

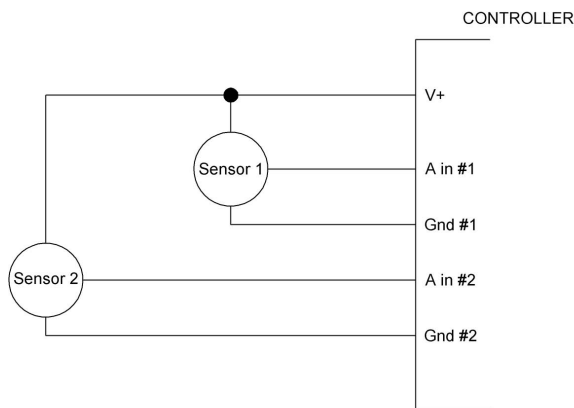
**The purpose of this document is describe methods to avoid ground loops.**

Ground loops can be a real nuisance in HVAC systems because they are hard to spot. Most of the time they do no harm but they can cause unpredictable problems years after the installation!

A ground loop is formed when there is more than one conductive path between the “ground” terminals on two or more pieces of equipment. The conductive loop forms a large loop antenna that picks up interference currents easily. The larger the loop the more interference; if you are using the building’s steel frame for your ground, then the loop can be as large as the whole building. The resistance in the ground wires turns the interference currents into voltage fluctuations in the ground system. The ground is no longer stable; therefore the signals you are trying to measure which are referenced to that ground are also unstable and inaccurate.

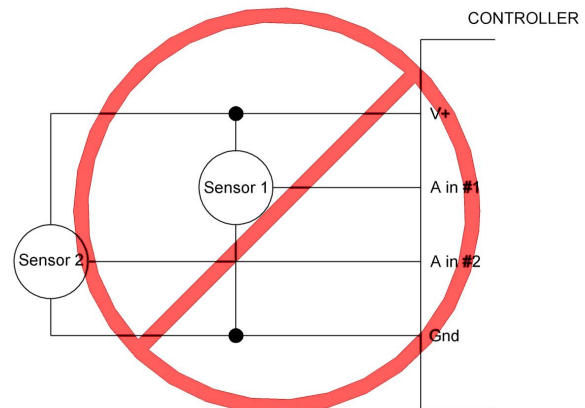
### Don't Share Grounds

The ground wires from a sensor should not be shared with any other sensor or power load (see Figures below). When a ground wire is shared between two sensors, the current from the first sensor will interfere with the signal of the second sensor.



**Figure 1:**

Don't Share Grounds. In the correct schematic above, each sensor has its own controller ground.



**Figure 2:**

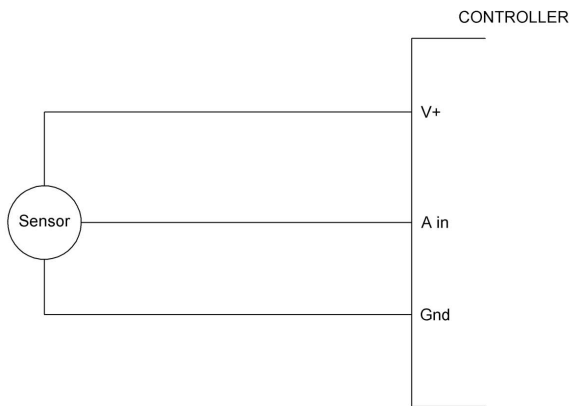
Don't Share Grounds. In the incorrect schematic above, the two sensors are sharing the same controller ground.

### Minimize Loop Area with Twisted Pair Wiring

The potential for ground loop interference can be greatly reduced by minimizing the loop area of the conductors between the sensor and the controller. The easiest and most effective way to reduce loop area is with twisted pair wiring. Twisted wires work by cancellation. Each twist works as a small loop antenna, but after the next twist the loop is reversed so the interference generated in the second loop cancels the interference generated by the first.

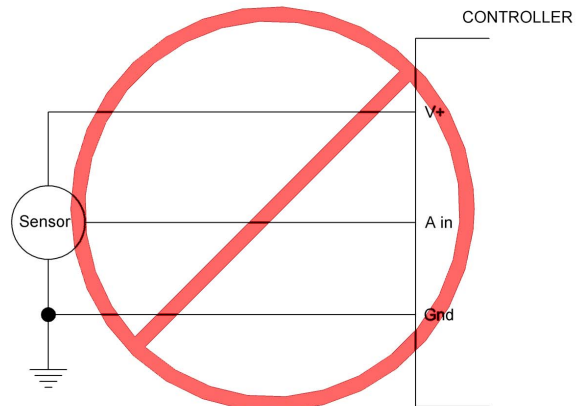
### Don't Ground Remote Sensors

If a sensor is placed more than one inch from a controller, only ground the sensor to the ground terminal on the controller which is associated with the analog input you are using (see figures below). Do not ground a remote sensor to building steel or the power system ground at the remote mounting point. If the sensor's case must be grounded for safety, isolate the case from the sensor and ground each separately.



**Figure 3:**

Don't Ground Remote Sensors. In the correct schematic above, the remote sensor is only grounded to a controller ground.

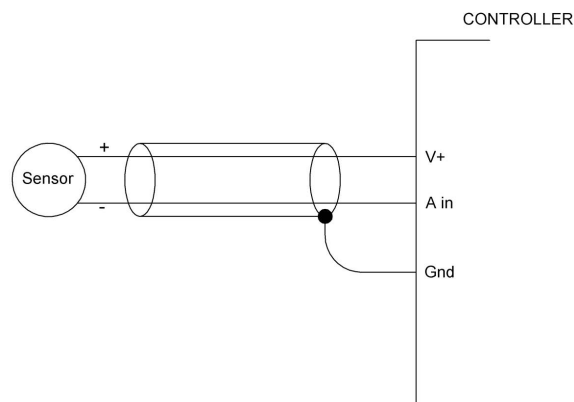


**Figure 4:**

Don't Ground Remote Sensors. In the incorrect schematic above, the sensor is grounded at a remote grounding point as well as to a controller ground.

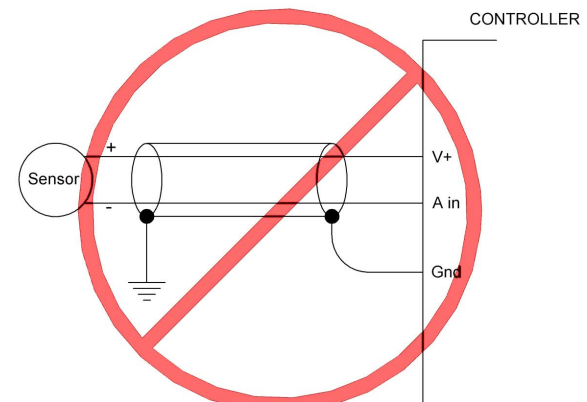
### Use Shielded Wire Grounded Only to the Controller

In very electrically noisy environments, shielded cable may have to be used (see figures below). The shield prevents electrical fields from penetrating the wire. The shield should only be grounded at the controller end. If the shield is grounded at both ends, a ground loop will occur.



**Figure 5:**

Using Shielded Wire Grounded Only to the Controller. In the correct schematic above, the shielded wire is only grounded to a controller ground.



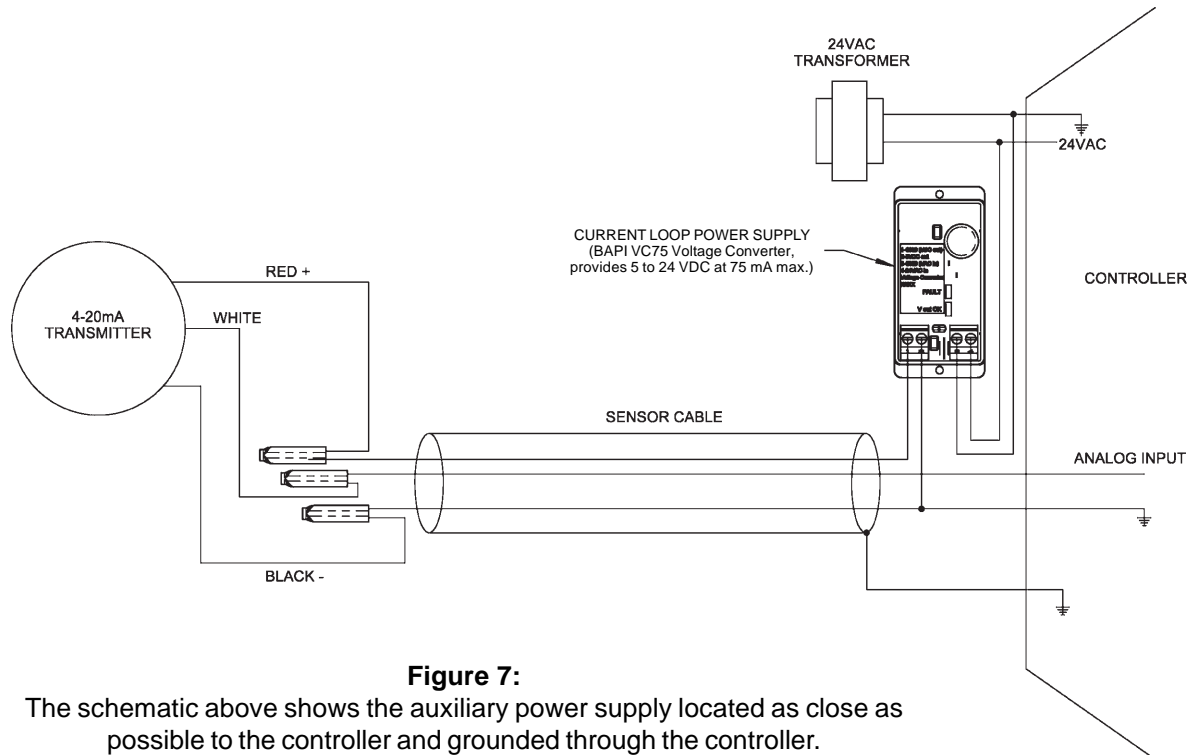
**Figure 6:**

Using Shielded Wire Grounded Only to the Controller. The incorrect schematic above has the shielded wire grounded at a remote mounting point as well as to a controller ground.

### Place Auxiliary Power Supplies As Close As Possible to the Controller

Auxiliary power supplies used to power three wire sensors should be placed as close as possible to the controller (see Figure 7). Ideally the auxiliary power supply should be grounded through the controller.

Note: Many controllers have DC voltage available to drive transmitters. If your controller has this DC voltage available, and the remote sensor does not overload the controller voltage supply, you may not need the external power supply shown in Figure 7.



**Figure 7:**

The schematic above shows the auxiliary power supply located as close as possible to the controller and grounded through the controller.

If you would like more indepth information about ground loops, call your BAPI representative or download the BAPI Application Note: [Understanding Ground Loops](#) from our website at [www.bapihvac.com](http://www.bapihvac.com)

### References

ANSI/NFPA 70, National Electric Code 2002 - National Fire Protection Association

CONSTRUCTION STRATEGIES FOR MINIMIZING STRAY VOLTAGE ON DAIRY FARMS  
[http://www.egr.msu.edu/age/aenewsletter/1\\_jan\\_feb\\_03/tinsey1\\_03.pdf](http://www.egr.msu.edu/age/aenewsletter/1_jan_feb_03/tinsey1_03.pdf)

Henry Ott, [Noise Reduction Techniques in Electronic Systems](#), 2nd edition, Wiley and Sons, NY, NY, 1988