

FIBERLESS OPTICAL COMMUNICATION TECHNOLOGY

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ABSTRACT

This article describes a fiberless optical communication system which finds computer network applications. The basic arrangement of the full duplex digital atmospheric optical link is presented. An optical link for measuring received optical signal fluctuations was set up, and the results concerning the „availability“ of the fiberless optical link even under impaired weather conditions are discussed.

KEYWORDS

Optical communication, atmospheric optical links, data transmission.

1. INTRODUCTION

Over the last few years, remarkable progress has been made in the field of optical communication systems. Optical networks are currently transferring data at over two Gbit/s. The discovery of optical and optoelectronic components (low-loss optical fibers, semiconductor lasers and photodiodes) stimulated great advance in optical communication systems.

deep valleys, rivers, railway tracks and busy city roads. They can be used as network reserve links as well. The principal advantages of fiberless optical systems in comparison to wireless microwave systems are: high directivity of the beam (elimination of information dissipation in non-requested direction), high bit-rate (unattainable with microwave wireless links) and the absence of legislative inconveniences.

Fiberless optical communication systems can be divided into four types (see Fig.1) [1]:

- free space optical communication (satellite to satellite links),
- free space to ground (terrestrial) links
- free space to underwater links,
- terrestrial fiberless optical communication systems (atmospheric optical links).

In the following, only terrestrial fiberless optical communication systems (atmospheric optical links) are discussed which are designed for digital transmissions and which operate in the atmosphere with a narrow optical beam.

2. ATMOSPHERIC OPTICAL LINK

The authors of the contribution belong to a team of designers, who make various prototypes of full-duplex digital atmospheric optical links (DAOLs). The DAOLs are transparent for the Ethernet, Token Ring protocols and for signals multiple of E1. The DAOLs for the transmission of FDDI-II and SDH/ATM protocols are developed. The corresponding bit rates of the links are: 10 Mb/s, 16 Mb/s, 100 Mb/s, 155 Mb/s and 622 Mb/s with of BER = 10^{-9} . Depending on the type, the link ranges are: 300 m, 500 m and 1000 m (up to 8000 km is possible). These links are equipped with a special adaptive system that guarantees good quality parameters of the link even if the weather deteriorates.

The basic arrangement of the DAOL included in the communication line between two computers of the network is shown in Fig. 2. The information is transmitted between personal computers (PC), in which the Ethernet Cards provide interface. The heads (H_1 , H_2) of the DAOL are connected with optotransceivers by optical fibres. Every DAOL head consists

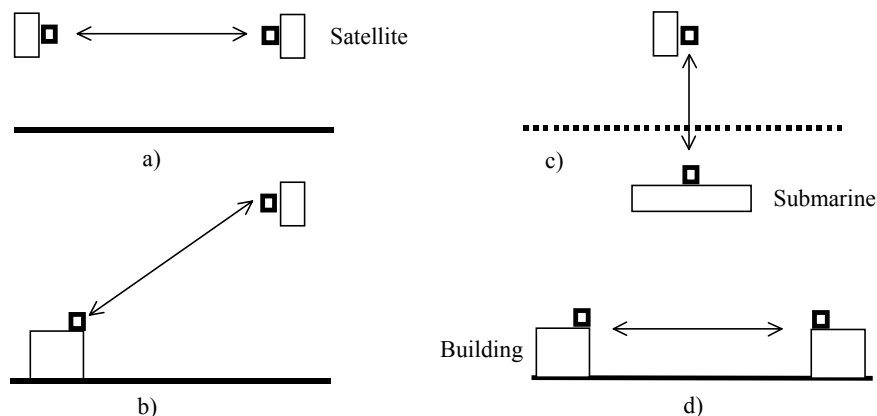


Fig.1. Wireless optical communication systems. (■ - Head of link)

In some cases, it is suitable to complement optical networks by fiberless communication devices. These technologies can span topological obstacles like rocky terrain,

of an optical part, an electronic part and a precision mechanics part. The optical signal (as a duplex) is carried between both heads through the atmospheric transmission medium.

The DAOLs designed by the team mentioned above were installed in several locations (universities, hospitals, observatory, etc.) in Brno in the Czech Republic [2]. The

non-homogeneity) and refraction (unstable atmospheric conditions like temperature inversions). Another cause of signal attenuation is the deviation of the beam due to

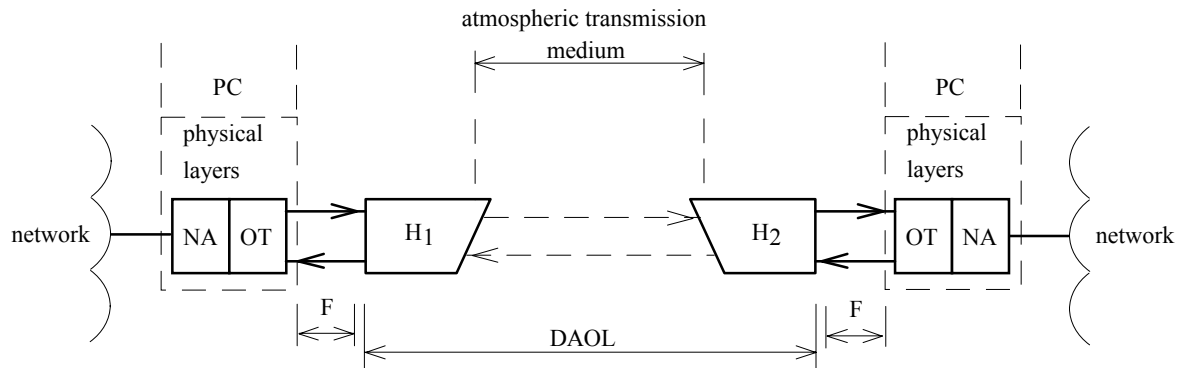


Fig.2. The basic network communication model with DAOL. (NA- network adapter/Ethernet Card; OT- optotransceiver; F - fibre; H₁, H₂ - DAOL heads; PC- personal computer.)

DAOL connecting two hospitals is shown in Fig.3. The significance of this DAOL for the staff of the hospitals consists in the possibility of making use of their own as well as international toxicological and pharmaceutical databases.

3. FLUCTUATIONS OF THE RECEIVED OPTICAL SIGNAL

The negative characteristic of DAOL is the link quality dependence on weather conditions. Therefore, it was necessary to aim research activities at measuring the received optical signal fluctuations. For statistical evaluation of link quality, it is important to know the time variance of the signal over a long time interval.

Some atmospheric effects may cause fluctuations of the received optical signal. The atmospheric influence on the DAOL consists in pollution of the atmosphere (gasses, aerosols), turbulence (wind influence and local temperature

mechanical and/or temperature deformation of the console.

In accordance with the above discussion, a DAOL was built for measuring received optical signal fluctuations. The level of the received monitoring signal is registered by a personal computer. In Fig.4 and Fig.5, samples of the monitoring signal time distribution are presented. The monitoring signal is transmitted between the DAOL heads over a distance of 700 m. The level of the internal receiver noise corresponds with a relative monitoring signal quantity of 20 mV. The maximum value is 400 mV, which corresponds to good weather conditions. But even if the atmosphere is clear, both fast and low monitoring signal fluctuations can appear. In those cases, the fast fluctuations are due to atmospheric turbulence and the low ones are due to mechanical deformations of the consoles or the loss of transmitted optical power - temperature effect. Nevertheless, the main reason for the signal drop consists in the measure of atmospheric pollution by various aerosols. In Fig.5, signal attenuation caused by a heavy rain is recorded.



Fig.3. Digital atmospheric optical link between two Hospitals and design of the DAOL head (in the upper right-hand part of the picture).

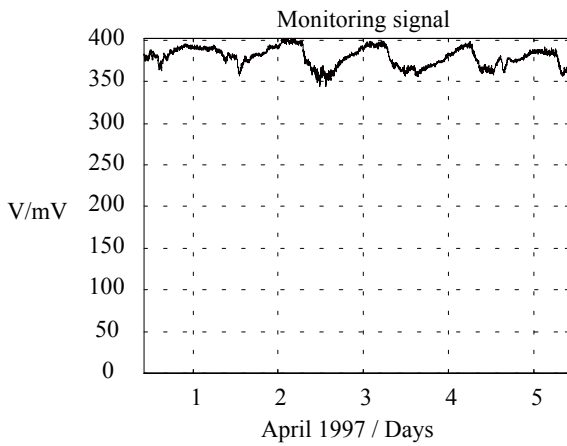


Fig.4. Fluctuations of the received optical signal (registration from 1 to 5 April 1997).

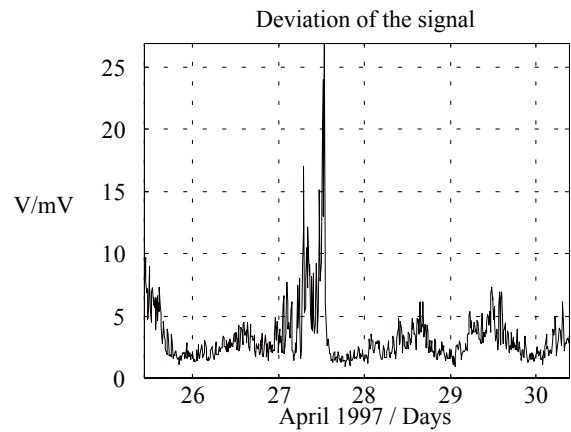


Fig.7. Mean square deviations of monitoring signal (registration from 26 to 30 April 1997).

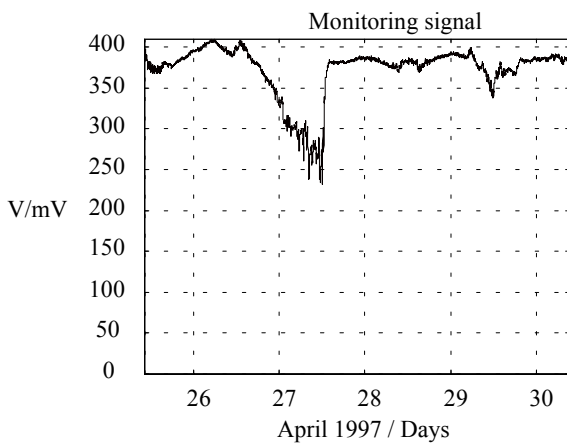


Fig.5. Fluctuations of the received optical signal (registration from 26 to 30 April 1997).

The mean square deviations of monitoring signal are presented in the Fig.6, and Fig.7. From the graphs in Fig.4, 5, 6 and 7 follows that signal deviation increases in high temperature conditions. In addition, the average value of the signal falls within the sunny day about midday - temperature effect. Drop in signal in this case is due to heat around the optical source driver.

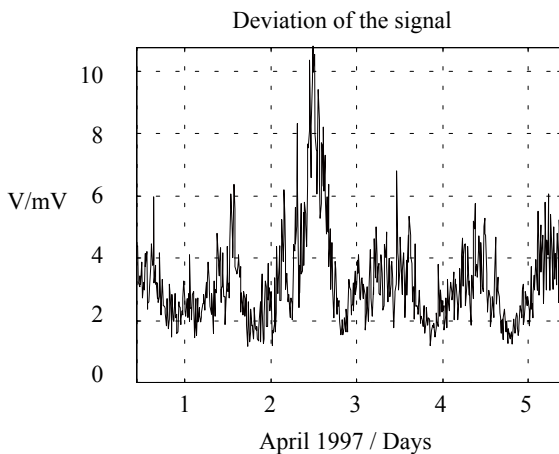


Fig.6. Mean square deviations of monitoring signal (registration from 1 to 5 April 1997).

A measuring chain was used to measure the temperature around the DAOL head, wind velocity and atmospheric pressure. All signals were analysed and evaluated by the PC Matlab program. The monitoring signal time distribution and the temperature signal time distribution are shown in Fig.8. From the graphs in Fig.8 it follows that the drop in received monitoring signal is due to the rise in temperature around the DAOL head. This signal cross correlation is marked on sunny days. The signals in Fig.8 were registered by measuring DAOL in Brno in spring 1998 from 13 to 19 May.

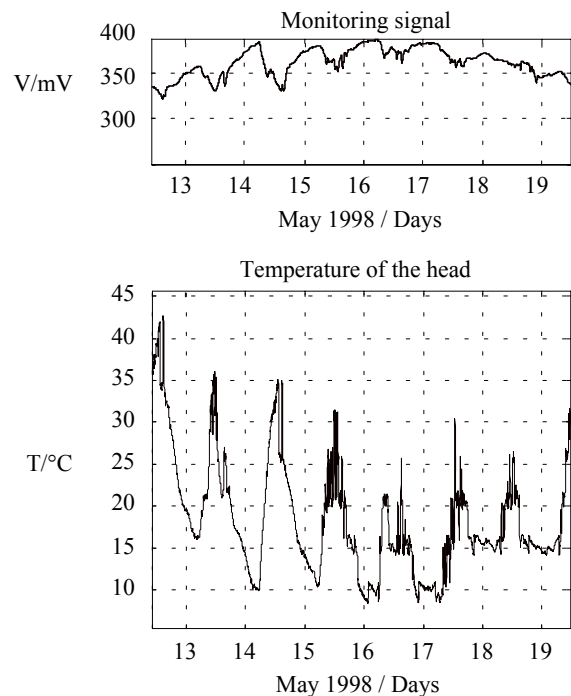


Fig.8. The monitoring signal and the temperature signal time distribution (registration from 13 to 19 May).

The results are applied to determine the link margin, which is the final and key concept in DAOL engineering.

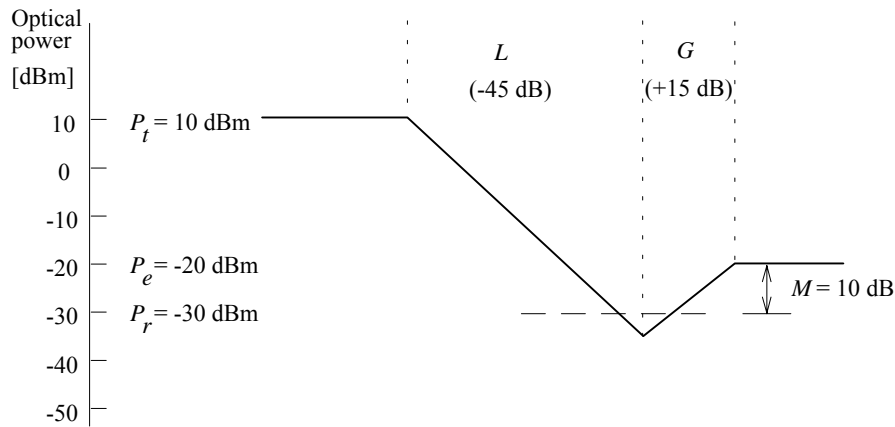


Fig.9. The power diagram of DAOL.

4. POWER DIAGRAM OF DAOL

The power balance in dB can be stated simply: the receiver sensitivity (P_r) equals the power transmitted (P_t) plus all gains (G), minus all losses (L) and minus link margin (M)

$$P_r = P_t + G - L - M .$$

The link margin M is the difference in dB between the expected value of received optical power P_e and the receiver sensitivity P_r

$$M = P_e - P_r .$$

An adequate link margin will allow the DAOL to deliver exceptionally good quality (high S/N, low BER) under good weather conditions. When DAOL is experiencing bad weather conditions (heavy rain, dense fog, etc.), the available link margin will determine how often and for how long the received optical signal will drop below the minimum allowable (threshold) value [3].

The criterion often used is called availability, which is the percentage of the time that the DAOL is above the threshold. A good-quality DAOL should operate at 98%, demonstrating a high availability. If the acceptable link margin is known, the power balance equation and the power diagram can be calculated as illustrated by the corresponding quantities in Fig.9.

5. CONCLUSION

A fiberless optical communication system, so-called DAOL (full duplex digital atmospheric optical link), was designed with good computer network applications. The DAOL is designed for optical connection, where fiber is impossible to use because of legislative inconveniences or other technical problems. The DAOL can be assigned to the network technology devices and can be used as a complementary, reverse, or route link with the possibility of changing (optimising) the network topology.

A DAOL for measuring received optical signal fluctuations was set up. The temperature around the DAOL head, wind velocity and atmospheric pressure were measured.

The characteristics of the signal are processed by the PC Matlab program. The results of long-term measurements are applied to the determination of link margin. The main aim of the development and design of the DAOL is obtaining high-quality parameters of the links even if the weather deteriorates (windy, sunny, fog, rain, snow).

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