EMC Problems in Devices Control Signalling and Telecommunication

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Summary
In this paper presents the problem of electromagnetic compatibility tests and systems with electrical and electronic equipment installed in the railway environment. The paper presents the test methods immunity to the type of exposure SURGE, BURST, ESD, voltage dips, short interruptions and voltage variations AC and DC, resistance to magnetic field pulse. Describes the test methods related to the issue conducted and radiated disturbances. Presented research positions and measuring apparatus used in such studies. Electromagnetic compatibility issues presented in the railway environment proves to multithreading electromagnetic compatibility.

Keywords: electromagnetic compatibility, railway traffic control devices, telecommunication systems

1. Introduction

The electronic devices, which are implemented for the rail area, need to perform research for compatibility of standard **requirements** such as electromagnetic compatibility. The research concern electrical and electronic devices installed in a rail area. The railway traffic control devices and telecommunication systems are installed in that area. Due to the specificity of rail area which depends on spatial location of devices, the devices are expose to natural electromagnetic force and others systems which are located there.

The European and Polish law determines performing every electromagnetic compatibility research. The general character of research includes defining the levels of disturbance generated, by this devices and resistance to sinusoidal and impulsive **electromagnetic disturbance**.

Comparing terms of research and parameters of exposure for devices installed in rail area to general purpose devices, reveals that devices are adapted properly to electromagnetic environment **requirements, where they will work.**

The research of conducted and radiated disturbance emission are performed due to the unwanted emission research generated by rail devices. The measurements of all in and out power interfaces are performed in the case of the conducted disturbance emission. Moreover the research of radiated disturbance concern only stationary and mobile objects and they are performed for enclosure port.

The devices resistance research are performed in terms of BURST, SURGE, ESD exposure, a loss of voltage, voltage dip and voltage change, resistance to radiofrequency electromagnetic field, resistance to radiofrequency conducted disturbances, resistance to electrical power frequency magnetic filed and resistance to impulsive magnetic filed. According to the directive states 2004/108/WE [1] and harmonized standard PN-EN 50121-4 [2] all above-mentioned research are required.

2. Methodology of EMC Measurements

2.1. The Research of Disturbances Conducted Emission Immunity Test

All unwanted high frequency band signals between 0,15 to 30 MHz, which occur in low voltage power grid and in signal of the used measure path electronic are treated as radio-electrical conducted disturbance.

The railway traffic control devices and other devices in accordance with the installation site can be tested in one of the two test-bench. First test-bench is allocated to little dimension devices. That device is tested after putting it on test-bench. The devices usually situated on the floor or on the ground are tested in the second test-bench. During measurements, that devices are situated on the 10 cm wooden insulating stand. The test-bench consist of measurements the used measure path, which fulfill PN-EN 55016-1-1 [3] standards:

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- disturbance measuring receiver EMI,
- measuring cable,
- line impedance stabilization network (LISN),
- high voltage probe.

On the first test-bench testing devices are situated on the measuring table. The table is made of wood and it has 80 cm high. The ground reference plane (GRP) is plate made of al of dimensions of not less than 2 m × 2 m and extended at least 0,5 m across testing devices lines. The ground plane is bonded to laboratory protective earthing.

On the second test-bench testing device is situated on the floor and it is put on a metal plate of dimensions of 63 × 73 cm. That metal plate is the ground reference plane and it is insulated from testing device, by wooden insulated stand. The wooden insolated stand should be 10 cm thick of dimensions of 50 × 150 cm. The testing devices intended for putting on the floor should be put on insulating stand, which lied on the floor according to operating conditions. Moreover all testing devices should be located at least 0,8 m from other metal surface.

The GRP should be connected with the earthing terminal of line impedance possibly, by the shortest wire. If equipment under test (EUT) is equipped with special earthing terminal, it should be connected with the ground, by the shortest wire. If earthing terminal wasn't provide, the device should be tested in normal working conditions for example with electric shock protection obtained, by power supply network.

There is also possibility to measure voltage of disturbance conducted on network supply clamps, which powered that device in screened room. Then floor or one of the wall in that screened room should be the earth of reference.

The measurements of emission of conducted disturbances is made by EMI test receiver with integrated system quasi-peak detector. The quasi-peak detector is fittings for measuring instrument. The research of emission conducted disturbance are made the 150 kHz to 30 MHz frequency band. First figure shows measuring station for laboratory research of emission conducted disturbance on network supply clamps which powered testing device.

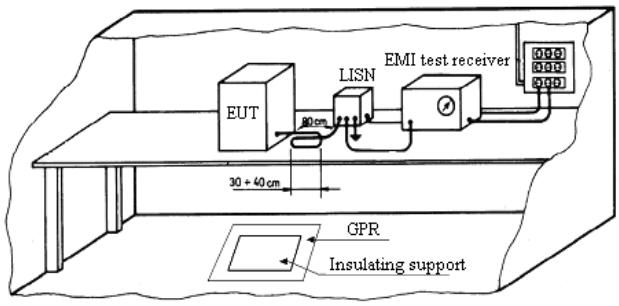

Fig. 1. General test-bench for laboratory research [Own figure]

During measurements of electromagnetic conducted disturbances the testing device should work at nominal load conditions, and it should be connected with type V 50Ω / 50 μH network, which provides required impedance in high frequency on network clamps in measurements spot and which insolated testing device from external disturbances conducted, by network wire. That research can be performed, by high voltage probe made up of blocking capacitor and appropriately selected resistor, which generates at least 1500 Ω resultant resistance between wire and ground.

The testing devices should be connected with line impedance stabilization network by 1 m wire. The measurement of the voltage disturbance on network supply clamps is preformed directly on testing device, by the EMI test receiver and its measurement wire. The measured values of the level of conducted disturbances for each power supply device should be registered in EMI test receiver and saved in its external memory.

One of the basic ways of limiting unwanted emission generated by device is choice of construction solution, which reduces the level of that emission to minimum value, by limiting it. The other way is using external suppress measures such as LC items or filters. Appropriate choice of suppress items should be preceded, by the correct assessment of the parameters generated, by the source of disturbances.

2.2. The Research of the Emission Radiated Disturbances Immunity Test

The limitation of emission radiated disturbances chiefly consists in using shield items and avoiding couplings between circuits, where this energy can escape (fig. 2). Appropriate design of screen is the major condition of its function, which consists in electrical tightness of the screen and the right selection of airhole with its right dimensioning, which is adjusted to electromagnetic wavelength suppressed by the screen.

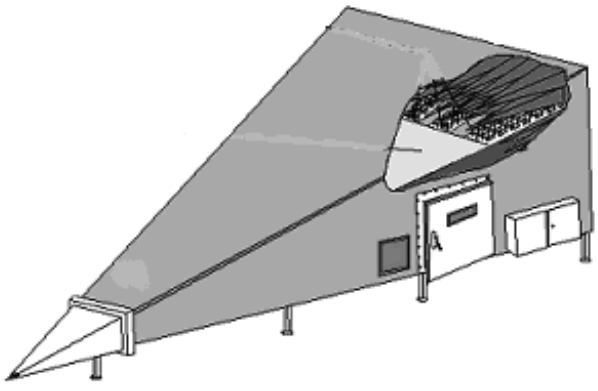

Fig. 2. The GTEM chamber [Own figure]

2.3. The Research of Surge Immunity Test

The PN-EN 61000-4-5 [4] standard describes in details**,** how the test-bench for the research of surge immunity test shall be equipped. It should have:

- voltage and current surge immunity test generator,
- coupling-decoupling network,
- auxiliary equipment (ground reference plane, laboratory power supply DC, insulating pads, insulating uprights, measuring cable and measuring tables),
- computer with software for generator control and for draw up testing protocol.

The generator provides voltage or current surge parameters, which are described in [4] standard and set out in figure 3.

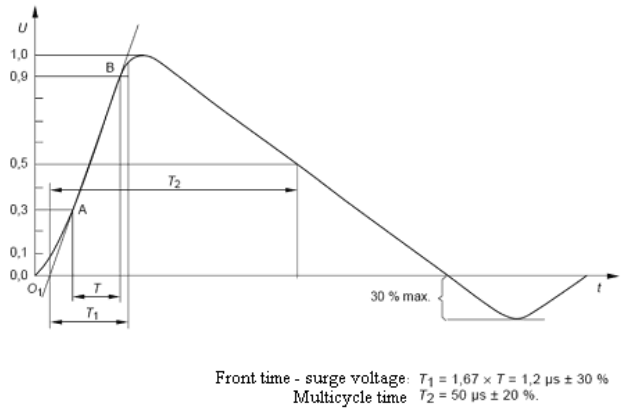

Fig. 3. The parameters and shape of the surge impulse [Own figure]

The generator produces voltage impulse in case of the high-impedance load open circuit. In case of the low-impedance load close circuit, the generator provides current impulse. The surge impulses are available at the end of external pistol working with generator or at the coupling-decoupling network output. The network provides appropriate coupling parameters with testing object. When exposure limits are made, the testing device should work constantly and it should perform testing program. The testing device should be observed and researcher should paired attention to accepted criterion for the assessment, which are named B.

The electrical and electronic circuit are protected from high energy disturbances, by preventing from signal energy penetrated the devices input circuit.

The systems and devices are protected from negative electromagnetic SURGE impulse impact, by eliminating all possible inductive couplings, the result of which unwanted energy can penetrate device circuits.

The basic items used to suppress SURGE impulse are lightning protectors, varistors and avalanche diodes. This items are used in feeder circuit, but in signal circuit there are used lightning protectors and ferrite bead.

2.4. The Research of Electrical Fast Transient Immunity Test

Depending on real installed spot the testing devices are exposed to exposure level on one or two test-bench. The first test-bench is intended for devices, which are used on the table (figure 4). On the second test-bench testing devices intended for ground or floor installation. That devices are situated on the stand. Every test-bench is supported by other devices and equipment:

- immunity test generator of disturbance impulse,
- coupling clamp,
- auxiliary equipment (GRP, laboratory power supply DC, testing cable, protective cable and measuring cable, insulating pads, insulating uprights),
- computer with software intended for generator control and for draw up testing protocol.

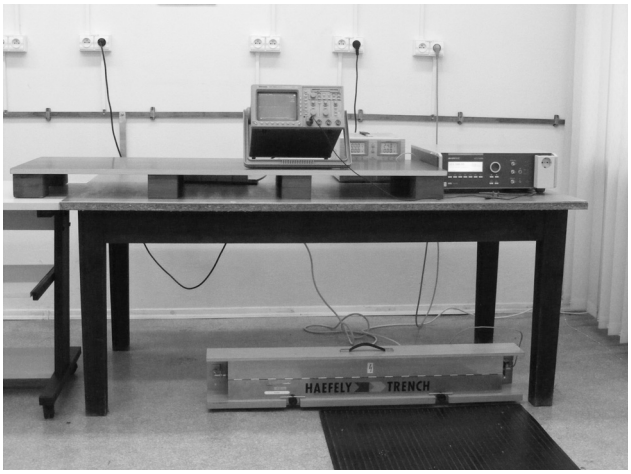

Fig. 4. General test-bench for laboratory research [Institute's own figure]

During the resistance research generator and coupling clamp are used. The coupling clamp is used during testing control and signal line. The devices used during research must fulfill requirements contained in PN–EN 61000-4-4 [5] standard.

The research of resistance to impulse nanosecond disturbance required for railway traffic control devices or for telecommunication systems consist in exposure level that devices to impulse sequences and in observation devices reactions to that exposure during the research. The shape and nature of impulse are shown in the figures 5 and 6. The devices reaction should be compatible with accepted parameters for testing object of research during that exposure. The **B** assessment criteria are used for railway traffic control devices and for telecommunication systems.

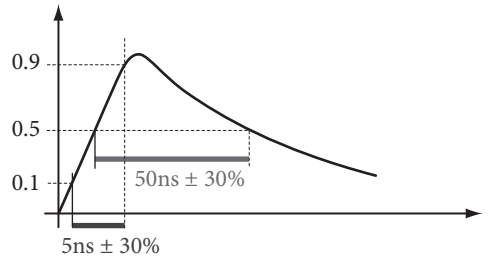

Fig. 5. The graph BURST 5/50 ns impulses [Own figure]

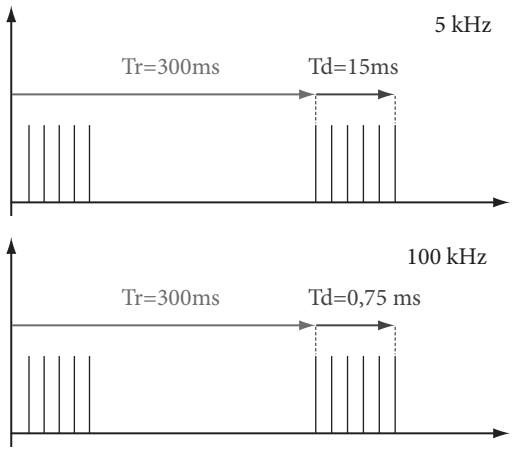

Fig. 6. BURST of disturbance impulse parameters for f = 5 kHz and 100 kHz [Own figure]

The standard [5] strictly defines the impulse sequences, which are the object of exposure. Power supply circuit and erthing testing device (direct generator coupling with device) and signal and control wires (coupling with coupling clamp) can be exposure. The amplitude and frequency of impulses generated, by unbiased generator are the parameter, which is the measure of device resistance to series of fast and electric transient state.

The basic method of limitation impact of high frequency BURST signals is necessity of installing avalanche diode in the input power supply circuit and limitation the possibility of came out capacity and inductive coupling between power supply circuit and signal circuit. Moreover the shielding very sensitive circuit is used in exceptional cases.

2.5. The Research of Supply Voltage Dips, Short Supply Interruptions and Changes in Supply Voltage Immunity Test

The research of resistance to voltage dips, short supply interruptions and changes in supply voltage are preformed for direct and alternating voltage. The PN-EN 61000-4-29 [6] and PN-EN 61000-4-11 [7] describes the research methods and criterions for the exposure.

The research of devices powered, by constant voltage are preformed on test-bench in accordance with measuring system showed in the figure 7. The test-bench is supplied with adequate measurement instruments:

- immunity test generation,
- digital oscilloscope,
- computer with software intended for generator control,
- digital multimeter,
- two digital laboratory power supplay.

The research should be preformed, by using the shortest power wires. If in technical specifications of testing device there isn't length of power wires, it shall use the shortest wires, which are enough for correct action testing device.

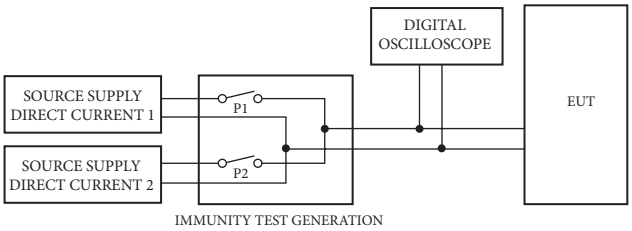

Fig. 7. The block diagram of measurement system [Own figure]

The point of research is to expose testing device in accordance with Client's guidelines connected with supply voltage dips, short interruptions during tests, and to observe device's reaction to exposure and after broke that exposure. Device's reaction should be identical to device's reaction working without exposure. The preliminary testing research should be preformed for comparison both reactions. The device's resistance measures to supply voltage dips, short supply interruptions parameters are:

- duration of voltage dips, short supply interruptions t_R,
- test level in supply voltage U_T,
- voltage dips and short supply interruption number n,
- repetition time.

The figure number 8 presents the test-bench where devices powered, by alternating voltage are tested. This test-bench should be equipped with:

- immunity test generation,
- digital oscilloscope,
- computer with software intended for generator control,
- automatic motowariac (autotransformer / autotransformers),
- digital multimeter.

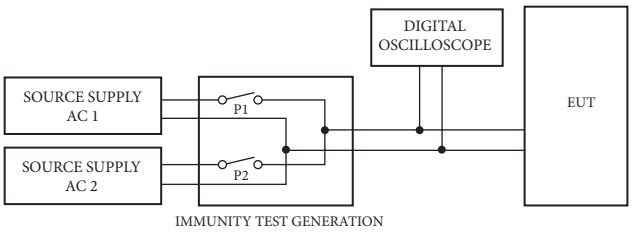

Fig. 8. The block diagram of measurement system [Own figure]

The point of research is to expose testing device in accordance with Client's guidelines connected with voltage dips, short supply interruptions and changes in supply voltage during tests and to observe reactions testing device to exposure during work. The device's reaction during exposure should be identical to accepted testing parameters for that device. The preliminary testing research should be preformed for comparison both reactions. The device's resistance measures to voltage dips, short supply interruptions and voltage variation parameters are:

- duration of voltage dips, short supply interruptions and voltage variation $t_{Z,}$
- test level in supply voltage U_T.

The exposure consists in following another individual exposure tests, which parameters U_T and t_Z has been established by Client. The device should work all the time and it should perform testing program during exposure. The testing devices should be tested with each chosen combination of level research and duration of sequence of three short voltage dips / supply interruption with minimum 10 seconds intervals between each test. Every represented mode should be verified.

In the case of voltage dips, the changes in supply voltage should followed with switch-over the voltage phase through zero and voltage delay angle 0°, 90°, 180°, 270°.

In case of changes in voltage, it should be tested at every required changes in supply voltage three times in 10 second intervals.

After ending exposure for each test it should be evaluated correctness actions of the testing device and it should be confronted the basic evaluation criterions.

2.6. The Research of Electrostatic Discharge ESD Immunity Test

The PN-EN 61000-4-2 [8] standard describes the test-bench which is used during the research of resistance to discharge to static electricity. The test-bench should be equipped with:

- static discharge generator with external ESD pistols with discharge return hose,
- discharge resistor 470 kΩ,
- ground reference plane,
- coupling plane horizontal (HCP) and vertical plane horizontal (VCP),
- links forming of discharge path.

The figure number 9 presents the test-bench for devices set on a table.

Fig. 9. The test-bench for testing device set on a table in laboratory [Institute's own figures]

The test-bench includes non-conductive table 0,8 ± 0,08 m height and situated on the GRP. On the table should be placed horizontal coupling plane dimensions 1,6 × 0,8 m. EUT and its wires should be insolated from coupling plane by isolation pads of 0,5 mm thick.

The test-bench includes test generator, testing device (ETU) and ancillary equipment indispensable to perform discharge in testing device (ETU), which is exposed direct and indirect as follows:

- contact discharge to conducting surface EUT and to coupling surface,
- air discharge to isolating coupling EUT.

There are two kinds of research:

- the type testing for the conformity preformed in laboratory,
- the testing in the installation location of the device and preformed in relation to device located in destination conditions.

The point of research of resistance to discharge to static electricity consist in exposing device to specified, single impulses and in observing device's reaction (ETU) to that exposure. The device's reaction should be identical to accepted testing parameters for that device during exposure. The preliminary testing research should be preformed for comparison both reactions.

The series of discharges to static electricity, which are the exposure object, is described strictly in the standard [8] and required level and evaluation criterions

are also described in the standard [2]. The circuit available for staff during normal operation can be exposed.

The resistance measure parameter is pulses amplitude and polarization, which are made by generator and it amounts to contact discharge ± 6 kV and to indirect discharge ± 8 kV.

In the electrical circuits the major method of suppression induced and unwanted signal thereby discharge to static electricity is using avalanche diode with ferrite choke of parameters adapted to suppressed signals.

The second method of limiting ESD discharges impact on devices is providing electrical tightness of the shield items with choice of air holes to frequency range ESD signals.

2.7. The Research of Pulse Magnetic Fields Immunity Test

The research method and the test-bench for research of resistance to pulsed magnetic field is describe in PN-EN 61000-4-9 [9] standard and it includes:

- ground reference plane (GRP),
- immunity test generator,
- the antenna in the guise of induction coil,
- decoupling network.

The research of resistance to pulsed magnetic shield should be preformed on the test-bench, which fulfilled requirements of the standards [9] and it could be preformed on the measuring table and on the floor. In the figure number 10 is exemplary test-bench.

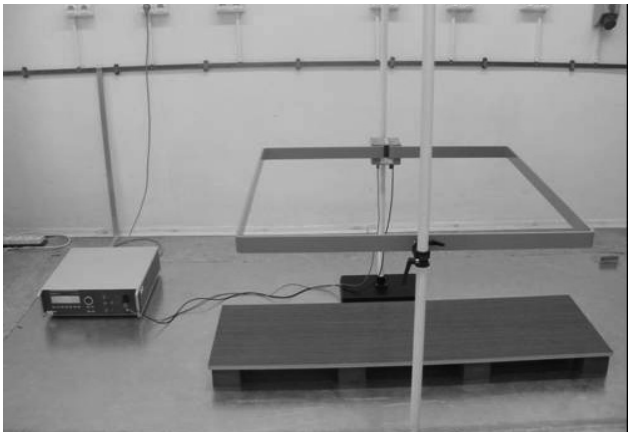

Fig. 10. The test-bench for research of resistance to pulsed magnetic filed [Institute's own pictures]

The point of research of resistance to pulsed magnetic filed consists in exposure device located inside the antenna being the induction coil in three planes. The testing level of exposure should be used in accordance with standard's required [2]. The research are preformed, by using at least five forward bias pulses per polarization and five substrate bias pulses per polarization. Required interval between another pulses should be no less than 10 seconds. The best way to protect from pulsed magnetic filed are screens made of high magnetic permeability materials.

3. Conclusion

The issues of electromagnetic compatibility in electrical and electronic circuit, and therefore in railway traffic control devices and information and communication technologies is multithreaded and it requires comprehensive approach. Appropriate system protection will rely on using optimal constructional solutions in model and at the planning stage. The next step involves using shielding technology in individual circuits. The elements, which suppresses energy of high frequency are the definitive way to protect device and to fulfill EMC requirements.

The methodology and the ways of devices protection in emissive power and resistance should be coordinated with each other, which will make it possible to simple solution to the problem and cost reduction.

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Problematyka EMC w urządzeniach sterowania ruchem kolejowym i telekomunikacyjnych

Streszczenie
W artykule przedstawiono problematykę badań kompatybilności elektromagnetycznej systemów i urządzeń elektrycznych oraz elektronicznych instalowanych w środowisku kolejowym. Opisano metody badawcze w zakresie odporności na narażenia typu SURGE, BURST, ESD, zapady napięcia, krótkie przerwy i zmiany napięcia zasilania AC i DC, odporności na impulsowe pole magnetyczne. Scharakteryzowano metody badawcze związane z emisją zaburzeń przewodzonych oraz promieniowanych. Opisano stanowiska badawcze oraz aparaturę pomiarową wykorzystywaną w tego typu badaniach. Przedstawiona problematyka kompatybilności elektromagnetycznej w środowisku kolejowym dowodzi wielowątkowości zagadnienia kompatybilności elektromagnetycznej.

Słowa kluczowe: kompatybilność elektromagnetyczna, urządzenia sterowania ruchem kolejowym, systemy telekomunikacyjne

Проблематика EMC в устройствах управления железнодорожным движением и телекомуникационных устройствах

Резюме
В статье представлена проблематика исследований в области електромагнитной совместимости електрических и електронных систем и устройств работающих в железнодорожной среде. В реферате представлены исследовательские методы в области сопротивления на воздействия типа SURGE, BURST, ESD, провалы напряжения, короткие перерывы и изменения напряжения питания постоянного и переменного тока, сопротивления против импульсивного магнитного поля. Описано исследовательские методы связанные с эмиссией проводимых и излучаемых помех. Представленно исследовательские стенды а также измерительные приборы используемые в таких исследованиях. Представленная проблематика электромагнитной совместимости в железнодорожной среде показывает многоплановость вопроссов електромагнитной совместимости.

Ключевые слова: електромагнитная совместимость, устройства управления железнодорожным движением, телекоммуникационные системы