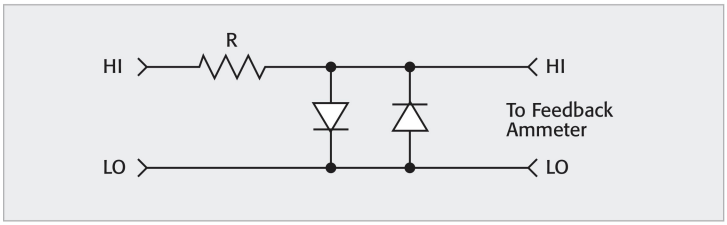
2.3.6 Overload Protection

Electrometers, picoammeters, and SMU instruments may be damaged if excessive voltage is applied to the input. Most instruments have a specification for the maximum allowable voltage input. In some applications, this maximum voltage may be unavoidably exceeded. Some of these applications may include leakage current of capacitors, reverse diode leakage, or insulation resistance of cables or connectors. If the component or material breaks down, all the voltage would be applied to the ammeter's input, possibly destroying it. In these cases, additional overload protection is required to avoid damaging the input circuitry of the instrument.

Electrometer or Picoammeter Overload Protection

Figure 2-29 shows a protection circuit for an electrometer ammeter or picoammeter, consisting of a resistor and two diodes (1N3595). The leakage of the 1N3595 diode is generally less than one picoampere even with 1mV of forward bias, so the circuit won't interfere with measurements of 10pA or more. This diode is rated to carry 225mA (450mA repeated surge). Because the voltage burden of the electrometer ammeter or picoammeter is less than 1mV, the diodes won't conduct. With two diodes in parallel back to back, the circuit will provide protection regardless of the signal polarity.

FIGURE 2-29: Overload Protection Circuit for Electrometers and Picoammeters



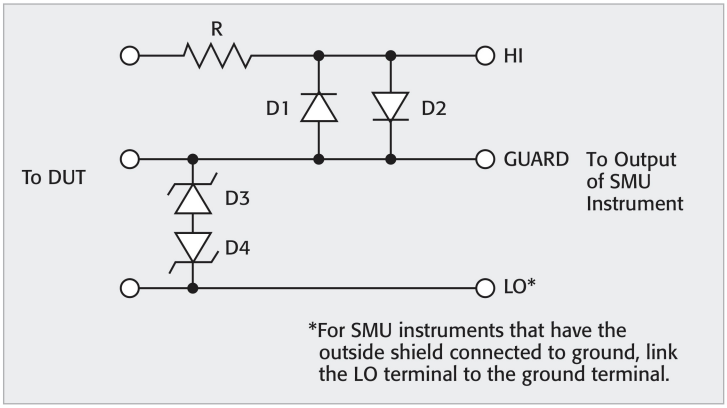
The resistor (R) must be large enough to limit the current through the diodes to prevent damage to the diodes. It also must be large enough to withstand the supply voltage. A good rule of thumb is to use a large enough resistor to cause a 1V drop at the maximum current to be measured.

The protection circuit should be enclosed in a light-tight shield because the diodes are photosensitive. The shield should be connected to the low of the ammeter.

SMU Instrument Overload Protection (in Force Voltage, Measure Current Mode)

Figure 2-30 illustrates an overload protection circuit for an SMU instrument in the ammeter mode. This circuit consists of two zener diodes (D3 and D4) connected between the Guard and LO (or Common) terminals, a current limiting resistor (R) in series with the HI terminal, and two low leakage diodes (D1 and D2) between the HI and Guard terminals.

FIGURE 2-30: Overload Protection Circuit for the SMU Instrument in Force Voltage, Measure Current Mode



The two zener diodes are used to clamp the guard to LO (or the Common terminal). These should be rated slightly higher than the SMU instrument's maximum measurable voltage. The leakage current through the zener diodes results in a voltage drop across the resistor, so low leakage zener devices are desirable.

The resistor (R) is used to limit the current through the diodes (D1 and D2). The resistance value should be large enough to limit the current flowing through the diodes to one-tenth of their forward current rating, thereby preventing diode damage. The resistor must also be rated high enough to meet the power dissipation requirements while the zeners are conducting.

If an overload occurs, one of the diodes (D1 or D2) will conduct and prevent the input from being damaged. The 1N3595 diode is a good choice for this function because it has low leakage current, typically less than 1pA, even with a forward bias of 1mV.

High impedance circuit construction, such as Teflon standoffs, must be used. The protection circuit should be built into a light-tight, metal-shielded enclosure with the shield connected to the LO terminal of the SMU instrument.

2.3.7 AC Interference and Damping

When measuring low current, electrostatic shielding (as discussed in Section 2.6.2) is the most common way to reduce noise due to AC interference. However, in some cases, shielding the device under test or the connecting cabling isn't practical. For these applications, a variable damping control may reduce the AC pickup enough to make meaningful measurements.