OWN TEST TOOLS and DEVICES

On the top of standard commissioning skills I have developed additional methods and devices to complete job in difficult scenarios. Professional testing equipment is not always available when needed. I found it very helpful to always have a set of portable testing equipment for troubleshooting. Portable testing equipment is not meant to replace manufactured and calibrated equipment but as a valuable addition.

The rental cost, weight, and shipping cost of professional equipment can be prohibitive when trying to have all possible testing equipment available onsite. I came up with the idea of having a set of small portable devices, wires, and wire jumpers connected with quick connectors to have always with me in toolbox. Solution was small size and low weight. I ended up with portable set *(Fig. 1)* weighting under 5 kg.

Most portable devices like oscilloscope, variable and floating DC power supply, DC signal generators, milli-ohm meter I just selected and purchased. However, I needed to design and build a breaker test station *(Fig. 2)* and universal programmable controller *(Fig. 4)* myself.

Figure 1: Portable toolset

Figure 2: Universal programmable controller

The programmable controller has 4 inputs (5-170VDC), 4 outputs (10A dry contacts), and a DC current sensor, weighing only 0.4 kg. It can be powered by a 5V battery bank or a laptop USB port. The controller's inputs and outputs are optically isolated, making it safe to connect to and operate by a laptop. The controller is programmed using a powerful and flexible C/C++ language. I can create or modify C/C++ programs for particular troubleshooting or testing requirements.

The 25 multicolor programmable LEDs provide visual status. Text messages can be sent to a laptop USB port and read by any terminal program. The device can be operated using mini buttons, input statuses, or a laptop keyboard.

Functional examples:

- **Breaker Simulator**: Allows saving the breaker mechanism while testing relays or testing a transfer scheme with a missing or defective breaker.
- **Multichannel Timer**: Helps find the operation sequence and events time spacing, aiding in systems troubleshooting, breaker or relay quick timing verification.
- **Visual Input Sensor**: Allows the operator to visually catch short pulses. The bottom input diodes are green when the input is open or low and red when closed or high. The second row of diodes is programmed to illuminate blue for 1 second when the associated input changes from open to close or yellow when the input changes from close to open.

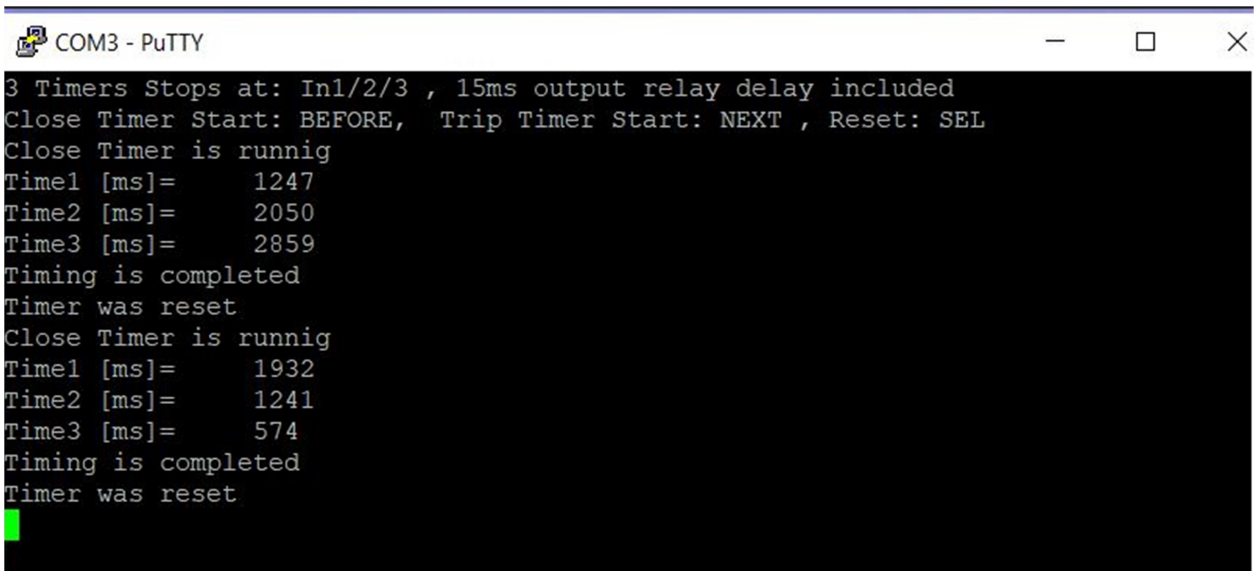

Figure 3: Close (NO) timer operation results from laptop terminal

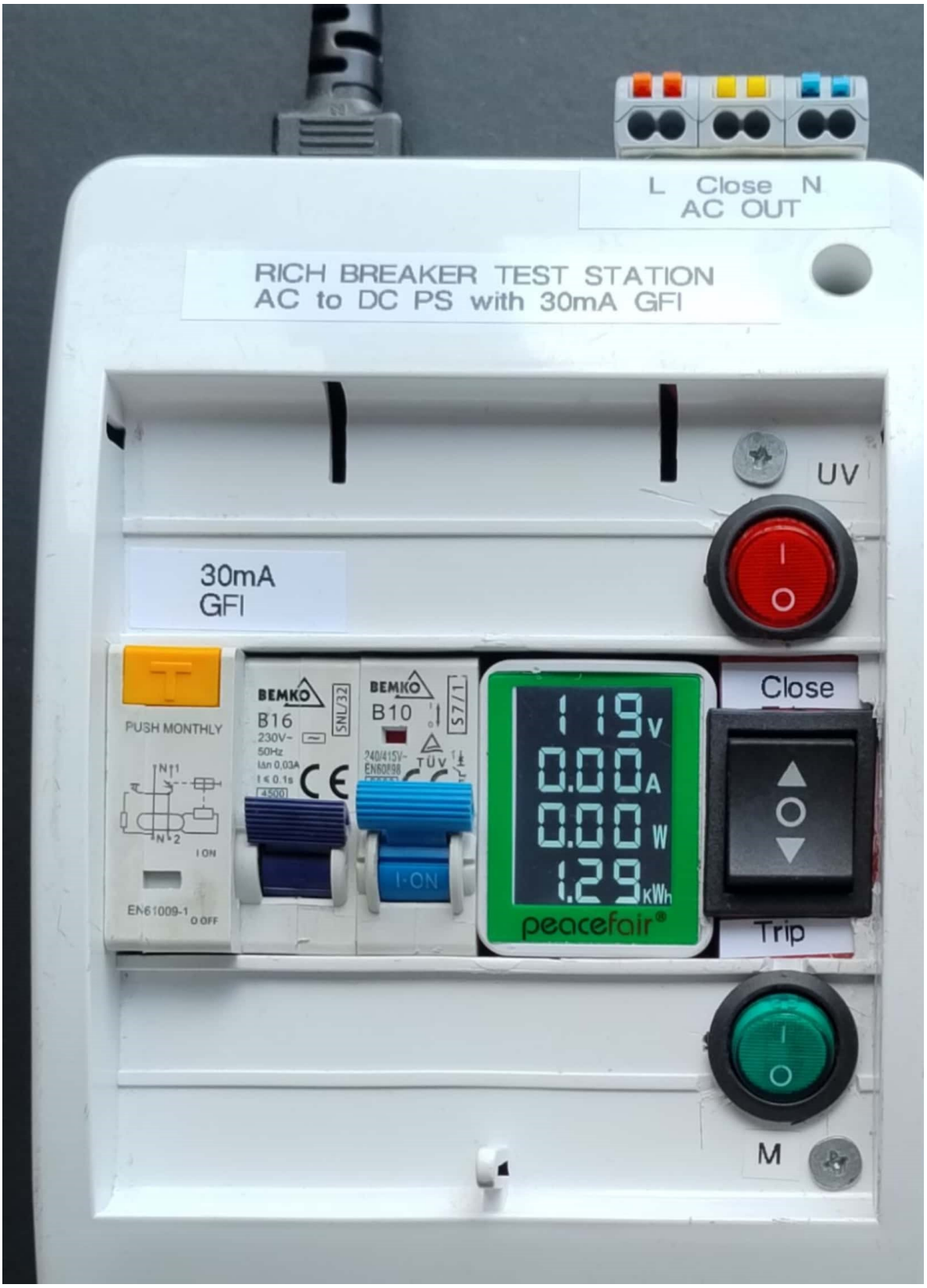

Figure 4: Breaker AC/DC test station

The AC/DC portable Breaker Test Station and DC Power Supply with a 30mA GFI weighs only 1.0 kg. The station can be powered by either AC or DC, or it can be used as just a button start/stop station for breakers and contactors. It is protected by a 16A 30mA GFI breaker combo in series with a 10A fast breaker, providing safety and fault indication. In the case of a ground fault, the 16A GFI breaker trips first. Overcurrent and short faults cause the 10A OC breaker to trip. A meter monitors current and voltage, helping to indicate problems within the attached breaker. The breaker plug is connected using simple wires attached to quick connectors and can be easily swapped.

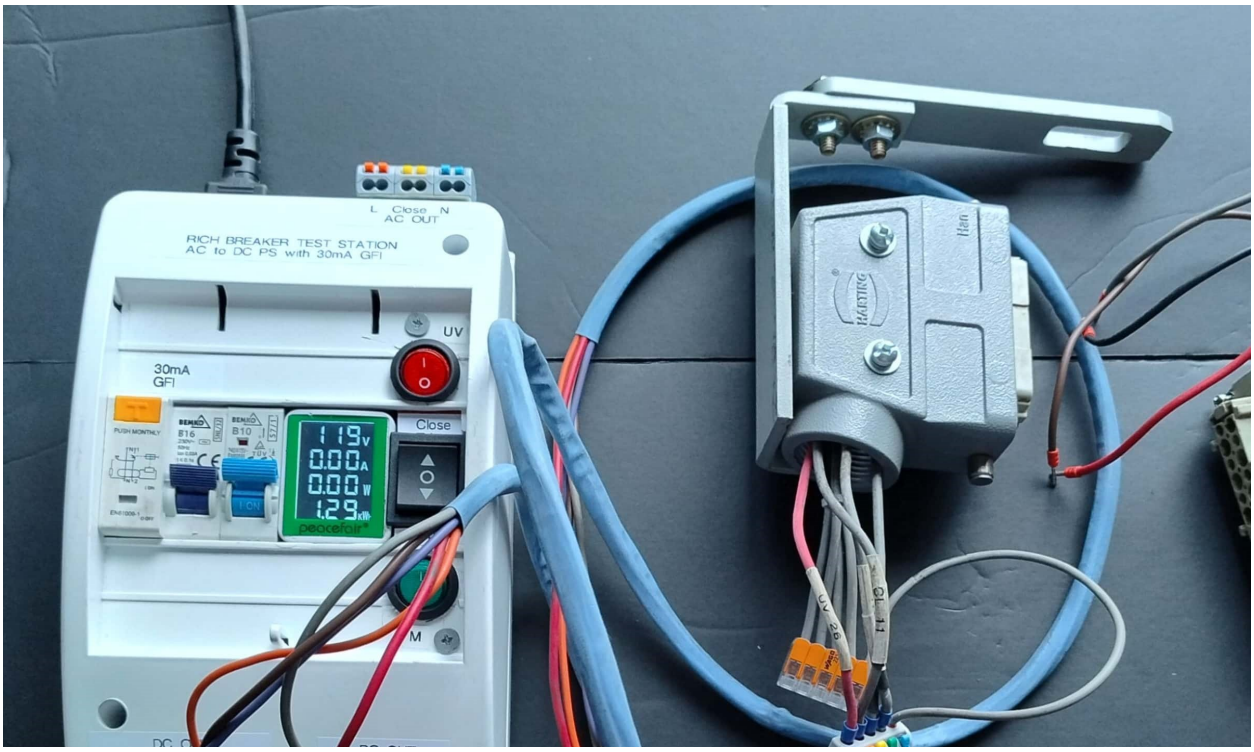

Figure 5: Breaker test station connections

Other practical examples:

- **3 Phase AC Source**: Symmetrical 3 phase AC output follows single phase voltage adjusted with small Variac transformer. I tested protective relays and transfer scheme with Omicron CMC356. Tester was taken away for another site. Few weeks later I used my AC source to simulate SCADA inputs and demonstrate transfer scheme to client.
- **DC Signal Generator**: I used the generator with resistors voltage divider to simulate all functions on DC traction relays.
- **Variable floating DC source**: I used it for testing relays when site DC was not available. (rectified AC does not work in control circuits.