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Review on High Gain Conical Horn Antenna for Short-Range Communications

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ABSTRACT
Horn antennas are very popular at UHF (300 MHz-3 GHz) and higher frequencies (as high as 140 GHz). Horn antennas often have a directional radiation pattern with a high antenna gain, which can range up to 25 dB in some cases, with 10-20 dB being typical. Horn antennas have a wide impedance bandwidth, implying that the input impedance is slowly varying over a wide frequency range. The bandwidth for practical horn antennas can be of the order of 20:1 (for instance, operating from 1 GHz-20 GHz), with a 10:1 bandwidth being common. The gain of horn antennas often increases as the frequency of operation is increased. This is because the size of the horn aperture is measured in wavelengths; at higher frequencies the horn antenna is "electrically larger" because high frequency has a smaller wavelength. Horn antennas have very little loss, so the directivity of a horn is roughly equal to its gain.

In this paper, we will present review about conical horn antenna which uses hybrid technique and provides high gain at frequencies ranging 3GHz keeping its size within limits. Also, literature survey will demostrate other reference papers will includes horn antennas using different techniques and used for various applications.

Index Terms- Conical horn, double ridge guide horn (DRGH) antenna, hybrid antenna, millimeter wave measurement

I. INTRODUCTION

The purpose of this paper is to provide researchers a systematic survey of different horn antenna and the various kinds of techniques used not only to enhance the gain, but also to keep the overall antenna size within acceptable limits. In recent years, there have been extensive research efforts in developing high-gain printed circuit microstrip antennas for various applications. One of the main gain-enhancing techniques can be achieved using array principle, but the antenna size and complexity of the feed network become limitation problems. But nowadays new techniques are introduced to increase antenna gain.

The most attractive technique is to use hybrid configurations [7]–[13] where multiple antennas are excited together with the same or different modes over the same frequency range of operation.

Recently, a hybrid technique has been proposed by Costanzo [7], where circular waveguide elements are electromagnetically coupled through circular apertures to a stripline to enhance the overall antenna gain. Another recent technique uses a surface-mounted pyramidal horn excited by a rectangular patch antenna and a dipole as in [8] or by a patch surrounded by a resonating ring as in [9]. In [10], stacked patches are used to feed a horn antenna, resulting in an obvious gain enhancement. To increase the overall antenna efficiency, the microstrip patch antenna was replaced by a rectangular DRA in [11]. Merging between antenna array and surface-mounted horn was introduced in [12]. Use of superstrate with or without parasitic radiators is considered as one of the novel gain-enhancing techniques [13]. However, it requires special fabrication facilities due to its design complexity.

In this review paper, a high gain conical horn hybrid antenna is proposed which can be used for short range communications. The proposed antenna design is also a good candidate to work as a scanning element in millimeter-wave (MMW) imaging systems for security applications or as a transreceiving sensor for high data rate exchange between home/small office electronic devices. The design should have high gain, light weight, and compact size compared to a standard horn antenna working in the same frequency range. The overall antenna gain should be as high as 12 dB and operate at frequencies ranging 3 GHz. This paper will be the base paper and its reference papers are discussed in literature review section.

II. LITERATURE REVIEW

In the literature, many horn antennas have been demonstrated which operates using different techniques and are used for different applications. A brief description of some of previous works is demonstrated in this section.

In [1], Optimization of a Compact Conical Horn Antenna System for High Power Microwaves in the 4 to 6 GHz Range has been proposed. In this, a conical horn antenna is being developed that radiates high power microwaves in this range into high gain and highly directive radiation patterns from the TE11 mode in the feeding circular waveguide. Utilizing finite element modelling techniques, the behaviour of these high power electromagnetic waves can be accurately described inside the waveguide as well as in the near and far field regions. These techniques in turn improve the quality of high power experiments performed on the compact structure. Compact sources allow for advances in the technologies of power beaming, space propulsion, and high power radar. Various advances in this field include (1) Texas Tech University has created a compact Marx generator and triode vircator system as a high power microwave source [6]. This source generates a substantial amount of power in the TE11 mode. A compact radiating system is needed for this source to produce desired radiation characteristics from this mode. The goal of the system is to maximize the power transfer from the vircator source to the radiating system while keeping the system as compact as possible. (2) A compact conical horn antenna has been designed at the University of Missouri that operates in the 4 to 6 GHz range and produces a forward directed radiation beam with an approximate directivity of 10-15 dB, which corresponds to a half power beam width of roughly 40 to 60 degrees in two orthogonal planes. Higher directivities produce too narrow of a beam, whereas lower directivities do not produce the desired power densities. COMSOL Multiphysics' RF Module, a software that implements the finite element method, was used to analyze the near and far field region of the electric field and radiated power patterns [5].

A conical horn antenna was designed to radiate high power microwaves in the 4 – 6 GHz range with a directivity of 10-15 dB. The design constraints state that the entire system must be no larger than 15 cm in diameter and must be as short as possible in length. The design parameters, labeled in Figure 1, and their selected values can be seen in Table 1. This geometry allows the TE11 mode to propagate into the antenna in the designated frequency range.

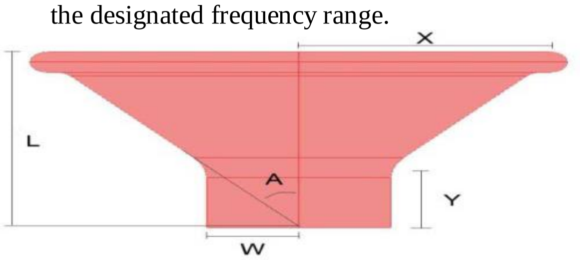


Figure 1. Cross section of conical horn antenna with design parameters, which correspond to Table 1.

Table 1 Selected Conical Horn Design parameters

Parameter	Value
X	7.3cm
W	3cm
L	8.6cm
Y	4.6cm
A	41.73°

By [2], An Improved Design for a 1–18 GHz Double-Ridged Guide Horn Antenna is studied. It is a well-known fact that the traditional 1–18 GHz double ridge guide horn (DRGH) antenna suffers from pattern deterioration above 12 GHz. At these frequencies, instead of maintaining a single main lobe radiation pattern, the pattern splits up into four lobes as shown in fig.2 and the boresight gain reduces by approximately 6 dB. This makes the use of these antennas for EMC and measurement applications less desirable. Subsequently, a new open boundary type of horn design that produces. a single main beam across the band was developed.

The new design included a number of changes:

- The dielectric sidewalls were removed to improve the radiation characteristics of the DRGH antenna above 12 GHz. It was found in that the dielectric rather than the metallic strips of the sidewalls causes an on-axis gain drop at 18 GHz. The removal of the sidewalls was at the expense of the low frequency (1–4 GHz) performance— the beamwidth increased and the gain decreased.
- The ridges and the conducting flares (top and bottom) were redesigned to reduce edge diffraction and improve the aperture match. The ridge's curvature was modified to a linear section near the feed point, an intermediate exponential section and a circular section near the aperture. The flare outlines were changed to eliminate sharp corners due to the removal of the sidewalls.
- The coax to ridge waveguide transition was redesigned and mode suppression fins were included to prevent the excitation of higher order modes. A cavity was included (just behind the mode suppression fins) to reduce the VSWR .
- The antenna was finally scaled down to further improve the high frequency behaviour.

These changes significantly improved the antenna performance at the higher frequencies,

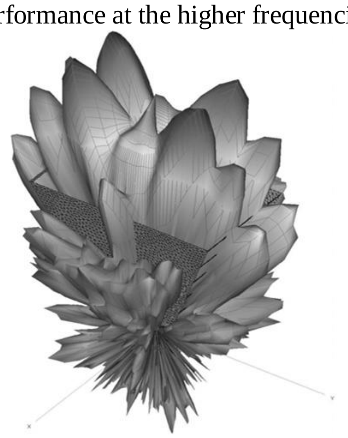


Fig.2. Simulated three dimensional radiation pattern of the traditional DRGH antenna with dielectric sidewalls at 18 GHz.

In this paper an improved double ridge guide horn antenna with metallic grid sidewalls to restore the lower frequency performance back to that of the traditional double ridge waveguide horn antenna is proposed. The coax-to-double ridge waveguide transition is redesigned to suppress any higher order double ridge waveguide modes that can propagate. In addition to the improved pattern and gain performance of the proposed antenna, the design of the coax-to-double ridge waveguide transition reduces any sensitivity caused by machining tolerances during the manufacturing process. This allows for mass production of 1–18 GHz double ridge waveguide horn antennas with improved repeatability, pattern and gain performance over the full 1–18 GHz band.

Advantages of new design include:
1. Eliminate any pattern deterioration due to the excitation of higher order modes across the entire frequency band.
2. Improve the gain and VSWR performance of the open boundary DRGH antenna in the 1 to 3 GHz range
3. Reduce the possibility of gaps that could lead to performance deterioration by reducing the number of individual parts in the antenna construction. Fig. 3 and Table II show the outline dimensions of the new design.

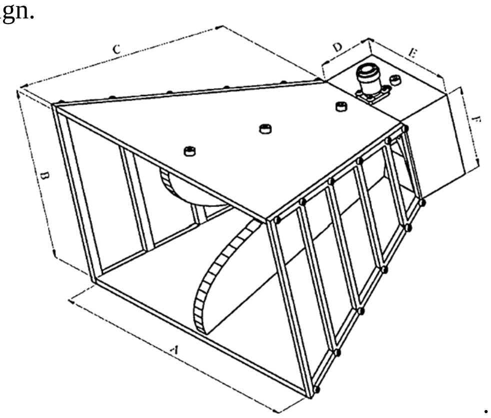


Fig. 3 New 1–18 GHz DRGH showing outline dimensions.

Table II New 1–18 GHz DRGH Final Antenna Dimensions

Fig. 12 reference	Description	Dimension (mm)
A	Aperture Width	242
B	Aperture Height	136
C	Waveguide axial length	168.8
D	Launcher axial length	41
E	Launcher Width	86
F	Launcher Height	66

In [3], Gain Enhancement by Dielectric Horns in the Terahertz Band is studied. The structure is based on a horn antenna etched in the substrate and fed with a planar printed antenna used for generation of terahertz radiation, designed for the 200 GHz to 3 THz range. A dielectric semiconductor horn antenna etched on a high permittivity and thick substrate is proposed to focus the radiation, reduce the energy distribution and enhance the gain of the device in the broadside direction in the THz band. A sketch of this process is shown in Fig. 4(a) and (b). In the first case a conventional system is depicted, where the radiation has a strong diffusion through the substrate. In order to overcome this issue, a horn antenna is etched into the semiconductor as shown in Fig. 4(b). The energy diffusion is reduced in the substrate, focalizing all the radiation into the broadside direction.

In this paper, horn substrate with a planar printed antenna over a dielectric slab propagating the mode has been used. The energy coupling to this mode is maximized through the dielectric slab. A 1:10 bandwidth has been achieved with a broadband log-spiral antenna.

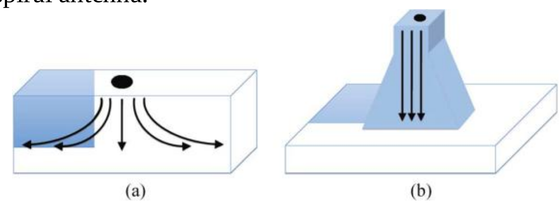
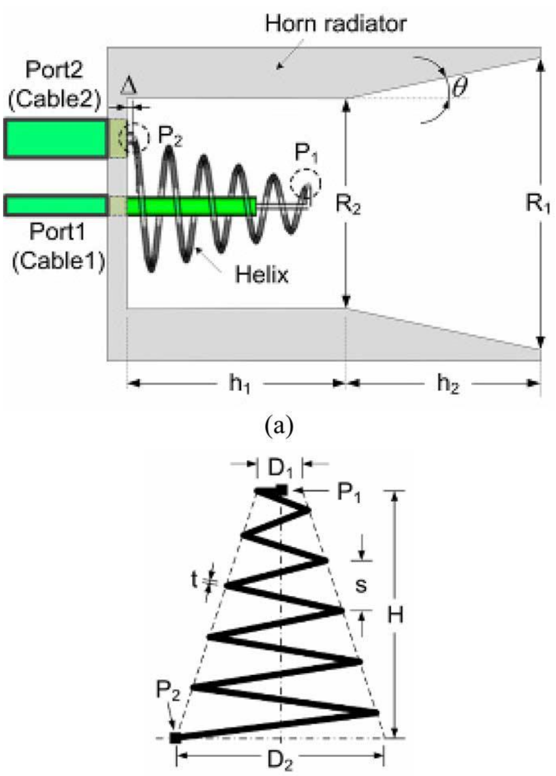


Fig. 4. (a) Energy distribution on a high permittivity substrate, (b) proposed structure with the antenna on top.

In [4], Dual-Band Horn Array Design Using a Helical Exciter for Mobile Satellite Communication Terminals is studied A horn array antenna is proposed for dual-band and dual-polarization operation. The array is optimally designed to be used as a feeder in mobile satellite terminals with a hybrid antenna (HA) structure, but it can be also used independently as a phased array. The array has an oval-shaped rim to maximize the efficiency of the HA, and is composed of 20 horn elements in a hexagonal structure. The element has a horn radiator with a conical helix, which is placed inside the horn and excited by two ports for TX and RX at both ends. Therefore, the antenna can be simultaneously operational in the Ka-band TX and K-band RX frequency bands, using a compact structure providing left-hand circular polarization (LHCP) for TX and right-hand circular polarization (RHCP). The antenna has a minimum gain of 21.7 dBi over the TX band and 19.7 dBi over the RX band over the desired scan region. The maximum pointing error is about 0.32 and the pointing loss is approximately 1.3 dB. In addition to meeting the above RF requirements, the antenna is designed to meet environmental specifications such as wind loads as required for mobile terminals. The array is composed of 20 elements in the aperture rim with a distorted oval shape to optimize the HA performance in a given size, and the element antennas are rotated by 90° for optimal beam pattern synthesis. The main specifications of the array are summarized in Table III. To realize an element antenna that meets the array antenna performance requirements listed in Table III in a small-sized structure, a horn antenna with a cone-type helix having two ports at both ends is proposed. The structural design is shown in Fig. 5

Table III
Main Specifications Of The Array

Parameter	TX	RX
Frequency	30.885GHz	21.155GHz
Polarization	LHCP	RHCP
Return loss	>10dB	>10dB
Axial ratio	<1dB	<1dB
Isolation	>15dB (for RX band)	>10dB (for TX band)



(b)

Fig. 5. Design of a horn antenna with helix exciter: (a) horn antenna structure and (b) geometry of the helix exciter.

III. DISCUSSION

Various horn antennas have been studied which include a conical horn antenna for high power microwaves[1] which provides high gain , highly directive radiation patterns and VSWR performance without any pattern deterioration. It includes compact sources that allow for advances in the technologies of power beaming, space propulsion, and high power radar.

Also, in [2] 1–18 GHz double ridge waveguide horn antenna is studied with improved repeatability, pattern and gain performance over the full 1–18 GHz band. The antenna has improved gain and VSWR performance.

Another antenna using Terahertz (THz) band [3] has been proposed due to its growing interest for spectroscopy, radio astronomy and high power radar. They can be used in high power radar systems, microwave weapons, power beaming etc.

Another antenna in [4] demostrates a horn array that can be loaded into mobile satellite terminals with an HA structure is studied. With the use of circular polarization, this horn antenna is easy to fabricate and its production costs is considerably reduced and it is expected to find extensive use in satellite communications.

IV. CONCLUSION

In the review paper, A high-gain conical horn hybrid antenna has been proposed in which overall antenna gain should be as high as about 12 dB, which makes it suitable for MMW imaging applications and short-range communications. It should have light weight and small size. We will work on this paper and use reference papers for study.

REFERENCES

[1] Erik C. Becker, Scott D. Kovaleski and John M. Gahl,“ Optimization of a Compact Conical Horn Antenna System for High Power Microwaves in the 4 to 6 GHz Range” *IEEE Transactions on Dielectrics and Electrical Insulation Vol. 18, No. 4; August 2011*

[2] Bennie Jacobs, Johann W. Odendaal,” An Improved Design for a 1–18 GHz Double-Ridged Guide Horn Antenna”, *IEEE Transactions on Antennas and Propogation, Vol. 60, No. 9, September* 2012

[3] Belen Andres-Garcia, Enrique Garcia-Muñoz, Sebastian Bauerschmidt, Sascha Preu, Stefan Malzer, Gottfried H. Döhler, Lijun Wang, and Daniel Segovia-Vargas,” Gain Enhancement by Dielectric Horns in the Terahertz Band”, *IEEE Transactions on Antenna and Propagation, Vol. 59, No. 9,* S 2011.

[4] Young-Bae Jun and Soon-Young Eom,”Dual-Band Horn Array Design Using a HelicalExciter for Mobile Satellite Communication Terminals” *IEEE Transactions on Antenna and Propagation, Vol. 60, NO. 3,* March 2012.

[5] COMSOL Multiphysics 3.5a. Burlington, MA: *COMSOL, Inc.*, 2008.

[6] J. Walter, J. Dickens and M. Kristiansen, "Performance of a compact triode vircator and Marx generator system", *IEEE Pulsed Power Conf.* pp.133-137, 2009

[7] S. Costanzo, “Hybrid array antenna for broadbandmillimeter-wave applications,” *Prog. Electromagn*. Res., *vol. PIER 83*, pp. 173–183, 2008.

[8] S. Methfessel and L.-P. Schmidt, “Design of a balanced-fed patch-excite horn antenna atmillimeter-wave frequencies,” *in Proc. 4th EuCAP, Apr. 12–16,* 2010, pp. 1–4.

[9] P. Kumar, D. Batra, and A. K. Shrivastav, “High gain microstrip antenna capacitive

coupled to a square ring with surface mounted conical horn*," Int. J. Electron. Commun. Technol., vol. 1, no. 1*, pp. 7–9, Dec. 2010.

[10] R. Shireen, "Stacked patch excited horn antenna at 94 GHz," *Microw. Opt. Technol. Lett., vol. 50, no. 8, pp. 2071–2074*, Aug. 2008.

[11] Nasimuddin, K. P. Esselle, and A. K. Verma, "GAIN enhancement of aperture-coupled dielectric-resonator antenna with surface mounted horn," in Proc. *28th Gen. Assembly URSI*, New Delhi, India, Oct. 23–29, 2005.

[12] A. Bedair, "Design and development of high gain wideband microstrip antenna and DGS filters using numerical experimentation approach," Ph.D. dissertation, Guericke-Universität, Magdeburg, Germany, 2005.

[13] H. Vettikalladi, O. Lafond, and M. Himdi, "High-efficient and high gain superstrate antenna for 60-GHz indoor communication," *IEEE Antennas Wireless Propag. Lett*., *vol. 8, pp. 1422–1425*, 2009