Robot Design and Competition
EN-2532
ESC Report

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1 What is Cogging?

Cogging happens due to the interaction between permanent magnets of the rotter and iron slots in the stator. This effect can be explained using the Lenz law. Magnetic conductors resist the change of magnetic fields. When permanent magnets pass an iron slot, the field changes, therefore, the iron slot creates an induced magnetic field to resist the change. This phenomenon creates an opposing torque for the rotation. In addition, this effect generates heat in the stator due to induced high currents. The cogging effect can be minimized by slicing the rotter and laminating those.

2 Electronic Speed Controller Choice

Figure 1: Spektrum SPMXAE1100 Avian

For this assignment, I have chosen the **"Spektrum SPMXAE1100 Avian"** Electronic Speed Controller module. It is one of best selling ESCs in the market. The references for this ESC have been given in the references section.

a) In the ESC I have chosen, there are four main terminals. Refer to **figure 1** for numbering.

1. Programming Port.
   This port is used to update and edit the firmware of the controller. To program, we need the "SpektrumRC Smart Programming module". After that, the user can access the firmware using a PC.
2. Throttle Connection.
   All the motor control instructions are sent via this port. In addition, there is a +5V output wire, which can be used to power RC electronics.
3. Battery Leads.
   The power source connects to this port. The power of the ESC, as well as the power for the motor, are supplied using these wires.
4. Motor Connection.
   The brushless DC motor connects to these wires. ESC outputs necessary voltage curves to control the motor via these.

b) The specifications and electrical characteristics of the controller are listed below.

1. Specifications

Motor Type	Brushless DC
ESC type	Sensor Less
Battery Type	3S - 6S Lipo
Water proofed	NO
Available Modes	Forward/Backward
Low Voltage Cut off	YES
Over Current Protection	YES
Signal Loss Protection	YES
Over Temperature Protection	YES

2. Electrical Characteristics

Continues Current	100 A
Peak Current	120 A
BEC output voltage	6V/7.4V/8.4V
BEC current	8A (cts) 25A (peak)

c) BEC stands for Batter Eliminator Circuit
The ESC has a BEC. The specifications of the BEC is given in the above answer. The purpose of the BEC is to eliminate the requirement of another lower voltage battery for powering RC and controlling electronics. In other words, BEC is a DC to DC converter. It steps down the main battery voltage for a sufficient level for other electronics. The ESC uses a switch-mode BEC.

d) 50 Hz PWM signal should be given as the input to the ESC from the microcontroller, with a duty cycle in the range of 5% to 10%. 5% represents lower speeds, and 10% represents higher speeds.

3 L6234 Integrated Circuit

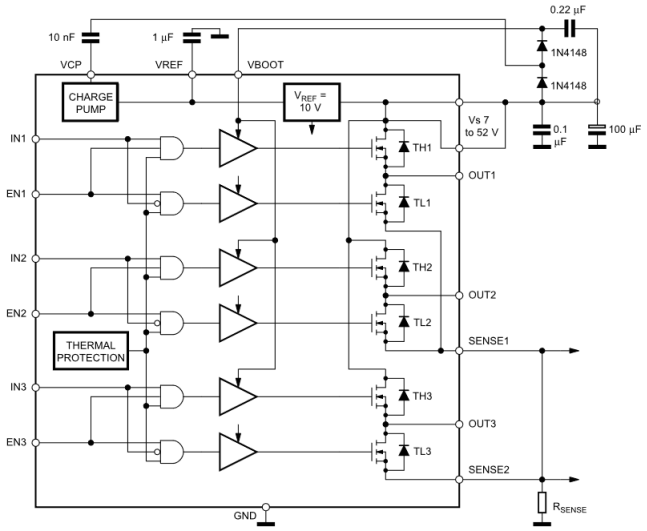

Figure 2: L6234 Integrated Circuit Diagram

The L6234 IC has three DMOS half-bridges with ENABLE/DISABLE pin. In addition, the in-built thermal sensor output is combined with the enable pin via a AND gate for thermal protection. All three half-bridges have enable, input, and output pins. Three outputs should be connected to three phases of the BLDC motor. Finally, this IC can handle peak 5A in range 7 to 52 Volts.

If ENABLE pin is LOW, all the MOSFETs switch off. Therefore, the driver will achieve a high impedance state.

If ENABLE pin is HIGH, HIGH input will switch on the high side MOSFET and switch off the lower side MOSFET. LOW input will switch off the high side MOSFET and switch on the lower side MOSFET.

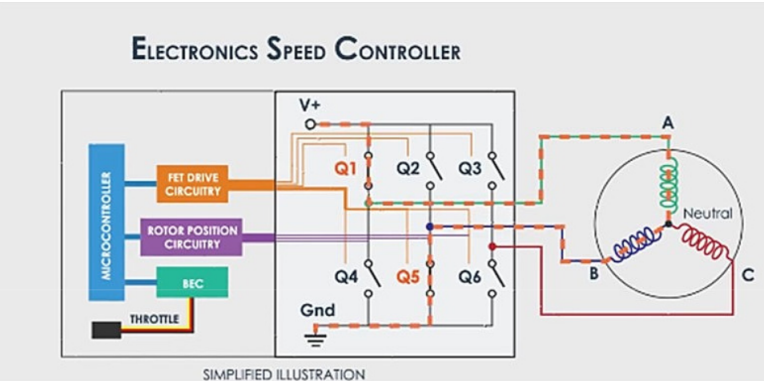

Figure 3: From Robot motion lecture slide 17

By setting IN1 to HIGH, IN2 to LOW, and EN3 to LOW, we can energize AN and NB inner coils. Likewise, we can shift these cycles to rotate the motor. In addition, we need circuitry to increase the frequency of these cycles according to a given 50 Hz PWM duty cycle.

4 A4988 Stepper Motor Driver

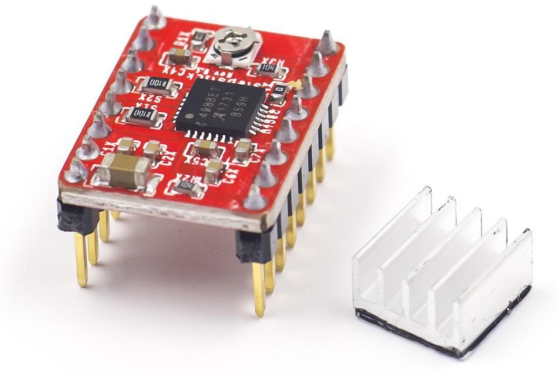

Figure 4: A4988 Motor Driver

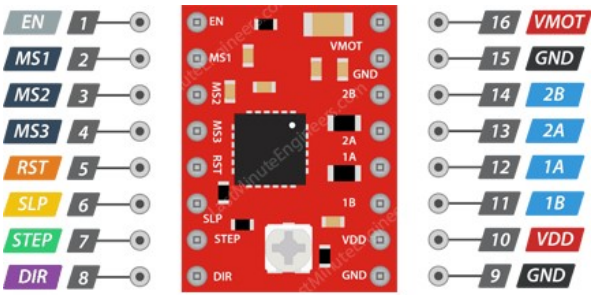

Figure 5: Motor Driver pinout

a) A4988ET integrated circuit.

b) Single Stepper Motor

c) It supports micro-stepping function. In addition, we can configure the stepping mode by providing necessary combination for MS1, MS2 and MS3 pins.

d) A stepper motor controller can be implemented as follows.

1. Firstly, we must supply 12V power for VMOT and GND pins, and 5V for VDD and GND.
2. Then, configure the stepping mode by setting MS1, MS2, and MS3 to correct values.
3. The RESET and ENABLE pins are active low pins. Therefore, it is mandatory to pull the RESET pin to 5V to prevent the driver from resetting.
4. The, SLEEP, DIR, STEP pins should connect to Arduinos' digital IO pins.
5. Finally, 1A and 1B pins are connected to a coil in the motor, also 2A and 2B pins are connected to the other coil.
   In the Arduino, we must pull the SLEEP pin to GND to provide power for the motor. We can set the direction to clockwise or anticlockwise by setting the DIR pin to HIGH or LOW. The corresponding direction will be changed with the connection of the coils. Finally, by giving a suitable pulse train to the STEP pin, the motor can be rotated. The speed of the motor will depend on the STEPPING MODE and the frequency of the pulse train.

5 References

- Spektrum ESC data-sheets and manuals.
  https://www.spektrumrc.com/Products/Default.aspx?ProdID=SPMXAE1100
- Spektrum ESC programming
  https://www.youtube.com/watch?v=gmyNrYZlQR0
- Make your own ESC (Great Scott)
  https://www.youtube.com/watch?v=W9IHEqlGG1s&t=254s
- About BEC
  https://en.wikipedia.org/wiki/Battery_eliminator_circuit
- L6234 Integrated Circuit Data-sheet
  https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjDw5mF4uLzAhWh7nMBHZsaCZsQFnoECAgQAQ&url=https\%3A\%2F\%2Fwww.st.com\%2Fresource\%2Fen\%2Fdatasheet\%2Fcd00000046.pdf&usg=AOvVaw172B1O3LwrwG-Cez1GeIpW
- A4988ET Stepper Motor Driver IC Data-Sheet.
  https://www.alldatasheet.com/datasheet-pdf/pdf/338780/ALLEGRO/A4988.html