ADVANCED CONTROL THEORY PROJECT

SPEED CONTROL OF BRUSHLESS DC MOTOR USING PWM CONTROL

WORKING

- BLDC motors can be controlled in two ways one is via hall effect sensors and other via sensorless control i.e using back EMF zero crossing points to adjust the position of rotor.
- The rotor shaft position is sensed by a Hall-effect sensor.These signals are 'decoded' by combinatorial logic to provide the firing signals for 120° conduction on each of the three phases.
- ´Programmable logic arrays, gate arrays, and EPROMS are all suitable for this function.
- ´The basic forward control loop is a voltage control, implemented by a mono stable clocked at a fixed reference frequency, which is typically a few kHz.
- ´The duty-cycle or off-time is controlled by an analogue voltage reference that represents the desired speed.

TEAM MEMBERS

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WHAT IS A BLDC MOTOR

As their name implies, brushless DC motors do not use brushes. With brushed motors, the brushes deliver current through the commutator into the coils on the rotor. Whereas in brushless DC motor because the coils are not located on the rotor. Instead, the rotor is a permanent magnet; the coils do not rotate, but are instead fixed in place on the stator. Because the coils do not move, there is no need for brushes and a commutator

With the brushed motor, rotation is achieved by controlling the magnetic fields generated by the coils on the rotor, while the magnetic field generated by the stationary magnets remains fixed. To change the rotation speed, you change the voltage for the coils. With a BLDC motor, it is the permanent magnet that rotates; rotation is achieved by changing the direction of the magnetic fields generated by the surrounding stationary coils. To control the rotation, you adjust the magnitude and direction of the current into these coils.

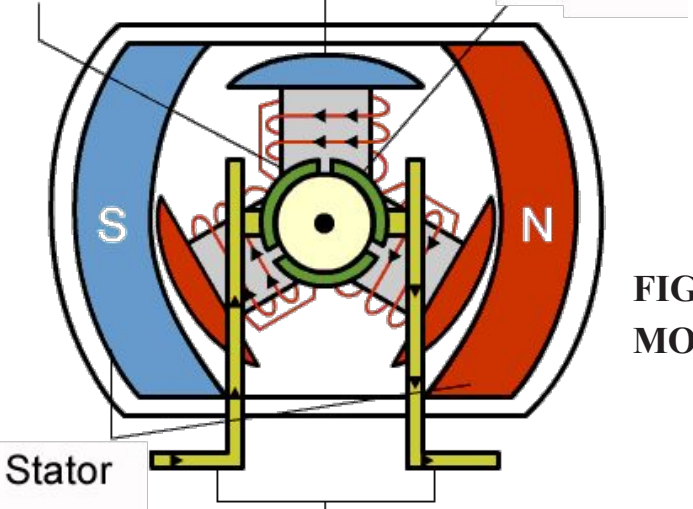
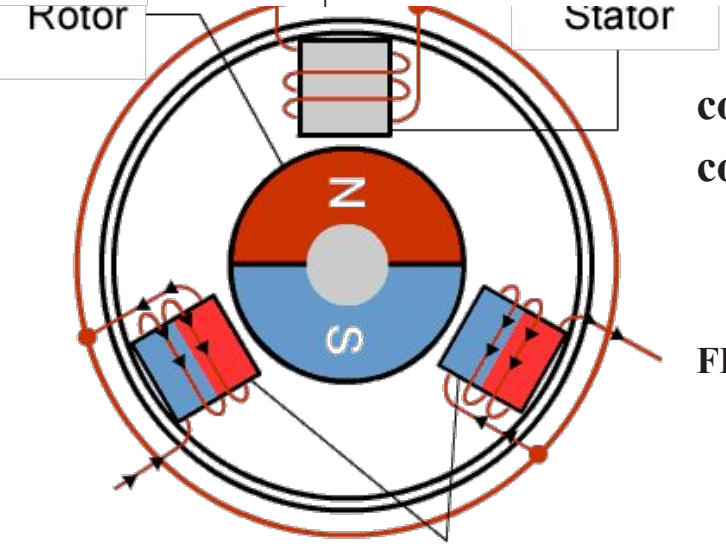


FIG-1 BRUSHED DC MOTOR



Basically brushed DC motors are mechanically commutated but brushless DC motors are electronically commutated.

FIG-2 BRUSHLESS DC MOTOR

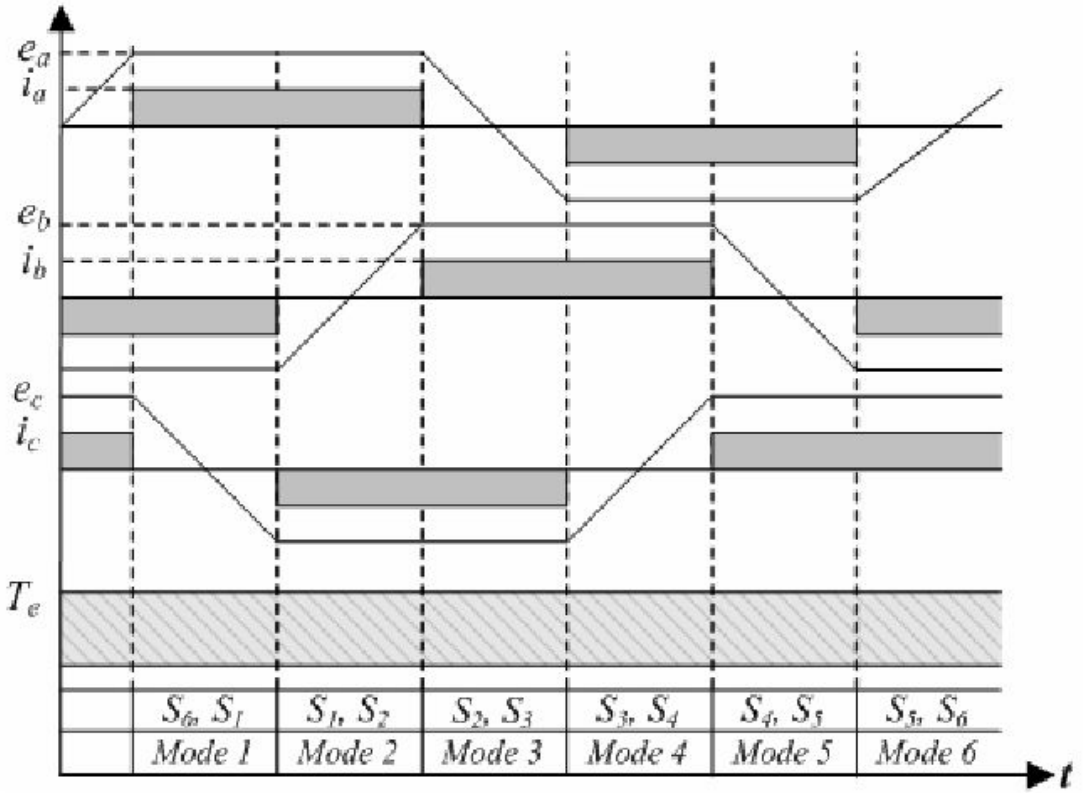
WORKING

- The p.w.m. is applied only to the lower phase leg transistors to reduce the current ripple and also to avoid the need for wide bandwidth in the level-shifting circuit that feeds the upper phase leg transistors. With higher D.C. supply voltages this can be a useful saving.
- AND gates are used as a simple way of combining the commutation and chopping signals to the lower transistors.
- Consequently it is possible to implement current (torque) feedback and speed feedback in the same way as for the d.c. motor, and generally this results in a well-behaved system although compensation may be necessary in either or both loops to improve stability and transient response.
- A tight speed control is thus possible over a wide range of speed and torque using relatively simple techniques that are familiar with commutator motors.

WORKING

- The speed controller uses six MOSFETs which are a type of electronic switch, unless we provide a voltage to the control pin. This then closes the switch and allows current to flow through it.
- The MOSFETs are grouped into three pairs, one pair for each phase. These are connected across the positive and the ground of the battery. The pulse width modulation signal is received by the internal controller which controls the MOSFETs, turning them on and off. The coils inside the stator then connect to the phases between the MOSFETs.
- In Sensorless control the using the BACK EMF of every phase we can determine the zero crossing points of every phase and adjust the rotor.

BACK EMF PROFILE OF BLDC MOTOR



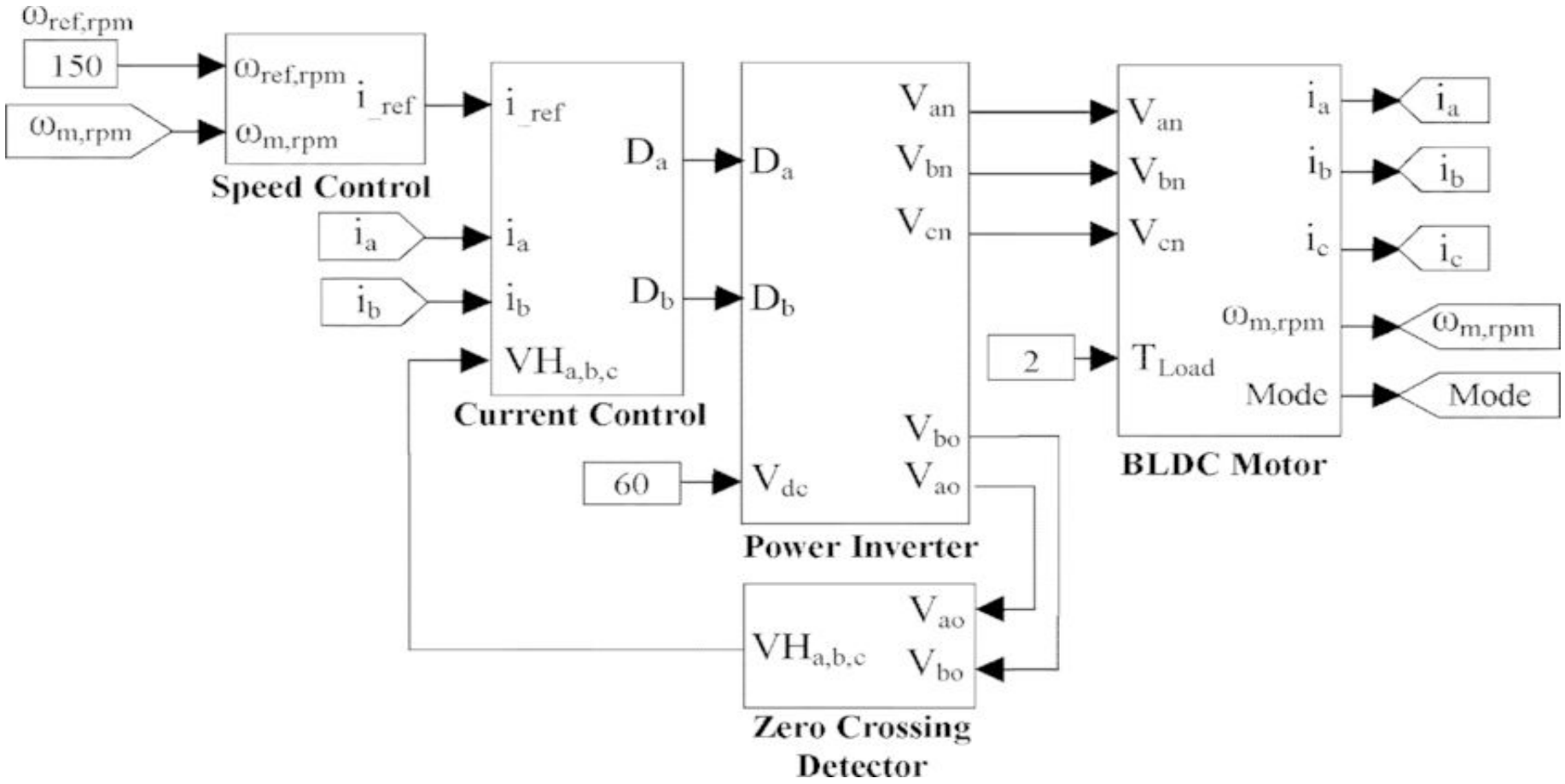
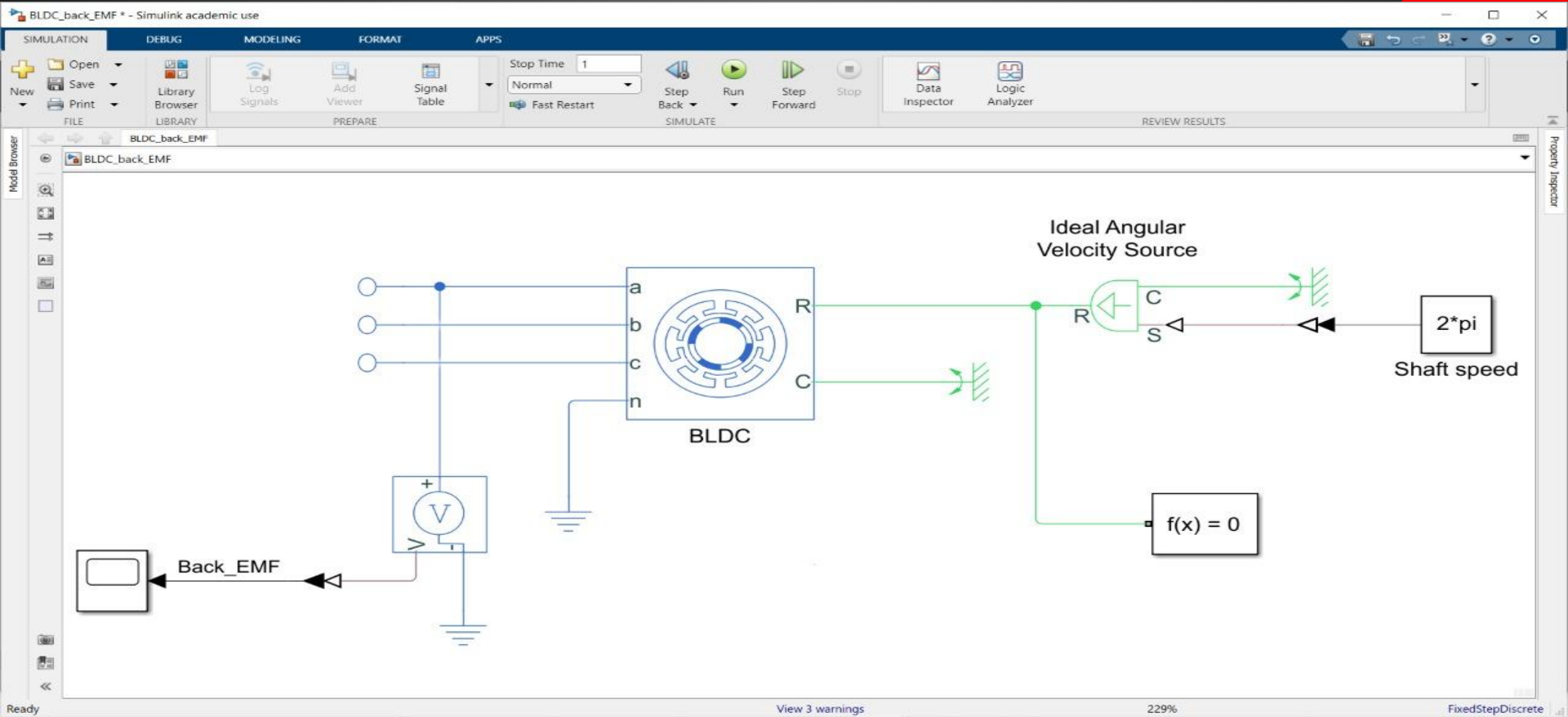
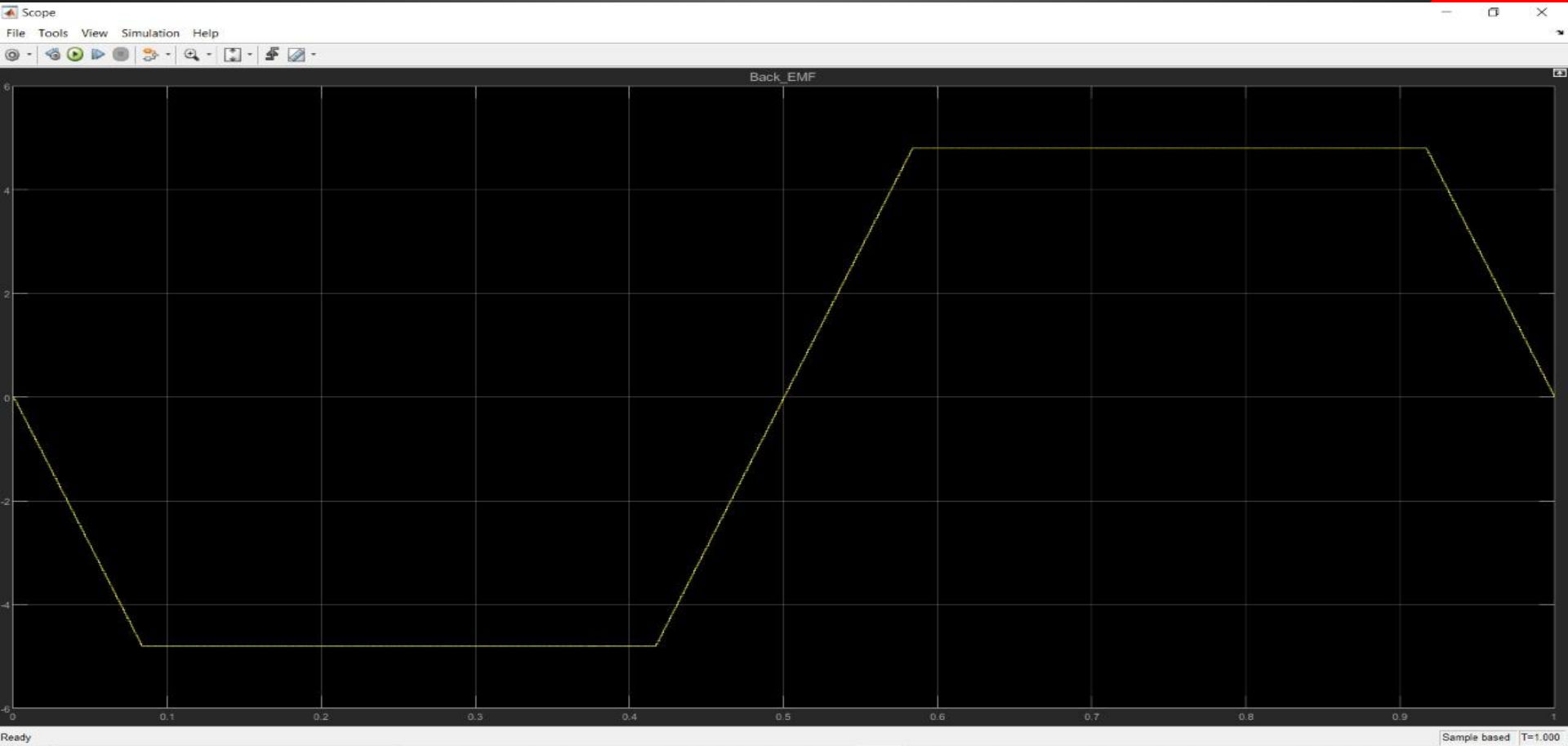


Fig-3 -BLOCK DIAGRAMN OF SENSORLESS CONTROL OF BLDC MOTOR

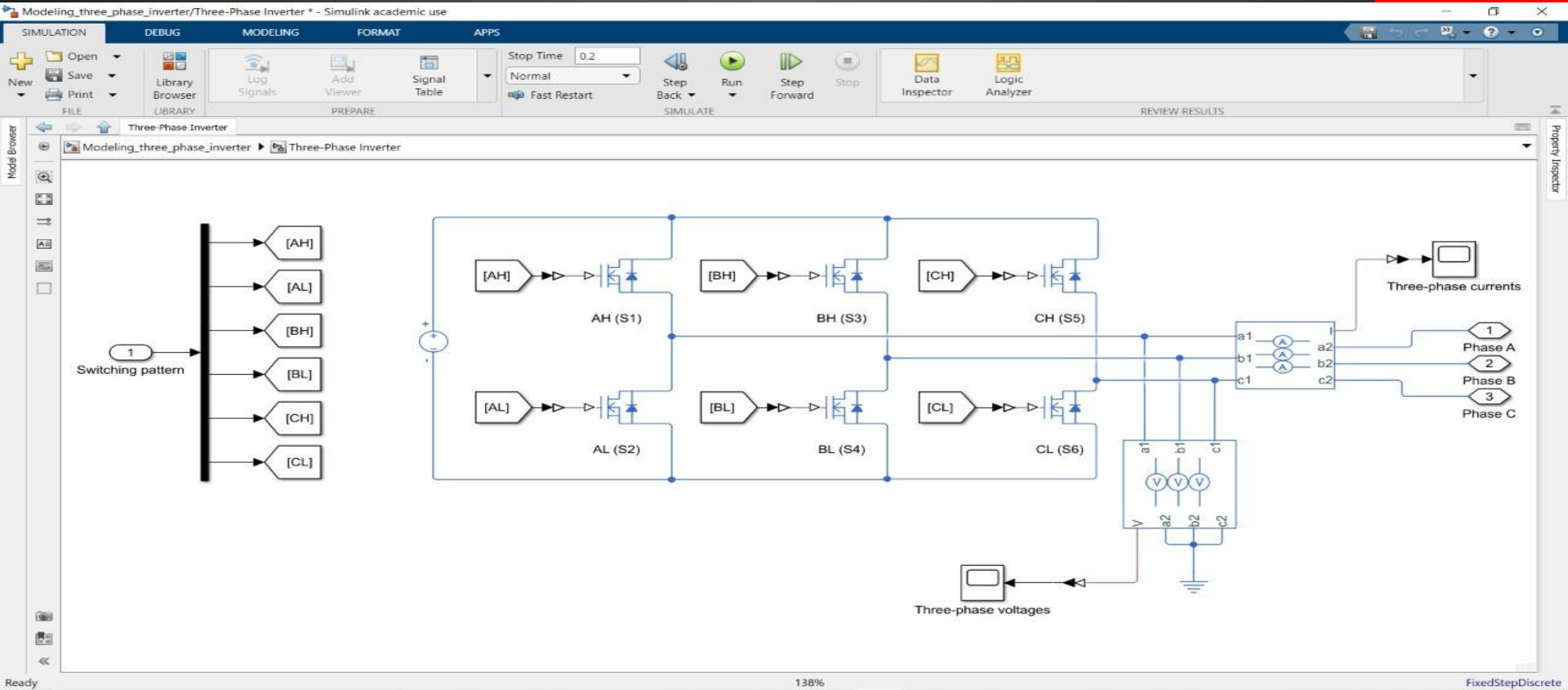
Simulation Results: circuit for generating back emf profile using ideal voltage source



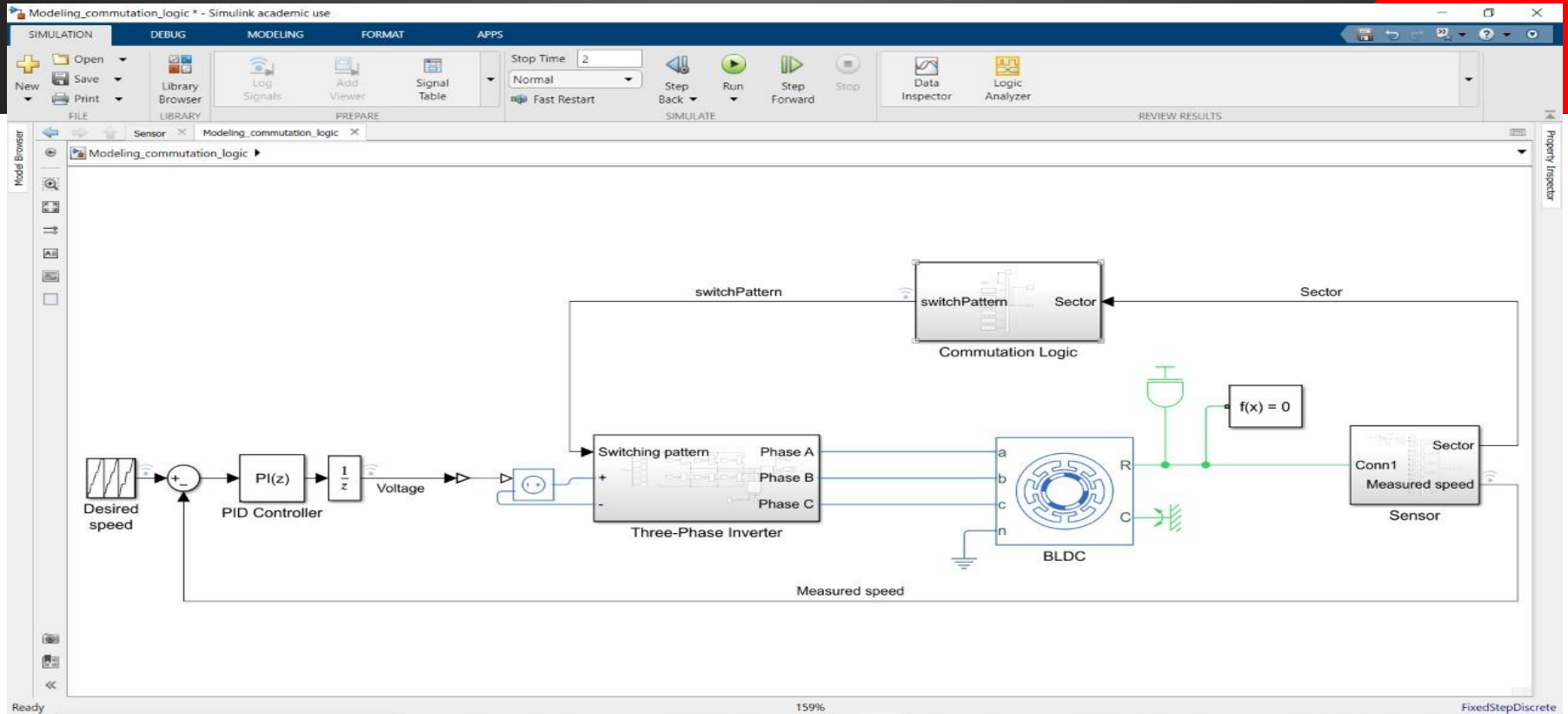
Simulation Results: Single Phase Back emf profile of BLDC motor



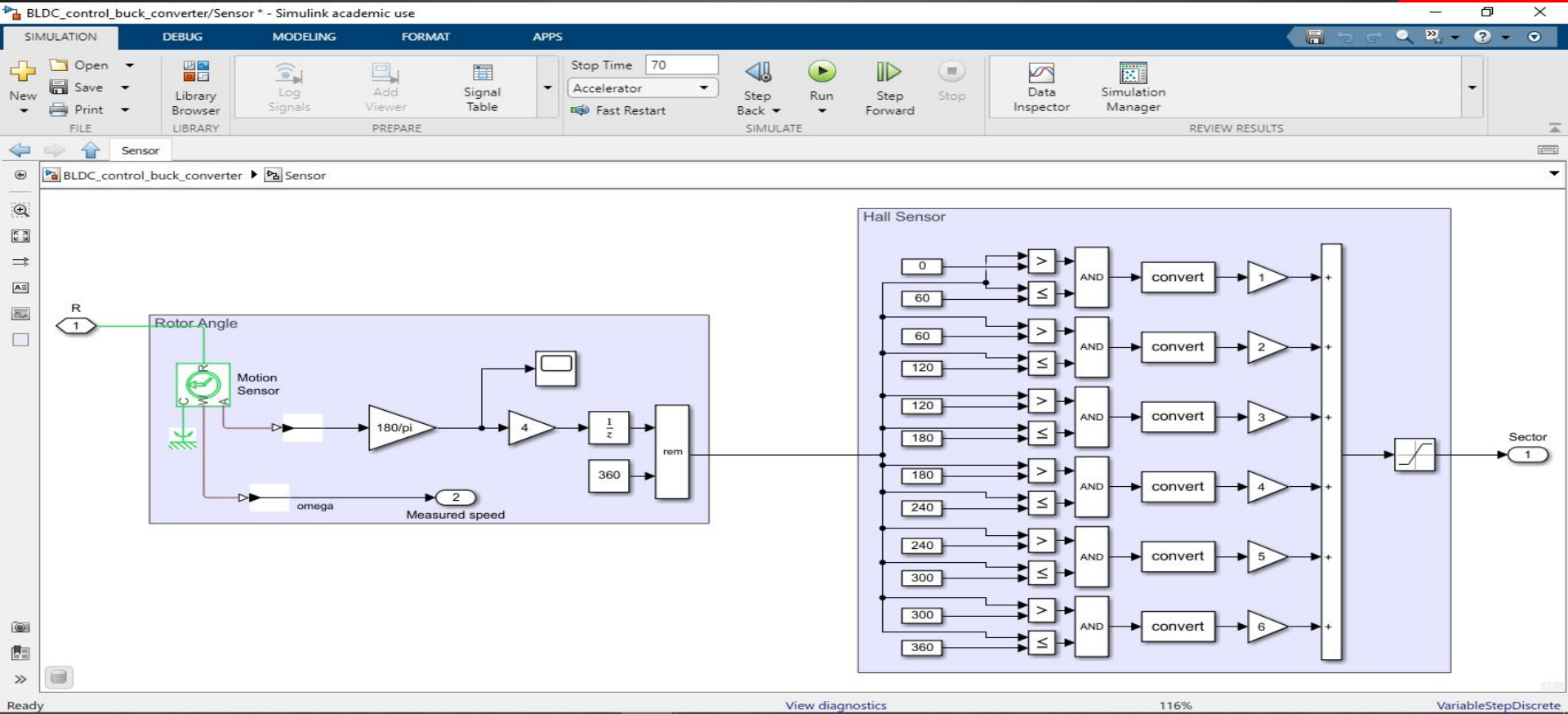
Simulation Results: Inverter circuit implementation for converting DC to AC

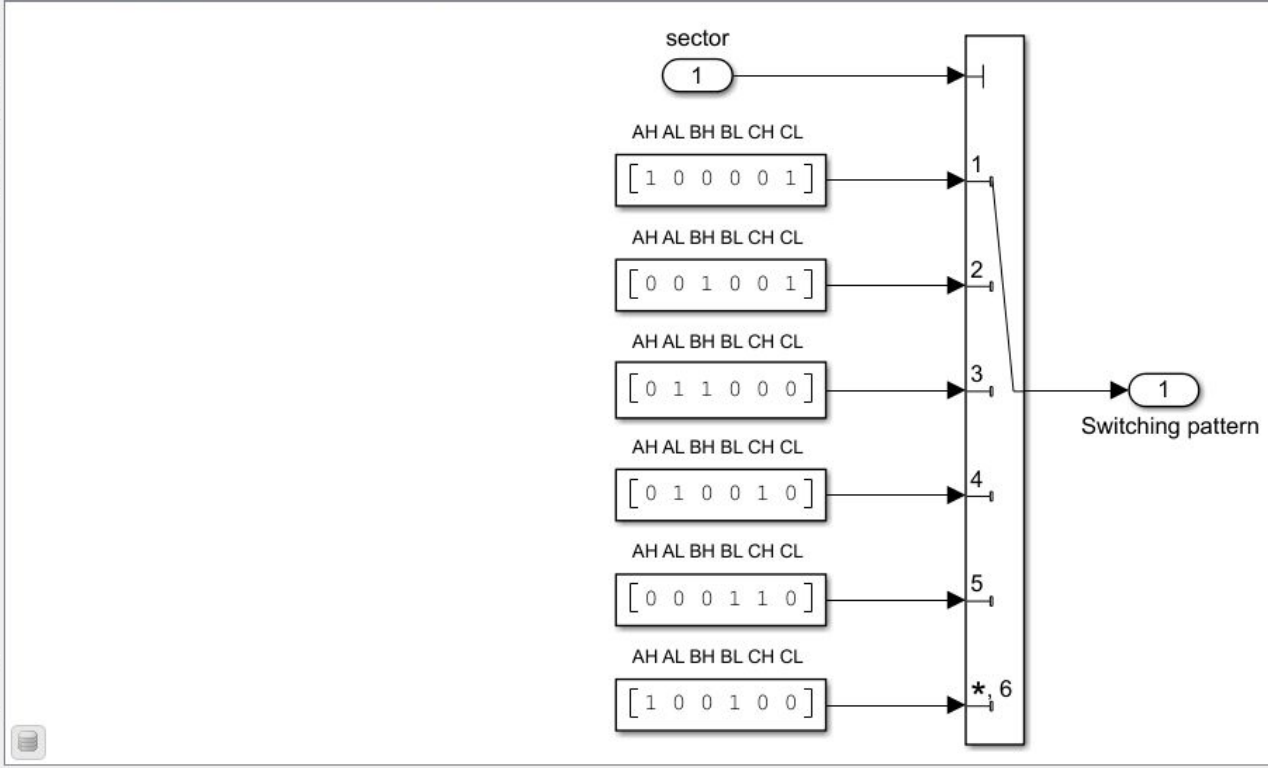


Implementing commutation circuit to control position of rotor and using PID controller to set the desired speed

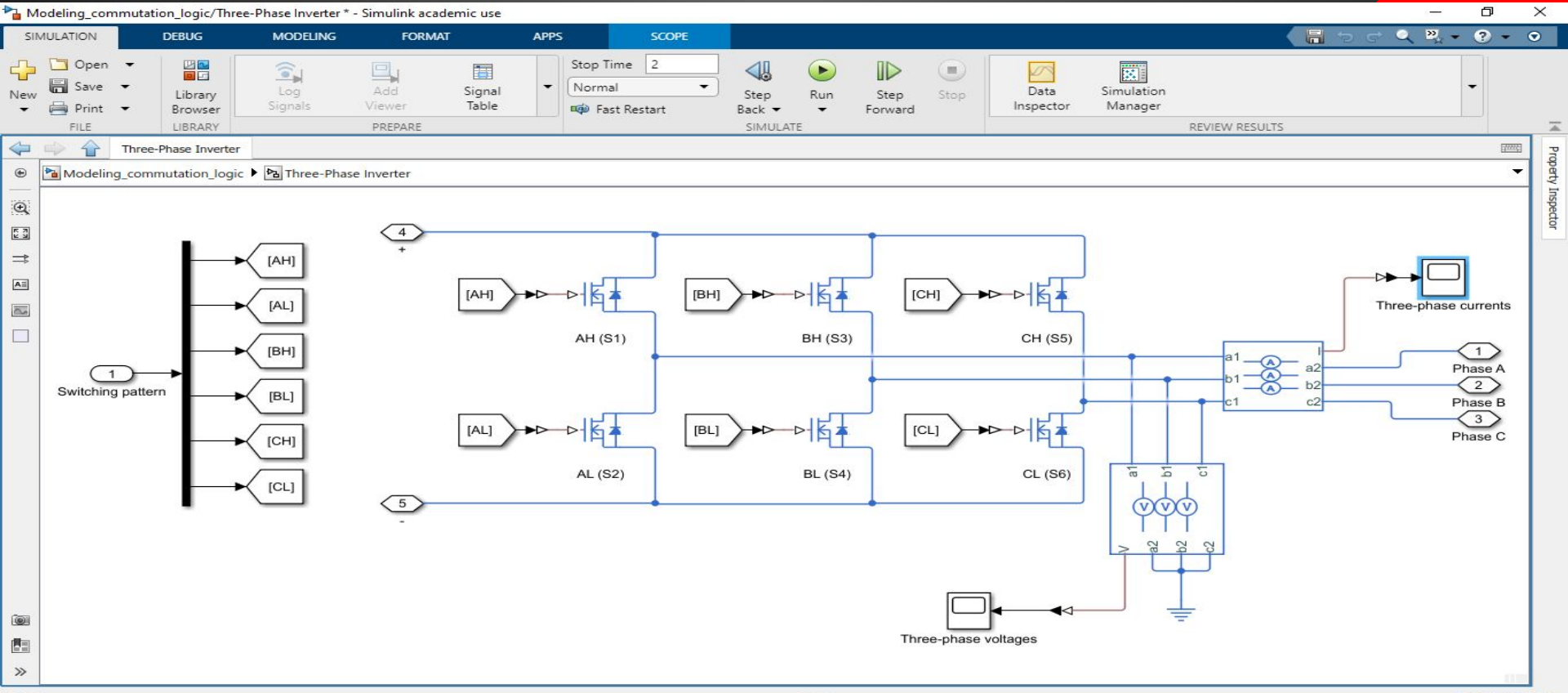


COMMUTATUON LOGIC DEVLOPED USING HALL EFFECT SENSORS

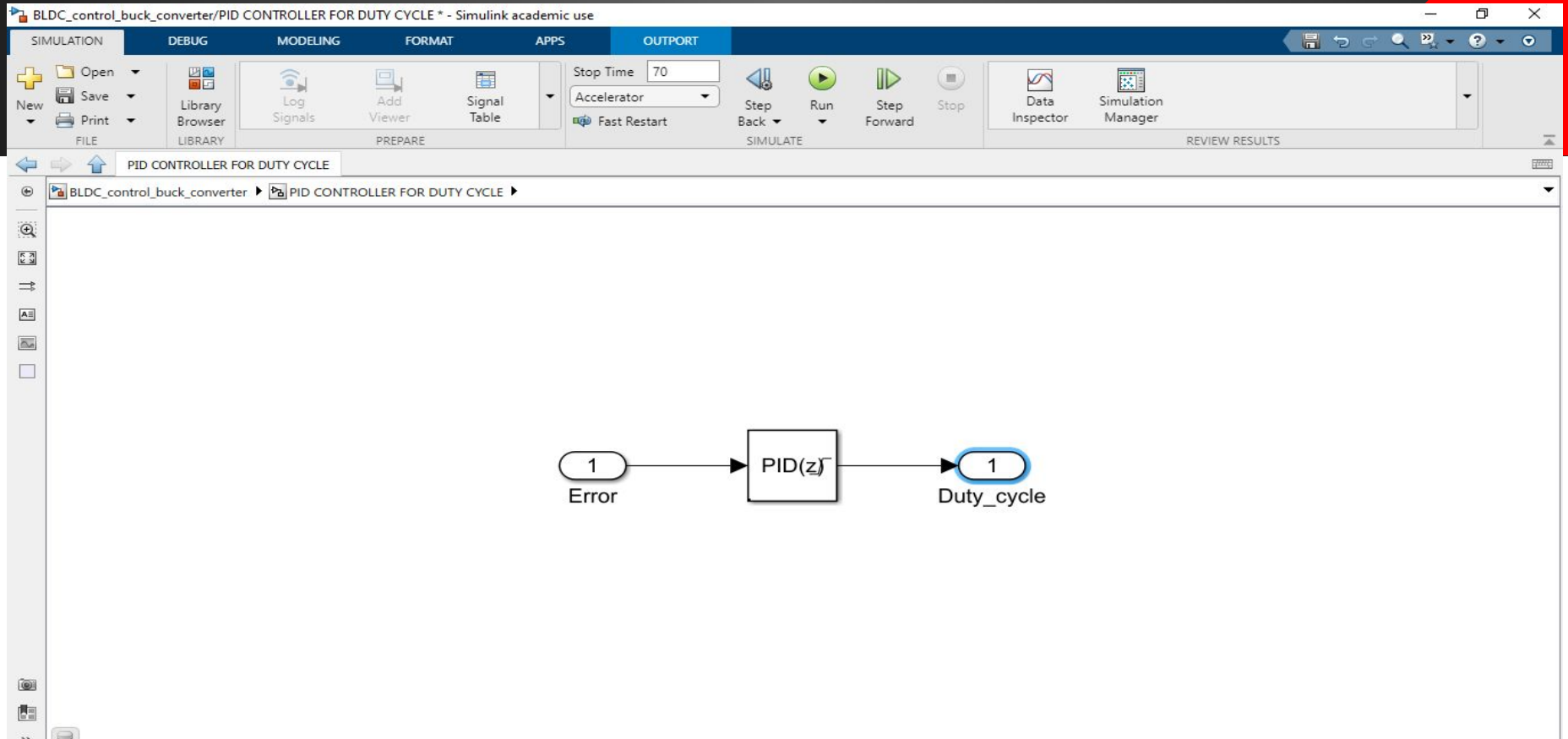



sector
1
AH AL BH BL CH CL
[1 0 0 0 0 1]
1
AH AL BH BL CH CL
[0 0 1 0 0 1]
2
AH AL BH BL CH CL
[0 1 1 0 0 0]
3
AH AL BH BL CH CL
[0 1 0 0 1 0]
4
AH AL BH BL CH CL
[0 0 0 1 1 0]
5
AH AL BH BL CH CL
[1 0 0 1 0 0]
*, 6
1
Switching pattern

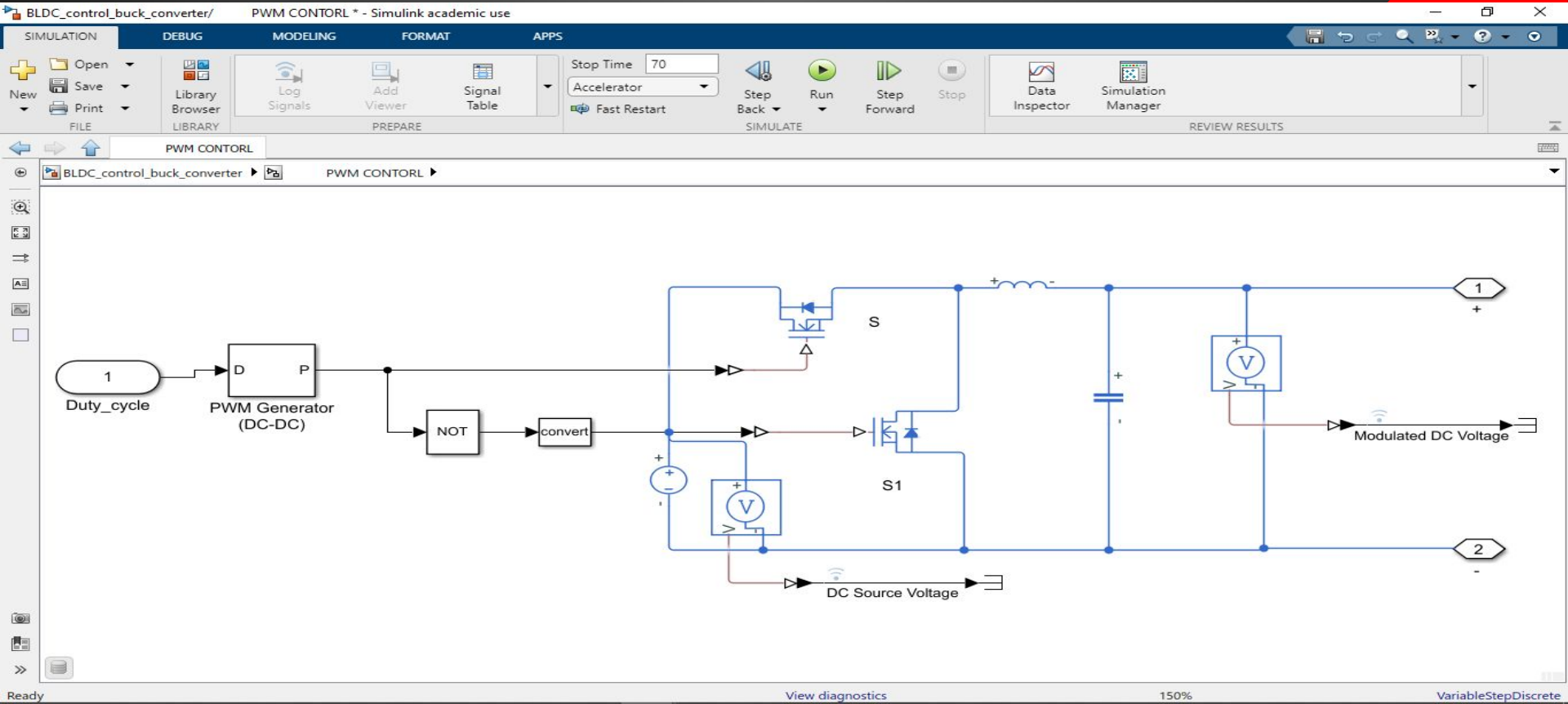
INVERTER CIRCUIT LOGIC



PID CONTROLLER FOR SETTING DUTY CYCLE



PWM CIRCUITRY (BUCK CONVERTER)



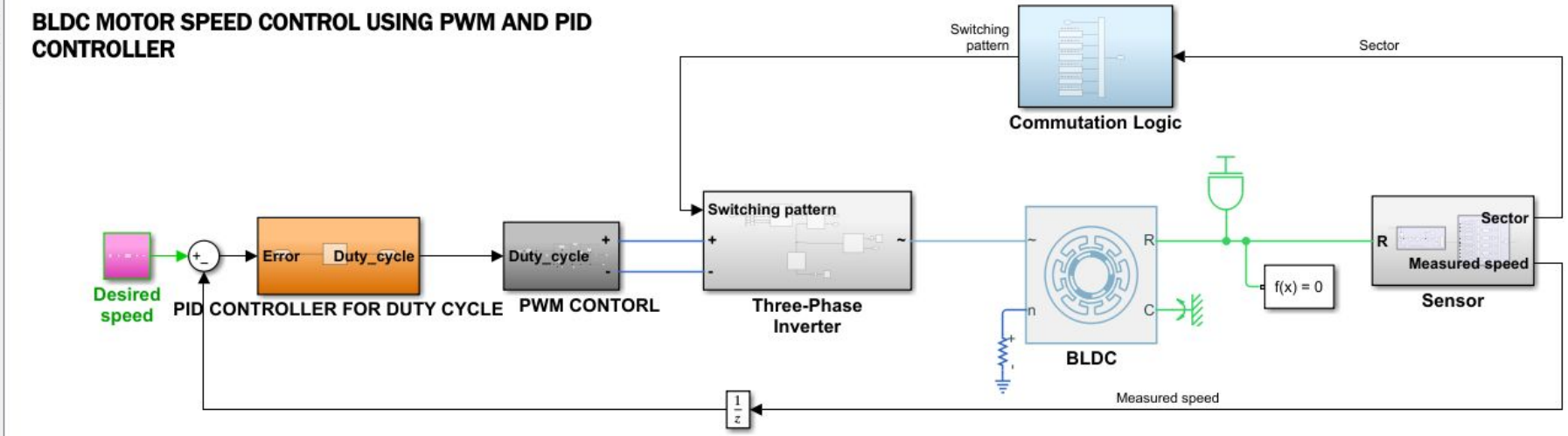
BLDC_control_buck_converter * - Simulink academic use

SIMULATION DEBUG MODELING FORMAT APPS

New Open Save Print FILE | Library Browser LIBRARY | Log Signals Add Viewer Signal Table PREPARE | Stop Time 70 Accelerator Fast Restart | Step Back Run Step Forward Stop SIMULATE | Data Inspector Simulation Manager REVIEW RESULTS

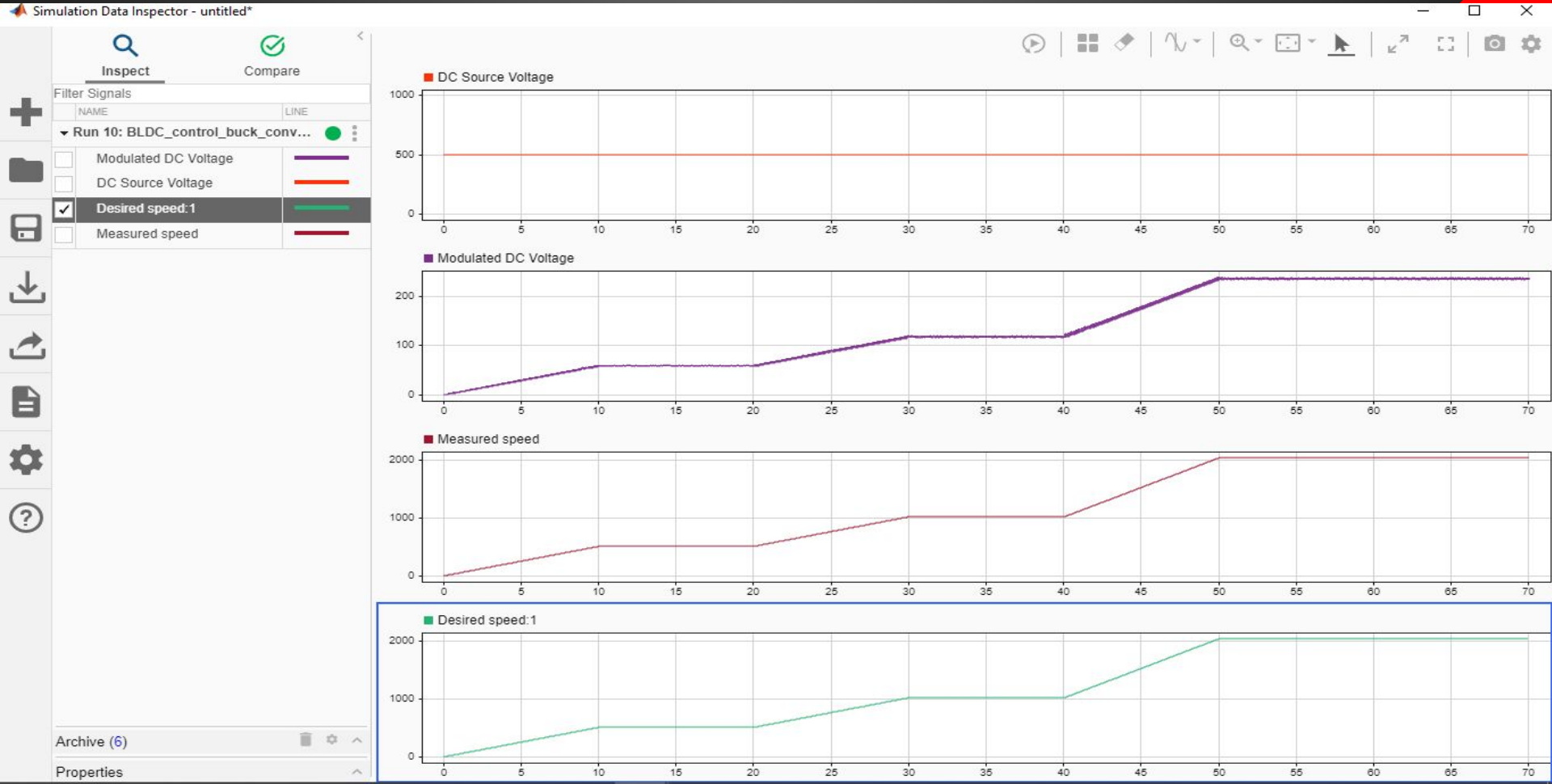
BLDC_control_buck_converter

BLDC_control_buck_converter



Ready View diagnostics 125% VariableStepDiscrete

RESULTS


Simulation Data Inspector - untitled*
Inspect
Compare
Filter Signals
NAME
LINE
Run 10: BLDC_control_buck_conv...
Modulated DC Voltage
DC Source Voltage
Desired speed:1
Measured speed
Archive (6)
Properties
DC Source Voltage
Modulated DC Voltage
Measured speed
Desired speed:1

REFERENCES

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3) Vinida, K. & Chacko, Mariamma. (2021). Implementation of speed control of sensorless brushless DC motor drive using H-infinity controller with optimized weight filters. International Journal of Power Electronics and Drive Systems (IJPEDS). 12. 1379. 10.11591/ijpeds.v12.i3.pp1379-1389.
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