International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 5 Issue 1, January-2016

Investigation of Electromagnetic Interference Generated by Switching Devices on Controller Based System

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ABSTRACT

Electromagnetic interference generated by switching devices is the major problem in the digital circuits facing today technology and study of this is discussed in this paper. The study, investigate the effect of electromagnetic emission on a controller system generated by electromechanical relays. It is the part of pulse discharge system which consists of relay board, controller section and pulse power module and ground system unit. The ground system unit activates the relay board, the power transfer from one stage to the other stage of the relay board and controller section control the pulse power module to generate the high output current pulse. The noise measurement was carried out with high voltage probe and digital phosphorus oscilloscope. The conductive emission test was carried out as per Mil-Std-461E. The measurements were carried out in time domain in CE102 test with 10 kHz to 10 MHz of frequency band. The functionality of the system was checked during the test. The measurements were taken twice before and after the test for authentication of results. The result of electromagnetic emission was recorded. The system performance was also analyzed parallel and recorded in real time. These measurements were helpful in analysis of EMI generated by switching devices on the controller based system and to mitigate the noise effecting the nearby system operating at very low voltages.

1. INTRODUCTION

The electromagnetic environment is an integral part of the world in which we live. It created by intentional, unintentional and natural sources. When, these sources sufficiently strong enough to create interference or disturbance in the operation of many electronics equipment and systems. Its effects range start from minor disturbance in broadcast reception to potentially fital accidents due to failure of safety critical control systems of aircraft, ship, missile and many more. There are three basic elements for EMI a source, a victim and a coupling path. If any one of these is missing, problem of EMI would not be there. Unfortunately, all three components are available all the time. The EMI can couple to victim either via radiated way or conducted way and some time simultaneously by both medium. A reverse action may also take place if the victim itself has strong enough electromagnetic emission to interfere the source.

The high frequency switching operation in power electronics devices has improved the dynamic performance but created the unexpected problems and high levels of conducted EMI. The passive filters eliminate the some part of the noise emitted from power devices. The LC and RC passive filters reduces the over voltage of the ac motor when derived by PWM. However only a certain part of noise gets eliminated using the passive filters as the compensating bandwidth is comparatively narrow [1].

The modern power switches used in power supplies with those from older generation, the new switches have significantly reduced the switching times, leading to faster and faster rise and fall times for the voltage and current waveforms. These fast edges produce significant energy at surprisingly high frequencies and are the root cause of all EMI problems. As long as voltage and current switched, EMI problem will be there [2].

The integrated circuits are facing different challenges with its high speed features. The EMI emission from the switching devices is the biggest challenge. The reduced size of the electronics devices and the faster speed are important factor for increasing EMI. As the size gets compact and in close proximity of the conductor causes the interference with in the signals in the device. There are two source of EMI, one is due to physical contact, which is called as conducted emission and it is measured below 30 MHz The other is radiated emission, which is found above the 30 MHz of frequencies [3]. The conducted emission depends upon many factors such as parasitic inductor and capacitor, ringing, voltage stress [4]. The parasitic components play an important role in the generation of noise. The stray capacitances between the high line and return are the main source of EMI in the circuit [5].

In the aerospace system different systems operate at different voltage levels and frequencies. This system performed in a complex noisy environment with different type of relays / switches operations. The switching operation of relay i.e make and break (ON/OFF) may leads to EMI. In a complex system, like the system used in aerospace applications, all the sub system integrated in closed and compact platform. These systems moved in the high speed and function in a predefined manor in that environment. Any sub-system failure/ malfunction due to EMI may fail the whole mission. Electromagnetic compatibility among the sub-systems in a closed space is critical design consideration for the system designed for industrial, medical, aerospace and defence applications.

2. EMI/EMC CONCEPTS

Electromagnetic interference is a serious form of noise, which adversely affects in operation of the electrical and electronics systems. The effects of EMI are variable from small disturbance to major system failure. The simple block diagram of EMI coupling is shown in figure1. The condition of EMI exists when all the three elements are present i.e. emitter, receptor and the coupling path. The emission generated by emitter is travel via cables or through air and get coupled to the receptor.

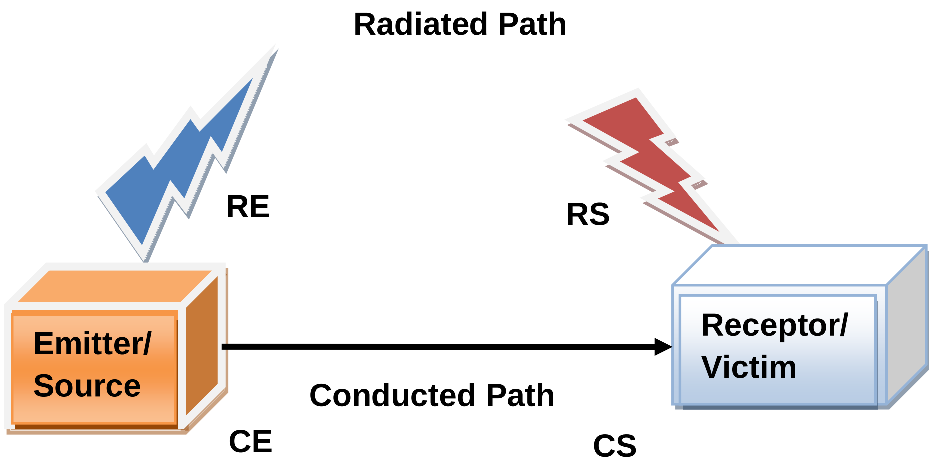

Figure1: EMI coupling Path

There are two coupling modes

a) **Radiation coupling**: **-** It is between the emitter and receptor through air. It can affect any signal path with in the equipment. The mechanism by which radiated electromagnetic energy becomes EMI is governed by Faradays Law [6]. The power and signals wires may act as radiating antenna and may behave like a receptor antenna under favorable conditions.

b) **Conducting coupling**: **-** It is between emitter and receptor through cables. The conducted interference occurs when the source is connected to the receptor by power or signal cables the interference is propagated from one unit to other along the cables. It usually affects the main supply to and from the equipment.

The EMI threat can be controlled by adopting the practices of electromagnetic compatibility. It is the ability of equipment, sub-system or a system to function satisfactorily without cause any degradation in the performance of other system in that environment and also without suffering interference from other sources.

3. SYSTEM DESCRIPTION

The pulse discharge system consists of relay board, controller based system and pulse power module and the ground system unit. The ground system unit was used to activate the relay board as and when required. The power from one stage to the next stage is switch by relay board which is having the number of electromechanical relays. The controller based system used to control in generation of high voltage in the pulse power module section. The controller based system having the power card and FPGA/ microcontroller card. The power supply used for pulse power module was routed through controller section. The pulse power module converts the low voltage into the high voltage. The block diagram of pulse discharge system is shown in figure2.

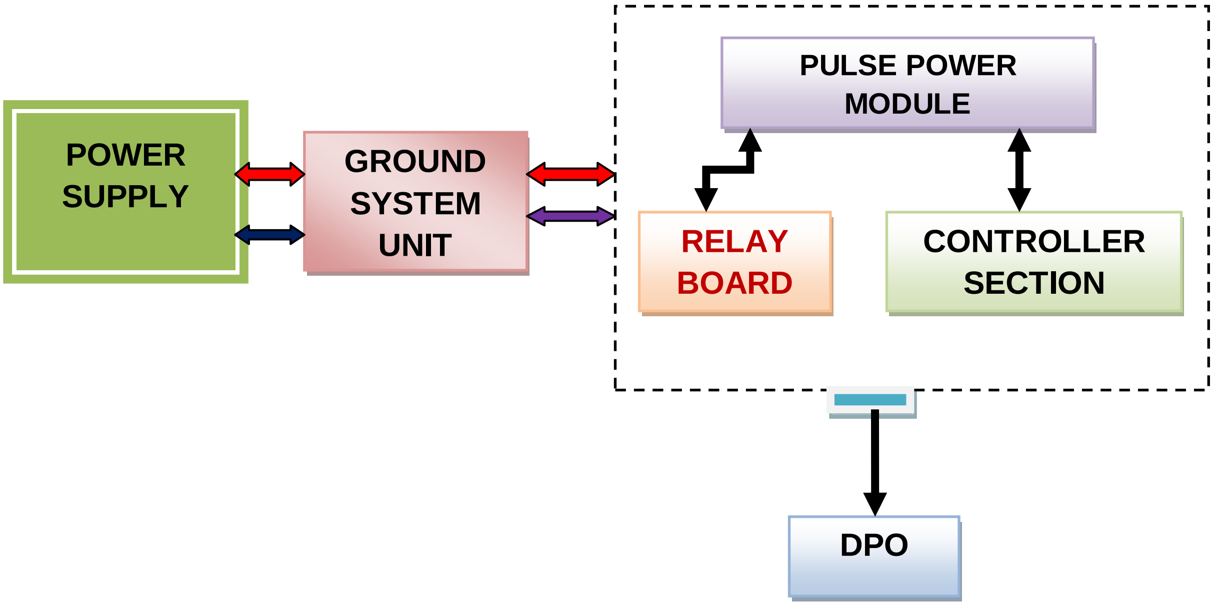

Figure 2: Block diagram of pulse discharge system

4. TEST INSTRUMENTATION AND EMI MEASUREMENT TEST SET UP

The noise measurements was carried out and recorded in DPO (Make- Tektronix, Model No. TDS3054C, 500MHz, 5GS/s). High voltage probe (Make-Tektronix, Model- P6015) and the DPO probes (Make- Tektronix) were used to sense the noise on the power lines and the signals lines. The power supplies used to power up the system were Regulated DC power supplies (Make –Aplab, 0-32Volts, 2A and 0-32Volts, 5A). The investigation of conducted noise in the system was carried out to analyses the affect of switching voltage on the function of the controller. The relays in the relay board switching & controller section communication was checked a ground system unit. The DPO probe was connected at high line and also to the low line of the supply with respect to the chassis of the system which routed through the controller section to monitor the noise level on the supply lines during switching of the relays. The input required for the controller section was 30V and the digital signals in the controller works on 3.3 V. The study of conducted emission was carried out to check the system performance. The main purpose of the test was to confirm that the emission which was emitted from the system is within the acceptance limit. The block diagram for the measurement set up is shown in figure3.

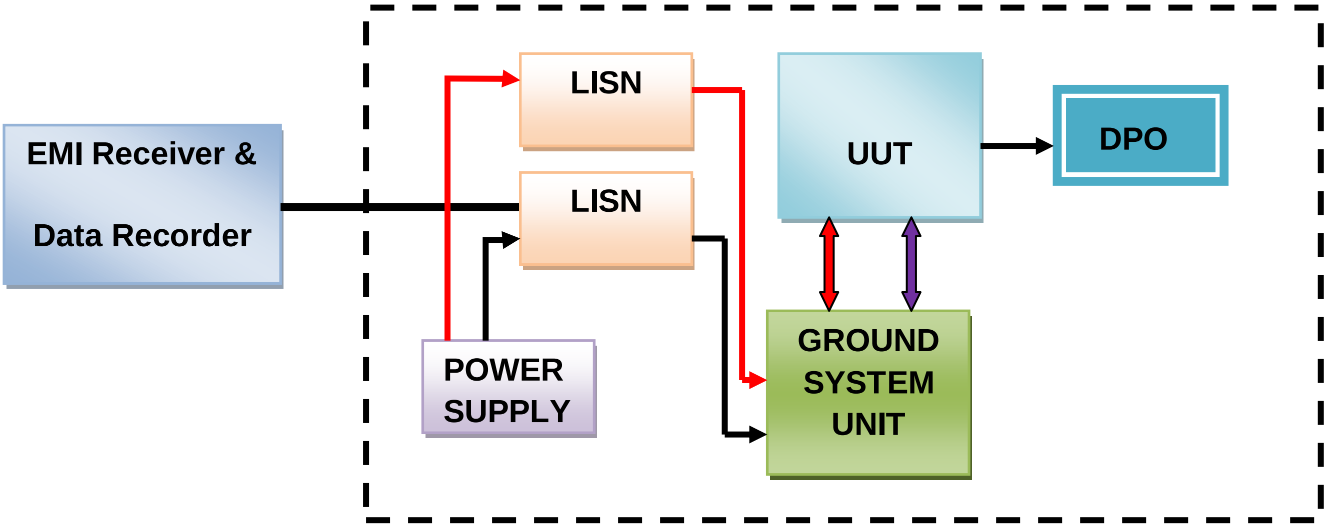

Figure 3: Block diagram of measurement set up

The measurements were carried out using the LISN (Model No-9233-50-TS-50-N, Make- Solar Electronics. Co.) with in the frequency band from 10KHz to 10 MHz The unit under test was set to operate with fully loaded condition. The RF voltage measured across the 50 ohm termination port of the LISN to the EMI test receiver & recorder. The frequency range was set as per the MIL-STD-461E for CE102 test [7]. The photograph of experimental setup used for measurements shown in figure 4.

Figure 4: Experimental set up

In the conducted emission test the LISN (line impedance stabilization network) provide the stabilized impedance. The LISN provide the low impedance path from source to the load impedance and high impedance path from load to ground. Two LISN were used during the test one for the positive line and other for the return line.

5. EXPERIMENTAL RESULTS AND DISCUSSION

The test results were measured and recorded at various conditions. First test was carried out to use all the power supplies (i.e. power supply used for relay board, controller section and for pulse power module) individually and activate the relays from the ground system unit. The controller based system was working. The test was repeated many times the functionality of the system was perfect. Second test was conducted to combine all the power. During this test the when the relay board was activated the communication of the controller units fails due to the noise generated by the relays by make and break of the circuit. The noise was monitored on the power line which routed through the controller unit to the pulse power module. When the relay operation carried out in the on & off state the noise observed 20.6V in both the cases. In the controller section the communication signals lines and the power lines route through the same connector and terminated to the PCB of the controller. The noise coupled with the reset signal line and interrupts the communication of the controller. The noise measured and recorded in real time in DPO. The measurement result as shown in figure 5.

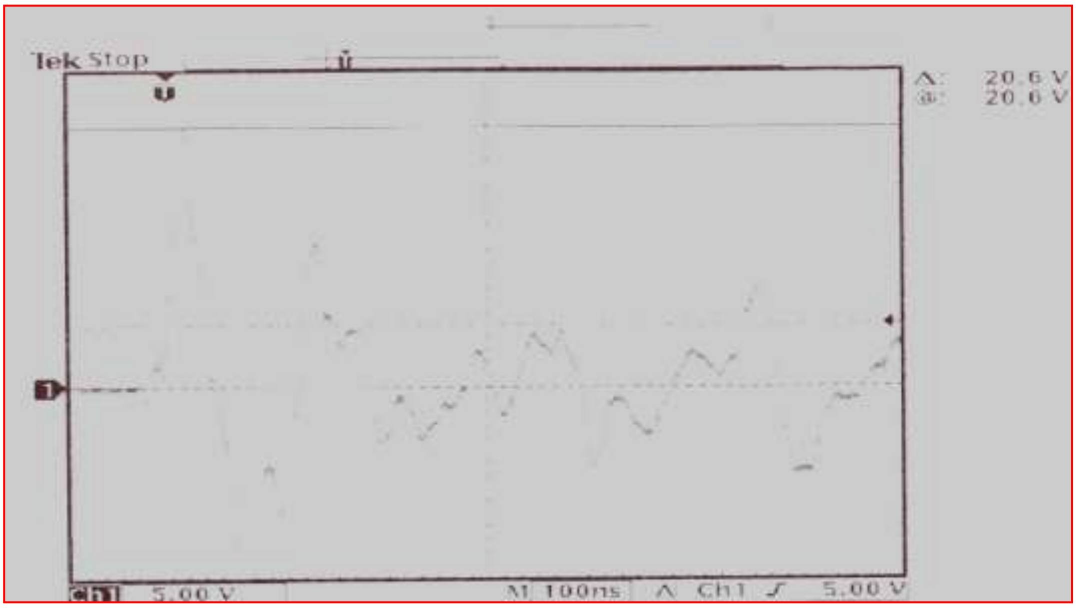

Figure 5: Graph at all power common

The again test conducted and noise measured between the return line and the digital ground line was 15.1V. This time also the communication of the controller fails. The test result shown in figure 6. The communication signals lines separated from the power lines and again the test was repeated this time the voltage measured was 7.4V shown in figure7.

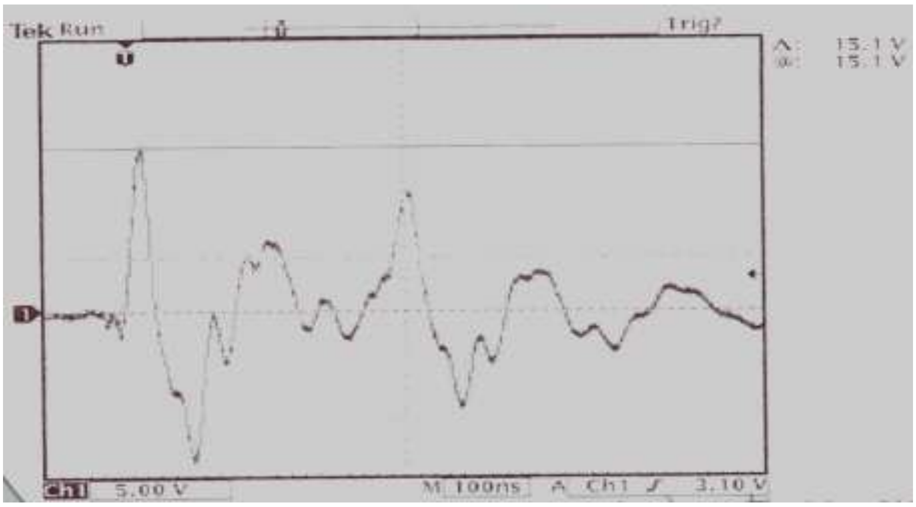

Figure 6: Graph between supply return and digital ground

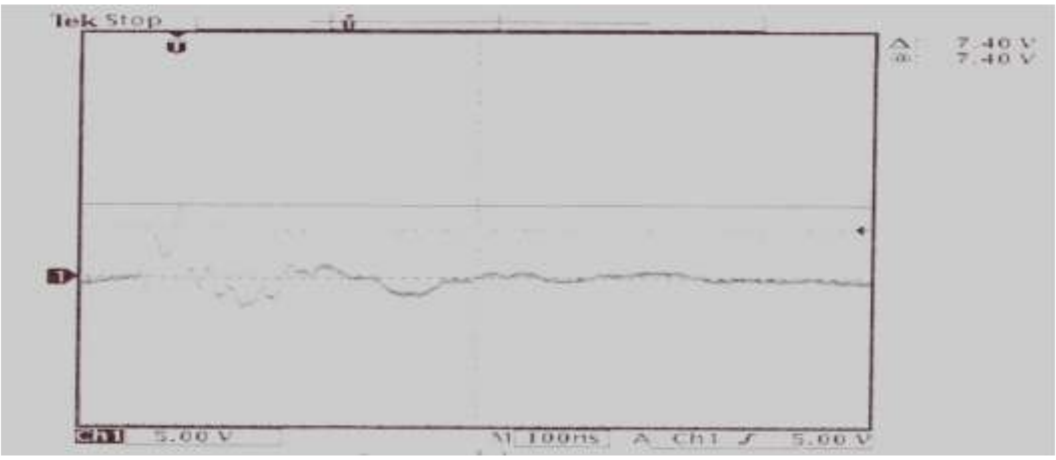

Figure 7: Graph of communication signals lines separated from power lines ground

The line filter (double T filter) of 100V, 10A was inserted between the positive line and negative line. The noise level decreased to 5V and test result was shown in figure8. Number of time the test was repeated every time the test results were normal.

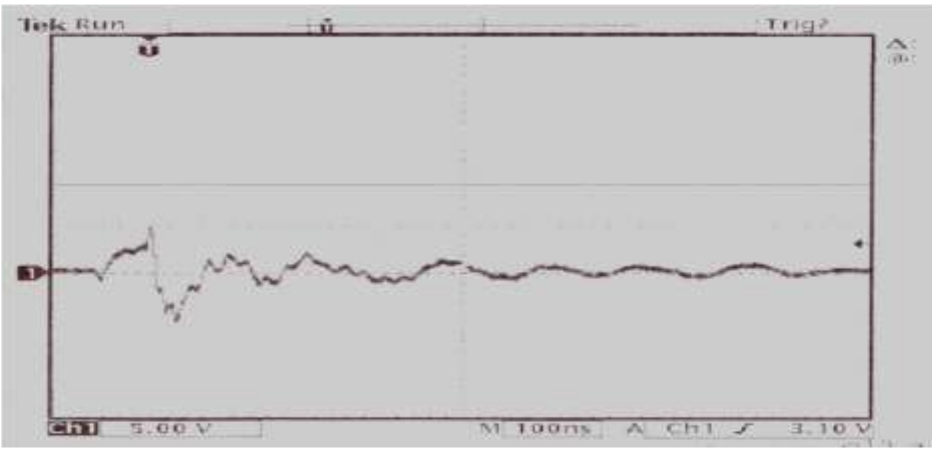

Figure 8: Graph with line filters

The system subjected to CE102 test to monitor the conducted emission from the unit as per the MIL-STD-461E in the frequency band of 10 KHz to 10 MHz the test was carried out in full loaded condition. The photograph of the unit under test was shown in the figure 9.

Figure 9: Photograph of unit under test

All the relays operated through the ground system unit and the output of the unit was recorded in the DPO. The voltage level monitors on the multimeter with the high voltage probe and controller communication recorded on the system. Test was carried out with mention frequency range bands and test results come out to be within the acceptance limit line. The measurement result as shown in the figure10. The red line shows the acceptance limit line.

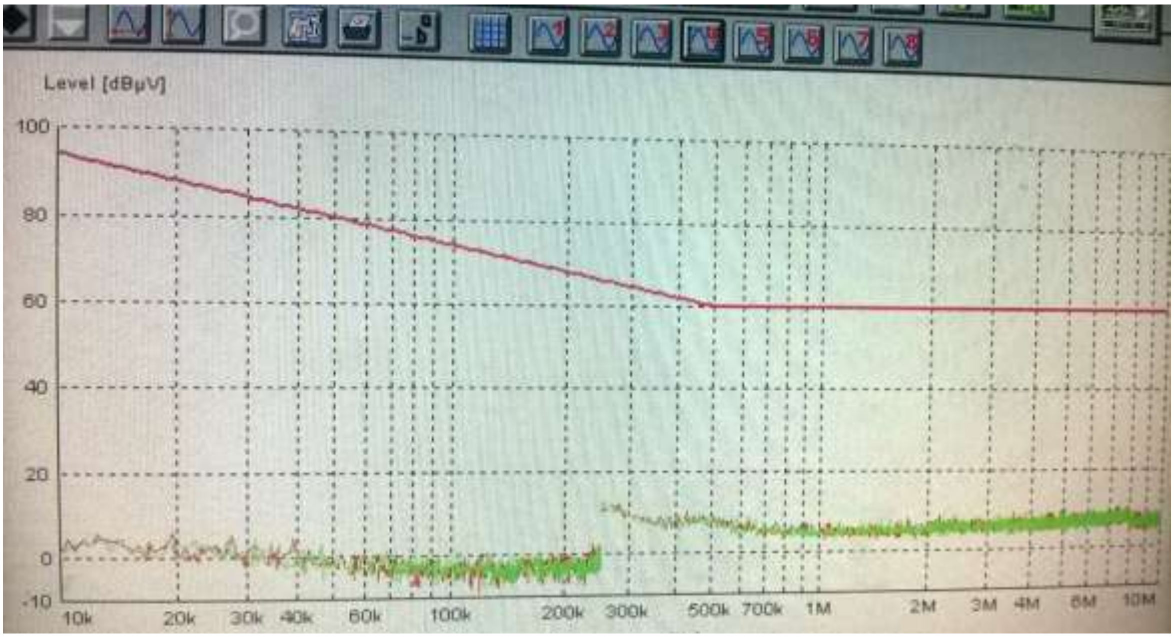

Figure10: Test result in CE102 Test result

CONCLUSION

When there is switching of voltage and current, then EMI will be generated. This is required to be addressed. As per analysis it shows that the proper shielding, routing and placement of wiring in the system solved the problem of conducted interference. The low pass filter was used to address the high frequency noise.

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