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Analysis of impulse signals with Hylaty ELF station

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Lighting discharges generate electromagnetic field pulses that propagate in the Earth-ionosphere waveguide. The attenuation in the ELF range is so small that the pulses originating from strong atmospheric discharges can be observed even several thousand kilometers away from the individual discharge. The recorded waveform depends on the discharge process, the Earth-ionosphere waveguide properties on the source-receiver path, and the transfer function of the receiver.

If the distance from the source is known, an inverse method can be used for reconstructing the current moment waveform and the charge moment of the discharge. In order to reconstruct the source parameters from the recorded signal a reliable model of the radio wave propagation in the Earth-ionosphere waveguide as well as practical signal processing techniques are necessary.

We present two methods, both based on analytical formulas. The first method allows for fast calculation of the charge moment of relatively short atmospheric discharges. It is based on peak amplitude measurement of the recorded magnetic component of the ELF EM field and it takes into account the receiver characteristics. The second method, called "inverse channel method" allows reconstructing the complete current moment waveform of strong atmospheric discharges that exhibit the continuing current phase, such as Gigantic Jets and Sprites. The method makes it possible to fully remove from the observed waveform the distortions related to the receiver's impulse response as well as the influence of the Earth-ionosphere propagation channel.

Our ELF station is equipped with two magnetic antennas for Bx and By components measurement in the 0.03 to 55 Hz frequency range. ELF Data recording is carried out since 1993, with continuous data acquisition since 2005. The station features low noise level and precise timing. It is battery powered and located in the sparsely populated area, far from major electric power lines, which results in high quality signal recordings and allows for precise calculations of the charge moments of upward discharges and strong cloud-to-ground discharges originating from distant sources. The same data is used for Schumann resonance observation.

We demonstrate the use of our methods based on recent recordings from the Hylaty ELF station. We include examples of GJ (Gigantic Jet) and TGF (Terrestrial Gamma-ray Flash) related discharges.