SUPERVISING DEPT.: E&D – PT – Bench Testing

MANAGING DEPT.: E&D – PT – Bench Testing

1

APPLICATION CRITERIA

The purpose of this Standard is to test in the frequency domain the quantity of interference emitted by the system tested off-vehicle that could be picked up by the receiver on-board.

The standard is to be used during the technical validation and qualification of the electronic system under test.

Change	Date	Description	
-	Apr. 95	Issue 1 –	New; issued as per Technical Memorandum Procedure, this standard supersedes item 1 of standard 7.Z0890/01. (LR)
-	Sept. 96	Issue 2 –	Updated. (SS)
-	May 04	Issue 3 –	Supervisor changed (was Durando). “Test schedule” paragraph removed. (SS)
-	Sept. 07	Issue 4 –	Draft updated and 2-3-4-6-7-8 forms changed. (SS)

PUBLISHED BY SATIZ - NORMAZIONE

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] Job:
Component Type: Drawing Number:
Supplier: Last Change:

2

REFERENCES

7-G0030 Significance of items under test (PGE)
9.90110 Automotives electrical and electronic devices (CEL)

3

TEST EQUIPMENT

3.1

Test environment

The room is to be sufficiently large to contain the instrumentation and test bench. There is to be no interference that could influence the test results.

3.2

Measuring equipment

It may be a measuring receiver or a spectrum analyzer fitted with pre-selector, in any case it is to have the following characteristics:

- Measurement frequency range: at least 150 kHz thru 110 MHz.
- Sensitivity – at least 10 dBµV (equal to -97 dBm) at 150 kHz, with bandwidth of 10 kHz and with peak detector,
  – at least 0 dBµV (equal to -107 dBm) at 150 kHz, with bandwidth of 9 kHz and with quasi-peak detector (if used).
- Input impedance: 50 Ω.
- Bandwidth selectable between the following values:
  1 kHz, 10 kHz and 100 kHz; if a quasi-peak detector is used the last two values are to be replaced by 9 kHz and 120 kHz.
- Peak detector for spectrum, peak analyzer of average value and possibly of quasi-peak for measurement receiver.

The detector is to have the following characteristics:

TYPE OF DETECTOR	LOAD TIME CONSTANT (tc)	UNLOAD TIME CONSTANT (ts)	
		0.15 to 30 MHz	more than 30 MHz
QUASI-PEAK	1 ms	160 ms	550 ms
PEAK	<<10 µs	1 s (*)	
AVERAGE VALUE	100 ms	100 ms	

(*) not applicable if a spectrum analyzer is used

3.3

Impedance stabilizer network (L.I.S.N.)

Electric circuit and impedance characteristic with changing frequency to be as per Help 1 in figures 1 and 2. Moreover, the following requirements shall be met:

- Resistance across terminals P and A to be below 5 mΩ.
- Impedance across terminals P and B, with terminals A and B shorted, not to exceed 10% of nominal curve shown in figure 2 within 100 kHz to 20 MHz.
- Capacitance C2 to withstand continuous voltage to 1500 V min.
- Inductance L to withstand supply current of test specimen.

3.4

Grounded top

High electrical conductivity sheet metal (e.g. copper, aluminum, brass, galvanized steel), 0.5 mm min. thickness, 1 x 0.4m.

The grounded top is to be placed at a minimum height 900 ± 50 mm, connected to test environment shield so that connection DC resistance is less than 2.5 mΩ.

3.5

Test table

Shall consist of insulating material (e.g. wood), of suitable size to adequately support grounded top.

3.6

Test specimen stimulating system

To correctly interface with DUT, without significantly altering the system electrical characteristics (impedance).

3.7

Test specimen load stimulating system

Shall permit correct operation of test specimen in normal service conditions as per dwg or P.S.

3.8

Supply unit

To be able to supply voltage and deliver maximum current required for correct functioning of test specimen.

Use supply unit with adjustable voltage 0 to 24V, 40 Amp, with 45 Ah, 225 Amp battery.

Note: *Equivalent equipment may be substituted but must be equal or superior in performance.*

Date:..... Exemption: NO [ ] YES [ ]

Test Engineer:…….…… Signature……

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] | Job:
Component Type: | Drawing Number:
Supplier: | Last Change:

4

DESCRIPTION OF ITEM UNDER TEST

4.1

ECU

SYSTEM:	
CODE:	
SUPPLIER:	
DWG. No.:	
ECU IDENTIFICATION NUMBER:	
PURPOSE:	
BUILD LEVEL	A [ ]
	B [ ]
	C [ ]
	D [ ]
	E [ ]

4.2

Wiring harness

TYPE:	
SUPPLIER:	
DWG. No.:	
BUILD LEVEL	A [ ]
	B [ ]
	C [ ]
	D [ ]
	E [ ]

4.3

Sensors / actuators

TYPE:	
SUPPLIER:	
DWG. No.:	
BUILD LEVEL	A [ ]
	B [ ]
	C [ ]
	D [ ]
	E [ ]

Date:.....

Test Engineer:…… Signature……

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] Job:
Component Type: Drawing Number:
Supplier: Last Change:

5

SIGNIFICANCE OF COMPONENTS UNDER TEST

COMPONENT WEIGHT AND CHARACTERISTICS FOR EVALUATING TEST SIGNIFICANCE					
Type of component	**% Significance (A)**	**Weight (B)**	**Component affecting test significance**	**Significant characteristics**	**Minimum build level**
Active		0.5	ECU	PCB, box if metallic, software release	B
Active		0.2	Wiring harness	Cable length and cross section	C
Active		0.3	Sensors / actuators	Impedance	C

Significance of item under test (%) = Σ (A x B) =

Note: *For each component, evaluate % significance for the three distinct levels indicated in Standard 7-G0030, recording values in column A.*

Date:..... Exemption: NO [ ] YES [ ]

Test Engineer:..... Signature.....

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] | Job:
Component Type: | Drawing Number:
Supplier: | Last Change:

6

PRELIMINARY OPERATIONS

6.1

Layout of test apparatus

6.1.1

Retrieve the documents needed for the test, included herein: [ ]

- Operating condition of test specimen (as indicted in system specification and/or agreed with supplier).
- Stimulator system (if applicable).
- Connection diagram of system during test.

6.1.2

Identify system under test and fill in "Description of item under test" form. [ ]

6.1.3

Prepare the equipment needed for the test (listed on the “TEST EQUIPMENT” form) as shown in the set-up diagram in help 2. [ ]

***Note**: If the vehicle DUT is connected to ground by connection more than 200 mm long, it is necessary that there are 2 LISN, one for the supply cable and the other for the ground (figures 3 and 5).*

If instead the DUT is connected to ground locally (length ≤ 200 mm), the only LISN will be connected for the battery positive cable (fig. 4).

The LISN (whether 1 or 2) shall be arranged directly in contact with the grounded top with the casing connected to it.

The ground cable between LISN and battery is to be connected to the grounded top.

The LISN measurement port not connected to the measuring device is to be terminated with a 50 Ω load.

6.1.4

Set the system to be tested at a distance of 50 ± 5 mm from the test surface and isolated from it with low relative permittivity material ($\varepsilon_r \leq 1.4$), unless the DUT installation on the vehicle has a direct ground connection on the body; in this case the DUT is to be connected to the test bench by a cable with the shortest length possible. [ ]

6.1.5

Place the system under test at a minimum distance of 200 mm from the edge of the grounded top. [ ]

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] Job:
Component Type: Drawing Number:
Supplier: Last Change:

6.1.6

Arrange the connection between LISN and DUT with two cables having a section Cu 2.5 mm², length $\begin{pmatrix} 200 + 200 \\ 0 \end{pmatrix}$ mm, arranged parallel at a distance of 20 ± 2 mm, and separated from the 50 ± 5 mm grounded top by non conducting material with low relative permittivity ($\varepsilon_r \leq 1{,}4$). [ ]

If, for certain test specimens (multi-connectors, special connectors, etc), it is not possible to use the indicated standard length supply lines, use cables with length l_p so that, having defined $f_c \approx 30 / l_P$ the result is $f_c \geq 108 MHz$.

If instead, f_c <108 MHz, the measurement will be limited to f_c.

To minimize coupling between power supply cables and DUT I/O signal cables, the distance between them is to be maximum possible (≥ 200mm), otherwise the two cable harnesses are to be arranged perpendicular.

The total length of the cable harness (excluding the power supply lines) is not to exceed 2 m. The type of cable depends on the specific type of application and the DUT requirements.

All cables are to be placed at 100 mm minimum from the edge of the grounded top.

6.1.7

Connect the load simulator directly to the grounded top and, if applicable, connect the metal casing to this. [ ]

As an alternative, the loads simulator can be connected at the side of the grounded top, connecting the metal casing to the top , where applicable.

***Note**: If the simulator is located on the grounded top, connect the load simulator to the supply directly on the battery and not downstream of the LISN.*

If the actuators are electric motors, there must be the mechanical load, or it is to be simulated by a brake.

Date:..... Exemption: NO [ ] YES [ ]

Test Engineer:…….…… Signature……

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] Job:
Component Type: Drawing Number:
Supplier: Last Change:

7

TEST PROCEDURE

During the measurements, the environment temperature is to be 23 ± 5°C, relative humidity 45% thru 70% and atmospheric pressure 860 mbar thru 1060 mbar.

7.1

Test setup activation

7.1.1

Connect and supply DUT test specimen as specified on drawing or P.S. [ ]

7.1.2

Apply signals needed for system operation to all relevant electrical inputs or physical sensors. [ ]

7.1.3

Start the DUT with load and operating conditions to obtain maximum emissions. [ ]

These static (no variations in stimulation signal) or dynamic (sequence of certain stimulation signal variations to deliberately change the system status or behavior) conditions are to be defined in the test plan.

7.2

Measurement setting

7.2.1

Measure the interference spectrum emitted by the system under test, under each operating condition of the system defined in the test plan and in the range of frequencies and with the conditions specified in P.S. 9.90110. [ ]

7.2.2

Broad band interference measurement

7.2.2.1

If a receiver is used, set the band widths (RBW) indicated in **Table I,** and a sweeping pitch equivalent to half the RBW. Use the peak detector with the related bandwidths, and as alternative, only if the emissions exceed the peak values, repeat the test with the quasi-peak detector. [ ]

TABLE I: Bandwidth and video filter and sweep time for broad band interferences measurement.

SUB-BAND (MHz)	BAND WIDTH (kHz) RBW		SPECTRUM ANALYZER	
	PEAK DETECTOR	QUASI-PEAK DETECTOR	VBW VIDEO FILTER (kHz)	MINIMUM SWEEP TIME (ms/MHz)
0.15 - 2	10	9	30	100
2 - 30	10	9	30	100
30 - 110	100	120	300	1

7.2.2.2

If a spectrum analyzer is used, set the peak detector, then the band widths (RBW and VBW) and the minimum sweep times indicated in **Table I**, taking into account, however, that some types of signals (for example low velocity repetition signals) require a longer time or a greater number of sweeps to obtain correct measurement. [ ]

7.2.3

Narrow band interference measurement

7.2.3.1

If a receiver is used, set the band widths (RBW) indicated in **Table II** and a sweep pitch equivalent to half the RBW. Use a medium or peak value detector. [ ]

TABLE II: Band width and video filter to measure narrow band interferences.

SUB-BAND (MHz)	RBW BAND WIDTH (kHz)	VBW VIDEO FILTER (kHz)
0.15 - 2	10	100
2 - 30	10	100
30 - 110	100	300

7.2.3.2

If a spectrum analyzer is used, set the RBW and video filter (VBW) with the values indicated in the appropriate column of **Table II**. [ ]

7.2.4

To ensure that the measurement has not been altered by environmental electromagnetic noise, sweep the measurement band with DUT not powered (background noise measurement) connecting the measuring device by means of a suitable shielded RF cable and an LISN port. The level measured is to be at least 6 dB less than the corresponding acceptability limit, indicated in P.S. 9.90110. [ ]

7.2.5

If this is not so, reduce the input attenuation until this condition is met, and use this adjustment for the actual measurement of the noise generated by the DUT. [ ]

7.2.6

Connect the measuring device with a shielded cable to the measurement port of the LISN as follows: [ ]

- If the DUT is connected to ground with a length of over 200 mm, the measurement is to be made at the LISN port connected to the positive cable and also the LISN port connected to the negative cable, in both cases referring it to the grounded top. The LISN port not used in the measurement is to be terminated with a load of 50 Ω.
- If the DUT is connected to a local ground (length ≤ 200 mm), the measurement is to be made at the port of the LISN connected to the positive cable, referring it to the grounded top.
- If the DUT is an alternator/generator, these are to be charged with a battery

and a resistive load, and connected to the LISN as in figure 5 of help 2.

7.2.7

Make the measurements, if the DUT has several connecting cables, collect the power supplies in a single bundle downstream of the LISN (in the same way, also ground cables, if there are several). [ ]

7.3

Broad band interference measurement

7.3.1

Select the detector used for the measurement and, in consistency with the measurement sub-bands and the device used, the band widths and ,if applicable, the video filter indicated in **Table I** in paragraph 7.2.2.1. [ ]

7.3.2

Set the sweep time (for spectrum analyzer) or dwell time at each frequency (for measurement receiver) to a value that is sufficiently high to obtain the correct measurement of the noise envelope. [ ]

If a spectrum analyzer is used, enter the memory function (“MAX HOLD”) and if necessary make several sweeps for the same sub-band.

7.3.3

Acquire the noise levels trend measured according to frequency. [ ]

7.3.4

Copy the graph obtained in the relevant space of the “Data processing” form then fill in the "Emissions out of range" table. [ ]

7.4

Narrow band interference measurement

7.4.1

According to the measurement sub-bands, select the appropriate bandwidths indicated in **Table II** at paragraph 7.2.3.1. [ ]

If a spectrum analyzer is used, set the video filter as indicated in the relevant column of **Table II**, paragraph 7.2.3.1.

If a measurement receiver is applied, use the medium or peak value detector.

7.4.2

Set the sweep time (for spectrum analyzer) or dwell time at each frequency (for measurement receiver) to a value that is sufficiently high to obtain the correct measurement of the noise envelope. [ ]

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] Job:
Component Type: Drawing Number:
Supplier: Last Change:

7.4.3

Acquire the noise levels trend measured according to frequency. [ ]

***Note**: When measuring narrow band interference only activate the parts of the system under test that have continuative functioning (exclude devices with intermittent operation or that operate for occasional periods of a few seconds).*

7.4.4

Copy the graph obtained in the relevant space of the "Data processing" form then fill in the "Emissions out of range" table. [ ]

Date:..... Exemption: NO [ ] YES [ ]

Test Engineer:…….…… Signature……

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] Job:
Component Type: Drawing Number:
Supplier: Last Change:

8

DATA PROCESSING

8.1

Broad and narrow bands interference measurement

POSITIVE POLE [ ] NEGATIVE POLE [ ]
SPACE FOR VOLTAGE RELATIVE TO FREQUENCY GRAPH **BROAD BAND**

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] Job:
Component Type: Drawing Number:
Supplier: Last Change:

POSITIVE POLE [ ] NEGATIVE POLE [ ]
SPACE FOR VOLTAGE RELATIVE TO FREQUENCY GRAPH **NARROW BAND**

EMISSIONS OUT OF RANGE		
Operating conditions		
Type of measurement	**Narrow band [ ]**	**Broad band [ ]**
Frequency	**Noise level measured out of range**	**Limit specified by P.S. 9.90110**

Date:..... Exemption: NO [ ] YES [ ]

Test Engineer:……..…… Signature……

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] Job:
Component Type: Drawing Number:
Supplier: Last Change:

9

POST-TESTING PROCEDURE

9.1

Disconnect sensors, actuators, probes, etc and all that is not integral to system from system under test. [ ]

9.2

Reinstate any connections altered to permit testing. [ ]

9.3

Restore test setup to original conditions ready for further testing. [ ]

9.4

Store the tested components for at least 10 years so they can be easily traced. [ ]

***Note**: After the storage time the components are to be managed for demolition.*

Date:..... Exemption: NO [ ] YES [ ]

Test Engineer:…….…… Signature……

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] | Job:
Component Type: | Drawing Number:
Supplier: | Last Change:

10

HELP

Help 1

IMPEDANCE STABILIZER NETWORK (L.I.S.N.)

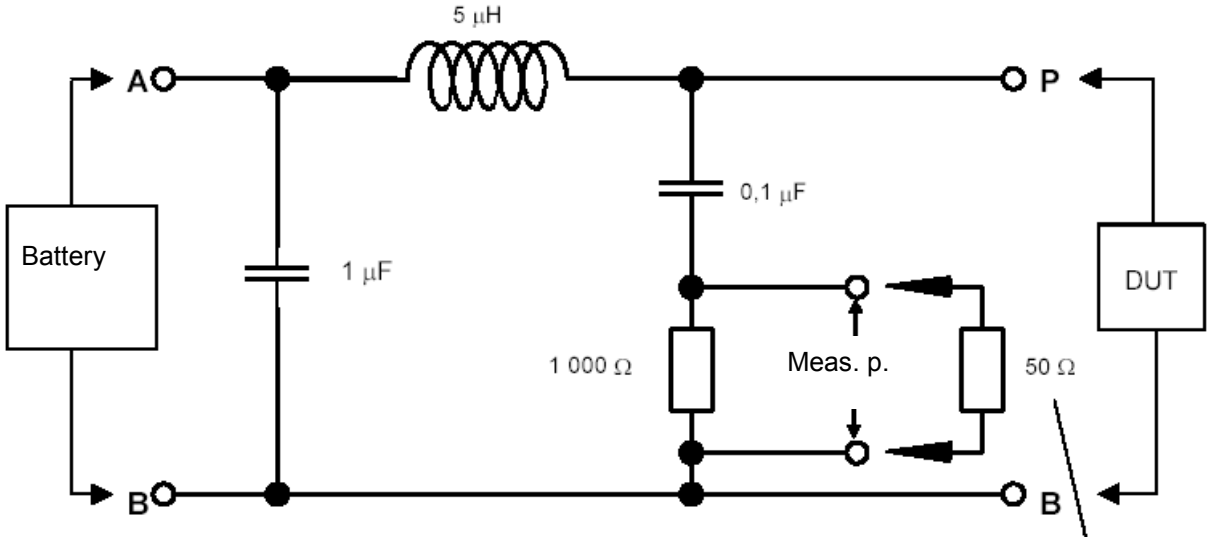


Figure 1 - Electrical scheme

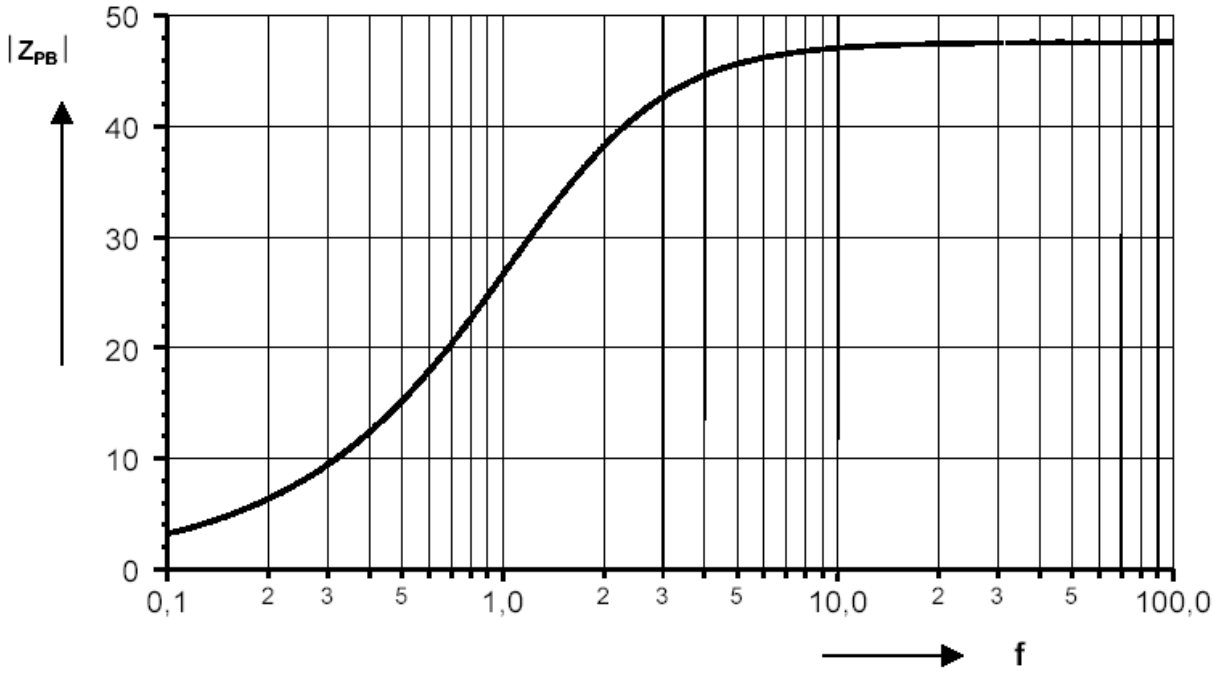


Figure 2 - Impedance form

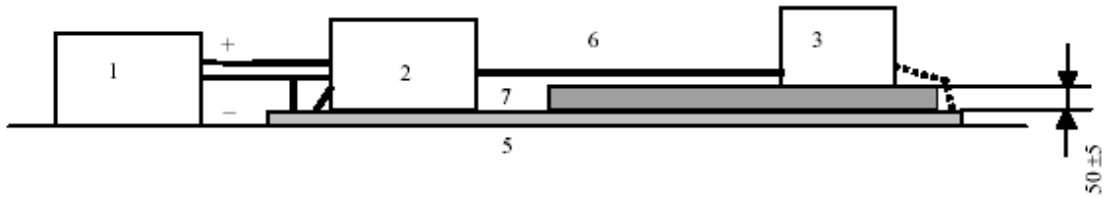
Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] Job:
Component Type: Drawing Number:
Supplier: Last Change:

Help 2

EQUIPMENT LAYOUT SETUP

Side view

Dimension (mm)



Top view

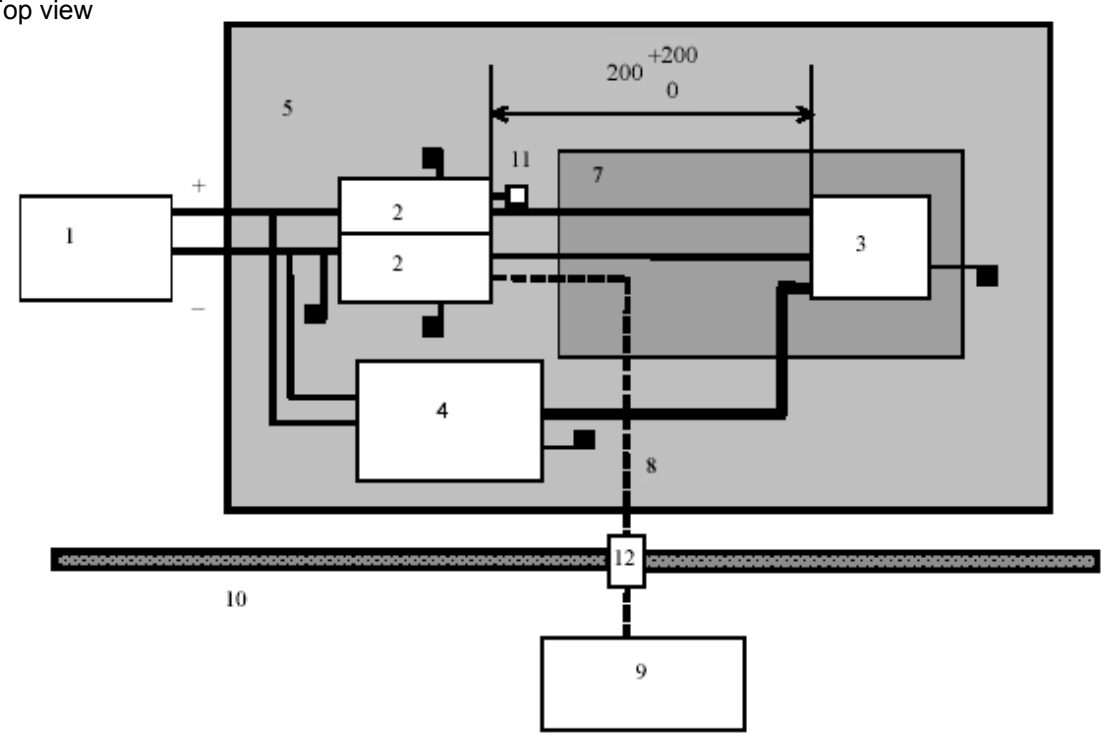


Figure 3 – Test layout for DUT connected to ground with cables > 200 mm

LEGEND:

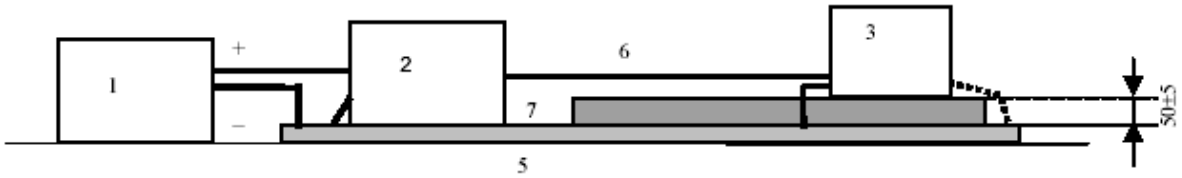
1. Power supply
2. LISN (2 off)
3. DUT (connected to grounded edge if necessary)
4. Loads simulator (signal cables connected to ground if necessary)
5. Grounded top
6. Power supply
7. Insulating support
8. Measurement cable (50 Ω)
9. Measuring equipment
10. Shielded environment
11. 50 Ω load
12. Thru connector

***Note** – The DUT connection to ground, if required, is not to be longer than 150 mm.*

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] Job:
Component Type: Drawing Number:
Supplier: Last Change:

Side view

Dimension (mm)



Top view

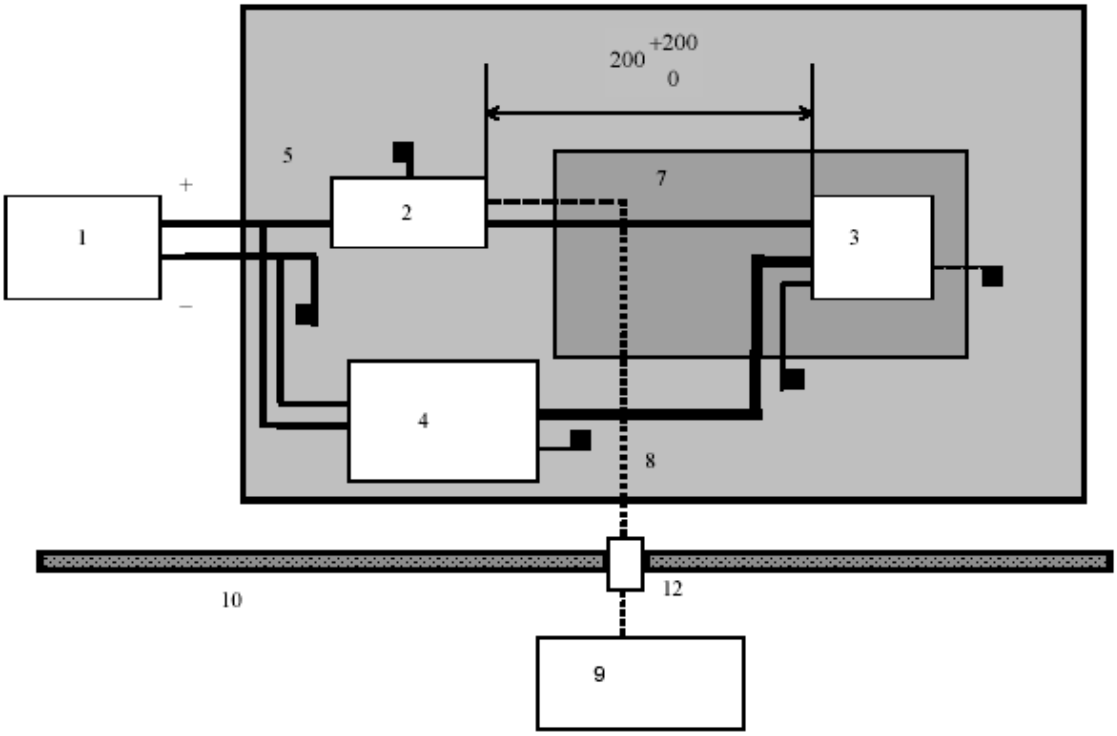


Figure 4 – Test layout for DUT connected to ground with cables ≤ 200 mm

LEGEND:

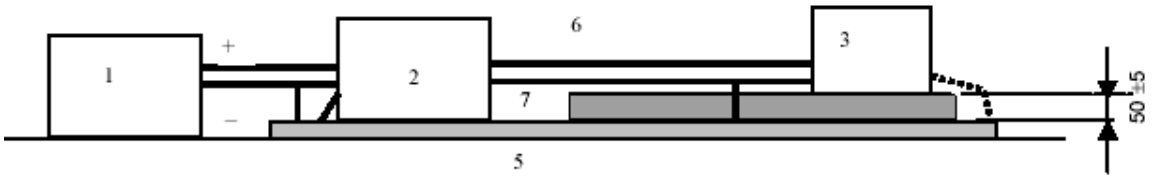
1. Power supply
2. LISN
3. DUT (connected to grounded edge if necessary)
4. Loads simulator (signal cables connected to ground if necessary)
5. Grounded top
6. Power supply
7. Insulating support
8. Measurement cable (50 Ω)
9. Measuring equipment
10. Shielded environment
12. Thru connector

Note – *The DUT connection to ground, if required, is not to be longer than 150 mm.*

Build Level: A[ ] - B[ ] - C[ ] - D[ ] - E[ ] | Job:
Component Type: | Drawing Number:
Supplier: | Last Change:

Side view

Dimension (mm)



Top view

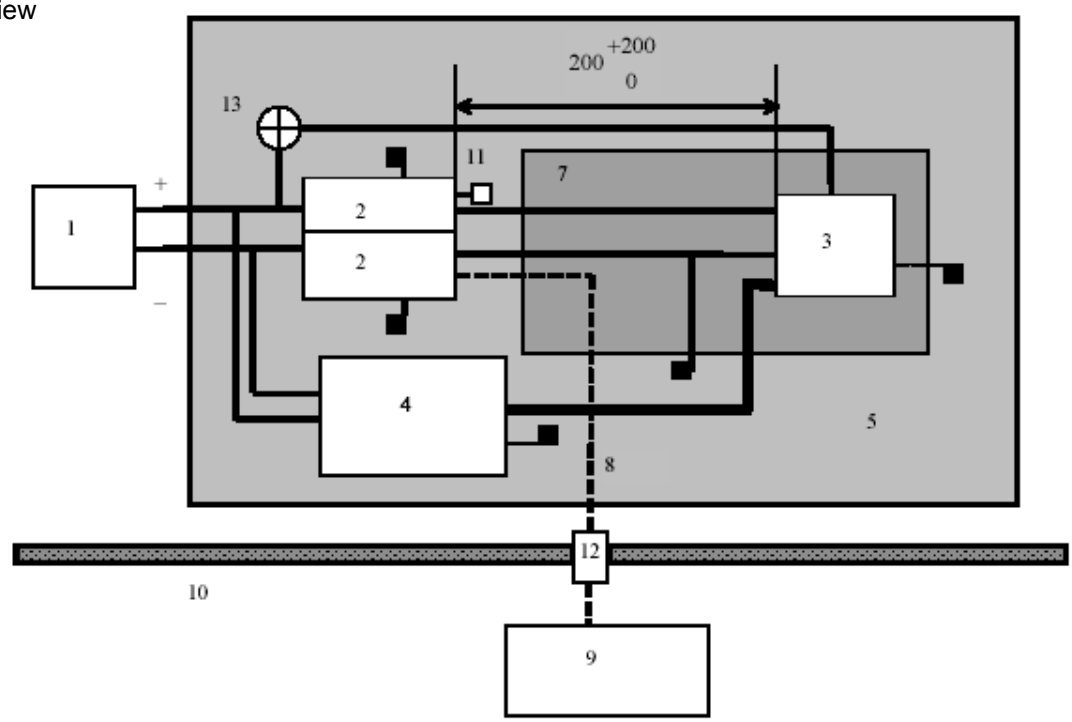


Figure 5 – Test layout for alternators and generators

LEGEND:

1. Power supply
2. LISN (2 off)
3. DUT (connected to grounded edge if necessary)
4. Loads simulator
5. Grounded top
6. Power supply
7. Insulating support
8. Measurement cable (50 Ω)
9. Measuring equipment
10. Shielded environment
11. 50 Ω load
12. Thru connector
13. Test lamp or control resistor (if applicable)

Note – *The DUT connection to ground, if required, is not to be longer than 150 mm.*