

B. Sc. Physical Sciences with Electronics as one of the Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – DSC 8-1: DIGITAL AND OPTICAL COMMUNICATION

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Digital and Optical Communication DSC 8-1	4	3	0	1	

COURSE OBJECTIVES

This course aims to provide students with a comprehensive understanding of the principles and applications of digital and optical communication systems. It covers the fundamentals of signal processing, various digital modulation techniques, and the operation of optical communication components such as lasers, LEDs, and photodetectors. The course also introduces the characterization of optical fibers and addresses key performance parameters such as noise, signal-to-noise ratio, and bit error rate.

LEARNING OUTCOMES

By the end of the course, students will be able to:

- Explain the principles of sampling, multiplexing, and the statistical behavior of random processes in communication systems.
- Describe and analyze various digital modulation schemes including ASK, FSK, PSK, QPSK, QAM, and M-ary coding techniques.
- Understand the working and characteristics of optical sources and detectors used in fiber-optic communication, such as laser diodes, LEDs, and photodiodes.
- Evaluate the characteristics and performance of optical fibers, including measurements of core radius, numerical aperture, and cut-off wavelength.
- Assess the impact of noise and signal degradation on communication performance, including calculation of SNR and BER in digital and optical systems.

SYLLABUS of DSC 8-1

THEORY COMPONENT

(Hours: 45)

Unit I

(8 Hours)

An overview of sampling theorem and multiplexing (digital Systems)

Random processes, stationary processes, mean, correlation, and covariance functions: autocorrelation function, cross-correlation function, Power spectral density

Unit II (11 Hours)
Digital Modulation Schemes: ASK (Amplitude Shift Keying), FSK (Frequency Shift Keying), PSK (Phase Shift Keying), DPSK(Differential Phase Shift Keying), QPSK (Quadrature Phase Shift Keying), QAM(Quadrature Amplitude Modulation), M-ary coding.

Unit III (15 Hours)
Sources and detectors for optical fibre communication: Optical Communication requirements, LASER fundamentals: Absorption and emission of radiation, condition for amplification of radiation. Basics of semiconductor lasers, laser diode characteristics, LED characteristics. Principle of optical detection, PIN photodetector, responsivity and quantum efficiency, speed of response, avalanche photodetector

Unit IV (11 Hours)
Characteristics of fiber optic communication system: Characterization of an optical fiber: measurement of its radius, numerical aperture, cut-off wavelength (Marcuse's formula) Analog and digital modulation (direct), noise in detection process: shot noise, thermal noise, SNR, Bit error rate (BER).

PRACTICAL COMPONENT: DIGITAL AND OPTICAL COMMUNICATION
(Hours: 30)

Students should perform at least six experiments from the following list:

1. Study Sampling theorem using software.
2. Study of Amplitude Shift Keying (ASK).
3. Study of Frequency Shift Keying (FSK).
4. Study Phase Shift Keying (PSK)- Binary Phase Shift Keying (BPSK)- and Quadrature Phase Shift Keying (QPSK)
5. Study of Quadrature amplitude Modulation (QAM).
6. To study the characteristics of LED.
7. To study the characteristics of semiconductor laser diode.
8. To study the characteristics of Silicon and Germanium photo-detectors.
9. To measure the parameters of a single mode optical fiber: radius, numerical aperture, cut-off wavelength.

REFERENCES

Essential readings

1. W. Tomasi, Electronic Communication Systems: Fundamentals through Advanced, Pearson Education (2024), 5th Edition
2. S. Haykin, Digital Communication, John Wiley India (Circa 2021), 3rd Edition
3. B. Sklar, Digital Communication, 2nd Edition, Pearson Education (2024)
4. J.G. Proakis, Fundamentals of Communication Systems, Pearson Education (2024), 2nd Edition

5. Ajoy Ghatak and K Thyagarajan, Introduction to Fiber Optics, Cambridge University Press, New Delhi (2024)
6. D.K. Mynbaev and Lowell L. Scheiner, Fiber-Optic Communication Technology, Pearson Education (2024).

Additional readings

1. L. W. Couch II, Digital and Analog Communication Systems, Pearson Education (2005)
2. H. P. Hsu, Analog and Digital Communications, Tata McGraw Hill (2006)
3. J. M. Senior, Optical fiber communication systems: principles and practice, Pearson Education in south Asia, (2009).
4. J. Gower, Optical communication systems, Pearson Education
5. G. Keiser, Optical communications, McGraw Hills education (2003)