Abstract – A family of Broadband antennas (HF-VHF-UHF) for installation on combat cars had been investigated. The Discone type appeared to provide the lowest profile (0.1λ at the lowest frequency) with minimal gain of -3 dBi in omnidirectional azimuth coverage and ±20° elevation coverage.

Index Terms - Tactical Antennas, Broadband Vehicular Antennas.

I. INTRODUCTION

Tactical antennas, mounted on vehicles, play an important role in many combat and anti-terror operations. The envelope of the antenna parameters requires broadband frequency (HF, VHF and UHF in one terminal), omnidirectional coverage and high power handling capability. A major consideration in these antennas is minimal size and low visibility.

In the current work, our main goal had been to develop a broadband radiator in the frequency range of 25-1000 MHz, with omnidirectional beam in azimuth and ±20° in elevation, while maintaining minimal gain of -3 dBi within this coverage. The polarization should be mixed, i.e. mainly vertical but with some horizontal component. The maximal height of the antenna, while mounted on the roof of a combat vehicle such as a Hammer (whose roof area is 2.5 x 1.8 meter), should be lower than 1.4 meter.

II. ANTENNA TYPES

The Biconical antenna (figure 1) is probably the best solution in terms of matching and gain but its height should be a quarter wavelength in the lowest frequency or at least 0.2λ. The Discone antenna (figure 2) which is basically a half Biconical with an upper ground plane, has lower gain and less matching results but with significant shorter height of 0.1λ to 0.15λ at the lowest frequency. The spiral antenna while mounted on a ground plane, radiates towards the sky. It has been found by simulations and by experiments that the available gain towards the horizon is lower than -10 dBi and thus this solution is not applicable for the relevant requirements. Other possible solutions are variants of these types: Biconical with folded arms (figures 3-4) and multi-wire dipoles (figure 5) fed by a printed BALUN. All the solutions are sensitive to the presence of the metallic roof of the car.
III. TEST MODELS AND RESULTS

In order to take the roof into full account, we have used a 1:10 car model and tested several reduced size antennas in 10:1 frequency range (250-10000 MHz) accordingly. All models were tested with a metallic ground of 25 x 18 cm which is the relevant roof size of the "Hammer" combat car.

Special attention should be given to the feed structure of the antennas. The feed design plays a major role in the matching process and also is the critical limit for the power handling of the antennas. For the Biconical antennas (also in the folded arms versions) we suggest an unbalanced feed as shown in figure 6. For the Discone antenna we suggest an unbalanced feed in which the diagonal arms are soldered to the inner conductor of a coax line and the upper ground arms are soldered to the outer conductor of the coax, as shown in figure 7. Some improvements in this feed design may validate the Discone as a viable alternative.
The Biconical with height of 25 cm (2.5 m in real situation) gave the best matching as presented in figure 8. The Discone with heights of 14-18 cm and the multi-wire dipoles with lengths of 12-14 cm were hardly matched in such broadband range as presented in figure 9. The optimal solutions which fulfill the required height of 14-17 cm (0.12-0.14λ at the lowest frequency) were Biconical antennas with folded arms as shown in Figures 3-4. The actual wires were bended in straight or curved lines in order to reduce the overall size. The optimal number of arms was found to be eight, but six arm Biconical antennas are also possible.

![Figure 8](image8) Measured return loss of the 25 cm Biconical VSWR < 3:1 in 250 - 3000 MHz range.

![Figure 9](image9) Measured return loss of the 15 cm Discone VSWR < 4:1 at 250-3000 MHz range.

Examples of measured radiation patterns for the azimuth coverage are given in figure 10 for the multi wire (flat azimuth patterns but low gain), in figures 11-12 for the 17 cm folded Bicone and in figures 13-14 for the 14 cm folded Bicone. In all tested patterns the polarization is mainly vertical.

![Figure 10](image10) Measured azimuth cuts of the Multi-Wire (300 -2450 MHz).

![Figure 11](image11) Measured azimuth cuts of 17 cm Height Biconical at 600 MHz in two polarization with a reference 6 dBi Antenna Gain is -2 dBi.

![Figure 12](image12) Measured azimuth cuts of 17 cm Height Biconical at 1800 MHz in two polarization with a reference 6 dBi Antenna Gain is 0 dBi.
A detailed comparison between folded Biconical antennas with heights of 14 cm and 17 cm reveals that the azimuth patterns are very close (ripple of +/- 1 dB) but the gain of the higher antenna is larger by 1-2 dB, especially at the higher frequencies. The specific choice of the height should be made with compliance to the tactical shape and visibility of the combat car.

IV. CONCLUSION

The optimal solution for reduced size tactical antenna, mounted on the roof of a combat car whose area is 2.5 x 1.8 meter was found to be the Biconical antenna with 8 folded upper wires and 8 folded lower wires. It has been demonstrated that this antenna can be matched in the range of 25-1000 MHz and provides -3 dBi to 0 dBi gain for height of 1.7 m and -5 dBi to 0 dBi gain for height of 1.4 m.

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