Radioengineering
Vol. 2, No. 1, April 1993

Programme Code for Projecting of WDM Fiber Optic Sensor Systems

Ján Turán, Robert Probstner
Department of Radioelectronics
EF TU Košice
Park Komenského 13
040 21 Košice
Slovakia

Abstract

Wavelength division multiplex (WDM) offers a potentially powerful technique for use within optical fibre sensor systems. The paper deals with short description of methodology and a programme code for WDM fiber optic sensor system projecting with use of CAD.

1. Introduction

Combining the sensing and signal-transmitting (i.e. telemetring) capability of optical fibers may provide the strongest driving force for fiber optic sensor network development in the coming years [1], [2]. This capability becomes increasingly attractive as fiber optic local area networks (LAN's) or local optical networks (LON's) are likely to be implemented in factories, buildings, offshore platforms, and mobile systems. This is expected to trigger the desire for using sensors of the same fiber optic technology [1]. Methodology of WDM fiber optic point sensor networking or multiplexing is outlined in this paper. The programme code (WDM-CAD) for the CAD system for WDM fiber optic sensor system projecting is also described.

2. WDM system projecting

Regarding the components for fiber optic sensors, there are various solutions and development lines among competitive technologies such as microoptics, fiber optics and integrated optics. Information may be carried by the amplitude (intensity), phase, polarisation, or spectral distribution of the optical carrier [2]. In addition, the sensor information may be encoded in frequency or time domain. The topology of a fiber optic sensor network is strongly determined by the desired method of sensor modulation and interrogation. The interrogation may be performed in the time (TDM), frequency (FDM), or wavelength domain (WDM). The WDM technique is feature unique for optical sensors, whereas the others are used addressing conventional electrical sensors [3], [4].

Key system characteristics of fiber optic sensor networks include the network topology, the number of addressable sensors, the degree of lead insensitivity, the down-lead fiber length, sensitivity and dynamic range, the power budget (i.e. source power, noise sources, losses, detector sensitivity), bandwidth and sampling rates, cross-talk, reliability, and cost [2].

WDM involves the transmission of a number of different wavelength optical signals in parallel on a single optical fibre link. Optical signal from optical transmitters emitting light of different wavelength $\lambda_1, \lambda_2, \ldots, \lambda_n$ is multiplexed into single optical fibre and transmitted along this fibre to the destination. There the composed WDM signal is demultiplexed and feed to optical receivers. The multiplexer and demultiplexer must not, however, give rise to any significant optical insertion losses and must provide good isolation between the information flows transmitted along optical carriers with wavelength $\lambda_1, \lambda_2, \ldots, \lambda_n$. The WDM multiplexing and demultiplexing devices rely on the utilisation of three wavelength-selective effects, (i.e. angular dispersion, interference and absorptance). As these devices in practice one can use optical prism, grating, filters (absorption, interference and holographic) and active devices [5]. Devices are characterised by reference to the insertion loss per channel and the cross-talk attenuation with respect to the adjacent channel. Such a WDM operation has generated particular interest within optical fibre sensing for respecting within intensity modulated sensor systems as well as for multiple sensor networking [2], [3].

The powerful attribute of WDM for the provision of multichannel network environment offers the potential of multiple sensor networks where each optical sensor modulates a specific and distinctive wavelength optical signal. Although such sensor networks would require the incorporation of wavelength multiplexing and demultiplexing devices, they offer the advantage of an integrated, fibre economic approach that may well prove attractive within the future application of optical fibre sensors. Multiple sensor network topologies can, however, be realised which provide a net benefit over the separate linking of individual optical fibre sensors by utilising the multichannel capability offered by WDM [3], [4]. Consideration of optical fibre LAN topologies tends to be dominated by the current lack, in general terms, of a T coupler analogous to the ones that be provided in coaxial cable networks that will allow the connection of many terminals onto a single transmission link.

There are a number of factors that need to be considered in relation to the implementation of the WDM sensor systems and networks. Major concerns include the possible spectral separation of the WDM channels and the system/network optical power budgets to achieve satisfactory operation.

A more general and complete theory is needed in order to perform network design modelling, with the aim of optimising the main system parameters such as input power, dynamic range, cross-talk, and the maximum number of sensors.

3. WDM-CAD programme code description

The programme code WDM-CAD was developed as a CAD system for fiber optic point sensor networking with WDM. WDM-CAD is controlled by five pull-down menus. Each menu is activated with hot keys, a colored highlighted alphabet in the screen. For the choice of the menu or its items use arrow keys, or hot keys.

The working core of the WDM-CAD may be divided to two parts :

1. Computing of interchannel cross-talk levels for the desired channel spectral bandwidth and separation;

2. Developing WDM fiber optic sensor network with desired architecture and use of choiced components from programme databases; Estimate of the channel separation required for specific spectral bandwidth of channels in order maintain particular levels of interchannel cross-talk; Computing the optical power budget requirements for the particular implementation;

The first part deals with theoretical estimation of possible channel configuration in the network, i.e. theoretical estimation of levels of interchannel cross-talk for the desired channel configuration. We can choice two ways for channel configuration description, namely : channels with equal optical bandwidth and separation, and channels with individual optical bandwidth and separation.

The second part deals with point fiber optic sensor networking. As a first step the user choice the sensor network architecture, this depends on source (single broadband or multiple narrowband optical source) and fiber optic sensor topology (transmissive or reflective). Parallel or serial configuration of the sensor network architecture may be used for transmissive fiber optic sensor topology. When the sensor network architecture is choiced, the designer picks the network components from the WDM-CAD databases (fiber, splices, connectors, multiplexers/demultiplexers, sources, detectors and sensors) and system power safety margin in the second step. In third step the physical parameters and dislocation of the network components are specified (i.e. the distance between sensors, the length of optical fibre used, etc.). In the fourth step the code controls the coincidence of input data; if any mismatch occurs user is notified and the choiced components or its parameters must be changed. If the choiced components satisfied to the choiced network topology the programme computes network power budget, interchannel cross-talk and create appropriate documents for network project.

Important part of WDM-CAD is system for creating and editing databases of network components. There are databases : fibers, connectors, sources, multiplexers / demultiplexers, sensors, detectors. Database files are created in text mode, so the user can view and edit them in any text editor. Programme code contains config mode that the user can change configuration of some its parts.

4. Conclusion

Networking of fiber optic sensors is expected to be an important aspect of the fiber optic technology for many years to come. It is likely that WDM offers a potentially powerful technique for use within optical fibre sensor systems. It is apparent from significant activities in this area that WDM is of increasing interest for the implementation of practical optical sensor systems and networks. The developed and described programme code WDM-CAD may be helpful tool for solution of many projection tasks of such systems.

References

1. Turán, J.-Petrík, S.: Fiber optic sensors. Alfa, Bratislava, 1990 (In slovak).
2. Turán, J.-Samy, M. H. A.-Petrík, S.: Multiplex in fiber optic sensor systems. Elektrotechn. čas., Vol. 41, No. 7, 1990, 573-584 (In slovak).
3. Turán, J.: Structure of wavelength division multiplexed optical fibre sensor systems. In : Proc. of discrete process control, Bratislava, Slovakia, 1991, 152-154.
4. Senior, J.M.-Cusworth, S.D.: Wavelength division multiplexing in optical fibre sensor systems and networks: a review. Optics and Laser Technology, Vol. 22, No. 2, 1990, 113-126.
5. Senior, J.M.-Cusworth, S.D.: Devices for wavelength multiplexing and demultiplexing. IEE Proc., Vol. 136, Pt J, No. 3, 1989, 183-202.

About authors

Ján Turán - see Radioengineering Vol. 1, No. 1, 1992, p. 24.

Coming events

Scientific conference **RADIOELECTRONICS 93** will beheld in April 29, 1993. The organizer is the Department of Radioelectronics, Technical University of Brno, Antonínská 1, 662 09 Brno. The program of the conference is intent in four sections:

Theory of Electronic Circuits and Systems,
Applications of Electronic Circuits and Systems,
Signal Processing and its Applications,
Electromagnetic Waves,
Antennas,
Microwaves and
Optoelectronics.

Over 49 papers of participants from radioelectronics and other related departments of Czech and Slovak Technical Universities will be presented at the conference and published in the proceedings. Further contributions may be presented in a poster section. Please contact the organizers.