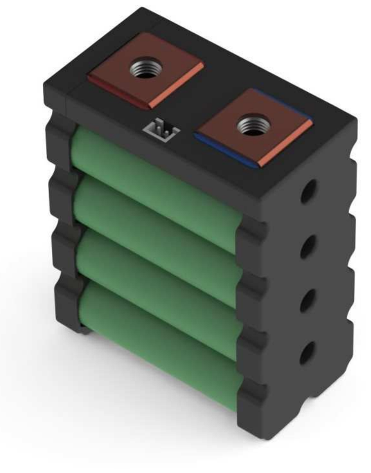
Li-ion building block Li8P25RT



INTRODUCTION

A Li-Ion building block was developed with simplicity and safety in mind. Using 18650 lithium-ion technology, such building blocks offer the most modern and energy-dense solution in easy to use package. 18650 is a very well established and time-tested battery cell standard, especially common in consumer devices. These cells are designed to withstand consumer's abuse, while offering the best in class energy density.

SAFETY

In addition to internal protection techniques, the module includes two fuses for each cell, 16 for entire 8-cell module. These act as a second level protection devices in case of cell failure.

In case of cell venting, released gas is travelled through dedicated channels to avoid pressure buildup.

FLEXIBILITY

Due to simple nature of these building blocks, desired battery pack configuration can be built in minutes, connecting them in series and parallel using bolt connections. Even MWh-scale batteries can be assembled with ease.

FEATURES

- Small size: 307 Wh per liter
- Low weight: 172 Wh per kg
- Individually fuse-protected cells
- Ultra low and equal self-discharge
- Rapid prototyping of battery pack
- Convenient thermal control
- Built from Samsung INR18650-25R cells
- Built-in 4-point temperature sensor
- UL94-V0 rated, fire-retardant plastics

APPLICATIONS

- Performance electric vehicles
- Special purpose machines
- Backup energy storage

Table 1. Product characteristics (all parameters rated at 25°C if not specified otherwise)

Parameter	Comment	Min.	Typ.	Max.	Unit
Battery voltage	Allowed range	2.50	3.60	4.20	V
Battery capacity	20A discharge to 2.5 V	19.5	20.4	-	Ah
	20A discharge to 2.5 V	70.2	73.4	-	Wh
	200A discharge to 2.5 V	18.5	19.5	-	Ah
Fast charge current	Forced air cooling	-	-	40	A
	No cooling, in a pack	-	-	30	A
	10 sec. pulse, 50% SOC	-	-	240	A
Discharge current	Forced air cooling	-	-	240	A
	No cooling, in a pack	-	-	120	A
	10 sec. pulse, fuse limited	-	-	360	A
Initial internal impedance	1kHz after rated charge	-	2.7	3.0	mΩ
Internal fuse rating	Holding current	-	-	360	A
Working temperature	Discharge	-20	25	60	°C
	Charge	0	25	45	°C
Dimensions	±0.5 mm	-	39×69.5×87	-	mm
Weight	Without fasteners	-	0.427	0.429	kg

DISCHARGE CHARACTERISTICS

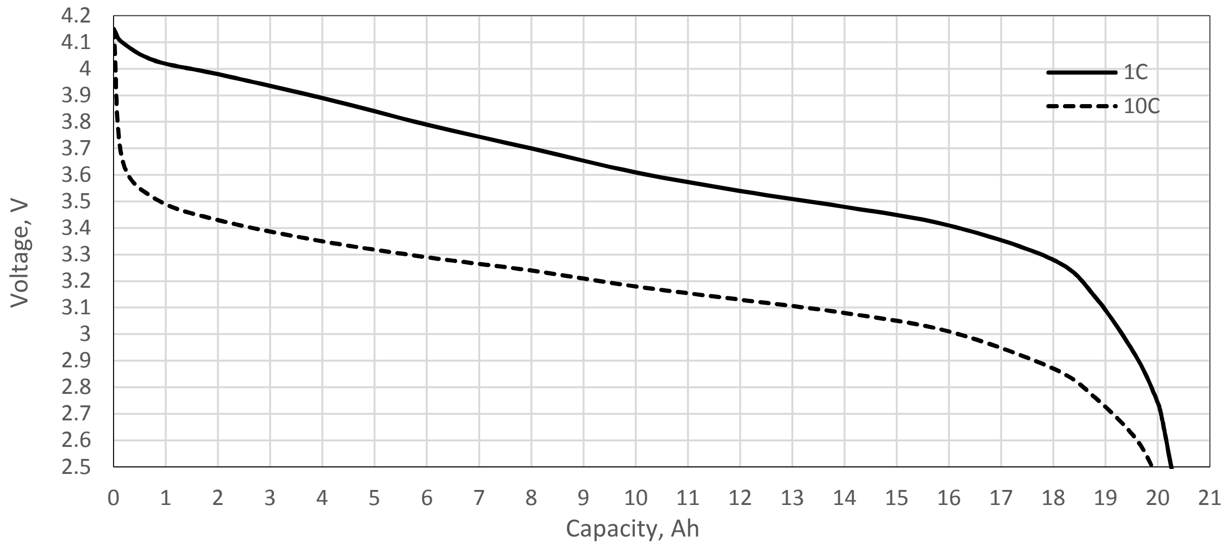


Figure 1. A typical discharge slope at 1.0C and 10C rate.

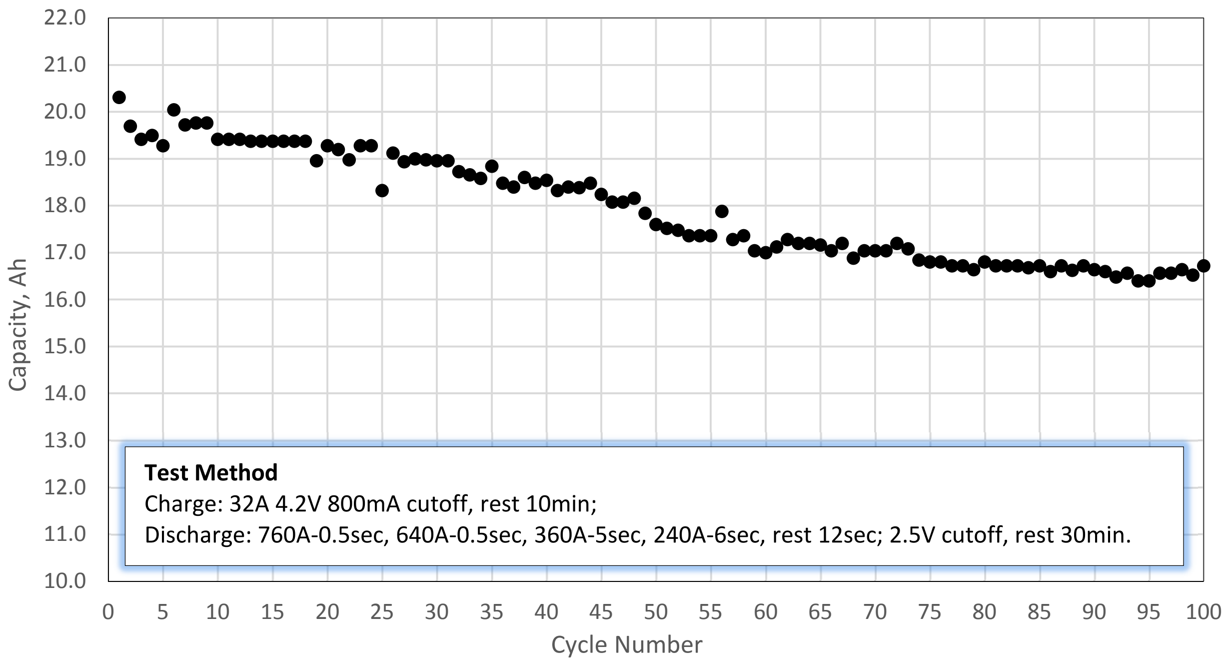


Figure 2. High current pulse discharge results. Test carried out without fuses, see Table 1. for fuse ratings.

TEMPERATURE SENSOR

The module has a 4-point temperature sensor built in, which meets and exceeds safety requirements of FSAE 2017 regulations. Each one of the four sensors is in physical contact with negative pole of two adjacent cells and provides very fast temperature measurement response. Such construction provides inexpensive monitoring of all 100% of cells (≥30% is required by FSAE).

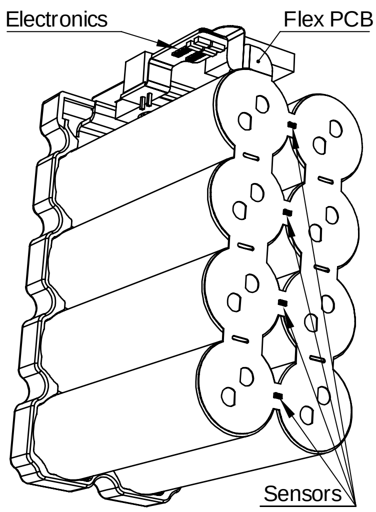


Figure 3. Sensor layout

Innovative analogue signal OR'ing technique allows all 4 sensor signals to be read with two-wire acquisition system: output acts as a hot spot detector and reports only the maximum temperature. When battery is operating within safe limits, all four sensors report similar temperatures and such measurement accurately represents overall temperature of the module. However, in case of failure event, hot spot is very quickly noticed.

The sensor is a special-made *temperature-variable voltage shunt reference*. In simple words, it acts as a zener diode, whose voltage drop depends on temperature. It requires a *pull-up* resistor (~680Ω) to operate at cell voltage level. For convenience, the module can be used to power the sensor as given in test circuit in Figure 4.

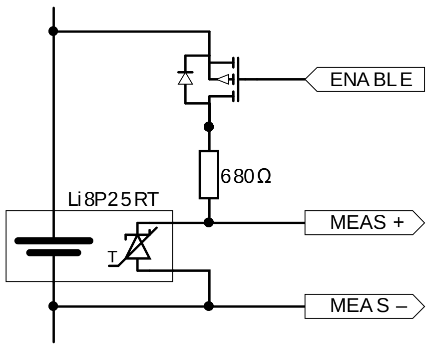


Figure 4. Test circuit

The signal is non-linear, as given in Figure 5 below. It is compensated internally to provide flattest possible curve in operating range of –40…+120°C. For convenience, conversion values are given in Table 2. Linear interpolation can be used to calculate more values with reasonable accuracy.

Table 2. Voltage-to-temperature conversion values

Temp, °C	-40	-35	-30	-25	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40
V_{out}, V	2.44	2.42	2.40	2.38	2.35	2.32	2.27	2.23	2.17	2.11	2.05	1.99	1.92	1.86	1.80	1.74	1.68

Temp, °C	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
V_{out}, V	1.63	1.59	1.55	1.51	1.48	1.45	1.43	1.40	1.38	1.37	1.35	1.34	1.33	1.32	1.31	1.30

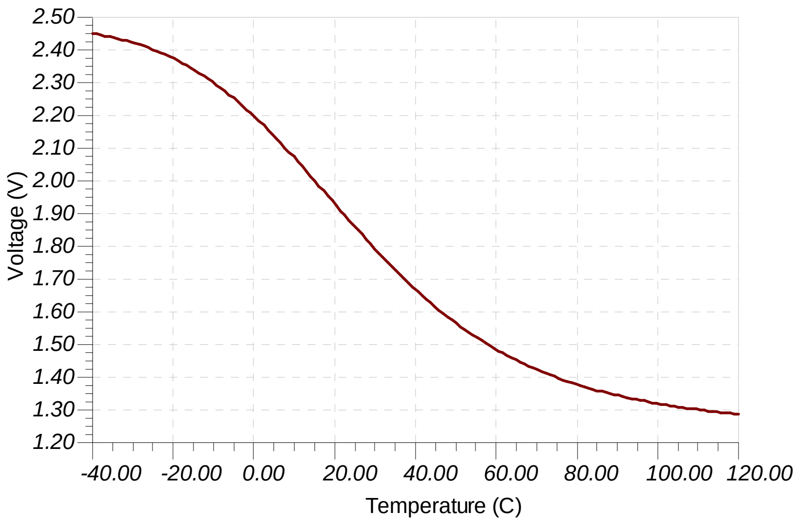


Figure 5. Temperature-Voltage response

Temperature sensor is galvanically isolated from cell terminals and signal can be safely read with separate circuit. However, it is very convenient to use a standard stack measurement ICs, usually used for battery monitoring and balancing. A circuit example with widely available LTC6803 is given in Figure 6.

To measure temperature, balancing switch is activated on the IC. After doing so, voltage difference between C_{n+1} and C_n represents temperature. During such measurement, sensor current flows from cell positive tab through series resistor to sensor, then to internal balancing FET of IC, and then to cell negative via another series resistor. Thus 330Ω resistors are used to form a total of ~680Ω resistance for the sensor in this case.

When switch is disabled, cell voltage can be measured. Note that extra care should be taken when adding capacitors for filtered measurement as this could lead to overcurrent condition in the sensor. Also note that adjacent balancing switches must not be enabled as this would also lead to overcurrent condition. If such technique is chosen, measurements should be done in two cycles, on every second cell at a time (for example: 1, 3 and 5, then 2, 4 and 6).

It is recommended to use separate ICs for battery management and temperature measurement, however, with extra care and smart engineering it is possible to use a single IC for cell voltage measurement, temperature measurement and balancing: cells can be bleed-balanced during temperature measurement if additional bleed resistor and MOSFET is added.

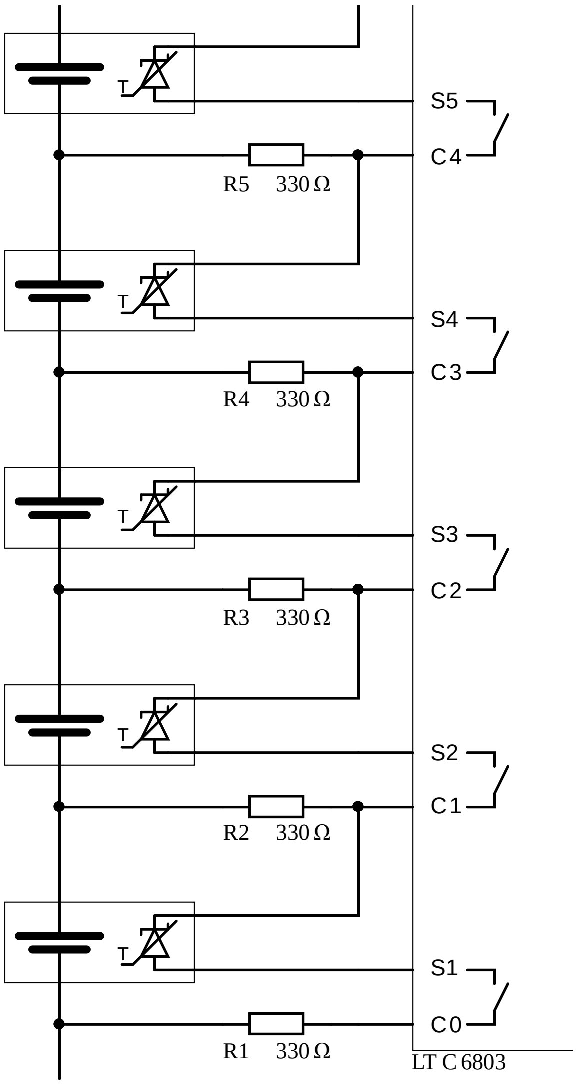


Figure 6. Suggested stack temperature acquisition circuit (simplified)

Table 3. Sensor characteristics (all parameters rated at 25°C if not specified otherwise)

Parameter	**Comment**	**Min.**	**Typ.**	**Max.**	**Unit**
Supply voltage	$V_{min} = V_{cc} - V_{out}$	10	20	-	mV
	When $T = -40°C$	1.21	1.24	-	V
Forward current	$I_{reg} = \frac{V_{cc} - V_{out}}{R}$	0.40	1	15	mA
Leakage current	When $V_{cc} < V_{out}$	-	5	400	nA
Measurement range	$V_{cc} > 2.5V$	-40	-	120	°C
Isolation	From cell terminals	-	-	60	V

MECHANICAL DATA

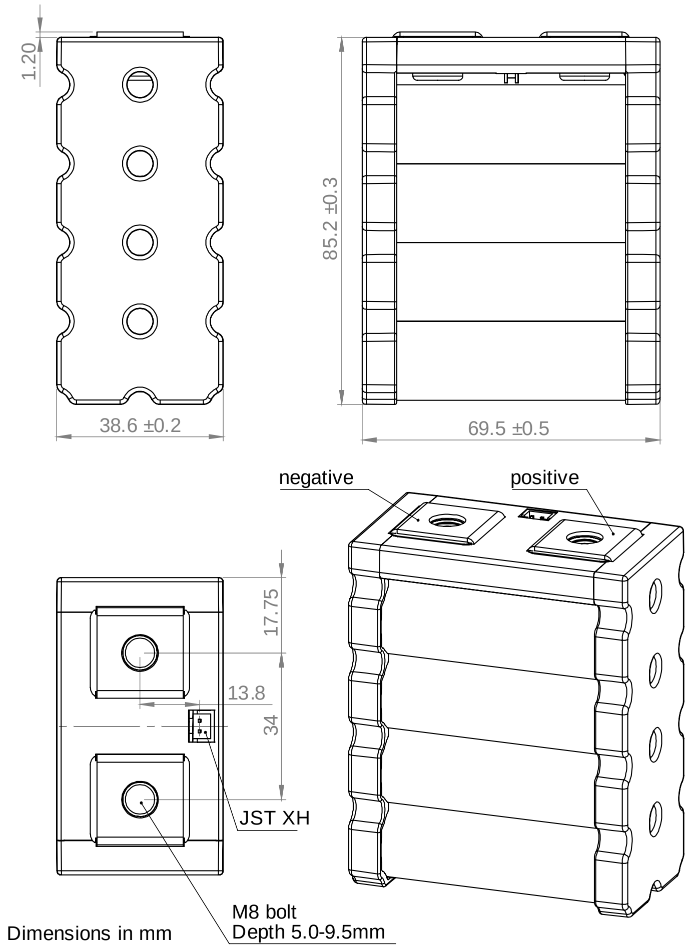


Figure 7. Mechanical dimensions

A simplified 3D STP model is available upon request.

Notes:

1. Inner M8 nut is stainless steel
2. Tightening torque: 10 Nm
3. Self-locking washers recommended
4. Modules should be mounted in a firm enclosure to avoid mechanical damage.
5. Modules should be protected from direct water ingress.
6. Temperature sensor connector: JST XH series.

Table 4. Revision history

Revision	**Date**	**Description**
A	2015-11-18	Initial Release.
B	2015-11-25	Updated mechanical drawings.
C	2015-12-10	Updated Discharge Slope in Figure 1.
D	2016-01-15	Public release.
E	2016-01-26	Updated Weight in Table 1.
F	2016-03-13	Pulse discharge updated in Table 1.
G	2016-05-15	Added high current pulse discharge cycle life in Figure 2.
H	2016-07-01	Added Energy Capacity and updated Weight in Table 1. Added Temperature Sensor description.
I	2016-07-06	Updated temperature sensor characteristics and pullup value Added Voltage-to-temperature conversion values in Table 2.
J	2016-07-27	Added flammability rating among Features on Page 1.
K	2016-10-19	Added pulse charge rating in Table 1.