

Final Report STSM-P18-01988

(The Physics of Lightning Flash and its Effects P18)

Short Term Scientific Mission, COST P18

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The object of the visit in Uppsala was to install a continuous E-field measurement system. The system consists mainly of three parts: a flat plate antenna for detecting the electrical field, an amplifier with automatically offset correction and a computer for recording the lightning field data. In the following a brief description of these components is given:

Because of the elementary physical model a **plate antenna** is used to measure the electrical field of lightning pulses. Figure 1 shows a principle arrangement of the measurement including the calibrating configuration. To avoid an enhancement of the electric field, the border of the inner circular plate is surrounded by a small concentric air gap extended by a conductor at ground potential. The plate above the capacitor is used to apply a known electrical field to calibrate the system. The measured current is proportional to the change of the electrical field as shown in equation (1), where “A” represents the area of the circular plate.

$$i = \varepsilon_0 \cdot A \cdot \frac{dE}{dt} \quad (1)$$

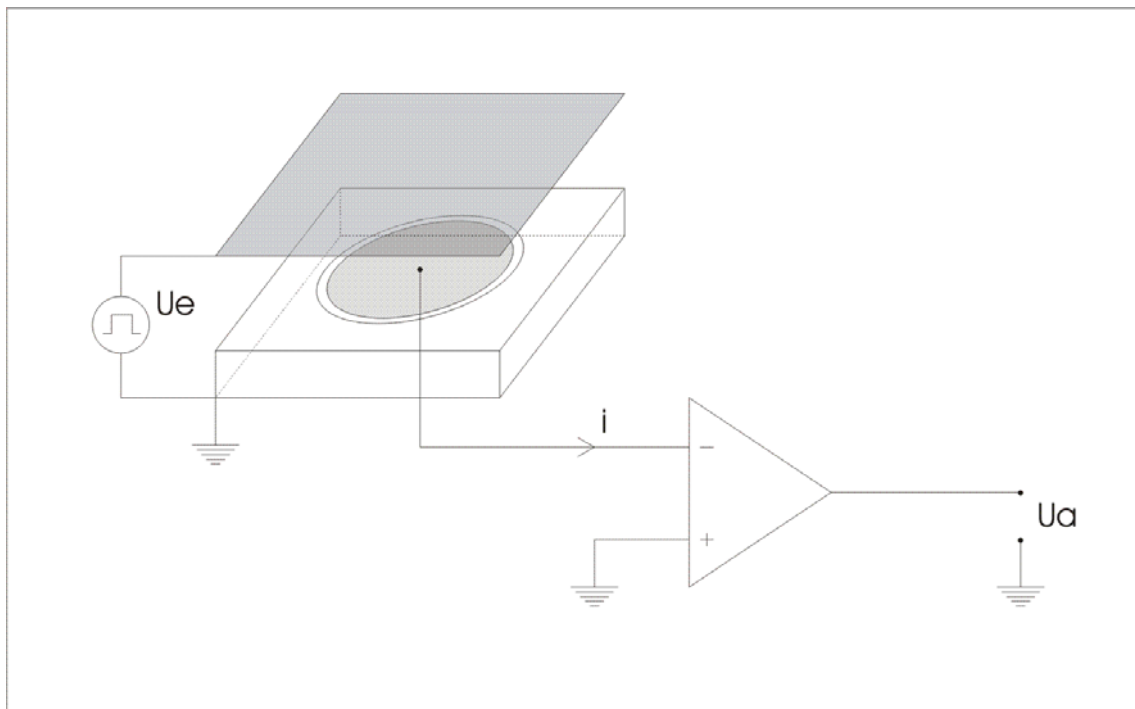


Figure 1: principal arrangement of E-field measurement

To get an output signal proportional to the electrical field the **amplifier** must have an integrative behaviour. The relation between the electrical field and the output voltage of such an amplifier is given in equation (2) where C_2 is a capacitor in the feedback loop of the amplifier.

$$U_a = -\frac{1}{C_2} \cdot \varepsilon_0 \cdot A \cdot E \quad (2)$$

This type of amplifier is very sensitive to the change of temperature. Compared to the fast measurement signal (in the range of ms) the change of the temperature and the offset voltage of the OPA is very slow (in the range of minutes). This allows controlling the output voltage of the amplifier to zero. If the time constant of the controller is within the range of a few seconds the fast measurement signal will not be affected by the controller. The lower cut off frequency of the amplifier is 320 Hz to reduce 50 Hz background noise of the electricity network and the sensitivity is about 45 mV/(V/m). At a power supply voltage of ± 9 V the range of the amplifier is ± 170 V/m. Because of the very low noise level (less than 0.1 V/m) it is possible to observe lightning activities at a distance of 200 km and more. Figure 2 shows the location of the antenna and the amplifier which are mounted on the tin roof of a four floor building.

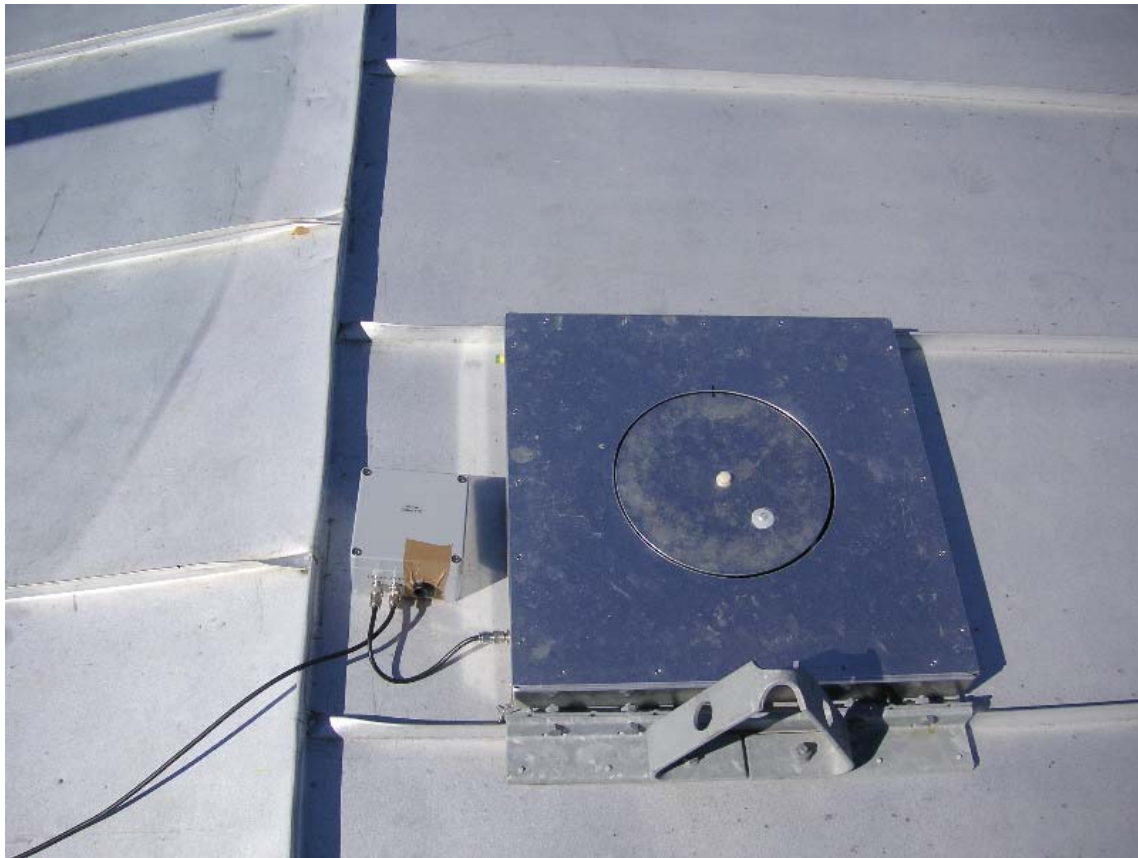


Figure 2: Location of the flat plate antenna and amplifier at the roof of Ångström Laboratories

The signal is recorded on a standard personal **computer** with a built in four channel digitizer from National Instruments (NI-PCI 6110). The sampling frequency is 5 MS/s at a resolution of 12 bit. It is possible to record continuously four channels directly to the hard disk. The whole measurement is time stamped with precise time and date which is determined from the GPS signal. For this reason the PC has a GPS-receiver PCI card from Meinberg (PCI 169). Figure 3 shows the Location of the GPS-antenna on the top of the roof.



Figure 3: GPS-antenna at Ångström Laboratories roof

During the measurement the whole system is powered by an UPS to avoid disturbances from the local power supply.

Because of the very accurate time of the measurement it is possible to compare the recorded signals to the data of the lightning location system (LLS). For this purpose a program called 'DataViewer' is used to request data from the LLS for a certain time period within a defined radius around the E-field measurement station. This information can be directly compared to the measured field signals.

Beside the installation of the E-field measurement theoretically work on transient processes at Gaisberg tower was done during the STSM: Discussions about the computer simulation of the current and electrical field of leaders in upward initiated lightning and how existing return stroke models could be adapted to tower lightning.