Current Sense

Products and Applications

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Agenda

- ✓ TT electronics Locations
- ✓ Current Measurement Methods
- ✓ Resistor Technologies
- ✓ Product Introduction
- ✓ Design Benefits
- ✓ Precision Current Measurement
- ✓ Applications

TT electronics

BI technologies | IRC | Welwyn

Fixed Resistors Manufacturing Locations

At the intersection of global and local.

Current Measurement Methods

- ✓ **Purpose of Current Sense**
  - Sense / Measure current – provides a signal to inform the current monitoring circuit "how much" current is flowing.
  - Protect from excessive current – provides a feedback signal to the current monitoring circuit to inform that "too much".

- ✓ Competing Methods of Measurement
  - ***Current Sense Resistors***
  - Current Transformers
  - Transistor Rds
  - Hall Effect

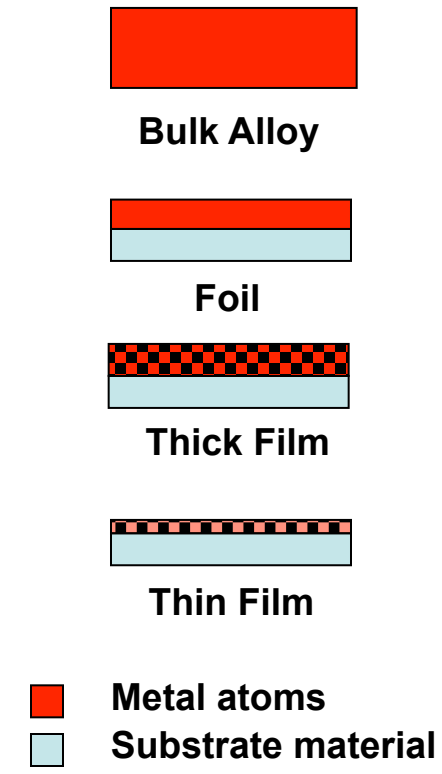
Current Measurement Methods

- ✓ **Current Sense Resistors**: direct
  - Advantage: Accurate direct current measurement
  - Disadvantage: Higher dissipated power, no isolation
- ✓ Current Transformer: indirect
  - Advantage: Isolation from high voltage, measure high currents with low loss.
  - Disadvantage: Measures AC only, susceptible to EMI
- ✓ Transistor (Drain to Source resistance): direct
  - Advantage: Uses existing components, reduces part count
  - Disadvantage: Low accuracy
- ✓ Hall Effect: indirect
  - Advantage: Low power dissipation
  - Disadvantage: Expensive, reduced accuracy in low current range

Resistor Technologies

- **Bulk Alloy**
  - Very large cross section and low resistance range
  - Very robust surge capability
- **Foil**
  - Large cross section compared to film technologies
  - Higher resistance values, but lower surge capability as compared to metal element construction
- **Thick Film** (0.000 5” – 0.002” thickness)
  - Approximately 100 x thicker than thin film technology
  - Greater surge capability but less precise
- **Thin Film** (0.000 0012” – 0.000 004” thickness)
  - High Precision
  - Least robust surge capability

Comparison of relative cross-section for resistor technologies



Product Overview

- ✓ **BI Technologies**
  - ❑ Surface Mount – (Bulk Alloy) – BCS
- ✓ **IRC**
  - ➢ AFD
    - ❑ Surface Mount – (Thick Film) – LRC, LRF, LRF3W
  - ➢ WAFT
    - ❑ Surface Mount – (Bulk Alloy) – CHP, OARS, OARS XP, ULR
    - ❑ Through-hole – (Bulk Alloy) – CSL, CSLS, OAR, LOB
- ✓ **Welwyn**
  - ❑ Surface Mount – (Bulk Alloy) – OLV
  - ❑ Through-hole – (Bulk Alloy) – 2500

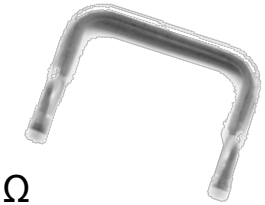
Product Overview – BI technologies and Welwyn

2500 (Thin Film)

Power Rating: 1.5 Watts
Ohmic range: 0.025 to 1 Ω
TCR: 100 to 350 ppm

OLV *(Bulk Alloy)*

Power Rating: 1, 2, 3 Watts
Ohmic range: 0.005 to 0.050 Ω
TCR: 200 ppm

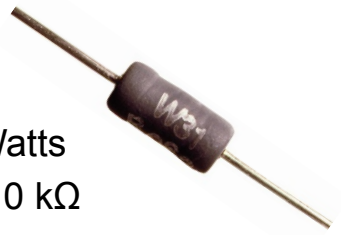


BCS8 (Bulk Alloy)

Power Rating: 8 Watts
Ohmic range: 0.5 to 10 mΩ
TCR: 50 ppm

W30 *(Wirewound)*

Power Rating: 1, 2, 3 Watts
Ohmic range: 0.010 to 10 kΩ
TCR: 200 ppm



Product Overview – IRC (Thick Film)

Package Sizes - 1206 (0.5 W) 2010 (1 W) 2512 (2 W) 1225 (3 W)

LRF3W

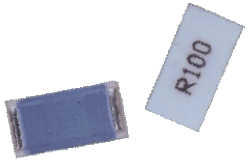
Efficient 1225 size

Ohmic range: 0.002 to 0.1 Ω

Smallest 3 Watt Package

LRF

Low Range Flip Chip



Planar Construction

Ohmic range from 0.002 to 0.025 Ω

SC3

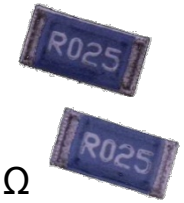
Power Rating: 3 Watts

Ohmic range: 1 to 100 kΩ

Alternative to SMT wirewound

LRC

Low Range Chip



Wrap around termination

Ohmic range from 0.025 to 1 Ω

Product Overview – IRC (Bulk Alloy – Surface Mount)

OARS XP

Open Air Resistor SMD
eXtended Performance
Ohmic Range: 1 mΩ - 25 mΩ
TCR: 40 ppm and 240 ppm

OARS

Open Air Resistor SMD
Ohmic Range: 2 mΩ - 50 mΩ
TCR: 40 ppm and 240 ppm

ULR

Ultra Low Resistance
Ohmic Range: 0.5 - 10 mΩ
Tolerance: 5% and 1%
TCR: 50 ppm – 150 ppm

CHP

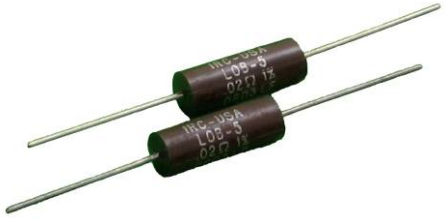
Cylindrical High Power
Ohmic Range: 0.1 Ω - 20 kΩ
Tolerance: 5% and 1%
TCR: 50, 150 ppm

Product Overview – IRC (Bulk Alloy – Through hole)

OAR

Open Air Resistor

Power Rating: 1, 3, and 5 Watts
Ohmic Range: 2.5 mΩ - 100 mΩ
TCR: 20 ppm (alloy)



LOB

Low Ohm (Boone)

Power Rating: 1, 3, and 5 Watts
Ohmic Range: 2.5 mΩ - 100 mΩ
TCR: 20 ppm (alloy)

CSL and CSLS

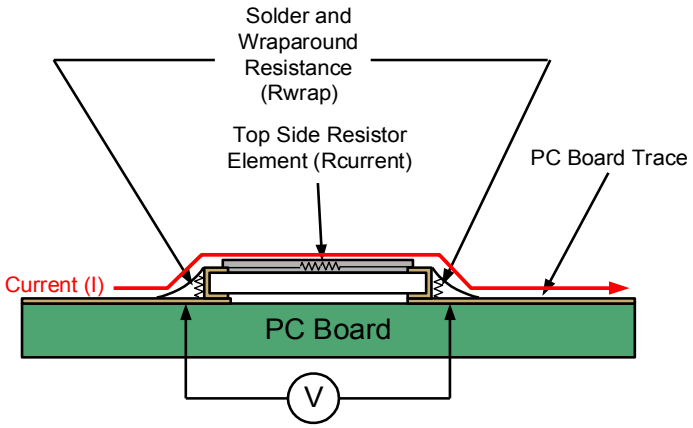
Current Sense in-Line

Ohmic Range: 0.25 mΩ - 2.5 mΩ
TCR: < 50 ppm

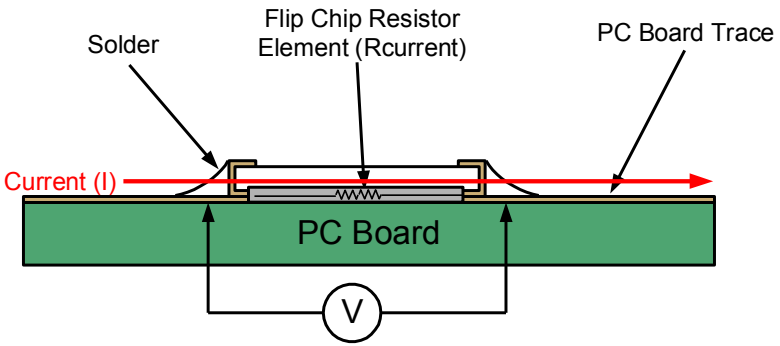
Design Benefits – Top Side v/s Flip Chip

✓ Flip Chip Benefits

- Flip chip mounting eliminates the wraparound resistance
- Planar with the PC board trace reducing inductance
- Measured voltage (V) is generated only by the current sense resistor (R current) times the current (I)



$V = I (R_{current}) + I (2R_{wrap})$

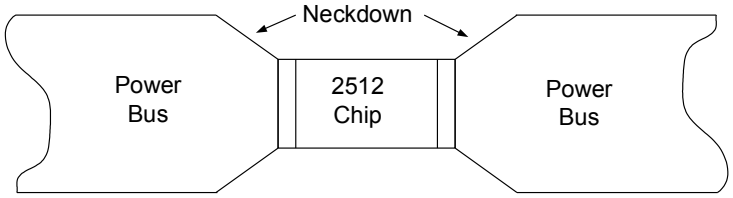


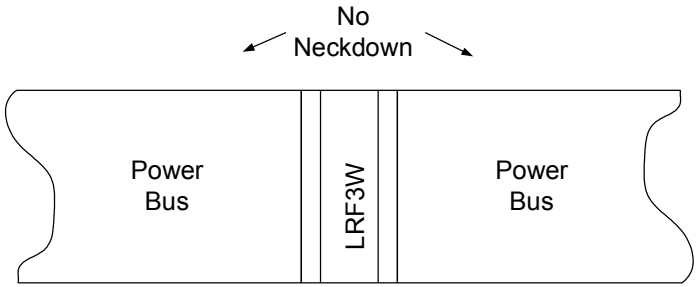
$V = I (R_{current})$

Design Benefits – LR Construction Advantages

✓ LRF3W and SC3

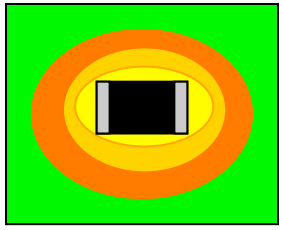
- No Trace Neckdowns at High Current
- LRF3W Has WIDE Pads (0.25”) to Accommodate Large PC Board Currents
- Solder Joint Stress – Heat generated has a shorter path to the PCB more directly, reducing stress because of TCE differences between PCB and component.

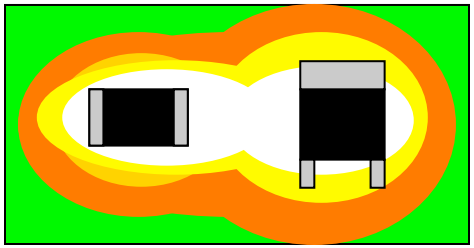




Design Benefits – PCB Heat Management

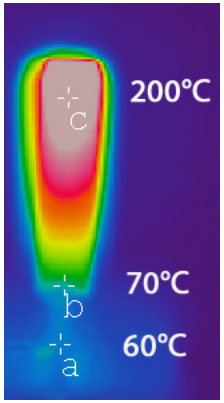
- ✓ Bulk Alloy – power capability
  - ➢ Mainly driven by circuit board design to remove heat from the solder joint.
  - ➢ Resistive Alloys are stable to over 300°C.
  - ➢ High Power can cause circuit board changes, which could be mis-diagnosed as resistor changes. For example, Solder Joint failure, board traces, plated through hole barrel failure.
  - ➢ Assuming the same power dissipation of a resistor in two different designs…



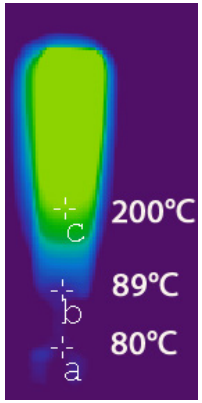


Design Benefits – PCB Heat Management

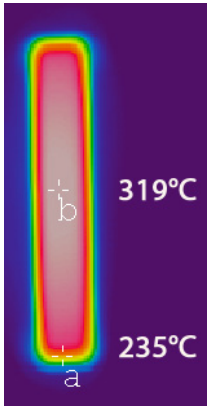
- ✓ Through-hole – Bulk alloy
- ✓ Superior thermal isolation
  - ➢ Hotspot elevated off of the board
  - ➢ Longer path to dissipate thermal energy
  - ➢ Take advantage of available air flow



OAR5 (2.94 Watts)
Side View



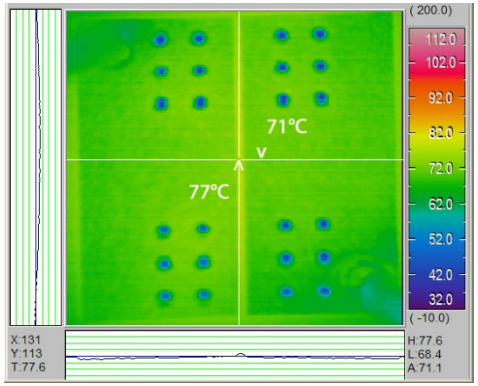
OAR5 (5.15 Watts)
Side View



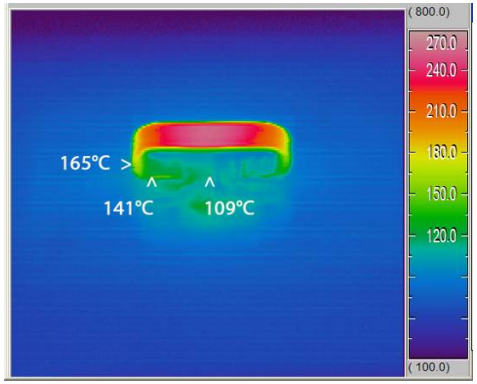
OAR5 (5.15 Watts)
Top View

Design Benefits – PCB Heat Management

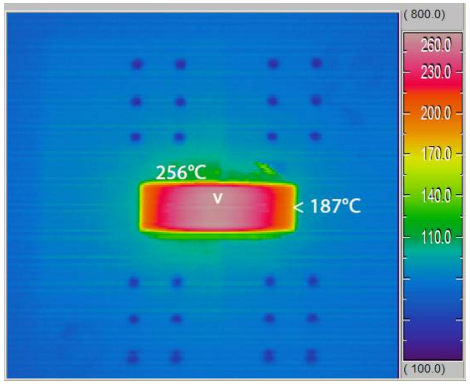
- ✓ Surface Mount – Bulk alloy
- ✓ Superior thermal isolation
  - ➢ Hotspot elevated off of the board
  - ➢ Longer path to dissipate thermal energy
  - ➢ Take advantage of available air flow



OARS (4.5 Watts)
Back View



OARS (4.5 Watts)
Isometric View



OARS (4.5 Watts)
Top View

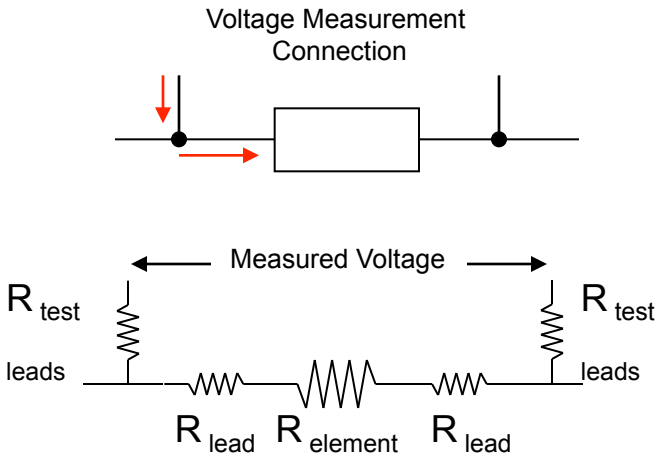
Precision Current Measurement – 2 v/s 4 terminal

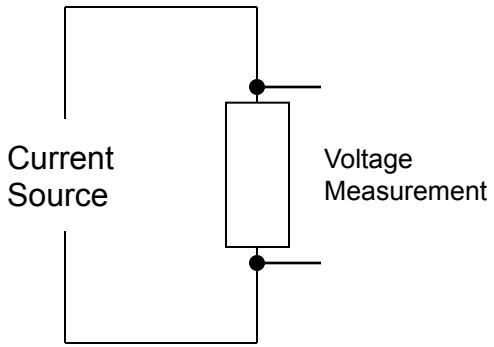
2 terminal measurement

- Low Accuracy
- Introduces additional voltage drop
- increases TCR effects through PCB traces and added lead length.

4 terminal Kelvin connection

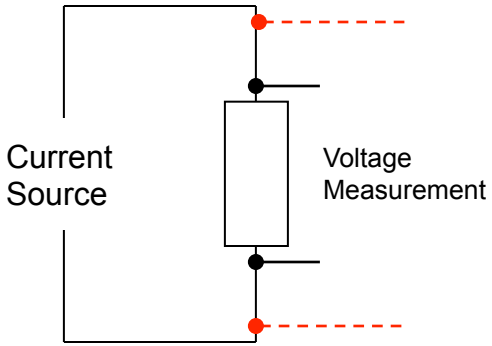
- High Accuracy
- Removes the measured voltage drop, to improving accuracy.
- Reduces TCR effects due to connection.





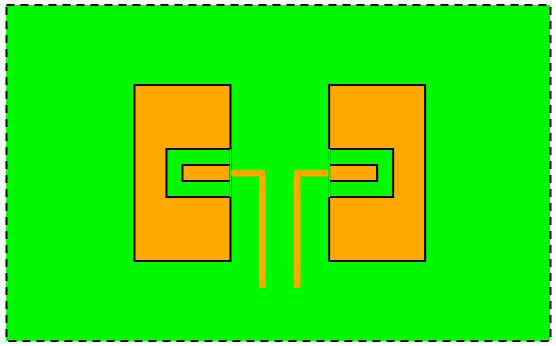
Precision Current Measurement – Challenges

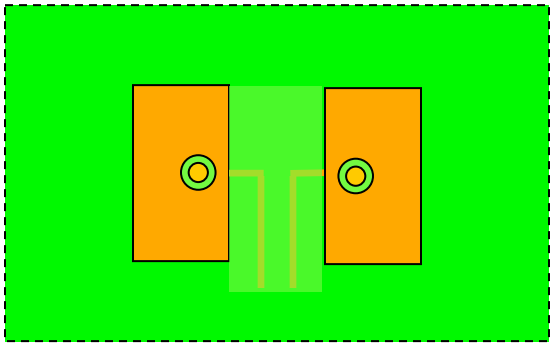
- ✓ Accuracy and Repeatability – require test fixtures
  - ➢ Contact Resistance – in the milli-ohm range contact resistance becomes a more significant fraction of the measurement.
  - ➢ Variation of contact location on the component based on repeated measurements.
  - ➢ Differences in mechanical test point contacts from one test fixture to another.



Precision Current Measurement – SMD Kelvin Connections

- ✓ Modified Kelvin connection
  - ➢ High Accuracy
  - ➢ Enables a four terminal connection for a conventional surface mount component in the place of a more costly 4 terminal shunt.





Vias with copper traces on internal layers.

Applications

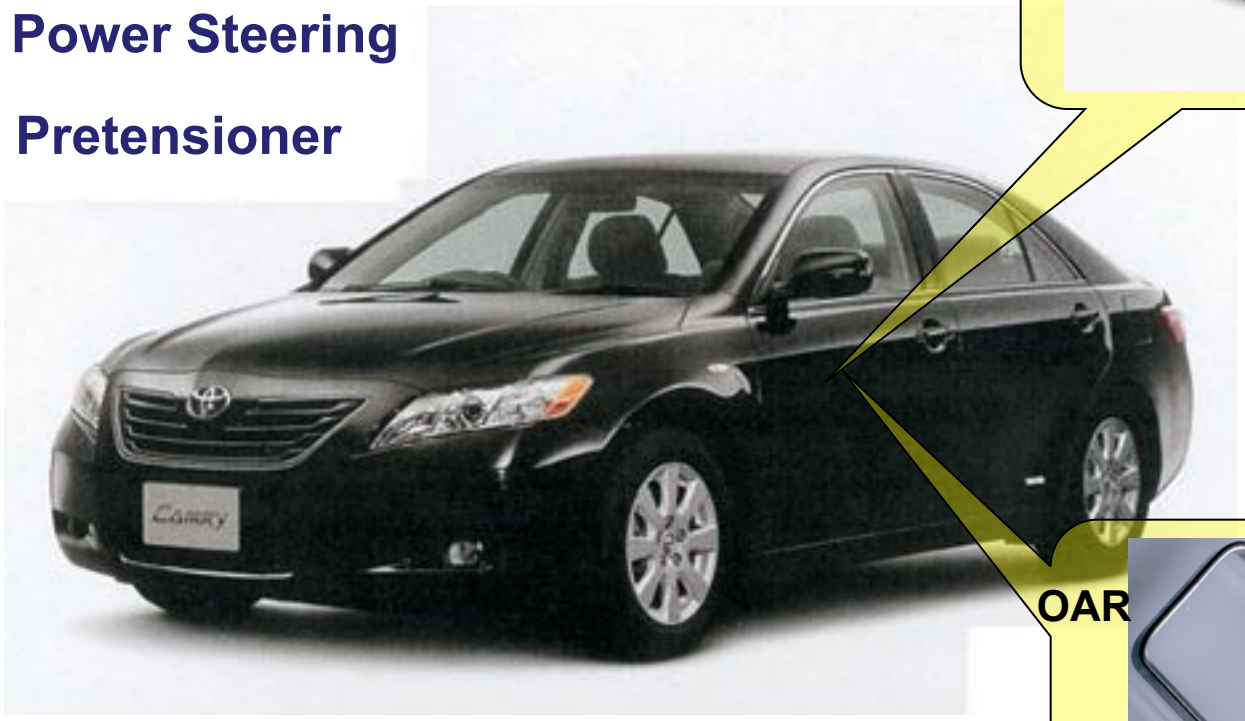
- ✓ Power supplies
- ✓ Motor controllers
- ✓ PWM controllers

- ✓ Purpose
  - ➢ Sense / Measure current – provides a signal to inform the current monitoring circuit “how much” current is flowing.
  - ➢ Protect from excessive current – provides a feedback signal to the current monitoring circuit to inform that “too much”.

Applications – Automotive

Electric Power Steering

Seat Belt Pretensioner



Applications

Computers

- Battery Packs - Fuel Gauging and Overcurrent Detection
- AC/DC, DC/DC Power Supplies and VRMs - Output Feedback
- Disk Drives - Motor Start-Up Current Control

Automotive

- Stereo Amplifier Output Stage Overcurrent Protection
- Lamp Out Detection - 0 Current - Lamp-out
- Fuel Pump Collision Cut-Off - Detect Air Bag Ignition
- Seat Heater – Short Detection
- Motorized Seat – Locked Rotor Detection
- Power Windows – Open/Closed Motor Shut Off

Available Resistances (mΩ)

Products	Rating	< 0.5	0.5	1	2.5	5	10	25	50	75	100	>100
Through Hole												
CSL	5	■	■	■	■							
CSLS	5	■	■	■	■							
LOB	1					■	■	■	■	■	■	
	3				■	■	■	■	■	■	■	
	5					■	■	■	■	■	■	
OAR	1				■	■	■	■	■	■	■	
	3				■	■	■	■	■	■	■	
	5				■	■	■	■	■	■	■	
Surface Mount Devices												
BCS	8	■										
CHP	2											■
	1											■
	1/2											■
	1/8											■
OARS	1				■	■	■	■	■			
	3				■	■	■					
OARS XP	5			■	■	■	■	■				
ULR B	1					■	■					
	2		■	■	■							
ULR G	1						■					
	2					■	■					
	2.5					■						
	3		■	■	■							
LRC	0.5					■	■	■	■	■	■	■
LRF	0.5					■	■	■				
LRF3W	3				■	■	■	■	■	■	■	

50 mV Signal

		0.5	5	10	20	30	50	Current (amps)
		0.5	0.01	0.005	0.0025	0.0015	0.001	Resistance (Ω)
	Rating	0.13	0.25	0.5	1	1.35	2.5	Power (W)
Through Hole								
CSL	5							
CSLS	5							
LOB	1							
	3							
	5							
OAR	1							
	3							
	5							
Surface Mount Devices								
BCS	8							
CHP	2							
	1							
	1/2							
	1/8							
OARS	1							
	3							
OARS XP	5							
ULR B	1							
	2							
ULR G	1							
	2							
	2.5							
	3							
LRC	0.5							
LRF	0.5							
LRF3W	3							

Any Questions?

http://www.irctt.com/sales_support.aspx