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Suggestions on experimental estimation of current portion measured by Rogowski Coil at the 474-m level of CN Tower

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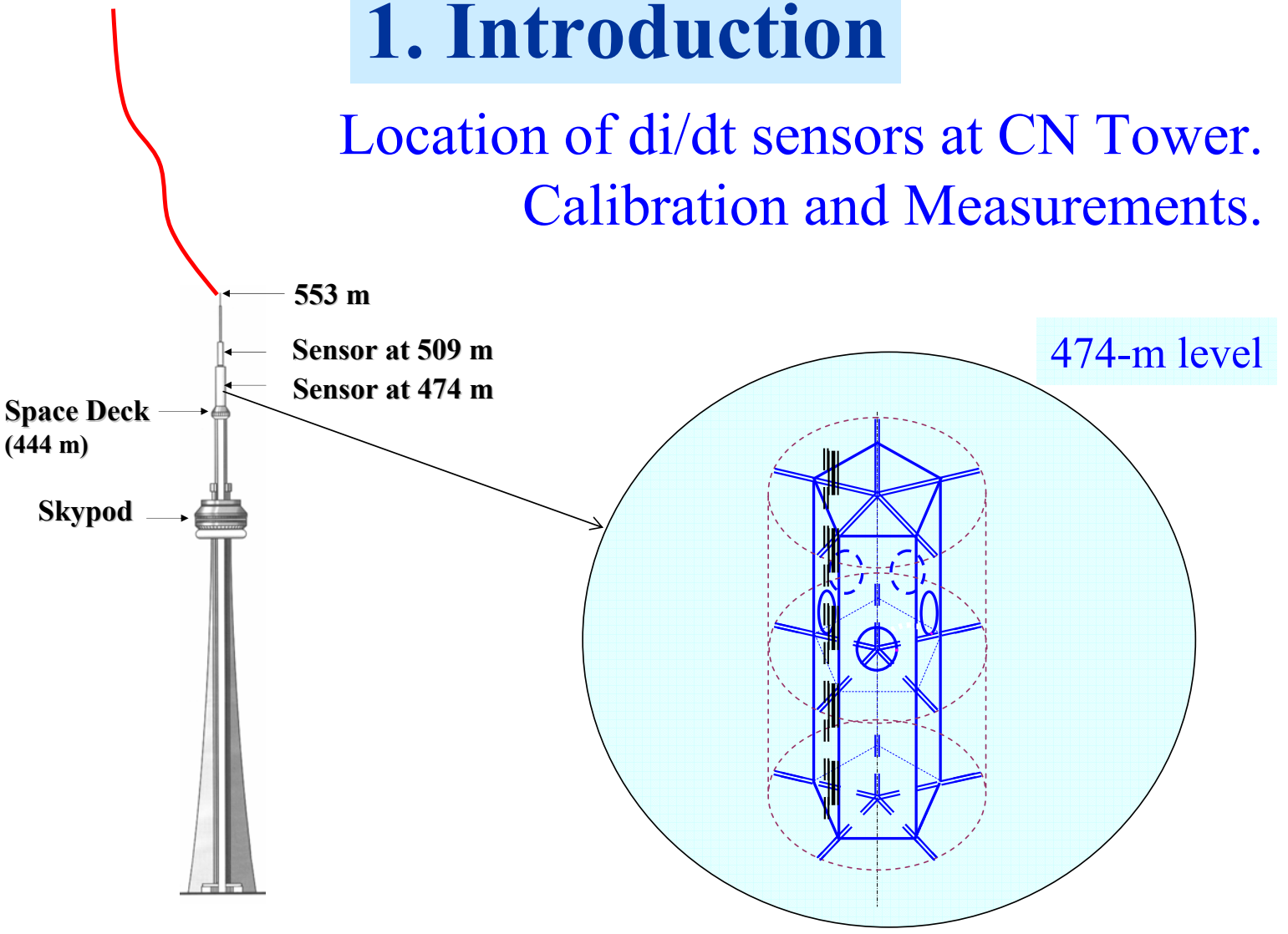
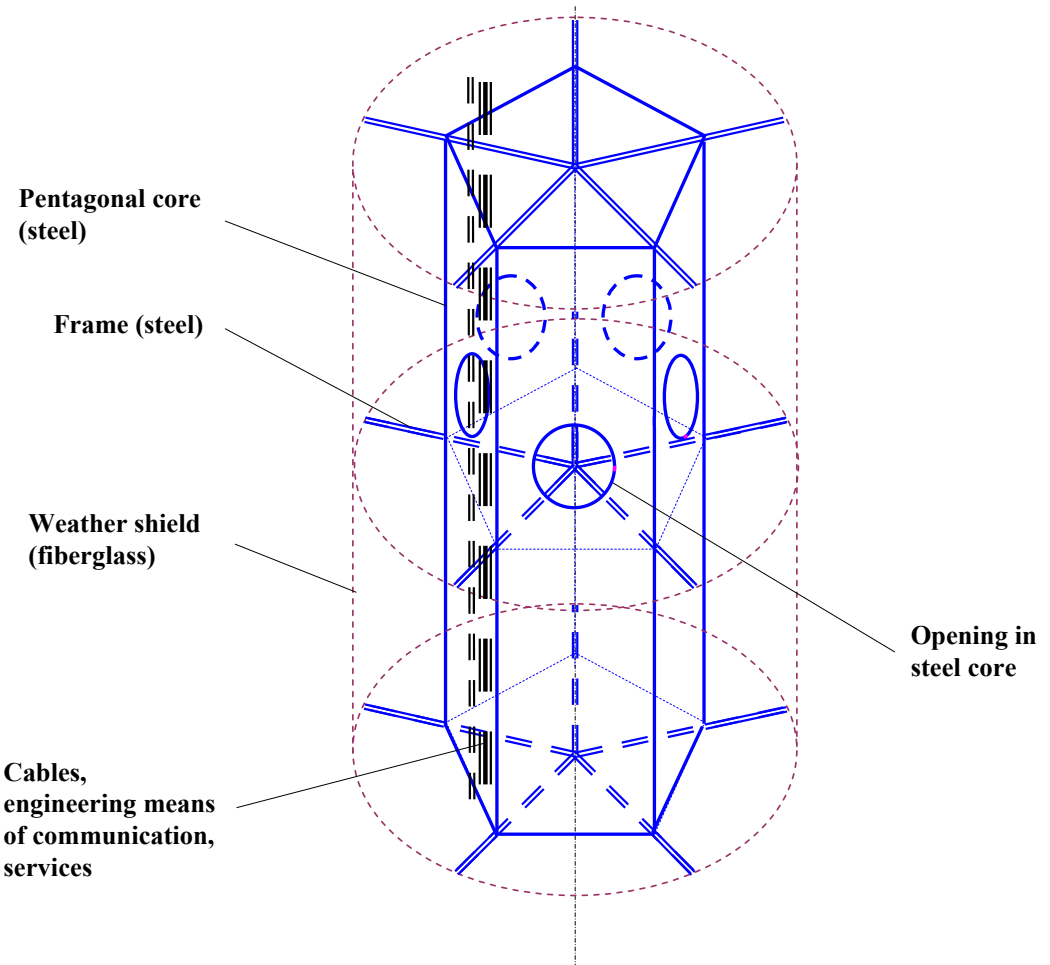
1. Introduction
2. CN Tower structure at 474-m level
3. Rogowski Coil installation. Calibration
4. Coil calibration of $(1/5)^{th}$ current
5. Estimations of test circuit characteristics
6. Some previously used approaches to I and dI/dt measurements at towers
7. Concluding remarks and discussion

1. Introduction

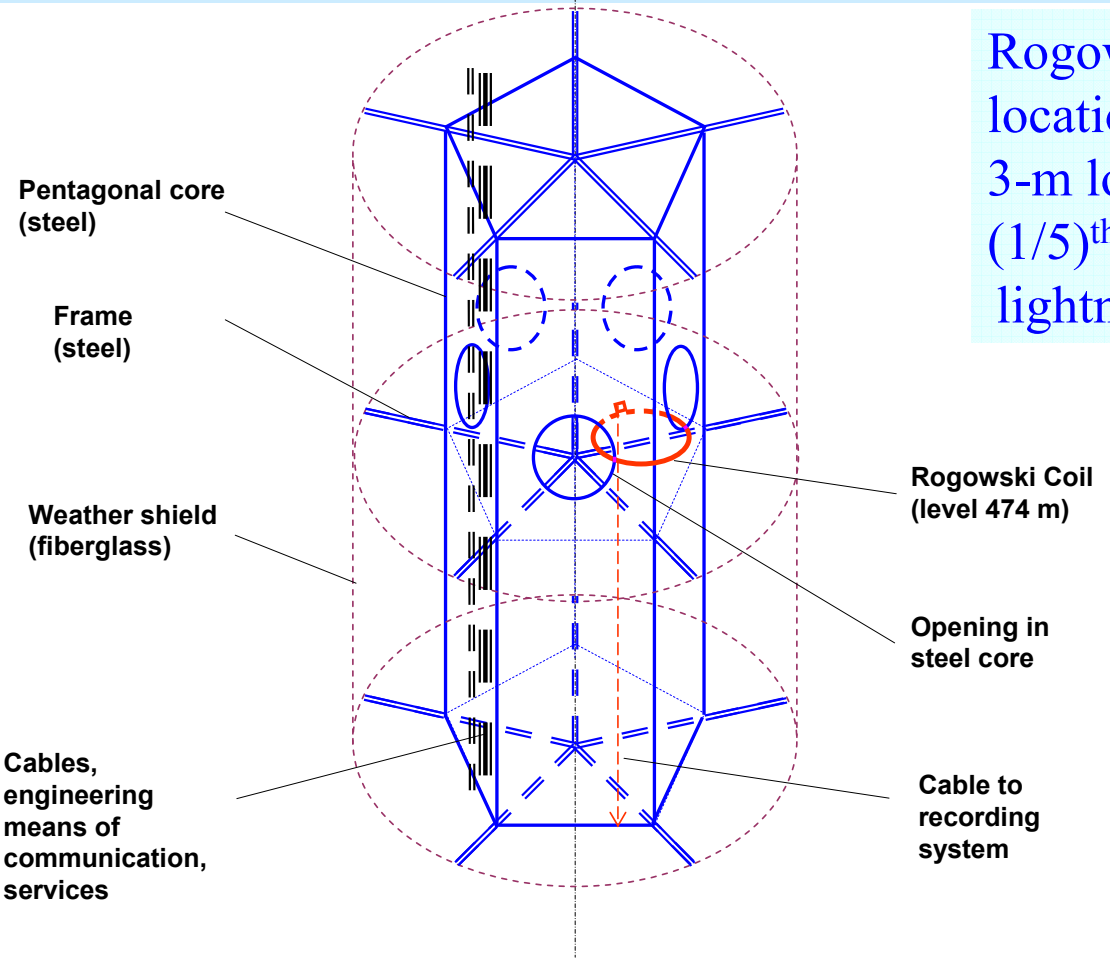
Location of di/dt sensors at CN Tower.
Calibration and Measurements.



2. Tower structure at the 474-m level

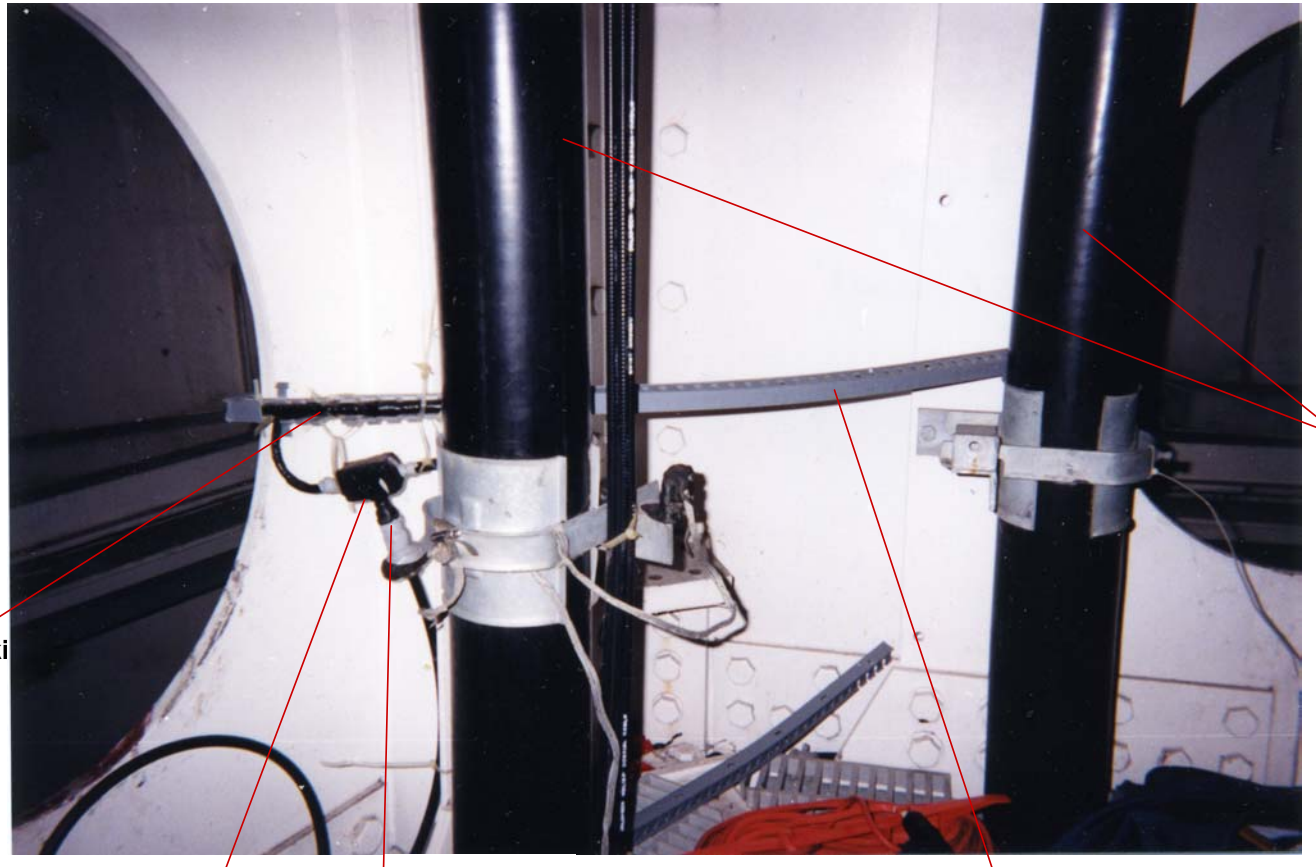


3. Rogowski Coil installation at the 474-m level. Calibration

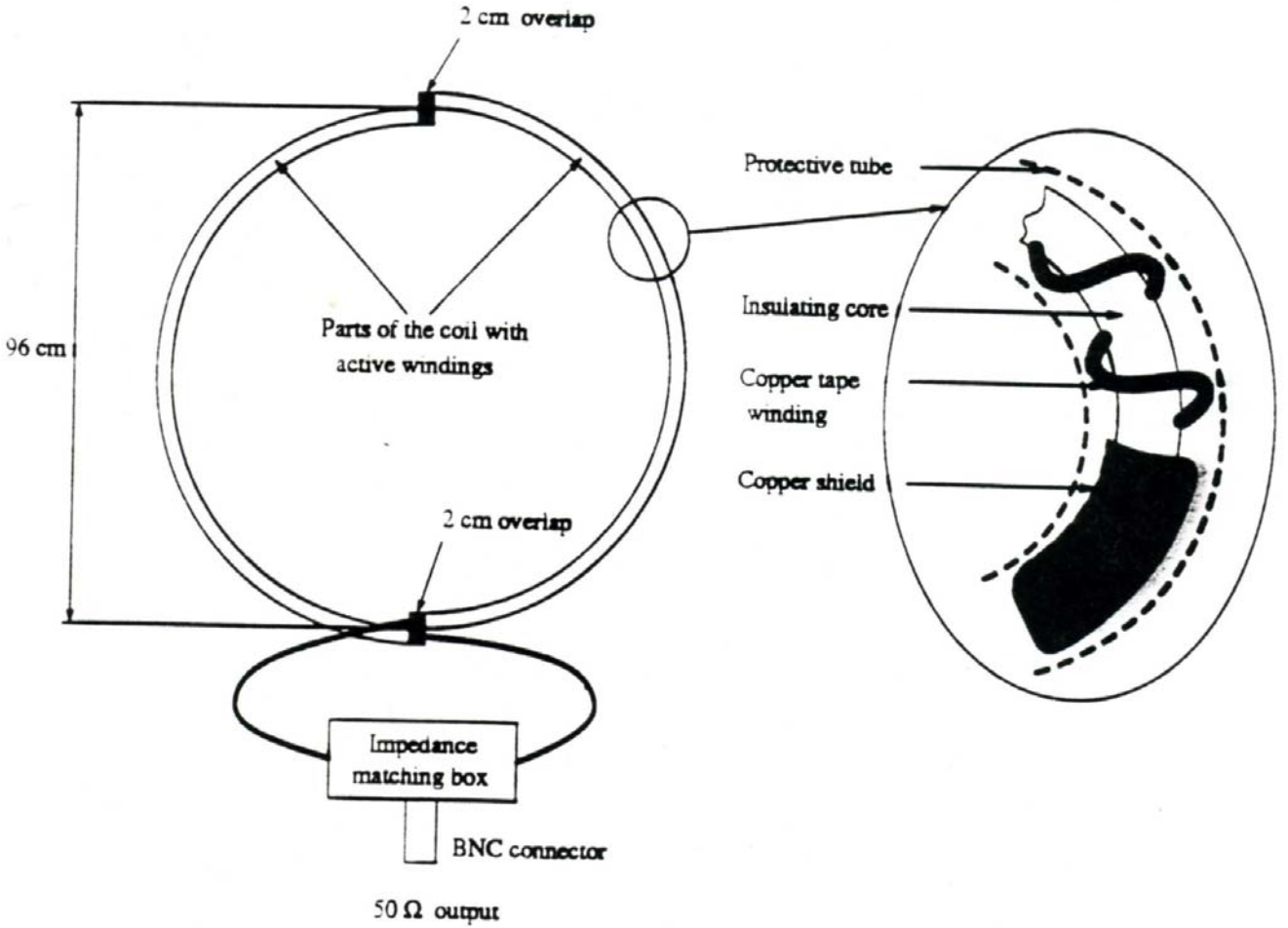


Rogowski Coil location.
3-m long.
$(1/5)^{th}$ of total lightning current

Placement of Rogowski Coil at the 474-m level (view from inside of the pentagonal core)



Details of Rogowski Coil installed at 474-m level of CNT



Circuit for Rogowski Coil sensitivity calibration

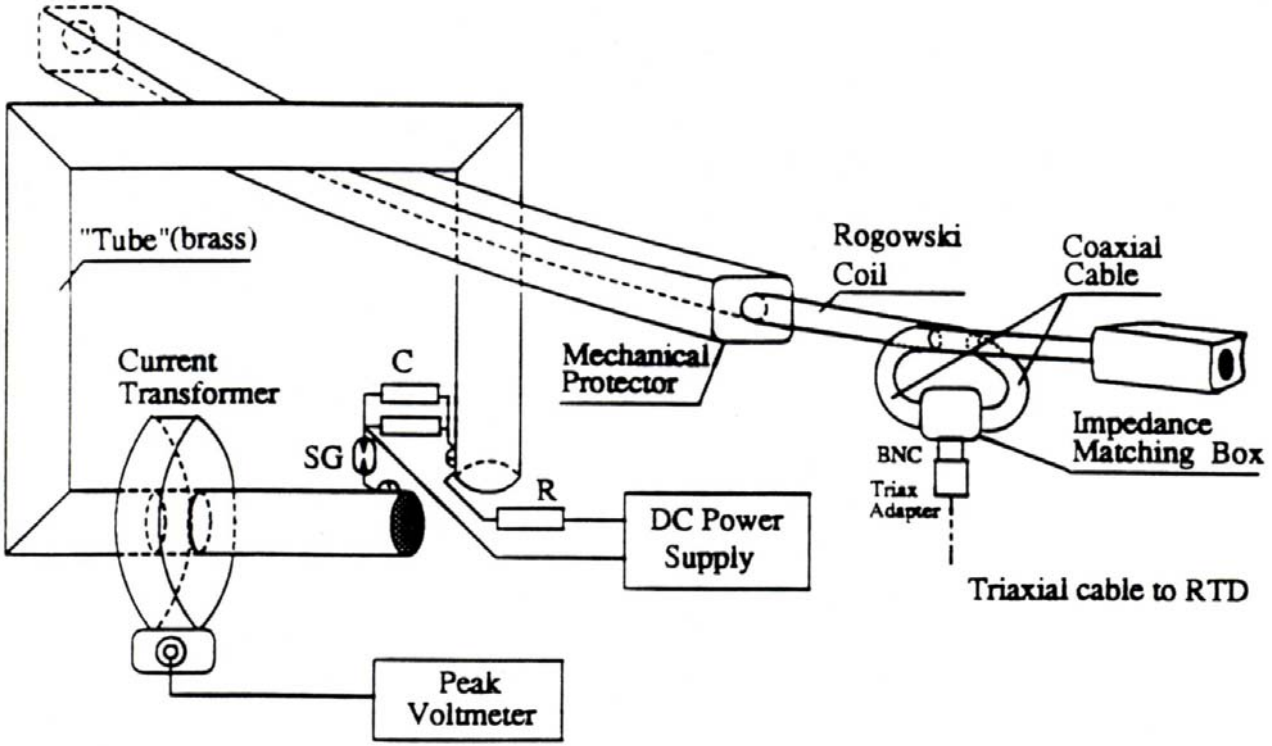
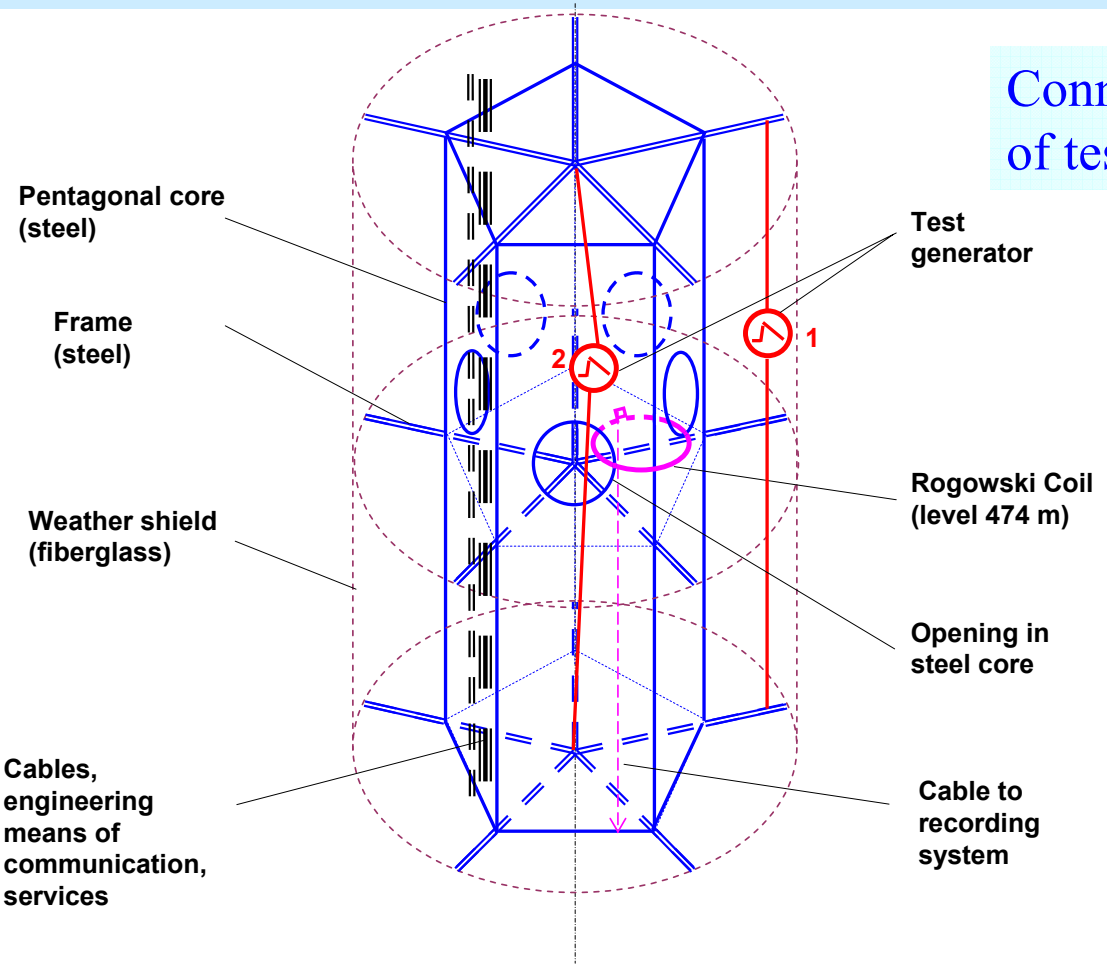


Figure 6: Calibration circuit.

4. Coil calibration of (1/5)th current

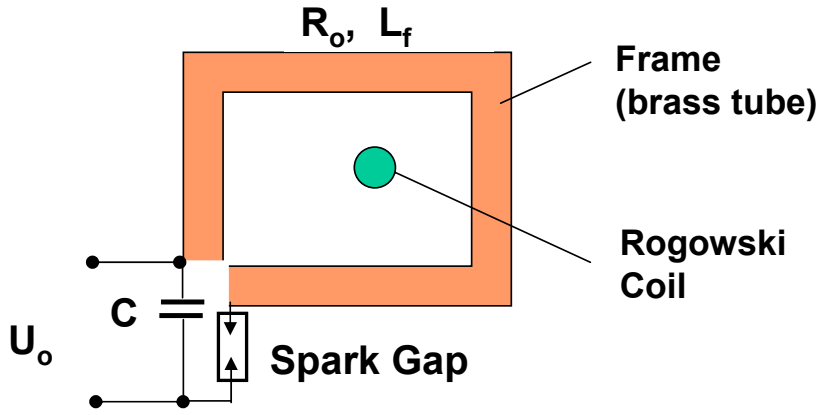
Connection of test generator

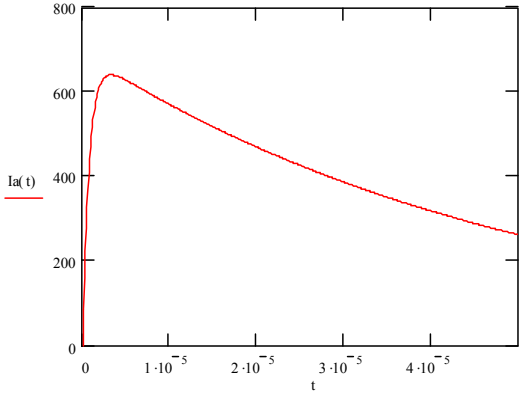


5. Some estimations of test circuit characteristics for calibrations of:

- Coil sensitivity and
- $(1/5)^{th}$ current portion

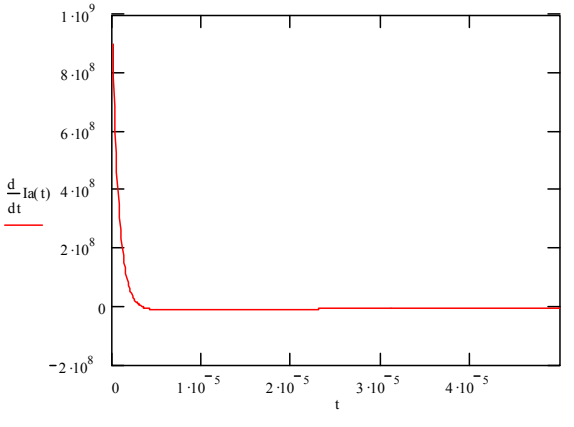
5.1. Rogowski Coil calibration using small frame



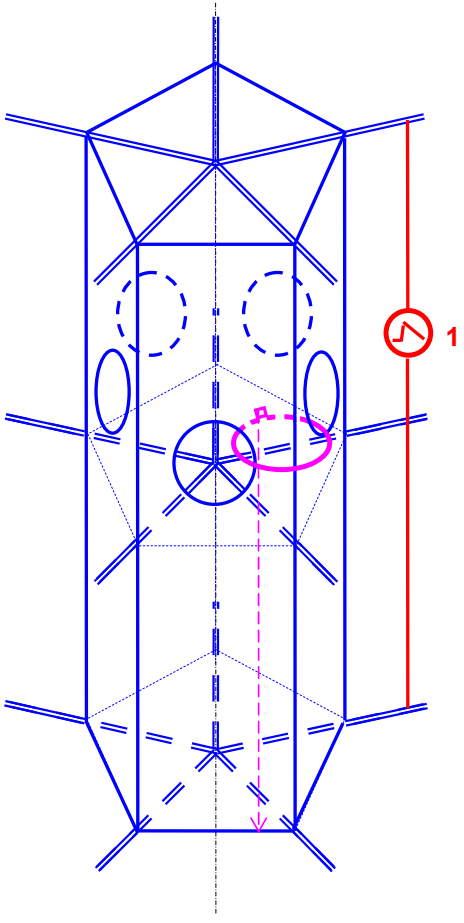


C=100 ❍ F, Uo = 350 V, L_f = 0.39 ❍H
Imax = 640 A
$(dI/dt)_{max}$ = 0.9 kA/ms
(0.84 kA/ms – in tests).

Larger (dI/dt), closer to lightning parameters, can be achieved using HV generators (tests could be done in the lab)



5.2. Calibration of 1/5th current portion (RLC-case)



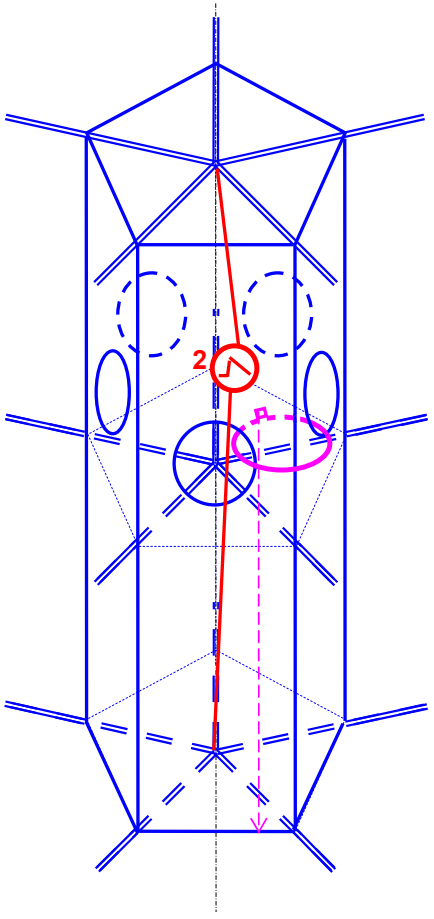
5.2.1. Wire (cable) and generator - outside of the pentagonal structure

U_o = 350 V,
10-m cable, r =0.005 m
Ls = L_{wire} + L_{core} = 16 ❍H
$\eta_o = 0.5R_o(C/L_s)^{0.5}$

C, ❍F	η_o	Mode	I_{max}, A	$(dI/dt)_{max}$, kA/❍s
300	**1.132**	**Damped**	**514**	**0.022**
234	**1**	**Critical**	**494**	**0.022**
100	**0.653**	**Oscillating**	**450**	**0.022**

Res: Larger (dI/dt) requires HV generators

5.2. Calibration of 1/5th current portion (RLC-case) – contd.



5.2.2. Wire (cable) and generator - inside of the pentagonal structure

U_o = 350 V,
6-m cable, r =0.005 m
L_{coax} = 6.3 ❍H; L_{core} = 1.295 ❍H (< 16 ❍H)
$\eta_o = 0.5R_o(C/L_s)^{0.5}$

C, ❍F	η_o	Mode	I_{max}, A	$(dI/dt)_{max}$, kA/❍s
200	**1.467**	**Damped**	**551**	**0.056**
5000	**16.18**	**Damped**	**668**	**0.056**

Res: **$(dI/dt)_{max}$ are increased by 2.5x against "outside" case.**

Larger (dI/dt) requires HV generators

6. Some previously used approaches to lightning I and dI/dt measurements at towers

Coil installation during early studies at CNT [by Podgorski et al.,1986]

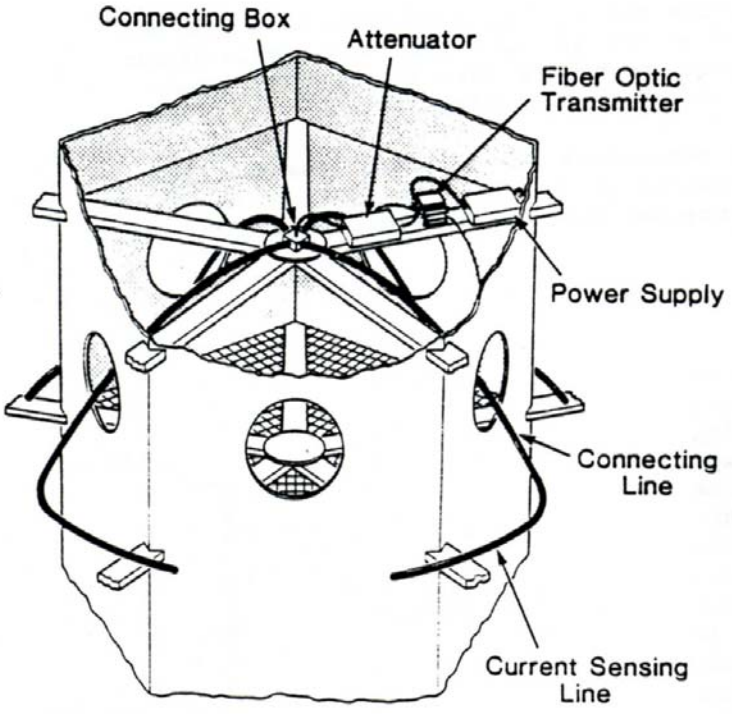


Fig. 2 View of the upper coil installation.

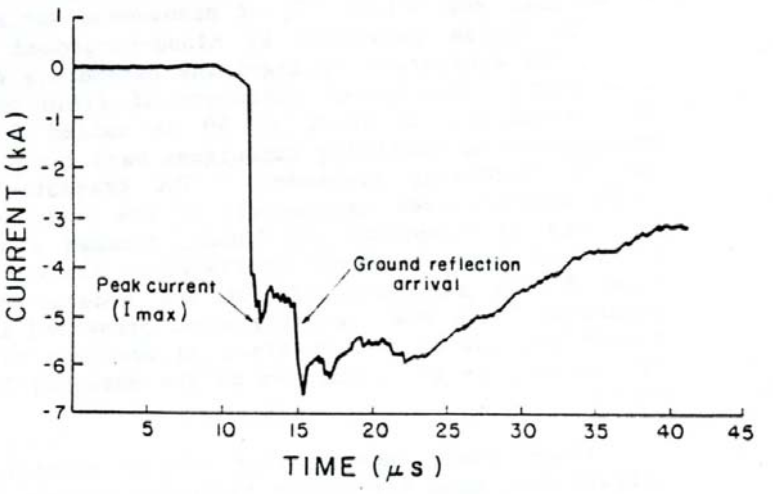


Fig. 4 The signature of a typical lightning stroke measured on the 553 m tall CN Tower. The sensing coil was located at the height of 473 m.

R: **Need to surround also engineering lines of CNT**

Lightning current waveform recorded at CNT

[Podgorski et al.]

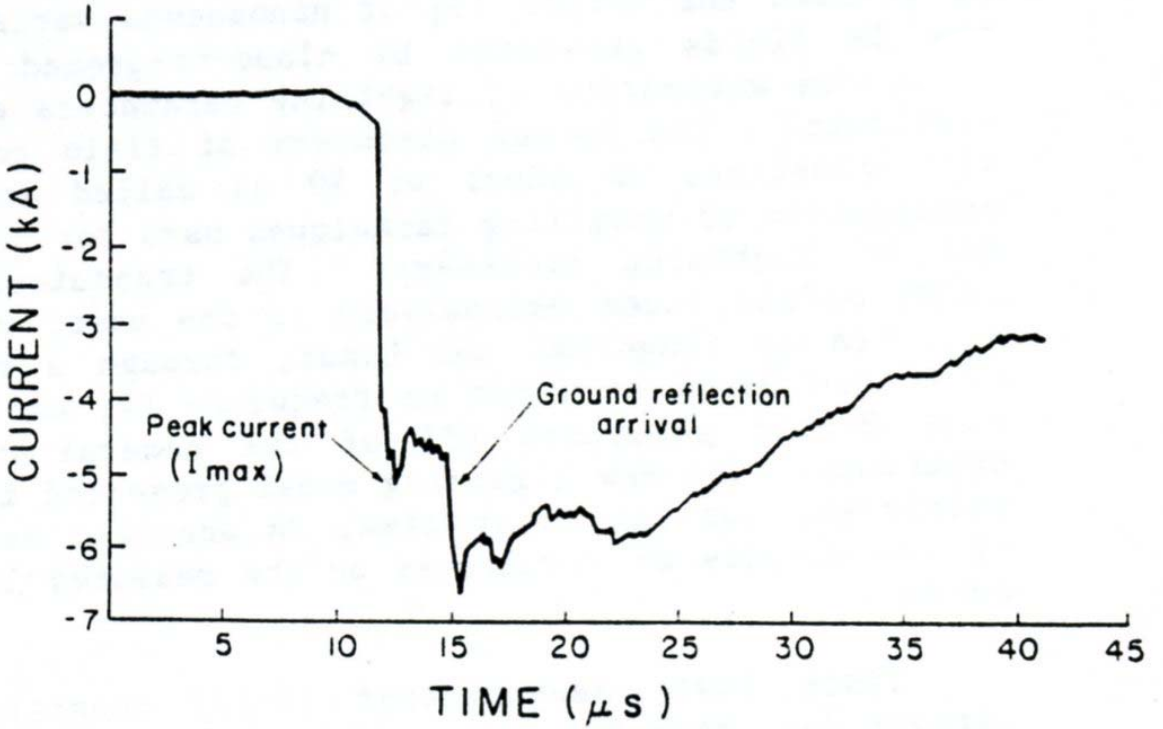


Fig. 4 The signature of a typical lightning stroke measured on the 553 m tall CN Tower. The sensing coil was located at the height of 473 m.

I & dI/dt measurement system at Swiss PPT telecommunication tower (St. Chrischona, 248 m) [Montandon et al.]

175-m

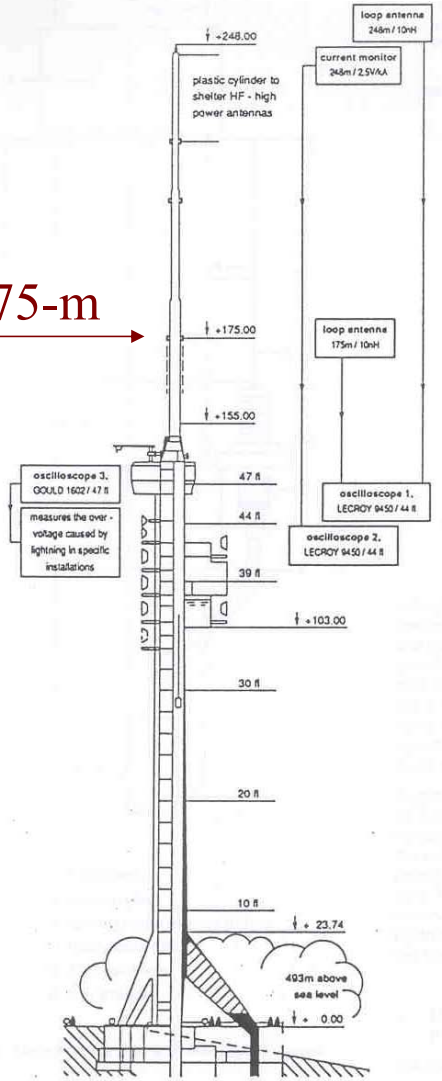
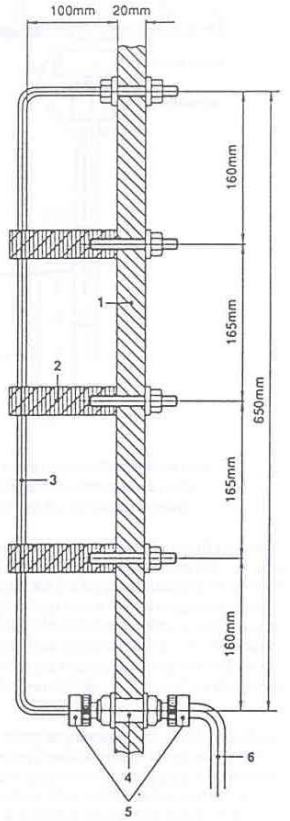


Fig. 1: Positions of the lightning measuring equipment in the tower "St. Chrischona" (all levels are given in m)



1) wall thickness of the steel mast (diameter = 2,6m)
2) plastic support
3) Cu Ø6mm
4) coax feed - through connector
5) special BNC Adapter
6) 200Ω cable

Fig. 2: Loop antenna (10nH) at 175m above ground

Loop antenna at 175-m level (dI/dt-sensor)

Partly external sensor.
Portion of the lightning current, going through the tower's body in place where the loop is arranged, is influencing the accuracy of measurements

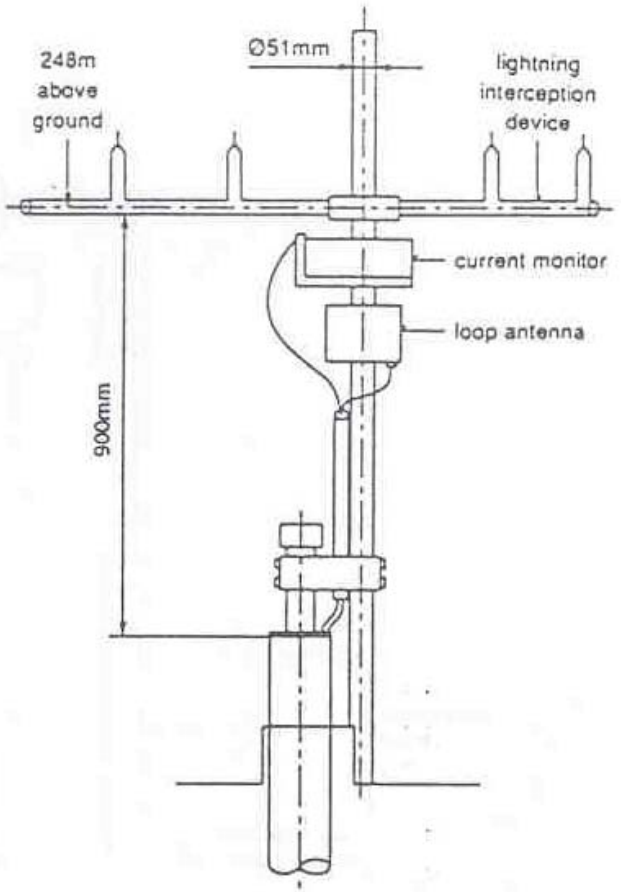


Fig. 4: Lightning interception device and current measuring probes at the top of the St. Chrischona tower.

I & dI/dt measurement system at Swiss PPT telecommunication tower (St. Chrischona, 248 m) [Montandon et al.]

Probes a the top (248-m level)

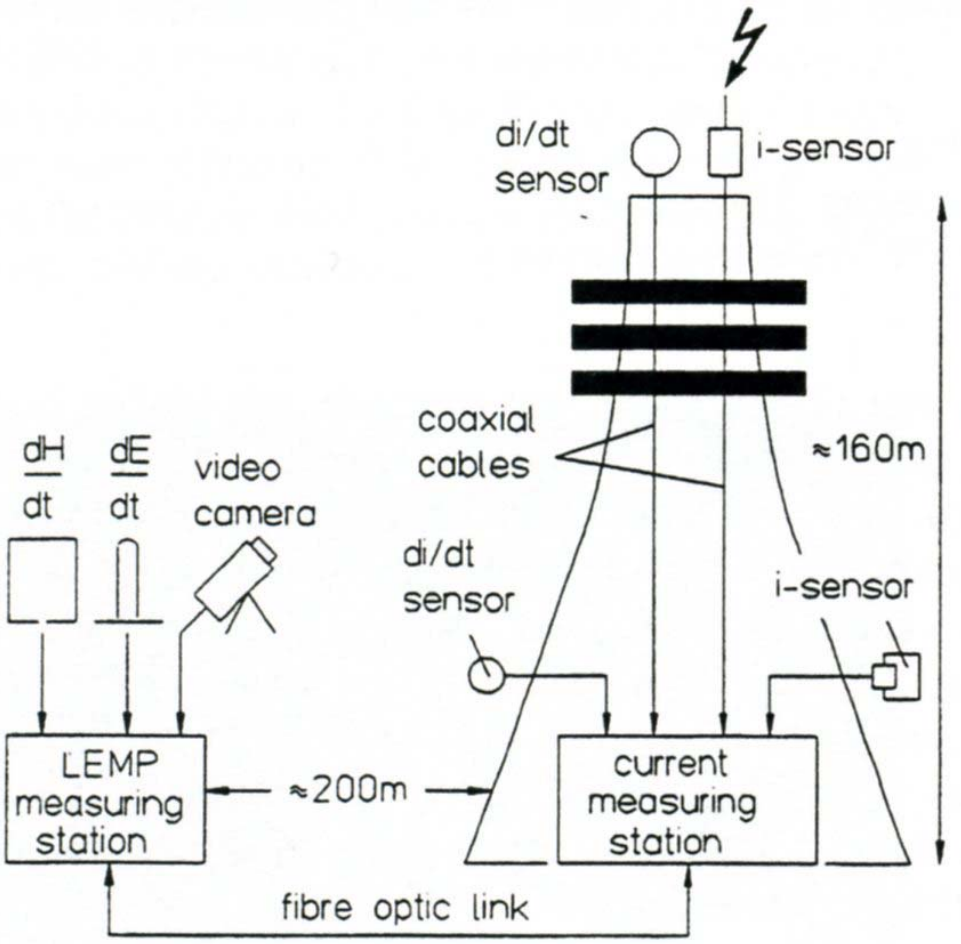


Fig. 2: Block diagram of the current and LEMI measuring station at the Peissenberg tower

Lightning parameters measurement system at Peissenberg Tower [Fuchs, Hopf, Heidler et al.]

I- and dI/dt-sensors, both at the top and base of the tower. Height. Complex structure. External sensors.

I and dI/dt measurement system at Peissenberg Tower [Fuchs, Hopf, Heidler et al.]

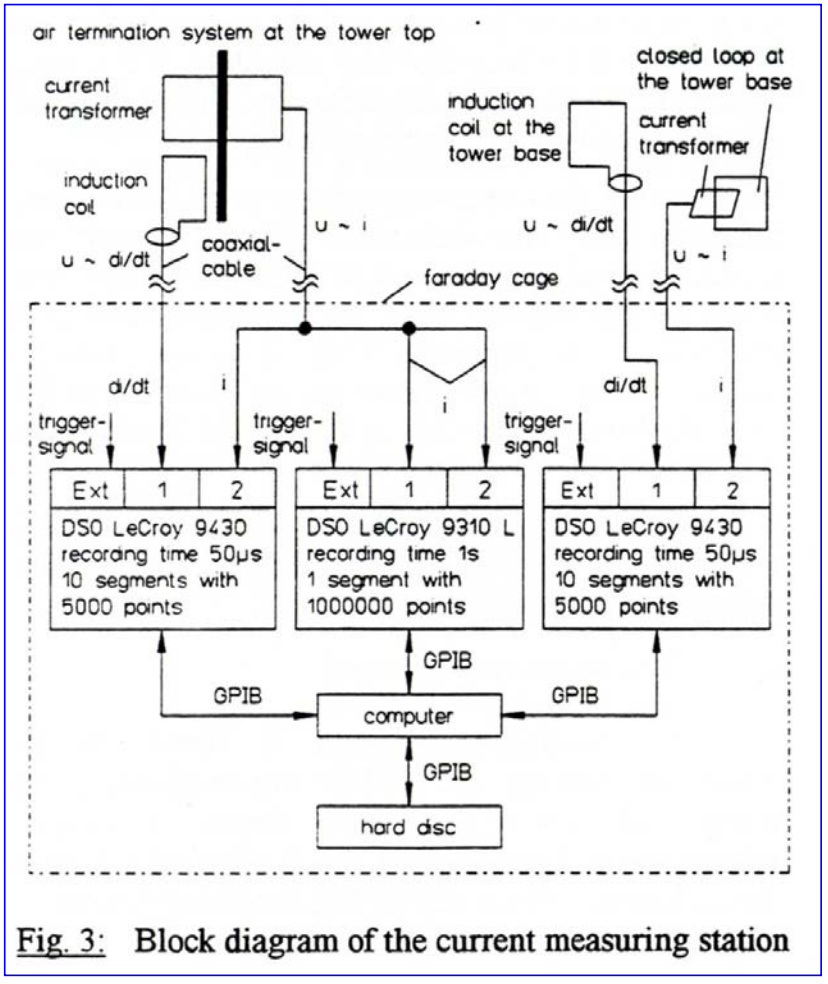


Fig. 3: Block diagram of the current measuring station

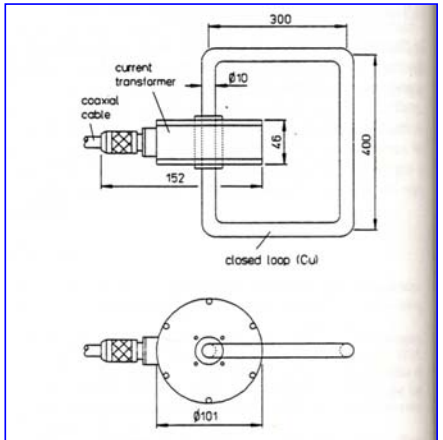


Fig. 4: Principle of the i sensor installed at the tower base

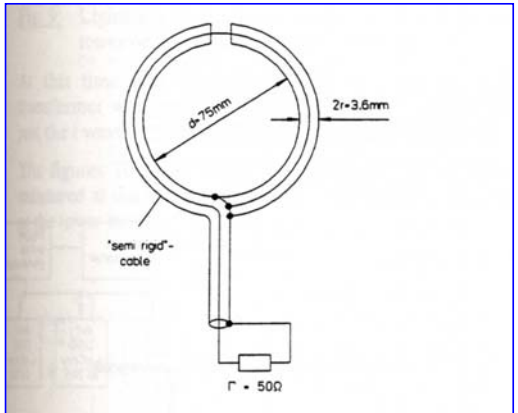


Fig. 5: Principle of the di/dt sensor installed at the tower base

7. Concluding remarks and discussion

- Possibilities of placing test generator inside and outside tower core for "1/5th"-calibration. "Inside" case seems better.
- Need in inspection of CNT structure outside the metallic pentagonal core.
- For larger dI/dt test signals, HV generators (3.5-5-15 kV) could be used.
- Periodical tests, information on tower installation changes.
- Other reasons of inaccuracy (channel inclination [Petrache et al.], skin effects, continuous currents, etc.).
- Other types of sensors (external installation), like those used in Switzerland, Germany, Brazil.
- Optimal heights of sensors' locations for specific towers' structures.