

A Novel Wideband and Wide Beam High Gain Unidirectional Dipole Antenna for Next Generation WLAN Applications

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Abstract— In this paper, a novel wideband and wide beam unidirectional magneto electric (ME) dipole antenna element for Wi-Fi-7 (5.18-7.125GHz) applications is presented. The element is printed on the low-cost substrate and is showing extremely wide band characteristics with impedance matching over more than 50% of fractional bandwidth. A tilted ME antenna with a tilted parasitic scatterer is radiating across wide frequency range, while meeting over 100° angular width in both E-plane and H-plane across the whole wide bandwidth from 5GHz to more than 8GHz. Adding one parasitic scatterer on each side of the dipole, broaden the bandwidth of antenna as well as directing the electromagnetic wave propagation to the sides which as a result broadens the beamwidth.

Index Terms—Dipole antenna, wide beamwidth, unidirectional antenna, parasitic scatterers, magnetoelectric (ME) antenna, wideband antenna, Wi-Fi, WLAN application.

I. INTRODUCTION

With the advent of IEEE 802.11ax & 802.11be wireless communication Technologies, there has greatly increased demand of wideband and widebeam unidirectional antennas that could accommodate farther and at the same time broader reach and achieve high throughputs. Antenna array system needs to maintain low side lobe level to increase coexistence among neighboring cells to participate in frequency re-use due to limited spectrum availability.

To achieve such electrical properties, a magneto-electric dipole antenna with scatterers needs to be employed to broaden the bandwidth and wider beam to cover entire cell region depending on mounting position of the antenna array. These antenna elements show stable performance and broad antenna patterns in elevation and azimuthal planes over the wide operations bands. To satisfy the requirements of both bandwidth and beamwidth in practical applications, such as increased wide coverage, different kinds of elements are proposed in the literature. For instance, a magneto electric dipole is shown in [1] is a bent metal which is showing wide beam properties over a wide frequency range (3.25-7.75 GHz). However, the structure is not practical for antenna mass production The bowtie dipole element above the ground plane is used in [2] to achieve wide beam pattern by adding a metallic bridge. Using this method, the radiation beamwidth of the antenna is 115° in H-plane and below 31° in the E-plan. A low-profile and wide beamwidth microstrip antenna is presented in [3]. Four isolated micro patches are proposed as the radiation components and are excited by compact differential-fed

network. By increasing the distance between the micro patches, the beamwidth in the E-plane could be broadened. The 3dB beamwidth of antenna can reach up to 116°. Besides, using parasitic radiators has been considered for improving 3dB beamwidth [4]. In [5], a wideband dual band ME dipole antenna is designed and studied. However, it is very difficult for the wideband antenna that the wide beamwidth capability in the H-plan and E-plane is realized in the whole operating higher frequency bandwidth. In this paper we are presenting a practical printed wide band antenna with wide radiation beam in both E-and H-plane.

II. ANTENNA DESIGN AND ASSEMBLY

The dipole antenna that we developed in this work is a magneto-electric (ME) dipole printed on FR-4 ($\epsilon_r = 4.3$, $\tan\delta=0.025$). In this manuscript we show all the steps for developing the wideband and wide beam antennas. The conventional printed dipole is not capable of providing wide beam in frequency range required for Wi-Fi 7 application from 5.18 GHz to 7.125 GHz. In the first step, we added one scatterer with 1mm longer length to add another resonance lower than the original resonant frequency of the conventional dipole. In the second step, we tilted radiators of conventional dipole with one scatterer to not only increase bandwidth but also concurrently increase beamwidth by redirecting the energy to the sides.

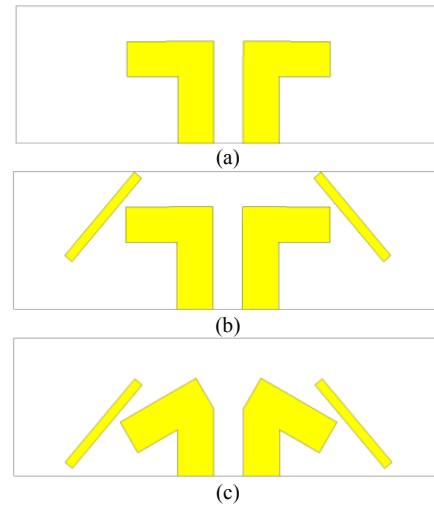


Fig. 1. (a) Conventional Dipole (b) Conventional Dipole with one scatterer (c) Tilted Dipole with one scatterer

Each antenna element is created from a tilted dipole with one scatterer printed on FR4 substrate. We assembled two elements in $+45^\circ$ and -45° inclination to create cross polarization. Element is fed by a gamma feed. It will help to create uniformity in radiation pattern over-the-air. Antenna system can take advantage of spatial diversity, and this helps combat fading and signal degradation caused by multipath propagation. It improves signal isolation between antenna elements. We can also take advantage of lower array gain rule for cross polarized antenna elements. The structure of proposed antenna design is shown in Fig.2.

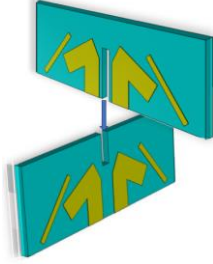


Fig. 2. Antenna Assembly

III. SIMULATION AND DISCUSSION

Based on the s-parameter results in Fig.3, conventional dipole element resonates for narrow band with high return loss at lower frequencies, while conventional dipole with one scatterer is resonating at lower frequency compared to dipole without scatterer. It became evident, element is not preferable design for wideband and wide beam applications. Tilted dipole element with one scatterer simulation shows simultaneous increase in bandwidth and beamwidth. Fig.3 shows improved return loss of the antenna element (red curve).

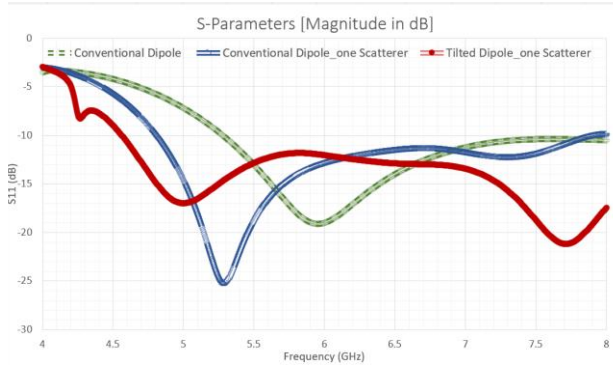


Fig.3. s-parameters comparison

Based on the one-dimensional radiation patterns of antenna elements in Fig.4, conventional dipole has lower azimuthal beamwidth of 80° . It's prudent to broaden band of operation and widen the beam to make it suitable to Wi-Fi applications. Tilted dipole with one scatterer shows increase in azimuthal beamwidth to over 100° , while staying resonant at higher frequencies without impact to radiation pattern. By tilting the radiators and adding scatterer, it will affect the distribution of

surface currents on the antenna structure. It will help reshape current distribution along the antenna element, and thereby improving antenna azimuthal beamwidth. It will also improve impedance characteristics of element across wide range of frequencies, making it ideal for wideband applications. Table I shows a quantitative comparison of beamwidth for the tilted dipole with one scatterer and the conventional design.

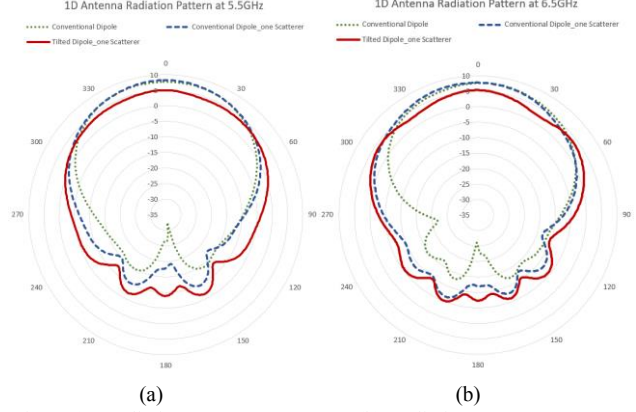


Fig. 4. (a) Radiation Patterns at 5.5GHz (b) Radiation pattern at 6.5GHz

Table I. Azimuth Beamwidth Comparison

Frequency	Conventional Dipole	Conventional Dipole + scatterer	Titled Dipole + scatterer
5.5GHz	80.4°	77.5°	118.9°
6.5GHz	78.5°	78.7°	132.6°

IV. CONCLUSION

In this paper, a novel ME dipole antenna with wide band, wide beamwidth, and simple structure has been demonstrated. The element performance has been simulated on FR-4 substrate which makes the antenna applicable for high volume applications. The dipole main radiating elements have been tilted and parasitic elements coupling to the main radiating elements helps to increase the bandwidth as well as increasing the beamwidth in both E- and H-Plane by directing the electromagnetic wave toward the sides.

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