High gain miniaturized multi-beam Luneburg lens antenna for satellite communications

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***Abstract*— A high directive gain spherical Luneburg lens antenna that is fed with 16 circular horn antennas is design for operation in the 40 GHz to 50 GHz (high altitude platform system). The overall gain is 26 dBi with -21dB side lobe levels. Advantages include small dimensions and simultaneous support of right-hand and left-hand polarizations.**

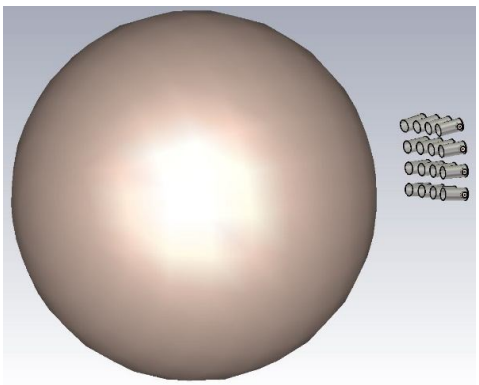
Keywords—Luneburg lens antenna; satellite communication; septum horn antenna

I. Introduction

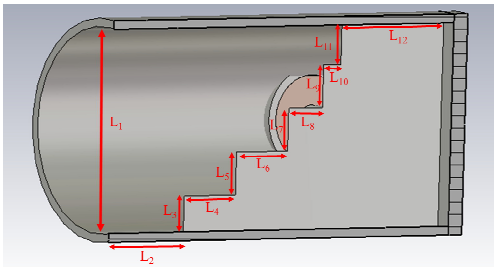
Satellite on the move communication systems offer high data rate on land, sea and in the air. Reflector antennas could be candidate antennas for these communication systems but their size imposes critical limitations for maritime and satellite applications. As an alternative, the spherical Luneburg lens antenna is also a good candidate for satellite communications when single or multi feed arrays are used [1] because it provides good aperture efficiency in miniaturized space and excellent performance.

II. Antenna design

We design a high directive gain spherical Luneburg lens antenna that is fed with 16 circular horn antennas. The frequency bandwidth for this project is from 40 GHz to 50 GHz (V band). For satellite communications, polarization of the antennas is a main factor and circular polarization is often recommended. The lens is fed by 16 septum horn antennas that are designed to provide 8 dBi gain and -15dB side lobe level (SLL). The septum horns are aperture type antennas with the possibility to radiate right and left circularly polarization (RHP and LHP) simultaneously, see Fig 1. In addition, their radiation patterns are rotationally symmetric [2]. The gain of the original septum horn antennas increases with the use of the Luneburg lens to achieve a value of 26 dBi of gain with -21dB SLL for the overall antenna, as shown in Fig. 2. The diameter of the Luneburg lens is 15 cm and its radiation pattern should cover a 17º spatial angle. All feeds are arranged to prevent overlap of their beams in two dimensions, based upon the HPBW of the overall antenna. This results into a 4 x 4 arrangement of the antennas as shown in Fig. 1a.



(a)



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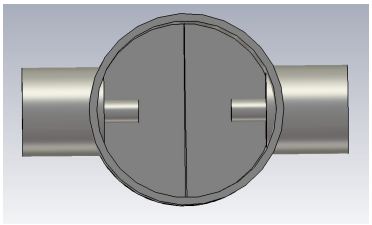


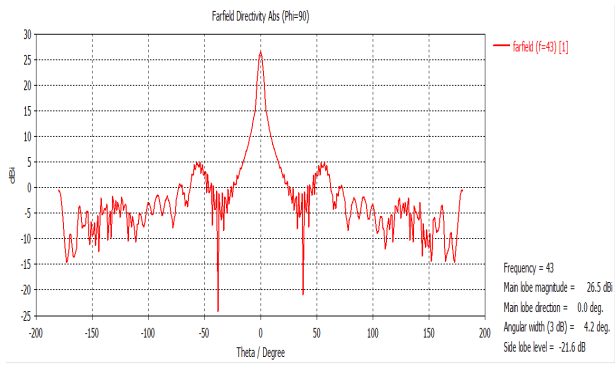
(c)

Fig 1. (a) Luneburg lens with 16 septum horn antenna array, practical primary feed using septum horn antenna, (b) side view (c) front view.

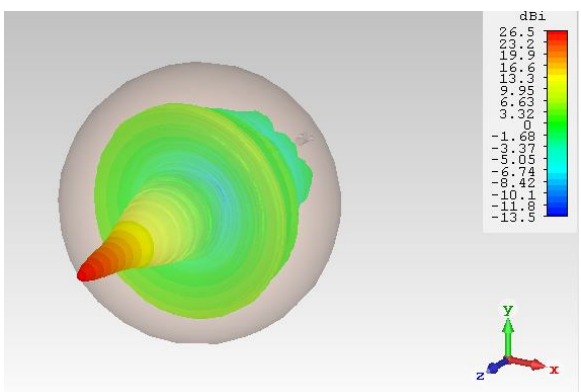
TABLE I. SEPTUM HORN ANTENNA DIMENSION

Parameter	L_1	L_2	L_3	L_4	L_5	L_6
Dimension (mm)	*4.85*	*2.5*	*0.85*	*1.5*	*1*	*1.5*
Parameter	L_7	L_8	L_9	L_{10}	L_{11}	L_{12}
Dimension (mm)	*1*	*1*	*1*	*0.5*	*1*	*3*

The dielectric material for the Luneburg lens is a one-layer high density polyethylene with $\varepsilon_r = 2.2$ and tan δ=0.0005. Septum horn parameter dimensions are listed in Table I.



(a)

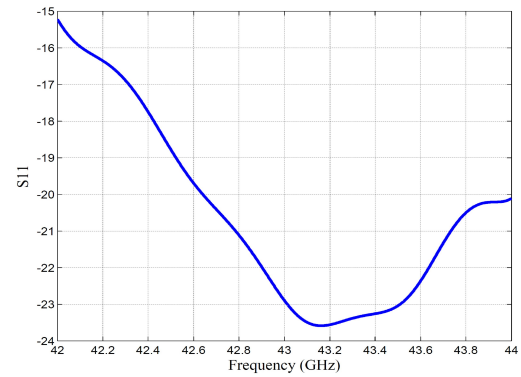


(b)

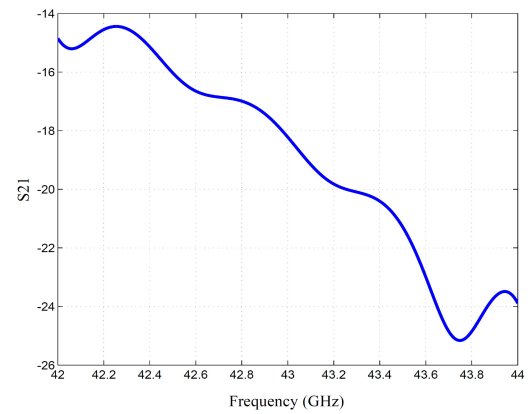
Fig 2. Simulated farfield radiation pattern with CST software for Luneburg lens antenna at 43 GHz (a) 2D plot, (b) 3D plot.

III. CONCLUSION

One advantage of this design, compared to other ones [3], is that the largest dimension of the cross-section of the whole structure is about 20 cm×20 cm. This structure can cover 17º with 4º resolution step in two dimensions. Another advantage of this design is that the antennas can support RHP and LHP with a simultaneous isolation of -21 dB. Finally, the gain of the overall antenna can be increased depending on the project requirements.



(a)



(b)

Fig 3. Simulated (a) S_{11} and (b) S_{21} with CST software for Luneburg lens antenna

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