Electromagnetic Radiation Measurements at Olympia Radio Short Wave Antennae Park

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Abstract: This paper presents and analyses measurements as well as theoretical calculations of the electromagnetic radiation emitted by a short wave antennae installation of the Greek incumbent Telecom Operator (OTE). The antennae park, named "Olympia Radio", is located in the Prefecture of Ilia in south-western Greece, is consisted of 24 antennae masts, and built in an area of 1.2 km^2. The radiation emitted by this installation when worst case scenarios were applied, was well bellow the limits set by European Community legislation, as well as national law.

Key-Words: Electromagnetic Radiation, Electromagnetic Emissions, Short Wave, Olympia Radio Antennae Park, RF Safety Measurements, Radiation Exposure Limits.

1. Introduction

"Olympia Radio" is a short wave antennae park, consisted by 24 antennae, and located in south-western Greece, occupying an area of 1.2 km^2. The nearest village, named Epitalion is in 3.5 km distance.

The scope of this study is to demonstrate that the radiation levels from the Olympia Radio antennae park is below the limits set both by the European Community and National Legislations.

Communication via short wave is a very old method, but still in use. The particular installation serves maritime communication needs, both telephony and data.

Safety was not the main issue for the designer engineer of Short waves antennae parks some years ago. Public awareness due to the expansion of mobile telephony, obliged the operators to look very carefully on this matter, asking expertise help from the academia [1].

These obligations are imposed to telecom operators through European and national legislation [2], [3].

2. Olympia Radio Emission Characteristics

The Transmission site includes 26 radio transmitters of maximum power of 10kW. The 24 antennae may be categorised in 5 groups as shown in the next table 1. Take off angle varies between 0^o to 10^o, and mast heights between 25 to 45 m. During the heavy load function of the installation, 16 radios are transmitting during a 24h period.

Antenna type	Amount	Frequency (MHz)	Technical Data
TCI 540-N-04	10	4 - 30	Omni, Horizontal Polarisation, Gain 6dBi at 4MHz, 19dBi at 30MHz, Dimensions (L,W,H) 90.2x90.2x30.2m
TCI 527-BN-04	4	6 – 30	Log Periodic, Horizontal Polarisation, Gain 15dBi Dimensions (L,W,H) 101x125x46m

TCI 550-6	4	1.6–30	Inverted Cone Omni, Horizontal / Vertical Polarisation, Gain 5dBi Dimensions (L,W,H) 88.7x88.7x43m
Andrew 3001-4L	3	8–30	Spiracone Omni, Horizontal / elliptical Polarisation, Gain 7dBi Dimensions (L,W,H) 41.2x41.2x36
AP LPH-9	3	6-30	Rotatable Log-Periodic, Horizontal Polarisation, Gain 13dBi Dimensions (L,W,H) 23.12x20.12x28.0

Table 1. Transmission Characteristics of Olympia Radio Antennae.

3. Critical distances calculations

The methodology used is based in the worst-case scenario, which takes into account that 16 out of the 24 radios are transmitting through their corresponding antennae. Considering the vertical cut of a typical radiation pattern generated by an omnidirectional antenna, as the one in fig. 1, a beamwidth angle (θ_s=AÔB) may be defined.

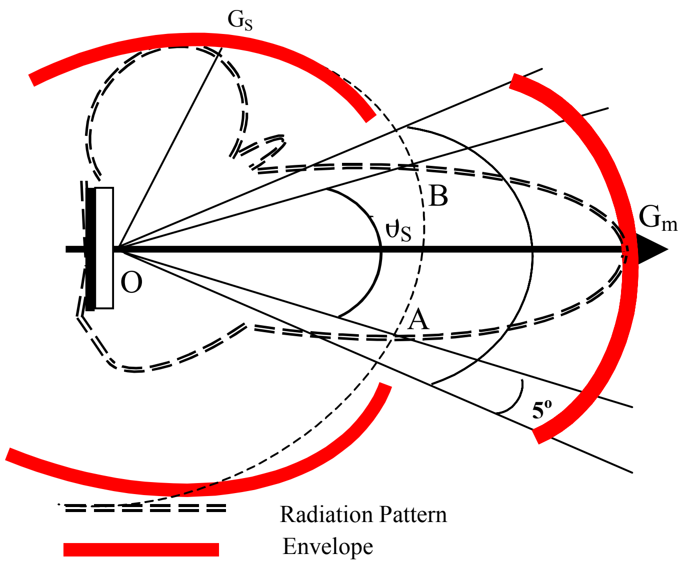

Fig.1 Radiation pattern envelope

Where G is the gain at bore site and G_s is the side lobe maximum gain. Points A and B are defined on the radiation pattern line when the gain on the main lobe equals to G_S.

In order to take into account various manufacturing and installation misalignments, the value of this angle is increased by a factor of 10^o and therefore angle α in fig.1 would be:

$$\alpha = \theta_s + 10^o \qquad (1)$$

The critical minimum distances form an antenna, corresponded to the diagram of fig.1 are given by [4,5]:

$$R_m = \sqrt{\frac{P \cdot 10^{0.1G_m}}{\pi S_{max}}} \qquad (2)$$

and

$$R_S = \sqrt{\frac{P \cdot 10^{0.1G_S}}{\pi S_{max}}} \qquad (3)$$

Where: S_{max}=Power density reference level [2,3]
P=Antenna feeding power
G_m=bore site antenna gain
G_s= max. side lobe gain

Furthermore, the radiation frequency for all transmitting antennae is considered 30MHz, as the reference power density levels are worse than in lower frequencies [2].

The critical distances, R_m and R_S, resulted form equations (2) and (3) are shown in table 2, along with take off and α (eq. 1) angles, taking into account that the transmitting power was 10kW and the frequency 30MHz.

Antenna type	R_m (m)	R_S (m)	Take off angle	α
TCI 540-N-04	70.6	56.10	10^o	20^o
TCI 527-BN-04	117.4	39.70	15^o	25^o
TCI 550-6	70.6	0	0^o	360^o
Andrew 3001-4L	70.6	31.5	10^o	20^o
AP LPH-9	140.9	88.9	5^o	13^o

Table2: Critical distances calculations.

The reference level set by National legislation, for the frequency of 30MHz, is 22.4 V/m and 1.6 W/m^2 [3]. These values are 20% less than those set in E.U. level [2].

4. Measurements campaign

Field strength measurements were recorded for each individual antenna type of Table 1, as well as for the resulted field from the simultaneous radiation more antennae.

In total 38 measurements were performed in 45 reselected locations, as shown in next fig. 2. E_{max} and E_{ave} were recorded for each one measurement. These values of the electric field were then compared to reference level set by the Greek national law, of 22.4 V/m, and the one of the relevant EU recommendation of 30V/m.

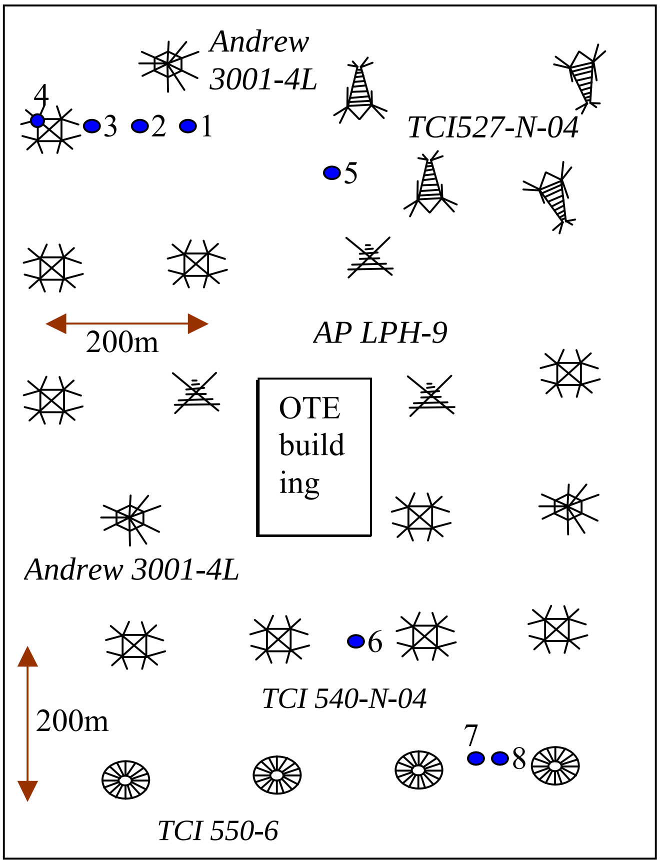

Fig. 2: Draft top view of Olympia Radio antenna park

Electromagnetic radiation measurements were executed with the aid of a suitable field strength meter [6].

The basic characteristics of the instrument are given in next table 3.

Field strength meter	
Manufacturer	Wandel & Goltermann
Model	EMR-200
Probe	Electric Field
Frequency Range	100 kHz - 3 GHz
Measurement Method	Isotropic
Dynamic Area	>60dB

Table 3. Field strength instrument basic characteristics

The experimental set-up is depicted in fig. 3. The electric field sensor was based at 2m height from the ground level. The duration of each measurement was 6 minutes. For each measurement E_{max} and E_{ave} were recorded.

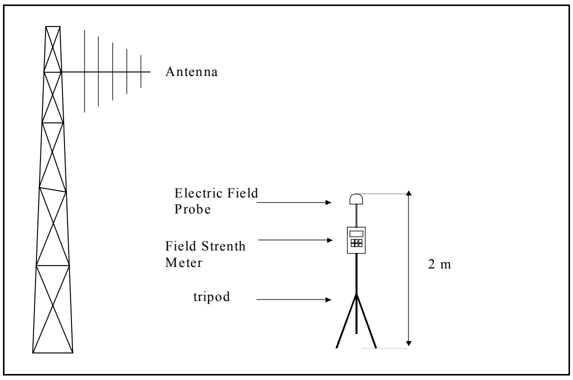

Fig.3: Measurement set-up

5. Results

The first set of measurements were related to radiation form a single antenna type. The second set was performed when 16 radios were emitting through their corresponded antennae. Finally far field readings were taken towards Epitalion village site.

5.1 Measurements by antenna type

Next table 4, shows some indicative results of the above-mentioned measurements

Antenna type	Distance form mast (m)	E_{max} V/m	P_{out} kW	F MHz
TCI 540-N-04	0	14,55	5	16
	20	16,82	5	16
TCI 527-BN-04	20	14,69	5	16
TCI 550-6	0	174,60	5	12
	20	44,82	5	12

	40	24,24	10	12
Andrew 3001-4L	0	35,14	5	16
	15	31,9	5	16
	30	13,5	5	16
AP LPH-9	25	27,91	5	22
	35	23,56	5	22
	25	16,50	8	22

Table 4. Measured values of the Electric field density.

The following graph compares E_{max} value for each type of antenna, as the field-strength meter was departing away from the mast.

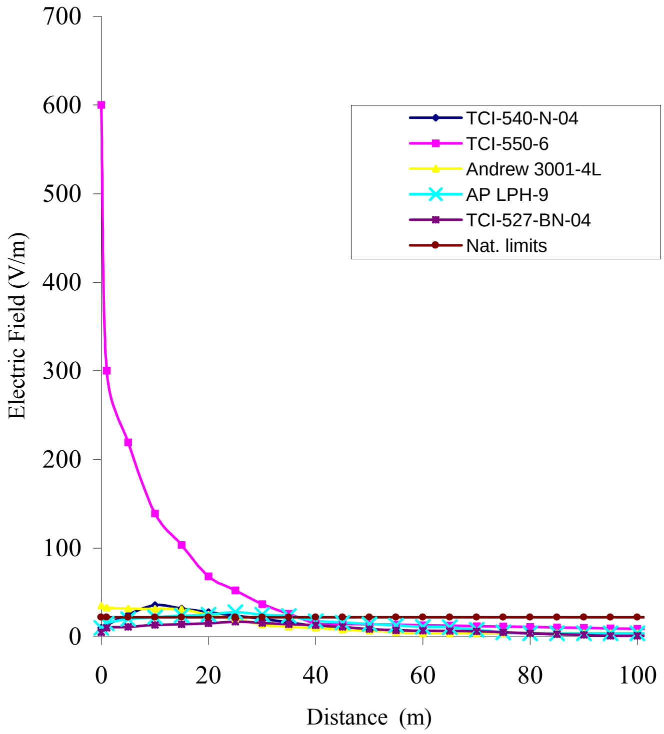

Fig. 4: Electric field strength –v- distance from the five type antennae masts at Olympia radio park

5.2 Multiple Antennae transmissions measurements

When 16 radios were on line, the measured results showed no difference, when the distance from an antenna mast was greater than 20 m. The resulting field had not any major influence at the ground level, as take-off angles, vary from 5^{o} to 15^{o}.

The measurements took place inside the antenna park, in random locations, as the next fig. 5 shows. These locations are noted in the top view of Olympia Radio Antennae Park of fig.2.

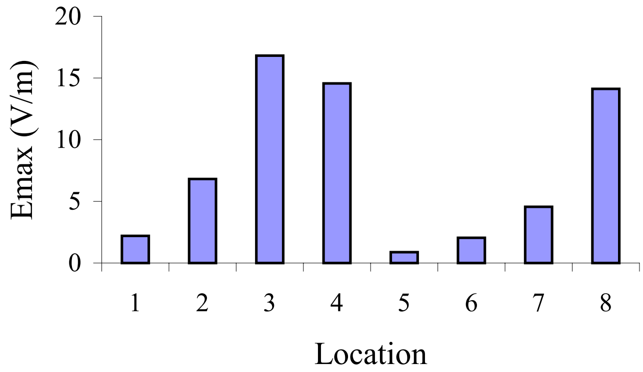

Fig. 5: Electric field values at random locations of the measurement instrument inside the antenna park.

5.3 Far field measurements

Finally, a lot of effort was made in order to measure values of the far-field, especially close to Epitalion village, without success. The electric field in all trials was zero.

5.4 Critical distances

Table 5 bellow, compares measured and calculated values of the minimum safety distance from the base of the antenna mast, at 2m height from the ground level.

Antenna type	Measured Critical distance (m)	Max. calculated critical distance (eq. 2) (m)	Min. calculated critical distance (eq. 3) (m)
TCI 540-N-04	30	70.6	56.1
TCI 527-BN-04	0	117.4	39.7
TCI 550-6	40	70.6	0
Andrew 3001-4L	25	70.6	31.5
AP LPH-9	40	140.9	88.9

Table 5. Measured –v- theoretical critical distances for each of the five type antennae.

Measured results do not match to the theoretical ones. This is due to the fact that calculations were performed without taking into account functional realities, such as the take-off angle and the feeding power. Furthermore equations (2) and (3) are valid for far field and consequently overpredict the relevant values of critical distances [5]. National legislation, uses these equations regardless the exposure distance from antennae, as the political will is to designed for maximum protection of the public [3]. Having in mind the worst-case scenario, predictions give safety distances multiplied by a factor between 2 and 4.

6. Conclusions

The results of this work, show that, based on worst case scenario, the values of the electromagnetic field are well bellow the limits set by the European Community Law, as well as national legislation. Near field measurements showed that the minimum distance from an antenna mast should be at least 40m while theory gave a figure of 100m. Far-field measurements showed that there is no electromagnetic field due to radiation emission from Olympia Radio. Taking in to account that distances between antennae masts inside the park are of the order of 200m, and the nearest populated area is at 3500m, we may safely conclude that the particular antennae park fulfils all European and national specifications related to possible hazards from electromagnetic radiation.

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