# Using A DVM To Self Calibrate A 752A Divider

The considerations and recommendations for DVM measurements versus using a Null Detector

# 10:1 Division with the 752A

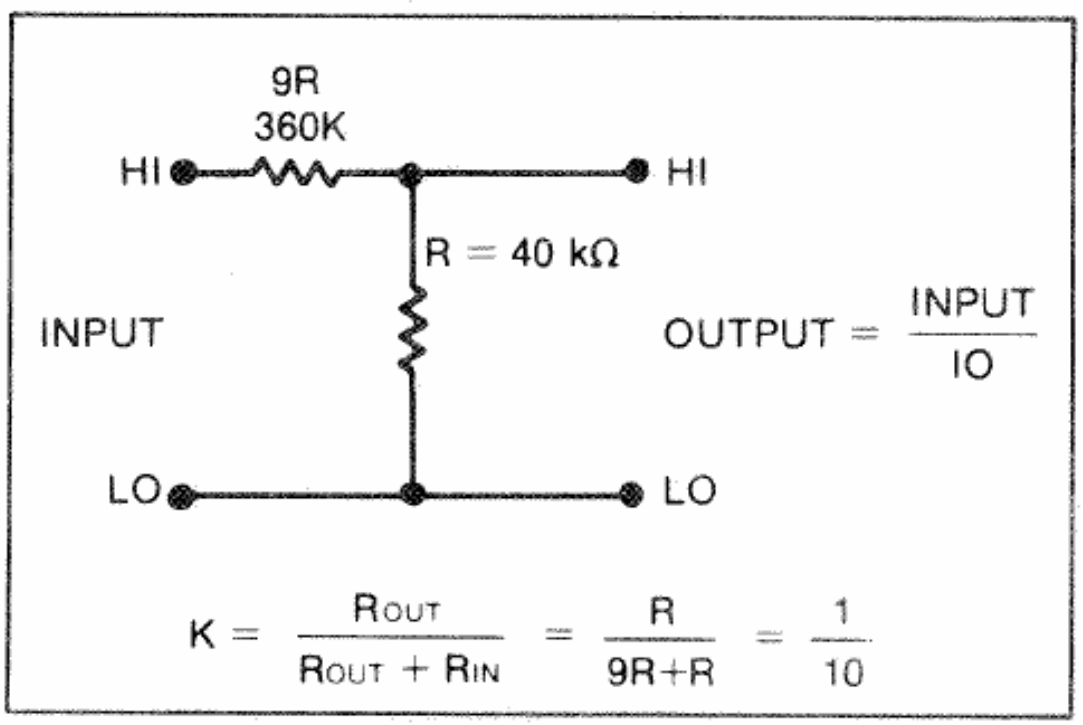



**Figure 3-4. 10:1 Voltage Divider**

Prior to use, the 360K and 40K resistors must be Self Calibrated – that is the ratio adjusted so errors are negligible.

# Calibration/Balancing Prior To Use

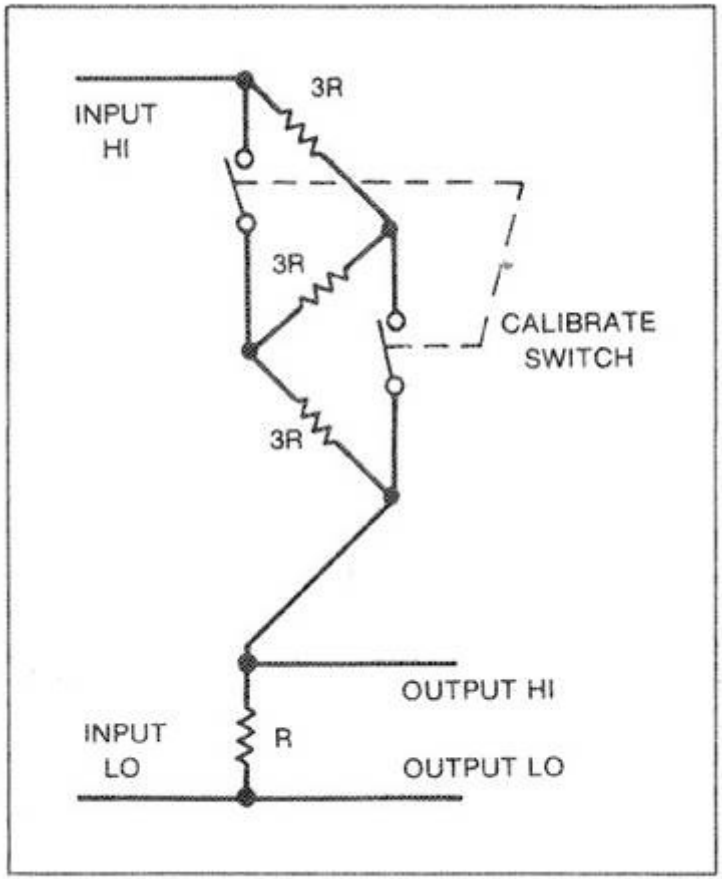
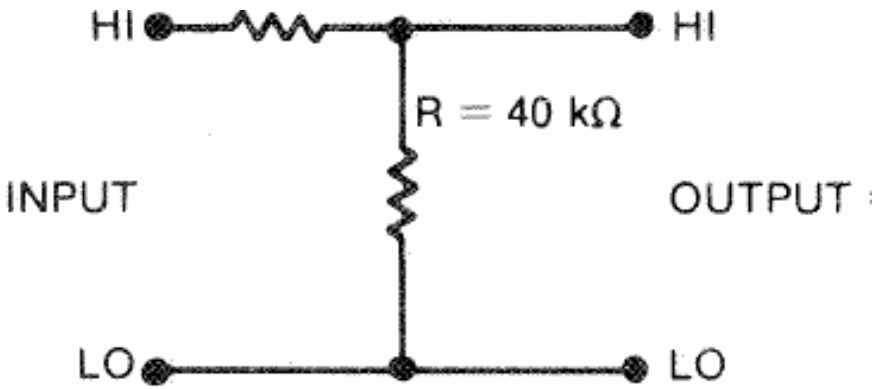



**Figure 3-6. Calibrate Mode Switching (10:1)**

The Calibration switch configures the 752A into 2 equal resistances in series for proper balancing

R = 40 kΩ
( A parallel combination
of 3 sets of 3×40 kΩ)



# Wheatstone Bridge Balance & Zeroing Circuit

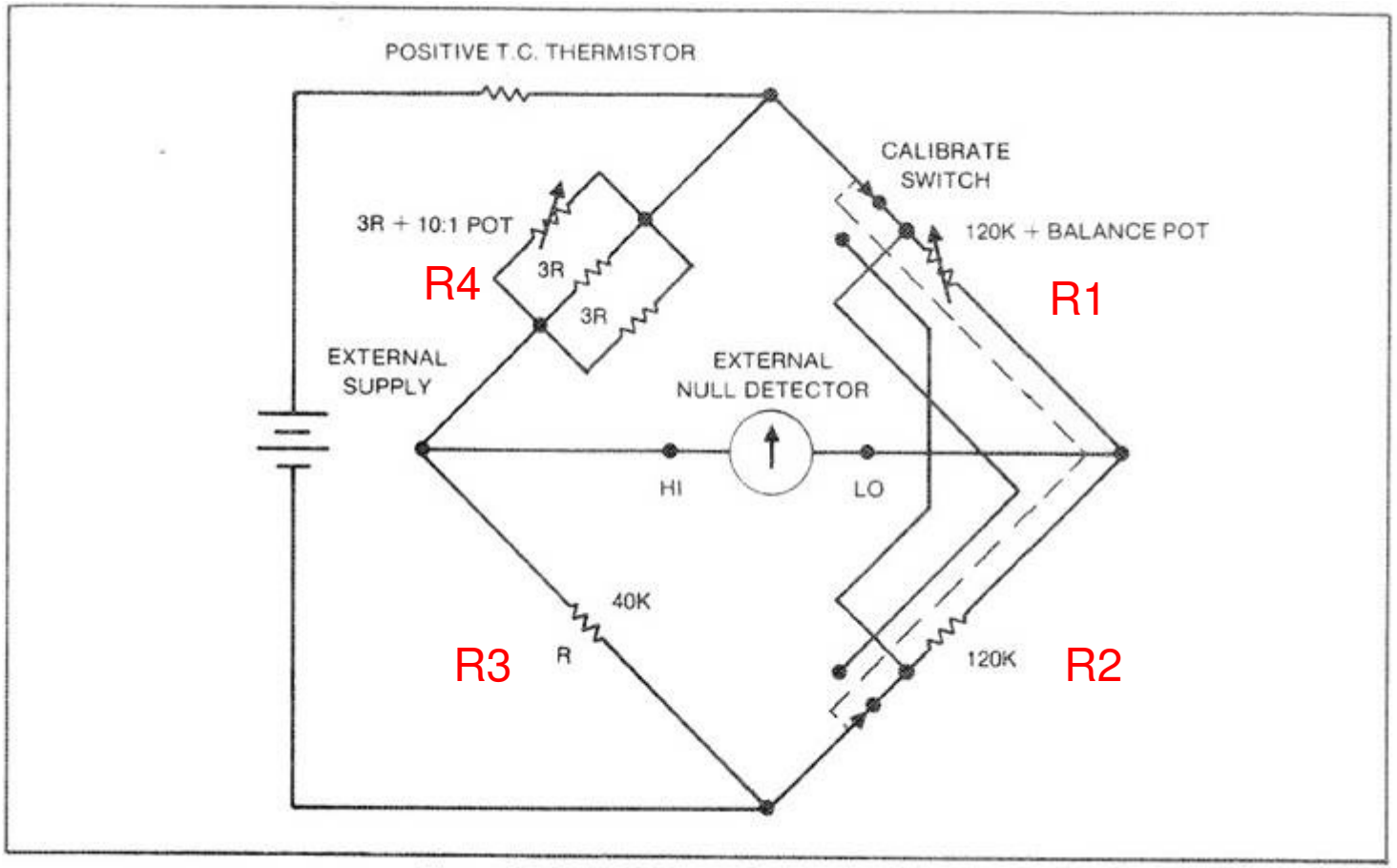



**Figure 3-7. 10:1 Divider and Calibration Circuit**

First R1 & R2 are balanced, then the full bridge is zeroed for a proper ratio

# Self Calibration Setup

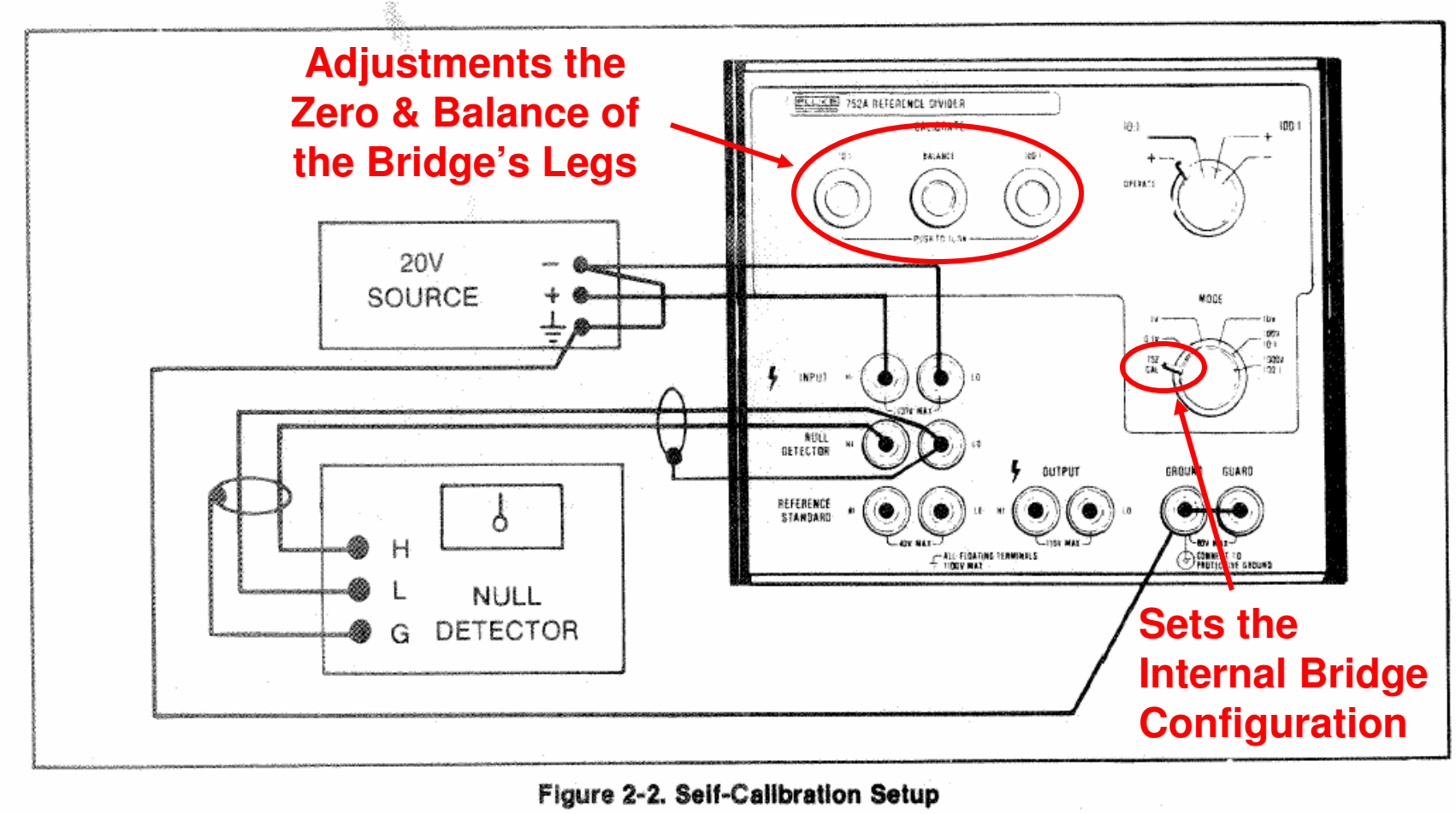
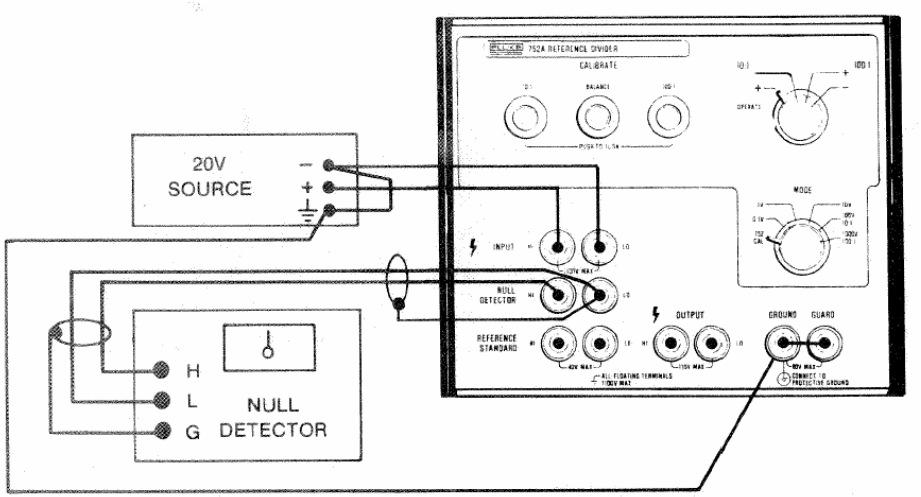



**Figure 2-2. Self-Calibration Setup**

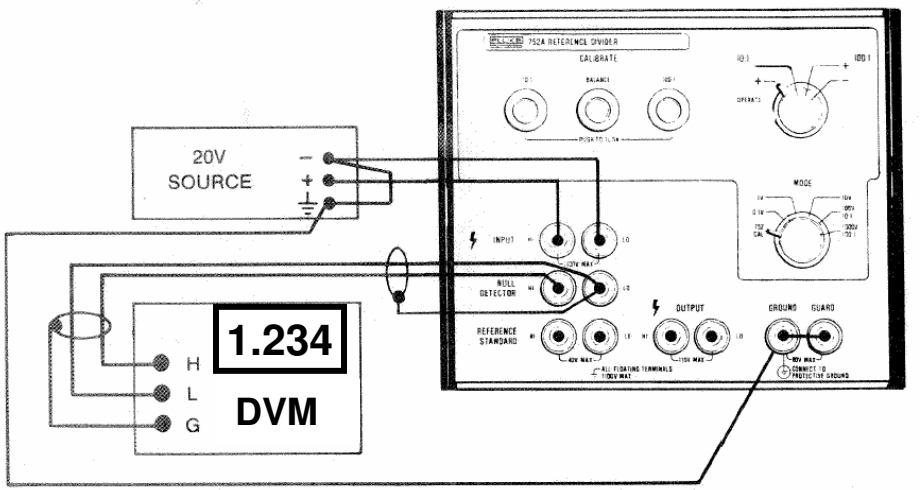
Controlling the resistor configuration switching for calibration and balancing

# Benefits Of Using A Null Detector



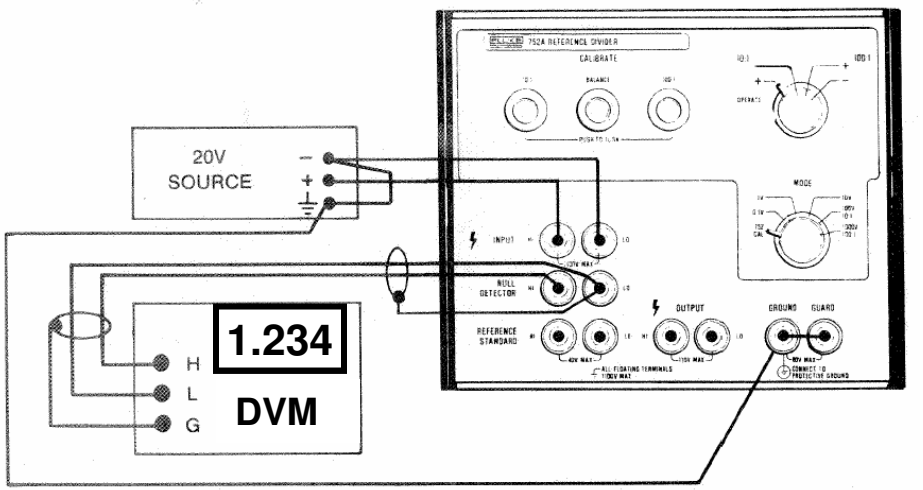

- Infinite Input Impedance at Null
- Negligible Bias Current (<1 pA)
- 1 µV Scale permits measurements with a sensitivity to better than . 1 µV
- Analog Scale integrates noise effects

# Key Considerations When Using a DVM Rather Than A Null Detector



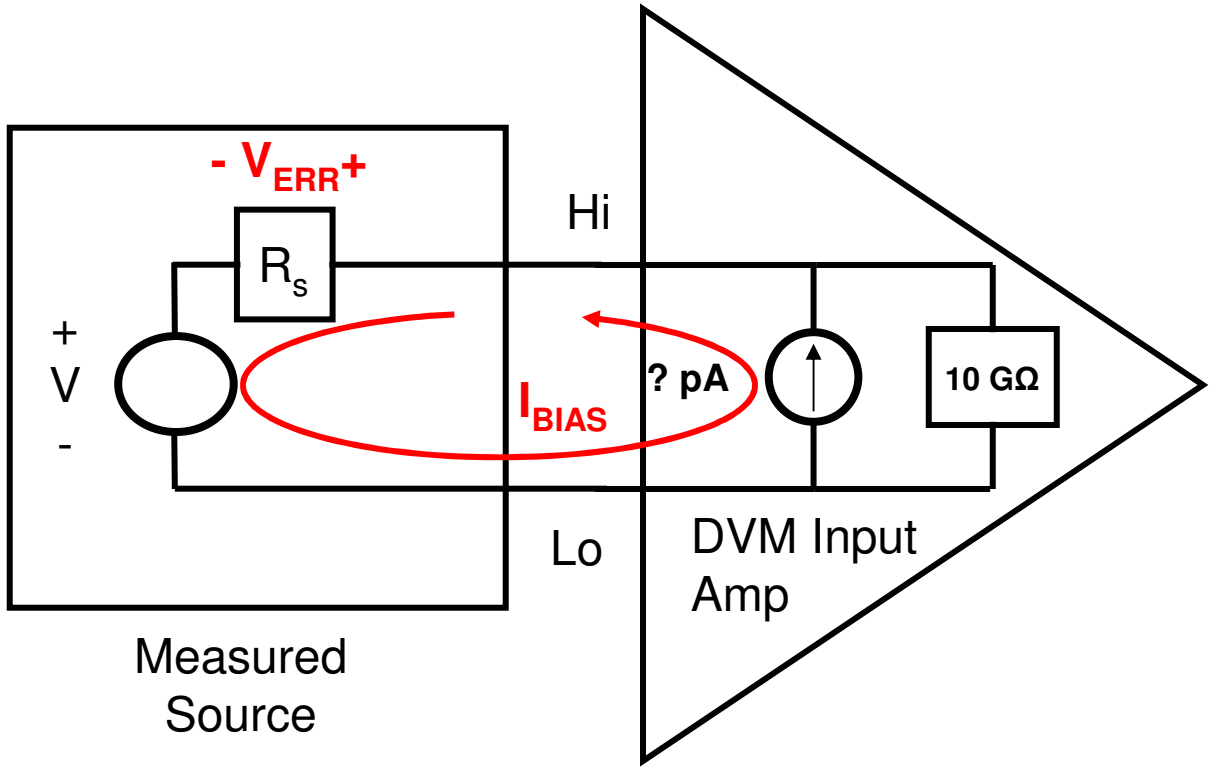

- Input Impedance of more than 10 GΩ
- Moderate Bias Currents, specified at up to 50pA (often ~ 10 pA to 20 pA)
- Measurements on the 100mV or lower ranges permit measurement sensitivities up to 10 nV
- Digital averaging techniques integrate out noise effects

# Can a DVM be Successfully Used For Self Calibration?



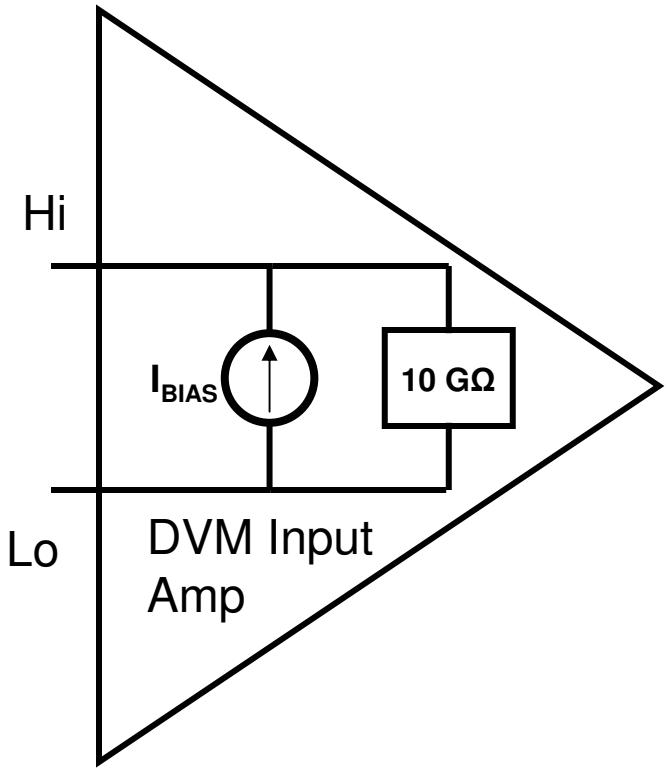

- The answer is a qualified yes
- There are conditions that must be met
- The largest concern is the DVM bias current's interaction with the 40 kΩ source resistance of the 752A
- Often a compatible DVM must be selected to do the test

# DVM Bias Current Induced Error Voltages



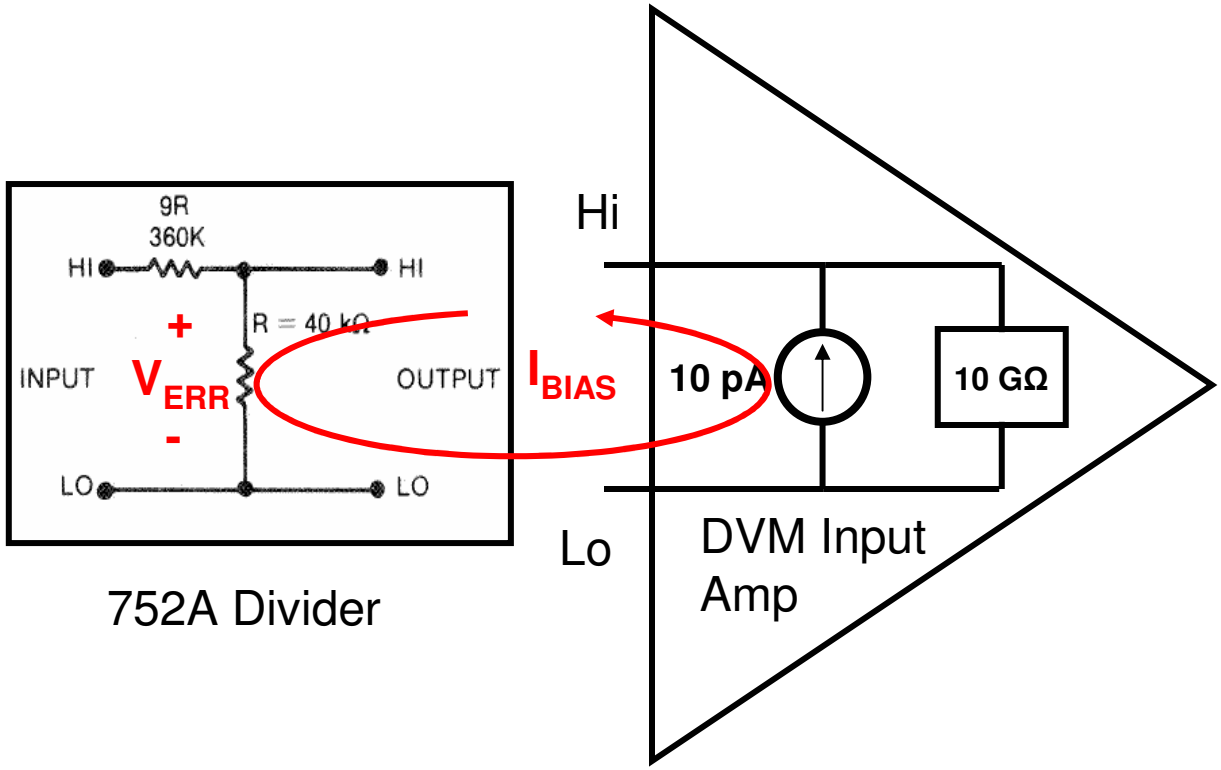

- **Bias currents through source resistances cause voltage offset errors**
- **The measured value equals the combination of the intended voltage (V) and the error voltage ($V_{ERR}$)**

# DVM Bias Current Considerations




- Each individual DVM has different bias current conditions
- The bias currents are not routinely adjusted to zero (could be possible with internal circuit adjustments)
- In this application the bias currents must be stable and be relatively low in noise

# 752A & DVM Bias Current Considerations




- The 752A requires balancing & zeroing to less than ±0.5 microvolts
- Bias currents can cause offset errors of a similar magnitude:
  (for example, 10 pA & 40 kΩ causes a 0.4 μV offset)
- This offset voltage must be considered to properly balance & zero the 752A

# Evaluating a DVM's Bias Current

- This a process to test a DVM to see if its bias current characteristics are acceptable
  - Examine zero stability, drift & noise with a shorted input terminals to prove the DVM is inherently stable enough
  - Examine stability, drift & noise with 40 kΩ across input terminals to see if the bias current is acceptable
- If acceptable, then The DVM can be corrected for the offset voltage condition in order to be used to self calibrate a 752A

# Step 1: Test The DVM's DCV Zero Performance

- Connect a high quality short to the input terminals of the DVM
  - Use a single, short portion of copper wire.
  - Do not use any plugs to avoid thermal emf errors
- Adjust the DVM measurement characteristics to a range where voltages < ±0.5 microvolts can be measured
  - Select DC Volts as measurement function
  - Set to a fixed range of 100mV or lower if possible
  - Use longer integration times of 3 to 5 seconds per reading
  - Use the DVM's analog filter settings to improve its Normal Mode Noise Rejection
- Zero the meter using the appropriate zero or offset correction method
- Examine that the zero remains stable with a small measurement scatter
  - In Fluke's lab we have seen short term noise stability approximately ±0.03 microvolts

# Step 2: Repeat the DCV Zero Test with a 40 kΩ Source Resistance

- Replace the zero ohm short on the DVM input terminals with a 40 kΩ resistor
- Connect resistor leads directly to the DVM's terminals. Do not use any connector plugs in order to minimize thermal emf errors
- Do not re-zero the meter. Monitor the new reading for drift, stability & noise
  - Expect the measurement values to be offset from the previous values due to bias current drop across resistor. (Bias current can be estimated as $V_{MEASURED}/40k\Omega$)
  - Insure the values are stable to within several tenths of a microvolt. In Fluke's lab we have seen short term noise stability within several tenths of a microvolt.
  - Insure the drift over 3 to five minutes is less than ±0.5 microvolts
- Use the offset function of the meter to subtract this bias offset out of the reading – the reading should again be near zero.
- Confirm that this offset measurement remains stable and does not drift during a 3 to five minute interval (this interval simulates the time required to zero and balance a 752A)
- NOTE: Not all dvms will have bias current signal characteristics that permit their use in this application. If a meter cannot be used, then select a different meter. The meter is not necessarily defective and is probably working within it's specifications.

# Step 3: Additional Noise Reduction Techniques

- If the DVM reading is too noisy, then it is possible to use a capacitor across the voltage measurement terminals of the DVM to reduce instability due to noise
  - Use a high quality, low leakage capacitor (low D / hi Q).
  - A suggestion is to use a 0.1 microfarad capacitor (use materials such as polystyrene as cereamic and tantilum caps are not appropriate)
- This will lengthen the settling time while the capacitor charges with the DC voltage offsets.
  - It can be as long as 3 to 4 minutes.
  - Monitor the measured zero value and wait until it is stable – showing normal reading to reading stability of one to two tenths of a microvolt.

# General Measurement Recommendations

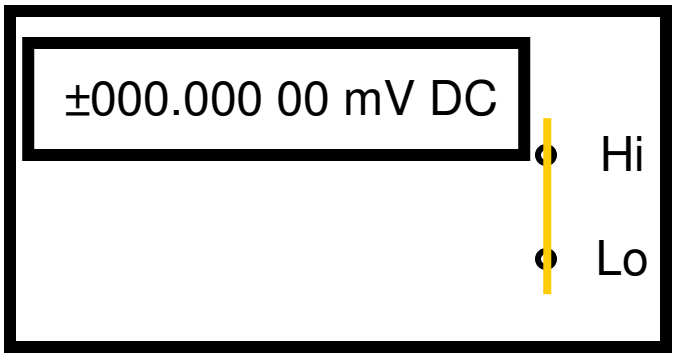
- Use connection leads that are made out of insulated copper wire. Pure “Bell Wire” such as used in telephone applications.
- Two wire shielded copper leads with Teflon insulation is a very good approach. Silver plated copper can also be considered.
- Avoid thermal emf errors. DO NOT use standard banana plugs. Small copper spade lugs can be used. If plugs are considered then use plugs with special low thermal emf contacts mounted to the copper leads
- Minimize all physical movement around the test set up during the measurements. Small charges can be induced into the leads due to the high impedance conditions. These will cause instability.

# A DVM & Self Calibration of the 752A

- If the DVM has compatible bias current characteristics, then it is possible to do the self calibration's balancing and zeroing operations on the 752A
- Prior to doing the balancing and zeroing on the 752A, first make the offset correction to the DVM using the following procedure. This correction will be used during the self calibration procedure.
- Following this, perform the Self-Calibration Procedure as documented in the 752A manual using the DVM rather than a Null Detector.

# Step 1: Zero the DVM

1. Apply a high quality short to the input terminals of the DVM.
2. Select the lowest range compatible with resolving 0.1 to 0.01 µV.
3. After the meter stabilizes, perform a zeroing of the measurement range.



# Step 2: Connect the DVM to the 752A Which Has A Shorted Input

- Apply a high quality, low thermal short between the Input Hi and Input Low of the 752A
- Remove the previously used short on DVM and connect it the Null Detector Hi and Low to the voltage measurement terminals of the 752A

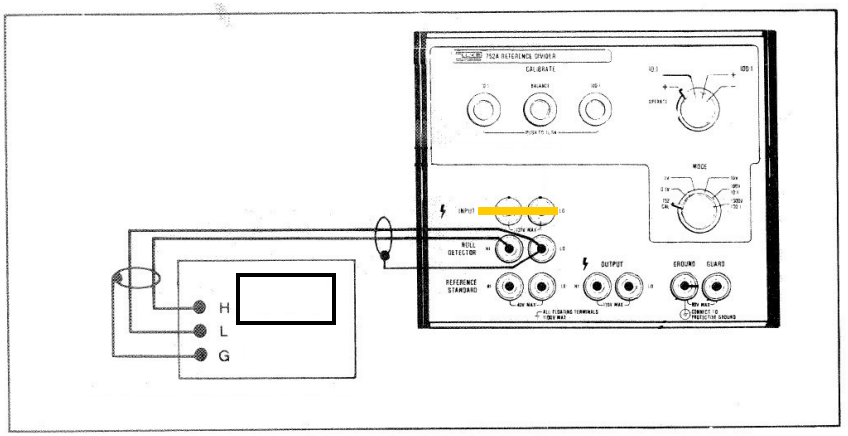



Figure 2-2. Self-Calibration Setup

# Step 3: Correct for the Bias Current Offset Error Measured By The DVM

1. Wait for the offset voltage measured by the DVM to settle to within several tenths of a microvolt of a particular value.
2. This value becomes the zero reference point for balancing and zeroing the 752A.
3. If convenient, store this value as a measurement offset so subsequent balancing and zeroing measurements display near zero volts.

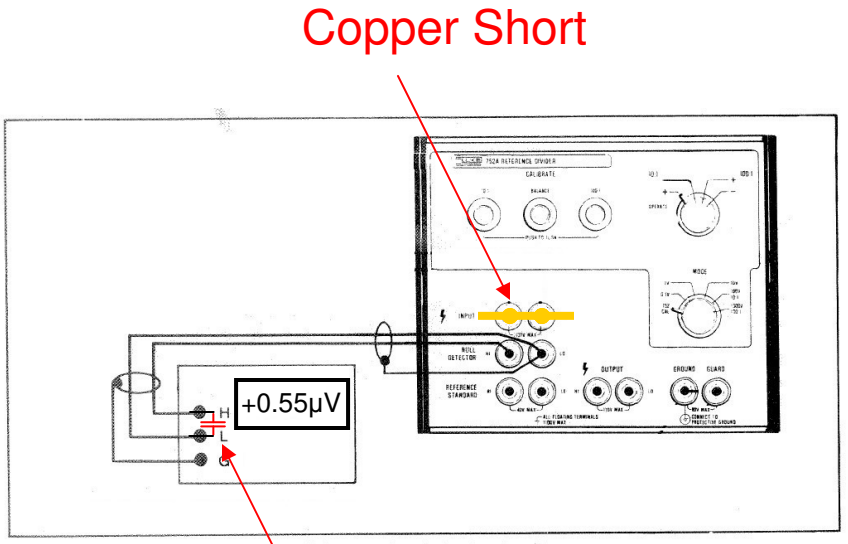
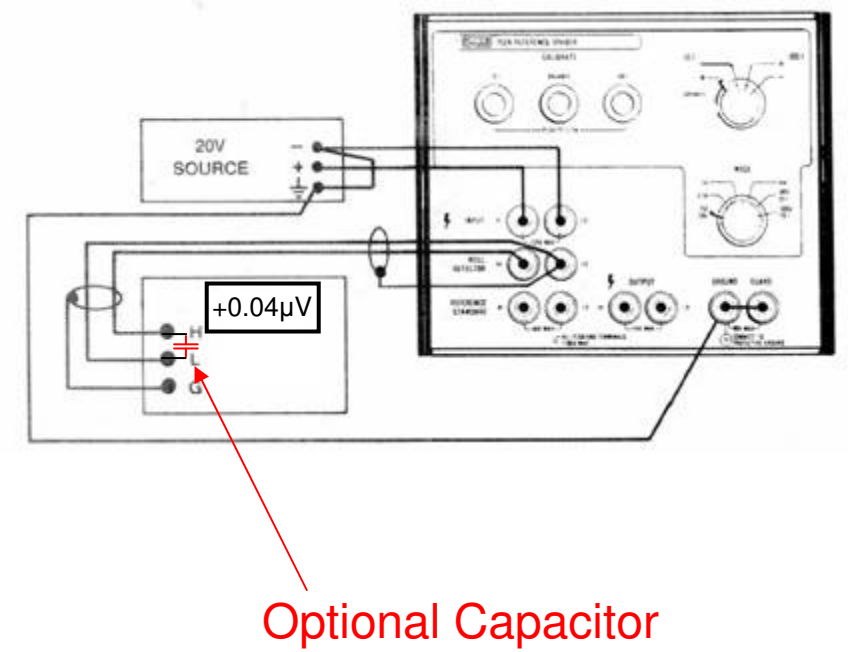



Figure 2-2. Self-Calibration Setup

# Step 4: Proceed With The Procedure To Self Calibrate The 752A

1. Connect the 752A, DVM and voltage source as shown.
2. Proceed with the Self Calibration Procedure as detailed in the 752A manual



# 752A Self Calibration Is Complete

- With the completion of the Self Calibration of the 752A, it now can be used to perform ratio measurements to the full extent of its specifications.
- During the ratio measurements, the DVM can now be used to read the null detector voltage signal out of the 752A.
  - Depending upon the amplitude of the voltages being nulled and the required measurement uncertainties, the bias current offset voltages still might be a consideration for these measurements. (Such for nulling voltages on the order of 0.1 volt)