ECE PARIS GRADUATE SCHOOL OF ENGINEERING

AEOLUS

System Architecture Document

for

PPE 1447 AEOLUS

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1 Introduction

Even in most developed countries, there are still a lots of places where electricity is not available, but there is no place in the world where wind energy wouldn't be accessible.

In today’s world, electronics devices are so involved in people's lives, that we need them every moment anywhere in the world. So our group is trying to invent a small portable device which uses wind energy and can provide electricity for small electronic devices.

AEOLUS is a light and small portable device, which converts wind energy into electricity. It provides compatible electricity for electronic devices according to their electrical requirements. It has two USB ports for charging small electronic devices and one socket, which supply 220 volt for other type of electronic devices.

Its efficiency depends on the air density, wind velocity and altitude of the specific areas.

1.1 Reference documents

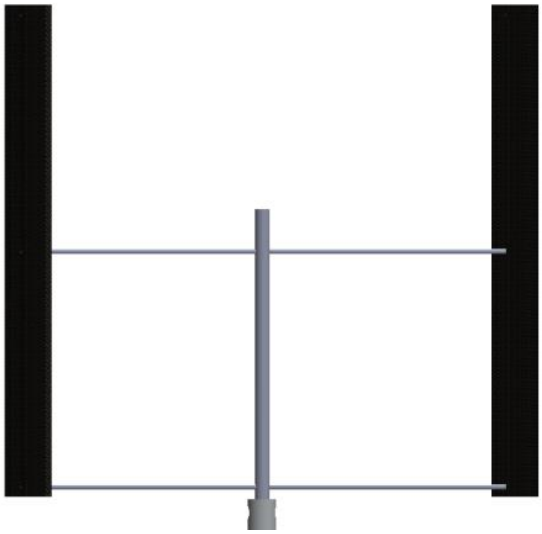
Document	**Number**	**Attached?**	**Application**
TRS	Version 4	Yes	Used in the description of the subsytems behavior
Comparaison Savonius-Darrieus	Version 1	Yes	Referred and cited in part 3.1.1 to explain the choice of the general structure
Savonius	Version 1	Yes	
Darrieus	Version 1	Yes	

2 System architecture

2.1 Subsystems

2.1.1 Subsystem 1: Blades + Axis

Role: Receive the wind and create the rotation movement necessary to make the engine create electrical power



Global Shape of the subsystem 1 (Realized with SolidWorks)

2.1.2 Subsystem 2: Box + Tripod

Role: carry the subsystems 1 (tripod's role) and the subsystems 3 and 4 (box's role). The System must be well fixed to the ground to avoid any fall of the whole system. So we have chosen to fix three metallic branches on the box which will contain the engine and other electronics devices needed to transform the mechanical power into electrical power.

Global Shape of the subsystem 2 (Realized with SolidWorks)

2.1.3 Subsystem 3: Engine

Role: Activated by the rotation of the axis (subsystem 1), it produces Direct current.

2.1.4 Subsystem 4: Power inverter

Role: Make the output of the Subsystem 3 usable by users (they should be able to load small electronic devices with that power)

2.1.5 Subsystem 5: Battery

Role: The battery is between Subsystem 3 and 4, it is a tamp battery it loads as the engine produces energy and unloads as the user plug his devices on one of the two outputs.

2.1.6 Subsystem 6: Guiding piece

Role: This piece has a major role, it is the link between the main axis of the wind turbine and the engine's axis.

2.1.7 Subsystem 7: Voltage regulator and charger switch

Role: The generator can't charge our battery as is. Plum batteries require a specific charger because they need pulsed current. Of course we don't have space to put such a big piece of electronics nor do we have enough current/voltage to power such charger.

2.2 System behavior

2.2.1 Interaction scenario A: Use of the USB plug

Load a phone or a small device with the USB plug.

In this scenario the user wants to load a small device such as a phone a MP3 or a GPS. So he will have to plug the USB cable into one of the two USB output of the power inverter (either 1A or 2,1A)

For this scenario to happen, it has to happen in the functional perimeter described in the part 4 of the TRS, use case (1) – (3) – (7)

2.2.2 Interaction scenario B: Use of the outlet

Load a bigger device (e.g. Laptop) with the outlet

in this scenario the user wants to load device such as a laptop. So he will have to plug the outlet into the outlet output of the power inverter.

For this scenario to happen, it has to happen in the functional perimeter described in the part 4 of the TRS, use case (1) – (3) – (8)

2.2.3 Interaction scenario C: Problems

This scenario is about the problems that could avoid the user to realize the first two scenarios

These different cases are explained in the part 4 of the TRS (see the Diagram of the different use case of the system):

- ➔ There is not enough wind (1) – (4)
- ➔ There is too much wind (1) – (5)
- ➔ The turbine are not turning in the right way (2) – (6)

3 DESCRIPTION OF THE HARDWARE ELEMENTS

3.1 Structure

3.1.1 Choice of the general structure

To make the choice of the general structure of the wind turbine, we were hesitating between two types: savonius and Darrieus.

We have studied both types on the attached document (comparaison Savonius - Darreius) the Savonius does not seem to be a good choice. Indeed Savonius wind turbine is very stable and starts very easily, and even if stability were a problem, we could balance the structure with masses (like balancing a car wheel). This choice introduces a major constraint: the difficulty of realization. Indeed, we must, because of our very limited budget (€ 300) offer the simplest possible embodiment, 3D printing is expensive (40 € for a disc ~ 150cm3) and the machining cost being dependent on the amount of material being machined and the type of machining, complex shapes are unthinkable for our budget. Likewise, our wind turbine being produced in small series (one prototype), it is impossible to consider making parts by molding. So we need to design our wind turbine by realizing a screwed assembly of parts made from profiles (plates / pipes) with the minimum machining (drilling).

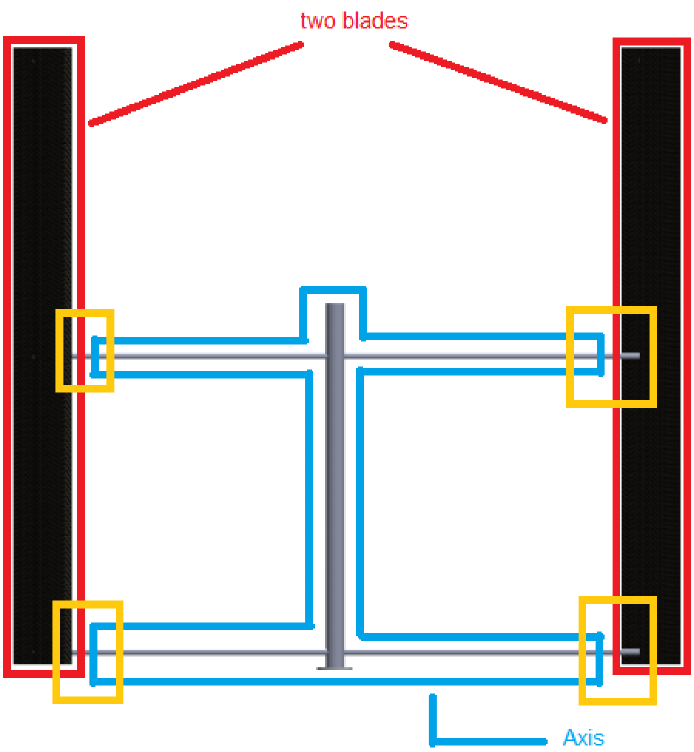
Moreover Savonius is not an ideal choice in terms of portability, although it is conceivable to mount / unmount the wind turbine, but it is a very inelegant solution that will require a storage bag. Furthermore blades are very thick (4mm in the current design state) simple assembly with screws seems difficult.

From this observation we considered another option: the realization of a Darrieus wind turbine with vertical blades, assembled from simple shapes and low-machining less cumbersome once stored and having a larger aperture area when deployed. I will present my idea about it later. So I decided to compare the powers provided by the two types of wind turbines with the documents that I have provided. So I used the page 8 of Darrieus.pdf and pages 23 and 24 of document Savonius.pdf as references.

3.2 Hardware components of the subsystems

3.2.1 Subsystem 1: Blades + Axis

As you can see on the following pictures the subsystem is made of two main parts the axis and the blades.



This subsystem has two main problematics:

- How to reduce the weight of the whole axis part as much as possible while keeping it tough enough
- How to fix the blades to the axis (orange areas on the picture)

The first problematic is about the choice of the materials and that choice will be explained on the 4th part of this document. The composition and the technique of realization of the blades will also be explained in the fourth part of this document.

The solution found to fix the blades to the main axis will be to insert PVC pieces in the blades during theirs construction (description in part 4).

3.2.2 Subsystem 2: Box + Tripod

This subsystem has a really important role because it has to carry all the upper part as well has all the electronics.

The Box that is a cylinder contain the engine, the convertor and the battery. We have chosen a tripod to carry the whole structure on the advices of our mentor because it would be the most stable way to do it. We have then chosen to directly fix the three branches of the tripod on the cylinder because the fact that the global weight of the box would be quite high because of all the electronics, as we can see on the schemas below, the global system would gain in stability.

We have chosen a cylinder rather than a rectangular box because it is easier to fix the tripod on a circle rather than on a square.

One of the constraints of a cylinder is that as almost all the electronics part (presented in the following section) have a rectangular shape it is harder to AGENCER them than if the box's shape would be rectangular.

3.2.3 Subsystem 3: Engine

We have chosen a 12v – 50w engine because the 12v voltage allow us to easily reach 220v with a power inverter. Moreover a direct current generator is lighter than a three phase alternator.

3.2.4 Subsystem 4: Power inverter

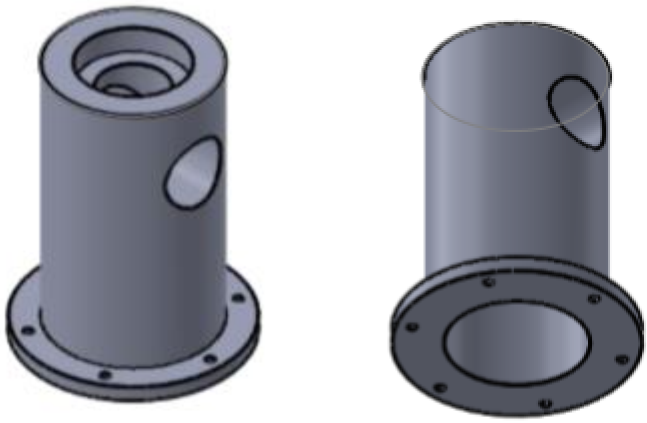
For our system, the input feature is 12v and the output feature is 220v. The main argument in the choice of our power inverter was to match these features. The fact that the maximum power of the power inverter that we have chosen is 300w is really interesting because it gives us a larger working range.

3.2.5 Subsystem 5: Battery

We have chosen a 12v battery to match the output voltage of the generator. The capacity of the battery is 3AH, which is enough to load entirely a laptop battery. (Budget is 30€)

3.2.6 Subsystem 6: guiding Piece

The Guiding piece had been realized of SOLIDWORKS software and will be made of aluminium. This piece will include two ball bearings to make the guiding stable and tough.



3.2.7 Subsystem 7: Voltage regulator and charger switch

We designed a small circuit that will regulate the generator's output in such way that it will be able to charge the battery. Moreover, the circuit also includes a switch with a command that will stop the battery from charging once it is full.

SCHEMA ELECTRIQUE CIRCUIT A INS2RER

3.3 Subsystem behavior

3.3.1 Interaction scenario

The blades receive the wind and the rotation of the main axis begins. The guiding piece makes the link between the main axis of the system and the axis of the engine in order to make the engine works and produce power. The power then is stocked in the battery and if the user wants to use the power stocked he plug his device on one of the output of the power inverter. The power inverter is linked with the battery and will convert (in the idea) 12V CC into 220V CA in order to match with the requirements of the electronic devices plugged.

4 Hardware element L

In this section we document the component design of a single hardware element in complete technical detail.

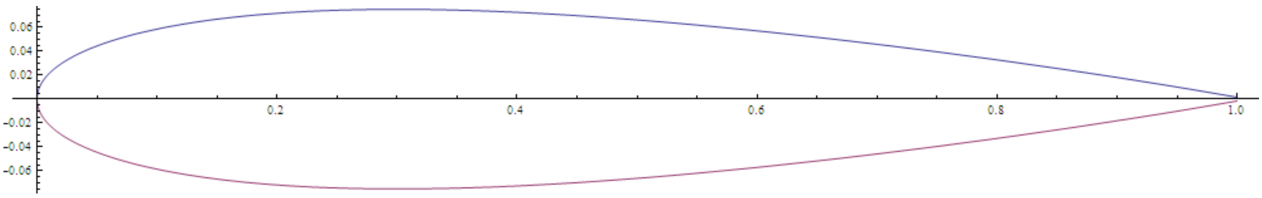
Here, resume the role of this element in the system, its roles and responsibilities, and which subsystem it is a part of. Provide references to relevant parts of this document.

4.1 Components

Define the static structure of the hardware components and their relationships. ***A diagram is required****. In the following subsections, define the role and responsibility of each individual component, and provide a complete technical reference for each.*

4.1.1 Component 1: Blades

To make the blades and have the best performances possible we have chosen the NACA 0012 SERIE 4 profile that is an aerodynamic profile used to build aircraft wings.

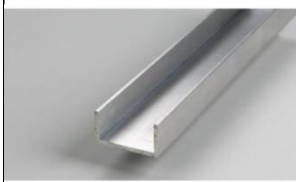


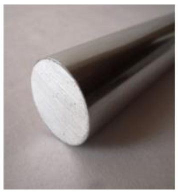
General shape of NACA profile

The materials used to build the blades will be polystyrene. The profile will be cut from a polystyrene bloc thanks to a special tool that we have built by ourselves (by following this tutorial http://aeropic.free.fr/pages/modelisme/decoupe/decoupe.htm). When the profile will be ready, fiber glass and epoxy resin will be added to solidify the blades. Finally, to fix the blades to the main axis, techniques from the fabrication of surfboard (especially how to fix the spoiler to the board (http://ph.bouet.pagesperso-orange.fr/surf/amateur/aileron.htm).

4.1.2 List of Components for the axis, box and guiding piece

In this part you will find the main components used to build the different subsystems that do not need more specification than the component itself.

Subsystem	**Components**	**Use**	**Material**
Box + tripod	Aluminium pipe 130*5mm	Will contain the electric components	
	Aluminium flat bar 30*5mm	Will form the tripod	
	Aluminium sheet	The box's lid	
Guide Piece	Aluminium Pipe ; Diameter 80 mm	Supports the axis while linking the motor to the axis/blades	

	Aluminium Pipe ; Diameter 30 mm	Supports the axis while linking the motor to the axis/blades	
Axis	Aluminium Pipe ; 1m length, 12mm diameter	Links the blades to the main axis	
	Aluminium round bar 3 cm diameter, 50 cm length	Main axis	

4.1.3 Final list of electronic elements (Subsystems 3, 4 and 5)

Subsystem	Electronic component chosen	Features	Photo
Power Converter	BESTEK convertisseur 12V->220V 300W	Power delivered: Direct= 300W, Max= 350 W, peak= 700W Convert 12V DC to 220V AC Has two USB ports (1A and 2,1A) Weight and dimensions: 510g, 12cm*8cm*4cm	
Engine	MAXICRAFT Moto-réducteur Ø 3 mm 42 W	Engine 12 Volt courant continu (Moto-reductor Ø 3 mm 42 W) Power supply: 12 V. 4 trains planétaires pour 4 réductions : 1/3 - 1/12 -	

		1/60 - 1/360. Diameter of the axis : 3 mm power : 42 W.	
Battery	Power Battery	12V 4Ah/48Wh (Lead-Acid) Size: 195mm x 47mm x 76mm	
Voltage Regulator	L200CV	Adjustable Output Current Up To 2 A Adjustable Output Voltage Down To 2.85V Input Overvoltage Protection (Up To 60V, 10ms) Short Circuit Protection Output Transistor S.O.A. Protection Thermal Overload Protection Low Standby Current Drain	

AJOUTER PHOTO CIRCUIT

5 Appendix: Glossary

Acronym	**Meaning**	**Explanation**
AC	Alternating current	The flow of electric charge periodically reverses direction.
DC	Direct current	the flow of electric charge is only in one direction

V	Volts	difference in electric potential between two points
W	Watts	derived unit of power
A	Ampere	unit of electric current
Cm	Centimeter	Unit of length
Mm	Millimeter	Unit of length