

**BUILT TO WIN**

VISHAY EVERYDAY

AMERICAS SALES CONFERENCE

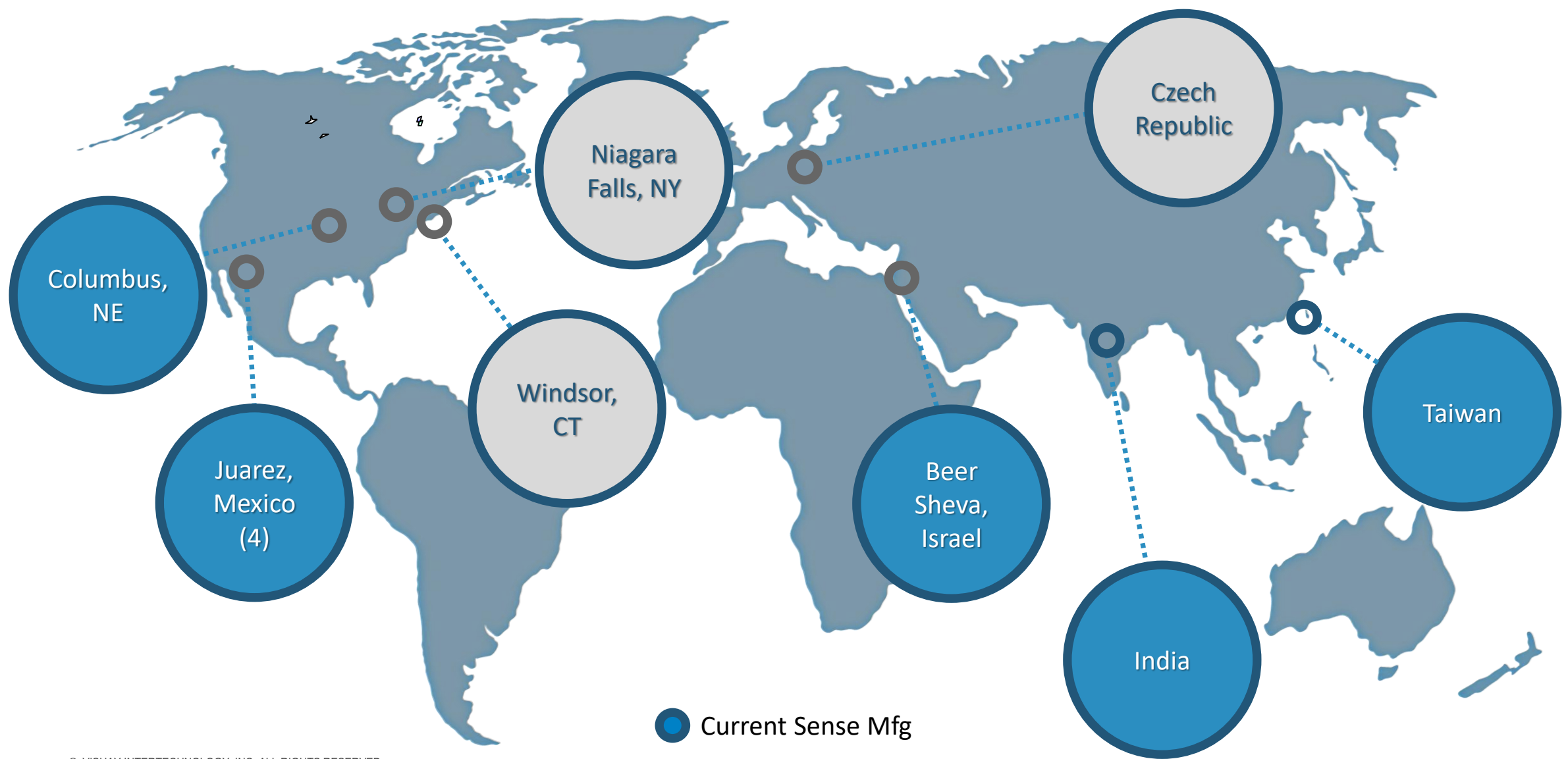
**VISHAY®**

**Dale Knows**

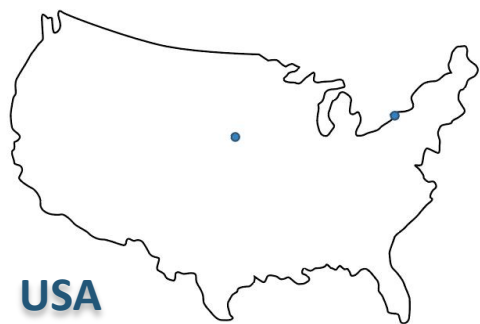
**VISHAY**

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# Vishay Dale Knows – Manufacturing



# Vishay Dale Knows - Americas



USA



Mexico



Israel



**Trevor H.**  
Columbus, NE



**Juan R.**  
Bermudez 1



**Pedro V.**  
Bravos Plant



**Tom M.**  
Niagara Falls, NY



Bermudez 2

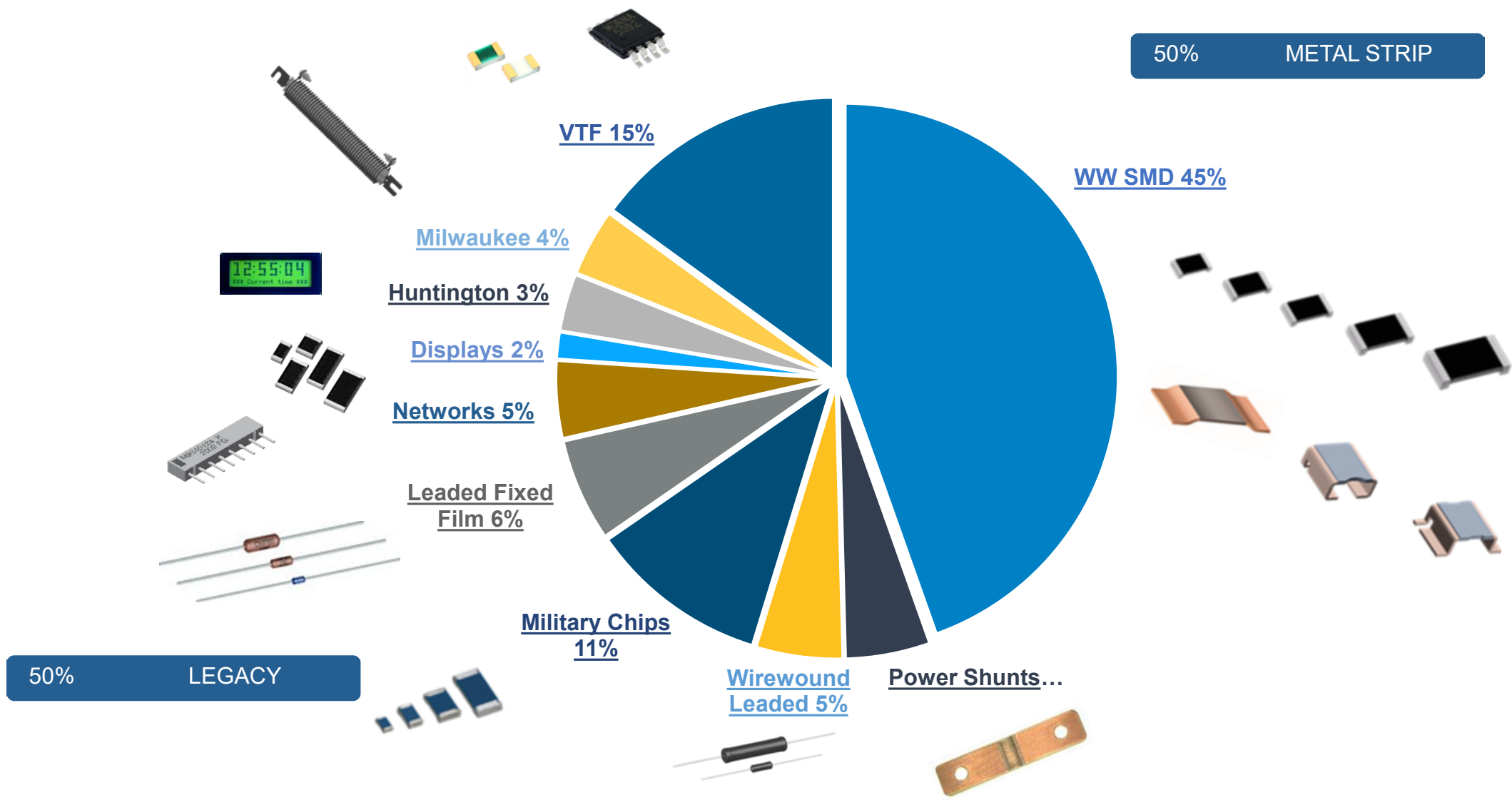


Las Torres Plant

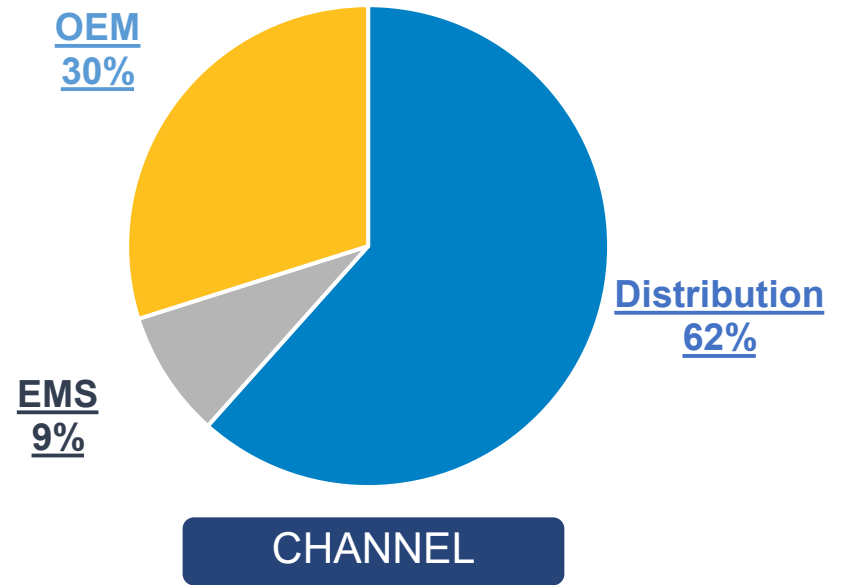
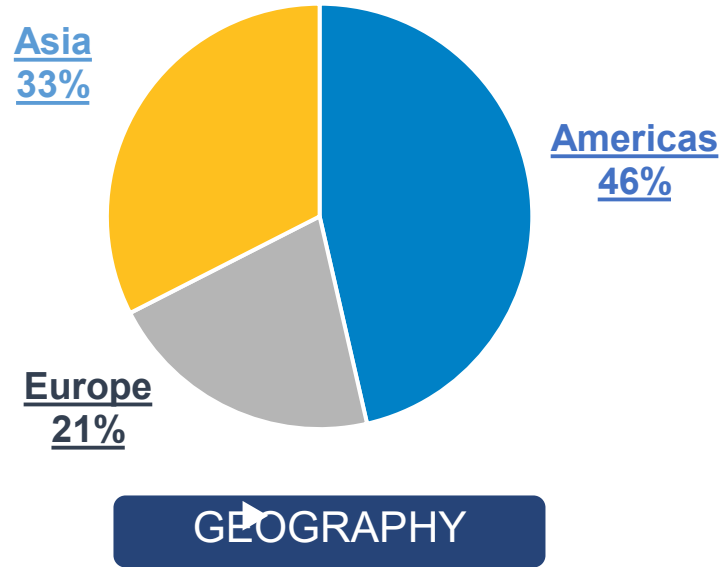
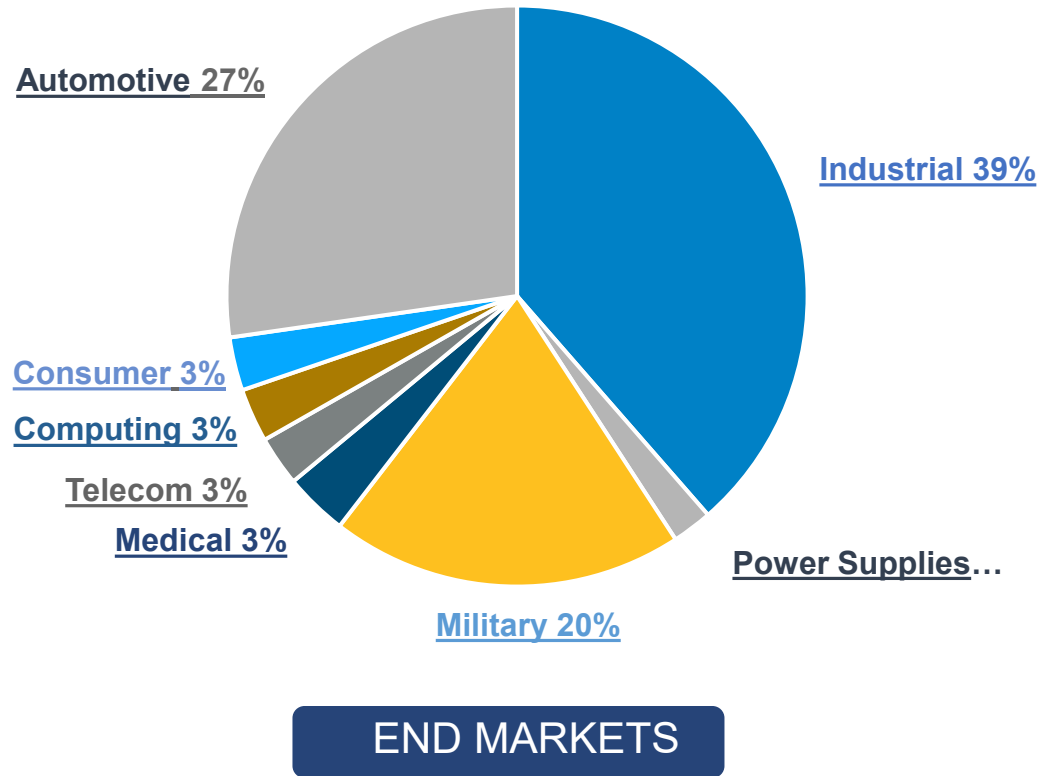


**Zion Y.**  
Beer Sheva

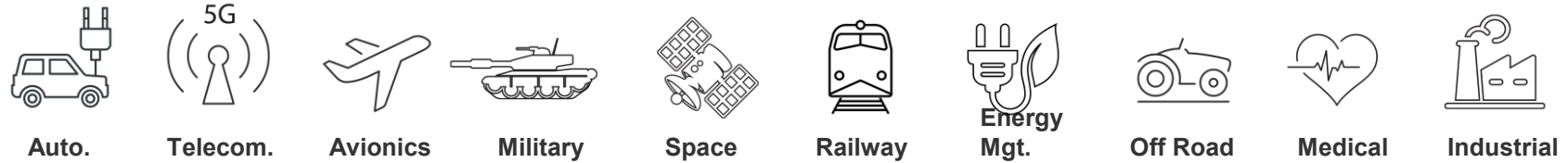
# Vishay Dale Knows - Resistors



# Vishay Dale Knows - Markets



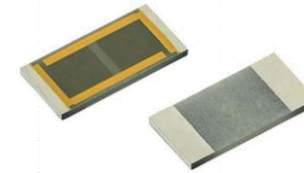
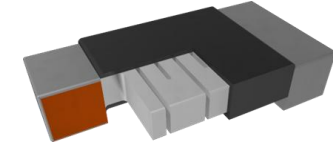
# Vishay Dale Knows – Markets and Technology Focus



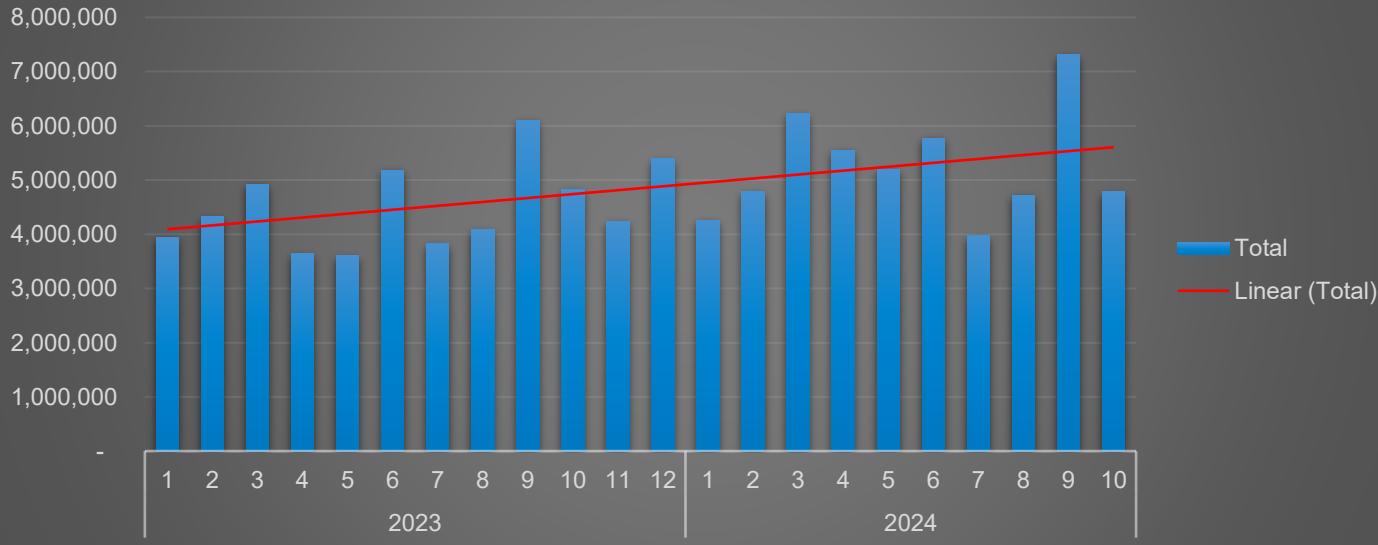
	Auto.	Telecom.	Avionics	Military	Space	Railway	Energy Mgt.	Off Road	Medical	Industrial
<b>Thick Film</b>	●	●	●	●	●	●	●	●	●	●
<b>Thin Film</b>	●	●	●	●	●	●	●	●	●	●
<b>Current Sense</b>	●	●	●	●	●	●	●	●	●	●
<b>Power</b>	●	●	●	●	●	●	●	●	●	●
<b>Networks and Arrays</b>	●	●	●	●	●	●	●	●	●	●
<b>Displays</b>	●	●	●	●	●	●	●	●	●	●

# Vishay Dale Knows - Capacity

- Power Metal Strip Current Sense (Mexico)
  - Dale invested \$90M over last 3 years.
    - WSLx 1206, 2010, 2512 lead times are currently less than 10wks.
- Thick Film Chips (Israel)
  - 5-year investment plan for Thick Film Chips – Mil 55342, RCWE, High Voltage Chips
    - Expand capacity by 278%
- VTF – Thin Film Chips (Niagara Falls, USA)
  - Capacity investment over 3-year period, started Q3 2022.



VTF Output



Goal set to **Double** Output over 2023 by EOY 2024. - Achieved

New Goal to increase another **30%** by end 2025

# Vishay Dale Knows - Automotive



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## PRODUCTS

- RHA Pre-Charge & Discharge Wirewound Resistors
- WSLx, WSKx, WSBE
- CRMA
- CRHA
- CDMA

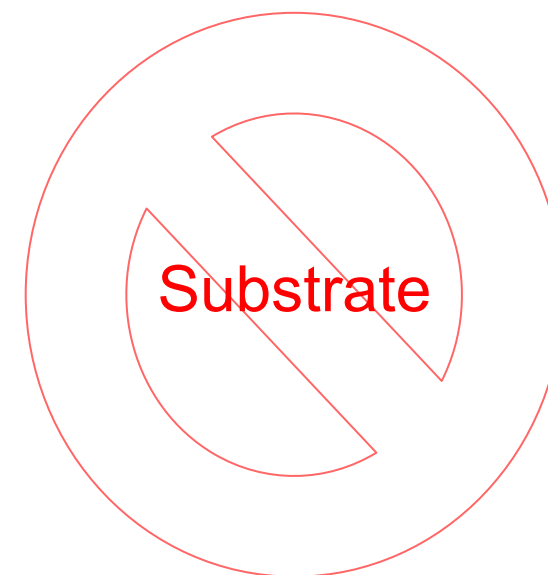
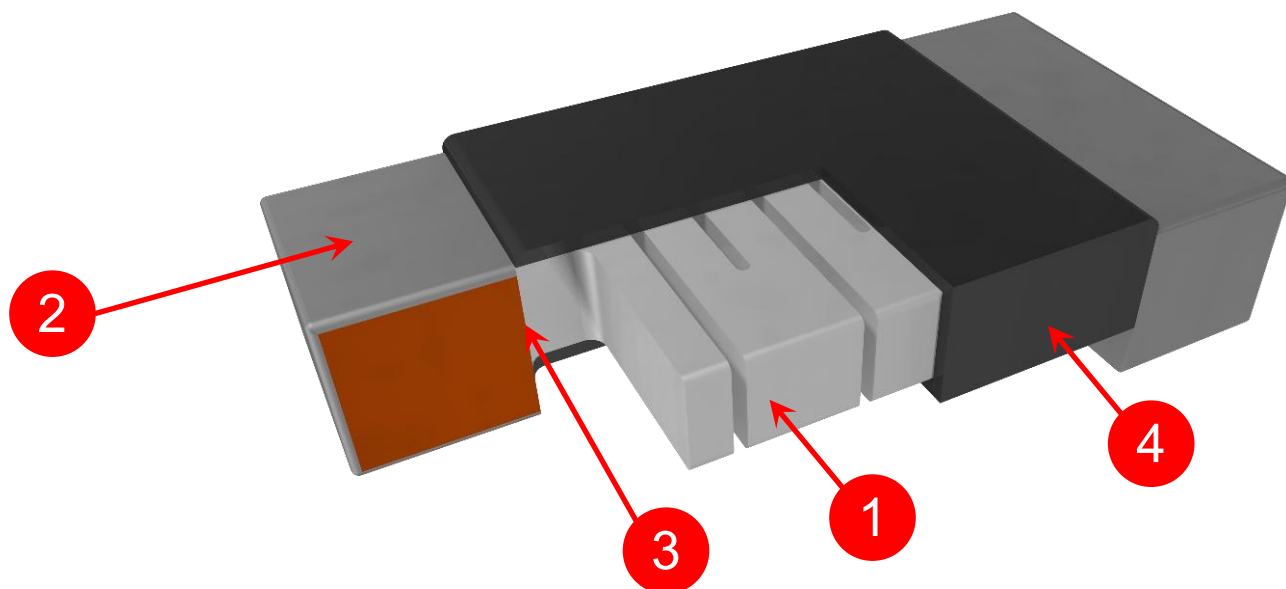
## COMPETITIVE EDGE

- AEC-Q200 qualified
- Molded construction for total protection
- Complete welded construction
- Mounts on chassis to utilize the heat-sink effect
- Excellent stability in operation
- #1 in Automotive Current Sensing

## APPLICATIONS

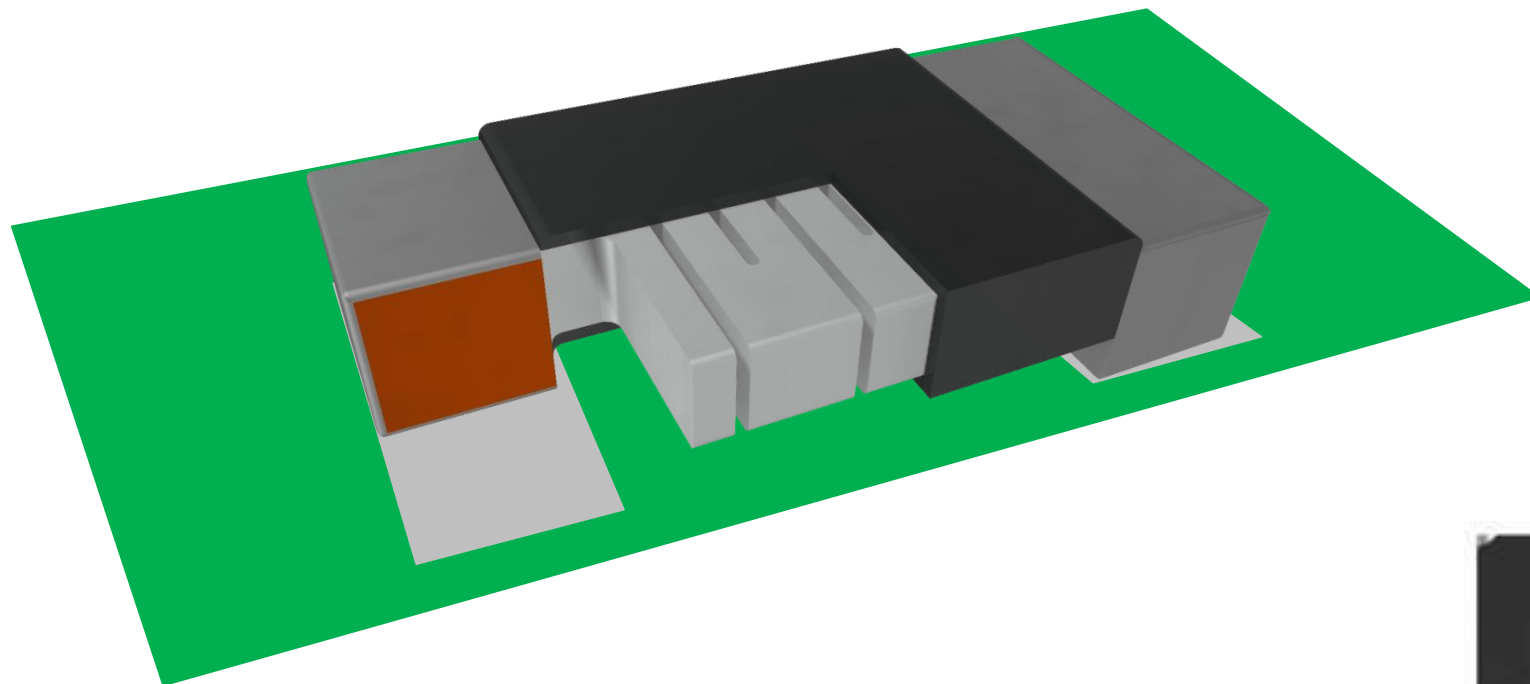
- Battery Management
- Motor Control
- Safety applications, such as Electric Power Steering and Braking

# Vishay Dale Knows - Power Metal Strip® - Construction



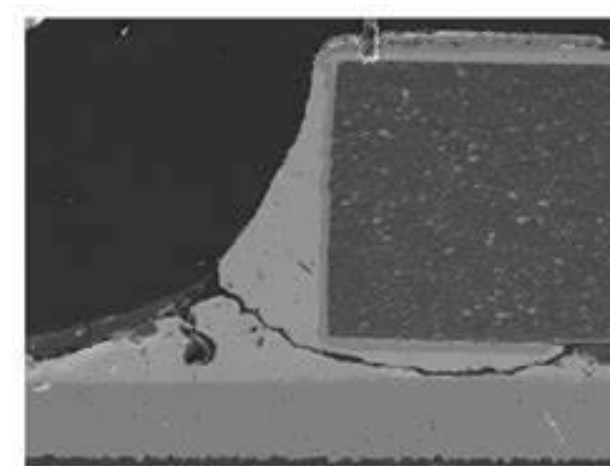
1. Resistive Element
2. Copper terminal with solderable finish
3. Terminal to Element weld
4. High temperature encapsulant

# Vishay Dale Knows – Board Level Reliability



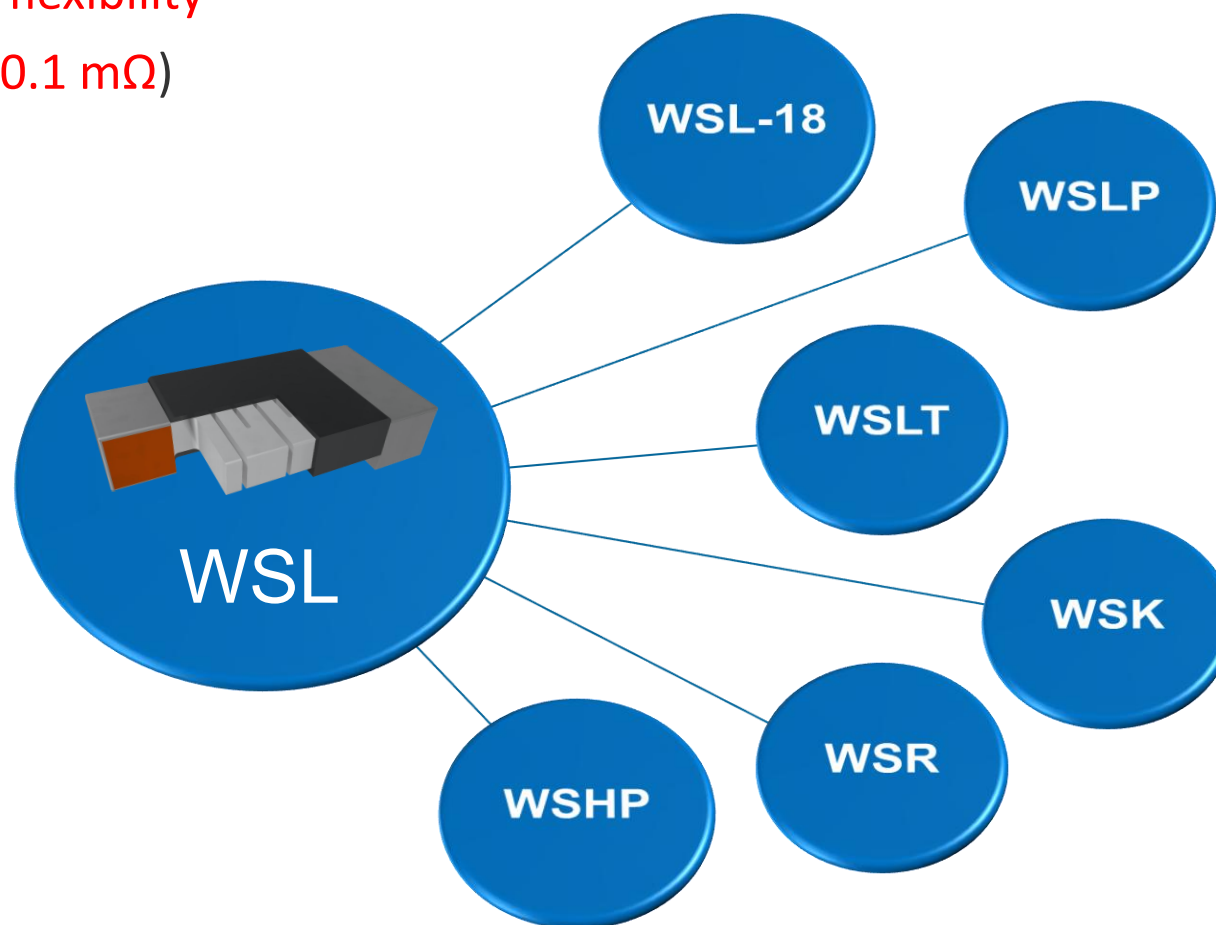
## CTE Values

1. FR4 pcb 15 ppm/°C
2. Ceramic 5 ppm/°C (**high** mismatch)
3. WSL 13 ppm/°C (**low** mismatch)



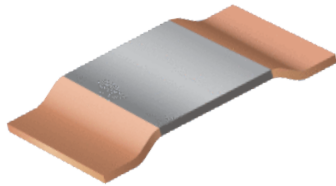
# Vishay Dale Knows - WSL Benefits & Related Product Families

- All metal welded construction (**no substrate**); superior pulse performance
- Laser trimmed providing design **flexibility**
- Low resistance values (down to **0.1 mΩ**)
- Low TCR (to **35 ppm/°C**)
- Lower thermal EMF (**< 3 μV/°C**)
- Tight tolerance (to **0.1%**)
- AECQ200 qualified



# Vishay Dale Knows – High Power Shunts

## WSLP3921

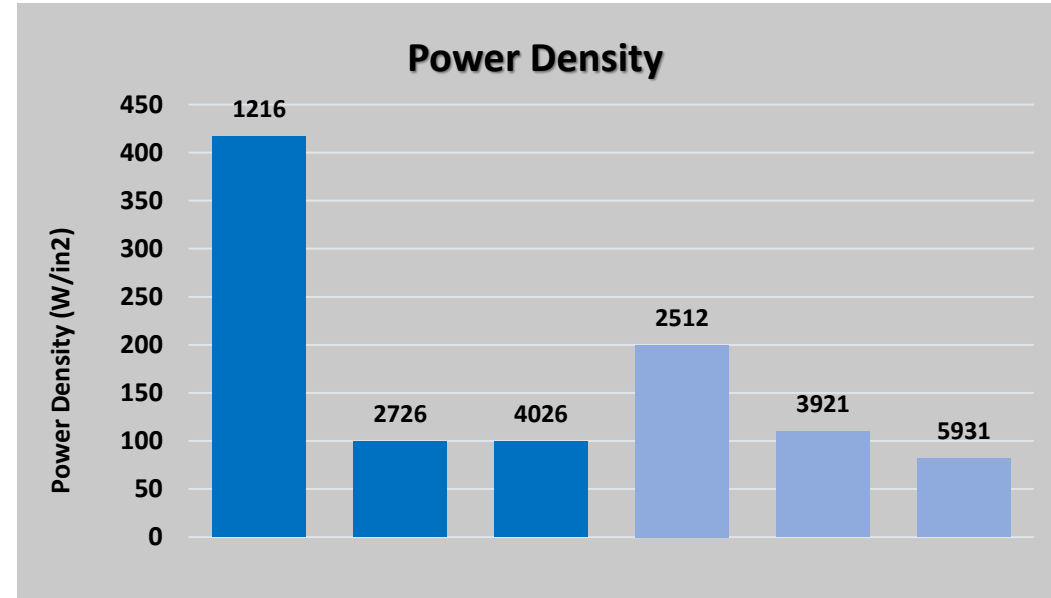


**9W** 0.1 mΩ to 1.5  
mΩ  
**5W** 2 mΩ to 4 mΩ

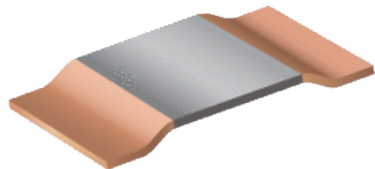
## WSLF2512



**10W** 0.3 mΩ, 0.5 mΩ  
**6W** 1 mΩ to 2 mΩ  
**4W** 3 mΩ  
**3W** 4 mΩ

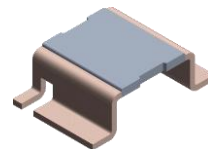


## WSLP5931



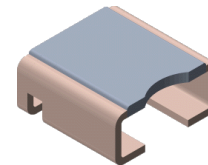
**15W** 0.1 mΩ  
**10W** 0.2 mΩ to 1  
mΩ  
**8W** 2 mΩ  
**7W** 3 mΩ

## WSLP4026



**12W** 0.2 mΩ  
**10W** 0.3 mΩ  
**7W** 0.5 mΩ to 1  
mΩ  
**5W** 1.3 mΩ to 5  
mΩ

## WSLP2726



**12W** 0.2 mΩ  
**10W** 0.3 mΩ  
**7W** 0.5 mΩ to 1 mΩ  
**5W** 1.3 mΩ to 5 mΩ

## WSK1216

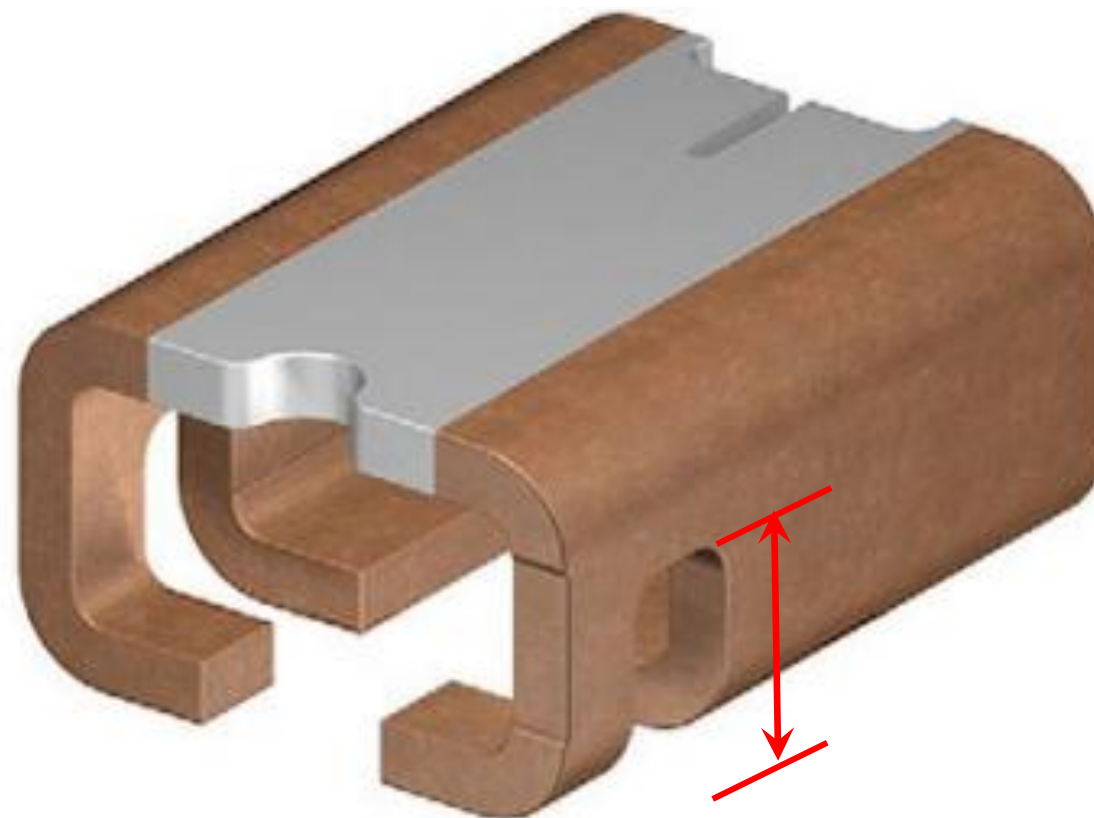


**8W** 0.2 mΩ, 0.3  
mΩ  
**5W** 0.5 mΩ  
**3W** 1 mΩ

# Vishay Dale Knows - 4-terminal Kelvin Termination

## Kelvin Termination Benefits

1. Improved measurement accuracy and repeatability as compared to a 2 terminal device.
2. TCR Performance of 50ppm/°C or better.



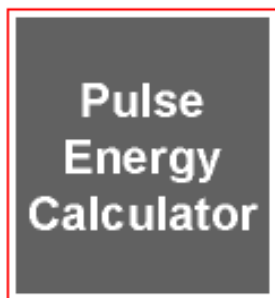
# Vishay Dale Knows – Engineering Tools

## JouleWizard

### PULSE TOOLS FOR CURRENT SENSE AND WIREWOUND RESISTORS

#### WAVEFORMS / SEARCH / CAPABILITY CURVES

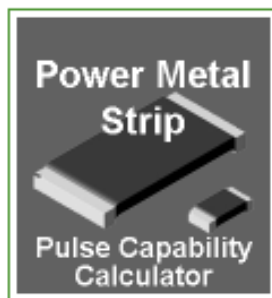
JouleWizard combines our pulse tools into a single location that enables you to determine the pulse energy of your waveform, parametrically searching for pulse capable products, to Pulse capability curves. JouleWizard also combines links to useful resources that will help you to understand the dimensions that affect product pulse performance.



**Determine**  
the energy content  
of a waveform



**Identify**  
products to meet the  
pulse requirements  
determined by the  
waveform



**Chart**  
the product specific capability over a wide range of time



#### Quick Reference

##### VIDEOS

[Power Metal Strip / Pulse Calculator](#)

[WSHP Overload video](#)

##### APPLICATION NOTES

[Pulse Handling](#)

[Pulse Load Checklist](#)

[Current Sense Measurements](#)

[Interactive Display](#)

[High Pulse Products](#)



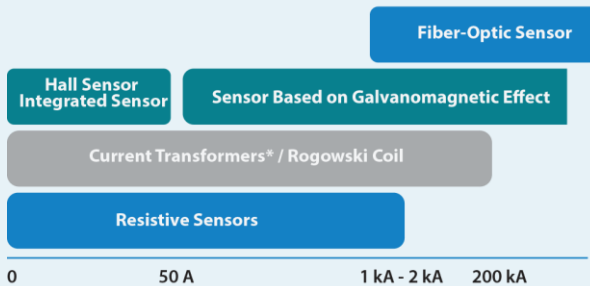
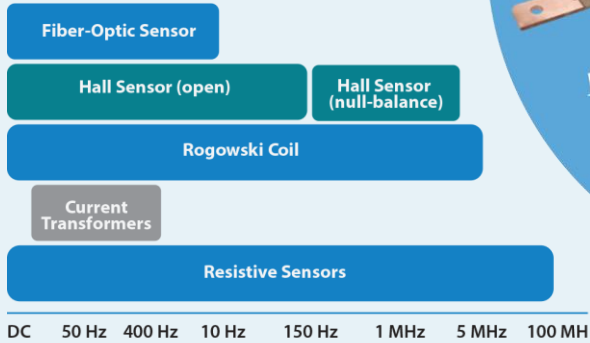
# POWER SHUNTS

## BATTERY AND METER CURRENT SENSE RESISTORS

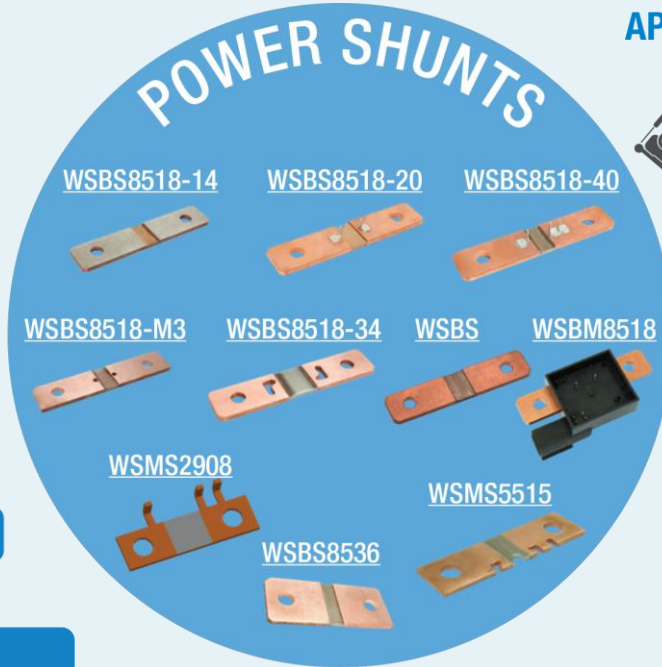
### FEATURES

- High power (up to 50 W)
- Pulse performance (> 1 kA)
- Stabilization available for low  $\Delta R$
- Not ESD-sensitive

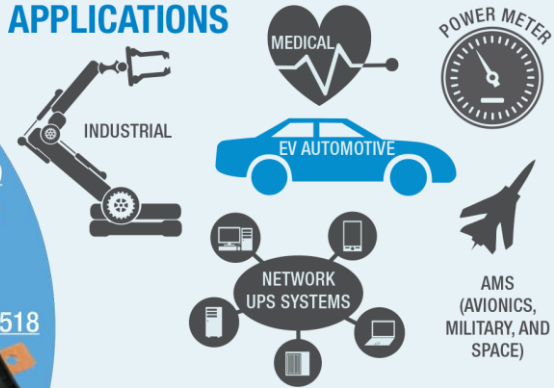
### THE GENERAL APPLICATION AREAS OF THE VARIOUS CURRENT SENSORS



\* For alternative current only

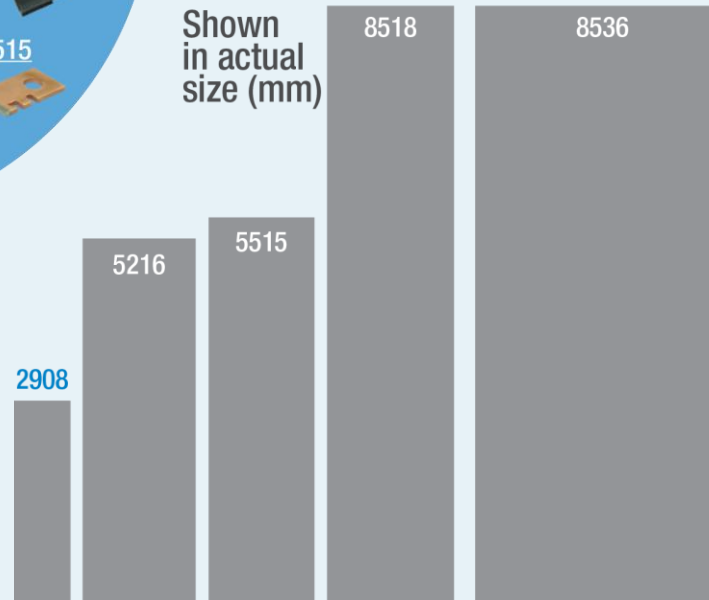


### APPLICATIONS



### FOOTPRINT

Shown in actual size (mm)



### CUSTOM OPTIONS

- Plated terminals
- Sense pins
- Shapes / sizes
- Molded body / connectors
- Improved RTC / thermal EMF alloys available

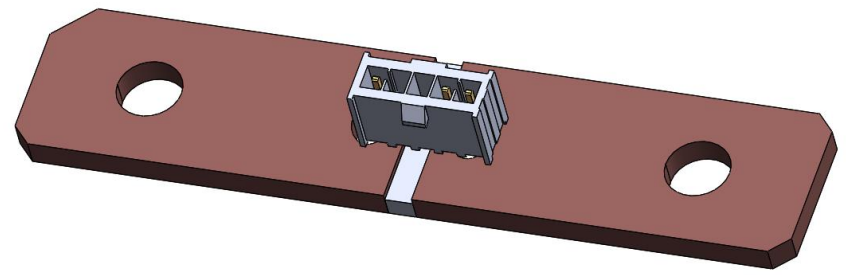
[ww2cresistors@vishay.com](mailto:ww2cresistors@vishay.com)

MS7515-2105

# Vishay Dale Knows - WSBE Series Optimized TCR

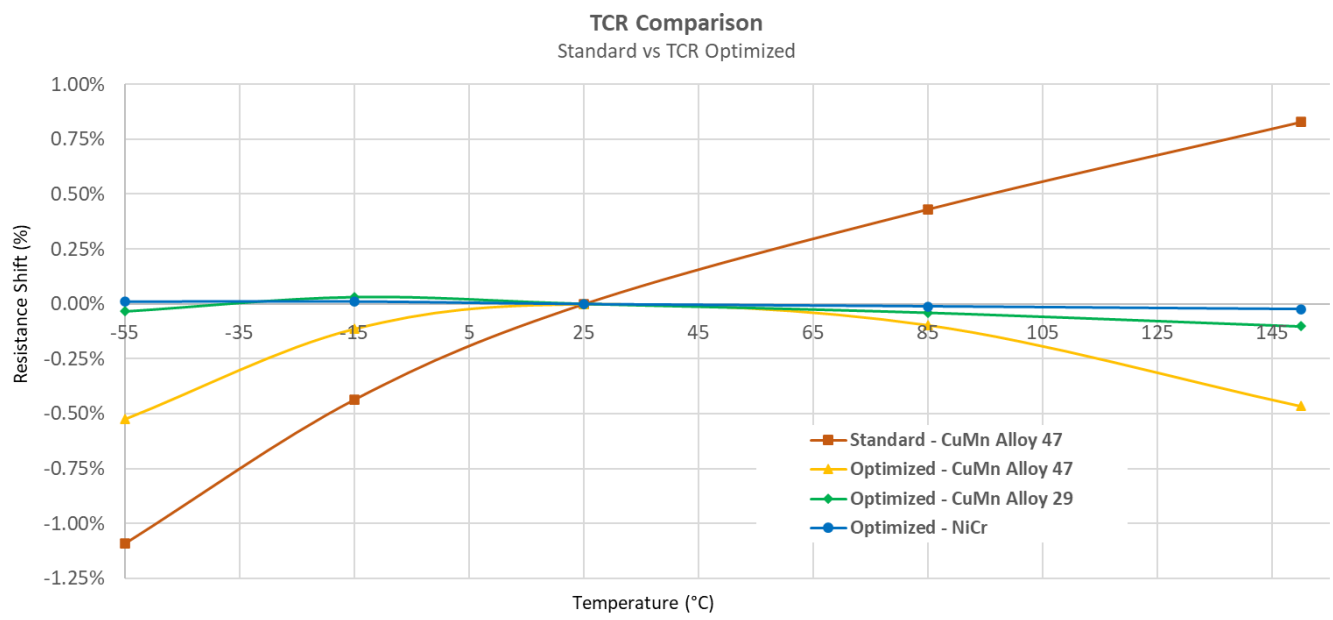
**Patented**

- Available standard sizes, 8518 and 8536
- Optimized TCR Series (**10 ppm/°C** and lower)
- Temperature compensation **not** required.
- High Power Rating (up to **50 Watts**)
- Resistance Range, down to **15μΩ**
- Multiple connection options enable design flexibility

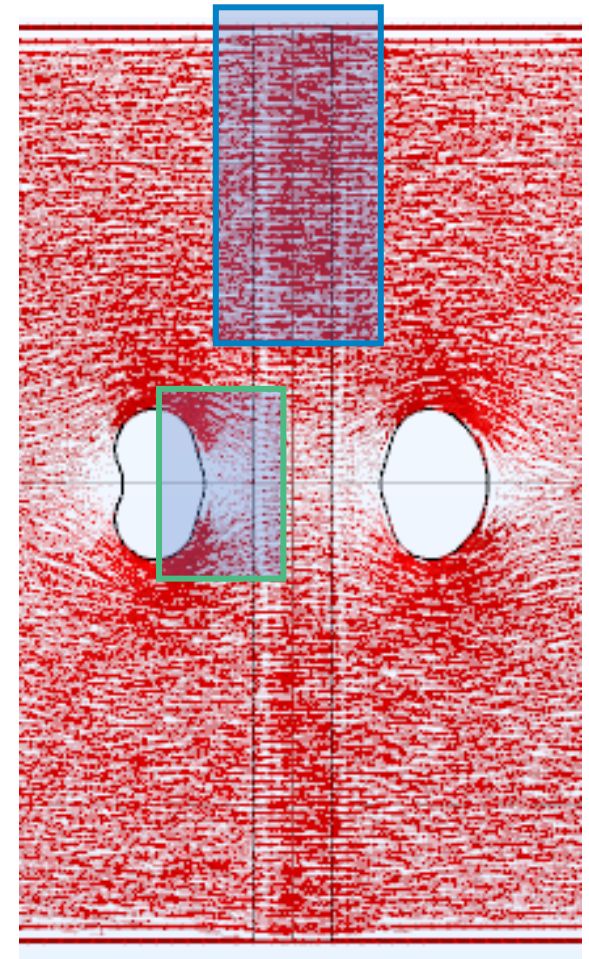
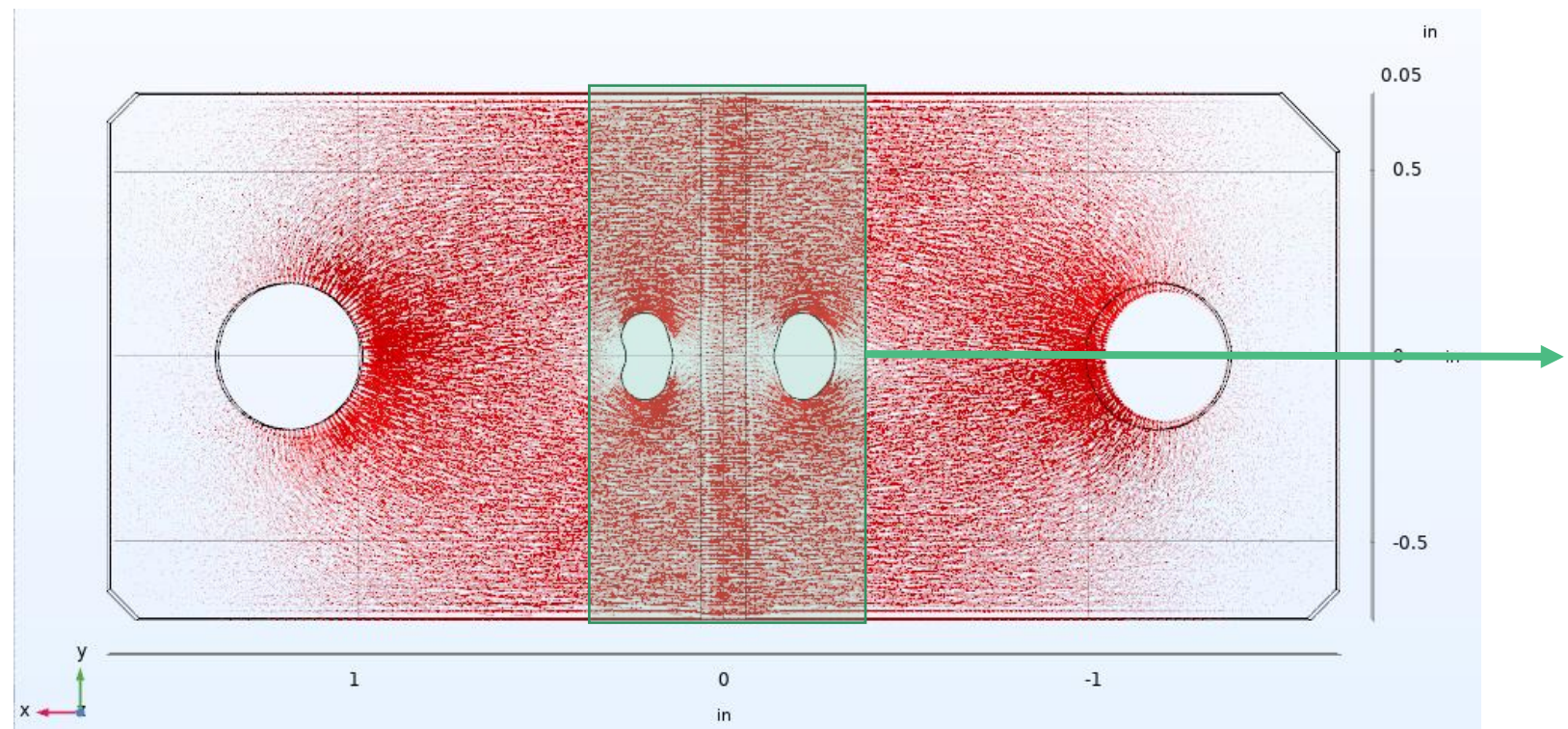


## Advantages

- Superior Temperature stability over Hall Effect for TCR and lifetime High Temperature environments.
- Fewer components
- Reduced circuit complexity, remove TCR compensation



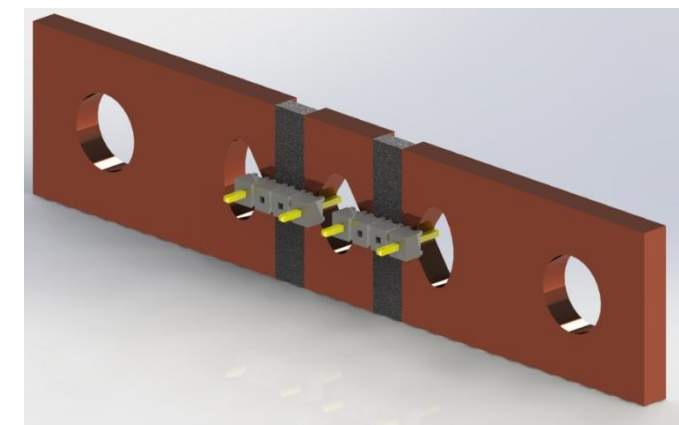
# Vishay Dale Knows - How It Works



**Patented**

# Vishay Dale Knows - WSBR Series (Redundant Element)

- Patented TCR Optimized Solution with redundant elements to support **ASIL-D** safety regulations for Automotive BMS.
- Available standard sizes are 8518 and 8536
- Power Rating up to **50 Watts** (up to 1,000 A)
- Low resistance values available down to **15 μΩ** per element
- Reduced Cost
  - fewer components, one shunt with redundancy instead of two separate assemblies.
  - Less space required for a single shunt.
  - design cost and fewer components by eliminating temperature compensation.
- **Multiple connection options enable design flexibility**



Severity	Exposure	Controllability		
		C1 (Simple)	C2 (Normal)	C3 (Difficult, Uncontrollable)
<b>S1</b> LIGHT AND MODERATE INJURIES	E1 (Very low)	QM	QM	QM
	E2 (Low)	QM	QM	QM
	E3 (Medium)	QM	QM	A
	E4 (High)	QM	A	B
<b>S2</b> SEVERE AND LIFE THREATENING INJURIES - SURVIVAL PROBABLE	E1 (Very low)	QM	QM	QM
	E2 (Low)	QM	QM	A
	E3 (Medium)	QM	A	B
	E4 (High)	A	B	C
<b>S3</b> LIFE THREATENING INJURIES, FATAL INJURIES	E1 (Very low)	QM	QM	A
	E2 (Low)	QM	A	B
	E3 (Medium)	A	B	C
	E4 (High)	B	C	D

**QM (Quality Management)**  
Development supported by established Quality Management is sufficient.

**A lowest ASIL**  
Low risk reduction necessary

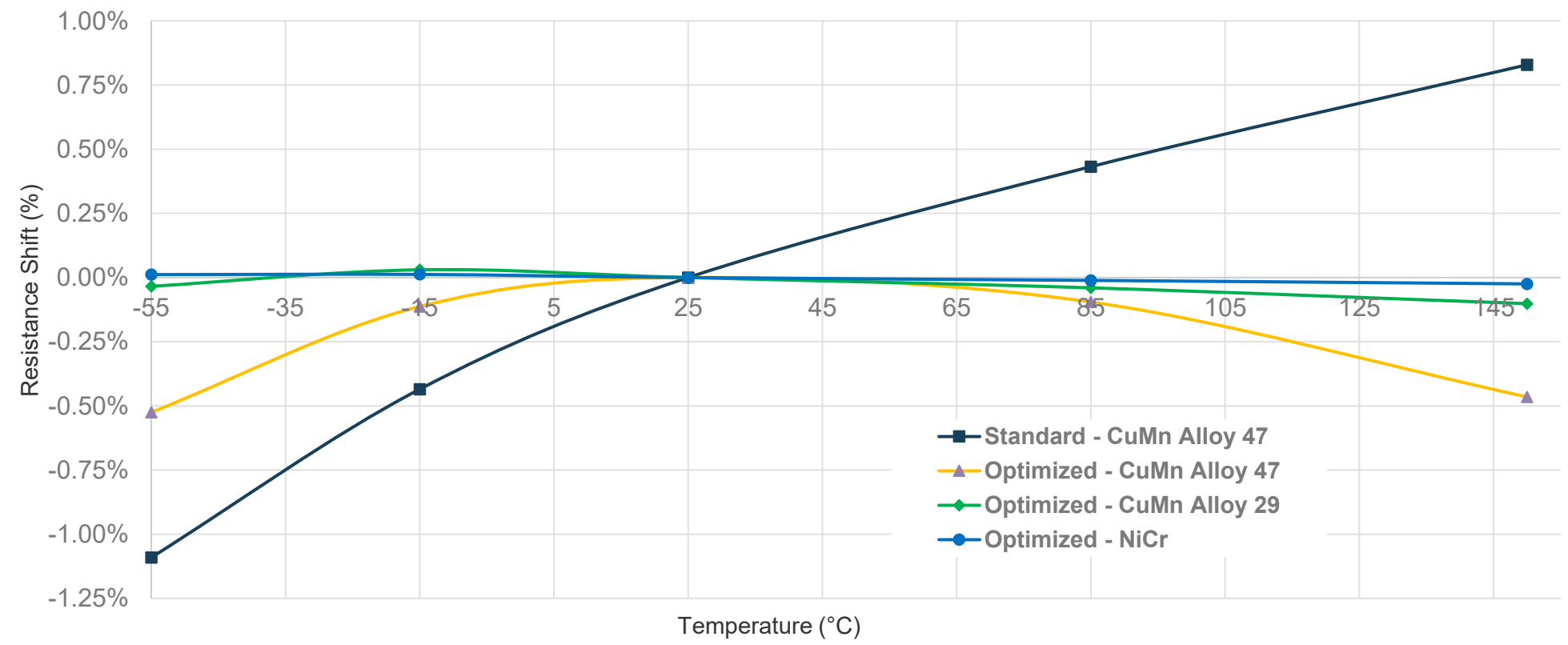
**B**  
:

**C**  
:

**D highest ASIL**  
High risk reduction necessary

# Vishay Dale Knows – Optimized TCR

**TCR Comparison**  
Standard vs TCR Optimized



## Vishay Dale Knows – Application Benefits

- Increased vehicle range
- Shorter high voltage charging times
- Longer battery life
- Improved battery safety
- High reliability



### Explainer Video

#### Active Discharge of 400 V and 800 V DC-Link

Active discharge is a known method to discharge the stored energy in a capacitor (or any other energy storing element) in a controlled manner in which the system voltage can reach a safe value within a certain amount of time. The video introduces the active discharge of 400 V DC link, which can discharge 600  $\mu$ F within 5 s to below 60 V.



### Reference Design

#### High Voltage Intelligent Battery Shunt Sensor With CANFD (HV-IBSS-CANFD)

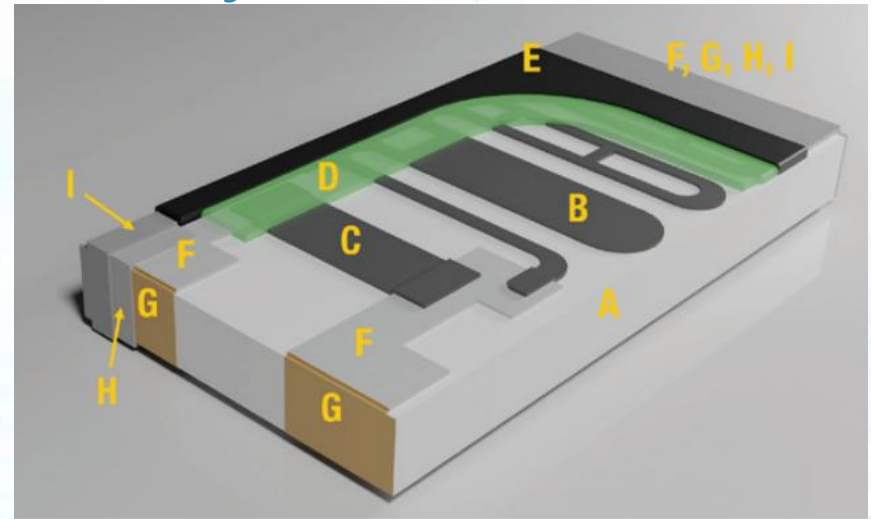
The Intelligent Battery Shunt Sensor (IBSS) reference design is based on Vishay's WSBE Low TCR shunt series and CDMV high precision low tracing error voltage divider allowing high bandwidth, high accuracy current and voltage measurements over a wide range of temperatures without the need for temperature compensation.

[Learn More](#)

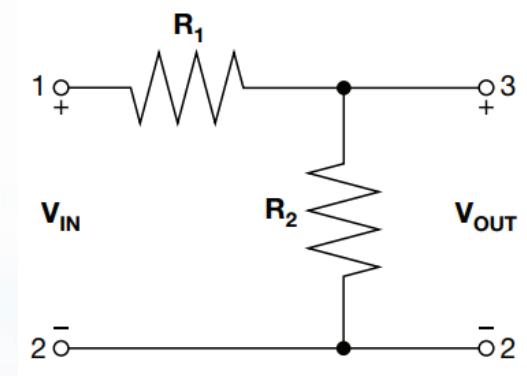


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# Vishay Dale Knows - Dividers – CDMA



- A** - Ceramic (alumina)
- B** - R1
- C** - R2
- D** - Dielectric
- E** - Epoxy topcoat
- F** - Thick film conductors
- G** - Sputter wrap
- H** - Nickel barrier (electroplated)
- I** - Tin layer (electroplated)



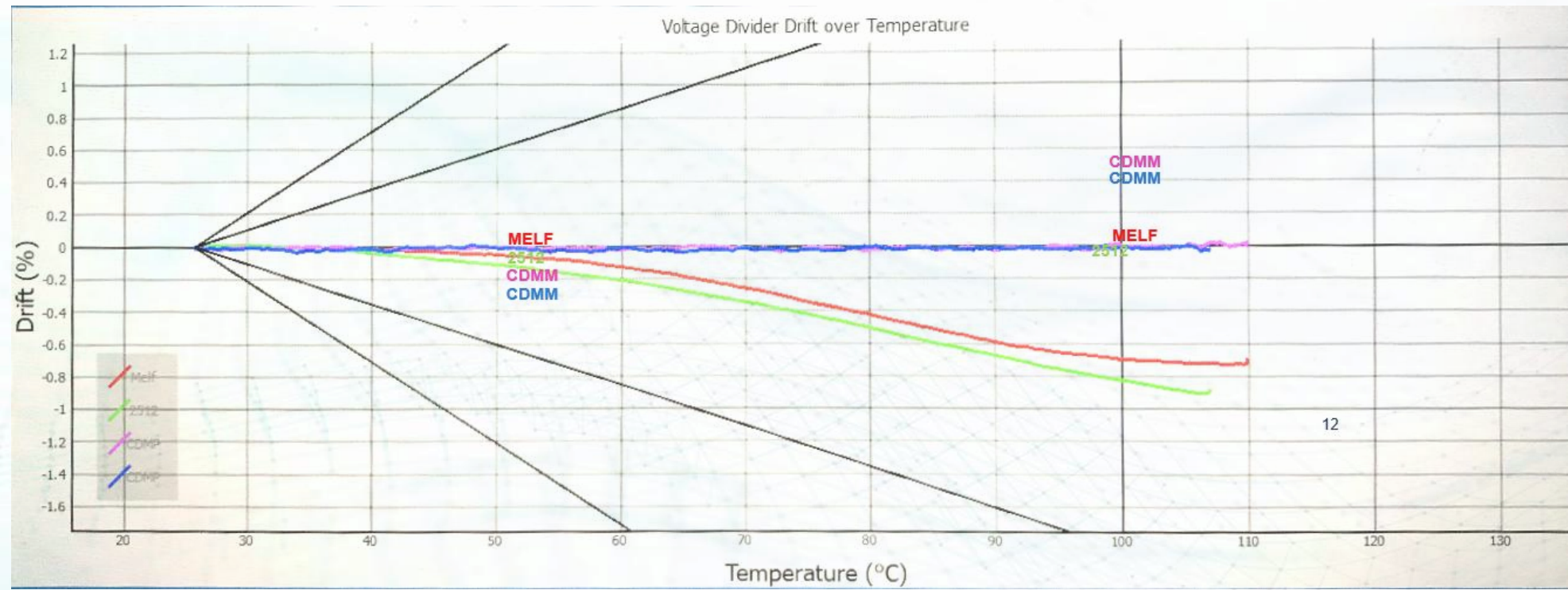
GLOBAL PART NUMBER INFORMATION																	
New Global Part Numbering: CDMA20K0J1000GEB (preferred part number format)																	
C	D	M	A	2	0	K	0	J	1	0	0	0	G	E	B		
GLOBAL MODEL	RESISTANCE VALUE (R <sub>1</sub> )	TOLERANCE	RATIO (R <sub>1</sub> + R <sub>2</sub> ) / R <sub>2</sub>	RATIO TOLERANCE	SOLDER TERMINATION	PACKAGING	SPECIAL										
CDMA = CDMA2512	K = kΩ M = MΩ 20K0 = 20 kΩ 800K = 800 kΩ 1M00 = 1 MΩ	D = ± 0.5 % F = ± 1 % G = ± 2 % J = ± 5 % K = ± 10 %	3 digit significant figure, followed by a multiplier 1000 = 100:1 2000 = 200:1	D = ± 0.5 % F = ± 1 % G = ± 2 % H = ± 3 % J = ± 5 %	E = Sn100	B = bulk (250 pcs max.) F = T / R (full reel) 1 = T / R (1000 pcs) 5 = T / R (500 pcs) T = T / R (250 pcs min.)											

While TCR tracking and efficiency of individual resistors in a voltage divider circuit can deviate, the CDMA utilizes a single film print with dual resistive elements. This ensures minimal drift and aging, while providing excellent TCR / VCR tracking over a wide temperature range.



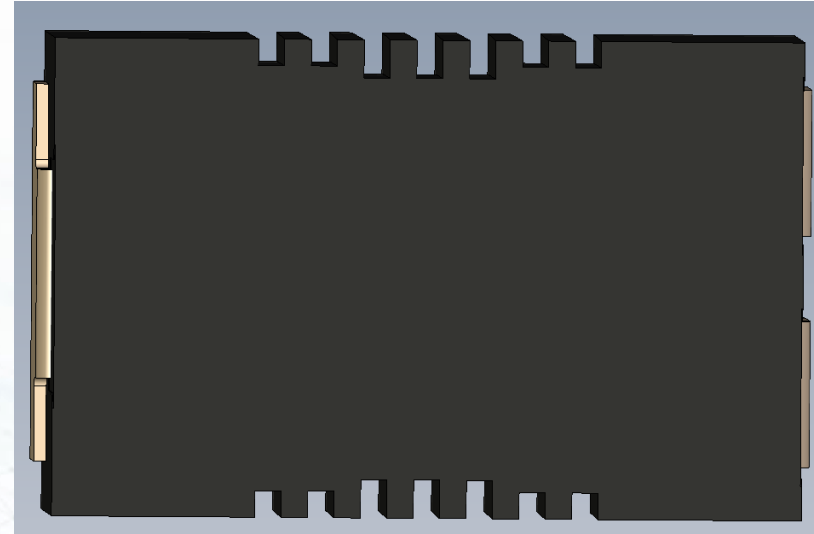
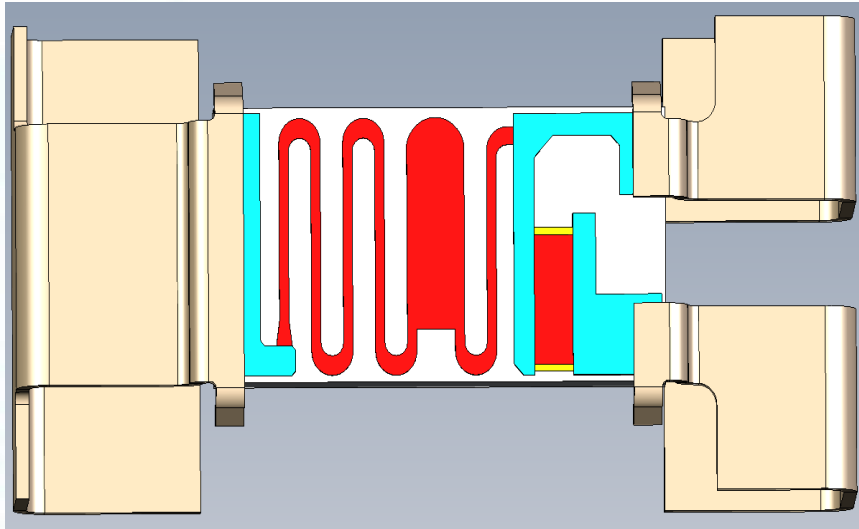
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# Vishay Dale Knows – Divider Benefits



Two discrete resistors will drift;  
Over time  
Over temp  
Over voltage

# Vishay Dale Knows – CDMM High Creepage



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1. Wide range of resistance values and ratios
2. Precision to +/-0.5% with low TCR tracking to 10 ppm/deg C utilizing thick film technology
3. High Voltage to 1500V

1. Automotive compliant terminations
2. 12.5mm creepage distance
3. Rated 1250V per IEC 60664-1
4. Sulfur resistant

# Vishay Dale – Knows HV Automotive

- **CDMA – HV Thick Film Chip Divider Automotive** NEW

- AEC-Q200 qualified
- Compact 2512 case size, rated 1W
- High working voltages up to 1415 V
- Wide resistance range from 500 kΩ to 50 MΩ
- Tolerances down to ± 0.5 %
- Lower Component Counts and Placement Costs
- Increased Accuracy and Stability

- **HV Thick Film Chip Divider Options:**



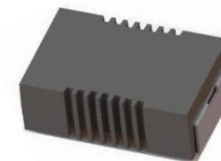
### CDHV

- 2512 Case size
- 3000 V
- 20M to 20G
- 100ppm TCR



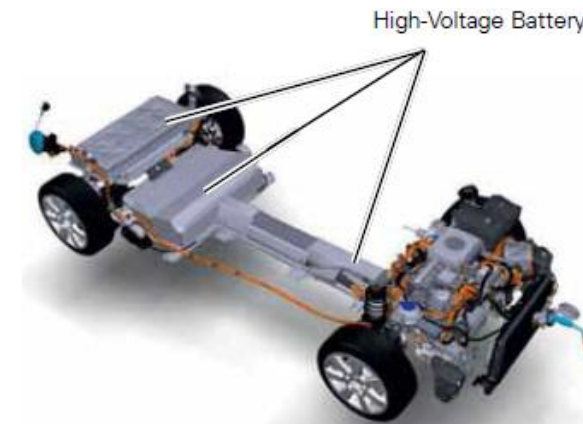
### CDMV

- 2512 Case size
- 1415 V
- 10K to 75M
- 100ppm TCR



### CDMM

- 4527 Case size
- 1500 V
- 500K to 50M
- 1.5W



### Target Applications:

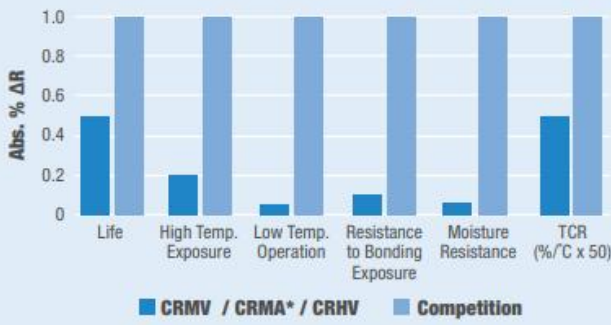
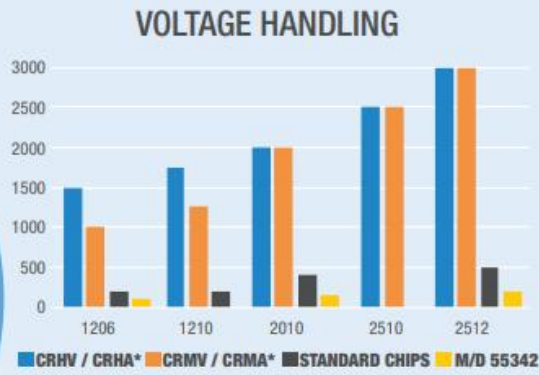
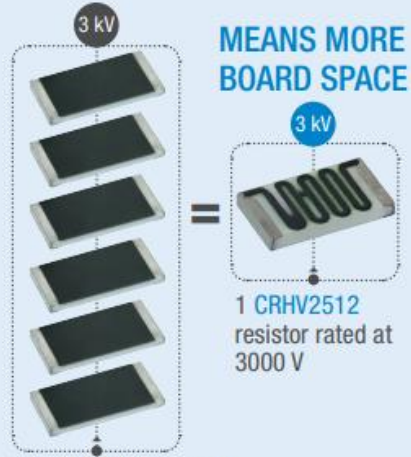
- Voltage monitoring and overvoltage protection in high power DC/DC converters and inverters
- On-board chargers
- Battery management systems in (EV) and industrial equipment.

# Vishay Dale Knows – High Voltage Chips



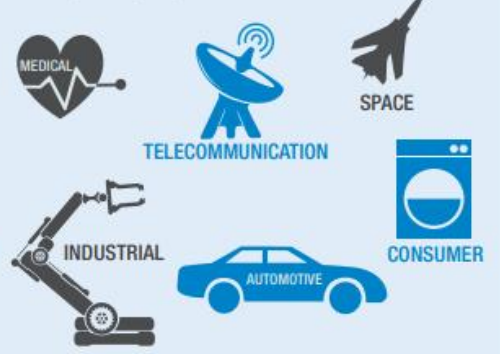
## CRHV / CRHA\* / CRMV / CRMA\* SERIES HIGH VOLTAGE THICK FILM RESISTORS

6 STANDARD RESISTORS = 1 CRxV



- Design flexibility with multiple termination configurations and materials including non-magnetic allow design flexibility
- Available as chip divider also – CDHV and CDMV respectively

### APPLICATIONS



**Note**  
\* CRHA and CRMA are the AEC-Q200 qualified versions of CRHV and CRMV

[te1resistors@vishay.com](mailto:te1resistors@vishay.com)

### BENEFITS

- High voltage handling capability (to 3000 V) compared to standard thick film chips resistors
- Enables designers to reduce component count, circuit board size, and placement costs
- AEC-Q200 qualified for rigorous automotive applications

### APPLICATIONS

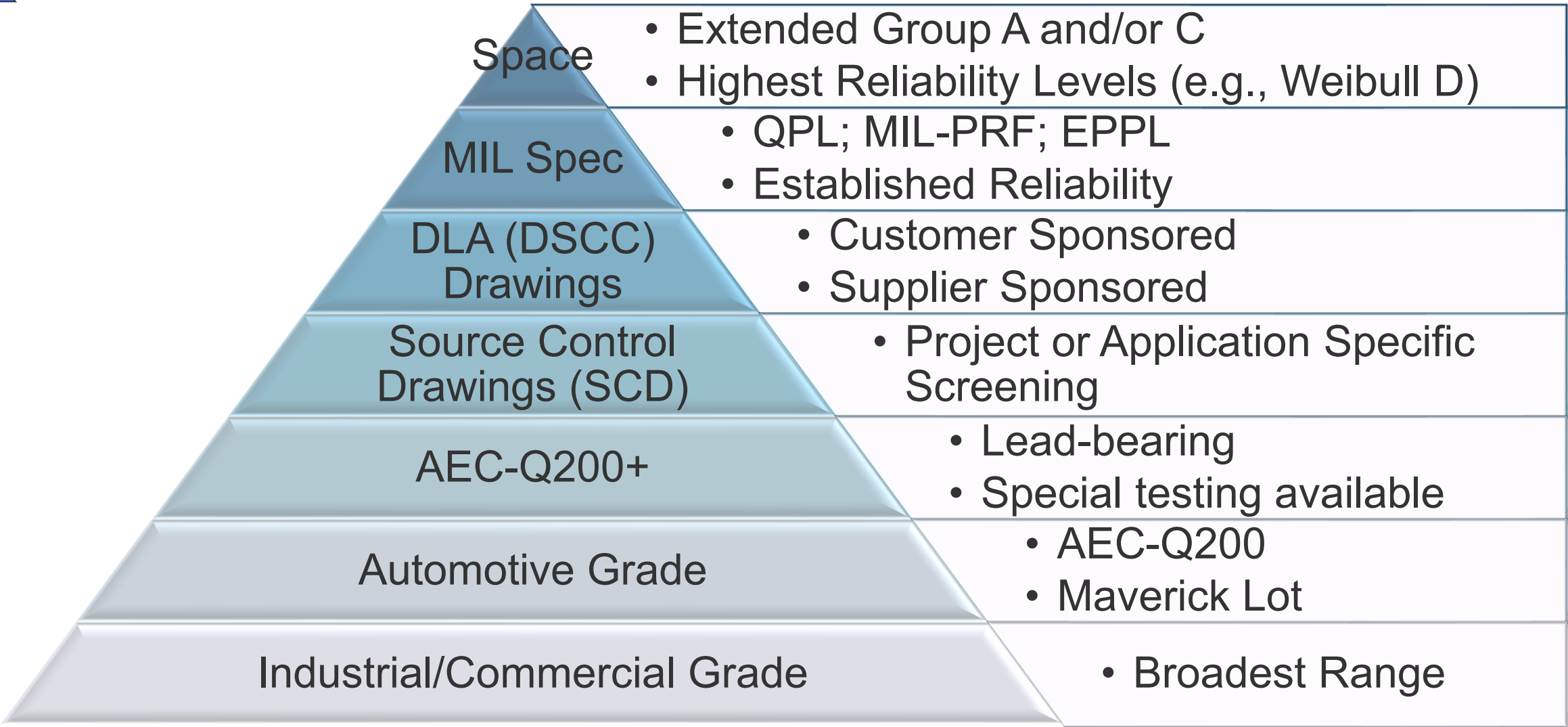
- Battery management
- Voltage monitoring
- High voltage regulators
- Smart circuit breakers
- Electric vehicle charging
- Power inverters
- High voltage power supplies
- Overvoltage protection

# Vishay Dale Knows - AMS

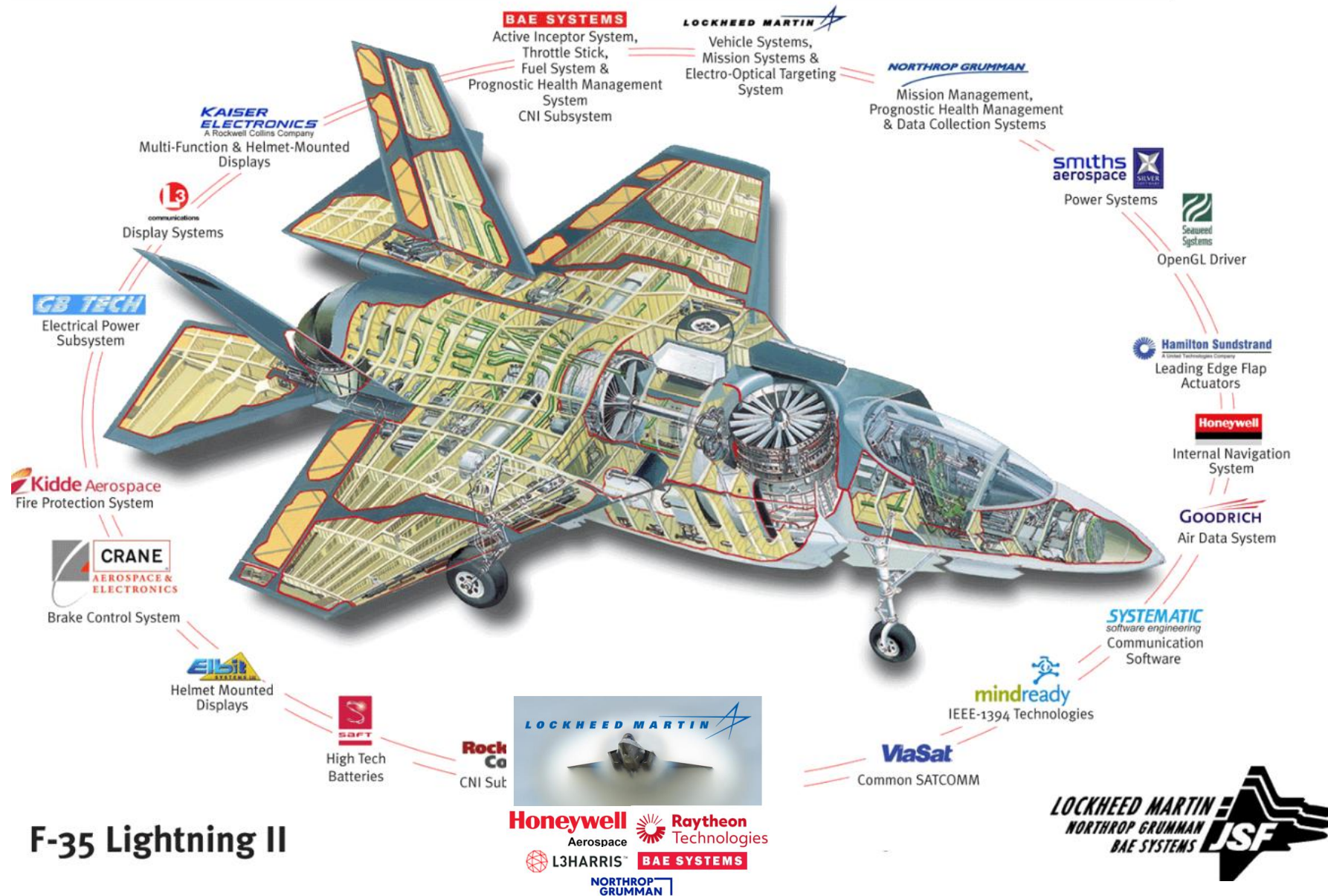


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# Vishay Dale Knows - High Reliability



# Vishay Dale Knows - Avionics



**F-35 Lightning II**

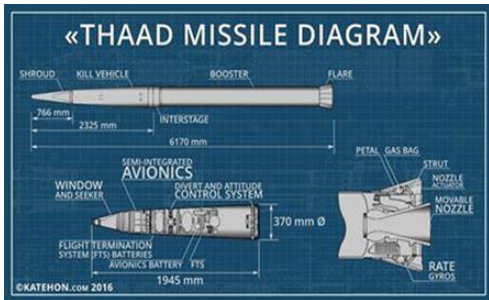
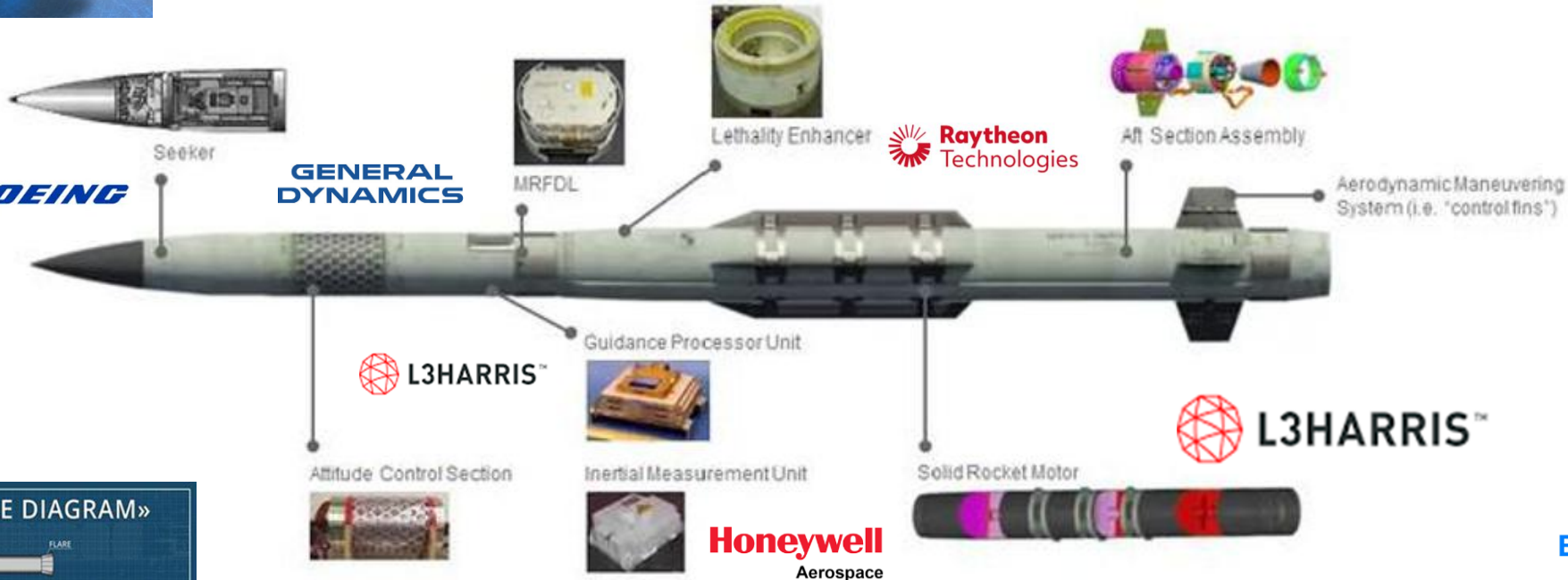
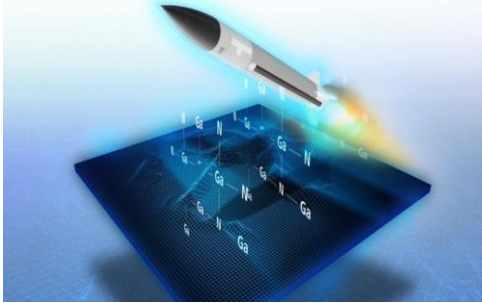
# Vishay Dale Knows – Missile Systems



Next Generation Interceptor (NGI)

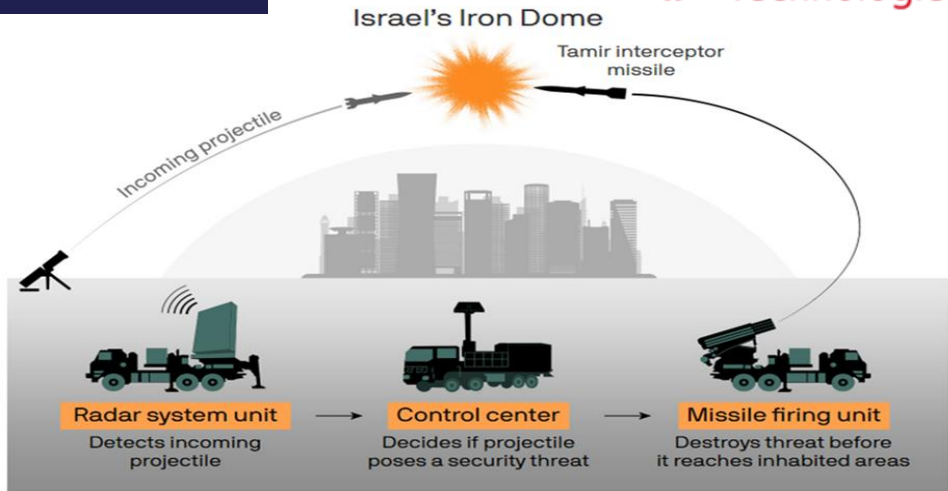


The DNA of tech.



Freedom Eagle (FE-1)

# Vishay Dale Knows – Real World Impacts



## U.S. COMMITMENTS

Total U.S. Security Assistance Committed Since Russia's Full-Scale Invasion on February 24, 2022



Commitments also include a wide range of other vehicles, unmanned aerial systems, small arms, communications equipment, protective gear, and other supplies and services. *The United States continues to work with its Allies and partners to provide Ukraine with additional capabilities to defend itself.*



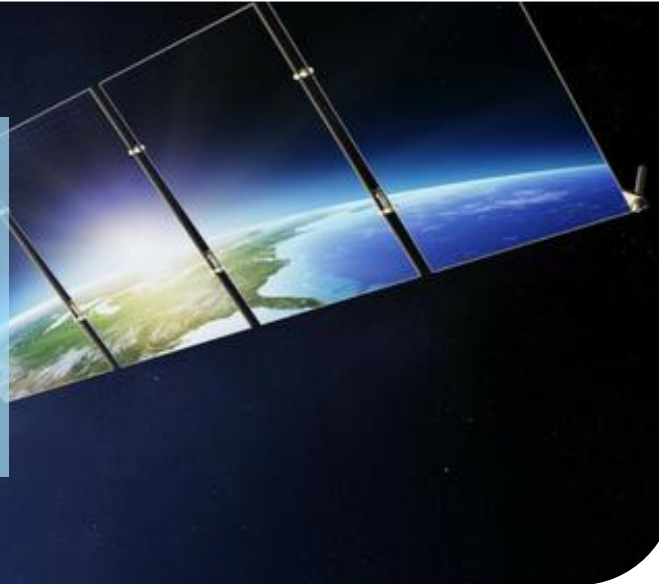
# Vishay Dale Knows - Space

## Low-Earth Orbit (LEO) Satellites

High Power density

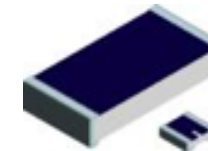
MIL, SPACE Grade qualification

High Reliability



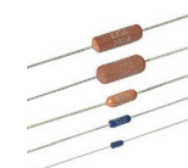
High Voltage SMD Resistor Chips

CRHV - 3K  
Volts



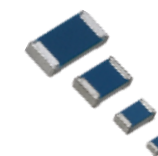
High Frequency Resistors

FC/FCHP - Thin Film  
RCP - Thick Film



Leaded Military Metal Film

RNC - Precision  
RLR  
RNR - Hermetically Sealed



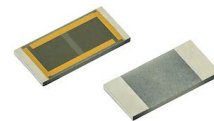
MIL qualified Resistor Chips

Thick/Thin Film  
55342



Power Metal Strip®  
current sense resistors

WSL/WSL  
P



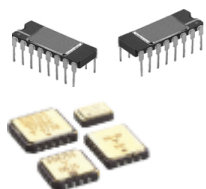
High Power Resistor Chips

PCAN - 6W 2512



Military and High Surge  
Leaded Wirewound

RWR - MIL  
CW Wirewound - High Surge



Custom/MIL and Standard  
Networks, Hermetic  
construction

Thick/Thin Film 83401, LCC/TLCC/FP  
Series

# Vishay Dale Knows – Established Reliability

## E-REL (Established Reliability)

- A quantitative maximum failure rate demonstrated under controlled conditions specified in a Department of Defense specification and usually expressed as percent failures per thousand hours of test.

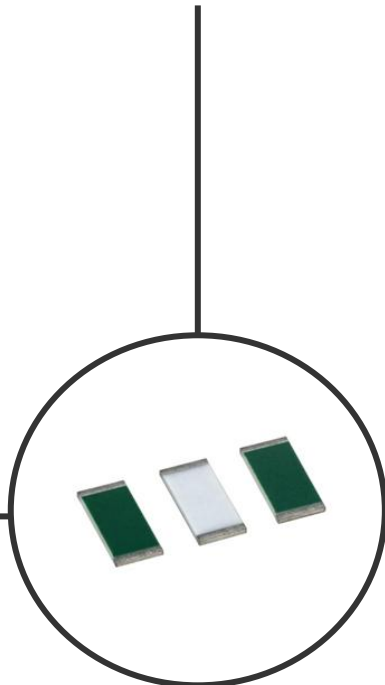
## Failure Rate

- The probability of failure per unit of time of items in operation. Sometimes estimated as a ratio of the number of failures to the accumulated operating time for the items.

Failure Rate Level Designation/Symbol	Failure Rate (Percent/1,000 Hours)
C	Non-Established Reliability
M	1
P	0.1
R	0.01
S	0.001
T	Space Level

Failure Rate	Failure Rate Substitution
T (Space)	—
S (0.001)	T
R (0.01)	T, S
P (0.1)	T, S, R
M (1.0)	T, S, R, P
C (Non-ER)	T, S, R, P, M

# VISHAY THIN & THICK FILM - QPL MIL-PRF-55342



## Market Segments

- Avionics, Military, Space

## Applications

- Cockpit, Flight Control, Radar
- Missile Guidance, Fuzing
- Communication, Transmission Base
- Vision Systems, UAV, Satellite

## Competitors

- State of the Art
- Mini-Systems
- IRC/TT Electronics

## Features

- Available in /01 through /13 case sizes
- Thick film /14 (0201 case size) **Coming Soon**
- TCR to  $\pm 25\text{ppm}/^\circ\text{C}$ , Tolerance to  $\pm 0.1\%$
- Termination style B - tin / lead wraparound over nickel barrier
- Established Reliability to C, M, P, R, S, U, V, and Space level T failure rates available

## Our Advantages

- Complete MIL-Testing available in house
- Thin Film Manufactured in USA
- Space Grade in both Thick and Thin Film
- MIL and Space Grade Jumper MIL-PRF-32159
- Resistive film options, Ruthenium Oxide and Tanelox, to meet performance needs

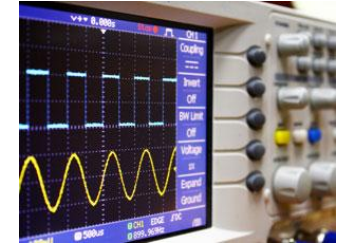
# Vishay Dale Knows - Competitors



- Founded in 1969 as a consulting business in Thick Film technology and developed into a manufacturer of Thick and Thin film resistive products focus on Military, Aerospace and Medical markets.
- Located in State College Pennsylvania
- With just over 100 employee's and an expected annual revenue of \$25M USD
- Focus Products:
  - Thick and Thin Film 55342 and 32159(Jumper) chip resistors.
  - Mil-PRF-914 resistor networks
  - Small level of RF, High Voltage and Silicone Chip Resistors in wire and epoxy bondable package.
- Why customers have used SOTA:
  - Business built on close relationships with small customer base
  - Quick turn (2-4 weeks) on small volumes and space level products
- Weaknesses:
  - High price in the market and limited position at stocking channel partners
  - Limited offering with niche focus

[State of the Art, Inc. Resistive Products](#)

# Vishay Dale Knows – Tantalum Nitride - PTN



## Market Segments

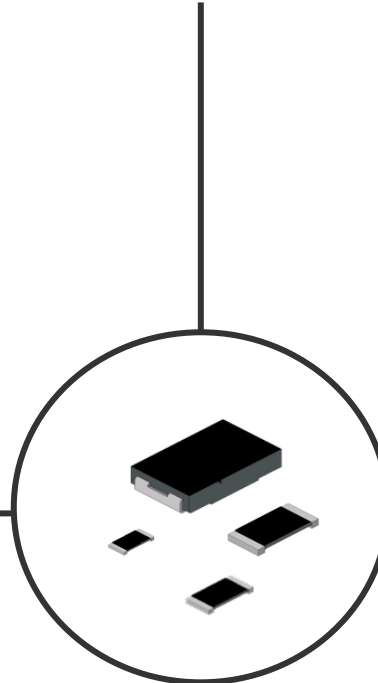
- Space, Military (AMS), Aerospace

## Applications

- Space Instrumentation
- Guidance and Control Systems
- Voltage Regulators, Power Supplies
- High moisture environments

## Competitors

- IRC/TT Electronics
- State of the Art



## Features

- Self Passivating Moisture resistant Tantalum Nitride Film
- Resistance Range: 1.0Ω - 3MΩ
- TCR to  $\pm 10\text{ppm}/^\circ\text{C}$ , Tolerance to  $\pm 0.05\%$
- Sulfur resistant, Low Noise and VCR
- Suitable for use in extreme conditions in high humidity applications

[ptn.pdf](#)  
[\(vishay.com\)](#)

## Our Advantages

- **Manufactured in the USA**
- Availability of non-standard values
- Additional protection with Vishay's proprietary special passivation methods
- Wide range of case sizes and resistance ranges with low tolerance and TCR
- **100% visual inspection per MIL-PRF-55342**
- **Approved on 12 DLA drawings**

# Vishay Dale Knows – E-REL Axial Film – RNC (ERC)

## Market Segments

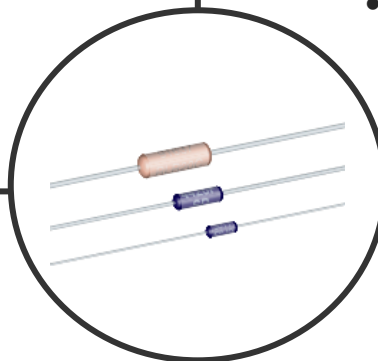
- Avionics, Military, Space, High Reliability

## Applications

- Current Limiting
- Short term pulse handling
- High vibration environments

## Highlights

- Axial film resistor
- Multiple body sizes
- Low noise
- Excellent high frequency characteristics



## Features

- Mil-R-55182 Qualified (RNC/RNR50, 55, 60, 65, 70)
- Low TCR  $\pm 25$  ppm/ $^{\circ}$ C
- 100% Stabilization and screening
- Failure rates M, P, R, S

## Our Advantages

- 200V-350V
- 0.1W – 0.75W
- 10 ohm – 3.01M ohm
- Abs tolerance  $\pm 0.1\%$
- Flame retardant coating
- Distributor stocked

[erc.pdf](#)  
[\(vishay.com\)](#)

# Vishay Dale Knows – Hermetically Sealed Axial Film – RNR/RNN

## Market Segments

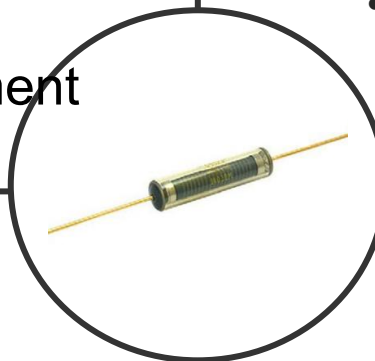
- Avionics, Military, Space, High Reliability

## Applications

- Current Limiting
- Short term pulse handling
- High moisture/corrosive environment

## Highlights

- Axial film resistor
- Multiple body sizes
- Low noise
- Hermetic glass enclosure



## Features

- Mil-R-55182 Qualified (RNR/RNN55, 57, 60, 65, 70, 75)
- Hermetically sealed
- Low TCR  $\pm 25$  ppm/ $^{\circ}$ C
- Can withstand 3000 psi external pressure
- Failure rates M, P, R, S

## Our Advantages

- 200V-750V
- 0.1W – 2W
- 10 ohm – 4.99 Mohm
- Abs tolerance  $\pm 0.1\%$
- RNR – solderable, RNN - weldable
- Distributor stocked

[hdn.pdf](#)  
[vishay.com](http://vishay.com)

# Vishay Dale Knows – Small Size Axial Film – RLR (ERL)

## Market Segments

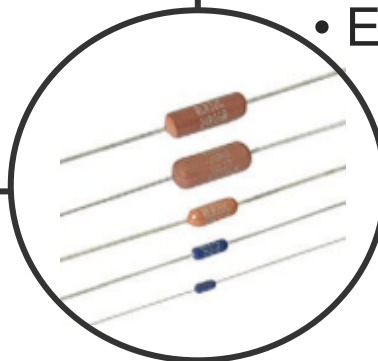
- Avionics, Military, Space, High Reliability

## Applications

- Current Limiting
- Short term pulse handling
- High vibration environments

## Highlights

- Axial film resistor
- Multiple body sizes
- Low noise
- Excellent high-frequency characteristics



## Features

- Mil-R-39017 Qualified (RLR05,07,20,32)
- Mil-R-98020, 99011, 98021, 98022, 97004, 96002
- Low TCR  $\pm 100$  ppm/ $^{\circ}$ C
- Failure rates M, P, R, S

## Our Advantages

- 200V-500V
- 0.125W – 2W
- 1 ohm – 22 Mohm
- Abs tolerance  $\pm 1\%$
- Distributor stocked

[erl.pdf](#)  
[\(vishay.com\)](#)

# Vishay Dale Knows – E-REL Axial Wirewound - RWR

## Market Segments

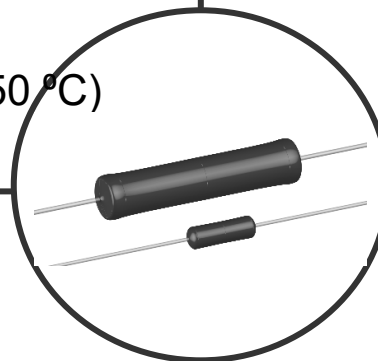
- Avionics, Military, Space, High Reliability

## Applications

- High pulse handling
- High power
- Temperature extremes (-55 °C to 250 °C)

## Highlights

- Axial-leaded
- Wirewound
- Precision
- Established reliability
- Power resistor



## Features

- Mil-PRF-39007 Qualified (RWR71, 74, 78, 80, 81, 82, 84, 89) up to S failure rate
- Inductive (S, W) and non-inductive (N, Z)
- Solderable (S, N) and weldable (W, Z)
- Low TCR as low as  $\pm 20$  ppm/°C
- Load life stability  $< \pm 0.5\%$  @ 2k hrs

## Our Advantages

- 1W – 10W
- 0.1 ohm – 39.2 kohm
- Abs tolerance  $\pm 0.1\%$
- High temperature silicone coating
- Distributor stocked

[rwrmil.pdf](#)  
[\(vishay.com\)](#)

# Vishay Dale Knows – E-REL Housed Wirewound - RER

## Market Segments

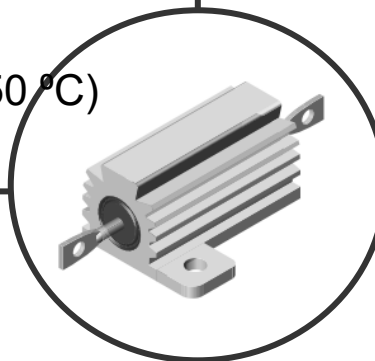
- Avionics, Military, Space, High Reliability

## Applications

- High pulse handling
- High power
- Temperature extremes (-55 °C to 250 °C)

## Highlights

- Chassis Mounted
- Wirewound
- Established reliability
- Discharge resistor



## Features

- Mil-PRF-39009 Qualified (RE40,45, 50, 55, 60, 65, 70, 75) up to R failure rate
- Non-inductive
- Load life stability <math>< \pm 1\% @ 2k \text{ hrs rated power}</math>
- Low TCR down to  $\pm 20 \text{ ppm}/^\circ\text{C}$

## Our Advantages

- 5W – 30W
- 0.1 ohm – 39.2 kohm
- Abs tolerance  $\pm 1\%$
- Aluminum heat sink housing
- Distributor stocked

[rermil.pdf](#)  
[\(vishay.com\)](#)

# Vishay Dale Knows- DLA Drawings / Custom Options

## Surface Mount Resistors

- Values less than 1 ohm
- Low Values / High Power
- High Voltage
- High Frequency
- Moisture Resistance
- Low TCR / High Precision / High Stability

## Networks

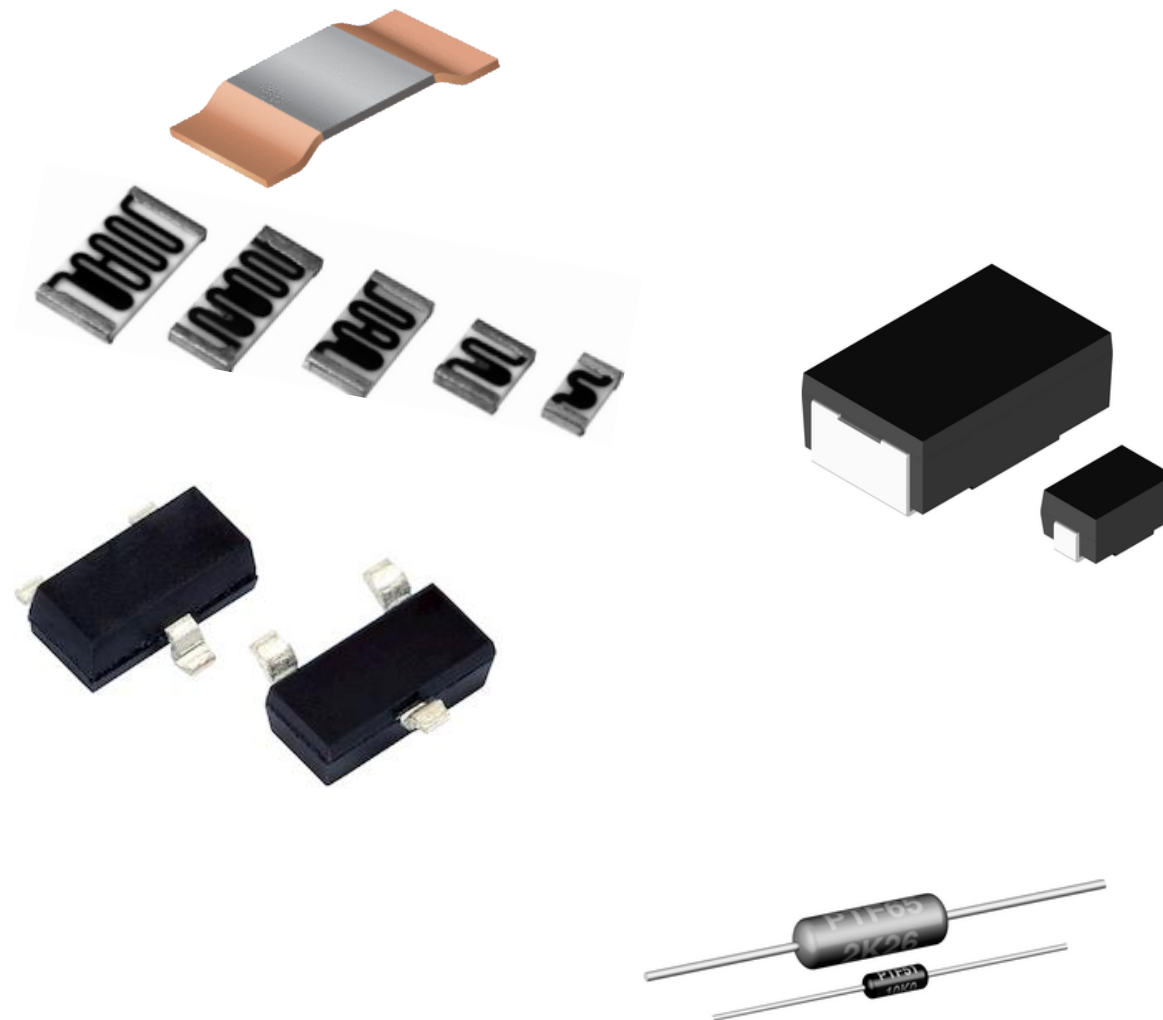
- Resistor Networks Multiple Schematics
- Resistor Networks Multiple Values
- Voltage Dividers
- Resistor Networks Extended Leads

## Axial Leaded

- Low Inductance
- Extended Value Range
- High Precision / High Stability

## User Defined Testing Capabilities beyond Military Standards

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# Vishay Dale Knows – Industrial and AI



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## PRODUCTS:

- Industrial Axial Metal Film Resistors - CMF/CPF/PTF series
- WSLP3921 - WSLP5931 - WSLF2512 – WSHP
- CRMV
- CRHV

## COMPETITIVE EDGE:

- Tin-lead and lead-free available
- Fully customizable
- Low Inductance, Ultra low resistance values support measuring high current

## APPLICATIONS:

- Industrial machines
- Automation
- Energy management
- Robotics
- Fabrication
- Robotic motor drives
- Backup Power Supplies

# Vishay Dale Knows - Energy Management



## PRODUCTS:

- Wirewound Tubular Resistors – FSE / FSOT / FST series
- WSLF2512 - WSLP2726 - WSLP3921 - WSLP5931 WSHP
- CRMV CRHV
- RCP

## COMPETITIVE EDGE:

- Long history developing technology
- Proven reliable with large customer base
- Fully customizable
- Ultra low resistance values to support measuring high current
- Temperature stability and long life stability

## APPLICATIONS:

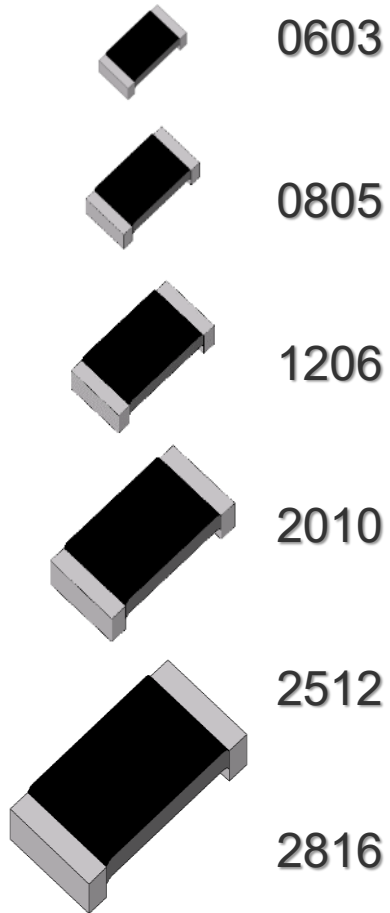
- Industrial
- Motor Drives & control – Energy Generation
- Energy Conversion & Storage – Machines & tools
- Battery Management - Solar Power Storage
- Micro-grid power management



# Vishay Dale Knows – Downsizing Power Metal Strip® - WSL / WSL-18 / WSLP / WSLP-18



The DNA of tech.

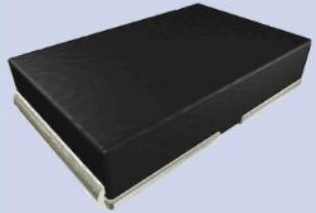


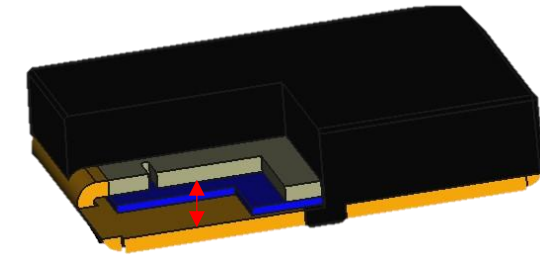
WSL	WSL-18	WSLP	WSLP-18 Automotive Grade Coming end of Q4/2024
<ul style="list-style-type: none"> <li>• <b>0.1 W</b></li> <li>• 10 mΩ to 100 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>0.2 W</b></li> <li>• 10 mΩ to 100 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>0.4 W</b></li> <li>• 10 mΩ to 100 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	
<ul style="list-style-type: none"> <li>• <b>0.125 W</b></li> <li>• 5 mΩ to 200 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>0.25 W</b></li> <li>• 5 mΩ to 200 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>0.5 W</b></li> <li>• 5 mΩ to 100 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>1 W</b></li> <li>• 5 mΩ to 10 mΩ</li> <li>• ± 1% / ± 5%</li> </ul>
<ul style="list-style-type: none"> <li>• <b>0.25 W</b></li> <li>• 0.5 mΩ to 200 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>0.5 W</b></li> <li>• 0.5 mΩ to 200 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>1 W</b></li> <li>• 0.5 mΩ to 50 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>2 W</b></li> <li>• 0.5 mΩ to 12 mΩ</li> <li>• ± 1% / ± 5%</li> </ul>
<ul style="list-style-type: none"> <li>• <b>0.5 W</b></li> <li>• 1 mΩ to 500 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>1 W</b></li> <li>• 1 mΩ to 500 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>2 W</b></li> <li>• 1 mΩ to 30 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	
<ul style="list-style-type: none"> <li>• <b>1 W</b></li> <li>• 0.5 mΩ to 500 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>2 W</b></li> <li>• 0.5 mΩ to 40 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	<ul style="list-style-type: none"> <li>• <b>3 W</b></li> <li>• 0.5 mΩ to 10 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>	
<ul style="list-style-type: none"> <li>• <b>2 W</b></li> <li>• 2 mΩ to 100 mΩ</li> <li>• ± 0.5 % / ± 1%</li> </ul>			

# Vishay Dale Knows – High Power WSHM2818 / WSHP2818

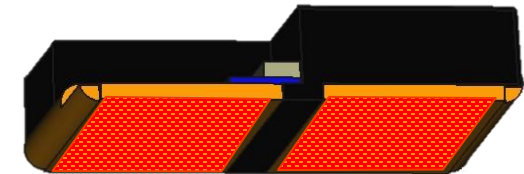


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	WSHM2818	WSHP2818
	<p><b>Resistance Range:</b> 0.001Ω to 0.2Ω</p> <p><b>Tolerance:</b> ± 0.5 % / ± 1%</p> <p><b>Power:</b> <b>7W</b></p> <p><b>TCR ppm/°C:</b> ± 250ppm for 1 mΩ to 1.99 mΩ ± 200ppm for 2 mΩ to 5.99 mΩ ± 75ppm for 6 mΩ to 200 mΩ</p> <p><b>Temperature Range:</b> -65°C to +170°C</p>	<p><b>Resistance Range:</b> 0.001Ω to 0.1Ω</p> <p><b>Tolerance:</b> ± 0.5 % / ± 1%</p> <p><b>Power:</b> <b>10W</b></p> <p><b>TCR in ppm/°C:</b> ± 200ppm for 1 mΩ to 5.99 mΩ ± 75ppm for 6 mΩ to 100 mΩ</p> <p><b>Temperature Range:</b> -65°C to +170°C</p>



Short thermal path



Large PCB contact area

## Construction Features

- Very short thermal path from resistive element to PCB and hence low thermal resistance
- Large contact area with PCB to dissipate heat
- Liquid Crystal Polymer mold compound instead of Epoxy
- Robust all metal welded construction
- Laser trimmed to value and tolerance
- High power density compared to Power to Size ratio

## Benefits

- Low thermal resistance
- Maximized heat transfer
- Resistant to Thermal Shock
- Superior pulse performance
- Design flexibility and Precision

Low thermal resistance means low self heating at high power density and minimizes measurement error caused by TCR effects.

# Vishay Dale Knows – Industrial Power - RCP

## Features:

- Thick Film resistive element on an aluminum nitride (AlN) substrate
- Very High Thermal conductivity in a small package size
- Termination: tin/lead wrap around termination over nickel barrier. Optional lead (Pb)-free.
- Capability to develop specific reliability programs designed to customer specific requirements
- High Frequency performance to 6 GHz
- Aluminum nitride provides 3 x more power than the same size thick film component



### Power Rating

Global model	Case size	Std. Bd Mount	Active Temp. control
RCP0505	505	1.4W	5.0W
RCP0603	603	1.5W	3.9W
RCP1205	1205	2.4W	11W
RCP2512	2512	3.5W	22W

MATERIAL SPECIFICATIONS	
Resistive element	Ruthenium oxide
Encapsulation	Epoxy
Substrate	Aluminum nitride
Termination	Solder-coated nickel barrier
Solder finish	Pure tin or tin / lead solder alloy

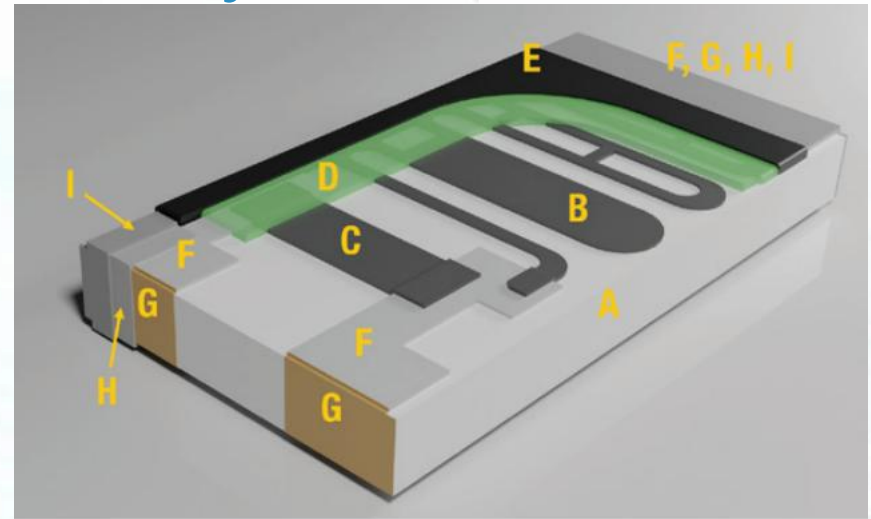


Resistance range: 10 to 2KΩ, tolerance of 1%,2%,& 5%, with a TC of 150 PPM /°C

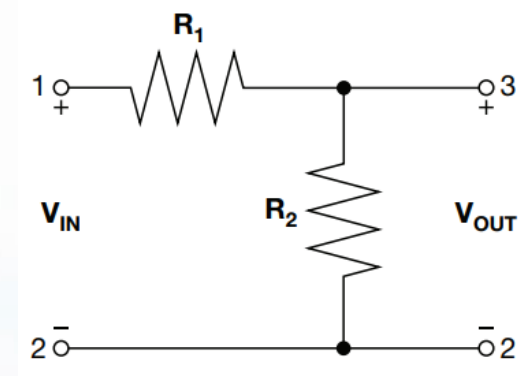


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# Vishay Dale Knows - Dividers – CDMA



- A** - Ceramic (alumina)
- B** - R1
- C** - R2
- D** - Dielectric
- E** - Epoxy topcoat
- F** - Thick film conductors
- G** - Sputter wrap
- H** - Nickel barrier (electroplated)
- I** - Tin layer (electroplated)



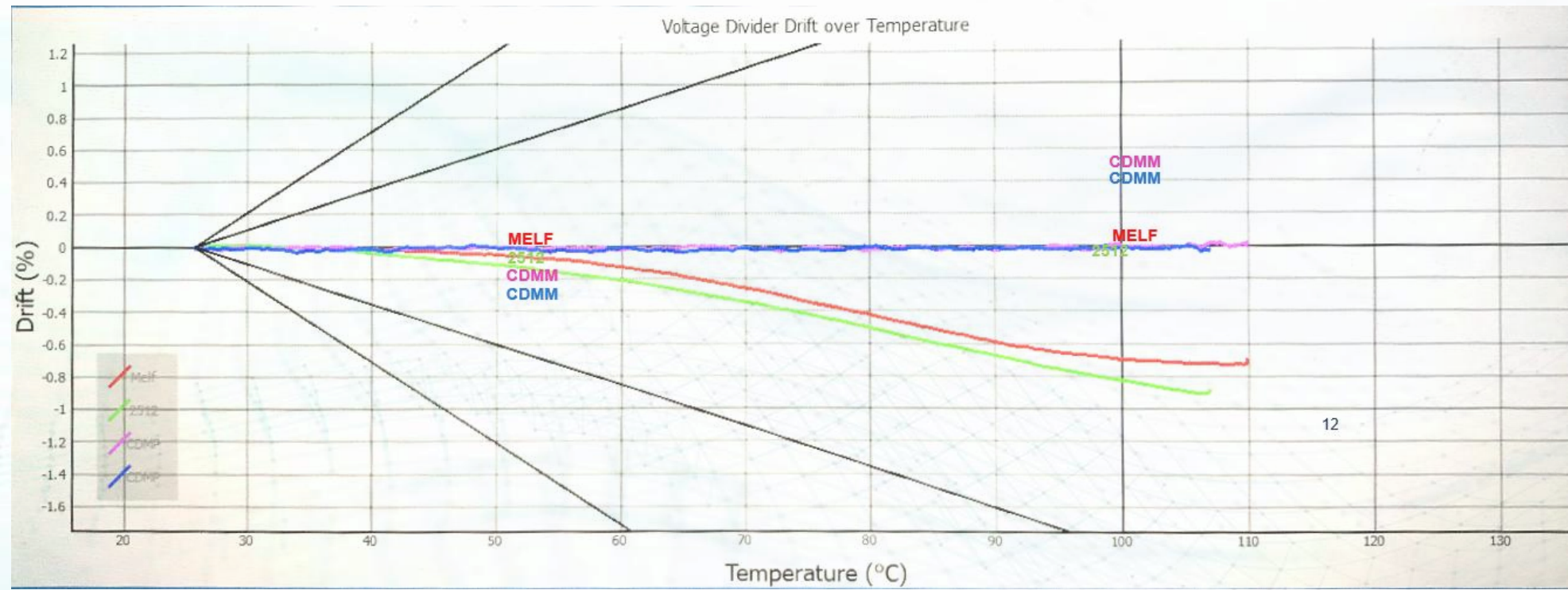
GLOBAL PART NUMBER INFORMATION																	
New Global Part Numbering: CDMA20K0J1000GEB (preferred part number format)																	
C	D	M	A	2	0	K	0	J	1	0	0	0	G	E	B		
GLOBAL MODEL	RESISTANCE VALUE (R <sub>1</sub> )	TOLERANCE	RATIO (R <sub>1</sub> + R <sub>2</sub> ) / R <sub>2</sub>	RATIO TOLERANCE	SOLDER TERMINATION	PACKAGING	SPECIAL										
CDMA = CDMA2512	K = kΩ M = MΩ 20K0 = 20 kΩ 800K = 800 kΩ 1M00 = 1 MΩ	D = ± 0.5 % F = ± 1 % G = ± 2 % J = ± 5 % K = ± 10 %	3 digit significant figure, followed by a multiplier 1000 = 100:1 2000 = 200:1	D = ± 0.5 % F = ± 1 % G = ± 2 % H = ± 3 % J = ± 5 %	E = Sn100	B = bulk (250 pcs max.) F = T / R (full reel) 1 = T / R (1000 pcs) 5 = T / R (500 pcs) T = T / R (250 pcs min.)											

While TCR tracking and efficiency of individual resistors in a voltage divider circuit can deviate, the CDMA utilizes a single film print with dual resistive elements. This ensures minimal drift and aging, while providing excellent TCR / VCR tracking over a wide temperature range.



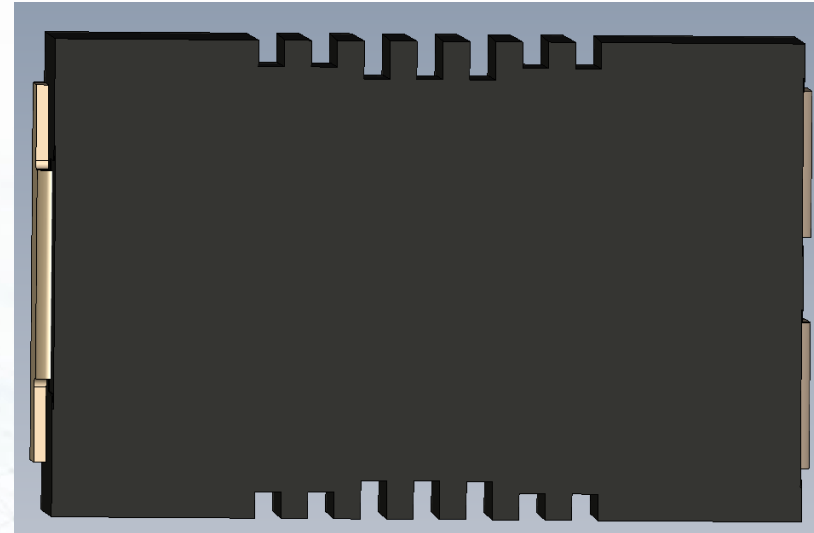
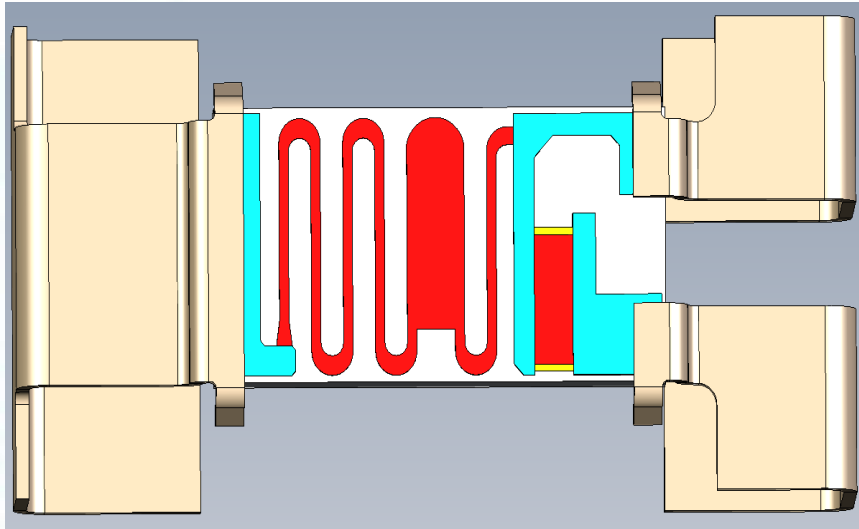
The DNA of tech.™

# Vishay Dale Knows – Divider Benefits



Two discrete resistors will drift;  
 Over time  
 Over temp  
 Over voltage

# Vishay Dale Knows – CDMM High Creepage



The DNA of tech.™

1. Wide range of resistance values and ratios
2. Precision to +/-0.5% with low TCR tracking to 10 ppm/deg C utilizing thick film technology
3. High Voltage to 1500V

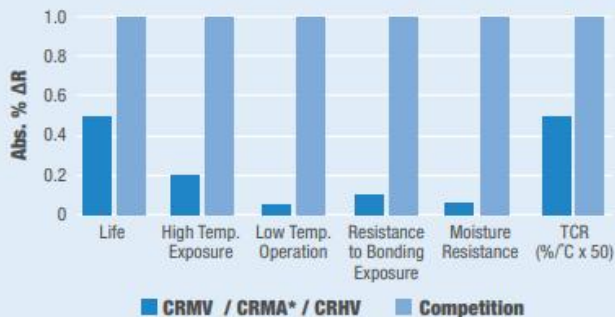
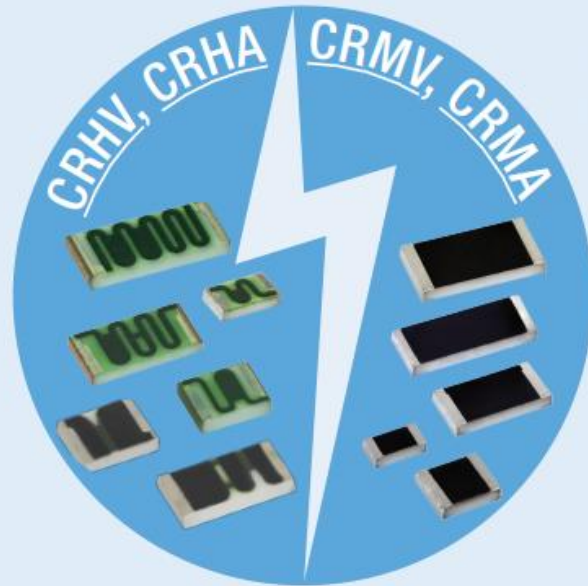
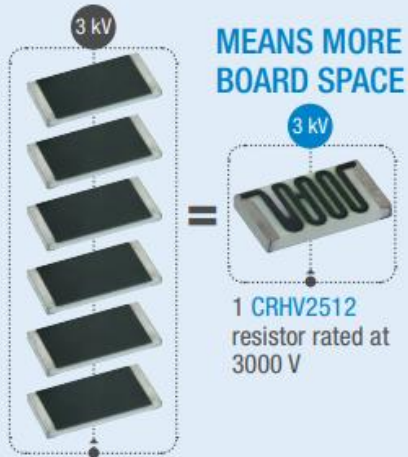
1. Automotive compliant terminations
2. 12.5mm creepage distance
3. Rated 1250V per IEC 60664-1
4. Sulfur resistant

# Vishay Dale Knows - HIGH VOLTAGE - CRMA



## CRHV / CRHA\* / CRMV / CRMA\* SERIES HIGH VOLTAGE THICK FILM RESISTORS

6 STANDARD RESISTORS = 1 CRxV

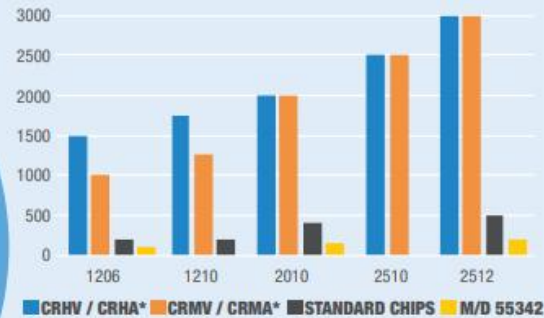


### FOOTPRINT Shown at actual size

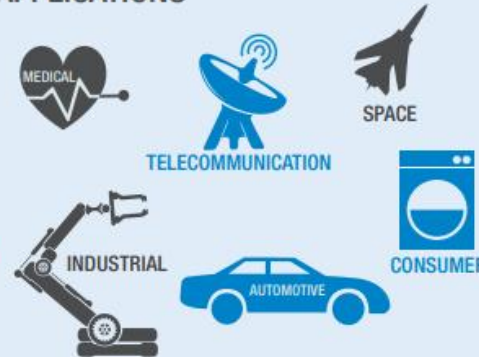


- Design flexibility with multiple termination configurations and materials including non-magnetic allow design flexibility
- Available as chip divider also – CDHV and CDMV respectively

### VOLTAGE HANDLING



### APPLICATIONS



#### Note

\* CRHA and CRMA are the AEC-Q200 qualified versions of CRHV and CRMV

[te1resistors@vishay.com](mailto:te1resistors@vishay.com)

## BENEFITS

- High voltage handling capability (to 3000 V) compared to standard thick film chips resistors
- Enables designers to reduce component count, circuit board size, and placement costs
- AEC-Q200 qualified for rigorous automotive applications

## APPLICATIONS

- Battery management
- Voltage monitoring
- High voltage regulators
- Smart circuit breakers
- Electric vehicle charging
- Power inverters
- High voltage power supplies
- Overvoltage protection

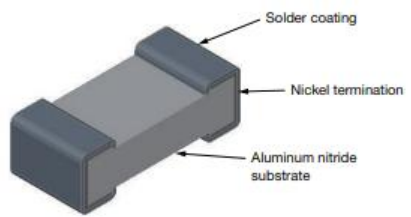
# Vishay Dale Knows - THERMAL MANAGEMENT SERIES – THJP AEC-Q200 QUALIFIED

## Helps remove heat from electrically isolated components

- Constructed using the thermally conductive, electrically insulating aluminum nitride
- Compatible with all conventional solder attach methods
- Connects high power devices to heat sinks without grounding or otherwise electrically connecting the devices

## Benefits

- Reduces component temperature
- Enables higher power handling
- Extends component life
- Facilitates sharing of heat sinks
- Reduces hot spots
- Enables high power components to float at a different voltage than the heat sink



## THERMAWick® THERMAL MANAGEMENT ELECTRICALLY ISOLATED THERMAL CONDUCTOR

Example THJP1206 Thermal Jumper Showing 36 % Surface Temperature Reduction

Ceramic Resistor Chip Without Thermal Jumper (149.8 °C)

Ceramic Chip Resistor With Thermal Jumper (95.5 °C)

THJP

Tin / lead and lead (Pb)-free  
RoHS-compliant solder finishes

### FEATURES

- Thin film surface-mount terminations
- High thermal conductivity
- High electrical insulation
- Low capacitance
- Long axis designs standard
- Custom sizes available

### APPLICATIONS

- Power supplies and converters
- RF amplifiers
- Synthesizers
- Switch mode power supplies
- Pin and laser diodes

INDUSTRIAL

TELECOM

MILITARY

### BENEFITS

**THERMAL CONDUCTIVITY**

↑

170 W/mK

**ELECTRICAL ISOLATION**

↑

> 999 MΩ

**CAPACITANCE**

↓

0.26 pF

CASE SIZE	0603	0612	0805	1206	1225	2512
Thermal Resistance (°C/W)	14	4	13	15	4	15
Thermal Conductance (mW/°C)	70	259	77	65	259	65
Capacitance (pF)	0.07	0.26	0.15	0.07	0.26	0.07
Dielectric Withstanding Voltage kV <sub>AC</sub> RMS (60 Hz)	> 1.5	> 1.5	> 1.5	> 1.5	> 1.5	> 1.5

### TYPICAL APPLICATION

www.vishay.com
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IG16843906-2210

# Vishay Dale Knows – AI Computing



## PRODUCTS:

- Vishay Industrial/High Reliability Surface Mount Chip Resistors
- WSK1216 - WSKP0612 - WSLP2726 - WSLF2512


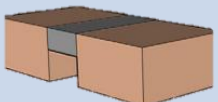
## COMPETITIVE EDGE:

- High power density, ultra low resistance values for high current measurement

## APPLICATIONS:

- Laptops
- Servers
- Memory devices
- Gaming
- Monitoring
- Ai Controller

# Vishay Dale Knows – Space Saving Form Factors

	WSLF3222	WSLF1206
<p><b>WSLF3222</b></p>   <p><b>WSLF1206</b></p>	<p><b>Resistance Range:</b> 0.00015Ω to 0.00027Ω</p> <p><b>Tolerance:</b> ± 1%</p> <p><b>Power:</b> <b>12W</b></p> <p><b>TCR ppm/°C:</b> ± 250ppm</p> <p><b>Temperature Range:</b> -65°C to +170°C</p>	<p><b>Resistance Range:</b> 0.0003Ω to 0.003Ω</p> <p><b>Tolerance:</b> ± 5 % / ± 1%</p> <p><b>Power:</b> <b>Up to 5W</b></p> <p><b>TCR in ppm/°C:</b> ± 275ppm 0.3mΩ ± 200ppm for 0.5mΩ ± 100ppm for 1mΩ ± 75ppm for 2mΩ and 3mΩ</p> <p><b>Temperature Range:</b> -65°C to +170°C</p>

## Benefits

- Low thermal resistance
- Maximized heat transfer
- Resistant to Thermal Shock
- Superior pulse performance
- Design flexibility and Precision

## Construction Features

- Very short thermal path from resistive element to PCB and hence low thermal resistance
- Robust all metal welded construction
- Punched trimmed to value and tolerance
- High power density compared to Power to Size ratio

Low thermal resistance means low self heating at high power density and minimizes measurement error caused by TCR effects.



## PRODUCTS:

- Industrial Axial Metal Film Resistors - CMF/CPF/PTF series
- WSL – WSLP – WSHM - WSLF2512 – WFC – WFCP

## COMPETITIVE EDGE:

- Tin-lead and lead-free available
- Fully customizable
- Robust construction that withstands fault conditions.

## APPLICATIONS:

- White goods
- Heating & Air
- Home security
- Lighting
- Home monitoring
- Direct Drive motor control - Power Factor correction – HVAC - white Goods



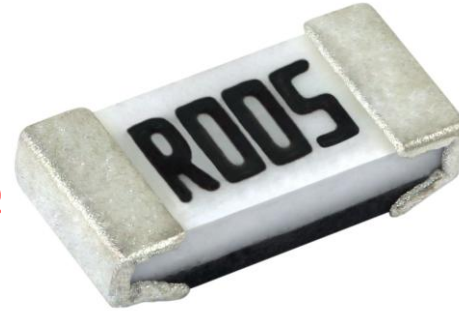
# Vishay Dale Knows – Small Size and Low Resistance Values

## Series

- WFC and WFCP

## Features

- Resistance values down to **1 mΩ**
- Small footprint down to 0402
- High power density in wide range
- TCR down to **50 ppm/C**



## Applications

- Battery management
- Power management
- Inverter control / motor control
- Power factor correction

## Markets (End Products)

- Telecomm: power management in cell phones
- Computer: power management, DC/DC converters, VRMs
- Consumer: air-conditioning / heat pump (inverter control), white goods (inverter control)
- Industrial: air-conditioning / refrigeration, motor control

GLOBAL MODEL	SIZE	POWER RATING W	RESISTANCE VALUE RANGE Ω
WFC0402	0402	0.125	0.003 to 0.05
WFC0603	0603	0.33	0.001 to 0.005
	0603	0.25	0.0051 to 0.03
WFC0805	0805	0.50	0.001 to 0.04
WFC1206	1206	1.0	0.001 to 0.05
	1206	0.5	0.100 to 0.18

GLOBAL MODEL	SIZE	POWER RATING W	RESISTANCE VALUE RANGE Ω
WFCP0402	0402	0.25	0.0025 to 0.050
WFCP0508	0508	0.5	0.005 to 0.03
WFCP0603	0603	0.5	0.002 to 0.03
WFCP0612	0612	1.0	0.0051 to 0.03
	0612	2.0	0.001 to 0.005

# Vishay Dale Knows – Kelvin Sensing

## Series

- WFK

## Features

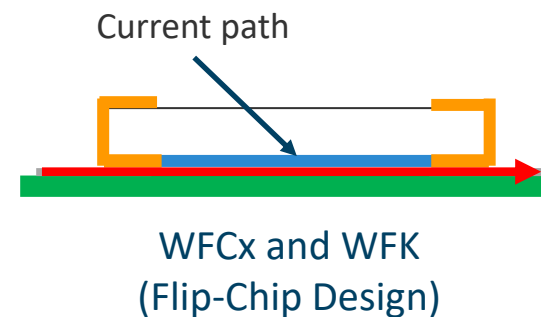
- 4 Terminal Kelvin Connection
- Resistance Values down To **1 mΩ**
- 0612 Footprint
- TCR down to **50 ppm/C**
- Low Inductance

## Applications

- Switching Power Supply
- Voltage Regulation Module
- Inverter control / Motor Control
- Power Factor Correction

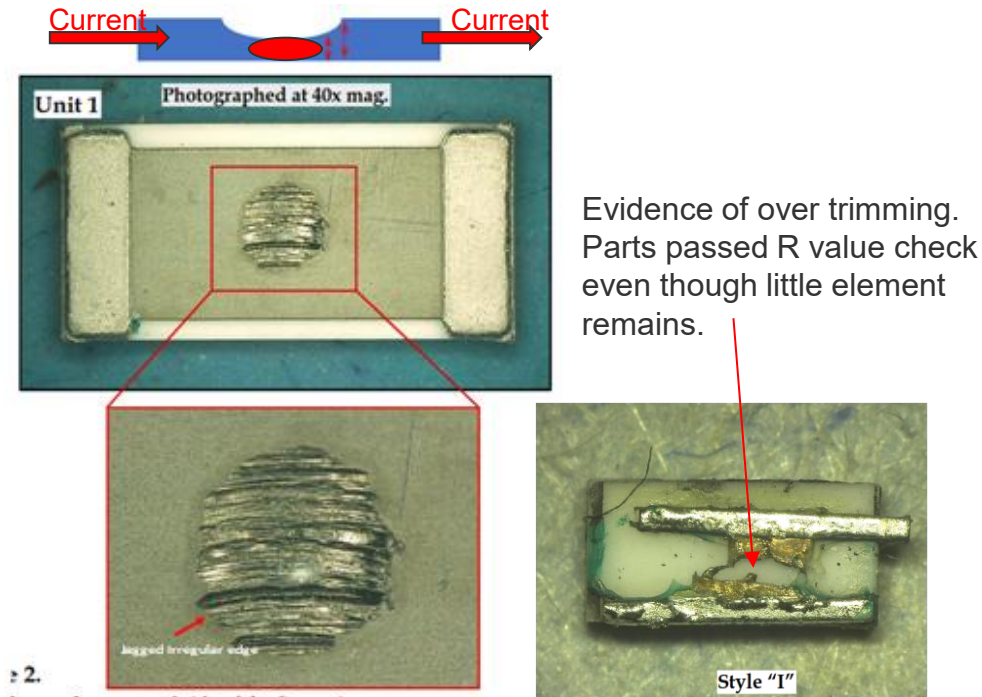
## Markets (End Products)

- Telecomm: Power Management in Cell Phones
- Computer: Power management, DC-DC converter, VRM's
- Consumer: Air-conditioning / Heat-pump (inverter control), White-goods (inverter control)
- Industrial : Air-conditioning / Refrigeration, Motor Control



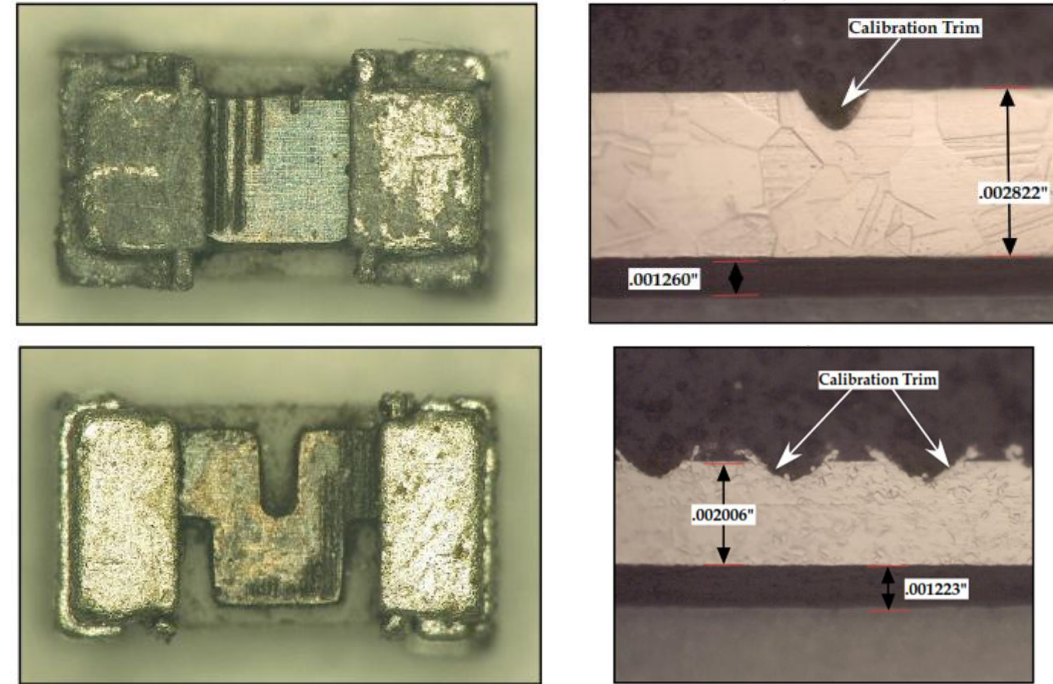
# Vishay Dale Knows - Trimming process Vishay vs. Competition

## Competition



- Competitors using a mechanical burr trim to get to R Value
- Thin Metal Foil with mechanical trimming causes much thinner area in the middle of element.

## Vishay



- Trimming by laser ablation and etching (block & serpentine)
- Uniform cut depth for maximum current carrying capacity
- Maximum heat disipation capacity
- No risk of fusing for STOL pulse

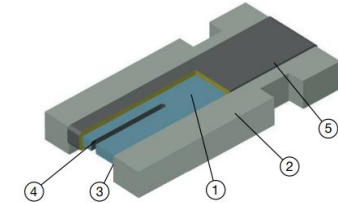
# Vishay Dale Knows - Low Inductance WSL0612/1020 & WSKW0612



The DNA of tech.

	WSL0612 (2-Terminal)	WSKW0612 (2-Terminal)	WSL1020 (2-Terminal)
	<p><b>Resistance Range:</b> 0.00075Ω to 0.005Ω</p> <p><b>Tolerance:</b> ± 1% / ± 5%</p> <p><b>Power:</b> <b>1W</b></p> <p><b>TCR ppm/°C:</b> +250ppm for 0.75 mΩ and 1.9 mΩ +150ppm for 2 mΩ to 6 mΩ</p> <p><b>Temperature Range:</b> -65°C to +170°C</p>	<p><b>Resistance Range:</b> 0.0005Ω to 0.005Ω</p> <p><b>Tolerance:</b> ± 1% / ± 5%</p> <p><b>Power:</b> <b>1W</b></p> <p><b>TCR in ppm/°C:</b> &lt; 50ppm</p> <p><b>Temperature Range:</b> -65°C to +170°C</p>	<p><b>Resistance Range:</b> 0.001Ω to 0.006Ω</p> <p><b>Tolerance:</b> ± 0.5 % / ± 1% / ± 5%</p> <p><b>Power:</b> <b>2W</b></p> <p><b>TCR in ppm/°C:</b> &lt; 50ppm</p> <p><b>Temperature Range:</b> -65°C to +170°C</p>

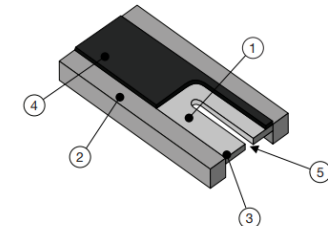
## CONSTRUCTION OUTLINE



### Notes

1. Resistive element: Mn-Cu
2. Terminal: solid copper and element with 100 % Sn finish
3. Terminal to element weld
4. Laser calibration
5. High temperature encapsulant: siliconized polyester coating material

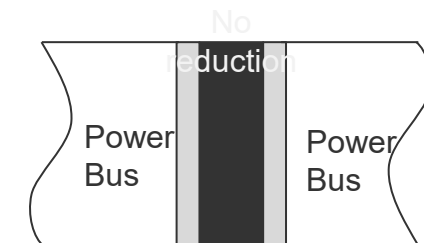
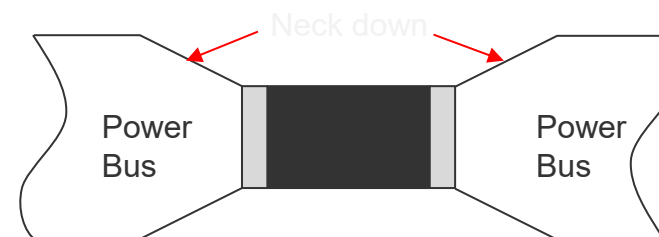
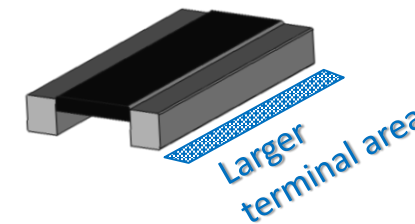
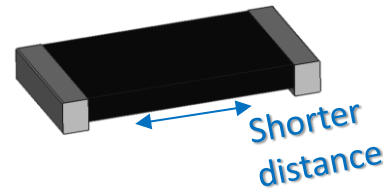
## WELDED CONSTRUCTION



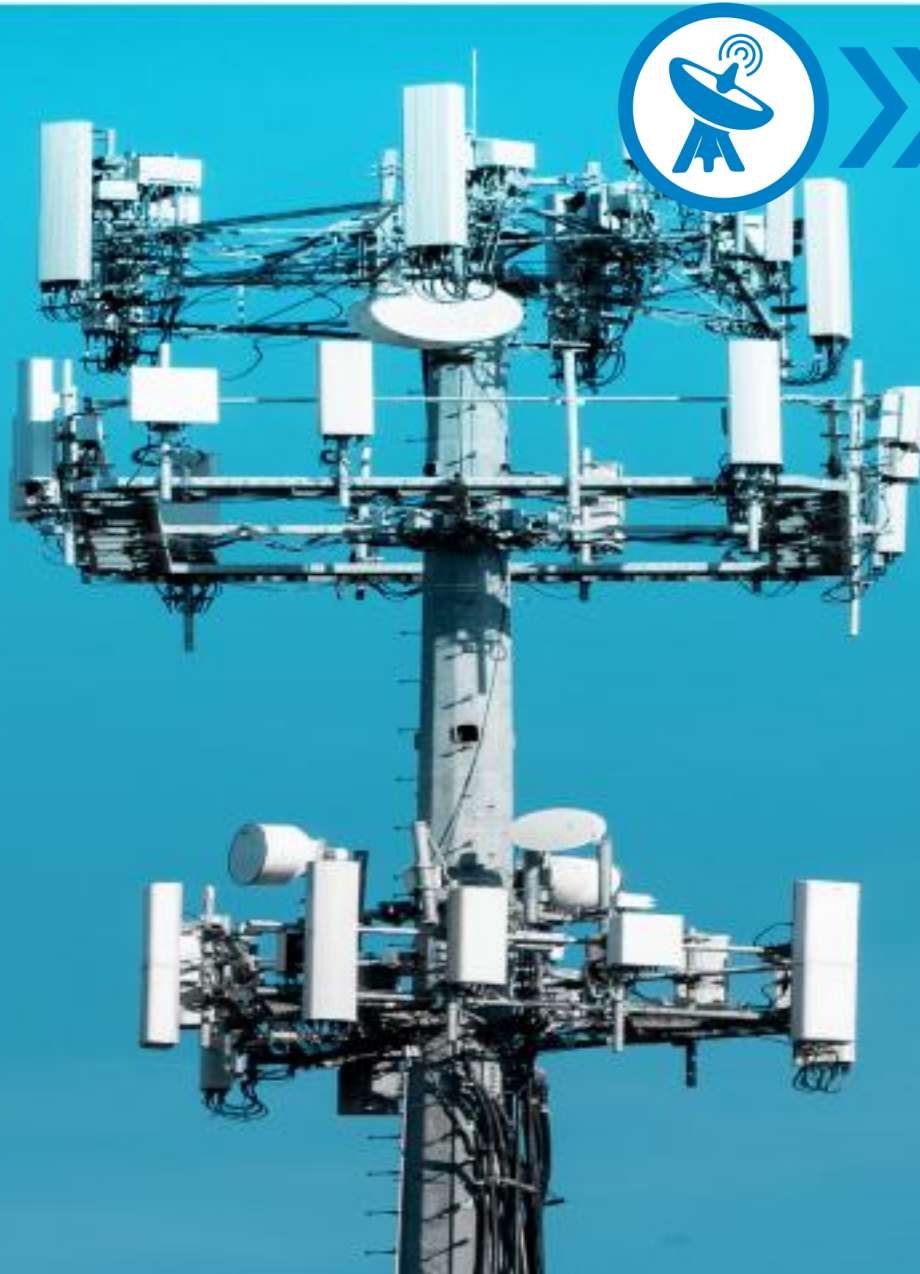
- 1 Resistive element: nickel-chrome or manganese-copper alloy with low TCR (< 20 ppm/°C)
- 2 Terminal: solid copper with 100 % Sn finish  
100 % Sn (100 μ<sup>2</sup> min.) with 100 % Ni (20 μ<sup>2</sup> min.) under layer finish
- 3 Terminal / element weld (electron beam weld)
- 4 High temperature encapsulant: "siliconized polyester" coating material
- 5 Laser calibration

## Key Benefits

- Higher power density than standard termination Low Inductance
- Very low resistance values
- Advanced heat transfer due to larger contact area



# Vishay Dale Knows - Telecommunications



## PRODUCTS:

- VISHAY INDUSTRIAL/HIGH RELIABILITY SURFACE MOUNT CHIP RESISTORS
- WFC - WFCP - WSKP0612 - WSLP3921 - WSLF2512
- FCxx High Frequency Chips

## COMPETITIVE EDGE:

- Low resistance range to minimize power loss and measure high currents

## APPLICATIONS:

- -Signal amplification
- Wireless communications
- Wi-Fi
- Satellites
- Fiber optics
- Broad band networks
- Inverter power supplies

# Vishay Dale Knows – High Frequency - FC SERIES

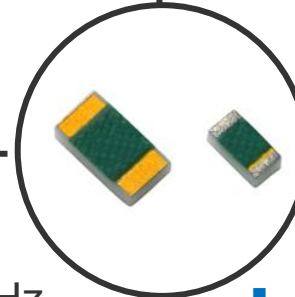
## Market Segments

- Telecommunication
- Industrial



## Applications

- Low noise amplifiers
- Transmission base stations
- Fiber optic transponders
- Attenuation
- Line Termination



## Features

- Frequency performance up to 40GHz
- TCR of  $\pm 25$  ppm/ $^{\circ}$  C
- Resistance range 10 $\Omega$  to 1k $\Omega$
- Tolerance to  $\pm 0.1\%$
- Multiple options for termination styles:
  - Top Sided or Wraparound Au term over Ni
  - Top Sided or Wraparound Sn/Pb with Ni barrier
  - Top sided or Wraparound lead-free solder with Ni barrier

## Key Advantages

- Precision tolerance to  $\pm 0.1\%$
- Low internal reactance (< 10 m $\Omega$ )
- Stable film and performance characteristics: 200 ppm at 70  $^{\circ}$ C, 2000 hours
- Flexible packaging options
- Competitors have limited offerings, while the FC series provides a wide range of Tolerance and Resistance

# Vishay Dale Knows – High Power / High Frequency

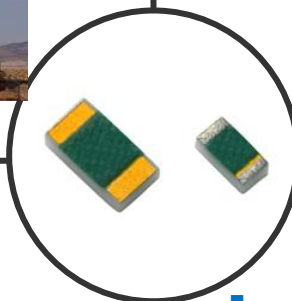
## Market Segments

- Telecommunication
- Industrial



## Applications

- 5G Communication systems
- Fiber optic transponders
- Attenuation



## Features

- Power rating to 1W
- Frequency performance up to 40GHz
- TCR of  $\pm 25$  ppm/ $^{\circ}$  C
- Resistances 50 $\Omega$  & 100 $\Omega$
- Tolerance to  $\pm 0.1\%$
- Multiple options for termination styles:
  - Top Sided or Wraparound
  - Gold or solder plated versions

## Key Advantages

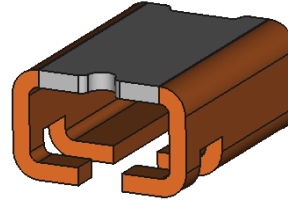
- Smaller case size 0402 with high power rating to 1W
- Precision tolerance to  $\pm 0.1\%$
- Flexible packaging options
- Provide stable resistance roll off at high frequency to 40 GHz for optical and copper transceivers

# Vishay Dale Knows – Beyond Datasheets

## Data Packages

- Reliability Reports
- Qualification data
- PPAP documentation

## 3d Models



## Performance Data

- Power vs Temperature
- TCR
- Inductance

## Design Tools

[www.vishay.com/en/resistors/joulewizard/](http://www.vishay.com/en/resistors/joulewizard/)



[JouleWizard Introduction - YouTube](#)

## Brochures & White Papers

Automotive 101 Brochure



## AECQ200

Robust Performance /  
Automotive Grade



[Resistors: Boost Power Density with Automotive Current Sense Resistors - YouTube](#)  
[Vishay Automotive Grade? - YouTube](#)



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