

6.5 Application Notes: Electromagnetic Compatibility (EMC) in Automotive Applications

Electromagnetic compatibility is the ability of an electric device to work satisfactorily in an electromagnetic environment without any impermissible influence on this environment (e.g. DIN VDE 0870).

The DIN 40839 and the comparable ISO 7637 standards insure EMC in road vehicles and define several types of tests:

DIN 40839-1: Injection of supply line transients (test pulses) in 12 V onboard systems

DIN 40839-2: Injection of supply line transients (test pulses) in 24 V onboard systems

DIN 40839-3: Injection of capacitive line transients

DIN 40839-3: Radiated interference

DIN 40839-1/-2: Injection of Supply Line Transients

Table 10 summarizes the amplitudes of the different transients. The respective pulse profiles are defined in the standards. The battery voltages used are $V_{\text{batt}} = 13.5 \text{ V}$ (27 V) for a 12 V (24 V) on-board voltage supply. Since some of the pulses are generated with the so-called Schaffner Generator, it is sometimes referred to as Schaffner test pulses.

Table 10
Severity Level of Test Pulse for 12 V Supply Voltage (24 V Supply Voltage)

Test Pulse	Pulse Amplitude V_s in Volts for Severity Levels			
	I	II	III	IV
1	– 25 (– 50)	– 50 (– 100)	– 75 (– 150)	– 100 (– 200)
2	+ 25 (+ 25)	+ 50 (+ 50)	+ 75 (+ 75)	+ 100 (+ 100)
3a	– 25 (– 35)	– 50 (– 70)	– 100 (– 140)	– 150 (– 200)
3b	+ 25 (+ 35)	+ 50 (+ 70)	+ 75 (+ 140)	+ 100 (+ 200)
4	– 4 (– 5)	– 5 (– 10)	– 6 (– 14)	– 7 (– 16)
5	+ 26.5 (+ 70)	+ 46.5(+ 113)	+ 66.5 (+ 156)	+ 86.5 (+ 200)

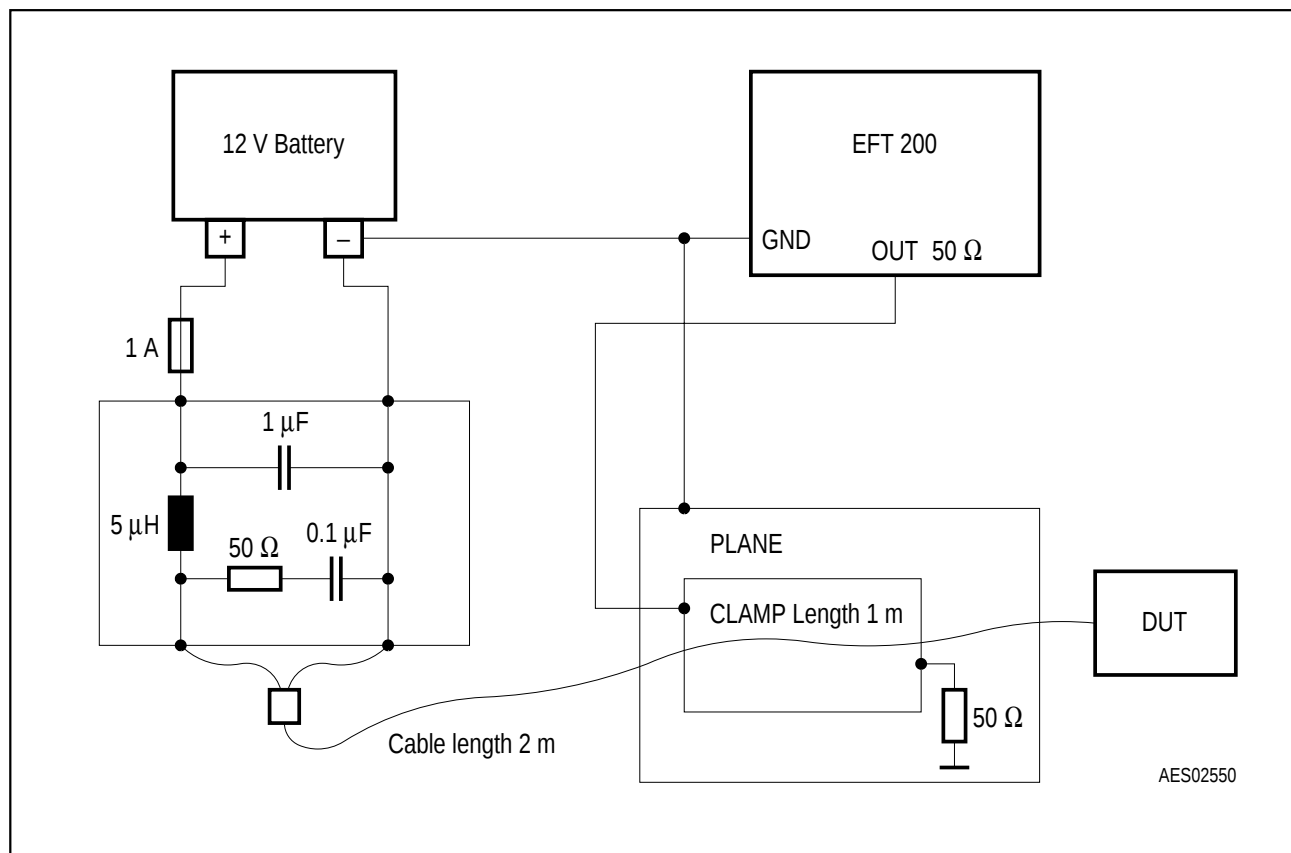
Table 11 lists the failure mode severity classification that applies to DIN 40839 and ISO 7637.

Table 11
DIN 40839 and ISO 7637 Failure Mode Severity Classification

Class A	All functions of a device/system perform as designed during and after exposure to disturbance.
Class B	All functions of a device/system perform as designed during exposure: however, one or more of them can go beyond specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions shall remain Class A.
Class C	All functions of a device/system does not perform as designed during exposure but returns automatically to normal operation after exposure is removed .
Class D	All functions of a device/system does not perform as designed during exposure and does not return to normal operation until exposure is removed and the device/system is reset by simple "operator/use" action.
Class E	One or more functions of a device/system does not perform as designed during and after exposure and cannot be returned to proper operation without repairing or replacing the device/system.

DIN 40839-3: Injection of Capacitive Line Transients

This test is used to simulate capacitive coupling of burst pulses into control and data lines of electric devices. A so-called coupling clamp is used to generate the capacitive coupling. The setup as used for the measurements is shown in **figure 39**.



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Figure 39
Coupling Clamp Measurement Setup (EFT 200: Pulse Generator)

The Hall IC (DUT: Device Under Test) is actuated with a magnetic coil ($\Delta B = 5 \text{ mT}$ @ $f = 200 \text{ Hz}$) and the supply line has a length of 2 m. Missing pulses are the malfunction criteria. **Table 12** shows the amplitudes of the capacitive pulses according to the DIN standard. Also in this test the severity classification in **table 11** applies.

Table 12
Severity Level of DIN 40839-3 Test Pulses (12 V Supply Voltage)

Test Pulse	Pulse Amplitude V_s in Volts for Severity Levels			
	I	II	III	IV
1	– 7.5	– 15	– 22.5	– 30
2	+ 7.5	+ 15	+ 22.5	+ 30
3a	– 15	– 30	– 45	– 60
3b	+ 10	+ 20	+ 30	+ 40

DIN 40839-4: Radiated Interference

There are different tests for exposing an electric device to electromagnetic radiation. The two most common test methods for single components as e.g. Hall ICs are

- Stripline measurements
- Measurements in a TEM cell (Transverse Electro Magnetic)

For stripline measurements a signal generator provides an electromagnetic field (frequency typically 10 kHz ... 1 GHz, E-field up to 250 V/m) between the two electrodes of an about 1 m long stripline. The wiring of the electric component is placed between the two electrodes of the stripline. The component itself is not exposed to the electromagnetic field. With this setup coupling of electromagnetic radiation into the wiring of the component is simulated. In a TEM cell the immunity of the component itself to electromagnetic radiation is measured. The component is placed in a homogeneous electromagnetic field, generated between the inner conductor of the TEM cell (septum) and its outer conductor (enclosure). **Figure 40** illustrates the structure of the TEM cell and the complete measurement setup, including the signal generator and the readout electronics.

Following the detailed measurement conditions for the differential ICs are summarized:

Electromagnetic Field

- TLE 4921-3U: Maximum carrier field 90 V/m, $f = 10 \text{ kHz to } 750 \text{ MHz}$, $AM = 1 \text{ kHz}$, $m = 80\%$ (peak value 160 V/m)
- TLE 4923: Maximum carrier field 110 V/m, $f = 10 \text{ kHz to } 750 \text{ MHz}$, $AM = 1 \text{ kHz}$, $m = 80\%$ (peak value 198 V/m)

Hall IC Actuation

- TLE 4921-3U: Target wheel, $\Delta B = 50 \text{ mT @ } f = 100 \text{ Hz}$
- TLE 4923: Magnetic coil for actuation, $\Delta B = 5 \text{ mT @ } f = 200 \text{ Hz}$
- The position of the cables is fixed on a wooden board (thickness 20 mm). The cables must not touch the cell.

Malfunction Criteria and Detection

- TLE 4921-3U: Missing pulses in the IC output
- TLE 4923: Jitter of $\pm 0.2 \text{ ms}$ is exceeded
- Detection: Oscilloscope and frequency counter

Measurement Method

Frequency sweeps in steps of 1 MHz at the highest E-field level, remaining one second at each frequency. In case of malfunction: Decrease of E-field to locate the minimum values.

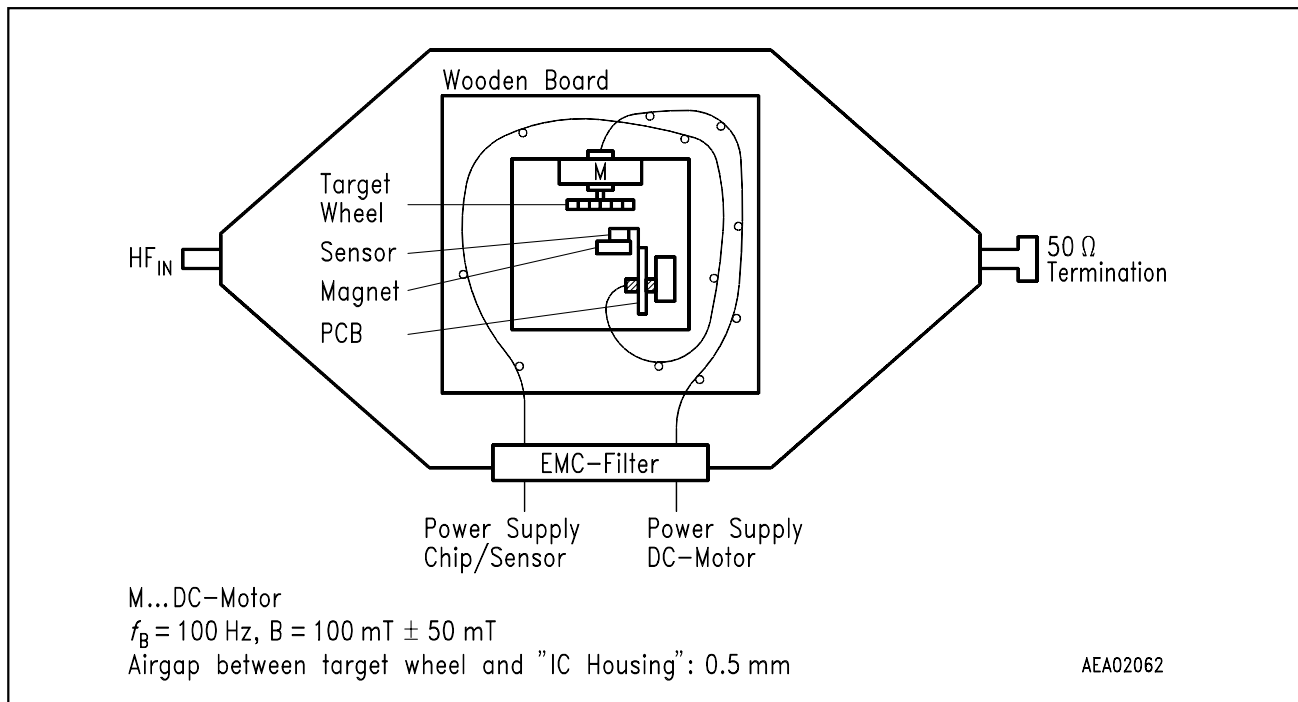


Figure 40
Top View of the TEM Cell with Target Wheel powered by a DC Motor (TLE 4921-3U) for Magnetic Actuation of the Hall IC Samples to be tested.