APPLICATIONS OF ANALOG MICROWAVE FIBER OPTIC COMMUNICATIONS

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Since the widespread production of semiconductor lasers starting in the 1980's, fiber optic communications has steadily proliferated. The majority of the telephony and datacommunications infrastructure is based on digital transmission protocols. However, analog applications are steadily growing as well. Today, for example, most CATV distribution networks are fiber-based, carrying both analog and digital video, broadband data, and voice-over-IP at modulation frequencies up to about 1 GHz. Extension of the modulation frequency into the 10's of GHz is accomplished by external modulation of the laser carrier using electro-optic or electro-absorptive modulation techniques.

System designers want to consider the technical benefits of analog fiber optic communications as compared to other approaches to closing their link budget. There are generally four major technical benefits to analog fiber optics for microwave and millimeterwave communications:

1. Lower loss and better noise performance compared to coax or waveguide.
2. Greater instantaneous bandwidth than an equivalent digital link.
3. Lower weight compared to coax or waveguide.
4. EMI immunity.

APPLICATIONS

In addition to the lower-frequency systems currently in use, such as CATV, telephony, and instrumentation, microwave fiber optics provides significant improvements in several key applications:

Antenna Remoting and Surveillance

In satellite ground applications, during periods of high rain fade, selection to an alternate antenna located several kilometers away from the primary can maintain link budget. The processing site must be able to receive both signals; fiber optics enables up to 10 km or more separation between remote antennas and ground station, a distance that is too remote for conventional electrical transmission.

Another common practice in satellite ground communications is to convert the microwave signals to L-Band for block transport to and from the ground station. This involves the use of nonlinear mixer elements, LO generation and line amplifiers, resulting in poor noise and spurious performance for distances greater than about 1 km. Microwave fiber optics allows the transmission of the C, Ku, or Ka band signals directly, avoiding these issues.

EMI immunity and mobile flexibility allow for electronic intelligence-gathering from a series of remote apertures with multi-octave bandwidth. In military communications, active antenna apertures are easily targeted for missile attack. Fiber links allow information-gathering sensors to be located remotely from the processing site, with lower loss, greater separation, and higher security.

Electronic Countermeasures
Multi-octave instantaneous bandwidth capability to 18 GHz and beyond is required for electronic warfare applications including fiber optic towed decoys, and shipboard/airborne signal distribution. Wide bandwidth capability and EMI immunity are particularly beneficial in an environment with high RF radiation density.

Delay Lines and Beamsteering
Large aperture phased arrays and radar signal processing equipment may require true time delay elements. The small volume and low loss of fiber makes it ideally suited for long microwave delay lines (hundreds of microseconds), an application that cannot be easily accomplished using electrical transmission lines.

LO distribution
For applications requiring frequency conversion at multiple locations (shipboard/airborne antennas, large antenna farms, phased arrays) high frequency LO distribution through fiber optics provides for improved phase stability compared to coaxial distribution. Microwave fiber optics allows direct LO transmission, eliminating nonlinear elements and phase-stable oscillators at each location. Furthermore, fiber is less susceptible than coax to phase variation due to temperature and other environmental variables.

LINEAR PHOTONICS
Linear Photonics, LLC (LPL) develops and manufactures microwave and millimeterwave fiber transmitters and receivers for commercial and government customers. Using advanced linearization techniques and hybrid micro-electrical/micro-optical packaging techniques, LPL is striving to enlarge the market space for high frequency analog fiber optic equipment worldwide.