ACT project - Drone control System using MATLAB Simulink

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***Abstract*—In this Project we have developed a drone control system using MATLAB Simulink. This Simulation will give us an insight on the working of a general drone and it can later be expanded for domestic and commercial purposes. In this project we will also dig a little deep in the world of PMBLDC motors which are an essential component for the development of a Quadcopter drone.**

I. Introduction

AS THE WORLD IS WITNESSING AN INNOVATIVE REVOLUTION DRONE TECHNOLOGY IS ALSO PAVING THE WAY FORWARD FOR THE PLENTIFUL YET DIVERSE ASPECTS OF THIS SECTOR. THE USE OF UNMANNED AERIAL VEHICLES (UAVS) IN THESE ASPECTS DRIVES THE INDUSTRY IN THE DIRECTION OF THE BUSTLING AND FLOURISHING SIDE IN THE WOODS OF PUBLIC INFRASTRUCTURE. DRONE TECHNOLOGY, ASSISTING THE PUBLIC SECTOR IN ATTAINING A CERTAIN LEVEL OF CONVENIENCE AND ADROITNESS, EMBODIES COMFORT IN PROFESSIONALISM.

II. Why we need drone technology

Inherently, managing the intricate layers of this sector may cause certain discrepancies and inconsistencies between facts and mechanisms of functioning, given that there are numerous techniques of approach. It is the public sector services that enable people to earn and lead good and content lives. At this junction, it becomes imperative to understand the health of the public sector, which is only deteriorating. The budget allocated and distributed to this sector may be a fat sum, although it does not compensate for the various hindrances that dare to threaten this industry.

A desperate attempt to not drown in the troubles encircling public sector undertakings has led to drones' onset and employment in this space. Drone technology being implemented in the same sphere as the state-run schemes have proven to be a sophisticated, intelligent, and economical choice. State-run pursuits subsume the industrial enterprises of infrastructure, health and welfare, environmental conservation, law enforcement and public safety, emergency response, and more. The cutting-edge technology of drones, coupled with artificial intelligence, makes it methodically coherent and productive for relevant purposes.

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A. Public Infrastructure

Infrastructure sums up to a significant share of the public sector because it encompasses the construction and maintenance of public amenities. This accommodates roadways, highways, bridges, buildings, railway tracks, public transport modes, and appreciably more. Drones and UAVs bring about the intricate details that go into the working of this field of state-run undertakings. Applicable for aerial surveillance and monitoring operations, drones use their robust features to serve land inspection and observation purposes. The benefits of 3D mapping, UAV data collection, and processing while capturing alluring aerial footage motivate workers to adopt drones' specialty for developing public infrastructure. The high-resolution cameras and sensors instilled in drones permit them to capture intricate details, more so in remote areas where human entry is not permissible. Drones can also detect and identify cracks and defective conditions, ensuring the public's safety and welfare. Analysis and evaluation of the construction conditions may be carefully, accurately, and comfortably performed, resulting in suitable determinations.

B. Agriculture

Shedding light on the various challenges the farmers face to cultivate and grow crops that yield good income, drone technology has proved its skill in understanding and overcoming these challenges. Intrinsically, drones can be used to monitor the fields and crops. The results would be tracked and displayed to the farmers without checking up on the crops manually. Using the features of 3D mapping, aerial surveillance, and imagery as brought about by drones, the challenges and primitive operations evolve into automated solutions with an edge of innovation. Drones, striving for better performance and efficiency, also entail spraying crops with fertilizers and insecticides to nurture them into healthy harvests. Recognizing and detecting crops for any diseased or rotting conditions are other adequate measures used by using drones in this space. Inherently, all these and more characteristics make drones and UAVs economical and resourceful tools of innovation to adopt in agriculture.

C. LAW Enforcement

The police and armed forces may employ unmanned Aerial Vehicles (UAVs) to scrutinize and observe the opponent side. Their high-sensitive cameras and sensors can quickly alert the details for notifiable signs ahead.

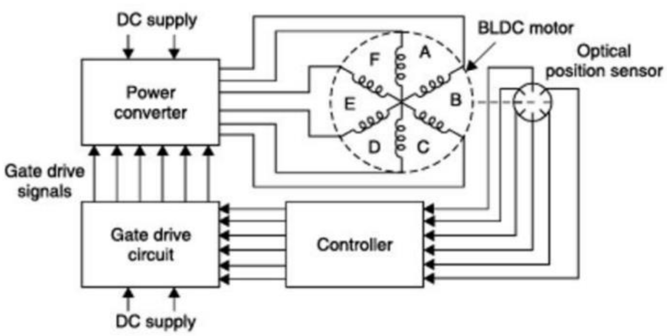
Manual inspection of sites, aerial surveillance for illegal or potential criminal offenses, etc., are a few instances where drones show much potential. In this sense, the armed forces and security can keep track of the public's issues, that is, in a cost-effective and time-critical manner.

III. PMBLDC

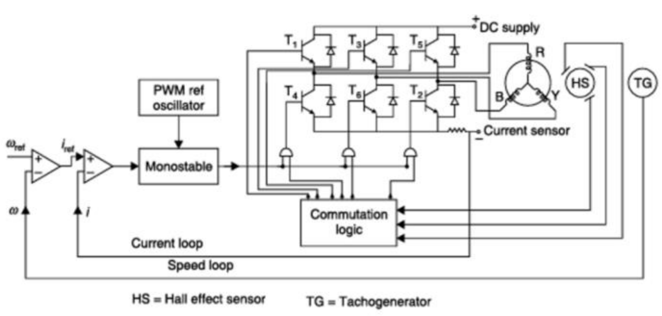
Before going into the Simulink model, we first have to understand BLDC motor. These motors come into the category of brushless DC motor. Here we don't give any DC or Sinusoidal voltage for operation, we usually give Quasi-DC voltage for its operation.

BLDC motor consists of a magnetic rotor electrically isolated from the stator. Stator consists of poles wounded with coils; it is called distributed winding. It also consists of position sensors between adjacent stator poles.

For operating a BLDC motor, we first need to figure out the orientation of the rotor which is achieved with the help of position sensors. Most common position sensor used is Hall effect sensor.

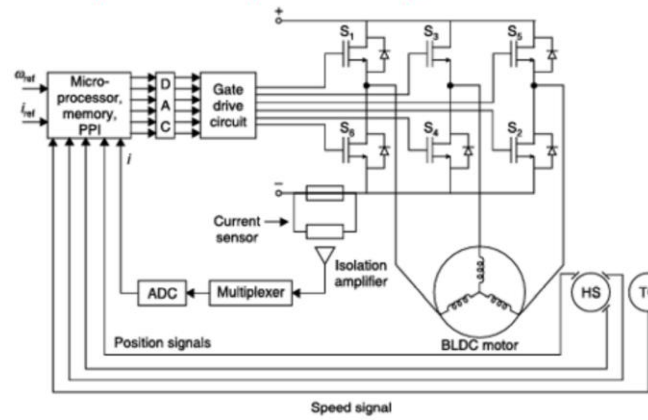


Operation of BLDC Motor



Motor control of BLDC motor

Micro processor based speed control of Square wave PMBLDC motor



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A. *Microprocessor control of BLDC*

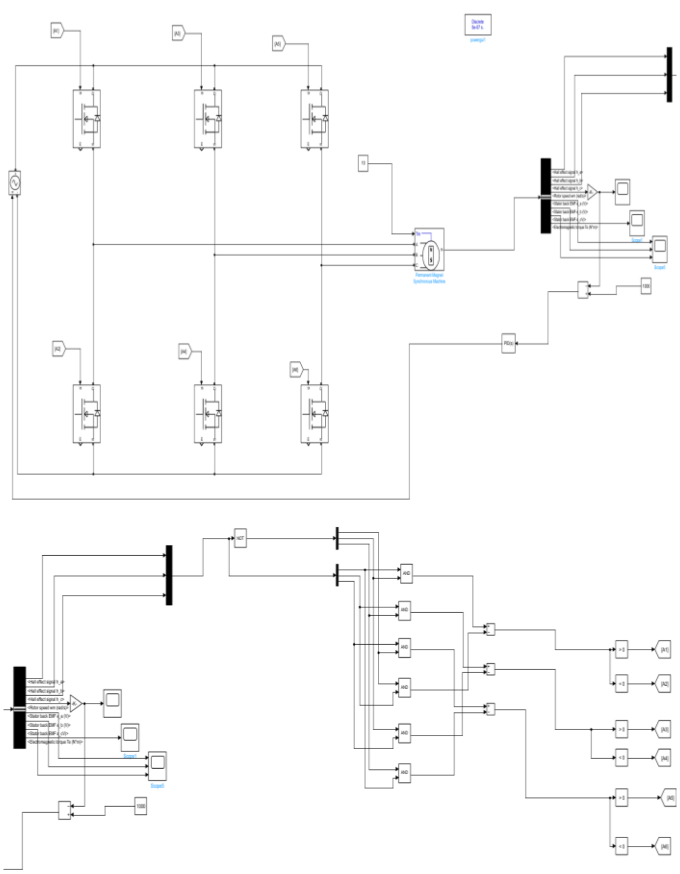
In the block diagram, the BLDC motor is supplied from a power converter circuit consisting of six static devices. A tachometer is mounted on the shaft to provide speed feedback signal. Hall sensors are used for providing position signal. The stator current is detected by current sensor and amplified by optically isolated amplifier. The output signals are multiplexed and converted to digital form by the ADC In normal operation, commands are sent from the input-output terminals, and the system variables (line current, rotor position and speed) are sensed and fed to the CPU. After processing, the microprocessor issues control signals to base/gate drive circuit where the signals are amplified. The base/gate drive circuit send appropriate signals to the semiconductor switching devices.

An inverter is implemented using power transistors T1, to T6. It controls the current and commutation. For 120° conduction, only two transistors carry current at any instant, i.e., one of the upper transistors T1, T3 and T5 and one of the lower transistors T2, T4 and T6 conduct at any moment. PWM technique is used to control the current through the winding to match the rectangular reference current waveform for 0° to 60° conduction with T1, and T6. ON. During this interval, T1, is kept ON and T6 chopped ON/OFF using a current controller with fixed switching frequency. During this interval R and Y phases conduct through T1, and T6. During the next interval of 60 to 120°, T6 is switched OFF and T2 is turned ON. For each interval of 60°, one of the upper transistors (T1, T3, T5) is turned ON for the entire interval and one of the lower transistors (T2, T4, T6) is always chopped for the 120° interval. The duty cycle depends on the desired (reference) speed. The application of PWM to one transistor reduces current ripples. The AND gates combine commutation signals and chopping signals for providing the input to lower transistors.

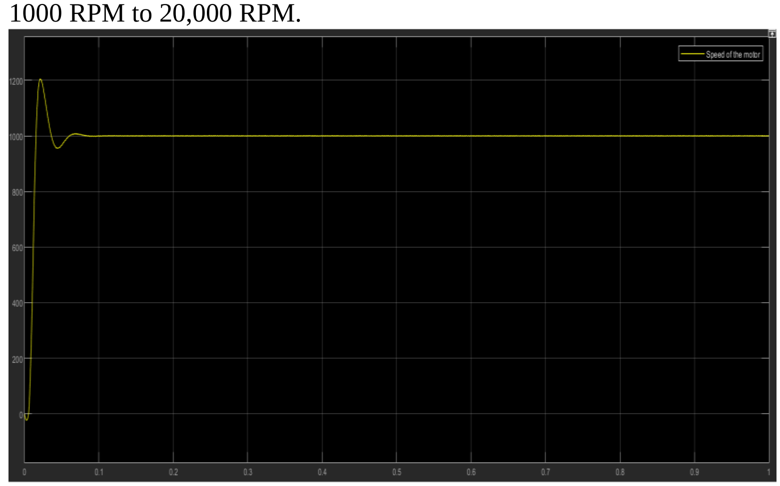
SL. No	Feature	BLDC motor	Brushed DC motor
1	Commutation	Electronic commutation based on position sensor	Brushed commutation
2	maintenance	Less	It need periodic maintenance
3	Life	Longer	shorter
4	Speed/torque Characteristics	Flat - enables operation of all speeds with rated load	Moderately flat - at higher speed, brush friction increases, thus reducing the useful torque
5	Efficiency	High - no voltage drop across brushes	Moderate
6	Output Power/ Frame size	High	Moderated low
7	Speed range	Low, because it has permanent magnet on the rotor. This improve the dynamic response	Higher rotor inertia which limits the dynamic characteristics
8	Electric noise generation	Low	Arcs in the brushes will generate noise causing EMI in the equipment nearly
9	Cost of building	Higher - Since it has permanent magnet	Low
10	Control	Complex and expensive	Simple and inexpensive
11	Control requirement	A controller is always required to keep the motor running. The same controller can be used for various speed control	No controller is required for fixed speed; a controller is required only if variable speed is desired.

Difference between BLDC Motor and Brushed Motor

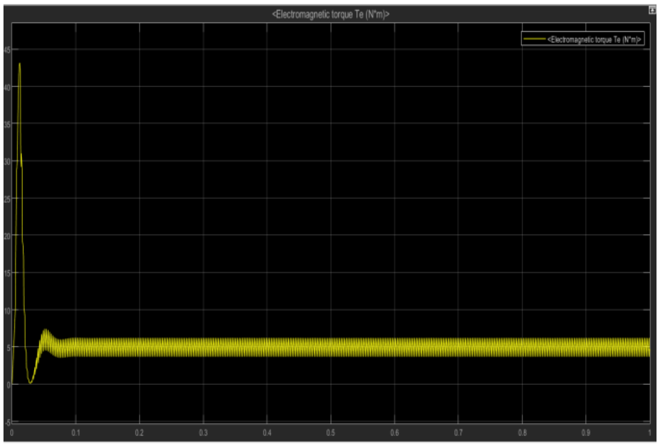
IV. SIMULATION OF PMBLDC MOTOR



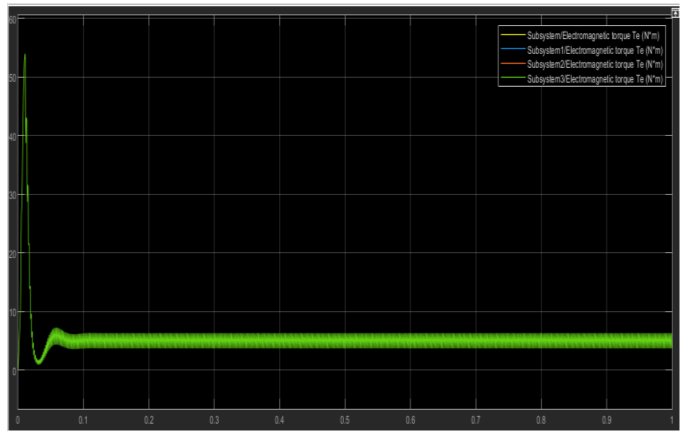
In this Simulation we have assume our BLDC motor to be a 6 pole, machine. Moreover, there is no BLDC motor available in MALAB Simulink SPS library, thus to imitate the actions of a BLDC motor we used a Permanent magnet synchronous machine (PMSM) with a trapezoidal Back emf.
We have also used Variable voltage supply for supplying stator current to our motor. In our simulation we have also used 6 power Mosfets that will supply energy to our stator poles whenever required. These 6 power Mosfets are in 120 deg mode of conduction, that will give AC supply to our PMSM motor.
The outputs of our PMSM motor are Torque, Speed, Back emf waveforms given by Hall effect sensor. We then compare the reference speed of our motor with the output speed and if there is any difference in the values it is supplied to the PID controller and then given to the Variable voltage supply. If the speed difference is positive, stator voltage will be increased, if speed difference is negative, stator voltage will be decreased. In this way we will control the speed of the PMBLDC motor. Moreover, the output back emf is given to a set of combinational logic circuit that will tell us about the orientation of the rotor. So, if the orientation of the rotor has been identified we later give this information to the mosfets so that nearby pole can be excited in advance to keep the rotation of the rotor intact.
Generally, the speed of BLDC motor in a drone goes from 1000 RPM to 20,000 RPM.



Speed of the motor

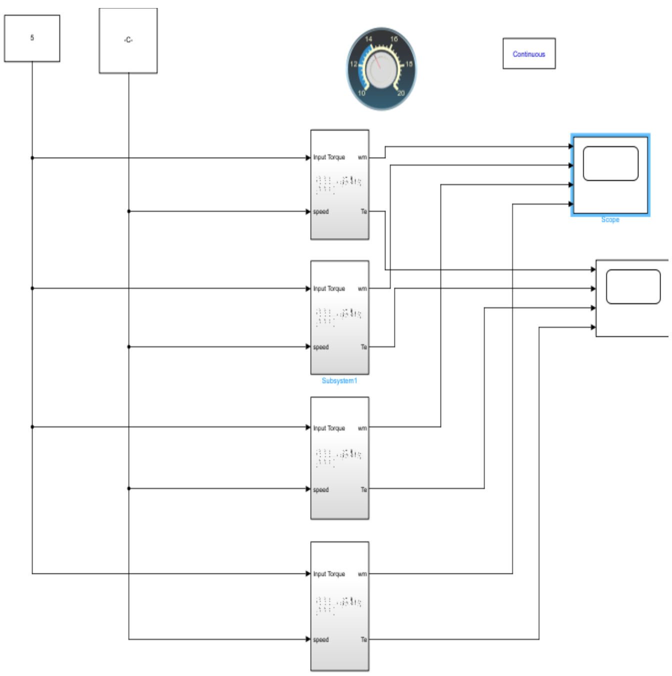


Torque of the motor

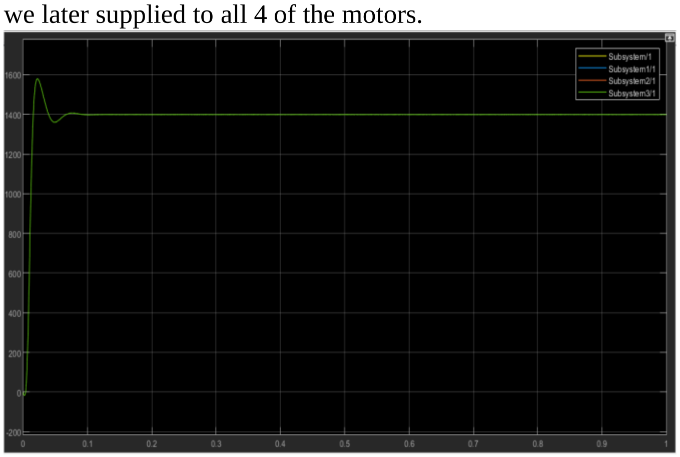


Torque developed by all the 4 motors

V. *Height Control of the Drone*

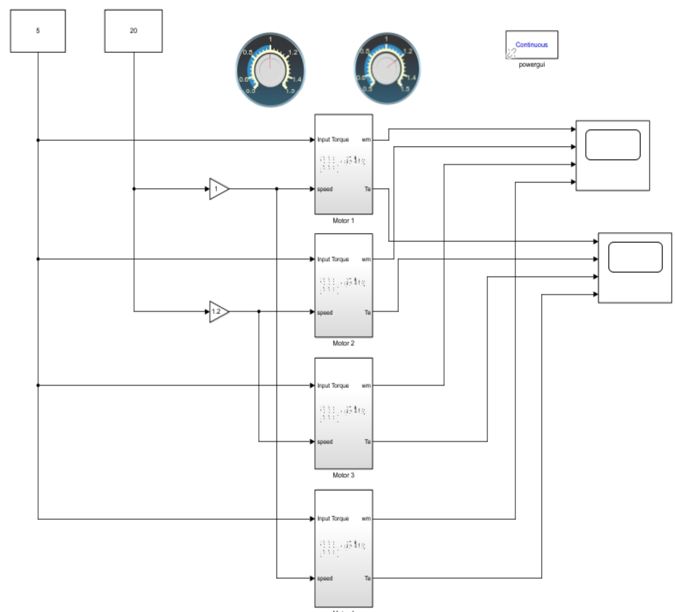


As stated earlier we will keep torque constant. We will vary the speed of the motor. If we vary the speed of all the 4 motors together then we can vary the height of the drone as well.
In this Simulation we varied the value of the constant which we later supplied to all 4 of the motors.

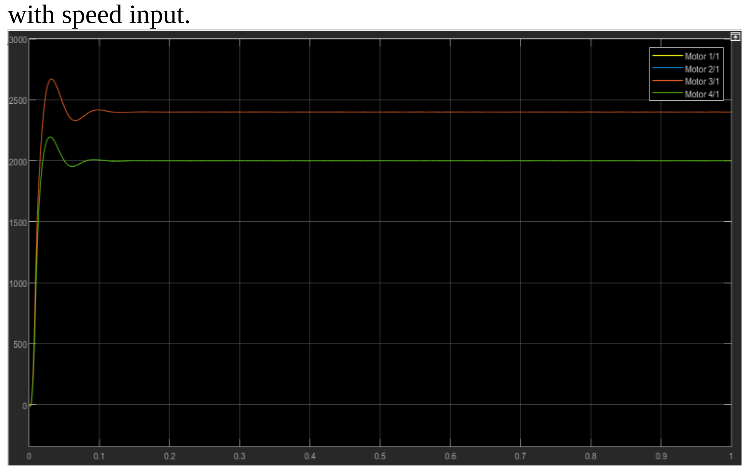


Speed of all the 4 motors

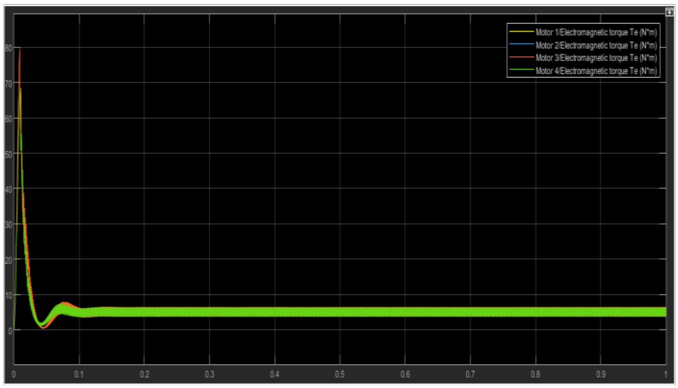
VI. *Movement Control of the Drone*



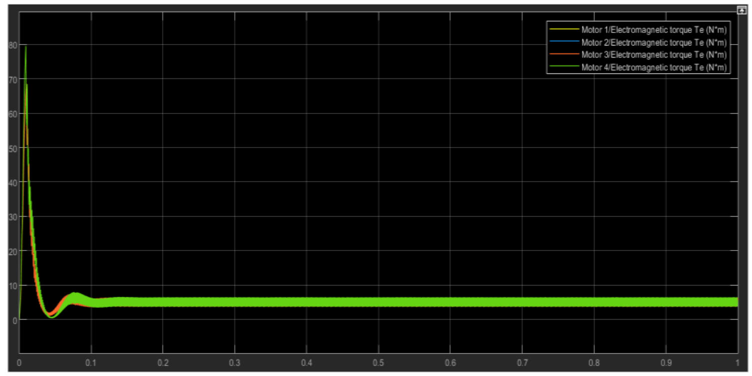
In this simulation we varied the speed of any 2 adjacent pair of motors together then it will generate torque and will make our drone to move in any particular direction.
Here we will control the value of gain given to the motors with speed input.



Speed of all the 4 motors

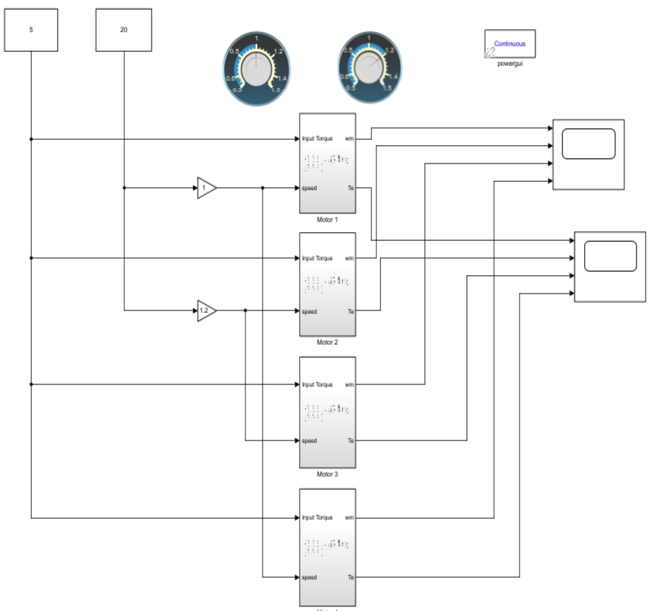


Torque developed by all the 4 motors

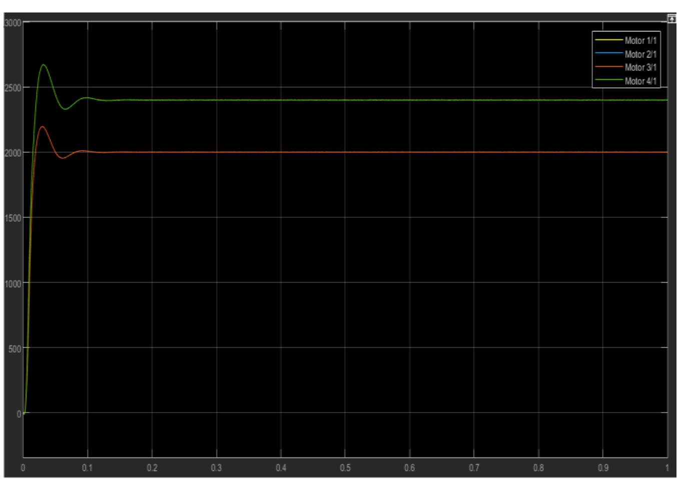


Torque developed by all the 4 motors

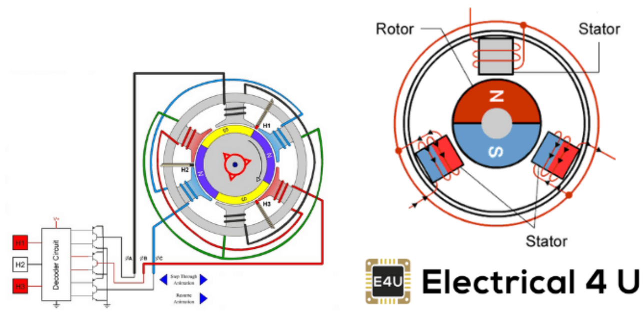
VII. ROTATION CONTROL OF THE DRONE



To control the rotation of the drone we have to increase the speed of any 2 opposite pair of motors which will give counter torque to the drone and thus our drone will later perform YAW.



Speed of all the 4 motors



BLDC Working

VIII. ACKNOWLEDGEMENT

I would like to Thank our professor DR Geetanjali P for giving her valuable guidance for this project

IX. CONCLUSION

This simulation can be used for studying the operation of a drone under given conditions without the need of buying a proper drone. This simulation can also be used for expansion of the drone technology for further fields of interest.

X. FUTURE SCOPE

Day by day importance of drones is increasing very rapidly whether it is for domestic purpose, commercial purpose or military purposes. With the help of this simulation, we can develop and upgrade drone further and can solve vast numbers of problems

XI. REFERENCES

J. A. Prakosa, D. V. Samokhvalov, G. R. V. Ponce and F. Sh. Al-Mahturi, "Speed Control of Brushless DC Motor for Quad Copter Drone Ground Test," 2019 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering (EIConRus), 2019, pp. 644-648, doi: 10.1109/EIConRus.2019.8656647.

https://www.youtube.com/watch?v=GK1t8YIvGM8