George-Iulian Uleru

george_uleru@yahoo.com

2. Subject name/title: Sensored Brushless DC Motor Control

3. Summary - synthetic subject presentation

The purpose of this project is to came with a solution for sensored brushless DC motor control. Based on Infineon XMC1100 this module should work as a open loop, analysing the motor internal sensors and responding with the proper waveform.

4. Introduction - generalities, utility, resources

The brushless DC (BLDC) motor is becoming increasingly popular in sectors such as automotive (particularly electric vehicles (EV)), HVAC, white goods and industrial because it does away with the mechanical commutator used in traditional motors, replacing it with an electronic device that improves the reliability and durability of the unit.

Another advantage of a BLDC motor is that it can be made smaller and lighter than a brush type with the same power output, making the former suitable for applications where space is tight.
The downside is that BLDC motors do need electronic management to run. For example, a microcontroller – using input from sensors indicating the position of the rotor – is needed to energize the stator coils at the correct moment. Precise timing allows for accurate speed and torque control, as well as ensuring the motor runs at peak efficiency.

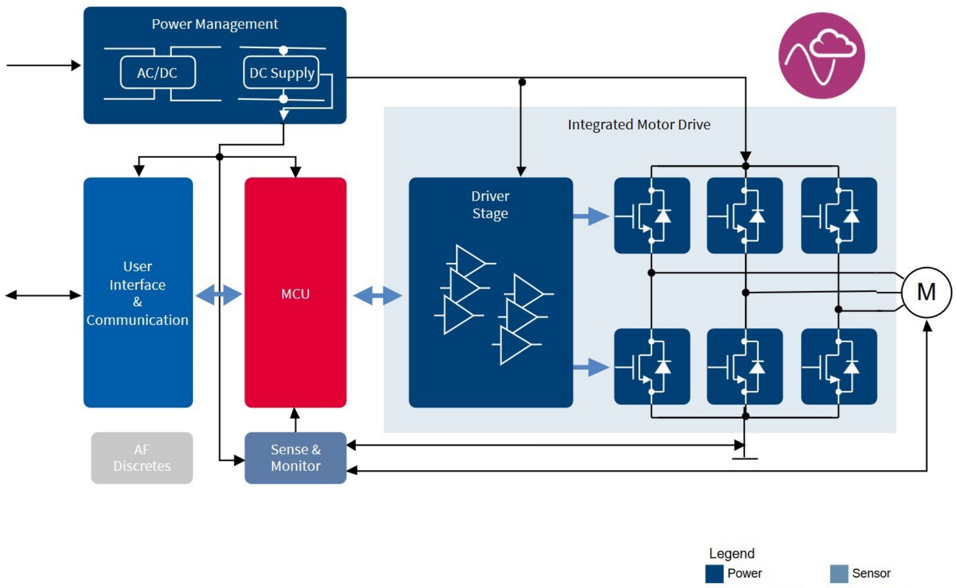
The used resources in the development of this project were:

- ARM XMC1100
- IR3205 Mosfet
- IR2301 Mosfet Driver
- Printed Circuit Board
- BLDC Motor
- Other components

5. Solution description, implementation details

The Brushless DC motors are a variant of Permanent magnet DC motors. PM DC Motors are synchronous motors in which the rotor field is driven with a constant current. By driving the rotor winding with a constant current, a fixed magnetic flux is established within the motor. The same also can be achieved by replacing the rotor winding with permanent magnets. By changing the stator magnets with three phase windings, the commutation can be achieved electronically compared to the mechanical commutation in common DC motors. Such motors are called Brushless DC motors. As this type of construction eliminates the need of brushes, the maintenance is reduced and the reliability is increased.

The following picture describes the guideline for our project:



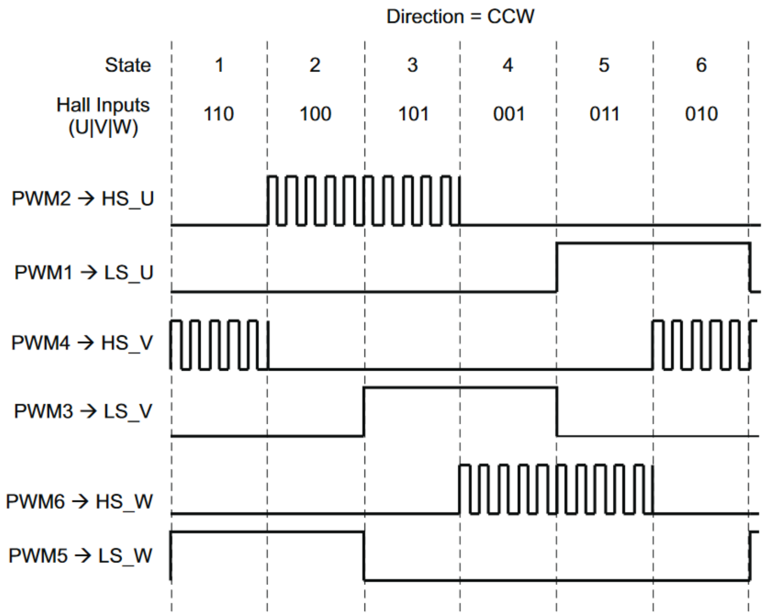
De la:
https://www.infineon.com/cms/en/applications/motor-control-drives/brushless-dc-motor/

In case of Common DC motors, the brushes automatically will come into contact with the commutator of a different coil causing the motor to continue its rotation. But in the case of BLDC motors, the commutation has to be done through electronic switches which need the position of the rotor. The appropriate stator windings have to be energized when the rotor pole lines up with the winding. It is possible to drive a BLDC motor with the predefined commutation interval. But in order to achieve precise control of speed and maximum generated torque, electronic commutation sh ould be done with known rotor position.

Most BLDC motors have internal sensors to provide rotor position information. Hall sensors are the most common type among them. Three phase motors typically have three Hall Sensors. Whenever the rotor magnetic poles pass near the Hall sensors, they give a high or low signal, indicating the N or S pole is passing near the sensor. Every Sensor outputs high level for 180 electrical degrees of electrical rotation and low level for 180 electrical degrees of electrical rotation. For a single pole pair machine, both electrical and mechanical degrees are same. For two pole machine, there are two electrical revolutions per mechanical revolution. In general, the relationship between mechanical and electrical degrees is as stated below.

Electrical revolution = Mechanical revolution / Pole pairs.

The following picture describes how the switching must be done based on the inputs from the sensors:



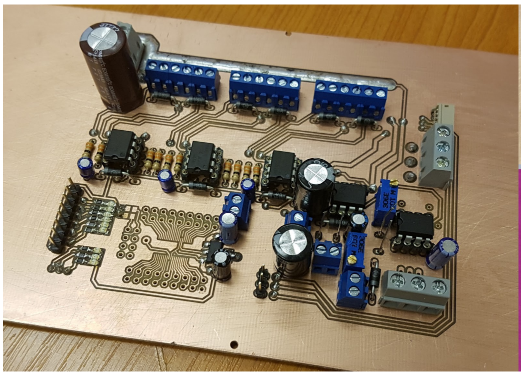
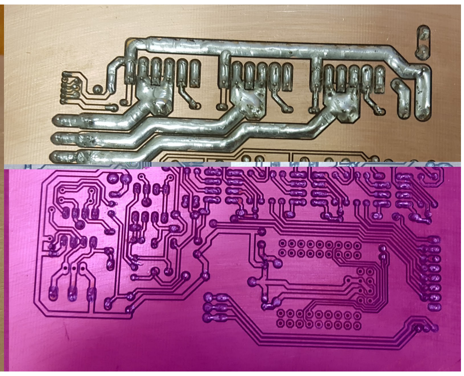
Hall Sensor Based Motor Commutation Sequence (One Electrical Cycle)

Further possible improvements:

- One issue that we want to improve for the future versions is the torque that the motor is developing on low speed. On this version the torque is increasing only on high speed. Also the optimization of the power consumption is on the top of the improvements list.

6. Results presentation, demonstrative sequence

The following pictures describe what we have accomplished. The project has been presented during the final classes of the semester. There is also a movie where the module can be seen working uploaded on youtube. You can watch it by clicking the link below:
https://www.youtube.com/watch?v=owZBKpEI92A&feature=share

7. Bibliography

- http://www.ti.com/lit/an/slaa503/slaa503.pdf
- https://www.digikey.com/en/articles/techzone/2013/mar/an-introduction-to-brushless-dc-motor-control
- https://www.infineon.com/dgdl/ap1611710_speed_control_bldc_hall%EC%85%A4davedrive.pdf?fileId=db3a3043139a1bac0113aacbc6ab02e6
- https://www.infineon.com/dgdl/Infineon-xmc1100-DS-v01_04-EN.pdf?fileId=5546d46255dd933d0155e31763e577dc