Simulation Software Development of Dispersion in a Single-Mode Fibre

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Abstract - **Modelling software for dispersion in single-mode fibres study is created. The program was created in a Microsoft Visual C + + environment. It has about 1,500 operators and works in a dialogue mode. It allows identifying the material, waveguide and dispersion of the refractive index profile. The calculation results are presented as a table and appropriate graphics are build.**

Keywords – **software, dispersion, single-mode fibre.**

I. INTRODUCTION

Conventional single mode fibres in the range of 1.2 - 1.6 μm have two areas with low attenuation values - transparency window at $l = 1,3$ μm and at $l = 1,5$ μm. In fibres with uniform or gradient core and uniform cladding, zero dispersion can be achieved only at one wavelength. To achieve the shift to zero-dispersion in long-wavelength region of 1.55 μm, the impurities in the core must be high to obtain the necessary large relative difference in refractive indices. This leads to an increase in intrinsic losses in fibre. In addition, these fibres have a short cutoff wavelength $l_c = 0,85$ μm LP_{11} mode, which defines the limit of a single mode, which entails an increase in losses at bends and microbends in an optical fibre cable.

Improvement of fibre characteristics can be achieved by increasing the number of claddings and matching their refractive indices. Thus, the introduction of intermediate cladding with low values of the refractive index reduces the required value of the relative refractive index difference on 15 - 20%.

As a third type of fibres with a low dispersion in the wavelength range, W-type fibres with gradient and homogeneous cores, fibres with segmented core, four layered core fibres, etc. are used. These structures have the ability to compensate in wide wavelength range materials dispersion equal but with an opposite sign to the waveguide dispersion. The drawback of such fibres is sensitivity to bends and microbends. In addition, to ensure the calculated dispersion, it is necessary to meet the tight tolerances to the basic parameters of fibre during manufacturing procedure.

In fibres with segmented core, the core is surrounded by three claddings. Moreover, the second cladding has a refractive index higher than the first and third surrounding claddings, and less than the core one. Therefore, it can be considered as an additional core. This core prevents the leakage of main mode and shifts the cutoff wavelength of LP_{11} mode into the range of longer wavelengths ($l_c = 1,2$ μm) due to the preservation of propagation constant of the main mode much higher than that of a planar electromagnetic wave in the core material throughout the operational wavelength range. This leads to losses reduction on microbends.

In fibres with four claddings, additional claddings are made to eliminate the losses of mode leakage at bending along the fibre axis.

II. CALCULATIONS

At strict calculations on the wavelength of zero-dispersion l_0, it is important to consider dispersive effects of the second order.

Developed software for dispersion modelling in a single-mode fibre was implemented in C + + environment in Microsoft Visual C + + 2008 using MFC libraries. The software works along the algorithm in interactive mode shown in Figure 1.

Databases for dispersion modelling are presented in the form of relevant graphs. For example, the dependence of the core refractive index on the wavelength is shown for four types of fibres: pure quartz fibre, two types of fibres doped with germanium dioxide and fibre doped with boron dioxide. The user of the program is free to choose the type of fibre and perform further calculations step by step. Detailed description of all steps of the program is beyond the scope of this article. Fragments of the program operation with the results of calculations are presented in the relevant windows.

III. SOFTWARE DESIGN

Listing of the program fragments and windows appearance are shown below in Figures 1-5.

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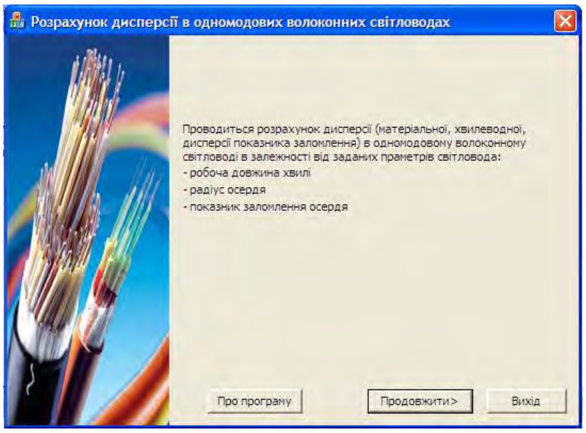


Fig.1. Starting window

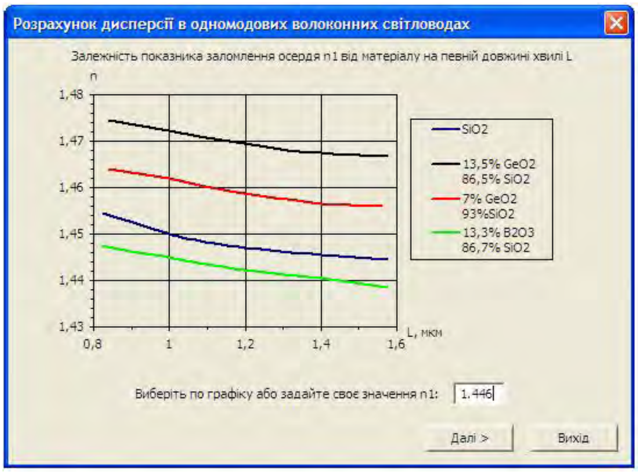


Fig.2. Window appearance: Choice of core refractive index

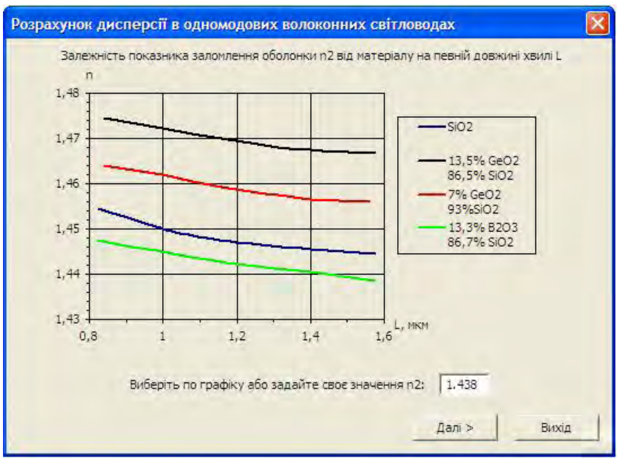
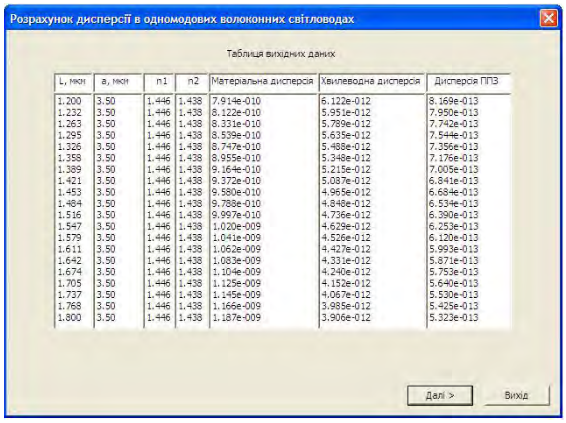


Fig.3. Window appearance: Choice of cladding refractive index



L, мкм	a, мкм	n1	n2	Матеріальна дисперсія	Хвилеводна дисперсія	Дисперсія ППЗ
1.200	3.50	1.446	1.438	7.914e-010	6.122e-012	8.169e-013
1.232	3.50	1.446	1.438	8.122e-010	5.951e-012	7.950e-013
1.263	3.50	1.446	1.438	8.331e-010	5.789e-012	7.742e-013
1.295	3.50	1.446	1.438	8.539e-010	5.635e-012	7.544e-013
1.326	3.50	1.446	1.438	8.747e-010	5.488e-012	7.356e-013
1.358	3.50	1.446	1.438	8.955e-010	5.348e-012	7.176e-013
1.389	3.50	1.446	1.438	9.164e-010	5.215e-012	7.005e-013
1.421	3.50	1.446	1.438	9.372e-010	5.087e-012	6.841e-013
1.453	3.50	1.446	1.438	9.580e-010	4.965e-012	6.684e-013
1.484	3.50	1.446	1.438	9.788e-010	4.848e-012	6.534e-013
1.516	3.50	1.446	1.438	9.997e-010	4.736e-012	6.390e-013
1.547	3.50	1.446	1.438	1.020e-009	4.629e-012	6.253e-013
1.579	3.50	1.446	1.438	1.041e-009	4.526e-012	6.120e-013
1.611	3.50	1.446	1.438	1.062e-009	4.427e-012	5.993e-013
1.642	3.50	1.446	1.438	1.083e-009	4.331e-012	5.871e-013
1.674	3.50	1.446	1.438	1.104e-009	4.240e-012	5.753e-013
1.705	3.50	1.446	1.438	1.125e-009	4.152e-012	5.640e-013
1.737	3.50	1.446	1.438	1.145e-009	4.067e-012	5.530e-013
1.768	3.50	1.446	1.438	1.166e-009	3.985e-012	5.425e-013
1.800	3.50	1.446	1.438	1.187e-009	3.906e-012	5.323e-013

Fig.4. Window appearance Display of values array for plotting

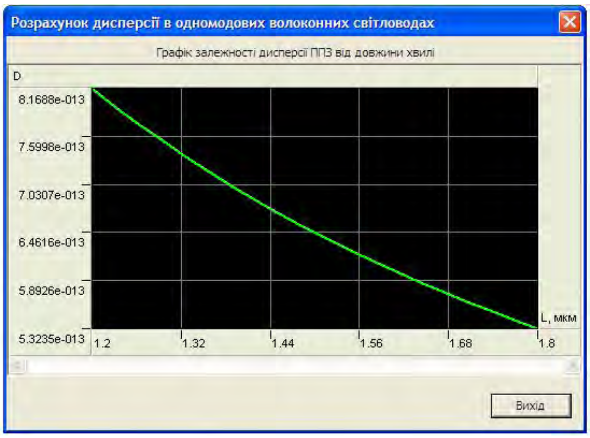


Fig.5. Window appearance Dependence graph of dispersion of the refractive index profile on the wavelength

IV. CONCLUSIONS

Thus proposed software allows modelling the material, waveguide and dispersion of the refractive index profile quantitatively. Also to identify the conditions under which optical fibre with zero dispersion can be manufactured.

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