Electromagnetic Compatibility Testing in an All-Electric Vehicle

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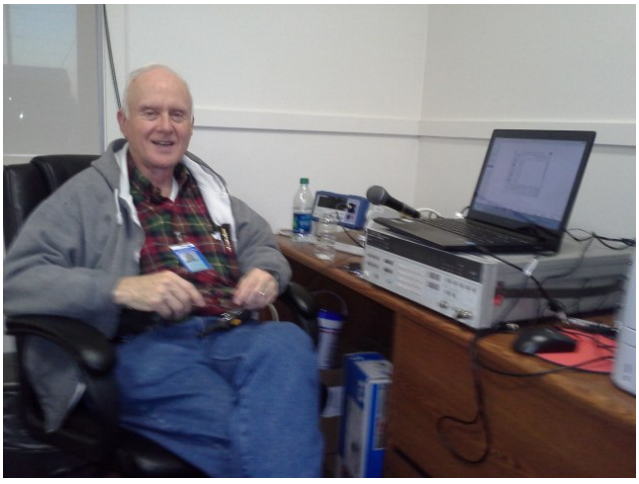
Charles R. Edelson and Lennart E. Long have tested vehicles from the Presidents Mobile Communications Platform, electric buses, trolley cars, subway cars and locomotives, and other vehicles.

Edelson and Long have very diverse backgrounds, from Program Manager; Intelligence analysis USAF Systems Command, Foreign Technology Division, to Reconnaissance Satellite, Tracking Station, Operations Director, to Program Manager and Acting Division Chief of the Safety and Security Division of the US Department of Transportation. Mr. Long has the most patents ever applied for in the Department of Transportation and was given the highest honor of IEEE USA for distinguished contributions to engineering professionalism award in 2013. Mr. Edelson and Mr. Long have held jobs requiring a wide range of skills and experience. Mr. Long headed the task force which resulted in the UMTA Recommended Test Practices for Electromagnetic Compatibility. Mr. Edelson and Mr. Long are well known for troubleshooting difficult EMC problems in the field and in the lab.

Mr. Long chaired the international effort to characterize and solve electromagnetic interference, susceptibility and compatibility issues with moving vehicles and write the UMTA Recommended Testing Practices. He has conducted field tests on locomotives, subway vehicles, trolleys and buses worldwide using the inductive, conductive and radiated UMTA Recommended Test Practices. Mr. Sauter has recently joined Mr. Long with field testing. This talk will concentrate on introducing vehicle EMC testing to the audience.



Summary of talk:

INTRODUCTION

The goal of out talk is to provide EMC awareness and analyses for road-going, non-rail vehicles. This is because of the latest developments in those vehicles which include single wire command and control (fly by wire).

It is good news for the packaging people that their work has been done because there has been an international effort to characterize and resolve electromagnetic interference, susceptibility and compatibility issues of moving vehicles.

Our introductory paper will outline the UMTA Recommended Test Practices for inductive, conductive, and radiated testing which are used on field testing for locomotives, subway vehicles, trolleys and buses worldwide. The UMTA Recommended Test Practices that we will talk about have already been applied for EMC testing of highway vehicles.

It is more efficient and accurate to perform EMC tests of a functioning vehicle than to require laboratory testing of each vehicle subsystem that may cause EMI or be susceptible to environmental emissions. This could save time and money and, if any threatening emissions are found in the system test, they can easily be localized to the offending subsystems.

THE THREAT

New vehicle subsystems like steering and braking are increasingly becoming guide controlled by wire using a local area network. There already exists a passenger bus buss which provides distribution of control signals for the engine, steering, LED signs and braking functions. These signals are digital in nature like on the LAN in your house or place of work. These signals emanate from a central processing unit and have an ack-nack protocol to assure reliability. These digital signals could affect vehicle subsystems as well as wayside subsystems adversely. For instance, they could be inductively coupled into road signaling control loops as well as being conducted to vehicle subsystems through the low voltage distribution system. Unintended emissions within the wideband spectrum could interfere with critical (signal) threat frequencies which are necessary for the safe operation of the vehicle.

Digital signals which travel through the vehicle may cause a spectral response of sinx/x or a cluttered spectrum of signal elements. In addition to that, new non-linear elements like LED displays and signal lights could further compound the EMC concerns because of the non-linear nature of those devices.

The sinx/x content of the digital signals caused by new chopper propulsion as as well as the amplifying effect of harmonics resulting from the non-linear elements would raise the radiated profile of the vehicle. The resultant electromagnetic emissions could affect the vehicle and the environment, including other vehicles and their subsystems such as

throttle position commands, anti-lock braking systems, anti-skid systems and steering systems.

THE PROCESS

Any Electromagnetic Compatibility issue is addressed by the EMC consultant and the client agreeing on the objectives. A proposed testing plan (this spells out the requirements) is then drafted. After the proposed Test Plan has been reviewed and approved by the client, a Detailed Test Procedure is prepared. The Detailed Test Procedure describes, step by step, every detail of the proposed testing. Upon client approval of the Detailed Test Procedure, field testing is performed. The resulting data is reduced and analyzed to identify and document worst case threats to vulnerable vehicle subsystems as well as possible threats to the wayside. A final report is prepared documenting operational compatibility of on-board subsystems as well as vehicle compatibility with wayside receptors and radiators.

INDUCTIVE EMISSIONS MEASUREMENT USES UMTA METHOD RT/IE01A

Inductive interference is measured using a road loop which measures the voltage induced in that road loop by the vehicle under test.

CONDUCTIVE EMC

A current sensor is paced on the output of the low voltage distribution network and is a measure of any emissions which travel to all of the vehicle subsystems. These measurements have been taken on vehicles operated by catenary, third rail, battery, gasoline or liquid propane.

RADIATED EMC

We have tested the radiated emanations from vehicles at a distance of 15 Meters for road going vehicles: trolley, bus and cars; 30 Meters for Main-line rail vehicles. This test is performed on both a moving and stationary (subsystems exercised) of an operational vehicle. This is what makes this so different from Lab testing of components. A fully assembled and functional vehicle cannot be tested in a screen room or shielded facility.

SUMMARY

Welcome to the ever changing world of electromagnetic reality. We, all of us, are both the cause, result, and the victims of this environment. But wait, it’s not over