EEE 3208

Communication Theory Lab

Experiment No: 08

Experiment Name: Study of Communication Using Optical Link

Submitted by,

Name: MD Reedwan Ahmed

ID : 20210205167

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Objective: The goal is to achieve communication through light and discuss methods to modulate signals through amplitude and frequency, consider these methods in an analogy to lighting, analyze how an analog or digital source of information impacts the modulated signal and realize how communication through an optical link takes place in reality.

1. Block Diagram, Merits, Demerits, and Applications of Optical Communication System:

1.Information Source:

This is the original letter or communication to be sent.
It may take digital or analog forms including sounds, video, or data.

2.Electrical Transmit (Transmitter Circuit):

The input is converted to an electric form in order to transmit.
This circuit tunes the signal to perfection in preparation to convert to light.

3.Optical Source:

The Laser Diode (or simply Light Emitting Diode (LED)) converts an electronic signal to an opto-electronic one.
The brightness, content, and hue can be altered in response to the received signal.

4. Optical Fiber Cable (Transmitter/Transmedium):

This is the route by which the optical signal is transmitted to transmission.
It provides little signal loss, improved speed in data transmission, and electromagnetic interference (EMI) shielding.
Light moves through the material through total internal reflection (TIR).

5.Optical Detector:

When light is absorbed by it, the energy is converted to an electric current. This is used to detect approaching light to an equivalent degree of electric output.

6.Electrical Receive (Receiver Circuit):

The electrical signal received is purified, increased in strength, and altered. Extra signal processing (for example, low-pass filtering (LPF) or amplifying) is used to recover the original signal.

7.Destination:

The final cue is sent to the target individual. We can use it to call someone, chat with messages, or stream movies.

Benefits of Optical Communication System:
Optical fiber communication is superior to conventional copper systems in various ways:

1. Fast speed in internet and data
Optical fibers transmit greater amounts of data compared to conventional copper cables.
It allows to transfer information quickly to terabits every second.
2. Low Signal Attenuation (Loss)
The loss in fibers is considerably less compared to cables carrying electricity.
It allows long-distance communication without frequent signal repeaters.
3. Keeping Electromagnetic Interference (EMI) Away
Fiber optics remain uninfluenced by electromagnetic radiation in comparison to copper cables.
This makes it ideal to apply in environments with extensive electromagnetic interference.
4. Safety and Privacy
Optical fibers transmit no signals, making it difficult to trace.
It provides solid defense to vital information.
5. Simple and Compact Design
Optical fibers are thinner and lighter compared to wire.

They take minimal amounts of space and can be quickly erected.
6. Corrosion Resistance
Optical fibers don't get rusty over time compared to copper.
This helps keep them healthier and perform better.
7. Long-Distance Communication
Optical fibers transmit messages over thousands of kilometers with minimal loss.
This is ideal for applications such as cables underwater and intercontinent communication.

Disadvantages of Optical Communication System:

1. Big upfront price
Installing and deploying fiber optics is more expensive than deploying copper cables.
However, the long-term benefits often outweigh the initial expense.
2. Weakness
Optical fibers are softer and can be damaged easier than copper wire.
You should take caution while handling, folding, and splicing.
3. Difficult Maintenance
Finding and repairing problems require special tools and expertise.
Fixing problems is more complicated than in copper-based systems.
4. Limited Flexibility
Bending too much can weaken signals because of the effect of bending.
This makes it not ideal to apply where extensive motion or stooping is required.
5. Losses in Connectors and Splicing
Fusion splicing and connection losses can both depreciate signal strength.
Good alignment is required in order to have properly working signals.

Uses of Optical Communication System:
Fiber optic communication is used in most areas because it is reliable and efficient.

1. Cellphone Networks
Fiber optics constitute the core of present communication systems.
They let individuals conduct free video and voice calling over extended distances.
2. Computer & Internet Communication
Internet service providers employ this to offer broadband service.
Optical fibers support fiber-to-home (FTTH) and 5G backhaul networks.
3. Train Conversation
Fiber optics is employed in communication systems and railway signalling.
They watch trains operate in action.
4. Military Communication
Optical fibers aid in transmitting military messages in an secure manner.
They can withstand electromagnetic interference (EMI) and computer hacking.
5. Satellite Communication
Optical links are used in inter-satellite and space-ground communication.
They move quickly and efficiently between ground facilities and satellites.
6. Industrial Automation
Used in industries and in smart factories to accelerate communication between equipment.
Optical sensors assist robots and automatic controllers.
7. Medical Applications Optical fibers have applications in endoscopy, treatments by lasers, and in medical imaging. They give definite pictures to treat and diagnose.

2. Submit all experimentally observed wave shapes:

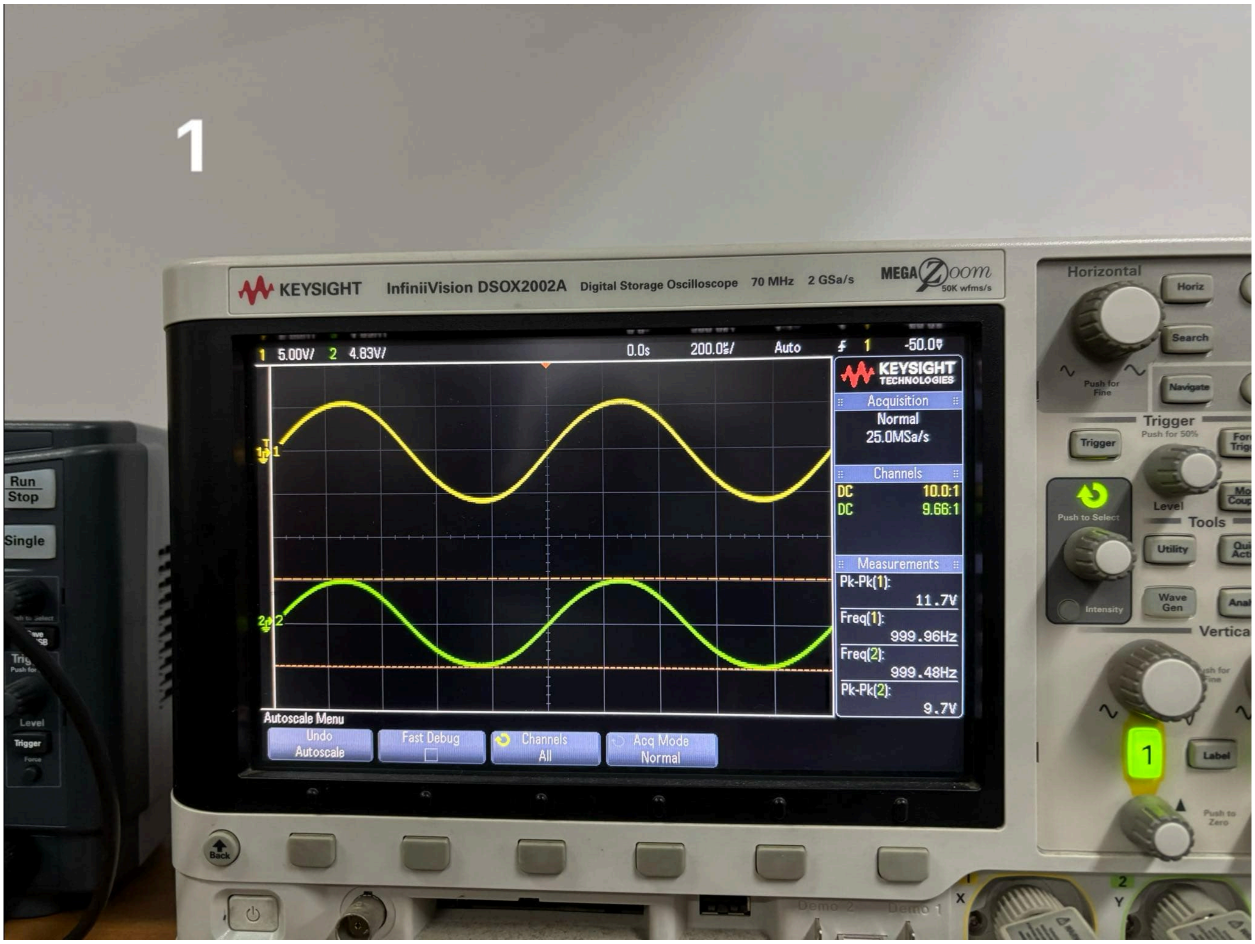

Fig: Input analog signal (yellow) and Output Amplitude modulated signal (green). Output amplitude reduces if we bend the cable.

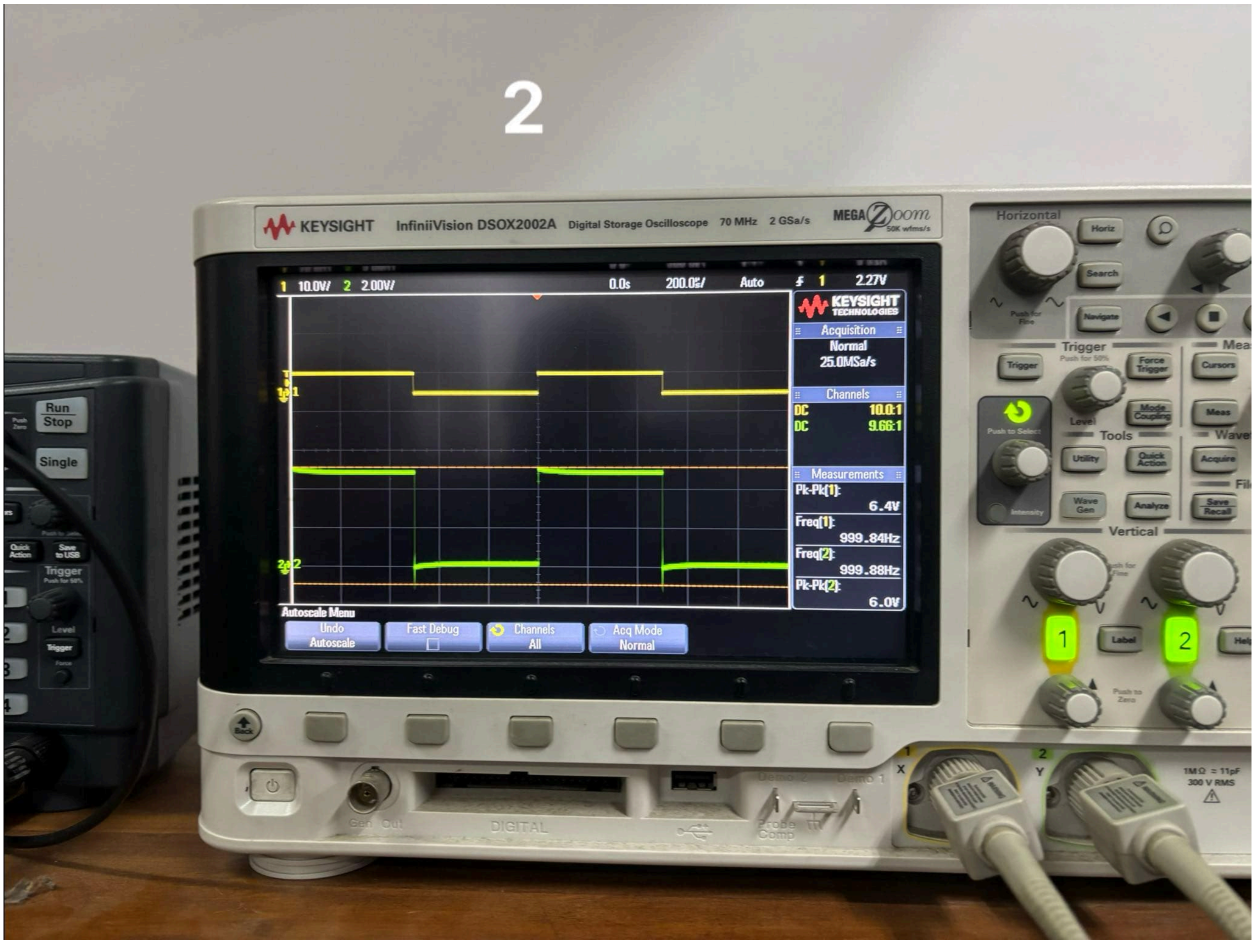

Fig: Digital input signal and Output AM signal

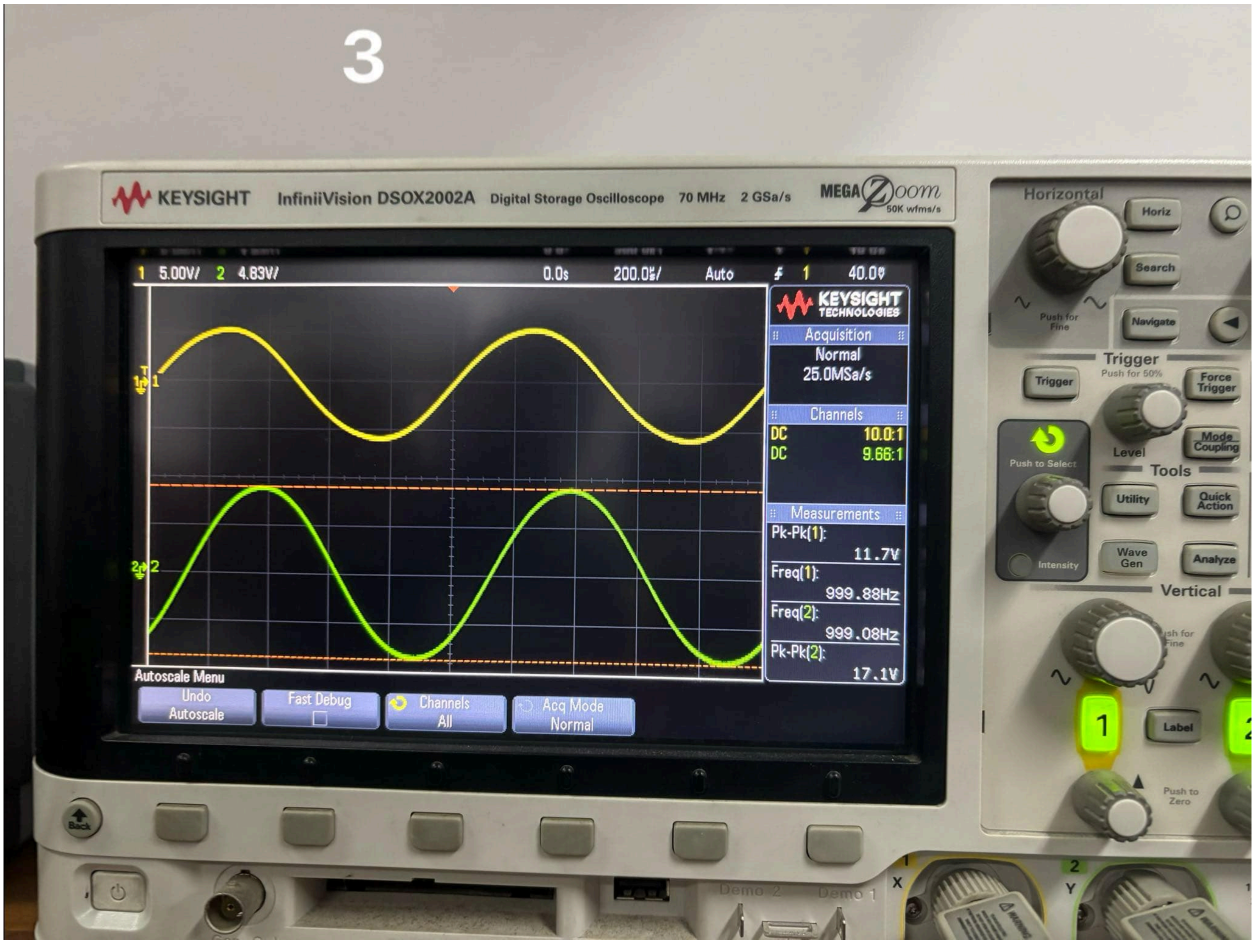

FIG: Analog FM input vs output

3. Purpose of Different Blocks in the Experiment

1. EMITTER BLOCK

The emitter converts electronic signals, both digital and analog, to light signals.
It has an LED or an Laser Diode.

2. COMPARATOR BLOCK

The comparator is employed to transmit digital messages.
It checks an input voltage to a reference voltage.
Gives a HIGH (5V) or LOW (0V) signal depending upon the comparison.
It helps to convert anolog signals to digital pulses.

3. DETECTOR PART

The detector converts light signals to electric signals.
It has a P-i-n diode or photo-diode.
The output is a weak electrical signal requiring amplification.

4. PLL (Phase-Locked Loop) BLOCK

Used in FM (frequency modulation) broadcasting.
Helps to recover original frequency content in an modulated signal.
Ensures stability and accuracy of frequency demodulation.

5. FREQUENCY MODULATOR PART

It changes the input to an FM (frequency modulated) light signal.
The output signal varies in frequency in accordance with the message signal.

6. LPF (Low-Pass Filtering)

Removes unwanted high-frequency noise from the detected signal.
Used in demodulation to recover the original message signal.

7. AC amplifier

Strengthens the weak signal to process later.
Important for both AM and FM reception.

4. Merits and Demerits of AM and FM for Analog & Digital Transmission

Amplitude Modulation (AM)
Benefits:
Easy design and installation.

Requires less bandwidth.

It works efficiently over distances.

Drawbacks:
Very affected by interference and noise.

Needs a powerful signal to travel over vast distances.

Not skilled in handling power.

AM for Digital Communication

Easy, but not sound-blocking.
Speed is not ideal because interference is present.

Frequency Modulation (FM)
Benefits:
Not easily disturbed by distractions or sounds.

Provides improved audio to address audio requirements.

Using power in a better manner than AM.

Drawbacks:
More complex receiver design. Needs more breathing room than AM.

Costs more to perform.
FM for digital transmission: More dependable and quieter Great for communication systems in hurry. Used in wireless communication systems in widespread practice.

Discussion:

In this experiment, Amplitude modulation (AM) and frequency modulation (FM) can be used commonly because both simplify receiver design in most systems in optics used in communication. Unlike traditional AM or FM used in communication in the radio frequency range, most systems in fibers tend to employ on-off keying (OOK) in most systems. OOK conveys digital data by exhibiting presence or absence of a signal. This technique has been most essential in digital communication in optics since the beginning and is to this day because broadband in fibers used in internet depends upon this technique.

Another point is dispersion and attenuation, which significantly influence signal quality over lengths. Signal deterioration due to attenuation is because fibers absorb, disperse, and deflect the fibers. Additionally, dispersion impacts transmission since various wavelengths travel with varying speed rates, leading to distortion in the signal. Fortunately, these issues can be resolved through wavelength-division multiplexing (WDM) and single-mode fibers that avoid wastage while making transmission efficient. We also discovered ways to strengthen weak signals over distances. Unlike electric amplifiers that initially convert light signals to electric signals before strengthening them, EDFA simply strengthens only light signals without making use of electricity. This is especially beneficial in communication over distances. It enables submarine cable fibers to transmit messages over oceans with fewer repeats required. Proper splicing and alignment is equally essential. We realize that splicing or alignment errors can lead to power loss in most amounts. Optical fibers have to have accurate fusion splicings or efficient connectors to maintain strength in the signal. This is because installation in fiber-optic systems is considerably more complicated compared to installation in conventional systems that utilize copper.