DESIGN AND SIMULATION OF 1x32 Y-BRANCH SPLITTER APPLYING DIFFERENT PHOTONICS TOOLS

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1. Abstract

This paper aims to investigate design, simulation and optimization of the low loss 1x32 Y-branch splitter applying two different photonics tools based on the Beam Propagation Method. Initially, a standard 1x32 Y-branch splitter is designed and simulated in 2D with OptiBPM photonics tool from Optiwave System Inc. We will show that optimizing this standard structure the asymmetric splitting ratio of the optical signal can be suppressed to one third of the original value. This optimized low loss structure was then designed and simulated in 3D with RSoft photonics tool from Synopsys Inc.

2. Introduction

Optical Access Networks (OAN) mostly use the tree topology to distribute the services from Optical Line Terminal (OLT) on the provider's side to the subscribers in an Optical Network Unit (ONU). The signal distribution from OLT to ONUs can be handled by optical splitters [1]. Splitters are the key components in Passive Optical Networks (PON), as they are beneficial to reduce the overall network cost implementation. Y-branch splitters are important passive optical devices in optical integrated circuits and widely used in Fiber-To-The-x (FTTx) networks because they are polarisation and wavelength independent, i.e. one device can be used to split optical signals in the whole operating wavelength window [2].

In this paper we focused on the design, simulation and optimization of 1x32 Y-branch splitter using two photonics tools.

3. Design and simulation of 1x32 Y-branch splitter with Optiwave photonics tool

The design of 1x32 Y-branch splitter concentrates on weakly guiding glass waveguides with a refractive index of the cladding n_{cl} = 1.445 and of the core n_c = 1.456 with a typical refractive index contrast Δn = 0.75% corresponding to the index contrast of the fibers. For a core size of the waveguides we chose standard (6x6) μm^2 dimension. The designed 1x32 Y-branch splitter was simulated at operating wavelength λ = 1550 nm using OptiBPM tool from Optiwave Systems Inc [3].

As presented in Fig. 1a) the length of linear input ports was set to 1000 μm. A 127 μm standard pitch, required for the connection with the fibers, was chosen for the port pitch of the output waveguides. Additionally, the length of output ports was set to 2000 μm. The length of the 1st branch layer was set $L(1^{st})$ = 5000 μm optimum length and the length of the 2nd branch layer was also doubled $L(2^{nd})$ = 10000 μm. To keep further the constant bending shape each next branch layer was also accordingly doubled, $L(3^{rd})$ = 20000 μm, $L(4^{th})$ = 40000 μm and $L(5^{th})$ = 80000 μm [4]. With decreasing number of Y-branches in each layer, also the pitch between the waveguides in each branch layer was accordingly doubled, i.e. in the 1^{th} branch layer $W(1^{st})$ = 127 µm, in the 2^{nd} branch layer $W(2^{nd})$ = 254 µm … , in the 5th branch layer $W(5^{th})$ = 2032 µm. After, the whole 1x32 Y-branch structure reached a length of 158000 µm and the width of the splitter was 3937 µm (= 31x127 µm).

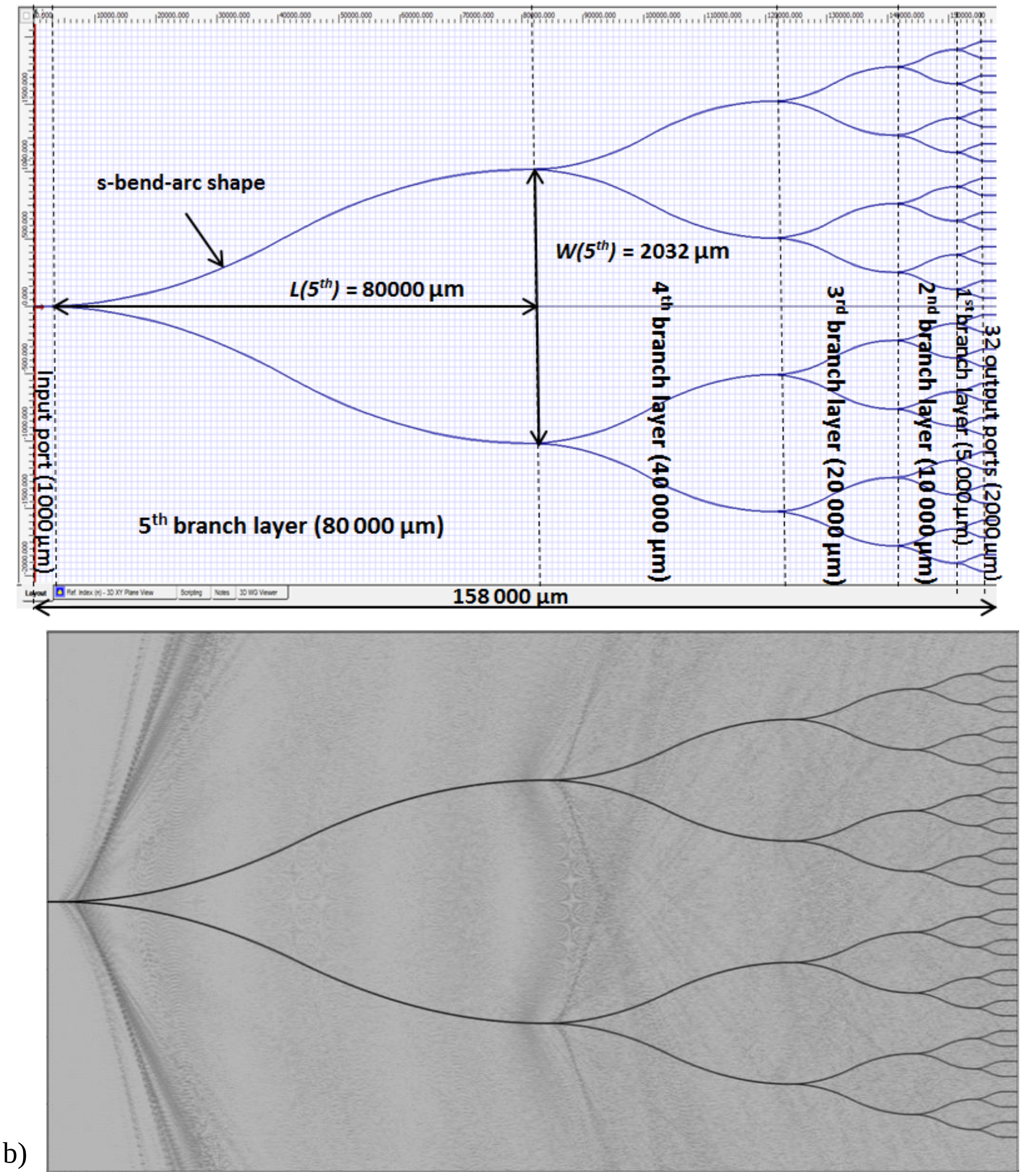
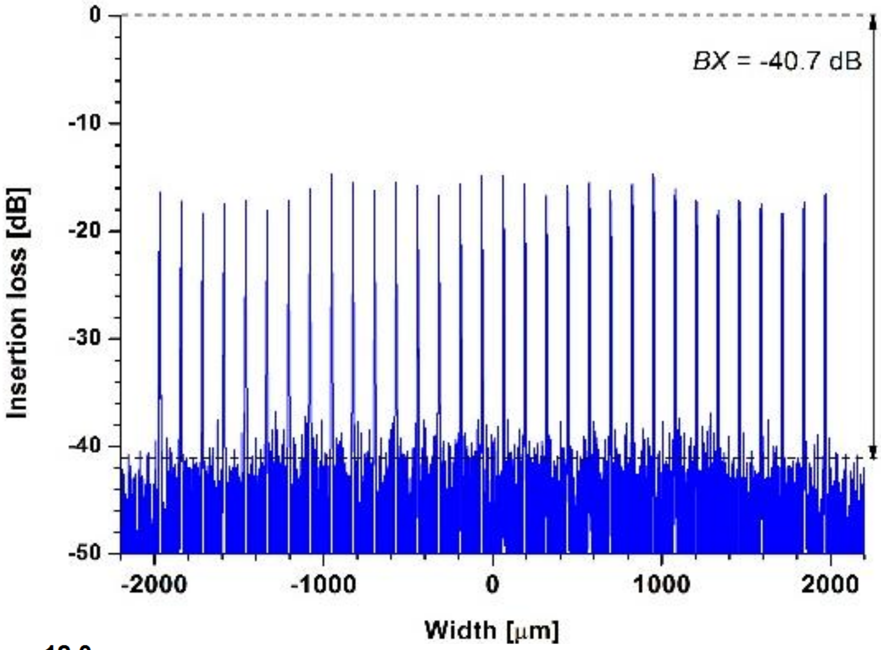
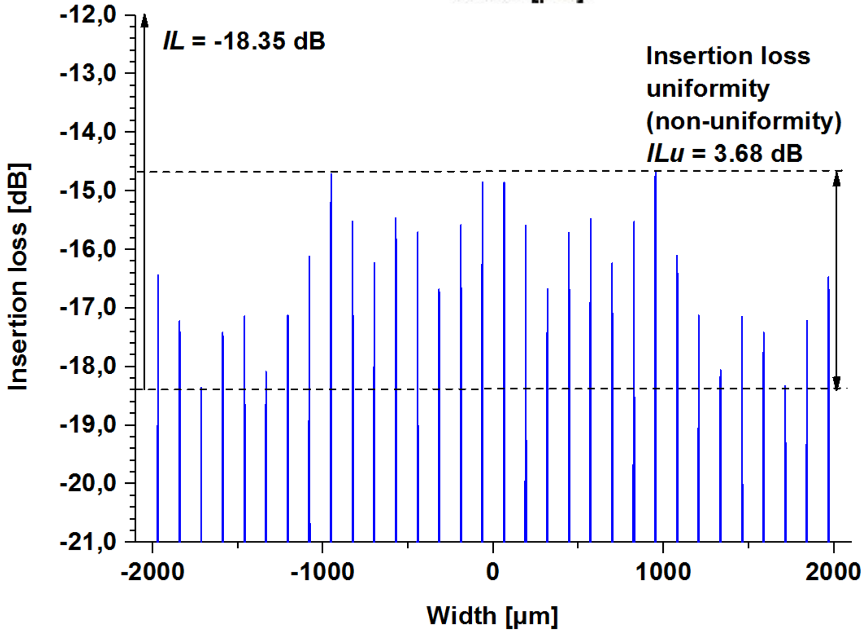
a)
b)


Fig.1: *a) Standard 1x32 Y-branch splitter structure designed using OptiBPM tool; b) Top view of the simulated standard 1x32 Y-branch splitter.*

The design of standard 1x32 Y-branch splitter was simulated in OptiBPM tool. Figure 1b) shows the top view of the simulated structure. The scattered light at the branching points causes losses in the Y-branch splitter. Figure 2 shows the simulation results of the simulated standard Y-branch structure, namely Fig. 2a) presents the corresponding field distribution at the end of the splitter structure. As can be seen, the maximum background noise of standard 1x32 Y-branch splitter, *BX* is better than -40.0 dB. The uniformity of the split power over all the output waveguides (also called insertion loss non-uniformity), *ILu* = 3.68 dB and the insertion loss (worst peak) *IL* = -18.35 dB as illustrated in Fig. 2b).



a)

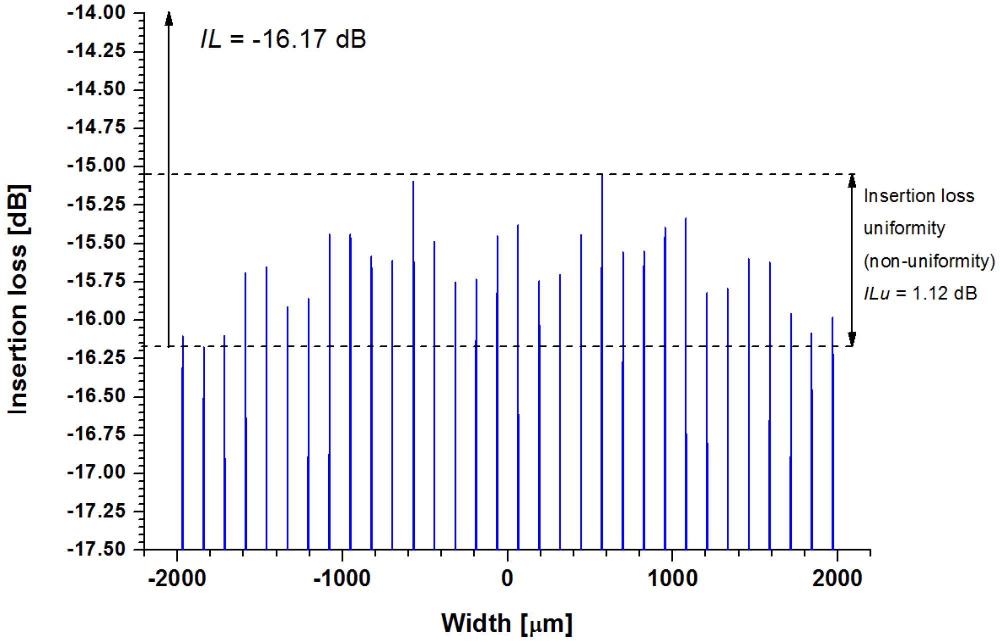


b)

Fig. 2: *Simulation results of the standard 1x32 Y-branch splitter structure: a) Field distribution at the end of simulated structure together with background noise, BX; b) Detailed view of the field distribution showing the non-uniformity, ILu and the insertion loss, IL with OptiBPM tool.*

3.1 Y-branch splitter optimization

From the simulation results it is evident that the designed standard 1x32 Y-branch splitter structure is not only too long but it also features high non-uniformity and insertion loss. Particularly the non-uniformity parameter *ILu* with over 3 dB is too high. Deep analysis of the achieved simulated results showed that the main reason for such a high non-uniformity is the presence of the first mode (besides the zero mode) propagating in the (6x6) μm^2 waveguide. To solve this problem, we reduced the waveguide core size from (6x6) μm^2 to (5.5x5.5) μm^2 [4]. Based on this waveguide core size optimization we were able to reduce the length of the designed standard structure from 158000 µm to 86000 µm without destroying its splitting properties [4]. For the convenience we will call this design "length optimized design". The "length optimized design" structure with waveguide core of (5.5x5.5) μm^2 was simulated and the results are shown in Fig. 3. As can be seen the non-uniformity, *ILu* is reduced to less than one third of the non-uniformity of the standard Y-branch splitter (*ILu* = 3.68 dB), namely *ILu* = 1.12 dB. The insertion loss was reduced from *IL* = -18.35 dB to *IL* = -16.17 dB and the length of the splitter was reduced nearly to the half of its original value.



b)

Fig. 3: *Detailed view of the field distribution at the end of simulated structure of the length optimized 1x32 Y-branch splitter structure with the waveguide core size of (5.5x5.5) μm^2 with OptiBPM tool.*

4. Design, simulation and optimization of 1x32 Y-branch splitter with RSoft tool

The standard 1x32 Y-branch splitter with the waveguide structure (6x6) μm^2 was additionally designed and 3D simulated in RSoft tool. The designed structure is shown in Fig. 4 and the simulation results are presented in Fig. 5a). The non-uniformity, *ILu* = 2.15 dB and the insertion loss, *IL* = -16.44 dB.

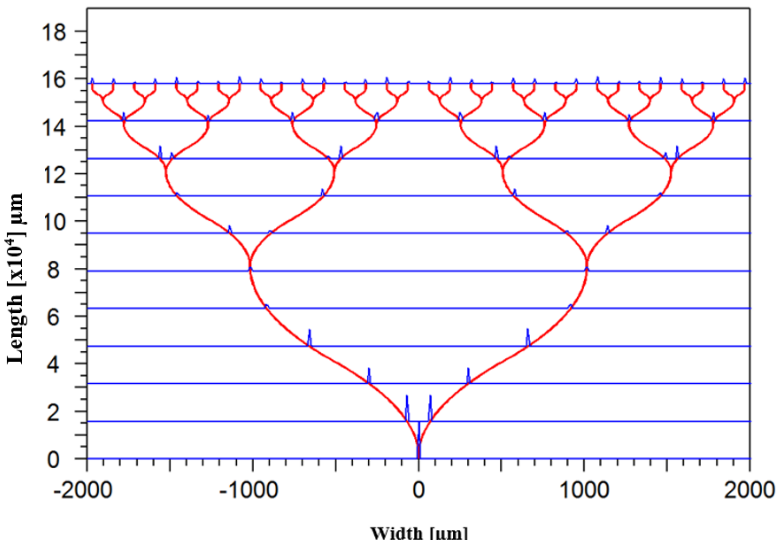
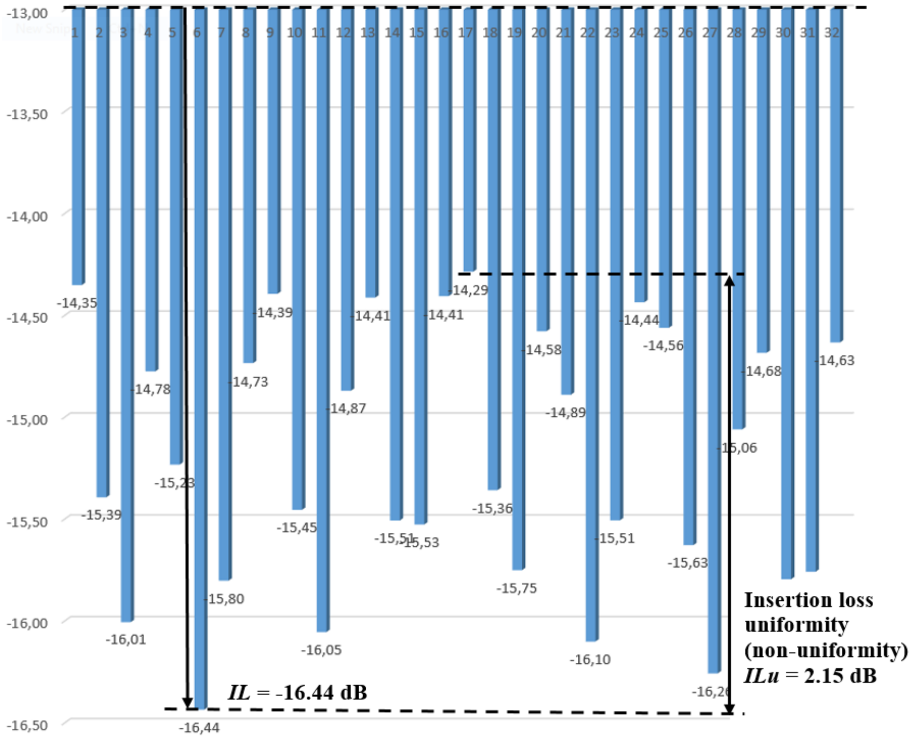
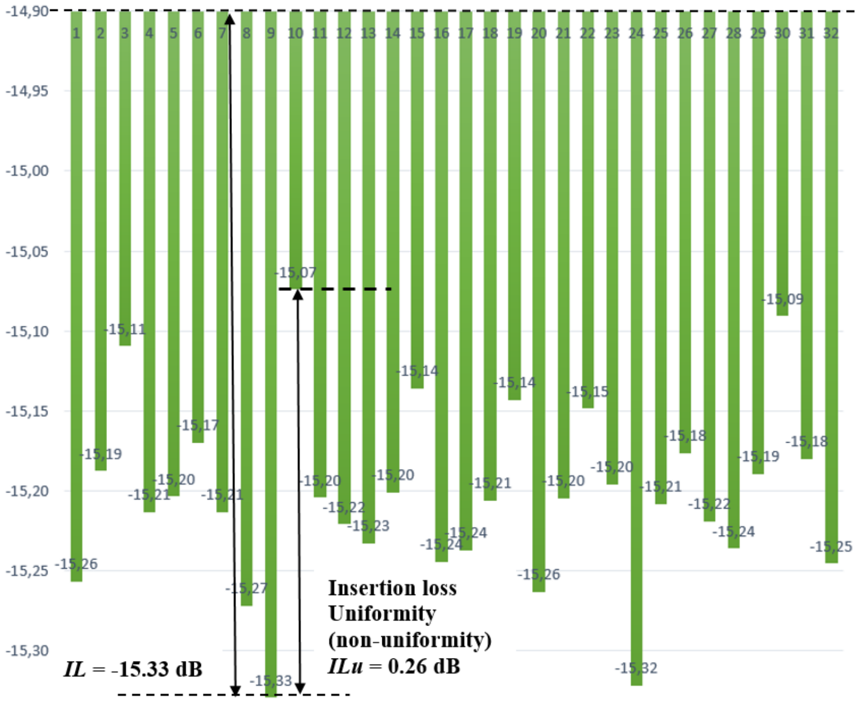


Fig. 4: *Standard 1x32 Y-branch splitter structure designed using RSoft tool.*

Consequently, the length optimized structure with the core size (5.5x5.5) μm^2 was simulated and the results are shown in Fig. 5b). As can be seen, the non-uniformity, *ILu* = 0.26 dB and the insertion loss was *IL* = -15.33 dB. From this follows that optimizing the waveguide core size led again to strong improvement of the splitting parameters of the Y-branch structure, namely the insertion loss, *IL* from -16.44 dB (standard structure) to -15.33 dB (optimized structure) and the non-uniformity, *ILu* from 2.15 dB (standard structure) to 0.26 dB (optimized structure).



a)



b)

Fig. 5: *Simulation results of: a) the standard 1x32 Y-branch splitter structure (6x6) μm^2; b) length optimized 1x32 Y-branch splitter structure with the waveguide core size of (5.5x5.5) μm^2 with RSoft tool.*

5. Discussions and conclusion

Table 1 summarizes all simulation results obtained with both software tools. From the results it is evident that reducing the waveguide core size of the optical Y-branch splitter from (6x6) μm^2 to (5.5x5.5) μm^2 led to the strong improvement of its splitting properties applying booth photonics tools. In this way we were able to reduce the length of the designed standard structure nearly to the half of its original value. From the results can also be concluded that better simulation results were obtained in 3D with RSoft software tool.

Tab. 1. *Summary of the simulation results obtained with the booth photonics tools.*

1x32 Y-BRANCH SPLITTER				
	OptiBPM		RSoft	
Waveguide core size	**Standard (6x6 μm^2)**	**Length optimized (5.5x5.5 μm^2)**	**Standard (6x6 μm^2)**	**Length optimized (5.5x5.5 μm^2)**
Non-uniformity, *ILu* Insertion loss, *IL*	**3.68 dB -18.35 dB**	**1.12 dB -16.7 dB**	**2.15 dB -16.44 dB**	**0.26 dB -15.33 dB**
Chip size	**158000 µm**	**86000 µm**	**158000 µm**	**86000 µm**

Acknowledgement

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