

EMR POLLUTION- AN IMPERCEPTIBLE THREAT FOR SAFETY

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ABSTRACT

Technology is an application of science for the betterment of humanity. The succession in technology must be harmonized with our mother nature. The progression must not result into destructive effects to human beings. Establishment of new technology must diminish the effects of detrimental factors. Electromagnetic waves have contributed significantly in the growth of communication systems. The adverse effects of progression in technology have led towards health issues as a consequence of radiation. The pollution is the phenomenon which causes adverse effects on environment or creatures. Electromagnetic waves are responsible for causing health risks to humanity and degrade the performance of equipments. So, it can be called pollution. In physics, radiation is a phenomenon in which energetic particles or energetic waves travel through a medium or space. EMR (Electro Magnetic Radiation) is hazardous to humanity and can be considered as a pollutant for the safety of environment, human beings and machines. Thus it can be mentioned as Electromagnetic interference. Electromagnetic interference is caused by electromagnetic radiation. Electromagnetic interference is a disturbance which may result into malfunctioning of equipments. EM waves, light, heat, x-ray and gamma rays are all different forms of electromagnetic radiation. However, they differ in their wavelength. These radiations have hazardous effects on human beings and material. The damaging levels depend on frequency, ambient temperature, body resistance and weight of individuals. Exposure over an energy density of 10 mw/cm² at any frequency is considered to be not safe. It can be categorised into broadband and narrowband interference. The sources of electromagnetic interference can be natural or man made. A systematic approach is required to deal with electromagnetic interference. Electromagnetic compatibility is a phenomenon to describe immunity of equipment or component in electromagnetic environment. EMC is a controlling mechanism to protect against EMI effects. Federal Communications Commission (FCC) in the US published a regulation in 1979 that required the electromagnetic emissions of all "digital devices" to be below certain limits. The intent of this rule was to try to limit the "electromagnetic pollution" of the environment in order to prevent, or at least reduce, the number of instances of EMI. Different military as well as civilian standards are developed for immunity and emission measurements. Military EMC standards are made in order to ensure system-to-system compatibility in the real time military environment. The civilian EMC

standards are applicable for equipments used for commercial, industrial and domestic applications. The emission standards are specified to protect the broadcast services from interference. These also take into account the physiological interference effects experienced by human beings. Military standards are more stringent than civilian standards. The standards are developed by different organisations like IEC, FCC and CISPR. This paper focuses on the probable hazards of electromagnetic Interference on human beings as well as machines and evolution of different standards for safety against electromagnetic interference. The motive of this paper is to disseminate an awareness about possible perilous effects of radiation and its counteractive measures.

KEY WORDS

EMI, EMC, EMR, Ionizing, Non ionizing, SAR, SAFCA, ICNIRP

INTRODUCTION

Electromagnetic spectrum is a broad range of frequencies from very low to ultra high range. This is the possible range of electromagnetic radiation. Electromagnetic spectrum is used in many applications like TV transmitter, mobile communications, FM transmitters, satellite communication etc. We do not realize that we are exposed to severe electromagnetic fields than in past generations. In fact: "Scientists estimate that your daily exposure to EMF radiation is 100 Million Times higher today than it was in your grandparents' time."

ELECTROMAGNETIC INTERFERENCE

Electromagnetic interference or EMR pollution is a disturbance that affects an electrical circuit due to either electromagnetic induction or electromagnetic radiation emitted from an Internal or external source. The disturbance may interrupt, obstruct, or otherwise degrade or limit the performance of a circuit or an equipment. This radiation also affects living beings. Electromagnetic interference can be generated from natural or man made source. Figure-1 shows the basic components of EMI occurrences.



Figure-1:Basic components of EMI occurrences.

The source is an emitter of EMR pollution. Which can be natural or artificial. The natural sources can be lightning, thunderstorms etc. Extra-Terrestrial natural Sources are sun-disturbance and cosmic noise. The manmade sources are transmission and distribution equipments. The transfer path is a channel. The channel can be a radio path or wireline path. The victim is any machine as well as living beings. Source produces the electromagnetic emission. Coupling path or medium transfers this emission to receiver. Receiver receives the emission and produces desirable / undesirable effects.

EXAMPLES FOR COMMONLY EXPERIENCED

electromagnetic effects

- Lightning

- TV sets are damaged via mains line

- Noise in the car radio

- Ignition creates disturbances

- GSM traffic burst to be heard in other audio

devices

- 50 Hz from mains to be heard in other audio devices

- Disturbance While Mobile Phone is placed near

Microphone

- Interference during landline call if there is an incoming call on mobile phone placed near landline phone

- Disturbances on TV sets or computer monitors by ordinary loudspeakers

EMI COUPLING MECHANISM

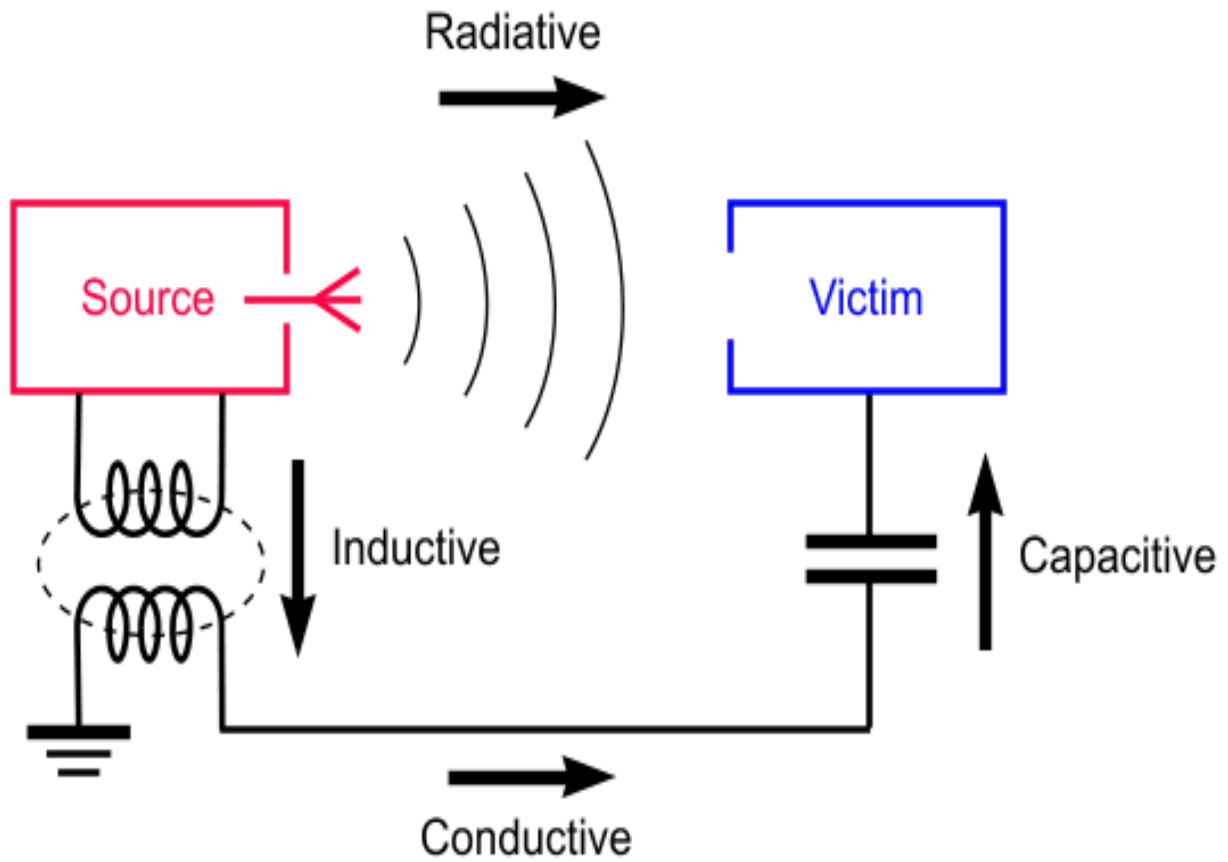


Figure-2: EMI coupling mechanism

EMI can be coupled by two ways. It can be radiative or conductive as shown in Figure-2. It can be through conduction phenomenon or through the principle of electromagnetic induction. The Inductive coupling can be due to the principle of mutual induction.

ELETROMAGNETIC COMPATIBILITY

Electromagnetic Compatibility (EMC) is the ability of apparatus to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbance to other apparatus in that environment. EMC is a controlling mechanism to protect against EMI effects.

A system is said to be electro magnetically compatible if it follows following requirements.

1. It doesn't cause interference with other system.
2. It is not susceptible to emissions from other systems.
3. It doesn't cause interference with itself.

Different EMC standards are developed for protection against EMR pollution. EMC standards enhance reliability, safety and compatibility. Standards also increases product life. The standards are developed by IEC, CISPER , FCC, BSI, VDE etc. There are two types of standards.

1. Military

Military EMC standards are made in order to ensure system-to-system compatibility in the real time military environment. Equipments are classified based on their deployment environment.

2. Civilian

In these standards, test procedures are well defined. Military standards are more stringent than civilian standards. Most of the military standards are broadly based on MIL-STD 461 and 462.

The civilian EMC standards are applicable for equipments used for commercial, industrial and domestic applications. The emission standards are specified to protect the broadcast services from interference. These also take into account the physiological interference effects experienced by human beings.

ANECHOIC CHAMBERS FOR EMC TESTING

An anechoic chamber(an-echoic meaning non-echoing or echo-free) is a room designed to stop reflections of either sound or electromagnetic waves. They are also insulated from exterior sources of noise. There are two types.

1. Full anechoic chambers

2. Semi anechoic chambers

Full anechoic chambers aim to absorb energy in all directions. Semi-anechoic chambers have a solid floor that acts as a work surface for supporting heavy items, such as cars, washing machines, or industrial machinery. Different standards are used to describe immunity and emission testing procedures for assessing the electromagnetic compatibility of equipments.

ADVERSE EFFECTS OF EMR POLLUTION ON HUMAN BEINGS

Electromagnetic spectrum is used in many applications like TV transmitter, mobile communications, FM transmitters, satellite communication etc. The growth in telecom sector depicts the socio economic growth of a country. India has witnessed a magnificent transformation in telecom sector. India has expected to reach 1 billion subscribers by the year 2014 [1]. Building pertinent telecom infrastructure has the major impact on growth of economy as infrastructure investments add to capital stock. India has around 3, 10,000 telecom towers [1]. These towers are responsible for adverse effects on the health of human beings. The adverse effects of electromagnetic radiation are peril and concealed. The adverse effects of RF/Microwave Radiations were recognized by the erstwhile USSR and, in fact, the same was used as a weapon to create mental disturbances, instability and high anxiety. The same was utilized by illuminating US Embassy in Moscow with high power Microwave Radiations [2]. Gradually the adverse health effects started coming to the notice of medical and radiological scientists. Certain measures were taken in advanced countries to formulate positive guidelines and to regulate exposure limits within safe levels. The United States FCC had guidelines FCC 56 revised by FCC65. Canadian Government incorporated Safety Code No. 6, European Countries developed ICNIRP and IEEE Guidelines. ICNIRP is the International Commission on Non-Ionizing Radiation Protection. It is a body of independent scientific experts consisting of a main Commission of 14 members, 4 Scientific Standing Committees covering Epidemiology, Biology and Optical Radiation and a number of consulting experts. This expertise is brought to bear on addressing the important issues of possible adverse effects on human health of exposure to non-ionizing radiation. Unfortunately, even with such a faster growth, RF Illuminating Towers in Indian cities could not magnetize the consideration of the Government of India. The Government of India is yet to take some steps either to evolve some strategy or to follow existing guidelines of other countries. Figure-3 shows the EM spectrum to describe the adverse effects of EMR pollution.

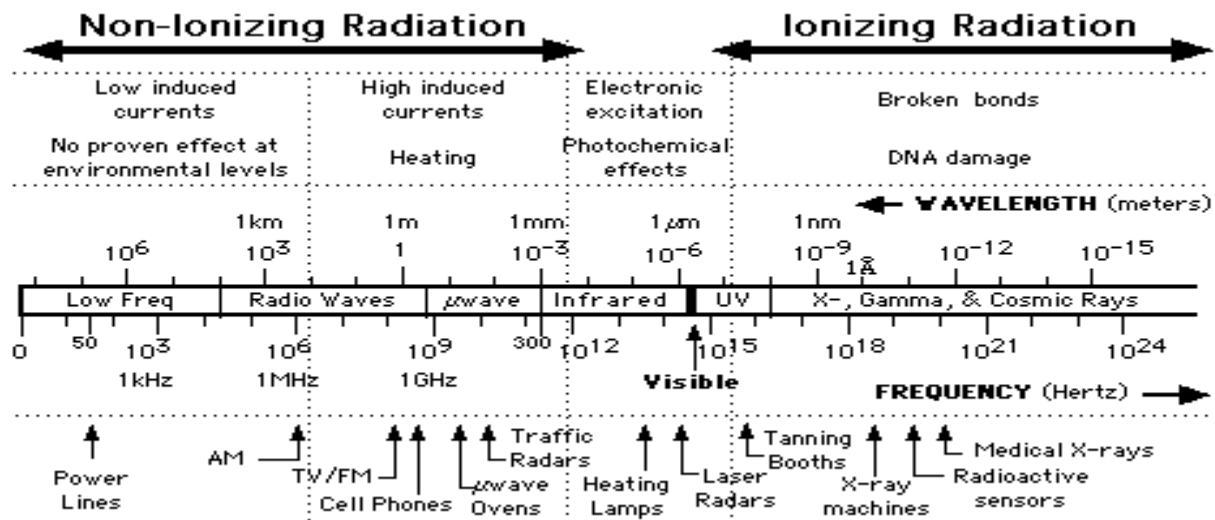


Figure-3: EM spectrum

1. Ionizing radiation

Ionizing radiation is composed of particles that individually have sufficient energy (or can liberate sufficient energy) to remove an electron from an [atom](#) or [molecule](#). This ionization produces [free radicals](#), which are atoms or molecules containing unpaired electrons. These tend to be chemically reactive, and they account for most of the unusually high biological damage of ionizing radiation.

2. Non-ionizing radiation

Non-ionizing radiation refers to any type of [electromagnetic radiation](#) that does not carry enough [energy](#) per [quantum](#) to [ionize](#) atoms or molecules—that is, to completely remove an [electron](#) from an [atom](#) or [molecule](#). Instead of producing charged ions when passing through matter, the electromagnetic [radiation](#) has sufficient energy only for excitation, the movement of an electron to a higher energy state. Nevertheless, different biological effects are observed for different types of non-ionizing radiation.

Thermal radiation is [electromagnetic radiation](#) generated by the [thermal motion](#) of [charged particles](#) in [matter](#). The current safety standards are based on thermal effects. Non thermal effects are several times more hazardous than thermal effects. Thus, current standards are inadequate. SAR (Specific absorption rate) is defined as the rate at which radiation is absorbed by human body. It is measured in watts per kg (W/kg). In USA, max. SAR limit for cell phones is 1.6W/Kg which is for 6 minutes.

It has a safety margin of 3 to 4, so a person should not use cell phone for more than 18 to 24 minutes per day. Blackberry has provided the user guidelines to keep the device at least 25mm away from the body. It is mentioned that “When you wear the Blackberry device close to your body, use a RIM approved holster with an integrated belt clip or maintain a distance of 0.98 in. (25 mm) between your Blackberry device and your body while the Blackberry device is transmitting. Use of body worn accessories, other than RIM approved holsters with an integrated belt clip, might cause your Blackberry device to exceed radio frequency (RF) exposure standards if the accessories are worn on your body while the Blackberry device is transmitting. The long term effects of exceeding RF exposure standards might present a risk of serious harm [3].” Interphone study reveals that for every 100 hours of use increases the risk of meningioma by 26%. It increases the risk of glioma by 55% to regular users. Regular users are taken as people who use it for 2hrs/month. Doubles or even quadruples the risk of brain tumor to heavy users. Heavy users are taken as people who use cell phone for 1/2 hour/day. Children and young adults are excluded from this study. International Agency for Research on Cancer (IARC), a part of WHO designates cell phones as "possible human carcinogen” .It has Found evidence of increase in glioma and acoustic neuroma brain cancer for mobile phone. ICNIRP (International Commission of Non Ionizing Radiation Protection) has declared that “ICNIRP is only intended to protect the public against short term gross heating effects and NOT against 'biological' effects such as cancer and genetic damage from long term low level microwave exposure from mobile phones, masts and many other wireless devices [4].” INTER-MINISTERIAL COMMITTEE (IMC) Report ON EMF RADIATION was uploaded on DOT website in Jan. 2011.It mentions several health hazards due to radiation on human health and environment The GSM emissions do cause a variety of problems like loss of appetite, irritation, discomfort, fainting, fatigue, difficulty in concentration and headaches generally known as Microwave Syndrome [5][6]. A study done in France by Santini showed significant association between symptoms fitting to the Microwave Sickness and the distance to the mobile base stations. More the nearness more the sickness effect [7]. Pre Adolescent Children are at greater threat than adults [8] because of absorption of Microwaves of the frequency used in Mobile communication, which creates an object of the size of child’s head and so called “head resonance” [9]. The still developing Nervous System and related Brain Wave activities in the child are more vulnerable to hostility by pulses of Microwaves used in GSM. The increased mitotic activity in cells of developing children makes them more vulnerable to genetic damage. Children are at the greatest risk, due to their thinner skulls, and rapid rate of growth. Also at larger risk are the elderly, the weak and pregnant women. Doctors from the United Kingdom have issued warnings urging children under 16 not to use cell phones, to reduce their exposure to radio frequency (RF) radiation. A pregnant woman and the fetus both are susceptible because of the fact that these RF Radiations

continuously react with the developing embryo, increasing cells, because of thermal heat also. Human Brain is the most defenseless portion to the NIEMR. Neurological effects [10], Increase in ODC (Ornithine De Carboxylase) activity [11], effect on enzymes and free radicals decreasing the brain metabolism [12]. The RF Exposure adversely affects implanted Pace Maker and becomes arhythmical. These radiations may stop Pace Maker from delivering pulses in a regular way or may generate some kind of external controlling pulse putting the patient to death. Depressed nocturnal melatonin levels in cattle is found as per [13], There is a six folds increase in chromosome damage in Cows is observed due to EMR [14].Table-1 Shows the case study at the distance of 91 meters from mobile tower in India.

Sr No.	Name	Year of death	Cause/Disease	Age at time of death
1	Radhabai Sathe	2005	Breast cancer	66
2	Deshpande	2006	Throat Cancer	48
3	Shubhangi deshpande	2007	Rectum Cancer	66
4	Pujaree	2008	Cancer	46
5	Gawai	2008	Breast cancer	52
6	Shah	2009	Cancer	48
7	Vidyadhar Dev	2009	Liver Cancer	52
8	Ransube	2009	Throat Cancer	73
9	Archana Malvadkar	2009	Spinal cord cancer	17

Table-1: Case study, Source: L.B. Deshpande who studied the deaths in his solapur locality since two towers were installed four years ago.

NOKIA GUIDELINES

We ignore the safety guidelines provided by manufacturer. It is clearly mentioned that ‘‘ Use of device accessories may result in different SAR values. SAR values may vary depending on national reporting and testing requirements and the network band.’’

During extended operation such as an active high speed data connection, the device may feel warm. In most cases, this condition is normal. If you suspect the device is not working properly, take it to the nearest authorized service facility.

- Operating environment

This device meets RF exposure guidelines in the normal use position at the ear or at least 1.5

centimeters (5/8 inch) away from the body. Any carry case, belt clip, or holder for body-worn operation should not contain metal and should position the device the above-stated distance from your body.

To send data files or messages requires a quality connection to the network. Data files or messages may be delayed until such a connection is available. Follow the separation distance instructions until the transmission is completed. Parts of the device are magnetic. Metallic materials may be attracted to the device. Do not place credit cards or other magnetic storage media near the device, because information stored on them may be erased.

- Medical devices

Operation of radio transmitting equipment, including wireless phones, may interfere with the function of inadequately protected medical devices. Consult a physician or the manufacturer of the medical device to determine whether they are adequately shielded from external RF energy. Switch off your device when regulations posted instruct you to do so. Hospitals or health care facilities may use equipment sensitive to external RF energy.

- Implanted medical devices

Manufacturers of medical devices recommend a minimum separation of 15.3 centimeters (6 inches) between a wireless device and an implanted medical device, such as a pacemaker or implanted cardioverter defibrillator, to avoid potential interference with the medical device. Persons who have such devices should:

1. Always keep the wireless device more than 15.3 centimeters (6 inches) from the medical device.
2. Do not carry the wireless device in a breast pocket.

Hold the wireless device to the ear opposite the medical device.

3. Turn the wireless device off if there is any reason to suspect that interference is taking place.
4. Follow the manufacturer directions for the implanted medical device.
5. If you have any questions about using your wireless device with an implanted medical device, consult your health care provider.

Potentially explosive environments

Switch off your device in any area with a potentially explosive atmosphere. Obey all posted instructions. Sparks in such areas could cause an explosion or fire resulting in bodily injury or death. Switch off the device at refueling points such as near gas pumps at service stations [16].

IARC DECLARATIONS

The WHO/International Agency for Research on Cancer (IARC) has classified radiofrequency electromagnetic fields as possibly carcinogenic to humans (Group 2B), based on an increased menace for glioma, a malignant type of brain cancer, associated with wireless phone use [17]. From May 24–31 2011, a Working Group of 31 scientists from 14 countries met at IARC in Lyon, France, to evaluate the probable carcinogenic hazards from exposure to radiofrequency electromagnetic fields. Dr Jonathan Samet (University of Southern California, USA), overall Chairman of the Working Group, indicated that "the evidence, while still accumulating, is strong enough to support a conclusion and the 2B classification. The conclusion means that there could be some risk, and therefore we need to keep a close watch for a link between cell phones and cancer risk"[18].

RECOMMENDATIONS OF THE INTER MINISTERIAL COMMITTEE ON EMF RADIATION

Government of India, Ministry of Communications & IT - Department of Telecommunications has given some recommendations of the Inter Ministerial Committee on EMF Radiation regarding mobile handsets [19].

- i) SAR level for mobile handsets shall be limited to 1.6 Watt / Kg, averaged over a 6 minutes period and taken over a volume containing a mass of 1 gram of human tissue.
- ii) SAR level shall be displayed on the handset.
- iii) All cell phone handsets sold in the market in India shall comply with relevant BIS standards and shall be with hand free devices .
- iv) SAR value information of the mobile hand sets shall be available on the manufacturer 's web site & in the handset 's manual . The information on SAR values shall be made available to the consumer at the point of sale.
- v) Mobile hand set manufactured and sold in India or Imported from other countries shall be checked for compliance of SAR limit .
- vi) The manufacturers in India shall provide self declaration of SAR value of the handset .In respect of imported handset from other countries , manufacturers apart from self declaration of SAR shall specify the SAR information in their documents for verification by the appropriate authority . Suitable amendments in the Indian Telegraph Rule under Indian Telegraph Act 1985 shall be enacted for strict compliance.
- vii) Manufacturer's mobile handset booklet shall contain the following safety precautions:

- a. Use a wireless hand - free system (headphone, headset) with a low power Bluetooth emitter.
 - b. Make sure the cell phone has a low SAR.
 - c. Keep your calls short or send a text message (SMS) instead. This advice applies especially to children, adolescents and pregnant women.
 - d. Use cell phone when the signal quality is good.
 - e. People having active medical implants should preferably keep the cell phone at least 15 cm away from the implant.
- viii) List of SAR values of different mobile phones shall be uploaded on DoT/TEC website.

REMEDIES

The adverse effects of EMR are not known to uninformed and innocent citizens. The following steps can be taken to reduce the harmful effects of electromagnetic radiation.

1. SAFCA (Standing advisory committee on frequency allocation) should follow the complete observation procedure of base station site before allocation and clearances.
2. Government should form stringent rules for service providers.
3. Rules should be modified and service providers must not be allowed to put the antennas on roof top.
4. EMR should be considered as pollutant and stringent law should be formed.
5. Monitoring and supervision must be done for the cell sites.
6. Safe radiation level must be adopted.
7. People must be informed about harmful effects of EMR.
8. All the mobile phone manufacturers as well as service providers must print warning on the respective documents as well disclose the radiation level.
9. People should use hands free if possible.
10. One should reduce the amount of time spent on calls.
11. Mobile phone must not be kept in pockets.
12. Cell size must be reduced to decrease the power level and radiation. Reduced cell size will require more number of cells and hence more operating and deployment cost to service provider. Thus service providers can not afford to cut their profit by reducing cell size. Safety of humanity is more important than profit of service providers. So, government must form stringent rules in the favor of citizens as this is a very serious issue regarding health and safety of humanity.

ADVERSE EFFECTS OF EMR POLLUTION ON MACHINES

The EMI Control Engineers/Scientists may come across the EMI Encounters right from the Design stage to the production stage like PCB Design, Components Assembling ,Routing of the cables, Design of Chassis and Coatings.In communication engineering, EMR pollution can result into hazardous accidents.Some of the examples are as follows.

1. Failure of aircraft control system
2. Communication may stop between Satellite nad earth station
3. Processor controlled systems may hang.
5. Erratic data values may generate from the controller.
6. Situation of no output data may occur.
7. Failure of Pacemaker

EMF DANGER SPOTS IN YOUR HOME

Circuit Breaker

These produce very high toxic readings, into radio wave frequencies and even microwave frequencies. This is because the electric wires attach to a fuse box draws a lot of electricity

Air Conditioners

Air conditioners can emit EMFs as high as circuit breakers. The older the unit, the greater the dangerous EMF radiation.

In-Floor Electrical Heating

This mode of heating utilizes electrical wires that are embedded right into a home's wood or concrete flooring. EMFs can reach 100+ mG at the floor and 30+ mG at waist height.

Fluorescent Lighting

Fluorescent lights create a higher level of EMFs than incandescent bulbs. A typical fluorescent tube may have a reading of 160 to 200 mG at 1 inch away. Even electromagnetic radiation from a compact fluorescent light can be problematic.

Halogen ceiling down or “can” lights

These lights require a transformer that can transmit EMF upward as well as downward, which means rooms above as well as below are affected.

Electric Sockets

Anything that’s plugged into a wall socket gives off an electromagnetic field (EMF) of 50-60 hertz, even if that appliance is turned off.

Cordless Phones

Cordless phones emit a tremendous amount of toxic radiation—twice as much as cell phone masts! The danger is in the handset as well as the base stations, which continuously give off harmful radio waves well over 100 hertz (1 kHz) every hour of the day.

Recently, the British Health Protection Agency found one of the causes of neuromas (tumors deep in the ear) are cordless phones. For cordless phones users the incidence of acoustic neuromas doubles in just 10 years.

Telephone Landlines

Even the handset of a land line telephone emits high EMFs. The telephone receiver, the part held to your ear, carries a harmful south polar magnetic energy.

TVs & Computers

TV screens and computer monitors radiate EMFs of 60Hz or more. Older style televisions and computer screens produce radio-frequency fields of 10,000-30,000 Hz (10-30 kHz) as well as 60 Hz fields.

REMEDIES

1. Awareness about EMR pollution
2. EMC Studies
3. Onsite Surveys
4. Design consultancy
5. Shielding and screening

6. Immunity testing
7. Emission testing
8. Construction of Anechoic chambers

CONCLUSION

As we are dealing with number of electronic gadgets and equipments in our daily life, apparently we are living in the world of waves. EMR Pollution is an emission which may cause harmful effects to machines or equipments. EMC is a phenomenon which ensures correct operation of an equipment as it evaluates the compatibility. The EMI/EMC tests have become inevitable to ensure the satisfactory operation of devices and safety of living beings.

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