European Electromagnetic Launch Society
12th Topical Meeting
10th to 12th September 2001, Ayr

ZnO-Arresters for Overvoltage Protection in Pulsed Power Circuits

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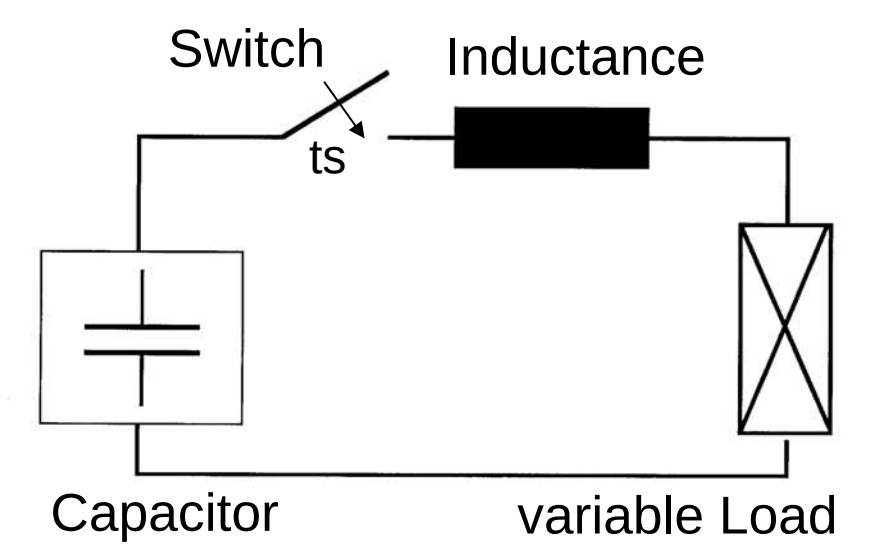
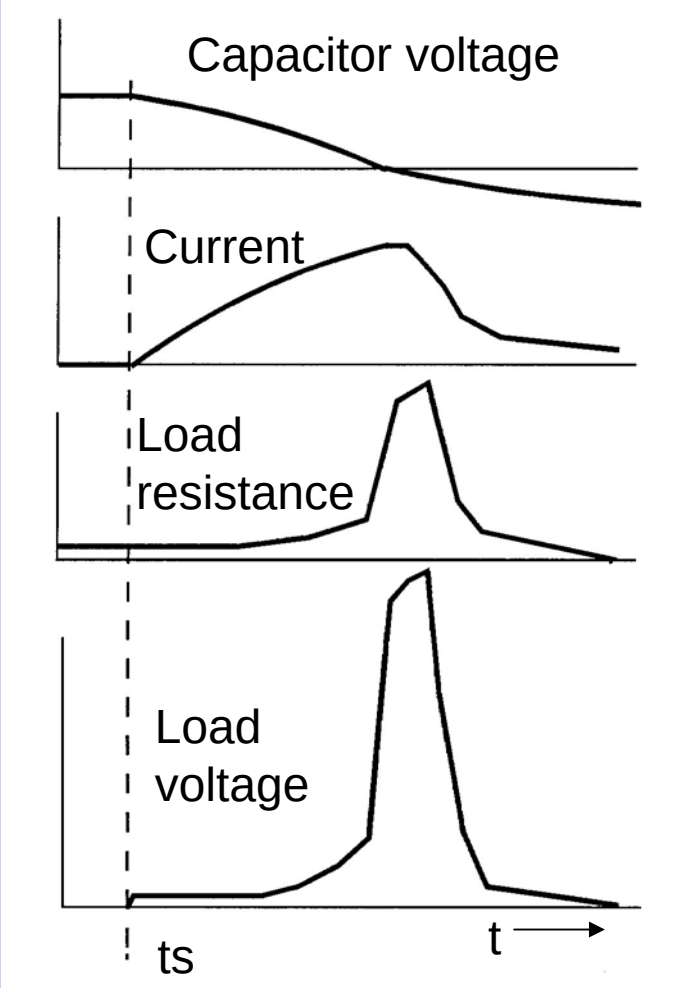
ZnO-Arresters for Overvoltage Protection in Pulsed Power Circuits

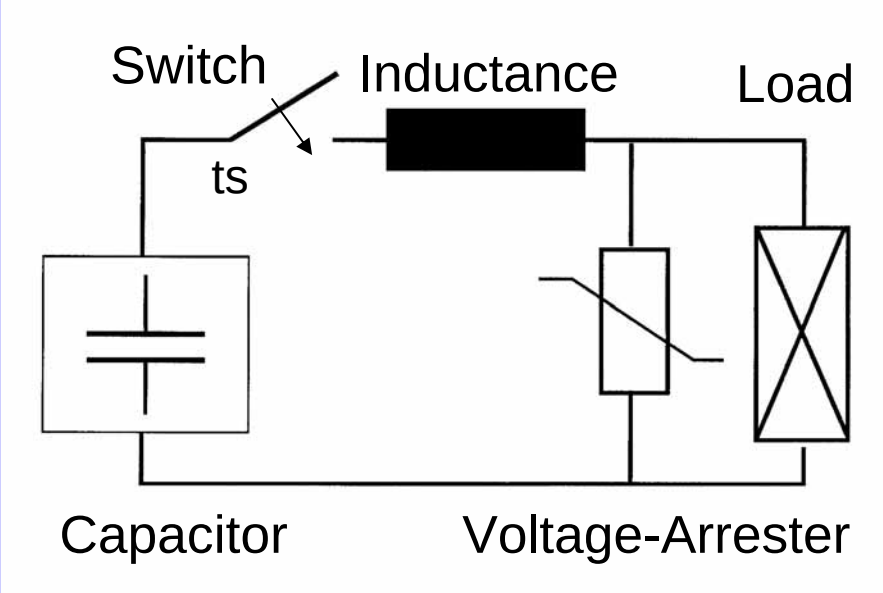
1. Introduction (1)

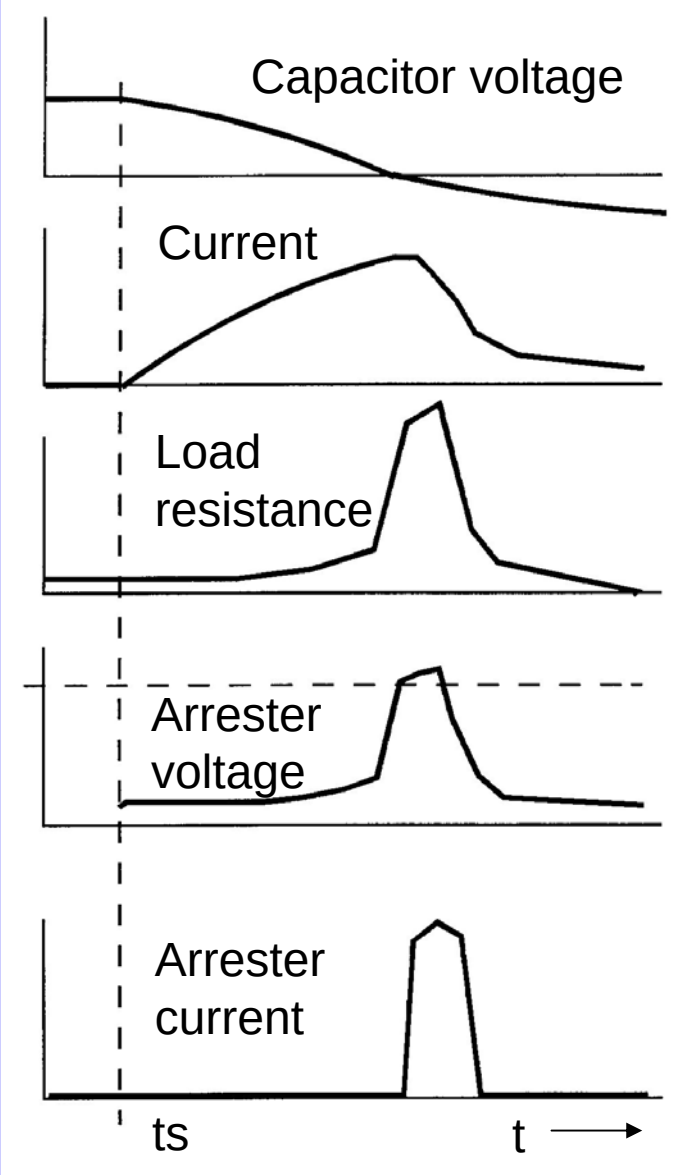




Overvoltage generation in
a pulsed power circuit

1. Introduction (2)



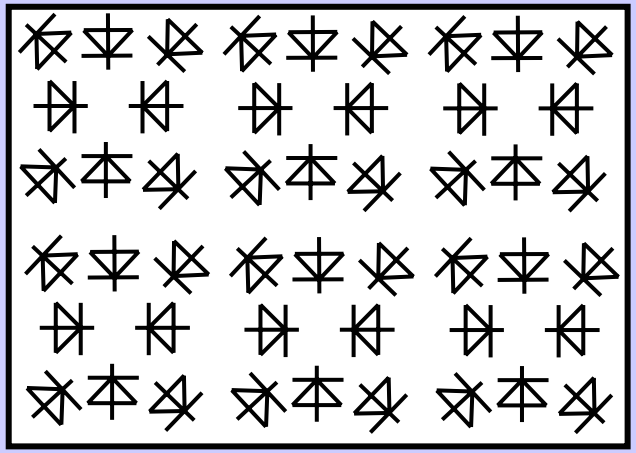


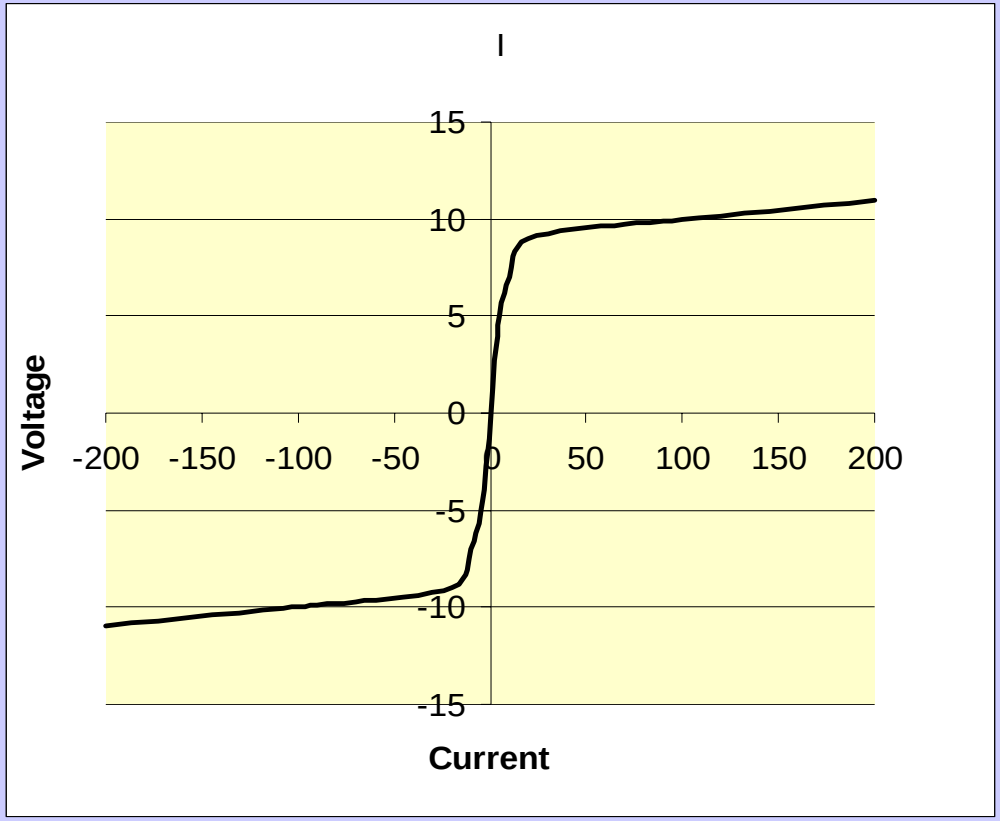
Overvoltage protection in
a pulsed power circuit

2. Properties of ZnO-varistors (1)

ZnO-varistor-disk, $U_{(10\ kA)}$ = 6 kV

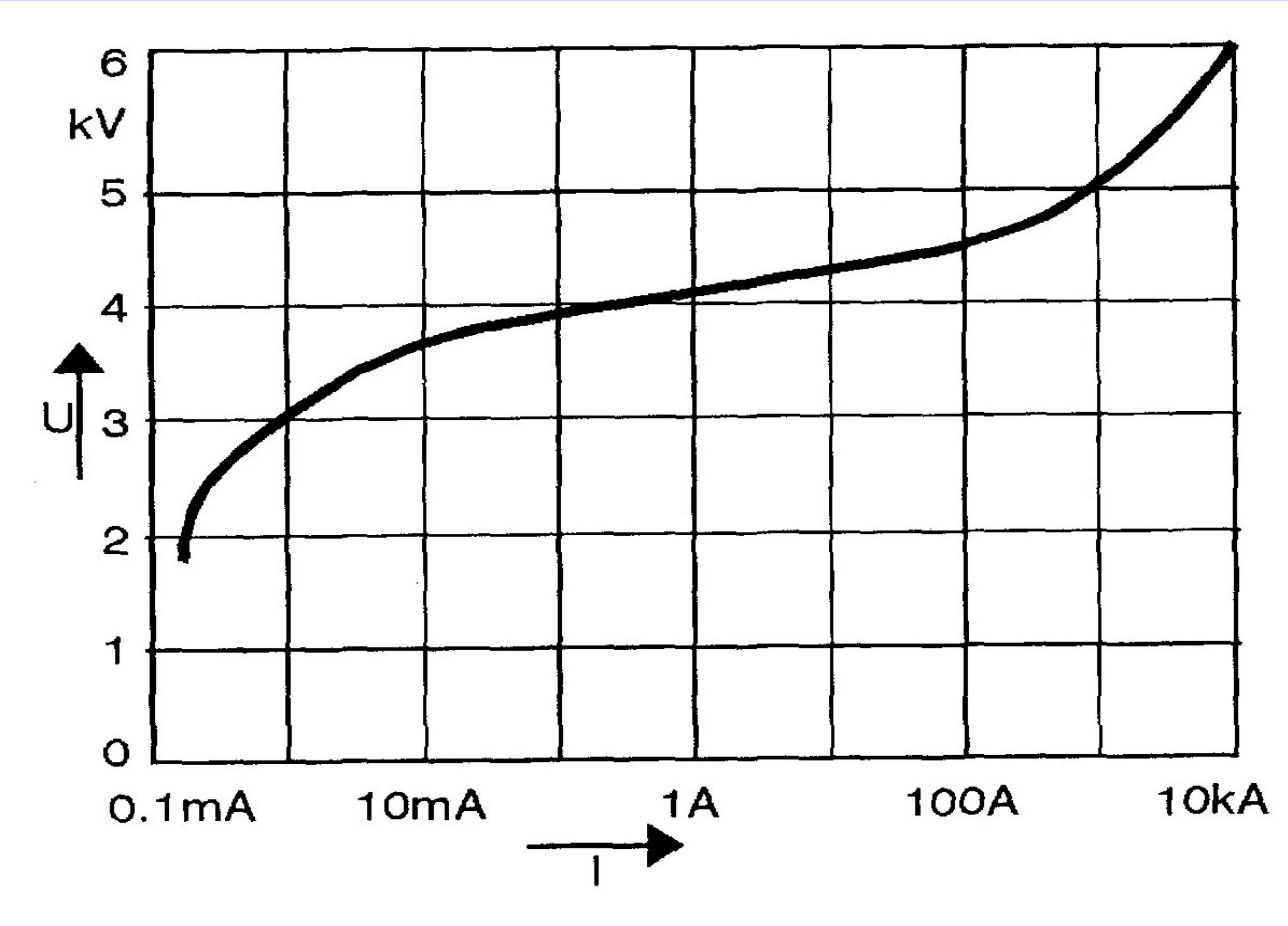
2. Properties of ZnO-varistors (2)





Double-diode-characteristic of the ZnO-varistor

2. Properties of ZnO-varistors (3)



Current-voltage-characteristic of one varistor-disk,
$U_{(10\ kA)}$ = 6 kV

2. Properties of ZnO-varistors (4)

High	**21 mm**
Diameter	**76 mm**
Disk volume	**95 cm³**
Specific mass	**5.5 g/cm³**
Thermal capacity	**2.75 J/(cm³ * K)**
Energy for 1 K temperature rise	**261 J**
Nominal temperature rise	**170 K**
Energy absorption	**44.3 kJ**

Physical properties of one varistor-disk, $U_{(10\ kA)}$ = 6 kV

3. Design criteria for ZnO-arresters (1)

Voltage-limiting-level

- determines the number (nS) of varistors to be connected in series

Maximum current

- determines the number (nP) of varistors or varistor columns to be connected in parallel

3. Design criteria for ZnO-arresters (2)

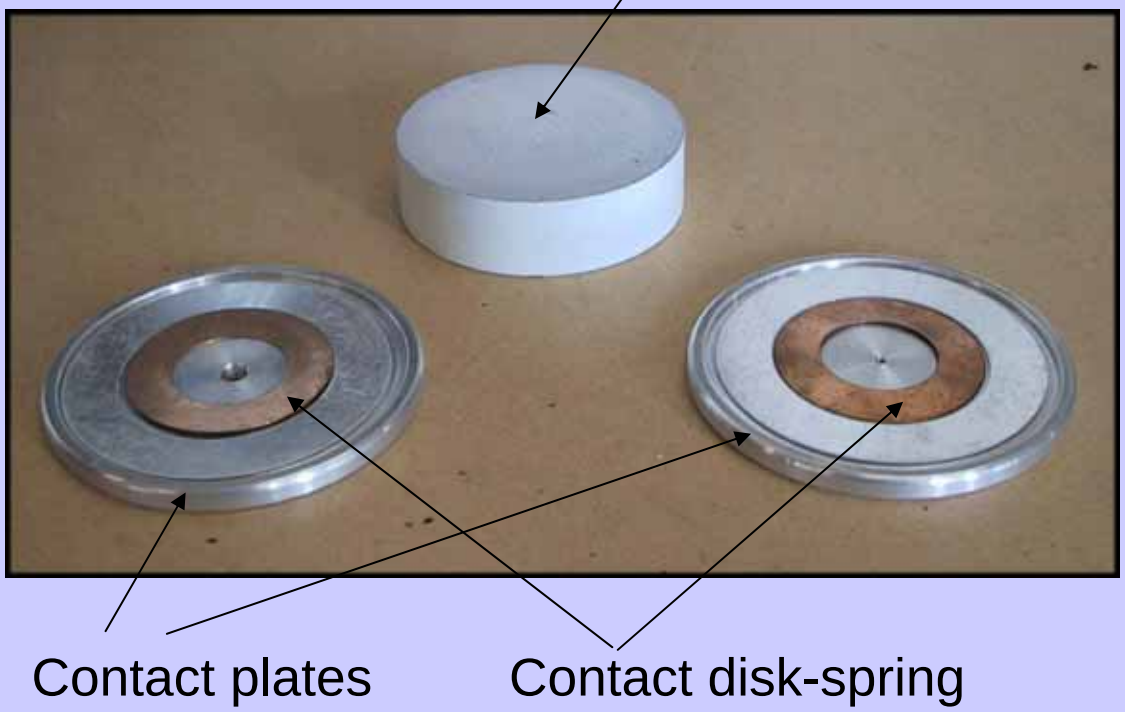
Energy to be absorbed in one pulse

- determines the total number of varistors needed for the Arrester (nW)

The number of disks necessary for an arrester is

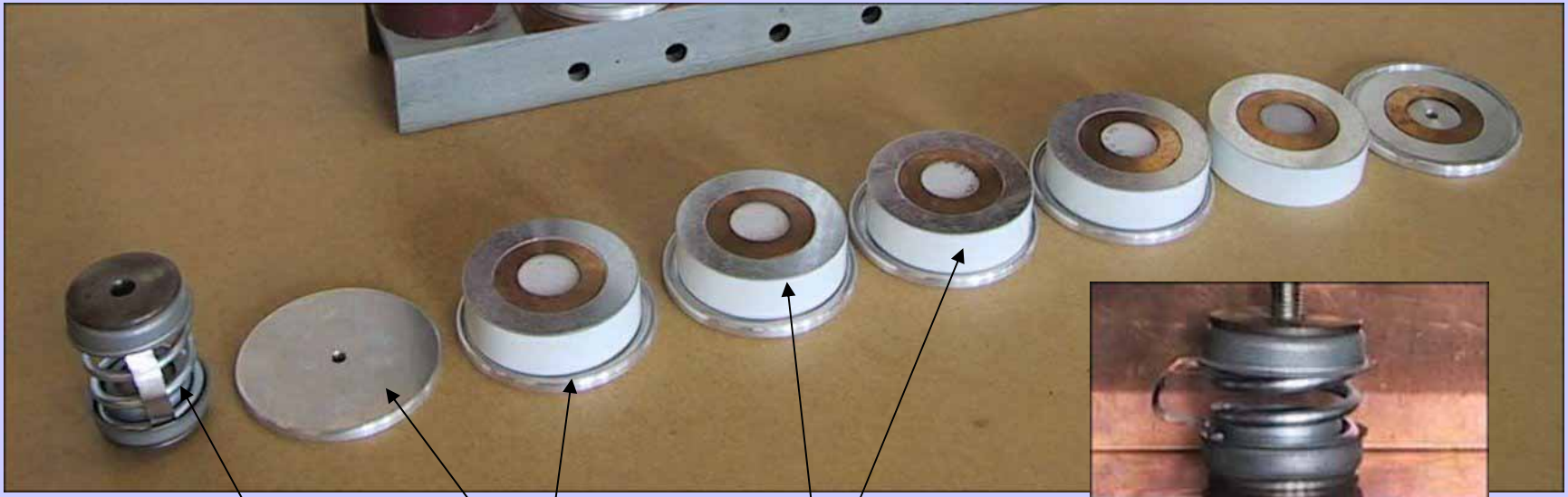
$$n_{(disk)} = MAX ((\ nS*nP) , nW\ )$$

4. Examples of ZnO-arresters (1)



Basic elements of a ZnO-arrester

4. Examples of ZnO-arrestors (2)



Varistor disks

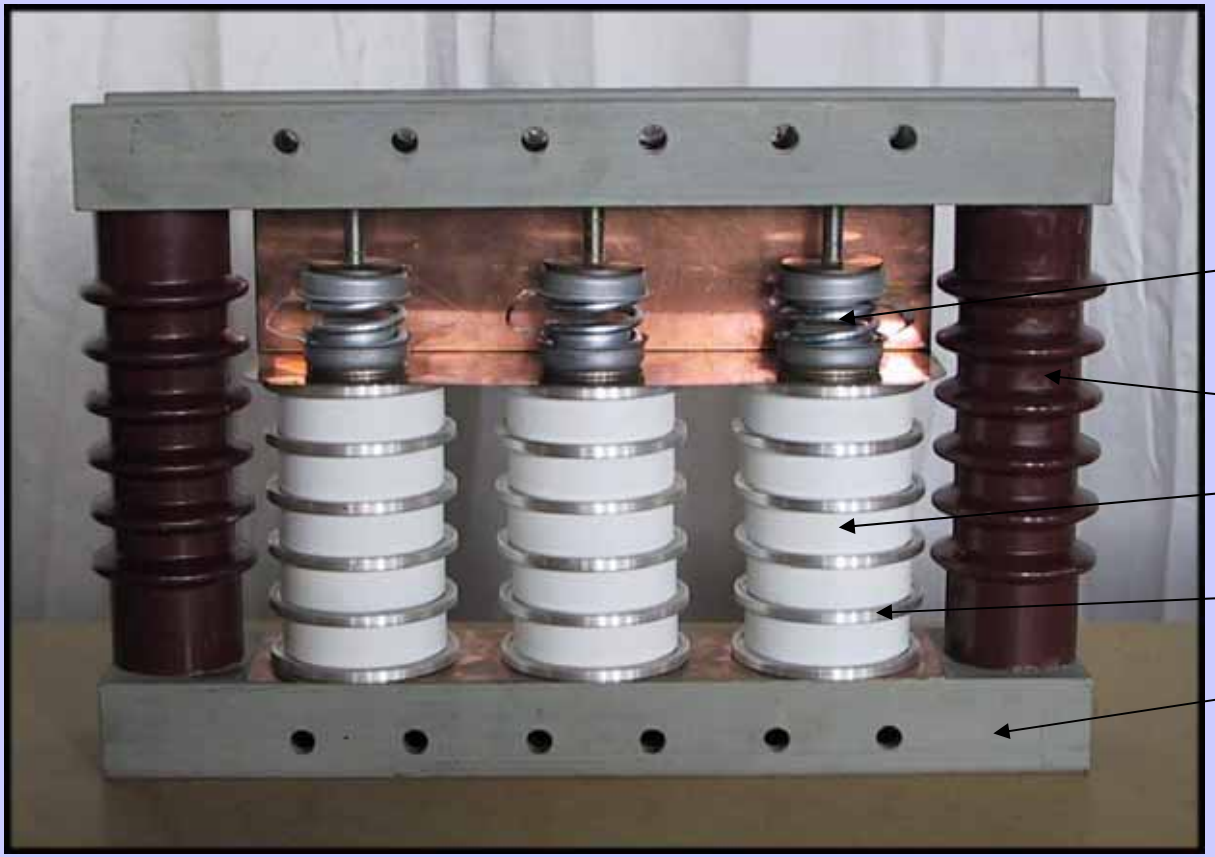
Contact plates

Contact pressure screw spring

Assembled varistor column

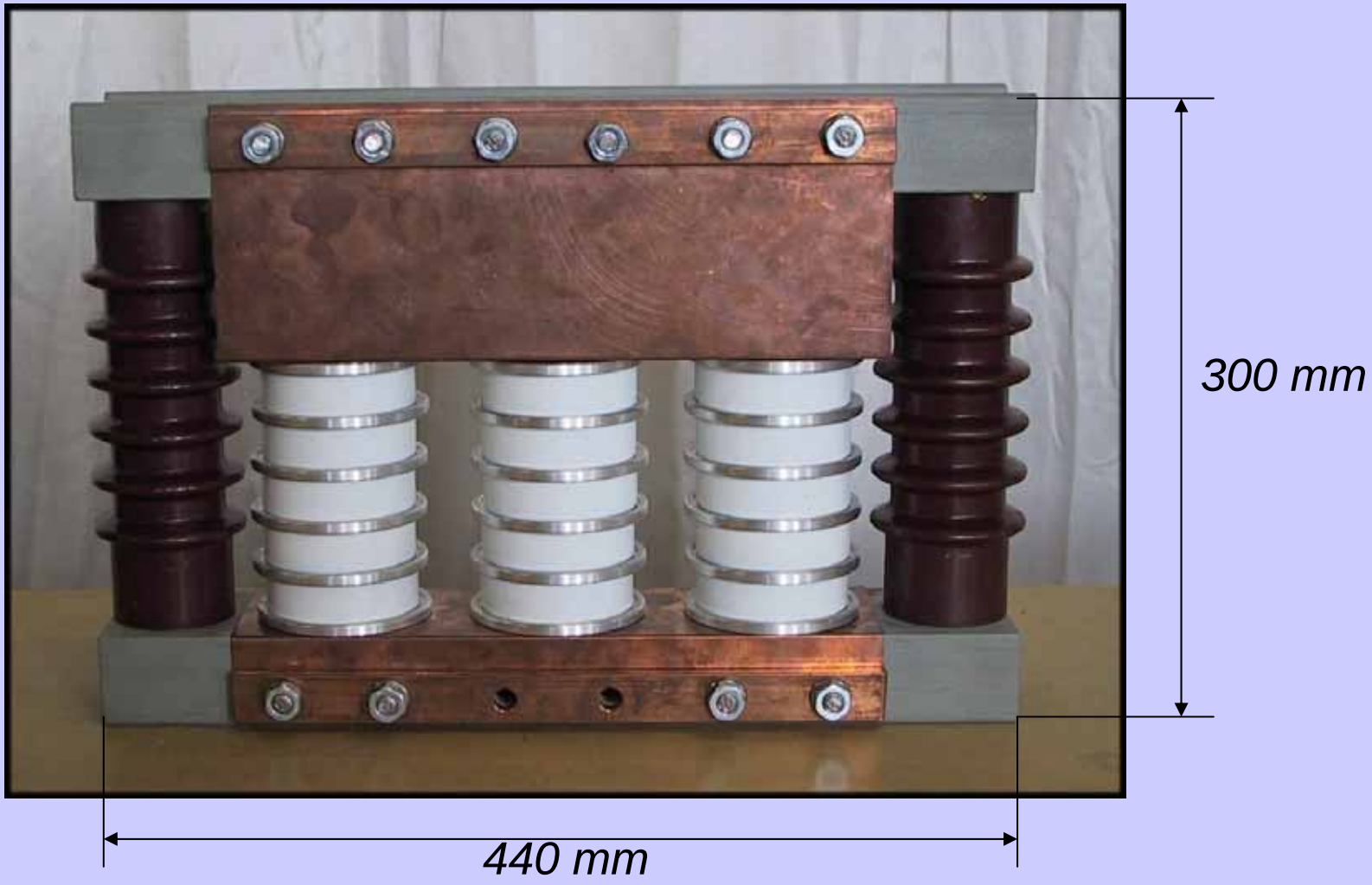
Parts of a varistor column

4.1. Arrester for 30 kV, 600 kJ (1)



Voltage arrester: Umax = 30 kV, Wmax = 600 kJ

4.1. Arrester for 30 kV, 600 kJ (2)



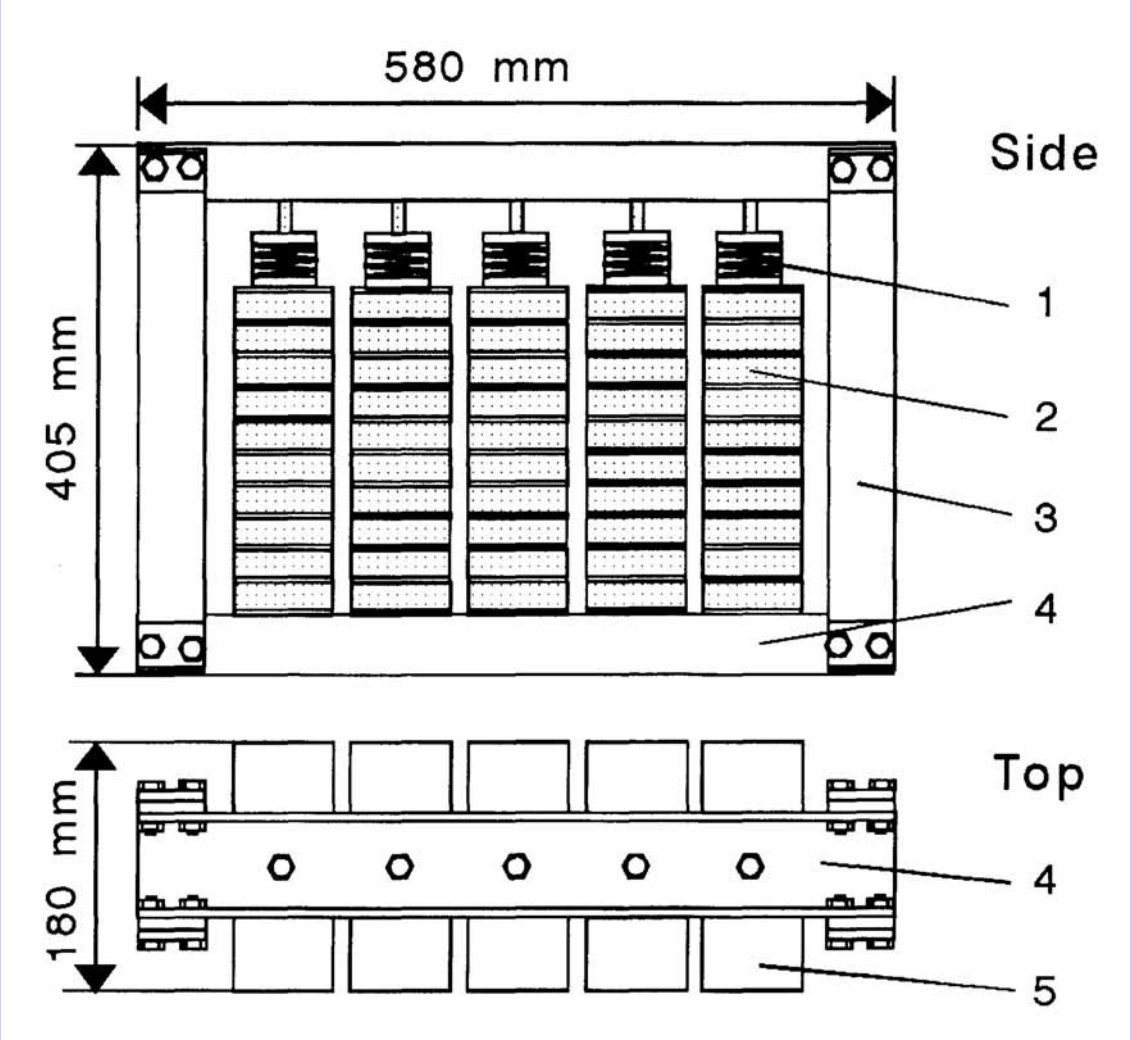
Voltage arrester: Umax = 30 kV, Wmax = 600 kJ

4.2. Arrester for 5 kV, 8 MJ (1)

$U_{(I=10kA)}$	I_{max}	W_{max}
6,250 V	188 A	37.4 kJ
6,230 V	199 A	39.5 kJ
6,210 V	218 A	43.3 kJ

Variation of current and absorbed energy in one varistor-disk during a nominal fault in an arrester-unit of 200 disks

4.2. Arrester for 5 kV, 8 MJ (2)



1 Screw spring

2 Varistor disk

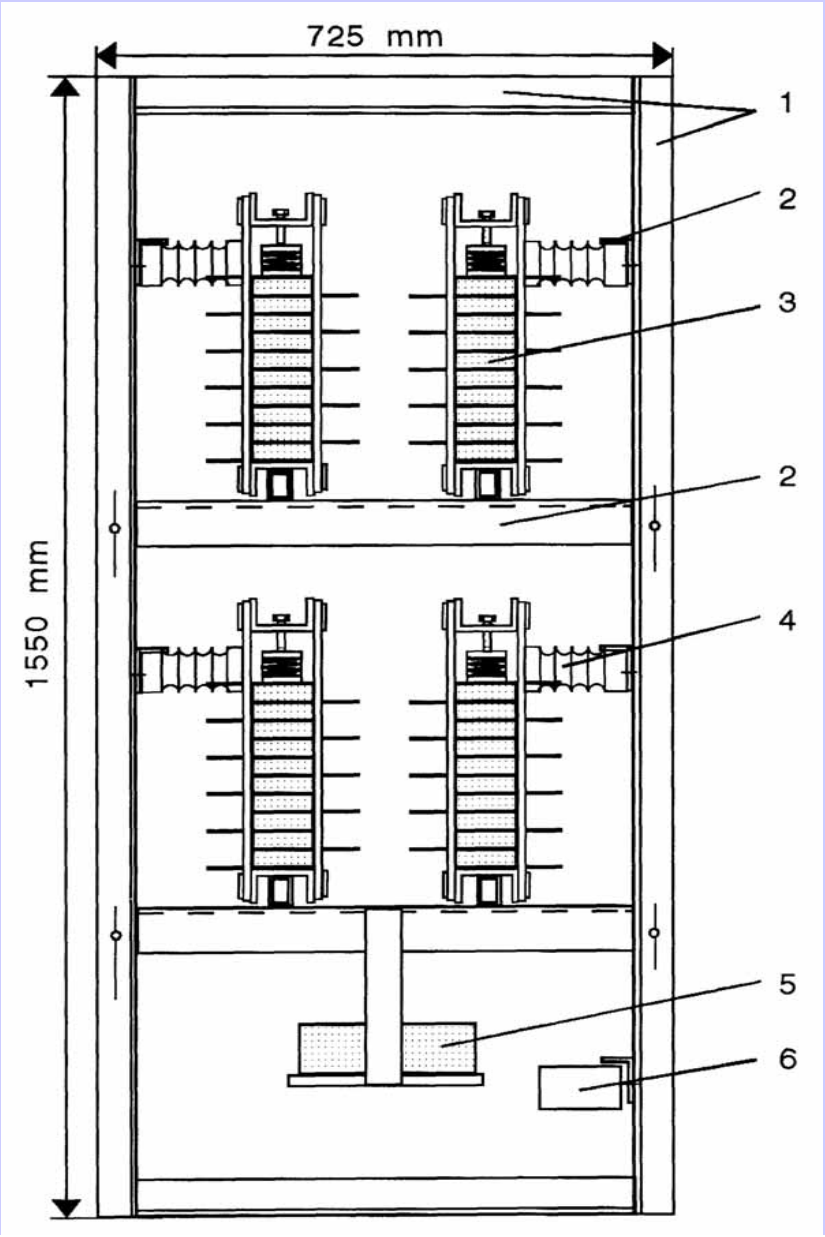
3 Insulating frame bar

4 U-steel frame

5 Connection plate

Sub-unit frame with 50 varistor disks

4.2. Arrester for 5 kV, 8 MJ (3)



1 Welded angle bar frame

2 Insulating angle bar supporter

3 Arrester sub-unit (front view)

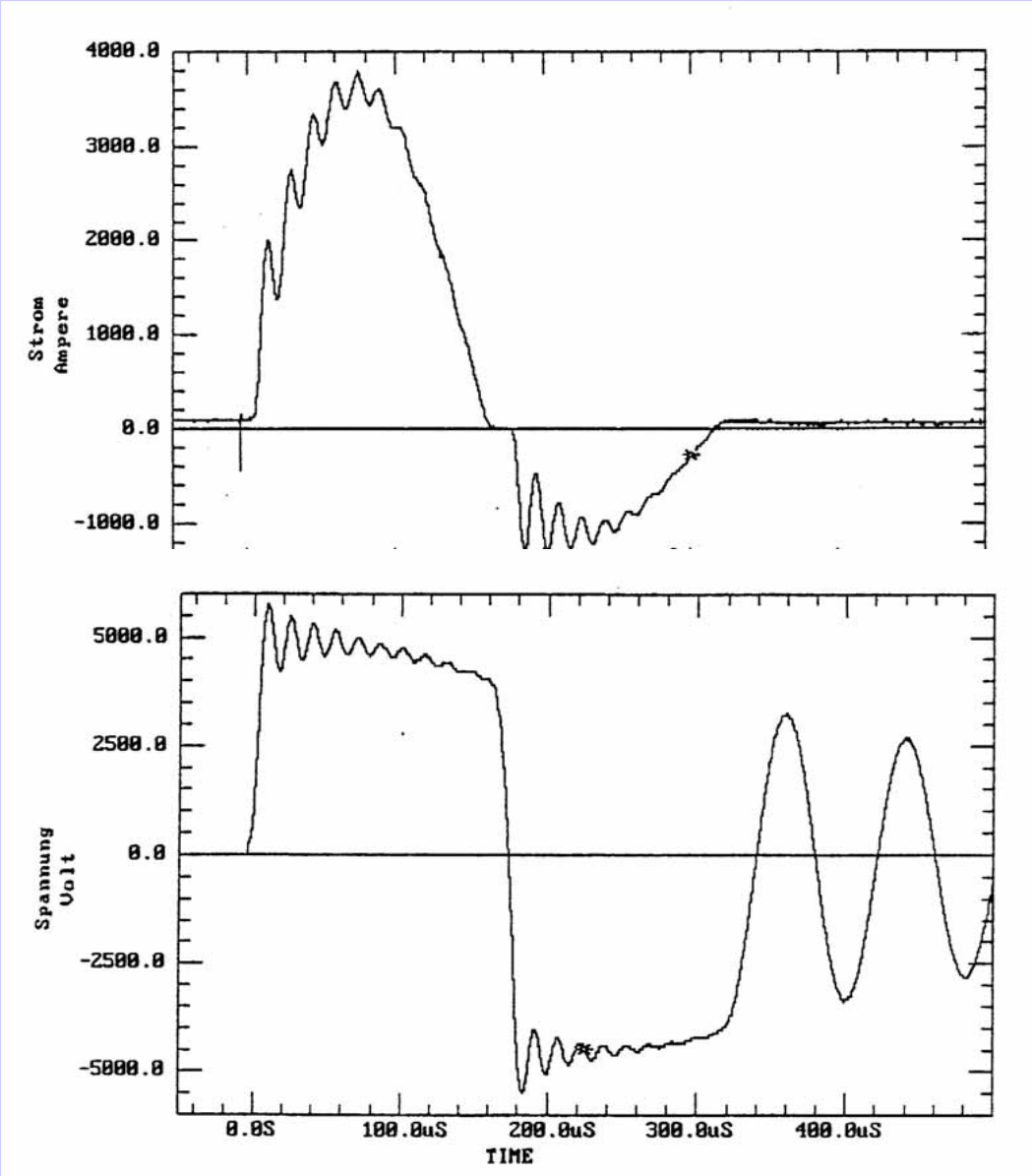
4 Cast resin insulator

5 Current monitoring transformer

6 Amplifier box

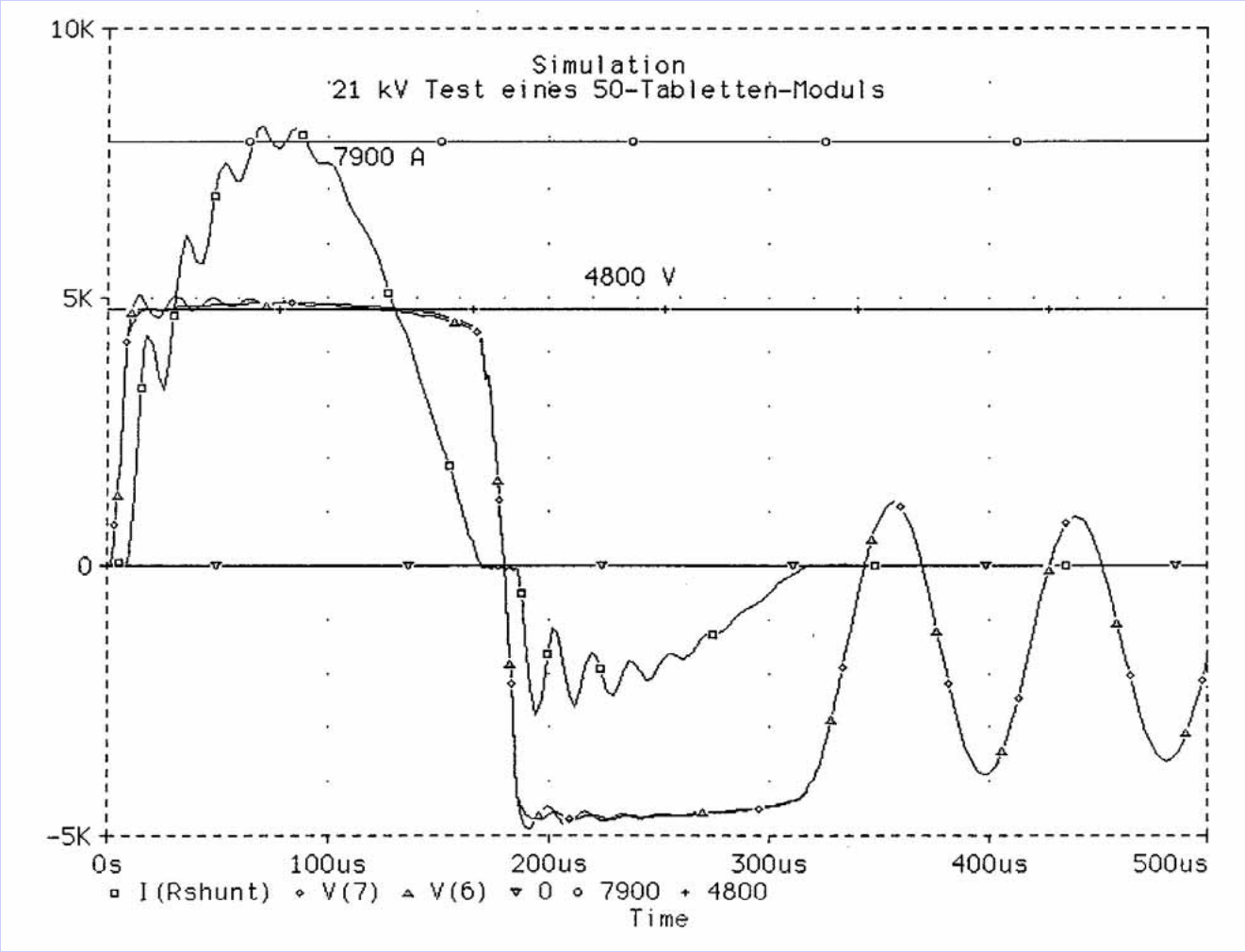
Front view of a complete arrester-unit

4.2. Arrester for 5 kV, 8 MJ (4)



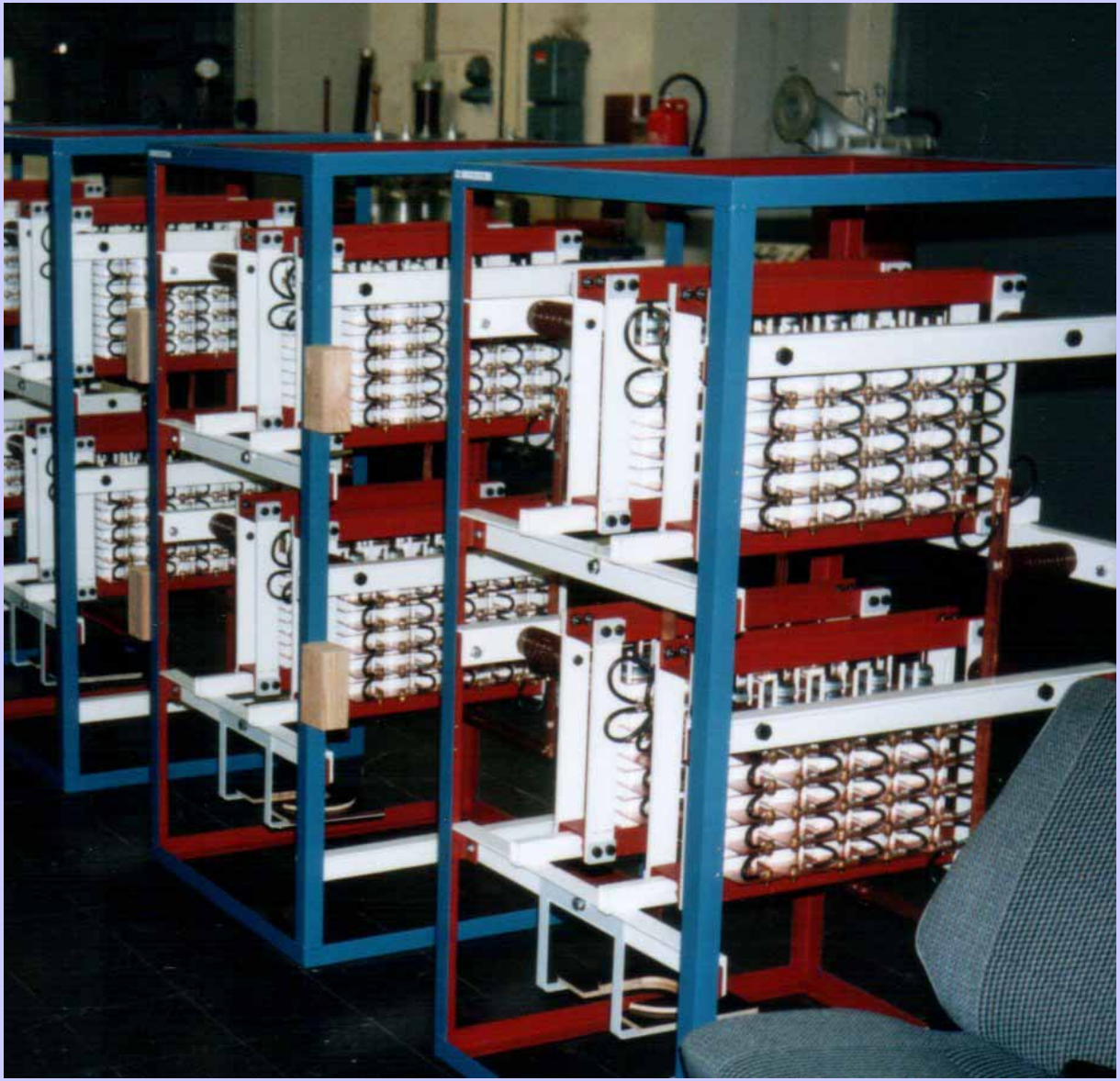
Measured current and voltage waveforms during a test of an arrester-unit with 50 ZnO-varistors in parallel

4.2. Arrester for 5 kV, 8 MJ (5)



Simulation results: Current and voltage waveform of an arrester-unit with 50 parallel ZnO-varistors

4.2. Arrester for 5 kV, 8 MJ (6)



Photograph of the 8 MJ-Arresters

5. Summary

- Necessity for overvoltage-arresters in pulsed power circuits was discussed
- ZnO-varistors are inherent save elements
- Properties of one ZnO-varistor (5 kV, 40 kJ) were treated
- Arresters can be matched to all conditions by series and parallel connection of varistors
- Two examples of realised arresters were described: 30 kV, 600 kJ and 5 kV, 8 MJ