Journal of ELECTRICAL ENGINEERING, VOL 57. NO 8/S, 2006, 114-117

THROUGH THE WALL DETECTION OF HUMANS USING ELF BAND

Jaroslav Čechák*

The presented contribution is aimed at the area of possibility to detect signals in the ELF band. It presents a designed and used aerial system suitable for the reception of ELF signals. The contribution includes a separate chapter on Schumann resonance which explains many processes in human mind. The results of digital processing of ELF signals are presented in the contribution in a graphical form, as well as in the form of photographs taken during the recording of signals. The conclusion of the contribution deals with the possibilities of using the analysis of ELF signals for the detection of persons, for example, stuck under an avalanche, caved in a mine, etc.

Keywords: extremely low frequencies, human detection, Schumann resonance

1 INTRODUCTION

Every living organism on our planet is surrounded with an energy in form of the signal environment. This energy is produced either by him as result of essence of his living and survival, or the energy occurs in form of natural and artificial signals of the terrestrial origin and further of extraterrestrial origin, signals coming from the near and deep space. If Man has the option, the gift to see far broader spectrum, so not to be limited by visible part of the spectrum only, he would be surprised, for sure, how dense spectrum exists on our planet. That magical word "energy", which is cause of everything, the word quoted in any form and connected with every living or dead form, is playing important part. There is no doubt that Man itself is emanating energy. However, it is necessary to remember how weak this field is. Signals emitted by the brain constitute one component of this energy. It concerns Extremely Low Frequencies – ELF [1].

2 ELECTROMAGNETIC FIELD OF HUMAN BODY

A cell is the basic, very small unit of the living substance. It measures about 10 microns, i.e. 10^{-5} m. But, it is still enormous to compare with particles carrying electrical charge (electrons) – there is place for at least 10,000 for them on the cell length and about 30,000 for them on the cell circumference. To create electricity in the cell, the cell needs capacity to process certain chemical materials, which the cell absorbs. The cell makes free chemical energy by chemical decomposition of the material and is using it for protein building, for its own work and for creating *electricity* in presence of oxygen. The electricity is the most important thing for some cells, for nerve cells for example. Communication between nerve cells (neurones) depends on the parameter called *resting membrane potential – RMP*. Cell interior is negative in respect to its surface and potential across the plasmatic cell membrane is reaching values between –20 mV and –200 mV. RMP of the nerve cell is in range –40 mV to –90 mV, the sustained value is –70 mV. We call such cells *polarised*. Aforesaid voltage values are really negligible; currents reach orders of magnitude of microamperes. Nevertheless, those values are not insignificant.

2.1 Schumann resonance

It concerns the state on boundary of beta and theta levels, at 7.83 Hz more precisely. Brain waves have no constant frequency, but their frequency is changing. The whole control system is buried deeply in the brain, in the thalamus. The *thalamus* is switching and integrating centre of excitements coming from sensors, from the spinal cord and the brain stem to the cerebral cortex. The system is called *thalamic rhythmic generator* or ”pacemaker”. Calcium ions are seeping slowly to particular *thalami-cortical neurones*, which are oscillating 1.528 sec and are triggering brain waves. Then, the brain waves propagate up to the cerebral cortex. If those neurones are *saturated* with calcium ions, the thalamic oscillations stop. The brain waves are ”idling” during this ”*silent phase*”, lasting from 5 to 25 seconds. The thalamic oscillations start again, when the calcium level in cells drops to the value allowing the neurone to oscillate again. EEG has shown that waves do not expand to the brain only, but through the whole nervous system (through the perineural system) and to every part of the organism. So, the brain waves adjust sensitivity and activity of the whole nervous system. The time domain, where the brain waves are not thalamus controlled is the most interesting part of the system. Then the *brain field* can be affected by electrical and magnetic *rhythms from outside*, natural or artificial. Magnetic field of Earth (geomagnetic field) is reason for magnetic needle of a compass pointing to the North Pole. But, if you look to the needle under the microscope, you see its minute movement due to *geomagnetic microscopic pulses*, which are reason for the unique geophysical mechanism – *Schumann resonance*. German atmospheric physician W. O. Schumann brought in the idea that the space between the Earth surface and the ionosphere behaves as the *resonance cavity* – energy for this cavity is supplied with thunderbolts. The Schumann theory was accepted in sixties. So, thunderbolts generate *electromagnetic standing waves* propagating around the globe. Those waves are reflected from the ionosphere back to the Earth surface and then back to the ionosphere. So, value

*University of Defense, Faculty of Military Technology, Radar Department, Kounicova 65, 612 00 Brno, Czech Republic, E-mail: jaroslav.cechak@unob.cz

ISSN 1335-3632 © 2006 FEI STU

of the Schumann resonance depends on the distance of the ionosphere from the Earth surface, which is subject to the *Sun activity*. This value is subject to the magnetic storms disturbing the ionosphere above all and the Schumann resonance trails off, so it is created by *terrestrial activities* and modified or *modulated by extraterrestrial* activities. The following correlation is interesting as well, resulting from that all – *wave length*. We can find out by calculation, that $\lambda = c/f = 2.997\ 924\ 580.\ 10^8/7.83 = 38.3$ thousand km. This number is not accidental and it is close to the value of the *Earth circumference* [2, 3].

3 MEASUREMENT IN THE ELF BAND

A proper antenna is the basic building element for man emission measurement in ELF band (1 – 15 Hz). Either a loop antenna used from ELF up to UHF bands from the very beginning of radio communication or large inductive coil can be used for this measurement. Both antenna types have the advantage that their sizes are relatively small comparing with the wavelength for which they are intended. The large copper quantity necessary to build the winding is their common disadvantage. In contrast to an electric monopole, these antennae are working with the magnetic field entirely and therefore it is advisable to use proper electrostatic shielding.

To compare expediency of antenna types for man emission measurement in ELF band, both above mentioned antenna types were built. The loop antenna was built first, its picture is shown on Fig.1.

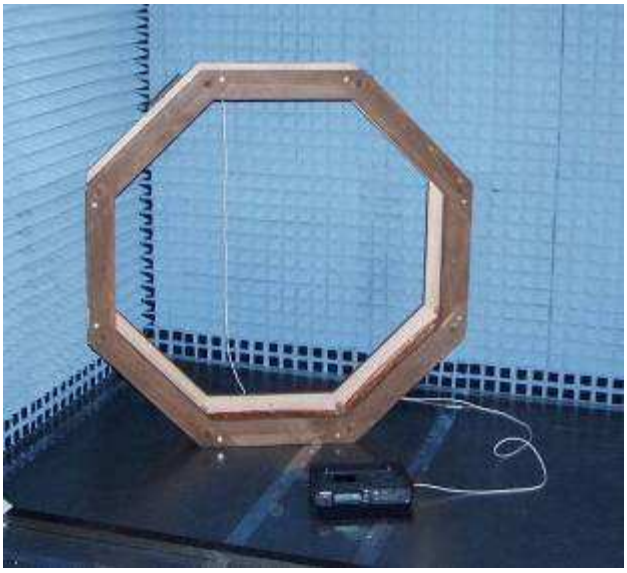

Fig. 1. Loop antenna in the anechoic chamber

The antenna is winded on a wooden frame in the shape of the regular octagon. Length of used 1.3 mm thick copper wire was almost 500 m. The antenna was shielded with an aluminous foil and grounded. The effective aperture size is 118.3 m^2, loop resistance is 5.98Ω, loop inductance is 31.2mH and the low cut-off frequency is 30.5 Hz.

The antenna of the inductive type was built as the second, its picture is on Fig. 2. More than 48,000 turns were wound on the PVC rectangular core with the proportions 25x50 mm and length of 700 mm. Length of used 0.33 mm thick copper conductor was approximately 9 km. The coil resistance is 1.92kΩ and measured inductance is 280H. Each of many layers is sandwiched with the thin insulation paper. The electrostatic shielding was provided in the same way like for the loop antenna. The coil magnetic core (filling almost whole inner space of PVC core) was provided from Mu-metal bands of the same width. Impregnated insulation fabric was inserted between bands. Mu-metal is a nickel-iron alloy (75% nickel, 15% iron, plus copper and molybdenum) that has a very high magnetic permeability. Permeability is represented by 100.000μ. The functional coil antenna construction is shown on Fig.2.

Fig. 2. Coil antenna construction

The Mu-metal bands of the same width of the 50 mm are presented in the Fig.3. To avoid the possible changes Mu-metal magnetic parameters, they have been cut using the water jet.

Fig. 3. Mu-metal bands

Signal from the antenna is fed into a current/voltage converter composed with the operation amplifier with ultra low basic noise level. Behind second stage with fixed voltage gain 45 dB, there is filtration cascade of the 8th order low-pass filter type with the corner frequency of 30 Hz. Used inverse Chebyshev approximation gives worse phase ratio, indeed. But the implemented filter has attenuation of 60 dB on 50 Hz, which is line frequency used in the Czech Republic. Filter output signal goes to input of the digital DAT tape recorder. DAT tape recorder has built-in 16-bit A/D converter and it works with the standard 44.1 kHz sampling frequency. The whole measurement chain was

supplied from accumulators during recording. The picture of the measurement chain is presented in the Fig.4.

Man emission in ELF band was measured both in the free-field chamber located in a building in the Brno City centre and in the free terrain approximately 8 kilometers from the town agglomeration. More then 15 hours of signal recording were made gradually under situation, when a man was moving in distance 0.5 – 2.5 m behind the brick or concrete wall from individual antennae or the man was tens of meters away from individual antennae.

Fig. 4. ELF measurement chain

Then, the recording was stored in PC through SP-DIF interface, converted to the data format suitable for MATLAB software environment and then it was digitally processed.

4 ELF BAND SIGNAL ANALYSING

There is an example of the signal time path in ELF band without man presence in Fig.5. Top diagram corresponds to the loop antenna recording; the lower diagram corresponds to the inductive coil recording. Although this record was made in the screened free-field chamber, it is obvious from the time path that very strong industrial interference was present. The spectral analyse can give us more information.

Well-known Welch method proved to be suitable means of the spectral analyse in the end. Smoothed out spectra diagrams corresponding to recordings from the loop antenna are shown in Fig. 6, then corresponding diagram for the inductive coil is shown in Fig. 7. To facilitate comparison, only two smoothed out spectra diagrams are shown in each figure, they correspond to human presence and absence in antenna proximity behind the wall.

It is typical for recordings made with the loop antenna (Fig. 6) that the man present is amplifying frequency components markedly near Schumann resonance. In addition to this resonance, presence of the man results in appearance of other distinctive frequency peaks on frequencies in 1.3 – 4 Hz band in signal spectres, furthermore on frequency 21.2 Hz and 28.7 Hz. The peak on frequency 16.7 Hz is not mentioned because this frequency value belongs to the 15kV tractive line supply abounds in the European railway transport.

It is typical for recordings made with large inductive coil (Fig. 7) that there is no visible amplification on Schumann resonance frequency (6.9 Hz) caused by presence of man. It is in contrast to recordings made with the loop antenna. But, man presence is the most distinctive in 1.3 – 4 Hz band. The third most distinctive frequency peak has value of 26.8 Hz, with splitting to the frequency of 28.7 Hz. It is necessary to mention here that the inductive coil sensitivity for man presence was on its highest if oriented in east-west direction.

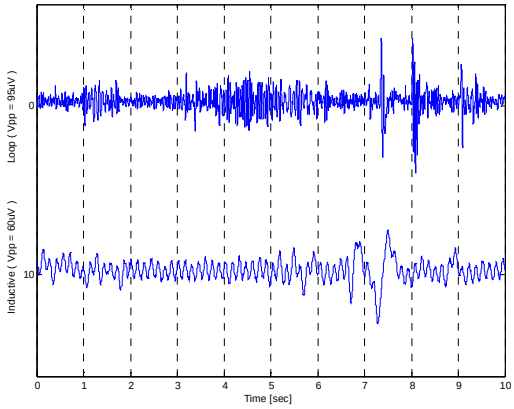

Fig. 5. Time path of the recorded signal

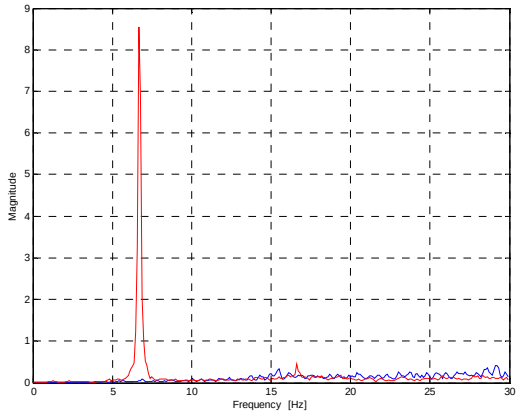

Fig. 6. Smoothed out spectra diagram, the loop antenna is used (Blue diagram – no man is present, red diagram– man is present)

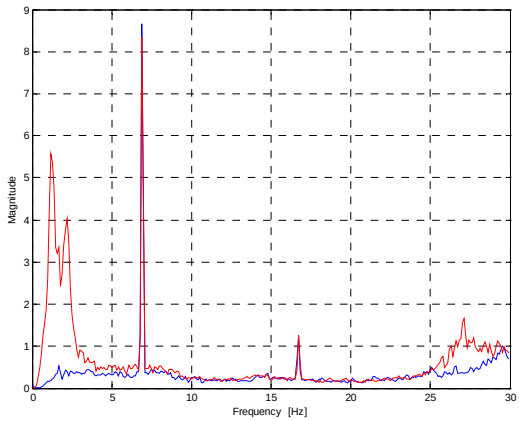

Fig. 7. Smoothed out spectra diagram, the coil antenna is used (Blue diagram – no man is present, red diagram– man is present)

Further experiment has been affected with the man detection inside car. The coil antenna has been placed 50cm under the concrete ramp. This situation is presented in the Fig. 8. Smoothed out normalized spectra diagrams corresponding to recordings from the inductive coil antenna are shown in Fig. 9.

Fig. 8. The coil antenna under the ramp

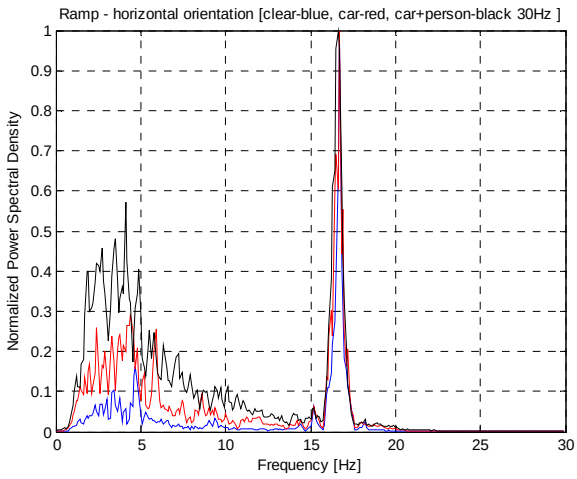

Fig. 9. Smoothed out spectra diagram, the coil antenna is used (Blue diagram – no man is present, red diagram– car is present, black – man is present inside car)

It can be stated generally that the inductive coil has shown better characteristics in the process of measurement. Because its size is smaller then that of the loop antenna, it is not sensitive to wind gusts and it appears to be more perspective for the future. The measurement proved that the man can be detected in the 1.3 –15 Hz frequency band.

5 CONCLUSION

This paper reports the measurement of the radiation from humans in ELF band using two types of antennas. A briefly analysis of the measured spectra diagrams is made and consequently a conclusion is made that man is emitting EM energy in the band of interest.

This band was situated deliberately to the frequency interval of 0.5 – 15 Hz. In the following works, it is necessary to optimize antenna aperture size from the point of view of reasonable dimensions and to carry on set of measurements allowing detection of the human body imprisoned under the snow avalanche, for example.

However, design and construction of ELF band antenna with the distinct directional characteristic is the necessary assumption, in order that other people in vicinity do not influence measuring results. Design of antenna system form is subject of research of this problem as well. Question arises, too, if it is advantageous to design the dedicated loop or inductive antenna with the free resonance frequency on 1 – 7 Hz approximately. Considering supposed applications, only magnetic component of the emission was recorded and analysed yet. Nevertheless, works on measurement and recording of electrical human body emission component are in stage of already designed dedicated measurement devices.

Results of future research of this certainly interesting problem will be presented.

Acknowledgement

Author is open to any motivating suggestions and opinions from expert community. The Ministry of Industry and Trade supported this work under grand No: FI-IM/015

REFERENCES

[1] BOCCIPPIO, D.J. — WONG, C. — WILLIAMS, E.R.,: Global validation of single-station Schumann resonance lightning location. Journal of Atmospheric and Solar-Terrestrial Physics 60, 1998

[2] BARR, R. — IRELAND, W. — SMITH, M.J.: ELF, VLF and LF radiation from a very large loop antenna with a mountain core. Proceedings H of the IEE 140, 1993

[3] GREINGER, C. — GREINGER, P.: Approximate method for determining ELF eigenvalues in the Earth-ionosphere wave guide. Radio Science 13, 1997

[4] GINZBURG, L.H.: Extremely low frequency (ELF) propagation measurements along a 4900km path. IEEE Transactions on Communications COM-22, 1974

[5] JONES, D.L. — KEMP, D.T.: Experimental and theoretical observations on the transient excitation of Schumann resonances. Journal of Atmospheric and Terrestrial Physics 32, 19970

[6] MORGAN, M.G.: An island as a natural very-low-frequency transmitting antenna. IRE Transactions Antennas and Propagation AP-8 (5), 1960

[7] TRAN, A., — POLK, C.: Schumann resonances and electrical conductivity of the atmosphere and lower ionosphere. Journal of Atmospheric and Terrestrial Physics 41, 1241, 1986

[8] WEEKS, K.: The ground interference pattern of very-low-frequency radio waves. Proceedings of the IEE 97 (III),1997

Received 8 November 2006

Jaroslav Čechák was born in Prostějov, Czech Republic, in 1964. He received his Ing (MSc) degree in Radioelectronics from the Military University, Liptovský Mikuláš, in 1986 and PhD Degree from University of Defense, Brno, in 1996. Since 1997 he has worked at the Radar chair, Faculty of Military Technology, University of Defense, Brno as an assistant professor. His research interests include digital signal processing from passive seismic sensors, magnetic sensors and infrared sensors, theory of radar signals and systems and electronics warfare.