POLITECNICO DI MILANO
Scuola di Ingegneria Industriale e dell'Informazione

Implementation of a bipolar stepper motor driver with L293D

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Introduction

The project consists in the study and realisation of an electronic card that simplifies the driving of a stepper motor. The interface has to be insensitive to the logical level of the microcontroller used (PIC uses 5V instead STM32F4 uses 3V) and converts logic signals into power electronics control signals.

The circuit has been made for simplifying the developing and prototyping of other more complex electronic systems.

First of all, I present here the basic components necessary for the system:

- 4-pins connector (2x);
- 2-pins connector (2x);
- Yellow LED (4x);
- resistance 1.5K (4x);
- base for integrated circuits (3x);
- 74HC125 (2x);
- L293D;
- Switch (2x);
- Red LED (2x);
- Bipolar stepper motor STH-39D254.

Bipolar stepper motor STH-39D254

This motor, produced by Shinano-Kenshi, is used in biomedical sector and products. In figure 1 is possible to see the motor used in the project while in figure 2 is possible to see a drawing of how a bipolar stepper motor is built. It's possible to see the working operations of a bipolar stepper motor in figure 3.

Observing figure 3, we can notice that the motor is controlled through 4 pins INPUT[1:4], while the driver will provide the proper current at the proper voltage to the motor.

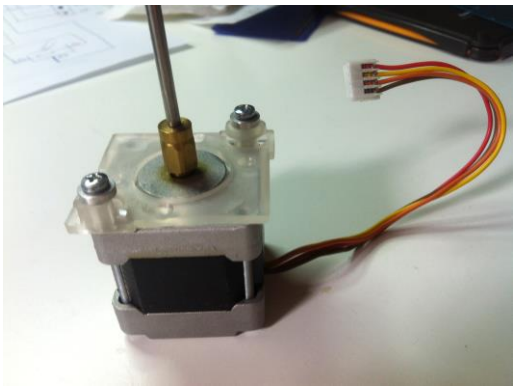

Figure 1) Bipolar stepper motor STH-39D254.

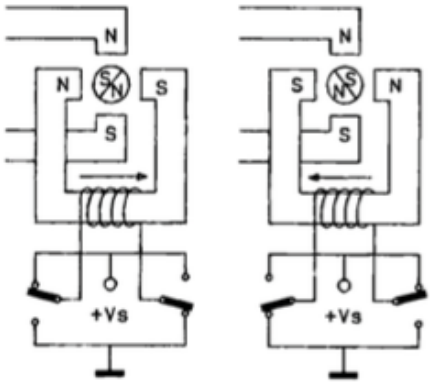

Figure 2) Outline of a generic bipolar stepper motor.

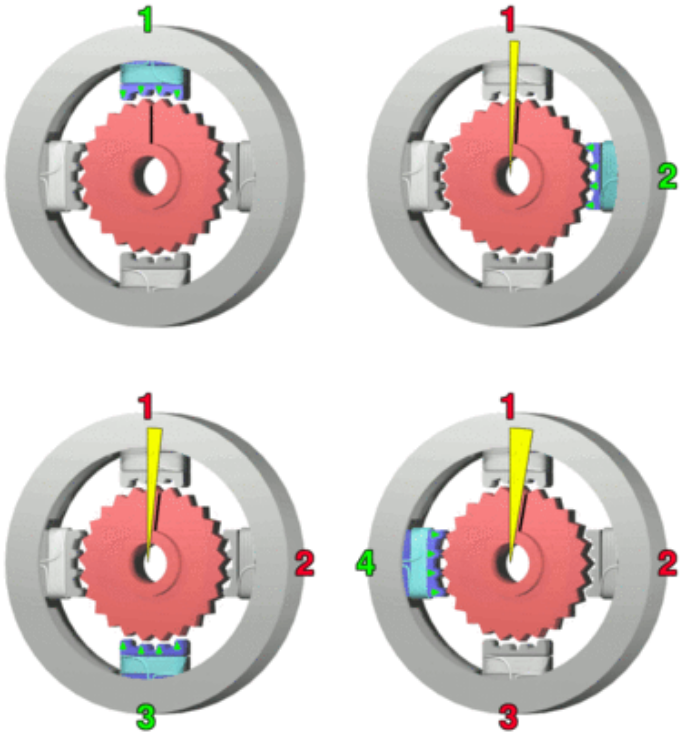

Figure 3) Working operations for a bipolar stepper motor.

Bipolar stepper motor

The stepper motor is a type of motor that divides the motion in small angles, called steps. The advantage of the stepper motor is basically the high reliability and the possibility of using it without any feedback control over position and speed of rotation, so is usable open loop. Before using it, is necessary to check whether the torque provided by the motor will be sufficient for the application, otherwise is possible that some step is going to be “skipped” (will not be made).

The bipolar stepper motor has a higher torque in respect to the unipolar one, as we can see from figure 4.

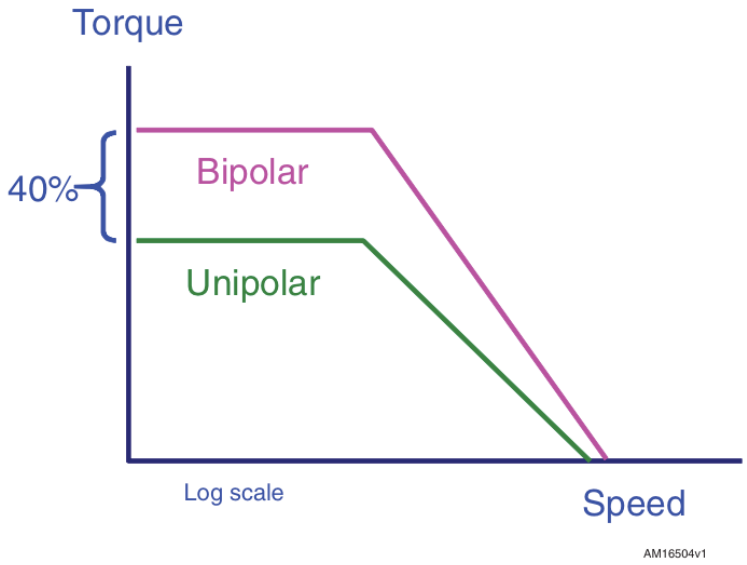

Figure 4) Log-Log plot representing the relation torque-speed of the unipolar and the bipolar stepper motors.

With this driver is possible to use all the three methods of driving a stepper motor:

1) Full-step mode
2) Half-step mode
3) Micro-step mode

Full-step mode

The full-step mode makes the motor make the entire step for every pulse given, as we can see from the image 5.

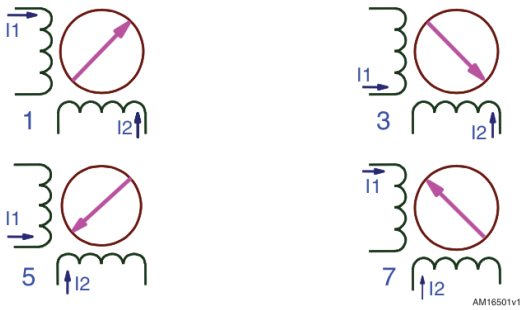

Figure 5) Set of instruction that have to be given to the motor for running the "full-step mode".

In the table are synthesizes the instruction that have to be sent to the motor:

Step\Wire	Wire 1	Wire 2	Wire 3	Wire 4
1	1	0	0	1
2	0	1	0	1
3	0	1	1	0
4	1	0	1	0

Half-step mode

This modality makes the motor make the half of the nominal step for every pulse given.

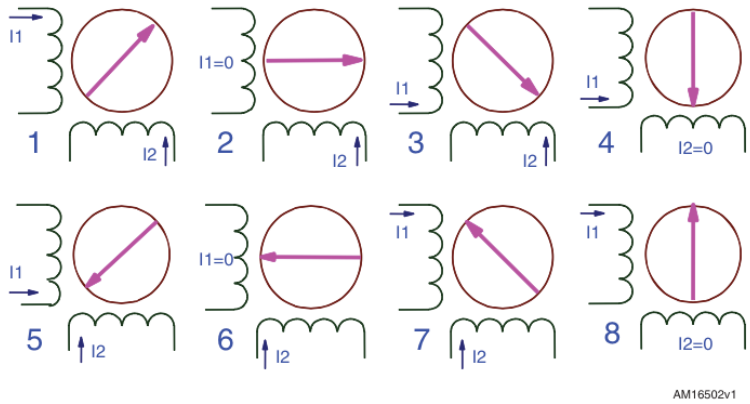

Figure 6) Set of instruction that have to be given to the motor for running the "half-step mode".

Here below we can see a table that resumes the instructions that have to be given to the motor for running the “half-step mode”:

Step\Wire	Wire 1	Wire 2	Wire 3	Wire 4
1	1	0	0	1
2	0	0	0	1
3	0	1	0	1
4	0	1	0	0
5	0	1	1	0
6	0	0	1	0
7	1	0	1	0
8	1	0	0	0

Finally, we conclude with a section that represents all the technical data referred to the bipolar stepper motor STH-39D254, so that is possible to model and simulate the motor in a simulation.

Steps per revolution	200 steps/revolution
Step angle	1.8 degree/step
Coil resistance	60 ohm
Voltage	24V

74HC125

This integrated circuit is made by 4 buffers tristate with triggered inputs. The role of the circuit is basically to regenerate the logic value of 5V. In fact, the microcontroller ST32F407 uses digital signals of (0-3)V, risking the not complete conduction of the half bridges of the integrated circuit L293D and so to cause cross conduction losses and not proper driving. Two of these integrated components are used in the electronic card. It’s possible to see a high level scheme of the component in figure 7.

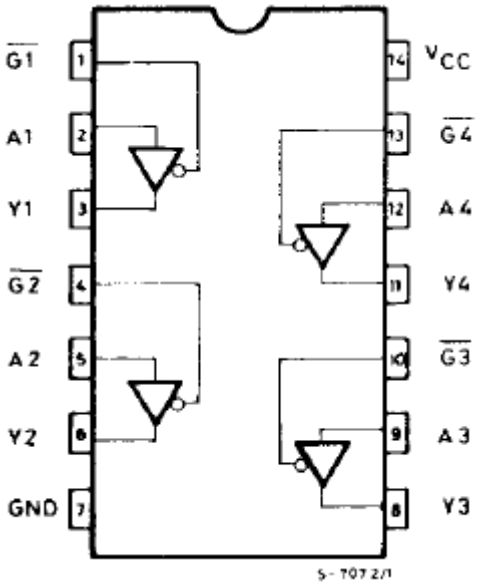

Figure 7) High level scheme of the 74HC125.

L293D

This component, produced by ST Microelectronics, is an IC that accomplish the function of transmitting and providing the electrical power to the load. Has been designed specifically for power applications.

In figure 8 we can see that the internal scheme of the IC is not complicated and as well the working operation is straightforward.

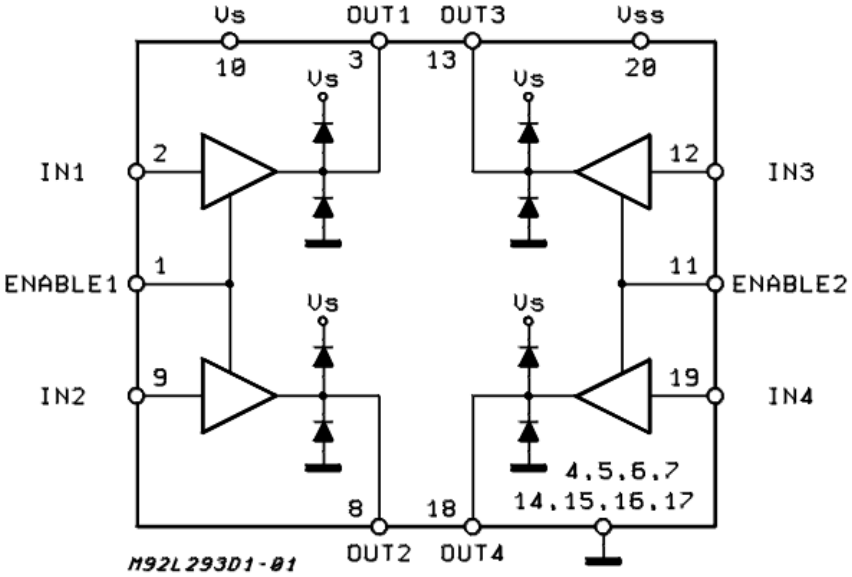

Figure 8) Internal structure of the L293D.

In figure 9 we can see the details of the usage of the component.

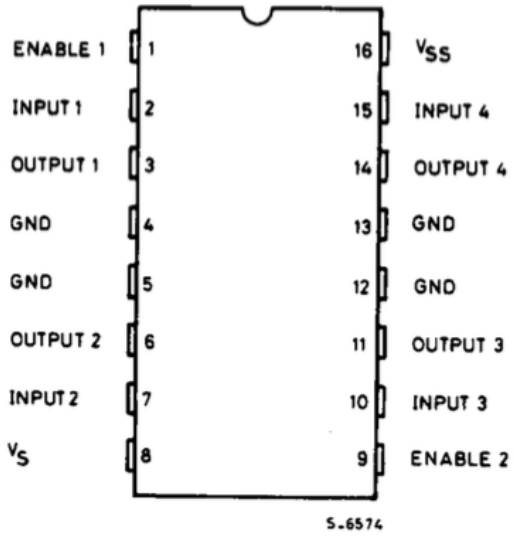

Figure 9) Pin layout of the L293D.

Results

The result of the project is the electronic card that simplifies the prototyping in other applications that use a bipolar stepper motor.

Layout

In figure 10 we can see the circuit layout of the system soldered on the card.

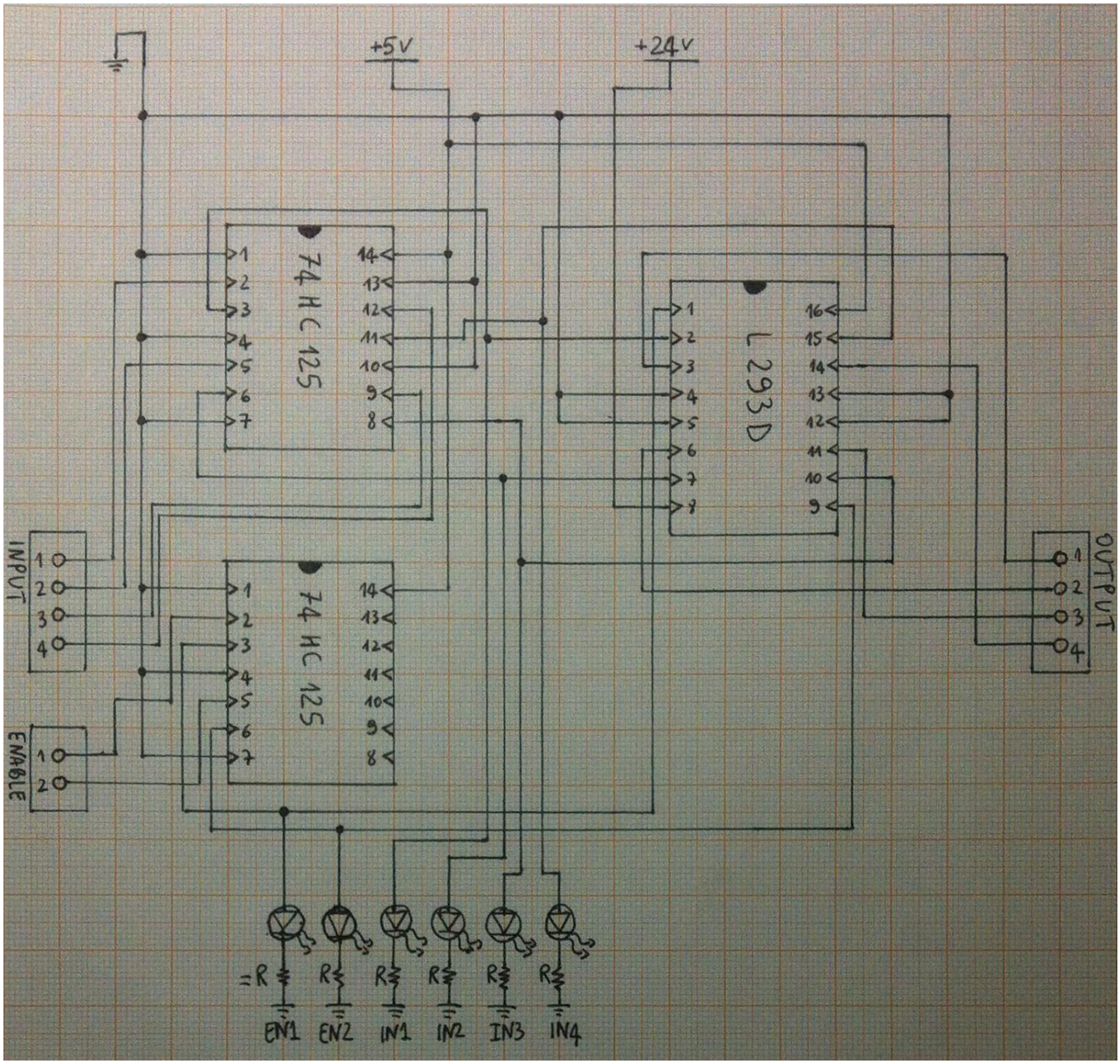

Figure 10) Layout of the system.

In the layout pins can be divided in three groups:

1) Inputs, IN1-IN4 and Enable1-2;
2) Outputs, OUT1-4;
3) Power supplies, the motor one (generally 12V or 24V) and the logical one (generally 5V).

Prototyping board

The circuit realised is viewable in figure 11.

1) **Inputs**
   The input pins are positioned below on the right, with numbering that goes from left to right. The enable pins are located below on the left and they have as well numbering going from left to right.

2) **Outputs**
   The output pins are above on the left with numbering from left to right.

3) **Power supplies**
   The power supplies are positioned above on the right with specified the positive and the negative pins.

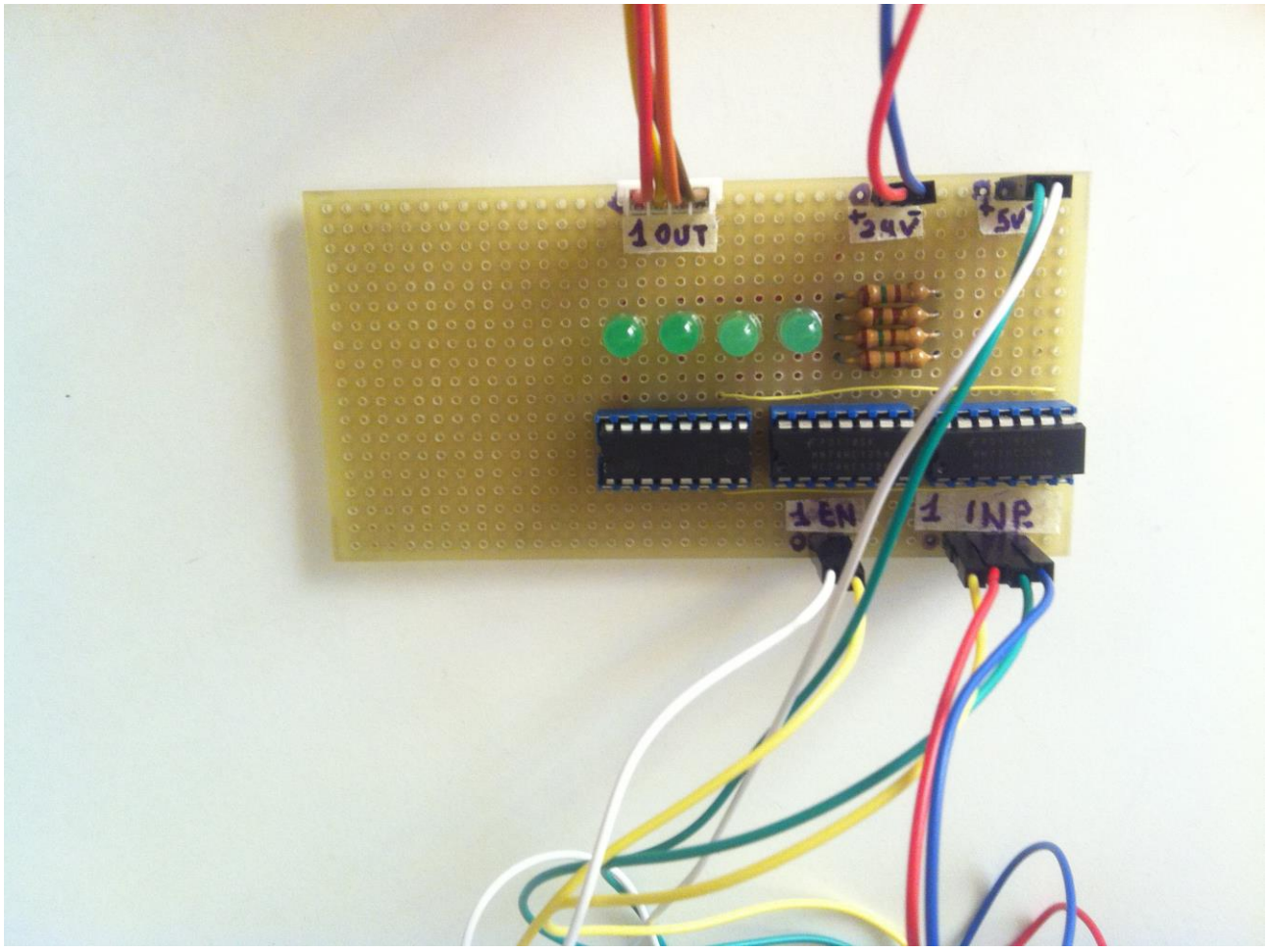

Figure 11) Prototyping board seen from above.

At the end I present an example of usage of the board with a ST32F4 Discovery, a stepper motor and a voltage stabiliser, in figure 12.

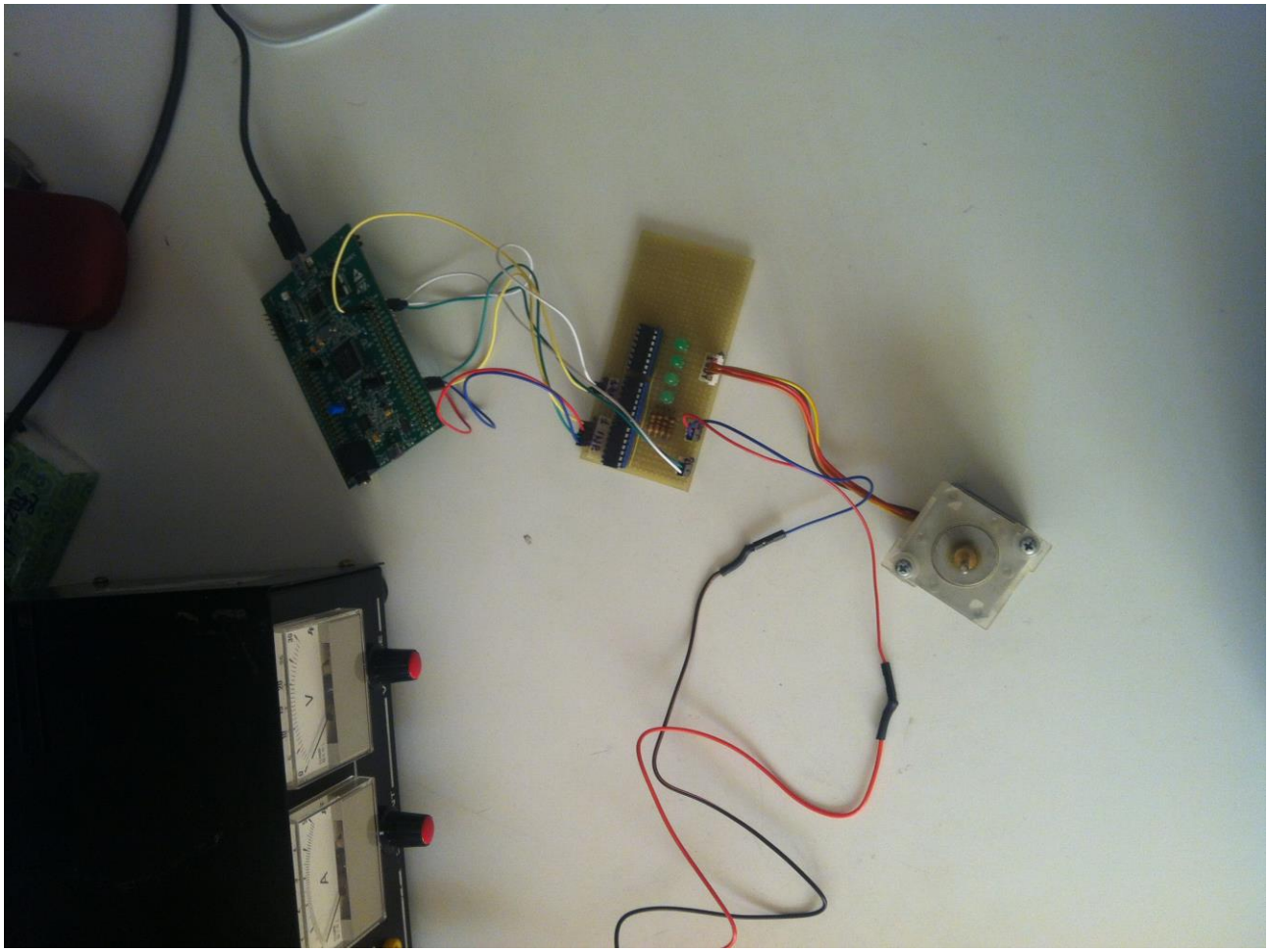

Figure 12) Example of usage of the board.