6.1. Qualification of Commercial Off-The-Shelf Supercapacitors for Space Applications

Petr Vašina, Lukáš Diblík, David Latif,

EGGO Space ,EGGO Space s.r.o , Dvořákova 328 56301 Lanškroun ,Czech Republic, E mail: info@eggo.cz

ABSTRACT

Theme of the presentation will focus on comparative test results (performed by EGGO Space s.r.o) of large format supercapacitors anonymously and well-known competitors (anonymously). All supercapacitor manufacturers use different measurement techniques making datasheet-based comparison unreliable. The test results presented have been performed according to IEC 62391 standard methods and thus provide high quality results with 10 units tested of each product.

In the tests Supplier 1 anonymously COTS supercapacitors have show exemplary power performance due to considerably lower ESR in comparison to competing products. The ESR of the best competing product was found to be twice as high with many competitor products having an ESR nearly three times as high.

The test results will be put into context by showing the effect of ESR on round trip efficiency and capacitor temperature performance at different loads and the accompanying effect on capacitor lifetime.

1. INTRODUCTION

Supercapacitors also called electrochemical double layer capacitors are energy storage devices storing electric energy in the double layer between a high surface area electrode and an electrolyte. As compared to batteries no chemical reactions should occur at the electrodes. The use of supercapacitors on spacecrafts and launchers can be manifold and its use is very potential in other civil and military areas .

2. EXPERIMENTAL

Comparison of Initial measurements of Capacity and ESR . Supplier 1 cells versus competitive cells 1200 F and 3000 F + types. The methods applied on this measurements confirms EGGO possibilities in reliable Qualification testing of this kind of Ultracapacitors with high capacitance level. The Initial values have been compared also with the data sheets records of the tested cell types.

Figure 1 cells 1200 F

Figure 2 cells 3000 F

Supplier 1 cells:

1200 F SCA1200 1200F 2,85V 1,35Wh

Competitive cells :

1200 F S2 1200F 1,22WhLs , Mtron Ltd

1200 F S3 BCAP1200 P270 1200F 2,7V 1,2Wh

Supplier 1 cells :

3000 F 3200F 2,85V 3,61wh

Competitive cells:

3000 F S2 i CAP iRB3000K270CT 3000F 2,7V 3,04Wh

3000 F S3 Tech K2SERIES BCAP3400 P285 3400F 2,85V 3,84Wh

3000 F S4 NE03V03400SW001 3400F 3,0V 4,2Wh

3000 F S5 LSUC 2,85V 3400F 3,84Wh

2.1 EGGO Testing methods for Capacitance and ESR measurements

Initial measurement methods have been applied in two specifications:

Measurement method 1A

1. Constant charging current set to 95% efficiency, ICC=UR/38RN
2. Charging up to rate voltage
3. Holding rate voltage 30 min
4. Discharging with rate discharge current (class 2, 3, see Table 1)
5. Time measurement for two Points, U1 (0,8 UR) and U2 (0,4 UR)

Measurement method 1B

1. Constant charging current set to 95% efficiency, ICC=UR/38RN
2. Charging up to rate voltage
3. Holding rate voltage 30 min
4. Discharging current set to 95% efficiency, ICC=UR/40RN, see Table 1
5. Time measurement for two Points, U1 (0,8 UR) and U2 (0,4 UR)

Table 01:

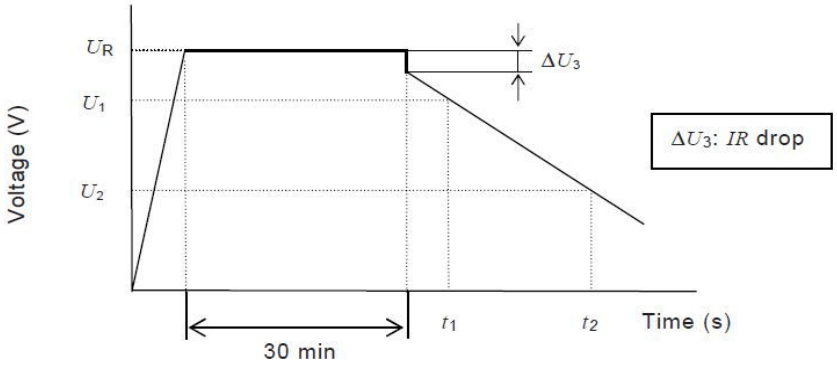
C in F	Nominal (predicted) in mOhm	Charge current, 95% Charge eff. In A	Class	Method 1A		Method 1B
				Discharge current (C) in A	Discharge current (R) in A	Discharge current ina A
1200	0,35	214	1	1,2	12	204
			2	1,368	13,68	
			3	13,68	136,8	
			4	136,8	1368	
3200	0,16	469	1	3,2	32	445
			2	3,648	36,48	
			3	36,48	364,8	
			4	364,8	3648	

Table 01 – charge and discharge current

Determination of Capacitance

Capacitance has to be either calculated by straight line approximation.

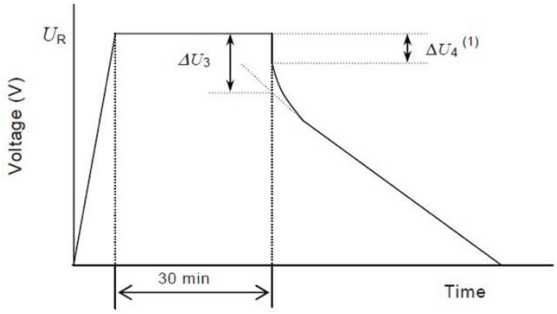
$$\boldsymbol{C = \frac{I_{CC} * (t_1 - t_2)}{U_1 - U_2}}$$



Determination of Resistance

Resistance has to be either calculated by least square internal resistance calculation method (1A) or intersection line internal resistance calculation method (1B).

$$R = \frac{\Delta U_3}{I_d}$$



Setup:

Wiring diagram:

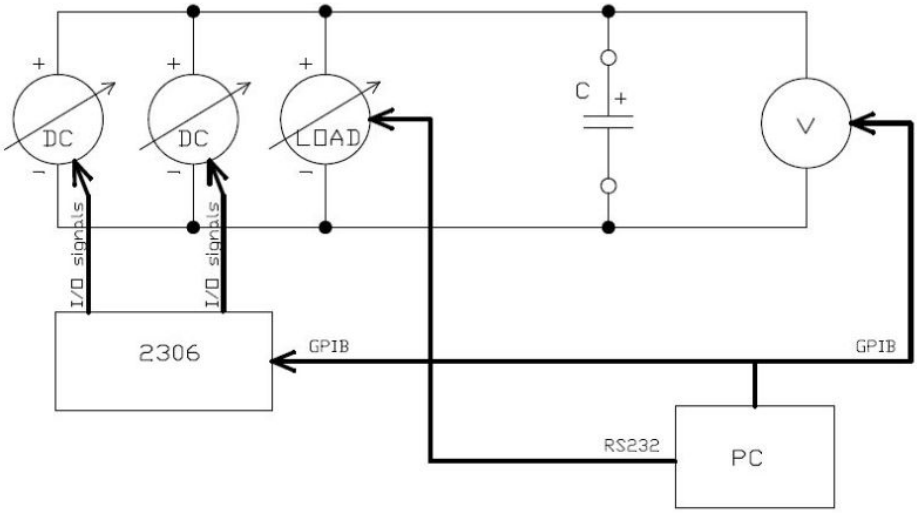


Image 01 – wiring diagram

Figure 3 Wiring diagram

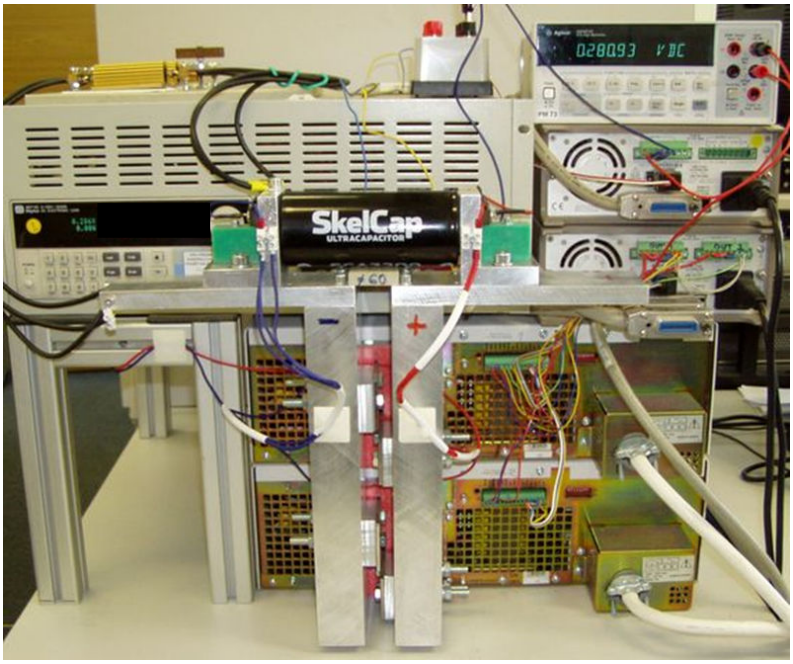
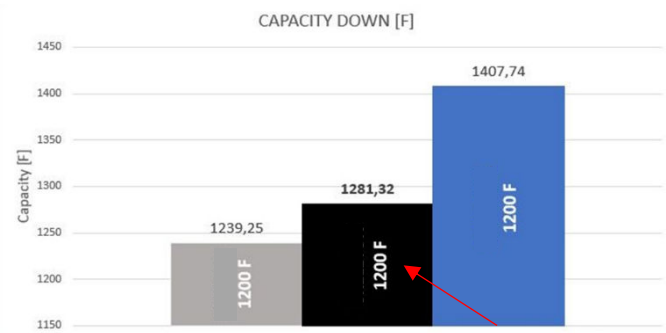


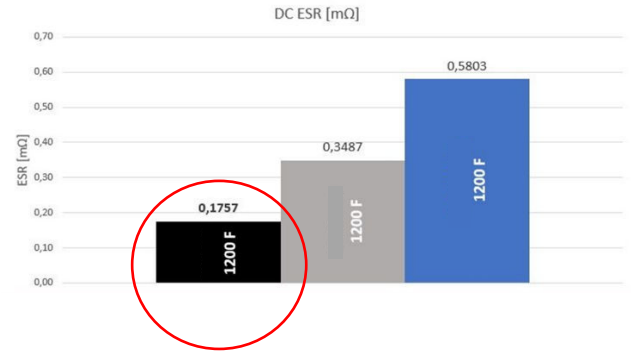
Figure 4 Set up

3. RESULTS AND DISCUSSION

3.1 Measurements results of Supplier 1 cells versus Competitive cells 1200 F and 3200 F + cells applied in EGGO Lab.

Method 1 A2 1200 F cells

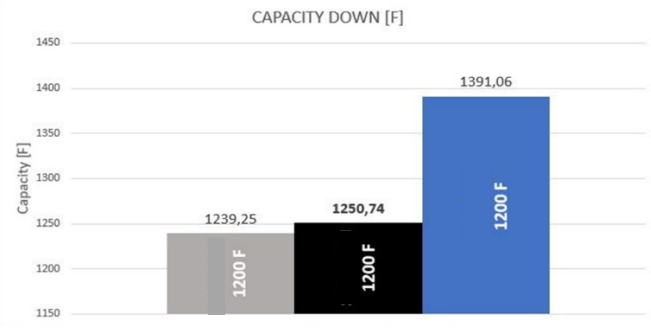


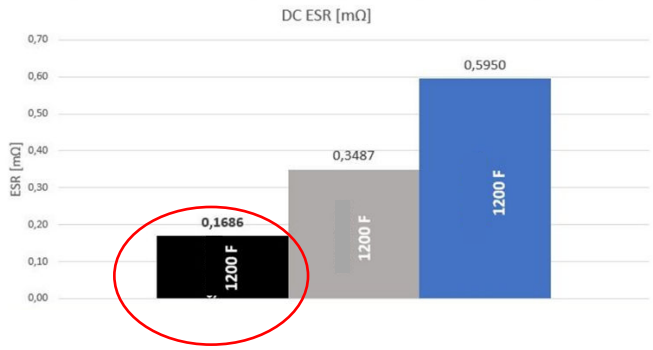


Within measurement Methods 1 A2 and 1B were ESR values of S1 cells lowest in comparison with Competitive cells. These values are just an initial and they are not determinant.

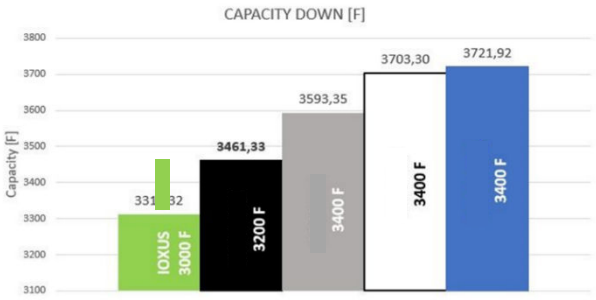
Initial capacitance values are little higher for all tested samples.

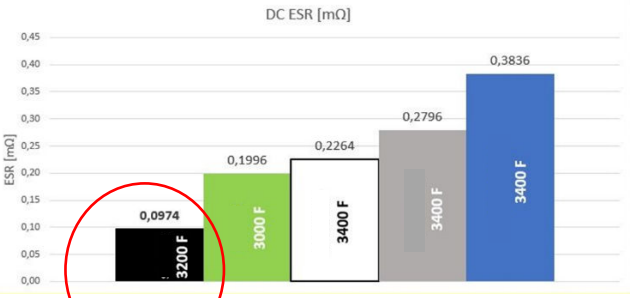
Method 1 B 1200 F cells





Method 1 A 3200 + cells

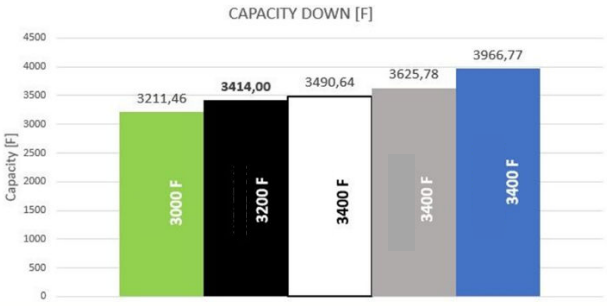


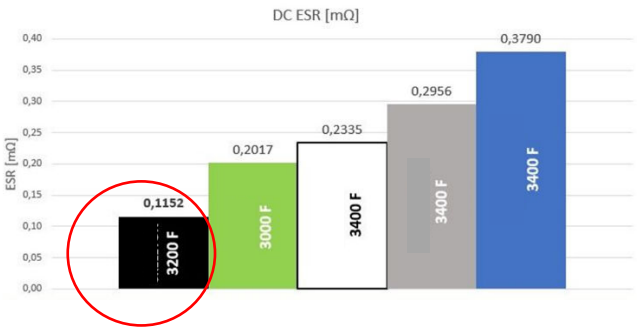


Initial Measurements method 1 A and 1B applied on 3200 cells shows the S1 cells (black bar) values of ESR as the lowest. These measurements are just an initial values and are not determinant.

Initial capacitance values are mostly little higher than data sheets data for all samples.

Method 1 B 3200 + cells





4. CONCLUSION

Based on this work seems high capacitance Ultracapacitors very potential in many applications incl the Space sector. Testing of this kind of cells requires very precise hardware facilities with software connection tuned individually to the customer prototypes or commercial items.

EGGO Space Testhouse is due to this work and long time experience in testing potential Lab for Qualification of this kind of Ultracapacitors with a good know how and Lab equipment.