휴대 단말 주파수 대역에서 동작하는 차량용 안테나 설계

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Antenna Design of Mobile Frequency bands for Vehicular Application

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요 약

본 논문은 차량용 휴대폰 단말기 대역의 안테나를 설계하였다. 제안된 안테나는 효과적으로 이중대역 동작을 할 수 있도록 저가격으로 쉽게 제작할 수 있는 FR 4 기판 위에 설계되었다. 제안된 모바일 안테나는 여러 가지 휴대 단말기 주파수 대역인 GSM(880∼960 MHz), AMPS(824∼894 MHz), DCS(1710∼1880 MHz), PCS(1850∼1990 MHz), UMTS(1920∼2170 MHz) 등에서 동작될 수 있도록 변형된 G 형태의 패치 안테나를 가진다. 제작 측정결과, VSWR 1:2.5에서 제안된 모바일 안테나의 임피던스 대역폭은 시뮬레이션 결과와 비슷한 경향을 나타내었다. 낮은 주파수 대역에서는 36.46% 대역폭을 가지며 높은 주파수 대역에서는 27.84%의 임피던스 대역폭을 얻었다. 이 논문에서는 또한 실험결과에 대한 3D 방사패턴과 이득 값들을 제시하고 설명하였다.

ABSTRACT

This paper presents the design of a novel integrated mobile antenna for vehicles. The proposed antenna fabricated on a low cost easily available FR4 substrate, which effectively covers both dual band operation. The proposed mobile antenna is a modified G-type patch antenna that can operate in various frequency bands, GSM (880∼960 MHz), AMPS (824∼894MHz), DCS (1710∼1880MHz), PCS (1850∼1990MHz), UMTS (1920∼2170). Experimental results indicate that the impedance bandwidth (VSWR 1:2.5) of the proposed mobile antenna agree that of the simulation results. It was validated that the configuration can meet the demands of Mobile frequency bands and effectively enhanced the impedance bandwidth to 36.46% for the lower band and 27.84% for the upper band. This paper also presents and discusses the 3D radiation patterns and gains according to the results of the experiment.

키워드

antenna, mobile antenna, multi-band operation, vehicle application

Ⅰ. INTRODUCTION

Today's vehicles are equipped with various electronic devices for radio services. Due to the increasing number of radio services using different frequency bands, the number of necessary antennas

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for a vehicle has also increased. Since antennas for different services usually need to be installed separately, the placement of various antennas to guarantee optimum performance for each service in a vehicle has posed a problem to users.

For vehicular application, whip or rod monopole antennas are generally used because they can provide a very good radiation pattern with an omni-directional radiation pattern in the azimuth plane. However, since these antennas have a high-profile appearance, they usually suffer from the disadvantages of being unstylish and being easily subjected to vandalism [1]. So, antennas for vehicles need to have low-profile characteristics. In addition to having low-profile characteristics, an antenna must also have radiation patterns for vehicle communication and the ability to cover all globally-used frequency bands.

A remarkable trend in modern mobile communication is that all available applications, such as the advanced mobile phone system (AMPS, 824-894MHz), global system for mobile communication (GSM, 890~960 MHz), digital communication system (DCS, 1710~1880 MHz), personal communication system (PCS, 1850~1990 MHz), and universal mobile telecommunication system (UMTS, 1920~2170 MHz), can be merged into a single terminal. To achieve the above-mentioned ideal features of a vehicle antenna, manufacturers are trying to come up with a low-profile and multi-band antenna [2]-[6].

In this research, we proposed an integrated antenna that is suitable for mounting on a vehicle for mobile services. This mobile antenna operates at the frequency bands of CDMA/GSM850 (824~894 MHz), GSM900 (880~960 MHz), K-PCS (1750~1880 MHz), DCS (1710~1880 MHz), PCS1900 /US-PCS (1850~1990 MHz), and UMTS (1920~2170 MHz). Details of the proposed antenna design and experimental results are described below.

II. ANTENNA DESIGN

Fig. 1 shows the configuration of the proposed low-profile vehicle antenna for mobile communications. The cross section and front view of the proposed mobile antenna is also shown in Fig. 1. The total size of the proposed antenna in the study is 1.0mm thick and made of 45×55mm^2 FR4 substrate, which is a reasonable size for practical vehicle application. This mobile antenna, which operates on GSM, AMPS, DCS, PCS, UMTS, etc. frequency bands, is designed with two arms, one of which provides multi-band operation.

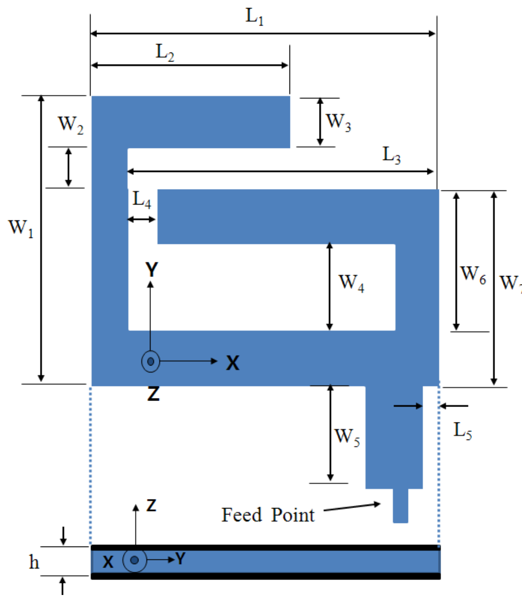

Fig. 1 Proposed mobile antenna

To obtain the optimal parameters (lines, lengths, and gaps) of the proposed mobile antenna for vehicle application, HFSS [7], which is a full-wave commercial EM software capable of simulating a finite substrate and a finite ground structure, was used. The length and width of the strip line should match the input impedance of the mobile patch antenna. Therefore, the dimensions of the proposed antenna are set as follows: L_1=30mm, L_2=17mm,

L_3=26mm, L_4=2mm, L_5=2mm, W_1=18mm, W_2=2mm, W_3=4mm, W_4=4mm, W_5=8mm, W_6=8mm, h=12mm.

III. MEASUREMENT

Based on the simulation results, the proposed mobile patch antenna is created and tested using the Agilent Technologies E8362B Vector Network Analyzer, with far-field patterns and gain within a compact range obtained from HCT Co. Ltd.

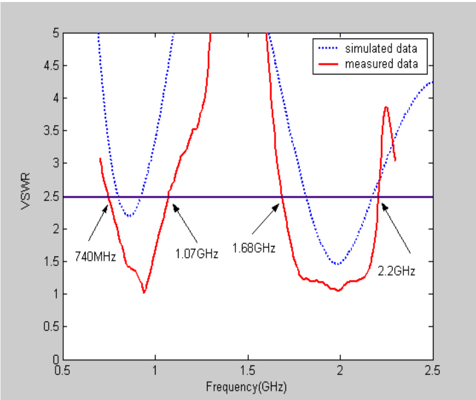

Fig. 2 simulated and measured return Loss of the proposed mobile antenna

Figure 2 shows the antenna's measured return loss according to the simulation result. The results showed a satisfactory match between the antenna's measurement and the data from the simulation obtained from Ansoft HFSS. The cured trend is behaved well over the whole operating bands. Based on the 7.5 dB return loss bandwidth (VSWR 1:2.5), which is acceptable for each application, the impedance bandwidth of this mobile antenna was about 330 MHz to 540MHz (740~1070 MHz, 1680~2200 MHz). The two wide-impedance bandwidths obtained cover the operating bandwidth of AMPS, GSM, DCS, PCS, and UMTS (824~960 MHz, 1710~2170 MHz).Both two arms are operated as quarter-wavelength structures this design. The long arm antenna of two arm portion generates a lower wide resonant mode at about 960MHz, while the short arm portion generates an upper wide resonant mode at about 2000MHz. Simulated surface current distribution at 960MHz and 2000MHz were plotted to visualize each resonant mode in Fig.3, respectively. At 960MHz, it was clearly seen that current mainly concentrates around long arm of the proposed antenna. Thus the first resonant mode is determined by the length of the long arm of the proposed antenna. The same as the first resonant mode, the second resonant mode is determined by the short are of the proposed. The lower and upper resonant modes are wide enough to cover the APMS/GSM and DCS/PCS/UMTS bands, respectiv-ely.

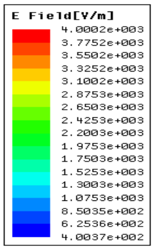

Fig. 3(a) the table of surface current distribution

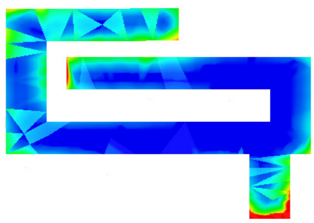

Fig. 3(b) surface current distribution at 960MHz

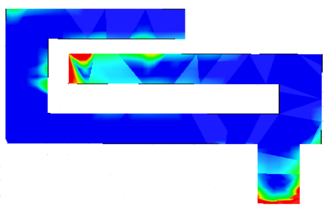

Fig. 3(c) surface current distribution at 2000MHz

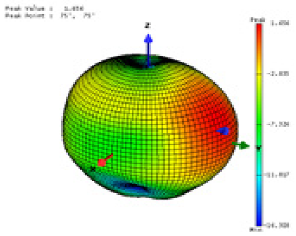

Fig. 4(a) 3D radiation pattern of 824MHz

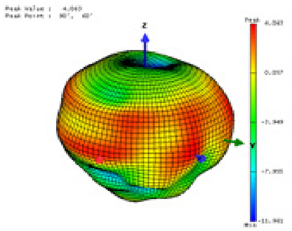

Fig. 4(b) 3D radiation pattern of 1750MHz

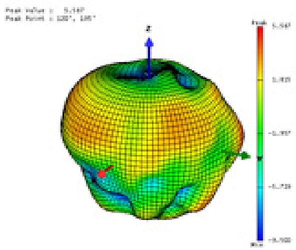

Fig. 4(c) 3D radiation pattern of 2170MHz

Figure 4 plots the 3D radiation pattern of the proposed mobile antenna. Figure 4(a), 4(b), 4(c) shows the 3D radiation pattern at 824MHz, 1750MHz, 2170MHz, respectively. Good radiation patterns are observed, especially for the lower operating frequencies in Fig 4(a) at 824GHz. Table 1 shows the measured peak and average gains for the operating frequencies. The measured peak gain of this mobile patch antenna varies within a wide range of about 1.441 to 5.43 dBi, and its measured average gain varies in a broad range of about -2.952 to 1.243 dBi.

Table 1. Measured gains of proposed mobile antenna

Mobile Antenna		
Frequencies (MHz)	Peak Gain (dB)	Average Gain (dB)
824	1.441	-2.952
890	4.314	-1.779
935	5.40	1.243
960	4.306	0.121
1710	4.577	-0.074
1840	5.43	-0.014
1950	4.455	0.136
2170	5.298	0.791

Ⅵ. CONCLUSION

The novel planar antenna suitable for mobile communications in vehicles was proposed, and its prototype operated successfully. The device was a modified G-type patch antenna designed for mobile application in vehicles. The optimum parameters were defined by varying the width and length of the strip line. The mechanism of dual band operation are also discussed. A prototype capable of generating two wide resonant modes to cover almost all existing mobile communication systems was tested. This proposed mobile antenna had an impedance bandwidth (VSWR 1:2.5) of about 330 MHz, 540MHz (740~1070 MHz, 1680~2200 MHz) or about 36.46%, 27.84%. The experiment results showed that good impedance matching was achieved. Good radiation pattern characteristics and gain for the proposed antenna were also observed. The proposed mobile patch antenna's measured peak gain varied between 1.441 to 5.43 dBi. The proposed antenna, therefore, has an excellent potential for vehicular application.

감사의 글

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REFERENCE

[1] T. J. Yalty, Y. Dai, and L. Lanctot, "Automotive antennas trends and future requirement", 2001 IEEE Antennas Propagat. Soc. Int. Symp. Dig., pp. 430-433, 2001.
[2] C. W. Su, C. M. Su, and K. L. Wong, "Compact dual band circularly polarized antenna for GPS/ETC operation on vehicles", Microwave and Optical Technology Letters, Vol. 40, No. 6, pp. 509-511, 2004.
[3] Y. T. Liu, S. W. Su, C. L. Tang, S. T. Fang, and K. L. Wong, "On vehicle low profile metal plate antenna for 900MHz operation", Microwave and Optical Technology Letters, Vol. 40, No. 1, pp. 79-80, 2004.
[4] S. W. Su, Y. T. Liu, K. L. Wong, and C. L. Tang, Low profile broadband printed VHF monopole antenna for vehicular application, Microwave and Optical Technology Letters, Vol. 42, No. 5, pp. 349-350, 2004.
[5] Y. T. Liu, S. W. Su, C. L. Tang, H. T. Chen, and K. L. Wong, "On vehicle Low Profile Metal plate antenna for AMPS/GSM/DCS/PCS/UMTS multiband operation", Microwave and Optical Technology Letters, Vol. 41, No. 2, pp. 144-146, 2004.
[6] M. Ali, G. Yang, H. S. Hwang, and T. Sittironnarit, "Design and Analysis of an r-shaped dual band planar inverted-F antenna for vehicular application", IEEE Trans. Vehicular Technology, vol. 53, No. 1, pp. 29-37, 2004.
[7] B. Jung, J. S. Lee, M. J. Park, Y. S. Chung, F. J. Harackiewicz and B. Lee, "TDMB/AMPS/GSM/DCS/PCS/SDMB internal antenna using parasitic element with switching circuit", Electronics Letters, Vol. 42, No. 13, pp. 734-736, 2006.
[8] Ansof High Frequency Structure Simulator (HFSS) Version 10.0, Ansoft Corporation, 2005.

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