Ahsanullah University of Science and Technology

Department of Electrical and Electronic Engineering

PROJECT REPORT

Course no: EEE 4228

Course name: Power Electronics Lab

Project name: Thyristor based Cycloconverter to vary speed of induction motor

Submitted by:

Group members:

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Group no: 2

Session: 4^{rth} year 2nd semester

Department: EEE

Objective:

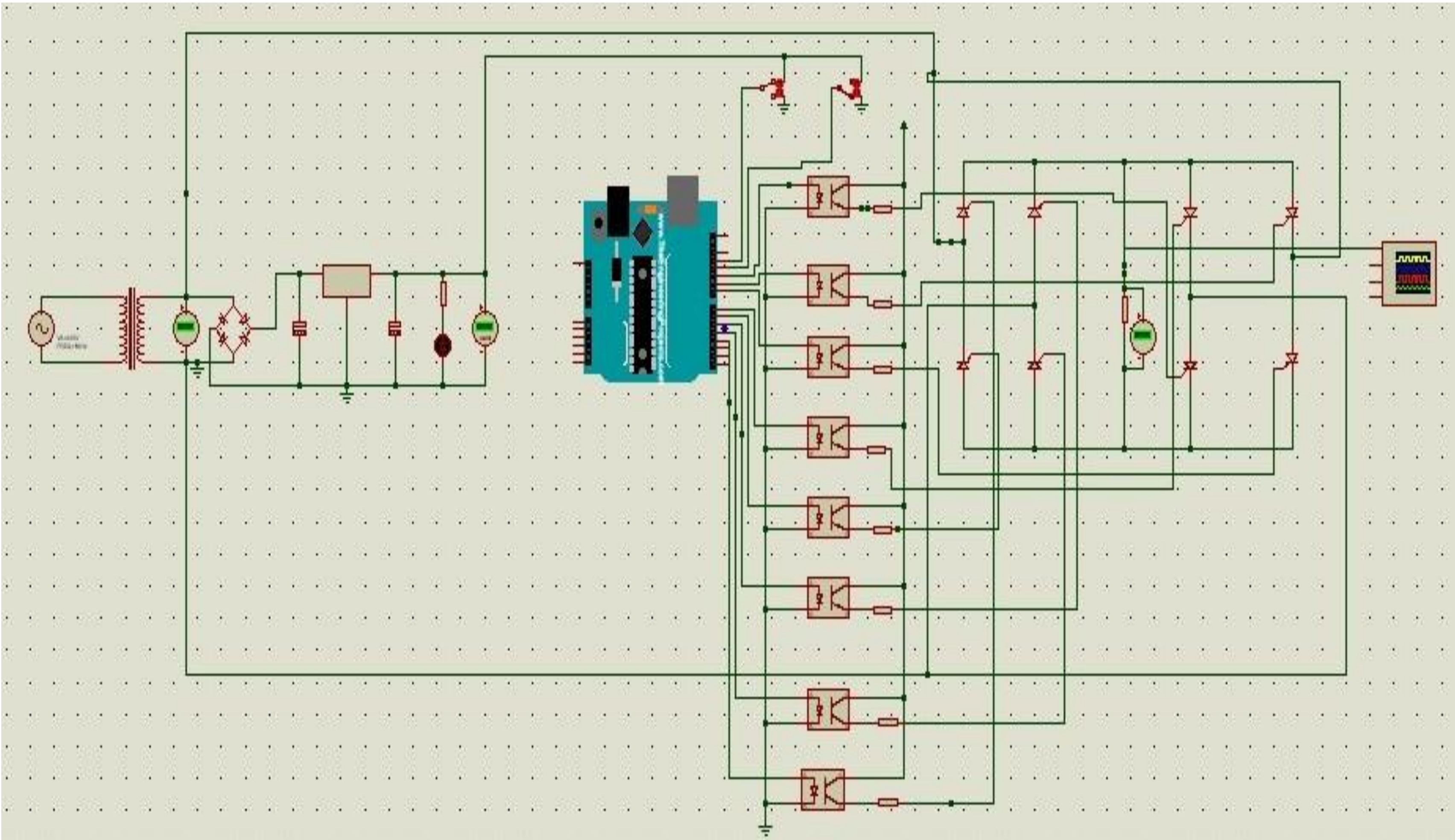
1. To obtain smooth and stepless control over the motor's speed, a thyristor-based cycloconverter is used to change the speed of an induction motor.
2. Cycloconverters are electronic components that can change AC electricity from one frequency to another.
3. The output frequency and voltage can be changed by varying the firing angles of the thyristors inside the cycloconverter, which in turn influences the speed of the attached induction motor.

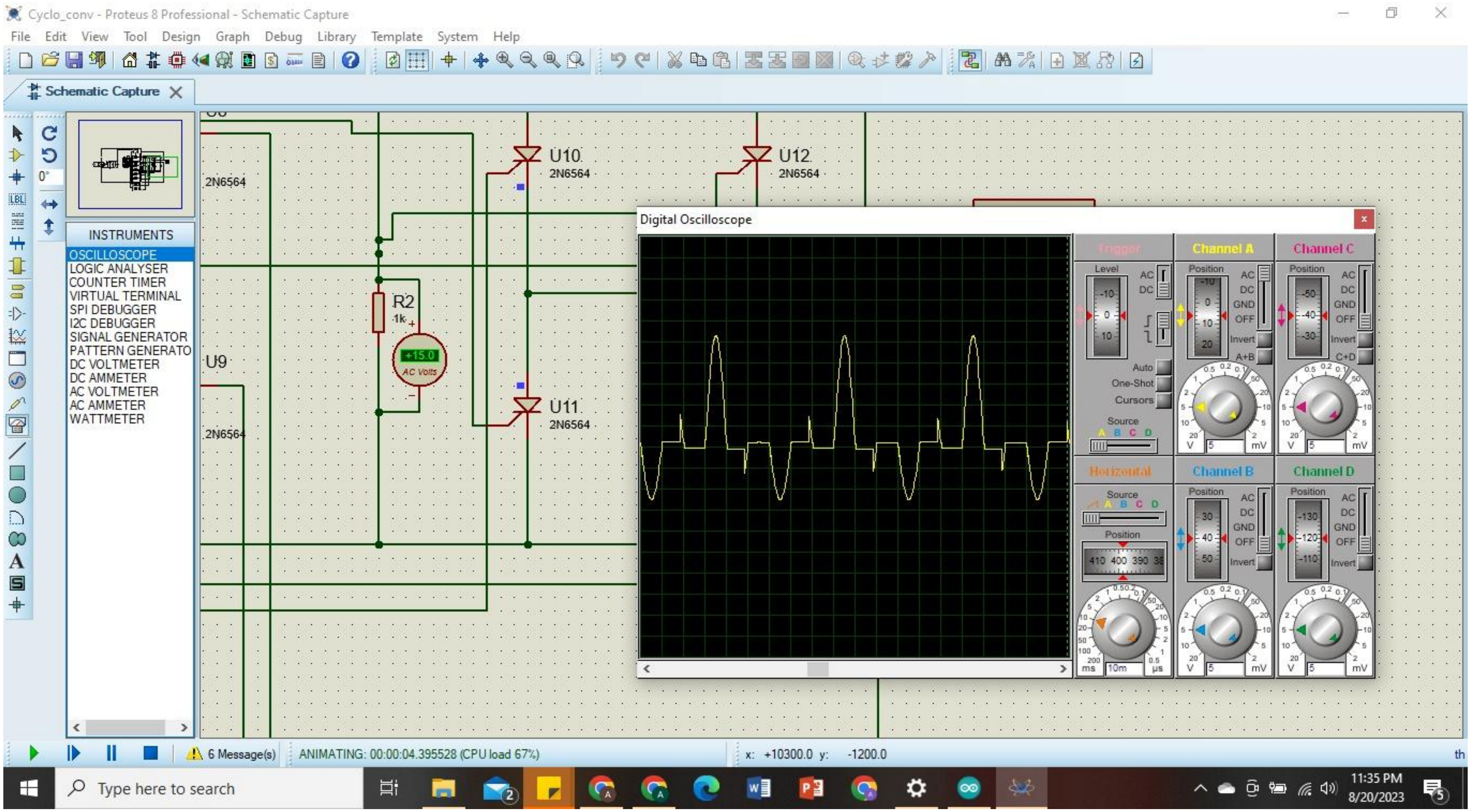
This technique enhances energy economy, enables accurate speed control, and reduces mechanical wear and tear in systems like industrial drives and automation systems.

List of Equipment:

1. Transformer 18.8V x1
2. Diodes x4
3. Capacitor 1000µF x2
4. Voltage Regulator Ul7805 x1
5. Resistor 220Ω x1
6. Optocoupler PC817C x8
7. Thyristor 2N6564 x8
8. Resistor 10K x8
9. Switch 3 pins (more than 5V) x2
10. Board x1
11. Small Bread Board x3
12. Wires
13. LED x1
14. Arduino Uno x1

Circuit Diagram:





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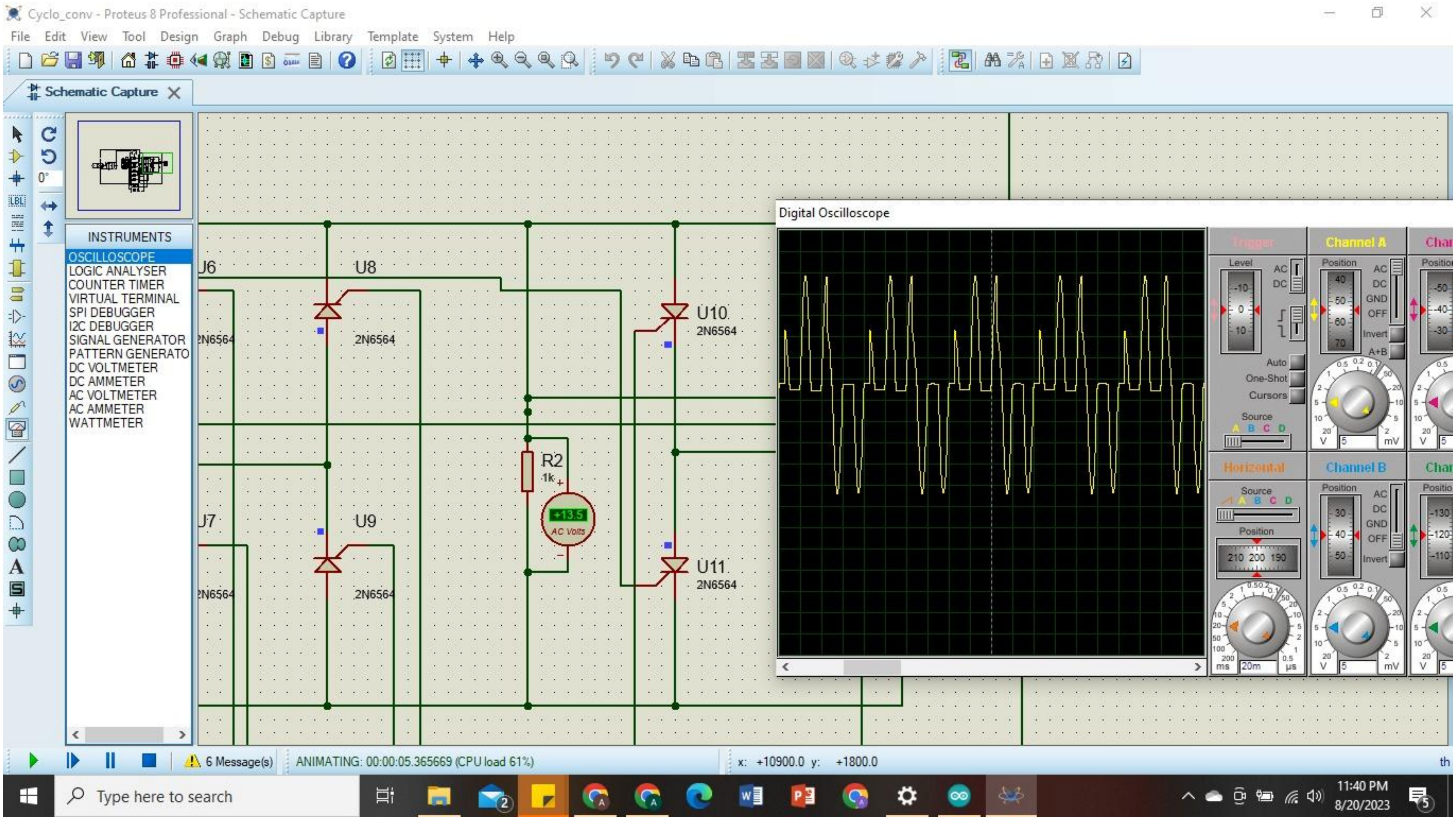
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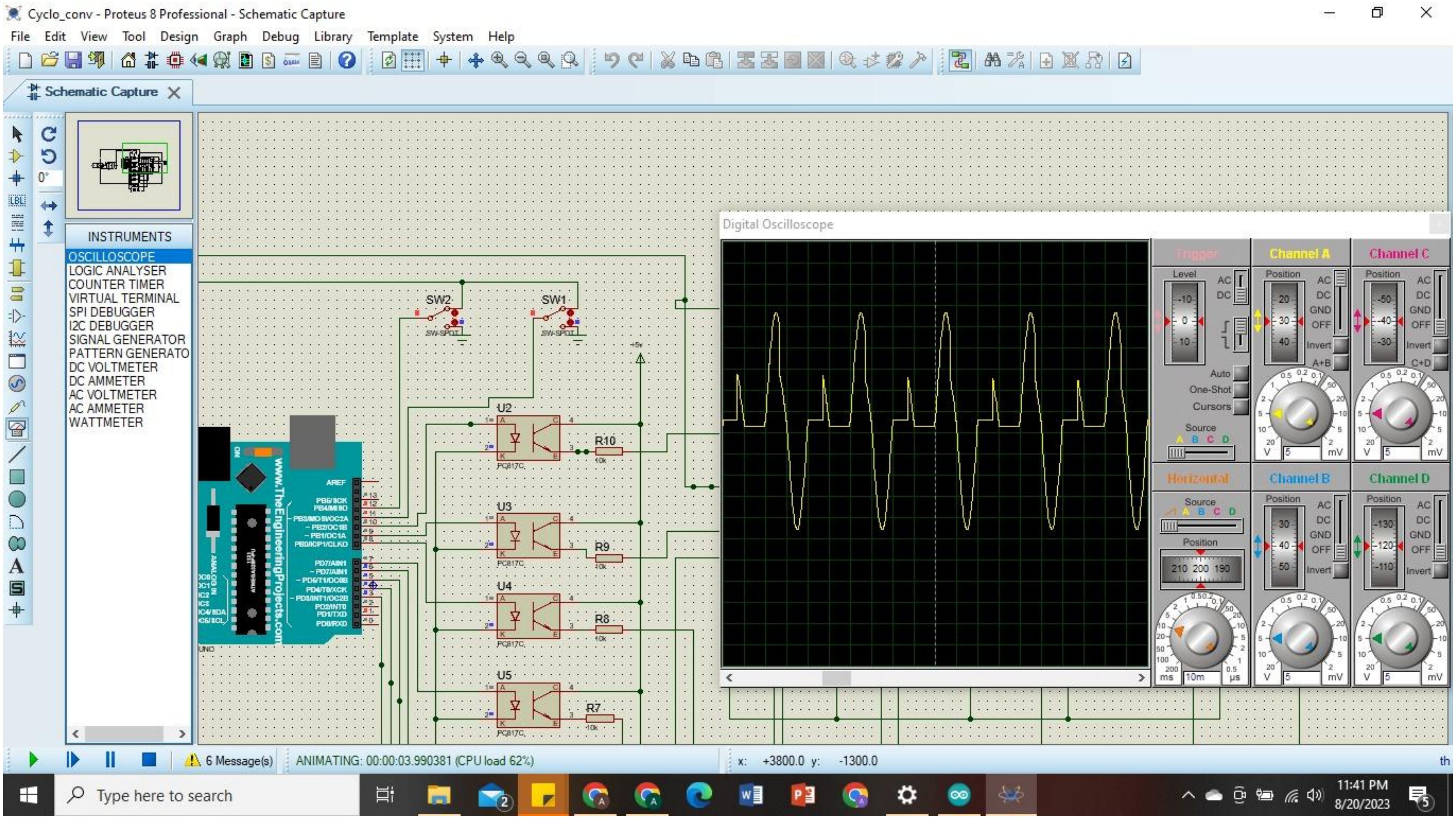
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Digital Oscilloscope
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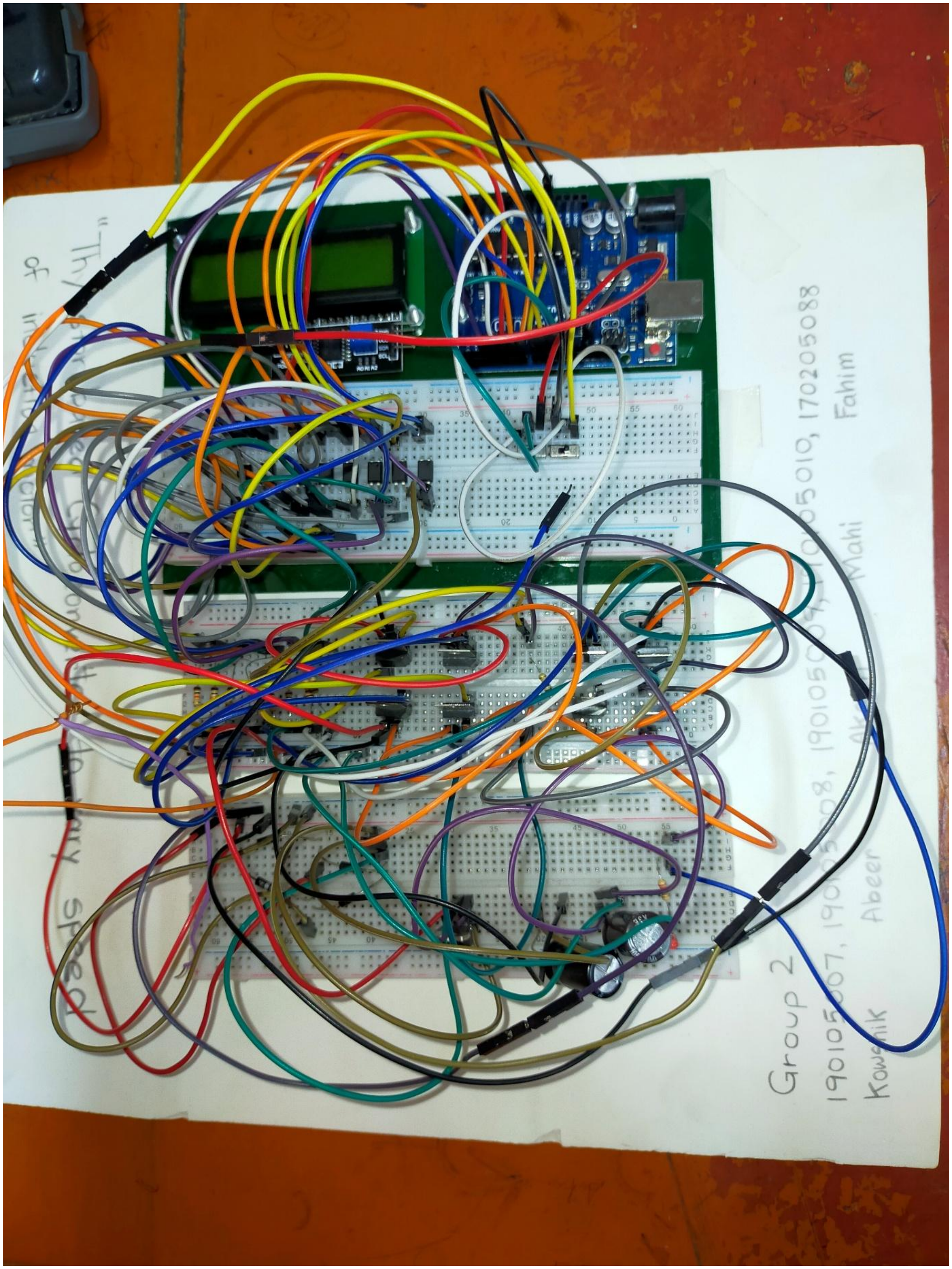
Project Image:



Working Principle:

A cycloconverter is a power electrical component that transforms an AC input with a fixed frequency into an AC output with a variable frequency. By changing the frequency of the AC power delivered to the motor, it is possible to regulate the speed of induction motors.

Thyristors are used in thyristor-based cycloconverters to regulate the output voltage of the cycloconverter. The current that passes through thyristors can be changed to switch on and off semiconductor devices.

The following describes how a thyristor-based cycloconverter works to change the speed of an induction motor:

1.DC voltage is created by rectifying the AC input voltage.

2. The thyristors divide the DC voltage into a string of pulses. 3. To alter the output voltage of the cycloconverter, the pulse width of the thyristors is regulated. 4. The induction motor receives the cycloconverter's output voltage. The frequency of the output voltage of the cycloconverter can be changed by adjusting the thyristors' pulse width. The induction motor's speed is then altered as a result. A thyristor-based cycloconverter is advantageous for controlling the speed of an induction motor since it can give a wide range of speed control and is reasonably priced. It lasts a very long time and is dependable.

The cycloconverter's number of thyristors is determined by the desired output frequency. For instance, six thyristors would be required for a cycloconverter with a maximum output frequency of 50 Hz. A pulse width modulation (PWM) controller regulates the thyristors' pulse width. The PWM controller determines the desired pulse width using a feedback signal from the induction motor. A filter can be used to reduce the cycloconverter's harmonic output. Typically, the filter is positioned in front of the induction motor, between the cycloconverter.

Advantages:

Smooth Speed Control: Cycloconverters offer stepless and continuous speed control, enabling precise changes to the motor's speed across a large range.

High Efficiency: Unlike conventional techniques that could lead to energy losses, thyristor-based cycloconverters can retain relatively high efficiency even at low speeds.

Reduced Mechanical Stress: By allowing for gentle acceleration and deceleration, cycloconverters extend the life of the motor and any related machinery by reducing mechanical stress.

Process Control Is Improved: Cycloconverters guarantee exact adjustments in applications needing precise control over motor speed, such as conveyor systems or pumps. This improves process control.

Maintenance Costs Lower: Smoother running reduces wear and tear, which can result in less frequent maintenance and a longer motor lifespan.Cycloconverters can also enable regenerative braking, in which energy lost during deceleration is returned to the power source to increase energy efficiency.Cycloconverters are relatively small and don't require major modifications to be integrated into current systems.

Disadvantages:

Complexity : Due to the difficult synchronization of numerous thyristors, thyristor-based cycloconverters are complex and call for careful design and supervision. Higher expenditures for development and
during switching transitions, which can shorten their lifespan and cause more wear and tear.

Size and Weight:

Thyristor-
based cycloconverters might use large, heavy components, which makes them unsuitable for situ ations where space and weight are strictly regulated.

Cooling and Heat Dissipation: Thyristor-
based systems have large power losses that call for effective cooling systems, which increases co mplexity and raises the possibility of maintenance difficulties.

High Total Harmonic Distortion (THD): The waveform produced by a cycloconverter may have a high THD, which may cause the motor to lose more efficiency and heat.

Limited Compatibility: A cycloconverter's control method might not be entirely compatible with some

Thyristors used in cycloconverters experience high voltage and current strains during switching transitions, which can result in more wear and tear and a shorter component lifespan.

Limited Compatibility: Some systems may not be directly compatible with a cycloconverter's control technique.

The control method of a cycloconverter, necessitating further modifications or adaptations.

Lack of current Features: Cycloconverters might not have the extensive diagnostic capabilities, s ensorless operation, or communication interfaces present in more current variable frequency driv es.Modernised variable frequency drive systems may provide more effectiveness, better control, and less harmo nic distortion.

Limited Compatibility: Some motor types may not be immediately compatible with a cycloconverter's control technique, necessitating further modifications or adaptations.The efficiency, control, and harmonic distortion of variable frequency drive systems may all be enhanced by more recent technological advancements.

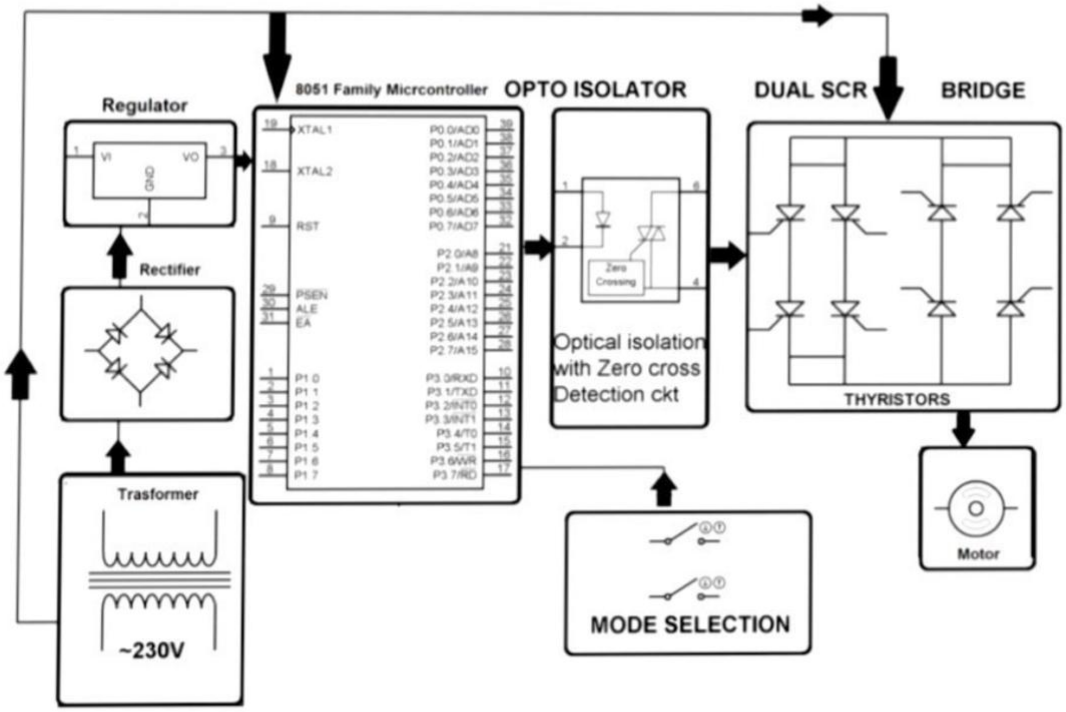
Low Efficiency: When compared to other variable speed drive systems, cycloconverters are known to be less efficient. The overall system efficiency may be decreased as a result of the power losses in the thyristors and the control circuits. Cycloconverters may induce voltage distortion and harmonics into the power supply, which may have a negative effect on the operation of the motor and other connected equipment.Cycloconverters may have limited control over a variety of speed fluctuations due to their restricted operating range. The output voltage may drop dramatically at lower speeds, which could interfere with the operation of the motor.

Application:

Thyristor-based many industrial applications, cycloconverters are used to change the speed of motors. They operate by changing one frequency of AC power into another frequency of AC power. This is advantageous in circumstances requiring precise speed control, such as those involving lifts, conveyor belts, and machine tools. The motor speed can be smoothly controlled by the cycloconverter by varying the frequency of the output voltage. The usage of modern motor control technologies like variable frequency drives (VFDs), which have greater efficiency and better control over a larger speed range, is more widespread, it is vital to mention.

REPORT

Answer to the question no : 1



Answer to question no: 2

The power factor is one potential performance criterion that could be important for a cyclo-converter using thyristors. The ratio of the actual power given to the load to the apparent power drawn from the supply is known as the power factor. It represents the effectiveness with which the cyclo-converter uses the input power. With a high power factor, the cyclo-converter uses less reactive power and experiences fewer supply system losses. A poor power factor causes the cyclo-converter to use more reactive power, which raises supply system losses.

A cyclo-converter's power factor is affected by a number of variables, including the output frequency, the load impedance, the switching scheme, and the harmonic filtering. Because the output frequency controls the thyristors' conduction angle and the phase difference between the input and output voltages, it has an impact on power factor. Because it controls the current waveform and its harmonics, the load impedance has an impact on the power factor. The commutation mechanism and the switching losses are determined by the switching strategy, which has an impact on the power factor. Because harmonic filtering lowers harmonic distortion and enhances waveform quality, it has an impact on power factor.

One of the international standards that regulates the power factor and harmonics of cyclo-converters is IEEE 519-2014, titled “IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems”. This standard specifies the limits for harmonic current injections from individual customers into a common point of coupling (PCC) with a public or private utility system. It also specifies the limits for harmonic voltage distortion at any point in a public or private utility system. The standard aims to ensure that harmonic levels are compatible with normal operation of equipment and do not cause interference or damage to other customers or equipment.

According to IEEE 519-2014, the maximum allowable total demand distortion (TDD) for current harmonics at a PCC depends on two factors: the short circuit ratio (SCR) and the individual harmonic order. The SCR is defined as the ratio of the maximum short circuit current at a PCC to the maximum demand load current at a PCC. The individual harmonic order is defined as an integer multiple of the fundamental frequency. The standard provides tables that show different TDD limits for different SCR ranges and harmonic orders.

For example, if a cyclo-converter has an SCR of 50 at a PCC, then its TDD limit for current harmonics is 5%. This means that its total harmonic current injection should not exceed 5% of its maximum demand load current at that PCC. Moreover, its individual harmonic current injection should not exceed 3% for odd harmonics up to 11th order, 1% for odd harmonics above 11th order, 1.5% for even harmonics up to 17th order, and 0.6% for even harmonics above 17th order.

Similarly, IEEE 519-2014 specifies the maximum allowable total harmonic distortion (THD) for voltage harmonics at any point in a utility system. The THD is defined as the ratio of the root mean square (RMS) value of all harmonic voltages to the RMS value of the fundamental voltage.

The standard provides tables that show different THD limits for different voltage levels and bus types.

For example, if a cyclo-converter operates at a voltage level of 69 kV or below, then its THD limit for voltage harmonics is 5%. This means that its total harmonic voltage distortion should not exceed 5% of its fundamental voltage at any point in that voltage level. Moreover, its individual harmonic voltage distortion should not exceed 3% for odd harmonics up to 11th order, 1% for odd harmonics above 11th order, 1.5% for even harmonics up to 17th order, and 0.6% for even harmonics above 17th order.

Reference from Datasheet of IC used:

Reference and Important pages/ figures from datasheet of any important IC that was used in the circuit.

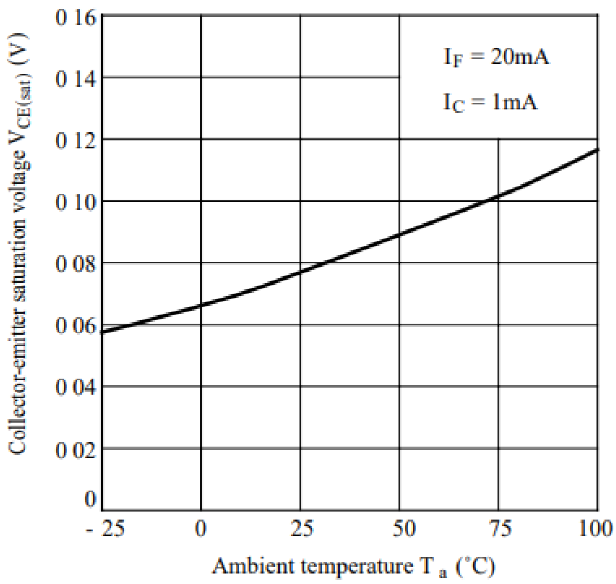
Answer:

Important pages and figures for PC817(Optocoupler) from the datasheet is listed below:

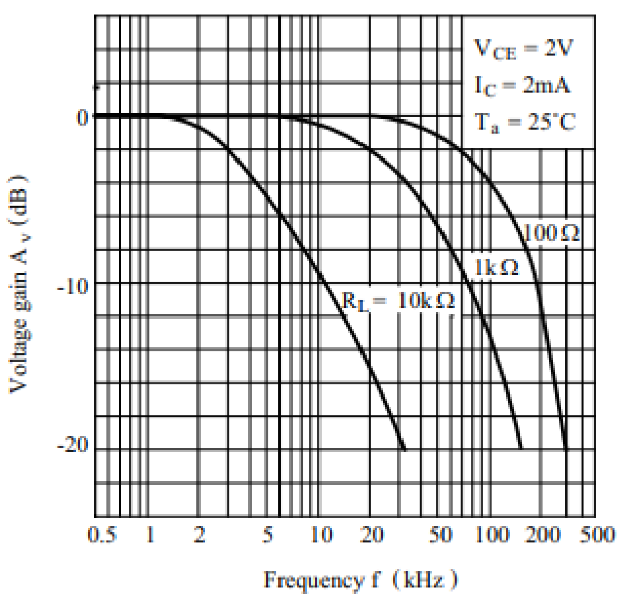
Absolute maximum Ratings:

Parameter	Symbol	Rating	Unit
Input Reverse voltage	V_R	6	V
Collector - Emitter Output Voltage	V_{CEO}	35	
Emitter-Collector Output Voltage	V_{ECO}	6	
Isolation Voltage	V_{ISO}	5000	V_{rms}
Input Forward Current	I_F	50	mA
Input Peak Forward Current (Note.1)	I_{FM}	1	A
Collector Current - Continuous	I_C	50	mA
Input Power Dissipation	P	70	mW
Collector Output Power dissipation	P_C	150	
Total Power Dissipation	P_{tot}	200	
Junction Temperature	T_J	125	℃
Soldering temperature	T_{sol}	260	
Operating Temperature	T_{opr}	-30 to 100	
Storage Temperature Range	T_{stg}	-55 to 125	

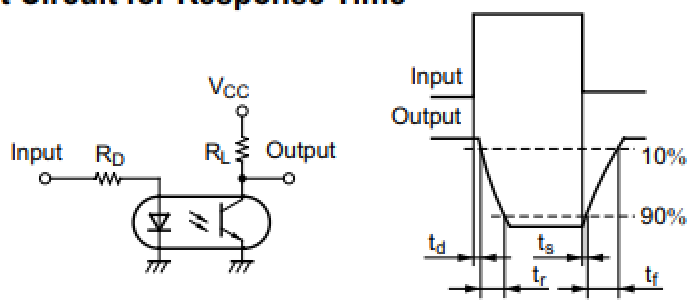
Collector-emitter Saturation Voltage vs. Ambient Temperature:



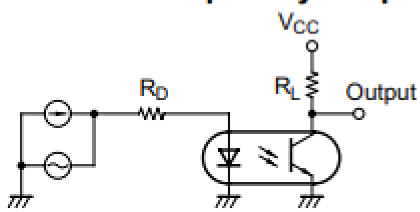
Frequency Response:



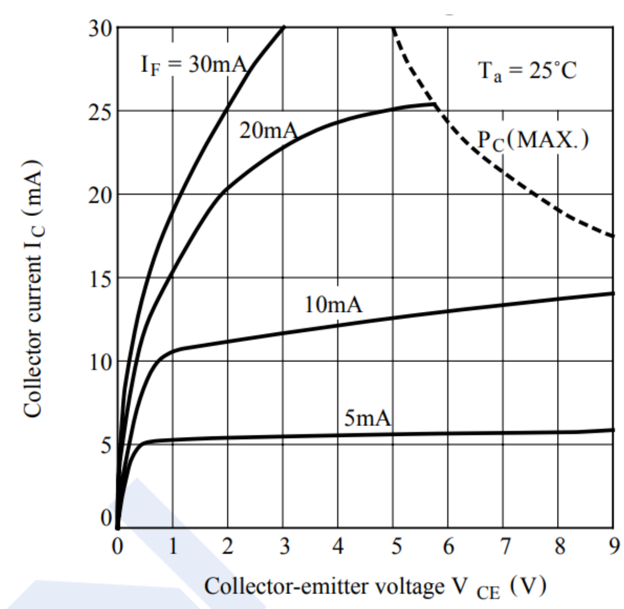
Test Circuit for Response Time



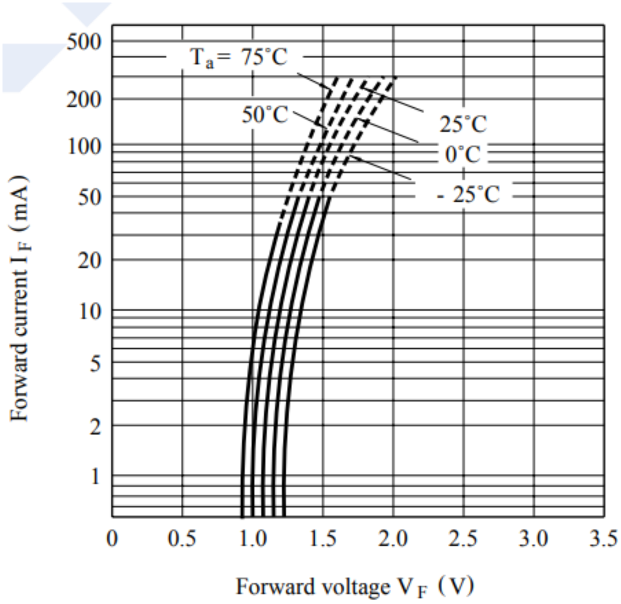
Test Circuit for Frepuency Response



Collector Current vs. Collector-emitter Voltage:



Forward Current vs. Forward Voltage:



Reference:

1)Electrical Characteristics at Ta = 25 degree C.

(page-01,datasheet of GUANGDONG KEXIN INDUSTRIAL CO., LTD.)

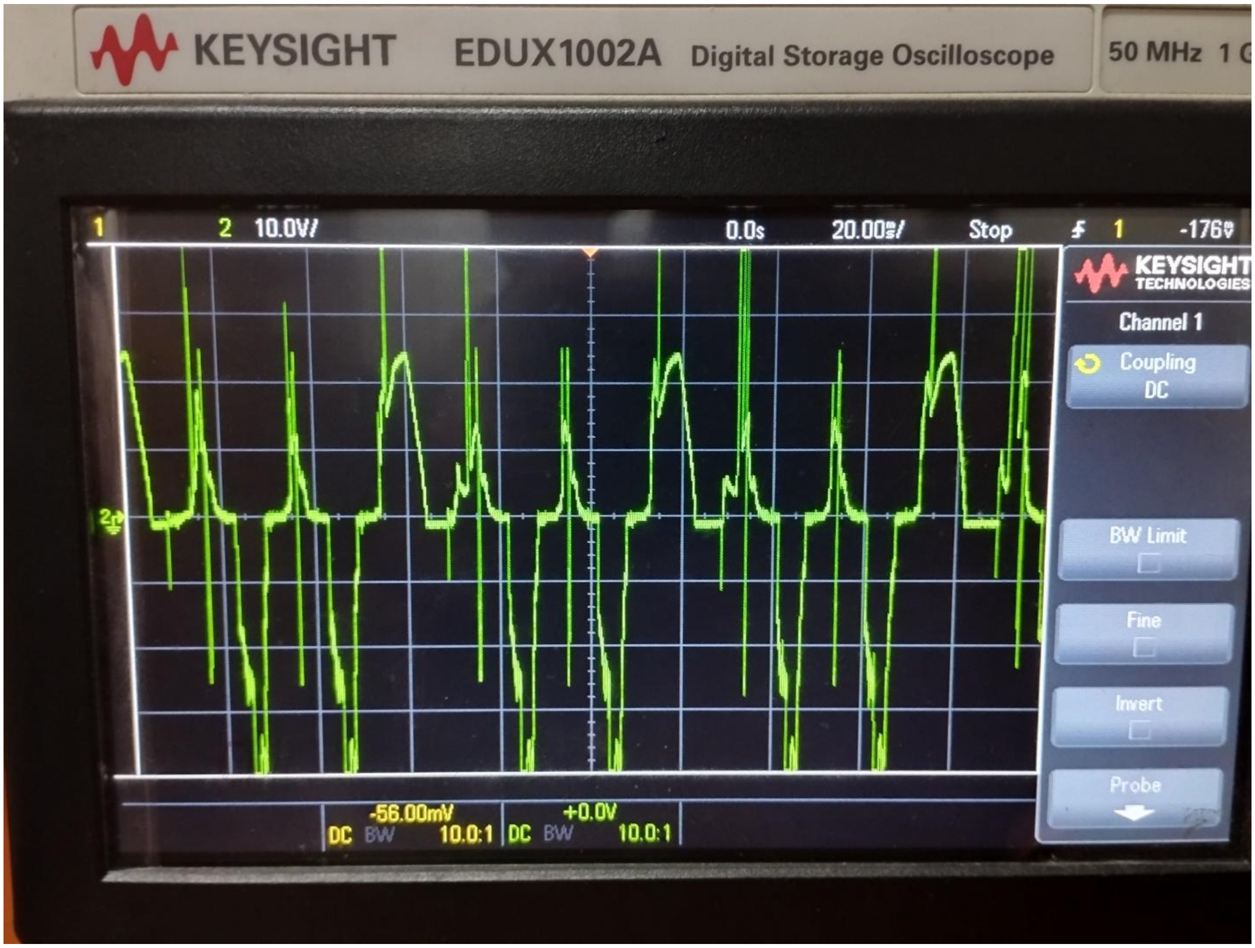
2) Response Time vs. Load Resistance(*page-04,datasheet of GUANGDONG KEXIN INDUSTRIAL CO., LTD.*))

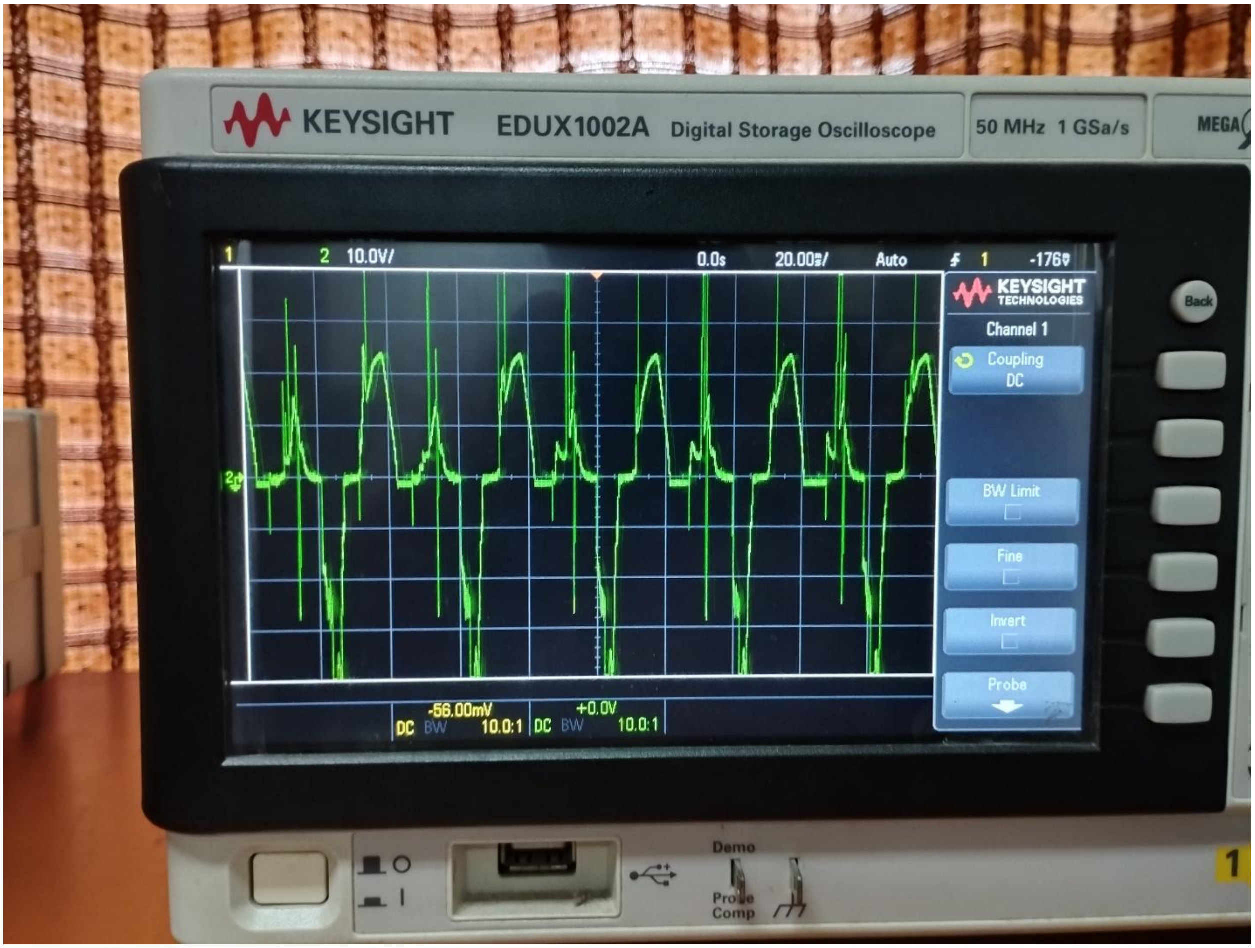
References:

https://circuitdigest.com/tutorial/cycloconverter-types-working-circuits-applications

https://www.researchgate.net/publication/328986183_Speed_Control_of_Single_and_Three_Phase_Induction_Motor_Using_Full_Bridge_Cycloconverter

Outputs from Laboratory :





KEYSIGHT
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50 MHz 1 GSa/s
1
2 10.0V/
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20.00ms/
Auto
1
Channel 1
Coupling
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BW Limit
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Probe
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Back
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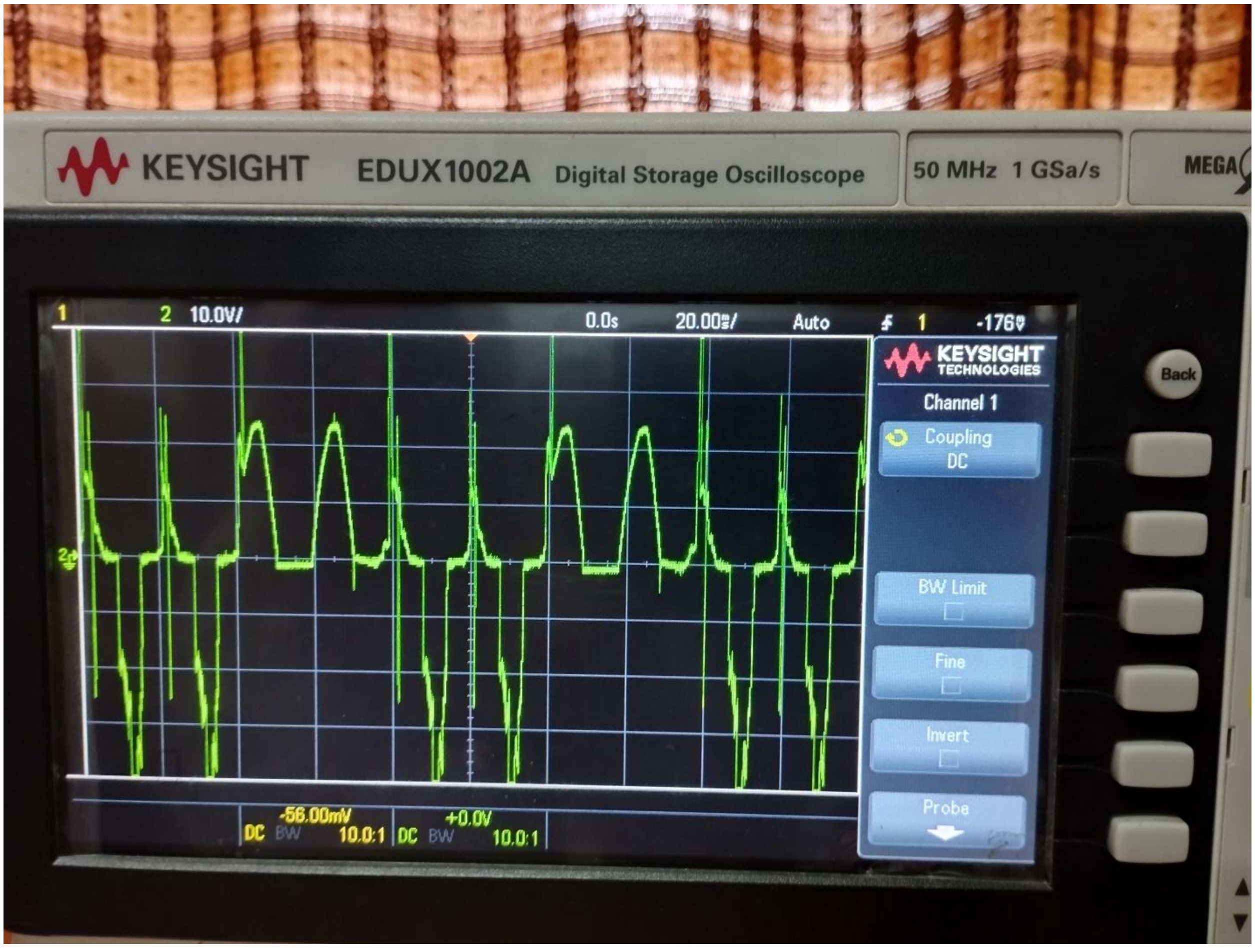
Probe Comp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