Examples of Electromagnetic Field Sources in an Indoor Distribution Substation

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Abstract— The paper presents example measurements of electromagnetic fields in an indoor distribution substation. We measured at different places: At Place A (near the fuse panel), using (1) frequency bandwidth (FB) 40 kHz–100 kHz, fields varied 0.011–0.039 μT and using (2) FB 5 Hz–100 kHz, fields varied 67–74 μT; at Place B (the surface of the collector meter), the fields varied from 0.022 to 0.083 μT (40 kHz–100 kHz); at Place C (near the antenna of the collector meter), the maximum radio frequency field was 1.0 W/m^2, and at Place D (the surface of the antenna), it was 1.8 W/m$^{2\cdot}$. The measured values were below ICNIRP guidelines.

1. INTRODUCTION

In indoor distribution substations, there are typically extremely low frequency (ELF) electric and magnetic field sources, e.g., transformers and cables. However, nowadays there can also be smart meters or collector meters. These smart meters most often send information or communicate using either a radio frequency (800–3000 MHz) aerial signal to masts or a 50–100 kHz electromagnetic field (EF) signal via cables [3, 5]. The International Commission on Non-ionizing Radiation Protection (ICNIRP) has set different guidelines for the general public [2, 4]. For the frequency range of 5 Hz–50 kHz, the guidelines are for the magnetic flux density 27–1000 μT and 83–5000 V/m for the electric field [2]. For the 50–500 kHz, the guidelines are 83 V/m for the electric field and 27 μT for the magnetic flux density [2]. For the frequency range of 800–3000 MHz, the ICNIRP guidelines are 4–10 W/m^2 [4]. The EU has given a directive for work-related exposure [1].

The aim of this paper was to present example measurements of EF exposure to sources in an indoor distribution substation.

2. MATERIALS AND METHODS

Figure 1 shows Place A measurements, which was near the fuse panel in an indoor distribution substation. Figure 2 gives measurements for Places B, C and D.

Figure 1: Measurement Place A, near fuse panel.

We used the magnetic field meter MFM 3000 by Combinova, with a separate probe version, video recording with RMS values, and spectrum (Samsung smart phone type Samsung Galaxy S

Figure 2: Examples of measurements in different areas (Places B, C, and D).

III), the Narda EMR-300 with probe T-33C, and a Holaday 3603 VLF Survey meter. We performed measurements at three places.

Place A (Figure 1) was near the fuse panel, where we made measurements with (1) frequency bandwidth 40 kHz–100 kHz (57 measurements) and (2) 5 Hz–100 kHz (62 measurements). Place B (Figure 2) was on the surface of the collector meter (15 measurements), Place C (Figure 2) was near the antenna of the collector meter (7 measurements), and Place D (Figure 2) on the surface of the antenna (24 measurements).

3. RESULTS AND DISCUSSION

Table 1 shows the magnetic field measurement results, and Tables 2 and 3 provide the radiofrequency results. Using the bandwidth (1) in Place A, we obtained 11 values, which varied from 0.011–0.039 μT; other values were 0.0038–0.0052 μT. The source of those values can be the collector meter, which signals via cables. Utilizing the bandwidth (2), the magnetic fields were 67–74 μT.

In Place B, the magnetic fields varied from 0.022 to 0.083 μT, and the frequency bandwidth was 40 kHz–100 kHz.

Table 1: Magnetic field measurement results in different places.

Amount of measurements	Max field, μT	Average MF (all) μT (40 kHz–100 kHz)	place
57 (11 during reading)	0.04	0.01 (during reading 0.03)	A*
9 (9 during reading)	0.08	0.06 (during reading same)	B
6 (6 during reading)	0.08	0.06 (during reading same)	C
		Average MF (all) μT (5 Hz–100 kHz)	
62	73.9	70.32 (standard deviation 2.02)	A*
58	70.4	66.8 (standard deviation 1.53)	A*

*distance 50 cm, height 1.7 m

Tables 2 and 3 reveal the radiofrequency EF measurement results in Places C and D.

In Place C, the radio frequency maximum field was 1.0 W/m^2, and in Place D, it was 1.8 W/m^2. To evaluate the possible effects of EFs, it is possible to use guidelines of the ICNIRP, and measured values were below guidelines.

Meters and guidelines have different frequency ranges, and the comparison of measurement results to guidelines is not so easy to do. Therefore, we have used frequency analysis of magnetic flux densities to be able to do those comparisons (Figure 3).

In that figure, we can see that there is a lot of magnetic flux on frequencies of less than 3 kHz. There is only a relatively small peak at the frequency of about 80 kHz that sends the information

Table 2: Radiofrequency EF measurement results in Place C.

n	RF field, W/m^2	Place
1	0.47	C
2	0.86	C
3	1.30	C
4	0.86	C
5	0.87	C
6	1.0	C
7	0.4	C

Table 3: Radiofrequency EF measurement results in Place D.

n	RF field,W/m^2	Place
1	0.47	D
2	0.47	D
3	1.76	D
4	0.86	D
5	0.51	D
6	0.99	D
7	1.0	D
8	1.3	D
9	0.43	D
10	0.84	D
11	1.06	D
12	1.28	D
13	1.48	D
14	1.23	D
15	0.62	D
16	0.64	D
17	0.65	D
18	0.65	D
19	1.31	D
20	0.68	D
21	1.3	D
22	1.80	D
23	1.64	D
24	0.53	D

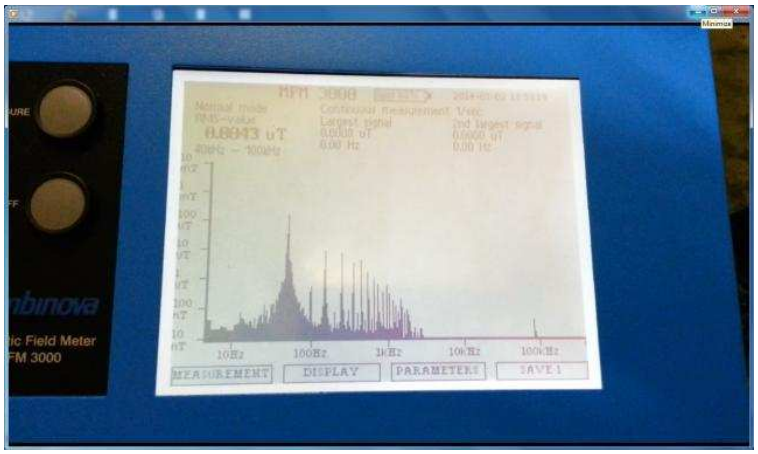

Figure 3: Example measurement.

of smart meters. For the radiofrequencies, the situation is similar, and then we must know what kinds of fields exist to be able to use broadband meters reliably.

4. CONCLUSION

The measured values at the indoor distribution substation were clearly less than the ICNIRP guideline values. Therefore, no special sheltering against these fields is needed. These measurements need many meters and careful analysis of frequencies if broadband meters are to be used. Frequency analysis helps to detect if any odd fields exist in spaces.

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