COURSES OF STUDY
FOR
POST GRADUATE PROGRAMMES

(2020 – 2022)

Defence Institute of Advanced Technology
(Deemed to be University)
Pune – 411025

Department of Applied Physics

M. Tech. in Optoelectronics and Communication Systems (Optical Communication and Photonics)

Brief Description: The rapid growth of networks and the internet over the past decade has been enabled by advances in photonics technology. Optical communication networks provide the high capacity ubiquitous connectivity that forms the backbone of global internet. Today, optics has become the way by which most of the information is communicated around the globe and is the only technology that is capable of meeting the exponentially growing demand for communicating information. The programme intends to impart training to selected candidates in the field of Optical Communication and Photonicsthat would enable them to meet the challenges in this rapidly developing field.

Stakeholders:

(i) Sponsored candidates from Army, Navy, Air Force, DRDO Laboratories, Public Sector Undertakings and other departments

(ii) Graduates in the relevant field of science/engineeringfrom recognized Universities/Institutes across the country.

Eligibility:

The candidate should possess Master degree or equivalent in Physics, Applied Physics, Electronic Science, Photonics **OR** B. E./ B. Tech/ BSc.(Engg.) or equivalent in Electronics Engg./ Electrical Engg./ Electrical & Electronics Engg./ Electronics & (Tele)Communication Engg./ Electrical Communication Engg./ Electronics & Instrumentation Engg./ Instrumentation Engg./ Optics & Optoelectronics.

Organization: The M. Tech. programme is of four-semester duration. In each of the first two semesters there are five courses and practical. There will be three continuous evaluation examinations and a final semester examination for every course. Half-yearly evaluation of the project takes place at the end of the third semester. At the end of the final semester the student submits a thesis and makes a presentation about the project, which is evaluated by the Internal and External examiners. Course syllabus has been updated periodically to keep pace with the

contemporary technological advancement.

Semester I

S. No	Course Code	Course Name	Credits			*Total Credits
			L	P (in Hr)	T	
1	AP 631	Applied Optics	3	0	1	4
2	AP 632	Laser & Optical Electronics	3	0	1	4
3	AP 643	Introduction to Fiber Optics	3	0	1	4
4	AP 635	Laser & Optical Communication Laboratory – I	0	8	0	4
5	AP 633	Semiconductor Photonic devices	3	0	1	4
6	AM 607	Mathematics for Engineers	3	0	1	4
		TOTAL	15	4	5	24

Semester II

S. No	Course Code	Course Name	Credits			*Total Credits
			L	P (in Hr)	T	
1	AP 644	Broadband Communication Systems	3	0	1	4
2	AP 645	Digital & Optical Communication Systems	3	0	1	4
3	AP 638	Laser & Optical Communication Laboratory – II	0	8	0	4
4	AP 647	Optical Networks	3	0	1	4
5		Elective – I	3	0	1	4
6		Elective-II	3	0	1	4
		TOTAL	15	4	5	24

Semester III:

Sl. No.	Course Code	Course Name	Credits		*Total Credits
			L	T / P	
1.	AP 651	M.Tech Dissertation Phase –I	28**		14
		Total	28		14

Semester IV:

Sl. No.	Course Code	Course Name	Credits		*Total Credits
			L	T / P	
1.	AP 652	M.Tech Dissertation Phase -II	28**		14
		Total	28		14

*****1 Credit in Theory/Tutorial means 1 contact hour and 1 credit practice/Project Thesis means 2 contact hours in a week.

****Contact Hours/ week**

List of Electives

Sr. No.	Course Code	Course
Elective I& II		
1	AP 646	Free Space Optical Communication
2	AP 641	Non-linear and Quantum Optics
3	AP 640	Nanophotonics
4	AP 648	Fourier Optics & Holography
5	EE 608	Advanced Wirless Communication
6	EE 631	Satelite Communication
7	EE 632	Advanced Communication Systems
8	EE 633	Underwater Communications

AP 643 Introduction to Fiber Optics

1. **Optical Fibers:** Light Propagation in Optical Fibers, Optical fiber Modes and Configurations, Mode Theory for Circular waveguides, SM and GI Fibers, Fiber Materials, PhC fibers, Fiber fabrication, Mechanical Property of Fiber and Fiber Optics Cables.
2. **Optical Fibers Characteristics:** Fiber Attenuation, Absorption losses, Scattering losses, Radiation losses, Bending losses, Measurement of losses, Dispersion in fibers, Effect of dispersion in communication link, Dispersion reduction and compensation techniques.
3. **Power Launching and Coupling:** Source to Fiber launching and Launching Schemes for Coupling Improvements. Fiber to Fiber joints, Laser coupling to SM fiber, Fiber splicing, Optical Fiber Connector.
4. **Optical Receivers:** Basic Concepts, Common Photodetectors, Receiver Design, Receiver Noise, Coherent Detection, Receiver Sensitivity, Sensitivity Degradation, Receiver bandwidth and Performance
5. **Fiber Amplifier:**Optical Amplification in rare-earth dopedfibers, Types of Fiber Amplifiers, EDFA, Amplifier Noise, Optical SNR, System Application, Raman Amplifiers, Wideband Optical Amplifier.
6. **Fiber Bragg Gratings:** Introduction, Methods for Fiber Bragg Grating Fabrication, Theory of Fiber Bragg Gratings, Types of Fiber Bragg Gratings, Measurement and Characterization of Gratings, FBGs in Fiber Lasers.
7. **Optical Fiber Sensor:** Introduction, Classification and Types of Optical Fiber Sensors, Sensor Modulation techniques, Fiber Bragg Grating Sensors: Principle and Applications.
8. **Overview of Optical Fiber Communication:** Light wave communications, Optical Spectrum Bands and Visible Units, Network Information rate and WDM concepts. Key Elements of fiber optics system, Standards for Optical fiber communications.
9. **OptisystemTuotorials**

a) Calculate the attenuation-limited fiber length based on the power budget equation. Simulate the resulting system and verify that it meets performance objectives.

b) Calculate the dispersion-limited fiber length for a fiber optic transport system that employs standard single-mode fiber and a directly-modulated single-mode laser diode transmitter. Simulate the resulting system and verify that it meets performance objective.

c) Design and simulate a fiber optic system using dispersion-compensating fiber to reduce chromatic dispersion.

Text Book:

1. A. K. Ghatak and K. Thyagarajan, Introduction to Fiber Optics, Cambridge University Press (1998).
2. G. Kaiser, Optical Fiber communication, 4th Edition, Tata McGraw Hill, 2008.

References

1. J. C. Palais, Fiber Optic Communications, Prentice-Hall Inc. 4th Ed. (1998).
2. S.K.Sarkar, Fiber optics in Telecommunications and Sensor Systems, S Chand & Co., New Delhi, 2002.
3. J. P. Dakin and B Culshaw, Optical Fiber Sensors, Vol. 1 & 2, Artech House, Boston and London, 1998.
4. R.Kashyap,Fiber Bragg Gratings, Academic Press, 1999
5. K.T.V. Grattan and B.T. Meggitt, Optical Fiber Sensor Technology, Vol. 2, Chapman and Hall, 1998

AP 644 Broadband Communication Systems

1. **Introduction:**Broadband Network Architectures, Future of broadband communications
2. **Basic Broadband Technologies:** Internet Protocol Suite, IPv6, Basics of Intranet & Extranet technologies, X.25 Technology, Frame Relay, Frame Relay Standards, Types of VPN and General Architecture, Fiber Channel Technology & topologies,
3. **xDSL:** IDSL, HDSL (SDSL, ADSL, RADSL, CDSL, and VDSL), xDSL, xDSL Coding Technologies, Provisioning of xDSL.
4. **Cellular Communication:** Analog Cellular Communications, The Cell site, The Mobile Telephone Switching Office (MTSO), Cell site Configurations, Tiered sites, Reuse of Frequencies, Allocation of Frequencies
5. **Global Services Mobile Communications (GSM), Wireless Data Communication (Mobile IP) and GPRS:** Analog to Digital Movement, GSM Architecture, Mobile Equipment (MS), BTS, BSC, BSS, MSC, VLR, IP Routing, Applications That Demand Mobile IP, Variations in Data Communications (Wireless), Possible Drawbacks with Wireless, Wireless Data Technology Options, The GSM Phase II Overlay Network, Circuit−Switched or Packet−Switched Traffic, GPRS Radio Technologies, PDP Contexts, GSM and NA−TDMA Evolution, Applications for GPRS
6. **Third−Generation (3G) Wireless Systems and VoIP:** EDGE, WCDMA, Applications of the Wireless Internet, Multimode Second Generation/UMTS Terminals, VoIP, QoS, Application of VoIP (H.323 Protocol Suites, Delay and Jitter on VoIP Networks, Protocol Stack.
7. **4G & 5G:**Introduction to 4G Standards, Introduction to 4G Architecture, components & basic internet & communication call flows. Introduction to 5G standards, basic 5G architectures, 5G services, Recent trends and applications in 5G, Massive Multiple□Input Multiple□Output (MIMO) Wireless Systems.

References:

1. **Cajetan M. Akujuobi, Matthew N.O. Sadiku, Introduction to Broadband Communication Systems, ,Chapman and Hall/CRC , 2007.**
2. Robert C. Newman, Broadband Communications Prentice Hall, NJ, USA, 2001.
3. Rajiv Ramaswami, Kumar N. Sivarajan and G. H. Sasaki, "Optical Networks: A Practical Perspective", Elsevier, Third Edition, 2010.
4. P.E. Green, Jr., "Fiber Optic Networks", Prentice Hall, NJ, 1993.
5. C. Siva Ram Moorthy and Mohan Gurusamy, "WDM Optical Networks: Concept,Design and Algorithms", Prentice Hall of India, Ist Edition, 2002.
6. Biswanath Mukherjee, "Optical WDM Networks", Springer, 2006.
7. B Sklar, "Digital Communications: Fundamentals and Applications" PH, 2001
8. Kuhn Paul J., Ulrich,Roya, "Broadband Communications" 1998.
9. SofoklisKyriazakos, River Publishers, 4G Mobile and Wireless Communications Technologies.
10. Jonathan Rodriguez, Wiley Publications, Fundamentals of 5G Mobile Networks

AP 645 Digital and Optical Communication Systems

1. **Elements of Digital Communication systems**: Model of Digital Communication Systems, Digital Representation of Analog Signal, Bandwidth-S/N tradeoff, Hartley Shannon Law, Sampling Theorem, Pulse Code Modulation, PCM Generation and Reconstruction, Quantization noise, Non uniform Quantization and Companding, DPCM, Adaptive DPCM, DM and Adaptive DM. Noise in PCM and DM,, Information Capacity, Bits, Bit Rate, Baud rate & M-ary Encoding.
2. **Digital Modulation techniques:** Introduction, Pulse amplitude modulation (binary and M-ary, QAM), Pulse position modulation (binary and M-ary), Carrier modulation (M-ary ASK, PSK, FSK, DPSK), Continuous phase modulation (QPSK and variants, MSK, GMSK), Trellis Code Modulation, Probability of Error & Bit Error Rate, Error Performance.
3. **Lightwave Systems:** System Architectures, Design Guidelines, Long-Haul Systems, Sources of Power Penalty, Forward Error Correction, Computer-Aided Design
4. **Multichannel Systems:** WDM Lightwave Systems, WDM Components, System Performance Issues, Optical Time-Division Multiplexing, Subcarrier Multiplexing, Code-Division Multiplexing
5. **Loss Management:** Compensation of Fiber Losses, Erbium-Doped Fiber Amplifiers, Raman Amplifiers, Optical Signal-To-Noise Ratio, Electrical Signal-To-Noise Ratio, Receiver Sensitivity and Q Factor, Role of Dispersive and Nonlinear Effects, Periodically Amplified Lightwave Systems
6. **Dispersion Management:** Dispersion Problem in SMF, Dispersion-Compensating Fibers, Fiber Bragg Gratings, Dispersion-Equalizing Filters, Optical Phase Conjugation, Channels at High Bit Rates, Electronic Dispersion Compensation.
7. **Nonlinear effects in Optical Fibers:** Stimulated Raman scattering, Stimulated Brillouin scattering, Self-phase modulation, Cross Phase modulation, Four-wave mixing. Solitons communication systems.
8. **Tutorials:Modelling of Fiber Optics Communication system**
   a. Simulate the broadening of a Gaussian pulse propagating through an optical fiber. Compare the results predicted by the linear system model of an optical fiber with the results of simulation.

b. Determine the sensitivity of a PIN photodiode based optical receiver by determining the minimum received power necessary to achieve a given Q factor. Compare the results of simulation with the results of an analytic approach.
c. Loss managements and Use of EDFA
d. Design and modeling of Multi amplifier system and Effect on OSNR

Text Books:

1. **G. P. Agarwal, Fiber-Optic Communication Systems, 4th Ed., Wiley, 2010.**
2. **Advanced Electronic Communications Systems, by Wayne Tomasi, 6 Edition Pearson Education.**

References

1. Principles of communication systems - Herbert Taub. Donald L Schiling, Goutam Sana, 3rd Edition,McGraw-Hill, 2008.
2. Digital and Analog Communicator Systems - Sam Shanmugam, John Wiley, 2005.
3. G. Keiser, Optical fiber communication systems, McGraw-Hill, New York, 2000.
4. Franz & Jain, Optical communication, Systems and components, Narosa Publications, New Delhi, 2000.
5. G. P. Agarwal, Non-linear Fiber Optics, Third Ed., Academic Press, New York, 2001.

AP646 Free Space Optical Communication

1. **Introduction FSOC/OWC**: Various modes of wired & wireless communication, Wireless access schemes, Historical perspective OWC, current scenario and challenges, Basic Link configuration of FSOC, various application areas of FSOC
2. **Laser sources & Receivers for free space communications:** Atmospheric low loss windows, optical sources and detectors for these windows, Characteristics of source and detectors.
3. **Channel Modeling -Indoor channel:** Various link configurations, propagation models for LOS, nLOS, Diffuse configurations, Artificial light interference effects in indoor channel.
4. **Channel Modeling -Outdoor channel:** Atmospheric channel loss, Absorption and scattering characteristics of atmosphere Fog & Visibility effects, Beam divergence, Optical & Window loss, Geometrical Loss, pointing loss, Various models of FSO in atmospheric channels, Power calculations,
5. **Atmospheric turbulence effects:** Atmospheric composition and structure, Significance and Measurement of $Cn^{2,}$ Atmospheric Attenuation, Various atmospheric turbulence models, Basic beam propagation types, Effects of atmospheric turbulence on laser beam propagation, Realization of atmospheric effects on OWC test beds
6. **Modulation Techniques:** Importance of modulationin FSO, various modulation formats, selection criteria for modulation, basic modulation schemes OOK,PPM, PIM, DH-PIM, BPSK etc. error propagation in Gaussian channels in each modulation formats
7. **FSO link Performance under atmospheric turbulence:** performance of FSO link in various modulation formats, comparison across the modulation formats, turbulence induced penalty in FSO link
8. **Mitigation techniques:** introduction, aperture averaging, various diversity techniques, spatial diversity, time diversity coding techniques, adaptive optics and other techniques

9. **Laser beam Tracking, pointing & acquisition:** Acquisition and Tracking systems, System description, Acquisition methodology, tracking and pointing control system, RF cross link system design, link equation.
10. **Introduction to Satellite free Space Communication and under water communication, visible light communication**

Tutorials: Relevant tutorial will be conducted using optisystem and matlab

Text/References

1. Morris Katzman, "Laser Satellite Communications", Prentice Hall Inc, New York, 1991.
2. J. Franz and V.K.Jain, "Optical Communication Systems", Narosa Publication, New Delhi, 1994.
3. Infrared Technology: Applications to Electro-Optics, Photonic Devices and Sensors, A.K.Jha

AP647 Optical Networks

1. **Introduction:** Telecommunications Network Architecture, Services,Circuit Switching and Packet Switching, Optical Networks, The Optical Layer, Transparency and All-Optical Networks, Optical Packet Switching, Transmission Basics, Network Evolution.
2. **Client Layers of the Optical Layer:** SONET/SDH, Optical Transport Network, Generic Framing Procedure, Ethernet, IP, Multiprotocol Label Switching, Resilient Packet Ring, Storage-Area Networks
3. **WDM Network elements:** Optical Line Terminals, Optical Line Amplifiers, Optical Add/Drop Multiplexers, Optical Crossconnects
4. **Control and Management:** Network Management Functions, Optical Layer Services and Interfacing, LayerswithintheOpticalLayer, Multivendor Interoperability, Performance and Fault Management, Configuration Management, Optical Safety
5. **Network Survivability:** Basic Concepts, Protection in SONET/SDH, Protection in the Client Layer, Why Optical Layer Protection, Optical Layer Protection Schemes, Interworking between Layers.
6. **WDM Network Design:** Cost Trade-Offs: A Detailed Ring Network Example, LTD and RWA Problems, DimensioningWavelength-RoutingNetworks, Statistical Dimensioning Models, MaximumLoadDimensioningModels.
7. **Photonic Packet Switching:** Optical Time Division Multiplexing, Synchronization, Header Processing, Buffering, Burst Switching, Testbeds.
8. **FTTx:**Introduction to FTTX, Fiber to the Home Architectures, FTTH in MDUs (Multiple Dwelling Units), FTTH PON Types, FTTH PON(Passive Optical Network), Triple Play Systems (BPON,GPON,EPON,RFOG) WDM and PON Other Uses For PONs, FTTX hardware and components (Cables, Splitters, Cabinets, Subscriber components).
9. **FTTx Installation, Testing and Management:**Outdoor cable installation, Duct, aerial, direct burial, Micro-duct solutions, Drop cable installation, Fiber terminations on with pigtail, Splicing and joint closing, Testing FTTH (Key factors affecting network, Testing during construction, Testing for commissioning).

Practical Exposure (Optional)

1. Practical View samples Set up FTTX link
2. Splicing and joint closing,
3. Installation of indoor hardware rack and wall mounting
4. Fiber arrangement and trucking

5. Connector installations
6. OTDR Testing, Troubleshooting
7. Multicore cable termination

Text/References

1. Rajiv Ramaswami, Kumar N. Sivarajan and G. H. Sasaki, "Optical Networks: A Practical Perspective", Elsevier, Third Edition, 2010.
2. P.E. Green, Jr., "Fiber Optic Networks", Prentice Hall, NJ, 1993.
3. C. Siva Ram Moorthy and Mohan Gurusamy, "WDM Optical Networks: Concept,Design and Algorithms", Prentice Hall of India, IstEdition, 2002.
4. Biswanath Mukherjee, "Optical WDM Networks", Springer, 2006.
5. Gerd Keiser , Wiley-IEEE "FTTx Concepts and Applications"
6. James Farmer, Brian Lane, Kevin Bourg, Weyl Wang, "FTTx Networks" 1st Edition November 2016.

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