



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 8, August 2023

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

[ijirset@gmail.com](mailto:ijirset@gmail.com)

[www.ijirset.com](http://www.ijirset.com)

# Optimal Cable Installation in Process Industry to Minimize Noise Interference

Binaya Kumar Sahoo<sup>1</sup>, Ashok R Tripathi<sup>2</sup>

Member IEEE, Fluor Daniel India Pvt Limited, Gurgaon, India<sup>1</sup>

Fluor Daniel India Pvt Limited, Gurgaon, India<sup>2</sup>

**ABSTRACT:** The objective of the paper is to define electrical noises induced in electrical control and instrumentation circuits that impacts the performance of control and instruments circuits. The inductive and capacitive coupling mechanism, installation and mitigation methods to minimize the influence of these noises on the equipment and systems are also discussed.

Generally, the lower the voltage level and the higher the circuit impedance, the greater the sensitivity to electrical noise. Hence the instrumentation cable with high circuit impedance needs a careful assessment of Electromagnetic Interference (EMI). The noise effect can be reduced with proper cable installation and shielding techniques. As a good practice, we cannot depend only upon shielding alone as a mitigation measure, so as an industry practice, barriers and physical separation between different voltage level cables are additionally used.

**KEYWORDS:** Electromagnetic Interference (EMI), Earthing, Bonding, Shielding, Coupling, Noise, Immunity

## I. INTRODUCTION

Noise are unwanted electrical signals superimposed on designed electrical signal (the controlled signal) and produce undesirable effects that impacts the performance. The coupling of noise signal on the circuit could be electromagnetic or electrostatic. Electrical circuits, instrumentation and control circuits are susceptible to such noise, in particular low power level circuits with high circuit impedance are highly susceptible, the designer role is to enhance immunity of the electrical or electronic circuits from such interference. A major factor in the susceptibility of control and signal circuits is their ability to reject common-mode interference. There are different mitigation techniques those are used in industry; however, the focus of this paper will be limited to wiring and cable installation, the objective is to support design engineer to design the right cable installation based on degree of susceptibility of any specific circuit.

## II. CLASSIFICATION OF ELECTRICAL NOISE

Typical sources of electrical noise are electrical or electromechanical devices which cause or produce very rapid or large amplitude changes in voltage or current. It could be while switching inductive or capacitive loads, phase control switching in thyristors and other semiconducting devices, fluorescent and neon lights, cable joints where thermal or chemical voltage differences due to dissimilar material in connection point etc. The noise can be classified to four major categories; that is: Electrostatic, Electromagnetics, Common Mode & Cross talk.

### Electrostatic:

The capacitive coupling because of electrical field around a voltage source induces power frequency voltage on the sensitive cable conductor located in the field, thereby a power frequency voltage gets superimposed on the circuit signal. The usual mitigation method is to provide high conductive shield around the sensitive circuit conductor grounded to reference voltage, usually ground potential, mostly copper or Aluminum braid or tape. It can also be attenuated by having physical separation; distance help in reducing the field strength, thereby induced voltage strength is lower. Ground wires, if placed between voltage source and susceptible cable also reduce the noise to large extent. An electrostatic shield is also obtained by directly burying the cable.

#### **Electromagnetic:**

Magnetic fields, stray magnetic fields generated out of transformers, HV equipment, power lines etc. when coupled to sensitive cable conductor, voltage is induced (transformer action) which superimpose on the signal and create noise. This either can be reduced/minimized by having a low reluctance, high permeable ferrous material magnetic shield or twist the conductors, by twisting the conductors the magnetic field of both the conductors gets cancelled as induced current direction oppose to each other. Twisted pair with close lay (maybe 1 inch or 2 inch lay), the noise attenuations is more than the conductor inside steel conduit. Physical separation also helps in reducing the noise by way of weakening magnetic field (high reluctance).

Electrostatic shield shall be of high conductive material (Aluminum or copper) to ensure the potential remains constant throughout while electromagnetic shield shall be a low reluctance high permeable material (Ferrous).

#### **Common Mode:**

This results because of varying ground potential at different geographical areas through which the circuit runs those results in a circulating current. This is alleviated by using differential input, high impedance across input signal to ground.

#### **Cross Talk:**

In multi-pair cable, through capacitive and magnetic coupling voltage gets induced in adjacent pair. The best way to mitigate such noise is by shielding individual pairs. Using twisted pair and individually shield pair cables is an effective means to reduce cross talk in communication circuit.

### **III. TYPE OF SHIELDING**

The objective of shielding is to protect the electrical circuits and its components against the effects of undesirable external disturbing sources. The types of shielding explained below are classified depending upon the characteristics of the external disturbing source and the mode of transmission of its disturbances, such as low- or high-frequency disturbing sources and electric, magnetic, or electromagnetic fields.

#### **Faraday cages:**

A Faraday cage is a metallic enclosure that surrounds a conductor or group of conductors. Faraday cages are effective at shielding against EMI because the metal walls of the cage act as a conductor, and any EMI that is encountered is conducted along the surface of the metal and grounded.

#### **Braided shielding:**

Braided shielding is a type of shielding that consists of a mesh of small wire strands that are woven around a conductor or group of conductors. The wire strands are typically made of a conductive material, such as copper or aluminium. Braided shielding is effective at shielding against EMI because it provides a large surface area for the EMI to be conducted along, reducing the amount of interference that is transmitted through the shielded circuit.

#### **Spiral shielding:**

Spiral shielding is a type of shielding that consists of a single conductor that is wound in a spiral around a central conductor or group of conductors. Spiral shielding is effective at shielding against EMI because the spiral shape of the conductor provides a low-impedance path for the EMI to be conducted along and grounded.

### **IV. SHIELD GROUNDING**

Shield grounding involves the use of a metallic shield or enclosure around a conductor or group of conductors to protect against EMI. The shield is connected to a ground reference, which serves as a low-impedance path for the EMI to be dissipated. This helps to prevent the EMI from being conducted through the shielded circuit and disrupting the signals being transmitted. The objective of shielding is to protect a component, circuit, or system against the effects of undesirable external disturbing sources. A tinned copper braid, drain wire and a tri-laminate aluminium foil offers the most complete protection against electrical noise across the full frequency range.

#### **Shield Grounded at one end:**

This is a technique to handle low frequency noise and may not be appropriate for high-frequency noise or noise due to transients. The shielding may be grounded at either the sending end or the receiving end. The advantages and disadvantages of each are described below.

#### **Shield Grounded at sending end:**

Grounding the overall shield of a cable or a shielded pair at the sending end eliminates the transient voltage on the cables due to the electric field. However, a different condition prevails for magnetically induced voltages. Grounding the shield at the sending end has no effect on a magnetically induced component.

#### **Shield Grounded at receiving end:**

Grounding the overall shield of a cable or a shielded pair at the receiving end again prevents the electric field from reaching the cables, eliminating field component. For the magnetically induced component, the input capacitance is now the only circuit element between the voltage source and the cable.

#### **Shield Grounded at both end:**

Grounding the shield at both ends completes a closed loop through the cable and ground mat system if the equipment or electronics at each grounded end are independently grounded.

### **V.CABLE INSTALLATION**

The designer should conceive a noise immune installation in process plant, for a highly sensitive and susceptible circuits additional filters or limiters may be utilized. Depending on circuit susceptibility cable and wire installation shall be designed, it may be noted, all methods for mitigating noise is to minimize interference but cannot be eliminated completely.

In general cable laying is either through Conduit, over Cable Tray or Cable trenches or buried in ground. As discussed above electrostatic coupling is eliminated by laying cable underground.

The following general points need to be considered for cable laying. However, local countries code may be referred while designing and selecting the installation methods.

#### **Spacing above Ground in Air:**

To define the spacing based on sensitivity & susceptibility of equipment to noise (EMI); following classifications have been categorized, thereby similar group of cable with similar noise susceptibility level can be laid in same tray or conduit and does not require physical spacing.

Clear Spacing: By providing spacing between noise source (time varying current and voltage,  $dv/dt$  or  $di/dt$ ) and the signal circuit, the electrostatic and electromagnetic field strength gets reduced (mutual capacitance and mutual inductance greatly are influenced by spacing). Shielding and twisted pair provide attenuation depending on % coverage of shield and inch lay of twisting. Spacing is also an effective way to minimize transient noise coupling.

- *Very Sensitive:* Analog signals (< 50V), RTD and TC cable, Analyzer signals, Data Cable
- *Low Sensitive:* Instrumentation Loop, Actuating logics, Vibration sensors, Binary Signals <50V,
- *LV-Indifferent:* Solenoids power cable, Power supply to Control Systems/Panels, Lighting and Single-phase general application, Electrical Control Cables < 250V.
- *LV-Disturbing:* Motor and MOV cable, VFD cable, SMPS power supply below 1000V
- *MV Cable:* All high voltage cable above 1000V

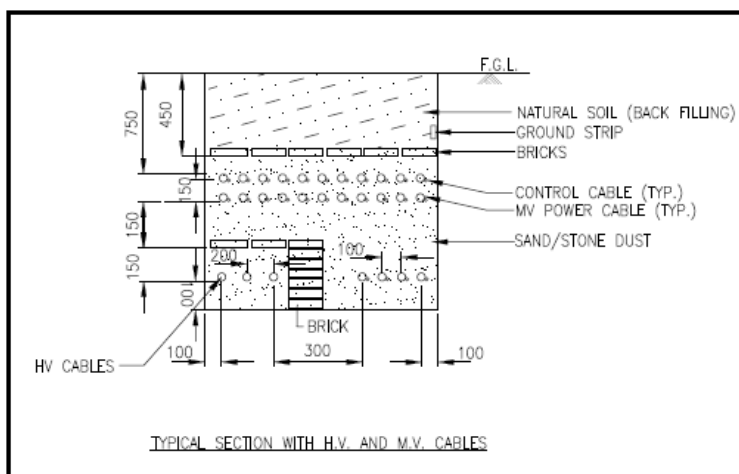
Very sensitive and Low sensitive instrument cables can go in same tray but with metal partition. The table under (Table:01) specifies the spacing in air in mm (measured from the bottom of the upper tray to the top of the lower tray).  
Table:01

Levels	Very Sensitive	Low Sensitive	LV-Indifferent	LV-Disturbing	MV
Very Sensitive		Metal partition (same tray)	300	600	900
Low Sensitive	Metal partition (same tray)		300	600	900
LV-Indifferent	300	300		300	600
LV-Disturbing	600	600	300		300
MV	900	900	600	300	

- Always run power wiring and instrument signal wiring in separate conduits or separate cable trays. Maintain this separation as much as practical in all routes including within the control panel.
- Cable trays installed in stacked manner (300 mm spacing between tray) shall be arranged in descending order of voltage level. HV cable at the top and the instrumentation at the bottom. A minimum of 230 mm from top of tray to beam/pipe/structure shall be allowed, minimum of 300 mm from insulated hot pipes.
- The minimum separation from power & Instruments/ Control cable shall be 600 mm.

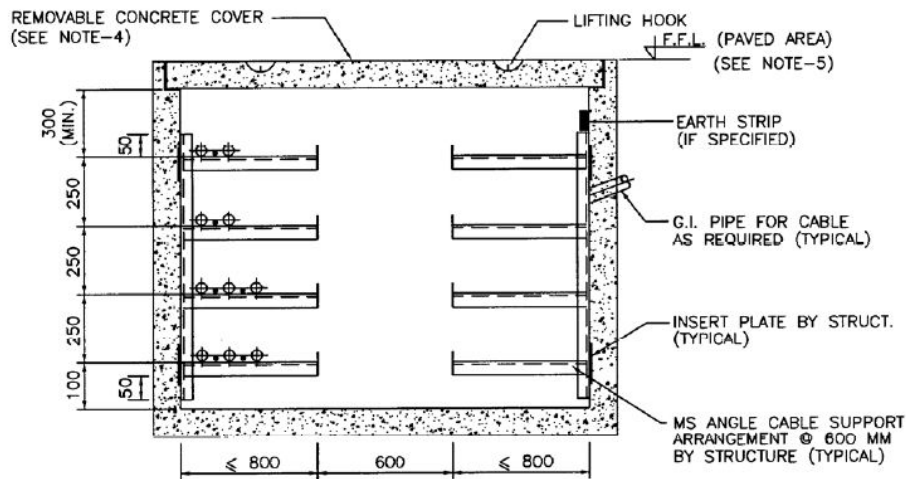
**Underground cabling (Directly Buried cable):**

- The distance between Power Cable trench & instrumentation cable (Instrument with sensitive and Low sensitive signal cable) trench will depend on the length/distance of trench running parallel and follow a linear curve.
- The MV (>1 kV) high disturbing cable can run in the same trench with LV disturbing and Indifferent cable but will have a clear spacing of 300 mm with Tiles/bricks in between.
- The control cable shall maintain 200 mm clearance from Power.
- Underground cable routes shall have a clear distance more than 300 mm between cable and insulated pipe. For hot liquid or gas pipes, the clearance shall be 600 mm, cables should run above pipeline.
- Load carrying cable shall be run single layer (including spare motors),
- Direct buried trench: HV Cable can be in same trench of LV but shall have a clear physical spacing of 600 mm or suitable barrier.



**Cable routing through Cable Trenches:**

- Cable trenches up to 1 meter width shall have a single ground flat/conductor for protection against induced lightning currents and EMC compliance. Above 1 meter it will have 2 earth flat or conductor one on each side.



**RCC CABLE TRENCH WITH RACKS**

- A typical installation uses 2/0 or 4/0 bare copper conductor in cable trench. Some places Copper/Aluminum strip also used to install on trench wall. Attached minimum 2 ground conductors on top side of each trench. If required additional ground conductors can be placed outside but in proximity of the trench. This places the ground conductors between radiated EMI source and cables. This conductor shall be connected to main grid mesh conductors at several locations.
- Similar group of cable with similar noise susceptibility level shall be laid in same tray. Very sensitive and Low sensitive instrument cables can go in same tray but with metal partition.

## VII.CONCLUSION

Following these guidelines will help ensure to reduce noise accurate measurements in environments with high levels of EMC (electromagnetic compatibility).

- Cable or circuit shield grounding shall be as recommended by the equipment manufacturer. In absence of equipment manufacturer recommendation, shield shall be grounded at one end only (the end of the circuit that provides power to the loop).
- Avoid forming loops in instrument wiring. Wire should run as straight as possible.
- Multi-pair cables used with thermocouples are to have individually insulated shields so that each shield may be maintained at the TC reference ground potential.
- RTDs consisting of one power supply should be grounded at one point only.
- RTDs embedded in the winding (Motor, Generator) should be grounded at the frame of the respective equipment. A separate ungrounded power supply is required for each piece of equipment. Sometimes back-to-back Zener diodes are used there ungrounded RTD may be accepted.
- The low or negative potential side of a signal pair should be grounded at the same point where the shield is grounded. Where a common power supply is used, the low side of each signal pair and the shield is grounded at the power supply end.
- Low level analog signal cables shall be twisted and shielded pair.
- Digital signal cables (data transmission) should be twisted and shielded pairs.
- Multi-pair cable utilizing individual pair shields, the shields should be isolated from each other except at the grounding connection. The overall shield also should be grounded at the same location only.
- In the control panel, minimize the length of unshielded instrumentation wires. Make sure the exposed wires remain tightly twisted all the way to their connection points.



- Equipment ground reference and Common ground reference within the equipment or structure shall be separate and shall be connected to plant ground at one point, ground loop shall be avoided.
- Armoring helps in minimizing magnetic and electrical field coupling (capacitive coupling not much since steel armor is of low conductive material, Aluminum armor will have both electrostatic and electromagnetic effective noise attenuation). Physical Spacing is not essential in armored cable. Therefore, preference should be given to armored cable that helps mitigating and minimizing EMC. The armor may be suitably sized to serve as PE conductor.
- VFD inverter output cable, the capacitance of long cable between inverter and motor can lead to reflected voltage on motor stator, the inception voltage must be calculated, and cable capacitance limited. Ideally the best practice would be to add EMI filter, go for isolation transformer at the input (all MV or HV has been specified with isolation transformer), add dv/dt filter at the output, the power cable at inverter output must have shield with high coverage.
- FO Cable should be installed in a separate duct installed in the tray, Conduit, or trench.

#### REFERENCES

- [1] IEEE Std 525 IEEE Guide for the Design and Installation of Cable Systems in Substations
- [2] IEEE Std 422 IEEE Guide for the Design of Cable Raceway Systems for Electric Generating Facilities
- [3] IEEE Std 1143 IEEE Guide on Shielding Practice for Low Voltage Cables
- [4] C. R. Paul and S. A. Nasar, Introduction to Electromagnetic Fields, McGraw Hill
- [5] P. Cook and I. O. E. Engineers, Commentary on IEE Wiring Regulations 16th Edition, BS 7671 :2001: Requirements for Electrical Installations Including Amendment No. 1 :2002: Institution of Electrical Engineers, 2002
- [6] Xin Yan, Chunyu Wu, Dave Zhang: EMI Investigation and Mitigation of Flexible Flat Cables and Connectors; 2021 IEEE International Joint EMC/SI/PI and EMC Europe Symposium
- [7] ] G. Mugala and R. Eriksson, "High frequency characteristics of a shielded medium voltage XLPE cable," in Electrical Insulation and Dielectric Phenomena, 2001 Annual Report. Conference on, 2001, pp. 132-136. <http://10.1109/CEIDP.2001.963504>
- [8] EMI Sensitivity Study and Mitigation Method of multi-GHz RF Cable and Connector", 2020 IEEE International Symposium on Electromagnetic Compatibility Signal/Power Integrity (EMCSI), pp. 127-132, 2020
- [9] Longhai Fu Analysis of Electromagnetic Interference in Shielded Cables by Ground Potential Difference in Substation; 2020-IOP Conference Series Materials Science and Engineering



**INNO SPACE**  
SJIF Scientific Journal Impact Factor  
**Impact Factor: 8.423**



**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

**9940 572 462** **6381 907 438** **ijirset@gmail.com**



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details