# EMC Test Report

# DRAFT

# Index

# 1 Electro Magnetic Compatibility (EMC) Setup and Definition

## EMC Test Standards

Overview about all required measurement methods and respective standards.

**Table 1** General information about the measurement standards as off 2022-05-16

| Measurement method | Coupling mode | Reference to the standard | Abbreviation |
|---|---|---|---|
| - | - | IEC 62215-3: 2013 | IC Performance Class |
| Transient disturbance | Conducted | ISO 7637-1: 2015<br>ISO 7637-2: 2011<br>ISO 7637-3: 2016<br>ISO 16750-2: 2012 | ISO |
| Direct Power Injection (DPI) | Conducted | IEC 62132-1: 2015<br>IEC 62132-4: 2006 | DPI |
| Emission direct coupling | Conducted | IEC 61967-1: 2018<br>IEC 61967-4: 2021 | 150Ohm |
| Emission with artificial Network | Conducted | IEC CISPR 25 : 2021 | LISN |
| Radiated Emission ALSE | Radiated | IEC CISPR 25 : 2021 | ALSE Absorbed Lined Shielded Enclosure |

## IC Performance Classes

According to Table 1
The test results are classified from $A_{IC}$ to $E_{IC}$. Table 2 shows the definition for each Class.

**Table 2** Definition of the IC Performance classes used for Transient- and RF- Immunity testing

| Class | Content |
|---|---|
| $A_{IC}$ | all monitored functions of the IC perform within the defined tolerances during and after exposure to disturbance. |
| $B_{IC}$[1] | short time degradation of one or more monitored signals during exposure to disturbance is not evaluable for IC only. Therefore this classification may not be applicable for ICs |
| $C_{IC}$ | at least one of the monitored functions of the IC is out of the defined tolerances during the disturbance but returns automatically to the defined tolerances after the exposure to disturbance; |
| $D1_{IC}$<br>$D2_{IC}$ | at least one monitored function of the IC does not perform within the defined tolerances during exposure and does not return to normal operation by itself. The IC returns to normal operation by manual intervention<br>Class D1IC: the IC returns to normal operation by manual intervention: (e.g. reset);<br>Class D2IC: the IC returns to normal operation by power cycling the device |
| $E_{IC}$ | at least one monitored function of the IC does not perform within the defined tolerances after exposure and cannot be returned to proper operation. |

## Device Under Test

**Table 3** Device Under Test Information

| Sales Code | Date Code | Design Step |
|---|---|---|
| TLD4020-3ET | | A11 |

[1] Short time degradation of one or more monitored signals can be tolerable in the application by its error handling. This error handling is unknown in most cases for IC test.

## Pin Definition

**Table 4** General pin classification

| Class | Definition |
|---|---|
| global pin | A 'global' pin carries a signal or power, which enters or leaves the application board. |
| local pin | A 'local' pin carries a signal or power, which does not leave the application board. It remains on the application PCB as a signal between two components with or without additional EMC components. |

## Pin Selection for Immunity and Emission Test

The following Table lists **all** IC Pins in order to classify and to select the required EMC-test.
The requirement listing for RF-immunity, RF-Emission-150R and RF-Emision-LISN are based on Table 5 .

**Table 5** IC-Pin definition considering Pin-class and required EMC test/simulation. Listing all IC Pins.

| Pin | | class | Immunity | | Emission |
|---|---|---|---|---|---|
| | | | Electrical transients (ISO) | Conducted Immunity (DPI) | Conducted Emission (150Ω) |
| 1 | VS | global | X | RF-VBAT | RF-VBAT |
| 2 | NC | – | – | – | – |
| 3 | NC | – | – | – | – |
| 4 | GND | global | – | – | – |
| 5 | NC | – | – | – | – |
| 6 | NC | – | – | – | – |
| 7 | LIN_M | global | X | RF-LIN_M | RF-LIN_M |
| 8 | LIN_S | global | – | RF-LIN_S | RF-LIN_S |
| 9 | GPIO0 | local | – | RF-GPIO0 | RF-GPIO0 |
| 10 | GPIO1/SWCLK | local | – | RF-GPIO1 | RF-GPIO1 |
| 11 | SWIO/TMS | local | – | – | – |
| 12 | NC | – | – | – | – |
| 13 | NC | – | – | – | – |
| 14 | OUT0 | global | – | RF-OUT0 | RF-OUT0 |
| 15 | OUT1 | global | – | RF-OUT1 | RF-OUT1 |
| 16 | OUT2 | global | – | RF-OUT2 | RF-OUT2 |

## General Test Setup

Figure 1 outlines all needed external components to operate the DUT under application conditions. These components can influence the final EMC result. They are treated as inherent part of the DUT during the EMC characterization.

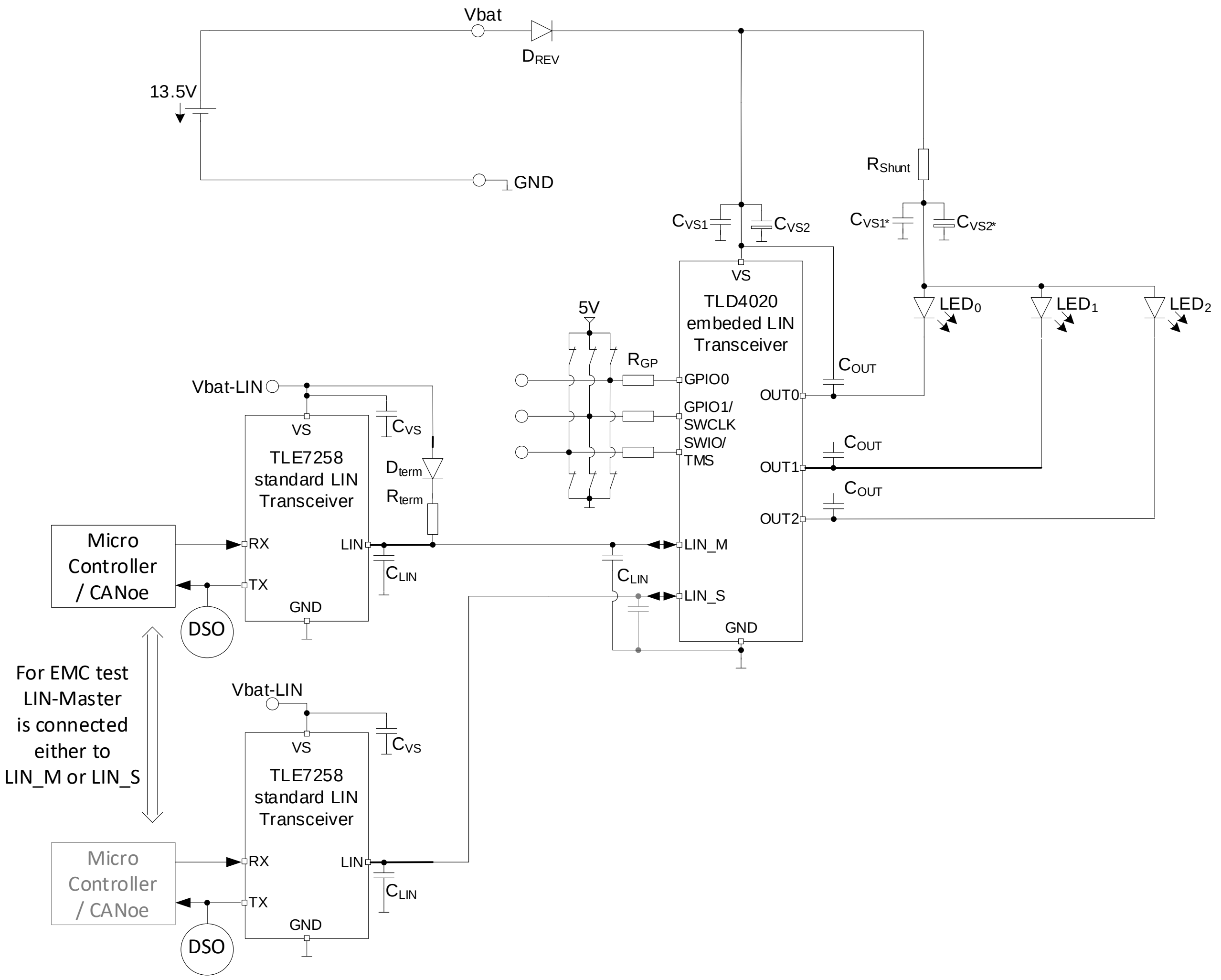



**Figure 1** Device under Test including the applicative external components that are needed to bring the DUT into its normal operation mode as well as the allowed additional components.

**Table 6** Part listing for normal operation mode

| Reference | Value | Type | Comment |
|---|---|---|---|
| Drev | 1A 200V | RB168MM200TFTR | to low reverse voltage! |
| $C_{VS1}$ | 100nF | X7R, 50V, 0805 | |
| $C_{VS21}$ | 4.7uF | X7R, 50V, 1210 | |
| $C_{OUT}$ | | X7R, 50V, 0805 | |
| $C_{LIN}$ | Open / 110pF | X7R, 50V, 0805 | IEC 62228-2 specifies limits with and without $C_{LIN}$ |
| $D_{Term}$ | | BYD17K | Optional |
| $R_{Term}$ | 1kR | X7R, 50V, 0805 | Master Termination |
| LED | | OVSTRGBB1CR8 | one color on each 50mA |
| Rshunt,on/active | 10Ohm | | 51mA per channel |
| Rshunt,off/sleep | 1kOhm | | <100uA per channel |

## Test Conditions

All general EMC-Test conditions are listed in Table 7 .

**Table 7** General EMC-Test conditions

| Parameter | Symbol | Value | Unit | Remark |
|---|---|---|---|---|
| Voltage reference | — | — | — | All voltages are referred to PCB-GND |
| Temperature | $T_A$ | 23 +/-5 | °C | — |
| Supply voltage | Vs | 13.5 ± 0.5<br>12 ± 0.5 | V | All test but not Starting Profile<br>Only for Starting Profile |
| Input voltage high level | $V_{IN,high}$ | 5 ± 5% | V | — |
| Input voltage low level | $V_{IN,low}$ | 0 + 5% | V | — |

## Operation Modes

**Table 8** Pin setting or/and alternatively SPI register in order to bring the device in the desired operation mode for Transient- and RF-Immunity test as well as for the RF-Emission test150R and Emission test LISN .

| Test Case | Operation Mode | Standard Test | LIN Test | Comment |
|---|---|---|---|---|
| TC1 | Off-all | X | – | All channels off |
| TC2 | On-all | X | – | All channels on, d=100% 10mA each , no PWM |
| TC3 | Pwm-all | X | – | All channels pwm 300Hz, d=50% 10mA each |
| TC4 | ADC-check | X | – | Read OUT1 voltage in ON Mode |
| TC5 | Sleep, unwanted wake up | – | X | Check OUT0 on/off |
| TC6 | Sleep, wanted wake up | – | X | Check OUT0 on/off<br>sending LIN Pattern TX3 |
| TC7 | LIN-respond | – | X | Device has to respond on this pattern.<br>GPIO-PWM by LIN Pattern TX2. |
| TC8 | | – | X | Interoperability test check that LIN communication with additional standard LIN Transceiver is not affected by DUT.<br>Sending 0xA5A5 and read RX<br>Master on LIN_M Receiver on LIN_S<br>Master on LIN_S Receiver on LIN_M |

Note :

**TC4** ADC Check : Average ( milli s range ) of ADC under normal undisturbed condition ADC result is internally stored as reference Value by sending a dedicated command. During EMC test average ADC readout is internally compared with previous stored reference value, readout within tolerance is pass result otherwise fail result. Readout is extern triggered by rising edge on GPIO1. GPIO0 indicate pass / fail result by digital high / low output value.

**TC5 & TC6**: special device Firmware for this test. If device wakes up OUT0 is turned on. After 1ms device returns automatically into sleep mode.

## Reset Routine

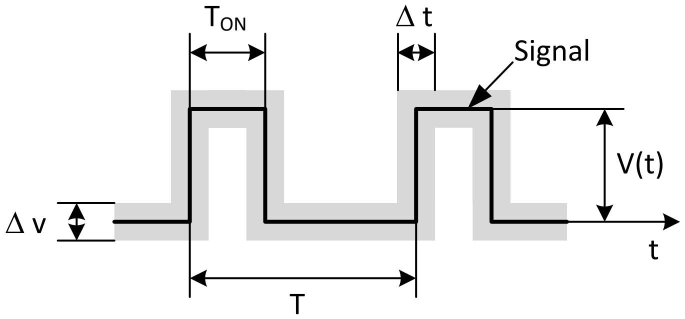
Before performing any EMC test the device is to be set into a defined functional state. This is done by the reset routine.

**Table 9** Reset routine

| Action | Pin -action | comment |
|---|---|---|
| 1 | Turn off Vs | No dedicated reset requirement defined |
| 2 | Wait 1sec | |
| 3 | Turn on Vs | |

## Pass/Fail Criteria for Immunity Tests

For evaluating the device behavior during Transient-Immunity and RF-Immunity tests monitoring criteria have to be defined. The device functionality is monitoring by checking required signals by an oscilloscope. Therefore a tolerance band for the nominal behavior is defined in amplitude and time. A signal within this specified tolerance band is a pass signal. For register readouts the nominal pass value for the register content is defined. For RF-immunity tests the monitoring is done with powered RF signal. The monitoring signal should not be superimposed by RF-signals therefore a low pass filter is inserted for RF-immunity tests.
Table 10 defines the tolerance band for different monitor Pins as well as the nominal register values.




Δv is calculated in relation to V(t)

Δt is calculated in relation to $T_{ON}$

**Figure 2** Tolerance band specification

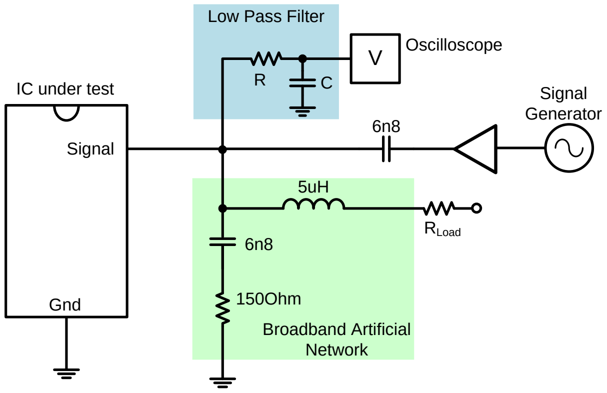



**Figure 3** Signal probing <u>with</u> low-pass filter used for RF-Immunity test

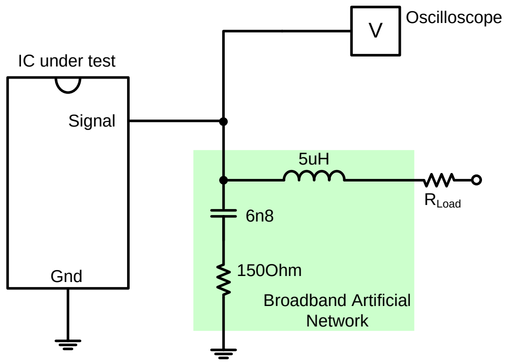



**Figure 4** Signal probing <u>without</u> Low Pass Filter used for Transient-Immunity test

**Table 10** Pass / Fail Criteria for Transient- and RF-Immunity test.

| Monitoring | Monitoring Pin/register | Operation mode | Failure Criteria: Tolerance Band: Amplitude | Failure Criteria: Tolerance Band: Time | Failure Criteria: Value |
|---|---|---|---|---|---|
| M0 | – | PWM | – | – | – |
| M1 | $I_{LED}$ | OFF | < 100uA | – | High/Low level |
| M2 | $I_{LED}$ | ON / PWM | ±10% | ±10% | Voltage within tolerance band |
| M3 | ADC readout | ON | ±20% | – | Average value compare to undisturbed readout |
| M4 | $V_{OUT0}$ | SLEEP | ΔVout0 | – | Out0 stays off (Auto Trigger) |
| M5 | $V_{OUT0}$ | Wake up | ΔVout0 | – | OUT0: off=>on |
| M6 | RX readout | | ±10% | ±10% | Voltage within tolerance band |

# 2 Conducted Immunity – Transient Disturbances (ISO)

“Conducted Immunity – Transient Disturbances” examines electrical transient conduction along supply lines according to Table 1 plus special electrical transients based on customer requirements.

## Test-/Simulation Setup for Transient Disturbances

Figure 5 shows the basic transient immunity test- simulation-setup for the injection of the standardized ISO pulses. For the pulse definition refer to the Appendix 5.

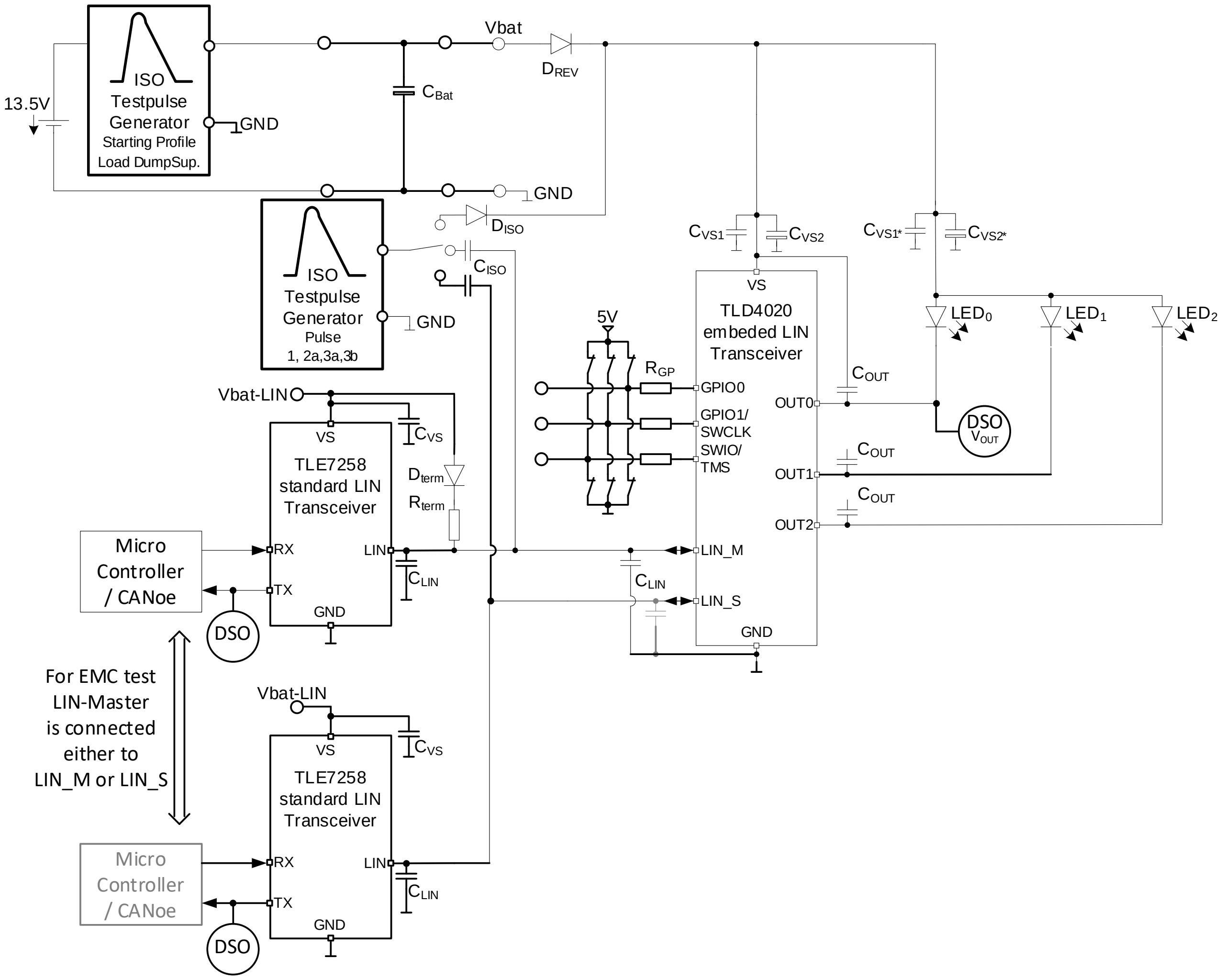



**Figure 5** Transient immunity test/simulation setup for injection into Vbat, ISO pulses 1, 2a, 3a, 3b, Starting Profile and Load Dump Suppression Pulse

# General Requirements for Transient Disturbances

The following tables outline the absolute minimum and target value for transient immunity of 12V system.

**Table 11** Transient immunity requirements [IC Performance Class $A_{IC}$]

| Test Pulse | Test Pulse voltage | | Injection | Coup-ling | BUS Filter | IC Performance Class Requirement Operation mode | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Absolute min. requirement | Target value | | | | TC1 | TC2 | TC5 | TC6 | TC7 | TC8 |
| 1 | -100V | -100V | Vbat | direct | X | – | – | – | – | – | – |
| | | | | | – | – | – | – | – | M2 | – |
| | | | LIN_M | 1nF | X | – | – | M4 | M5 | M2 | M6 |
| | | | | | – | – | – | M4 | M5 | M2 | M6 |
| 2a | +75V | +112V | Vbat | direct | X | – | – | – | – | – | – |
| | | | | | – | – | – | – | – | M2 | – |
| | | | LIN_M | 1nF | X | – | – | M4 | M5 | M2 | M6 |
| | | | | | – | – | – | M4 | M5 | M2 | M6 |
| 3a | -150V | -150V | Vbat | direct | X | – | – | – | – | – | – |
| | | | | | – | – | – | – | – | M2 | – |
| | | | LIN_M | 1nF | X | – | – | M4 | M5 | M2 | M6 |
| | | | | | – | – | – | M4 | M5 | M2 | M6 |
| 3b | +100V | +100V | Vbat | direct | X | – | – | – | – | – | – |
| | | | | | – | – | – | – | – | M2 | – |
| | | | LIN_M | 1nF | X | – | – | M4 | M5 | M2 | M6 |
| | | | | | – | – | – | M4 | M5 | M2 | M6 |
| Starting Profile | +5.5V | +5.5V | Vbat | direct | X | M1 | – | – | – | – | – |
| Load Dump Suppression | +35V | +39V | Vbat | direct | X | M1 | M2 | – | – | – | – |

**Table 12** Transient Disturbance Result injected to Vbat Line, Operation mode TC7 = Lin respond

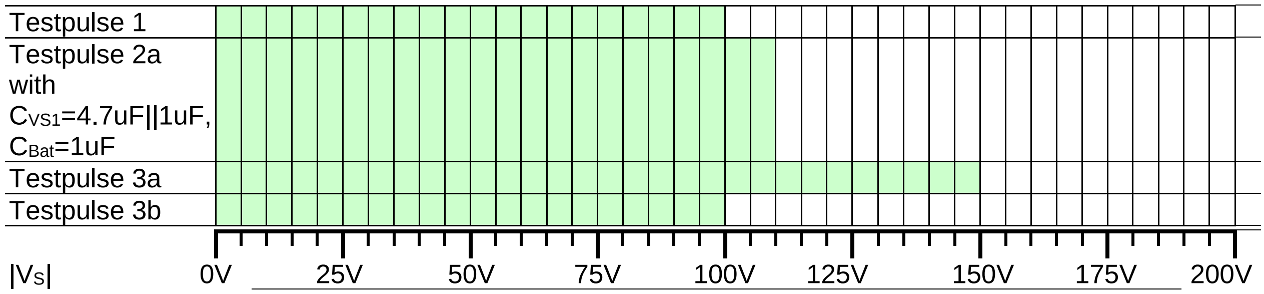



**Table 13** Transient Disturbance Result injected to LIN-M, Operation mode TC7 = Lin respond

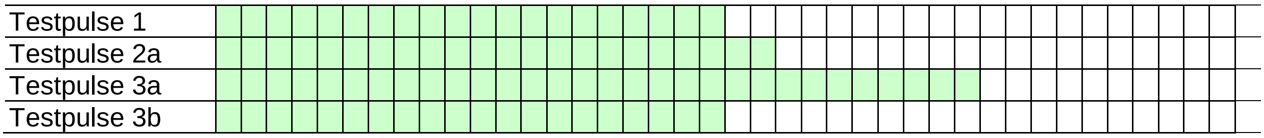
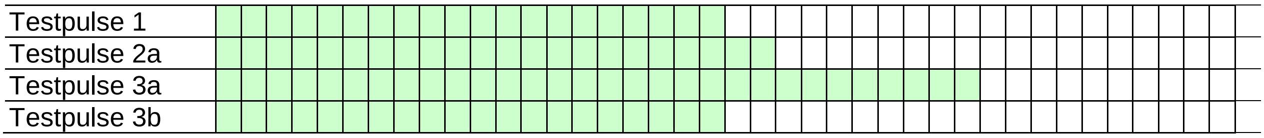



**Table 14** Transient Disturbance Result injected to LIN-M, Operation mode TC5 and TC6



# 3 Conducted Immunity – Direct Power Injection (DPI)

“Conducted Immunity – Direct power Injection” examines the RF susceptibility level according to Table 1

## Hardware test setup

**Table 15** Disturbance signal, Test bench and Presentation

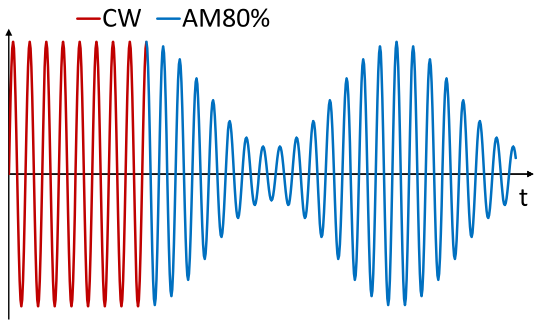
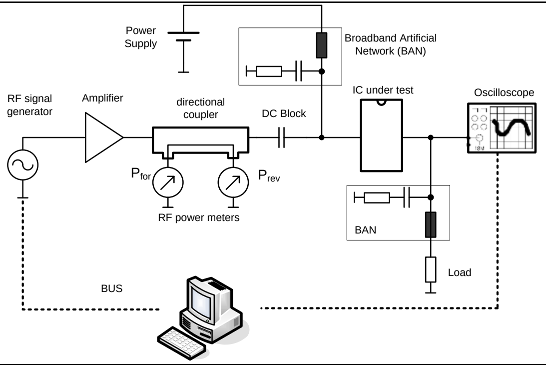
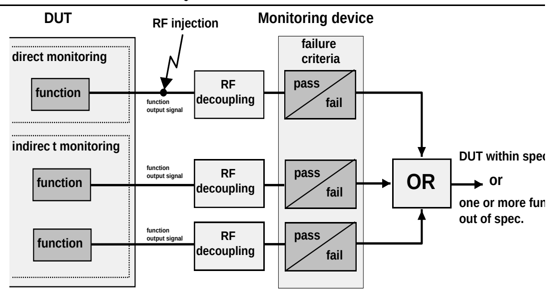
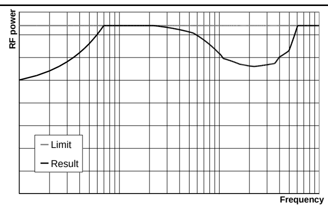
| | | |
|---|---|---|
| Forward power: | 17 dBm (local pin)<br>37 dBm (global pin) |  |
| Modulation: | CW (no modulation)<br>AM (80%, 1kHz sine wave, $P_{PEAK,AM} = P_{PEAK,CW}$) | |
| Dwell time: | $t_D$ = 1s *)<br>*) can be increased in order to do current averaging for monitoring | |
| Monitoring time: | $t_M$ = 0.5s*) | |
| Test Bench | A signal generator is used to provide the disturbance signal that is further amplified. A directional coupler and a power meter are used to measure the actual forward power that is coupled to the IC under test. The DC supply and the load are connected to broadband artificial networks. To monitor the behaviour of the IC measurement devices (e.g. oscilloscopes) are used |  |
| DUT monitoring | The monitored signals are combined to a logical sum "*within specification or out of specification*” as shown in the figure. As monitoring device an oscilloscope with a programmable signal tolerance mask is used. To prevent the monitoring device from the disturbance a RF decoupling filter is necessary |  |
| Typical diagram | The graph in the immunity diagram shows the value of the maximum injected RF power to a pin up to that the DUT operates without any failure. The maximum RF power to apply is defined by the limit line. |  |

**Table 16** Frequency ranges for direct power injection test

| Method | Frequency range | | | Frequency step | RF power step |
|---|---|---|---|---|---|
| DPI | 1 MHz | to | 10 MHz | 0.5 MHz | 0.2 dB |
| | 10 MHz | to | 100 MHz | 1 MHz | 0.2 dB |
| | 100 MHz | to | 200 MHz | 2 MHz | 0.2 dB |
| | 200 MHz | to | 400 MHz | 4 MHz | 0.2 dB |
| | 400 MHz | to | 1000 MHz | 10 MHz | 0.2 dB |

## Test-/ Simulation Setup for DPI

Below picture show the conducted immunity test/simulation setup.

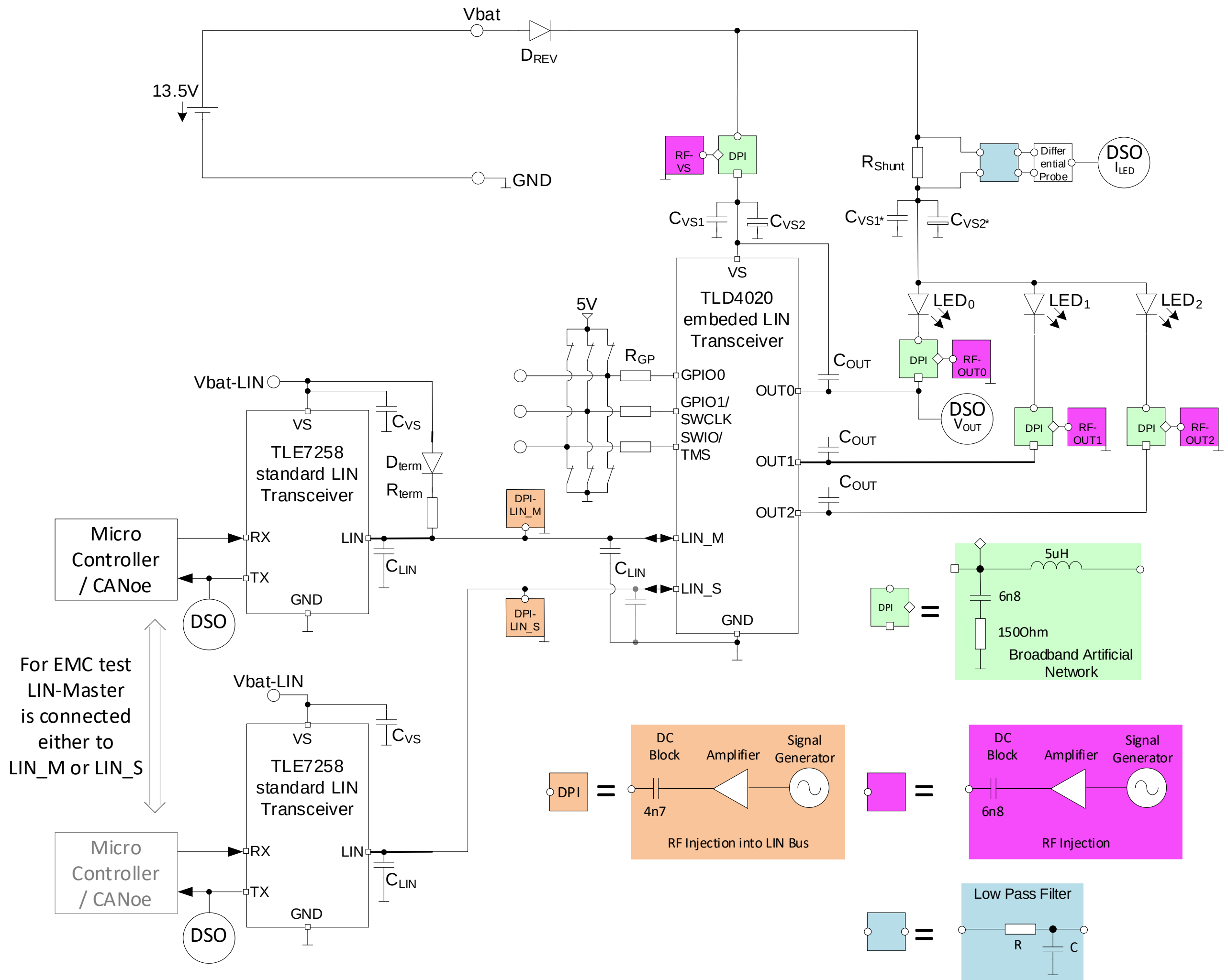



**Figure 6** Conducted RF-Immunity test/simulation setup

## Susceptibility Level Area Definition

The following figure shows the susceptibility level scheme for the DPI- classification of global and local pins.

**Above Class III:**
The Class III defines a range where usually no susceptibility issues occur on device level. The test Limit represents the design target. The Class III level itself represents the absolute minimum requirement.

**Class I:**
A result between Class III and Class I defines a range where additional simple external filtering/decoupling components usually improves the susceptibility level back to the Class III range. In the unlikely event that the susceptibility level is within the Class III and Class I although external components are used, please align with the EMC and AE colleagues on the further proceeding.

**Below Class I:**
A result below Class I is a severe and non-acceptable susceptibility level for the DUT with and without additional external components.

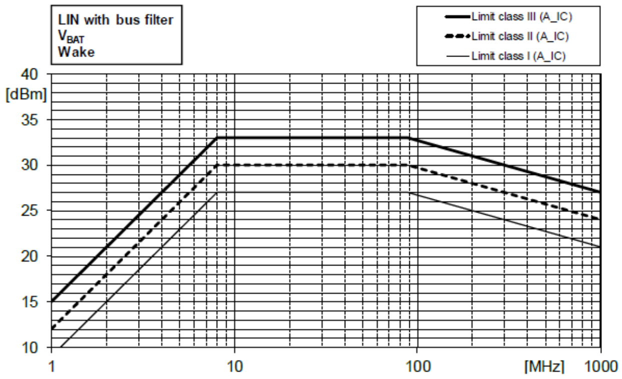



**Figure 7** “LIN with bus filter”
Functional Status $A_{IC}$
Applicable for VS, LIN-BUS, Wake

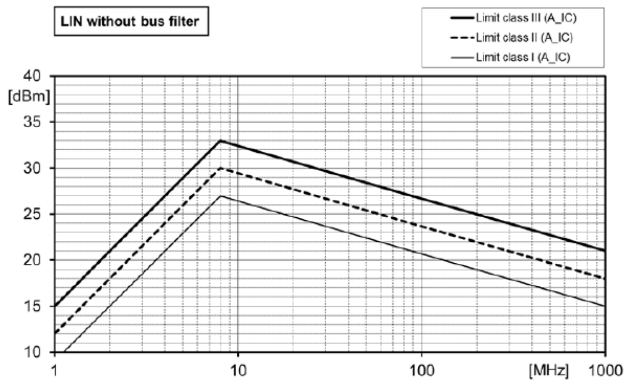



**Figure 8** “LIN without bus filter”
Functional Status $A_{IC}$
Applicable for VS, LIN-BUS, Wake

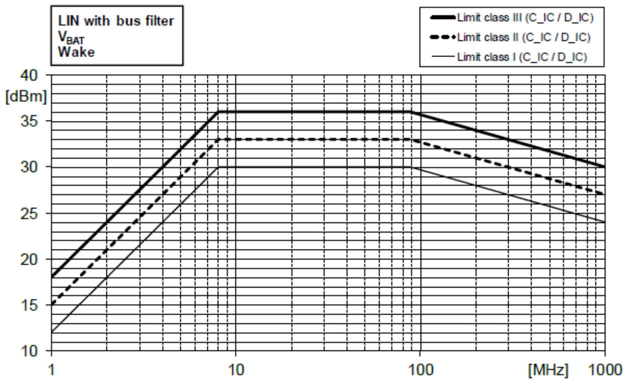



**Figure 9** “LIN with bus filter”
Functional Status $C_{IC}$ or $D_{IC}$
Applicable for VS, LIN-BUS, Wake

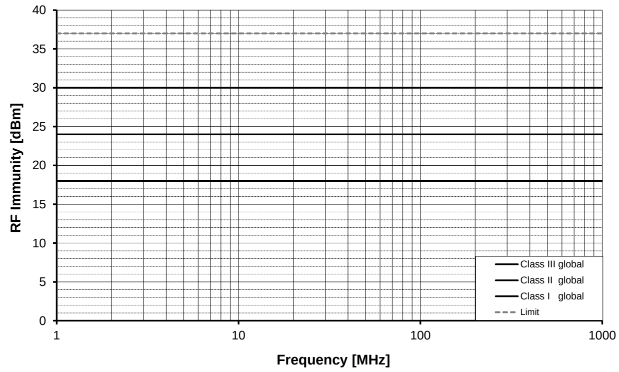



**Figure 10** “DPI global Pins”
Susceptibility level for DPI global Pins

## Pass/Fail Requirements for DPI

In general the green area has to be reached. If the test without external components results in the yellow area then a second test with external components needs to result in the green area.

**Table 17** Conducted immunity requirements (test levels), Pin selection regarding Table 5

| RF-injection into Pin | Target value | IC Performance Class & Limit | BUS Filter | Modulation, Pass / Fail Criteria and Operation Mode | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | TC1 | TC2 | TC3 | TC4 | TC5 | TC6 | TC7 | TC8 |
| RF-VS | 37dBm | $A_{IC}$, DPI Global | X | CW M1 | CW M2 | CW M2 | CW M3 | – | – | – | – |
| | 36dBm | $A_{IC}$, LIN with BUS filter | X | – | – | – | – | – | – | – | – |
| | | $A_{IC}$, LIN without BUS filter | – | – | – | – | – | CW,AM M4 | – | CW,AM M2 | – |
| | | $D_{IC}$, LIN without BUS filter | – | – | – | – | – | – | – | CW M0 | – |
| RF-OUT0,1,2 | 37dBm | $A_{IC}$, DPI Global | – | CW M1 | CW M2 | – | – | – | – | – | – |
| RF-LIN_M | 36dBm | $A_{IC}$, LIN with BUS filter | X | – | – | – | – | CW M4 | CW M5 | CW M2 | CW M6 |
| | | $A_{IC}$, LIN without BUS filter | – | – | – | – | – | CW,AM M4 | CW,AM M5 | CW,AM M2 | CW,AM M6 |
| | | $D_{IC}$, LIN with BUS filter | X | – | – | – | – | – | – | CW M0 | – |
| RF-LIN_S | 36dBm | $A_{IC}$, LIN with BUS filter | X | – | – | – | – | CW M4 | CW M5 | CW M2 | CW M6 |
| | | $A_{IC}$, LIN without BUS filter | – | – | – | – | – | CW,AM M4 | CW,AM M5 | CW,AM M2 | CW,AM M6 |
| | | $D_{IC}$, LIN with BUS filter | X | – | – | – | – | – | – | CW M0 | – |

Note: Bus Filter always only to the LIN Bus used for RF injection.

## Test Result

## RF-VS

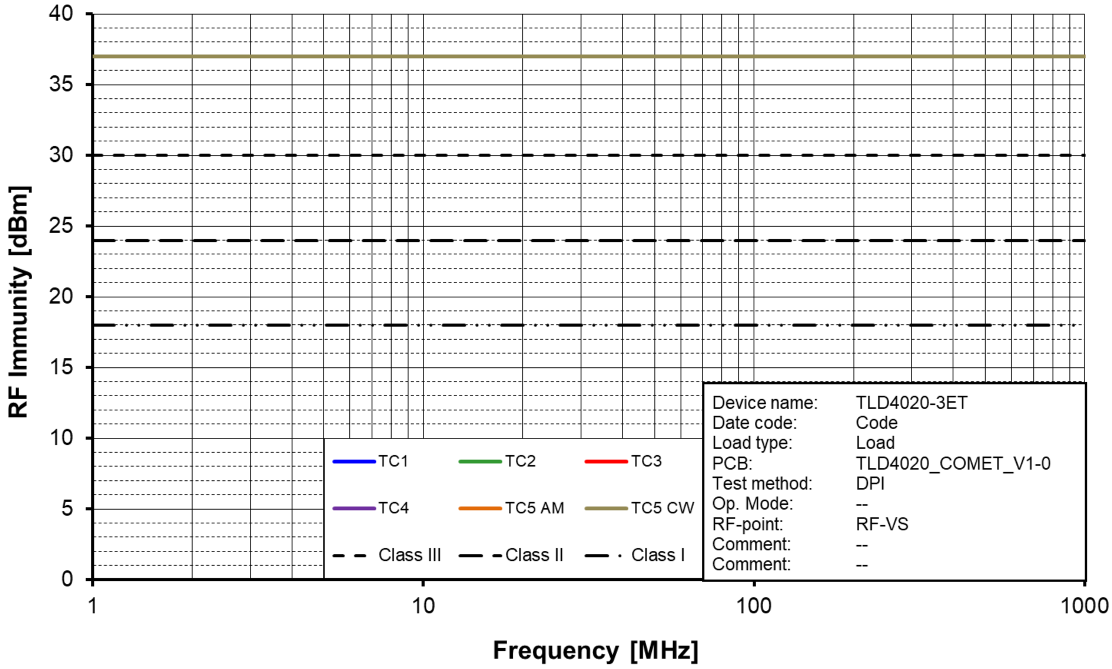



**Figure 11** Conducted RF-Immunity into VS.

## RF-OUT0

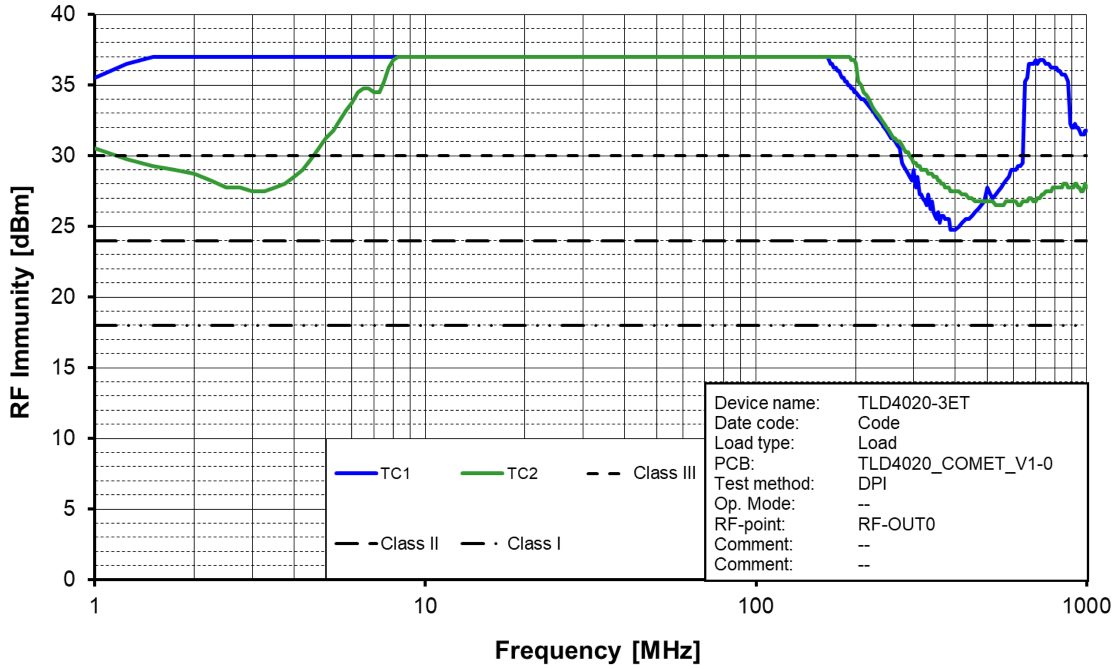



**Figure 12** Conducted RF-Immunity into OUT0.

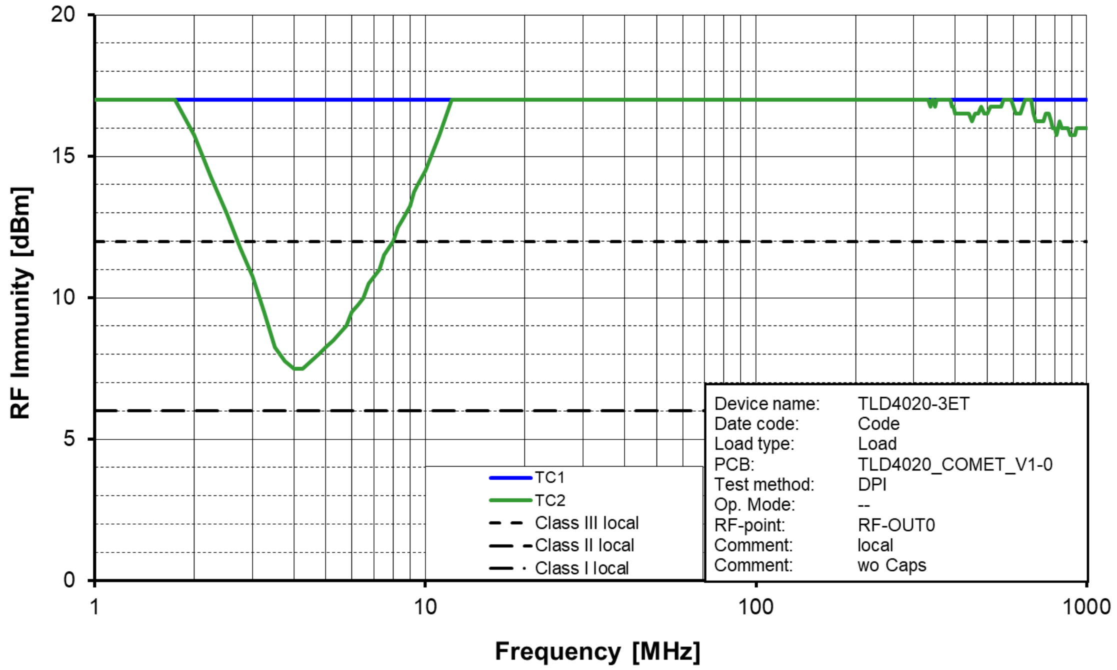



**Figure 13** Conducted RF-Immunity into OUT0 for local limits with Cout left open.

## RF-OUT1

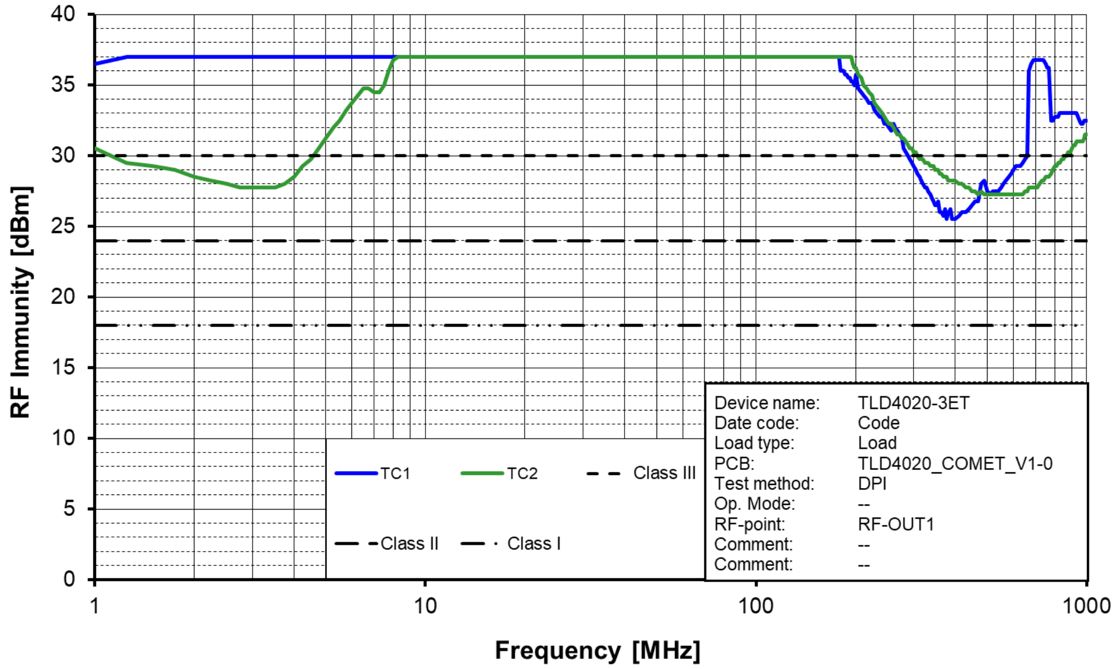



**Figure 14** Conducted RF-Immunity into OUT1.

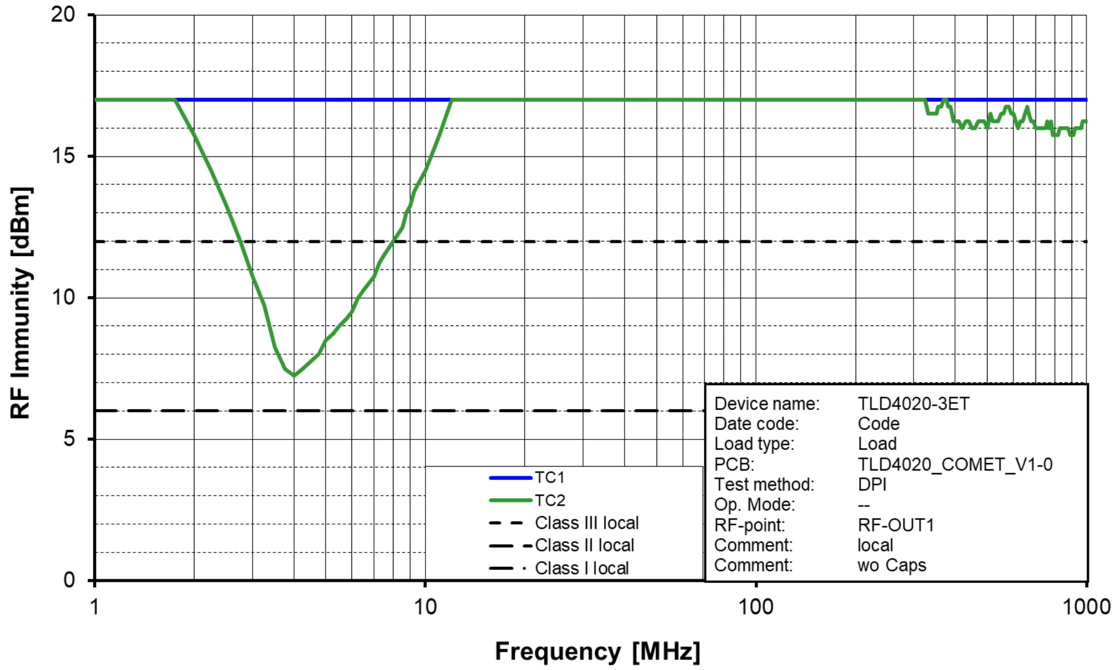



**Figure 15** Conducted RF-Immunity into OUT1 for local limits with Cout left open.

## RF-OUT2

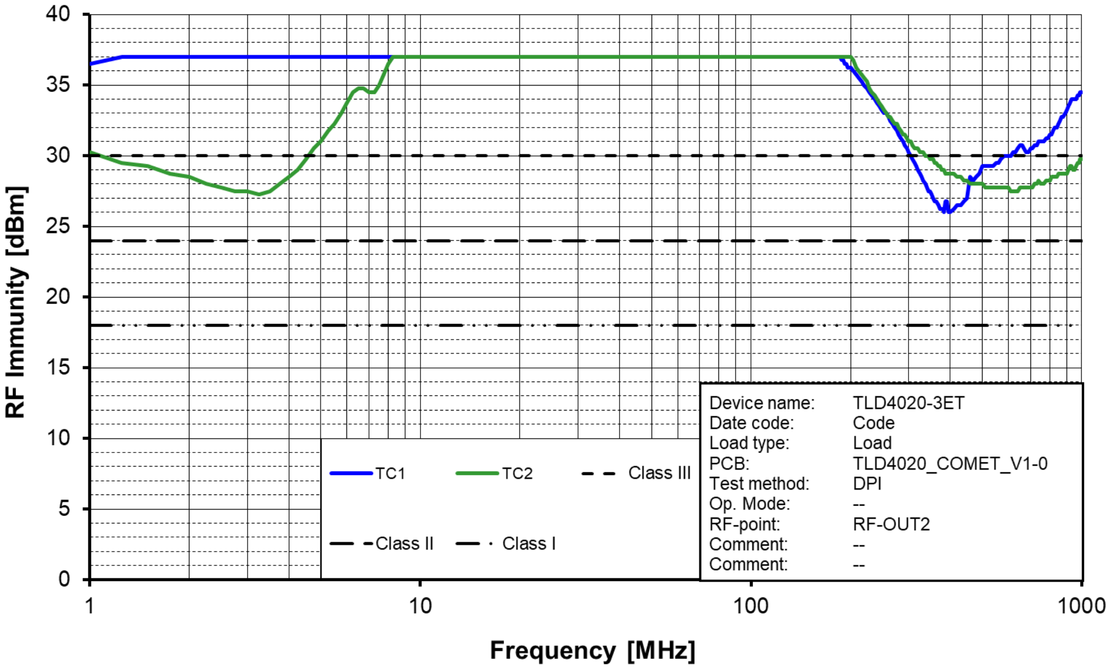



**Figure 16** Conducted RF-Immunity into OUT2.

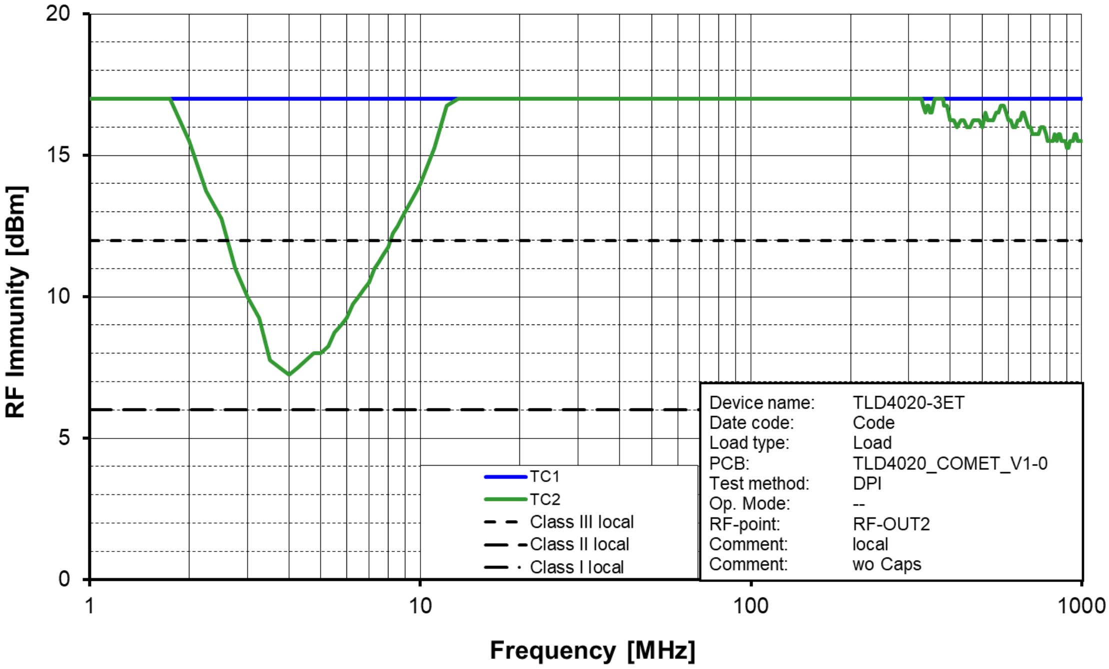



**Figure 17** Conducted RF-Immunity into OUT2 for local limits with Cout left open.

## RF-LIN-M

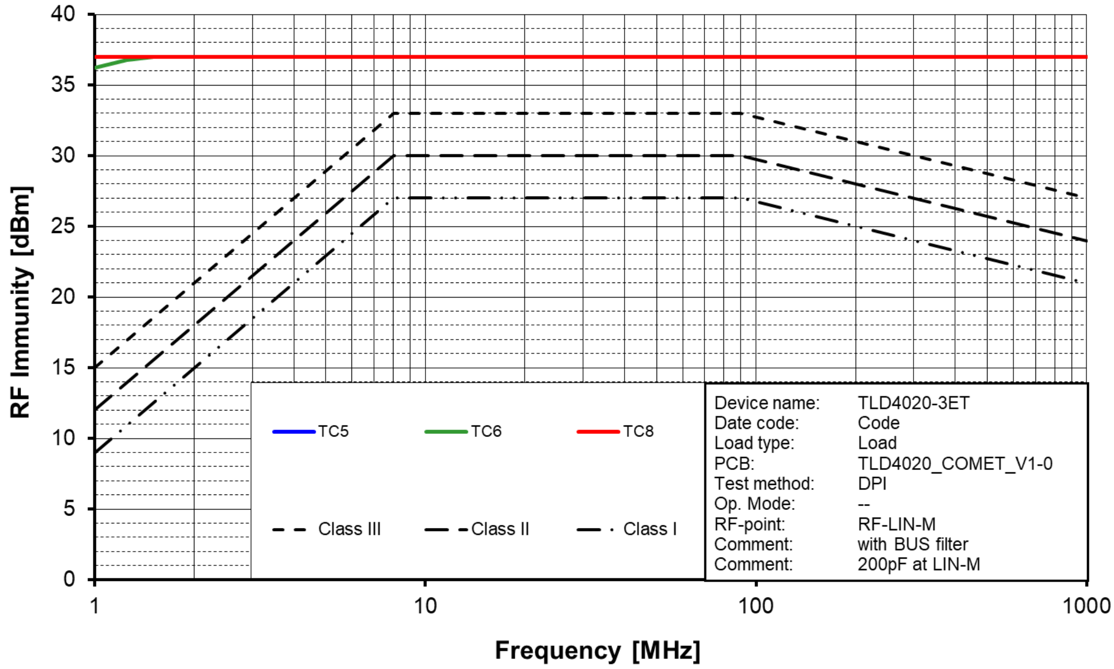



**Figure 18** Conducted RF-Immunity into LIN-M with BUS filter.
TC5 = sleep unwanted wake, TC5 = sleep wanted wake, TC8 = interoperability check

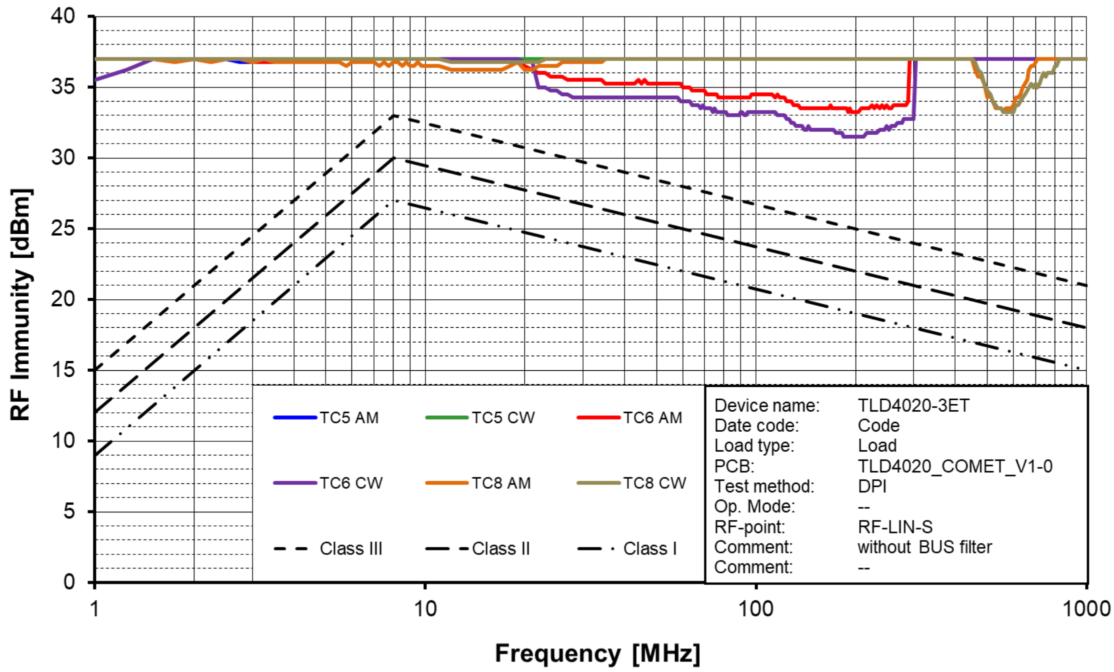



**Figure 19** Conducted RF-Immunity into LIN-M without BUS filter.
TC5 = sleep unwanted wake, TC5 = sleep wanted wake, TC8 = interoperability check

## RF-LIN-S

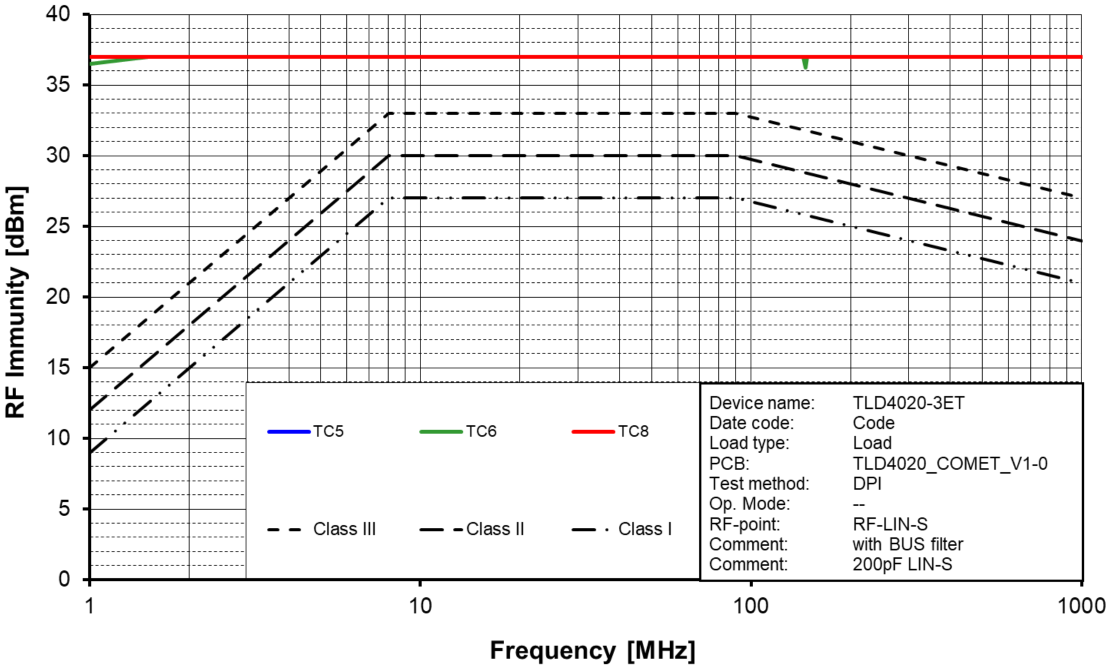



**Figure 20** Conducted RF-Immunity into LIN-M with BUS filter, 200pF at LIN-S.
TC5 = sleep unwanted wake, TC5 = sleep wanted wake, TC8 = interoperability check

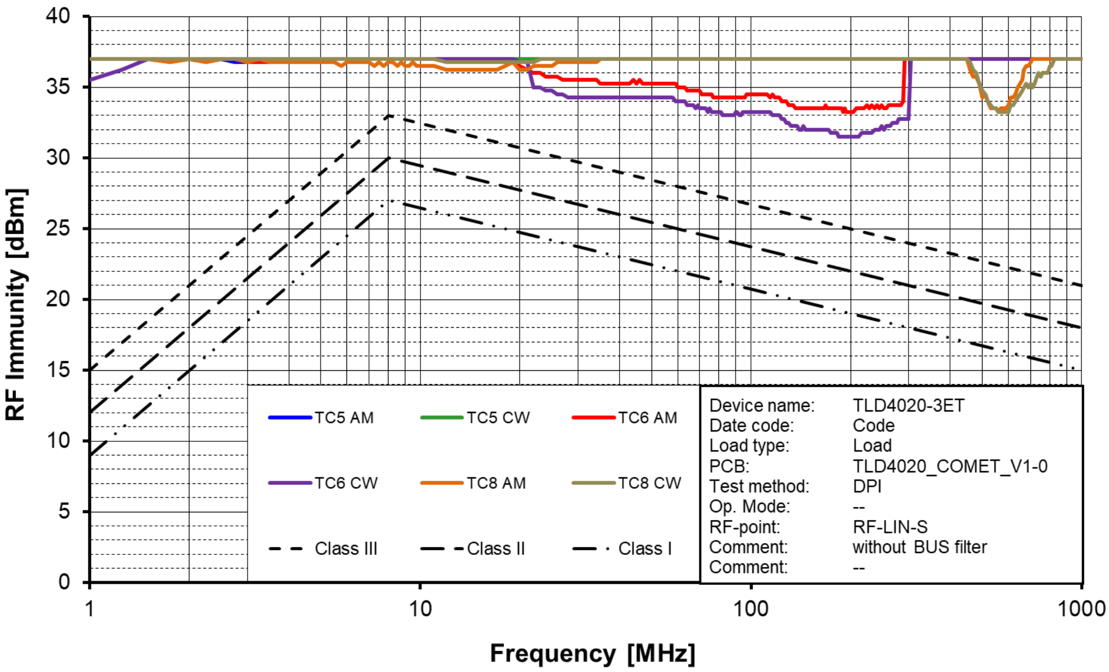



**Figure 21** Conducted RF-Immunity into LIN-M without BUS filter.
TC5 = sleep unwanted wake, TC5 = sleep wanted wake, TC8 = interoperability check

# 4 Conducted Emission - 150Ω direct coupling method

“Conducted Emission – 150Ohm direct coupling “examines conducted emissions according to Table 1

## Hardware Test Setup

**Table 18** Frequency range and settings for the EMI test receiver

| Frequency range | | | Receiver | | | |
|---|---|---|---|---|---|---|
| | | | RBW | step size | Meas. time | Detector |
| 150 kHz | to | 30 MHz | 9 kHz | 5 kHz | >= 10 ms | Max. Peak |
| 30 MHz | to | 1 GHz | 120 kHz | 50 kHz | >= 10 ms | |

## Test-/ Simulation Setup for Conducted Emission

Below picture show the conducted emission test/simulation setup.

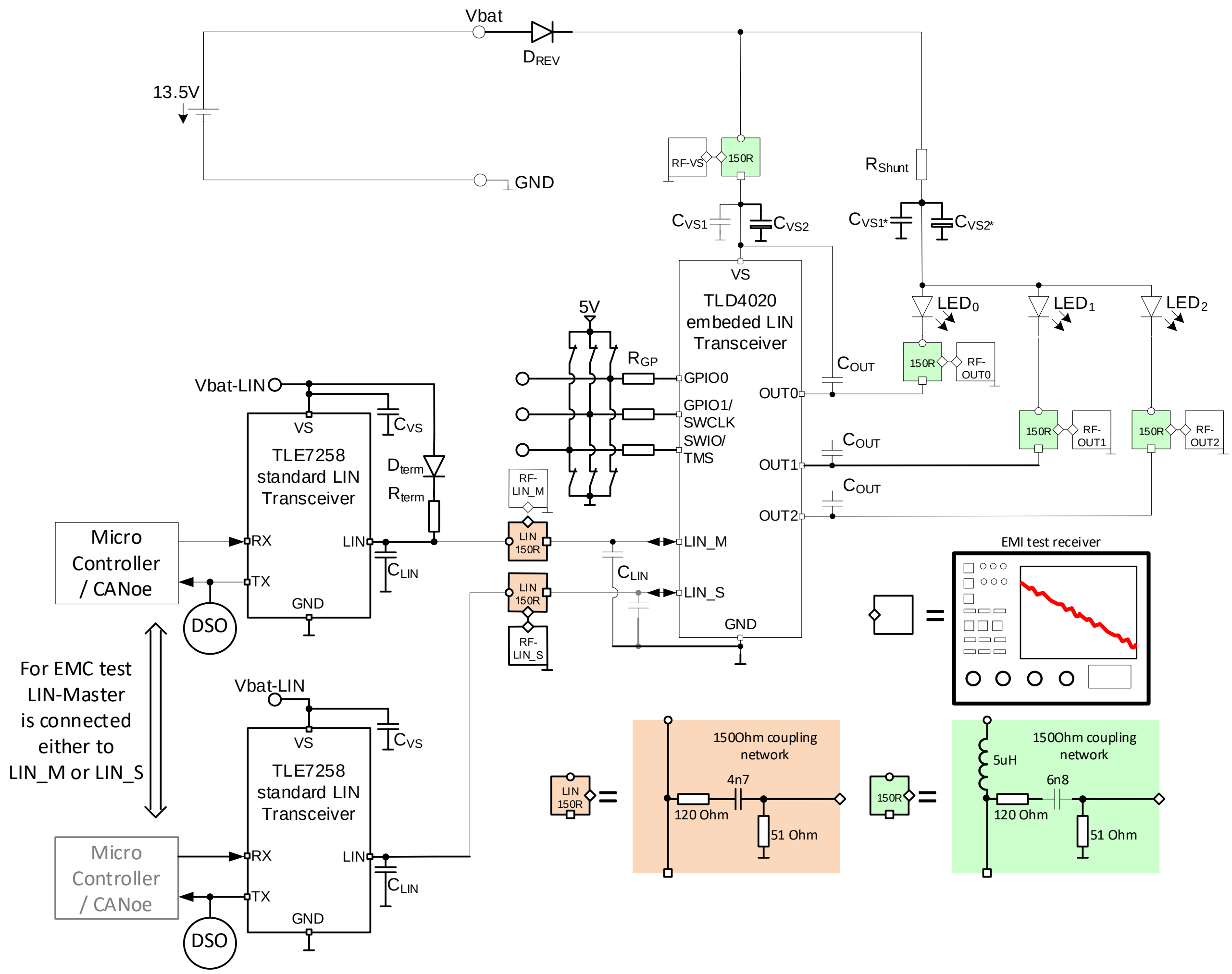



**Figure 22** Conducted RF-Emission test/simulation setup

## Emission Levels Area Definition

Below Figure shows the emission level scheme for the 150Ω classification for global and local pins.

**Below Class III:**

The area below Class III defines a range where usually no emission issues occur on device level. The Class III value itself represents the internal design target.

**Class I:**

A result between **Class** III and **Class** I defines a range where additional simple external filtering/decoupling components usually improve the emission level back to the **Class** III range. In the unlikely event that the emission level is within **Class** III and **Class** I range although external components are used, please align with the EMC and AE colleagues on the further proceeding.

**Above Class I**

The result above **Class** I is not-acceptable.

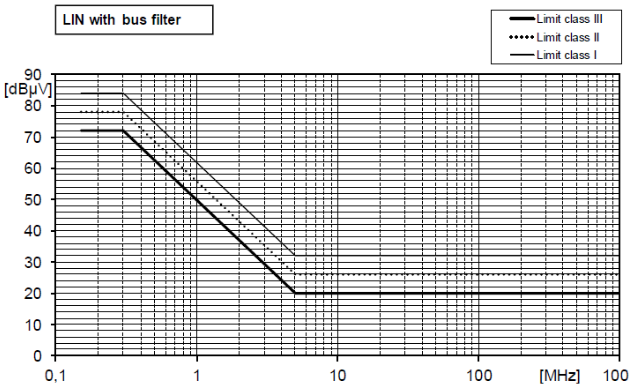



**Figure 23** "LIN with bus filter"
Applicable for LIN-BUS

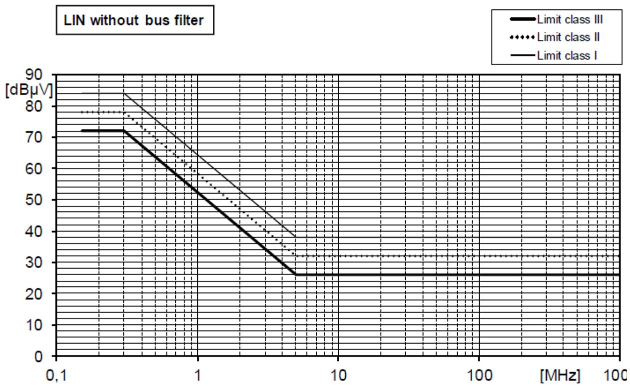
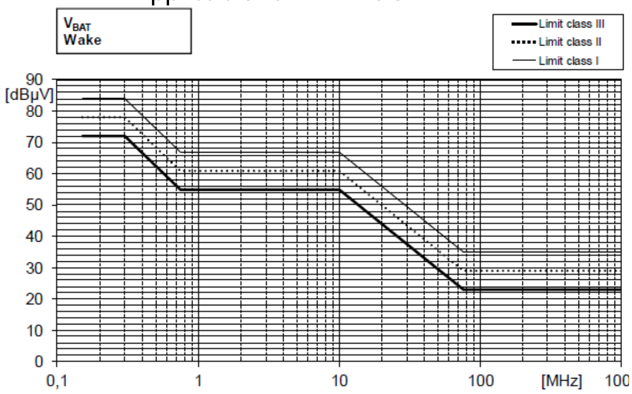



**Figure 24** "LIN without bus filter"
Applicable for LIN-BUS




"

**Figure 25** "LIN device"
Applicable for VS and Wake

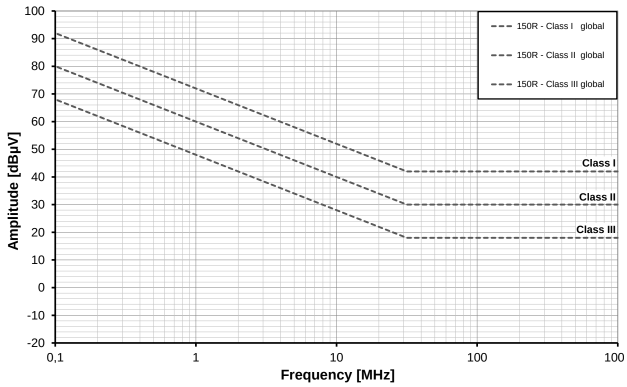



**Figure 26** "150R global"
Emission Limit for OUT

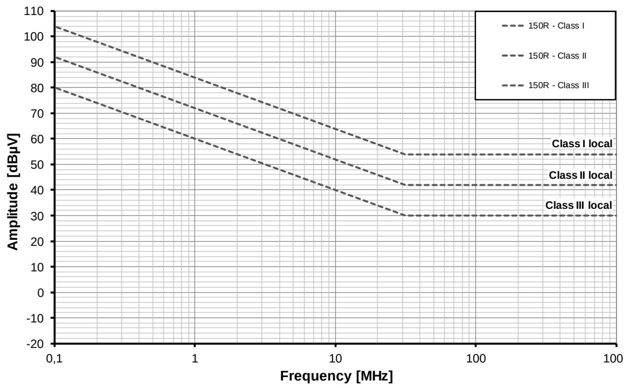



**Figure 27** "150R local"
Emission Limit for OUT

## Test Result

### RF-VS

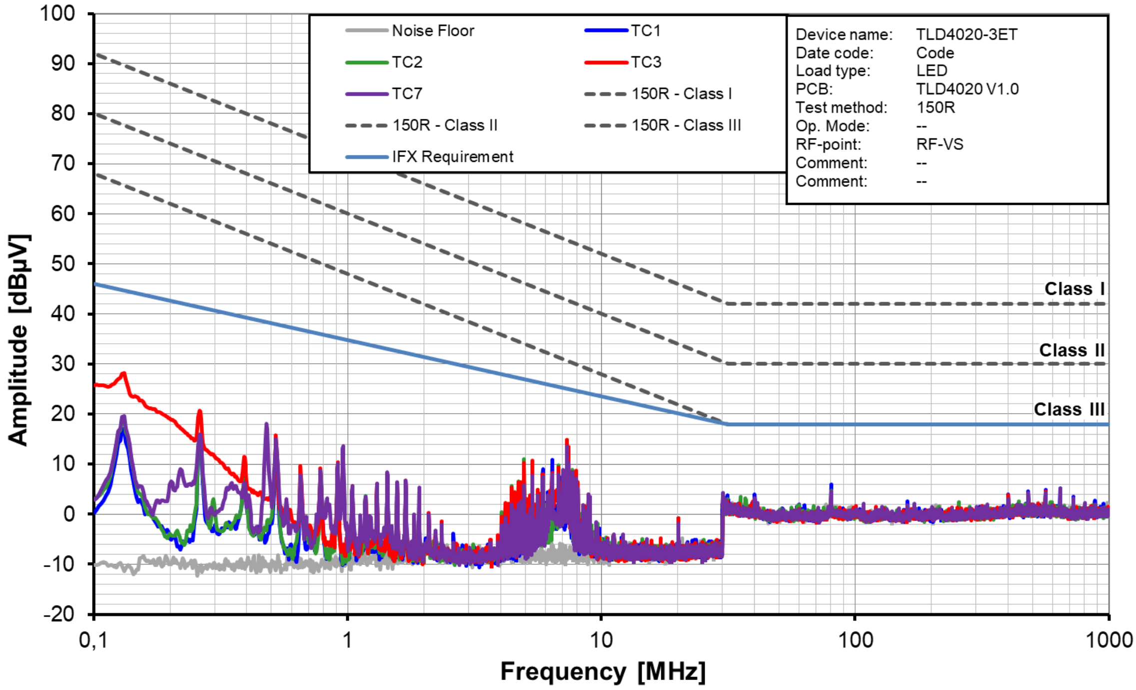



**Figure 28** Conducted Emission 150R method RF-VS

### RF-OUT0

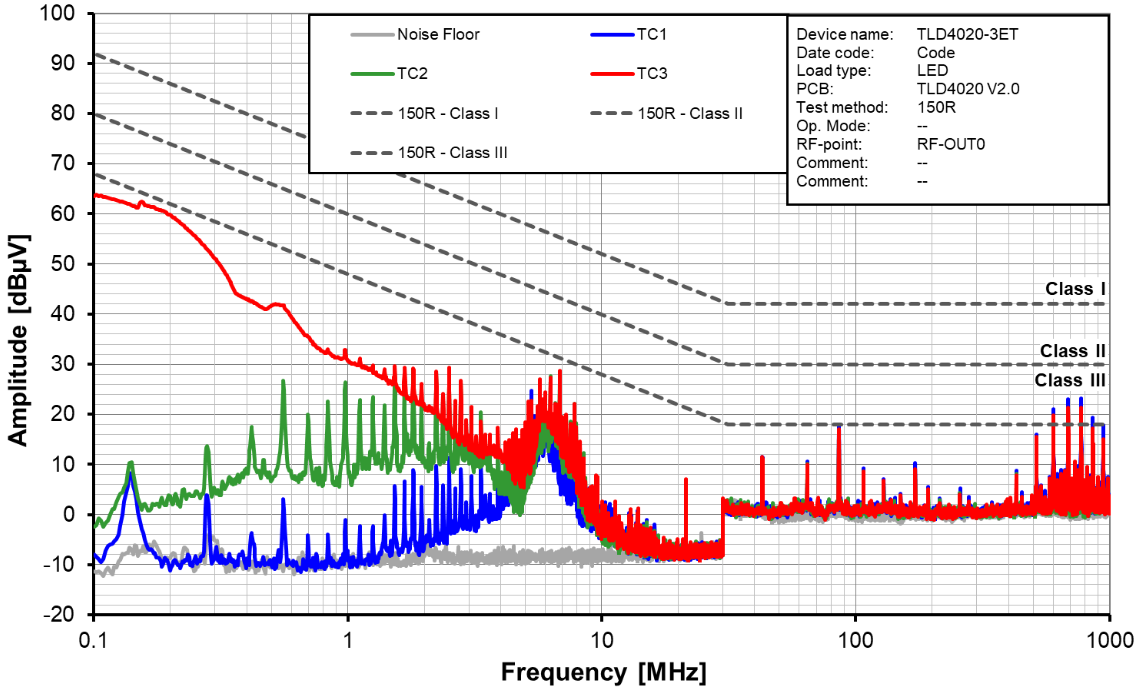



**Figure 29** Conducted Emission 150R method RF-OUT0

## RF-OUT1

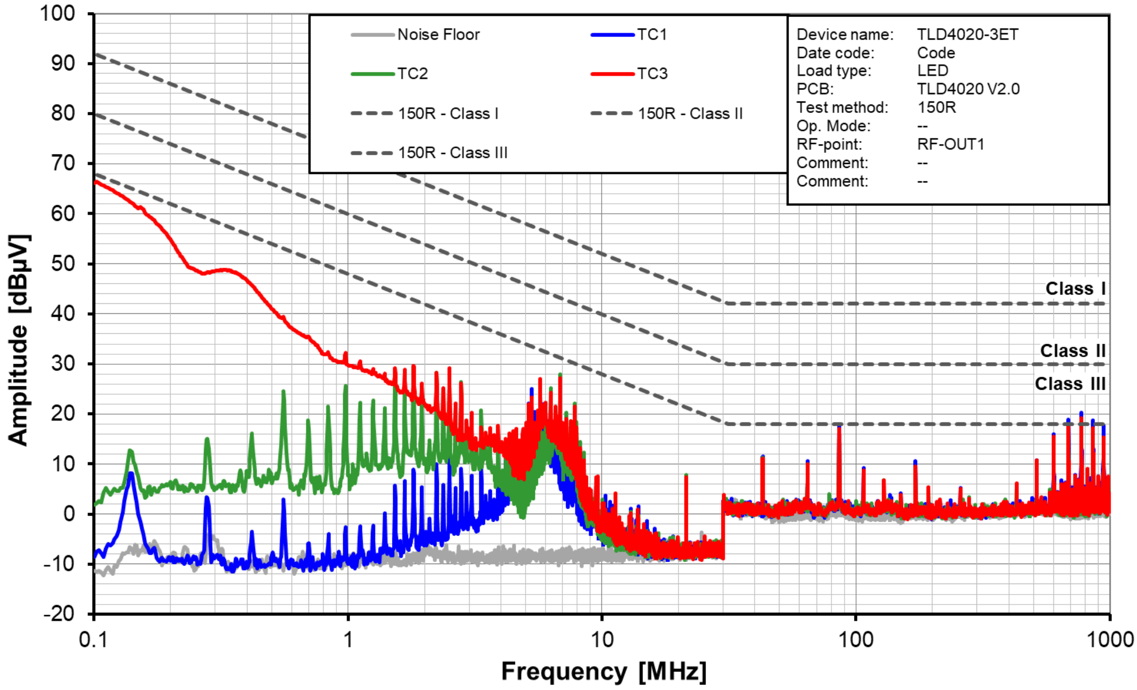



**Figure 30** Conducted Emission 150R method RF-OUT1

## RF-OUT2

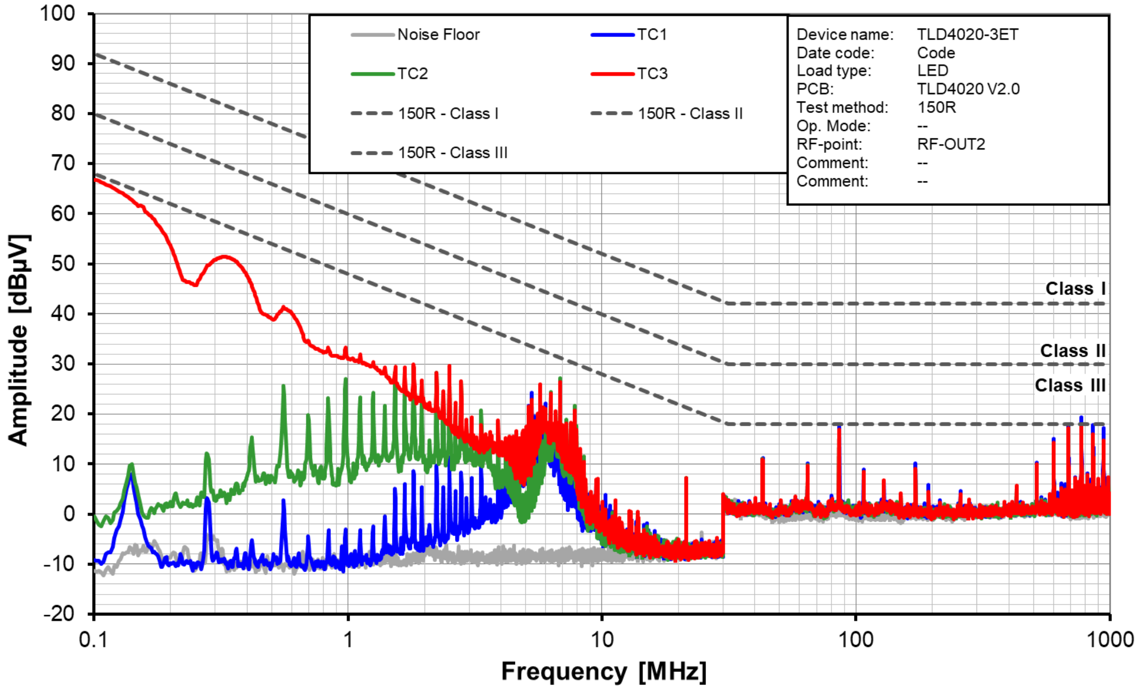



**Figure 31** Conducted Emission 150R method RF-OUT2

## RF-LIN

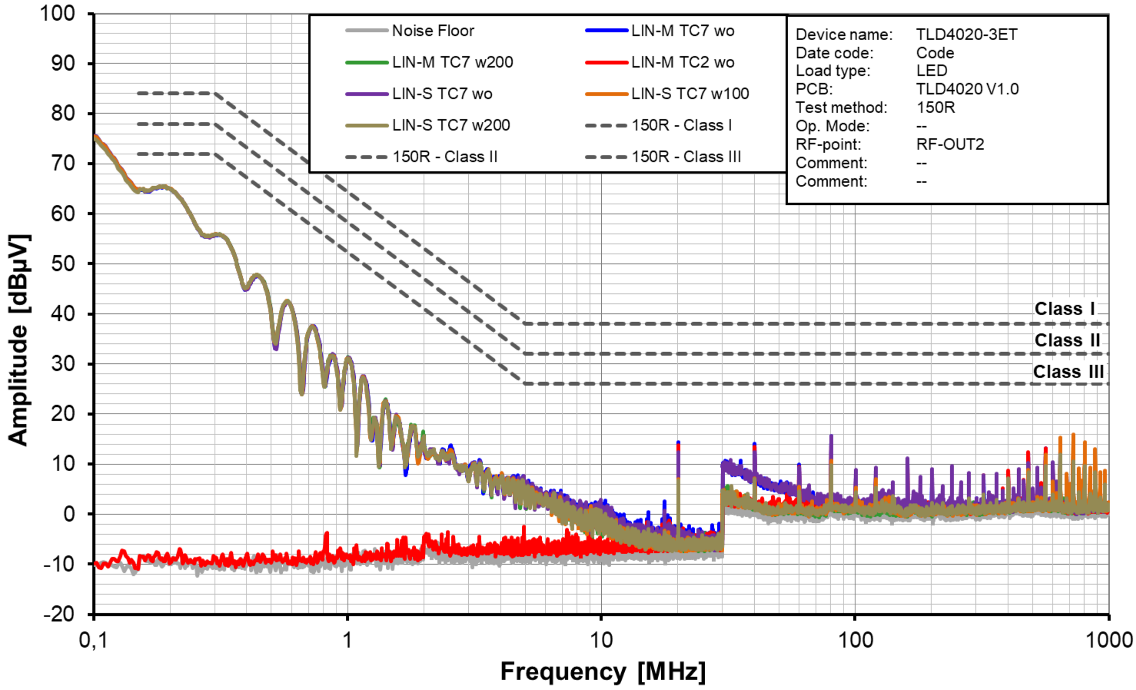



**Figure 32** Conducted Emission 150R method RF-LIN. LIN without Bus Filter

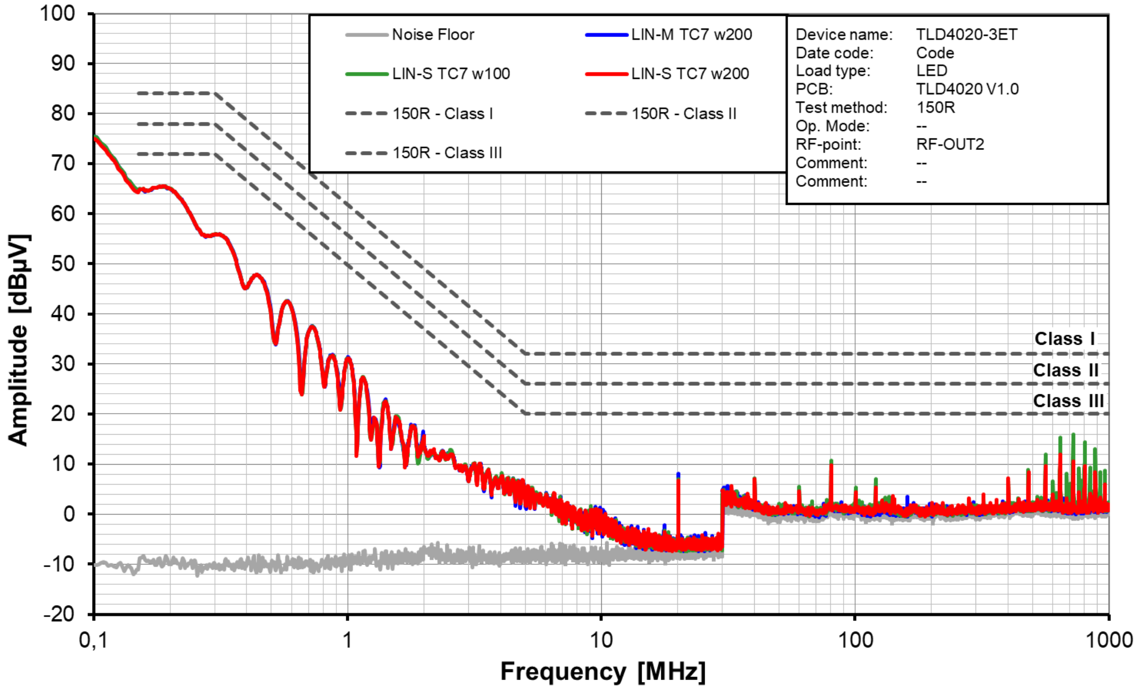



**Figure 33** Conducted Emission 150R method RF-LIN. LIN with Bus Filter

# 5 Conducted Emission - LISN method

“Conducted Emission – LISN method “examines conducted emissions according to Table 1

## Hardware Test Setup

**Table 19** Frequency range and settings for the EMI test receiver

| Frequency range | | | Receiver | | | |
|---|---|---|---|---|---|---|
| | | | **RBW** | **step size** | **Meas. time** | **Detector** |
| 150 kHz | to | 30 MHz | 9 kHz | 5 kHz | >= 10 ms | Max. Peak & Average |
| 30 MHz | to | 108 MHz | 120 kHz | 50 kHz | >= 10 ms | |

## Test-/ Simulation Setup for Conducted Emission

Conducted Emission test setup for the Line Impedance Stabilization Network (LISN) method.

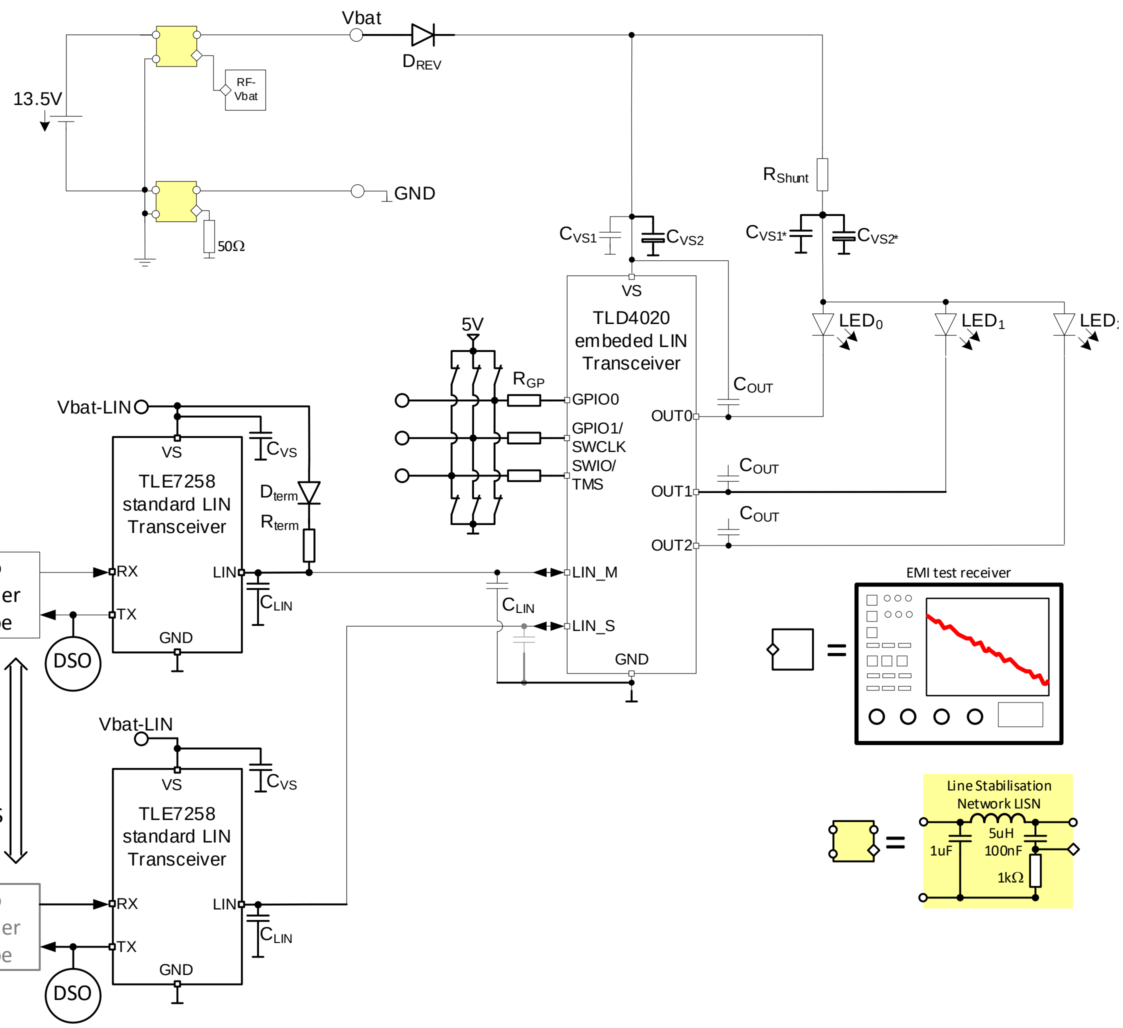



**Figure 34** Conducted emission test/simulation setup for the Battery Line.

## Emission Levels Classification

Emission Levels Class-I to Class-V for peak and average detector.

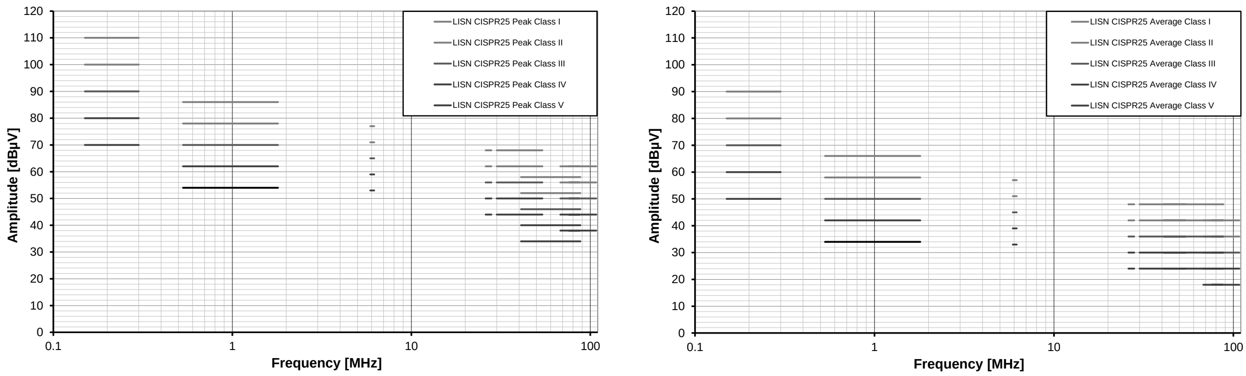



**Figure 35** Emission level characterization for peak and average detector.

## Requirements for Conducted Emission (LISN)

Table 20 show the requirements for the conducted emission test.

**Table 20** Conducted emission requirements, Pin selection regarding Table 5

| Pin | Bus Filter | Required Target Value for | |
|---|---|---|---|
| | | **Operation Mode** | requirement |
| Vbat | X | TC1, TC2, TC3, TC7 | < Class V peak & average |

# Test Result

## Emission on Vbat

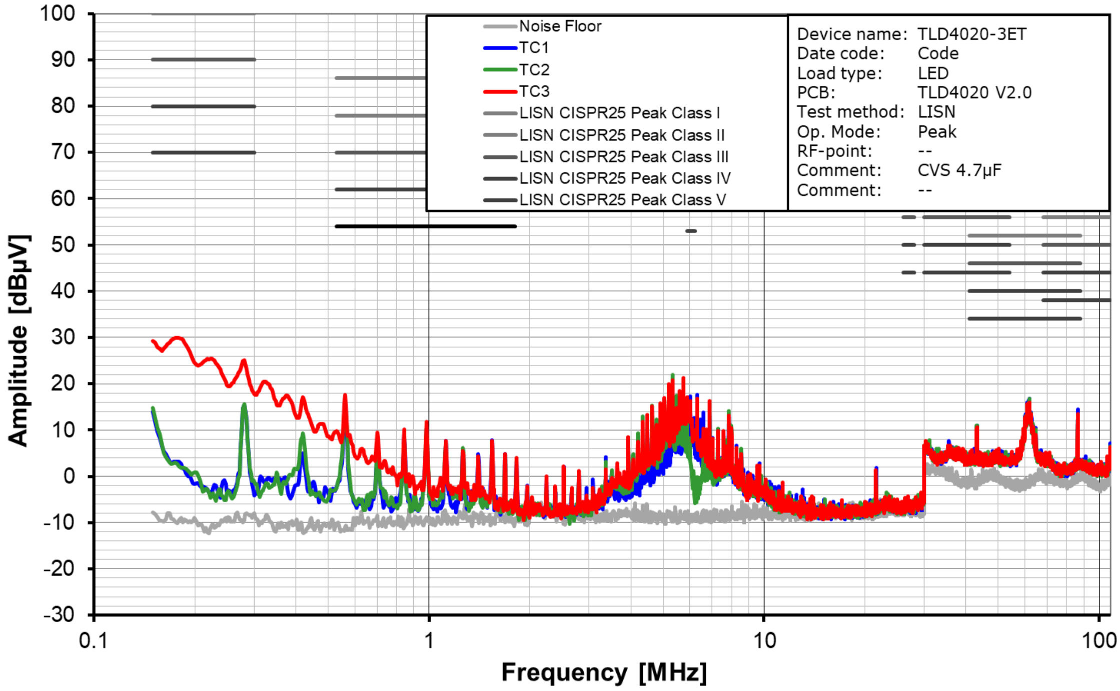



**Figure 36** RF peak emissions on the Battery Line.

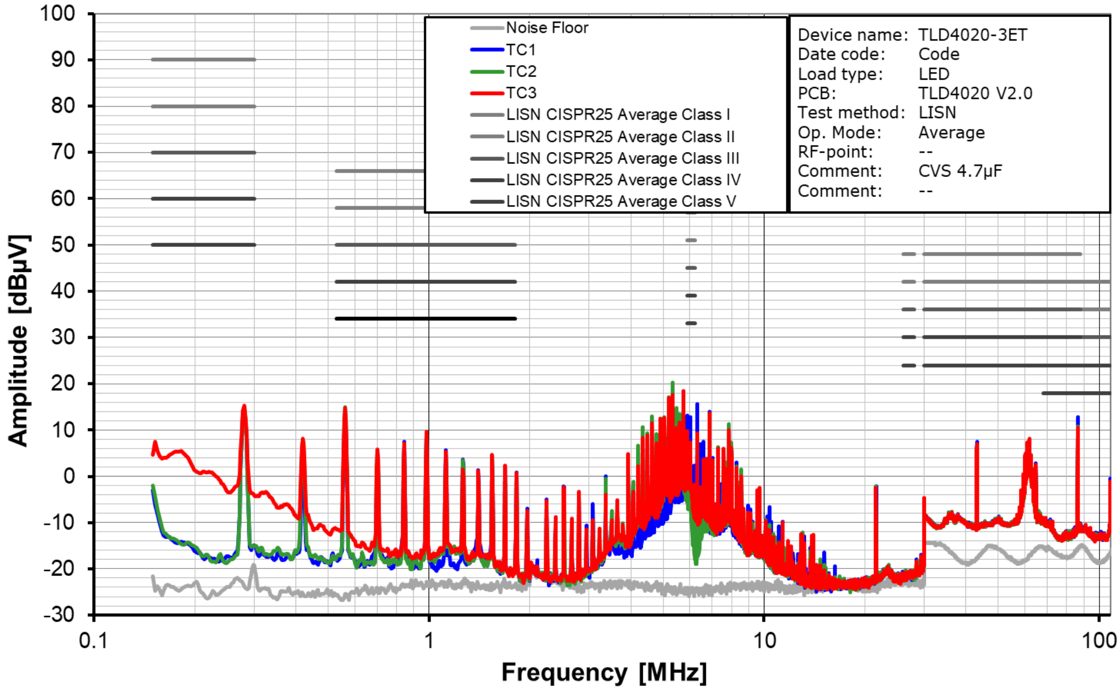



**Figure 37** RF average emissions on the Battery Line.

# 6 Radiated Emission (RE)- ALSE method

"Radiated Emission – Antenna methode" examines radiated emissions according to Table 1

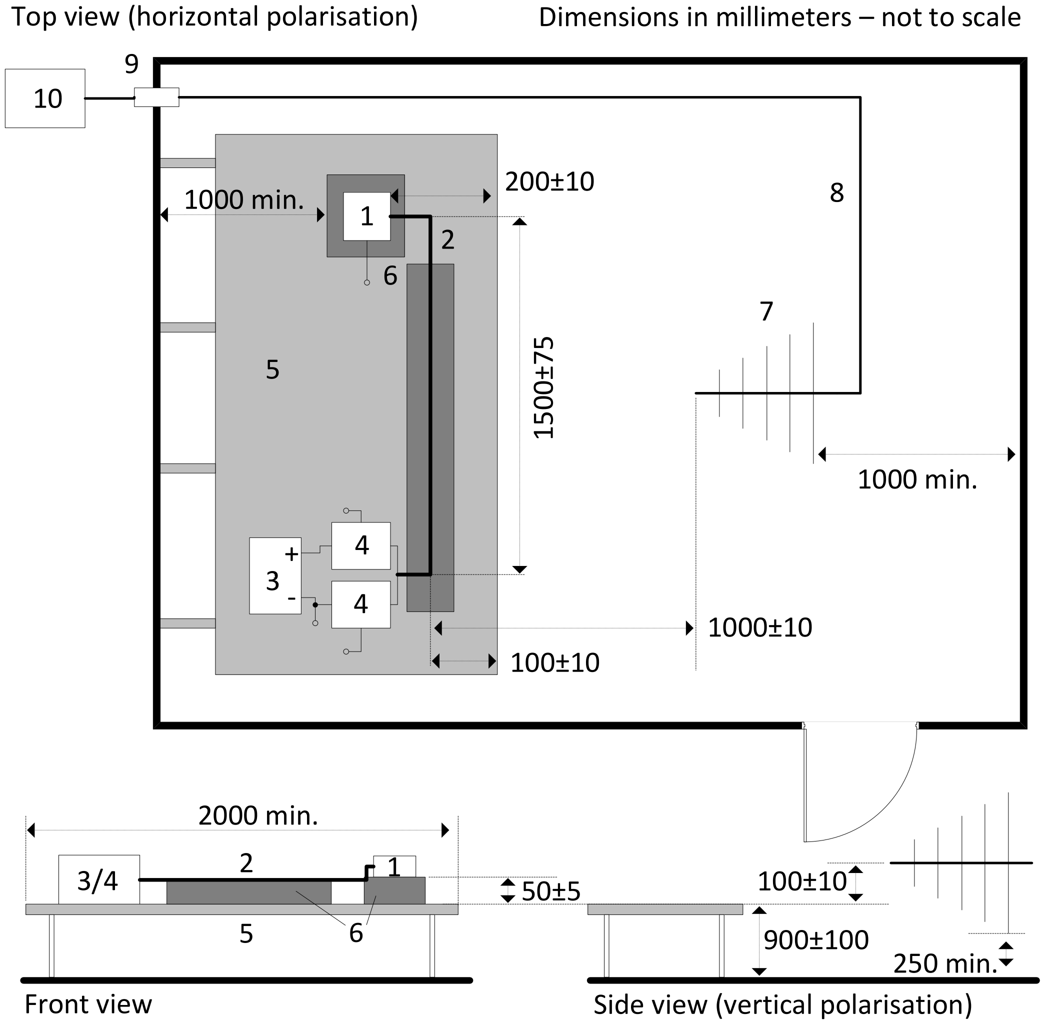
## Hardware test setup

**Table 21** Frequency range and settings for the EMI test receiver

| Frequency range | Receiver setting for radiated emission - ALSE | | | | |
|---|---|---|---|---|---|
| | Antenna | RBW | Step size | Meas time | detector |
| 150 kHz to 30 MHz | Rod | 9 kHz | 5 kHz | >= 5ms | peak, average |
| 30 MHz to 200 MHz | Biconical | 120 kHz | 50 kHz | >= 5ms | peak, average |
| 200 MHz to 1000 MHz | Log-Periodic | 120 kHz | 50 kHz | >= 5ms | peak, average |

## General Test-Setup for Radiated Emission

The RE test setup as shown in the net picture, Antenna type and polarization needs to be adapted.




Key:

1 EUT (grounded locally if required in test plan)
2 Test harness
3 Power supply (location optional)
4 Artificial network (AN)
5 Ground plane (bonded to shielded enclosure)
6 Low relative permittivity support ($\varepsilon_r < 1.4$)
7 Log-periodic antenna
8 High-quality coaxial cable e.g. double-shielded (50 Ω)
9 Bulkhead connector
10 Measuring instrument

**Figure 38** General Test Setup Radiated Emission ALSE method.

## Hardware Test-Setup for Radiated Emission

The RE test setup is the same as for the CE

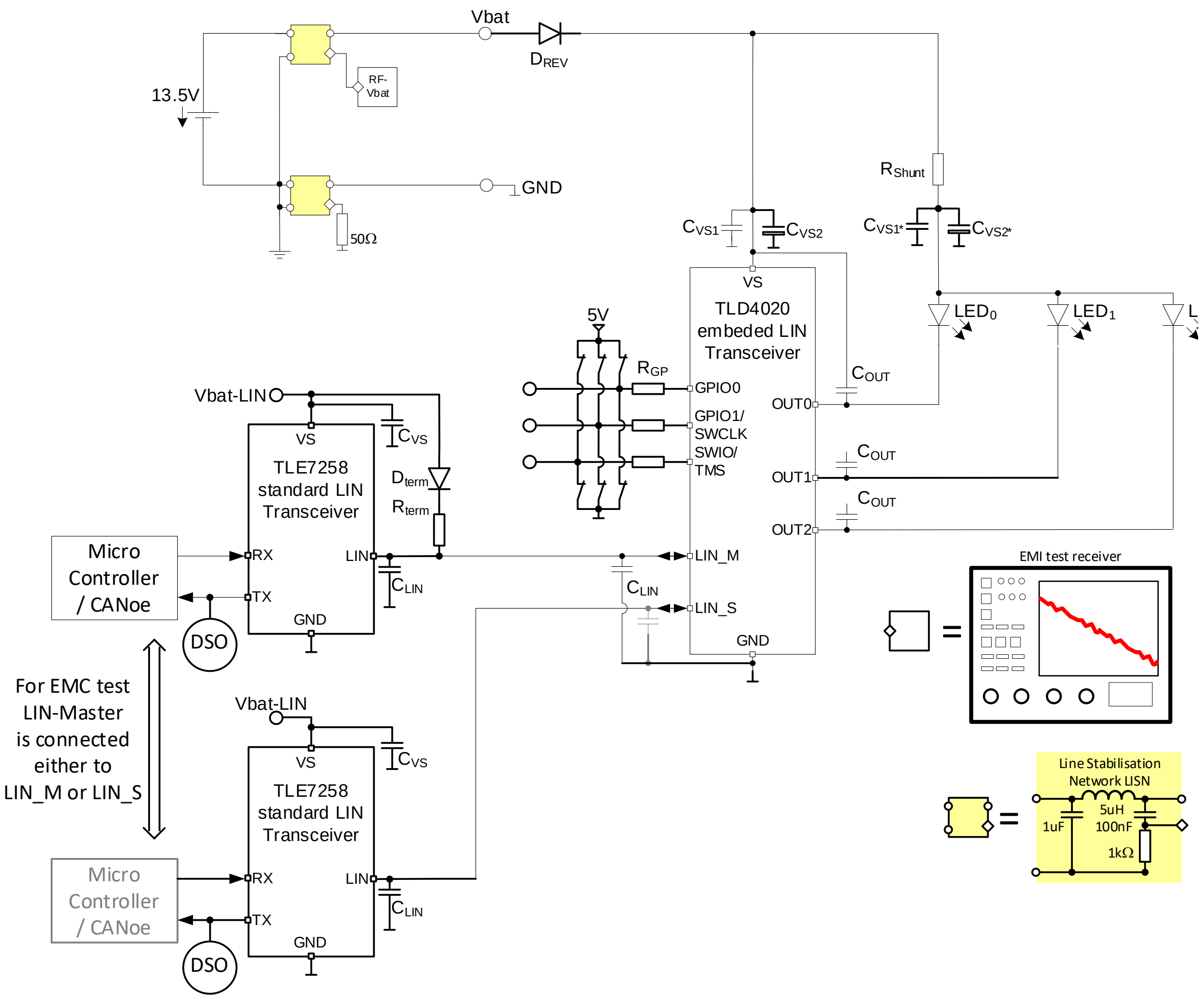



**Figure 39** Radiated Emission test/simulation setup according to CISPR-25 ALSE.

## Requirements for Radiated Emission (ALSE)

Table 22 show the requirements for the conducted emission test.

**Table 22** Radiated emission requirements.

| Pin | Input Pi-Filter | Input Common Mode Choke | Load | Required Target Value for Operation Mode | |
|---|---|---|---|---|---|
| | | | | ON | Spread Spectrum |
| VBAT | No | No | Load1 | < Class-V for peak & average | |

## Test Result

## Emission on Vbat

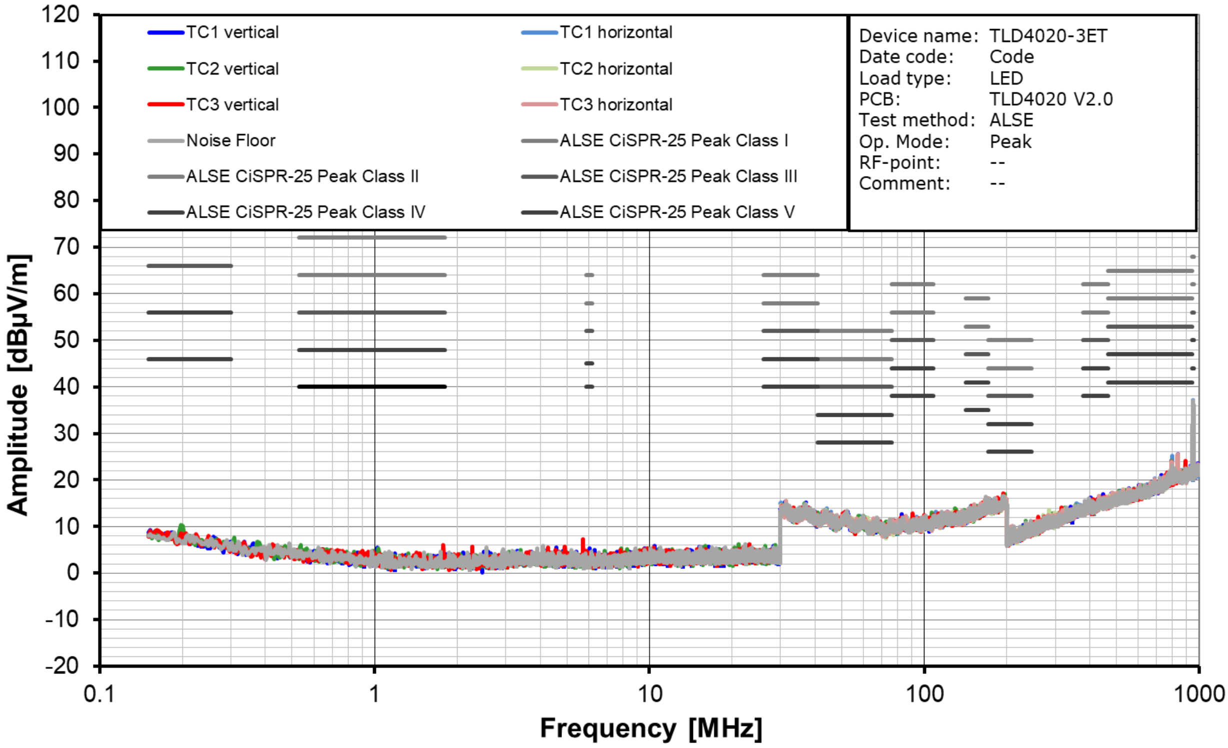



**Figure 40** Radiated peak emissions on battery line.

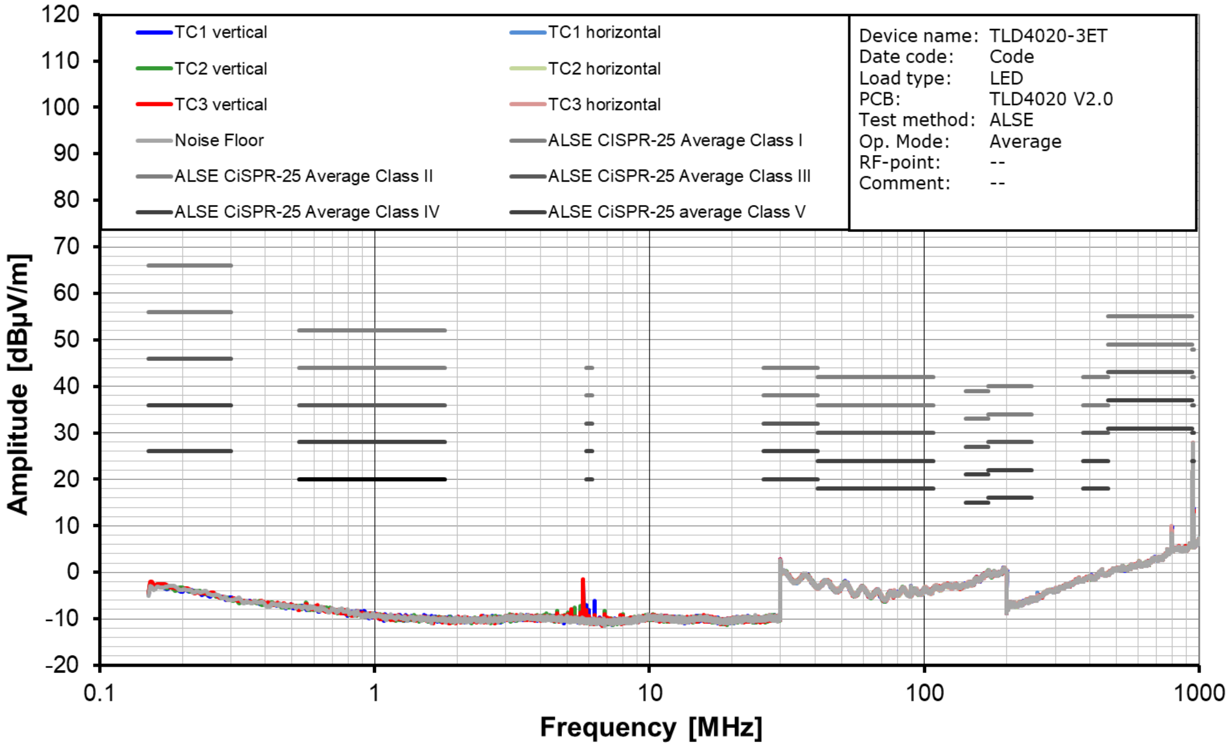



**Figure 41** Radiated average emissions on battery line.

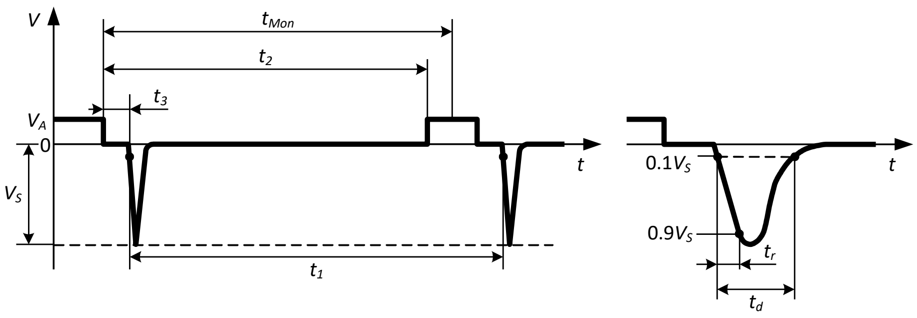
# Appendix

## Test Pulse Definition for the 12V System[1][2]

**Table 23** Test Pulse 1

back to requirement

| | |
|---|---|
| $V_A$ | 13.5V |
| $V_{Smax}$ | -75V to -150V |
| $R_i$ | **10Ω** |
| $t_d$ | 2ms |
| $t_r$ | 1µs (+0µs, -0.5µs) |
| $t_1$ | ≥0.5s |
| $t_2$ | **As short as possible** |
| $t_3$ | <100µs |
| # of pulses | 5000 |
| $t_{Mon}$ | Time between 2 pulses |
| Standard | ISO7637-2: 2010 |

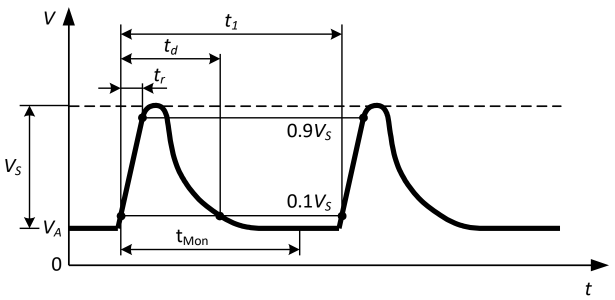



Test Pulse1 simulates the turn-of for inductive loads parallel to the DUT. Battery voltage is turned-off for 200ms.

**Table 24** Test Pulse 2a

back to requirement

| | |
|---|---|
| $V_A$ | 13.5V |
| $V_{Smax}$ | +37V to +112V |
| $R_i$ | **2Ω** |
| $t_d$ | 50µs |
| $t_r$ | 1µs (+0µs, -0.5µs) |
| $t_1$ | 0.2s to 5s |
| # of pulses | 5000 |
| $t_{Mon}$ | Time between 2 pulses |
| Standard | ISO7637-2: 2010 |
| | |




Test Pulse 2a simulates transients due to sudden interruption of currents in a device connected in parallel with the DUT generated in the inductance of the wiring harness.

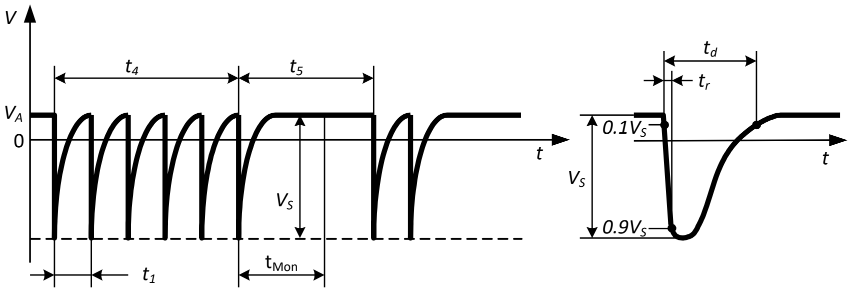
[1] The peak voltage $V_S$ shall be adjusted to the test levels with a tolerance of +10%, -0%.
The timing tolerances and internal resistance $R_i$ tolerance shall be ±20%, unless otherwise specified.

[2] The pulse voltage- amplitude and waveform are specified for the idle pulse.

**Table 25** Pulse 3a

back to requirement

| | |
|---|---|
| $V_A$ | 13.5V |
| $V_{Smax}$ | -112V to -220V |
| $R_i$ | **50Ω** |
| $t_d$ | 150ns ± 45ns |
| $t_r$ | 5ns ±1.5ns |
| $t_1$ | 100µs |
| $t_4$ | 10ms |
| $t_5$ | 90ms |
| test time | 1h |
| $t_{Mon}$ | between burst package |
| Standard | ISO7637-2: 2010 |

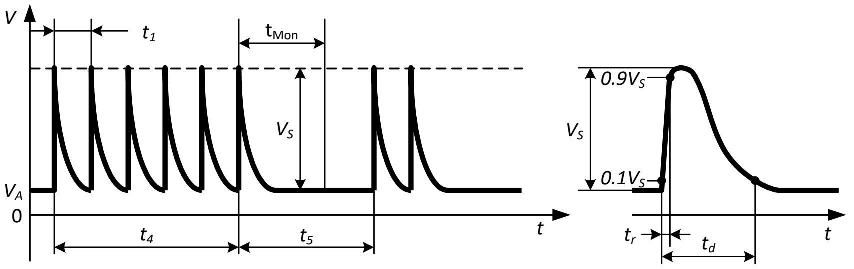



Test Pulse 3a simulates a switching process.

**Table 26** Pulse 3b

back to requirement

| | |
|---|---|
| $V_A$ | 13.5V |
| $V_{Smax}$ | +75V to +150V |
| $R_i$ | **50Ω** |
| $t_d$ | 150ns ± 45ns |
| $t_r$ | 5ns ±1.5ns |
| $t_1$ | 100µs |
| $t_4$ | 10ms |
| $t_5$ | 90ms |
| test time | 1h |
| $t_{Mon}$ | between burst package |
| Standard | ISO7637-2: 2010 |

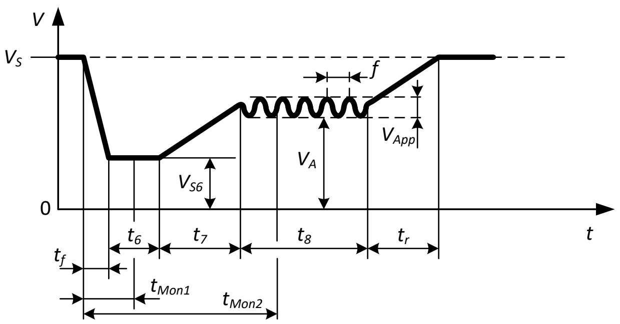



Test Pulse 3b simulates a switching process.

**Table 27** Pulse Starting Profile

back to requirement

| | |
|---|---|
| $V_S$ | +12V |
| $V_{S6}$ | **5.5V** |
| $V_A$ | **7.5V** |
| $V_{APP}$ | 2.0V |
| $R_i$ | 0.01Ω |
| $t_f$ | 5ms |
| $t_6$ | 15ms |
| $t_7$ | 50ms |
| $t_8$ | 10s |
| $t_r$ | 100ms |
| $f$ | 20Hz |
| # of pulses | 1 |
| $t_{Mon1}$ | during $t_6$ |
| $t_{Mon2}$ | during $t_8$ |
| Standard | ISO 16750-2: 2010 |



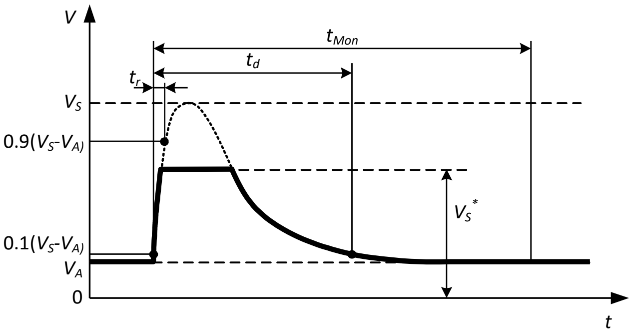

The starting Profile simulates the battery voltage during the ignition process

$V_{S6}$ and $V_A$ depend on device requirement

**Table 28** Pulse Load Dump Suppression

back to requirement

| | |
|---|---|
| $V_A$ | +13.5V |
| $V_{Smax}$ | +79V to +101V |
| $V_S^*$ | +35V |
| $R_i$ | 0.5Ω to 4Ω **2Ω** |
| $t_d$ | 40ms to 400ms |
| $t_r$ | 10ms(+0ms, -5ms) |
| # of pulses | 10 pulses at intervals of 1 min |
| $t_{Mon}$ | between burst package |
| Standard | ISO16750-2: 2010 |




This pulse simulates the load dump pulse in case of suppressor diodes integrated into the generator.

$V_S^*$ depend on device requirement

## Definition for LIN Communication signals

**Table 29** LIN test pattern TX1 return to Operation Modes

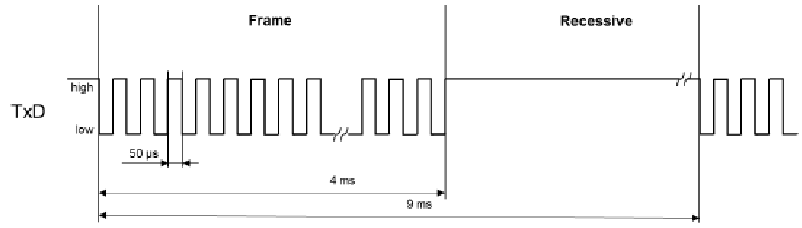
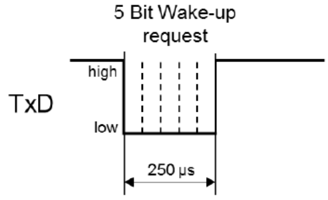
| | |
|---|---|
| Test Signal | LIN Communication test signal TX1 |
| Signal Type | Standard test signal (periodic)<br><br><br>source: IEC 62228-2 |
| Frequency | 10kHz |
| Cycle time | 9 ms |
| Frame length | 4 ms |
| Amplitude | $V_{CC}\pm0{,}1V$ |
| Standard | IEC 62228-2 chapter 5.4 |

**Table 30** LIN test pattern TX2 return to Operation Modes

| | |
|---|---|
| Test Signal | LIN Communication test signal TX2 |
| Signal Type | LIN frame |
| Protocol | ISO 17987-6-2 |
| Data bit rate | 19,2 kB/s |
| PID and Data | Depending on designed or programmed functionality |
| Cycle time | 9 ms(default) |
| Amplitude | $V_{CC}\pm0{,}1V$ |
| Standard | IEC 62228-2 chapter 5.4 |
| TLD4020 GPIO-PWM | Insert LIN Pattern which will show PWM on GPIO |

**Table 31** LIN Test Pattern TX3 return to Operation Modes

| | |
|---|---|
| Test Signal | Wake up from sleep mode |
| Signal Type | Standard test signal (periodic)<br><br><br>source: IEC 62228-2 |
| Amplitude | $V_{CC}\pm0{,}1V$ |
| Standard | IEC 62228-2 chapter 5.4 |

Note : TX3 is send only once during each wake request.
Apply RF, wait for 1second (dwell time) then send TX3 and evaluate respond.
TX3 is 250us low signal.

# EMC Testboard Schematic

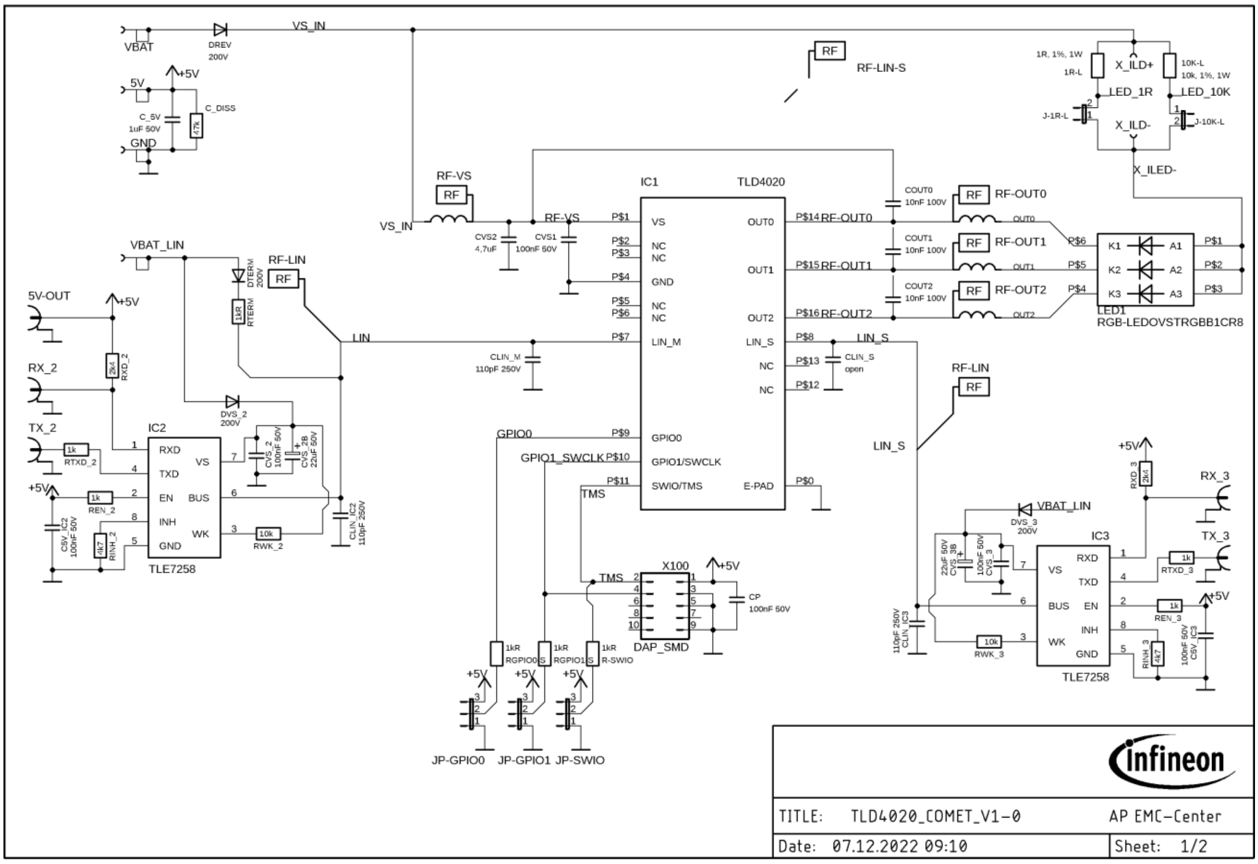



**Figure 42** EMC Testboard Schematic Page 1 of 2

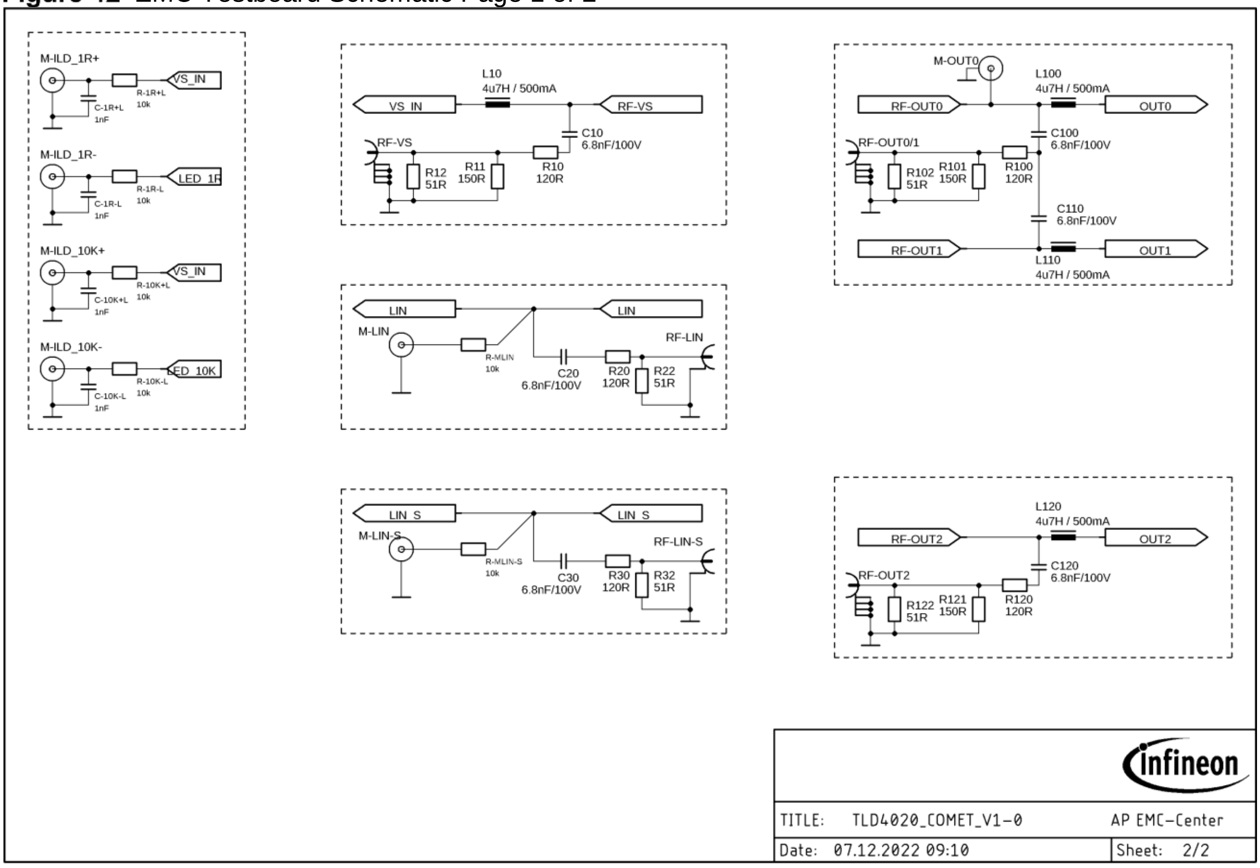



**Figure 43** EMC Testboard Schematic Page 2 of 2

## EMC Testboard Layout

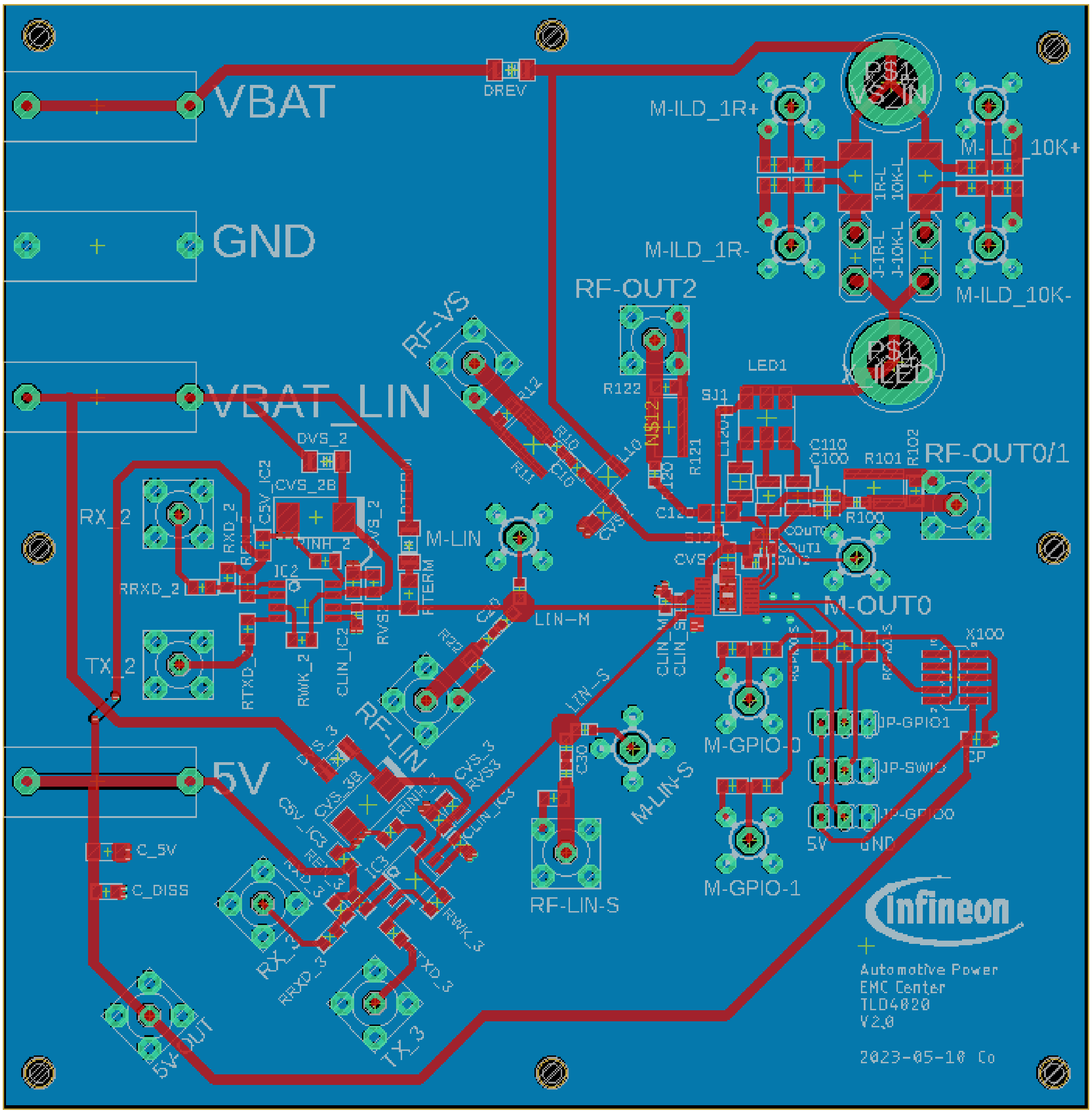



**Figure 44** EMC Testboard Top(red) and Bottom(blue) Layer

## RX-TX Adapter

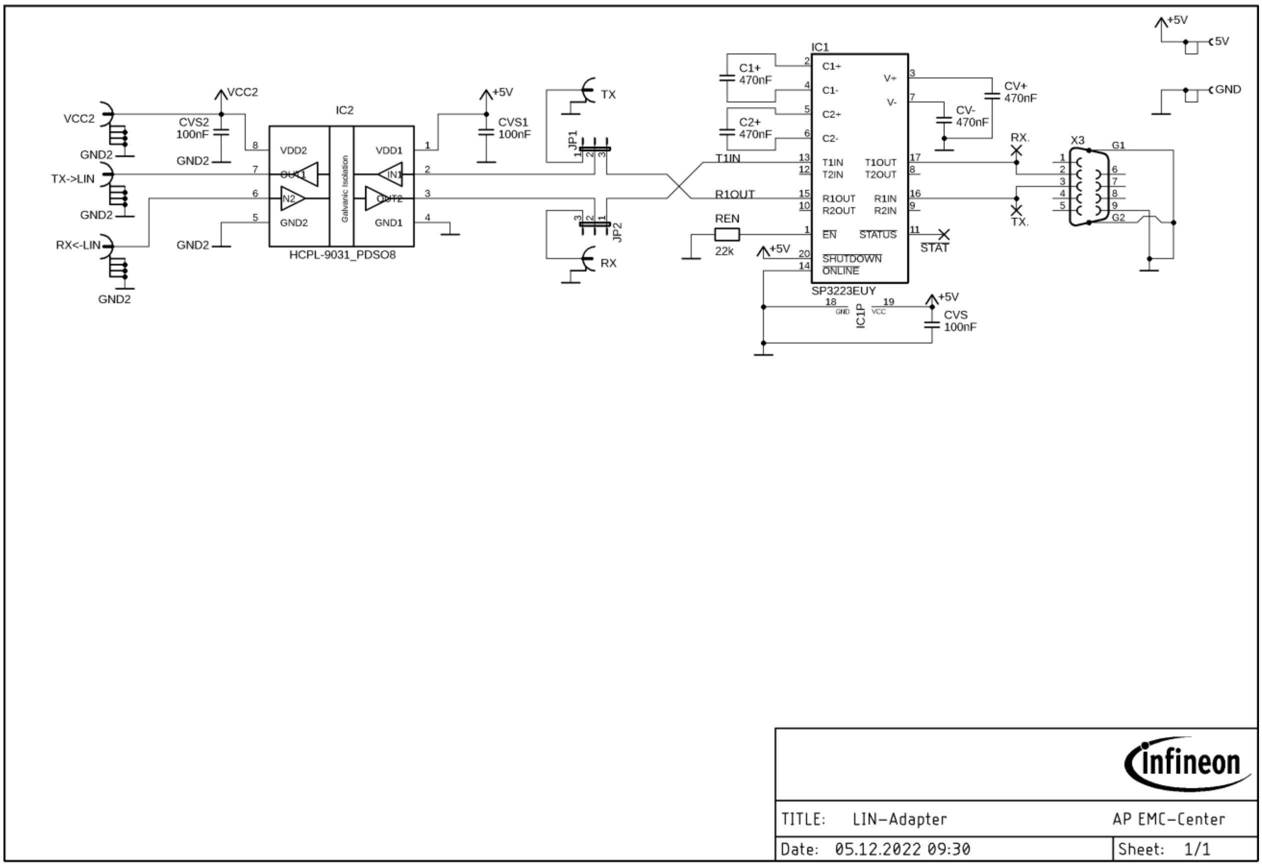



**Figure 45** EMC RX-TX Coupler Page 1 of 1

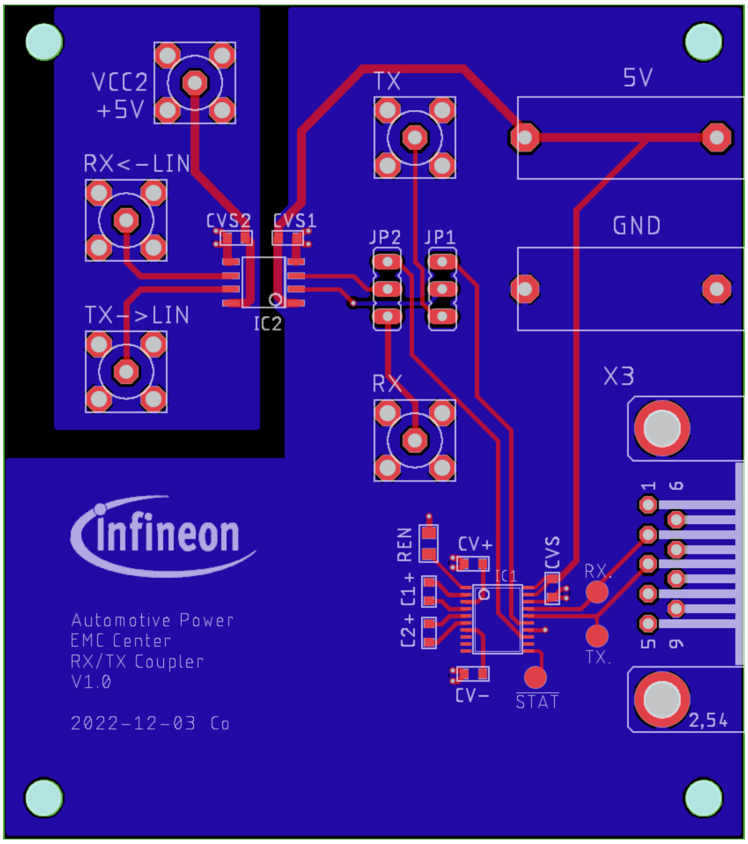



**Figure 46** EMC RX-TX Coupler Top(red) and Bottom(blue) Layer

# Revision History:

| Revision | Date | Description of change |
|---|---|---|
| 1.3 | 2023-06 | EMC test results on $1^{st}$ silicon |
| 1.4 | 2023-08 | DPI Out local results added |

**Trademarks**
All referenced product or service names and trademarks are the property of their respective owners.

**Published by**
**Infineon Technologies AG**
**81726 Munich, Germany**



**Do you have a question about this document?**
**Email: erratum@infineon.com**

**Document reference**
**EMC Test Report**