

Bourns Current Sense Intro

2015

BOURNS®

Bourns – resistor technology

- Bourns, Inc. is a leading provider of components and solutions for ***Motion Control, Circuit Protection and Circuit Conditioning***
- **Founded in 1947**, by Marlan Bourns, the inventor of the Trimpot[®] trimming potentiometer, and his wife Rosemary Bourns
- Majority of our product lines are based on resistor technology, trimmers, sensors & control, automotive sensors, fixed resistors



Bourns Fixed Resistors – by technology type



Networks



Arrays



Current Sense



Wirewounds



Specialized Chips



Power Resistors



Chip Resistors (thick)



Chip Resistors (thin)



RF Resistors

Resistor Technology



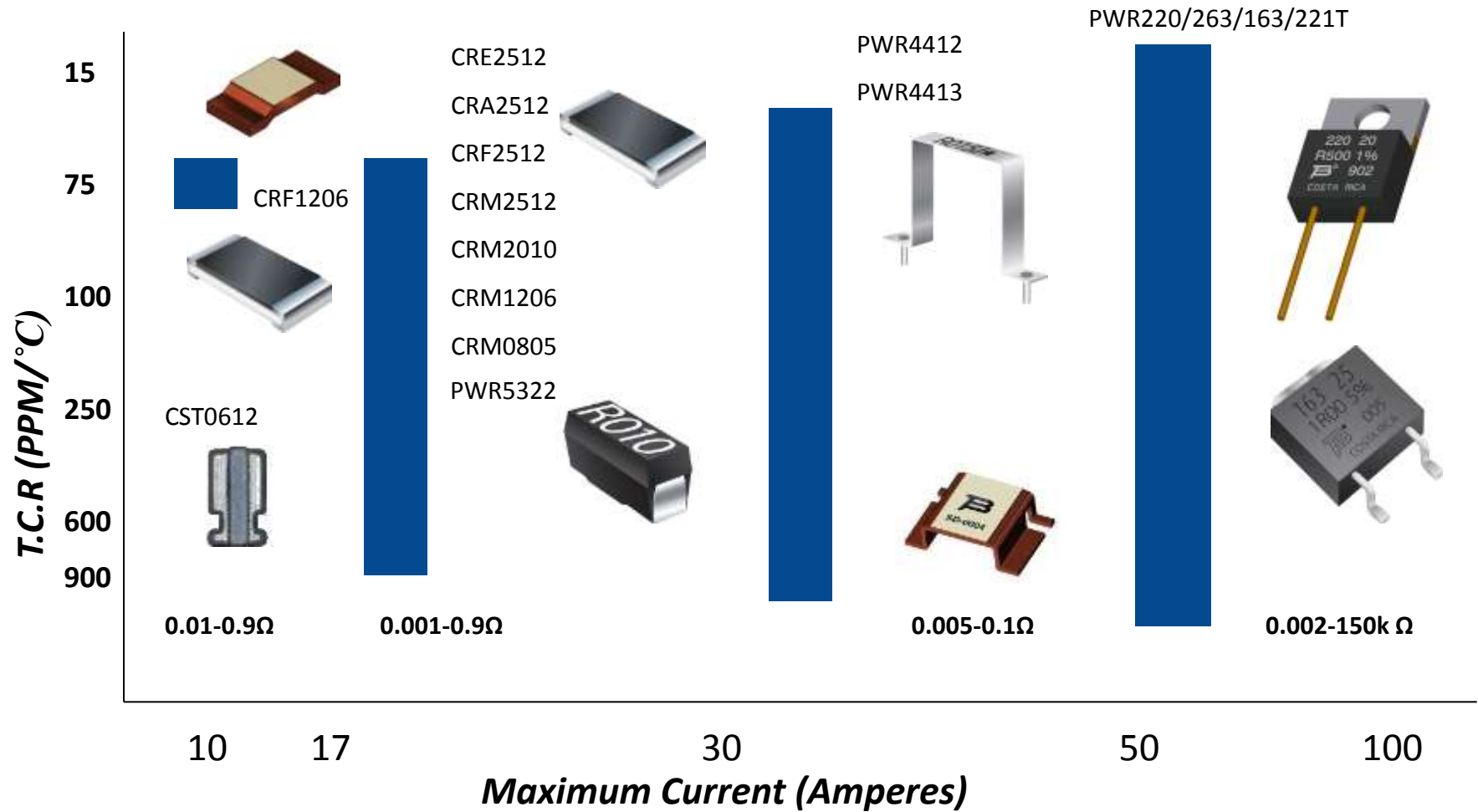
Bourns Value Proposition

- In-house design, toolmaking, screen-printing, cermet firing & compression molding
 - Development of proprietary resistive ink
 - Worldwide engineering support capabilities
 - All manufacturing sites are TS 16949 certified
 - >12,000 part numbers, 53 product families and 5 different resistive element types
-
- Automotive grade resistors are made in Heredia, Costa Rica










Fix Resistor products

Diagram



Focus Power Resistor Products

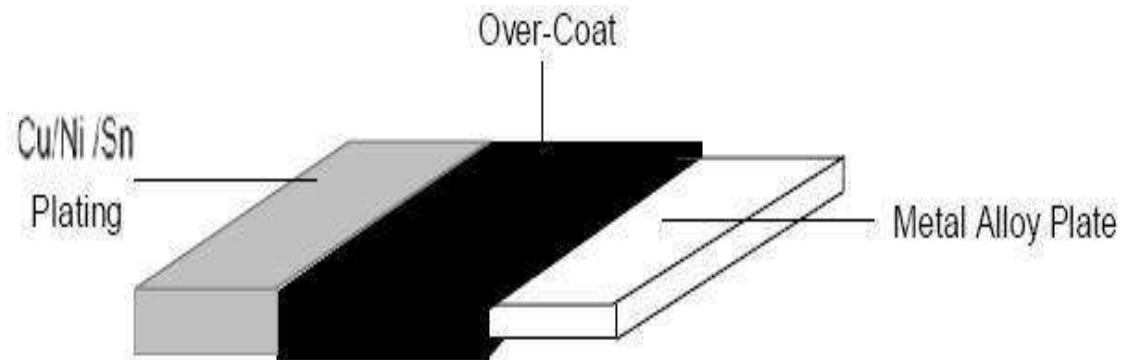
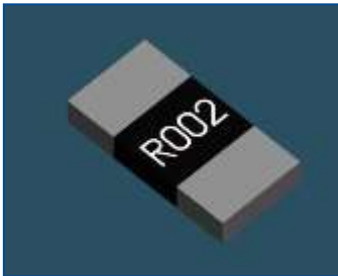
Function	Product type	Outline Shape	Typical Model	Target Application	Competitor Model
Current Sense	Thick Film	 	CRM CRS	Power/SMPS/Mot or Driver	Vishay WSL/WSC WALSIN, IRC
	Shunt	 	CST0612 CSS2H/3N/4H	BMS&Automotive	ISA BVR/BVE/BVS Vishay 5930/5931
Current Limiting	SMD DPAK		PWR163 PWR263	BMS/BBU	Vishay LTO/ D2TO CADDOCK MP725
	TO-220 THRU Hole	 	PWR220T PWR221T PWR247		Vishay RTO CADDOCK MP820/850/930 BI MHP

Bourns Advantage:

- Automotive AEC Q200 approved products
- Competitive price with Vishay/Isabella/CADDOCK
- Customized parts available
- Friendly technical and sales staff, Available through major distributors

Current Sensing

- Traditional resistors using thick film technology are limited in the low resistance they can achieve, $\sim 20\text{m}\Omega$
- To achieve lower resistance values, metal element shunts need to be employed.



Typically $< 20\text{m}\Omega$

Helps maximize energy conversion efficiency

Helps minimize power consumption



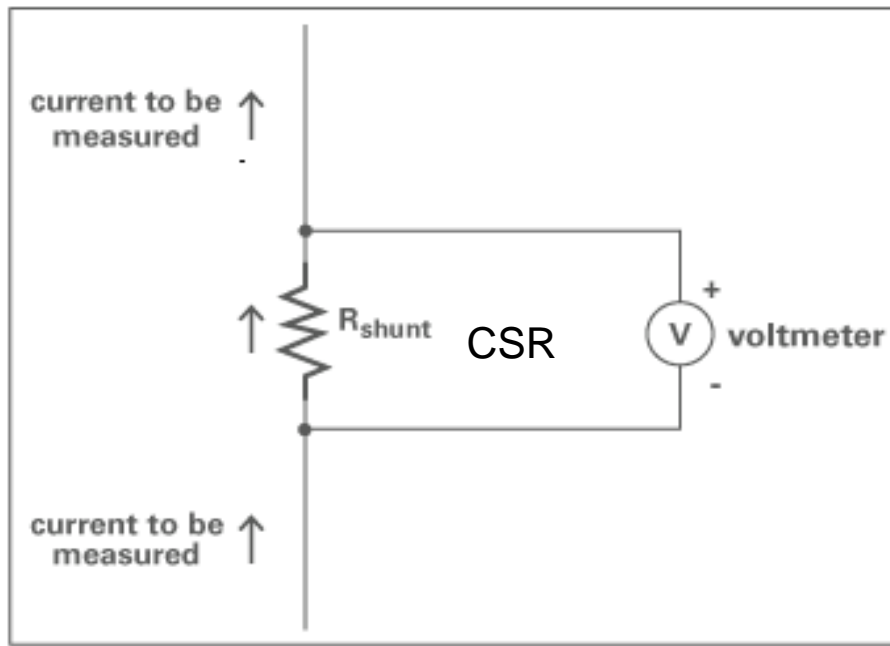
Current Sensing

- Circuits that Rely on Current Sensing
 - Current Sense Amplifiers (eg Telecom Supply Current Monitor)
 - H-Bridge Current Monitoring
 - Bi Directional (Battery Load/Charge) Control
 - High Voltage Sampling
 - Li Ion Gas Gauges
 - Buck/Boost Switching Regulators
- As power supply technology advance so does the need for accurate currents sensing
- Current sensing options:
 - Current sense Resistor Shunt – ease of design, cost, accuracy
 - Hall effects sensors – high costs and variation with temp
 - Magnetics – e.g. rogowski coils. Good for high currents but once magnetized, it loses accuracy



What is a Current Sensing Resistor?

CSR is used to monitor the current in a circuit and translate the amount of current in that circuit into a voltage that can be easily measured and monitored.



Ohm's Law: $V = I \times R$



Current Sensing Resistors

- Current Sense resistors perform:
 - Current measurement
 - Detect Overcurrent events
 - Monitor remaining battery levels
- Low Resistance:
 - Typically $> 25\text{m}\Omega$
 - Helps maximize energy conversion efficiency
 - Helps minimize power consumption
- Tight resistance tolerances:
 - Typically 1%
 - Helps maximize the energy saving
 - Helps maximize the sensing performance





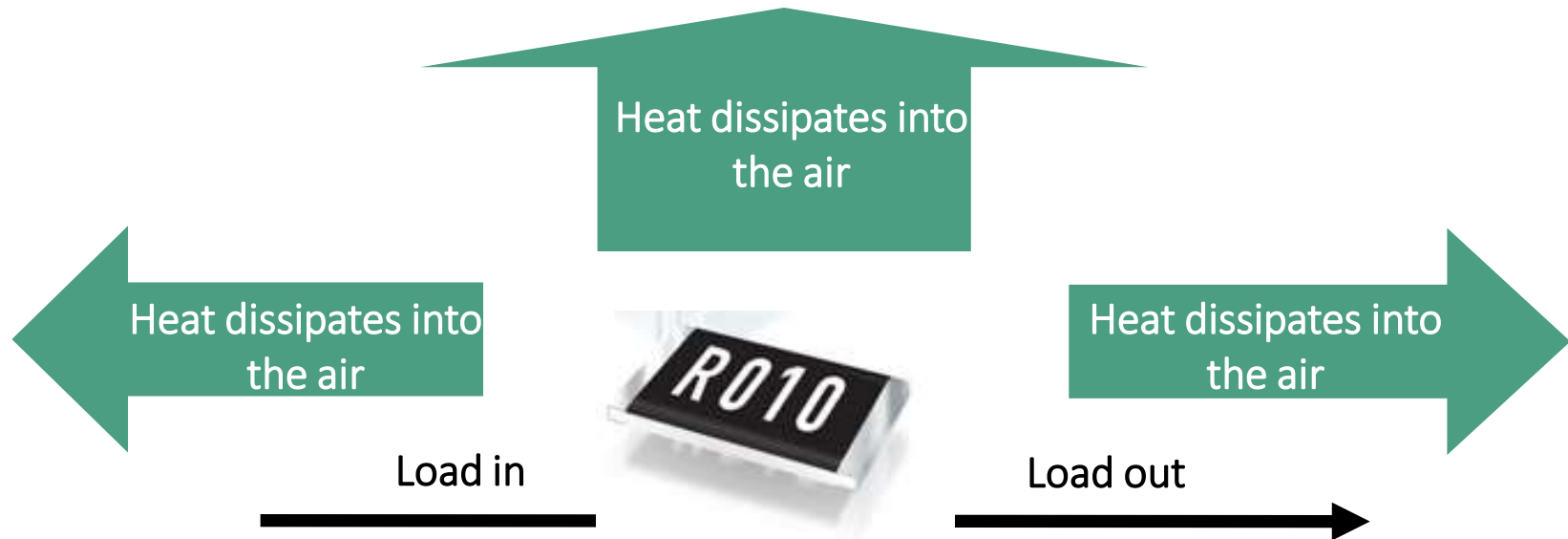
Current Sense Resistors – critical features

- Low TCRs:
 - Typically 75ppm
 - Stable operating accuracy over wide temperature range
 - Crucial for industrial and auto applications
- Low thermal EMF:
 - Thermocouple effect of different metals in direct contact with each other
 - Causes a voltage variation with temperature changes at the intermetallic junctions
 - Typically a Thermal EMF of $<50\mu\text{V}/^{\circ}\text{C}$ (vs copper) is preferred






Current Sense Resistors – critical features

Heat Dissipation

- Depends on :
 - Resistive element
 - Heat dissipation rate



Current sense matrix

Model	Image	Size (mm)	Terminals	Min Resistance Available (Ohm)	Power Rating (W)	TCR (PPM/C)	Resistance Tolerance (%)	Maximum Temperature °C	Maximum Current
CRE2512		6.45 x 3.35	2	0.001	3	+/-75	+/-1	170	55
CRA2512		6.45 x 3.35	2	0.01	3	+/-75	+/-1	170	17
CRF0805		2x1.25	2	0.005	0.5	+/-100	+/-1	170	10
CRF1206		3.2x1.65	2	0.001	1	+/-275	+/-1	170	32
CST0612		1.65x3.05	4	0.0005	1	+/- 200	+/- 1	170	45
CSS2H-5930		15 x 7.75	2	0.001	10	+/-50	+/-1	170	100
CSS2H-3920		10 x 5.2	2	0.001	8	+/-50	+/-1	170	89
CSS2H-2512		6.35 x 3.05	2	0.0005	6	+/-50	+/-1	170	110



Current Sensing Resistors Elements

As applications tending higher power and smaller size, the current sensing resistors are requested to be:

Low Resistance → $0.02\Omega \sim 9.1\Omega$

Handling More Power → $0.1W \sim 3W$

Higher Current Capability → $80A$

Device Size Decreasing → $0402 \sim 2512$

Tight Resistance Tolerance → $0.5\% \sim 5\%$

Low TCR (Temperature Coefficient of Resistor) → $50ppm / ^\circ C$

Low Thermal EMF

Environment Friendly → SGS, Lead-free, HF

Bourns Current Sensing Resistors

2 Terminal Families

CRA Series - Metal foil resistors (Mn-Cu alloy)

- 2512 Size

CRE Series - Metal foil resistors (Mn-Cu alloy)

- 2512 Size

CRF Series - Metal foil resistors (Mn-Cu alloy)

- 0805~2512 Sizes

- 75 ~ 275ppm/°C

CRL Series - Thick film resistors

- 0402~2512

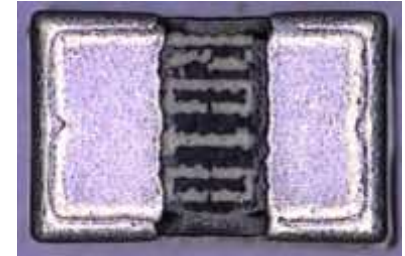
- 200 ~ 400ppm/°C

4 Terminal Family

CST Series - Metal foil

0612 – 4 terminals

CRL Series

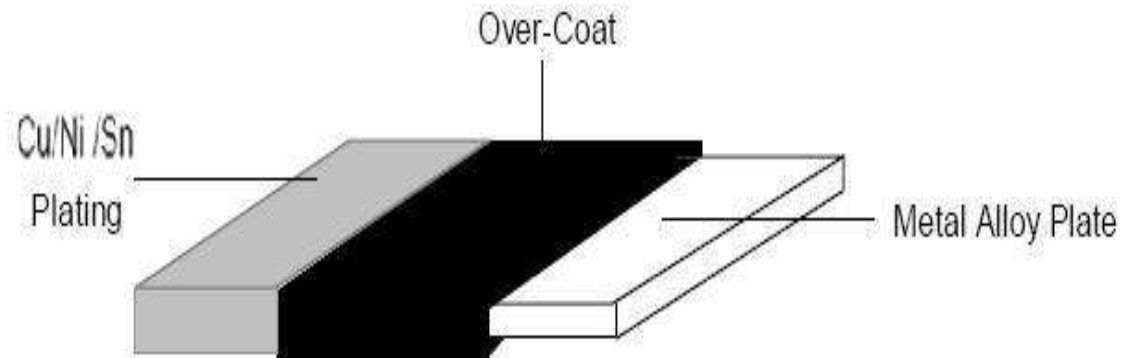
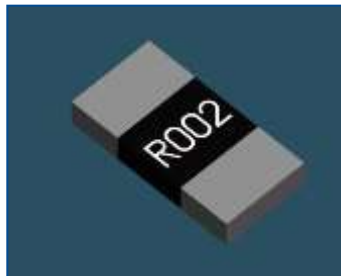


CRA, CRE & CRF Series





CRA, CRE & CRF Structures



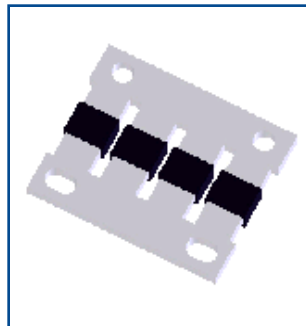
CRA, CRE & CRF Materials

Material of Resistive Plate	CRF	Nickel-Copper (NiCu) Alloy or Manganese-Copper (MnCu) Alloy
	CRA & CRE	Nickel-Copper (NiCu) Alloy or Manganese-Copper (MnCu) Alloy

CRA, CRE & CRF Process



Resistive Plate
Forming by Punch



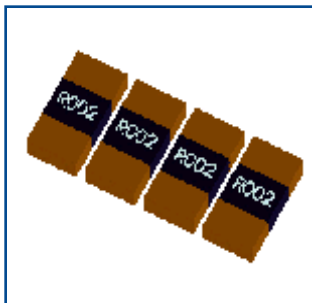
Protection
Layer Coating



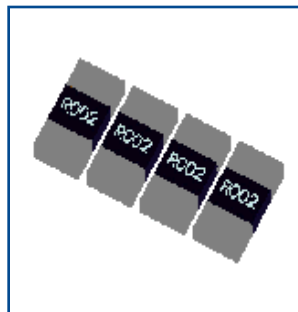
Marking



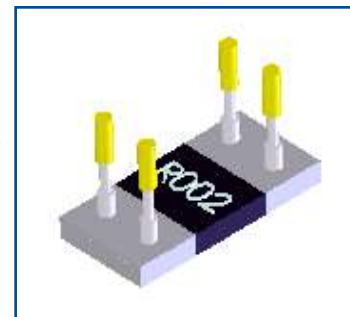
Chip Separation



Electrode
Plating Cu



Electrode
Plating Ni/Sn



Test & Sorting

CRA & CRF Specs

	CRF	CRA & CRE
Power Rating	1W&2W	2W & 3W
Resistance Value	1~50mΩ	1~100 mΩ
T.C.R	275ppm/° C (R<3mΩ)	75ppm/°C
	100ppm/° C (3mΩ ≒ R ≒ 10mΩ)	
	75ppm/° C (R>10mΩ)	
Tolerance	1%(F), 2%(G), 5%(J)	
Operating Temperature	-55°C ~ +170°C	



CRF Specs

Type	CRF0805	CRF1206	CRF2512
Power Rating	1/4W&1/2W	1W & 1/2W & 1/4W	1W & 2W
Resistance Value	5~20mΩ	5~30mΩ	1 ~ 50mΩ
T.C.R	275ppm /°C (R ≤ 2mΩ)		
	100ppm /°C (2mΩ < R ≤ 10mΩ)		
	75ppm /°C (R > 10mΩ)		
Operating Temperature	-55°C ~ +170°C		
Maximum Working Voltage	$(P \times R)^{1/2}$		
Tolerance	1%(F), 2%(G), 5%(J)		



CRA Specs

Type	CRA2512
Power Rating	1W & 2W & 3W
Resistance Value	1.1m~100 mΩ
T.C.R	75 ppm/°C
Operating Temperature	-55°C ~ +170°C
Maximum Working Voltage	$(P \times R)^{1/2}$
Tolerance	1%(F), 2%(G), 5%(J)

CRL Specs

Type	CRL0402	CRL0603	CRL0805	CRL1206	CRL2010	CRL2512
Power Rating	1/16W	1/8W	1/4W	1/2W	3/4W	1W
Resistance Value	0.2~9.1Ω	0.1~9.1Ω	0.05~9.1Ω	0.02~9.1Ω	0.02~9.1Ω	0.02~9.1Ω
T.C.R	200ppm/° C (50mΩ~910mΩ)					
	400ppm/° C (21mΩ~49mΩ)					
	600ppm/° C (20mΩ)					
Operating Temperature	-55~+125 (° C)					

Thick Film Chip Resistors

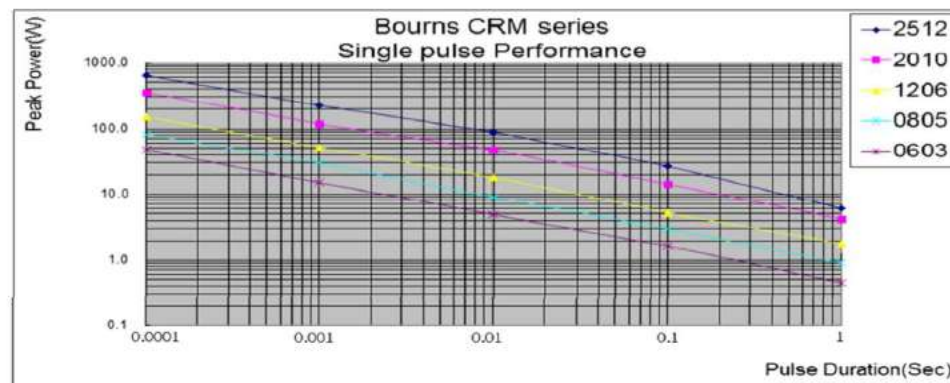
For current sensing

CRM Series - chip resistors with high power ratings



	CRM0805	CRM1206	CRM2010	CRM2512
Resistance range	47 mohm to 1 Mohm			110 mohm to 1Mohm
Power rating	0,25 W	0,5 W	1 W	2 W
TCR	±100 ppm/°C ±200 ppm/°C			
Tolerance	±1 %, ±5 %			
Working temperature	-55 to +155°C			

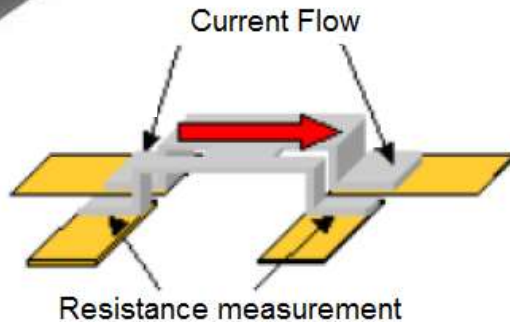
- Strong pulse performance
- Power supplies
- Stepper motor drives
- Current limiting
- Snubber





CST Series

4 terminal type



Application: Consumer (graphic cards), Industrial electronics

Competitive Advantage: less hot spots due to trimming by grinding

Market Benefit: Low cost method to monitor the current in a circuit and translate the amount of current into a voltage that can be easily measured and monitored



CST Series

4 terminal type

Features

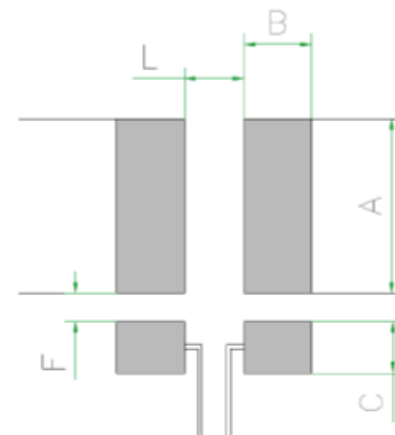
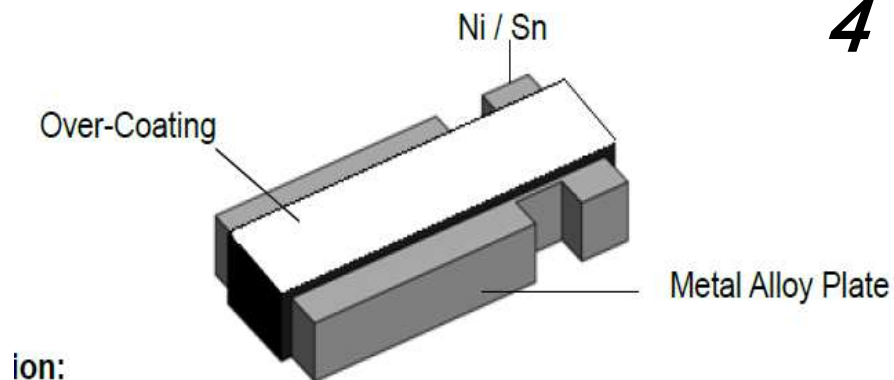
Type	CST0612
Power Rating	1/2 W&1W
Resistance Value	0.5m Ω ~ 5m Ω
Operation Temperature Range	-55°C~+170°C
Temperature Coefficient of Resistance	$\pm 200\text{ppm}/^\circ\text{C}$ (0.5m $\Omega \leq R \leq 3\text{m}\Omega$)
	$\pm 150\text{ppm}/^\circ\text{C}$ (3 m $\Omega \leq R \leq 5\text{m}\Omega$)
Tolerance	$\pm 1\%$, $\pm 2\%$, $\pm 5\%$
Insulation Resistance	Over 100M Ω
Maximum Working Voltage(V)	$(P \cdot R)^{1/2}$

Note*:1 Watts with total solder pad and trace size of 300mm²

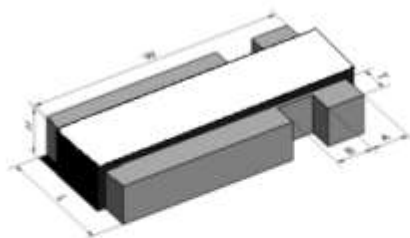


CST Series

4 terminal type



Copper foil minimum thickness of PCB: 3oz



抵抗値 (Ω)	A	B	C	L	F
0.0005-0.005	2.3	1.0	0.8	0.7	0.4





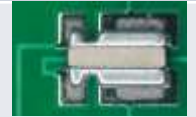




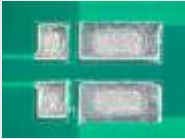







Unit: mm

L	W	H	T	A	B	Material
1.65±0.2	3.05±0.25	0.65±0.2	0.4±0.25	0.51±0.13	0.51±0.13	Strip : Alloy Over Coating : molding Compound UL-94V-O grade

Comparison between technologies

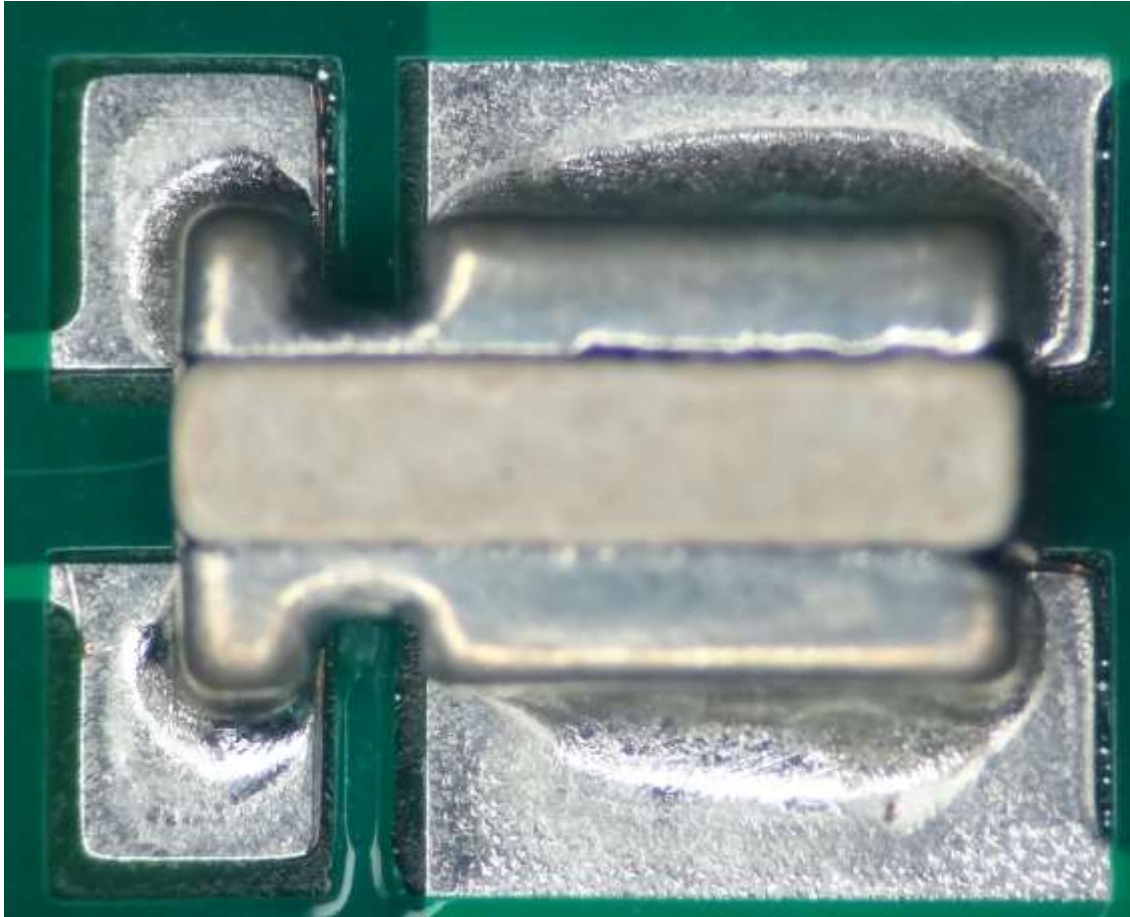
Current Sensing Technology	Low resistance current shunt	Current Transformer	Hal Effect Sensor	Rogowski Coil
Cost	Very Low	Medium	High	Low
Linearity over measurement range	Very Good	Fair	Poor	Very Good
High Current measuring capability	Very Poor	Good	Good	Very Good
Power consumption	High	Low	Medium	Low
DC/high current saturation problem	No	Yes	Yes	No
Output variation with temperature	Medium	Low	High	Very Low
DC offset problem	Yes	No	Yes	No
Saturation and Hysteresis problem	No	Yes	Yes	No

Current sense resistors can be influenced by production conditions so Bourns uses specialized in house EMS service for production testing

Solder Paste Level	Process	0.1mm	0.15mm	>0.15mm
For TCR Test	Solder paste print			
	Mount Resistor			
	IR Reflow			
For Power Rating Test	Solder paste print			Not available
	Mount Resistor			
	IR Reflow			

EMS solder printing and resistor assembly

Solder paste thickness = 0.1mm



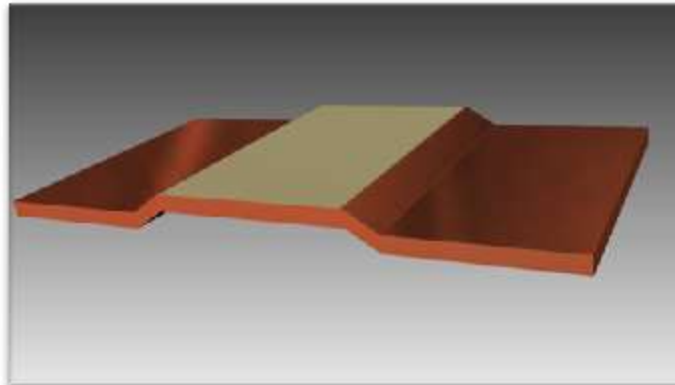
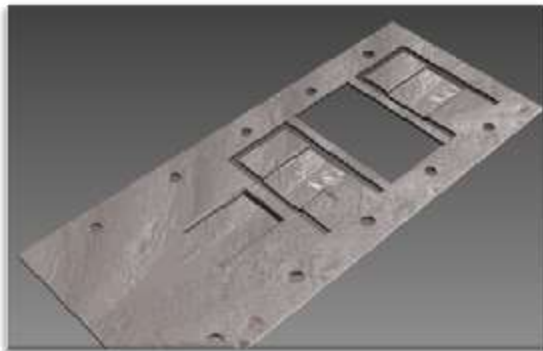
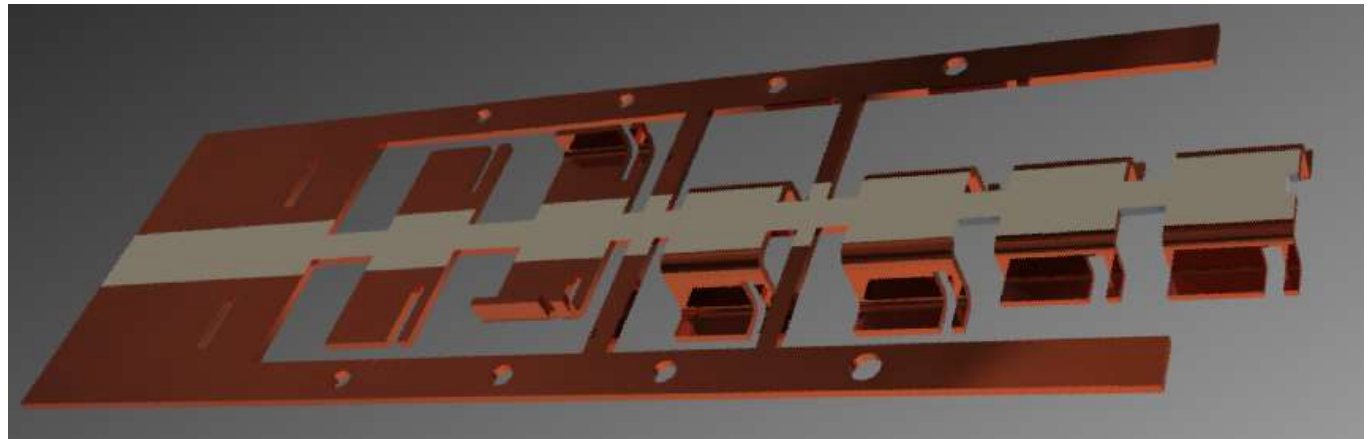
- Different Solder conditions has not caused significantly different solder joints

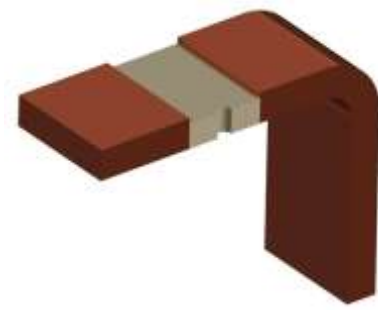
SHUNTS



Current Sense

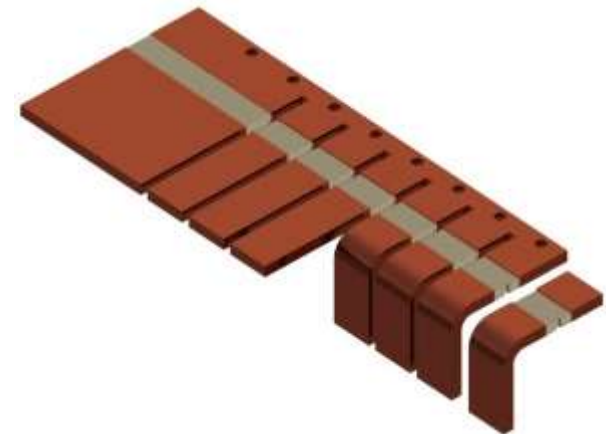
- Very low Resistance values
- Made out of Electron Beam welded resistive element to copper sheets
- Die forming out of the metal sheet
- SOP Q3 2015 in Costa Rica





Product Release

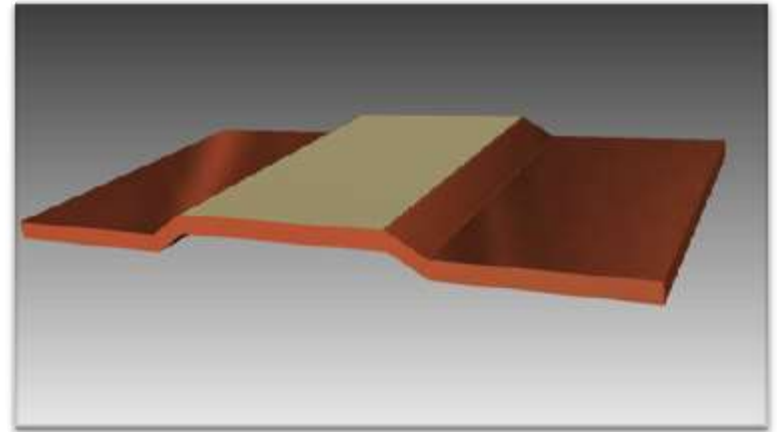
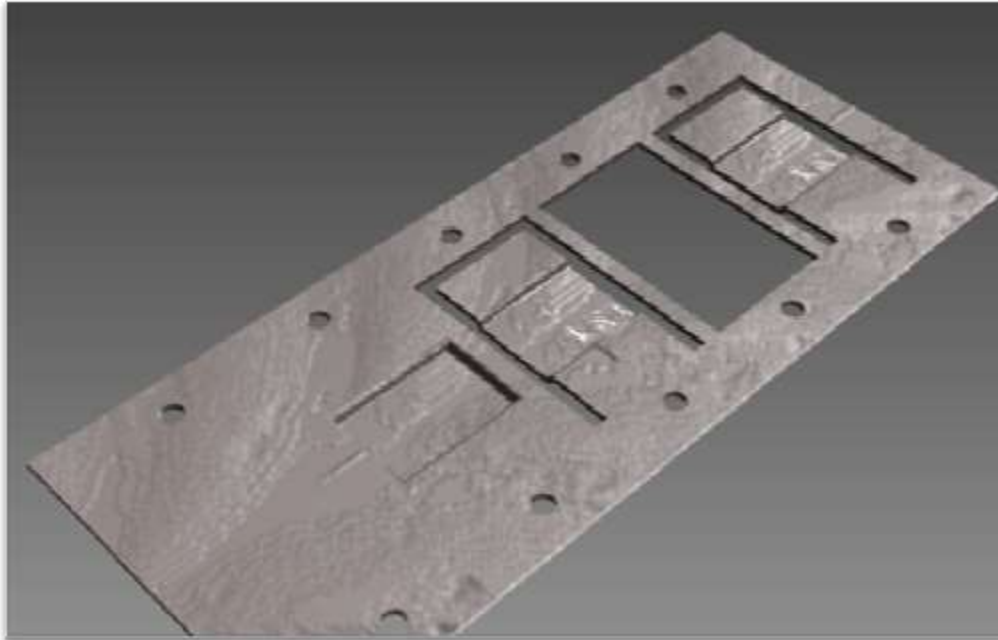
1. Release specific customer project, Delta (Lear)
2. Release individual part numbers first :
 - Equivalent to ISA BVE 1m Ω & 2m Ω
 - Equivalent to ISA BVT 1m Ω & 2m Ω
 - Equivalent to ISA BVR 1m Ω & 2m Ω
3. Flesh out families with specific customer requests



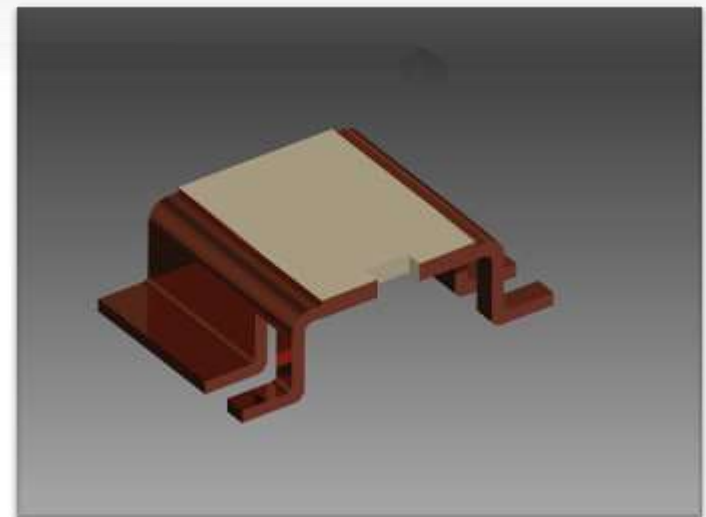
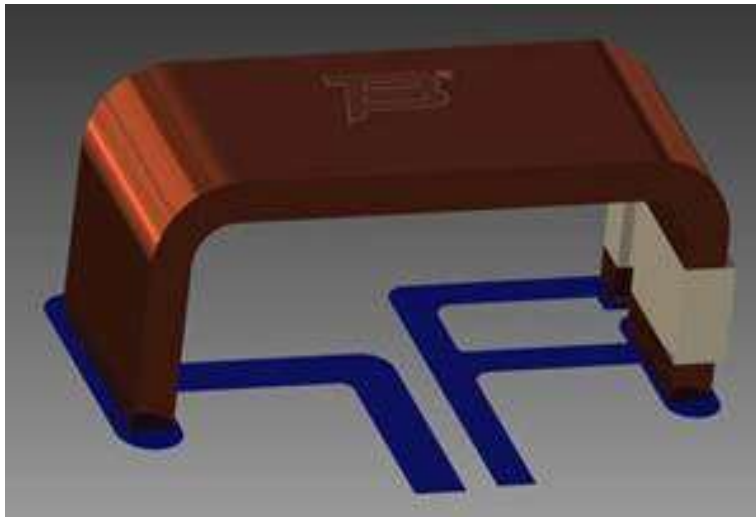
SHEET METAL DESIGN

ISA BVE

VISHAY




ISA BVR
VISHAY





ISABELLENHUETTE [ISA]


BOURNS STYLE


Type/series	Picture	Type	Description	Connector style	Power	Tolerance	Resistance (min)	Resistance (max)	TC
BVx		BVE	2-terminal-resistors with large connectors for high performance.	5930	10 W	1 %	0.0002 Ω	0.002 Ω	50 ppm/K


Type/series	Picture	Type	Description	Connector style	Power	Tolerance	Resistance (min)	Resistance (max)	TC
BVx		BVS	2-terminal-resistors made of composite material	3920	12 W	1 %	0.0002 Ω	0.005 Ω	50 ppm/K

Type/series	Picture	Type	Description	Connector style	Power	Tolerance	Resistance (min)	Resistance (max)	TC
BVx		BVT	2-terminal-resistors made of composite material.	2512	3 W	1 %	0.0003 Ω	0.0068 Ω	50 ppm/K

Type/series	Picture	Type	Description	Connector style	Power	Tolerance	Resistance (min)	Resistance (max)	TC
BVx		BVB	4-terminal-resistors made of composite material. Perfectly suitable for the use on DBC or ceramic. Space-saving design.	2725	12 W	1 %	0.0002 Ω	0.005 Ω	20 ppm/K

Type/series	Picture	Type	Description	Connector style	Power	Tolerance	Resistance (min)	Resistance (max)	TC
BRS		BRS	2-terminal-resistors made of composite material. Perfectly suitable for the use on DBC or ceramic. Space-saving design.	3812	2 W	1 %	0.002 Ω	0.010 Ω	100 ppm/K

Type/series	Picture	Type	Description	Connector style	Power	Tolerance	Resistance (min)	Resistance (max)	TC
BVx		BVH	Heavy copper connectors	3820	5 W	3 %	0.0003 Ω	0.002 Ω	300 ppm/K

Type/series	Picture	Type	Description	Connector style	Power	Tolerance	Resistance (min)	Resistance (max)	TC
BVx		BVR	4-terminal-resistors made of composite material. Perfectly suitable for the use on DBC.	4026	5 W	1 %	0.0002 Ω	0.003 Ω	20 ppm/K

H

C

N

J

PART NUMBER:

CSS2H-2512-L500F

MODEL: _____

CSS = CURRENT SENSOR SHUNT

PIN COUNT: _____

2 or 4

STYLE: _____

C,H,J [N,L]

SIZE: _____

L x W (INCH THOU)

RESISTANCE: _____

(milliohms)

“L” represents decimal point

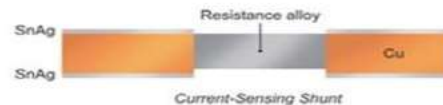
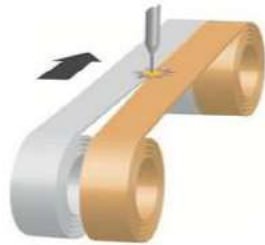
ABSOLUTE TOLERANCE: _____

F = 1%

J = 5%

High Power – Welded Strip Shunts

New production line in Costa Rica

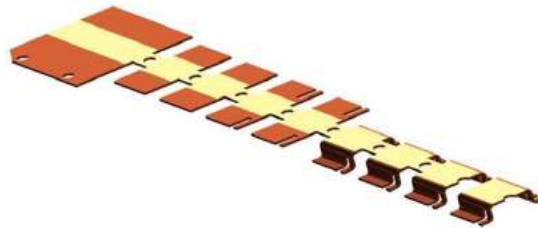


Release Q2 2015

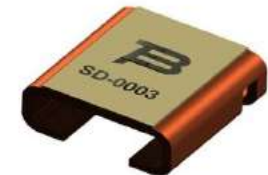
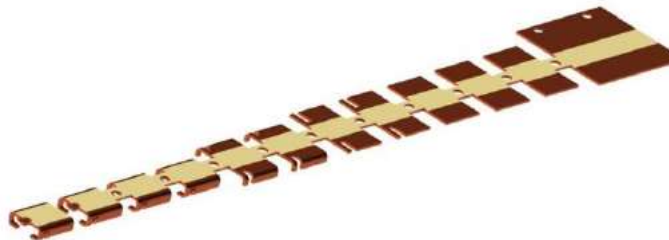
- AEC Q200 qualified **Q2 2015**
- Very low Resistance values
- Made out of Electron Beam welded resistive element to copper sheets
- Customized parts available

High Power – Welded Strip Shunts

Size	7 mm
R range	0.2 – 3 mohms
Power rating	5W
TCR	<20 ppm
Tolerance	1%, 5%
Working Temperature	-55~170



Size	7 mm
R range	0.2 – 3 mohms
Power rating	5W
TCR	<20 ppm
Tolerance	1%, 5%
Working temperature	-55~170



Size	3 mm to 7 mm
R range	0.2m~2mohms
Power rating	4W~10W
TCR	<100ppm
Tolerance	0.5%, 1%
Working temperature	-55~170



High Power – Surface mounted

PWR 1913/2010/3014/4318

5312/2615/4525/6327

Features

- Power 1,5-3 W
- Resistance value 0,01-25k
- Low TCR 20-150 ppm
- Surge Protection
- High Pulse Power

Application:

- Power supplies
- Motor drives
- Electricity metering



High Power – Bare metal element

PWR4412, 4413, **4414**

Features

- Power 1-5W
- Resistance value: 0,005 to 0,1 ohm
- Through hole & SMT
- Current Sense
- High Current, High Temperature

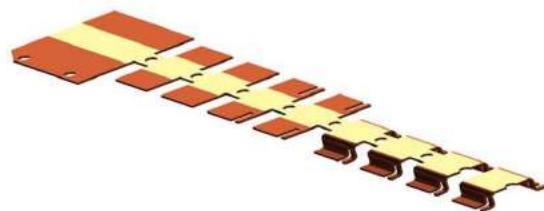
Applications

- Power supplies
- UPS
- Motor drivers



High Power – Welded Strip Shunts

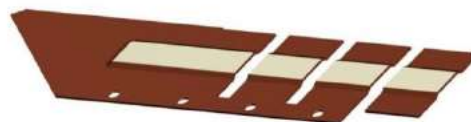
Size	7 mm
R range	0.2 – 3 mohms
Power rating	5W
TCR	<20 ppm
Tolerance	1%, 5%
Working Temperature	-55~170



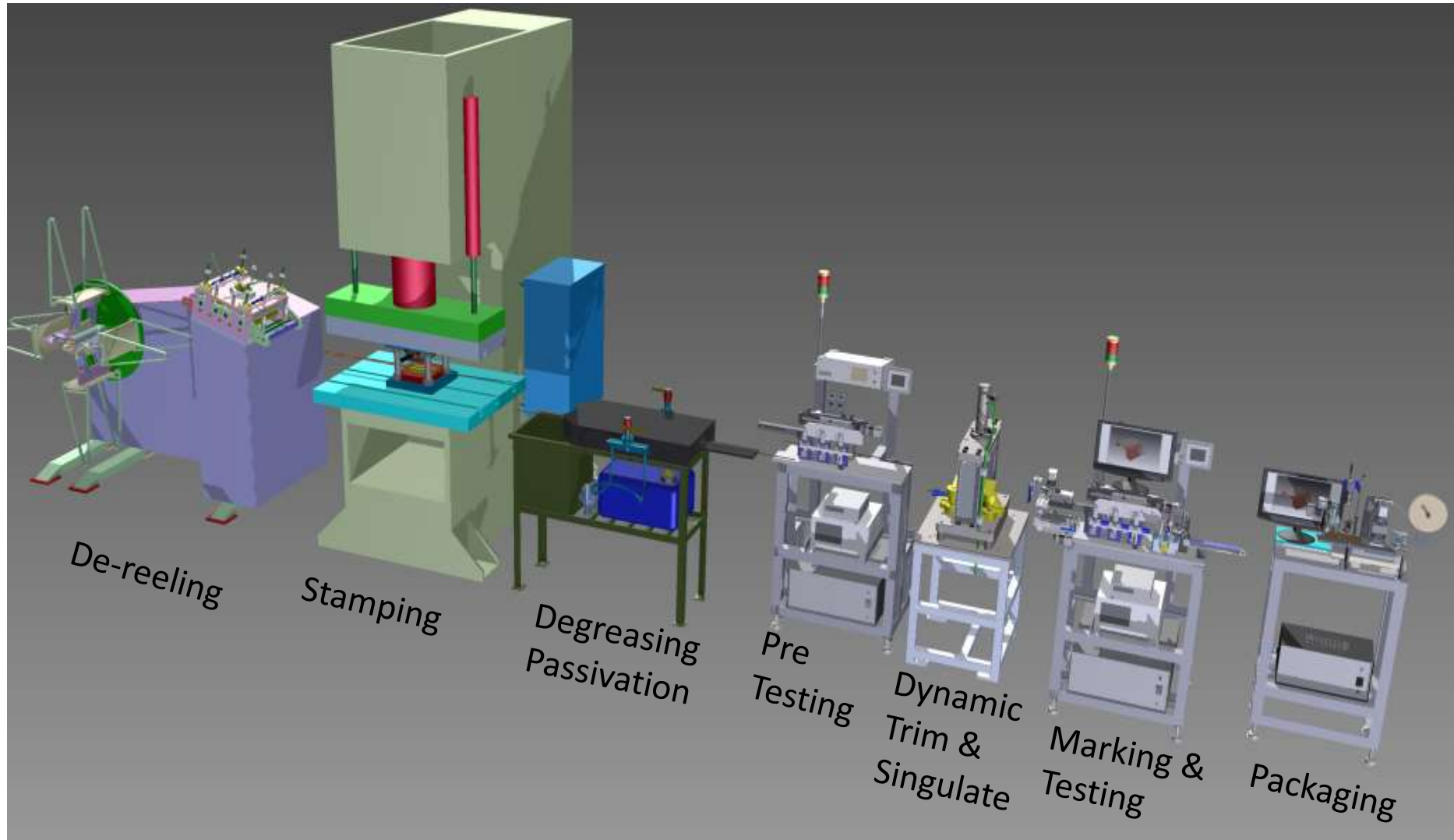
Size	7 mm
R range	0.2 – 3 mohms
Power rating	5W
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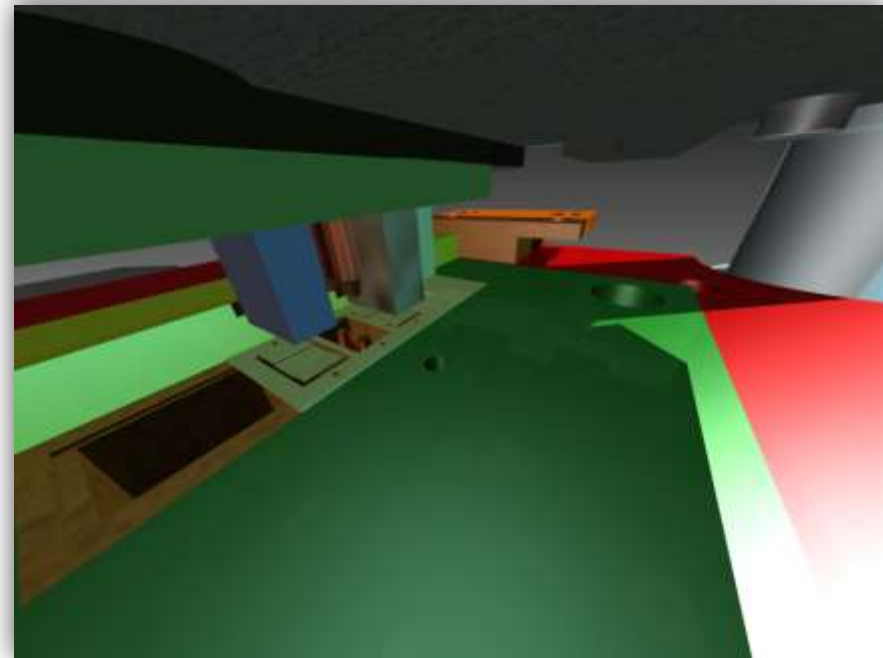
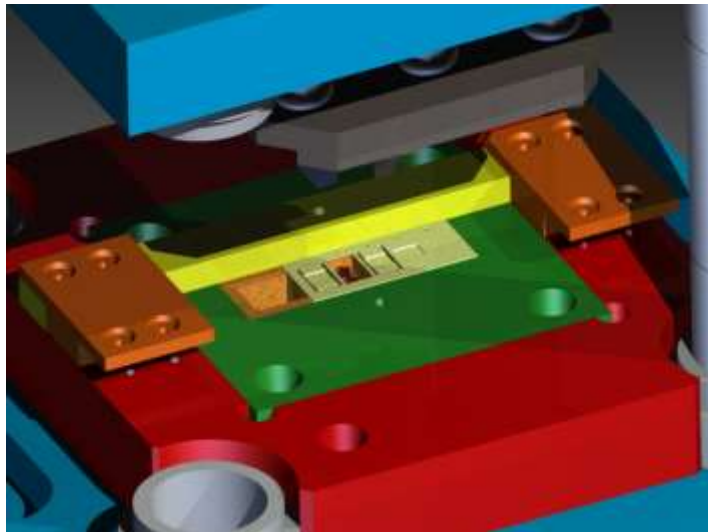
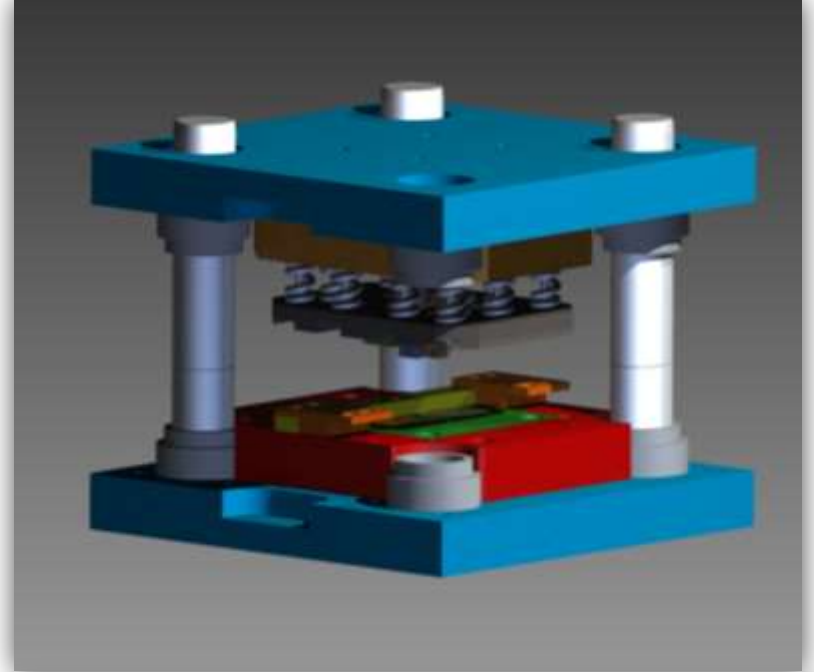
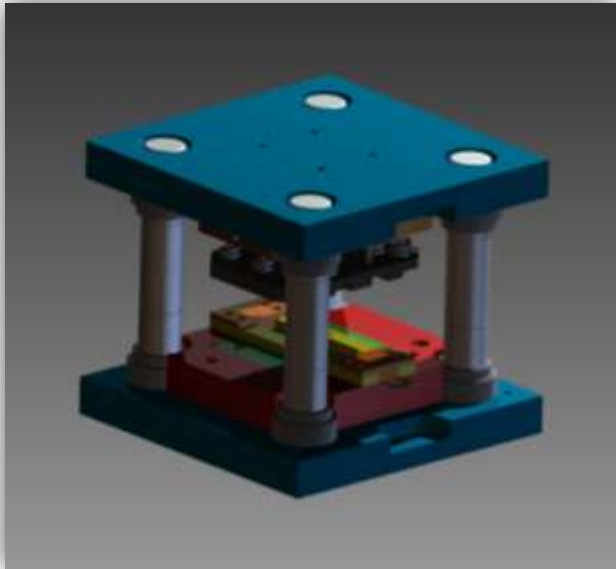
Size	3 mm to 7 mm
R range	0.2m~2mohms
Power rating	4W~10W
TCR	<100ppm
Tolerance	0.5%, 1%
Working temperature	-55~170



Shunt Production Line



DIE SET ASSEMBLY



The background is a deep blue gradient. A bright, curved light streak, resembling a comet or a high-speed light trail, sweeps across the upper half of the frame. Below this, the lower half is filled with numerous out-of-focus light spots, creating a bokeh effect. The overall composition is dynamic and futuristic.

Thank you!

BOURNS®