SPEED CONTROL OF A BRUSHLESS DC MOTOR USING A MICROCONTROLLER

Assignment - 8

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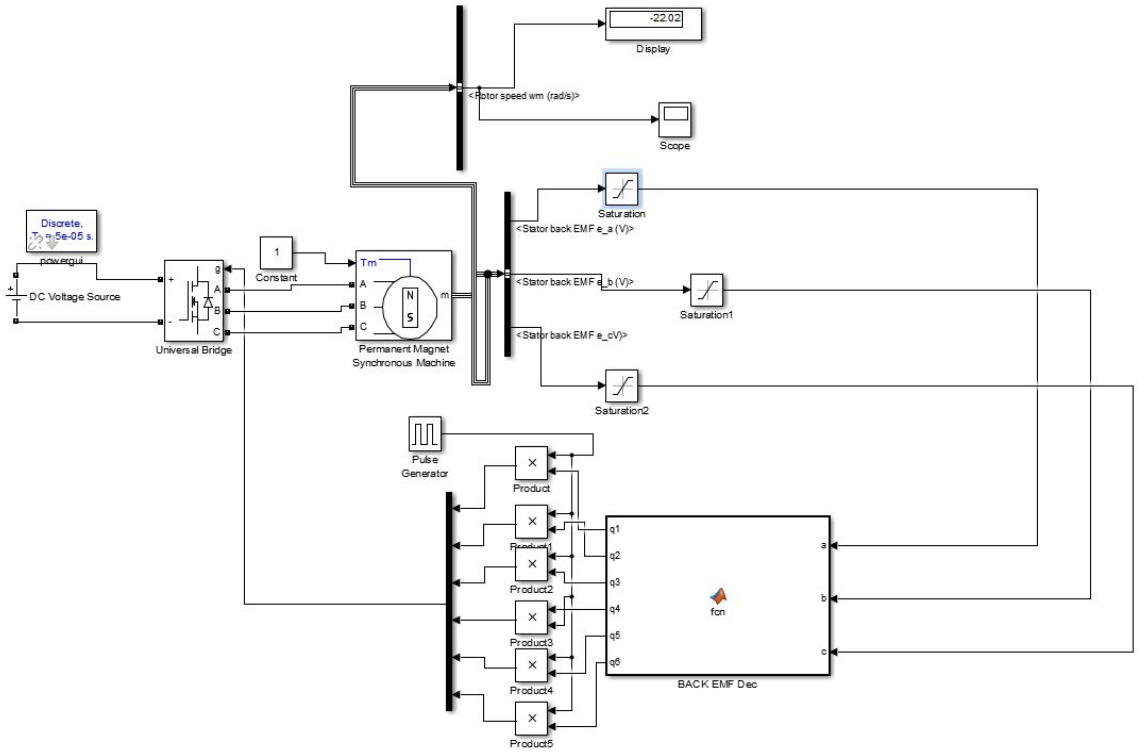
ABSTRACT

This project aims to control the speed of a brushless DC motor. This is necessary because BLDC motors are used in a variety of everyday circuits including CD drives, drones, electric vehicles, etc. Here, we use an automatic speed controller that has an in-built back EMF sensor.

SIMULINK MODEL

The simulink model is given in the following figure,



The back EMF decoder decides the switches that need to be turned on, depending on the trapezoidal back EMF obtained from the motor.

SIMULATION RESULTS

The model works for a small range of speeds. While the motor settles at a constant speed, there seems to be an issue with its sensitivity to the duty cycle. The trapezoidal waveforms are obtained though.

HARDWARE MODEL

The following components are required. We have,

1. A BLDC Motor : A2212/13T was chosen. It has 14 stator poles and is an outrunner motor, hence the enclosing case is actually the rotor.
2. ESC : This speed controller is an IC that consists of a back EMF sensor, a voltage regulator and a 3 phase inverter. It expects only a PWM input with a certain duty cycle as input.
3. Arduino - Uno : This is the microcontroller that is attached to the motor and ESC. It is also interfaced to the hex keypad, which enables independent input of speed without the requirement of a computer.
4. Digital Tachometer : To verify/test results by measuring speed.
5. Power Supply
6. Hex keypad - This requires 8 pins on the Arduino.

PROCEDURE

1. The circuit is assembled. The Arduino can be powered up by the laptop or the ESC itself.
2. The required speed is fed using the hex keypad. When the speed changes, the voltage and currents drawn are noted to calculate input power.
3. The current and voltage are noted for the same duty cycle, after putting a small load on the shaft.
4. Torque is calculated using the following equation,

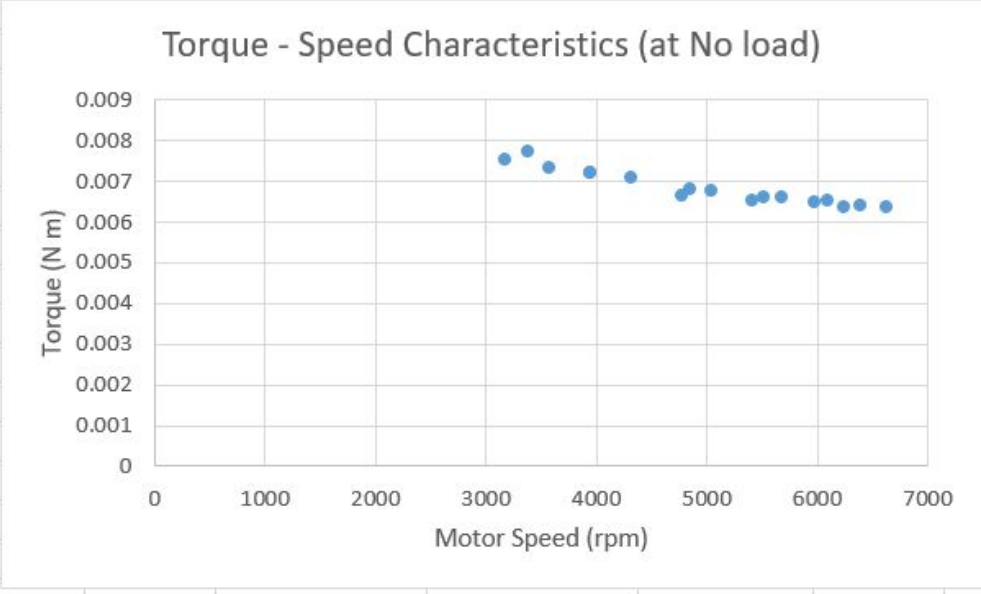
$$T = P_{IN} / \omega$$

It is to be noted that the above equation assumes an efficiency of 1.

OBSERVATIONS

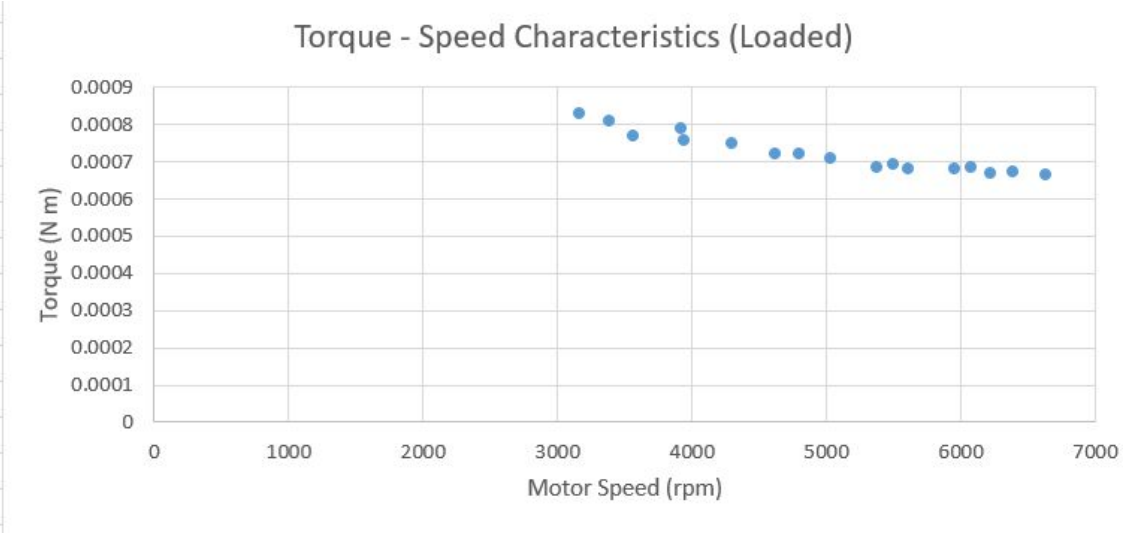
1. No Load

Speed (RPM)	Speed (rad/s)	Vdc (V)	Idc (A)	Pin (W)	Torque (N m)
3177	332.694662	11.9	0.21	2.499	0.007511392
3390	354.9999699	11.9	0.23	2.737	0.00770986
3571	373.9542455	11.9	0.23	2.737	0.007319077
3946	413.2241537	11.9	0.25	2.975	0.007199482
3953	413.957192	11.9	0.25	2.975	0.007186733
4320	452.3893421	11.9	0.27	3.213	0.007102289
4781	500.6651492	11.9	0.28	3.332	0.006655147
4844	507.2624938	11.9	0.29	3.451	0.006803184
5045	528.3111646	11.9	0.3	3.57	0.006757381
5410	566.5338752	11.9	0.31	3.689	0.006511526
5520	578.0530483	11.9	0.32	3.808	0.006587631
5688	595.6459671	11.9	0.33	3.927	0.006592842
5971	625.2816578	11.9	0.34	4.046	0.006470684
6090	637.7433087	11.9	0.35	4.165	0.006530841
6247	654.1843102	11.9	0.35	4.165	0.006366707
6391	669.263955	11.9	0.36	4.284	0.006401062
6628	694.0825369	11.9	0.37	4.403	0.006343626



2. Loaded

Speed (RPM)	Speed (rad/s)	Vdc (V)	Idc (A)	Pin (W)	Torque (N m)
3161	331.0191459	11.9	0.22	2.618	0.007908908
3384	354.3716513	11.9	0.23	2.737	0.00772353
3566	373.4306468	11.9	0.23	2.737	0.00732934
3926	411.1297586	11.9	0.26	3.094	0.007525605
3940	412.5958352	11.9	0.25	2.975	0.007210446
4300	450.294947	11.9	0.27	3.213	0.007135323
4624	484.2241477	11.9	0.28	3.332	0.006881111
4800	502.6548246	11.9	0.29	3.451	0.006865546
5036	527.3686868	11.9	0.3	3.57	0.006769458
5375	562.8686838	11.9	0.31	3.689	0.006553927
5500	575.9586532	11.9	0.32	3.808	0.006611586
5611	587.582546	11.9	0.32	3.808	0.006480792
5956	623.7108615	11.9	0.34	4.046	0.00648698
6081	636.8008309	11.9	0.35	4.165	0.006540507
6224	651.7757559	11.9	0.35	4.165	0.006390235
6384	668.5309167	11.9	0.36	4.284	0.006408081
6628	694.0825369	11.9	0.37	4.403	0.006343626



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[1] Vishnuvardhan Vadla, Chappidi Suresh and Ravi Naragani, "Simulation of Fuzzy Based Current Control Strategy for BLDC Motor Drive," International Journal of Scientific Engineering and Technology Research, vol. 04, issue 24, pp.4626-4632, July 2015

[2] .Vinatha U, Swetha Pola and K P Vittal, "Simulation of Four Quadrant Operation & Speed Control of BLDC Motor on MATLAB / SIMULINK"