LV 124 / LV 148

WKS Informatik Solutions

LV 124

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Experts in Testing

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RT Stand
HIL - TEST AND SIMULATION

Industrial Automation

Tube Analyzer

µfi Ultra Fast Interrupter

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Overview

1. LV 124: covers tests for electric and electronic components for use in motor vehicles up to 3,5 t with a 12 V electric system

2. LV 148: covers tests for electric and electronic components in motor vehicles 48V electrical system

3. LV 124 vs. LV 148

4. WKS Informatik solutions for electrical tests

References

- Volkswagen 80000 - Electric and Electronic Components in Motor Vehicles up to 3,5 t - General Requirements, Test Conditions and Tests - Issue June 2013
- VDA 320 - Elektrische und elektronische Komponenten im Kraftfahrzeug - 48V-Bordnetz - Anforderungen und Prüfungen – Issue August 2014

LV 124

Voltages and currents	
VN	Nominal voltage
VBmin	Lower operating voltage limit
VB	Operating voltage
VBmax	Upper operating voltage limit
Vmax	Maximum voltage that may occur during a test
Vmin	Minimum voltage that may occur during a test
VPP	Peak-peak voltage
Veff	RMS value of a voltage
Vtest	Test voltage
IN	Nominal current
GND	Device ground
VA, VT, VS, VR	Voltage level of the start voltage pulse

Times/durations	
tr	Rise time (e.g., of a voltage curve)
tf	Fall time (e.g., of a voltage curve)

Temperatures	
Tmin	Minimum operating temperature
TRT	Room temperature
Tmax	Maximum operating temperature
Ttest	Test temperature

Encoding	V_{Bmin}	V_{Bmax}	Description
a	6 V	16 V	For functions that must retain their performance during starting of the engine
b	8 V	16 V	For functions that do not have to retain their performance during starting of the engine This encoding must only be used if the component cannot be classified in the encoding a, c or d.
c	9 V	16 V	For functions that must retain their performance when the engine is not running
d	9,8 V	16 V	For functions that must retain their performance when the engine is running

LV 148

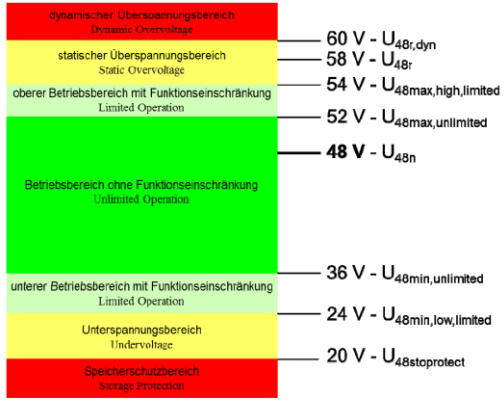
Terms	
A, B, C, D in Diagrams	Functional status A, B, C, D
BN12	12V-on board supply
BN24	24V-on board supply
BN48	48V-on board supply
GND	Ground – Masse BN12/BN24 (Kl. 31)
GND48	Ground 48 V – Masse BN48 (Kl. 41)
n.c.	Not connected
PTB	Physikalisch-Technische Bundesanstalt
RMS	Root Mean Square

Times/durations	
tr	Rise time (e.g., of a voltage curve)
tf	Fall time (e.g., of a voltage curve)
ttest	Test time

Temperatures	
Tmin	Minimum operating temperature
TRT	Room temperature
Tmax	Maximum operating temperature
Ttest	Test temperature

- Klemme 40 is the Plus of the 48 V supply.
- Klemme 41 is the Ground of the 48 V supply.

Shortcut	Terms LV 148	Value
U48r,dyn	Lower voltage limit of the dynamic overvoltage range	60 V
U48r	Lower voltage limit of the 2 V tolerance to the dynamic overvoltage range	58 V
U48max,high,limited	Max. voltage of the upper operating range with functional restriction	54 V
U48max,unlimited	Max. voltage of the operating range without functional restriction	52 V
U48n	BN48- nominal voltage	48 V
U48min,unlimited	Min. voltage of the operating range without functional restriction	36 V
U48min,low,limited	Min. voltage of the lower operating range with functional restriction	24 V
U48stoprotect	Accumulator protected voltage	20 V
U48pp	Peak – peak- voltage	
U48rms	Effektive value of a voltage	
U48max	Maximum voltage that may occur during a test	
U48min	Minimum voltage that may occur during a test	
U48test	BN48- test voltage	
U12test	BN12- test voltage	14 V
U24test	BN24- test voltage	28 V



LV124 vs. LV 148

	LV 124	LV 148
Frequencies	±1%	±1%
Temperatures	±2 °C	±2 °C
Humidity	±5%	±5%
Times/durations	+5%; 0%	+5%; 0%
Voltages	±2%	±0.5%
Currents	±2%	±2%

Room temperature	TRT = 23 °C ± 5 °C	TRT = 23 °C ± 5 °C
Humidity	Hrel = 25% to 75% relative humidity	25 % (+ 5 % bis 0 %) to 75 % (- 5 % bis 0 %)
Test temperature	Ttest = TRT	Ttest = TRT
Operating voltage (for test)	VB = 14 V	U48max
Source impedance Ri	Ri ≤ 100 mΩ (E6) Ri < 30 mΩ / 100 mΩ (E15)	10 mOhm ≤ Ri ≤ 100 mOhm

Tolerances & standard values

LV124 vs. LV 148

LV 124

Functional status A
The DUT must fulfill all functions during and after exposure to the test parameters.
Functional status B
The DUT must fulfill all functions during exposure to the test parameters; however, one or more functions can lie outside the specified tolerance. After exposure to the test parameters, the DUT must automatically achieve functional status A again.
Functional status C
The DUT does not fulfill one or more functions during exposure to the test parameters. After exposure to the test parameters, the DUT must automatically achieve functional status A again. Undefined functions are not permissible at any time.
Functional status D
The DUT does not fulfill one or more functions during exposure to the test parameters. After exposure to the test parameters, the DUT must achieve functional status A again by means of a terminal changeover, a reset, or a simple intervention (e.g., replacement of a defective fuse). Undefined functions are not permissible at any time.
Functional status E
The DUT does not fulfill one or more functions during exposure to the test parameters and must be repaired or replaced after exposure to the test parameters.
The device under test (DUT) must comply with the requirements for nonflammability as per UL94-v0.

LV 148

Functional status A
The DUT must fulfill all functions during and after exposure to the test parameters.
Functional status B
The DUT must fulfill all functions during exposure to the test parameters; however, one or more functions can lie outside the specified tolerance. After exposure to the test parameters, the DUT must automatically achieve functional status A again.
Functional status C
The DUT does not fulfill one or more functions during exposure to the test parameters. After exposure to the test parameters, the DUT must automatically achieve functional status A or B again. Undefined functions are not permissible at any time.
Functional status D
The DUT does not fulfill one or more functions during exposure to the test parameters. After exposure to the test parameters, the DUT must achieve functional status A again by means of a terminal changeover, a reset, or a simple intervention (e.g., replacement of a defective fuse). Undefined functions are not permissible at any time.
Functional status E
The DUT does not fulfill one or more functions during exposure to the test parameters and must be repaired or replaced after exposure to the test parameters.
The device under test (DUT) must comply with the requirements for nonflammability as per UL94-v0.

An electrical test begins when the DUT is completely started up and is in functional status A.
A set of sensitive parameters, so-called key parameters, e.g. closed-circuit current consumption, operating currents, output voltages, contact resistances, input impedances, signal rates (rise/fall times), and bus specifications, must be defined in the Component Performance Specification or in agreement with the purchaser. **The key parameters to be monitored must be recorded during each test.**

Before and after each test, the DUTs must be subjected to a **parameter test (small):** The key parameters must be measured and the functional behavior of the components must be examined at TRT and VB

Before the first and after the last electrical test, the **parameter test (large):** The key parameters must be measured and the functional behavior of the components must be measured at temperatures Tmax, TRT, and Tmin, in each case at voltages VBmin, VB, and VBmax.

Before and after each test, the DUTs must be subjected to a **parameter test (small):** The key parameters must be measured and the functional behavior of the components must be examined at TRT and U48n.

LV 124 vs. LV 148

Operating mode I - DUT not electrically connected

Operating mode I.a
The DUT is not electrically connected, without plug and harness.
Any present coolant circuit is not filled, and the connections are sealed.

Operating mode I.b
The DUT is not electrically connected, but with connected plugs and harness.
Any present coolant circuit is filled, and the coolant hoses are connected.

Operating mode II - DUT electrically connected

Operating mode II.a
The DUT must be operated without operating load.
Any present coolant circuit must be filled, and the coolant hoses must be connected. If necessary, the flow rate and temperature of the cooling medium must be set – as specified in the Component Performance Specification.

Operating mode II.b
The DUT must be operated with minimal operating load.
The DUT must be operated in a way that minimal self-heating occurs (e.g., by reducing a continuous output power or by infrequent activation of external loads).
Any present coolant circuit must be filled, and the coolant hoses must be connected. If necessary, the flow rate and temperature of the cooling medium must be set – as specified in the Component Performance Specification.

Operating mode II.c
The DUT must be operated at maximum load (power user, but no misuse).
The DUT must be operated in a way that maximum self-heating occurs (e.g., by means of a realistic maximization of a continuous output performance or frequent activation of external loads).
Any present coolant circuit must be filled, and the coolant hoses must be connected. If necessary, the flow rate and temperature of the cooling medium must be set – as specified in the Component Performance Specification.

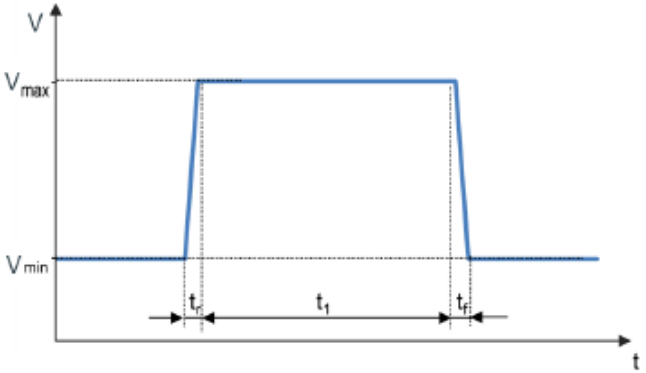
LV124 vs. LV 148

E-01 Long-term overvoltage	Components supplied via the 12 V electric system	E48-01a,b Long-term overvoltage	
E-02 Transient overvoltage	Components supplied via the 12 V electric system	E48-02 Transient overvoltage	
E-03 Transient undervoltage	Components supplied via the 12 V electric system	E48-03 Transient undervoltage	
E-04 Jump start	Components supplied via the 12 V electric system	E48-04 Jump start	
E-05 Load dump	Components supplied via the 12 V electric system	E48-05 Superimposed alternating voltage	
E-06 Superimposed alternating voltage	Components supplied via the 12 V electric system	E48-06a,b,c Slow decrease and increase of the supply voltage	
E-07 Slow decrease and increase of the supply voltage	All components	E48-07 Slow decrease, quick increase of the supply voltage	
E-08 Slow decrease, quick increase of the supply voltage	All components	E48-08 Reset behavior	
E-09 Reset behavior	All components	E48-9 Short interruptions	
E-10 Short interruptions	All components	E48-10 Start pulses	
E-11 Start pulses	Components supplied via the 12 V electric system	E48-11 Masseverlust BN48	
E-12 Voltage curve with electric system control	Components supplied via the 12 V electric system	E48-12 Ground offset	
E-13 Pin interruption	All components	E48-13 Internal dielectric strength	
E-14 Connector interruption	All components	E48-14 Closed-circuit current	
E-15 Reverse polarity	Components that can be subjected to reverse polarity in the vehicle	E48-15 Operation in range without function limitation	
E-16 Ground offset	All components	E48-16 Operation in the upper range with function limitation	
E-17 Short circuit in signal circuit and load circuits	All components	E48-17 Operation in the lower range with function limitation	
E-18 Insulation resistance	Components with galvanically isolated portions	E48-18 Overvoltage range	
E-19 Closed-circuit current	Components that are continuously supplied with voltage	E48-19 Undervoltage range	
E-20 Dielectric strength	Components with inductive parts	E48-20a Fault current Teil 1, Teil 2	
E-21 Backfeeds	Components that are electrically connected to T.15 or other terminals with wake-up function	E48-21 Short circuit in signal circuit and load circuits	
E-22 Overcurrents	Components that have an output		

LV 124 vs. LV 148

E01 Long-term overvoltages

DUT operating mode	Operating mode II.c
V_{max}	17 V (+4%, 0%)
V_{min}	13,5 V
t_r	<10 ms
t_f	<10 ms
t_1	60 min
T_{test}	T_{max} – 20 K
Number of cycles	1
Number of DUTs	At least 6

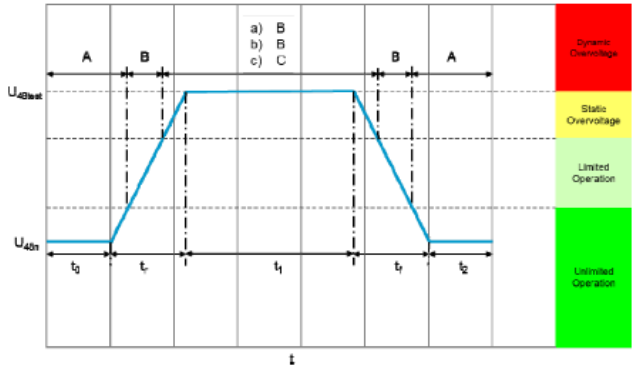


Requirements:
Components necessary for driving operation: Functional status B
For all other components: Functional status C

E48-01a Long-term overvoltages

Aim: The component's resistance to long-term overvoltage is tested. A generator control fault during driving operation is simulated.

Betriebsart des Prüflings	Betriebsart II.a, II.b und II.c
t_0	Funktionszustand A eingenommen
t_r	0,1 s
t_1	60 min
t_f	0,1 s
t_2	1 s
U_{48test}	$U_{48r,dyn}$
T_{test}	T_{max} - 20 °C
Anzahl der Zyklen	1
Anzahl der Prüflinge	6



Requirements:
Components which convert electrical energy: Functional status B
Components necessary for driving operation: Functional status B
For all other components: Functional status C

LV 124 vs. LV 148

E48-01b Long-term overvoltages on recuperating components

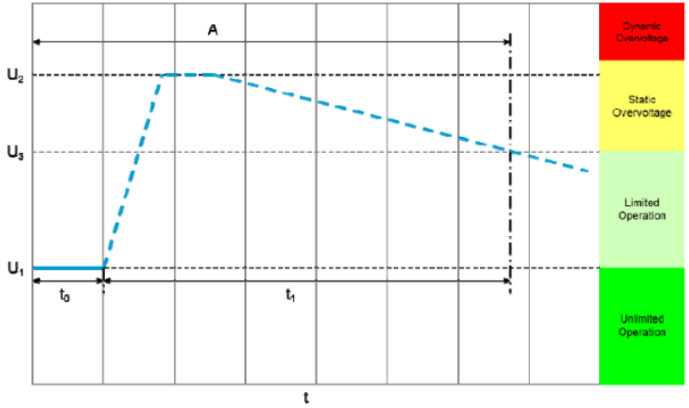
Aim: Testing for recuperation components in the electrical system where the energy can not be removed and therefore it results in a over voltage.

Part 1 Test with a source which does not act as a sink. Regenerative current < 10 mA. Current measurement must be made.

Betriebsart des Prüflings	Betriebsart II.c
T_{test}	T_{min}, T_{RT} und T_{max}
U_1	$U_{48max,unlimited}$
U_2	U_{48r}
U_3	$U_{48max,high,limited}$
t_0	≥ 1 s (die Rückspeisung beginnt nach dieser Zeit)
t_1	≤ 300 ms
Anzahl der Zyklen	je 3 Zyklen bei allen 3 Temperaturen
Anzahl der Prüflinge	6

Part 2 The DUT is connected to a powerful 4 quadrant amplifier and must be operated for at least t0 at U1. Thereafter, the activation of the feedback begins and at maximum regenerative current of the DUT, the decrease in the regenerative power abruptly (toff) must be terminated.

Betriebsart des Prüflings	Betriebsart II.c
T_{test}	T_{min}, T_{RT} und T_{max}
U_1	$U_{48max,unlimited}$
U_2	U_{48r}
U_3	$U_{48max,high,limited}$
t_0	≥ 1 s
t_1	≤ 300 ms
t_{off}	≤ 10 µs
Anzahl der Zyklen	je 3 Zyklen bei allen 3 Temperaturen
Anzahl der Prüflinge	6



Requirements:
Functional status A.

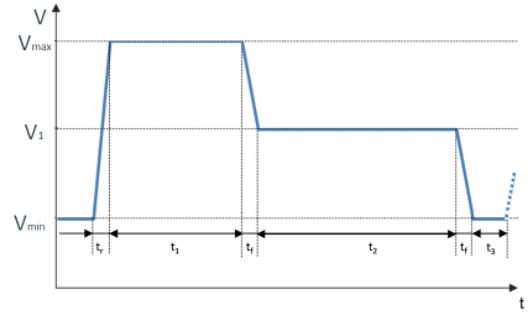
The time t1 from the voltage exceeding U1 until voltage falls below U3 must not be exceeded and must be determined!

LV 124 vs. LV 148

E02 Transient overvoltages

Aim: Transient overvoltages may occur in the electric system due to the switching off of loads and due to short accelerator tip-ins. These overvoltages are simulated by means of this test.

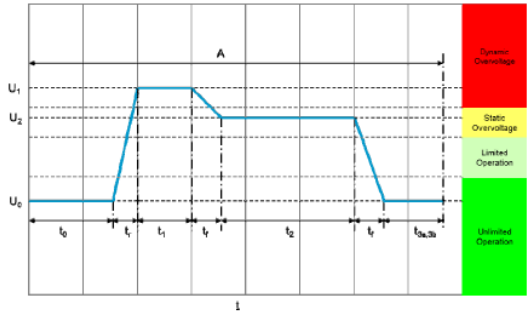
DUT operating mode	Operating mode II.c
V_{min}	16 V
U_1	17 V
V_{max}	18 V (+4%, 0%)
t_r	1 ms
t_f	1 ms
t_1	400 ms
t_2	600 ms
Number of DUTs	At least 6
Test case 1	
T_{test}	T_{max}
Number of cycles	3
t_3	2 s
Test case 2	
T_{test}	T_{min}
Number of cycles	3
t_3	2 s
Test case 3	
T_{test}	T_{RT}
Number of cycles	100
t_3	8 s



Requirements:
Functional status A

E48-02 Transient overvoltages

Betriebsart des Prüflings	Betriebsart II.c
U_0	U_{48n}
U_1	70 V
U_2	U_{48r}
t_0	100 ms
t_r	1 ms
t_1	40 ms
t_f	1 ms
t_2	600 ms
t_{3a}	2,5 s
t_{3b}	9 s
R_i	10 mΩ ≤ R_i ≤ 100 mΩ
Anzahl der Zyklen	1. Kurztest: 3-mal mit t_{3a} 2. Dauertest: 1000-mal t_{3b} Beide Prüfungen werden sequenziell durchgeführt.
Anzahl der Prüflinge	6

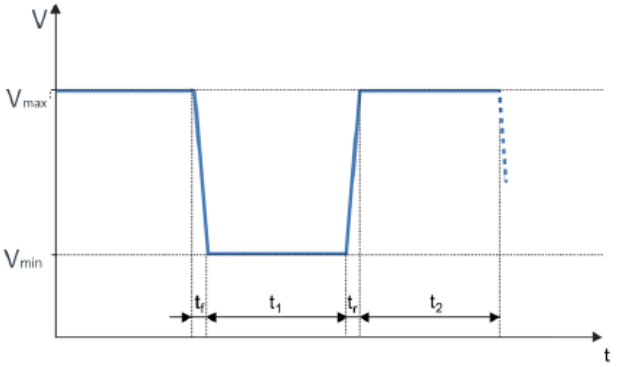


Requirements:
Functional status A

LV 124 vs. LV 148

E-03 Transient undervoltage

DUT operating mode	Operating mode II.c
V_{max}	10,8 V (+4%, 0%)
V_{min}	9 V (0%, -4%)
t_r	1,8 ms
t_f	1,8 ms
t_1	500 ms
t_2	1 s
Number of DUTs	At least 6
Test case 1	
T_{test}	T_{max}
Number of cycles	3
Test case 2	
T_{test}	T_{min}
Number of cycles	3

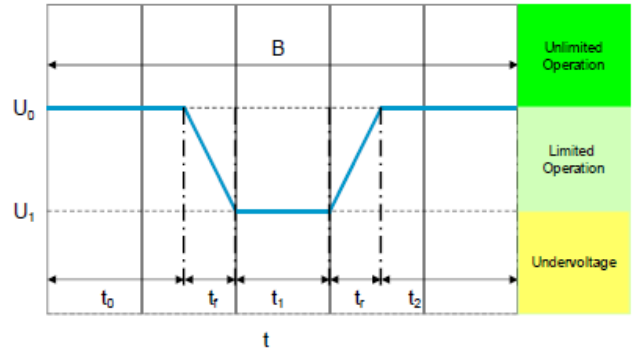


Requirements:
Functional status A

E48-03 Transient undervoltages

Aim: Transient undervoltages in the electric system may occur due to switching on of loads. These undervoltages are simulated by means of this test.

Betriebsart des Prüf-lings	Betriebsart II.c
U_0	$U_{48min,unlimited}$
U_1	$U_{48min,low,limited}$
t_0	60 s
t_f	2 ms
t_1	500 ms
t_r	2 ms
t_2	500 ms
Anzahl der Zyklen	1
Anzahl der Prüflinge	6

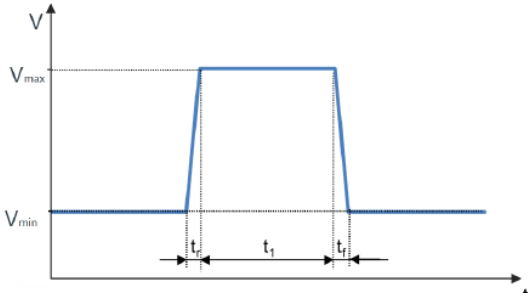


Requirements:
Functional status B

LV 124 vs. LV 148

E-04 Jumpstart

DUT operating mode	Operating mode II.c
V_{min}	10,8 V
V_{max}	26 V (+4%, 0%)
t_1	60 s
t_r	<10 ms
t_f	<10 ms
Number of cycles	1
Number of DUTs	At least 6



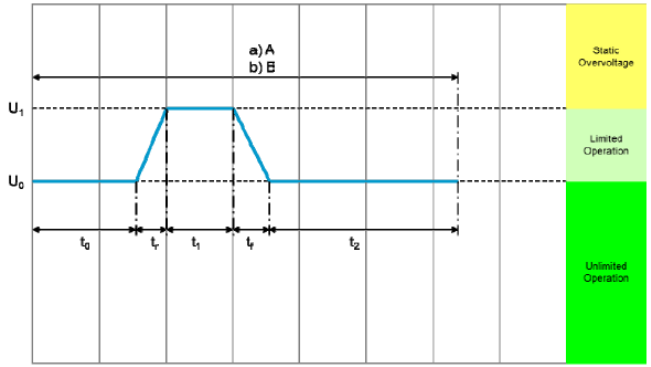
Requirements:
Components relevant to starting (e.g., starter): Functional status B
Sensors must provide valid values during the entire
All other components: Functional status C

E48-04 Jumpstart / recuperation

Aim: Jump starting of the vehicle is simulated. The maximum test voltage results from commercial vehicle systems and their elevated electric system voltages.

LV 148: Longer recuperation is simulated.

Betriebsart des Prüflings	Betriebsart II.c
U_0	$U_{48max,unlimited}$
U_1	$U_{48max,high,limited}$
t_0	60 s
t_r	100 ms
t_1	60 s
t_f	100 ms
t_2	60 s
Anzahl der Zyklen	1
Anzahl der Prüflinge	6

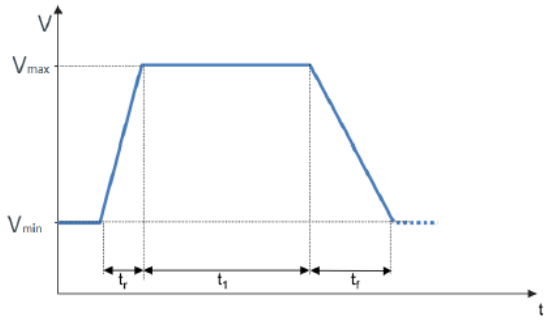


Requirements:
For recuperation and driving relevant components: Functional status A
All other components: Functional status B

E-05 Load dump

Aim: Dumping of an electric load, in combination with a battery with reduced buffering ability, results in an energy-rich overvoltage pulse due to the generator characteristics. This pulse is simulated by means of this test.

DUT operating mode	Operating mode II.c
V_{min}	13,5 V
V_{max}	27 V (+4%, 0%)
t_r	≤2 ms
t_1	300 ms
t_f	≤30 ms
Break between cycles	1 min
Number of cycles	10
Number of DUTs	At least 6



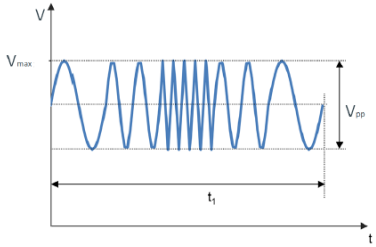
Requirements:
Safety-relevant components: Functional status B
All other components: Functional status C

LV 124 vs. LV 148

E-06 Superimposed alternating voltage

Aim: Voltages may be superimposed to the electric system. The superimposed alternating voltage may be applied during the entire running time of the engine..

DUT operating mode	Operating mode II.c
V_{max}	V_{Bmax}
R_i	≤100 mΩ
Frequency range	15 Hz – 30 kHz
Wobble duration t_1	2 min
Type of wobble	Triangle, logarithmic
Number of cycles	15
Number of DUTs	At least 6
Test case 1	
V_{PP}	2 V (+4%, 0%)
Test case 2	
V_{PP}	3 V (+4%, 0%) only for components between battery and generator, in particular for battery connection far from generator
Test case 3	
V_{PP}	6 V (+4%, 0%) for all components during driving without battery (emergency mode) or for connection close to generator

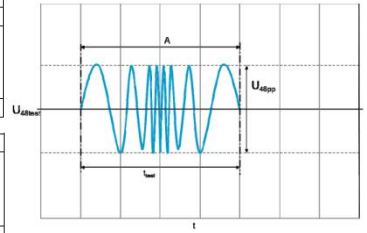


Requirements:
Test case 1: Functional status A
Test case 2: Functional status A
Test case 3:
a) Components necessary for driving operation: Functional status A
b) For all other components: Functional status B

E48-05 Superimposed alternating voltage

Betriebsart des Prüflings	Betriebsart II.c
R_i	≤ 60 mΩ Ein hierbei auftretender maximaler Rippelstrom ist mit der Fachabteilung des Auftraggebers abzustimmen.
U_{48test}	$U_{48min,unlimited}$
t_{test}	30 min
f	F1: 15 Hz bis 30 kHz F2: 30 kHz bis 200 kHz
Wobble-Periode	2 min
Wobble-Art	Dreieck logarithmisch
U_{48pp}	für F1: 6 V ± 2 % (Einzustellen vor Anschluss an Prüfling) für F2: 2 V ± 2 % (Einzustellen vor Anschluss an Prüfling)
Anzahl der Prüflinge	6

Betriebsart des Prüflings	Betriebsart II.c
R_i	≤ 60 mΩ Ein hierbei auftretender maximaler Rippelstrom ist mit der Fachabteilung des Auftraggebers abzustimmen.
U_{48test}	$U_{48max,unlimited}$
t_{test}	30 min
f	F1: 15 Hz bis 30 kHz F2: 30 kHz bis 200 kHz
Wobble-Periode	2 min
Wobble-Art	Dreieck logarithmisch
$U_{48pp,}$	für F1: 6 V ± 2 % (Einzustellen vor Anschluss an Prüfling) für F2: 2 V ± 2 % (Einzustellen vor Anschluss an Prüfling)
Anzahl der Prüflinge	6

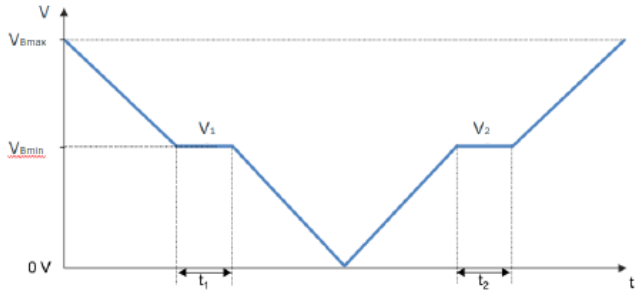


Requirements:
All components: Functional status A

LV 124 vs. LV 148

E-07 Slow decrease and increase of the supply voltage

DUT operating mode	Operating mode II.a and II.c Must be performed for all relevant statuses of the voltage supply terminals (e.g., T.15, T.30, T.87) and their combinations.
Start voltage	V_{Bmax} (+4%, 0%)
Voltage change speed	0,5 V/min (+10%, -10%)
U_1	V_{Bmin}
t_1	Holding time at V_1 until event memory has been completely read out
Minimum voltage	0 V
U_2	V_{Bmin}
t_2	Holding time at V_2 until event memory has been completely read out
Final voltage	V_{Bmax} (+4%, 0%)
Number of cycles	Per relevant terminal status and their combinations: 1 cycle with operating mode II.a 1 cycle with operating mode II.c
Number of DUTs	At least 6

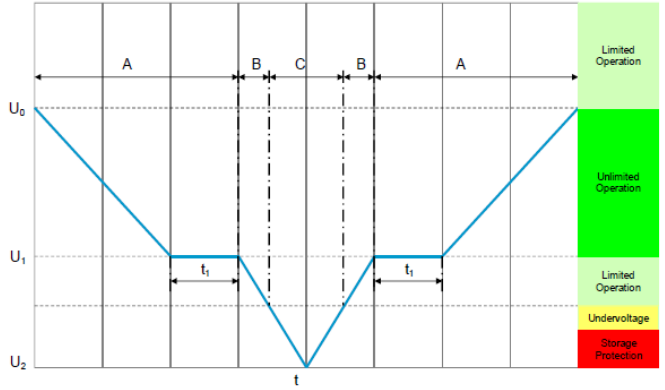


Requirements:
Within the defined operating voltage of the component: Functional status A
Outside of the defined operating voltage of the component: Functional status C

E48-06a Slow decrease and increase of the supply voltage (without energy storage)

Aim: The slow decrease and increase of the supply voltage is simulated as it occurs during the slow descharging and charging procedure of the vehicle battery.

Betriebsart des Prüflings	Betriebsart II.a und II.c
U_0	$U_{48max,unlimited}$
Spannungsgradient	± 2 V/min
U_1	$U_{48min,unlimited}$
U_2	0 V
t_1	Solange bis Fehlerspeicher vollständig ausgelesen wurde
Anzahl der Zyklen	1 Zyklus in Betriebsart II.a 1 Zyklus in Betriebsart II.c
Anzahl der Prüflinge	6



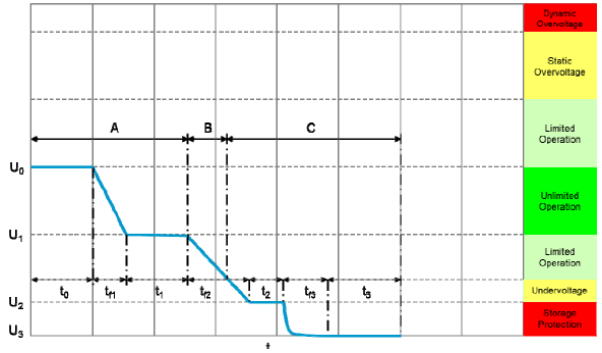
Requirements:
depends on voltage range

LV 124 vs. LV 148

E48-06b Slow decrease and increase of the supply voltage (with energy storage – Part 1)

Aim: Checks will slow the supply voltage decrease to the energy storage protection voltage, followed by energy storage disconnection.

Betriebsart des Prüflings	Betriebsart II.a
U_0	$U_{48max,unlimited}$
U_1	$U_{48min,unlimited}$
U_2	$U_{48stoprotect}$
U_3	0 V
t_0	100 ms
t_{f1}	8 min
t_1	≥ 60 s (während dieser Phase wird der Fehlerspeicher ausgelesen)
t_{f2}	8 min
t_2	60 s
t_{f3}	3 s
t_3	60 s
Anzahl der Zyklen	1
Anzahl der Prüflinge	6

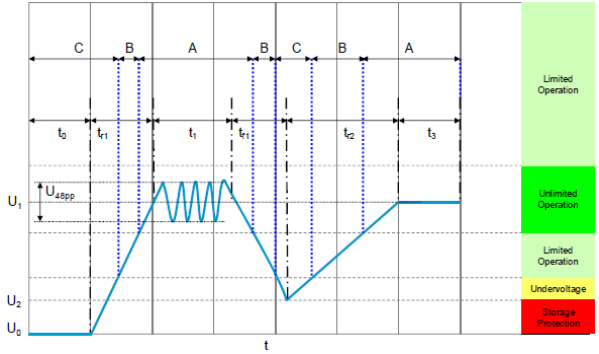


Requirements:
depends on voltage range

E48-06c Slow decrease and increase of the supply voltage (with energy storage – Part 2)

Aim: Checks the behavior that occurrs when the elelctrical system is operated without battery, and then a discharged battery is connected

Betriebsart des Prüflings	Betriebsart II.b nach Erreichen der End-spannung
R_i	≤ 60 mΩ
U_0	0 V
U_1	U_{48n}
U_{48pp}	6 V bei 10 kHz
U_2	$U_{48stoprotect}$
t_0	100 ms
t_{r1}	300 ms
t_1	≥ 60 s (während dieser Phase wird der Fehlerspeicher ausgelesen)
t_{f1}	1 ms
t_{r2}	14 min
t_3	100 ms
Anzahl der Zyklen	1
Anzahl der Prüflinge	6



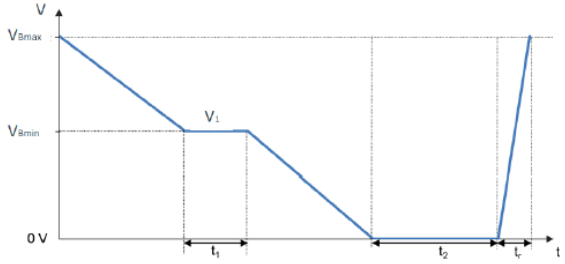
Requirements:
depends on voltage range

LV 124 vs. LV 148

E08 Slow decrease, quick increase of the supply voltage

Aim: This test simulates the slow decrease of the battery voltage to 0 V and the sudden reapplication of the battery voltage, e.g., by applying a jump start source.

DUT operating mode	Operating mode II.a and II.c Must be performed for all relevant statuses of the voltage supply terminals (e.g., T.15, T.30, T.87) and their combinations.
Start voltage	V_{Bmax} (+4%, 0%)
Voltage drop	0,5 V/min (+10%, -10%)
V_1	V_{Bmin}
t_1	Holding time at V_1 until event memory has been completely read out
Holding time at V_{Bmin}	Until the event memory is completely read out.
Minimum voltage	0 V
t_2	At least 1 min; however, as long as internal capacity is completely discharged
Final voltage	V_{Bmax} (+4%, 0%)
t_r	≤0,5 s
Number of cycles	Per relevant terminal status and their combinations: 1 cycle with operating mode II.a 1 cycle with operating mode II.c
Number of DUTs	At least 6

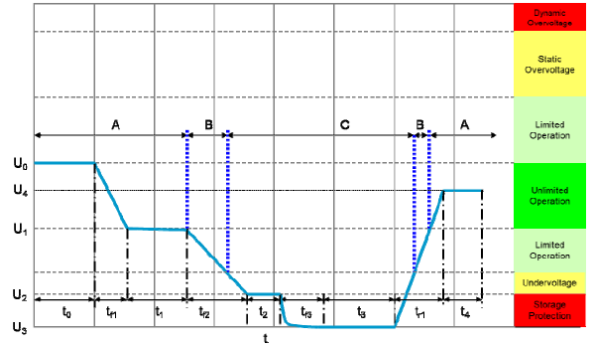


Requirements:
Within the defined operating voltage of the component: Functional status A
Outside of the defined operating voltage of the component: Functional status C

E48-07 Slow decrease, fast increase in the supply voltage

Aim: This test simulates the slow decrease of the vehicle system voltage to the energy storage protection voltage followed by shutdown to 0V and the sudden reconnect the system voltage by a charged or new energy storage battery.

Betriebsart des Prüflings	Betriebsart II.a
U_0	$U_{48max,unlimited}$
U_1	$U_{48min,unlimited}$
U_2	$U_{48stoprotect}$
U_3	0 V
U_4	U_{48n}
t_0	100 ms
t_{f1}	8 min
t_1	≥ 60 s (während dieser Phase wird der Fehlerspeicher ausgelesen)
t_{f2}	8 min
t_2	60 s
t_{f3}	3 s
t_3	300 s
t_{r1}	≤ 100 ms
t_4	100 ms
Anzahl der Zyklen	1
Anzahl der Prüflinge	6



Requirements:
Functional status A

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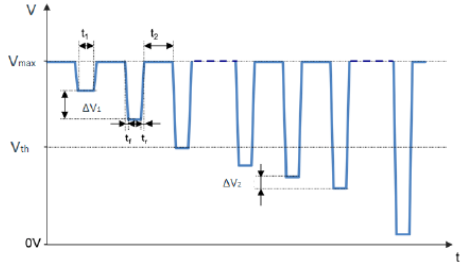
LV 124 vs. LV 148

E09 Reset behavior

DUT operating mode	Operating mode II.a and II.c Must be performed for all relevant statuses of the voltage supply terminals (e.g., T.15, T.30, T.87) and their combinations.
V_{max}	V_{Bmin} (0%, -4%)
V_{th}	6 V
ΔV_1 (range from V_{max} to V_{th})	0,5 V
ΔV_2 (range from V_{th} to 0 V)	0,2 V
t_2	At least ≥10 s and until the DUT has returned to 100% operability (all systems rebooted without error).
t_r	≤10 ms
t_f	≤10 ms
Number of cycles	For each test sequence, per relevant terminal status and their combinations: 1 cycle with operating mode II.a 1 cycle with operating mode II.c
Number of DUTs	At least 6
Test case 1	
t_1	5 s
Test case 2	
t_1	100 ms

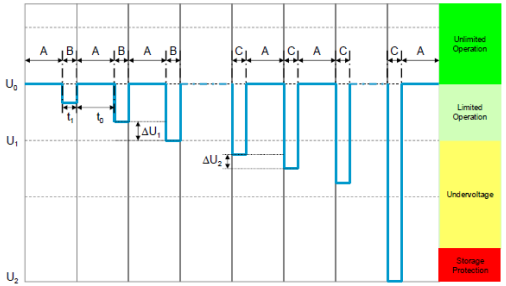


Requirements:
Functional status A when Vmax is reached again.Undefined operating statuses must not occur under any circumstances. It must be verified and documented that the specified threshold voltage level beyond which the component leaves functional status A for the first time is adhered to.

E48-08 Reset behavior

Aim: The reset behavior of a component in its environment is simulated and tested. Test boundary conditions (e.g., assembly, terminal, system) must be described in detail. During operation, an arbitrary sequence of repeated switching-on/off procedures occurs; this must not lead to an undefined behavior of the component. The reset behavior is represented by a voltage variance and a time variance. Two different test sequences are required to simulate different switch-off times. A component must always undergo both sequences.

Betriebsart des Prüflings	Betriebsart II.c
U_0	$U_{48min,unlimited}$
ΔU_1 (Bereich zwischen U_0 bis U_1	2 V
U_1	$U_{48min,low,limited}$
ΔU_2 (Bereich $U_{48min,low,limited}$ bis 0 V)	0,5 V
U_2	0 V
t_0	mindestens 10 s und bis der Prüfling wieder eine 100%-Betriebsfähigkeit erreicht hat (alle Systeme sind wieder fehlerfrei hochgefahren)
t_1 – Prüfablauf 1	5 s
t_1 – Prüfablauf 2	100 ms
$t_{f/r}$	≤ 100 ms (gilt für alle Prüfimpulse)
Anzahl der Zyklen	1
Anzahl der Prüflinge	6



Requirements:
Functional status: **A** at reaching of U48min,unlimited
B up to 24 V, U 48min,low,limited + Requirements LV 124
C below 24 V U 48 min,low,limited

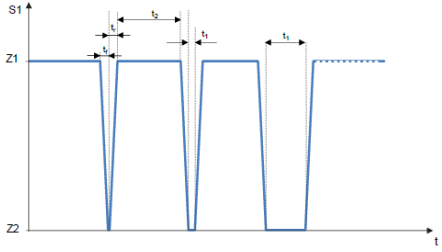
LV 124 vs. LV 148

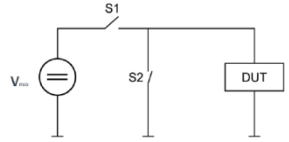
E10 Short interruptions

Aim: The component's behavior at short interruptions of different durations is simulated.

Test case 1 represents interruption of the supply voltage on the component.
Test case 2 represents interruption of the supply voltage in the electric system.
Such interruptions can occur due to events such as contact and line errors or bouncing relays.

DUT operating mode	Operating mode II.c	
V_{test}	11 V	
Z1	S1 closed	
Z2	S1 open	
t_r	≤(0,1 * t_1)	
t_f	≤(0,1 * t_1)	
Switch S1 must be switched with the following sequences:	t_1	Intervals
	10 µs to 100 µs	10 µs
	100 µs to 1 ms	100 µs
	1 ms to 10 ms	1 ms
	10 ms to 100 ms	10 ms
	100 ms to 2 s	100 ms
t_2	>10 s The test voltage V_{test} must be held at least until the DUT and the periphery have reached 100% operability again.	
Number of cycles	1	
Number of DUTs	At least 6	
Test case 1	S1 switched, S2 statically open	
Test case 2	S1 switched, S2 opposite S1	



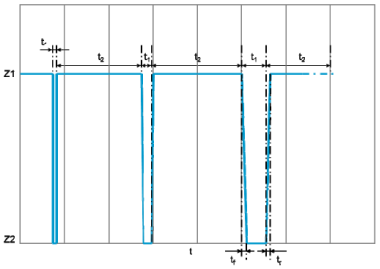


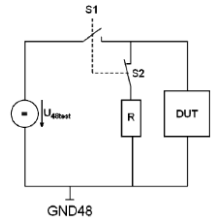
One reference measurement each with 100 Ω (±5%) and 1 Ω (±5%) as a DUT substitute must be performed and documented.

Requirements:
For t1 <100 µs: Functional status A
For t1 ≥100 µs: Functional status C
It must be documented as of which time value t1 the DUT leaves functional status A for the first time.

E48-09 Short interruptions

Betriebsart des Prüflings	Betriebsart II.c	
Prüfaufbau	Prinzipschaltung nach Abbildung 15. Die Bordnetznachbildung ist mit der Fachabteilung des Auftraggebers abzustimmen.	
R_i	≤ 60 mΩ inkl. Schalter S1	
R	≤ 100 mΩ Gesamtwiderstand inkl. Leitungsverlegung und Schalter S2	
Z1	S1 geschlossen und S2 offen	
Z2	S1 offen und S2 geschlossen	
U_{48test}	U_{48n}	
t_1	Die Versorgungsspannung wird von U_{48test} in variierenden Zeitabschnitten unterbrochen. Folgende Sequenz ist dafür einzuhalten	
	100 µs bis 1 ms	100 µs-Schritte
	1 ms bis 10 ms	1 ms-Schritte
	10 ms bis 100 ms	10 ms-Schritte
	100 ms bis 2 s	100 ms-Schritte
t_2	> 10 s Die Prüfspannung U_{48test} muss mindestens so lange gehalten werden, bis der Prüfling wieder eine 100%-Betriebsfähigkeit erreicht hat (alle Systeme sind wieder fehlerfrei hochgefahren).	
t_f	≤ 10 µs	
t_r	≤ 10 µs	
Anzahl der Zyklen	1	
Anzahl der Prüflinge	6	





One reference measurement each with 1 kΩ (± 5%) and 10 Ω (± 5%) as a DUT substitute must be performed and documented.

Requirements:
It must be noted, at which time t1 the DUT to **functional status A** leaves the first time. Functional status A : t1 ≤ 100 µs
Functional status C : t1 > 100 µs

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LV 124 vs. LV 148

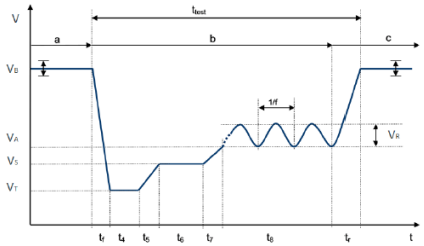
E11 Start impulses

Aim: When starting the engine, the battery voltage falls for a short period to a low value, and then again to rise slightly. The start process can happen under different vehicle start situations: To cover both cases at cold start and warm start two different test cases are required. A component has always to go through both test procedures.

DUT operating mode	Operating mode II.a, II.b, and II.c If necessary, additional operating loads must be defined in the respective operating mode.
Test pulse	- Cold start: "normal" and "severe" test pulse as per Table 23 - Hot start: "short" and "long" test pulse as per Table 24
Number of DUTs	At least 6

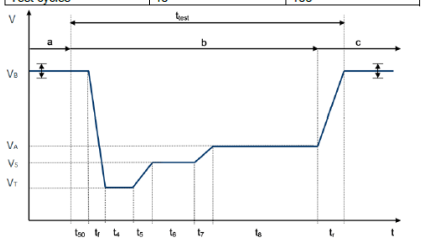
Test case 1 – Cold start

Parameter	"Normal" test pulse	"Severe" test pulse
V_B	11,0 V	11,0 V
V_T	4,5 V (0%, -4%)	3,2 V $^{+0,2\,V}$
V_S	4,5 V (0%, -4%)	5,0 V (0%, -4%)
V_A	6,5 V (0%, -4%)	6,0 V (0%, -4%)
V_R	2 V	2 V
t_f	≤1 ms	≤1 ms
t_4	0 ms	19 ms
t_5	0 ms	≤1 ms
t_6	19 ms	329 ms
t_7	50 ms	50 ms
t_8	10 s	10 s
t_r	100 ms	100 ms
f	2 Hz	2 Hz
Break between two cycles	2 s	2 s
Test cycles	10	10



Test case 2 – Hot start

Parameters	"Short" test sequence	"Long" test sequence
V_B	11,0 V	
V_T	7,0 V (0%, -4%)	
V_S	8,0 V (0%, -4%)	
V_A	9,0 V (0%, -4%)	
t_{50}	≥10 ms	
t_f	≤1 ms	
t_4	15 ms	
t_5	70 ms	
t_6	240 ms	
t_7	70 ms	
t_8	600 ms	
t_r	≤1 ms	
Break between two cycles	5 s	20 s
Test cycles	10	100

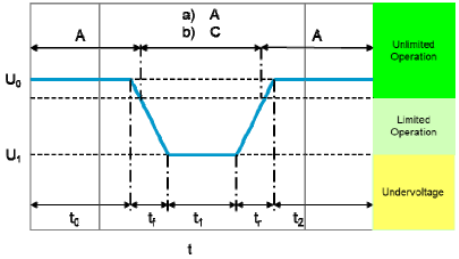


Requirements:
Components relevant for starting:
Test case 1 – Cold start: "Normal" test pulse: functional status A;"Severe" test pulse: functional status B
Test case 2 – Hot start: "Long" test sequence: functional status A;"Short" test sequence: functional status A
Components not relevant to starting:
Test case 1 – Cold start: "Normal" test pulse: functional status C;"Severe" test pulse: functional status C
Test case 2 – Hot start: "Long" test sequence: functional status A;"Short" test sequence: functional status A

E48-10 Start impulses

Aim: During a **cold start** (motor start), the energy storage battery voltage decreases for a short, then increases again. The warm start is not considered, because the operating range is maintained

Betriebsart des Prüflings	a) Für startrelevante Komponenten: Betriebsart II.c b) Für nicht startrelevante Komponenten: Betriebsart II.b
Prüfimpuls	Prüfimpuls „normal" und „scharf"
U_0	U_{48n} für Kaltstart normal 40 V für Kaltstart scharf
U_1	$U_{48min,low,limited}$
t_0	2 s
t_f	1 ms
t_1	1 s
t_r	1 ms
t_2	2 s
Anzahl der Zyklen	10
Anzahl der Prüflinge	6



Requirements:
Functional status: **A** for start relevant components
Functional status: **B** for not start relevant components

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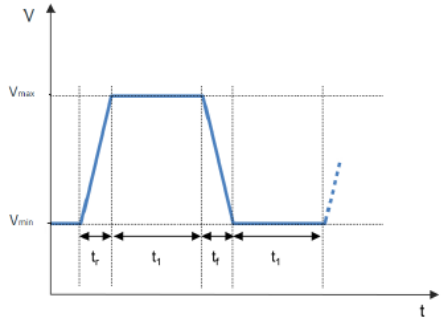
E12 Voltage curve with electric system control

Aim: The behavior of the electric system with voltage controls, e.g., with the use of intelligent generator controls or DC-DC converter controls, is simulated.

DUT operating mode	Operating mode II.c
V_{min}	(11,8 V - ΔV) (0%, -4%)
V_{max}	(15 V - ΔV) (+4%, 0%)
t_1	2 s
t_r	≥300 ms
t_f	≥300 ms
Number of cycles	10
Number of DUTs	At least 6
Test case 1	
ΔU	0 V
Test case 2	
ΔV	0,7 V
Test case 3	
ΔV	2 V

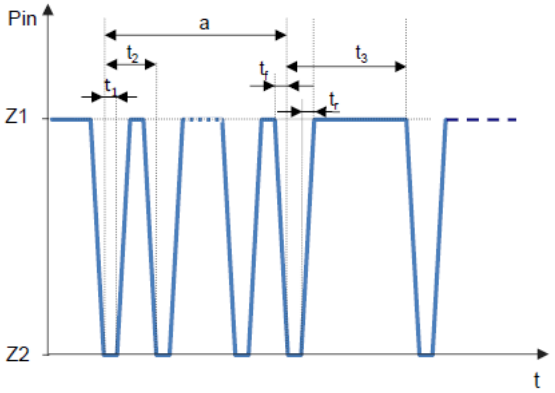


Requirements:
Functional status A

E13 Pin interruption

Aim: The supply line interruption of individual pins is simulated. The test must be performed in two different operating states. Different pulse forms must be used, because the possible interruptions may differ greatly regarding their duration (from loose contacts to permanent interruption).

DUT operating mode	Operating mode II.a and II.c Must be performed for all relevant statuses of the voltage supply terminals (e.g., T.15, T.30, T.87) and their combinations.
Z1	Condition 1: pin connected
Z2	Condition 2: pin interrupted
t_r	≤(0,1 * t_1)
t_f	≤(0,1 * t_1)
Number of cycles	The following applies to the two test cases and the relevant terminal status: 3 cycles with operating mode II.a 3 cycles with operating mode II.c Each test must be evaluated separately.
Number of DUTs	At least 6
Test case 1	
	Each pin must be removed for t = 10 s and then replaced (slow interval).
Test case 2	
	Burst on each pin in order to simulate a loose contact (Figure 16)
Number of pulses t_2 in the burst	4 000
a	Burst
t_1	0,1 ms
t_2	1 ms
t_3	10 s



The component is connected to the voltage supply.
The test must not be performed on the supply pins.The test must also be performed on ground pins.
One reference measurement each with 1 kΩ (±5%) and 1 Ω (±5%) as a DUT substitute must be performed and documented.

Requirements:
Functional status C

E14 Connector interruption

Aim: The line interruption of connectors is simulated

DUT operating mode	Operating mode II.a and II.c
Number of cycles	Each connector must be removed once in both operating modes.
Number of DUTs	At least 6

Each connector must be removed from the DUT for 10 s and then replaced. If the DUT has several connectors, each connector must be tested individually. The test sequence must be variable. If there are several connectors, their combinations must also be tested.

Requirements:
Functional status C

LV 124 vs. LV 148

E15 Reverse polarity

Aim: The resistance of the DUT against reverse-polarity battery connection during jump starting is simulated. Reverse polarity can occur several times and must not cause damage to the component. Reverse polarity protection must be ensured for any voltages down to the minimum test voltage. The vehicle fuse is not part of the reverse polarity protection concept.

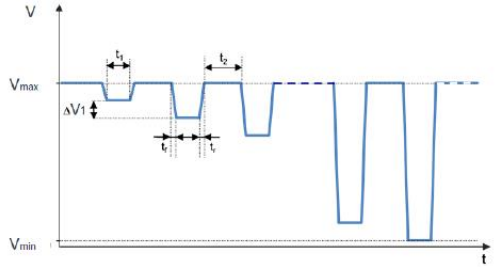
DUT operating mode	Operating mode II.a
Test case 1	Static reverse polarity as per Table 29
Test case 2	Dynamic reverse polarity as per Table 30
Number of DUTs	At least 6

All relevant connections of the original circuitry must be tested. The DUT must be addressed in the same way as it is in the vehicle circuit. The test must be performed at various voltages between 0 V and the maximum values specified below:

Test case 1 – Static reverse polarity

This test case checks the robustness of the component at various reverse polarityvoltages that can arise depending on the vehicle state

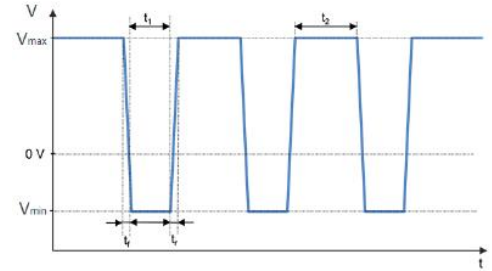
V_{max}	0 V
V_{min}	-14,0 V
ΔV_1	-1 V
Severity 1	R_i <100 mΩ
Severity 2	R_i <30 mΩ
t_1	60 s For a component for which the operating voltage is switched off by a relay in the event of reverse polarity, the following deviating value applies: 8 ms
t_2	≥60 s, but at least until the component has reached the same thermal state as at the beginning of the test
t_r	≤10 ms
t_f	≤10 ms
Number of cycles	1



Test case 2 – Dynamic reverse polarity

This test case checks the reverse polarity of the component during operation in a vehicle that is no longer capable of starting.

V_{max}	10,8 V
V_{min}	-4,0 V
Severity 1	R_i <100 mΩ
Severity 2	R_i <30 mΩ
t_1	60 s For a component for which the operating voltage is switched off by a relay in the event of reverse polarity, the following deviating value applies: 8 ms
t_2	≤5 min
t_r	≤10 ms
t_f	≤10 ms
Number of cycles	3



Requirements:

When reverse polarity is applied, no safety-relevant functions must be triggered, e.g., for electric window lifts, electric sunroof, starter.
Functional status C

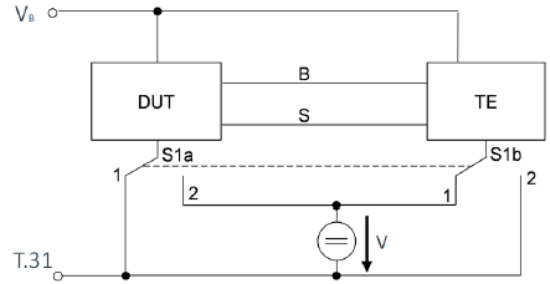
LV 124 vs. LV 148

E16 Ground offset

Aim: Potential differences between various ground connection locations can cause signal distortions between components at these connection locations**.** It must be ensured that potential differences between ground points up to a magnitude of ±1 V (static) in the electrical assembly do not affect component functions.

If the DUT has several voltage and ground connections, the test must be performed individually for each connection point.

DUT operating mode	Operating mode II.c
V	1 V
Number of cycles	Both switching positions
Number of DUTs	At least 6



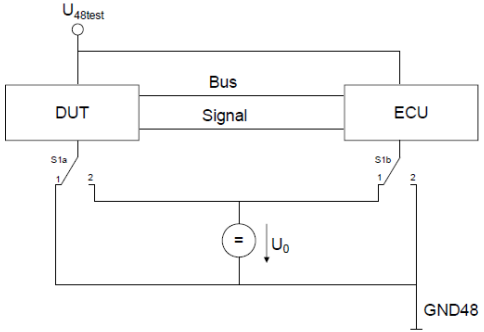
Legend
B Bus system
S Signal line
S1 Two-pin (a/b) change-over switch
TE Other component, e.g., test reference, test bed, simulation electronic control unit, actuator, sensor, or load

Requirements:
Functional status A

E48-12 Ground offset

If the DUT has several voltage and ground connections for the BN48, the test shall be carried out separately for each connection point. In general, a mass offset of ± 1.0 V is to be provided in the interface dimensioning between two components.

Betriebsart des Prüflings	Betriebsart II.c
U_{48test}	U_{48n}
U_0	1,0 V
Anzahl der Zyklen	beide Schaltpositionen
Anzahl der Prüflinge	mindestens 6



Requirements:
Functional status: A

LV 124 vs. LV 148

E17 Short circuit in signal circuit and load circuits

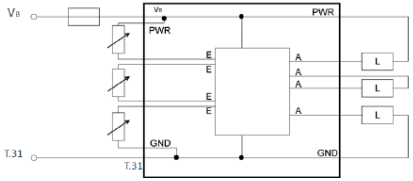
Aim: Short circuits on all device inputs and outputs and in the load circuit are simulated. All inputs and outputs must be short-circuit-proof to +VB and GND (for activated and non-activated outputs with and without voltage supply and with and without ground connection). The component must able to withstand a permanent short circuit.

If the voltage supply/ground supply is provided via several pins, combinations must also be taken into account.

DUT operating mode	Operating mode II.c
Test duration	Short circuit of each pin individually for 60 s to ground and to V_B
Test voltages	V_{Bmin} and V_{Bmax}
Test case 1	Each pin alternately to V_B and GND with voltage supply and with ground connection
Test case 2	Each pin alternately to V_B and GND without voltage supply and with ground connection
Test case 3	Each pin alternately to V_B and GND with voltage supply and without ground connection
Number of DUTs	At least 6

Test setup

The power supply unit used for the test must be able to supply the short-circuit currents to be expected by the component. If this is not possible, buffering of the power supply unit by means of a car battery is permissible (VBmax is the maximum charging voltage in this case).



Legend

L	Load
E	Input
A	Output
PWR	Output V_B
GND	Input/output T.31

Requirements:

For inputs and outputs: record and evaluate the curve of the short-circuit current over time.
For inputs and outputs (E and A): functional status C
For looped-through supply voltages (PWR): functional status D
For device ground (GND): functional status E

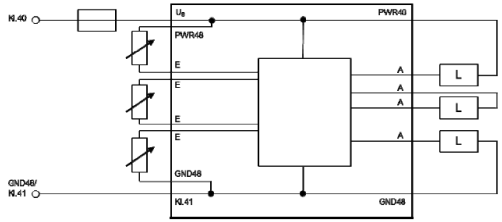
E48-21 Short circuit in signal circuit and load circuits

Aim: Short circuits are tested at all BN48 device inputs and outputs as well as in the BN48 load circuit. There is no test against the possibly existing BN12 / BN24 part. All BN48 inputs and outputs must be short-circuit-proof against the test voltage and GND48. The following tests shall be carried out:

- with activated and not activated outputs
- in the absence of power supply
- if the mass is missing

Betriebsart des Prüflings	Betriebsart II.c
Dauer der Prüfung	Kurzschluss jedes BN48 Pins einzeln für 60 s jeweils auf Prüfspannung und GND48
Prüfspannung	$U_{48max,unlimited}$ und $U_{48min,unlimited}$
Prüfaufbau	Das verwendete Netzteil zur Prüfung muss die von der Komponente zu erwartenden Kurzschlussströme liefern können.
Anzahl der Zyklen	Jeder Pin einmal gegen die Prüfspannung/Kl.40 und einmal gegen GND48/ Kl.41
Anzahl der Prüflinge	6

Test setup



Legende

L	Last
E	Eingang
A	Ausgang
PWR48	Ausgang U_B/Kl.40
GND48	Eingangs/Ausgang Kl.41
U_B	BN48 Versorgung des DUT

Requirements:

For inputs and outputs (E and A): Function C
For supply voltages (PWR48): Functional state D
For device ground (GND48): Functional state E

E18 Insulation resistance

Aim: The insulation resistance between parts without galvanic connection is determined. Only the galvanically isolated pins that are connected in the vehicle and that required isolation properties for their function are examined.

DUT operating mode	Operating mode I.a
Test voltage	500 V DC
Test duration	60 s
Test points	Application of the test voltage - To terminals without galvanic connection. - Between connection pins and conducting housing without galvanic connection. - Between connection pins and an electrode around the housing if the housing is non-conducting. – To further test points coordinated with the appropriate department.
Number of cycles	1 cycle must be performed, in which each of the points defined above must be tested at least once.
Number of DUTs	At least 6

For preparation, the DUTs must undergo the "damp heat, cyclic" test, which must be agreed upon with the purchaser. Before the measurement, the DUTs must be allowed to dry for 30 minutes.

Requirements:
The insulation resistance must be at least 10 MΩ.
After the test, functional status A must be verified.

E19 Closed-circuit current

Aim: The closed-circuit current consumption must be determined.

For components with an after-run function (e.g., fan), the closed-circuit current consumption must be determined after this function has ended.
The component must be measured with the associated periphery and circuitry.

DUT operating mode	Operating mode II.a
Test voltage	12,5 V (+4%, 0%)
Number of DUTs	At least 6
Test case 1	
T	T_{min}
Test case 2	
T	T_{RT}
Test case 3	
T	T_{max}

Requirements:
The closed-circuit current consumption target for any DUT must be 0 mA.
For DUTs that must be operated after T.15 OFF, a closed-circuit current equivalent (average over 12 h) of ≤0,1 mA corresponding to 1,2 mAh (above +40 °C ≤0,2 mA) applies in the idle phase. This must be complied with under any conceivable at-rest conditions of the vehicle and at any 12 h period. Otherwise, release by the department responsible for closed-circuit current management is required.

LV 124 vs. LV 148

E19 Closed-circuit current

DUT operating mode	Operating mode II.a
Test voltage	12,5 V (+4%, 0%)
Number of DUTs	At least 6
Test case 1	
T	T_{min}
Test case 2	
T	T_{RT}
Test case 3	
T	T_{max}

Requirements:
The closed-circuit current consumption target for any DUT must be 0 mA.
For DUTs that must be operated after T.15 OFF, a closed-circuit current equivalent (average over 12 h) of ≤0,1 mA corresponding to 1,2 mAh (above +40 °C ≤0,2 mA) applies in the idle phase. This must be complied with under any conceivable at-rest conditions of the vehicle and at any 12 h period. Otherwise, release by the department responsible for closed-circuit current management is required.

E48-14 Closed-circuit current

Aim: The closed-circuit current consumption must be determined.

For components with an after-run function (e.g., fan), the closed-circuit current consumption must be determined after this function has ended.
The component must be measured with the associated periphery and circuitry.

Betriebsart des Prüflings	Betriebsart II.a	
U_{48test}	U_{48n}	
Prüfbedingung	Temperaturbereich	Max. Ruhestrom
	T_{min} bis 40 °C	0,1 mA
	40 °C bis T_{max}	0,2 mA
T_{test}	T_{min}, T_{RT} und T_{max}	
Anzahl der Prüflinge	6	

Requirements:
The closed-circuit current consumption target for any DUT must be 0 mA.

E20 Dielectric strength

Aim: The dielectric strength between parts of the DUT that are galvanically isolated from each other, e.g., connector pins, relays, windings, or lines, is simulated. The test must be performed on components that contain or control inductive parts.

For preparation, the DUTs must undergo the "damp heat, cyclic" test. Before the measurement, the DUTs must be allowed to dry for 30 minutes.

DUT operating mode	Operating mode II.a
Test voltage V_{eff}	500 V AC, 50 Hz, sinusoidal
Test duration	60 s
Test points	Application of the test voltage - To terminals without galvanic connection. - Between connection pins and conducting housing without galvanic connection. - Between connection pins and an electrode around the housing if the housing is non-conducting. - To further test points coordinated with the appropriate department.
Number of cycles	1 cycle must be performed, in which each of the points defined above must be tested at least once.
Number of DUTs	At least 6

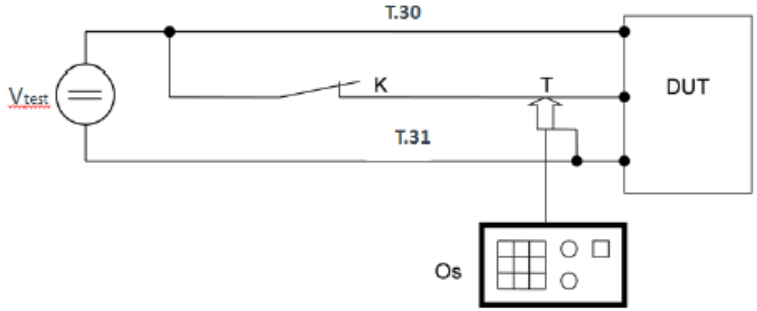
Requirements:
Functional status C
Dielectric breakdowns and electric arcs are not permissible.

E21 Backfeeds

Aim: The behavior of the DUT on T.15 and all other lines that can be used as wake-up lines in the electric system is simulated. This test must be performed for all components connected to T.15 and/or other "wakeable" lines.

The DUT must be connected according to the circuitry in the vehicle (including sensors, actuators, etc.) and operated in normal operation. The voltage curve at the terminal to be tested must be measured during switch-off of the terminal. The terminal must be switched off, e.g., by means of a relay or a switch (Ropen_switch→∞). Other possible voltage sources such as T.30 must not be interrupted or switched off during the test (in accordance with the behavior in the vehicle). Other resistors on the terminal to be tested are not permitted for this test.
The voltage curve at the terminal to be tested must be examined with an external resistance of ≥10 MΩ (e.g., oscilloscope) to T.31.

DUT operating mode	Operating mode II.c
V_{test}	V_{Bmax} – 0,2 V
Test temperatures	T_{Bmax}, T_{RT} and T_{Bmin}
Number of DUTs	At least 6



Requirements:
Backfeed to the terminal to be tested is permissible only up to a maximum level of 1 V.
This voltage range must be achieved within t = 20 ms after cutoff.
The voltage on the unconnected terminal to be tested must drop below a voltage of 1 V within t = 20 ms from the time of the switch-off.
The voltage curve over time must continuously fall. A discontinuity of the curve due to positive pulses is not permitted.

Legend

T	Scanner head
Os	Oscilloscope
K	Terminal to be tested

E22 Overcurrents

Aim: The overcurrent protection of mechanical switches, electronic outputs and contacts is tested. Higher currents than in the normal load case (e.g., maximum blocking current Iblock of a motor) must also be considered.

DUT operating mode	Operating mode II.c
Temperature	T_{max}
Test conditions for electronic outputs	The output must withstand at least the triple value of the nominal load without damage. Load duration 30 min
Test conditions for switched outputs	For components with $I_N \leq 10$ A: $I_{test} = 3 \times I_N$ For components with $I_N > 10$ A: $I_{test} = 2 \times I_N$, but at least 30 A and at most 150 A For components with $I_{block} > 3 \times I_N$: $I_{test} = I_{block}$ Under load, switch "OFF," "ON," and "OFF" again once. Load duration 10 min Each contact must be tested individually in the case of multiple-contact relays and multiple-contact switches.
Number of DUTs	At least 6

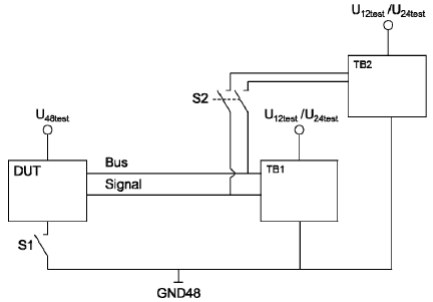
Requirements:
Functional status A for mechanical components without fuse. If fuse elements are available in the load circuit, these may be triggered.
Functional status C for electronic outputs with overload detection (current, voltage, temperature).

LV 124 vs. LV 148

E48-11 Mass loss on BN48

Aim: The test simulates a mass loss of a BN48 component which is exclusively supplied by BN48 and has interfaces to BN12 / BN24 components (eg CAN / LIN / FlexRay bus or other analog or digital signal lines). It must be ensured that the mass loss of the BN48 component does not interfere with the other BN12 / BN24 communication users (eg due to excessive voltages or polarity reversal). Furthermore, it must be ensured that the mass loss does not have any destructive effect on any component.

Betriebsart des Prüflings	Betriebsart II.c
t_{test}	siehe Prüfungen
U_{48test}	U_{48n}
T_{test}	T_{max} - 20 °C
Anzahl der Zyklen je Prüfung	1
Anzahl der Prüflinge	6



Test case 1
S1 closed
S2 closed
All components DUT / TB1 / TB2 work without errors.
S2 is opened.

Requirements:
There must be errors in TB1 and TB2:
- TB1: Bus communication with TB2 is interrupted
- TB2: Bus communication interrupted with TB1
- TB2: Signal lines interrupted
No error in DUT - functional state A.

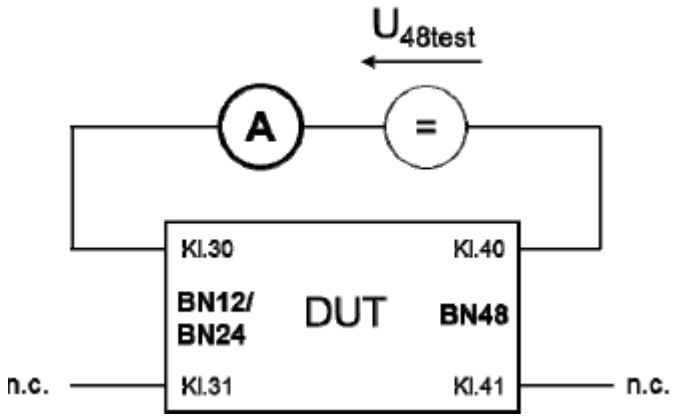
Test case 2
S1 closed.
S2 closed.
All components DUT / TB1 / TB2 work without errors.
S1 is opened.
The test takes 30 minutes after opening S1.

Requirements:
In TB1 and TB2, no voltages may exceed the defined interface voltages and no currents above the defined interface current may occur. This applies to all bus and signal lines.
Bus communication: The bus communication between TB1 and TB2 works error-free - no error in the error memory.
Signal line:
Case distinction
A) DUT reads this line, that is, TB1 is the transmitter.
Requirement: No error entry in TB1 and TB2.
B) DUT is the transmitter.
Requirement: Incorrect entry in TB1 and TB2 due to loss of the signal.

E48-13 Internal dielectric strength

Aim: The stationary internal voltage strength between BN48 pins and BN12 / BN24 pins is determined if both voltages are used in one component.

Betriebsart des Prüflings	Betriebsart I.a
U_{48test}	$U_{48r,dyn}$
t_{test}	60 min
F_{rel}	50 %
T_{test}	35 °C
Prüfpunkte	Anlegen der Prüfspannung zwischen – beiden Versorgungsanschlüssen – weiteren, mit der jeweiligen Fachabteilung des Auftraggebers abgestimmten, Prüfpunkten siehe Abbildung 19
Anzahl der Zyklen	1
Anzahl der Prüflinge	6

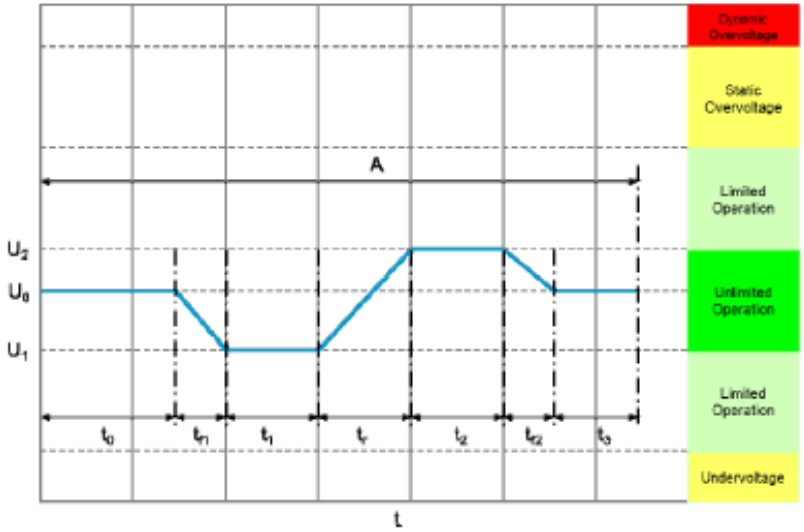


Requirements:
The resistance resulting from the required voltage strength must be at least 1 MΩ. Proof that no damage to the test specimen has occurred is to be provided.
After the test, the functional state A is to be verified.

E48-15 Operation in the range without function restriction

Aim: The operating behavior at the range limits is checked.

Betriebsart des Prüflings	Betriebsart II.c
U_0	U_{48n}
U_1	$U_{48min,unlimited}$
U_2	$U_{48max,unlimited}$
t_0	100 ms
t_{f1}	1 ms
t_1	1 s
t_r	1 s
t_2	10 s
t_{f2}	1 s
t_3	100 ms
T_{test}	T_{max}, T_{RT} und T_{min}
Anzahl der Zyklen	10
Anzahl der Prüflinge	6



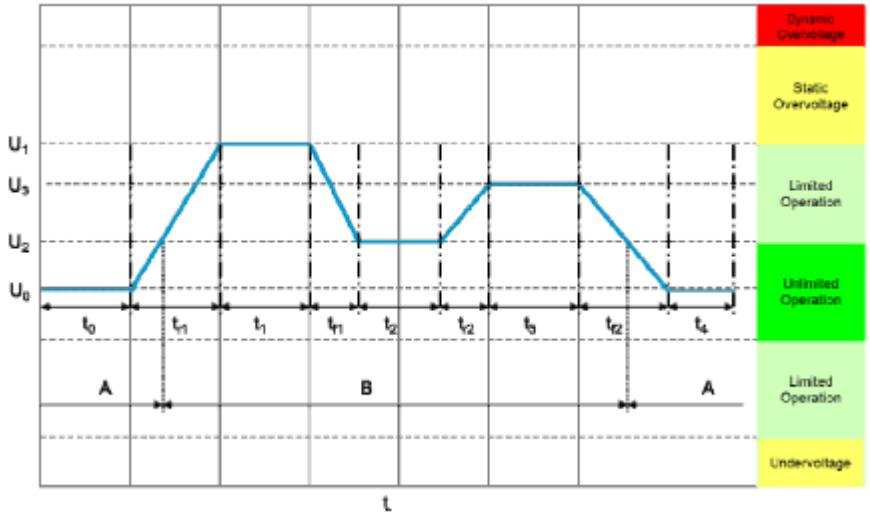
Requirements:
Functional state A

LV 124 vs. LV 148

E48-16 Operation in the upper range with function limitation

Aim: The operating behavior with change and at the range limits is checked.

Betriebsart des Prüflings	Betriebsart II.c
U_0	U_{48n}
U_1	$U_{48max,high,limited}$
U_2	$U_{48max,unlimited}$
U_3	$U_{48max,unlimited}$ + 1 V
t_0	100 ms
t_{r1}	4 s
t_1	10 s
t_{f1}	2 s
t_2	10 s
t_{r2}	2 s
t_3	10 s
t_{f2}	2 s
t_4	100 ms
T_{test}	T_{max}, T_{RT} und T_{min}
Anzahl der Zyklen	10
Anzahl der Prüflinge	6

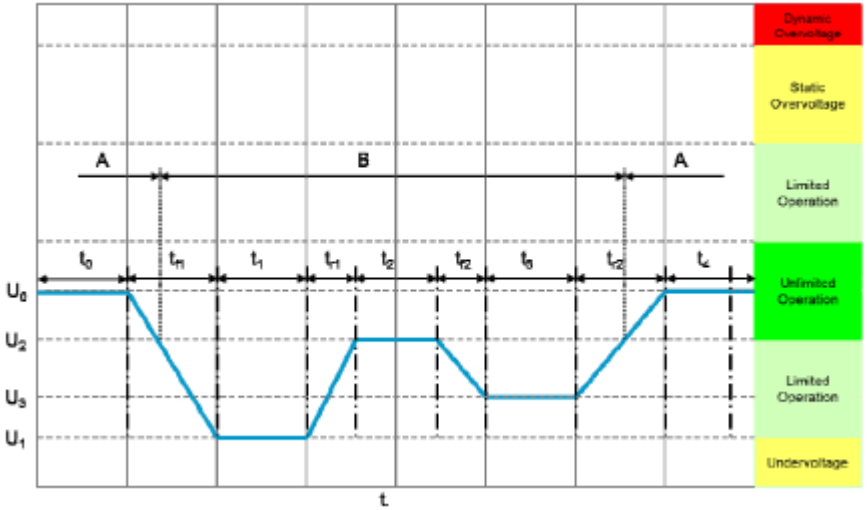


Requirements:
See illustration.
No error is stored in the error memory.

E48-17 Operation in the lower range with function limitation

Aim: The operating behavior with change and at the range limits is checked.

Betriebsart des Prüflings	Betriebsart II.c
U_0	U_{48n}
U_1	$U_{48min,low,limited}$
U_2	$U_{48min,unlimited}$
U_3	$U_{48min,low,limited}$ + 1 V
t_0	100 ms
t_{f1}	2 s
t_1	10 s
t_{r1}	4 s
t_2	10 s
t_{f2}	2 s
t_3	10 s
t_{r2}	2 s
t_4	100 ms
T_{test}	T_{max}, T_{RT} und T_{min}
Anzahl der Zyklen	10
Anzahl der Prüflinge	6



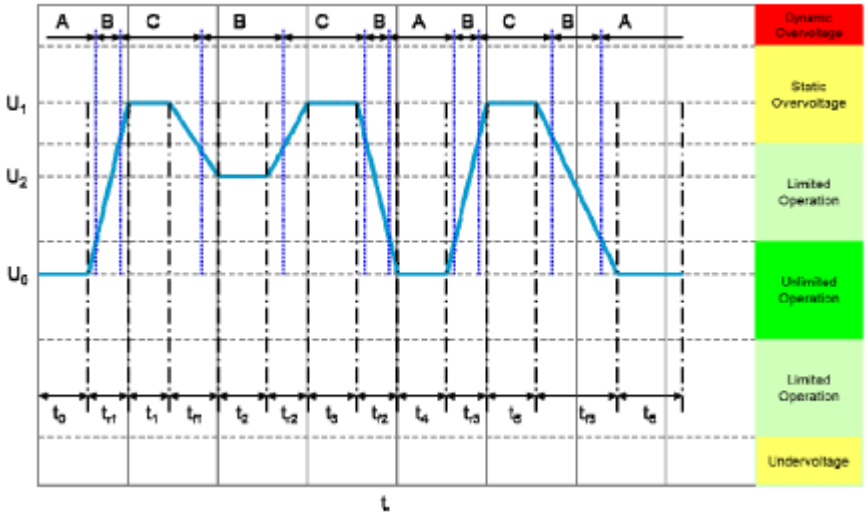
Requirements:
See illustration.
No error is stored in the error memory.

LV 124 vs. LV 148

E48-18 Overvoltage range

Aim: The test is to show the load cut-off during storage charging and check the changes of the operating behavior into the overvoltage range.

Betriebsart des Prüflings	Betriebsart II.c
U_0	U_{48n}
U_1	U_{48r}
U_2	$U_{48max,unlimited}$ + 1 V
t_0	100 ms
t_{r1}	10 ms
t_1	1 s
t_{f1}	1 s
t_2	10 s
t_{r2}	1 ms
t_3	2 s
t_{f2}	1 s
t_4	5 s
t_{r3}	10 s
t_5	2 s
t_{f3}	10 s
t_6	100 ms
T_{test}	T_{max}, T_{RT} und T_{min}
Anzahl der Zyklen	10
Anzahl der Prüflinge	6



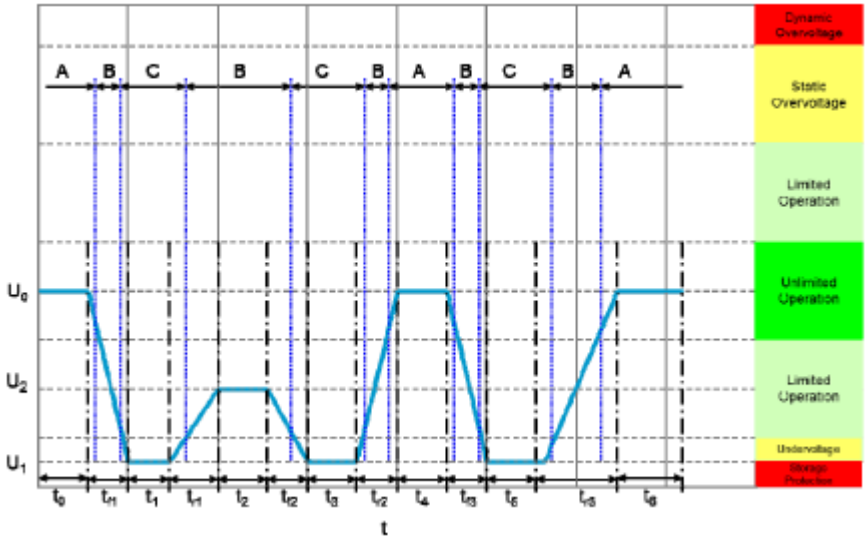
Requirements:
See illustration.

LV 124 vs. LV 148

E48-19 Undervoltage range

Aim: The changes of the operating behavior down to the undervoltage range are checked.

Betriebsart des Prüflings	Betriebsart II.c
U_0	U_{48n}
U_1	$U_{48stoprotect}$
U_2	$U_{48min,low,limited}$ + 6 V
t_0	100 ms
t_{f1}	1 s
t_1	1 s
t_{r1}	10 ms
t_2	10 s
t_{f2}	1 s
t_3	2 s
t_{r2}	1 ms
t_4	5 s
t_{f3}	10 s
t_5	2 s
t_{r3}	10 s
t_6	100 ms
T_{test}	T_{max}, T_{RT} und T_{min}
Anzahl der Zyklen	10
Anzahl der Prüflinge	6



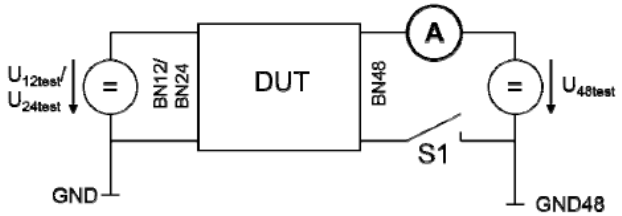
Requirements:
See illustration.

LV 124 vs. LV 148

Aim Part 1: The fault current resistance of a component with connection to both wiring systems (BN12 / BN24 and BN48) is checked and thus the immunity to interference against other components.

The component to be tested (DUT) is connected to a test stand as shown in the figure. Switch S1 is open (KL 41 is disconnected). KL40 is supplied (the behavior is tested at two different voltages). The BN12 / BN24 part of the component is supplied. The current flowing through the KL40 of the component is to be measured.

Betriebsart des Prüflings	II.a
Prüfaufbau	siehe Abbildung 25
U_{48test}	a) U_{48n}
	b) $U_{48r,dyn}$
t_{test}	10 min
T_{test}	T_{RT}
Anzahl der Zyklen	1
Anzahl der Prüflinge	6



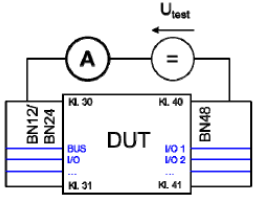
Requirements:
The following applies to the current on the supply voltage KL40: $|I| \leq 1\ \mu A$

E48-20a Fault current

Aim Part 2: The fault current resistance of a component with connection to both wiring systems (BN12 / BN24 and BN48) is checked.

The component to be tested (DUT) is placed on a test bench as shown in the figure. All BN12 / BN24 contacts (supply and communication) are interconnected (short-circuit). All BN48 contacts (supply) are connected to each other (short-circuit). A test voltage from Utest is applied between BN48 and BN12 / BN24. The current, which flows through the component, is to be measured.

Prüfaufbau	siehe Abbildung 26
U_{test}	70 V
t_{test}	10 min
T_{test}	T_{RT}
Anzahl der Zyklen	1
Anzahl der Prüflinge	6



Requirements:
The following applies to the current between BN12 / BN24 and BN48: $|I| \leq 1\ \mu A$

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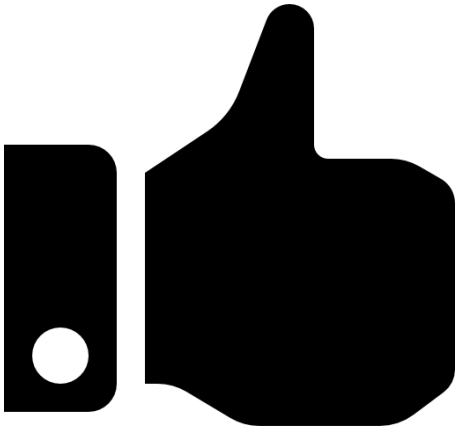

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