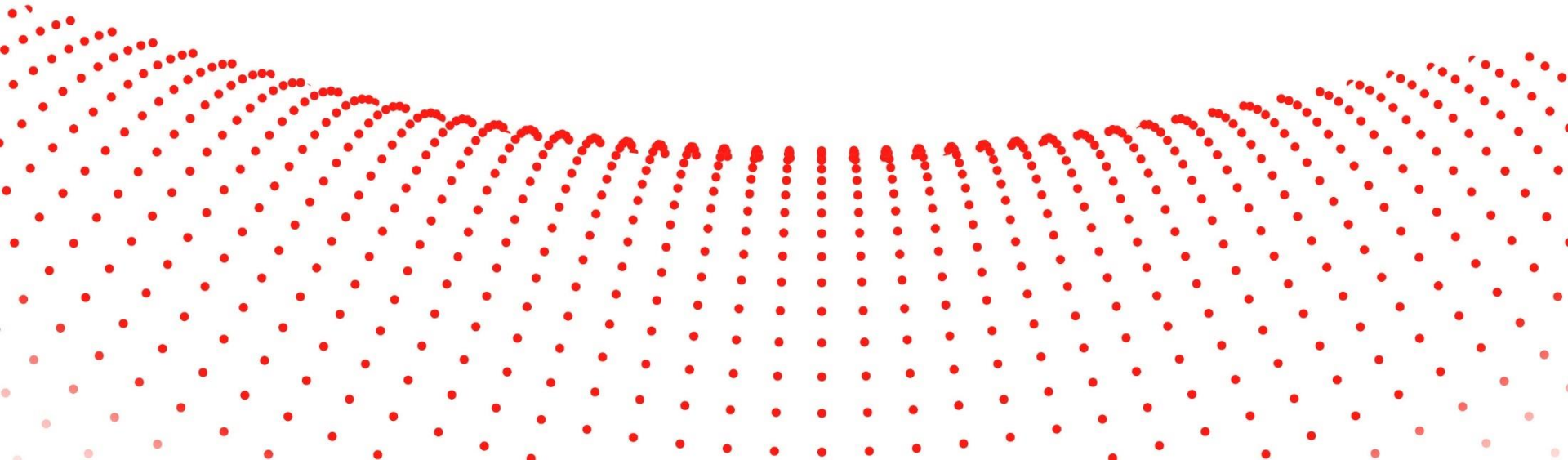


# KANTHAL RESISTORS AND APPLICATIONS



# Safety First

Kanthal's objective is zero harm to our people, the environment we work in, our customers and our suppliers.



PROTECTIVE  
EQUIPMENT



FIRST AID  
KIT



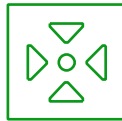
ALARM



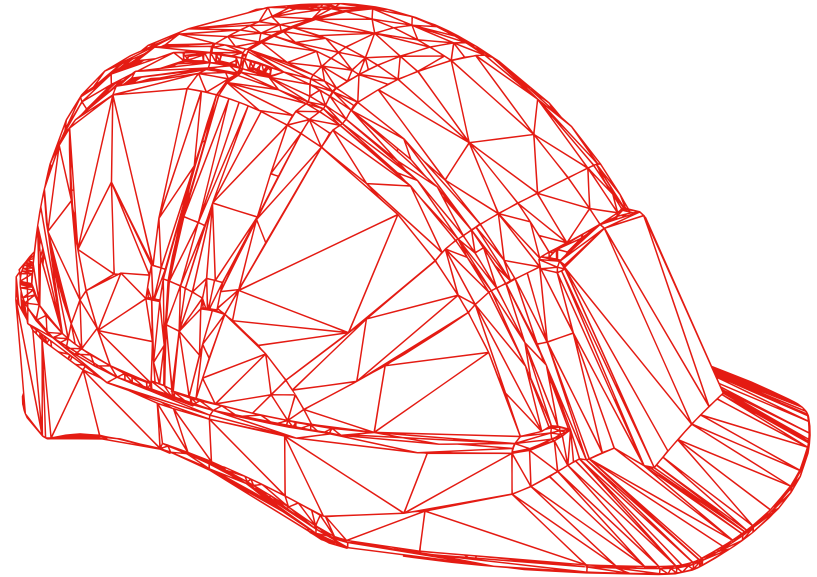
EMERGENCY  
NUMBER



EMERGENCY  
EXIT



ASSEMBLY  
POINT



# CONTENT

## Kanthal resistors and applications

1. Brief history – technology
2. Key application areas
3. Design considerations
4. Product overview

# BRIEF HISTORY

- **Founded February 1927 as the Carborudum Company, Niagara Falls, NY**
- **Previous company names via acquisition:**
  - Standard Oil of Ohio (Sohio)**
  - Carborundum**
  - Cesiwid**
- **Mid 2000's purchased by Kanthal Company.**
  - **During this time, Kanthal was acquired by Sandvik AB**
- **August 2017 renewed focus on “Kanthal, Part of Sandvik Group.”**

# ORIGINAL "CARBORUDUM" RESISTOR PRODUCTS

*Radio News for February, 1927* 1027

**And Now Announcing!**  
**CARBORUDUM GRID LEAKS**  
REG. U. S. PAT. OFF.  
**AND COUPLING RESISTORS**



**Send for the new Carborundum Hook-Up Book D-1**

**ABSOLUTELY noiseless—**  
 Do not disintegrate with use or time—  
 No metallic film but instead a solid rod of dense unbreakable Carborundum—one of the greatest of all electrical resisting materials.  
 Made in all standard values and tested under actual operating conditions.

*Grid Leaks or Resistors from your dealer or direct, 35c. each*

IN ORDERING PLEASE STATE VALUES REQUIRED

**THE CARBORUDUM COMPANY, NIAGARA FALLS, N. Y.**

SALES OFFICES AND WAREHOUSES IN  
 New York : Chicago : Boston : Philadelphia : Cleveland : Detroit : Cincinnati : Pittsburgh : Milwaukee : Grand Rapids  
 The Carborundum Co., Ltd., Manchester, Eng.

# KEY APPLICATION AREAS

**KANTHAL®**

Part of Sandvik Group



**Transportation**



**Defense**



**Oil & Gas**



**Medical**



**Motor Drives**



**Semicon**



**Power  
generation  
Including  
renewables**



**Research**



# RESISTOR APPLICATION CHALLENGES

Applications Requiring Combinations of:

- ✓ High Energy
- ✓ High Power
- ✓ High Voltage
- ✓ High Current
- ✓ Low Inductance

Present a Problem for Conventional Resistor Technologies

- ✓ Film
- ✓ Wire-Wound

# HIGH STRESS APPLICATION RESISTOR CIRCUITS

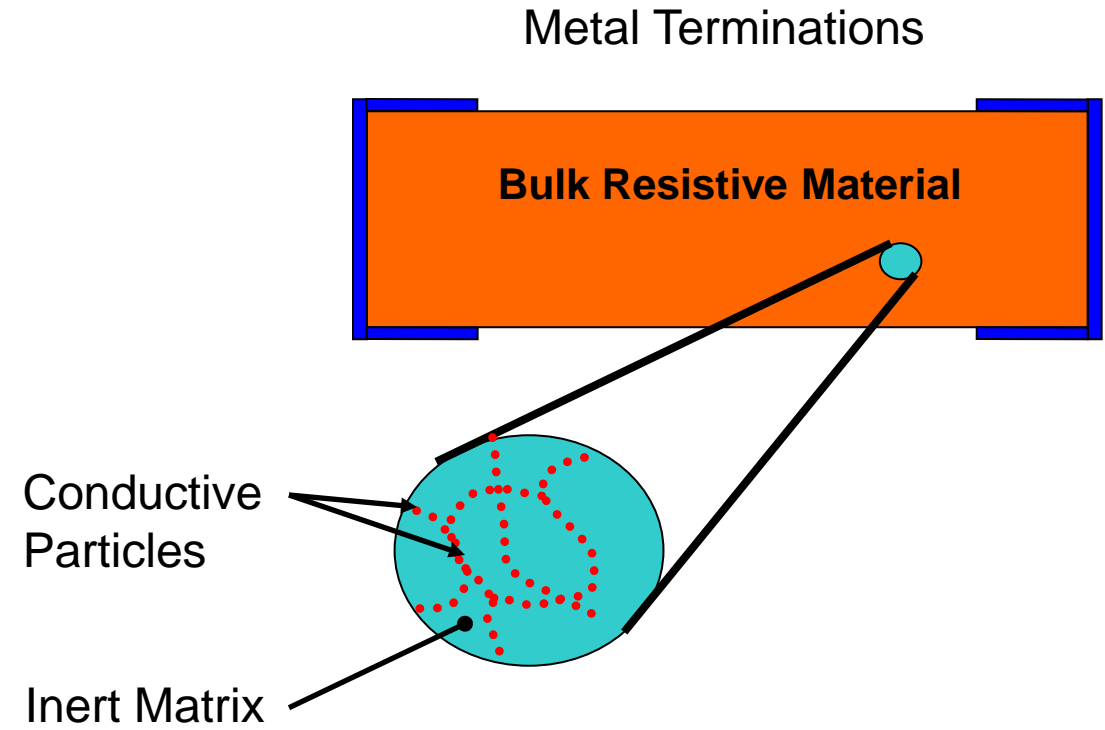
- ✓ High Energy Capacitor Charge/Discharge Circuits
- ✓ Inrush Current Limit (Soft Start)
- ✓ Transient Suppression (Snubber) Circuits
- ✓ Dynamic Braking
  - DC – Link Chopper
  - Crowbar
- ✓ High Power/Voltage Tube Circuits (e.g. Radar & X-Ray)
- ✓ Harmonic Filter
- ✓ High Frequency/RF Loads
- ✓ Pulse Forming Networks



- Non-Inductive
- High Peak Power
- High Energy Absorption
- Flexible Geometries
- High Voltage
- High Current
- Overload Capability
- Custom Packages

Simple !

# BULK RESISTOR CONCEPT



# KANTHAL ROBUST CERAMIC RESISTORS

**KANTHAL®**

Part of Sandvik Group

Step 1

**Powder**



+



+



Step 2

**Mixed & Formed**



Step 3

**React High Temperature**



Step 4

**Final Product**



# RESISTOR TECHNOLOGY COMPARISON

<u>Characteristic</u>	<u>Wire Wound</u>	<u>Film</u>	<u>Carbon Composition</u>	<u>Ceramic</u>
Non-Inductive	Poor	Excellent	Good	<b>Good</b>
Peak Power	Poor	Poor	Good	<b>Excellent</b>
Overload	Medium	Poor	Poor	<b>Excellent</b>
Geometry Size	Complex. Pkg 5W to 1KW	Flexible 1W to 1KW	Limited 0.5W to 2W	<b>Flexible 1W to 1KW</b>
Cost	Medium	Low	Low	<b>Med - High</b>

# RESISTOR MATERIALS

Type AS

High Energy\*  
High Voltage  
Non-Inductive

Type SP

High Power\*  
Non-Inductive

Type A

High Resistance\*  
Non-Inductive

# TODAY'S "KANTHAL" RESISTOR PRODUCTS



# RESISTOR SHAPES

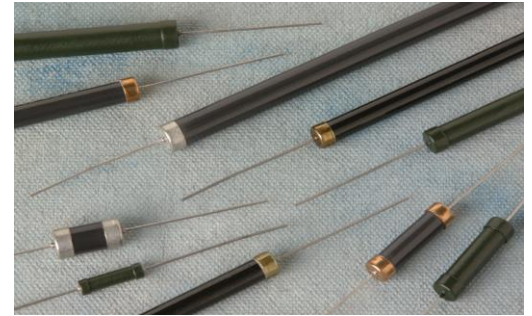
Tubular



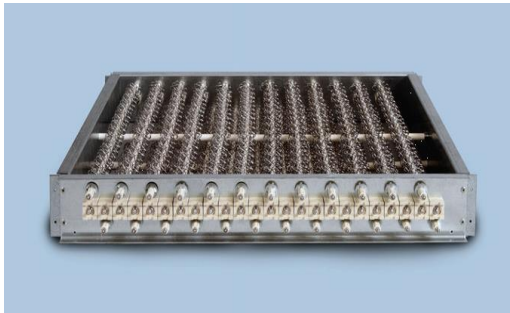
Slab



Axial Leaded



Metallic



Disk & Washer



# ASSEMBLY OPTIONS – CUSTOM DESIGNS

- ✓ PROVIDE CONCEPTUAL & DETAILED DESIGNS (SOLID WORKS)
- ✓ WORK CLOSELY WITH CUSTOMERS AND MATERIAL SUPPLIERS TO MEET CUSTOMER SPECIFICATIONS & PROJECT TIMETABLE
- ✓ NEW PRODUCT TESTS / EVALUATION / DOCUMENTATION
- ✓ ON-GOING CUSTOMER SUPPORT

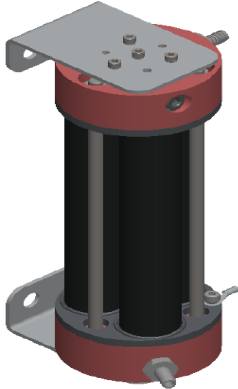


# RESISTOR SELECTION PARAMETERS

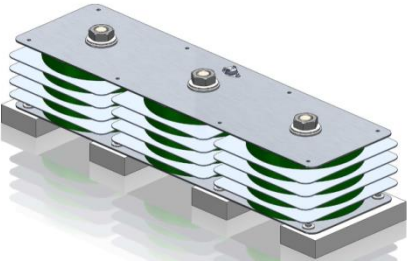
- ✓ PEAK VOLTAGE
- ✓ RESISTANCE VALUE & TOLERANCE
- ✓ ESTIMATED TRANSIENT PULSE ENERGY
- ✓ AVERAGE POWER (NOT INCLUDING TRANSIENT REPETITION RATE)

# ASSEMBLY OPTIONS

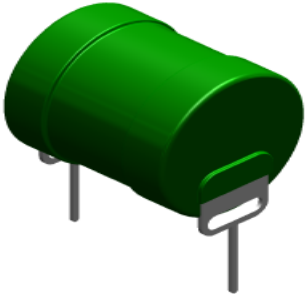
LIQUID COOLED RESISTOR



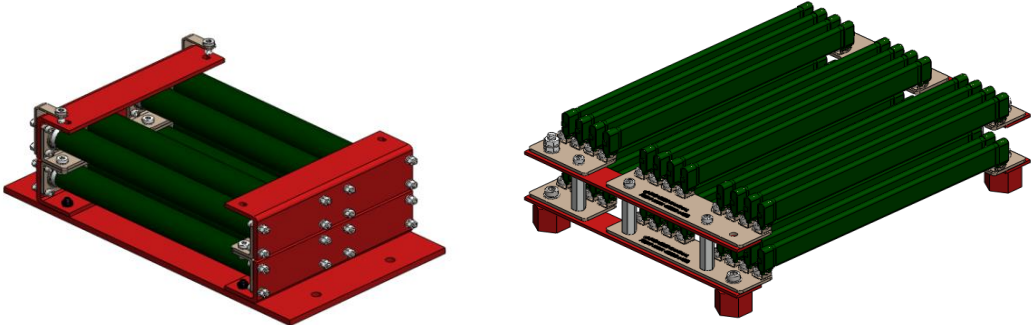
BRAKING RESISTOR



BOARD MOUNTABLE SURGE RESISTOR

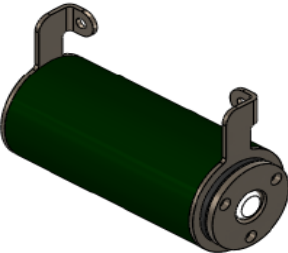


CAPACITOR DISCHARGE RESISTORS

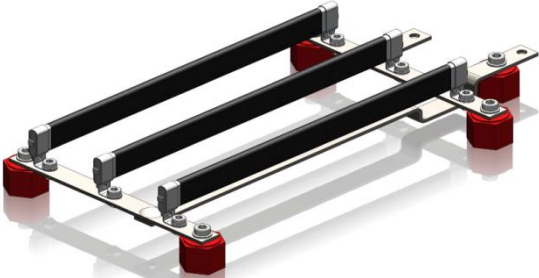


# ASSEMBLY OPTIONS

HIGH CURRENT TUBULAR  
WITH EASY MOUNT  
TERMINALS



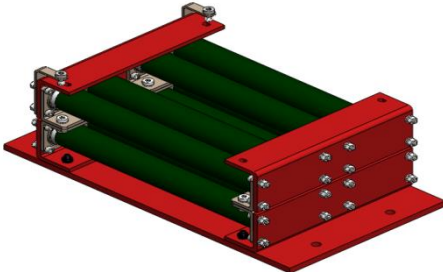
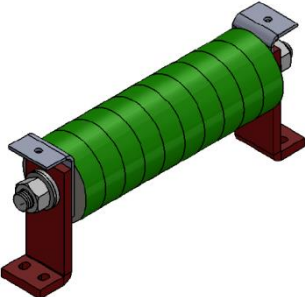
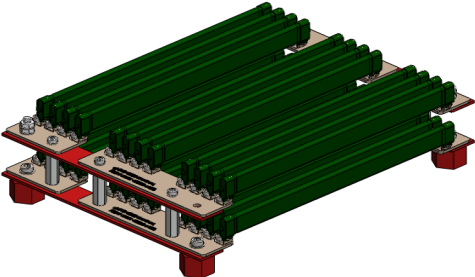
SNUBBER RESISTOR



CHASSIS MOUNT

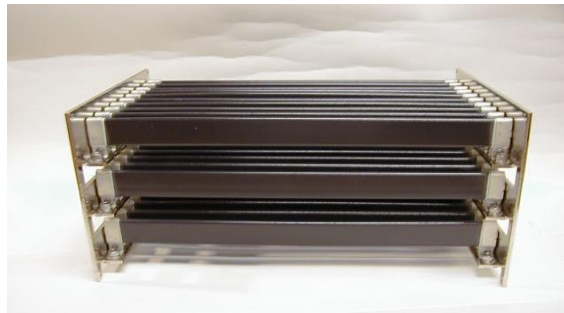
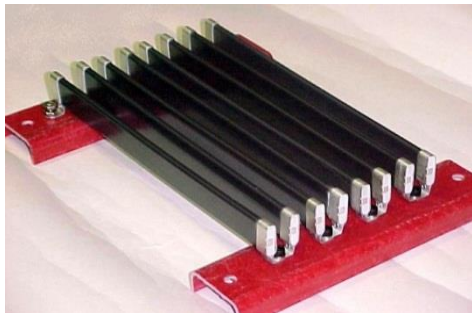


CAPACITOR DISCHARGE RESISTORS

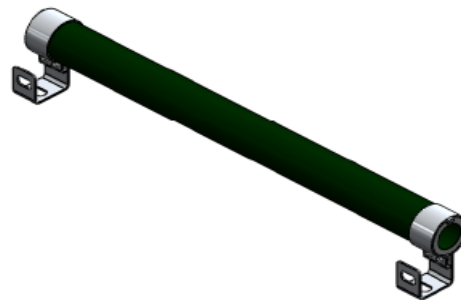


# ASSEMBLY OPTIONS – CUSTOM SHAPES AND HARDWARE

## SERIES OR PARALLEL SLAB ASSEMBLY'S



## SPECIAL MOUNTING HARDWARE

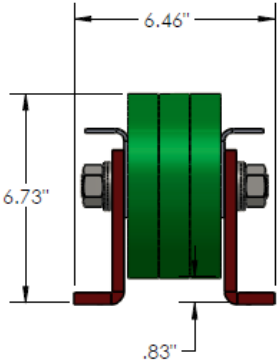
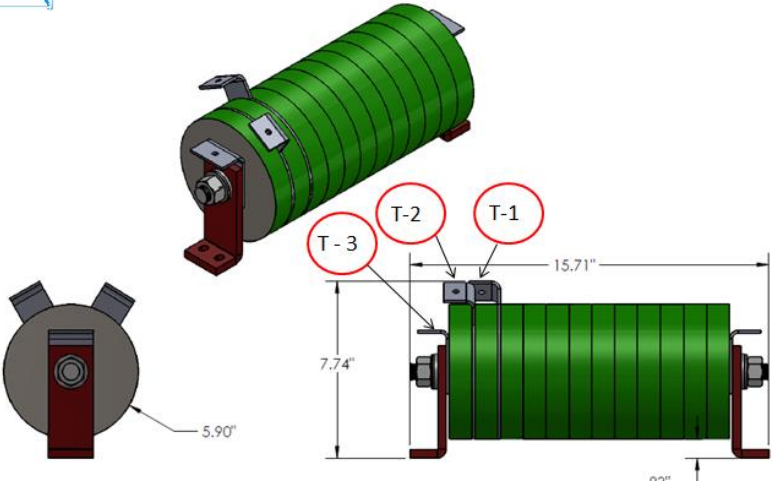
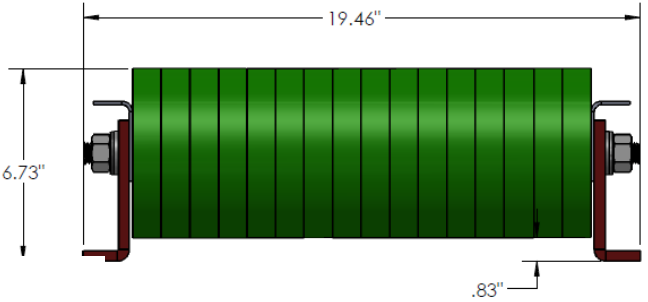
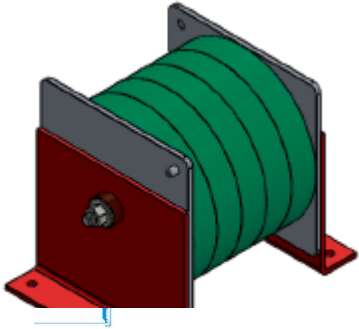


# ASSEMBLY OPTIONS – OIL RESISTIVE COATING OR HEAT SYNC

## LIQUID COOLED RESISTORS



# ASSEMBLY OPTIONS – DISK WASHERS



# CUSTOMER SUCCESS STORY

## TUBULAR RESISTORS

ELECTROSTATIC PRECIPITATOR  
SURGE RESISTOR

**FAILED RESISTOR**



TUBULAR RESISTOR REPLACEMENT



# RESISTOR APPLICATIONS

## ELECTRICAL & ELECTRONIC EQUIPMENT

### Aerospace / Defense

- Radar
- Radio
- Avionics
- Motion Drive Controls
- Land, Air, Naval
- Heavy Vehicle Controls

### Gov't Labs

- Energy Research

### Automotive & Transport

- EV/Hybrid Vehicles
- Ship Motor Drive & Control
- Rail Motion Control
- Truck (Heavy Vehicle)

### Energy & Utilities

- Electric Generation, Trans. & Distr.
- Power Generation & Storage
- Switchgear
- Transformers and Power Conversion

### Telecommunications Equipment

- Broadcast Transmitters
- RF Loads
- Test Equipment

### Medical/Health Care Equipment

- x-Ray
- Cancer Treatment
- Defibrillators
- Patient Monitors
- Medical Lasers

### Construction

- Cranes
- Heavy Vehicles

### Industrial Automation

- Motors & Motor Drives
- Elevator Controls
- Various Industry Specific Mfg. Equip

### Metals & Mining

- Mining Equipment

### Semiconductor Equipment

### Electronic Measurement & Testing Equipment

### Industrial Manufacturing Agricultural Equipment



# RESISTOR APPLICATIONS

## LOW VOLTAGE DRIVES

**KANTHAL**<sup>®</sup>

Part of Sandvik Group



# RESISTOR APPLICATIONS

## LOW VOLTAGE DRIVES



# RESISTOR APPLICATIONS

## MEDIUM VOLTAGE DRIVES

**KANTHAL**<sup>®</sup>

Part of Sandvik Group



# RESISTOR APPLICATIONS

## MEDIUM VOLTAGE DRIVES

**KANTHAL®**

Part of Sandvik Group



# RESISTOR APPLICATIONS

## ROBOTICS AND ASSEMBLY LINE TOOLS

**KANTHAL**<sup>®</sup>

Part of Sandvik Group



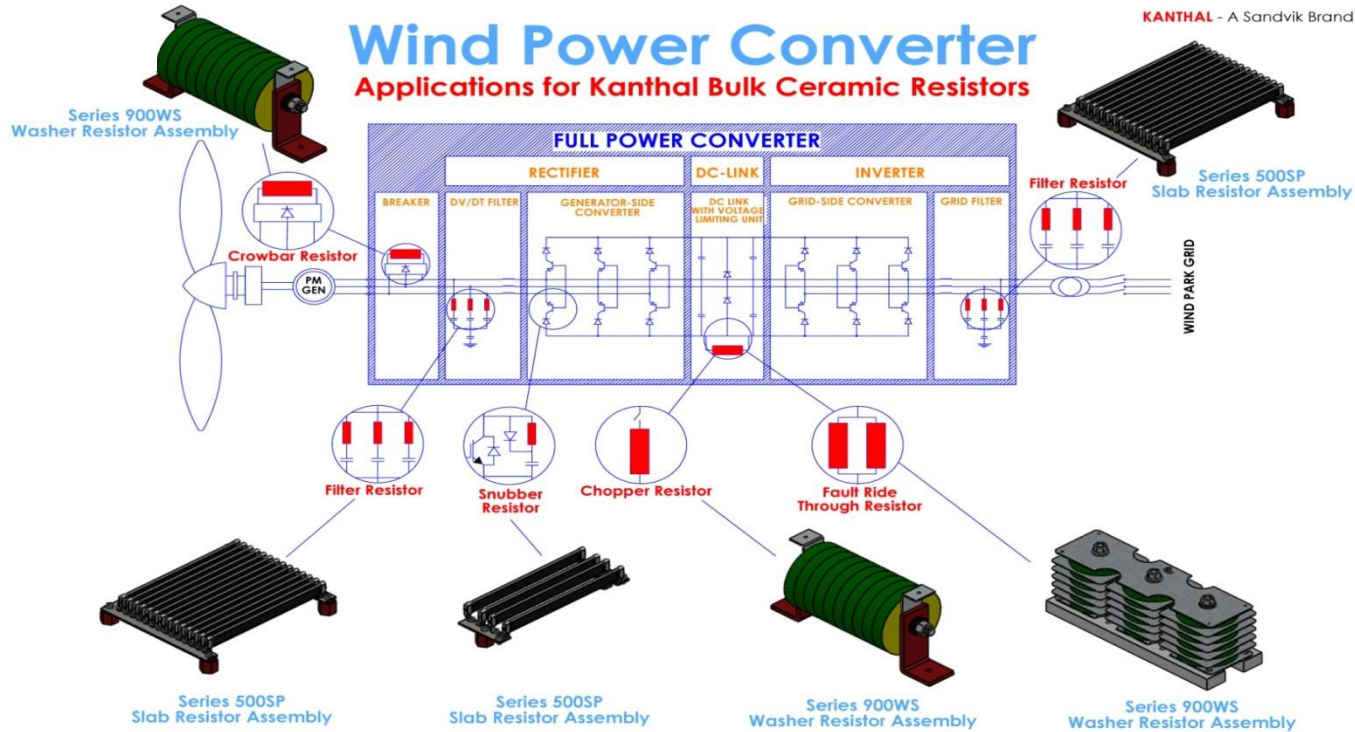
# RESISTOR APPLICATIONS

## POWER GENERATION – TRANSMISSION SWITCHGEAR

- ✓ **Renewable Energy: Wind Power - Power Converters**  
  
(Also, power converters/inverters for large solar installations, biomass, fuel cell and wave power.)
- ✓ **High Voltage Power AC & DC Transmission Circuit Breakers**
- ✓ **Transformer Protection (R-C Snubber) Circuits**

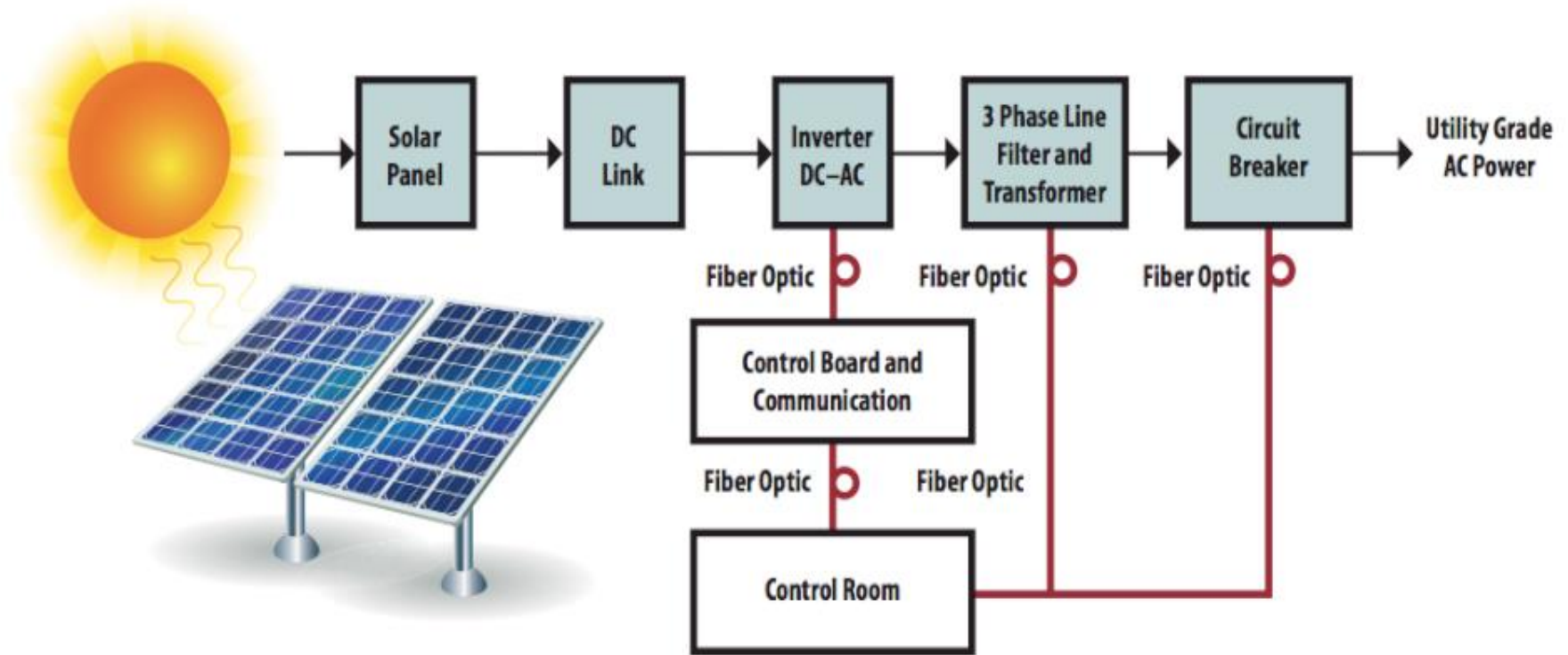
# RESISTOR APPLICATIONS

## POWER GENERATION – WIND



# RESISTOR APPLICATIONS

## POWER GENERATION – SOLAR





# RESISTOR APPLICATIONS

## ELECTRIC VEHICLE

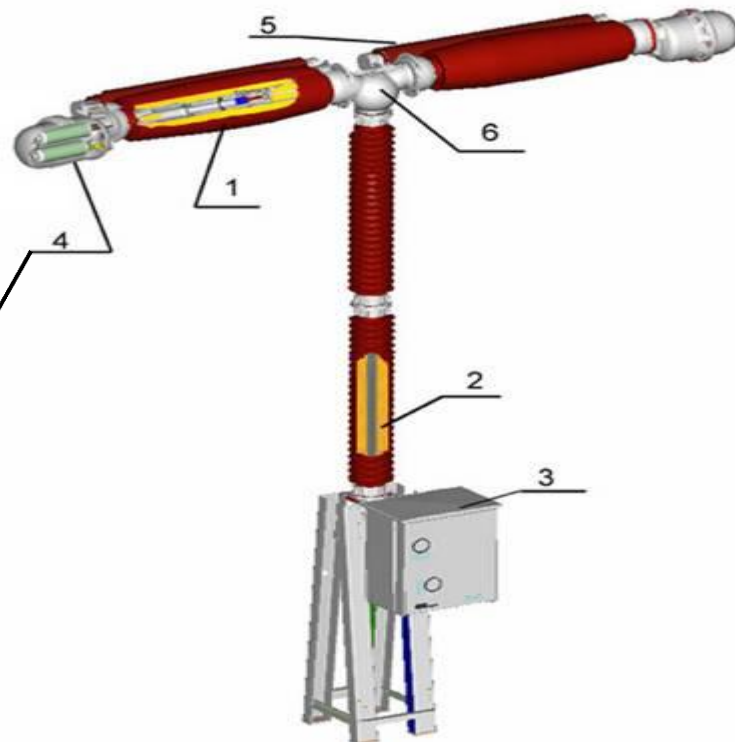
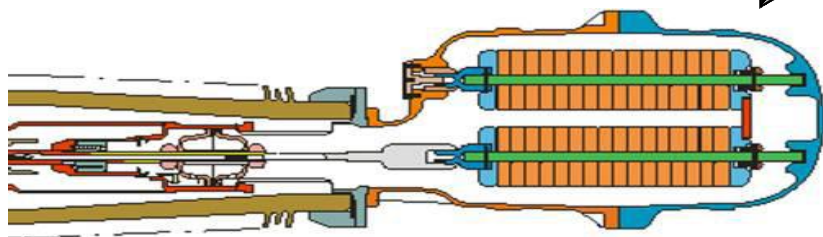
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# RESISTOR APPLICATIONS

## POWER TRANSMISSION – HIGH VOLTAGE CIRCUIT BREAKERS



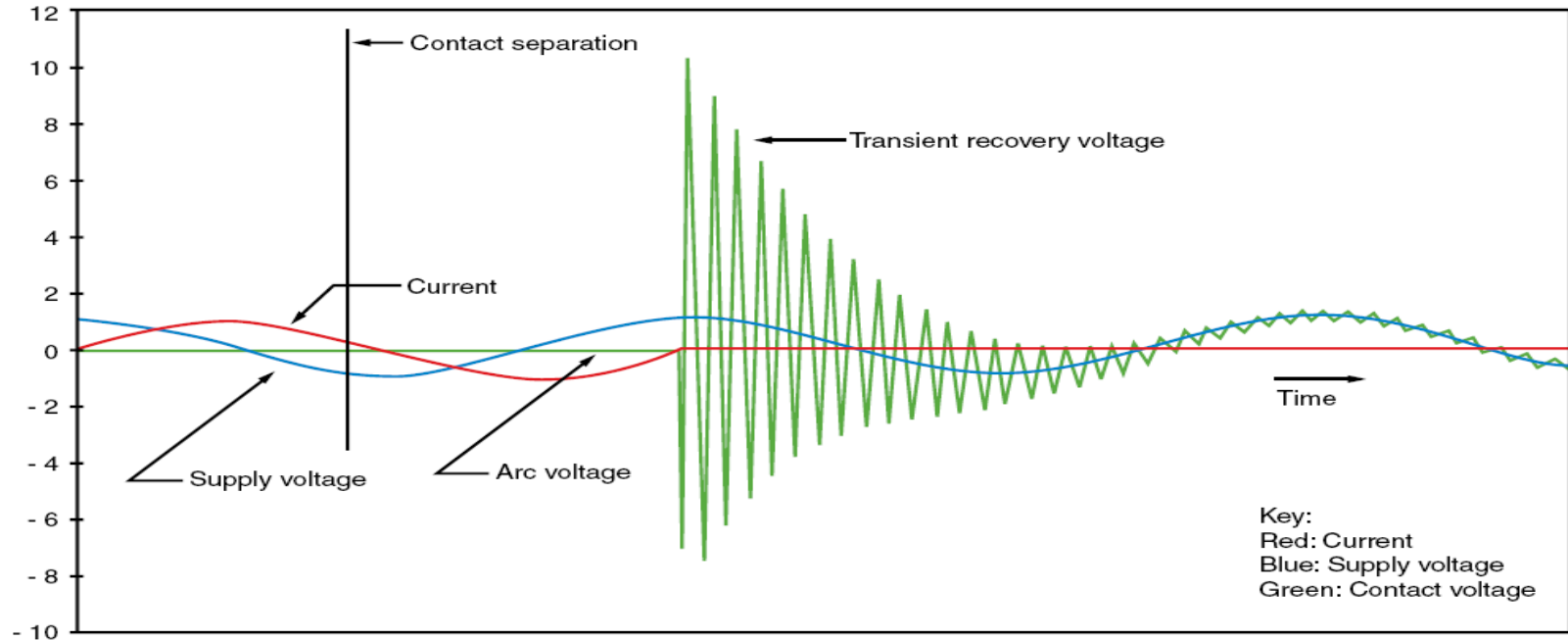
# RESISTOR APPLICATIONS

## POWER TRANSMISSION – HIGH VOLTAGE CIRCUIT BREAKERS



# RESISTOR APPLICATIONS

## POWER TRANSMISSION – TRANSFORMER PROTECTION DAMAGING HIGH VOLTAGE TRANSIENT

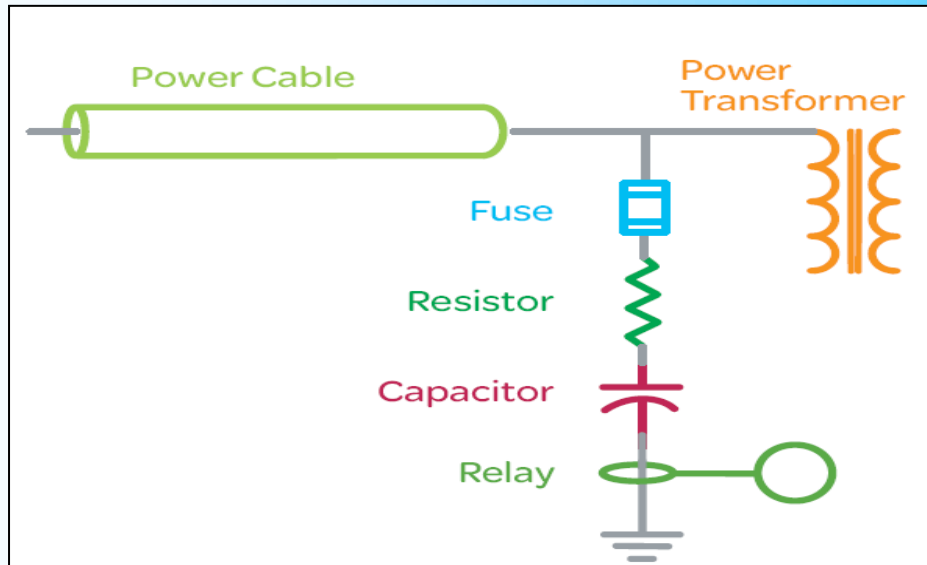


# RESISTOR APPLICATIONS

## POWER TRANSFORMER PROTECTION SOLUTION

### TYPICAL R-C SNUBBER CIRCUIT & COMPONENTS

PROVIDING LOW IMPEDANCE PATH TO THE GROUND FOR ENERGY, ESPECIALLY WHEN SWITCHING WITH VACUUM BREAKERS

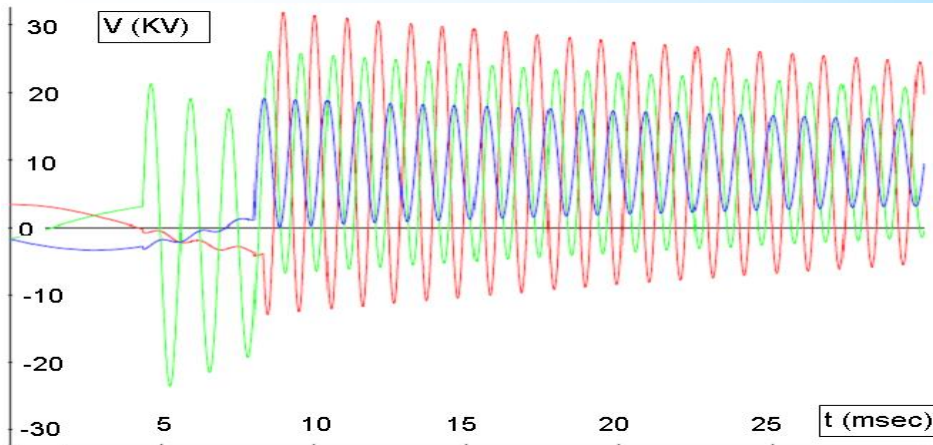


# RESISTOR APPLICATIONS

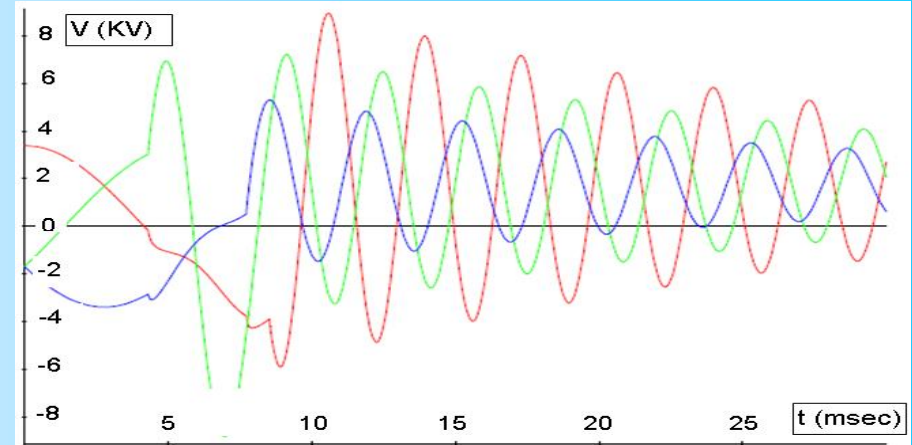
## POWER TRANSFORMER PROTECTION SOLUTION

EXAMPLE OF VACUUM BREAKER TRANSIENT WAVEFORM  
WITHOUT AND WITH R-C SNUBBER

Without R-C Snubber



With R-C Snubber



WITH R-C SNUBBER PULSE ENERGY TO TRANSFORMER IS SIGNIFICANTLY REDUCED

ABOVE CASE, TRANSIENT PEAK VOLTAGE IS REDUCED FROM 31 KV TO 9 KV WHILE SPIKE FREQUENCY IS CUT BY HALF

# RESISTOR APPLICATIONS

## POWER TRANSMISSION – TRANSFORMER PROTECTION

### Example of Transformer Damage from Circuit Breaker Transients



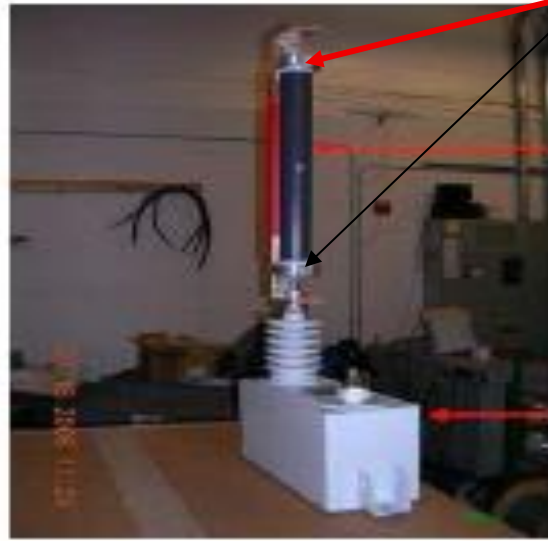
**Close up of Flash  
Burn Marks – Coil  
to Coil**



# RESISTOR APPLICATIONS

## POWER TRANSMISSION – TRANSFORMER PROTECTION

### TYPICAL RESISTOR AND CAPACITOR INSTALLATION

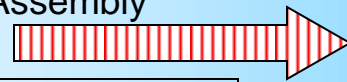


**Kanthal  
Connector  
Caps**

**Kanthal  
Resistor**

3 Phase R-C  
Assembly

**Capacitor**



Assembly in Transformer

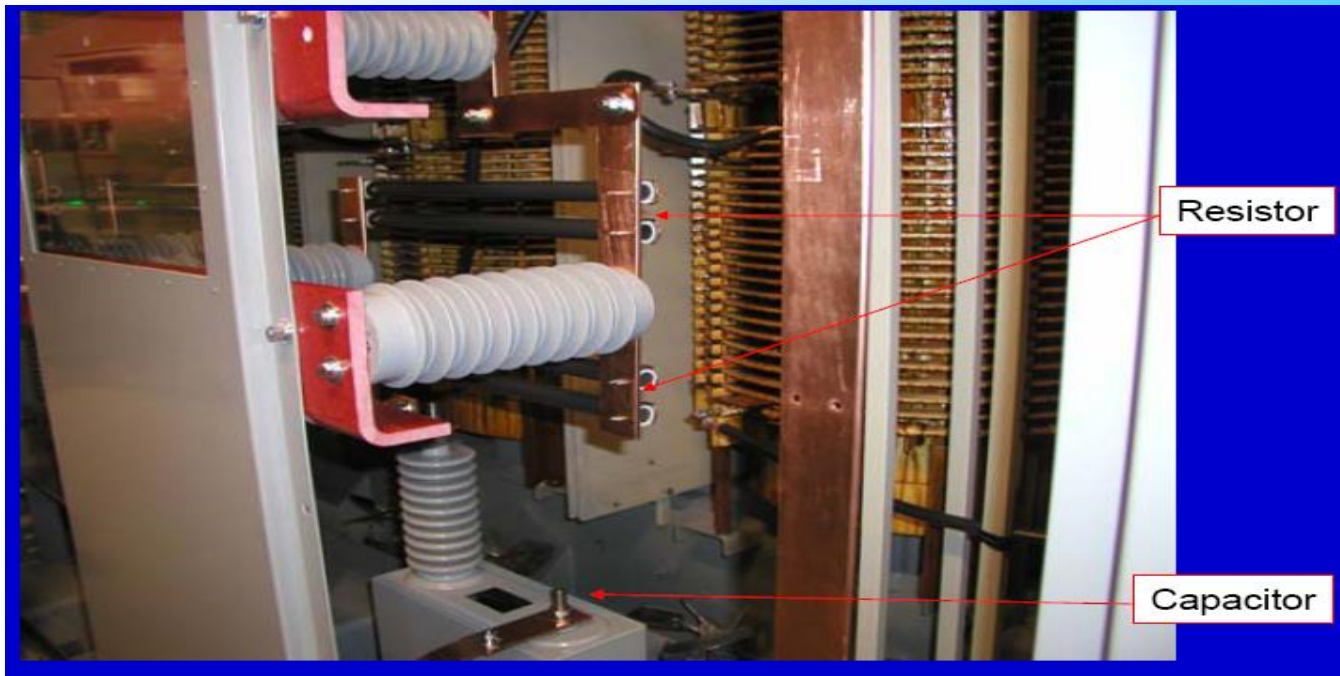




# RESISTOR APPLICATIONS

## POWER TRANSMISSION – TRANSFORMER PROTECTION

### EXAMPLES OF R-C SNUBBER ASSEMBLIES



# RESISTOR APPLICATIONS

## POPULAR KANTHAL TUBULAR RESISTORS FOR TRANSFORMER PROTECTION R-C SNUBBERS

<b>Model</b>	<b>Length</b>	<b>Dia.</b>	<b>Rated Peak</b>	<b>Rated Avg.</b>	<b>Rated Peak</b>
<b><u>No.</u></b>	<b><u>Inch (mm)</u></b>	<b><u>Inch (mm)</u></b>	<b><u>Voltage</u></b>	<b><u>Power</u></b>	<b><u>Energy</u></b>
<b>888SP</b>	8" (203)	1" (25.4)	8KV	190W	2.1KJ
<b>888AS</b>	8" (203)	1" (25.4)	45KV	75W	16.5KJ
<b>1028AS</b>	8" (203)	1.5" (38.1)	45KV	100W	45KL
<b>889SP</b>	12" (305)	1" (25.4)	10KV	275W	3.2KJ
<b>889AS</b>	12" (305)	1" (25.4)	75KV	100W	27KJ
<b>1032AS</b>	12" (305)	1.5" (38.1)	75KV	150W	75KJ
<b>890SP</b>	18" (457)	1" (25.4)	16KV	375W	4.2KJ
<b>890AS</b>	18" (457)	1" (25.4)	120KV	150W	43KJ
<b>1038AS</b>	18" (457)	1.5" (38.1)	120KV	225W	119KJ
<b>891SP</b>	18" (457)	2" (50.8)	16KV	750W	15KJ
<b>844SP</b>	24" (610)	1" (25.4)	22KV	500W	7KJ
<b>1044AS</b>	24" (610)	1.5" (38.1)	165KV	300W	164KJ
<b>892SP</b>	24" (610)	2" (50.8)	22KV	1000W	17.5KJ
<b>856SP</b>	36" (914)	1" (25.4)	34KV	750W	9KJ

Requests for custom resistor sizes are welcomed.

# RESISTOR APPLICATIONS

## KANTHAL TUBULAR RESISTOR & MOUNTING HARDWARE OPTIONS

### Heavy Duty Low Profile Radial Clamp



Std Mounting Clips



Connector Caps

- Aluminum Housing, or
- Tin Plated Copper Housing and Contact Strip



Std Radial Clampss



Std Radial Clamps  
with Right Angle



Un-Plated Copper Connector Caps  
(With or Without Support )

# RESISTOR APPLICATIONS

## KANTHAL TUBULAR MOUNTING HARDWARE MATERIALS

### Kanthal Mounting Hardware

Std Mounting Clips

Std Radial Clamps

Heavy Duty Low Profile Radial Clamps

Std Aluminum Connector Caps

Tin Plated Copper Connector Caps

### Material

Tin Plated Beryllium Copper

Tin Plated 0.030" Thick Brass

Tin Plated 0.060" Thick Brass

Aluminum Housing with  
Unplated Beryllium Copper Contact Strips

Copper Housing with Beryllium Copper Contact Strips  
(All Tin Plated)

Requests for custom hardware designs are welcomed.

# MAJOR TRENDS IN TRANSFORMER TRANSIENT PROTECTION

- In NAFTA demonstrated need for RC Snubber transformer transient protection due primarily to increased use of fast acting SF6 and vacuum breakers
- Requirements in other Regions (APAC – EMEA) could be different in each country depending on Grid robustness and degree of vacuum breaker usage
- Worldwide, likely to see more demand due to increased use of distributed power generation.  
(e.g., wind, solar ) which are known to introduce transients to the grid
- Wind and solar installations can also be subject to transients from the grid

# RESISTOR APPLICATIONS

## DEFENSE - RADAR

### Leading Global Radar Systems

Airborne – AWACS

Naval - AEGIS

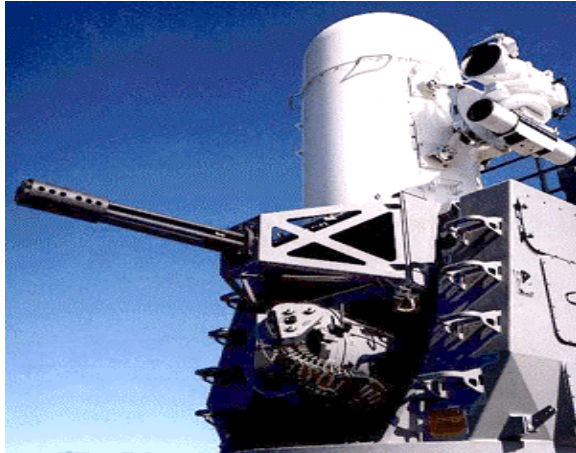


# RESISTOR APPLICATIONS

## DEFENSE - RADAR

### Strategic Radar

Phalanx



Firefinder



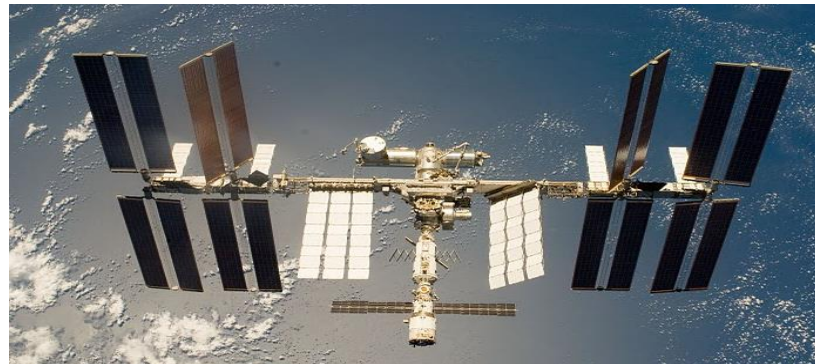
Patriot



# RESISTOR APPLICATIONS

## DEFENSE - RADAR

Require Custom Resistor Designs





# RESISTOR APPLICATIONS

## BROADCAST TRANSMITTERS & RESISTIVE LOADS

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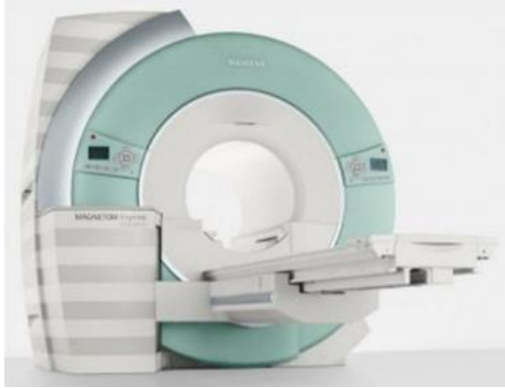
# RESISTOR APPLICATIONS

## SEMICONDUCTOR EQUIPMENT – ION IMPLANT & CVD/PVD



# RESISTOR APPLICATIONS

EQUIPMENT: ONCOLOGY – MRI, X RAY, COSMETIC LASER



# MANUFACTURING FOOTPRINT



**[www.kanthal.com](http://www.kanthal.com)**