Measurement of EMI at Nuclear Power Plants during Wireless Communications

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1. Introduction

Until now, we normally use communication through wire for maintenance in a nuclear power plant during a planned overhaul period or an unexpected plant stop period. But the use of wireless communication reduces working time required for maintenance than the case to use communication through wire in a power plant, so there are many advantage such as work efficiency and electric power production[1].

And the utility has implemented digital technology into the design of the plant protection system in new nuclear power plants and also replaced existing analog instrumentation and control (I&C) systems with computer based digital I&C systems as the analog systems become obsolete. On the other hand, digital I&C systems, which provide more operating capabilities than analog systems, operate wireless communication at conditions that are more vulnerable to electromagnetic interference (EMI) than existing analog systems[2].

This paper deals with measurement and analysis of the electric field intensity for the operation of a wireless phone at the frequency range of 2.4 GHz in the area of the main control room at Uljin nuclear power plants. Also, the results of immunity test about the equipments were installed in under condition to generate high output in a wireless phone are presented.

2. Methods and Results

In this section some of the measurement results and formulas for exclusion zone for using wireless phone are described. Particularly, wireless internet phone (IP) and access point (AP) made by Nortel Inc. were used in this measurement.

2.1 Measurement of EMI

In order to determine characteristics of radiated noise with using the wireless communication, measurements were taken for various conditions. The measurements were taken for two weeks by performing EMI test, from 0 % to 100 % output of the 1,000 MW reactor.

Ten plant control system (PCS) and two core protection calculator (CPC) cabinets were selected to represent composition and function of their internal circuit. The frequency ranges of radiated emissions, in EPRI TR-102323-R1, USNRC Guide 1.180 and MIL-STD-462D were chosen as follows;

- Radiated magnetic field noise : 30 Hz to 100 kHz
- Radiated electric field noise : 10 kHz to 7 GHz.

The procedures of calibration for all measurement equipments were performed in accordance with P226 of the electromagnetic test operation procedures document of the Korea Testing Laboratory (KTL). Radiated noise, the measurement antenna was selected to match with each frequency band. The rod antenna was placed on the ground plane at the selected measurement position according to MIL-STD-462D. Other antennas were rotated, lowered and raised to determine the position of the maximum emissions, and scanning was performed at such position. All scanning was performed with vertical polarization of the antenna in the frequency range from 10 kHz to 7 GHz and horizontal polarization in the frequency range of 30 MHz to 7 GHz. Figure 1 shows a view of the EMI measurement using biconical antenna.

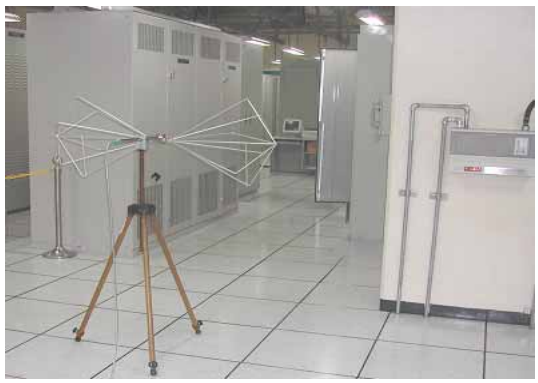

Figure 1. Measurement environment of the radiated emissions.

Results of the radiated noise measurement, which was acquired both during shut down period and full power operation period of power plants, were analyzed, and the maximum level of radiated noise in each frequency range are shown in figures 2 and 3. These values were compared to limits specified in the USNRC.

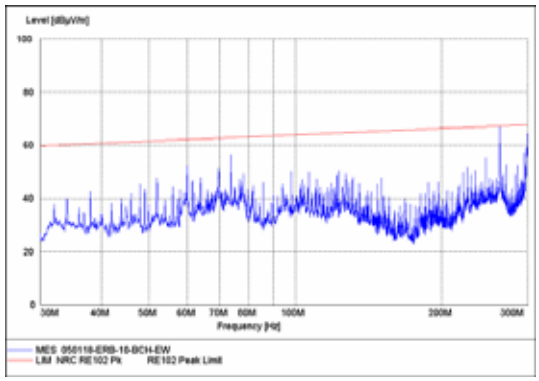

Figure 2. Measurement results from 30 MHz to 300 MHz.

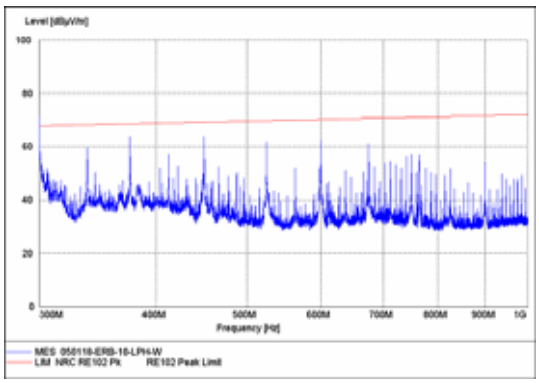

Figure 3. Measurement results from 300 MHz to 1,000 MHz.

In above figures, the majority values of all frequency ranges are within their respective USNRC limits. These narrow-band noises mainly originated in the digital circuits of many air sampling smoke detectors (ASSD) that were installed in the equipment room and the main control room. Because they can cause interference in the interior and exterior of the main control room, shielding devices are needed to reduce these noise emissions. However, the radiated magnetic field emissions in the frequency range from 30 Hz to 100 kHz were not detected, considerably, for the PCS and CPC.

2.2 Immunity test for wireless phone

The immunity test of digital I&C to electromagnetic effects is of concern to the nuclear power plant because the faster microprocessor clock rates and lower logic voltage levels being employed can increase the potential for disruption by wireless communication. Next, figure 4 shows the measurement results of electric field intensity during to use wireless phone of 2.4 GHz in the main control room. An EMI level around the frequency range of 2.4 GHz measured in this study, is exceeding the limit that proposed in USNRC on largest 40 dB. As for the measurement results of the following figure, it was judged that digital I&C was affected enough, but as a result of having carried out a immunity test, all equipment did a normal action without degradation of performance. But some error can be because it was not to have carried out an immunity test on all equipments.

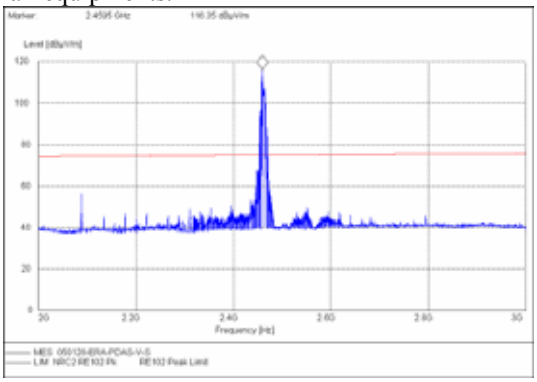

Figure 4. Measurement results from 2.4 GHz wireless phone.

2.3 Formula for exclusion zone

Wireless internet phone made by Nortel Inc. is hand-held, not wired into the power plant, and is intended as an active transmitter. So, exclusion zones should be established through administrative controls to prohibit the activation of portable wireless phone in areas where safety-related I&C equipments have been installed. An exclusion zone is defined as the minimum distance permitted between the point of installation and where portable EMI emitters are allowed. The size of this exclusion zones should be site-specific and depend on the effective radiated power and antenna gain of the portable EMI/RFI emitters used within a particular nuclear power plant.

$$d = \frac{\sqrt{30PtGt}}{E} \quad [\text{m}]$$

Pt [W] = the effective radiated power of the emitter;
Gt = the gain of the emitter (dimensionless); and,
E [V/m] = the allowable radiated electric field strength of the emitter at the point of installation.

Table 1. Minimum exclusion zone for wireless internet phone and access point.

Item	Mode	Pt [W]	Gt	E [V/m]	d [m]
Access Point	Standby mode	0.297	3	4	1.29
	Saving mode	0.396	3	4	1.49
	Transmitting	1.155	3	4	2.54
	Receiving	1.221	3	4	2.62
Internet Phone	Minimum	0.010	3	4	0.23
	Maximum	0.100	3	4	0.75

3. Conclusion

The purpose of this paper is to measure and analyze the electromagnetic interference (EMI) during wireless communications at the main control room, which was recently constructed in Uljin nuclear power plant. Measurements were performed for two weeks where phases of the power output were elevated from 0 % to 100 % of reactor power. Analyzing 120 items of measured data and determining the maximum electromagnetic noise level, the level of emissions are within their respective USNRC limits. On the other hand, analysis revealed that there is no mis-operation in equipment expected that is sensitive to an EMI, but is exceeding on largest 40 dB from the limit proposed by USNRC surrounding frequency range of 2.4 GHz.

REFERENCES

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[2] G. G. Champiot and J. C. Agostini, "*Electromagnetic environment in a PWR power plant*," in Proc. IEEE Int. Symposium on EMC, pp. 377-387, 1982.