# INTRODUCTION TO ELECTROMAGNETIC INTERFERENCE

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## 1 Scope of the Presentation

Electromagnetic interference (EMI) arises from many and diverse sources, takes many forms, is propagated by different physical mechanisms and may have a wide range of effects. It is the objective of this presentation:

a) to provide an overview of the various aspects of EMI;
b) to indicate the nature of the physical generation and propagation mechanisms;
c) to indicate the range of techniques available for protection purposes, ie for achieving electromagnetic compatibility (EMC);
d) to outline areas of possible concern;
e) to outline the national and international EMC standards;
f) to outline EMI/EMC testing methods;
g) to identify requirements for EMI/EMC education and training;
h) to identify future trends.

The following presentation is to be treated only as a broad introduction to the topics of EMI and EMC. More detailed aspects are covered elsewhere.

## 2 General Nature of EMI

The more common sources of EMI encountered by electrical/electronic systems of various types are (internal) thermal, shot and 1/f noise and (external) ignition systems, flourescent lighting, electrical machines, electronic systems, thunderstorms, solar noise, intentional and unintentional transmitters, and galactic noise etc. Many of these will be considered in more detail later. As our society becomes increasingly dependent upon electrical and electronic systems of different types for its' day-to-day activities, the number and diversity of EMI sources can also be expected to increase; the corresponding effects of EMI are likely to become more varied, and possibly more subtle. These effects cause particular concern if they form a direct threat to public health and safety, or if they cause key electrical/electronic systems to malfunction, eg in manufacturing industry, communications or defence.

## 3 General Considerations

There are many aspects of system design which are becoming more susceptible to the effects of EMI whilst, at the same time, the EMI environment is becoming progressively more severe. EMC is the discipline which attempts to overcome, or limit, the effects of this mismatch in accordance with agreed standards and specifications. The EMC design and implementation problem in electrical/electronic system design may be summarised as:

a) minimising the level of EMI emissions from electrical and electronic systems;
b) reducing the vulnerability of electrical and electronic systems to those EMI emissions which do occur.

At this stage, it is useful to attempt a formal definition of EMC in relation to EMI.

EMC has two important aspects:

(i) it quantifies the extent to which given electrical and electronic systems can function as specified without generating EMI at a level which would cause a malfunction in other electrical/electronic systems - the "EMISSION" aspect;

(ii) complementing (i), it also quantifies the extent to which given electrical and electronic systems can function as specified in a defined EMI environment without being caused to malfunction - the "IMMUNITY" aspect.

In practice, all EMI/EMC problems have elements which are unique to the particular equipments and environments in question.

## 4 EMI Propagation Mechanisms

There are three major physical mechanisms by which EMI can be propagated, viz: conduction; reactive coupling; radiation. It should be noted that, in any given situation, EMI propagation may well be via a combination of two or three mechanisms, rather than being due to a single mechanism in isolation.

## 5 Sources of EMI

The major sources can be categorised into two groups, ie "natural" and "man-made" sources. The important considerations associated with each source are summarised as follows:

| | |
|---|---|
| lightning:- | ground conductivity, position exposure, thunderstorm activity and type of strike (direct, induced transients in conductors, radiated energy); |
| solar effects:- | ionosphere and hence communications, transionospheric propagation; electrostatic discharge [ESD], ease with which charges are built up by different materials, path to ground for discharge; |
| electrical and electronic systems:- | emissions may cause spectral pollution, environment (ie business, residential, rural); |
| bona fide spectrum users:- | regulations, mobiles proliferating, spectrum deregulation, numbers of users, anomolous propagation mechanisms, non-linearities in RF units, spurious emissions from transmitters, propagation and noise database restricted and imperfect natural isolation. |

## 6 Areas of Concern

Six areas in which EMI and its effects may be a cause for concern are ignition and detonation hazards, spectrum pollution, disturbances on the mains supply, unquantified interaction and malfunction of electrical and electronic systems, compromisation of data security and integrity, and biological effects of non-ionising radiation.

## 7 EMC Practices

The major aspects of interest are design, installation and the nature of the environment. The major techniques used are suppression and filtering, screening, earthing and bonding.

## 8 National and International Standards

The areas in which standards development are of greatest importance include:

(a) use of the mains for purposes other than power distribution at frequencies below 150 kHz;
(b) the characterisation of large electrical and electronic installations, (eg telephone exchanges) from the EMC viewpoint;
(c) the "tightening" of standards which may realistically be possible as a result of the widespread application of EMC-oriented system design techniques;
(d) improvements in the understanding of the physical basis of EMC measurements and testing.

## 9 EMI/EMC Testing

The main methods of EMI/EMC testing that are used currently fall into two basic categories:
(a) screened enclosure testing; (b) open-site testing.

There is still a wide margin of uncertainty in the accuracy and interpretation of many EMC/EMI measurements.

## 10 EMI/EMC Education and Training

There are many problems associated with the provision of adequate EMI/EMC education and training services. It should be noted that EMC is a much broader discipline than simply "fields and waves"; for example, in addition to classical electromagnetic theory, it also ideally requires a knowledge of:

(a) signal generation and processing techniques;
(b) measurement and information theory;
(c) probability and statistics;
(d) communication and modulation;
(e) linear and non-linear system analysis, etc

One way to raise the awareness of EMI/EMC among students taking higher education courses would be to introduce appropriate EMC case studies into the teaching of say EM theory. There is also a need for EMC education in the form of short continuing education courses given to industry, and extended postgraduate courses.

## 11 Future Trends and Outstanding Problems

The major future trends and outstanding problems that can be identified in the overall EMI/EMC area can be summarised as:-

EMC Directive: who will it effect?
large installations
environmental characterisation
development of EMI/EMC design methodologies
mobile EMI sources proliferating
deterioration and malfunction of installed systems
possible effects of spectrum deregulation
illegal transmitters and problems of enforcement generally
general raising of man-made EMI background
effects of non-ionising EM radiation;

There are developing threats to electrical and electronic system operation in all six of the areas of concern listed earlier; these require the application of substantial R & D effort - particularly in respect of design methodologies and environmental characterisation.