Hearing Aid Compatibility Improvement for Mobile Phones.

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1. Introduction

HAC indicates the electromagnetic interference level, which is regulated by FCC, between the terminal and the hearing aid in order to avoid discomfort from people with impaired hearing, while they are using mobile terminals. More than 28 million people in USA (more than 1/10 of population) are using hearing aids [1].

There are two HAC approval items for the types of hearing aids. RF-emission is evaluated by measuring the electric and magnetic fields that are emitted toward the receiver and have carrier frequency of the terminal. T-coil measures the magnetic field at the voice band in the receiver of the terminal. Compared to T-coil, RF-emission is more closely related to the emission performance of the portable terminal [1]-[4]

Presently, there are two methods by which the HAC Performance can be improved [4]-[6]. One is dual parasitic element (DPE) method. The other is adjusting the performance so that there is no margin of emissions performance in the business Spec. DPE method has problems, such as interference with sub-antennas and causing lack of mounting space, as portable terminals become more and more multifunctional and miniaturized.

This paper presents a new HAC improvement method which has low interference with sub-antennas by decreasing the number of parasitic elements.

2. HAC Improvement Method

2.1 Specification for HAC

How to measure HAC is as follows: An area of 50x50 mm^2, around the ear-point of the portable terminal, is divided into 9 grids. Then, E- and H-fields are scanned. Except the grid having a maximum field value and its two adjacent grids, the peak value is selected on the six grids except those three grids [1]. Figure 1 shows graphical representation of HAC measurement.

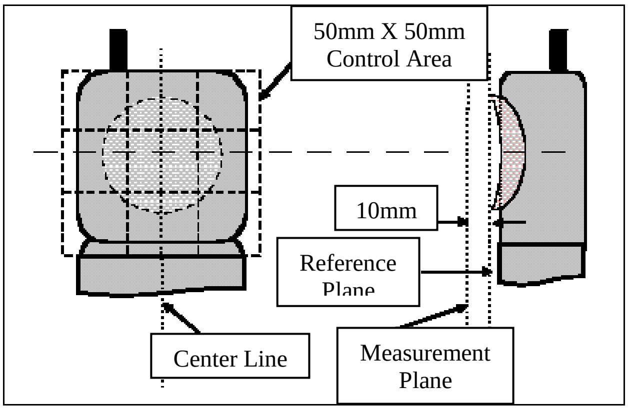


Figure 1: HAC measurement

There are two HAC specifications for the low and high frequency bands. Low frequency HAC specification is using a carrier frequency of 96MHz. According to the communication standard or band, high frequency band for the specification is defined. Especially, the GSM system using TDMA 217Hz has tighter HAC specification due to an AWF of -5dB.

The transmit frequency (1850-1910 MHz) of PCS (Personal Communications system) is the most critical for HAC performance. At that frequency band, the category M3 defines an electric field |E| less than 84.1 V/m and a magnetic field |H| less than 0.254 A/m [1]. FCC targets for more than 33% of the manufacturers and 50% of the service providers in its specification applying plan.

2.2 HAC vs. Antenna Performance

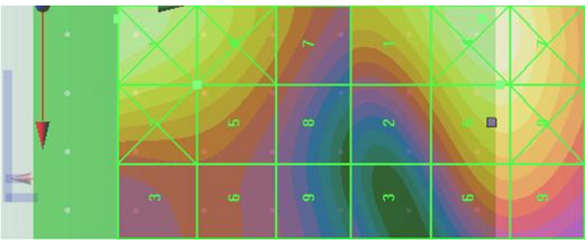
The relationship between HAC performance and conduction power was experimentally evaluated using a PIFA antenna for the PCS band on bar-type bear board which has a size of 50x106x1mm (X, Y, Z axis). Table 1 shows the measured HAC according to the conduction power level. Increasing a conduction power by 1dB degrades HAC performance by 1dB.

Table 1: Performance comparison: HAC vs. conduction power

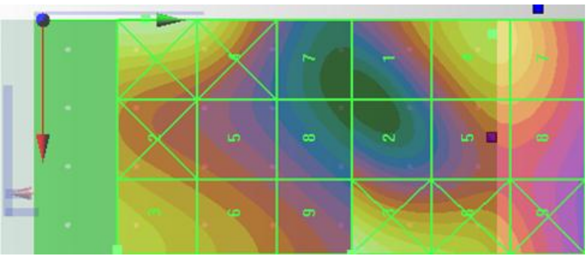
Con. Pwr (dBm)	HAC (dBV/m)	Delta (dB)
29.0	39.70	**1.00**
28.0	38.70	**1.00**
27.0	37.70	**1.00**
26.0	36.70	**1.00**
25.0	35.71	**0.99**
24.0	34.70	**1.00**

2.3 Performance Change Based on Electric Field

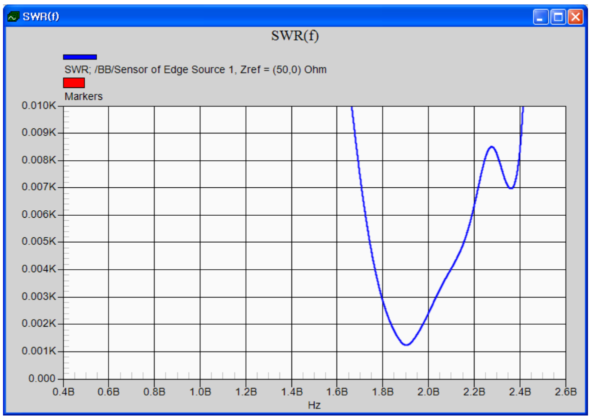
For the same TRP(Total Radiated Power) on the same sized of boards the HAC performance improvement can be found for the case that the electric field has multiple peaks compared to the case that the electric field has a peak. Figure 2 shows electric field distributions and VSWR's according to the states of the electric field.



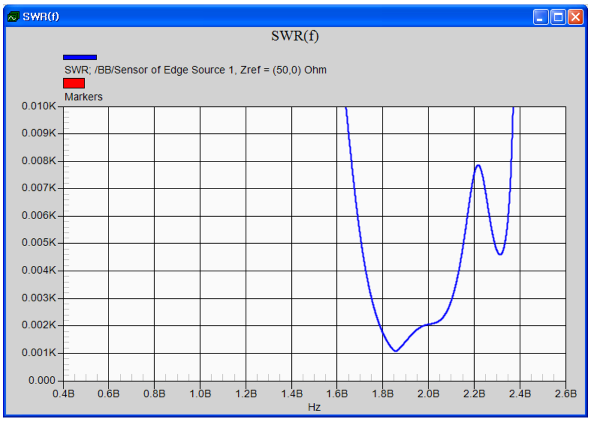
(a) electric field of default state



(b) Separated electric field



(c) VSWR of default state



(d) VSWR of Separated electric field

Figure 2: The electric field distributions: (a) one peak. (b) multiple peaks. VSWR's (c) one preak (d) multiple peaks

Table 2: HAC Performance comparison according to the states of the electric fields
(HAC performance comparison is based on the ear-point)

		Default state	Separated state
TRP (dBm)		29.2	29.3
HAC (E-Field)	Category	M1	M3
	RF-Emission (V/m)	158	76.9
	RF-Emission (dBV/m)	43.97	37.72
	Delta (dB)	**6.25**	

2.4 Proposed Method

For the same TRP, the electric field distribution of the portable terminal can be adjusted to have an improved HAC using SPE(Single Parasitic Element) method.

3. Fabrication and Experiment

3.1 Proposed Structure

The application point of SPE is located on the opposite side of the radiator, i.e. the closest end of the antenna on the PCB. The length is 4/λ including a gap for the target frequency and the gap in the PCB is more than 1mm.

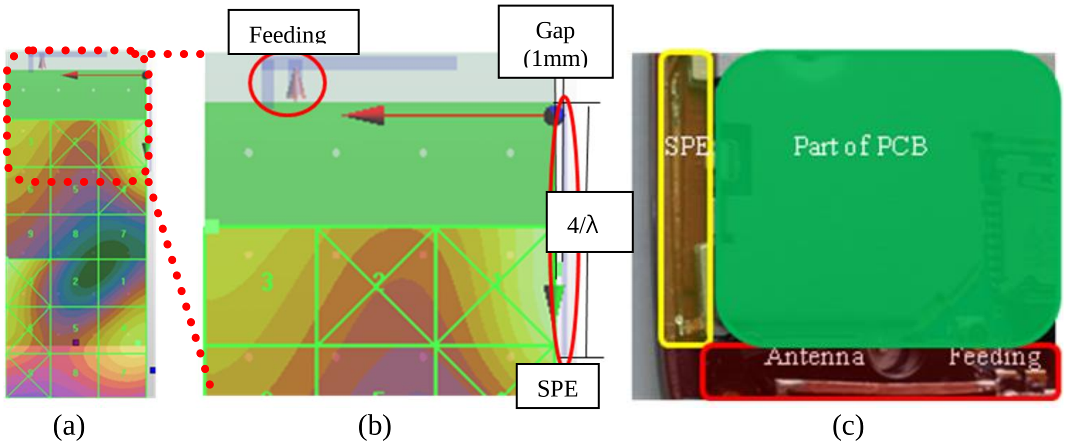


Figure 3: SPE structure with field pattern: (a) an entire structure, (b) an extended structure , (c) an experiment structure in the mobile phone

3.2 Experiment Result

The electric field with a single peak on the board was distributed for the electric field to have two small peaks using SPE as shown in Figure 2(b). The simulation result reveals that more than 6dB improvement of HAC performance was found for the same TRP. A 4 dB improvement of HAC performance was experimentally achieved for the practical portable terminal. Table 3 summarizes the simulated and experimental results.

Table 3: The simulated and experimental HAC performances

		Simulated results		Experimental results	
		Default	SPE	Default	SPE
TRP (dBm)		29.2	29.3	26.3	26.5
HAC (E-Field)	Category	M1	M3	M2	M3
	RF-Emission (V/m)	158	76.9	118.3	73.5
	RF-Emission (dBV/m)	43.97	37.72	41.46	37.33
	Delta (dB)	**6.25**		**4.13**	

TRP difference between the simulation and experiment is because of the TRP dependence on the antenna gain used for the portable terminal as TRP ≒ Conduction Power X Antenna Gain.

4. Conclusion

For the proposed method, the number of parasitic elements was reduced from two to just one, which simplifies the configuration and reduces the size. For the experimental verification, in this paper, a SPE is mounted around the antenna at the bottom of the bar-type mobile phones, which lowered an interference with other sub–antennas due to the decreased number of parasitic elements from DPE. Around 4~6dB of HAC performance improvement was achieved without degrading the emission characteristics of the antenna. In the HAC specifications, a category of M1 can be improved to M3 for the optimal use of the proposed SPE.

References

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