

Chapter 8 – How to Apply Digital Instrumentation in Severe Electrical Noise Environments

8.1 Overview

Guideline overview

Products that incorporate digital technology provide recognized performance advantages over conventional analog instrumentation used for process control. These advantages can result in better product uniformity and greater overall efficiency when used correctly.

There are, however, certain guidelines regarding installation and wiring which must be carefully followed in order to achieve this performance. In addition to the traditional precaution of the separation of signal and power wiring in separate conduits, other measures must be taken to minimize the effects of electromagnetic interference (EMI) and radio frequency interference (RFI) on the operation of the equipment. Otherwise, if high level, short duration, noise spikes are permitted to enter the digital equipment, the noise can be transferred into the system's logic networks and can be misinterpreted as signal data, resulting in erroneous system operation and other unpredictable responses.

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8.2 Potential Noise Sources

Overview

Noise can enter electronic equipment via three methods of coupling, namely:

- Capacitive (or electrostatic)
 - Inductive (or magnetic)
 - Impedance.
-

Capacitive and inductive coupling

Capacitive and inductive coupling have the same essential effect — they couple current or voltage, without any actual connection of the two circuits. Impedance coupling requires a connection between the two circuits. Typical noise-generating sources that could affect electronic equipment through capacitive and inductive coupling include:

- Relay coils
 - Solenoids
 - AC power wires — particularly at or above 100 Vac
 - Current carrying cables
 - Thyristor field exciters
 - Radio frequency transmissions.
-

Impedance-coupled noise

Impedance-coupled noise may enter by way of the lines used to power the digital equipment or by way of improper grounding. Most power lines, at typical industrial locations, are far from noise-free. The noise on them can be generated in many ways, but are nearly always associated with switching circuits of some nature.

These include:

- Large relays
 - Contactors
 - Motor starters
 - Business and industrial machines
 - Power tools
 - HID (high intensity discharge) lights
 - Silicon controlled rectifiers (SCRs) that are phase-angled fired.
-

8.3 Prevention Methods

Introduction

There are three ways to prevent electrical noise from interfering with the operation of the electronic digital equipment.

- Built-in noise rejection
 - Separation of signal and power lines
 - Noise suppression at source
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Built-in noise rejection

The first method is to design the digital equipment with a high degree of noise rejection built in. This includes housing the equipment in a case that will provide shielding, liberal use of noise rejection filters and opto-isolators, and the use of noise suppressors on potential noise sources within the equipment itself. This, of course, is the responsibility of the manufacturer who usually performs extensive laboratory and field testing of newly designed digital equipment to insure the adequacy of its immunity to noise. As a minimum requirement, the equipment should be able to pass the tests outlined in the IEEE Standard 472-1974 (*Surge Withstand Capacity Tests*).

Signal and power line separation

The second method is to prevent noise from getting on the signal and power lines that are connected to the equipment. This is achieved by proper separation and shielding of those lines. In some cases, separate power lines or special power line regulation or filtering may be required for satisfactory electronic digital equipment operation. It is the responsibility of the installer to follow good wiring practices.

Suppression at the source

The third prevention method is to suppress the noise at its source. This is the most effective but also the most difficult because it is not easy to identify all of the potential noise sources in a typical industrial installation. Therefore, "suppression" is usually a last resort for those extreme situations where the other methods are insufficient by themselves. See *Noise Suppression at Source* which follows.

8.4 Recommended Wiring Practices

General rules

- All wiring must conform to local codes and practices.
- Wires carrying similar types of signals (Table 8-1) may be bundled together, but bundles with different types of signals must be kept separate to prevent inductive or capacitive coupling.

Wire bundling

Table 8-1 shows what wiring should be bundled together to prevent inductive or capacitive coupling.

Table 8-1 External Wiring

Wire Function		Bundle No.	Are Shielded Twisted Wires Recommended?
No.	Type		
1 2 3	HIGH VOLTAGE Line Power Earth Ground Line Voltage Digital I/O	1	NO
4 5	ANALOG I/O Process Variable RTD Thermocouple dc Millivolts Low Level (<100V) 4-20 mA dc 1-5 Vdc	2	YES
6 7	DIGITAL I/O Low Voltage (<100V) Computer Interface	3	YES

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8.4 Recommended Wiring Practices, Continued

Additional rules

Please observe these additional rules for wire bundling:

- For distances over five (5) feet, and when shielding is recommended, use a separate metal tray or conduit for each bundle. Where conduits or trays are not practical, use twisted wires with a metal overbraid and provide physical separation of at least one foot.
- Tray covers must be in continuous contact with the side rails of the trays.
- When unlike signal levels must cross, either in trays or conduits, they should cross at a 90-degree angle and at a maximum spacing. Where it is not possible to provide spacing, a grounded steel barrier or grid should be placed between the unlike levels at the crossover points.
- Trays containing low level wiring should have solid bottoms and sides. Tray covers must be used for complete shielding. Tray cover contact with side rails must be positive and continuous to avoid high reluctance air gaps, which impair shielding. Trays for low level cables should be metal and solidly grounded.
- Wires containing low level signals should not be routed near any of the following:
 - Contactors,
 - Motors,
 - Generators,
 - Radio transmitters, and
 - Wires carrying high current that is being switched on and off.
- Use a 12-gage (or heavier) insulated stranded wire for the ground connection. Attach it firmly to a proven good earth ground such as a metal stake driven into the ground.
- All shields should be grounded at one end only — preferably the instrument end.

8.5 Power Source Considerations

Operate within limits

The AC power for the digital electronic equipment must be within the voltage and frequency limits specified for that equipment. Attempts to operate outside the specified limits will result in no performance. For those installations where the supply voltage will not stay within the specified limits, a ferroresonant transformer, for voltage resolution, should be used.

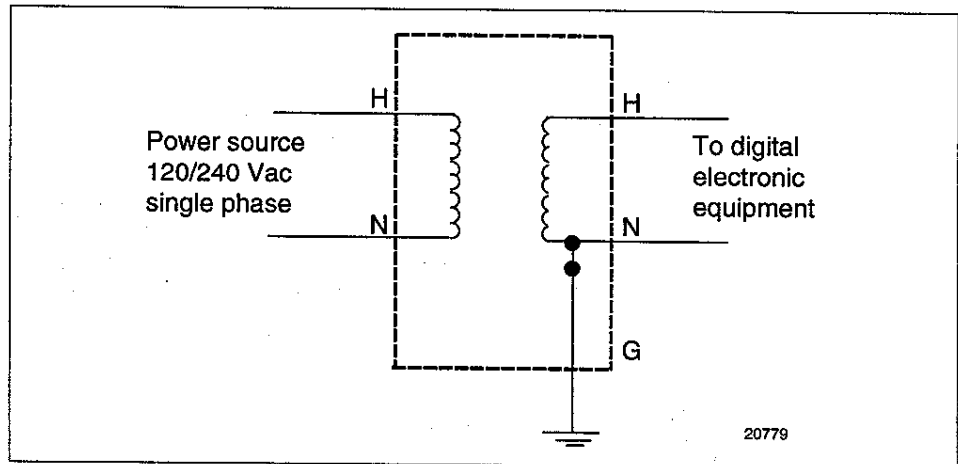
Independent AC source

For protection against noise, the AC source for the digital electronic equipment should be independent of all other loads especially when switching loads are involved. For example, it should not provide power for air-conditioning, convenience outlets, lighting, motors, or similar noise-generating devices. To obtain electrical isolation (see Figure 8-1) a separate transformer is required to supply power to the digital equipment. For additional noise and transient rejection, shielded primary and secondary windings may be required. And, if necessary, power line filters may be added to attenuate noise signals that have a higher frequency than the power line frequency.

Transformer for digital equipment

Figure 8-1 is an illustration of a separate transformer required to supply power to digital equipment.

Figure 8-1 Transformer for Digital Equipment



8.6 Noise Suppression at the Source

Introduction

Generally speaking, when good wiring practices are used with well-designed digital electronic equipment, no further noise protection is necessary. However, in some severe electrical environments, the magnitude of the electrical noise is so great that it must be suppressed at the source. In most control cabinets, the main sources of noise are motor starters, contactors, relays, and switching gear. For this reason, many manufacturers of these devices supply "surge suppressors" which mount directly on the noise source (for example, on the coil of a control relay or motor starter).

For those devices that do not have accessory "surge suppressors," resistance-capacitance (RC) circuits and/or voltage limiters such as metal varistors may be added when and where needed. This can be broken down into two categories, namely inductive loads (for example, a relay switch in series with a relay coil) and contacts.

Inductive coils

Metal Oxide Varistors (MOVs) are recommended for transient suppression in inductive coils. An MOV is connected in parallel with the coil and is as close as physically possible to the coil (see Figure 8-2). MOV devices (listed in Table 8-2) are recommended for general purpose applications.

Table 8-2 lists part numbers for recommended MOV devices.

Table 8-2 MOV Devices

Part Number	30732481-501	30732481-502
Maximum AC	130V	275V
Energy Pulse Rating	10 Joules	15 Joules
Supplier (General Electric)	V130LA10A	V275LA15A

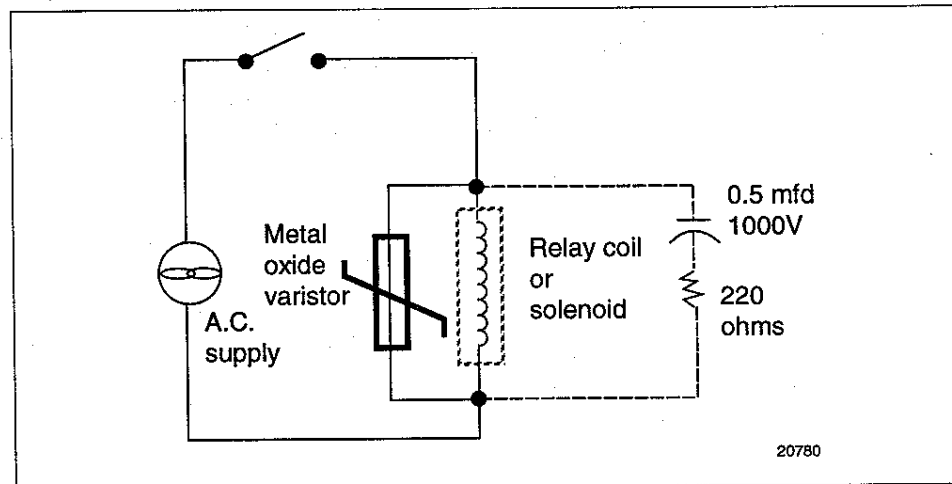
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8.6 Noise Suppression at the Source, Continued

Inductive coils,
continued

Figure 8-2 is an illustration of transient suppression in inductive coils.

Figure 8-2 Transient Suppression in Inductive Coils



Additional protection may be provided by adding an RC circuit in parallel with the MOV. This consists of a 220-ohm resistor in series with a 0.5 microfarad, 1000V capacitor. The power rating of the resistor will depend on the voltage rating of the coil (see Table 8-3).

Table 8-3 Coil Voltage vs Resistor Voltage Rating

Coil Voltage	Resistor Voltage Rating
115V	1/4 Watt
230V	1 Watt
460V	3 Watt
550V	5 Watt

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8.6 Noise Suppression at the Source, Continued

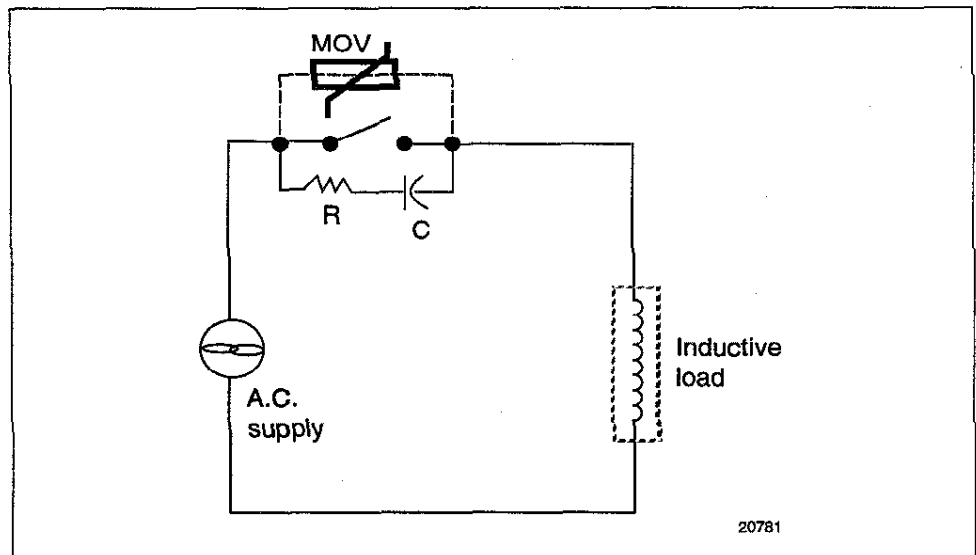
Contacts

When a contact interrupts an inductive load, a certain amount of energy is stored in the load. An MOV or RC circuit in parallel with the load provides a place where this energy may be dissipated. However, if there is no MOV or RC circuit, the energy may create a visible electrical arc across the open contacts. This, in turn, results in electrical noise as well as damage to the contacts.

One way to eliminate this arc is to connect a resistor and capacitor across the contacts (see Figure 8-3). A combination of 47 ohms and 0.1 microfarads (1000 Vdc) is recommended for circuits up to 3 amps and 300 Vac. For voltages above 2000 Vac, an MOV across the contact may be added for extra protection.

Figure 8-3 is an illustration of a resistor and capacitor connected across a contact to eliminate electrical noise.

Figure 8-3 Contact Noise Suppression



For large load currents, a rule of thumb is to size the capacitor so that the number of microfarads equals the number of amperes in the load current, and the resistor has the same resistance value as the load. The objective is to eliminate the visible arc.

Either discrete resistors and capacitors or packaged RC networks may be used. An RC network (47 ohms and 0.1 microfarad) is available from Honeywell as part number 30371852-001. Similar RC networks are available from Electrocube Inc. (part number RG1782-3) and from Industrial Condensor Corporation.

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8.6 Noise Suppression at the Source, Continued

Contacts, continued

In DC circuits, the power dissipation under steady state condition can be eliminated by placing a diode (in series with a resistor) in parallel with the load (see Figure 8-4). The value of R should be less than or equal to the DC resistance of the inductive load.

Figure 8-4 is an illustration of DC load noise suppression.

Figure 8-4 DC Load Noise Suppression

