

## Overload Protection for Keithley Products

Any instrument can be damaged if excessive voltage or current is applied to it. Most Keithley products specify the maximum allowable input. In some applications this maximum may unavoidably be exceeded. In these cases additional overload protection is required.

### I. Picoammeter Protection

The instrument most frequently needing protection is the picoammeter (or the electrometer in current mode). The instrument may be used to measure the leakage current of reverse biased diodes, capacitors, cables or connectors. If the applied voltage exceeds the maximum recommended for the particular instrument then additional protection is necessary.

The protection circuit shown in Fig. 1 depends upon the low input burden of the feedback picoammeter, typically less than one millivolt. The diode leakage at this level is generally less than one picoampere, so the circuit will not interfere with measurements of 10 pA or more.

The resistor must be high enough in resistance to limit the diode current to a safe value, and it must be able to withstand the maximum input voltage without arcing or burning up. The 1N3595 is rated to carry 225 mA (450 mA repeated surge). With two diodes in parallel, back-to-back, the circuit will provide protection regardless of the input polarity.

The series resistor may cause excessive loading error at high input currents, but this is usually not a problem. A good rule-of-thumb is to use a large enough resistor to cause a one volt drop at the maximum current to be measured.

### II. Voltmeter Protection

Voltmeters may be exposed to excessive voltage, especially from spikes caused by current interruption in inductors, large motors or transformers. The spike voltage may appear as a normal-mode voltage, between the two input terminals, or it may be a common-mode voltage from either input terminal to earth ground.

The circuits in Fig. 2 are for normal-mode protection. The spark gap is one of the best since it is very fast acting and will rarely interfere with normal operation.

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The neon bulb is not nearly as fast and may have some effect on high impedance measurements.

The varistor is probably the least desirable of these three since it may conduct a significant amount of current at input voltages well below its voltage rating. It is available in a wide range of energy dissipation ratings. The shunt capacitance of the varistor may be a problem with AC volts.

All three protective devices shown display a negative resistance region where the voltage drop decreases as the current thru the device increases. The series resistor is needed to prevent damage to the device.

For common-mode voltage protection, any of the above devices may be connected between the input LO terminal and earth ground. Usually no series resistance is included, it being assumed that the common mode voltage source is energy limited.

### III. Ammeter Protection

The ammeter function of a DMM is always provided by one or more shunt resistors. Excessive input current will cause the shunt to overheat and fail. A fuse is usually included to prevent this. The Model 196 is a good example.

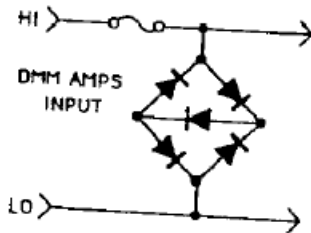
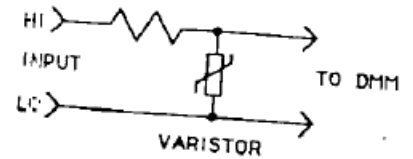
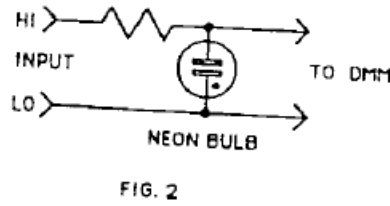
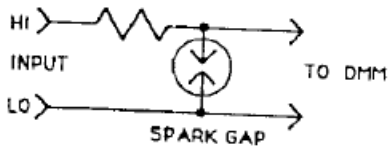
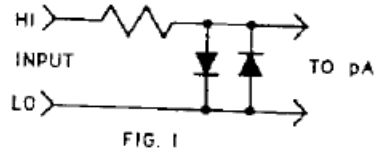
On the 3 Ampere range the shunt resistor is a four-terminal 100 milliohm resistor. At full scale the voltage drop is 300 millivolts. The input fuse, lead wiring and two MOSFET switches (Q39 and Q40) add to this drop, so the specified voltage burden is 2 volts.

If a current well in excess of 3 amperes is applied the fuse will fail before the shunt resistor is damaged. However, on the 300 mA range this current may damage either the shunt resistor or the MOSFET switches, Q38 and Q26, or both. To guard against this the diode bridge CR6 and diode CR7 are connected across the input such that the voltage applied to the shunts will never exceed 2.1 volts, and an extreme overload will cause the fuse to fail regardless of the current range selected.

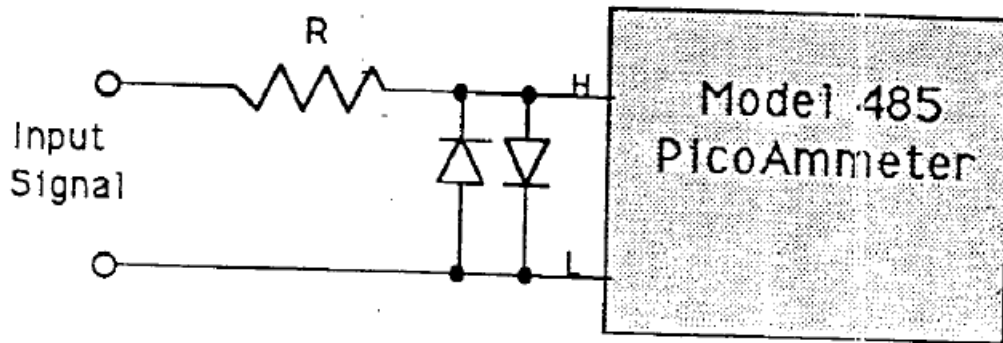
Note the fuse has a maximum voltage rating of 250 volts. If this is exceeded there is the possibility of a sustained arc inside the fuse which may result in a fire. Do not use the 196 to monitor the current in a 440 volt line.

### IV. Ohmmeter Protection

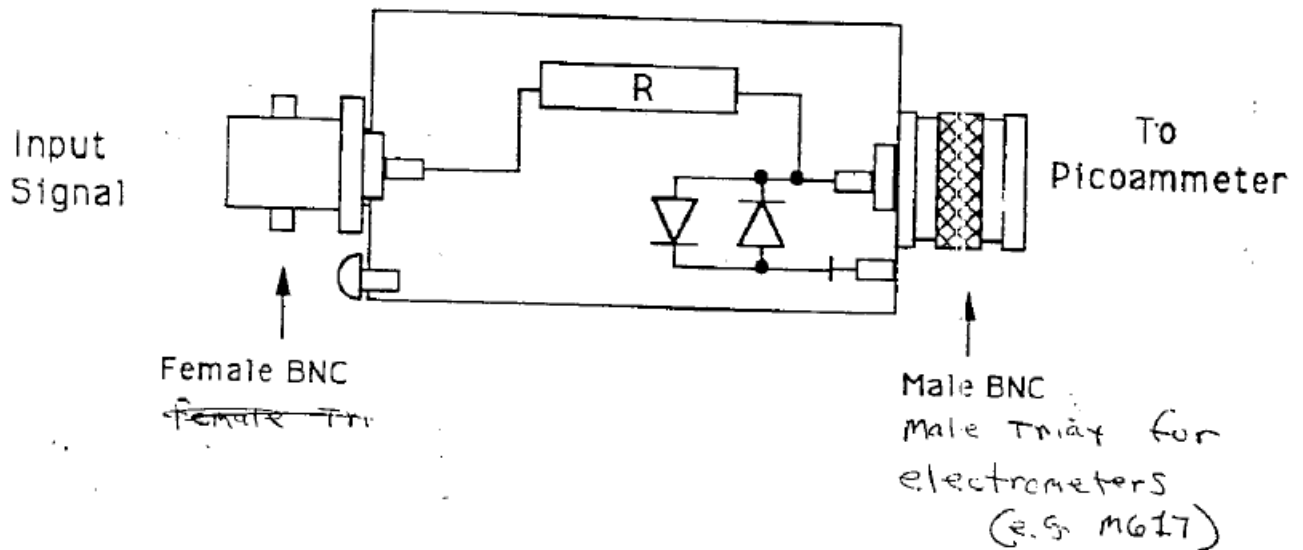
All ohmmeter circuits include a source of test current and this source is usually protected against externally applied voltage. The most common cause of ohmmeter damage in the past is the inadvertent application of line voltage to the input with the meter in the Ohms function. To allow for use on 220 volt circuits the maximum allowable input is usually specified at 300 volts rms.



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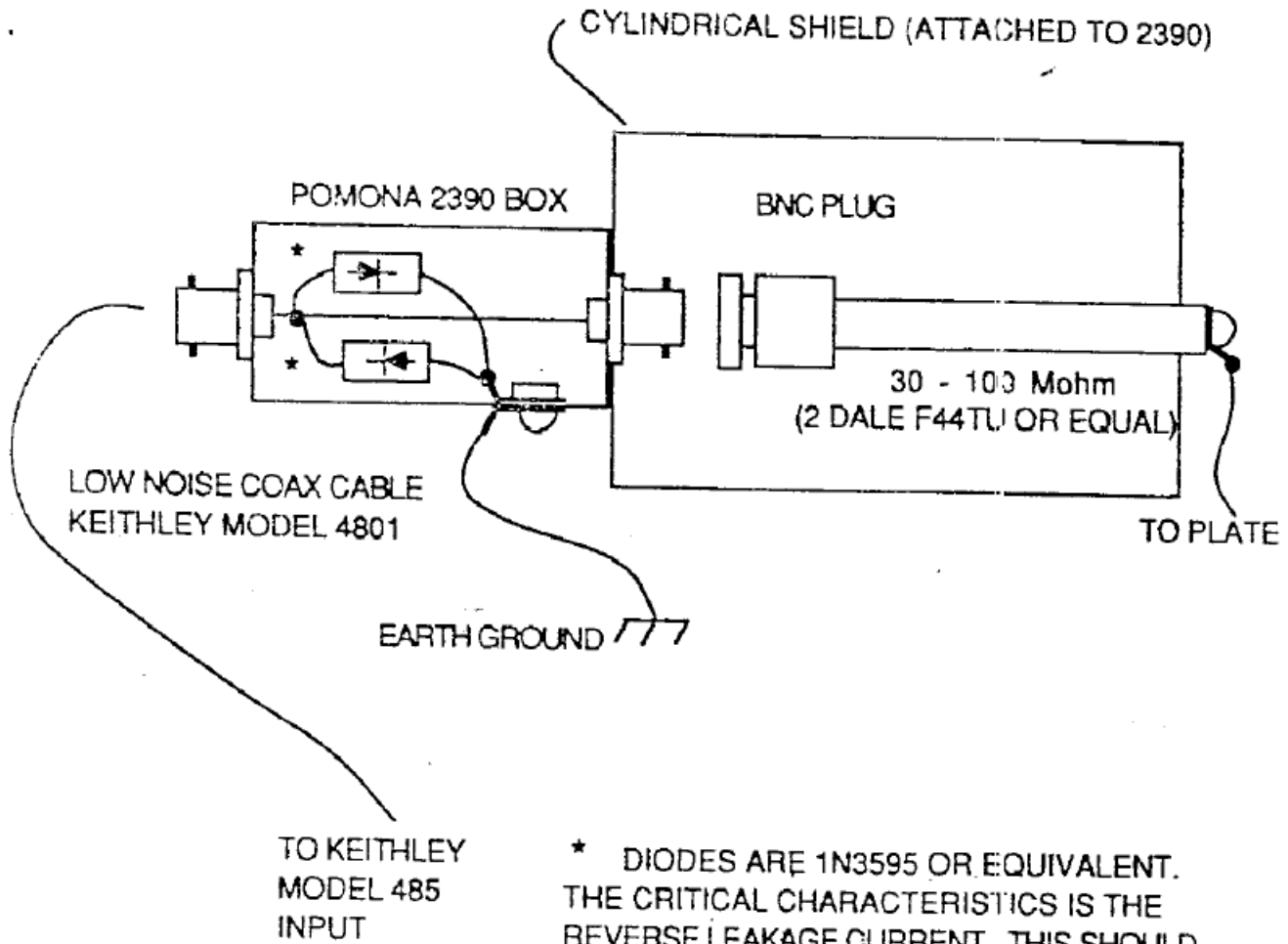


1. Diodes are 1N3595. Very low leakage. They clamp the input signal to less than one volt.
2. Resistor is in series with the input signal. It limits the current applied to the picoammeter. Select resistance so that maximum current is less than 2 mA.



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### 30 KILOVOLT INPUT PROTECTION FOR MODEL 485 PICOAMMETER



\* DIODES ARE 1N3595 OR EQUIVALENT. THE CRITICAL CHARACTERISTICS IS THE REVERSE LEAKAGE CURRENT. THIS SHOULD BE LESS THAN 1 nA AT 125 VOLTS.

JR YEAGER 12/15/88