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Research paper

Design and Optimization of a Dual Polarized Hat Feed Reflector Antenna

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Abstract

Background and Objectives: Self-supported rear-radiating feeds have been widely used as reflector antenna feeds for mini terrestrial and satellite links. While in most terrestrial and satellite links a dual-polarized antenna for send and receive applications are required, all of the reported works regarding this topic are presenting a single polarized self-supported reflector antenna. In this paper, a dual-polarized hat feed reflector antenna with a low sidelobe and low cross-polarization level is presented.

Methods: The proposed antenna consists of an orthogonal mode transducer (OMT), a 60 cm ring focus reflector, and a rear radiating waveguide feed known as the hat feed. 21 parameters of hat feed structure are selected and optimized with a genetic algorithm (GA). A predefined ring focus curve is used as a reflector in the optimization procedure. Dual polarization for send and receive applications is also obtained by an OMT at the rear side of the reflector antenna.

Results: A prototype of the proposed hat feed reflector antenna is fabricated and the measurement results are compared with simulation ones. The proposed antenna has return loss better than 15 dB at both polarizations in the 17.7~19.7 GHz frequency range. The 60cm reflector antenna has 40dBi gain which means that the proposed antenna has about 70% radiation efficiency. About 20dB sidelobe level and more than 40 dB cross-polarization have also been realized in the measurement patterns of the proposed antenna.

Conclusion: A dual-polarized hat feed reflector antenna with excellent radiation efficiency, high sidelobe, and low cross-polarization level is proposed. The proposed antenna can be a good candidate for high-frequency terrestrial and satellite communications.

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Introduction

Self-supported rear-radiating feeds have been widely used over the past years as reflector antenna feeds for mini terrestrial and satellite links [1]-[3]. In these feeds, mechanical support is provided by the feeding waveguides that extend from the reflector vertex to the feed, and additional struts are omitted from the feed structures.

This geometry makes it possible to simply locate the transmitter and receiver at the rear side of the reflector. Until now Different types of Self-supported feeds such as splash plate feed [4]-[6], cup feed [7]-[9], hat feed [10]-[20], and even some types of microstrip feed [21]-[24], have been designed and used for the reflector antenna.

Hat feeds are one of the compact well-known self-supporting feeds for reflector antennas. The hat feeds usually consist of a waveguide neck, a dielectric head,

and a corrugated hat. Due to the uniform radiation pattern, hat feeds have low cross-polarization levels, low far-out sidelobe, and high efficiency. However, these excellent performances are usually provided in a very narrow bandwidth (less than 10%) which is limited the hat feeds applications. In recent years some approaches, to improve the impedance bandwidth of the hat feed reflector antenna are proposed [15]-[18].

In [16], a hat feed reflector antenna was designed by genetic algorithm (GA) optimization. The designed antenna has 33%, impedance bandwidth, however, the radiation performance of the antenna was not very well in the designed frequency band. Another hat feed reflector antenna without the dielectric head and 26% bandwidth is reported in [17].

However, due to the use of a non-symmetrical structure, the body of revelation (BOR) efficiency of the designed antenna was very low.

A recent development in the hat feed reflector antenna is reported in [18]. In that paper, a single polarized Ku-band hat feed reflector antenna is designed via a comprehensive GA optimization. A ring focus reflector has also been used for obtaining nearly 100% phase efficiency. The final antenna has a low sidelobe level and low cross-polarization in the whole operational impedance bandwidth and fulfills the requirements of the ETSI EN 302 standard for terrestrial fixed radio systems [25].

It should be said that all of the papers mentioned above are presenting a single polarized hat feed reflector antenna. While in most terrestrial and satellite links a dual-polarized high gain antenna for send and receive applications is required 0-[29]. The effects of dual-polarization on the performance of an optimized hat feed reflector antenna are not studied well until now.

In this paper, a novel dual-polarized hat feed reflector antenna for 17.7~19.7 GHz frequency band is presented. The proposed hat feed structure is optimized via GA with a novel strategy that considers reflector efficiency at two different polarization and feeds impedance bandwidths simultaneously. The final antenna has a 60 cm ring focus reflector, a corrugated hat feed, a self-supported transition waveguide, and an orthogonal mode transducer (OMT) at the rear side of the reflector. A prototype of the proposed antenna is fabricated and the measurement results are compared with the simulations.

The effects of dual-polarization on the measured reflection coefficient and the measured radiation pattern are carefully studied. The measurement results show the proposed dual-polarized hat feed reflector antenna is a good candidate for high-frequency point-to-point communication.

This paper is organized as follows. The antenna structure is introduced in the second section. The optimization producer of the proposed antenna is explained in the third section. In the fourth section, results and discussion have been presented. The conclusion is provided in the fifth section.

Antenna Design

The configuration of the proposed dual-polarized hat feed reflector antenna is shown in Fig. 1. As it can be seen in this figure the proposed antenna consists of a compact hat feed structure, a 60 cm ring focus reflector, and an OMT structure at the rear side of the reflector to create the dual-polarization.

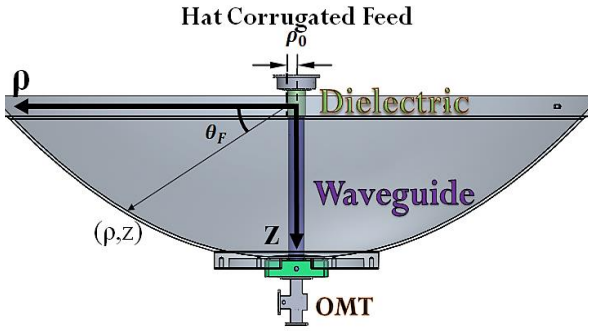


Fig. 1: Configuration of the proposed dual-polarized hat feed reflector antenna which consists of an orthogonal mode transducer (OMT), a 60 cm ring focus reflector, and a rear radiating hat feed.

A cross-section of the hat feed structure is shown in Fig. 2 (a). As it can be seen the hat feed antenna is consisting of a metallic head, a circular waveguide, and a Teflon dielectric which is attached to these parts.

The metallic head of the feed antenna has several symmetrical metallic corrugations in its body. These corrugations are used to improve the reflector illuminations and reduce the sidelobe level of the reflector antenna in the operational bandwidth. The width and the height of these corrugations are determined from GA optimization.

A dielectric head, so-called the antenna neck, is made of a Teflon dielectric with $\varepsilon_r = 2.2$ and $tan\delta = 0.001$. This neck surrounds the circular waveguide to provide a rigid structure.

A cylindrical air transition is also created in this dielectric neck to improve the impedance matching of the hat feed antenna. The parameters of this transition are also determined by GA optimization.

The metallic waveguide in this structure has two main roles. First, it is used as the mechanical supporter of the feed structure, and second, it is used as an electromagnetic transition between the OMT output and the dielectric head. The inner diameter of this cylindrical waveguide at the hat end and OMT output is 14mm and

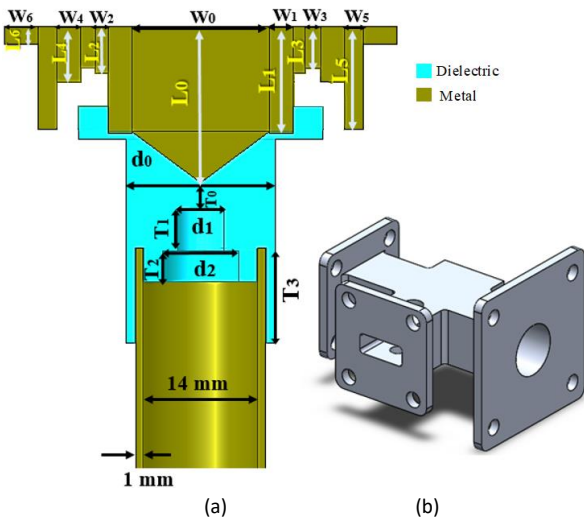
11mm respectively, while the outer diameter is fixed at 15mm.

To improve the radiation efficiency of the proposed antenna, a ring focus parabolic antenna is used as the antenna reflector. The shape of the ring focus reflector antenna is defined as follows:

$$\rho = 2F\tan(\theta_f/2) + \rho_0 \quad (1)$$

$$z = F - F\tan^2(\theta_f/2)$$

In which ϑ_f is the polar angle of the feed as shown in Fig. 1, F is the focal length of the ring focus reflector and is chosen to be 15 cm, and ρ_0 is the radius of the reflectors focus ring and is selected as 14 mm. The diameter of this reflector is about 60cm and the value of the F/D is chosen to be 0.25. This value for F/D is chosen according to [16], and [18] to have optimum radiation efficiency in the designed antenna.



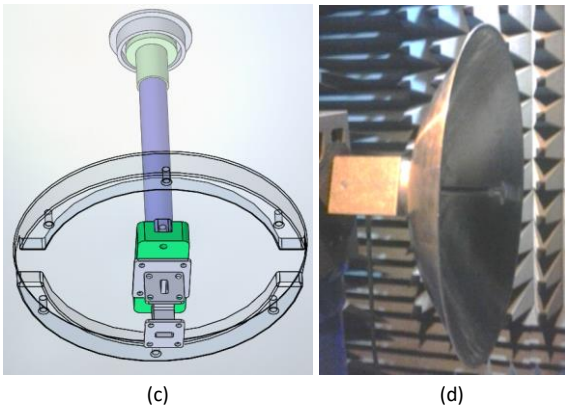


Fig.2: Configuration of the proposed hat feed reflector structure. (a) The cross-section of that feed antenna, (b) the configuration of the OMT for creating dual-polarization, (c) the alignment of the hat feed and OMT, (d) the fabricated prototype of the proposed hat feed reflector antenna.

To create a dual-polarization radiation with the proposed hat feed reflector antenna, an orthogonal mode transducer (OMT) [29] is designed and placed at the rear side of the proposed reflector antenna. As shown in Fig. 2 (b) and (c) this Ku band OMT consists of two WR51 rectangular flanges and an 11mm cylindrical output. About 35 dB isolation between OMT ports is considered and the cylindrical output of the OMT excites the cylindrical waveguide of the hat feed antenna with two different polarizations. To have tuned in the fabrication process of the dual-polarized hat feed some metallic screws are inserted at the cylindrical waveguide of the OMT.

Table 1: The final optimized value of the proposed dual-polarized hat feed reflector antenna. [mm]

Para.	Value	Para.	Value	Para.	Value
L_0	19.7	W_0	16.85	d_0	18.4
L_1	13.1	W_1	2.95	d_1	5.65
L_2	5.72	W_2	1.49	d_2	9.31
L_3	5.13	W_3	1.86	T_0	3.18
L_4	6.85	W_4	2.95	T_1	5.17
L_5	12.7	W_5	2.33	T_2	3.78
L_6	2.26	W_6	4.08	T_3	11.65

Optimization Procedure

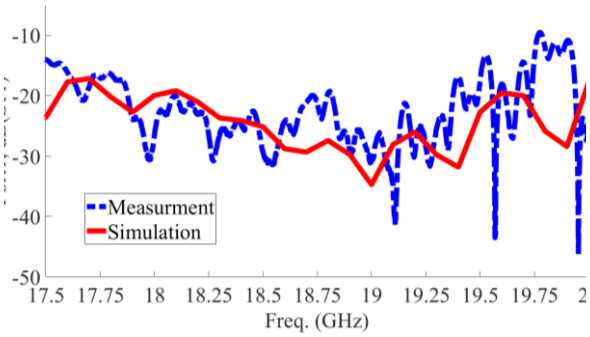
The proposed dual-polarized antenna should cover a 17.7 ~ 19.7 GHz frequency band with a reflection coefficient less than -15dB. The boresight gain of this reflector antenna should be greater than 38.7 dBi at both polarizations of 18.7 GHz frequency. Furthermore, more than 20 dB sidelobe level in the whole frequency band of operation is needed.

To fulfill these requirements, as shown in Fig. 2 (a), 21 parameters of the hat feed reflector antenna are optimized with a genetic algorithm. These parameters change the corrugations and the dielectric transitions of the hat feed antenna.

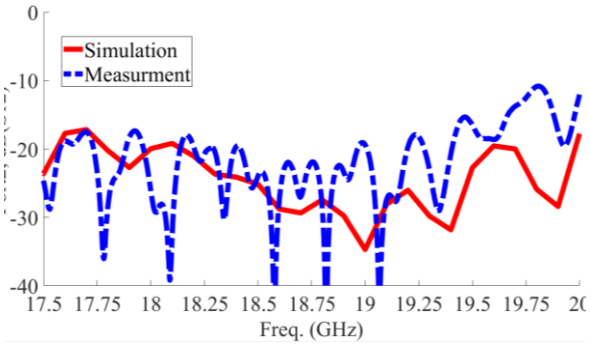
The GA is implemented in MATLAB software. A population of 50 randomly generated chromosomes is created in the GA routine in MATLAB. These chromosomes are interpreted as the value of the 21 parameters of the hat feed antenna. The hat feed antenna and the OMT are simulated with an FEM solver in the well-known HFSS software. The link between HFSS and MATLAB is created by Visual Basic scripting (VB) [30]. The reflection coefficient and the radiation pattern of the hat feed antenna and OMT are extracted from the

HFSS. The phase center of the simulated feed is also calculated in this step.

At the next step, the feed radiation pattern is used to illuminate the predefined 60 cm ring focus reflector antenna in HFSS-IE. The feed phase center is placed at the focal center of the reflector antenna and the radiation pattern of the reflector antenna is calculated with the method of moments in HFSS. The handoff process between FEM and IE solver of HFSS is also done with VB scripting.



(a)



(b)

Fig. 3: The measured and simulated return loss of the proposed dual-polarized hat feed reflector antenna from OMT output ports (a) first OMT output port, (b) second OMT output port.

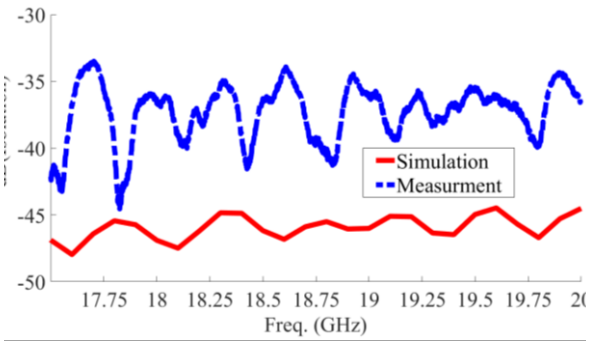


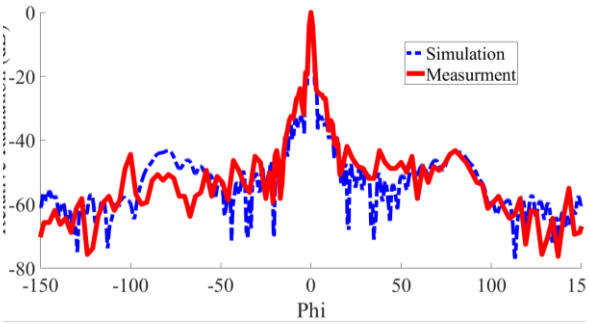
Fig. 4: The measured and simulated isolation of the proposed dual-polarized hat feed reflector antenna.

After obtaining the radiation pattern of the whole reflector antenna, the generated chromosome should be evaluated with a cost function. Therefore, a multi-criteria function is defined as follows:

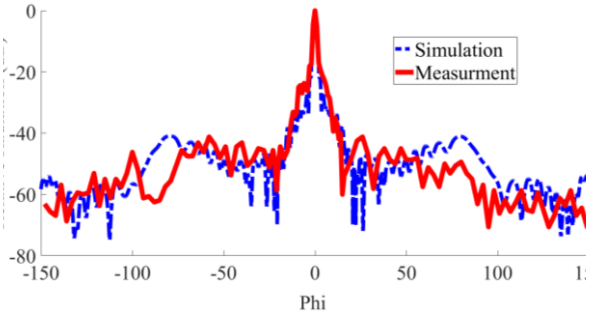
$$F = \sum_{i=1}^{N} \left[w_{1i} \left(E_1(f_i) \right)^2 + w_{2i} \left(E_2(f_i) \right)^2 \right] \quad (2)$$

in which N is the number of the sampling frequency, w_i represents the weighting value at the ith sample and f_i is the ith sampling frequency. E_1 and E_2 are the error functions for the reflection coefficient and peak gain of the evaluated antenna respectively and can be defined as follows:

$$E_1(f_i) = \begin{cases} |S_{11}(f_i)| - 0.09 & |S11| > 0.09 \\ 0 & |S11| \le 0.09 \end{cases} \quad (3)$$



(a)



(b)

Fig. 5: The simulated and measured normalized radiation pattern of the proposed hat feed reflector antenna at each polarization at 18 GHz (a) first OMT output port, (b) second OMT output port.

$$E_2(f_i) = (15 + 20\log(f_i)) - PeakGain(f_i) \quad (4)$$

In (3) the value of 0.09 corresponds to the return loss of -20 dB and the value of 15 corresponds to the peak gain of 60 cm reflector antenna with 80% aperture efficiency. The aperture efficiency of the reflector antenna is related to the antenna peak Gain with the following formula [31]:

$$\eta(\%) = \frac{G\lambda_0^2}{4\pi A_{phy}} \quad (5)$$

in which η is the aperture efficiency of the proposed antenna, G is the value of antenna peak gain at the corresponding wavelength λ_0, and A_{phy} is the physical aperture area of the reflector antenna.

To accelerate the GA optimization, the cost function (2) is evaluated at six equally spaced frequencies sampled in the 17.7~ 19.7 GHz frequencies band. After evaluating each chromosome of a generation, the next generation is obtained from the previous ones by 80% crossover function, 14% tournament selections, and 6% mutation function.

The GA is converged to the desired results after passing 70 generations. The final optimized value for each parameter is shown in Table .1.

Results and Discussion

A prototype of the proposed dual-polarized hat feed reflector antenna is fabricated as shown in Fig. 2 (d). The metallic head is inserted in the dialectic neck and sticks to the dielectric neck and the metallic waveguide with a high-temperature glue.

This metallic waveguide is then screwed to the rear side of the ring focus reflector and the OMT as shown in Fig. 2 (c).

The fabrication accuracy of the hat feed antenna and the surface accuracy of the reflector antenna are less than 0.1 mm and 0.4mm respectively.

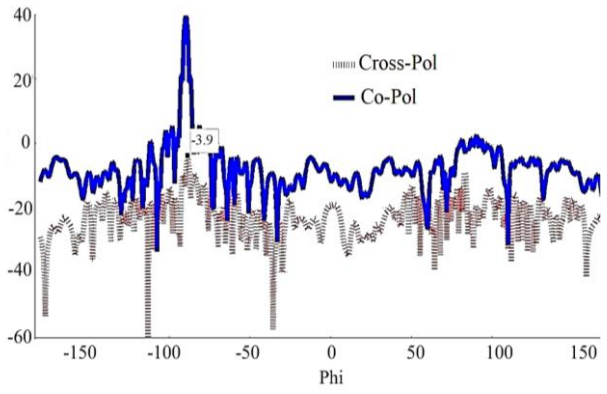


Fig. 6: The measured co and cross-polarization Gain of the proposed dual-polarized hat feed reflector antenna at 19 GHz frequency.

The return loss of the proposed antenna from OMT outputs is measured and compared with the simulation results in Fig. 3. The measured results in this figure are reported after some tuning with the tuning of metallic screws at the OMT. These screws are fixed in their optimum positions. From Fig. 3 it is clear that the proposed antenna has a return loss better than 15 dB in the whole frequency band of 17.7~19.7 GHz and for both OMT ports. The measured and simulated isolation between each port of the proposed antenna is shown in Fig. 4. As it can be seen more than 30 dB isolation between antenna ports is obtained in the measurement result.

The far-field radiation pattern of the proposed antenna for each polarization is also measured in the anechoic chamber. Fig. 5 compares the simulated and measured normalized radiation pattern of the proposed antenna at each polarization at 18 GHz frequency. As it can be seen in this figure the proposed antenna has a sidelobe level of about 20 dB at both polarizations. The front-to-back ratio better than 50 dB can also be realized from Fig. 5.

The measured peak gain and the cross-polarization of the proposed antenna are shown in Fig. 6. As it can be seen the proposed antenna has about 40 dBi Gain at 19 GHz frequency. According to (5) the proposed has about 70% aperture efficiency at 19 GHz frequency. This radiation efficiency can be considered as high efficiency in the Ku bands. From this figure, it is obvious that the proposed antenna has also more than 40 dB cross isolation.

Table 2: Comparison of the reported hat feed reflector antenna with the proposed antenna.

Ref.	Sim./ Meas.	Polarization	Freq. band	η(%) @Midpoint	SLL. @Midpoint	Bandwidth (%)
[13]	Sim.	Single	ka	78	40dB	N/A
[14]	Meas.	Single	K/Ka	70	10dB	N/A
[15]	Meas.	Single	Ku	74	20dB	47
[17]	Meas.	Single	Ku	63	15dB	26
[18]	Meas.	Single	Ku	65	25dB	30
This work	**Meas.**	**Dual Pol.**	**Ku**	**70**	**20dB**	**13**

Sim. /Meas.: Declaration of the nature of work as simulation or experiment.

N/A: Not available.

In order to make a fair assessment of the performance between the proposed hat feed reflector antenna and other similar antenna, Table 2 is also given. As can be seen in this table the proposed antenna is the first reported dual-polarized hat feed reflector antenna.

This antenna has an acceptable aperture efficiency and low side lobe level in compared to the previous works. It should be mentioned that the bandwidth of the proposed antenna is limited to the performance of the OMT structure and is different from single polarized antennas. From all of these results, it can be concluded that the proposed dual-polarized antenna is a good candidate for high-frequency terrestrial and satellite communications.

Conclusion

This paper describes the concept and design of a novel dual-polarized hat feed reflector antenna. The proposed hat feed antenna has a 60 cm ring focus reflector and is designed for 17.7~19.7 GHz frequency with a reflection coefficient less than -15 dB and radiation efficiency greater than 70%. To fulfill these requirements 21 parameters are defined at the metallic head and dielectric transition of the hat feed antenna. A two-step GA optimization process is also created with the HFSS MATLAB link.

A prototype of the optimized antenna with an orthogonal mode transducer is fabricated and the measured results are compared with the simulation ones.

The measured results show that for both input ports of the hat feed antenna a low reflection coefficient and high radiation efficiency can be realized. The proposed dual-polarized antenna can be used for high-frequency terrestrial and satellite communications.

Author Contributions

Both M. Bod and F. Geran developed the proposed antenna idea and performed the analytic simulations and measurements. M. Bod has written the manuscript and F. Geran edited/reviewed the paper.

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Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

Abbreviations

A_{phy}	the physical aperture area
BOR	body of revelation
E_1	the error functions of the reflection coefficient
E_2	the error functions of the peak gain
F	focal length
f_i	the ith sampling frequency
GA	genetic algorithm
G	antenna peak gain
OMT	orthogonal mode transducer
w_i	the weighting value at the ith sample
ϑ_f	polar angle of the feed
ρ_0	radius of the reflectors focus ring
η	aperture efficiency
λ_0	corresponding wavelength

References

[1] S. Rao, S. K. Sharma, L. Shafai., Handbook of reflector antennas and feed systems. Artech House, 2013.

[2] A. Rebollo, Á.F. Vaquero, M. Arrebola, M.R. Pino, "3D-Printed Dual-Reflector antenna with self-supported dielectric subreflector," IEEE Access, 8: 209091-209100, 2020.

[3] H.D. Lang, S. Flepp, H. Mathis, "Self-Supporting circularly polarized backfire helix feed antenna with reflector and director for deep dish reflector antennas in the L-Band," in Proc. 2021 XXXIVth General Assembly and Scientific Symposium of the International Union of Radio Science (URSI GASS): 1-4, 2021.

[4] C. Liu, S. Yang, Z. Nie, "Design of a parabolic reflector antenna with a compact splash-plate feed," in Proc. Cross Strait Quad-Regional Radio Science and Wireless Technology Conference: 24-244, 2013.

[5] Y. Asci, E. Curuk, K. Yegin, C. Ozdemir, "Improved splash-plate feed parabolic reflector antenna for Ka-Band VSAT applications," in Proc. 46th European Microwave Conference: 1283-1286, 2016.

[6] P. Tang, "A design of high performance splash-plate feed for parabolic reflector antenna," in Proc. Sixth Asia-Pacific Conference on Antennas and Propagation: 1-3, 2017.

[7] G.T. Poulton, T.S. Bird, "Improved rear-radiating waveguide cup feeds," in Proc. International Symposium on Antennas and Propagation, 24 :79-82, 1986.

[8] R. Schwerdtfeger, "A coaxial dual mode feed system," in Proc. 9th European Microwave Conference: 196-200, 1979.

[9] A. Moallemizadeh, R. Sarraf-Shirazi, M. Bod, "Design of a novel compact cup feed for parabolic reflector antennas," Prog. Electromag. Res. Lett., 64: 81-86, 2016.

[10] M.K. Dwivedi, A.K. Sharma, "Compact reflector antenna system for ku-band satcom on the move (SOTM)," in Proc. 6th International Conference on Signal Processing and Integrated Networks: 254-257,2019.

[11] P.S. Kildal, "The hat feed: A dual-mode rear-radiating waveguide antenna having low cross polarization," IEEE Trans. Antennas Propag., 35(9):1010-1016, 1987.

[12] J. Yang, P.S. Kildal, "Calculation of ring-shaped phase centers of feeds for ring-focus paraboloids," IEEE Trans. Antennas Propag., 48(4): 524-528, 2000.

[13] Y. Zhao, B. Zhu, Y. Meng, Z. Yan, "Design of a hat feed for ring focus reflector antenna," in Proc. International Conference on Microwave and Millimeter Wave Technology, 2019.

[14] F. Greco, L. Boccia, E. Arnieri, G. Amendola, "K/Ka-Band cylindrical reflector antenna for compact satellite earth terminals," in Proc. IEEE Trans. Antennas Propag., 67(8): 5662-5667, 2019.

[15] E. Geterud, J. Yang, T. Ostling, "Wideband hat-fed reflector antenna for satellite communications," in Proc. 5th Eur. Conf. on Antennas Propag., Rome, 2011.

[16] M. Denstedt, T. Ostling, J. Yang, P.S. Kildal, "Tripling bandwidth of hat feed by genetic algorithm optimization," in Proc. IEEE AP-S Int. Symp., Hawaii, 2007.

[17] W. Wei, J. Yang, T. Ostling, T. Schafer, "A new hat feed for reflector antennas realized without dielectrics for reducing manufacturing cost and improving reflection coefficient," IET Microwaves Antennas Propag., 5(7): 837–843, 2011.

[18] E.G. Geterud, J. Yang, T. Ostling, P. Bergmark, "Design and optimization of a compact wideband hat-fed reflector antenna for satellite communications," IEEE Trans. Antennas Propag., 61(1): 125-133, 2013.

[19] F. Greco, G. Amendola, L. Boccia, E. Arnieri, "A dual band hat feed for reflector antennas in Q-V band," in Proc. 10th Eur. Conf. on Antennas Propag., 2016.

[20] Y.J. Zhao, B.C. Zhu, Y.B. Meng, Z.H. Yan, "Design of a hat feed for ring focus reflector antenna," in Proc. International Conference on Microwave and Millimeter Wave Technology, 2019.

[21] A.A. Kishk, L. Shafai, "Optimization of microstrip feed geometry for prime focus reflector antennas," IEEE Trans. Antennas Propag., 37(4): 445-451, 1989.

[22] M.Q.E. Maula, L. Shafai, "Low-Cost, microstrip-fed printed dipole for prime focus reflector feed," IEEE Trans. Antennas Propag., 60: 5428-5433, 2012.

[23] T. Chen, H. Wu, "Dual-Polarized planar reflector feed for direct broadcast satellite systems," IEEE Antennas Wireless Propag. Lett., 9: 693-696, 2010.

[24] M.Q.E. Maula, L. Shafai, Z. A. Pour, "A Corrugated printed dipole antenna with equal beamwidths," IEEE Trans. Antennas Propag., 62: 1469-1474, 2014.

[25] Fixed Radio Systems Characteristics and Requirements; Final Draft, ETSI EN 302 217-4-2 V1.5.1 (2009-09), ETSI [Online].

[26] Z. Zhang, Y. Zhao, N. Liu, L. Ji, S. Zuo, G. Fu, "Design of a dual-beam dual-polarized offset parabolic reflector antenna," IEEE Trans. Antennas Propag., 67(2): 712-718, 2019.

[27] A. Mehrabani, L. Shafai, "Compact dual circularly polarized primary feeds for symmetric parabolic reflector antennas," IEEE Antennas Wireless Propag. Lett., 15: 922-925, 2016,

[28] R. Olsson, P. Kildal, S. Weinreb, "The eleven antenna: a compact low-profile decade bandwidth dual polarized feed for reflector antennas," IEEE Trans. Antennas Propag., 54(2): 368-375, Feb. 2006.

[29] S. Manshari, S. Koziel, L. Leifsson, "Compact dual-polarized corrugated horn antenna for satellite communications," IEEE Trans. Antennas Propag., 68(7): 5122-5129, July 2020.

[30] A. R. Mallahzadeh, M. Bod" Method for designing low-pass filters with a sharp cut-off," IET Microwaves Antennas Propag. 8: 10–15, 2014.

[31] C.A. Balanis, Antenna Theory: Analysis and Design, John Wiley & Sons, 2005.

Biographies



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