Appliance Leakage Current Adapter

Schmidt Consulting

Tom Schmidt

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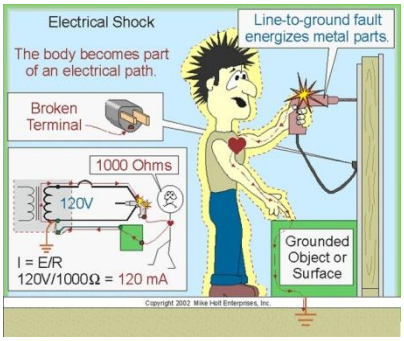
tom@tschmidt.com

http://www.tschmidt.com/

Simple adapter used in conjunction with commercial leakage current tester to verify integrity of appliance safety ground and measure leakage current.

I wanted to be able to verify the safety of appliances and tools in addition to checking the homebrew stuff I was building. This paper describes a simple adapter used in conjunction with a commercial leakage current meter to verify device leakage current and safety ground conductor to insure it is able to operate as needed.

Safety Testing Basics



There are three basic electrical safety checks: insulation breakdown, ground conductivity and leakage current. HiPot is short for high potential. It applies a high voltage, typically several thousand volts, to power and neutral conductors verify there is no arcing to safety ground or chassis. Conductivity testing verifies safety ground (green) conductor is able to carrying enough current to trip the over current device rendering the unit safe. Leakage testing simulates human contacts and measures how much current will flow between the device and ground.

Dielectric Withstand/HiPot

As part of manufacturing process the manufacture performs an insulation resistance test prior to the unit being powered up. A high voltage is used to detect insulation faults and other problems such as too closely spaced conductors that only show up if a high voltage is applied resulting in arcing. Both AC and DC testing is used. Electronic devices often use a line filter to reduce radiated and conducted noise. The filter adds a capacitive component between the power and neutral conductors and to the ground conductor. As voltage is increased the amount of current flowing through these capacitive paths significantly increases. HiPot testing can be complex due to numerous capacitive paths to ground and possibility of damaging semiconductor components.

The adapter does include provisions for insulation testing. A dedicated high resistance tester is used when needed.

Leakage Current

People often underestimate the danger of 120 volt branch circuits. Even a small amount a current flowing through the body can be deadly.

60 Hz Current	Result
<0.5ma	Threshold of perception
>0.5ma	Startle reaction
>5ma	Inability to let go
>50ma	Ventricular fibrillation
>70ma	Electrical burns

Ground Fault Circuit Interrupters (GFCI) are designed to trip if there is a difference between hot and neutral current indicating a fault path to ground exists. If current exceeds 6 ma GFCI will trip and it will

not trip if difference is less than 4 ma. Consumer electrical devices must have less than 0.5ma of leakage current. This allows multiple devices to be used on a GFCI protected branch circuit without nuisance tripping and they will not present a shock hazard even if safety ground is not connected.

To simulate a “typical” human contact current is measured through a 1500 resistor shunted by a .15 microfarad capacitor.

There are numerous leakage current testers available new or used: for example the Simpson 229 or the RCA WT-540A and the Yokogawa 3225. I purchased a 3225 on eBay. It has the advantage of not requiring a battery (great for an infrequently used piece of gear). An interesting feature is that is has 1ma and 10ma AC and DC current ranges. The DC range is handy when for low power digital devices. Both the 3225 and the 229 measure AC line voltage in addition to current. Not terribly useful for our purposes but handy to verify proper line voltage.

Since leakage current may flow to either the hot or the neutral conductor to adequately test the device it is necessary to swap hot and neutral and use the highest reading to determine pass or fail. One of the functions of the leakage current adapter is to reverse the normal power connections. The normal/reverse toggle switch has a center off position allowing the unit under test (UUT) to be connected to a deenergized receptacle. A neon pilot light indicates when test socket is live.

The leakage current meter is able to measure line voltage. Another switch is used to select which one is being measured. Since applying full line voltage to a low current meter can be exciting I used a safety cover on the switch to minimize the possibility of accidently selecting voltage. Beside it looks cool on the adapter.

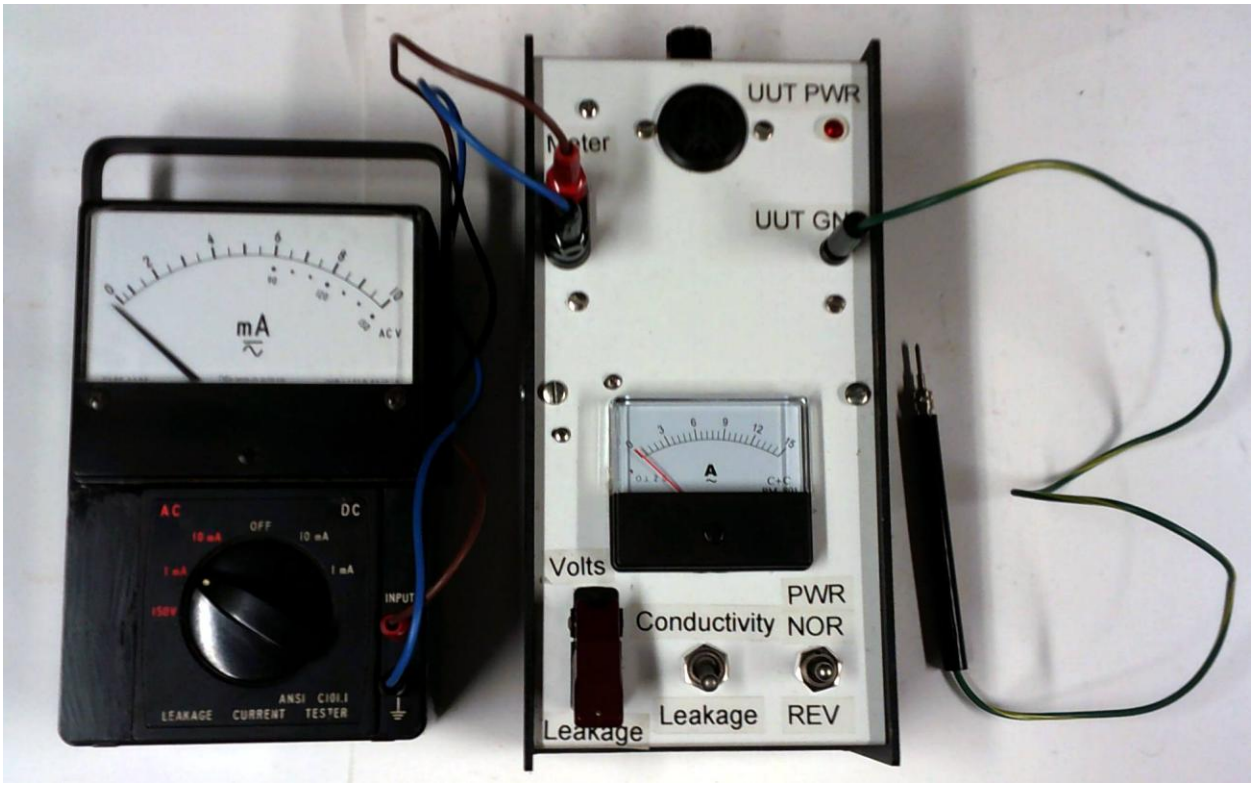
Ground Conductivity

The other test I wanted to be able to do is verify safety ground conductor (green) is able to carry enough current to cause the overcurrent device to trip. This could be a fuse or circuit breaker in the device itself or branch circuit breaker rated at 15 or 20 amps.

The middle adapter switch selects leakage mode or conductivity mode. In conductivity mode one end of the 12 volt transformer is connected to ground contact of the test socket. The other end is connected to a test probe through a 1 ohm resistor and AC amp meter. The probe is used to touch exposed metal parts on the device and the meter records the current. This needs to be a short term test because the short circuit current significantly exceeds the rated capacity of the transformer.

Typical Test Scenario

The test process is different depending on whether the device uses a 3-wire or 2-wire mains plug.



3-wire Grounded Device.

External test meter toggle switch is always in leakage position. The conductivity/leakage switch is in the conductivity position and UUT power switch in center off position. The leakage current tester is set to 1 ma range.

Conductivity

The device under test is plugged into the test socket and exposed metal parts are probed with the test probe while watching the ammeter. Short circuit current is about 10 amps. If current is much less or nonexistent it indicates a problem with the safety ground portion of the device that must be corrected.

Leakage

After the conductivity test is complete the conductivity/leakage switch is flipped to leakage position and leakage current read out on the leakage current tester, value must be less then .5ma, anything greater needs to be investigated. The UUT normal/reverse switch is flipped between normal and reverse. The greater of the two reading is used to evaluate the device. Being a three wire device the test probe does not need to be used as leakage current flows through green wire safety ground to the plug.

2-wire Ungrounded Device

Many consumer devices have only a two wire power cord. There is no safety ground conductor so it is not possible to perform the conductivity test.

Leakage

The leakage test is conducted in the same fashion as a three-wire device except the test probe is used to contact accessible metal parts. As with three-wire device this must be performed on both normal and reverse line condition.

Other Tests

If the external test meter has a voltage range it can be used to check supply voltage. The cover over the voltage/leakage switch is flipped up and switch moved to voltage position.

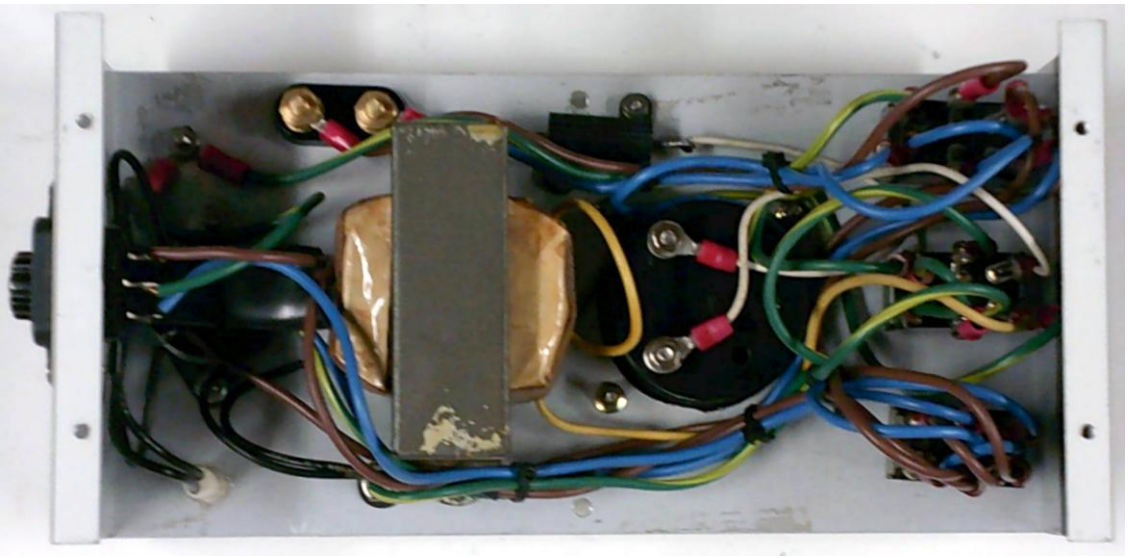
If it is desired to measure current draw or wattage of the unit under test it is a simple matter to plug a Kill-a-Watt meter into the test socket and the UUT in turn into the Kill-a-Watt. I positioned the UUT test socket so there is enough room to accommodate the Kill-a-Watt.

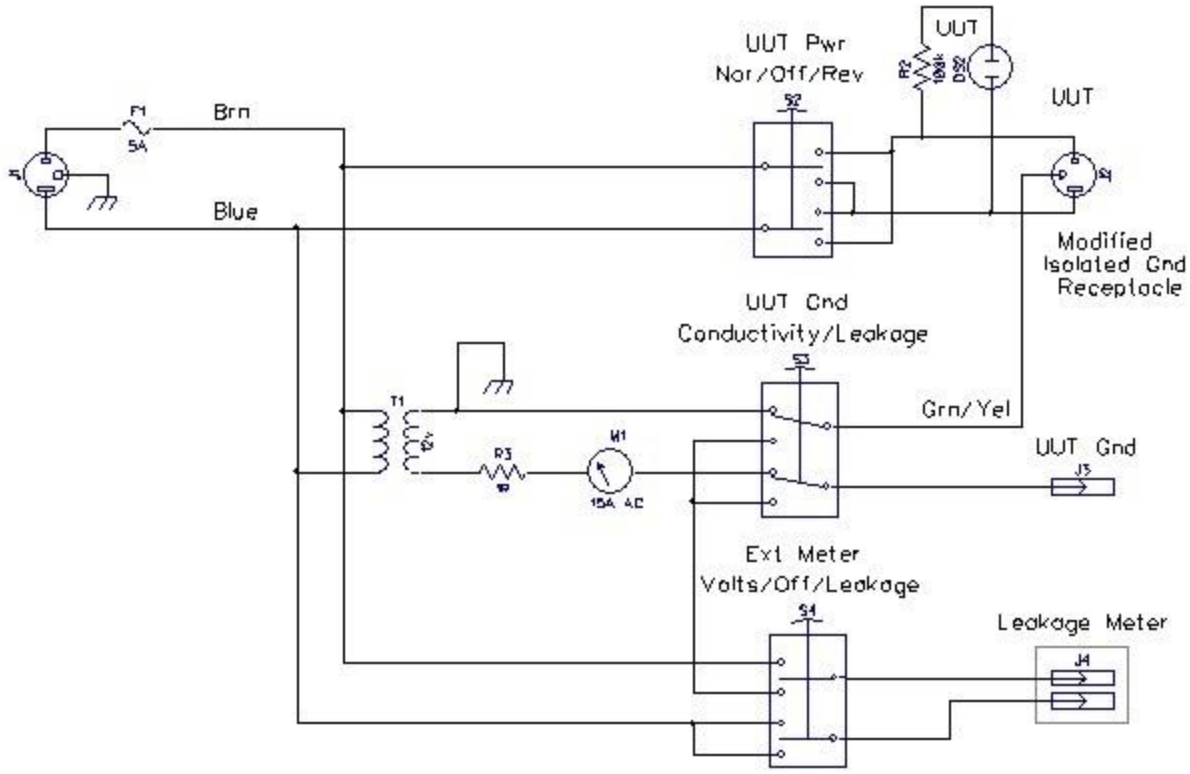
Adapter Construction

I built the unit out of parts lying around in my junk bin. For wire I stripped the jacket off a line cord to yield a nice set of properly colored 18 AWG hook up wire: Brown, Blue, Green/Yel. The only unique item is the test socket. It had to be modified to allow the ground contact to be isolated from the chassis. I drilled out the rivet bonding the contact to the chassis mounting strap, bent the strap out of the way and replace rivet with a small screw to retain the ground contact.

Because of the relatively high current involved I used the line cord wire to make up the test leads, rather than use the more common ultra-flexible test probe wire.

All in all a quick winter construction project that should turn out to be a handy piece of test gear.





Ground Conductivity & Leakage Current Adapter