



Part Number	LSUC 002R8S 0600F EA
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# TEST REPORT

- 1) Characterization test
- 2) Reliability test



# TEST REPORT

## Characterization Test & Reliability Test

### 1. Introduction

- 1) Characterization tests consist basically of measurement of capacitance, internal resistance, electrical power, leakage current, self-discharge, EDLC performance at operational temperature based on referred several test conditions. And specific electrical properties have been calculated by using above measured values and product dimension.
- 2) Reliability test consisting of vibration & shock test, load life test, high temperature storage life test are carried out in the each accelerated stress conditions to predict durability of products according to below several standard.

### 2. Product Specification

- 2.1 Product type : LSUC series (Electric double layer capacitor)
- 2.2 Part number : LSUC 002R8S 0600F EA

### 3. The Measurement condition of Performance

Test was performed based on "Electric Vehicle Capacitor Test Procedures Manual, DOE/ID-10491", "FreedomCAR Ultracapacitor Test Manual, DOE/NE-ID-11173", "IEC 60068-2", "IEC 62391", and "ISO 16750-3"

# TEST REPORT

## Characterization Test & Reliability Test

No.	Type of test	Test item	Standard	Results
1	Physical Dimensions	Appearance	IEC62391-1	No appearance defect 
2		Polarity	IEC62391-1	Distinct polarity mark 
3		Dimension / weight	IEC62391-1	Ø 35(+1) X 71mm(±2) / 90g

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## Characterization Test & Reliability Test

No.	Type of test	Test item	Standard	Results		
4	Electrical Properties	Capacitance (F)	IEC62391-1	Current (A)	Capacitance (F)	Ratio (%)
				5.0	606.7	-5% / +15%
5		DC ESR (mΩ)	IEC62391-1	Measured value 1.939mΩ (Max. 3.2 mΩ)		
6		Peak power density (kW/kg)	LS Mtron Engineering Specification	6.80 kW/kg $= \frac{V^2}{4 \times ESR_{DC} \times weight}$		
7		Stored energy (Wh)	LS Mtron Engineering Specification	0.653 Wh $= \frac{1/2 CV^2}{3600}$		
8		Leakage current (mA)	IEC62391-1, LS Mtron Engineering Specification	0.758 mA (avg.) (Max. 1.3mA)		
9		Self discharge (V)	IEC62391-1, LS Mtron Engineering Specification	2.480 V (avg.)		

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## Characterization Test & Reliability Test

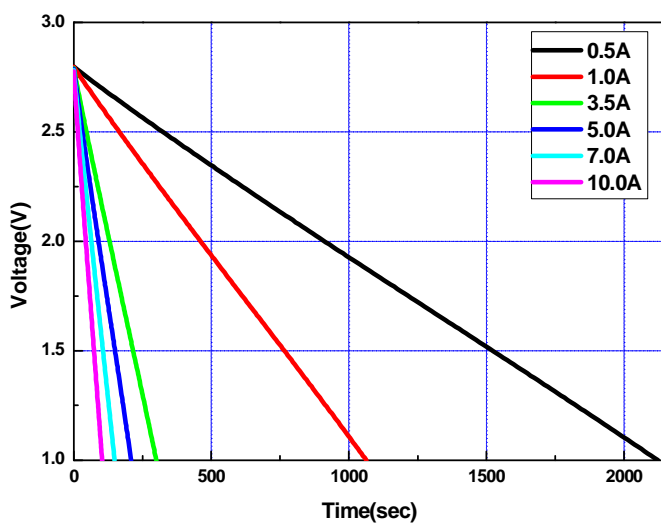
No.	Type of test	Test item	Standard	Results
10	Temperature Characteristics	High Temperature Characteristic Test	IEC62391-1, LS Mtron Engineering Specification	609.1 F, 2.018 mΩ @ 65℃
11		Low Temperature Characteristic Test		604.9 F, 2.447 mΩ @ -40℃
12	Reliability	Load life test	IEC62391-2, LS Mtron Engineering Specification	$\Delta C \left( = \frac{C_{\text{specified}} - C_{\text{end of test}}}{C_{\text{specified}}} \right) \leq 30 \%$ <p>@ 65℃, 1500hr</p> $\Delta ESR \left( = \frac{ESR_{\text{end of test}} - ESR_{\text{specified}}}{ESR_{\text{specified}}} \right) \leq 150 \%$ <p>@ 65℃, 1500hr</p>
13		Vibration	IEC60068-2-6 (2007)	$\Delta C \left( = \frac{C_{\text{specified}} - C_{\text{end of test}}}{C_{\text{specified}}} \right) \leq 1 \%$ $\Delta ESR \left( = \frac{ESR_{\text{end of test}} - ESR_{\text{specified}}}{ESR_{\text{specified}}} \right) \leq 1 \%$ <p>(No visible damage / No electrolyte leakage, There is no degradation of performance)</p>

# TEST REPORT

## Appendix 1. Test results

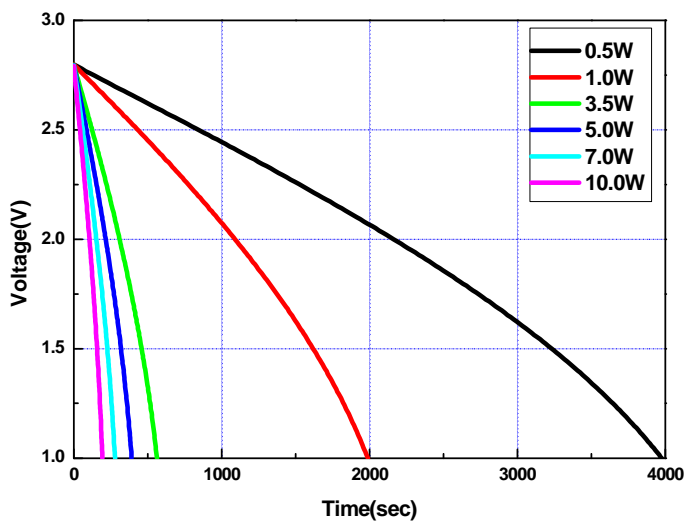
### 1. Electrical Properties

#### 1) Discharging Constant Current Test



Current (A)	Capacitance (F)	Ratio (%)
0.5	602.84	100.0%
1	601.40	99.8%
3.5	596.02	98.9%
5	593.82	98.5%
7	591.92	98.2%
10	589.83	97.8%

#### 2) Discharging Constant Power Test



Power (W)	Energy (Wh)	Ratio (%)
0.5	0.551	100.0%
1	0.552	100.1%
3.5	0.547	99.3%
5	0.544	98.8%
7	0.541	98.2%
10	0.536	97.4%

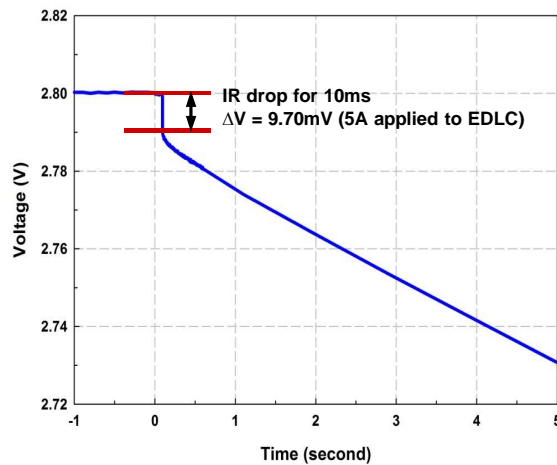
# TEST REPORT

## Appendix 1. Test results

### 1. Electrical Properties

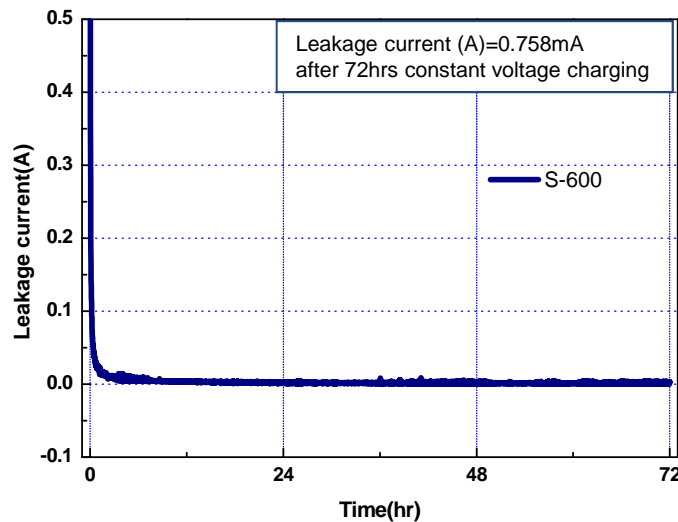
#### 3) DC ESR test

Temp. (°C)	DC ESR (mΩ)	Test condition
25	1.94	IR drop for 10ms @ 5A discharging



#### 4) Leakage current test

: The leakage current shall be measured applying rated voltage at a reference temperature of 20°C for 72hours.



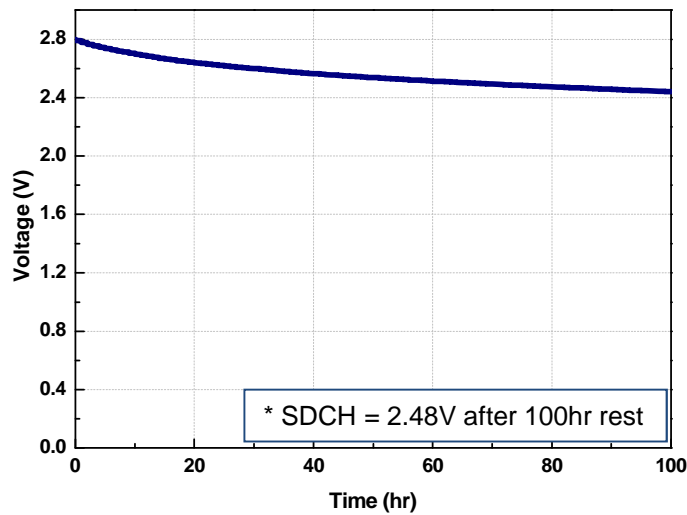
# TEST REPORT

## Appendix 1. Test results

### 1. Electrical Properties

#### 5) Self Discharge test

Self discharge voltage shall be measured after charging up for 12hours, disconnect the capacitor terminals from the voltage source. The capacitor shall be kept under standard condition for 100hours.

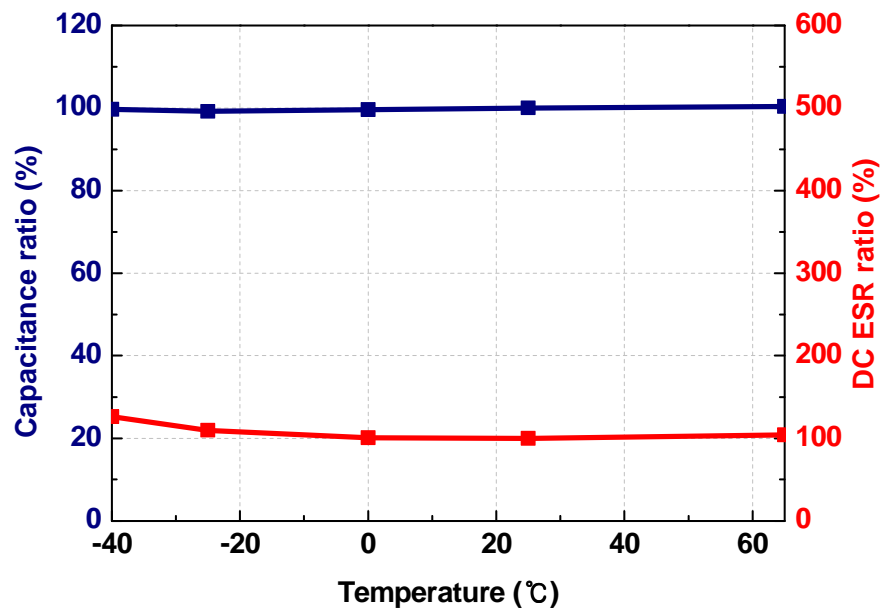




# TEST REPORT

## Appendix 1. Test results

### 2. Temperature Characteristics



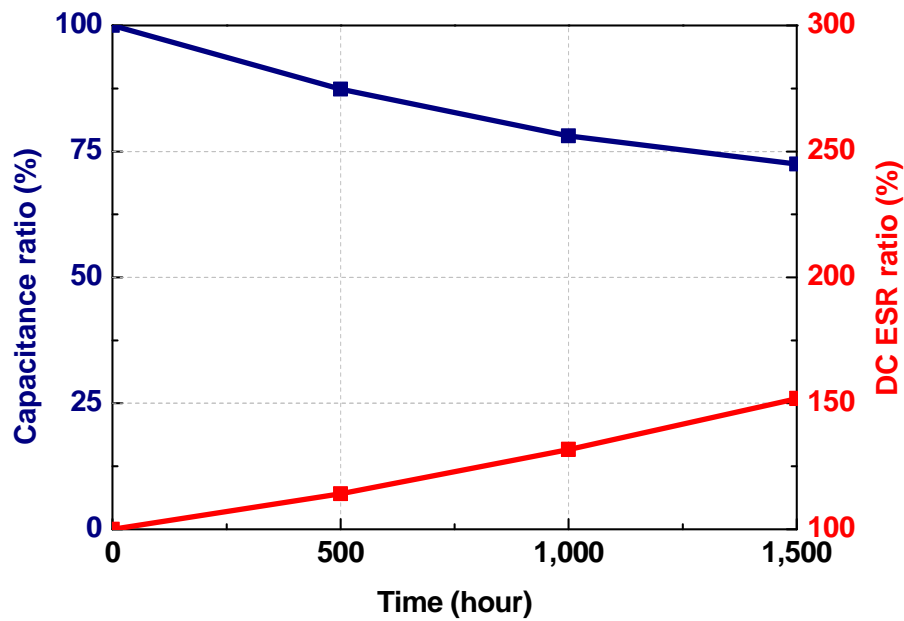
Temp.	Capacitance ratio (%)	DC ESR ratio (%)
65 °C	100.4 %	104.1%
25 °C	100.0 %	100.0 %
0 °C	99.6 %	100.5 %
-25 °C	99.2 %	109.8 %
-40 °C	99.7 %	126.2 %

# TEST REPORT

## Appendix 1. Test results

### 3. Reliability

#### 1) 2.8V 65°C Load life test



Time (hour)	Capacitance ratio (%)	DC ESR ratio (%)
0	100.0 %	100.0 %
500	87.4 %	114.0 %
1000	78.1 %	131.7 %
1500	72.5 %	151.9 %

# TEST REPORT

## Appendix 1. Test results

### 3. Reliability

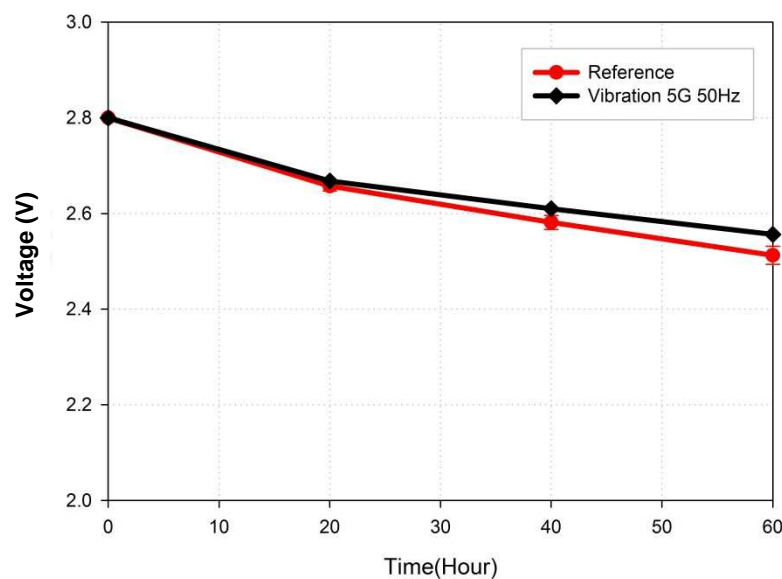
#### 2) Vibration in a charged

- A. Keep the test cell at 2.8V for 24 hours
- B. During a total measurement time of 60 hours, the directions were changed in the x, y and z axes every 20 hours. And the vibration test was carried out at 5G 50Hz.
- C. The test cell was measured every 20 hours by changing the axis.

#### ① Vibration test condition

Acceleration (G)	Frequency range (Hz)	Direction	Test time at each condition (hour)	Total test Time (hour)
5	50	X, Y, Z axis	20	60

600F Self Discharge on Vibration Test



Time	No Vibration (Reference)		Vibration 5G 50Hz	
	Capacitance ratio (%)	DC ESR ratio (%)	Capacitance ratio (%)	DC ESR ratio (%)
0	100%	100%	100%	100%
60 hour	99.2%	100.6%	99.1%	100.4%

# TEST REPORT

## Appendix 1. Test results

### 5. Mechanical Test

#### - Cell Drop test



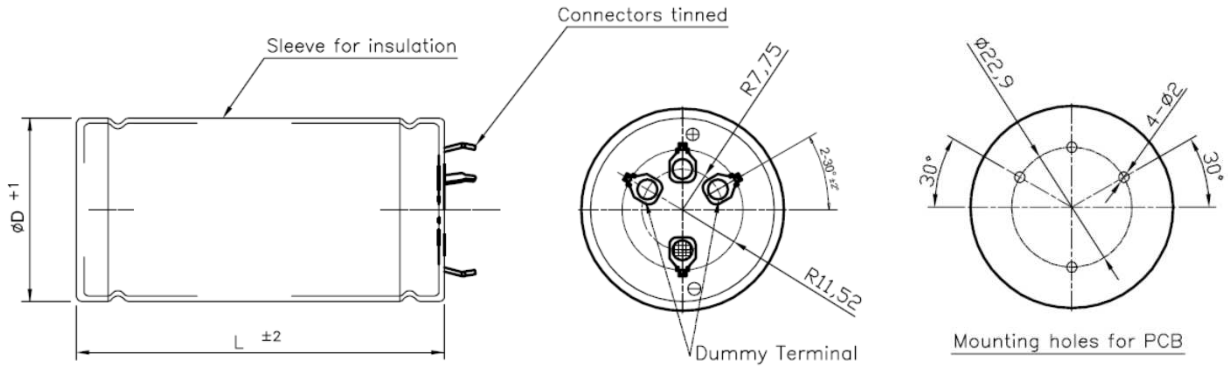
Drop test	
Standard test procedure	ISO 16750-3 (Mechanical loads)
Height	1m
Drop surface material	Steel plate
Number of drops	10 times (Standard 3 times)
Temperature	25℃
Drop direction	a downward direction of cell terminal

Test item	Results
Drop test	wobbling detected after more than 10 times drop

# Product specification

## Physical properties

Dimension in mm (not to scale)



## Specification

Rated Voltage	2.8 V	
Max. Voltage <sup>1</sup>	3.0 V	
Capacitance Tolerance	-5% / +15%	
Operating temperature range	-40 ~ 65 °C	
Storage temperature range	-40 ~ 70 °C	
Endurance Life (65°C)	1,500 Hours	
	Capacitance change	Within 30% of initially specified value
	ESR change	Within 150% of initially specified value
Projected Life Time (25°C)	10 Years at rated voltage	
	Capacitance change	Within 30% of initially specified value
	ESR change	Within 150% of initially specified value
Shelf Life (25°C)	4 Years stored uncharged state	
Certifications	ROHS, REACH, UL810A (Certificate No. : MH46367)	

## Standard Ratings

Part number	Capacitance (F)	Max. ESR (mΩ)		Max. Current (A) Non-repeated (Calculated value)	Leakage Current (mA)	Max. Stored Energy (Wh)
		AC (1kHz)	DC			
LSUC 002R8L 0600F EA	600	3.0	3.2	288	< 1.3	0.65
Part number	Max. Continuous Current (A) <sup>3</sup>		Thermal Resistance (°C/W) _ Cell Surface	Dimension (mm)		Weight (g)
	ΔT=15 °C	ΔT=40 °C		D1 (+ 1.0)	L (±2.0)	
LSUC 002R8L 0600F EA	25	40	8.0	35.0	71.0	90

\*Remark

1) Non-repeated, not to exceed 1sec.

2) Actual cycle value can be subject to various application conditions.

3) Initial state value.

# Technical Information (1)

## ■ How to calculate specification value

### 1. The Measurement Methods

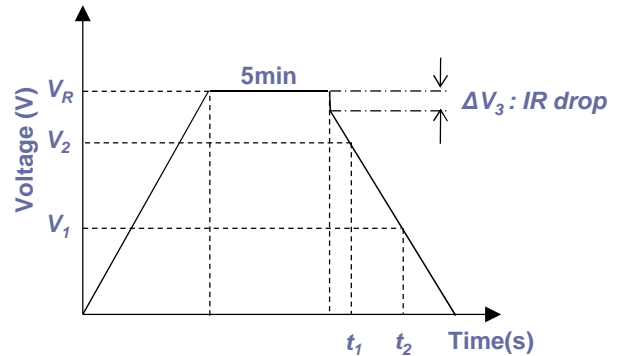
#### 1-1 Capacitance

Apply rated voltage and charge for 5min after the constant current / constant voltage power supply has achieved the rated voltage. After a charge for 5min has finished, discharge with 10mA/F to 0.1V.

Measure the time  $t_1$  to  $t_2$  where the voltage between capacitor terminals at the time of discharge reduces from  $V_1$  to  $V_2$  as shown figure and calculate the capacitance value by the following formula:

- 1) Constant current charge with 10mA/F to  $V_R$
- 2) Constant voltage charge at  $V_R$  for 5min
- 3) Constant current discharge with 10mA/F to 0.1V

$$C = \frac{I \times (t_2 - t_1)}{V_2 - V_1}$$



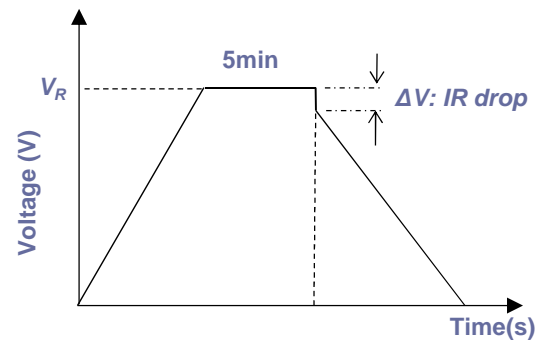
#### 1-2 Resistance

The AC and DC resistance of a capacitor shall be calculated by the following formula;

$$R_{AC} = \frac{V}{I_{AC}} \quad (\text{The frequency of the measuring voltage shall be 100Hz})$$

$$R_{DC} = \frac{\Delta V}{I_{DC}}$$

Where  $R_{AC}$  is the AC internal resistance ( $\Omega$ );  
 $R_{DC}$  is the DC internal resistance ( $\Omega$ );  
 $V$  is the effective value of AC voltage (V);  
 $\Delta V$  is the drop voltage for 10ms (V);  
 $I_{AC}$  is the effective value of AC current (A);  
 $I_{DC}$  is the discharge current (A);



## Technical Information (2)

### 1-3 Leakage current & Self discharge

The leakage current shall be measured using the direct voltage appropriate to the test temperature(25℃) for 72hrs. Self discharge voltage shall be measured after charging up for 12hrs, disconnect the capacitor terminals from the voltage source. The capacitor shall be kept under standard condition for 100hrs.

### 1-4 Maximum current

Current for 1sec discharge from the rated voltage to the half of it in constant current discharge,

$$I_{Max} = \frac{V_R - 0.5 \cdot V_R}{\Delta t / C + R_{DC}}$$

Where  $I_{Max}$  is the Maximum current (A);  
 $\Delta t$  is the discharge time (sec), 1 sec in this case ;  
 $C$  is the capacitance (F);  
 $R_{DC}$  is the DC resistance ( $\Omega$ );  
 $V_R$  is the rated voltage (V).

### 1-5 Maximum stored energy ( $E_{MAX}$ )

$$E_{MAX} (Wh) = \frac{\frac{1}{2} C V_R^2}{3600}$$

## 2. The Standard Atmospheric Condition for Measurement

All test and measurements shall be made under standard atmospheric conditions for testing. Before the measurements are made, the capacitor shall be stored at the measuring temperature for a time sufficient to allow the entire capacitor to reach this temperature. The period as prescribed for recovery at the end of a test is a normally sufficient for this purpose.

Temperature : 15~35 ℃  
 Relative humidity : 25~75%  
 Air Pressure : 86~106 kPa