

Low Leakage Measurements With the SS-150 Test Station

Low leakage measurements, to 1 picoampere and below, have never been easy. When the speed of an automatic test system (ATE) is needed, the problem becomes even more difficult. As with most measurement problems, the best approach is to carefully analyze the sources of error and eliminate or control them, one by one.

Components

To have an effective picoammeter, all stray leakage must be eliminated. Low-leakage circuitry is usually built with Teflon-coated wire and components mounted on Teflon standoffs. Circuit-board material is generally not an adequate insulator, and capacitance effects on circuit boards can be difficult to control.

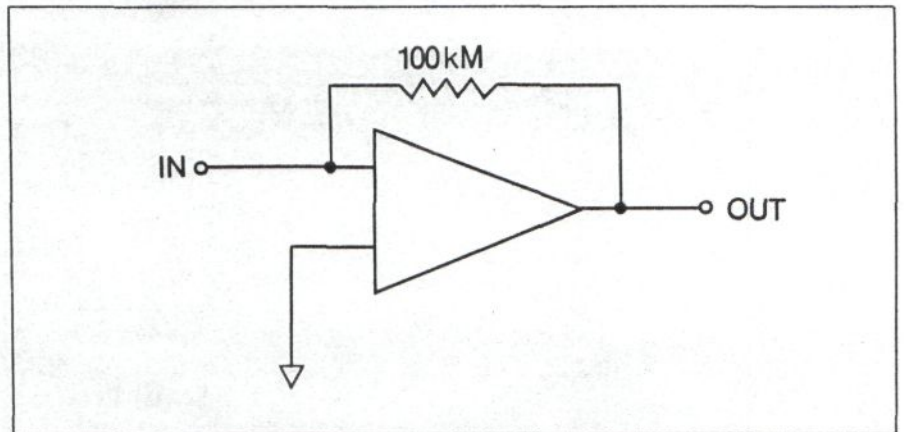
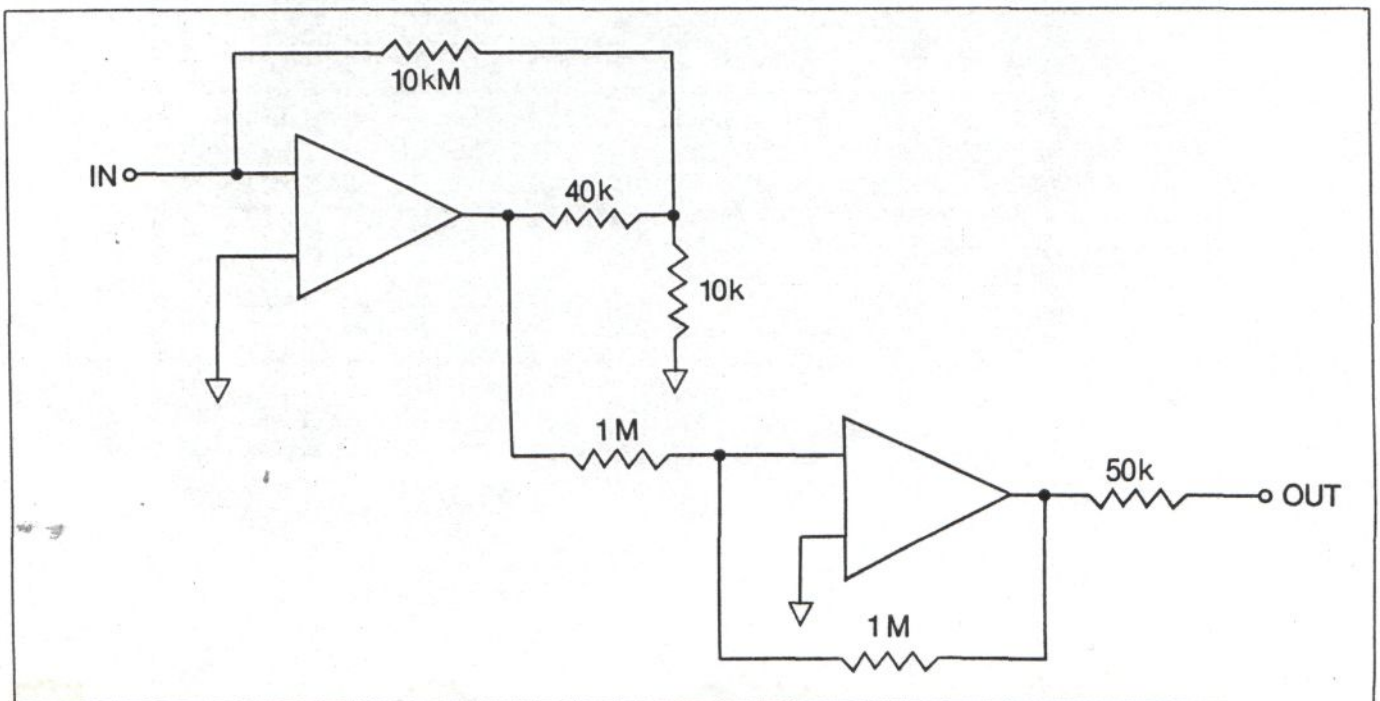


Fig. 1 (A) Simplified current to voltage converter;

Fig. 1 (B) Improved configuration.



All connectors in the measurement path must be gold plated. By far, air is the best insulator for high impedance circuits. It should be used liberally.

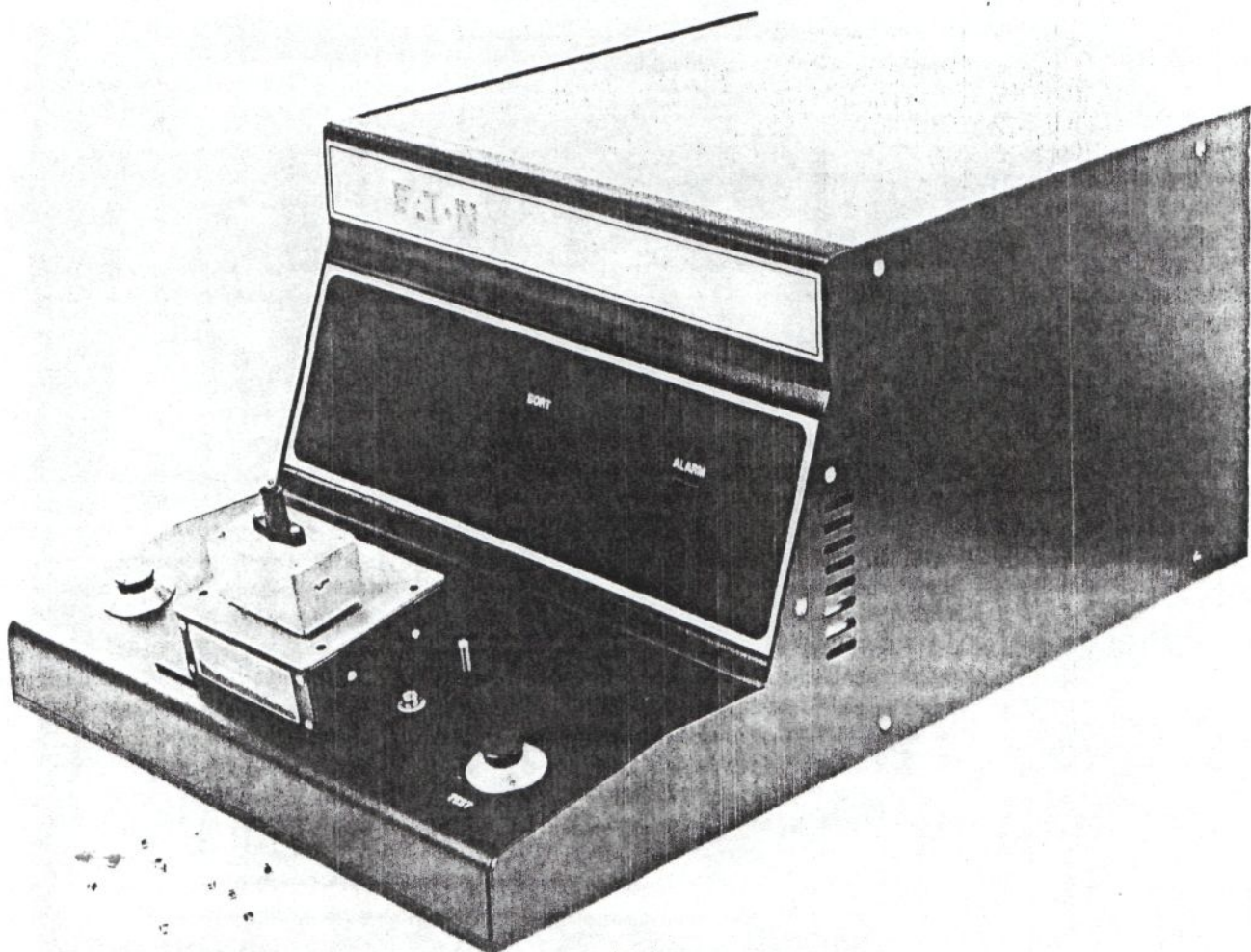
The circuit must be handled very carefully during manufacture. And during maintenance, an item often forgotten. A fingerprint or other contaminant can easily increase leakage current to the nanoamp

range. After any handling, the input stage should be degreased with fluorocarbon solvent and rinsed several times in deionized distilled water before careful drying. Test fixtures will require the same treatment on a regular basis.

Resistors can be troublesome because of the very high values employed. Above hundreds of

megohms, problems of stability and leakage increase as values go up. At very high values, just determining that a resistor is of correct value is a challenging task. In a typical current amplifier (shown in Fig. 1A), the feedback resistor must be very large. Its value can be reduced by a factor of 10 by employing the circuit in Fig. 1B. High value resistors are also needed as calibration

The Eaton SS-150 is a general-purpose low-leakage test head. It provides picoamp measurements with 100 femtoamp resolution. Options allow testing of up to 10 devices in a package, high accuracy capacitance measurements, and VGS matching of dual devices.



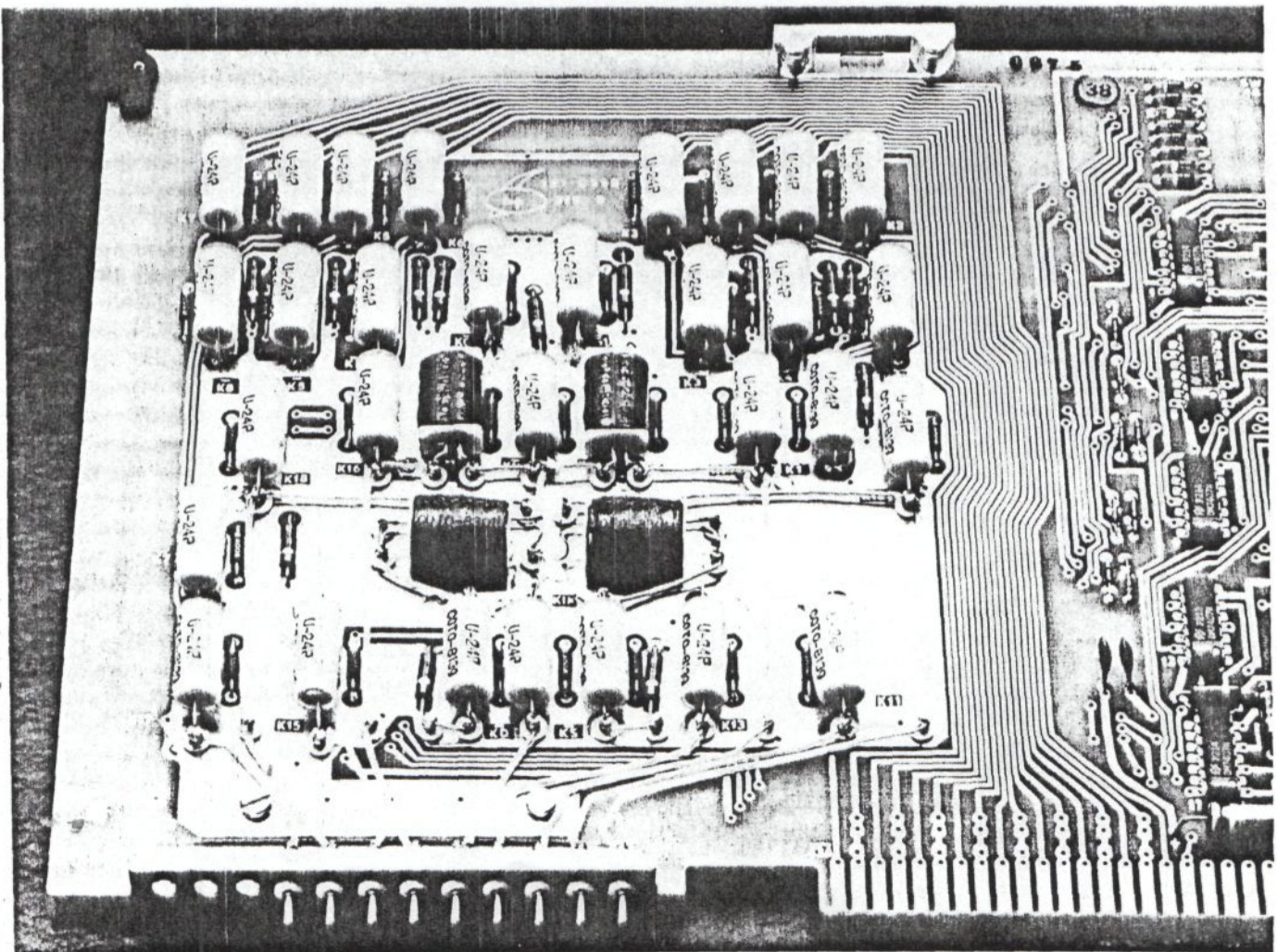
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standards for picoammeters. These resistors are typically glass type with voltage limits of 200 or less. In ATE systems it is possible to apply more than 200 V, which often results in measuring the leakage across the glass rather than the resistor itself.

Picoamp measurement circuits require calibration. Using a calibration resistor, a series of tests at different forcing voltages can check for offset. Some users try to run such tests with an open test socket. This method often results in variable results, because the open socket is the highest impedance configuration and, thus, most susceptible to noise

and moisture effects. In any calibration or analysis routine, it is best to work with a standard rather than an unknown.

This relay matrix has been designed for low leakage measurements. The connector to the left is a special assembly with Teflon insulation and gold-plated pins. All circuitry in the measurement path is interconnected with Teflon-coated wire and insulated stand-off posts. The relays include integral driven shields.



Simple calculations show that test speed is a function of capacitance, so every effort must be made to reduce capacitance effects. The popular method is to use driven shields on the connection leads out to the device under test (DUT). For best results, any switching relays should be of the reed type with provision for integral shields. The design of fixtures and test sockets must take into account the need to minimize capacitance. Simply, the shorter the leads and the lower stray capacitance, the better.

Shunt resistance should not be a problem in a simple picoammeter. However, in ATE applications the ability to test multidevice packages and to perform capacitance measurement are desirable. The matrix employed for dual, quad and larger packages also employs reed relays. The better "reeds" exhibit 10^{13} ohms or more with a result of extremely low leakage. However, you can parallel only so many such relays before you are measuring the relays rather than the DUT.

The capacitance of low-leakage devices such as field-effect transistors is important in many applications. Thus, a capacitance-measurement capability is needed in many ATE applications. The "cap" meter requires more of those pesky, leaky relays. So it is best to design a capacitance measurement unit as an optional, removable unit. In this way it can be used when required and removed when high accuracy leakage measurements are needed.

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Noise

Measurements in the subpicoamp region are an attempt to measure nothing, accurately. Unfortunately, the circuits employed are very high impedance and, thus, susceptible to pickup of noise from electromagnetic and radio sources. Most factory environments are loaded with noise generators.

Commercial low-leakage measurement equipment is provided with shielding to reduce noise sources. All of this shielding will be ineffective if the unit is not grounded or if noise is injected via the power line.

Adequate grounds are difficult to achieve. In some areas, only a water-drip ground will do. Most factories are built with little or no thought about grounding. However, a quality ground is required for all measurement equipment. In ATE systems, it is important to ground each test head to the mainframe, as well as the mainframe to the ground connection. Heavy copper braid, 1/2 inch or more in diameter should be employed, with ground straps kept as short as possible.

Ac lines which feed an assortment of equipment usually carry medium or high levels of noise. Filters at the ac input to the test equipment and good grounding techniques can minimize these effects. However, a "clean" power source is the best answer. In extreme cases, a power conditioner may be necessary.

The device under test can pick up noise directly. If measurements with limits below 1 picoamp are needed, it is best to shield the device under test. For manual-insertion testing, a simple grounded aluminum cover lowered over the DUT will do. This technique has been proven to work with low leakage test stations such as Eaton's SS-150. Test results to below 0.5 picoamp can be achieved with this technique. When the test head is connected to a handler, the problem of shielding the DUT while in the contactor is more complex mechanically, but it can be implemented with popular handlers. To work, of course, the handler must be grounded to the test system via heavy braid.