Int. j. adv. multidisc. res. stud. 2024; 4(1):124-127

Received: 15-11-2023
Accepted: 25-12-2023

International Journal of Advanced Multidisciplinary Research and Studies

ISSN: 2583-049X

Electromagnetic Interference Impacts on Electronic Systems and Regulations

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Abstract
The electromagnetic interference (EMI) is dangerous for our daily lives. It produces vital electronic failures. These problems are due to bad shielding materials for electronic systems. The main objective of this article is to raise the awareness of EMI and its consequences on critical functions of electronic systems. In this article, the general aspects of this topic are introduced. Case histories about EMI are presented. It was suggested that the study of the optical properties of materials is a central task for reducing the effect of EMI on the proper function of electronic devices.

Keywords: Electromagnetic Interference (EMI), Electronic System Failures, Electromagnetic Spectrum, EMI Case History, Distortion of Signals

1. Introduction

The classifications and properties of electromagnetic spectrum have been published elsewhere [1]. A detailed account of the theoretical and experimental progress in electromagnetic spectrum can be found in [2, 7].

This paper discusses the conceptual aspects of the electromagnetic Interference (EMI) of radio and micro radiative systems with electrical and electronic devices. Electromagnetic Interference (EMI) can be defined as a process by which disruptive electromagnetic radio and micro wave radiations are transmitted from one electrical or electronic device to another by means of radiated sources [8]. It can be stated that, all electronic components emit some levels of radio frequency known as electromagnetic radiation [9]. Such a mechanism can adversely affect the performance of the electrical and electronic components, devices and systems [8]. These can be seen from daily life (distorted television reception) to medical applications, industrial applications, military activities and aerospace explorations [10]. If these EMI problems are left disregarded, they may cause severe damage to communication systems [11], interference with aircraft control systems, automotive safety systems, medical devices [8] and safety operation of many critical electronic devices [11].

The increasing development of electronic systems and devices and the tendency towards the idea of space economy, through designing electronic components with a higher packing density for swift response has resulted in electromagnetic interference. High RF signals are used in the operation of many electronic devices and can be transmitted out of the device to the surrounding environment, tending to cause the malfunctioning of nearby equipment [11]. EMI also causes health risks such as symptoms of nervousness, headache, and insomnia [11]; such causes should be known when making medical diagnosis.

2. EMI Coupling

The Electromagnetic radiations can interfere and disturb each other even if they are not on the same frequency. The flow of electricity through the electronic circuits of devices creates some amount of electromagnetic energy. This energy can be propagated through the air as radiation or coupled into cables of other device resulting in the malfunctioning of device [12].

Due to the high technological and modern environments, EMI can emerge in several ways. It happens when two signals come close to each other or when multiple signals pass through one device at the same frequencies. It can also happens due to natural phenomena on earth and space like lightning, electric storms, cosmic noise, solar magnetic storm, airport radar, electrostatic discharge, and white noise, transmission from TV, radio AM, FM, and Satellite [12].

It is stated that in all cases there must be a source of interference emissions and a receptor (victim) which is susceptible to this interference [13] (see figure1.). Knowledge of how the EMI source emissions are coupled to the receptor (victim) is essential, since a reduction in the coupling factor reduces interference effects and a production of electronic device meets its performance specification [13].

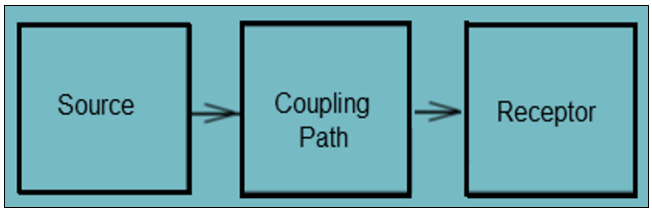

Fig 1: Source-Coupling path- Receptor Model

The mechanisms of EMI are based on three main elements: a source (an emitter) which may be called a transmitter. A receptor (victim) is an electrical or electronic component or device that receives the interference from the source. A coupling path transmits the interference signal(s) from the source to the receptor [14].

2.1 EMI Coupling Paths

Electromagnetic interference can take place through the following: conduction, radiation, capacitive, and inductive couplings.

Conduction coupling happens when EMI emissions travel along a direct physical conduction route, wires, and cables that transfers electromagnetic emissions to connected equipment (the source and receiver) [12]. Conductive coupling often happens on power distribution lines [13], or through a power cord, interface cables, antenna input terminals, ground returns, housings, and external conductors such as metallic cases [14].

Radiation coupling happens when the source and receiver are separated by a large distance that is more than a wavelength. There is no physical contact between the source and receiver since the EMI is radiated via space to the receiver [12]. It usually occurs when the unwanted electromagnetic signals are radiated from the source operating at high frequency and received by a different electronic unit nearby [13]. Because of this wide separation, the source is usually not affected by the presence of the receptor. Radiative fields decay as 1/R for points far away from the source [14].

Capacitive Coupling is due to the electric field component and happens between two very close parallel conductors and store a capacitive charge between them [13]. It occurs when a voltage that changes from a source, capacitive transfers the charge to the receptor [14].

Inductive coupling is due to the magnetic field generated by the source around the receptor conductor [13]. It occurs when distances between the source and receptor are much less than a wavelength. The relatively small separation, the presence of the receptor can affect the behavior of the source as well [14]. When a varying magnetic field is present between source and receptor, a sufficient amount of current will be induced in the receptor circuitry. This results in signal transfer from the source to the receptor conductor [12].

Perhaps the most emerging points about EMI topic are to emphasize the important impacts of EMI on commercial, military electronic systems, medical, and industrial applications. Therefore, it was thought of great importance to boost the attention of serious and vital problems that are facing most electronic activities and to acquaint the reader with electronic systems failures case histories caused by electromagnetic interference (EMI). It can be stated that any electronic and electrical devices emit electromagnetic energy (disturbance) that can interfere with the operation of other devices, and cause electronic systems failure [15]. EMI is a combination of terms that broadly refers to any type of interference that can potentially disrupt or degrade any authorized electronic emissions over specific portions of the electromagnetic spectrum [15]. Such electronic systems failure can presented in the following Case Histories:

3. Case Histories

- In the late 1980s, a truck, skidding out of control, crashed into an ice cream parlor in Munich, killing 13 teenagers and injuring others. Subsequent examination indicated that the truck's anti-skid breaks locked up when near certain type transmitters (an EMI problem) [15].
- In the mid-1980s, the US Army experienced 5 crashes of its UH-60 Black Hawk helicopters, which were believed to be due to RFI [15].
- The U.S. Food and Drug Administration (FDA) is cautioning consumers with pacemakers and other implantable medical devices about the potential for interference from radio frequency identification (RFID) tags. Implantable medical devices can be susceptible to interference from radio frequency sources, including RFID tags, resulting in malfunctions and even device failures [15].
- Some Nissan owners have found that if their cellphones and 'intelligent' car keys (known as I-Key) are touching, incoming or outgoing calls can alter the electronic code in the I-Key with the result that the car will not start. The I-Key cannot subsequently be reprogrammed [15].
- Hazards of interference with prosthetics [15].
- Immunity problems with consumer appliances. 30,000 reported cases of radio interference in Canada involving consumer electronic products [15].
- Interference with gas cooker control creates safety risks. In one Canadian community, many residents had complained over a number of years about interference with gas cooking ranges and other appliances located in their homes [15].
- Lifesaving equipment in hospitals may be switched off by radio-frequency devices used to track people and machines, Dutch scientists claim. Radio frequency identification devices (RFIDs) are on the rise in healthcare, helping identify patients, and reveal the location of equipment. The Journal of the American Medical Association study found they could interfere with machines [15].
- RF interference in ambulance causes death Medical technicians taking a heart-attack victim to the hospital in 1992 attached her to a monitor/defibrillator. Unfortunately, the heart machine shut down every time the technicians turned on their radio transmitter to ask for advice, and as a result the woman died. Analysis showed that the monitor unit had been exposed to exceptionally high fields because the ambulance roof had been changed from metal to fibreglass and fitted with a long-range radio antenna. The reduced shielding from the vehicle combined with the strong radiated signal proved to be too much for the equipment [16].
- Magnetic airline tray tables wipe hard drives It was reported in the Sunday Times (15/2/98) and New Scientist (7/3/98) that Sabena Belgian World Airlines had installed magnetic tray tables in its new fleet of A340 Airbuses, to prevent the nuisance of rattling trays

on their flights, but that these tray tables were apt to cause loss of data on PC hard disc drives [16].

- Licensed TV transmissions interfere with intensive care, kills babies Seems a hospital had a high incidence of infant deaths in the intensive care section of the maternity ward. Late at night, the alarms on the babies' monitors would go off for no apparent reason. Annoyed, the nurses would turn them off and do the rounds on foot. After some preliminary investigations, they found out that a nearby TV transmitter was allowed by their license to increase their output wattage by some enormous amount. The cable interconnecting the nurses' station to the various baby monitors interferes with these frequencies and set off alarms with the induced voltages [16].
- NOAA-11 is a weather satellite launched September 24, 1988, and operated by NASA for the National Oceanographic and Atmospheric Administration (NOAA). In September 199 1, a series of phantom commands were observed and determined to be caused by EM1 due to a noisy very high frequency (VHF) environment [17].
- Extreme Ultraviolet Explorer (EUVE) Data Loss. The EUVE was launched June 7, 1992. In October and November of that year, EM1 caused data loss in satellite transmissions to Earth [17].
- Voice of America (VOA) radio transmitter case involved a blimp over Greenville, flying near the VOA transmitter; the blimp suddenly had double engine failure. The flight crew followed emergency procedures and made a successful unpowered landing. An investigation determined that the failure of the ignition system was due to EMI [17].
- In mid-May 1984, a Soviet ammunition depot exploded. The cause of the accident, according to the Soviets, was an over-the-horizon radar that had illuminated the depot [17].
- Another VOA HIRF case occurred in 1984 near Munich, Germany. A West German Tornado fighter crashed after flying too close to a powerful VOA transmitter [17].
- Aircraft Passenger Carry-on Devices Cases. Passenger carry-on devices provide another group of case histories. They show the increased susceptibility to external EM1 sources those modern automated electronic systems aboard aircraft experience. This external EM1 is generated by seemingly innocuous electronic devices, which include portable computers, AM-FM "Walkman" cassette players, dictaphones, radios, heart monitors, and cellular phones [17].
- It is interesting to note that cellular phones are frequent EM1 culprit devices. They have interfered with the operation of incubators, infusion pumps and controllers, dialysis equipment, and defibrillators as well as with aircraft systems. A large hospital in Chicago and a large healthcare center in Indiana have banned the use of cellular phones. These phones are also banned in some European hospitals. Cellular phones that use the new European GSM standard have been reported to produce audible interference in hearing aids up to a distance of 30 m [17].
- Ambulance Heart Monitor /defibrillator. Susceptibility of medical equipment to conducted or radiated emission is a concern. In this case, a 93-year-old heart attack victim was being taken to the hospital and the medical technician had attached a monitor/defibrillator to the patient. Because the machine shut down every time the technicians turned on the radio transmitter to request medical advice, the patient died. An investigation showed that the monitor/defibrillator was exposed to exceptionally high radiated emissions because the ambulance roof had been changed from metal to fiberglass and fitted with a long-range radio antenna [17].
- Apnea Monitor Case**. A** physician at a major university hospital reported that apnea monitors would not work in some surrounding neighborhoods. Prolonged sleep apnea (cessation of breathing) is detrimental to adults and can be fatal to infants. Other reports of monitor failures prompted the **FDA** (U.S. Food and Drug Administration**)** to conduct tests. The conclusion that low levels of EM1 detected by commercial apnea monitors could erroneously indicate respiration prompted a recall of those particular monitors [17].

4. Results and Discussion

A careful review of the aforementioned cases confirms an important fact that there is a defect and negligence in the manufacture and design of electronic components shielding, which in turn led to the occurrence of these problems and disasters. The use of weak shielding techniques in electronic device designs caused these problems. Using poor shielding materials against strong environmental radiated radio signals will result in electromagnetic interference (EMI). A guideline on the use of these reference materials have been published in [18]. For Standards and Regulations (see [19, 20]). It was suggested by [17] that everyone working with advanced electrical or electronic systems must be aware of the potential consequences of EMI.

The relationship between electricity and magnetism is well established. The flow of electric current in conductor produces magnetic field, and a moving magnetic field produces an electrical current. Such conditions may provide electromagnetic radiation interactions in electrical and electronic systems, which in turn lead to EMI. To reduce the effects of EMI on electrical and electronic systems implies that careful and diligent attention must be paid to the shielding materials (shielding effectiveness) used for electrical and electronic systems. This requires a deeper understanding of the optical properties of materials, mainly, reflection (conductivity) and absorption (permeability) at radio and micro electromagnetic energy radiations. This will be the task of the next article.

5. Conclusion

It can be concluded that the consequences of EM1 on electrical and electronic systems are serious and of ever growing concern because of their direct connections to our daily lives and activities. The extensive use of modern electronic devices in an increasingly scattered electromagnetic environment (EMI) should be carefully reconsidered and thoroughly retested. Finally, it is of extreme importance of having up-to-date EMI guidelines, standards, and test procedures, so that a minimization of electromagnetic interference can be achieved.

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