

Basis for Kelvin Contacts

Background

Kelvin sockets are an important part of electrical component testing. The Kelvin description comes from Lord Kelvin, the honorary title given William Thomson in the late 1800's. William Thomson was a physicist, inventor, engineer, and professor for more than 50 years at the University of Glasgow in Scotland. One of his main projects was the design and implementation of the first transatlantic telegraph cable. As part of that project, he developed the Kelvin Bridge in 1861, which enabled the accurate measurement of very low resistances. The Kelvin Bridge uses four terminal connections at the high current resistors, thereby giving the name Kelvin connection to the means of providing separate force and sense connections to components.

Principles of Use

A Kelvin socket provides separate force and sense connections to each lead of the component. Schematically this is shown in Figure 1. In a typical implementation, a relatively high current passes through the force contacts. Connections to the sense contacts (shown as blue lines in Figures 1, 2 and 3) are used to measure a precise voltage. The reason why measurements are much more accurate using this approach is that the contact and interface resistance of the high current force contacts does not affect the accuracy of the voltage reading across the sense contacts.

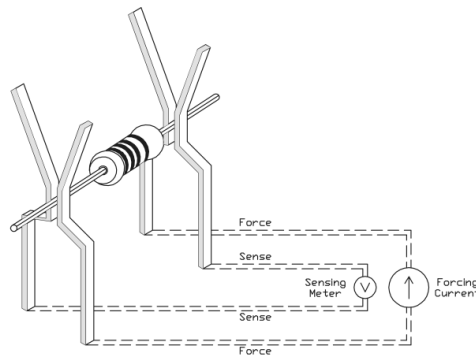


FIGURE 1
Kelvin Socket

Why Use Kelvin Sockets

There are four basic reasons why Kelvin Sockets are used. They allow accurate measurement of very low resistance values, accurate voltage measurement, assurance of test, and improved heat dissipation.

Low Resistance Measurement

A common application of Kelvin sockets is to allow accurate measurement of low resistance. An example of this is the need to measure the low RDS-ON values (resistance between drain and source leads when the transistor is "on") in a MOSFET. These values can be as low as 1 milliohm, which requires a Kelvin socket connection during test to measure this low of a resistance value. Figure 2 shows a schematic of a MOSFET connected to read RDS-ON. A voltage signal is introduced into the gate contact to turn the MOSFET on. A high current is fed into the force contact of the drain and through the source lead. The second set of contacts (sense leads) at the drain and source are connected to a voltage measuring instrument. As there is little current flowing in the sense leads, the voltage drop on the sense connections is minimal. The RDS-ON resistance is calculated by dividing the drain and source sensed voltage by the drain to source current.

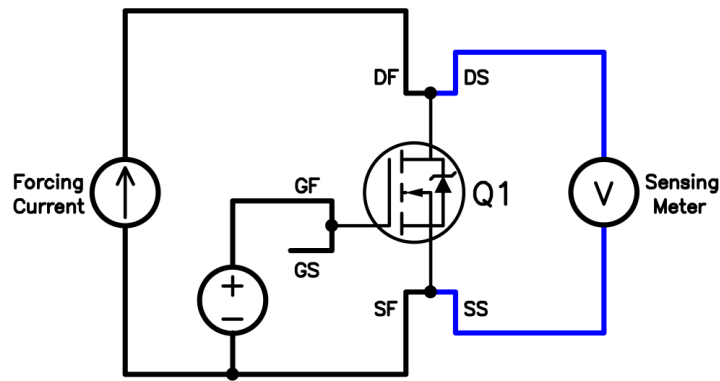


FIGURE 2
MOSFET Configured for RDS-ON Test

Accurate Voltage Measurement

When device voltages are required to be measured very accurately, the Kelvin socket can be used to insure that inaccuracies caused by device current or interface resistances are minimized. An example of this is the need to measure the output voltage of a voltage regulator that is outputting a high current into a resistive load as shown in Figure 3. The force contact would carry the load current while the sense contact current draw would be negligible. Also the sense contact could be positioned at the precise location on the device lead or pad to provide accurate and repeatable results. A sensing meter connected to the sense contacts could more accurately measure the output voltage of the device.

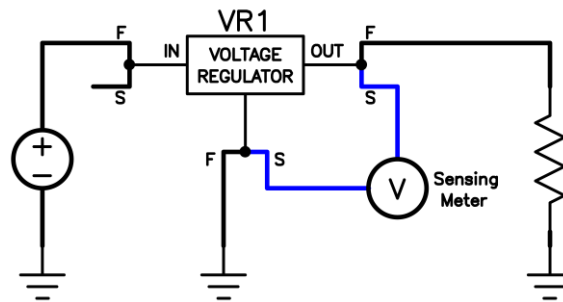


FIGURE 3
Voltage Regulator Testing

Assurance of Test

When using a Kelvin socket with force and sense contacts, the sense contact can be used to monitor whether the force contact is actually delivering the proper signal to the device lead. Also, in applications where the Kelvin capability is not used but the same signal is applied to both force and sense contacts, the additional redundant contact provides added assurance that the signal is actually reaching the device lead.

Improved Thermal Performance

Often the heat dissipated by the device under test causes difficulties. The temperature of the device may exceed its own recommended level or the temperature rating of the socket. With the Kelvin socket there are at least two separate contacts for each device lead. Theoretically this would allow twice the thermal conduction through the device leads than that of a single contact, non-Kelvin socket, and would also allow additional current carrying capability.

Burn-in Use

Although Kelvin sockets may not be needed for traditional burn-in, the use of Kelvin sockets on the burn-in board may permit the use of test probes to perform Kelvin testing without the need to load and unload devices to a special test fixture. For example, interchangeable program cards on the burn-in board can be used to achieve burn-in in a chamber, or Kelvin testing while the board is connected to a bench top measuring instrument.

Kelvin Socket Examples

As a result of the need for Kelvin style testing on electrical components, several styles of Kelvin sockets are available. Figure 4 shows Kelvin sockets for axial and radial lead, gullwing SOIC, TO, QFN, and SMD Power packages.



Conclusion

Kelvin sockets are a useful and important tool in electronic component testing. The Kelvin socket has two contacts per device lead. The force contact carries the current necessary to operate the device. The sense contact carries a low current and can be connected to a measuring device to more accurately measure the voltage drop between device leads.