

## GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

### Competency-focused Outcome-based Green Curriculum-2021(COGC-2021)

Semester-IV

#### Course Title: Fiber Optics Communication

(Course Code: 4341103)

Diploma programme in which this course is offered	Semester in which offered
Electronics & Communication Engineering	4 <sup>th</sup> Semester

#### 1. RATIONALE

Fiber Optics Communication is an essential component of the modern Telecom Industry. Therefore, it is desired that the diploma engineering students should be able to operate and maintain the components and equipment used in Optical Communication system.

#### 2. COMPETENCY

The content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Maintain Fiber Optics Communication link.**

#### 3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

- Analyze optical fiber.
- Install fiber optic cables.
- Test optical driver and receiver circuits.
- Identify optical components.
- Measure optical fiber parameters in optical network.

#### 4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(\*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to

betaken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

**Legends:** **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination.

## 5. SUGGESTED PRACTICAL EXERCISES

Following practical outcomes (PrOs) are the sub-components of the Course Outcomes (Cos). Some of the **PrOs** marked “\*” are compulsory, as they are crucial for that particular CO at the ‘Precision Level’ of Dave’s Taxonomy related to ‘Psychomotor Domain’.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Measure N.A. of optical fiber.	1, 5	2*
2	Establish Analog communication optical link.	1, 3	2*
3	Establish Digital communication optical link.	1, 3	2*
4	Established Pulse Width Modulation (PWM) using optical link.	1,3	2*
5	Measure attenuation/Propagation loss of given optical fiber.	1,3	2*
6	Measure bending loss of given optical fiber.	1,5	2*
7	Demonstrate various fiber cables.	2	2*
8	Demonstrate fiber splicing process.	2	2
9	Plot characteristics (Current Vs light intensity) of LED.	3	2*
10	Plot characteristics (Current Vs light intensity) of LASER diode.	3	2
11	Plot characteristics of (Light intensity Vs Current) Photo Diode.	3	2
12	Build and test LED drive circuits.	3	2*
13	Build fiber optics link using TDM technique.	4	2
14	Study the Optical Coupler, Switch, and beam splitter.	4	2*
15	Demonstrate OTDR and optical power meter.	5	2*
16	Demonstration of FTTH.	5	2*
17	Study of FDDI.	5	2
Minimum 12 Practical Exercises			34

### Note

- More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.

- ii. Care must be taken in assigning and assessing study report as it is a first year study report. Study report, data collection and analysis report must be assigned in a group. Teacher has to discuss about type of data (which and why) before group start their market survey.

The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Prepare of experimental setup	20
2	Operate the equipment setup or circuit	20
3	Follow safe practices measures	10
4	Record observations correctly	20
5	Interpret the result and conclude	30
<b>Total</b>		<b>100</b>

## 6. MAJOR EQUIPMENTS/ INSTRUMENTS REQUIRED

These major equipments with broad specifications for the PrOs is a guide to procure them by the administrators to use in uniformity of practical's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Optical Fiber Trainer Kit.	1,2,3,4,5,6,9,10,11,12,13
2	Digital Multimeters.	9,10,11,12
3	Optical source: LED, LSER diode.	1,2,3,4,5,6,8,9,10,11,12,13
4	Optical Detector: PD, PIN diode, APD	2,3,4,5,6,9,10,11,12,13
5	NA testing zig	1
6	Cathode Ray Oscilloscope (20MHz Dual Channel) with probes	2,3,4,5,6,13
7	Function Generator	2,3,4,5,6,13
8	Splicing unit.	8
9	Optical Fiber cables	1,2,3,4,5,6,7,8,9,10,11,13
10	OTDR	15
11	Optical Power Meter	5,6,8,9,10,11,16

## 7. AFFECTIVE DOMAIN OUTCOMES

The following **sample** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

- a) Work as a leader/a team member.
- b) Follow ethical practices.
- c) Follow safety precautions.
- d) **Realize importance of E-waste management.**

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- i. 'Valuing Level' in 1<sup>st</sup> year,
- ii. 'Organization Level' in 2<sup>nd</sup> year,
- iii. 'Characterization Level' in 3<sup>rd</sup> year.

## 8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
<b>Unit-I Optical Fiber Waveguide</b>	1a. Explain light propagation in optical fiber waveguide. 1b. Classify the different types of Optical fiber used in industry. 1c. Classify different types of losses in Optical fiber. 1d. Describe Fiber optics communication system with its advantages & disadvantages.	1.1 Optical fiber waveguide: 1.1.1 Ray propagation in step index fiber, 1.1.2 Numerical Aperture and acceptance angel, 1.1.3 Skew rays and Meridional rays, 1.1.4 Optical signal as a EM wave with mode concept, 1.1.5 V-number & normalized frequency. 1.2 Types of Optical Fiber: 1.2.1 Step Index and Graded Index. 1.2.2 Single Mode and Multi-Mode, 1.2.3 Cut off wavelength. 1.3 Attenuation:

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		1.3.1 Absorption losses: intrinsic and extrinsic, 1.3.2 Linear scattering losses: Rayleigh and Mie, 1.3.3 Fiber bend losses: micro and macro. 1.4 Dispersion: 1.4.1 Intermodal Dispersion in Multi-mode Step Index fiber, 1.4.2 Intra-modal (Chromatic) Dispersion: material and Wave guide dispersion. 1.5 General configuration of Fiber optic communication system.
<b>Unit– II</b> <b>Optical Fiber: Cables &amp; Connections</b>	2a. Explain Fiber fabrication process and cabling techniques. 2b. Describe splicing and joining of fiber cable 2c. List types of connectors and give their applications.	2.1 Fiber Fabrication: 2.1.1 Fiber Materials, 2.1.2 Double crucible method, 2.1.3 Vapor deposition methods: MCVD, VAD, 2.1.4 Fiber drawing process. 2.2 Fiber Optic Cables: 2.2.1 Needs of cabling, 2.2.2 Fiber Cables: Slotted core, loose tube and multi-fiber ribbon. 2.3 Connection losses: 2.3.1 Extrinsic Parameters: Fresnel reflection, Misalignment, and other factors, 2.3.2 Intrinsic Parameters: NA mismatch, diameter mismatch, 2.3.3 Fiber end preparation for loss minimization. 2.4 Splices: 2.4.1 Fusions Splices, 2.4.2 Mechanical splices: Capillary, V-grooved, Loose tube, Spring groove and

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		<p>elastomeric splices.</p> <p>2.5 Fiber optic connectors types as per TIA, IEC and ANSI standards.</p> <p>2.6 <b>SOP for Fiber cable laying.</b></p>
<b>Unit-III</b> <b>Optical Sources and Detectors</b>	<p>3a. Describe working principle of various optical Source</p> <p>3b. Describe working principle of various optical detector</p> <p>3c. Explain various methods for coupling</p> <p>3d. Understand digital driver circuits used in Optical communication system</p>	<p>3.1 Basic concepts of Absorption and Emission in semiconductor.</p> <p>3.2 Characteristic of ideal optical source.</p> <p>3.3 Construction and Operating Principle of LED.</p> <p>3.4 Concept of Heterojunctions LED structure:</p> <p>3.4.1 SLED,</p> <p>3.4.2 EELED.</p> <p>3.5 Construction and Operating Principles of Semiconductor LASER Diode.</p> <p>3.6 Quantum efficiency and Responsivity.</p> <p>3.7 Photo diodes</p> <p>3.7.1 p-n photodiode,</p> <p>3.7.2 p-i-n photodiode,</p> <p>3.7.3 Avalanche photodiode.</p> <p>3.8 Coupling between fiber and Source/ detector:</p> <p>3.8.1 Source to fiber,</p> <p>3.8.2 Fiber to detector.</p> <p>3.9 LED driver circuit (digital).</p> <p>3.10 LASER driver circuit (digital).</p> <p>3.11 Optical receiver block diagram.</p> <p>3.12 Regenerative repeater.</p>
<b>Unit-IV</b> <b>Optical Components</b>	<p>4a. Explain the functions of various Optical Components</p> <p>4b. Describe principle and application of Bragg grating</p> <p>4b. Describe concept of optical amplifier</p> <p>4c. Explain the working of SOA, EDFA, Raman amplifier</p>	<p>4.1 Optical components: types and functions:</p> <p>4.1.1 Optical Coupler,</p> <p>4.1.2 Optical switches,</p> <p>4.1.3 Beam splitter,</p> <p>4.1.4 Optical multiplexer and demultiplexer,</p> <p>4.1.5 Optical wavelength</p>

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
		converter, 4.1.6 Isolators. 4.2 Concept of Bragg grating. 4.3 Optical Amplifiers: 4.3.1 Semiconductor Optical Amplifiers, 4.3.2 EDFA, 4.3.3 Raman amplifier.
<b>Unit-V</b> <b>Optical parameter measurement and applications of WDM</b>	5a. Measure optical fiber parameters 5b. Describe working principle of Optical Power Meter & OTDR 5c. Understand application of WDM in Fiber optics communication Networks	5.1 Fiber parameters measurement: 5.1.1 Attenuation, 5.1.2 Numerical Aperture, 5.1.3 Inter modal dispersion, 5.1.4 Refractive Index profile. 5.2 Optical power meter 5.3 Optical time domain reflectometer. 5.4 WDM & DWDM. 5.5 SONET/SDH, FDDI, FTTP. 5.6 <b>E-waste Management of Optical waste.</b>

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Optical Fiber Waveguide.	10	5	7	3	15
II	Optical Fiber: Cables & Connections.	08	5	8	2	15
III	Optical Sources and Detectors.	12	6	6	3	15
IV	Optical components.	06	8	2	1	11
V	Optical parameter measurement and applications of WDM.	06	5	7	2	14
<b>Total</b>		<b>42</b>	<b>29</b>	<b>30</b>	<b>11</b>	<b>70</b>

**Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

## 10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

- I. Read and note down specifications of Optical fiber: Optical fiber mode, types. Application of single mode fiber, and multi-mode fiber, Splicing Technology, Use of Connectors, Couplers, Laser, LED, PN photo diode, p-i-n photo diode, Avalanche photodiode, Bragg grating, SONET, SDH, FDDI, and FTTP.
- II. Solve real life problems using optical fiber communication.
- III. Explore working of SONET/SDH, FDDI and FTTP.

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- a) Massive open online courses (**MOOCs**) may be used to teach various topics/sub topics.
- b) Guide student(s) in undertaking micro-projects.
- c) '**L' in section No. 4** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- d) About **20% of the topics/sub-topics** which are relatively simpler or descriptive in nature is to be given to the students for **self-learning**, but to be assessed using different assessment methods.
- e) With respect to **section No.10**, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.
- f) **Introduce E-waste recycling technology among the students.**
- g) Internet based home assignments.
- h) Micro projects (in group of three to four students).

## 12. SUGGESTED MICRO-PROJECTS

**Only one micro-project** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16 (fourteen to sixteen) student engagement hours** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.



A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

- a) Build and test fiber optic link
- b) Build and test LED driver circuit
- c) Build and test LASER diode driver circuit
- d) Build and test repeater circuit
- e) **Identify E-Waste of Optical fiber cable, optical communication and prepare a brief Report of Remedies for it.**

### 13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Books	Author	Edition/ Impression & Year	Publication
1	Optical Fiber Communication	John M Senior.	8 <sup>th</sup> , 2014.	Pearson
2	Fiber Optic Communication	D C Agarwal.	2004.	S Chands
3	Optical Fiber Communication	Gerd Keiser.	5 <sup>th</sup> , 2017.	McGraw Hill Education
4	Fiber Optics & Optoelectronics	R P Khare.	10 <sup>th</sup> , 2010.	Oxford
5	Fiber Optic Essentials	Casimer M. DeCusatis, Carolyn J. SherDeCusatis.	1 <sup>st</sup> , 2010.	Academic Press

### 14. SOFTWARE/LEARNING WEBSITES

1. <https://computer.howstuffworks.com/fiber-optics-info.htm>
2. <https://nptel.ac.in/courses/108106167>
3. <https://www.thefoa.org/tech/>
4. <https://www.techtarget.com/searchnetworking/definition/fiber-optics-optical-fiber>
5. <https://vitextech.com/fiber-connector-types/>

#### Videos:

1. <http://nptel.iitm.ac.in/courses/117101002/>
2. <http://www.youtube.com/watch?v=aqazAcE19vw>
3. <http://www.youtube.com/watch?v=plIBINW7sOo>
4. [http://www.youtube.com/watch?v=lll8Mf\\_faVo](http://www.youtube.com/watch?v=lll8Mf_faVo)
5. <http://fiberu.org/basic/LP3.html>
6. <https://www.otelco.com/resources/a-guide-to-fiber-optic-internet/>
7. <https://www.youtube.com/watch?v=xba2MThR9Ls>

**15. PO-COMPETENCY-CO MAPPING**

Semester IV	Fiber Optics Communication (Course Code: 4341103)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
<u>Competency</u>	Maintain fiber Optics Communication link.						
CO1: Analyze optical fiber	3	1	2	3	-	1	2
CO2: Install fiber optic cables	3	2	2	2	3	3	2
CO3: Test optical driver and receiver circuits	3	3	2	3	1	1	2
CO4: Identify optical components	3	1	1	1	-	-	2
CO5: Measure optical fiber parameters	3	2	1	3	1	1	3

Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

**16. COURSE CURRICULUM DEVELOPMENT COMMITTEE****GTU Resource Persons**

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