QuadTech

Application Note

Resistive Load Boxes for Hipot Testers and Megohmmeters

Resistive load boxes are used for a variety of purposes from daily verification of a hipot tester on a production line to annual calibration or performance verification. Choosing the correct resistor for a high voltage application is not always easy. This application note will provide useful information on high voltage resistors and the manufacturers that make high voltage resistors.

Figure 1.0: Resistive Load Box

It is important to look at maximum voltage rating, power rating, temperature coefficients and voltage coefficients when specify resistors for these types of applications.

The voltage rating is the maximum voltage that can be applied to the resistor without causing damage to the resistor due to arcing or breakdown.

The power rating defines how much power the resistor can dissipate without damaging the resistor due to overheating. It is important that the power being dissipated is calculated at the intended operating voltage. Do not assume that just because the resistor is being used under the maximum voltage rating that there will not be a problem. It is always advisable to calculate the power using $P=V^2/R$ where V = test voltage and R = resistance value of the resistor or $P = I^2*R$ where I = current through the resistor.

The temperature coefficient expresses the change in resistance value due to a change in temperature of the resistor. The temperature coefficient is normally repressed in ppm/°C and can be positive or negative.

The voltage coefficient expresses the change is resistance value due to a change in the amount of applied voltage. The voltage coefficient for a resistor is normally expressed in ppm/Volt and is always negative. That is the higher the applied voltage the lower the resistance value.

Resistor Manufacturers

There are a number of different companies that manufacture high voltage (HV) resistors. This application note defines high voltage resistors as resistors with voltages over 1000V but less than 10,000V. Manufacturers Ohmite/Victoreen, Caddock, and Vishay produce HV resistors.

Investigate these manufacturers on the web at:
http://www.ohmite.com/victoreen/
http://www.caddock.com
http://www.vishay.com

Consider various types of resistors:

1.) Mini-Mox Resistors by Ohmite/Victoreen, they are available in a variety of voltage ratings, accuracies and high resistance values.
http://www.ohmite.com/catalog/v_minimox.html

Mini-Mox resistors have voltage ratings to 6000V and values from 1000Ω to 10GΩ. Standard values of 10MΩ, 100MΩ and 1GΩ are available from distributors such as Newark Electronics under part numbers 19C0477, 19C0479, 19C0481 respectively. These resistors are ideal for calibration and verification as they are highly stable and have low voltage coefficients. The epoxy-coated resistors can also be used in an oil bath for improved performance.

2.) Dale/Vishay RS-10 Wire wound resistors and TR-30 High Voltage resistors are also a good choice depending upon the application. The RS-10 wire wounds are rated for 10W and 1000VAC. These are ideal for higher power applications where two or more can be used in series or parallel combinations. Typical applications are load boxes with resistance values less than 1MΩ. QuadTech typically uses two or more RS-10 resistors in most of its load boxes. These are ideal for daily verification of a hipot.
http://www.vishay.com/docs/30204/rs_ns.pdf (RS-10)

The Vishay TR series is similar to the ohmite Mini-Mox. The TR series features a voltage coefficient of 0.1ppm/V and resistance values from 3000Ω to 6TΩ.
http://www.vishay.com/docs/68000/tr-td.pdf (TR Series)

3.) Caddock makes a number of different high voltage resistors. The TF Series are high precision to 0.01%, highly stable, low temperature coefficients and feature resistance values from 1kΩ to 125MΩ.
http://www.caddock.com/Online_catalog/Mrktg_Lit/TypeTF.pdf

Typical Load Box Application

The AC hipot tester is setup for: Test Voltage = 1250VAC
High Limit = 5mA Low Limit = Disabled
Ramp Time = 1s Test Time = 1s

A typical load box for this application should have two resistor values: one that will cause a pass indication and the other a fail indication. It is always advisable to have a pass as this allows the operator to look for a known leakage current reading when the resistor is connected. If the current reading changes then this could indicate that the programmed voltage has change or the incorrect setup is being used. It also has the advantage of verifying that the meter is reading correctly.

Using Ohms Law: 1250V/5mA = 250kohms

The resistor value for a pass indication should be slightly higher than 250kohms and the resistor for a fail indication should be slightly lower than 250kohms. Values of 200kohms for fail and 300kohms for pass could be chosen.

The required power dissipation = $(1250V)^2/200{,}000ohms = 7.8W$ (Fail Condition)
The required power dissipation = $(1250V)^2/300{,}000ohms = 5.2W$ (Pass Condition)

The recommended resistor for this application would be the Vishay RS10 as the power rating is 10W. The voltage rating however is 1000VAC and needs to be taken into consideration. To increase the voltage rating, the use of two 100kohm resistor in series would mean that ½ of the voltage is applied to each resistor. This would also reduce the power requirements as well.

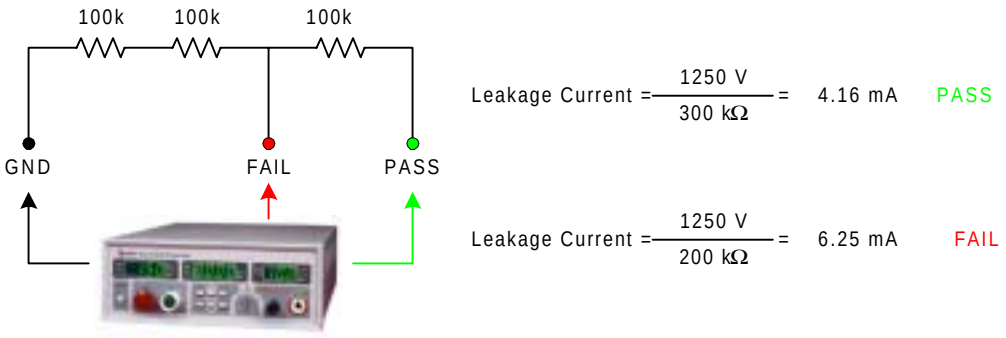

Figure 2.0: Leakage Current

When the hipot tester is connected between GND terminal and the fail terminal the hipot tester should indicate a leakage current of 1250V/200000ohms = 6.25mA. The operator can then connect to the fail terminal and verify the hipot tester fails for a high current reading over the set high limit of 5.0mA.

When the hipot tester is connected between GND terminal and the pass terminal the hipot tester should indicate a leakage current of 1250V/300000ohms = 4.16mA. The operator can then look for this value of leakage current each time verification is performed. Verification is normally performed at the beginning of every shift or another convenient time interval.

T-Networks

For high resistance measurements a T-network is often used with instruments such as megohmmeters equipped with a guard terminal. A T-network uses low value resistors to achieve what electronically looks like a high value resistor. The basic operation of a T-network is three resistors are place in a T configuration and connected to the positive, negative and guard terminals of the megohmmeter. The ratio of the resistors then determines the effective resistance value that will actually be displayed by the megohmmeter. The advantages of the T network is that low value resistors are used that can be easily and accurately measured as compared with trying to calibrate a single high value resistor. This technique is used quite often in calibration where it is difficult to accurately calibrate a resistor.

A T-network is illustrated in Figures 3.0 and 4.0 along with the formula to calculate the effective resistance.

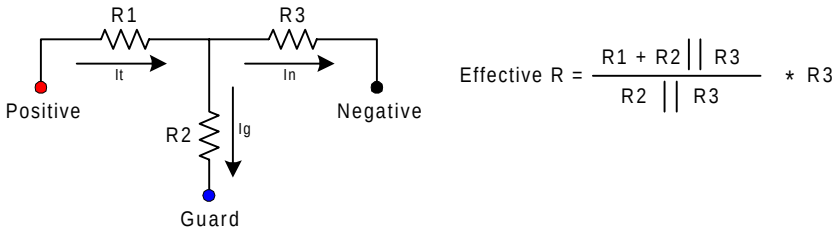

Figure 3.0: T-Network Model

Figure 4.0 illustrates an example T-network comprised of two 100Mohm resistors and a single 100kohm resistor to create a T-network that has an effective resistance of 100Gohms.

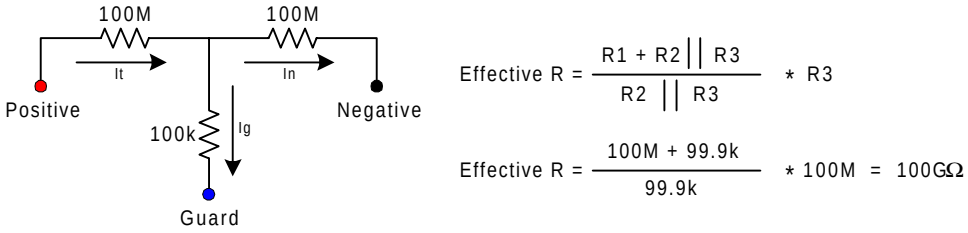

Figure 4.0: T-Network Example

For answers to questions on resistive load boxes not answered herein, please contact QuadTech for applications support. For complete product specifications on any of QuadTech's products, visit us at http://www.quadtech.com/products. Call us at 1-800-253-1230 or email your questions to info@quadtech.com.

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