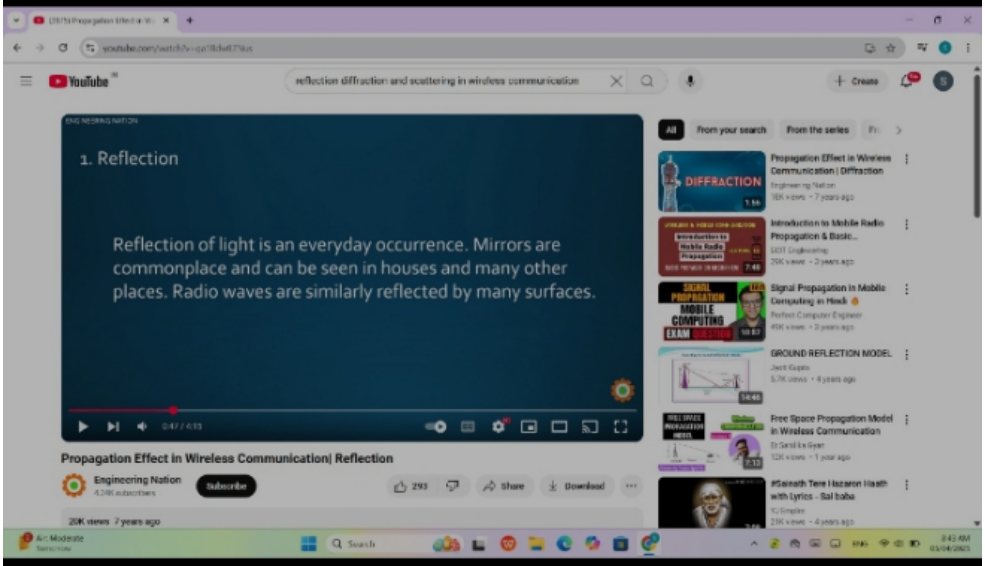
reflection diffraction and scattering in wireless communication
1. Reflection
Reflection of light is an everyday occurrence. Mirrors are commonplace and can be seen in houses and many other places. Radio waves are similarly reflected by many surfaces.
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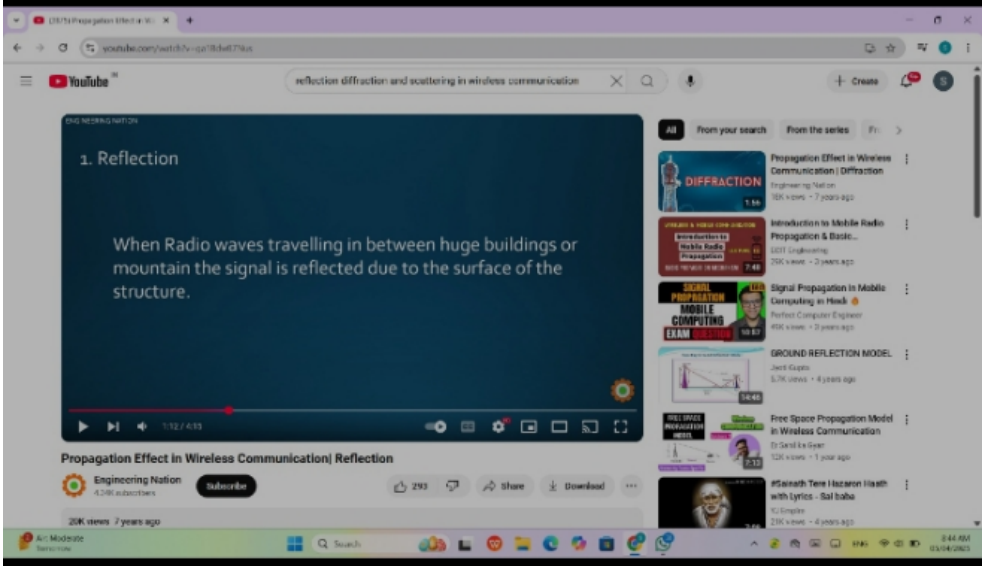
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1. Reflection
When Radio waves travelling in between huge buildings or mountain the signal is reflected due to the surface of the structure.
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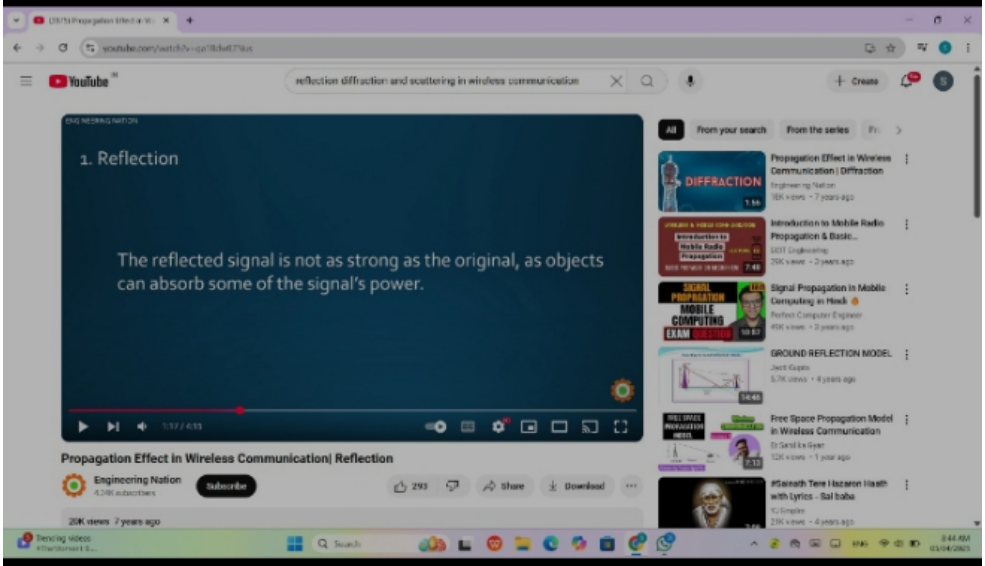
reflection diffraction and scattering in wireless communication
1. Reflection
The reflected signal is not as strong as the original, as objects can absorb some of the signal's power.
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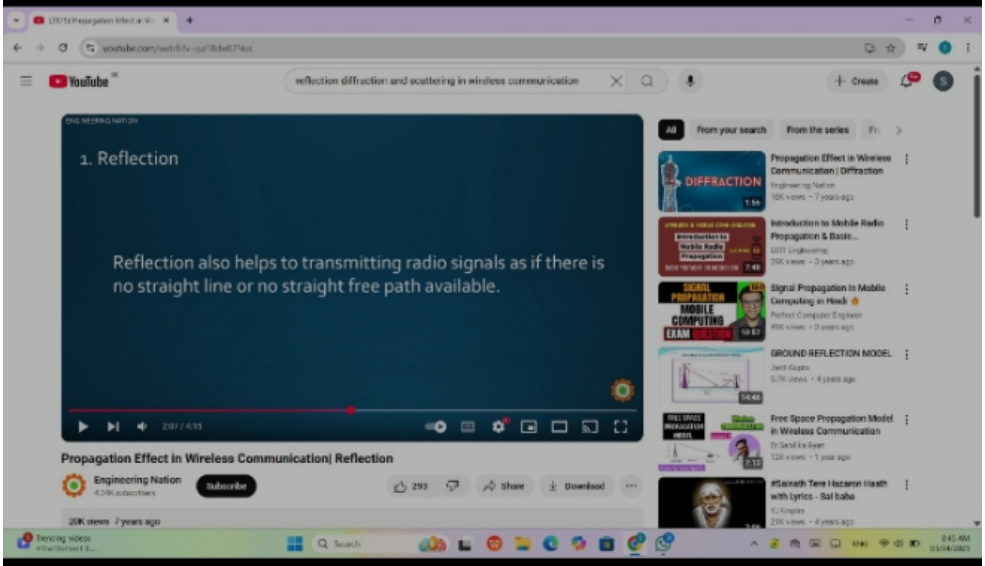
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1. Reflection
Reflection also helps to transmitting radio signals as if there is no straight line or no straight free path available.
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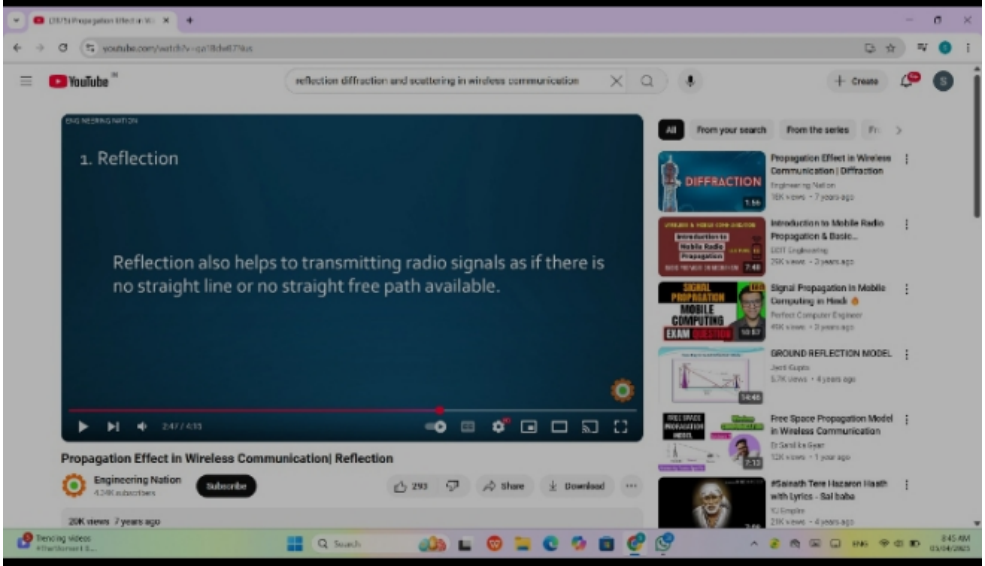

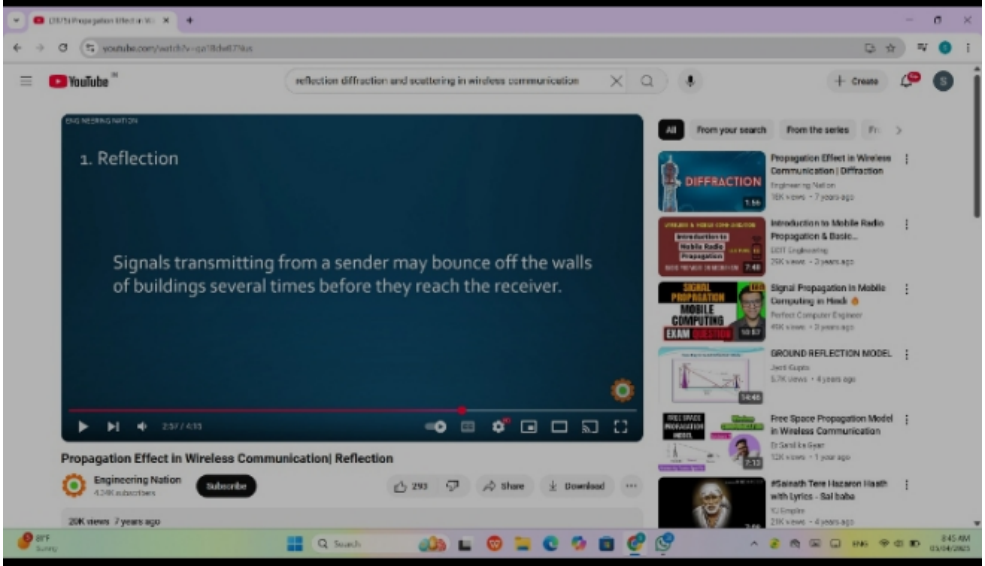
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Signals transmitting from a sender may bounce off the walls of buildings several times before they reach the receiver.
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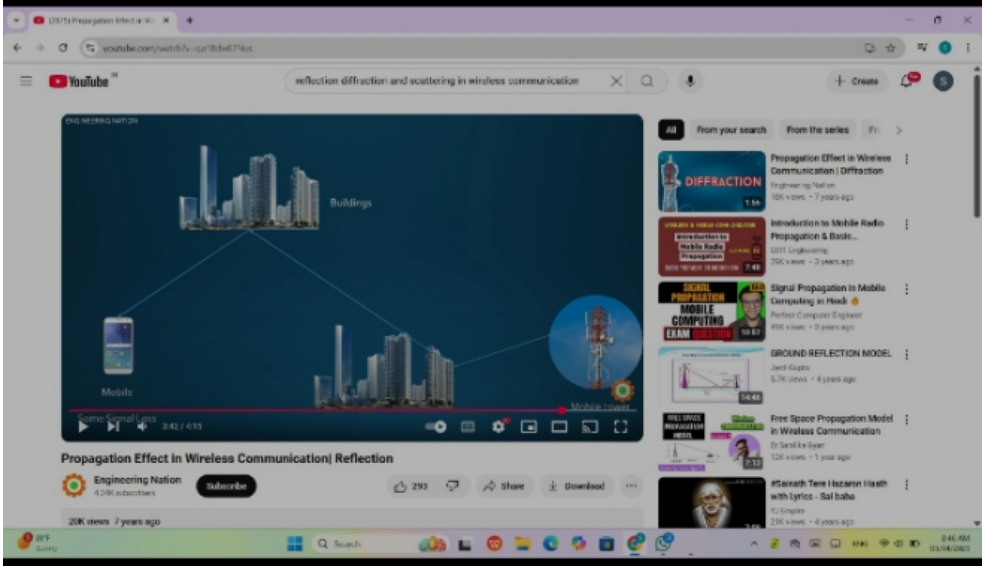
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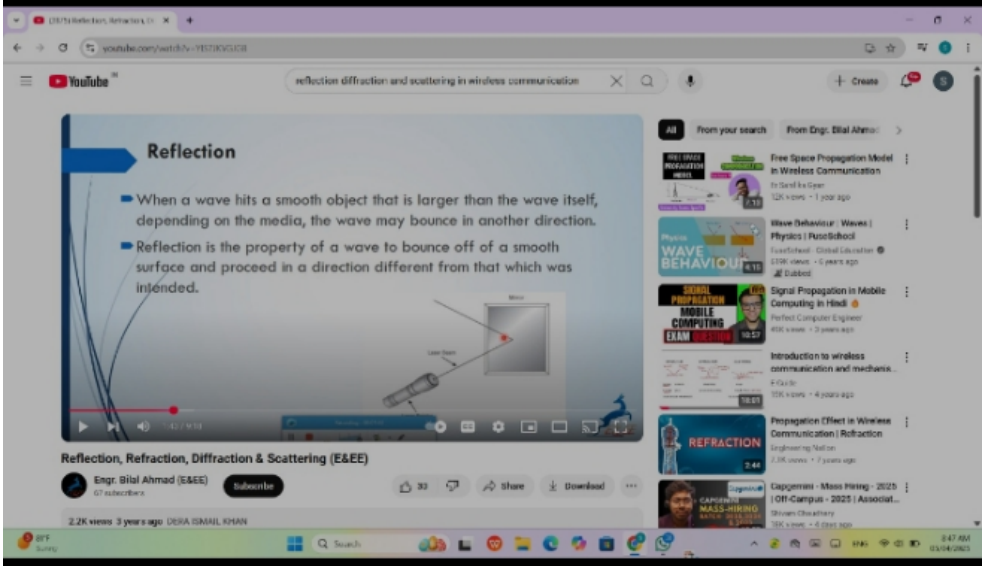
Reflection
When a wave hits a smooth object that is larger than the wave itself, depending on the media, the wave may bounce in another direction.
Reflection is the property of a wave to bounce off of a smooth surface and proceed in a direction different from that which was intended.
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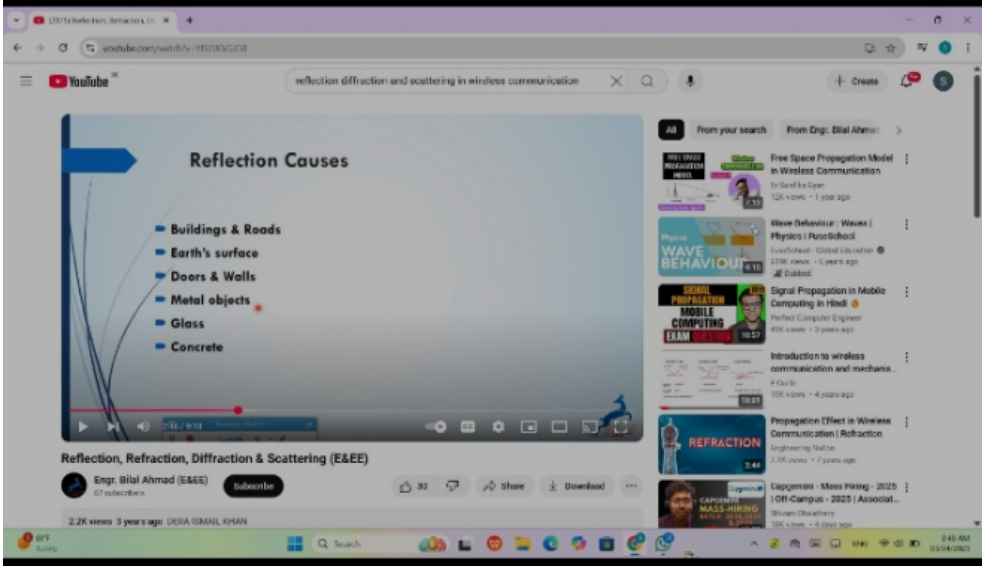
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Buildings & Roads
Earth's surface
Doors & Walls
Metal objects
Glass
Concrete
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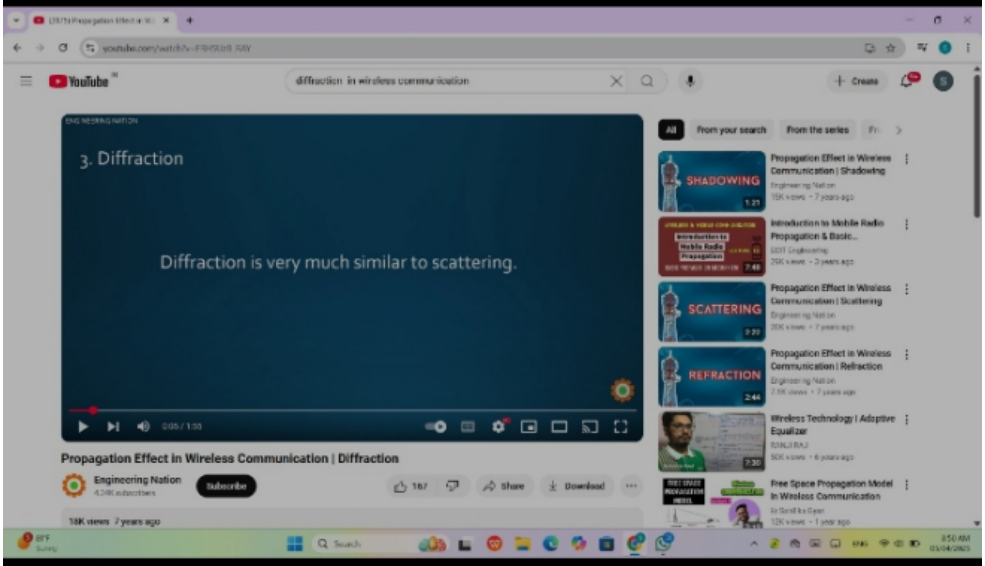
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3. Diffraction
Diffraction is very much similar to scattering.
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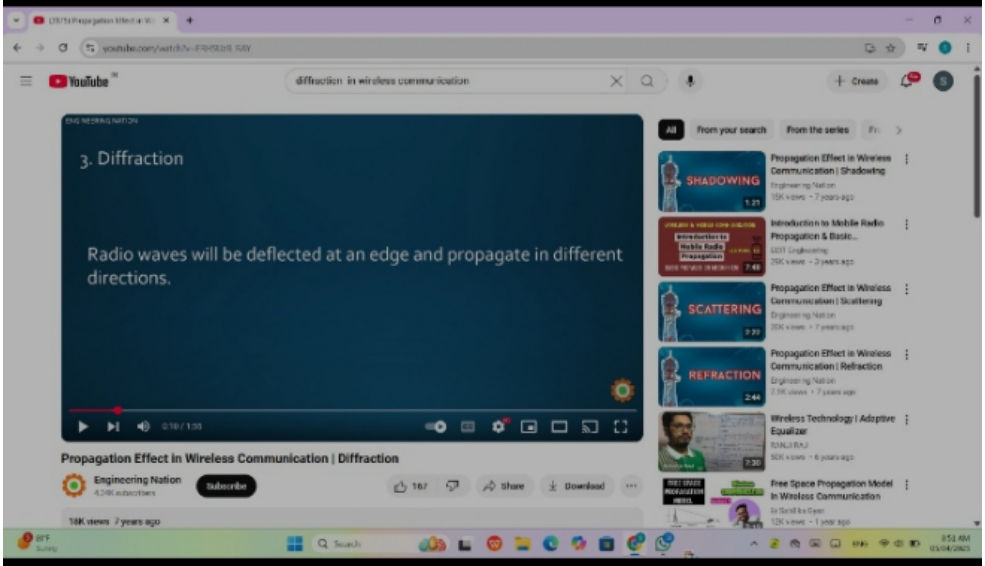
3. Diffraction
Radio waves will be deflected at an edge and propagate in different directions.
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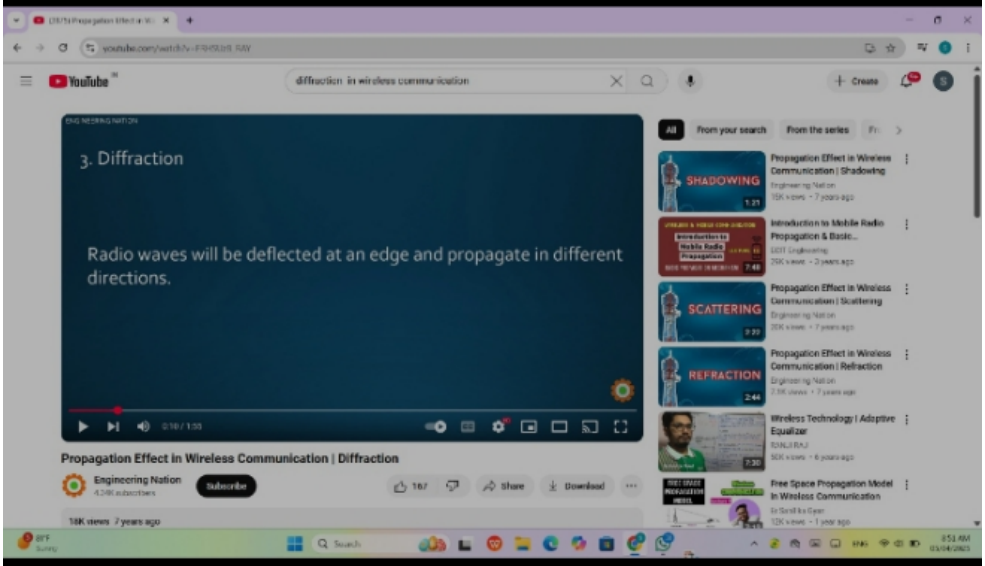
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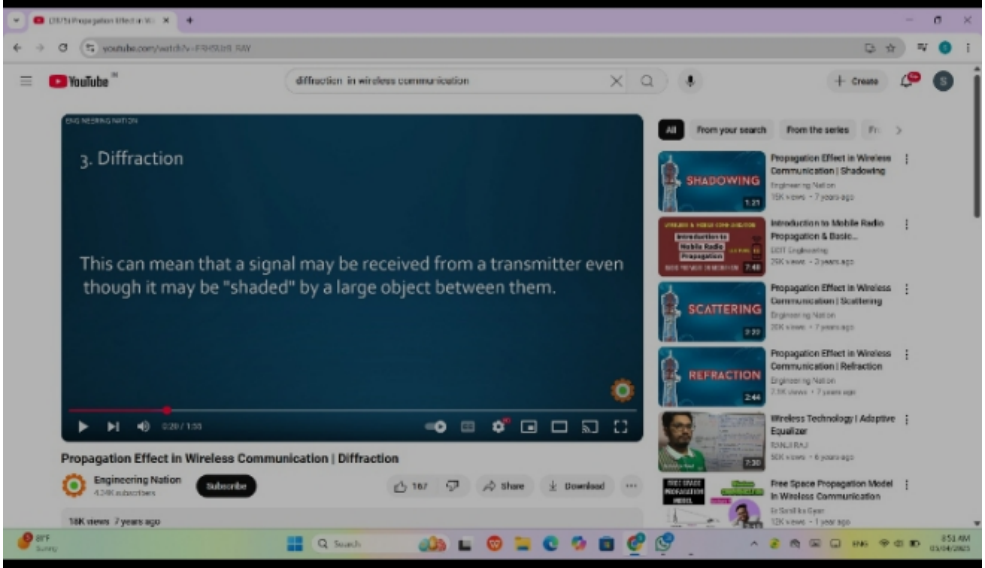
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3. Diffraction
This can mean that a signal may be received from a transmitter even though it may be "shaded" by a large object between them.
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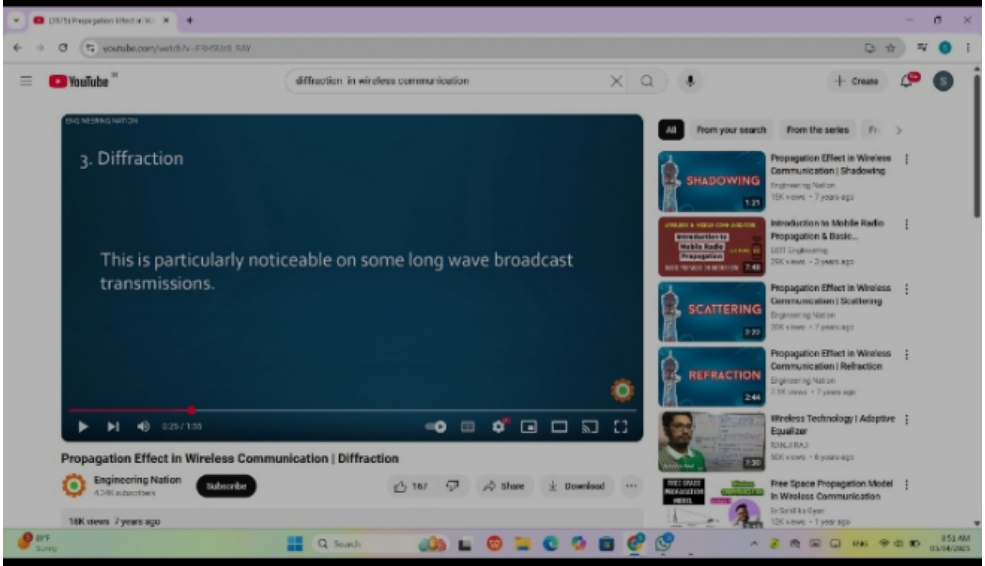
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3. Diffraction
This is particularly noticeable on some long wave broadcast transmissions.
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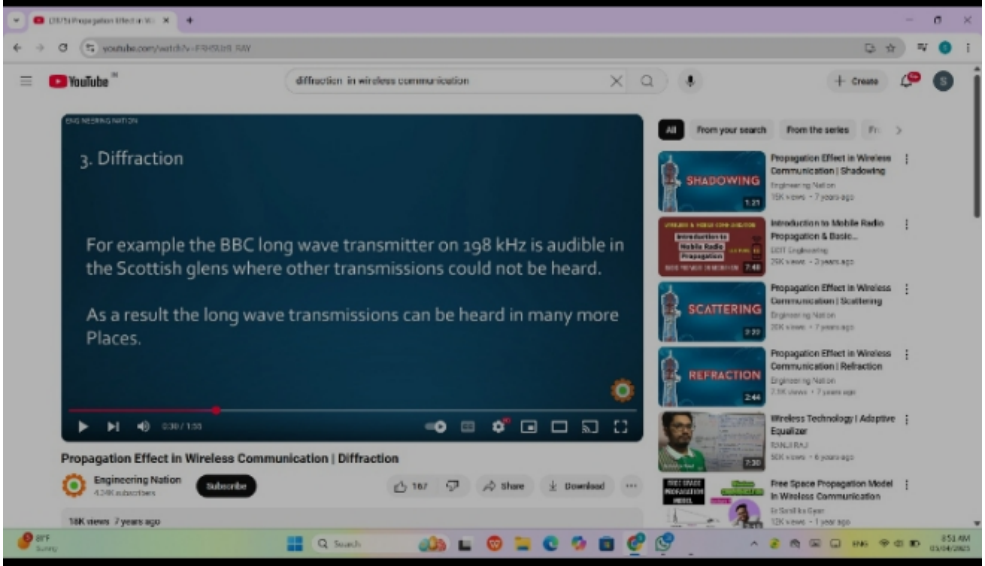
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3. Diffraction
For example the BBC long wave transmitter on 198 kHz is audible in the Scottish glens where other transmissions could not be heard.
As a result the long wave transmissions can be heard in many more Places.
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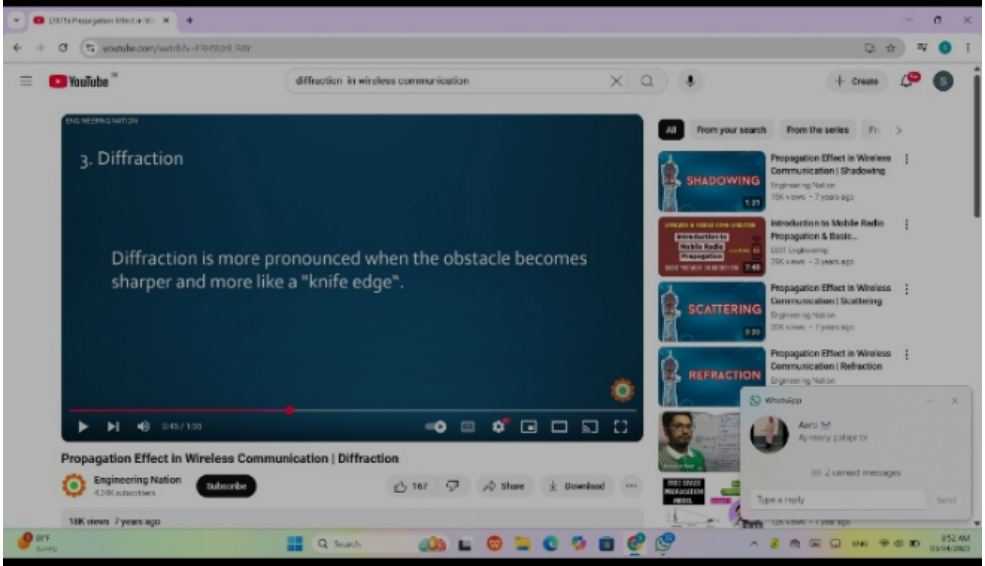
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3. Diffraction
Diffraction is more pronounced when the obstacle becomes sharper and more like a "knife edge".
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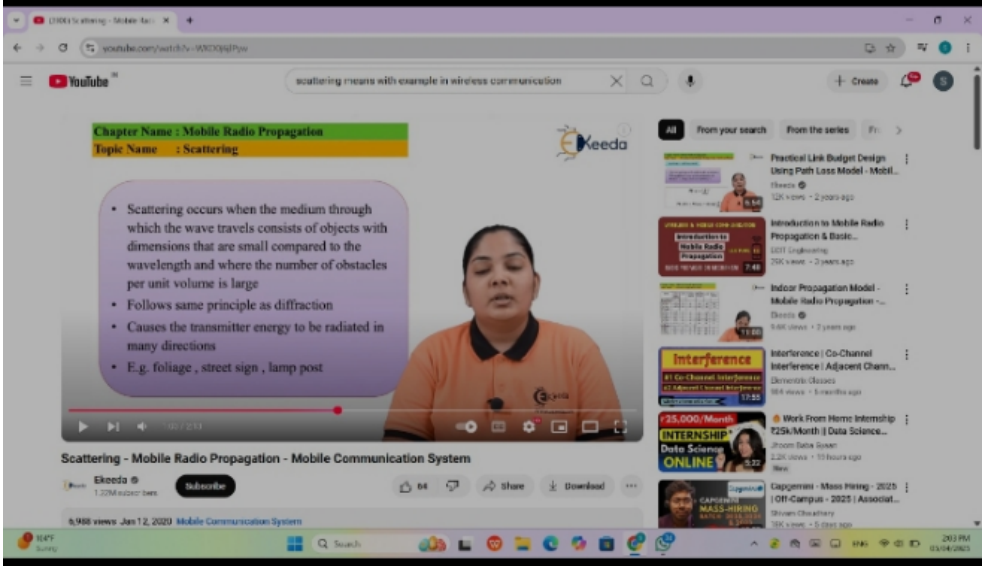
scattering means with example in wireless communication
Chapter Name : Mobile Radio Propagation
Topic Name : Scattering
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• Scattering occurs when the medium through which the wave travels consists of objects with dimensions that are small compared to the wavelength and where the number of obstacles per unit volume is large
• Follows same principle as diffraction
• Causes the transmitter energy to be radiated in many directions
• E.g. foliage , street sign , lamp post
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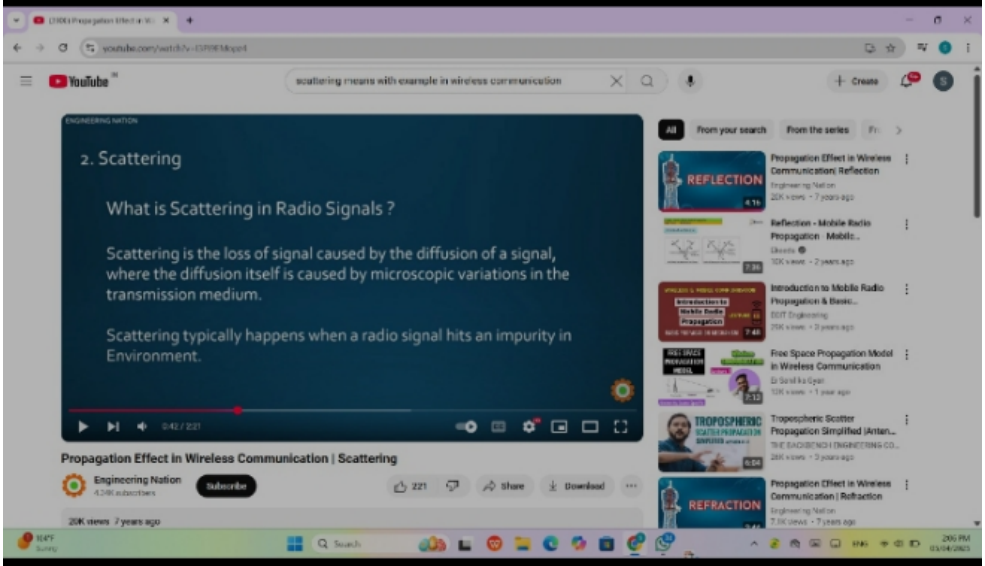
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2. Scattering
What is Scattering in Radio Signals ?
Scattering is the loss of signal caused by the diffusion of a signal, where the diffusion itself is caused by microscopic variations in the transmission medium.
Scattering typically happens when a radio signal hits an impurity in Environment.
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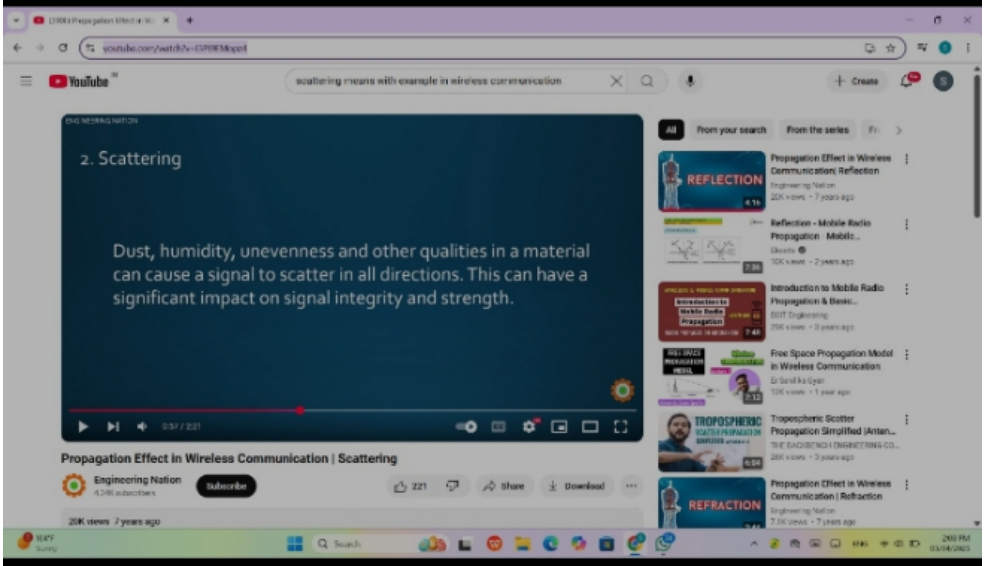
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2. Scattering
Dust, humidity, unevenness and other qualities in a material can cause a signal to scatter in all directions. This can have a significant impact on signal integrity and strength.
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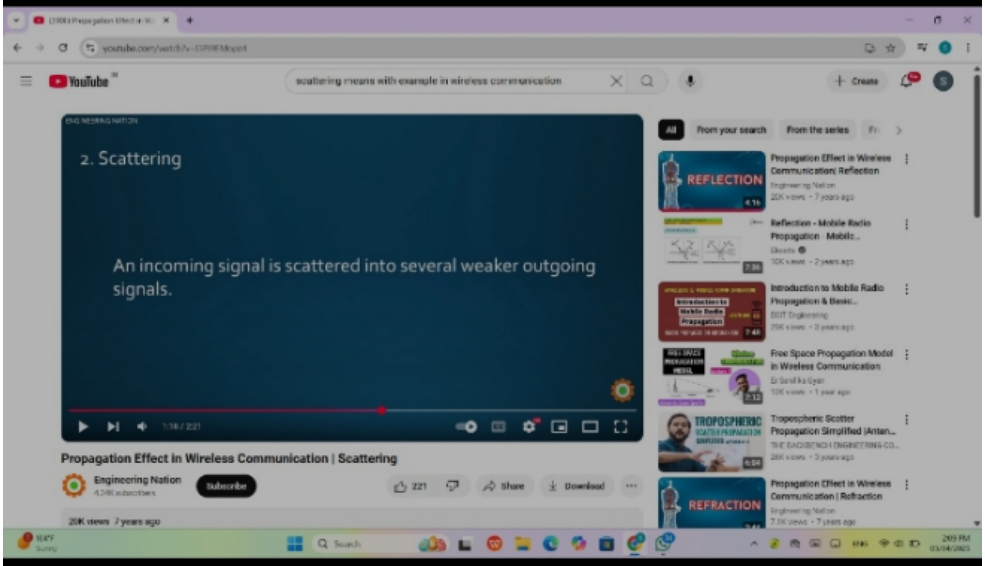
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2. Scattering
An incoming signal is scattered into several weaker outgoing signals.
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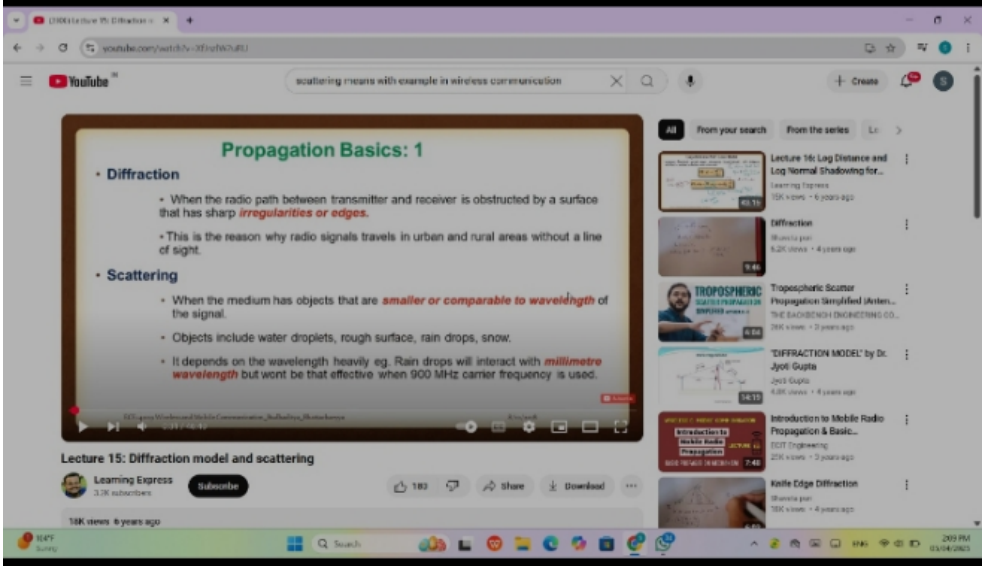
scattering means with example in wireless communication
Propagation Basics: 1
• Diffraction
• When the radio path between transmitter and receiver is obstructed by a surface that has sharp irregularities or edges.
• This is the reason why radio signals travels in urben and rural areas without a line of sight.
• Scattering
• When the medium has objects that are smaller or comparable to wavelength of the signal.
• Objects include water droplets, rough surface, rain drops, snow.
• It depends on the wavelength heavily eg. Rain drops will interact with millimetre wavelength but wont be that effective when 900 MHz carrier frequency is used.
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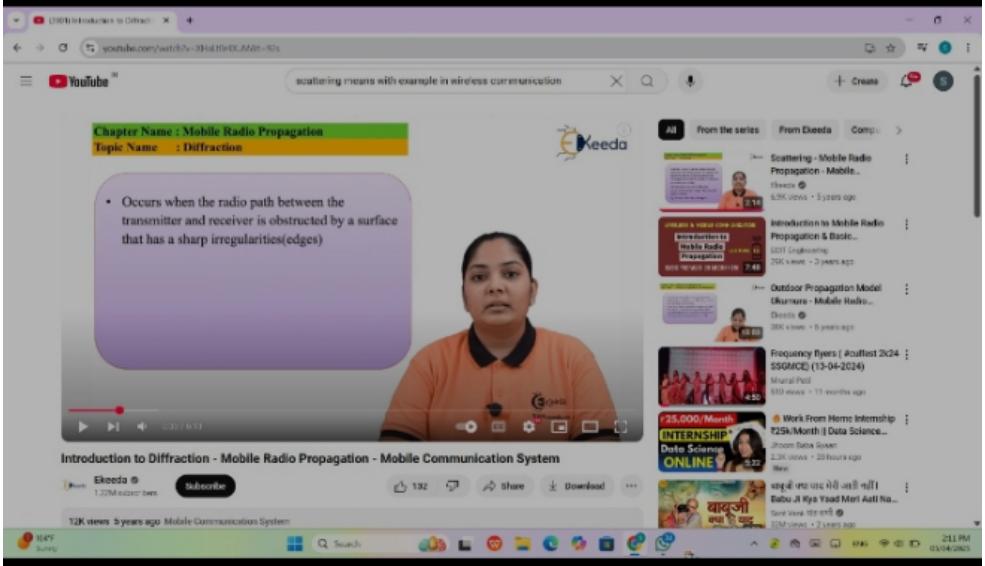
Chapter Name : Mobile Radio Propagation
Topic Name : Diffraction
• Occurs when the radio path between the transmitter and receiver is obstructed by a surface that has a sharp irregularities(edges)
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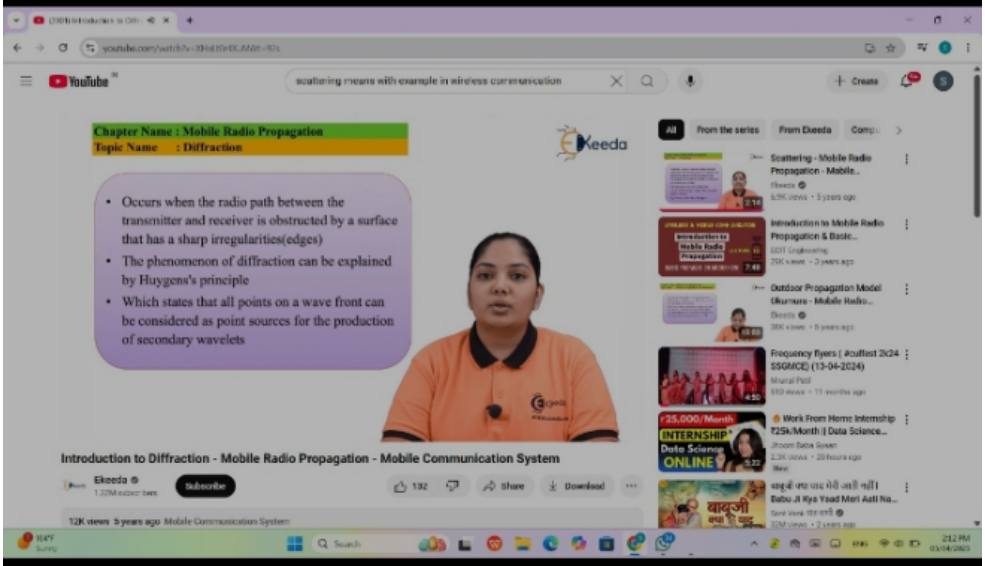

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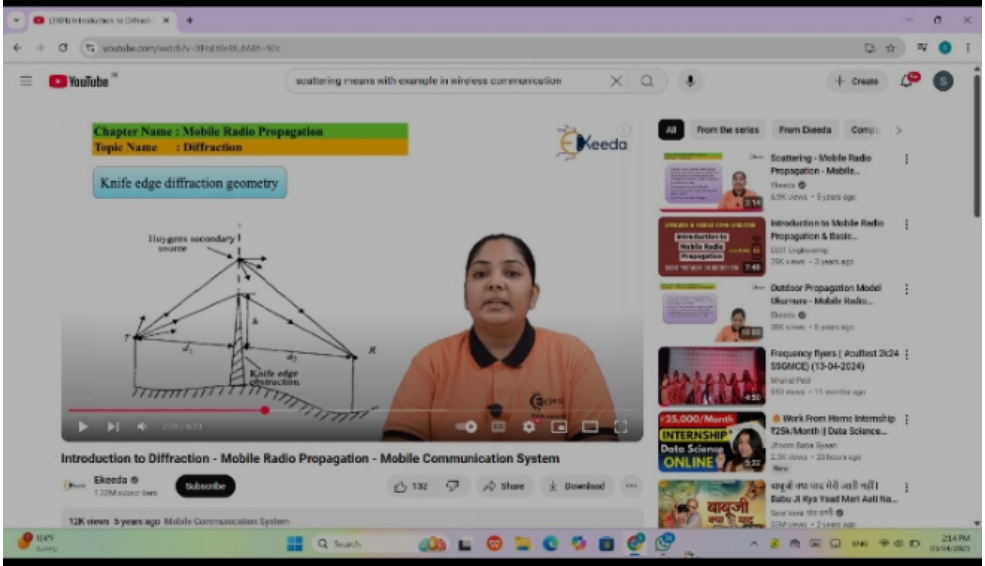

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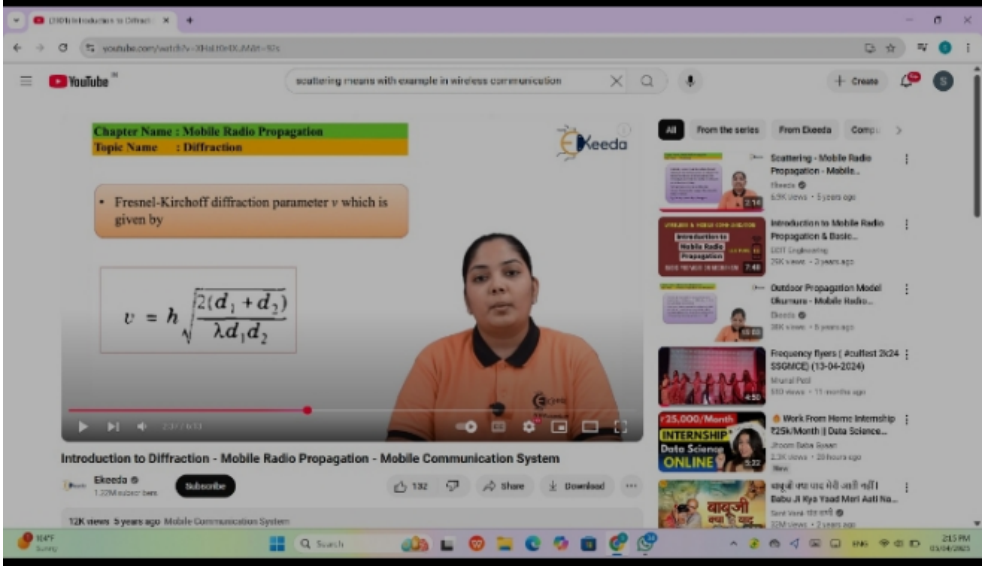

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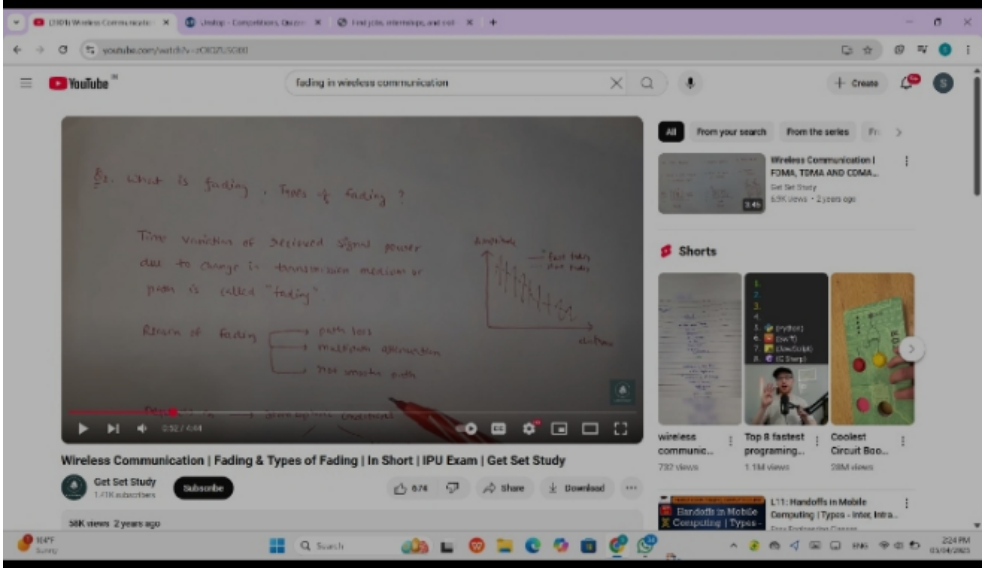

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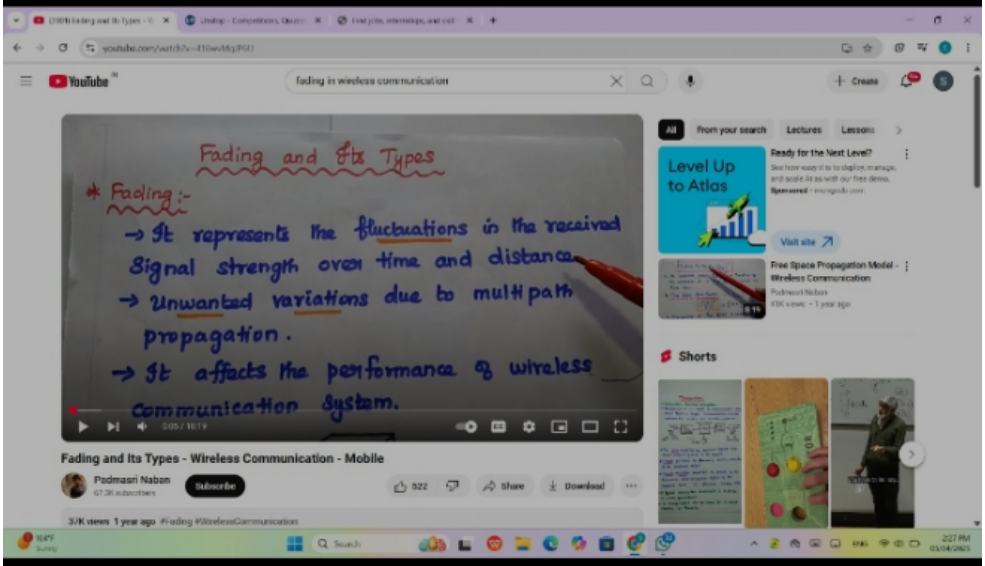

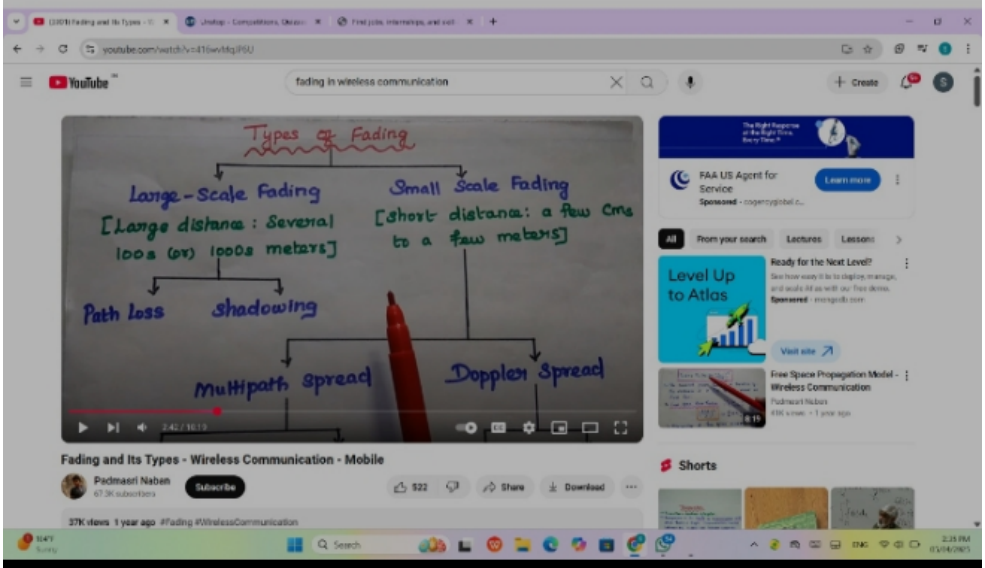
fading in wireless communication
Types of Fading
Large-Scale Fading
[Large distance : Several 100s (or) 1000s meters]
Small Scale Fading
[Short distance: a few cms to a few meters]
Path loss
Shadowing
Multipath Spread
Doppler Spread
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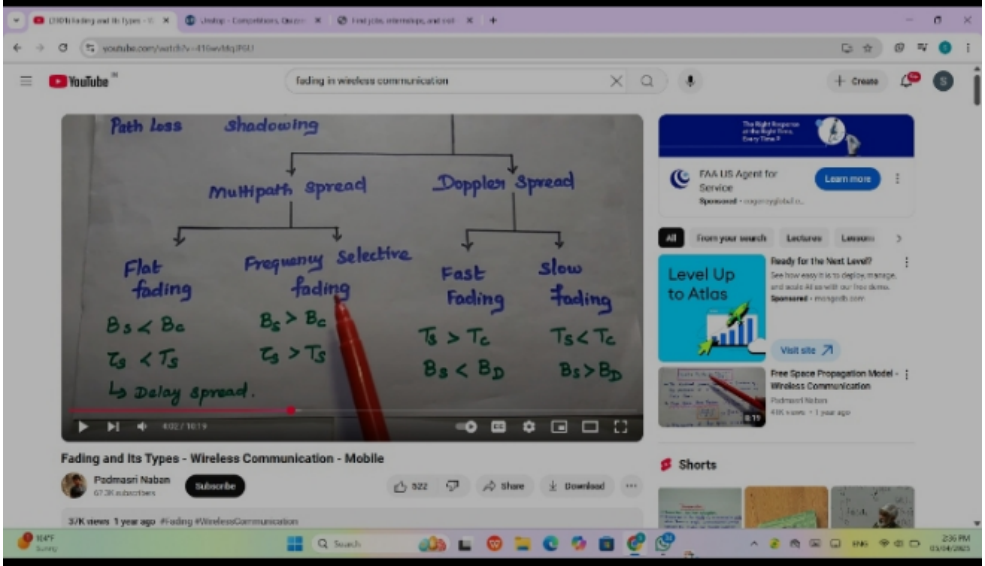

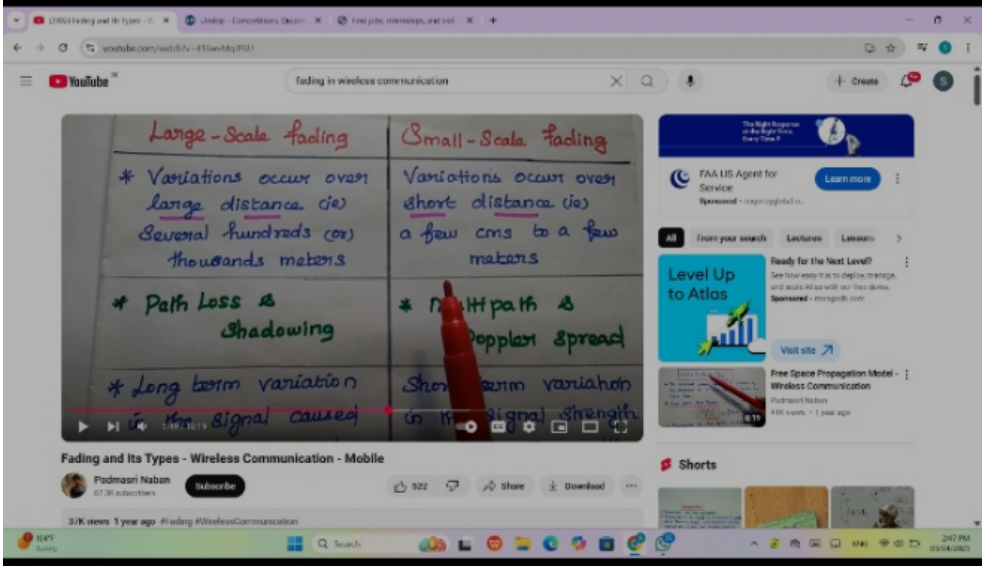
fading in wireless communication
Large - Scale fading
Small - Scale fading
* Variations occur over large distance (ie) Several hundreds (or) thousands meters
Variations occur over short distance (ie) a few cms to a few meters
* Path loss & Shadowing
* Doppler Spread
* Long term variation
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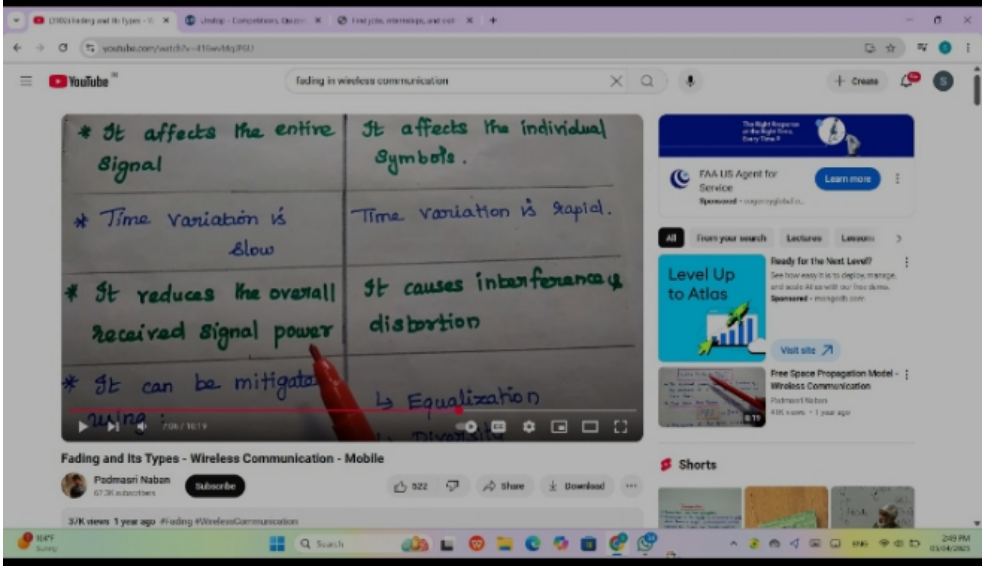

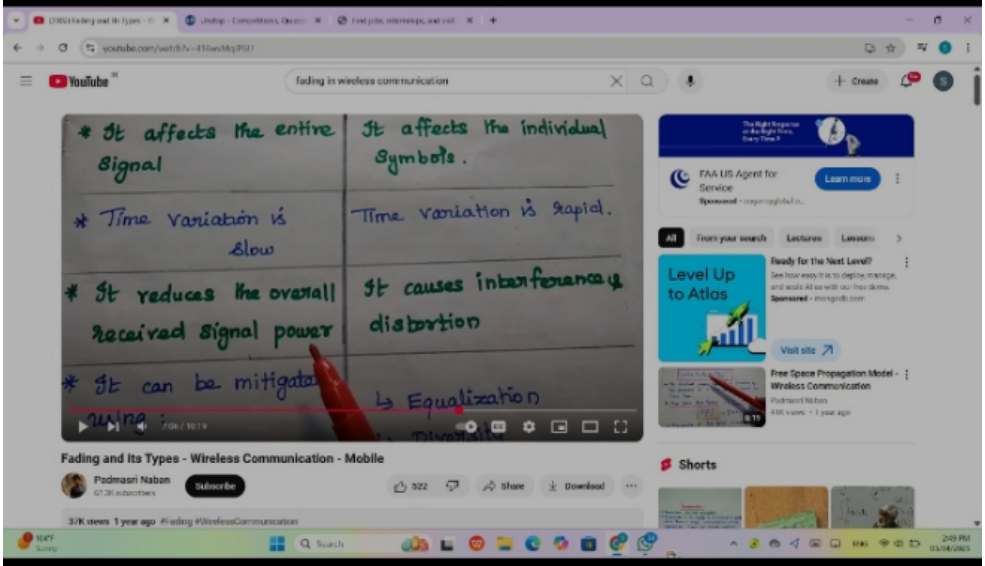

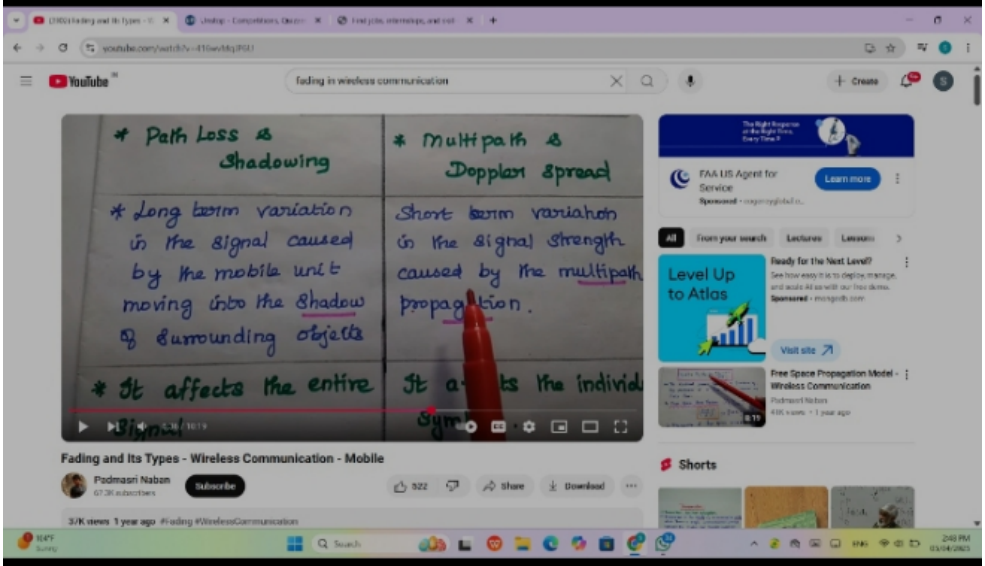
fading in wireless communication
* Path Loss & Shadowing
* Long term variation in the signal caused by the mobile unit moving into the Shadow of surrounding objects
* It affects the entire
* Multipath & Doppler Spread
Short term variation in the signal strength caused by the multipath propagation.
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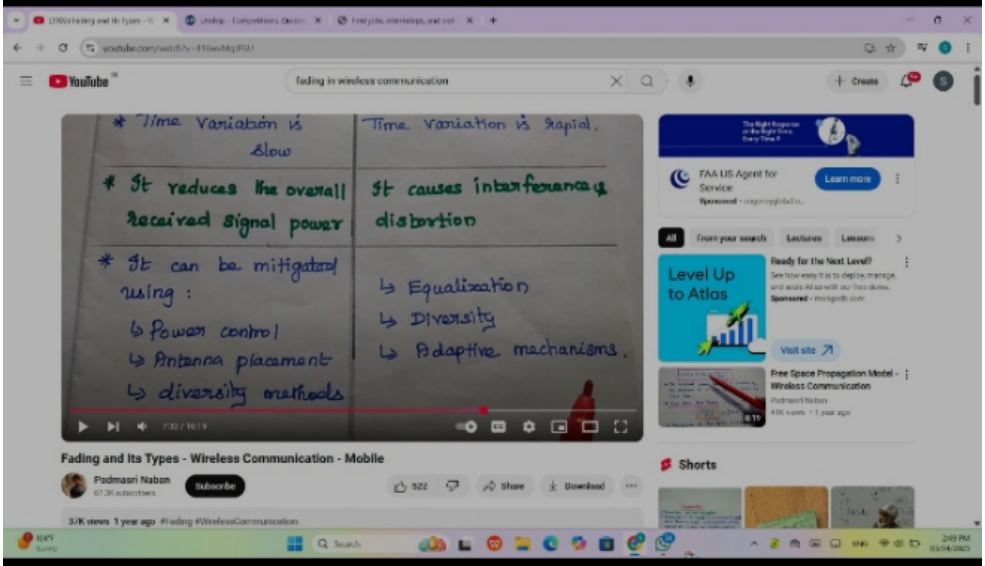
fading in wireless communication
* Time Variation is Slow
Time Variation is Rapid.
* It reduces the overall received signal power
It causes interferance & distortion
* It can be mitigated using :
↳ Power control
↳ Antenna placement
↳ diversity methods
↳ Equalization
↳ Diversity
↳ Adaptive mechanisms.
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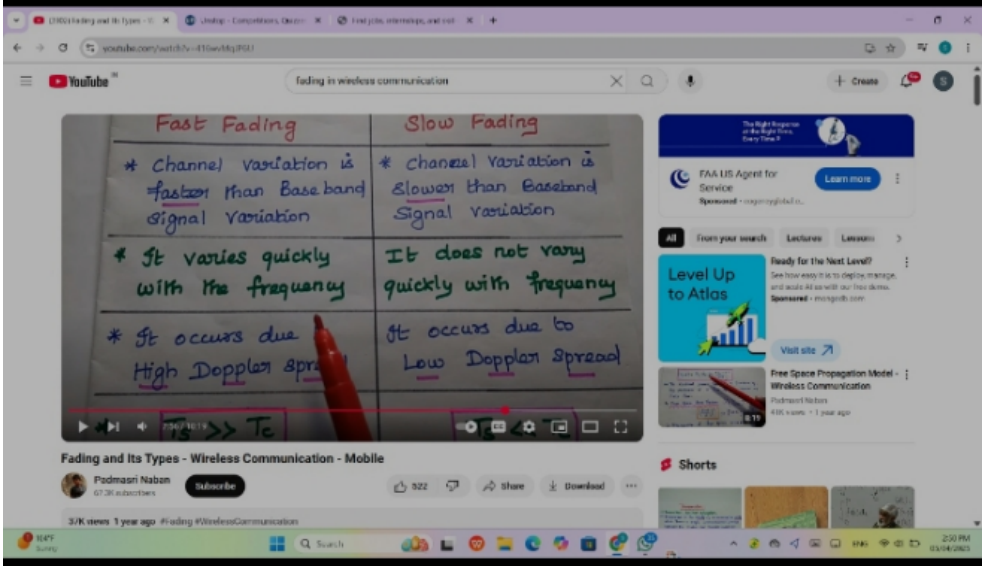
fading in wireless communication
Fast Fading
* Channel variation is faster than Baseband signal variation
* It varies quickly with the frequency
* It occurs due High Doppler spr
Slow Fading
* Channel variation is Slower than Baseband Signal variation
It does not vary quickly with frequency
It occurs due to Low Doppler Spread
Fig >> Tc
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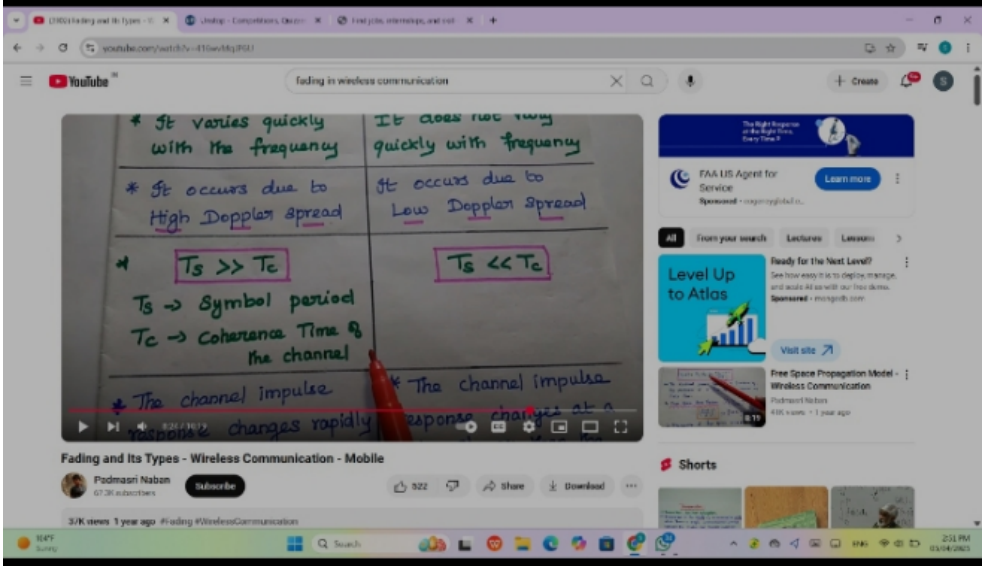
fading in wireless communication
* It varies quickly with the frequency
It does not vary quickly with frequency
* It occurs due to High Doppler spread
It occurs due to Low Doppler Spread
Ts >> Tc
Ts << Tc
Ts → Symbol period
Tc → Coherence Time of the channel
* The channel impulse
* The channel impulse
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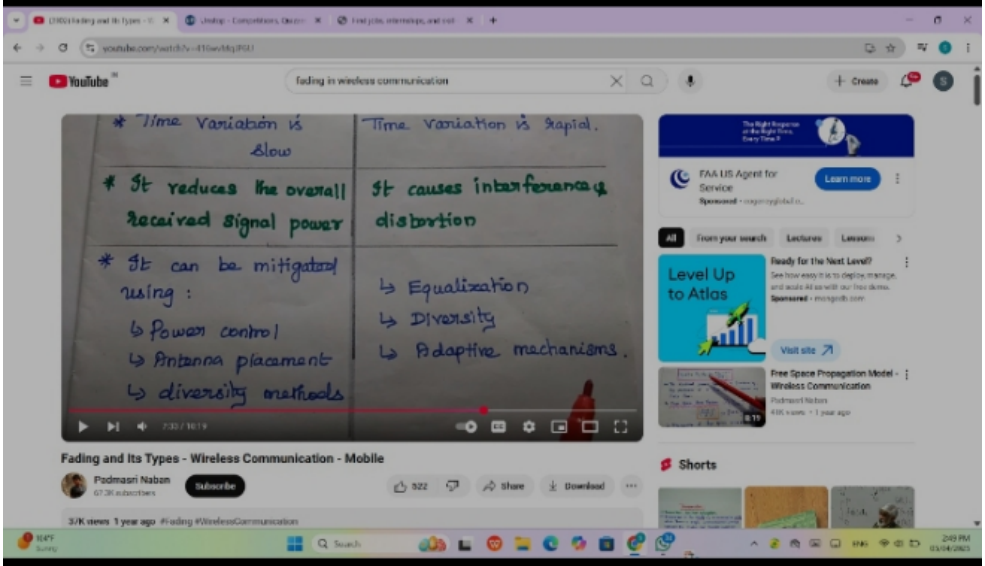
fading in wireless communication
* Time Variation is Slow
Time Variation is Rapid.
* It reduces the overall received signal power
It causes interferance & distortion
* It can be mitigated using :
↳ Power control
↳ Antenna placement
↳ diversity methods
↳ Equalization
↳ Diversity
↳ Adaptive mechanisms.
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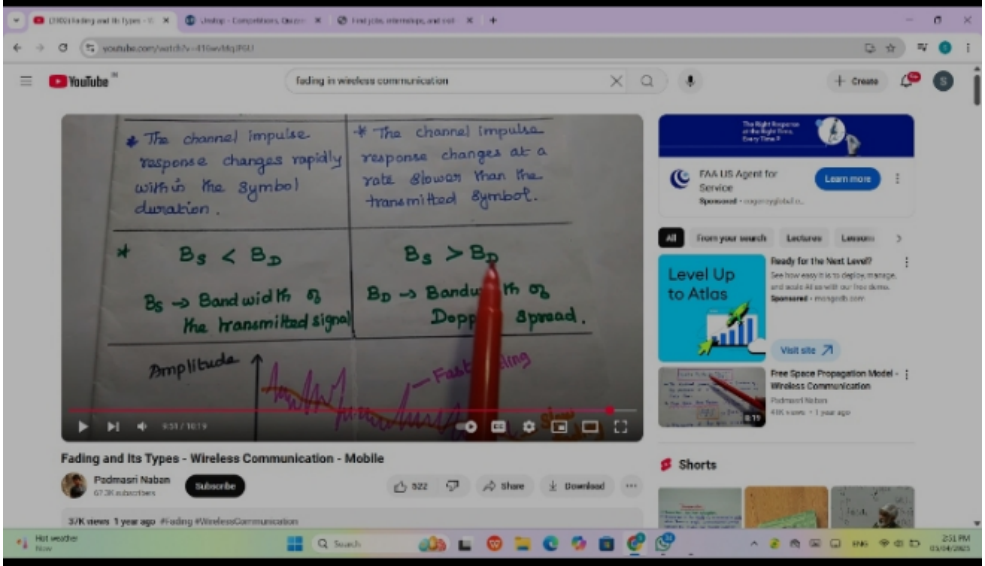
fading in wireless communication
The channel impulse response changes rapidly within the symbol duration.
The channel impulse response changes at a rate slower than the transmitted symbol.
Bs < BD
Bs > BD
Bs → Bandwidth of the transmitted signal
Amplitude
Fast fading
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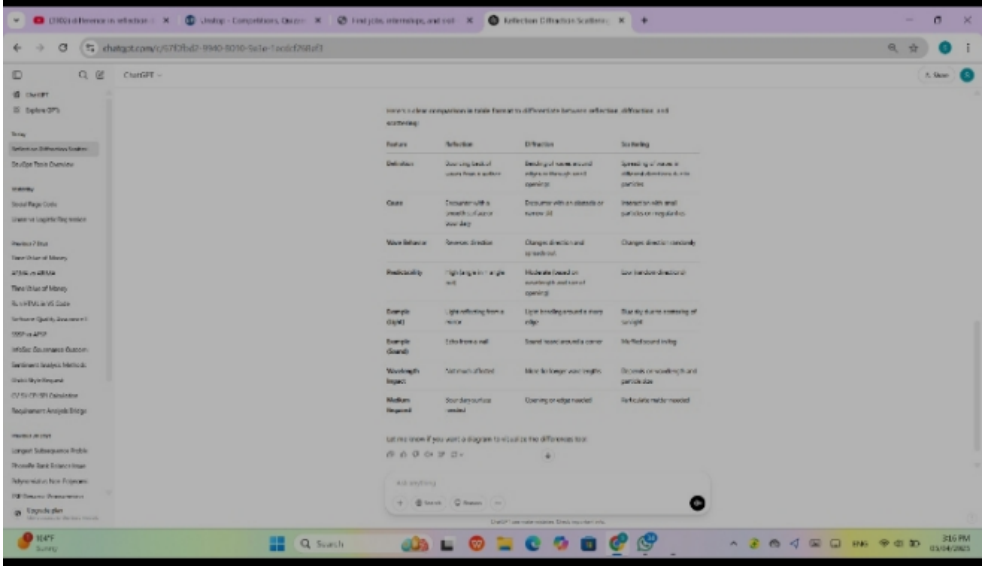

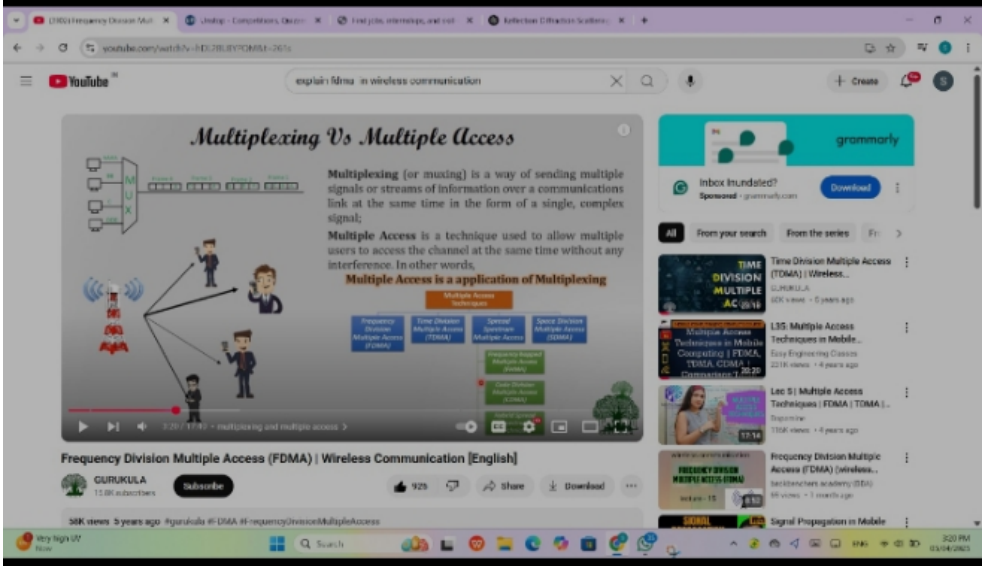
explain fdma in wireless communication
Multiplexing Vs Multiple Access
Multiplexing (or muxing) is a way of sending multiple signals or streams of information over a communications link at the same time in the form of a single, complex signal;
Multiple Access is a technique used to allow multiple users to access the channel at the same time without any interference. In other words,
Multiple Access is a application of Multiplexing
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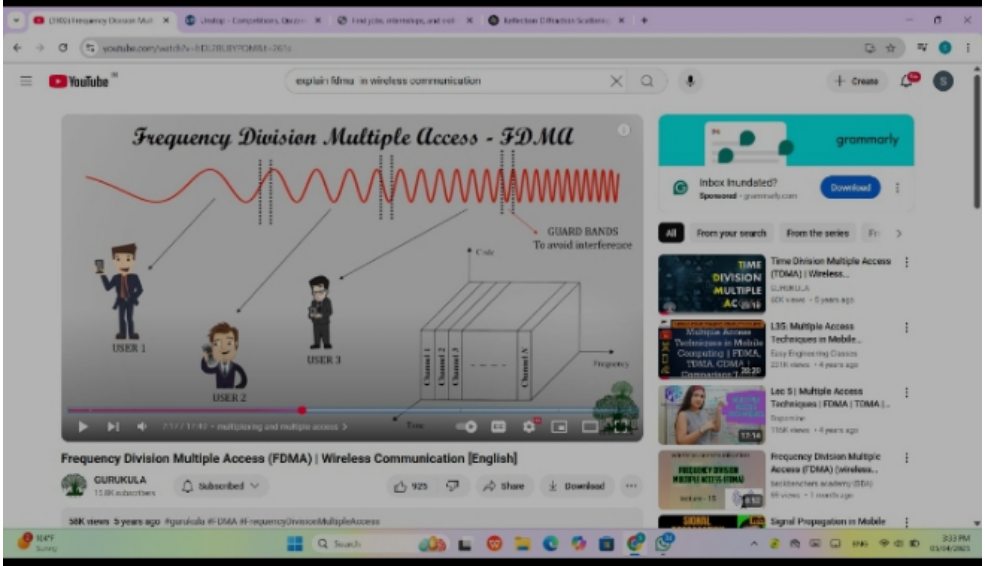
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GUARD BANDS
To avoid interference
USER 1
USER 2
USER 3
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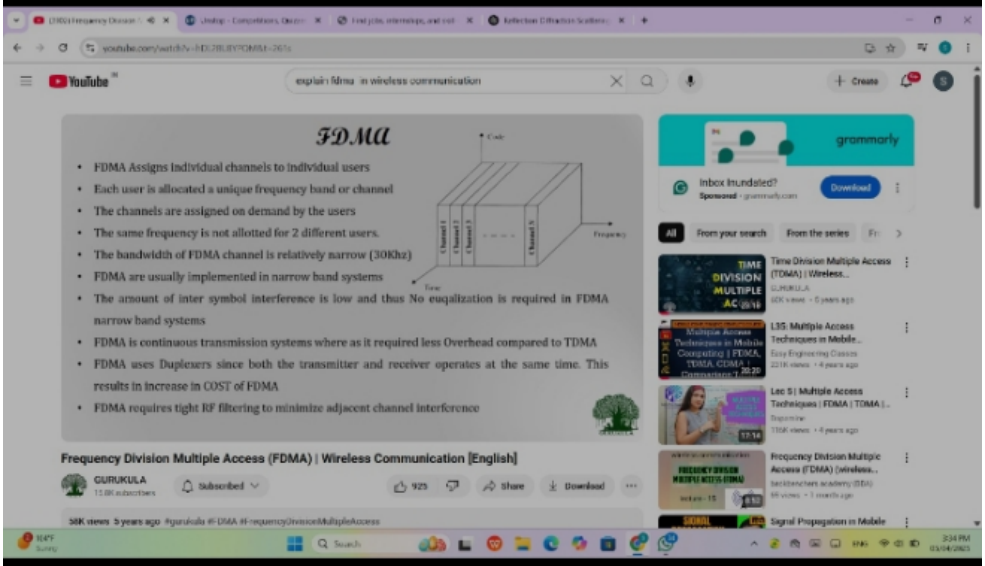
explain fdma in wireless communication
FDMA
FDMA Assigns Individual channels to individual users
Each user is allocated a unique frequency band or channel
The channels are assigned on demand by the users
The same frequency is not allotted for 2 different users.
The bandwidth of FDMA channel is relatively narrow (30Khz)
FDMA are usually implemented in narrow band systems
The amount of inter symbol interference is low and thus No euqalization is required in FDMA narrow band systems
FDMA is continuous transmission systems where as it required less Overhead compared to TDMA
FDMA uses Duplexers since both the transmitter and receiver operates at the same time. This results in increase in COST of FDMA
FDMA requires tight RF filtering to minimize adjacent channel interference
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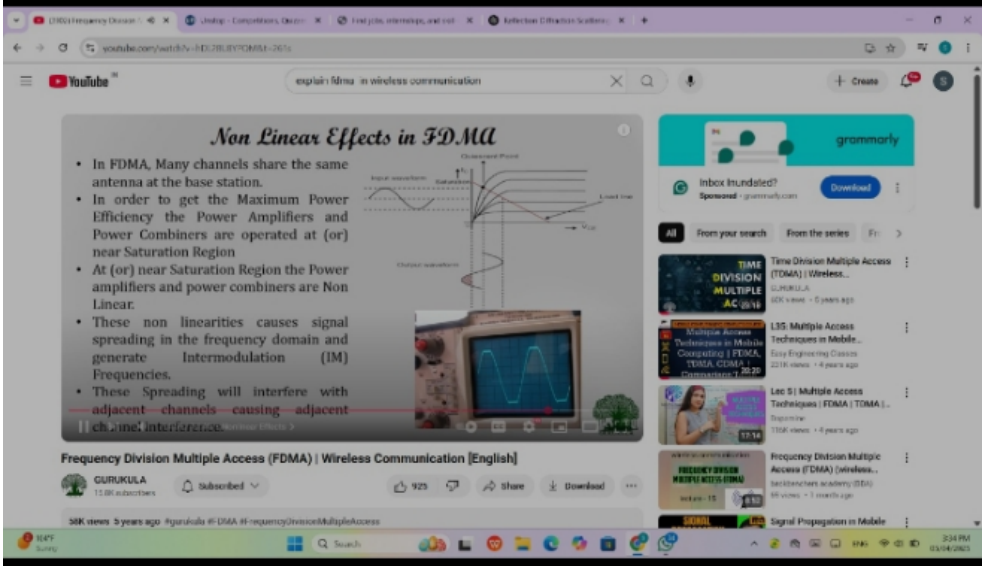
explain fdma in wireless communication
Non Linear Effects in FDMA
In FDMA, Many channels share the same antenna at the base station.
In order to get the Maximum Power Efficiency the Power Amplifiers and Power Combiners are operated at (or) near Saturation Region
At (or) near Saturation Region the Power amplifiers and power combiners are Non Linear.
These non linearities causes signal spreading in the frequency domain and generate Intermodulation (IM) Frequencies.
These Spreading will interfere with adjacent channels causing adjacent channel interference.
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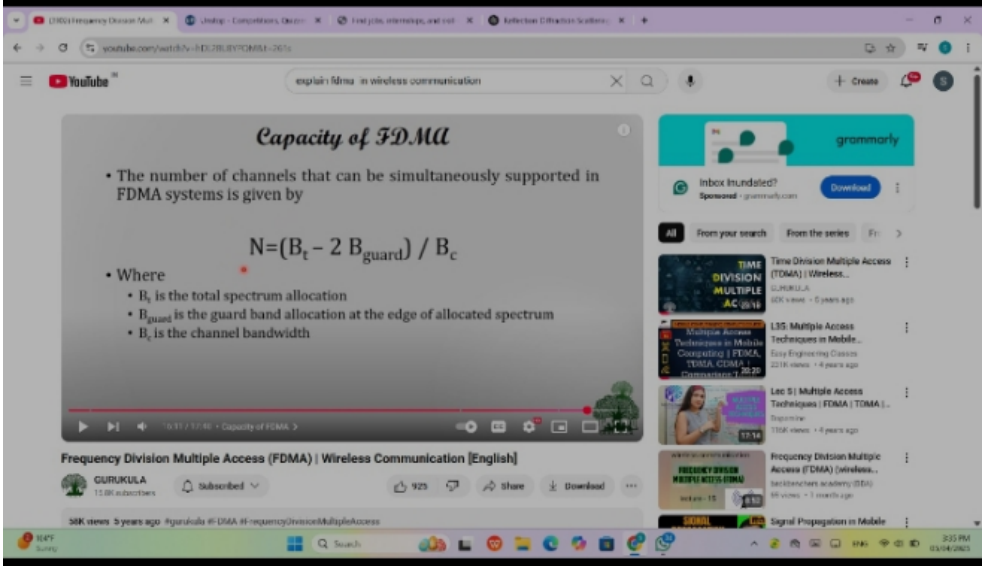

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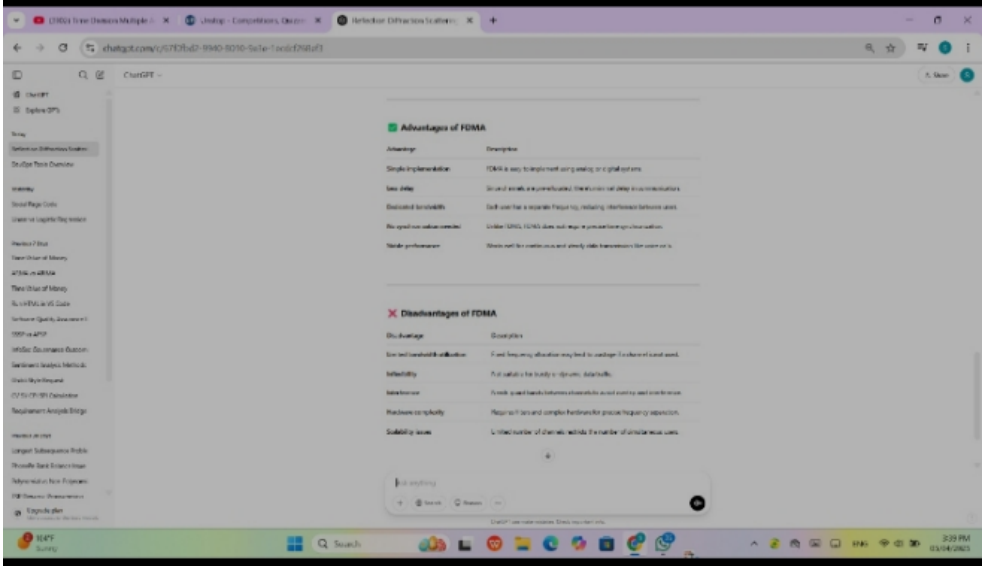

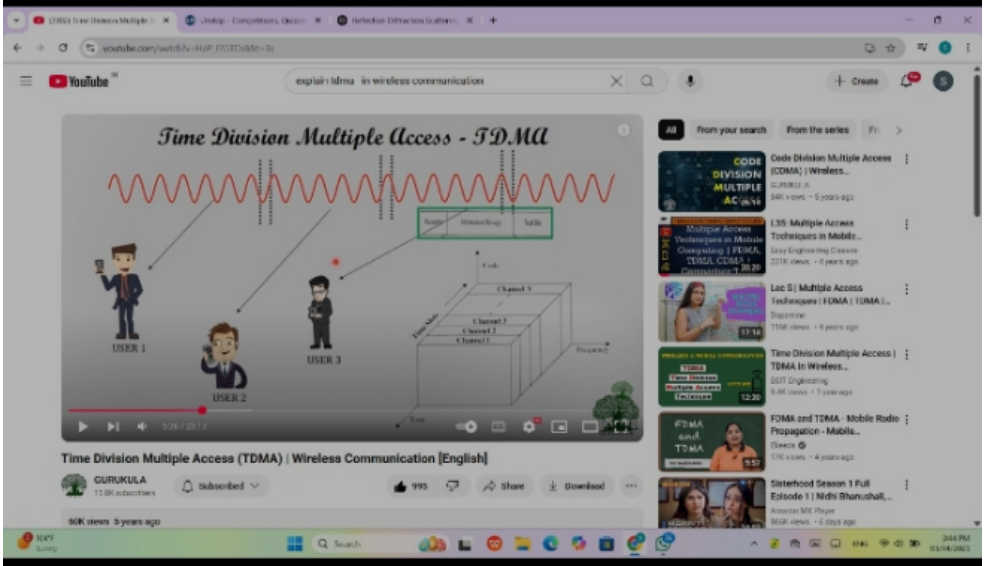
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USER 1
USER 2
USER 3
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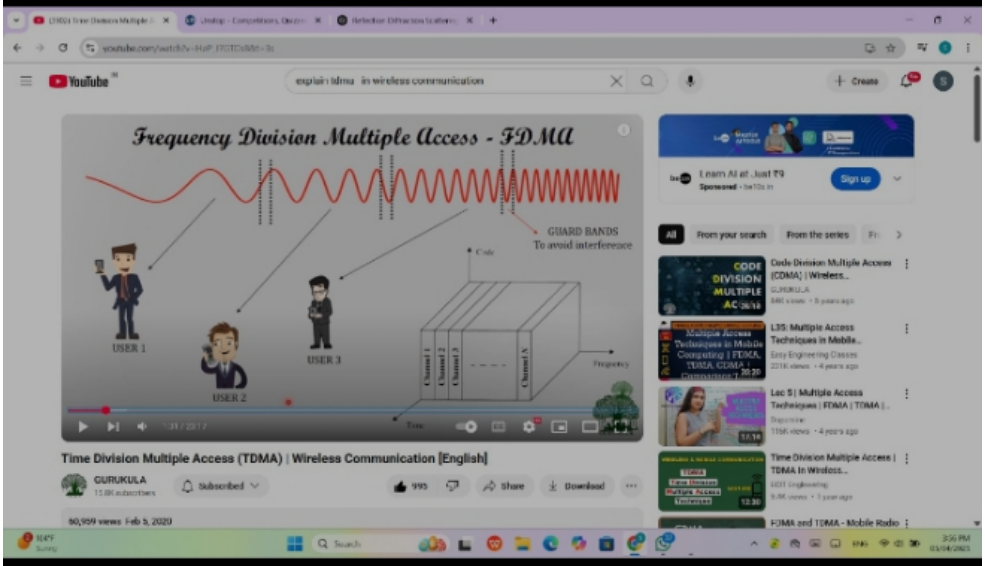
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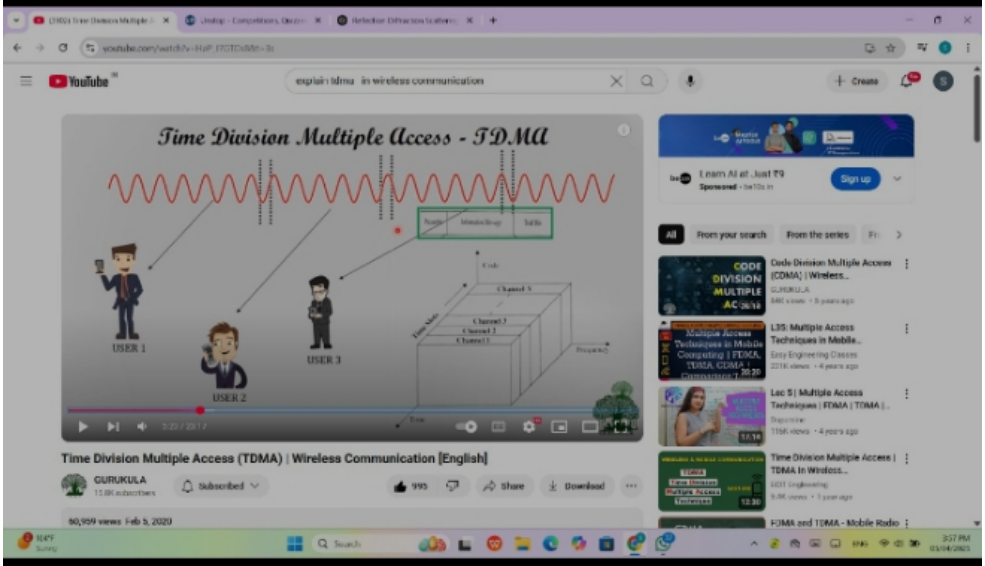
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USER 2
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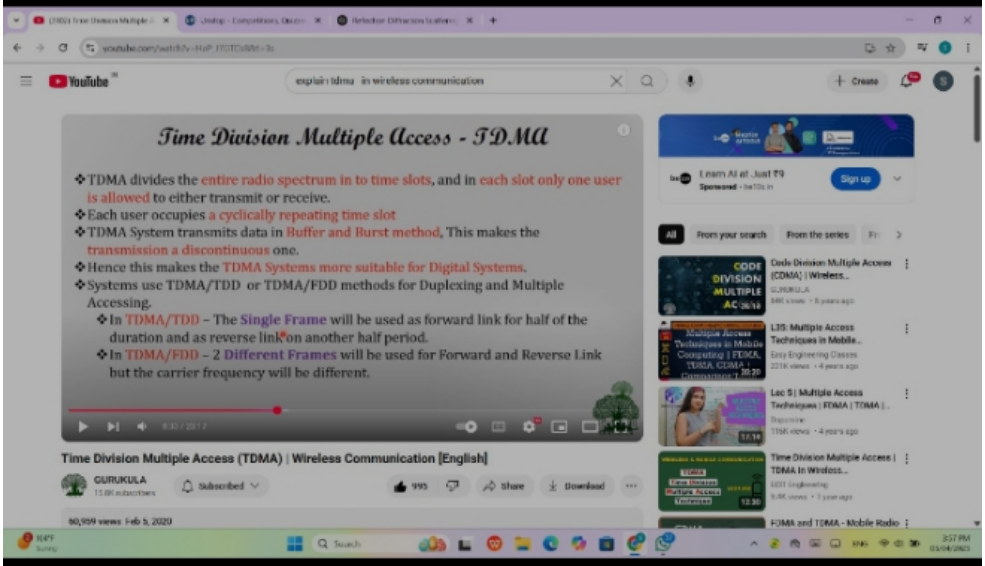
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Time Division Multiple Access - TDMA
❖TDMA divides the entire radio spectrum in to time slots, and in each slot only one user is allowed to either transmit or receive.
❖Each user occupies a cyclically repeating time slot
❖TDMA System transmits data in Buffer and Burst method, This makes the transmission a discontinuous one.
❖Hence this makes the TDMA Systems more suitable for Digital Systems.
❖Systems use TDMA/TDD or TDMA/FDD methods for Duplexing and Multiple Accessing.
❖In TDMA/TDD – The Single Frame will be used as forward link for half of the duration and as reverse link on another half period.
❖In TDMA/FDD – 2 Different Frames will be used for Forward and Reverse Link but the carrier frequency will be different.
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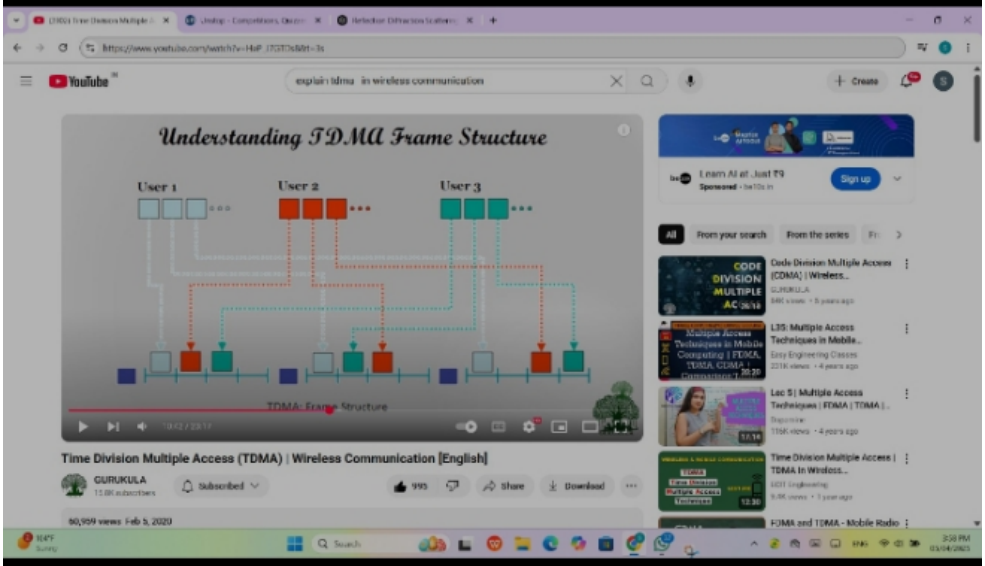
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Understanding TDMA Frame Structure
User 1
User 2
User 3
TDMA: Frame Structure
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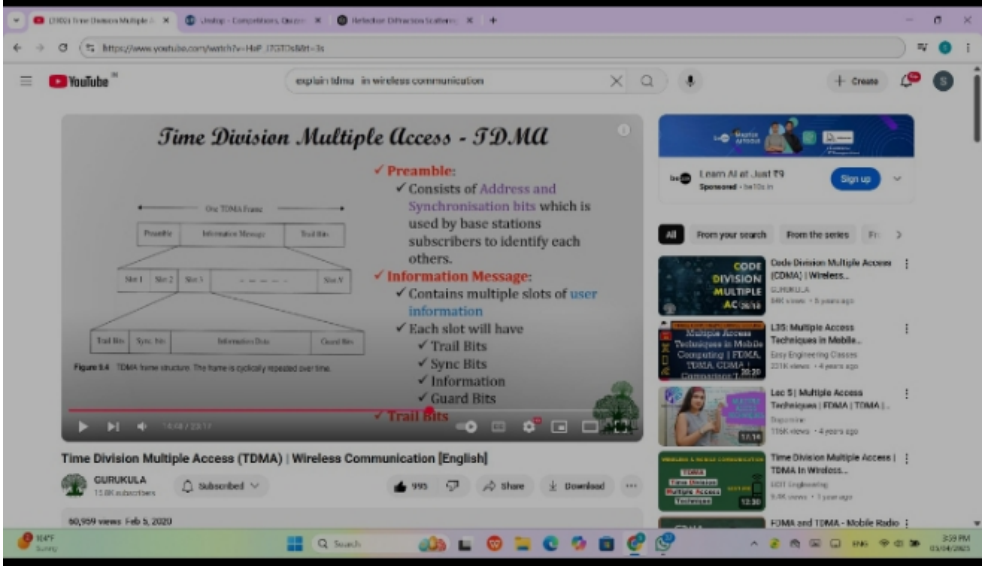
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Time Division Multiple Access - TDMA
✓ Preamble:
✓ Consists of Address and Synchronisation bits which is used by base stations subscribers to identify each others.
✓ Information Message:
✓ Contains multiple slots of user information
✓ Each slot will have
✓ Trail Bits
✓ Sync Bits
✓ Information
✓ Guard Bits
✓ Trail Bits
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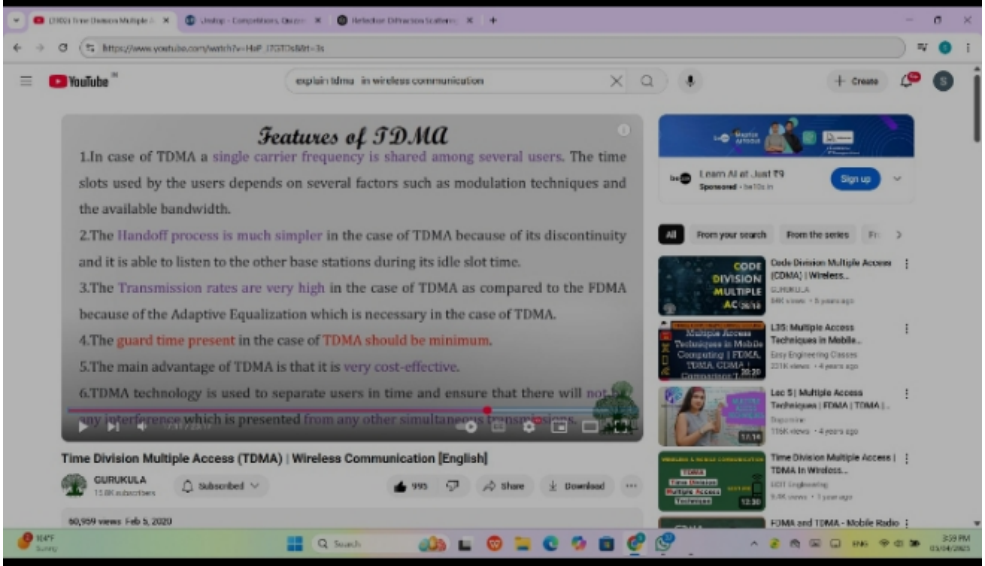
explain tdma in wireless communication
Features of TDMA
1.In case of TDMA a single carrier frequency is shared among several users. The time slots used by the users depends on several factors such as modulation techniques and the available bandwidth.
2.The Handoff process is much simpler in the case of TDMA because of its discontinuity and it is able to listen to the other base stations during its idle slot time.
3.The Transmission rates are very high in the case of TDMA as compared to the FDMA because of the Adaptive Equalization which is necessary in the case of TDMA.
4.The guard time present in the case of TDMA should be minimum.
5.The main advantage of TDMA is that it is very cost-effective.
6.TDMA technology is used to separate users in time and ensure that there will not be any interference which is presented from any other simultaneous transmissions.
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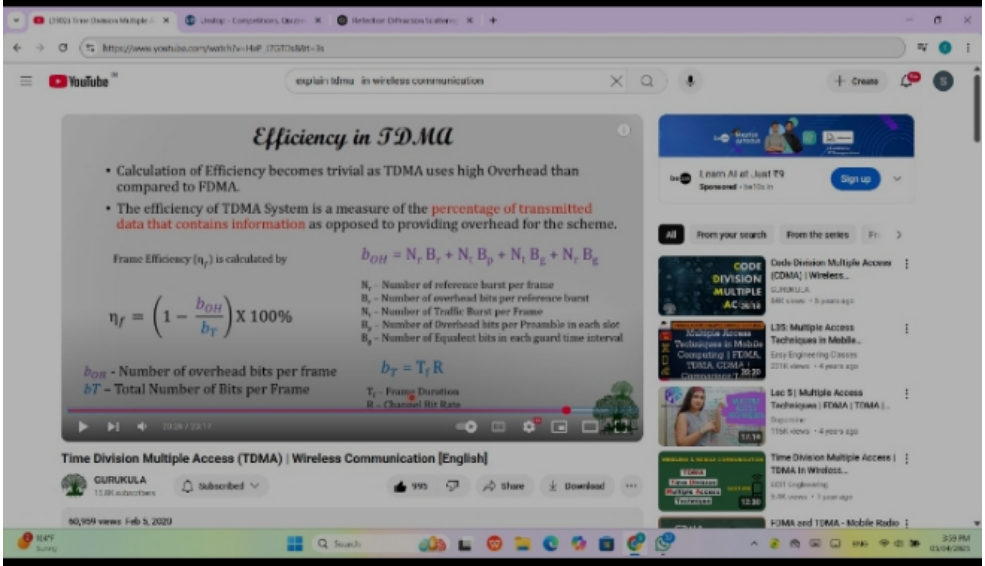

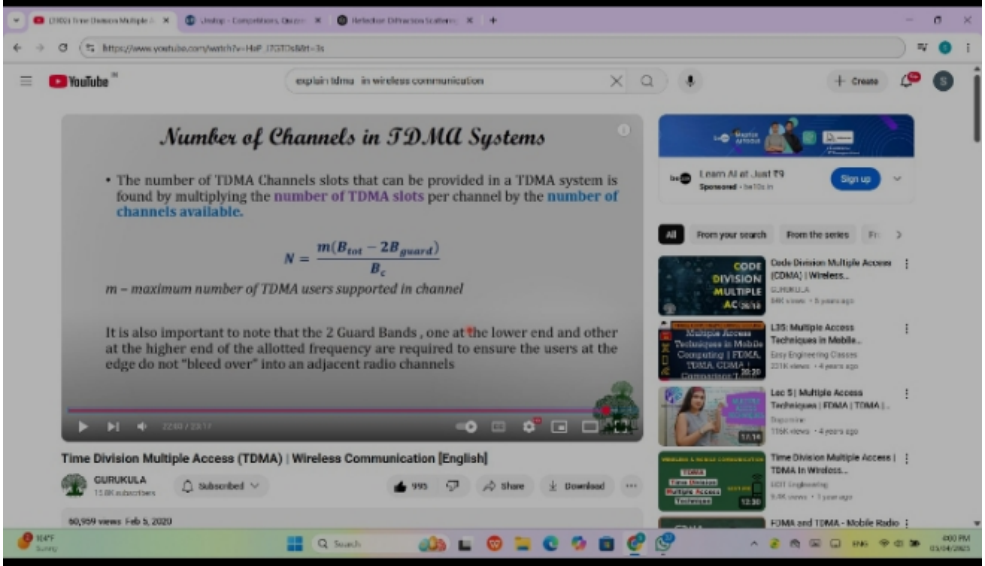
Number of Channels in TDMA Systems
• The number of TDMA Channels slots that can be provided in a TDMA system is found by multiplying the number of TDMA slots per channel by the number of channels available.
$$N = \frac{m(B_{tot} - 2B_{guard})}{B_c}$$
m – maximum number of TDMA users supported in channel
It is also important to note that the 2 Guard Bands , one at the lower end and other at the higher end of the allotted frequency are required to ensure the users at the edge do not "bleed over" into an adjacent radio channels
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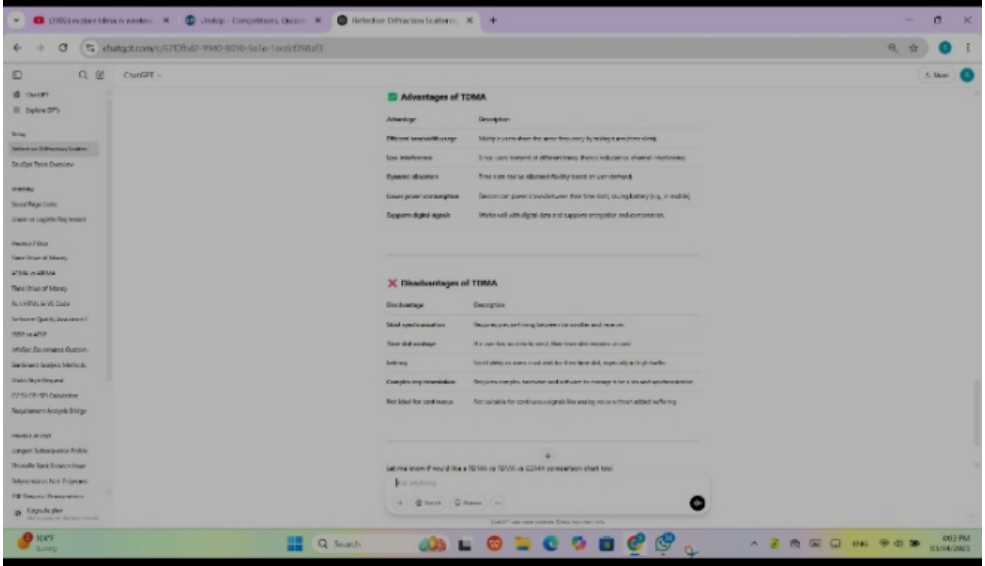

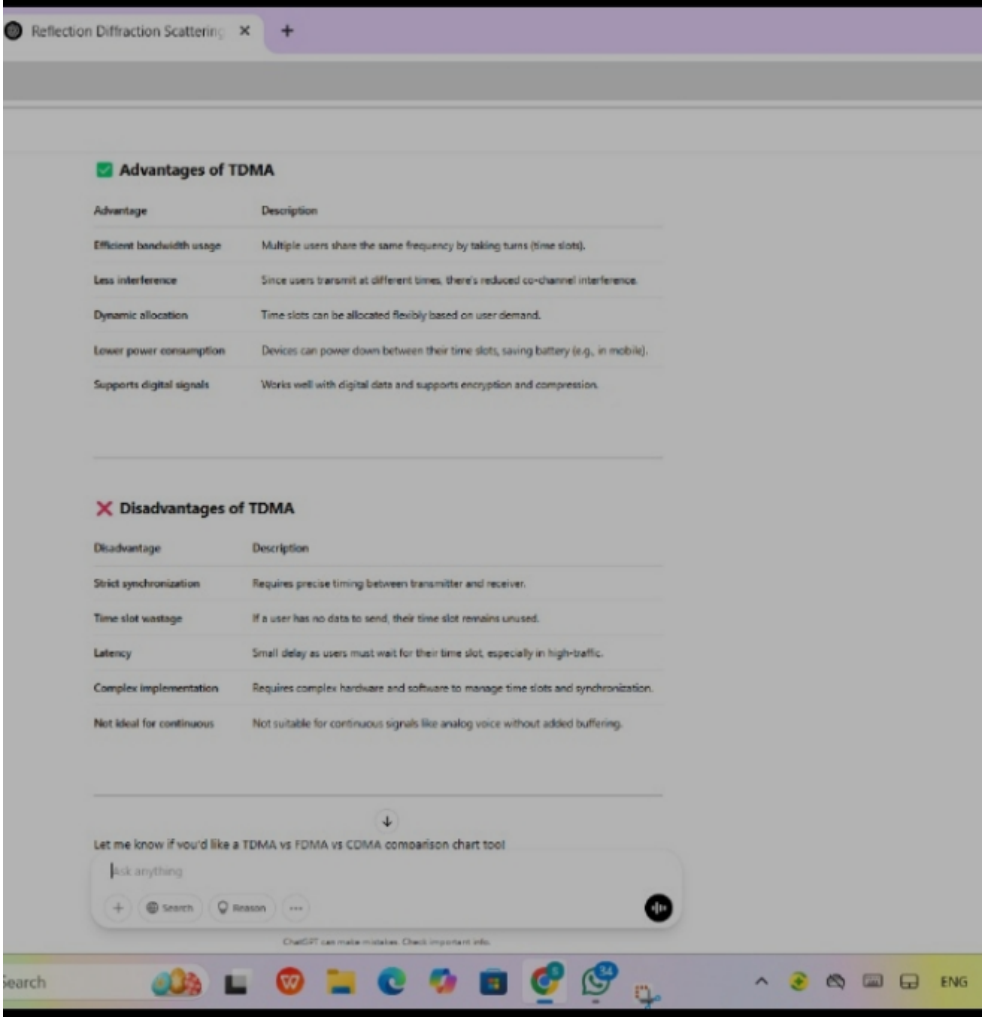
Reflection Diffraction Scattering
Advantages of TDMA
Advantage
Description
Efficient bandwidth usage
Multiple users share the same frequency by taking turns (time slots).
Less interference
Since users transmit at different times, there's reduced co-channel interference.
Dynamic allocation
Time slots can be allocated flexibly based on user demand.
Lower power consumption
Devices can power down between their time slots, saving battery (e.g., in mobile).
Supports digital signals
Works well with digital data and supports encryption and compression.
Disadvantages of TDMA
Disadvantage
Description
Strict synchronization
Requires precise timing between transmitter and receiver.
Time slot wastage
If a user has no data to send, their time slot remains unused.
Latency
Small delay as users must wait for their time slot, especially in high-traffic.
Complex implementation
Requires complex hardware and software to manage time slots and synchronization.
Not ideal for continuous
Not suitable for continuous signals like analog voice without added buffering.
Let me know if you'd like a TDMA vs FDMA vs CDMA comparison chart too!
Ask anything
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Reason
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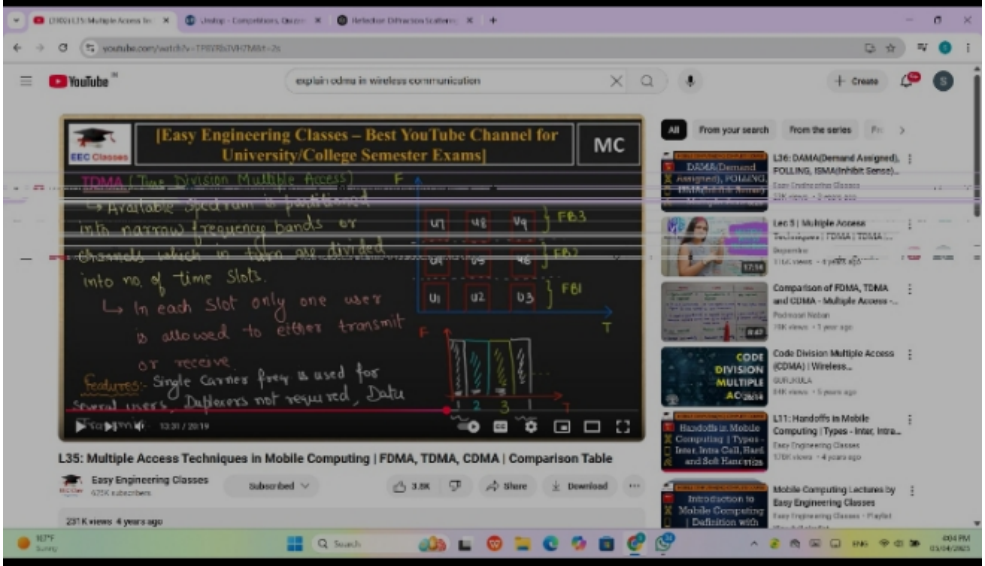

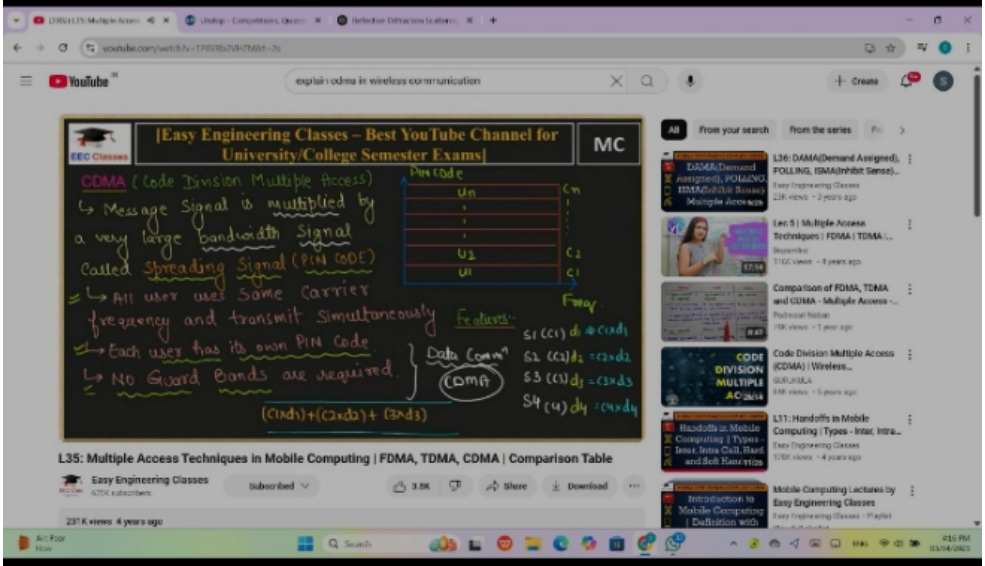
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MC
CDMA (Code Division Multiple Access)
Message Signal is multiplied by a very large bandwidth Signal
Called Spreading Signal (PIN CODE)
All user uses Same Carrier frequency and transmit simultaneously
Each user has its own PIN Code
No Guard Bands are required
Features:
Data Comm
CDMA
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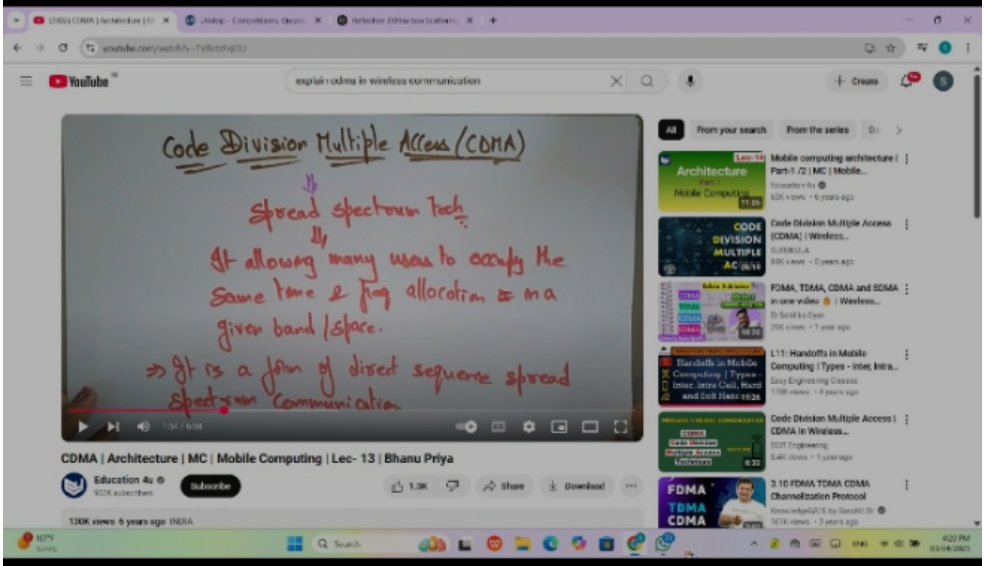
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Code Division Multiple Access (CDMA)
Spread spectrum Tech.
It allows many users to occupy the same time & freq allocation in a given band/space.
⇒ It is a form of direct sequence spread spectrum communication.
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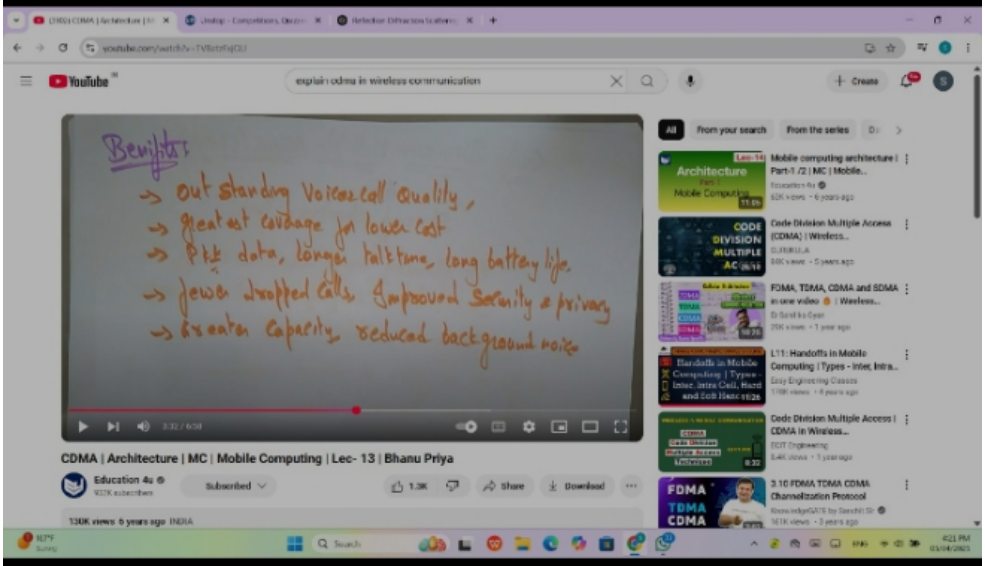
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Benifits
-> Out standing Voice call Quality,
-> Greatest coverage for lower cost
-> High data, longer talk time, long battery life.
-> fewer dropped calls, Improved Security & privacy
-> Greater Capacity, reduced background noise
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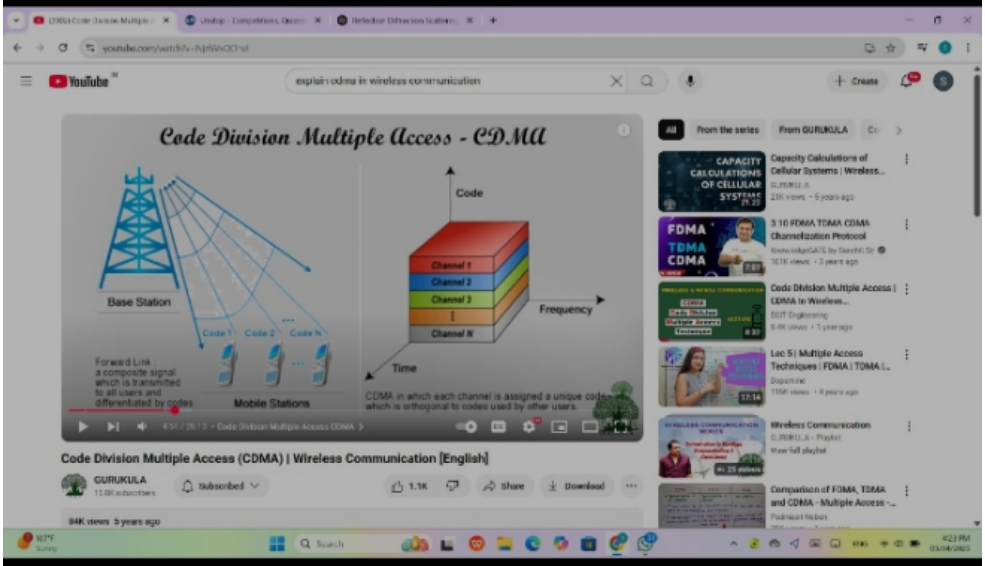
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Code Division Multiple Access - CDMA
Base Station
Code
Channel 1
Channel 2
Channel 3
Channel N
Frequency
Time
Code 1
Code 2
Code N
Forward Link
a composite signal
which is transmitted
to all users and
differentiated by codes
Mobile Stations
CDMA in which each channel is assigned a unique code
which is orthogonal to codes used by other users
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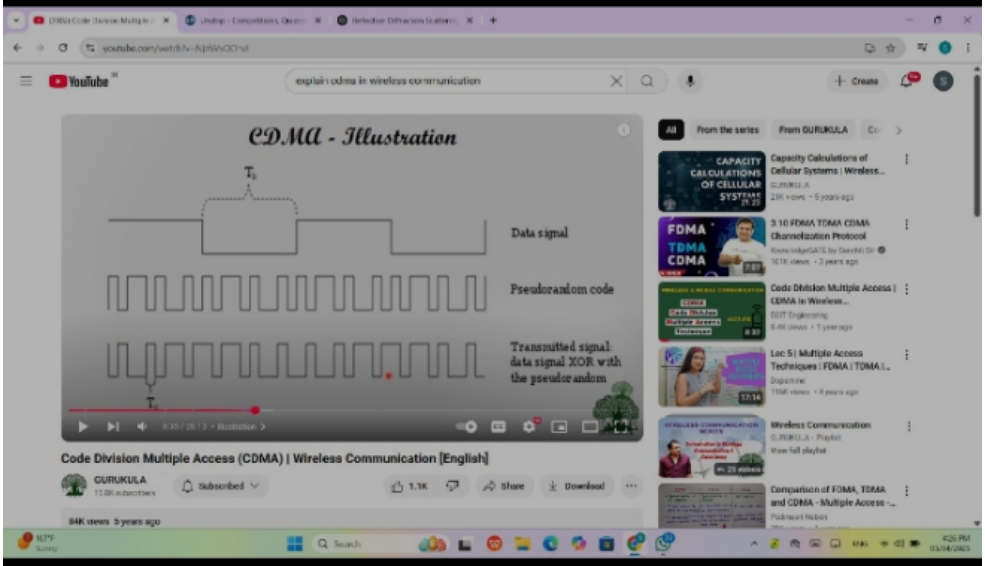
Wireless Communication
Comparison of FDMA, TDMA and CDMA - Multiple Access -...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CDMA - Illustration
Data signal
Pseudorandom code
Transmitted signal: data signal XOR with the pseudorandom
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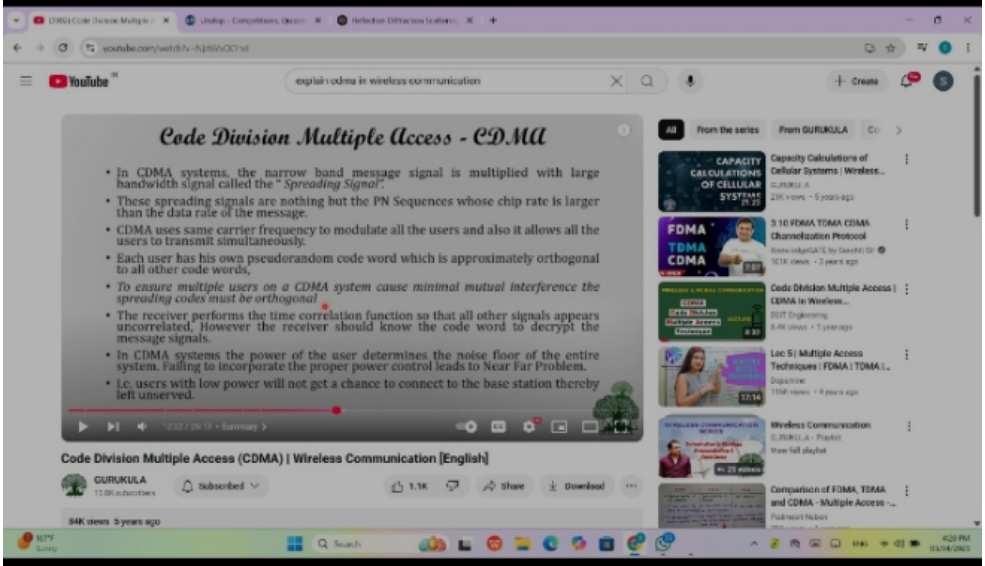

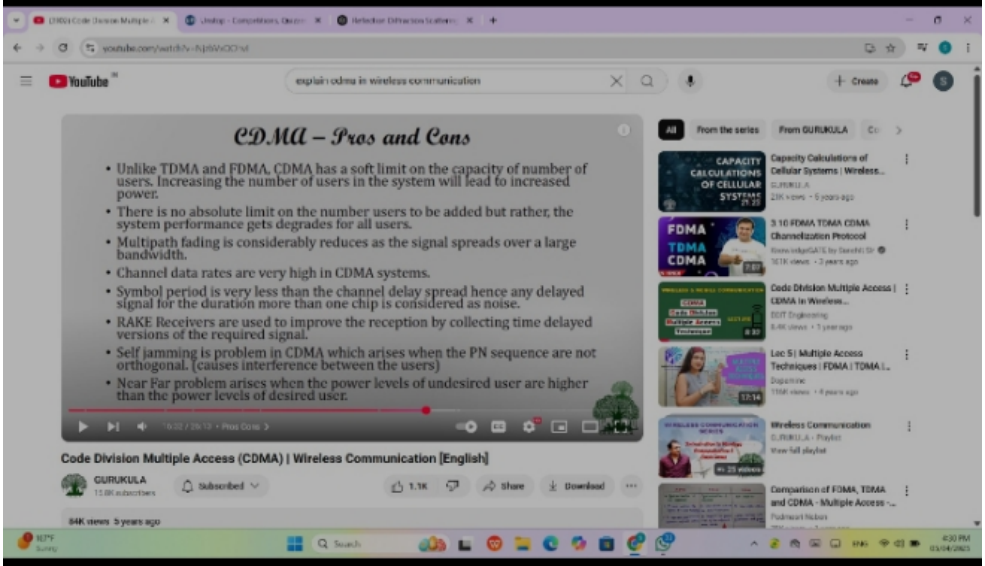
explain cdma in wireless communication
CDMA – Pros and Cons
• Unlike TDMA and FDMA, CDMA has a soft limit on the capacity of number of users. Increasing the number of users in the system will lead to increased power.
• There is no absolute limit on the number users to be added but rather, the system performance gets degrades for all users.
• Multipath fading is considerably reduces as the signal spreads over a large bandwidth.
• Channel data rates are very high in CDMA systems.
• Symbol period is very less than the channel delay spread hence any delayed signal for the duration more than one chip is considered as noise.
• RAKE Receivers are used to improve the reception by collecting time delayed versions of the required signal.
• Self jamming is problem in CDMA which arises when the PN sequence are not orthogonal. (causes interference between the users)
• Near Far problem arises when the power levels of undesired user are higher than the power levels of desired user.
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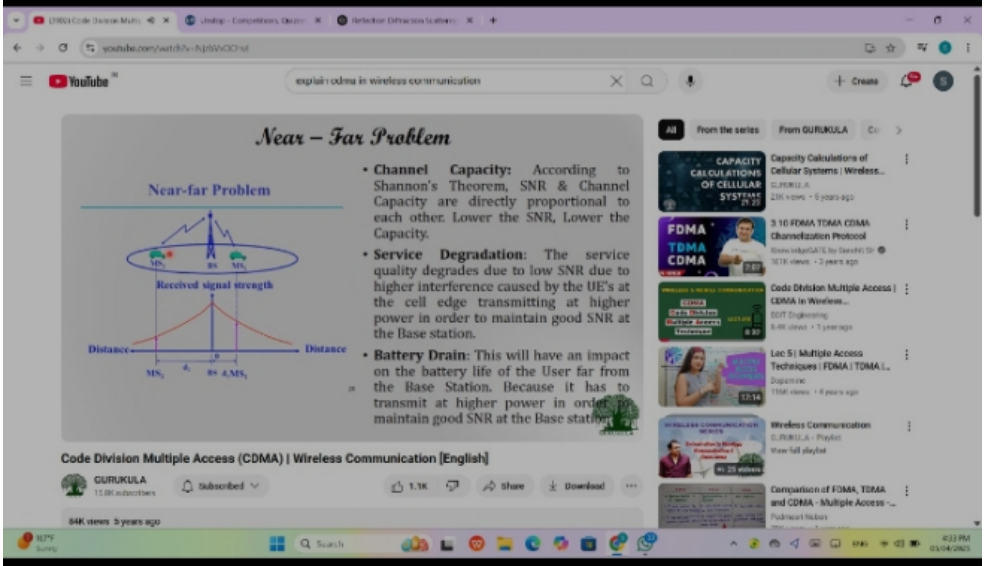

SNR - Signal to noice ratio

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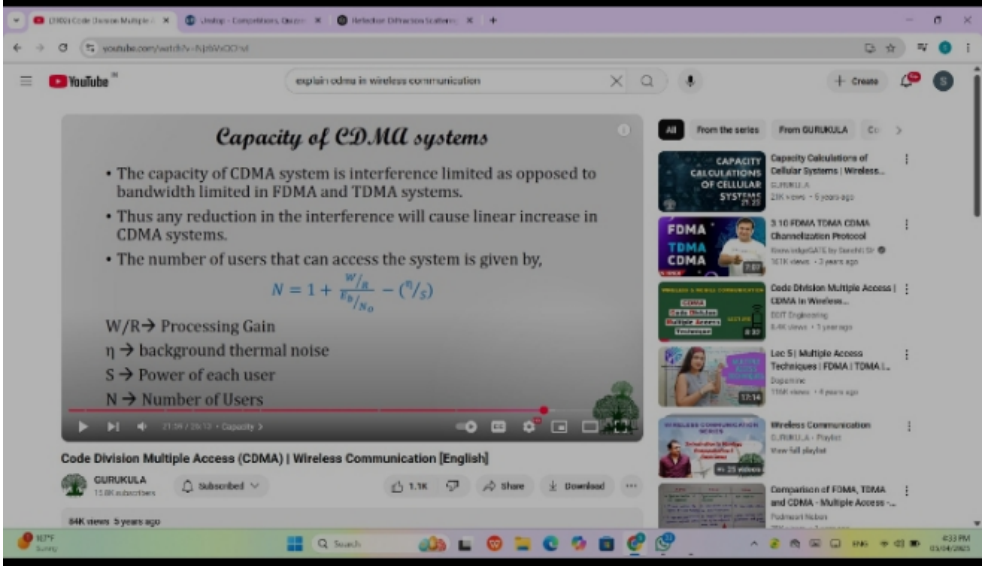

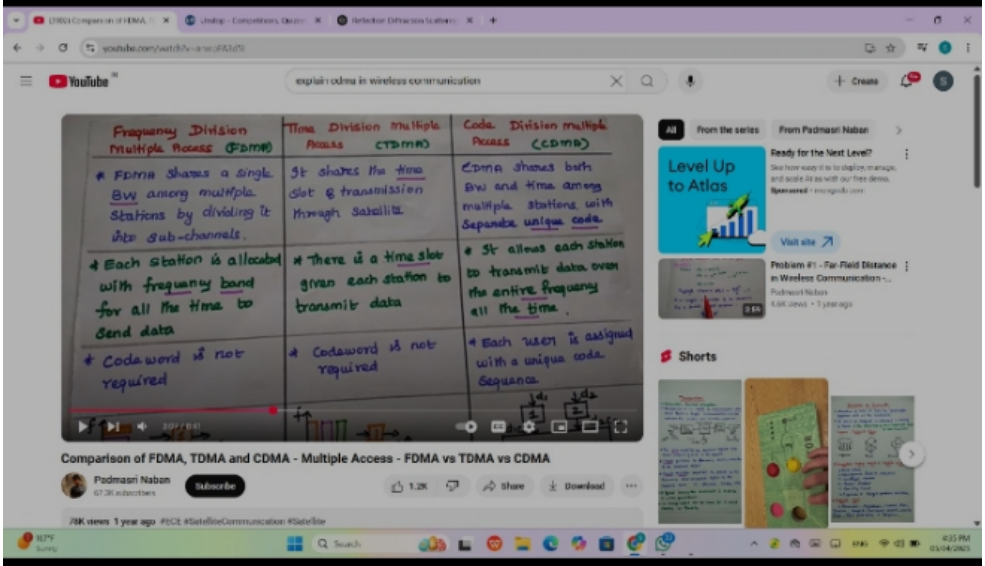

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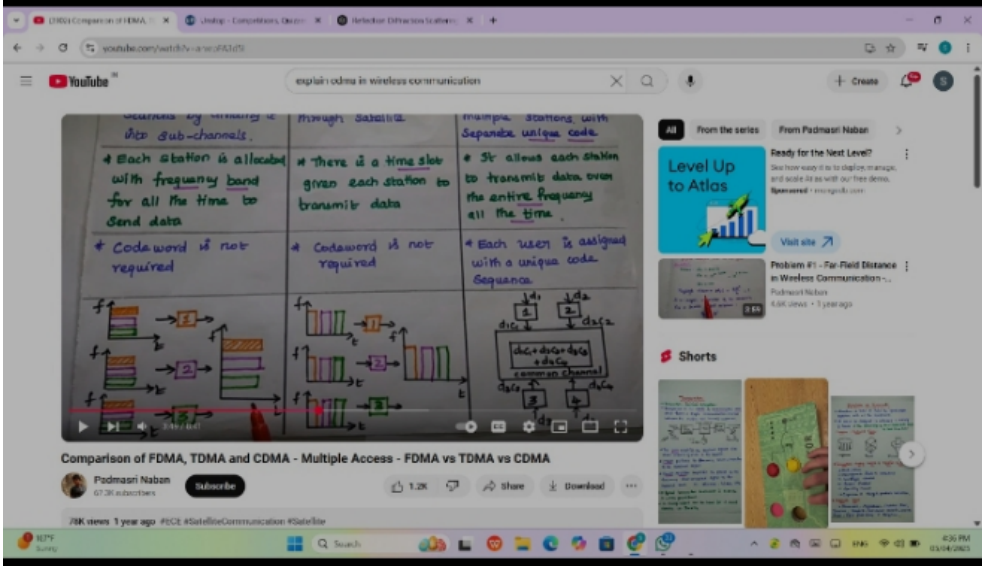
explain cdma in wireless communication
Create
Each station is allocated with frequency band for all the time to send data
There is a time slot given each station to transmit data
It allows each station to transmit data over the entire frequency all the time.
Each user is assigned with a unique code sequence
Codeword is not required
Codeword is not required
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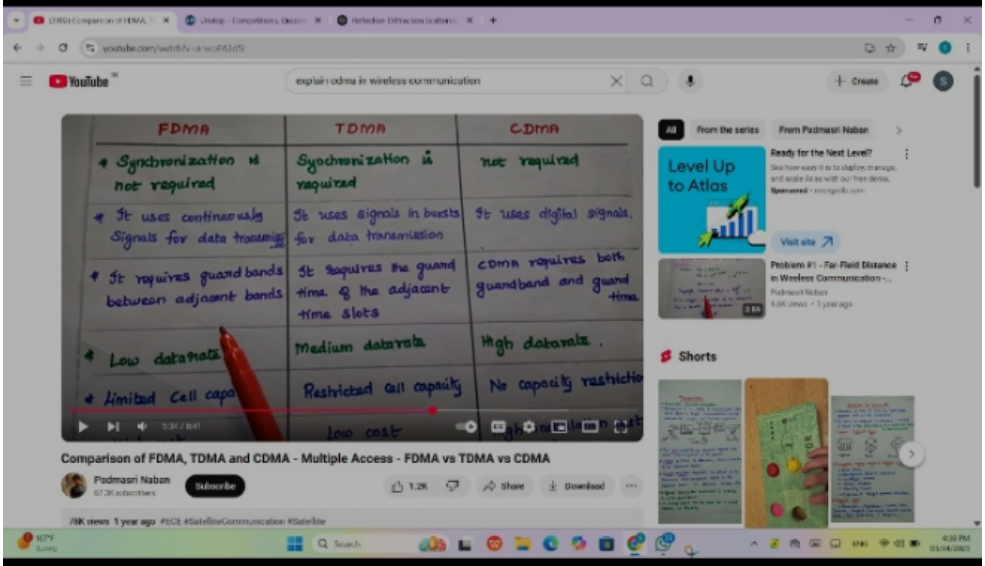
explain cdma in wireless communication
FDMA
TDMA
CDMA
Synchronization is not required
Synchronization is required
not required
It uses continuously signals for data transmission
It uses signals in bursts for data transmission
It uses digital signals.
It requires guard bands between adjacent bands
It requires the guard time of the adjacent time slots
CDMA requires both guardband and guard time.
Low datarate
Medium datarate
High datarate.
Limited Cell capa
Restricted Cell capacity
No capacity restrictio
Low cost
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