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Wideband High Gain Compressed Dipole Antenna for Drone Jammer Application

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Abstract: - This paper presents a wideband high gain conical shaped dipole with reduced side-lobe levels. The dipole antenna is operating at higher order mode and having a compressed version of 3λ/2 length at its center frequency of operation. The dipole is made conical to achieve wide-bandwidth and the length is miniaturized by meandering the central portion of λ/2 length. The side-lobe level is reduced due to the meandered portion. The central meandered part is surrounded by one additional wide metallic ring. The 10-dB impedance bandwidth of 560 MHz (~10%) the antenna is at the deigned center frequency of 5.8 GHz. The side-lobe level shows approximately 10 dB at the center frequency of operation. The realized gain shows 5.21 dBi at the center frequency. The pattern has got elevation plane beam-width of approximately 33o for 360o azimuthal direction which is suitable for the drone jammer application.

Keywords: Higher order mode, Conical dipole, Wideband antenna, Side-lobe reduction, Jammer application

I. INTRODUCTION

Fundamental mode operation of dipole antenna suffers from low gain and wide beam-width due to single current domain formed on the antenna with nulls at two ends. Whereas, drone jammer applications require high gain and narrow beam-width to effectively spread noise signals to all direction. In this scenario, the drones can fly from all directions towards the target military base and the base should send jamming signals to them in order to avoid attack. The antenna should be mounted on the target base which should radiate large noise power in all direction. The bandwidth requirement is also high as the noise power needs high mount of bandwidth. For high power applications, microstrip patch antenna is not a suitable candidate because of the high substrate leakage. Wire antennas such as dipoles are one of the potential solutions for these kinds of applications. Another advantage of using dipole antennas is they have omni directional pattern which is indeed important for this application.

In literature, in recent years, higher order mode-based antennas were reported in large numbers owing to their attractive high gain property. Mostly, the publications were focused on planar microstrip patch antennas [1-4]. High gain and high bandwidth applications were reported in [5-6] by properly utilizing higher order modes and placing several modes close to each other in terms of frequency. Higher order mode operating antennas face challenge in that they produce large number of unwanted side-lobes. In [7-8], techniques such as introducing slots or meandering some parts of the antennas, were reported to eliminate the side-lobes.

In recent studies, the higher order mode operation of a narrow band printed dipole antennas was conducted [9]. The central part of the antenna was meandered to achieve low side lobes. In this present work, a wideband conical dipole antenna is chosen for the desired jammer application. Higher order mode is used here for achieving high gain. The original conical dipole is of 3λ/2 length. By meandering the central λ/2 portion, the antenna is miniaturized and the sidelobe level also reduced as compared to no meandering. A wrapping cylindrical ring is placed around the central part of the antenna in order to further reduce the side-lobes. The final design is having total length of 1.25λ instead of 1.5λ. So, the total length is reduced by 0.25 lambda (λ/4).

II. HIGHER ORDER MODE OPERATION OF DIPOLE ANTENNA

The fundamental mode of dipole antenna provides omnidirectional pattern without any side lobes and the current distribution is half wave (λ/2) on it. But for this present application the gain should increase in order to effectively throw power to the free space to jam the drone systems. So, a 3λ/2 mode dipole is chosen. For, 3λ/2 mode as shown in Fig. 1, the vector current profile (of the three current domains) is on opposite direction on the dipole arm. In this case, the side-lobes appear mainly due to the opposite polarity of the current on central portion

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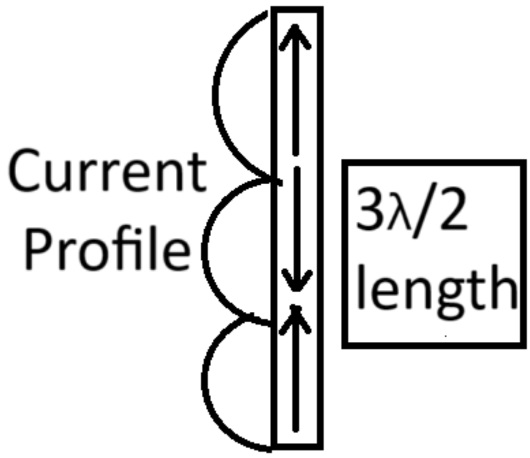


Fig. 1: The current profile and vector distribution on a dipole antenna

with respect to the two ends. The two extreme ends together work as array with current in the same direction and are responsible for enhancement of the gain. To alleviate that effect the central portion is kept meandered which is discussed in the next section.

III. MINIATURIZATION OF DIPOLE BY MEANDERING THE CENTRAL PORTION: SIDE LOBE REDUCTION

The meandering as shown in Fig. 2 of the central λ/2 portion i.e. λ/4 portion from each arm will cancels the radiation at the far-field of the central portion current, as the vector direction of the current is opposite in the meander lines. This reduces the side lobes for the dipole. The current exists on the other two ends intact and flows in the same direction. This increases the gain and narrows down the beam-width. In meandering the overall length of the dipole is reduced by λ/4. Only two end portions of λ/2 length will take part in radiation performance. These two will form array with a separation of λ/4. Some vertical currents will still be there on a and b position as shown in Fig. 2 which will produce some sidelobes. To curb this effect a cylindrical ring is placed around the central portion to restrict the radiation from the oppositely directed central current.

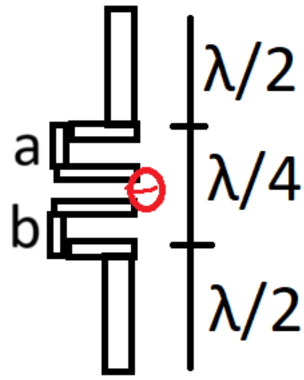


Fig. 2: Meandering the central portion of the 3λ/2 dipole

IV. CONICAL DIPOLE DESIGN WITH CYLINDRICAL RING STRUCTURE

A conical dipole of 3λ/2 length is taken (two conical arms) with conical end wire diameter d=3mm. The central λ/2 portion of the dipole meandered (λ/4 from each arm) as shown in Fig. 3. The total length of the meandered central portion is λ/4. The meandered line's length M=8.5mm and arm length L=27mm as shown in the figure. The feed is placed at the middle portion, shown 'red' in Fig. 3. A wide cylindrical hollow ring is placed surrounding the central meandered portion with a diameter of 18mm and height of 14mm as shown in Fig. 4. The full structure as shown in Fig.4(a) is simulated using CST Studio Suite [10]. In Fig. 4(b), a blue foam layer is attached inside the cylinder to support for the mechanical structure (in simulation).

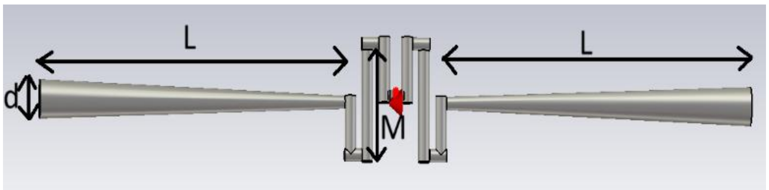
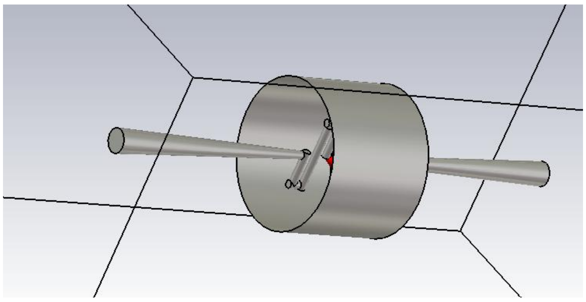
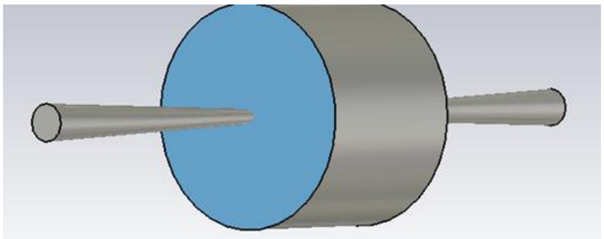


Fig. 3: Conical dipole antenna design with meandering the central λ/2 portion



(a)



(b)

Fig. 4: (a) Wide cylindrical ring is placed at the central meandered portion, (b) Blue portion shown in picture is foam for mechanical holding of the structure

V. RESULTS AND DISCUSSIONS

The simulated -10 dB impedance bandwidth shows 560MHz (5.44-6GHz) bandwidth at the center frequency of 5.8GHz as shown in Fig. 5. The realized gain plot in Fig. 6 shows that a 5.21 dBi gain at the center frequency of 5.8GHz. However, the gain is falling down a little bit towards the two extreme edges of the frequency band, not below approximately 4.3 dBi. The simulated absolute gains on two orthogonal vertical planes are shown in Fig. 7, which confirms that the pattern has a balanced gain profile in both planes and on both the directions. The simulated co and cross poles of the normalized radiation patterns are plotted in Fig. 8. At Phi=0^o plane, the cross polar discrimination is significantly high but in the other vertical plane Phi=90^o the cross polar discrimination is 10 dB, which can be acceptable for this type of application. Fig. 9 shows the 3D gain pattern of the antenna. The pattern is omnidirectional with respect to the axis of the antenna, which is required for the jammer application as discussed in the introduction section. The side-lobes shown in this figure are insignificant as compared to the main beam. The vertical beamwidth is approximately 33^o as evident from the Fig. 7 which is also an important constraint of jammer applications.

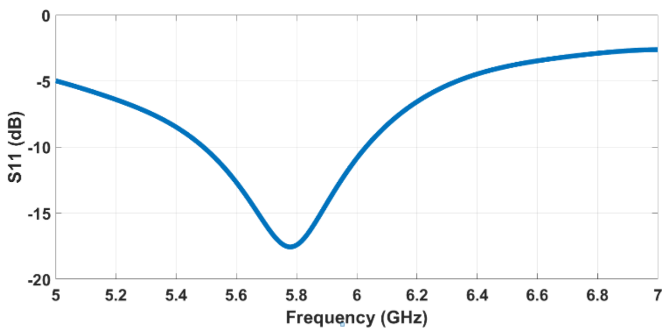


Fig. 5: Simulated S-parameter plot over frequency

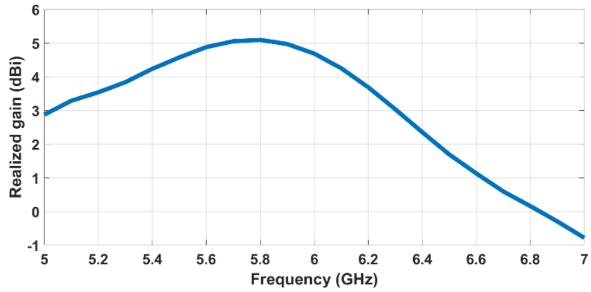


Fig. 6: Simulated realized gain over frequency at the azimuthal direction with respect to the vertical antenna axis

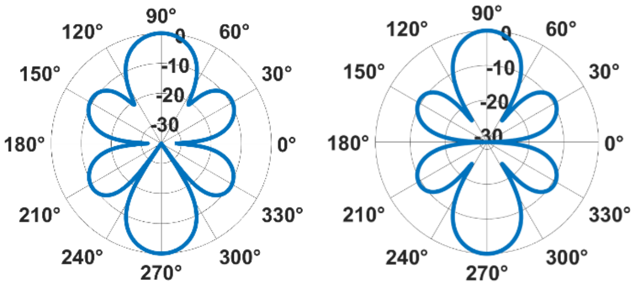
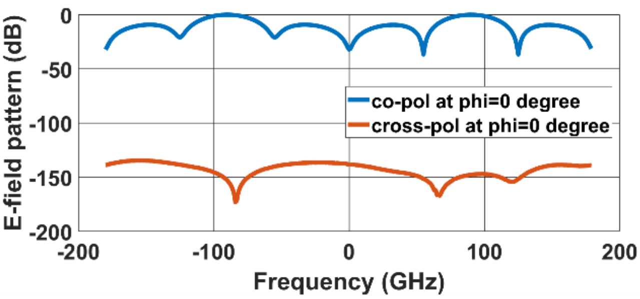
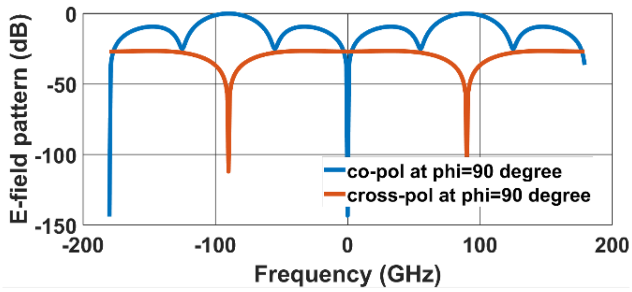


Fig. 7: Simulated absolute gain plot on two vertical planes, Left: Phi=0º, right: Phi=90º, respectively



(a)



(b)

Fig. 8: Simulated normalized gain plots on two vertical planes: (a) co and cross poles on Phi=0º and (b) co and cross poles on Phi=90º

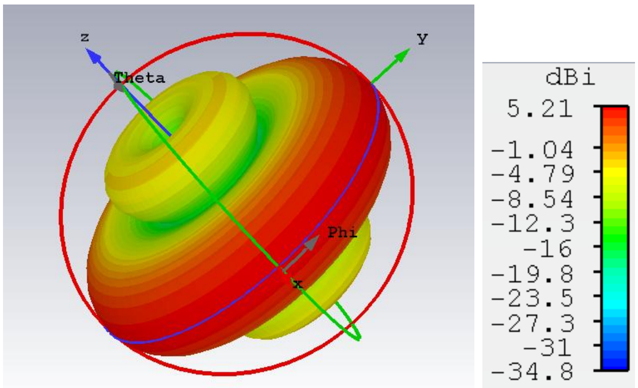


Fig.9: Simulated 3D gain pattern of the antenna. The antenna axis is along Z-axis in the figure.

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