VOLKSWAGEN AG	**Immunity against electrostatic discharges (ESD)**	**TL 824 66**
Konzernnorm		

Descriptors: EMC, ESD, electrostatic discharge

Foreword

Additional tests necessary for evaluation and release of electronic assemblies beside the EMC test are defined and specified in the drawing, Technical Supply Specification (TL) or other documents.

Content

Changes

The following changes have been made as compared to the August 1998 issue:

- standard restructured and completely revised
- sections updated and explained in detail complying with latest developments
- section 7, test setup: assembly/system level/vehicle level
- section 8, test procedure: assembly/system level/vehicle level
- appendix A: description/assignation of ESD functional states

Previous issues

First issue: 1998-08

Fachverantwortung/*Technical responsibility*	Normung/*Standards* (EZTN, 1733)
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1 Scope

This TL standard contains requirements and tests to ensure electromagnetic compatibility (EMC) of electronic assemblies with respect to electrostatic discharge. This applies to discharges in the following cases:

- discharge in assembly,
- discharge caused by Customer Service employees
- discharge caused by occupants

These discharges either directly influence the assembly or neighboring devices that can couple into supply and signal lines of the vehicle and/or electric assemblies.

2 Standard basis of this standard

This TL is based on DIN EN 61000-4-2, version March 1996, (Testing of interference immunity against electrostatic discharge) and adds vehicle-specific requirements. ISO CD 10605, dated 16.03.99, serves as a basis for vehicle tests.

3 Purpose of protection

There shall be no permanent damage to an assembly caused by electrostatic discharge resulting from assembly, Customer Service measures or occupants. Furthermore, discharge caused by persons in or near the vehicle shall not lead to malfunction or function failure.

4 Definitions

Definitions acc. to DIN EN 61000-4-2 shall apply unless otherwise specified in this standard.

Air discharge:

Test method characterized by bringing the test generator electrode close to the equipment under test (EUT); the discharge is by arcing on the EUT.

Direct contact discharge:

Test method characterized by contact of the test generator electrode with the EUT; discharge is initiated by the generator discharge switch.

Direct discharge:

Discharge is directly on the EUT.

Indirect discharge:

Discharge is on a coupling plate near the EUT; simulates discharge by a human being on items near the EUT.

Surface:

Surfaces are defined as uninterrupted surfaces as well as gaps and openings (switches, tip switches, points of contact, air vents, speaker openings, etc.).

Assembly:

An assembly is defined as one single component or a combination of components as supplied by the supplier.

System:

A system is defined as the assembly complete with all connected components necessary for unrestricted performance (tip switches, switches, antennas, displays, etc.).

Malfunction:

Disturbance of the function of a device that is no longer permissible. Malfunction ends after transient is removed.

Damage:

One or more functions of the device do not perform as designed during exposure and after removal of exposure, the device has to be repaired or replaced, or, some parameters do not lie within the specified tolerances if performance is still given.

5 Test scope and test severity level

ESD testing shall be performed on assembly, system and vehicle level. Component-specific performance specifications may contain additional tests or deviations from the test scope test severity defined in this TL.

Direct contact discharge shall be the preferred test method; the air discharge method shall be used wherever direct contact discharge is not possible.

The semiconductor components shall pass this test without additional protective switching. If this is not complied with by semiconductor assemblies that are used, the assembly engineer will have to explain how sufficient ESD interference immunity can be achieved using other suitable protection measures.

Table 1 Test scope overview

Test	**Direct contact discharge**	**Air discharge**	**Protection against**	**To be performed by**
Assembly (packaging / handling) **see 8.1**	on pins and metallic areas / surfaces ±2 kV, ±4 kV, ±6 kV, ± 8 kV using: R_d = 330 Ω, C_i = 150 pF	other areas / surfaces: ± 4 kV, ± 8 kV, ± 15 kV using: R_d = 330 Ω, C_i = 150 pF	**damage**	supplier
System (laboratory setup) **see 8.2**	accessible points and coupling plates: ± 2 kV, ± 4 kV, ±6 kV, ± 8 kV using: R_d = 330 Ω, C_i = 330 pF	accessible points: ± 4 kV, ± 8 kV, ± 15 kV, ± 25 kV[1] using: R_d = 330 Ω, C_i = 330 pF	**malfunction** and damage	supplier
Vehicle **see 8.3**	omitted	accessible points: ± 4 kV, ± 8 kV, ± 15 kV[2], ± 25 kV using: R_d = 330 Ω, C_i = 150/330 pF[3]	**malfunction** and damage	car manufacturer

[1] The energy storage capacity C_i can be set to 150 pF for system testing with 25 kV.

[2] Upon consultation with the EMC engineering department, it is possible to restrict the maximum test voltage to 15kV if the system / assembly and all connected parts can only be touched by occupants inside the vehicle and not from persons standing on the outside next to the vehicle (the possibility of contact via door or open window shall also be considered).

[3] Upon consultation with the responsible EMC engineering department, the discharge capacitor capacitance can be set to 150pF if the system / assembly and all connected parts cannot be touched by vehicle occupants inside the vehicle.

Three different tests shall be performed, the first two shall be performed in the laboratory:

- testing on assembly level (packaging / handling)
- testing on system level (laboratory setup)
- testing on vehicle level

6 Test equipment and test conditions

Requirements for test generators acc. to DIN EN 61000-4-2 shall apply, except for the following specifications:

- The test generator shall have two different settings for energy storage capacity: 150 pF and 330 pF.
- There shall be an output voltage setting of up to and including 25 kV for air discharge.
- In case of discharge with charging voltages exceeding 15 kV, the discharge resistance R_d can also be set to 2000 Ohm.
- The test generator properties are documented acc. to DIN EN 61000-4-2 with an energy storage capacity of 150 pF.

7 Test setup

As conditions special to automotive vehicles are not regarded in DIN EN 61000-4-2 when defining the test setup, the details of the setup are described here.

The test setup contains the following items: test generator, EUT (in case of testing on system level including the related components) and auxiliary components necessary for performing the direct and indirect discharge on the EUT. The following methods shall be used:

- direct contact discharge on conducting surfaces and coupling plates,
- air discharge on other surfaces.

The discharge will result in a build-up of charges on conducting surfaces or pins. These charges shall be removed before each new discharge.

The usual method to achieve this is to connect a line with bleeders to the metal surface or pins. Two high-voltage protected 470 kΩ resistors shall be inserted into this line between the discharge and ground point. The length of the line between the discharge point and the first resistor shall not exceed 20 mm. If there is proof that the line does not impair the test result, it can remain connected to the EUT.

Alternatively, the time span between a sequence of discharges can be lengthened so that the build -up charge has vanished owing to natural charge decay.

Usually, an insulating base is used between the EUT and HCP (horizontal coupling plane). This base shall have a thickness between 0.5 and 2 mm and a dielectric constant between 2 and 5 (e.g. polyethylene or PTFE). The base shall also have suitable puncture strength and it shall surround the EUT for more than 10 mm.

For testing pins in contact mode, a copper extension line for easy discharge can be used. The line shall have a diameter between 0.5 mm² and 2 mm² and shall be no longer than 25 mm.

The return line of the ESD generator discharge circuit shall be laid at the highest possible distance from the point of discharge.

7.1 Test setup for laboratory testing

For laboratory testing, the specifications acc. to DIN EN 61000-4-2 shall apply to the ground reference plane (GRP), ground connections, return lines, test table, HCP and VCP (vertical coupling plane).

7.1.1 Test setup for testing on assembly level (packaging / handling)

The test setup for testing on assembly level is shown in figure 1. Setup acc. to DIN EN 61000-4-2. The EUT shall be tested without periphery, as supplied by the supplier.

When testing pins of EUT with a conducting housing, the EUT shall be placed directly on the HCP, without insulating base.

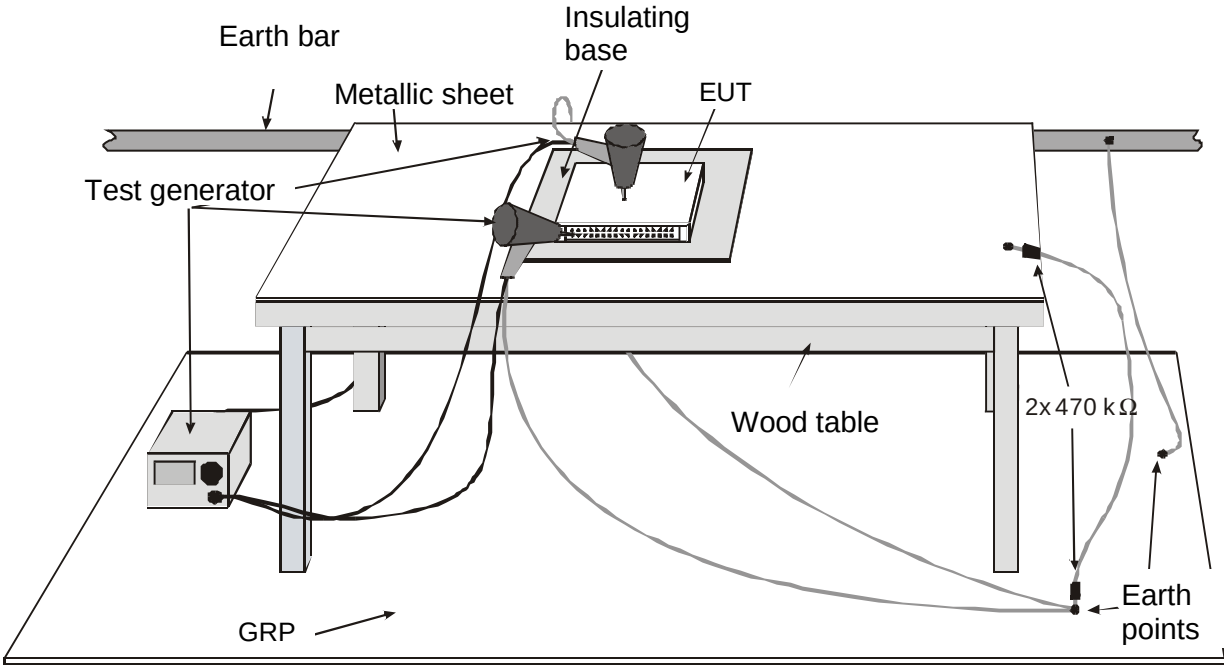

Figure 1: Example test setup for testing on assembly level

7.1.2 Test setup for testing on system level

The test setup for testing on system level is shown in fig. 2. The EUT shall be arranged and connected acc. to the functional requirements. The return line in the ESD generator discharge circuit shall be directly connected to the horizontal coupling plane and not to the ground reference plane (GRP). The combined ground connection shall have a distance of 20 mm from the edge of the HCP.

For testing, the assembly shall be connected to all peripheral units necessary for functional testing, as well as all controls, sensors and actuators. The line lengths used should be approximately as long as those used in the vehicle. If controls or assemblies connected in the vehicle that can be touched are not available for testing, it shall always be assumed that a puncture on the connecting lines is possible; therefore there shall be direct discharge on the corresponding pins.

All components on the test table shall have a minimum distance of 20 cm from each other. The lines shall be laid so that they run directly over the HCP and parallel to the HCP edges and - like all components - have a distance of at least 10 cm from the HCP edges. Line harnesses shall correspond to those used in the vehicle.

The supply battery, which does not have to be the same as the vehicle battery, shall be on the test table and is directly connected to the HCP. The explosion hazard of the battery shall be taken into account here, appropriate protective measures shall be taken.

If the assembly under test is directly connected to the vehicle body, the component shall be placed directly on the HCP and connected for testing. If the assembly is connected in the vehicle while being insulated from the body, it shall be separated from the HCP by an insulating base. This also applies to the connected periphery and controls, etc. The exact configuration of the test setup with the functional states shall be agreed upon with the VW Group engineering department responsible for EMC release.

The length of the HCP may exceed 1.6 m if required by the setup.

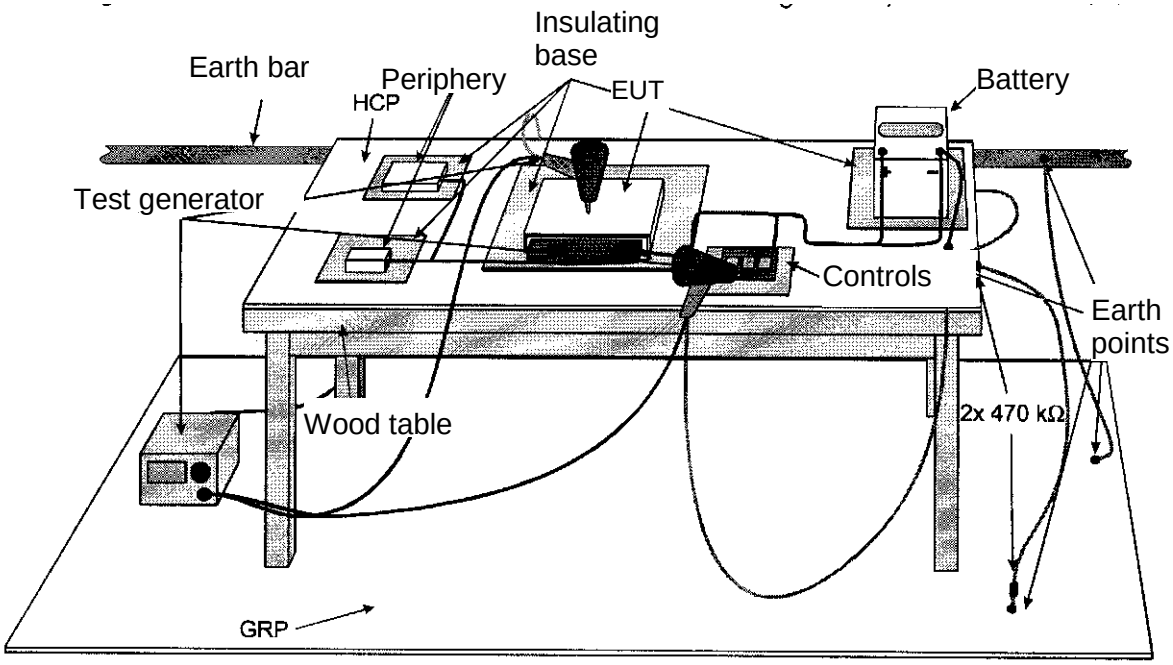

Figure 2: Test setup example for testing on system level against direct ESD

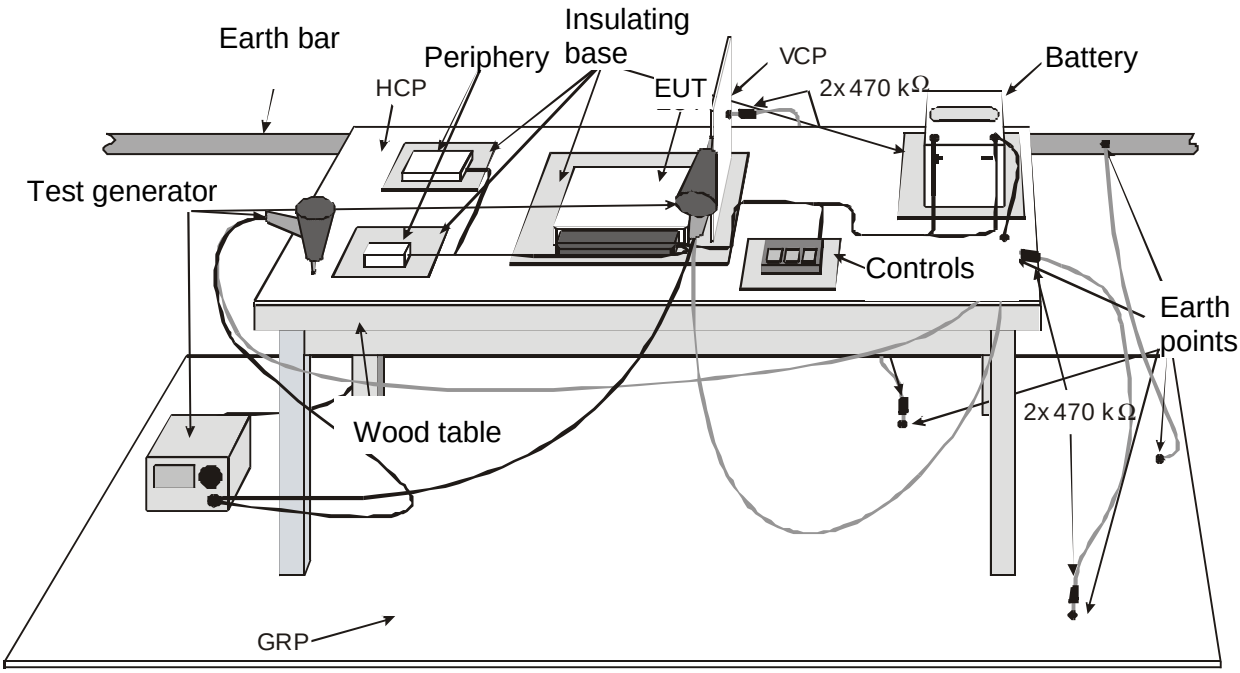

Figure 3: Test setup example for testing on system level against indirect ESD

7.2 Test setup for testing on vehicle level

The return line in the ESD generator discharge circuit shall be directly connected to the vehicle body. The seat slide can be used for testing in the passenger compartment.

8 Test procedure

The specifications made in DIN EN 61000-4-2 shall apply to conditions in the laboratory (e.g. temperature, air pressure), to the test programs running during testing and to the test procedure itself, observing the exceptions and amendments made in this section.

- Relative humidity shall be between 20 and 60 % during testing.
- Discharges shall occur on all areas / surfaces that can be touched during assembly, servicing or normal operation.
- direct contact discharge can only replace air discharge up to 15 kV, if application is possible. If air discharge up to 25 kV is specified, this test shall be performed in any case.
- Pins that do not allow for discharge due to the surrounding structure can be exempted from testing.
- One individual test begins with the lowest and ends with the highest test voltage (separate test runs with positive / negative test voltage values are possible; e.g. ± 4 kV → ± 25 kV, or + 4 kV → + 25 kV → - 4 kV → - 25 kV).
- 10 discharges shall be applied to all areas under test for each specified charging voltage and polarity. The number of discharges for each charging voltage and polarity can be reduced to 3 for packaging / handling tests. Intervals between individual discharges shall be longer than 1 s.

See section 5 for the test severity level to be used.

8.1 Testing on assembly level

Testing on assembly level is performed by the supplier acc. to DIN EN 61000-4-2 observing the amendments and changes stated here.

Testing involves direct contact discharge on all pins and contact and/or air discharge on all areas / surfaces that can be touched.

Having performed complete testing, the assemblies under test shall pass complete function testing successfully. There shall be no permanent damage. Additionally, effectiveness of the EMC protective switching (e.g. input capacitors ensuring electromagnetic interference immunity, emission, respectively) shall be tested after ESD exposure.

8.2 Testing on system level

Testing on system level is performed by the supplier acc. to DIN EN 61000-4-2 observing the amendments and changes stated here. Prior to testing, a test plan shall be written describing all areas under test and operating states .

All areas that can be reached by vehicle occupants (surfaces, tip switches, switches, antennas, displays etc.) and the diagnostic plug shall be tested with contact and/or air discharge and with contact discharge on the horizontal and vertical coupling plane. Perform one complete test for each important operating state.

Indirect discharge on the HCP and VCP[4] shall be applied at a distance of 0.1 m from the system under test. Be sure to also discharge along the wiring. The interval between the individual discharges can be reduced to 50 ms for indirect discharge on HCP and VCP if the ESD generator used allows for it.

During testing, the system shall be operated at intervals to ensure that performance is given during ESD exposure.

8.3 Testing on vehicle level

Testing on vehicle level is as a rule performed by the responsible VW Group EMC engineering department. Prior to testing, a test plan shall be written describing all areas under test, operating states and test severity.

The tests are performed with the vehicle's engine running. If spee-d-dependent assemblies are tested (e.g.cruise control), the vehicle should be running on a roller test bench during testing. The required speed should be specified in the test plan. Testing is performed on and in the vehicle by applying discharges on all areas that can be reached by the person using the vehicle (tip switches, switches, displays, surfaces, steering lock, controls, antennas, etc.).

Choose a generator capacitance C_i of 330 pF for areas that can easily be touched only from the inside of the vehicle. The maximum charging voltage can be limited to 15 kV. Choose a capacitance C_i of 150 pF for areas that can easily be touched only from the outside of the vehicle. The maximum charging voltage is in this case 25 kV. Areas that can be touched both from the outside and inside shall be tested with both generator capacitance values and 15 kV, 25 kV maximum charging voltage, respectively.

Direct contact discharge shall be applied to all metallic surfaces, open pins or painted metallic surfaces that are designated non-insulating. In these cases it shall suffice to only apply air discharge for a specified charging voltage of 25 kV. All other areas are tested with air discharge.

During testing, the all systems shall be operated at intervals to ensure that performance is given during ESD exposure.

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[4] Discharges onto the VCP simulate discharge on neighboring metallic items that are mounted separately in the vehicle.

9 Documentation

Documentation of ESD strength shall be made available to the EMC engineering department in order to obtain ESD release; the following items shall be documented:

a) System designation
b) System description
c) State of hardware with circuit diagram, layout and description of the essential EMC measures relevant for ESD (e.g. filter and screening circuits for in/outputs, internal reset lines, and supply lines, screening measures)
d) State of software with description of the essential EMC measures (e.g. filtering of signals implemented in software, temporary deactivation of individual circuit components, run flat characteristics)
e) Measuring report with test conditions (among others also climatic and electromagnetic conditions) and description of the test setup for testing on assembly and system level acc. to sections 7 and 8; if applicable, it shall include an explanation why requirements are not met and specification of alternative measures taken to ensure ESD strength.
f) Measurement report with test conditions on vehicle tests acc. to section 8.3, of applicable
g) ESD evaluation of the packaging material used for transportation and storage.

10 Referenced standards

DIN EN 61000-4-2,	Electromagnetic compatibility (EMC); test and measuring methods
ISO CD 10605	Road vehicles - Electrical disturbances from Electrostatic discharges

Appendix A

ESD functional states are assigned to test severity levels in this appendix.

The responsible EMC department can specify reduced ESD requirements for an assembly[5].

A.1 Description of ESD classification of functional states

The classification applies to the entire device or system condition. It shall be noted that the ESD functional states can differ to a great extent from functional states defined in another context.

Functional state I: The assembly / system operates during and after exposure as designed and within the permissible tolerances.

Functional state II: Individual functions of the assembly / system fail but return to normal operating state after removal of interference. Requirements acc. to functional state I apply to memory functions.

Functional state III: Individual functions or the complete assembly / system fail. Function can be returned to normal after the exposure has been removed by simple operations.

Functional states IV: Individual functions or the complete assembly / system fail. The function cannot be returned to normal without repair or replacement.

A.2 Assignment of ESD classification of functional states

Functional states for testing on assembly level acc. to section 8.1					
	Functional state depending on charging voltage				
Charging voltage for direct contact / air discharge	**2 kV/ -**	**4 kV/4 kV**	**6 kV/8 kV**	**8 kV/15 kV**	**- /25 kV**
Reduced ESD requirements	I	II	II	III	IV
Standard ESD requirements	I	I	I	II	II

Functional states for system testing against indirect ESD by discharge on coupling plates acc. to section 8.2				
	Functional state depending on charging voltage			
Charging voltage for direct contact discharge	**2 kV**	**4 kV**	**6 kV**	**8 kV**
Reduced ESD requirements	I	II	II	III
Standard ESD requirements	I	I	I	II

A regeneration time of up to 30 s is permissible for displays tested at a test voltage of more than 4 kV.

A.3 Assignment of memory states to ESD functional states

[5] Reduced ESD requirements can be agreed upon if there is for example very low probability of contact (not accessible in standard operation).

The changes specified in the following table are permissible for memory data, depending on the ESD function states:

	Change in memory data permissible depending on ESD functional state			
Type of memory data	**I**	**II**	**III**	**IV**
Fault data without consequence for person using the vehicle or other customer-relevant memory data (e.g. memory functions)	no	no	yes	yes
Fault data with consequence for the person using the vehicle (system in emergency mode etc.)	no	no	no	yes