IVECO Standard

TESTING STANDARD

RESISTANCE TO ELECTROMAGNETIC DISTURBANCES, INDUCED TYPE, OF ELECTRONIC DEVICES

Source:
ISO 7637/3
with modifications

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Edition	Date	Description of modifications	Group
1	23.04.1992	New.	
2	06.09.1993	Modified points: 4.1 (Tables 1a and 1b), 4.2 (Classes C and D), 4.3.1, 4.3.2, 5.2, 7.8 and 8.1 (“Title” and “Test pulse 1a” modified, “Test pulse 1b” cancelled).	
3	10.02.1995	Point 7.8 modified.	
4	28.08.1999	Modified: points 4.1 (values in Tables 1a and 1b changed), 4.3.1, 4.3.2, 8.3 and 8.4.	**PEL**
5	13.09.2001	Point 7.7 “Acceptability limits” modified.	
6	14.04.2006	Revised for complying with ISO 7637/3 Technical Procedure.	
7	12.03.2009	Changes to Supervisor and paras.: 4.1, 7.1.1.9, 7.1.2.6, 7.3.2, 8.3, 8.4, 10. Updated Manager function and added para. 7.4.	

1 PURPOSE

Defining test equipment and methods to verify at the bench the resistance of electronic devices to capacitive and inductive electromagnetic disturbances induced on signal lines.

2 SUBJECT

The present standard is valid for equipment installed on vehicles with a 12–V and 24–V electric system, equipped with internal combustion engines with “Diesel” and “Otto” cycles.

3 GENERAL TEST CONDITIONS

The tests must be carried out on electronic devices that have already passed functional checks recalled in the general IVECO STD. 18–2252 specification and in the specific specifications.

3.1 Test environment (unless otherwise required)

Environment:
premises whose dimensions are such as to contain test instruments and bench that have a minimum size of 2 x 1 m.

Test environment:
must be free from noises that can affect the test results:

– Temperature :23 ± 5 °C
– Atmospheric pressure: 860 – 1060 mbar
– Relative humidity: 45 – 70 %

3.2 Test voltage

The one required on drawing or on the specific Specification for the tested device.

TABLE 1

Voltage	For 12 V systems (V)	For 24 V systems (V)
U_A	13.5 ± 0.5	27 ± 1
U_B	12 ± 0.2	24 ± 0.4

where:

– U_A System voltage (engine ON).
– U_B System voltage (engine OFF).

4 TEST PULSE LEVEL AND FUNCTIONAL CLASSES

4.1 Test pulse level

Through the help of three **CCC**, **DCC**, **ICC** methods, verify component/system immunity to induced disturbances present on signal lines by applying the test levels described in **Tables 2** and **3** unless otherwise required by the drawing/specific reference specifications.

TABLE 2
Test levels and related functional class for 12 V equipment

<table>
<tr><th colspan="2">Pulse</th><th rowspan="2">Method</th><th rowspan="2">Notes</th><th rowspan="2">Test level [V]</th><th rowspan="2">Test length [minutes]</th><th rowspan="2">Required class</th><th rowspan="2">Pulse description</th></tr>
<tr><th>Pulse type</th><th>Polarity</th></tr>
<tr><td>FAST</td><td>Negative</td><td>CCC</td><td>not applicable for slow pulses</td><td>– 60</td><td>10</td><td>A</td><td>point 8.3</td></tr>
<tr><td>FAST</td><td>Positive</td><td>CCC</td><td>not applicable for slow pulses</td><td>+ 40</td><td>10</td><td>A</td><td>point 8.4</td></tr>
<tr><td>FAST</td><td>Negative</td><td>DCC</td><td>not applicable on twisted cables</td><td>– 60</td><td>10</td><td>A</td><td>point 8.3</td></tr>
<tr><td>FAST</td><td>Positive</td><td>DCC</td><td>not applicable on twisted cables</td><td>+ 40</td><td>10</td><td>A</td><td>point 8.4</td></tr>
<tr><td>SLOW</td><td>Negative</td><td>DCC</td><td>not applicable on twisted cables</td><td>– 30</td><td>5</td><td>A</td><td>point 8.1</td></tr>
<tr><td>SLOW</td><td>Positive</td><td>DCC</td><td>not applicable on twisted cables</td><td>+ 30</td><td>5</td><td>A</td><td>point 8.2</td></tr>
<tr><td>SLOW</td><td>Negative</td><td>ICC</td><td>not applicable for fast pulses</td><td>– 6</td><td>5</td><td>A</td><td>point 8.1</td></tr>
<tr><td>SLOW</td><td>Positive</td><td>ICC</td><td>not applicable for fast pulses</td><td>+ 6</td><td>5</td><td>A</td><td>point 8.2</td></tr>
<tr><td>LOW VOLTAGE</td><td>Positive</td><td>connected to coil primary</td><td rowspan="4">applicable only to leads routed next to supply coil of controlled ignition systems</td><td>+ 15000</td><td>60</td><td>A</td><td rowspan="2">point 7.4</td></tr>
<tr><td>HIGH VOLTAGE</td><td>Positive</td><td>connected to HT lead of coil secondary</td><td>+ 15000</td><td>60</td><td>A</td></tr>
<tr><td>FAST</td><td>Negative</td><td>CCC</td><td>– 300</td><td>30</td><td>A</td><td>point 8.3</td></tr>
<tr><td>FAST</td><td>Positive</td><td>CCC</td><td>+ 300</td><td>30</td><td>A</td><td>point 8.4</td></tr>
</table>

TABLE 3
Test levels and related functional class for 24 V equipment

Pulse		Method	Notes	Test level [V]	Test length [minutes]	Required class	Pulse description
Pulse type	*Polarity*						
FAST	Negative	CCC	not applicable for slow pulses	– 80	10	A	point 8.3
FAST	Positive	CCC	not applicable for slow pulses	+ 80	10	A	point 8.4
FAST	Negative	DCC	not applicable on twisted cables	– 80	10	A	point 8.3
FAST	Positive	DCC	not applicable on twisted cables	+ 80	10	A	point 8.4
SLOW	Negative	DCC	not applicable on twisted cables	– 45	5	A	point 8.1
SLOW	Positive	DCC	not applicable on twisted cables	+ 45	5	A	point 8.2
SLOW	Negative	ICC	not applicable for fast pulses	– 10	5	A	point 8.1
SLOW	Positive	ICC	not applicable for fast pulses	+ 10	5	A	point 8.2
LOW VOLTAGE	Positive	connected to coil primary	applicable only to leads routed next to supply coil of controlled ignition systems	+ 15000	60	A	point 7.4
HIGH VOLTAGE	Positive	connected to HT lead of coil secondary		+ 15000	60	A	
FAST	Negative	CCC		– 300	30	A	point 8.3
FAST	Positive	CCC		+ 300	30	A	point 8.4

4.2 Functional class classification

The functional states of electronic devices during EMC tests can be included in the following classes:

– *CLASS A:* All device functions meet requirements both during and after the test.

– *CLASS B:* All device functions meet requirements both during and after the test; however, one or more of them can be out of tolerance.
These functions however reach back their characteristic value at the end of the disturbance.

– *CLASS C:* A device function can be in failure, but automatically goes back to its characteristic value at the end of the disturbance through an autoreset function that brings back the device into conditions that are complying with present parameters.

– *CLASS D:* A device function can be in failure and does not go back to its characteristic value at the end of the disturbance, until a reset from the outside occurs.

– *CLASS E:* One or more device functions can be in failure both during and after the test. These functions do not go back to their property value at the end of the disturbance, until the device is repaired or replaced.

NOTE **:** *It is not allowed that on tested devices, subjected to the maximum test level, irreversible failures occur (FUNCTIONAL CLASS E).*

4.3 Failure classification

Related to below performed functions by component/system, the following defect Classification is provided:

– **P**: Priority failure that affects vehicle control, perceivable by the Driver or other road user, or that generates operation alterations which could cause confusion to other road users.

– **NP**: Non–priority failure that does not affect vehicle control or secondary functions for the examined system.

These classifications will be defined on the relevant Product Specifications.

5 TEST EQUIPMENT

<u>Pulse generator</u>:
it has to be able to generate pulses defined in points 8.1, 8.2, 8.3, 8.4.
Tolerances with respect to the required values are ± 10% for timing, ± 2% for R_i resistances and ± 10% for voltages.

<u>Power supply with adjustable voltage between 0 V and 40 V, 80 A</u>:
according to IVECO STD. 16–2108, with a 12 V, 70 Ah 350 A battery as a backup.
One battery for 12–V tests; 2 batteries in series for 24–V tests.

Digital memory–oscilloscope with a pass–band F ≥ 200 MHz:
sampling via single pulse: 4 x 10^8 samplings/s per channel.

Voltage probes having the following properties:

– damping: 10 x (R ≥ 10 MΩ, C ≤ 12 pF, max voltage 500 V, pass–band F ≥ 200 MHz);

– damping: 100 x (R ≥ 10 MΩ, C ≤ 2.5 pF, max voltage 1500 V, pass–band F ≥ 120 MHz).

Ground plane:
sheet made of highly electrically conductive material (Cu, Al, brass) with minimum thickness: 1 mm and minimum sizes: 2 x 1 m.
The ground plane will have to be connected to the ground line of the building through an adequate connection (copper plait or strap) welded to the plane itself.

Test bench:
made of insulating material (wood), with dimensions suitable to support the ground plane.

Simulator:
suitable to reproduce operation of sensors and dampers composing the tested system. This device must not alter its set of signal also when disturbances are like those described in points 8.1, 8.2, 8.3, 8.4.

6 TEST METHODS

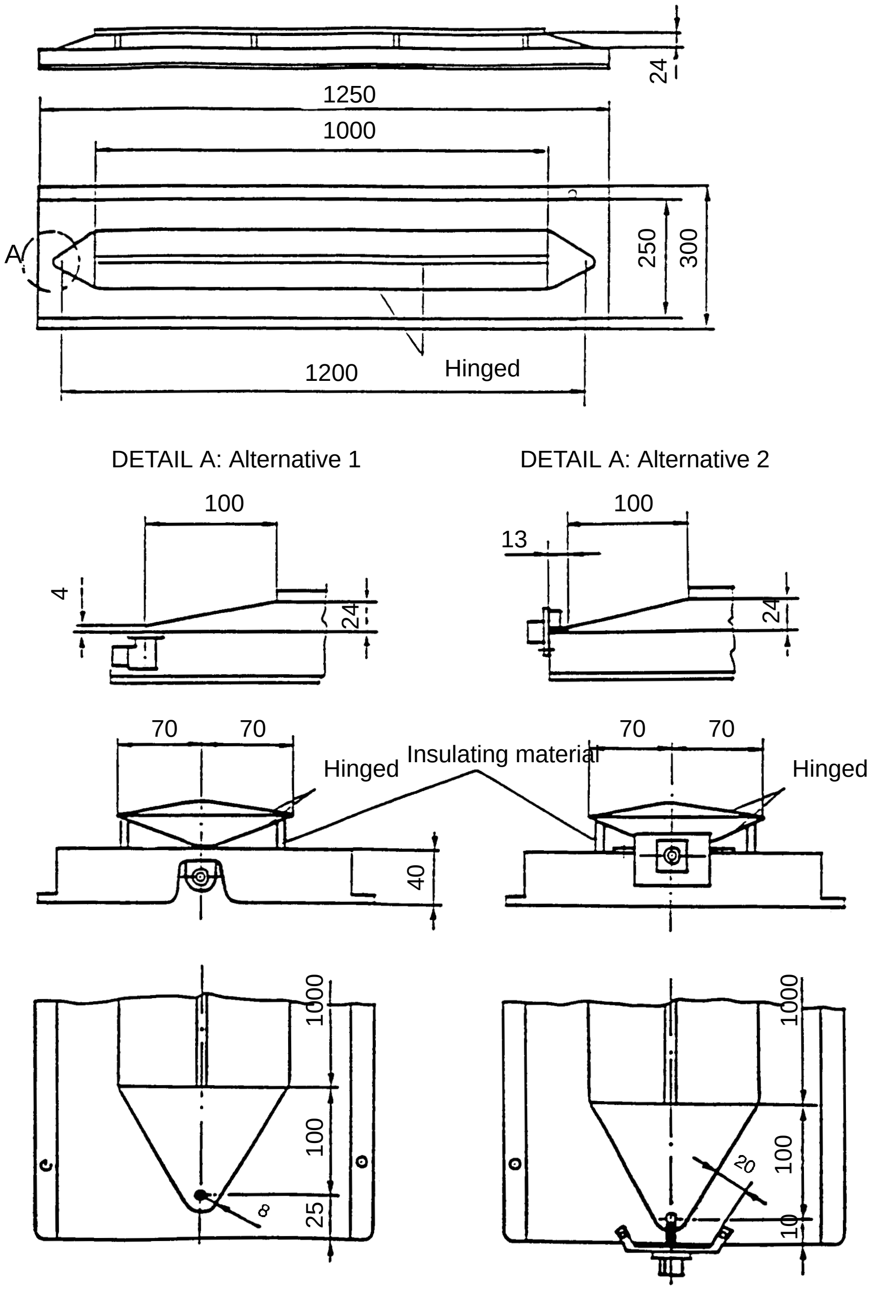
6.1 Coupling Clamp – CCC

The CCC method is based on a device (see **Figure 1**), which allows coupling signals without any galvanic connection. The coupler must be equipped on both its ends with coaxial 50Ω connectors. As input through a coaxial 50 Ω cable, while the other end must be connected to an attenuator terminated at 50 Ω..
The required technical properties are as follows:

– Typical capacity value between coupling clamp and wires inside it:	100 pF (max 200 pF)
– Diameter of the wire bundle that can be inserted:	4–40 mm
– Provided level of insulation:	≥ 200 V
– Coaxial connector impedance (without inserted wiring):	50Ω ± 10%

The connection length between pulse generator and Coupling Clamp BNC connector must not be greater than 0.5 m.

FIGURE 1
Coupling Clamp



6.2 **Inductive Coupling Clamp – ICC**

The ICC method is based on an inductive probe like the one used for Bulk Current Injection (BCI) test with special characteristics. It allows coupling the signals without any galvanic connection between pulses generation (with slow times) and the circuit being tested, which will be connected through its wiring to other devices

The coupling circuit consists in a ICC which winds all non–ground lines of the tested system. Normally ground lines are excluded from the probe, apart from when also on a vehicle there are separate ground lines.

6.3 **Direct Capacitor Coupling – DCC**

The DCC method is based on an unbiased high voltage capacitor (> 200 V) and can be used both for fast pulses and for slow pulses, taking however care to use the appropriate capacity value according to the types of pulse to be tested.
The capacity values will be 100 pF $\pm$10% for fast pulses and 0.1 μF $\pm$10 % for slow pulses.

Fast pulses (differently from the coupling clamp) must be tested on one line at a time.
It cannot be used on those lines where it is not guaranteed that the signal is not disturbed, like in case of twisted cables or bus communication cables.

7 BENCH TEST CIRCUITS AND MEASUREMENTS

7.1 COUPLING CLAMP METHOD – CCC

7.1.1 Bench test circuit through the Coupling Clamp method – CCC

7.1.1.1 Prearrange the test circuit according to the diagram in **Figure 2**

7.1.1.2 Verify that the pulse generator is able to reproduce the test pulse, whose width, depth and length are required without wires inside the Capacitive Coupling Clamp.

7.1.1.3 Wire lengths of the tested device (apart from supply ones) must be 1 m.

7.1.1.4 The ground plan must be grounded through a copper plait or strap. The inductance value must be $\leq 2\ \mu H$.

7.1.1.5 The device under test (D.U.T.) must be placed at a 50/100 mm distance from the test plane and insulated from it, unless the direct ground connection on frame is expressly required; in this case, the connection with the test plane must be as short as possible. Moreover, the device under test and its related sensors/actuators must be placed at a distance of 400 ± 50 mm from the coupling clamp, or other conductive structures. Other ground connections of the device under test are not allowed, apart from those required on drawing.

7.1.1.6 Connect the pulse generator to the coupling clamp input.

7.1.1.7 Connect the oscilloscope to the 50Ω resistive terminal connected to the coupling clamp output.

7.1.1.8 Verify that there are no metallic objects that are less than 500 mm far from the coupling clamp and the tested system, apart from the ground plane.

7.1.1.9 Using a test wiring, the following standards will have to be observed:

a) The supply lines related to DUT and to its possible sensors/actuators must be placed outside the Capacitive Coupling Clamp and anyway must be 1 meter long. If this provisions cannot be observed, it is allowed, only however for sensors/actuators, to insert supply lines inside the coupling clamp.

b) The distance between device under test and Capacitive Coupling Clamp and between Capacitive Coupling Clamp and peripheral equipment must be 400 ± 50 mm.

c) Wires outside the Capacitive Coupling Clamp must be lent on an insulating support placed at a height of 100 mm above the ground plane and perpendicularly (90 ± 15°) with respect to the longitudinal position of the Capacitive Coupling Clamp.

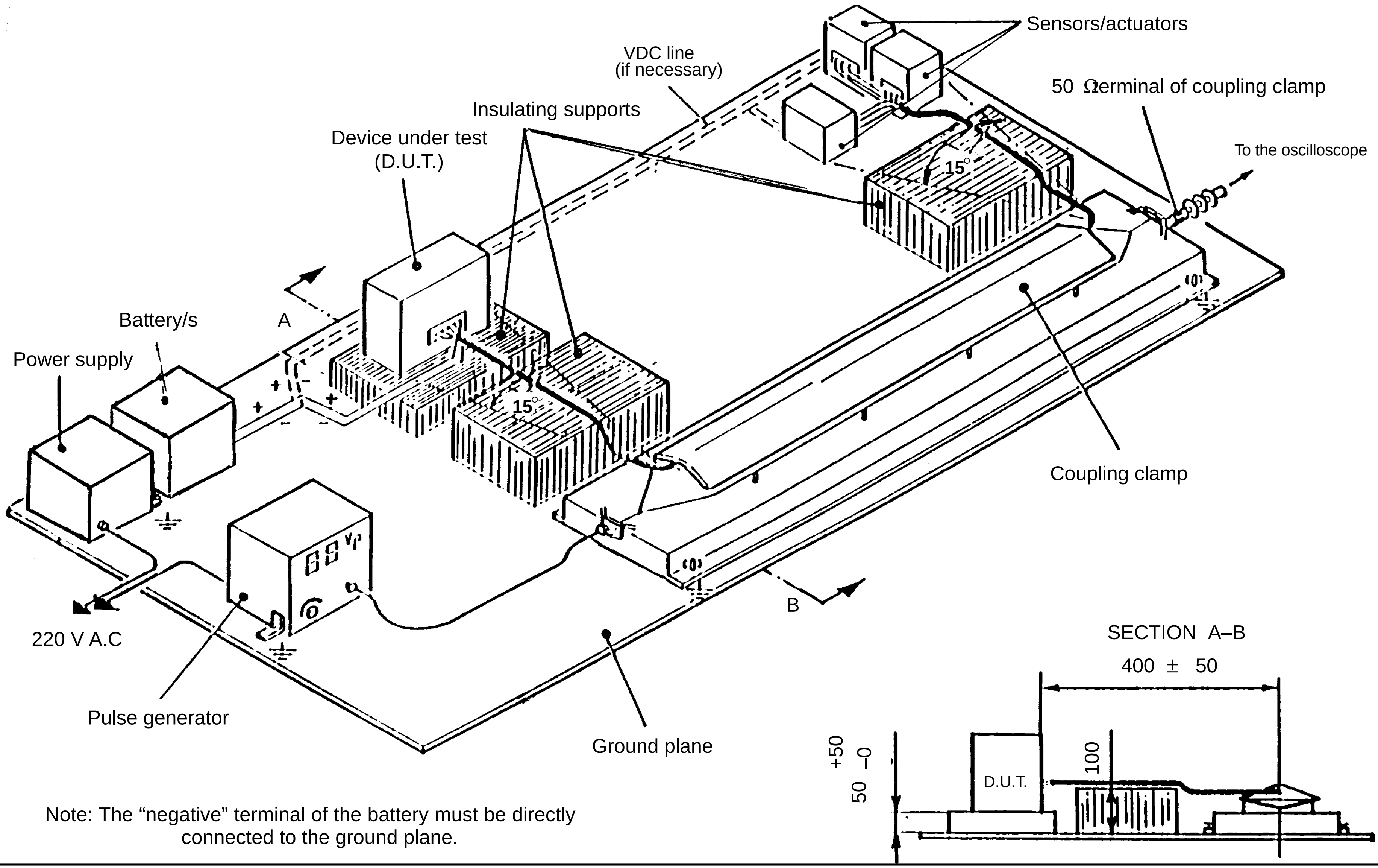
d) If using a standard wiring whose length is > 2 m, the exceeding part of the wiring can be collected into a winding with turns whose diameter is 0.3 m and that is placed at a height of 0.10 m from the ground plane. The maximum distance of 0.45 m between device under test and Capacitive Coupling Clamp must anyway be kept.

e) If some wires are less than 1 m long, they will have to be brought (through a junction) to the minimum length required by the test.

f) For devices with connection wiring (except power leads) to be connected to engine controlled ignition system leads, the wiring harness shall run under the Capacitive Coupling Clamp placed sidewise so as to ensure conductor contact with both armatures of CCC.

7.1.1.10 The “negative” terminal of the battery/s must be directly connected to the ground plane.

FIGURE 2
Injection of transient disturbances on signal lines – CCC –
Equipment layout



Note: The "negative" terminal of the battery must be directly connected to the ground plane.

7.1.2 **Measurements through Capacitive Coupling Clamp (CCC)**

To be applied simultaneously on all the bunch of cables only to fast pulses described in points 8.3, 8.4.

7.1.2.1 System gauging: apply the required test pulses to the Capacitive Coupling Clamp, with the 50Ω terminal connected, without the wire bundle of the tested system (see **Figure 3**) adjusting electric properties (width, frequency, rising times, length), as indicated in Figures 9 and 10 at points 8.3, 8.4.

7.1.2.2 Insert the wire bundle that connects the device under test to its related sensors/actuators in the Capacitive Coupling Clamp (apart from supply lines), as indicated in **Figure 2**, caring to lock in closing position the mobile parts of the coupling clamp in contact with the wire bundle.

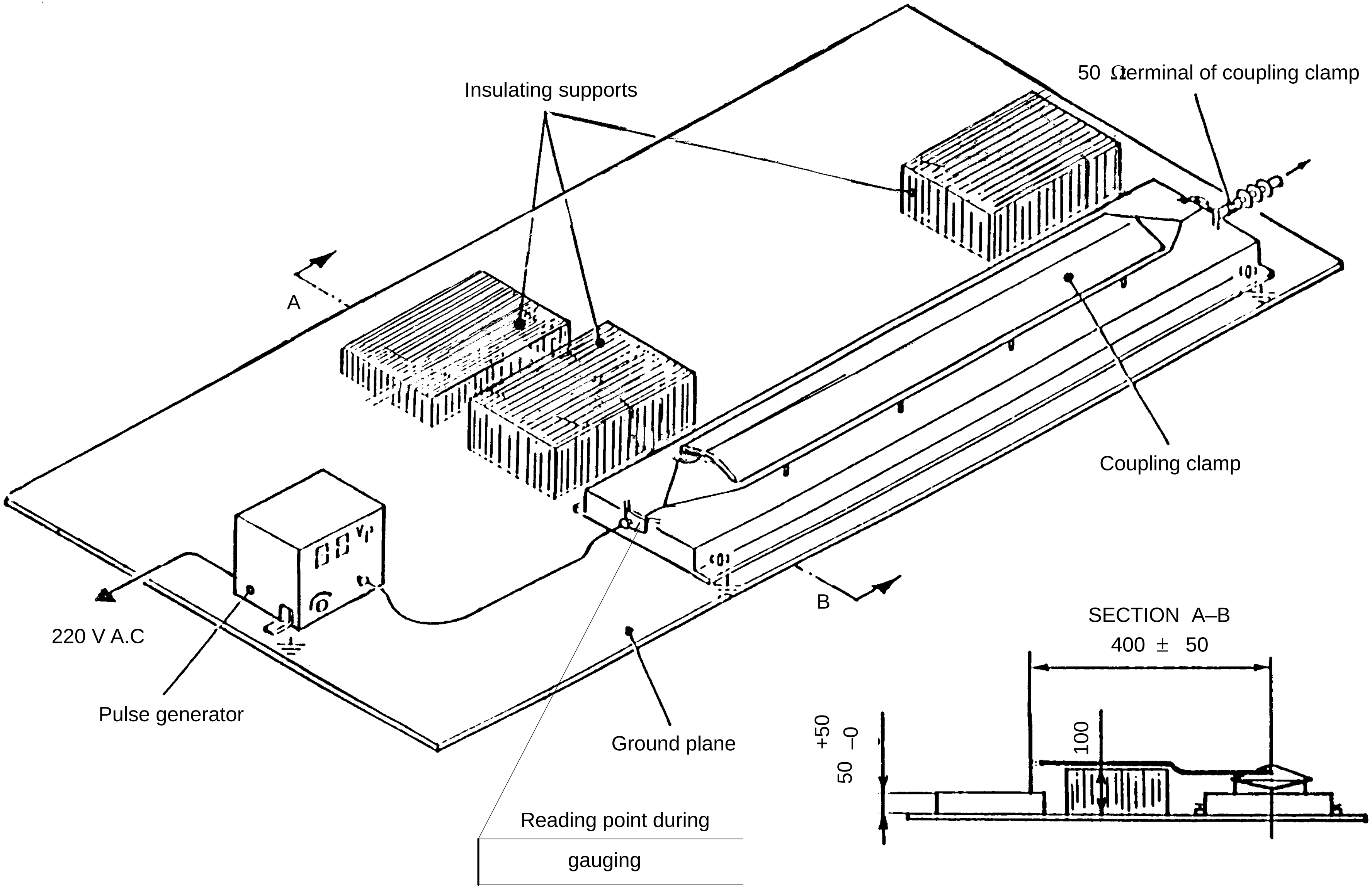
7.1.2.3 Place the power supply on the ground plane at a distance of at least 500 mm from the device under test and the Capacitive Coupling Clamp; then, connect the supply line of the device under test to the power supply.
In case of a common connector for signal and supply lines, the wires related to the latter one must be placed at 90 ± 15° with respect to the signal ones, and as near as possible to the electric terminals.

7.1.2.4 Supply and prearrange the tested device in the normal conditions of use as provided by the related Specification.

7.1.2.5 Connect the Capacitive Coupling Clamp to pulse generator, prearrange the device in the normal conditions of use as provided by the related Specification, preferring a physical stimulation of the sensors.

7.1.2.6 To device under test apply specified pulses, i.e. fast pulses **type 3a** and **3b** as shown in **Figs. NO TAG** and **NO TAG** described in paras. NO TAG and NO TAG, except those leads which run adjacent to engine controlled ignition wiring, where the test must be carried out lead by lead, or by families of leads associated with the same device function.

FIGURE 3
CCC system gauging layout



7.2 INDUCTIVE COUPLING CLAMP METHOD – ICC –

7.2.1 Bench test circuit through the Inductive Coupling Clamp method (ICC)

7.2.1.1 Arrange the test circuit according to the diagram described in **Figure 4.**
The coupling circuit consists in a ICC which winds all non–ground lines of the tested system.

7.2.1.2 Verify through the oscilloscope with 1 MΩ input connected with coaxial cable to the inductive coupler in turn connected, always through a coaxial cable, to the pulses generator.
Comply with parameters included in **Table 4** below.

TABLE 4

Parameters	Values
t_d [µs]	7 µs ± 30 %
t_r [µs]	≤ 1.2 µs

7.2.1.3 The cable length of the device being tested must be less than 2 m.

7.2.1.4 The ground plane must be earthed through copper braid or bus bar. The inductance value must be ≤ 2 µH.

7.2.1.5 The ICC must be placed at 150 mm from the device under test.

7.2.1.6 The Device Under Test (D.U.T.) must be placed at a height of 50 ± 10 mm from the test plane and insulated therefrom, unless the direct ground connection is expressly provided on the frame. In this case the connection with the test plane must be as short as possible.
The device is spaced from related sensors/actuators through a wiring whose length < 2000 mm and distance from other conductive structures > 500 mm.

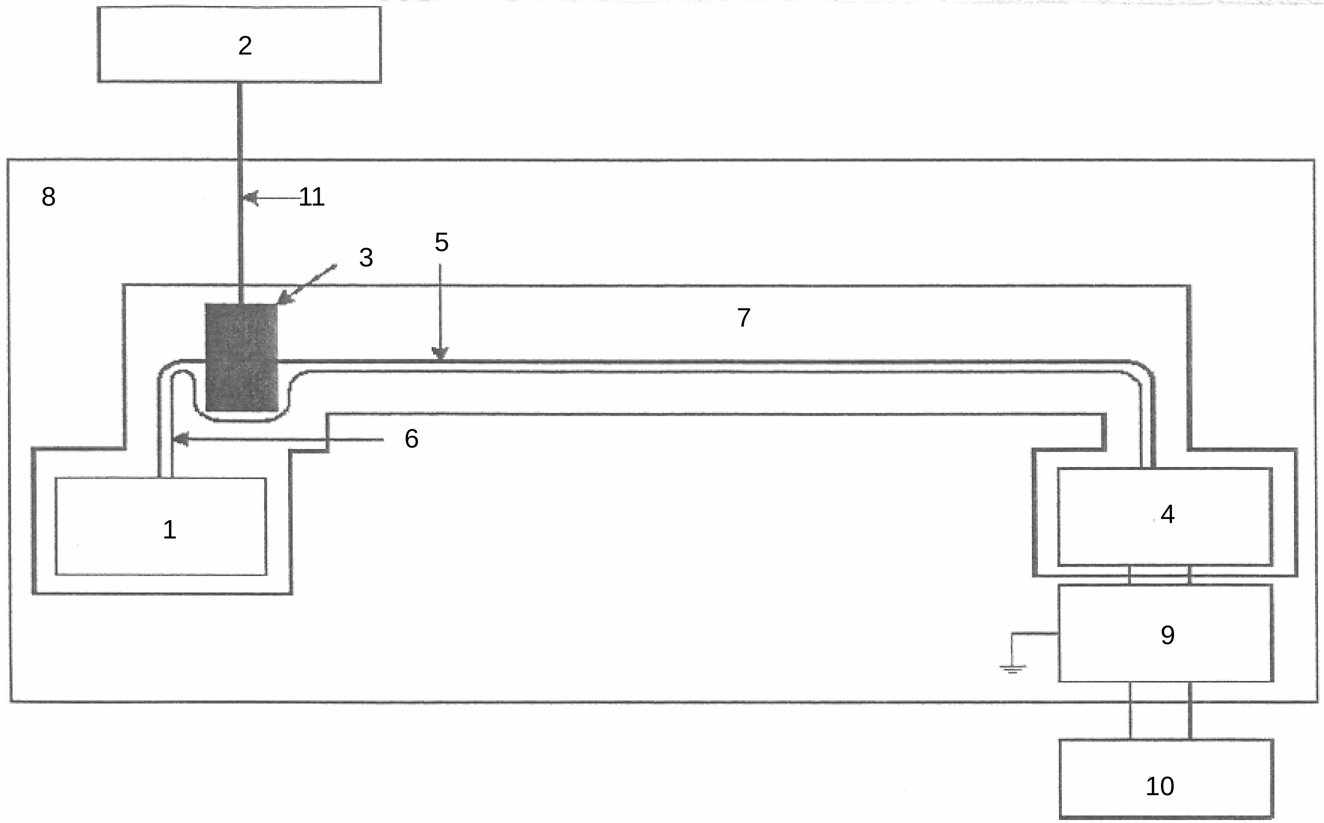
7.2.1.7 Connect the pulse generator to the inductive coupler input through a 50 Ω coaxial cable whose length is less than 0.5 m.

7.2.1.8 Verify that there are no metallic objects spaced away by less than 500 mm from the inductive coupling and the system being tested apart from the ground plane.

7.2.1.9 Ground lines related to D.U.T. and possible sensors/actuators must be placed outside the probe. Cables outside the probe must be abutted onto an insulating support placed at a height of 50 ± 10 mm above the ground plane and parallel to the bundle of cables inserted in the probe.
Normally, ground lines are excluded from the probe, apart when also on a vehicle there are separate ground lines. No other ground connections are allowed for the device to be verified apart from those required by the drawing.

7.2.1.10 The ”negative” terminal of/from the battery must be directly connected to the ground plane.

FIGURE 4
Layout of equipment for injecting transient disturbances on signal lines through Inductive Coupling Clamp – ICC –



where:
1) Device under test (D.U.T.)
2) Pulse generator
3) Inductive Coupling Clamp – ICC – must be placed at 150 mm from the D.U.T.
4) Peripheral units
5) Test wiring – must not be longer than 2 meters
6) Ground line
7) Insulator (50 ± 10 mm)
8) Ground plane
9) Battery
10) DC current generator
11) 50Ω coaxial cable (maximum length 0.5 m)

7.2.2 **Measurements through Inductive Coupling Clamp method (ICC)**

To be applied simultaneously on all the bundle of cables (excluding ground cables) only to slow pulses described in points 8.1, 8.2.

7.2.2.1 *System gauging: see **Figure 5***

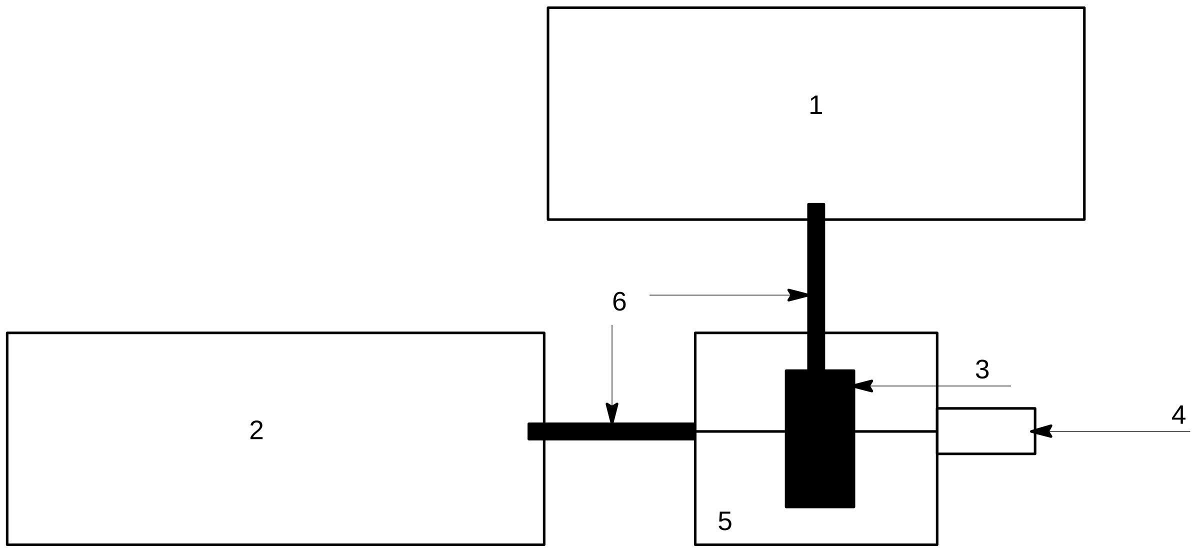
7.2.2.2 Insert the bundle of cables which connect the tested device with related sensors/actuators in the Inductive Coupling Clamp (excluding ground lines) as shown in **Figure 4.**
Tests on devices with multiple connectors can be carried out on all branches simultaneously or on a branch at a time.

7.2.2.3 Connect the Inductive Coupling Clamp to pulse generator, prearrange the device in the normal conditions of use as provided by the related Specification, preferring a physical stimulation of the sensors.

7.2.2.4 Supply and prearrange the tested device in the normal conditions of use as provided by the related Specification.

7.2.2.5 Apply the required pulses to the device under test, i.e.: pulses of **type 1** and **2** as shown in **Figures 7** and **8** at points 8.1, 8.2.

FIGURE 5
ICC system gauging layout



where:

12) Pulse generator

13) Oscilloscope – 1 MΩ input

14) ICC – (inductive coupler)

15) Short circuit

16) Calibration equipment

17) 50 Ω coaxial cable

7.3 DIRECT CAPACITOR COUPLING METHOD – DCC –

7.3.1 Bench test circuit through the Direct Capacitor Coupling method (DCC)

7.3.1.1 Prearrange the test circuit according to the diagram in **Figure 6.**

7.3.1.2 Verify that the pulse generator terminated with an adequate resistance is able to reproduce the test pulse having width, depth and length required at open circuit.

7.3.1.3 The cable length of the device under test must be included between 1 and 2 m.

7.3.1.4 The ground plan must be grounded through a copper plait or strap. The inductance value must be $\leq$ 2 μH.

7.3.1.5 The capacitor will be interposed between pulse generator and line under test spaced away by 100 m. Such capacitor connection will in turn have to be spaced by 50 mm from the device under test.

7.3.1.6 The device under test must be placed at a minimum distance of 100 mm from the metallic plane edge apart from the ground plane.

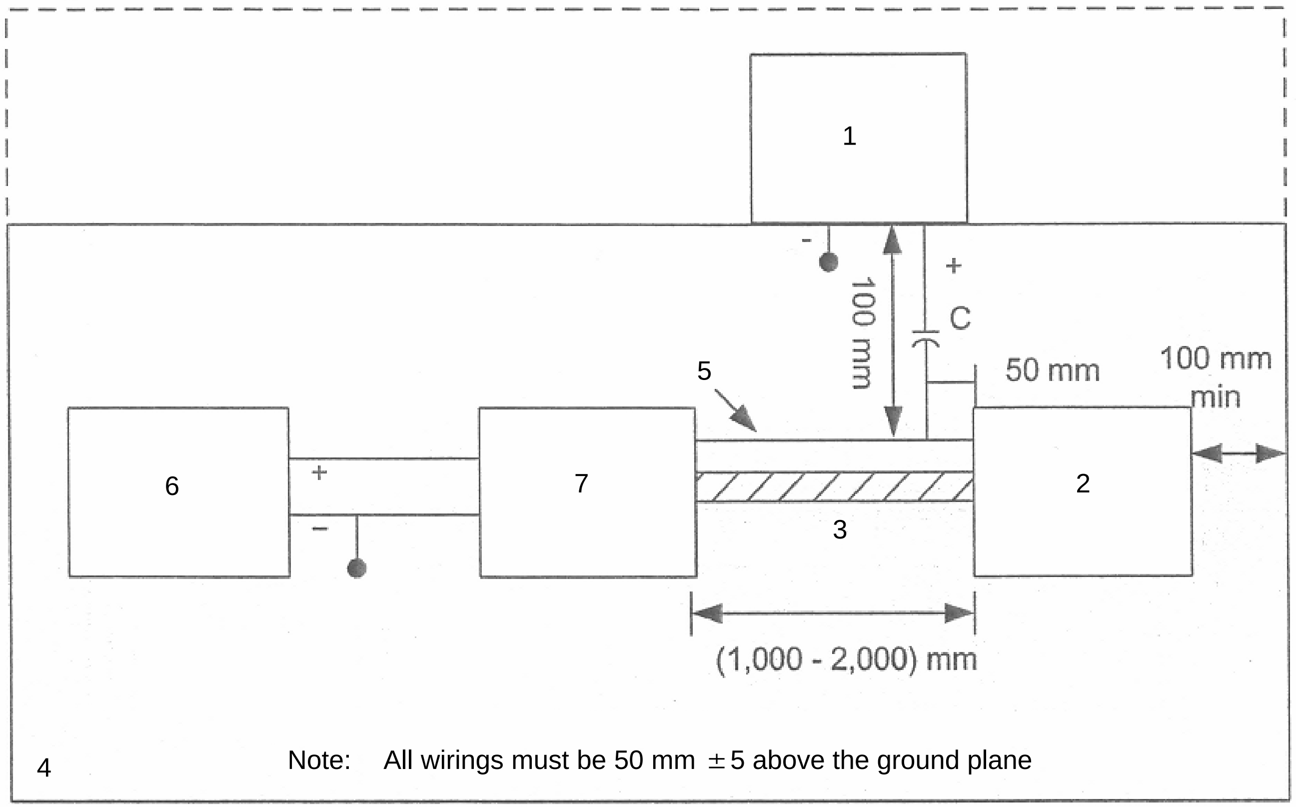
7.3.1.7 Pulse generator, capacitor and device under test must be spaced away by at least 500 mm from metallic objects apart from the ground plane.

7.3.1.8 Cables must be abutted on an insulating support placed at a height of 50 $\pm$ 10 mm above the ground plane and parallel to the cable under test.

7.3.1.9 The “negative” terminal of the battery/s must be directly connected to the ground plane.

FIGURE 6

Layout of equipment for injecting transient disturbances on signal lines through Direct Capacitor Coupling – DCC –



where:

C) Insulating high voltage capacitor made of ceramics (minimum 200 V)

1) Pulse generator

2) Device Under Test (D.U.T.)

3) Test wiring

4) Ground plane

5) Input / Output Line Under Test

6) Supply

7) Operating Device Under Test (D.U.T.).

7.3.2 **Measurements through Direct Capacitor Coupling – DCC –**

To be applied on one cable at a time are both slow pulses (**types 1 and 2**) described in points 8.1, 8.2, and fast pulses (**types 3a and 3b**) described in points 8.3, 8.4

7.3.2.1 System gauging:
apply, without the bundle of cables of the tested system, pulses required to **DCC** with termination at 2 Ω for slow pulses (**types 1 and 2**) described in points 8.1, 8.2, and at 50 Ω for fast pulses (**types 3a and 3b**) described in points 8.3, 8.4, adjusting electric characteristics (amplitude, frequency, rising times, length) as shown in **Figures 7**, **8**, **9**, **10.**

7.3.2.2 Insert, one cable at a time, the bundle of cables which connect the device under test to the related sensors/actuators in the Direct Capacitor Coupling as shown in **Figure 6**.

7.3.2.3 Connect the Direct Capacitor Couplingto pulse generator, prearrange the device in the normal conditions of use as provided by the related Specification, preferring a physical stimulation of the sensors.

7.3.2.4 Supply and prearrange the tested device in the normal conditions of use as provided by the related Specification.

7.3.2.5 Apply to the device under test, first of all, slow pulses (**types 1 and 2**) described in points 8.1, 8.2 through the unbiased 0.1 μF capacitor, then fast pulses (**types 3a and 3b**) described in points 8.3, 8.4 through the unbiased 100 pF capacitor.The pulse generated shall be as specified in **Table NO TAG** for 12 V devices and in **Table NO TAG** for 24 V devices.

7.4 **MONITORING IMMUNITY TO CONNECTION WITH ANY CONTROLLED IGNITION SYSTEM LEADS**

7.4.1 On devices with connecting leads, other than power leads, for connection to engine controlled ignition leads, test for immunity to induced interference on signal leads of ignition system wiring harness as specified in paras.1.2.1.1 and 1.2.1.2.

7.4.1.1 **LT interference**

Connect signal leads of device under test, one by one, for 1 ± 0,05 m length, to pilot lead of coil primary.
Test time shall be 1 h and device performance shall be to ”Class A” level.

7.4.1.2 **HT interference**

Connect signal leads of device under test, one by one, for 0,5 ± 0,05 m length, to one HT lead of coil secondary.
Test time shall be 1 h and device performance shall be to ”Class A” level.

7.4.2 In both tests as per paras.1.2.1.1 and 1.2.1.2, monitor the signal on DUT terminal of lead connected and enter in test report.
Connection of lead of circuit under test to lead of interfering circuit shall be by direct contact, holding DUT harness and any ground mass 0,15 ± 0,05 m away.
The leads used for testing shall be the same as those installed on the vehicle.
Discharge shall be by spark gaps, without suppressors and/or discharge current limiters, and discharge frequency at 1500 to 7000 engine rpm.
In both tests trigger voltage shall not be less than 15 KV.
The vehicle electrics design engineer may exceptionally decide to allow one or both of these tests to be carried out with the wiring of the actual vehicle instead of connection to individual leads.

8 TEST PULSES

8.1 Test pulse type 1

Low frequency transients coming from supply cables and caused by the detachment of inductive loads, such as for example radiator electric fan, conditioned air compressor, etc.

FIGURE 7
Waveform of negative low–speed transients

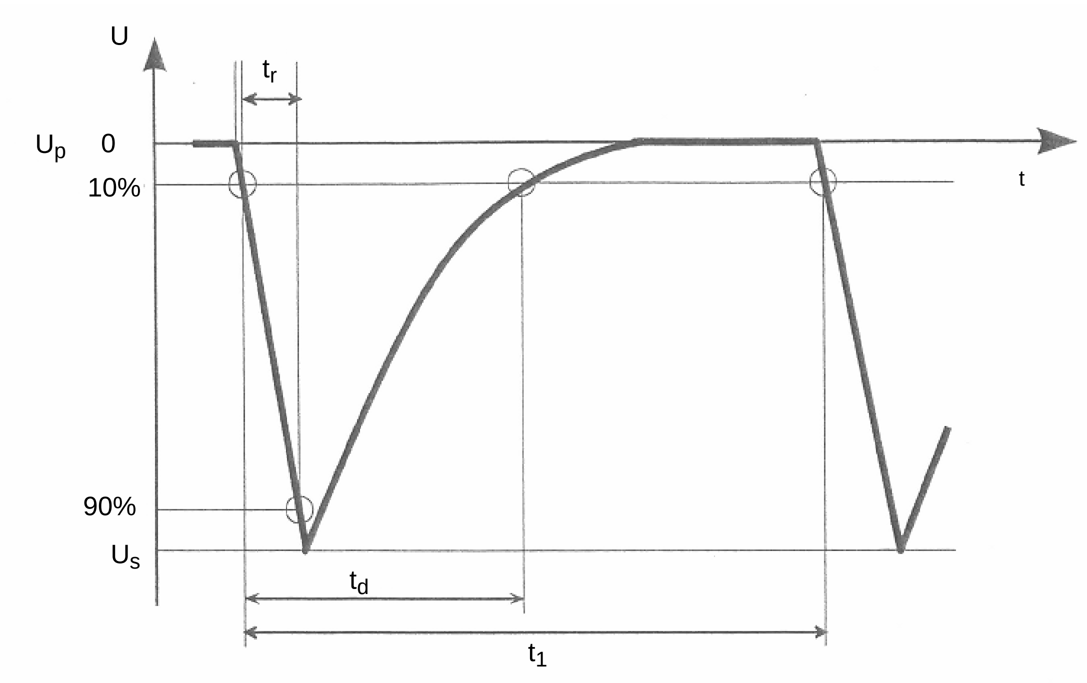


TABLE 5
Negative low–speed transients, parameters to be applied by ICC

Parameters	12 V			24 V		
U_a	13.5 V			27 V		
U_s	– 8 V	to	– 30 V	– 8 V	to	– 45 V
t_d	0.05 ms			0.05 ms		
t_r	1 µs			1 µs		
t_1	0.5 s	to	5 s	0.5 s	to	5 s
R_i	2Ω			2Ω		

8.2 Test pulse type 2

Low–frequency transients generated by the disconnection of inductive loads placed in series to the device.

Figure 8
Waveform of positive low–speed transients

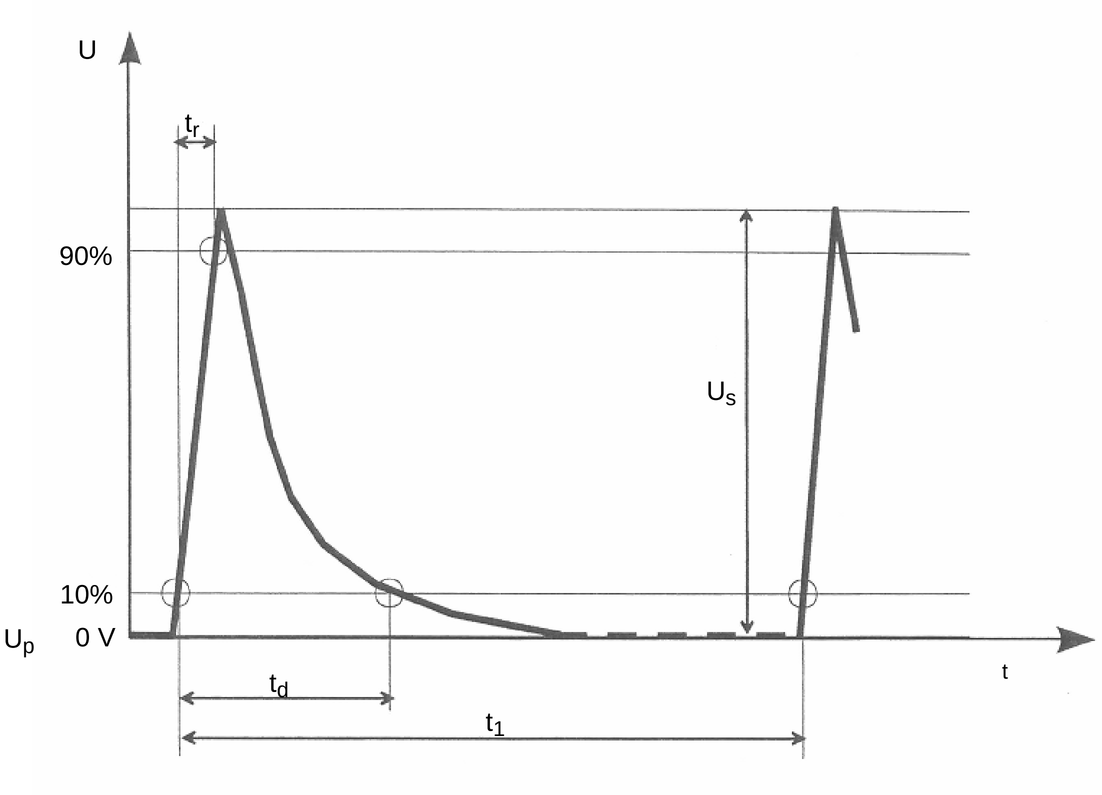


TABLE 6
Slow positive transients, parameters to be applied by ICC

Parameters	12 V			24 V		
U_a	13.5 V			27 V		
U_s	+ 8 V	to	+ 30 V	+ 8 V	to	+ 45 V
t_d	0.05 ms			0.05 ms		
t_r	1 µs			1 µs		
t_1	0.5 s	to	5 s	0.5 s	to	5 s
R_i	2Ω			2Ω		

8.3 Test pulse type 3a

High–frequency negative transients generated by opening and closing operations and that are characterized by the distributed wiring capacity and inductance.

FIGURE 9
Waveform of negative high–speed transients

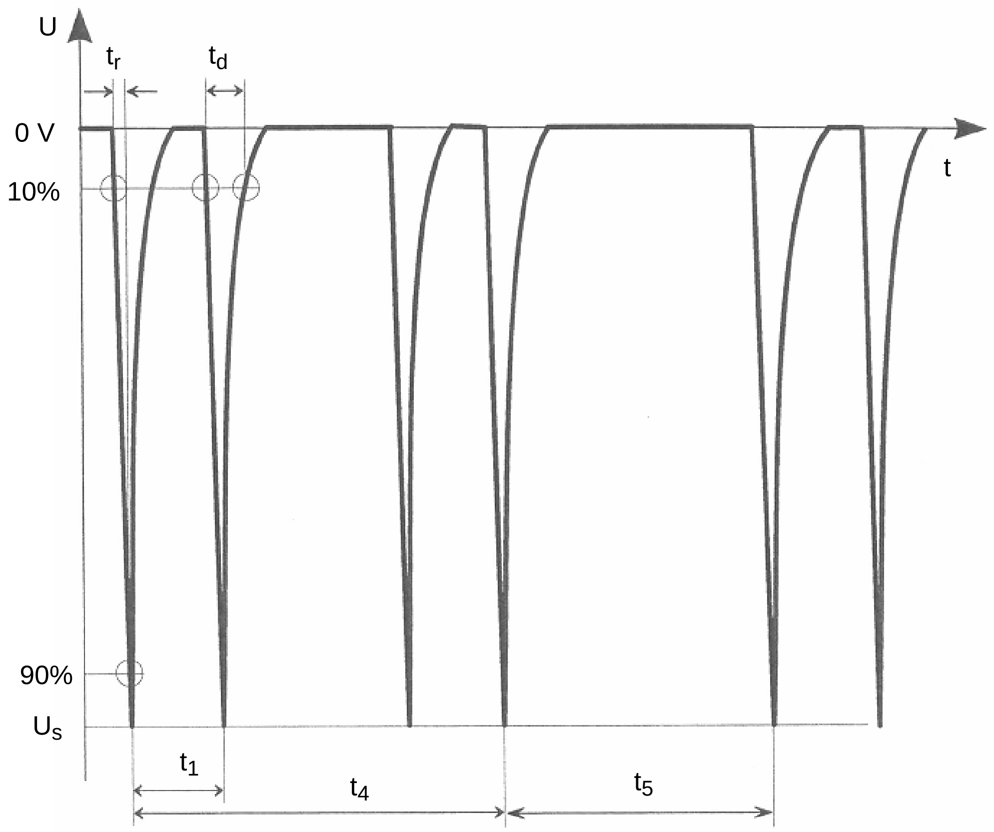


TABLE 7
Fast negative transients, parameters to be applied by CCC

Parameters	12 V			24 V		
U_a	13.5 V			27 V		
U_s	– 10 V	to	– 60 V (*)	– 14 V	to	– 80 V (*)
t_d	0.1 µs			0.1 µs		
t_r	5 ns			5 ns		
t_1	100 µs			100 µs		
t_4	10 ms			10 ms		
t_5	90 ms			90 ms		
R_i	50Ω			50Ω		

(*) Apply up to –300 V to leads running adjacent to engine controlled ignition coil leads.

8.4 Test pulse type 3b

High–frequency positive transients generated by opening and closing operations and that are characterized by distributed wiring capacity and inductance.

FIGURE 10
Waveform of positive high–speed transients

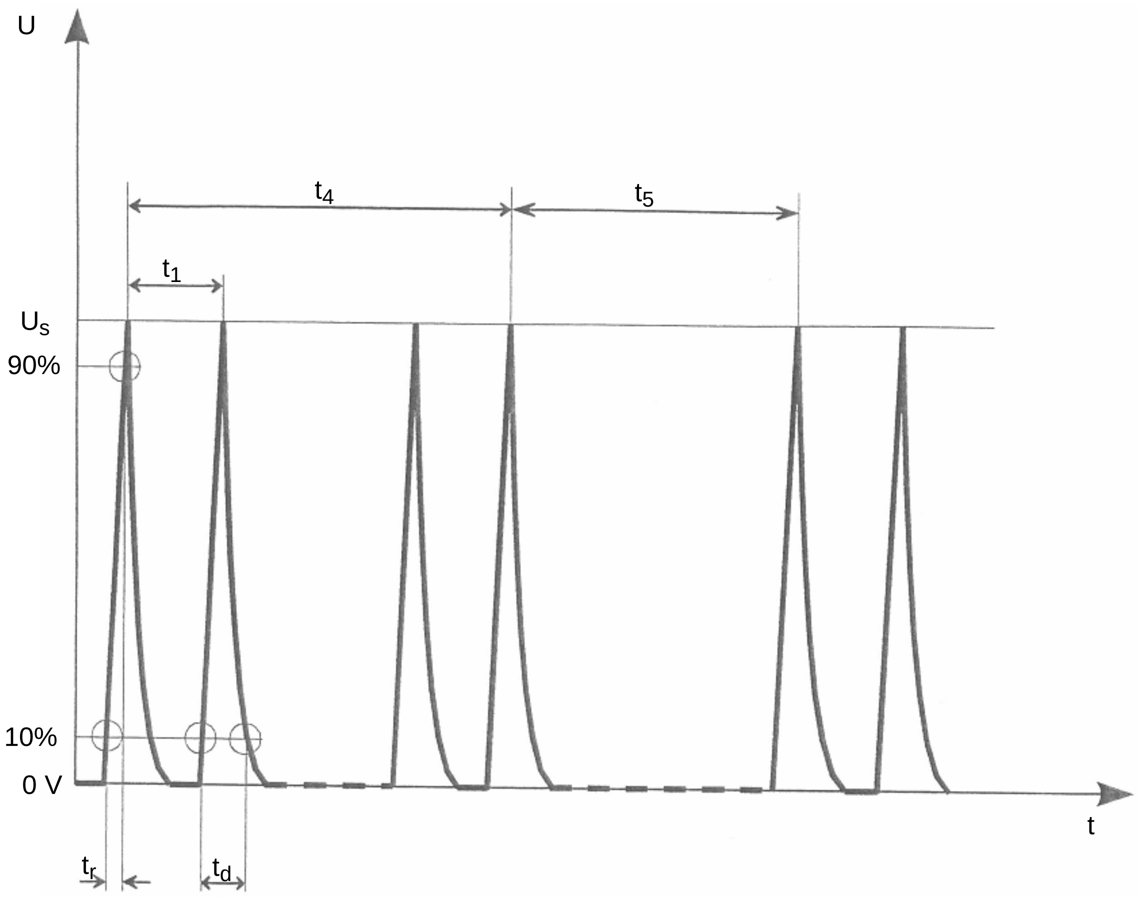


TABLE 8
Positive high–speed transients, parameters to be applied by CCC

Parameters	12 V	24 V
U_a	13.5 V	27 V
U_s	+ 10 V to + 40 V (*)	+ 14 V to + 80 V (*)
t_d	0.1 μs	0.1 μs
t_r	5 ns	5 ns
t_1	100 μs	100 μs
t_4	10 ms	10 ms
t_5	90 ms	90 ms
R_i	50Ω	50Ω

(*) Apply up to +300 V to leads running adjacent to engine controlled ignition coil leads.

9 ACCEPTABILITY LIMITS

The related functional class reached (A – B – C – D – E) by the examined product when applying the discharge must be complying or better than what is required, by the present standard or Specifications/Product Specification, for all test levels.
In case of device malfunction, a manual search must be carried out of minimum voltage levels at which the device starts again to correctly operate (susceptibility limits search).

10 RESULT PRESENTATION

The results will have to include the reached test level without having detected anomalies and for every type of pulse, values related to rising times, repetition, length must be signalled, pointing out possible malfunctions and stating whether they are temporary or permanent, together with their functional classes. Take **Table 9** as an example.

TABLE 9
Example of parameters mandatory for presentation of results

Pulse	*Pulse type*	*Polarity*	**Used method**	**Notes**	**Operating device conditions**	**Test level [V]**	**Test length [min]**	**Required class**	**Result**
Fast	3a	Negative	CCC					A	
	3b	Positive	CCC					A	
	3a	Negative	DCC	C = 100 pF ±10 %**(2)**				A	
	3b	Positive	DCC					A	
Slow	1	Negative	DCC	C = 0.1 μF ±10 %**(2)**				A	
	2	Positive	DCC					A	
	1	Negative	ICC	Specify grounds layout **(1)**				A	
	2	Positive	ICC					A	
Low voltage	≥ 15 KV **(3)**	Positive	Coil primary	To be applied only to signal leads running adjacent to controlled ignition system leads				A	
High voltage	≥ 15 KV **(3)**	Positive	Coil secondary					A	

(1) *In the test through ICC, the status configuration of ground lines must be inserted in the test report.*

(2) *In the test through DCC, the used capacity value must be inserted in the test report.*

(3) *When testing by connection to coil primary or secondary, the trigger voltage used shall be specified and shall not be less than 15 KV.*

STANDARDS QUOTED

IVECO STD.: 16–2108, 18–2252

ISO: 7637 / 3.