Use an Ohms Scale to Measure High Capacitance Values

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Some DMMs (digital multimeters), such as the Agilent 34410A[1], have a built in capacitance function that works to some full scale value (100 µF for the 34410A). However, with just a little bit of extra effort, you can measure capacitance values up to 100,000 µF using the DMM ohmmeter function.[2]

The 34410A ohm meter uses a constant current source. While the display is in kilo ohms, the displayed value actually represents a measured voltage. For example, the 1k "ohms" scale calibration uses a 1 mA constant current source, and as expected by Ohm's law, a 1 V measurement across the input terminals gives a displayed indication of 1 kilo ohm.

Now, turning from Ohms to Farads, charging a capacitor with a constant current is particularly convenient, since it gives a linearly increasing voltage according to the equation:

$$C = I * \frac{(\Delta T)}{(\Delta V)}$$

When starting with a fully discharged capacitor, the number of seconds to a displayed reading of 1 kilo ohm gives the capacitance value in units of 1,000 µF / second. For example, from releasing a short across a 17,000 µF capacitor the reading will reach 1k ohm in about 17 seconds, or C = 1mA*(17seconds/1V) = .017 Farads (which is the same as 17 mF or 17,000 µF).

By enabling the math limit function and setting the high limit to 1k, you can watch an asterisk symbol move towards full scale as the capacitor charges with the "beep" sounding at the high limit of 1k ohms.

To perform the high value capacitance measurement, first fully discharge the capacitor (i.e. short across the terminals of the -out of circuit- high value capacitor). Wear safety glasses. If you think the capacitor under test might be pre-charged, to avoid sparks, start with a low valued resistor (e.g. 100 ohms for low voltages) as opposed to a wire short.

Next, connect the plus DMM lead to the plus capacitor terminal and the minus DMM lead to the minus capacitor terminal. Start a stop watch at the moment you release the short (as letting go of a wire held against the terminals). When you hear the beep (if using the 34410A high limit function) and/or see the desired ohms value (e.g. 1 k ohm), stop the clock! In the example above, an elapsed time of 17 seconds gave a capacitance of 17 mF on a 1 kilo-ohms scale. As shown in the tables below, other ohms scales have different constant currents and/or different full scale voltages.

Agilent 34410A DMM lower Ohms Scales (10M, 100M, and 1G not included here)

Ohms Scale	Resistor Under Test	Constant Current	Voltage across RUT
100 ohms	0 ohms	1 mA	0 V
100 ohms	100 ohms	1 mA	0.1 V
1 k ohms	1 k ohms	1 mA	1 V
10 k ohms	10 k ohms	100 µA	1 V
100 k ohms	100 k ohms	10 µA	1V
1 M ohms	1 M ohms	5 µA	5 V

hp 3456A DMM Ohms Scales

Ohms Scale	Resistor Under Test	Constant Current	Voltage across RUT
100 ohms	0 ohms	1 mA	0 V
100 ohms	100 ohms	1 mA	0.1 V
1 k ohms	1 k ohms	1 mA	1 V
10 k ohms	10 k ohms	100 µA	1 V
100 k ohms	100 k ohms	50 µA	5 V
1 M ohms	1 M ohms	5 µA	5 V

Full Scale Values for the Ohms Scales for to exemplary DMMs, the Agilent 34410A and the hp 3456A DMM.[3]

Other DMMs might use similar constant current schemes and might also be suitable for such high capacitance measurements. You can determine how your DMM measures ohms by placing an ammeter in series with the shorted DMM leads in various ohms ranges and with various series resistors.

A Simpson 260 VOM[4] (volt ohm meter) can similarly be used on the x100 ohms scale, however most VOMs, including the Simpson 260, do not use a constant current, so you need to use the classic RC equation:

$$C = -\frac{\Delta T}{R \ln\left(\frac{I_t R}{V_0}\right)}$$

where R is the equivalent series resistance (~1.2k ohm), V_0 is the open circuit voltage (~1.5 V, the “D cell”), and I_t corresponds to the current at your chosen end point (a percentage down scale of the meter, where 100% at time t_0 is about 1.25 to 1.3 mA). If you time for an excursion down to 30 on the meter face (3k ohms on the x100 scale), you would use an I_t of about 380 µA, for the final current at about a 29% final scale deflection (i.e., the meter moves down scale about 71% from the initial zero ohms indication). For example, a charging event that took 27 seconds to make such a 71% downward deflection (to "30" on the meter face ohms scale) would correspond to a measured capacitance value of ~19,000 µF.

There are other relevant capacitor measurements, for example, leakage current, ESR, and D (ESR/Xc) as well as a range of test conditions (e.g. frequency, voltage, and current) over which measurements can be made. All of these testing techniques, alone or in combination, have their applications. Here, we just add another tool for the bench, an option for looking at high capacitance values.

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[1] http://www.home.agilent.com/agilent/product.jspx?id=692834&pageMode=OV&pid=692834&lc=eng&ct=PRODUCT&cc=US&pselect=SR.PM-Search%20Results.Overview .

[2] Agilent also offers a relatively low cost handheld capacitance meter (U1701B) with a 200 mF scale, and a series of relatively low cost LCR meters, each with a 20 mF scale http://www.home.agilent.com/agilent/product.jspx?nid=-34196.0.00&cc=US&lc=eng .

[3] DMM Ohmmeter constant current and full scale voltage values, Joe Geller, July, 2011.

[4] http://www.simpsonelectric.com/index.asp?p=Products&id=30&sid=39&ss=31 .