MILITARY OPTICAL TENCHNOLOGY FOR TRANSMISSION OF MICROWAVE SIGNALS

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Abstract: - This work involves analysis, optimization and design principles for mathematical and engineering models of subsystem and system level development of linear fibreoptic products Ortel comp., routinely used for transporting high dynamic range RF and microwave signals, often over long distances. These signals may be from military or commercial communication satellites, modern tracking systems, wireless cellular networks, or a variety of other sources.

Key-Words: - Analysis, optimization, design, mathematical model, linear fibreoptic products, microwave signals, multi-parametric relations, computer aided solutions, optical communication systems

1 Introduction

The main objective of research, the results of which are presented in research report [1], is to design and to optimize the conception for analogue and digital RF transmission, especially microwave signals in gigahertz frequency range with fibres, over the distance of tens of kilometres [2], applying the optical technology of Ortel company (see Table 1) which fulfils requirements of military standard MIL-HDBK-141 [3].

The paper presents a partial result of computer implementation of multi-parametric correlations expressed in analysis, optimization and design of conception for transporting high dynamic range RF and microwave signals.

2 Computer implementation of analysis and optimization mathematical-physical multiparametric relation in optical microwave transmission system

Regarding the main objective, mentioned above, there were defined partial points, which include technological analysis of high dynamic range RF and microwave signals systems in light of individual component identification, which are used in optical transmitter and receiver, delivered by Ortel corporation catalogue [4]; diagram design in optical and electrical way and formation of mathematical and physical model for this optical transfer system's conception with a view to quantitative numerical verification in every key system parameter with goal to compare immediately this values with values in Ortel catalogue. The optimization of parameters' values, in a complex interconnection of partial components defined in accordance with the previous goal. For this purpose was created a programme which calculates values of multi-parametric relations necessary for final design with Ortel components.

Research report [1] includes 80 pages, therefore, it is beyond the scope of this presentation. Report [1] is solving computer support for analysis and optimization of transporting high dynamic range RF and microwave signals conception in light of input parameters' value for optical transmitter and receiver, optical receiver efficiency calculations, relation between SNR and BER, optical losses, energetic balance of haul, amplifier's parameters suggestion, noise restriciton, dynamic range and intermodulation distortion.

Mathematical and physical description is in the above-mentioned original [1] and it is source for a computer implementation of multi-parametric programme. Limit possibilities were given by designing optical component technology on the basis of Ortel catalogues [4].

We have to know main requirements for transmission system, including signal input parameters and input component parameters to be able to design a concrete solution [1], [4].

Optical transmitters

Model number			Frequency (GHz)	Optical wavelenght (nm)	Dynamic range	Laser type	Isolator	Min. gain* (mW/mA)	Min. power (mW)
Module	Flange Mount	Plug-In							
1510A	3510A	10350A	.01 to 3	1310	Medium	FP		.02	0.4
1510B	3510B	10350B	.01 to 6	1310	Medium	FP		.02	0.8
1515A	3515A	10355A	.1 to 10	1310	Medium	FP		.02	0.8
1515B	3515B	10355B	.1 to 12	1310	Medium	FP		.02	0.8
1530A	3530A	10330A	.1 to 10	1310	Medium	FP	Y	.075	3
1530B	3530B	10330B	.1 to 12	1310	Medium	FP	Y	.075	3
1540A	3540A	10340A	.1 to 5	1310	High	DFB	Y	.1	4
1541A	3541A	10341A	.1 to 10	1310	High	DFB	Y	.06	2.4
1541B	3541B	10341B	.1 to 13	1310	High	DFB	Y	.06	3
1541C	3541C	10341C	.1 to 15	1310	High	DFB	Y	.06	3
1740A	3740A	10370A	.1 to 4	1550	Medium	DFB	Y	.05	3
1741A	3741A	10371A	.1 to 10	1550	Medium	DFB	Y	.05	3

Optical receivers

Model number			Frequency (GHz)	Gain** (dB)	Max. power (mW)	R (Ohms)
Module	Flange-Mount	Plug-In				
2510A	4510A	10450A	0.01 to 3	-6	2	50
2510B	4510B	10450B	0.01 to 6	-6	2	50
	4511A		0.01 to 2	25	2	50
	4512A		2 to 6	25	2	50
2515A	4515A	10455A	0.1 to 10	-6	2	50
2515B	4515B	10455B	0.1 to 12	-6	2	50
2516A	4516A	10456A	1 to 20	-6	2	50

* Laser's DC modulation gain

**Gain is relative to the unmatched responsivity of the photodiode, which typically ranges from 0.65 to 1.0 mA/mW depending on model and wavelength

Table 1: Application of Ortel optical technology

To fulfil requirements for this publication, there are presented only some extracts from report [1] computer support for analysis and optimization of optical system with high dynamic range RF and microwave signal with corresponding extracts from programmes and related multi-parametric relations in graphical representations of optical transmission system optimization.

Computer support for optimization of optical transmissions system is an original programme created in programming environment Matlab 6.5 R13. The programme (gradually) calculates multi-parametric relation in a defined sequence and converts them into graphical representations. We can determine optimal values for selected system parameters from graphs according to set points.

3 Selected graphical results from system analysis and optimization computer support

We can see an evident shift in haul gain with insertion of amplifiers in Fig.1. Curves for minimal and typical efficiency enclose the area in which value of haul gain move. Bandwidth for 1550 nm wavelength is narrower then bandwidth for 1310 nm wavelength which is caused by a narrower interval of values for laser diode. Sudden declines in curves are caused by increasing attenuation due to inserted connectors.

After band comparison for both wavelengths (3rd graph in Fig.1) it is obvious that the system fulfils the requirement of zero haul gain for both wavelengths.

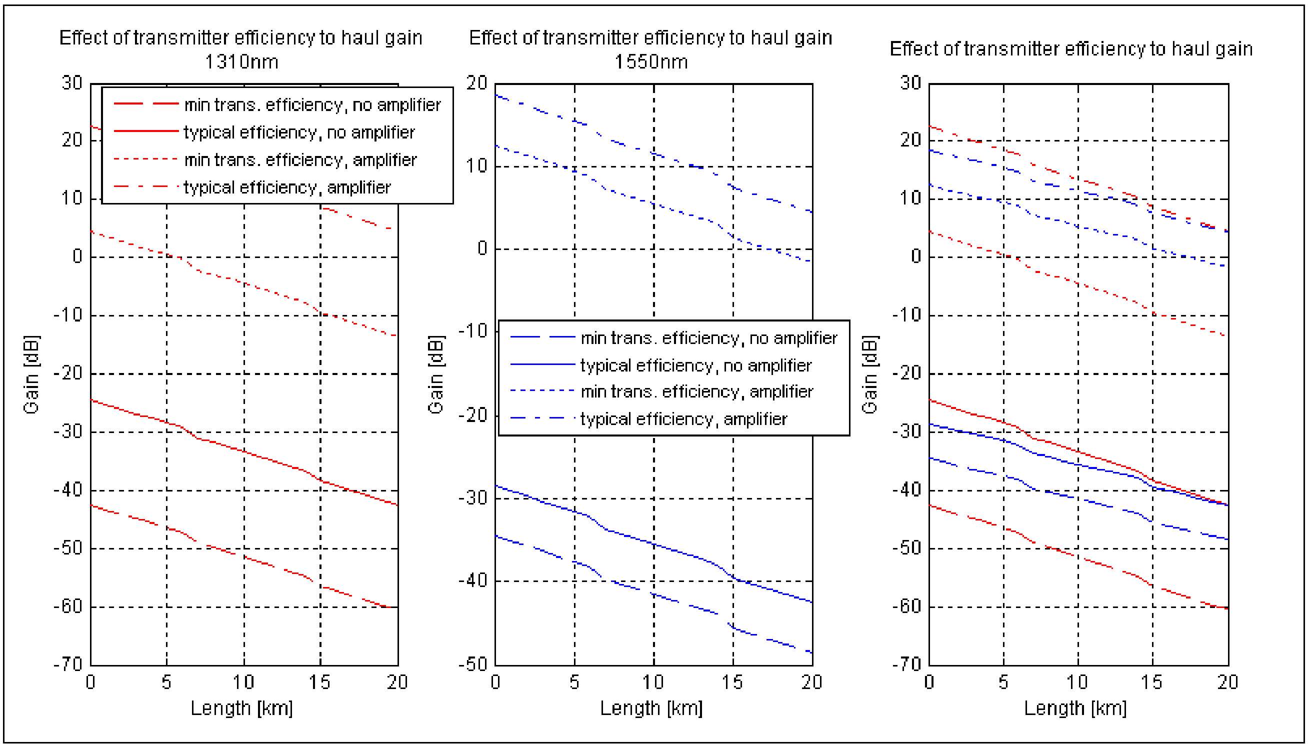

Fig.1: Relation between transmitter efficiency, wavelength and haul gain

Increasing parameter IIP3 from 22 dB to 35 dB and subsequently comparing different channel bandwidth values with application dynamic range, we can state, in accordance with Fig.2, that amplifier choice was the right one in this case because application dynamic range is smaller than all three values for channel bandwidth. If IIP3 parameter is increasing, then parameter SFDR is increasing too.

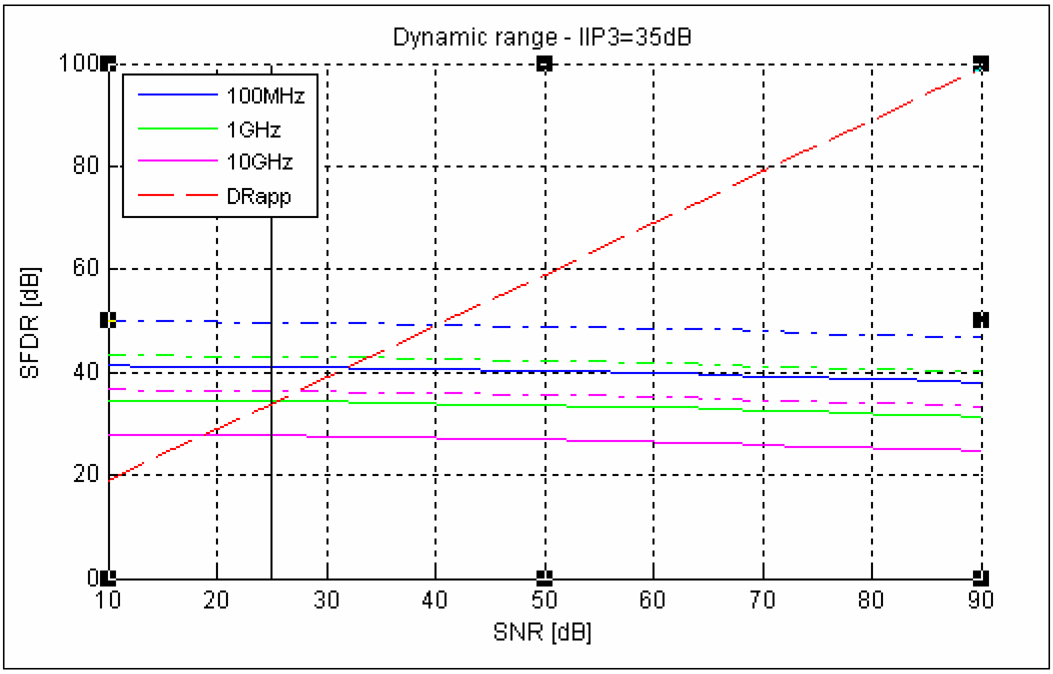

Fig.2: Dynamic range

In Fig.3 is showed a relation between bit error ratio and signal-to-noise ratio. BER declines exponentially with the increase of SNR. Bit error ratio decreases by three degrees with 10 dB SNR improving.

There is showed a 10^{-9} bit error ratio in optical transmitting systems. This limit system is not exceeded if parameter SNR is smaller than 35 dB, if parameter SNR = 25 dB is required, then bit error ratio is bigger than 10^{-7}, according to second graph in Fig.3.

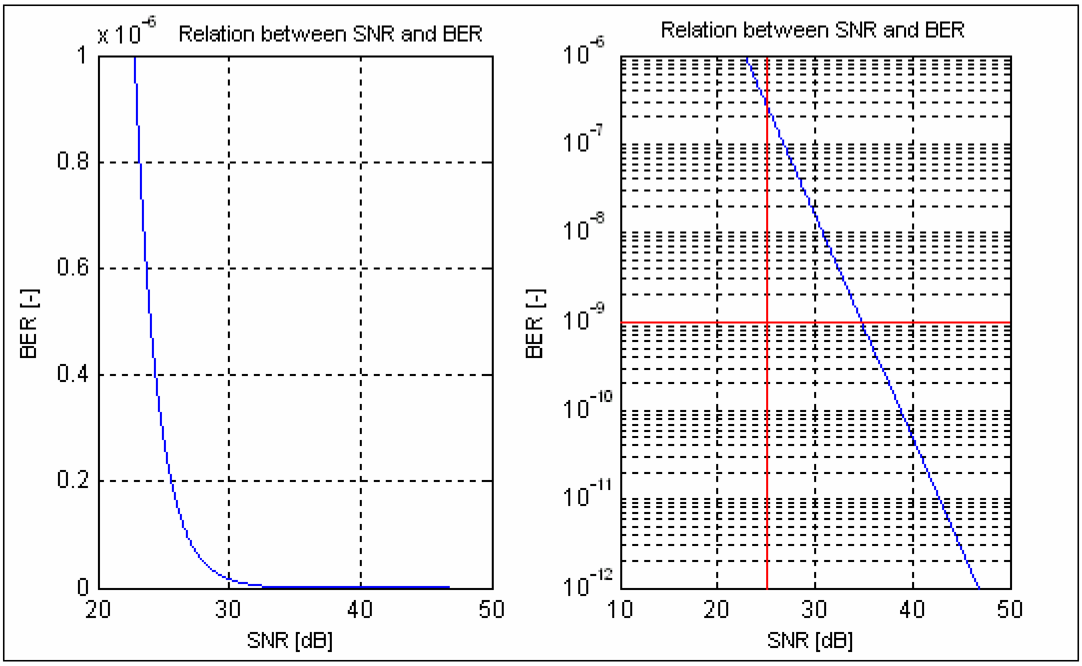

Fig.3: Relation between SNR a BER

4 Conclusion

The created model of optical high dynamic range RF and microwave signals transmission system and analysis supported by computer programme allow to make cost-effective decision in designing individual components delivered by Ortel company. This is done to achieve an optimal solution for general/overall system conception in accordance with tactical-technical requirements imposed on optical high dynamic range RF and microwave signals transmission system.

References:

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