

Li-ion building block with Sony/Murata VTC5A datasheet

RoHS
Compliant



FEATURES

- Small size: 206-357 Wh per liter
- Low weight: 157-164 Wh per kg
- Individually fuse-protected cells
- Ultra low and equal self-discharge
- Rapid prototyping of battery pack
- Convenient thermal control
- Built-in temperature sensors
- UL94-Vo rated, fire-retardant plastics
- UN38.3 certified

APPLICATIONS

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

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 rough treatment, while offering the best in class energy density.

SAFETY

In addition to internal protection techniques, the module includes two fuses for each cell. 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.

Table 1: Working temperature

	Min.	Typ.	Max.
Discharge	-20 °C	25 °C	60 °C
Charge	0 °C	25 °C	45 °C

Table 2: Product characteristics (all parameters rated at 22°C if not specified otherwise)

Module	Battery voltage (V)			Battery capacity (A)		Fast charge current (A)	Discharge current (A)* ¹	Initial internal impedance (mΩ)* ²	Internal fuse rating (A)* ³
	Min.	Typ.	Max.	Ah	Wh				
Li1x1pVTC5A	2.5	3.6	4.2	2.6	9.36	6	35	13.1	45
Li1x2pVTC5A				5.2	18.72	12	70	6.9	90
Li1x3pVTC5A				7.8	28.08	18	105	4.6	135
Li1x4pVTC5A				10.4	37.44	24	140	3.5	180
Li1x5pVTC5A				13	46.8	30	175	2.8	225
Li1x6pVTC5A				15.6	56.16	36	210	2.3	270
Li1x7pVTC5A				18.2	65.52	42	245	2	315
Li1x8pVTC5A				20.8	74.88	48	280	1.8	360
Li1x9pVTC5A				23.4	84.24	54	315	1.7	405
Li1x10pVTC5A				26	93.24	60	350	1.6	450
Li2x1pVTC5A				5.2	18.72	12	70	6.2	90
Li2x2pVTC5A				10.4	37.44	24	140	3.8	180
Li2x3pVTC5A				15.6	56.16	36	210	2.3	270
Li2x4pVTC5A				20.8	74.88	48	280	1.9	360
Li2x5pVTC5A				26	93.6	60	350	1.4	450
Li2x6pVTC5A				31.2	112.32	72	420	1.2	540
Li2x7pVTC5A				36.4	131.04	84	490	1.1	630
Li2x8pVTC5A				41.6	149.76	96	560	1	720
Li2x9pVTC5A				46.8	168.48	108	630	0.9	810
Li2x10pVTC5A				52	187.2	120	700	0.8	900

*¹ - With 80 deg temperature cutoff. *² - Measurements are done with B&K Precision BA6010 device. *³ - Approximately.

DISCHARGE CHARACTERISTICS

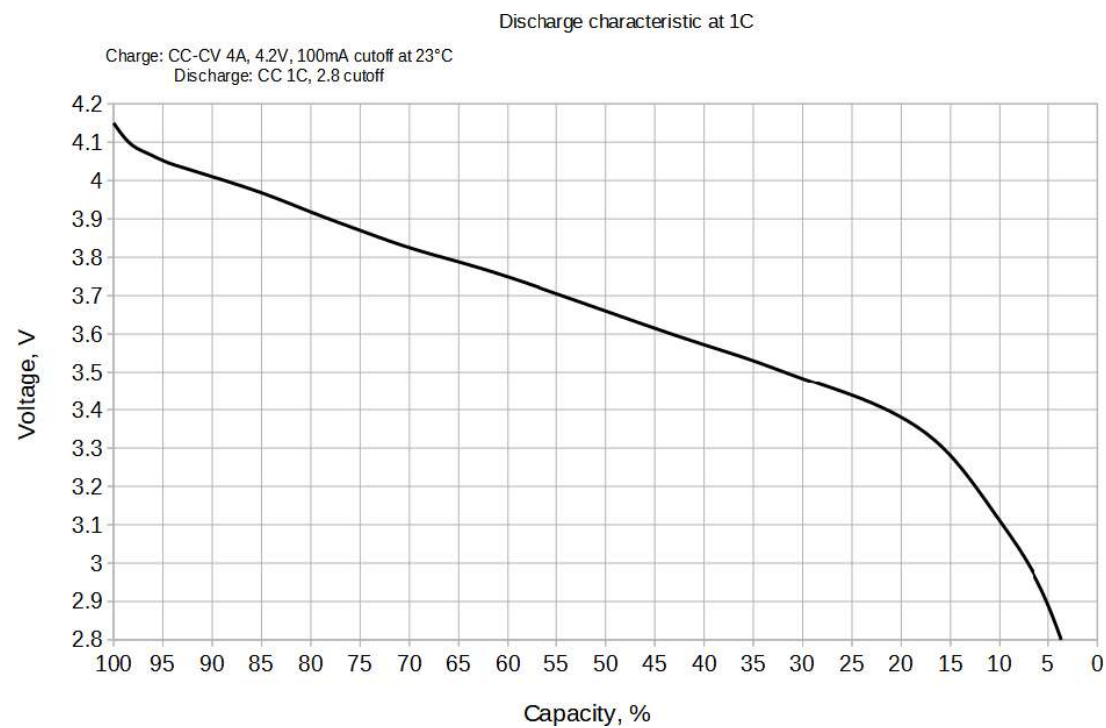


Figure 1: A typical discharge slope at 1C rate.

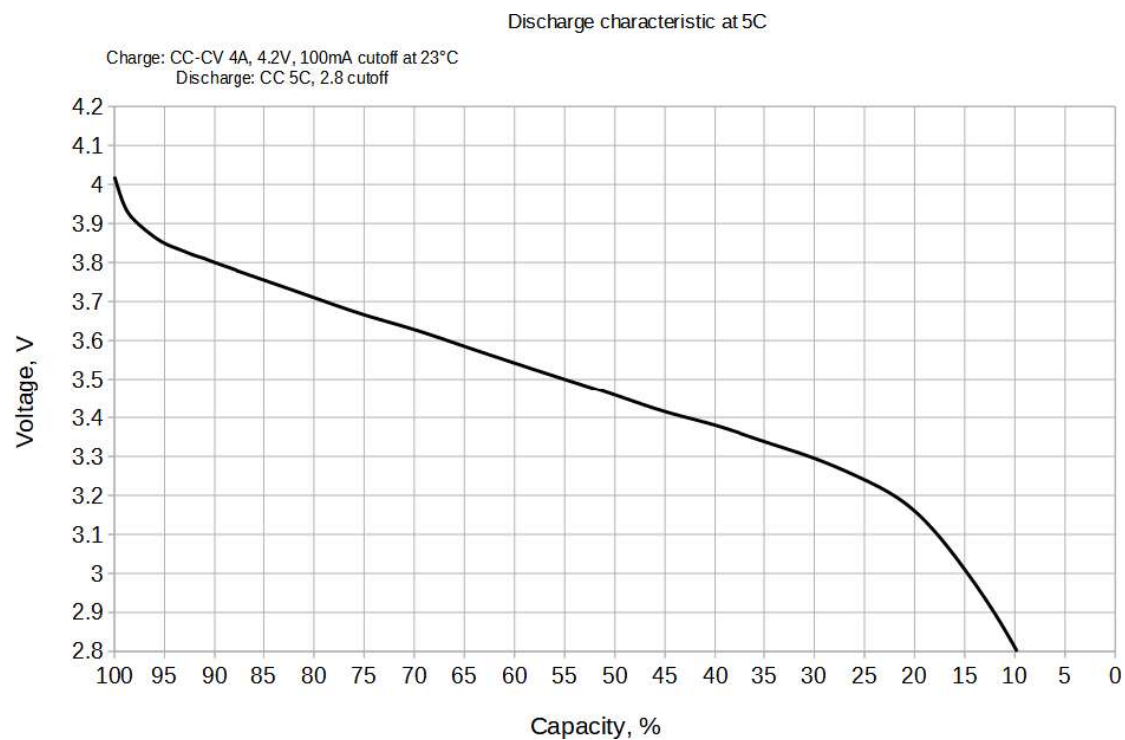


Figure 2: A typical discharge slope at 5C rate.

Test current	Measured energy (Wh)
1C	8.892
5C	8.132

Table 3: Measured energy at different load.

TEMPERATURE SENSOR

The module has a temperature sensor built in, which meets and exceeds safety requirements of FSAE and FSG 2025 regulations. Each one of the 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 FSG).

Innovative analogue signal OR'ing technique allows all 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 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.

The signal is non-linear, as given in Figure 5 below. It is compensated internally to provide flattest possible curve in operating range of $-40\dots+120^\circ\text{C}$. For convenience, conversion values are given in Table

2. Linear interpolation can be used to calculate more values with reasonable accuracy.

Table 4: Sensor quantity for modules

Module	1x1	1x2	1x3	1x4	1x5	1x6	1x7	1x8	1x9	1x10
Qty	0	1	1	2	2	3	3	4	4	4
Module	2x1	2x2	2x3	2x4	2x5	2x6	2x7	2x8	2x9	2x10
Qty	1	1	2	2	2	3	3	4	4	4

Table 5: 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	

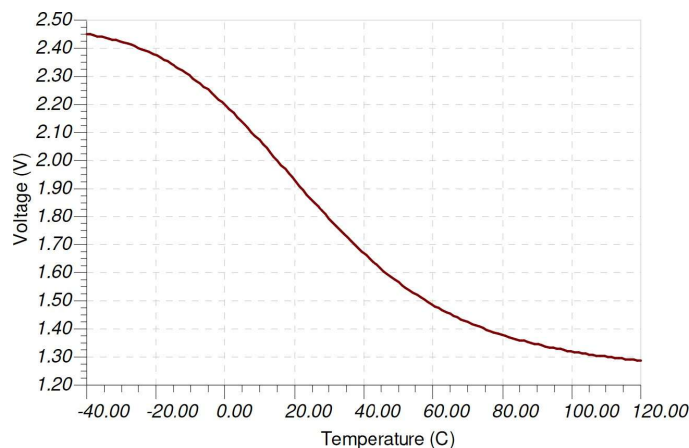


Figure 5: Temperature-Voltage response.

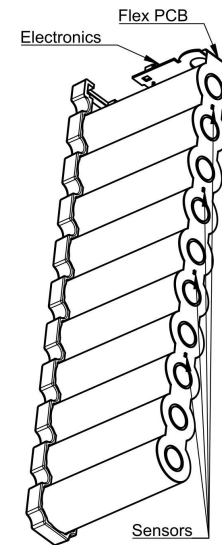


Figure 3: Sensor layout.

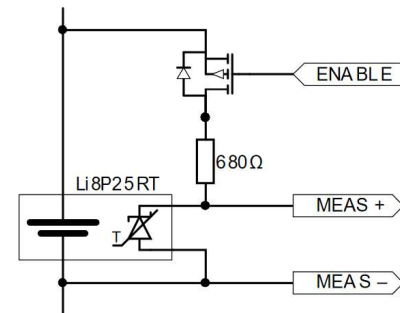


Figure 4: Test circuit.

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.

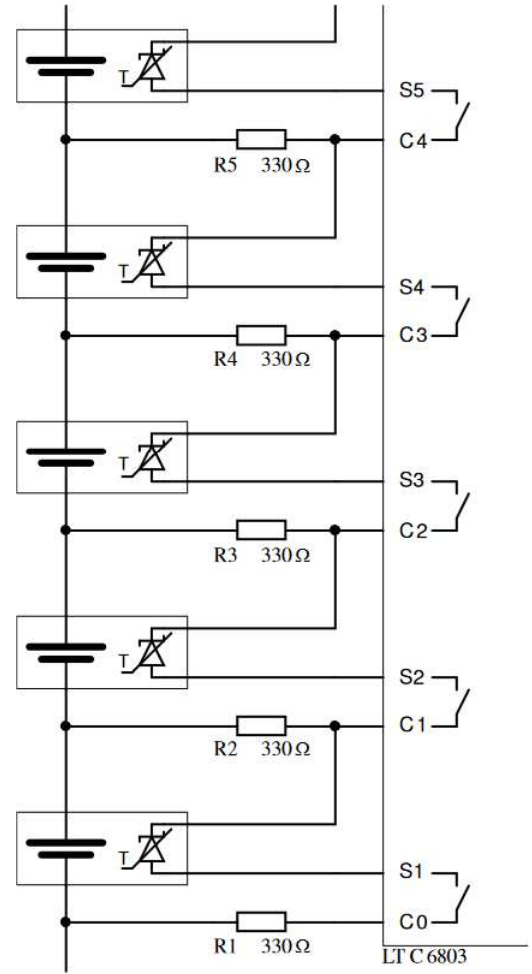


Figure 6: Suggested stack temperature acquisition circuit (simplified).

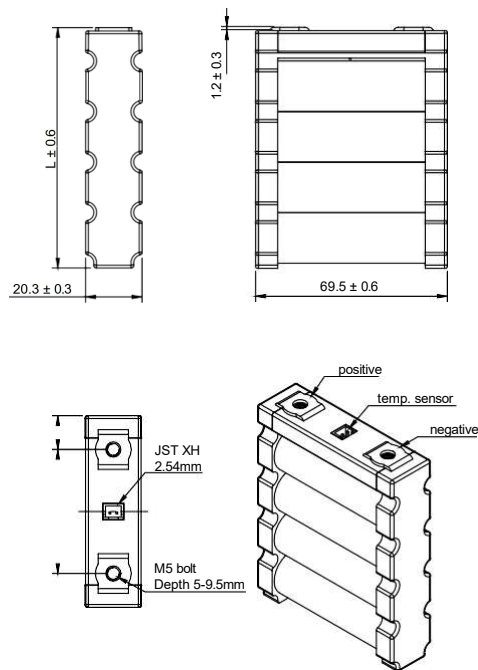
Table 6: Sensor characteristics (all parameters rated at 25°C if not specified otherwise)

Parameter	Comment	Min.	Typ.	Max.	Unit.
Supply voltage	$V_{min} = V_{cc} - V_{out}$	10	20	-	mV
	When $T = -40^{\circ}\text{C}$	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	$V_{cc} > 2.5\text{V}$	-40	-	120	$^{\circ}\text{C}$
Isolation	From cell terminals	-	-	60	V

MECHANICAL DATA

A simplified 3D STP model is available upon request. 1xNp notes:

- 1. Inner M5 nut is stainless steel
- 2. Tightening torque: 6 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



Module	L (mm) ± 0.6	Weight* (g)
1x1	32.4	60
1x2	50.7	114
1x3	69.0	171
1x4	87.3	229
1x5	105.6	283
1x6	123.9	337
1x7	142.2	397
1x8	160.5	452
1x9	178.8	509
1x10	195.7	565