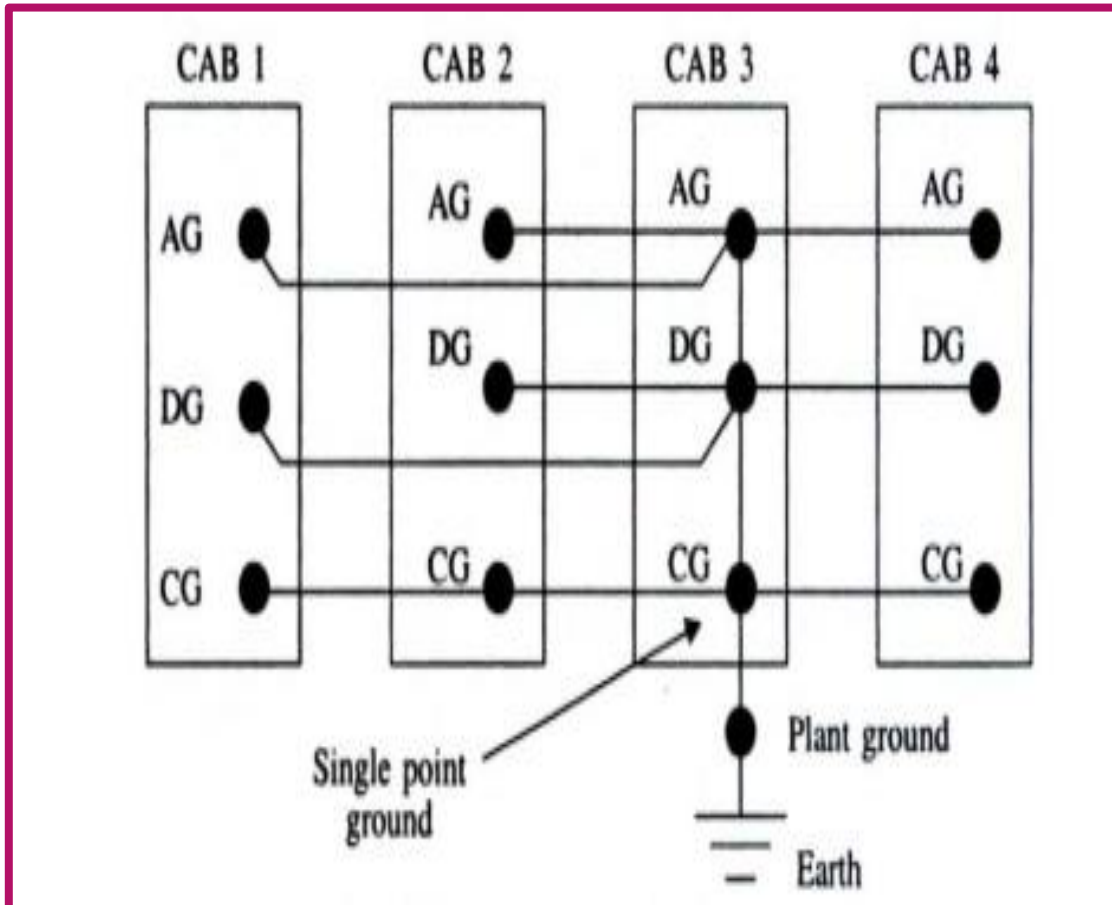
GROUNDING & SHIELDING

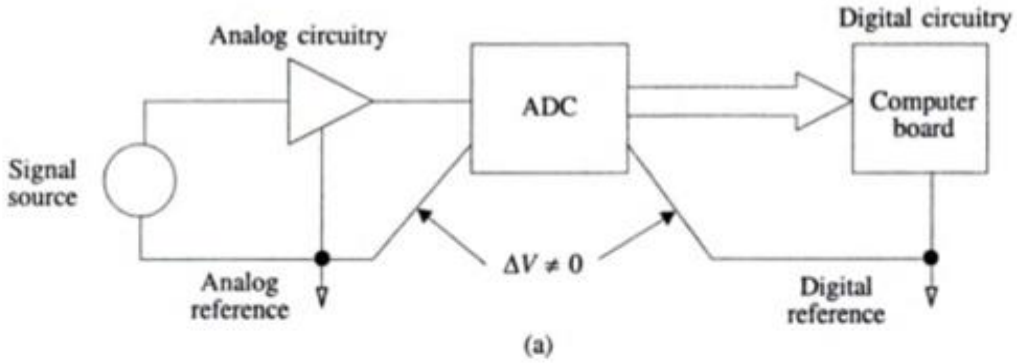
Multi cabinet Grounding

- In industries large number of analog and digital circuits are used all together.
- So all the power return of analog circuits terminals must be connected together to terminal AG while the power return of digital circuits must be connected to single point DG.
- Generally 4 American wire gauge (AWG) are used for plant grounds.



Interfacing ADC Between Analog & Digital Circuits

- The Analog to Digital converter requires a single point ground for signal reference.
- Multiple ground points generates the noisy ground loops.



Interfacing an ADC between analog and digital circuits: (a) bad design and (b) better design.

Multilayer PCB

- The use of multilayer PCB allows the use of multiple ground planes buried under the signal layers, V_{cc} and ground layers.
- These layers act as distributed bypass capacitor.
- VIA is an hole connecting various unattached layers but act as anchor point.

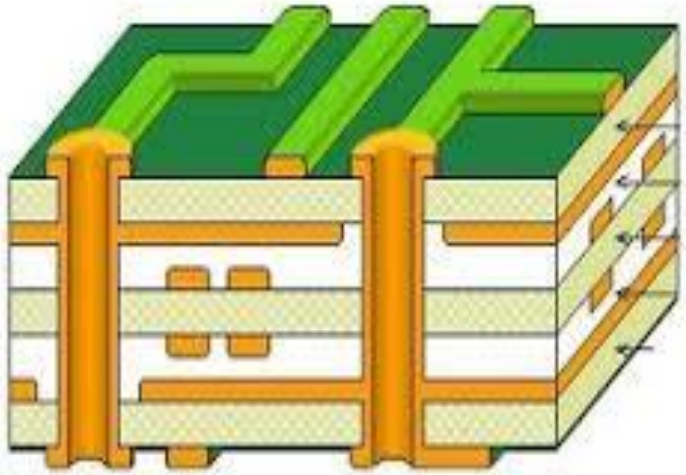
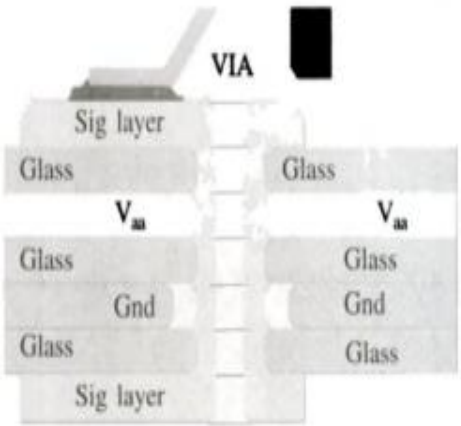
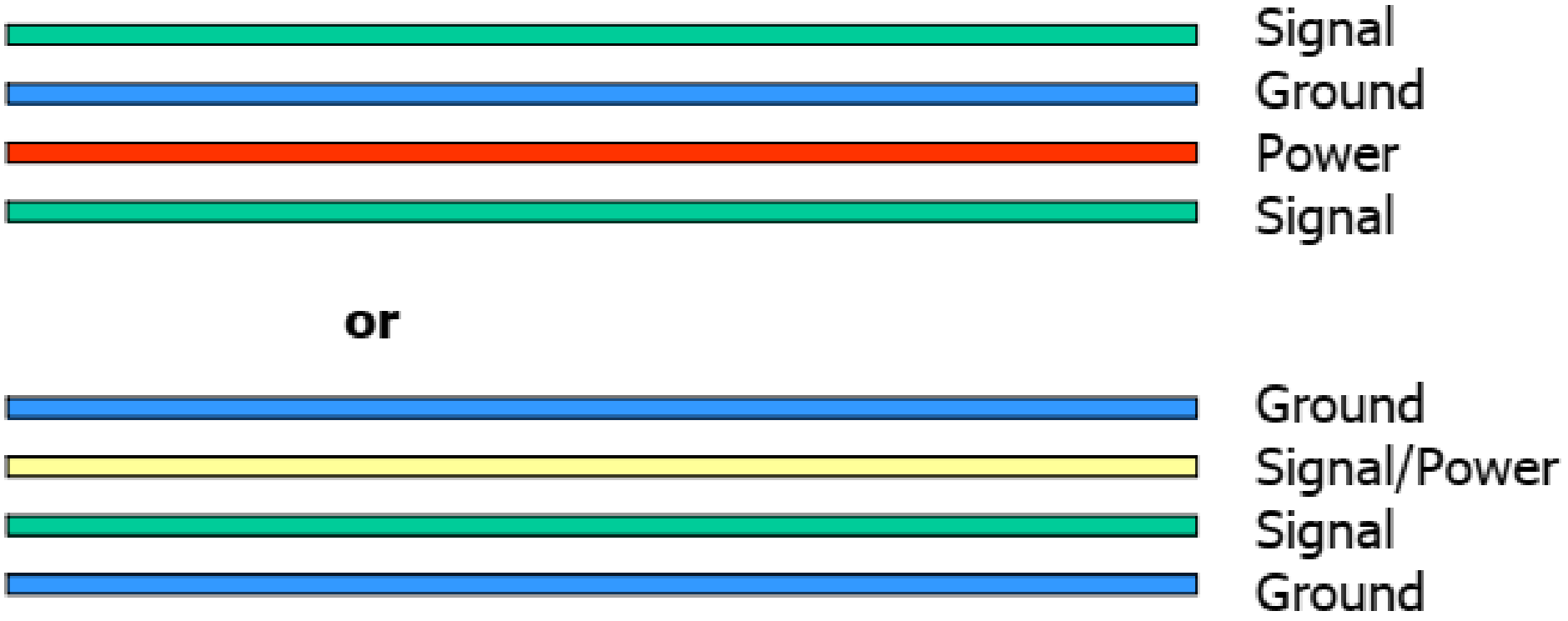


Figure: Multilayer PCB

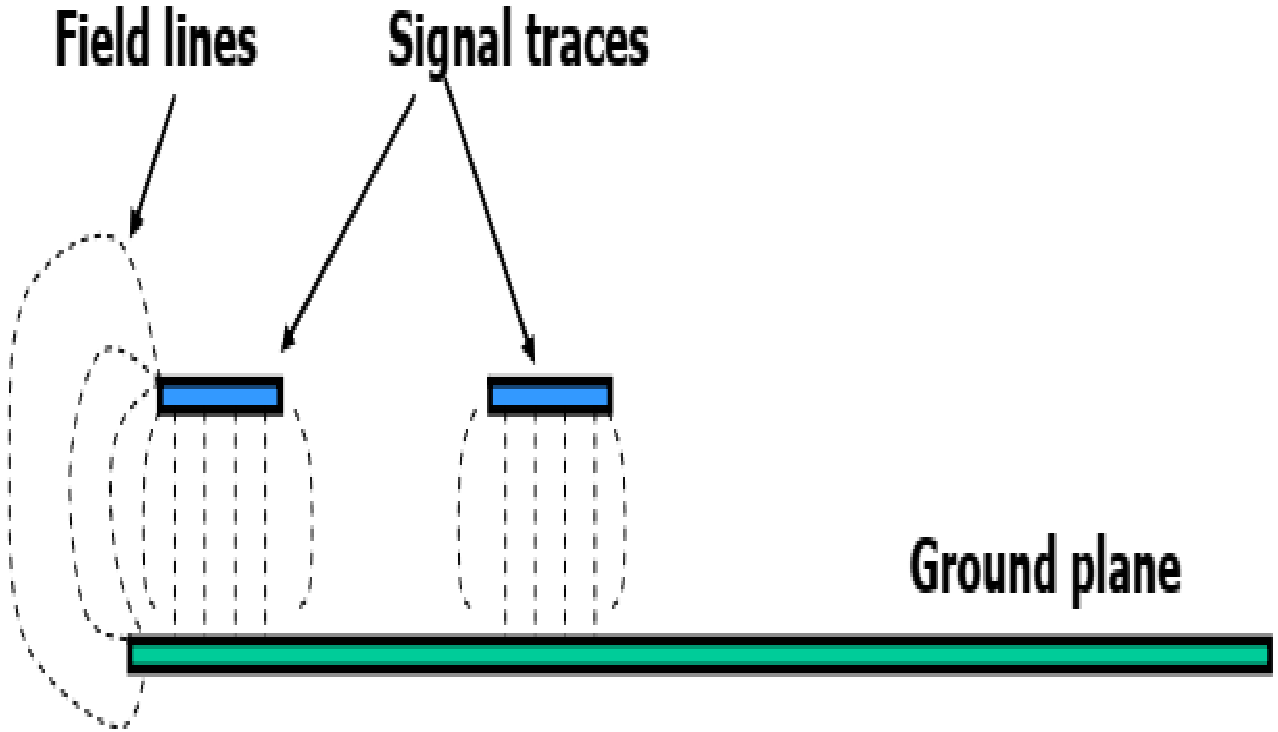


Layer Stacks For Four Layer PCB



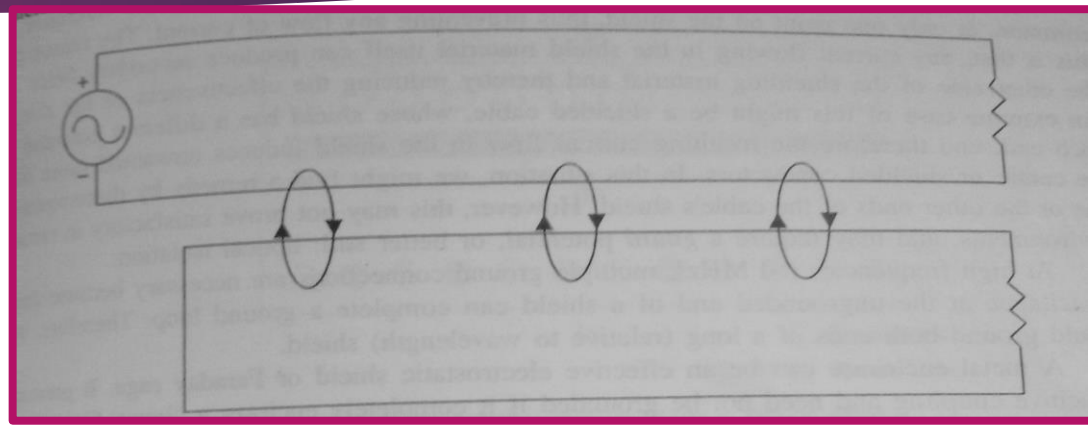
Layout Near Board Edge

- Fringing near edge changes the characteristic impedance of the signal.
- This can result in fringing and additional radiation for high frequency signals.
- The advantages of the ground plane may be lost completely, if traces are laid outside the ground plane boundary.

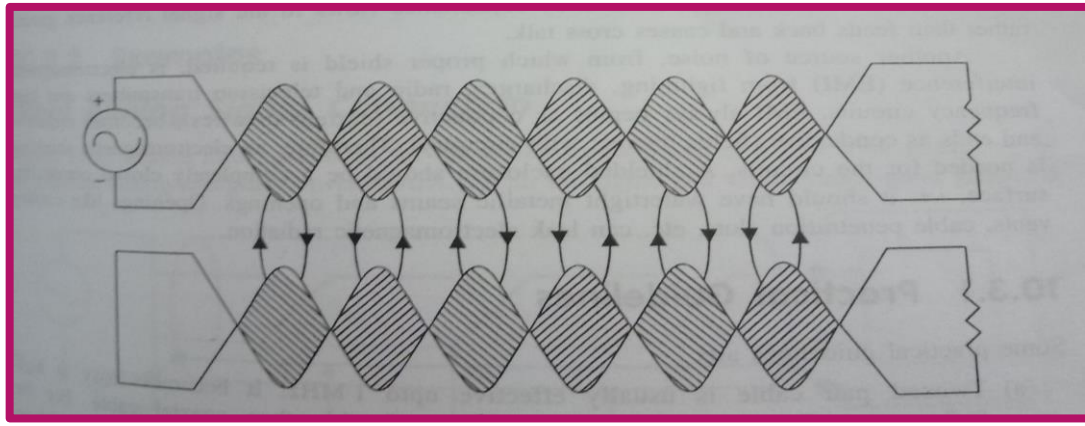


Use of Twisted wires

- Inductive coupling arises in the cables that connect various circuits on the PCB board.
- The long and straight wires contributes to a loop area that provides an inductive reactance and inductance coupling.
- Twisting the pairs of signals and return lines eliminates the loop area.
- For inductive shielding, a signal wire should be paired with return wire



(a) Straight wires



(b) Twisted wires

Shielding

- The objective of electromagnetic, electric and magnetic shielding is to provide a significant reduction or elimination of incident fields that can affect sensitive circuits as well as to prevent the emission of components of the system from radiating outside the boundaries limited by the shield.
- The basic approach is to interpose between the field source and the circuit a barrier of conducting or magnetic material.
- Shielding effectiveness can be defined as the reduction in magnetic, electric or electromagnetic field magnitude caused by the shield.
- The effectiveness of a shield depends on the shield material as well as the characteristics of the incident field (far or near field), which is defined by the distance between the source and the victim.
- The techniques for shielding depend on the type of source; whether the source is a magnetic field, electric field or electromagnetic field source.
- The shielding effectiveness (S) in dB $S = A + R + B$

  Where R is reflection loss (R), A is absorption loss (A) and B is correction factor (B)

Electromagnetic field shielding

- When an electromagnetic wave passes through a medium, two phenomena, known as absorption and reflection losses, are present.
- In the former, induced currents generate ohmic loss, heating the material, and producing an exponential attenuation of the amplitude in the direction of the wave propagation.
- In the latter, when a field arrives at an interface between two media, part of the field can be reflected, introducing new losses.
- Basically the total loss is a combination of these two losses.

Electric field shielding

- The basic mechanisms of shielding observed for far-field sources are valid for near-field sources, but the type of source is critical for determining the shielding methodology to apply.
- For sources dominated by high voltages the predominant near-field is characterized by an electrical field, whereas for sources with high currents the dominant near-field is a magnetic field.
- Electric shielding consists of conductive barriers, metal enclosures, metal conduits or cable coverings around circuits.
- The spatial electric shield acts as a capacitive voltage divider between the field source and the circuit.
- A perfectly conducting enclosure that completely surrounds a given volume prevents anything within that volume from electrically coupling to anything outside that volume.
- This type of enclosure is called a Faraday cage.

Figure. Faraday's Cage

Magnetic field shielding

- Two different ways for shielding against low frequency magnetic fields deviation of the magnetic flux with high permeability material.
- The shorted tuned method, which consists in the generation of opposing fluxes that cancel the magnetic field in the area of interest.
- To deviate the magnetic flux, it is recommended the use of magnetic material instead of conductor material because it increases the absorption losses.
- Hence improving the attenuation of the magnetic field a magnetic material such as steel or mu-metal makes a better magnetic field shield at low frequencies than does a good conductor such as aluminum or copper.
- However at high frequencies, good conductors provide better magnetic shielding.

Shielding

- Shielding can be provided by using Twisted pair cables, or coaxial cables or ribbon cables.
- The ribbon cable with single return line is suitable for low frequency.
- A return plane and return lines suitable for reducing inductive loop area and can be used for high frequency.

Figure: Ribbon cable

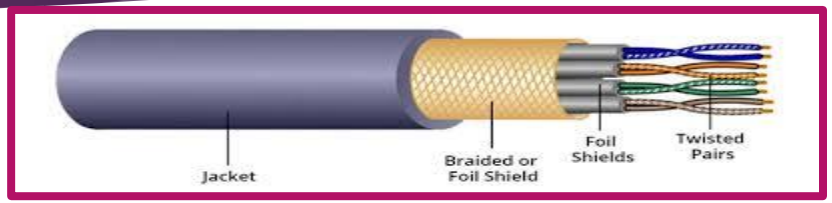
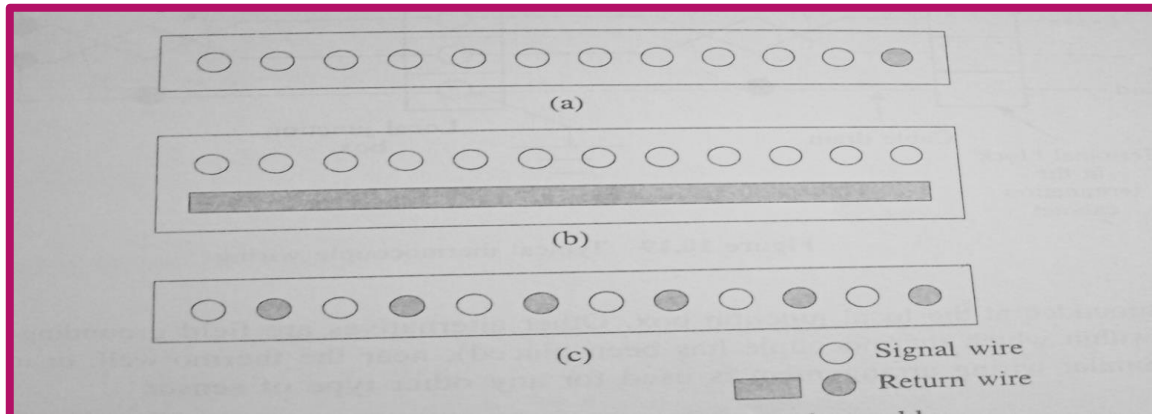
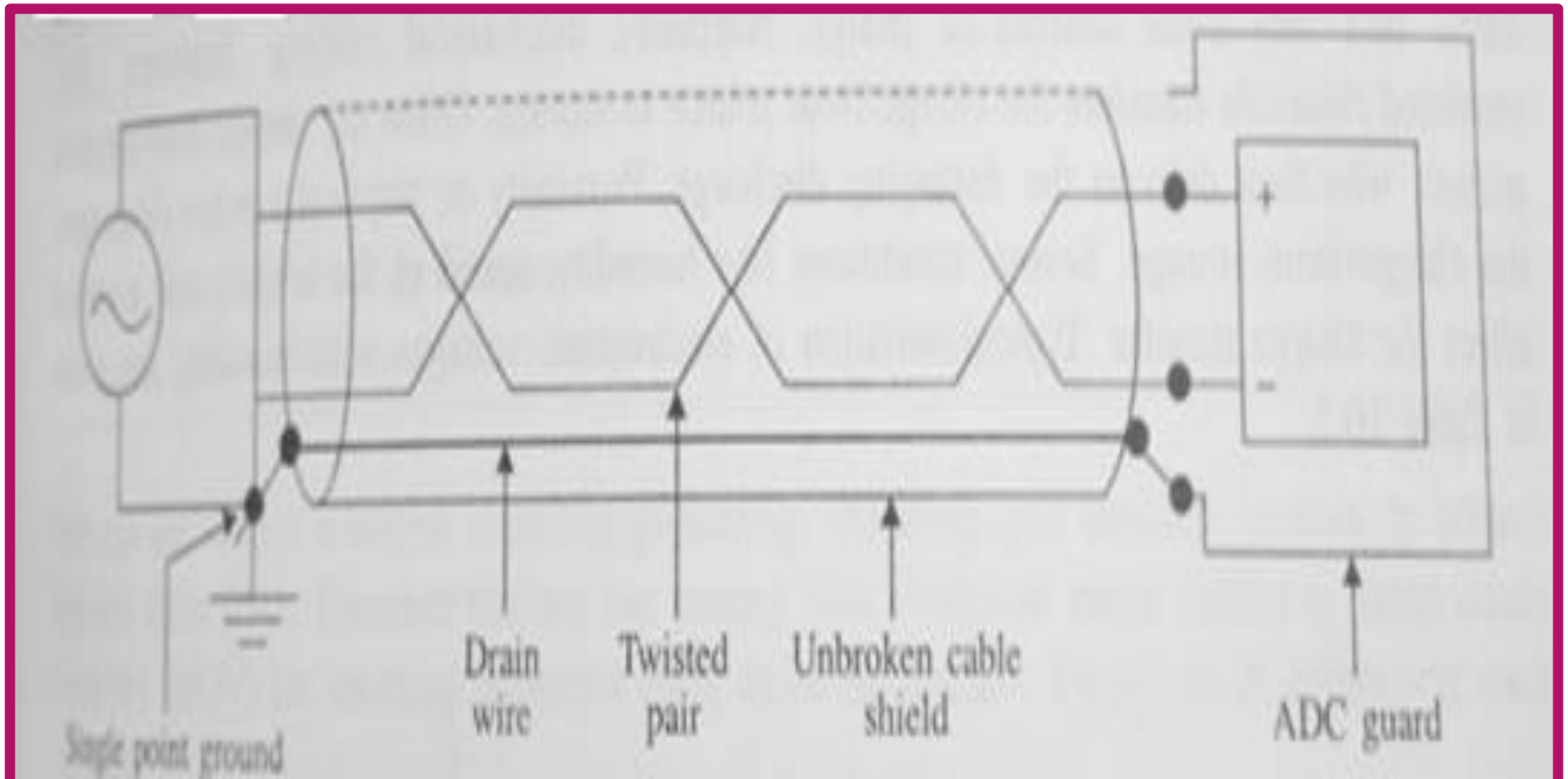


Figure: Twisted cable

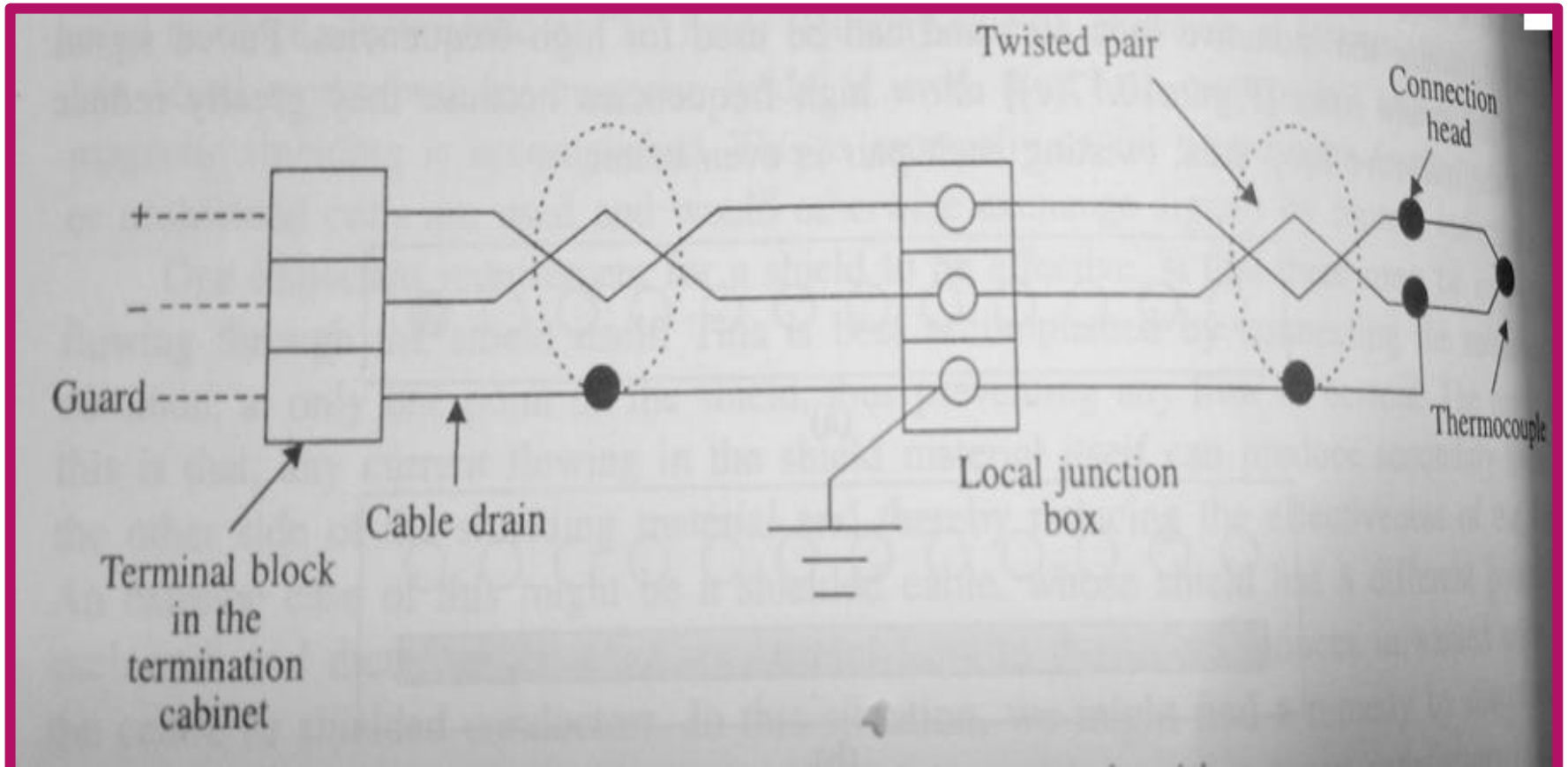
Figure: Coaxial cable



Analog signal connection



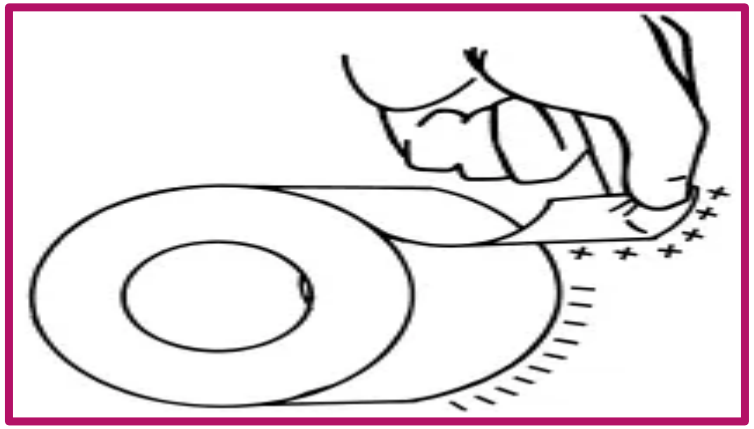
Thermocouple signal wiring

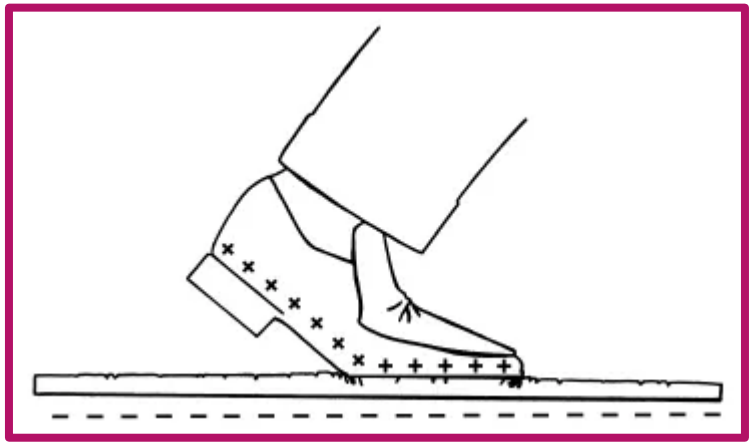


Electrostatic charge

- The transfer of an electrostatic charge between bodies at different electrical potentials. Also referred to as static electricity.
- Electrostatic charge is most commonly created by the contact and separation of two materials which results in Tribo-charging

Means of static generation	Electrostatic voltages	
	10 to 20 percent relative humidity	65 to 90 percent relative humidity
Walking across carpet	35,000	1,500
Walking over vinyl floor	12,000	250
Worker at bench	6,000	100
Vinyl envelopes for work instructions	7,000	600
Common poly bag picked up from bench	20,000	1,200
Work chair padded with polyurethane foam	18,000	1,500

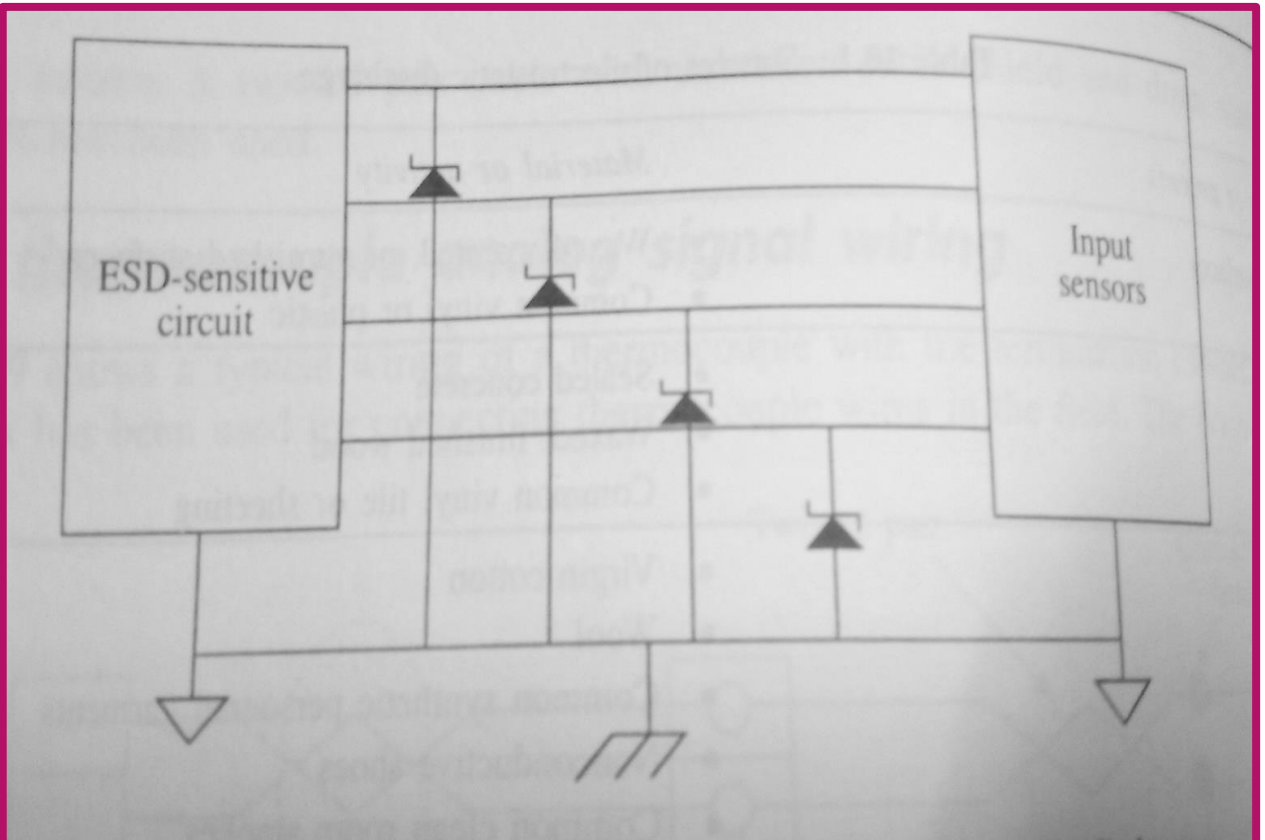


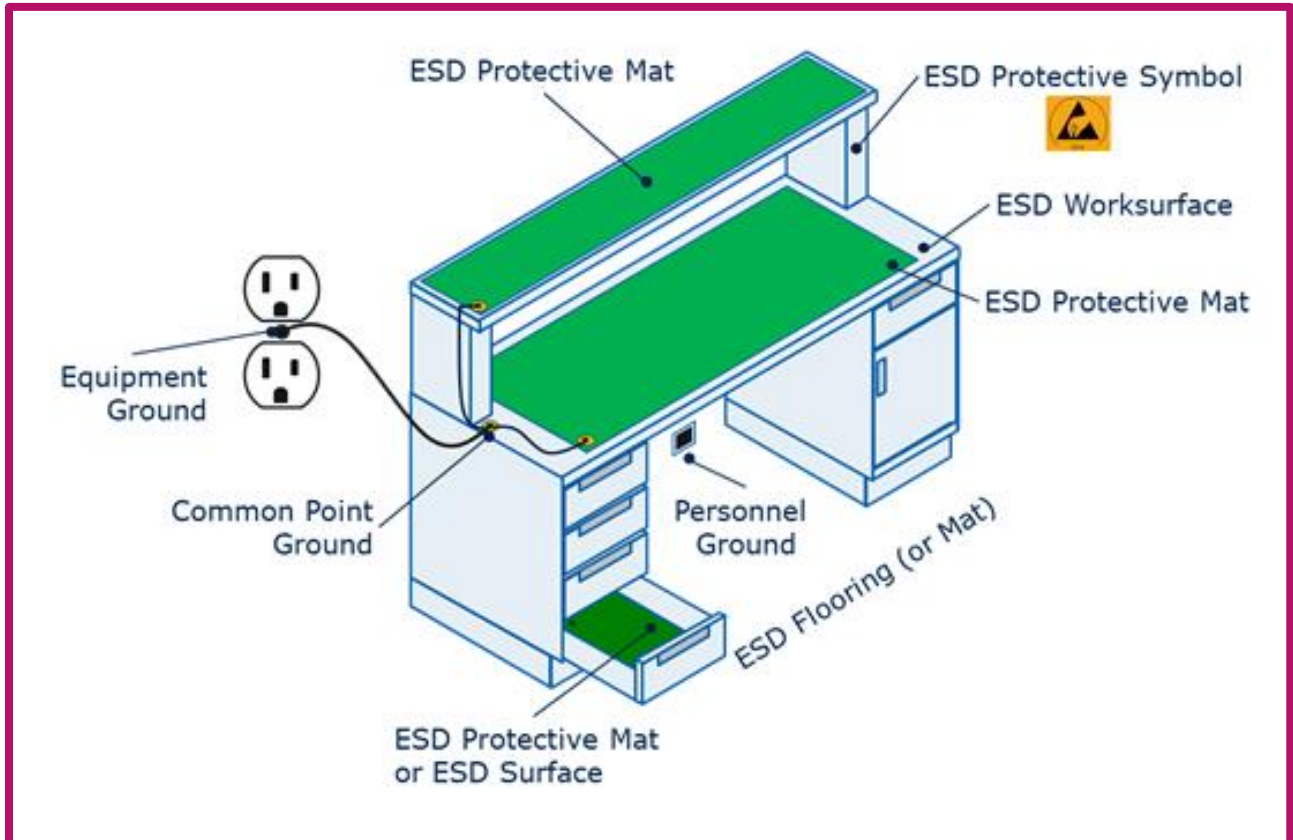


Sources of Electrostatic charge

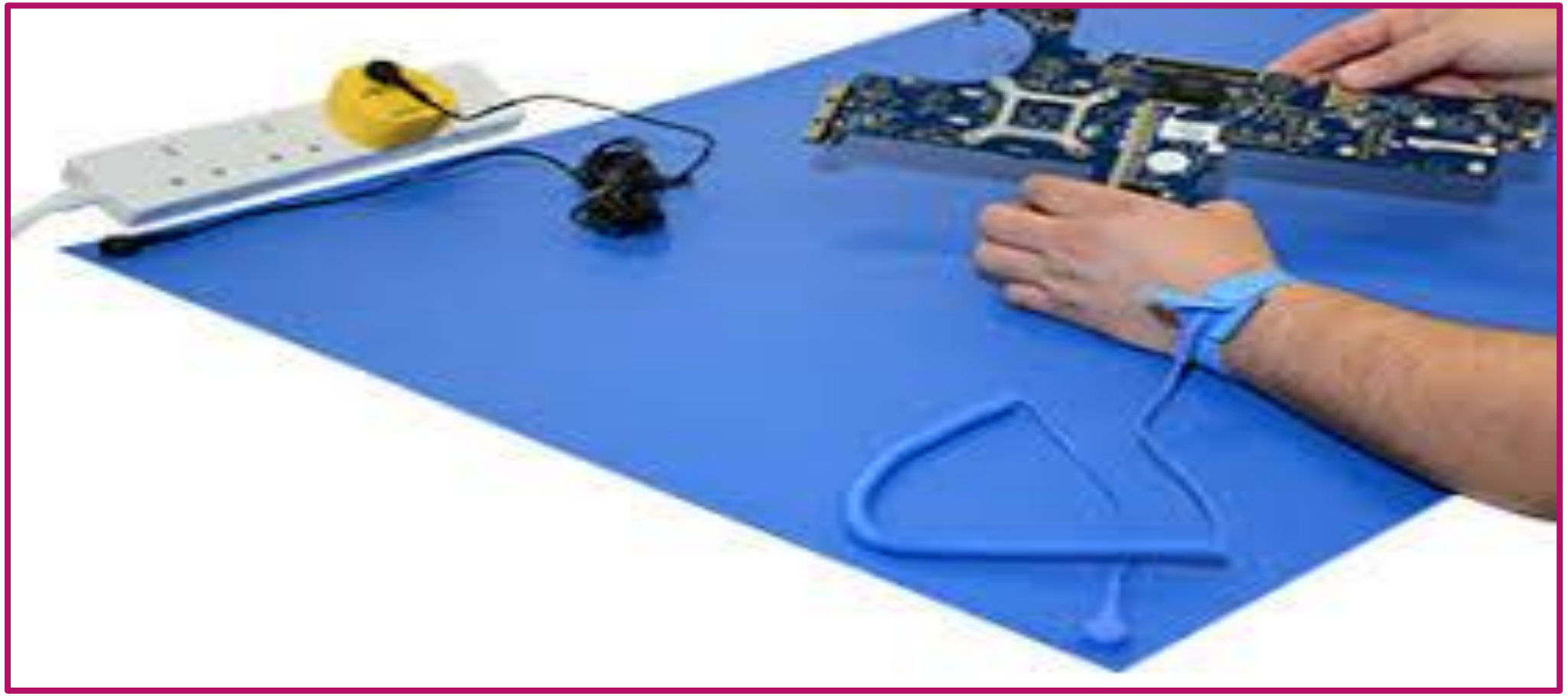
- Equipment covers
- Plastic document holders/sheet protectors
- Plastic pens
- Bubble wrap
- Plastic housings on equipment
- Paper, schematics, etc.
- Plastic work travelers
- Plastic spray bottles
- Purses
- Sweaters/jackets
- Insulated lunch totes
- Combs/brushes
- Lotion bottles

Protection from Electrostatic discharge





ESD MATS



References

- Deltoro, Electrical engineering fundamental, Pearson, 2015.
- G Vijayaraghavan, Mark Brown, Malcolm Barnes, Practical Grounding, Bonding, Shielding and Surge Protection, Newness Publisher, 2004.
- *Anand, M.M.S., Electronic Instruments and Instrumentation Technology, Prentice Hall of India Private Limited, 2004.*