How to Apply Digital Instrumentation in Severe Electrical Noise Environments
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About This Document

Contacts

World Wide Web

The following lists Honeywell’s World Wide Web sites that will be of interest to our customers.

<table>
<thead>
<tr>
<th>Honeywell Organization</th>
<th>WWW Address (URL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate</td>
<td><a href="http://www.honeywell.com">http://www.honeywell.com</a></td>
</tr>
<tr>
<td>Sensing and Control</td>
<td><a href="http://www.honeywell.com/sensing">http://www.honeywell.com/sensing</a></td>
</tr>
</tbody>
</table>

Telephone

Contact us by telephone at the numbers listed below.

<table>
<thead>
<tr>
<th>Organization</th>
<th>Phone Number</th>
</tr>
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<tbody>
<tr>
<td>United States and Canada</td>
<td>Honeywell</td>
</tr>
<tr>
<td></td>
<td>1-800-423-9883</td>
</tr>
<tr>
<td></td>
<td>1-888-423-9883</td>
</tr>
<tr>
<td></td>
<td>1-800-525-7439</td>
</tr>
<tr>
<td>Asia Pacific</td>
<td>Honeywell Asia Pacific</td>
</tr>
<tr>
<td></td>
<td>(852) 2829-8298</td>
</tr>
<tr>
<td>Europe</td>
<td>Honeywell PACE, Brussels, Belgium</td>
</tr>
<tr>
<td></td>
<td>[32-2] 728-2111</td>
</tr>
<tr>
<td>Latin America</td>
<td>Honeywell, Sunrise, Florida U.S.A.</td>
</tr>
<tr>
<td></td>
<td>(954) 845-2600</td>
</tr>
</tbody>
</table>
## Symbol Definitions

The following table lists those symbols used in this document to denote certain conditions.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>![CAUTION symbol]</td>
<td>This CAUTION symbol on the equipment refers the user to the Product Manual for additional information. This symbol appears next to required information in the manual.</td>
</tr>
<tr>
<td>![WARNING symbol]</td>
<td>WARNING: risk of electrical shock. This symbol warns the user of a potential shock hazard where HAZARDOUS LIVE voltages greater than 30 Vrms, 42.4 Vpeak, or 60 VDC may be accessible.</td>
</tr>
<tr>
<td>![ATTENTION symbol]</td>
<td>ATTENTION, Electrostatic Discharge (ESD) hazards. Observe precautions for handling electrostatic sensitive devices</td>
</tr>
<tr>
<td>![Protective Earth (PE) terminal]</td>
<td>Protective Earth (PE) terminal. Provided for connection of the protective earth (green or green/yellow) supply system conductor.</td>
</tr>
<tr>
<td>![Functional earth terminal]</td>
<td>Functional earth terminal. Used for non-safety purposes such as noise immunity improvement. NOTE: This connection shall be bonded to protective earth at the source of supply in accordance with national local electrical code requirements.</td>
</tr>
<tr>
<td>![Earth Ground]</td>
<td>Earth Ground. Functional earth connection. NOTE: This connection shall be bonded to Protective earth at the source of supply in accordance with national and local electrical code requirements.</td>
</tr>
<tr>
<td>![Chassis Ground]</td>
<td>Chassis Ground. Identifies a connection to the chassis or frame of the equipment shall be bonded to Protective Earth at the source of supply in accordance with national and local electrical code requirements.</td>
</tr>
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Noise Suppression for Recorders and Controllers

Introduction

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.
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.
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

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 Suppression at Source which follows.
Recommended Wiring Practices

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

CE compliance
Refer to individual Product Manuals for details on CE compliance.

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

Table 1  External wiring

<table>
<thead>
<tr>
<th>No.</th>
<th>Wire Function</th>
<th>Bundle No.</th>
<th>Are Shielded Twisted Wires Recommended?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HIGH VOLTAGE</td>
<td>1</td>
<td>NO</td>
</tr>
<tr>
<td>2</td>
<td>Line Power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Earth Ground</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Line Voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Digital I/O</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>ANALOG I/O</td>
<td>2</td>
<td>YES</td>
</tr>
<tr>
<td>7</td>
<td>Process Variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RTD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thermocouple</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>dc Millivolts</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low Level (&lt;100V)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4-20 mA dc</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1-5 Vdc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>DIGITAL I/O</td>
<td>3</td>
<td>YES</td>
</tr>
<tr>
<td>9</td>
<td>Low Voltage (&lt;100V)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Computer Interface</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


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
  - 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.
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 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 1 is an illustration of a separate transformer required to supply power to digital equipment.
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 2). MOV devices (listed in Table 2) are recommended for general-purpose applications.

Table 2 lists part numbers for recommended MOV devices.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>30732481-501</th>
<th>30732481-502</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum AC</td>
<td>130V</td>
<td>275V</td>
</tr>
<tr>
<td>Energy Pulse Rating</td>
<td>10 Joules</td>
<td>15 Joules</td>
</tr>
<tr>
<td>Supplier (General Electric)</td>
<td>V130LA10A</td>
<td>V275LA15A</td>
</tr>
</tbody>
</table>

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

![Figure 2: Transient suppression in inductive coils](image-url)
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 3).

**Table 3  Coil voltage vs resistor voltage rating**

<table>
<thead>
<tr>
<th>Coil Voltage</th>
<th>Resistor Voltage Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>115V</td>
<td>1/4 Watt</td>
</tr>
<tr>
<td>230V</td>
<td>1 Watt</td>
</tr>
<tr>
<td>460V</td>
<td>3 Watt</td>
</tr>
<tr>
<td>550V</td>
<td>5 Watt</td>
</tr>
</tbody>
</table>

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

![Figure 3 Contact noise suppression](image)

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 discreet 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 30756746-001. Similar RC networks are available from Electrocube Inc. (part number RG1782-3) and from Industrial Condensor Corporation.

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 4). The value of R should be less than or equal to the DC resistance of the inductive load.

Figure 4 is an illustration of DC load noise suppression.

![Figure 4 DC load noise suppression](20782)