FEATURES

- *Rated voltage of 48V and capacitance of 166F*
- *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:*
  - *Hybrid Bus, Transportation and Automotive*
  - *Wind Turbine, Industrial UPS and DVR*

** Image is not to scale*

SPECIFICATIONS

ELECTRICAL		EMHSR-0166C0-048R0S
Rated Voltage, V_R		**48 V_{DC}**
Surge Voltage[1]		51.3 V_{DC}
Rated Capacitance[2]		**166 F**
Capacitance Tolerance	Maximum	0% / +20%
	Average[4]	+3% / +8%
DC-ESR (Equivalent Series Resistance)[3]	Maximum	5.6 mΩ
	Average[4]	3.1 mΩ
Typical Leakage Current[5]	Under 36V	5.2 mA
	Over 36V	45 ~ 59 mA
Maximum Peak Current, Non-repetitive[6]		2,000 A
Maximum Stored Energy, E_{max}[7]		53.1 Wh
Gravimetric Specific Energy[7]		3.3 Wh/kg
Usable Specific Power[7]		3.0 kW/kg
Impedance Match Specific Power[7]		6.4 kW/kg

TEMPERATURE	
Operating Temperature Range	-40 ~ 65°C (ΔCAP<5% and ΔESR<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)[8]	1,500 hours
Room Temperature (at V_R and 25°C)[8]	10 years
Cycle Life (at 25°C)[9]	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

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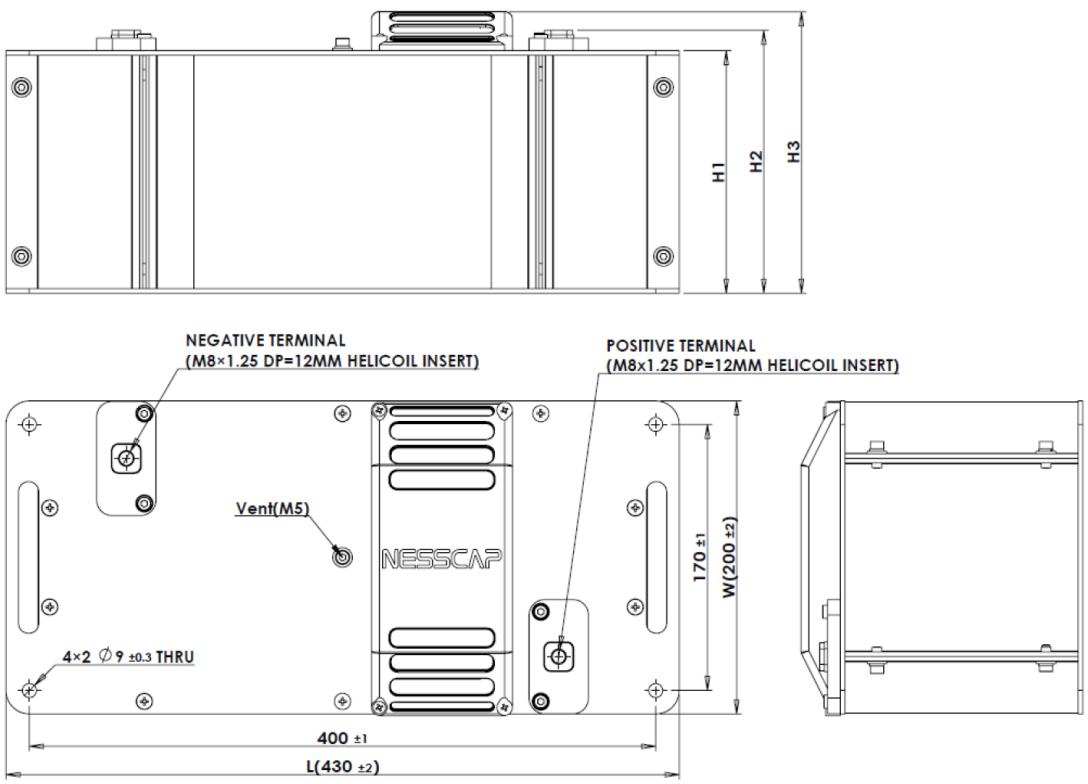
SPECIFICATIONS (Cont'd)

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)	0.3 °C/W
Typical Thermal Capacitance, C_{th}	12,500 J/°C
Maximum Continuous Current (ΔT = 15°C)[10]	90 A
Maximum Continuous Current (ΔT = 40°C)[10]	150 A

SAFETY	
RoHS	Compliant
REACH	Cell-level compliant

DRAWING



DIMENSION & WEIGHT					
L (±2.0)	W (±2.0)	H1 (Max)	H2 (Max)	H3 (Max)	Nominal Weight
430 mm	200 mm	160 mm	170 mm	182 mm	16 kg

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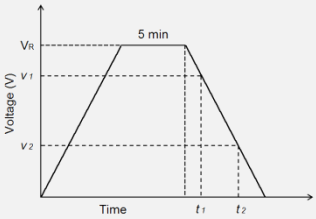
NOTE

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 48V-166F module, 4 x 166 x 48 = 31,800mA = 31.8A
> Constant voltage charge at V_R for 5min.
> Constant current discharge with 4CV [mA] to 7.2V.

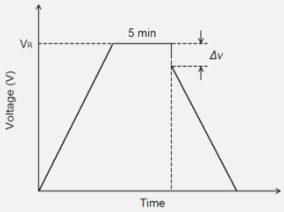


$$C = \frac{I \times (t_2 - t_1)}{v_1 - v_2}$$

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 x V_R (V);
v_2 is the measurement end voltage, 0.4 x 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 to V_R.
> Constant voltage charge at V_R for 5min.
> Constant current discharge with 100A to 45V.



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

where ESR_{DC} is the DC-ESR (Ω);
Δv 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 36V (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 36V (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);
Δt is the discharge time (sec); Δt = 1 sec in this case;
C is the rated capacitance (F);
ESR_{DC} is the maximum DC-ESR (Ω);

> 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) = $\frac{\frac{1}{2}CV_R^2}{3600}$

> 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 ± 2°C, 25 ± 2°C
- Applied Voltage: V_R ± 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°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);
ΔT is the change in temperature (°C);
R_{th} is the thermal resistance (°C/W);
ESR_{DC} is the DC-ESR (Ω)

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