



VISHAY INTERTECHNOLOGY, INC.



VISHAY DALE RESISTORS - AUTOMOTIVE 101

Automotive Applications

Automotive Systems

- Body and Comfort
- Chassis
- Powertrain (Underhood)
- Driver Information
- Lighting Systems

Automotive Key Contacts

Acronyms / Automotive Expectations

Production Part Approval Process (PPAP)



Automotive Applications

Engine / Transmission / Emission Controls

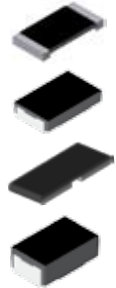


Engine control components assist in providing engine status, as well as to control the many system components that make performance, efficiency and pollution control possible.

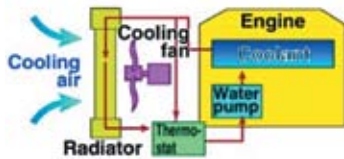
VISHAY DALE Resistor Solutions

WSL / WSLP / WSLT / WSLS / WSR / WSH / WSC

- High temperature (up to 275 °C)
- High power handling (up to 5 Watts)
- Element with low TCR (< 20 ppm/°C)



Engine Fan and Cooling



Applications may include switch-mode current regulation and PWM power controllers with special requirements: for example, measuring up to 100 A for a radiator fan and other brushless DC motor controls.

VISHAY DALE Current Sense Resistor Solutions

WSL3921 / WSL5931 / WSL2726 / WSL4026

- Low resistance values (down to 0.0002 Ω)
- High temperature (up to 275 °C)
- High power handling (up to 5 Watts)



Electronic Power Steering (EPS)



Designed to use an electric motor to reduce effort by providing assist to the driver of a vehicle. Most EPS systems have variable assist, which allows for more assistance as the speed of a vehicle decreases and less assistance from the system during high-speed situations.

VISHAY DALE Current Sense Resistor Solutions

WSL3637 / WSL5931 / SPR4000

- High current capability (over 160 A)
- Low resistance values (down to 0.0002 Ω)
- Four-terminal Kelvin connection available



Brushless DC Motor Controls



Applications include over-current protection for power seats, windows, mirrors, roofs and cargo doors. Also, current sensing for precision motor controls such as EPS, Engine Fan and Climate Controls.

VISHAY DALE Current Sense Resistor Solutions

WSL / WSLP / WSLT / WSLS / WSR / WSH

- Low resistance values (down to 0.0002 Ω)
- High current capability (over 160 A)
- High power handling (up to 5 Watts)





Automotive Systems

Chassis

- Active Safety (ESP, ABS, ASR, USC)
- Electric Park Brake (EPB)
- Sensors
- Electrical Transmission (CVT, ASG, Double Clutch Shifting)
- EAGR, Electrical Catalytic Converter, Diesel Particle Filter
- Active Suspension, Dynamic Control
- Tire Pressure Monitoring
- Electrical Hydraulic Power Steering (EHPS)
- Electrical Power Steering (EPS)

Driver Information

- Driver Information System
- Bluetooth Communication
- GPS Car Navigation & Audio System
- SDARS/Antenna/Amplifier System
- Sensors (ACC, LIDAR)

Powertrain (Underhood)

- Common Rail Diesel Electrical Control
- Piezoelectric-Injection Driver
- Engine Control Unit (ECU)
- Turbo Charger Control Unit
- Ignition Electrical Drive
- Engine Sensors
- Electrical Water Pump
- Boardnet Management
- Integrated Starter Generator 14 V / 42 V (ISG)
- Board Load-Control Unit
- Engine Cooling (Electrical Fan Control)



Lighting Systems

- Headlight Leveling Control and Advanced Front Lighting Headlight Cleaning System
- LED Lighting (Front and Rear)
- HID Electrical (Xenon Driver)
- Sensors (Night Vision Systems, Fog Detection)
- Ambient Lighting

Body and Comfort

- Sensors
- Immobilizer & Security Systems
- Door / Window / Sunroof Control
- Seat Adjust and Memory
- HVAC (Heating, Ventilating, Air Conditioning)
- Climate Control
- Dashboard and Interior Illumination
- Passive Safety (Airbag, Restraint Systems)
- Reversible Wiper Drives
- Keyless or Passive Entry, Passive Start, Bluetooth Communication
- Car TV and DVD Systems (Multimedia)



Automotive Key Contacts

Global Purchasing Team (Commodity Team)

1. Qualify Core Suppliers for Each Commodity
2. Coordinate Global Sourcing Quotations
3. Establish Terms and Conditions (Payment, Delivery)
4. Champion Supplier Issues that Impact Operations
5. Monitor Supplier Scorecard

Regional Purchasing

1. Release Contracts based on Global Contract
2. Request Support for Local Issues for Specific Site

Advance Quality Engineer

1. Audits Manufacturing Locations
2. PPAP Documentation (Control Plans, FMEA, etc.)
3. Supplier Visits for Existing Quality Issues
4. Component Approval Status (Family Approvals)
5. Supports Commodity Team Objectives

Automotive Key Contacts

Global Purchasing Team
(Commodity Team)

Regional Purchasing

Production Control Logistics
Group (Planners)

Design Engineer (Program)

Sustaining Engineer
(Manufacturing)

Component Engineer

Supplier Quality Engineer

Advance Quality Engineer

Production Control Logistics Group (Planners)

1. Contact to Ensure Accurate Forecasts (EDI or non-EDI)
2. Program Start-Up/Termination
3. Delivery Support
4. Special Routing (Carrier, Premium, etc.)
5. Shortage Issues
6. Allocation Distribution Plan (Corporate)

Supplier Quality Engineer

1. Coordinates Quality Issues During Production Programs
2. Initiates/Closes Formal 8D or Quality Reports

Design Engineer (Program)

1. Design Contact for New Programs/Applications
2. Provide Samples and Technical Support
3. Submit Budgetary Pricing
4. Ensure Design Validation/Pilot Validation

Component Engineer

1. Drawing Specifications
2. Component Qualification Data (AEC Q100, Q200)
3. Application Support in Existing Programs
4. Champion for Product Improvements or Changes
5. Maintains Records for Quality Certifications (Component, Manufacturing Site, Laboratory, etc.)

Sustaining Engineer (Manufacturing)

1. Redesign for Existing Programs in Production
2. Support for Cost Reductions in Existing Programs
3. Improvements for Manufacturing Challenges



Acronyms / Automotive Expectations

Acronyms

ABS = Anti-lock Braking Systems	FMEA = Failure Mode and Effects Analysis
ACC = Adaptive Cruise Control	GPS = Global Positioning System
AEC = Automotive Electronics Council	HEV = Hybrid Electric Vehicle
AIAG = Automotive Industry Action Group	HID = High Intensity Discharge
APQP = Advanced Product Quality Planning	HUD = Head-Up Display
ASR = Automatic Skid Reduction (traction)	HVAC = Heating, Ventilation & Air Conditioning
CVT = Continuous Variable Transmission	ISG = Integrated Starter Generator
DV = Design Validation	PSW = Part Submission Warrant
ECU = Engine Control Unit	QS-9000 = Quality Standard for auto industry
EHPS = Electro-Hydraulic Power Steering	SDARS = Satellite Digital Audio Receiver Service
EPS = Electronic Power Steering	SOC = State Of Charge
EPB = Electric Park Brake	SOH = State Of Health
ESP = Electronic Stability Program	TECU = Transmission ECU
ETC = Electronic Throttle Control	TPMS = Tire Pressure Monitoring System
EV = Electric Vehicle	



Automotive Expectations

- Suppliers are Qualified by their Technology Offering and Ability to Support the Automotive Requirements
- Product Support Mandated for both Production and Service Requirements at Qualified Sites (End of Life Changes Properly Coordinated in Accordance with Customer Guidelines)
- Compliance to IMDS (International Material Data System)
- Proper notification and compliance to PCN Process—Product Change Notification (Vishay CQA 0006)
- Maintain Part Number Traceability
- Compliance to all Customer Specific Requirements (Component Labeling, Manufacturing, etc.)
- Escalation Contact List
- Logistics Support
- Price Agreements (Annual vs Multi-Year)
- Volume Commitment
- Supplier Savings Suggestions



Production Part Approval Process (PPAP)

Component Product Qualifications

- Certified Laboratories (Perform Product Qualifications)
- Component Qualification (Automotive Electronics Council)
 - Passive (AEC, Q200, Stress Test Qualification for Passive Components)
 - Active (AEC, Q101, Stress Test Qualification for Discrete Semiconductors)

Quality

- PPAP Compliance per AIAG Requirements
- ISO/TS-16949:2000 Compliance
- Corrective Actions (24 hr, 10 Day)
8D's/Immediate Containment

When Is Submission Required?

1. A new part or product
2. Correction of a discrepancy on a previously submitted part
3. Engineering change to design records, specifications, or material for production product/part number(s)

Submission Levels

- Level One** — Warrant only submitted to customer
- Level Two** — Warrant with product samples and limited supporting data submitted to customer
- Level Three** — Warrant with product samples and complete supporting data submitted to the customer
- Level Four** — Warrant and other requirements as defined by customer
- Level Five** — Warrant with product samples and complete supporting data reviewed at the organization's manufacturing location

PPAP Requirements

Requirement		Submission Levels				
		1	2	3	4	5
1	Design Records	R	S	S	*	R
2	Engineering Change Docs	R	S	S	*	R
3	Cust. Eng. Approval	R	R	S	*	R
4	Design FMEA	R	R	S	*	R
5	Process Flow	R	R	S	*	R
6	Process FMEA	R	R	S	*	R
7	Control Plan	R	R	S	*	R
8	Measurement System Analysis	R	R	S	*	R
9	Dimensional Results	R	S	S	*	R
10	Performance Test Results	R	S	S	*	R
11	Initial Process Study	R	R	S	*	R
12	Qualified Laboratory Docs	R	S	S	*	R
13	Appearance Approval Report	S	S	S	*	R
14	Sample Product	R	S	S	*	R
15	Master Sample	R	R	R	*	R
16	Checking Aids	R	R	R	*	R
17	Records of Compliance	R	R	S	*	R
18	Part Submission Warrant	S	S	S	S	R

R = Required AND Retained by Manufacturer S = Required AND Submitted with PPAP Package * = Action is defined by the Customer



Automotive Applications

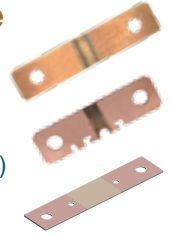
Hybrid / Electric Vehicle Battery Management

For proper battery management, a low-ohmic current sensing resistor is used to sense the amount of current flowing into the vehicle's electrical system. Basic function is to determine battery State of Health and State of Charge.

VISHAY DALE Current Sense Resistor Solutions

WSBS / WSMS / SPR3004

- Low resistance values (down to 0.00005 Ω)
- High current capability (> 600 A)
- All welded construction



DC/DC Converter for Multi-Media



VISHAY DALE Current Sense Resistor Solutions

WSL / WSLP

- Low resistance values (typically 0.005 Ω to 0.050 Ω)
- Resistive element with low TCR (< 20 ppm/ $^{\circ}$ C)
- Low thermal EMF (< 3 μ V/ $^{\circ}$ C)



Spark Noise Suppression

NSR Resistor



Used in automotive ignition systems to reduce Radio Frequency Interference (RFI) caused by electrical discharge.

VISHAY DALE Noise Suppressor Solution

NSR

- Wide range of resistance values (1 k Ω to 15 k Ω)
- Special terminal designs available
- Capability to withstand high voltage pulses at high frequency



Small Signal Amplification



In occupant weight sensing and electric vehicle battery management, the MPM manages op amp gain from small signals.

VISHAY THIN FILM Resistor Solution

MPM - matched pair divider

- 1:1 to 100:1 ratio range
- Small size (SOT23 format)
- Tight ratio tolerances (down to \pm 0.01 %)
- Low noise (< -30 db)
- Tight TCR tracking of \pm 2 ppm/ $^{\circ}$ C





SEMICONDUCTORS:

Rectifiers • High-Power Diodes and Thyristors • Small-Signal Diodes • Zener and Suppressor Diodes
• FETs • RF Transistors • Optoelectronics • ICs • Modules and Assemblies

PASSIVE COMPONENTS:

Resistive Products • Magnetics • Capacitors • Strain Gage Transducers and Stress Analysis Systems

**One of the World's Largest
Manufacturers**
of Discrete Semiconductors and Passive Components

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