The GE-MOV Saga

Retrospective 1970-2004

The GE-MOV saga was made possible when General Electric (GE) acquired a license for patents such as the one on the next page (filed in 1970 and issued in 1972) and cited here as an acknowledgment to the origins of the technology. GE then launched the "GE-MOV" ®[1] varistors in 1972, blossoming into a full line of two-terminal devices for low-voltage applications [2] and recognized by an IR 100 Award. The saga then begins with an excerpt from a product specification bulletin listing the wide range of ratings available by the mid-seventies. On the occasion of its Centennial, GE seemed determined to stay in the business of transient protection, as claimed by an advertisement citing its deep roots in the field of lightning research and transients surveys. However, while expansion of the variety of MOV structures continued, as shown by the covers of successive editions (avatars) of the ***Transient Voltage Suppression Manual***, GE eventually did exit the business of low-voltage MOVs, with Harris Semiconductor taking over. That exit was later followed by yet another divestiture, now apparent as the latest MOV avatar when browsing the Internet for present MOV manufacturers – a long way from the 1970s GE-MOVs.

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[1] Then a trademark of the General Electric Company.

[2] The MOV applications to high-voltage surge arresters were also developed during that period, but are not covered in this Anthology, except for the seminal Shakshaug et al. paper which is included as an annex of this Part 7.

United States Patent Office

3,6l82,841

Patented Aug. 18, 1972

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3,682,841
VOLTAGE DEPENDENT RESISTORS IN A BULK TYPE

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Int. Cl. H01b *1/06*
U.S. Cl. 252—518 5 Claims

ABSTRACT OF THE DISCLOSURE

A voltage dependent resistor of the bulk type. The resistor has a sintered body consisting essentially of, as a major part, zinc oxide (ZnO) and, as an additive, 0.05 to 10.0 mole percent of beryllium oxide (BeO) and 0.05 to 10.0 mole percent, in total, of at least one member selected from the group consisting of bismuth oxide (Bi_2O_3), cobalt oxide (CoO) manganese oxide (MnO), barium oxide (BaO), strontium oxide (SrO) and lead oxide (PbO). Electrodes are provided which are in contact with said body.

This invention relates to voltage dependent resistors having non-ohmic resistance due to the bulk thereof and more particularly to varistors comprising zinc oxide and beryllium oxide.

Various voltage dependent resistors such as silicon carbide varistors, selenium rectifiers and germanium or silicon p-n junction diodes have been widely used for stabilization of voltage or current of electrical circuits. The electrical characteristics of such a voltage dependent resistor are expressed by the relation:

$$I=\left(\frac{V}{C}\right)^n$$

where V is the voltage across the resistor, I is the current flowing through the resistor, C is a constant corresponding to the voltage at a given current and exponent *n* is a numerical value greater than 1. The value of *n* is calculated by the following equation:

$$n=\frac{\log_{10}(I_2/I_1)}{\log_{10}(V_2/V_1)}$$

where V_1 and V_2 are the voltages at given currents I_1 and I_2, respectively. The desired value of C depends upon the kind of application to which the resistor is to be put. It is ordinarily desirable that the value of *n* be as large as possible since this exponent determines the extent to which the resistors depart from ohmic characteristics.

Voltage dependent resistors comprising sintered bodies of zinc oxide with or without additives and silver paint electrodes applied thereto, have previously been disclosed. The non-linearity of such varistors is attributed to the interface between the sintered body of zinc oxide with or without additives and the silver paint electrode and is controlled mainly by changing the compositions of said sintered body and silver paint electrode. Therefore, it is not easy to control the C-value over a wide range after the sintered body is prepared. Similarly, in varistors comprising germanium or silicon p-n junction diodes, it is difficult to control the C-value over a wide range because the non-linearity of these varistors is not attributed to the bulk but to the p-n junction. On the other hand, the silicon carbide varistors have non-linearity due to the contacts among the individual grains of silicon carbide bonded together by a ceramic binding material, i.e. to the bulk, and the C-value is controlled by changing a dimension in the direction in which the current flows through the varistors. The silicon carbide varistors, however, have a relatively low n-value ranging from 3 to 6 and are prepared by firing in non-oxidizing atmosphere, especially for the purpose of obtaining a lower C-value.

An object of the present invention is to provide a voltage dependent resistor having non-linearity due to the bulk thereof and being characterized by a low C-value and high n-value.

Another object of the present invention is to provide a method for making a voltage dependent resistor having the non-linearity due to the bulk thereof and being characterized by a high n-value, without using non-oxidizing atmosphere.

These objects are achieved by providing a voltage dependent resistor of the bulk type comprising a sintered body consisting essentially of, as a major part, zinc oxide (ZnO), and, as an additive, 0.05 to 10.0 mole percent of beryllium oxide (BeO) and 0.05 to 10.0 mole percent, in total, of at least one member selected from the group consisting of bismuth oxide (Bi_2O_3), cobalt oxide (CoO), manganese oxide (MnO), barium oxide (BaO), strontium oxide (SrO) and lead oxide (PbO), and electrodes in contact with said body.

These and other objects of the invention will become apparent upon consideration of the following description taken together with the accompanying drawing in which the single figure is a partly cross-sectional view through a voltage dependent resistor in accordance with the invention.

Before proceeding with a detailed description of the voltage dependent resistors contemplated by the invention, their construction will be described with reference to the aforesaid drawing wherein reference character **10** designates, as a whole, a voltage dependent resistor comprising, as its active element, a sintered body having a pair of electrodes **2** and **3** applied to opposite surfaces thereof. Said sintered body **1** is prepared in a manner hereinafter set forth and is in any form such as circular, square or rectangular plate form. Wire leads **5** and **6** are attached conductively to the electrodes **2** and **3**, respectively, by a connection means **4** such as solder or the like.

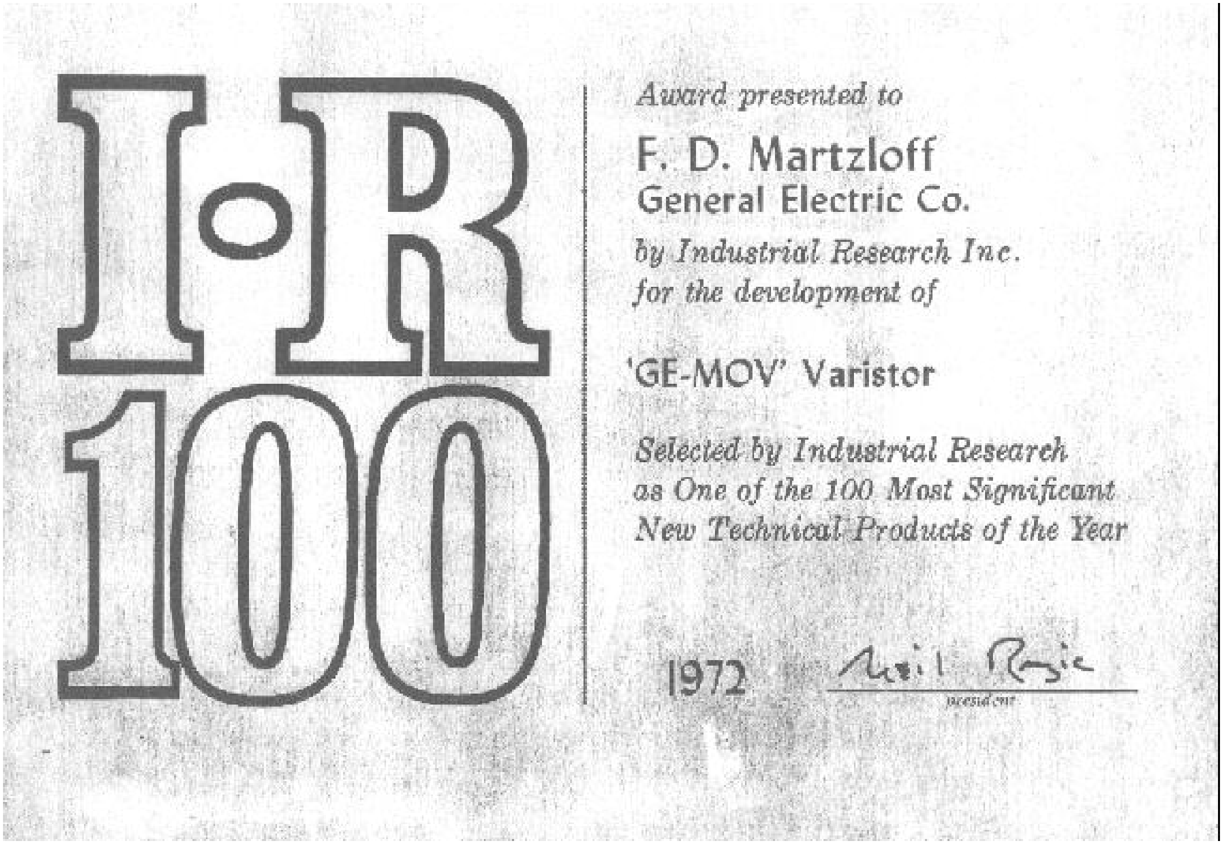
The sintered body **1** of the voltage dependent resistor according to the invention comprises a composition consisting essentially of, as a major part, zinc oxide (ZnO) and, as an additive, 0.05 to 10.0 mole percent of beryllium oxide (BeO) and 0.05 to 10.0 mole percent, in total, of at least one member selected from the group consisting of bismuth oxide (Bi_2O_3), cobalt oxide (CoO), manganese oxide (MnO), barium oxide (BaO), strontium oxide (SrO) and lead oxide (PbO) and has the electrodes **2** and **3** in contact with said body.

A higher n-value can be obtained when said additive consists essentially of 1.0 to 8.0 mole percent of beryllium oxide (BeO) and 0.1 to 3.0 mole percent, in total, of at least one member selected from the group consisting of bismuth oxide (Bi_2O_3), cobalt oxide (CoO), manganese oxide (MnO), barium oxide (BaO), strontium oxide (SrO) and lead oxide (PbO).

Table 1 shows the optimal compositions of said additives for producing a voltage dependent resistor having hibh n-value, low C-value and high stability with respect to temperature, humidity and electric load.

The sintered body **1** can be prepared by a per se well known ceramic technique. The starting materials having the compositions described in the foregoing description are mixed in a wet mill so as to produce homogeneous mixtures. The mixtures are dried and pressed in a mold into the desired shape at a pressure of from 100 kg./cm.^{2} to 1000 kg./cm.^{2}. The pressed bodies are sintered

Just one of the IR plaques awarded to the GE team members after formal introduction of the GE-MOV varistors



I·R 100

Award presented to

F. D. Martzloff
General Electric Co.

by Industrial Research Inc.
for the development of

'GE-MOV' Varistor

Selected by Industrial Research
as One of the 100 Most Significant
New Technical Products of the Year

1972

president

Let the saga begin ...

GE-MOV® Metal-Oxide Varistors

GE has been helping customers solve transient voltage problems since the introduction of GE-MOV® varistors in 1972. The GE-MOV® team is constantly researching the causes and effects of transients and developing new solutions to meet all types of transient suppression needs; committed to innovation beyond today's technology.

As the field of electronics has grown rapidly through the use of solid-state components, so have the applications for surge suppressors to protect these transient-sensitive devices. Innovations such as surface-mount technology have also altered the demand profile by adding packaging considerations to functional ones.

As a result of innovation and research, the GE-MOV® line of metal-oxide varistors has expanded to include surface-mount devices, new high-energy packages, connector-pin varistors, and high-temperature, low-profile varistors. These new products supplement the GE-MOV® line of radial, axial, and high-energy packaged varistors, already the broadest in the industry.

GE-MOV® Specification Guide

Series	Ratings & Characteristics Table Page(s)
CH	13
SM	14, 15
CP	16
MA	17
ZA	18, 19
LA	20
RA	21, 22
PA	23
DA/DB	24
BA/BB	24
CA	25
High Reliability	26

GE-MOV® Features

FAMILY FEATURES:

- Wide Voltage/Energy Range
- Excellent Clamp Ratio
- Power
- No Follow-On Current
- Fast Response Time
- Low Standby
- UL Recognized

TYPE FEATURES:

CH/SM Series
Surface Mount Varistors
- Better Performance
- Higher Reliability
- Lower Equipment Cost
- Saves on Board Height/Bulk/Weight

CP Series
Connector Pin Varistors
- Provides transient protection in connectors
- Available in 22, 20, and 16 gauge sizes

MA Series
- Axial Package
- Wide Voltage Range
- Automatic Insertion

ZA Series
- Radial Package
- Low Voltage Operation

LA Series
- Radial Package
- Line Voltage Operation
- UL Recognized

RA Series
- Low Profile
- High Temperature Capability
- Precise Seating Plane
- In-Line Leads

PA Series
- Rigid Mountdown
- NEMA Creep and Strike Distance
- Quick Connect Terminal
- UL Recognized

DA,DB,BA,BB Series
- High Energy Capability
- Rigid Terminals
- Isolated
- Low Inductance
- Improved Creep and Strike
- UL Recognized

CA Series
- Industrial Discs

Hi Reliability Series
- 100% Prescreened
- 100% Process Conditioning
- Meets Military Specifications

GE Centennial Advertisement

How does GE intend to keep its lead in transient protection?

Staying power.

Most people recognize GE-MOV® varistors as the ultimate in system transient protection. With good reason. These metal oxide varistors, or movistors, are the result of research and experience that stems from the early years of General Electric, celebrating in 1978 its 100th birthday.

You may have shared our excitement along the GE path to leadership. Steinmetz' lightning generator demonstration in 1922. Anderson's lightning measurements on the Empire State Building in the 1930's. The definitive study of surge voltages in residential and industrial circuits formulated by Martzloff and Hahn of GE's Corporate R&D Center in 1970. And, of course, GE's $10 million investment relating to the introduction of GE-MOV® varistors six years ago.

But in our view, the best is yet to come. GE's R&D work on transient protection continues to find more sophisticated materials, better measurements and standardization. Soon, you'll be able to put the resulting new products and new ideas to work for you.

Experience, Innovation. Staying power. It's what you've come to expect, and can expect from GE when you need transient protection.

For the full story on GE-MOV® varistors, call your local authorized GE semiconductor distributor, or write General Electric Co., Electronics Park 7-49, Syracuse, N.Y. 13221. 222-06

® Registered Trademark of General Electric Co

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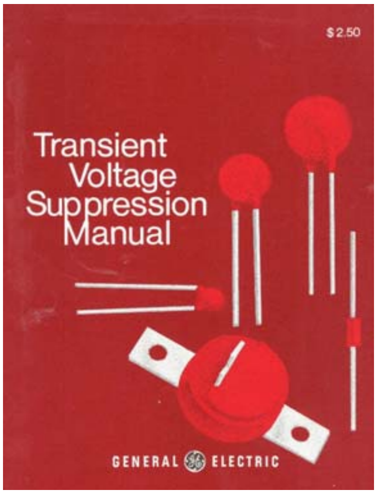
There's more to GE semiconductors than meets the eye

GENERAL ELECTRIC

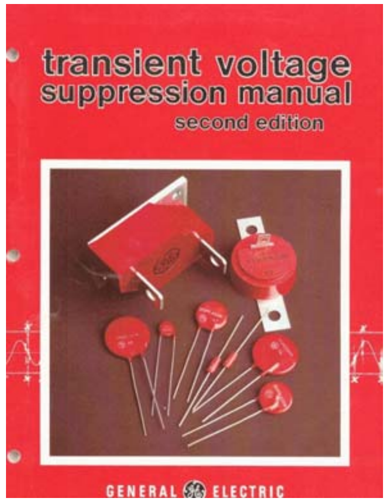
Avatars of the GE Transient Voltage Suppression Manual

1976 - 2004

1976 – First Edition
(A collector's item)

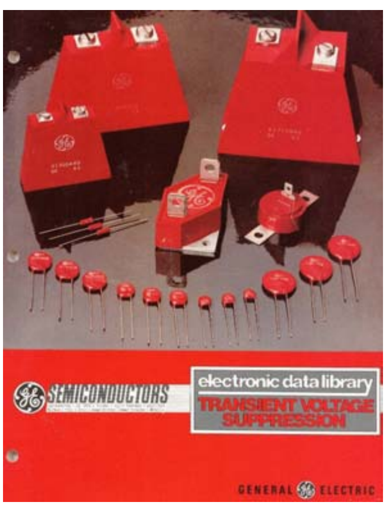


1978 – Second Edition
The line expands

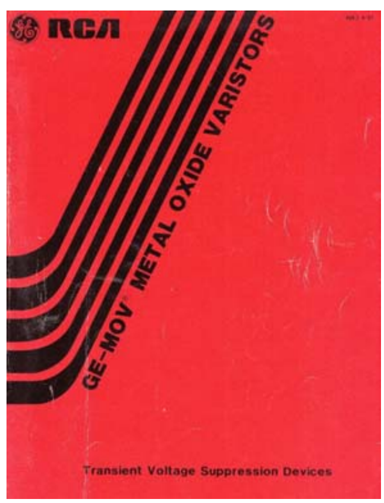


1982 – Third Edition
Bigger is better

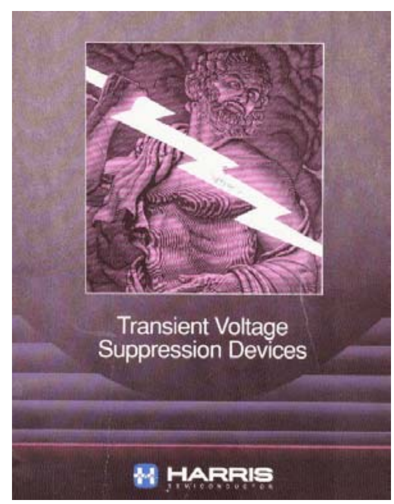
1983 – Fourth Edition
(More big discs/)



1986 – Fifth Edition
Last Hurrah for GE-MOV



1992 – Same Text
A New Home



Browsing the Web in 2004 for varistor vendors delivers the following message:

Divested Product Family

The product you're searching for is part of a family that is no longer in the Intersil Corporation product portfolio.

TRANSIENT VOLTAGE PRODUCTS

The former Harris Semiconductor and RCA Solid State family of transient voltage products (Radial Varistors, Multi-Layer Varistors, Industrial MOVs, Diode Arrays and Surgector TVS Thyristors) were sold to Littlefuse, Inc. These include products with prefixes of LA, ZA, CIII, MLA, MLE, AUML, RA, BB, MA, HA, NA and SP.