Large-sized Li-ion Battery Module for Hybrid Powered Energy System

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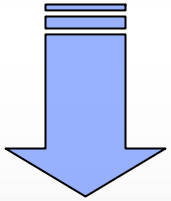
*** GS Yuasa Corporation**
****United Lithium Systems**

Background of Development

- Increasing demand of large-scale lithium ion batteries for high power industrial applications such as hybrid powered energy systems



Development of new, large-scale lithium ion cell and battery modules which have high power, long life and superior cooling performance

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Agenda

- **Cell Specifications, Technologies and Performance**
- **Battery Module Specifications and Cooling Evaluation**
- **Evaluation of Energy Efficiency for Hybrid Powered Energy System (Railway Vehicle Systems)**

LIM30H Cell Specification

Mass / kg	**2.0**
Dimension / mm	**47W, 170L, 133H**
/ in	**1.85” x 6.7” x 5.2”**
Nominal voltage / V	**3.6**
Nominal capacity / Ah	**30**

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Key Technologies of LIM30H

- **Positive active material:**

  $LiMn_2O_4$ improved for safety and long life

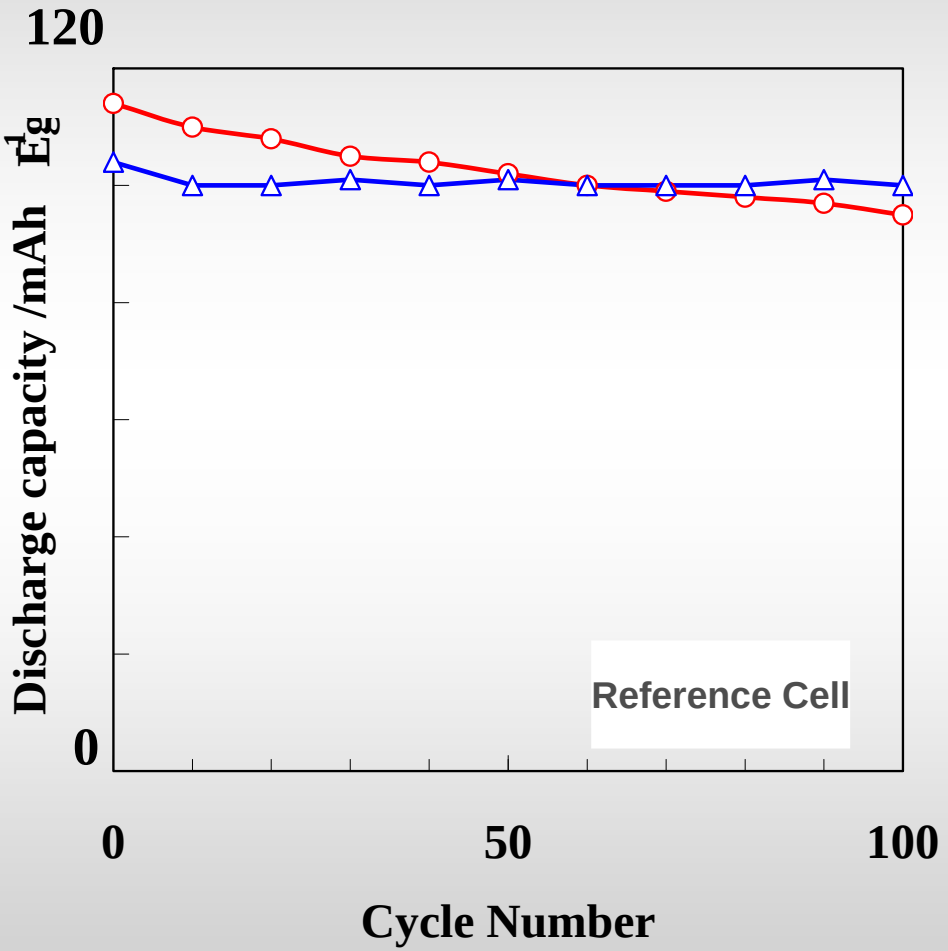
- **Negative active material:**

  Hard carbon for improved high rate charge/discharge performance and high energy efficiency

- **Structure:**

  Robust current collecting construction for high amperage charge/discharge

Cycle Life Performance of Improved Manganese Active Material



Charge : 1.0 mA / cm^2 to 4.3 V
Discharge : 2.0 mA / cm^2 to 3.0 V
Temperature : 60□ ž
Electrolyte : Standard
Working electrode : LiMn2O4
Counter electrode :Li metal
Reference electrode :Li metal

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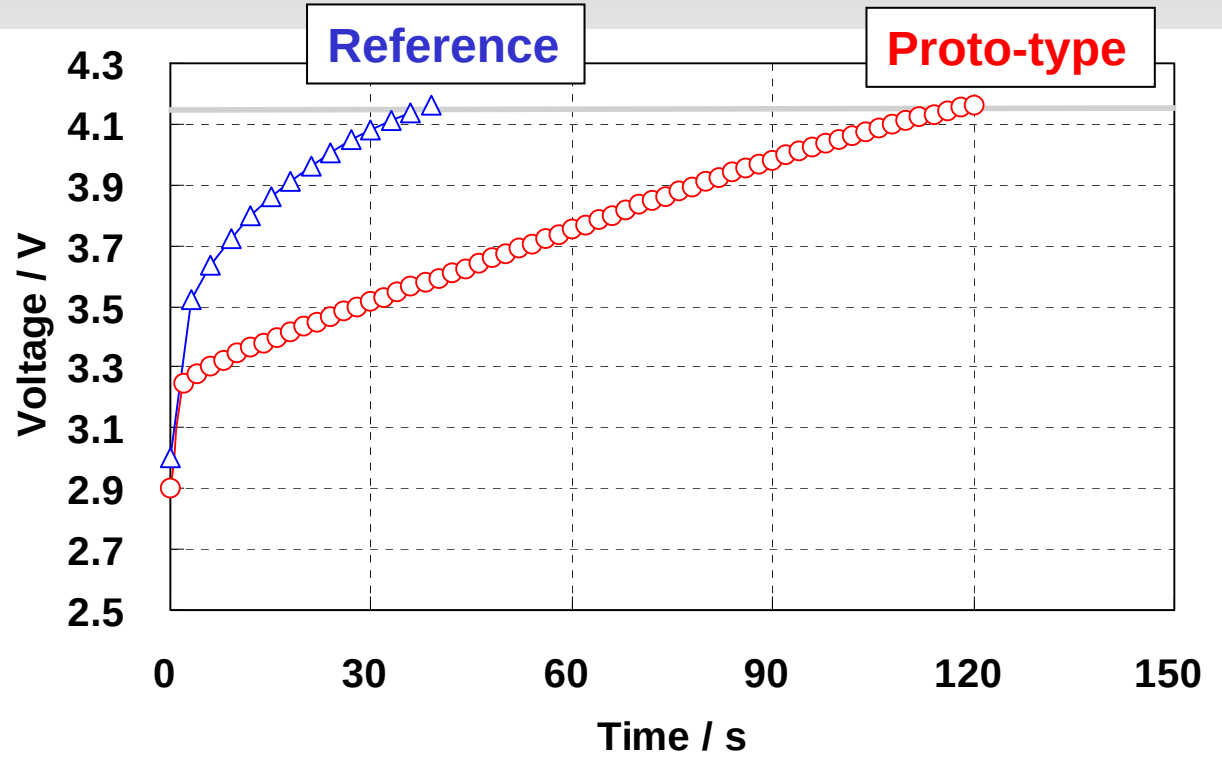
Quick Charge Performance of the Cells with Various Negative Active Materials



1. Proto-type cell Negative active material: Hard carbon

2. Reference cell Negative active material: Graphite

Charge conditions Discharge : 1CA to 2.75 V at 25°C

Charge : 10CA to 4.15 V at 25°C

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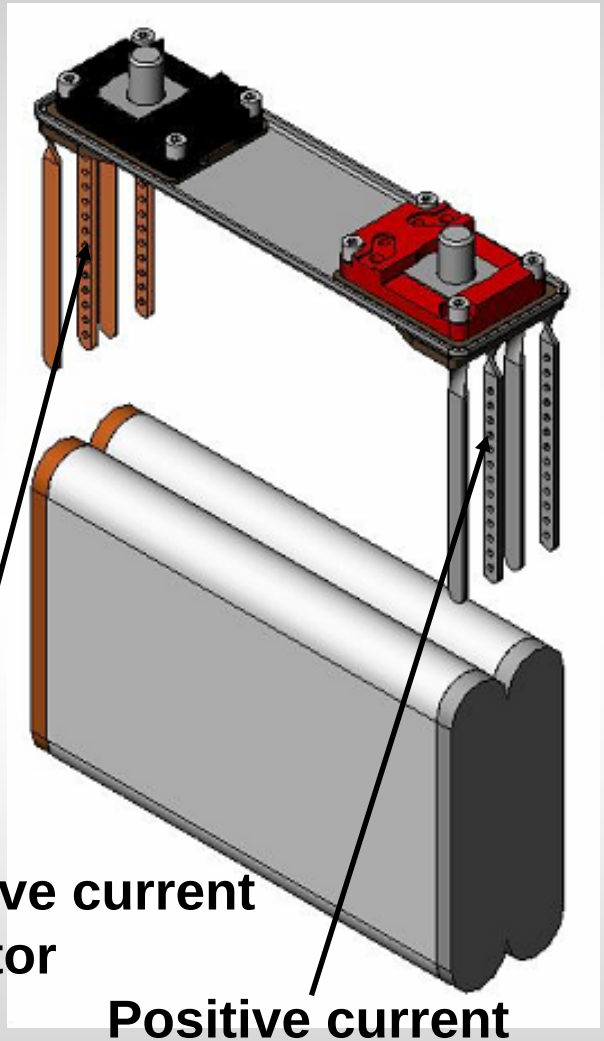
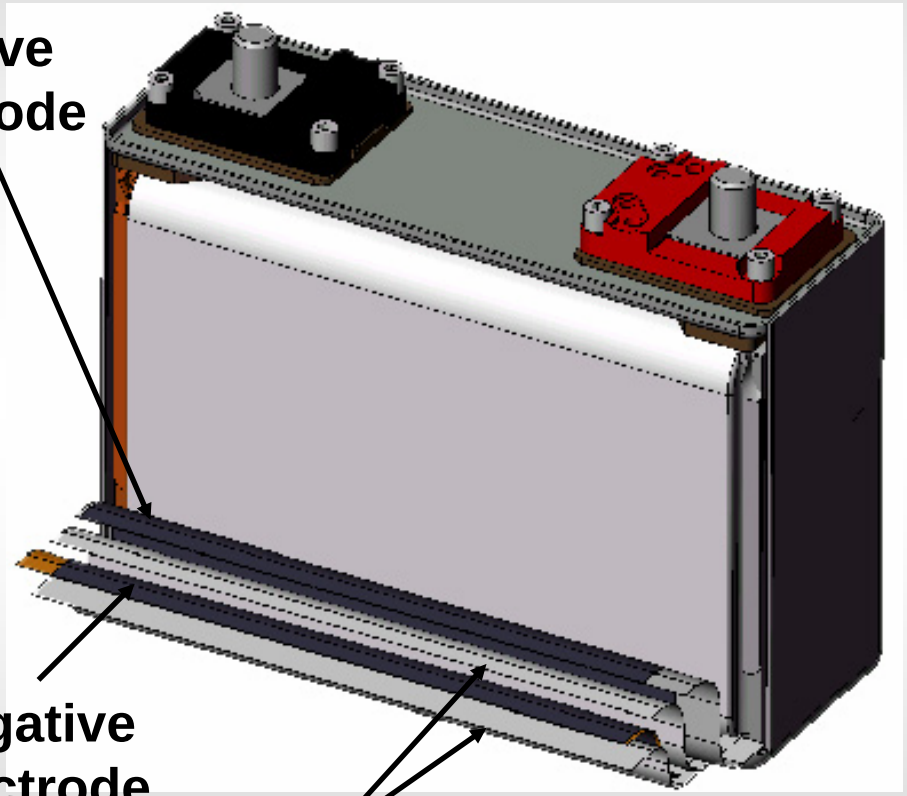
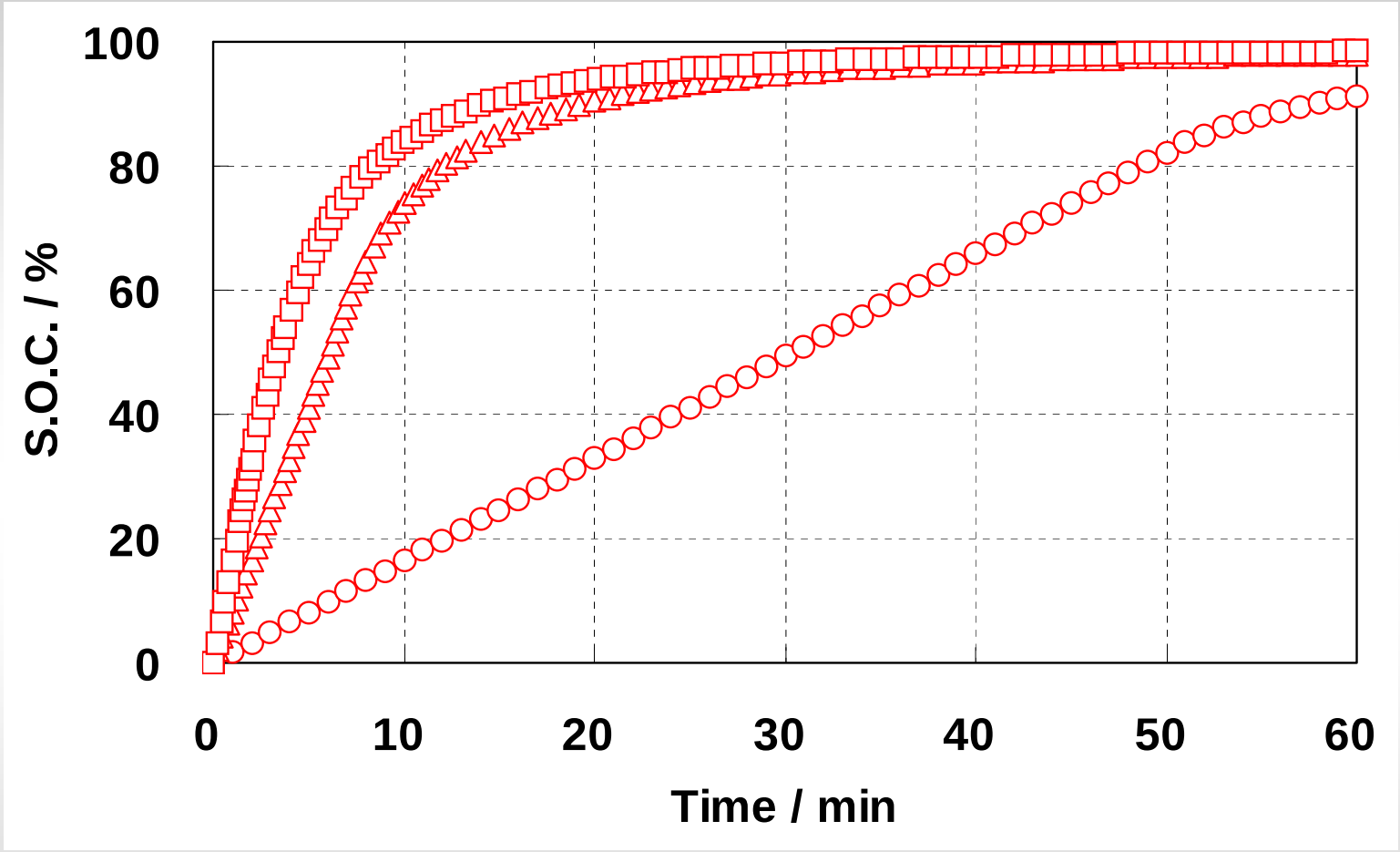
Structure of LIM30H





Quick Charge Performance of LIM30H



Charge : (○)30 , (□)150, and (□)300 A to 4.15 V followed by constant voltage of its value for 3 hours at 25 °C

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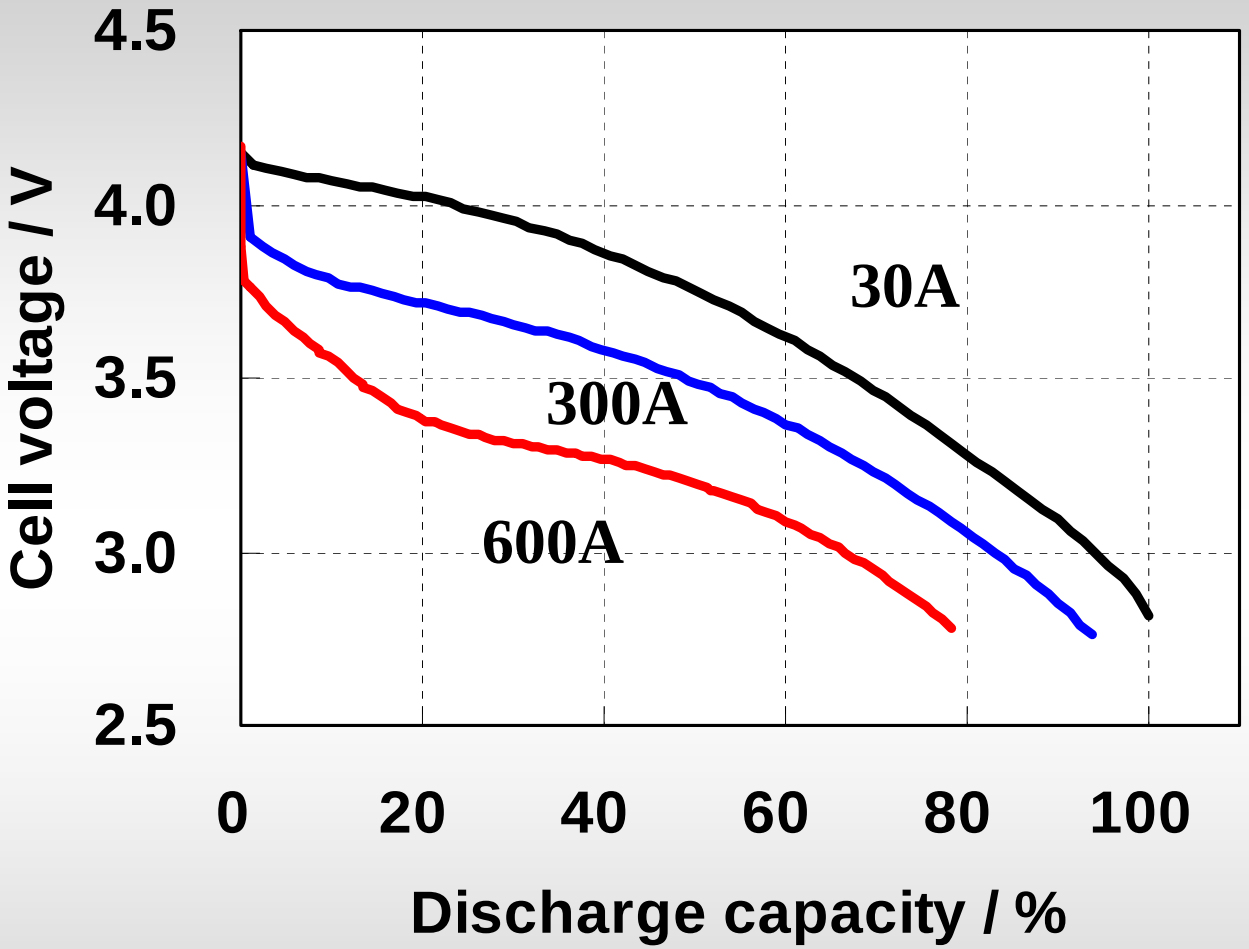
Discharge Performance of LIM30H



Charge : 30 A to 4.15 V followed by constant voltage of its value for 3 hours at 25°C

Discharge : Discharge with various current at 25°C

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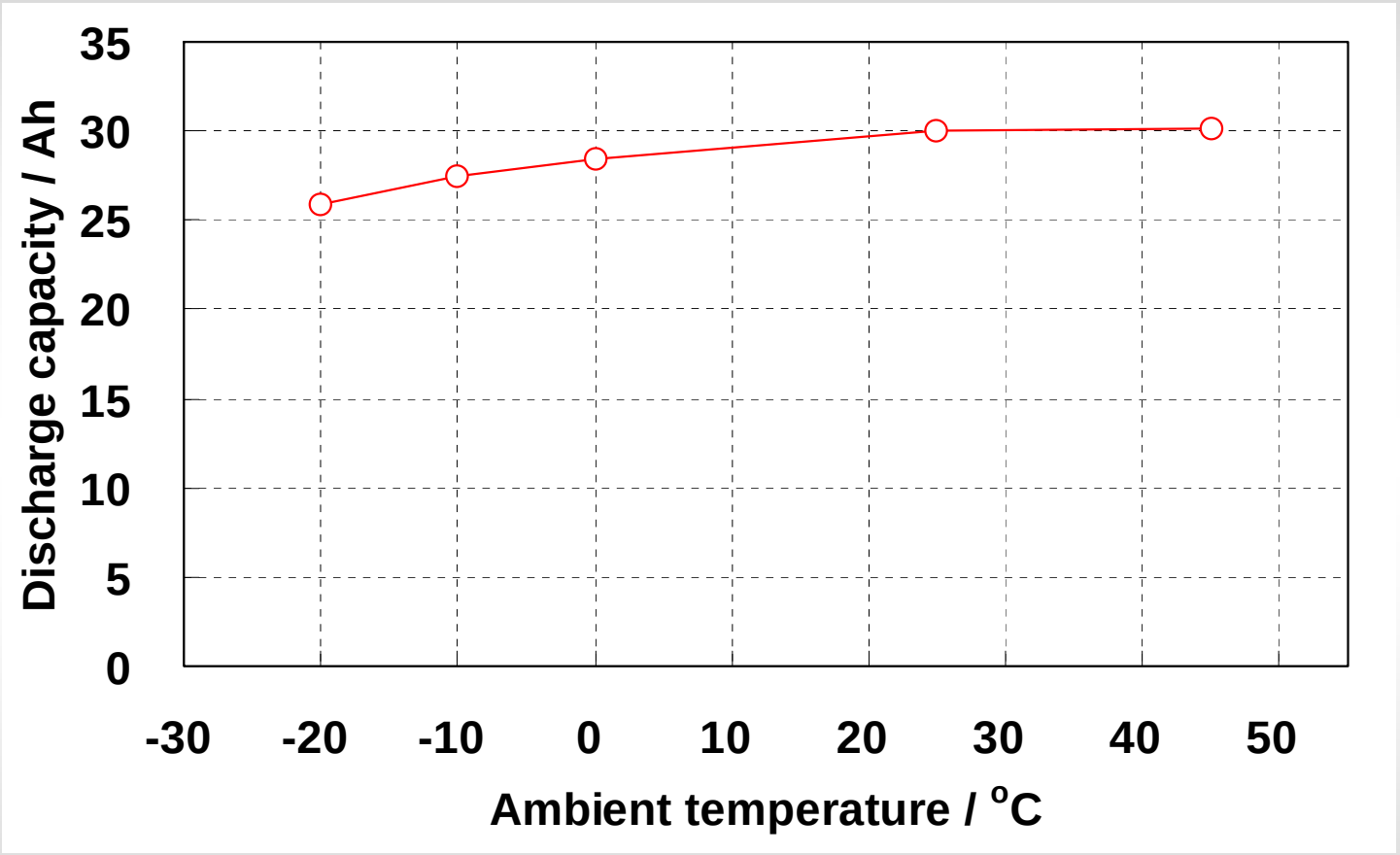
Discharge Capacities of LIM30H at Various Ambient Temperature



Charge : 30 A to 4.15 V followed by constant voltage for 3 hours at 25°C

Discharge : 30 A to 2.75 V at various ambient temperature

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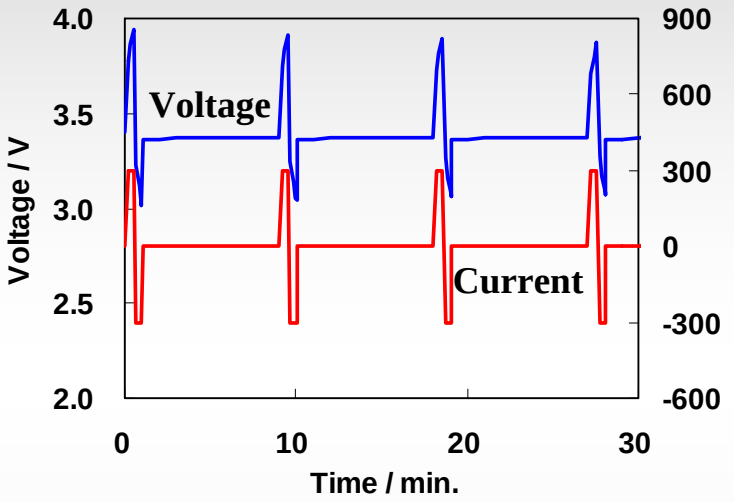
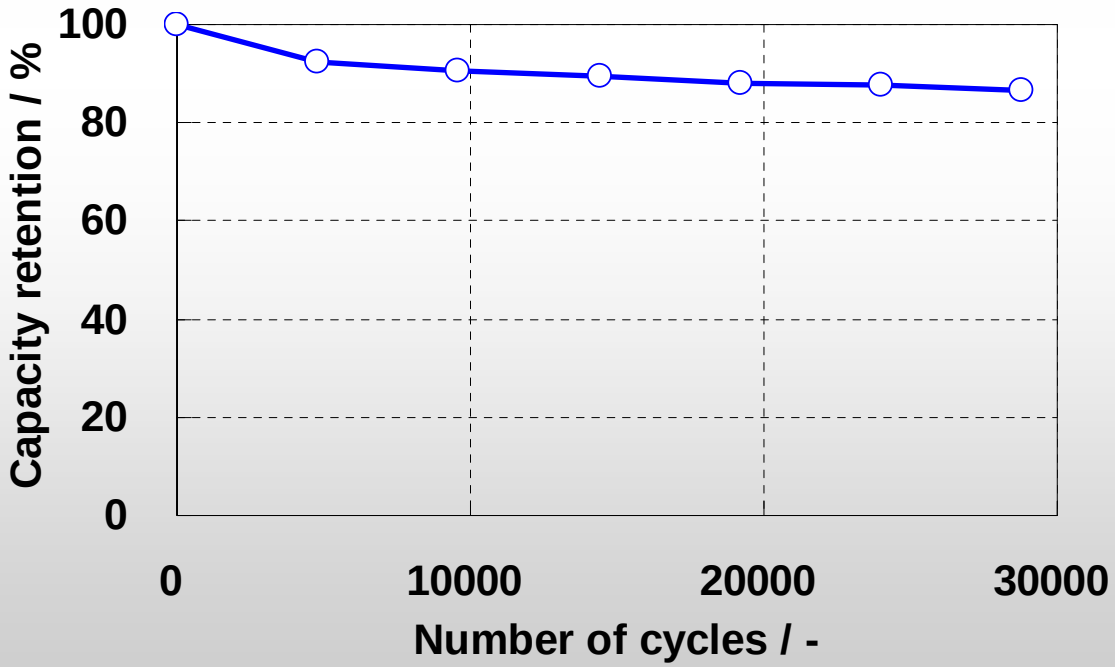
Life Performance of LIM30H under Large Current Charge Discharge Pulse Cycle



300A pattern cycle:

Charge- 300A 30sec.
Discharge- 300A 30sec.
Rest- 480sec.



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LIM30H-8R Module Specifications

Items	Specifications
Cell	LIM30H (8 cells in series)
Nominal capacity	30 Ah
Nominal voltage	28.8 V (3.6 V / cell)
Operating voltage	20.0 – 33.6 V (2.5 – 4.2 V / cell)
Dimensions	W231 – D375 – H147 / mm
Mass	18.5 kg
Cooling	Designed for forced air cooling
Cell management	Cell Scanner(CS) installed

LIM30H-8R

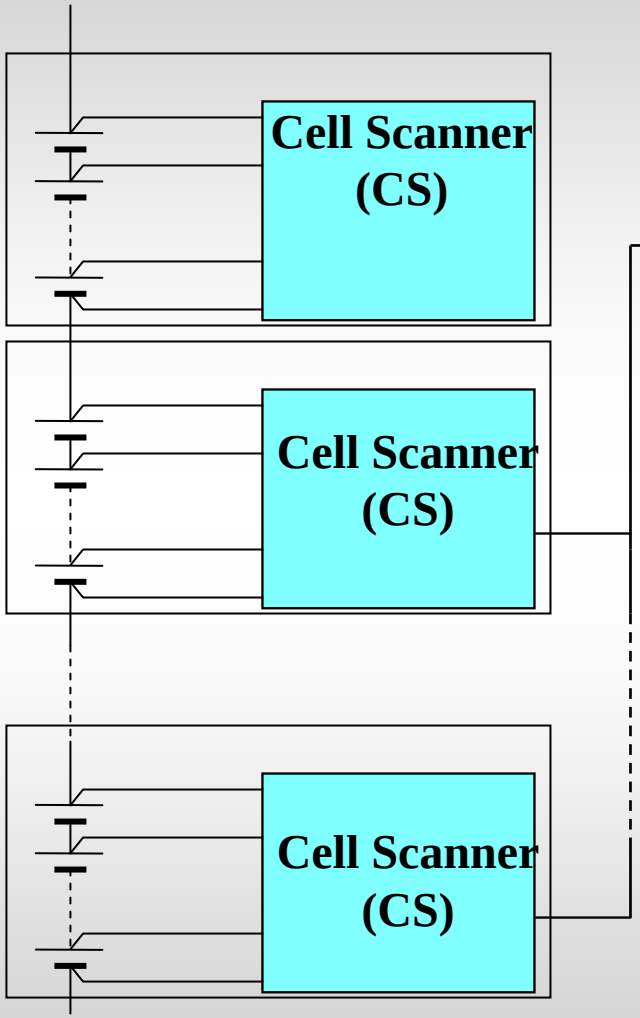
Negative Terminal

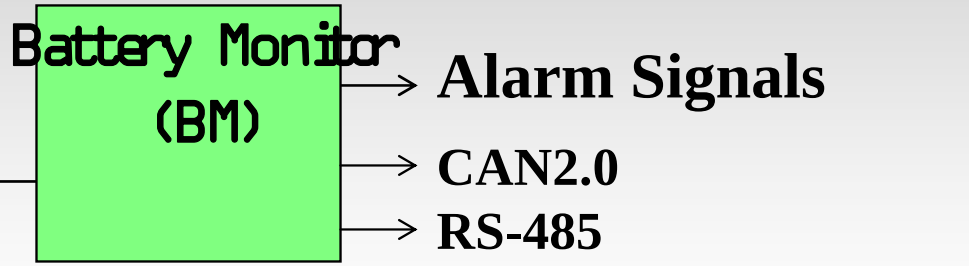
Cell Scanner

Air Intake

Positive Terminal

Battery Monitoring System of LIM30H-8R





Functions of CS

>Monitor the each cell voltage
>Monitor the battery temp
>Balance the cell voltage
>Communicate with BM

Functions of BM

>Out put alarm Signals
>Communicate with outer systems
>Calculate State of Charge
>Balance the Module voltage

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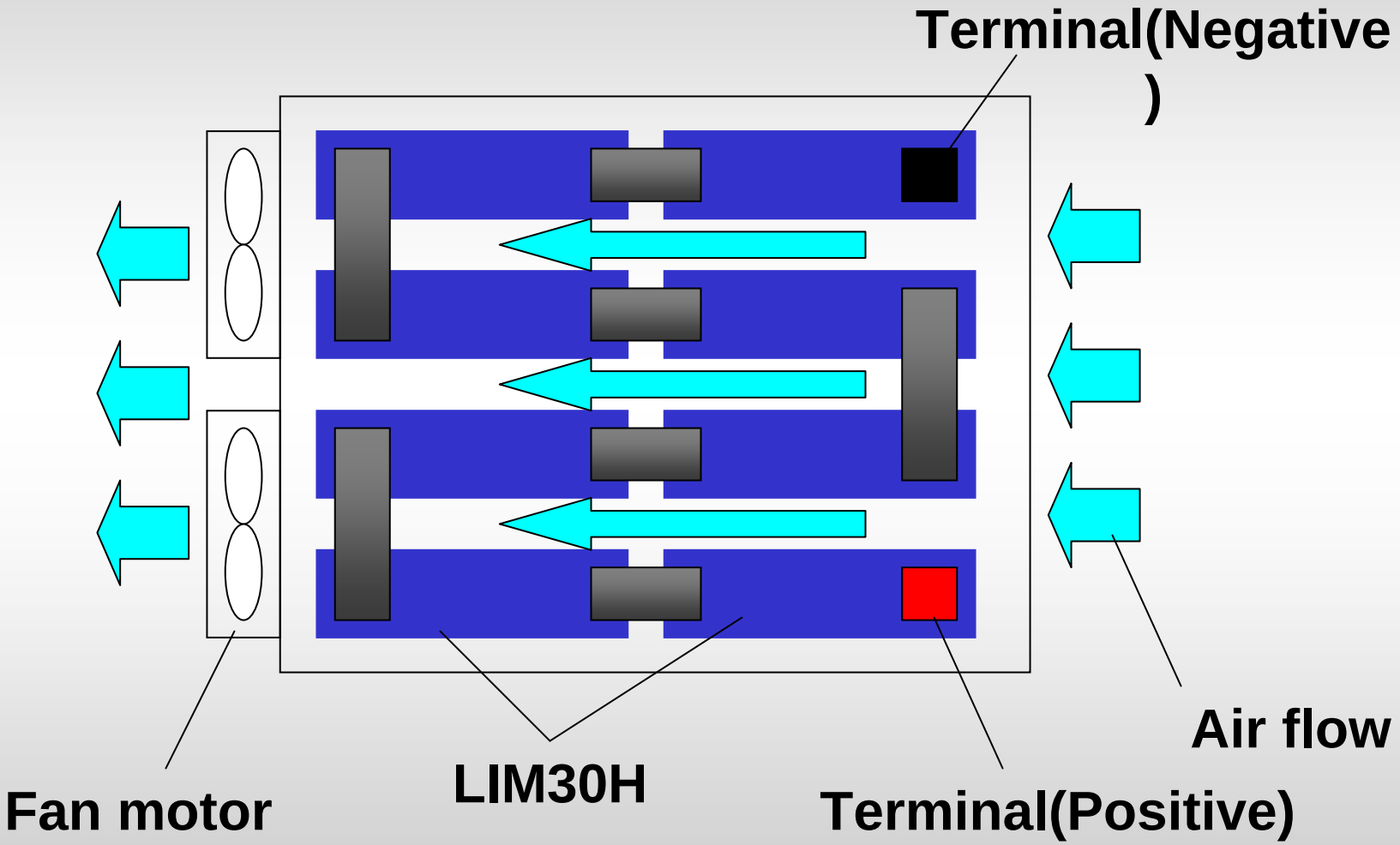
Cooling Air Flow of LIM30H-8R



Battery powered tram

(Railway Technical Research Institute,Japan)-

Cell	**55Ah-class proto type**
	(92W, 170L, 133H)
Battery system	**168 cell-series**

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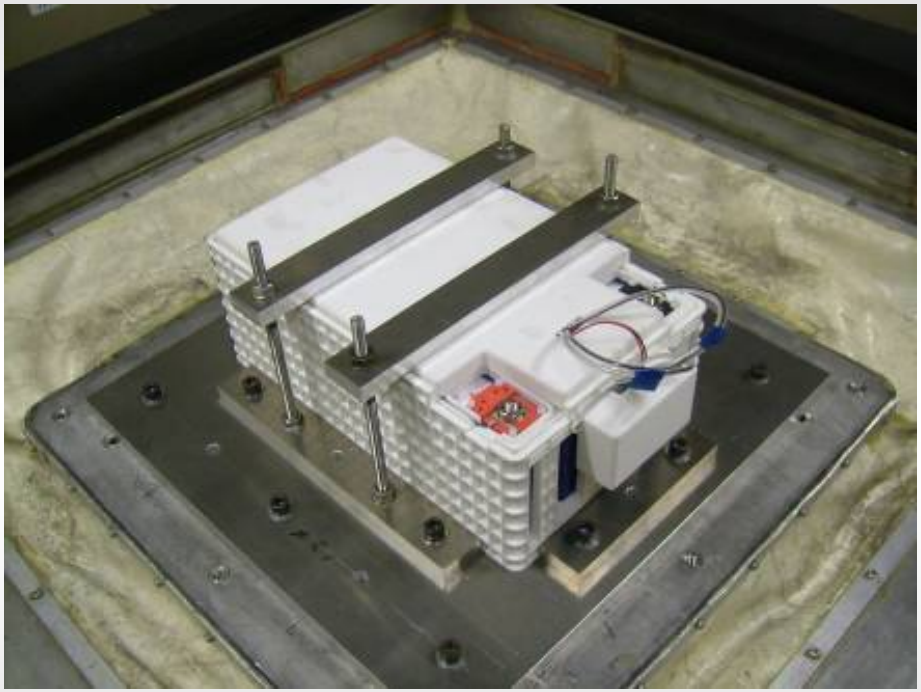
LIM30-8

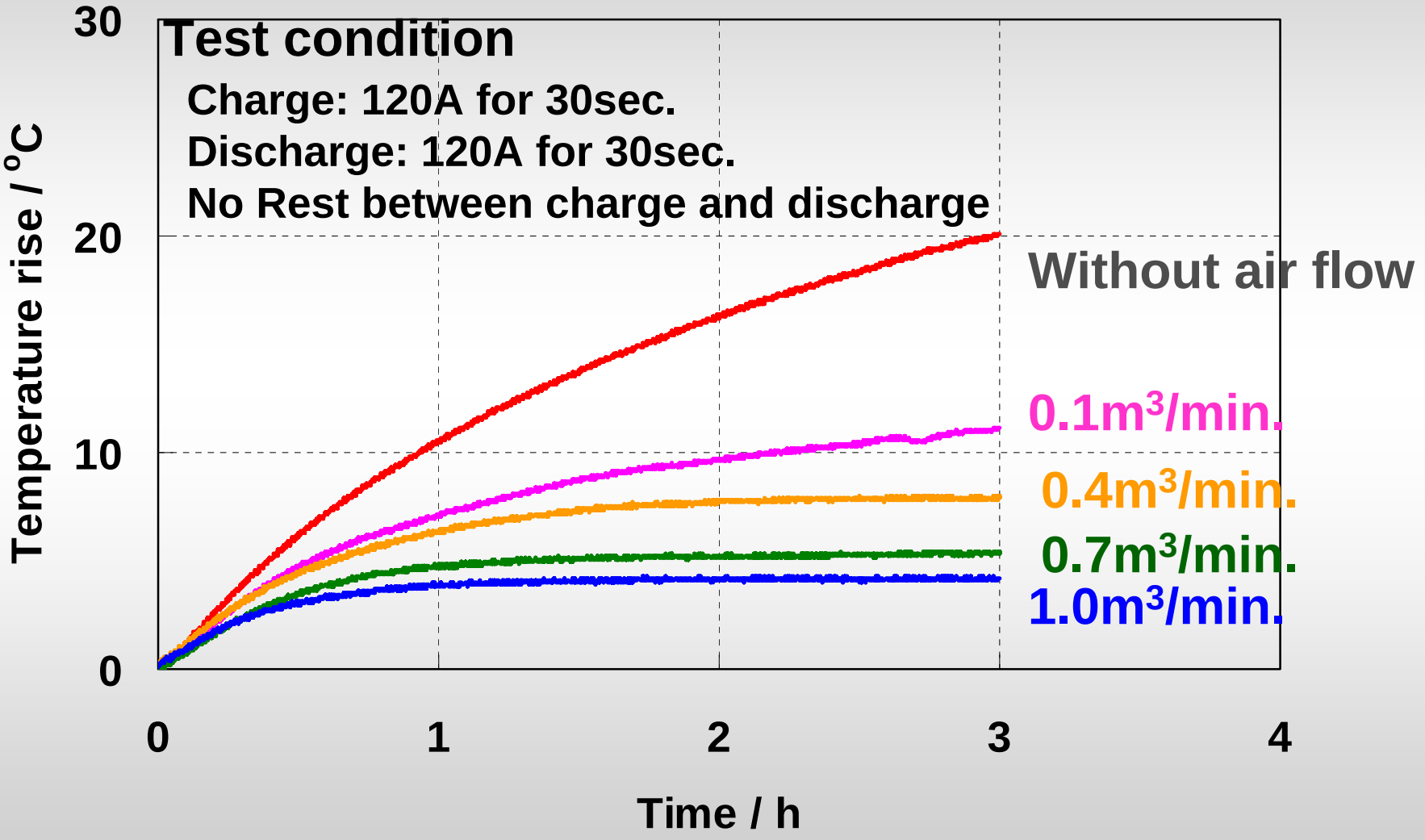
Environmental Test



Vibration test

- UN3090
- JIS E 4031 2B (JIS : Japanese Industrial Standard)

Temperature Rise of LIM30H-8R with Large Current (120A) Operation with Various Air Flow



Agenda

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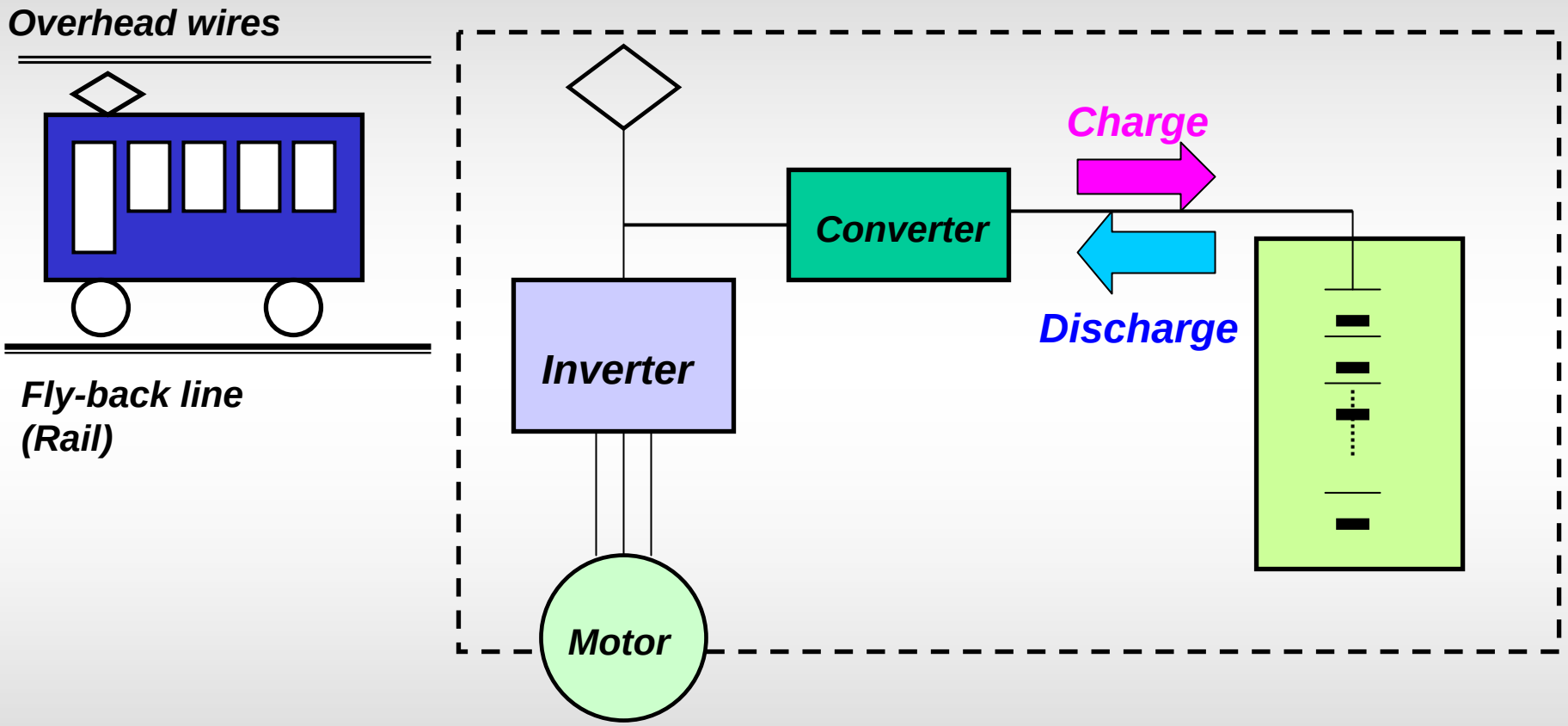
Example of Hybrid Powered Energy System (Hybrid Railway Vehicle Power System)



Evaluation of Energy Efficiency for Hybrid Railway Vehicle Power System

Test Battery: LIM30H-8R-22series (30Ah-634V)

Charge discharge conditions:

1. **Discharge** (Acceleration assist): **90kW for 60 sec.**
2. **Rest** (Constant speed running): **180 sec.**
3. **Charge** (Regeneration at Decelerating):**200kW for 30 sec.**
4. **Rest** (Stop at the station): **30 sec.**

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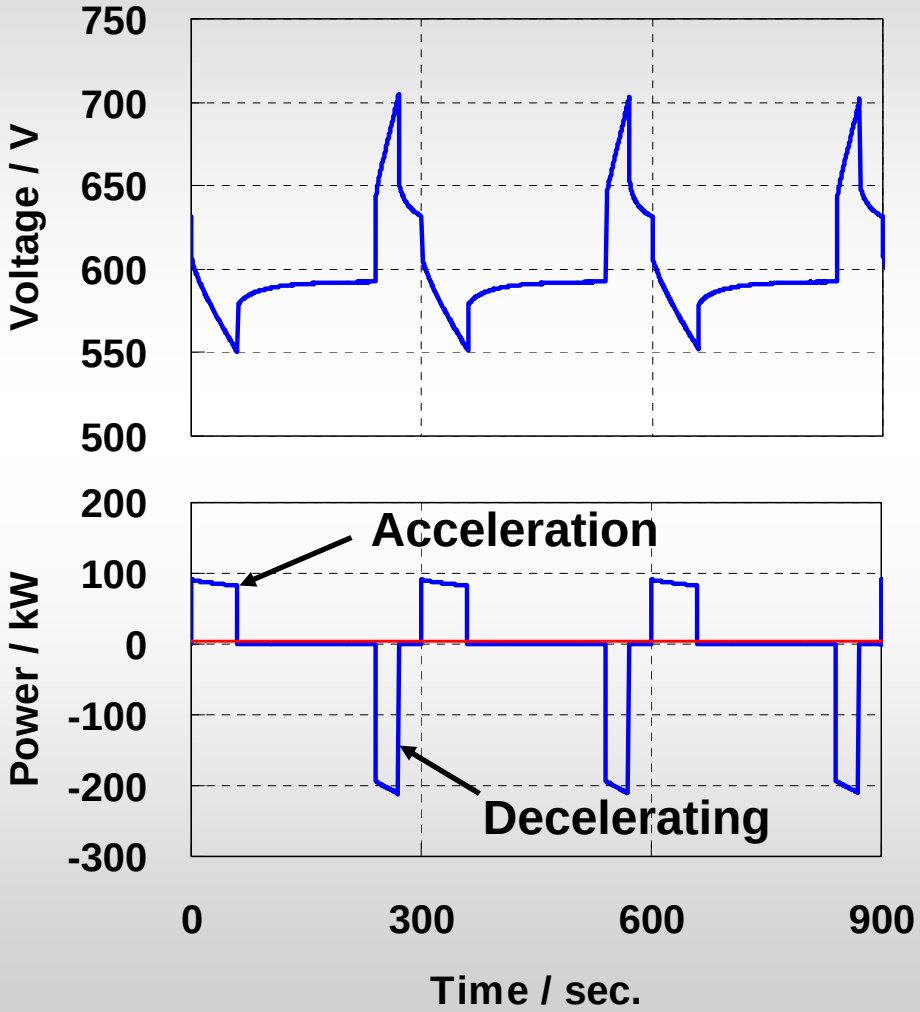
Result of Energy Efficiency Test for Hybrid Railway Vehicle Power System



Energy efficiency

$$= \int W_{out}\,dt \Big/ \int W_{in}\,dt$$

= 82%

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Conclusions

Newly developed Large-sized Li-ion Battery Module(LIM30H-8R) for Hybrid Powered Energy System has the following features:

- **High rate charge and discharge capability**
- **Longer life performance under large current charge discharge pulse cycles**
- **CS (cell scanner) is included in each battery module, Battery Monitor communicates to vehicle**
- **Thermal management for large current continuous operation**
- **Higher energy efficiency suitable for hybrid energy system**

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