AOC Newsletter

Advanced Optical Communication Testbed

JULY, 2025

Published by AOC Testbed, a consortium project funded by the Department of Telecommunications, Government of India
https://www.aoctestbed.in/

Dear Readers,

Welcome to the inaugural issue of the bi-monthly newsletter from AOC testbed project.

The project is progressing well and has developed good traction with the industry. We are happy to share that the Multicore fiber testbed readiness at the IITM campus was announced during TTDF Symposium-2025 on 19 June 2025. It's the first of its kind field deployed MCF testbed with armored underground cable (4 Km) and aerial cable (1.2 Km) installations.

The cables have 12 multi-core fibers (4 cores each) alongside 12 standard single-mode fibers and are made by Sterlite Technologies Limited, India. We have completed initial tests with transmission of 1.024 Terabits/second data transmission through these fibers with standard 32 GBaud electronics with polarization multiplexed 16QAM modulation.

The MCF testbed is available for academic and industry partners to assess the use-cases and test the interoperability of components within the MCF ecosystem. Going forward, we will be sharing the highlights and key milestone achievements of the project through this newsletter regularly.

Please stay connected with us on https://www.aoctestbed.in/ to learn more.

Yours sincerely,
Deepa Venkitesh
Project Lead, AOC testbed project

Consortium Members

Academia

IIIT Delhi

IIT Delhi

IIT Madras

Industry

Quanfluence

SASMOS

SFO Technologies

SIGNALCHIP

SIGNALTRON

Sterlite Technologies

R&D

ERNET

Patents & Papers

18 Patents (Submitted)

62 Publications

AOC Testbed: Powering India's Future in Optical Communication
A consortium project led by IIT Madras.
Funded by Department of Telecommunications (DoT), Govt. of India

The Advanced Optical Communication (AOC) Testbed is a pioneering national consortium led by IIT Madras, funded by the Department of Telecommunications, Government of India. This consortium brings together academia, industry, and R&D partners to develop a next-generation optical communication ecosystem tailored to India's needs.

Our goal is to enable technologies that scale from Gbps to Pbps, through modular, field-deployable testbeds supporting >1 Tbps capacity, with a clear pathway to 1 Pbps. We emphasize the indigenous development of standards-compliant devices, subsystems and networks that are market-ready and support high-volume and niche product segments.

In addition to infrastructure and product development, AOC is committed to IPR generation, contribution to global standards, performance benchmarking and skill development, while fostering collaboration across the ecosystem.

Technology focus areas:

Transmission Systems:

- Multicore fiber field testbed-
  4-core fiber installation and capacity scaling
  (Sterlite Technologies Limited & IIT Madras)
- Single-mode fiber capacity scaling (IIT Madras)
- FSO system for turbulence-
  resilient high data-rates (IIT Delhi)
- Outreach (IIT Madras)

Radio over Fiber/5G and Beyond:

- Hybrid RFoF link for *mm*-wave transport
  (IIT Madras)
- 26 GHz RFoF WDM transceiver for
  aerial fiber (SASMOS Technologies)
- Fully hybrid optical communication link
  (IIT Delhi)

Optical Devices:

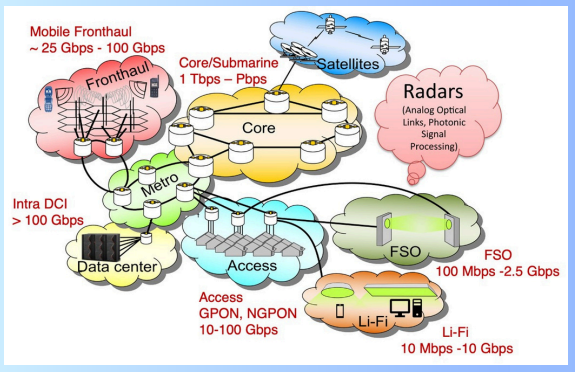
- Fan-In Fan-Out device: Process & Product Development
  (IIT Madras, SFO Technologies)
- Reconfigurable optical filter (IIT Delhi)
- Optical frequency comb technology (IIT Delhi)

Optical Networks:

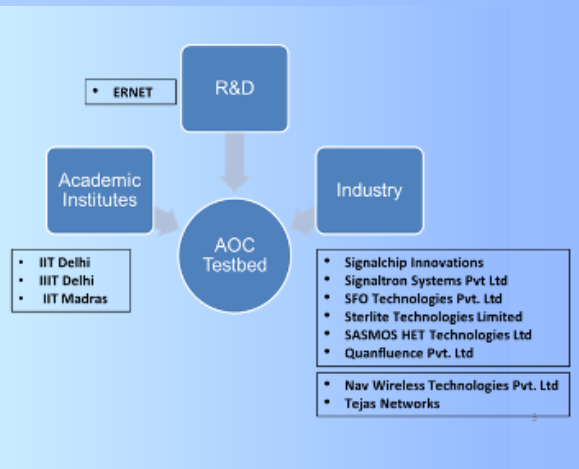
- AI-enabled pre-emptive network control in multiband
  networks (IIIT Delhi)
- Network security enhancements through Quantum key
  distribution (ERNET India)
- LiFi network deployment (IIT Delhi)

Optoelectronic Devices:

- Retimer chip development for QSFP transceivers (Signalchip)
- Development of transceivers (Signaltron)
- Hybrid integration of QSFP transceivers (IIT Madras)
- SiN parametric amplifier, homodyne detector (Quanfluence)



Ubiquitous presence of optical communication



Collaborative architecture of AOC testbed

Transmission System: Enabling Ultra-High-Speed Data Transfer

1. From Vision to Reality: Multicore Fiber (MCF) Testbed

The installation of first MCF testbed globally with both underground and aerial installations completed. The MCF fibers and cables are manufactured and installed by Sterlite Technologies Limited in the IITM campus. The AOC Testbed enables high-capacity data transmission using multi-core fibers (MCFs), achieving >6.4 Tbps, ideal for data centres, long-haul 5G/6G fronthaul, and RF-over-Fiber (RFoF) applications. They also find applications in Quantum key distribution and integrated sensing with communication.

Key Features:

- High-Speed Transmission
- Lab-to-Field Translation
- Optical Frequency Comb
- Multi-Core Access Link
- RFoF + digital transmission, advanced DSP

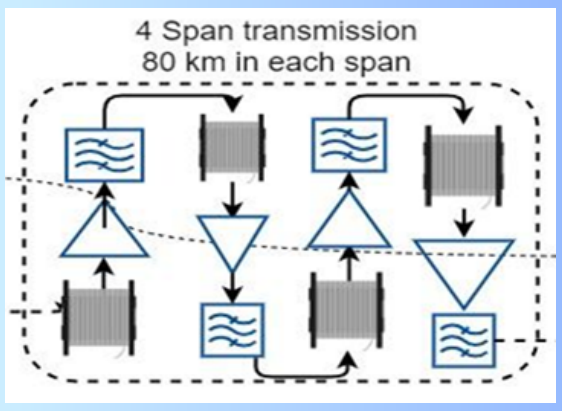
Transmission testbed @ IITM

2. Pushing the Limits: Capacity Scaling

IIT Madras work focuses on the indigenous development of high-speed, long-haul optical communication technologies, enabling >1 Tbps data rates over 320 km using advanced DSP and optical components.

Key Features:

- 1 Tbps Metro Link
- Mid-Span Spectral Inverter
- Low-Noise Parametric Amplifier and Optical Phase Conjugation
- BharatNet Integration



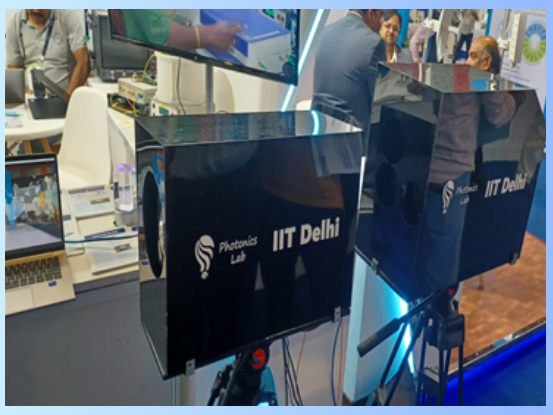
System demonstration of multi span link

3. Bridging Distance: Turbulence-Resilient Free Space Optics (FSO)

This project pioneers the development of a high-speed, turbulence-resilient Free Space Optical (FSO) communication system—bringing broadband connectivity to villages, campuses, and remote terrains. In partnership with Navtech, these innovations will be integrated into next-gen FSO products.

Key Features:

- Specially Engineered Laser Beam
- Automatic Position and Tracking System
- 10 Gb/s FSO Testbed over 5 km with forward error correction (FEC)



FSO communication system

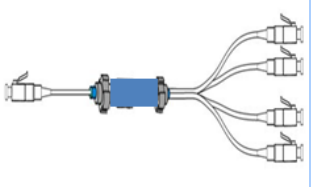
Optical Devices: Precision Tools for the Future of Fiber

1. Seamless Coupling: Multicore Fiber Couplers (Fan-in / Fan-Outs)

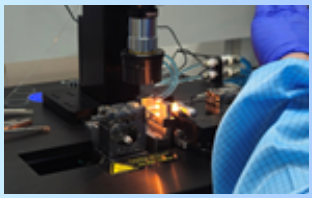
IIT Madras, in collaboration with SFO Technologies, is developing a critical enabler for next-gen optical networks—an all-fiber Fan-In/Fan-Out (FIFO) device that seamlessly connects multi-core fibers (MCFs) to standard single-mode fibers (SMFs). IIT Madras leads design and prototyping, with SFO Technologies commercialize the product. Real-world testing on the IIT Madras multi-core optical testbed.

🔹 Key Features:

- Custom-designed FIFO coupler for 4-core MCFs with square lattice geometry
- Low insertion loss (≤1.0 dB) and crosstalk < -20 dB
- Operating Wavelength: 1525–1565 nm
- Temperature Range: -20°C to +75°C



4-Channel FIFO



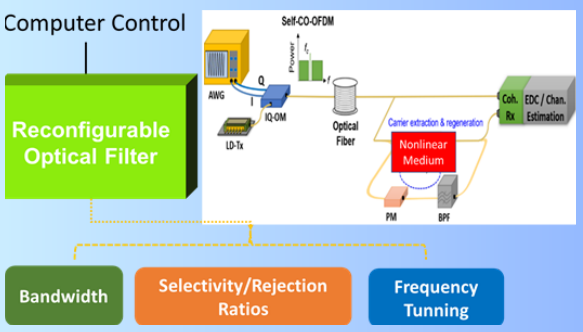
Preliminary tapering trials

2. Precision Engineering: Reconfigurable Optical Filter

IIT Delhi is developing a reconfigurable and tunable microwave optical filter designed to dynamically adapt to diverse frequency bands and signal types—delivering versatile, high-performance filtering for modern microwave communication systems.

🔹 Key Features:

- Wavelength Range: C-band, High Power Per Line: >0 dBm, Multi-Line Capability: >10 lines
- Spectral shaping and equalization
- Interference mitigation in dense wireless environments,
- Replacement for low-resolution tunable filters



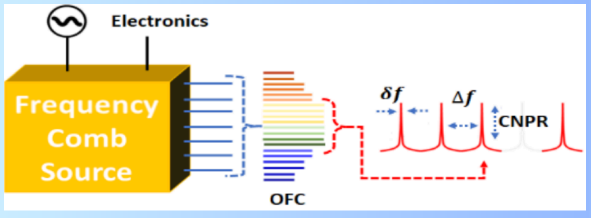
Reconfigurable optical filters

3. Enabling Terabit Highways: Optical Frequency Comb Source

IIT Delhi is developing a rugged, stable optical frequency comb source based on nonlinear fiber loops and electro-optic modulators, tailored for C-band communication systems.

🔹 Key Features:

- Wavelength Range: C-band Power Per Line: > 0 dBm, Number of Lines: >10, Packaged in a ruggedized box
- 100 Gbps to 2 Tbps data transmission
- Dense WDM transport, coherent communication, and advanced optical signal processing



Frequency combs

Radio Over Fiber: Fast Wireless, Powered by Light

1. Saving Bandwidth: Hybrid RFoF DU-RU link for Generation & Transport of *mm*-wave

IIT Madras is advancing the future of 5G infrastructure with the development of a hybrid analog-digital radio-over-fiber (RoF) fronthaul system. This innovation enables the relocation of the RFSoC from Remote Radio Head (RRH) to the Baseband Unit (BBU), linked via a 2 km fiber connection, fully compliant with 5G NR specifications.

Key Features:

- Low Bandwidth Operation
- Frequency Multiplier
- RF Generation without VCO
- Lightweight & Energy-Efficient RRHs

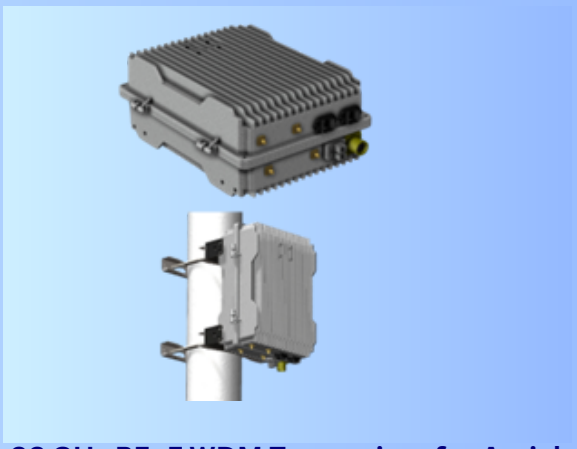
Four-channel IFoF transceiver module

2. Elevating 5G: 26 GHz RFoF WDM Transceiver for Aerial Fiber

SASMOS is developing a cutting-edge Wavelength Division Multiplexed (WDM) photonic link for *mm* -wave 5G fronthauling in the n258 band (24.25–27.5 GHz), integrated into the multi-core fiber AOC testbed.

Key Features:

- Gain Control: 30 dB,
  Minimum Detectable Signal: -80 dBm,
  Max Input Power: -20 dBm
- Deploy and test two-channel WDM RoF
- High-performance WDM mmWave photonic links for 5G
- Frequency Range: 24.25–27.5 GHz,
  Link Gain: 0 ± 1 dB



26 GHz RFoF WDM Transceiver for Aerial Fiber Tests

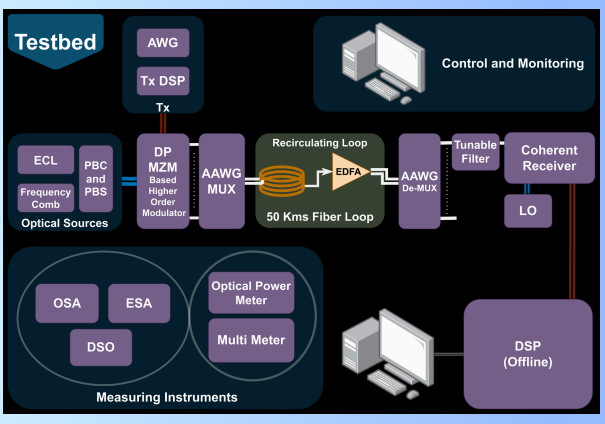
Optical Networks: Smarter, Faster, and More Secure

1. Unified Speed: Fully Hybrid Optical Communications Link:

IIT Delhi is developing the coherent optical communications testbed capable of delivering over 2 Tbps data throughput.

Key Features:

- Ultra-High Data Rates >2 Tbps transmission
- Advanced Modulation & Multiplexing
- AI-Powered Signal Processing



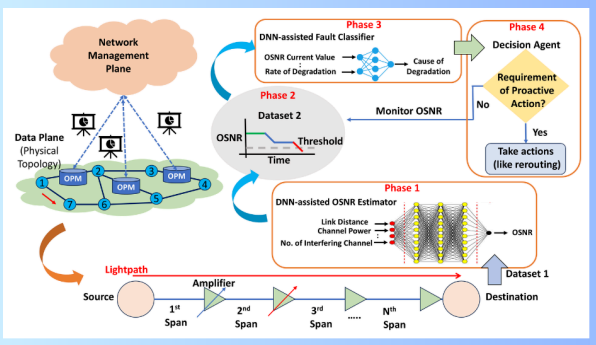
Fully hybrid optical communications link

2. Think Ahead: AI-Enabled Pre-Emptive Network Control in Multiband Optical Networks

IIIT Delhi is pioneering AI-assisted control strategies for next-generation C+L band optical networks, enabling proactive fault detection and automated network recovery.

🔹 Key Features:

- ML-Based Quality of Transmission (QoT) estimator with 1 dB accuracy
- QoT Degradation Classifier with ≥ 95% accuracy
- Integrated C+L band simulator embeds AI tools for real-time automation and pre-emptive fault response
- Field-Test Ready: To be demonstrated on Tejas/C-DOT's testbed



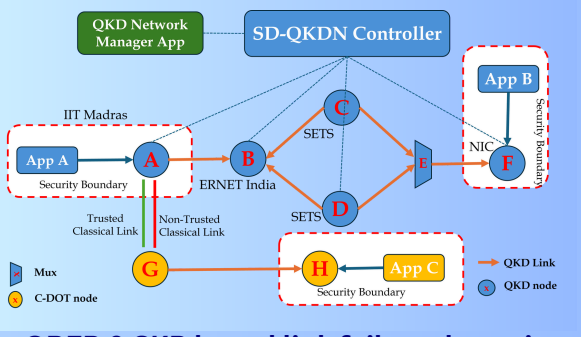
AI-Enabled pre-emptive network control

3. Unbreakable by Design: Network Security

IIT Madras, in collaboration with ERNET India, C-DOT, and MAQAN partners, is developing a secure, Software Defined Network (SDN) enabled Quantum Key Distribution (QKD) network under the AOC Testbed. This initiative establishes field-deployable QKD systems for secure communication across metro-area optical networks.

🔹 Key Features:

- QKD Network Testbed resilient to DDoS-style quantum channel attacks (e.g., QBER > 20%, SKR < 10 Kbps)
- SDN-Controlled QKD Path Management
- 24x7 Monitoring Framework
- Participation in Standards Development Organizations (SDOs)



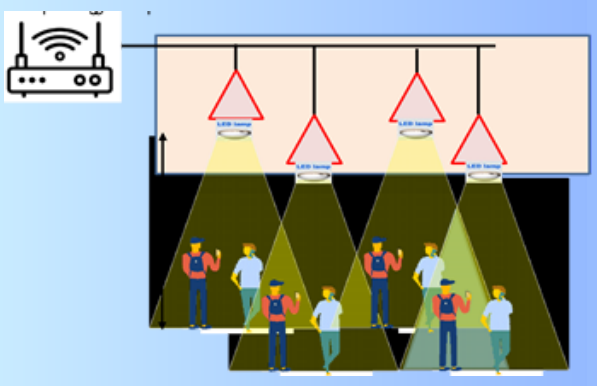
QBER & SKR based link failure detection

4. Light Up your Connection: LiFi Network

IIT Delhi is at the forefront of developing a high-speed LiFi (Light Fidelity) network, positioning it as the next-generation indoor wireless communication technology. Designed to deliver seamless internet connectivity through optical access points, the LiFi system will support data rates up to 200 Mbps with a reach of up to 3 meters, even for mobile devices.

🔹 Key Features:

- Development: transmitter and receiver
- Simulation, design, and fabrication of optimized receiver optics
- Implementation of a full LiFi protocol stack on FPGA
- Equalization circuit design to boost data rate of bandwidth limited white LED
- Network-on-Chip (NoC)-based architecture supporting full duplex and Internet access



Networked LiFi

Optoelectronic Devices: Powering High-Speed Photonics

1. Chip Scale Precision: SiN Parametric Amplifier & Homodyne Detector

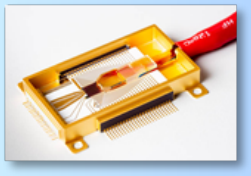
Quanfluence is developing a chip based compact electro-optic products.

SiN Parametric Amplifier built on a 2-meter-long spiral waveguide using a low-loss, dispersion-engineered SiN platform, this optical parametric amplifier leverages Four-Wave Mixing (FWM) to deliver broadband amplification with excellent phase matching.

Homodyne Detector is a receiver which contains a tunable beam splitter, balanced photodiodes, and a low-noise, wideband transimpedance amplifier co-packaged with the photonic chip. The detector is realized on a SiGe BiCMOS platform, ensuring compactness, power efficiency, and high sensitivity.

🔹 Key Features:

- High nonlinearity + low loss PIC
- Heterogeneous photodiode integration
- Coherent optical communication
- Quantum optics



Parametric Amplifier

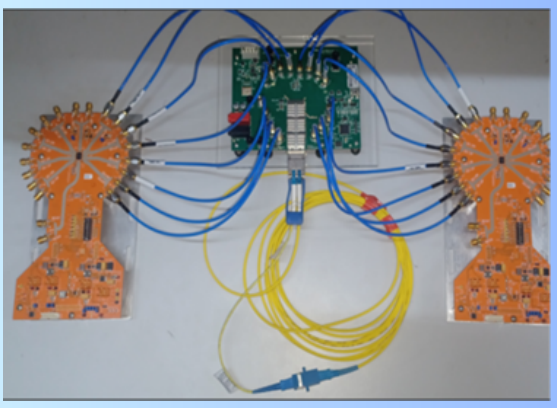
Homodyne Detector

2. Built For Speed: Hybrid integration for high-speed transceiver

IIT Madras is developing electronic retimer ICs on a 28nm CMOS platform, supporting data rates of >100 Gb/s and >200 Gb/s per fiber. The solution is fully aligned with IEEE 802.3bs standards, targeting ultra-low jitter and seamless interoperability.

🔹 Key Features:

- Board-level demo of PAM4 data transmission
- Optical validation: Eye diagram analysis and Interoperability testing with reference receivers



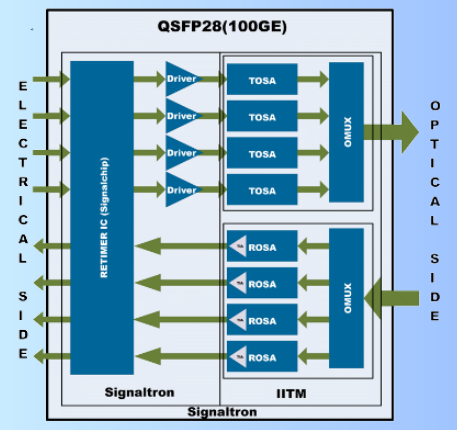
Hybrid integration for high-speed transceiver

3. Signal Perfected: Development of retimer chip for QSFP transceiver

Signalchip is developing a production-ready retimer chip for QSFP Optical transceivers, fully compliant with IEEE 802.3ba standards.

🔹 Key Features:

- Quad-channel
- Multi-protocol retimer with integrated signal conditioning
- Designed to support 100 Gbps transmission with a stretch goal of 200 Gbps



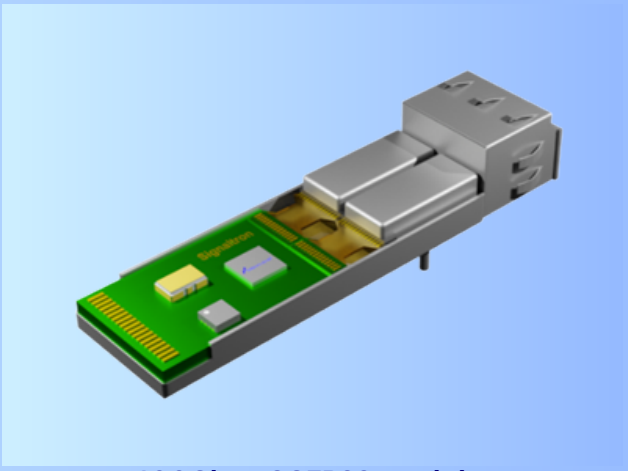
Retimer chip (OOK, 100 Gbps)

4. Next-Gen Ready: Development of Transceiver

Signaltron is developing production-ready 100Gbps QSFP28 optical transceivers, tailored for long-reach data communication needs. These transceivers are designed with full compliance to industry standards and built-in diagnostics, with a stretch goal of 200Gbps to future-proof India's optical networking infrastructure.

🔹 Key Features:

- 100Gbps QSFP28 module
- Compact, hot-pluggable form factor
- Single power supply
- Stretch goal: 4 × 50 Gbps PAM4 electrical interface



100Gbps QSFP28 module

Commercialization of Products Developed under AOC testbed project:

As part of the AOC testbed project, a few products are being developed under various work packages. The development roadmap is closely monitored using a TRL framework. Commercialization of the products under development for the work packages of academia is explored with industry partners on the ToT model.

The Consortium got visibility in various global forums:

Outreach:

AOC testbed is actively pursuing outreach activities. A glimpse of activities conducted and participated so far:

Multi-Core Fiber Field Testbed Facility announced
TTDF Symposium 2025, 19 June 2025

AOC Lab Visit
TTDF Symposium 2025

For more information and opportunities, visit https://www.aoctestbed.in/
Contact us at aociitm@ee.iitm.ac.in