VERIFICATION OF WAVELENGTH DIVISION MULTIPLEXER PARAMETERS

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ABSTRACT

This paper deals with wavelength division multiplexers from the system properties point of view. The parameters that should be considered during WDM system design are described and results from measurement performed on experimental system are presented.

1 INTRODUCTION

During the past few decades the needs for communication speeds have been rapidly growing. One method that helps to fulfill these requirements is wavelength division multiplexing (WDM) technique, where individual channels are carried on separate optical wavelengths by means of one optical fibre.

The aim of this article is to describe the basic properties of wavelength division multiplexer (WDMX) and demultiplexer (WDDX) as functional blocks. These parameters have to be taken into account during such a system design in addition to what is commonly considered in non-WDM fibre systems. Further, the reader is presented an experimental system designed and used for the parameter measurements including obtained results.

The conclusions of this work will be used by *Eldis Pardubice Company* for the replacement analysis of coaxial cables in radar systems with optical fibres.

2 WDMX AND WDDX PARAMETERS

The block of a WDMX and WDDX is shown on Figure 1. For simplicity only two-channel blocks are depicted. The main difference between combiner and WDMX is that WDMX has optical filters on its inputs while combiner has not. Similarly WDDX applies optical filters on its outputs. But WDDX splitting process differs from that used in the classical splitter in power area: while splitter divides optical power, WDDX routes wavelengths to the appropriate output.

To the main system parameters of WDMX and WDDX belongs:

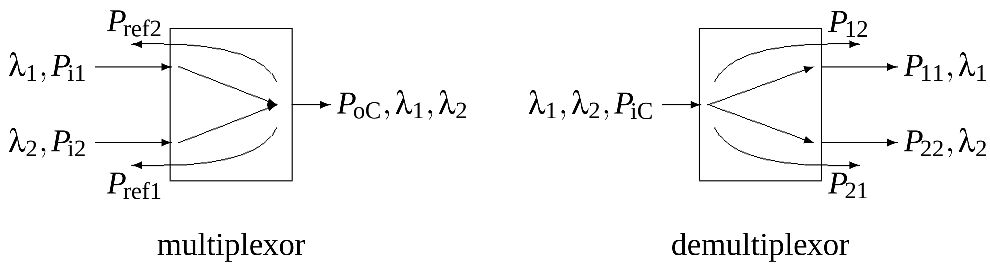

Figure 1: Two channel WDMX and WDDX.

- Passband B_{F_x}, where x is number of input or output channel,
- Excess loss L_{WDMX_x} , L_{WDDX_x} – typically up to 1 dB. Providing measurement when only one channel is under operation and further considering Figure 1, the excess loss can be defined as follows:

$$L_{\mathrm{WDMX}_x} = -10\log\frac{P_{\mathrm{oC}}}{P_{\mathrm{i}_x}}, \quad x \in \mathbf{N}; \quad [\mathrm{dB}], \tag{1}$$

$$L_{\mathrm{WDDX}_x} = -10\log\frac{P_{xx}}{P_{\mathrm{iC}}}, \quad x \in \mathbf{N}; \quad [\mathrm{dB}]. \tag{2}$$

- Isolation I_{xy} of WDDX – it has the main contribution to crosstalk among channels. Assuming P_{xy} (crosstalk power) is optical power on the output of WDDX x branch that comes from channel y and providing P_{iC} on its input is power only from channel y, isolation can be expressed as:

$$I_{xy} = 10\log\frac{P_{\mathrm{iC}}}{P_{xy}}, \quad x \neq y; \quad x, y \in \mathbf{N}; \quad [\mathrm{dB}]. \tag{3}$$

- Directivity D_x of WDMX – typically > 50 dB – is the ratio of power P_{i_x} in the input x branch to the power P_{ref_x} reflected to the adjacent input branches:

$$D_x = 10\log\frac{P_{\mathrm{i}_x}}{P_{\mathrm{ref}_x}}, \quad x \in \mathbf{N}; \quad [\mathrm{dB}]. \tag{4}$$

3 SYSTEM UNDER TEST

The full variant of the system designed for measurement is at Figure 2, where LD_x are laser drivers and PIN_x are PIN photodetectors. As the used WMDX is bidirectional and also due to reducing of overall system costs, only the left half of it was implemented. Instead of a PIN photodetector, a calibrated optical power meter was used. Such a configuration is sufficient for the verification of parameters mentioned in section 2. The system is designed for single mode operation.

Here is a list of used devices:

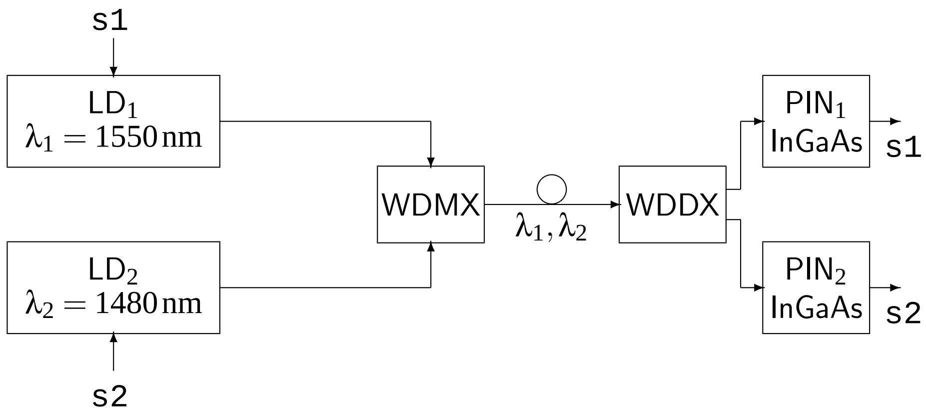

Figure 2: Full variant of the system under test.

- As laser driver, driver from [3] was used; for cost reduction, laser diodes in the window package were chosen.
- WDM multiplexer under test was WD202C-FC. It is the bidirectional type that can be used both as WDMX and WDDX. For its parameters see Table 1.
- For optical power measurement, the optical power meter Anritsu ML9002A with MA9721A sensor was used.

Table 1: The parameters of WDMX Thorlabs WD202C-FC.

Parameter	Blue fibre	Red fibre	Unit
Channel number	1	2	
Passband	1450 – 1490	1530 – 1580	nm
Insertion loss	0.3	0.5	dB
Minimal isolation	12	12	dB
Directivity	> 55	> 55	dB

4 MEASURING CHAINS

For easy description of measuring chain, the block of WDMX is further represented as depicted on Figure 3.

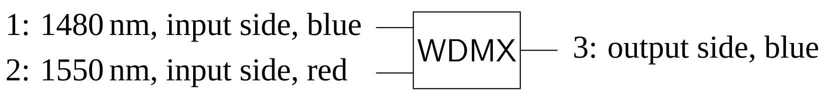

Figure 3: Representation of WDMX block.

A connector joint to the chain input is marked as J_*, C is an optical connector, J is an optical connector joint (not input), PM is an optical power meter and PC is a symbol for an optical patchcord. The connectors to be connected to the PM are marked with letters A and B. Rows under WDMX block describe how this block is to be connected to the input (J_*) and output (PM) of the measuring chain. Behind the "@" sign follows the wavelength of the optical source that is to be used for that row – it is to be present in the connector on the left side of J_*. Each line means one measurement.

The designed system per section 3 is convenient for the verification of insertion loss – see Figure 4, isolation – see Figure 5 and directivity – see Figure 6.

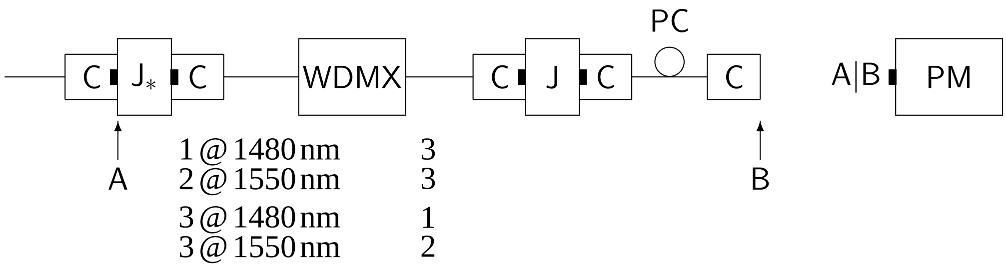

Figure 4: Measuring chain for insertion loss.

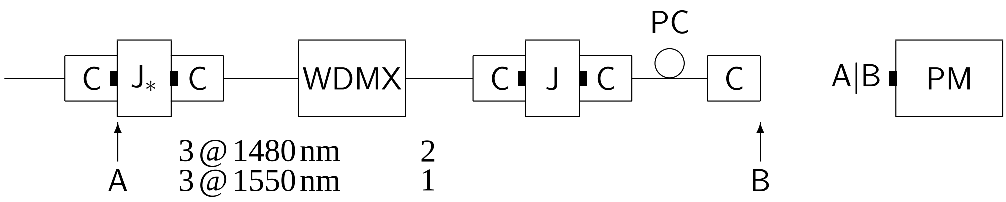

Figure 5: Measuring chain for isolation.

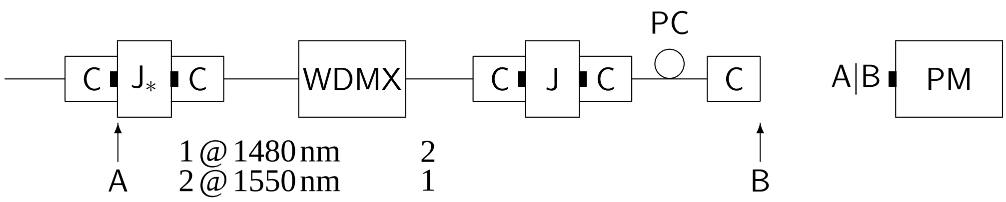

Figure 6: Measuring chain for directivity.

5 MEASUREMENT RESULTS

Due to the availability of only one optical power meter and laser driver at the time of measurement, connectors were subjected to several mounting cycles. It was found out that the measured optical power exhibits variation due to that. For elimination of this effect, each measurement was performed three times and results were processed with measuring error evaluation methods to get the order of precision. Final results are in Table 2.

Table 2: Measurement results.

Parameter	Direction	$\lambda_1 = 1480\,\text{nm}$	$\lambda_2 = 1550\,\text{nm}$	Unit
Insertion loss	WDMX	0.7	1.3	dB
Insertion loss	WDDX	0.7	1.7	dB
Isolation	WDDX	11	14.3	dB
Directivity	WDMX	29	28.1	dB

6 CONCLUSION

This article is focused on system parameters of wavelength division multiplexer and demultiplexer. Besides the theoretical description, measurements on WD202C-FC multiplexer were also performed.

During the measurement, the random nature of insertion loss caused by mounting cycles of single mode FC connectors was observed. This effect was eliminated by using of measuring error evaluation methods.

Further, optical fibres of the multiplexer exhibited increasing insertion loss with lower bend radius. These fibres were more sensitive to it on 1550 nm than on 1480 nm wavelength. To obtain representative results it was necessary to avoid bends of the optical fibres.

After the comparison of measured results to the catalogue values of the multiplexer it is obvious that in compliance with it we got the lower insertion loss in channel 1 than in channel 2. The numerical difference of what we got and what is in the specification is not critical and can be caused by not fully clean connectors.

The measured isolation complies with the specification. The rather big difference between the measured and the catalogue directivity can be caused by the fact that optical powers during this measurement were only slightly above the minimal measurable power of the power meter.

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