

# FIBER OPTIC TEST EQUIPMENT

## General Information

Probably the most remarkable fact about the evolution of fiber optics has been their rapid market growth. Design work began some twenty years ago, with trial projects carrying live telephone traffic being installed ten years later. Today, optical fibers are mass-produced for many applications worldwide.

### Technical Background

In general, all fiber optic systems incorporate the following elements: transmitters, fibers, repeaters, and receivers, all of which are linked by connectors and/or splices.

Today, size, lifetime, reliability and ruggedness are major factors in the choice of sources and receivers for optical communication links.

Sources employ LED's or LD's (laser diodes) to generate the optical output, while APD's or PIN diodes are used to detect the incident optical power on the receiving side.

### Optical Sources

LED's are primarily used in short distance systems (<10km) with data rates below 100MHz. A limiting factor is their broad spectral width and the low coupling efficiency compared with an LD. Advantages are their simpler drive electronics, a higher reliability, and the lower price.

LD's, on the other hand, feature a small spectral width, an excellent coupling efficiency, and reach data rates up to 2 GHz. Thus LD's enable repeaterless data transmission over great distances (40km).

### Optical Fibers

Inside the fiber, light is guided by total reflection at the core/cladding boundary due to corresponding differences in the refractive indices. Fibers employed as transmission media fall into three categories:

**Step Index Fiber.** Nowadays this type is of less importance due to its low bandwidth (<5MHz), high multimode dispersion, and high attenuation. Mainly used in industrial applications (in avionics, vessels, or automobiles).

**Graded Index Fiber.** This type features higher data rates (up to 800MHz x km), a lower dispersion and attenuation. This fiber is frequently used in datacom or LAN applications.

**Single-Mode Fiber.** This fiber is preferred when highest data rates are required. Based on data rates up to 100GHz x km and low dispersion and attenuation, this fiber is the ideal transmission media in long-haul telecommunication systems.

### Optical Receivers

To convert light back into an electrical signal for further processing PIN, diodes serve as receiving detectors when high data rates are required. This property is combined with favorable linearity and high stability. When increased sensitivity is of major concern, APD's are preferred. Due to their non-linearity, APD's are used only for purely digital applications, while PIN diodes can be used in both analog and digital systems.

### Fiber Optic Test Environments

HP's line of fiber optic test equipment offers new measurement capabilities for design and production engineers in a number of different application areas.

### Computers

The increasing sophistication of computers and their distributed services, prompted by the need for greater data handling capabilities and higher memory densities, has resulted in a demand for fiber optic systems. Major application areas include the mutual interfacing of central processors, the linking of them to peripheral devices, and data transmission within the mainframe. Reduced bit error rates — free from environmental interference — are assured.

### Local Area Networks

The development of Local Area Networks has been stimulated by the availability of low-cost, intelligent, digital terminal hardware and the trend towards distributed data acquisition and processing. Here also, optical fibers often serve as the transmission medium in networks which may be configured as ring, star or bus structures. Such systems are primarily installed in business environments to support office operations, manufacturing facilities or private automatic branch exchanges; they all take advantage of the absence of crosstalk, electromagnetic interference or echoes — often a problem in twisted pair and coax systems.

### Industrial Electronics

Industrial environments represent an ideal market for numerous fiber optic applications. Examples include power plants, railroad networks and the metal industry, where data acquisition, control and process signals need to be transmitted, without being affected by strong electromagnetic fields.

Some automobile and avionics manufacturers have begun to install optical fibers instead of copper cables to increase safety and reliability, and to save weight.

Fiber optic sensors are gaining importance in hazardous environments to monitor chemical, biological, and physical processes.

### Telecommunications

The telecommunications industry has traditionally been the sphere of greatest interest and highest investment for fiber optics technology. The majority of resources are employed to investigate, design and install new information transfer and processing equipment; long-haul transmission systems (submarine fiber optic cables linking continents,

for example), and networks in high traffic environments.

### Measurement Problems and Solutions

Designers, manufacturers and end-users of fiber optic components, modules or systems face a large variety of measurement tasks. These tasks range from physical measurements, such as fiber geometry or numerical aperture, to system performance tests in the time or frequency domain.

HP offers three powerful lines of fiber optic test instruments. The first line consists of the HP 8150A Optical Signal Source, the HP 8151A Pulse Power Meter, and the HP 81511/81512A Optical Heads. This test equipment offers new ways to perform parametric tests with reliable and repeatable results in the 850 and 1300nm wavelength range.

Testing the sensitivity or defining the pulse response of a receiver demands a stimulus such as the HP 8150A. With the help of this instrument, it is an easy task to perform parametric tests at calibrated levels, under fully-specified and precisely-controlled conditions.

Its counterpart the HP 8151A, together with the HP 81511/81512A, provides technicians and engineers with an ideal tool for verifying analog and digital power level parameters in terms of peak and average power.

The second line consists of the HP 8152A Optical Average Power Meter with two different optical heads for the 450-1700nm range, the HP 8154B LED Sources for 850nm, 1300nm and 1550nm (option 001, 002, and 003), the HP 8155A LD Sources for 1300nm and 1550nm (option 002 and 003), the HP 8157A Optical Attenuator for 1200-1650nm, single-mode, the HP 8158B Optical Attenuators for 600-1200nm and 1200-1650nm (option 001 and 002), for multimode and single-mode, and the HP 8159A Optical Switch.

The HP 8152A features excellent accuracy (directly traceable to NBS and PTB) and linearity (typically better than 1%) for absolute and relative power measurements.

The 8157A Optical Attenuator offers very high optical return loss and polarization insensitivity for tests on your fastest transmitters and automated bit error rate measurements. The HP 8158B Optical Attenuator is very flexible as it handles all fibers with an NA <0.3.

And the HP 8154B LED Sources and HP 8155A LD Sources serve as very stable stimuli for insertion loss measurements. The HP 8159A Optical Switch allows to automate these reference measurements.

The third line consists so far of one instrument, the HP 8145A Optical Time Domain Reflectometer. It is a portable, high performance unit for field maintenance and applications in a factory environment. Large dynamic range and superb measurement speed are its main contributions.