OBJECTIVES

- Compares multimode versus single mode optical fiber, for both attenuation and dispersion characteristics
- Describes optical sources, including light emitting diodes (LED) and laser diodes
- Describes optical detectors, including PIN photodiodes and avalanche photodiodes
- Explains wavelength-division multiplexing (WDM) as a way to expand the bandwidth or accommodate multiple signals in a single fiber.
- Presents methods for calculating the repeater spacing as a function of system parameters such as bandwidth, rise time, transmitter power, and receiver sensitivity.
- Discusses innovative approaches to fiber optic transmission, including coherent transmission, optical amplifiers, and soliton transmission
- Describes standards for fiber optic transmission developed in North America as the Synchronous Optical Network (SONET) and by the ITU-T as the Synchronous Digital Hierarchy (SDH)

8.1 Introduction

A fiber optic transmission system has the same basic elements as a metallic cable system—namely a transmitter, cable, repeaters, and a receiver—but with an optical fiber system the electrical signal is converted into light pulses. The principal application of fiber optics is with digital transmission, where rates well in excess of 1 Gb/s are now in use. Fiber optic transmission now
dominates long-haul national and international communications systems, and is expected to dominate short-haul systems as well. Today's fiber optic systems typically use binary transmission with on-off keying (OOK) of the optical source and direct detection of the received signal. Other technologies described in this chapter, such as coherent detection, wavelength-division multiplexing, optical amplifiers, and soliton transmission, are now available and will eventually extend existing transmission rates and repeater spacings by one or two orders of magnitude. Also of significance are national [1] and international [2] standards which now provide the opportunity for common interfaces and interoperable systems among the world's fiber optic transmission systems.

The advantages of fiber optic cable over metallic cable and terrestrial digital radio are illustrated here with a series of comparisons:

- **Size:** Since individual optic fibers are typically only 125 μm in diameter, a multiple-fiber cable can be made that is much smaller than corresponding metallic cables.
- **Weight:** The weight advantage of fiber cable over metallic cable is small for single-fiber, low-rate systems (such as T1) but increases dramatically for multiple-fiber, high-rate systems. As a result of this weight advantage, the transporting and installation of fiber optic cable is much easier than for other types of communication cable.
- **Bandwidth:** Fiber optic cables have bandwidths that can be orders of magnitude greater than metallic cable. Low-data-rate systems can be easily upgraded to higher-rate systems without the need to replace the fibers. Upgrading can be achieved by changing light sources (LED to laser), improving the modulation technique, improving the receiver, or using wavelength-division multiplexing.
- **Repeater spacing:** With low-loss fiber optic cable, the distance between repeaters can be significantly greater than in metallic cable systems. Moreover, losses in optical fibers are independent of bandwidth, whereas with coaxial or twisted-pair cable the losses increase with bandwidth. Thus this advantage in repeater spacing increases with the system's bandwidth.
- **Electrical isolation:** Fiber optic cable is electrically nonconducting, which eliminates all electrical problems that now beset metallic cable. Fiber optic systems are immune to power surges, lightning-induced currents, ground loops, and short circuits. Fibers are not susceptible to electromagnetic interference from power lines, radio signals, adjacent cable systems, or other electromagnetic sources.
- **Crosstalk:** Because there is no optical coupling from one fiber to another within a cable, fiber optic systems are free from crosstalk. In metallic