Power line emission 50/60 Hz and Schumann resonances observed by microsatellite Chibis-M in the Earth's ionosphere

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1. Introduction

The fundamental frequency 50/60 Hz of power line emission (PLE) and the Schumann resonance (SR) harmonics were detected by use of very short electric field sensor of 0.42 m length during the low Earth orbit microsatellite Chibis-M mission in the years 2012-2014. The initial orbit of Chibis-M was almost circular about 500 km height and 57.7 inclination. We present the space distribution of observed events and connections of PLE with the possible ground pulse. PLE has been recorded both in the shadow and sunlit parts of the orbits as opposed to SR which have been recorded only in the shadow zones.

2. Basics

- **Power line emission (PLE)**: The overhead power lines are the sources of intense ultraweak electromagnetic (EM) emission, especially at 50/60 Hz range, because of significant length (up to a few thousand kilometers) and strong 50/60 Hz currents with noticeable harmonic distortion.
- **The radiation efficiency of the PLE increases with the harmonic order, so they are well observed by ground based EM sensors.** Their observations by low orbiting satellites (LEO) are very rare, particularly in basic harmonics 50/60 Hz, because of the ionospheric plasma opacity in EM band.

3. Chibis-M

The microsatellite (580 kg mass) Chibis-M (chibis-mcosmo.ru), was designed by the Space Research Institute (Moscow) in cooperation with other Russian, Ukrainian and hungarian space centers (Belenkin et al., 2014).

4. Electric field sensor

The Chibis-M EM field sensor was developed and designed in Lviv Centre of Institute for Space Research, Ukraine (Koreanov et al., 2014).

5. Results

- **The orbits of Chibis-M satellite where PLE (top) and SR eigenmodes (bottom) were detected**: The shadow parts of MS orbits are marked by black. The illuminated parts of MS orbits are marked by orange for MS over Earth’s night side and by yellow for MS over Earth’s day side.

6. References

Chibis-M launching by the cargo ship “Progress M-13M”

The electric sensor electrodes were placed on the center axes of two combined wave probes.

**The Schumann resonance (SR):** The narrow-band EM noise that originates due to the global thunderstorm activity in the Earth-ionosphere cavity. The first few eigenmodes of the SR are 7.6, 14.3, 20.6, 27.3 and 33.8 Hz and, thus, SR harmonics are also strongly absorbed by the Earth ionosphere.

- **The published numerical simulations show that the penetration depth of such an EM emission into the Earth-ionosphere is limited to 50-70 km for electric field and 220-240 km for magnetic field.**

- **From this follows, that PLE and SR can hardly ever be detected by LEO satellites, i.e. above the F-layer of ionosphere.** In spite of this fact, these emissions were recently observed with use of the electric field antennae placed on the satellites C/NOFS (USA) and Chibis-M (Russia).

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7. Very long distance PLE propagation?

- **PLE 50 Hz observed over Maldives**
- **PLE 50/60 Hz and SR observed over China Sea and Japan**
- **PLE 60 Hz observed over Canada and USA (dayside)**
- **PLE 60 Hz observed over Pacific Ocean**
- **PLE 50/60 Hz and SR observed over India Sea and Japan**

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7. References

- **Chibis-M EM field sensor** was developed and designed in Lviv Centre of Institute for Space Research, Ukraine (Koreanov et al., 2014).

- **Dipole effective length:** 0.42 m
- **Frequency range:** 0.1 – 140 Hz
- **Sensitivity:** 5×10⁻⁵ V/m/μV/m
- **Input noise level:** 0.5×10⁻⁹ V/√Hz (10 μm/s) or 0.5×10⁻⁹ V/√Hz (3 m/s)
- **Bandwidth:** 0.2–3 kHz

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- **Launch date:** 2012-03-24
- **Decay date:** 2014-10-15
- **Total mass:** 40 kg
- **Altitude:** 500 km
- **Inclination:** 57°
- **Orbit period:** 94.6 min
- **Mission:** continuous monitoring of lightning discharges in radio, optical and gamma bands with very high time resolution (10µs resolution).