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Electromagnetic and Thermal Analysis of Automotive Active Safety Vision Sensor

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Abstract: This paper presents a simulation based approach to analyse EMI/EMC levels or effect on a vision sensor PCB enclosed in a metallic enclosure. Specifically EMI analysis is done based on radiated emission test, Conducted emission test and ESD test. In this project focus is given to Radiated emission test based on CISPR 25 standard, which is standard to carry out EMI/EMC tests. Apart from electromagnetic tests, thermal analysis of the board is also performed using simulation methods. For simulation purpose ANSYS tools are used here. Proper analysis of Radiated emission and thermal aspects would ensure reliability of the board. EMI effects can lead to failure and misfunctioning of the components, whereas thermal effects can lead to failure of interconnects and increasing overall temperature of the environment.

Keywords: Electromagnetic interference(EMI), ANSYS, CISPR 25, Thermal, Radiated emission, Conducted emission, ESD.

I. INTRODUCTION

Technical advancement and geometrical aspects makes an electronic equipment exposed towards EMI and accurate analysis becomes difficult. resonant enclosures, coupled wiresand due to linear and non linear components on the PCB boosts up the cost of computation. Number of tools makes the job easy as they can be used for analysis of EMI/EMC , for EMI couplings metallic enclosures and PCB , techniquesare developed for computation of the same. Moreover these methods can be combined to make computation mor effective and accurate.

In simulation tools PCB can be assigned ports and S- parameter simulations can be carried out. By setting up schematic as per board, excitations can be pushed through board to run near field simulations, near field source can be generated and used as PCB in enclosure to setup CISPR 25 standard setup for RE calculation.

In this manner the possible computing constraints for wavemodelling of devices by utilising the positives of EMI and circuit analysis tools.

II. EMI/EMC EFFECTS IN PCB

An electronic system is composed of PCB , cables, IC ,etc. Interconnects act as antennas with high frequencies, based on their length and current they are carrying, which ultimately results in EMI . International standards governs level of emissions. Which makes control and measuring of radiation a critical necessity. As it preserve the integrity of components.

Electromagnetic radiation can be of radiation and conduction type. For conducted emissions to enter into system ,power rails, cables are some ways. On the otherhand in radiated emission case it can come through cables, switching devices and power rails too. It travels through air from electronic devices and can hamper other components performance. For example mobiles can hamper air craft performance. Through line filters in the lower rails this issuecan be mitigated. Another way could be ferrite rings which controls conducted emissions. For construction of high frequency noise reduction devices high frequency ferrite core used.

III. TOOLS TO BE USED

ANSYS SI wave

A sophisticated PCB, package, silicon interposer, and RDL analysis and design tool called SIwave. By utilising a variety of cutting-edge full-wave EM solvers, SIwave assists designers in resolving SI, PI, EMI/EMC, and other problems in Chip/Package/Board systems. In addition to generating S-parameters, RLCG extraction methods, and SPICE netlists, SIwave performs a number of analysis, such as impedance scan, DC IR drop, time-domain reflectometry (TDR), and impedance optimization of PDN using decoupling capacitors. One can insert ports, terminations, and circuit components into the design to set up the simulation and model the machine.

ANSYS EDT

High-frequency digital equipment such antennas, antenna arrays, RF or microwave components, high-speed interconnects, filters, connections, IC packages, and circuit boards are designed and simulated using the full - wave electromagnetic (EM) simulation programe Ansys HFSS. ADAS units and a variety of other contexts use high speed, high frequency circuits developed with AnsysHFSS.

ANSYS spaceclaim

For engineers who want access to 3D solutions but don't have the time or desire to learn complicated conventional CAD tools, Ansys SpaceClaim is the ideal knowledge of the proposed. With the elimination of delays across design engineers, it gives you the instruments to hasten geometry creation and simulation.

ANSYS ICEpak

The sophisticated computational fluid (CFD) solver Ansys Fluent is used by Ansys Icepak to evaluate the temperature and liquid flow of integrated circuits (ICs), packages, printed circuit boards (PCBs), and electronic assemblies.

IV. METHODOLOGY

1. PCB board is imported in ansys SIwave
2. Layer stack up is done
3. S-parameter simulation with port assignment forsignals and power rails intended.
4. Linking SIwave file to ANSYS AEDT for schematicsetup.
5. Spice models are assigned to active and passivecomponents along the path during schematic setup.
6. Provided proper frequency and amplitude details forCAN-FD and PMIC switching.
7. LISN is connected to counter noise as it acts as lowpass filter.
8. Transient analysis
9. Pushing excitations to parent siwave file after signalexcitation through transient analysis.
10. Running near field simulations in SIwave to get switching regions on the board or region with maximum emission.
11. Setting up CISPR 25 setup for carrying out Radiatedemission analysis in AEDT.
12. Linking AND file(file contains near field data) generated after near field simulation to board in AEDT which produces near field source.
13. Fitting layout in enclosure and connecting connector at appropriate place.
14.Connection between cables and Appropriate connector pins.
15. Assigning a line source at 1m distance from nearfield source.
16. Running simulations and collecting results.
17. Collecting frequencies where peaks are present.

MEHTODOLOGY FOR THERMAL ANALYSIS:

Thermal analysis is done on the basis of selection of nets, here first board is opened in siwave and layer stack up for the PCB is done.

For active passive components like diodes ,capacitors and inductors spice models will be assigned in siwave to provide port functionality, then IR drop analysis will be done. File will be linked with ICEpak for final simulation, and thermal map is generated.

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1. Loading board to Ansys SIwave
2. Verifying layer stackup and circuit parameters
3. Assign spice models for active passive components like capacitors, diodes and inductors.
4. Selecting nets for IR drop analysis
5. Validation and simulation
6. Linking file to Icepak for final simulation togenerate thermal map

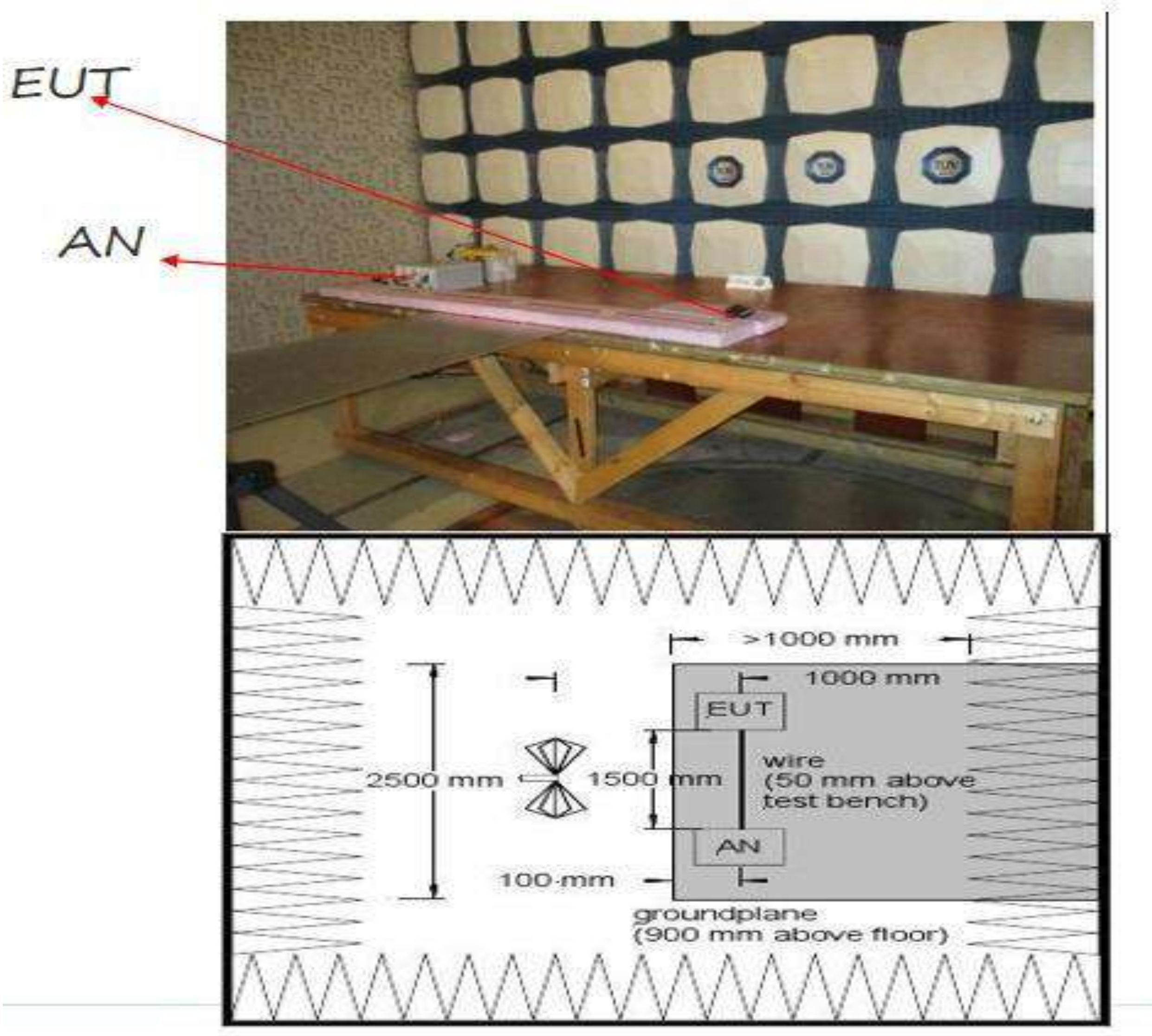

Fig1. CISPR 25 setup

V. CIRCUITS AND CISPR25 ENVIRONMENT USED IN SIMULATION

POWER MANAGEMENT IC (PMIC):

Power management integrated circuits (PMICs)are solo chip IC's having number of power lines and power management units. Voltage converters andregulators, battery chargers, are usually included into a PMIC unit. The PMIC controls battery charging, sleep modes , DC-to-DC conversion and volt- age scaling. PMICs handle heat dissipation and powerconsumption in a more reliable manner, and radiations will be more accurate.

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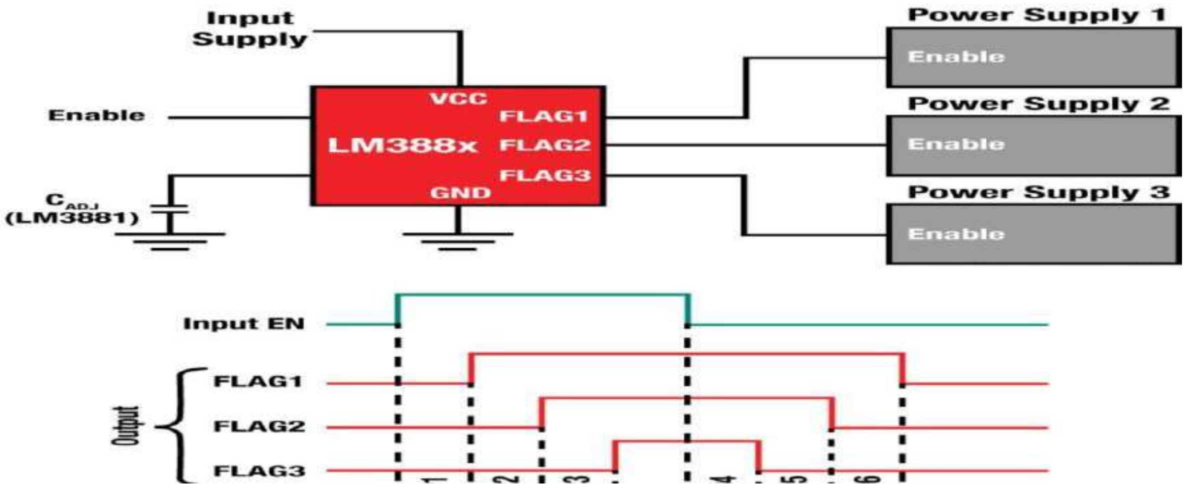

Fig 2. Basic PMIC circuit

Inrush current protection circuit:

Electronic circuit requires huge amount of current just to get started in order to generate initial magnetic or electric fields and this makes circuit's input resistance very low this can lead to deteriorating effects.

To implement inrush protection, resistor limittechnique is used and a current limiter based on a thermocouple or NTC.in resistor based approach at the input a resistance is applied to limit the current but drawback of this method is that even after current becomes normal it'll keep on limiting it which might lead to wastage of power, so instead of it thermocouple is used which will offer high resistance at low temperatures and gradually reduce the resistance we with effect of increasing current

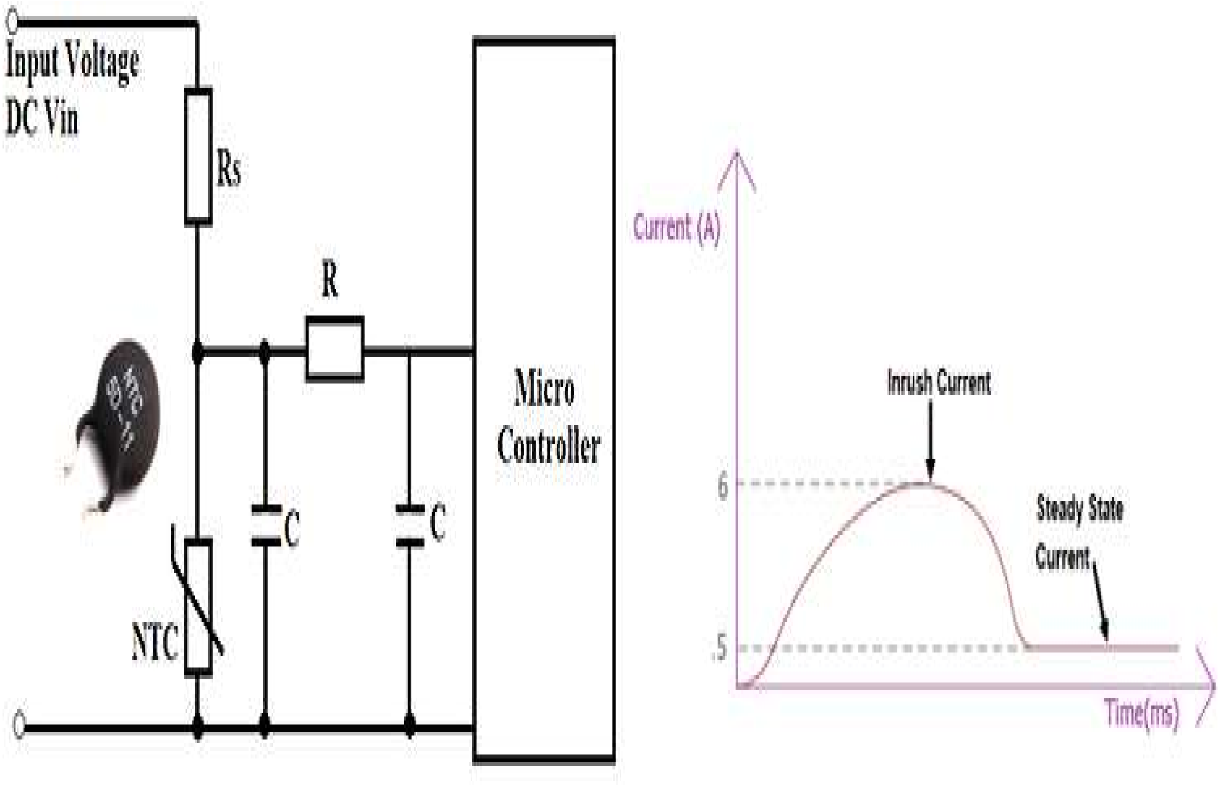

Fig 3. Inrush current limiter

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Schematic:

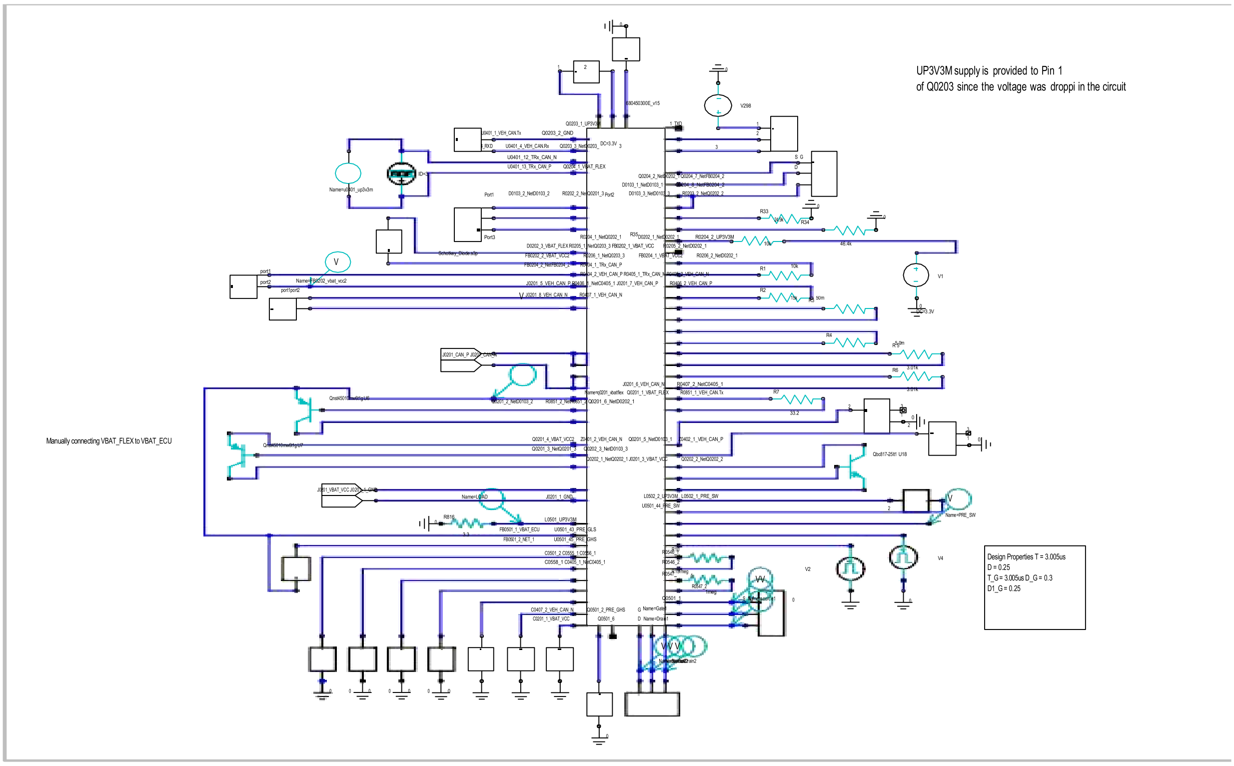
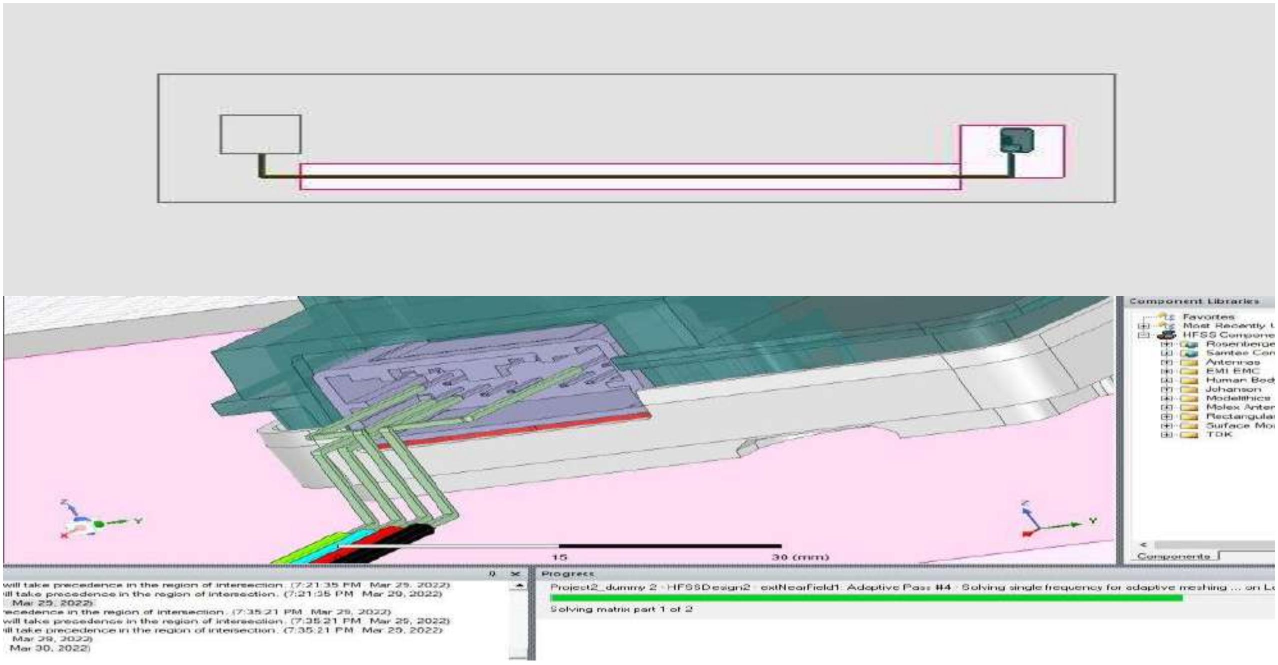


Fig 3. Schematic for transient analysis

CISPR25 environment in EDT:



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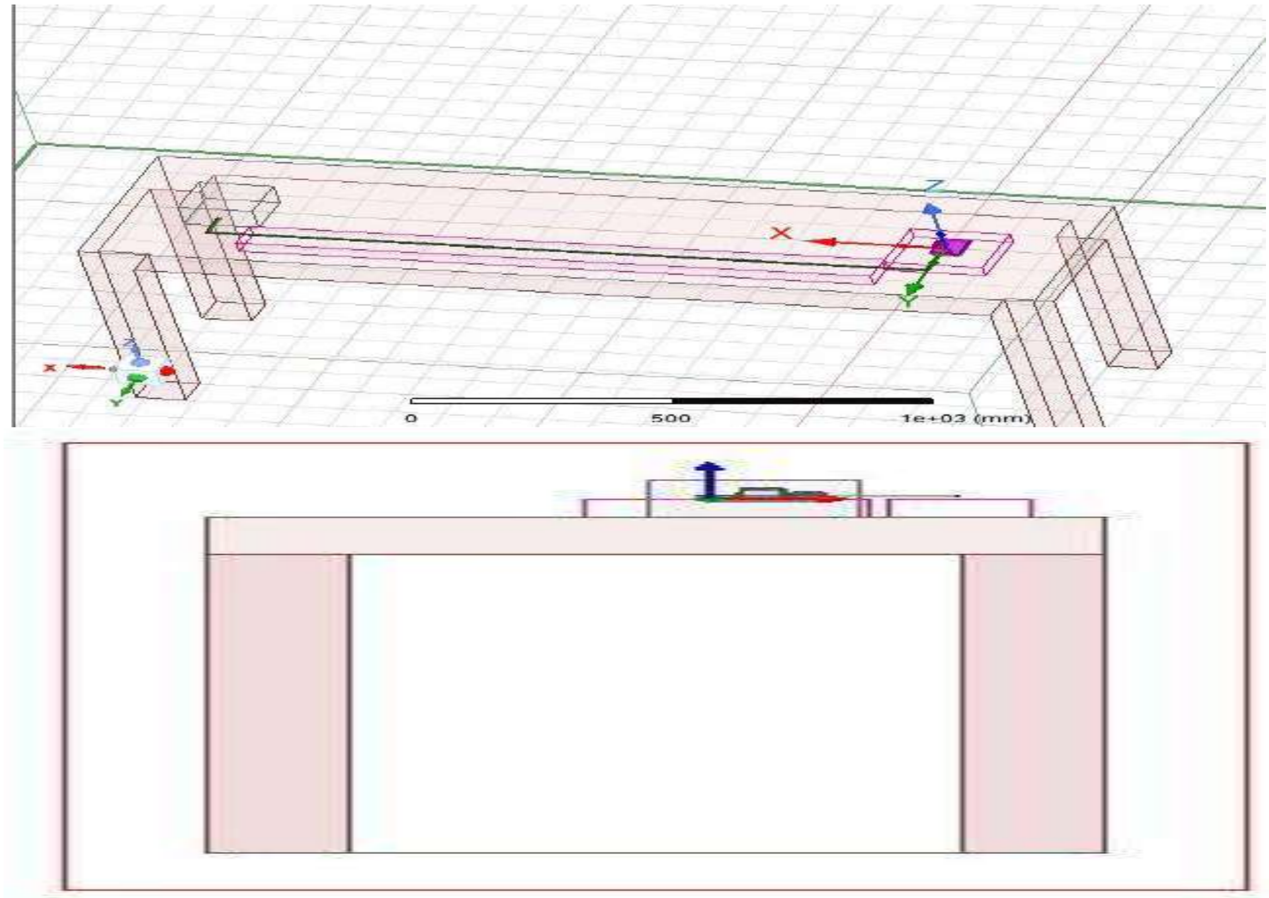
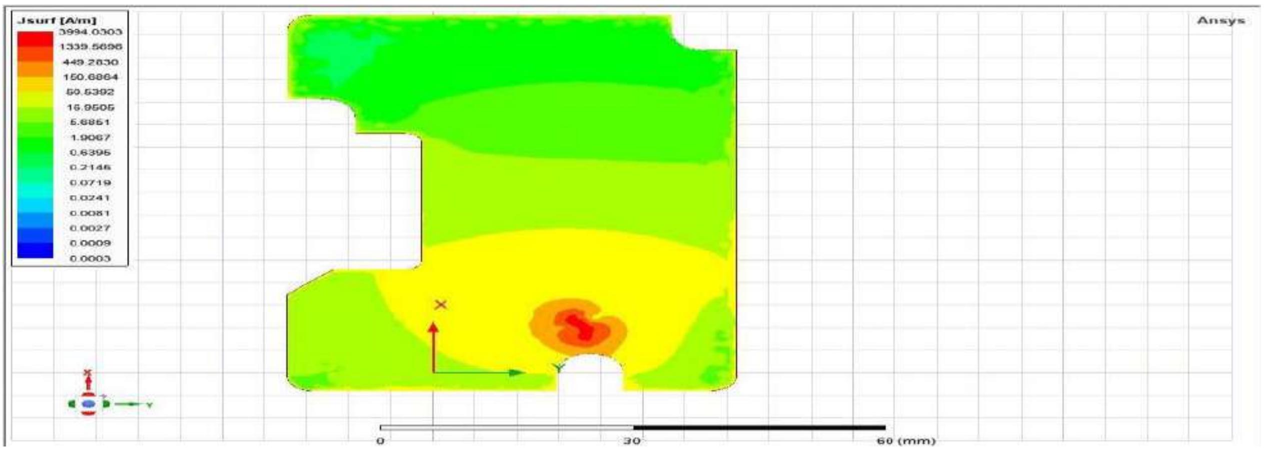


Fig 5. Modelled setup CISPR 25

VI. RESULTS AND ANALYSIS

Fig 6 current density map of the PCB, it basically shows the level of current density at various parts of the board, in this the hotspot region is known as the one which has highest level of current density and is shown with red colour.



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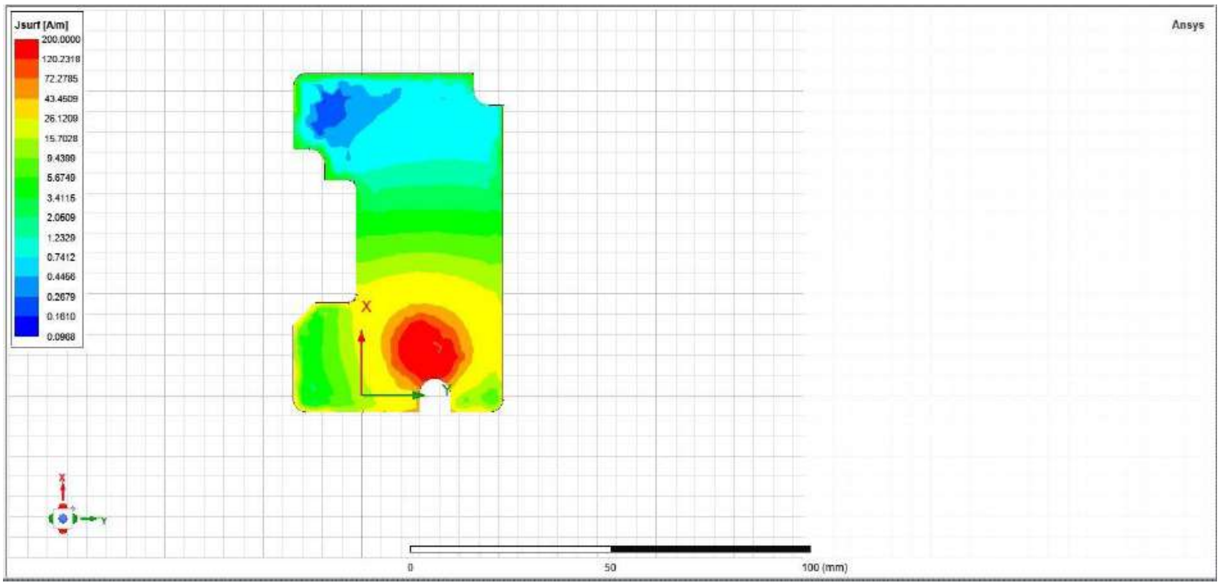

Fig 6. Current density distribution on board

In Fig 7 and 8, FET levels are shown and Vload levels,load level shows working of the circuit properly as load drop is coming at desired level.

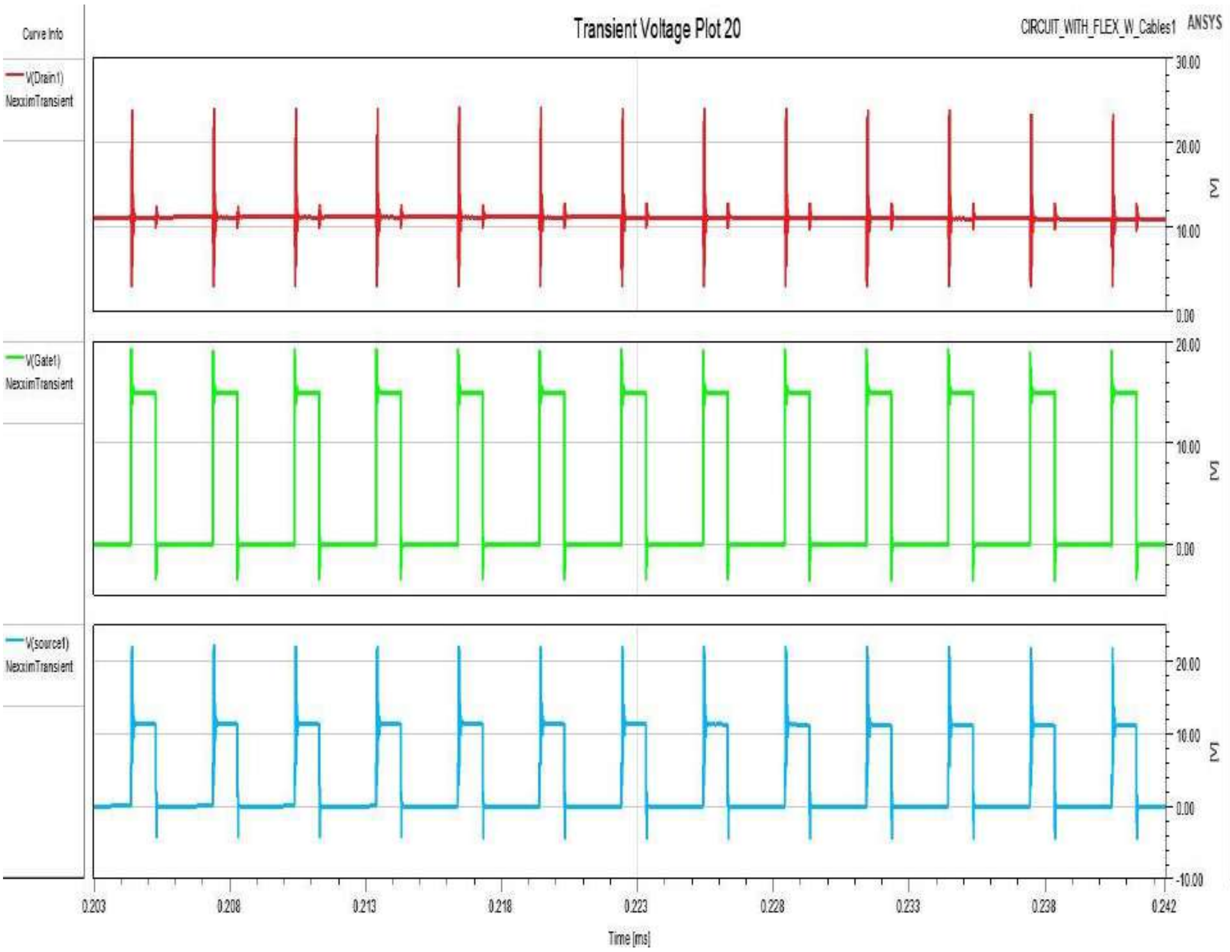

Fig 7. FET gate, source, drain voltages

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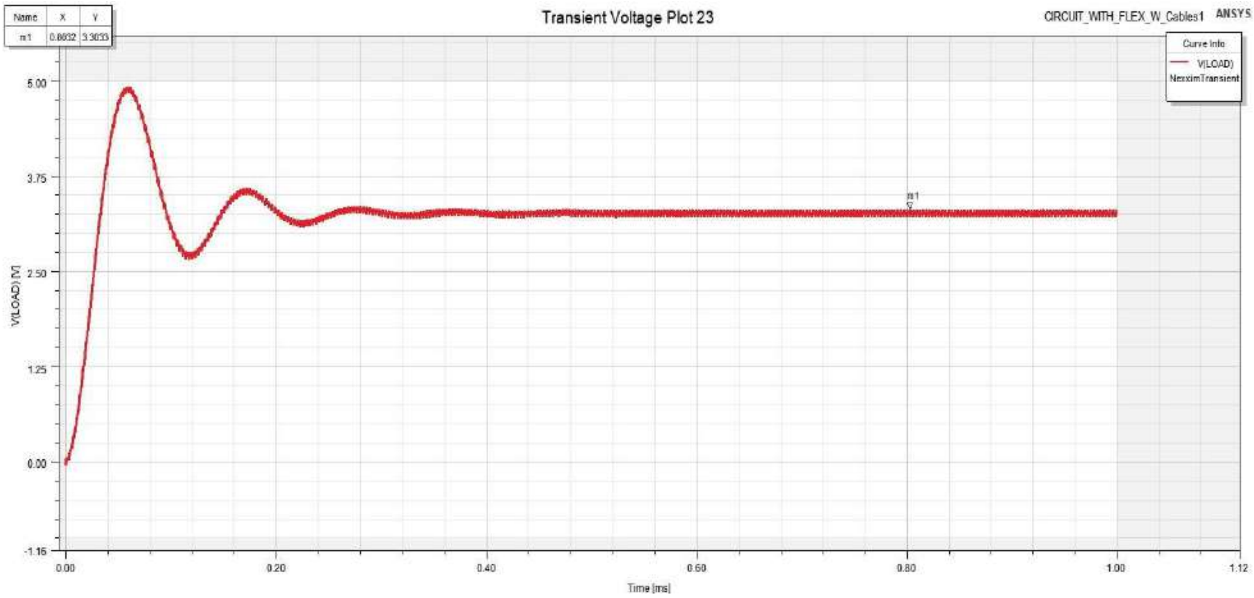

Fig 8. Load Voltage

In Fig 9 , Radiated emission plot is showsn which shows three peaks over a frequency range of 530Khz-1.73Mhz. These peaks shows the frequency points where radiation is getting emitted, i.e the current density map will only be visible ate there frequencies.

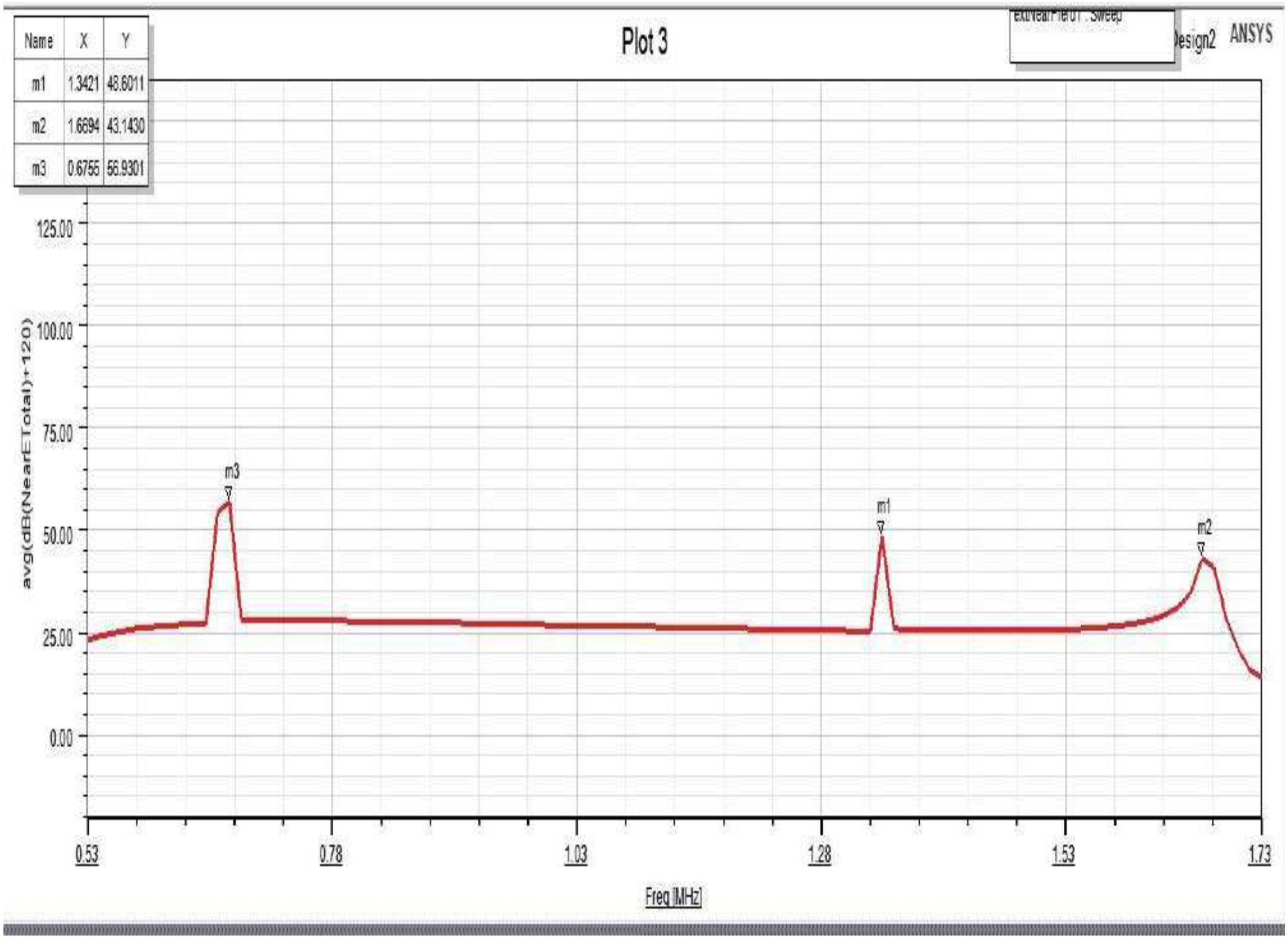

Fig 9. Radiated emission plot(frequencies of emission)

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In Fig 10 thermal map of the board is displayed, it can beeaily pointed out that the place of maximum current density will have highest temperature levels, because current densityis directly proportional to temperature rise, as it shows region where PMIC is residing is the one with orange shadesin the map which shows high temperature compared to rest, by this map thermal aspects can be analysed and required changes can be done to improve thermal resistance of the board.

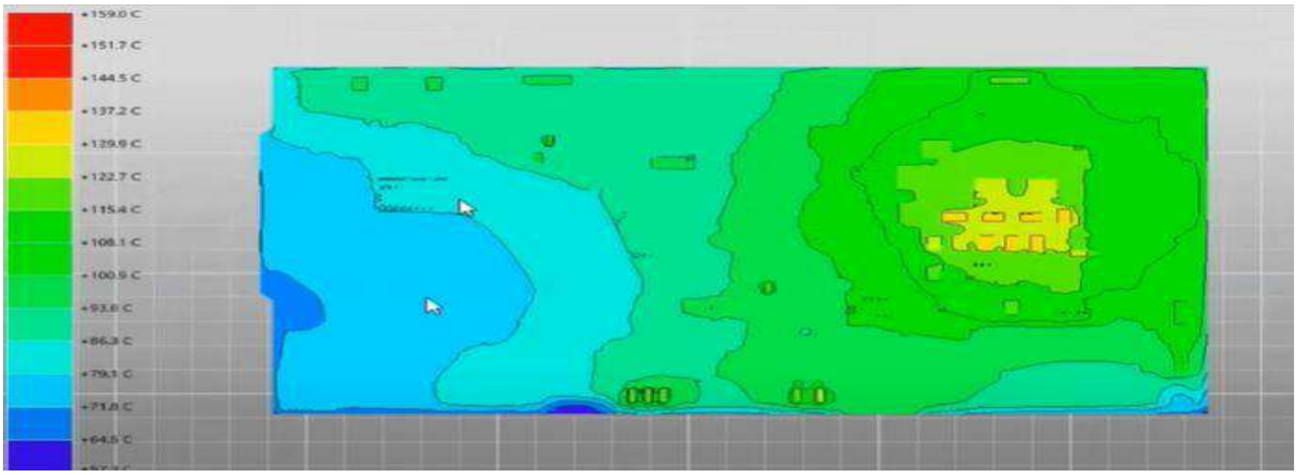

FIG 10. THERMAL MAP OF BOARD

VII. CONCLUSION AND FUTURE SCOPE

Analysis of EMI/EMC is being carried out using Ansystools, along with it thermal analysis is also carried out using Icepak. Radiated Emission test is performed through simulations, to analyse EMI. Frequencies of radiation are found out and thermal map of the PCB is generated by combination of SIwave and ICEpak. Futher scope to verify EMI could be to perform other tests like Conducted emission , ESD and radiated immunity for compatibility.

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