Mitigation Techniques for Enhancing Mobile Radio EMC Performances

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Abstract

The number of mobile Radio equipments has increased tremendously which enhance harmful mutual interference and people exposed to non ionized radiation .The levels of Electromagnetic field effects from base stations affecting people are significantly lower than from headsets due to the separation distances and far field propagation conditions.Are presented main mitigation techniques for enhancing base station performances and a thorough analysis of near field mobile headsets EMF effects. Main headsets mitigation techniques are discussed: Using an auxiliary antenna, distancing the headset radiating parts from their users, space polarization diversity and meta-material antennas. Simulation and computation results are added.

1. Introduction

A tremendous increase in the number of mobile radio users, equipment and systems enhances the probability of receivers and people exposure to interference and of non ionized radiation effects. Therefore efficient mitigation techniques are required to reduce Electro-Magnetic Field (EMF) pollution, interference and improve radio communication performances [1,2]. The sources of Radio interference and EMF effects are derived from the offender Transmitters (Tx) and the victims are the systems multitude of Receivers (Rx) and individual human mobile headset users, who are exposed to mutual interference and to parasitic EMF thermal non ionized radiation [3,4].

2. Base Stations EMF Pollution Mitigation Techniques.

When security parameters are respected ,the people and Rx exposed to base station effects are located in the well defined Fraunhofer Far Field (FF) radiation zone. In the FF zone the radiated power density levels decrease as the square of the separation distance d and in several cases even more as shown in Figure 1[3,4]. The base stations TX power density S in W/m^2 and other EMF parameters are also very easy to measure and compute as described in figure 1 due to the FF propagation conditions [3,5].

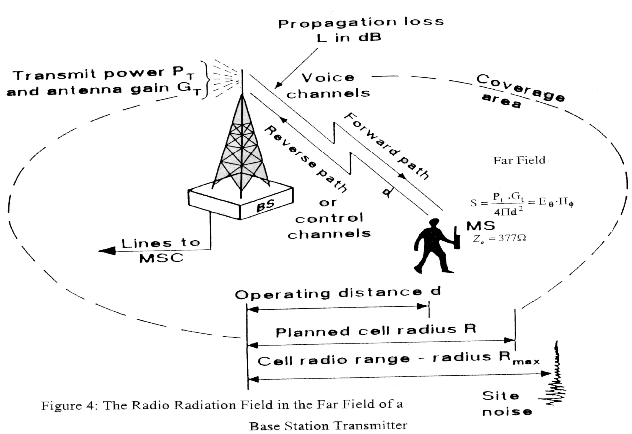

Fig 1 – The Radio Radiation Effects in the Far Field of a Base Station Transmitter

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The power efficiency and capacity of base stations can be enhanced by using segment directional antennas instead of omni-directional ones. A better solution is the use of smart antennas which require also signal processing units. The smart antenna concentrates the power transmission towards the mobile desired Rx user and significantly reduces interference from near TX by forming a null steering at the base station Rx as shown in figure 2. The smart antenna technique may also contribute to enhance transmitted power and energy efficiencies, increase Rx signal to noise and interference ratio, and decrease the required base station TX power, EM pollution and interference levels to other Rx[1,6]. The base station power density and radiation effects can also be decreased by increasing the number of base stations and decreasing the operation radius.

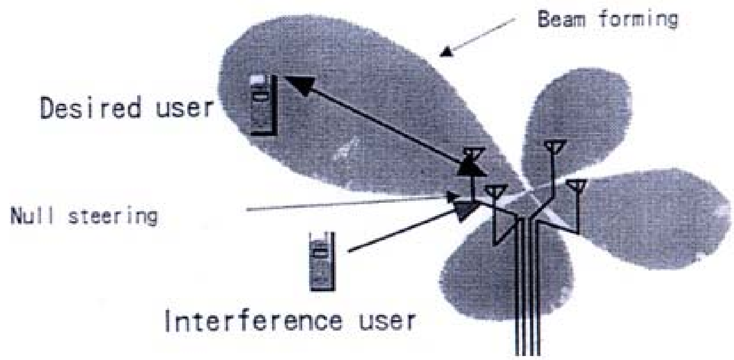

Fig 2. The Principles of Smart Antennas used in a Radio Base Station

A novel improvement for future mobile radio systems is the development of High Altitude Platforms (HAPS) which will have the function of a base station located in the stratosphere at an altitude of 17 to 24 km from the ground ,where winds velocities are minimum[7,8]. Therefore the radiation intensity levels will be significantly lower than from terrestrial base stations. The HAPS base station performances are significantly better than the Geo-stationary satellites due to significantly lower dispersion losses, time delay and cost as shown in figure 3.

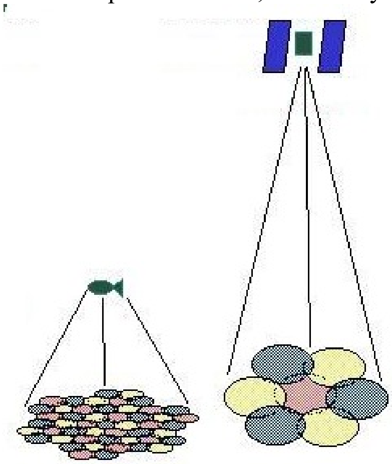

Fig 3. .Future base station using a Stratospheric HAPS compared to a Geostationary station [7].

Experimental HAPS are built in the USA, Russia and Europe. In a few years it seems that HAPS will begin to be used commercially, especially useful as base stations for the 4th generation (4G) of cellular radio systems [8].

3. Headsets EMF Effects Mitigation Techniques.

The headsets EMF affecting their users are much more complex, unpredictable and significantly stronger than base stations because of the reactive near field conditions Measurements and simulation results show that 30% up to 75% of the radio frequency power transmitted from headsets may be absorbed in the users head, hand and body due to the very short separation distances [3,9]. Without considering the health issues, it is obvious that this important part of the headset transmitted energy is wasted instead of reaching the base station. The headsets power density is not well defined therefore has been standardized the Specific Absorption Rate "SAR" of the temperature increase measured in Watt per kg representing the non-ionized thermal radiation effects generated from headsets EMF induction in human tissues especially in the users head.[3,10]. Therefore, the real problems limiting mobile radio power efficiency and enhancing human EMF absorption SAR are the radio headsets and not the base stations [9,10].The popular headsets radiating antennas towards the users head were the low cost, high SAR helical or monopole quarter wavelength. Later were used numerous planar micro-strip antennas such as the compact and multi-band Planar Inverted F Antenna (PIFA) or (PILA) where the absorbed radiation absorption by the head is reduced slightly, but the absorption due to the user hand is increased significantly[2,11]. The use of a small array including two antenna elements connected to a headset, reducing the power absorbed by the user head and enhancing the propagation efficiency in the direction of the base station [12]. A more efficient mitigation technique suggests a mobile headset apparatus using a two part fold-over mobile phone where the upper part is a cover containing only the radiating high frequency elements including a duplexer and an extendable quarter wave length monopole antenna The duplexer output is connected via a simple adaptive circuit and a short coaxial cable of less than 0.1 dB insertion loss to the top of the antenna where a peak of current and of radiation intensity are developed. Thus, raising the locus of radiation laterally and vertically above the head as shown in figure 4

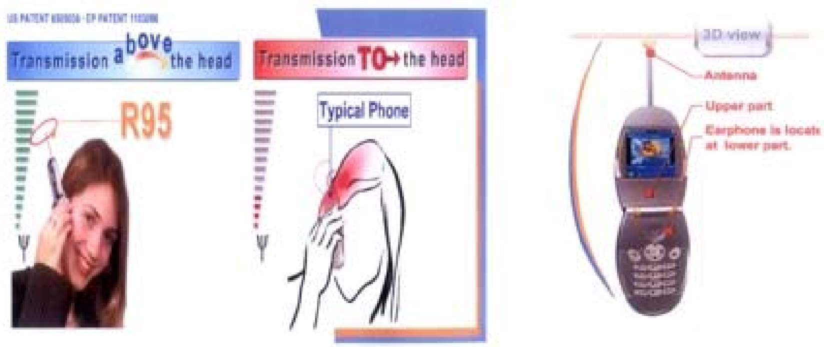

Fig4. Suggested R95 Technique Headset to Decrease Significantly the SAR in Comparison with a Typical One.

This space separation technique headset, named R95, significantly enhance antenna and headset power efficiency and reduces drastically the SAR to the user head [4,13]. Simulation computation results obtained in cooperation with a scientist team of the Toronto Roger institute show that the SAR of the R95 is more than 50 times better than for classical headsets[14]. The R95 can be efficient for ordinary and large dimensions headsets and especially for children who have usually a smaller head than adults. However the R95 technique will not be useful for small dimensions headsets and for multi bands antennas requirements considering that the separation distance to the transmitting headset will be significantly smaller. In these cases polarization diversity implementation may increase the useful power to and from the base station and decrease the parasitic radiation power and the SAR to the user head and body [15]. A novel and more promising technique is the use of Meta- Materials (MM) [16]. MM are characterized by negative refractive index a the property that MM antenna resonance can occur at wavelengths 5 to 10 times longer than their physical size by storing RF energy and reradiating it. MM will significantly reduce the required physical dimensions of wireless headsets confining the currents to the area near the antenna structure, decreasing headset SAR and increasing power efficiency [16]. Due to the MM antennas smaller physical dimensions , can be applied the efficient Multi- Input Multi-Output (MIMO) technology, which can increase the power transmission toward the base station and reduce it significantly towards the users head and body [17,18].Recently was developed a new fractal and MM antennas technique to implement low SAR and high power efficiency headsets[19].

4. Conclusions

The main mitigation techniques suggested for base stations are: A significant increase of the numbers of base stations, adaptive smart antennas and troposphere located HAPS for the coming 4G of mobile radio systems. The improvements in power efficiency and SAR of mobile headsets are significantly more important and complex for computation than from the base stations. The main headsets mitigation techniques are: space diversity using an auxiliary antenna and an efficient space separation methods. .However for small physical dimensions and multi-function headsets recent Meta Material and meta Cloak antennas are promising. The mitigation techniques presented in this paper are very useful for improving mobile radio systems power efficiency and decreasing significantly electro-smog and SAR induction affecting human head and body.

5. References

1. J.Gavan, "Base Stations and Headsets Mobile Radio Systems Radiation: Analysis, Mitigation and Simulations Techniques" International Conference on Communication Systems. Gold Coast Australia. December 2007.

2. N. Kuster. Q.Balzano.,J.C.Lin., Editors, "Mobile Communications Safety", Chapman & Hall, 1997. Chapters 1-4.

3. R. Perez, Editor, "Handbook of Electromagnetic Compatibility" Academic Press, 1995 Chapters1,19,20, and Appendix 4.

4. J. Gavan, "Transmitters Interference to Victim Receivers and Radiation Hazards to Humans: Are they Correlated?" URSI General Assembly E/F-4 pp (1-4) August 2002.

5. R. Ciccheti., A. Faraone., "Estimation of the Peak Power Density in the Vicinity of Cellular and RadioBase Station Antennas" IEEE Trans. On EMC, pp (275-290) May 2004.

6. C.A. Balanis "Modern Antenna Handbook" J. Wiley 2008.

7. T.C.Tozer, D.Grace; 'High Altitude Platforms for Wireless Communication' Electronics & Communication Engineering Journal, pp(275-288) May 2001.

8. J.Gavan, S.Tapuchi,,D.Grace; "Concepts and Main Applications of High-Altitude-Platform Radio Relays" Radio Science Bulletin N 330, pp(20-31) September 2009.

9. ICNIRP "Exposure to High Frequency Electromagnetic Fields, Biological Effects and Health Consequences (100 kHz-300 GHz)", 2009.

10. J.C. Lin; "Current Standards and Their Bases for Safe Human Exposure to Radio-Frequency Radiation" The Radio Science Bulletin pp(50-52) June 2004.

11. S.H, Yeh., C.Y., Fang., K.L. Wang, "PIFA Monopole Internal Mobile Phone Antenna for GSM/DCS/PCS Triple Band Operations" MW and Optical Technology Letters, pp(217-219), Nov.2002.

12. M. Bank ,B. Levin, "The development of a Cellular Phone Antenna with Small Irradiation of Human Organism Tissues", IEEE Antennas and Propagation Magazine Vol.49 N 4 ,pp(65-73) August 2007.

13. D. Zilbergerg., J. Gavan., "Apparatus and Method for Reducing Effect of Mobile Telephone Radiation" United States Patent 6505036, 2004. European Patent 1103086. 2005.

14. J..Martinko, R.S.Adve, "SAR Evaluation in an Heterogeneous Head Model Using the Galerkin Moment Method" URSI General Assembly New Delhi October 2005.

15. T.W.C ,Brown; S .R,Stavrou; M ,Fiacco, 'Characterization of Polarization Diversity at the Mobile", IEEE Transactions on Vehicular Technology, Volume 56, Issue 5, pp(2440 – 2447). Sept. 2007.

16.R.W Ziolkowski, A.Erentok, "Meta-Material Based Efficient Electricity Small Antennas" IEEE Transactions on Antennas and Propagation, Vol. 54 N 7,pp(2113-2130), July 2006.

17. T. Nozawa, "Antenna Technology Advance for MIMO Era", Nikkei Electronics Asia Newsletters, pp(1-5), September 2008.

18-20. WWW.Rayspan.com . WWW.metacloak.net , WWW.fractenna.com