GSM and UMTS Radio Frequency Monitoring

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***Abstract*— The effect of EMF on human health is the subject of recent interest of study. Prolonged exposure from EMF sources such as Fm radio, microwave oven, mobile handsets, Base Transceiver Station (BTS), etc. is said to cause impairments in human health. The number of mobile users in India has recently crossed 100 cr. which is around 79% of the total population. This has led to an increase in the RF radiations in the country. We have done the repeat procedure after 2 years with the help of a quad-band antenna AMB-8057-SW02, intend to continuously monitor radiofrequency radiation levels for GSM and UMTS in our college surrounding located in Sion, Mumba, India. The result of this will create awareness among the society about radiation levels in the environment and their effects on human health.**

***Index Terms*—AMB-8057-SW02, Base Transceiver Station, Quad-band, Radio frequency radiation**

I. INTRODUCTION

To provide more efficient services, an increased number of mobile towers/stations has been noted, leading to a speculated increase in radiations in the environment. In today's era, our world has transcended to an information age in which telecom industry has flourished. Emerging new technologies like 3G and 4G have been introduced which while being beneficial to the user, have also been claimed to be jeopardous for the human body. People have started realizing that they are living in malicious environment and that it could be fatal in the long run.[1]-[3] They have started filing petitions to know more about radiation levels in the vicinity and make these records public. Detailed information and analysis of signal strength measured by AMB-8057 is mentioned in this paper. This works we have carried out again after 2 years at same location with same device for GSM and UMTS. Work carried out is totally based on our previous work [4] and it also includes sources of emf, its hazardous effects, and guidelines set by various regulatory bodies about radiations emanating from mobile towers.

II. EXPERIMENTAL SETUP ON ROOFTOP

The Area Monitor Broadband (AMB-8057) was sponsored by Fastech Communications Pvt. Ltd.. The antenna was installed on the rooftop of Padmabhushan Vasantdada Patil Pratishthan's College of Engineering, Sion, Mumbai in September 2017.

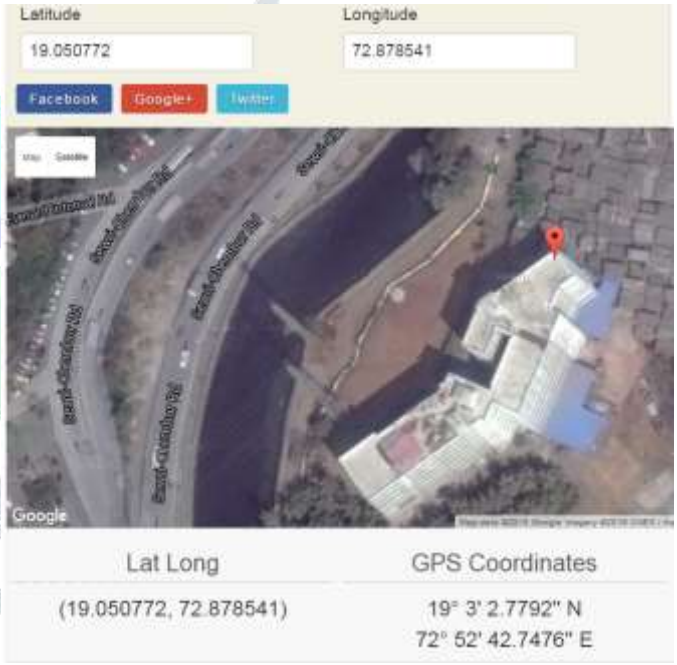

Fig.1. Location 1

The given latitude and longitude is the first location where we installed the antenna with the help of Fastech Communications' engineer. The antenna was at the near side of the college from buildings and the main highway. At this point, the power transmission lines were also very close. The readings hence measured for 3 months from October to December This speculated increase was because of the disturbance of electric fields from the power lines.

This work is carried out at Padmabhushan Vasantdada Patil Pratishthan's College of Engineering, Sion, Mumbai – 400 022

We wish to acknowledge the constant support of Fastech Communications Pvt. Ltd. for providing AMB-8057 antenna for our research.

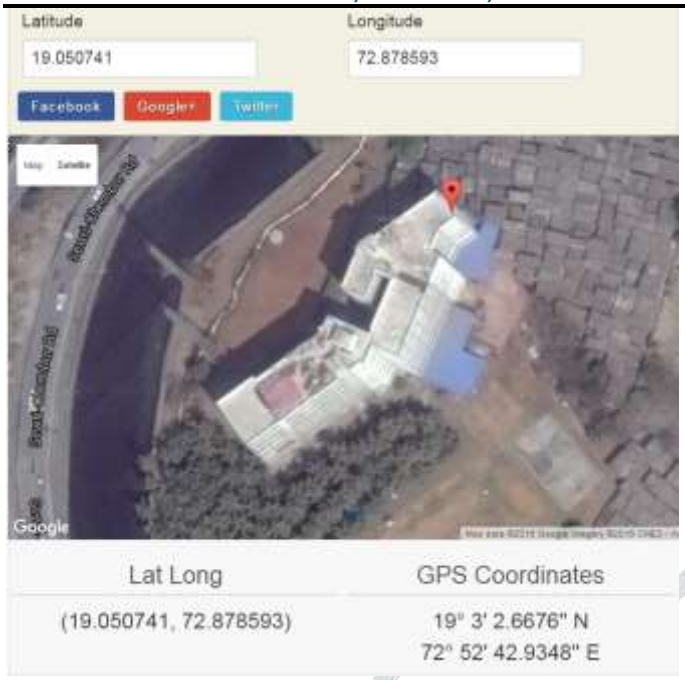

Fig.2. Location 2

In January, we shifted the antenna to the opposite side of the rooftop where the antenna was at a safe distance from the power lines. The second location is given in the figure above.

On 28th February we shifted the antenna to yet another site to avoid interference from the 110kV and 200KV power lines which were very close by. The readings mentioned in this paper are only confined to a latest set of readings

III. SPECIFIC MEASUREMENT PROCEDURE

A. Antenna Specifications

Area Monitor Broadband (AMB-8057) antenna does continuous remote monitoring and logging of electric (E) or magnetic (H) fields generated by low and high frequency sources such as radio / TV, GSM, UMTS, transformer stations, power lines and others. The Area Monitor AMB-8057 is weatherproof, light (< 3 kg) and can be easily installed outdoors or indoors, using the pole and base designed for it.

Some of the specifications of antenna are:

1) Solar panel and internal rechargeable battery for unlimited outdoor operation.

2) Internal Li-ion disposable battery for up to one year's operation.

3) A high sensitivity probe that measures the EM field around 3 axes.

4) A sophisticated data logger that stores the measured values, events (alarm, signals, communications), and settings in non-volatile memory.

5) A dual-band GSM/GPRS modem for uploading data and remote control.

B. Electric Field Probe

Fig.3.Electric probe

AMB-8057 uses EP-4B-01 probe for measurement of field strength situated inside a protective layer.

The probe measures the total electric field strength and captures the values of the overall electric field, E(t), generated by all surrounding sources.

The electric probe possesses internal pass band circuits (probe filters) and A/D converters. The probe filters allow discrimination of the fields generated by different sources in the frequency bands of the GSM 900, GSM 1800, UMTS 2100 and inside a wide range of frequencies. This feature determines the GSM and the UMTS contributions to the overall electric field strength. The sampling rate of the probe is20 samples per minute[5].

The main characteristics of the electric field probe are as shown in the Table 1 below

TABLE I
CHARACTERISTICS OF ELECTRIC PROBE

	Wide band	GSM	GSM	UMTS
Frequency range [MHz]	0.1 - 3000	925 - 960	1805 - 1880	2110 - 2170
Measuring range [V/m]	0.2 - 200	0.03 - 30	0.03 - 30	0.03 - 30
Resolution [V/m]	0.01	0.01	0.01	0.01
Flatness at 6V/m [dB]	+/- 1.5	+0.5/-2.5	+0.5/-2.5	+0.5/-2.5
Anisotropy at 3V/m [dB]	±0.8	±0.8	±0.8	±0.8
H field rejection [dB]	>20	>20	>20	>20
Temp. error for all bands	-20ºC ÷ 0ºC : -0.1dB/ºC		0ºC ÷ 50ºC : ±0.3dB	

The samples obtained from the probe are sent to the data logger as it is the consecutive unit of the sensor element.

C. Data Logger

The second essential part of the sensor element is the data logger, which performs post-processing and storing of the data obtained from the probes. Its functioning depends on the sensor setup parameters, such as threshold level, averaging period, storing time, sending date/time and some others. The parameters of the sensor can be set remotely or can be set locally through the communication part.

The post-processing of the measured samples corresponds to the averaging of the sampled data. The number of the samples, N, depends on the averaging time interval, t_{AVG}, due to the expression $N = 20 \times t_{AVG}$, where t_{AVG} is expressed in minutes. International Commission on Non-Ionizing Radiation Protection (ICNIRP) recommends that for the frequencies between 100 kHz and 10 GHz, an electric field is to be averaged over a 6 minutes period. The time of 6 minutes corresponds to 120 samples.

The averaging can be arithmetic (AVG), appropriate for the frequencies below 10 MHz, and is defined by the equation

$$B_{AVG} = \frac{\sum_{n=1}^{N} B(n)}{N}\ ,\ or E_{AVG} = \frac{\sum_{n=1}^{N} E(n)}{N} \qquad (1)$$

The quadratic averaging (RMS), appropriate for the frequencies between 100 kHz and 10 GHz is defined as

$$B_{RMS} = \sqrt{\frac{\sum_{n=1}^{N} B^2(n)}{N}}\ ,\ or E_{RMS} = \sqrt{\frac{\sum_{n=1}^{N} E^2(n)}{N}} (2)$$

The sensor element detects the maximum (MAX) value during the same time period performing the functions

$$B_{max} = \max\{B(n)\}, or E_{max} = \max\{E(n)\}, n = 1, 2 \dots N$$
(3)

The functions AVG, RMS and MAX of the electric field are simultaneously estimated in all bands[6].

The estimated values of AVG, RMS, and MAX are stored into the internal memory during one of the selectable time intervals, as described in Table 2

TABLE 2
MEMORY SPECIFICATION

Storing Rate	Memory capacity
30 sec	113 days
6 min	1,355 days
15 min	3,387 days

The storing time, t_{store} depends on the sensor setup parameters and can be shorter or longer than the averaging time, $t_{AVG.}$The processing time window, of the lengtht_{AVG}, slides through the samples. At every storing time interval, t_{store}, the sensor element memorizes the estimated values based on the samples inside the current position of the processing time window. Depending on the storing time interval, the sensor element can memorize different amounts of the estimated values as shown in Table

The sensor has a 4MB internal memory, which can store up to 32512 records of the 16 bytes data. When the memory is full, the new data overwrites the oldest to ensure the availability of the memory for the most recent measurement period. The maximum number of days for which the probe can store data without overwriting the previous data is given by the following equation

$$Memory\ capacity(days) = N_{records} \times [\frac{Rate_{min}}{minutes/day}] (4)$$

Where $N_{records}$ is the number of records that the probe can store.

For example, with a storing rate of 6 min, considering that a day consists of 1440 minutes, the memory capacity formula is 32,512 ×[6 / 1,440] = 1,355 days

D. Communication

The third unit facilitates the remote communication between the sensor and the Computer Communication System (CCS) via GSM modem. Small amount of data in form of a daily report can be sent as an SMS message to a mobile phone. Additionally, the communication block has the ability to receive instructions from the CCS in order to perform the setup of the data logger. Besides the GSM modem, an RS232 interface enables local connection to the sensor element for the measurements and collection of the stored data.

E. AMB-8057 SW02 control software

The control software named Narda Safety Solutions, is a Windows TM-based control software that provides all the functions needed for efficiently controlling everything from a single station to a complete monitoring network. CSD and FTP communication modes are provided as well as local control via RS232 cable. The user station list can be created simply by providing all the relevant parameters, such as station name (ID), APN for Internet access, FTP server IP address, as well as the data telephone number for CSD communication.

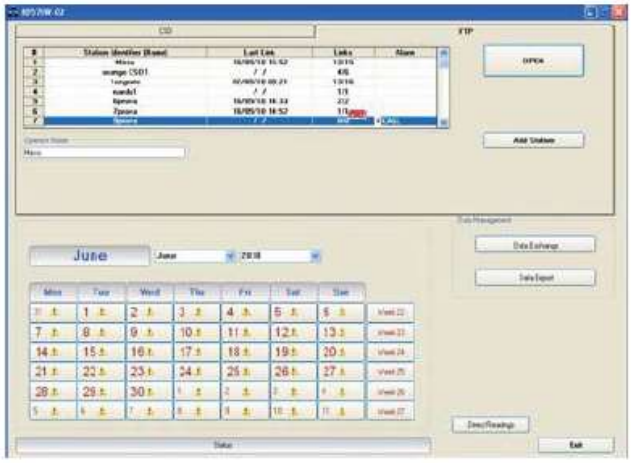

Fig.4.Narda Safety Solution Software Main Window

The station list, shown in the main window, allows access to a specific station or station folder on the FTP server by simply clicking on a dedicated button for:

1) Reading, editing and transmitting all measurement settings and communication schedules.

2) Selecting and downloading logged data, either manually or automatically.

3) Receiving warnings and alarm signals.

Data management functions are provided for:

1) Saving, printing and exporting data.

2) Displaying data in graphs or tables.

3) The data transfer and all the station parameters can therefore be monitored, modified, and set through either a remote or a direct connection by means of this software.

4) Data integrity checking and double-password access provides a maximum of reliability and security. Polling of the station from the PC is easy and can be conveniently set to manual or automatic mode according to the user's requirement.

The control software fetches the information from Narda FTP which is downloaded and stored by us. The data is stored in the form of TXT file which can accessed using notepad or any other text editor.

Readings for 15th February, 2018 are shown as an example in the following figure.

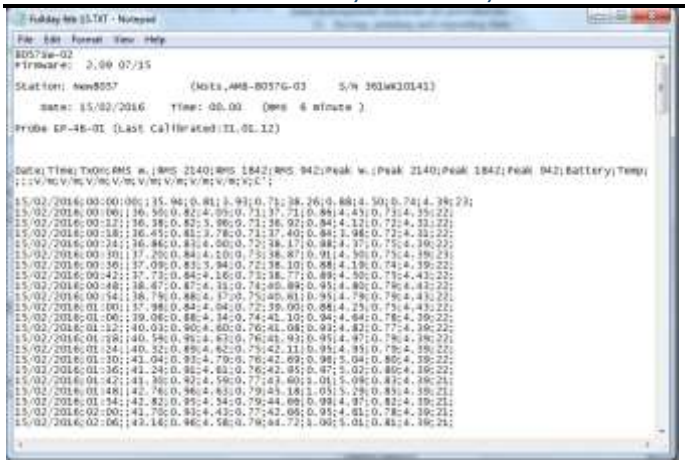

Fig.5.Sample Readings

IV. VALIDATION OF SITE SPECIFIC MEASUREMENTS WITH REGULATORY BODIES

A. *Standardized Guidelines of Regulatory bodies*

International organizations like International Commission for Non-Ionizing Radiation Protection (ICNIRP), Federal Communications Commission (FCC) and others decide the safety level of radiation for the general populace.

According to ICNIRP guidelines, the safety levels are:

TABLE 3
SAFETY LEVELS BY ICNIRP

Frequency (MHz)	Electric field strength (V/m)	Power Density (W/m2)
400 MHz – 2 GHz	$1.375f^{1/2}$	$f/200$
2 GHz – 300 GHz	61	10

f is frequency and should be in MHz for the calculation of power density for 400 MHz to 2 GHz range in the table above.

In India, monitoring of radiation emanating from mobile base station (BTS) is carried out by the Department of Telecommunication (DoT) which acts as the regulatory body along with Telecom Regulatory Authority of India (TRAI). India has adopted stringent guidelines for EMF radiations from Base stations which is 1/10th of the international norms (ICNIRP). DoT has prescribed limits for general public exposure in which are:

TABLE 4
SAFETY LEVELS BY DOT

Frequency (MHz)	Electric Field Strength(V/m)	Power Density (W/m2)
400 MHz – 2 GHz	$0.434f^{1/2}$	$f/2000$
2 GHz – 300 GHz	19.29	1

f is frequency and should be in MHz.

B. *Analysis of Readings*

The EP-4B-01 probe of AMB-8057 takes a reading for every 6 minutes for the functions of AVG, RMS, and MAX functions as discussed in earlier section. We fetch the TXT file, convert it into a CSV file format by modifying some of the data and upload it onto our website www.rfmonitoring.com

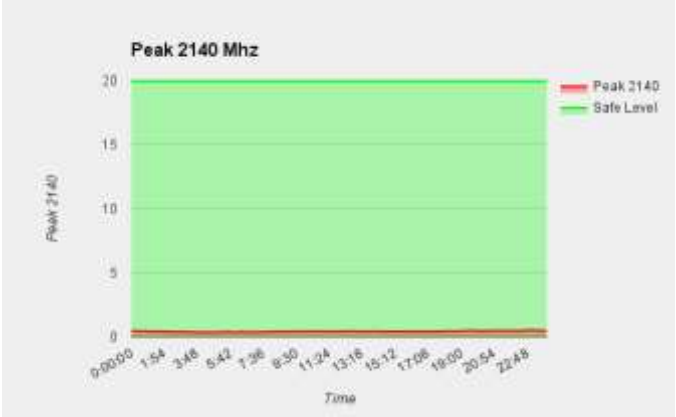

Fig. 6.For 2140 MHz

Figure above is a graph for the peak 2140 MHz band of one full day. The green level lines are the readings measured by the antenna and the red line is the safe level as mentioned by DoT for India.

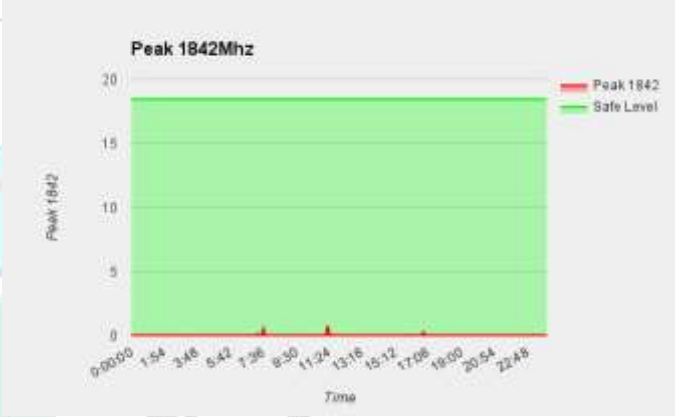

Fig. 7.For 1842 MHz

Figure above is a graph for the peak 1842 MHz band of one full day. This graph has the same nomenclature as the graph above. We can see that the readings measured are well below the safety limit adopted by India.

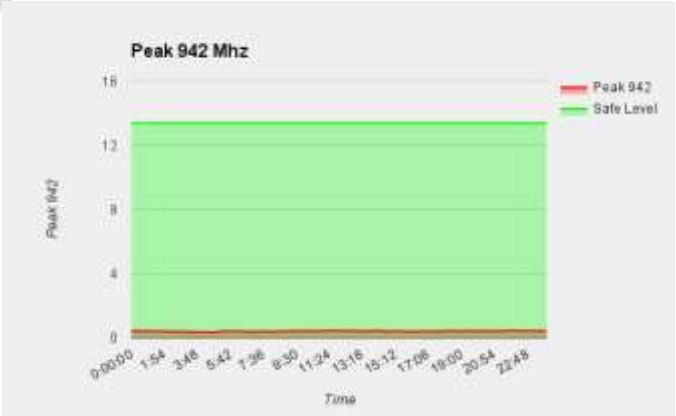

Fig. 8.For 942 MHz

The above figure is a graph for the peak 942 MHz band of one full day. The nomenclature is the same in this case too. The

readings are below the safety limits prescribed by DoT and TRAI.

Fig. 9.For 100KHz-3GHz MHz

The above figure is a graph for the peak wide band of one full day. The nomenclature is the same in this case too. The readings are below the safety limits prescribed by DoT and TRAI.

V. CONCLUSION

If the strength of the signals emanating from mobile base station is kept constant then it will not be harmful for the people of this area in near future. Through our analysis over stipulated period of time and repeated after 2 years, we came across conclusion that the radiation levels in Sion, Mumbai area are below safety levels as prescribed by DoT and TRAI. We will continue these efforts of monitoring radiations in successive years, if found harmful we will inform it to the regulatory bodies.

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[8] IEEE International Committee on Electromagnetic Safety, " Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," ANSI/IEEE-C95.1, 1992.