Tutorial for Lifetime Requirements and Physical Testing of Automotive Electronic Control Units (ECUs)

Presentation supported (alphabetical order) by:
Stefan Buntz (Daimler)
Thomas Hogenmüller (Robert Bosch)
Stephane Korzin (Renault)
Kirsten Matheus (BMW Group)
Michael Mehnert (Robert Bosch)
Nicolas Morand (PSA Peugeot Citroën)
Thilo Streichert (Daimler)
Mehmet Tazebay (Broadcom)
Jens Wuelfing (TE Automotive)
Helge Zinner (Continental)

Purpose of this Presentation

- This presentation will explain typical requirements for automotive ECUs mainly used in engine compartment
- Physical requirements are very divers and dependent on:
  - OEM test requirements
  - Electric/ Electronic Architectures
  - Use Cases
  - Specific location
  - Other specifications such as (ISO26262, DIN EN 60529, ...)

- This presentation is not a complete summary of all requirements

Performance Characteristics

Features	PC, LD_CV (Passenger-Car, Light-Duty Commercial vehicle)
Service life	15 years
Hours of operation (active operation during service life)	8,000 h
Mileage	300,000 km
Days of operation per year	365 days
Cold starts All start-up procedures (averaged over service life)	2/day =10950 6/day*

* Not considered Start/Stop Systems

Active Operation: Typical Temperature-Load Distribution (ambient)

$T_{i,ECU}$ = ECU inner air temperature	Typ. load (Passenger Car)	
	Vehicle body, bulkhead, extension close to the engine	
-40°C..10° C	6.0 %	480 h
10°C...45° C	20.0 %	1600 h
45°C...60° C	33.0 %	2640 h
60°C...70° C	18.0 %	1440 h
70°C...80° C	9.0 %	720 h
...85° C	3.0 %	240 h
...90° C	2.0 %	160 h
...95° C	1.7 %	136 h
...100° C	1.5 %	120 h
...105° C	1.4 %	112 h
...110° C	1.3 %	104 h
...115° C	1.2 %	96 h
...120° C	1.0 %	80 h
...125° C	0.9 %	72 h
Total	**100%**	**8000 h**

ECU Tests

- High Temperature Endurance Test
  - 125° C ECU inner air temperature (= max. ambient temperature of components)
  - 2,000 h operation
  - operating state: active
  - ECUs will be tested autarkic with corresponding loads
  - Pass criteria: functional test within specified tolerances

- Damp Heat, constant
  - 85° C inner air temperature, 85 % rel. humidity
  - 1000h
  - operating state: 1h on, 1h off alternating
  - Pass criteria: functional test within specified tolerances
  - Following specification is used by some OEMs: IEC60068-2-30

ECU Tests

- Temperature Cycles – Shock Test
  - -40° C to +125° C
  - 1650 cycles
  - 30 min. dwell time
  - 10 s transfer time
  - operating state: passive
  - Pass criteria: final functional test within specified tolerances

ECU Tests

- Vibrations, often combined with temperature changes (min to max)

Installation position	Stimulus	ISO16750-3: 2007	Acceleration	Bandwidth	t_{Test}
Passenger compartment / car body / chassis	Noise	Test IV	$a_{noise,\ eff}$ =27,8 m/s²	10Hz...1000Hz	12h

- Mechanical Shock

Parameter	Value
Reference	DIN EN 60068-2-29:1995
Use case	Passenger car
Pulse shape	Half sinusoidal
Acceleration	500m/s² ~ 51 G
Duration	11ms
Number of shocks	10 per direction, 3 directions (a separate test sample has to be used per direction)
Operating state	active

ECU Tests

- Drop test

Parameter	Value
Reference	ISO16750-3:2007, DIN EN 60068-2-32:1995
Drop height	1m, free fall
Surface	Concrete
Number	2 falls per direction, maximum 2 falls per sample
Operating state	Passive (without plug)

Examples Automotive Components

Electronic Control Units:

- Chassis & Safety Control Unit
- Body Computer w/ integrated gateway
- Diesel Control Unit

Cable Harness:

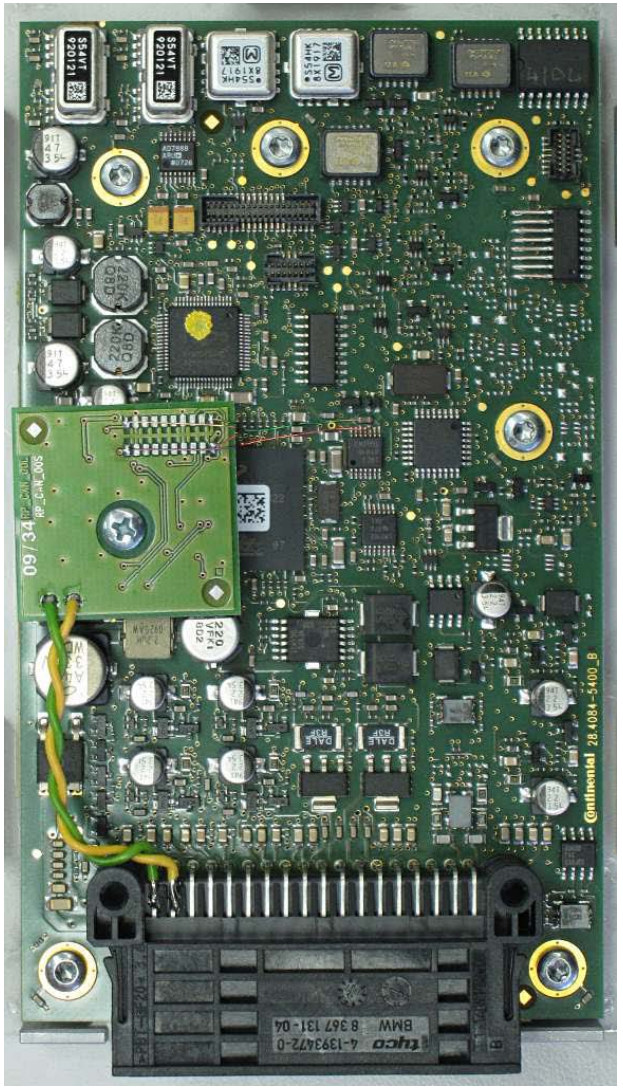
- Harness for headlights
- Harness for Cockpit
- Harness for Body

Many Thanks for providing us these samples to:
Helge Zinner (Continental)
Stefan Buntz (Daimler)
Michael Mehnert (Bosch)

Chassis & Safety Control Unit (B-Sample)

Hardware

- Dual Core CPU
- Communication Interfaces
  - 3x CAN
  - 1x FlexRay
- 3 x Gyros (X,Y,Z-Axis)
- 2 x Accelerometer
- Automotive Temperature Range -40°C – +85°C



Features

- Focus on body control (ESP)
- Architecture based on fail safe CPU
- AUTOSAR stack implemented

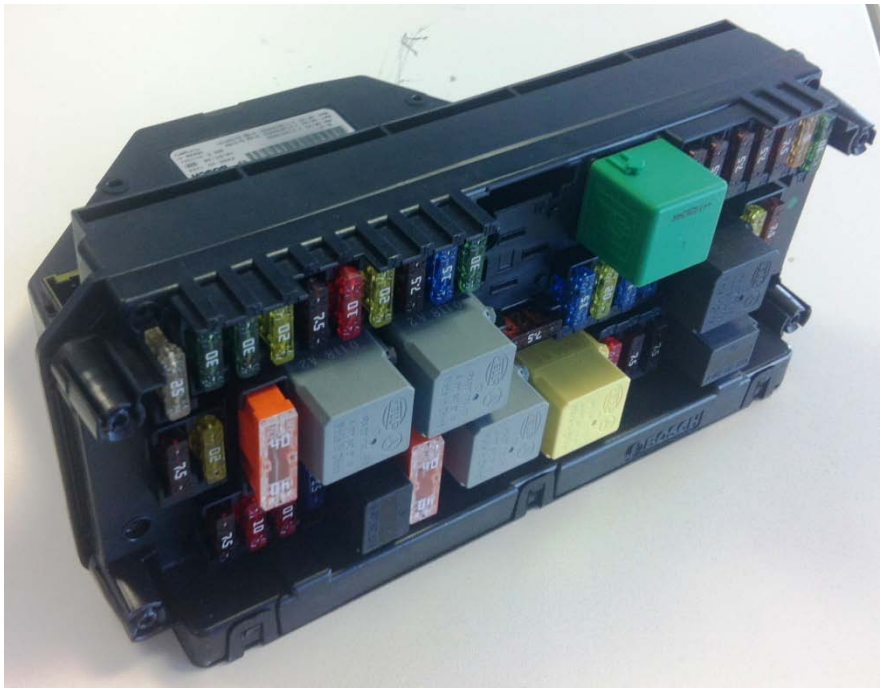
Engine Control Unit

- Solenoid valve injector and piezo injector control for Diesel Systems
  - Conform to actual exhaust gas legislativ regulations
  - Scalable SW product: from basic to high-end segment
  - Optional features availabe such as
    - Start-Stop,
    - Diesel Particle Filter (DPF),
    - Selective Catalytic Reduction (NOx reduction) (SCR)

Body Computer w/ Integrated Central Gateway

Features:

- 2 CPUs
- Additional fail safe CPU
- 4 CANs
- 2 LINs
- Several I/Os up to 40 A
- Integrated fuses and relays



Requirements:

- Service Life: 15 years
- Sleep mode current consumption: 350µA (2 ECU in one, Daimler default per ECU 100µA)
- Normal mode (no function active) current consumption: 250mA
- Wake up time: 120ms

Mercedes-Benz S-Class (2006) complete cable harness

- about 38kg, following slides show details of this harness (parts of some dedicated harnesses)

engine harness (e.g. headlights)

cockpit harness

body harness (part)