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Z Shaped like resonator with crystal in the presence of flat mirror based standing wave ratio for optical antenna systems

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ABSTRACT

This study has outlined the Z resonator shaped with Brewster crystal in the presence of flat mirror for measuring the standing wave ratio. Stability parameter and beam radius are simulated versus thickness, refractive index of the crystal and first and second folding ranges. Beam radius variations are studied against phase angle and curvature radius of spherical mirror in T and S planes. Intermode beat frequency of the system is 216.276 MHz and total cavity length is 693.078 mm. It is important the standing wave ratio is dependent on stability parameter and beam radius variations.

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1. INTRODUCTION

The basic type of resonators are classified to V like three element resonator, Z like resonator, simple ring resonator, spherical resonator, singlet, telescope and z crystal resonator. In all types of these resonator are focusing in to the crystal Brewster plate in air medium [1-4]. They have outlined effective optical axis at elements of the basic crystal. Pump focusing lens and active crystal medium are taken into account. Effective misalignment, beam parameters at crystal elements are studied [5-8].

They have shown round trip matrix, multiply selected forward elements and selected backward elements. Plot caustic against different element in the crystal resonator is simulated in their works. They have also measured the intermode beat frequency of the system is and total cavity length for the crystal resonator system at each element [9-12].

In other research the resonators used as circuit which it is called resonance circuit. The essential elements for this circuit are the inductors and capacitors and the assistant element is the resistor [13, 14]. When the balance between capacitive part and inductive part is happened and the gain is optimized in this case [15-17]. In resonance case the gain is maximum and the impedance of the resonator circuit is equal to the resistance value. Noise figure of resonator circuit in this case is reduced and the gain become larger suitable for optical communication applications [18-20].

2. MODEL DESCRIPTION AND RESEARCH METHOD

Figure 1 presents the basic schematic view of z like resonator with a crystal and flat mirror. M4 is the first element in the resonator system which is the flat mirror. L2 is the second folding range or represents the space length between the flat mirror and spherical mirror. M2 is the third element in the resonator system which is the spherical mirror with curvature radius of R and phase angle of alpha. Curvature radius is measured in mm units while the alpha phase angle is measured in degree. d2 is the fourth element in the resonator system which represents the space length between the spherical mirror and crystal. Cr is the five element in the resonator system which is represented by the crystal whose it thickness of t and refractive index of n. the thickness of the crystal is measured in mm units while the refractive index of a crystal is dimensionless.

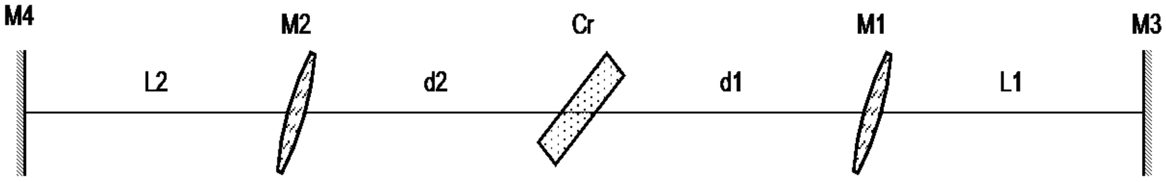

Figure 1. Schematic view of Z like resonator with crystal and flat mirror

d1 is the six element in the resonator system which represents the space length between the crystal and spherical mirror. The space length is measured in mm units. M1 is the seven element which is represented by the spherical mirror radius of R and phase angle of alpha. L1 is the eight element in the resonator system which is represented by the space length or the second folding range between the spherical mirror and flat mirror. M3 is the nine element in the resonator system which represents the flat mirror.

3. PERFORMANCE ANALYSIS WITH DISCUSSIONS

This study has presented the z shaped like resonator with crystal in the presence of flat mirror for standing wave ratio based on the resonator simulation. Variations of refractive index and thickness of Brewster plate in air are deeply studied against variations of both first and second folding ranges. Stability parameter is also investigated versus first and second folding range. Thickness and refractive index of the crystal plate are simulated with phase angle and curvature radius of spherical mirror. Beam radius variations through the crystal is also simulated against variations of thickness and refractive index of Brewster plate in air.

As shown in Figure 2, the variations of refractive index of Brewster plate in air against first folding range. Stability parameter is increased in T plane in compared to S plane. As first folding range increases, this leading to increase in refractive index of Brewster plate in air while the refractive index of Brewster plate in air decreases in S plane. Thickness of Brewster plate in air in relation to second folding range is shown in Figure 3. As second folding range increases, the thickness of Brewster plate in air decreases in both S plane and T plane. T plane has presented high stability parameter than S plane.

Variations of thickness for Brewster plate in air in relation to phase angle of spherical mirror is shown in Figure 4. As phase angle of spherical mirror increases, stability parameter of thickness for Brewster plate in air decreases in T plane but it is increases in S plane. The thickness of Brewster plate is more stable in S plane than T plane.

Variations of refractive index for Brewster plate in air in relation to phase angle of spherical mirror is shown in Figure 5. As phase angle of spherical mirror increases, stability parameter of refractive index for Brewster plate in air decreases in S plane but it is increases in T plane. The refractive index of Brewster plate is more stable in T plane than S plane. Beam radius at crystal in relation to refractive index of Brewster plate in air is shown in Figure 6. Beam radius increases with increasing refractive index of Brewster crystal plate in T plane only. There is no variations for beam radius in S plane.

Figure 7 clarifies the relation between beam radius at crystal and thickness of Brewster plate in air. Beam radius increases with increasing the thickness of Brewster crystal plate in air in both T and S planes. T plane gas presented higher performance in beam radius stability up to 2.3 mm thickness. But after the thickness of Brewster crystal plate with a value of 2.4 mm the S plane has presented higher stability in beam radius than T plane. By choosing the optimum values of the operating simulation parameters. Therefore the total cavity length is estimated as 250(L2) + 14.7(d2) + 1.79·2(Cr) + 24.8(d1) + 400(L1) =693.078 mm.

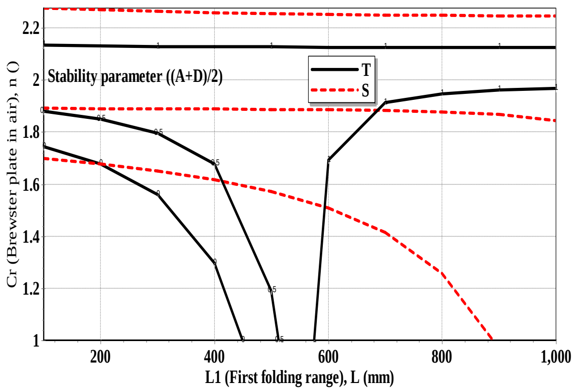

Figure 2. Variations of refractive index of Brewster plate in air against first folding range

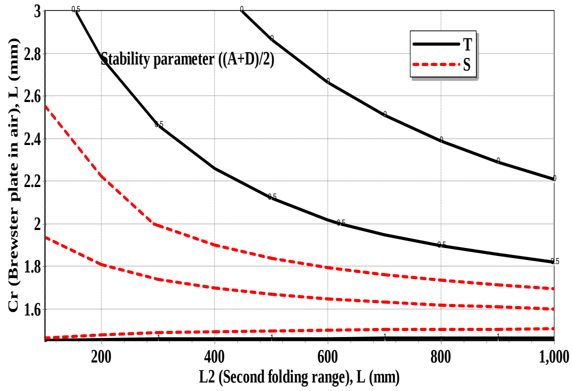

Figure 3. Thickness of Brewster plate in air in relation to second folding range

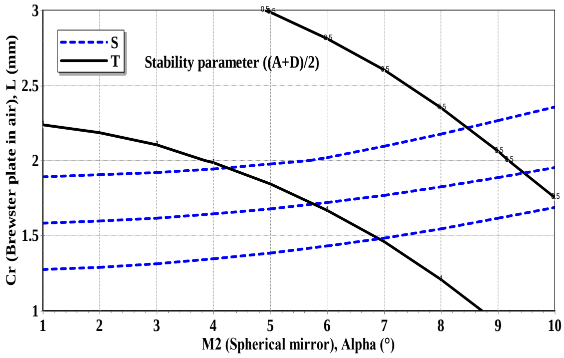

Figure 4. Thickness of Brewster plate in air in relation to phase angle of spherical mirror

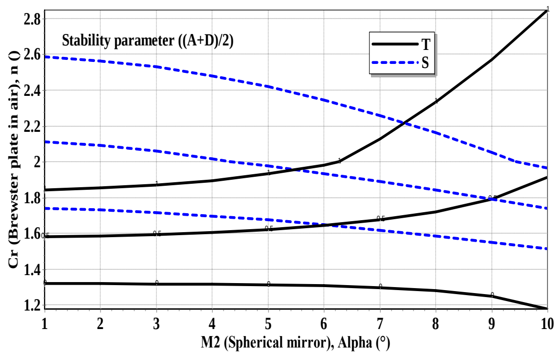

Figure 5. Refractive index of Brewster plate in air variations versus phase angle of spherical mirror

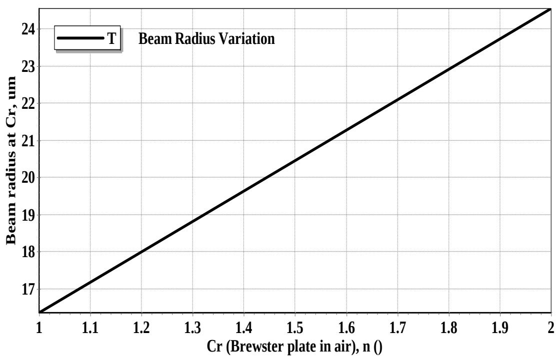

Figure 6. Beam radius at crystal in variations to refractive index of Brewster plate in air

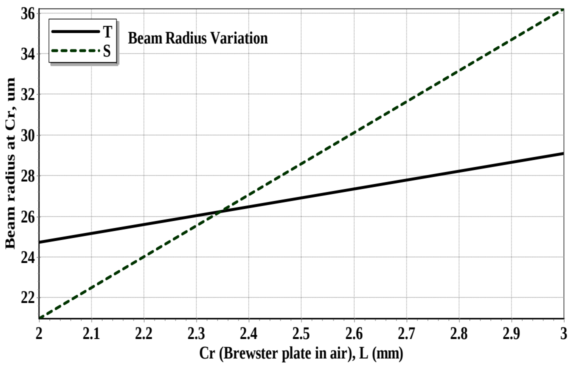

Figure 7. Beam radius at crystal in variations to thickness of Brewster plate in air

4. CONCLUSION

In a summary, it is concluded that intermode beat frequency of the system is 216.276 MHz. Total cavity length is estimated by 693.078 mm. The optimized values for beam radius and stability parameter are calculated. The study has presented the negative effects of increasing thickness and refractive index of Brewster crystal on the beam radius stability and consequently the system stability and accuracy. In addition to the negative effects of phase angle and curvature radius of spherical mirror on the system resonator operation performance efficiency.

REFERENCES

[1] S. M. J. Alam, *et al.*, "Improvement of Bit Error Rate in Fiber Optic Communications," *International Journal of Future Computer and Communication*, vol. 3, no. 4, pp. 281–286, Aug 2014.

[2] Ahmed Nabih Zaki Rashed, and Mohamed A. Metwae'e, "Optical Filters Dimensions and Thermal Operation Conditions Impact on Its Transmission Considerations in Near Infrared (NIR) Optical Spectrum Transmission Region," *Optoelectronics and Advanced Materials Journal– Rapid Communications*, vol. 8, no. 3-4, p. 175 – 184, March-April 2014.

[3] A. Taya, *et al.*, "Design and Analysis of Low Power Universal Line Encoder & Decoder," *Microelectronics and Solid State Electronics Journal*, vol. 5, no. 1, pp. 7–13, 2016.

[4] C.T. Manimegalai and S. G. Kalimuthu, "Underwater Optical Channel Analysis Using DPIM & PPM," *European Journal of Applied Sciences*, vol. 9, no. 3 pp.154–162, 2017.

[5] M. V. Raghavendra, *et al.*, "Estimation of Optical Link Length for Multi Haul Applications," *International Journal of Engineering Science and Technology*, vol. 2, no. 6, pp. 1485-1491, 2010.

[6] S.-C. Wang, *et al.*, "Optically Pumped GaN Based Vertical Cavity Surface Emitting Lasers: Technology and Characteristics," *Jpn. J. Appl. Phys.*, vol. 46, pp. 5397–5407, 2007.

[7] T.-C. Lu, *et al.*, "CW Lasing of Current Injection Blue GaN Based Vertical Cavity Surface Emitting Laser," *Appl. Phys. Lett.*, vol. 92, pp. 1–3, 2008.

[8] Christopher J. Stapels, *et al.*, "CMOS Based Avalanche Photodiodes for Direct Particle Detection," *Nuclear Instruments and Methods in Physics Research A,* vol. 579, no. 1, pp. 94–98, Aug. 2007.

[9] A. Pulvirenti, *et al.*, "Characterization of Avalanche Photodiodes (APDs) for the Electromagnetic Calorimeter in the ALICE Experiment," *Nuclear Instruments and Methods in Physics Research A*, vol. 596, no. 1, pp. 122-125, Oct. 2008.

[10] Abd El-Naser A. Mohammed, *et al.*, "Transient behavior and transmission bit rates analysis of optoelectronic integrated devices laser diode (LD) and light emitting diode (LED) under amplification and ionizing irradiation environments," *Journal of Electrical and Electronics Engineering Research,* vol. 3, no. 7, pp. 121-133, 2011.

[11] I. T. Lima, *et al.*, "A Receiver Model for Optical Fiber Communication Systems With Arbitrarily Polarized Noise," *Journal of Lightwave Technology*, vol. 23, no. 3, pp. 1478–1490, Mar 2005.

[12] S. Norimatsu and M. Maruoka, "Accurate Q-factor Estimation of Optically Amplified Systems in the Presence of Waveform Distortions," *Journal of Lightwave Technology*, vol. 20, no. 1, pp. 19–27, Jan 2002.

[13] S. M. Jahangir Alam, *et al.*, "Bit Error Rate Optimization in Fiber Optic Communications," *International Journal of Machine Learning and Computing*, vol. 1, no. 5, pp. 435–440, Dec 2011.

[14] Z. Kornain, *et al.*, "The Simulation of Indoor Service Range Prediction of Wireless Radio Access Point for Radio over Fiber System," *IACSIT International Journal of Engineering and Technology*, vol. 5, no. 1, pp. 136–140, Feb 2013.

[15] Ahmed Nabih Zaki Rashed, "High Performance Photonic Devices For Multiplexing/Demultiplexing applications in Multi Band Operating Regions," *Journal of Computational and Theoretical Nanoscience*, vol. 9, no. 4, pp. 522-531, April 2012.

[16] E. Feltin, *et al.*, "Blue Lasing at Room Temperature in an Optically Pumped Lattice Matched AlInN/GaN VCSEL Structure," *Electron. Lett.*, vol. 43, pp. 924–926, 2007.

[17] M. C. Shih and C. S. Chen, "A Semiconductor Soliton Cavity Laser Diode and its Output Characteristics," *Japanese Journal of Applied Physics,* vol. 50, no. 4, pp. 17-22, 2011.

[18] C.-C. Kao, *et al.*, "The Lasing Characteristics of GaN Based Vertical Cavity Surface Emitting Laser With AlN–GaN and Ta_2O_5 –SiO_2 Distributed Bragg Reflectors," *IEEE Photon. Technol. Lett.*, vol. 18, no. 7, pp. 877–879, 2006.

[19] J.-T. Chu, *et al.*, "Room-Temperature Operation of Optically Pumped Blue Violet GaN Based Vertical Cavity Surface Emitting Lasers Fabricated by Laser Lift Off," *Jpn. J. Appl. Phys*, vol. 45, pp. 2556–2560, 2006.

[20] J.-T. Chu, *et al.*, "Emission Characteristics of Optically Pumped GaN Based Vertical Cavity Surface- Emitting Lasers," *Appl. Phys. Lett.*, vol. 89, pp. 1–3, 2006.

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