HPEM Susceptibility Test on Train Control System

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Abstract—This paper presents the effects of High Power ElectroMagnetic (HPEM) on main equipment of Train Control System (TCS). A test-bed of TCS is constructed through an actual inspection. The DS (Damped Sinusoidal) and the UWB (Ultra-Wide Band) test setup was employed in order to investigate HPEM effects. The results are reported as normalized thresholds of the susceptibility. An assessment of immunity into various Equipment Under Test (EUT) will help you understand the susceptibility threshold of TCS test-bed on the HPEM environment.

Keywords: Electromagnetic Pulse, Susceptibility, HPEM, UWB, DS, Train Control System, ATS, CBTC

I. INTRODUCTION

HPEM pulse has characteristics of high power and short duration. This broadband, high-amplitude electromagnetic pulse, when coupled into electronics, has a capability to produce disruption and damage to IT devices including the critical infrastructures [1]. There is a clear trend in the transportation infrastructures with railroad system toward increased use of multiple electronics, thereby increasing potential HPEM vulnerability. The principal elements of the railroad are TCS that is used to control a signal and locomotives. Based on assessments and test results, a weak part in the railroad infrastructure is the railroad signal controllers, which can break down following exposure to HPEM fields as low as a few kV/m [2].

II. HPEM Test Environment

A. DS and UWB Simulator

A pulse generator HPEMcase T is compact and autonomous enclosed equipment. It can generate both DS and UWB pulse through the gap adjustment of the resonant antenna. The Electric field strength in the test area was measured in the absence of the EUT. Due to security reasons, the measured E-field strength E was normalized with a normalization factor E_n. The HPEM tests were completed in an anechoic chamber to guarantee precise environmental conditions that generate little reflections and disturbances. For each set of parameters (amplitude, polarization, and exposure time) the burst illumination was repeated several times in order to verify repeatability and reproducibility. In any case, the E-field exposure started only after normal operation of the EUT.

B. Target System

HPEM susceptibility investigations were executed in two kinds of TCS that can control signal of the railway system; One (Fig.1, left side) is Automatic Train Stop (ATS) system, the other (Fig.1, right side) is Communication Based Train Control (CBTC) system. We have selected five different EUTs in various ATS and CBTC devices by considering the accessibility and the priority of the system.

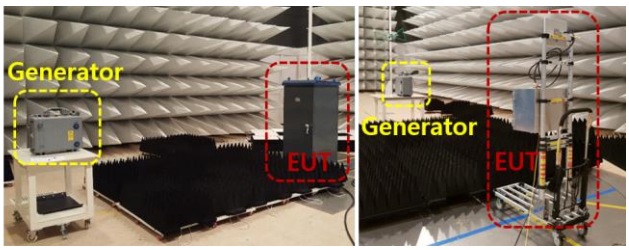

Figure 1. Example of experimental setup for HPEM susceptibility

III. HPEM Test Results

HPEM test on the five different EUT resulted into three types of observable effect level [3].

- N.E: No effect occurs
- S.R: System recovers without human intervention
- H.R: Effect is present until reset or restart of function

In this part, we will present and discuss the result of HPEM test on the ATS and CBTC system. When DS pulse was exposed to a vertically polarized E-field with a threat level of E/E_n = 4.16 (Table I, green box), EUT #2 is not working only during exposure to DS pulse and EUT #3~#5 need rebooting power. The comparison of effect level to ATS (Table I, red box) with CBTC (Table I, blue box) indicates that CBTC is more susceptible than ATS. There is no H.R result in ATS. Also, all EUT are more susceptible to a vertical than to a horizontal polarized threat. The H.R result only exists in case of exposure to the vertical E-field with DS and UWB pulse.

TABLE I. Test Results for TCS against HPEM attacks

			ATS		CBTC		
Pulse Type	**Polarization**	**E/E_n**	**#1**	**#2**	**#3**	**#4**	**#5**
		1.00	N.E	N.E	N.E	N.E	N.E
DS	**Vertical**	**4.16**	N.E	S.R	H.R	H.R	H.R
	Horizontal	**1.00**	N.E	N.E	N.E	N.E	N.E
		3.90	N.E	N.E	N.E	N.E	N.E
UWB	**Vertical**	**1.00**	N.E	N.E	N.E	N.E	N.E
		5.06	S.R	S.R	H.R	H.R	H.R
	Horizontal	**1.00**	N.E	N.E	N.E	N.E	N.E
		4.97	N.E	S.R	N.E	N.E	S.R

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