Design of a simple diversion charge controller Final report

WindEmpowerment
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Executive summary

The installation of a small wind turbine without grid connection requires the use of a battery and a charge controller. This unit is a safety system for the turbine, protects and allows a better use of the battery and therefore extends the lifetime of the installation. The charge controllers available on the market are expensive and often difficult to acquire in developing countries. This aim of the project was to design a prototype of a charge controller for small wind turbine systems. The project has been running between April and September 2016 and a prototype for 24 and 48 Volts as well as a prototype for 12 Volts system have been designed.
The document presents the different steps in the project. The final prototypes stabilize the voltage of the battery to a preselected value by sending part of the energy in a dump load so that the wind turbine never freewheels. It works with a Pulse Width Modulation which controls Mosfet transistors.
The first step of the work was to identify the role of a charge controller, complete the requirements and chose the technical solution. Then, the circuit has been designed as well as the PCB. The project goes now toward more testing of the controller and improvements of the prototype.

1 Selection of the technical solution

The solution we are using is similar in function to the design of the *Tristar*, sold by the *Morningstar Corporation* and the *C40* sold by *Xantrex*. It uses a Pulse Width Modulation (PWM) to regulate the voltage. When the voltage of the DC bus reaches a maximum, some of the energy is transferred to a dump load. The dump load is connected to the battery only during a short period of time at a frequency of 300 Hz. As a result, the wind turbine needs to produce more current and the dump load acts like a brake. The voltage is therefore regulated at a predefined value. On the figure 1, we can see a simulation of the response of the circuit to a voltage higher than the reference. The first curve shows the battery voltage. When it exceeds the topping voltage, then the duty cycle starts increasing and the Pulse signal starts emitting and therefore the dump load is connected. The connection of the dump load will decrease the voltage of the battery until it remains at the topping voltage, the duty cycle then remain at its value.

More simply, the charge controller just works like a switch which is constantly open and closed when the regulation is needed. The duty cycle δ defines the percentage of time when it is ON. It is presented on figure 2 where I_e represents the current provided by the turbine which is distributed between the battery, the load and the dump load when it is regulating.

2 Design of the circuit

The overall circuit uses an Integrated Circuit which drives the PWM : the SG3525. It is a wide used integrated circuit, first designed by *Texas Instrument* and now by many other manufacturers. A small documentation on how to use the SG3525 can be found on `http://tahmidmc.blogspot.fr/2013/01/using-sg3525-pwm-controller-explanation.html`. The circuit can be divided into 5 parts :

- **The DC supply** : used to power some components such as the Op Amp and the SG3525 and is also used to give a reference for the voltage measurement. The input is the DC Bus and the output gives a stabilized voltage of 15 V. It can work with a input from 20 V to 100 V and gives a maximum of 200 mA.

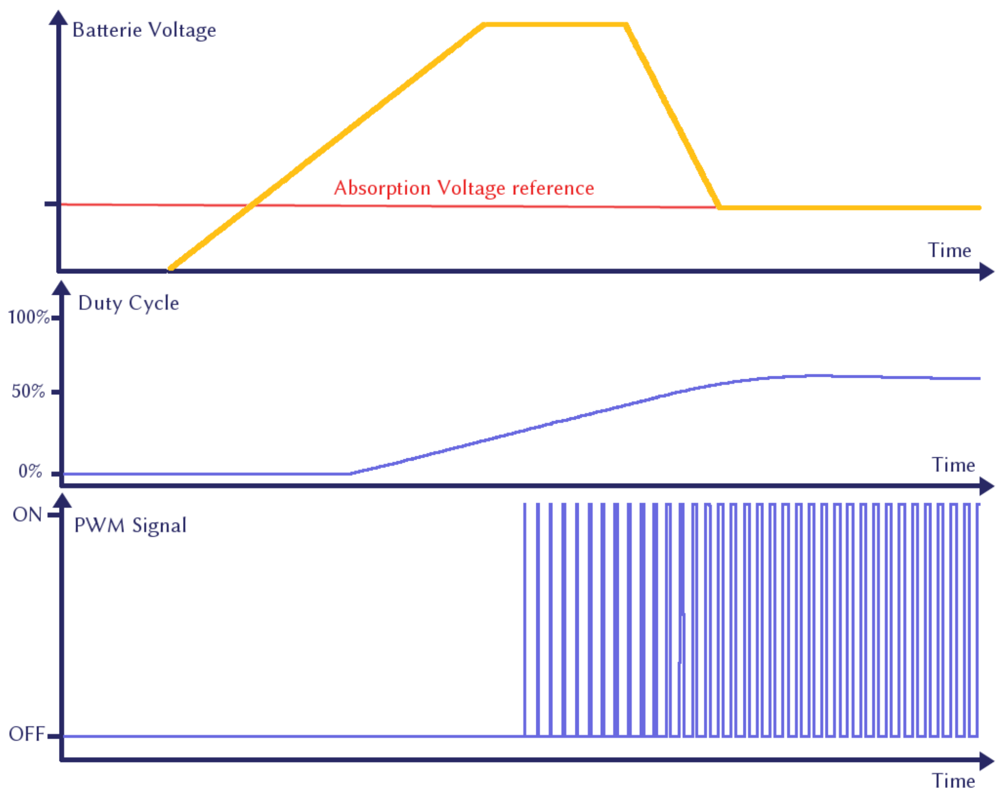

Figure 1: Simulation of the response of the circuit

- **The voltage selection module** : aims to select the voltage reference we are using. The reference is given by a simple voltage divider. It gives a voltage of 10 Volts for the 48 V mode and 5 Volts for the 24 V mode.

- **Comparator** : it is the first part of the signal processing. It uses an operational amplifier to compare the battery voltage with our reference. A trimmer enable a fine setting of the reference. The output of this stage is a voltage higher than V_{Ref} if the battery voltage is lower than the reference and lower than V_{Ref} if the voltage is higher than the reference.

- **SG3525 driver** : We need to integrate the signal in order to keep increasing the duty cycle of the PWM if the voltage stay higher than the reference. Moreover, if the voltage stabilizes at the value of the reference, the duty cycle need to remain constant. For this purpose,

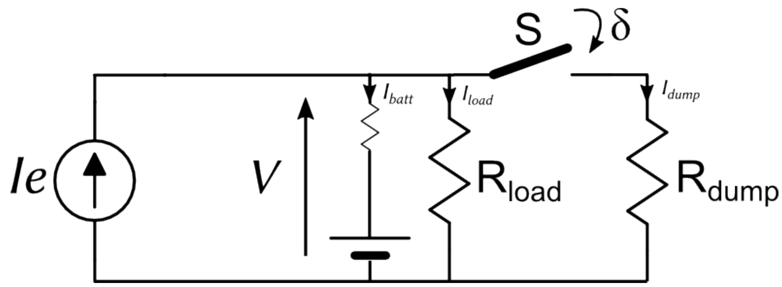

Figure 2: Charge controller seen as a controlled switch

we use an inverting integrator stage. This stage will provide a signal that directly drive the duty cycle of the PWM : a signal of 0 Volts leads to no regulation and a signal greater than 5 Volts correspond to a duty cycle of 100 %.

- **Power part** : The power circuit uses a Mosfet transistor that works at 200 V and 34 A. We will put 3 of them in parallel in order to support a maximal current of 100 A, maximal required current being 50 A.

3 Design of the PCB

3.1 Design of a first prototype

During July, The PCB of a first prototype has been designed and ordered. An overview of this PCB is shown in figure **??**. By testing it, we realized some important problems and a new prototype has been done with wider tracks for the power part and changing some mistakes that has been done on this first prototype.

3.2 Second prototype

The second prototype is smaller and has been sized to fit in a metal box with heat sink included. Small mistakes has been fixed and all the tracks have been re-sized to enable more current. The printed circuit has been received and we assembled some of them. During the meeting in Argentina in November 2016, ten prototypes have been given to members of WindEmpowerment and Tripalium for testing.

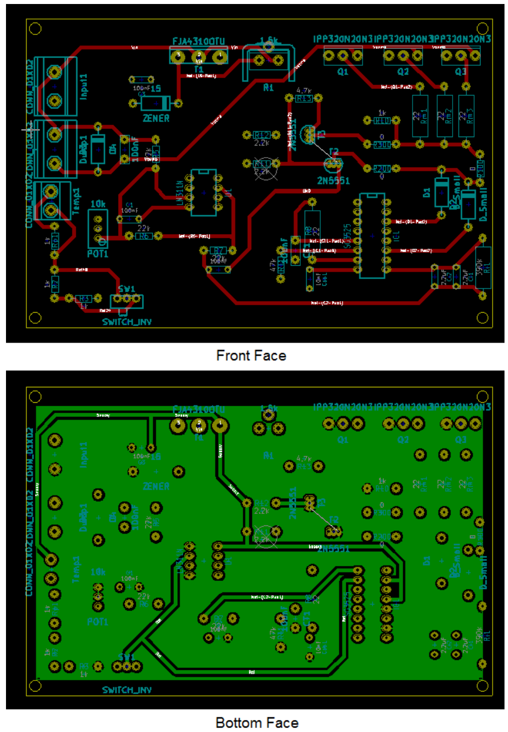

Figure 3: Design of the first PCB

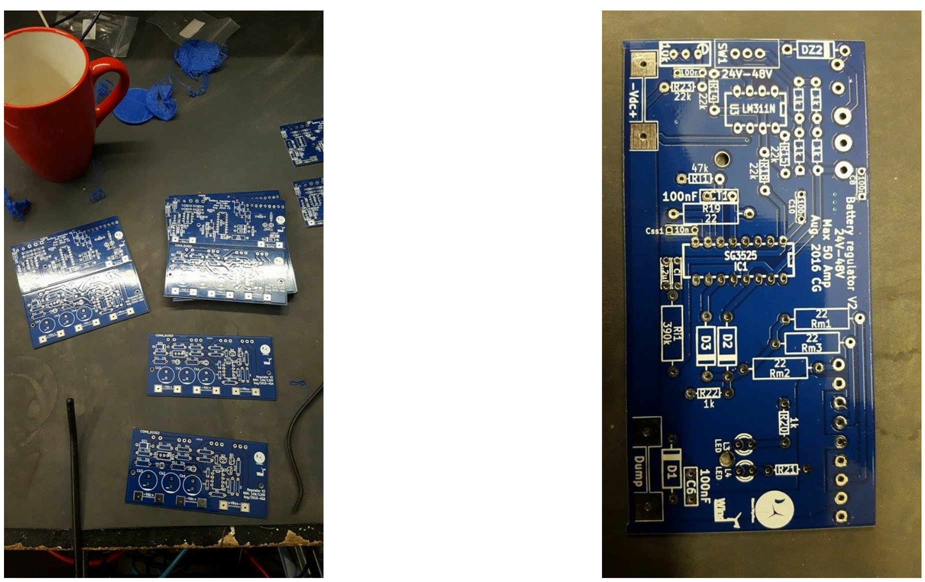

Figure 4: Pictures of the new prototype

4 12 Volts regulator

A prototype for a regulator working in 12 Volts has also been designed and tested. It is simpler than the 24/48 Volts regulator and a picture of the prototype is showed in figure 5.

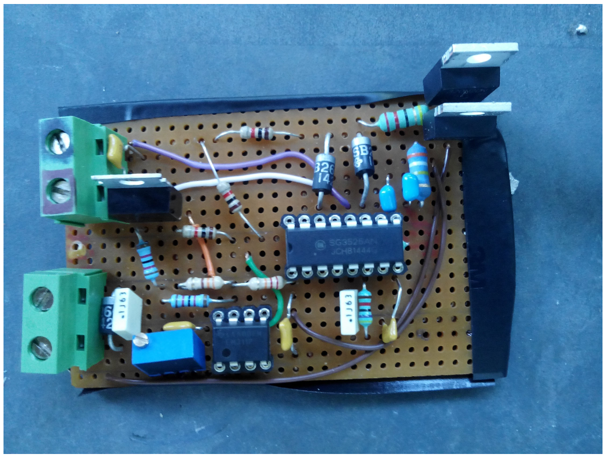

Figure 5: Picture of the 12V prototype

5 Manual

A manual for the fabrication and installation of this prototype has already been done and is available on the website of WindEmpowerment. The forum topic has also been updated so that anyone can participate in this project.

6 Next steps of the project

After the conference WEPatagonia 2016, kits have been given to WindEmpowerment members. We are waiting to have some feedback on their tests. Moreover, the work on this regulator continues and we are going to test it in different situations and try to improve the circuit.

If you have any questions or remark regarding the project, please contact me : `clem.gangneux@gmail.com`.