VOLKSWAGEN AG	Electromagnetic Compatibility of Automotive Electronic Components Conducted Interference	TL 82066
Konzernnorm		

Descriptors: electric component, electronic component, line, interference, EMC, conducted interference, line fault

Contents

Changes

The following changes have been made as compared to Technical Supply Specification TL 82066, 2004-10:

- In order to comply with the EC directive 2004/104/EC, the test voltages are intensified,
  - for 12 V power supply systems, pulse 2, from +50 V to +75 V
  - for 24 V power supply systems, pulses 1 to 3, from +75 V and -150 V to +150 V and -450 V.
- The pulses 4 and 4b are tested within the framework of VW 80101 and are no longer defined within the framework of this Technical Supply Specification.
- The definitions of the functional states A – D have been adapted according to DIN/ISO standards.

Previous issues

1982-05, 1983-02, 1984-03, 1992-11, 1993-09, 1994-09, 1995-06, 1997-05, 2001-09, 2004-10

1 Scope

This Technical Supply Specification TL 82066 includes requirements and tests for determining the electromagnetic compatibility (EMC) of electronic components with respect to interferences due to the vehicle power supply system. These interferences are caused by electric and electronic components and affect power supply lines as well as signal and sensor lines that are directly or indirectly galvanically connected to the power supply lines (via switch or relay contacts or valves/actuators/sensors, for example). Component-related requirements (pulses) are specified in the respective drawings or in the Technical Supply Specification.

2 Definitions

2.1 Vehicle power supply system

The vehicle power supply system is the electrical circuitry present in a motor vehicle to provide electrical power, including the attached battery and generator with regulator.

Fachverantwortung/Technical responsibility	Normung/Standards (E2TC, 1733)
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2.2 Supply voltage

The voltage measured at any arbitrarily chosen pair of terminals on the power supply system; one terminal may also be a ground connection.

2.3 Nominal voltage of the power supply system

The nominal voltage of the power supply system is specified in order to achieve independence from the battery technology.

2.4 Disturbance

Disturbance is the electromagnetic quantity causing an undesirable effect in electronic equipment.

NOTE: Disturbance serves as a generic term for such terms as "disturbance voltage," "interference current," "interference signal," and "interference energy".

2.4.1 Interference source

The origin of disturbances, i.e. electrical equipment in vehicles.

2.4.2 Interference sink

Electrical equipment in the vehicle, the function of which can be influenced by disturbances.

2.4.3 Interference emission

Disturbance emitted by an interference source.

2.4.4 Interference immunity

Ability of electrical equipment to withstand disturbances of given values without malfunctioning.

2.5 Steady condition

This is the condition occurring after the switch-on procedure and the condition in which the values of electric quantities basically remain constant.

2.6 Ripple

More or less regular changes in voltage around the voltage level that arises in the system in the steady condition.

Transitional processes are excluded and so are frequencies below 10 Hz, except during starting.

2.7 Ripple magnitude

The maximum changes in voltage caused by rippling over or below the average level are termed upper or lower amplitude. Ripple from amplitude to amplitude is defined by the maximum distance between the upper and lower amplitude.

2.8 Transitional process of supply voltage

Temporary increase or decrease of the supply voltage caused by rapid changes in load.

2.9 Peak

Transitional process, during which the height of the ripple amplitude is exceeded for less than 150 µs. Generally, there is an oscillating peak as a result of high-frequency currents caused by sudden load changes. The duration of a decreasing oscillation is according to definition shorter than 1/20 of the interval between a sequence of two peaks. Thus, decreasing oscillation exceeding this value shall be regarded as ripple. Frequent causes for decreasing oscillations are for instance ignition systems or rectifiers located at the output of generators.

2.10 Peak energy

This is the energy to be absorbed if a peak is attenuated to given voltage values with the aid of a load that is connected to the interference sink terminals. With this load the voltage shall be attenuated to a specified value for positive current and to zero value for negative current.

2.11 Peak power

Energy per unit time for decreasing peaks.

2.12 Single pulse

A single pulse is a non-oscillating transitional process, singularly and infrequently occurring, with a duration considered long compared to 150 µs, lying outside the ripple amplitude.

2.12.1 Height of single pulse (U, I)

Maximum height exceeding the ripple amplitude.

2.12.2 Duration of single pulse (t_d)

Time interval between rise of the pulse over 10% of the amplitude and subsequent decrease below this value.

2.12.3 Rise time (t_r) and fall time (t_f)

The time interval that it will take the value to rise from 10% to 90% of the amplitude, or that it will take the value to fall from 90% to 10% of the amplitude respectively.

2.12.4 Pulse repetition frequency

Number of pulses per unit time.

2.12.5 Pulse interval

Time interval between the end of one pulse and the start of the following pulse.

2.13 Return time

Interval between the state in which the voltage increases above its normal value due to a transitional process and the point in time at which the voltage drops back to its original value and stays there.

2.14 Interferences during starting

Voltage drop below the normal level, caused by switching on and turning the starter. For engaging generators this interference generally includes an initial single pulse when switching the starter on and a state when turning the starter.

3 Test equipment

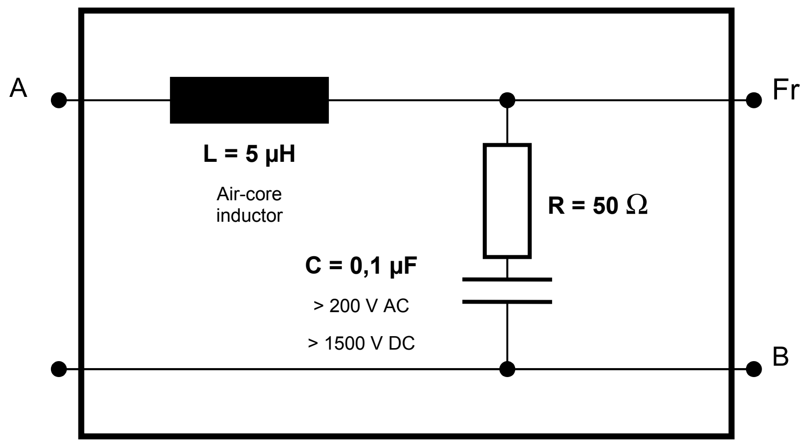
3.1 Artificial network for 12-V, 24-V, 42-V vehicle power supply systems

The artificial network is used to simulate the average impedance of the vehicle power supply circuitry in order to evaluate the behavior of equipment and electrical/electronic components under bench test conditions.

A schematic diagram is shown in Figure 1. Figure 2 shows how the impedance of the artificial network changes as a function of frequency.

Direct current voltage drop at maximum load shall not exceed 250 mV.

NOTE: The artificial network is defined for measuring peaks rather than ripple and single pulses.



Legend
A Power supply terminal
B Reference ground terminal
P DUT connection

Fig. 1 – Schematic diagram of artificial network

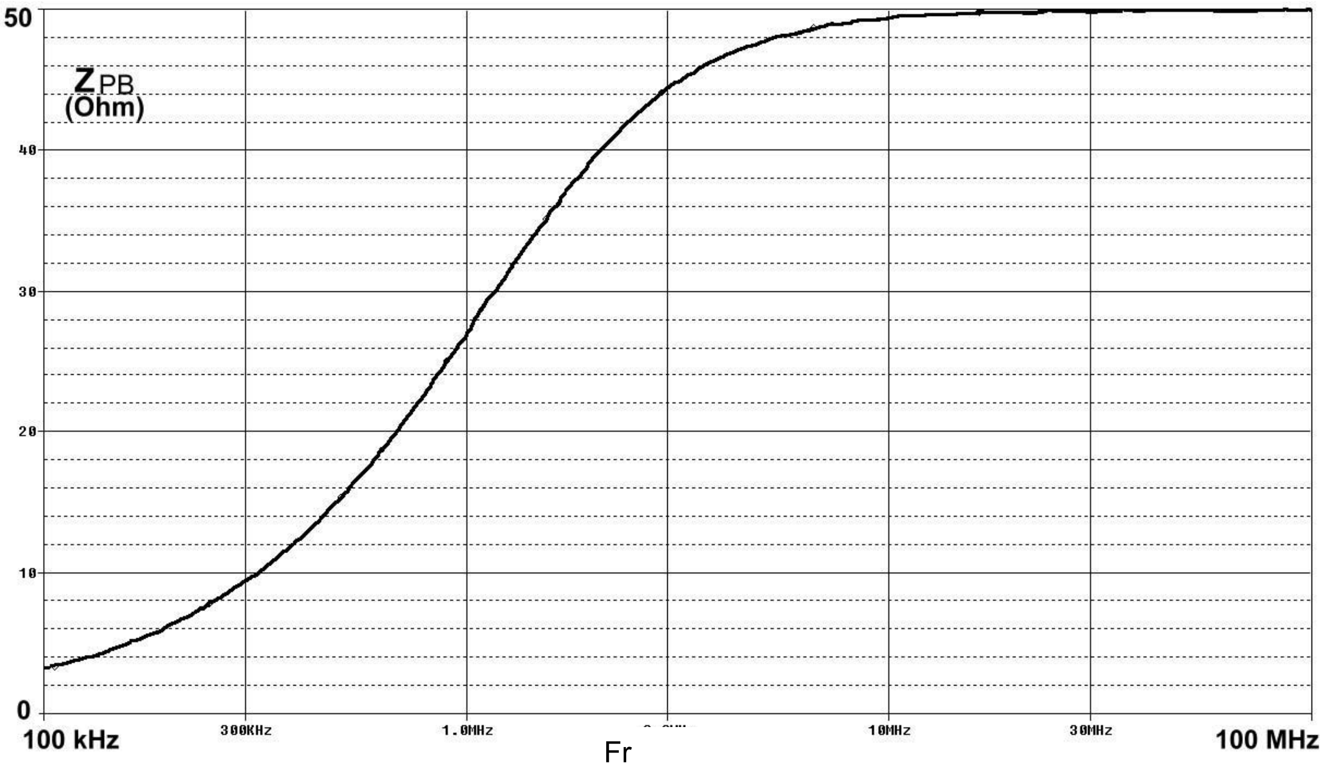


Fig. 2 – Impedance Z_{PB} (Ω) of artificial network as a function of frequency

As seen from the DUT side (between terminals P and B).

Tolerance ± 10 %; terminals A and B are short-circuited.

3.2 Voltage test equipment

Oscilloscope:

Bandwidth	min. 400 MHz
Writing time division	min. 5 ns/div

Scanner head:

Division ratio	min. 10/1
Permissible input voltage	min. 1 kV
Length of connecting line	max. 150 cm
Length of ground line	max. 10 cm

NOTE: Differing line lengths may affect the measuring result; they shall be documented in the report.

3.3 Circuit breaker

For measuring the interference emission (interference pulses), the electric or electronic equipment shall be switched via the vehicle power supply system. This is achieved using the circuit breaker.

3.3.1 Electronic switch

This device shall ensure the switching-on and the transmission of the current avoiding too great a voltage drop; it shall also ensure contact breaking without bouncing and arcing (see Table 1).

Table 1 – Requirements on electronic switches

	Electronic switch	
Current capacity I_{max}	25 A	2,5 A
Peak current (t ≤ 1 s) I_{peak}	100 A	10 A
Dielectric strength U_{max}	400 V	
Voltage drop U_{diff}	≤ 1 V at 25 A	≤ 1 V at 2,5 A
Test voltages	13,5 V; 27 V; 41,5 V	
Switching times t_r	300 ns ± 20 % with DUT *) at 12 V: R=0,6 Ohm, L = 50 µH at 24 V: R= 2,4 Ohm, L = 200 µH at 42 V: R= 5,4 Ohm, L = 450 µH	300 ns ± 20 % with DUT *) at 12 V: R= 60 Ohm, L = 50 µH at 24 V: R= 240 Ohm, L = 200 µH at 42 V: R= 540 Ohm, L = 450 µH
Short-circuit protection	yes	
Trigger options	externally and internally	
*) Total resistance including internal resistances of the air-core inductors ± 10 %, while L is measured at 1 kHz, ± 20 % NOTE: Considering the current state of the art, the large switch (for 25 A) is not suitable for switching currents less than 1 A (capacitance of the transistors). In this case an electronic switch made up of fewer parallel transistors shall be used.		

3.3.2 Mechanical switch

The switch (or relay) that is designated for the later use with the DUT shall be used. Alternatively, a switch or relay with silver contacts may be used.

3.4 Pulse generator

The generators must be capable of producing pulses according to the definitions in Section 5. Under load with the prescribed internal resistance R_i, the voltage pulse shall not drop below half its initial intensity. In stationary mode, the generator must be capable of supplying the currents required by the DUT.

Unless otherwise specified, the peak voltage must be set within the tolerances +10% / -0 %. Resistances and times may display tolerances of ± 20%.

The generator is tested according to ISO 7637-2, Annex D.

4 Environmental conditions

4.1 Temperatures

4.1.1 Operating temperatures

According to drawing and/or Technical Supply Specification.

4.1.2 Test temperature

(23 ± 5) °C, operating temperature in special cases.

4.2 Voltages

For nominal voltage, see Table 2.

Table 2 – Nominal voltage

	Power supply system, nominal voltage (in V)		
	12	24	42
Operating voltage	10,8 to 15	21 to 30	32 to 45
Test voltage U_A	13,5 ± 0,5	27 ± 1	41,5 ± 1,5
Test voltage U_B	12	24	36

5 Interference immunity verification test

5.1 Measuring setup

The DUT is connected to the power supply via the substitute interference source (pulse generator) as specified in Figure 3 or Figure 7 respectively. The connecting line between substitute interference source and interference sink shall have a length of (50 ± 5) cm for pulses 1, 2, 5b and 6 and a length of (20 ± 2) cm for pulses 3a and 3b.

Voltages are set with the pulse generator in idle state by using the oscilloscope or, in the case of automated test sequences, by using other suitable measuring instruments integrated into the testing system. The measuring instruments shall be inspected for proper function before testing.

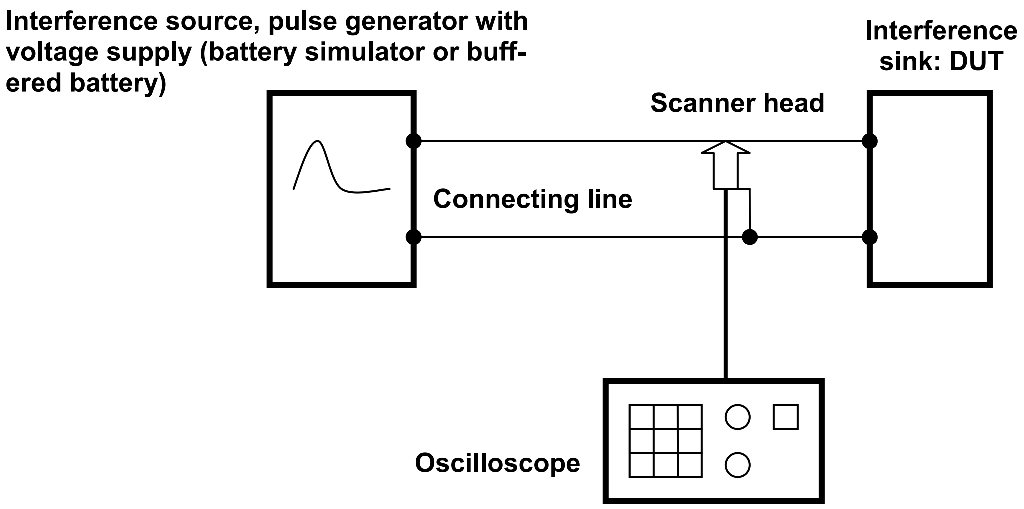


Figure 3 – Measuring setup for interference immunity testing

5.2 Test sequence

The following test sequence with settings according to Tables 2 to 4 shall be used for testing.

5.2.1 Pulse group 3a + 3b 10 Hz repetition frequency, test duration at least 2 hours
t_1 = 100 µs, t_4 = 10 ms, t_5 = 90 ms

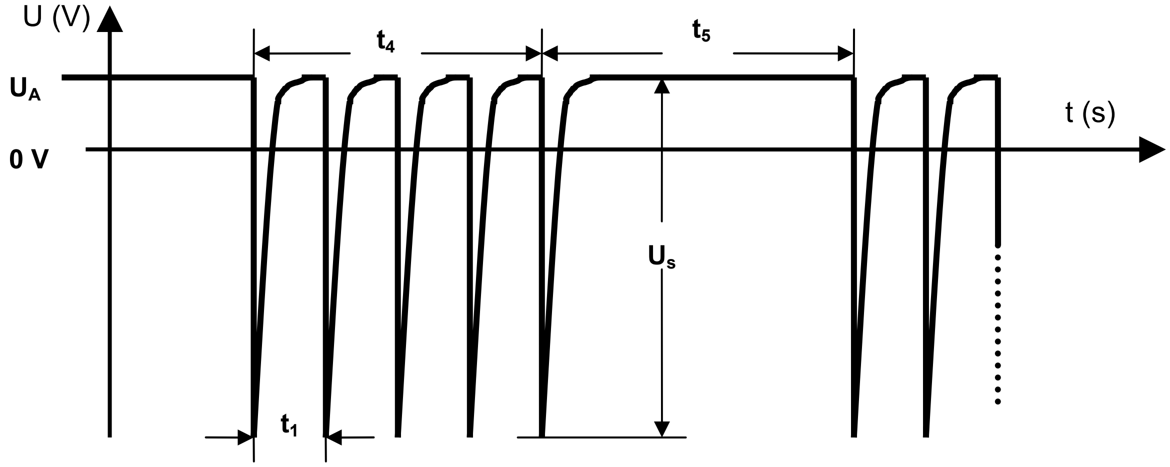


Figure 4 – Pulse 3a

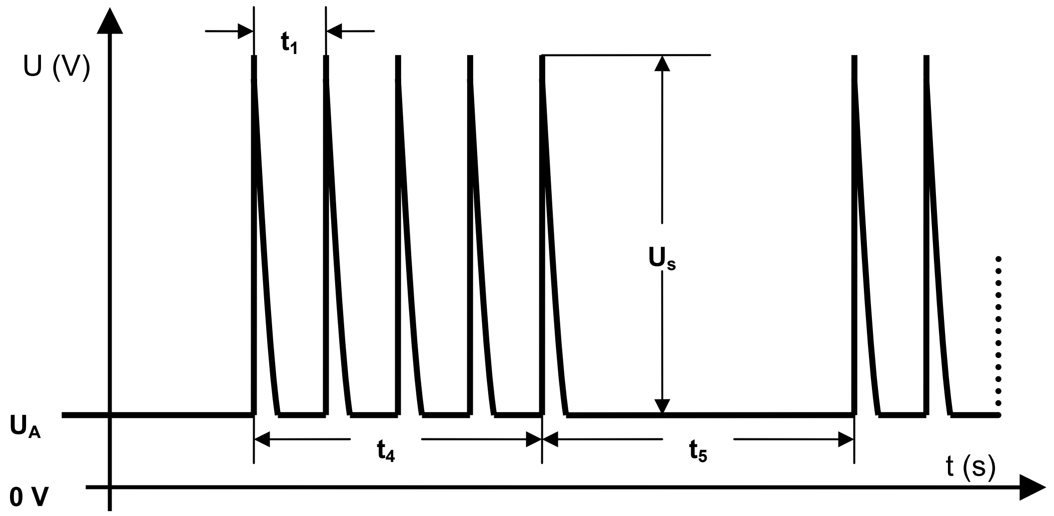


Figure 5 – Pulse 3b

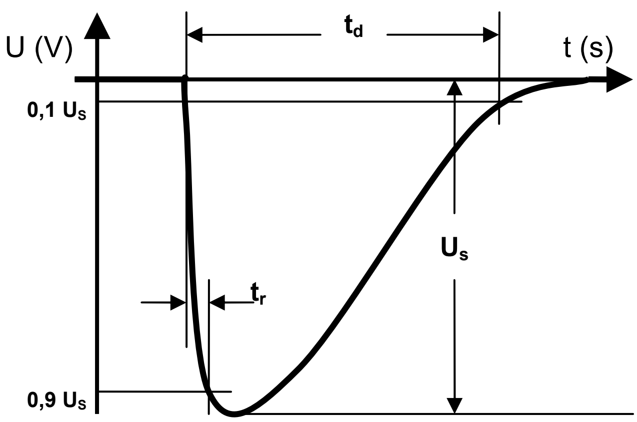


Figure 6 – Individual pulse 3a, (pulse 3b accordingly)

5.2.2 Pulse 6 Pulse repetition frequency 0,2 Hz – 5 Hz, 1 000 Pulses

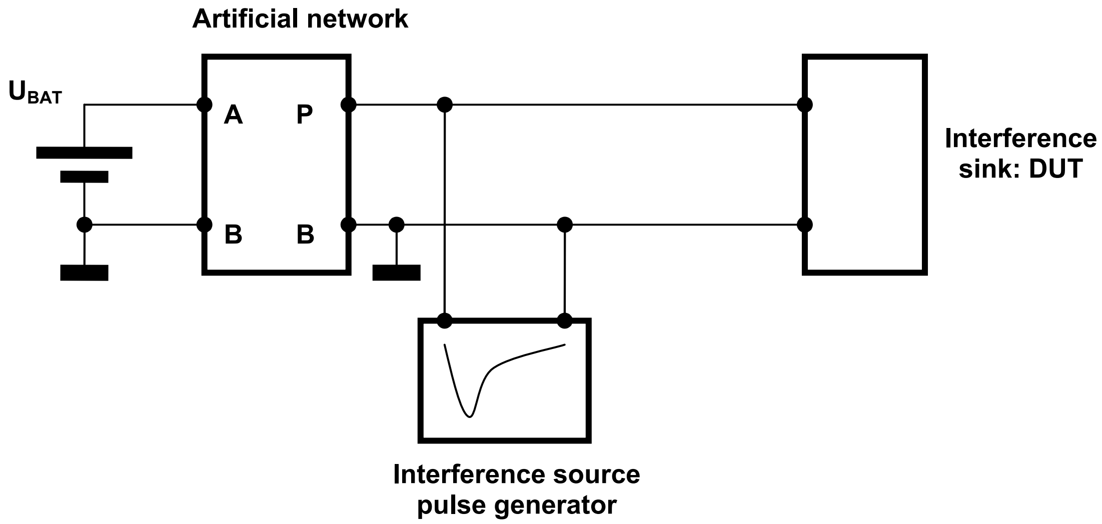


Figure 7 – Measuring setup for pulse 6

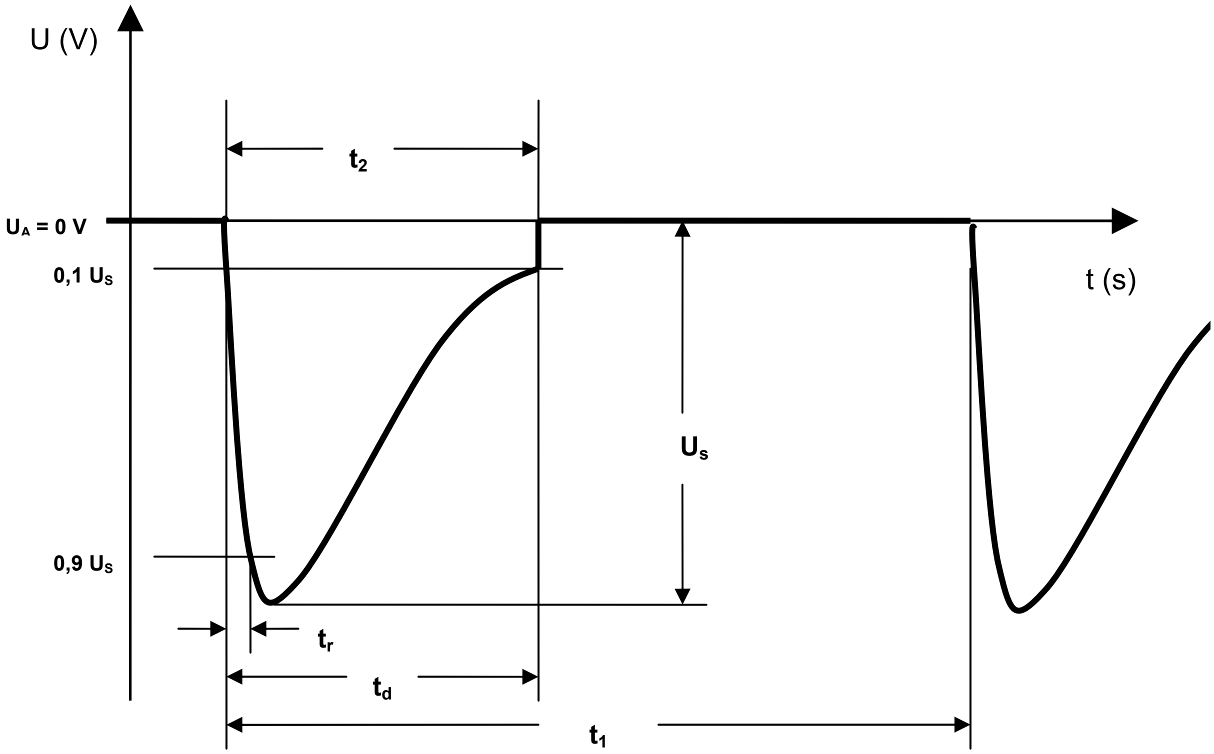


Figure 8 – Pulse 1 with U_A = 0 V is used to generate pulse 6.

The voltage for U_s is set in idle state, then the pulse generator is connected in parallel to the output terminals of the artificial network.

5.2.3 Pulse 2 Max. 5 Hz (t_1 = 0,2 s) pulse frequency; at least 5 000 pulses

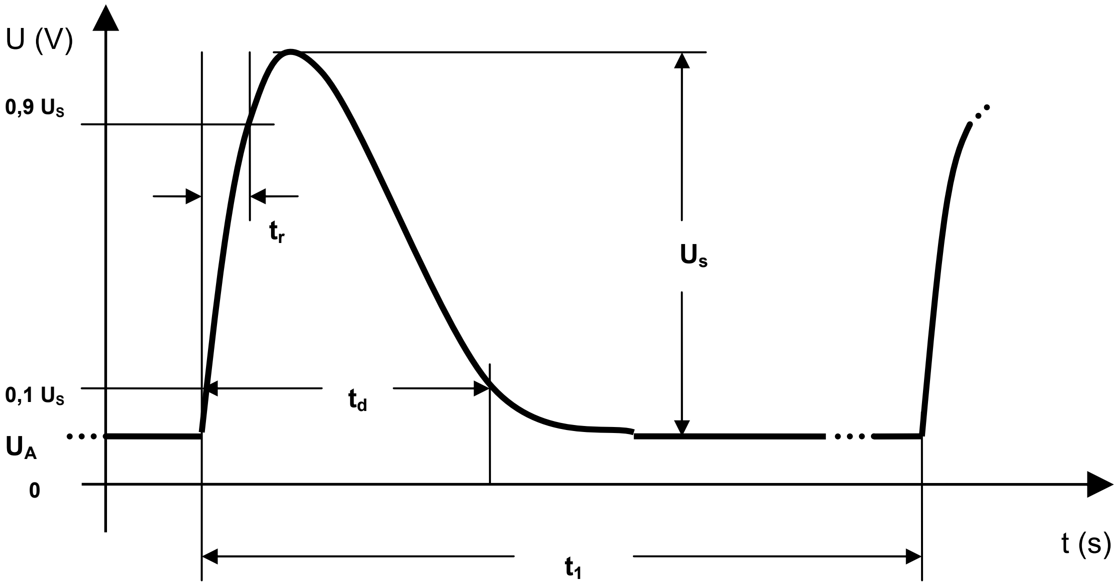


Figure 9 – Pulse 2

5.2.4 Pulse 1 Max. 0,2 Hz (t_1 = 5 s) pulse repetition frequency, at least 5 000 pulses, at terminal 30 at least 50 pulses, t_2 = duration of the voltage switch-off, t_3 = minimum possible time between switching off the battery and the start of the pulse

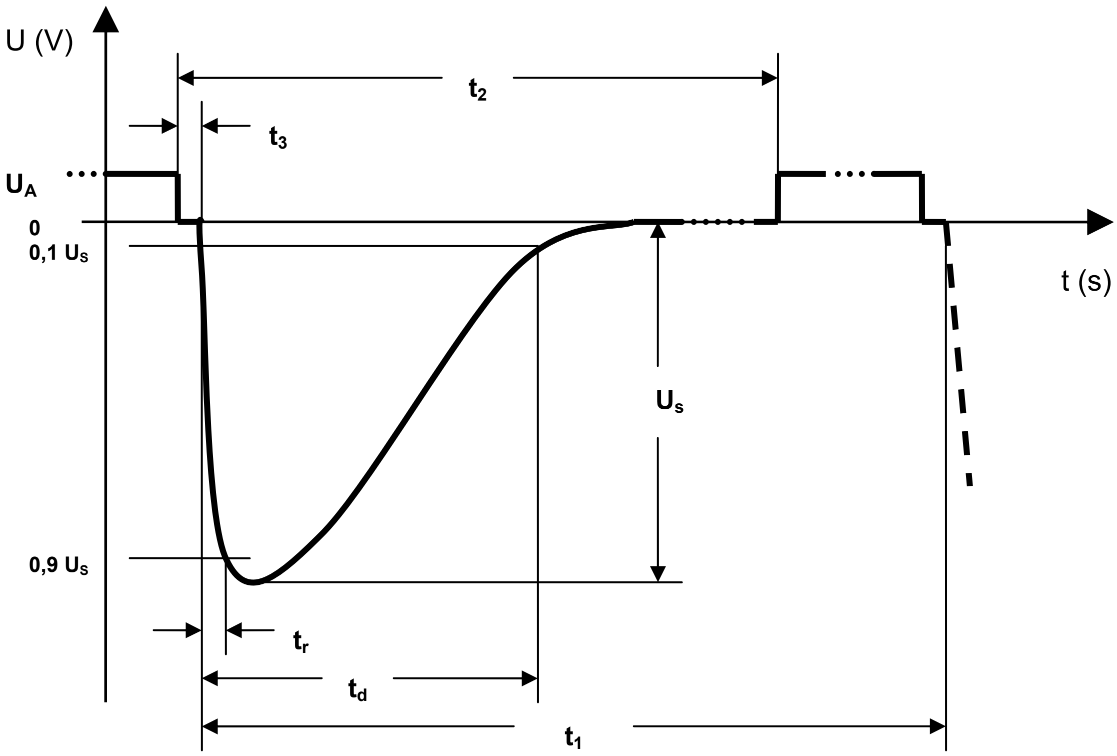


Figure 10 – Pulse 1

5.2.5 Pulse 5b 10 pulses at 1-minute intervals (only for 42-V power supply systems)

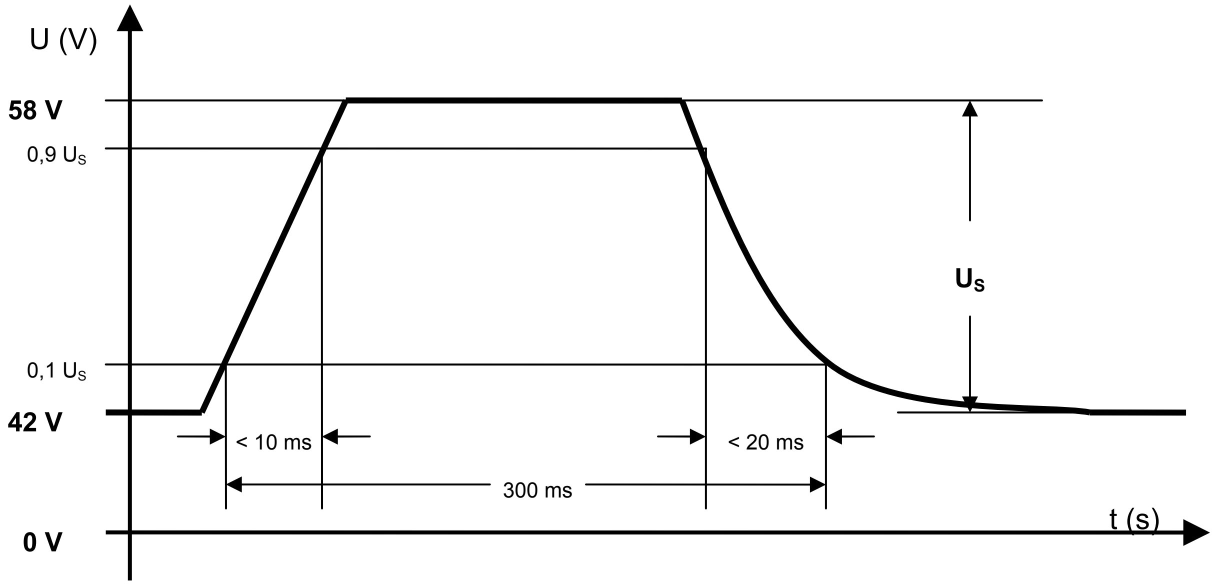


Figure 11 – Pulse 5b

NOTE: It is planned to use energy recovery technologies for 42-V systems. Increased voltage up to 55 V is applied for rapid charging of the accumulators. It shall be observed that this voltage can occur as maximum operating voltage for t > 10 s!

5.2.6 Setting values

See Tables 2 to 4.

Table 3 – Settings for interference immunity measurements: pulses 1 – 3 and 6 (12 V and 42 V)

Pulse	Number	U_s (V)	t_d (µs)	t_r (µs)	Generator R_i (Ω)		Remarks
					12 V	42 V	
Pulse 1	5 000 pulses	-100	2 000	1	4	10	Voltage switch-off for 200 ms
Pulse 2	5 000 pulses	+75	50	1	4	10	
Pulse 3a	2 h 10 Hz	-150	0,1	0,005	50		Burst pulse
Pulse 3b	2 h 10 Hz	+100	0,1	0,005	50		Burst pulse
Pulse 6	1 000 pulses	-50	200 to 500	1	4	10	Set in idle state first, then connect in parallel to the artificial network.

Table 4 – Settings for interference immunity measurements: pulses 1 – 3 and 6 (24 V)

Pulse	Number	U_s (V)	t_d (µs)	t_r (µs)	Generator R_i (Ω)	Remarks
Pulse 1	5 000 pulses	-450	2 000	1	10	Voltage switch-off for 200 ms
Pulse 2	5 000 pulses	+150	200	1	10	
Pulse 3a	2 h 10 Hz	-450	0,1	0,005	50	Burst pulse
Pulse 3b	2 h 10 Hz	+150	0,1	0,005	50	Burst pulse
Pulse 6	1 000 pulses	-75	200 to 500	1	10	Parallel to the artificial network with connected battery

5.3 Functional states

The following functional states can occur during or as a result of testing:

Functional status A

All device/system functions perform as specified during and after exposure to the disturbance.

Functional status B

All device/system functions perform as specified during exposure. However, one or more functions may be outside the specified limit deviation. All functions automatically return to the specified limits once exposure has ended. Memory functions must remain in functional status A.

Functional status C

One or more device/system functions do not perform as specified during exposure, but return to normal operation once exposure has ended.

Functional status D

One or more device/system functions do not perform as specified during exposure, not returning to normal operation before exposure has ended and the device/system has been restarted ("reset") by user intervention.

Functional status E

One or more device/system functions do not perform as specified during and after exposure and cannot be returned to normal operation without repairing or replacing the respective device/system.

5.4 Notes on interference immunity test

- If specific requirements are missing, complete testing shall be performed. Functional state A is required in this case.
- Unless otherwise specified, flashing malfunction indicator lights and self-erasing error log entries shall be assigned to functional status C.
- Pulse 1 with a switch-off time of 200 ms simulates the switching-off of power-consuming devices that are switched off together with the DUT. In this case functional state C is required. Furthermore, the pulse serves to check for damaged components. This test may also be done if the voltage is switched off for a duration of t_d only.

- Pulse 1 normally does not reach terminal 30 because it requires switching off the ignition (or a load circuit by means of a switch). However, pulse 1 may occur on these terminals when a fuse trips or when the battery is disconnected. A test comprising 50 pulses thus is necessary for this terminal, too. In this case functional state D is permissible.
- The purpose of pulse 6 is to simulate malfunctions caused by short-term voltage drops as they occur during bouncing of relay contacts, e.g. for wipers.
- Pulse 5, load dump on generator. The load dump pulse (for 12-V and 24-V power supply system voltages) is only tested upon special requirement. Requirements for overvoltage protection are specified in Volkswagen standard VW 80101.

  Modern compact generators currently use bridge rectifiers with Zener diodes, limiting overvoltage to approx. 30 V (for the 12-V power supply system) and thus serving as central load dump protection in the very unlikely event of failure. If vehicles are manufactured using other generators, the necessity to perform the test shall be agreed upon separately.

  For 42-V generators, only the values indicated in Table 5 are permissible acc. to ISO 21848.
- For sensors/actuators supplied with 3,3/5 V from a control unit, this test cannot be carried out separately, but shall be carried out within the framework of a system test including the control unit. The sensor/actuator must not be affected by pulses overcoupled from the power supply lines.

NOTE: The following examples for the signal and sensor cables mentioned in Section 1 (Scope) shall be considered:

- Terminal 58 d, interior lighting: The PWM dimmer normally comprises a MOSFET that transmits all terminal 30-related interferences without filtering.
- Readback inputs such as e.g. stop lamp, brake test, clutch switch are often directly connected to terminal 30 or terminal 15.

6 Interference emission measurement

6.1 Measuring setup

The setup depicted in Figure 12 shall be used for measuring permanent interferences, switching bursts as well as switch-on transients and switch-off transients; the switch is located in the connecting line to the interference source. Once the power supply has been switched on, the permanent interferences generated by the interference source can be measured. Switch-off transients shall be registered at the instant the power supply is switched off. Switch-on transients can be measured when closing the switching contacts. Switching bursts result from glow discharges or arcing when opening the switching contacts. Therefore, they can be measured either when switching off the interference source power supply or at bouncing switching contacts when switching on.

Measurement is carried out directly on the DUT. All switch statuses designated for operation of the DUT, including deliberate motor deceleration by short circuit, shall be run through 10 times each. In the case of DUT with moving masses (e.g. motors) the switching element designated for standard production or an equivalent one with silver contacts shall be used in order to include possible switch bouncing in the test. For DUT that do not accumulate energy in the form of moving masses (e.g. follow-up motors) an electronic switch according to Section 3.3.1 is also permissible. The maximum measured value may not exceed the limit values specified in Section 6.2.

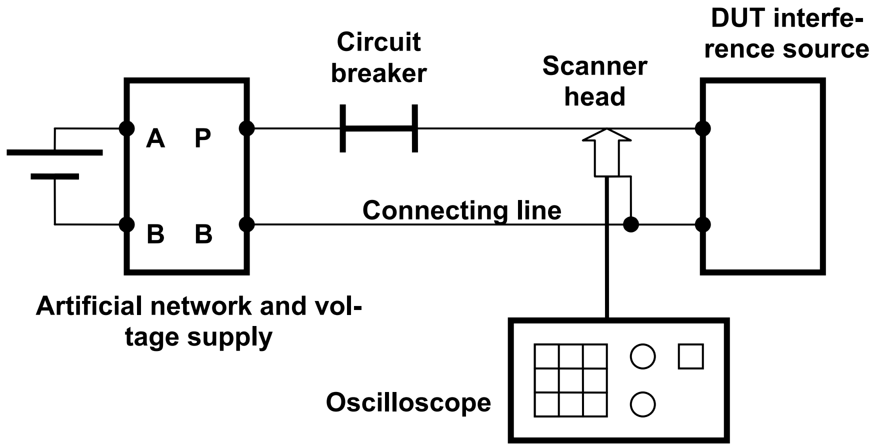


Figure 12 – Measuring setup for switching bursts and transients that are generated by the interference source and/or by the switch

6.2 Limit values for interference emission in vehicle power supply systems

Disturbance voltage occurs in the form of a pulse as a function of time or as interference oscillation. In most cases, the actual voltage curve cannot be directly compared with the “standard” pulses 1 to 5. However, the measured pulses can at least be assigned to the “standard” pulses. Disturbance voltage amplitudes and pulse time periods shall not exceed the limit values given in Tables 5 and 6.

The test voltage serves as the reference potential for the disturbance voltage (except for pulse 1). For pulse 1, ground potential serves as the reference.

The maximum value out of 10 individual measurements shall be the voltage amplitude value.

Table 5 – Maximum permissible interference emission for 12-V and 24-V interference sources

Pulse	U_s (V)	t_d (µs)	t_r (µs)
Pulse 1	≥ -100	≤ 2 000	≥ 1
Pulse 2	≤ +50	≤ 50	≥ 1
Pulse 3a	≥ -150	≤ 0,1	≥ 0,005
Pulse 3b	≤ +100	≤ 0,1	≥ 0,005
Pulse 5b (only 42 V)	≤ 16	≤ 300 000	10 000

Table 6 – Maximum permissible interference emission for 24-V interference sources

Pulse	U_s (V)	t_d (µs)	t_r (µs)
Pulse 1	≥ -150	≤ 2 000	≥ 1
Pulse 2	≤ +75	≤ 200	≥ 1
Pulse 3a	≥ -150	≤ 0,1	≥ 0,005
Pulse 3b	≤ +100	≤ 0,1	≥ 0,005
Pulse 5	Not applicable		

7 Referenced standards[1]

VW 80101	Electrical and Electronic Assemblies in Motor Vehicles; General Test Conditions
DIN 40839-1	Electromagnetic Compatibility (EMC) in Road Vehicles; Interferences Conducted along Supply Lines in 12-V and 24-V Onboard Systems
ISO 7637-1	Road Vehicles – Electrical Disturbances from Conduction and Coupling; Part 1: Definitions and General Considerations
ISO 7637-2	Road Vehicles – Electrical Disturbances from Conduction and Coupling; Part 2: Electrical Transient Conduction Along Supply Lines Only
ISO 21848	Road vehicles - Electrical and electronic equipment for a supply voltage of 42 V - Electrical loads
Directive 2004/104/EC	EC Type approval of vehicle

[1] In this Section, terminological inconsistencies may occur as the original titles are used.