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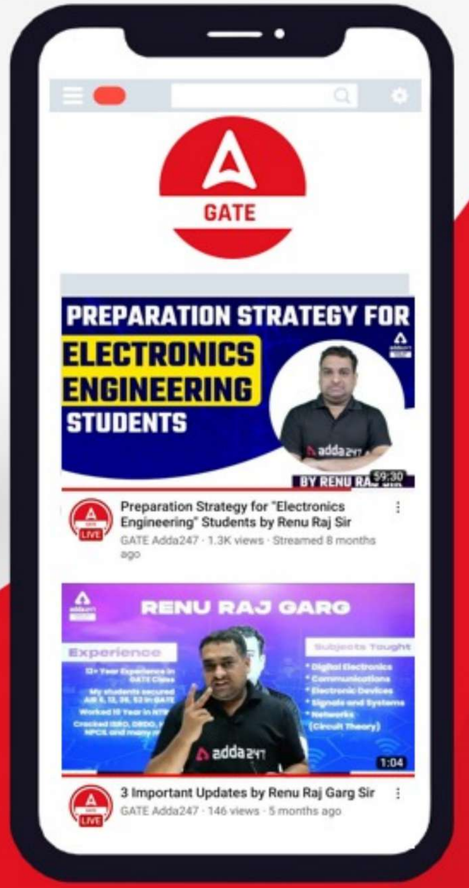
Renu Raj Garg
M.Tech (VLSI Design)
13 Year of Teaching Experience
Worked 10 Year in NTRO



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Communications (EC)

Syllabus of GATE-2023

1. **Random Processes**: Auto correlation and power spectral density, properties of white noise, filtering of random signals through LTI systems.
2. **Analog Communications**: Amplitude modulation and demodulation, angle modulation and demodulation, spectra of AM and FM, super heterodyne receivers.
3. **Information Theory:** Entropy, mutual information and channel capacity theorem.
4. **Digital Communications**: PCM, DPCM, digital modulation schemes (ASK, PSK, FSK, QAM), bandwidth, inter-symbol interference, MAP, ML detection, matched filter receiver, SNR and BER.
5. **Fundamentals of error correction:** Hamming codes, CRC.

Communications Weightage in Previous Year GATE Exam (EC)

SUBJECT	GATE 2012 100 Mark	GATE 2013 100 Mark	GATE 2014 100 Mark	GATE 2015 100 Mark	GATE 2016 100 Mark	GATE 2017 100 Mark	GATE 2018 100 Mark	GATE 2019 100 Mark	GATE 2020 100 Mark	GATE 2021 100 Mark	GATE 2022 100 Mark	GATE 2023 100 Mark	GATE 2024 100 Mark
Communication	9 Mark	9 Mark	10 Mark	8 Mark	9 Mark	9 Mark	11 Mark	10 Mark	9 Mark	13 Mark	13 Mark	12 Mark	13

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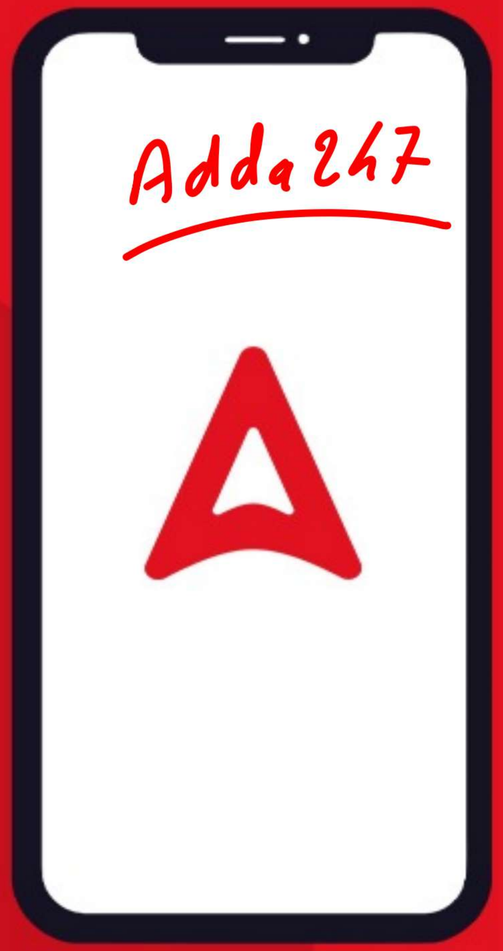
Chapter-1

Analog Communications

In today's lecture we will cover the following Topis :

1. *Different Types of Signals used in Communications*
2. *Different Types of Transmission Medium*
3. *Need of Modulation*
4. *Standard Modulation and Demodulation in AM*
5. *Types of Modulation Scheme (Amplitude and Angle Modulation)*
6. *Amplitude Modulation (DSB-SC)*
7. *Generation of AM Signal : Square Law Modulator*



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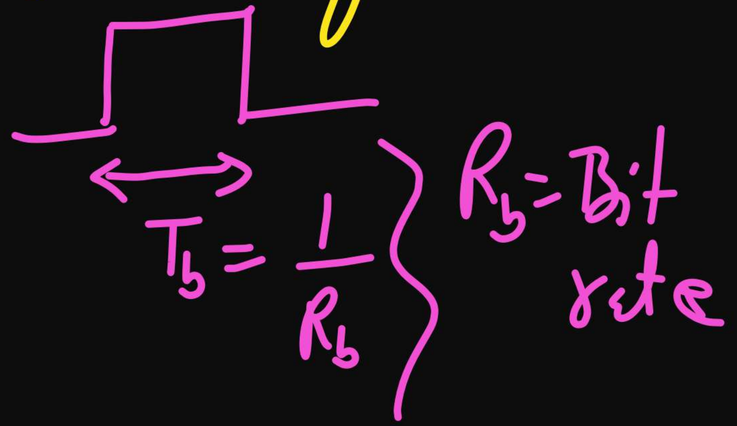
Different Types of Signals used in Communications :

(i) Voice signal (Speech signal) → Voice signal is a part of Audio signal.

(ii) Audio signal

(iii) Video signal

(iv) Data signal



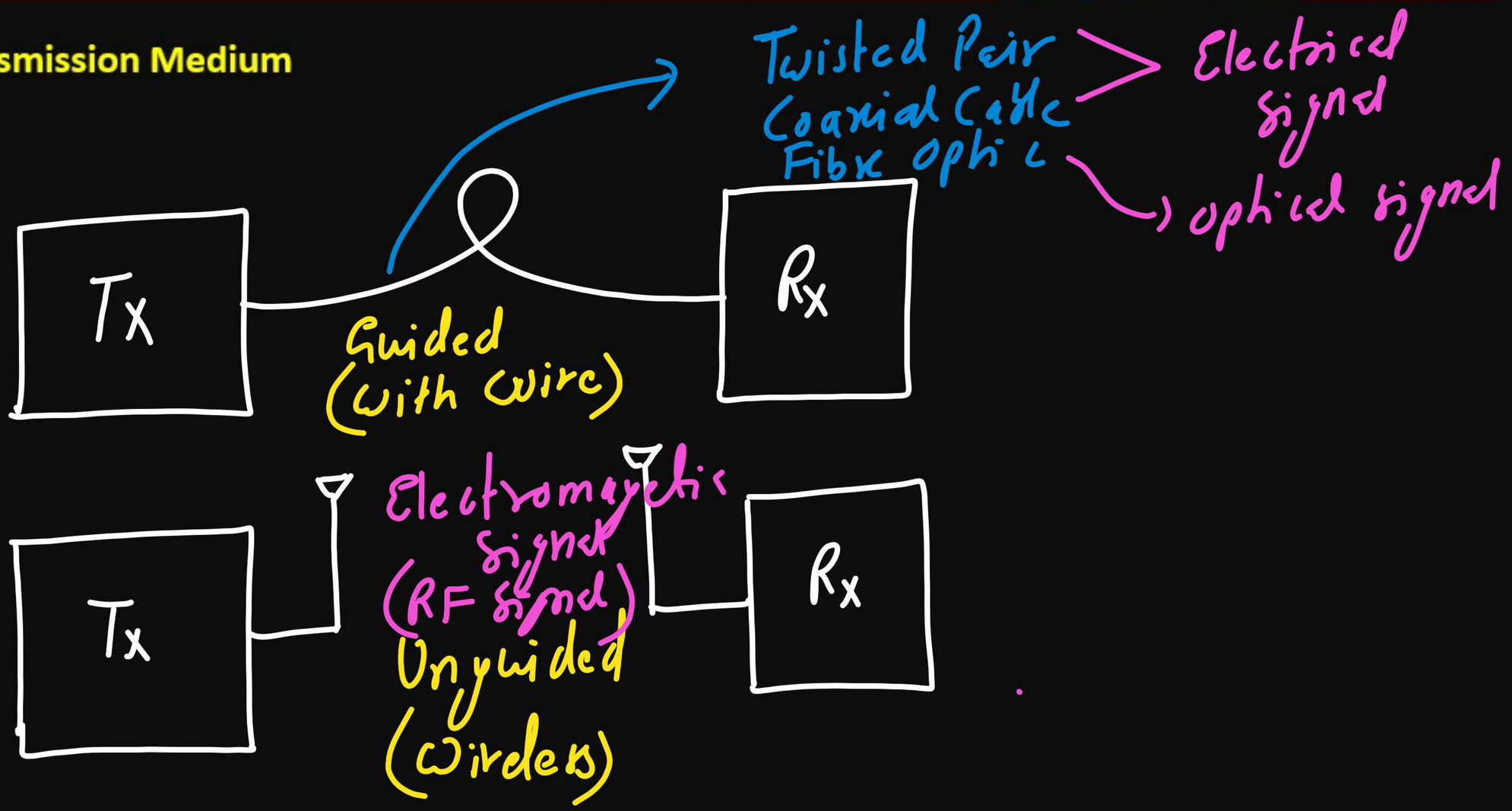
Voice signal range : 300Hz - 3.5KHz

Audio signal range : 20Hz - 20KHz

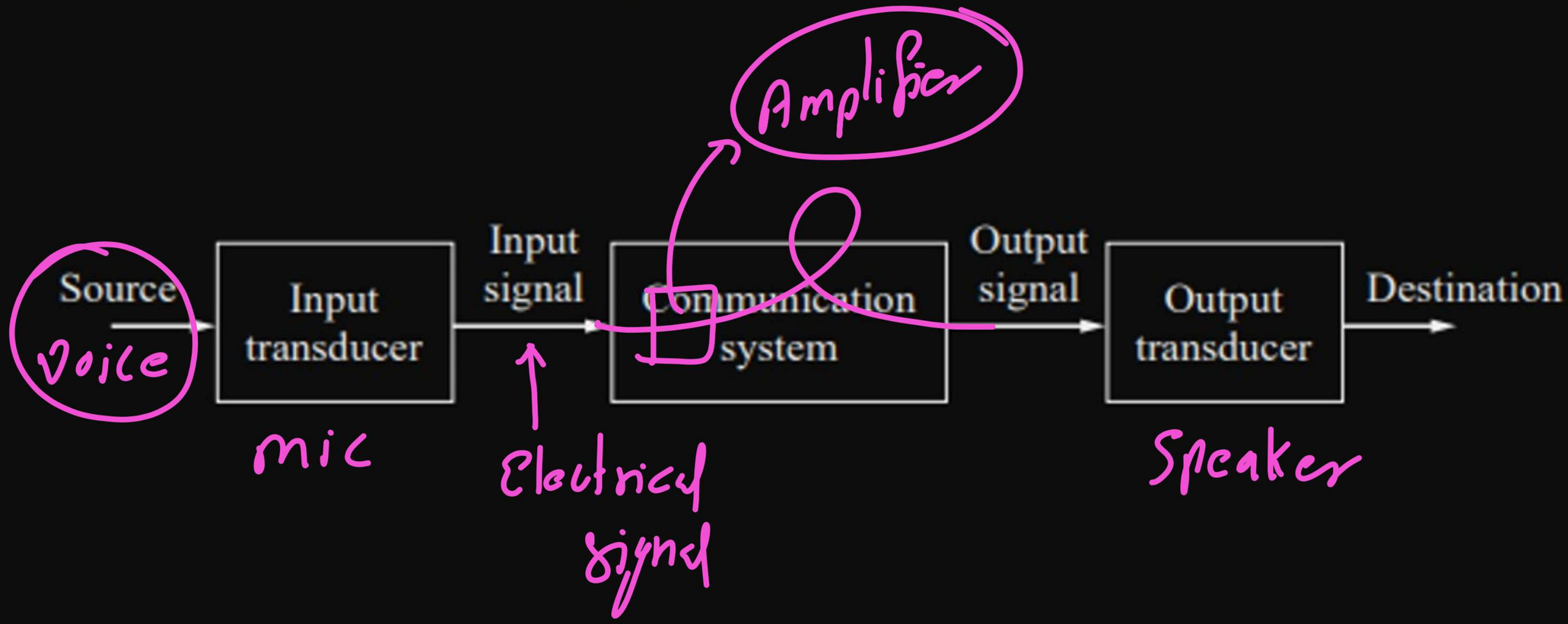
Video signal range : 0Hz - 4.5MHz

* Voice & Audio signal is not a part of Video signal.

Different Types of Transmission Medium

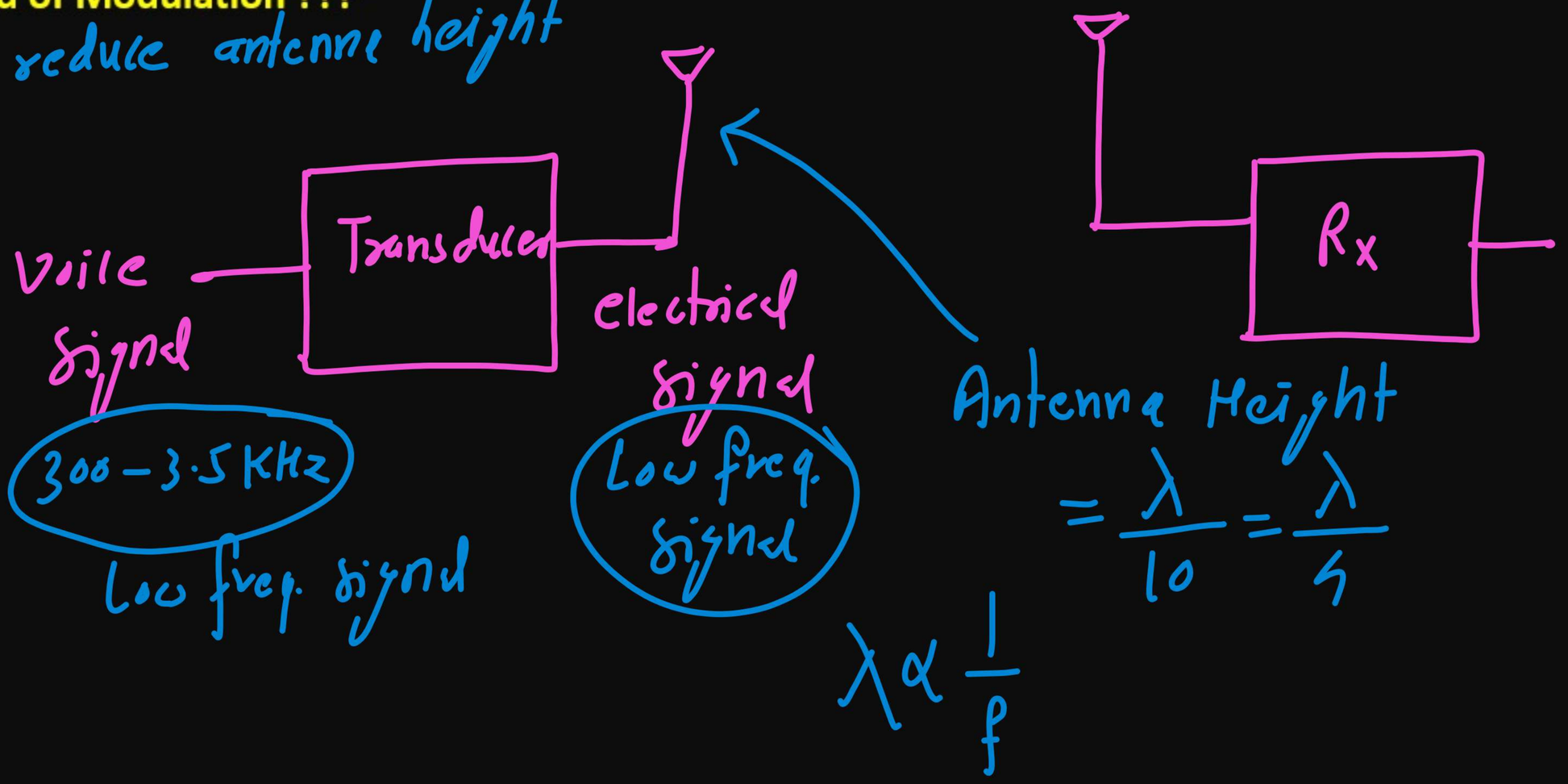


Block diagram of a Analog Communication System (with wire)



Need of Modulation ???

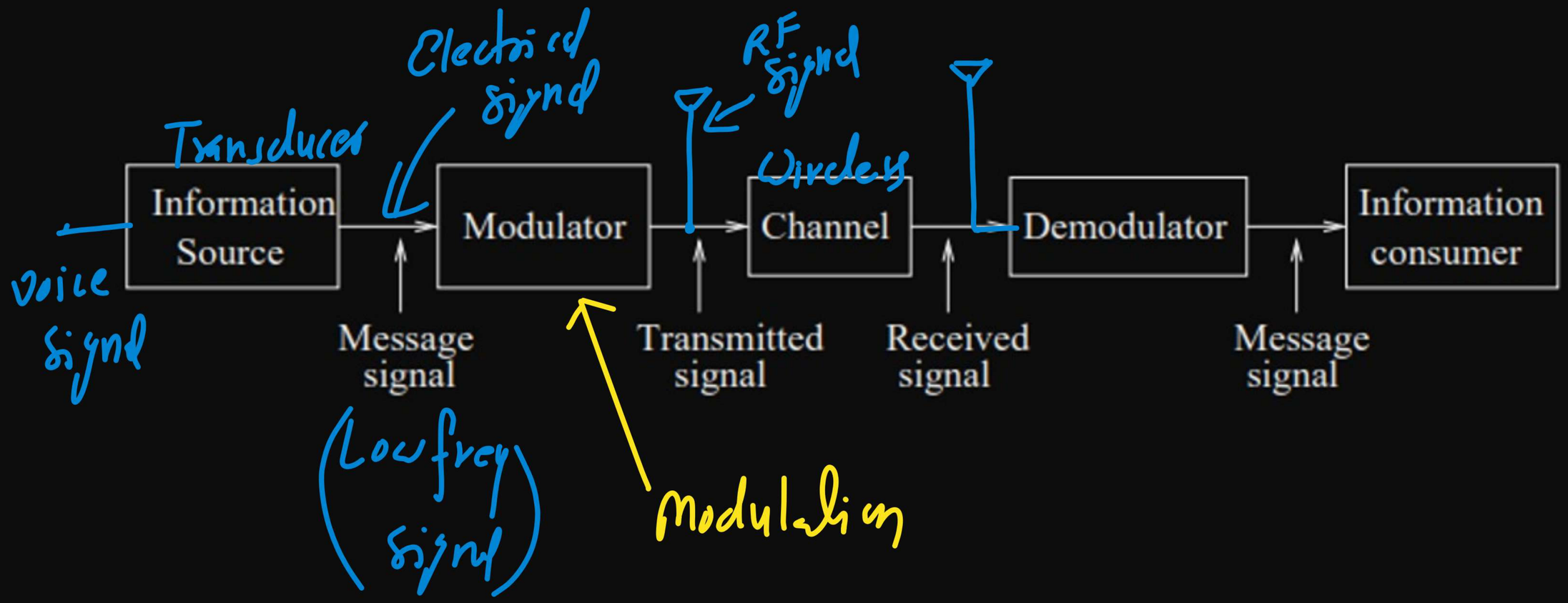
To reduce antenna height



$$= \frac{\lambda}{10} = \frac{\lambda}{4}$$

$$\lambda \propto \frac{1}{f}$$

Block diagram of a Analog Communication system (Wireless)

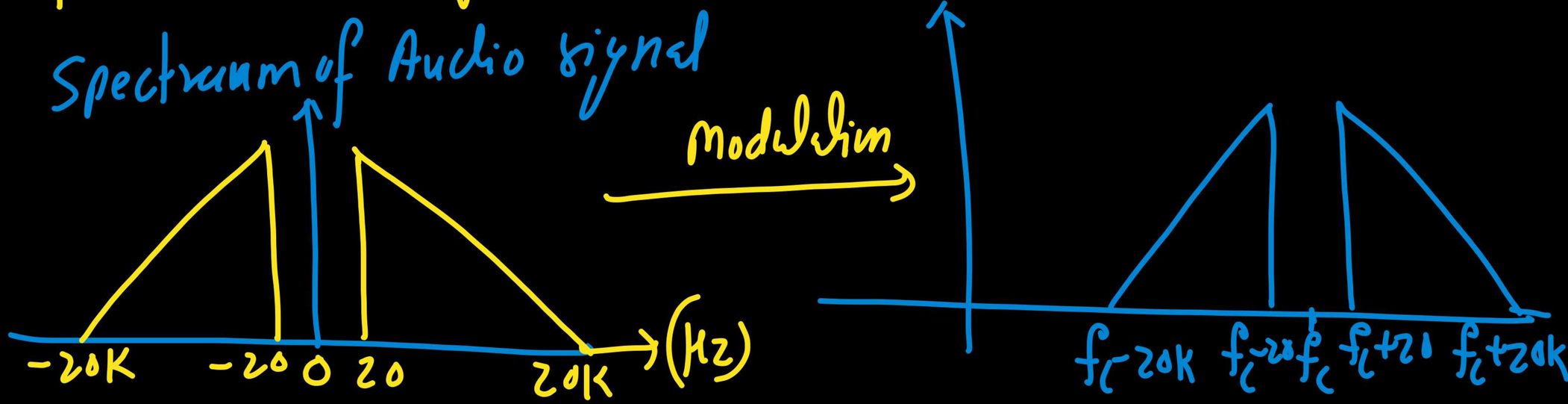


What is modulation?

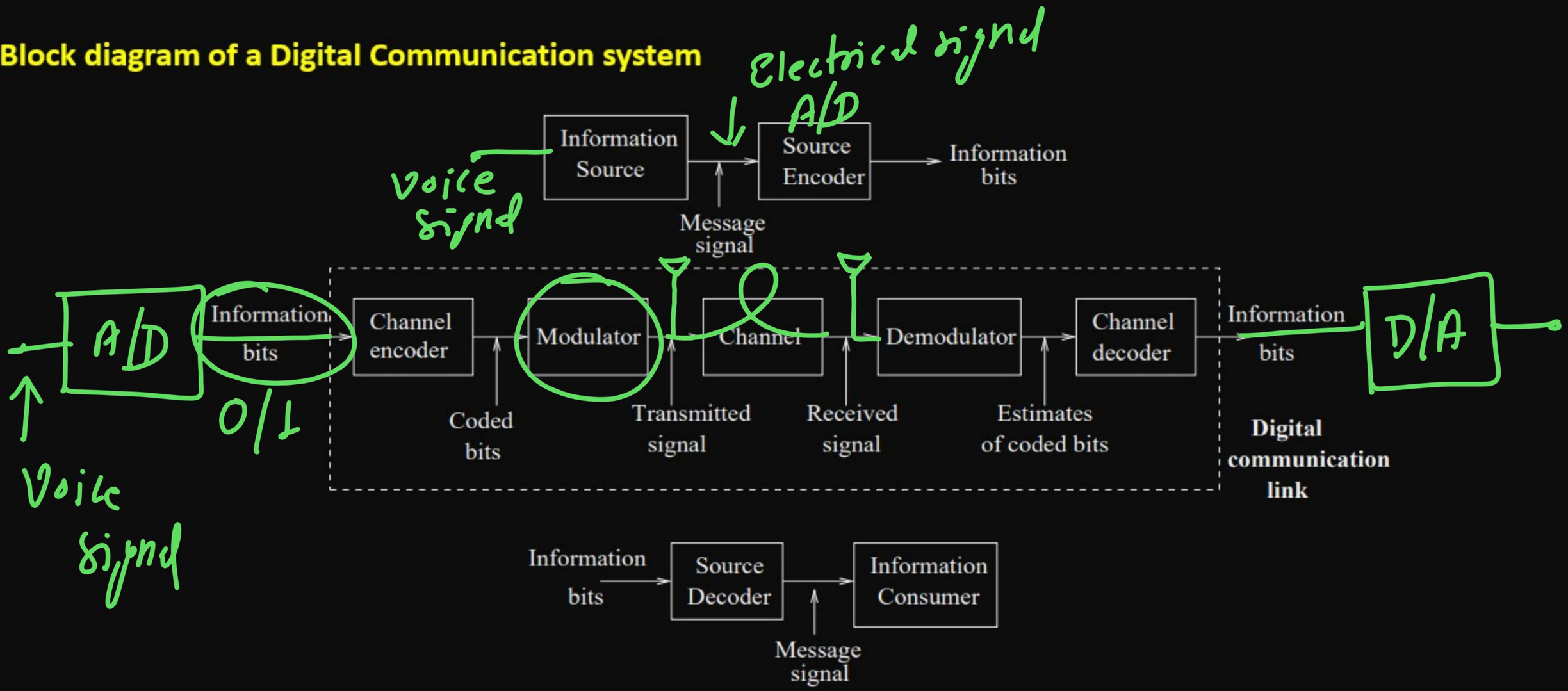
(i) Low freq. signal ⟶ High freq. signal

(ii) Electrical signal ⟶ RF signal (Electromagnetic signal)
(Msg signal)

(iii) freq. Translation from Low freq. to High Freq.



Block diagram of a Digital Communication system

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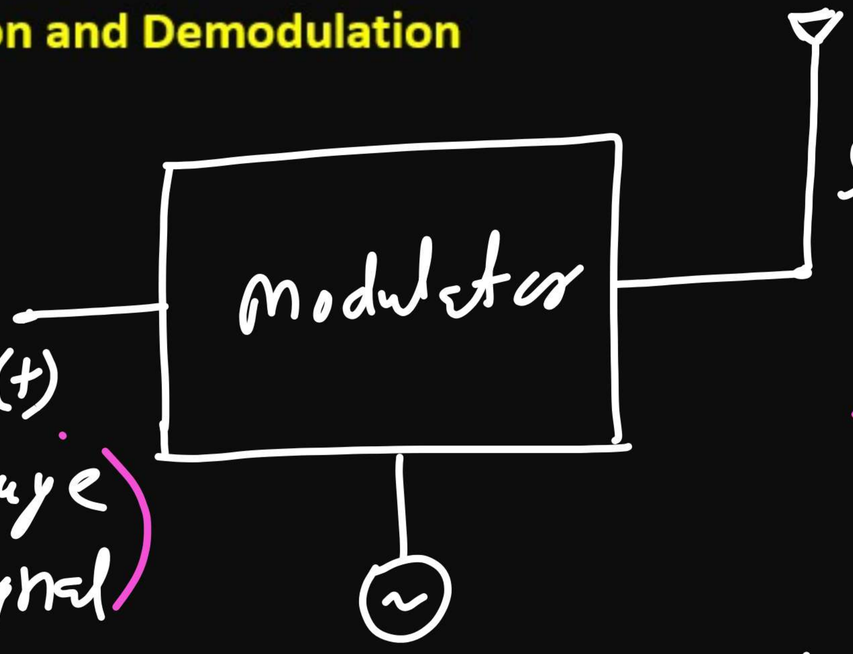
Standard Modulation and Demodulation



= Modulated Carrier signal

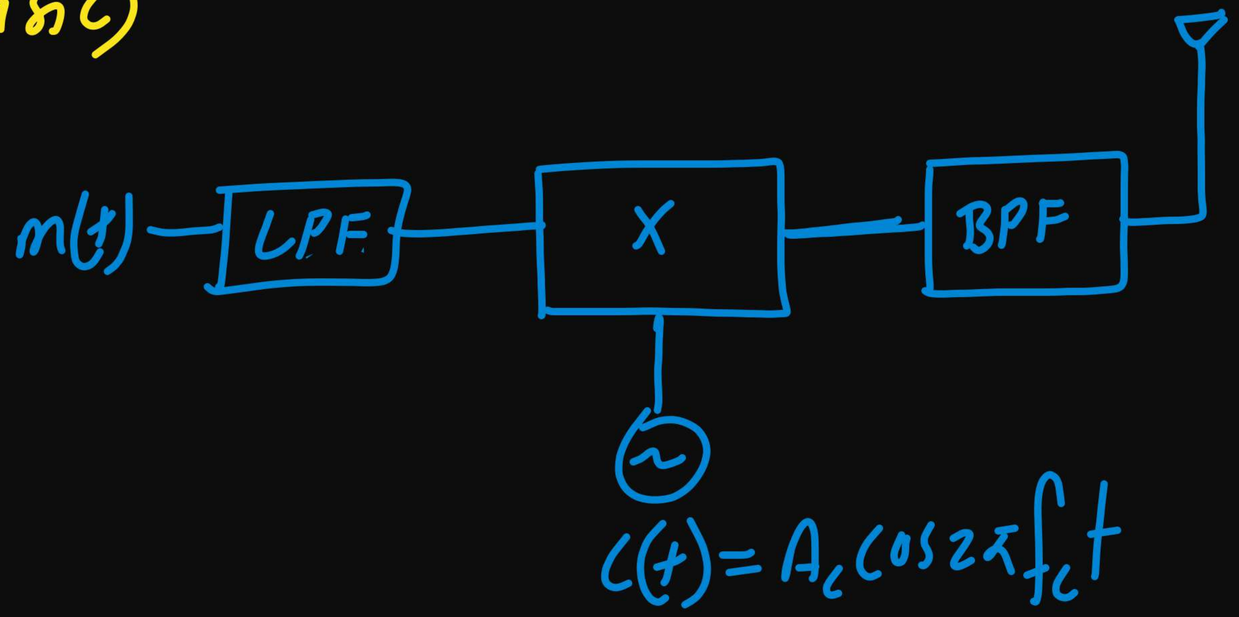
$s(t)$ = modulated signal

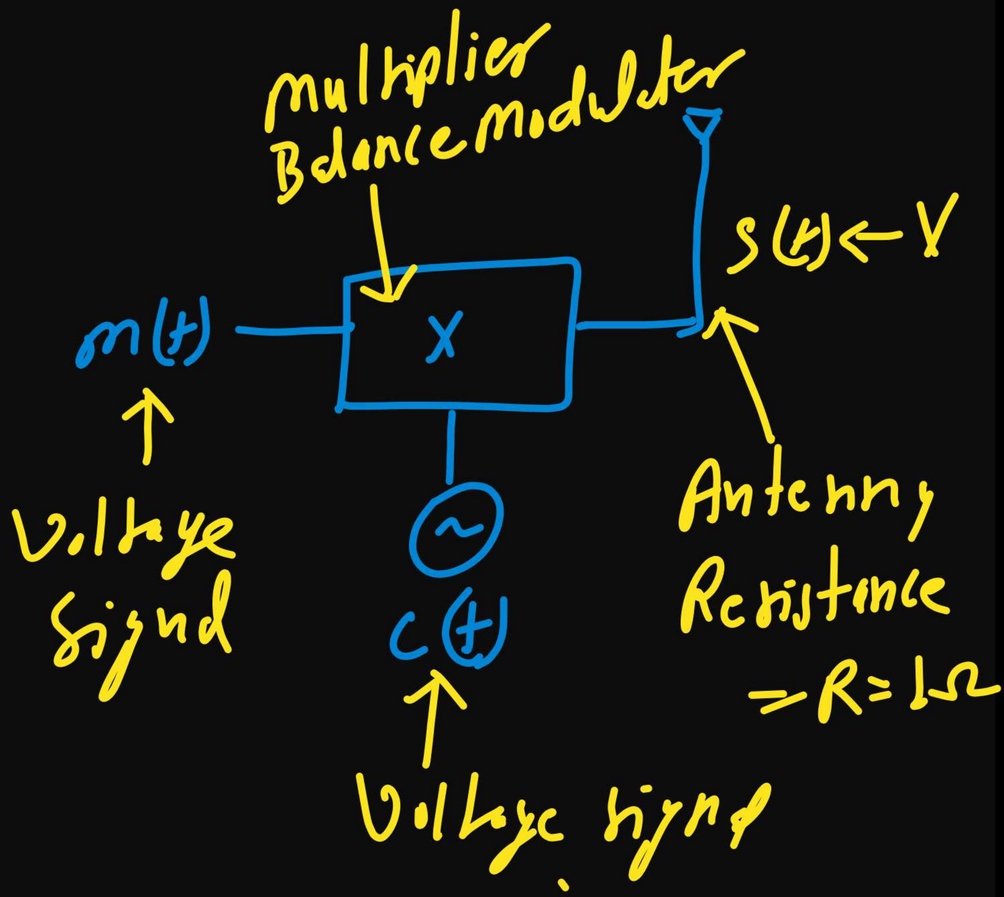
if $m(t) = 0$

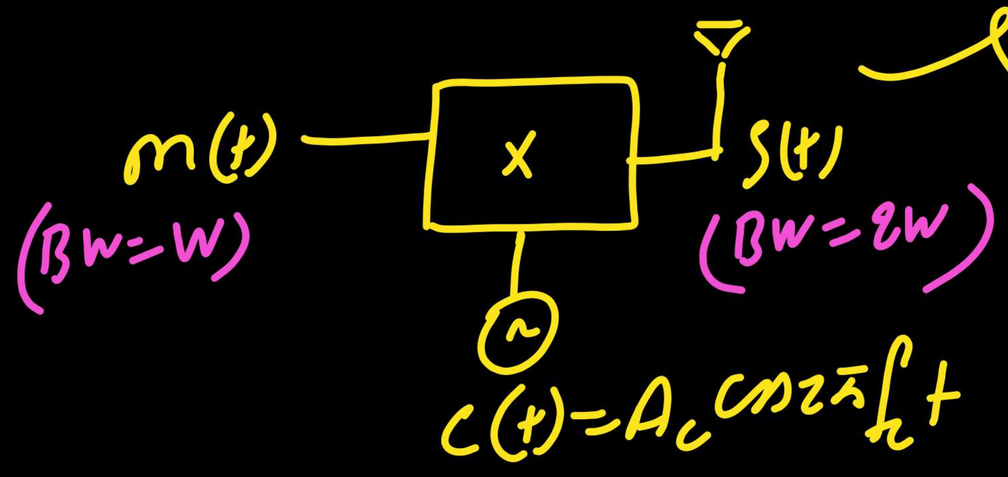
$s(t) = c(t)$ = Unmodulated Carrier signal

Standard Modulation and Demodulation (cont..)

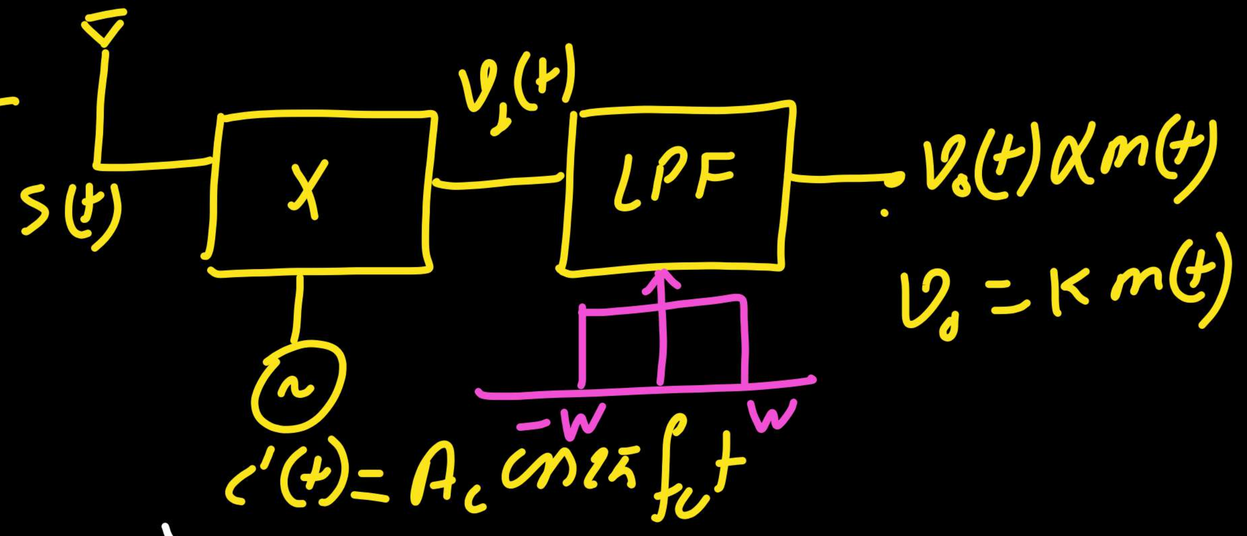
(Basic)



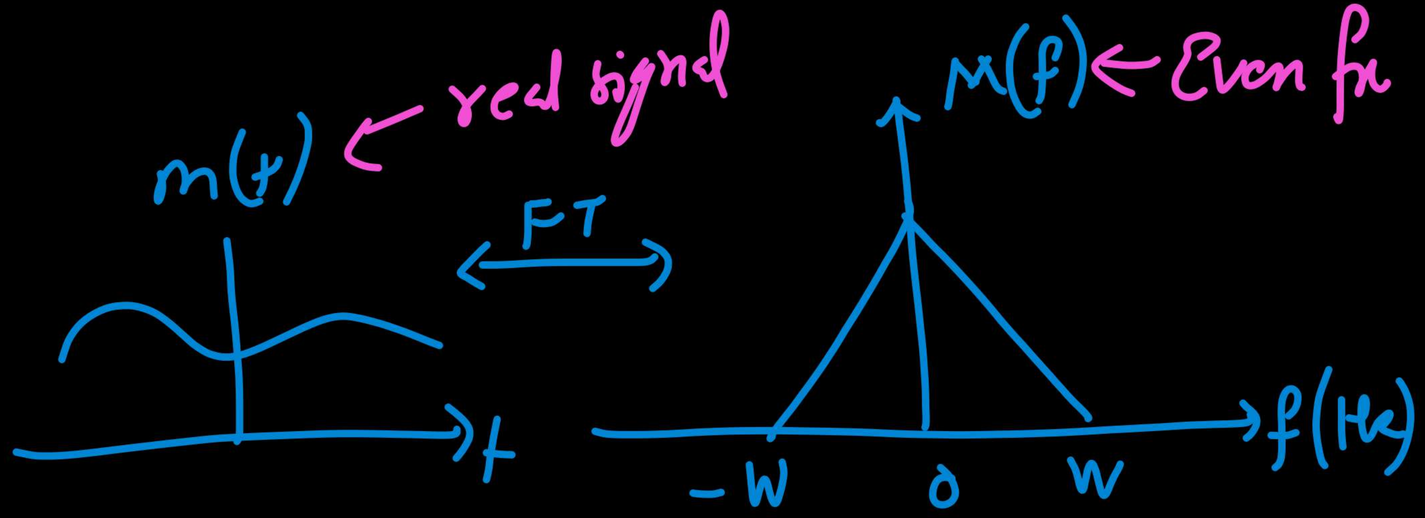




Basic modulator



Basic demodulator



$m(t)$

$C(t) = A_c \cos 2\pi f_c t$

$S(t) = m(t) \cdot A_c \cos 2\pi f_c t$

Prop. of F-T:

$$x(t) \longrightarrow X(f)$$

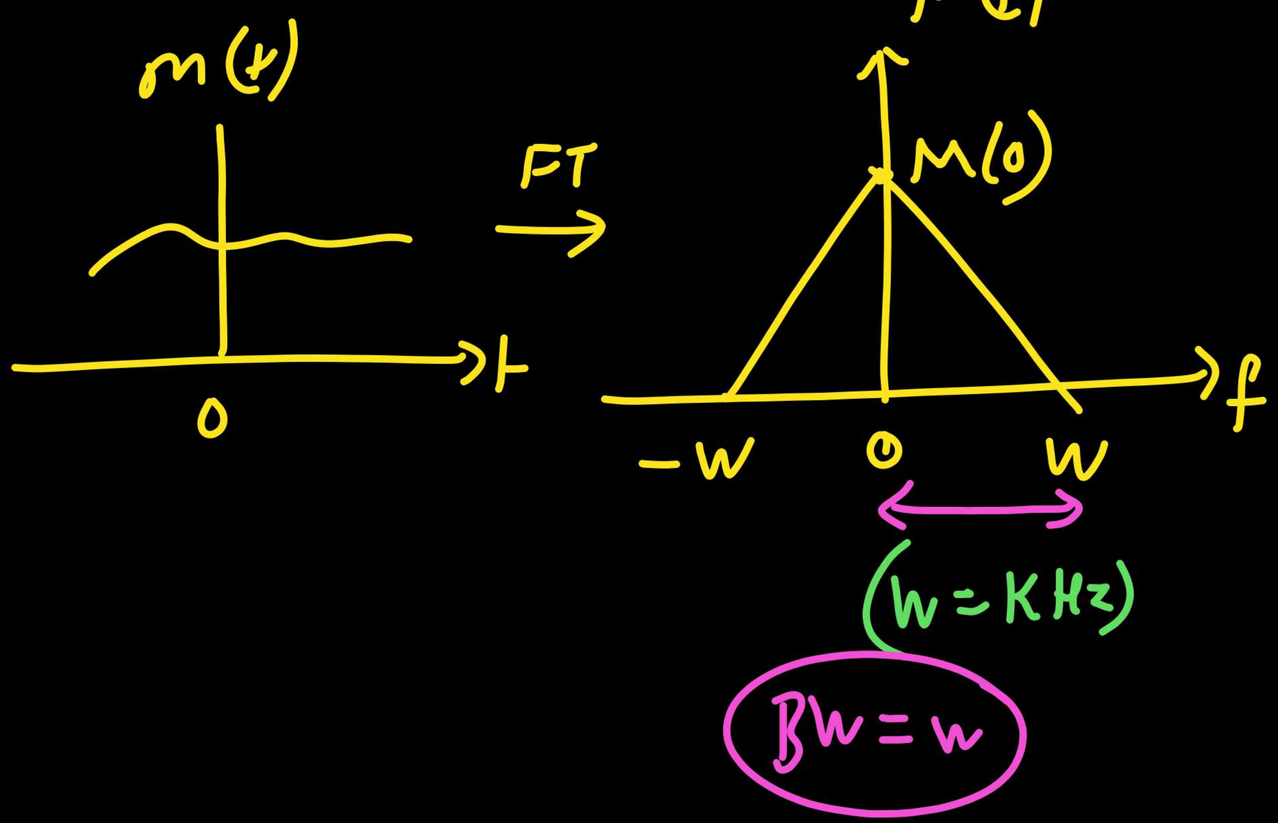
$$x(t)\cos 2\pi f_c t \longrightarrow \frac{1}{2}\left[X(f-f_c) + X(f-f_c)\right]$$

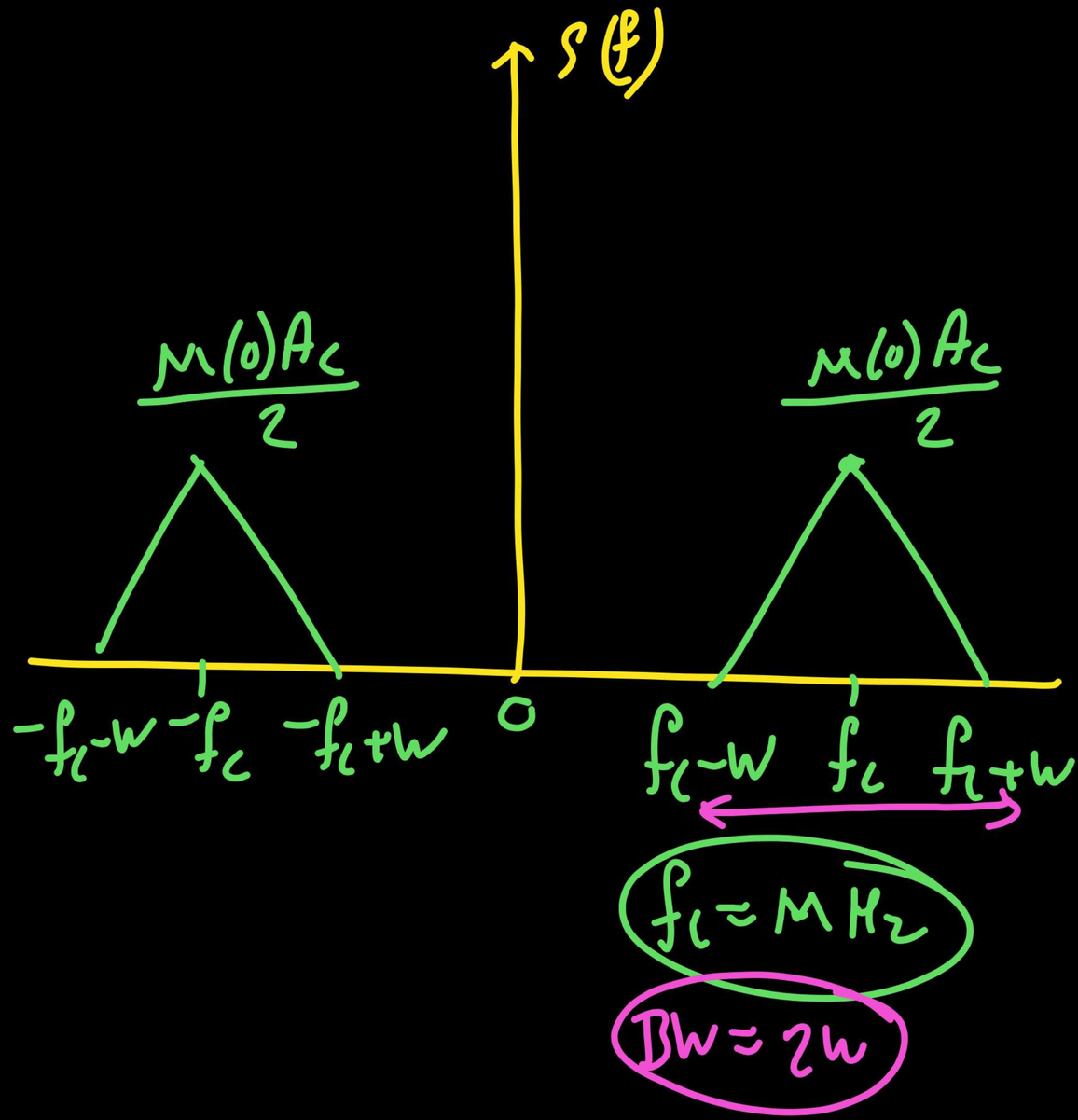
$$\Rightarrow x(t)\cdot\left[\frac{e^{j2\pi f_c t} + e^{-j2\pi f_c t}}{2}\right]$$

$$\Rightarrow \frac{1}{2}x(t)e^{j2\pi f_c t} + \frac{1}{2}x(t)e^{-j2\pi f_c t} \longrightarrow \frac{1}{2}X(f-f_c) + \frac{1}{2}X(f+f_c)$$

$$s(t) = A_c\, m(t) \cos 2\pi f_c t$$

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





After demodulation

$$v_1(t) = s(t) \cdot A_c \cos 2\pi f_c t$$

$$= A_c m(t) \cos 2\pi f_c t \cdot A_c \cos 2\pi f_c t$$

$$= A_c^2 m(t) \left[\frac{1 + \cos 2\pi \cdot 2f_c t}{2} \right]$$

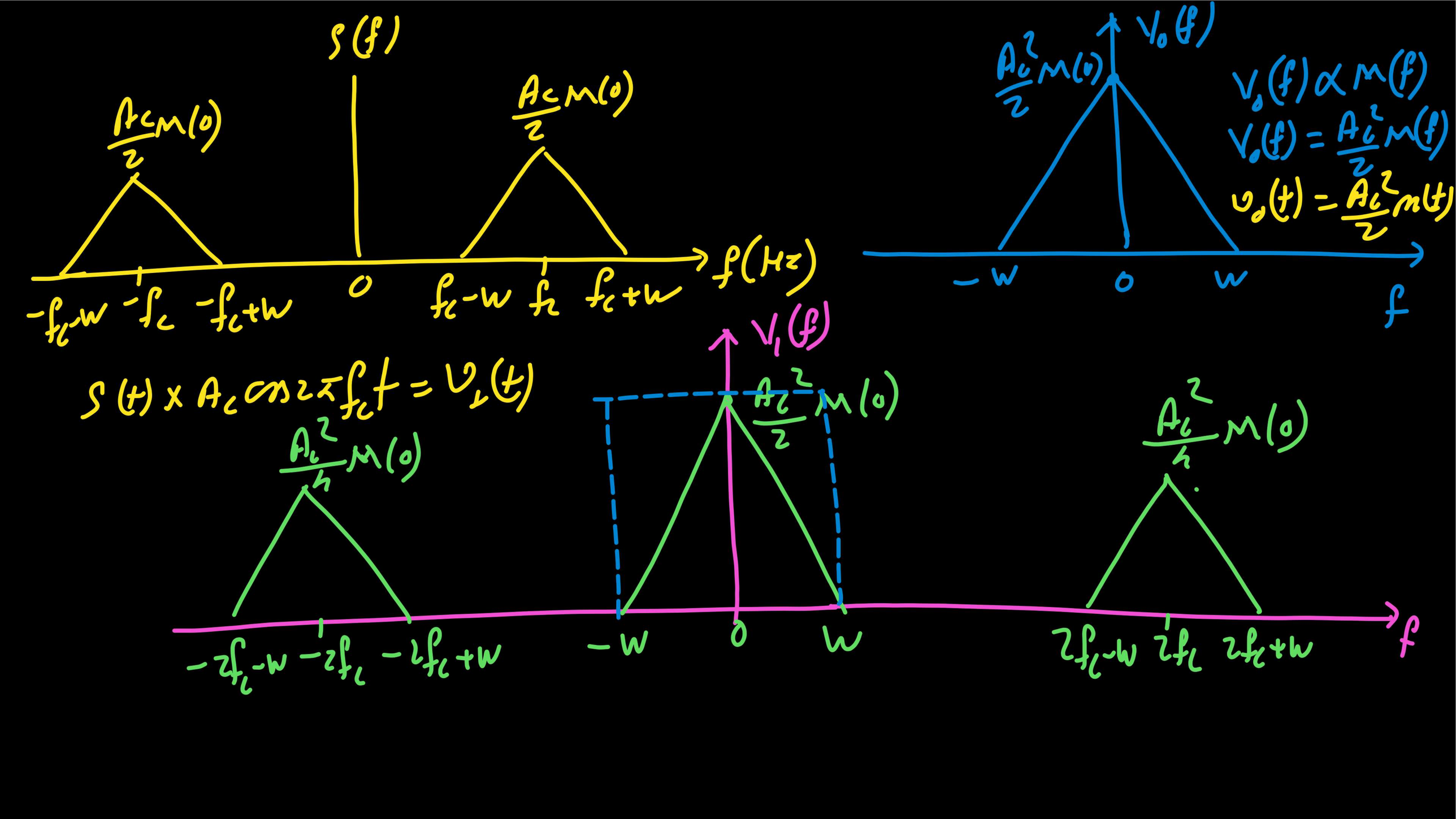
$$v_1(t) = \frac{A_c^2}{2} m(t) + \frac{A_c^2}{2} m(t) \cdot \cos 2\pi \cdot 2f_c t$$

$\frac{A_c^2}{2} m(t)$ ~ $\times$

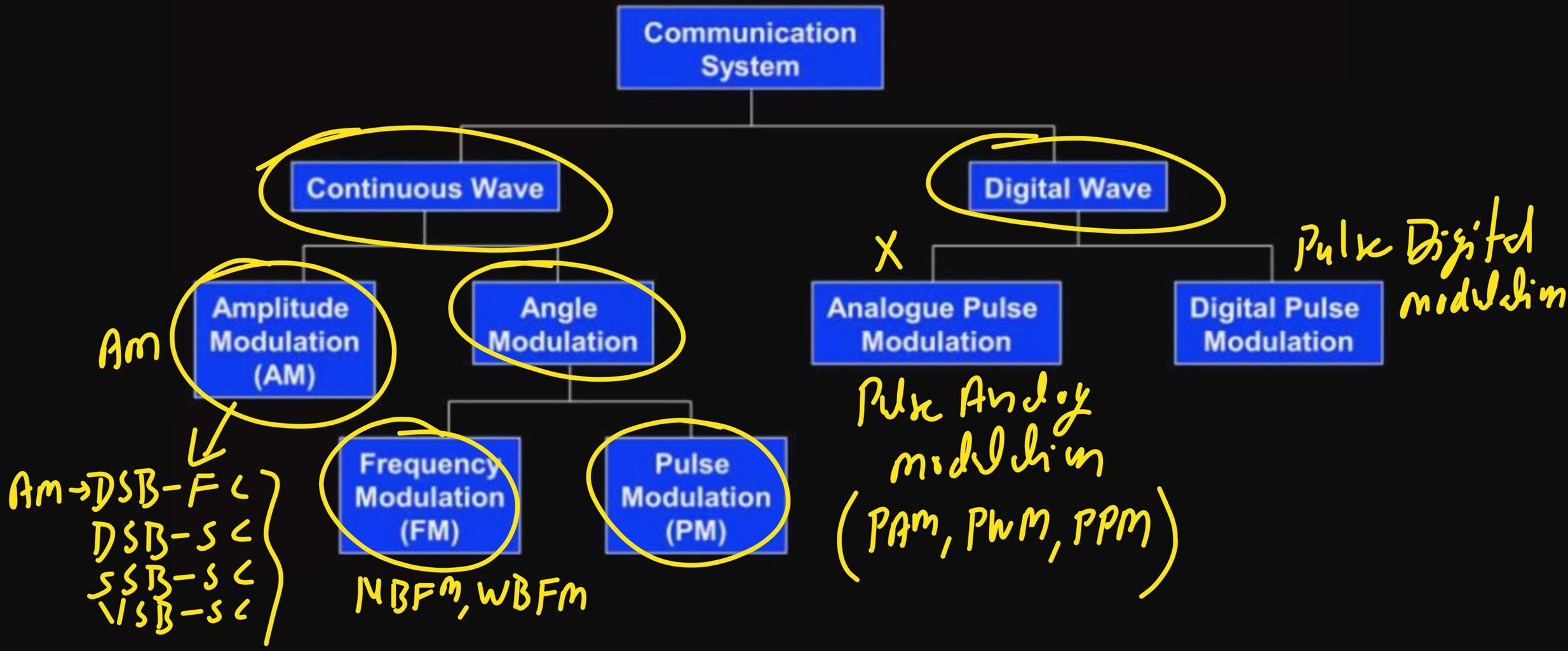
$\downarrow$ LPF

$$v_0(t) = \frac{A_c^2}{2} m(t)$$

$$v_0(t) \propto m(t)$$


S(f)
$\frac{A_c M(0)}{2}$
$\frac{A_c M(0)}{2}$
$-f_c-w$ $-f_c$ $-f_c+w$ 0 f_c-w f_c f_c+w
f(Hz)
$V_0(f)$
$\frac{A_c^2 M(0)}{2}$
$V_0(f) \propto M(f)$
$V_0(f) = \frac{A_c^2}{2} M(f)$
$v_0(t) = \frac{A_c^2}{2} m(t)$
$-w$ 0 w
f
$s(t) \times A_c \cos 2\pi f_c t = v_1(t)$
$V_1(f)$
$\frac{A_c^2}{4} M(0)$
$\frac{A_c^2}{2} M(0)$
$\frac{A_c^2}{4} M(0)$
$-2f_c-w$ $-2f_c$ $-2f_c+w$ $-w$ 0 w $2f_c-w$ $2f_c$ $2f_c+w$
f

Different Types of Modulation Scheme



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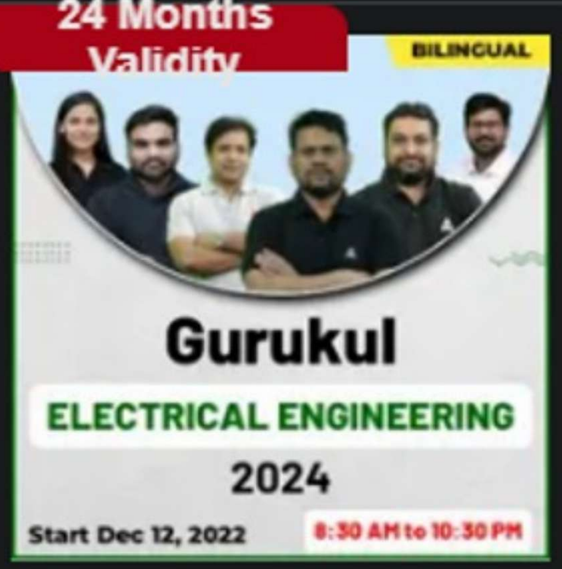

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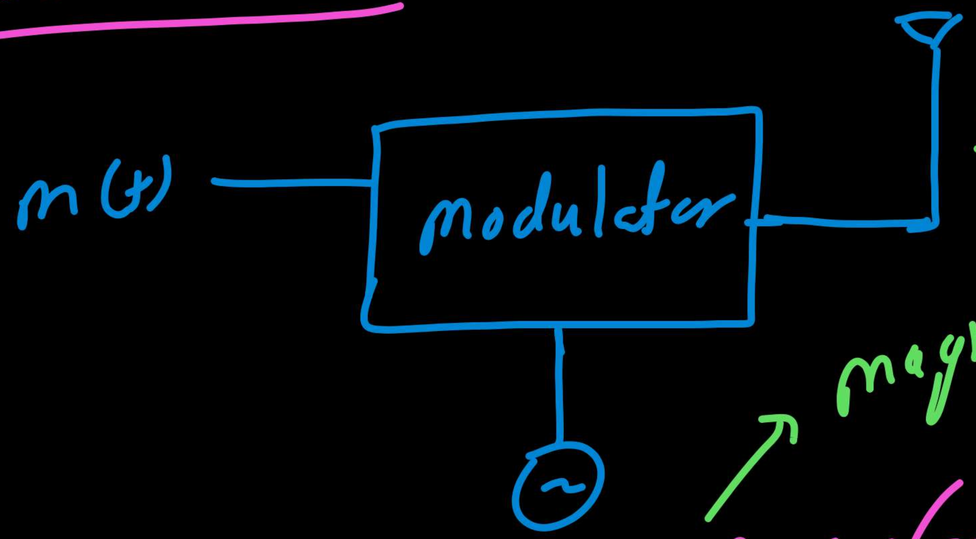
Specific Modulation:



AM
FM
PM
] Angle Modⁿ
AM + FM
AM + PM
FM + PM
AM + FM + PM
}

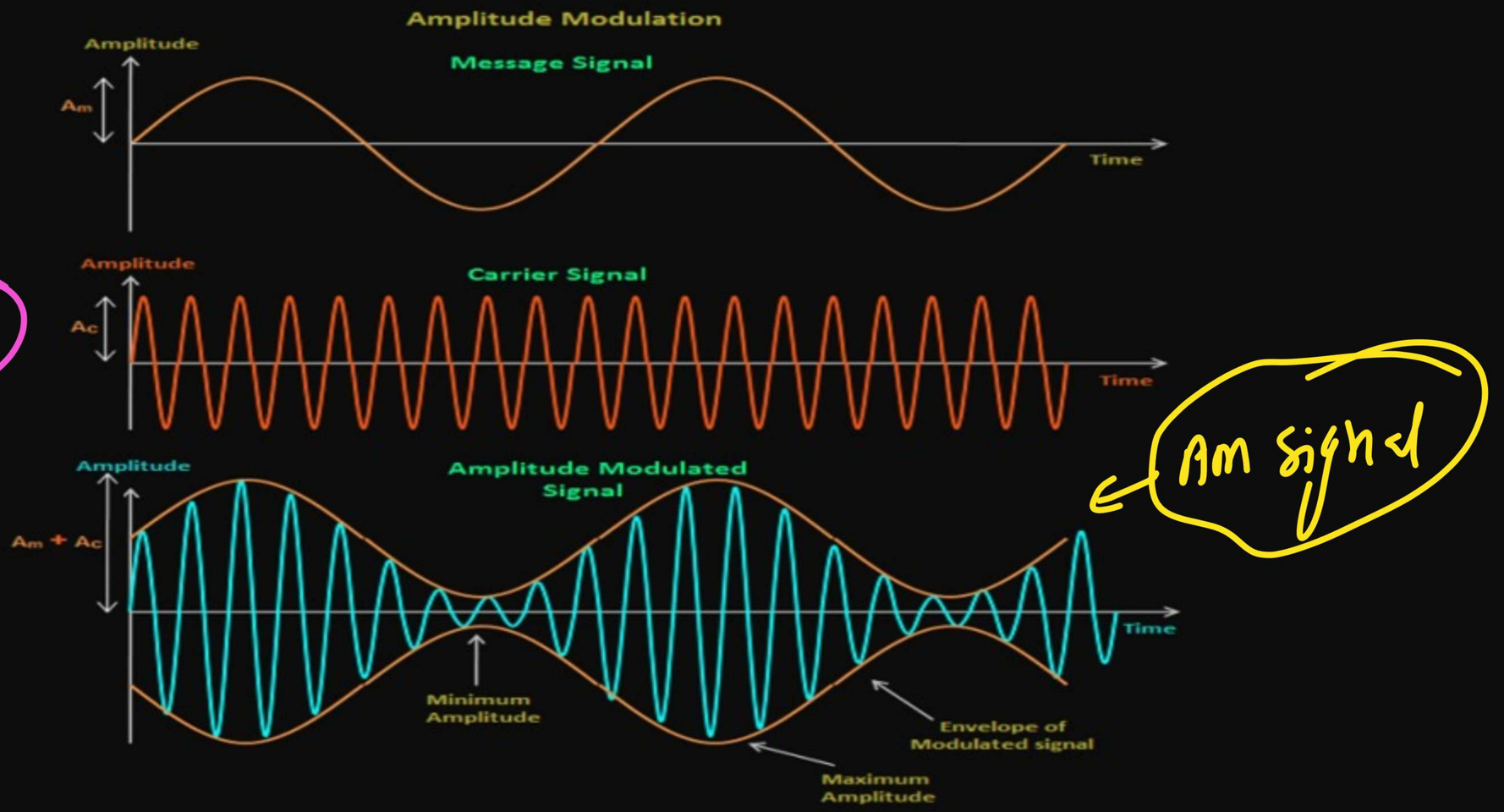
$$c(t) = A_c \cos(2\pi f_c t + \phi)$$

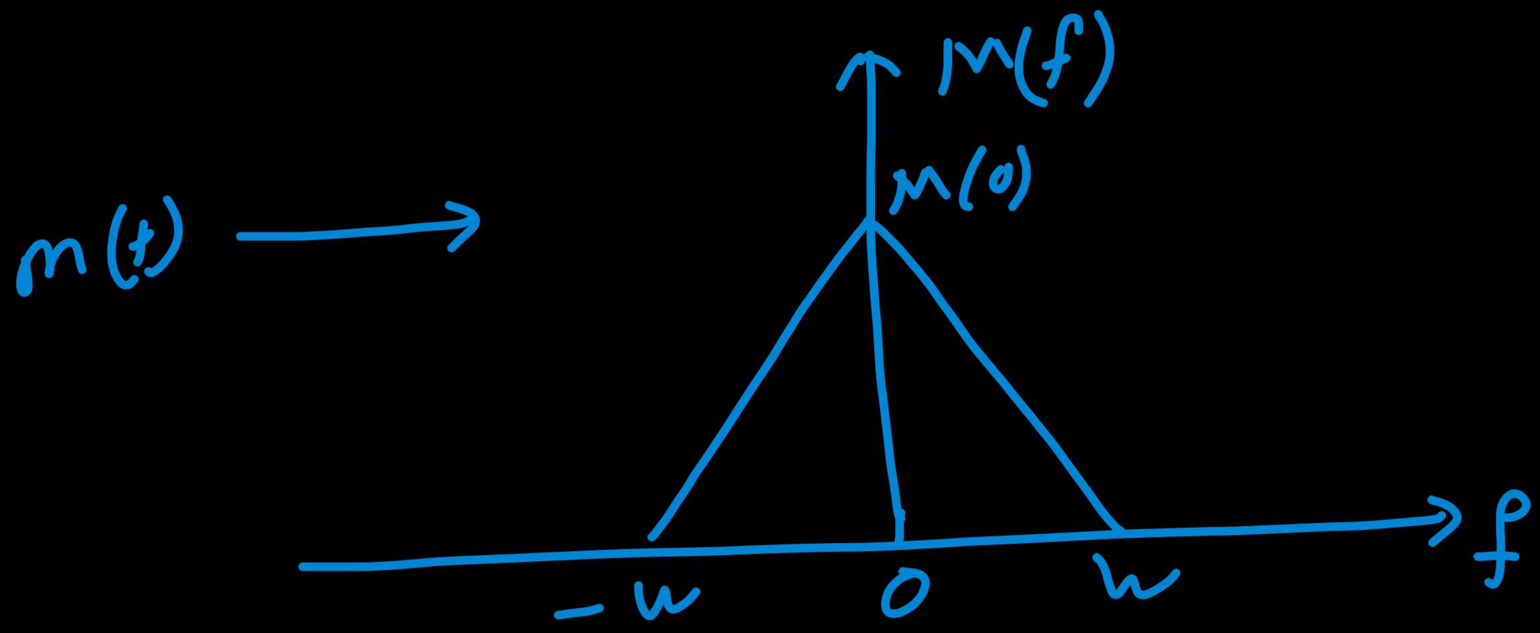
magnitude, 0, phase, freq.

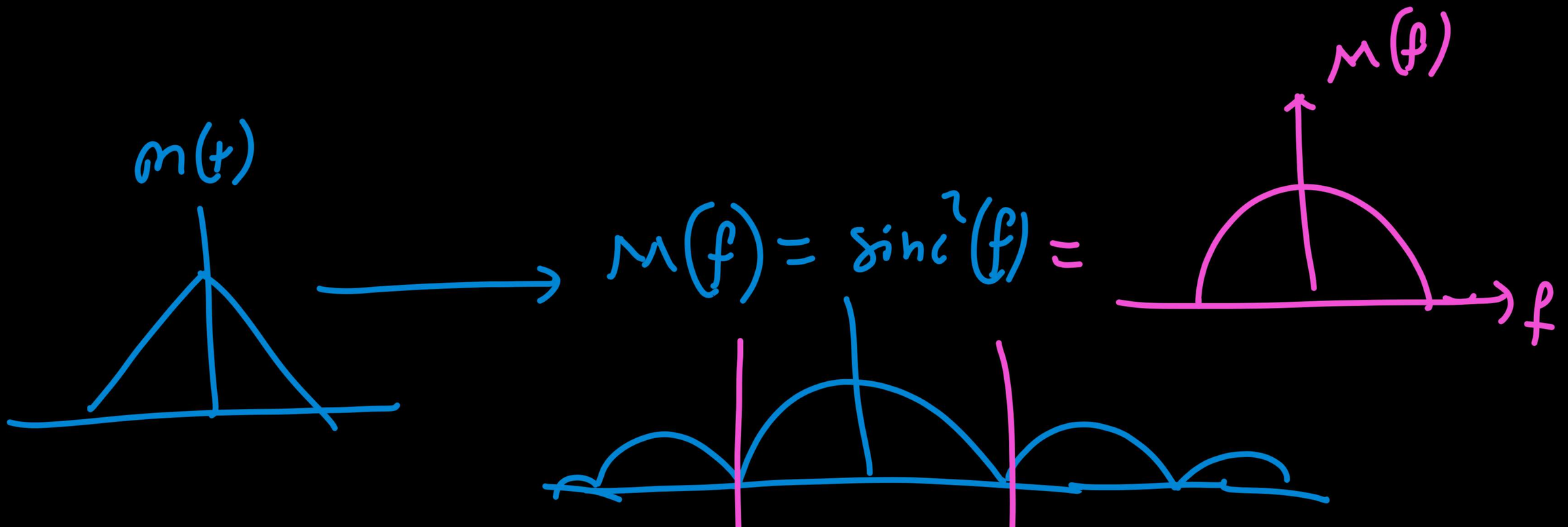
$$= A_c \cos \theta(t)$$

Amplitude, Angle

Amplitude Modulation (AM), Double Side Band-Full Carrier (DSB-FC)




m(t)
M(f)
M(0)
-W
0
W
f


m(t)
M(f) = sinc²(f) =
M(f)
f

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