



Part Number	LSCU 003R0L 0380F EA
Document Number	V0_20160216

# 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 003R0L 0380F 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

### 4. Test Protocol

Sample



Appearance



Electrical  
Characteristics



Mechanical  
Characteristics



Environmental  
Characteristics

Standard	Appearance	n
IEC62391-1	Appearance	100
	Polarity	100
	Dimension / weight	100

Standard	Electrical Characteristics	n
ES-100	Standard atmospheric conditions	-
ES-101	Open circuit voltage	100
ES-102-01	Capacitance	100
ES-103-01	Internal resistance	100
ES-104	Leakage current	20
ES-105-01	Self discharge	100
ES-107	Constant current & power test	20
ES-109	Max. continuous current	20
ES-110	Load life test	60
ES-111(UL810A)	Cycle life test	9

Standard	Mechanical Characteristics	n
ES-201	Vibration	18
ES-202	Shock	18

Standard	Environmental Characteristics	n
ES-305	Temperature Characteristics	20

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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 61mm(±2) / 72g

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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 (%)
				3.8	396.7	+4.4% of Rated capacitance
5		DC ESR (mΩ)	IEC62391-1	Measured value 2.308mΩ(±10%) (Max. 3.2 mΩ)		
6		Peak power density (kW/kg)	LS Mtron Engineering Specification	$9.77 \text{ kW/kg}$ $= \frac{V^2}{4 \times ESR_{DC} \times weight}$		
7		Stored energy (Wh)	LS Mtron Engineering Specification	$0.475 \text{ Wh}$ $= \frac{1/2 CV^2}{3600}$		
8		Leakage current (mA)	IEC62391-1, LS Mtron Engineering Specification	$0.461 \text{ mA (avg.)}$ $\text{(Max. 1mA)}$		
9		Self discharge (V)	IEC62391-1, LS Mtron Engineering Specification	2.639 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	397.1 F, 2.402 mΩ(±10%) @ 65 °C
11		Low Temperature Characteristic Test		395.6 F, 2.856mΩ(±10%) @ -40 °C
12	Reliability	Load life test	IEC62391-2, LS Mtron Engineering Specification	$\Delta C \left( = \frac{C_{initial} - C_{end\ of\ test}}{C_{initial}} \right) \leq 20\%$ <p>@ 65 °C, 1000hr</p> $\Delta ESR \left( = \frac{ESR_{end\ of\ test} - ESR_{initial}}{ESR_{initial}} \right) \leq 100\%$ <p>@ 65 °C, 1000hr</p>
13		Vibration and Shock test	IEC60068-2-6 (2007), IEC60068-2-27 (2008)	$\Delta C \left( = \frac{C_{initial} - C_{end\ of\ test}}{C_{initial}} \right) \leq 1\%$ $\Delta ESR \left( = \frac{ESR_{end\ of\ test} - ESR_{initial}}{ESR_{initial}} \right) \leq 1\%$ <p>(No visible damage / No electrolyte leakage, There is no degradation of performance)</p>

# TEST REPORT

## Characterization Test & Reliability Test

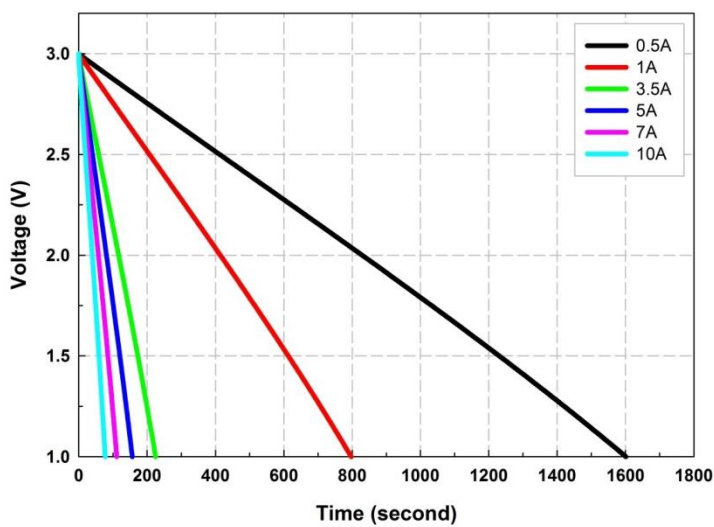
No.	Type of test	Test item	Standard	Results
14	Reliability	Cycle life test	LS Mtron Engineering Specification	$\Delta C \left( = \frac{C_{initial} - C_{end\ of\ test}}{C_{initial}} \right) \leq 20\ \% \ @\ 25\ ^\circ C,$ <p>500k cycles</p> $\Delta ESR \left( = \frac{ESR_{end\ of\ test} - ESR_{initial}}{ESR_{initial}} \right) \leq 100\ \%$ <p>@ 25 °C, 500k cycles</p>
15		Drop test	ISO16750-3	Wobbling detected after more than 8 times drop

# TEST REPORT

## Appendix 1. Test results

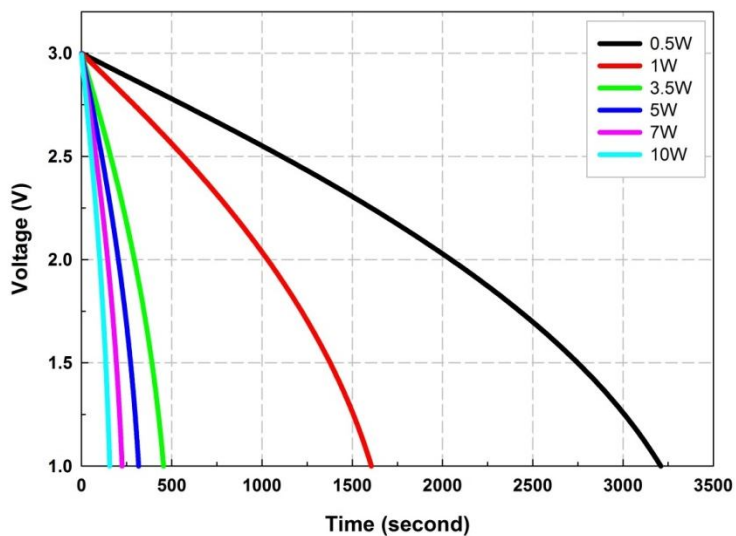
### 1. Electrical Properties

#### 1) Discharging Constant Current Test



Current (A)	Capacitance (F)	Ratio (%)
0.5	400.98	100%
1	397.57	99.1%
3.5	393.45	98.1%
5	391.96	97.8%
7	391.11	97.5%
10	390.67	97.4%

#### 2) Discharging Constant Power Test



Power (W)	Energy (Wh)	Ratio (%)
0.5	0.445	100%
1	0.446	100.1%
3.5	0.441	99.2%
5	0.439	98.7%
7	0.437	98.1%
10	0.433	97.4%

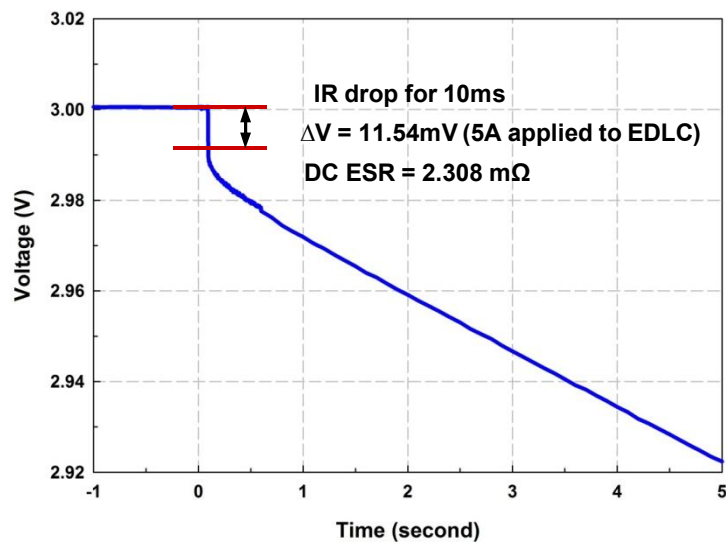


# TEST REPORT

## Appendix 1. Test results

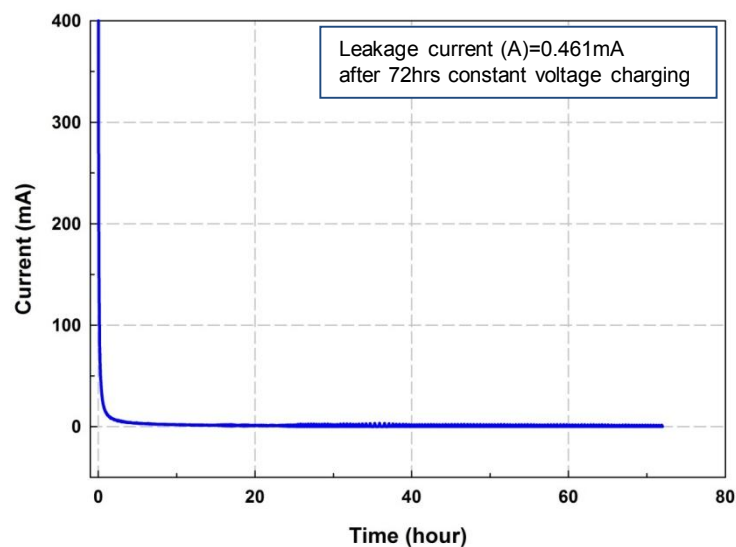
### 1. Electrical Properties

#### 3) DC ESR test



#### 4) Leakage current test

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



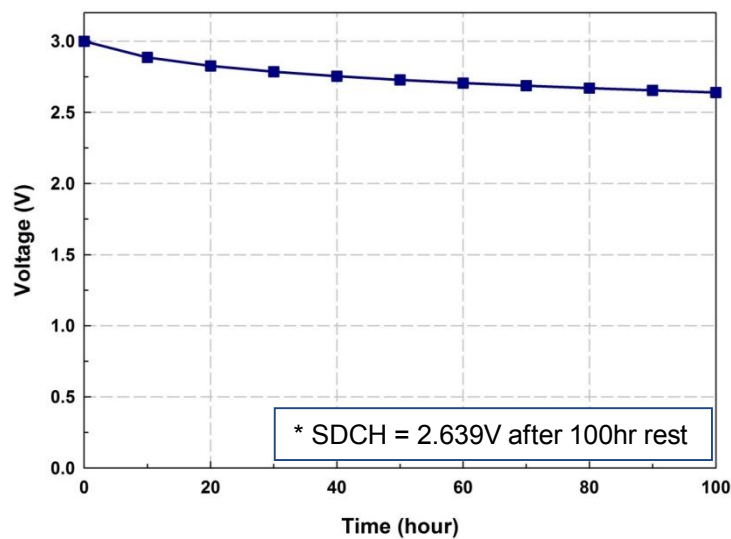
# TEST REPORT

## Appendix 1. Test results

### 1. Electrical Properties

#### 5) Self Discharge test

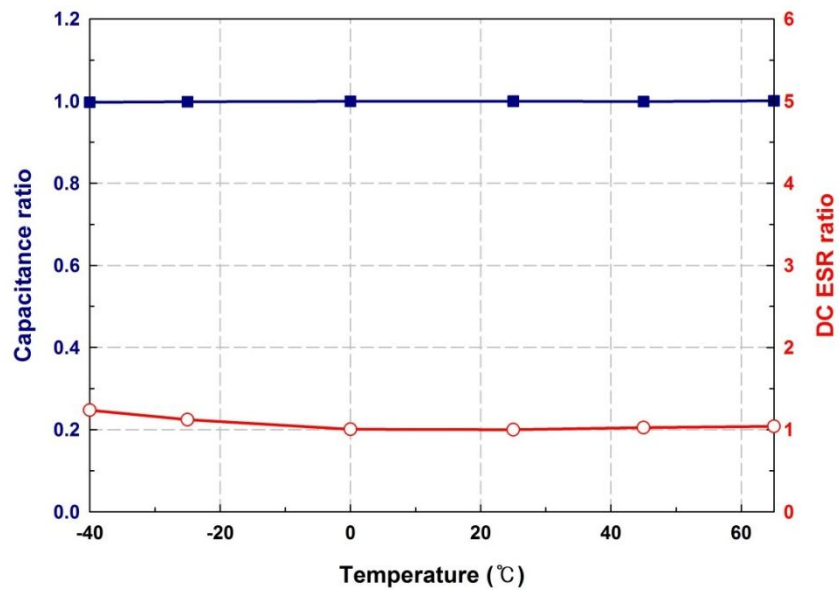
Self discharge voltage shall be measured after charging up for 12hours, disconnect the capacitor terminals from the voltage source. The capacitor shall be kept under standard condition for 100hours.



# TEST REPORT

## Appendix 1. Test results

### 2. Temperature Characteristics



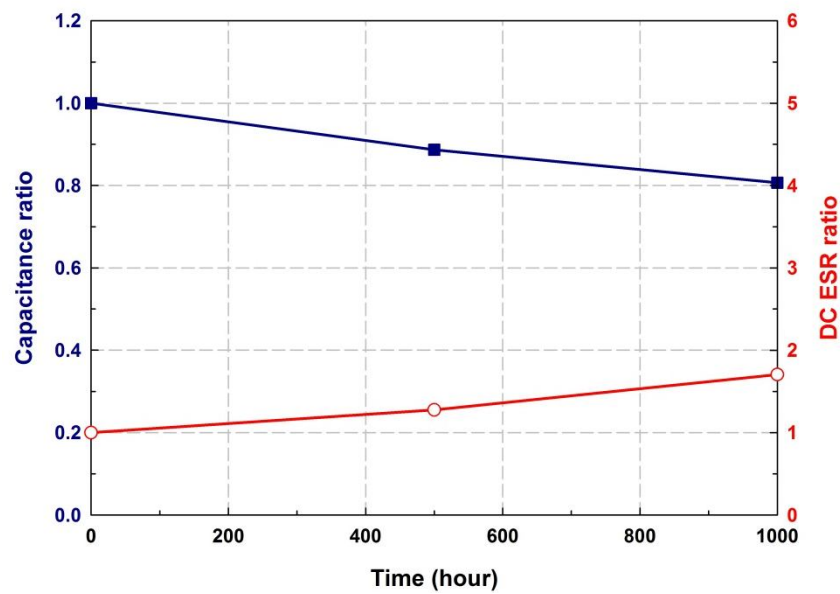
Temp.	Capacitance ratio (%)	DC ESR ratio (%)
65 °C	100.1 %	104.1 %
25 °C	100 %	100 %
0 °C	100.0 %	100.6 %
-25 °C	99.9 %	112.1 %
-40 °C	99.7 %	123.7 %

# TEST REPORT

## Appendix 1. Test results

### 3. Reliability

#### 1) 3.0V 65°C Load life test



Time (hour)	Capacitance ratio (%)	DC ESR ratio (%)
0	100 %	100 %
500	88.7 %	127.6 %
1000	80.7 %	170.5 %

# TEST REPORT

## Appendix 1. Test results

### 3. Reliability

#### 2) Vibration and shock test

Capacitance and DC ESR have been measured before and after vibration & shock test.



#### ① Vibration test condition : IEC 60068-2-6 (2007)

Frequency range (Hz)	Displacement (mm)	Acceleration (G)	Sweep rate (octave/min)	Test duration (cycle)	Direction	Total number of cycle
10 ~ 82	0.75	-	1.0	20	X, Y, Z axis	60
82 ~ 500	-	10.2				

#### ② Shock test condition : IEC 60068-2-27 (2008)

Acceleration (G)	Duration (ms)	Pulse shape	Number of shock	Direction	Total number of shock
100.0	6.0	Half-sine	+3, -3	X, Y, Z axis	18
40.0			+660, -660		3960

#### ③ Test results

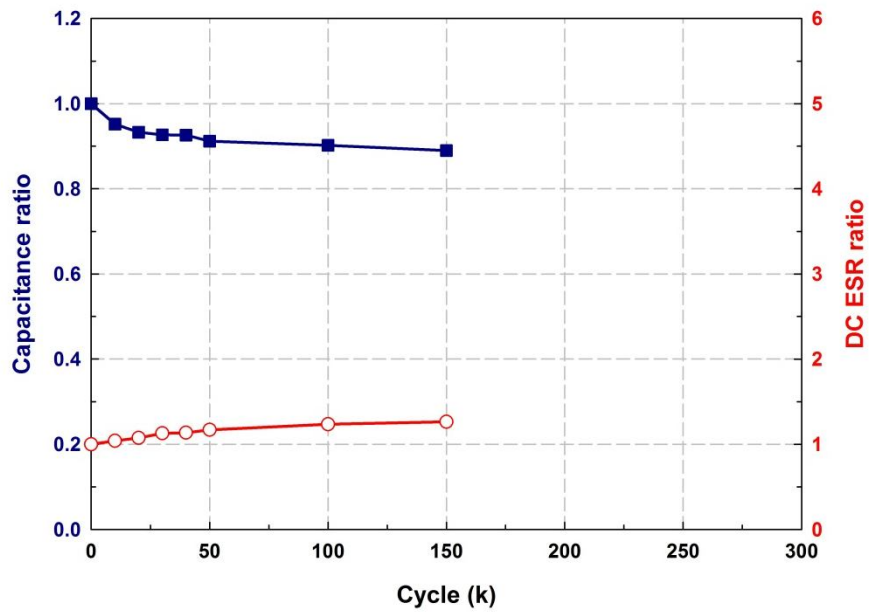
Item	Appearance defect	Capacitance ( $\Delta\%$ )	DC ESR ( $\Delta\%$ )	Self discharge ( $\Delta V$ )
After vibration & shock test	No major defects	-0.617%	+0.72%	-0.128

# TEST REPORT

## Appendix 1. Test results

### 3. Reliability

#### 3) Cycle life test

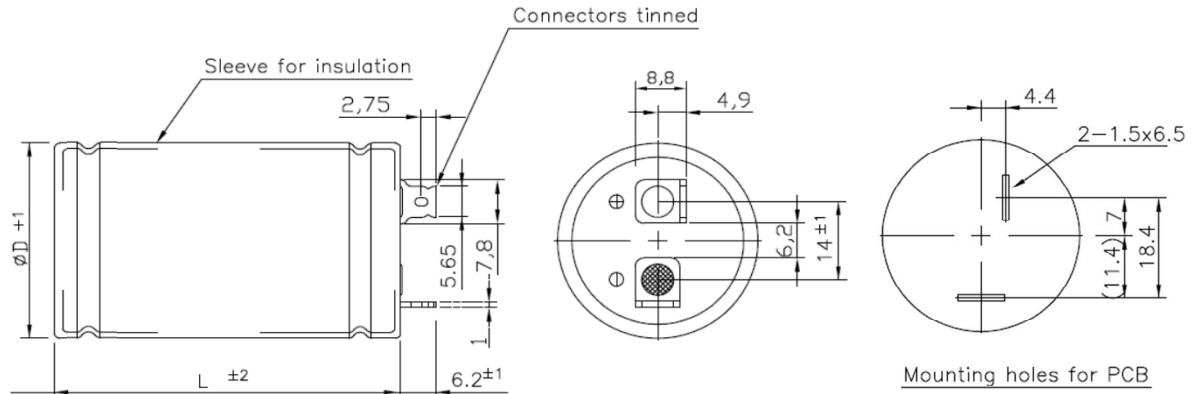


Cycle (k)	Capacitance ratio (%)	DC ESR ratio (%)
0	100 %	100 %
10	95.2 %	104.1 %
20	93.3 %	107.4 %
30	92.7 %	112.8 %
40	92.6 %	113.6 %
50	91.2 %	116.9 %
100	90.2 %	123.5 %
150	89.0 %	126.5 %

# Product Specification

## Physical Properties

Dimension in mm (not to scale)



## Specification

Rated Voltage	3.0 V	
Surge Voltage	3.2 V	
Capacitance Tolerance	-5% / + 15%	
Resistance Tolerance	< Spec. Value	
Operating temperature range	-40 ~ 65 °C	
Storage temperature range	-40 ~ 70 °C	
Endurance Life (65°C)	1,000 Hours at rated voltage and +65°C	
	Capacitance change	Within 20% of initially specified value
	Internal resistance change	Within 100% of initially specified value
Life Time (25°C)	10 Years at rated voltage and +25°C	
	Capacitance change	Within 20% of initially specified value
	Internal resistance change	Within 100% of initially specified value
Cycle Life (25°C)	500,000 Cycles between rated voltage to half rated voltage at +25°C	
	Capacitance change	Within 20% of initially specified value
	Internal resistance change	Within 100% of initially specified value

## Standard Ratings

Part number	Capacitance (F)	ESR (mΩ)		Max. Current (A)	Leakage Current (mA)
		AC (1KHz)	DC		
LSUC 003R0L 0380F EA	380	3.0	3.2	257	< 1

Part number	Max. Stored Energy (Wh)	Max. Continuous Current (A)	Dimension (mm)		Weight (g)
			D1 (+ 1.0)	L (±2.0)	
LSUC 003R0L 0380F EA	0.48	25	35.0	61.0	72

## Technical Information (1)

### ■ How to calculate specification value

#### 1. The Measurement Methods

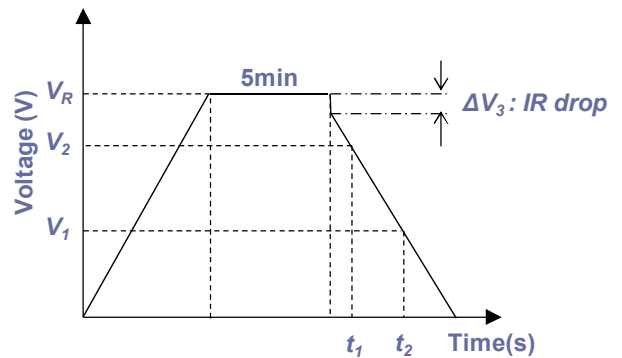
##### 1-1 Capacitance

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

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



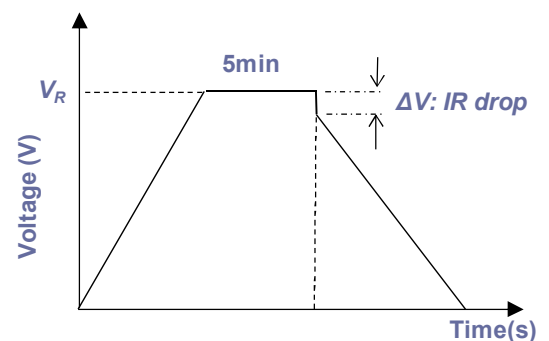
##### 1-2 Resistance

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