



Energy meter - HydroContest-X

1. Introduction

In order to limit the problem of heterogeneity in the batteries used during the HydroContest-X competition, the decision was taken to create a single energy meter for all teams. This energy meter will measure in real time the energy used by boats during competition races.

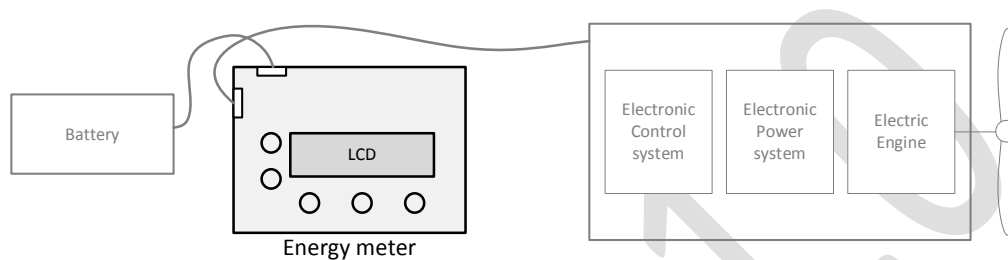


Figure 1: Energy meter

The School of Engineering and Architecture of Fribourg (HEIA-FR), a member institution of the HES-SO, is in charge of building and supplying these energy meters to all participating teams. As shown in Figure 1, the energy meter must be connected directly between the battery pack and the boat's electronic systems.

2. Description

Connected between the battery pack and the boat's electronic systems, the energy meter measures in real time the voltage and current used by the boat. It calculates the power and integrates it to provide a real-time value of the capacity used. An LCD screen constantly displays the log of measured capacity, energy, voltage and current values. The log of these measurement values is also saved to a micro-SD¹ card, which makes it possible to observe and analyze their temporal evolution in post-processing.

Measured values of battery capacity used are displayed on the screen with a resolution of 1mAh. A measurement of the energy in Joules, the voltage and the current is also made and displayed with a resolution of 1J, 1V and 1A. It is possible to navigate through the log of saved capacity values using the 'Up' and 'Down' buttons. The capacity values saved on the SD card are stored in mAh. The measured capacity is achieved by integrating the current. The energy meter can measure a current above 65Adc.

The energy meter has 3 operating modes; the 'Free' mode, the 'Speed' mode and the 'Endurance' mode. The 'Free' mode is intended for boat testing. The other two modes for Speed races and Endurance races. The mode and all data are saved on the micro-SD card every second. A new file is created each time the energy meter is reconnected to the power supply. The micro-SD card must be inserted before connecting the energy-meter to log values.

¹ Official micro-SD cards will only be provided for the competition week.

3. Basic use

The energy meter must be connected between the battery and all of the boat's control and power electronic systems.

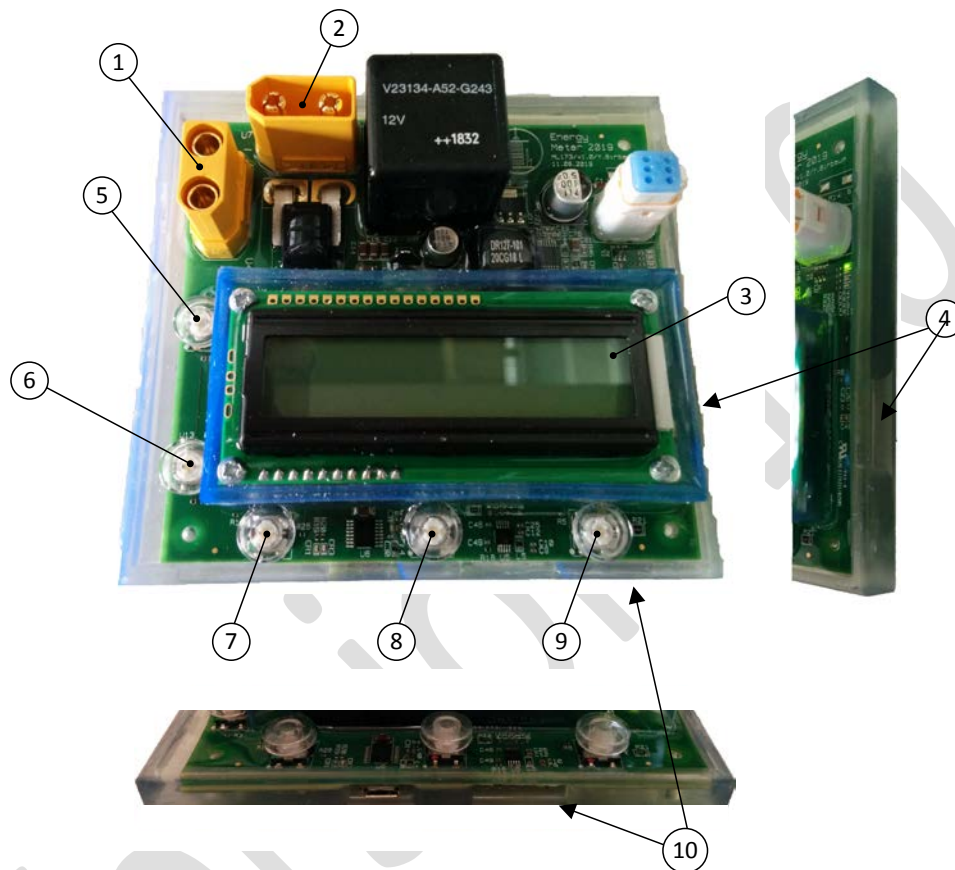


Figure 2: Energy meter

- | | |
|--|--|
| 1. Output power connector (XT90 typ) | 6. Down button to parse energy measurement log |
| 2. Input power connector (XT90 typ) | 7. Speed race button |
| 3. LCD screen | 8. Endurance race button |
| 4. Micro-SD card | 9. Reset displayed energy value or race mode |
| 5. Up button to parse energy measurement log | 10. Analog outputs (E, Cap., I, U) |

By default, the capacity used is measured constantly and without an upper limit. The maximum value is 65535mAh. If this value is exceeded, the next value will restart at 0, which allows for boat tests to be carried out without a system cut-out being activated. The log of measured values is always saved both in the memory and on the SD card. By default, the LCD display shows the last measured capacity value. This value is refreshed every second.

When the energy meter is disconnected from the battery, the log of measured values is saved automatically. Measurement will start again at the point where it was when the energy meter was disconnected.



Figure 3: Display reset

To reinitialize the 'Free' measurement mode, press button 9 'Reset displayed energy value or race mode' during 1 second.

3.1. Analog Outputs

Analog outputs allow users to have real-time information on capacity used, energy, voltage and current measurements. The range of these analog outputs is 0 to 3.3Vdc.



Figure 4: Analog outputs

- | | |
|--|---|
| 1. DAC Enable (active Low) | 4. Current [A], $I_{tot} = U_{A3} \cdot 51.2A/3.3V \cdot$ |
| 2. Energy [J], $E_{tot} = U_{A5} \cdot 1'024kJ/3.3V \cdot$ | 5. Voltage [V], $U_{bat} = U_{A2} \cdot 51.2V/3.3V$ |
| 3. Capacity [mAh], $I_{tot} = U_{A4} \cdot 8192mAh/3.3V$ | 6. GND |

By default, these outputs are disabled as high impedance. To enable them, the pin 6 'DAC Enable' must be connected to GND.



3.2. Log

Buttons 5 and 6, 'Up' and 'Down', allow you to navigate through the log of the measured capacity and the energy values displayed on the LCD screen before last disconnection of the power supply. The start voltage of the battery is in the log also. To start the navigation, simply press the 'Up' button to go back, and press the 'Down' button to move forward.

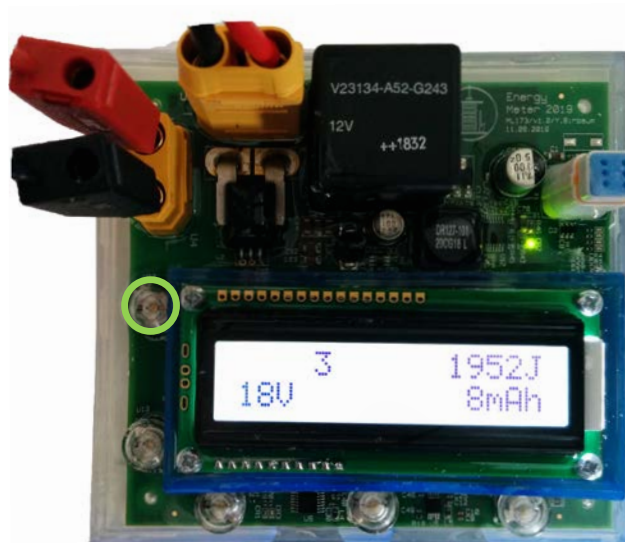


Figure 5: Log – 'Up' button

In addition to the display of the values, there is also increment information. When the 'Up' button is pressed, the refresh of the current measurement stops and the increment is '0'. Then it is possible to press the 'Up' button again to go back up in the measurements and the incremental field increases.

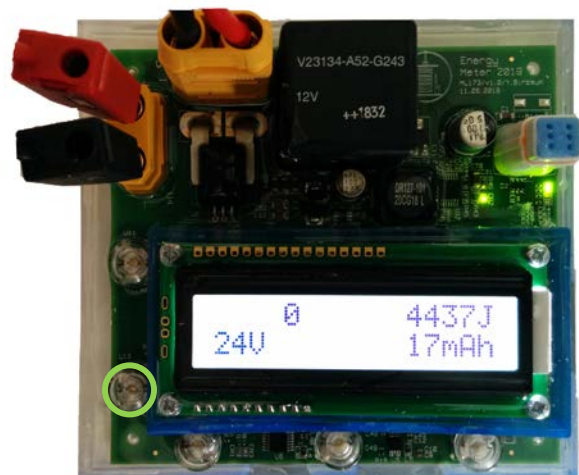


Figure 6: Log – 'Down' button



The 'Down' button allows you to go back down in the measurements and decrease the increment field. When this field is '0', each time the 'Down' button is pressed, a refresh is performed.

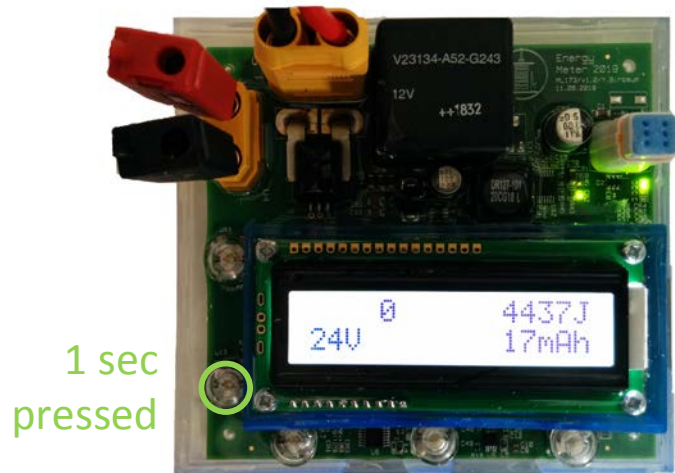


Figure 7: Back to the standard display

At any time, it is possible to return to the standard energy meter display by pressing the 'Down' button during 1 second.



4. Speed Race mode

The energy limit is 7000mAh. The energy meter will physically open the contact when this energy limit is exceeded. To initialize Speed Race mode, the following procedure must be followed:



4 sec
pressed

Push down button 7 for 4 seconds.

LED of button 7 will switch on.

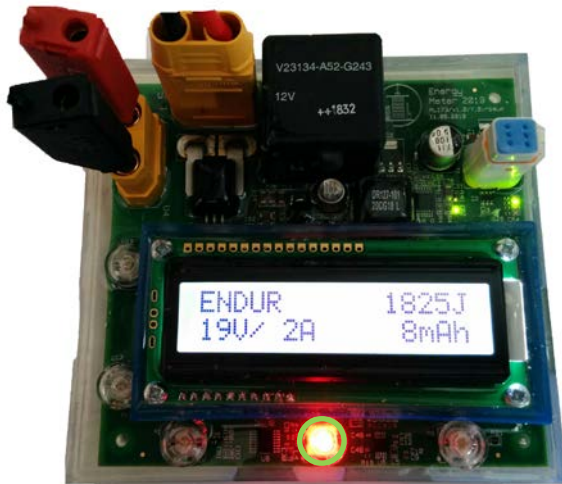
Figure 6: Speed Race mode

The LCD screen displays 'SPEED' on the top left. If the energy meter is disconnected from the battery and then reconnected, energy measurement will restart from where it was, and Speed Race mode will remain activated. To exit the 'Speed' mode, press the button 'Reset displayed energy value or race mode' during **15 minutes**.



5. Endurance Race mode

The energy limit is 7000mAh. The energy meter will physically open the contact when this energy limit is exceeded. To initialize Endurance Race mode, the following procedure must be followed:



4 sec
pressed

Push down button 8 during 4 seconds.

LED of button 8 will switch on.

Figure 9: Endurance Race mode

The LCD screen then displays 'ENDUR' on the top left. If the energy meter is disconnected from the battery and then reconnected, energy measurement will restart from where it was, and Endurance Race mode will remain activated. To exit the 'Endurance' mode, press the button 'Reset displayed energy value or race mode' during **15 minutes**.