ISSN 0735-2727, Radioelectronics and Communications Systems, 2020, Vol. 63, No. 1, pp. 15–23. © Allerton Press, Inc., 2020.
Russian Text © The Author(s), 2020, published in Izvestiya Vysshikh Uchebnykh Zavedenii, Radioelektronika, 2020, Vol. 63, No. 1, pp. 21–32.

Optimum Septum Polarizer Design for Various Fractional Bandwidths

F. F. Dubrovka[1*], S. I. Piltyay[1], R. R. Dubrovka[1***], M. M. Lytvyn[1], and S. M. Lytvyn[1]**

[1]*National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine*
**ORCID: 0000-0002-3485-6822, e-mail: fedor.dubrovka@gmail.com*
***ORCID: 0000-0002-6927-8663*
****ORCID: ???*

Received May 20, 2019
Revised January 22, 2020
Accepted January 22, 2020

Abstract—The numerical optimization results of constant thickness septum polarizer's performances for various operating fractional bandwidths (FBW) are presented in the paper. The polarizer's structure includes a common input square waveguide, a constant thickness septum with several steps, and two output rectangular waveguides. The polarizer design of 2-, 3-, 4-, and 5-step septums is optimized for different narrow and wide operating FBWs to obtain the simultaneously maximum values of cross-polarization discrimination and isolation between rectangular ports and return losses. The optimized dimensions of the septums for FBW = 5, 10, 15, 18, and 20% are presented. Based on the obtained results, Q- and K-band prototypes were manufactured and their performances were measured. The measurements of the prototypes are in good agreement with simulations. These optimization results can be widely used for the development of septum polarizers and prediction of their performances for various FBW in the required frequency range.

DOI: 10.3103/S0735272720010021

INTRODUCTION

Septum polarizers are widely used in modern microwave systems with orthogonal circularly polarized signals. Such polarizer is an effective compact device, which transforms right-hand circularly polarized (RHCP) and left-hand circularly polarized (LHCP) electromagnetic waves into linearly polarized ones and vice versa. Simultaneously it separates RHCP and LHCP waves and directs them to different rectangular waveguides. Therefore, a septum polarizer integrates the performances of a polarizer and of an orthomode transducer.

There are many designs of septum polarizers developed for various applications and frequency bands [1–7]. The septum polarizer in [1] consists of a square waveguide and a septum with 4 steps. Feature of the suggested design is the triangular shape of a septum, which improves the characteristics of the polarizer. In [2] the authors analyze a 4-step septum polarizer for Ka-band (27.5–30 GHz). The improvement of the polarizer's performance is obtained due to the modification of the septum's longitudinal profile using Legendre polynomials. The design of septum polarizer [3] includes compact transition from a square waveguide to a circular one and two bends with integrated transformers. The operating frequency range is 214–236 GHz. A septum polarizer for X-band (8–9 GHz) is demonstrated in [4]. The polarizer is based on a square waveguide and its septum has 4 steps. In [5, 6] the authors present a septum polarizer for communication transceivers. The design is based on a septum with 3 steps. The polarizer operates in Ku-band 12.7–14.8 GHz. A compact septum polarizer with an integrated square to circular waveguide transition is developed in [7]. A 4-step septum is placed in the transition of the polarizer. The operating frequency range of the polarizer is 18.5–21.5 GHz.

Characteristics of the modern septum polarizers for various fractional bandwidths (FBW) in different frequency ranges discussed hereinabove are summarized in Table 1. Axial ratios (AR) of the polarizers are recalculated into cross-polarization discrimination (XPD) and presented in Table 1 as well.

As we can see from Table 1, the characteristics of septum polarizers deteriorate with FBW expansion. Isolation between rectangular waveguides is always worse than the XPD.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ADDITIONAL INFORMATION

The initial version of this paper in Russian is published in the journal "Izvestiya Vysshikh Uchebnykh Zavedenii. Radioelektronika," ISSN 2307-6011 (Online), ISSN 0021-3470 (Print) on the link http://radio.kpi.ua/article/view/S0021347020010021 with DOI: 10.20535/S0021347020010021.

REFERENCES

1. 1. J. Kim, S. Yoon, E. Jung, J. W. Lee, T. K. Lee, and W. K. Lee, "Triangular-shaped stepped septum polarizer for satellite communication," *IEEE Antennas and Propagation Society, AP-S International Symposium (Digest)*, 854 (2011). DOI: 10.1109/APS.2011.5996409.
2. J. C. Angevain and N. J. G. Fonseca, "Waveguide septum polarizer shaped with Legendre polynomials," *Proc. of 2017 11th European Conf. on Antennas and Propagation*, EUCAP 2017 (2017), pp. 2286–2290. DOI: 10.23919/EuCAP.2017.7928324.
3. C. A. Leal-Sevillano, K. B. Cooper, J. A. Ruiz-Cruz, J. R. Montejo-Garai, and J. M. Rebollar, "A 225 GHz circular polarization waveguide duplexer based on a septum orthomode transducer polarizer," *IEEE Trans. Terahertz Sci. Technol.* **3**, No. 5, 574 (2013). DOI: 10.1109/TTHZ.2013.2264317.
4. W. Zhong, B. Li, Q. Fan, and Z. Shen, "X-band compact septum polarizer design," *ICMTCE2011 - Proceedings 2011 IEEE Int. Conf. on Microwave Technology and Computational Electromagnetics* (2011), pp. 167–170. DOI: 10.1109/ICMTCE.2011.5915191.
5. J. A. Ruiz-Cruz, M. M. Fahmi, M. Daneshmand, and R. R. Mansour, "Compact reconfigurable waveguide circular polarizer," *IEEE MTT-S Int. Microwave Symp. Dig.* (2011). DOI: 10.1109/MWSYM.2011.5972872.
6. J. A. Ruiz-Cruz, M. M. Fahmi, S. A. Fouladi, and R. R. Mansour, "Waveguide antenna feeders with integrated reconfigurable dual circular polarization," *IEEE Trans. Microw. Theory Tech.* **59**, No. 12 PART 2, 3365 (Dec. 2011). DOI: 10.1109/TMTT.2011.2170581.
7. N. Nikolic, A. Weily, I. Kekic, S. L. Smith, and K. W. Smart, "A Septum Polarizer with Integrated Square to Circular Tapered Waveguide Transition," *2018 IEEE Antennas and Propagation Society Int. Symp. and USNC/URSI National Radio Science Meeting, APSURSI 2018 - Proceedings* (2018), pp. 725–726. DOI: 10.1109/APUSNCURSINRSM.2018.8608909.
8. F. F. Dubrovka, S. I. Piltyay, "Eigenmodes of coaxial quad-ridged waveguides. Theory," *Radioelectron. Commun. Syst.* **57**, No. 1, 1 (2014). DOI: 10.3103/S0735272714010014.
9. F. F. Dubrovka, S. I. Piltyay, "Eigenmodes of coaxial quad-ridged waveguides. Numerical results," *Radioelectron. Commun. Syst.* **57**, No. 2, 59 (2014). DOI: 10.3103/S0735272714020010.
10. S. I. Piltyay, "High performance extended C-band 3.4-4.8 GHz dual circular polarization feed system," *Proc. of 2017 11th Int. Conf. on Antenna Theory and Techniques*, ICATT, 24-27 May 2017, Kyiv, Ukraine (IEEE, 2017), pp. 284–287. DOI: 10.1109/ICATT.2017.7972644.
11. F. F. Dubrovka, P. Ya. Stepanenko, "Broadband sections of differential phase shift on a corrugated square waveguide," *Izvestiya Vysshikh Uchebnykh Zavedenij. Radioelektronika* **39**, No. 1, 3 (1996).