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Technical Regulation
Requirements and verification methods for electrical factors in a 24V system

TABLE OF CONTENTS

1 SCOPE

This is a general technical regulation that describes requirements and verification methods for electrical factors in a 24V system.

2 NORMATIVE REFERENCES

ISO 11451-2:2005 and ISO 11451-3:1994
ISO 11452-2:2004
CISPR25:2002
ISO 7637-2:2004
ISO 16750-2:2006
ISO 10605:2001
IEC 61000-4-2:2001
SAE J1455:2006

3 TERMS AND DEFINITION

ECU	**E**lectronic **C**ontrol **U**nits
DUT	**D**evice **U**nder **T**est
VOR	**V**ehicle **O**ff **R**oad
NB	**N**arrow **B**and
BB	**B**road **B**and
$\mathbf{T_{max.op}}$	Maximum operating temperature
$\mathbf{U_{op}}$	Operating voltage
t	Time
f	Frequency
$\mathbf{t_{drop}}$	Drop out time
$\mathbf{I_{nom}}$	Nominal current
$\mathbf{t_{rise}}$	Rise time (10-90%)
$\mathbf{t_{fall}}$	Fall time (90-10%)
LISN	Line impedance stabilizations network
Supply voltage lines	Battery and wake-up supply lines and other inputs connected to the supply voltage (battery/alternator circuit)
Battery supply voltage line	Connected to 24V battery circuit
Wake-up signal line	Connected to 24V battery circuit via ignition key or simular devices

4 TEST CONDITIONS AND TOLERANCES

4.1 Climatic Test Conditions

Unless specified otherwise, the following climatic test condition is valid:

Temperature: 23 ± 5°C
Humidity: 20 to 80% relative humidity

4.2 Permissible Test Tolerances

Unless specified otherwise, the following tolerance is valid:

Voltage, current, time interval:	±5%
Length, energy, power:	±5%
Resistance, capacitance, inductance, impedance:	±10%
Temperature:	±2°C

5 EVALUATION

Before, during and after a test or a series of tests different kinds of evaluation are required.

Test procedure:
In order to verify the functional status described below, two test procedures shall be developed and documented:
Test procedure I: A comprehensive test where all functional requirements are verified. This test shall be performed before and after exposure.
Test procedure II: A reduced function test where the fundamental requirements are verified. This test shall be possible to perform during exposure. Reduced versions of test procedure II may be defined and used during various tests.

Functional status based on ISO7637-2:2004 (Annex A):
All classifications given below are for the total device/system functional status:

Class A: All functions of a device/system perform according to specification during and after exposure to disturbance.

Class B: All functions of a device/system perform according to specification during exposure. However, one or more of them can go beyond the specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions shall remain Class A.

Class C: One or more functions of a device/system do not perform according to specification during exposure but return automatically to normal operation after exposure is removed.

Class D: One or more functions of a device/system do not perform according to specification during exposure and do not return to normal operation until exposure is removed and the device/system is reset by simple ‘operator/use’ action.

Class E: One or more functions of a device/system do not perform according to specification during and after exposure and cannot be returned to proper operation without repairing or replacing the device/system.

Note: The word ‘function’ as used here only concerns the function performed by the electronic system

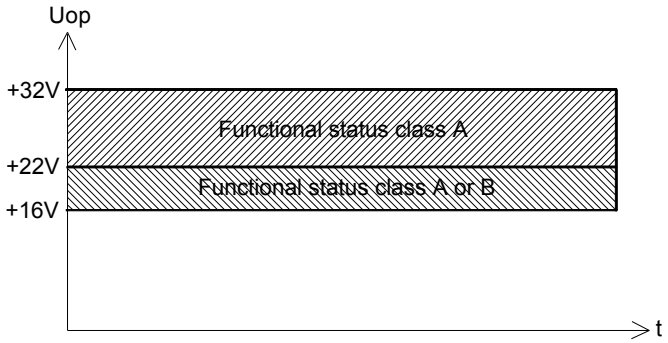
If class B or C is used the acceptable deviations shall be specified in an additional specification.

If more than one class is described in a test the class that is relevant for the specific DUT shall be specified in an additional specification.

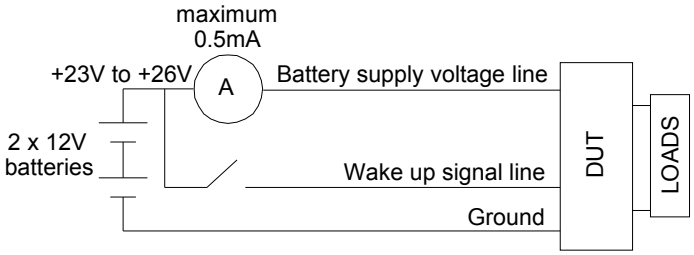
6 REQUIREMENTS AND VERIFICATIONS METHODS

6.1 Electrical Loads

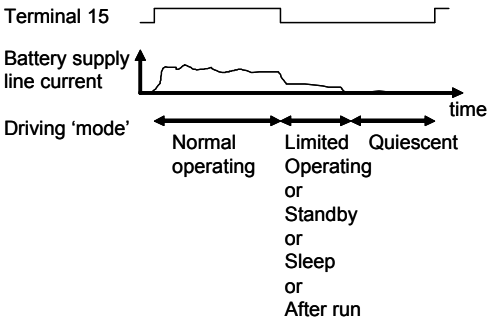
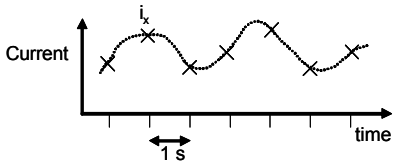
6.1.1 Operating Voltage

Background	Requirement	Test and acceptance criteria
The voltage range +16V to +32V is according to standard ISO 16750-2:2006, Code F for 24V Power Supply systems.	+16V to +32V (typical voltage +28V) at -40ºC to + $T_{max.op.}$ºC  Figure 1: Normal operating voltage range	+16V ≤ Operating voltage < +22V Functional status class A or B. +22V ≤ Operating voltage ≤ +32V Functional status class A. 1) Perform test procedure I at +28V. Functional status class A. 2) Perform test procedure II at +16V. Functional status class A or B. 3) Perform test procedure II at +22V. Functional status class A. 4) Perform test procedure II at +32V. Functional status class A. 5) Perform test procedure I at +28V. Functional status class A.

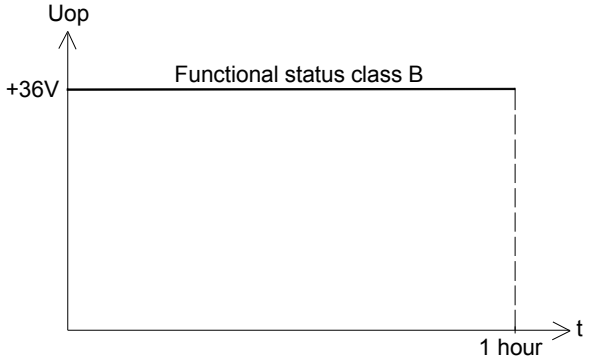
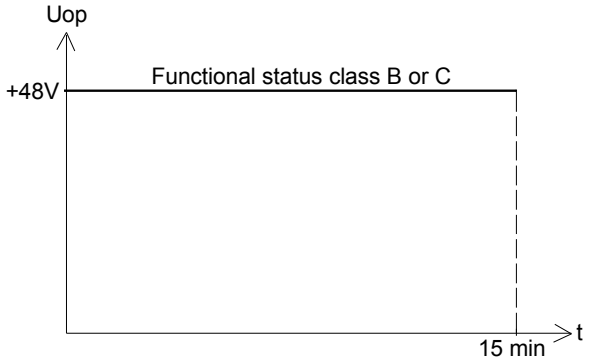
6.1.2 Engine off electric power limitation - Quiescent current

Background	Requirement	Test and acceptance criteria
The reason for keeping the quiescent current low is to ensure that the vehicle starts after a long duration stop (prevent discharged batteries).	Quiescent current ≤ 0.5mA at -40ºC to + $T_{max.op.}$ºC at U_{op}=+23 to +26V.  Figure 2: Quiescent current measurement	1) Connect the DUT as in the real vehicle for normal operation with normal loads. 2) Apply a voltage between +23V and +26V to the battery supply voltage lines of the DUT. 3) Make sure that the wake up signal line of the DUT is disconnected and the DUT is in quiescent mode. 4) Measure the quiescent current in the battery supply voltage lines of the DUT and check that the requirement is fulfilled. 5) Note the actual quiescent current and the actual U_{op} in the test report.

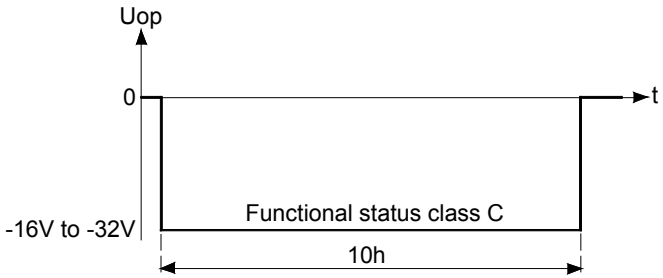
6.1.3 Engine off electric energy limitation – Max amp hours (Ah)

Background	Requirement	Test and acceptance criteria
The reason for limiting the electrical energy (i.e. time integrated current) is to ensure that the vehicle starts after a long duration stop (to prevent discharged batteries).  Figure 3: Mode definitions	The electrical energy consumption must be limited and set with Scania to a certain number of Ah at -40ºC to + $T_{max.op.}$ºC at engine off[1)]. This requirement is not valid for safety critical functions. Note 1) Engine off is defined by the time between two engine on periods excluding the time the DUT is put in 'quiescent mode'. In practice, this can be detected by one of the following methods. • Terminal 15 low • Terminal 61 low • rpm = 0 • U_{op} < 26V during a minimum of 2 minutes	1) Connect the DUT as in the real vehicle for normal operation with normal loads. 2) Apply a voltage between +23V and +26V to the battery supply voltage lines of the DUT. 3) Put the DUT in the specified mode of operation e.g. limited operating, stand by, sleep or after run mode. 4) Current measurement, one sample per second, the Ah is the sum of all current samples. 5) Stop the current sampling when the DUT has switched to quiescent mode. 6) Check that the requirement is fulfilled. 7) Note the Ah and Uop in the test report.  $$Ah = \int idt = \frac{\sum_x i_x}{3600}$$ Figure 4: Current measurement method

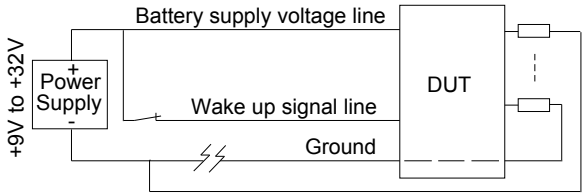
6.1.4 Over voltage

Background	Requirement	Test and acceptance criteria
The over voltage is caused by a charge regulator failure in the alternator.	+36V, 1 hour at -40ºC to + $T_{max.op.}$ºC  Figure 5: Over voltage, charge regulator failure	1) Connect and fuse the DUT as in the real vehicle for normal operation but without alternator and batteries. 2) Apply +36V to the supply voltage lines of the DUT. 3) Perform test procedure II at +36V during 1 hour in operation. Functional status class B. 4) Perform test procedure I at +28V. Functional status class A.
The over voltage is usually caused by the use of jump start equipment on a vehicle with an interruption in the battery circuit. The +48V voltage level is based on standard SAE J1455:2006.	+48V, 15 minutes at -40ºC to +30ºC  Figure 6: Over voltage, jump start	1) Connect and fuse the DUT as in the real vehicle for normal operation but without alternator and batteries. 2) Apply +48V to the supply voltage lines of the DUT. 3) Perform test procedure II at +48V during 15 minutes in operation. Functional status class B or C. 4) Perform test procedure I at +28V. Functional status class A.

6.1.5 Reversed operating voltage

Background	Requirement	Test and acceptance criteria
This test simulates installation of incorrect types of batteries (reversed batteries) or a faulty cable harness in the supply voltage lines. Loss of gnd of two devices sharing the same gnd can cause a reversed operating voltage during driving. The test is based on standard ISO 16750-2:2006.	The DUT shall withstand instant reversed operating voltage at the supply voltage lines. -16V to -32V, 10 hours at -40ºC to $T_{max.op.}$ºC  Figure 7: Reversed operating voltage	Functional status class C is valid after replacement of broken fuses. 1) Connect and fuse the DUT as in the real vehicle for normal operation, but without alternator and batteries. 2) Use a power supply capable of providing at least 5 X I_{nom} of the fuse (if applicable). 3) Apply an instant reversed operating voltage of -32V at the supply voltage lines during 10 hours. 4) Perform test procedure II during the test. Functional status class C. 5) Remove the reversed operating voltage and replace broken fuses if applicable. 6) Perform test procedure I at +28V. Functional status class A.

6.1.6 Loss of gnd

Background	Requirement	Test and acceptance criteria
This test simulates a loss of gnd to the DUT. Loss of gnd can occur during EOL programming and repair or because of faulty cable harness.	The DUT shall withstand a loss of gnd at -40ºC to + $T_{max.op.}$ºC and operating voltage range +9V to +32V. All outputs of the DUT shall be inactive during the loss of gnd.  Figure 8: Loss of gnd	1) Connect and fuse the DUT as in the real vehicle for normal operation with normal loads. 2) Remove the gnd connection(s) to the DUT. 3) Apply +9V / +32V to the battery supply voltage lines of the DUT. 4) Apply +9V / +32V to the wake up signal line of the DUT. 5) Check that all outputs of the DUT are inactive. 6) Repeat steps 2 to 5 five times at operating voltage +9V and +32V. 7) Repeat steps 2 to 5 five times in following sequence 2, 4, 3, 5 at operating voltage level +9V and +32V. 8) Repeat steps 2 to 5 five times in following sequence 3, 4, 2, 5 at operating voltage level +9V and +32V. 9) Repeat steps 2 to 5 five times in following sequence 4, 3, 2, 5 at operating voltage level +9V and +32V. 10) Perform test procedure I at +28V. Functional status class A.

6.1.7 Line interruption

Background	Requirement	Test and acceptance criteria
This test simulates an open contact condition. Open circuits can occur during service / maintenance or repair but also during operation due to a damaged component or a faulty cable harness. The test is according to standard ISO 16750-2:2006.	The DUT shall withstand a single line interruption on all connector pins at -40ºC to + $T_{max.op.}$ºC at U_{op}=+16V to +32V, functional status class C. Interruption time: 10 seconds Open circuit resistance: ≥ 10 Mohm	1) Connect and fuse the DUT as in the real vehicle for normal operation with normal loads. Use U_{op}=+28V. 2) Break the connection to one pin of the DUT for 10 seconds and then restore the connection. Perform test procedure II, functional status class C. 3) Repeat step 2 for each connector pin of the DUT. 4) Perform test procedure I at +28V. Functional status class A.
This test simulates disconnection of the DUT connector(s) during normal operation. Multiple line interruption can occur during service / maintenance or repair. The test is according to standard ISO 16750-2:2006.	The DUT shall withstand a multiple line interruption, disconnection of DUT connector or connectors, at -40ºC to + $T_{max.op.}$ºC at U_{op}=+16V to +32V, functional status class C. Interruption time: 10 seconds Open circuit resistance: ≥ 10 Mohm	1) Connect and fuse the DUT as in the real vehicle for normal operation with normal loads. Use U_{op}=+28V. 2) Disconnect one connector of the DUT for 10 seconds and then restore the connection. Perform test procedure II, functional status class C. 3) Repeat step 2 for each connector of the DUT. 4) Perform test procedure I at +28V. Functional status class A.

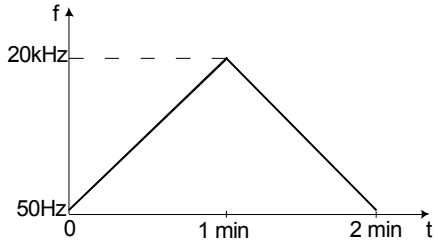
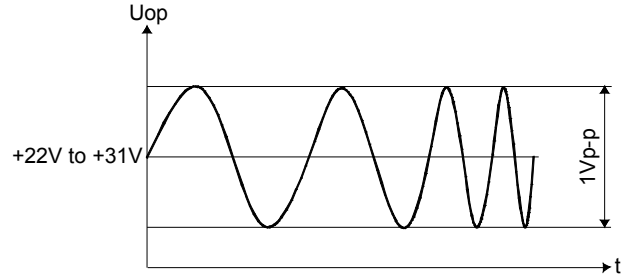
6.1.8 Short circuit protection

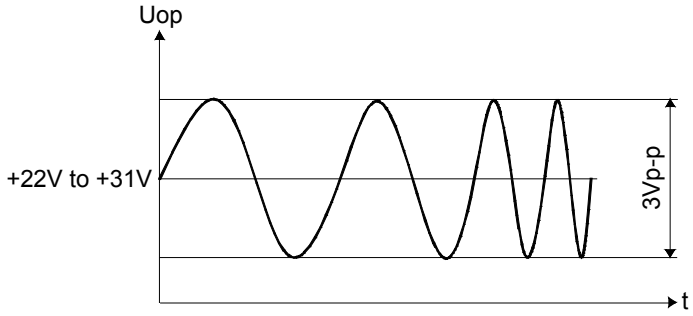
Background	Requirement	Test and acceptance criteria
This test simulates a short circuit on a connection pin of the DUT. Short circuits can occur during service / maintenance or repair but also during operation due to a faulty cable harness.	All connection pins of the DUT one at a time shall withstand continuous direct short circuit (≤ 10mohm) to ground / U_{op} at -40ºC to + $T_{max.op.}$ºC at U_{op}=+16V to +32V. Alternatively, when specified, some connection pins (e.g. ground returns) shall withstand a direct short circuit and a partial (soft) short circuit to ground / U_{op}=+32V via a system fuse installed as in real vehicle. If applicable the partial short circuit current shall be 1.35 X I_{nom} of the fuse for at least 30 minutes. Primary short circuit protection is not allowed to be implemented in software. Functional status class C.	1) Connect and fuse the DUT as in the real vehicle for normal operation with normal loads. Use U_{op}=+32V. 2) Use a power supply capable of providing at least 5 X I_{nom} of the fuse. 3) Perform the direct short circuit tests below at $T_{max.op.}$ºC. 4) Firstly short each pin of the DUT one at a time to ground / +32V respectively. Then switch on the power for at least 1 minute. 5) Remove the short circuit and perform test procedure II, functional status class C. 6) Secondly switch on the power and then short each pin of the DUT one at a time to ground / +32V respectively for at least 1 minute. 7) Remove the short circuit and perform test procedure II, functional status class C. 8) Perform test procedure I at +28V. Functional status class A.

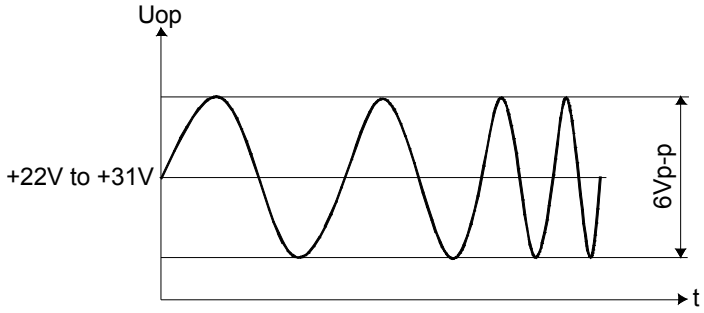
6.1.9 Insulation resistance

Background	Requirement	Test and acceptance criteria
This test is for checking the insulation of the housing of the DUT. Short circuit between the housing and the supply voltage is mainly caused by cable chafing or a damaged cable strain relief. But it can also occur during service / maintenance or repair.	The ground pin(s) shall not be DC coupled to the housing of the DUT. The insulation resistance shall be > 10 Mohm. The housing of the DUT shall withstand continuous direct short circuit (≤ 10mohm) to ground / U_{op} respectively at -40ºC to + $T_{max.op.}$ºC at U_{op}=+16V to +32V. Functional status class A.	1) Connect and fuse the DUT as in the real vehicle for normal operation with normal loads. 2) Use a power supply capable of providing at least 5 X I_{nom} of the fuse. 3) Check that the insulation resistance between the housing and the ground pin of the DUT is >10 Mohm (stabilized). 4) Short the housing of the DUT to ground for at least 1 minute at $T_{max.op.}$ºC. 5) Perform test procedure II. Remove the short circuit. Functional status class A. 6) Short the housing of the DUT to +32V for at least 1 minute at $T_{max.op.}$ºC. 7) Perform test procedure II. Remove the short circuit. Functional status class A. 8) Check that the insulation resistance between the housing and the ground pin of the DUT is > 10 Mohm (stabilized). 9) Perform test procedure I at +28V. Functional status class A.

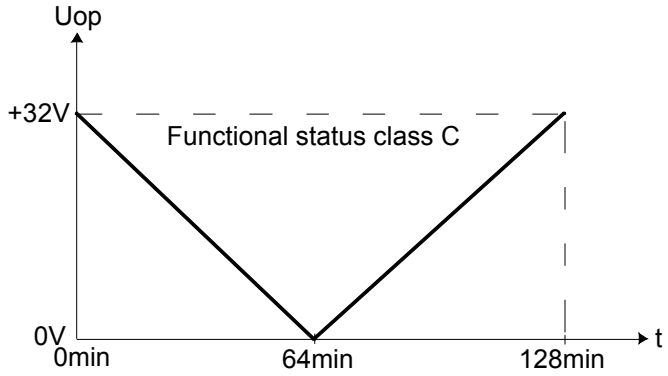
6.1.10 Superimposed voltage ripple

Background	Requirement	Test and acceptance criteria
The voltage ripple is mainly caused by interferences from the alternator. The test is based on standard ISO 16750-2:2006.	+22V to +31V, with sinusoidal ripple 1Vp-p at -40ºC to + $T_{max.op.}$ºC. Power supply source impedance: 50 to 100mohm Frequency range: 50Hz-20kHz Type of frequency sweep: Triangular, logarithmic Test sweep duration: 2 minutes Electrical load: Maximum Functional status class: A  Figure 9: Frequency sweep  Figure 10: Superimposed sinusoidal ripple 1Vp-p	1) Apply +22V to the supply voltage lines of the DUT. 2) Start frequency sweep 3) Perform test procedure II during the test. Functional status class A. 4) Repeat steps 1 to 3 five times. 5) Apply +31V to the supply voltage lines of the DUT. 6) Start frequency sweep. 7) Perform test procedure II during the test. Functional status class A 8) Repeat steps 5 to 7 five times.

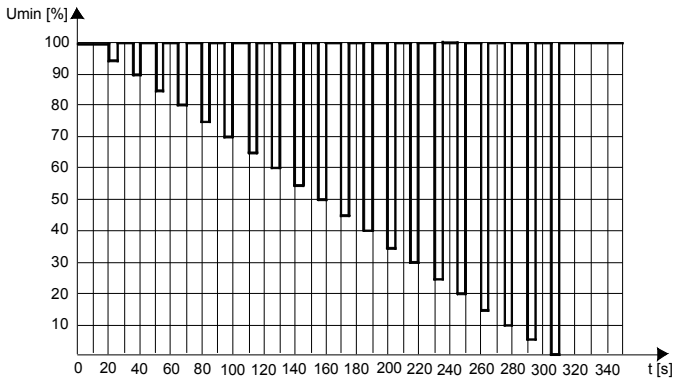
Background	Requirement	Test and acceptance criteria
The voltage ripple is mainly caused by interferences from the alternator. This test simulates high alternator rpm and high alternator current. The test is based on standard ISO 16750-2:2006.	+22V to +31V, with sinusoidal ripple 3Vp-p at -40ºC to + $T_{max.op.}$ºC. Power supply source impedance: 50 to 100mohm Frequency range: 50Hz-20kHz Type of frequency sweep: Triangular, logarithmic Test sweep duration: 2 minutes Duration of required DUT life length: 2.5% Electrical load: Maximum Functional status class: A  Figure 11: Superimposed sinusoidal ripple 3Vp-p	1) Apply +22V to the supply voltage lines of the DUT. 2) Start frequency sweep 3) Perform test procedure II during the test. Functional status class A. 4) Repeat steps 1 to 3 five times. 5) Apply +31V to the supply voltage lines of the DUT. 6) Start frequency sweep. 7) Perform test procedure II during the test. Functional status class A. 8) Repeat steps 5 to 7 five times.

Background	Requirement	Test and acceptance criteria
The voltage ripple is mainly caused by interferences from the alternator. This test simulates interrupted battery connection. The test is based on standard ISO 16750-2:2006.	+22V to +31V, with sinusoidal ripple 6Vp-p at -40ºC to + $T_{max.op.}$ ºC. Power supply source impedance: 50 to 100mohm Frequency range: 50Hz-20kHz Type of frequency sweep: Triangular, logarithmic Test sweep duration: 2 minutes Duration of required DUT life length: 0.1% Electrical load: Normal Functional status class: A  Figure 12: Superimposed sinusoidal ripple 6Vp-p	1) Apply +22V to the supply voltage lines of the DUT. 2) Start frequency sweep 3) Perform test procedure II during the test. Functional status class A. 4) Repeat steps 1 to 3 five times. 5) Apply +31V to the supply voltage lines of the DUT. 6) Start frequency sweep. 7) Perform test procedure II during the test. Functional status class A 8) Repeat steps 5 to 7 five times. 9) Perform test procedure I at +28V. Functional status class A.

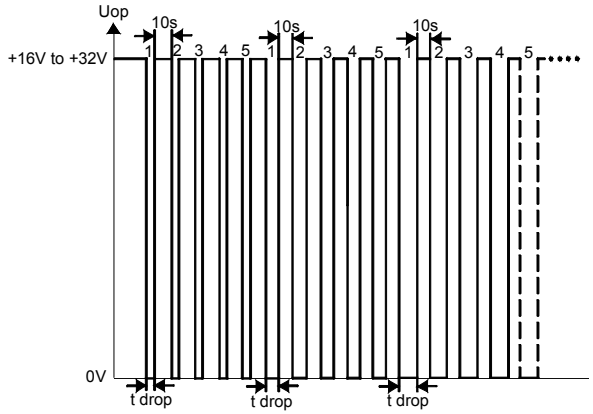
6.1.11 Slow decrease and increase of operating voltage

Background	Requirement	Test and acceptance criteria
This test simulates a gradual discharge and recharge of the battery. The test is according to standard ISO 16750-2:2006.	A slow decrease of the operating voltage from +32V to 0V and then a slow increase from 0V to +32V at -40ºC to + $T_{max.op.}$ºC. Change rate: 0.5±0.1 V/min  Figure 13: Slow decrease and increase of operating voltage	1) Connect and fuse the DUT as in the real vehicle for normal operation with normal loads. 2) Decrease the operating voltage from +32V to 0V according to the required change rate at the supply voltage lines of the DUT. 3) Increase the operating voltage from 0V to +32V according to the required change rate at the supply voltage lines of the DUT. 4) Perform test procedure II during the test. Functional status class C. 5) Perform test procedure I at +28V. Functional status class A.

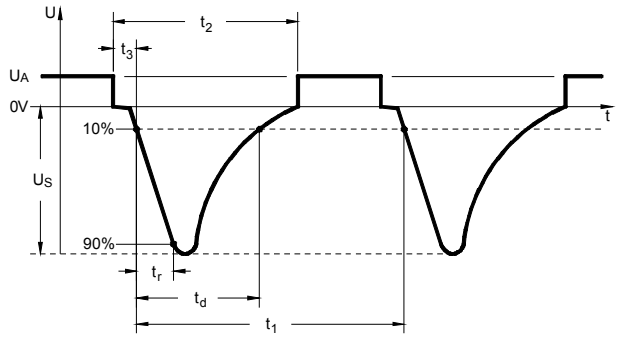
6.1.12 Supply voltage drops

Background	Requirement	Test and acceptance criteria
This test simulates temporary voltage drops on the supply voltage lines. Voltage drops may occur due to high loads in combination with discharged batteries. The test is according to standard ISO 16750-2:2006.	The DUT shall withstand and perform a correct and well defined reset (if applicable) at distinct voltage drops of the operating voltage from Umin to 0.95 * Umin and up to Umin again in steps of 5% of Umin down to 0V at -40ºC to + $T_{max.op.}$ºC. Functional status class C. Drop duration at each voltage level: 5s Time between repetition: ≥ 10 s Fall time: ≤ 10ms Rise time: ≤ 10ms  Figure 14: Profile for supply voltage drops	1) Connect a power supply to the supply voltage lines of the DUT (incl. normal load). 2) Perform a distinct decrease of the operating voltage by 5% from Umin to 0.95 * Umin. 3) Hold the voltage for 5 seconds. Then raise the voltage to Umin. 4) Hold Umin for at least 10 seconds and perform test procedure II. Functional status class C. 5) Continue the voltage drop of the operating voltage in voltage steps of 5 % of Umin and repeat test steps 3 and 4, next low level 0.90 * Umin, until the lower value has reached 0V. 6) Perform test procedure I at +28V. Functional status class A.

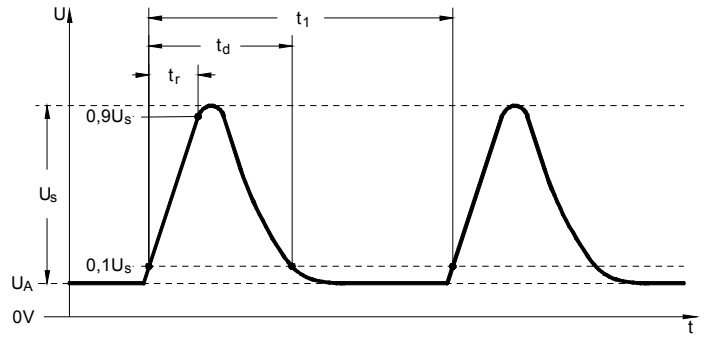
6.1.13 Supply voltage interruption

Background	Requirement	Test and acceptance criteria
This test simulates temporary short voltage interruptions on the supply voltage lines. Temporary voltage interruptions may be caused by blown fuses, faulty contacts, installation and maintenance work.	The DUT shall withstand and perform a correct and well defined reset (if applicable) at short voltage drops to zero volt on the supply voltage lines at -40ºC to + $T_{max.op.}$ºC. No locking of the DUT function is accepted after exposure is removed, functional status class C. Drop out duration / increment: 30µs to 100µs / 10µs (t_{drop}) 100µs to 1ms / 100µs 1ms to 10ms / 1ms 10ms to 200ms / 10ms Operating voltage range: +16V to +32V Pulse repetition: 5 Time between repetition: ≥ 10 s t_{fall} (if applicable): ≤ 3µs t_{rise} (if applicable): ≤ 3µs  Figure 15: Profile for supply voltage interruptions	1) Apply +28V to the supply voltage lines of the DUT (incl. normal load). 2) Apply a parallel resistive load to achieve required fall and rise time. (may not be achievable for highly reactive loads) 3) Drop U_{op} to 0V and wait t_{drop} = 30µs. 4) Increase U_{op} to +28V and hold for at least 10 seconds. Perform test procedure II. Functional status class C. 5) Repeat test steps 2 and 3 five times. 6) Increase drop out time t_{drop} with increment 10µs and repeat test steps 2, 3 and 4 until t_{drop} = 100µs is tested. 7) Continue the voltage drop out test in the same way for all drop out duration ranges with increments according to the requirement. 8) Perform test procedure I at +28V. Functional status class A.

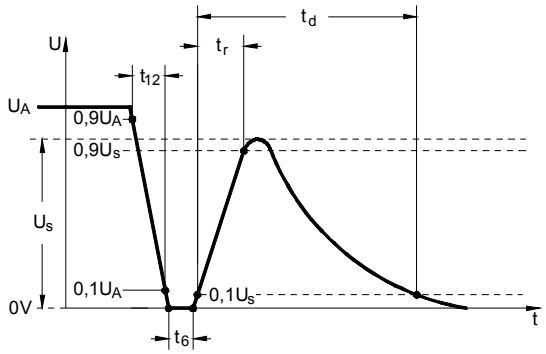
6.1.14 Transient protection, test pulse 1

Background	Requirement	Test and acceptance criteria
This test pulse simulates negative transients caused by turning off inductive loads connected in parallel with the DUT. The supply voltage lines are exposed. Other inputs and outputs can also be exposed to these transients. The test is based on standard ISO 7637-2:2004.	The DUT shall resist transient, test pulse 1 at -40ºC to + $T_{max.op.}$ºC. Functional status class C. No unintended error code may be created as a result of the test pulse. U_A = + 28V U_S = - 450V R_i = 50ohm t_d = 1ms t_r = 3µs t_1 = 0.5-5s (t_1 is chosen so that the DUT is correctly initialized before the next pulse) t_2 = 200ms t_3 < 100µs Duration: 5000 pulses  Figure 16: Test pulse 1	1) Apply test pulse 1 to the supply voltage lines of the DUT (incl. normal load). 2) Perform test procedure II during the test. Functional status class C. 3) Apply test pulse 1 to the battery supply voltage lines of the DUT (incl. normal loads). 4) Perform test procedure II during the test. Functional status class C. 5) Apply test pulse 1 only to the wake up signal line of the DUT. 6) Perform test procedure II during the test. Functional status class C. 7) Perform test procedure I at +28V. Functional status class A.

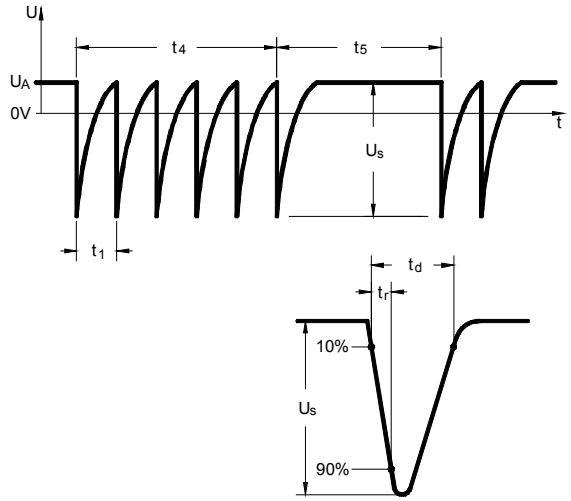
6.1.15 Transient protection, test pulse 2a

Background	Requirement	Test and acceptance criteria
This test pulse simulates positive transients caused by sudden interruption of current in a load connected in parallel with the DUT due to the inductance of the wiring harness. The supply voltage lines are exposed. Other inputs and outputs can also be exposed to these transients. The test is based on standard ISO 7637-2:2004.	The DUT shall resist transient, test pulse 2a at -40ºC to + $T_{max.op.}$ºC. Functional status class B. No unintended error code may be created as a result of the test pulse. U_A = + 28V U_S = + 37V R_i = 2ohm t_d = 0.05ms t_r = 1µs t_1 = 0.2-5s Duration: 5000 pulses  Figure 17: Test pulse 2a	1) Apply test pulse 2a to the supply voltage lines of the DUT (incl. normal load). 2) Perform test procedure II during the test. Functional status class B. 3) Apply test pulse 2a to the battery supply voltage lines of the DUT (incl. normal loads). 4) Perform test procedure II during the test. Functional status class B. 5) Apply test pulse 2a only to the wake up signal line of the DUT. 6) Perform test procedure II during the test. Functional status class B. 7) Perform test procedure I at +28V. Functional status class A.

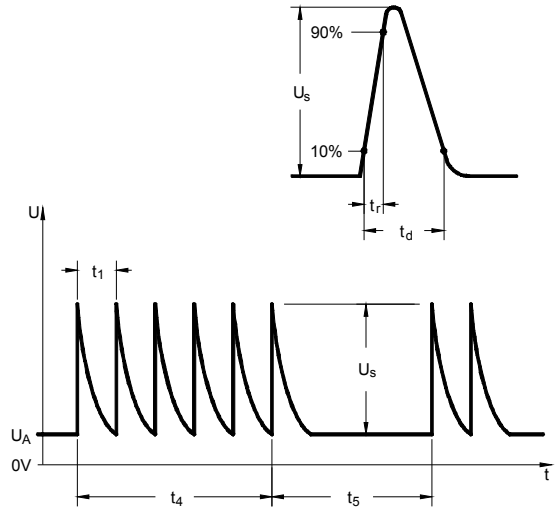
6.1.16 Transient protection, test pulse 2b

Background	Requirement	Test and acceptance criteria
This test pulse simulates positive transients caused by dc motors acting as generators after the wake up signal line is switched off. The supply voltage lines are exposed. Other inputs and outputs can also be exposed to these transients. The test is based on standard ISO 7637-2:2004.	The DUT shall resist transient, test pulse 2b at -40ºC to + $T_{max.op.}$ºC. Functional status class C. No unintended error code may be created as a result of the test pulse. U_A = + 28V U_S = + 20V R_i = 0-0.05ohm t_d = 0.2-2s t_r = 1ms t_6 = 1ms t_{12} = 1ms Duration: 10 pulses Pulse repetition time: 0.5-5s  Figure 18: Test pulse 2b	1) Apply test pulse 2b to the supply voltage lines of the DUT (incl. normal load). 2) Perform test procedure II during the test. Functional status class C. 3) Apply test pulse 2b to the battery supply voltage lines of the DUT (incl. normal loads). 4) Perform test procedure II during the test. Functional status class C. 5) Apply test pulse 2b only to the wake up signal line of the DUT. 6) Perform test procedure II during the test. Functional status class C. 7) Perform test procedure I at +28V. Functional status class A.

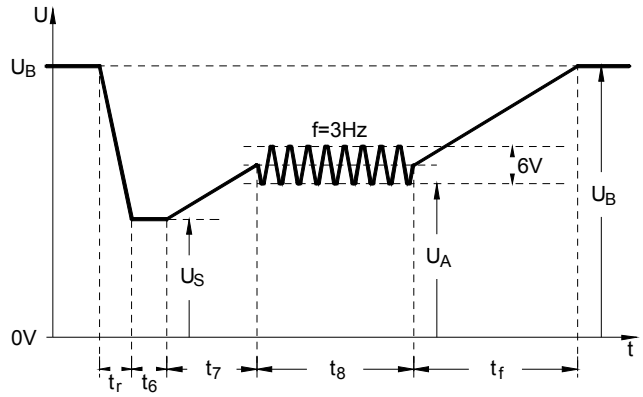
6.1.17 Transient protection, test pulse 3a

Background	Requirement	Test and acceptance criteria
This test pulse simulates negative transients caused by switching processes in the electrical system. The transients are influenced by distributed capacitance and inductance of the wiring harness. The supply voltage lines as well as other inputs and outputs are exposed to these transients. The test is based on standard ISO 7637-2:2004.	The DUT shall resist transient, test pulse 3a at -40ºC to + $T_{max.op.}$ºC. Functional status class A. U_A = + 28V U_S = - 150V R_i = 50ohm t_d = 0.1µs t_r = 5ns t_1 = 100µs t_4 = 10ms t_5 = 90ms Duration: 1 hour  Figure 19: Test pulse 3a	1) Apply test pulse 3a to the supply voltage lines of the DUT (incl. normal load). 2) Perform test procedure II during the test. Functional status class A. 3) Apply test pulse 3a to the battery supply voltage lines of the DUT (incl. normal loads). 4) Perform test procedure II during the test. Functional status class A. 5) Apply test pulse 3a only to the wake up signal line of the DUT. 6) Perform test procedure II during the test. Functional status class A. 7) Perform test procedure I at +28V. Functional status class A.

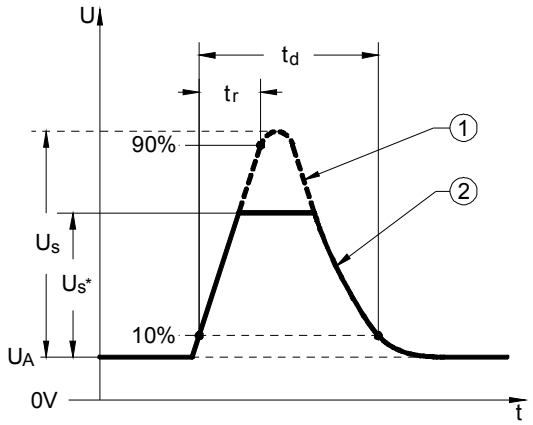
6.1.18 Transient protection, test pulse 3b

Background	Requirement	Test and acceptance criteria
This test pulse simulates positive transients caused by switching processes in the electrical system. The transients are influenced by distributed capacitance and inductance of the wiring harness. The supply voltage lines as well as other inputs and outputs are exposed to these transients. The test is based on standard ISO 7637-2:2004.	The DUT shall resist transient, test pulse 3b at -40ºC to + $T_{max.op.}$ºC. Functional status class A. U_A = + 28V U_S = + 150V R_i = 50ohm t_d = 0.1µs t_r = 5ns t_1 = 100µs t_4 = 10ms t_5 = 90ms Duration: 1 hour  Figure 20: Test pulse 3b	1) Apply test pulse 3b to the supply voltage lines of the DUT (incl. normal load). 2) Perform test procedure II during the test. Functional status class A. 3) Apply test pulse 3b to the battery supply voltage lines of the DUT (incl. normal loads). 4) Perform test procedure II during the test. Functional status class A. 5) Apply test pulse 3b only to the wake up signal line of the DUT. 6) Perform test procedure II during the test. Functional status class A. 7) Perform test procedure I at +28V. Functional status class A.

6.1.19 Transient protection, test pulse 4

Background	Requirement	Test and acceptance criteria
This test pulse simulates the starting behavior of a DUT during and after cranking. The supply voltage lines are exposed. Other inputs and outputs can also be exposed to these transients. The test is based on standard ISO 7637-2:2004 and ISO 16750-2:2006.	The DUT shall resist transient, test pulse 4 at -40ºC to + $T_{max.op.}$ºC. Functional status class B or C. No unintended error code may be created as a result of the test pulse. U_B = + 24V U_S = + 7V U_A = + 9V R_i = 0-0.02ohm t_r = 10ms t_6 = 300ms t_7 = 50ms t_8 = 0.5s-60s t_f = 40ms Duration: 10 pulses, 1 minute between each pulse  Figure 21: Test pulse 4	1) Apply test pulse 4 to the supply voltage lines of the DUT (incl. normal load). 2) Perform test procedure II during the test. Functional status class B or C. 3) Perform test procedure I at +28V. Functional status class A.

6.1.20 Transient protection, test pulse 5b

Background	Requirement	Test and acceptance criteria
This transient test pulse simulates a load dump and occurs when the battery for different reasons is disconnected from a charging alternator. The supply voltage lines are exposed. Other inputs and outputs can also be exposed to these transients. The test is based on standard ISO 7637-2:2004.	The DUT shall resist transient, test pulse 5b at -40ºC to + $T_{max.op.}$ºC. Functional status class B or C. No unintended error code may be created as a result of the test pulse. U_A = + 28V U_S = + 140V U_{S^*} = + 30V R_i = 1.0ohm t_d = 600ms t_r = 10ms Duration: 10 pulses (1 minute between each pulse)  Figure 22: Test pulse 5b 1: Unsuppressed (defines the pulse shape) 2: Due to zener clamping inside the alternator the voltage will be suppressed to a maximum of +58V.	1) Apply test pulse 5b to the supply voltage lines of the DUT (incl. normal load). 2) Perform test procedure II during the test. Functional status class B or C. 3) Perform test procedure I at +28V. Functional status class A.

6.1.21 EMC protection, emission (component level testing)

Background

Electromagnetic interferences from the DUT and its wiring harness installed in the vehicle shall not disturb other devices or radio usage.

The interferences are produced by devices such as microcontrollers, switched power supplies and electric motors.

Requirement

Electromagnetic interferences from the DUT and its wiring harness shall not exceed the following tables at -40ºC to + $T_{max.op.}$ºC.

Table 1: Radiated emissions based on CISPR25:2002

Frequency band	NB (dBuV/m)	BB (dBuV/m)	
		Peak	QP
30-68 MHz	22	36	23
68-108 MHz	12	25	12
108-140 MHz	25	38	25
140-180 MHz	12	25	12
180-512 MHz	19	32	19
512-960 MHz	25	38	25
1570-1580 MHz	30	36	23
1710-2025 MHz	35	48	35
2400-2500 MHz	40	51	38

Table 2: Conducted emissions based on CISPR25:2002

Frequency band	Voltage method			Current probe		
	CE NB limit dBuV	CE BB limit dBuV		CE NB limit dBuA	RE NB limit dBuA	
		Peak	QP		Peak	QP
0.15-0.53 MHz	50	73	60	40	60	47
0.53-5.9 MHz	34	63	50	34	60	47
5.9-6.2 MHz	33	53	40	33	50	37
6.2-68 MHz	28	53	40	28	50	37
68-108 MHz	18	37	24	28	44	31

Note: For short duration noise (see CISPR25:2002) the BB demands can be increased +6 dB.

Test and acceptance criteria

1) Apply +24V to +28V via an LISN to the supply voltage lines of the DUT (incl. normal load).

2) Perform radiated emission test method according to CISPR25:2002 §6.4.

3) Perform conducted emission test, voltage method according to CISPR25:2002 §6.2.

4) Perform conducted emission test, current probe method according to CISPR25:2002 §6.3.

Acceptance criteria:
According to requirement table 1 and 2.

6.1.22 EMC protection, immunity (component level testing)

<table>
<tr><th>Background</th><th>Requirement</th><th>Test and acceptance criteria</th></tr>
<tr>
<td>Off-vehicle sources are transmitters such as radio stations, TV and telephone etc. The DUT must be able to work correctly under the influence of these sources of electromagnetic field strength.

On-board sources are the communication radio, data transmitters in vehicles and mobile telephones etc.

<u>Applicable to:</u>
Electronic control units including their peripheral components.

<u>Not applicable to:</u>
Components such as fuses, electromechanical relays, valves and electrical motors which do not have electronic control.</td>
<td>The DUT shall operate according to the functional status classification in the tables below at -40ºC to + $T_{max.op.}$ºC.

<table>
<tr><th colspan="3">Table 3: ISO 11452-2:2004 (Free field)
Functional status classification</th></tr>
<tr><td>Field strength and frequency area</td><td>VOR and traffic safety related functions</td><td>Other functions</td></tr>
<tr><td>25V/m
150 kHz-3 GHz</td><td>A</td><td>A</td></tr>
<tr><td>50V/m
2 MHz-2 GHz</td><td>A</td><td>B</td></tr>
<tr><td>100V/m
20 MHz-2 GHz</td><td>B</td><td>C</td></tr>
</table>
</td>
<td>1) Apply +24V to +28V via an LISN to the supply voltage lines of the DUT (incl. normal load).

2) Perform free field testing according to ISO 11452-2:2004.

Modulation:
Under 800 MHz: AM 80%, 1 kHz sinus
Over 800 MHz: PM 50%, 217 Hz pulse
Test cycle: 2s CW+ 2s modulation at each step. Forward power is used for calibration.

Maximum frequency step size:
0.1 MHz at 150 kHz-1 MHz
0.5 MHz at 1 MHz-20 MHz
1 MHz at 20 MHz-220 MHz
2 MHz at 220 MHz-200 MHz
5 MHz at 500 MHz-1000 MHz
10 MHz at f>1 GHz

<u>Acceptance criteria:</u>
According to requirement table 3.</td>
</tr>
</table>

6.1.23 ESD protection (unpowered test)

Background

This test condition represents the handling of the DUT prior to vehicle fit, either during storage or line-fit by assembly staff or user fit by an after market installer or the vehicle owner/user.

Discharges shall be applied using the direct discharge method. The test simulates metal discharges.

Selected test points shall be documented.

The test is based on standard ISO 10605:2001 and IEC 61000-4-2:2001.

Applicable to:
Components with metallic housing containing active electronic devices.

Not applicable to:
Passive components such as fuses, electromechanical relays and valves.

Requirement

The DUT shall withstand ESD events that occur during handling, storage, assembly and service at -40ºC to +30ºC.

Test each connector pin, case, case screw, button, and display of the DUT that is accessible during handling.

Each test point shall be subjected to all levels and polarity according to the table below. The test order is test level I followed by II, III and IV. Discharge repetition time=1second.

Between each discharge event the test point shall be drained through 4 x 470 kΩ resistors in series to reference ground.

Test level	Type of discharge / Human body model	Test voltage level (kV)	Min. no. of discharges at each polarity	Functional status * (after test)
I	Contact / 150pF;330Ω	±2	10	A
II	Contact / 150pF;330Ω	±4	10	A
III	Contact / 150pF;330Ω	±6	10	A
IV	Contact / 150pF;330Ω	±8	10	A

* I/O performance (resistance, capacitance, leakage current, signal rise/fall times, etc.) shall remain within the specified tolerances.

Humidity: 30 to 60% relative humidity

Test and acceptance criteria

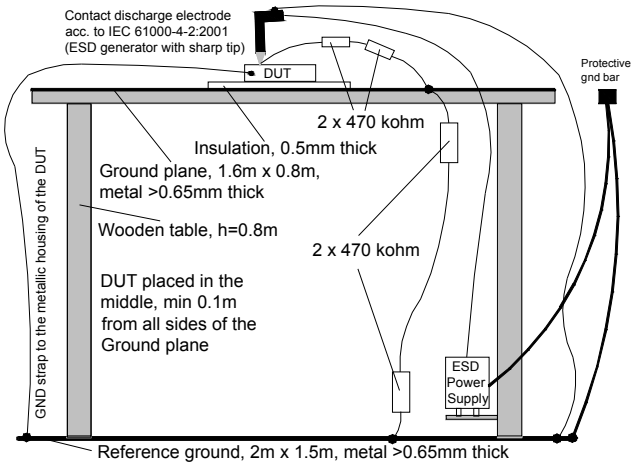
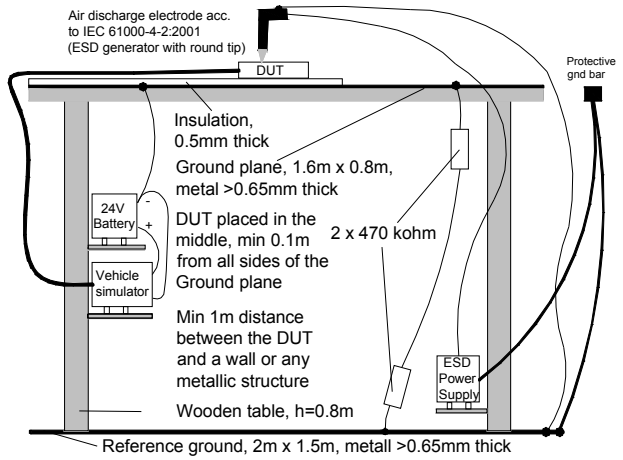


Figure 23: Test set up, ESD unpowered test

1) Apply ten ESD contact discharges on each test point according to requirement at test level I, positive polarity (drain the residual charge between each pulse).
2) Perform test procedure I at +28V. Functional status class A.
3) Repeat steps 1 and 2 with negative polarity.
4) Repeat steps 1, 2 and 3 with test level II followed by III and IV.

Acceptance criteria:
According to the requirement table.

6.1.24 ESD protection (powered-up test)

Background	Requirement	Test and acceptance criteria
This test condition represents an in use situation. Discharges shall be applied using the direct discharge method. The test simulates hand discharges from a person inside the cab. Selected test points shall be documented. The test is based on standard ISO 10605:2001 and IEC 61000-4-2:2001. <u>Applicable to:</u> Components with plastic (isolating) housing containing active electronic devices. <u>Not applicable to:</u> Passive components such as fuses, electromechanical relays and valves.	The DUT shall be immune to ESD events that occur during normal operation at -40ºC to + $T_{max.op.}$ºC. Test the case, each case screw, button, display and case opening of the DUT that is accessible during normal operation. Each test point shall be subjected to all levels and polarity according to the table below. The test order is test level I followed by II and IV. Start 15mm from test point and move slowly ≤ 5mm/s towards the test point until a single discharge occurs. If no discharge occurs, discontinue testing at that voltage level and test point. **Test level** / **Type of discharge / Human body model** / **Test voltage level (kV)** / **Min. no. of discharges at each polarity** / **Functional status classification*** I / Air / 330pF; 2 kΩ / ±4 / 3 / A II / Air / 330pF; 2 kΩ / ±8 / 3 / A or B IV / Air / 330pF; 2 kΩ / ±15 / 3 / A or B or C * I/O performance (resistance, capacitance, leakage current, signal rise/fall times, etc.) shall remain within the specified tolerances. Humidity: 30 to 60% relative humidity	 Figure 24: Test set up, ESD powered up test 1) Apply three ESD air discharges on each test point according to the requirement at test level I, positive polarity (wait 1 minute between each pulse if a discharge occurs) 2) Perform test procedure II during the test. Functional status class A. 3) Repeat steps 1 and 2 with negative polarity. 4) Repeat steps 1, 2 and 3 with test level II followed by IV. <u>Acceptance criteria:</u> According to the requirement table.

6.1.25 EMC protection, emission (vehicle level testing)

<table>
<tr><th>Background</th><th>Requirement</th><th>Test and acceptance criteria</th></tr>
<tr>
<td>Electromagnetic interferences from the DUT and its wiring harness installed in the vehicle shall not disturb other devices or radio usage.

The Interferences are produced by devices such as microcontrollers, switched power supplies and electric motors.</td>
<td>Electromagnetic interferences from the DUT and its wiring harness shall not exceed the following table at -40ºC to + $T_{max.op.}$ºC.

<table>
<tr><th colspan="3">Radiated emissions according to CISPR25:2002</th></tr>
<tr><th>Frequency band</th><th>NB (dBuVpeak)</th><th>BB (dBuVpeak)</th></tr>
<tr><td>0,15-20 MHz</td><td>+10</td><td>+20</td></tr>
<tr><td>20 MHz-2 GHz</td><td>-3</td><td>+12</td></tr>
</table>

A few NB peaks, (maximum 4) < 6dB above the limit can be accepted depending on at which frequencies they occur.</td>
<td>1) Perform the emission test on a complete vehicle according to CISPR25:2002 with measurement bandwidth:
<20 MHz BW=3 kHz
>20 MHz BW=10 kHz

<table>
<tr><th>Frequency band MHz</th><th>Scania vehicle aerials or the equivalent</th></tr>
<tr><td>0.15-20</td><td>EZ12, CB/FM</td></tr>
<tr><td>20-30</td><td>Loaded ¼ wave</td></tr>
<tr><td>30-88</td><td>Military dipol</td></tr>
<tr><td>68-88</td><td>4m CB ¼wave</td></tr>
<tr><td>88-108</td><td>FM ¼wave*</td></tr>
<tr><td>108-140</td><td>FM ¼wave*</td></tr>
<tr><td>140-180</td><td>2m CB ¼wave</td></tr>
<tr><td>180-820</td><td>Tetra etc. ¼wave</td></tr>
<tr><td>820-960</td><td>GSM ¼wave</td></tr>
<tr><td>1567-1583</td><td>GPS</td></tr>
<tr><td>1710-2025</td><td>GSM ¼wave</td></tr>
</table>

* Scania uses the 4m band CB aerial for FM</td>
</tr>
</table>

6.1.26 EMC protection, immunity (vehicle level testing)

Background

Off-vehicle sources are transmitters such as radio stations, TV and telephone. The DUT must be able to work correctly under the influence of these sources of electromagnetic field strength.

On-board sources are the communication radio, data transmitters in vehicles and mobile telephones etc.

Applicable to:
Electronic control units including their peripheral components.

Not applicable to:
Components such as fuses, electromechanical relays, valves and electrical motors which do not have electronic control.

Requirement

The DUT shall operate according to the functional status classification in the tables below in an electromagnetic field at -40ºC to + $T_{max.op.}$ ºC.

ISO 11451-2:2005 (Off vehicle) Functional status classification

Field strength and frequency area	VOR and traffic safety related functions	Other functions
50 V/m 150 kHz-2 MHz	B	C
25 V/m 150 kHz-2 MHz	A	B
100 V/m 2 MHz-1000 MHz	B	C
50 V/m 2 MHz-1000 MHz	A	B
50 V/m 1000MHz-2000MHz	B	C
25 V/m 1000MHz-2000MHz	A	B

ISO 11451-3:1994 (On board) Functional status classification

Power and frequency	VOR and traffic safety related functions	Other functions
100 W / 30-88 MHz	A	B
50 W / 380-440 MHz	A	B
20 W / 890-915 MHz	A	B
10 W / 1710-1785 MHz	A	B
10 W / 1970-2100 MHz	A	B
2 W / 2.4-2.5 GHz	A	B

Test and acceptance criteria

1) Perform the off-vehicle test on a complete vehicle according to ISO 11451-2:2005.

   Modulation:
   Under 800 MHz: AM 80%, 1 kHz sinus
   Over 800 MHz: PM 50%, 217 Hz pulse
   Test cycle: 2s CW+ 2s modulation at each step.
   Forward power is used for calibration.

   Maximum frequency step size:
   0.1 MHz at 150 kHz-1 MHz
   0.5 MHz at 1 MHz-20 MHz
   1 MHz at 20 MHz-220 MHz
   2 MHz at 220 MHz-200 MHz
   5 MHz at 500 MHz-1000 MHz
   10 MHz at f>1 GHz

2) Perform the on-board transmitter simulation according to ISO 11451-3:1994 in the following bands:

Frequency Band	Modulation,	Aerial, position
30-88 MHz	AM 1 kHz 80%	Military, on roof
380-440 MHz	PM 70 Hz 50%	Tetra, on roof
890-915 MHz	PM 217 Hz 50%	GSM900, in cab
1710-1785 MHz	PM 217 Hz 50%	GSM1800, in cab
1970-2100 MHz	PM 217 Hz 50%	UMTS, in cab
2.4-2.5 GHz	Blue tooth	Blue tooth, in cab

Acceptance criteria:
According to the requirement table.

7 CHANGES

Change	ECO number	Section	Change description	Date	Sign	Pho.