Lightning Research at Säntis Tower

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EMC (Electromagnetic Compatibility) Lab

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Welcome to the Electromagnetic Compatibility Laboratory (EMC Lab)

The EMC Laboratory of the Swiss Federal Institute of Technology is active in EMC research since early 1980s. Our Research is essentially sponsored by various programs of Swiss National Science Foundation, European Community, Swiss Electrical Utilities (PSEL, CREE-RDP), as well as by private companies.

We collaborate with many international research centers and universities among which Universities of Bologna and Rome (Italy), University of Toronto (Canada), University of Florida (USA), Radio Research and Development Institute (Russia), etc.

Students at Swiss Federal Institute of Technology have an opportunity to get involved in EMC research through semester projects (undergraduate level), diploma projects (equivalent to MS), and

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International Union of Radio Science (URSI)

• URSI is a non-governmental and non-profit organisation under the International Council for Science
• Stimulating and co-ordinating, on an international basis, studies, research, applications, scientific exchange, and communication in the fields of radio science.
• Active since 1922
• http://ursi.org
URSI Scientific Commissions

- Commission A: Electromagnetic Metrology
- Commission B: Fields and waves
- Commission C: Radiocommunication Systems and Signal Processing
- Commission D: Electronics and Photonics
- Commission E: Electromagnetic Environment and Interference
- Commission F: Wave Propagation and Remote Sensing
- Commission G: Ionospheric Radio and Propagation
- Commission H: Waves in Plasmas
- Commission J: Radio Astronomy
- Commission K: Electromagnetics in Biology and Medicine
The Säntis Tower is one of the hotspot of lightning activities in Europe.

It is instrumented for lightning current measurement since June 2010.

Since then, over 500 lightning flashes were successfully recorded.
Swiss Experimental Station on Lightning Research at Mount Säntis
Lightning flash density in Switzerland

Flashes \( \frac{\text{km}^2}{\text{year}} \)

<table>
<thead>
<tr>
<th>Flashes</th>
<th>&lt; 1</th>
<th>1 – 2</th>
<th>2 – 3</th>
<th>3 – 4</th>
<th>4 – 5</th>
<th>5 – 6</th>
<th>&gt; 6</th>
</tr>
</thead>
</table>

Lightning flash density in Switzerland

Flashes per km² · year:
- < 1
- 1 – 2
- 2 – 3
- 3 – 4
- 4 – 5
- 5 – 6
- > 6

History: Berger’s Tower Measurements at Monte San Salvatore
Lightning flash density in Switzerland

Flashes \( \frac{\text{km}^2 \cdot \text{year}}{} \)

- < 1
- 1 – 2
- 2 – 3
- 3 – 4
- 4 – 5
- 5 – 6
- > 6

Lightning flash density in Switzerland

2011

Säntis mountain: 2502 m;  Säntis Tower: 123.5 m
Two Rogowski Coils at each height

B-dot sensors

Fiber Optic Link

Control room

monitoring, management, and control system

Current + Current derivative

82 m

24 m
B-Dot Multigap Sensor
EMC Box Design

1. Metal enclosure
2. Input connectors
3. Rogowski integrators
4. Power adapters
5. Power supply
6. Analog / Fiber system
7. Surge peak arresters
8. CompactRio
9. Ethernet / Fiber LAN
10. Heating system
11. Isolation transformer
12. System FAN
13. Fiber input connector
14. Insulation material

1. Honeycomb fan pattern
2. Berilium copper finger gasket
3. Isolation transformer
4. Stainless steel transformer box
5. Input filter connector
6. Input connectors
7. Fiber pass hole HF filter
8. Stainless steel metal box
Equipment Installation
Equipment Installation
Equipment Installation

*B-Dot installed along with Rogowski Coils*

*View of the tower*
Recent updates

- Installation of isolation transformers
- Installation of UPS
- Software upgrade
Maintenance, monitoring and control tasks can be carried out remotely using a remote control system over the Internet using a standard DSL link on the Säntis.
Obtained Data

- From 19 May 2010, about 500 flashes were successfully recorded on the Säntis.
Obtained Data: Negative Flashes

Monthly flash count to the Säntis tower, recorded in the period from May 2010 to January 2013.

- **N negative = 231**
- **N positive = 38**
- **N bipolar = 6**

![Monthly flash count graph](image-url)
Gathered Data

Example of a Negative Flash

Initial Continuous Current (ICC)

Return stroke
Gathered Data

Example of a Negative Flash: Detail

**Peak Current**: 22kA
**Rise time**: 1.2μS
**Charge**: 2.77 C
Example of a Negative Flash

$\frac{di}{dt}$

Detail of the last stroke. Negative Measurement Date: 2010-09-12 Time: 19:52.29

Current derivative (kA/μs)

Time (ms)

B-dot: 82 m
### Statistical Parameters of Peak Current

<table>
<thead>
<tr>
<th>Tower</th>
<th>Sample size</th>
<th>Percentage Exceeding Tabulated Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>95%</td>
</tr>
<tr>
<td>Empire State Building [19]</td>
<td>82</td>
<td>-</td>
</tr>
<tr>
<td>San Salvatore [20]</td>
<td>176</td>
<td>-</td>
</tr>
<tr>
<td>Moscow Ostankino Tower [22]</td>
<td>58</td>
<td>-</td>
</tr>
<tr>
<td>Peissenberg [21]*</td>
<td>125</td>
<td>-</td>
</tr>
<tr>
<td>CN Tower [17]*</td>
<td>387</td>
<td>1.3</td>
</tr>
<tr>
<td>Gaisberg Tower [5]*</td>
<td>476</td>
<td>3.5</td>
</tr>
<tr>
<td>Säntis (This study)</td>
<td>1987</td>
<td>2.9</td>
</tr>
</tbody>
</table>

*Measurements at 533 m above ground

* for ICC pulses and return-stroke pulses

* Current pulses underwent a 250-kHz low pass filtering
Positive Flashes

• Positive flashes are of particular interest for a number of reasons, most importantly:

(1) They are characterized by high peak currents and large impulse charges.
Positive Flashes

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(1) They are characterized by high peak currents and large impulse charges.

✓ They are a major concern for the designers of lightning protection systems of structures such as wind turbines and telecommunication towers.
Positive Flashes

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(1) They are characterized by high peak currents and large impulse charges.

(2) Their EM field waveforms are characterized by a complex structure.
Positive Flashes

- Positive flashes are of particular interest for a number of reasons, most importantly:

  1. They are characterized by high peak currents and large impulse charges.

  2. Their EM field waveforms are characterized by a complex structure.

✓ Hard to detect and classify by lightning location systems
Positive Flashes

• Positive flashes are of particular interest for a number of reasons, most importantly:

(1) They are characterized by high peak currents and large impulse charges.

(2) Their EM field waveforms are characterized by a complex structure.

(3) They are related to the initiation of transient luminous events in the middle atmosphere.
Example of a Positive Flash

August 27, 2011
Example of a Positive Flash

August 27, 2011

93 kA
Example of a Positive Flash

August 27, 2011

Q = 400 C
Another example of a positive flash current
Performance of Lightning Detection Networks

![Map of lightning detection network locations from 2010-2013. The map shows a high concentration of detections in a specific area, with a median distance error of 186 m. The map includes elevation contours and locations detected by the EUCLID system.]
Performance of Lightning Detection Networks
Conclusions

• Instrumentation of the Säntis Tower for lightning current measurements
• Remote Maintenance, Monitoring, Calibration and Control System
• Long term:
  – Enlarge our measurement database
  – Revisit statistical data
  – Enhance instrumentation
  – Create a Center for Lightning Research where international groups can conduct experiments and share data
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Improve our understanding of the lightning phenomenon and its Effects
Säntis Project Team

Dr. Carlos Romero  Mohammad Azadifar  Alex Smorgonskiy

Prof. M. Rubinstein  Prof. M. Paolone  Prof. D. Pavanello
Säntis Project team: Collaborating Institutions
Annual number of thunderstorm days on Säntis