EXPERIMENT NO.9

OBJECT: To perform the 4-quadrant operation using IGBT based chopper capable of driving a 0.5-hp dc motor.

APPARATUS REQUIRED:

1. 4 - QUAD chopper DC drive (POWERCON make)
2. CRO DUAL TRACE. (Unearthed C.R.O.)
3. DMM
4. 40 W– Dummy load
5. 40 W to 200W – Source receptive Lamp
6. 40 to 200 W – DBR Lamp.

THEORY:

INTRODUCTION:

When variable Dc voltage is to be obtained from fixed DC voltage, DC chopper is ideal choice. Use chopper in traction systems is now accepted all over the world. A chopper is inserted in between fixed voltage DC source and the DC motor armature for its speed control below base speed. Chopper drive enables regenerative braking of dc motor and thus K. E. Of the system can be returned to the DC source. These results in overall energy saving which is must welcome feature bin transportation systems suffering heavy slopes and frequent stops. Chopper drive plays important in battery operated vehicles where energy saving is of prime importance.

Choppers can be used for regenerative braking, dynamic braking, combined regenerative and dynamic control of dc drive.

FOUR QUADRANT CHOPPER:

Four quadrant choppers signify that with this configuration we can observe all the four quadrant of V_0-I_0 diagram.

Out of four quadrants two quadrants [I & II] are observed in four quad motion of motor i.e. forward motoring and forward generating remaining two quadrant [III & IV] are observe in reverse direction of motion i.e. reverse motoring and reverse generating.

Thus at a time we can have two quadrant

Part 1 : **forward motion**

First and **second** quadrant

Part 2 : **reverse motion**

Third and **fourth** quadrant

Part 1 :During forward motion

1. Forward MOTORING:-

when switches are ON $+V_0$ is across armature and motors run in forward direction. Speed of motor is control by using POT. Thus output load voltage $+V_0$ and load current $+I_0$ shows working of motor in first quadrant as forward mo0toring.

2. Forward. GENERATING:-

Motor is running in forward motoring in first quadrant now when input supply to armature cut OFF, then also motor maintain its forward motion because of its K.E. this K.E. is enhancing or aiding by external energy source motor [M2]

This operation of motion of rotor in presence of filed produces voltage at the armature terminal with same polarity as in the case of motoring maintaining the V_0 voltage polarity same, thus current flow in opposite direction through power circuit. this $+V_0$ and $-I_0$ shows second Quadrant operation of motor which is forward Generating.

The $-I_0$ is flowing in opposite direction and generated power is consumed in receptive source.

Part 2 : During reverse motion:-

1. Reverse motoring:

Reverse motoring : concerning with third and forth quadrant for this configuration we are using only CH2 and CH 3 and CH1 & CH4 are made OFF throughout this operation CH2 and CH3 are operating simultaneously . when controlled supply through CH2 and CH4 are given to armature of motor i.e. $-V_0$ then motor runs in reverse direction constituting $-I_0$ this $-V_0$ and $-I_0$ forms the III quadrant and motor works as reverse motoring speed of motor in controlled by charging the duty cycle of switches with pot.

2. REVERSE GENERATING :

Current motor is in reverse motoring now at this stage if power to armature is cut off i.e. $V_0 = 0$ then also motor continuous its motion in reverse direction because of its K.E. this K.E. is chancing or aiding by external energy source. This reverse motion of rotor [armature] in presence of magnetic field constitute a voltage with same polarity as in reverse motoring i.e. -A and +AA and motor act as generator.

Thus keeping the output $-V_0$ same and flowing current in opposite direction i.e. $+I_0$ it works in fourth quadrant showing reverse generating operation.

The circuit operates on +5 V and -5 V supply which are generated by using IC1 & IC2 . The negative full wave signal is taken from diode d5 & dc level is added in this signal This signal is inverted & amplified by using IC3 which is given to pin '3' of IC5 through diode d10. The soft start is generated using capacitor C13 . The level of soft start changes according to position of pot . This output is given to IC 5 , IC 5 generates error voltage which is decided by pot . position & feedback .Feedback is taken from armature voltage . Armature voltage changes w.r.t. firing angle & by using divider & rectified circuit feedback added to input of IC 5 . So as to keep the motor speed constant , closed loop system is used . This controlled voltage is given to pin2 of IC 5 At pin 1 , IC 5 generates pulses which are rectified & are at TTL level & given to IC 7 . Pin '3' & pin '11' of IC 7 indicates the status of FR & REV direction .

According to the position of toggle switch, motor selects forward & reverse direction. The flip - flop stores the command of toggle switch to select the direction . In FWD position D = 1, Q = 1 , Q bar = 0 , If we change the toggle switch to rev position both OR gates outputs become 1 due

to combination of existing Q , bar Q levels & pull up resistors . Therefore the motor stops running in forward direction. When we change the direction of toggle switch , voltage across capacitor C 13 must go to zero . For this transistor Q1 is used. The high inhibit signal is given to base of Q1 through R 40 . Whenever changing direction Q1 is made ON & voltage across capacitor C13 goes to zero . In this way, motor starts running in reverse direction. When we press stops signal the NO contact gives high inhibit signal to both control cards so as to facilitate soft start action during each start stop action .

TEST POINTS:-

1) TP1 : This is speed pot. Variable .we can vary the voltage from 0 to -3 V.
2) TP2 : Soft start. The soft start changes w.r.t. Position of pot & Motor speed slowly increases.
3) TP3 : Error voltages is amplified by using IC5 at pin no 7 .
4) TP4 : Synchronizing ramp signal available at pin no. 1 of IC 3.
5) TP5 : Duty Cycle.
6) TP6 : Armature voltage is feedback to C5 (-ve) terminal by using Divider circuit so as to keep motor speed constant at Particular position of pot.
7) TP7 : This signal is available at pin 8 of connector 1. This INH signal changes when we change the direction of toggle switch .
8) TP8 : FWD signal is available at Q1 & Q4 of connector 2 .Alpha is present at this point , When we select FWD direction .
9) TP9 : REV signal is available at Q2 & Q3 of connector 2 . Alpha is present at this point .
10) GND : Control circuit ground.
11) TP10 WRT TP11 : Armature Voltage.
12) TP11 WRT TP12 : Armature current.
13) TP13 WRT TP14 : DC Link bus Current.
14) TP13 WRT TP15 : DC Link bus voltage.
15) TP16 WRT TP17 : Motor Field voltage.
16) TP18 WRT TP19 : D.B.R. IGBT Duty Cycle. (20% to 95 %)

PROCEDURE: - (For Resistive Load)

1) Connect the 230 V plug into mains socket.
2) Connect the resistive load arrangement into the 4 pin O /P plug .
3) Connect the 40 W lamp on side panel as a dummy load in place of Armature.
4) Connect a 60 w lamp on the holder on load arrangement board to Simulate the field of motor.

(This lamp is essential to start the unit .In absence of field the unit will not start due to field failure protection .The FIELD indicator green LED on front panel must glow brightly to indicate sufficient field current.)

5) Keep the SPEED / ALPHA / DUTY CYCLE POT at min. (zero position) & direction switch in FWD position.

6) Switch on the mains & Rocket. Rocker glows , If field lamp glows the green LED will glow . If not so, increase the wattage of field lamp upto 100W
7) Press start button.
8) Increase the duty cycle pot upto position 5.
9) Observe the waveforms of TP1 to TP 9 w.r.t. GND with unearthed CRO only.
10) Observe the o/p waveform TP10 w.r.t TP11 with unearthed CRO only.
11) Measure the O/p voltage on DC voltmeter. On the loading arrangement board .(**caution - These are direct connections of chopper o/p .Take care while selecting the DMM range .To avoid short at to the load & damage to the unit & DMM.)**
12) Measure the output voltage for each step of POT position .
13) Measure the duty cycle at TP5 for each step of POT position .
14) Plot the graph of O/P voltage v/s duty cycle.
15) Note the similar reading in a reverse direction by repeating above steps .
16) Plot the graph o/p vol. v/s duty cycle on same graph paper .
17) Measure the load current in step 12 to15 & plot the graph of load Voltage. v/s load current in FWD & REV direction on same graph paper .(to indicate first & third quadrant operation .)

PROCEDURE:- (FOR MOTOR LOAD)

1) Connect 230 V plug into mains.
2) Connect the motor [1/2 HP (DC)] connector into the 8 pin output plug.
3) Connect the dummy load of 40 watt lamp to the side panel holder.
4) Connect of 40 W the side panel DBR holder.
5) Connect the Source Receptive lamp (40Watt) to side panel holder.
6) Keep speed pot fully anticlockwise i.e. minimum.
7) Keep feedback switch (SW 2) on open loop position.
8) Keep direction switch (SW 1) in FWD position.
9) Keep the switch to Non-Receptive position.
10) Keep the Regeneration switch to OFF position.
11) Switch ON the mains using Rocker switch,' FIELD ON' 'yellow LED' glows.
12) Press 'start button'. 'Motor ON''RED LED' glows.
13) Turn the SPEED pot clockwise and observe the motor speed increases slowly.
14) Vary speed pot slowly. (Wait for Motor Response).
15) Now increase the load using "Round wheel" and fill the readings in following table.
    # Note that the rated arm current [2A] should not be crossed due to Over loading.
16) Decrease the speed pot to minimum position and press stop button.
17) Observe the Voltage waveform across TP10 w.r.t TP12. and Current Waveform across TP 11 w.r.t. TP12.
18) Change the direction switch to REV position.
19) Repeat the steps 12 to 15 and again take the reading.
20) Keep the feedback switch (SW 2) on close loop position & direction switch (SW 1) to FWD position.
21) Repeat the steps from 8 to 12 and take the reading.
22) Change the direction switch to REV position.

23) Repeat the steps 12 to 15 and again take the reading.
24) Observe the Voltage waveform across TP10 w.r.t TP12. and Current Waveform across TP 11 w.r.t. TP12.
25) Plot the graph of load weight v/s speed position in open loop & close loop condition.
26) Comment on graph.
27) Switch off the unit.

PROCEDURE:- (for Regeneration): -

1. Connect 230 V plug into mains.
2. Connect the motor -generator set [1/2 HP (DC)].Connector into the 8 pin output plug.
3. Connect the dummy load of 40 watt lamp to the side panel holder.
4. Connect of 40 W the side panel DBR holder.
5. Connect the Source Receptive lamp (40Watt) to side panel holder.
6. Keep speed pot fully anticlockwise i.e. minimum.
7. Keep feedback switch on open loop position.
8. Keep direction switch in FWD position.
9. Switch ON the mains using Rocker switch,' FIELD ON' 'yellow LED' glows.
10. Keep the Regeneration switch to ON position.
11. Generator starts running in FWD position and so motor also starts running.
12. Observe the Voltage waveform across TP10 w.r.t TP12 and Current Waveform across TP 11 w.r.t. TP12.
13. Observe the DC source current waveform across the TP 13 w.r.t TP 14.
14. Keep the Direction switch to REV position.
15. Repeat the above procedure by changing the Direction switch
16. Observe the Voltage waveform across TP10 w.r.t TP12 and Current Waveform across TP 11 w.r.t. TP12.
17. Observe the DC source current waveform across the TP 13 w.r.t TP 14.

NOTE: -Without giving the start to unit, generator starts running. If you press the start and increase the SPEED pot slowly, then you will observe that motor speed increases due to generation action.

PROCEDURE:- (for D.B.R)

NOTE: - For observing the effect of dynamic braking action, Regeneration switch must be off, if you do not off the switch, you will not get the effect of dynamic braking.

1. Connect 230 V plug into mains.
2. Connect the motor [1/2 HP (DC)] connector into the 8 pin output plug.
3. Connect the dummy load of 40 watt lamp to the side panel holder.
4. Connect of 40 W the side panel DBR holder.
5. Connect the Source Receptive lamp (40Watt) to side panel holder.
6. Keep speed pot fully anticlockwise i.e. minimum.
7. Keep feedback switch (SW 2) on open loop/closed position.
8. Keep the Regeneration switch to off position.
9. Keep direction switch (SW 1) in FWD position.

10. Keep the D.B.R. switch to FWD position.
11. Keep the D.B.R. pot to minimum position.

NOTE: - Keep the Direction switch and D.B.R. switch to same position, i.e. in FWD or REV position. (Both at same position). If both switches are not at same position, then you will not get the effect of dynamic Braking.

12. Switch ON the mains using Rocker switch,' FIELD ON' 'yellow LED' glows.
13. Press 'start button'. 'Motor ON''RED LED' glows.
14. Turn the SPEED pot clockwise and observe the motor speed increases slowly.
15. Vary speed pot slowly. (Wait for Motor Response).
16. After attaining full speed by motor, press the STOP button to stop the motor, then you will see the effect of dynamic braking.
17. Note down the time at which from STOP Command to motor stop running.
18. Repeat the procedure by changing the lamp across D.B.R. and by changing the D.B.R. pot position.
19. Take the reading by changing the D.B.R. lamp and D.B.R. pot.

NOTE: - For more effect of D.B.R., you can connect external rheostat at the points (BT30, RED & BLACK) given at side panel holder.

20. You can repeat the procedure by changing the Direction switch and D.B.R. switch.

NOTE: - You will see that as the D.B.R. lamp and D.B.R. pot increases, the motor takes much less time to stop the motor.

OBSERVATION TABLE: -

FOR CLOSED LOOP in FWD

LOAD	VOLTAGE	CURRENT	SPEED