PROBLEM-7

MATHEMATICAL MODELLING AND SIMULATION OF ELECTROMAGNETIC SHIELDING EFFECTECTIVENESS OF POLYESTER – COTTON BLENDED WOVEN FABRIC

Problem Presenter

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1. Introduction

The trend in today's electronic devices is more faster.

Any electrical or electronic apparatus such as high voltage power lines, radar, communication system, radios, televisions, household appliances, computer, mobile phones etc generates electromagnetic waves, that are produced when an electric field comes in contact with the magnetic field.

Today's high-tech electronic gadgets, not only bring us convenience but also many negative effects.

These electromagnetic waves create electromagnetic interference to the electrical circuits and also adversely affect human health after prolong exposure.

When electromagnetic waves enter the human body, it will destruct regeneration of DNA and RNA in the cell.

Furthermore, it causes cancer, brain tumor, heart attack and skin diseases etc.

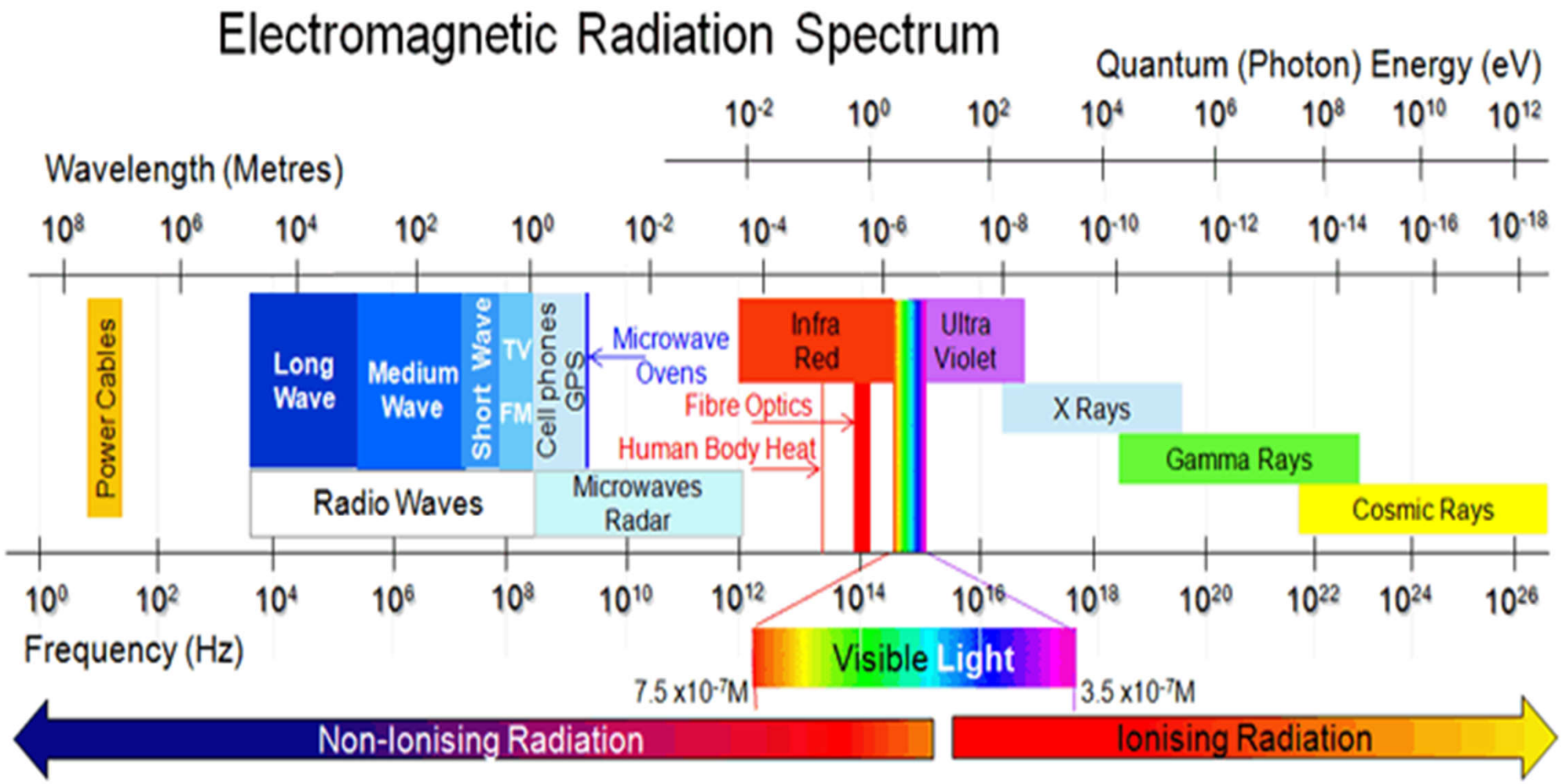
Electromagnetic Interference is encountered by all of us in our daily life and are expected to face exponential rise in future due to the growing number of wireless devices and standards including cell phones, GPS, Bluetooth, WIFI, etc.

Electromagnetic Interference (EMI) is the disturbance that affects the working of an electrical circuit due to either electromagnetic induction or electromagnetic radiation emitted from an external source.

This disturbance may interrupt, obstruct or degrade the effective performance of circuit.

What is EMI….???

When electromagnetic energy from external or internal sources to electrical or electronic equipment affects the equipment adversely by causing it to have undesirable responses, such as degraded performance or malfunctions, this electromagnetic energy is called electromagnetic interference (EMI)


Electromagnetic Radiation Spectrum
Quantum (Photon) Energy (eV)
10-2 10^0 10^2 10^4 10^6 10^8 10^10 10^12
Wavelength (Metres)
10^8 10^6 10^4 10^2 10^0 10-2 10-4 10-6 10-8 10-10 10-12 10-14 10-16 10-18
Power Cables
Long Wave
Medium Wave
Short Wave
TV
FM
Cell phones
GPS
Microwave Ovens
Infra Red
Ultra Violet
Fibre Optics
X Rays
Human Body Heat
Gamma Rays
Radio Waves
Microwaves Radar
Cosmic Rays
10^0 10^2 10^4 10^6 10^8 10^10 10^12 10^14 10^16 10^18 10^20 10^22 10^24 10^26
Frequency (Hz)
Visible Light
7.5 x10-7M
3.5 x10-7M
Non-Ionising Radiation
Ionising Radiation

When low power levels are used in either of these circuits, they become more susceptible to the interference from external electromagnetic fields.

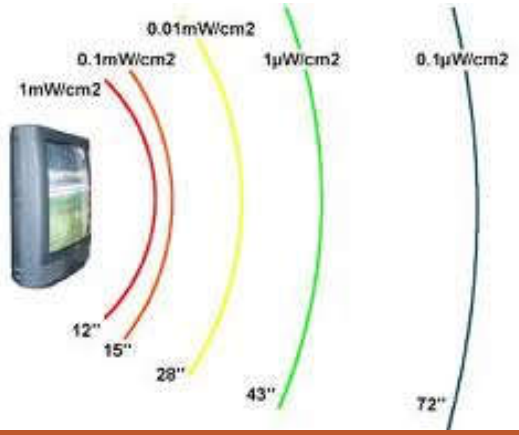
The interference can cause erroneous data, unwanted results, false alarms or even complete shutdown of the instrument.

The effects can be totally unpredictable. Adequate electromagnetic protection is being recognized as a critical element in design of low power equipment.

SOURCE OF EMI & frequency

cellular phones

garage door openers,



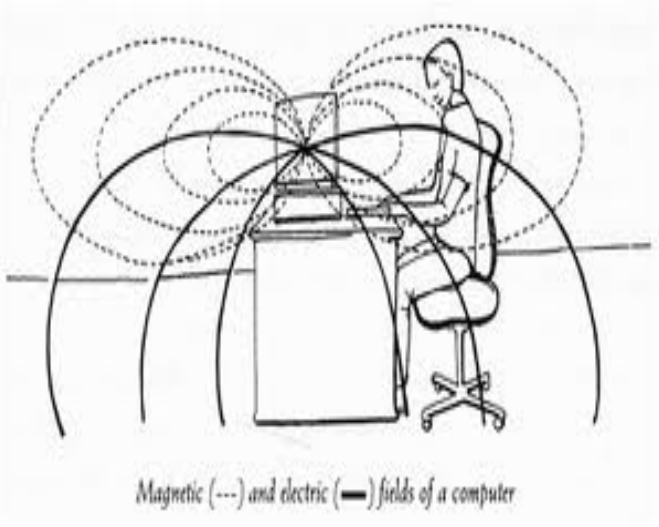
television (TV) stations,

walkie talkies

Atrillion EMI Killer for Cell phone Electromagnetic Wave shield

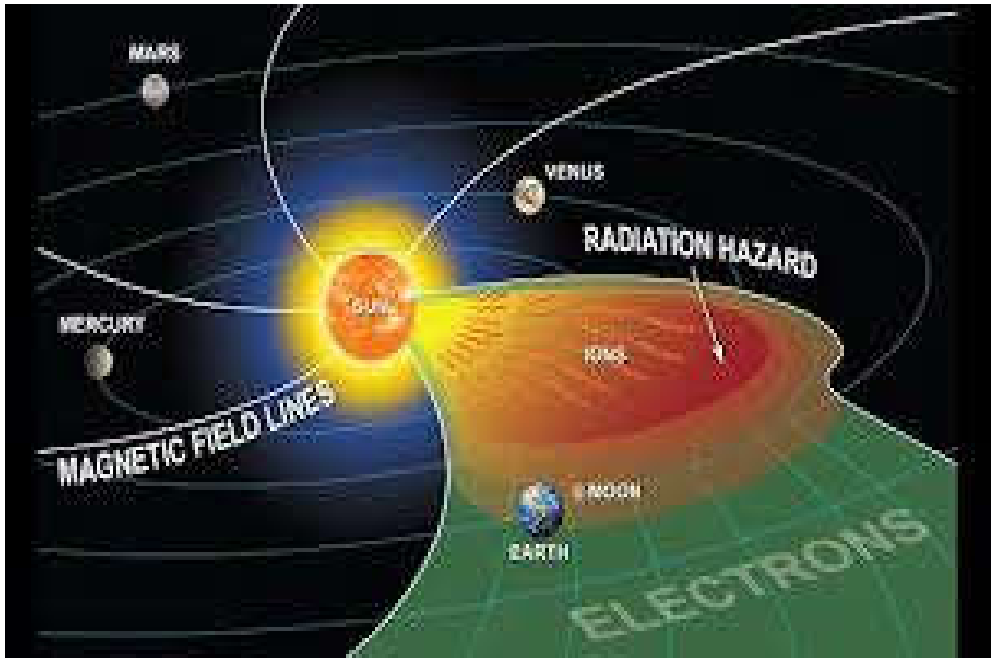
medical equipment

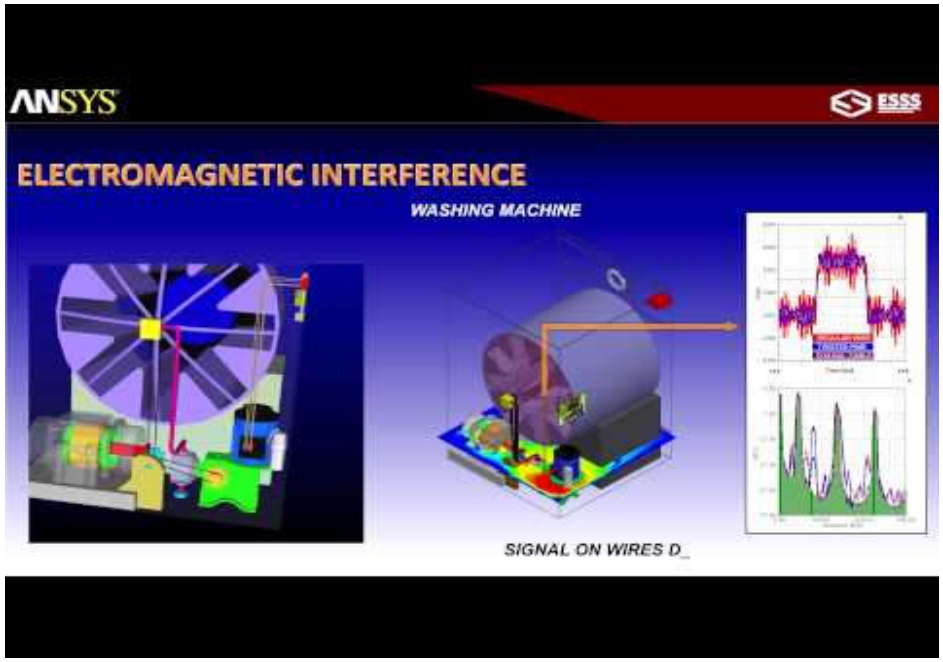
ignition systems of gasoline engines



computer systems

Even the sun produces radio frequency electromagnetic radiation.





AM radio	535 kilohertz to 1.7 megahertz
Short wave radio	5.9 megahertz to 26.1 megahertz
Citizens band (CB) radio	26.96 megahertz to 27.41 megahertz
Television stations, channels 2 through 6	54 to 88megahertz
FM radio	88 megahertz to 108 megahertz
Television stations, channels 7 through 13	174 to 220 megahertz

Some Wireless Technology Bands

Garage door openers, alarm systems Around	40 MHZ Standard
cordless phones	40 to 50 MHz
Baby monitors	49 MHz
Radio controlled air plains Around	72 MHz
Radio controlled cars Around	75 MHz
Wildlife tracking collars	215 to 220MHz
MIR space station	145 to 437 MHz
Cell phones	824 to 849 MHz
cordless phones	900 MHz
Air traffic control radar	960 to 1,215 MHz
Global Positioning System	1,227 and 1,575 MHz
Deep space radio communications	2,290 MHz to300MHz

Protection Method:

The simplest way of protection from electromagnetic waves is to stay away from it but this is not always possible in real life.

The most effective method of protection from electromagnetic waves is the use of shielding or electromagnetic shielding material.

Electromagnetic shielding is a conductive barrier that completely envelops an electronic device to protect from environmental interference or to stop emission from the device itself interfering with other devices.

In other words, electromagnetic shielding is the practice of reducing the electromagnetic field in a space by blocking the field with barriers made of conductive or magnetic materials.

SHIELDING EFFECTIVENESS

- Shielding Effectiveness is calculated according to the formula:

$$SE = 10 \log_{10} \left(\frac{P_1}{P_2} \right) dB$$

Where,

SE – shielding effectiveness,

P_1 – receive power without the material present,

P_2 – receive power with the material present.

- It depends on the distance of the shield from the source, the thickness of the shield, and the shield material.
- Shielding effectiveness is normally expressed in decibels (dB)

Testing method

In 1989, on the basis of a report from the NBS, the American Society for Testing and Materials (ASTM) developed and issued the D4935 standard .

In this method, the test adapter is constructed using a section of 50 Ω coaxial aerial, having a external-to-internal diameter ratio of 76 to 33 mm.

The shielding effectiveness measurements are carried out for frequencies ranging from 30 MHz to 1.5 GHz.

Network Analyzer

Transmitter

Receiver

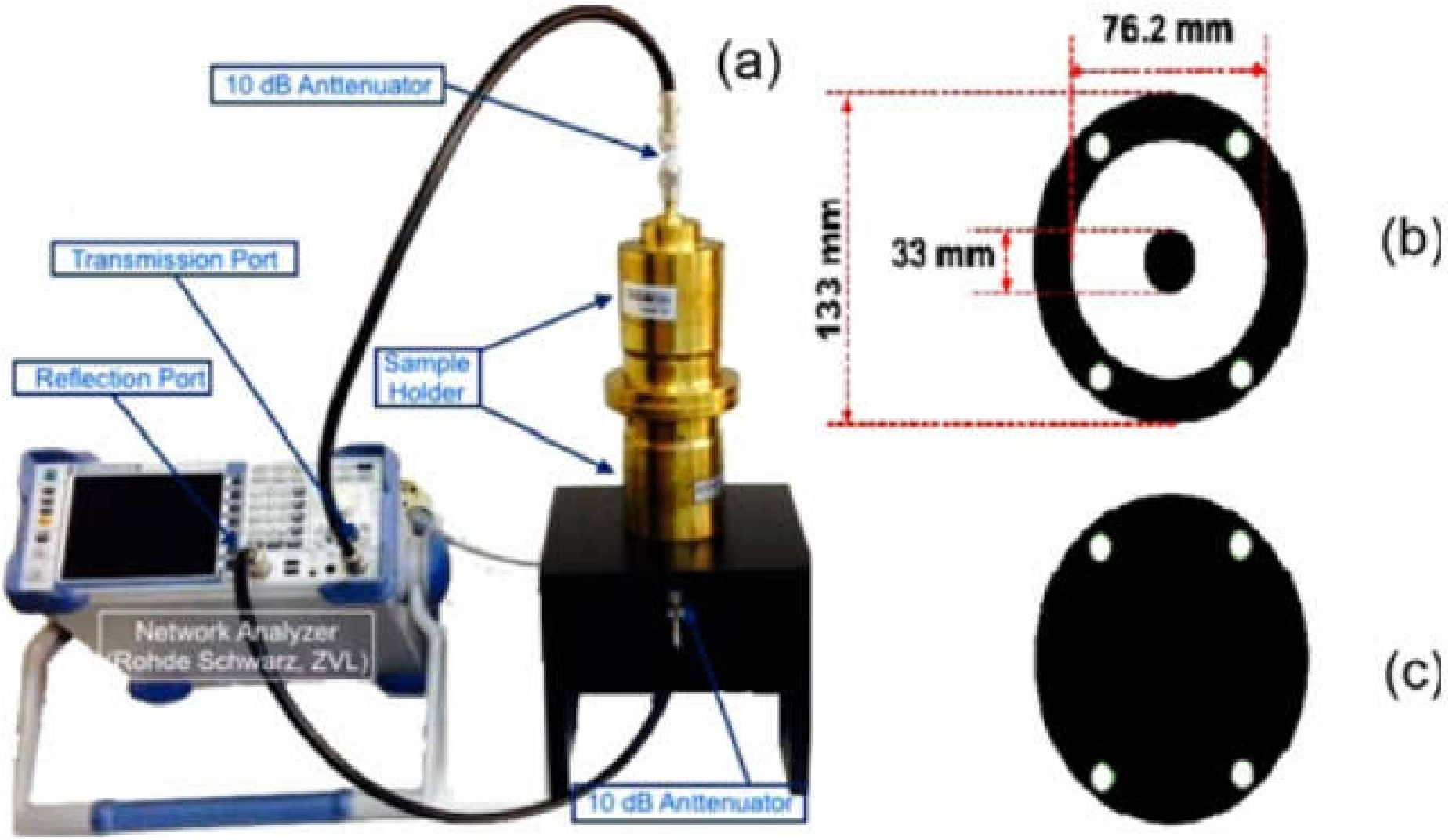


Figure 2. (a) Set up of the electromagnetic shielding effectiveness testing apparatus, (b) and (c) specimen for reference and load respectively.

Motivated by the increase of stress over electromagnetic pollution issues arising from the fast-growing development and need for electronic and electrical devices.

The demand for material with high electromagnetic interference shielding performance has become an urgency.

The common material used for construction of enclosure for shielding is metal such as copper, brass, aluminium, silver, nickel, stainless steel etc.

Although such material has good shielding performance but it has some disadvantages like low elasticity, heavy weight, high cost, easy to corrode, etc.

So, there is a need of material which is light weighted, flexible, corrosion resistant and cheap.

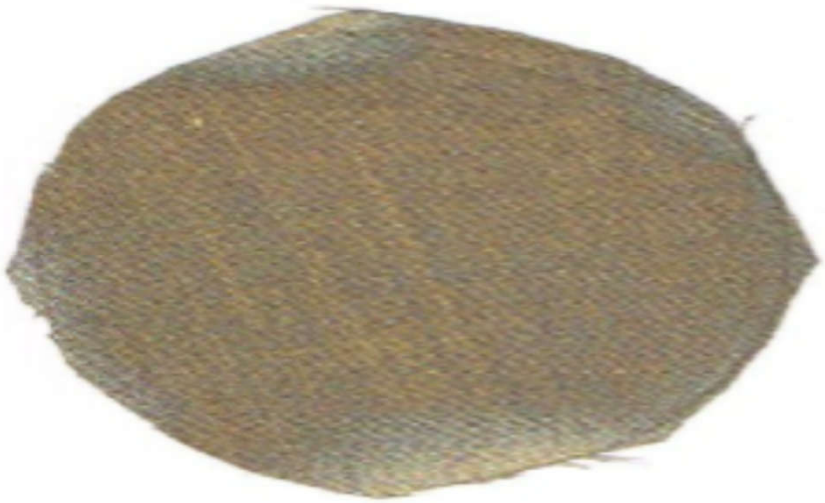
Textile material fulfils all these requirements.

But textile materials are electrically nonconductive. So, it is necessary to make it electrically conductive.

These are various methods available for imparting electrical properties to textile material such as coating of metal on fabric by magnetron sputtering, incorporating conductive fibres or yarns in fabric etc.

In our experiment, a commercially available polyester-cotton(PC) blended fabric was chosen and it was made electrically conductive by coating with silver metal using magnetron sputtering technique.

Sample prepared for the experimental work



Silver coated Fabric

Original non coated Fabric

Three different PC blended fabric samples were coated with 1, 3, and 5 micrometer thickness of silver to make fabric electrically conductive and then they were tested as per the ASTM D4935 method for electromagnetic interference shielding effectiveness test.

From the experiment it was observed that shielding effectiveness increases by increasing the thickness of silver coating.

Performing the experiment every time, to know electromagnetic interference shielding effectiveness of given material, will be costly and time-consuming process.

So, mathematical model and simulation will avoid the actual experimentation and helps in designing the more suitable material in faster way.

Problem definition

Therefore, our objective is

To Develop The Model To Predict Electromagnetic Shielding Effectiveness.


Thank You!