HIGH SENSITIVITY BRIDGE CONNECTIONS

Purpose

This Application Guide discusses suggested instrument interconnections and supplemental filtering to allow maximum resolution when the AVM-2000, or other very high sensitivity null meters, are used in conjunction with such instruments as Reference Dividers, Kelvin-Varley Dividers and other high-impedance ratio dividers.

Background

One very common null meter application is indication of balance (or small difference) between two voltages where one of the voltages is a reference and the other is an unknown, typically the product of a voltage source and a high impedance divider. For example, a common application is the Calibration Mode of a Reference Divider such as the Fluke 752A. When in the Calibration mode, a simplified schematic representation (Figure 1) of the resulting bridge circuit shows:

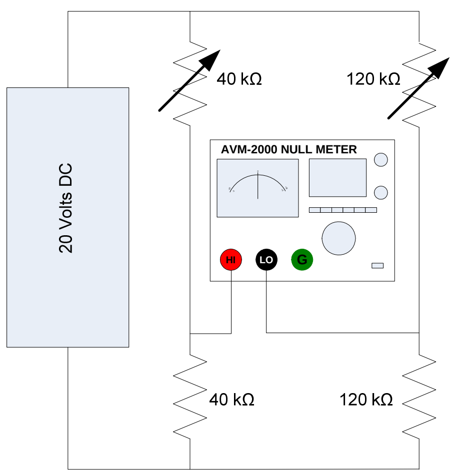

Figure 1

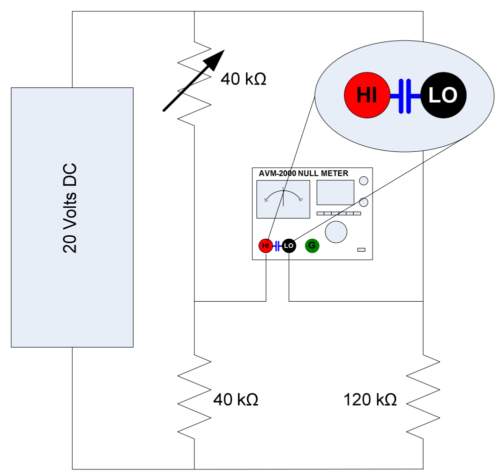

Figure 2

In this schematic we see a null meter connected to the bridge center points. Treating the 20 VDC source as having zero impedance, we find the source resistance driving the null meter to be approximately the combination of two 40 kΩ resistors in parallel (20 kΩ) plus the parallel combination of two 120 kΩ resistors for a total of 80 kΩ. As these resistors are physically quite large, they are susceptible to significant 50/60 Hz pickup when the 752A is used in a normal (i.e. non-Faraday Shielded) environment. Additionally, significant common mode (LO to Ground) 50/60 Hz voltage may be found at the bridge excitation source. Proper attention to Guard connections can make a significant reduction in this source of noise. A good balance ensures a null of 100 to 200 nV (1 part in 10^8 of the 20 V source). If external sources induce signals of 20 mV (for example), this is 100 dB greater than the desired null voltage and may well cause erratic null meter readings. For the most part, this can be compensated for by carefully observing Earth and Guard connections between the various

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instruments. Connections that have been tested to give good results in the lab are offered as Figures 3(a) through 4(b).

The addition of input capacitance at the null meter terminals provides significant reduction (filtering) of the line-frequency interfering signal. This is shown in Figure 2 as a small blue capacitor between the null meter input terminals. Note: TEGAM provides such a 2 µF Filter Block with each AVM-2000 for this purpose. If the recommended connections shown in this application note can not reduce the noise due to the ambient fields and the source to a tolerable level, then use of the capacitor block can further attenuate the effects of AC pickup.

Null measurements are also highly susceptible to minute DC voltages generated from thermo-electric and electro-chemical effects. For example, if a copper-to-gold connection is used for the wires from the bridge to the null meter, a temperature difference of 1 °C between any two terminals, can generate DC offsets of 200 to 300 nV — an offset that is 100% the target value for a good null! Therefore, close attention must be paid to ensuring good connections as well as to reducing the impact of any external electro-magnetic fields.

The Technique:

Calibrating a Reference Divider (such as the Fluke 752A):

NOTE: A filter block is mentioned during parts of this section but is not shown on the diagrams that follow. In most cases the filter will not be required but if in the presence of AC interference, you find a filter is required, connect the supplied 2 µF filter block across the AVM-2000 input terminals as shown in Figure 2.

The following procedure is a guide to those techniques which do the best job possible of ensuring external influences do not impact null measurements made when performing the 10:1 and 100:1 calibration steps on a Reference Divider.

a) Connect the Voltage Source (20V), REFERENCE DIVIDER (752A) and NULL METER as in Figure 3(a) or 3(b) including a 2 µF filter block at the NULL METER input terminals.
b) Set the 752A Mode Switch to 752 Cal and Calibrate Switch to +100:1.
c) Set the Voltage Source to ZERO volts.
d) Place a low EMF short at the 752A NULL DETECTOR output terminals.
e) Adjust the NULL METER for zero on each of the µV ranges by rotating the INPUT OFFSET knob in “V” mode. (To select “V” mode if “V” is not displayed on the screen to the left of the knob, press the knob to cycle through “V”, “I”, and “Lock” until “V” is displayed.)
f) Remove the low EMF short from the 752A NULL DETECTOR output terminals.
g) Place the low EMF short at the 752A INPUT terminals.

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h) Adjust the null meter for zero on the 10 µV range by rotating the INPUT OFFSET knob in "I" mode. (To select "I" mode if "I" is not displayed on the screen to the left of the knob, press the knob to cycle through "V", "I", and "Lock" until "I" is displayed.) This adjustment is range-independent, so if additional resolution is desired then down-range to 3µV.

i) Switch 752A Calibrate Switch between +100:1 and -100:1 to achieve best null.

j) Remove the low EMF short from the 752A INPUT terminals.

k) Set the Voltage Source for 20 VDC.

l) Perform 752A Self-Calibration Procedure per manufacturer's directions.

Using the Reference Divider:

Ensure the Reference Divider, Voltage Source to be calibrated and null meter are connected as shown in Figure 4(a) or 4(b) including the 2 µF filter block at the null meter input terminals if required. Follow the manufacturer's instructions for using the Reference Divider to calibrate an unknown voltage source.

Extending these techniques to similar divider setups:

The basic concepts outlined above and shown in Figures 3(a) through 4(b) (shown both as a standard connection and as an unshielded twisted pair) are applicable to both Reference Divider and Ratio Divider setups. These configurations are also used in typical configurations using the Fluke 720A Kelvin-Varley Voltage Divider.

NOTE: There are many different configurations that may be assembled with a Kelvin-Varley Voltage Divider, a Nullmeter and various voltage sources or resistances. The purposes of these diagrams are to illustrate component interconnection techniques that minimize the impact of external and wiring issues on the measurements. These possible impacts include:

- Ensuring the wiring between units minimizes offset voltages due to thermo-electric and electro-chemical sources as well as minimizes induced (inductively or capacitively) voltages from local electromagnetic fields.
- Providing a single point earth referenced shield for all high-sensitivity and high-impedance wiring. If any of the instrument cases are connected to Earth through a rack mounting, for example, then the chassis to guard connections shown in the diagram may need to be changed in your installation to preserve single-point connection.
- When using high-impedance dividers, use a filter block at the null meter (as shown in Figure 2), to reduce the impact of inductively or capacitively induced line-frequency voltages.
- Zero the null meter for both offset voltage and offset current with the null meter fully connected to the measurement circuits.

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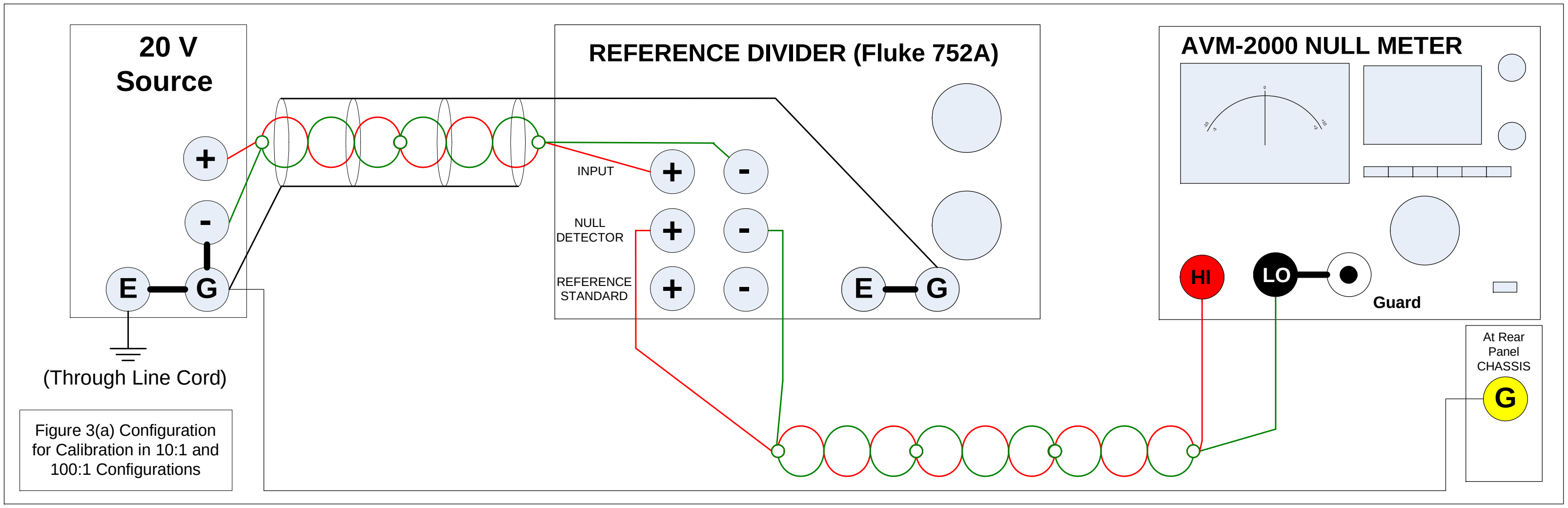


Figure 3(a) Configuration for Calibration in 10:1 and 100:1 Configurations

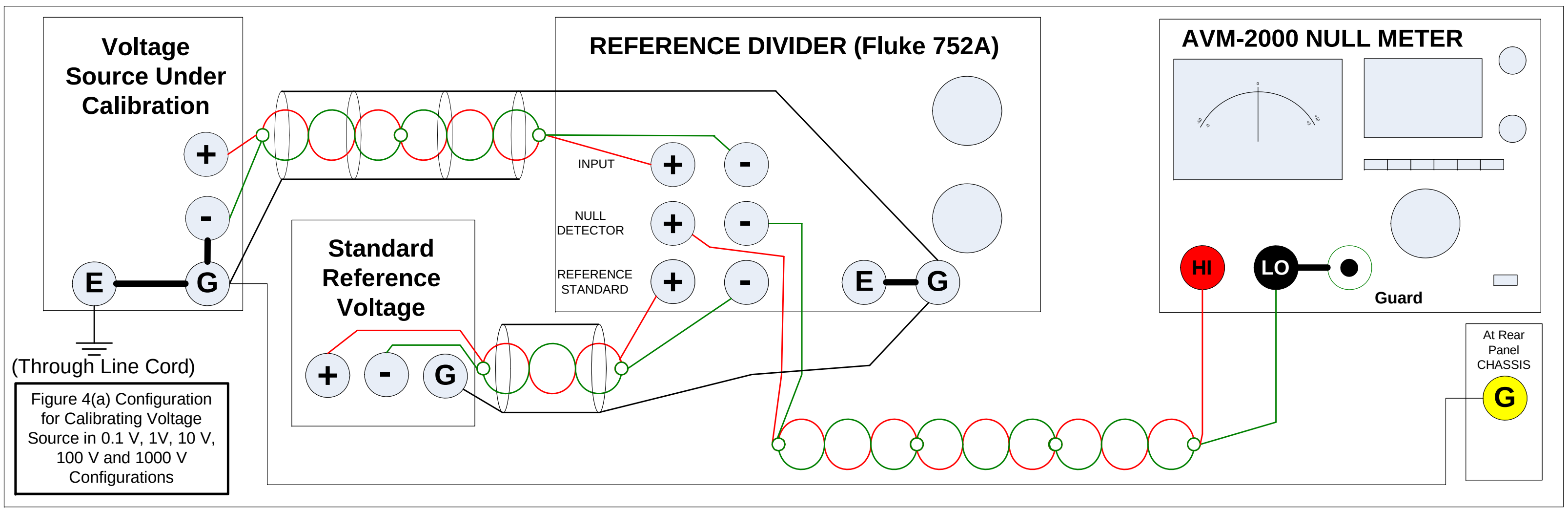
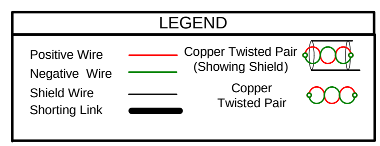


Figure 4(a) Configuration for Calibrating Voltage Source in 0.1 V, 1V, 10 V, 100 V and 1000 V Configurations



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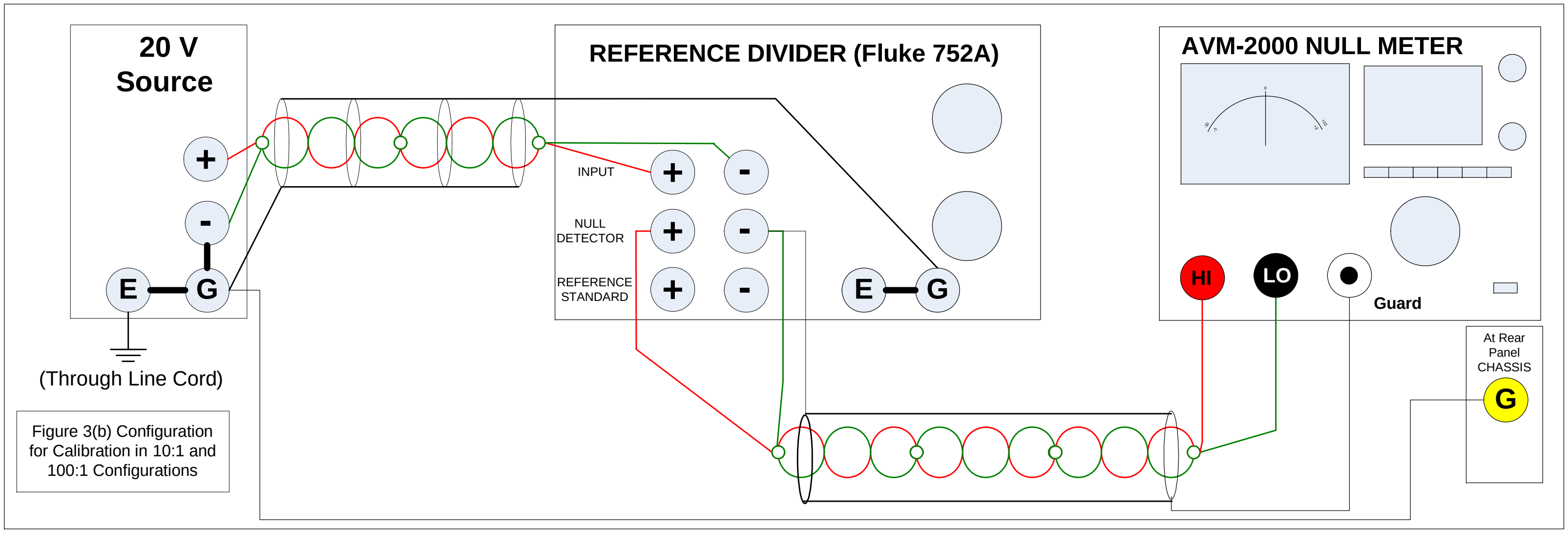


Figure 3(b) Configuration for Calibration in 10:1 and 100:1 Configurations

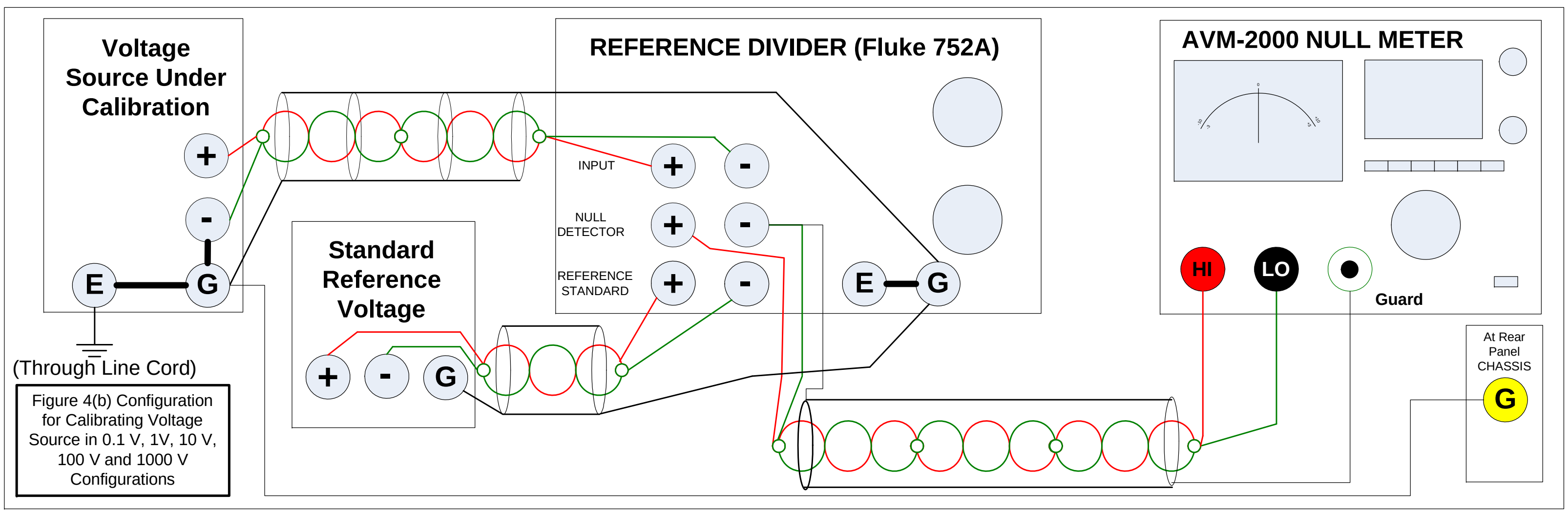
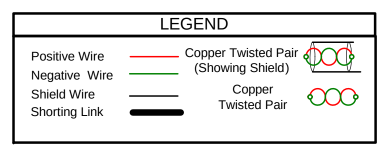


Figure 4(b) Configuration for Calibrating Voltage Source in 0.1 V, 1V, 10 V, 100 V and 1000 V Configurations



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