UHF SATCOM Broadband CP Antenna: Moxon Type Bent-dipoles over a Ground Plane

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Abstract— In this paper, we investigate and compare two different antenna types for UHF SATCOM applications; proposed Moxon type (bent dipole) and conventional egg beater (loop) antennas in terms of antenna performance and physical size. Bent dipole and egg beater antennas are simulated using HFSS software. Prototype antenna for Moxon type is also fabricated and measured for its return loss using Agilent network analyzer and compared to that of an egg beater antenna. Antenna gains are also simulated. Simulation results show that Moxon type antenna has more impedance bandwidth than egg beater antenna with smaller dimensions and hence can be used for broadband SATCOM applications.

1. INTRODUCTION

For UHF SATCOM mobile applications, antennas are required to have high-performance including a broadband operation, circular polarization as well as a large angular coverage from horizon to zenith. For airborne systems at these frequencies, wavelength could be on the order of meters and conventional antennas may be "too big" for deployment. Compact size antennas with desired antenna performance become very crucial part of these airborne systems. In this paper, a novel antenna "Moxon type" bent dipole is proposed for circular polarization and its performance is compared to a conventional egg beater antenna whose dimensions are larger than the proposed Moxon type antenna.

For UHF satcom applications, broadband antennas can be employed such as sleeve dipoles [1]. However, for mobile applications, the antenna size is critical and obtaining a circular polarization with sleeve dipoles will result in complicated antenna structures. Egg beater antennas are another choice for obtaining circular polarization with loop antennas at UHF frequencies [2]. Egg beater antennas may not be easily deployable on mobile platforms due to their dimensions. In this paper, we implement a Moxon type antenna [3] (bent dipole over a ground plane) to obtain circular polarization with its compact size compared to conventional eggbeater antenna which comprises two circular loops fed with a quadrature coupler for circular polarization. Rest of the paper is organized as follows: in Section 2, moxon type bent dipole antenna and egg beater antenna will be described in details, in Section 3, simulation and experimental results are given and finally paper is concluded.

2. MOXON TYPE BENT DIPOLE AND EGG BEATER ANTENNAS

2.1. "Moxon Type" Bent Dipole Antenna for Circular Polarization

A sketch of one of the bent dipole antenna is shown in Figure 1. The length of the one arm of the dipole is $L + W$, the arm is bent toward a ground plane from L distance away from the center

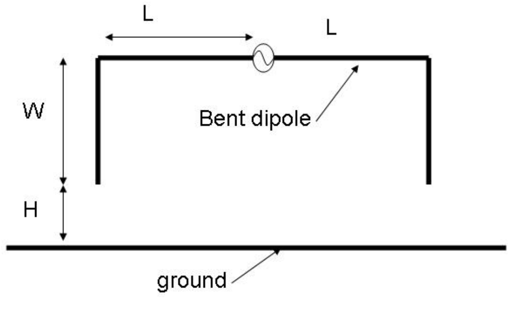

Figure 1: Bent dipole antenna over a ground plane.

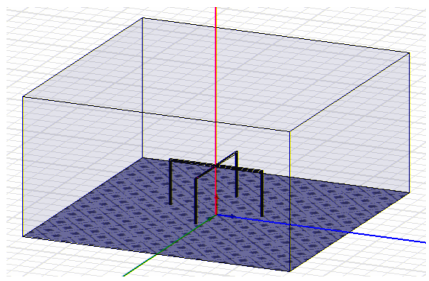

Figure 2: Two perpendicular bent dipole antennas for circular polarization radiation.

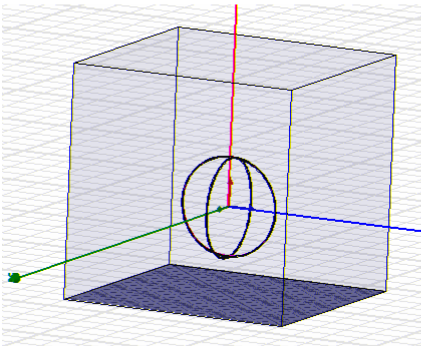

Figure 3: Two circular loop antennas for circular polarization radiatio.

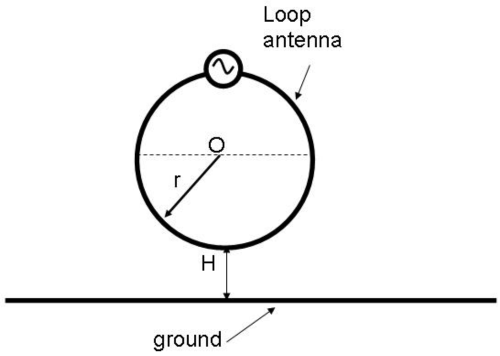

Figure 4: Loop antenna over a ground plane.

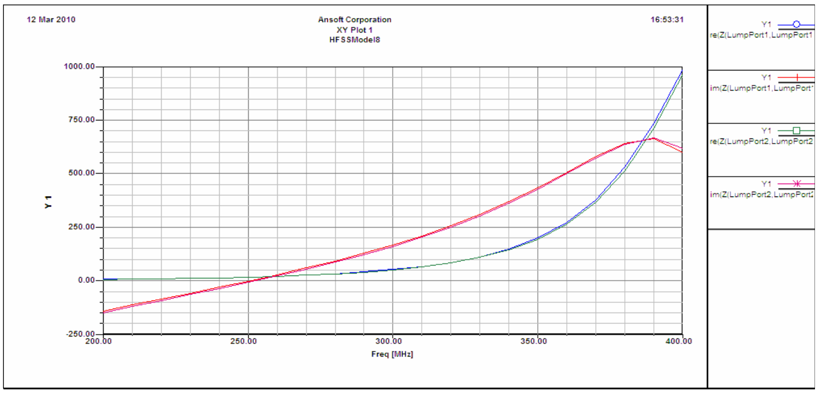

Figure 5: Z_{11} and Z_{22}, impedances of the dipole antennas.

of the dipole. The end point of the bent dipole antenna is H away from the ground plane as in Figure 1. The bent dipole is fed from the center of the antenna with a differential input. The RHCP is obtained simply by placing two dipole bent antennas perpendicular to each other, one in x-z plane, the other in y-z plane as in Figure 2. The bent dipole antennas are made of four L shaped metallic rectangular conductors which have square cross-sectional areas.

The electromagnetic simulations are performed using HFSS (for antenna) and ADS (matching circuit) software. For the simulations, the geometrical parameters are chosen as follows to obtain good RHCP properties as well as good impedance matching: W — length of vertical arms — 126.5 mm, H — distance from the ground plane — 12 mm, L — length of horizontal arms — 138.5 mm, Cross sectional area of the antenna is 4×4 mm (copper rectangular tubes).

The ground plane is finite and its dimensions are $4L \times 4L$. The power handling capability has not been taken into consideration for simulations. The material for the antenna conductor is chosen as copper. The two dipole antennas are fed by a 90 degree phase shift from the two lumped ports in simulations. In real implementation, the antennas are fed by a quadrature coupler connected to the center of the dipole antennas.

2.2. The "Eggbeater" Antenna for Circular Polarization

To form the eggbeater antenna, two circular loop antennas are located perpendicular to each other as shown in Figure 3. The loop antennas are made of metallic circular conductors which have square cross-sectional areas. A sketch of one of the loop antenna is shown in Figure 4. The radius of the loop is r and the loop antenna is H away from the ground plane as in Figure 4. The RHCP is obtained simply by placing two loop antennas perpendicular to each other, one in x-z plane, the other in y-z plane as in Figure 3. One of the loops is shifted in z-direction with respect to the other loop so that two loops do not intersect.

The electromagnetic simulations are performed using HFSS software. For the simulations, the geometrical parameters are chosen as follows to obtain good RHCP properties as well as good

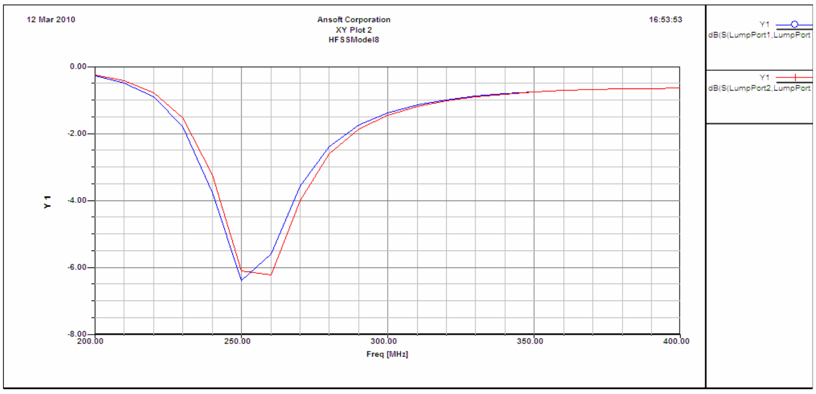

Figure 6: S_{11} and S_{22}, input return loss of the bent dipole antennas.

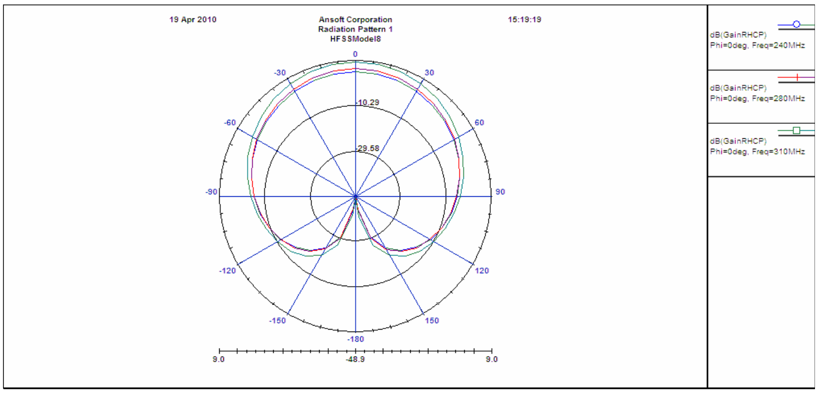

Figure 7: Bent dipole RHCP gain radiation pattern at 240, 280 and 310 MHz.

Table 1: Maximum RHCP and LHCP antenna gains for bent dipoles.

Frequency (MHz)	Max Gain (dB — RHCP)	Max Gain (dB — LHCP)
240	3.98	−9.34
280	5.31	−10.2
310	8.18	−8.85

matching: r — radius of the loops — 170 mm ($2 * \pi * r$ is around one wavelength at 280 MHz), H — distance from the ground plane — 130 mm (approximately 1/8 wavelength at 280 MHz). One of the loop is shifted 5 mm in z-direction with respect to the other loop. Cross sectional area of the antenna is 4×4 mm (copper rectangular tubes). The material for the antenna conductor is chosen also as copper. The two loop antennas are fed by a 90 degree phase shift from the two lumped ports. In real implementation, the antennas will be fed by a quadrature coupler connected to the center of the loop antennas.

3. SIMULATION AND MEASUREMENT RESULTS

Figures 5 and 6 displays the input impedances and the S parameters of the two dipole antennas, real part (green, blue curves) and imaginary parts (red curve). For the above assumed dimensions, it is seen that antennas have series resonance around 250 MHz, and the real part of the impedance is changing from 20 to 60 Ohms between the interested frequency range of 240 to 310 MHz.

With these input impedance values, it seems feasible to be able design a matching circuit such that the two antennas will be matched easily to a single source. The antenna radiation pattern gains are plotted for the three frequency points in the band, at 240, 280 and 310 MHz. RHCP performance at 240, 280 and 310 MHz are shown in Figure 7.

Maximum of the gain patterns for both RH and CH are summarized in Table 1.

Figure 8 displays the input impedances of the two loop antennas, imaginary part (red curve)

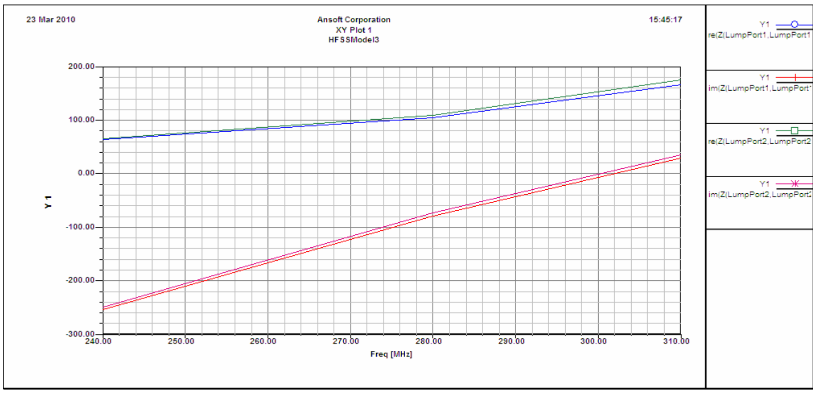

Figure 8: Z_{11} and Z_{22}, impedances of the loop antennas.

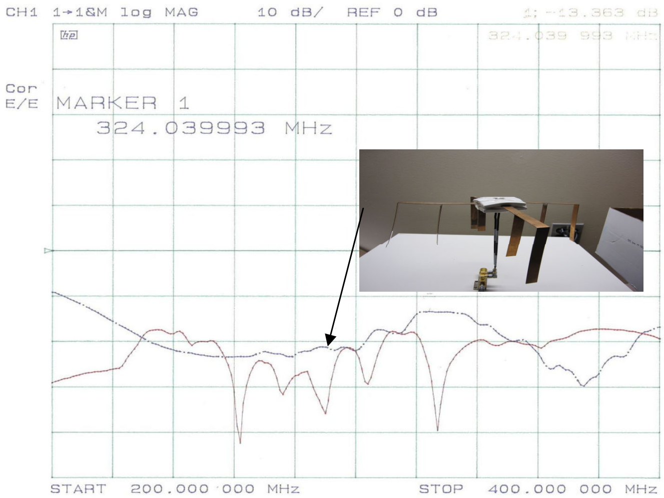

Figure 9: Measured S_{11} of the Moxon and eggbeater antennas.

Table 2: Maximum RHCP and LHCP antenna gains for eggbeater.

Frequency (MHz)	Max Gain (dB — RHCP)	Max Gain (dB — LHCP)
240	5.59	−4.55
280	5.94	−5.02
310	5.40	−5.18

and real parts (green, blue curves). For the above assumed dimensions, it is seen that antennas have series resonance around 300 MHz, and the real part of the impedance is changing from 60 to 180 Ohms between the interested frequency range of 240 to 310 MHz. One should also look at the S-parameters of the antenna since the antennas will be fed from a single source. Figure 9 shows the S_{11} and S_{22} of the antennas in dB versus frequency.

Maximum of the gain patterns for both RH and LH are summarized in Table 2.

When we compare the bent dipoles to egg beater, we see that size is much smaller for the same frequency band of operation. Polarization ratio (RHCP-LHCP) is also improved for the bent dipole. A prototype antenna was fabricated resulting in a height of 17.5 cm and maximum horizontal length of approximately 25 cm as seen in Figure 9. Double vertical elements are added for broader bandwidth operation. In Figure 9, S_{11} of both Moxon bent dipoles and egg beater antennas are shown for the band of 240–310 MHz. Both antennas are well matched within the desired band.

4. CONCLUSION

Simulation results show that the bent dipole antenna has good return loss properties within the frequencies of 240–310 MHz UHF satcom band, and its physical size is much smaller compared to an conventional egg beater antenna.

A prototype antenna is implemented and measured for its return loss and it is shown that S_{11} is well below -10 dB within the UHF satcom band. Simulated antenna gains show that RHCP gain is changing between 4 to 8 dB within the band and show RHCP/LHCP ratio of 13–17 dB within the band.

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