ZVEI:

Electronic Components
and Systems

Automotive Application Questionnaire for Electronic Control Units and Sensors

Automotive Application Questionnaire
for Electronic Control Units and Sensors

Published by:
German Electrical and Electronic Manufacturers´ Association (ZVEI)
Electronic Components and Systems Division
Stresemannallee 19
60596 Frankfurt am Main
Fon 069 6302-276
Fax 069 6302-407
Mail zvei-be@zvei.org
www.zvei.org/ecs

Editorial:
Christoph Stoppok

Authors:
Walter Unger, DaimlerChrysler AG
Dr. Rolf Becker, Robert Bosch GmbH
Michael Goroll, Infineon Technologies AG

Picture credits:
Robert Bosch GmbH
Hella KG Hueck & Co.
Siemens AG - Bereich Siemens VDO Automotive

Edition: October 2006

1. Preamble

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.

2. Mounting Situation and Service Life in Field

The mounting position in the car has a great influence on the reliability of the product.
Therefore a description (e.g. drawing) of mounting position in the car is necessary.

The reliability is influenced by:

- Service life
- Temperature profile
- Temperature changes
- Vibration
- 'Protection' against intrusion of solid foreign objects, water salt.....
- Chemical stress
- Corrosion profile
- Humidity and water load, e.g. regular drop water
- Protection against UV
- Connector position.....

2.1. Service Life in Field

Service Life in Field	Mileage during Service Life in Field	Operating Time	Non-Operating Time	Engine On/Off Cycles
10 years	400 000 km	8000 h	79600 h	36 000

Table 1: Example for Service Life in Field
Please add correct values in the templates in chapter 2.2....

2.2. Temperature Loads

In principle, temperature stress on the component during its Service Life in Field contributes 'diffusion' failures in the components and the joining and assembly technologies. Despite this fact, mission temperature profiles and service life requirements are necessary to calculate the reliability of electronic control units and devices.

2.2.1. Temperature Mission Profile and Service Life Requirements

	operation in cold climata			
	time	temperature		
	t_{active} in h	$T_{mediate}$	$T_{ambient}$ in °C	%
	80	-30	-40 bis -20	5.0
	400	-10	-20 bis 0	15.0
	1000	20	0 bis 40	30.0
	1300	50	40 bis 60	20.0
	3000	70	60 bis 80	14.0
	1700	90	80 bis 100	10.0
	400	110	100 bis 120	5.0
	120	130	120 bis 140	1.0
	0	150	140 bis 160	0.0
	0	170	160 bis 180	0.0
sum	8000			100.0

yellow: please add correct values

	operation in hot climata			
	time	temperature		
	t_{active} in h	$T_{mediate}$	$T_{ambient}$ in °C	%
	0	-30	-40 bis -20	0.0
	80	-10	-20 bis 0	5.0
	400	20	0 bis 40	15.0
	1000	50	40 bis 60	30.0
	1400	70	60 bis 80	20.0
	3000	90	80 bis 100	14.0
	1700	110	100 bis 120	10.0
	300	130	120 bis 140	5.0
	120	150	140 bis 160	1.0
	0	170	160 bis 180	0.0
sum	8000			100.0

yellow: please add correct values

Table 2: Example for a Temperature Profile and Service Life Requirements

To 'analyse' the temperature profile it is stronlgy recommended to separate between 'arctic' and 'hot' climata. The full temperature range is between $T_{cold\ Min}$ and $T_{hot\ Max}$.

2.3. Temperature Delta Profiles

In principle, every little temperature change by the component during its Service Life in Field contributes to its total thermo-mechanical stress. Despite this fact, only two large thermal cycles per day are usually sufficient to determine cumulative effect of thermo-mechanical stresses. Based on this assumption, the total Number of 'passive' temperature cycles can be calculated as function of the service life in field:

Number of Temperature Cycling (Cold Starts) = 2 x 365 x Service Life in Field

Keep in mind, that in some cases the number of temperature cycles can vary.

2.3.1. Temperature Delta Mission Profile

Temperature Cycling (TC) Profile für Electronic Control-Units (in Cold Countries)

	quantum n per year	ΔT in K	%	number n over lifetime	
	150	30	21	1500	
	300	50	41	3000	
	200	70	27	2000	
	80	90	11	800	Lifetime of ECU in years
	0	110	0	0	10
	0	130	0	0	
sum	730		100	7300	yellow: please add correct values

Temperature Cycling (TC) Profile für Electronic Control-Units (in Hot Countries)

	quantum n per year	ΔT in K	%	number n over lifetime	
	200	30	41	2000	
	370	50	27	3700	
	150	70	21	1500	
	10	90	1	100	Lifetime of ECU in years
	0	110	0	0	10
	0	130	0	0	
sum	730		90	7300	yellow: please add correct values

Table 3: Example for a Temperature Delta Profile and Service Life Requirements

For products thermal coupled to cooler or in similar ambient mounting position it is recommended to separate between cold and hot countries because of different ΔT-distributions.

2.4. Vibration Classification

Verify functional performance of component after exposing the vibration profile based on component location as described in Chapter 4.3.

The 'accelerated' vibration profiles described in this section simulate vibrations due to road conditions while driving and/ or engine cranking. A suggested class description is shown in Chapter 4.3. Keep in mind that holders, connectors ...may change the conditions.

More detail information of Environmental Conditions and Testing: ISO/DIS 16750-3.

2.4.1. Vibration Profile

Vibration Profiles für Electronic Control-Units		
Random Vibration		
Frequency (Hz)	Power spectral density (PSD) [$(m/s^2)^2/Hz$]	
10	10.0	
100	10.0	
300	0,5	
500	20.0	
2000	20.0	Lifetime of ECU in years
		10
Sinusoidal Vibration		
Frequency (Hz)	Amplitude of acceleration [m/s^2]	testing time in h per axis
100	100	20
150	150	
200	200	
240	200	
255	150	
440	150	yellow: please add correct values

Table 4: Example for a vibration Profile and Lifetime Requirements

2.5. Solid and Liquid Intrusion of ECU

Please add Yes / No in table 5.

Protection against intrusion of solid foreign objects	Yes	No
No protection		
With diameter >50 mm		
With diameter >12.5 mm		
With diameter >2.5 mm		
With diameter >1.0 mm		
Dust protection		
Dust proof		
Others		

Protection against intrusion of liquids	Yes	No
No protection		
Vertical water drips		
Water drips (15°C inclination)		
Water spray		
Water splash with pressure		
Winter-salt		
High-velocity water jet		
High-velocity water jet with increased pressure		
Temporary immersion in water		
Continuous submersion in water		
High-pressure steam-jet cleaning		
Other liquids (eg. oil, brake liquid)		
Gases (e.g. exhaust)		
Salty air		
Motor-Cleaner		
Cabin-Cleaner		
Others		

Table 5: Contamination with solid foreign object, with liquid intrusion and gases[2]

[2] based on DIN 40050

3. Responsible Persons

CUSTOMER	
CUSTOMER PROJECT NAME	
CUSTOMER SYSTEM	
MECHATRONIC OR ECU FUNCTION	
VERSION	
SUPPLIER 1	
SUPPLIER 1 PRODUCT NAME	
SUPPLIER PART NUMBER	
ECU FUNCTION	
VERSION	
SUPPLIER 2	
SUPPLIER PRODUCT	
SUPPLIER PART NUMBER	
DEVICE FUNCTION	
VERSION	
Additional Comment	
Customer Contact Information DEVELOPMENT / TECHNICAL CONTACT PARTNER	Name: Address: Function: Telefon #: E-mail:
CUSTOMER RETURN REFERENCE NUMBER	
Date	
Supplier 2 Contact Information DEVELOPMENT / TECHNICAL CONTACT PARTNER	Name: Address: Function: Telefon #: E-mail:
SUPPLIER 1 RETURN REFERENCE NUMBER	
Date	
Supplier 2 Contact Information DEVELOPMENT / TECHNICAL CONTACT PARTNER	Name: Address: Function: Telefon #: E-mail:
SUPPLIER 2 RETURN REFERENCE NUMBER	
Date	
	yellow: please add information

Table 6: Responsible Persons

4. Appendix (Examples for Mission Profiles)

4.1. Examples for Simplified Temperature Loads

Class I

	Distribution Cabin/Trunk Location	Distribution Cabin/Trunk Location
-40°C	6%	6%
23°C	65%	20%
60°C	20%	65%
80°C	8%	8%
85°C	1%	1%

- Insulated areas in cold box in engine compartment
- Insulated areas away from heat sources on Chassis, suspension, under body and wheels
- Instrument panel, console, doors, headliner-not exposed to direct sunlight
- Cabin Floor or any other space in cabin floor
- Luggage compartment/trunk

Table 7: Typical Class I Temperature Mission Profiles and Applications

Class II

	Distribution
-40°C	6%
23°C	65%
60°C	20%
100°C	8%
105°C	1%

- Away from heat sources in engine compartment

Table 8: Typical Class II Temperature Mission Profiles and Applications

Class III

	Distribution
-40°C	6%
23°C	20%
76°C	65%
120°C	8%
125°C	1%

- Near engine, transmission or other heat sources in engine compartment
- Vehicle exterior receiving direct sun light

Table 9: Typical Class III Temperature Mission Profiles and Applications

Class IV

	Distribution
-40°C	6%
23°C	20%
100°C	65%
150°C	8%
155°C	1%

- Engine/transmission mounted units, or adjacent to exhaust manifold
- Near transmission, exhaust manifold, brake/wheel-hubs

Table 10: Typical Class IV Temperature Mission Profiles and Applications

Class V

Other locations empirically specified.

4.2. Examples for Simplified Temperature Delta Mission Profile

	Class I	Class II	Class III	Class IV	Class V
Typical Average Temperature Delta (1)	34°C	40°C	46°C	55°C	Empirically specified

Table 11: Classification of Average Temperature Delta profiles based on Temperature Class

1) Based on Coffin-Manson model with exponent c=2
Definition of Classes see chapter 2

Class V
Other locations empirically specified.

4.3. Examples for Vibration Profiles and Classifications

Class I

Random Vibration Frequency (Hz)	Power spectral density (PSD) [(m/s²)²/Hz]
5	0.884
10	20
55	6.5
180	0.25
300	0.25
360	0.14
1000	0.14
2000	0.14
RMS*	30,8 m/s²

Component mounted on:
- Instrument Panel
- Body sheet metal
- Overhead console
- Doors
- Lift Gate
- Trunk

Table 12: Typical Class I Vibration Profiles and Applications

* Root Mean Square Acceleration
* Test duration per axis: 20 hours for 10 years lifetime or 30h for 15 years lifetime.
(The first 8 hours with thermal profile)

Class II

Random Vibration Frequency (Hz)	Power spectral density (PSD) [(m/s²)²/Hz]
10	10
100	10
300	0.51
500	20
2000	20
RMS*	181 m/s²

Sinusoidal Vibration Frequency (Hz)	Amplitude of acceleration [(m/s²)]
100	100
150	150
200	200
240	200
255	150
440	150

Component mounted on:
- Engine

Table 13: Typical Class II Vibration Profiles and Application

* Root Mean Square Acceleration
* Test duration per axis: 48 hours for 10 years lifetime or 72h for 15 years lifetime.
(Whole time with thermal profile cycling)

Class III

Random Vibration Frequency (Hz)	Power spectral density (PSD) [(m/s²)²/Hz]
10	10
100	10
300	0.51
500	5.0
2000	5.0
RMS*	96.6 m/s²

Sinusoidal Vibration Frequency (Hz)	Amplitude of acceleration [(m/s²)]
100	30
200	60
440	60

Component mounted on:
- Transmission

Table 14: Typical Class III Vibration Profiles and Application

* Root Mean Square Acceleration

* Test duration per axis: 48 hours for 10 years Lifetime or 72h for 15years Lifetime. (Whole time with thermal profile cycling)

Class IV

Random Vibration Frequency (Hz)	Power spectral density (PSD) [(m/s²)²/Hz]
20	200
4	200
300	0.5
800 1000 2000 RMS*	0.5 3.0 3.0 107 m/s²

Component mounted on:
- Suspension
- Wheel

Table 15: Typical Class I Vibration Profiles and Applications

* Root Mean Square Acceleration

* Test duration per axis: 20 hours for 10 years lifetime or 30h for 15 years lifetime. (The first 8 hours with thermal profile)

Electronic Components
and Systems

German Electrical and Electronic
Manufacturers´ Association (ZVEI)
Electronic Components and Systems Division
Stresemannallee 19
60596 Frankfurt am Main
Fon 069 6302-276
Fax 069 6302-407
Mail zvei-be@zvei.org
www.zvei.org/ecs