

# Conducted Susceptibility Assessment of Music Infotainment System

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**Abstract**—Today is the world of dense EMI environment. Therefore, all the electronic equipments are constantly being exposed to EMI. While the installation of any electronic equipment, wiring may act as receiving antenna for RF signals, which may result in impairment of its operation. EMI such as lightning, electromagnetic pulses, transients, RF noise, etc get coupled to a product directly through its AC/DC power lines and input/output lines. Therefore, to protect the devices from breaking down in the presence of such interferences, there is a need for them to undergo Conducted Susceptibility testing. Music infotainment system usually installed in our vehicles may also get affected by RF noise and transients. This paper mainly lays emphasis on Conducted Susceptibility testing of Music Infotainment System conducted at General Industrial Control, Pune, India test laboratory. This model with and without RFI filter was tested for Conducted Susceptibility where transient glitch of  $\pm 100V$ ,  $1 \mu s$  was generated and RF input of 5V and 1V RMS for a sweep of frequency band 100 KHz to 250MHz and 250 MHz to 410 MHz respectively was connected to the power supply line. Observations for any malfunctioning in the operation of equipment were made.

**Keywords**—EMI/EMC, Conducted Susceptibility, RFI filter, Transient Absorber, Automotive Test Standard.

## I. INTRODUCTION

Electronic equipments that we use in our day to day life are constantly being exposed to Electromagnetic Interference present in the environment. These interferences can be in the form of lightning, electromagnetic pulses, RF noise, etc which gets coupled to a product directly through AC / DC power lines and input / output lines leading to the equipment malfunctioning. Electromagnetic field produced by electromagnetic pulses are strong enough to produce short duration transient voltages on electric conductors such as wiring, conductive traces on printed circuit boards which acts as a receiving antenna for these signals. Receivers of all types are highly sensitive to electromagnetic pulses and mainly transistors and diodes are destroyed when exposed to high voltage transients. Due to the presence of lengthy copper cables between devices, Telecommunications equipment is also highly exposed to these interferences. Also, in PCB designs, EMI can get coupled from the ground plane which interferes

with all the IC pins and has worse effects when ICs are connected to long wires [1, 2].

Therefore, there is a need for electronic devices to be designed in such a manner that they do not malfunction when exposed to these interferences. Thus, Conducted Susceptibility testing of electronic/wireless equipments is highly recommended to mitigate these effects. The equipments can be made EMC compatible by introducing RFI filter, surge arrestors and by implementing proper grounding techniques.

Music Infotainment System operating at 12V DC with accessories like car speakers, mobile audio power amplifier, subwoofers generally installed in vehicular platform has been taken as the model for research work. It has an additional feature of steering wheel control and also supports Bluetooth, SD card port, SMS notifications. If, any kind of EMI like transients or RF noise gets coupled to this device, may result in the malfunctioning of its operation.

This paper mainly lays emphasis on Conducted Susceptibility testing of Music Infotainment System, its results, and how EMI can be minimized by introducing various mitigation techniques from getting coupled to the equipment.

## II. CONDUCTED SUSCEPTIBILITY TESTING

Conducted Susceptibility tests are performed to monitor the operation of the Equipment under test to make sure whether there is any disruption in its operation or not and if present, then up to what extent and the disruption is acceptable or not. The major source of transients and RFI noise in automobiles is vehicle ignition system, engine, power system and other electronic equipments from which transients and RFI noise gets coupled into the cables, supply lines, etc and may affect the functionality of the system adversely [3].

The test is destructive test and it can damage permanently the sensitive processors and sensitive electronic components if due care is not taken in the design. The transients generated on power supply line would be reaching to power supply pin of the ICs damaging them permanently. Conducted Susceptibility testing has the characteristics of energy efficiency, repeatability, simplicity and less time consuming when

conducted with the use of Bulk Current Injection (BCI) probes clamped on cables [4].

The Music Infotainment System unit with and without RFI filter and transient suppressors had been mounted in EMI chamber. For transients, during this test the transient glitch of  $\pm 100$  V,  $1 \mu\text{s}$  with repetition rate of  $100 \mu\text{s}$  and total duration of  $1$  ms was generated by spike generator and for RF noise, RF input at sweep of  $5$  V and  $1$  V RMS for frequency band  $100$  KHz to  $250$  MHz and  $250$  MHz to  $410$  MHz respectively was connected to the power supply line [5, 6].

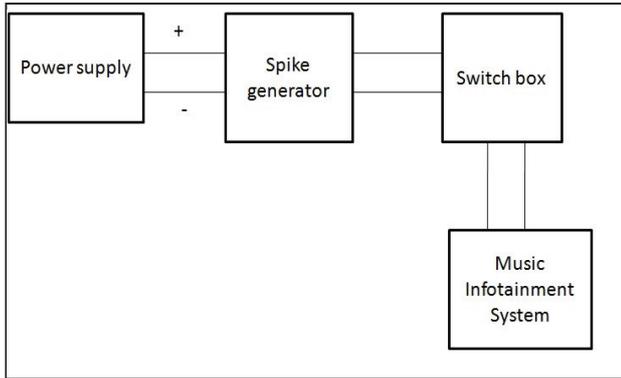


Fig. 1. CS test (Transients) conducted at test laboratory

Figure 1 shows the test setup for Conducted Susceptibility (Transients). In this, the transient glitch of  $\pm 100$  V,  $1 \mu\text{s}$  with repetition rate of  $100 \mu\text{s}$  for total duration of about  $1$  ms was generated by signal generator as per Automotive standard ISO 7637 - 2 and these spikes were then added to the  $12$  V supply cable of Music Infotainment System [6].

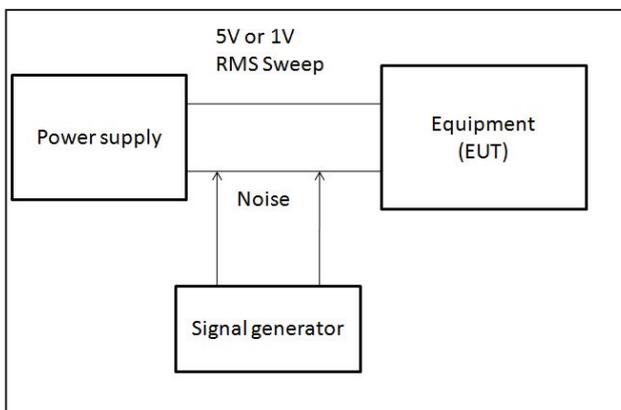


Fig. 2. CS test (RFI) conducted at test laboratory

Figure 2 shows the test setup for Conducted Susceptibility (RFI) as per Automotive Standard ISO 11452 - 4. In this, RF signal was introduced on  $12$  V supply of Music Infotainment System [7].

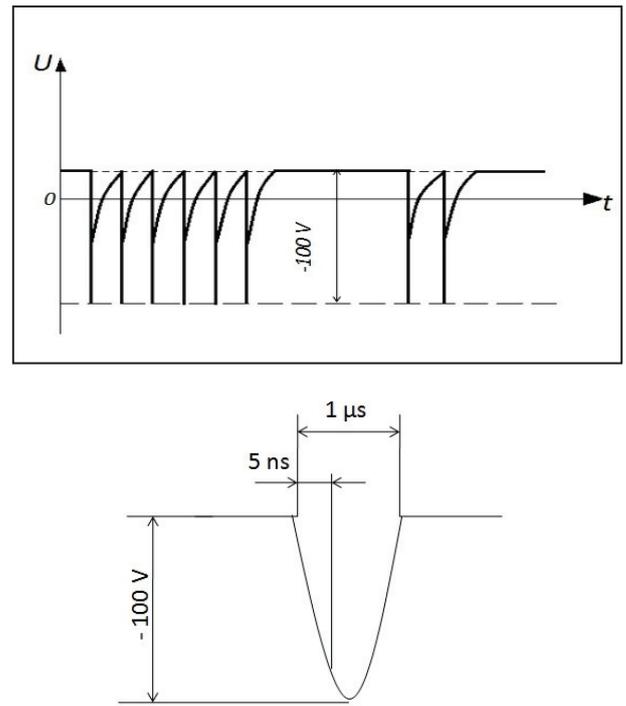


Fig. 3. Test pulse 1 produced for Conducted Susceptibility

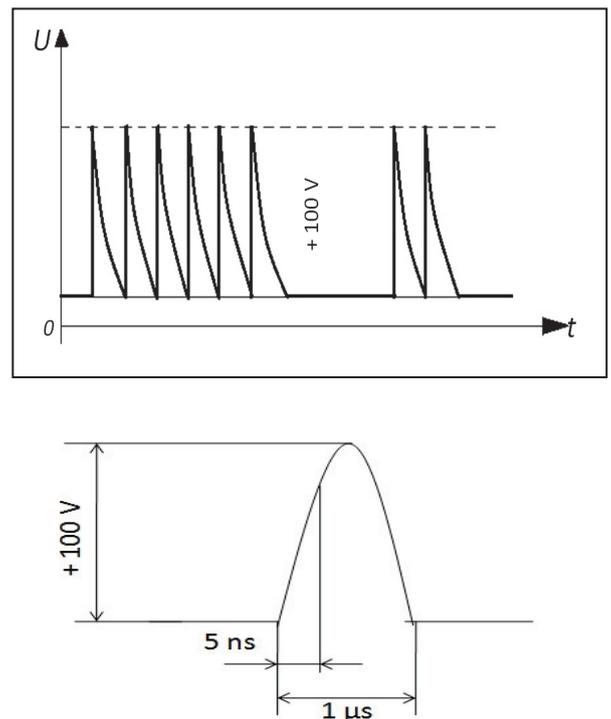


Fig. 4. Test pulse 2 produced for Conducted Susceptibility

Figure 3 & 4 shows the transients generated for Conducted Susceptibility testing. These transients were introduced at power supply section of the Music Infotainment System to conduct CS test for transients [5].

### III. MITIGATION TECHNIQUES

There are few techniques that can help in protecting these transients and RFI noise from getting coupled to the AC/DC line and input / output lines of the equipment [8].

1. Introduction of in - house designed RFI filter to isolate RF noise.
2. Introduction of transient suppressors to suppress the transients.
3. Proper grounding system provides protection against emission.
4. Use of shielding cables and EMI proof connectors.

These methodologies are adopted practically as described in the section IV.

### IV. METHODOLOGY ADOPTED

For Music Infotainment System Aluminum Enclosure of dimensions of 290 x 190 x 120 mm with material thickness of 1mm coated with conductive paint and sealed with conductive gaskets with shielding effectiveness of around 100 dB has been designed to prevent it from getting exposed to the radiations.

To suppress the transients entering into the system through power supply line or input / output lines, RFI filter and Zener over voltage Transient suppressors has been introduced in the power supply section of the Music Infotainment. To suppress the transients, RFI filter, Zener over voltage Transient suppressors with 600 W peak power rating has been introduced in between the power supply lines of the model and RFI filter was designed to isolate RF noise on power supply lines. Two separate EMI proof connectors were used for Ground and VCC as per EMI/EMC standard and also shielded cables were used to protect the transients from getting into the AC/DC lines or input/output lines [8].

Normally, Zener Diodes and Metal Oxide Varistors are used to suppress the line voltage surges but are not effective enough to limit very large surge. Therefore, we proposed transient absorbers which possess the advantage of handling high energy content to bypass the high spikes from getting coupled into AC/DC lines or input/output lines.

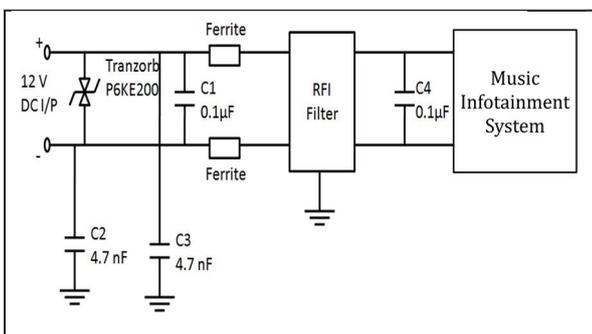


Fig. 5. Music Infotainment System with RFI filter and Transient absorber

### V. TEST RESULTS AND DISCUSSION

Transients were introduced in the 12 V supply line of Music Infotainment system. It had the potential to damage the ICs which may affect their operation. Also, RF signal was injected on the 12 V supply to the model through signal generator which interferes with the supply lines, cables, etc damaging the device and severely affecting the system functionality. Music Infotainment system performance was investigated for Conducted Susceptibility test.

RFI filter to isolate the RF noise from entering into the system and Zener over voltage transient suppressor to suppress the strength of the transients were introduced in the power supply section of the model.

Upon implementing several mitigation techniques like proper grounding system, introduction of RFI filter and transient absorber, shielded cables, EMI proof connectors, tests were re-conducted.

After the destructive Conducted Susceptibility test with transients and RF noise, the Music Infotainment System was found to be functioning satisfactorily and observations were found to be fulfilling the requirements of EMI/EMC standards.

Thus, we can say that with the introduction of RFI filter, transient absorber, use of shielded cables and EMI proof connectors and by adapting several other mitigation techniques, its operation was found satisfactory, thereby proving the effectiveness of the technique used. No destruction was observed.

Therefore, with the introduction of RFI filter, transient suppressor and enclosing the model in Aluminium enclosure and by adopting other mitigation techniques, it did not malfunctioned upon being exposed to radiation proving the effectiveness of the technique proposed. No operational failure was noticed while operating the system during the test and Music Infotainment System was found compatible with the Automotive Standard ISO 7637 – 2 and ISO 11452 - 4. Design of RFI filter and introduction of Transient absorber was very effective in suppressing its effects.

### VI. CONCLUSION

Conducted Susceptibility test for transients and RFI noise was conducted on Music Infotainment System. After incorporation of RFI filter and Transient suppressor with 600 W peak power rating, the system was found to be protected from transients and RF noise from any kind of damage. Use of Shielded cables, EMI proof connectors separately for ground / VCC, enclosing the model in Aluminum enclosure coated with conductive paint and sealed with conductive gasket reduced the effect of radiations. The techniques also ensured protection from transients from getting into the AC/DC lines or input/output lines. Music Infotainment System was found to be compatible for Conducted Susceptibility with the EMC requirements as per Automotive standard ISO 7637 – 2 and ISO 11452 – 4.

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