Absorbed Power Minimization in Cellular Users with Circular Antenna Arrays

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Abstract. Nowadays electromagnetic pollution of non ionizing radiation generated by cellular phones concerns millions of people. In this paper the use of circular antenna array as a means of minimizing the absorbed power by cellular phone users is introduced. In particular, the different characteristics of radiation patterns produced by a helical conventional antenna used in mobile phones operating at 900MHz and those produced by a circular antenna array, hypothetically used in the same mobile phones, are in detail examined. Furthermore, the percentage of decrement of the power absorbed in the head as a function of direction of arrival is estimated for the circular antenna array.

Keywords: Power, conventional, circular antenna array, cellular phones
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INTRODUCTION

Cellular Phones and Mobile Wireless Communication Systems are being introduced into society at a very rapid rate. This very rapid development in mobile communication has drawn attention to eventual possible health risks due to electromagnetic (EM) energy emitted from the mobile phones transmitters as well as from base stations located in populated areas. In wireless communications the electromagnetic interaction between antennas and the nearby biological tissue is a key consideration. Due to this interaction, a certain amount of energy radiated by the antennas is absorbed by the user's body tissue, affecting both antennas performance and human health. The study of this interaction has resulted in gaining a detailed understanding of the EM field distribution and power absorption distribution inside the human head and in concern and attention to the biological effects of electromagnetic fields (EMFs) and consequently the health hazards of RF electromagnetic fields that are emitted by the mobile devices [1,2,3].

In the present paper we introduce the use of circular antenna array as a means of minimizing the absorbed power by mobile phone users. In particular, we examine in detail the difference between the characteristics of gain patterns produced by a helical conventional antenna used in mobile phones and those produced by smart antennas, hypothetically used in the same mobile phones with and without the presence of a human head phantom. Furthermore, we estimate the percentage of decrement of the power absorbed in the head as a function of smart antenna's direction of arrival.

HELICAL ANTENNA

The influence of human head phantom on the radiation characteristics of a conventional helical antenna operating at 900MHz has been studied in previous work [4]. The far field radiation patterns of a conventional helical antenna for xy, yz, xz planes are shown in figure 1 for two cases: (a) absence of human head's phantom G_0 and (b) presence of human head's phantom G_H [4]. The power absorbed by the head ($Pabs_c$) is calculated as the difference between the radiated power by the antenna without the presence of the human head (P_0) and the radiated power by the antenna when the human head is present (P_H).

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$$Pabs_c = P_t \Delta \overline{G} = P_t(\overline{G}_0 - \overline{G}_H) \quad (1)$$

$$P_H = P_t \overline{G_H}, \quad P_0 = P_t \overline{G_0}, \quad \overline{G_0} \approx \frac{\sum_{i=1}^{36} G_0 i}{36}, \quad \overline{G_H} \approx \frac{\sum_{i=1}^{36} G_H i}{36} \quad (2)$$

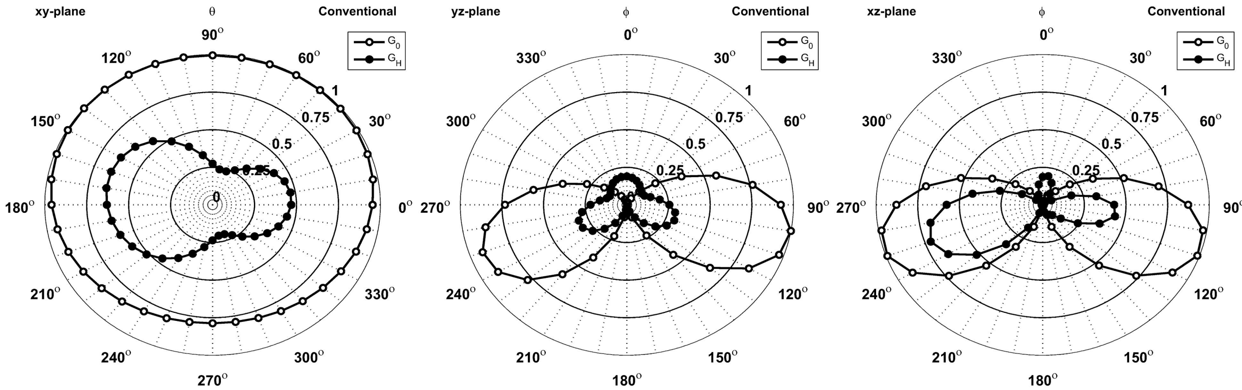

FIGURE 1. Gain patterns with (G_H) and without (G_0) human head phantom for (a) xy, (b) yz and (c) xz plane

CIRCULAR ANTENNA ARRAY

For a circular antenna array (figure 2), where the radiation pattern can be electronically modified, the absorbed power in the human head phantom is not constant. Keeping in mind the radiation patterns of the helical antenna and using the pattern multiplication principle we calculate the gain patterns of the circular antenna array for the three planes. The array factor (AF) of circular antenna array of figure 2 is given by:

$$AF(\theta,\phi) = \sum_{n=1}^{N} a_n e^{j\left[\beta_n - kR\cos(\theta-\theta_n)\sin(\phi)\right]} \quad (3)$$

Where R is the circle's semi diameter, α_n and β_n the amplitude and phase taper respectively. The number of elements used were N=8.

Similarly to the case of a helical antenna the value of the power in the human head phantom is given by:

$$Pabs_s(\gamma) = P_t \Delta \overline{G}(\gamma) = P_t(\overline{G}_0(\gamma) - \overline{G}_H(\gamma)) \quad (4)$$

Where direction of arrival is symbolized by γ.

Combining the above equations, the coefficient n is delivered:

$$n(\gamma) = \left|\frac{Pabs_c - Pabs_s(\gamma)}{Pabs_c}\right| = \left|\frac{\Delta G_c - \Delta G_s(\gamma)}{\Delta G_c}\right| \% \quad (5)$$

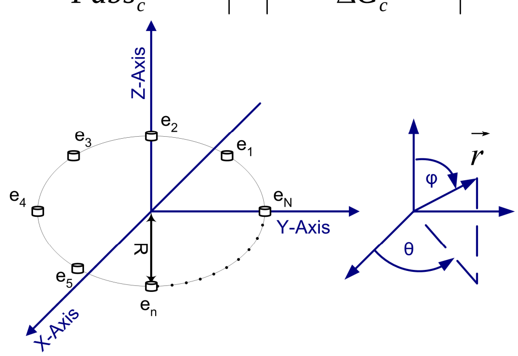

FIGURE 2. Circular antenna array configuration.

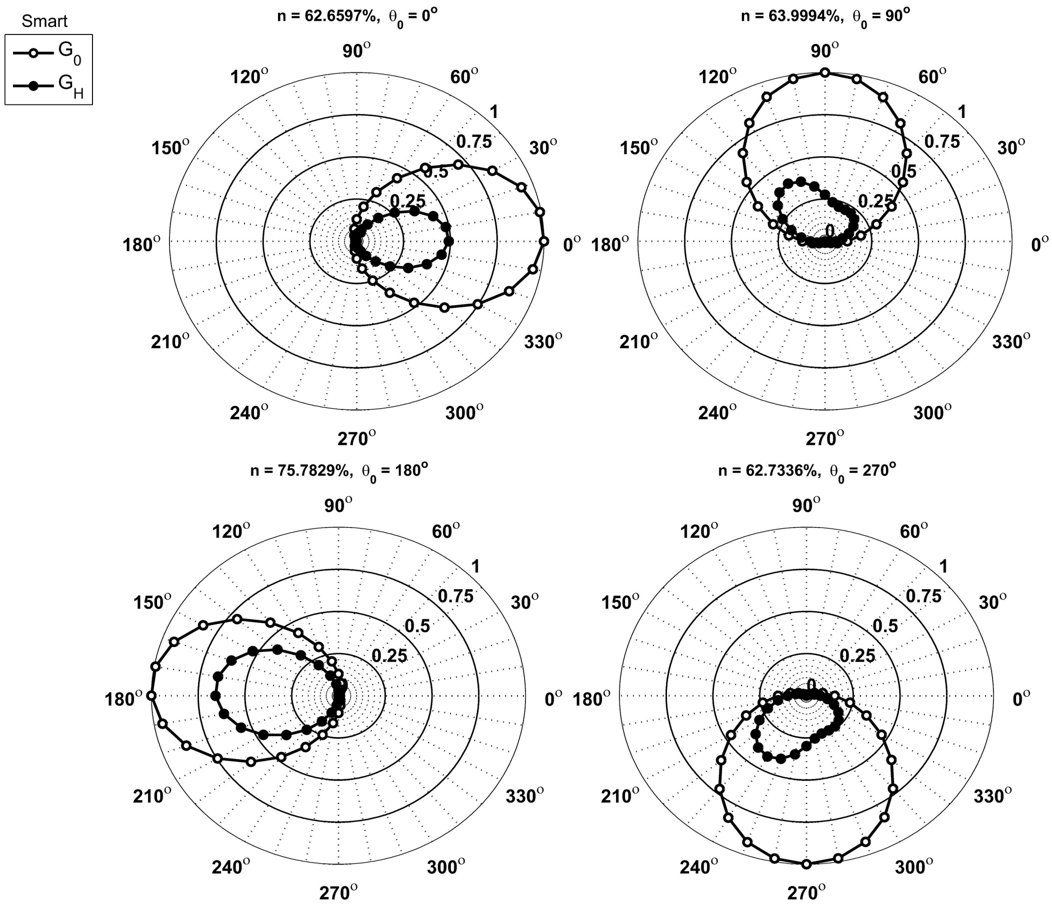

FIGURE 3. xy-plane, $\varphi=\pi/2$ - Circular antenna array gain patterns G_0, G_H for 4 directions of arrival.

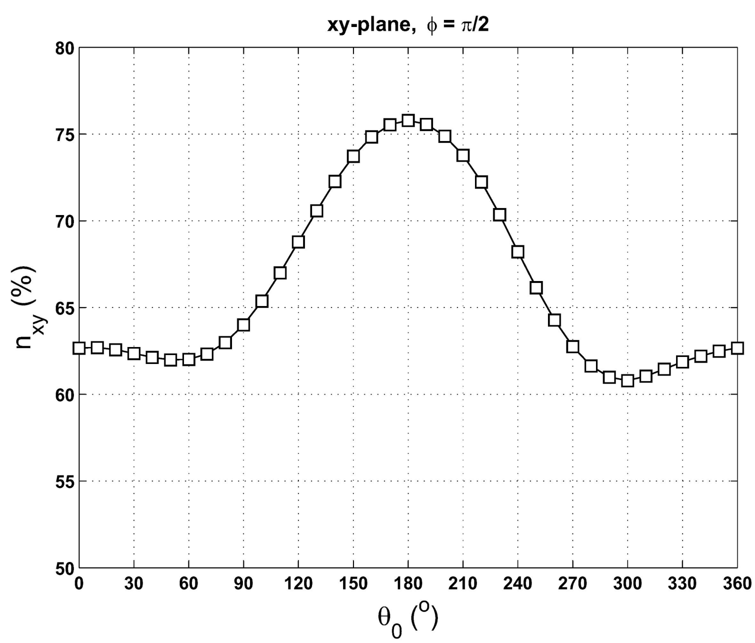

FIGURE 4. n_{xy} as a function of direction of arrival θ_0.

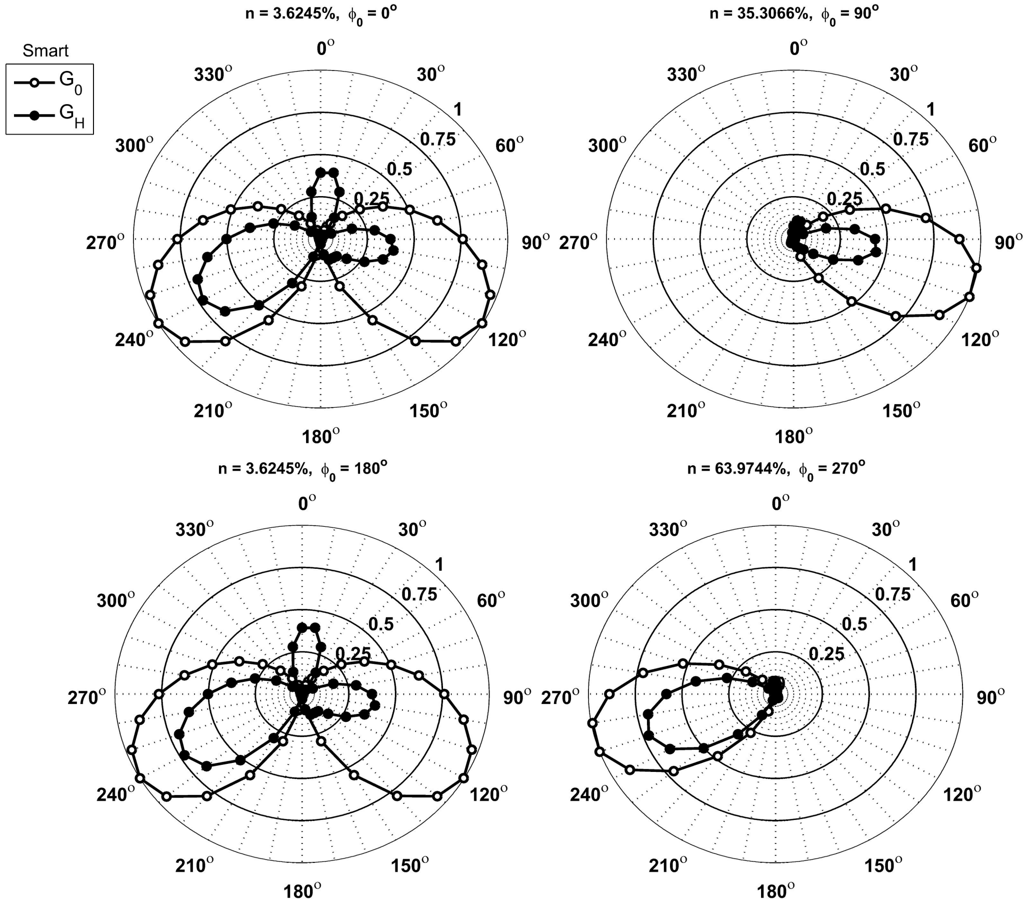

FIGURE 5. xz-plane, θ=0 - Circular antenna array gain patterns G_0, G_H for 4 directions of arrival.

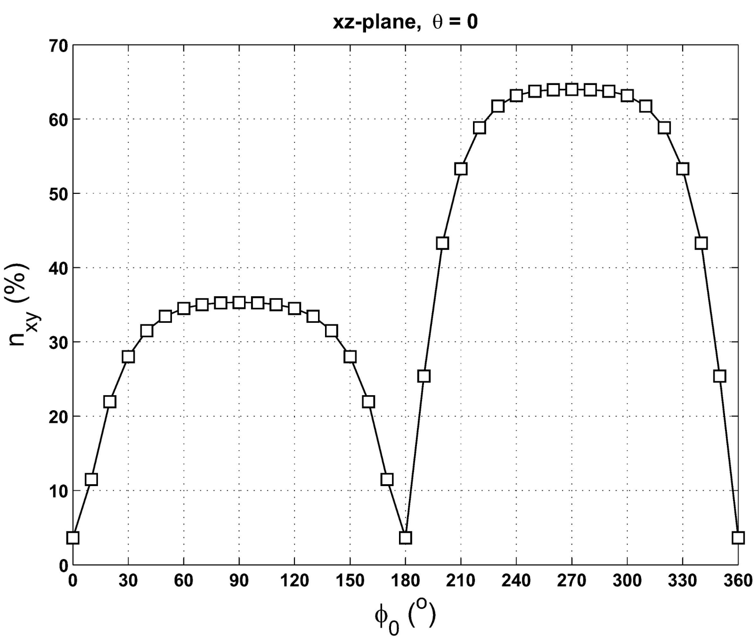

FIGURE 6. n_{xz} as a function of direction of arrival φ_0.

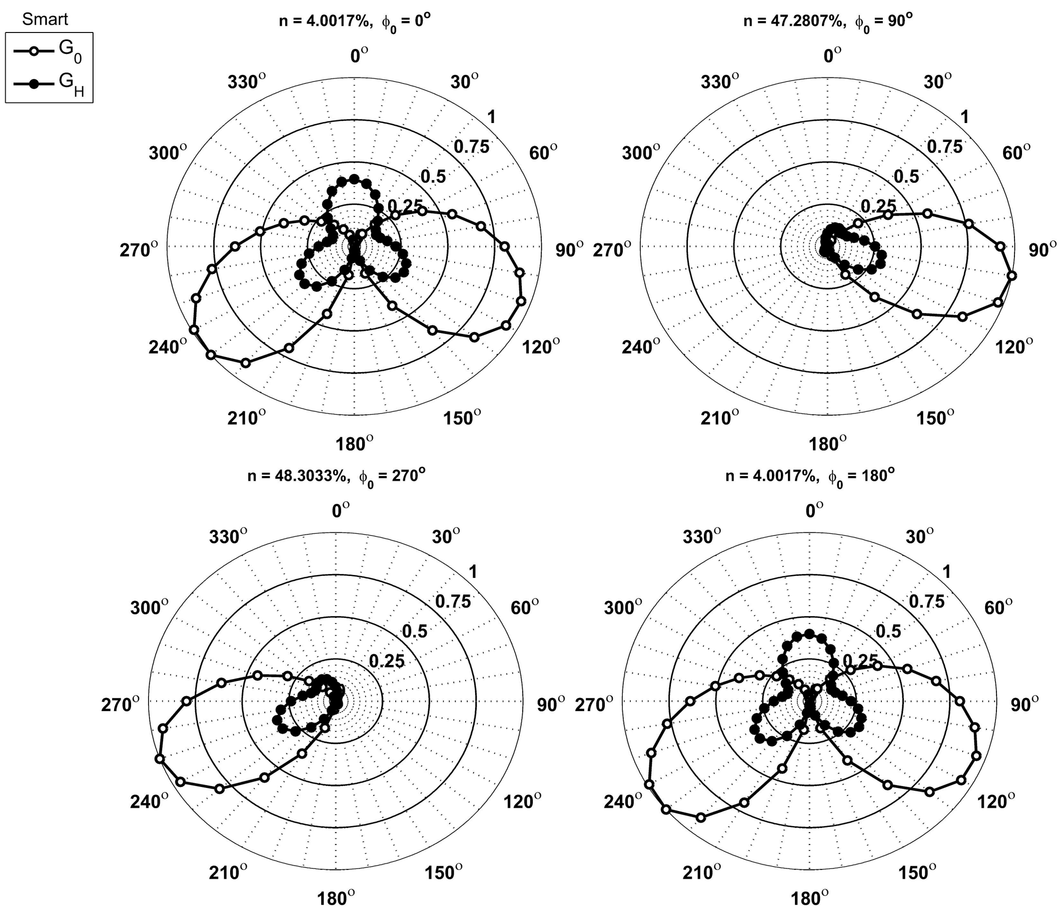

FIGURE 7. yz-plane, θ=π/2 - Circular antenna array gain patterns G_0, G_H for 4 directions of arrival.

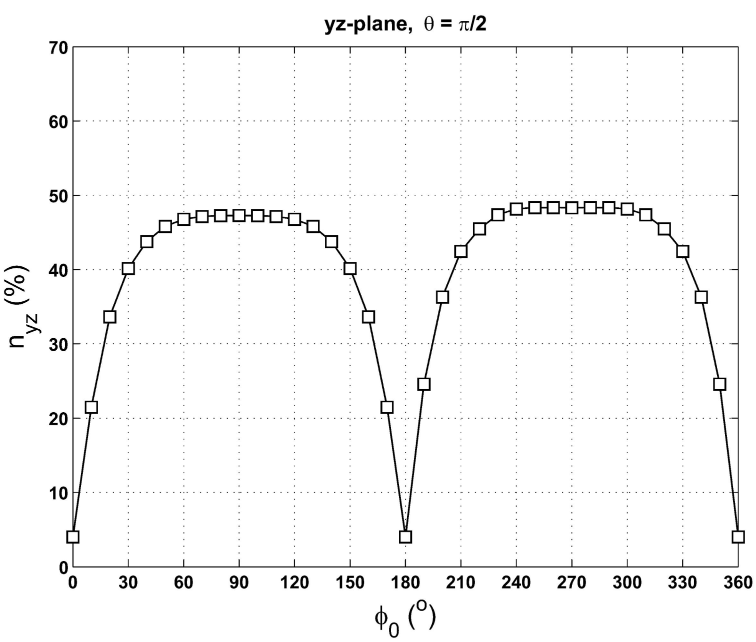

FIGURE 8. n_{yz} as a function of direction of arrival φ_0.

From equation (5) it is derived that higher values of n entail decrement of P_{abs} in relation with the conventional antenna. Indicatively, for each plane the radiation patterns are shown for 4 directions of arrival. More analytically:

xy - plane, $\varphi=\pi/2$ and direction of arrival is symbolized by θ_0 (figures 3,4). It is estimated that for all directions of arrival there is a decrement of at least 60% for the power absorbed by the human head phantom. The largest decrement of the power absorbed is achieved when the main beam is turned in direction opposite to the human head's phantom, that is between angles 150 to 210 degrees. Comparing ΔG in figure 3 for direction of arrival 0 and 180 degrees, it is resulting that there is a noticeable difference, which is also determined by the effect of the human head phantom in the radiation pattern of the conventional helical antenna, figure 1.

xz - plane, $\theta=0$ and direction of arrival is symbolized by φ_0 (figures 5,6). The absorbed by the head power is almost null for angles round 0 and 180 degrees and that is due to the low directionality of AF on that plane. Observing the gain patters for direction of arrival 0 and 180 degrees of figure 5 we realize that ΔG is almost the same and similar to that of the conventional helical antenna. The largest n values are achieved when the main beam is turned in direction opposite to the human head's phantom, that is between angles 240 to 300 degrees. Comparing ΔG in figure 5 for direction of arrival 90 and 270 degrees it is obvious that there is a noticeable difference, which is also determined by the effect of the human head in the radiation pattern of the conventional antenna, figure 1.

yz - plane, $\theta=\pi/2$ and the direction of arrival is symbolized by φ_0 (figures 7,8). Percentage decrement of the absorbed power by the human head phantom is almost zero round angles 0 and 180 degrees due to the low directionality of AF on that plane. The coefficient n_{yz} presents catoptric symmetry since yz-plane does not cross the human head phantom.

CONCLUSIONS

In this paper we calculated the power absorbed by the human head for two different antennas used in the case of a helical antenna and one circular antenna array. The results are presented in detail. The power absorbed by the human head phantom for various directions of arrival is presented and discussed. It is apparent that significant decrement does exist in the power absorbed by the human head for the case of circular antenna array. Future work could include measurements and results using printed antenna elements.

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