oscillator : Generates the carrier signal with a frequency that varies based on the instantaneous value of message signal.

(c) Phase modulator : Modifies the phase of the carrier signal in proportion to the instantaneous value of message signal.

(d) Bandpass Filter : Filters the modulated signal.

(e) Power amplifier : Amplifies the filtered signal.

(f) Antenna: Transmits the modulated signal over air.

The VCO in the FM transmitter produces a carrier signal whose frequency is directly propotional to the audio signal. This frequency modulation helps in amplitude variations & provides better signal quality.

- The modulation index K_f determines the extent of frequency deviation based on the amplitude of the message signal.
- The Bandpass filter ensures that only the desired frequency band contⁿ the modulating signal.

(6) (a) The carrier power, $P_c = \frac{A_c^2}{2R_L} = \frac{(100)^2}{2 \times 50} = 100W$ //

(b) The total side band, $P_{SB} = \frac{\mu^2 P_c}{2} = \frac{(0.8)^2 100}{2}$

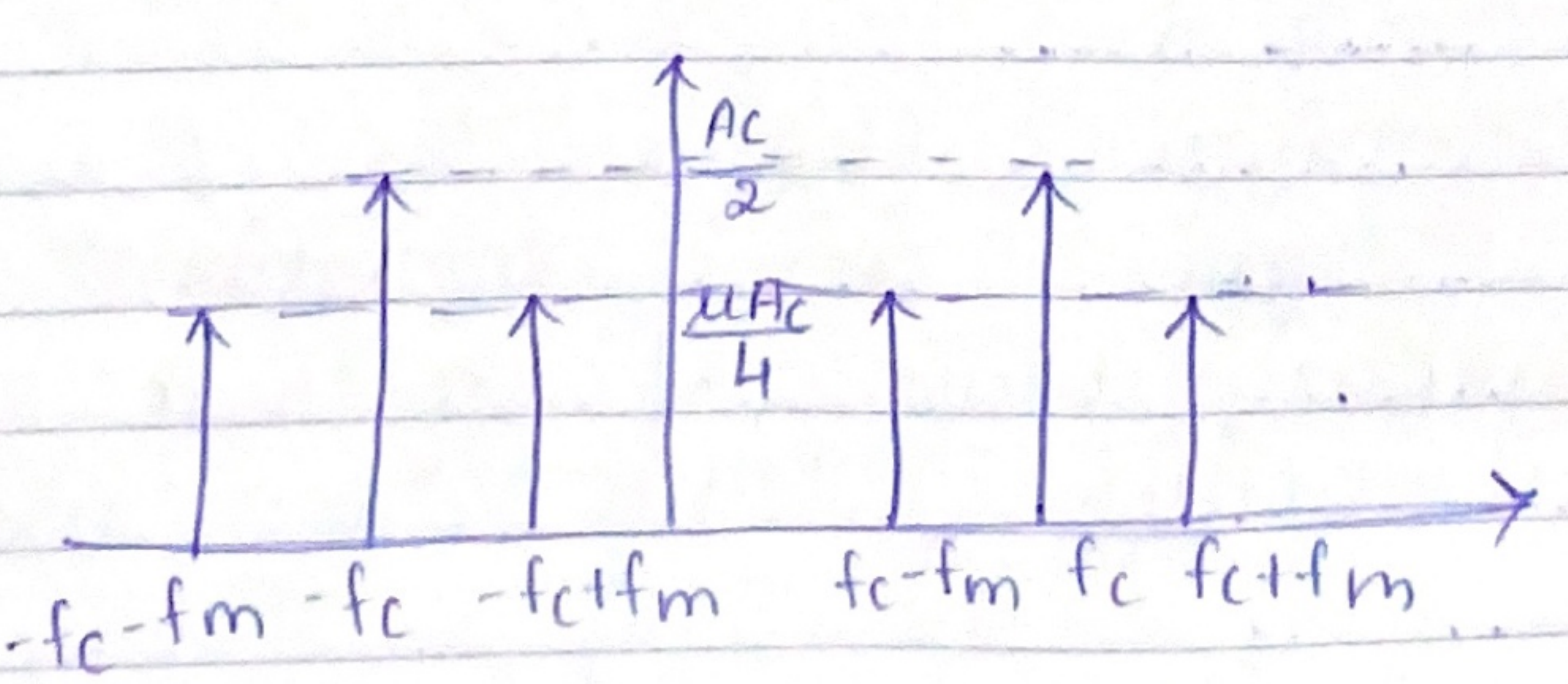
$= 50(0.64) = 32W$ //

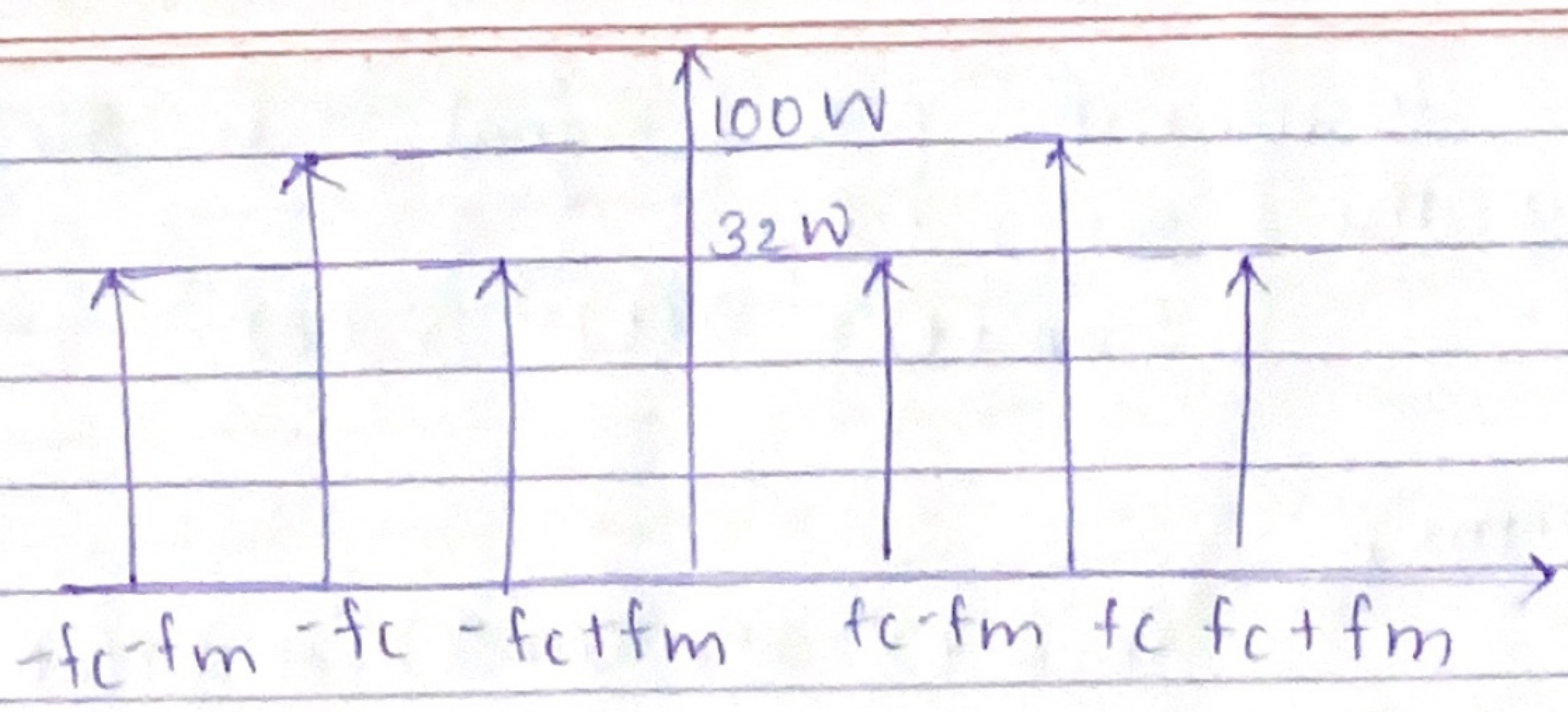
(c) Total power, $P_T = P_c\left(1 + \frac{\mu^2}{2}\right) = 100\left(1 + \frac{(0.8)^2}{2}\right) = 100\left(\frac{2+0.64}{2}\right)$

$= 50\left(\frac{2.62}{2}\right)$

$P_T = 132W$ //

(d)





(e)

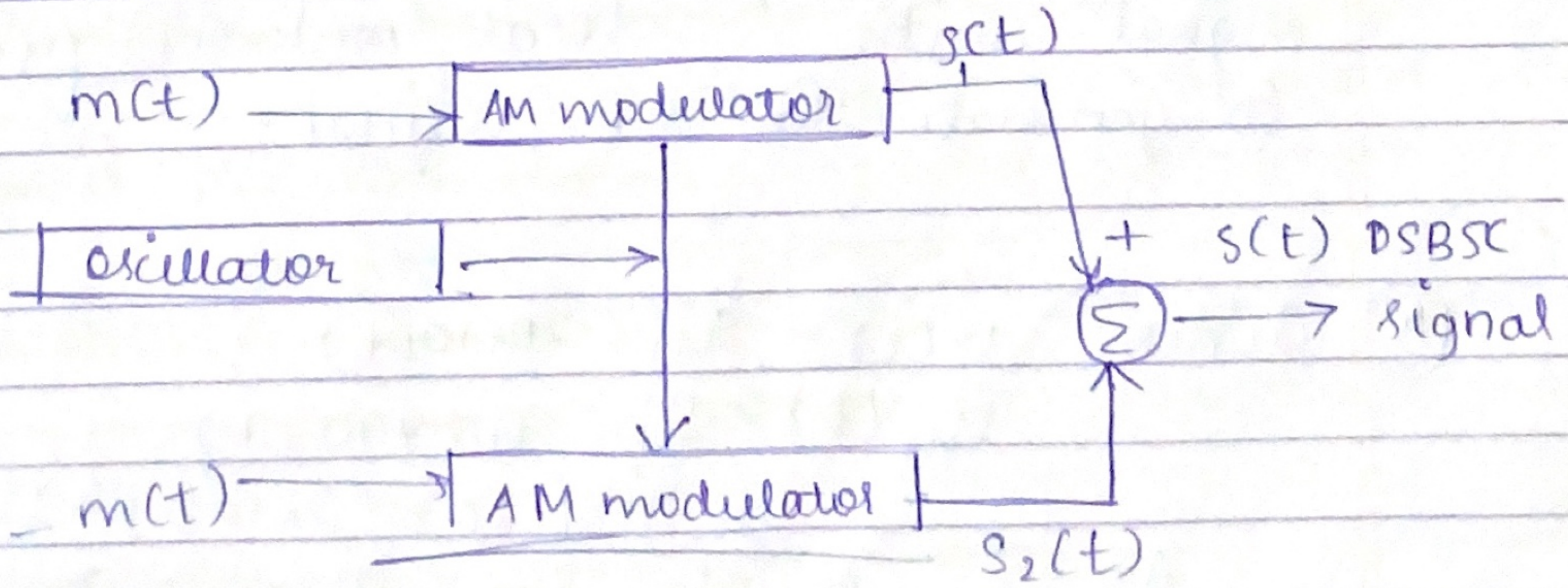
AM variants	Transmitted Power
DSBFC / DSBWC	$P_C + P_{LS} + P_{US} = 132W$
DSBSC	$P_{LS} + P_{US} = 32W$
SSB	$P_{LS} = P_{US} = 16W$
VSB	$P_{LB} + P_{UB} = 16 + P_{UB}$

The SSB uses the less power & the DSBFC uses the more power from the above table.

(8) Double sideband suppressed carrier (DSB-SC) modulⁿ, in which the transmition wave consists of only the upper & lower sideband. Transmitted power saved here thro' the suppression of the carrier wave, but the channel BW requiⁿ is the same as before.

$$= \frac{A_c}{2}\left[M(f-f_0) + M(f+f_0)\right]$$

Balanced modulator is used to generate the DSBSC.



$$S_1(t) = A_c(1 + K_a m(t))\cos(2\pi f_c t)$$
$$S_2(t) = A_c(1 - K_a m(t))\cos(2\pi f_c t)$$

The resultant DSB signal is the difference b/w the two, i.e

$$S_{DSB}(t) = S_1(t) - S_2(t)$$

Hence,

$$S_{DSB}(t) = 2A_c k_a m(t) \cos 2\pi f_c t$$

$$S_{DSB}(t) = A_c' m(t) \cos(2\pi f_c t)$$

(10) - Single Side band modulation is reflected to as "frequency changing" & In SSB modulation the carrier & one of the sidebands are suppressed.

- SSB modulation involves changing the frequency of the original signal. By suppressing one sideband & the carrier.

- The term 'mixing' is used, because SSB is often generated thro' a process called Heterodyning or mixing. Through appn filtering, one of these sidebands is selected; & the other components are discarded.

- Heterodyning is the process of mixing low frequencies to produce new frequencies In the content of SSB moduln, it refers to the mixing of the original signal with a local oscillator frequency to generate the SSB signal.

(11) Given $V_c(t) = \sin(2\pi + 100t)$

$V_m(t) = \sin(4\pi + 103t)$

$= \sin[(2\pi \times (2 \times 103)k)$

$A_c = 5$, $A_m = 1$, $f_m = 103 \times 2 = 206$, $f_c = 106$

$$\mu = \frac{A_m}{A_C} = \frac{1}{5} = 0.2$$

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

$$= 5\sin(2\pi f_c t) + 0.5\cos(2\pi(-100)t) - 0.5 (\sin(2\pi(312)t))$$

$$s(t) = 5\sin(2\pi f_c t) + 0.5\cos(2\pi(100)t) - \cos(2\pi 312 t)$$

(15) PAM

PWM

PPM

- Time slot representation: Fixed time period is divided into discreate.
- Pulse position variation: The position of a pulse within the determined by the amplitude of moduling signal.
- Signal Transmission: The modulated signal with vary pulse positions is transmitted thro' the commn channel.

Applications:

(a) Radar systems.
(b) Wireless comm.
(c) High Resolution data transmitted.

Advantages:

(a) Time precision:

(b) Resistance to channel distortion.

Limitations:

(a) Sensitivity to timing errors.
(b) Bandwidth utilization.

(21) $P_T = 10kW$

$\mu = 0.8$ same power

WKT

$$P_T = P_c\left(1 + \frac{\mu^2}{2}\right)$$

$$10\times10^3 = P_c\left(1 + \frac{0.64}{2}\right)$$

$$\frac{10\times10^3}{1.32} = P_c$$

$$P_c = 7.57\,kW.$$

$$P_B = P_{VB} = P_{LB} = \frac{A_c^2\mu^2}{8R_L} = \frac{7.57\times10^3\times(0.8)^2}{4}$$

$$= 1.21kW.$$

Now,

$$\eta = \frac{\mu^2}{2+\mu^2}\times100$$

$$\eta = \frac{0.64}{2.64}\times100 = 24.24\%$$

(22) $s(t) = 5\cos(6000\pi t) + 5\cos(8000\pi t) + 10\cos(10000\pi t)$

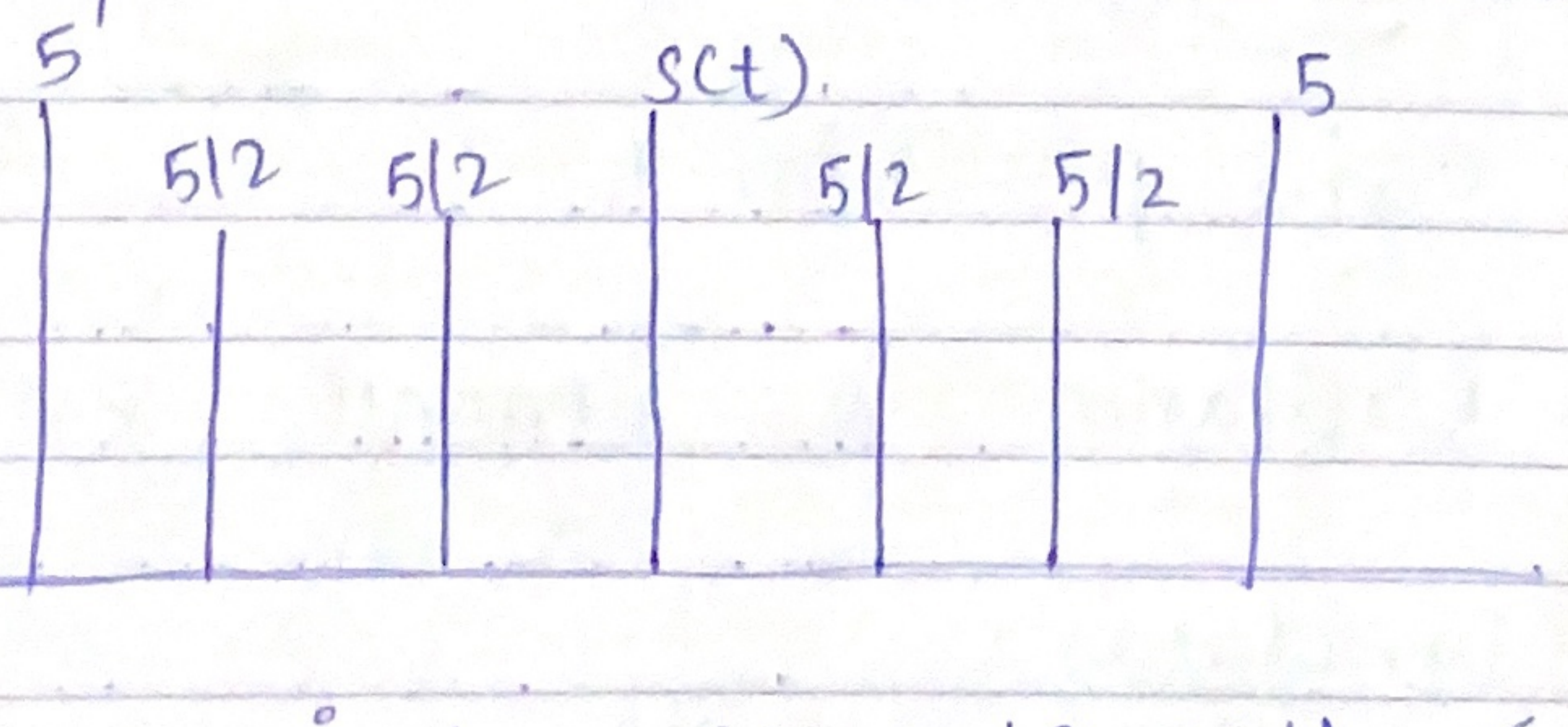
$= 5\cos(2\pi\cdot3000t) + 5\cos(2\pi\,4000t) + 10\cos(5000\,2\pi t)$

$= \frac{5}{2}\,\delta(f-3000) + \delta(f+3000) + \frac{5}{2}\,\delta(f-4000) + \delta(f+4000) + \frac{10}{2}(f-5000) + \delta(f+5000)$

$f_{nyquist} = 2\times\frac{W_{max}}{2\pi}$

(a) low pass signal : $2f_m$

band pass : $2\times BW$



low pass signal : $2f_m = 19000Hz.$

Band pass $= f_s = 2\times BW = 4000\,Hz$

(21) Given,

$$s(t) = 3\cos(50\pi t) + 10\sin(300\pi t) - \cos(100\pi t)$$

here consider,

(i) $f_{max} = 300\,Hz$.

(ii) $f_{nyquist} = 2 \times f_{max} = 2 \times 300 = 600\,Hz$

(iii) The recomended sampling freq $= 2 \times f_{nyquist}$
$= 2 \times 600$
$= 1200\,Hz.$

(12) $P_c = ?$, $P_{LSB} = ?$

$$P_T = P_c\left[1 + \frac{\mu^2}{2}\right]$$

$$10kW = P_c\left[1 + \frac{0.8^2}{2}\right]$$

$$P_c = 7.57kW.$$

$$P_{LSB} = P_{USB} = \frac{P_T - P_c}{2} = \frac{10k - 7.57k}{2} = 1.21k.$$

x ——— x ——— x