HEMP Coupling Measurement and Assessment of a Modern Electrical Substation

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Abstract — A unique opportunity emerged during the Summer of 2019 to carry out Electromagnetic (EM) coupling measurement survey of a newly built electrical substation, before the 420kV HV at the substation was energized. The substation included design measures to mitigate High Altitude Electromagnetic Pulse (HEMP) and Intentional Electromagnetic Interference (IEMI) effects utilizing both radiated and conducted protection measures. The survey was constrained by the geometry of the site and the time available yet useful insights were gleaned. Subsequent to completion of the measurement survey, which looked at both cable coupling and structural shielding effectiveness, analysis was carried out to assess the coupling of HEMP E1 into the facility.
This paper summarizes the observations from the measurement survey and the analysis.

I. INTRODUCTION

Statnett is the Transmission System Operator (TSO) in Norway. Statnett is currently undergoing a large-scale investment program expected to run for a total of 20 years – in the main to support the Norwegian electricity grid.
Part of this investment includes upgrading substation infrastructure with buildings and equipment capable of satisfying the latest Norwegian requirements, including those related to protection from HEMP [1] and IEMI environments. A series of EM coupling measurements was organized to inform Statnett of the intrinsic HEMP protection offered by the protection measures employed in the latest substation construction. Figure 1 shows the substation which was evaluated. The measurements were concentrated on coupling to critical systems located within the substation control room, via coupling onto control/signal cables (conducted coupling) and via radiated coupling through the control room building structure to within the control room. The survey was performed employing two coupling techniques, known as Low Level Swept Current (LLSC) and Low Level Swept Field (LLSF), these have been used for many years to assess the EM coupling into various platforms and Critical Infrastructure [2].

Figure 1. The switching and transformer yard where coupling was evaluated

The LLSC technique requires the use of long dipole antennas (up to 30 m long) mounted 3-4 m above ground level. Using these onsite in proximity to an energized substation would constitute a considerable safety hazard hence the need for a de-energized site. Still, there were severe time constraints, only 5 working days were available and physical constraints on the siting of antennas which meant that compromises were unavoidable.

II. RESULTS

On completion of the swept frequency assessment analysis of the HEMP E1 response was analysed by employing the convolution process. Convolution primarily consists of merging two frequency-domain waveforms to predict the response of a particular cable to a given threat.
The results were broadly consistent with the data on the conducted E1 HEMP environment contained in IEC 61000-2-10 (Buried cables). For the vast majority of cases the highest calculated E1 HEMP current results from horizontal polarisation of the E-field.
A summary of the data will be provided during the presentation.

REFERENCES

[1] 61000-2-9:1996, “Electromagnetic Compatibility (EMC) – Part 2: Environment – Section 9: Description of HEMP Environment – Radiated Disturbance”,

[2] IEC 61000-4-36 Ed. 1.0 (2014-11-07): Electromagnetic compatibility (EMC) – Part 4-36: Testing and measurement techniques – IEMI immunity test methods for equipment and systems.

[3] IEC 61000-2-10 Ed. 1.0 (1998-11-24): Electromagnetic compatibility (EMC) – Part 2-10: Environment – Description of HEMP environment – Conducted disturbance.