
**Shape Memory Alloy (SMA)
Technology for Battery Protector**

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(THERM-O-DISC, INC., USA)

Shape Memory Alloy Battery Protectors

Therm-O-Disc, Inc.

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Overview

- **Company History and Products**
- **SMA Technology Description**
- **Comparison of SMA and Other Technologies**
- **Benefits of SMA**
- **High Current Performance**

Therm-O-Disc is a subsidiary of Emerson Electric Company

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- **Emerson FY2000 revenues are over \$15 billion**
- **Emerson key business segments:**
 - **Industrial automation - motors, drives, valves, ultrasonics**
 - **Process Control - automation, software, measurement**
 - **HVAC - compressors, thermostats, hermetic terminals**
 - **Electronics and telecommunications - UPS, environ. control**
 - **Appliance and tools - motors, power & hand tools**
- **Emerson technology centers:**
 - **Software**
 - **Materials**
 - **ASICS**

Therm-O-Disc Has Been in Business for Over 50 Years

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- **Core business is bimetal electro-mechanical thermostats and controls**
- **FY2000 revenue of just under \$300 million**
- **Core markets include:**
 - **Appliance**
 - **HVAC**
 - **Automotive**
- **Core technologies include:**
 - **Bimetal**
 - **Organic pellets**
 - **Polymer PTC**
 - **SMA**

SMA Technology Overview

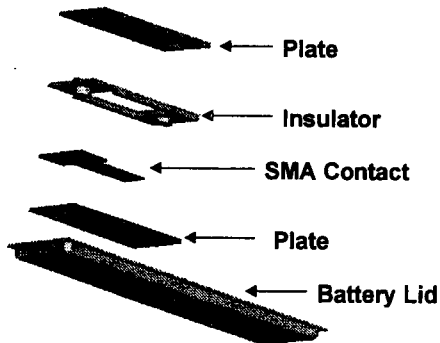
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- SMA changes dimension at a specified temperature
- A phase change within SMA causes the movement
- Activation temp. range - 50°C to 120°C (adjustable)
- High force per unit volume in one direction of motion



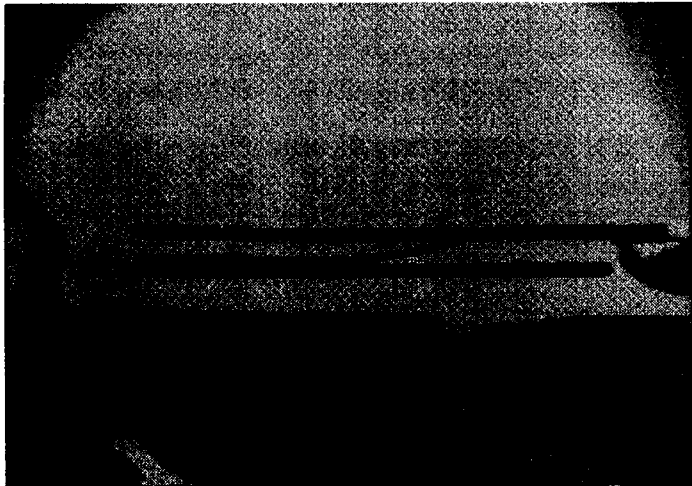
SMA Battery Protector For Prismatic Cells

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X-ray Video of SMA Operation

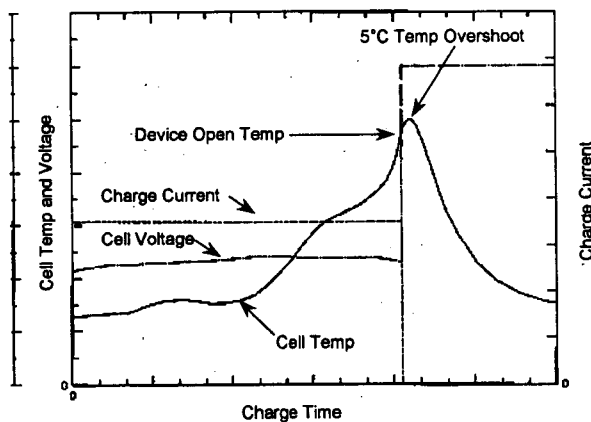
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SMA Requires 5°C Overshoot to Ensure One-shot Operation

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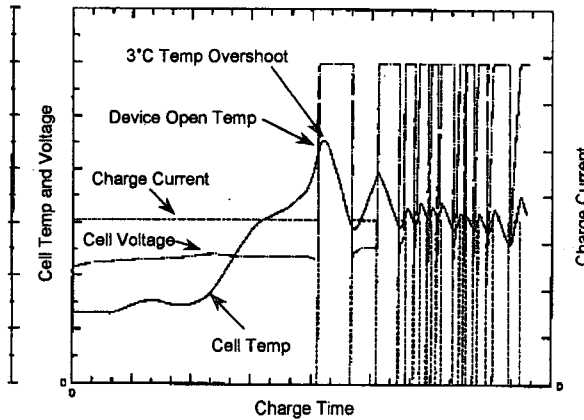
TYPICAL CELL OVERCHARGE TEST



The Device Can Re-close Without 5°C Overshoot

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TYPICAL CELL OVERCHARGE TEST



Protector Technology Comparison

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<p><u>Bi-Metal</u></p> <ul style="list-style-type: none"> + Can be designed as a fuse or cycling control + Has very low resistance - Sensitive to shock 	<p><u>Eutectic Fuse</u></p> <ul style="list-style-type: none"> + Has very low resistance + Inexpensive - Can be used as a fuse control only - Maximum rated current is 4 amps
<p><u>PPTC</u></p> <ul style="list-style-type: none"> + Can be used as a fuse or cycling control + Performs well under "dashboard" test + Small size - Power must be removed to reset the switch - Initial resistance 15 to 50 mΩ - Max hold current at 25°C is 2.3 amps - Max hold current at 60°C is 0.9 amps 	<p><u>Shape Memory Alloy</u></p> <ul style="list-style-type: none"> + Max hold current at 25°C is 9.0 amps + Max hold current at 60°C is 6.5 amps + Typical resistance < 5 mΩ - Can be used as a fuse type control only - Requires 5 °C of overshoot to ensure open circuit

SMA Benefits

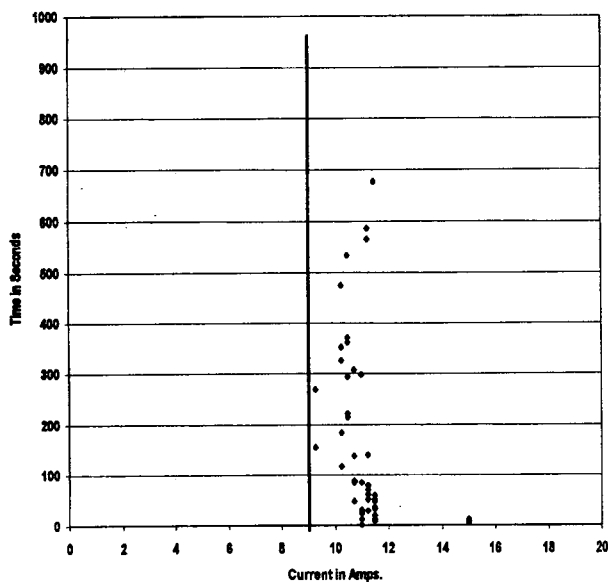
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■ Higher Current Carrying Ability

- SMA based controls carry more than twice the rated current of PPTCs
- Does not require elevated switch temps like PPTCs
- High pulse rate capability
 - ✓ 100A for 10 msec at 25°C
- High current carrying ability at elevated temperatures allows increased cell performance under extreme conditions

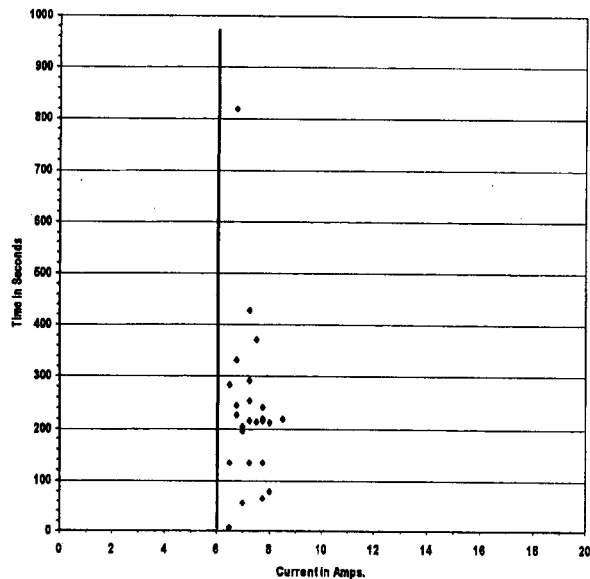
UT Test Data - Current Vs. Trip Time 25°C

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UT Test Data - Current Vs. Trip Time 60°C

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SMA Benefits

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- **Low Switch Resistance:**
 - Resistance specification is < 10 mΩ
 - Typical resistance is < 5 mΩ
 - Lower resistance minimizes power losses due to circuit resistance
 - Lower switch resistance minimizes current de-rating effect on open temperature

Therm-O-Disc Product Offerings

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- **SMA based switches as well as SMA components can be custom engineered to specific applications**
- **Licensing of SMA technology is available**
- **Switches using other basic technologies are also available from Therm-O-Disc / Emerson Electric**