Li-ion building block with Amprius SA110 datasheet

FEATURES

- Small size: 818 Wh per liter
- Low weight: 293 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-V0 rated, fire-retardant plastics
- UN38.3 certified *5

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 channeled through dedicated channels to avoid pressure buildup.

FLEXIBILITY

Due to the simplicity 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: Ambient operating and cell surface temperatures

	Ambient			Cell surface		
	Min.	Typ.	Max.	Min.	Typ.	Max.
Charge	0°C	25 °C	45°C	0°C	25 °C	60°C
Discharge	-20 °C	25 °C	60 °C	-20 °C	25 °C	70 °C

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

Module	Battery voltage (V)			Battery capacity		Fast charge current (A)*1	Discharge current (A)*2	Initial internal impedance (mΩ)*2	Internal fuse rating (A)*4
	Min.	Typ.	Max.	Ah	Wh	Max.	Max.	Typ.	Typ.
Li1x1pSA110	2.5	3.52	4.2	4.0	14.08	4	12	25.0	35
Li1x2pSA110T				8.0	28.16	8	24	12.5	70
Li1x3pSA110T				12.0	42.24	12	36	8.3	105
Li1x4pSA110T				16.0	56.32	16	48	6.3	140
Li1x5pSA110T				20.0	70.40	20	60	5.0	175
Li1x6pSA110T				24.0	84.48	24	72	4.2	210
Li1x7pSA110T				28.0	98.56	28	84	3.6	245
Li1x8pSA110T				32.0	112.64	32	96	3.1	280
Li1x9pSA110T				36.0	126.72	36	108	2.8	315
Li1x10pSA110T				40.0	140.80	40	120	2.5	350
Li2x1pSA110T	2.5	3.52	4.2	8.0	28.16	8	24	12.5	70
Li2x2pSA110T				16.0	56.32	16	48	6.3	140
Li2x3pSA110T				24.0	84.48	24	72	4.2	210
Li2x4pSA110T				32.0	112.64	32	96	3.1	280
Li2x5pSA110T				40.0	140.80	40	120	2.5	350
Li2x6pSA110T				48.0	168.96	48	144	2.1	420
Li2x7pSA110T				56.0	197.12	56	168	1.8	490
Li2x8pSA110T				64.0	225.28	64	192	1.6	560
Li2x9pSA110T				72.0	253.44	72	216	1.4	630
Li2x10pSA110T				80.0	281.60	80	240	1.3	700

*1(Only Charge with 60 deg.cell surface temp. cutoff.) *2(Only Discharge with 70 deg. Cell surface temp. cutoff) *3(Approximately) *4(Approximately) *5 (Due to the wide range of available module types and the continuous introduction of new variations, the module in your specific configuration may not yet hold UN38.3 certification. For detailed information regarding certification status, please contact our sales managers. Upon request, the UN38.3 (and many others) certification processes for the selected module can be initiated in accordance with the customer's requirements)

SINGLE CELL DISCHARGE CHARACTERISTICS

Typical Charge: 0.5C (2000mA) CC/CV charge to 4.20V,
Charge termination: 0.02C (80mA)
Typical Discharge: 1.0C (4000mA) continuous down to 2.50V

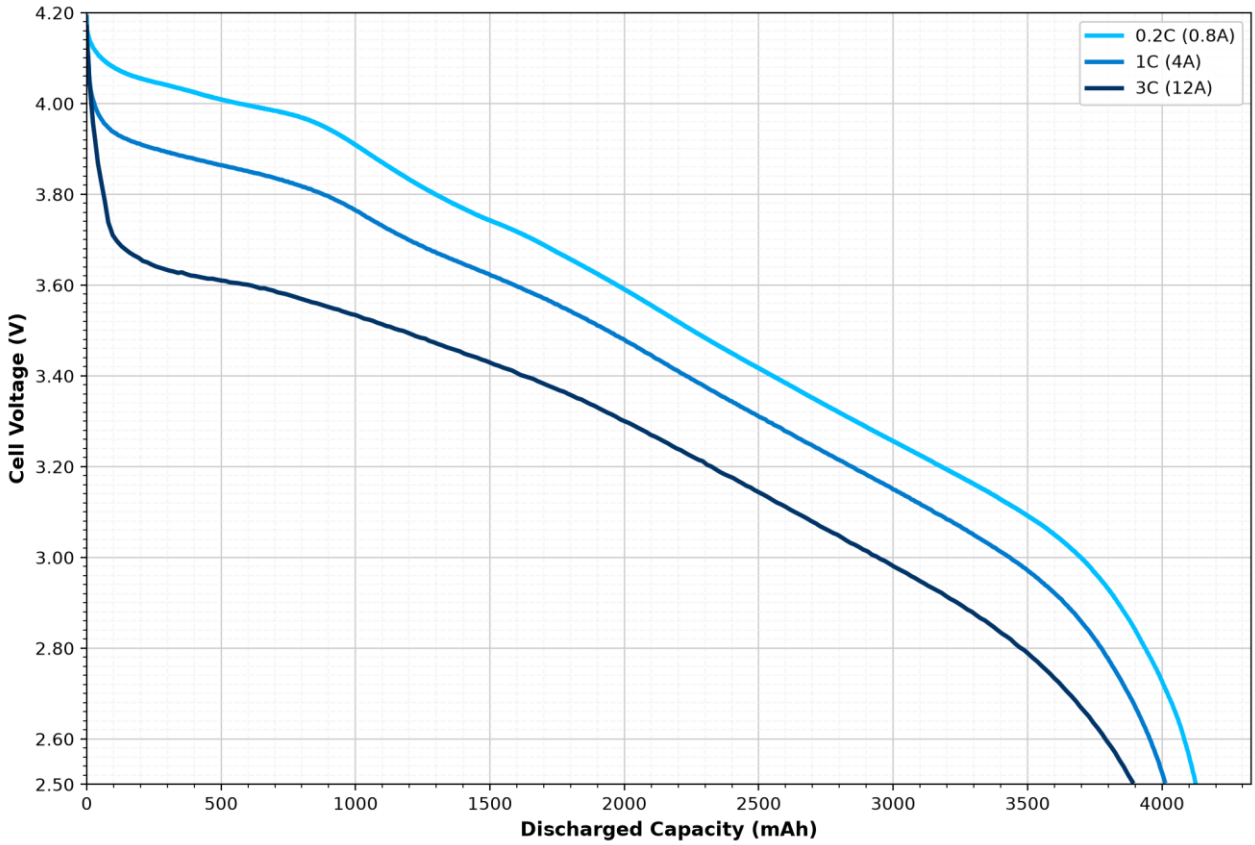

Figure 1: Discharge characteristics of Li1x1pSA110 at different loads

Discharge current		Measured energy	
0.2C	0.8A	4.12 Ah	14.55 Wh
1C	4A	4 Ah	13.74 Wh
3C	12A	3.9 Ah	13.07 Wh

Table 3: Li1x1pSA110 Measured energy at different load.

TEMPERATURE SENSOR

The module has a temperature sensor built in, which meets and exceeds safety requirements of Formula SAE (FSAE) and Formula Student Germany (FSG) 2025 regulations. Each one of the sensors is in physical contact with the negative poles 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 a 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 specially-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 the flattest possible curve in operating range of –40...+120°C. For convenience, conversion values are given in Table 5
Linear interpolation can be used to calculate more values with reasonable accuracy.

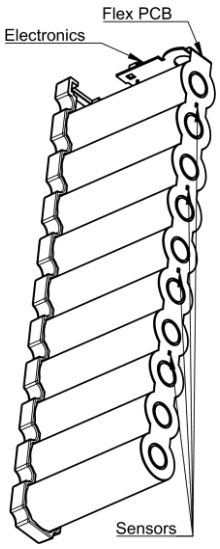

Figure 2: Sensor layout.

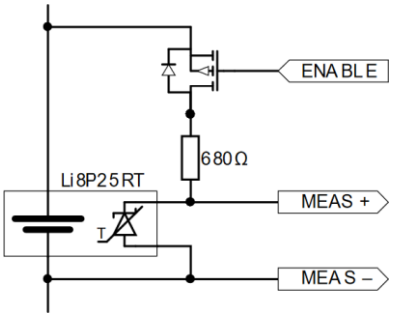

Figure 3: Test circuit.

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
Vout, 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	
Vout, 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	

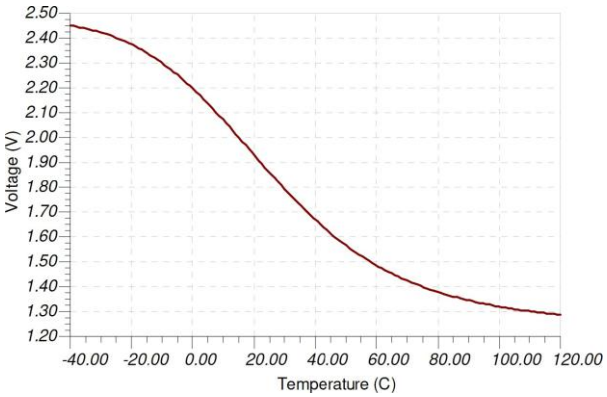

Figure 4: Temperature-Voltage response.

Temperature sensor is galvanically isolated from the cell terminals and signal can be safely read with a 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 Cn+1 and Cn 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 an 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.

* The 680 Ω value is used because it is a standardized resistor nominal rather than the non-standard 660 Ω.

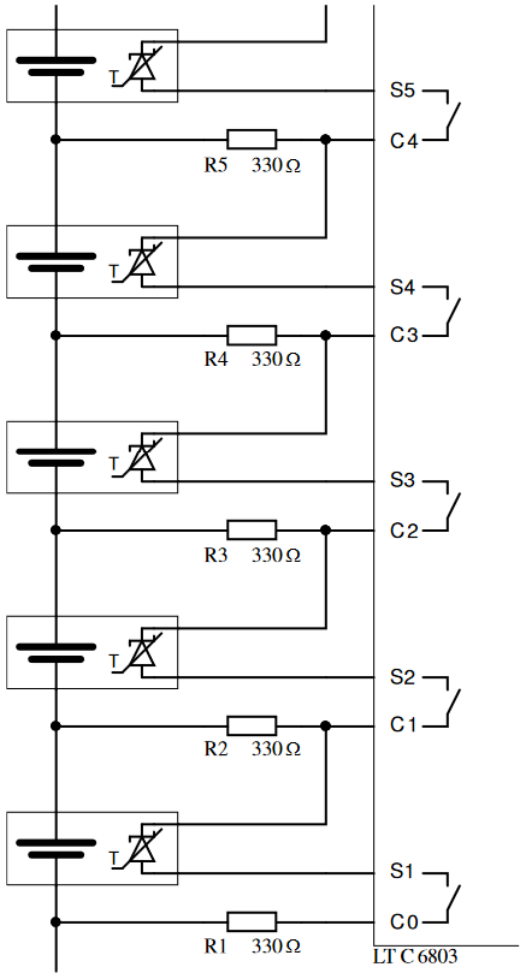

Figure 5: Suggested stack temperature acquisition circuit (simplified).

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°C	1.21	1.24	-	V
Forward current	$I_{reg} = \frac{Vcc - V_{out}}{R}$	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

A simplified 3D STP model is available upon request.

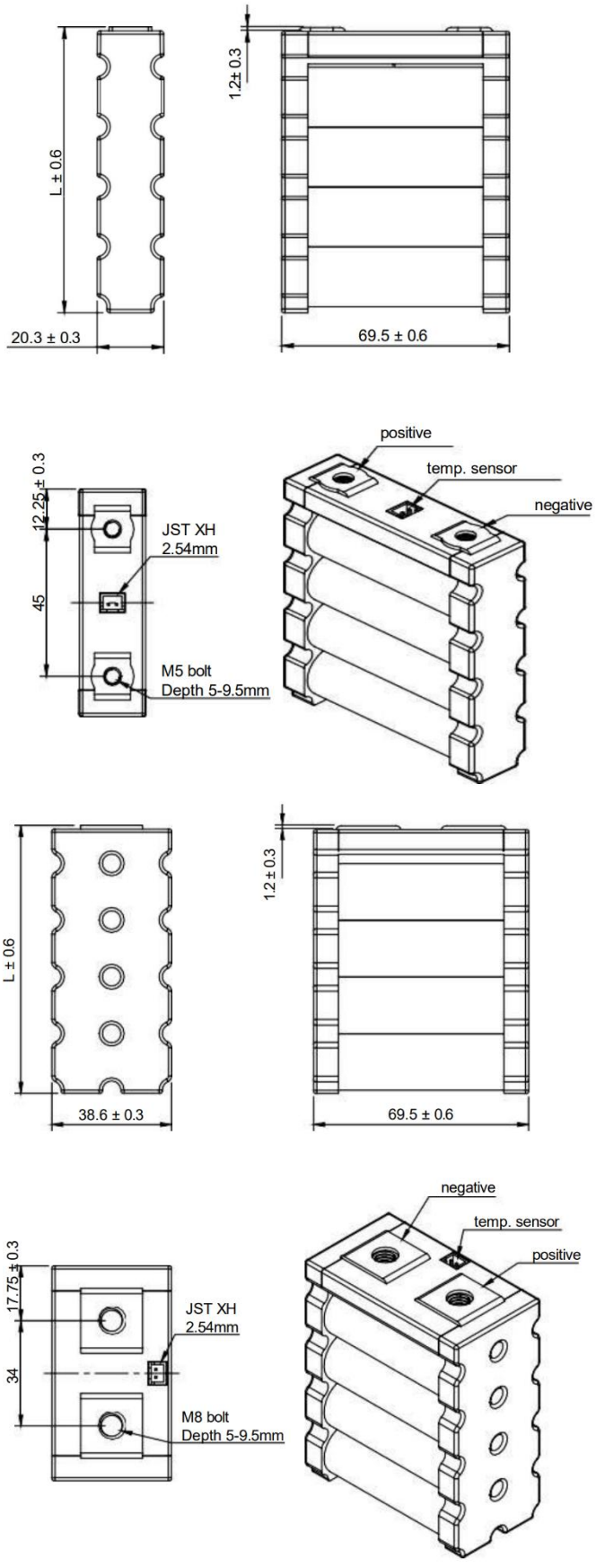

Table 7: Li1x[P]p Notes:	
Inner nut	M5 stainless steel
Tightening torque	6 Nm
Temperature sensor connector:	JST XH series
Self-locking washers recommended	
Modules should be mounted in a firm enclosure to avoid mechanical damage	
Modules should be protected from direct water ingress	

Figure 6: Mechanical dimensions of Li1x[P]p modules ,

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

*-Approximate / Without fasteners

Table 8: Li2x[P]p Notes:	
Inner nut	M8 stainless steel
Tightening torque	10 Nm
Temperature sensor connector:	JST XH series
Self-locking washers recommended	
Modules should be mounted in a firm enclosure to avoid mechanical damage	
Modules should be protected from direct water ingress	

Figure 7: Mechanical dimensions of Li2x[P]p modules

Module	L (mm) ±0.6	Weight* (g)
2x1	31.5	114
2x2	49.8	229
2x3	68.1	342
2x4	86.4	456
2x5	104.7	570
2x6	123.0	684
2x7	141.3	798
2x8	159.6	912
2x9	177.9	1026
2x10	195.7	1140

*-Approximate / Without fasteners

TERMS OF USAGE

Storage conditions

Module should be stored within a range of temperatures specified as below: Store the battery at 0 ~ 23℃, low humidity (below 65%), no dust and no corrosive gas atmosphere. Otherwise, it may cause loss of performance characteristics, leakage and/or rust.

Long-term storage

If long-term (but not longer than Warranty Period) storage is necessary, Module shall be stored at shipping voltage, because storage with higher voltage may cause more loss of performance characteristics.
All devices or components connected to module clamps must be disconnected, preventing current leak from module.
Enepaq shall not be liable if any defects of module occur after Warranty Period even if Module is stored in accordance with Sections above.

Warranty

Enepaq warrants that Module will be free from defects in manufacturing for a period of 12 months from the date of shipping ("Warranty Period"). In case of defects, Enepaq will only replace the affected modules. However, Enepaq shall not be liable if:

The buyer undertakes to check the goods immediately upon receipt. If the Buyer receives the order and notices any quality issues or discrepancies, he must notify the Seller in writing within 7 days from receiving the order. In case of concealed defects, the Buyer must notify the Seller within the warranty term, but always within 7 days from noticing the defect.

Module was improperly installed, repaired, altered or otherwise modified (other than by Enepaq)
Module was subjected to misuse, abuse, negligence or accident
Module was used, handled, stored, sold or distributed in a manner contrary or inconsistent to the handling /use instructions provided in this product specification sheet.

Application

The products do not have required certification for aircraft use (any type of aircrafts, drones, planes or other flying, gliding or hovering mechanisms, contraption, devices or other objects) and Enepaq can not be held liable for any damage incurred if the modules are used in such applications. The Buyer takes their own risk for any damages resulting from such use or misuse.

The Seller does not undertake to indemnify the Buyer of any loss or expenses which are caused by misguided use of Products.

Usage

The Buyer is exclusively responsible for the installation, storage, operation and maintenance of the Goods. The Buyer must ensure that the personnel installing and operating the Goods has appropriate qualifications entitling the personnel to provide handling services with respect to the Goods (including toxic, flammable). The Buyer carries out the installation, storage, operation, maintenance of the Goods, personnel training at its own risk and expense.

The Seller is not liable for defects in the Goods or inconsistencies of the Goods with the Order if they occurred after the transfer of the Goods to the Buyer due to failure of the Buyer and/or the Buyer's staff to ensure proper installation, storage, operation within specified limits, maintenance of the Goods or due to the fault of third parties or force majeure or other similar circumstances.

Note: *This product is made to order and is non- cancelable and non-returnable (NCNR) and once the order is placed with the factory no changes may be made.*

MODEL NUMBERING SYSTEM & OPTIONS

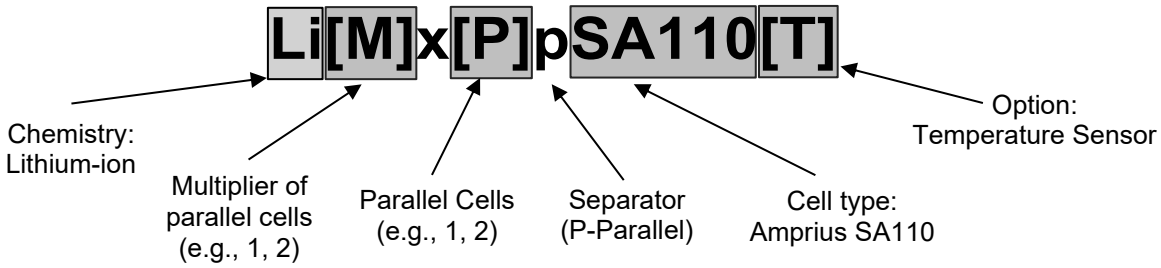

Figure 8: Model numbering system

Temperature sensor option ('T')

'T' suffix in the model number indicates the inclusion of the built-in temperature sensor described on Page 3. The sensor provides valuable thermal monitoring. However this feature is optional. Clients may choose to order modules without the temperature sensor at a discounted price.

Note: *Temperature sensor option isn't available on Li1x1p modules*

Table 9: Revision history

Revision	Date	Description
A	2026-08-27	Initial Release.