

A Capacitor DC Leakage Tester

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The Antique Wireless Association Capacitor DC Leakage Tester

I admit to having components in my junk box that I collected from curbside television sets back in the 1960s; but at least that hoard doesn't include any capacitors from those TV sets. Still, my junkbox does have some oldies and the question always remains: "are they still good?" To help answer that question, I built the Capacitor DC Leakage Tester from the Antique Wireless Association (AWA).

This handy project is offered by the AWA not as a complete kit, but simply as a high-quality PCB together with Mouser part numbers for all components. The cost of the board (Figure 1) is a very economical \$25.00 US and is available via their webpage[†]

The AWA does dispatch internationally too. Details are on the ordering web page.

Easy Assembly

The board assembled easily, all the Mouser parts fitting perfectly. AWA leaves it to the builder to mount the project into an enclosure. Care should be taken in this as high voltages are involved. The project assumes the builder will use two sets of banana plug sockets to attach two voltmeters (DMM or VOM). One meter displays the voltage applied to the capacitor under test while the other displays the leakage voltage. Thanks to R10, a 1K Ω 2W 1% resistor in parallel with the leakage meter, 1 volt of leakage very conveniently equals 1 mA of current.

In my implementation (Figure 2), I chose to incorporate a panel mount voltmeter (YB5135DB via Amazon) to display the applied voltage. Other builders incorporated panel mounted meters for both displays. I did not do this for the

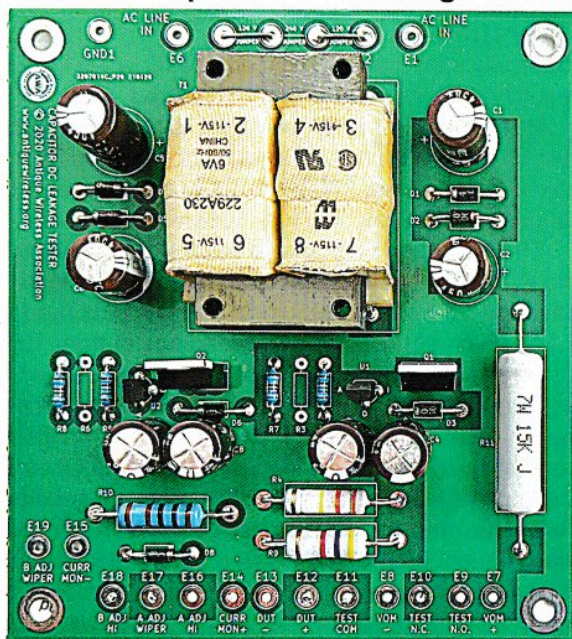


Figure 1

The Antique Wireless Association capacitor DC leakage tester printed circuit board accommodates a dual primary transformer which can be wired into the board for 120- or 240-volt AC operation. The large resistor at R11 on the lower right-hand side of the board slows capacitor charging, limiting in-rush current. The board comes with the list of Mouser part numbers and wiring instructions.

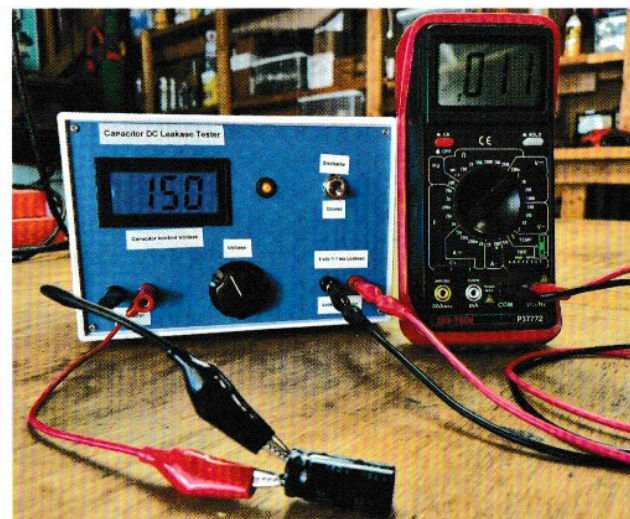


Figure 2

My implementation of the project board includes a built-in meter displaying the voltage applied to the capacitor under test. The leakage voltage is displayed on a DMM. In this example 150 volts is being applied, resulting in 11 μ A of leakage.

checked with an Ohm meter to see if it's a dead short. Assuming the capacitor passes that test, power up the tester with the switch in the discharge position. Attach the capacitor to the device under test (DUT) connections, switch the tester to charge, and bring up the applied voltage to close to the rated voltage for the DUT. The leakage voltmeter will now show the voltage which is also the current leakage in milliamps. Detailed use instructions of the tester are supplied with the board documentation.

Post Measurement

After the measurement, drop the applied voltage and switch to discharge. The capacitor current bleeds through R9, a 4.7K Ω 2W $\pm$ 5% resistor mounted on the board. You can watch the charge diminish on the applied voltage display to know when it is safe to remove the capacitor.

Conventional capacitors should show little to no leakage. It was reassuring to test some of my hundred-year-old mica caps and observe no leakage at all. However, the usefulness of the AWA tester really shines when testing electrolytic capacitors.

Electrolytics are polarised, of course, and care should be taken when attaching them to the tester. Initiate the test as before and pay close attention to the leakage measurement. The plates of an electrolytic capacitor are separated by an insulating oxide layer which can age, permitting significant leakage. Fortunately, this insulating layer can be reformed, restoring the capacitor and making it useful. The AWA Capacitor DC Leakage Tester allows you to see this restoration process in action.

leakage measurement for two reasons. First, I anticipated the need to select between different voltage scales. Second, a simple voltmeter offers low impedance and, thus, cannot simply be wired to the board. A circuit to provide high impedance isolation would need to be inserted between the board and the meter. Some builders have done this and examples are readily found on YouTube.

Once the unit is complete, the fun begins. Before testing any capacitor it should be

Figure 3 shows a graph of the restoration of a Teapo 100 μ F 160v electrolytic capacitor for a duration of six minutes. When charge was first applied, the leakage was a whopping 1.21 mA. Leakage declined rapidly as the dielectric layer reformed, dropping to 65 μ A after one minute and declining further to 13 μ A after six minutes. It's enormously satisfying to watch this process in real time.

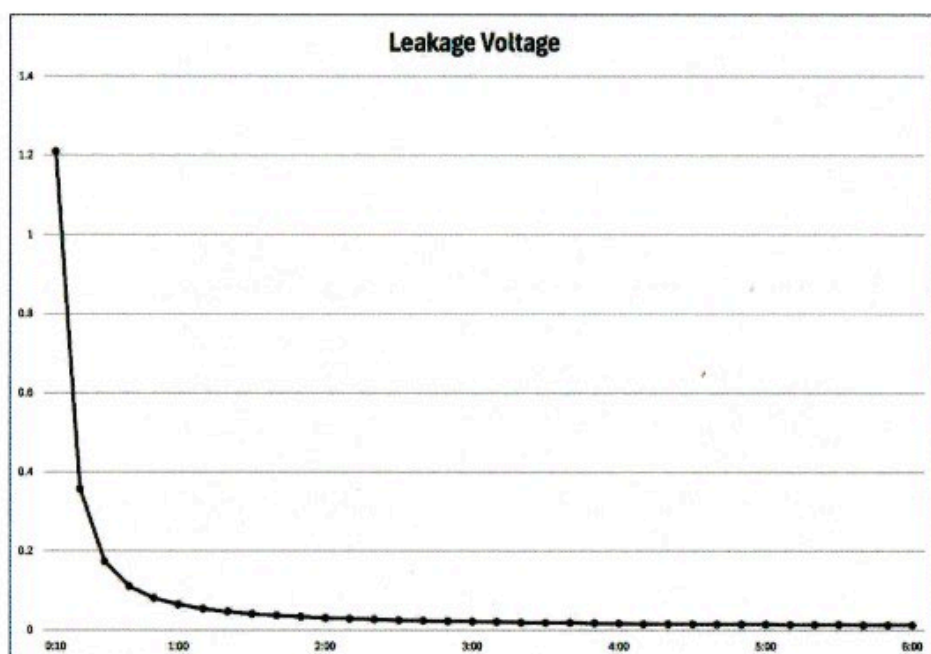


Figure 3

This graph shows the reformation of an electrolytic capacitor dielectric layer over a period of six minutes. I plotted the leakage values at ten second intervals ending with a DC leakage of only 13 μ A. As designed, 1 volt of leakage potential equals 1 mA of current. Thus, the voltage leakage values on the vertical axis can be read directly as milliamps.

In my experience, the time needed to

reform seems closely related to the physical size of the capacitor. I tested a large CE Manufacturing C-EC30X3-525 30 μ F 525v can capacitor which started out with a leakage of 73 μ A steadily decreasing to 23 μ A after 45 minutes. As you watch the reformation process, you'll note that the applied voltage creeps up as leakage diminishes. This is normal as less leakage means higher resistance to the passage of DC current. This is also why you may not want to set the initial applied voltage to the maximum rated voltage of the DUT.

All electrolytic and tantalum capacitors will normally have some leakage. So, how much is too much? If you're lucky enough to have the datasheet, it will include a formula to calculate permissible leakage. For my Teapo, that formula may be something like $IL = K * C * V$, where IL = Leakage current after five minutes, C is capacitance in μ F, V is applied voltage, and K is a constant. Alternate formulas exist but the datasheet for a particular capacitor is definitive.

It is important to note that the resistance offered by the insulating component is not the Equivalent Series Resistance (ESR) of a capacitor. The ESR is the inherent AC resistance of the physical construction, and being AC resistance, it is frequency dependent. To fully characterise a capacitor you need to measure the capacitance, the leakage, and the ESR. Unfortunately, measuring ESR is not as simple as measuring leakage.

All-in-all, the AWA Capacitor DC Leakage Tester is a terrific little product and nicely fills a niche amongst my pieces of test equipment.

±1: <https://www.antiquewireless.org/homepage/pcb-item-4/>