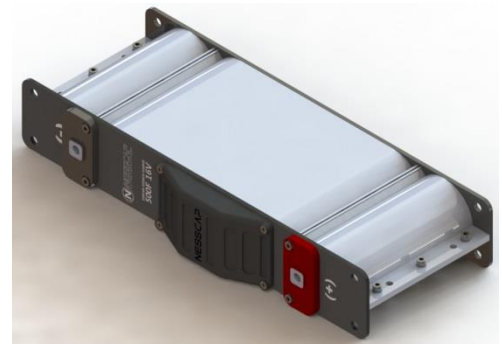


## FEATURES

- » Rated voltage of 16V and capacitance of 500F
- » High power module with ultra-low ESR
- » Exceptional shock and vibration resistance
- » Long lifetimes with up to 1 million duty cycles
- » Integrated UMU (Ultracapacitor Management Unit) for effective cell balancing and monitoring
- » Typical applications:
  - Transportation and automotive
  - Wind turbine, Industrial UPS and DVR



\* Image is not to scale

## SPECIFICATIONS

ELECTRICAL		EMHSR-0500C0-016R0S
Rated Voltage, $V_R$		<b>16 V<sub>DC</sub></b>
Surge Voltage <sup>1</sup>		17.1 V <sub>DC</sub>
Rated Capacitance <sup>2</sup>		<b>500 F</b>
Capacitance Tolerance	Maximum	0% / +20%
	Average <sup>4</sup>	+3% / +8%
DC-ESR (Equivalent Series Resistance) <sup>3</sup>	Maximum	1.9 mΩ
	Average <sup>4</sup>	1.1 mΩ
Typical Leakage Current <sup>5</sup>	Under 12V	5.2 mA
	Over 12V	45 ~ 59 mA
Maximum Peak Current, Non-repetitive <sup>6</sup>		2,000 A
Maximum Stored Energy, $E_{max}$ <sup>7</sup>		17.7 Wh
Gravimetric Specific Energy <sup>7</sup>		2.9 Wh/kg
Usable Specific Power <sup>7</sup>		2.6 kW/kg
Impedance Match Specific Power <sup>7</sup>		5.6 kW/kg

TEMPERATURE	
Operating Temperature Range	-40 ~ 65°C ( $\Delta$ CAP<5% and $\Delta$ ESR<100% of initial value measured at 25°C)
Storage Temperature Range	-40 ~ 70°C (storage without charge)

LIFE	
Endurance (at $V_R$ and 65°C) <sup>8</sup>	1,500 hours
Room Temperature (at $V_R$ and 25°C) <sup>8</sup>	10 years
Cycle Life (at 25°C) <sup>9</sup>	1,000,000 cycles
Shelf Life	2 years (stored without charge at under 70°C and 40% RH)

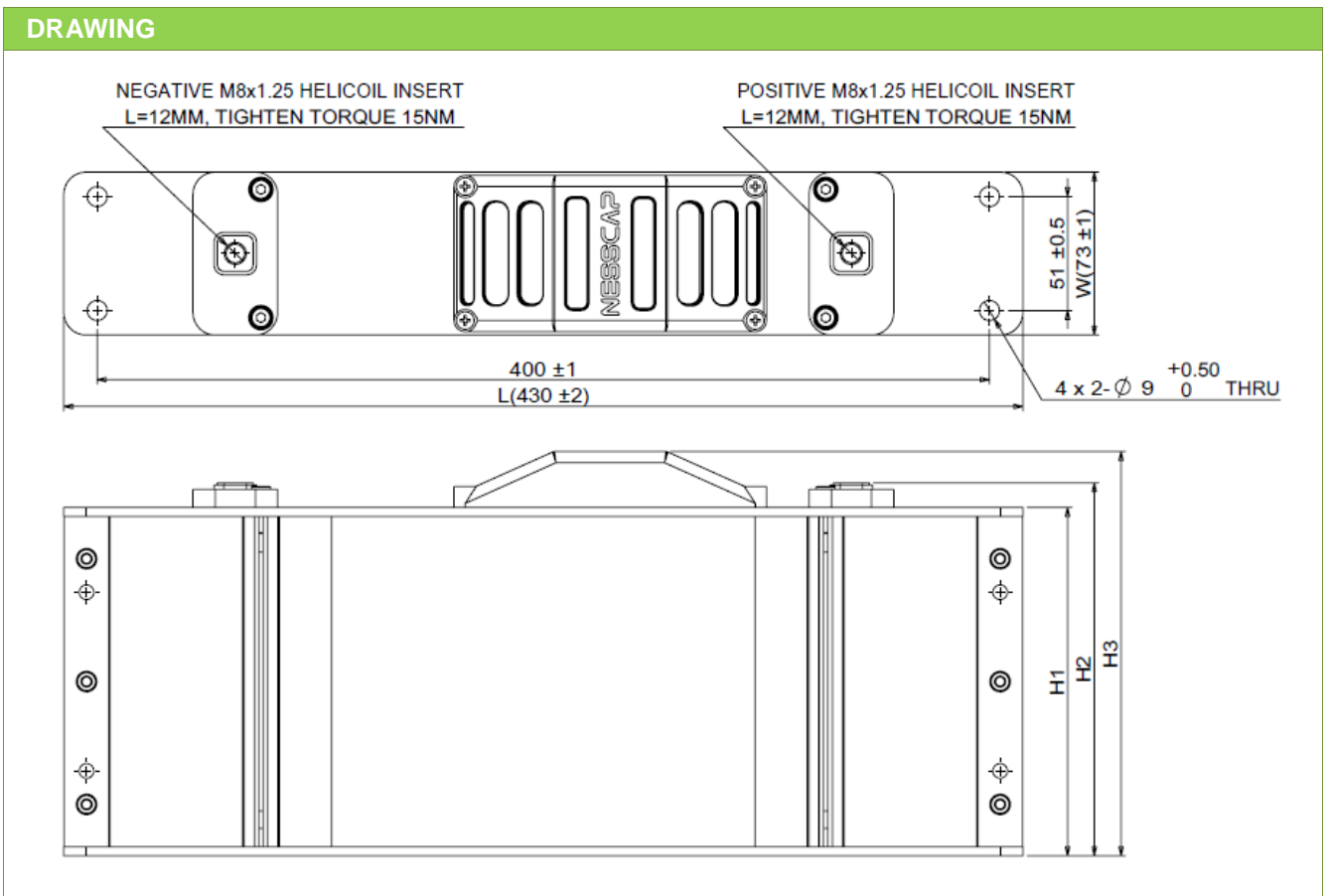
PHYSICAL	
Output Terminals	M8 screw holes
Insulation Coordination	IEC 61287-1 (Category: OV II) Rated insulation voltage: 1kV DC or 2.8kV AC (at 50Hz, 10 sec) Rated impulse withstand voltage: 6kV DC
Protection Degree	IEC 60529 IP 65 (Dust-tight and protected against water jets)
Vibration Specification	SAE J2380
Shock Specification	SAE J2464

SPECIFICATIONS (Cont'd)

UMU / MONITORING	
Cell Balancing	Active single cell balancing
Voltage Monitoring	5V, high and low over-voltage logic signal
Temperature Monitoring	Resistance via NTC thermistor (10kΩ at 25°C)
Connector	Deutsch 4-pin water-proof connector

THERMAL	
Typical Thermal Resistance, $R_{th}$ (Temperature Sensor Output)	0.8 °C/W
Typical Thermal Capacitance, $C_{th}$	4,100 J/°C
Maximum Continuous Current ( $\Delta T = 15^\circ\text{C}$ ) <sup>10</sup>	100 A
Maximum Continuous Current ( $\Delta T = 40^\circ\text{C}$ ) <sup>10</sup>	160 A

SAFETY	
RoHS	Compliant
REACH	Cell-level compliant



DIMENSION & WEIGHT					
L (±2.0)	W (±1.0)	H1 (Max)	H2 (Max)	H3 (Max)	Nominal Weight
430 mm	73 mm	160 mm	170 mm	185 mm	6.0 kg

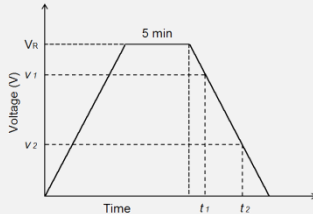
## NOTE

### 1. Surge Voltage

- > Absolute maximum voltage, non-repetitive. The duration must not exceed 1 second.

### 2. Rated Capacitance (Measurement Method)

- > Constant current charge with 4CV [mA] to  $V_R$   
e.g. In case of 16V-500F module,  $4 \times 500 \times 16 = 32,000\text{mA} = 32\text{A}$
- > Constant voltage charge at  $V_R$  for 5min.
- > Constant current discharge with 4CV [mA] to 2.4V.

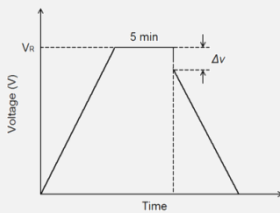


$$C = \frac{I \times (t_2 - t_1)}{v_1 - v_2}$$

where  $C$  is the capacitance (F);  
 $I$  is the absolute value of the discharge current (A);  
 $v_1$  is the measurement starting voltage,  $0.8 \times V_R$  (V);  
 $v_2$  is the measurement end voltage,  $0.4 \times V_R$  (V);  
 $t_1$  is the time from discharge start to reach  $v_1$  (s);  
 $t_2$  is the time from discharge start to reach  $v_2$  (s);

### 3. DC-ESR (Measurement Method)

- > Constant current charge with 4CV [mA] to  $V_R$ .
- > Constant voltage charge at  $V_R$  for 5min.
- > Constant current discharge with 100A to 12V.



$$ESR_{DC} = \frac{\Delta v}{I}$$

where  $ESR_{DC}$  is the DC-ESR ( $\Omega$ );  
 $\Delta v$  is the voltage drop during first 10ms of discharge (V);  
 $I$  is the absolute value of the discharge current (A)

### 4. Average

- > Typical value or percentage spread that may be present in one Shipment

### 5. Typical Leakage Current (LC)

- > LC under 12V (2V per cell) is equal to the LC of the cell measured at the cell's rated voltage and at room temperature after 72 hours.
- > LC over 12V (2V per cell) is the sum of the LC of the cell and the bypass current created by the active balancing circuit.

### 6. Maximum Peak Current

- > Current for 1-second discharging from the rated voltage to the half rated voltage under the constant current discharging mode

$$I = \frac{\frac{1}{2}V_R}{\Delta t / C + ESR_{DC}}$$

where  $I$  is the maximum peak current (A);  
 $V_R$  is the rated voltage (V);  
 $\Delta t$  is the discharge time (sec);  $\Delta t = 1$  sec in this case;  
 $C$  is the rated capacitance (F);  
 $ESR_{DC}$  is the maximum DC-ESR ( $\Omega$ );

- > The stated maximum peak current should **not** be used in normal operation and is only provided as a reference value.

### 7. Energy & Power

- > Maximum Stored Energy,  $E_{max}$  (Wh) =  $\frac{1}{2}CV_R^2 / 3600$

- > Gravimetric Specific Energy (Wh/kg) =  $\frac{E_{Max}}{Weight}$

- > Usable Specific Power (W/kg) =  $\frac{0.12V_R^2}{ESR_{DC} \times Weight}$

- > Impedance Match Specific Power (W/kg) =  $\frac{0.25V_R^2}{ESR_{DC} \times Weight}$

### 8. Endurance and Room Temperature DC Life

- > Test Conditions:
  - Temperature:  $65 \pm 2^\circ\text{C}$ ,  $25 \pm 2^\circ\text{C}$
  - Applied Voltage:  $V_R \pm 0.02V$
- > End-of-Life Conditions:
  - Capacitance: -20% from the rated minimum value
  - DC-ESR: +100% from the rated maximum value
- > Capacitance and ESR measurements are taken at  $25^\circ\text{C}$

### 9. Cycle Life

- > Test Conditions (1-minute cycle at room temperature):
  - Constant current charge from  $1/2V_R$  to  $V_R$ .
  - Constant current discharge from  $V_R$  to  $1/2V_R$ .
  - Repeat the cycle for the desired number of times.

### 10. Maximum Continuous Current

- > Current which can be used within the allowed temperature range under the constant current discharging mode

$$I = \sqrt{\frac{\Delta T}{R_{th} \times ESR_{DC}}}$$

where  $I$  is the maximum continuous current (A);  
 $\Delta T$  is the change in temperature ( $^\circ\text{C}$ );  
 $R_{th}$  is the thermal resistance ( $^\circ\text{C}/\text{W}$ );  
 $ESR_{DC}$  is the DC-ESR ( $\Omega$ )

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 <b>Nesscap Energy Inc.</b> Suite 3800, Royal Bank Plaza, South Tower, 200 Bay Street, P.O. Box 84, Toronto, Ontario, M5J 2Z4 <b>CANADA</b>	 <b>Nesscap Energy Inc.</b> S24040 Camino Del Avion #A118, Monarch Beach, California, 92629 <b>USA</b>	 <b>Nesscap Co., Ltd.</b> 17, Dongtangiheung-ro 681beon-gil, Giheung-gu, Yongin-si, Gyeonggi-do <b>REPUBLIC OF KOREA</b>	 <b>Nesscap China</b> Room 1608, Block N, Cangson Building, Chegonmiao, Futian District, Shenzhen City, P.R.C <b>CHINA</b>	 <b>Nesscap Energy GmbH</b> Beerengarten 4 D-86938 Schondorf <b>GERMANY</b>
<a href="mailto:marketing@nesscap.com">marketing@nesscap.com</a>				<a href="mailto:info@nesscap-energy.de">info@nesscap-energy.de</a>