Kookabus-03

8 x AA battery pack with a 4 / 6 / 8 cell selector, XT60 output and battery test

Adventures in Silicon Pty Ltd
Australia

Datasheet, board revision 5. Document revision 0.5 (draft), 30 September 2026. Preliminary: no hardware has been built. Values are from design calculations and component datasheets.

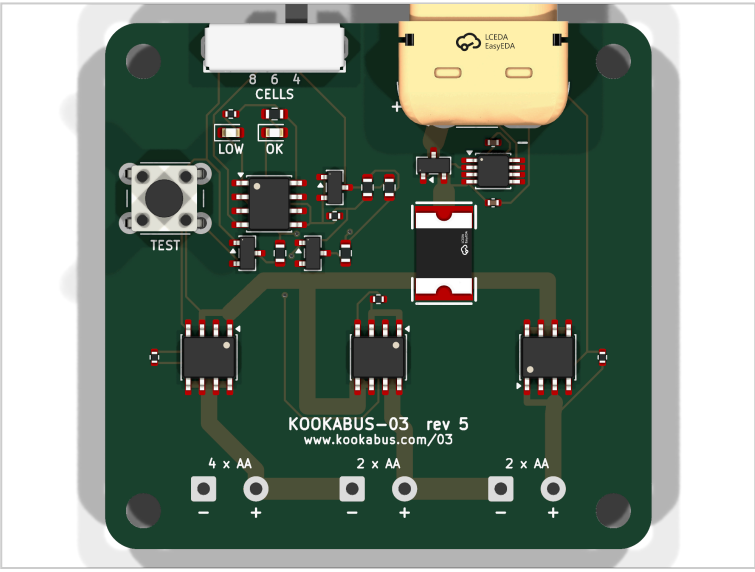


Figure 1. Top view (render). Mode switch and XT60 on the top edge, TEST button and LEDs at the left, selector FETs across the middle, battery holder pads along the bottom edge.

Description

Kookabus-03 turns eight AA cells into a switchable robot or bench supply. The cells sit in three off-the-shelf holders (one 4 x AA and two 2 x AA) whose leads solder to the board. A three-position slide switch selects 4, 6 or 8 cells in series; the switch only drives the gates of three dual P-channel MOSFET pairs, which carry the load current. The output is a female XT60 behind a 3 A resettable fuse and a smart-diode reverse-current block, so nothing connected to the XT60 can push current back into the board or the cells.

Holding the TEST button checks the cells the switch has selected: the green LED lights if they average more than about 1.1 V a cell, the red one if they do not.

An optional 3D-printed enclosure holds the holders and the board, opens with two screws to change cells, and clips to a TS35 DIN rail.

Applications

- Portable 5, 7.2, 9 or 12 V supply for small robots, servos and motor drivers
- Field or bench power where rechargeable packs are not wanted: cells from any shop

Features

- 4, 6 or 8 AA cells in series, alkaline or NiMH: 4.8 to 12.8 V
- Selector switch carries only microamps; the load runs through AO4805 MOSFETs
- No tap can feed another in any switch position (body diodes blocked or pointing away)
- XT60 female output, mating end overhanging the board edge
- 3 A hold, 5 A trip resettable fuse (PTC)
- Reverse-current block (LM74610 smart diode): no current back into the cells, 0 uA idle, about 0.07 V drop at 3 A
- TEST button: green OK / red flat for the selected cells, threshold follows the switch
- Idle drain 13 uA at most; the test circuit and both LEDs draw nothing when the button is released
- Battery holders wired to solder pads: Keystone 2478 (4 x AA) and 2463 (2 x AA), or similar
- 50 x 48 mm, 2 layers, 1 oz copper, four M3 holes, all parts on the top side
- Optional enclosure: 139 x 105.5 x 23.8 mm, two-screw lid, DIN rail clip

- A 4.8 to 12 V source for Kookabus-01 or Kookabus-02 testing

1. Block diagram

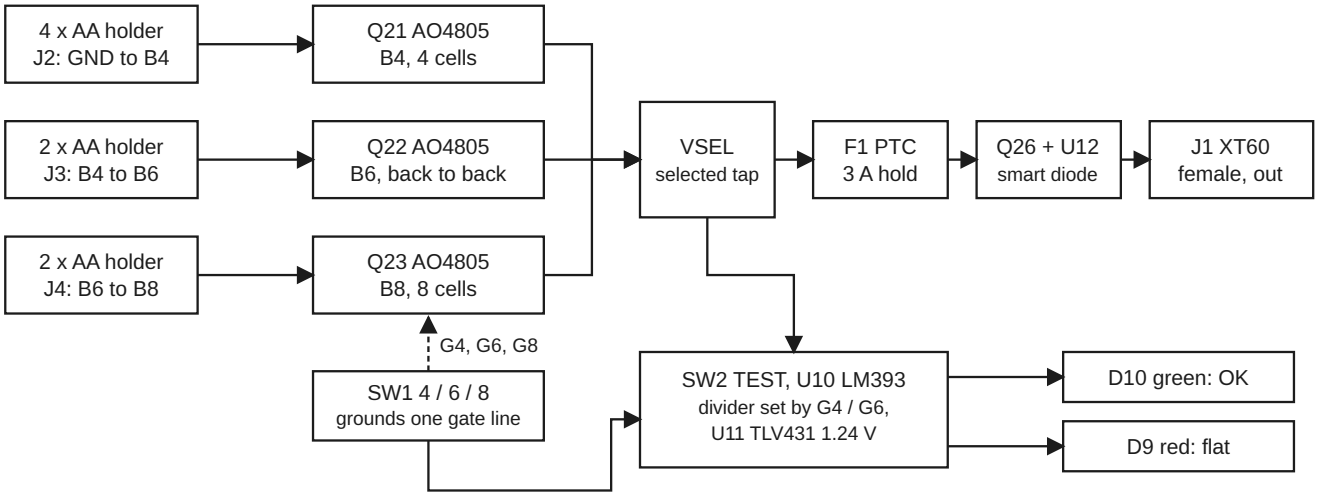


Figure 2. Power and signal flow. The load current flows from the holders through one MOSFET pair, the PTC and the smart diode to the XT60. The switch and the TEST circuit carry only microamps to milliamps.

2. Absolute maximum ratings

Stresses beyond these values may cause permanent damage. These are limits, not operating conditions.

Parameter	Min	Max	Unit	Limiting part or note
B8 (top of the 8-cell stack) to GND	0	20	V	BSS84 gate to source (Q24, Q25, +-20 V). Other limits: PTC 24 V, AO4805 and AO3400A 30 V. Reversed holders are not protected.
External voltage on the XT60 above the pack		30	V	Blocked by Q26 (AO3400A, 30 V). LM74610: 45 V.
Output current, continuous		3	A	PTC hold current at 25 °C.
Output current, fault		40	A	PTC maximum fault current. AA cells cannot deliver this; the PTC trips first.
TEST button (SW2) switched voltage		12	V	K2-1102DP rating (50 mA). Eight fresh alkaline cells reach 12.8 V open circuit; the switched current is under 10 mA.
Operating ambient temperature	-20	60	°C	SW1 slide switch (-16 °C minimum) and cell limits. Not characterised over temperature.
Storage temperature	-20	60	°C	With cells fitted; remove cells for long storage.

3. Recommended operating conditions

Parameter	Min	Typ	Max	Unit	Note
Cell voltage, alkaline	1.0	1.5	1.6	V	1.6 V fresh, open circuit. Below 1.1 V the cells are near the end of their useful capacity.
Cell voltage, NiMH	1.0	1.2	1.45	V	1.45 V straight off the charger.

Parameter	Min	Typ	Max	Unit	Note
Output current, continuous		0.5	2	A	AA cells sag heavily above about 2 A, alkaline far more than NiMH.
Operating ambient temperature	0	25	40	°C	The PTC's hold current falls with temperature.

4. Electrical characteristics

Calculated at 25 °C from component datasheets unless stated. VSEL is the tap SW1 selects (B4, B6 or B8, less the MOSFET drop); VOUT is the XT60's + pin, after F1 and the smart diode.

4.1 Output and power path

Parameter	Condition	Min	Typ	Max	Unit
Output voltage, 4 / 6 / 8 cells	NiMH, 1.2 V a cell		4.8 / 7.2 / 9.6		V
Output voltage, 4 / 6 / 8 cells	Fresh alkaline, open circuit		6.2 / 9.3 / 12.4	12.8	V
MOSFET on-resistance, each half	AO4805, VGS = -10 V			18	mOhm
Selector resistance	4 or 8 cells (halves in parallel) / 6 cells (halves in series)		9 / 36		mOhm
PTC hold current	Never trips at or below, 25 °C still air			3.0	A
PTC trip current	Always trips at or above, 25 °C	5.0			A
PTC resistance	New / after a trip or reflow	12		48	mOhm
Smart diode drop, Q26 on	3 A, gate 5.15 to 6.3 V		0.07		V
Smart diode off periods (body diode)	C1 = 220 nF, forward current above about 1 mA		5 in 270		ms
Extra drop during an off period	Body diode, 2 A		0.7		V
Reverse current into the board	13.5 V reversed across Q26		60	110	uA
Reverse turn-off time	VOUT 20 mV above VFUSE		2.2	5	us
Board drop, holder pads to XT60	2 A, 8 cells, Q26 on		0.15		V
Idle current, TEST released	4 / 6 / 8 cells (one 1 MOhm gate resistor)			6 / 10 / 13	uA

Below about 1 mA of load the smart diode never switches on and Q26 acts as a plain diode (about 0.5 V drop), which only matters for very small loads. The selector resistance is at VGS = -10 V. In 4-cell mode the gate sees only about -4.5 V and the resistance is higher, which matters little at the currents four AA cells deliver. The holders' springs and leads add more resistance than the board.

4.2 TEST button (SW2, U10, U11, D9, D10)

Parameter	Condition	Min	Typ	Max	Unit
Threshold on VSEL, 4 cells	Green above, red below	4.33	4.46	4.59	V

Parameter	Condition	Min	Typ	Max	Unit
Threshold on VSEL, 6 cells		6.44	6.64	6.84	V
Threshold on VSEL, 8 cells		8.50	8.76	9.02	V
Threshold per cell	4 / 6 / 8 cells		1.12 / 1.11 / 1.09		V
Reference	TLV431A, 10 k from TEST	1.228	1.240	1.252	V
D9 (red) current	VSEL at the 4 / 8 cell threshold, through 1 k		2.5 / 6.9		mA
D10 (green) current	VSEL 4.5 V / 12.8 V, through 1.5 k		0.9 / 6.3		mA
Current while held	LM393, reference, divider and one LED	2		9	mA
Current when released			0		uA

The minimum and maximum thresholds are worst-case sums of the reference (+-1 %) and the four divider resistors (+-1 % each), about +-3 %. The test runs at almost no load, so it reads the cells' open-circuit voltage.

5. Controls, indicators and connectors

Ref	Function	Part	Detail
J1	Output	AMASS XT60PW-F (female, right angle)	Pin at x = 31.0 mm: + (VOUT). Pin at x = 38.2 mm: - (GND). Takes a male XT60 lead. The mating end overhangs the top edge by 7.9 mm.
SW1	Cell count	ROCPU SK-13D07-4, SP3T slide, right angle	Lever over the top edge. Positions marked 8, 6, 4 CELLS. Change modes with the load off. Pad 2 (centre) is the common.
SW2	TEST	Hroparts K2-1102DP-S4SW-04, 6 x 6 mm, 13 mm tall	Hold to test. Tall enough to come through the enclosure lid.
D9	LOW	KT-0603R, red	On while TEST is held and the selected cells are below the threshold. Never lit with the button released.
D10	OK	KT-0603G, green	On while TEST is held and the selected cells are above the threshold.
J2	4 x AA holder	Wire pads, 4.8 mm pitch, 1.15 mm holes	- to GND, + to B4. Black lead to -, red lead to +.
J3	2 x AA holder (cells 5, 6)	As J2	- to B4, + to B6.
J4	2 x AA holder (cells 7, 8)	As J2	- to B6, + to B8.
Q26, U12	Reverse-current block	AO3400A N-MOSFET, TI LM74610 smart diode controller	Between F1 and J1. Conducts only toward the XT60; no idle current.
F1	Output fuse	BHFUSE BSMD2920-300-24V PTC	Resets by itself once the fault is removed and it cools.

In 4-cell mode only J2's holder is used and in 6-cell mode J2 and J3's; the unused holders can stay loaded, since nothing draws from them. Every holder that is used must be fitted: an empty holder in the middle of the stack breaks the circuit.

6. Using the TEST button

Hold TEST for a second and read the LEDs:

LEDs while TEST is held	Meaning
🟢 green only	The selected cells average more than about 1.1 V: OK to use.
🔴 red only	The selected cells average less than about 1.1 V: replace them (all of them, as a set).
both, or flickering	At the threshold: nearly flat.
neither	A holder in use is empty, a cell is reversed or missing, or the cells are completely flat.

The threshold follows SW1: the switch's gate lines also set the test divider, so the same 1.1 V a cell applies in all three modes. Because the test runs at almost no load, cells that pass can still sag below a motor controller's cut-off under a heavy load. The test averages the selected cells, so one weak cell among good ones may not show; replace cells as a set.

Nothing checks the cells while the button is released: both LEDs are powered through the button, so neither can light on its own. Press TEST before use, and whenever the load starts to struggle.

7. Protection and safety

Event	Response
Short or overload on the output	F1 trips above 5 A and limits the output to a trickle until the fault is removed and it cools.
SW1 moved with the load on	The output dips or steps for a moment. For a few milliseconds the old and new taps are joined through the MOSFETs while the released gate discharges (about 8 ms through 1 MOhm), which puts a short pulse of a few amps through the cells between the two taps. Calculated to be harmless, but switch modes with the load off.
Holder wired reversed, or a cell reversed	Not protected. A reversed holder can drive the MOSFET body diodes and the test circuit backwards. Check each holder's polarity before fitting cells.
A supply or charger connected to the XT60	Blocked by the smart diode (Q26, U12) up to 30 V above the pack: at most 110 uA flows back. Without it the selected MOSFET pair, which conducts both ways, would charge the cells.
Motor braking (regeneration) or a charged capacitor bank on the output	Blocked as above, so the returned energy stays on the load side: the load's own capacitors or clamp must absorb it.
Short from the XT60 + pin to a higher voltage, then released	Q26 turns off within 5 us; a brief reverse current flows only for that time.
Cells left in for months	The idle current (13 uA at most) takes up to about 4.5 % of a 2.5 Ah alkaline cell's capacity a year. There is no off position; unplug the load. Remove cells for long storage.
Mixed fresh and flat cells	Not detected reliably: the test sees the total of the selected cells, not single cells. Replace cells as a set, and do not mix chemistries.

Warning. Do not charge the cells in the pack: the XT60 blocks reverse current, but there is no charging circuit. Do not mix alkaline and NiMH cells, or old and new ones. A shorted AA pack gets hot enough to burn; F1 limits the fault only once it trips.

8. Mechanical

Parameter	Value
Board size	50.0 x 48.0 mm, 3 mm corner radius
Thickness	1.6 mm FR-4, 2 layers, 1 oz copper both sides
Finish	Lead-free HASL, green solder mask, white silkscreen
Mounting holes	4 x 3.2 mm for M3, centres 3.5 mm from each edge (43.0 x 41.0 mm pattern), 3.6 mm radius clear of copper
Component height, top	13.0 mm at SW2, 9.0 mm at the XT60, 3.9 mm at SW1, under 2 mm elsewhere
Component height, bottom	None. Through-hole leads protrude up to 2.3 mm.
Overhang	XT60: 7.9 mm past the top edge. SW1's lever: past the top edge.

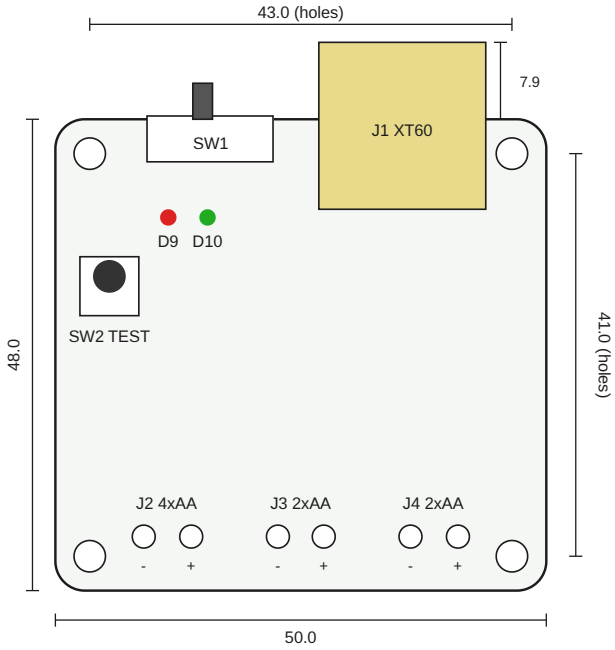


Figure 3. Outline, top view, millimetres. XT60 and SW1 body outlines are approximate.

8.1 Positions

Board-local coordinates, origin at the top-left corner of the outline as viewed from the top, x to the right, y down.

Item	x (mm)	y (mm)	Note
J1 XT60 pins (+, -)	31.0, 38.2	7.55	Mating end toward the top edge
SW1 lever, middle position	15.5	0	2 mm travel each way; 8 cells toward x = 13.5
SW2 plunger	5.5	16.0	3.4 mm diameter, top 13.0 mm above the board
D9 red, D10 green	11.5, 15.5	10.0	0603, 4 mm apart
J2 pads (-, +)	9.0, 13.8	42.5	4 x AA holder
J3 pads (-, +)	22.6, 27.4	42.5	2 x AA holder, cells 5 and 6
J4 pads (-, +)	36.2, 41.0	42.5	2 x AA holder, cells 7 and 8
H1 to H4 holes	3.5, 46.5	3.5, 44.5	3.2 mm

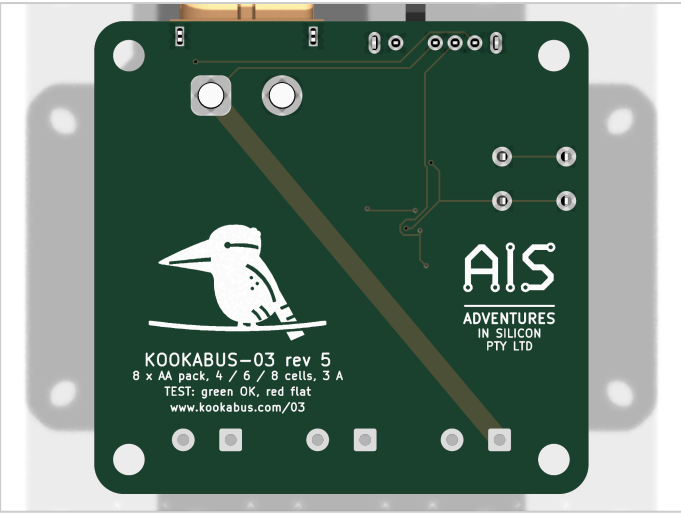


Figure 4. Bottom view. The 2 mm GND track from J2 to the XT60, the kookaburra and board summary, and the Adventures in Silicon mark.

9. Optional enclosure

A 3D-printed enclosure holds the three battery holders and the board. It is generated by `tools/enclosure.py` (FreeCAD) from the board's 3D model and checked for collisions; the printable files are in `production/enclosure/`.

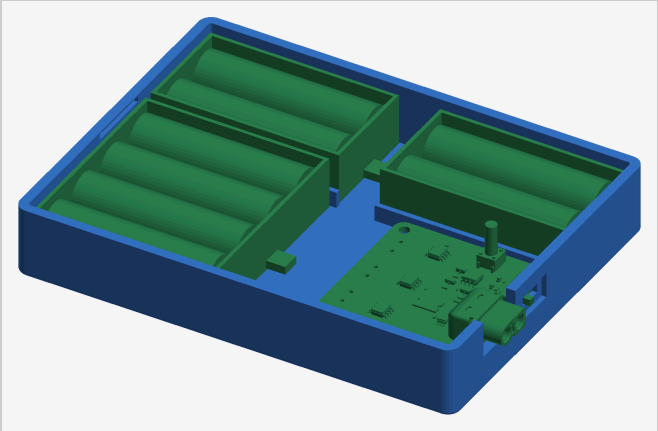


Figure 5. Lid off: the 4 x AA holder and the board in the front row, the two 2 x AA holders behind, their lead ends facing a gap that opens into the channel beside the board.



Figure 6. Closed: XT60 and mode switch in the end wall; TEST button, LOW and OK LEDs and the switch markings on the lid.

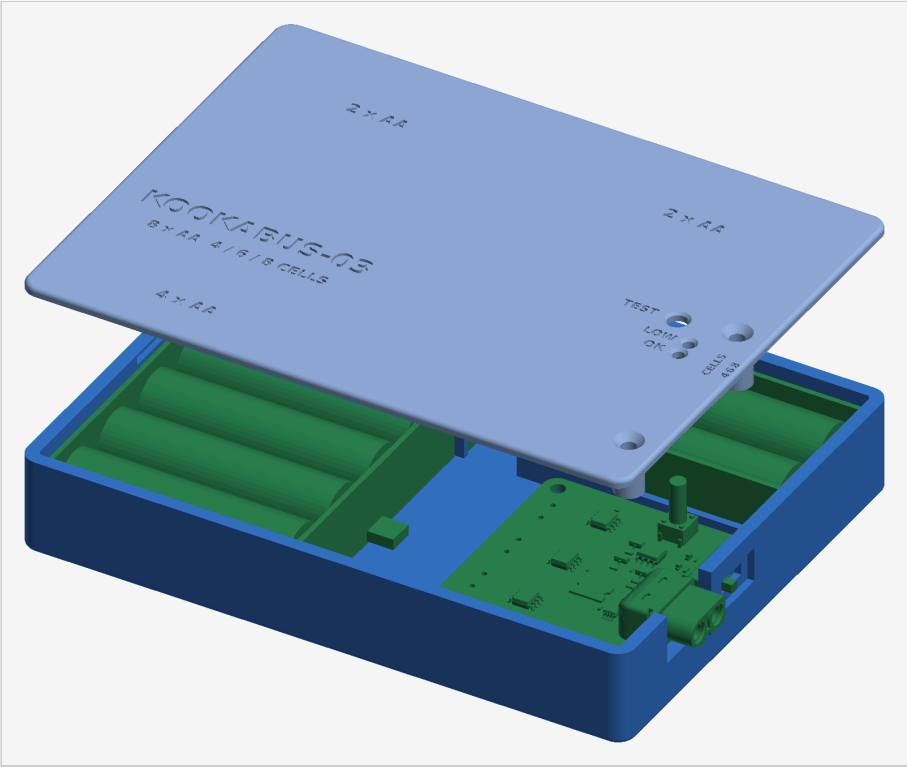


Figure 7. Exploded: lid, base with holders and board, DIN rail clip.

9.1 Dimensions and parts

Item	Value
Outside size, closed	139.0 x 105.5 x 23.8 mm; 32.8 mm deep with the DIN clip
Base (`kookabus-03-base.stl`)	139.0 x 105.5 x 21.8 mm, 3 mm walls and floor. Print floor down.

Item	Value
Lid (`kookabus-03-lid.stl`)	2 mm plate with a locating lip, a tab at one end and two screw tubes at the other. Print top face down.
DIN clip (`kookabus-03-din-clip.stl`)	100 x 64 mm plate with a fixed hook and a spring latch for TS35 rail, rail along the long side. Print as exported.
Other files	`kookabus-03-enclosure.step` (assembly), `kookabus-03-enclosure.FCStd` (with board and holders)
Openings	XT60 window and SW1 lever slot with finger recess in the end wall; TEST (4.4 mm), LOW and OK (2.6 mm) holes in the lid

9.2 Battery holders

Qty	Part	DigiKey	Size (L x W x H)	Note
1	Keystone 2478, 4 x AA, open, 6 in (152 mm) leads	36-2478-ND	58.0 x 63.0 x 16.0 mm	Cells 1 to 4, to J2
2	Keystone 2463, 2 x AA, open, 6 in (152 mm) leads	36-2463-ND	59.5 x 32.9 x 16.0 mm	Cells 5 and 6 to J3, 7 and 8 to J4

The leads are 26 AWG, stripped and tinned; cut them to length and solder them into the wire pads. Other holders fit if their sizes and mounting holes are entered in `tools/enclosure.py` (`CASE4`, `CASE2`, `HOLES4`, `HOLES2`) and the enclosure is rebuilt.

9.3 Hardware

Qty	Part	Where
4	M3 heat-set insert, 4.6 mm knurl, 5 mm long	Board posts
2	M3 x 20 countersunk screw	Lid, through the board into the inserts
2	M3 x 6 pan-head screw	Board, the two holes away from the XT60
6	M2.5 x 5 countersunk screw and M2.5 nut	Holders to the floor, nuts in pockets underneath
4	M3 x 6 countersunk screw and M3 nut	DIN clip (optional)

9.4 Assembly

1. Press the four heat-set inserts into the board posts.
2. If the DIN clip is wanted, fit it now: four M3 countersunk screws go down through the floor into nuts in the clip's pockets. The holders cover the screw heads.
3. Screw each holder to the floor through its own two holes (M2.5 countersunk, nut underneath), lead ends toward the channel beside the board.
4. Solder the holder leads to J2, J3 and J4 (black to -, red to +), routing them through the channel and the gap between the 2 x AA holders. Check each holder's polarity with a meter before fitting cells.
5. Set the board on the posts with the XT60 and switch in the end wall, and fix it by the two holes away from the XT60 (M3 x 6).
6. Fit the cells, hook the lid's tab under the far wall, lower it over the TEST button and fix it with the two M3 x 20 screws through the board's other two holes.

9.5 Changing the batteries

Undo the two lid screws at the XT60 end, lift that end and slide the lid's tab out of its slot. All eight cells are then open from above; nothing else has to come apart. The screws go into brass inserts, so the lid can be opened as often as needed. Bars under the lid hold the cells in their holders when it is closed.

9.6 DIN rail mounting

Hook the clip's fixed lip over the top of a TS35 rail and press the box against the rail until the spring latch snaps behind the bottom edge. To remove it, lever the latch down with a screwdriver. The clip adds 9 mm to the depth.

10. Application information

10.1 Typical connection

1. Set SW1 for the voltage the load needs (4, 6 or 8 cells) with nothing plugged into J1.
2. Fit cells in every holder that mode uses, and press TEST: green means ready.
3. Plug the load in with a male XT60 lead.
4. When TEST shows red, replace all the cells in use.

10.2 Choosing cells

NiMH cells (about 2 Ah) hold their voltage and capacity up to about 2 A and suit motors and servos. Alkaline cells give more energy at low currents but lose much of it above a few hundred milliamps and sag early under motor loads. Lithium AA primary cells (1.5 V nominal, up to 1.8 V fresh) raise the 8-cell voltage to about 14.4 V: check the load's limit before using them.

10.3 Thermal

At 2 A the board dissipates about 0.25 to 0.5 W (selector MOSFETs, smart diode, PTC and copper; most in 6-cell mode, where Q22's halves are in series) and barely warms. The cells themselves warm more than the board at high currents.

11. Ordering and fabrication

Item	Detail
Product	Kookabus-03, board revision 5
PCB	`production/kookabus-03-gerbers.zip`: 2 layers, 50 x 48 mm, 1.6 mm, 1 oz copper, HASL lead-free
Assembly	Top side only. `kookabus-03-jlcpcb-bom.csv` and `-cpl.csv`: 22 lines, 27 placements. The `-smd` pair (19 lines, 24 placements) leaves J1, SW1 and SW2, all through-hole, for hand soldering.
Parts cost	About $4.00 a board (JLCPCB, 30 September 2026), plus about $4.82 for the three holders (DigiKey, quantity 1)
Design files	KiCad 10 project, Gerbers, drill, position and BOM files, JLCPCB assembly files, enclosure STL, STEP and FreeCAD files
Key components	3 x AO4805 dual P-MOSFET, LM74610 smart diode controller with AO3400A, BSMD2920-300-24V PTC, LM393 comparator, TLV431A reference, 2 x BSS84, XT60PW-F, SK-13D07-4 slide switch, K2-1102DP tactile switch

12. Revision history

Board rev	Date	Change
1	30 September 2026	First design: eight SMT AA holders on a 75 x 95 mm board, four cells a face, and a green cell-OK LED with its own boost driver for every cell. Not built: about $30 of parts a board.
2	30 September 2026	Cost-down: off-board holders wired to pads, per-cell LEDs removed, 50 x 42 mm board. Optional 3D-printed enclosure with DIN clip.
3	30 September 2026	TEST button with green OK and red flat LEDs, threshold set by the mode switch. Board 50 x 48 mm. Kookaburra, board summary, website and Adventures in Silicon mark on the back.
4	30 September 2026	Reverse-current block between F1 and the XT60 (LM74610 smart diode, AO3400A). First SW1 rewiring (superseded by revision 5).
5	30 September 2026	SW1 rewired to the ROCPU drawing (common on pad 2, the centre terminal): earlier revisions followed KiCad's generic symbol or a misread note and would have worked in one mode only. Always-on low-battery detector (HT7044A-1) removed: the red LED is fed from TEST and lights only while the button is held.

Document rev	Date	Change
0.1	30 September 2026	First draft, for board revision 3. Calculated values only.
0.2	30 September 2026	Updated for board revision 4: reverse-current block, SW1 pinout.
0.3	30 September 2026	Internal draft, not released: first SW1 correction.
0.4	30 September 2026	Updated for board revision 5: SW1 pinout corrected after a production-readiness review, always-on low-battery LED removed, mode-change behaviour described.
0.5	30 September 2026	Checked against board revision 5 and its renders: VOUT definition, board dissipation with the smart diode, TEST plunger diameter.

Adventures in Silicon Pty Ltd. Kookabus-03 Datasheet, document revision 0.5 (draft), 30 September 2026. www.kookabus.com/03

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