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Conducted susceptibility measurement according PCS-08 and PCS-09 procedure of NO-06-A500:2012 standard example's of measurement for national security and defence

Abstract. *The article presents a procedure of compliance according the requirements of Polish national security and defence standards. Electromagnetic compatibility tests are necessary to confirm compliance of marine military equipment with those standards. This paper shows an example of EMC procedures according NO-06-A500:2012 PCS-08 conducted susceptibility, damped sinusoidal transients, cables and power leads in frequency range of 10 kHz to 100 MHz, PCS-09 conducted susceptibility, transient, power leads.*

Streszczenie. *W artykule przedstawiono wymagania według polskich norm obronnych. Badań kompatybilności elektromagnetycznej są niezbędne w celu potwierdzenia zgodności morskiego sprzętu wojskowego z tymi normami. W artykule przedstawiono przykład procedur EMC zgodnie NO-06-A500: 2012 PCS-08 badanie odporności na tłumione sinusoidalne sygnały nieustalone, kable i przewody zasilania w zakresie częstotliwości od 10 kHz do 100 MHz, PCS-09 badanie odporności przewodzonej na, stany nieustalone w przewodach zasilania (**Badania odporności przewodzonej według procedur PCS-08, PCS-09 normy NO-06-A500:2012, w procesie oceny zgodności na rzecz obronności i bezpieczeństwa państwa.**)*

Keywords: electromagnetic compatibility, conducted susceptibility; transient power leads; damped sinusoidal transients.
Słowa kluczowe: kompatybilność elektromagnetyczna, odporność na zaburzenia przewodzone, przebiegi nieustalone na złączu zasilania, przebiegi nieustalone tłumione oscylacyjne.

Introduction

Conducted susceptibility procedures transient power leads and dumped sinusoidal transients are described in Polish military standard number NO-06-A500:2012 procedure PCS-08 and PCS-09 and in US Army military standard number MIL-STD-461F procedure CS106 and CS116.

Procedure PCS-08 conducted susceptibility, damped sinusoidal transients, cables and power leads in frequency range of 10 kHz to 100 MHz is used to simulate electromagnetic phenomena such as: lightning electromagnetic pulse and electrical switching. This measurement is a requirement to all electrical cables interfacing with each EUT enclosure and also individually on each power lead. This procedure is applicable to equipment and subsystems installed in: - surface ships; - aircraft for army, navy and air force; - space systems, including launch vehicles, - ground army, navy and air force. Dumped sinusoidal transient is our so requirement in limited range to equipment installed in submarines. Disturbance signal is normalized according the equation (1):

$$e^{-\frac{\pi \cdot f \cdot t}{Q}} \cdot \sin\left(2 \cdot \pi \cdot f \cdot t\right) \tag{1}$$

where: Q – dumping factor
This signal is shown on figure 1. Current level shown on figure 2.

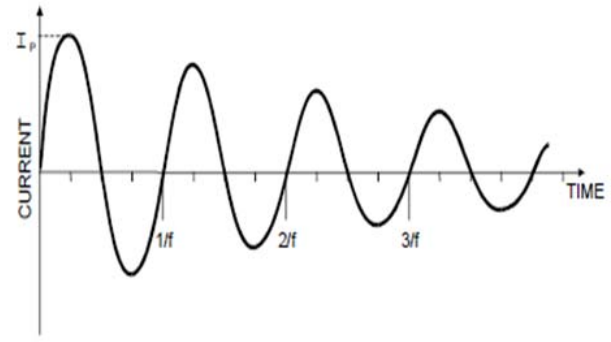

Fig. 1. Disturbance signal in procedure PCS-08 [1]

Procedure PCS-09 conducted susceptibility, transient, power leads is used to simulate disturbance which is coming from power input leads on surface ships and submarines that obtain power from the external powers source that are not part of the EUT (Equipment Under Test). This procedure simulate the electrical transients on the power leads. Electrical transient can cause problems in circuits which tend to be sensitive to voltage transients, such as latching circuits expecting a single trigger signal. This procedure is applicable to equipment and subsystems installed in: surface ship, submarines. Disturbance signal shown on figure 3. Maximum voltage amplitude of disturbance is 400V.

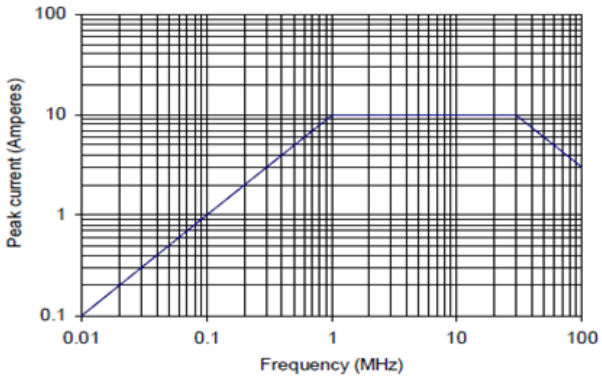

Fig. 2. Current level in procedure PCS-08 [1]

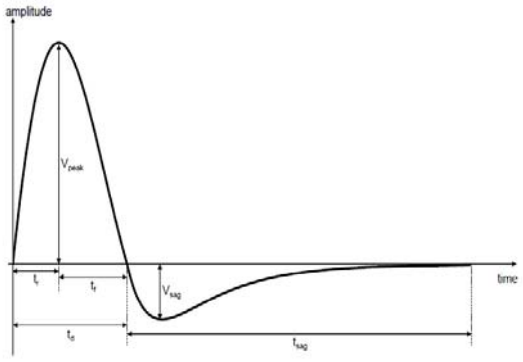

Fig. 3. Disturbance signal in procedure PCS-09 [1]

Calibration procedure

Calibrations of PCS-08 and PCS-09 procedures stands were done before every measurement.

Calibration schematic of the PCS-08 procedure shown in figure 4. For this measurement the following equipment is required:

- storage oscilloscope;
- attenuator;
- injection probe;
- calibration fixture;
- damped sinusoid Transient Generator.

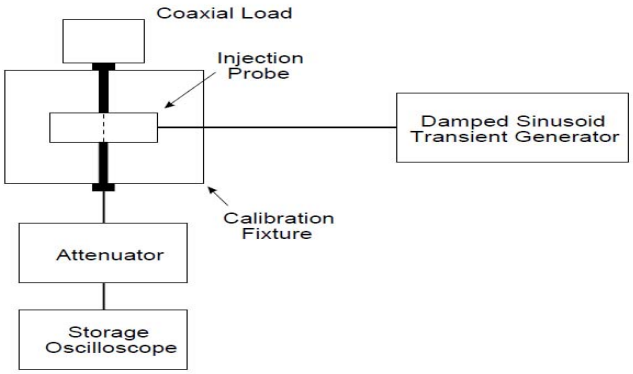

Fig. 4. Calibration of PCS-08 procedure schematic [1]

Calibration was performed for verification of the waveform. At the beginning the injection probe has to be put to the calibration fixture and on one side coaxial load 50 Ω should be connected. On the other side the attenuator and storage oscilloscope were connected. The frequency value of the damped sinusoid generator was set to 10 kHz, then the amplitude of the damped sine waveform was adjusted to the level specified in requirement according figure 2. Measurement voltage on oscilloscope is calculated according equation (2):

$$U_{Oscilloscope} = I_P \cdot R_0 \cdot 10^{\frac{-T}{20}} \tag{2}$$

where: $U_{Oscilloscope}$ – measured voltage on oscilloscope [V], I_P – max amplitude of the disturbance current according figure 2 [A], T – attenuation of the attenuator [dB], R_0 – coaxial load (50 Ω).

The damped sinusoid generator settings were recorded. Calibration fixture shows figure 5. Calibration stand is shown on figure 6. Calibration result for 10 MHz is shown on figure 7.

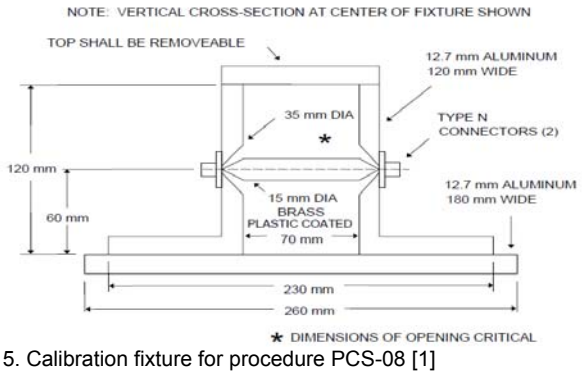

Fig. 5. Calibration fixture for procedure PCS-08 [1]

Calibration schematic of the PCS-09 procedure presents figure 8. For this measurement is required some equipment such as:

- transient generator;
- oscilloscope;
- 5Ω resistor.

Calibration was performed for verification of the waveform. At the beginning 5 Ω resistor was connected to the input of the transient generator along with the storage oscilloscope. The amplitude was set to 400V and the oscilloscope measurement of voltage was done.

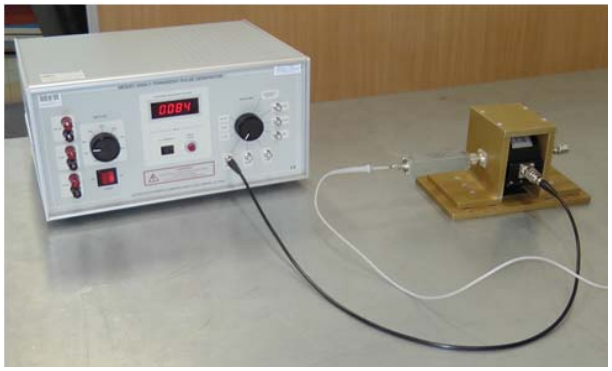

Fig. 6. Calibration stand procedure PCS-08.

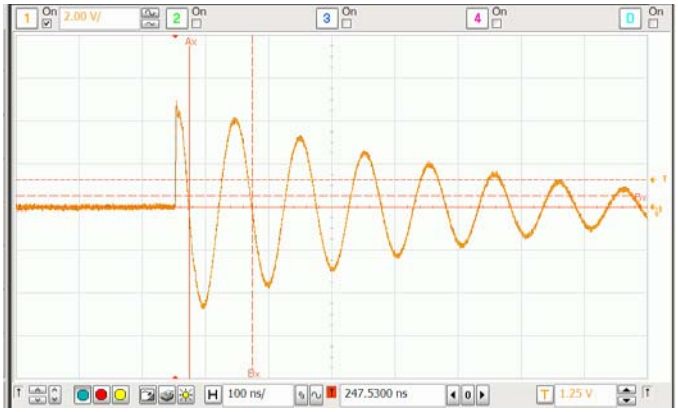

Fig. 7. Calibration result for 10 MHz

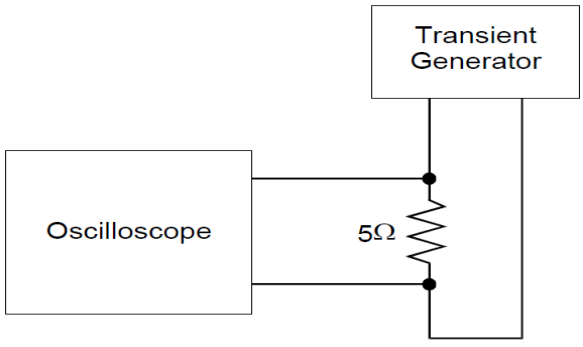

Fig. 8. Calibration of PCS-09 procedure schematic [1]

Fig. 9. Calibration of PCS-09 procedure [1]

Fig. 10. Calibration result acording procedure PCS-09

After the calibration the stand is ready to done the test.

Test procedure

The PCS-08 test procedure starts with connecting the injection probe and monitor probe to the EUT cable. The next step is to adjust the amplitude of the generator to get disturbance signal according figure 2 which was measured and calculated during the calibration. This test procedure should be repeated for each frequency: 0,01;0,1;1;10;30 and 100 MHz. Measurement schematic shown on figure 11. Measurement result on power cord cable is shown on figure 12.

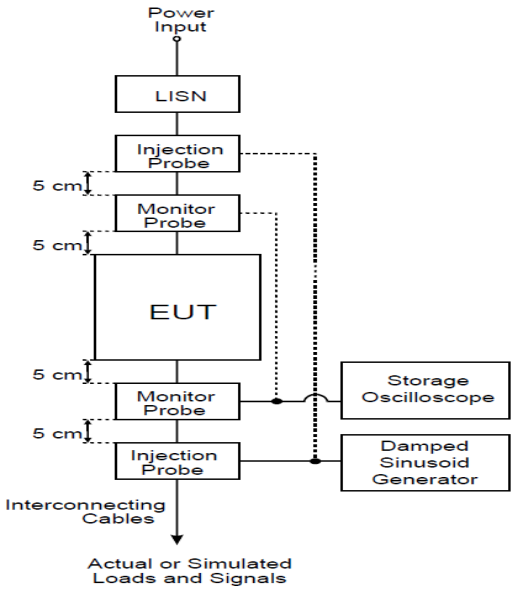

Fig. 11. Measurement schematic procedure PCS-08 [1]

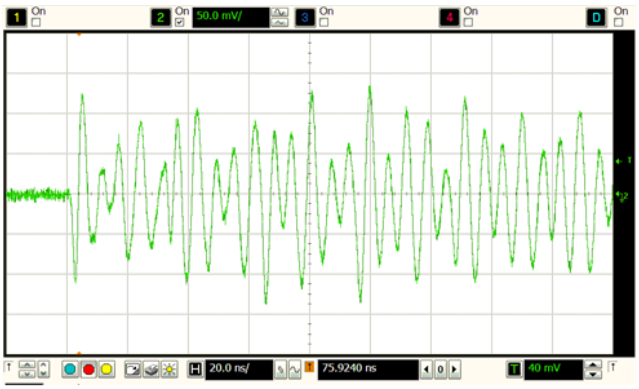

Fig. 12. Example test result on power cord cabel procedure PCS-08

The differences of course made during the course of calibration and measured in real terms due to the inductance and capacitance occurring in the cables examined and disrupting other kinds of wire than during calibration.

The PCS-09 test procedure starts with connecting the power leads to the EUT power cable. The next step is to adjust the amplitude of the PCS-09 generator to 400V.

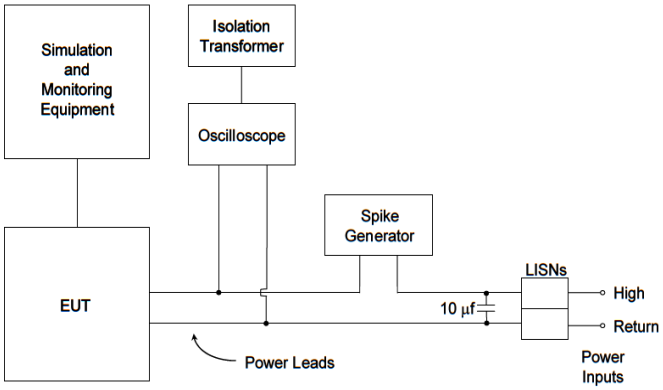

Fig. 13. Measurement schematic procedure PCS-09 [1]

According to the standard there should be applied transient pulses to the test sample's ungrounded input lines at a pulse rate of between 5 and 10 pulses per second for not less, then 5 minutes. This test procedure should be repeated for each power lead and test condition as required.

Comparison between military and commercial equipment standard

This two procedures described in this article also has their equivalent commercial equipment standard. First procedure PCS-08 conducted susceptibility, damped sinusoidal transients, cables and power leads in frequency range of 10 kHz to 100 MHz in civilian standard is represented by the PN-EN 61000-4-12 [4]. It describes test procedure for ring wave disturbances. According this civilian standard there should be only two test frequency 100 kHz and 1 MHz, comparison of this standard shown on figure 14.

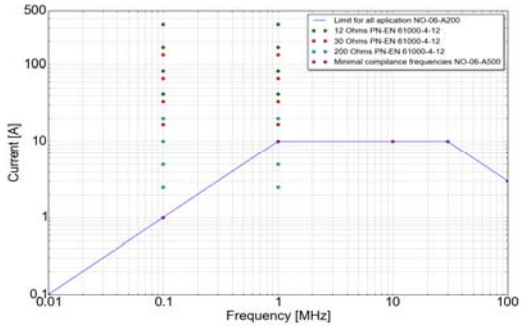

Fig. 14. Comparison of commercial equipment standard PN-EN 61000-4-12 and military standard NO-06-A500 procedure PCS-08 [6], [7]

The commercial equipment standard delivers disturbances to the equipment under test by capacitors in military by injection probe. Generator in commercial equipment standard has got different resistance output such as: R=12, 30 and 200 Ω.

The second procedure PCS-09 conducted susceptibility, transient, power leads in commercial equipment standard is represented by the PN-EN 61000-4-5 [5]. In civilian standard it is equal to special pulse called Surge. It has 1,2

µs rise time and 50 µs time to half. In military standard this pulse is different and it has 1,5 µs rise time, 3,5 µs fall time. Comparison between this two signal is shown in figure 15, for best comparison effect on this figure both signals are in the same amplitude 400V.

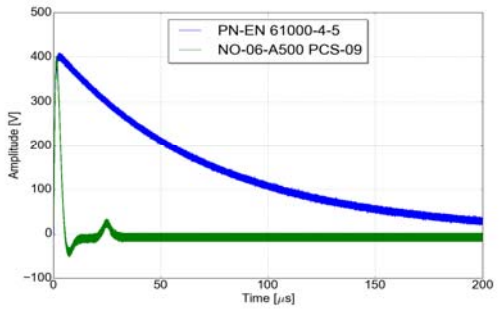

Fig. 15. Comparison beetwen pulse in commercial equipment standard PN-EN 61000-4-5 blue color and military standard NO-06-A500 procedure PCS-09 green color

In civilian standard there are 4 levels of disturbance signal 0,5; 1,0; 2,0; 4,0 kV but in military standard there is only 400 V. In commercial equipment standard measure is perform for 4 angles of power supply: 0°, 90°, 180°, 270° in military standard the test is perform without synchronization with power supply.

Conclusion

The intention of ensuring the EMC requirements of military equipment is to provide an effective and efficient operation and safety during the exploitation. Testing for compliance with PCS-08 and PCS-09 procedures are not too common. However, they are required by the applicable standards, especially PCS-09 is a requirement for equipment designed for naval vessels. The aim of the EMC tests is to eliminate the possibility of for example unwanted underwater weaponry components activation.

It differences between civil and military procedures stem from the fact that military procedures are more restrictive as to the requirements, a larger number of frequencies with resistance test conducted on a sine wave fading, shorter trailing edge of the pulse at exposure levels.

In the paper the calibration stands for procedures PCS-08 and PCS-09 were described. The test procedure according those standards were presented. Some examples of preliminary testing were shown.

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