Control Technology Corporation

Control TechNotes

Reducing Noise Susceptibility

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25 South Street, Hopkinton, MA 01748

Overview

This technical note discusses electrical noise problems and provides solutions for reducing noise in an industrial control system.

Two factors are critically important in insuring noise immunity in an industrial control system:

- Selecting control system components designed to work with the loads and conditions present in your application.
- Using wiring and design practices that promote noise immunity and preserve the controller’s built-in noise protection.

System Grounding

Proper grounding of a control system is important for the following reasons:

1. The effective shielding of control components and any shielded cable used in a system is dependent on the quality of the ground connection to the shield.
2. A controller's noise protection system is dependent on a good ground connection. This type of noise protection system usually short-circuits any electrical noise to ground. If you remove the ground connection, the noise protection is essentially defeated.

Good Grounding Practices

This section describes how to establish good ground connections. Consider the following:

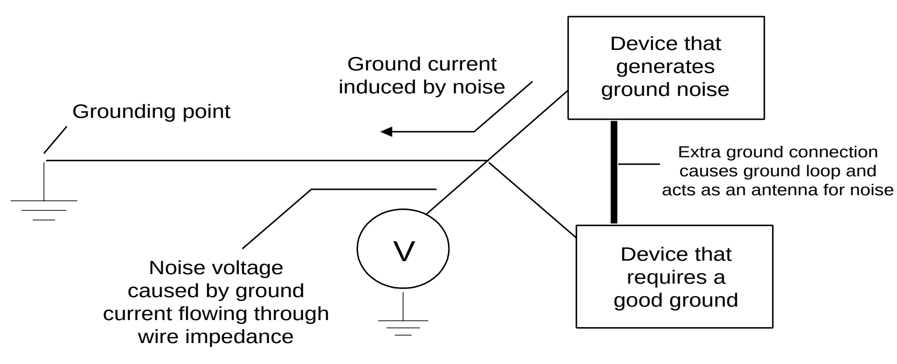
- **Low Impedance Connections** - Impedance is the resistance to AC current flow. This connection type should be as short as possible and should be made with wire that has low resistance (such as heavy gauge wire). Typically, for machines that require relatively little electrical power, an outlet that is known to be properly grounded satisfies this requirement.

  Conventional electrical outlets are often wired improperly or have defective grounds. This can lead to noise susceptibility and the lack of a system ground may also create a shock hazard caused by leakage currents. Outlet testers are available from electrical supply houses if you have any doubt about the condition of the electrical outlets in your building.

  If a machine has been wired directly into a power source by an electrician, it is much more likely to have an adequate ground connection. Most local electrical codes require good grounding with heavy gauge wire. This provides the added benefit of better noise immunity.

- **Careful Ground Path Design** - In a control system, the best approach is to establish a central grounding point for all circuitry. Often, this is a separate grounding screw in the electrical enclosure or control panel that is used solely for the purpose of grounding. UL and other safety authorities do not allow the use of mounting screws as grounding points. The illustration below shows a bad grounding technique.

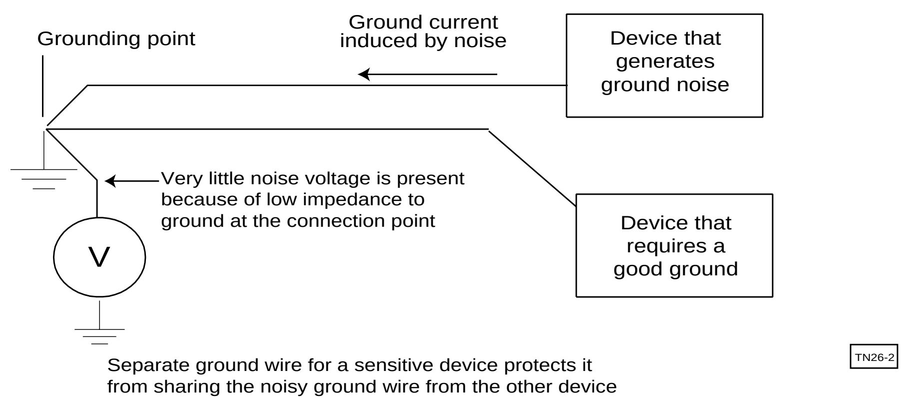
Bad Grounding Technique



Noise-sensitive device experiences a noise voltage on its ground connection

The importance of a good grounding path is illustrated below. If several devices have their grounds connected together and then routed through a single wire to the grounding point, any noise currents generated by one of the devices can show up as a noise signal that is superimposed upon the ground of the other devices.

Good Grounding Technique



Proper grounding technique dictates using separate ground wires from each device back to the central grounding point (as shown above). This technique is a compromise from the ideal of a separate ground wire running directly to a nearby earth ground. However, this ideal is usually not considered very practical.

Protecting Switch and Relay Contacts

Mechanical switch contacts are found on devices such as manual switches, limit switches, relays, motor starters, and contactors. These contacts are not only a major source of electrical noise in control circuits but also fall victim to this noise.

The devices mentioned above share a common characteristic. They contain two metallic surfaces that complete an electrical circuit when they are brought together. Whenever these surfaces (contacts) are opening or closing, there is a point where the electrical potential between the two contacts is sufficient to ionize the surrounding air and cause a spark to jump between the contacts.

This situation is bad because the temperatures and electrochemical effects associated with this sparking tend to destroy the electrical contacts over a period of time. In addition, the arcing of electricity can generate both severe high frequency electrical noise and radiated RFI (Radio Frequency Interference). Electrical noise is conducted through wiring and can ultimately affect other devices. RFI is transmitted through the air and may possibly affect other devices in the vicinity.

Although manual and limit switches seldom cause interference to control systems, the use of Hall-effect, solid-state switches (or proximity sensors) eliminates the problem of contact destruction or contamination.

Solid state relays (SSRs) are often a good alternative to mechanical relays for controlling AC loads. In particular, solid state relays capable of zero-cross switching can dramatically reduce the generation of electrical noise. This type of SSR only turns on a load when the instantaneous voltage present on the AC line is zero. Because the load is switched only when there is no voltage present, transient voltage spikes caused by the sudden switching of the load are eliminated. Selecting an SSR involves careful matching of characteristics to the load being switched.

Contact Protection

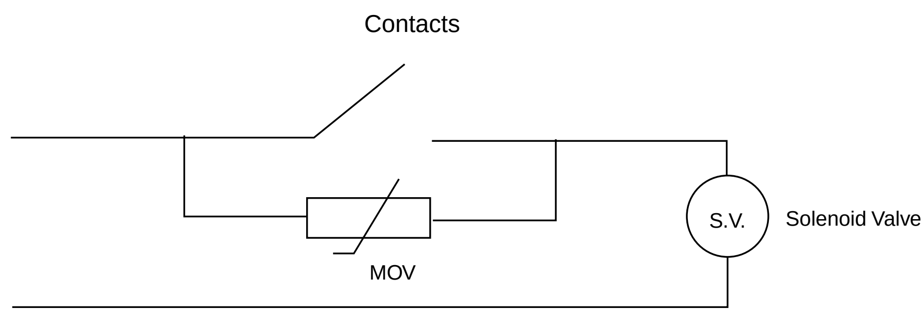
Some control system designs require the use of mechanical contacts. There are ways to protect the contacts that will reduce the electrical noise being generated and also increase the life of the contacts.

This protection is particularly important when switching inductive loads. An inductive load is any load that consists of a coil such as a motor, solenoid valve, relay, or transformer. This type of load has the characteristic of generating high voltages when the current flow through them is suddenly interrupted. These voltages can sustain an arc across a pair of opening electrical contacts for a prolonged interval and can cause severe contact damage and an extreme level of electrical noise.

Most protection techniques involve providing other paths for the generated voltage that needs to be discharged. One approach is to bridge the contacts with a device that breaks down (or temporarily short-circuits) whenever a certain threshold voltage is reached. Typical protection devices include MOVs (metal oxide varistors) and TransZorbs (transient voltage suppressors).

A protection device with the proper voltage and power rating can be placed across the contacts being used to switch an inductive load (shown below). When the contacts open, the protection device reacts to the rapidly increasing voltage generated by the conducting current and allows the inductor to discharge until the voltage across the contacts subsides to a normal value. This prevents an arc from being maintained across the contacts and creates a much cleaner break of the contacts than would normally occur.

Finally, it is recommended that relays, motor starters and similar devices be kept physically separate from the controller. This reduces the chance that radiated interference will affect the control system.



Typical connection of an MOV for noise suppression TN26-3

Separation of Wiring Harnesses

The separation of input, output and power wiring harnesses is another practice that helps increase noise immunity in control systems. Although most industrial controllers have extensive protection against noise on their input and output terminals, it is still a good idea to separate these functions.

Output device switching can generate substantial noise currents through the wiring leading to these devices. For example, if sensitive input wires such as analog input lines are bundled closely together with these output wires, noise currents can be transformer-coupled into the inputs. The same principle applies to wires carrying AC line voltage because the electrical noise present on the AC line can be transformer-coupled to the input wiring.

A system with greater noise immunity is created by completely separating each class of wiring harness (even a distance of 0.5" is helpful).

Cable shielding is also an effective technique for isolating these signals although care must be taken to properly terminate the shield. DO NOT connect the shield to ground on both ends of the cable because any difference in ground potential between the two grounds will result in a noise current flowing through the shield. With the close contact between the shield and the conductors you are trying to protect, this noise current is very likely to be coupled to the wiring within.

Proper grounding technique for a shield is to ground the shield on one end only. The preferred end is the one closest to the main grounding point. This is usually the end that is terminated at the controller.

An Ounce of Prevention

The best approach for reducing noise susceptibility is to incorporate the techniques described above into all your original designs. Systems which work initially may experience noise problems as electrical contacts wear out or as environmental conditions change.

Careful design and construction practice can result in a system with inherent noise immunity and greater reliability without having to resort to extensive debugging and redesign.