SOLID STATE ELECTRIC MOTOR DRIVES
LAB MANUAL

Year	:	2019 - 2020
Course Code	:	AEE109
Regulations	:	IARE - R16
Semester	:	VI
Branch	:	EEE

INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad - 500 043

Department of Electrical and Electronics Engineering

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Department of Electrical and Electronics Engineering

VISION AND MISSION OF THE DEPARTMENT:

VISION:

The vision of the Electrical and Electronics Engineering department is to build a research identity in all related areas of Electrical Engineering uniquely. Through core research and education, the students will be prepared as the best professional Engineers in the field of Electrical Engineering to face the challenges in such disciplines.

MISSION:

The Electrical and Electronics Engineering Department supports the mission of the College through high quality teaching, research and services that provide students a supportive environment .The department will make the best effort to promote intellectual, ethical and technological environment to the students. The department invokes the desire and ability of life-long learning in the students for pursuing successful career in engineering.

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	Program Outcomes
PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design / development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader indiverse teams, and in multidisciplinary settings.
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

	Program Specific Outcomes
PSO1	**Professional Skills:** The ability to understand, analyze and develop computer programs in the areas related to algorithms, system software, multimedia, web design, big data analytics, and networking for efficient design of computer-based systems of varying complexity.
PSO2	**Problem-Solving Skills:** The ability to apply standard practices and strategies in software project development using open-ended programming environments to deliver a quality product for business success.
PSO3	**Successful Career and Entrepreneurship:** The ability to employ modern computer languages, environments, and platforms in creating innovative career paths to be an entrepreneur, and a zest for higher studies.

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ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

S. No	Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
Week - 1	Single phase rectifier fed DC shunt motor	PO3, PO4	-
Week - 2	Three phase rectifier fed DC separately excited motor	PO3, PO4	PSO2
Week - 3	Speed measurement & closed loop control of PMDC motor	PO2, PO4	-
Week - 4	Four quadrant chopper drive	PO1, PO3	-
Week - 5	AC voltage controller fed Induction motor	PO3, PO4	PSO2
Week - 6	DC Jones Chopper	PO1, PO2	-
Week - 7	Speed control of DC motor with external contacts and potentiometer arrangement	PO2, PO4	PSO2
Week - 8	Speed control of Synchronous motor with Variable Frequency Drive	PO2, PO4	-
Week - 9	Stepper motor speed control using digital simulation	PO3, PO4, PO5	PSO2
Week - 10	Universal motor speed control using digital simulation	PO3, PO4, PO5	PSO2
Week - 11	SVPWM control of Induction motor using digital simulation	PO3, PO5	-
Week - 12	Direct Torque Control of Induction motor drive using digital simulation	PO3, PO4, PO5	PSO2
Week - 13	Four quadrant operation of DC Motor using digital simulation	PO3, PO5	-
Week - 14	BLDC motor drive using digital simulation	PO3, PO4, PO5	PSO2

EXPERIMENT – 1

SINGLE PHASE RECTIFIER FED DC SHUNT MOTOR

1.1 AIM:

To control the speed of the DC motor using thyristorized converter unit

1.2 APPARATUS:

Thyristorized converter unit, CRO, patch cards, 1HP DC motor set etc.
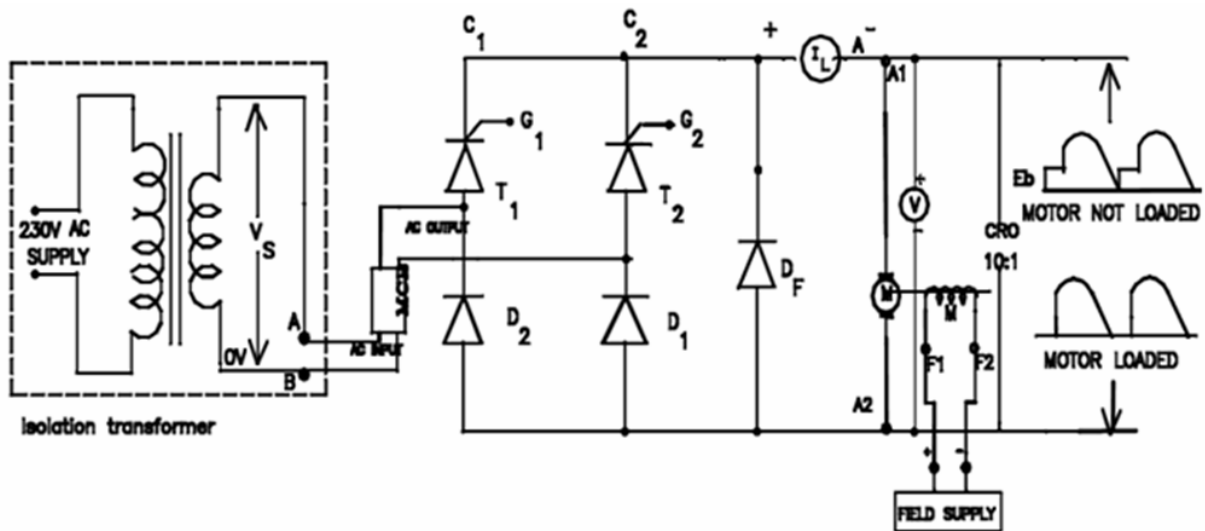
1.3 CIRCUIT DIAGRAM:

Fig 1.1 1HP DC Motor with Speed Measurement and Closed Loop Control

1.4 PROCEDURE

1. Connect DC motor field & armature terminals to respective points in the power circuit & speed sensor to feedback terminals socket. Connect the voltmeter & ammeter to the respective points.
2. Circuit connections are made as shown in the circuit diagram.
3. Check the connections and conform the connections made are correct before switching on mains supply.
4. Keeping all the knobs at minimum position.
5. Keeping PID switches ON (down ward) position.
6. Switch on the field supply to the motor.
7. Switch on the firing controller POWER supply switch.
8. Switch on the Power Circuit. Single phase auto transformer may be used set the voltage slowly or to avoid sudden surge of current.
9. Set the rpm to suitable value through the knob SET RPM (say 1000rpm).

10. Using P, I, D knobs adjust the running rpm to set rpm by varying P gain, I timing, D gain.
11. Load the motor up to 2A load. Note down the speed for different loads. Observe the current & voltage waveforms using CRO.
12. Slowly reduce the load, set rpm to minimum value, reduce autotransformer voltage, Switch off MCB, switch off the triggering circuit, switch off field supply & remove the connections.

   Note: While changing the set rpm vary the knob slowly.

1.5 TABULAR COLUMN:

S.No	Firing Angle	Speed
1.		
2.		
3.		
4.		

1.6 RESULT:

1.7 PRE LAB VIVA QUESTIONS:

1. What is the emf equation of dc motor?
2. How you measure the speed of dc motor?
3. What is the function of Thyristorised converter?
4. What is the function of PID controller?
5. What is mean by Isolation transformer?

1.8 POST LAB VIVA QUESTIONS:

1. What are the types of DC Motors?
2. What are the advantages of isolation transformer?
3. What are the applications of PID controller?

EXPERIMENT – 2

THREE PHASE RECTIFIER FED DC SEPARATELY EXCITED MOTOR

2.1 AIM:

To construct a three phase fully controlled full wave bridge rectifier and to control speed of the DC motor.

2.2 APPARATUS:

415V input 185V output or any suitable isolation transformer, controlled rectifier module, firing unit, DC shunt motor, patch cards etc.
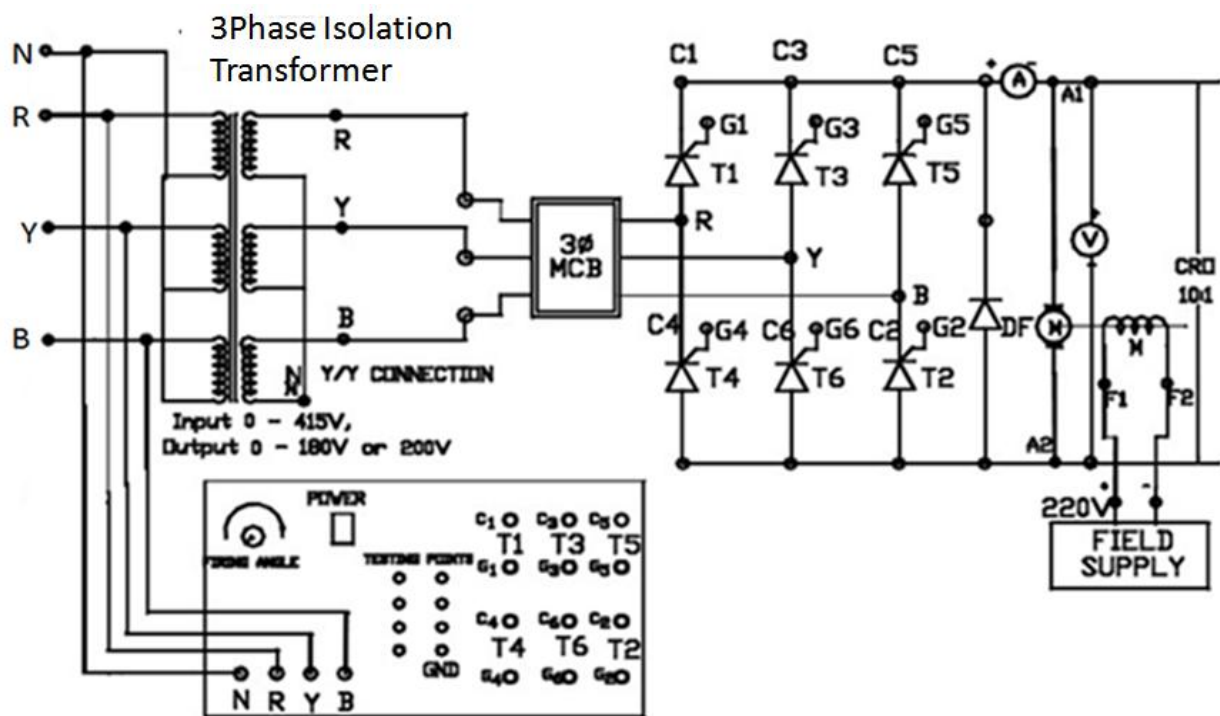
2.3 CIRCUIT DIAGRAM:

Fig - 2.1 Three Phase Input Thyristorised Drive for Dc Motor with Closed Loop Control

2.4 PROCEDURE:

1. Connect motor terminals (field & armature) to respective points in the power circuit & speed sensor to feedback terminals socket.
2. Circuit connections are made as shown in the circuit diagram using 3 phase auto transformer.
3. Connect 3 pin power cards from power unit (rectifier) to the mains supply.
4. Switch on the field supply of the motor.
5. Keeping PID switches at ON position, keep all knobs at minimum position now switch on the firing unit.

6. Switch on the three phase power input. Switch on the power circuit through MCB.

7. Adjust the gains of PID knobs.

8. Set the rpm through the knob slowly (say 800 rpm). Increase auto transformer voltage slowly.

9. Load the motor up to 3 Amp load. Note down the speed for different loads.

10. Release the load slowly. Bring the set rpm knob to minimum position slowly & all the knobs at minimum position. Reduce auto transformer voltage to zero.

11. Switch off power circuit by MCB, switch off firing circuit, switch off field supply & remove the connections.

2.5 TABULAR COLUMN:

Set RPM = 800 rpm(Say)

S.No.	Firing Angle	Speed
1.		
2.		
3.		
4.		
5.		
6.		

Note: Field supply must be switched on before applying voltage to armature.

2.6 RESULT:

2.7 PRE LAB VIVA QUESTIONS:

1. What is the difference between open loop and closed loop control?

2. What is mean by 3phase isolating transformer?

3. What are the types of transformers?

4. What is the difference between DC Motor and DC Generator?

5. What is mean by 3phase MCB?

2.8 POST LAB VIVA QUESTIONS:

1 What is the advantage of Thyristorised control unit?

2 What is advantage of 3phase isolating transformer?

3 What is the torque equation of DC Motor?

4 What is the difference between field and armature windings?

5 What is the differences between separately and self excited dc motors?

EXPERIMENT – 3

SPEED MEASUREMENT & CLOSED LOOP CONTROL OF PMDC MOTOR

3.1   AIM:

To Construct chopper drive circuit and to control the speed of the PMDC motor.

3.2   APPARATUS:

Chopper PMDC motor control module, DC power supply 30V / 1A, CRO, patch cards, etc.

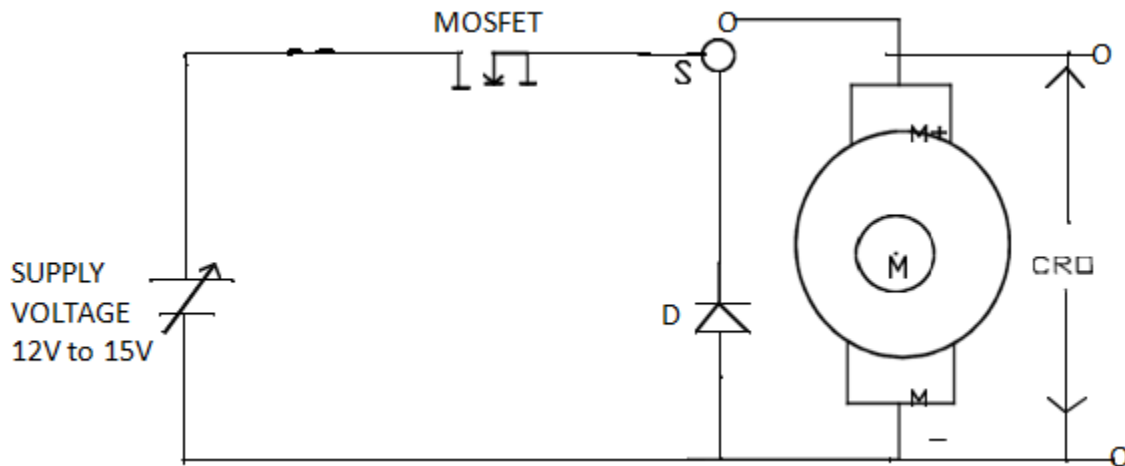**3.3   CIRCUIT DIAGRAM:**

**Fig – 3.1 Speed Measurement and Closed Loop Control of PMDC Motor
Using MOSFET / IGBT Chopper Drive**

3.4   PROCEDURE:

1. Connect motor terminals to respective points in the power circuit & speed sensor to feedback terminals socket. Connect the voltmeter & ammeter to the respective points.

2. Circuit connections are made as shown in the circuit diagram.

3. Check the connections and conform the connections made are correct before switching on mains supply & DC power supply.

4. Connect suitable DC regulated voltage using regulated power supply 30V/1A.

5. Keeping all the knobs at minimum position switch on the DC power supply adjust the DC voltage to say 12V.

6. Keeping PID switches ON (down ward) position.

7. Switch on the POWER supply switch.

8. Set the rpm to suitable value through the knob SET RPM (say 1000rpm).

9. Using P, I, D knobs adjust the running rpm to set rpm by varying P gain, I timing, D gain.

10. Load the motor up to 250 grams load in steps of 50 grams. Note down the speed for different

11. Loads. Observe the current & voltage waveforms using CRO.

12. Slowly reduce the DC voltage to zero switches off the unit, DC power supply & remove the connections.

Note: While changing the set rpm vary the knob slowly.

3.5   TABULAR COLUMN:

S. No	Load in grms	Running rpm
1		
2		
3		
4		

3.6   RESULT:

3.7   PRE LAB VIVA QUESTIONS:

1. What is the function of PMDC MOTOR?
2. What is the function of MOSFET and IGBT?
3. What are the advantages of CRO?
4. What are the characteristics of Diode?

3.8   POST LAB QUESTIONS:

1. What are the advantages of MOSFET and IGBT?
2. What is the function of PID controller?
3. What are the applications of PMDC Motor?

FOUR QUADRANT CHOPPER DRIVE

4.1   AIM:

To Construct closed loop chopper drive circuit and to control the speed of the dc motor

4.2   APPARATUS:

Four quadrant chopper unit, 12V DC motor with speed sensor, CRO, patch cards, etc.

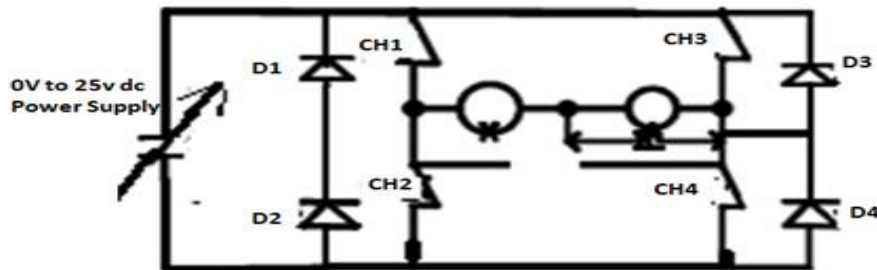**4.3   CIRCUIT DIAGRAM AND EXPECTED GRAPHS:**

Fig 4.1 Closed Loop Control of DC Motor Using Four Quadrant Chopper

4.4   PROCEDURE:

1. Connect motor terminals to respective points in the power circuit & speed sensor to feedback terminals socket. Connect the voltmeter & ammeter to the respective points.
2. Circuit connections are made as shown in the circuit diagram.
3. Connect suitable DC voltage using regulated 30V/1A power supply.
4. Check the connections and conform the connections made are correct before switching on   mains supply & DC power supply.
5. Keeping all the knobs at minimum position switch on the DC power supply adjust the DC voltage to say 12V.
6. Keeping PID switches ON position.
7. Keep the FM/RM switch to upward position for forward rotation.
8. Set the rpm to suitable value through the knob (with in 1000rpm).
9. Using P, I, D knobs adjust the running rpm to set rpm.
10. Load the motor up to 250 grms load in steps of 50 grams.. Note down the speed for different loads. Observe the current & voltage waveforms using CRO four chopper operations
11. Slowly reduce the DC voltage to zero. Change the FM/RM switch to downward position, do the above procedure for the reverse rotation.

Note: While changing the set rpm vary the knob slowly.

4.5   TABULAR COLUM

Forward Rotation:

During this mode chopper is operating in I quadrant (I & V are positive) however chopper is made to jump to IV quadrant momentarily. Therefore in forward motoring current is always positive but voltage may be positive or negative. In this way chopper operated in I and IV quadrants.

Set RPM=

S. No	Load in grms	Running rpm
1.		
2.		
3.		
4.		
5.		

4.6   REVERSE ROTATION:

During this mode chopper is operating in III quadrant (I & V are negative) however chopper is made to jump to II quadrant momentarily. Therefore in reverse motoring current is always negative but voltage may be positive or negative. In this way chopper operated in III and II quadrants.

Set RPM=

S. No	Load in grms	Running rpm
1.		
2.		
3.		
4.		

4.7   RESULT:

4.8   PRE LAB VIVA QUESTIONS:

1. What are choppers?
2. What does a chopper consist of?
3. On what basis choppers are classified in quadrant configurations?
4. What is different control strategies found in choppers?
5. Explain the principle of operation of a chopper?

4.9 POST LAB VIVA QUESTIONS:

1. Define duty cycle.
2. How can ripple current be controlled?
3. What is step up chopper?
4. On what does the commutating capacitor value depend on?
5. What are the disadvantages of choppers?
6. How do they have high efficiency?

EXPERIMENT – 5

AC VOLTAGE CONTROLLER FED INDUCTION MOTOR

5.1   AIM:

To construct a single phase AC voltage controller fed induction motor and to study its performance

5.2   APPARATUS:

Input: 230V, Output: 115V-0-115V output isolation transformer, AC Voltage controller power circuit with firing circuit, loading rheostat 100 Ohm/2A, Motor –1/2HP AC induction motor, CRO, patch cards etc.
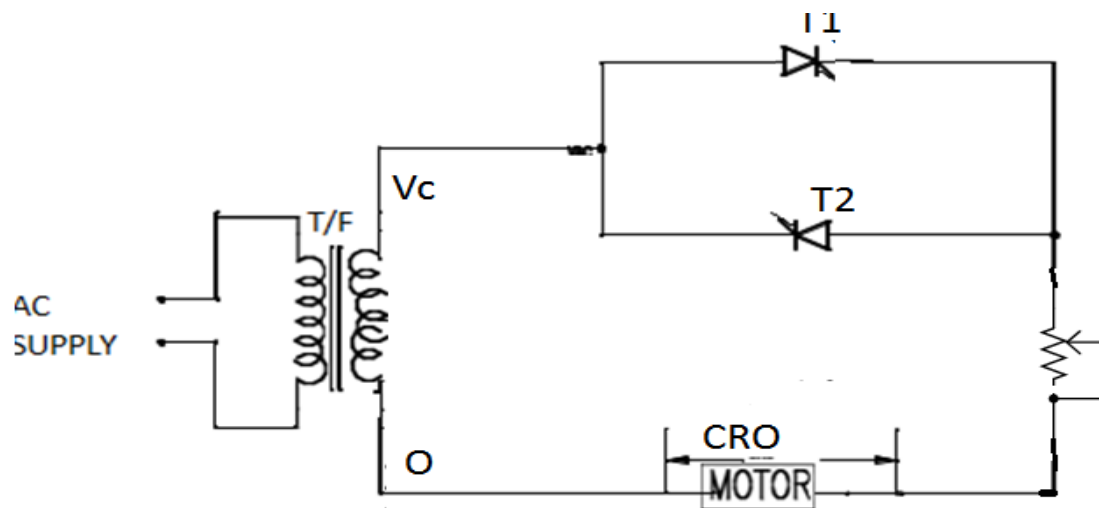
5.3   CIRCUIT DIAGRAM:

Fig 5.1 Single Phase Cycloconverter

5.4   PROCEDURE:

1. The connections are made as shown in the circuit of single phase AC Voltage controller with motor load with divided by 1 frequency using suitable isolation transformer.

2. The gate cathode terminals of the Thyristorised are connected to the respective points on the firing circuit.

3. Check all the connections and confirm connections made are correct before switching on the equipments.

4. Switch ON power supply & triggering circuit.

5. The output wave forms are seen on a CRO.

6. The firing angle is varied and AC output voltage across the load and rpm are noted.

7. Repeat the above procedure for divided by two frequencies.

5.5 TABULAR COLUMN:

S.No.	Firing Angle	Speed
1.		
2.		
3.		
4.		
5.		
6.		

5.6 RESULT:

5.7 PRE LAB VIVA QUESTIONS:

1. What is meant by AC Voltage controller? What are the types of AC Voltage controller?
2. Classify AC Voltage controllers.
3. Draw the circuit diagram of three phase AC Voltage controller
4. Draw the circuit diagram of single phase bridge AC Voltage controller

5.8 POST LAB VIVA QUESTIONS:

1. What are the Applications of AC Voltage controllers?
2. What is meant by Positive & negative converter groups in AC Voltage controller
3. List the advantages & disadvantages of AC Voltage controllers.
4. What are the factors affecting the harmonics in AC Voltage controller?

DC JONE'S CHOPPER

6.1   AIM:

To study the characteristics of DC Jone's Chopper.

6.2   APPARATUS:

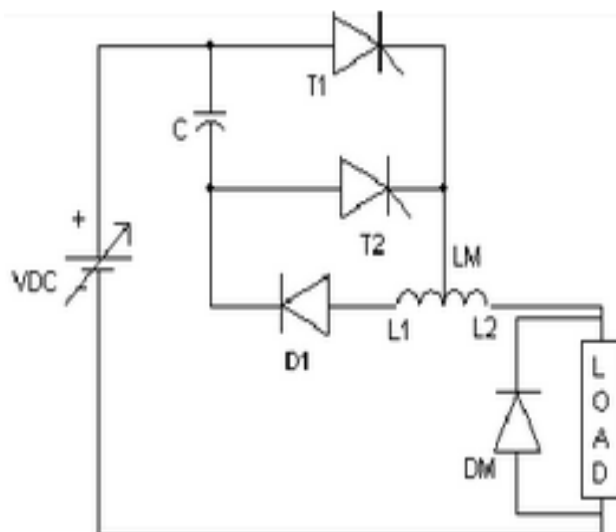| S. No	Equipment	Range	Type	Quantity
1	DC chopper power module			
2	Triggering circuit (DC chopper)			
3	Rheostat			
4	Digital multimeter			
5	CRO			
6	Patch Cards			

6.3   CIRCUIT DIAGRAM:

Fig - 6.1 Circuit Diagram of Jones Chopper

T1, T2 – TYN 616

D1 – BYQ 28200

C – Commutation Capacitor 10µF / 100V

L1- 0 –L2 - Commutation Inductor 500-0-500µH / 2A

6.4 PROCEDURE:

a) For R – Load :

1. Connections are made as shown in the figure. Use 50Ω Rheostat for R - Load (Freewheeling diode (DM) is to be connected only for RL load).
2. Adjust V_{RPS} output to 10v and connect to DC chopper module.
3. Switch on DC toggle switch of chopper module.
4. Switch on the trigger input by pushing- in pulse switch.
5. Observe the output waveform across load on CRO.
6. Keep the duty cycle at mid position and vary the frequency from minimum to maximum and record the output voltage readings.
7. Note down the output waveform for mid value of frequency and duty cycle.

b) R - L Load :

1. Connections are made as shown in fig. Load is 50Ω Rheostat in series with inductor L =25mH or 50mH.
2. Follow the same procedure as listed in steps 2 to 8 above.3. Readings and output waveform is to be recorded with and without freewheeling diode. [NOTE: In both switching on / switching off of the equipment. First use DC toggle switch and then the pulsar].

6.5 TABULAR COLUMN:

Constant Duty Cycle

Duty Cycle: 50%, V_{IN}=10 to 15 V

S. No	Frequency(Hz)	V0(Volts)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Constant Frequency, Frequency Control

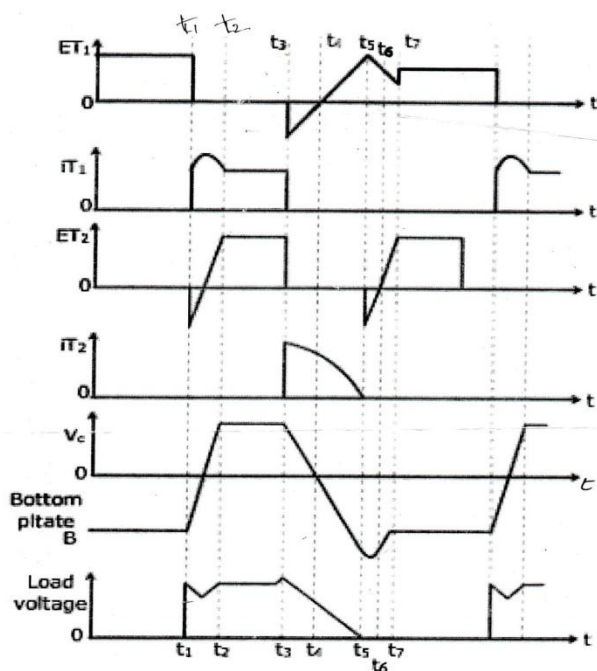| S. No	T_{ON}(sec)	T_{OFF}(sec)	Duty Cycle (%)	V_O (Volts)
1				
2				
3				
4				
5				
6				
7				
8				
9				

6.6   MODEL GRAPH:

Fig – 6.2 Output Characteristics of DC Jones Chopper

6.7   RESULT:

6.8. PRE LAB VIVA QUESTIONS:

1. What are choppers?
2. What does a chopper consist of?
3. On what basis choppers are classified in quadrant configurations?

6.9 POST LAB VIVA QUESTIONS:

1. Define duty cycle.
2. How can ripple current be controlled?
3. What is step up chopper?
4. On what does the commutating capacitor value depend on?
5. What are the disadvantages of choppers?
6. How do they have high efficiency?
7. What are the applications of dc choppers?

SPEED CONTROL OF DC MOTOR WITH EXTERNAL CONTACTS AND POTENTIOMETER ARRANGEMENT

7.1   AIM:

To control the speed of DC motor with external contacts and potentiometer arrangement

7.2   APPARATUS:

External contacts and potentiometer kit, DC Motor, Voltmeter (0-500V), Ammeter (0-5A), Tachometer
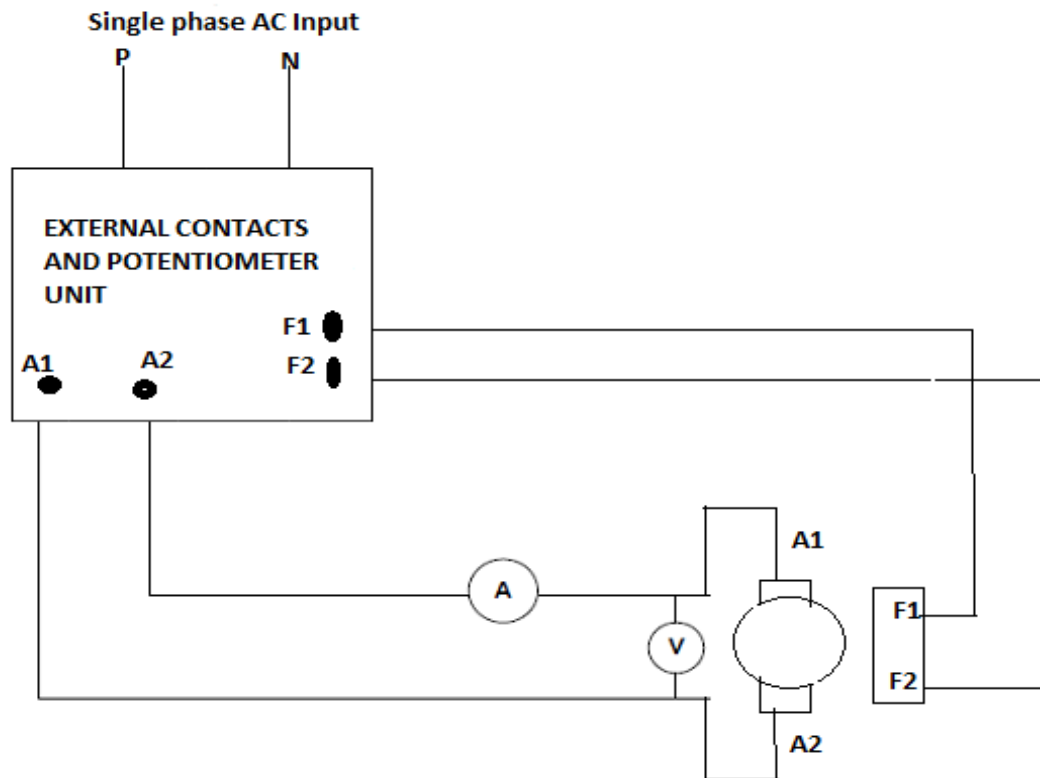
7.3   CIRCUIT DIAGRAM:

Fig – 7.1 Circuit Diagram of DC Motor with external contacts and potentiometer

7.4   PROCEDURE:

1. Connect the circuit as per the circuit diagram

2. Switch ON supply for field and armature

3. Vary the potentiometer in steps note down the readings of voltmeter, ammeter and speed

7.5   TABULAR COLUMN:

S. No	Voltage	Current	Speed

7.6   RESULT:

7.7   PRE LAB VIVA QUESTIONS:

1. What is the importance of potentiometer control in DC motor?
2. What are the applications of DC motor speed control

7.8   POSTLAB VIVA QUESTIONS:

1. What are the advantages of DC drives?
2. What are the limitations of potentiometer control?

EXPERIMENT – 8

SPEED CONTROL OF SYNCHRONOUS MOTOR WITH VARIABLE FREQUENCY DRIVE

8.1   **AIM:**

To control the speed of synchronous motor with Variable Frequency Drive.

8.2   **APPARATUS:**

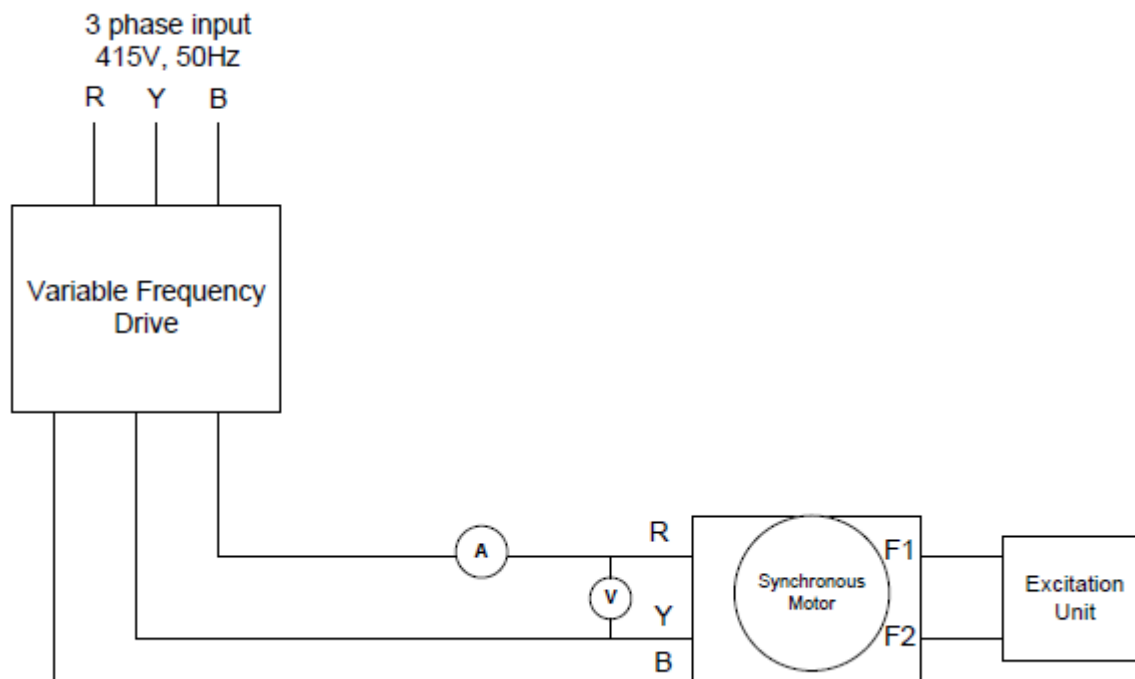Variable Frequency Drive, Synchronous Motor, Voltmeter (0-500V), Ammeter (0-5A), Tachometer

8.3   **CIRCUIT DIAGRAM:**

Fig – 8.1 Circuit diagram of synchronous motor with Variable Frequency Drive

8.4   **PROCEDURE:**

1. Connect the circuit as per the circuit diagram

2. Switch ON VFD and keep the program in forward mode

3. Switch on Excitation Unit

4. Vary the voltage/frequency in steps note down the readings of voltmeter, ammeter and speed

5. Switch OFF the VFD

6. Switch ON VFD and keep the program in reverse mode

7. Switch on Excitation Unit

8. Vary the voltage/frequency in steps note down the readings of voltmeter, ammeter and speed

8.5 **TABULAR COLUMN:**

Forward Mode:

S. No	Voltage	Current	Speed

Reverse Mode:

S. No	Voltage	Current	Speed

8.6 **RESULT:**

8.7 **PRE LAB VIVA QUESTIONS:**

1. What is the importance of V/F control in synchronous motor?

8.8 **POSTLAB VIVA QUESTIONS**

1. What are the advantages of synchronous motor drive?
2. What are the limitations of V/F control?
3. What are the drawbacks of VFD?

EXPERIMENT – 9

STEPPER MOTOR SPEED CONTROL USING DIGITAL SIMULATION

9.1   AIM:

To control the speed of Stepper motor speed control using digital simulation

9.2   APPARATUS:

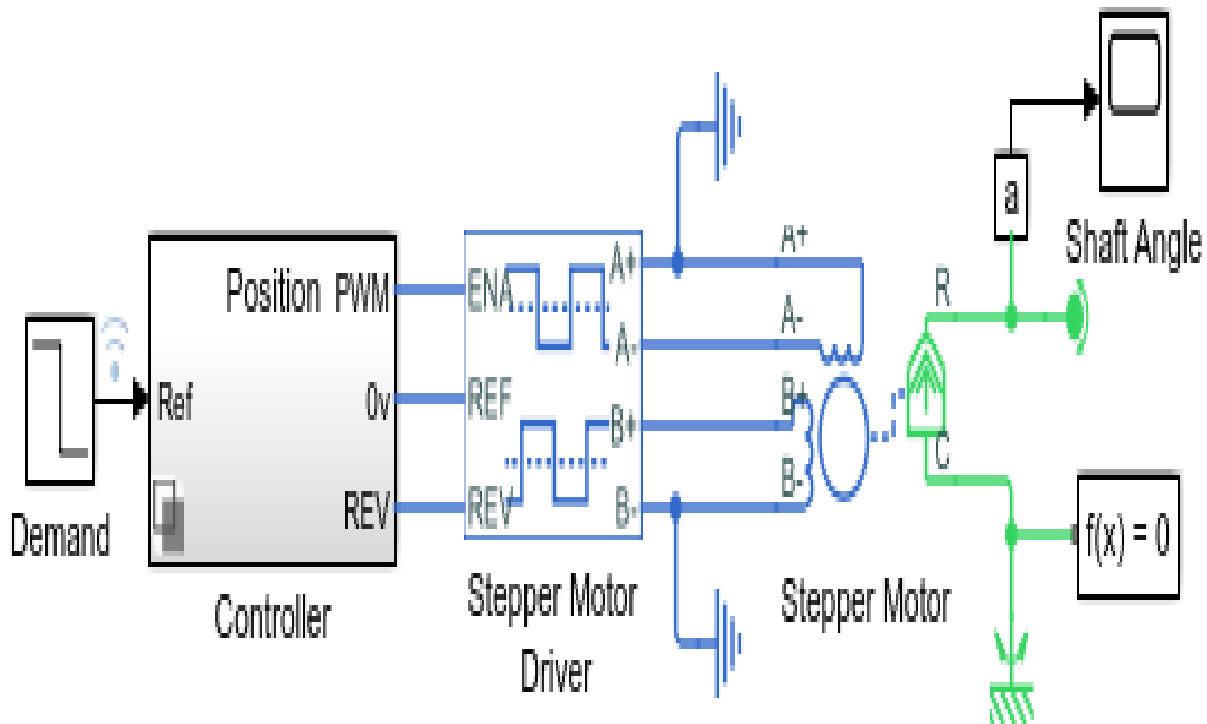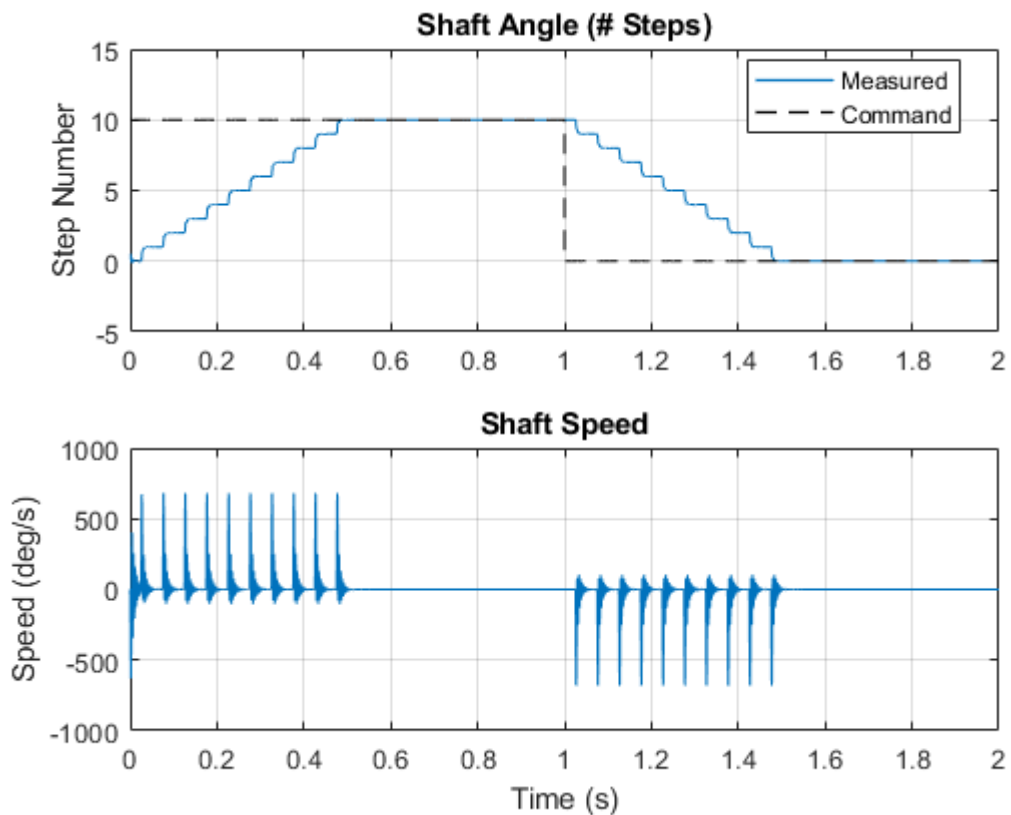| S. No	Equipment	Quantity
1	Desktop with MATLAB	1

9.3   CIRCUIT DIAGRAM:

Fig – 9.1 Circuit Diagram of Stepper motor speed control

9.4   PROCEDURE:

1   Make the connections as shown in the figure by using MATLAB Simulink.
2   Set the parameters in firing circuits for switching operations, set the values for load and input voltage.
3   Check the scope wave forms in each circuit.

9.5   **EXPECTED GRAPH:**

9.6   **RESULT:**

9.7   **PRE LAB VIVA QUESTIONS:**

1. What are the advantages of stepper motor?
2. List the applications of stepper motor

9.8   **POSTLAB VIVA QUESTIONS**

1. What are the limitations of stepper motor speed control?
2. What are the drawbacks of stepper motors?

EXPERIMENT – 10

UNIVERSAL MOTOR SPEED CONTROL USING DIGITAL SIMULATION

10.1 AIM:

To control the speed of Universal motor speed control using digital simulation

10.2 APPARATUS:

S. No	Equipment	Quantity
1	Desktop with MATLAB	1

10.3 CIRCUIT DIAGRAM:
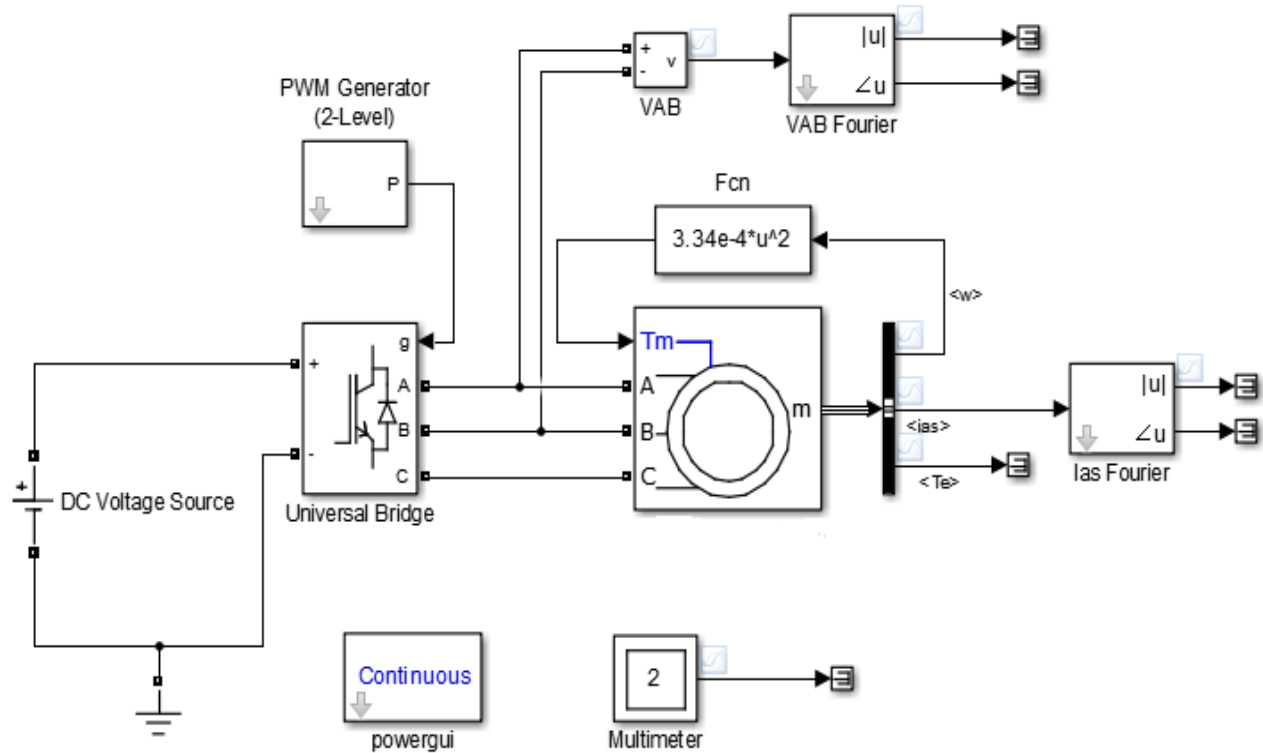
Fig – 10.1 Circuit Diagram of Universal motor speed control

10.4 PROCEDURE:

1. Make the connections as shown in the figure by using MATLAB Simulink.
2. Set the parameters in firing circuits for switching operations, set the values for load and input voltage.
3. Check the scope wave forms in each circuit.

10.5   EXPECTED GRAPH
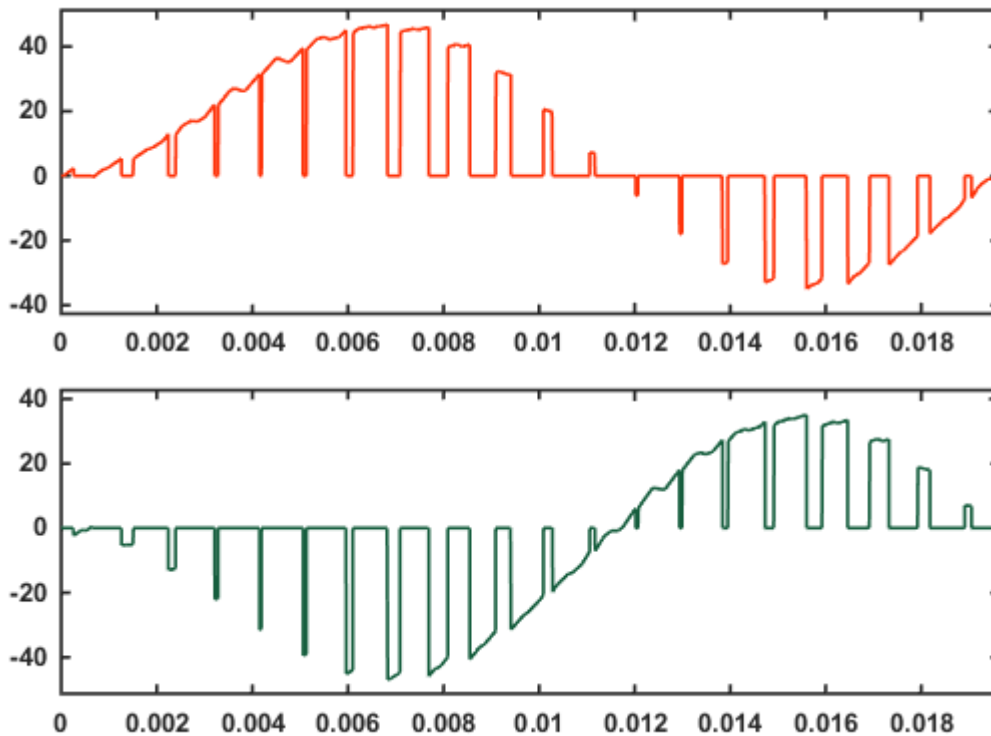
10.6   RESULT:

10.7   PRE LAB VIVA QUESTIONS:

1. What are the advantages of universal motor?
2. List the applications of universal motor

10.8   POSTLAB VIVA QUESTIONS:

1. What are the limitations of universal motor speed control?
2. What are the drawbacks of universal motors?

EXPERIMENT – 11

SVPWM CONTROL OF INDUCTION MOTOR USING DIGITAL SIMULATION

11.1   AIM:

To control the speed of induction motor with SVPWM technique using digital simulation

11.2   APPARATUS:

S. No	Equipment	Quantity
1	Desktop With MATLAB	1

11.3   CIRCUIT DIAGRAM:
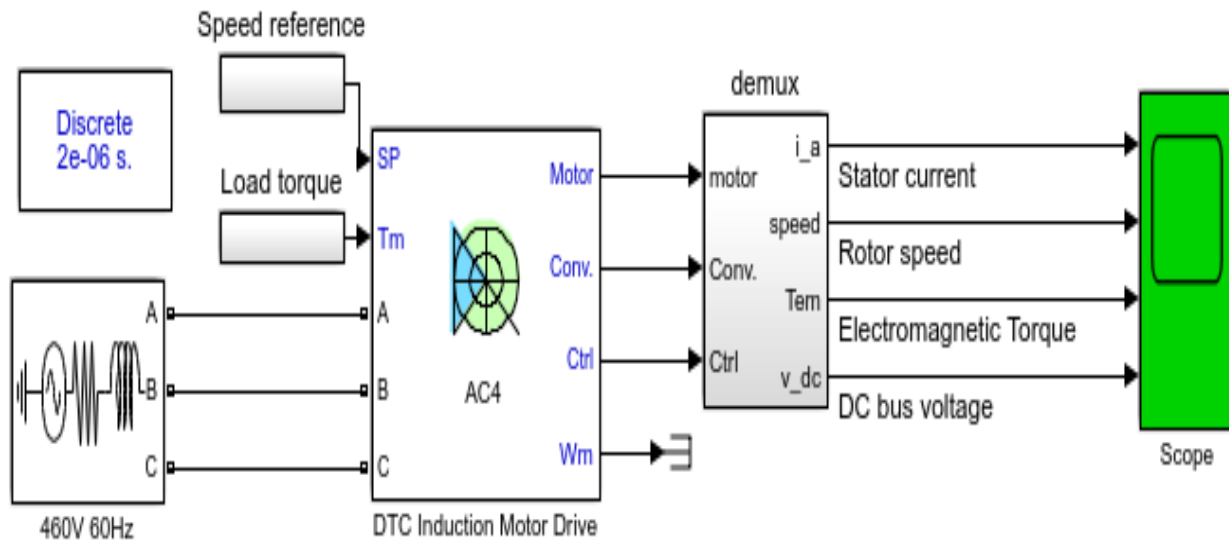
Fig – 11.1 Circuit Diagram of speed control of induction motor using SVPWM inverter

11.4   PROCEDURE:

1. Make the connections as shown in the figure by using MATLAB Simulink.

2. Set the parameters in firing circuits for switching operations, set the values for load and input voltage.

3. Check the scope wave forms in each circuit.

11.5   EXPECTED GRAPH:
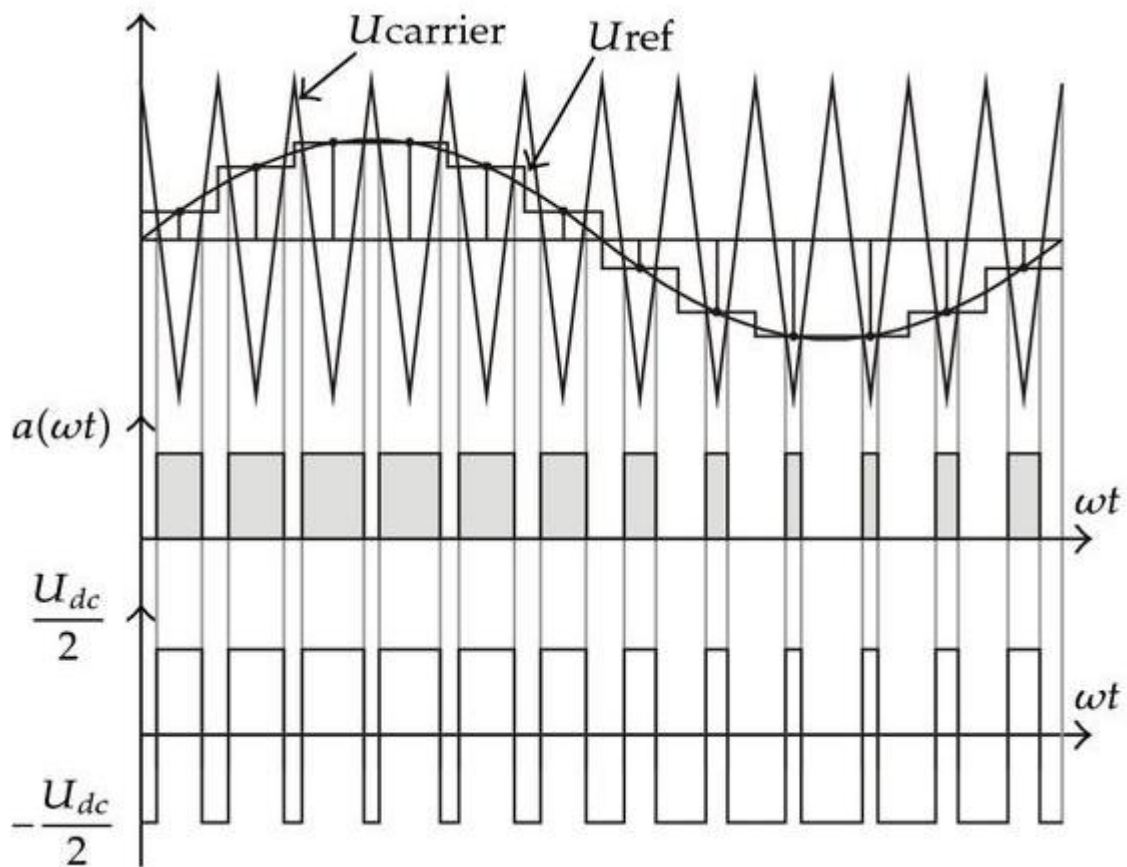
11.6   RESULT:

11.7   PRE LAB VIVA QUESTIONS:

1. Compare SVPWM and PWM techniques.
2. What is SVPWM?

11.8   POSTLAB VIVA QUESTIONS:

1. What are the advantages of SVPWM technique?
2. What are the limitations of PWM techniques?
3. What are the drawbacks of SVPWM inverters?

DIRECT TORQUE CONTROL OF INDUCTION MOTOR DRIVE USING DIGITAL SIMULATION

12.1 AIM:

To control the speed of induction motor with direct torque control using digital simulation

12.2 APPARATUS:

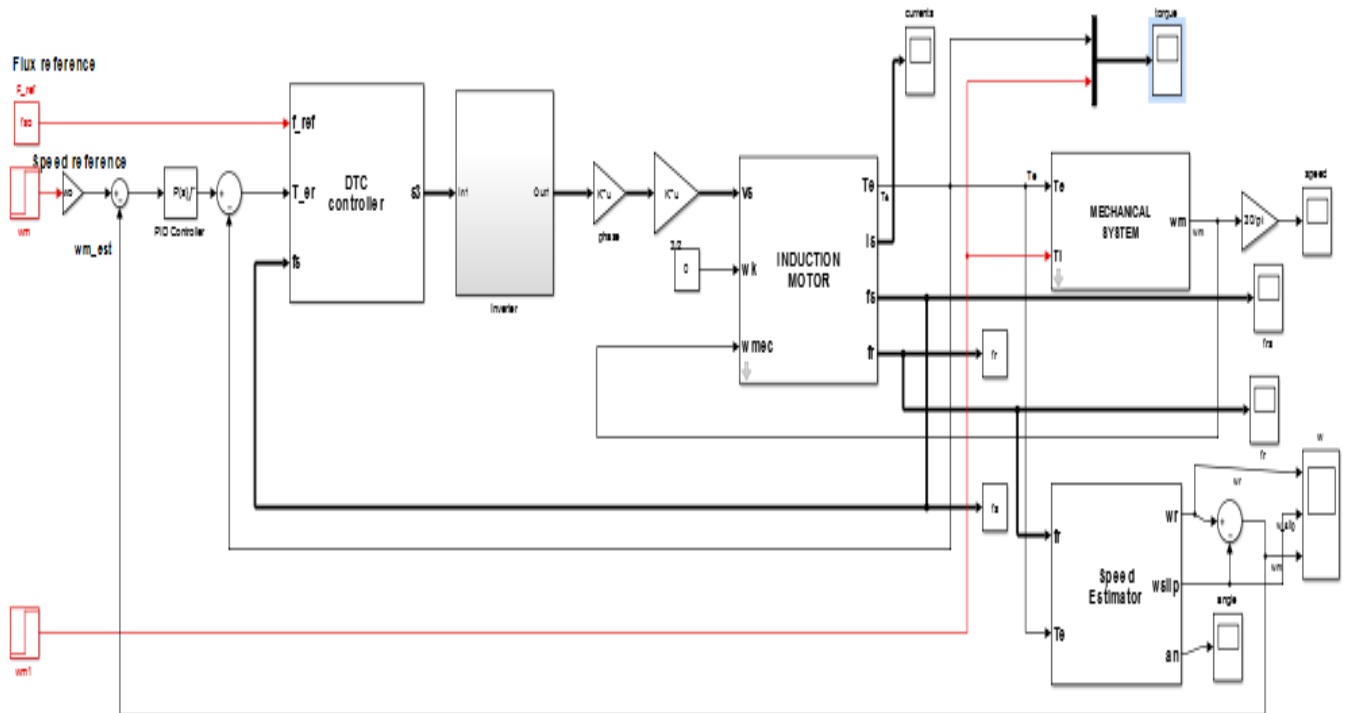| S. No	Equipment	Quantity
1	Desktop With MATLAB	1

12.3 CIRCUIT DIAGRAM:

Fig – 12.1 Circuit Diagram of speed control of induction motor with direct torque control

12.4 PROCEDURE:

1. Make the connections as shown in the figure by using MATLAB Simulink.
2. Set the parameters in firing circuits for switching operations, set the values for load and input voltage.
3. Check the scope wave forms in each circuit.

12.5   RESULT:

12.6   PRE LAB VIVA QUESTIONS:

1. What are the applications of induction motor drive?

12.7   POSTLAB VIVA QUESTIONS:

1. What are the advantages of direct torque control of induction motor?
2. What are the limitations of direct torque control?
3. Compare direct torque control and indirect torque control in induction motor?

<h1 style="text-align:center">EXPERIMENT – 13</h1>

<h2 style="text-align:center">FOUR QUADRANT OPERATION OF DC MOTOR USING DIGITAL SIMULATION</h2>

13.1   AIM:

To control the speed of DC motor in four quadrants with three phase dual converter using digital simulation

13.2   APPARATUS:

| S. No	Equipment	Quantity
1	Desktop With MATLAB	1

13.3   CIRCUIT DIAGRAM:
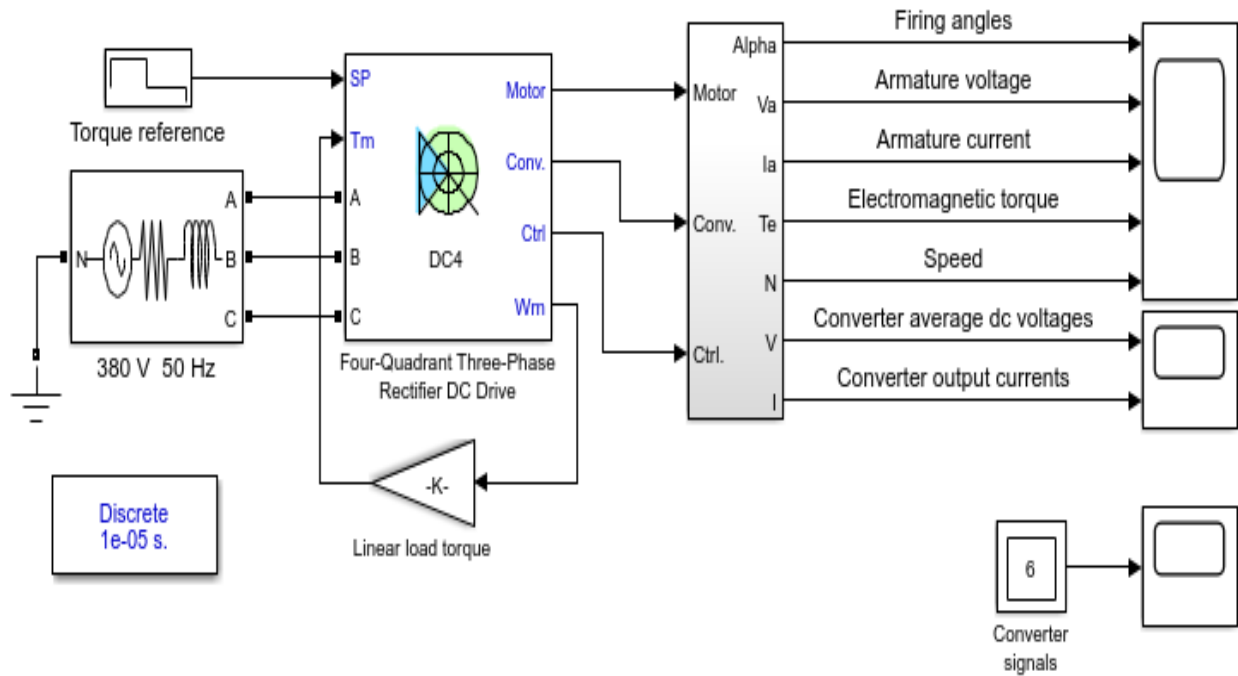
Fig – 13.1 Circuit Diagram of Four quadrant operations of DC motor

13.4   PROCEDURE:

1. Make the connections as shown in the figure by using MATLAB Simulink.

2. Set the parameters in firing circuits for switching operations, set the values for load and input voltage.

3. Check the scope wave forms in each circuit.

13.5   EXPECTED GRAPH:
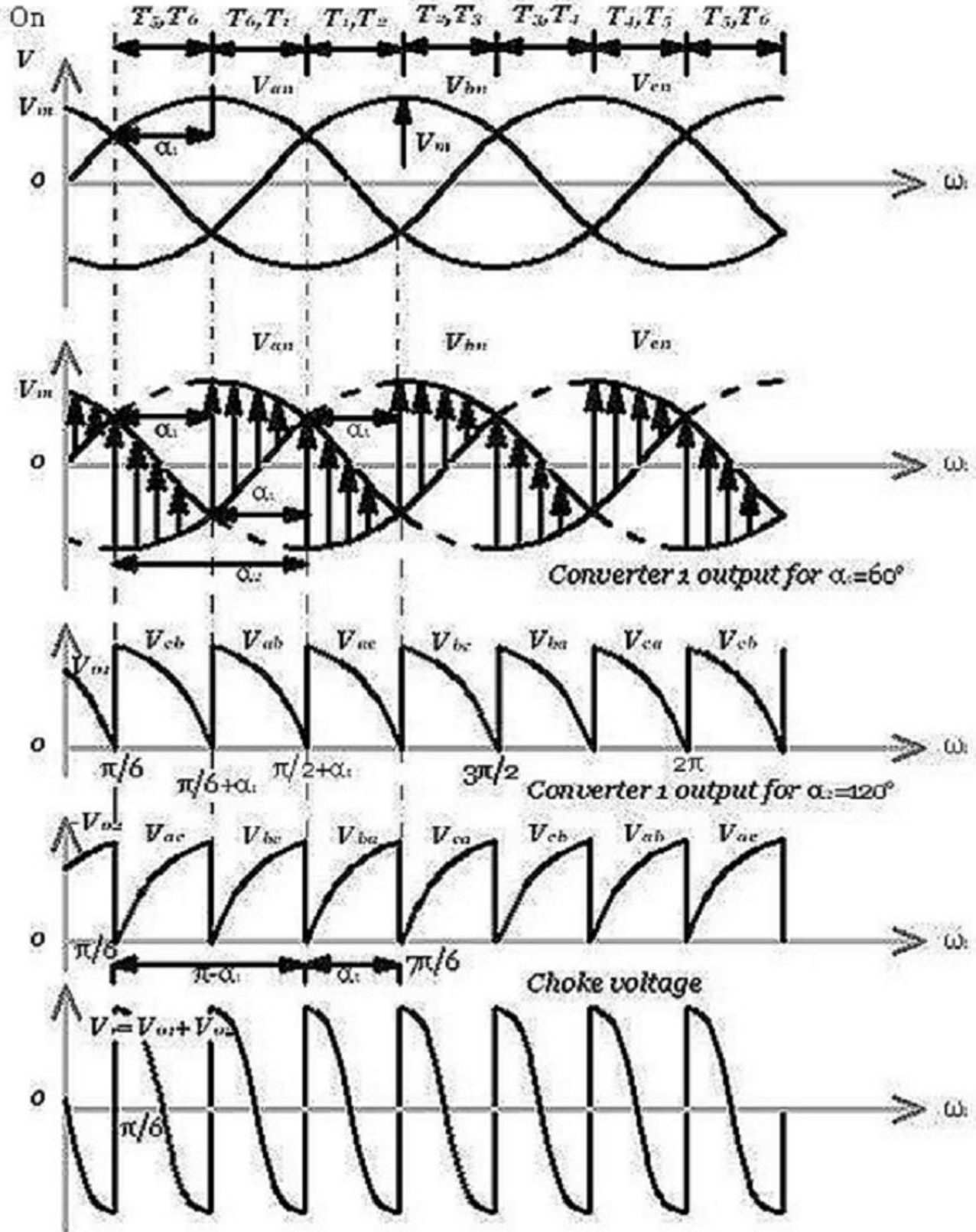
13.6   RESULT:

13.7   PRE LAB VIVA QUESTIONS:

1. Define dual converter.
2. What is the relation for firing angles in dual converters?
3. What is simultaneous control of dual converters?
4. What is non simultaneous control of dual converters?

13.8   POSTLAB VIVA QUESTIONS:

1. What are the advantages of Dual converters?
2. Define circulating current.

EXPERIMENT – 14

BLDC MOTOR DRIVE USING DIGITAL SIMULATION

14.1 AIM:

To control the speed of brushless DC motor using digital simulation

14.2 APPARATUS:

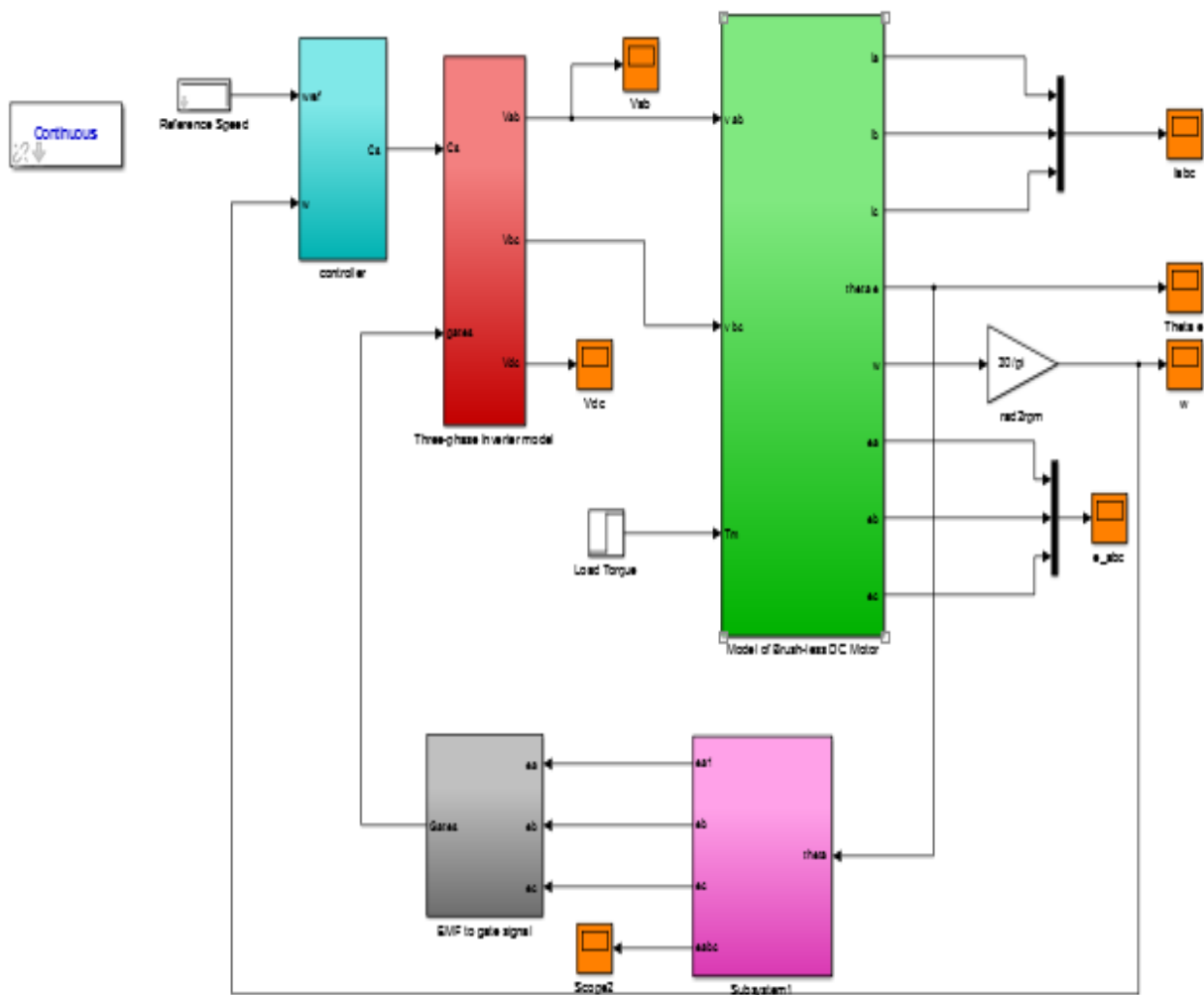| S. No	Equipment	Quantity
1	Desktop With MATLAB	1

14.3 CIRCUIT DIAGRAM:

Fig – 14.1 Circuit Diagram of speed control of BLDC motor

14.4 PROCEDURE:

1. Make the connections as shown in the figure by using MATLAB Simulink.
2. Set the parameters in firing circuits for switching operations, set the values for load and input voltage.
3. Check the scope wave forms in each circuit.
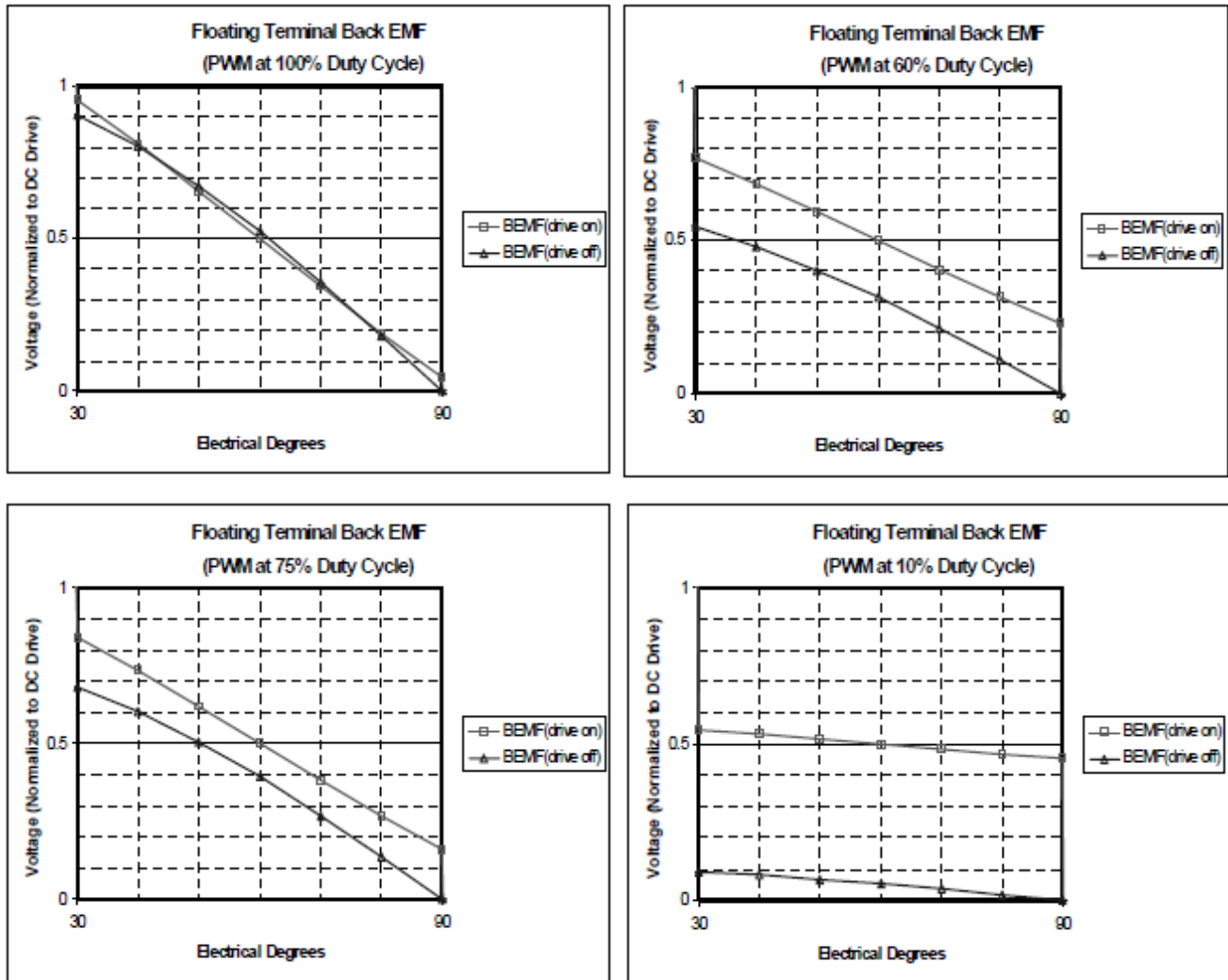
14.5 EXPECTED GRAPH:

Fig – 14.2 Expected Graph

14.6 RESULT:

14.7   PRE LAB VIVA QUESTIONS:

1. What are the advantages of BLDC motor?
2. List the applications of BLDC motor.

14.8   POSTLAB VIVA QUESTIONS:

1. What are the limitations of BLDC motor speed control?
2. What are the drawbacks of BLDC motors?