Novel TEM Horn Antenna Based on the Linearly Tapered Slot Antenna

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Abstract- A novel TEM horn antenna is proposed by unite its typical structure and the linearly tapered slot antenna structure. The simulation reveals that the proposed antenna performs best in the port matching and has the similar gain with the typical TEM horn antenna, which are much remarkable than those of the linearly tapered slot antenna. Significantly, the proposed antenna can be fabricated based the PCB (printed circuit board) technology which is lower in cost and easier in implement than the typical TEM horn antenna used to be made with complete metal structure.

I. INTRODUCTION

TEM horn antenna has been a viable candidate for the ultrawideband (UWB) communication, imaging radar, and pulse radiation applications with its extremely-wideband, nearly dispersion-less characteristics and simple structure [1]. The arms of TEM horn antennas are always metal with different changes to obtain desired characteristics for special applications. For example, the antennas with two metal plates (sometimes one plates with a giant ground plane) flaring both linearly in E-plane and H-plane [2], linearly in E-plane but functionally in H-plane [3], both functionally (like exponentially, elliptically etc.) in E-plane and H-plane [4], antennas with expended metal plates and resistive loads made of metal [5] or dielectric [6], the functional expansion can improve the matching between the feeding point and the free space, the resistive loads are always used to reduce the aperture reflections at low frequencies. Besides, a novel combined antenna approach has been proposed for the TEM horn antenna to reduce the turn-on frequency and improve gain [7]. For feeding the TEM horn antennas excited by balanced-mode signals, ultra-wideband balanced-unbalanced mode transformation (balun) must be constructed using transmission lines. The baluns utilized to feed the TEM horn antennas in the works above-cited are mostly the microstrip type that can transform the unbalance-mode signals from the coax lines into the needed balanced-mode signals. The desired expansion for a TEM horn antenna is always realized by machining or 3-D printing [8], the cost and complexity of which depend on the function followed by the expansion.

In this paper, the authors propose a novel TEM horn antenna designed on the basis of the linearly tapered slot antenna (LTSA), which can be implemented by the PCB (printed circuit board) technology. The antenna proposed in this paper is composed by inserting two isosceles-triangle metal plates along edges of the linearly tapered slot which are also height-legs of bases of the two isosceles-triangles, as



Fig. 1. Schematic of the proposed antenna.

shown in fig. 1. For fabrication, the metal plates and the tapered slot are made up on the substrate FR4 (permittivity of 4.3, thickness of 1 mm and tangent loss of 0.001) and the substrate F4b (permittivity of 2.65, thickness of 1 mm and tangent loss of 0.001) respectively. The all-PCB structure is lighter in weight and easier in manufacture. The antenna is modeled and simulated in Ansoft HFSS.

II. ANTENNA DESIGN AND ANALYZE

Before the design, characteristics of the proposed antenna, the single TEM horn antenna and the single LTSA are simulated and discussed. The antennas are modelled just using Perfect-E suffices following the schematic in fig. 1. Structural parameters of the antennas are listed in table I. W_0 and g_0 are the initial width and height of the TEM horn antenna respectively, W_1 and W_2 are the terminal width and height of the TEM horn antenna respectively. And g_0 and W_2 are the initial width and terminal width of the linearly tapered slot respectively. Length of both the TEM horn antenna and the LTSA is L_0 .

Fig. 2 shows the simulated VSWRs of the three antennas and the measured VSWR of the proposed antenna. It can be observed that the proposed antenna and the typical TEM horn antenna have the similar characteristic in port matching, which is much better than that of the LTSA. VSWRs of the proposed



Fig. 2. VSWR of the typical TEM horn antenna, the LTA and the proposed antenna.



Fig. 3. Input impedances of the typical TEM horn antenna, the LTA and the proposed antenna.

antenna and the TEM horn antenna are both less than 2 in the frequency from 2.3 to 15 GHz, and the curve of the proposed antenna is much flatter than that of the TEM horn antenna, especially in the low-frequency range from 2.3 to 9.5 GHz, which is more obviously revealed by the input impedance curves shown in fig. 3. But the imaginary part of the input impedance for the proposed antenna arises along with the lowering frequency, just like that of the LTSA, which makes the impedance inductive. The inductance is created by the microstrip-line/slot-line transition balun, in which the circle slot is a wideband quarter-wavelength long short-circuited transmission line that has inductive input impedance when the electrical length of the transmission line is less than a quarter.

As shown in fig. 4, the three antennas have the similar cross-polarization gain, but the LTSA has its co-polarization gain notably lower than those of both the TEM horn antenna and the proposed antenna. Besides, the proposed antenna and the TEM horn antenna have the similar low-frequency co-polarization gain, the proposed antenna has its high-frequency co-polarization gain slightly decreased, and the frequency demarcation is about 9 GHz.

III. CONCLUSION



Fig. 4. Gain of the typical TEM horn antenna, the LTA and the proposed antenna.

A novel TEM horn antenna that can be fabricated based on the PCB technology is proposed. The antenna is designed based on the linearly tapered slot antenna structure by inserting two isosceles-triangle metal plates along edges of the linearly tapered slot which are also height-legs of bases of the two isosceles-triangles. The antenna proposed has the best port matching characteristic and the similar radiation characteristics. Significantly, the proposed antenna is easier for implementing than the typical TEM horn antenna that is always fabricated using metallic structure.

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