"REVIEW OF HORN ANTENNA"

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ABSTRACT

Objective of this paper is to depict a survey of the work done describing the researches in the area of the horn antenna design, so as to get a clear idea on history of techniques developed for design of the horn antenna also the current research going on for this era. Many applications make use of horn antenna. For example, Electromagnetic compatibility testing, standard gain measurement, satellite tracking system, radar, communication system and reflectors feeding etc. In early 90s, use of ridges in waveguides became proposed to meet the want for broadband antennas. In addition to that, horn antennas were having many advantages such as they are simple to build, provide very good directional performance, and show excellent peak power handling capability. Simple horn antennas have relatively limited bandwidth. In order to increase this bandwidth ridges are used in horns. Ridges are inserted to increase bandwidth, cut-off frequency, surfaces of antenna provided for larger radiation and energy that can be radiated. Different types of horn antennas are studied. Properties of antenna such as gain, bandwidth, directivity, radiation pattern, return loss, radiation efficiency etc are varied based on their shapes, dimensions, thickness, conducting material and feeding techniques.

Keyword - *Dual ridge horn antenna, Electromagnetic compatibility testing, FDTD*

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1. INTRODUCTION

In today's innovative world, remote correspondence has turned into a critical piece of human lives. We utilize wide range of remote gadgets, for example, radios, mobile phones, remote web, and satellite dish and so forth. Mobile phones and remote gadgets speak with each other by transmitting and getting electromagnetic waves. Horn antennas are described using several parameters like gain, VSWR, geometry, half power beam width, frequency of operation and polarization.[6] Horn antennas are mostly used in various areas such as EMC testing, standard gain measurement, radars, satellite tracking systems, reflectors feeding and communication systems.[5]

An advantage of horn antennas is, no resonant elements, also can operate over a wide bandwidth and a wide range of frequencies. A horn antenna is employed to transmit radio waves from a wave guide out into surrounding or collect radio waves into a wave guide for reception. The ridges in waveguides produce capacitance effects that decrease the bring to an end frequency of the dominant propagating mode (TE10) and increase the single-mode.[5-12] In 1960s, single mode operation over the largest possible bandwidth has been realized. The propagation of the higher order modes will cause unwanted effects within the radiation characteristics of the antenna.

Horn antennas are simple and widely used microwave antennas also they have applications in the areas of wireless communications, electromagnetic sensing, biomedicine and RF heating. The DRH antennas are mostly used in electromagnetic interference and compatibility applications for generating electromagnetic fields. The revolutionary growth in wireless communication technology makes great demands on design of antennas with compact size and multi band operation.

2. HORN ANTENNA

The use of double ridged horn antennas continues to increase. The various applications of this antenna are made possible due to the characteristics of these antennas such as versatility, easy excitation, comparatively simple construction, high gain and directivity performance. [2] Ridges are introduced into the flared part of the antenna to extend the maximum practical bandwidth of horns. This is generally performed in waveguides to decrease the cut off frequency of the dominant propagating mode (TE10) and thus expands the single mode range. Spreading of higher order modes arises from power division between the modes and due to various field distributions, they influence the desired radiation patterns and especially the main lobe deteriorates for higher frequencies. The simple horn antennas have a limited bandwidth. Ridges are introduced in the flare section of the antenna, to extend the maximum practical bandwidth [3]. The ridges in a waveguide or horn cause capacitance effects and therefore decrease the cut off frequency of dominant propagating mode (TE10), increasing the single mode bandwidth [5].

A horn antenna has short length of rectangular, pyramidal or cylindrical waveguide which is closed at one end and open ended pyramidal or conical shaped horn on the other end. The radio waves were introduced into the waveguide by using a coaxial cable attached to the side. Then introduced radio wave radiates out in narrow beam at the horn end..

3. LITERATURE SUREVY

In literature survey, the previously developed techniques for horn antenna design are discussed with their advantages and disadvantages

C. Bruns et al [1] has presented the electromagnetic simulation for 1 to 18GHz broadband DRH antenna including a coaxial excitation. In this frequency domain MOM simulation have been used for measurements. In this paper, first time such a complete antenna system was simulated in one step over the entire frequency range. It was observed that to get satisfactory antenna performance, small geometric tolerances of the ridged waveguide horn needs to be maintained and that the introduction of mechanical imperfections into the simulation model significantly enhances the agreement between measurements and simulations. Disadvantage of this approach is that designed broadband ridged horns exhibit same performance that is degradation in upper frequency range, because propagation of higher order modes were fail to suppress effectively.

A. R. Mallahzadehet et al has explained Dual polarized antenna which is widely used in different communication systems like ECM and DF system. In this paper, for 8–18 GHz dual polarized double ridged horn antenna was introduced. In this, five layer polarizer was used to provide dual polarizations of the DRH antenna. In order to achieve dual polarizations the strips width, strips spacing and layers distances were optimized. CST software was used for analysis of designed antenna. The $E\theta$ and $E\phi$ pattern of designed antenna for x-y plane and y-z plane for various frequencies show that, the antenna proposed yields good performance for dual polarizations application. Moreover, the antenna VSWR is < 2 over the operating frequency band which is require in UWB application [2].

A. Mallahzadeh et al[3] has explained a modified double ridged antenna for the 2-18 GHz band .HFSS and CST software were used for analysis of designed antenna. Compared to conventional antennas DRH with rectangular openings, the antenna designed (with smaller opening) has low cross polarization and lower weight. Also, manufacturing of designed antenna is easier than DRHA. The disadvantage of the conventional broadband double ridged pyramidal horn antenna was distortion of the radiation patterns at higher frequencies. Radiation patterns of conventional broadband double ridged pyramidal horn antenna distorts at higher frequencies, this is the main disadvantage conventional broadband double ridged pyramidal horn antenna. Furthermore, designed antenna provides good VSWR (less than 2.4) over operating frequency band. Based on different characteristics, proposed antenna can be useful for EMC applications.

M. Botello Perez et al has explained design and it's simulation of broadband DRHA including a coaxial excitation for 1-14GHz range. In this, time domain electromagnetic simulation software was used. It was found that designed antenna can work satisfactory up to 14 GHz. Also the horn with the modified ridges performs a little better than traditional horn [4].Disadvantage of this design is degradation in the upper frequency range, because they fail to effectively suppress the propagation of higher order modes.

Abbas Azimi, et al [5], In this paper new method for design of broadband DRH antennas was presented. To overcome antenna deficiencies like antenna radiation pattern at higher frequencies. Thorough sensitivity analysis was done for different structural parameters of the 1–18 DRH antennas; also so many modifications are applied. Final design achieved was scaled up in frequency, to obtain design for higher frequency range. The final design achieved was used for prototype antenna design because it is more compact as compared with other antennas. Validity of designed DRH antenna at the 18–40 GHz band has been verified by numerical simulations and measurements. Advantage of this design is, the presented procedure was applied to design of an 18–40 GHz DRH antenna, also it can be used to design other high frequency DRH antennas. Because the fundamental frequency band of initial DRH antenna is 1–18 GHz has a 1:18 ratio which exceeds the frequency ratio of high frequency DRH antennas used in different EMC applications.

M. Abbas Azimi, F et al has explained properties of a 1-18 GHz DRH antenna. In this feeding section which includes coaxial input and shorting plate at back were rigorously investigated, and then sensitivity of antenna parameters was analyzed. The parameter tolerances are very strict and can vary antenna characteristics considerably. HFSS software was used for simulation of designed 1-18 GHz DRGH. Then, sensitivity of antenna characteristics was analyzed [7].

W. Sun and C. A. Balanis has explained the analysis and design of ridged waveguides by using a magnetic field integral equation formulation. The designed ridged waveguides used in microwave components and systems. The proposed theory is compared with exact closed form solutions and other published results and then verified. [9]In this paper, magnetic field integral equation technique is proposed to find precise and complete solutions for ridged waveguide modes, also obtained cutoff frequency, bandwidth, attenuation and waveguide impedance.

S. B. Cohn [11] has presented the equations and curves which gives cutoff frequency and impedance for rectangular wave guide which were having rectangular shaped ridge pointing inward from one or both sides. It was shown that ridge wave guide has a lower cut off frequency, impedance and greater higher mode separation than a plain rectangular waveguide of the same width and height. This wave guide is having number of uses.

M. Kujalowicz et al [12] has explained the complete design procedure for DRH antenna. Numerical study of FDTD is presented for sinusoidal dual ridge antenna. First step of the study was different transitions from coaxial to double-ridged waveguide. Second, suitable configuration to feed the antenna ridges (sinusoidal ridge taper) was chosen. Finally, the simulations results of complete antenna were presented.

V. Venkatesan et al has presented gain estimation of a wideband DRH antenna of 2 to 4.8 GHz frequency range. Strict gain measurements using the two-antenna measurement method were carried out on a wideband ridge horn in the 2.0–4.8 GHz frequency range. [13]The gain and frequency characteristic of the DRH was observed. Two nominally identical double ridged horns (with parabolic ridges) were designed and fabricated for use in the 2.0–4.8 GHz frequency.

Hana Amjadi et al has designed two ridged horn antennas with modified versions used for breast cancer detection and explained comparison of both versions for breast tumor detection. Simulation is carried out to investigate capabilities of both versions of antenna. Both versions of antennas gives low return loss for 3-10 GHz frequency range and can be used for microwave imaging.[14] Both proposed structures were simulated using HFSS software. The results obtained conclude that sensitivity for the detection of asymmetric tumor increases when polarizations are parallel to tumor's major axis.

Ockert B.et al QRH antenna used for radio astronomy applications has presented. [15] Elliptically shaped sidewalls were used in designed antenna to limit beam width variation for large frequency range also used to get greater rotational symmetry in radiation pattern .The antenna was dissected with a prime concentration reflector to decide the scope of efficiencies that can be normal. FEKO commercial software was used to model proposed antenna. The parametric model was designed to allow changes in geometry so that it can easily implement. Design includes feed pins, orthogonal ports, ridges, flared section and back cavity. Waveguide which has small gap in two opposing ridges produce low impedance. Vector network analyzer (HP 8510) was used to measure VSWR and coupling. The simulated and measured results were obtained and can be conclude that reflection coefficient measured was high as compared to simulated result. To obtain good return loss, connection is required between sidewalls and outer connector. Also good return loss can be achieved by establishing good contact between feed pin and connector. This antenna can be used as feed in Radio astronomy for reflector antennas because it gives high efficiency and low spillover larger bandwidth. The spillover was high at lowest frequency.

P.H. vander Mer et al [16] has presented compact QRH antenna for 0.2 to 10 GHz frequency. Designed QRH Antenna was dual polarized and return loss obtained was greater than 10db.In this antenna was characterized into two parts first flared horn and second transition from coaxial to ridged waveguide. Separately these two parts were designed, simulated and then optimized. After that both the parts were combined and complete simulation was performed. Here optimization was applied on width of ridges, length of back cavity and gap between ridges to extend the usable bandwidth. Antenna was designed using pyramidal horn and exponential profile ridges. Due to insertion of ridges in the horn, smooth impedance transformation established between 50 Ω coaxial cable to free space. Designed antenna model was simulated using FEKO software and MOM technique.

Hesham A. Mohamed has explained a compact QRH antenna for 50MHz to 500 MHz operating frequency which was designed to use for water detection in radar. Two modifications were applied on conventional triangular TEM horn antenna. First taper inserted into horn was designed for multifunction with curvature at end. Second two different ridges were inserted and gap between ridges and aperture were filled using high dielectric material. These modifications were applied to lower operating frequency without increasing size of antenna.[17] To reduce antenna size and to improve impedance matching, two ridges were replaced with four. CST Microwave studio was used to design, fabricate and simulate proposed antenna. This antenna mainly used for water level detection in underground water for GPR application. The antenna designed was fabricated by using stainless steel metal plates. N-type connector of 50Ω matching was used for antenna feeding. Two ridges were added between plates to reduce antenna size and to increase bandwidth. The designed antenna dimensions were 145 x 102x 124 cm3.Simulation results of designed antenna presents high gain and efficiency increase.

The different authors has designed different DRH and QRH antenna for various application to reduce size of antenna and to improve gain, bandwidth, efficiency and VSWR parameters so forth.

4. CONCLUSIONS

An extensive review of horn antenna for EMC testing and radar application has been carried out. Gain, bandwidth and efficiency of various DRH antennas have been identified. After study of literature survey it is conclude that as compare to simple horn antenna, DRH antenna gives better result. Also there is benefit of QRH antenna over DRH antenna that they are dual-polarized.

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