AP7301 ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY **L T P C**
3 0 0 3

COURSE OBJECTIVES:

- To understand the basics of EMI
- To study EMI Sources
- To understand EMI problems
- To understand Solution methods in PCB
- To understand Measurement technique for emission
- To understand Measurement technique for immunity

UNIT I EMI/EMC CONCEPTS **9**

EMI-EMC definitions and Units of parameters; Sources and victim of EMI; Conducted and Radiated EMI Emission and Susceptibility; Transient EMI, ESD; Radiation Hazards.

UNIT II EMI COUPLING PRINCIPLES **9**

Conducted, radiated and transient coupling; Common ground impedance coupling; Common mode and ground loop coupling ; Differential mode coupling ; Near field cable to cable coupling, cross talk ; Field to cable coupling ; Power mains and Power supply coupling.

UNIT III EMI CONTROL TECHNIQUES **9**

Shielding- Shielding Material-Shielding integrity at discontinuities, Filtering-Characteristics of Filters-Impedance and Lumped element filters-Telephone line filter, Power line filter design, Filter installation and Evaluation, Grounding- Measurement of Ground resistance-system grounding for EMI/EMC-Cable shielded grounding, Bonding, Isolation transformer, Transient suppressors, Cable routing, Signal control. EMI gaskets.

UNIT IV EMC DESIGN OF PCBS **9**

EMI Suppression Cables-Absorptive, ribbon cables-Devices-Transient protection hybrid circuits ,Component selection and mounting; PCB trace impedance; Routing; Cross talk control-Electromagnetic Pulse-Noise from relays and switches, Power distribution decoupling; Zoning; Grounding; VIAs connection; Terminations.

UNIT V EMI MEASUREMENTS AND STANDARDS **9**

Open area test site; TEM cell; EMI test shielded chamber and shielded ferrite lined anechoic chamber; Tx /Rx Antennas, Sensors, Injectors / Couplers, and coupling factors; EMI Rx and spectrum analyzer; Civilian standards-CISPR, FCC, IEC, EN; Military standards-MIL461E/462.Frequency assignment - spectrum conversation. British VDE standards, Euro norms standards in japan - comparisons. EN Emission and Susceptibility standards and Specifications.

TOTAL= 45 PERIODS

COURSE OUTCOMES:

Upon Completion of the course, the students will be able to

- To design a EMI free system
- To reduce system level crosstalk
- To design high speed Printed Circuit board with minimum interference
- To make our world free from unwanted electromagnetic environment

REFERENCES:

1. V.P.Kodali, “Engineering EMC Principles, Measurements and Technologies”, IEEE Press, Newyork, 1996.
2. Clayton R.Paul,” Introduction to Electromagnetic Compatibility”, John Wiley Publications, 2008.
3. Henry W.Ott.,”Noise Reduction Techniques in Electronic Systems”, A Wiley Inter Science Publications, John Wiley and Sons, New York, 1988.
4. Bemhard Keiser, “Principles of Electromagnetic Compatibility”, 3rd Ed, Artech house, Norwood, 1986.
5. Don R.J.White Consultant Incorporate, “Handbook of EMI/EMC”, Vol I-V, 1988.

UNIT- I EMI/EMC CONCEPTS

PART-A

1. What is meant by electromagnetic compatibility?
2. Define ESD.
3. What are the three criteria to be satisfied by any system to become electromagnetically compatible?
4. How do you prevent emission?
5. Why is EMC a vital problem?
6. Why do we feel electric shock at times, when we touch TV and Computer monitors?
7. List the sources of EMI.
8. What is conducted coupling of EMI?
9. A bike started or a mixie under running condition disturbs a TV receivers functioning. Why?
10. Draw an equivalent circuit model for electrostatic discharge.
11. What are the various type of radiation coupling in EMI?
12. What is conducted interference?
13. Is it possible to develop circuit models of EMI?
14. Name the two factors that tend to affect the amount of interference that would otherwise be transmitted along a conducted path.
15. Define EMI and EMC.
16. What is transient suppression?
17. How to classify EMI/EMC?
18. What are the different units of parameters for the measurements of EMI?
19. What are CE and RE?
20. What is EMP? What do you understand about the effect of EMI on secured communications?

PART-B

1. (i) Distinguish between the features of conducted EMI and radiated EMI.
(ii) Explain the different sources of EMI in detail. Give examples.
2. (i) What are the sources and victims of EMI? Explain with examples.
(ii) Explain in detail classification of EMI/EMC. How do you minimize each?
3. (i) Compare time domain EMI with frequency domain EMI.
(ii) Explain ESD in detail. What are all the remedial procedures?
4. (i) Why is EMI significant in system design? Explain with industry citations. What are the sources and victim of EMI?
(ii) How do electrostatic discharges occur? Explain in detail EMI radiation Hazards.
5. How are the various sources of EMI kept under control and measured? What are the various parameters of measurement? Give their relevant units.
6. Discriminate time domain and frequency domain EMI. Why does one analyze in frequency approach analysis, design and location of high voltage equipments?
7. Discuss how lightning discharges affect the transmission line communication. Explain the transients, transient effects and how to minimize the transient effects?

8. (i) Discuss in detail the design practice for minimizing conductive interference.
(ii) Discuss how lightning discharges affects the transmission lines communication.

9. (i) Explain in detail the conducted EMI and radiated EMI with examples.
(ii)An ESD discharge is modeled as a capacitance of 150pf. Charged to 2 KV and discharged through a resistance of 1 k ohms.(a)Write down the expression for the current waveform (b) Approximating the current waveform as a short dipole, calculate the interference power at a distance of 10cm and find its variation with time.

10. (i) Explain in detail classification of interference? How do you minimize each?
(ii) With suitable examples, explain intentional and unintentional electromagnetic emissions during operation of various equipments. How to control them?

UNIT- II EMI COUPLING PRINCIPLES

PART-A

1. List out the types of coupling between cables (or) List the EMI coupling methods.
2. Define Ground coupled Interference.
3. Define edge rate. Define Transient Coupling.
4. What is transient coupling?
5. Define cross talk with reference to EMI/EMC design issues?
6. Define 'Ground' with respect to working on electrical gadgets.
7. What is electromagnetic emission?
8. How does one avoid power mains interference?
9. Why is a limit on the lower frequency portion of the conducted emission and which is the standard followed during the testing accordingly?
10. What are the steps in the procedure to analyze EMP susceptibility?
11. What allows a conductive transfer to occur?
12. What does coupling mean?
13. What is mean by ground loop coupling? (or) What is GLC?
14. Draw common mode and differential mode coupling in circuits.
15. List the drawbacks of various coupling mechanisms.
16. Brief about power supply and power main coupling?
17. How field coupling affects the systems?
18. Define LISN.
19. Draw CM and DM coupling in circuits.
20. How field coupling affects the system?

PART-B

1. (i)Describe the differences between radiated DM and CM coupling with suitable example.
   (ii) With neat diagram explain near field coupling.
2. Discuss in detail with neat diagram about ground loop coupling and power supply coupling. (or) Explain in detail various coupling methods/mechanisms.
3. Explain in detail the conducted, radiated and common impedance ground couplings with examples.
4. What is radiated differential mode coupling? In what way this is different from the radiated common mode coupling? Explain this with example.
5. Explain cable coupling and its electromagnetic impact in system design.
6. What is Differential mode coupling (DMC)? How do radiated coupling and transient coupling vary from DMC?
7. Discuss the impact of radiated common mode and radiated differential mode coupling? Also explain how do common mains supply is a frequent source of conducted interference. How do surges on main power supply affect appliances? How to avoid it with appropriate design and location?
8. Give suitable examples for intentional and unintentional electromagnetic emissions during operation of various equipments. How to control them? Also list out electric field intensity levels of various home appliances. Also prove CE is more significant than radiated one.
9. How do cable coupling, near and far coupling of EM fields produced can be reduced? How to enhance immunity of circuits/equipments systems.
10. (i) Explain various remedial activities for coupling in circuits.
    (ii) Explain how power supply main affects the system.

UNIT- III EMI CONTROL TECHNIQUES

PART-A

1. What is EMI shielding? What is the need for shielding?
2. Classify EMI filters.
3. What are the advantages of multipoint grounding?
4. What is the functionality of transient suppressors?
5. What is meant by 'bulging' capacitor?
6. What does transient suppressor mean?
7. Name four techniques/approaches to combat EMI.
8. What does 'Chemical Salting' mean?
9. What is an electrical filter?
10. Write the definitions of grounding and bonding.
11. Draw the diagram of isolation transformer?
12. What are all the procedures considered for cable routing?
13. What is meant by signal control?
14. Give at least 2 procedures for component selection and mounting.
15. Differentiate various shielding methods.
16. What is the need for EMI Gasket?
17. What is an opto-isolator?
18. Define SEMCAP.
19. What are all the tests that can be carried over in a shielding room?
20. Define shielding effectiveness. List any four shielding materials.

PART-B

1. (i) Explain about the various types of non-solid shielding techniques.
   (ii) Describe the shielding effectiveness of both solid and non-solid materials including multiple soil shields and thin film shielding.
2. What ate the factors influencing the EMI performances of the bonding? How can bonding be made? Mention some guidelines for good bonds.
3. (i) What are Isolation Transformers? Explain in detail.
   (ii) Explain various method of grounding with examples.
4. (i)What are transient suppressors? Explain them.
   (ii)Explain briefly the cable routing and signal control techniques.
5. (i) How does an isolation transformer control EMI? Explain shielding and filtering methods of controlling EMI.
   (ii) Explain the basics of shielding (or) Explain different shielding techniques (or) Explain the concepts of shielding?
6. (i) How does cable routing control EMI? How is signal control achieved?
   (ii) Explain various grounding techniques used in electronic circuits.

7. (i) Using spherical ground electrodes define ground resistance. How does the ground resistance vary with different soils?

(ii) What are the various precautions taken to reduce ground resistance?

8. (i) Illustrate how the effectiveness of shielding obtained in SMPS and industrial computers.

(ii) Discuss in detail grounding design guidelines.

9. (i) Explain Chemical salting technique, Various procedures for cable routing and With neat diagram, explain bonding.

(ii) Filters may be designed with two different types of components. What are they? Discuss all the techniques for designing filter.

10. (i) Differentiate between single and double shields. Briefly explain about shielding discontinuities.

(ii) What are EMI Gaskets? Explain. List the applications of Gaskets.

UNIT- IV EMC DESIGN OF PCBS

PART-A

1. List out the coupling situations to be addressed during the physical layout process.
2. Define : PCB trace impedance with respect to EMI.
3. What is Zoning?
4. Define zoning.
5. What is meant by termination in PCB fabrication?
6. What do you understand by 'routing' with reference to PCB design and fabrication?
7. How does cable routing avoid EMI?
8. List some procedures for reducing cross talk.
9. Define the term trace in PCB.
10. What is the use of decoupling capacitors?
11. Why grounding is such an important issue in PCB design?
12. List some procedures for effective grounding in PCB design.
13. What is impedance control in PCBs?
14. How effectively PCBs are designed?
15. List the important consideration of the PCB sizing.
16. Give at least two procedures for component mounting.
17. What is the relation between Radiation and loop area in PCB design?
18. Draw the circuit equivalent of L and C used in PCB design.
19. How to avoid cross talk in PCB design.
20. What is PCB via termination?

PART-B

1. (i) Discuss about the various factors to be considered for EMC design of PCB.
   (ii) Explain in detail about VIAs connection and termination.
2. (i) What is meant by susceptibility level? Explain the relationship between PCB traces and susceptibility level.
   (ii) Discuss briefly on control devices for cross talk.
3. (i) How do you control the impedance value while designing the PCB? Explain.
   (ii) Explain the power distribution decoupling concept.
4. Write short notes on the following: (i) PCB Motherboard design (ii) Propagation delay.
5. (i)Discuss how electromagnetic compatibility is achieved while PCB is prepared for industry applications. (ii) Why digital circuits are so sensitive in PCBs. Explain.
6. Write short notes on the following: (i) Zoning in PCB design (ii) Power distribution decoupling (iii) Termination (iv) Various suppression techniques in PCB design.
7. (i) What is cross talk with reference to the design of PCBs and how to minimize it when miniaturization is the concern of today's technology?
   (ii) Explain the importance of PCB design.
8. (i) Discuss how component selection and mounting control EMI?
   (ii) What are all the procedures used for effective grounding in PCB design?
9. (i) How do motherboard designs and performance models help for better performance?
   (ii) Explain in detail the steps involved in motherboard design.
10. (i) Select and recommend a suitable capacitor of a standard value to offer maximum filtering and also meet the safety requirement of less than 5mA leakage current when connected between the line and ground of a 230V50Hz power supply.
    (ii) Explain various procedures for reducing cross talk.

UNIT- V EMI MEASUREMENTS AND STANDARDS

PART-A

1. What is the main difference between radiated measurements for class A devices and others?
2. What is the significance of narrow band test?
3. What for MIL STD 461, 462 and 463 are used?
4. What are class A devices with reference to FCC?
5. Mention the two very important needs for TEM cell. With neat diagrams explain TEM cell.
6. Why do CISPR standards evolve?
7. Can High Voltage lines be allowed to cross residential sites? Justify.
8. How test bed is selected for ESD testing?
9. What are CISPR standards for EMIC?
10. What are Class A devices with reference to FCC?
11. What are MIL STD 461,462 and 463?
12. Name at least two standards for design guidelines and Test and Measurement procedures published by IEEE/ANSI.
13. What is the objective of requirements CS 103/104/105?
14. Expand the terms CISPR, FCC? Differentiate Military standard and Civilian standards in measurements?
15. What are the advantages of loop antenna? Specify the antenna used for microwave frequencies.
16. Define the term LISN? With LISN draw the basic circuit used for RI measurements?
17. What is a current probe? Give some guidelines to carry OATS.
18. What are the advantages and drawbacks of OATS?
19. What are all the factors to be considered for OATS?
20. What are all the types of OATS? Draw two arrangements of OATS.

PART-B

1. (i) What is the need for EMI standards? Explain. (ii) Explain the civilian standards FCC, CISPR and IEC in detail. (iii) Mention the requirements for the EMI shielded chamber.
2. (i) Explain the MIL STD 461E. (ii) Briefly explain the various EMI Test instruments. (iii) What is EFT test bed?
3. How are measurements made in the following : (i) Tx/Rx Antennas (ii) EMI Rx and spectrum analyzer
4. Why do the standards vary with reference to civilian and military applications? What are the various standards for civilian applications? How do they evolve? Discuss them in detail.
5. (i) Explain various testing antenna and their frequencies as specified in CISPR standard.
   (ii) What is TEM cell? Explain in detail with neat diagram.
6. (i) What is the need for standards? Why to evolve military and civilian standards? Discuss a test bed for ESD and EFT based on suitable standard.
   (ii) What are the needs for civilian and military standards? Compare and contrast these standards with reference to IEC and MIL461E462.
7. (i) Explain about anechoic chamber (or) Explain briefly about the measurements using an anechoic chamber. (ii) Explain the procedure for selection of OATS.
8. (i) How does Time domain method improve the effectiveness of shielding? (ii) Explain FCC/CISPR CE and RE standards.
9. (i) Explain and test procedure for MILSTD. (ii) Write short notes on sensors/Injectors, Couplers?
10. (i) Explain the two types of OATS measurements (or) Explain the measurement of RE and RS using OATS. (ii) Compare shielding with OATS.