Analysis and Minimizing Strategies for Conducted Emission from Power Supply Cable of GPS Based Vehicle Tracking System

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***Abstract*— The Main objective of the research proposal is to investigate Conducted Emission from power supply cable of Global Positioning System (GPS) based Vehicle Tracking System (VTS) and to make the system compatible with MIL-461E EMI/EMC standard. The Conducted Emission from GPS VTS Transmitter Board (SMS Based), GPS VTS Receiver Board (SMS Based) and GPS VTS Board (GPRS Based) had been measured with HAMEG make Line Impedance Stabilization Network (LISN) and Agilent Spectrum analyzer E-4411B. Conducted Emission levels were measured with and without RFI filter used in power supply section of the system. The Conducted Emission level was found to be around 50 dBμV. With addition of RFI Filter, the Conducted Emission level found to be reduced by around 15 dB to 20 dB. These levels are compared with MIL-461E, FCC and CISPR Standards for Conducted Emission. GPS VTS Boards (GPRS/SMS Based) with RFI Filter could meet compatibility requirements with MIL-461E, FCC and CISPR EMI/ EMC Standards for Conducted Emission.**

***Index Terms*—GPS, VTS, Conducted Emission, RFI Filter, LISN.**

I. Introduction

Conducted emission from the power supply cables for electronic equipment and circuits is affecting the performance of other electronic equipments operating in the near vicinity. If the amount of emission is beyond the safe limit, the other equipment which is connected to equipment under test through input / output / Power supply cable may get damaged or its functional performance may get affected. A wide variety of electrical and electronic equipments like Computers, Telephone sets, Television Sets, Radar Transmitters, and Laboratory Electronic Equipments contribute to electromagnetic conducted emission on the cables connected to them. Hence it is necessary to control the emission which is coming out from the cables of the equipment. It is essential to suggest and implement the strategies to minimize the emission from the cables.

There are many consumable types of equipment like Computers, Television sets; Tape Recorders, Microwave Ovens, and Industrial Electronic Equipments are connected to mains supply (230V, AC). It is observed that because of the conducted emission through supply line, the voltage of neutral of mains supply which is required to be zero volts, changes to certain level. This may be dangerous to other equipments which are operating on the same supply voltage. Also these equipments emit the AF / RF Noise on input data / output data / signal cables connected to the equipments. This RF Noise may cause disturbances in the functional operation of the equipment. It may disturb the quality of the picture on Television, quality of sound on Tape Recorders. This problem of conducted emission is really gaining importance in today's world of dense EMI environment.

Conducted Emissions are regulated by the FCC over the frequency range 450 kHz to 30 MHz and the CISPR Conducted Emissions limits extend from 150 kHz to 30 MHz. When testing a device for compliance with the FCC and CISPR 22 regulatory limits, a line impedance stabilization network (LISN) is inserted between the AC/DC power cord of the device under test and the commercial power supply. Conducted Emissions may also cause unwanted radiation. As the Conducted Emissions are placed onto the cables external to a particular equipment, they cause radiation to occur. This unwanted radiation can induce currents on other wires, cables and cause interference with other devices. [1]

This paper describes minimizing strategies, measurement methodologies and results for Conducted

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Emission measured from GPS based Vehicle Tracking System boards (GPRS/SMS based).

II. Minimizing Strategies for Conducted Emission

Following methodologies could be used to reduce Conducted Emission levels.

A. Use of RFI Filter in Power Supply Lines

The use of Pi type Radio Frequency Filter (RFI) with X and Y capacitors and choke can reduce the Conducted Emission level to safer limits.

RFI Filter can attenuate common mode and differential mode noise on power supply lines.[2] RFI Filters using Ferrites beads can be very much effective at frequencies below 10 MHz.

B. Use of RFI Filter in Power Supply Lines

EMI Enclosures made from material like Aluminum and its alloys with proper grounding strategies; control the level of Radiated as well as Conducted Emission levels. [3]

C. Use of RFI Filter in Power Supply Lines

The shielded cables with shield grounded at one end of the enclosure can restrict the Conducted Emission level to minimum. [4]

III. Methodologies for Mesurement of Conducted Emission

Following methodologies currently used to measure Conduced Emission. [5]

- Close-field electric and magnetic loop probes along with EMC Receiver are used to measure Conducted Emissions at frequencies below 30MHz.
- Bug detectors can be used for identifying Conducted Emissions.
- Current probes are used for testing of Conducted Emissions.
- Absorbing clamps and Voltage probes are also used to measure the Conducted Emissions on power terminals, when LISNs are not available.
- LISNs and AMNs Line Impedance Stabilization Networks (LISNs) – also called as Artificial Mains Networks (AMNs) are used for measuring Conducted Emissions in many test standards. LISN serves three purposes in Conducted Emission measurements. It presents constant impedance to device under test (DUT) power cords over entire frequency range, it prevents conducted noise from power systems and passes required power supply input to DUT. [6]

IV. Research Work Undertaken

Two Models were used in the research work for investigation of Conducted Emission through power supply line cable. Model 1 has GPS and GPRS based Vehicle Tracking System Board and model 2 has GPS based Vehicle Tracking System Transmitter (TX) and Receiver (RX) Boards (SMS Based). GPS and SMS /GPRS Based Vehicle Tracking Systems are used for displaying the location of the vehicle on Google/ Local Maps. The GPS VTS Systems are intended to be used in stringent environmental and dense EMI/EMC Conditions. These GPS VTS Boards have been subjected to different Environmental and EMI/EMC Tests as per environmental standard MIL-810 and MIL-461E. These details are published in the paper given at reference [7].

RFI Filter had been used in power supply lines of GPS VTS Boards to reduce the Conducted Emission. The RFI filter was having Return loss of 20 dB to 25 dB in the frequency range of 50 KHz to 50 MHz. The shielded cables were used for power supply and antenna input for these GPS VTS Boards. The boards have been enclosed in specially designed EMI Enclosures.

Fig. 1 shows RFI filter schematic. In this filter, X capacitor (0.1 μF) used to reduce common mode noise. Y capacitors (3300 pF) used to reduce common and differential mode noise. Choke (28mH) had been used to minimize differential mode noise. Green Wire inductance L1 (1mH) had been used to reduce common mode noise. [6], [8]

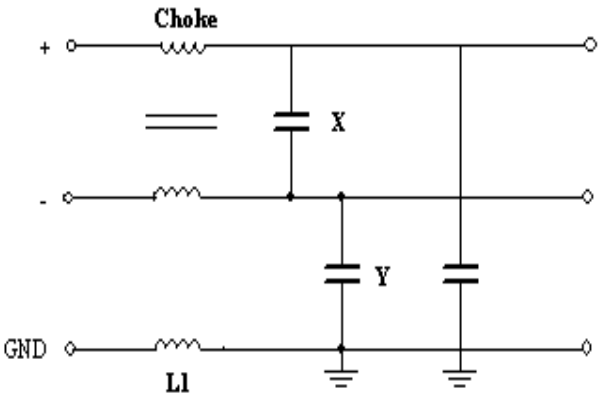

Figure 1. RFI Filter schematic

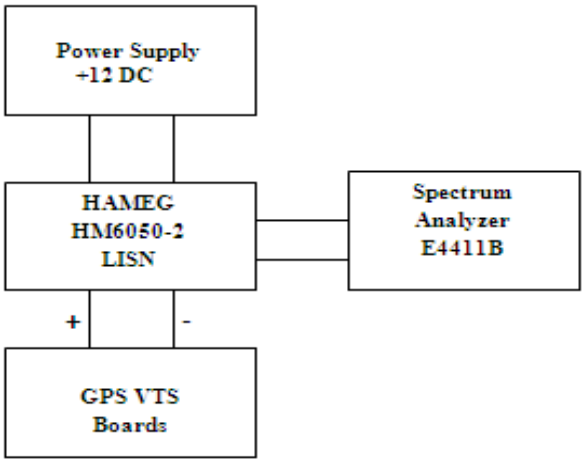

Figure 2. Test set up for measurement of conducted emission

Fig. 2 shows experimental set up for measurement of Conducted Emission from power supply cables of GPS

VTS Boards. The GPS VTS Boards were connected with 12 V DC Power supply through Line Impedance Stabilization Network (LISN). HAMEG Instruments make HM6050-2 LISN was used for isolating power supply noise from GPS VTS Boards. The output of LISN was connected to Agilent Spectrum Analyzer E-4411B for observing the Conducted Emission from GPS Boards. [9] The observations were made for Conducted Emission with and without RFI Filter in power supply section. Figures 3 to 14 show some of the observations for the spectrums of Conducted Emission measured from GPS VTS Boards.

V. Observations/Results for Conducted Emission

A. *GPS* VTS *Board (GPRS Based)*

Fig. 3 to 6 indicate the spectrums for Conducted Emission from GPS VTS board (GPRS based) with and without filter.

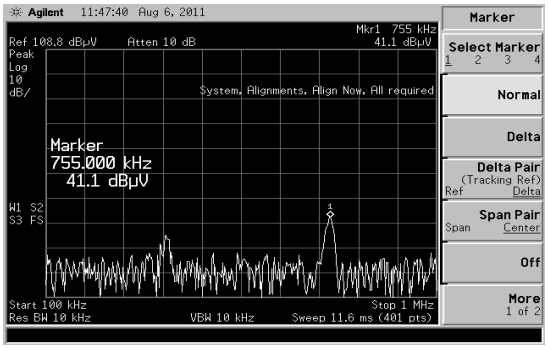

Figure 3. Conducted emission without RFI filter

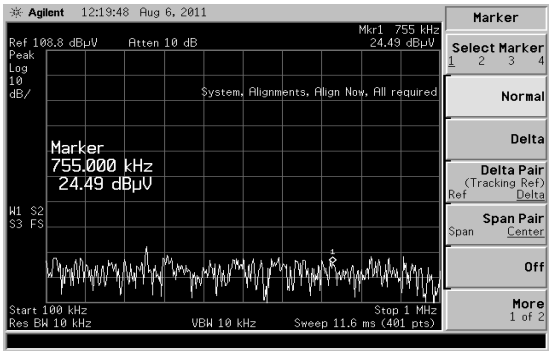

Figure 4. Conducted emission with RFI filter

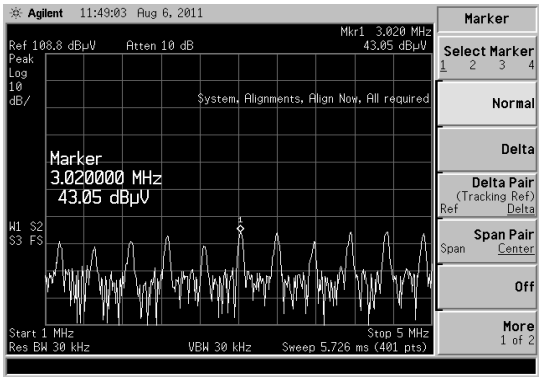

Figure 5. Conducted emission without RFI filter

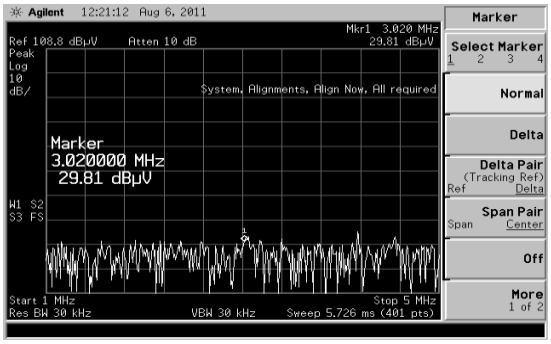

Figure 6. Conducted emission with RFI filter

B. *GPS* VTS *TX Board (SMS Based)*

Fig. 7 to 10 indicate the spectrums for Conducted Emission from GPS VTS TX board (SMS based) with and without filter.

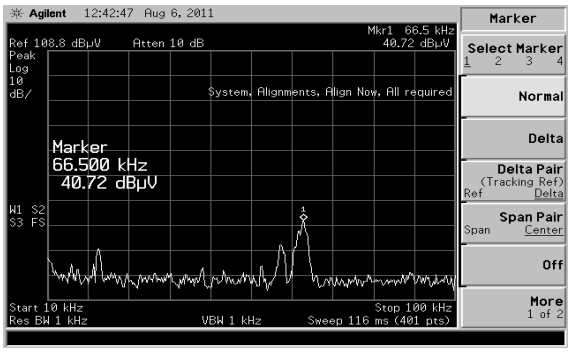

Figure 7. Conducted emission without RFI filter

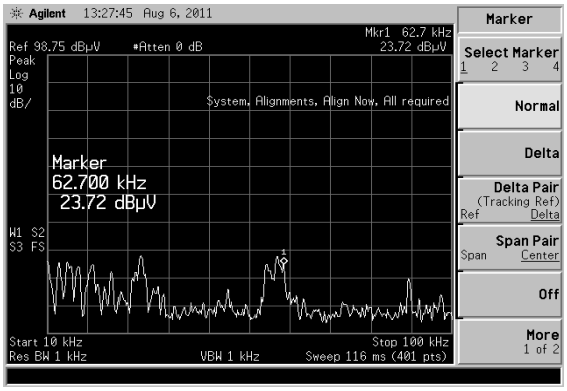

Figure 8. Conducted emission with RFI filter

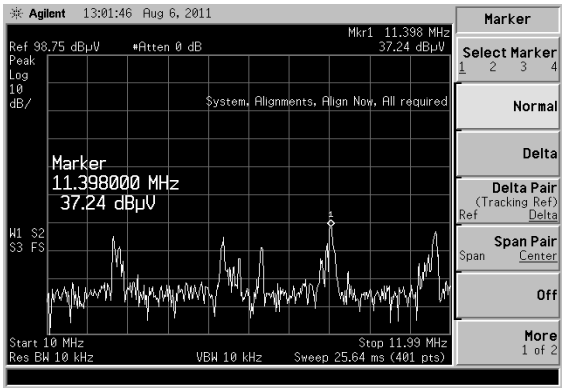

Figure 9. Conducted emission without RFI filter

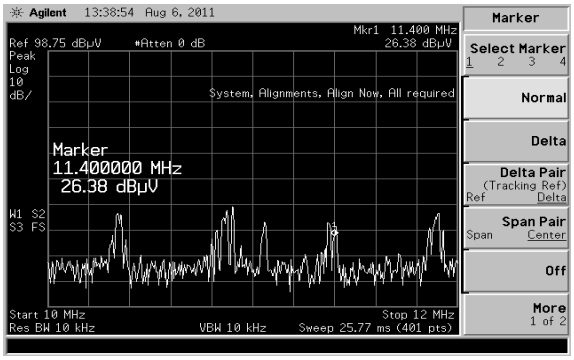

Figure 10. Conducted emission without RFI filter

C. *GPS* VTS *RX Board (SMS Based)*

Fig. 11 to 14 show the spectrums for Conducted Emission from GPS VTS RX board (SMS based) with and without filter.

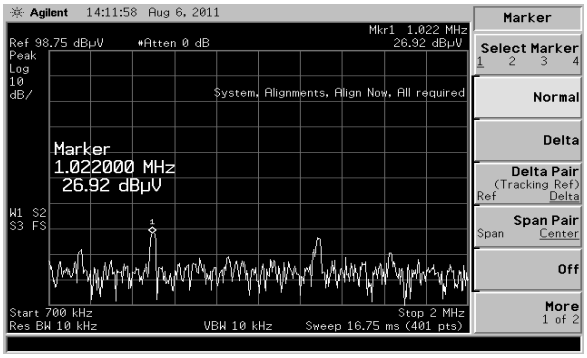

Figure 11. Conducted emission without RFI filter

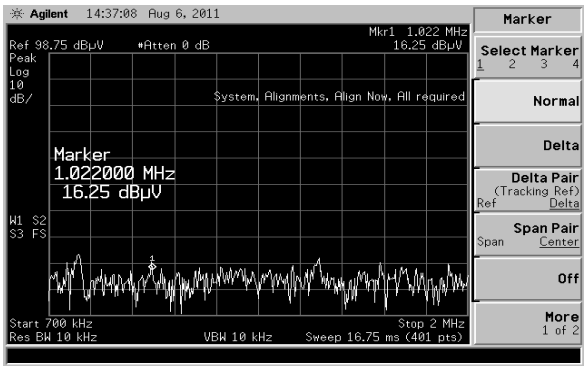

Figure 12. Conducted emission with RFI filter

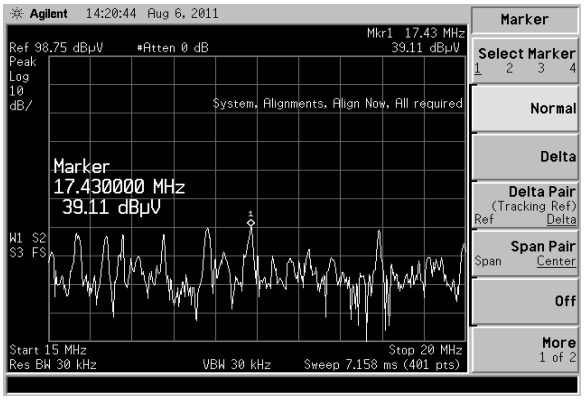

Figure 13. Conducted emission without RFI filter

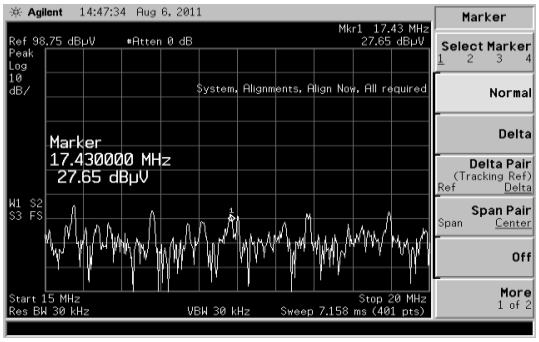

Figure 14. Conducted emission with RFI filter

The Conducted Emission (CE) levels measured in dBµV at different frequencies were observed for GPS VTS Boards with and without RFI Filter and plotted on Y- axis against frequency in MHz on X-axis. Figures 15, 16 and 17 show these plots. From the above observations, Conducted Emission levels from these GPS VTS Boards were found to be less than 50 dBµV without RFI Filter. These Conducted Emission levels were reduced by around 15dB to 20dB by incorporation of RFI Filter in the power supply lines. The levels were restricted to around 35dBµV.

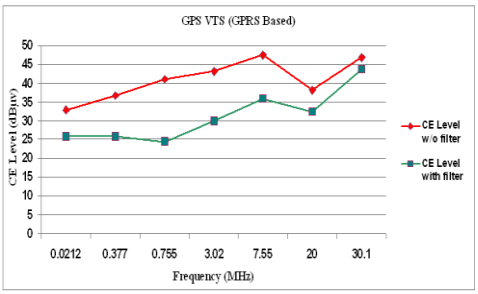

Figure 15. GPS VTS Board (GPRS Based) CE level with and without RFI filter.

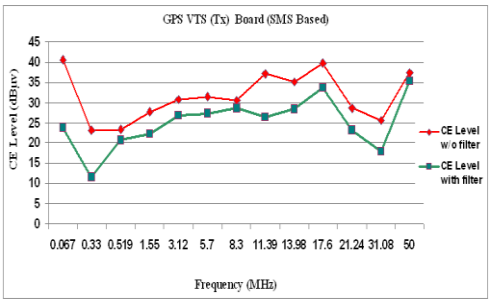

Figure 16. GPS VTS TX Board (SMS Based) CE level with and without RFI filter.

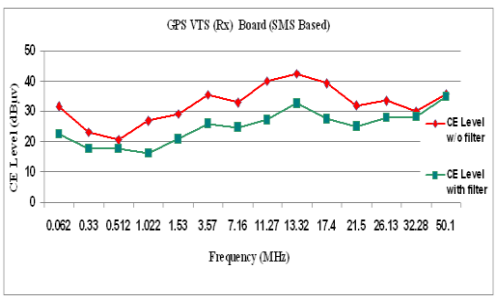

Figure 17. GPS VTS RX Board (SMS Based) CE level with and without RFI filter.

Fig. 18 shows Conducted Emission limits for MIL-461E, FCC and CISPR standards. [4], [10], [11]

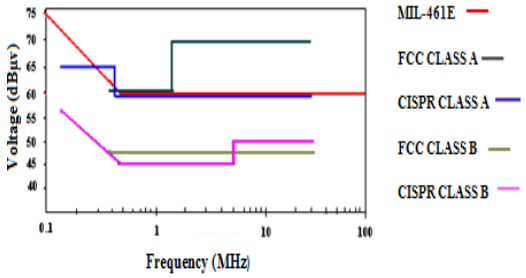

Figure 18. MIL-461E, FCC and CISPR22 conducted emission limits.

The observations in figure 15, 16 and 17 were compared with these standards. The Conducted Emission levels for GPS VTS Boards with RFI Filter were found to within the maximum limits of these standards. Hence models implemented with GPS VTS Boards with RFI Filter could meet compatibility requirements of these standards for Conducted Emission limits. The Conducted Emission Test on GPS VTS Transmitter (TX) Board had already been conducted in national EMI Test Laboratory, Automotive Research Association of India (ARAI), Pune, India. The paper indicated at reference [12] published these test results and results were compatible with MIL - 461E standard.

VI. Conclusion

The Conducted Emission from GPS VTS Boards power supply cable had been investigated. The RFI Filter connected in power supply section of GPS VTS Board was effective for reducing the Conducted Emission Level by around 15 dB to 20 dB. The Conducted Emission level for GPS VTS Boards with RFI Filter was restricted to around 35dBμV. The Model 1 and Model 2 incorporating GPS VTS Boards (GPRS/SMS Based) with RFI Filter could meet compatibility requirements with MIL-461E, FCC and CISPR EMI/ EMC Standards for Conducted Emission.

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