PROJECT ON NEW LOCAL LIGHTNING DETECTION NETWORK (LLDN) IN THE REGION OF WARSAW

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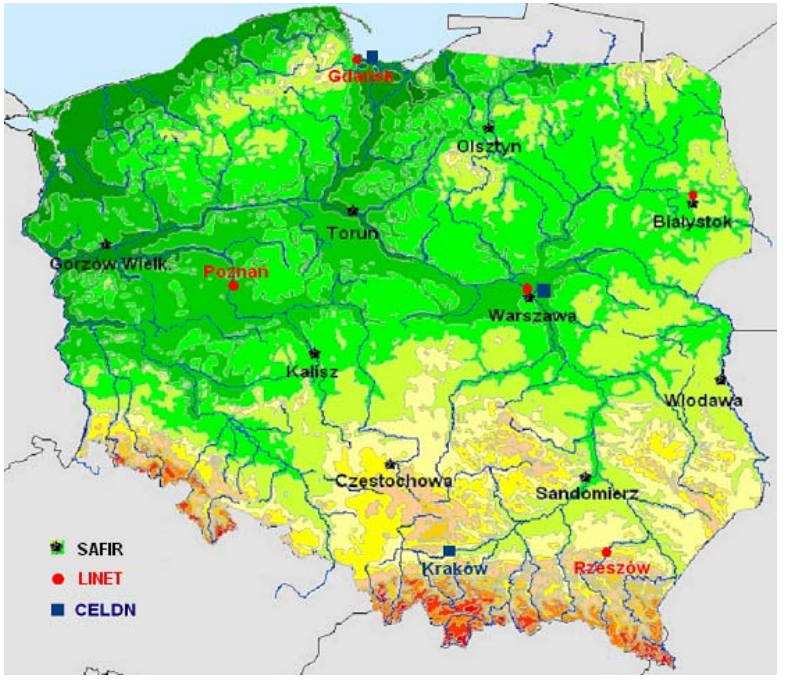
Local Lightning Detection Network (LLDN) in the region of Warsaw

- The project related to the installation of new local lightning detection network LLDN in the region of Warsaw started in March 2007.

- The new LLDN is intended to be complementary and additional source of multiple stroke CG lightning flash data, which are presently delivered by Polish SAFIR/PERUN operated by the Institute of Meteorology and Water Management in Warsaw.

- Additionally lightning data for Poland are available from LINET system and occasionally from the CELDN (EUCLID).



Configuration of LLDN

The LLDN will consist of six measuring stations installed in Warsaw area.

Each station will be equipped with:

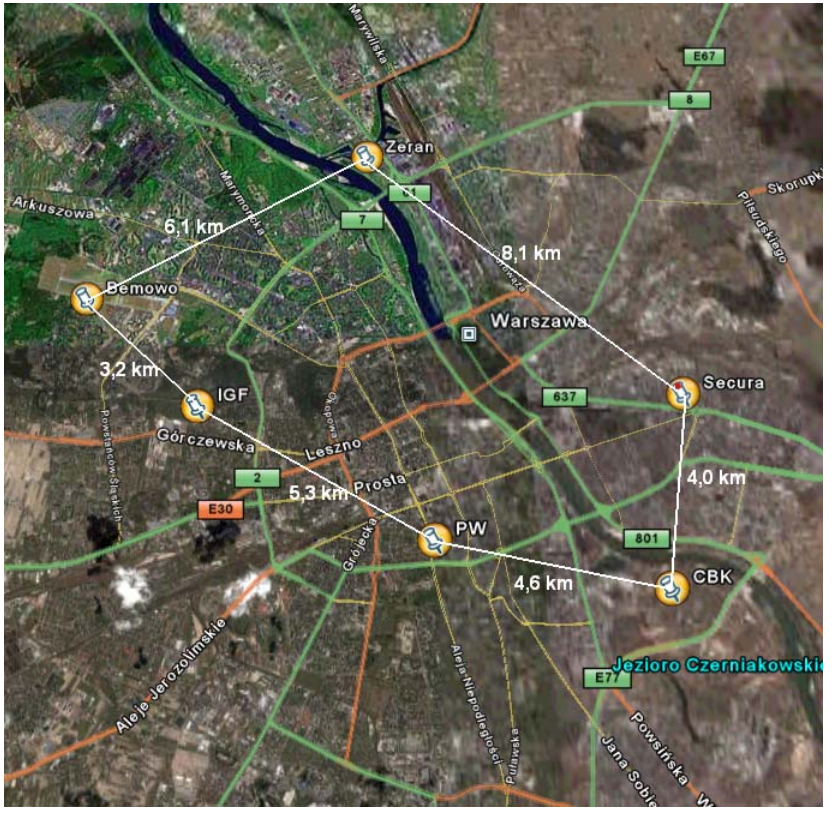
- **electric field antennas** (flat and rod) with frequency band from 20 Hz - 20 kHz, with

  - electric field amplifier with input gain > 60 dB and time constant 1 s

  - pre-triggered 14-bit A/D converter with individual memory storage bank

- six **two channel digital** data recorders

- GPS antennas (synchronization clock)



Additionaly will be used two **high speed cameras** and one **field mill.**

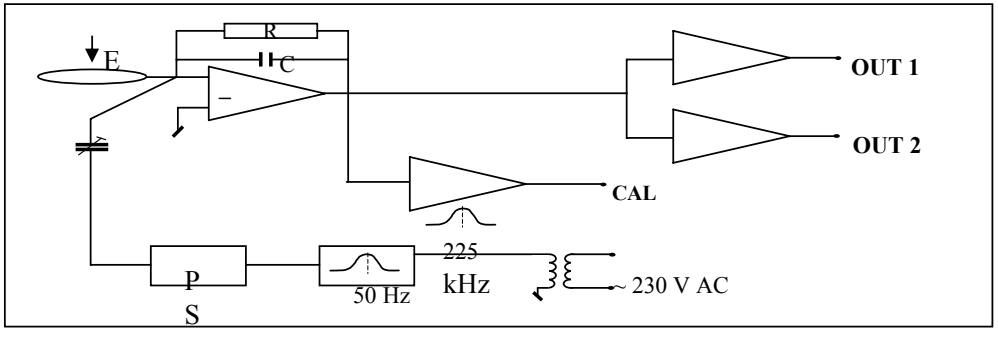
Configuration of LLDN

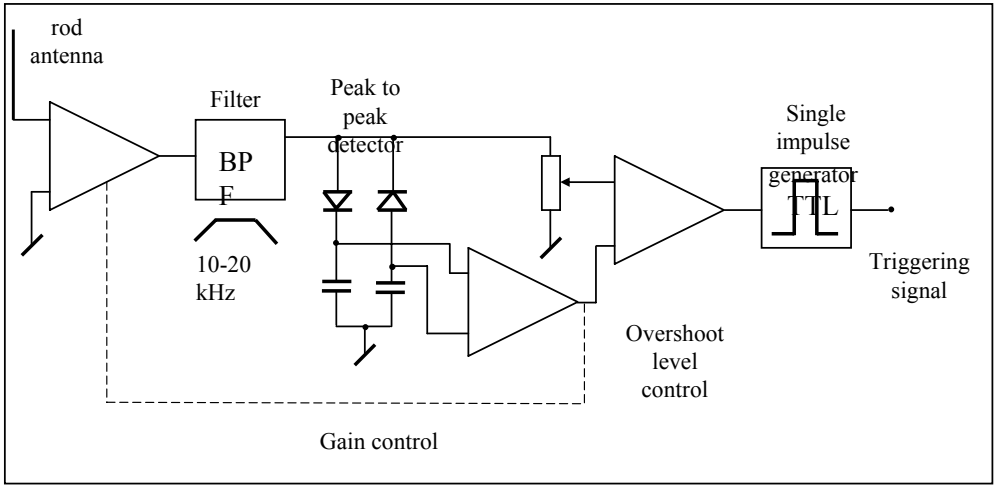
E - field meter with AC component

Parameters

- range of E- field strength up to ± 20 kV/m
- frequency range 20 Hz ÷ 20 kHz
- estimetad distance to stroke location d ≈ 1km ÷ 12 km

  - for Δ E ~1/R³ : $\Delta E_{max} / \Delta E_{min}$ ~ 65 dB
  - for ΔE_{min} /with error < 1% /: + 20dB
  - required rangeability (gain differnece between low and high range): > 85 dB





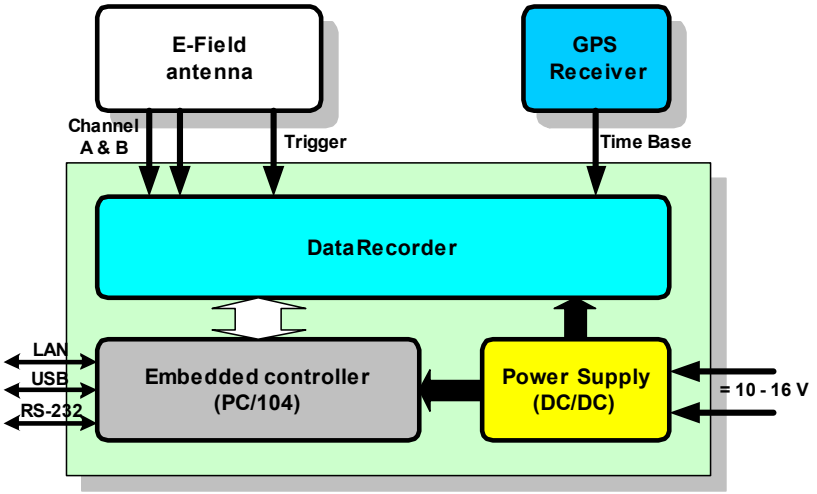
Configuration of LLDN

Two channel data recorder - parameters

Parameter	Value
General	
Mass	5.0 [kg]
Power	15.0 [W] (+30% / - 30 %)
Supply Voltage	12.0 [V] (+4/- 2)
Functional	
Number of channels	2
Frequency range: Slow mode Fast mode	20.0 [Hz] to 20.0 [kHz] 20.0 [Hz] to 100.0 [kHz]
Sampling rate: Slow mode Fast mode	50.0 [kS/s] (20.0 μs) 250.0 [kS/s] (4.0 μs)
Dynamic range [dB]	80.0 (TBC)
One shot recording time	2 x 1.0[s]
Pre-triggering time	0.5 [s]
Time base: Resolution Accuracy	1.0 [μs] +/- 1.0 [μs]
Operational	
Analog inputs (differential)	2.0 [V p-p]/ 1.0 kΩ
Trigger input	3.3 [V] (LVTTL)/1.0 kΩ
ADC: Sampling rate Resolution	50.0 [MHz] 14 bit
Data buffer	2 Mbits (2 sec continue recording)
Memory storage	40 GB (TBC)

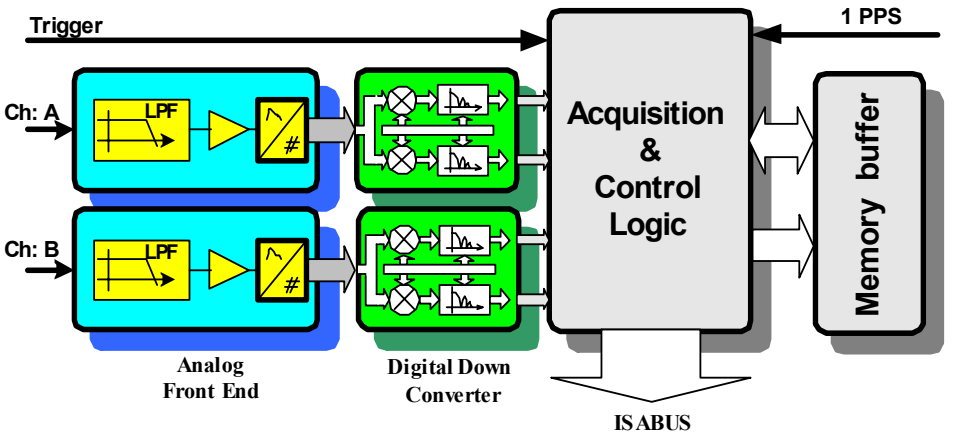
Configuration of LLDN

Two channel data recorder – block diagrams



Measuring station

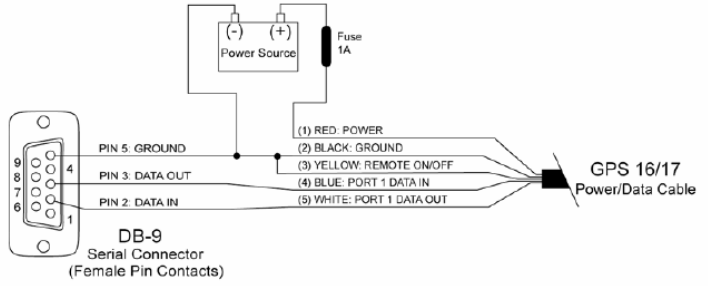
Recorder



Configuration of LLDN

GPS system – Garmin GPS 17HVS

GPS17HVS with Pole Mount



GPS Performance

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Receiver

WAAS Enabled™; 12 parallel channel GPS receiver continuously tracks and uses up to 12 satellites (up to 11 with PPS active) to compute and update your position.

Acquisition Times

- Reacquisition: Less than 2 seconds
- Warm: Approx. 15 seconds (all data known)
- Cold: Approx. 45 seconds (initial position, time, and almanac known; ephemeris unknown)
- AutoLocate®: 5 minutes (almanac known; initial position and time unknown)
- SkySearch: 5 minutes (no data known)

Sentence Rate

1 second default; NMEA 0183 output interval configurable from 1 to 900 seconds in 1-second increments

Accuracy

- GPS Standard Positioning Service (SPS)
  Position: <15 meters, 95% typical (100 meters with Selective Availability on)
  Velocity: 0.1 knot RMS steady state
- DGPS (USCG/RTCM)
  Position: 3–5 meters, 95% typical
  Velocity: 0.1 knot RMS steady state
- DGPS (WAAS)
  Position: <3 meters, 95% typical
  Velocity: 0.1 knot RMS steady state
- PPS Time: ±1 microsecond at rising edge of PPS pulse (subject to Selective Availability)
- Dynamics: 999 knots velocity (only limited at altitude greater than 60,000 feet), 6g dynamics

Additional equipment

High speed cameras

For observations and record of lightning channel image in selected parts of the horizon including tall structures in Warsaw.

Base required parameters:

1000 fps, 1000 x 1000 pixels, 8 bits, GPS time stamping, recording time 1s, 2 GB, pretriggering.

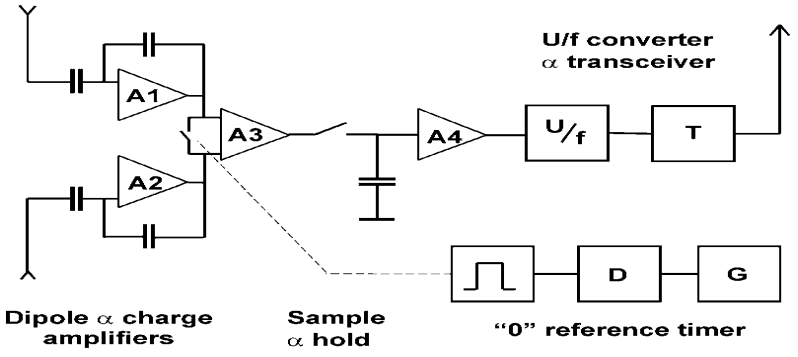
Redlake, Photron, PhotoSonics, Weinberger, others
– any suggestions???

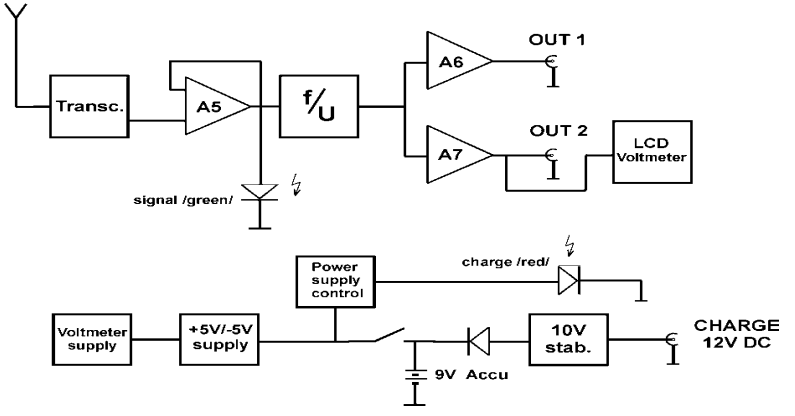
Additional equipment

Field mill – EFMR-1

Electric field mill

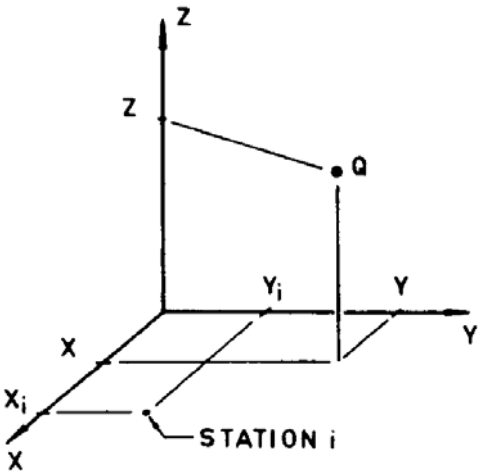
Signal receiver





Analyses of collected lightning data

For post-time processing of stored lightning data from six individual stations will be used single point charge model (Krehbiel and al..*)

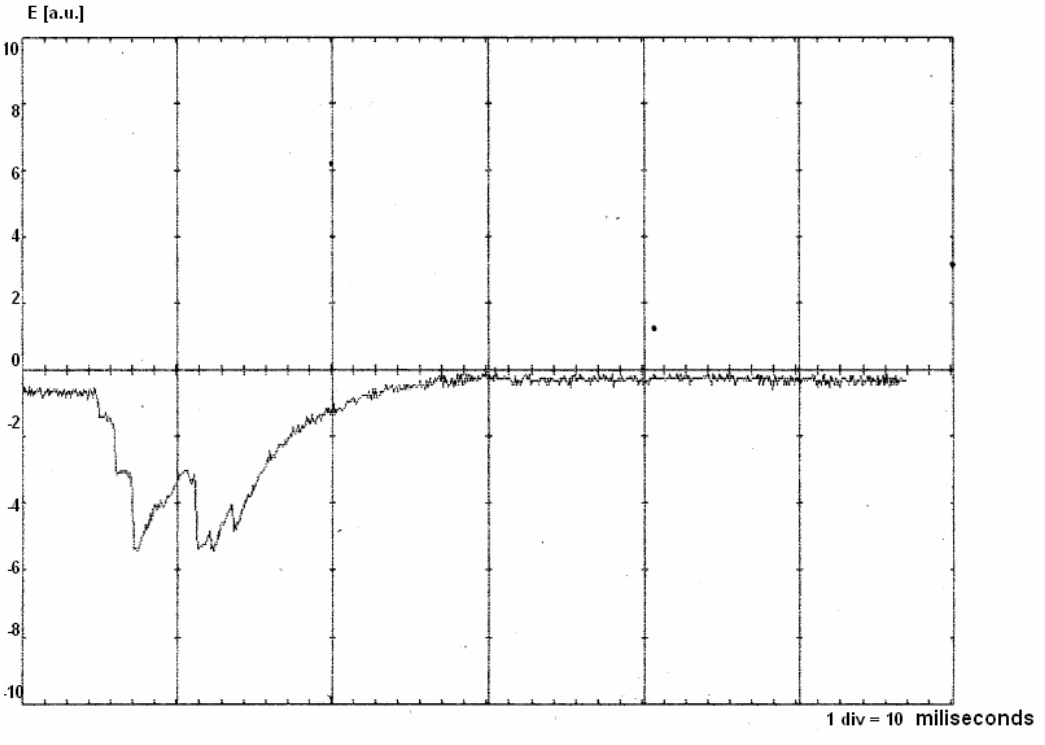


The charge and cartesian coordinates (3D) of single stroke in individual point will be derivated from set of equations for each individual station results having the form:

$$\Delta E_i = \frac{1}{4\pi \cdot \varepsilon_0} \frac{2Q_z}{\left[(x - x_i)^2 + (y - y_i)^2 + z^2\right]^{3/2}}$$

* P.R. Krehbiel, M. Brook, R.A. McCrory: „An Analysis of the Charge Structure of Lightning Discharges to Ground", Journal of Geophysical Research, Vol.84, No C5, pp. 2432-2456.

Analyses of collected lightning data



Typical record of E-field versus time from flat antenna from CG discharge (3 strokes observed).

It is expected to record simultanously six E-field waveforms produced by the same CG flash (stroke).

Based on the electrostatic single point charge model for the assumed thundercloud distribution and $(\chi)^2$ test for statistical assessment of applicable resolution fit , it will be developed the algorithm and software for calculation of charge value and its coordiantes.

Analyses of collected lightning data

LLDN data can be used for validation of other CG flash records, available other lightning detection systems covering larger and more extended areas.

Starting from the lightning season in 2008, the lightning data will be collected with 3D information on individual stroke locations obtained from LLDN. It will be possible to incorporate the determined lightning discharges locations into maps available from meteorological radar observations, e. g. pseudoCAPPI or VCUT, and to examine the relationship between precipitation phenomena and development of the observed multiple CG flash events.

Comparative analyses of new LLDN data and the SAFIR (PERUN), LINET and eventually the CELDN lightning data are planned to be carried out with the aim to verify the lightning data quality in Warsaw region recorded by different lightning detection systems and compare the statistical lightning data in this region.

THANK YOU FOR YOUR ATTENTION !

QUESTIONS ?