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Standard Guide for Specifying Dynamic Characteristics of Optical Radiation Transmitting Fiber Waveguides[1]

This standard is issued under the fixed designation E1653; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide covers the key parameters that determine the dynamic performance of an optical radiation transmitting fiber waveguide (see Note 1). For the purpose of this guide, optical radiation is electromagnetic radiation of wavelengths from about 200 to about 5000 nm (correspondingly, frequencies of 50 000 cm^{-1} to 2000 cm^{-1}, and photon energies of 6 eV to 0.25 eV).

NOTE 1—Typical designations of radiation transmitting fiber waveguides include optical waveguide, fiber-optic, fiber-optic waveguide, and fiber-optic radiation guide.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E131 Terminology Relating to Molecular Spectroscopy

3. Terminology

3.1 *Definition of Terms and Symbols*—For definitions of terms and symbols, refer to Terminology E131.

4. Significance and Use

4.1 Many characteristics of a fiber-optic waveguide affect the dynamic performance. Quantitative values of certain key parameters (characteristics) need to be known, *a priori*, in order to predict or evaluate the dynamic performance of a waveguide for specific conditions of use. This guide identifies these key parameters and provides information on their significance and how they affect performance. However, this guide does not describe how the needed quantitative information is to be obtained. Manufacturers of fiber-optic waveguides can use this guide for characterizing their products suitably for users who are concerned with dynamic performance. Users of fiber-optic waveguides can use this guide to determine that their waveguides are adequately characterized for their intended application.

5. Key Dynamic Characteristics

5.1 Dynamic characteristics and dynamic performance, for the purposes of this guide, have to do with the time- or frequency-domain response of a fiber-optic waveguide to pulsed or sinusoidally modulated optical radiation. Fig. 1 and Fig. 2 show hypothetical outputs of an optical fiber to pulsed and sinusoidally modulated radiation inputs. (Either the time- or the frequency-domain can be used to characterize the temporal features of a fiber-optic waveguide, because the two are related through the Fourier transform.) It is this response, as it is affected by launch condition, input radiant flux, wavelength, bend radii, temperature, and spatial position across the face of a fiber-optic waveguide, that is the concern of this guide.

5.2 *Ideal Fiber-Optic*—Features that would be possessed by an ideal fiber-optic waveguide provide a basis for discussing the key parameters that determine the dynamic aspects of a fiber-optic waveguide. An ideal fiber-optic radiation guide would have the following features.

5.2.1 A large numerical aperture, such that noncollimated or poorly collimated radiation sources (for example, arc lamps) could be coupled to it effectively.

5.2.2 Wide transmissive (spectral) bandwidth, within the range from 200 to 5000 nm, so that experiments requiring ultraviolet (UV), visible, and IR radiation may be performed with the minimum change in radiation guides.

5.2.3 Wide temporal bandwidth (gigahertz; picosecond to femtosecond), so that time resolution would not be compromised, and that high data-transfer would be possible.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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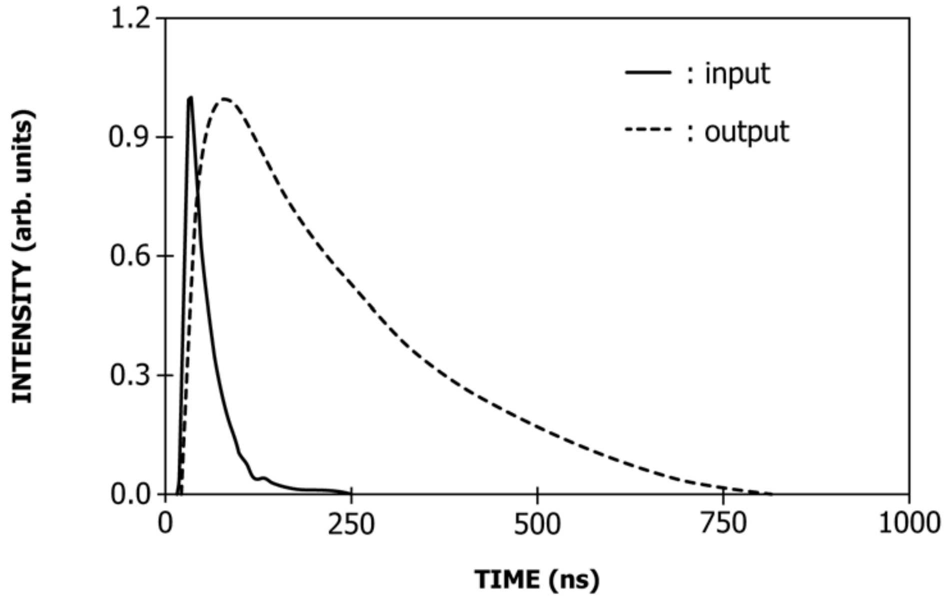

FIG. 1 Output of an Optical Fiber to a Radiation Input Pulse

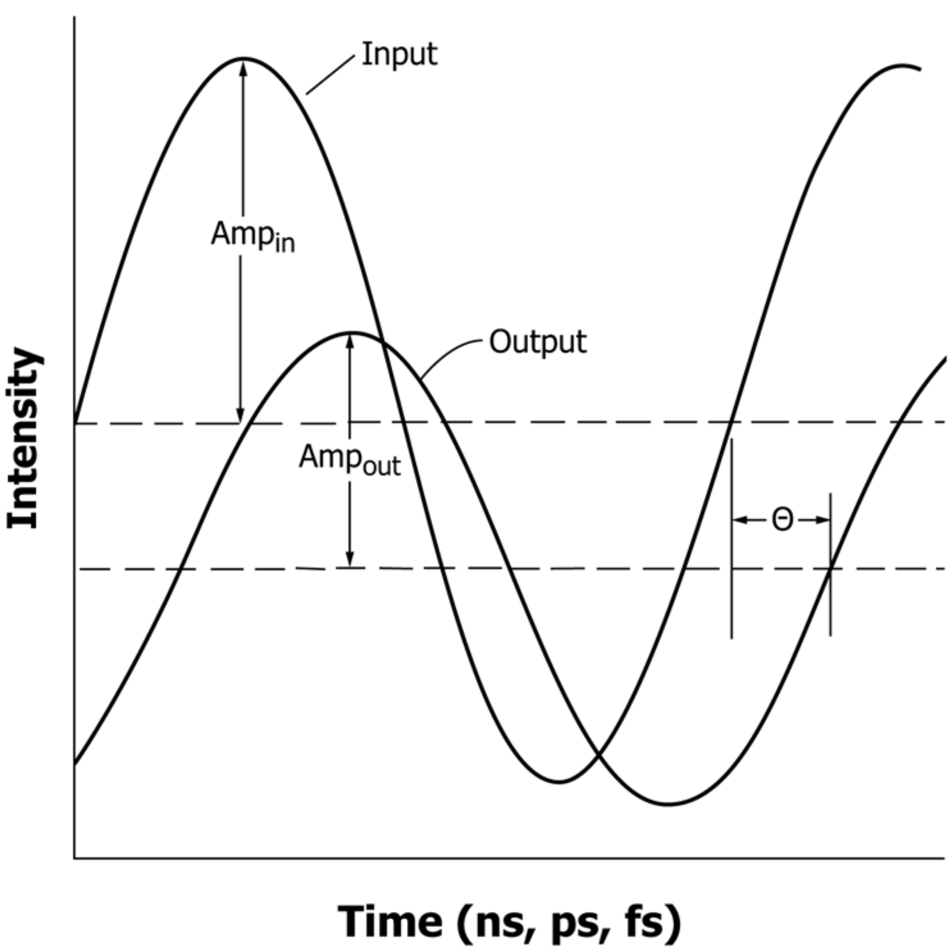

FIG. 2 Output of an Optical Fiber to a Sinusoidal Waveform Radiation Input

5.2.4 Known temporal response (although not necessarily constant) across the spectral bandwidth, so that a researcher could determine how using a fiber-optic waveguide might compromise particular experiments.

5.3 *Key Parameters*—A great many parameters must be known, ultimately, to use fiber-optic radiation guides most effectively. The following are seven of the key parameters that determine the dynamic aspects of a fiber-optic radiation guide.

5.3.1 *The Diameter of the Fiber-Optic*—This should be included in all reports.

5.3.2 *The Length of the Fiber Optic from Which All Results Are Compiled*—It is important that the guide be long enough to ensure that the system attains equilibrium numerical aperture.

NOTE 2—It is recommended that a fiber-optic cable be at least 5 m long for all measurements.

5.3.3 The peak-power handling capability of a fiber-optic radiation guide are critical for several reasons: possible destruction of the fiber-optic by high-photon flux (namely, melting or ablation of the fiber's core material and surrounding cladding); non-linear effects (for example, second harmonic generation, and overloading problems); and luminescence backgrounds generated from low levels of impurities. It is especially important to determine the temporal bandwidth as a function of incident radiation flux at the input of the fiber-optic radiation guide.

5.3.4 *The Wavelength-Dependent Temporal Bandwidth*—It is important to determine *a priori* how a fiber-optic radiation guide will suffice for a particular experiment. For example, for a study of processes that occur on a picosecond time scale, the radiation guide must have sufficient bandwidth. If the input pulse (see Fig. 1) or the sinusoidal waveform (see Fig. 2) are broadened too much or demodulated significantly, then the required time resolution will be lost and the study will fail.

NOTE 3—This parameter is closely related to the "spectral dispersion" commonly specified in the telecommunications field.

5.3.5 *The Effects of Launch Conditions on the Temporal and Spectral Bandwidths*—These must be known because, for many possible reasons, the input to the fiber may not be at exactly the numerical aperture. It would be important to know, for example, what a ±20 % change in the launching numerical aperture would have on the temporal and spectral bandwidths.

5.3.6 *The Temperature- and the Bend-Stabilities of the Fiber-Optic Radiation Guide*—In many circumstances (for example, field analyses), it is difficult to control temperature and fiber orientation (for example, in a well hole, or coiled on a laser table), and it is therefore necessary to know what effect these parameters have on the temporal and spectral bandwidths.

5.3.7 *The Temporal and Spectral Characteristics of a Fiber-Optic Radiation Guide as a Function of Position Across the Face of the Fiber*—This is especially important for imaging techniques or methods that require that the spatial profile remain homogeneous, or at least known.

5.4 *Reporting Key Parameters*—Quantitative values of the key parameters should be provided in graphical form for convenience of access.

6. Report

6.1 In addition to reporting values of the relevant key parameters of an experiment, results should be reported with respect to the input radiation source. For example, temporal distortion should be reported as the ratio for the full-width-at-half-maxima (FWHM) for the radiation pulse after and before passing through the fiber-optic guide ($FWHM_{intrinsic}/FWHM_{fiber}$). Also, specify the intrinsic FWHM of the radiation source, and the length and diameter of the fiber-optic radiation guide.

7. Keywords

7.1 bend characteristics; dynamic characteristics; fiber optics; optical fibers; peak power

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