1 Scope

This technical supply specification (TL standard) includes requirements and tests for ensuring electromagnetic compatibility (EMC) of electronic components with respect to interferences coupled in the vehicle’s signal or sensor cables.

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 alternator with regulator.
2.2 Supply voltage

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

Nominal voltage of the power supply system

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

2.3 Coupling

Coupling is the disturbance of circuits effected by energy transfer from one circuit to another.

2.4 Coupling clamp

A coupling clamp is a device of defined dimensions and characteristics for common mode coupling of interferences to a test circuit without any galvanic connections to it.

2.5 Interference pulse

An interference pulse is a non-periodic, short-time, positive and/or negative transient (voltage or current) occurring between two steady conditions.

2.6 Pulse sequence

A pulse sequence is a number of repeated pulses during a given time interval.

2.7 Signal or sensor cables

In this TL standard, signal and sensor cables are defined as all cables that are neither directly nor indirectly (via switch or relay contacts or valves / actuators / sensors) connected to the power supply cables. TL standard 820 66 applies to the cables excluded here.

2.8 Interfering circuits

An interfering circuit is the circuit emitting electromagnetic disturbance.

2.9 Electromagnetic compatibility (EMC)

The ability of electrical equipment to function satisfactorily in an electromagnetic environment without unduly influencing its environment (including other equipment).

2.10 Electromagnetic interference

Electromagnetic effects (e.g. fields) on circuits, components and systems (e.g. of a vehicle).

2.11 Disturbance of function

Undesired disturbance of a device’s function.
2.12 Degraded function
A function is degraded if the function of a device is disturbed in a way that cannot be neglected but nevertheless can be accepted as being permissible. Degraded function ends after the transient has been removed.

2.13 Malfunction
Disturbance of a device’s function that is no longer permissible. Malfunction ends after the transient has been removed.

2.14 Function failure
Disturbance of a function of a device no longer permissible; function can only be restored by technical measures.

2.15 Transient
Electromagnetic quantity having undesirable effects on electronic equipment.

2.16 Interference source
The origin of transients.

2.17 Interference sink
Electronic equipment the function of which can be influenced by transients.

2.18 Transient emission
Transient emitted by an interference source.

2.19 Interference threshold
Minimum transient value effecting malfunctioning in an interference sink.

2.20 Interference immunity
Ability of electronic equipment to withstand transients of given values without malfunctioning.

2.21 Parallel routing
Parallel routing results in joint lines in several places within a harness.

2.22 Current injection probe
The current injection probe is a current transformer for differential mode-coupling of a transient into the test circuit without any galvanic connections to it.
3 General test conditions

Deviations from the following test conditions shall be noted in the test report.

3.1 Environmental conditions

Temperatures
Operating temperatures According to drawing, TL and/or performance specifications
Test temperature \((23 \pm 5) ^\circ C\); operating temperature in special cases

3.2 Voltages

Nominal voltages see table 1.

<table>
<thead>
<tr>
<th></th>
<th>Power supply system, nominal voltage (in V)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12</td>
</tr>
<tr>
<td>Operating voltage</td>
<td>10.8 to 15</td>
</tr>
<tr>
<td>Test voltage</td>
<td>13.5 ± 0.5 V</td>
</tr>
</tbody>
</table>

4 Functional states

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

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

Functional state B
Individual functions of the assembly / system work beyond the prescribed tolerances, but independently return to normal operation after the disturbance has been removed. Requirements acc. to functional state A apply to memory functions. Warning lights shall not go on. Error log data are not permissible.

Functional state C
Individual functions of the assembly / system fail and warning lights may go on, but the functions independently return to normal operating state after removal of the disturbance. Automatic elimination of error log data which are not customer-relevant (emergency mode) is permissible.

5 Test documentation

In order to check relevancy for EMC the following information shall be given when delivering the sample to the EMC department:

a) System designation
b) System description
c) State of hardware with information on the essential EMC measures (e.g. filter and screening circuits for in/outputs 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 selected circuit components)
e) Deviations from TL standard specifications as agreed upon between Volkswagen Group and supplier

f) Measurement reports

6 Testing

A coupling clamp is used to implement capacitive coupling of a transient into the interference sink. In the case of inductive coupling, the injection probe is used. Thus, reproducible and comparable results can be achieved.

During the bench test, the interferences are coupled into the sensor cables, which are designed as a test harness, using coupling clamp and injection probe.

6.1 Capacitive coupling clamp

6.1.1 Setting of test voltage

No lines are permitted to route through the coupling clamp during calibration. For of measuring setup see figure 1.

![Diagram](image)

1 Test pulse generator
2 50 Ω cable
3 Coupling clamp
4 50 Ω attenuation device
5 Oscilloscope (50 Ω)

Figure 1 - Measuring setup for voltage setting

6.1.2 Test setup

The test setup in figure 2 shall be followed in principle.

The device under test (DUT) shall be connected to its original operating environment, to loads (equivalent loads, respectively), sensors, and others by means of a test harness. Only the lines necessary for connecting the DUT with its periphery are to be connected in the test harness. Lines in the test harness that are not used are not permitted to be terminated. Supply lines necessary for the periphery and DUT are to be routed outside the coupling clamp. The cover shall be placed flat on the coupling clamp.

The test harness is to be arranged outside the coupling clamp, above the ground plane (100 ± 20) mm, and preferably perpendicular to the longitudinal axis of the coupling clamp.

The minimum distance between the DUT and all other conductive structures, such as walls of a shielded room (with the exception of the ground plane, see section 7) shall exceed 0.5 m. Ground connections of DUT shall be identical with those in the vehicle. The DUT shall be placed on the ground plane and shall be separated from it by an insulated support having a thickness of 0.05 to 0.1 m, unless the DUT casing is connected with chassis and has its own ground connection.

Pulse generator and DUT shall both be connected on one side of the coupling clamp.

The ground plane serves as reference ground. All individual devices shall be connected to this plane by lines as short as possible.
The coaxial cable between coupling clamp and pulse generator shall not exceed a length of 0.5 m.

In order to ensure that measuring results are reproducible the test setup has to be mechanically fixed in an exact manner.

The test setup shall be documented.

This will include the following information:

- Location and length of supply lines
- Type and location of ground connection
- Type and arrangement of periphery
- Design of test harness

Dimensions in millimeters

![Diagram](image_url)

Figure 2 - Test setup (DIN 40 839-3)
6.2 Current injection probe

6.2.1 Setting of test voltage

The induced test voltage is measured by means of a calibration bracket as depicted in figure 3.

![Figure 3 – Measuring setup for voltage setting in a calibration bracket according to DIN ISO 11452-4:2000-03](image)

Pulse intensity change of the original pulse (test pulse 1 of the generator) and of the pulse induced in the calibration bracket shall be documented in order to prove the injection probe’s suitability. Both signals have to display similar rise times.

![Figure 4 – Interdependence of generator voltage (setting) and induced voltage (peak value) in a calibration bracket](image)
6.2.2 Test setup

The test setup in figure 5 shall be followed in principle.

The device under test (DUT) shall be connected to its original operating environment, to loads, (equivalent loads, respectively), sensors and others by means of a test harness. Only the lines necessary for connecting the DUT with its periphery are to be included in the test harness. Lines in the test harness that are not used are not permitted to be terminated. Ground lines shall be routed outside the injection probe. The distance between DUT and injection probe shall be 30 ± 3 cm.

The test harness shall be fixed outside the injection probe (50 ± 10 mm) above the ground plane.

Minimum distance between the DUT and all other conductive structures, such as walls of a shielded room (with the exception of the ground plane) shall exceed 0.5 m.

Ground connections of DUT shall be identical with those in the vehicle. The DUT shall be placed on the ground plane and shall be separated from it by an insulated support having a thickness of 50 ± 10 mm, unless the DUT casing is connected with chassis and has its own ground connection.

The ground plane serves as reference ground (see section 4.5). All individual devices shall be connected to this plane by lines as short as possible.

The coaxial cable between injection probe and pulse generator shall not exceed a length of 0.5 m.

In order to ensure that measuring results are reproducible the test setup has to be mechanically fixed in an exact manner.

The test setup shall be documented. This will include the following information:

• Location and length of supply lines
• Type and location of ground connection
• Type and arrangement of periphery
• Design of test harness
6.3 General requirements on input circuitry

Input circuitry of control units has to be dimensioned in a way that

- The desired signals are not unduly affected
- Interfering signals above the tenfold maximum desired frequency\(^1\) can be attenuated using adequate filter structures like RC combinations.

6.4 Interference immunity verification test

All requirements specified in this TL standard or in the respective performance specifications shall be met for EMC-release.

Test scope and permissible functional states as well as their product-specific evaluation criteria shall be stated in the product TL standard. As a rule, for tests according to this TL standard, only the functional states A and B are permissible for the DUT.

In order to perform the interference immunity test the test pulses are coupled into the sensor cables- which are designed as a test harness - using coupling clamp and injection probe.

The test pulses to be used are described in section 7.4. The following test scope must be adhered to:

\(^1\) In order to reduce efforts, the filter’s upper limit frequency does not have to be less than 10 kHz. Desired signals requiring filter frequencies above 1 MHz need special protection the measures for which are not within the scope of this TL.
6.4.1 Coupling clamp test

a) Test pulses 3a and b:
test duration 10 min each
10 Hz repetition frequency \( U_s = \pm 120 \text{ V} \)

a) Test pulses 1 and 2:
100 pulses
Repetition frequency 0.2 Hz to 5 Hz \( U_s = \pm 100 \text{ V} \)

The voltages shall be measured at the 50 \( \Omega \) terminal of the coupling clamp (see section 6.1.1, figure 1).

6.4.2 Injection probe test

Test pulses 1 and 2: Repetition frequency 0.2 Hz to 5 Hz
500 pulses
Induced test voltage \( \pm 5 \text{ V (amplitude)} \), if not otherwise specified.

7 Test equipment

Tolerances: voltage and resistance values \( \pm 10 \% \); time periods \( \pm 30 \% \).

7.1 Voltage test equipment

Oscilloscope (preferably with digital storage function):
Bandwidth minimum 400 MHz
Writing time division minimum 5 ns/div

Scanner head:
Division ratio minimum 10/1
Permissible input voltage minimum 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 noted in the report.

7.2 Artificial mains network for 12 V / 24 V / 42 V vehicle power supply systems

The artificial mains 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 cabling diagram is depicted in figure 6. Figure 7 shows how the impedance of the artificial mains network changes as a function of frequency.

Direct voltage drop at maximum load must not exceed 250 mV.
A: power supply terminal
B: reference ground terminal
P: connection DUT

Figure 6 - Cabling diagram of artificial mains network

As seen from the DUT side (between terminals P and B); tolerance ± 10 %; terminals A and B short-circuited.

Figure 7 - $|Z_{PB}|$ (Ω) impedance of artificial mains network as a function of frequency

7.3 Starter battery / power supply

There are two alternatives for power supply:

- A sufficiently powerful power supply unit with an artificial mains network (according to section 7.2) connected to it
- A buffered starter battery common for the respective application, i.e. operating voltage is maintained at $U_p$ by continuous loading
7.4 Pulse generator

An interference pulse generator acc. to DIN ISO 7637 shall be used as substitute interference source. The specified values refer to the generator only. The exact procedure is described in section 5.5.

\[ U_S = 0 \text{ to } -200 \text{ V} \]
\[ R_i = 50 \text{ Ohm} \]
\[ t_r = 5 \text{ ns} \]
\[ t_1 = 100 \mu \text{s} \]
\[ t_2 = 10 \text{ ms} \]
\[ t_3 = 90 \text{ ms} \]
\[ t_d = 0.1 \mu \text{s} \]

Fig. 8 - Test pulse 3a

\[ U_S = 0 \text{ to } 200 \text{ V} \]
\[ R_i = 50 \text{ Ohm} \]
\[ t_r = 5 \text{ ns} \]
\[ t_1 = 100 \mu \text{s} \]
\[ t_2 = 10 \text{ ms} \]
\[ t_3 = 90 \text{ ms} \]
\[ t_d = 0.1 \mu \text{s} \]

Fig. 9 - Test pulse 3b

---

2 Illustrations, graphics, photographs and flow charts were adopted from the original German standard, and the numerical notation may therefore differ from the English practice. A comma corresponds to a decimal point, and a period or a blank is used as the thousands separator.
7.5 **Coupling clamp**

The coupling clamp provides the means of coupling the transient into the disturbance sink without any galvanic connection of the interference source to parts of the DUT.

The coupling clamp design is specified in detail in ISO 7637-3.

Requirements deviating from ISO 7637-2:

Puncture strength of insulation against pulse voltage \[ \geq 240 \text{ V} \]

7.6 **Ground plane**

The ground plane serves as support and reference ground level for the test setup with coupling clamp. It is constituted by a metal plate (e.g. copper/zinc or brass/copper alloy) with a nominal thickness of 1.0 mm. Its minimum size shall be 2 x 1 mm.

The ground plane is connected to the grounding system’s protective ground.

7.7 **Injection probe**

The injection probe provides the means of coupling the transient into the disturbance sink without any galvanic connection of the interference source to parts of the DUT.

For sufficient transmission of the test pulses stated in this standard, transmission frequency response shall be 200 kHz to 30 MHz minimum.

The insulation shall withstand more than 100 V.
7.8 Test harness

The test harness consists of a number of sensor cables necessary for the electrical connection of the DUT with its periphery. Its length shall not exceed \((1.8 - 0.2)\) m.

7.8.1 Position in the coupling clamp

The test harness is inserted in the coupling clamp symmetrically. There are no requirements for the setup and the line diameters of the test harness concerning EMC.

7.8.2 Position in the injection probe

All lines except the ground lines are enclosed in the injection probe. The ground line shall be routed around the injection probe using the most direct path possible.

8 Referenced standards\(^3\)

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL 820 66</td>
<td>EMC of Automotive Electronic Components, Conducted Interferences</td>
</tr>
<tr>
<td>DIN 40 839-3</td>
<td>Electromagnetic Compatibility (EMC) in Motor Vehicles, Electrical Transient Transmission by Capacitive and Inductive Coupling via Lines in 12 V and 24 V Power Supply Systems</td>
</tr>
<tr>
<td>DIN ISO 7637-3</td>
<td>Electrical Disturbances by Conduction and Coupling – Electrical Transient Transmission by Capacitive and Inductive Coupling via Lines Other than Supply Lines</td>
</tr>
</tbody>
</table>

\(^3\) In this section terminological inconsistencies may occur as the original titles are used.