Journal of Engineering Science and Technology Review
Special Issue on Telecommunications, Informatics, Energy and Management 2019

Conference Article

JOURNAL OF
Engineering Science and Technology Review

www.jestr.org

Measurements, Analysis and Attenuation of Electromagnetic Fields Strength Using Spectrum Analyzer in the Area of Health Safety (Kalamitsa) of Kavala

Panagiotis G. Kogias[1], Michail N. Malamatoudis[1], Sezgin S. Ibramov[2] Denitsa R. Dimitrova[2], Kiriakos Ovaliadis[1] and Eleni K. Papadopoulou[1]

[1]*Department of Electrical Engineering, Technological Educational Institute of Eastern Macedonia and Thrace Ag. Loukas, 65404 Kavala, Greece*
[2]*Department of Electronics, Faculty of Electrical Engineering and Automation "Angel Kanchev" University of Ruse 8 Studentska str., POB 7017, Ruse, Bulgaria*

Received 27 September 2019; Accepted 24 February 2020

Abstract

We used the spectrum analyzer with logarithmic – periodic antenna and we adjusted the parameters of spectrum. The purpose of the measurements is to detect whether there are cellular mobile antennas in the particular gym that is of interest to the health due to this area a lot of children play every day. The frequencies we analyzed were GSM-1800 and GSM-900. The specific frequencies were measured, analyzed in five points of interest and in three directions for finding signals of the mobile antennas in the broader area. Cellular mobile antenna signals were detected in specific areas calculated and analyzed the summary of the electromagnetic field strength. We made measurements for educational purposes and the results are indicative and didn't correspond to measurements with more precision and certified equipment.

Keywords: Electromagnetic Wave, Electromagnetic Field Strength, Cellular Mobile Phone, Radiation, Power Density, Wave Propagation, Signal Power, Polarization, Fading Channel, Intersymbol Interference, Poynting vector, Multipath Propagation

1. Introduction

Electromagnetic waves are oscillations transmitted to the free space at the speed of light (c = 299.792.500±300m/sec, for more applications c = 3 x 108 m/sec). The propagation of electromagnetic waves has many similarities to the propagation of waves created by the in water when a stone disturbs its balance, with a significant difference.

Electromagnetic waves are transverse while waves in the water longitudinal. The electrical and magnetic fields of electromagnetic wave are vertically between them as shown in figure 1. This is a theory that practically cannot be verified since electromagnetic waves are invisible. However, this approach can be used to predict the behavior of waves according to refraction, transmission and diffraction [1].

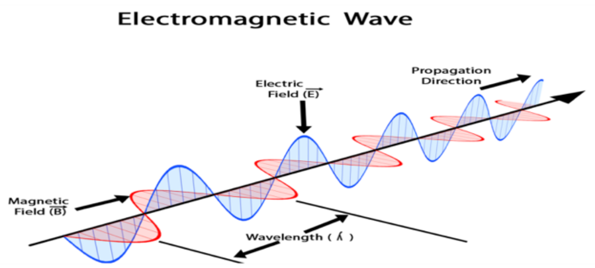

Fig. 1 Electromagnetic Wave

2. Free space transmission

An electromagnetic wave transmitted by a point source is propagated in the free space evenly towards all directions. The wave propagation is spherical as shown in figure 2. To simplify the concept of propagation we imagine rays transmitted from the point source in all directions.

At a distance P from the point source the wave has a specific phase. The radius leaves the point source when the voltage and current are maximized in a circuit that supplies the point source e.g. maximum of the electric and magnetic field.

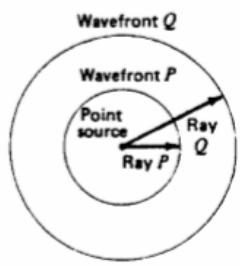

Fig. 2 Spherical Wave

All those points which have the same form a level of called wave front. If the length of ray Q is twice the P then

* E-mail address: kogias@teiemt.gr
ISSN: 1791-2377

the new sphere created has a surface 4 times larger than P ray sphere. So if we set the power density as the radiated power per unit area then the power density decreases to ¼ of its value when the distance from the source doubles [2].

It is shown that the power density is inversely proportional to the square of the distance from the source. This law is called the inverse square law and applies to all forms of dissemination in the open space. So we have:

$$P = \frac{P_t}{4\pi r^2} \qquad (1.1)$$

where P = power density at distance r from the isotropic source. P_t = radiated power.

By isotropic source we mean a source that radiates uniformly in all directions in space. Although it doesn't really is not isotropic source, the concept of isotropic radiation is very useful and very often used. It turns out that the inverse square law applies even when the source is not isotropic. However, for spherical waves, the radiation propagation rate must be constant at all points in space (such as in free space, for example). A space for which the above applies during the propagation of spherical electromagnetic waves is called isotropic [3].

The electric and magnetic field intensities of an electromagnetic wave are also important. These two quantities represent the voltage and current in an electrical circuit, and their units are Volt / m and A / m respectively. For an electric circuit we have V = ZI, while for an electromagnetic wave we have:

$$\varepsilon = f \cdot H \qquad (1.2)$$

where ε = active value of the electric field strength, H= active value of magnetic field strength, f= characteristic vertical resistance (Ω).

The characteristic vertical resistance is given by the relation:

$$Z = \sqrt{\frac{\mu}{\varepsilon}} \qquad (1.3)$$

where μ = magnetic reluctance of the means, ε = dielectric constant of the means

For Free Space we have:

$$\varepsilon = 8,854 \cdot 10^{-12} F/m$$
$$\mu = 1,257 \cdot 10^{-6} H/m$$

We recall that permeability is equivalent to induction and dielectric constant is the equivalent of capacity in electrical circuits. We can now calculate from the above relation characteristic resistance of the free space [4].

$$z = \sqrt{\frac{\mu}{\varepsilon}} = 120\pi = 377\Omega \qquad (1.4)$$

Knowledge of the characteristic resistance makes it possible to calculate the field intensity at a distance r from the isotropic source. Thus, as in the electrical circuits applies $P = V^2 / Z$, for an electromagnetic wave applies $P = \varepsilon^2 / Z$.

From the last equation and equations (1.1) and (1.2) we have:

$$\varepsilon = P \times Z = \frac{P_t}{4\pi r^2} \times 120\pi = \frac{30P_t}{r^2}$$
$$\therefore \varepsilon = \frac{\sqrt{30P_t}}{r} \qquad (1.5)$$

It can be seen from the equation (1.5) that the intensity of the electric field is inversely proportional to the distance from the source and proportional to the square root of the power density.

3. Measurements and Results

3.1 Channel Power

Frequency	CELL A	PSx	PSy	PSz
1.879 GHZ	dBm	-702.15	-704.41	-708.16
	E (V/m)	5.97e-8	3.37e-8	2.41e-8
	S (W/m^2)	7.45e-8	1.66e-9	2.79e-9
975,5 MHZ	dBm	-706.52	-706.59	-705.25
	E (V/m)	5.22e-8	3.85e-8	5.32e-8
	S (W/m^2)	2.97e-8	3.99e-8	5.45e-9

Frequency	CELL B	PSx	PSy	PSz
1.851 GHZ	dBm	-703.03	-715.28	-707.7
	E (V/m)	3.17e-8	5.97e-8	5.97e-8
	S (W/m^2)	9.08e-9	5.41e-8	4.85e-8
952.5MHZ	dBm	-702.78	-705.63	-708.4
	E (V/m)	1.17e-8	2.37e-8	4.77e-8
	S (W/m^2)	1.52e-8	4.99e-8	1.66e-8

Frequency	CELL C	PSx	PSy	PSz
1.873 GHZ	dBm	-704.38	-707.28	-706.91
	E (V/m)	4.33e-8	6.29e-8	7.44e-8
	S (W/m^2)	6.65e-8	3.41e-9	3.72e-8
930.5 MHZ	dBm	-707.66	-707.06	-703.25
	E (V/m)	2.67e-8	2.55e-8	7.97e-8
	S (W/m^2)	3.13e-9	3.59e-9	8.63e-8

Frequency	CELL D	PSx	PSy	PSz
1.873 GHZ	dBm	-705.51	-701.69	-704.53
	E (V/m)	3.97e-9	5.90e-8	3.41e-8
	S (W/m^2)	5.14e-8	1.24e-8	6.43e-9
957.5 MHZ	dBm	-703.44	-701.19	-705.38
	E (V/m)	1.91e-8	5.95e-8	2.57e-8
	S (W/m^2)	1.44e-8	1.39e-8	5.28e-9

Frequency	CELL E	PSx	PSy	PSz
1.873 GHZ	dBm	-701.47	-709.13	-707.44
	E (V/m)	5.88e-8	4.97e-9	3.97e-8
	S (W/m^2)	1.30e-8	1.77e-9	3.29e-7
957.5 MHZ	dBm	-708.55	-705.97	-709.09
	E (V/m)	2.27e-8	2.51e-8	4.35e-8
	S (W/m^2)	1.22e-8	1.99e-8	2.25e-8

3.2 Electromagnetic Field Power

We are in our measurements we used the spectrum analyzer and the parameters of the spectrum analyzer shall be presented in appendix. The following images (Fig. 5-14) as shown the results of our measurements. All measurements became in a closed gym (Kalamitsa) in a Kavala area.

We found that there are the nearest base station that was the reference point of us transmitted two frequency bands

(GSM 900 and UMTS 1800) and we received measurements in five points in the gym area which they received from the nearest base station from 260m to 410m, Fig. 4. The Cell points A, D and E have visual contact with the nearest base station and there is intersymbol interference only the atmospheric air.

Cell point	Distance From Nearest Base Station	Frequency	V/m	A/m	W/m^2
A	400m	1.879 GHZ	1.5e-8	2.47e-9	2.87e-10
		957.5 MHZ	1.0e-8	1.97e-9	3.47e-9
B	260m	1.851 GHZ	5.0e-8	1.38e-9	2.92e-9
		952.5 MHZ	6.0e-8	1.55e-9	1.45e-9
C	280m	1.873 GHZ	1.7e-8	2.31e-9	5.11e-8
		930.5 MHZ	2.8e-8	1.91e-9	1.74e-8
D	410m	1.873 GHZ	2.7e-8	2.19e-9	4.65e-9
		957.5 MHZ	2.3e-8	1.78e-9	3.47e-10
E	300m	1.873 GHZ	8.0e-8	1.87e-9	4.93e-9
		957.5 MHZ	1.1e-8	1.27e-9	2.22e-9

The Cell's B and C there are intersymbol interference depending the shadowing and reflection of buildings, cars and trees but the most important thing is that there are altitudes different between the measurement points and nearest base station [5]. The direction of the antenna receiver of spectrum analyzer is to the nearest base station and in each point shall be taken by polarization X, Y, Z. There is fading of the signal depending on the distance between the transmitter and the receiver. One of the causes of intersymbol interference is multipath propagation in which a wireless signal from a transmitter to the receiver via multiple paths. Shadowing is the effect that the received signal power fluctuates due to objects obstructing the propagation path between transmitter and receiver [1].

Generally the phenomenon in which the transmitter signal reaches the receiver attenuated and results in the alteration of the data being sent is called fading [3].

The Cell's B and C there are intersymbol interference depending the shadowing and reflection of buildings, cars and trees but the most important thing is that there are altitudes different between the measurement points and nearest base station. The direction of the antenna receiver of spectrum analyzer is to the nearest base station and in each point shall be taken by polarization X, Y, Z. There is fading of the signal depending on the distance between the transmitter and the receiver. One of the causes of intersymbol interference is multipath propagation in which a wireless signal from a transmitter to the receiver via multiple paths. Shadowing is the effect that the received signal power fluctuates due to objects obstructing the propagation path between transmitter and receiver [5].

Generally the phenomenon in which the transmitter signal reaches the receiver attenuated and results in the alteration of the data being sent is called fading.

Fig. 4 Cell Points of Measurements

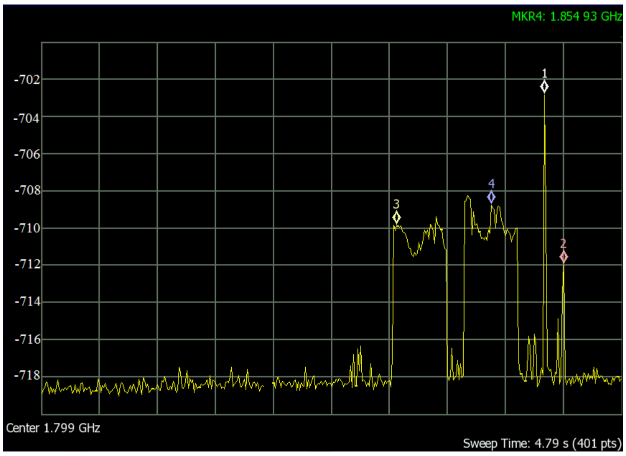

Fig. 5 Point Cell A in 1.8 GHZ Frequency

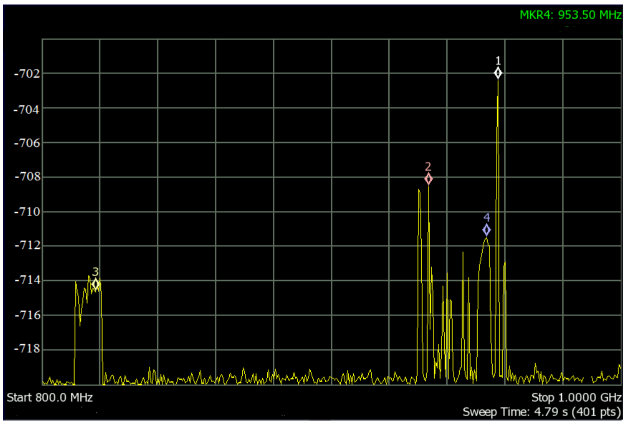

Fig. 6 Point Cell A in 800 MHZ Frequency

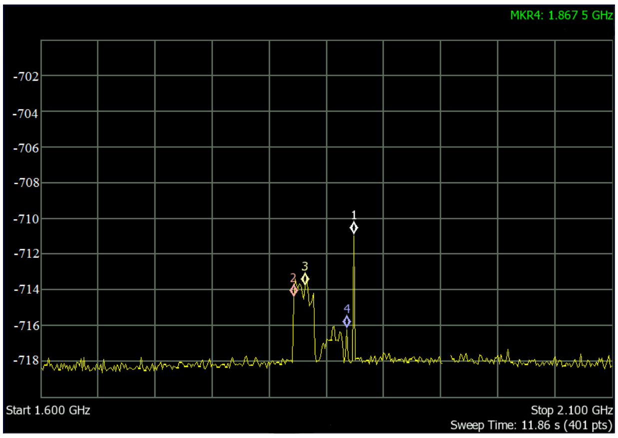

Fig. 7 Point Cell B in 1.8 GHZ Frequency

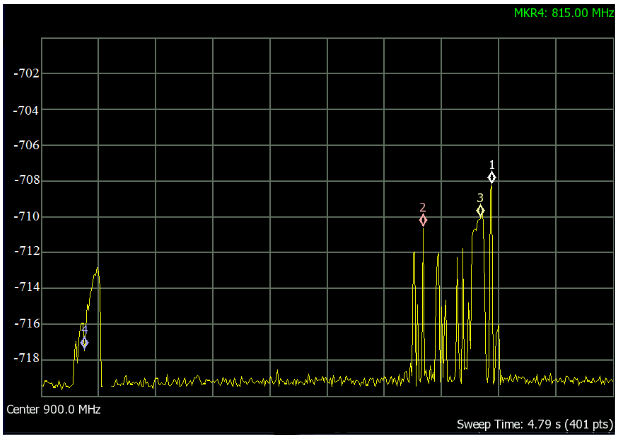

Fig. 8 Point Cell B in 800 MHZ Frequency

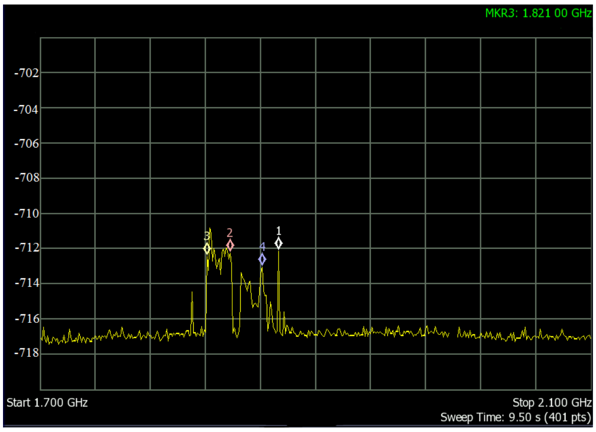

Fig. 9 Point Cell C in 1.8GHZ Frequency

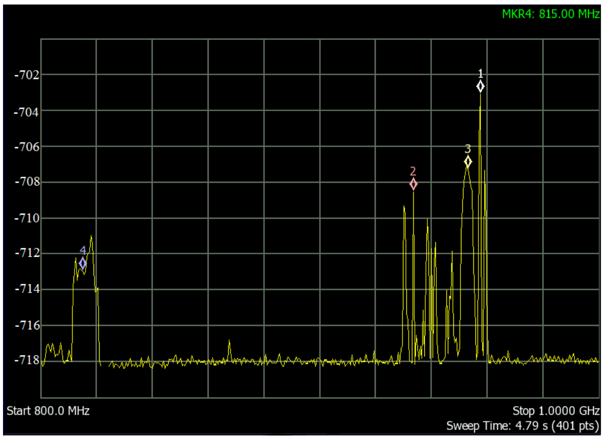

Fig. 10 Point Cell C in 800 MHZ Frequency

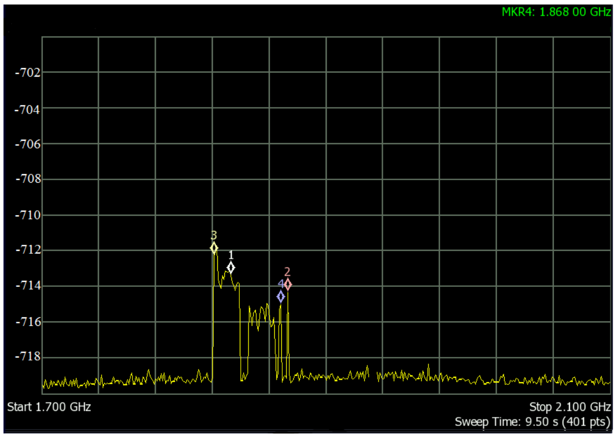

Fig. 11 Point Cell D in 1.8 GHZ Frequency

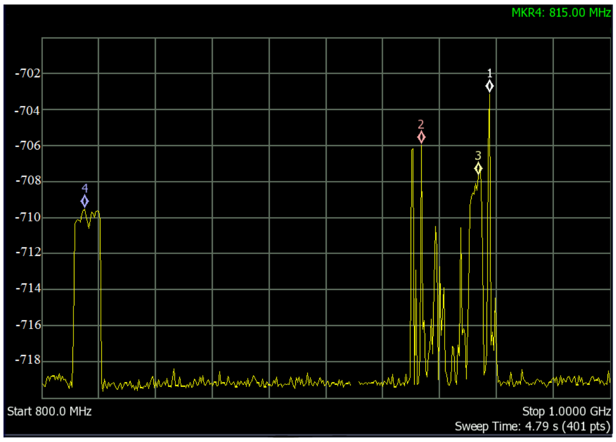

Fig. 12 Point Cell D in 800 MHZ Frequency

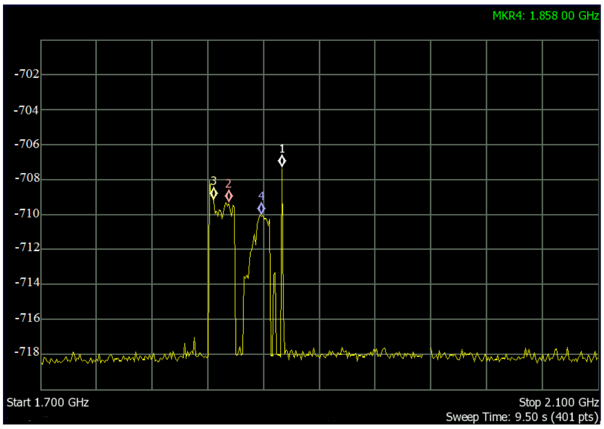

Fig. 13 Point Cell E in 1.8 GHZ Frequency

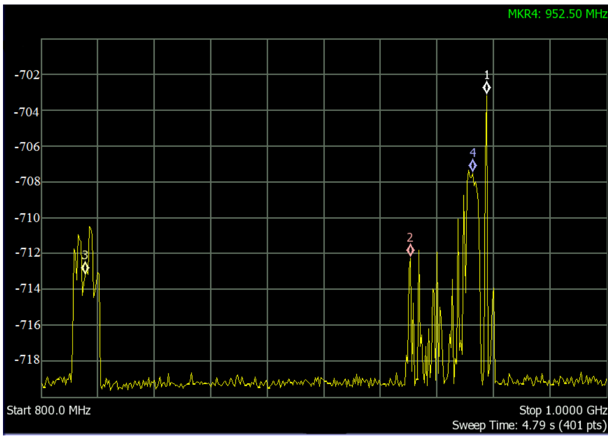

Fig. 14 Point Cell E in 800 MHZ Frequency

4. Conclusions

Based on the measurements, we calculated the results and analyzed of the electromagnetic field strength via the signal power. We carried out the measurements at a high – health interest point. **We made measurements for educational purposes and the results are indicative and didn't correspond to measurements with more precision and certified equipment.** The area has been confirmed to have mobile antennas. Also, the Poynting vector is frequently used to calculate the power density. It may be necessary to further analyze with more specialized machines to determine if they are within the permissible limits based on the legislation in force in Greece due to our non-specialized equipments deviations that had occurred.

Acknowledgements

People who contributed to the work have a nice corporation, I would like to warmly thank the members of the research team for this publication. In addition, I would like to thank Technological Educational Institute of Eastern Macedonia and Thrace for the specialized equipment machine that offered us to carry out the measurements.

References

1. W. Stallings, "Wireless communications and networks second edition" Upper Saddle River, NJ.
2. A. H. C. Wong, "Antenna Selection and Deployment Strategies for Indoor Wireless Communication Systems" University of Auckland, 2007, pp26-96.
3. Michail Malamatoudis, Panagiotis Kogias, Nikolay Manchev, Stanimir Sadinov, Design, Implementation and Analysis of a Wireless Network Coverace Using a Nanostation, ARPN Journal of Engineering and Applied Sciences, ISSN 1819-6608, vol. 14, no. 11, June 2019.
4. Study of Electromagnetic Fields Measurement Methodology of Pulsed Rotating High-Power Signals by Pantelaki Kalliopi.
5. A. Mousa, "Electromagnetic Radiation Measurements and Safety Issues of some Cellular Base Stations in Nablus" An Najah University, Palestine 2011, pp15-65