EXTENSION OF ELECTROMAGNETIC COMPATIBILITY LABORATORY WITH A VIEW TO PROVIDING THE CONDITIONS FOR TESTING THE AUTOMOTIVE ELECTRIC AND ELECTRONIC SUB-ASSEMBLIES IN ACCORDANCE WITH THE PROVISIONS OF EUROPEAN DIRECTIVE 2004/104/EC

STAGE 02

Drawing up and achievement of the functional model
for ESA testing circuits

During the second stage of the project, which was developed within the period 01.12.2006 - 31.08.2007, the following activities were foreseen to be completed:
1. Drawing up the design for the functional model
2. Achieving the functional model
3. Analyzing the new testing and measuring methods
4. Experimenting in laboratory the new functional testing methods
5. Corrective actions for improving the technical performances of the testing circuits

In accordance with the tasks provided in contract, the activity developed as follows:
1. During the first period, the "Functional model design" was achieved. The list of the tests provided by Directive 2004/104/EC for ESA, also the reference standards indicated in the directive for each tests separately were analyzed one more time.
Thus, designs of the test set-ups for all ESA tests provided in Directive 2004/104/EC, on the basis of which the tests indicated below should be developed and accredited within the project, were carried out:

- **Measurement of radiated emissions produced by ESA**
- **Measurement of ESA immunity to electromagnetic radiations**
- **Measurement of voltage transient emissions produced by ESA**
- **Measurement of immunity to transient conducted disturbances transmitted on ESA supply lines**

The detailed lists of the measuring and auxiliary equipment necessary for developing and performing the tests were drawn up, too.
The equipment already existent in the laboratory, its operating condition, calibration validity, and also the compliance between the technical performances and the specific requirements of the tests following to be performed within the project were carefully analyzed.
At the analysis end, the list of equipment following to be proposed with a view to purchasing within the project was drawn up.

2. Within the second activity performed during this project stage, specifications for any equipment following to be purchased were drawn up, and technical parameters of the apparatus and equipment from as many as possible equipment manufacturers in the field were analyzed. For some equipment existing only partially in laboratory, the idea was to complete it by purchasing new equipment from the same company, for assuring a good coordination of that test by means of unique software, already known.
The technical and financial documentation was prepared, with a view to organizing the auctions and activities for purchasing the equipment.
For some equipment, the auctions had to be resumed according to legal regulations, because the assignment conditions were not fulfilled at the first auction.
Then ,the purchasing contracts were drawn up and the necessary equipment was purchased
3. Within the third activity, "analysis of new testing and measurement methods", the acceptance and

commissioning of the equipment was performed.

The arrangements of the test set-ups were carried out for each test separately; photos presenting both the arranged test set-ups and the equipment purchased within the project will be presented in this paper.

4. Within the stage of „laboratory experiments on the new functional testing methods", demonstrative measurements and tests were carried out for verifying that the achieved set-ups are in accordance not only with the standards, but also with the actual testing conditions.
   Photos and records related to the values of the measured emissions were done; for the calibrations of the immunity testing circuits, records of impulse shapes or field levels got during calibrations are also presented.
5. Within the stage „corrective actions for improving the technical performances of the testing circuits", a detailed analysis of the results got for each test separately was carried out. At the same time, the differences between the express provisions of the Directive (especially regarding the number of tests and their severity degree) and the provisions of the standards indicated in the directive (stipulating a higher number of tests) were analyzed.
   As far as the equipment existing in the laboratory allows it, for the future it is foreseen to broaden the testing field of the laboratory, by adding these tests; although not directly provided in the Directive, they are provided in the reference standards and in the own standards of large automotive manufacturers (e.g. Ford, Renault, a.s.o.).
   The results of the preliminary tests carried out within this stage were very carefully analyzed, so that in the next stages all the necessary corrections and improvements could be done, aiming at accrediting a number of tests as high as possible within the action of extending the accreditation.

DRAWING UP THE FUNCTIONAL MODEL DESIGN

1. Measurement of radiated emissions produced by ESA is going to be performed within the project, in accordance with the provisions of sub-clause 6.5 (for broadband emissions) and 6.6 (for narrowband emissions) from Directive 2004/104/EC.

By analyzing the sub-clauses 6.5 and 6.6, it results that the measurement methods which could be used are those presented in Annexes VII and VIII, namely:

a. According to sub-clause 3.1 of Annexes VII and VIII, radiated emission measurement will be done in a semi-anechoic chamber, complying with the test set-ups provided in CISPR 25, second edition (ALSE method – see Figures 10,11,12)
b. According to sub-clause 3.2 of Annexes VII and VIII, radiated emission measurement could be done in an OATS which should comply with the provisions from CISPR 16-1, second edition, and Figure 1 from Annex VII of Directive 2004/104/EC

Within this project, we propose ourselves to achieve firstly the test in accordance with sub-clause 3.1, i.e. inside a semi-anechoic room, because this exists in ICMET Craiova and fulfills the minimal requirements presented in CISPR 25.

For being able to implement the radiated emission measurement, we must provide:

- Designing and achievement of the testing set-up(s)
- The necessary measuring equipment

During this stage of „functional model design", the design of the test set-up will be achieved, in order to arrange the existent semi-anechoic room in accordance with the requirements from CISPR 25 (Figures 10, 11, 12). It means that a test set-up according to Figure 12 from CISPR 25 will be arranged.

The proposed measurement set-up is presented in Figure1.

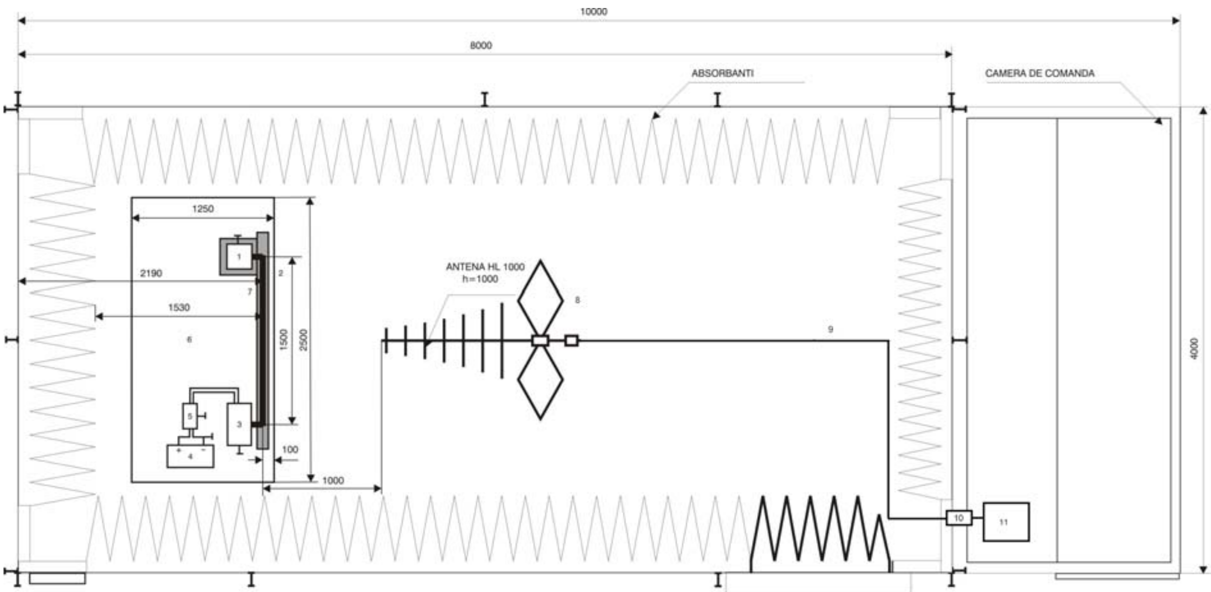

Fig. 1 - Measurement set-up for radiated emissions

Within this project stage, after purchasing the equipment and materials set in the functional model design, the arrangement of the test set-ups was carried out.

For instance, with a view to achieving in good conditions the measurement of radiated emissions produced by ESA, the test set-up was arranged inside the anechoic room existent in the laboratory; it could be seen in the photo from Figure 9:

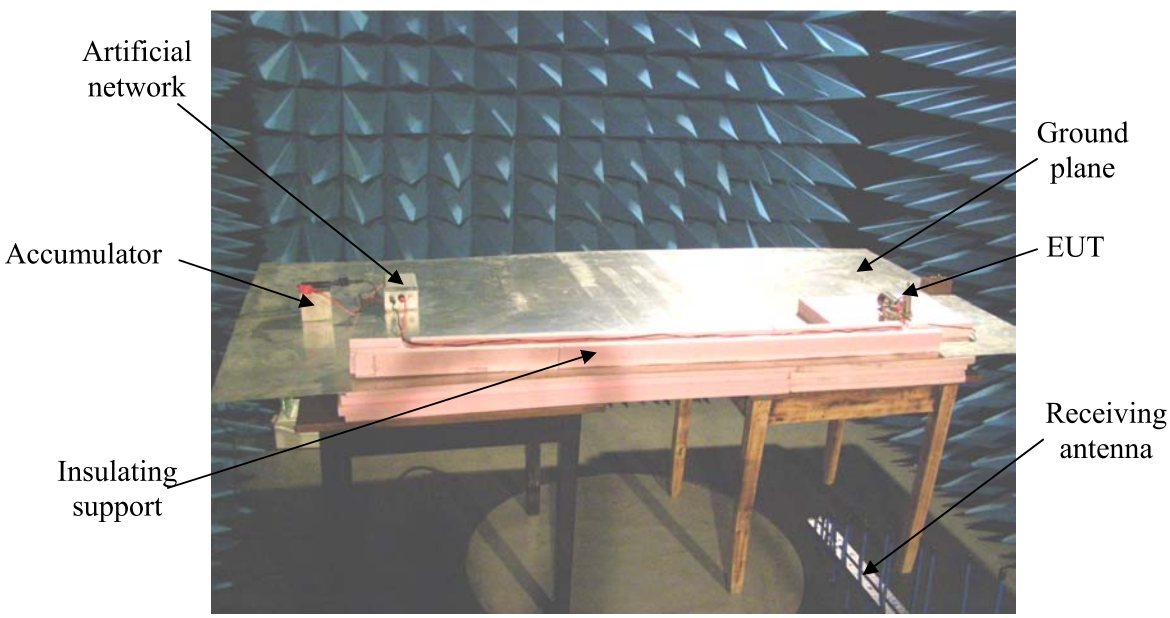

Fig. 9 Photo of the radiated emission measurement set-up

It should be mentioned that the dimensions and distances are in accordance with that ones provided in the functional model design, in Directive and CISPR 25.

The ground plane was achieved from galvanized steel sheet, with 1.5 mm thickness and dimensions 2500 x 1250 mm; it was placed on two wooden tables at 900 mm height from the floor.

The measuring equipment was placed in the control room.

In the example shown above, a motor for windscreen wiper was chosen as EUT, and under these circumstances no load simulator was necessary (position 3 from Figure 1)

2 Measurement of ESA immunity to electromagnetic radiations should be achieved in accordance with the provisions of sub-clause 6.7 from Directive 2004/104/EC.

The electromagnetic field immunity test for ESA will be performed by one of the methods presented in Annex IX of this directive, or by a combination of these methods.

For electromagnetic field immunity test, the Directive imposes the frequency range of 20 MHz – 2000 MHz, allowing choosing any combination of the provided testing methods, namely:

a. Test in a semi-anechoic room, according to the provisions of ISO DIS 11452-2:2003
b. Test in a TEM cell, according to the provisions of ISO11452-3:2001 Edition 3
c. Current transformer test (BCI), according to the provisions of ISO DIS 11452-4:2003
d. 150 mm Stripline test, according to the provisions of ISO 11452-5:2002 Edition 2
e. 800 mm Stripline test, according to sub-clause 4.5, Annex IX, Directive 2004/104/EC.

The tested signal modulation should be:

- AM, with 1kHz and 80% modulation factor within the range 20-800MHz
- PM, with duration 577μs and period 4600 μs within the range 800-2000MHz

if it is not otherwise agreed between the ESA manufacturer and Technical Department.

The test levels for each method separately are presented in sub-clause 6.7.2.1 of this Directive.

The frequency step and the standing time on each frequency separately are provided in chapters 4.5 and 4.6 of ISO 11452-1, and they should be documented in the Test Report.

Test in semi-anechoic room

This method allows testing the electric and electronic automotive systems by exposing an ESA to the electromagnetic radiation generated by an antenna. For performing this test, the semi-anechoic room existent within EMC laboratory – ICMET Craiova will be used.

The frequency range coverable by the electromagnetic immunity test inside the semi-anechoic room is from 80 MHz up to at least 2000 MHz, in accordance with the value from Table 1 from ISO 11452-1.

Within the stage „Functional model design”, the test set-up for electromagnetic field immunity test was designed in accordance with the provisions of the chapter 7.6 from ISO 11452-2: 2004, also with the dimensions and features of the semi-anechoic room existent within EMC laboratory – ICMET .

The drawing for the set-up designed in this way is shown in Figure 2, for the frequency range 80 - 1000 MHz and in Figure 3 for frequencies above 1000 MHz.

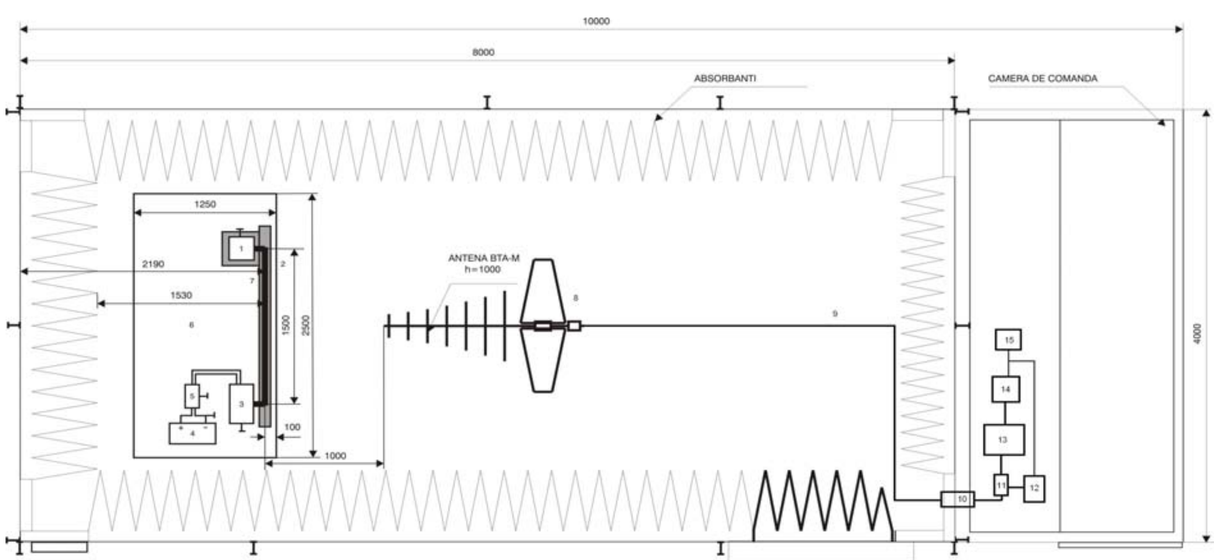

Fig. 2 Set-up for electromagnetic radiation immunity test
in the frequency range from 80 to 1000 MHz

Stripline test

This testing method consists in overlapping the connecting cables and/or ESA to certain strength of electromagnetic field.

The frequency range for this test will be 20 MHz - 400 MHz.

The testing methodology is presented in ISO 11452-5:2002; for performing the test, a stripline structure in accordance with the provisions of the above mentioned standard will be purchased within the project.

Because stripline is an open structure, it could disturb the environment during operation. That is why the stripline structure should be located in a semi-anechoic or shielded room.

The test set-up which should be achieved within the project is shown in Figure 4 and provides mounting the stripline in the semi-anechoic room existent in ICMET..

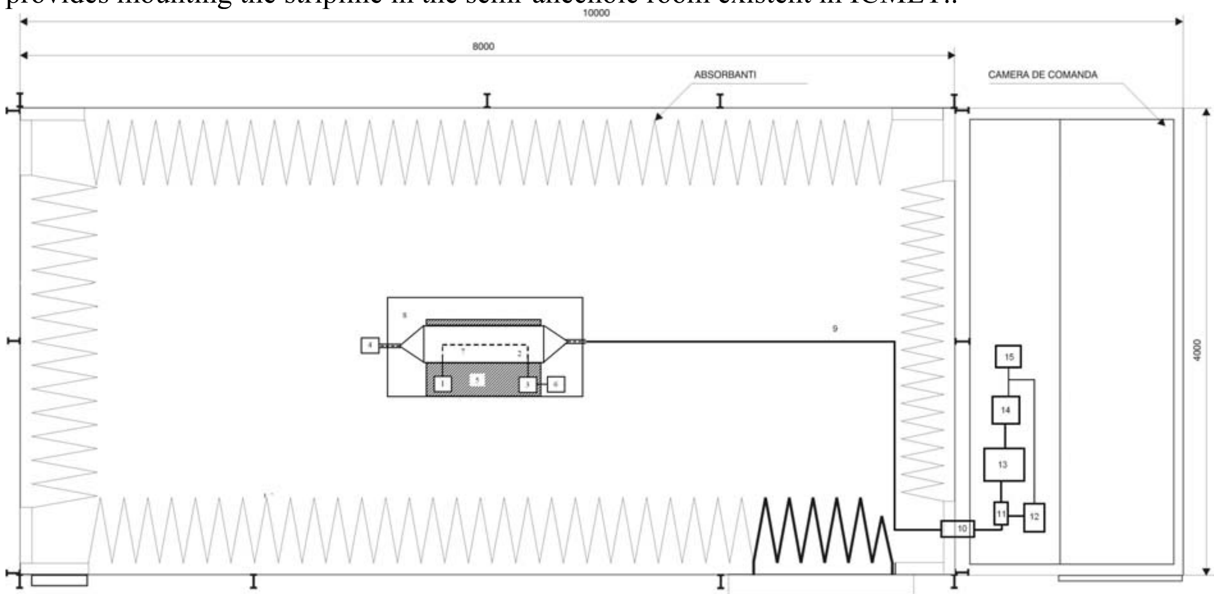

Fig. 4 Set-up for electromagnetic radiation test radiation test – stripline method

800 mm stripline test

The 800 mm stripline test method is provided in the chapter 4.5 from annex IX of the Directive 2004/104/EC. The 800 mm stripline structure exists in EMC laboratory of ICMET Craiova, and consists in two metallic parallel planes, 800 mm far away one from another. The equipment to be tested is centrally located between the two planes and subjected to certain strength of electromagnetic field.

The frequency range for this test is 20 -1000 MHz.

The method is suitable for testing the complete electronic systems, including sensors and actuators, as well as controllers. It is convenient for testing apparatus whose maximum dimensions are less than 1/3 of 800 mm.

The stripline should be introduced into a shielded room (for avoiding the external emissions) and placed at 2 m distance to the wall and to any other metallic wall, for preventing the electromagnetic reflections. The RF absorbing material can be used for reducing the reflections. The stripline should be placed on a non-conducting support, at least 0.4 mm above the floor.

Within this project stage, after purchasing the equipment and materials set in the functional model design, the arrangement of the set-ups has began

For instance, in order to perform under good conditions the test of ESA immunity to electromagnetic radiations, all the test set-ups were arranged in the semi-anechoic room existent in laboratory, in accordance with the item 1.2 from “Functional model design”.

a) For immunity test in antenna field, the set-ups were carried out according to Figures 2 and 3;

they could be seen in the next photos:

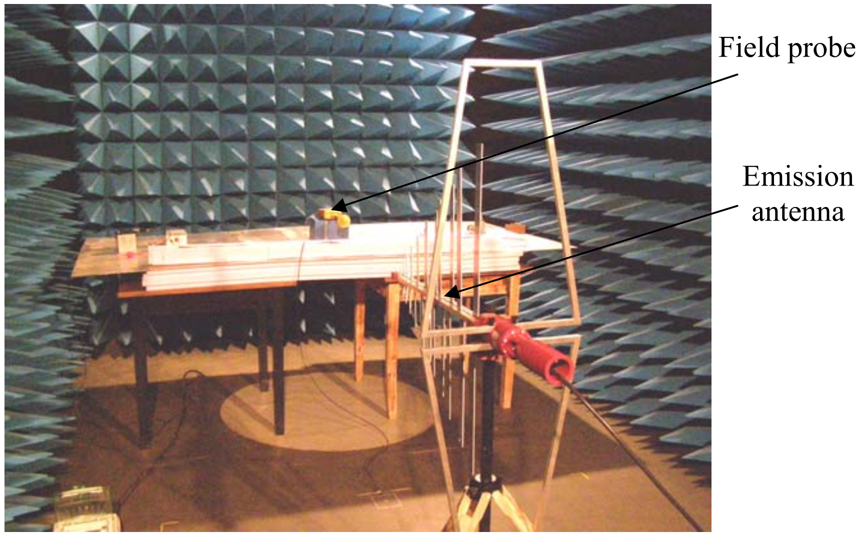

Fig. 10 - Photo of the set-up for electromagnetic radiation immunity test, for the frequency range from 80 up to 1000 MHz

It should be mentioned that the dimensions and distances are in accordance with those ones provided in the functional model design, in Directive and CISPR 25.

For immunity test in 800 mm stripline structure, the test set-up was achieved according to Figure 4 from "Functional model design"; a photo of this set-up is shown in Figure 12:

The stripline structure was located in the semi-anechoic room, on 400 mm insulating support.

The electric field probe used for calibrating the stripline was of EMR20-type.

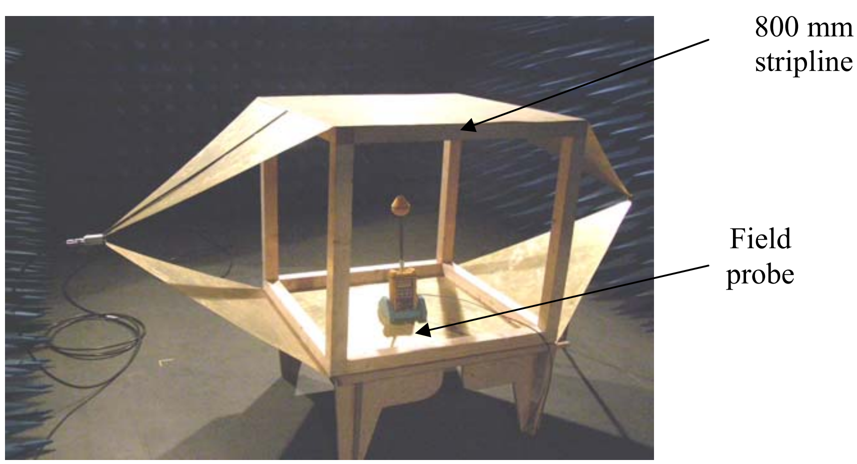

Fig. 12 Photo of the set-up for electromagnetic radiation immunity test, in 800 mm stripline

<u>3 Measurement of voltage transient emissions produced by ESA</u> will be performed within the project in accordance with the provisions of the sub-clause 6.9 of the Directive 2004/104/EC

The voltage transient emissions produced by ESA will be measured in accordance with the method proposed at item 3 from Annex X of Directive, and the testing levels are given in Table 2 of this Directive.

The sub-clause 4.3 of ISO 7637-2: 2004 presents a testing procedure for ESA evaluation regarding the conducted disturbance emissions. A digital oscilloscope will be used for measuring the conducted emissions caused by transients on the supply lines.

The transient voltages from the disturbance source which is the device under test are measured using the artificial network for stabilizing the impedance which is the load of the device under test. The disturbance source is connected by the artificial network to the shunt resistance (see sub-clause 5.2 from ISO 7637-2), to the switch S (see 5.3 from ISO 7637-2), and to the supply source (see 5.4) from ISO 7637-2, like in Fig. 1a) or b) from ISO 7637-2.

In the next Figures, the test set-ups for measuring the transient voltage emissions are presented. .

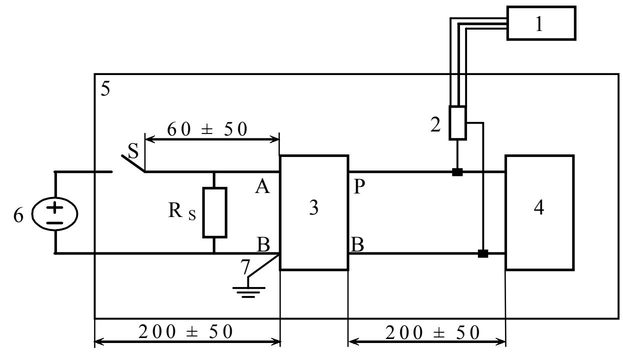

Fig. 6 Test set-up for transient voltage emissions - slow impulses

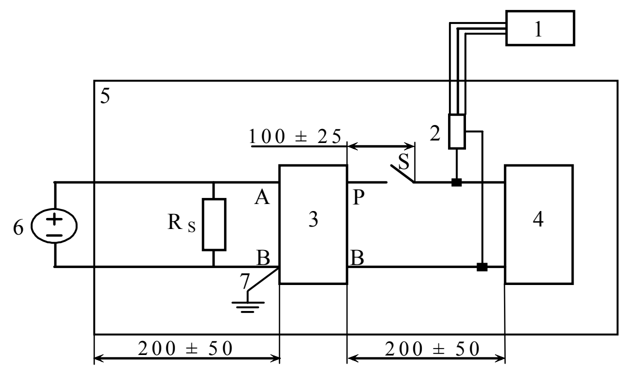

Fig. 7 Test set-up for transient voltage emissions - fast impulses

The connections between the artificial network, the switch and the device under test should be at a distance of (50±0.1) mm above the metallic ground plane.

The transient forms should be assessed in accordance with Annex C from ISO 7637-2. All the pertinent information and test results should be recorded. If the requirements from the test plan include the results of transient assessment complying with the performance objectives, they will be specified in the test plan.

Within this project stage, after purchasing the equipment and materials set within the functional model design, the arrangement of the test set-ups was carried out.

For instance, in order to perform in good conditions the measurement of transient voltage emissions, the test set-ups were arranged; this could be seen in the photos from Figures 13 and 14. These arrangements are in accordance with the dimensions imposed in the "functional model design"

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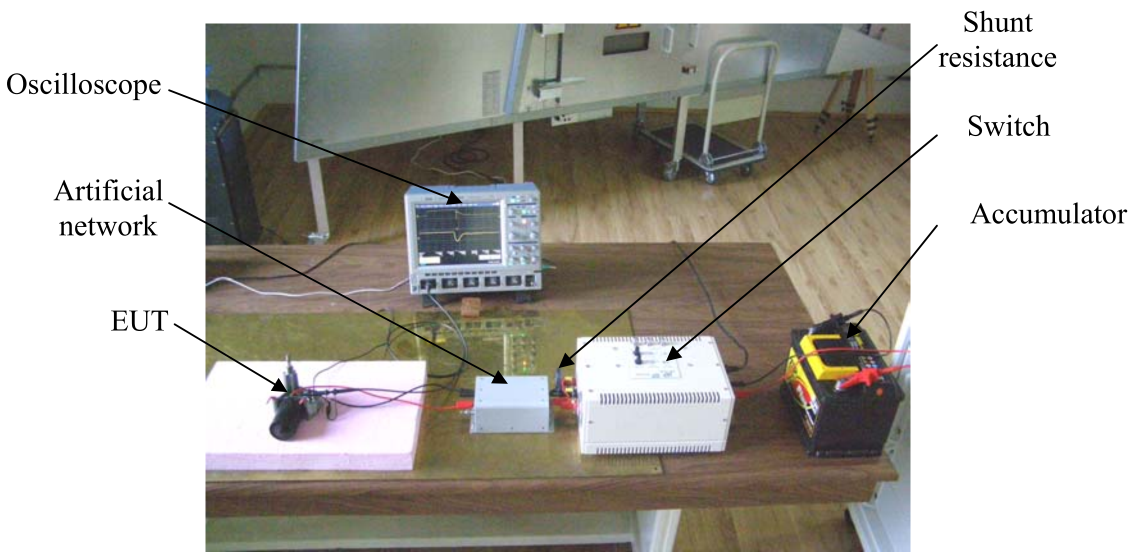

Fig 13 Test set-up for transient voltage emissions – slow impulses

It should be mentioned that the dimensions and distances are in accordance with those ones provided in the functional model design, Directive and CISPR 25.

The ground plane was achieved from brass sheet, with dimensions of 2000 x 600 mm; it was placed on a wooden table at 850 mm above the floor.

In the presented example, a windscreen wiper motor was used as EUT.

4 Measurement of immunity to transient conducted disturbances transmitted on ESA supply lines will be performed in accordance with the provisions of the sub-clause 6.8 of the Directive 2004/104/EC

This specifies that the representative ESA immunty should be tested by the methods presented in ISO 7637-2:DIS 2002, chapter 4.4.

The testing diagram for ESA immunity to transients is presented in Figure 2, ISO 7637-2.

For the test impulses type 3a and 3b, the connections between the terminals of the test impulse generator and DUT should be put in parallel straight lines at (50±0.1) mm above the reference plane and they have a length of (0.5±0.1) m.

From this point of view, this test set-up should be designed so that it corresponds to Figure 2 from the reference standard; the result is presented in Figure 8:

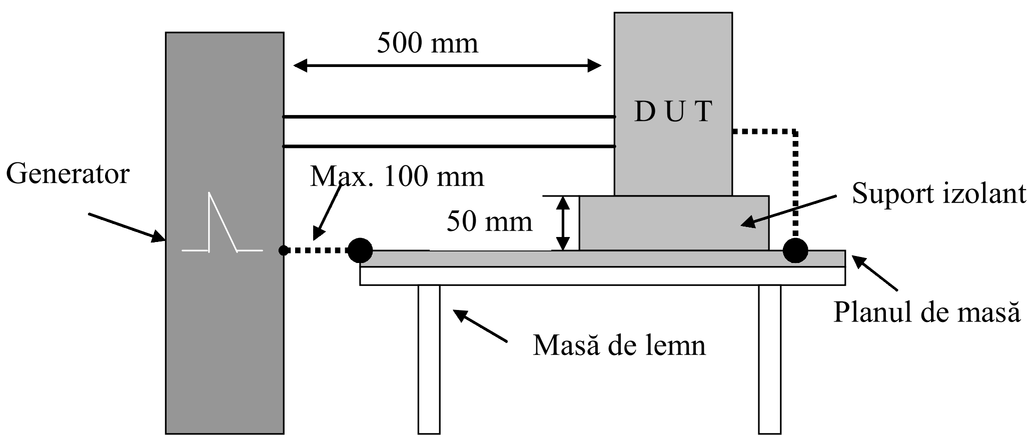

Fig. 8 Test set-up for immunity to transient conducted disturbances, transmitted on supply lines

Legenda figurii (nu am putut intra in desen)
Generator
Insulating support
Wooden table
Ground plane

The impulse generator to be tested (see 5.6 of ISO 7637-2) is set for providing the specific impulse polarity, amplitude and duration with DUT and optional resistance R_V disconnected(see Figure 2a, ISO 7637-2). The adequate values are selected from Annex A of ISO 7637-2. Then, DUT is connected to the la generator (see Figure 2b, ISO 7637-2), if the oscilloscope is disconnected. Depending on the actual conditions, DUT operation should be assessed during and/or after applying the testing impulses.

For generating correctly the required testing impulses, it might be necessary to connect and disconnect the supply source. The connection may be performed by the test impulse generator, if the supply source is integrated in it.

One way for simulating the waveform generated by an alternator in the moment when the load decreases suddenly (see Figure 12, ISO 7637-2) is to connect a diode (diode bridge) at the output terminals of the test impulse generator [see Figures 2a) and b from ISO 7637-2].

Within this project stage, after purchasing the equipment and materials set in the functional model design, the arrangement of the test set-up for immunity to conducted transient disturbances was carried out.

For instance, in order to perform in good conditions the immunity test to conducted transient disturbances, the test set-up was arranged. It could be seen in the photo from Figure 15; this arrangement is in accordance with the dimensions imposed in the project, namely:

- The ground table is made of brass and has the dimensions of 2 x 0.6 m
- The table height is 85 cm
- The grounding is made of copper sheet with 0.3 mm thickness and 95 mm length.

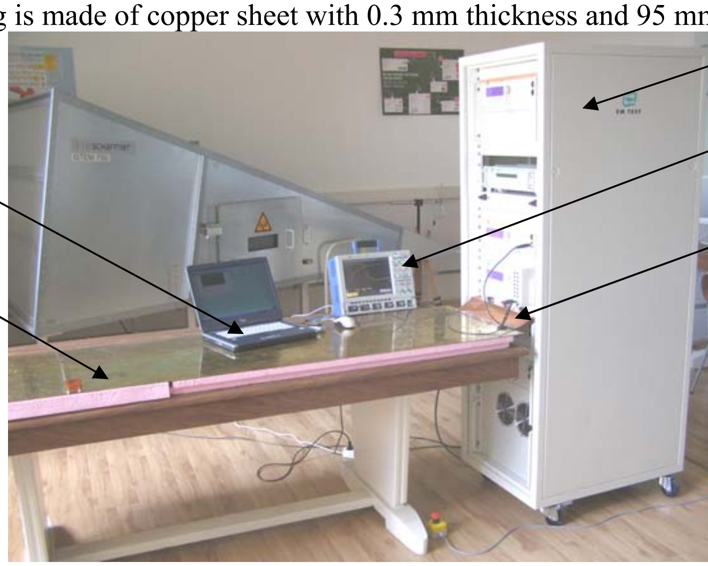

Fig. 15 Test set-up for immunity to conducted transient disturbances

The generator and monitoring system are integrated into a rack and connected by an interface type GPIB IEEE 488.2 to a Laptop.

Thus, the whole testing process for immunity to conducted disturbances is handled by means of the software purchased together with the equipment.