Spectrum Analyzer Measurement Technique for Safety Evaluation on Wireless Communication Systems

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Abstract

In this paper, general information about, unionized radiation, wireless communication systems and electromagnetic fields are given. The safety of mobile phones has been evaluated in terms of specific absorption ratio (SAR). This SAR values have been defined discussing among international standard organizations. Electromagnetic Compatibility (EMC) measurements are made with a compact spectrum analyzer device, measure 400 MHz- 6 GHz bandwidth, and a triaxial antenna. Electromagnetic fields and power flux density values are measured and compared with the SAR values and ICNIRP standard curve. These values are observed for different times a day.

1. Introduction

With the increase of wireless communication devices exponentially over the last years, the health risk due to electromagnetic fields have became a focus of public concern. This was associated with raised public concern regarding human safety related to electromagnetic waves. This issue has developed in to an important subject of the study in the EMC research field. The public perception of increase in ambient background of radio frequency (RF) or high frequency (HF) radiation in the environment has developed in to a public concern. As a result, this required an engagement of public health authorities to quantify these fields by measurement [1, 10].

This article will focus on the issue of high frequency, used for wireless communication and television receivers, electromagnetic field measurement. This called non-ionizing radiation measurement. There is not any nucleus particle radiation similar to very high frequency nuclear radiation. The frequency bandwidth and wavelengths for different events are shown in Figure 1 [2, 6].

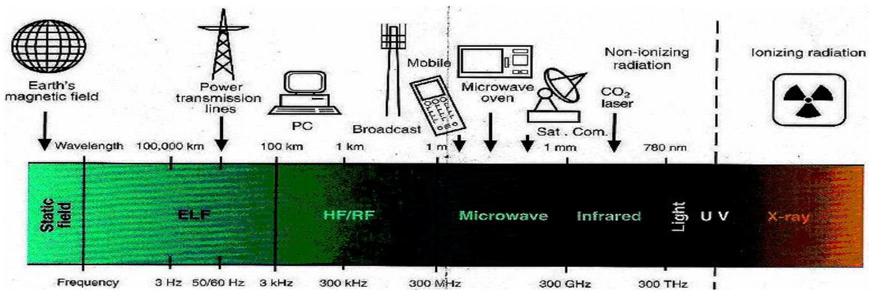

Figure 1. The frequency bandwidth and wavelengths for different events

In practice, it's impossible to measure directly SAR values. Therefore measurement practice introduced electric and magnetic field strength in the near field and power density in the far field in addition to absorbed energy units. The statistically averaged SAR over 6 minutes as specified in safety guidelines. This time is defined the basis of bio-electromagnetic research in the field of thermal effects and used all the safety measurements as a standard [3-5].

To research accumulating effects of exposure to electromagnetic radiation emitted by a conventional mobile phone (stand by position) 24 adult male rabbits are used. This rabbits are equally divided three groups to measure sperm count for different conditions. As a result mobile phone applied one of the rabbits group for 8 hours daily for 12 weeks, and at the end of this time phone applied rabbits sperm accounts are reduce nearly 50% ratio. This study has indicated significant decrease in sperm count and motility at weeks 8 and 10 because of exposure to mobile phone emission respectively [7, 8, 11].

Electromagnetic Compatibility (EMC) measurements are made with a compact spectrum analyzer device, produced by NARDA named SRM 3006 model and measure 400 MHz- 6 GHz frequency range, with a triaxial

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coil antenna. Electric fields is converted magnetic fields and power flux density values using a standard table for far measurements. This measured and calculated values compared with the SAR values and ICNIRP or other standard curves. These curves can be changed with public rules. In this experimental study, measured EM field values are observed and safety values and distance are estimated [6, 9].

2. Electromagnetic Fields and Antennas

Electromagnetic fields properties are described by Maxwell's equations. It says that a source of emitting time varying electric field induces magnetic field. A time varying electric field generates a time varying magnetic field or vice versa. Both electric and magnetic field components oscillate in phase perpendicular to each other. The electromagnetic field is the combination of these fields. Fundamental dipole equations see as what is depicted in Table 1.

Table 1. Fundamental dipole equations

High Frequency	Field Parameters
S=E*H (W/m²)	S=Power flux density
E=Z0*H (V/m)	E=Electric field strength
H=E/Z0 (A/m)	H=Magnetic field strength
Low Frequency	Z0=377 ohm (space emp.)
$B=\mu_0*H$	B=Magnetic flux density or magnetic induction (in Tesla or Gauss)
$\mu_0=4*\pi*10^{-7}$ Vs/Am	

Two main zones are used for measurement. One of them near zone the other one is far zone. The zone limit defined with the distance from field source (R). If $R<3\lambda$ is accepted near field. If wavelength (λ) less than the diameter (D) of the antennas (e.g. radars) then $R>2D^2/\lambda$ for far field [2]. For far zone E and H fields in phase as shown in Figure 2.a. If only one component must be measured since the other can be computed. For near zone, E and H fields decoupled and are not in phase as shown in Figure 2.b. The two quantities must be measured separately.

Figure 2. (a) E and H fields in phase for far zone (b) E and H fields did not in phase for near zone

Magnetic fields are measured by coils as sensors. The induced current corresponds to the field strength. A triaxial array consists of three coils, each covering an area of 100cm² to conform to European standards.

Electric fields are measured using sensors based on principle of dipoles or capacitors. The output voltage is proportional to the field strength. Triaxial dipoles arrays for the high frequency range measurements, capacitors arrays for the low frequency range measurements. For far zones, magnetic field is computed from electric field by using equations in Table 1. For near zone, the total electric field is obtained using three axis measurements.

3. Standards and Guidelines

HF or RF electromagnetic fields can heat the all body or parts of the body depending on the frequency. Heating and burning of tissue can be caused as a short term effect. The body and body parts act as a lossy antenna in the 0.75m to 2m wavelength range. This wavelength is the resonance frequency of the body. The body's qualitative absorption curve as a function of radio frequency is shown in Figure 3.

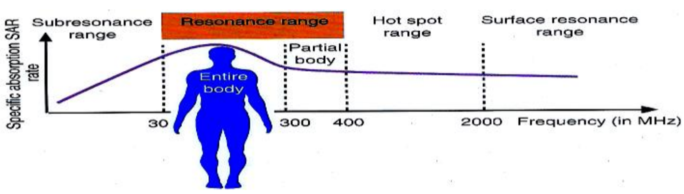


Figure 3. The body's absorption curve

Presently, existing standards and guidelines (e. g. ICNIRP, IEEE, WHO) take Specific Absorption Ratio (SAR) as a reference quantity. This rate is defined as RF electromagnetic energy absorbed in the body in average 6 minutes. In practice, it's impossible to measure SAR value directly. Therefore, recommended measurement practice is introduced as exposure levels in terms of unperturbed electric and magnetic field strength in the near field and power density in the far field, in addition to absorbed energy units. Since the guidelines and the standards have been developed on the basis of bio electromagnetic research in the field of thermal effects, the spatial and time-averaged values are needed to be measured [12].

Depending on absorption curve, ICNIRP guidelines for electric field is defined as shown in Figure 4. This electric field curve can be converted magnetic field curve and power density curve easily for far field region using a conversion table and the formulas. Two guidelines are shown in Figure 4, one of them is valid for general public and the other one is for continuously exposed to electromagnetic radiation occupations. For continuously exposed to electromagnetic radiation occupations is permitted more than public standards.

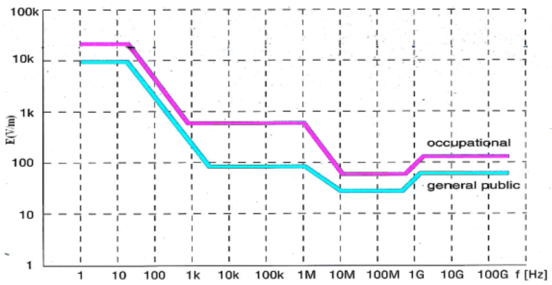


Figure 4. ICNIRP guidelines for electric field

Turkish public safety evaluation standards are defined using ICNIRP guidelines and this are decelerated at last in 2009. These evaluation standards are used in measurement device and define safety values [10, 13].

4. Measurement System and Routines

RF field probes are often preferred for EMF measurement because of being it is fast, simple and convenient. In general, RF probes have wide operation frequency but not selective. For frequency selective measurement it is needed to have an antenna and a spectrum analyzer operated in a sweeping time mode over the frequency range of interest. In these measurements used NARDA SRM 3006 model device which can measure 400MHz-6GHz bandwidth with a triaxial antenna. This device is included all the equipment and software in it as a compact system. The measurement results are recorded in device and can be uploaded to a computer easily using its special software. The calibrations are made for antenna, connection wire and spectrum analyzer separately. With the GPS system in it, coordinates are defined easily. Using the unit change operations electric field, magnetic field and power density can be converted each other and the results are shown on the screen how you wanted. Another property of device is that it can select the spectrums for different services and can show the results of maximum, average, actual, maximum average of signals as a table or a bar graphic. Also it can compare the results with the standard curve on the screen.

5. Experimental Measurements

In this study, some of the measurements are performed at Rize University campus area where TV transmitter towers and base stations are located in a near hill. The measurements are performed on the roof of the highest building in the university campus where the distance is the nearest point from the antenna is horizontally. The Electric field spectrum measurement results from 420MHz to 2.17GHz as an average is shown in Figure 5.

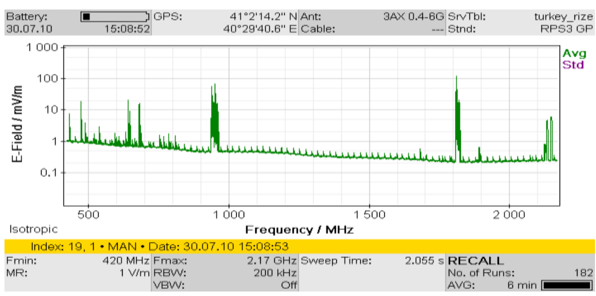


Figure 5. Electric field measurement results

For this spectrum, selected frequency services electric field and total electric field are shown as a table in Figure 6.a. The bar graphic of this table is shown in Figure 6.b. to be compare easily.

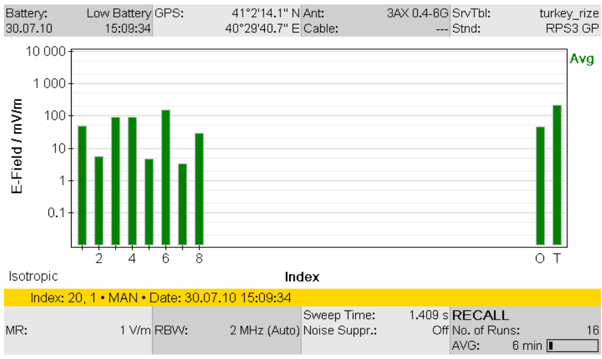
Battery: Ext. Power 30.07.10 15:29:28	GPS: 41°2'16.2" N 40°29'36.0" E	Ant: 3AX 0.4-6G Cable: ---	SrvTbl: turkey_rize Stnd: RPS3 GP	
Distribution: Detailed				
Index	Service	Fmin	Fmax	Avg
1	TV	470.000 MHz	862.000 MHz	41.31 mV/m
2	GSM900_UL	890.000 MHz	915.000 MHz	5.324 mV/m
3	turkcell	935.000 MHz	946.200 MHz	113.7 mV/m
4	vodafon	946.400 MHz	957.000 MHz	103.4 mV/m
5	GSM1800_UL	1 710.000 MHz	1 785.000 MHz	5.008 mV/m
6	Avea_DL	1 805.200 MHz	1 818.400 MHz	101.5 mV/m
7	UMTS_UL	1 930.000 MHz	1 970.000 MHz	3.262 mV/m
8	UMTS_DL	2 120.000 MHz	2 170.000 MHz	88.05 mV/m
	Others			42.61 mV/m
	Total			212.8 mV/m

Isotropic

Index: 23, 1 • MAN • Date: 30.07.10 15:29:29

MR: 1 V/m	RBW: 2 MHz (Auto)	Sweep Time: 1.440 s Noise Suppr.: Off	RECALL No. of Runs: 262 AVG: 6 min

Figure 6. (a) Electric field detailed service table.



(b) Electric field detailed bar graphic.

Safety distance for an antenna is calculated using the Equation 1. In this equation, P is the device output power, G is the antenna gain as dB, and E is the electrical area limit value. Using this formula and measurement distance safety distance can be estimated about 5m to 10m.

$$d = \frac{\sqrt{30.P.10^{G/10}}}{E} \text{ (meter)} \qquad (1)$$

6. Conclusions

In this paper, general information about non ionizing radiation, measurement equipments and standards are given. Measurement systems and experimental results are studied in detail. For different measurement routines results are compared with standards and using this results, safety distance estimated. For different stations electric fields, magnetic fields and power densities are measured similarly. As a future study, it can be measured different points fields and located on a map. So an electromagnetic pollution map can be formed for any place like a campus or Rize city.

7. References

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