Proceedings of ISAP2007, Niigata, Japan

Multi-Wideband Antenna Using A Novel 3-D Multi-Branch Loaded-Monopole For GSM-Family and Other Cellular Applications

Marai M. Abousetta[1], *member, IEE* and Salah I. Y. Al-Mously [2], *member, IEEE*
School of Applied Sciences and Engineering, Academy of Graduate Study,
Tripoli, Libya.
[1] maraibusetta@yahoo.co.uk, [2] salah.mously@hieb.edu.ly

1. Abstract

A design of a novel 3-D multi-branch loaded-monopole antenna for cellular hand-set and portable equipments will be presented in this paper. The suggested single-feed antenna is covering all GSM family standards including the 3G-UMTS, and WLAN+ Bluetooth. A loaded-monopole was adopted to decrease the antenna length and make it more practical for the cellular hand-set. A genetic algorithm was used to optimize the loaded-monopole length, loading length, and branches length.

2. Introduction

Research efforts in upgrading the performance of cellular handset using external antenna, like monople and helix, without altering its basic function have been presented. These upgrading comprise first, its ability to operate with multi-resonance frequency, and second in designing antenna that occupy less space.

Many types of single-feed wire antenna with (monopole or/and Helix) were suggested to operate with different frequency standards. Some works has been done in the field of multi-band terminal antenna design, including dual-band antenna [1]–[7] and triple-band antenna [8]. The antenna in [1] uses two helical elements, the antenna in [2]-[3] uses three monopoles, the antenna in [4] uses multi-branch monopole, the antenna in [5] uses a stepped and a tapered-stepped monopole, the antenna in [6]-[7] uses a monopole inside a helix, while the antenna in [8] uses a monopole inside a double-helix.

To design an antenna that firstly, can operate with GSM-family standards including the 3G-UMTS and WLAN+ Bluetooth, secondly, suitable for cellular handset and portable equipments like PDA, and thirdly, occupy less space, a novel 3-D multi-branch loaded-monopole was proposed. A genetic algorithm was used for optimizing the antenna dimensions to achieve an impedance bandwidth less than -10dB for the GSM-family frequencies and other interested frequencies. Also, a finite-element based solver was used to achieve the proposed antenna design.

3. Antenna Structure

The photo of the proposed antenna prototype is shown in Fig. 1. Fig. 2 shows the dimensions of the antenna structure. As shown in Fig. 2, a single-feed loaded-monopole with four branches was adopted. Each two equal-length branches are place in a plane that is perpendicular to the plane of the other two equal-length branches. The loaded-monopole antenna should works for the lower band and the branches should work with the other high bands. The loading on the monopole decreases it's basic $\lambda/4$-length about 16.6%.

ISBN: 978-4-88552-223-9 C3055©IEICE

4. Simulation and Experimental Results

A Genetic Algorithm (GA) was used to optimize the proposed antenna dimension and achieving the cost function which gives return loss less than -10dB for the standards bandwidth of E-GSM 900, GSM 1800/DCS, GSM 1900/PCS, 3G-UMTS, and WLAN+Bluetooth / 2.4 GHZ. A finite element-based package (HFSS), from HP EEsof Design technology, was used to design and calculate the proposed antenna properties. The monopole length, and spacing, height and length of the branches were found and optimized using the adopted package and as shown in Fig. 2. The antenna is attached to the top centre of a metal box (100x50x20 mm) to simulate the cellular handset as shown in Fig. 3. Fig. 4 shows the simulated and measured input return loss versus frequency. A BOONTON 2300 scalar network analyzer was used to measure the input return loss. If the antenna is attached in off-centre position, the maximum radiation plane will be tilted according to distance from centre. As we can see from Fig. 4, the impedance bandwidths under -10dB can cover the cellular standards; E-GSM 900, GSM 1800/DCS, GSM 1900/PCS, 3G-UMTS, and WLAN+Bluetooth. Fig. 5 shows the azimuth and elevation planes radiation patterns at the adopted frequencies. The antenna is vertically polarized.

5. Conclusion

A single-feed 3-D multi-branch loaded-monopole antenna was designed and investigated experimentally and using a finite element-based package. A genetic algorithm was used to optimize the antenna dimensions. It was shown that by selecting appropriate lengths of the monopole, branches and spaces between branches, an antenna that can operate with most cellular standards (E-GSM 900, GSM 1800/DCS, GSM 1900/PCS, and UMTS) in addition to special applications like WLAN+Bluetooth can be achieved. By loading the monopole, it's basic $\lambda/4$-length can be decreased by 16.6%. The input return losses in the operating bandwidths were less than -10 dB (VSWR < 0.2).

References

[1] P. Haapala, P. Vainikainen, and P. Eratuuli, "Dual frequency helical antennas for handsets," IEEE VTS 46th Vehicular Technology Conference Proceedings vol. 1, 00.336-338, April 28-May 1, 1996, Atlanta, GA.

[2] D. Liu, "Analysis of a closely-coupled dual band antenna," Wireless Communications Conference, Boulder, Colorado, Aug.19-21, 1996, pp.86-89.

[3] D. Liu, "A Dual-band antenna for cellular applications," IEEE Antennas and Propagation Society International Symposium and URSI Radio Science Meeting Proceedings vol. 2, pp786-789, June 21-26, 1998, Atlanta,GA.

[4] Duixian Liu, "A Multi-Branch Monopole Antenna for Dual-Band Cellular Applications," 1999 IEEE Int. Antennas Propagation Symposium Dig. vol. 37, pp. 1578 - 1581, June 1999

[5] Guangping Zhou and Bahadir Yildirim, "A multi-band fixed cellular phone antenna," 1999 IEEE Int. Antennas Propagat. Symp. Dig. vol. 37, pp. 112 - 115, June 1999

[6] S. I. Al-Mously and M. M. Abousetta, "Stepped And Tapered-Stepped Constructions Of A Monopole Antenna For Handset Mobile Telephones" 3G-2003 conference, 23 June, 2003, IEE, Michaeal Fraday House, Stevenage, Herts, United Kingdom, SG1 2AY. http://conferences.iee.org/3G2003/.

[7] Ziad K. Alhamdani, Marai M. Abousetta, Mohammed E. Al-Daghistani, Salah I. Al-Mously, and Khadija F. Omran, "Dual-Frequency Operation For A Hand-Set Mobile Telephone With Reduced EMW Hazard" Antenna and Propagation Conference AP'2000, (No. 1125), Switzerland / 9-14 April 2000.

[8] Salah I. Al-Mously, Mohammed E. Al-Daghistani, Ziad K. Alhamdani, Marai M. Abousetta,, and Khadija F. Omran, "Three-Element Array Antenna With Triple-Frequency Operation in Mobile Telephone," The 10th Mediterranean Electrical Conference, Paper No. MEL0119, May 29-31, 2000, CYPRUS.

Fig. 1 The photo of the proposed antenna.

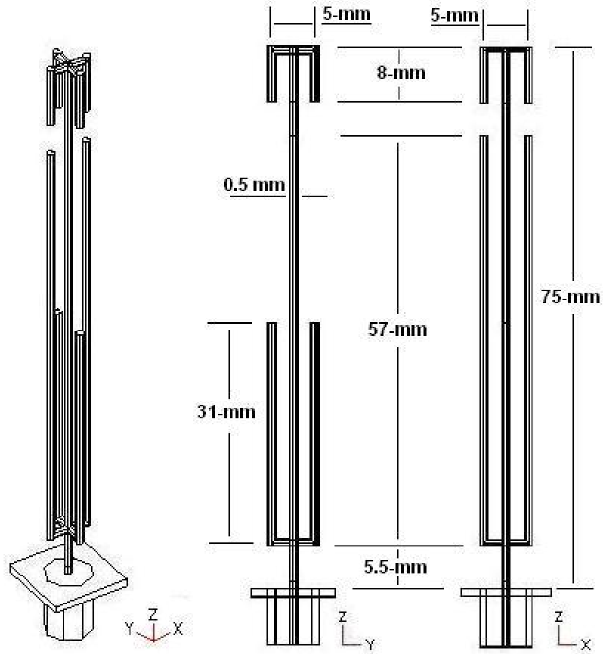


Fig. 2 The antenna configuration with dimensions.

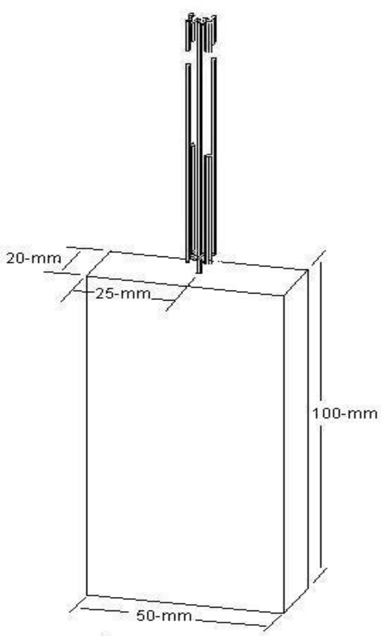


Fig. 3 3-D multi branch loaded-monopole antenna mounted on a metal box.

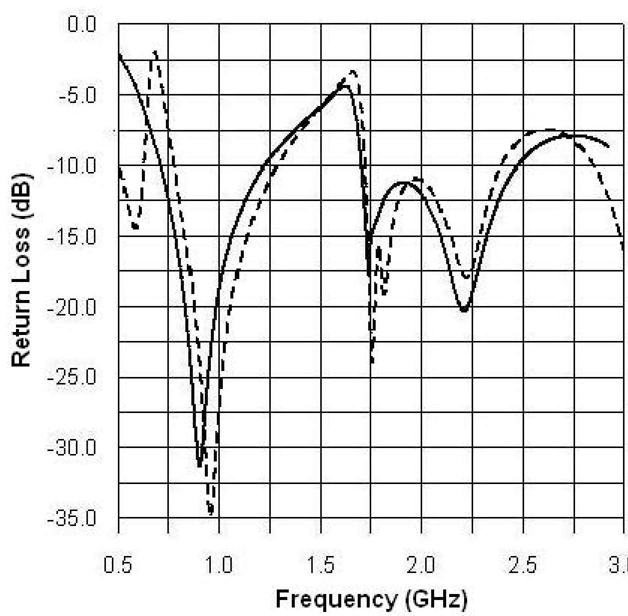
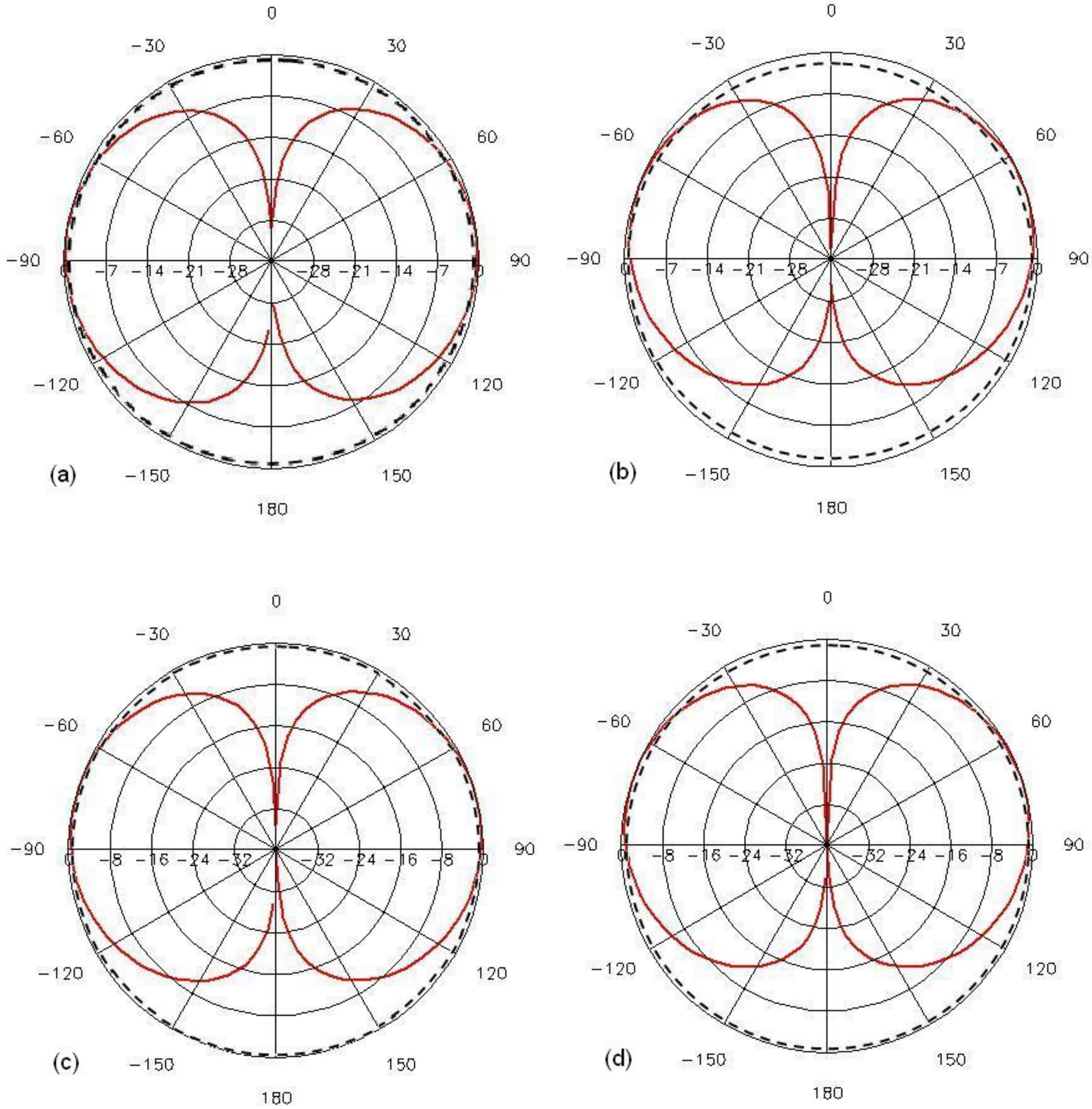


Fig. 4 The simulated (dashed-line) and measured (solid-line) of the return loss in dB with frequency.



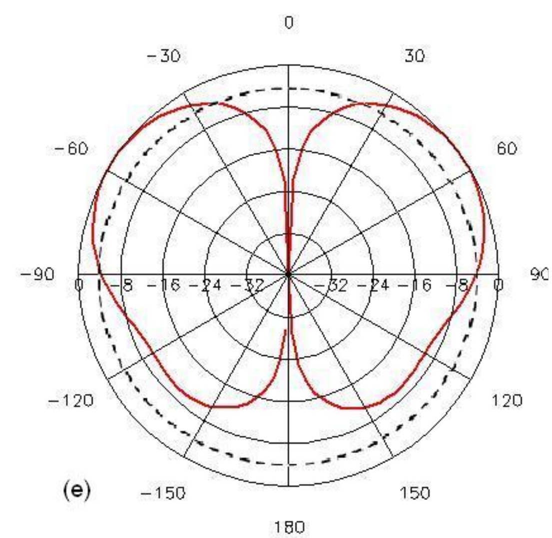


Fig. 5 Azimuth plane radiation pattern (dashed line) and elevation plane radiation pattern (solid line) at; (a) 920 MHz, Max. directivity = 1.93dBi, (b) 1795 MHz, Max. directivity = 2.51dBi, (c) 1912.5 MHz, Max directivity = 2.27dBi, (d) 2042.5 MHz, Max directivity = 2.50dBi, and (e) 2400 MHz, Max. directivity = 3.73dBi.