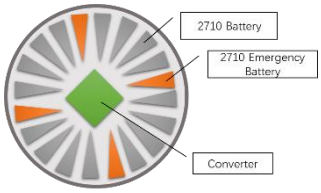
PPU FOR RETRACTABLE ROOF C12

Company logo: Hang Xu 1856033

PPU render: The top view is showed. And the PPU is located in the central box of the roof.



Top view

PPU title and subtitle: Power Processing Unit for Retractable Roof

Technical Description:

The Power Processing Unit is the main power supply for the umbrella shaping retractable roof for Nelson Mandela Bay Stadium. The umbrella membrane roof with 16 rails on the support structure is controlled by servo DC motors on each rail. Because of the special design, the calculated data is different with regular stadium roofs. The 80-ton roof is light enough so that the power rate of each servo DC motor can be 50W, which is able to be driven by Li-on batteries. And base on the information above, the Power Processing Unit consists of three parts, the converter part, the battery pack part and the PWM output control part. The usage of the 2170 Battery (which is also used by Tesla and Samsung) separates the whole system into two subsystems, power supply system (using industrial electricity to charge the battery) and control system (using the battery voltage to drive the motor and adjust motor speed by changing the output PWM duty of the battery).

Key Feature:

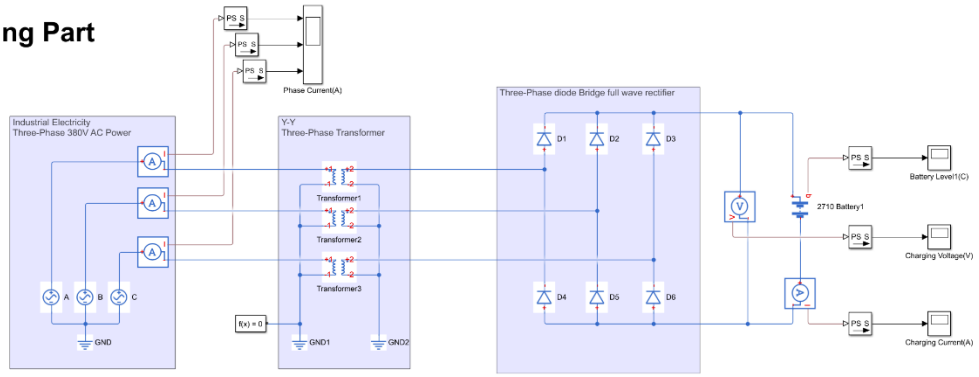
1. Fast charge: Convert three-phase industrial electricity to the highest possible DC power which can be accept by the battery and will not make the battery overheating.
2. Super stable DC output: With the storage power, each piece of battery is able to output a super stable and adjustable DC power for the servo motors.
3. Easier and cheaper method of maintenance: The converter, battery pack, PWM and motors, each part is an independent and replaceable module.
4. Emergency case solver: The battery is able to work at any situation unless itself broken. In that situation, the backup battery will help.
5. Energy efficiency: the system will not waste any energy when not activated. The connection between loads and the battery will be disconnected after the roof open or close.

Technical Specification:

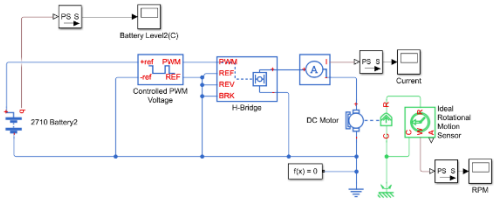
- Power input: three-phase 380V AC
- Converter output: 480V DC
- Power output: 0-60V DC
- Battery: 2170 Battery *14 *20
- Total Battery Weight: 66g *14 *20 =18.48kg
- Total Battery Volume: 24250mm^3 *14 *20 =6.79 *$10^6 mm^3$

Model:

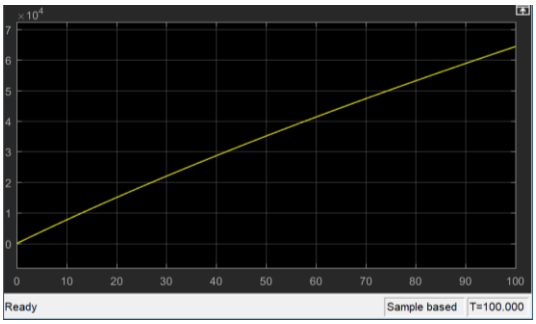
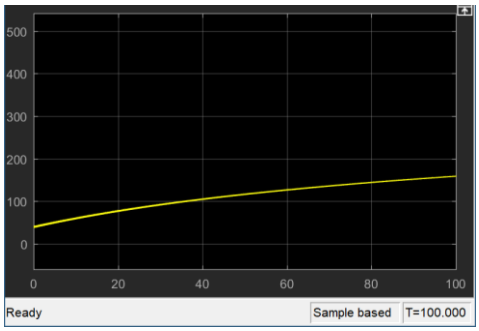
Battery Charging Part



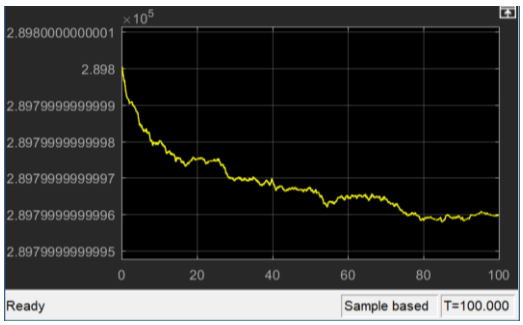
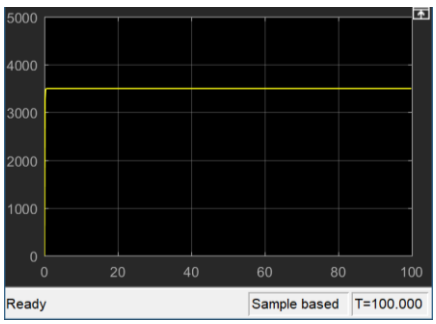
Motor Operating Part



Charging Part

Charging Battery Level (C)	Charging Voltage (V)
	

Operating Part

Working Battery Level (C)	RPM
	

Calculation:

Number of the battery cell:

The servo motor's rate voltage is 60V, so that each battery pack for each rail should contain 60/3.7=14 cells, and for there are 16 rails, also consider having a backup battery pack for each 4 pack, the total number of the battery comes to 14*20= 280.

Pack charging capacity:

Each battery pack have a full battery level at 5.75Ah*14 = 289800C, which is showed in the *Working Battery Level* figure.

Available operating time:

Each rail has two servo motors on it. And the power rate of a motor is 50W. So, each battery pack can support more than 21.275Wh*14/100W = 3 hours operating.

2170 Battery Spec

Property	Value	Unit
Length	70	mm
Diameter	21	mm
Volume	24,250	mm^3
Weight	66	gram
Voltage	3.7	V
Charge	5,750	mAh
Capacity	21.275	Wh
Energy density	877,5	Wh/L
Specific energy	322,3	Wh/kg
Density	2,72	kg/L

Work Plan:

Although I spent whole week on the simulation and calculation, this is still just a v0.22 DEMO which is only better than a few simple attempt files. The Simulink library is not that friendly to use because the incompatibility between the foundation library and technologies library. So, I need to build more useful module which is needed like voltage regulator by the basic components. Also, the temperature problem needed to be consider, fortunately, the charging voltage I select is already putted into practice by Tesla. The efficiency of the circuit is also unable to calculate because the lack of module. After all these problem settled, I will combine all that separated Simulink module together with the control system.

Reference:

Three-phase ac-dc power supply design and experiments using a sic based power module
By Chintan A. Raval
https://www.electronics-tutorials.ws/connectivity/ac-dc-converters.html
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https://www.reddit.com/r/teslamotors/comments/65pt0k/tesla_2170_battery_cell_specifications_calculated/