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Optical Fiber Alignment

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INTRODUCTION

Most optical networks have many fiber couplings and even minor losses at these junctions will produce significant signal losses that cause problems in data transmission. Precise fiber alignment at the optical couplings in a network is therefore a prerequisite for accurate and reliable optical data transmission since it produces the least signal loss before assembly or packaging of an optical system. Minimal signal loss also results in the lowest optical power requirements which, in turn, means fewer repeaters, lower capital costs and reduced incidence of failure.

Alignment Parameters and Procedures

Effective fiber alignment requires the precise adjustment of a precision motion control device and a suitable search algorithm that has been optimized for use in the alignment application. Figure 1 shows a typical search operation along with the positional parameters that are associated with optical fiber alignment. In the search procedure, the intensity of a well-characterized optical input beam (the laser diode in Figure 1) is compared against the output signal of the optical fiber being aligned.

Positional/Rotational Parameters

Motion controllers are employed that use a coordinate system in which an object is considered to have six degrees of freedom: three linear position parameters, along the X, Y, and Z-axes in a Cartesian co-ordinate system and three rotational parameters around those axes (see Figure 1(c)). All movements are defined in terms of translations along and/or rotations about the Cartesian axes. The fiber position is moved through a raster scan to detect first light - when the laser beam first enters the optical fiber (Figure 1(a)). Once first light is detected,

Figure 1. The operations and positional parameters of optical fiber alignment. (a) scan operations, (b) positional parameters for the optical fiber alignment.

the lateral, longitudinal, and angular coordinates of the fiber are incrementally adjusted to maximize the intensity of the optical signal output from the fiber. In the simplest case, only lateral (X, Y) adjustments are necessary, while in multi-channel cases, adjustments to all six degrees of freedom (X, Y, Z, θx, θy, and θz) may be required (Figure 1(b)).

Motion Control Parameters

Linear or rotary motion stages produce the controlled motions and trajectories that move objects during optical fiber alignment. The following parameters must be considered when selecting a motion system for optical fiber alignment:

- *Minimum Incremental Motion (MIM)* is the smallest increment of motion that a device can consistently and reliably deliver. It is the actual physical performance of the motion controller (as opposed to Resolution which is a theoretical capability and not a practical parameter) and can range from 100 nm to 1 nm. Smaller MIM comes at significant costs in terms of alignment speed and beam power increments. MKS Instruments' XMS linear stages are capable of 1 nm MIM and 300 mm/s speed.

Optical Fiber Alignment

Minor losses in fiber couplings translate to large problems in data transmission. This paper discusses the alignment of optical fiber devices, the motion parameters that must be considered, the methods that are used to find the location of peak power and the motion and other peripheral equipment that are recommended for fiber alignment.

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