RADIANT TECHNOLOGIES, INC.

Radiant Technologies, Inc.
2835B Pan American Freeway NE
Albuquerque, NM 87107
Tel: 505-842-8007
Fax: 505-842-0366
e-mail: radiant@ferrodevices.com
www.ferrodevices.com
www.ferroMEMS.com

Curve Energy Results for EEStor's Ultra Capacitors

Rev A

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Author: Joe T. Evans, Jr.

Discussion:

I am the President and chief technologist at Radiant Technologies, Inc. in Albuquerque, NM. Radiant Technologies has as one of its primary businesses the manufacture and sale of test equipment for non-linear capacitors. EEStor Corporation provided three samples of its Ultra capacitor to Radiant in December 2017 to verify the operation of Radiant's 10kV hysteresis measurement equipment as a condition for the possible purchase of the equipment by EEStor. I conducted tests of those samples on December 20, 2017 and provided the data to EEStor. The results are described below. This report is provided by Radiant as a courtesy to EEStor.

The three capacitors and electrodes were of unknown composition and had thicknesses of 11.5 micrometers, 11.7 micrometers, and 12.5 micrometers respectively. Capacitor area was standardized at 0.36 square centimeters. I executed a test definition on the three capacitors consisting of 1) one bipolar hysteresis loop, 2) one monopolar Curve Energy loop, and 3) one monopolar hysteresis loop, all with 100 millisecond periods. The three tests were repeated at increasing voltages until destructive breakdown occurred. The Curve Energy Task as executed by Radiant's testers measures the charge absorbed and returned by the capacitor under test when raised to the assigned voltage and brought back to zero. The task reports the energy density stored in the capacitor while voltage increases, the energy released by the capacitor as the voltage decreases, and the difference between the two which constitutes the energy lost during the cycle. The loss mechanism cannot be identified by the task and could be due to resistive heating inside the device or due to a slow release mechanism. Energy density is defined as Joules of energy per cubic centimeter of volume and is calculated as the product of polarization and electric field. Breakdown voltage is the hysteresis voltage during the test loop at which arcing occurred through the dielectric material, rendering the device unusable. An efficiency value for each capacitor is reported in the table below. It is defined as the ratio of energy density delivered by the capacitor while discharging in 100 milliseconds divided by the energy density stored in the capacitor while charging in 100 milliseconds.

Ultra Capacitor	Energy Stored (J/cm^3)				Energy Returned				Breakdown Voltage
	1200V	2000V	2400V	3100V	1200V	2000V	2400V	3100V	
11.5 µm	2.83	7.56	11.18	-	45%	35%	27%	-	2800V
11.7 µm	2.53	6.72	10.01	19.04	40%	30%	23%	3%	3200V
12.5 µm	2.86	7.48	10.89	-	45%	36%	30%	-	2500V