A Comparative Study of Litao$_3$ Y-Branch Symmetric and Asymmetric Optical Power Splitter with S-Bend Waveguides with Various Parameters

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***Abstract:** A novel low-angle power splitters in a Z-cut Lithium Tantalate (LiTaO3) are presented in this paper with a comparison of symmetric and asymmetric power splitting ratios with the S-bend waveguide structures. Power splitters are the most important components in any integrated optical circuits. This study gives a comparison between different splitting ratios of transmitted powers with effect of different parametric changes and to obtain the preferred power splitting ratios in the asymmetric Y-branch splitters.*

***Index Terms:** Symmetric power splitters (SOYS), Asymmetric power splitters (AsOYS), R-Soft CAD Tool, Beam propagation method, power splitting ratios.*

I. INTRODUCTION

An optical waveguides are the physical structures that guide EM waves in the optical spectrum. They are the key elements in an integrated photonic circuits and transmission medium for long haul in a light wave communications. The applications for integrated optics are pervasive. The significance in integrated optics is owing to its various advantages over other optical technologies. These include large bandwidth, low power consumption, compactness, compatibility and reliability. Power splitters are the passive optical devices that can split, or separate, an incident light beam into several light beams at a certain desired ratio. Figure 2 and 4 shows how optical splitter with 1×2 split configurations can separate an incident light beam from a single input two light- beams and transmit them through two individual output waveguides[1][2]. These devices are designed on Lithium Tantalate due to its nonlinear integrated property with high optical threshold. Lithium Tantalate ($LiTaO_3$) is also called as LT is yet interesting crystal in the fabrication of integrated optical devices due of their exceptional properties.It is well known from the previous studies that the loss due to radiation tends to increase with structural design along with many other parameters like branching angle, width of the device, length of the device etc. And this is considerable for large angles exceeding specified value. Thus, to keep the losses low branching angles of the device should be small has to be designed with a consideration of the influence of waveguide. It is also found that they undergo high coupling losses.

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Attenuation losses [3] also occur along with the above said parameters. Although, these are uninvited they exists due to the structure size, consequently, optimum design geometry in dimensions is needed to improve the whole performance, like optical losses and power division ratios. The change in width of waveguide and the angle between the two output arms are discussed in this paper in order to study its impact on the output power assuming single mode operation.

II. THE STRUCTURAL DESIGN POWER SPLITTER

The Y-branch SOYS is shown in Fig.1. This structure is basically a low loss single mode 1x2 Y- branch optical splitter (Fig.1) comprising of a straight waveguide (for input signal) (designated as 1 in the Fig.1), two S- bend waveguides which meet at the linearly tapered waveguide and two straight output waveguides that are attached to the two S-bend waveguides which are the for the output signal. When the two waveguide meet a sharp inner edge is formed with equal branching angle for the two S-bend waveguides, which facilitates equal splitting of 50% to 50% by the Y-branch. Narrow gap between the two output waveguides is maintained. The distance between the two output waveguides is 125μm from centre-to-centre and the total length of the device is 27000μm [5] [6]. The most agreed wavelength for optical communications is 1.55 μm wavelength due of the minimal attenuation.

The compared structures are designed to be the channel waveguides. This paper is structured as follows.

1. The design of 1×2 symmetrical and asymmetrical optical splitters are presented. 2. Simulation results are performed by Beam propagation Method(BPM) software with R-Soft CAD software designed modules.

The influence of affected parameters on transmitted power is discussed graphically.

2. The control of the width (w) of optical channel waveguide on the output power dividing ratio at specified values and branching angle for power division is investigated in detail. The performance of the device may be improved by introduction of these optical waveguide by appropriate choice of width and branching angles and may not require any more added process during the fabrication.

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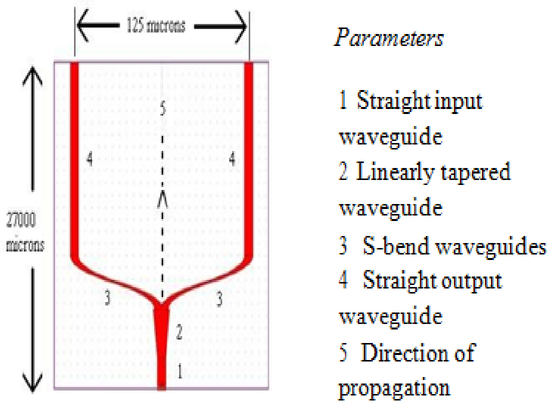


Fig1: Symmetrical Y-branch power splitter

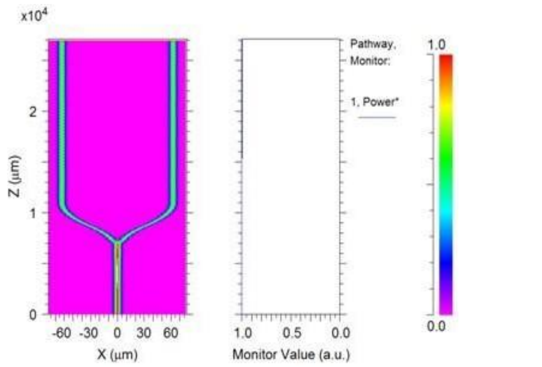


Fig. 2: Simulation of optical signal in Symmetric power splitter

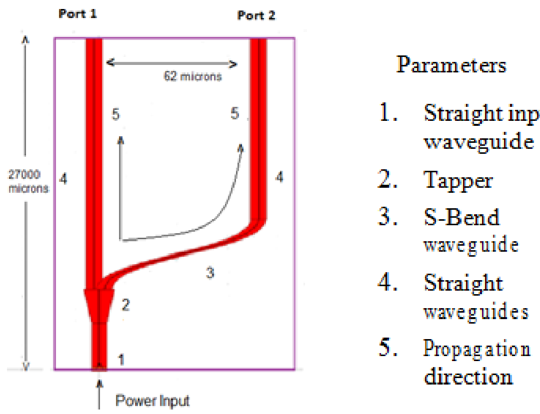


Fig.3 Asymmetric Y-Branch Splitter

III SPLITTING RATIO

The power splitting ratio is the redistribution of power among the two output waveguides at the junction, which is also referred to as the splitting ratio. A splitting ratio of 50/50 means that there is an equal distribution of optical power which is the case of symmetric power splitters as shown in Fig. 1. The output power can also be spitted as per desired ratios as 60/40 ratio means 60% of the power is transmitted to a primary output and 40% to the secondary output, 70/30 or as 55/45 even.

Fig. 4 Simulation of optical signal in Asymmetric power splitter.

This asymmetric power splitting ratios of transmitted power can be achieved by changing the design of the structure of waveguide and also by changing different parameters[3].

IV EFFECT OF BRANCHING ANGLE

A branching angle is a key factor to reduce the scattering losses which arises from optical branching. A variation of the transmitted power with the branching angle 2θ is shown in Fig. 5. Branching angle is varied from 0.6^{o} to 0.7^{o} for 6μm wide both symmetrical and asymmetric single-mode branching optical power splitter. The transmitted power increased with increase in branching angle and reached a maximum value at 0.62º in case of SOYS and 0.60º for AsOYS, which are greater values of the minimum branching angle for splitting the modes compared with fundamental 1x2 optical splitter.

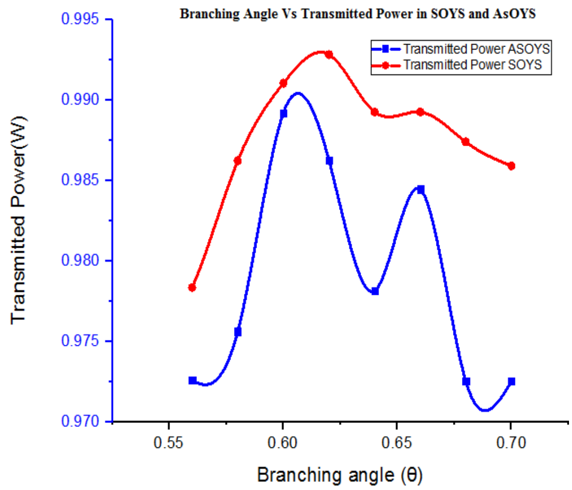
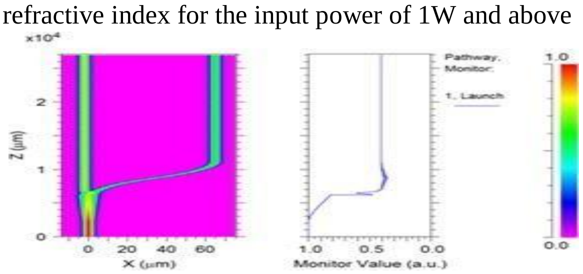


Fig.5 Comparison Graphs between Symmetric and Asymmetric power splitter Branching Angle Vs Transmitted Power

V EFFECT OF WIDTH (W)

The optical power splitter transmitted power depends on the width (core) of the waveguide. The width is varied from 3 to 6µm then the transmitted power is observed for both symmetric and asymmetric power splitters. The transmitted O/P power is gradually increased with width, then it becomes upper limit at 6µm. It is observed that at 6µm a maximum power transmission of 0.9991W for SOYS and till 6.5 µm in case of asymmetric splitter and desired effective refractive index for the input power of 1W and above



this width the power started decreasing.

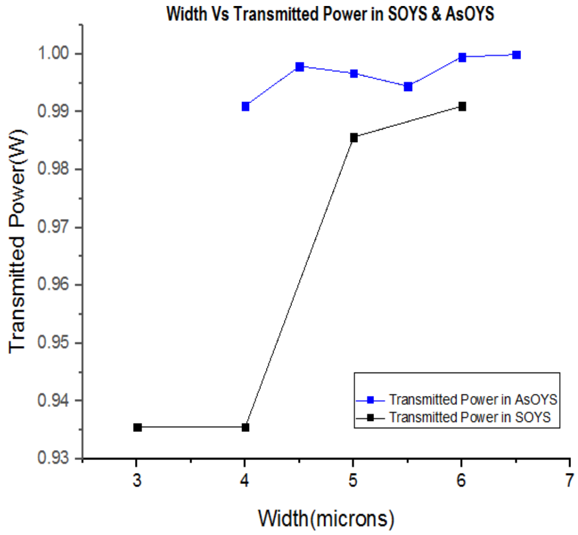


Fig. 6 Comparison Graphs between Symmetric and Asymmetric power splitter Width of the Device Vs Transmitted Power

CONCLUSION

A Y-branch with a single mode optical power splitters with both symmetric and asymmetric power splitting ratios have been designed and simulated. The comparative studies are discussed between SOYS and AsYOS. These are designed by R-Soft CAD waveguide optics modeling software system and simulation was performed by Beam Propagation Method. The influence of waveguide width and branching angle on the output power of optical splitter has been investigated for both SOYS and AsOYS. The Y-branch designed gives a low loss for the symmetric power splitter case and this has been verified by the simulation results. A wide range of branch desired splitting ratios for the asymmetric case has been achieved as shown in the above while keeping low loss. The overall results show much less losses in case of symmetric splitters while Asymmetric splitters have their own advantages. The study is done by varying different parameters like width and branching angle.

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