VOL. 15, NO. 20, OCTOBER 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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MEASUREMENTS, ANALYSIS AND ATTENUATION THE COMPARISONS IN THREE AREAS HEALTH SAFETY (FALIRO PARK, 19TH ELEMENTARY SCHOOL AND KALAMITSA'S GYM OF KAVALA) OF ELECTROMAGNETIC FIELDS STRENGTH USING SPECTRUM ANALYZER

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ABSTRACT

We used the spectrum analyzer with logarithmic - periodic antenna and we adjusted the parameters of spectrum. The purpose of the measurements were to detect whether the cellular mobile antennas are affected by the differentiaton of altitude difference, other antennas interference and intermediate obstacles in the particular gym, the 19th Elementary School of Kavala and Faliro Park are of interest due to the everyday high frequency of human activities at those points and if there are any health risks due to exposed frequencies. The frequencies we analyzed were GSM-1800 and GSM-900 but we will focus at 1.850GHz because it is our most interesting frequency in addition of to 950MHz. The specific frequencies were measured, analyzed in five points of interest, three directions and 1m height of ground at each point for finding signals of 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.

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.

INTRODUCTION

Spectrum can be assigned on an exclusive basis, or on a shared basis. That determines to a large degree the multiple access scheme and the interference resistance that the system has to provide:

Spectrum dedicated to service and operator: in this case, a certain part of the electromagnetic spectrum is assigned, on an exclusive basis, to a service provider. A prime point in case is cellular telephony, where the network operators buy or lease the spectrum on an exclusive basis (often for a very high price). Due to this arrangement, the operator has control over the spectrum and can plan the use of different parts of this spectrum in different geographical regions, in order to minimize interference.

Spectrum allowing multiple operators:

Spectrum dedicated to a service: in this case, the spectrum can be used only for a certain service (e.g., cordless telephones in Europe and Japan), but is not assigned to a specific operator. Rather, users can set up qualified equipment without a license. Such an approach does not require (or allow) interference planning. Rather, the system must be designed in such a way that it avoids interfering with other users in the same region. Since the only interference can come from equipment of the same type, coordination between different devices is relatively simple. Limits on transmit power (identical for all users) are a key component of this approach – without them, each user would just increase the transmit power to drown out interferers, leading essentially to an "arms race" between users.

Free spectrum: is assigned for different services as well as for different operators. The ISM band at 2.45 GHz is the best known example - it is allowed to operate microwave ovens, WiFi LANs, and Bluetooth wireless links, among others, in this band. Also for this case, each user has to adhere to strict emission limits, in order not to interfere too much with other systems and users. However, coordination between users (in order to minimize interference) becomes almost impossible - different systems cannot exchange coordination messages with each other, and often even have problems determining the exact characteristics (bandwidth, duty cycle) of the interferers.

After 2000, two new approaches have been promulgated, but are not yet in widespread use:

Ultra-Wide Bandwidth systems (UWB) spread their information over a very large bandwidth, while at the same time keeping a very low-power spectral density. Therefore, the transmit band can include frequency bands that have already been assigned to other services, without creating significant interference.

Adaptive spectral usage: another approach relies on first determining the current spectrum usage at a certain location and then employing unused parts of the spectrum. This approach is also known as cognitive radio.

WIRELESS COMMUNICATIONSAND NETWORKS

In a data transmission system, the transmission medium is the physical path between transmitter and receiver. Transmission media can be classified as guided or unguided. In both cases, communication is in the form of electromagnetic waves. With guided media, the waves are guided along a solid medium, such as copper twisted pair, copper coaxial cable, or optical fiber. The atmosphere and outer space are examples of unguided media, which provide a means of transmitting electromagnetic signals but do not guide them; this form of transmission is usually referred to as wireless transmission.

The characteristics and quality of a data transmission are determined both by the characteristics of the medium and the characteristics of the signal. In the case of guided media, the medium itself is usually more important in determining the limitations of transmission. For unguided media, the bandwidth of the signal produced by the transmitting antenna is usually more important than the medium in determining transmission characteristics. One key property of signals transmitted by antenna is directionality. In general, signals at lower frequencies are omnidirectional; that is, the signal propagates in all directions from the antenna. At higher frequencies, it is possible to focus the signal into a directional beam.

Figure-1 depicts the electromagnetic spectrum and indicates the frequencies at which various guided media and unguided transmission techniques operate. In the remainder of this section, we provide a brief overview of unguided, or wireless, media.

For unguided media, transmission and reception are achieved by means of an antenna. For transmission, the antenna radiates electromagnetic energy into the medium (usually air), and for reception, the antenna picks up electromagnetic waves from the surrounding medium. There are basically two types of configurations for wireless transmission: directional and omnidirectional. For the directional configuration, the transmitting antenna puts out a focused electromagnetic beam; the transmitting and receiving antennas must therefore be carefully aligned. In the omnidirectional case, the transmitted signal spreads out in all directions and can be received by many antennas. Three general ranges of frequencies are of interest in our discussion of wireless transmission. Frequencies in the range of about 1 GHz (gigahertz = 10^9 Hz) to 100 GHz are referred to as microwave frequencies. At these frequencies, highly directional beams are possible, and microwave is quite suitable for point-to-point transmission. Microwave is also used for satellite communications. Frequencies in the range 30 MHz to 1 GHz are suitable for omnidirectional applications. We refer to this range as the radio range.

Another important frequency range, for local applications, is the infrared portion of the spectrum. This covers, roughly, from 3 x 10^{11} to 2 x 10^{14} Hz. Infrared is useful in local point-to-point and multipoint applications within confined areas, such as a single room.

Table-1. Transmission characteristics.

Band (GHz)	Bandwidth (MHz)	Date Rate (Mbps)
2	7	12
6	30	90
11	40	135
18	220	274

Transmission Characteristics Microwave transmission covers a substantial portion of the electromagnetic spectrum. Common frequencies used for transmission are in the range 2 to 40 GHz. The higher the frequency used, the higher the potential bandwidth and therefore the higher the potential data rate. Table-1 indicates bandwidth and data rate for some typical systems.

As with any transmission system, a main source of loss is attenuation. For microwave (and radio frequencies), the loss can be expressed as:

$$L = 10\log(\frac{4\pi d}{\lambda})^2 \text{ dB} \quad (1.1)$$

where d is the distance and λ is the wavelength, in the same units. Thus, loss varies as the square of the distance. In contrast, for twisted pair and coaxial cable, loss varies exponentially with distance (linear in decibels). Thus repeaters or amplifiers may be placed farther apart for microwave systems-10 to 100 km is typical. Attenuation is increased with rainfall. The effects of rainfall become especially noticeable above 10 GHz. Another source of impairment is interference. With the growing popularity of microwave, transmission areas overlap and interference is always a danger. Thus the assignment of frequency bands is strictly regulated.

The most common bands for long-haul telecommunications are the 4-GHz to 6-GHz bands. With increasing congestion at these frequencies, the 11-GHz band is now coming into use. The 12-GHz band is used as a component of cable TV systems. Microwave links are used to provide TV signals to local CATV installations; the signals are then distributed to individual subscribers via coaxial cable. Higher-frequency microwave is being used for short point-to-point links between buildings; typically, the 22-GHz band is used. The higher microwave frequencies are less useful for longer distances because of increased attenuation but are quite adequate for shorter distances. In addition, at the higher frequencies, the antennas are smaller and cheaper.

VOL. 15, NO. 20, OCTOBER 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

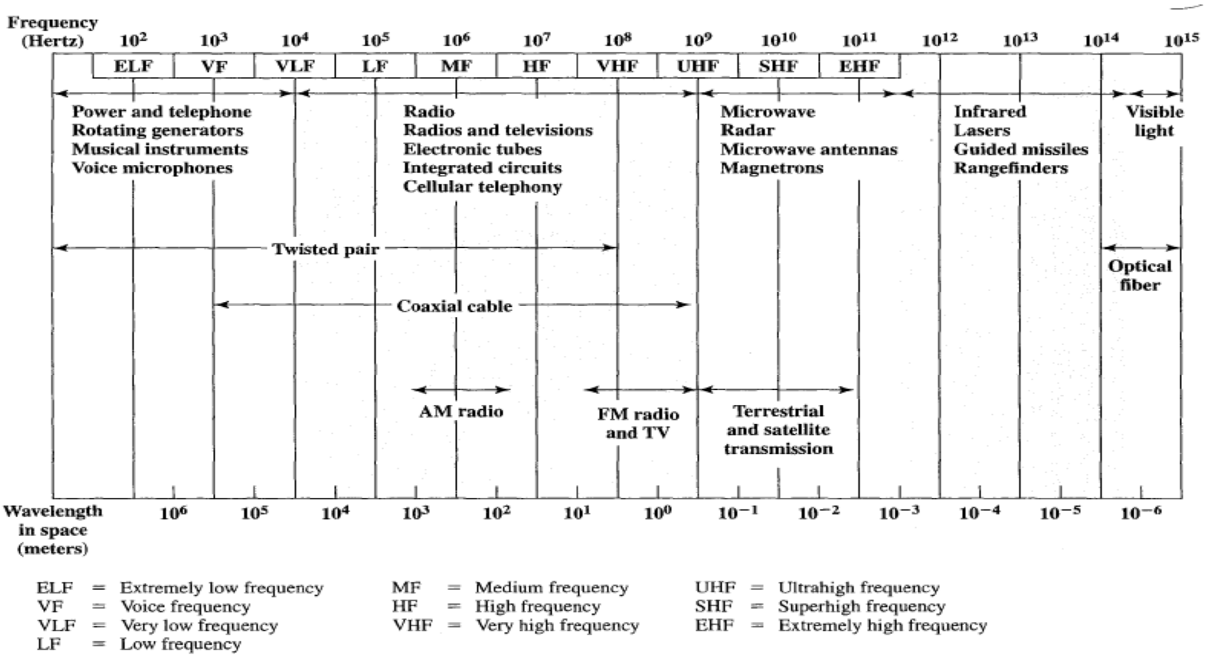

Figure-1. Electromagnetic spectrum for telecommunications.

MEASUREMENTS AND RESULTS

The calculation of the power and energy of the electromagnetic wave is important for numerous applications. There are some equations to compute the power and energy density of the electromagnetic wave radiation. For instance, the Poynting vector is frequently used to calculate the power density. However those including the Poynting vector are not perfect to represent the actual values because the equations are frequency independent. In the present study we have derived the frequency-dependent equations to calculate the power and energy flux density of the electromagnetic wave by help of the classical electromagnetic theories. It is seems that the correct only for a specific frequency. However our equations are perfect to calculate the values of the power and energy flux density for all frequencies of the electromagnetic radiation. The equations may help to develop the applications of the electromagnetic wave radiation, see Table-2.

Table-2. Electromagnetic field power.

	Kalamitsa's Gym				Faliro Park				19th Elementary School			
Cell Point	Distance From Nearest Base Station	Frequency	V/m	A/m	Distan-ce From Nearest Base Station	Frequency	V/m	A/m	Distan-ce From Nearest Base Station	Frequency	V/m	A/m
A	400m	1,850GHz	1.5e-8	2.47e-9	1007m	1,850GHz	1.8e-11	2.8e-14	107m	1,850GHz	1.8e-7	1.77e-9
		950MHz	1.0e-8	1.97e-9		950MHz	3.9e-11	2.3e-14		950MHz	4.2e-7	1.67e-9
B	260m	1,850GHz	5.0e-8	1.38e-9	1010m	1, 850GHz	2.2e-11	1.9e-14	108m	1,850GHz	2.4e-7	1.47e-9
		950MHz	6.0e-8	1.55e-9		950MHz	2.1e-11	2.1e-14		950MHz	1.7e-7	1.57e-9
C	280m	1,850GHz	1.7e-8	2.31e-9	995m	1,850GHz	1.2e-11	2.0e-14	123m	1,850GHz	1.2e-7	1.33e-9
		950MHz	2.8e-8	1.91e-9		950MHz	1.3e-11	2.2e-14		950MHz	1.4e-7	1.27e-9
D	410m	1,850GHz	2.7e-8	2.19e-9	947m	1,850GHz	1.7e-10	1.8e-14	121m	1,850GHz	1.3e-7	1.09e-9
		950MHz	2.3e-8	1.78e-9		950MHz	1.6e-10	1.7e-14		950MHz	1.9e-7	1.03e-9
E	300m	1,850GHz	8.0e-8	1.87e-9								
		950MHz	1.1e-8	1.27e-9								

VOL. 15, NO. 20, OCTOBER 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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CELL CHANNEL POWER

We are in our measurements we used the spectrum analyzer and the parameters of the spectrum analyzer shall be presented in EU standards. The following Table-4 (Figures 5-17) as shown the results of our measurements. All measurements became in a closed gym (Kalamitsa), Faliro Park and 19th Elementary School in a Kavala area.

We found that there are the nearest base stations that were the reference points of us transmitted frequency bands (UMTS 1800) and we received measurements in the points in the gym area which they received from the nearest base station from 260m to 410m, Table-3 (Figure-2). The Cell points A, D and E have visual contact with the nearest base station and there is intersymbol interference only the atmospheric air.

The Cell's B and C there are intersymbol interference depending the shadowing and reflection of buildings, cars and trees but the most important things was the altitude difference there was two of the other three points and the nearest base station.

The same goes for Figure-3 (Table-3) in four points in the park area which they received from the nearest base station from 947m to 1010m. The Cell points A, B and D have visual contact with the nearest base station and there is intersymbol interference only the atmospheric air.

The Cell's C and D there are intersymbol interference depending the shadowing and reflection of buildings, cars and trees but the most important things was the altitude difference there was two of the other two points and the nearest base station.

Lastly we repeated the same method of measurement at Figure-4 (Table-3). We found that there are the nearest base station that was the reference point of us transmitted two frequency bands (UMTS 1800) and we received measurements in four points in the School which they received from the nearest base station from 107m to 121m in Figure-4 (Table-3).

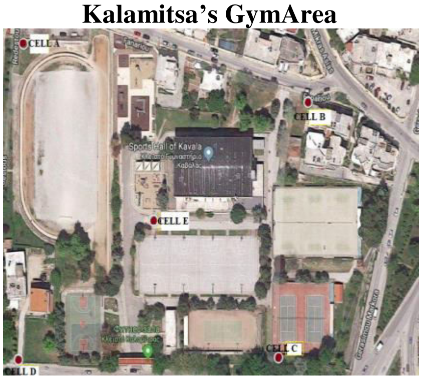
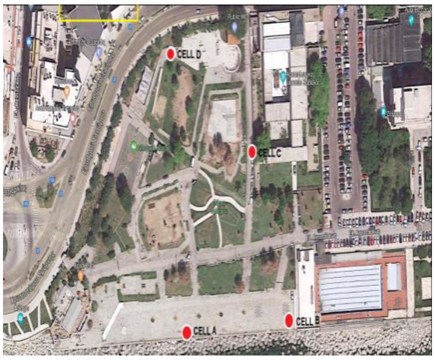
The Cell points A, B have visual contact with the nearest base station and there is intersymbol interference only the atmospheric air.The Cell's A, B, C and D there are intersymbol interference depending the shadowing and reflection of buildings but the most important things was the altitude difference there was all of the points and the 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 reaches 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.

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.

Table-3. Cell points of measurements.

Kalamitsa's GymArea		**Faliro Park**		**19th Elementary School**	
 **Figure-2.**Cell Points of Measurements		 **Figure-3.**Cell Points of Measurements		 **Figure-4.**Cell Points of Measurements	
Cell Points	Distance	Cell Points	Distance	Cell Points	Distance
A	400m	A	1007m	A	107m
B	260m	B	1010m	B	108m
C	280m	C	995m	C	123m
D	410m	D	947m	D	121m
E	300m	-	-	-	-

VOL. 15, NO. 20, OCTOBER 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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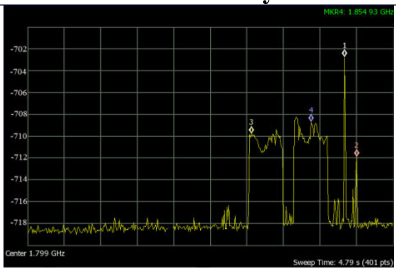
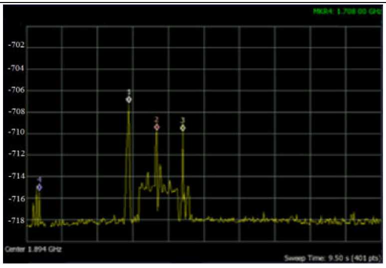
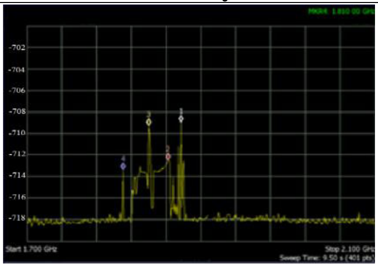
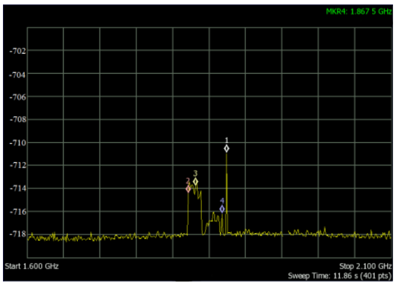
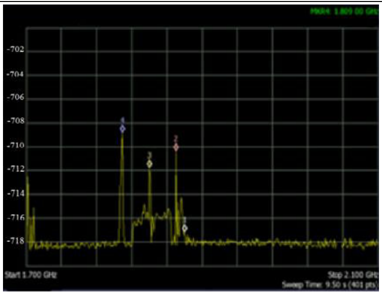
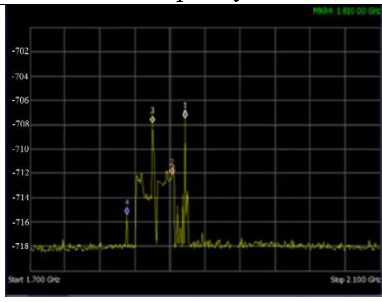
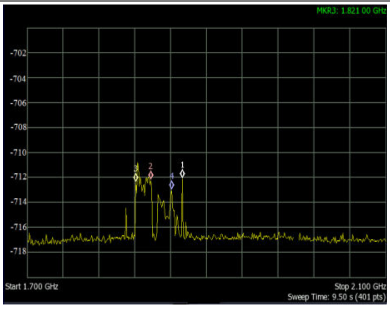
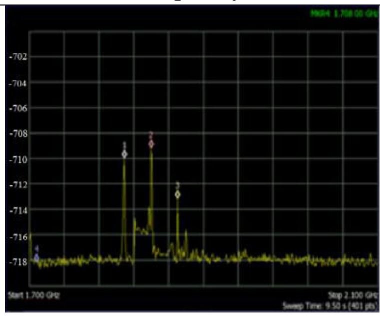
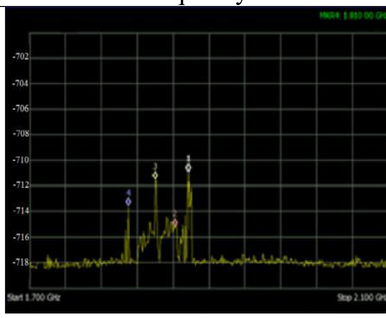
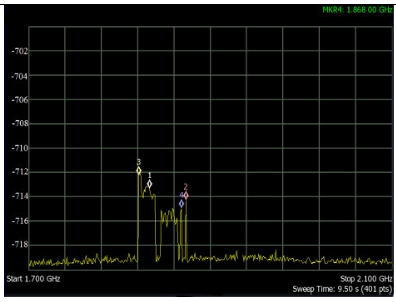
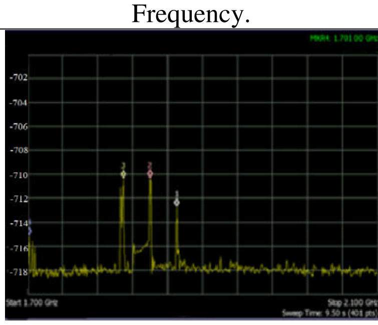
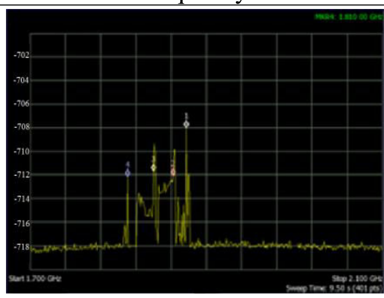
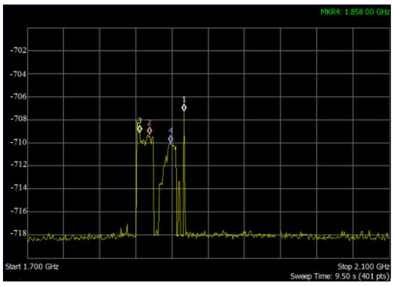
Table-4. Channel power of measurements.

Kalamitsa's Gym	Faliro Park	19th Elementary School
 **Figure-5.** Point Cell A in 1.8 GHZ Frequency.	 **Figure-6.** Point Cell A in 1.8 GHZ Frequency.	 **Figure-7.** Point Cell A in 1.8 GHZ Frequency.
 **Figure-8.** Point Cell B in 1.8 GHZ Frequency.	 **Figure-9.** Point Cell B in 1.8 GHZ Frequency.	 **Figure-10.** Point Cell B in 1.8 GHZ Frequency.
 **Figure-11.** Point Cell C in 1.8GHZ Frequency.	 **Figure-12.** Point Cell C in 1.8GHZ Frequency.	 **Figure-13.** Point Cell C in 1.8GHZ Frequency.
 **Figure-14.** Point Cell D in 1.8 GHZ Frequency.	 **Figure-15.** Point Cell D in 1.8 GHZ Frequency.	 **Figure-16.** Point Cell D in 1.8 GHZ Frequency.
 **Figure-17.** Point Cell E in 1.8 GHZ Frequency.		

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 Greecedue 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 Kavala for the specialized equipment machine that offered us to carry out the measurements.

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