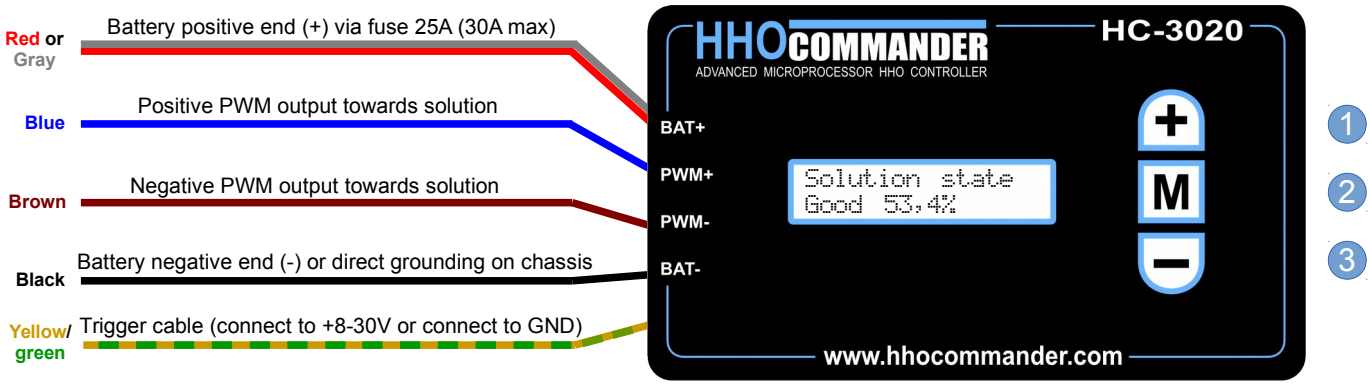
PWM regulator for electrolysis cell H_2O



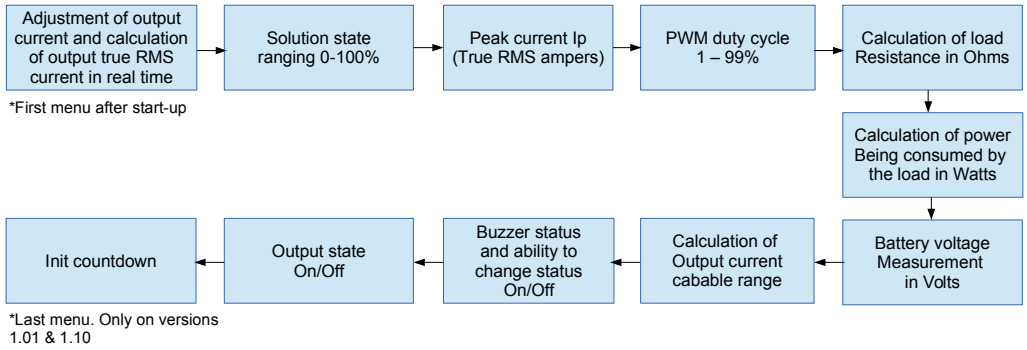
***The fuse must be located in a easily accessible location near the battery's positive end for immediate removal**

WARNING: READ THE FOLLOWING INFORMATION WITH EXTREME CAUTION. NOT COMPLYING WITH THESE INSTRUCTIONS COULD LEAD IN A FIRE OR DEADLY INJURY INCIDENT!!!

The PWM regulator uses a special software for sampling, measuring and calculating all values appearing on the lcd display. The magnitudes taken under consideration for calculating all the values are: Battery voltage, Output peak current (Ip) and load resistance connected at the regulator's output. Be ware that for measuring and confirming the output current with an external instrument, you have to use a TRUE RMS meter otherwise you will get a wrong reading. That, however, is not of essence as the regulator achieves quite high precision on all values being measured.

Adjustment buttons use

There are 3 buttons +, M & - as seen at the illustration above. We can use the buttons + & - for increasing and decreasing output current level accordingly, for enabling and disabling the buzzer and for enabling and disabling the PWM output. Button M is used for selecting between the display menus. Pressing & releasing will sequentially take you through the menus indicated at the illustration below.



Initiating operation

During start-up, you will notice some information on the display regarding the model and the software version currently installed and later on the final countdown before the PWM output is activated. You can cancel the countdown by pressing any key momentarily. Canceling the countdown will directly take you to the first menu that relates to the output current level adjustment.

S/W Version 1.10 introduces a 5th cable coloured yellow/green which acts as a trigger signal meaning that this cable, if connected to any voltage (relative to the GND) from 8 to 30V, will power on the HC3020 regulator. This cable is a direct replacement of the relay used to power on/off the HC3020. It will then act like a power-off signal if disconnected from any voltage source. Being disconnected from any voltage source is defined, in the case of the yellow/green cable, as being in a floating state or being connected to the GND (vehicle's chassis). It is strongly recommended to connect this cable to a GND point as close to the HC3020's black cable (GND) as possible, if you choose to connect it to the ground while powering off the regulator. HC3020 with the s/w version 1.10 is in a power-down state when the trigger cable is disconnected and consumes around 10mA at 12 Volts which is an extremely low current that introduces zero chances that the battery capacity can be badly affected if the vehicle is left at a stand still even for a period of 15 days.

1) Adjusting output current.

Current adjustment is possible by pressing-releasing the buttons + & -. There are 2 rows in the display. The upper row represents the preset current (required output current set by the user). The lower row represents the actual current being drawn by the load. When there is no load connected, the lower row shows 0.00A. In this case, the display will loop sequentially through the figures 1 & 2 so that you are warned of no load detection. The “No load detected” message will show up regardless of the selected menu. In the case of having selected solution state menu with button M, you would still see the figure 2 message, then the solution, then the message and so on.

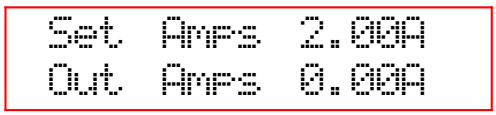


Fig. 1

Fig. 2

2) Solution state indication

The solution state ranges down from 0% and up to a bit higher than 100%. When the percentage is 100% then the peak current is precisely 20A. We define “Peak current” as the current measured with a common amperage meter when the solution cell is directly connected to the vehicle's battery ends. Solution state indicates the dilution of the electrolyte in the water. The lower the solution state goes, the less its' conductivity is. When the solution state gets lower than 30%, the regulator will notify the driver with the buzzer once every half an hour. Even though the regulator has quite a few kilometers of driving ahead, it is recommended for the driver to add electrolyte into the cell. In order for the solution status indication to be well comprehended, it is accompanied by a characterization such as Excellent, Good, Average etc. Re-filling with electrolyte must be performed with the solution state menu selected. Adding electrolyte MUST be done slowly while watching the display percentage reading. Gradually, the reading will keep increasing and stabilizing after a while, increasing and stabilizing and so on. As soon as the indication is close to 100% you are almost done. Care must be taken so that the indication does not go higher than 105%. A good practice would be to observe how much time the solution state indication takes to stabilize after a specific amount of electrolyte and therefore be able to estimate whether more electrolyte is needed or not thus avoiding excessive solution cell filling with electrolyte.

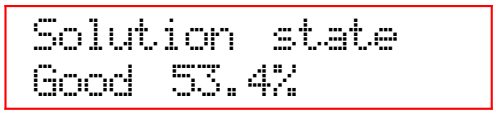


Fig. 3

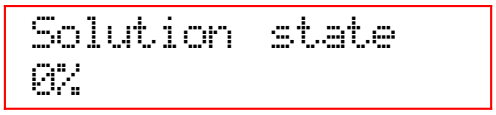


Fig. 4

3) Peak current indication.

The regulator has been designed to take for granted that whenever the peak current is 20A, the solution state is then 100%. The peak current reading is an indirect indication of the solution dilution. If the peak current rises above 21.5A, the display will show the message of figure 6. That is a strong indication of electrolysis cell overfilling with electrolyte. In this case all we have to do is to manually dilute the cell solution by adding some water.

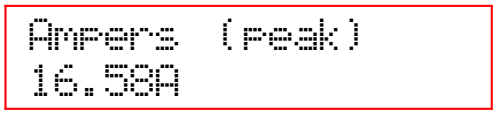


Fig. 5

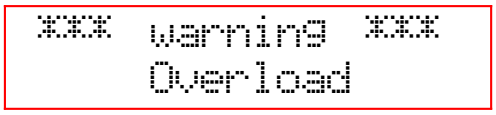


Fig. 6

4) PWM duty cycle

The regulator maintains constant output current by re-calculating duty cycle many times per second with a 16bit resolution (every step is 0.0015%) so that it compensates for any battery voltage ripple or load resistance changes. What is constantly altered over time is solution's conductivity (dropping). This results in more and more increased duty cycle which keeps a perfectly constant current towards the cell solution thus maintaining stable performance and hydrogen production.

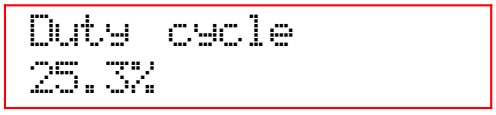


Fig. 7

5) Load resistance indication (Solution cell)

This indication is load's (cell solution) resistance and is basically useful for confirming normal operation and status of the load as well as calibrating of the device by the manufacturer.

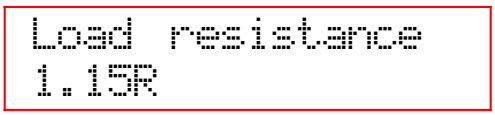


Fig. 8

6) Indication of load power consumption (Solution cell)

The calculation of the duty cycle does not just keep the output current constant but concurrently it maintains a stable power consumption on the load (Solution cell). You could confirm this right away by supplying the regulator with any voltage between 8-30VDC from a power supply that is capable of adjusting its' output anywhere within that voltage range. Connect one or more high power resistors with a total resistance of 1 Ohm at the regulator's output. Power up the regulator and select the menu that indicates the output power consumption. You will notice that no mater what the regulator's supply voltage is, the output power consumption remains the same. This means that whatever the voltage of the battery is at any time, the output power consumption of the regulator and hence the hydrogen production are kept at a stable level.

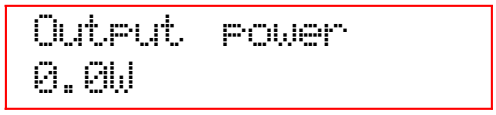


Fig. 9

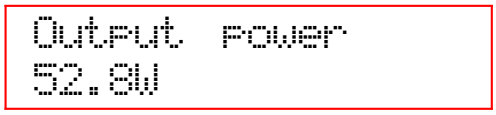


Fig. 10

7) Vehicle battery voltage indication

The battery voltage indication (regulator's supply voltage) appears on the display. It should not exceed 30V no matter what and should not be lower than 8V. The regulator may be used at 12 & 24V vehicles without any modifications on its' circuitry.

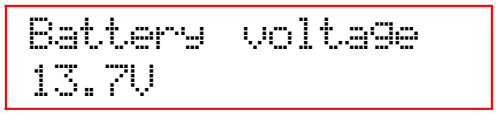


Fig. 11

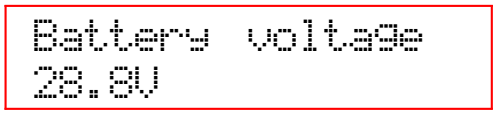


Fig. 12

8) Output current range

This indication informs you about the min and max output current the regulator is capable of at that exact time. These two values are constantly updated while the cell solution dilutes. The min is a little higher than 1/10 of the max.

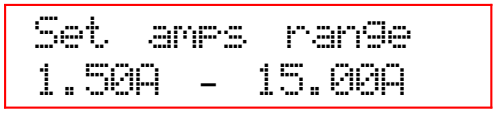


Fig. 13

9) Buzzer status

The buzzer status indication informs you whether the buzzer is enabled or not. You can change the status to OFF or ON depending on whether you wish to be notified via one or more beeps every time that a situation comes up. The buzzer notifies you with 2 short beeps in case of any display messages or with 3 short beeps every 30 minutes when the solution status is less than 30%. You can change the status of the buzzer by using the buttons + & -. If you wish to maintain the change of the status, you have to save this as described on page 5.

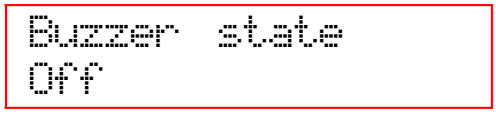


Fig. 14

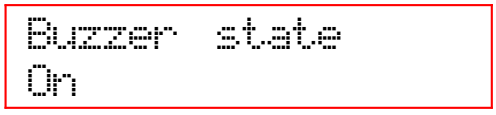


Fig. 15

10) Output state

If required, you can shut down the PWM output. The PWM output is always on under normal operation conditions. If you shut down the PWM output, you will no longer be able to switch through the menus, i.e pressing button M will have no effect. In order for you to be able to switch to the next menu, press on the button + to enable the PWM output. This function is useful when you wish to keep the hydrogen production off while driving or for service / maintenances purposes of the solution cell.

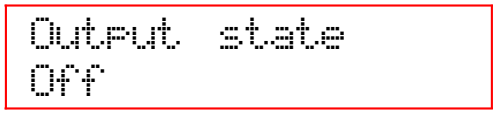


Fig. 16

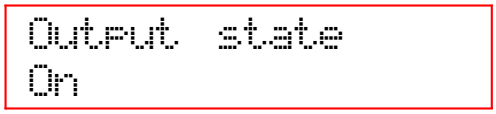


Fig. 17

11) Init countdown (S/W versions 1.01 or later)

Init countdown makes it possible for the initialization countdown timer to be adjusted from 0 up to several seconds depending on each vehicle's requirements. One case that the init countdown is preferred to be zero is when the vehicle stops its' engine on every red traffic light. Given that the init countdown is adjusted to 5, 10 or more seconds, this stop and start procedure creates great periods of time during which the regulator remains inactive thus minimizing H2O generation. If adjusted to zero, the regulator will be started almost a second after engine ignition which in return will maximize the efficiency of the engine's operation and preserve high fuel saving levels even at traffic jams.

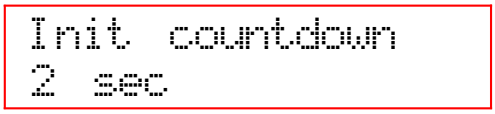


Fig. 18a

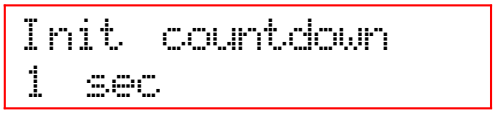


Fig. 18b

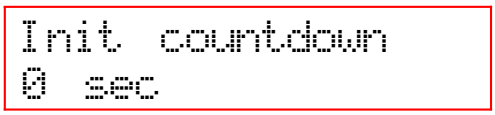


Fig. 18c

Critical situations and errors

12) PWM output ends shorted

CAUTION: This is a condition that must be avoided. Furthermore the safety of the wiring installation must be a high priority matter for the technician who is in charge of the overall installation in vehicles. In case of PWM output ends being shorted together, the electronic protection of the regulator may work. In case the protection is not activated soon enough, the fuse in series with the power supply of the regulator will be burned. Figures 18x illustrate messages that will show up on the display in case of shorted output ends. A short circuit, deliberate or not, results in extremely high stresses on the electronic components that handle the PWM output. Beware that in rare occasions such an event could destroy these components and therefore set the regulator unsuitable for normal operation.

Fig. 19a

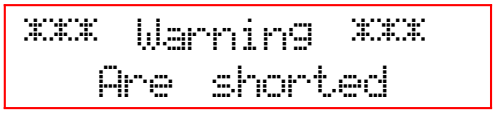


Fig. 19b

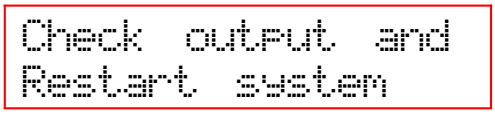


Fig. 19c

13) Message: “Critical Error ... Errorcode: 100”

In this case the display will show:
“* Warning ***, Critical Error, Shut down your vehicle now and remove the fuse that connects battery to the HC3020 regulator. Call your installation company asap! Error code: 100.”**

If this message shows up while the regulator is working normally, then it is possible that the regulator's output power stage has been damaged. In such an occasion it is possible that the battery positive pole will directly be connected to the solution cell's positive end. This would result in constant current up to 20A. The protection fuse will probably not be burned because its' max current is 25-30A. You have to immediately remove the protection fuse close to the battery (which is connected to the regulator) and as such cut the power supply to the regulator.
You could consider that the reason of such a message could, but not limited, be due to one of the following:

- The solution cell supply ends were, mistakenly, connected to the PWM + output and the vehicle's chassis.
- The regulator's output power stage is damaged. The regulator in no longer suitable for normal operation and must be returned for repairing.
- Faulty message that resulted due to bad installation or other unknown cause.

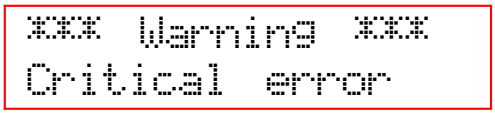


Fig. 20a – First message

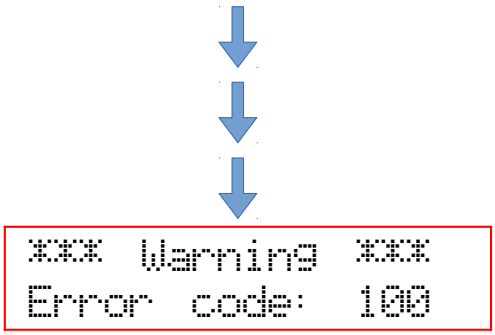


Fig. 20b – Last message

***Inform your customers regarding their next action in case of an “Error code 100” message.**

14) Display warning messages

Depending on the case, various warning messages could appear on the display as seen below.

Figure 21: No load is connected or no solution cell is connected to the regulator.
Figure 22: Amps have been adjusted below the lowest current value that the regulator is capable of maintaining.
Figure 23: Amps have been adjusted over the highest current value that the regulator is capable of maintaining.
Figure 24: The peak current is over 21.5A. The solution is probably too strong and needs to be diluted.
Figure 25: This message appears about 5 seconds after you adjust the output current or the buzzer status. If you wish to maintain the changes the next time the vehicle will be started, press the button M as soon as you see the message of figure 25. After you press the button M, you will see the message of figure 26 which confirms that any changes done will be saved for future operation.

Fig. 21

Fig. 22

Fig. 23

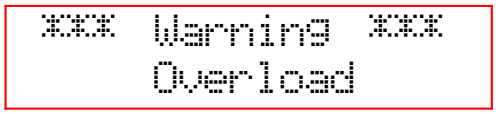


Fig. 24

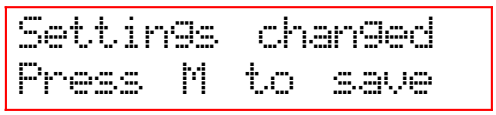


Fig. 25

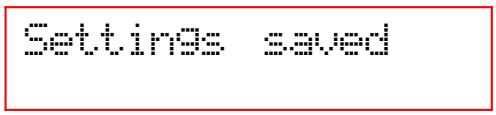


Fig. 26

PWM REGULATOR HC3020

The regulator has 4 wires. 2 of them **red** (**or gray**) and **black** are the power supply input from the vehicle's battery. The wires used should be of adequate gauge (min: 2.5mm^2). The wire connected to the battery positive end must be supplied via a fuse of max current 25-30A. The fuse must be as close as possible to the battery end. It is highly preferable for a fuse case directly mounted / screwed on the battery positive end to be used for max safety. The 2 output wires **blue** and **brown** must also be of similar gauge as pointed out above. Take under serious consideration that the PWM positive output (**blue**) is permanently connected with the positive battery end. Extreme caution is necessary for the positive output to stay clear of the vehicle's chassis or any other wire connected to GND. The black wire (regulator negative supply end) must be connected as close to the vehicle's battery negative end as possible. Installing the fuse (25-30A) should be considered as the last action after inspecting very carefully all wiring connections as well all parts / components involved in the overall installation.

A 5th cable[1] yellow/green is the “so called” **trigger cable**. The trigger cable switches on and off the HC3020 regulator if connected to a positive voltage anywhere between 8-30V or left floating/connected to the GND respectively. The trigger cable is available only in HC3020's with the S/W version 1.10. Its' gauge can be anything close to 1-1.5mm^2 because the current flowing through this wire is basically insignificant (1-2mA).

Warning: In case of inverse polarity connection of the regulator power supply ends, permanent damage will result to the regulator internal circuitry and will therefore need repairing.

Specifications

Input voltage range: 8-30VDC

Max output current: 20A RMS

Current preset step: 0.5A

Supply inverse polarity protection: No

Output overload indication: Yes

Output short citcuit protection: Yes

PWM range: 1-99%

PWM resolution: 16bits (0.0015% step)

Weak solution notification: By buzzer

Power down mode consumption: 10mA (12VDC)[1]

Operation temperature range: -10 – 50 celsius

IP class: 51

*Last update date 15 Dec 2015

1. Applies only to S/W version 1.10