

CPM

THE CELL PERFORMANCE MONITOR

4 – 16 cells LiFePO₄/LTO

Technical manual

Module description

The Cell Performance Monitor (GWL CPM) is an easy-to-use and effective solution for the protection of the LiFePO₄ and LTO batteries from excessive discharge or overcharge.

The key features:

- When exceeding the user-adjustable minimum or maximum of any cell, CPM module closes or opens the output contacts for the relay coils.
- It brings the lowest and highest cell voltages of the cells in pack to separate outputs (for monitoring measurements or for connection of the LED display or the communication module).
- The multi-colour LEDs indicate the highest and lowest voltage cells and the operating status of the module.
- It has very low power consumption and a built-in function of battery emergency disconnection from the powered system, including self-disconnection and shutdown.
- It is part of the GWL/Modular series, i.e., it is an open-source solution that is and will be compatible with the related GWL products and with other commonly available components.
- The quality of the design, versatility and technical support options make it suitable for industrial applications and sophisticated home installation solutions.

Application possibilities

- For a battery with 4 to 16 LiFePO₄ or 5 to 16 LTO cells (any number in this range).
- To control a bi-stable (dual coil) relay with a coil of full battery control voltage (or lower) by a pulse of 150 ms. One bi-stable relay can disconnect the charger, the second load, and the third (emergency) is a back-up in case the main relays fail to open.
- For controlling conventional single-coil NO/NC relays with a coil's voltage of full battery voltage. Two can be used to disconnect and connect the charger, load, or as an information to a additional system, such as a charger, converter or communications module. The third relay is back-up (emergency).
- For various display and communications modules, such as a digital voltmeter, Arduino and Raspberry microcomputers, LAN Controller by Tinycontrol, Siemens LOGO PLCs, Schneider Zelio PLC module, Eaton Easy PLC, TECO Foxtrott PLC, etc.
- For many other modules and devices which CPM can forward the necessary voltage information. Additional custom functions and algorithms can be programmed.

Functions

- Powered directly from a protected battery (always from all cells, total voltage 9 V min., 60 V max.).
- Continuous measurement (200 Hz) of all cell voltages and the lowest and highest voltages output to two separate high impedance outputs (Ucells) for further processing.
- Labelling of the lowest and highest voltage cells using a two-colour LED; see the specifications.
- Choice of four fixed predefined upper voltage limits for LiFePO₄ cells and four upper voltage limits for LTO cells (Umax).
- Choice of four fixed predefined lower voltage limits for LiFePO₄ cells and four lower voltage limits for LTO cells (Umin).
- The upper and lower voltage limits are set by hardware, independently of each other, with the rotary switch, without the need for programming.
- Two outputs for standard single-coil relays (Umin – load disconnection and Umax – charger disconnection).
- Four outputs for two-coil bi-stable relays (Umin = load disconnection and connection and Umax – charger disconnection + connection).
- The single-coil relay always opens 20 seconds earlier than the two-coil relay, which can be used to relieve the load or charge before completely disconnecting the battery.
- Emergency outputs for single-coil and two-coil bi-stable relays (Uemergency) designed for emergency load disconnection if Umin and Umax disconnection fails.
- Emergency disconnection of the board's own consumption and safety disconnection from the battery cells after activation of the emergency output.
- Optimization of CPM consumption by divided even power from all connected cells.
- Switching the module on and off using the hardware buttons on the board.
- Switching on, off and reset by potential-free shorting of specified outputs (see the specifications).

Technical specifications

Model	4 – 16 cells	LFP/LTO
Operating voltage, ranges		
Max. total pack voltage (operating/critical) Total operating voltage of the pack min. / max.	9V / 60V	
Number of monitored cells	4 – 16 (any number in this range)	
Cell voltage indication range	1.7 – 4.09V	
Max. operating voltage at cell input	5.5V	
Max. relay output voltage (1, 2, 3 Umin, Umax, Uemergency)	60V	
Current, power		
Own operating consumption	0.65 W	
Own consumption after shutdown	lim 0 (in nanoW)	
Max. permanent relay output load (No 3 Umin, Umax, Uemergency)	0.5 W	
Highest short-time load of relay outputs No. 1 and 2 Umin Umax Uemergency) (150ms)	10 W	
Maximum output current Umin Umax (terminals No. 1, 2 and 3, 4 Ucells)	5 mA (only for high-impedance digital input)	
Voltage protection settings		
Relay switch options for Umin	1.7V 1.8V 1.9V 2.0V (LTO) 2.8V 2.9V 3.0V 3.1V (LFP)	
Relay switch options for Umax	2.5V 2.6V 2.7V 2.8V (LTO) 3.5V 3.6V 3.7V 3.8V (LFP)	
Emergency relay switch of Uemergency, incl. power off of own consumption	0.3V below set Umin	
Emergency relay switch of Uemergency, excl. power off of own consumption	0.3V above set Umax	
Return to operating state	By shorting terminals 8, 9 or switching off and on the board	

Technical specifications

Times	
Cell voltage measurement frequency	200 Hz
Relay switch delay U _{min} U _{max}	35 s for terminal 2, 15 s for terminal 3 If the voltage returns to the set interval after terminal 3 is switched off, terminal 2 does not switch off
Relay switch delay U _{emergency}	30 s (both terminals 2 and 3) (both terminals turn off immediately if U _{emergency} occurs within 30 s of previous U _{min} or U _{max} state reached)
Pulse length for bi-stable relay	150 ms
Switch-on delay	With button on board > 2 s; Terminals 4, 5 > 300 ms
Switch-off delay	With button on board > 2 s Terminals 6, 7 > 300 ms
Reset delay	Terminals 8,9 > 5 s
Dimensions, weight	
Dimensions (L x W x H)	170 x 100 x 23
Weight	150 g
Operating environment	
Operating temperature	-40°C +80°C
IP code in application	At least IP 20
Certification	
EMC	Interference and radiation resistance, protocols according to EN 61 000

Input and output description

CELLS inputs

GND	Negative (-) pole of 1st cell (the first cell is the one where the negative (-) pole of the entire battery is).
1 to 16	Positive (+) pole of cells 1 to 16 (the (+) pole of the entire battery is on the last input).

Ucells outputs

1	The voltage of the cell with the lowest voltage of all battery cells is mirrored here.
2	GND
3	The voltage of the cell with the highest voltage of all battery cells is mirrored here.
4	GND

EXT outputs

1, 2, 3 Not used.

Umin outputs

1	150 ms GND pulse for bi-stable relay after switching on or resetting the board.
2	150 ms GND pulse for bi-stable relay if Umin lasts 35 seconds or immediately at any loss of voltage on any cell.
3	Standard single-coil relay output: If all cells are within set limits, the output is closed (shortened to GND). After reaching Umin and its uninterrupted duration for 15 seconds or immediately upon loss of voltage on any cell, it will disconnect from GND.
4	Not used.

Umax outputs

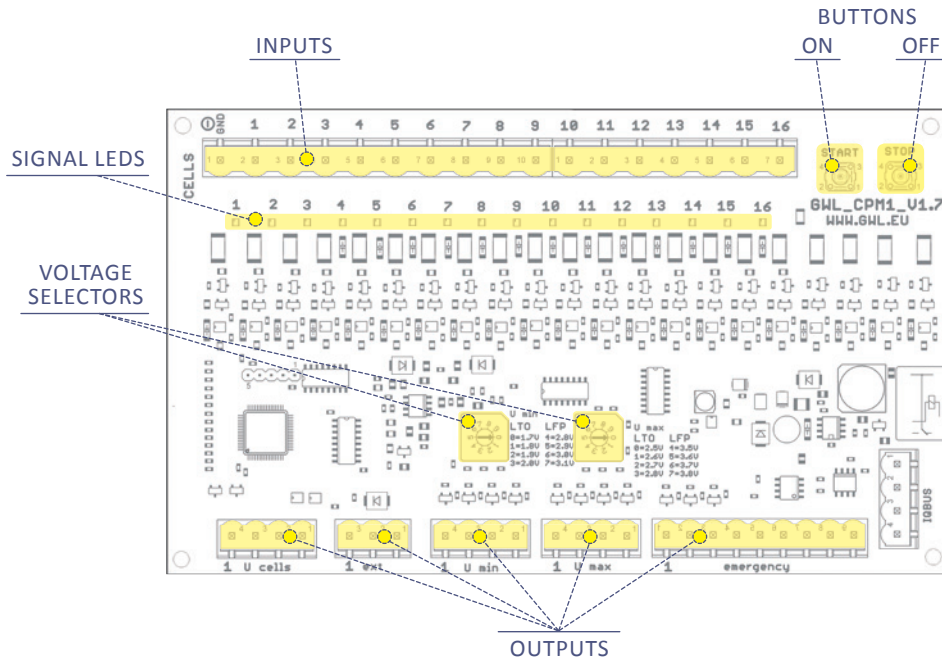
1	150 ms GND pulse for bi-stable relay after switching on or resetting the board.
2	150 ms GND pulse for bi-stable relay if Umax or higher lasts 35 seconds continuously. If the cell voltage returns under Umax within these 35 seconds, it will not open.
3	Output for a standard single-coil relay: if all cells are within set limits, the output is closed (shortened to GND). If Umax takes 15 seconds continuously on any cell, it will disconnect from GND (unless voltage returns below Umax within 15 s).
4	Not used.

Emergency outputs

1	150 ms GND pulse for bi-stable relay after switching on or resetting the board.
2	150 ms GND pulse for bi-stable relay 30 seconds after reaching Uemergency (i.e., Umin minus 0.3 V or Umax plus 0.3 V).
3	Standard single-coil relay output: If all cells are within set limits, the output is closed (connected to GND). 30 seconds after reaching Uemergency (i.e., Umax plus 0.3 V or Umin minus 0.3 V) or immediately at voltage on any cell, it will disconnect from GND.
4, 5	Switching on the module by shortening terminals (caution; the positive pole is on the terminals). Caution; CPM does not respond to closing 6 + 7 and 8 + 9 in case of permanent connection of these terminals.
6, 7	Switching off the board with by shortening for > 300 ms (all relays switch off when CPM is turned off).
8, 9	Resetting the board fault condition by shortening for > 300 ms (the board will not switch off, only the relays in the fault state will switch to operating state).

IQ BUS outputs

1, 2, 3, 4 Not used.



Description of controls and LED indication

Buttons

Button 1	Press > 2 s = turning on the board.
Button 2	Press > 2 s = turning off the board.

Potentiometers

Voltage selector Umin	Setting Umin 8 positions							
	<table border="0"> <tr> <td>0 = 1.7 V</td> <td>1 = 1.8 V</td> </tr> <tr> <td>2 = 1.9 V</td> <td>3 = 2.0 V</td> </tr> <tr> <td>4 = 2.8 V</td> <td>5 = 2.9 V</td> </tr> <tr> <td>6 = 3.0 V</td> <td>7 = 3.1 V</td> </tr> </table> <p>The zero position (0) is at 'three o'clock', then numbered clockwise.</p>	0 = 1.7 V	1 = 1.8 V	2 = 1.9 V	3 = 2.0 V	4 = 2.8 V	5 = 2.9 V	6 = 3.0 V
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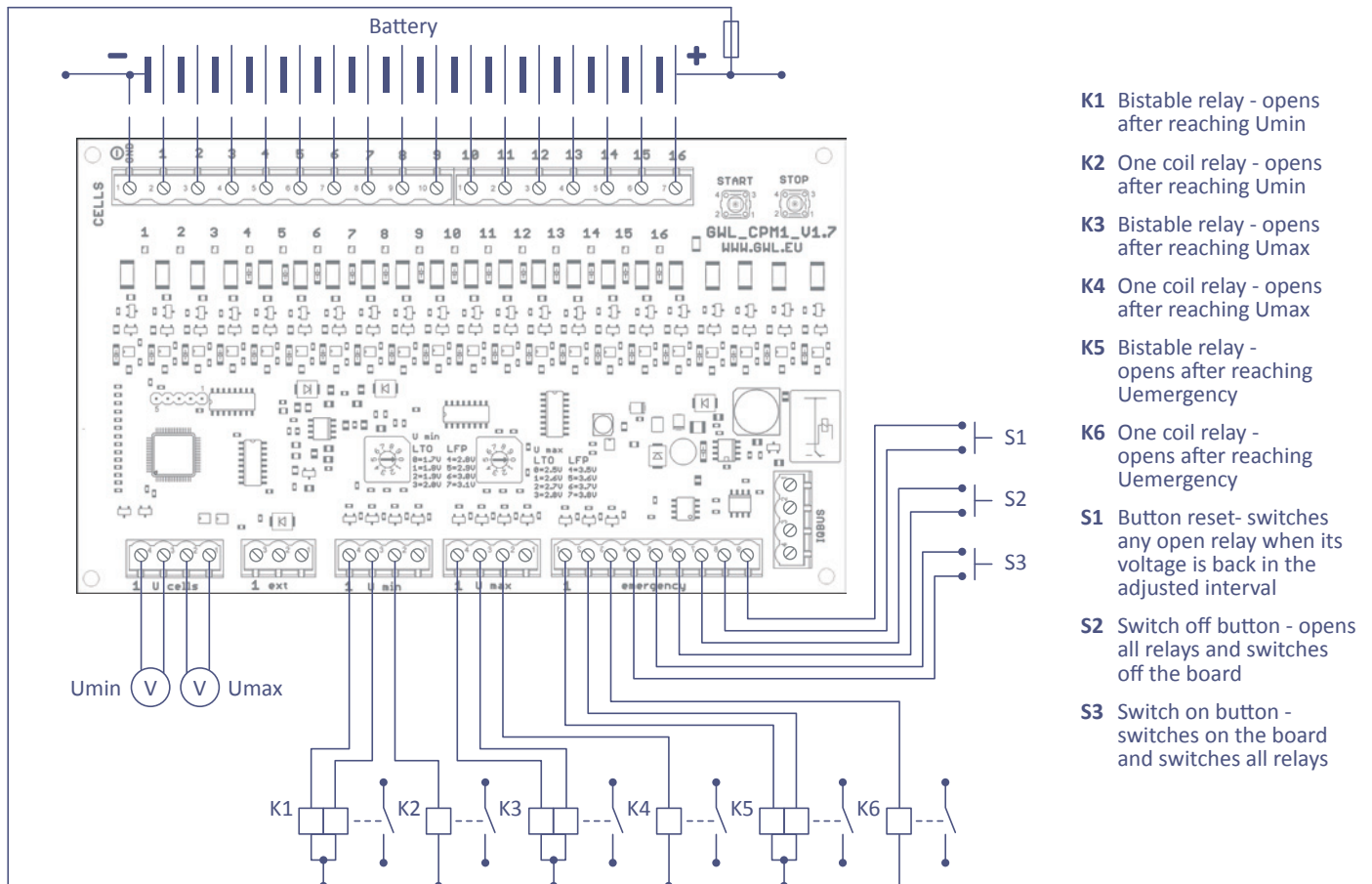
Description of controls and LED indication

LEDs	
Red – Short flashing every 5 s for one cell	Signalling of normal board operation + identification of a cell with the lowest voltage in the set range U_{min} to U_{max} .
Blue – Short flashing every 5 s for one cell	Signalling of normal board operation + identification of a cell with the highest voltage in the set range U_{min} to U_{max} .
The blue and red LEDs of connected cells lit together for a short time	Identification of the connected cells after switching on the board.
The blue and red LEDs of connected cells flashing together quickly	Signalling of the board switching off.

Installation procedure and safe wiring principles

- When handling and attaching, avoid bending the plate and touching the bottom of the board with conductive items.
- Use the voltage selectors to select U_{min} and U_{max} as recommended for the type of battery used and operating conditions. Avoid rough handling and inaccurate positioning of the selector in between the positions.
- Always connect the wires and change the connections with both CPM and other connected modules off. Connect the inputs to the battery using a high-quality, easy-to-disconnect element (connectors, terminals). Always connect GND first. Number the battery cells, terminals and wires in the same way.
- CPM can only be connected to a system in which other devices/modules are negative grounding, or neutral grounding. The system cannot be directly connected to devices with positive grounding.
- If the U_{cells} outputs are connected to the input of another active element (e.g., LAN Controller, PLC), potential equalization must not occur through these outputs. In addition to the principles outlined above, we recommend avoiding a switched-mode power supply. It is ideal to use a battery connected to CPM and connect GND for powering the connected device.
- Provide adequate protection for power and control circuits. Do not add a fuse into the GND control circuit.

Basic connection of inputs and outputs



BATTERY – Connect the battery to GND and CELLS inputs 1–16.

GND is always negative (-) of the entire battery. Connect the positive (+) poles of each battery cell to inputs 1–16 in the electrical order from GND as they are connected in series.

U_{cells} – Connect digital voltmeters (not analogue with pointers), bargraphs, or use for communication with a connected device. Use only the high impedance load and follow the principles of safe connection to the connected systems described in the 'Installation procedure and safe wiring principles' section.

U_{min} – Use to open the load relay or for optical and sound indication of low battery cell voltage or to communicate with the connected system.

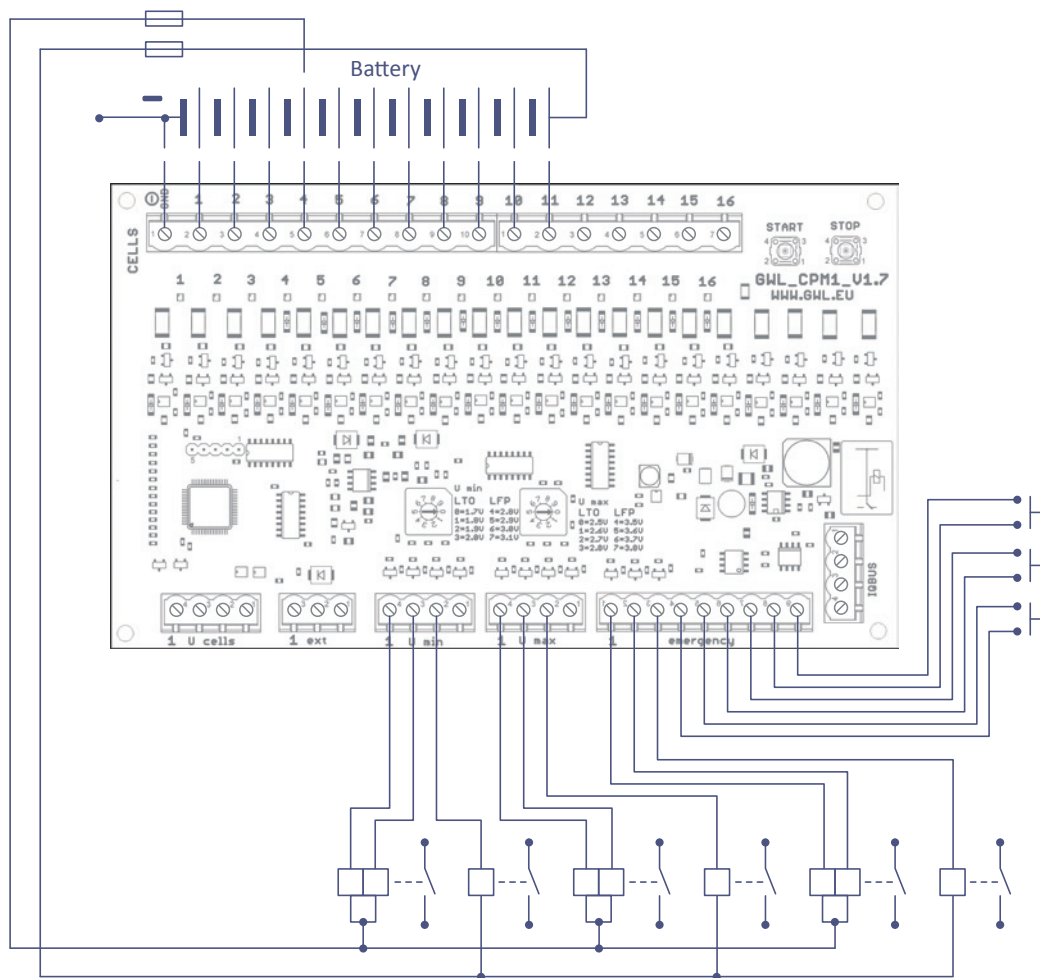
U_{max} – Use to open the charger relay or for optical and sound indication of high battery cell voltage or to communicate with the connected system.

Emergency 1, 2, 3 – Use for emergency battery disconnection.

Emergency 4–9 – Use to control the module by pulse switching (> 300ms, start, stop, reset). If inputs 4 + 5 are permanently connected, the module does not respond to commands via outputs 6, 7 and 8, 9.

Some examples of possible connections

1. CONNECTING A BATTERY WITH A DIFFERENT NUMBER OF CELLS AND RELAY WITH DIFFERENT COIL VOLTAGE

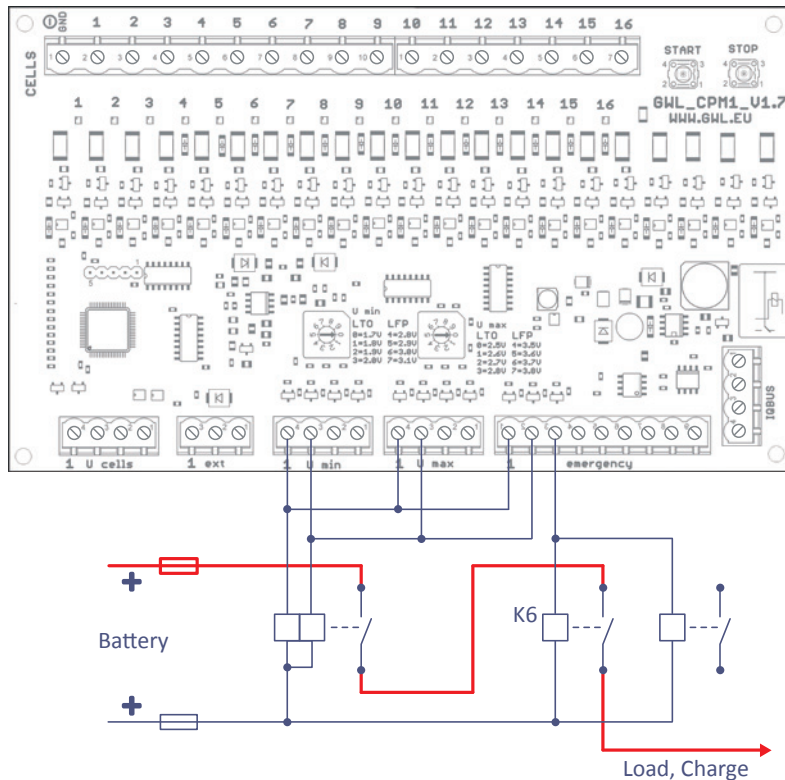


Any number of cells in the range of 4–16 can be connected; always from terminal 1 in the electrical sequence of the serial connection to the battery. A parallel battery cell connection is considered to be one cell.

Always connect the control contact of single-coil monostable relay to the last cell (total battery voltage), otherwise the cells will discharge unevenly and unbalance.

Alternatively, you can connect the control contacts of a two-coil bi-stable relay to any battery cell (part of the battery voltage), as short control pulses will not normally cause the battery to unbalance.

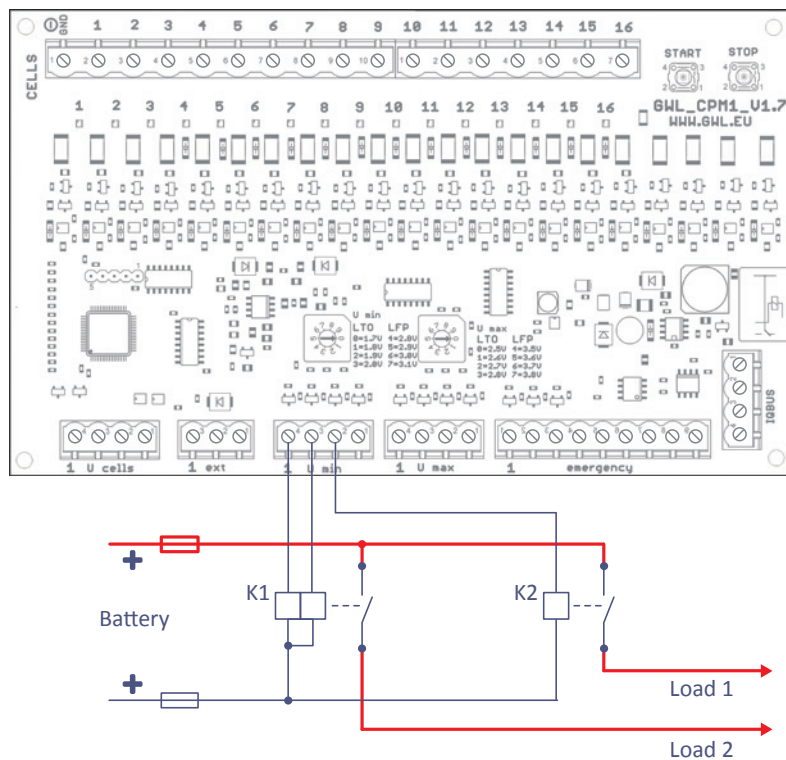
2. POSSIBILITIES OF COMBINED BI-STABLE RELAY FUNCTION AND MULTI-USE OF SWITCH TERMINAL



For each protection (Umin Umax Uemergency), it is advisable to use a separate relay for maximum battery protection. The combination of two or three pulse outputs per bi-stable relay reduces the quality of protection (possibility of contact bonding, coil or output failure, etc.). The combination of pulses can be used in justified cases; the electrical module structure makes it possible.

The use of a switching output for connecting multiple relays is possible if the maximum output load as specified is maintained. Otherwise, use the power contacts of an auxiliary relay.

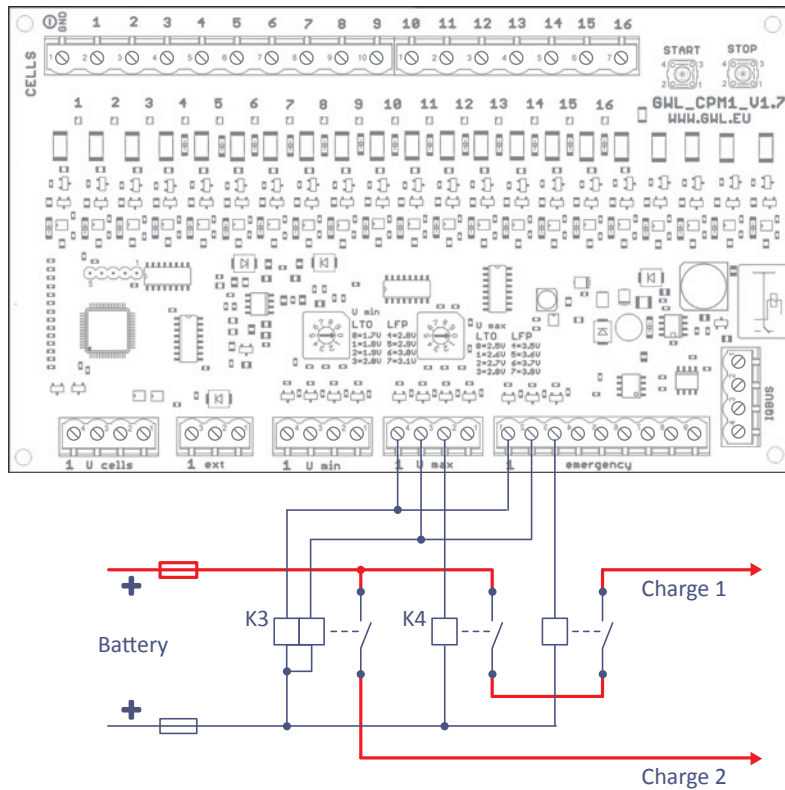
3. CONNECTING A LARGE DISPENSABLE AND SMALL USER-IMPORTANT LOAD



Connect high dispensable load via a standard relay, indispensable via a bi-stable relay. The high load will be disconnected first, and if the cell voltage is stable within 20 s, the important load will no longer be disconnected.

The dispensable load can be switched on again via the RESET output after recharging the battery without interrupting the important load.

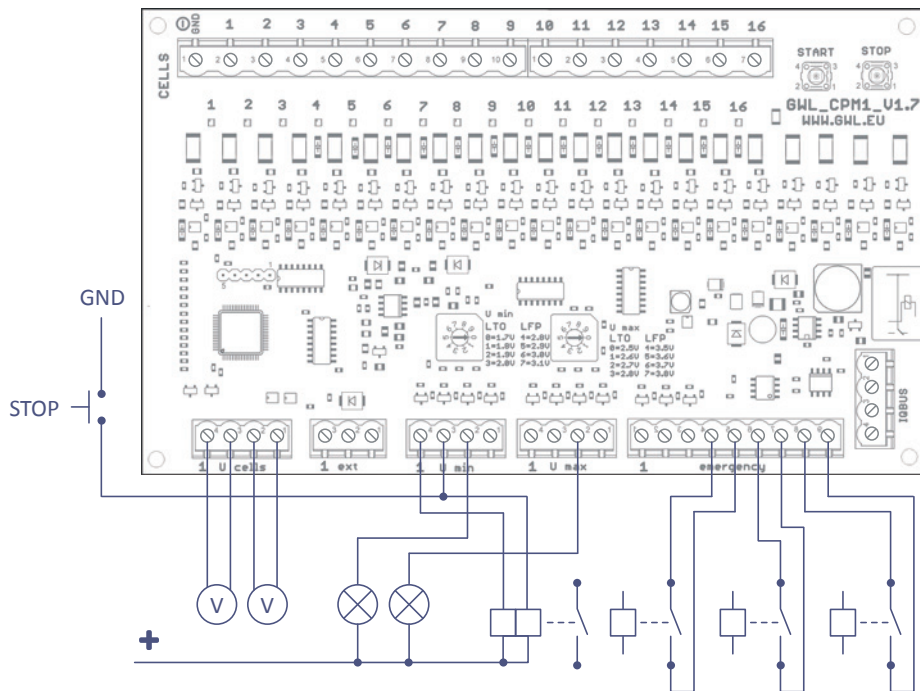
4. CONNECTING HIGH-PERFORMANCE AND CONTINUOUS (CHARGING) CHARGER



Connect the high charge current via a standard single-coil relay, low charge current via a two-coil bi-stable relay. The 'Charge 1' high charge power will be disconnected 15 seconds after reaching U_{max} , and the 'Charge 2' low charge current will no longer be disconnected if the cell voltage drops below U_{max} again within 20 seconds.

The 'Charge 1' high charge current can be switched on again using the RESET output without the low charge current being interrupted.

5. POSSIBILITIES OF CONNECTING CONTROL OUTPUTS AND MONITORING ELEMENTS

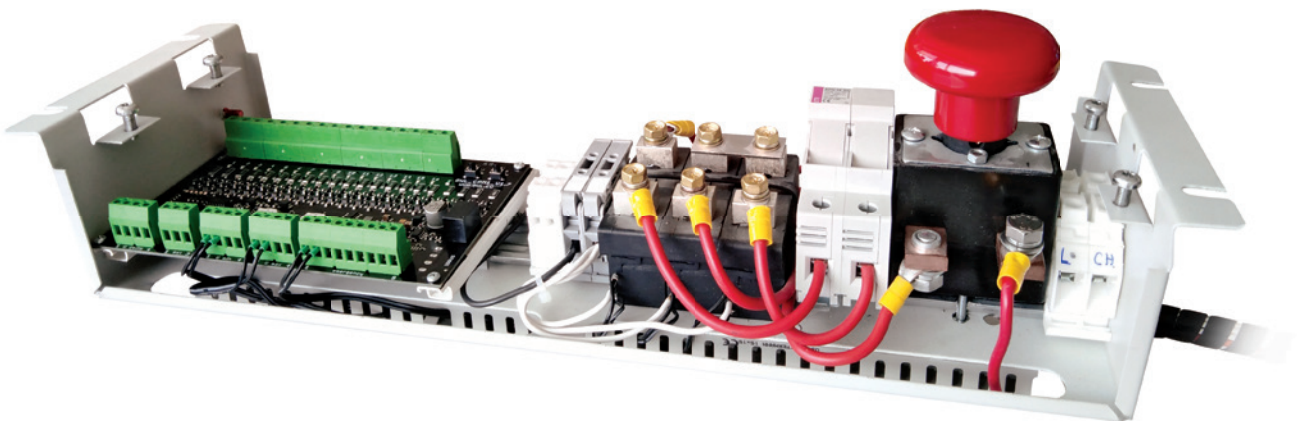
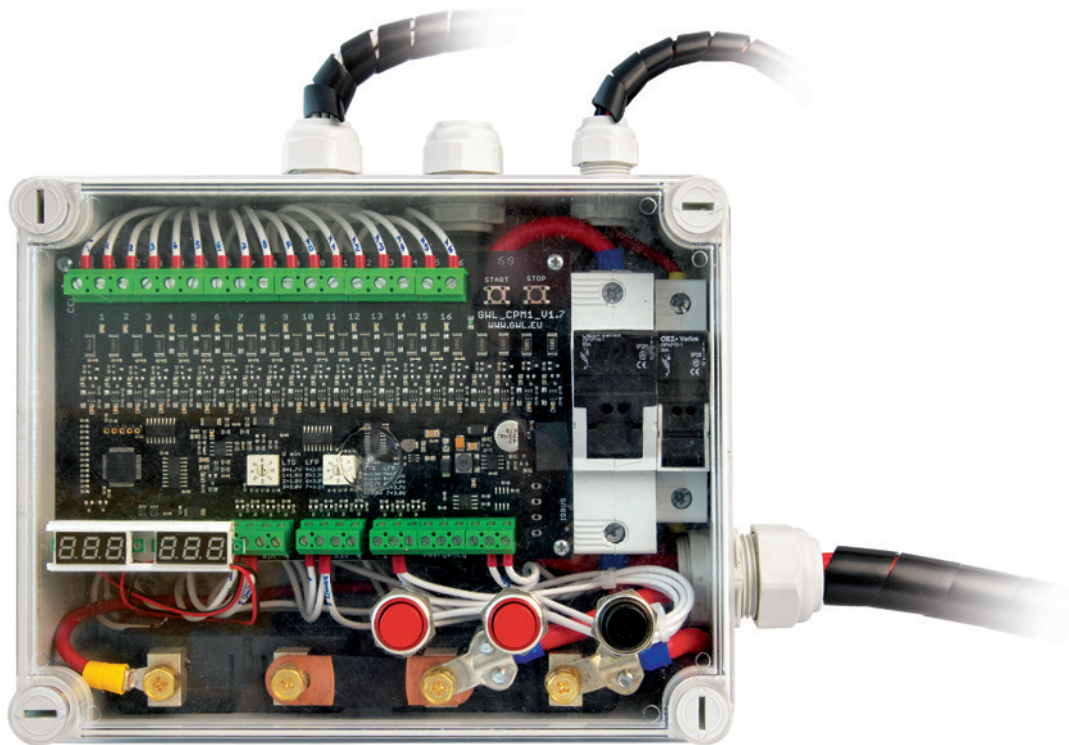


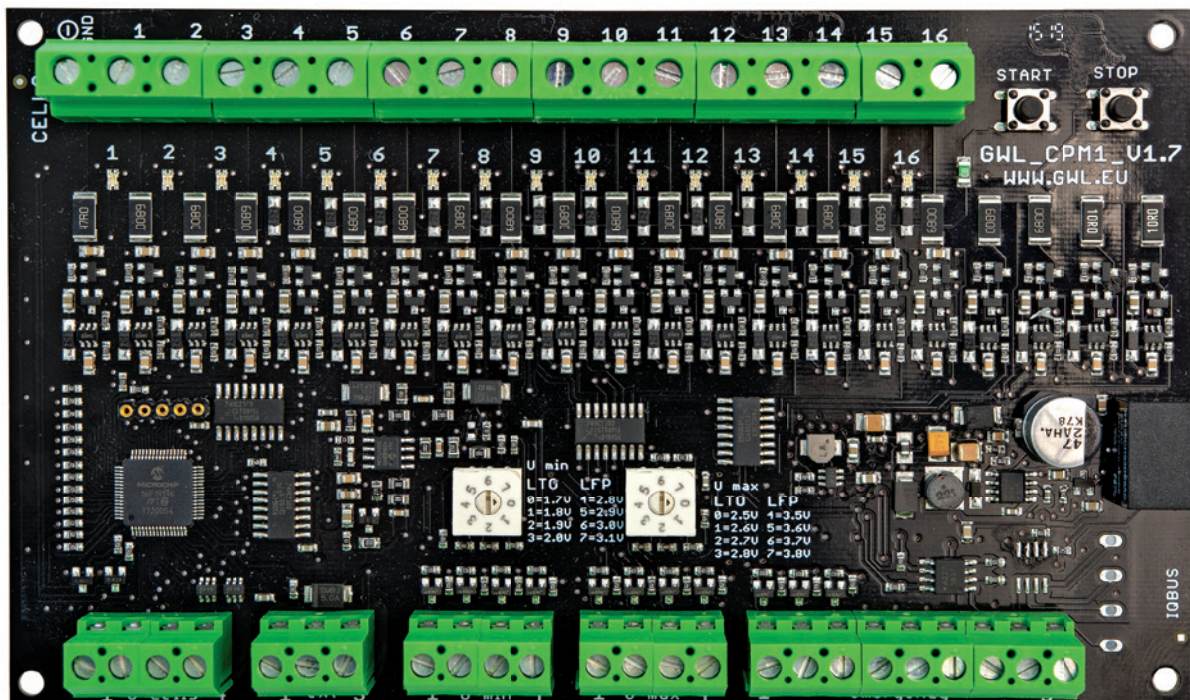
Relay disconnection states (failures) do not have hysteresis of returning to the operating state deliberately for security reasons. To return to the operating state, the RESET output is used. For example, use a time relay, button or other external communication device which shortens contacts to switch it on. The same options apply to the STOP output. Caution! The total battery voltage is presented on START output 4 and 5.

Whenever the CPM is turned off in any way, all relay outputs are turned off. Free relay outputs can be used, for example, to signal the switch-off status externally.

The bi-stable relay can be switched off by GND pulse via the external 'red' button for safety and control reasons. The 'green' button is connected to the RESET output.

CPM Installation Examples





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