ELF receiver for EM waves beyond 46 Hz

Rudi Čop

At the PIA Geomagnetic Observatory (Piran, Slovenia) (hereinafter: the Observatory) we measure changes in the Earth's magnetic field according to the international recommendations with digital magnetometers with one-second sampling. Since we wanted to detect the noise sources in the geomagnetic field in frequency range from 0.05 Hz to 0.5 Hz, the antenna of the ELF receiver was first directed vertically. On the territory of Slovenia the Z component of the geomagnetic field is the noisiest one. We found that the frequency range from 5 Hz to 50 Hz contains electromagnetic disturbances of artificial origin. We then tried to determine, by the spectral analysis, their sources and the possible influence of these disturbances in the frequency range below 1 Hz.

From the measurements which took ten months, we selected three typical measurements in geomagnetically calm days: 5 July 2017 (Figure 1) and 11 November 2017, all time from 08:10 to 08:20 UTC. The mean value of the output voltage from the ELF receiver changes with the time and direction of the B-antenna axes. This is due to the change in the operating temperature of the low noise operating amplifier at the pre-amplification stage.

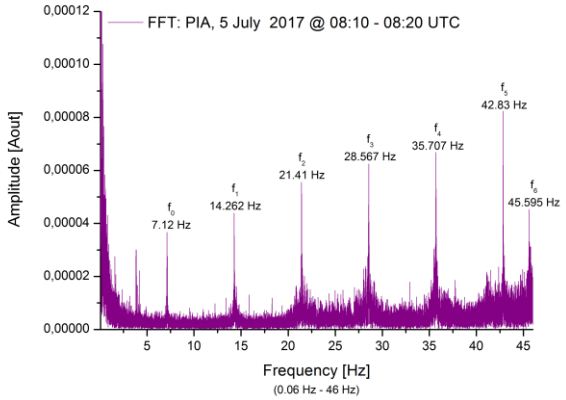

Figure 1: Spectral analysis of the ELF receiver data on 5 July 2017 between 08:10 and 08:20 UTC in the frequency range from 0.06 Hz to 46 Hz.

The analysis of phenomena in the frequency range from 0.06 Hz to 46 Hz (Figure 1) does not yet reveal the true sources of the emerging frequencies. From the frequency f = 50 Hz, which is the frequency of the electro-energy network, the frequency f_5 is spaced by Δf = 7.1 Hz. The same distance exists between all other frequencies lower than f = 50 Hz. The sum of each pair of these frequencies $f_0 + f_5$, $f_1 + f_4$, $f_2 + f_3$ gives the value of the base frequency f = 50 Hz. These would be sub-harmonic frequencies. However, it is not possible to explain the source of the frequency f = 45.6 Hz and frequencies lower than 7.12 Hz.

The true source of the output frequencies in the frequency range from 0.06 Hz to 46 Hz is shown only when the considered frequency range is expanded to 360 Hz. There exist the odd and even higher harmonic frequencies from 100 Hz to 350 Hz, which are multiple fundamental harmonic frequencies f = 50 Hz. They are caused by electric currents. A more detailed frequency analysis from 1 Hz to 95 Hz shows the lower and upper bands. These two bands are the result of pulse-with modulation for asynchronous motor control. The degree of modulation of the example from 5 July (Figure 1) is equal to β = 1, and in the following case on 11 November 2017, β > 1.

On 29 May 2018, at 6:00 UTC, the supply of electricity was interrupted at the Observatory and in its wider surroundings. The nearest still operating consumers of electricity were at least 2 km far away from the Observatory. In the frequency range from 0.3 Hz to 360 Hz the upper and lower side band, due to pulse-width modulation, completely disappeared. On the frequency range from 0.05 Hz to 0.5 Hz the effect of such a switch-off is detected as a reduction of correlation between the mean values of all amplitudes in this frequency range and amplitudes of industrial frequency of f = 50 Hz.

References:

K. Schlegel, M. Füllekrug, 2002. 50 Years of Schumann Resonance. Translation: Catarina Geoghan, 2007. Physik in unserer Zeit, 33 (6), 256-26.
C. Constable, 2016. Earth's Electromagnetic Environment. Surveys in Geophysics, 2016, 37, 27–45.
Different PWM Waveforms Generation for 3-Phase AC Induction Motor with XC164CS, 2006. Application Note AP16097. München (D): Infineon Technologies.
P. Saurabh, S. Singh, 2017. Operation of Induction Motor with Different Modulation Index. International Research Journal of Engineering and Technology (IRJET), 4 (4), 2002-2006.

Author:
Rudi Čop
Institute Sv. Peter, 6320 Sečovlje, Slovenia

Corresponding author:
Rudi Čop
Institute Sv. Peter, Sv. Peter 115, 6320 Sečovlje, Slovenia
Tel.: +386 51 644 022
e-mail: rudi@artal.si