REFERENCE PHYSICAL LAYER ANALYSIS OF WDM FIBER OPTIC NETWORK FOR AEROSPACE PLATFORMS

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We review a proposed physical layer reference path for an optical WDM network for avionics. To obtain the most realistic assessment, critical components are identified and their characteristics measured.

Introduction

WDM fiber optic networks are increasingly becoming interesting for aerospace platforms due to high data carrying capacity and lower weight compared to copper. Fiber optics is already in use for in-flight entertainment and other flight non-critical applications [1, 2], whereas flight critical applications, such as flight controls and navigation systems, are still placed on older and tested copper based networks. The SAE Avionic Systems Division has launched an effort to develop the Aerospace WDM LAN Standard AS-5659, which aims to specify the architectural requirements, as well as identifying and developing modeling tools for fiber optic networks on aerospace platforms. In this paper we describe a reference physical layer path for this process.

Architectural and physical layer considerations

The network investigated in this work is meant to carry all types of traffic envisioned onboard an aircraft, including flight controls and other mission critical information, as well as less-critical information. A network architecture suggested by these requirements is shown in Figure 1 (left). It is a meshed network with a maximum of 256 nodes, full interconnectivity, supporting mixed digital and analog transmission with each line capable of handling greater than 1 Tbps using DWDM. Figure 1 (right) illustrates the proposed physical layer with nodes and interconnecting fibers.

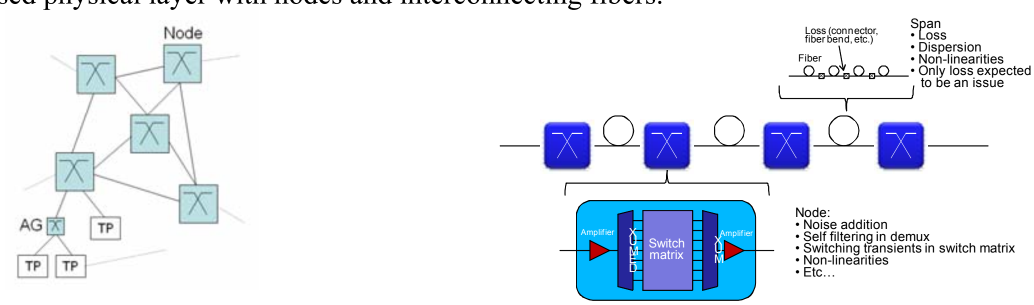

Fig. 1. Meshed network with interconnected switching nodes and terminations points (TP, end user) and aggregation points (AG) for low traffic volume termination points (left). Reference physical layer path with nodes interspersed by fiber.

From source to destination the signal passes through a number of optical nodes, interspersed by fiber spans. Each fiber span consists of a length of fiber and a discrete loss element. The discrete loss element is included to account for the additional loss encountered on an airborne platform due to tight fiber bending radii around bulkheads and added connector losses due to dirt and/or loose connectors due to vibrations. The nodes themselves will consists of an input amplifier, a 1:N wavelength DEMUX, a switching element, an N:1 wavelength MUX and an output booster amplifier. They will perform switching between ports as well as amplification due to loss in both the nodes and fiber spans. The amplifiers are EDFAs, as they are broadband and can be made almost gain flattened (within ~1dB).

In the current reference network, the fiber is SMF-28 with a maximum length of 75m per span, and the additional loss between nodes in the fiber span is chosen to be 5, 10, 15 and 20dB respectively. The main inhibiting factors in the fiber spans are loss, dispersion and non-linear effects. However, as the spans are

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so short the impact of non-linearity is expected to be insignificant. The node MUX/DEMUXES are chosen to be of the Arrayed Waveguide Grating (AWG) type due to its maturity. They exhibit low loss, are very stable and compact, and can be made temperature insensitive. Choosing the right pass-band characteristics is crucial, which translates into a trade-off between pass-band filter shape, 3dB bandwidth and dispersion. A Gaussian filter shape will exhibit very little, if any, dispersion in the pass-band, but will be limited in the number that can be traversed due to self-filtering (the effective signal bandwidth continuously decreasing as more filters are passed). Therefore, a more square shaped (i.e., flat-top) filter is preferable, as the impact from self-filtering is minimized. The drawback is the increased dispersion in the pass-band of such a filter. To ensure the best simulation scenario possible, the measured pass-band characteristics for a 40-channel flat-top AWGR with a channel spacing of 0.8nm and a 3dB pass-band of ~0.6nm is incorporated into the system simulation tool OptSim [5]. The 3dB bandwidth for the AWG filter is varied for the different simulation runs. The measured pass-band is shown in Figure 2 (top). In addition, a 4x4 strictly non-blocking switch matrix with short switching times is required. One such implementation is based on an integrated SOA gate matrix, as illustrated in Figure 2 bottom. Due to the monolithic integration, it is very stable and compact. Furthermore, typical switching times are on the order of ~1ns or lower. The main drawbacks are the addition of noise, added chirp in the SOAs, switching transients and cross-talk due to waveguide crossings and insufficient signal suppression in the SOAs. There are a number of other considerations to take into account for this network, including that of component parameter variations. Results of these analyses will be presented during the conference.

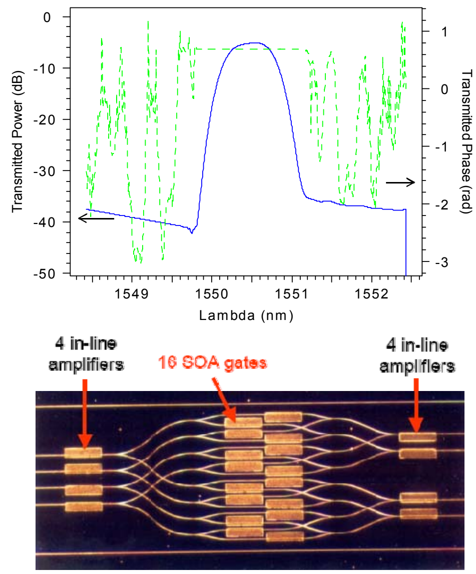

Figure 2. Measured flat-top pass-band amplitude and phase characteristics (top) and proposed 4x4 integrated optical switch matrix based on SOAs (bottom).

Conclusions and Future Work

To address the requirements of an avionics WDM LAN, a physical layer reference path has been proposed and the main components identified. The expected limiting factors have been identified and will be thoroughly evaluated through physical-layer simulations using commercial component specifications, where available. Through the work of the SAE ASD AS-5659 group more detailed investigations will also be proposed and initiated.

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