

Proper System Grounding Techniques for 6B Series Systems

INTRODUCTION

The 6B series of digital signal conditioning modules, when properly applied and configured, can provide the user with unsurpassed accuracy and stability in industrial data acquisition and control applications.

However, in order to obtain the maximum performance from these modules, it is necessary to pay careful attention to the ways in which the 6B backplanes are powered and grounded.

It has been our experience that, when faults and errors are encountered in 6B applications, the culprit almost invariably can be traced to system grounding techniques. The errors produced by bad grounding sometimes manifest themselves as unstable, noisy or erratic readings from thermocouples, RTDs, or other signals. Occasionally, the errors result in "code faults," i.e., disturbances to the execution of the microcontroller, which is contained within the 6B itself. In severe cases, the errors can result in disturbances to the communications between the 6B system and the host computer, or even damage to the host computer's communications ports.

All of these effects can frequently be avoided via the use of proper grounding and shielding techniques. As an aid to understanding the problem, consider the diagram in Figure 1, which illustrates a single 6B module application.

Modeling a 6B Application

First, let's consider the model for a typical industrial signal source, such as a thermocouple. The source has a dc component, in the range of 100 mV or less, which is the thermocouple signal itself; this component changes with temperature, but since most temperature measurements are narrow bandwidth phenomenon (i.e., slowly changing), we can model the signal as dc.

The signal may also have an ac component, most typically a 50 Hz or 60 Hz "pickup" from adjacent power circuits. The 6B series modules are particularly good at rejecting this ac component, since they employ an integrating converter design with a rectangular window of integration linked to the power line frequency (and programmable for either 50 Hz or 60 Hz operation over the communications interface).

Both of the signal components we've just discussed are often referred to as "normal-mode signals," since they appear differentially between the sensor's high and low terminals. Normal-mode signals are the signals we want to measure.

In addition to the normal-mode components of our signal, a "common-mode" signal present may also be. The common-mode signal is that signal which appears between the low side of the normal-mode signal, and earth ground or any other point of reference. The com-

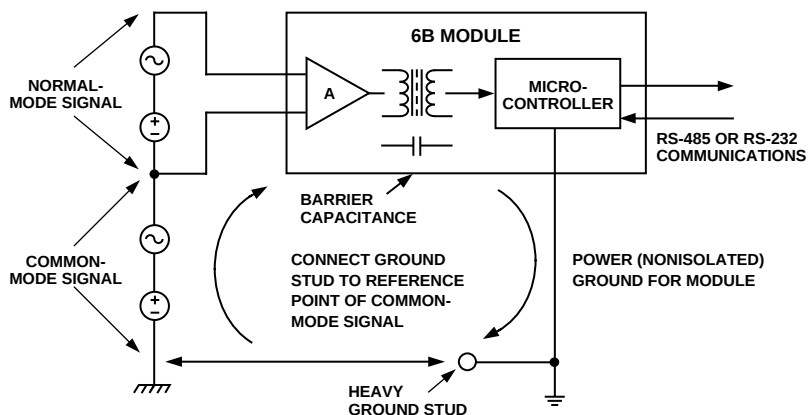


Figure 1. Normal-Mode and Common-Mode Signals in a 6B Application

mon-mode signal is often unintentional, and caused by ground drops between earth ground potential near the signal source and earth ground potential near the 6B system. In these cases, the common-mode signal can be dc, ac, or a combination of the two.

In some applications, the common-mode signal may be completely intentional; cases such as these include applications where the sensor, such as a thermocouple, is in electrical contact with a high electrical potential (for example, a thermocouple “buried” within the stator of an electric motor). In such a case, the design depends on the isolation characteristics of the 6B module to reject the common-mode signal and measure only the normal-mode component. In situations like these, the common-mode component is mostly ac, and frequently at power line frequency and potential. Another example can be found in aluminum manufacturing (electrolytic reduction), where measurements are often made of voltage and current at each crucible, and the crucible itself is at an elevated dc potential with respect to earth ground.

Finally, there are some applications in which there is no intentional common-mode component to the signal, but the user is employing an isolated signal conditioner like the 6B in order to preclude damage in the event of an error such as a short circuit or an unintentional miswiring of the system.

The isolation barrier within the 6B module (as with most of Analog Devices’ industrial signal conditioning products) is a magnetic barrier, built in the form of a transformer. This kind of barrier offers superb rejection of common-mode signals within a reasonable bandwidth, but is not perfect. The barrier has capacitance and fast common-mode transients can cause impulse currents to flow through the barrier in an effort to find their way back to the common, or ground, of their source.

Consider the diagram in Figure 2, where a very fast transient appears in common-mode at the input to a 6B. Due to barrier capacitance, the transient generates an impulse of current that needs to return to the source from which it is generated. In this case, the return path is via the 6B’s nonisolated ground (which is in common with the 6B power supply ground).

The transient current will follow the path of least resistance back to its source. If the 6B system has no ground connection to the ground of the source of the transient, the ground potential will follow whatever path it can find to return to its source. If it can find a return path locally (i.e., near the 6B backplane itself), then it will even attempt to return via the communications ground, thereby putting the control computer in jeopardy!

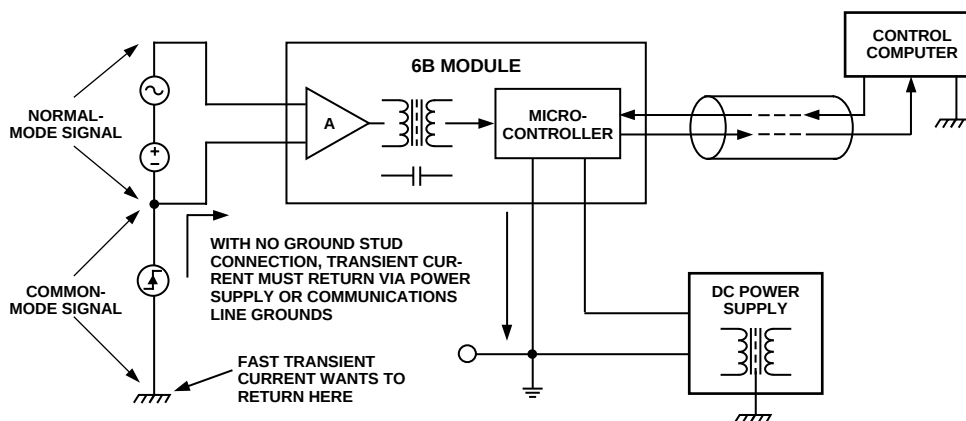


Figure 2. Transient Current Return Path Without Ground Stud Connection

Solving the Problem

The designers of the 6B took this into consideration when creating the 6B subsystem. We have provided a heavy ground stud on each backplane, connected to the nonisolated ground of the system. The purpose of this ground stud is to provide a suitable connection point for attaching a ground lead that will divert transient current through the isolation barrier, back to its source.

It is important that the application be wired such that any potential transient currents be diverted back to their source via a heavy wire from this ground stud. Without this ground, transient currents will choose whatever path they can find to return to their source. One possible path is via the power supply used to power the 6B backplane; all transformer-based power supplies have capacitance between their outputs and the power line, and sometimes this barrier capacitance can reach hundreds of picofarads, making them an attractive path to the transient current *if no more suitable path is provided!*

Where Do Fast Transients Come From?

Many industrial environments are, unfortunately, a rich source of high current fast transient signals. Things like motor controllers, etc., often use IGBT (Insulated Gate Bipolar Transistor) devices, or SCR (Silicon Controlled Rectifier) devices as control elements; these devices can generate transients as fast as several thousand volts per microsecond, or faster, and often switch currents on the order of tens or even hundreds of amperes! The magnetic fields created by these transients are pervasive, and difficult to suppress.

How to Minimize the Transient Problem

Unfortunately, grounding methodologies don't lend themselves to "cookbook" analysis, because every situation is different. However, the following considerations

are good ones to follow when dealing with 6B signal conditioning subsystems.

1. **Use the ground stud.** When wiring a 6B backplane, be sure to attach the ground stud to the most likely point of reference where common mode transients originate. Often, this point is earth ground near the source of heavy equipment or high power sources associated with the measurement being made. Use a heavy lead, as short as possible, in as straight a route as possible, for best results.
2. **Ground the power supply.** Don't ignore the power supply being used to power the 6B backplane. Its own barrier capacitance may be significant, and can represent a path to earth ground. However, *don't* try to use the power supply in place of the ground stud on the backplane, because this can exacerbate the problems.
3. **Consider isolating the communications lines.** In very severe cases, fast transients may actually attempt to return to their point of origin via the ground conductors of the RS-485 communications connection to/from the 6B system. While this situation is rare, it has been known to happen and can cause faults or even damage to the computer being used to interface to the 6B subsystem.

Normally, the proper use of the ground stud can prevent this situation. In extreme cases, however, it may be helpful to use an isolation barrier on the communications port of the 6B to prevent these transients from using this path. A number of RS-485 and/or RS-232C isolation devices are available, or the Applications staff at Analog Devices can recommend devices for this purpose.