Ametherm

Inrush Current Limiters (ICL)
and Custom Temperature Sensors (NTC)

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Focus Areas

Inrush Current Limiters:

- Negative Temperature Coefficient (NTC)
- Positive Temperature Coefficient (PTC)
- UL- and CSA-Rated ICLs
- Manufacturing Locations: Carson City, NV, USA

Custom Temperature Sensors:

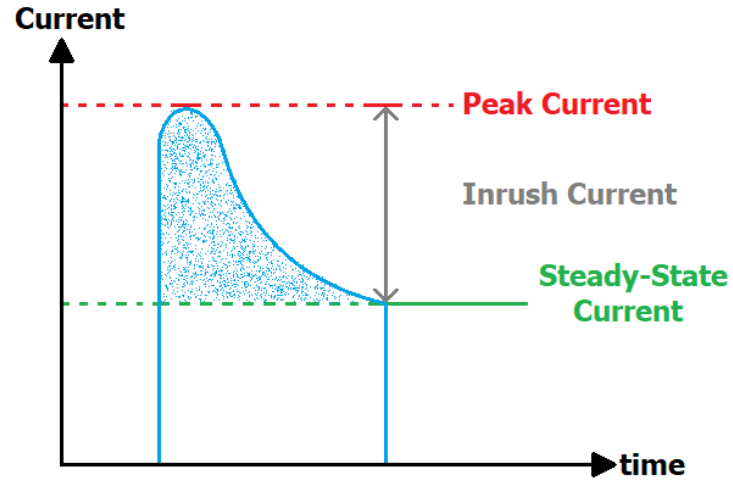
- Custom Probes and Leads
- Negative Temperature Coefficient - NTC
- Resistance Temperature Detectors (RTDs)
- Assembly Locations: Carson City, NV, USA or La Laguna, Mexico

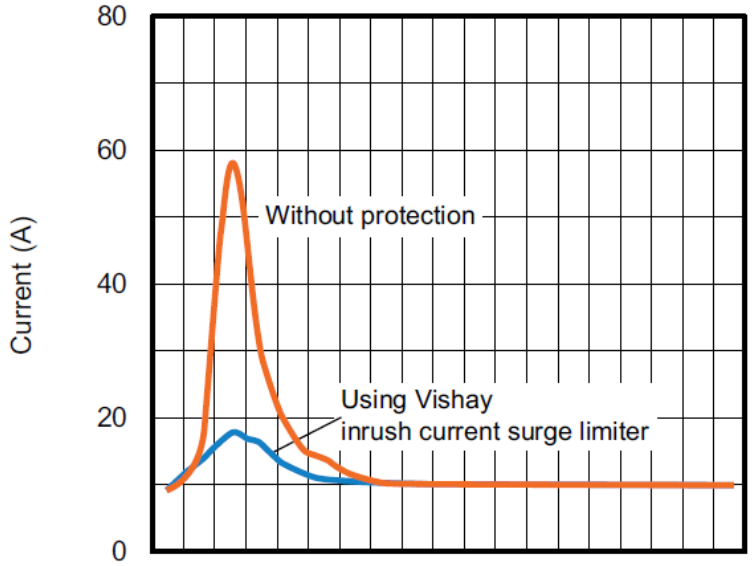
Inrush Current Limiters (ICLs)

Why Inrush Current Protection is Critical

Inrush Current: Surge or Spike in Current When Electrical Device is Turned on

- Protects sensitive or expensive components – rectifiers, capacitors, MOSFETs, IGBTs
- Prevents component stress or premature failure
- Reduces nuisance breaker trips
- Improves system reliability
- Extends product lifetime
- Supports compliance with energy and safety standards



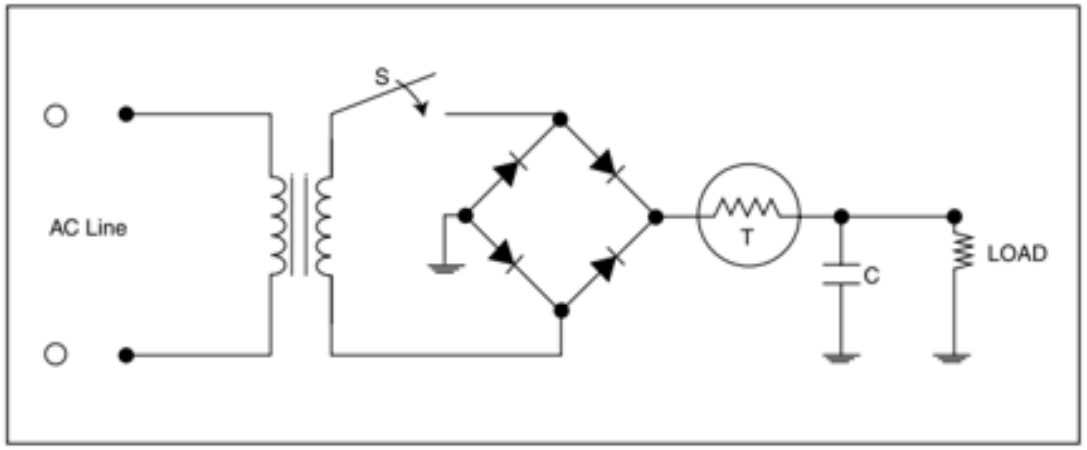


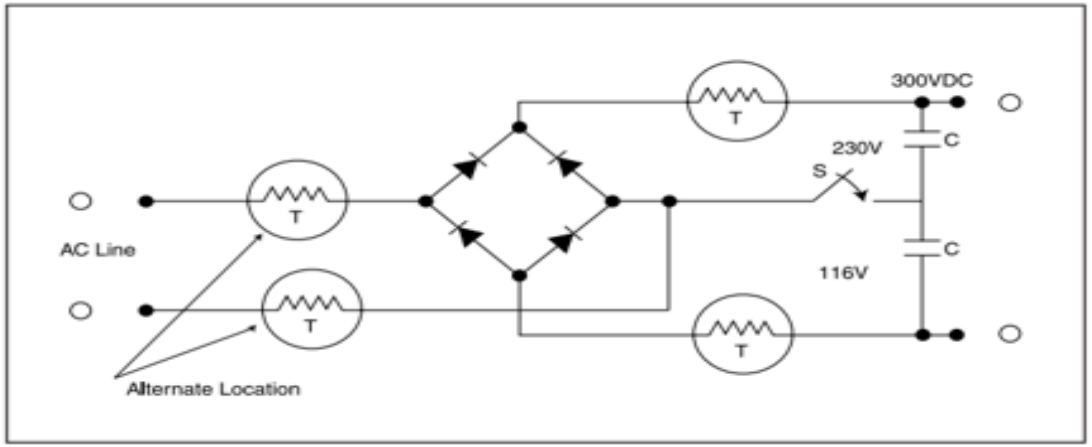
Solutions for Inrush Current Comparison

Technology Solution	Advantages	Disadvantages
NTC ICL	• **Single-part solution** for inrush as NTC removes itself from circuit after initial startup • **Lower total cost** compared to other solutions with relay • **Better reliability** (no relay) • **Excels in very high energy applications**	• Small amount of power loss through NTC during steady-state condition • Not ideal if ambient temperature will be low (too high of resistance at power on) • Necessary reset time for NTC ICL to cool after circuit is discharged
Resistor or Resistor with Bypass Relay	• Resistance will be steady for entire temperature range (good for broad operating ambient temperature, but requires relay)	• Power loss during steady-state (without relay) • Larger size versus energy capability of ICL / weight • Increased cost, space, reliability concerns from relay
NTC ICL with Bypass Relay	• Smaller PCB footprint than resistor + relay solution • No reset time, as the NTC ICL cools when bypassed once steady-state condition of circuit is reached • Excels in very high energy applications	• Increased cost, space, reliability concerns from relay
PTC ICL with Bypass Relay	• In case of a fault of the load, PTC opens circuit • PTC can be used at low startup temperature and wider operating temperature range than NTC	• Increased cost, space, reliability concerns from relay
Soft Start (Active Solution, Using Thyristors / SCRs)	• Can also offer additional built-in protection against overcurrent / voltage imbalance	• Complex in implementation and part count on BOM • Expensive, especially for very high energy / high voltage conditions requiring more active components

Growth Drivers:

- Expansion of EV and charging Infrastructures
- Electrification across industries
- Growth in renewable energy systems
- Increasing industrial automation
- Rising demand for energy efficiency





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Industry Segments - Inrush Current Limiters

Industrial

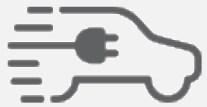
- Power supplies
- Inverters
- Motor drives
- Pumps
- Welders
- Robotics
- Test equipment

Green Energy

- EV fast charging
- Solar inverters
- Energy storage systems
- Wind converters
- LED lighting systems
- Solid oxide fuel cells

Automotive

- EV fast charging
- On-board chargers
- DC/DC converters
- Motor drives

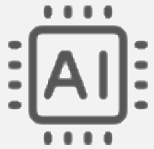


Medical

- Imaging systems
- MRI
- Robotic surgery
- Monitoring equipment

Data Centers

- Server power supplies
- UPS systems
- Network equipment
- Telecom power modules



Product Selection

Inrush Current Limiter (ICL)

- Is **power supply section of application design done in-house**?
- Are high capacitance **electrolytic capacitors** or **power transformers** used in the design?

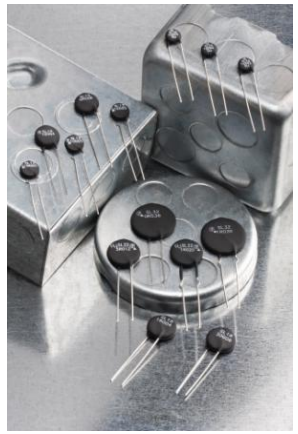
Need to know…

- **Input voltage** (V - volts) & **output power** (W - watts) to calculate..
  - **Steady-state current** (SSI in unit A – amps) requirement
- **Voltage** (V - volts) & **capacitance** (C in unit µF - microFarads) to calculate…
  - **Max energy** requirement (E in unit J - joules)
- Resistance (R in unit ohms (Ω))
  - Resistance at 25 °C ($R_{25°C}$)
  - Resistance at 50 % max current
  - Resistance at 100 % max current

PART NUMBER	RESISTANCE AT 25 °C (R_{25}) (Ω)	TOLERANCE ON R_{25} VALUE (%)	MAX. STEADY-STATE CURRENT UP TO 65 °C (A)	MAX. RECOMMENDED ENERGY RATING (J)	MAX. VOLTAGE (V_{RMS})
SL220R516	0.5	± 25	16	160	265
SL220R516A	0.5	± 25	16	160	265
SL220R712	0.7	± 25	12	120	265
SL220R712B	0.7	± 25	12	120	265
SL221R020	1	± 20	20	65	265
SL222R018	2	± 20	18	90	265

Example specifications from SL22 datasheet

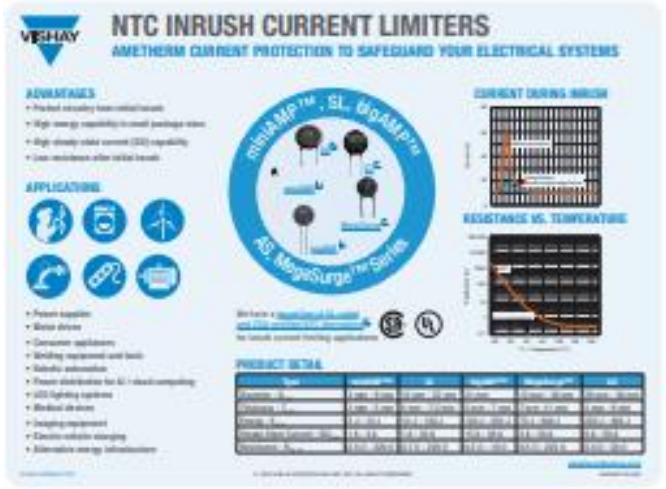
NTC ICL Series

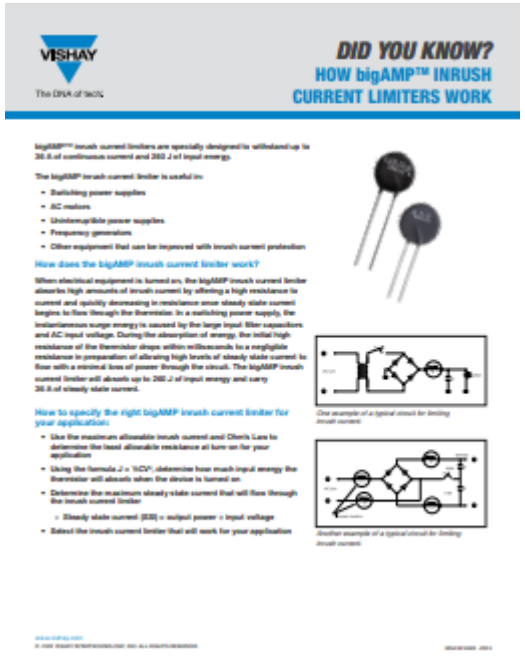


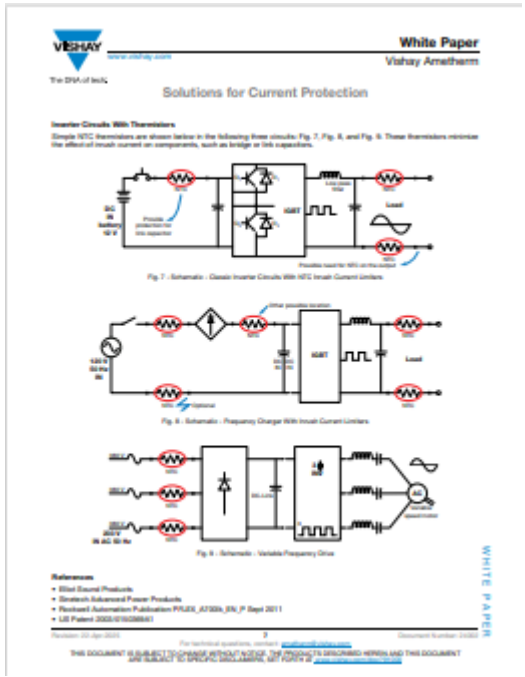
Type	miniAMP – SL03, SL05, SL08	SL – SL10, SL12, SL15, SL18, SL22	bigAMP – SL32	MegaSurge – MS	AS
Diameter - D_{max}	3 mm – 9 mm	10 mm – 22 mm	31 mm	14 mm – 38 mm	29 mm – 36 mm
Thickness - T_{nom}	3 mm – 5 mm	4 mm - 7.5 mm	5 mm – 7 mm	7 mm – 11 mm	5 mm – 9 mm
Energy - E_{max}	2 J – 12 J	10 J – 150 J	100 J – 250 J	75 J – 800 J	250 J – 800 J
Steady-State Current – SSI_{max}	1 A -3 A	1 A – 20 A	15 A – 36 A	2 A – 50 A	6 A – 50 A
Resistance - $R_{25°C}$	2.5 Ω - 220 Ω	0.7 Ω – 220 Ω	0.3 Ω – 10 Ω	0.5 Ω – 220 Ω	0.5 Ω – 50 Ω
Applications	Small appliance, amplifier, phone charger	Large appliance, motor drive, power supply	Frequency generator, motor drive, power supply	Imaging scanner, robotic automation, LED lighting power distribution	Residential energy storage, test equipment, solid oxide fuel cell, laser

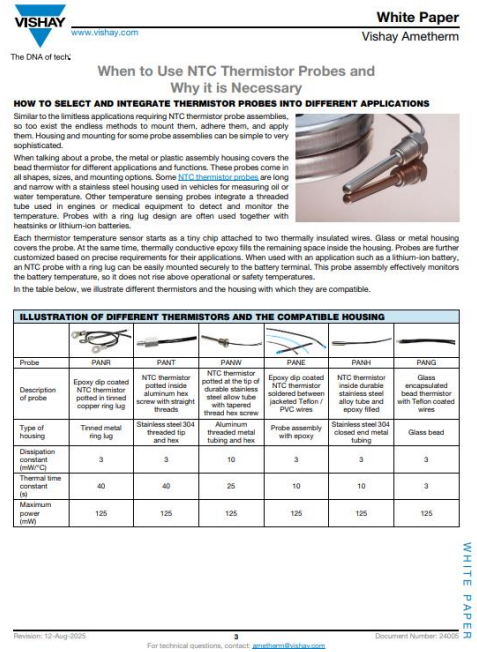
Supporting Tools

- **Infographic** – NTC ICLs
- **Did you know** -- Circuit Protection with miniAMP
- **Did you know** -- How bigAMP Inrush Current Limiters Work
- **White Paper** -- Solutions for Current Protection (PTC & NTC ICLs)
- **White Paper** -- When to Use NTC Thermistor Probes and Why it is Necessary









NTC INRUSH CURRENT LIMITERS

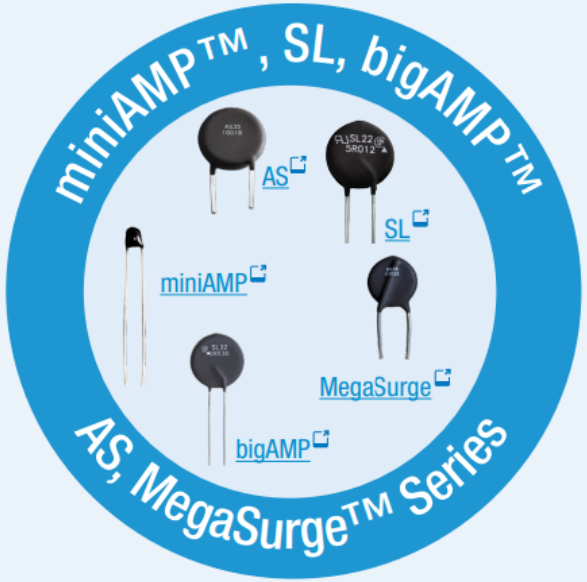
AMETHERM CURRENT PROTECTION TO SAFEGUARD YOUR ELECTRICAL SYSTEMS

ADVANTAGES

- Protect circuitry from initial inrush
- High energy capability in small package sizes
- High steady-state current (SSI) capability
- Low resistance after initial inrush

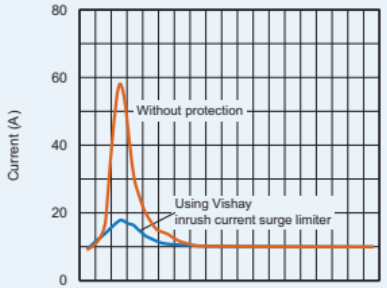
APPLICATIONS

- Power supplies
- Motor drives
- Consumer appliances
- Welding equipment and tools
- Robotic automation
- Power distribution for AI / cloud computing
- LED lighting systems
- Medical devices
- Imaging equipment
- Electric vehicle charging
- Alternative energy infrastructure

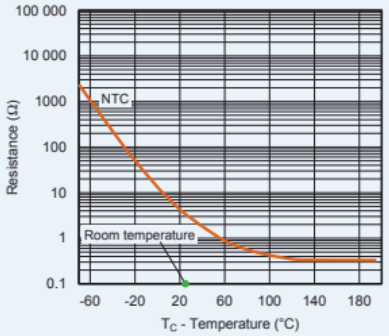


We have a broad line of UL-rated and CSA-certified NTC thermistors for inrush current limiting applications

CURRENT DURING INRUSH



RESISTANCE VS. TEMPERATURE



PRODUCT DETAIL

Type	miniAMP™	SL	bigAMP™	MegaSurge™	AS
Diameter - D_{max}	3 mm - 9 mm	10 mm - 22 mm	31 mm	12 mm - 38 mm	29 mm - 36 mm
Thickness - T_{nom}	3 mm - 5 mm	4 mm - 7.5 mm	5 mm - 7 mm	7 mm -11 mm	5 mm - 9 mm
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IG40956778-2503

Custom Temperature Sensors and Probe Assemblies

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Temperature Sensor Technologies

Type of Temp Sensors	Temperature Range & Applications
• NTC	• -50 °C – 250 °C, low cost, ease of packaging, sensitivity, accuracy, fast response
• Silicon	• -20 °C – 150 °C, linearity, low power
• Thermocouple	• -200 °C to +1750 °C, harsh corrosive environment
• RTD	• Accurate, repeatable, high cost

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Industry Segments - Temperature Sensors

Industrial

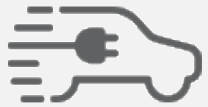
- Welders
- Plasma cutters
- Inverters
- HVAC water heaters
- Grid tie inverters

Medical

- Thermometry
- Control circuits for release of medication under certain temperature
- Respiratory pumps

Automotive

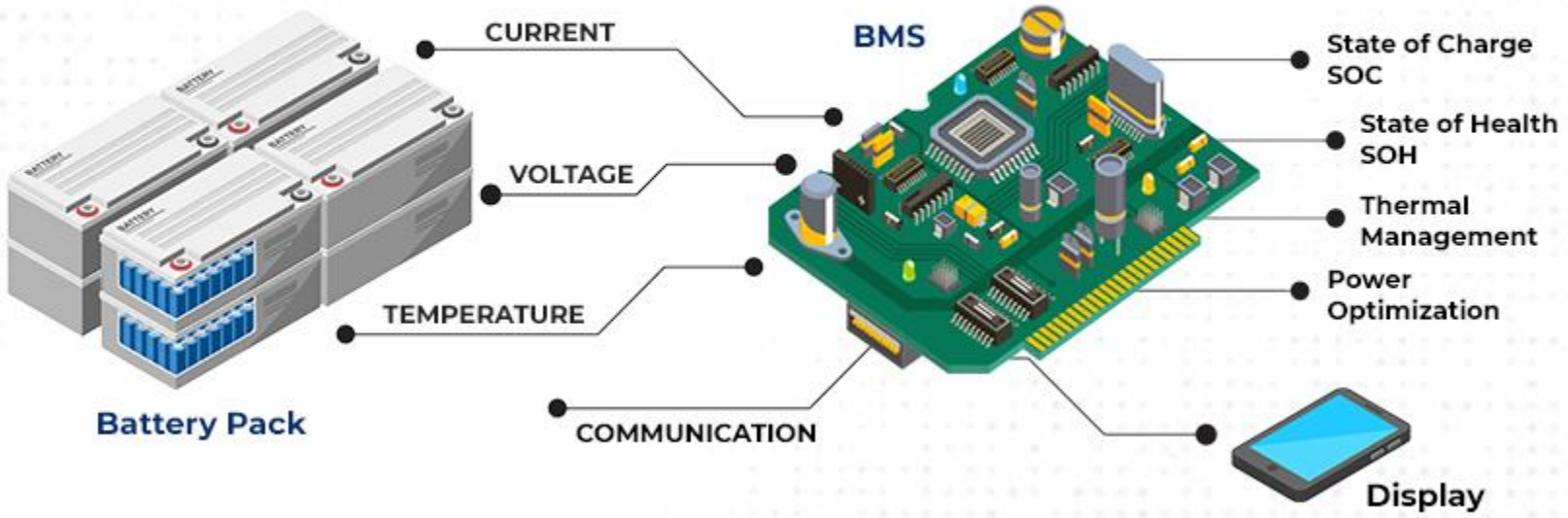
- EV charging
- EV cable assemblies
- BMS
- Battery testers
- Monitor of fluid temperatures
- Climate control



Aerospace / Military

- Refrigeration in airplanes
- BMS
- Proprietary monitoring of temperature for military hardware

BATTERY MANAGEMENT SYSTEM
FOR ELECTRIC VEHICLES



Advantages

- UL-recognized probes with values of 10 KΩ and 30 KΩ
- Fast response and high sensitivity
- Accuracy up to ± 0.1 °C, fast response, high sensitivity,

Operating Conditions

- -50 °C to +250 °C
- Dielectric up to 5000 V_{AC}
- Pull test up to 10 Kgf for use in demanding harnesses

Custom Temperature Sensors and Probes

Product Examples

Probe w/ Ring Lug

Probe w/ Threaded Hex

Custom Probe Threaded Long Tip

Probe w/ Epoxy

Accu Curve

DG Series

Probe Assembly Steel Housing

Custom Temperature Sensors and Probes

Customization Options

What is…

1) …the operating temperature range?
2) …the RT curve (resistance-temperature curve)?
3) …the medium that a sensor is needed to sense the temperature?
4) …the dielectric voltage requirement?

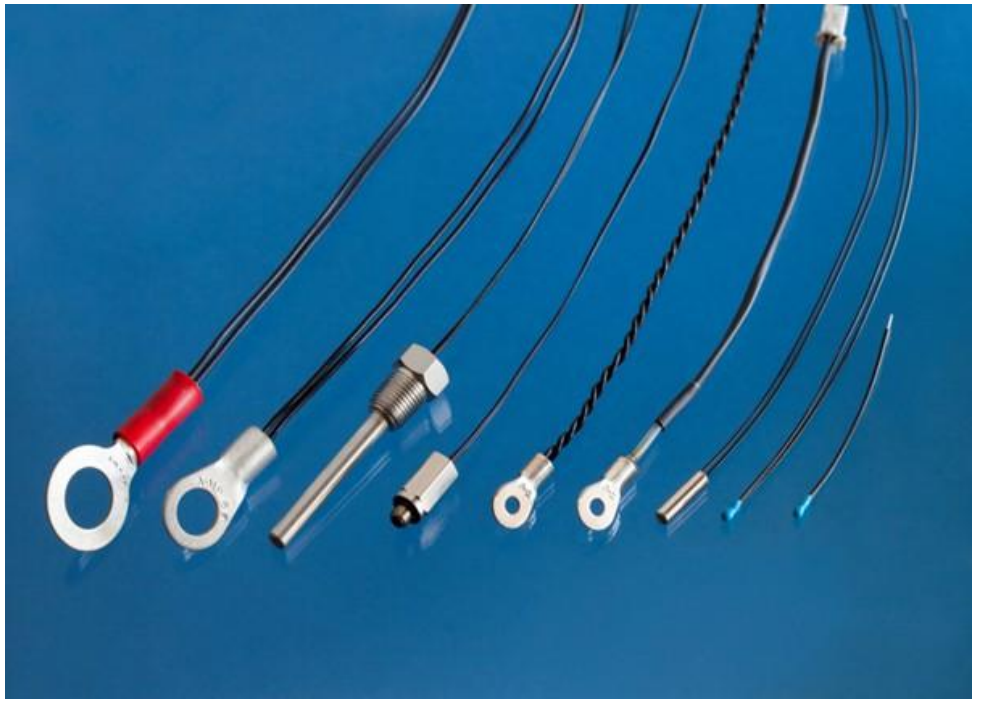
Knowing answers to the above four questions will help you ask the following questions:

1) What type of housing is needed?
2) What type of wire is required?
3) How much wire is required?
4) What type of connectors, if any, for ease of measurement is needed?

Custom Temperature Sensors and Probes

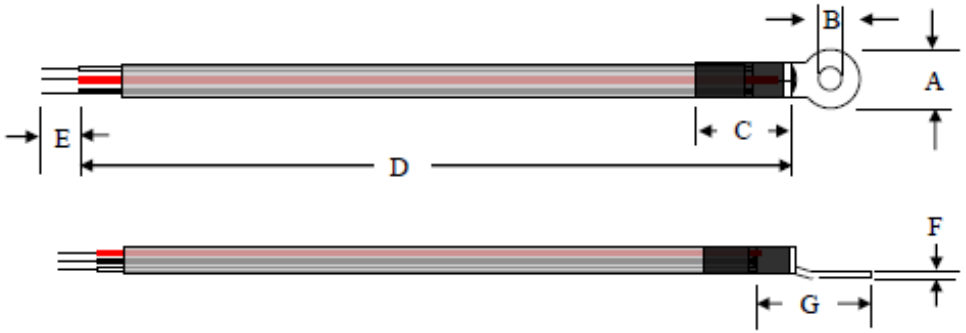
Customization Options

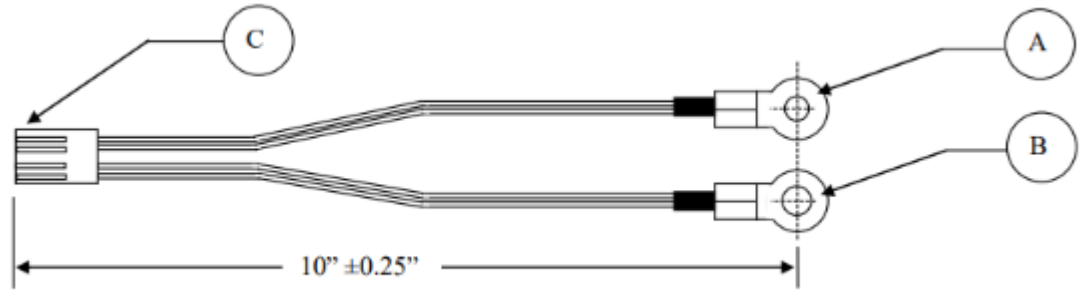
- Probe housing or ring lug or epoxy coated
- Operating temperature range
- RT curve (resistance-temperature curve)
- Wire length
- Wire gauge
- Bonded pair / twisted pair / sleeved wires / etc.
- Connector type
- Special certifications, such as UL approval
- High dielectric strength

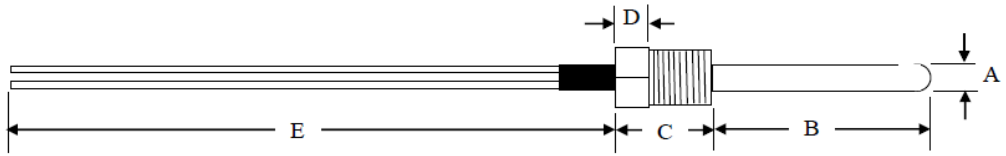


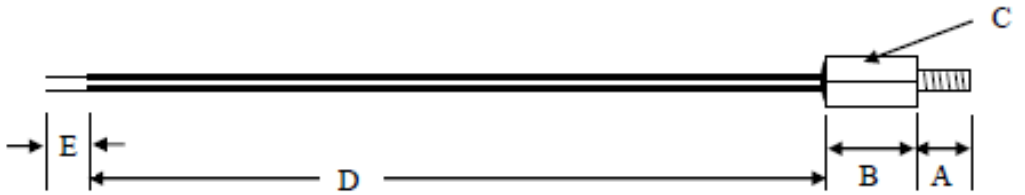
Custom Temperature Sensors and Probes

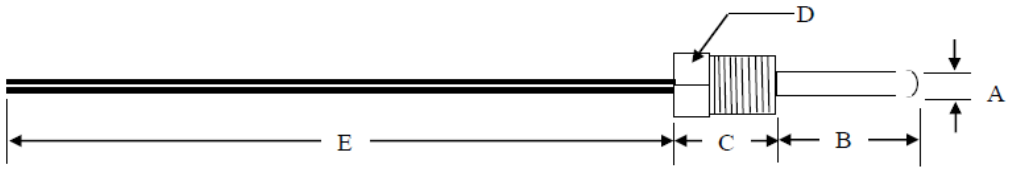
Product Examples

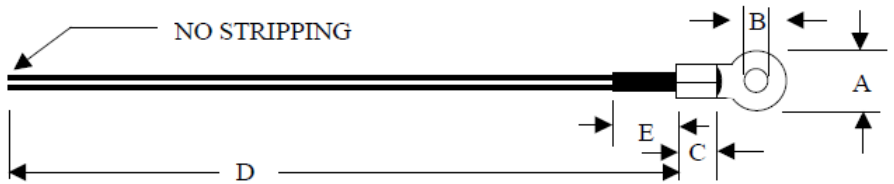


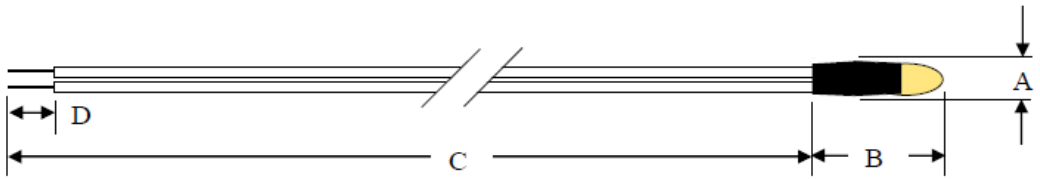


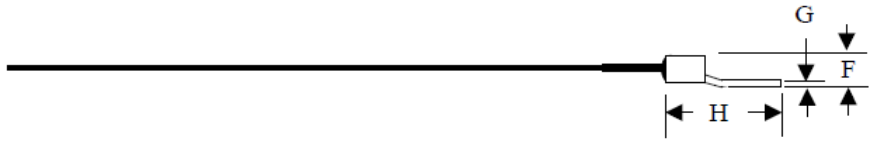












Ametherm

Inrush Current Protection – Inrush Current Limiters (ICLs) &
Custom Temperature Sensing Probes

WHERE TO HUNT

Target Customers: ChargePoint, BiAmp, Eaton, Emerson, Enphase, Rheem, GE health, Generac, Rockwell Automation, Schneider, Ford, Tesla, Rivian, Lucid, Miller, Ametek, Astrodyne, ABB, Acuity, Moog, Ryobi, Verizon, Caterpillar, Lincoln Electric, HACH, Nidec, MPS, Boston Scientific, SpaceX, Medtronic, Carrier, Philips Respironics, Stryker, Thermo Fisher Scientific

Door Opener Questions:

- Is the **power supply** section of the application designed in-house?
- Does your design include **electrolytic capacitors**, **power transformers**, or **motor drives** that cause inrush or need controlled energization?
- Does **sensitive equipment** need protection from startup **voltage spikes** or **high current draw**?
- Is Inrush condition causing **breakers to trip** or **blown fuses**?
- Very high energy Inrush Conditions up to E = 800Joules?
- Is Steady State Current draw more than I=10A up to 50Amp?
- Any special requirements for temperature sensing probes?

HOW TO CLOSE: Advancing the opportunity

- MOST ICL PNs are available in stock at sample site today!
- Fast PN development and samples for custom temperature probes

APPLICATIONS

Industrial: Power Supply, Inverter, Motor Drive, Pump, Welder, Robotics, Test equipment, Grid Tie Inverter

Green Energy: Solid Oxide Fuel Cell, Solar Inverter, Wind Converters, Energy Storage Systems, LED Lighting Systems

Medical: Imaging Systems / MRI, Monitoring Equipment, Thermometry, Respiratory Pump, Robotic Surgery

Data Centers: UPS Systems, Telecom Power Modules, AI / Cloud server power supplies

Automotive: EV Charging, On-board Charger, BMS, Climate Control

HOW TO SELL: Sell the Solution, not the component

- **NTC ICLs** – **highest energy** inrush circuit protection with no relay
- **NTC ICLs** -- Country of Origin **USA**
- **PTC ICLs** – high energy inrush circuit protection for **wide operating temperature range** (-40°C to +120°C)
- **Custom Temperature Sensing Probes** – highly customizable including wire length/type, connector, housing, RT curve, high dielectric voltage strength, special safety certifications (i.e. UL)
- **Temperature Sensing Probes** – Low or Medium quantity volume high mix industrial customers are no problem
- **Temperature Sensing Probes** – Assembled in **USA** or **Mexico**

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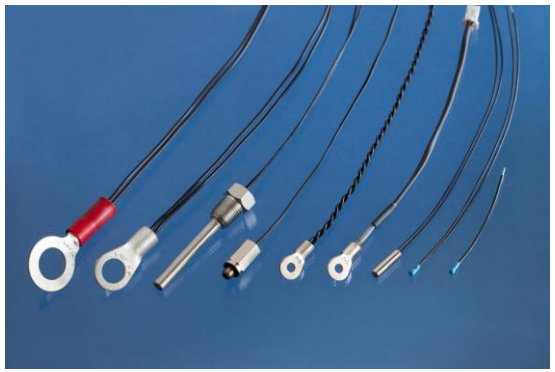
Why Ametherm:

- Manufacture Locations:
  - Carson City, NV USA
  - La Laguna, Mexico
- Power Density
- Ruggedized and Reliable
- Recognized by UL and CSA
- Flexibility and Customizable



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