A fully portable apparatus for surveillance of electromagnetic broadcast spectrum and measurement of electromagnetic radiation levels

PAVLOS LAZARIDIS, ARISTOTELIS BIZOPOULOS, EMILIJA LAZAREVSKA (*), ZAHARIAS ZAHARIS (**), ANASTASIA PAPASTERGIOU, STYLIANOS KASAMPALIS

Department of Electronics
Alexander Technological Educational Institute of Thessaloniki,
Sindos, 57400 Thessaloniki, GREECE

(*) Technical division Radio & Network implementation
Cosmofon A.D. Skopje, Cosmote Group

(**) Telecommunications Centre
Aristotle University of Thessaloniki,
54124 Thessaloniki, GREECE

Abstract
A fully portable electromagnetic radiation level measurement system is used for measuring radiation levels of commercial FM-TV broadcasts in the VHF-UHF range, as well as GSM 900-1800 MHz signals from nearby base stations. The system consists of a portable battery operated spectrum analyzer and two high precision wideband biconical antennas. The whole system weights less than 3 kg and can be very easily and time-effectively deployed, executing the required measurements in only a few minutes. The precision of the measurement system is thoroughly studied and accurately determined under laboratory conditions. An extensive survey of measurements is under way in the region of central Macedonia, the city of Thessaloniki and its suburbs, including several sensitive areas such as schools, children playgrounds, kindergartens and high radiation regions, including high-power antenna parks.

Key-Words: measurements, electromagnetic radiation, spectrum analyzer, FM-TV, VHF-UHF, GSM

1 Introduction

A fully portable electromagnetic radiation level measurement system is used for measuring radiation levels of commercial FM-TV broadcasts in the VHF-UHF range, as well as GSM 900-1800 MHz signals from base stations [1-5]. The system is made of [6-9]:

- a portable battery operated spectrum analyzer Rohde-Schwarz FSH3 + tracking generator (100 kHz – 3 GHz) with calibration certificate by the manufacturer, which states a measurement accuracy ±0.7dB and weights only 2.5 Kg! (Fig. 1).
- two Schwarzbeck wideband biconical antennas, [9], of type (a) SBA 9113 with built-in balun of high symmetry (for frequencies between 500 MHz and 3 GHz), and (b) BBVU 9135 with built-in 4:1 balun type UBAA 9115 of high symmetry (for frequencies between 30 MHz and 1 GHz) with calibration certificate by the manufacturer, stating a measurement accuracy of ±1.0dB.
- a low loss high frequency coaxial cable by Suhner (Switzerland) of type GX-07272-D 50 Ohm, [6], 1.80 meters in length, with N type connectors.

The system includes also high-precision N type coaxial attenuators by Radiall, DC – 12.4 GHz, 2W, 5 dB, 12 dB, [7], and Diconex, DC – 2.5 GHz, 2W, 20 dB, [8], as well as a wooden (dielectric) adjustable tripod antenna base with height up to 2.5 meters.

2. Measurement system accuracy

The main objective of this study is to implement a fully portable system for spectrum surveillance and accurate measurement of levels of electromagnetic radation (FM, VHF-UHF, TV, DTV, GSM-900MHz, GSM-1800MHz, WiFi-2.4 GHz, etc.) (Fig. 2).

The initial objective of the study was to carry out extended measurements in the laboratory in order to evaluate the accuracy of the complete measurement system.

The measurement of Suhner GX 07272-D coaxial cable, as shown in Fig. 3, indicates low losses for the frequency region of interest, i.e., from 30 MHz up to 1880 MHz, cf. Table 1. However, this double armoured cable can be used for frequencies up to 6 GHz.

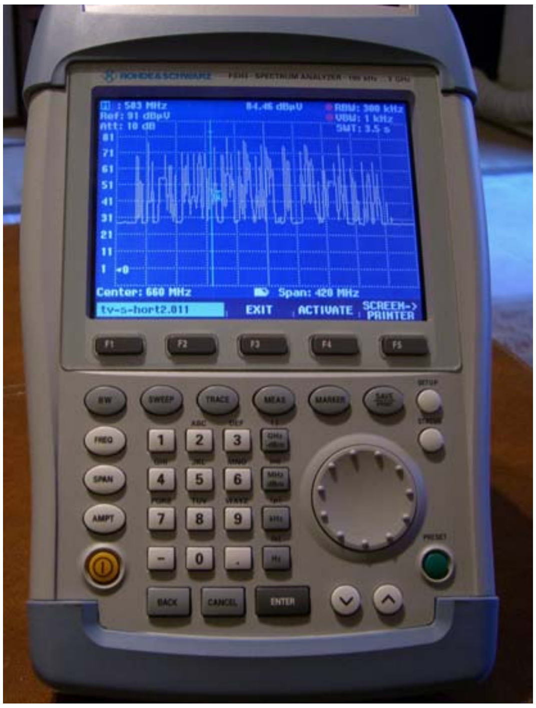

Fig. 1. Portable spectrum analyzer Rohde-Schwarz FSH3.

FM	87.6 MHz – 108 MHz	< 0.1 dB
VHF – TV	174 MHz – 230 MHz	< 0.2 dB
UHF – TV	470 MHz – 860 MHz	< 0.4 dB
GSM 900	921 MHz – 960 MHz	< 0.4 dB
GSM 1800	1805 MHz – 1880 MHz	< 0.6 dB

Table 1. Coaxial cable loss.

The results of the measurements are very close to the manufacturer nominal loss values (nominal attenuation) and are very low, almost negligible. However, the cable losses will be taken into consideration for greater measurement precision. The maximum measurement error for the losses of the coaxial cable, taking into account also the N type low loss connectors is estimated to be ±0.2dB. The figures below depict frequency response measurements of the above-mentioned 5 dB, 12 dB, and 20 dB attenuators (Figs. 4, 5 and 6).

Fig. 2. Measurement system layout.

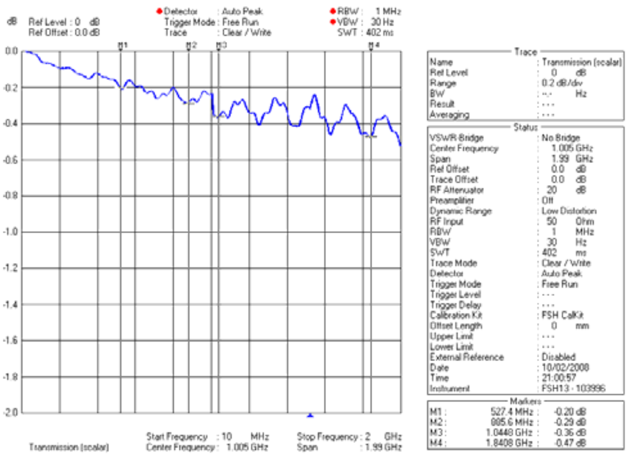

Fig. 3. Suhner GX 07272 D coaxial cable measurement (1.80 meters fitted with N type connectors).

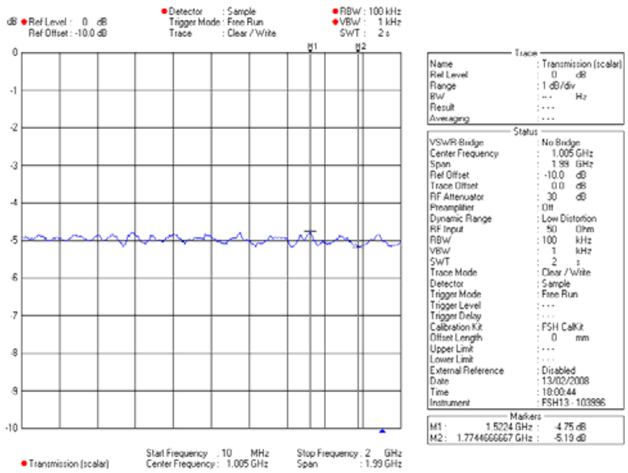

Fig. 4. Measurement of N type coaxial attenuator with nominal attenuation 5 dB.

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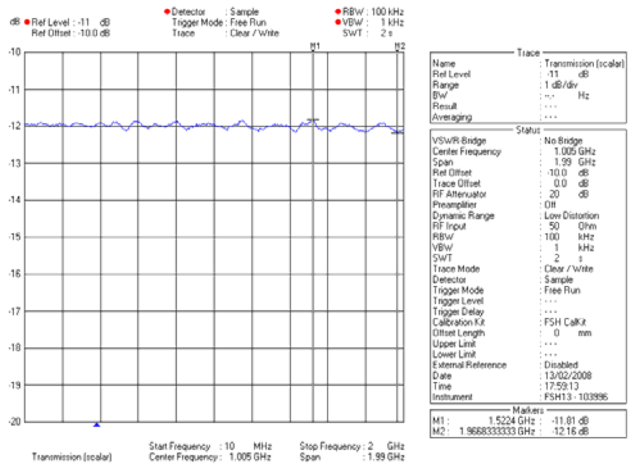

Fig. 5. Measurement of N type coaxial attenuator with nominal attenuation 12 dB.

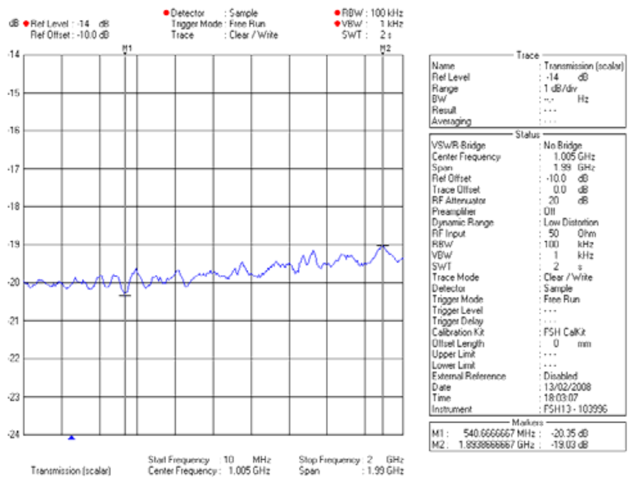

Fig. 6. Measurement of N type coaxial attenuator with nominal attenuation 20 dB.

It is noted that the accuracy of the first 2 attenuators is very good, and in particular better than ±0.25dB for the frequency region of our concern, i.e., from 10 MHz up to 2 GHz. Generally speaking, the accuracy gets worse in higher frequencies. The third attenuator (20 dB) by Diconex has worse frequency behavior and an error close to 1 dB in the region near 2 GHz. These results have led us to avoid using external attenuators in our measurement system in order to obtain more accurate measurements. On the contrary, the internal attenuators of the spectrum analyzer (10 dB and 20 dB attenuation) are systematically used, helping also in obtaining a better impedance match of the antennas (low SWR).
Thus, taking into account all contributions, the total maximum error in the measurements of the electrical field intensity made by our portable measurement system is estimated to be ±1.9dB in the worst case.

3. Measurements of GSM 900 MHz – 1800 MHz base stations.

In the case study presented below (Fig.7), the measurements are taken in the terrace of an apartment building situated in the city centre of Thessaloniki, in short distance (100 m) and in direct line of sight with GSM base station antennas (GPS: HOME: N40.61582 – E22.95577, OTE: N40.61508 – E22.95645).

Fig 7. Field strength measurements at 100m from a GSM base station.

Fig. 8. Measurements of electrical field intensity in front of a school playground.

According to the Schwarzbeck SBA-9113 wideband biconical antenna calibration datasheet:

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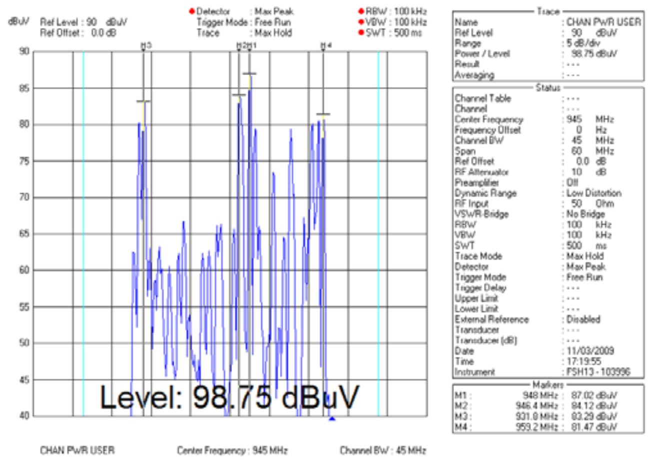

Fig. 9. GSM-900 (antenna SBA-9113) measurements.

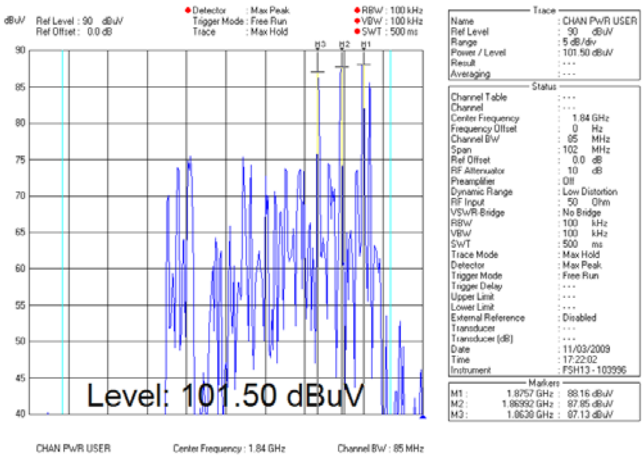

Fig. 10. GSM-1800 (SBA-9113) measurements.

1. the antenna factor is 30.2 dB/m @ 940 MHz and the main peak electrical field intensity is at 948 MHz:

Peak GSM 900 – E = 87.0 + 30.2 (antenna factor) + 0.4 (cable loss) = 117.6 $dB\mu V/m$ = 0.76 V/m (<< 34.5 V/m)

However, the total electrical field intensity for the whole GSM 900 band is:

Total GSM 900 – E = 98.7 + 30.2 (antenna factor) + 0.4 (cable loss) = 129.3 $dB\mu V/m$ = 2.9 V/m (<< 34.5 V/m), i.e. 8% of the highest permissible value.

2. the antenna factor is 35.4 dB/m @ 1875 MHz and the peak electrical field is at 1875 MHz:

Peak GSM 1800 – E = 88.2 + 35.4 (antenna factor) + 0.6 (cable loss) = 124.2 $dB\mu V/m$ = 1.6 V/m (<< 48.8 V/m)

However, the total electrical field intensity for the whole GSM 1800 band is:

Total GSM 1800 – E = 101.5 + 35.4 (antenna factor) + 0.6 (cable loss) = 137.5 $dB\mu V/m$ = 7.5 V/m (<< 48.8 V/m), i.e. 15% of the highest permissible value.

These results are much lower than the upper limits according to Greek legislation shown in parenthesis. Similar results have been found in other base station antenna measurements throughout this study.

As we can conclude from these results, for a distance greater than 100 meters the electromagnetic radiation levels are relatively low and safe.

4. Conclusions

The purpose of this study was the measurement of the electrical field intensity at locations with special interest, the processing of data and their graphical presentation and interpretation.

Measurements were conducted at several locations near GSM 900 MHz – GSM 1800 MHz base stations emphasizing at schools, playgrounds, and buildings close to base stations. High power radio and TV transmitters and antenna parks were also measured.

Our observation was that for a distance greater than about 100 meters from base station antennas the electromagnetic radiation levels are relatively low and safe. All the locations measured at this or at greater distance show that the levels are much lower (8% for GSM-900 and 15% for GSM-1800) than the maximum field intensity values allowed by the Greek legislation according to the article 2-4 no. 53571/3839/6.9.2000 Common Ministerial Decree, [1].

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