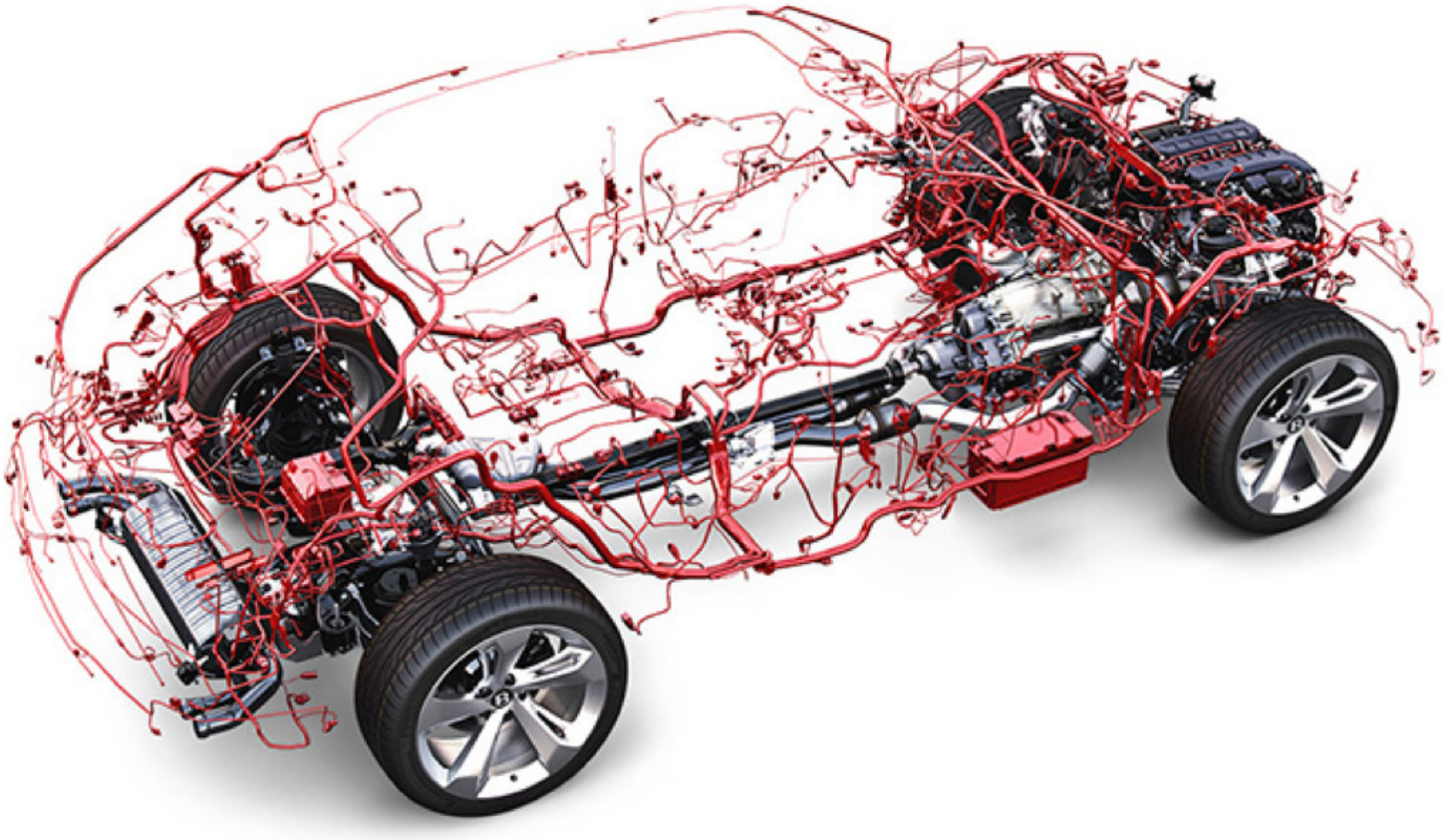
An Introduction to Automotive Grade Components

A brief introduction to standards which apply to components used in automotive applications

By Mouser Electronics



(Photo source: Bentley)

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Automotive technology is nothing new

In 1898, a Columbia Electric Car from the Electric Vehicle Company was the first electric car with working electric lights. One hundred three years ago, Mary Anderson patented the manual window wiper. And 37 years later an owner of a 1940 Packard 180 would be the first to roll down their hydraulic windows at the touch of a button with the first power windows.

The pace of innovation to enhance our automotive experience has been a constant and relentless.

Thankfully having to move our window wipers back and forth manually has long since passed. Advancements in electronics hardware and software drive progress in automotive technology today. Without ticking all the optional extras, a typical car can contain over 10,000 MLCC capacitors and dozens of microcontrollers. Even the internal combustion engine (ICE) is getting an electronics upgrade with Lithium-Ion batteries, regenerative breaking and Silicon Carbide (SiC) inverters as we move into electrification.

Automotive electronics are everywhere

Automotive electronics: keeping us safe, navigating us to our destination or entertaining the kids on a 4-hour drive. Failure to connect Spotify to the car stereo is one thing, but as we rely on more systems to keep us safe on the road, how do we ensure they are there when we need them?

Powertrain/EV/HEV	Infotainment & HMI	Assisted Driving
▪ Electric Motor	▪ Display Mirror	▪ Lane Keep Assist
▪ Regenerative Braking	▪ Headup Display	▪ Automatic Emergency
▪ DC/DC Converter	▪ Wireless Charging	▪ Braking
▪ Inverter	▪ USB Connectivity	▪ Parking Sensors
▪ Onboard Charger	▪ Keyless Entry	▪ Surround View Camera
▪ Battery Management	▪ Stereo	▪ Autonomous Parking
▪ System	▪ Navigation	▪ Rain Sensor
▪ Thermal System	▪ Rear Seat Entertainment	▪ Lane Departure
▪ ESound	▪ Kick Sensor	▪ Back up Camera
▪ ECU	▪ Active Noise Cancellation	▪ Pedestrian Detection
	▪ Door Control Panel	▪ Collision Avoidance
	▪ Heated Seats	▪ Blind Spot Detection
	▪ WiFi	▪ Adaptive Lighting
		▪ Traffic Sign Recognition
		▪ TPMS
		▪ Adaptive Cruise Control

Figure 1: *Automotive electronic systems in a modern car. (Source: Mouser Electronics)*

Almost every element of automotive design is regulated to ensure passengers, pedestrians and other road users are kept safe. From the height of the breaking light for maximum visibility to the protrusion of door handles to protect passersby and electronic systems are no exception.

Quality from the start

Companies working within the global automotive industry adhere to IATF 16949 as defined by the International Automotive Task Force (IATF). Built upon the ISO 9001 framework, IATF 16949 is a quality management system (QMS) incorporating all of the existing requirements of ISO 9001 plus some additional criteria to reflect specifics within the automotive industry and the more extensive supply chain.

Certified IATF 16949 suppliers such as TE Connectivity's **HIRSCHMANN MOBILITY** brand apply continuous improvement to product development, focus on preventing defects in their antenna and tuner technology and aim to reduce waste in the supply chain by minimizing variations where possible. Automotive OEMs can rely on their products to provide connectivity and communication within and outside the vehicle using different services and new technologies such as 5G and V2X communication.

Figure 2: *From shark fin antennas to a future with 5G, TE has been at the forefront of advances in antenna technology. (Source: Mouser Electronics)*

If you're going to fail, fail safely

Working hand in hand with quality management systems are standards such as ISO 26262, which applies to electrical and electronic systems in road vehicles up to 3500kg. ISO 26262 relates to the behaviour of electronic safety systems when they receive standard inputs and how to mitigate any hazards if they go wrong. This safe failure or fail-safe system is known as functional safety.

Fundamental to ISO 26262 is the definition of four Automotive Safety Integrity Levels (ASILs), A, B, C and D based upon a combination of three factors.

- **Severity** - The type of injury a driver or passenger may receive from no injuries (S0) to life-threatening (S3).
- **Exposure** - The probability of the circumstances resulting in a hazard. From incredibly unlikely (E0) to high probability (E4).
- **Controllability** - How likely it is for a driver to manage the situation and avoid harm, from generally controllable (C0) to Difficult to control (C3).

Automotive safety systems certify to a required ASIL level. A failure in both rear lights would be level A, and an unexpected application of the ABS would be level D. With automotive technology constantly evolving more detail on how to classify applications is available in **SAE J2980**, Considerations for ISO 26262 ASIL Hazard Classification.

Designing for functional safety in automotive applications

Everything incurs an element of risk; functional safety aims to employ measures to bring those risk down to an acceptable level and reduce any adverse effects as much as possible. Microchip Technology has several components which are described as "Functional Safety ready" to make your certification process more straightforward.

For example, used in digital power applications such as on-board chargers (OBCs) select members of the dsPIC33 family of Digital Signal Controllers (DSC) include integrated safety features and documentation for the ASIL testing process. Also, the MPLAB® XC Compiler is ISO 26262 qualified up to ASIL D.

Support Collateral*	Hardware functional safety
▪ Functional Safety Diagnostic Firmware (with complete requirements mapping, static/dynamic analysis and test reports) ▪ Failure modes, Effects and Diagnostic Analysis report ▪ Functional Safety Manual ▪ MCAL Drivers for Autosar	▪ Memory: ECC, CRC, RAM BIST ▪ System: DMT, WDT/Windowed WDT, POR/BOR, MCLR ▪ Clocking: Redundant Oscillator, Fail-Safe Clock Monitor (FSCM) ▪ CPU: Error Trap Monitors ▪ GPIO: ESD Protection, I/O Port Readback

Figure 3: *Functional Safety Ready support for dsPIC33. (Source: Mouser Electronics)*

*These collaterals are available under NDA upon request from your local Microchip Sales office

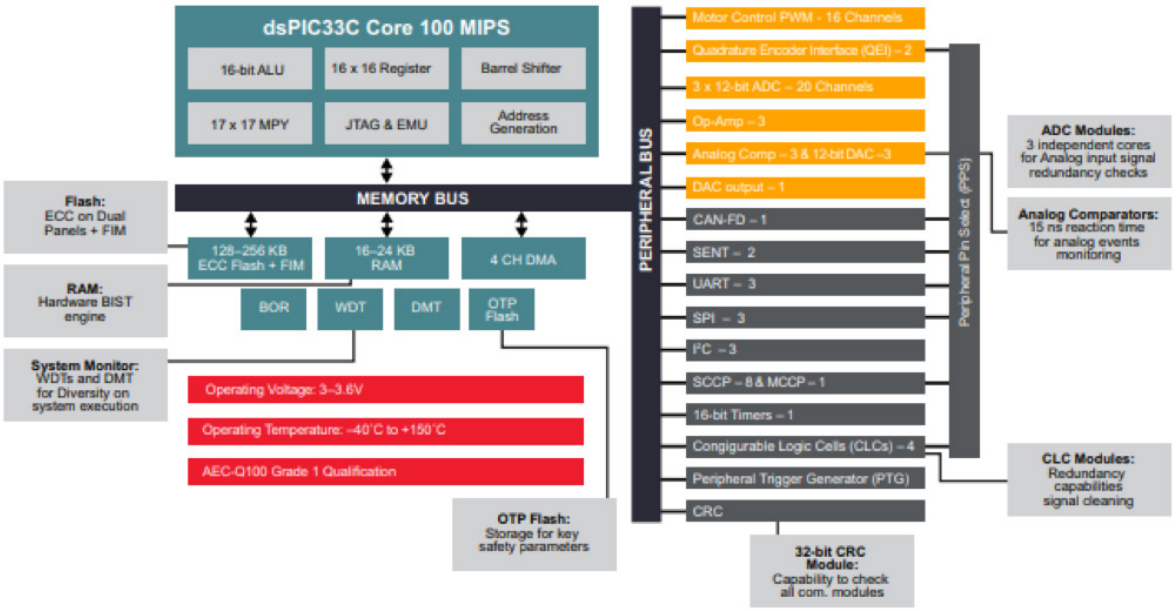

Figure 4: *dsPIC33 Block Diagram. (Source: Mouser Electronics)*

Safe Foundations

The **Automotive Electronics Council** (AEC) set reliability standards to ensure components can withstand the harsh conditions created in an automotive environment. Components must be as reliable in the Nevada desert as they are in the arctic circle.

AEC - Q100: Failure Mechanism Based Stress Test Qualification For Integrated Circuits

AEC - Q101: Failure Mechanism Based Stress Test Qualification For Discrete Semiconductors

AEC - Q102: Failure Mechanism Based Stress Test Qualification for Discrete Optoelectronic Semiconductors

AEC - Q103: Failure Mechanism Based Stress Test Qualification for Sensors in Automotive Applications

AEC - Q104: Failure Mechanism Based Stress Test Qualification For Multichip Modules

AEC - Q200: Stress Test Qualification For Passive Components

The dsPIC33 mentioned earlier has met a series of standardized tests to ensure it is reliable for use in automotive applications to achieve Q100 qualification. These include testing ESD, latching, package and production reliability. Their operating temperature range then grades components. Select components from the dsPIC33 series are grade 0, meaning they reliably work between -40°C to +150°C.

Grade	Ambient Operation Temperature Range
0	-40°C to + 150°C
1	-40°C to + 125°C
2	-40°C to + 105°C
3	-40°C to + 85°C

Figure 5: *AEC-Q100 operating temperature grades. (Source: aecouncil.com)*

AEC-Q200 has a separate temperature grading table for passives and supplementary tests for flame retardance, voltage surges and terminal strength.

Grade	Temperature Range		Passive Component Type Maximum Capability Unless Otherwise Specified and Qualified	Typical/Example Application
0	-50°C	+150°C	Flat chip ceramic resistors, X8R ceramic capacitors	All automotive
1	-40°C	+125°C	Capacitor Networks, Resistors, Inductors, Transformers, Thermistors, Resonators, Crystals and Varistors, all other ceramic and tantalum capacitiors	Most underhood
2	-40°C	+105°C	Aluminum Electrolytic capacitors	Passenger compartment hot spots
3	-40°C	+85°C	Film capacitors, Ferrites, R/R-C Networks and Trimmer capacitiors	Most passenger compartment
4	0°C	+70°C		Non-automotive

Figure 6: *AEC-Q200 operating temperature grades. (Source: aecouncil.com)*

The datasheet of the **type RQ73 Series** of automotive-grade thin film precision chip resistors from TE Connectivity gives a good overview of the test criteria required to pass the AEC-Q200 standard. The resistors use high-grade raw materials, are laser-trimmed to provide more precise tolerance figures, have a tight temperature coefficient of resistance (TCR) and include anti-corrosive protection layer to achieve this.

Stay Connected

Whilst the world is going wireless when it comes to connecting things in automotive technology is very much still in the wired domain. A modern car can contain over a Km of cable. So how do you ensure everything stays connected?

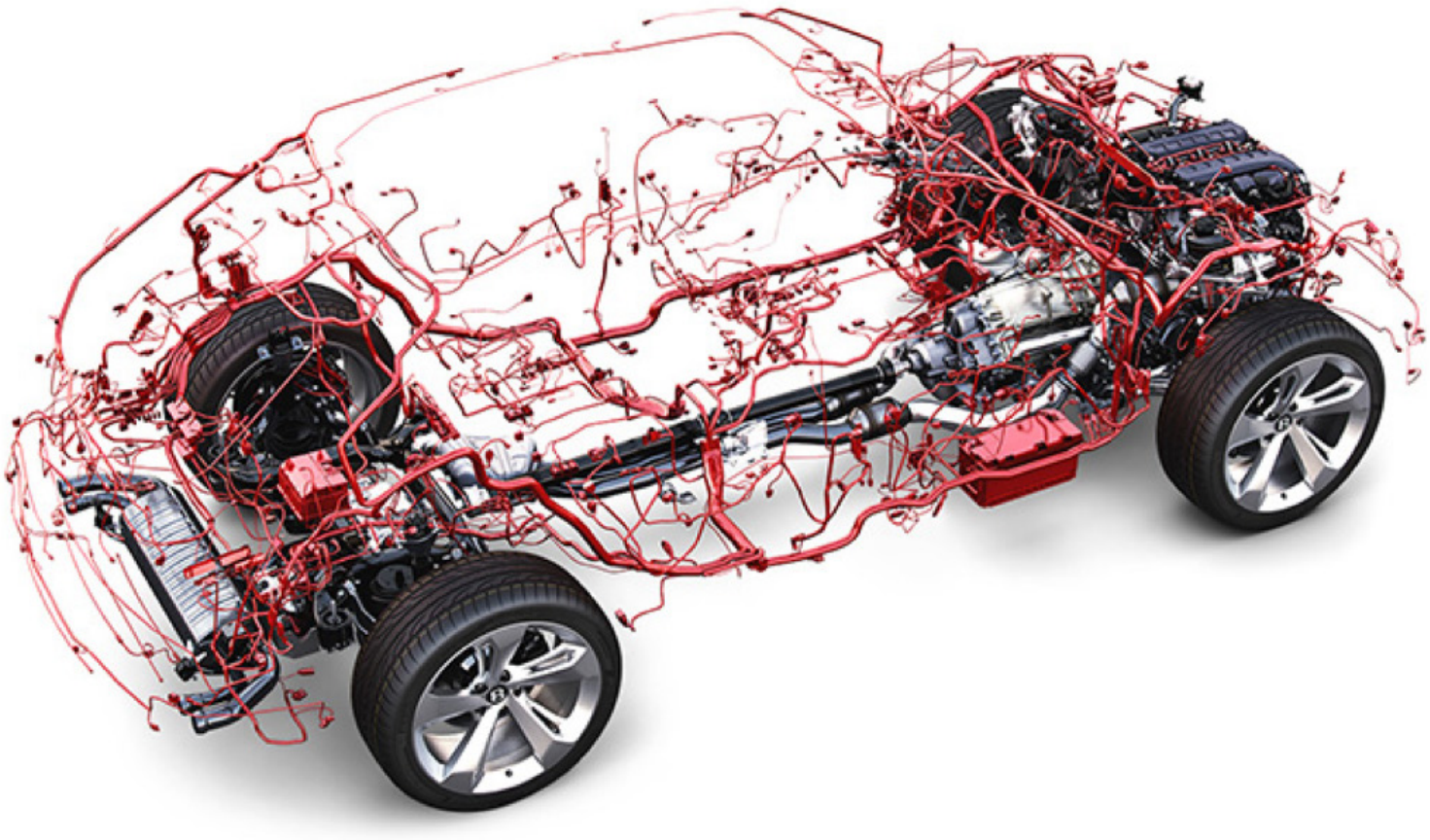

Figure 7: *Bentley Bentayga 48V wiring system. (Source: Bentley)*

Whilst some OEMs have their standards two are most widely adopted.

- **USCAR2-7** - United States Council for Automotive Research Performance Specification for Automotive Electrical Connector Systems.
- **LV 214** - The German Automotive OEM Connector Test Specification

Both standards apply to test throughout development and production of electrical terminals and connectors in low voltage road vehicle applications. While there are many variations, both focus fundamentally ensure good contacts are made despite the heavy vibrations through driving at speed.

TE Connectivity's DEUTSCH **DTM Series Connector System** takes things one step further. Suitable for meeting the extreme conditions in sports and touring car racing, these connectors go through an even more rigorous set of tests. The **DTM Series Connector System Product Specification** highlights some of the test required to meet the chemical, mechanical and thermal tests to maintain connectivity throughout extreme vibration tests.

Test Description	Requirement	Procedure
Thermal Cycle	There shall be no evidence of cracking, distortion or detrimental damage to the connector following the test.	Cycle mated connectors from -55°C to +125°C. Connectors to remain at each temperature extreme for one (1) hour minimum. Mated connectors are to be cycled a total of 20 complete cycles.
Thermal Shock 1	There shall be no evidence of cracking, distortion or detrimental damage to the connector following the test.	SAE J2030 Subjected test sample to 10 cycles. One cycle shall consist of a soak time at -55°C then a transition within 2 min to an ambient of +125°C, with a soak time there and then a transition back to -55°C within 2 min. The soak times shall be established as the time necessary to bring the internal connector temperature on test to within 5°C of each of the ambient temperatures.
Thermal Shock 2	There shall be no evidence of cracking, distortion or detrimental damage to the connector following the test.	ISO 16750-4 Subject the sample: (1) 20 minutes at -40°C (2) ≤ 30 second transition time (3) 20 minutes at +125°C (4) ≤ 30 second transition time Repeat 100 times

Figure 8: *Excerpt from TE's DEUTSCH DTM Connector Series Product Specification. (Source: TE Connectivity)*

Not just for cars

Rigorous testing, higher quality materials and extra safety features built-in, there are benefits of using automotive grade components in other industries which have to survive in harsh conditions. Similarly to selecting components which are IP rated for ingress protection by selecting components which are AEC-Q100 or AEC-Q200 qualified ensures they are up to the challenges of your next designs.

While there are many standards to adhere to when designing your next automotive or industrial application, discover the automotive range of components from **Microchip Technology** and **TE Connectivity** at **mouser.com**.