International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 4 Issue 12, December-2015

Study of Electromagnetic Interference Generated from the Sub-System of Pulse Discharge System

Surender Mohan[1], Jitender Khurana[2]

[1]Research scholar, Electronics Department, Baba Mastnath University, Rohtak, Haryana
[2]HOD, Electronics Department, Baba Mastnath University, Rohtak, Haryana

ABSTRACT

In this paper, the electromagnetic interference generated by high voltage components studied. The paper investigates the electromagnetic emission in a pulse discharge system. It consists of pulse generation section, command section, controller section and transmission line. On receiving charging command the charging circuit charges the energy storage capacitor which is the part of pulse generation section. When control section issued command, the trigger circuit initiates the electronics switch; the charged capacitor gets discharged through the load of very less inductance and few milliohms. The low inductance load results in high rise time pulse at the output of the system. The emission measurement were carried out as per the MIL_STD 461E. The measurements were carried out in time domain with active rod antenna, conical antenna, log periodic antenna and horn antenna in the frequency band 10 kHz to 18GHz. The functionality of the system was checked during test. Additionally measurements were also done before and after the test to ensure proper calibration of the test setup. The results of electromagnetic emission were recorded. The system performance also analyzed parallel and recorded in real time. The quantitative measurement and characterization are helpful in analysis of noise generated by high voltage pulse discharge system and to mitigate the noise effecting the nearby system operating at very low voltages.

INTRODUCTION

Electromagnetic interference is the phenomena resulting in degradation of performance of a component, sub-system or a system due to electromagnetic disturbance. The conducted interference occurs because when the source is connected to the receptor by cables. The interference propagates from one system to the other along the cables. However the problem can be easily addressed by using in line filters. Radiated interference can affect any signal with in equipment and is much more difficult to shield. The mechanism by which radiated electromagnetic energy couples to the circuit is governed by Faraday's Law [1].

The small leads and tracks act as antenna and the high frequency signal generated during discharge of high voltage gets coupled to the system through these antennas. This results a strong absorb and cause them to misbehave. The digital circuits may get effected severely [4]. For near-field radiation measurement, a few millimeters change in antenna size can affect the results. It is very difficult to analyze the receiving power from near field radiation in mobile antenna because of their very small size [6]. With the advancement in semiconductor technology the operating voltages for digital circuits has come down drastically. This is reduced the power requirement however the same has increased their susceptibility towards EMI.

To mitigate radio frequency interference and achieve high speed control, complete isolation of the control system from high voltage supplies is achieved by using optical digital signals for every interface between these systems [7]. It is not possible for aerospace system to use the optical system because the space requirement is very important criteria of these types of systems. Any flight worthy system consists of an on-board system and supporting ground system. The flight system consists of control and guidance system, radar and ignition control system. The electromagnetic compatibility at system level is not possible without addressing it at sub-system level [2].

In a complex system like missile or satellite, different systems are provided by different agencies. In standalone mode every sub system works fine but when integrated together, the failure/ malfunction observed. This is mainly attributed to the EMI from one system to another. This makes system integration a very complex and critical job. The system integration is the process of packaging of all essential sub-system into single entity for predefined intended function. Malfunction of any of the sub-system due to integration may fail the entire mission. Electromagnetic interference and electromagnetic compatibility among the sub-systems in a compact space are vital design consideration for successful design and development of any critical system for defence, aerospace, automobile and medical applications etc.

PULSE DISCHARGE SYSTEM

The pulse generator circuit is based on capacitor charge transfer pulse generator topology. Due to fast discharge, high frequency electromagnetic waves are generated which gets coupled to different sub-system in the vicinity. Various digital systems operate at very low voltage level and have different frequency of operation. Hence it is very critical for the system operating at low voltage for consistence performance. The block diagram of pulse discharge system is shown in figure1.

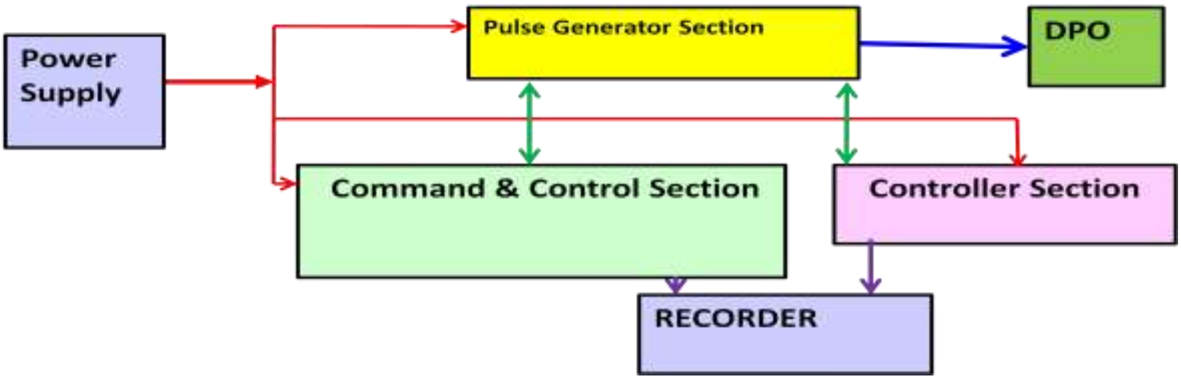

Figure1: Block Diagram of Pulse Discharge System

It consists of pulse generator, command interface and controller section. This system used in our analysis has controllable and capable of generating the output current upto 10 kAmp. The system is controlled by controller section. The pulse generator section converts the low voltage into high voltage.

At charging command energy storage capacitor was charged and at discharging command the capacitor was discharge through the electronic switch to the load. The transmission lie used was double braided cable of a low inductance (0.04µH/m) and low impedance (11mΩ/m). Figure2 shows the measurement setup with system under test placed. The system performance was recorded in real time. The system voltage was measured with high voltage probe (FLUKE 80k-40 HV Probe) and Multimeter (FLUKE-115). The peak output current was measured and recorded in digital phosphorus oscilloscope (DPO).

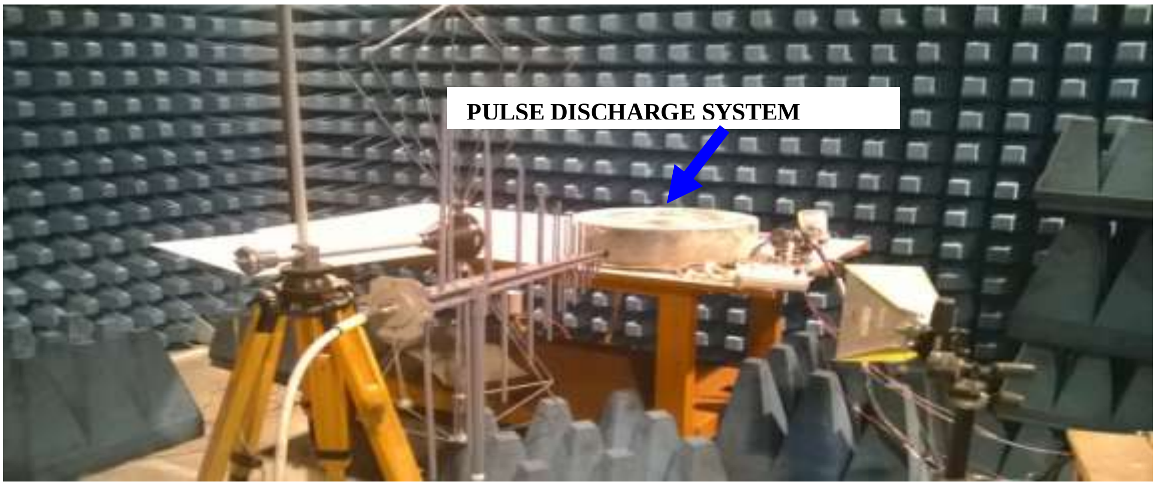

Figure 2: Photograph of measurement test set up

The peak output current of the pulse discharge system is give by the equation (1)

$I_{Peak}=V_c / (L/C-R^2/4)^{1/2}$ --- (1)

Where

- I_{Peak} - Output Peak Current (kA)
- V_c -Capacitor Voltage (kV)
- R- Total Circuit Resistance (Ω)
- L- Total Circuit Inductance (µH)
- C- Total Circuit Capacitance (µF).

The total circuit capacitance is the sum of the paratactic capacitance in the circuit, energy storage capacitance and the circuit capacitance. Here the capacitance of the energy storage capacitor was taken in consideration because the other circuit capacitance value (few Pico farads) was very less tan this capacitor (μF).

EMI MEASUREMENT TEST SET UP

The study of EMI radiated emission in the system was carried out to check the proper function of all the sub-system in the pulse discharge system. The main purpose of this test was to confirm that electric field which is emitted from the system is within the acceptance limit. The acceptance limit line for aircraft and space system application was used during the test measurements. The acceptance limit was used for measurement as per table1.

Table-1

Frequency Range	Field Intensity
10kHz to 2MHz	From 54 dBμV/m to 24 dBμV/m (decreasing)
2MHz to 100MHz	24 dBμV/m
100MHz to 18GHz	From 24 dBμV/m to 69 dBμV/m (increasing)

The frequency band of 10 kHz to 18 kHz was used for the measurement. Since one antenna does not cover the entire band of frequency, various antennas as listed in table 2 were used to measure the field in different frequency band.

Table-2

Frequency Range	Antenna used
10kHz to 30MHz	Active Rod Antenna
30MHz to 200MHz	Bio Conical Antenna
200MHz to 1GHz	Log Periodic Antenna
1GHz to 18 GHz	Horn Antenna

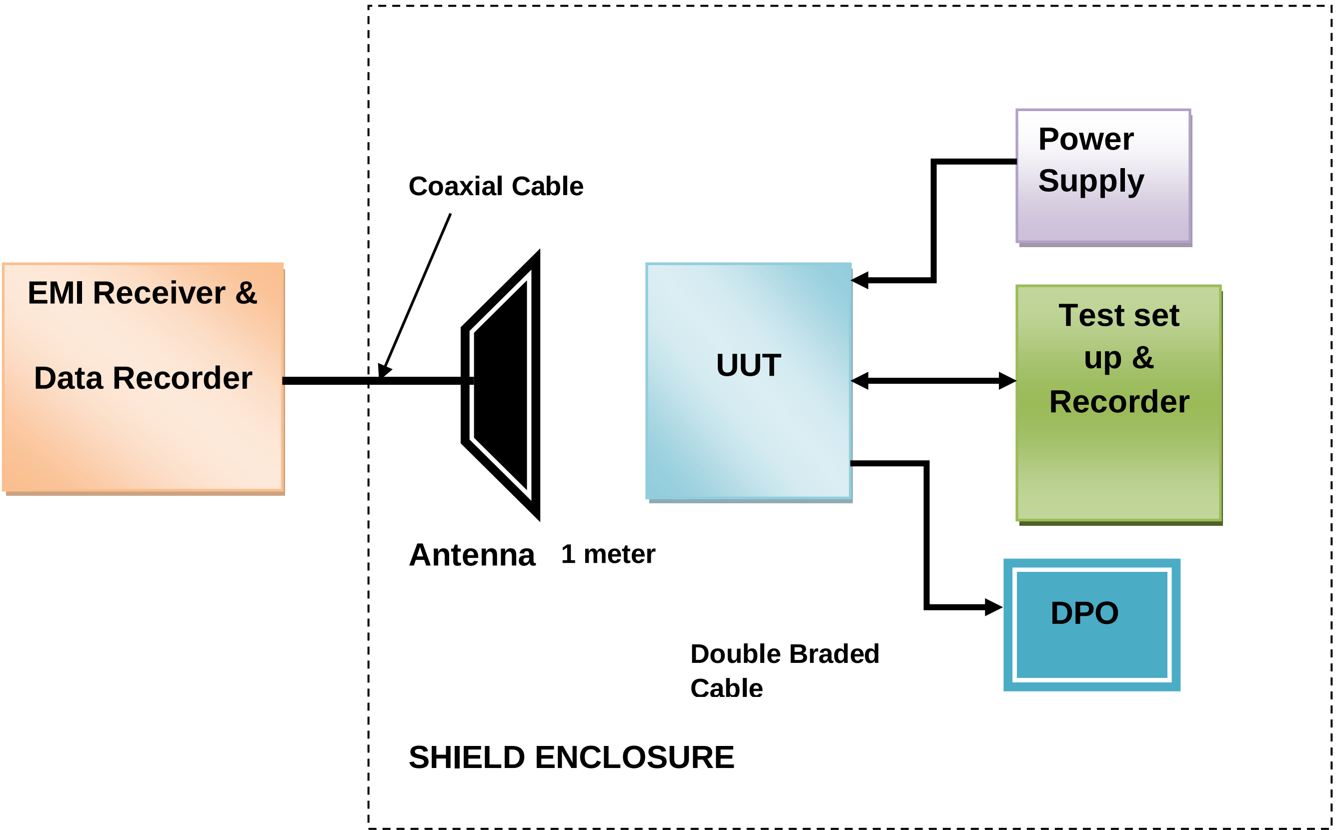

Figure 3: EMI Measurement Set Up

The test set up for EMI measurement is shown in figure 3.The antennas were kept 1m away from the system. EMI Test receiver and data recorder (Make – Rohde & Schwarz, Model No - ESIB 40) was placed outside the shield enclosure. The antenna was connected with EMI test receiver with the coaxial cable. The field measurement was carried out with Active Rod Antenna (Make- RODHE & SCHWAEZ, 9 KHz-30MHz), Bio Conical Antenna (Make- ETS – LINDGREN, Model No.-31408), and Log Periodic Antenna (Make- LINDGREN), Horn Antenna. The system under test was connected with the power supplies (Make-TDK – Lambda, Model No.- Zup 36-12, 0-36 V, 0-12A) and testing cable looms.

The output of the pulse discharge system was connected to DPO. The output current was measured with current probe (Make-ION physics, Model No CM-1-L) which is based on Rogowski principle for measuring the current pulses. The output current was recorded with the 50Ω termination on the DPO (Make –Tektronix, Model No -TDS 3054C, 500 MHz, 5GS/s). Various parameters of the system were monitored on the test set up and recorder. The system output current waveform was as shown in figure4. The peak current was in kiloampears and the pulse width is in microsecond. A high di/dt trigger spike is generated which is the main source of radiated and conducted noise.

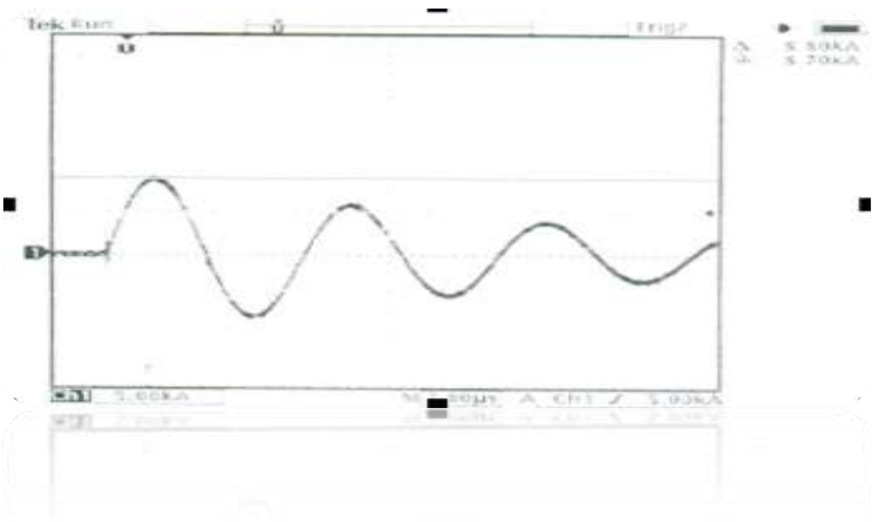

Figure 4: OUT PUT Current Waveform of PDS

RESULT AND DISCUSSION

The test results were recorded at various levels in MIL-STD -461E RE102 test [8]. The test was carried out for both horizontally and vertically polarized fields. The system performance was tested after the test set up inside the shielded chamber. The system under test was integrated in the container. The test was carried out when the cover plate of the system was open. The emission measurement was monitored during charging and discharging of the capacitor. The measured emission levels were higher (25 to 60 dBµV/m) from 30 MHz to 1 GHz. The test results were shown in figure 5.

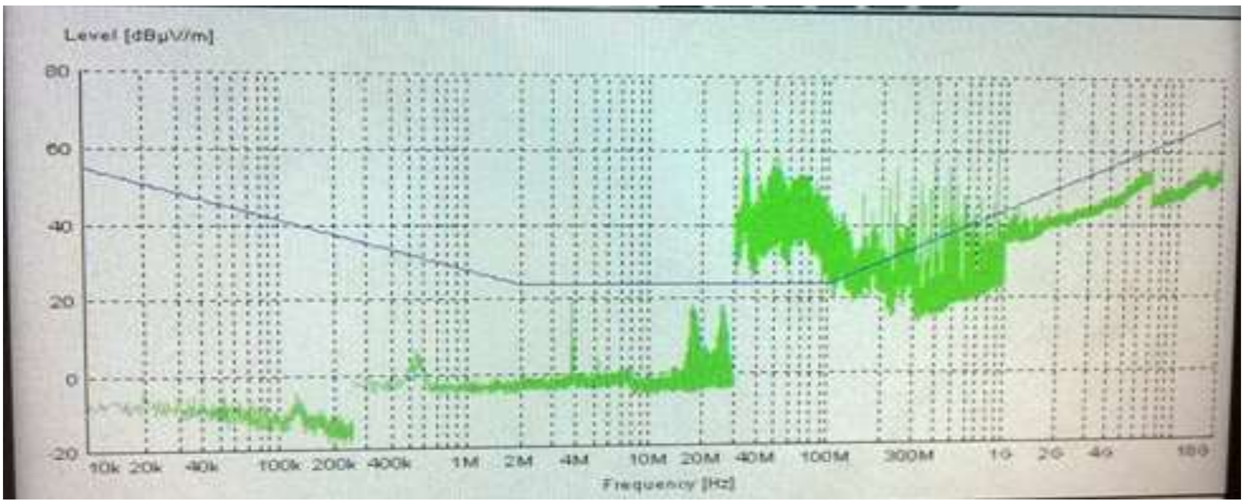

Figure 5: Emission when PDS was in open Condition

The system was closed with cover plate and again the test was conducted. The emission level reduced to acceptance limit line (24 to26 dBμV/m) from 30MHz to 100 MHz. The test result was shown in figure 6. The test results were taken system was closed with cover plate, shielded the port holes and cover all the power supplies, cables ,transmission line with the observers, the measured emission level was below acceptance limit (22 dBμV/m). The results shown were in figure 7.

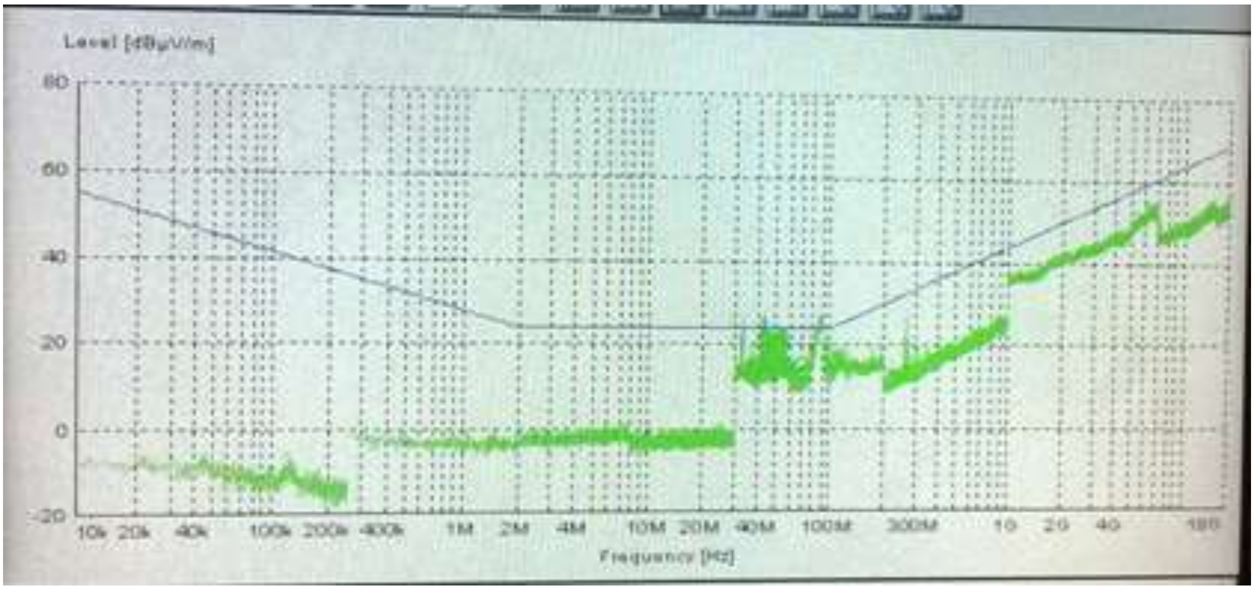

Figure 6: Emission when PDS was in Closed Condition

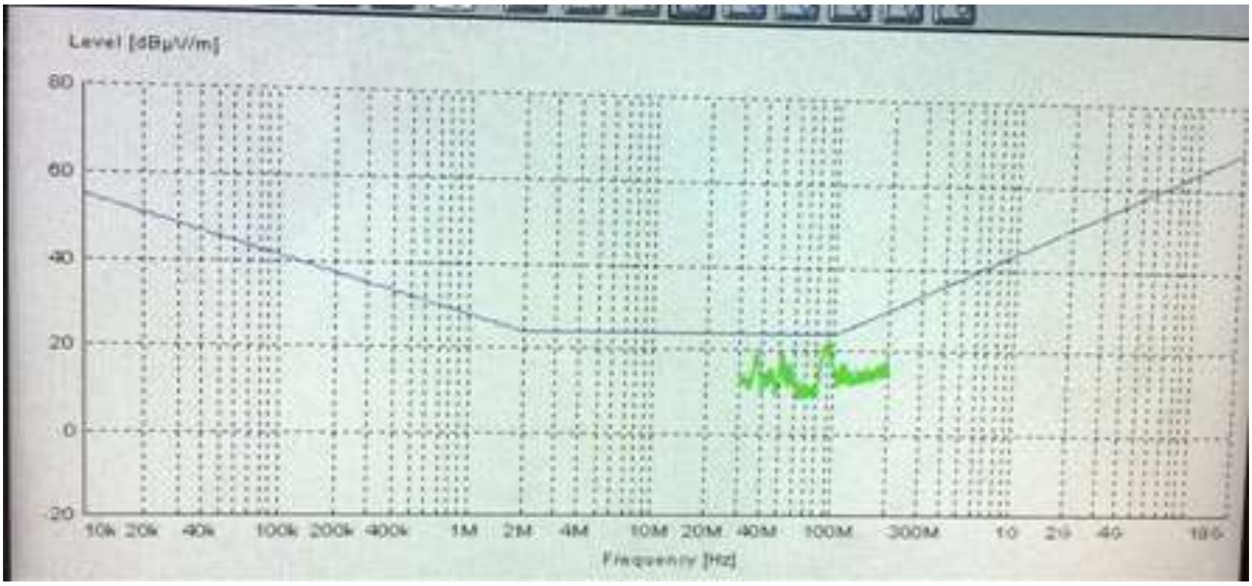

Figure 7: Emission when all the port hole sealed and covered sealed open Condition

CONCLUSION

Pulse discharge system is an important system in the flight hardware. The system should function in the electromagnetic environment and also not cause electromagnetic interference to other sub-system which is placed near to this. As per analysis, it shows that the field intensity 60 dBμV/m, which is much higher than acceptance limit (24 dBμV/m) as specified in Mil-Std -461E for airborne and missile system using pulse discharge system was in higher side when the system operates with open condition. This result in malfunction of digital sub-system placed in the close vicinity. However after using the metallic shield of copper mesh the resulting in effectiveness. The noise was less down EMI with in the limit of 22dBμV/m. However careful design of sub-system and proper shielding method may result in reducing the EMI and make the system work satisfactorily and as per its intended function. As long as voltage and current are being switched, electromagnetic noise will be generated and need to be addressed.

REFERENCES

[1]. JW Motyoux- Child: “EMC shielding materials".
[2]. Michael Abrames, (2003)," Drawn of the E-Bomb,” IEEE spectrum, pp. 24.
[3]. Gyu Yeong Cho and Wee Sang Park,"On the Validity of Approximate Formulas for Correlating TEM Cell and Near-Field Transmission Measurement," IEEE Transactions on electromagnetic compatibility, Vol.57, No 2, April, 2015.
[4]. Sherry Rosily, Manjiri Pande, Pitamber Singh," Interlock and Protection System for 1MW klystron RF System of LEHIPA," 2013 International Conference on Control Communication and Computing (ICCC).
[5]. Sandeep M. Satav, V.V. Rama Sarma, “EMI-EMC issues in system Integration".
[6]. Mil-Std-461E, “Requirements for the control of Electromagnetic interference characteristics of subsystems and equipment”.