

Study on Measurement Methods for Electromagnetic Interference Site Survey

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1. Introduction

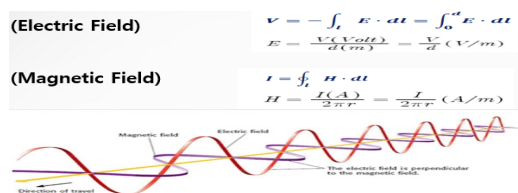
In nuclear power plants, numerous analog and digital devices are installed, and electronic devices are operated while emitting electromagnetic waves and being exposed to the electromagnetic Interference environment. By measuring the electromagnetic environment at key points such as the installation areas of safety-related instrumentation and control (I&C) systems, we can collect information on the electromagnetic conditions during plant operation and review their soundness. This allows us to utilize it for managing the electromagnetic environment within the plant both currently and in the future.

2. measurement methods and Location selection

In this section, we will review the method of measuring electromagnetic emission and selecting locations for an EMI site survey.

2.1 Electric and Magnetic Fields

According to Maxwell's equations, electric fields that change with time and magnetic fields that also change with time are always coupled together and create each other. Electromagnetic waves (EM Waves) take on this form where these two fields propagate simultaneously while being perpendicular to one another. The electric field E, magnetic field H, and direction of propagation make up a right-handed orthogonal system.



2.2 Types of EMI/RFI Emissions

CE101 (Low Frequency Conductive Emissions) is measured at the power terminals in the range of 30 Hz to 10 kHz with the purpose of limiting harmonics emitted by the power line so that the target equipment (newly installed equipment) does not degrade the quality of power supplied through the power lines for

existing power plant facilities. CE102 (High Frequency Conductive Emissions) is measured at the power terminals in the range of 10kHz to 10MHz and aims to verify that they do not degrade the quality of power supply systems and connecting cables (buses). The RE101 (Magnetic Field Radiated Emissions) measures low-frequency magnetic fields in the range of 30 Hz to 100 kHz for interface cables and devices with the aim of managing electromagnetic interference. The RE102 (Electromagnetic Field Radiation Noise) measures high-frequency electric fields in the range of 2 MHz to 10 GHz for interface cables and devices, with the purpose of protecting sensitive equipment from interference that may be combined through an antenna when generating electric fields on the device itself.

2.3 EMI Site Survey

The purpose of measuring electromagnetic field conditions at key points such as safety-related analog/digital instrumentation and control systems, electrical equipment installation areas is to collect information on electromagnetic field conditions during power plant operation. This data will be used in the future for managing changing electromagnetic fields within the power plant.

The site survey method and reference values for CE101, CE102, RE101, and RE102 EMI (Electromagnetic Interference) are as follows:

The comparison curve for CE101 has an attenuation of -8 dB relative to the immunity test level in the CS101 susceptibility test.

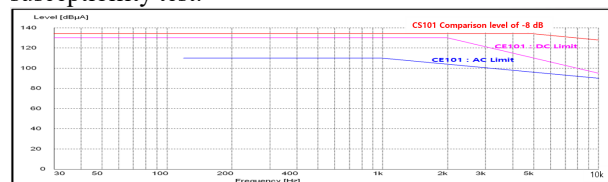


Figure 1. CE101

The comparison curve for CE102 has an attenuation of -8 dB relative to the immunity test level in the CS114 susceptibility test. At low frequencies, the emission limit exceeds the tolerance value, which is due to different energy transfer paths in CE102 and CS114 tests (CE102 involves physically connected conductors in equipment, whereas CS114 involves electromagnetic

coupling from air to conductor). Therefore, direct comparison of reference values at low frequencies should not be made, and comparisons should be performed in frequency bands above 1 MHz

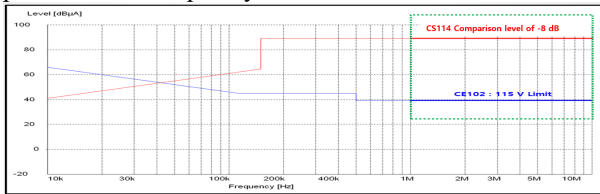


Figure 2. CE102

The comparison curve for RE101 has an attenuation of -8 dB relative to the immunity test level in the RS101 susceptibility test. When measuring at a distance of 7 cm, caution is required due to the risk of contact between the exposed safety device and the antenna.

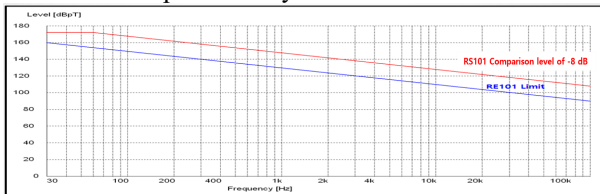


Figure 3. RE101

The comparison curve for RE102 has an attenuation of -8 dB relative to the immunity test level in the CS114 & RS103 susceptibility test. In the frequency range of 200 MHz to 1 GHz, when considering the size of the DRG antenna, if it is difficult to secure an interval of 1 meter, measurements will be made within 1 meter as a precaution. Since there are no RS103 test levels between 2 MHz and 30 MHz, the measurement uses the conversion method through CS114 specified in MIL-STD-461G Appendix A.50.12 to derive the allowable level. It converts the unit of CS114, dBμA, into the RS103 unit, dBμV/m, to determine the permissible level.

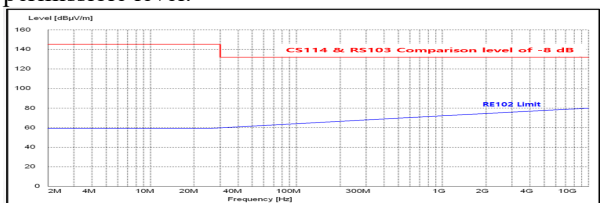


Figure 4. RE102

The appropriate method for selecting an EMI site survey location is as follows:

a) Locations with high electromagnetic wave generation: Select areas where there is a dense concentration of measuring and electrical equipment that may have an unfavorable electromagnetic environment due to numerous processors, power supplies, communication modules in cabinets, or other

sources of electronics emitting radiation near critical infrastructure and surrounding facilities.

b) Near I&C safety-related equipment: Select locations where various and numerous equipment is located in close proximity to I&C safety-related devices.

c) Location of digital devices installation: Select the location where the digital device is installed or will be installed. Specifically, this includes the site for installing distributed control systems and the site for installing PLCs.

3. Conclusions

In an EMI site survey, measurement points are selected within the power plant where instrumentation and control systems as well as electrical equipment operate in close proximity to each other, resulting in additive electromagnetic emissions that can be measured at their maximum levels. The EMI site survey test method is conducted according to the requirements of Regulatory Guide 1.180 Rev.2 (Electromagnetic Interference (EMI): CE101, CE102, RE101, RE102, 2019). If the measurement results show high or near-threshold values compared to reference limits, technical measures such as shielding, grounding reinforcement, management actions like setting exclusion zones, or even replacing components and equipment may be implemented to contribute to safe operation of the power plant.

REFERENCES

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