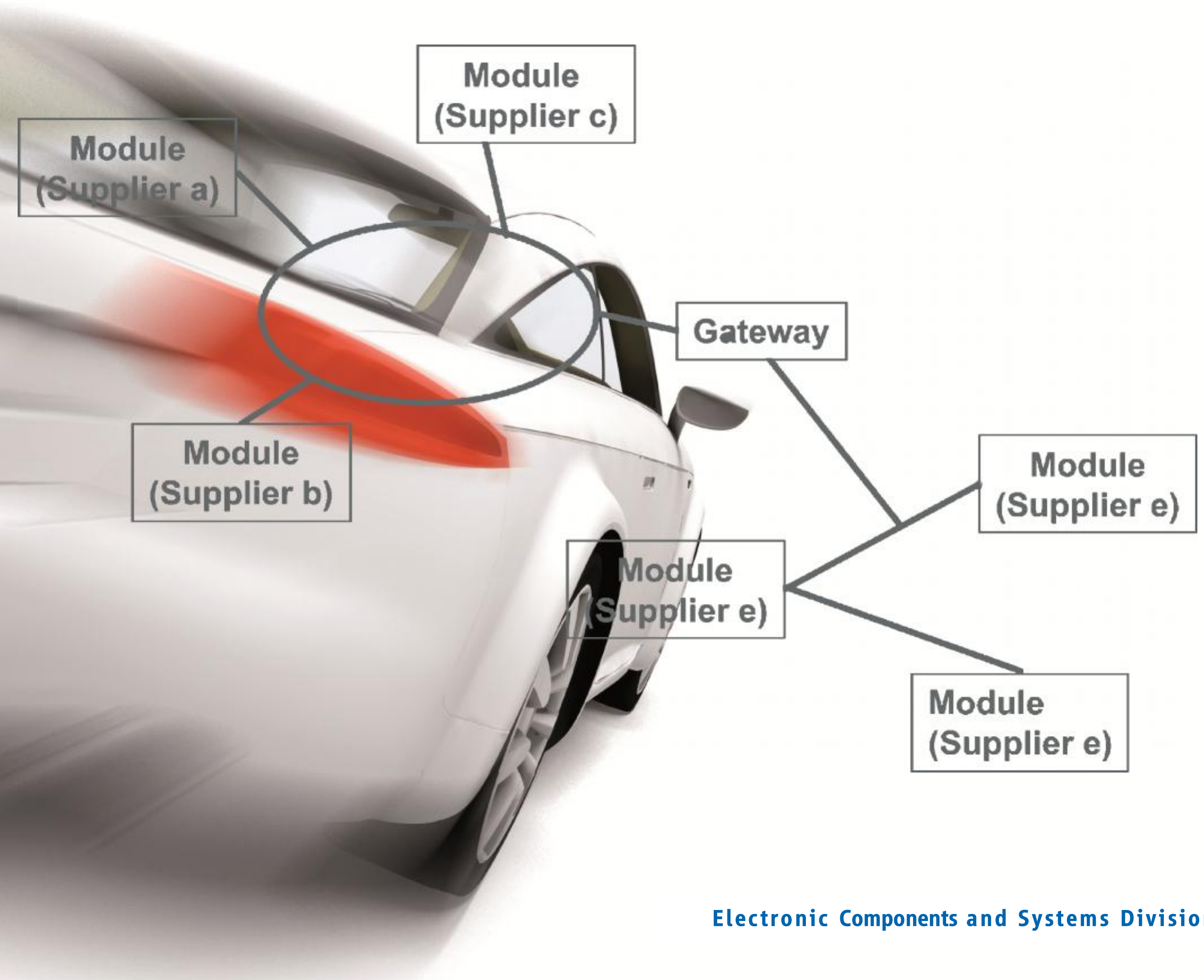
Robustness Validation – System Level

Appendix to Robustness Validation Handbook for EEM



Electronic Components and Systems Division

Robustness Validation - System Level

Appendix to Robustness Validation Handbook for EEM

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2. Edition: April 2014 (new layout)

The Document and supporting materials can be found on the ZVEI website at: www.zvei.org/RobustnessValidation

CONTENT

DEFINITION – VEHICLE FUNCTIONAL SYSTEM (VFS)

1 Introduction

The project „Robustness validation System Level" is the 3rd project of the joined Robustness Validation Groups of ZVEI and SAE.

Until now two reference documents have been published by ZVEI and SAE:

- Handbook for Robustness Validation of Semiconductor Devices in Automotive Applications
- Handbook for Robustness Validation of Automotive Electrical/Electronic Modules

Whereas the first Handbook is about the validation of Semiconductor and electronic components in general, the 2nd Handbook is concerning about Robustness validation of stand-alone Electronic Control Units.

Important:
The communication between OEM and Tiers is fundamental in order to achieve a robust system.
As already described in the RV Handbooks for Components and EEM:
Basis for a robust System is a mutually agreed System-Mission-Profile in very early phase of the development process.

With this 3rd publication the focus is drawn to the validation of robustness of a group of two or more interacting Electronic Control Units respectively Electrical/Electronic Modules.

This appendix to the Handbook for Robustness Validation of Automotive Electrical/Electronic Module highlights additional points which originate from the interaction of EEMs.

The already existing handbooks with the focus on components and stand alone electrical modules have definitely lifted up the way someone looks to the robustness and the methods standing behind. However this ends up in between and cannot consider the interrelation of module combination(s). The total robustness assessment is expected to be done on system level by taking all the relations into consideration. This would not only feedback some robustness numbers but as well closing the loop to modify or change the **Mission Profiles** for the stand alone units.

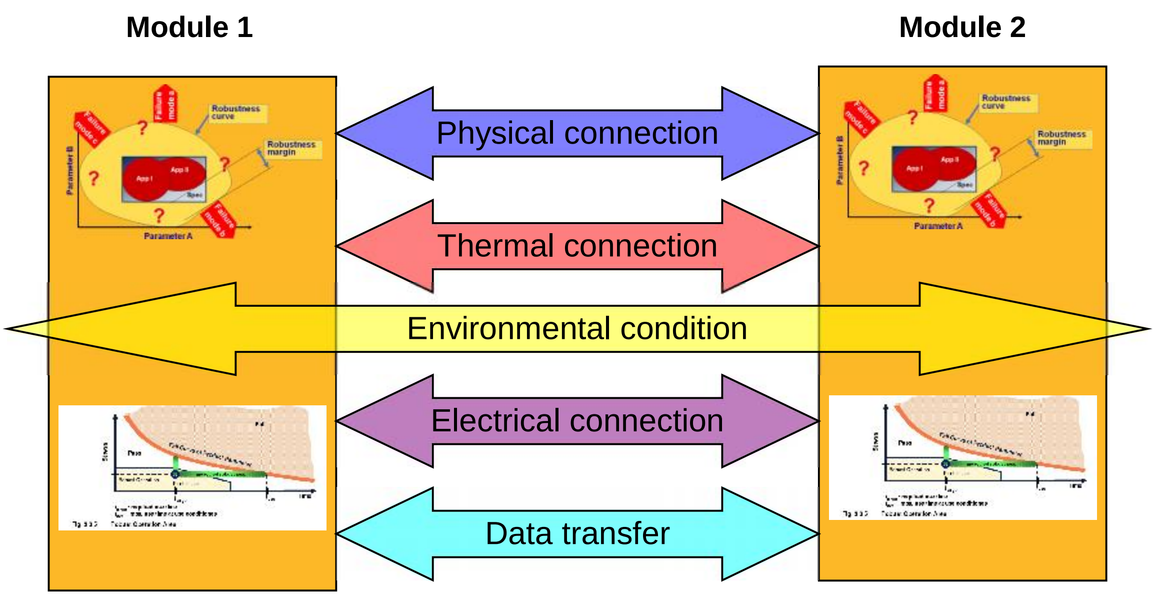

Figure 1 For individually released Modules several interactions has to be taken into account.

The above schematic shows the general and balanced interconnection of two individual electronic modules as to be uniquely qualified according to the RV standard. The balance of all factors does not negatively affect any of these which go in line with the RV result.

In reality this assumed balance is not always but more rarely the case. Furthermore there is on the one site a non balanced load sharing and on the other site as well an interrelation between the individual stressors. This overlay may end up in an indirect Mission Profile change between the stand alone modules in a non embedded environment and the connected ones.

Based on these reasons the validation on system level may become mandatory and should take into consideration the overlaying stressors.

If the overlay can be calculated the individual Mission Profile of the stand alone module can be upgraded or lifted up as well. This represents that at least the interacting characteristic of two or more Modules was taken in consideration.

2 Definition - Vehicle Functional System (VFS)

A Vehicle Functional System (VFS) is understood as

- a set of several electric/electronic modules (EEM), mechatronics or sensors/actuators (wired or wireless),

and is required to ensure an intended distributed functionality.

The power distribution and additional electrical and electronic hardware (E/E) and mechanical devices are included, if necessary for mounting, assembly, test and operation of the system. That means all electrical and electronic and mechanical hardware that is required to set up complete functional control loops contributes to a "Vehicle Functional System":

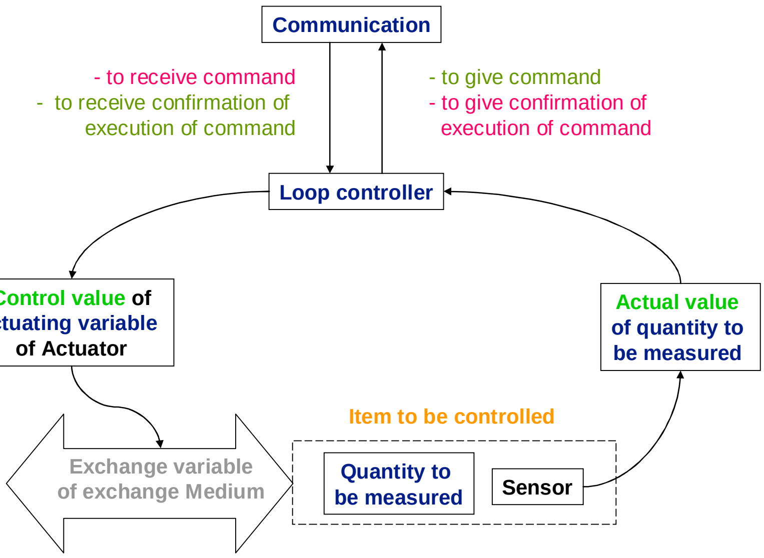

Figure 2: Functional view of a module: i.e. Example of a closed loop control (here distance control system)

Although vehicle system functions are not restricted to close loop controls only, the above Diagram gives a representative view of system parameters provided by different system components (EEMs). Typical electrical/electronic (E/E) system modules are connected to power and Ground and include a communication bus interface for the communication with other system modules and power output stages if driving external loads (actuators).

Based on the definitions given in the Robustness Validation Handbooks for Semiconductor Components (ICs) and for Automotive Electrical/Electronic Modules (EEMs), ***physical and functional classifications*** are used in the following paragraphs for the description of the Vehicle Functional Systems (VFS).

2.1 Physical classification

Physical classification is based on adding/combining individual modules along the ***supply chain*** and is required for the intelligent testing matrix.

Per definition module means “part of the whole”. In order to use the term module in a stringent way, module is defined in relation to a control loop. The scope of supply of a supplier may either be a part of all equipment which is needed to set up a complete control loop or may contain all of this equipment. The next picture illustrates the situation.

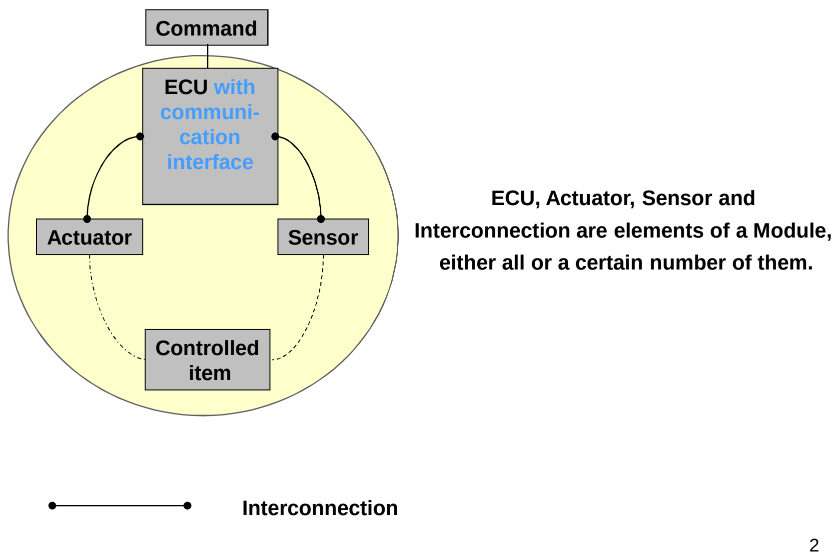

Figure 3: Control loop as structure element (Hardware view)

By this approach the physical classification of vehicle functional system is

1st level: complete vehicle

2nd level: The combined networks do consist of communication infrastructure, the complementary modules and the power generation, power distribution, power management as well (figure 4).

The complementary modules are users and builders of the bus-systems, power generation, power distribution, power management and of the infrastructure as well.

DEFINITION – VEHICLE FUNCTIONAL SYSTEM (VFS)

The border line between a bus system and the module is the communication interface in the ECU (see figure 3): Bus systems provide the communication infrastructure between Electronic Control Units from different modules (see figure 4).

Four basic communication cases exist

- *to receive command*
- *to give confirmation of execution of command*
- *to give command*
- *to receive confirmation of execution of command*

3rd level: sub system: modules provided by more than 1 supplier

4th level: semi finished system level: modules provided by 1 supplier only

5th level: stand alone module or stand alone ECU (from of one supplier)

<u>The following pictures will illustrate this definition</u>

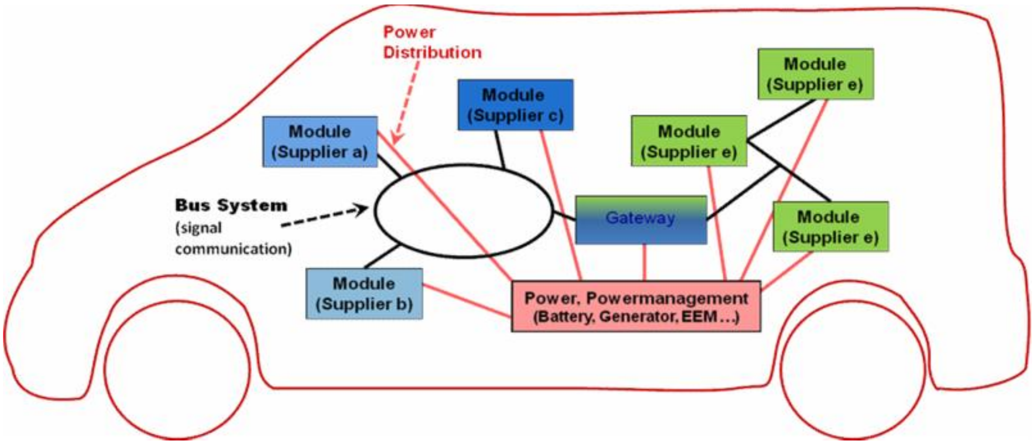

Figure 4: Overview of Level 2: Bus systems provide the communication infrastructure between Electronic Control Units from different modules.

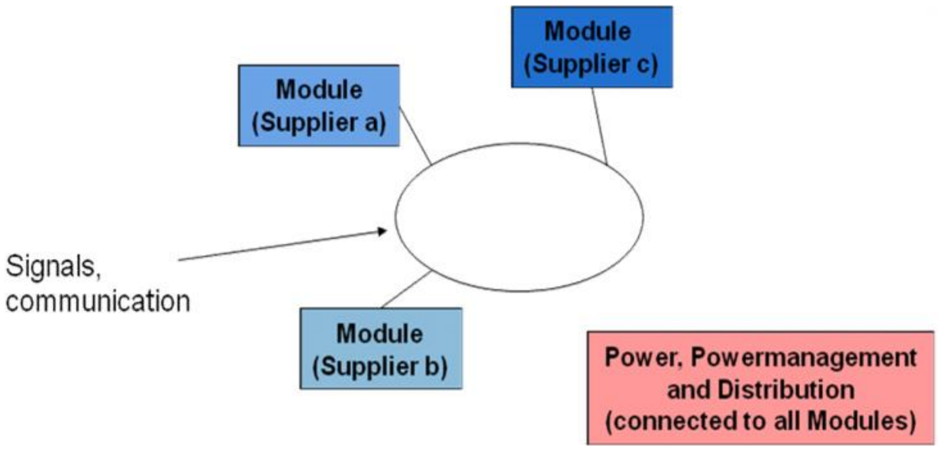

Figure 5: 3rd level sub system: modules provided by more than 1 supplier

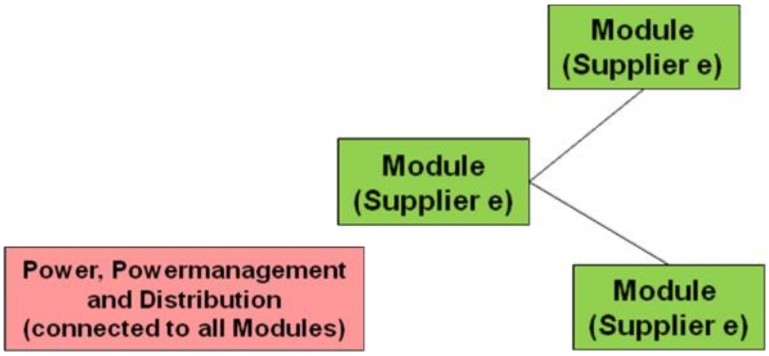

Figure 6: 4th level: semi finished system level: modules provided by 1 supplier only

2.2 Functional classification

The following definition is based on the complexity, number of functions in vehicles and modules (EEM or ECUs) involved:

1st stage: interaction among ***all functions***

2nd stage: interaction between two or more than two functions (***from different modules***)

Examples

- distance control function with impact on engine/transmission control management

or

- curve light function calculated from steering- and speed functions

3rd stage: interaction between two or more than two functions of the ***same module***

4th stage: components (e.g. ***single IC***)

Some comfort functions (e.g. seat memory) belong to the 2nd stage since at least two ECU' s are involved (door module functions (for rear mirror adjustment), seat adjustment functions and steering column adjustment functions).

Functions like "standard" seat adjustment belong to 3rd stage.

3rd and 4th stage of functional classification are covered by Robustness Validation of Semiconductor Devices (4th stage), respectively Automotive Electrical/Electronic Modules EEMs (3rd stage).

Robustness validation system level is dealing with structures of functional classification 2nd stage.

The next pictures visualize the basic physical contents of stage 2 either without or with human machine interface.

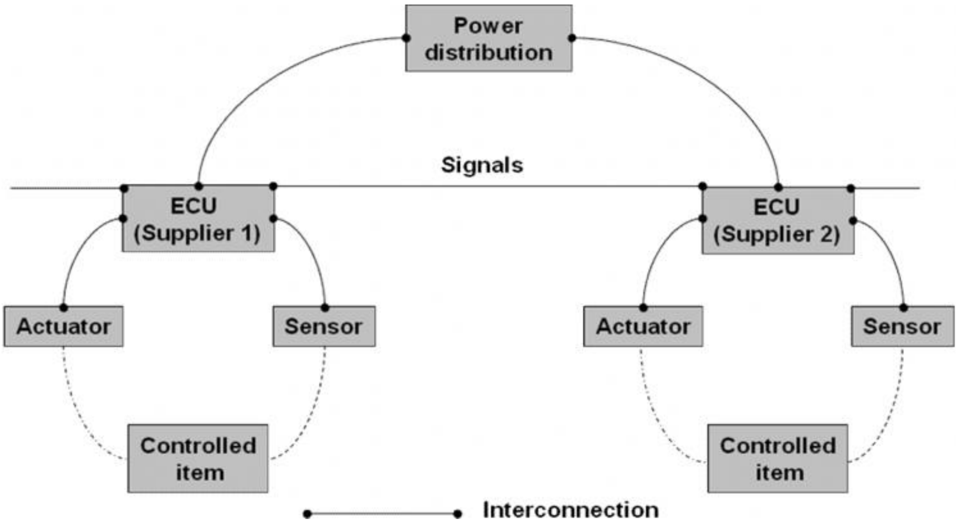

Figure 7: *Example for functional classification 2nd stage. Imagine full interconnection to 3p which is partly shown.*

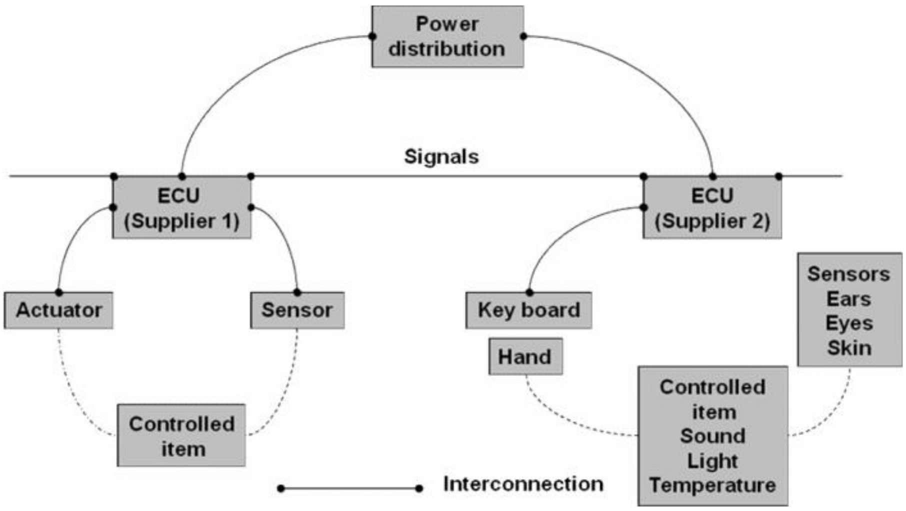

Figure 8: *Example for functional classification 2nd stage with Human-Machine-Interface. Imagine full interconnection to 3p which is partly shown.*

Therefore a “Vehicle Functional System” usually consists of two or more EEMs (electrical/electronic module) or ECUs, and mechatronics and/or actuators and sensors and, in some cases, the person which drives the car.

3 Flow of Robustness Validation on System Level for "Vehicle Functional Systems"

Preconditions for the definition of Vehicle Functional System

Robustness Validation considerations for a "Vehicle Functional System" as defined in chapter 1 assumes that certain preconditions for the electrical/electronic module (EEM), mechatronics and actuators/sensors that build the system are met.

For all system modules software testing is completed and all functional requirements are met according to the expected robustness and the specified Mission Profile, e.g. all necessary test cases have already been considered.

Every system component e.g. each individual module that belongs to the system works as intended. That means all modules fulfill their individual module specification, Hardware and Software requirements as well as EMC, environmental stress and functional load stress tests.

The Mission Profile is a representation of all relevant conditions an electrical/electronic system will be exposed to in all of its intended applications throughout its entire life cycle from manufacturing until safe disposal of product. It is therefore important that the Mission Profile for each individual electrical/electronic system be developed and communicated to the engineers designing the system as soon as possible.

With a good description of the Mission Profile, engineers can begin to estimate reliability and quality levels and start to work toward achieving 'Zero Defects'.

A robust System is one that is sufficiently capable of functioning correctly and not failing under varying application and production conditions. The Robustness Validation process (Fig 9) relies heavily on team expertise and knowledge, and therefore requires detailed explanation and intensive communication between the user and supplier.

FLOW OF ROBUSTNESS VALIDATION ON SYSTEM LEVEL

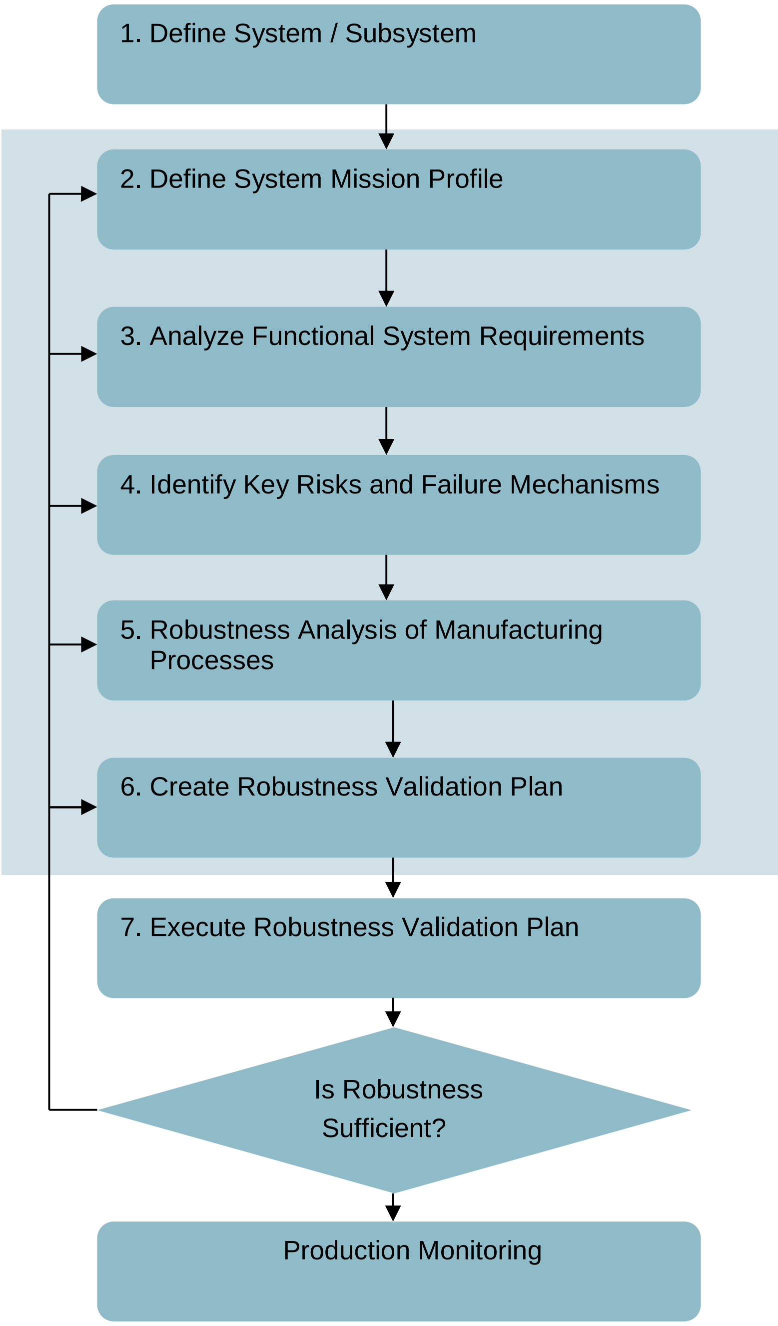

Figure 9: *Robustness Flow for System Level*

3.1 Unexpected loss of robustness during system integration

Unintended effects, that may arise when connecting different modules together in order to build a system, can cause system failures and/or module damage.

Those effects originate from areas like Electro-Magnetic Compatibility (EMC), Environmental Load Parameters, Vehicle Grounding Concept and Consumer Electronic plug-in devices.

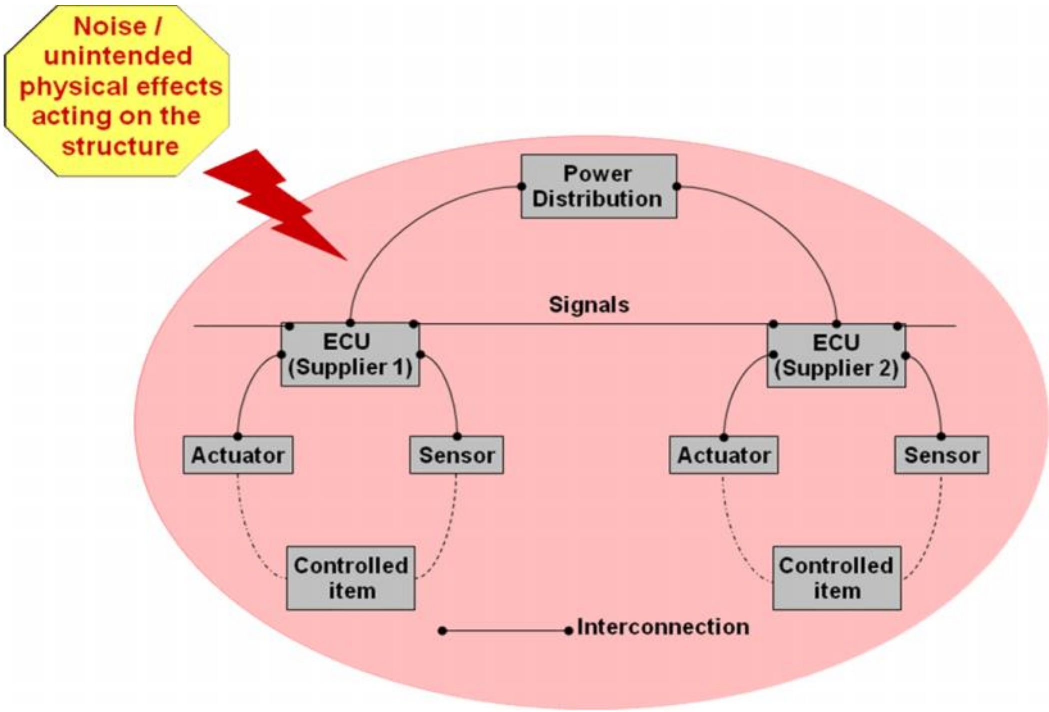

Figure 10: Basic elements for Robustness validation System level

3.2 Example for Unexpected loss of robustness during subsequent steps of manufacturing process

The following example illustrates the risk of overrunning the maximum allowed mating cycles of electrical connectors by e.g. reducing contact normal forces and or mechanical wear of plating surfaces.

In-line connectors consist of four different parts

- *The tab housing*
- *The receptacle housing*
- *The tab or blade*
- *The receptacle*

The tab as well as the receptacle is made of metal. Their task is the termination of the wire. The housings are usually made of plastic. The task of the housings is the electrical insulation of the different terminations in the interconnected state and to provide the geometrical arrangement of the receptacle and the tabs.

The terminations may be realized either in circular or rectangular geometry. When geometry is circular, pin is the word for tab and socket the expression for receptacle.

FLOW OF ROBUSTNESS VALIDATION ON SYSTEM LEVEL

In case of the electrical connection of electronic control units the wording for the housings is different.

The tab housing usually is part of the electronic control unit and is called header. The header also includes the tabs. The tabs are connected to the printed circuit board inside the electronic control unit and the tabs terminate the conductive paths (wiring) of the printed circuit board.

Both examples clearly demonstrate that a lot of parties are involved in the realisation of an interconnection of an electronic control unit with the wire harness. In general the design of the interface is defined in a design specification. The design specifications are developed under the responsibility of one OEM or an OEM working group.

To obtain access to the market, the producer of receptacles has to demonstrate that the receptacle is able to withstand a certain number of engagement cycles and disengagement cycles. Often this number depends on the surface plating and is requested in the test specification. The proof is documented in the product specification of the contact.

According to the common understanding the number of engagement cycles of the receptacle refers to the engagement cycles during the lifetime of the connector in the car for repair and maintenance. The supply chain shall refrain from more than one engagement process during assembly.

During production process the testing situation is as follows:
For providing electrical contact to the ECU, test adapters will be used. Instead of receptacles the adapting housing is populated with spring forced contact pins. These contact pins will contact non functional areas (egg. the tip of the tabs) and provide contact.

In the reverse case when components along the wire harness have to be tested, Interconnection between the wire harness and test electronic has to be made via receptacles, because receptacles terminate wires, however, without contacting the contact area of the receptacle. In order to keep the number of engagement cycles and disengagement cycles along the supply chain for receptacles at one, the receptacle manufacturer provides so called test channels in the receptacle housing.

Special test adapters populated with test needles which contact the receptacles through the test channels have to be built and used. Whilst working with this equipment no engagement process in the contact area of the receptacle will happen.

The example given below, the above mentioned text and the knowledge of the zero defect group underline once more that it will be a win-win situation for the parties along the supply chain to exchange information from top to bottom and vice versa as well. The processing specification of the contact shall be available and applied along the supply chain.

Number of Mating cycles of a connector along the Supply Chain:

Product Specification: 10 mating cycles

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OEM Tests — *3 mating cycles*

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Tier 1 Tests — *3 mating cycles*

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Sub supplier Tests — *4 mating cycles*

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10 mating cycles

Any additional cycles e.g. warranty, retesting, maintenance and vehicle life will **exceed the specification of the connector!**

4 Questionnaire for a Mission Profile

Building up a good Mission Profile requires good understanding of the system. The stress magnitudes are important details of the “Mission Profile” of the system´s total lifetime. All relevant stressors and loads have to be considered during the overall use life of the product. The collection of loads and stressors can be facilitated by applying the intelligent testing table.

The generation of the Mission Profile is not a one-time activity, and it is not a one-way street of data transportation. Rather, as already described in the RV handbook [Chapter 6.1 in RV EEM], it is an interactive process that needs communication and reiteration to ensure mutual understanding of each other’s issues and viewpoints. This is essential to finding optimal solutions taking into account the whole system.

Much of the information needed for the Mission Profile will come from application engineering and product definition/development. In order to support the gathering of data, the intelligent testing table can be used, depending on the case under consideration, some questions may not be applicable and other relevant items may not be included. Comments are made to several of the items that try to help interpret the point.

In most cases more than one application will be targeted, so the requirements for each application have to be specified. Although one may tempt to seemingly simplify matters by defining an “enveloping profile”, no attempt should be made in the phase of collecting data for the Mission Profile to somehow condense, convert, or select requirements from different applications with respect to their importance, criticality, or whatever criterion one may imagine. The objective is to gather and document information on the requirements without any biasing. Any discussion of the relevance of specific information shall be handled in the subsequent risk assessment. The main reason behind is that relevant information may get distorted or lost that would be needed for considering the failure mechanisms.

5 Objectives of the intelligent testing table

The intelligent testing table shows where an optimization of the test procedure from module to the complete car is possible. It can be used as a guideline along the complete validation flow.

A discussion and agreement of testing on different levels in an early development phase between tier one and OEM is recommended and can prevent from gaps in testing or redundant testing effort and decrease costs of testing (see complete table attached).

OBJECTIVES OF THE INTELLIGENT TESTING TABLE

Items		Mission Profile	5th Level Modul/ECU	4th Level semi finished "one company system"	3rd Level sub system "Brettaufbau"	2nd Level Network (LIN, CAN, MOST, Battery..	1st Level car
				Complete system, all parts to one companies responsibility	complete system with modules/parts from the other suppliers or equivalent values for the others		
	Test Responsibility →		Tier 1	OEM or Tier 1	OEM or Tier 1	OEM	OEM
Testgroup	**Test**	ng to the requirements of the Mission Profile of the System					
Initialize System	Start		x		test	test	
	Restart/Reset caused by EMI or electrical disturbance		covered by electrical test	discuss	depends on system architecture, therefore OEM is responsible		
EMI	radiated immunity		x	discuss	tbd	tbd	test
	radiated emission		x	discuss	tbd	tbd	test
	conducted immunity		x	discuss	tbd	n.a.	tbd
	conducted emission		x	discuss	tbd	n.a.	tbd
	ESD		x	If ESD Requirements for all			
	Wireless communication range testing (BT, RKE, etc)		x (sensitivity, output power, polar plots, etc)	Test Receiver & Transmitter together (BER, distance, etc)	Test with intended Receiver & Transmitter (BER, distance, etc)	n.a.	Test with worst case potential shielding and loads in the car.
	BCI		x	discuss	tbd	n.a.	tbd
Electrical Test	reverse voltage		not necessary, if system protection (e.g. mechanical solution) is available at all levels (manufacturing, car assembly and testing, maintenance)				
	Electrical consumption in "sleep" or idle mode		x	Consumption at different temperatures and voltage levels	Consumption at different temperatures and voltage levels	Consumption at different temperatures and voltage levels	Consumption at different temperatures and voltage levels
	Load dump		state of the art regarding system protection (zener-diodes at generator) is <36V				
	ripple on power supply lines		x	discuss	depends on system architecture, therefore OEM is responsible		
	Ground offset voltage		x	discuss	depends on system architecture, therefore OEM is responsible		
	disconnection of connector pins		x	discuss	depends on system architecture, therefore OEM is responsible		
	Short circuit to ground		x	discuss	depends on system architecture, therefore OEM is responsible		
	Short circuit to supply voltage		x	discuss	depends on system architecture, therefore OEM is responsible		
	Transient overvoltage (18V pulse)		x	discuss	depends on system architecture, therefore OEM is responsible		
	Decreasing / increasing of operating voltag		x	discuss	depends on system architecture, therefore OEM is responsible		

Table 1: Detailed requirements for testing at different system integration levels (double click to enlarge / 2 pages)
(Also free available as an excel sheet under www.zvei.org/RobustnessValidation)

OBJECTIVES OF THE INTELLIGENT TESTING TABLE

In the first two columns, required tests – sub classified into the groups initialize system, EMI, electrical and environmental requirements, production, repair, maintenance, Certification & Homologation – are listed. It is assumed that the modules by themselves already fulfil contractual testing requirements. The intention of the table is to provide information on which system integration level either:

- test is recommended but conditions have to be agreed between the partners (mainly tier1 and OEM) (discuss)
- a test is mandatory (test)
- a test is not possible or the module test is already sufficient to fulfil the requirement (n.a.)
- it has to be defined if a test is applicable (tbd).

The intelligent testing table does not intend to be complete.

This job has to be done individually from all parties involved for each specific case.

Please consider during discussions the total lifecycle of the product, which includes also manufacturing, assembling, handling, repair and maintenance (see also definition of Mission Profile). For some tests on specific system levels the contribution of OEM is needed in order to fix an assessment.

The main results of the discussion about the system test for the seven test groups are:

- **Initialize system**

  The start of a subsystem can be tested by tier 1, but the OEM is responsible for system state after a restart/reset of one or more ECU´s

- **EMI**

  For the group EMI and grounding the most discussions between Tier 1 and OEM are needed.

- **Electrical Test**

  For most electrical tests the restart/reset of the system has to be tested.

- **Grounding & Shielding**

  For the group EMI and grounding the most discussions between Tier 1 and OEM are needed.

- **Environmental Tests**

  For most of the environmental tests no problems on system level should occur if requirements for all modules are fixed and the tests are positive.

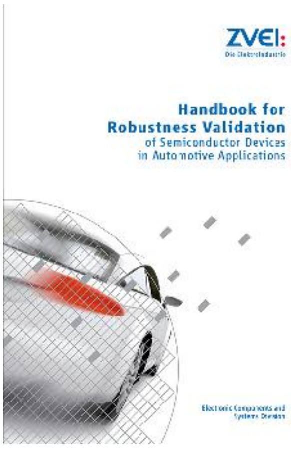
- **Production, Repair and Maintenance**

  Tests conditions are derived from OEM processes and therefore the OEM has to define the test requirements.

- **Certification & Homologation**

  Focus on testing is to fulfil legal requirements and / or needed to bring the product to specific markets.

Annex A
Related Documentation



Handbook for Robustness Validation of Semiconductor Devices in Automotive Applications
(Pages 60, April 2007, Revision February 2013)

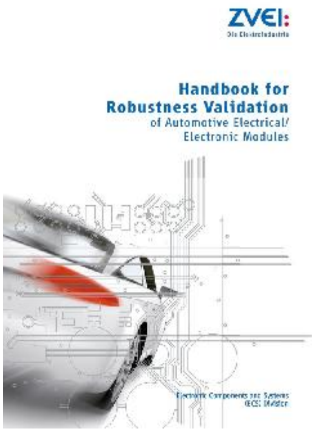
The quality of the vehicles we buy and the competitiveness of the automotive industry depend on being able to make quality and reliability predictions. Qualification measures must provide useful and accurate data to provide added value. Manufacturers of semiconductor components must be able to show that they are producing meaningful results for the reliability of their products under defined Mission Profiles from the whole supply chain.

This includes screening methods and reliability methodologies applied on technology level during development.

Contents:
- Terms, Definitions, and Abbreviations
- Definition and Description of Robustness Validation
- Mission Profile / Vehicle Requirements
- Technology Development
- Product Development
- Potential Risks and Failure Mechanisms
- Creation of the Qualification Plan
- Stress and Characterization
- Robustness Assessment
- Improvement
- Monitoring
- Reporting
- Examples

This handbook gives guidance to engineers how to apply Robustness Validation during development and qualification of semiconductor components. It was made possible because many companies, semiconductor manufacturers, component manufacturers (Tier1) and car manufacturers (OEMs) worked together in a joint working group to bring in the knowledge of the complete supply chain.

RELATED DOCUMENTATION



Handbook for Robustness Validation of Automotive Electrical/Electronic Modules
(Pages 148, June 2008, Revision June 2013)

This document addresses robustness of electrical/electronic modules for use in automotive applications. Where practical, methods of extrinsic reliability detection and prevention will also be addressed. This document primarily deals with electrical/electronic modules (EEMs), but can easily be adapted for use on mechatronics, sensors, actuators and switches. EEM qualification is the main scope of this document. Other procedures addressing random failures are specifically addressed in the CPI (Component Process Interaction) section 10. This document is to be used within the context of the Zero Defect concept for component manufacturing and product use.

The Robustness Validation approach emphasizes knowledge based engineering analysis and testing a product to failure, or a predefined degradation level, without introducing invalid failure mechanisms. The approach focuses on the evaluation of the Robustness Margin between the outer limits of the customer specification and the actual performance of the component. These practices integrate robustness design methods (e.g., test-to-failure in lieu of test-to-pass) into the automotive electronics design

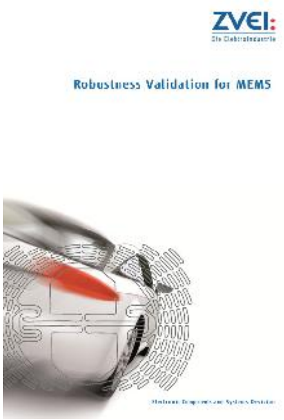
and development process. The objectives of improved quality, cost, and time-to-market can be realized.

Contents:

- Introduction
- Scope
- Definitions
- Definition and Description of Robustness Validation
- Information and Communication Flow
- Mission Profile
- Knowledge Matrix for Systemic Failures
- Analysis, Modeling and Simulation (AMS)
- Intelligent Testing
- Manufacturing Process Robustness and its Evaluation
- Robustness Indicator Figure (RIF)
- Appendix:
- Section Examples
- Prototype Test Examples

This Robustness Validation Handbook provides the automotive electrical/electronic community with a common qualification methodology to demonstrate robustness levels necessary to achieve a desired reliability.

RELATED DOCUMENTATION



Robustness Validation for MEMS –
Appendix to the Handbook for Robustness Validation of Semiconductor Devices in Automotive Applications
(Pages 38, October 2009, Revision 2014)

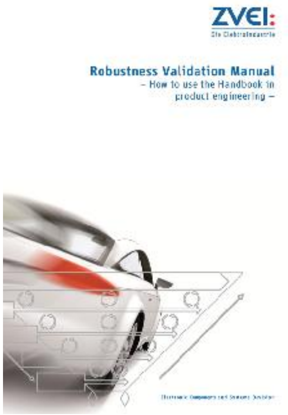
Robustness Validation (RV) is a valuable failure-mechanism-driven approach to product reliability and qualification, which relates real application conditions to test conditions.
MEMS sensors present a special category of devices that need specific considerations. By their very nature, MEMS sensors are often exposed to harsh environmental conditions that are in an obvious way not covered by standard stress test conditions used in product qualifications. Neither commonly referenced product qualification standards nor “Handbook for Robustness Validation of Semiconductor Components in Automotive Applications” published by ZVEI in April 2007 adequately represent the sensor needs. It is for this reason that sensor manufacturers and users joined in a team organized by ZVEI to discuss the application of Robustness Validation to sensor devices.

1. Introduction
2. Terms, Definitions, and Abbreviations
3. Mission Profile
4. Knowledge Matrix
5. Acceleration Factors / Testing
6. Summary and Outlook
7. References and Additional Reading
8. Participants of the Working Group

Annex
A.1 Mission Profile Examples
A.2 Knowledge Matrix Table
A.3 Overview Stress Tests

The results are published and can be ordered from ZVEI.

RELATED DOCUMENTATION



Robustness Validation Manual
– How to use the Handbook in product engineering
(Pages 25, January 2010, Revision March 2014)

Frontloading is the key to enable success at qualification of a semiconductor component or electric and electronic module [EEM]. This requires early integration of the Robustness Validation [RV] approach in the development project. This also ensures the use of the available knowledge of the project team, starting at the requirement management phase where the Mission Profile is created until the robustness assessment after completion of the qualification tests. The basic deliverable of Robustness Validation is knowledge for decision making.
The RV flow describes the framework to generate the required knowledge throughout the entire development process. RV is based on experience and knowledge about the behavior of semiconductors and EEMs under application conditions and the relevant physics of failure. Generation of MP creates knowledge for future/further designs. To enable development teams to perform RV, training is prerequisite but expertise (learning) is generated by doing. Coaching by experts is recommended for roll out phase of RV.
This Manual is intended to be a guideline supporting the application of RV as described in the RVHB.

The Handbook is free for download under ZVEI Homepage:
http://www.zvei.org/RobustnessValidation

RELATED DOCUMENTATION

Automotive Application Questionnaire for Electronic Control Units and Sensors

This Automotive Application Questionnaire helps the parties involved (OEM, Tier1, Tier2...) to select critical application parameters (= environmental loads) in a simplified and standardized way:

- Evaluation of loads
- Better, failure free communication between all parties:
  - Car manufacturer
  - Supplier of the ECU or Sensor
  - Supplier of the electrical (mechanical) devices

The filled in data content has to be handled confidentially by request of one of the parties:

- Therefore the affected parties can decide to put down the contact persons and companies over the whole supply chain by name or not.
- The parties are responsible for validation and sufficiency of the questionnaire, not the ZVEI.

The application questionnaire will help to describe the different loads in the cars and important functional/electrical loads of the components in a short, compact way, so that the parties could make estimations about reliability and quality in order to create 'zero defect' over the supply chain.
With progress in product development Mission Profiles and functional loads will be rendered more precisely. Therefore changes and revisions in the loads during development are admissible.
The questionnaire will also help to check new mounting positions in the car of a well established product.

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This table does not intend to be complete. This job has to be done individually from all parties involved for each specific case

Testgroup	Items	Mission Profile	5th Level	4th Level	3rd Level	2nd Level	1st Level
			Modul/ECU	semi finished "one company system"	sub system "Brettaufbau"	Network (LIN, CAN, MOST, Battery..	car
				Complete system, all parts to one companies responsibility	complete system with modules/parts from the other suppliers or equivalent values for the others		
	Test Responsibility →		Tier 1	OEM or Tier 1	OEM or Tier 1	OEM	OEM
Testgroup	Test						
	Start	All test procedures have to be according to the requirements of the Mission Profile of the System	x		test	test	
Initialize System	Restart/Reset caused by EMI or electrical disturbance		covered by electrical test	discuss	depends on system architecture, therefore OEM is responsible		
EMI	radiated immunity		x	discuss	tbd	tbd	test
	radiated emission		x	discuss	tbd	tbd	test
	conducted immunity		x	discuss	tbd	n.a.	tbd
	conducted emission		x	discuss	tbd	n.a.	tbd
	ESD		x	If ESD Requirements for all			
	Wireless communication range testing (BT, RKE, etc)		x (sensitivity, output power, polar plots, etc)	Test Receiver & Transmitter together (BER, distance, etc)	Test with intended Receiver & Transmitter (BER, distance, etc)	n.a.	Test with worst case potential shielding and loads in the car.
	BCI		x	discuss	tbd	n.a.	tbd
Electrical Test	reverse voltage		not necessary, if system protection (e.g. mechanical solution) is available at all levels (manufacturing, car assembly and testing, maintenance)				
	Electrical consumption in "sleep" or idle mode		x	Consumption at different temperatures and voltage levels	Consumption at different temperatures and voltage levels	Consumption at different temperatures and voltage levels	Consumption at different temperatures and voltage levels
	Load dump		state of the art regarding system protection (zener-diodes at generator) is <36V				
	ripple on power supply lines		x	discuss	depends on system architecture, therefore OEM is responsible		
	Ground offset voltage		x	discuss	depends on system architecture, therefore OEM is responsible		
	disconnection of connector pins		x	discuss	depends on system architecture, therefore OEM is responsible		
	Short circuit to ground		x	discuss	depends on system architecture, therefore OEM is responsible		
	Short circuit to supply voltage		x	discuss	depends on system architecture, therefore OEM is responsible		
	Transient overvoltage (18V pulse)		x	discuss	depends on system architecture, therefore OEM is responsible		
	Decreasing / increasing of operating voltag		x	discuss	depends on system architecture, therefore OEM is responsible		
	Test of cranking profiles		x	na	na	Test communication protocol during cranking using simulation from real data/battery voltage records in the car.	Test at different temperatures, with different batteries and charging conditions (big & small batteries with full, medium, low charge).
	Very brief / brief voltage dip		x	discuss	depends on system architecture, therefore OEM is responsible		
	Quick chargers / jump start		x	discuss	depends on system architecture, therefore OEM is responsible		
Grounding & Shielding	missing ground		is covered by the test "disconnection of connector pins"	discuss	investigate effect, develope common understanding, consider "BOSCH presentation"	discuss	discuss
	Bad ground connection		is covered by the test "ground offset voltage"	discuss	discuss	discuss	OEM has to ensure correct and proper ground connection
	hot plug		is partially covered by the test "disconnection of connector pins"	hot plugging is not allowed			
	high impedant ground		not required	discuss	discuss	discuss	discuss
Environmental Requirements	High Temperature		x	n.a.	n.a.	n.a.	n.a.
	Low Temperature		x	n.a.	n.a.	n.a.	n.a.
	Temperature Change		x	discuss	discuss	discuss	discuss
	Shock Temperature Change		x	n.a.	n.a.	n.a.	n.a.
	Thermal shock in air/splash water		depends on application	discuss	discuss	discuss	discuss
	Stepped temperature		depends on application	discuss	discuss	discuss	discuss
	Long term storage conditions (Temperature, Humidity) unpowered		x	n.a.	n.a.	n.a.	n.a.
	Humidity constant powered		x	n.a.	n.a.	n.a.	n.a.
	Condensation		depends on application	discuss	discuss	discuss	discuss
	Humidity Change		x	n.a.	n.a.	n.a.	n.a.
	Squeak & Rattle testing		x	test	test	n.a.	test
	Random Vibration		x	test	test	n.a.	test
	Sinus Vibration		x	test	test	n.a.	test
	Functional performance during vibration levels for normal driving conditions		x	n.a.	n.a.	n.a.	Test at different speeds and with different road conditions
	Mechanical Shock		x	test	test	n.a.	test
	Drop Test		x	n.a.	n.a.	n.a.	n.a.
	Penetration of Liquids (IP class)		x	n.a.	n.a.	n.a.	n.a.
	Penetration of Particles (IP class)		x	n.a.	n.a.	n.a.	n.a.
	Salt Fog		depends on application	n.a.	n.a.	n.a.	n.a.
	Chemical Fluids		x	n.a.	n.a.	n.a.	n.a.
	Hot water jet		depends on application	n.a.	n.a.	n.a.	n.a.
	Resistance to Fire		x	n.a.	n.a.	n.a.	n.a.
	Insulation Resistance		depends on application	n.a.	n.a.	n.a.	n.a.
	Immersion		depends on application	n.a.	n.a.	n.a.	n.a.
	Spraying water		depends on application	n.a.	n.a.	n.a.	n.a.
	Stone chip		depends on application	n.a.	n.a.	n.a.	n.a.
	Noxious gas		depends on application	n.a.	n.a.	n.a.	n.a.
	Soiling		depends on application	n.a.	n.a.	n.a.	n.a.

Items		Mission Profile	5th Level	4th Level	3rd Level	2nd Level	1st Level
			Modul/ECU	semi finished "one company system"	sub system "Brettaufbau"	Network (LIN, CAN, MOST, Battery..	car
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production, repair, maintenance (additional, if not covered above)	Transportation simulation tests (vacuum, salt mist atmosphere, etc)		x	No mandatory if higher system level is tested.	No mandatory if higher system level is tested.	No mandatory if higher system level is tested.	Vehicle level test
	Mechanical strength of fastening elements (screws, clipping fixtures, etc)		x	n.a.	n.a.	n.a.	n.a.
	Mechanical strength of connectors/terminals		x	n.a.	n.a.	n.a.	n.a.
	Programming compatibility testing		x	n.a.	n.a.	n.a.	Check performance with any autorized flashing tool (OEM & dealers)
	Diagnostic (OBD-II) compatibility testing		x	n.a.	n.a.	n.a.	Check worst case performance with any autorized diagnostic tester (OEM & dealers)
	Network (LIN, CAN, MOST...) communication testing		x	n.a.	n.a.	Check worst case performance	Check worst case performance with different network stress
	Electrical disturbances during initialization		ISO 7637 testing during initialization	n.a.	n.a.	ISO 7637 testing during initialization	Test effects of activation of high loads during wake-up sequence
	Interruption testing during initialization processes		Power drops testing during initialization	n.a.	n.a.	Test effects of power drops during wake-up sequence	Test effects of power drops during wake-up sequence
	Interruption testing during programming process		Power drops testing during programming	n.a.	n.a.	Test effects of power drops during programming	Test effects of power drops during programming sequence
	Interruption testing during diagnostic process		Power drops testing during diagnostic testing	n.a.	n.a.	Test effects of power drops during diagnostic testing	Test effects of power drops during diagnostic sequence
	Interruption testing during key learning process		Power drops testing during key learning process	n.a.	n.a.	n.a.	Test effects of power drops during key learning process
	Electro-magnetic interferences during programming		Programming test in electrical noisy environment	n.a.	n.a.	n.a.	Programming test with more electrical noisy authorized environment (OEM & Dealers)
	Electro-magnetic interferences during key learning		Key Learning in electrical noisy environment	n.a.	n.a.	n.a.	Key Learning with more electrical noisy authorized environment (OEM & Dealers)
Certification & Homologation	Mechanical homologation Testing (Knee impact, head impact, etc)		No mandatory if higher system level is tested.	n.a.	n.a.	n.a.	Vehicle based assessment Test
	Telecom Type approval testing		x	n.a.	n.a.	n.a.	n.a.
	Radio Type Approval testing		x	If requested by specific market countries	n.a.	n.a.	n.a
	EMC Type Approval testing		No mandatory if higher system level is tested. Mandatory for Aftermarket components	No mandatory if higher system level is tested.	No mandatory if higher system level is tested.	No mandatory if higher system level is tested.	Vehicle EMC Type approval testing in worst case configuration
	Alarm Type Approval Testing		n.a.	test	test	test	Vehicle based assessment Test
	Electrical Health & Safety Testing		x	No usually	No usually	No usually	No usually

test	a test is mandatory
discuss:	test is recommended but conditions have to be agreed between the partners (mainly tier1 and OEM)
n.a.	a test is not possible OR the module test is already sufficient to fulfill the requirement
x	common test requirement at module level
tbd	applicable

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