Effect of Electromagnetic Compatibility and Interference on Electrical Gadgets

Prachi Laxman Kotwal

Dr. Babasaheb Ambedkar Technological University, Lonere, Raigad

Gyanendra Verma

SAMEER, IIT Powai, Mumbai (R & D Lab of Ministry of Electronics and Information Technology, Government of India)

Dr. P. K. Katti

Dr. Babasaheb Ambedkar Technological University, Lonere, Raigad

ABSTRACT:

Nowadays the use of electronics and electrical devices in various fields such as home appliances, information technology, industrial, scientific and medical equipments are increasing widely. This paper expresses the survey outline of the electromagnetic compatibility and interference which is important for electronics and electrical engineering. As per the properties of electronics devices, Generation, propagation and reception of electromagnetic energy which causes unwanted effects such as electromagnetic interference (EMI) or physical harm in operational equipment. The motivation behind EMC is the appropriate operation of different equipments in the normal electromagnetic condition.

Keywords- EMC, EMI, Emission, Susceptibility, FCC, RFI.

INTRODUCTION

In the early days due to the continuous growth in technology electrical and electronic devices are constantly present in human lives, as providing communication, entertainment or transportation. In many cases, integrated circuit is the main cause of interference in electronic equipments. The Electromagnetic Compatibility (EMC) of an electrical device is its capability to operate safely in an electromagnetic environment without interfering [1, 2].

The IEEE Dictionary defines EMC and EMI as follows:

EMC: The capability of electronic equipment or systems to be operated in the intended operational electromagnetic environment at designed levels of efficiency.

EMI: Impairment of a wanted electromagnetic signal by an electromagnetic disturbance [3].

This paper is also concerned with the design of electronic systems such that interference from or to that system will be minimized. The emphasis will be on digital electronic systems. An electronic system that is able to function compatible with other electronic systems and not produce or be susceptible to interference is said to be electromagnetically compatible with its environment. The objective of this paper is to learn concept of electromagnetic compatibility (EMC). A system is electromagnetically compatible with its environment if it satisfies three criteria [4]:

1. It does not cause interference with other systems.

2. It is not susceptible to emissions generated from other systems.

3. It should not cause interference with itself.

NEED TO EMC COMPLY

Electrical and electronic products often produce electromagnetic energy and every digital device has the inherent capacity of causing unintentional interference to other electrical devices. These devices provide luxurious life to human beings but also affected on human health due to radio frequency interference (RFI). Therefore, control of electromagnetic compatibility becomes necessity. Proper design methods provide: Reliable operation, minimizes liability risk, reduces project timescales and helps to meet regulatory requirements.

Electromagnetic Interference was also a problem during World War II. Communication transmitters and receivers were developed along with radar system. Due to emergency of Wartime, no extensive test was conducted on equipments which results that problems occurs in planes, ships. In the 1960's, NASA began stepped-up EMI control programs for its launch vehicles and space system projects. Governmental agencies and private corporations become involved with combating EMI Emission and Susceptibility in security system, hi-fidelity amplifier, etc. Between 1970's the growth in digital electronics system were increasing very fast. Digital equipments such as T.V., camcorders, personal computers, communication equipment, intelligent transportations, control systems. During this period the public become aware of EMC and problems associated with it.In order to tackle the problem of EMC, the Federal Communications Commission (FCC) was established [2].

CONCEPTS OF ELECTROMAGNETIC INTERFERENCE TRAVEL

An electromagnetic disturbance is an electromagnetic phenomenon which may decrease the performance of the system or equipment or device. It can be present in nature of an electromagnetic noise or an unwanted signal or change in propagation medium itself. Electromagnetic interference can travel from its source to a receptor in various mechanisms are illustrated: Fig.1

1. Direct radiation from source to receptor. (Path 1)

2. Direct radiation from source picked up by the electrical power cables or the signal or control cable connected to the receptor, which reaches receptor via conduction. (Path 2)

3. Electromagnetic interference radiated by the electrical power, signal or control cable of the source. (Path 3)

4. Electromagnetic interference directly conducted from its source to the receptor via common electrical power supply lines or via common signals or control cables. (Path 4) [5]

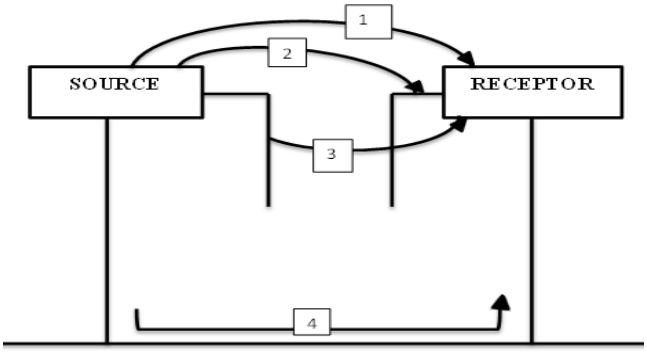

Fig 1: Mechanism of Electromagnetic Interference

CLASSIFICATION OF EMC

Electromagnetic compatibility (EMC) classified into two main classes as:

1. Emmission: Emission is the generation of electromagnetic energy, whether deliberate or accidental, by some source and its release into the environment. EMC studies the unwanted emissions and the countermeasures which may be taken in order to reduce unwanted emissions.

2. Immunity: Immunity is the ability of equipment to function correctly in the presence of Radio frequency interference (RFI).

Above each classes are further divided into conducted and radiated class as show in Fig. 2

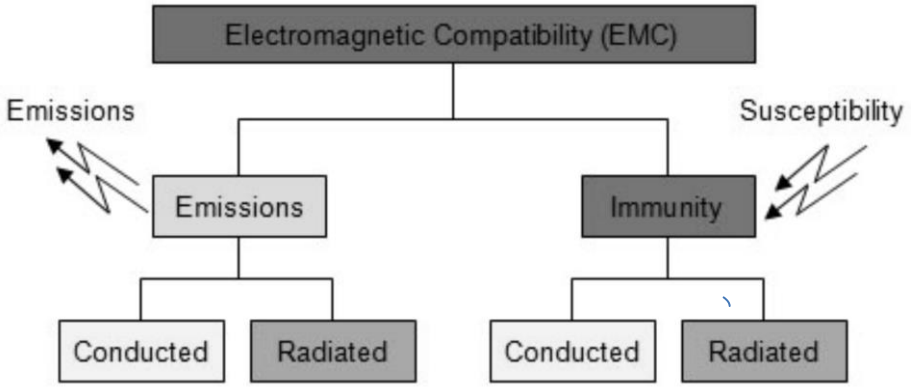

Fig 2: Classification of Electromagnetic compatibility

Electromagnetic compatibility divides broadly into emission and susceptibility testing. It is required to make sure that particular device meets the required standards. For emission and susceptibility measurement different EMC methods are used. These are open area test site (OATS), anechoic chamber, transverse electromagnetic (TEM)cell and gigahertz transverse electromagnetic (GTEM) cell [6].

HIGH FREQUENCY RADIATED EMISSION

While there is no fixed definition as to where high frequency starts, EMC authorities typically consider everything from a few kHz (kilohertz = 1000 cycles per second) upwards to be HF. In the EMC field, the term radio frequency (RF) is often used instead of HF. Air-transmitted interference, called radiated emission, can be measured with a receiving antenna on a proper test site. The sample set shows in Fig.3.

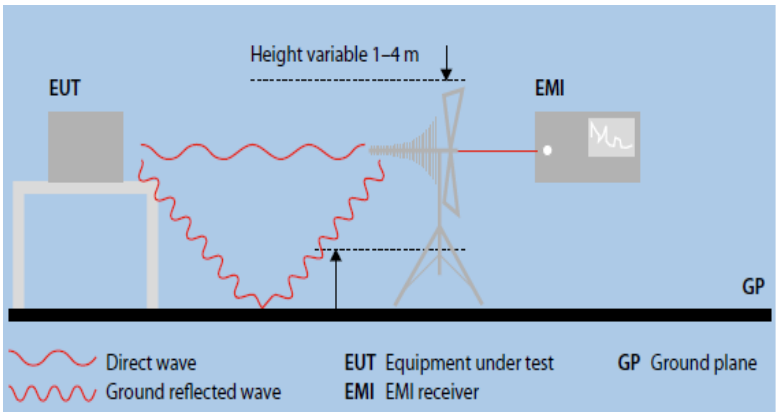

Fig 3: Setup of High Frequency Radiated Emission

HIGH FREQUENCY CONDUCTED EMISSION

Conducted emission is any emission transported from equipment to the environment along cables. The main emphasis in measuring line-conducted emission is placed on the AC mains input of the EUT, though other interface ports are becoming more and more important, like telecom and network ports on information technology equipment. In order to measure conducted emission, a line impedance stabilization network (LISN) is inserted into the mains power supply of the EUT. Newer standards call this network artificial mains network (AMN). The LISN leads the RF signals from the EUT to the output for the measurement receiver, while at the same time blocking the AC input voltage from the receiver. Fig.4 [7]

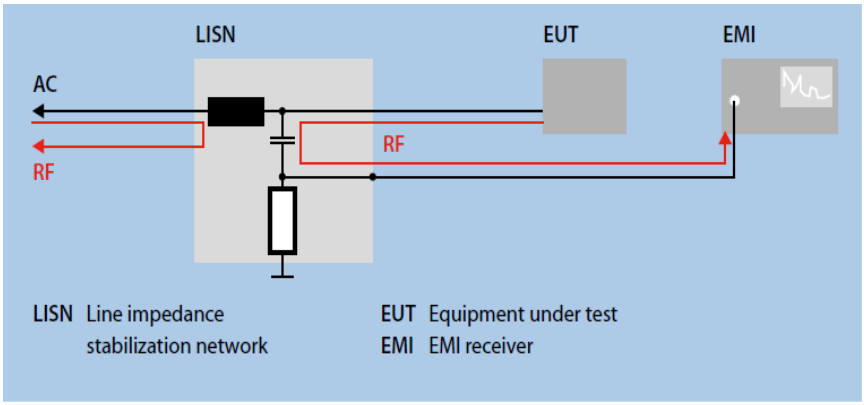

Fig 4: Setup of High Frequency Conducted Emission

Table 1 shows the IEC standards for Emission measurements.

Table1. IEC standards for Emission measurements

IEC/TR EN 61000-2-1	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 1: Description of the environment - Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems
IEC/TR EN 61000-2-3	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 3: Description of the environment - Radiated and non-network-frequency-related conducted phenomena
IEC EN 61000-3-2	Electromagnetic compatibility (EMC) - Part 3-2 - Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
IEC EN 61000-3-4	Electromagnetic compatibility (EMC) - Part 3-4: Limits - Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A
IEC/TS EN 61000-3-5	Electromagnetic compatibility (EMC) - Part 3: Limits - Section 5: Limitation of voltage fluctuations and flicker in low-voltage power supply systems for equipment with rated current greater than 16 A

RADIATED IMMUNITY

The theory behind the radiated immunity test is that your device will encounter many different types of electric field disturbances in normal usage. For example, someone

might use a cellphone next to it; someone operate motor next to it. There are lots of electric field sources that may interact with each other. This test is intended to see performance of equipment when it is subjected to an electric field of specified amplitude. The standard test for radiated immunity is IEC/EN 61000-4-3. This requires a radiated RF field generated by an antenna in a shielded anechoic enclosure using a pre-calibrated field, swept from 80 MHz to 1000 MHz with a step size not exceeding 1 % of fundamental and a dwell time sufficient to allow the EUT to respond. The antenna faces each of the four sides of the EUT in each polarization (and top and bottom, if these might be affected), hence there are 8 (or 12) tests in all. Fig. 5

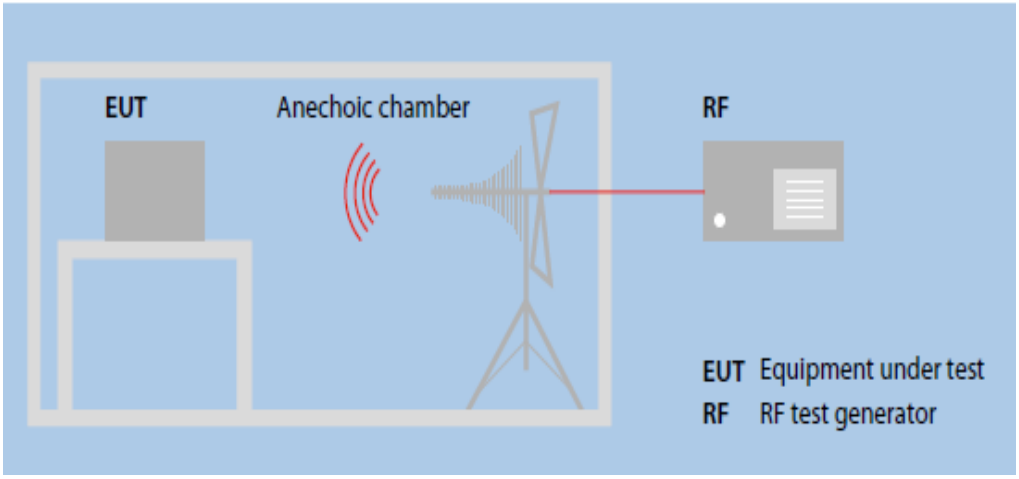

Fig 5: Setup of radiated Immunity

CONDUCTED IMMUNITY

It is a test to determine overall immunity to radiated fields, but the test performed with signals injected onto cables i.e. conducted into the EUT.Cable testing is therefore an important method for checking RF susceptibility, and IEC/EN 61000-4-6 specifies the test methods. Any method of cable RF injection testing should require that the common-mode impedance at the end of the cable remote from the EUT be defined. Each type of cable should have a common mode decoupling network at its far end to ensure this impedance with respect to the ground reference plane (GRP) and to isolate any ancillary equipment from the effects of the RF current on the cable. For equipment to be used and tested in a system where the cable lengths and terminations at either end are controlled, these terminations provide the appropriate common-mode impedance. Fig .6 [7]

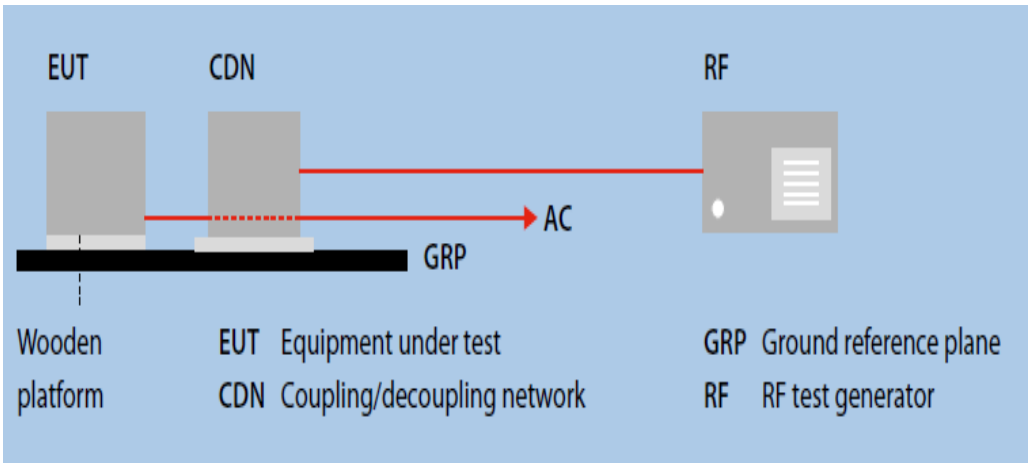

Fig 6: Setup of conducted Immunity

Table 2 shows the IEC standards for Immunity measurements

Table 2. IEC standards for Immunity measurements

IEC EN 61000-4-2	Electromagnetic compatibility (EMC)- Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
IEC EN 61000-4-3	Electromagnetic compatibility (EMC)- Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test
IEC EN 61000-4-4	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test
IEC EN 61000-4-5	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test
IEC EN 61000-4-6	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields
IEC EN 61000-4-7	Electromagnetic compatibility (EMC) - Part 4-7: Testing and measurement techniques - General guide on harmonics and inter-harmonics measurements and instrumentation, for power supply systems and equipment connected thereto
IEC EN 61000-4-8	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test
IEC EN 61000-4-9	Electromagnetic compatibility (EMC) - Part 4-9: Testing and measurement techniques - Pulse magnetic field immunity test
IEC EN 61000-4-11	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests

ADVANTAGESOF EMC DESIGN

The primary advantages of adequate EMC design as per standards are:

1.Minimizing the additional cost required by suppression elements or redesign in order to satisfy the regulatory requirements (minimizing product cost),

2.Maintaining the development and product announcement schedule (minimizing development schedule delays),

3. Ensuring that the product will operate satisfactorily in the presence of the inevitable external noise sources at its installation location (minimizing customer complaints) [4]

CONCLUSION

This paper has presented the concept of electromagnetic compatibility (EMC) and its classifications. The current live needs to diagnosis electromagnetic compatibility (EMC) of electrical gadgets. Further it is proposed to design standard device for electromagnetic compatibility. Procedure for emission and immunity testing is described in IEC standards. It is conclude that the device will be satisfied the standards.

REFERENCES

[1] Electromagnetic Compatibility (EMC) – Part 4: Testing and Measurement Techniques – Section 3: Radiated, Radio- Frequency, Electromagnetic Field Immunity Test, International Standard CEI/IEC 1000-4-3, Geneva, Feb. 1995.

[2] M. I. Montrose, E. M. Nakauchi, "Testing for EMC Compliance," IEEE Electromagnetic Compatibility Society, Sponsor, 2004. M. I. Montrose, E. M. Nakauchi, "Testing for EMC Compliance," IEEE Electromagnetic Compatibility Society, Sponsor, 2004.

[3] M.T. Ma, M. Kanda, "Electromagnetic Compatibility and Interference Metrology" U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, Secretary National Bureau of Standards, Ernest Ambler, Director. Tech Note 1099, 178 pages, July 1986.

[4] Clayton r. Paul, "Introduction toElectromagneticCompatibility" 2nd edition published by John Wiley & Sons, Inc., Hoboken, New Jersey, 2006.

[5] V. Prasad Kodali, "Engineering Electromagnetic Compatibility" published by Wiley-Blackwell, 1996.

[6] Madhu suman, Er. MandeepkaurSaini, Dr. Anupamdeep Sharma "Electromagnetic Interference and Compatibility- A Review" International Journal of Advanced Research in Computer Science, Volume 8, No. 4, May 2017

[7] Schaffner Group, "Basics in EMC / EMI and Power Quality Introduction, Annotations, Applications" Headquarters, global innovation and development center, January 2013.