Building and Using A Hi-Pot Leakage Tester

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THE PROBLEM: In these times of dwindling parts supplies, we A.M.'ers are forced into scrounging items for construction projects that are, in many cases, 30, 40, 50 or more years old. Practically all of these used components are from obscure origins. And, many have been used in multiple construction projects down through the years, to finally be acquired at a hamfest, through the mail, or via another channel of dubious reliability. The care that has been exercised in using and storing these parts over the decades is unknown. Using them in a new project is, therefore, risky business unless they have been properly evaluated and tested first.

Many transformers and filter chokes have likely been stored in less than ideal environments over the decades, absorbing considerable moisture and making their insulation now incapable of sustaining normal operating voltages. This even happens to potted units, depending on how they were cased and if the potting compound has cracked deeply or not. Another possibility is that internal insulation may have been damaged by previous abuses in someone else's rig.

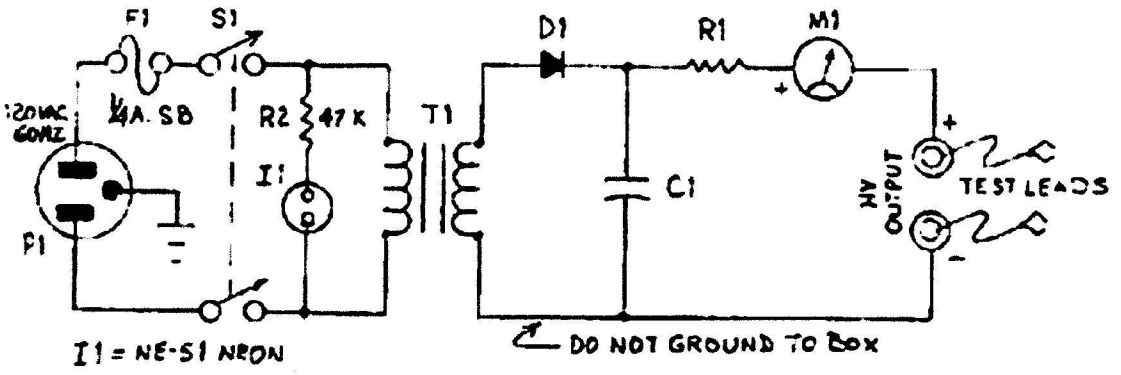
Used tubes, while generally impervious to moisture, (except for possible oxidation of base pins and their solder joints) may have one or more problems like broken filaments, gas, low emission, sagging elements, and defective insulating structures.

Fatal internal "injuries" to components are seldom apparent to the enquiring eye. To determine if such problems exist before the parts are used in your next homebrew project requires a little evaluation and diagnosis. And in most cases, that old standby, the volt-ohmmeter (VOM), will not do the job in finding such failures, particularly those that would only show up in the presence of normal operating voltages. What's a fellow to do?

THE ANSWER: USE A HI-POTTER to evaluate the condition of such parts before you attempt to test them

in-circuit. A description follows of this valuable test equipment item which I have found to be indispensable in <u>quickly</u> testing the above mentioned components.

Known as a "Hi-pot" (high-potential) Leakage Tester, or "Hi-potter", it is a simple, easily built, device which tests for small leakage currents under high-voltage conditions, without the need to actually apply operating voltages which may result in fireworks and further damage to the part being evaluated. Basically, the Hi-potter unit described here is nothing more than a high-voltage, low-current, d.c. power supply with a sensitive current meter in series with the output terminals. Think of it as sort of a H.V. ohmmeter. Because it registers leakage current in the presence of a few kilovolts, it will indicate insulation failures in transformers and chokes as well as gas in transmitting tubes Such tests are impossible with the puny 1.5 v. d.c. output of a standard or digital VOM.



<u>THE CIRCUIT</u>: The figure shows all there is to this nifty addition to your workbench. In my unit, transformer T1 is a small H.V. transformer out of an old oscilloscope. It furnishes about 1,600 vac. at 2 or 3 milliamps. Other transformers can be used for T1 so long as they provide somewhere between 1,000 and about 3,000 vac. Current demand is very low in this application. So for conservation and safety reasons,

using a big plate or power transformer is not advised.

Diode D1 is a H.V., half-wave rectifier. It's peak inverse voltage (PIV) needs to be at least double the r.m.s. voltage of T1's secondary. You can use an old TV high-voltage rectifier or focus rectifier, a rectifier block from an old microwave oven, or several of the 1 kV. general purpose diodes in series. The current rating of D1 needs to be only a few milliamps.

Next comes filter capacitor C1. The value of this cap. is not critical. Anything from 0.01 to 0.1 mFd. works here. Be sure its voltage rating is about 50-percent greater than 1.4 times the r.m.s. voltage of T1's secondary.

Resistor R1 limits the amount of current available at the output terminals of the device to just full-scale on the meter, M1, when the Hi-potter's output terminals are shorted together. For the meter I have (100 microamps full-scale) and the amount of voltage out of the rectifier/filter (about 2,200 v.d.c.), Ohm's Law said my R1 had to be about 220 megohms. To avoid burning out the coil of M1, you may want to start with more resistance than this and reduce it gradually until a full scale reading on M1 is obtained with the output terminals of the Hi-potter shorted. Another alternative is to calculate R1 , install it, and then gradually bring up the voltage on T1's primary with a small variac until you see that R1 is going to limit the M1 reading to just full-scale with 120 v.a.c. line input. To prevent H.V. breakdown of R1, it should be made from ten or more 1/2 watt resistors in series, mounted on plexiglass or phenolic sheet, with about 1/2-inch space between each. Do not use a standard terminal strip with solder lugs. All of the resistors should be of the same value, adding up to the total value needed for R1.

If desired you can also mount D1 and C1 on this board. Just leave plenty of space between components to make the leakage paths long. Support the board with ceramic standoff insulators, keeping ample clearance between board and everything else.

The meter is not a critical item either. Anything with a range of 100 ua. to 1 ma., full-scale, is good. But, the more sensitive the meter, the higher will be

the leakage resistances that you will be able to observe. Be sure the meter has a nice thick plastic case. Do not use a metal-cased meter. It's best to mount the meter in a subpanel of insulating board, again taking care to insure plenty of clearance around it so that leakage paths to the instrument's metal box or other components are kept long. IMPORTANT: Be sure to get the meter polarity right the first time around!

The + and - output terminals of the Hi-potter can be ceramic feed-thru insulators or something like plastic banana jacks or binding posts, mounted through a sheet of insulating board. Again, long leakage paths are important around the jacks (3/4-inch, or more) to whatever metal panel or brackets you mount the terminal board to. Also, the terminals should be spaced no less than 3/4-inch apart.

For safety reasons, it is highly advisable to enclose the Hi-potter in a box of some sort. I used a large, metal, minibox. If you use a metal box, be sure to use a 3-conductor line cord with the ground lead connected to the box. But, do not connect the negative of the H.V. d.c. to this ground point. I have found it best if the negative side of the device is allowed to "float" above ground. An alternative enclosure could be made from insulating material of some sort. Wood is not a good substitute.

Be sure to include the indicator light, I1! Seeing it on may save you from getting a painful shock. But, if you select the proper value for R1, limiting the current output of the Hi-potter to 1 ma. or less, the shock will hurt but will not be fatal. Also, do not omit the line fuse, F1, from this or any other a.c. powered project.

Interconnect the H.V. circuits with wire that has insulation known to be sufficient to carry the voltage present. Use the same wire, or better, for the test leads (which need to be flexible and have insulated alligator clips on the end). I used 5 kV. test probe wire inside the unit and 10 kV. probe wire for the test leads. TV anode lead is another possibility, although it is too stiff for test leads. Also, neon sign shops have a good grade of neoprene insulated wire around that is good for this application and for high-power

transmitter B- leads.

USING THE "HIGH-POTTER": Using this device has been a real joy. It has reliably shown me the relative insulation leakage (or the absence thereof) in many old transformers and chokes, and gas in transmitting tubes. All such tests are made without having to run the risk of damage to the components by applying normal operating voltages.

Though not necessary, you may want to calibrate the meter scale before using the device for the first time. This is done by connecting several different, known values of high resistance across the terminals, one at a time, and noting the meter readings. Start with a resistance around 20 megohms and go up and down from this value. Make a calibration chart and keep it with the Hi-potter.

For safety's sake, turn the unit off and then short its leads together briefly between tests. Do all testing with everything in the clear. Place the Hi-potter and the component under test atop a dry, non-metallic, workbench or table top, dry piece of wood, or insulating sheet. Do not leave big transformers or chokes sitting on a concrete floor while testing them (or when storing them!). Keep test leads separated by several inches. Support the leads with cardboard or other insulating material if necessary. Be sure any additional clip-leads used have high-voltage insulation. Stand clear when turning on the Hi-potter and while it is on. ALWAYS WORK WITH ONLY ONE HAND, KEEPING THE OTHER IN YOUR POCKET OR BEHIND YOU!

TESTING TRANSFORMERS AND CHOKES: For testing these items, the insulation from primary to each secondary winding, and from each winding to the core, should be checked. It is helpful to have some idea as to how much voltage the insulation of the transformer might be rated for before you begin. If the output of your Hi-potter exceeds the insulation rating of the transformer under test, usually no damage will result because of the small amount of current available. But, a small arc or corona may occur inside the transformer

that would make you think it was bad, when in fact you had merely exceeded its insulation rating.

Now, after a preliminary quick-check for "hard" shorts using a VOM, start with winding-to-winding tests using your new Hi-potter. Do this by connecting one lead of the Hi-potter to an end of one winding, while connecting the other test lead to the end of each of the other windings, one at a time. After your test leads are connected, move away from the transformer under test and switch on the Hi-potter. The meter will indicate any significant leakage current. A full scale reading indicates a H.V. short or heavy leakage.

To check for leakage from windings to core, turn off and disconnect the Hi-potter. Then use a well insulated clip lead and short each winding of the transformer (or choke) to the core to discharge any internal capacitance. Now, connect one of the Hi-potter's leads to the core, and one lead to the end of a winding, and check for leakage. Repeat for every winding. On some power transformers, a little leakage between the primary and the core can be tolerated, if the primary is the first winding on the core and if the other windings do not show significant leakage to the core or each other. NOTE: At times, it is possible to hear leakage within the transformer or choke as a weak frying or hissing sound.

TESTING TRANSMITTING TUBES FOR GAS AND SHORTS: Although the Hi-potter will not check a tube's emission, it will indicate excessive gas. To check a tube for gas, be sure it is not plugged into any equipment. Be sure its base and envelope are clean (dust and dirt retain small amounts of moisture). Make a continuity check of the filament using a VOM or the Hi-potter. Then just lay the tube on the bench and connect one Hi-potter lead to one filament pin and the other lead to the grid (not to screen or plate). When the Hi-potter is turned on, any leakage due to gas or defective internal insulation will show up on the meter. With practice, you will be able to tell what level of gas leakage current is excessive, after you try tested tubes in an operating circuit. On my Hi-potter, gas leakage in a transmitting tube is too high if it exceeds about 30-microamps. Sometimes, with

the lights out, you can see the gas glow or see a small corona inside the tube where the insulation is damaged. All of the tubes I have tested have been the size of an 811A, or larger. You will have to experiment to see if smaller ones can be successfully checked for gas without flashing over between grid and filament or cathode. A flashover in a tube due to excessive voltage from the Hi-potter will not cause any damage. On small, indirectly heated tubes, connect one lead to the cathode pin and the other lead to possibly the screen or plate if flashover is a problem.

OTHER HI-POTTER USES: This useful device can also be employed to test the insulation condition of shielded cables, leakage in wiring bundles (if the ends are not connected to anything), and leakage in transmitting mica and vacuum capacitors. You will probably think of other applications.

A useful modification to the instrument might be to apply a current sensitivity switching system where a 100-microamp meter could be shunted to read 0-1 milliamp. This would also require switching out resistance so R1 would allow a maximum of 1 ma. to flow. Due to the H.V. involved, regular toggle switches will not be sufficient for this.

Happy Hi-potting!