Multi-Knowledge Electronic Comprehensive Journal for Education and Science Publications (MECSJ)
ISSUE (34), July (2020)
ISSN: 2616-9185

CONTROL OF DC MACHINE USING ARDUINO

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Abstract:

Four quadrant speed control model is designed by using chopper to control the speed of DC motor. The designed model provides four quadrant speed control of DC motor in both directions, i.e. clockwise direction, counter- clockwise direction along with braking of the DC motor. This operation will most superior in DC motor than the AC because changing the rotation of motor is difficult and complicated in AC as compare to DC. It can design a simple power electronic circuit can used to control the applied voltage in electric machine. The complete circuit consists of control circuit and power circuit based on IGBT. It can gain the student practical Knowledge and Skills in choosing the electronics elements, control techniques and preparing circuits Moreover, It can think that the cost of the preparing the project is small as possible.

Keywords — MATLAB, IGBT, Four Quadrant, DC Chopper, Isolation Circuit, Modelling and Simulink

الملخص

تم تصميم نموذج تحكم أربع أرباع السرعة باستخدام مغيّر للتحكم بسرعة محرك التيار المستمر. يتيح النموذج المصمم تحكم بأربع أرباع السرعة لمحرك تيار مستمر وفي كلا الاتجاهين، أي باتجاه دوران عقارب الساعة وبعكس اتجاه دوران عقارب الساعة إضافة إلى فرملة محرك التيار المستمر. إن هذه العملية ستتفوق في محركات التيار المستمر عن محركات التيار المتناوب بسبب أن تغيير اتجاه دوران محرك التيار المتناوب أصعب وأعقد منه في محركات التيار المستمر. يمكن تصميم دارة طاقة الكترونية بسيطة والتي يمكن استخدامها للتحكم في الجهد المطبق على الآلة الكهربائية. تتكون الدارة الكاملة من دارة التحكم ودارة الطاقة على أساس IGPT. يمكن أن يكتسب الطالب المعرفة والمهارات العملية في اختيار العناصر الإلكترونية وتقنيات التحكم وإعداد الدارات وعلاوة على ذلك، ويمكن التفكير في أن تكلفة إعداد المشروع هي صغيرة قدر الإمكان.

الكلمات المفتاحية: ماتلاب، IGBT، أربع أرباع، مغيّر التيار المستمر، دارة العزل، النمذجة والمحاكاة.

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I. INTRODUCTION

Electrical power engineering has various sections and applications, one of the most important Sections is power electronics and its applications, when power electronics begin to be available in the markets, it was able to solve so many issues in the field. Also, it opens a big area to apply allot of useful applications like controlling and switching. Our project is small example of these applications, INS function would be to take in a DC voltage input, something like a battery or Sola cell or IGBT cell then control a DC machine by using DC/DC Chopper.

A. Simulation of the proposed system

In this chapter, the simulation of the motor controlled by DC chopper will be discussed using ARDUINO UNO. The complete block diagram is shown in Figure (1). The proposed system of project our project divided to four circuits (power circuit, buffer circuit, isolation circuit, Auxiliary power circuit) . Control circuit (Arduino Uno) software control DC motor, the power circuit containing the DC motor circuit and H-Bridge configuration.

Shows MATLAP SIMULINK model of the proposed system. The signal generation is performed by Figure (2), The Repeating Sequence block outputs a periodic scalar signal having a waveform that you specify using the **Time values** and **Output values** parameters. The Time **values** parameter specifies a vector of output times. The **Output values** parameter specifies a vector of signal amplitudes at the corresponding output times, as showing in figure (3)

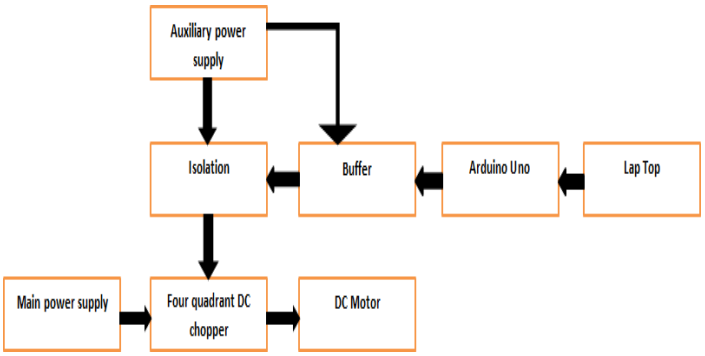

Figure 1: Block diagram of project

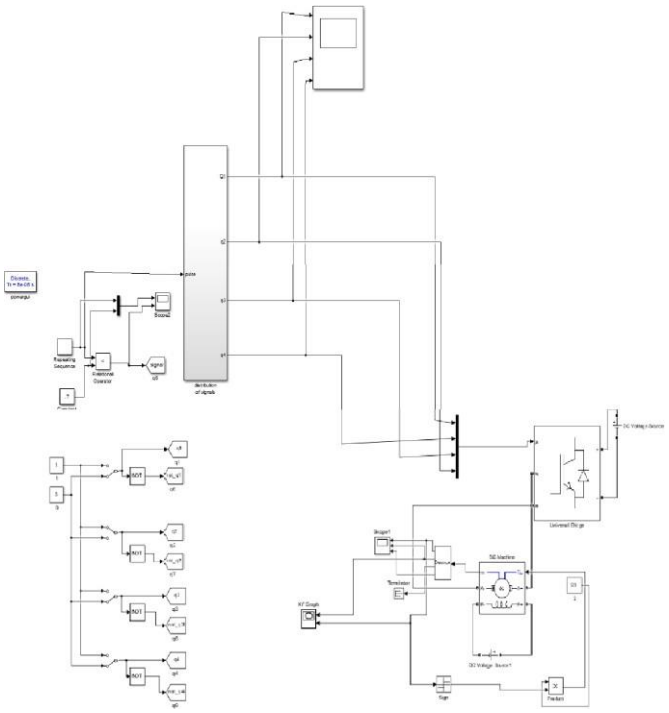

Figure 2 MATLAP SIMULINK complete model

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Control the motor by Four Quadrant Generation of the repeating sequence

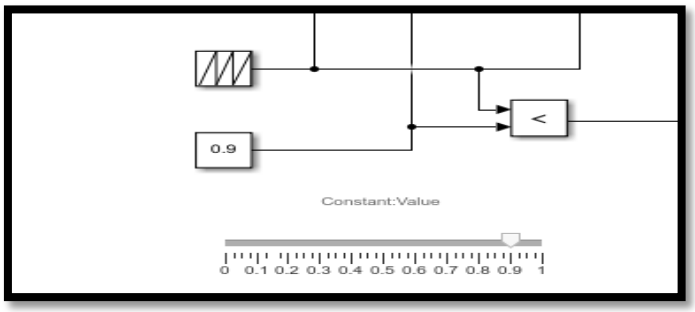

Figure 3: Generation signal of the cetose

B.FOUR QUDRANTS

DC machines play a very important role in industries and in our daily life. The outstanding advantage of DC machines is that they offer easily controllable characteristics. This paper is designed to develop a four quadrant speed control system for a DC motor using Arduino. In this work the concept of four quadrant speed control i.e. clockwise movement, anticlockwise movement, instantaneous forward braking and instantaneous reverse braking of a dc motor with the help of Arduino through motor driver (L293D) has been proposed .Block Diagram of Four Quadrant DC Motor Speed Control By Using Arduino Uno

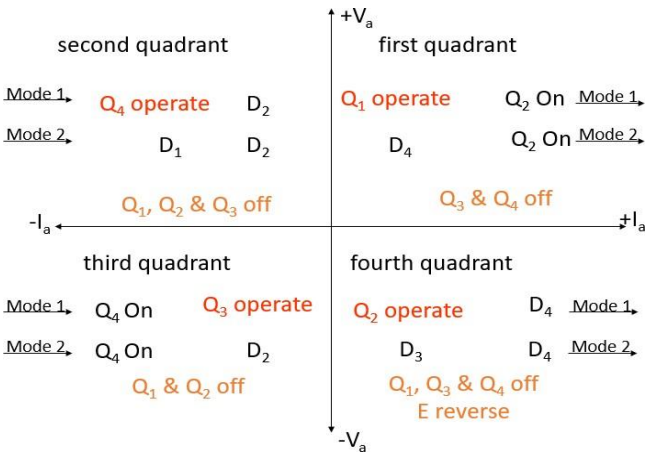

Figure 4: Four quadrant

* In first quadrant, opening the IGBTs 1 and 2 (forward operation).
* In second quadrant, opening IGBT 4 and diode 2 (forward brake).
* In third quadrant, opening the IGBTs 3 and 4 (reverse operation).
* In fourth quadrant, opening the IGBT 2 and diode 4 (reverse brake).

So, we need to control the signals that flow to each IGBT in circuit.

Table controlling signals by switches:

Manual switch	Signal allows to pass
S1	Q1 & Q2
S2	Q4
S3	Q3 & Q4
S4	Q2

The Truth Table:

	Pulse	Input				Output				
		S1	S2	S3	S4	Q1	Q2	Q3	Q4	S1S2S3S4
Forward motoring	1	1	0	0	0	1	1	0	0	S1S2'S3'S4'
	0	1	0	0	0	0	1	0	0	S1S2'S3'S4'
Forward break	1	0	1	0	0	0	0	0	1	S1'S2S3'S4'
Reverse motoring	1	0	0	1	0	0	0	1	1	S1'S2'S3S4'
	0	0	0	1	0	0	0	0	1	S1'S2'S3S4'
Reverse break	1	0	0	0	1	0	1	0	0	S1'S2'S3'S4

There are some cases to control the motor by the four quadrants as following:

-At duty raito 0.9 : DC lever & repeating sequence :

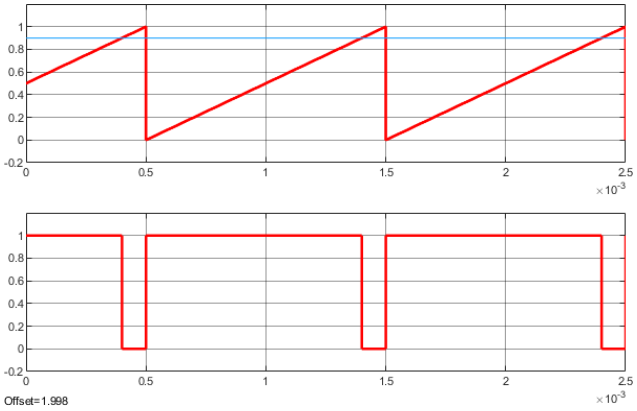

Figure 5: The state of DC level & repeating sequence

Case #1(A): FIRST QUADRANT (Foreword) (with 0.9 duty ratio)

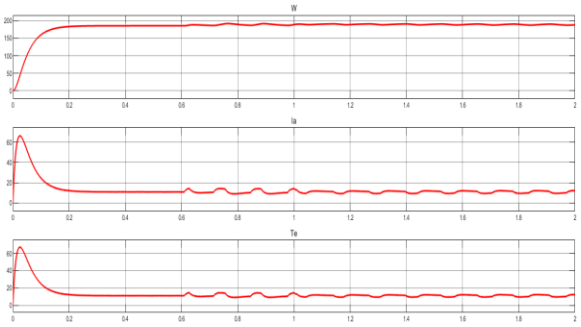

Figure 6: The state of SPEED, TORQUE and Current

Speed start from zero and increase instantaneously to rated speed at 0.2 second, the current and torque instantaneously jump to rated then decrease to study stat at 0.15 second.

X-Y Plane: Y-axis is SPEED – X-axis is TORQUE

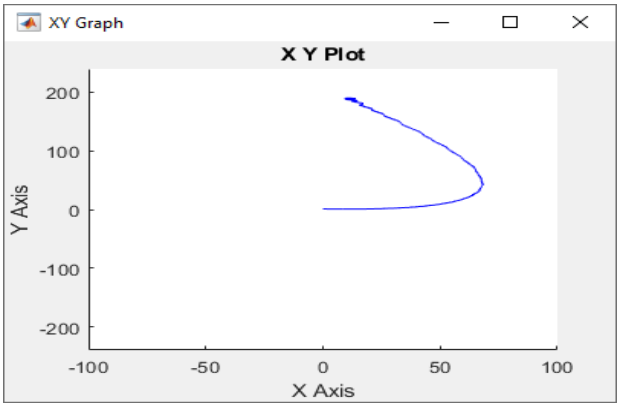

Figure 7: X-Y Plane

Switches State:

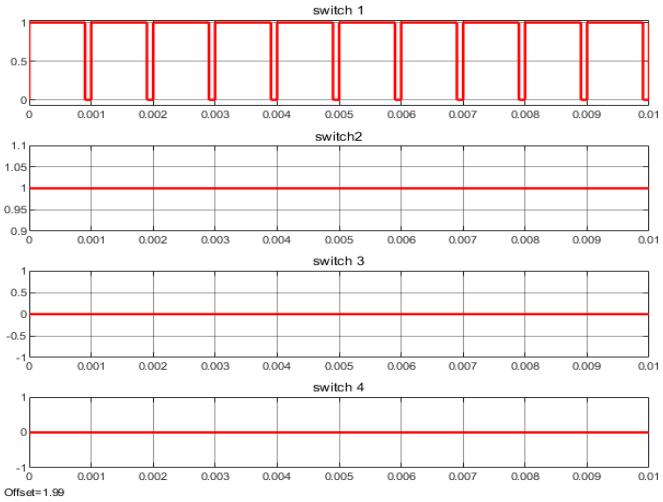

Figure 8: The state of All Switches

Show the stat of all switches when the motor operate in first quadrant, Q1 ON, OFF and Q2 ON, Q3, and Q4 OFF

Case #2(A) FROM QUADRANT 1 TO QUADRANT 2 (with 0.9 duty ratio)

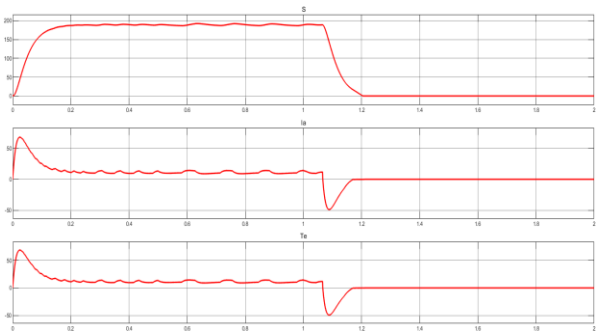

Figure 9: The state of SPEED, TORQUE and Current

Speed start from zero and increase instantaneously to rated speed at 0.2 second, the current and torque instantaneously jump to rated then decrease to study stat at 0.15 second.

Speed start from zero and increase instantaneously to rated speed at 0.2 second then the motor stopped at 1.1, the current and torque instantaneously jump to rated then decrease to 0 at 1.15 second.

X-Y Plane: Y-axis is SPEED – X-axis is TORQUE

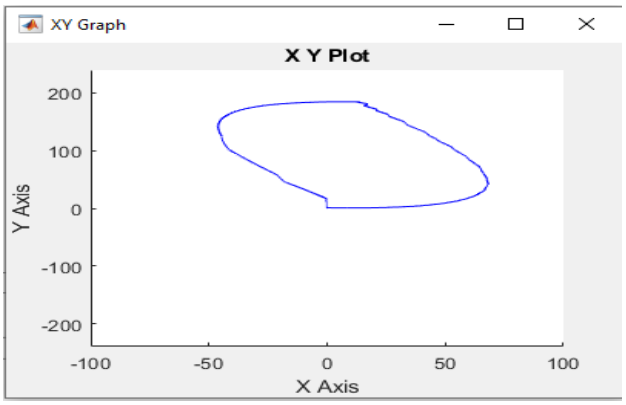

Figure 10 :X-Y Plan

Switches State:

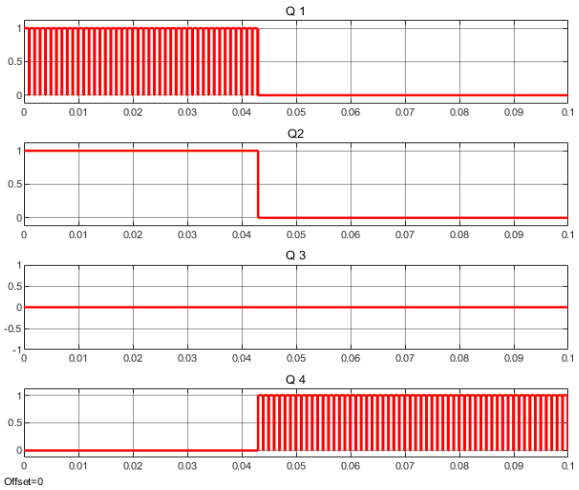

Figure 11: the state of All Switches

Show the stat of all switches when the motor operate in first quadrant, Q1 ON, OF and Q2 ON, Q3, and Q4 OFF

When the motor operates in second quadrant Q1 OFF, Q2 ON and OFF, Q3 and Q4.

Case #3(A) Third quadrant reverse (with 0.9 duty ratio)

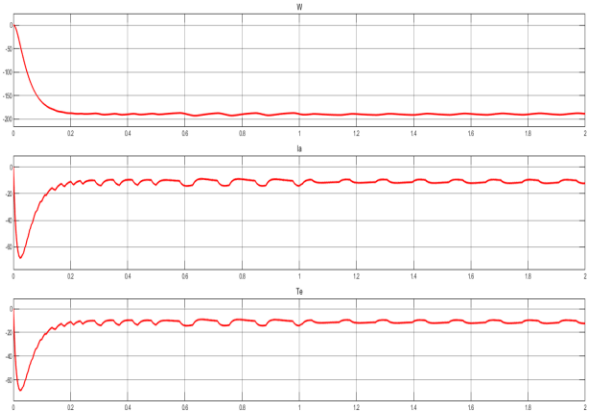

Figure 12: the state of SPEED, TORQUE and Current

Speed start from zero and increase instantaneously in the negative said to rated speed at 0.2 second, the current and torque instantaneously jump to rated value in negative side then decrease to study stat at 0.2 second.

X-Y Plane: Y-axis is SPEED – X-axis is TORQUE

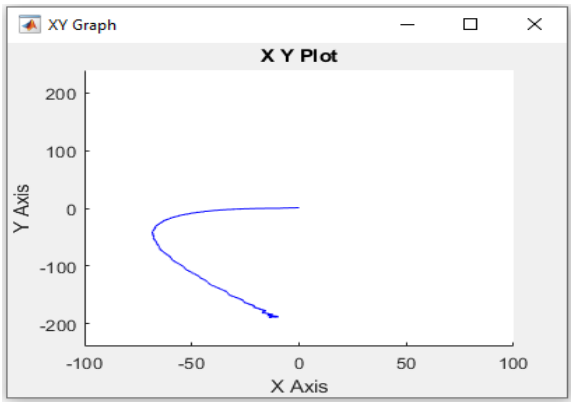

Figure 13: X-Y Plane

Switches State

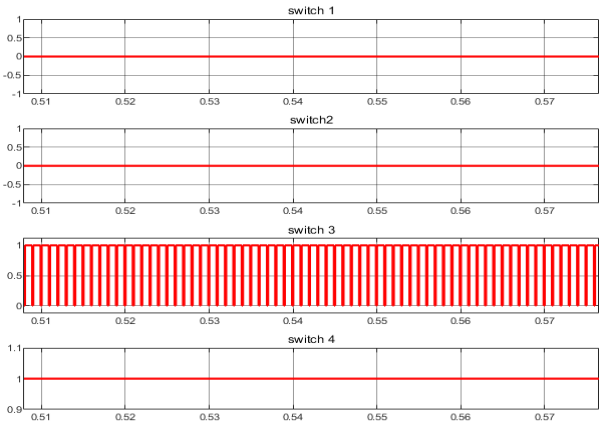

Figure 14: The state of All Switches

show the stat of all switches when the motor operate in third quadrant, Q3 ON, OFF and Q4 ON, Q1,and Q2 OFF .

Case #4(A) FROM QUADRANT 3 TO

QUADRANT 4 (with 0.9 duty ratio*)*

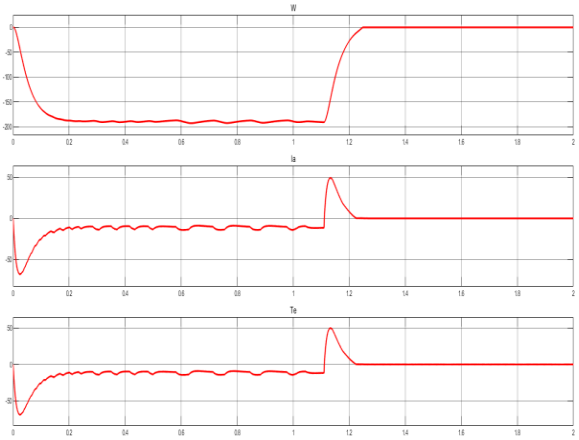

Figure 15: the state of SPEED, TORQUE and Current

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Speed start from zero and increase instantaneously in negative said to rated speed at

0.2 second then the motor stopped at 1.1, the current and torque instantaneously jump to rated in negative said then decrease to 0 at 1.1 second

X-Y Plane: Y-axis is SPEED – X-axis is TORQUE

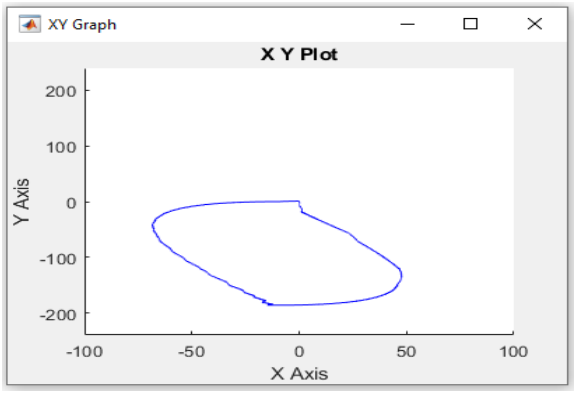

Figure 16 : X-Y Plane

Switches State

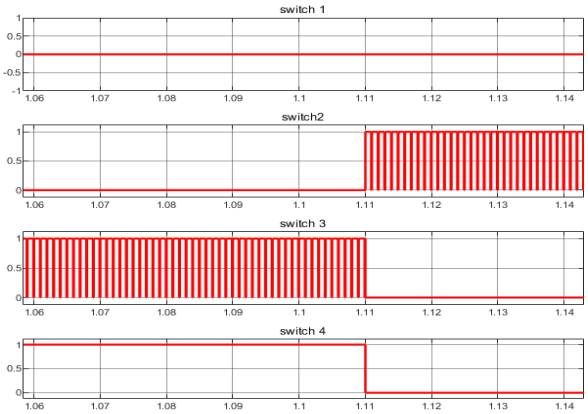

Figure 17: The state of All Switches

Show the stat of all switches when the motor operates in third quadrant, reveres motion. Q3 ON, OF and Q4 ON, Q1 and Q2 OFF.

When motor operates forth quadrant Q1, Q2, and Q3, OFF, Q4, ON and OFF.

Case #5(A): FROM QUADRANT 1 TO QUADRANT 3 (with 0.9 duty ratio)

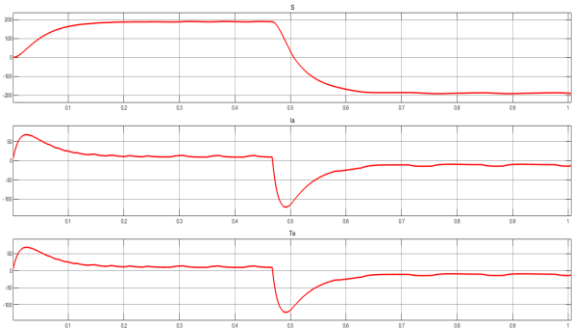

Figure 18: The state of SPEED, TORQUE and Current

Speed start from zero and increase instantaneously to rated speed at 0.15 second then at 0.47 second the motor change motion to the reverse motion, the current and torque instantaneously jump to rated then decrease to negative value to change torque and current to change motion.

X-Y Plane: Y-axis is SPEED – X-axis is TORQUE

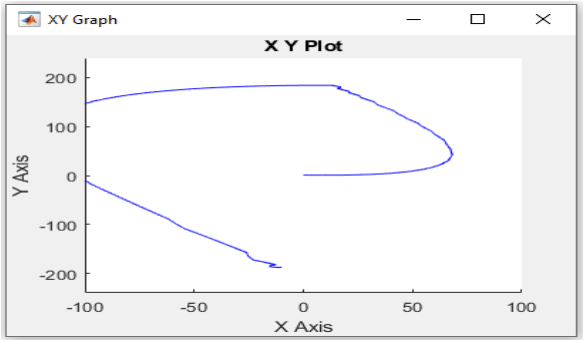

Figure 19: X-Y Plane

Switches State

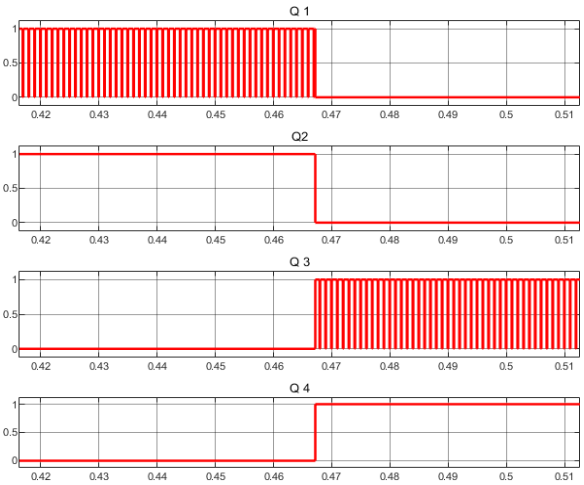

Figure 20: The state of All Switches

Show the stat of all switches when the motor operates in first quadrant, forward motion. Q1 ON, OF and Q2 ON, Q3 and Q4 OFF.

when motor operates in third quadrant Q3 ON, OF and Q4 ON, Q1 and Q2 OFF.

I .Buffer circuit

Buffer circuit prevents loading of the source. If the load to a voltage source is a low value, it practically shorts the source and draws too much current from the source for which the source is not rated which is harmful for the source. So by cascading a buffer after a source provides division of lab our- the source only generated the correct voltage and the buffer provides the demanded current keeping the voltage constant AND without loading the source as the buffer has very high input impedance, it draws negligible current from the original source, thereby preventing loading.

Application

Single input voltage buffers are used in many places for measurements including:

* In strain gauge circuitry to measure deformations in structures like bridges, airplane wings and I-beams in buildings.
* In temperature measurement circuitry for boilers and in high altitude aircraft in a cold environment.
* In control circuits for aircraft, people movers in airports, subways and in many different production operations

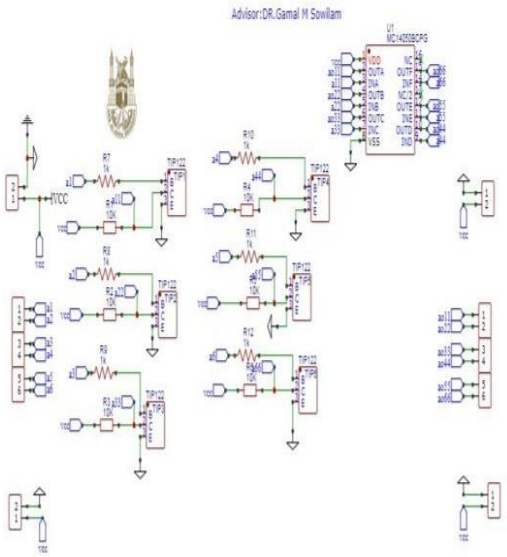

Figure 21: Block diagram of buffer circuit

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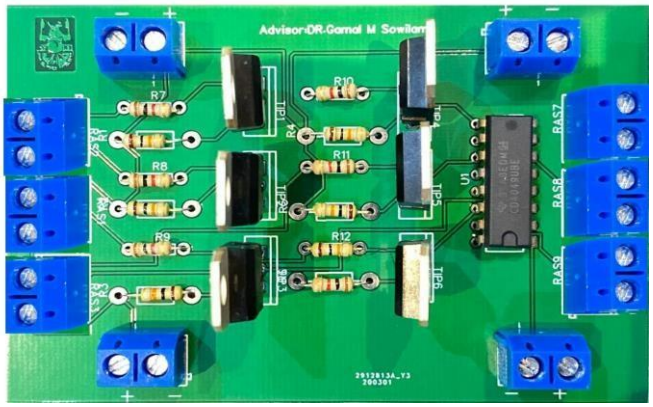

Figure 22: buffer circuit

I I. Isolation circuit

The main function of the isolator is to block such high voltages and voltage transients, so that a surge in one part of the system will not disrupt or destroy the other parts. So to protect our control circuit from high voltages that came from the power circuit, we are connecting the both circuits though a circuit known as isolation circuit.

The part that we used to isolate our control circuit is an opt coupler isolator , the main function of the opto-coupler is transmit the signals by the light, then isolate the ground of the control circuit, and the ground of the power circuit from another .show Figure (12) 6NOpto-coupler.

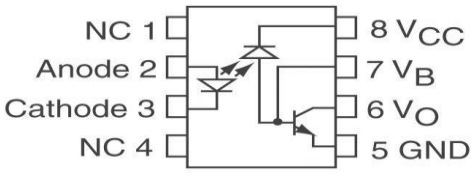

Figure 23: 6NOpto-coupler

The figure (13) show the diagram of Isolation circuit and figure (14) show inputs and outputs in Isolation circuit. Figure (15) show the isolation circuit.

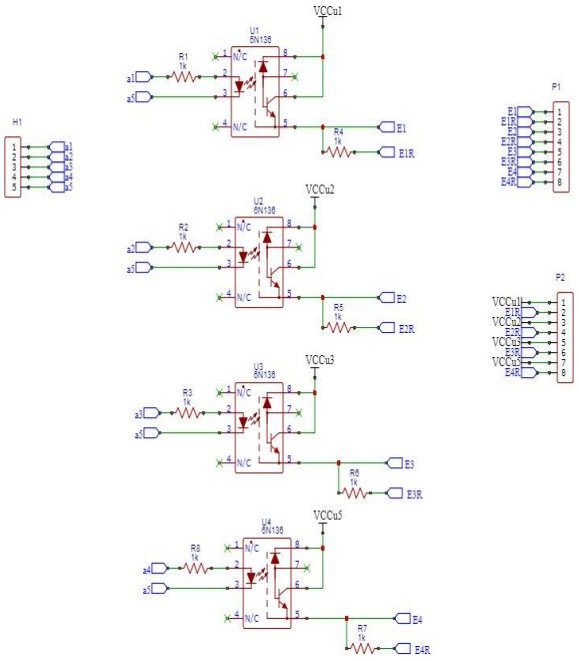

Figure 24: Diagram of Isolation circuit

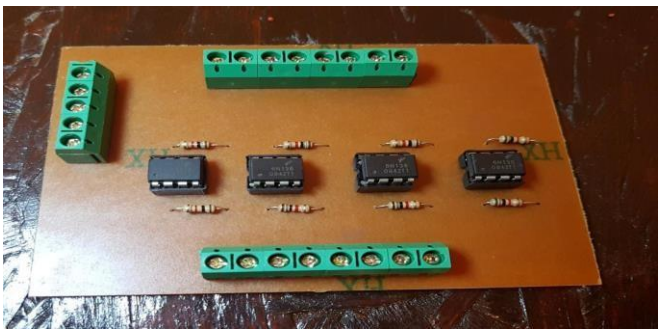

Figure 25: Isolation circuit

III. Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter show in figure (16).

Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode. Revision 3 of the board has the following new features:

- 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.
- Stronger RESET circuit.
- Atmega 16U2 replace the 8U2. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward.

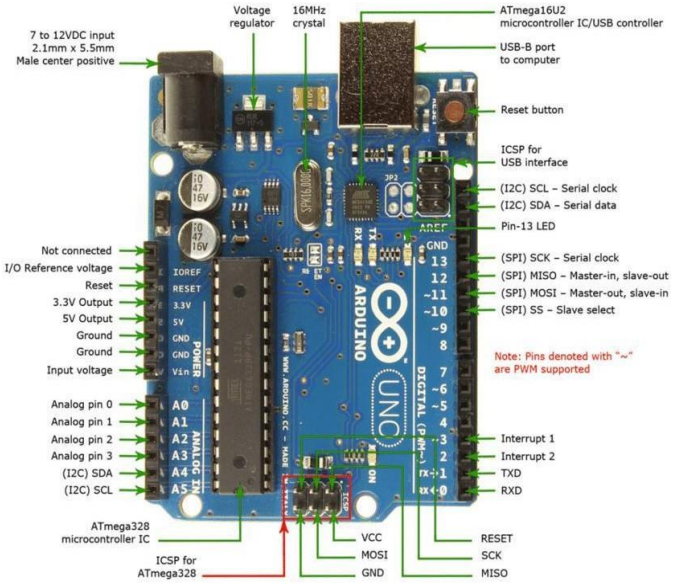

Figure 26: Arduino Uno

F. CONCLUSION

Used isolation circuit for protect control circuit (Arduino uno.) from high voltage come from power circuit.Generate PWM (Pulse Width Modulation) method simulation in LabVIEW by generate reference signal is DC level and the carrier signal is triangular wave that feed into a comparator which creates output signals by block in LabVIEW software name comparison.

Control in DC motor in four quadrant DC chopper by building simulation control circuit in LabVIEW by logic gate and transmitted into NI card.

Apply four quadrant DC chopper by power circuit based on four IGBT to do chopper connected with Arduino uno.

ACKNOWLEDGMENT

For his contribution, exemplary guidance monitoring, cordial support, and valuable information that is always helpful, a sincere regards to our professor Gamal M Sowilam

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