# UWB pulse susceptibility testing of Gigabit Routers in a GTEM cell

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***Abstract***—This paper describes measurements of the susceptibility to UWB pulses of two gigabit routers considered by the automotive industry; one representing current standards and the second being considered for a future platform of cars from Volvo Car Corp. While the former failed at all levels the latter endured until the most severe test cases where the link margin dropped below acceptable level, mainly at the highest pulse amplitudes.

Keywords- ultra-wideband; pulse repetition frequency; UWB; GTEM cell; automotive; vehicle; gigabit; router; IEMI; interference; safety

## I. INTRODUCTION

Today the automotive industry is taking major leaps towards the fully autonomous vehicle. This goal requires that the vehicle can guarantee safe operation on a level at least as high as a human driver. To achieve this the vehicle needs, on top of the normal engine, and power-train related information, information about everything a human would perceive; meaning that there will be a drastically increased amount of sensors required and hence an increased demand for real-time data flow between sensors, controllers, and actuators. These devices are all interconnected in a network which will have to carry high-speed data with data-rates typically reaching gigabits per second. Intentional electromagnetic interference (IEMI) attacks against vehicles have already been documented [1] and there is no reason to believe that autonomous vehicles will escape such attacks. Therefore a set of UWB-pulse tests have been conducted on one of the key components in the vehicle internal network, the high speed data router.

## II. TESTING

The testing was conducted using an ETS-Lindgren model 5402 gigahertz transverse electromagnetic, GTEM, cell, and a High Voltage Pulse Generator, FPG 20-1PM, from FID Technologies.

### A. *Test Method*

The router under test (RUT) was positioned manually in four positions, three with 90 degrees horizontal rotation and one with the top side facing the feeder entrance. The pulse repetition frequency, PRF, of the source was set to minimum and the input voltage increased from lowest to highest (20 kV) in 10 steps while the data transmission through the RUT was observed. The RUT response was coded according to Table 1, adopted from [2] with slight modifications. This was repeated while the PRF was changed in steps from lowest to highest (1 kHz).

TABLE I. DEFINITIONS OF INTERFERENCE LEVELS

| Level | Indication/ Failure Mode |
|---|---|
| 1 | Normal function. No disturbance. |
| 2 | Moderate interference. A few drops in Link margin while irradiated. |
| 3 | Severe interference. Link margin below 5 at 50% of time. Self-recovery when irradiation stops. |
| 4 | Loss of function/crash. Link goes down. No self-recovery. Needs operator intervention |
| 5 | Fatal. Physical damage. Needs repair or replacement |

### B. *Test Objects*

The routers tested are a) one commercial, off-the-shelf (COTS), rugged gigabit router and b) one automotive grade gigabit router, both equipped with optical fiber connections.

## III. RESULTS AND CONCLUSIONS

Although being a rugged model, the COTS router went straight to Level 4 where the router went down and could not self-recover, already from the lowest PRF and input amplitudes. The automotive router exhibited failure levels from 1 to 3 depending on both PRF and amplitude. At low PRF's the router stayed at Level 1; however, the sensitivity increased suddenly when the PRF was set to maximum and gave Level 2 and 3 errors as the amplitude was increased. Considering that the electric field that the RUT's were subjected to was at least a factor 100 higher than what they are specified for it is not strange that the COTS router failed at all levels and at the same time a good sign for the future of autonomous vehicles that the automotive grade RUT worked as well as it did.

## REFERENCES

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