Nybill's Capacitor

February 4, 2017

@nybill posted on GNU Social the following:

> "Charged a 63v 22000uf cap up to 30v last Friday for kicks. It still has 13v on it."

From this, we can calculate the approximate resistance in the circuit, modeling the situation as a resistor-capacitor (RC) circuit. The key equation is the voltage-time relationship from RC circuit analysis:

$$V(t) = V_0 e^{-t/(RC)}$$

where R is the resistance of the circuit (unknown), C is the capacitance (known, $C = 22,000\mu$F), and V_0 is the voltage placed across the capacitor at time $t = 0$s($V_0 = 30$V). We can estimate the time since charging, but only to within about 12 hours. We can estimate that @nybill charged the capacitor fully at noon on the Friday in question. The post was made 5 hours ago, at 13:32 US Central Standard Time. @nybill claims to be in New York - the US Eastern timezone, so this post was made at 14:31 Eastern Standard Time. This corresponds to an approximate time since start of charging of $t = (696,600 \pm 43,200)$s (a 6% uncertainty due to the 12-hour window of uncertainty on the original Friday).

We can determine the resistance in the effective circuit @nybill has, even if the capacitor was just left to sit without a connection (e.g. left with just air between the terminals). The leakage of current off the capacitor can be modeled as a "leaky RC circuit," with an effective resistance, R.

To solve for the resistance:

$$\begin{aligned} \frac{V(t)}{V_0} &= e^{-t/RC} \\ ln\left(\frac{V(t)}{V_0}\right) &= -\frac{t}{RC} \\ R &= \frac{-t}{C \cdot ln(V/V_0)}. \end{aligned}$$

We can then insert the known numbers and solve:

$$R = 3.8 \times 10^7 \Omega.$$

If we then vary the time by the uncertainty, we can get an estimate of the uncertainty on the resistance:

$$R = (3.79 \pm 0.23) \times 10^7 \Omega.$$

This is compatible with the typical resistance of air, so the leakage could be explained by leakage of current through air. But this also might be consistent with the resistance of the dielectric inside the capacitor. One would have to do more measurements to discern between such hypotheses.