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Diploma seminar 2

Q16_Electromagnetic compatibility

politechnika wrocławska

Presentation plan

- Introduction
- Sources and parameters of electromagnetic interferences
- Electrical equipment and system protection against overvoltage, nonlinear protection elements: gas spark gaps, varistors, diodes, thyristors
- Lightning discharges as source of electromagnetic stress
- Electromagnetic shielding, effectives of shielding from electric and magnetic interference sources in near and far field, low frequency magnetic field shielding
- Voltage quality indices and parameters, disturbances influence on power supply system.

Introduction

"Electromagnetic Compatibility" refers to the ability of electronic devices and systems to function properly in the presence of electromagnetic interference (EMI) from other electronic devices or from natural sources such as lightning. EMC is important because if electronic devices are not designed to be EMC-compliant or resistant, they can emit electromagnetic radiation that can interfere with other surrounding devices, or they can be susceptible to interference from other devices or sources of EMI. EMC standards and regulations help ensure that electronic devices meet minimum levels of EMC performance to reduce interference and improve the reliability of electronic systems.

Sources and parameters of electromagnetic interferences

- any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades the equipment performances.
- It can be induced unintentionally, as a result of spurious emissions, vulnerabilities, etc.
- It can also be induced intentionally, as in some forms of electronic warfare or terror.
- Electromagnetic interference (EMI) can be caused by a variety of sources, including:

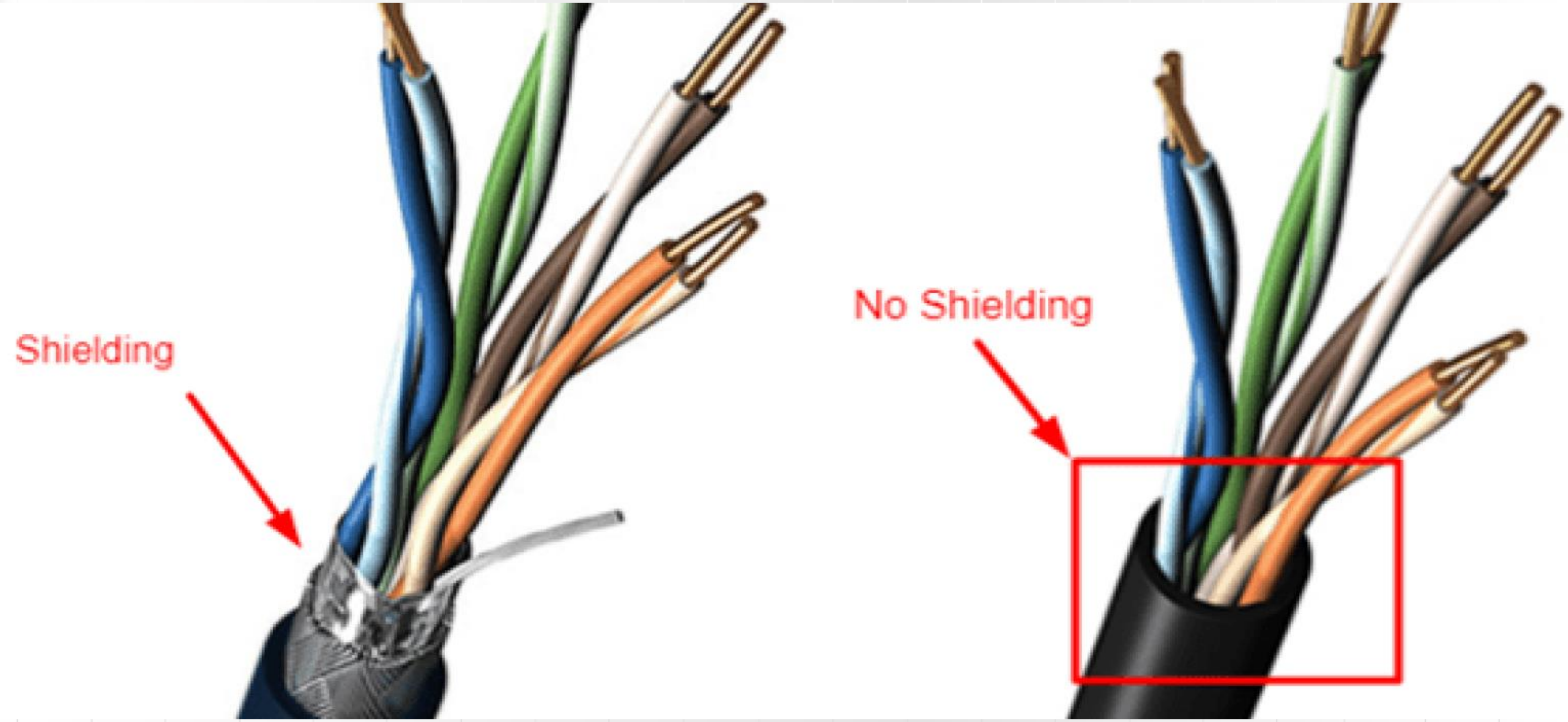
1. Power sources: Electrical power sources such as high-voltage power lines, transformers, and motors can produce electromagnetic fields that interfere with electronic devices.

2. Radio Frequency (RF) interference: RF interference is caused by radio and television broadcasts, cellular and wireless communication devices, and other sources of electromagnetic radiation in the RF spectrum.

3. Electronic devices: Electronic devices such as computers, printers, and other digital devices can emit EMI due to the rapid switching of their internal circuits.

4. Environmental factors: Environmental factors such as lightning, solar flares, and other natural phenomena can also produce EMI.

5. Cables and wiring: Poorly shielded cables and wiring can also contribute to EMI.



parameters of electromagnetic interferences:

1. Frequency: The frequency of the electromagnetic radiation can determine the level of interference. Higher frequencies typically produce stronger EMI.
2. Amplitude: The amplitude or strength of the electromagnetic field can also affect the level of interference.
3. Distance: The distance between the source of the EMI and the electronic device can affect the level of interference.
4. Shielding: The quality of shielding used to protect electronic devices can also affect the level of interference. Well-designed shielding can reduce EMI.

Overvoltage protection

- Electrical equipment and systems are vulnerable to damage from overvoltage, which occurs when the voltage level exceeds the nominal or rated value. Overvoltage can be caused by lightning strikes, power surges, or other electrical disturbances, and can lead to equipment failure, downtime, and safety hazards.
- To protect against overvoltage, nonlinear protection elements such as gas spark gaps, varistors, diodes, and thyristors are commonly used. These elements are designed to conduct current when the voltage exceeds a certain level, thereby diverting the excess energy away from the equipment or system being protected.
- **Gas spark gaps** consist of two electrodes separated by a small gap filled with a gas. When the voltage exceeds the threshold level, a spark jumps across the gap, creating a low-resistance path for the current to flow through. This protects against transient overvoltage events.

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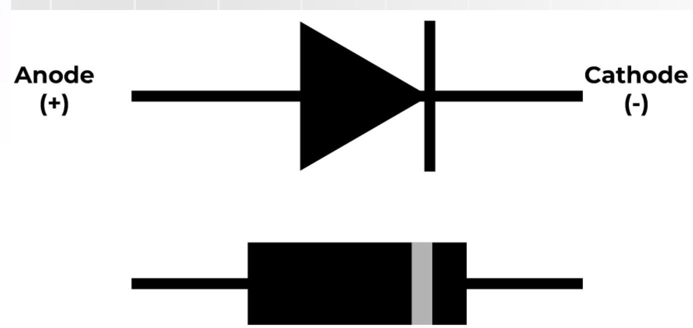
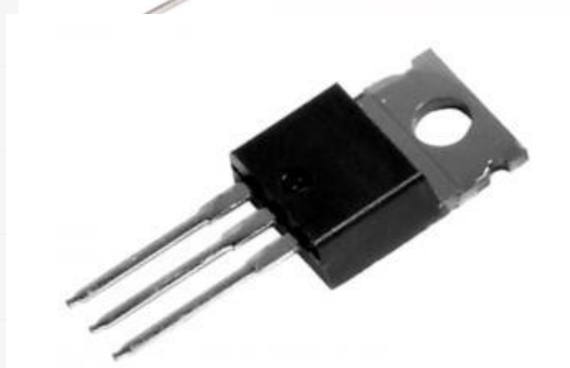
- **Varistors** are ceramic or metal oxide devices that have a non-linear current-voltage characteristic. They have a high resistance at low voltage levels, but their resistance decreases sharply as the voltage exceeds a certain threshold. This causes them to conduct current and divert excess energy away from the equipment.
- **Diodes** are semiconductor devices that allow current to flow in only one direction. When reverse voltage exceeds a certain level, a diode will break down and conduct current, protecting against overvoltage events.
- **Thyristors** are similar to diodes but can conduct current in both directions. They are commonly used in power electronics applications to protect against overvoltage events.





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Effects of lightning

lightning effects can be distinguished into:

1- indirect effects---> overvoltages:

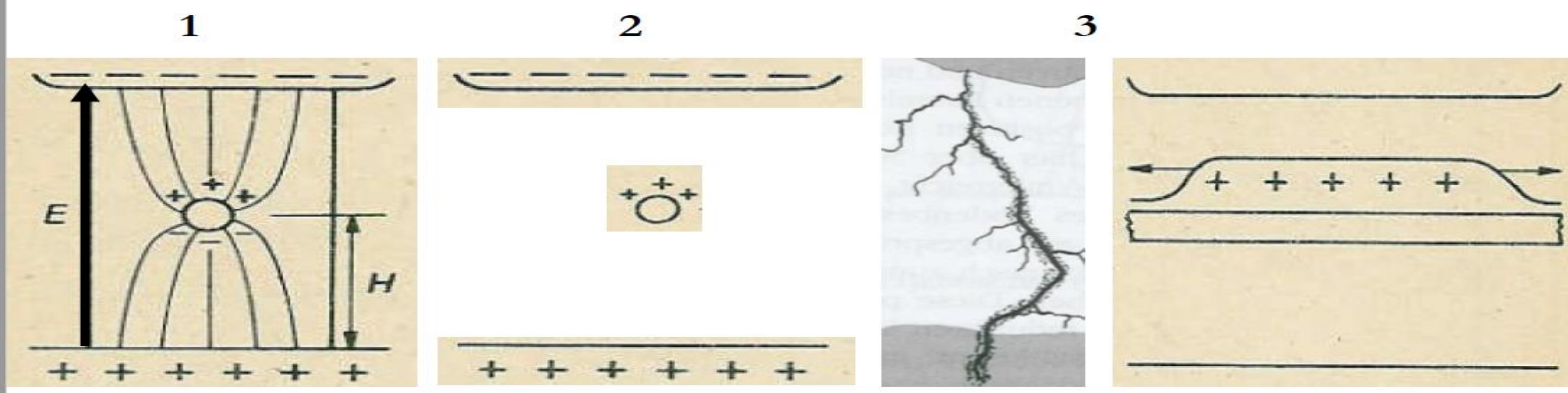
- Overvoltages on overhead lines caused by „liberation“ of influenced charges or as „back-flashover“ from tower to phases.
- Overvoltages in loops (installation, equipment) by inducing effects of lightning current.

- direct effects---> electrical, thermal, chemical, biological

Lightning current effects by:

- current flows through the object
- voltage drop on the ground
- thermal action into the object
- (overheating, radiation, melting, explosion)

Generation of overvoltages on overhead lines by lightning



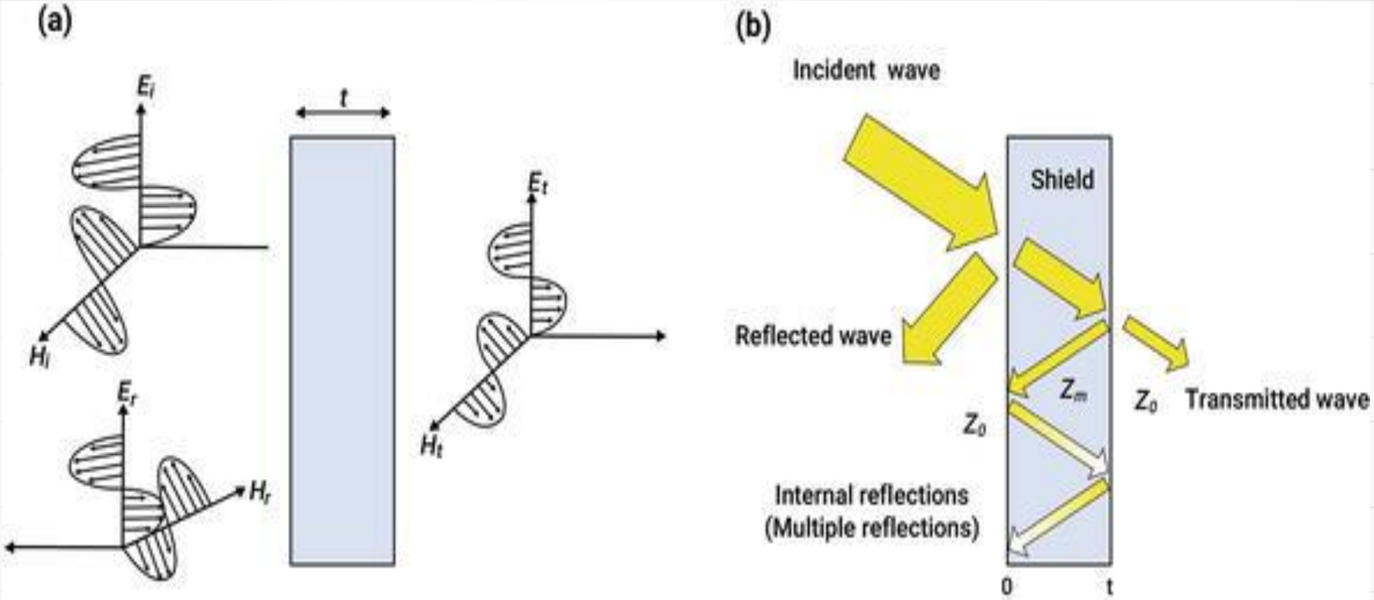
1 -influenced charged on overhead lines (o.l.) at thunderstorm
2 -due to admittance of lines remains positive charge only on o.l.
3 -occurring a stroke the charge is not further fixed --> travelling overvoltage wave along the line.

lightning overvoltages can damage electrical equipment for power transmission which connected on overhead lines e.g power transformers, switch-gears ,etc...

* all equipments for power transmission must be tested before going in operation (test against „atmospheric overvoltages“)

Shielding

- Electromagnetic shielding is a technique used to protect electronic devices and systems from unwanted electromagnetic interference (EMI).
- Shielding can be effective in reducing EMI by providing a physical barrier between the source of the interference and the device being protected.
- Shielding can be made from materials such as metal, conductive paints or fabrics, and special composite materials that absorb or reflect electromagnetic waves.
- At low frequencies, magnetic fields are the primary concern for EMI shielding. Magnetic fields can penetrate most materials, including metals. To shield against low frequency magnetic fields, materials with high magnetic permeability, such as mu-metal or ferrites, can be used. These materials can redirect the magnetic field lines away from the sensitive electronic components, reducing the impact of the magnetic field.



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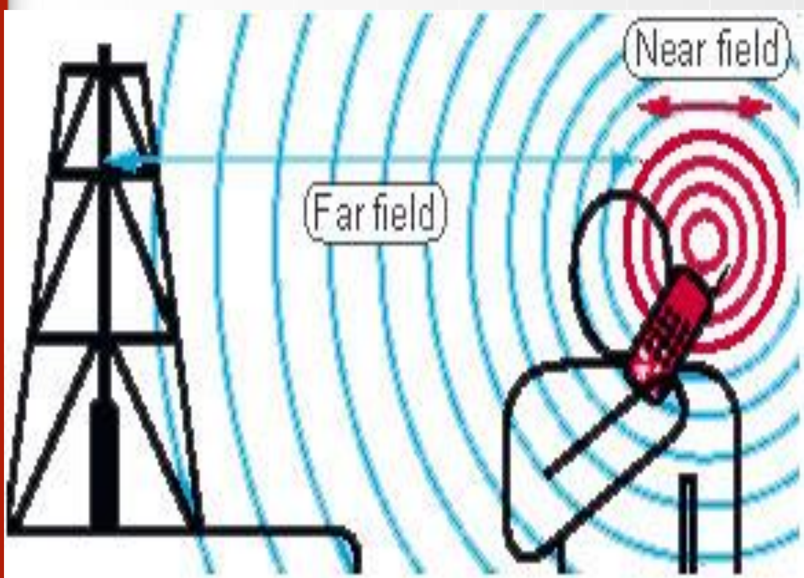
Shielding techniques

- In the near field, which is defined as the region within one wavelength of the source, shielding is more effective for magnetic fields than for electric fields. This is because electric fields can penetrate most materials, while magnetic fields can be blocked by conductive materials such as metals. Therefore, shielding materials for the near field must be chosen based on their magnetic permeability.

- In the far field, which is defined as the region beyond one wavelength of the source, both electric and magnetic fields can be shielded effectively using a variety of materials. For example, a metallic enclosure can block both electric and magnetic fields. Conductive coatings or meshes can also be effective at blocking electromagnetic waves in the far field.



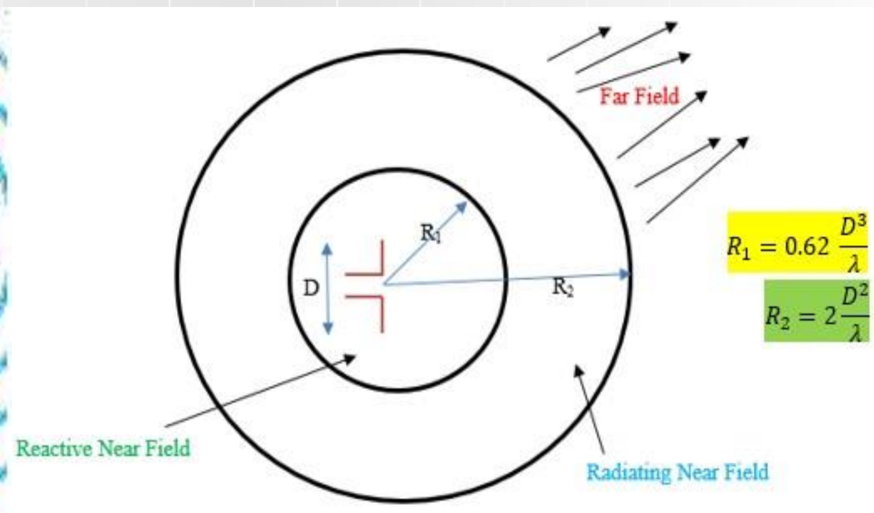


Figure: Field Regions surrounding an Antenna

Voltage quality indices and parameters, disturbances influence on power supply system

1. Voltage magnitude: The voltage magnitude is the amplitude or strength of the voltage signal. It is typically measured in volts (V) or kilovolts (kV). Voltage magnitude can be affected by various factors such as load changes, network topology, and system faults.
2. Voltage stability: Voltage stability is the ability of the power system to maintain a constant voltage level under varying load conditions. Voltage instability can result in voltage fluctuations, which can cause equipment damage and affect system performance.
3. Voltage unbalance: Voltage unbalance is a condition where the voltage levels on the three phases of a three-phase power system are not equal. This can result in uneven loading of the system and can cause damage to equipment.
4. Voltage harmonics: Voltage harmonics are periodic variations in the voltage waveform at frequencies that are multiples of the fundamental frequency. Harmonics can cause interference and distortion in sensitive electronic equipment.
5. Transients and surges: Transients and surges are brief disturbances in the power supply system that can cause damage to equipment. They are typically caused by lightning strikes, switching operations, and other events.

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Thank You

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