RESEARCHERID
THOMSON REUTERS

[Martin, 6(9): September 2019]
DOI- 10.5281/zenodo.3402539

ISSN 2348 – 8034
Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

SCHUMANN RESONANCES MEASUREMENTS FROM SÃO JOSÉ DOS CAMPOS, BRAZIL

Inácio Malmonge Martin*[1] & Inácio Vinicius S. dos Santos[2]
[*1]Physics Department of Technological Aeronautics Institute – ITA – Brazil
[2]School Mª Nazareth de M.Veronese – São José dos Campos, Brazil

ABSTRACT

The Schumann resonances (SR) are a set of spectrum peaks in the extremely low natural frequency (ELF) interval. This natural fundamental mode frequency pulsation of 7.8 Hz was discovered and predicted it mathematically in 1952 by German physicist and Professor Winfried Otto Schumann. A new method to observe these peaks near the ground surface were used in this article. The Schumann resonance is not a new phenomenon. Earth has been pulsating exactly at 7.8 Hz fundamental frequency for thousands of years. Schumann resonances are formal electromagnetic resonances, excited by lightning discharges from troposphere in the cavity formed by the Earth's surface and the ionosphere height. Using one SpectranNF-5035 receiver it is make the monitoring in São José dos Campos, Brazil region of electromagnetic spectrum in 1Hz to 40 Hz. The peaks of resonances measured during 2016 - 2019 shows7,8Hz; (14-16)Hz, 20 Hz and 33 Hz present in each monitoring.

Keywords*: Schumann resonances, non-ionizing radiation, extremely low frequency*.

I. INTRODUCTION

The non-ionizing radiation environment of a region has its intensity that can be measured in power (**dB_m**) in milliwatts, in Volt/meter (**V/m**) corresponding the electric field or Volt (**V**) in the case of electric potential relative to ground level. These values always vary with the frequency band [1] to be measured. General spectrum analyzers can observe this radiation in a particular frequency range, with continuous monitoring or discrete values of predetermined frequency. In general, analyzers covering the frequency range of 1 Hz to 26 GHz, which are currently available on the international trade marked in addition to having high costs, are used for measurements inside laboratories. They are not portable, and do not have sufficient sensitivity to observe radiation intensities in power with less than -90 **dB_m** values which corresponds to 1 ×$\mathbf{10^{-12}}$ **W** of power [2]. These analyzers also require multiple sets of antennas to cover the entire frequency range to be used. The non-ionizing radiations are those which do not produce direct ionization, that is, do not have sufficient energy to strip out electrons from atoms (<12eV), the means have enough power to dissociate molecules, or, break chemical bonds. Non-ionizing radiation are always present in the environment [3]. Electromagnetic radiation also consists of waves that propagate through space. These waves can be ionizing or non-ionizing radiation and are formed by composing an electric field (**E**) and magnetic field (**B**) which oscillates perpendicular to one another in the simplest case. The direction of propagation corresponds to the energy displacement (Poynting vector). These radiations include ultraviolet (near the visible), visible light, infrared, ELF (Extremely Low Frequency), LF (Low Frequency), VHF (Very High Frequency) and microwave. Some of this radiation is an electromagnetic spectrum band called Radio Frequency (RF) [4, 5]. The alternating electric current also produces electromagnetic fields around the various conductors and equipment in any place also Brazil. For example, the oscillation frequency of the alternating current in Brazil is 60 Hz and its harmonics are as 120Hz, 180Hz, 240Hz and more. Between 1 Hz and 40 Hz (ELF) are naturally Schumann waves determined by the resonances in 7.8 Hz, (14-16) Hz, 20.0 Hz and 33.0 Hz. Between (1-12) Hz, according to the recent theoretical work [6, 7], waves formed in the ionosphere through HF wave and local ions interactions can exist.

These waves are extremely difficult to be measured given the low electric field values (E) and magnetic fields (B) by which they are transported [8, 9, 10].In the case of Schumann resonances, they exist since the formation of planet Earth. It is now known that they are produced in the earth's troposphere through electrical discharges across the planet.

II. METHODS & MATERIALS

To collect the measures of non-ionizing radiation from 1 Hz to 1MHz, one good commercial equipment purchased from Company Aaronia AG, Germany it was used. A SpectranNF-5035 RF detector works between the frequency (1 Hz to 1 kHz, and 1 kHz to 1 MHz) with a compact and omnidirectional antenna. The sampling time in the measurements may be chosen from 5ms to 3,000ms.The resolution band width (RBW-Resolution Band Width) may range from 0.3 Hz to 1MHz. The RF detector is fully portable with its own batteries for 8 hours of continuous operation. Specific software provided by Aaronia AG writes the data on files (.ldt) and simultaneously generates graphics on screen display of computer that can save images. All details of the parameter settings and operation of the frequency spectrum analyzer can be found in the above-mentioned manufacturer's website [11]. A laptop PC (Dell Vostro i5) it was used for the acquisition and determination of the frequency spectra with the measured data files. Because the system is compact and portable, it is possible to carry out surveys of non-ionizing radiation field at any remote location. Figure 1 shows the lifting of the electric field (V/m) environment at ITA campus in São José dos Campos, SP, Brazil. It is observed in this graph that the electric transmission line on site (ITA campus) induces the electric field at 60 Hz and its harmonic 120 Hz, showing the proper functioning of SpectranNF-5053 RF detector. Different color lines represent the number of sampled waveforms measured.

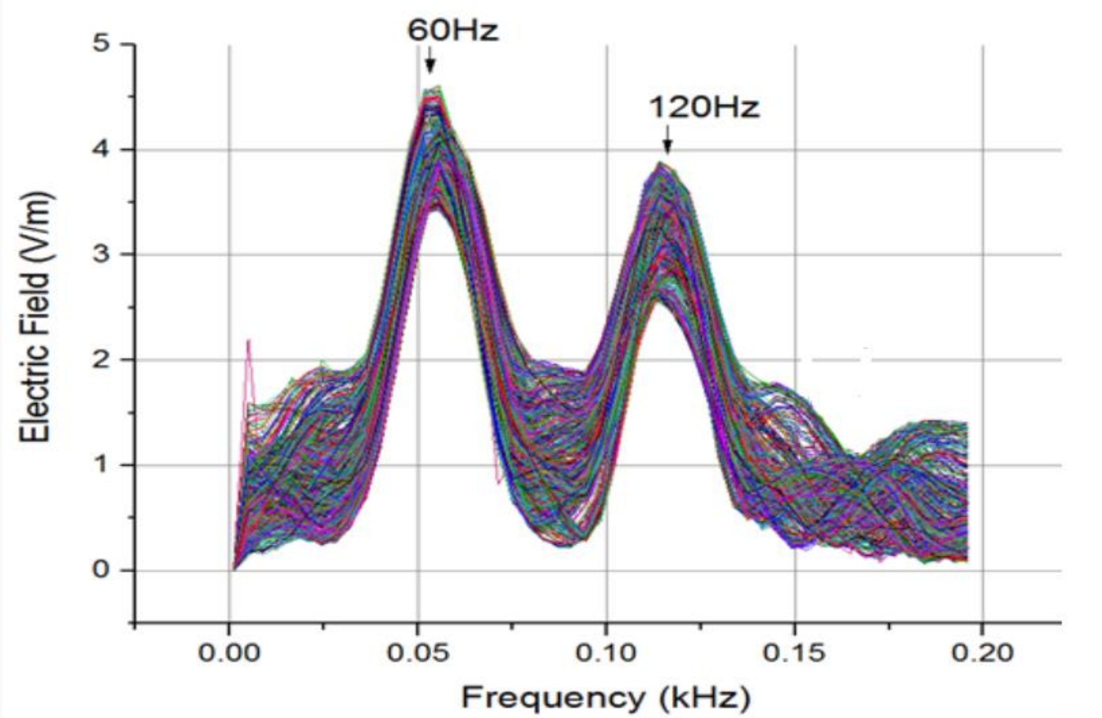

Fig. 1 – Calibration of SpectranNF-5035 measuring electric field under electric power line of 220V and 110V (data in V/m x 1000). The 60 Hz and 120 Hz are the frequency of transmissions line in Brazil giving maximum value of 0.45milliVolt/m.

Schumann waves across their main resonances are represented in Figure 2. These resonant frequencies that must be observed in measurements taken anywhere near the Earth's surface. This Figure 2 shows the Schumann waves that circulate around the Earth in the cavity formed between the surface and the planet's ionosphere These Schumann waves guided by the Earth's surface ionosphere cavity are produced by lightning strikes throughout the Earth's troposphere.

ISSN 2348 – 8034
Impact Factor- 5.070

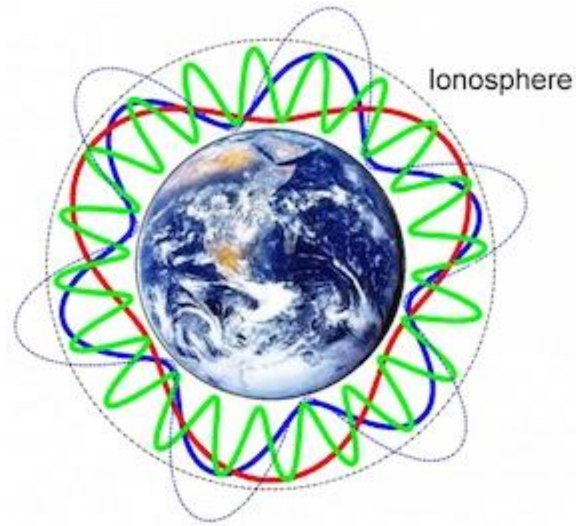

Fig. 2–Schematic view of ***electromagnetic waves created by lightning flashes and trapped between the ground and the ionosphere – here shown in blue, green, and red – circle around Earth, creating Schumann resonance. (Image Credit: NASA/Simoes)***

Thus, the greater or lesser amount of Schumann waves depends on the amount of lightning existing in that exact time interval in which the measurement is being performed. For measurements taken near the ground this intensity also varies with local time due to greater or lesser ionization of the ionosphere mainly by Sun radiations.

III. RESULT & DISCUSSION

From 2016 to 2019 a large number of measurements of Schumann resonances were taken from the ITA campus in the city of São José dos Campos ($23^0$11`S, $45^0$53`W) in Brazil. Figure 3 shows measurements taken on 08/12/2016 from 07:52 to 07:55 between 1Hz and 40Hz, time sampling in 50 milliseconds and 0.3 Hz bandwidth After 3 minutes of measurement time a large amount of values obtained at each pass (colored lines) is placed the thick black line indicating an average of all passages When these measurements are performed at night and very early in the morning if seen in Figure 4, the intensity of ELF waves in this frequency range (1Hz to 40Hz) can be noted without Schumann resonances (background).

ISSN 2348 – 8034
Impact Factor- 5.070

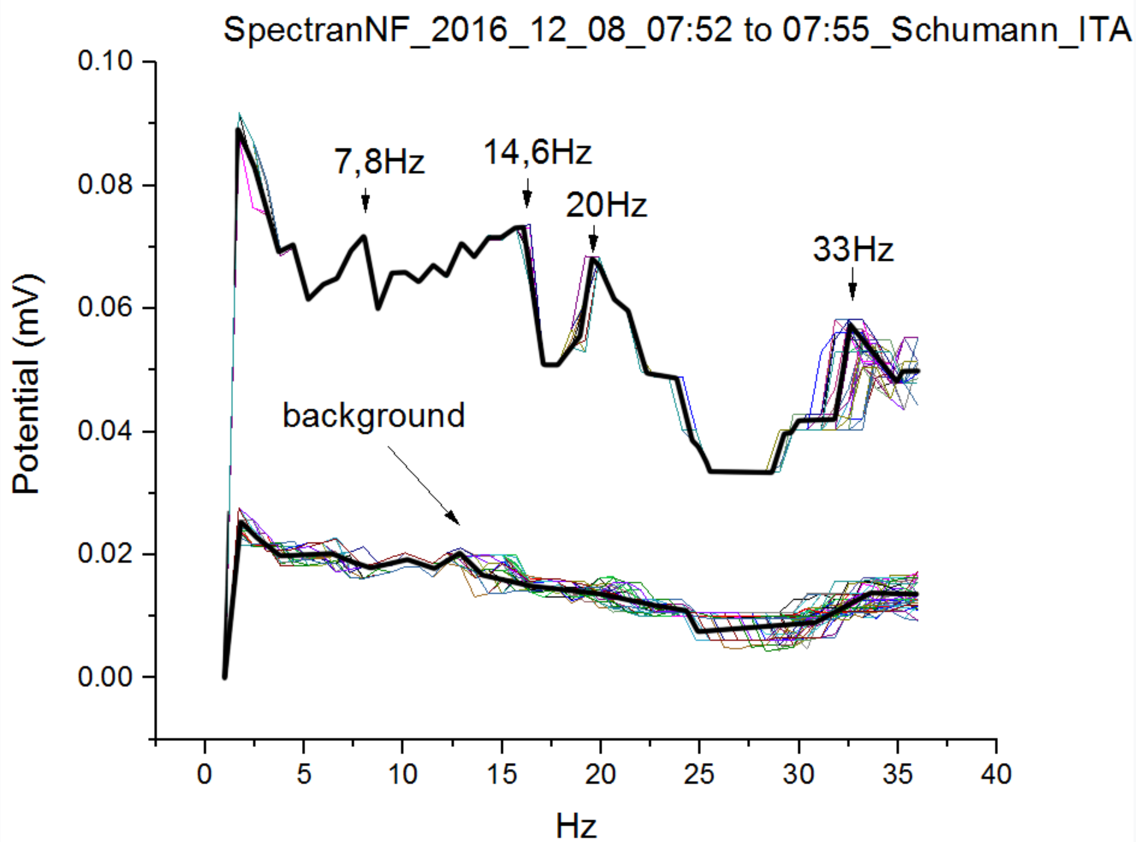

Fig. 3 – Measurement of Schumann`s resonances and (ELF background) during 3 minute in 2016/12/08 early morning in potential millivolt (mV).

Figure 4 highlights the measurements of Schumann resonances on 8/2/2016 in the afternoon between 4:17 pm and 4:20 pm local time. Note that in this afternoon the local ionosphere is fully ionized and makes it difficult to measure the ELF background.

[Martin, 6(9): September 2019] ISSN 2348 – 8034
DOI- 10.5281/zenodo.3402539 Impact Factor- 5.070

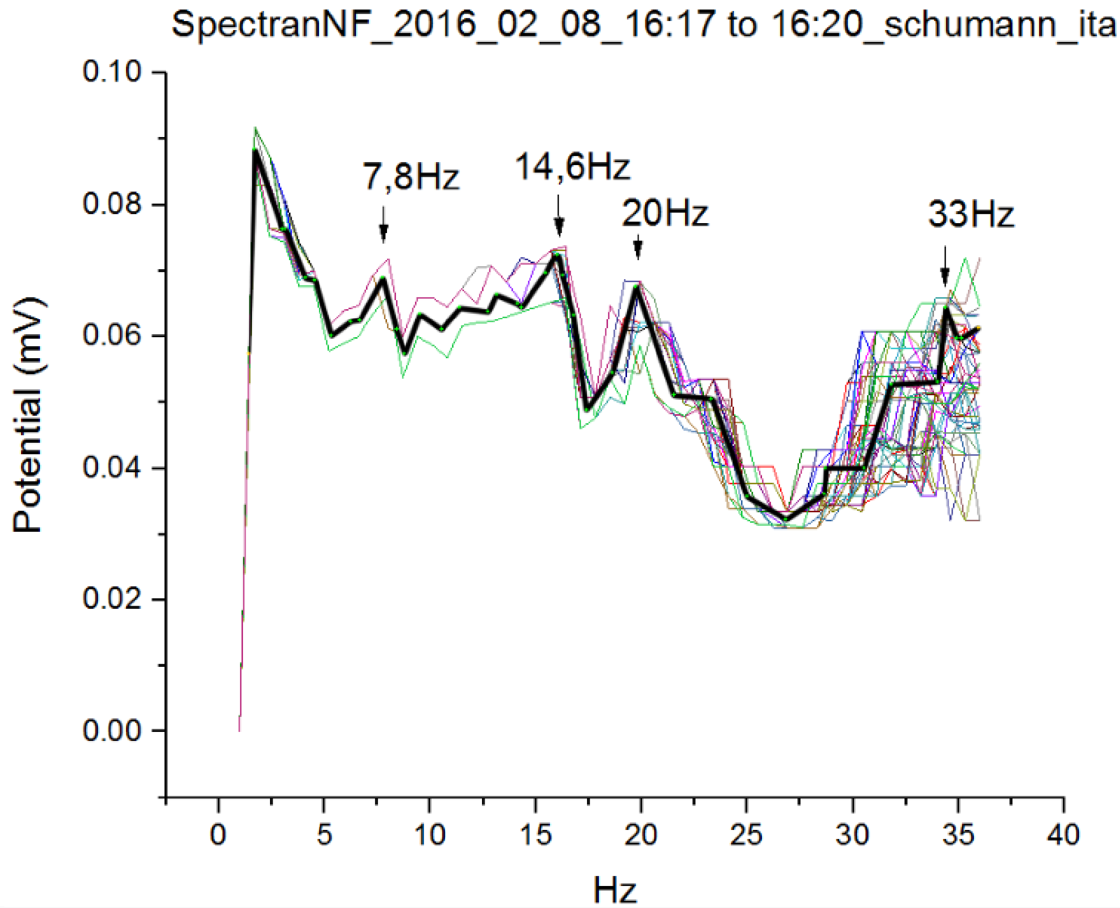

Fig. 4 - Measurements of Schumann resonances on 08/02/2016 in the afternoon, with absence of the (ELF background) in potential millivolt (mV)

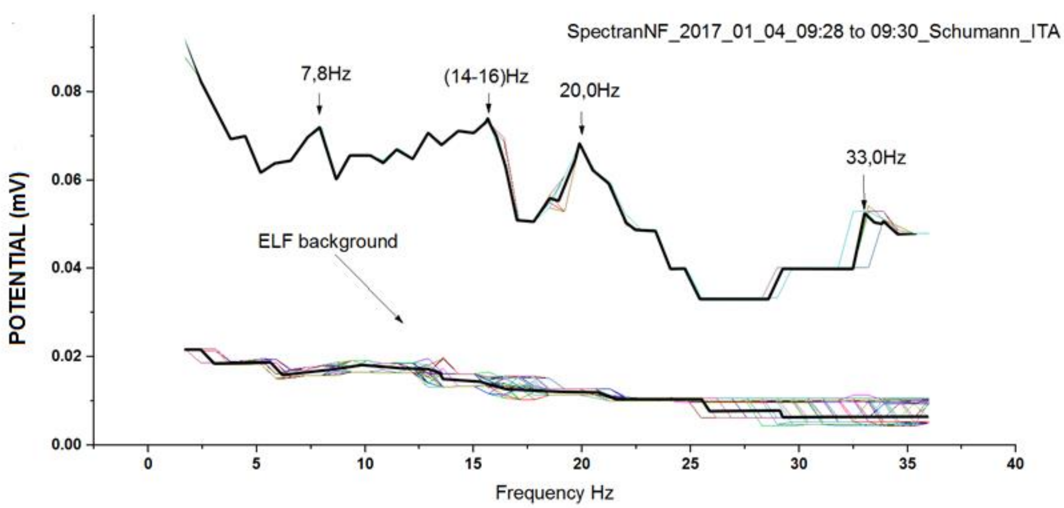

Fig. 5 – Observation of Schumann resonances on 01/04/2017 during morning period showing the presence of (ELF background) in potential millivolt (mV)

[Martin, 6(9): September 2019]
DOI- 10.5281/zenodo.3402539

ISSN 2348 – 8034
Impact Factor- 5.070

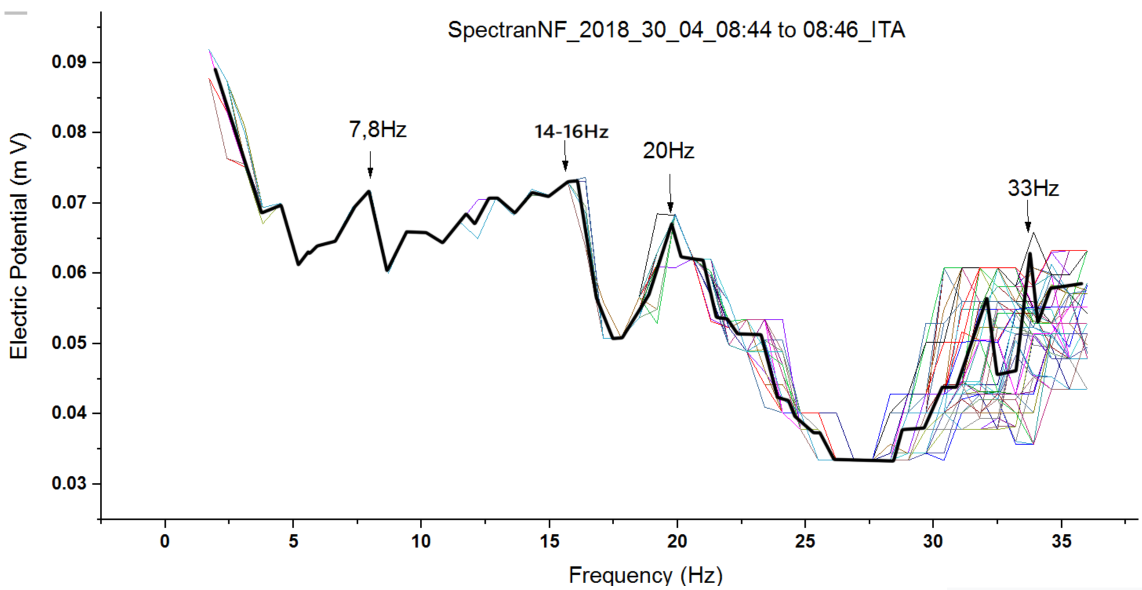

Fig. 6 – Measurements of Schumann resonances during morning period of 2018/30/04 showing ***absence of the (ELF background)and*** *in vertical axe the Electric Potential in millivolt (mV)*

Figure 7 highlights the measurements of the resonance peaks viewed on the laptop screen used for these observations. In the vertical axis of the screen has the electric potential measured in microvolt and in the horizontal axis stands out unit Hertz.

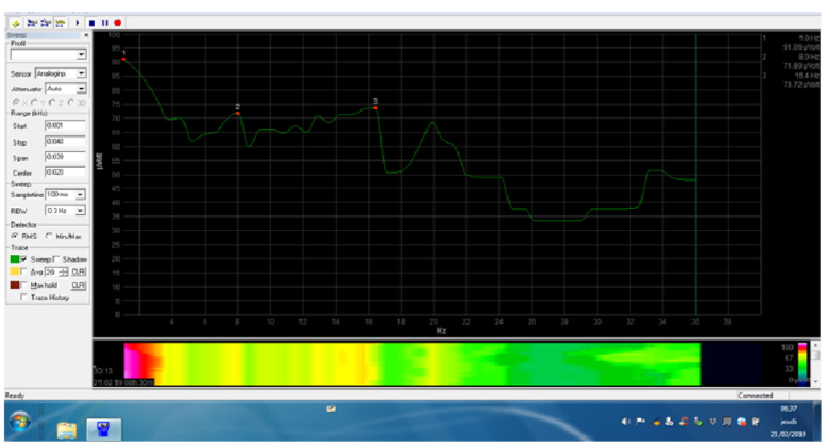

Fig. 7 – Measurements of resonance peaks on 2019/20/02 seen directly in the screen of used laptop during afternoon period. The vertical units ranging from 0 to 70 microvolt and horizontal go from 1Hz to 40Hz

Figure 8 presents a new measurement taken in 2019 in the morning at the ITA campus in São José dos Campos, southern and eastern Brazil.

ISSN 2348 – 8034
Impact Factor- 5.070

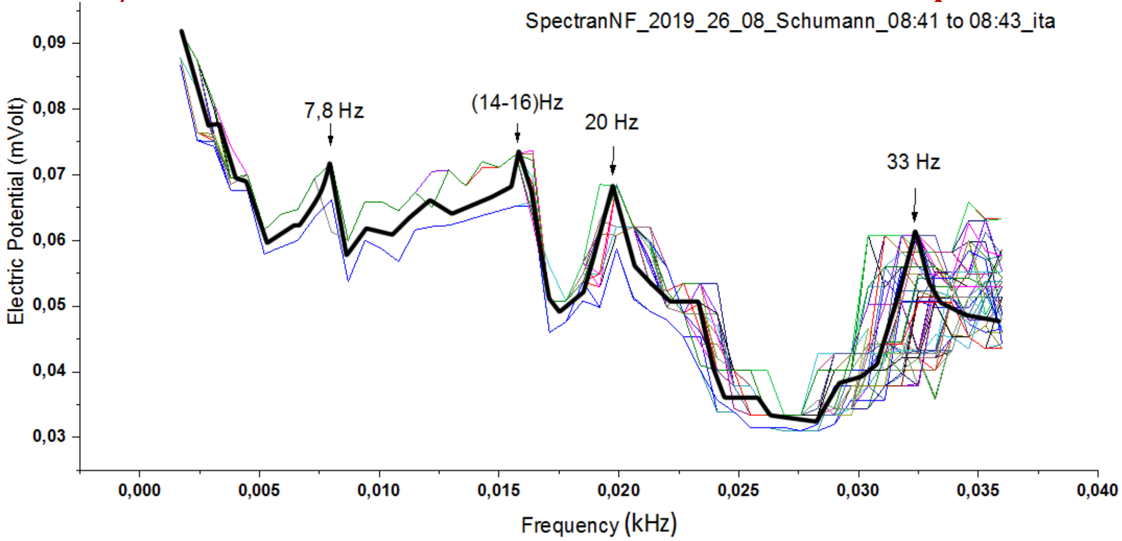

***Fig. 8** - Measurements of Schumann resonances during morning period of 2019/26/08 showing **absence of the (ELF background) and** in vertical axe the Electric Potential in millivolt (mV)*

Finally, Figure 9 shows the measurements made down of the local electric field in units of Volt / meter, in the frequency range from 1Hz to 200Hz. This type of measurement serves to verify that the SpectranNF-5035 RF detector is calibrated and measuring normally.

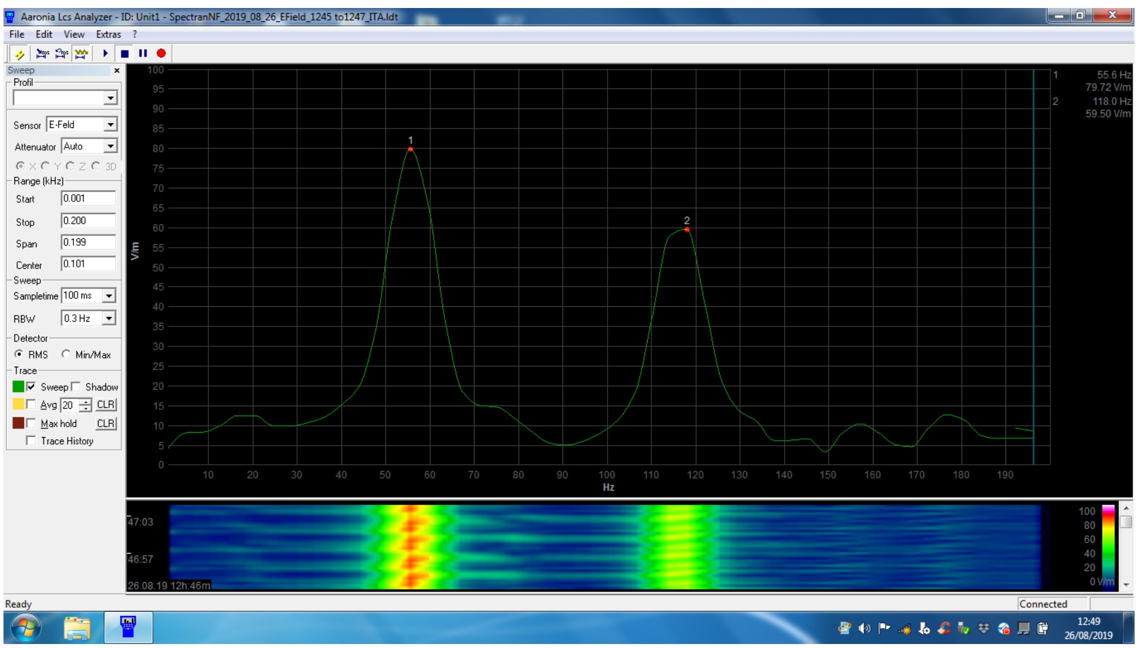

***Fig. 9**Electric field measurements made in 2019/26/08 between 1Hz to 200Hz horizontal scale and from 0 to 70 V / m on the vertical scale showing two harmonic peaks at 60 Hz and 120 Hz from down power electric supply lines in São José dos Campos, Brazil.*

Checking the results of the electrical potential measurements shown in the graphs of figures 3 to figure 8 can be said that the ionosphere is always more ionized in the local afternoon period. In the early morning and evening always appears the (ELF background) component that indicates minimal ionization of the local ionosphere.

The electrical potential intensities observed with the SpectranNF-5035 detector during the period from year 2016 to August 2019 in the São Jose dos Campos region, Brazil, had few variations in Schumann resonance lines. The uncertainties in frequencies at resonances 7.8 Hz, (14-16) Hz, 20.0 Hz and 33.0 Hz are due to sampling time and statistical problems of the obtained data. Figure 9 shows the degree of operation of the SpectranNF-5035 detector in the frequency range 1Hz to 200Hz. It can clearly measure and separate the three harmonic peaks (60, 120, 180 Hz) of the electric field caused by the down local electric power transmission line as shown in the Figure 9. The Schumann resonance is not a new phenomenon. Earth has been pulsating exactly at 7.8 Hz for thousands of years. Many ancient civilizations were also familiar with the Earth's resonance. Scientists have discovered there is a connection between brain waves and the Earth's fundamental pulse of 7,8 Hz.

IV. CONCLUSION

Schumann resonance peak measurements in terms of intensity versus frequency may indicate a greater or lesser degree of ionization of the ionosphere in that time. Certainly, these peaks are related to more or less lightning existing in the Earth's troposphere in the whole global.

These measurements realized with a simple and portable detector using the electric power transmission line (with ELF antenna) become an excellent experimental tool for studying the degree of ionization of the ionosphere and the amount of lightning existing in the Earth's troposphere at that time.

V. ACKNOWLEDGEMENTS

To CNPq and CAPES-ITA for scholarships to researchers and students to ITA - Fundamental Sciences Division for infrastructure support.

REFERENCES

1. *Martin, I. M., Marcelo Pêgo Gomes and Mauro Ângelo Alves.2013. "Measurements of the non-ionizing radiation spectra of São José dos Campos and Taubate."Brasil Revista Telecomunicações 15 (1): 7-1,Brazil.*
2. *Rapid Tables. "How to Make the Decibel-dBm Conversion on Watts (W)."Online Reference & Tools Accessed October2016 in www.rapidtables.com/convert/power/Watt_to_dBm.htm.*
3. *Gusev, A. A., Martin, I. M., Ferreira, D. V., and Otani, E. C. 2005. "The Shelter of High Energy Electrons Produced by the Powerfull HF Transmitter." IMOC-2005 (IEEE-USA) Accessed October 2016 in http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=15800030003*
4. http://ieeexplore.ieee**.**
5. *Viega, F. M., and Martin, I. M. 2012. "Measurements of non-ionizing radiation in the city of São José dos Campos, SP, Brazil."XII ENCITA-ITA, Brazil.*
6. *5.Sharma, S., Eliasson, B., Mlikh, G. M., Najmi, A., Papadopoulos, K., Shao, X., et al. 2016. "Low-Frequency Waves in HF Heating of the Ionosphere." Low-Frequency Waves in Space Plasmas, Geophysical Monograph 216: 31-49.*
7. *WimHordijk is a computer scientist currently on a fellowship at the* Institute for Advanced Study *of the University of Amsterdam, The Netherlands(* https://plus.maths.org/content/citizen-science-schumann-resonances) accessed in 09/03/2019.
8. *Cohen, M. B., and Golkowski, M. 2013. "100 Days of ELF/VLF Generation via HF Heating with HAARP." J. Geophys. Res. 118 (A10): 6597-6607, USA.*
9. *8. W. O. Schumann, "Über die strahlungslosen Eigenschwingungeneinerleitenden Kugel, die voneiner Luftschichtundeiner Ionosphärenhülleumgebenist." Zeitschriftfür Naturforschung, vol. 7A, pp. 149-154,1952, Germany.*
10. *9. Chand, R., Israil, M., and Rai, J. 2009. "Schumann Resonance Frequency Variations Observed in Magnetotelluric Data Recorded from Garhwal Himalayan Region India." AnnalesGeophysicae27: 3497-3507 Germany.*

11. *10. T. R. Larsen and A. Egeland, "Fine structure of the Earth-Ionospherecavity resonance." Journal of Geophysical Research, Space Physics Letters, vol. 73, no. 15, pp. 4986-4989, August, 1968, USA.*
12. *11. AARONIA. 2011. "World's Smallest up to 9,4GHz Analyzer Spectrum."AARONIA, Accessed October 2018.www.aaronia.de. , Germany.*