



Prince Mohammad University
Department of Electrical Engineering

Design and Implementation of Electrical Vehicle Using Three- phase Induction Motor

Abdulaziz Alsaleh	201700157
Abdulaziz Alsubaie	201303093
Hussain Alsubaie	201300242
Omer Malik	201202993

Advisor: Mr. Saifullah Shafiq

Co Advisor: Mr. Ahmed Abul Hussain

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Outline

- ❖ **Project Definition**
- ❖ **Project Objectives**
- ❖ **Project Specifications**
- ❖ **Project Architecture**
- ❖ **Background Problem & Previous Projects**
- ❖ **Design: Subsystems and Component Selection**
- ❖ **Testing**
- ❖ **Project Management & Team Work**
- ❖ **Planning**
- ❖ **Budget/Cost**
- ❖ **References**

Project Definition

Design and implement a fully electric vehicle by using three phase induction motor.

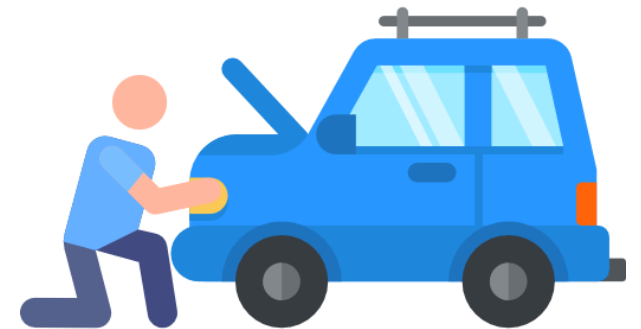


Project Objectives

- **Increase use of environmental friendly technologies**



- **Reduce maintenance cost of vehicles**

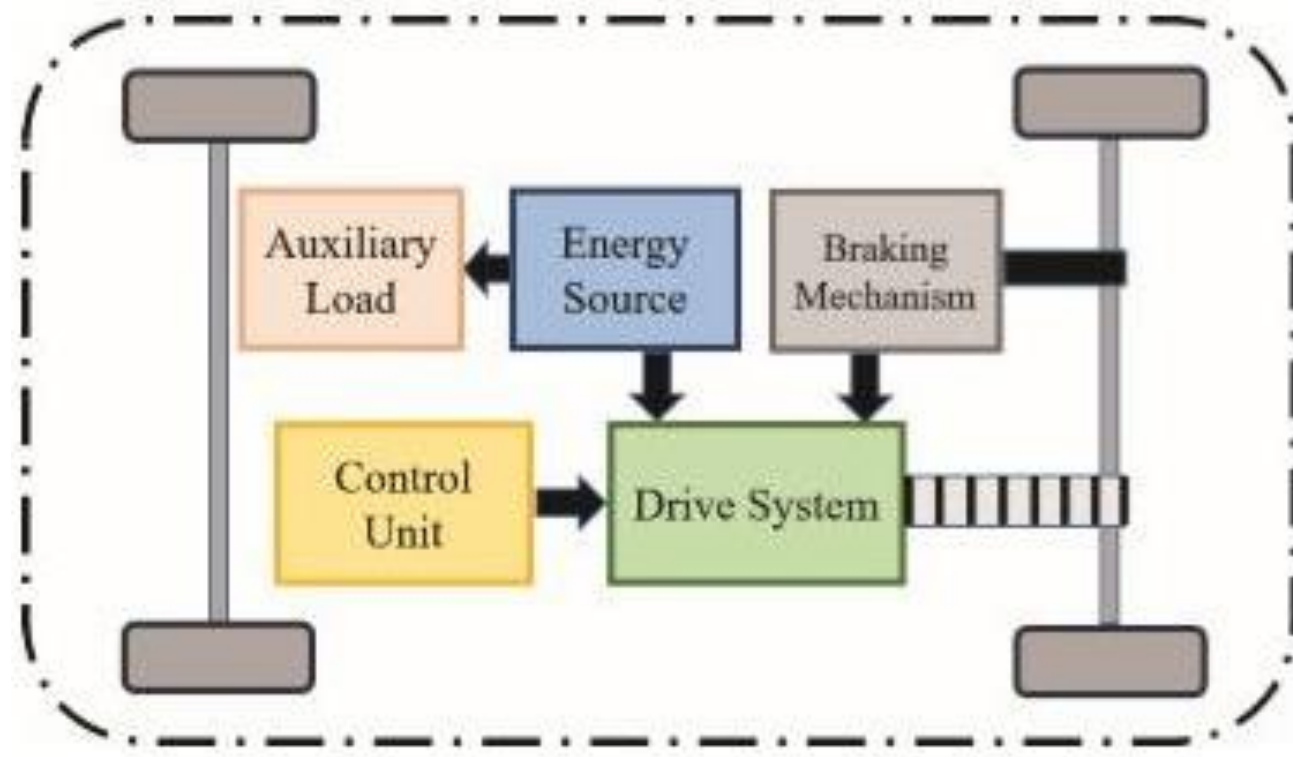


Project Specifications

- **Capacity for one passenger**
- **Speed up to 35 *km/h***
- **Battery charge lasts up to 20-25 km**
- **Use three phase induction motor (5.5 hp)**
- **Breaking mechanism**



Project Architecture

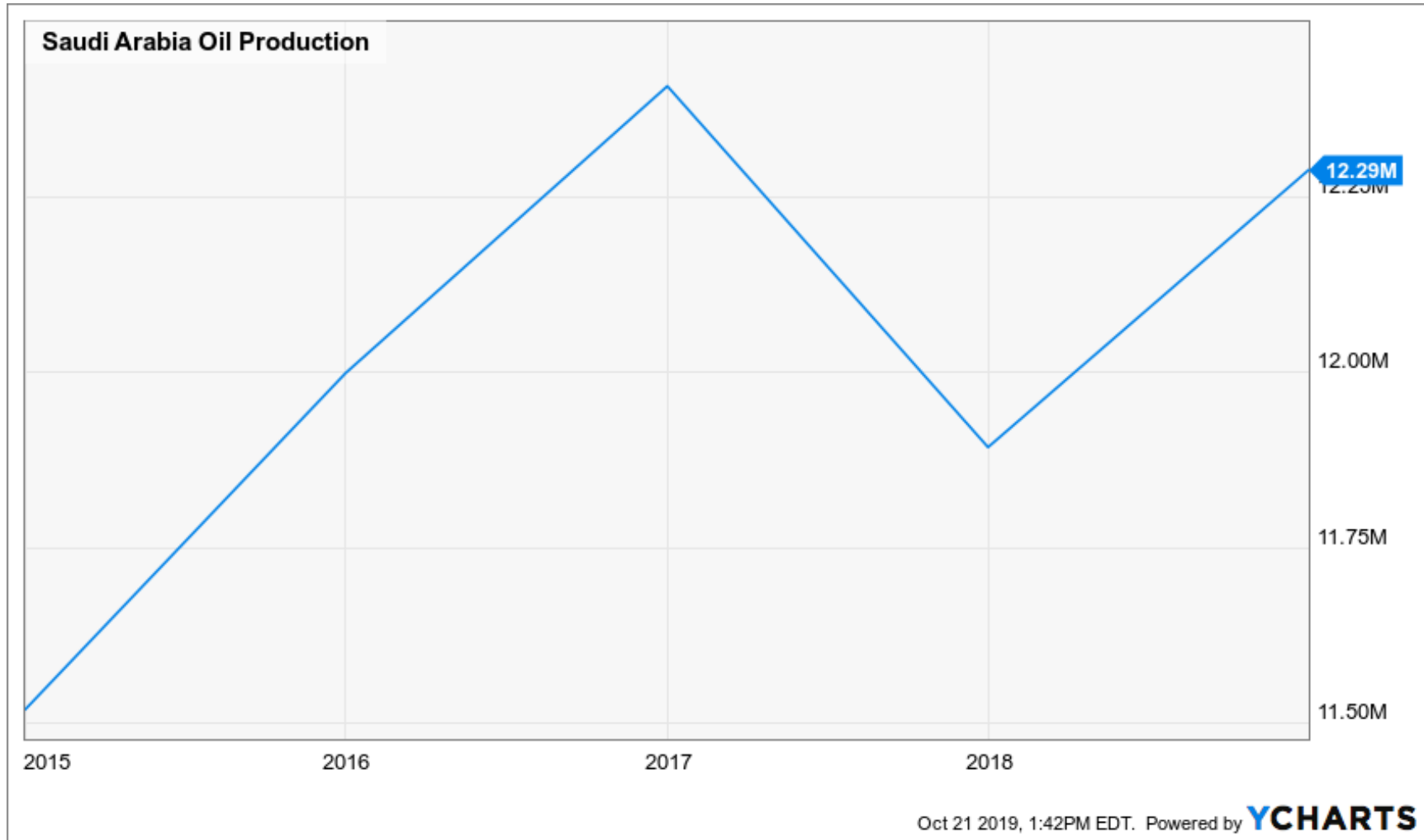


Background: Fossil Fuel consumption

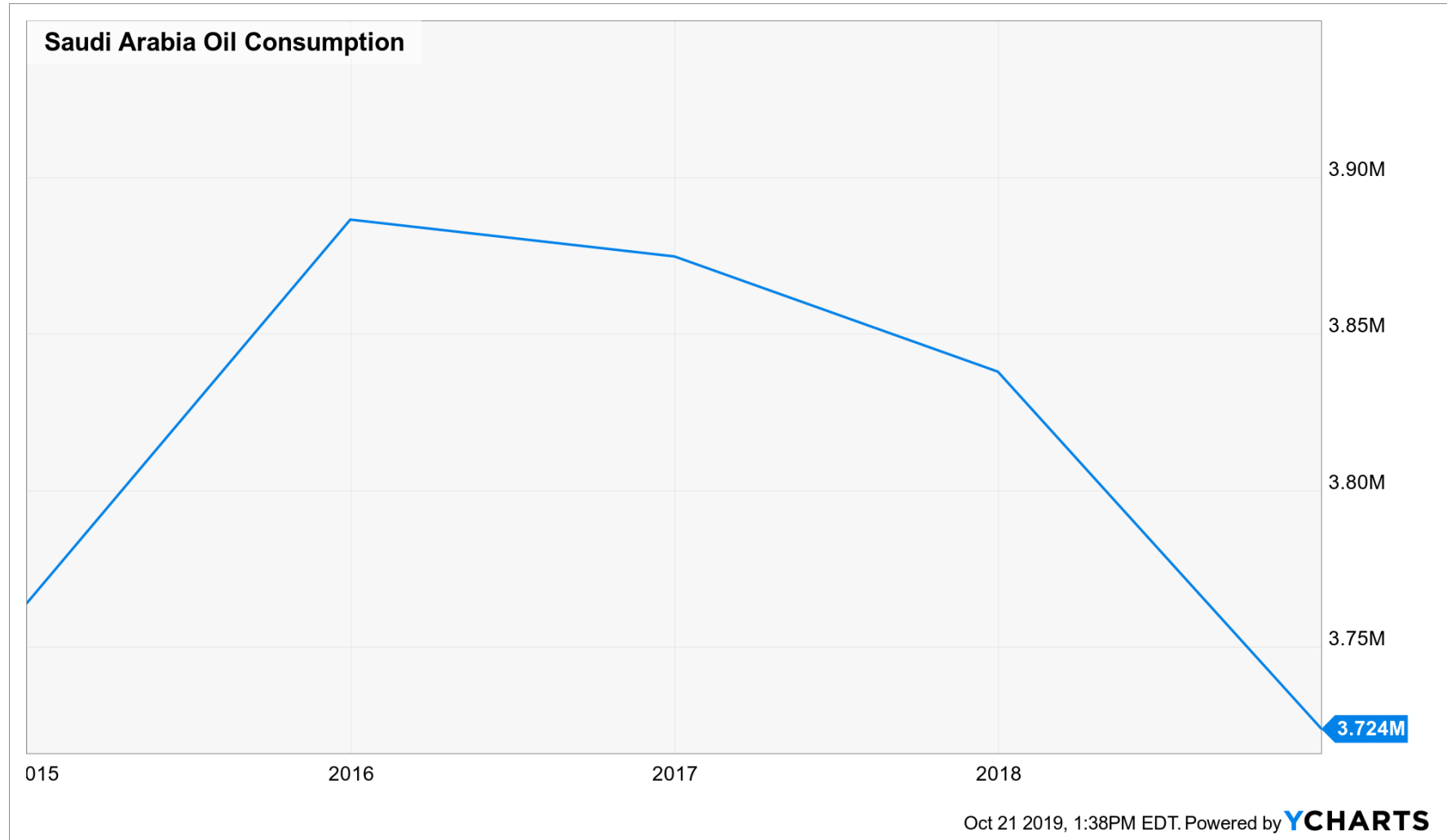
- **High oil consumption in Kingdom of Saudi Arabia.**
Saudi Arabia Oil Production vs. Oil Consumption



Production Summary Chart



Consumption Summary Chart



Background: CO₂ Emissions

- **Pollution due to high emissions.**

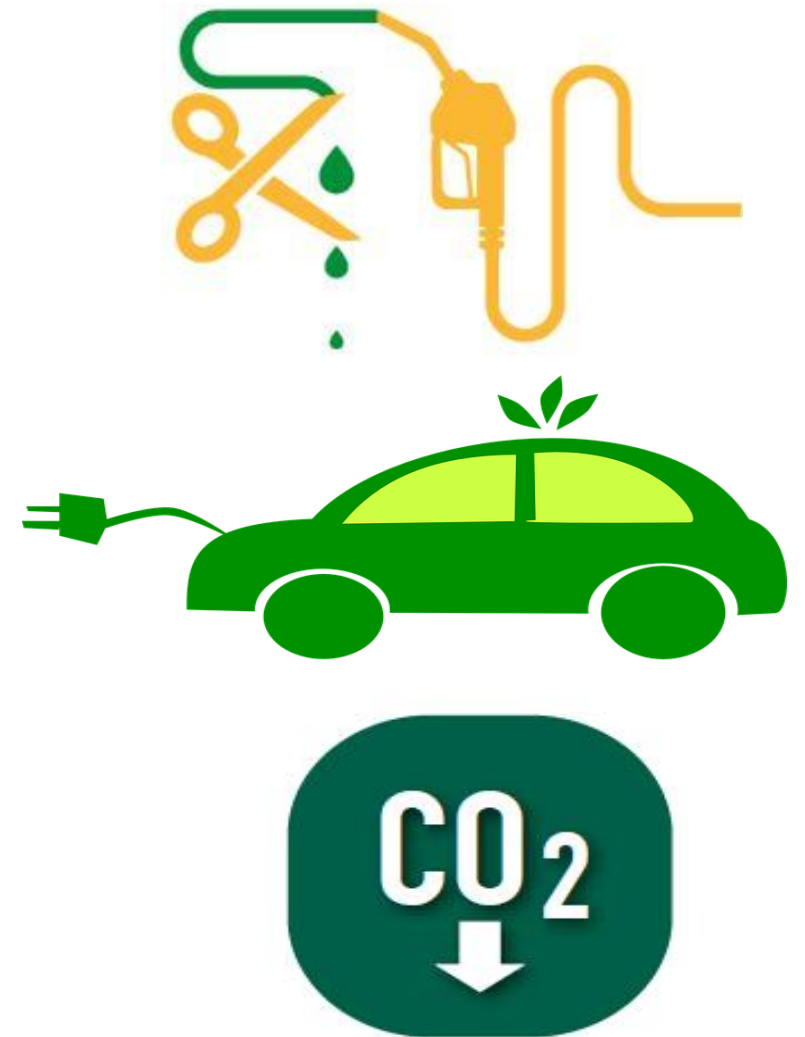


Planning for the Project

- **We did verify the project feasibility in local market.**
- **We verified that most of the components are available locally or can be ordered within a reasonable time.**
- **All the required testing have been performed at PMU Labs, also we confirmed that instruments and technical help are available.**

Background: Solution – Electric Vehicles

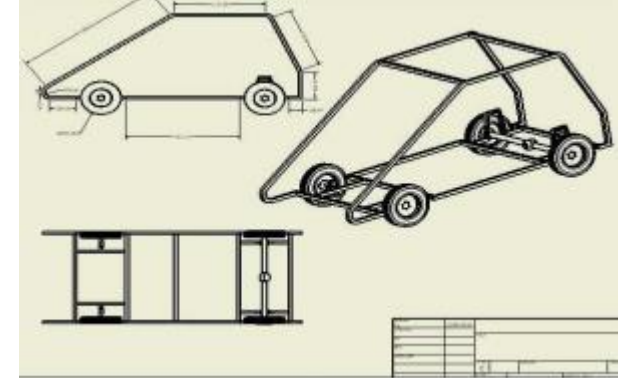
- Reduce fuel consumption significantly.
- Eco friendly transportation.
- Reduce green house emissions.



Previous Projects (I)

Construction of an Electric Vehicle Implemented in Egypt

- **Electric DC motor 15 hp, 3200 rpm ,and 72 V input.**
- **Suspension, steering and braking systems**
- **Eight batteries connected in series creating a battery pack of 64 V and 170 Ah.**

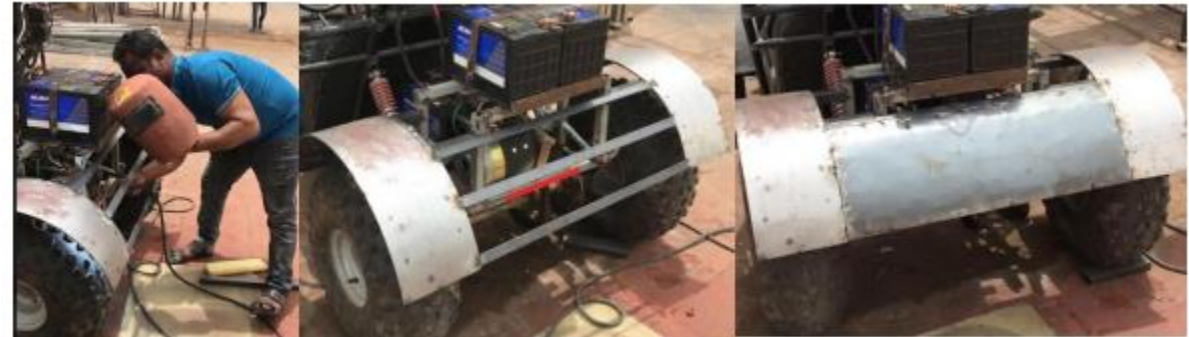


Previous Projects (2)

Fully Electric Car with Solar Cells as a Secondary Source of Power in PMU



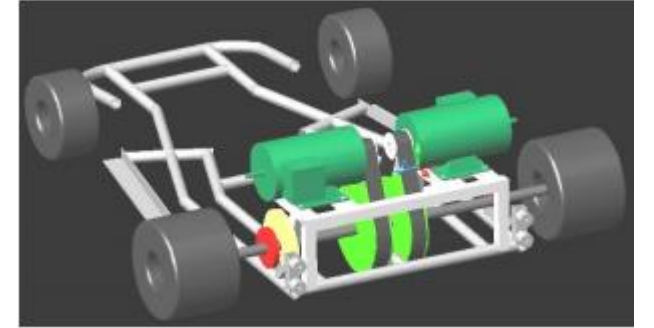
- **AC DELCO 12V 80 Ah Lead-Acid Battery**
- **XQ-3-4 Series DC motor**
- **Four batteries of 12V connected in series**



Previous Projects (3)

Small Personal Electric Vehicle as an Educational Project in Belgium

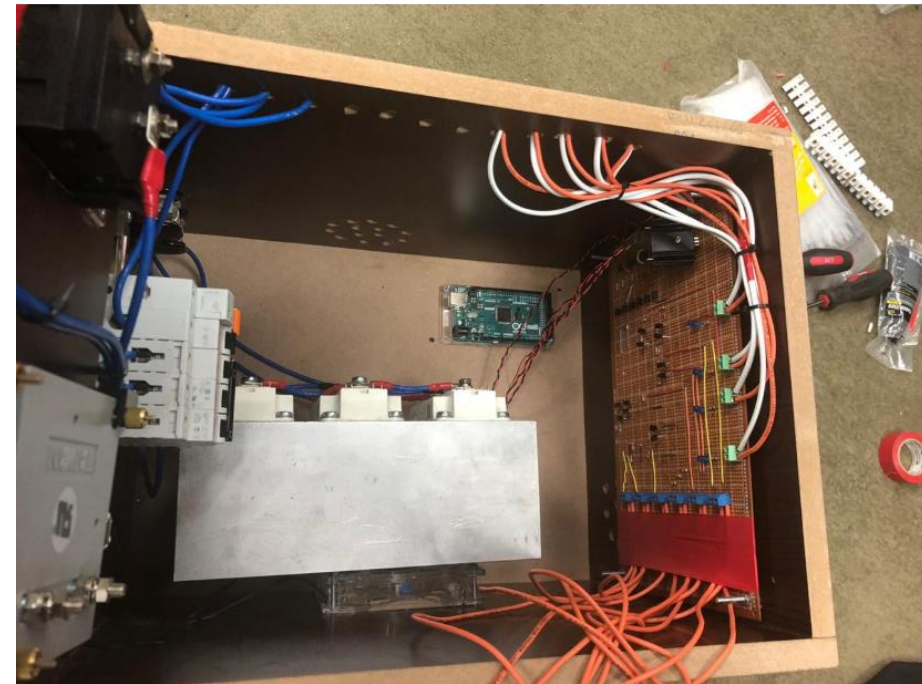
- **Three Phase Induction motor**
4 kW, 400 V, 3000 rpm
- **Maximum torque of 70 Nm at**
550 rpm
- **20 Batteries of 12 V and 12**
Ah.



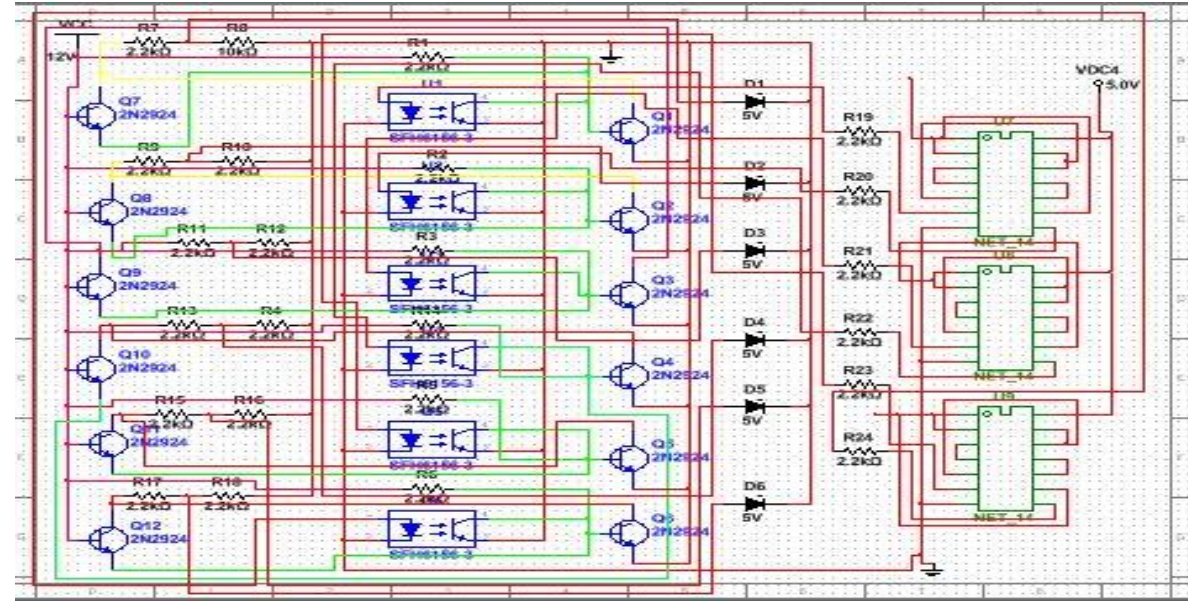
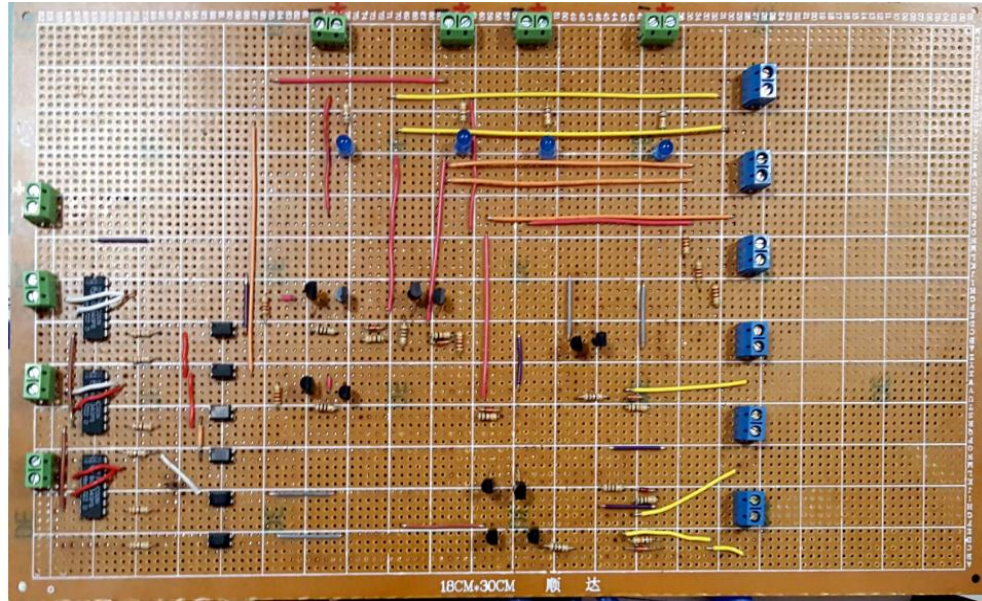
Previous Projects Summary

Projects	1	2	3	Our Project
Motor Type	DC Motor	DC Motor	Three Phase Motor	Three Phase Motor
Battery Type	Li-ion	Li-ion	Lead Acid	Lead Acid
Solar Panel	YES	YES	NO	NO
Inverter	NO	NO	YES	YES
Microcontroller	Arduino	Arduino	Arduino	Arduino

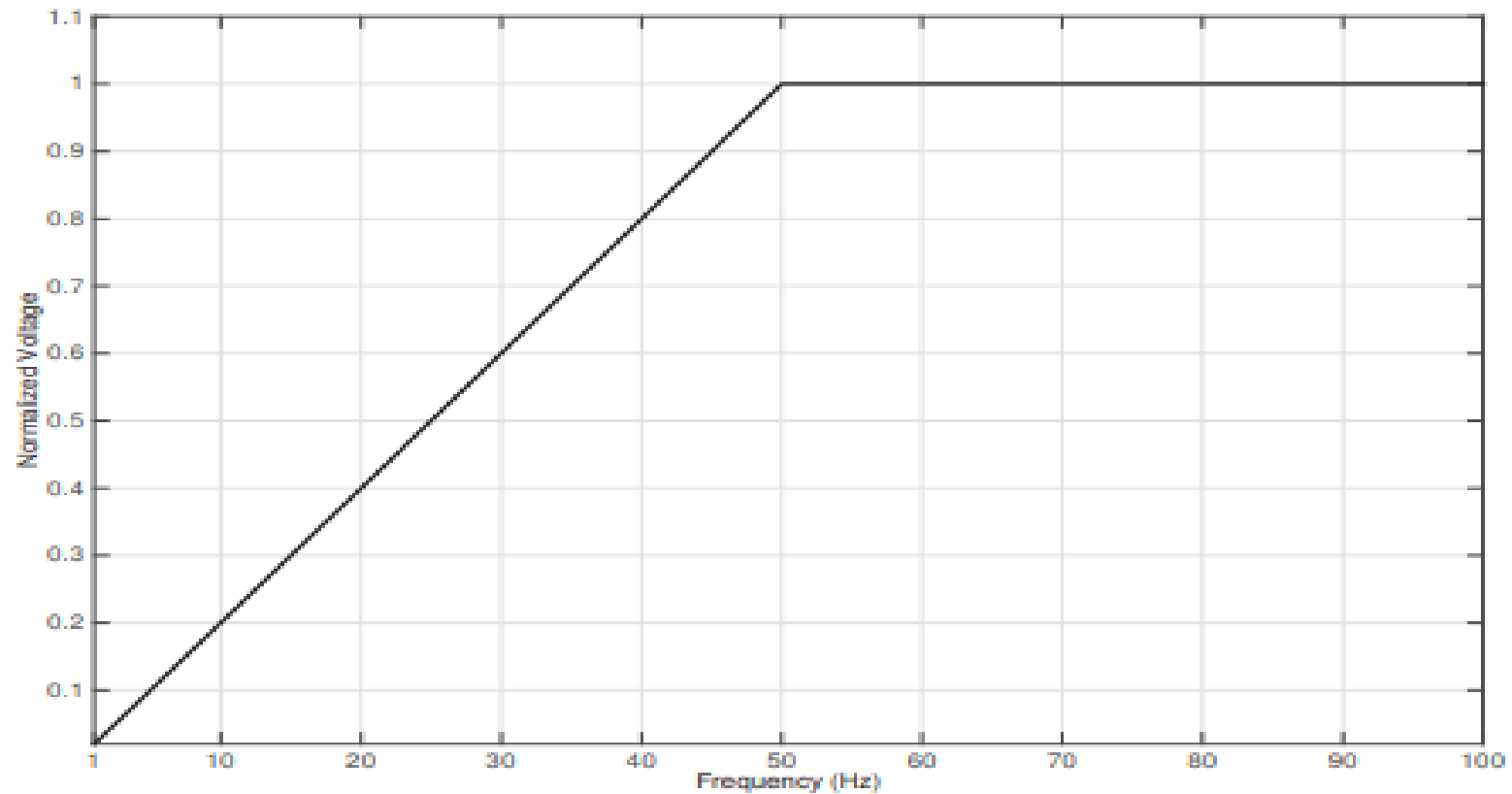
Design: Sub 1 & 2 Gate Driver & Inverter



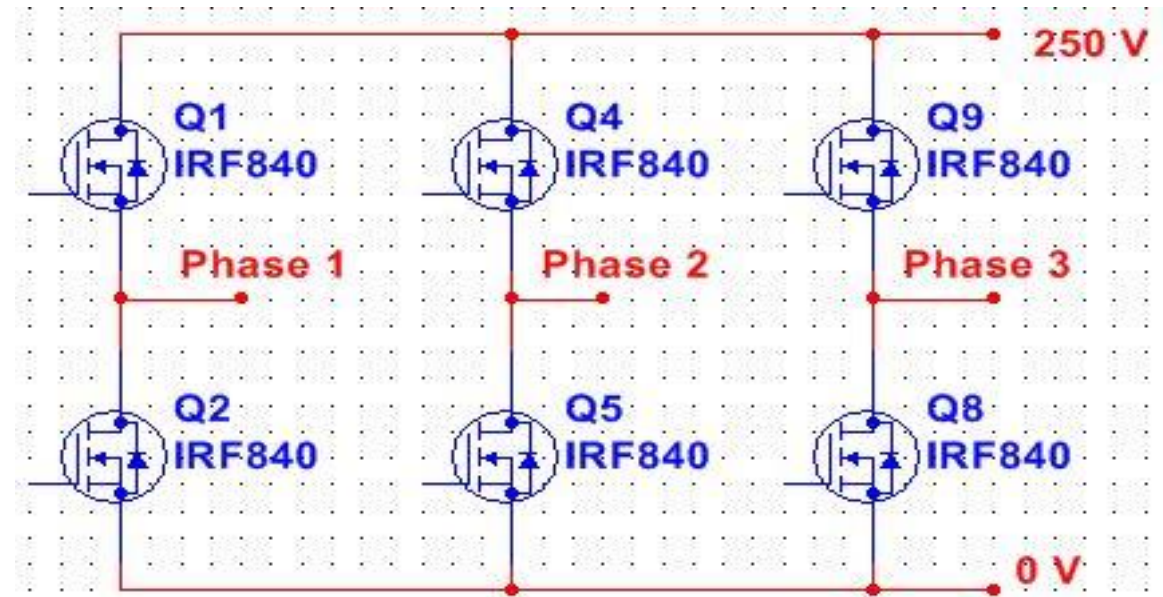
Design: Subsystem #1 Gate Driver



Design: Implementation of VFD using Microcontroller

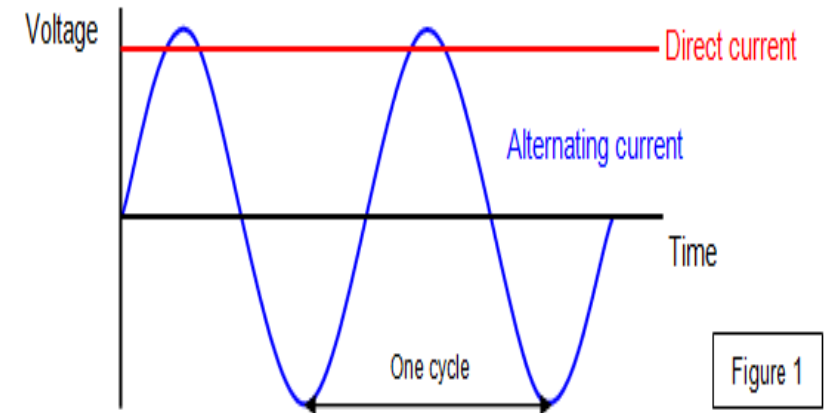


Design: Subsystem #2 Inverter

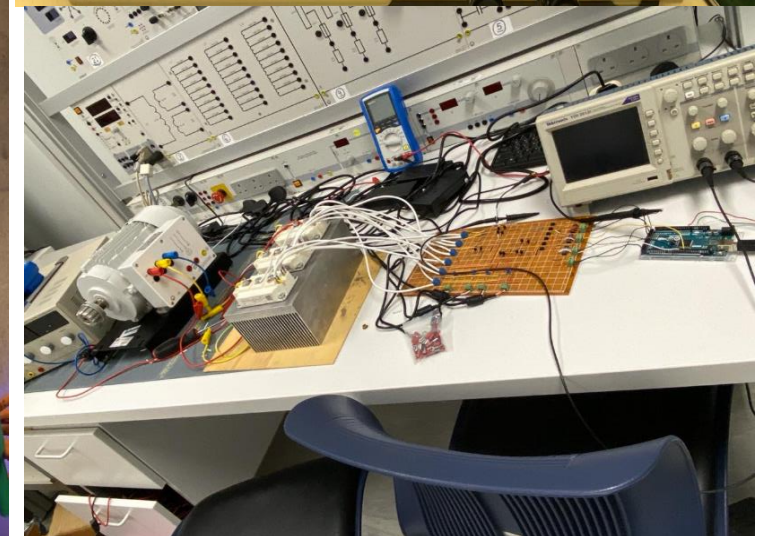
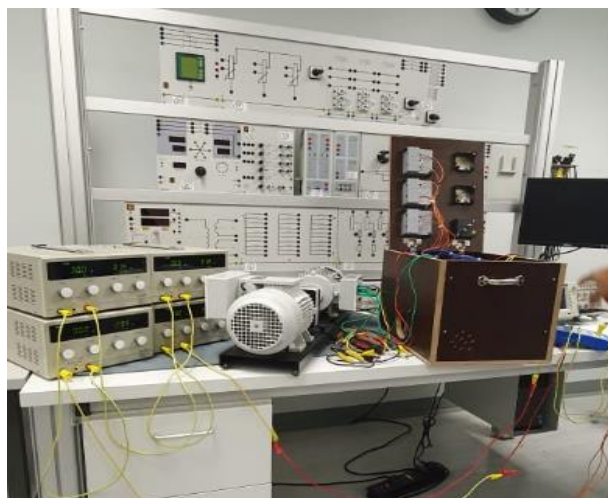
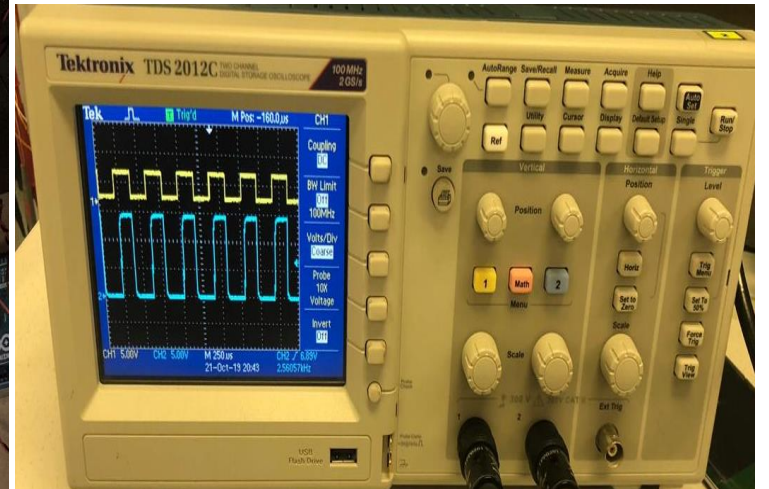
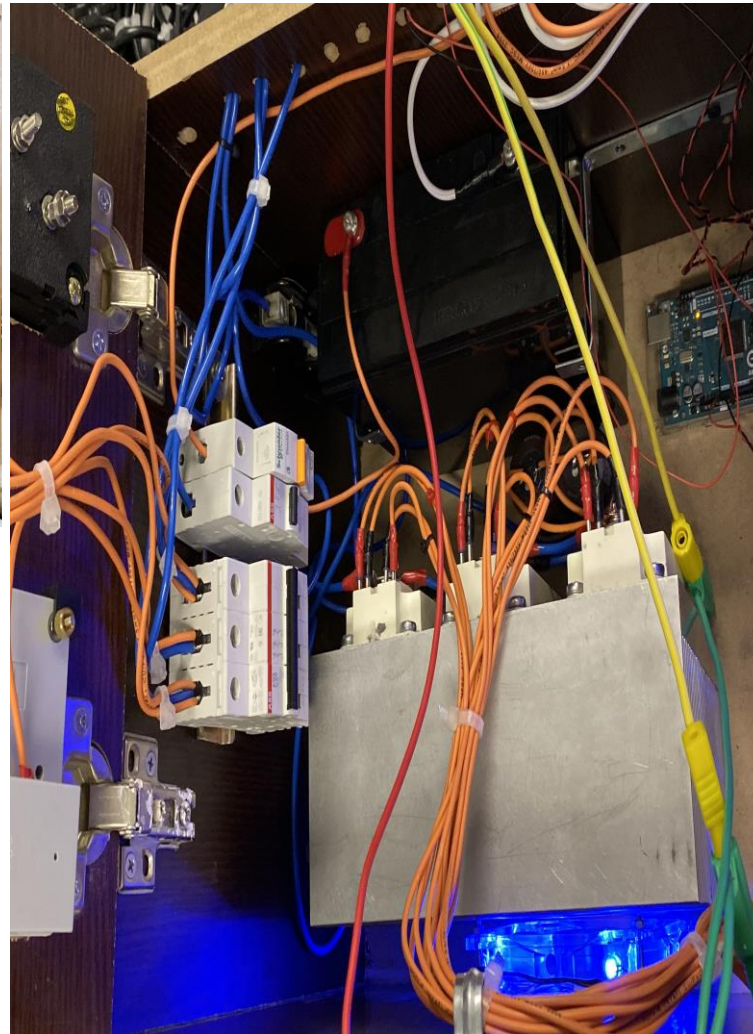
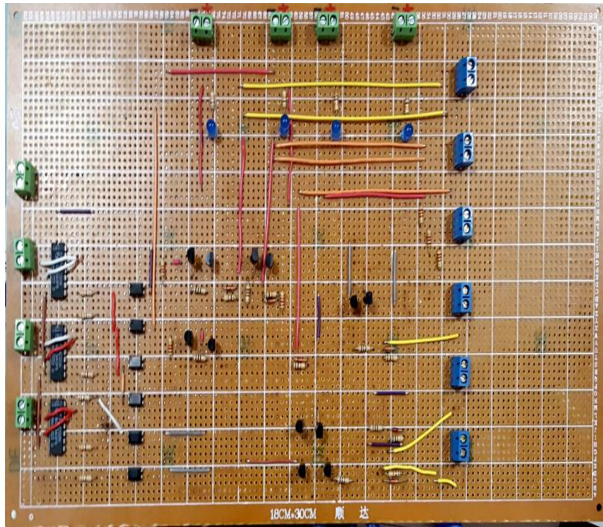


Description of Inverter

- The idea of making an inverter to convert the direct current (DC) to alternating current (AC)



Testing Gate Driver & Inverter

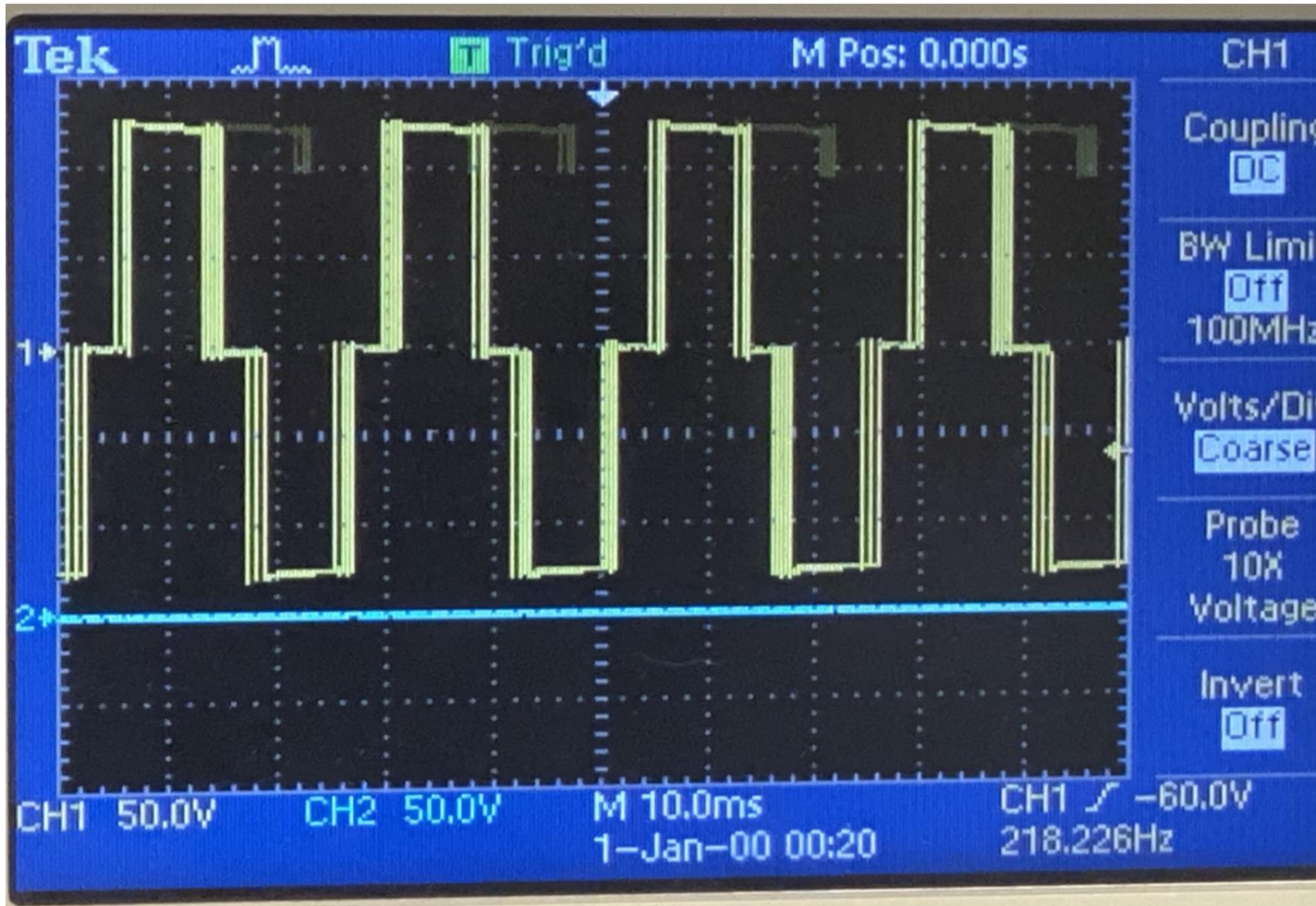


VFD Test :

Sinusoidal square wave



VFD Test : (Quasi square wave)



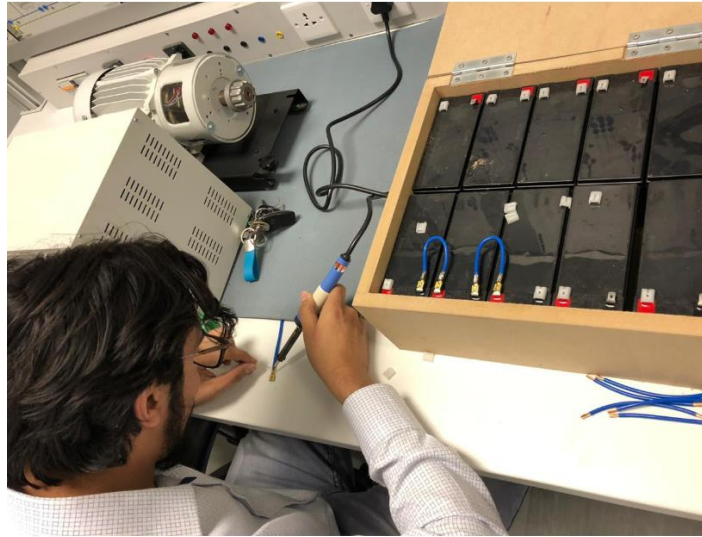
Challenges

- There is a reverse voltage coming from induction motor when motor stopped which becomes a major cause of burning our two IGBTs
- Solution : Replacing two IGBTs and adding two capacitors of 400 V in series across 2 IGBTs so that capacitors will suck the reverse voltages with opposite polarities coming from motor.

Improvement

- We can add a switch that can control the motor to move forward or backward and required only changing in programming.
- We can add solar panel to charges the batteries.
- We can increase the speed of car up to 80 km/h
- We can add sonar sensor to indicate the driver while parking.

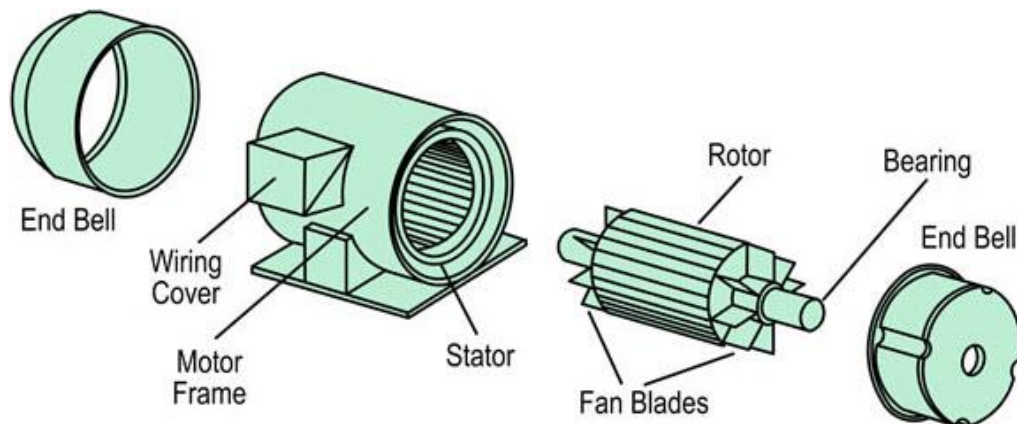
Design: Sub 3&4 Motor & Batteries



Design: Motor Specification

Three Phase Induction Motor

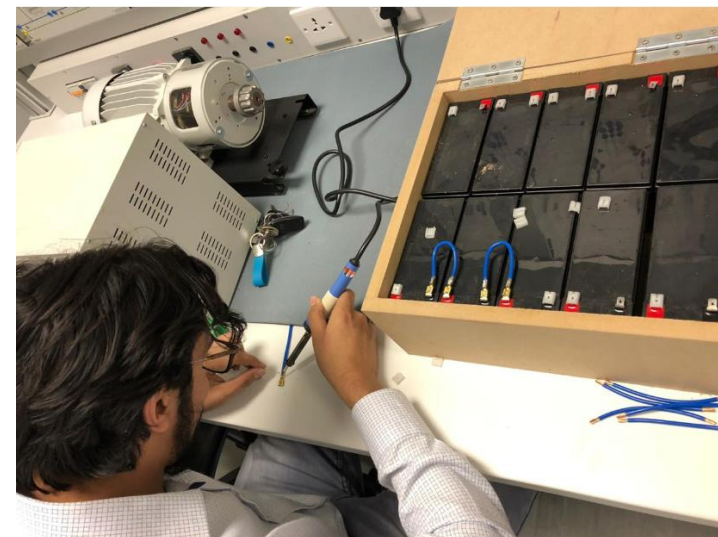
Motor Horse Power	5.5hp
POWER = Numbers of HP x 746W	4103 W
INVERTER: 240V AC	12 kW
Weight of the motor	55 kg



Design: Batteries Specification

Lead Acid Batteries

Number Of Batteries	18	
Voltage For Each Battery	12V	216V
Ampere-hour For Each Battery	9Ah	
Weight For Each Battery	2.4 kg	43.2 kg



Design: Operational Calculations

No. of batteries required: $\frac{220 \text{ VDC}}{12 \text{ V}}$	18
Battery Capacity Available	$12\text{V} * 18 * 9\text{Ah} = 1.944 \text{ kWh}$
Weight	$(2.4 \text{ kg}) \times (18 \text{ batteries}) = 43.2 \text{ kg}$
Average Current drawn by motor	13 A
Duration	$\frac{1.944 \text{ kWh}}{(18 * 12) * 13} = 0.7 \text{ h} \approx 45 \text{ minutes}$
Charging time	Depends on charging current. If charging current is 9 A it will take 1 hour

Design: Structure

Chassis Specification	
Height	1.5 m
Weight of chassis	120 kg
Weight with battery, motor load and passenger	336 kg
Width	1.2 m
Length	1.6 m

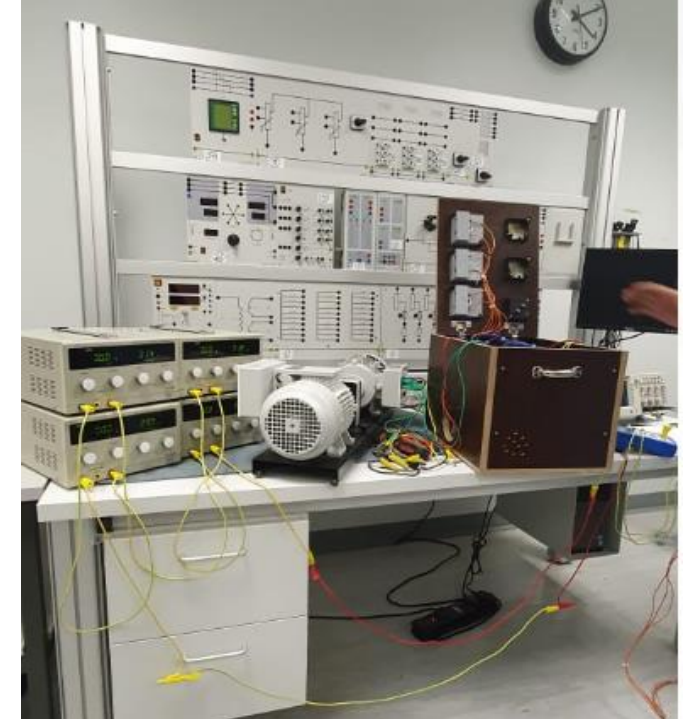


Design Problems: Other Option Comparison

Batteries		
Type	Lead Acid	Li-ion
Cost	Low	High
Safety	Good	Poor
Charging time	8 hrs	2-6 hrs
Weight	Heavy	Light

Motor		
Type	Three Phase	Single Phase
Cost	Low	High
Size	Small	Big
Efficiency	Very Good	Poor

Testing and Installation



Project Management Plan

Smart Electric Car		Advisor: Mr Saifullah Shafiq					Design II (ASSE 3)					Fall 2019									
Abdulaziz Alsaleh (AAA)		Project PLAN & Progress																			
abdulaziz Alsubaie (AAS)		ProgRpt No. 4																			
Hussain Alsubaie (HAS)		Plan updated (Date): NOV 7, 2019																			
Omar Malik (OM)		Instructor: Dr. Sadiq Alhuwaidi																			
		Period Highlight: 4					Plan					Actual									
		Actual (beyond plan)					Complete (beyond plan)														
ACTIVITY		PLAN	PLAN	Assigned	ACTUAL	PERCENT	Periods (Weeks 1-15)														
		TARGET	START	To	START	COMPLETE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Designing Gate Driver circuit on veroboard		1	1	OM	2	2	100%														
Testing Gate driver on veroboard		2	1	OM	2	2	100%														
Designing Inverter circuit on veroboard		2	1	OM	2	3	100%														
Testing inverter on veroboard		2	1	OM	3	5	100%														
Programming STM 32		2	7	AAA	3	8	90%														
Buying Motor and adjusting torque		3	2	AAS	6	2	100%														
Buying Batteries		3	4	HAS	7	2	100%														
Buying Gearbox		4	4	HAS	7	2	100%														
Preparing midterm presentation		5	4	AAS	6	1	100%														
Testing Motor		5	2	ALL	3	1	100%														
Testing Batteries		6	5	ALL	3	1	100%														
Testing Gearbox		7	3	ALL	3	1	100%														
Connecting the gate driver with inverter and motor		5	3	OM,AAA	6	2	100%														
Checking the breaking mechanism		8	2	ALL	3	1	100%														
Changing the tires		9	2	ALL	3	1	100%														
Adjusting chasis(Implementing components in the E		9	3	ALL	3	1	100%														
Drive test		10	4	ALL	0	0	100%														
Prepape final report		10	2	ALL	0	0	85%														
Prepape final presentation		11	1	ALL	0	0	100%														
Prepare project demo		12	3	ALL	10	1	100%														
Submit Rpt/PPT/Brochure ...		13	2	ALL	0	0	100%														
Progress Details for the third meeting:							Issues (delay -):														
tested on motor, battery and gearbox							No issues														
checked the breaking mechanism							No issues														
implemented the components except for few							No issues														
changed the tires							No issues														
connect the gate driver with the inverter and motor							No issues														

Project Management & Team Work

- **Team work task division**

Task	Abdulaziz	Abdulaziz Alsubaie	Hussain	Omer
Search & acquire components	10%	50%	30%	10%
Design & Implement Subsystem 1	25%	25%	25%	25%
Design & Implement Subsystem 2	25%	25%	25%	25%
Testing	25%	25%	25%	25%
Write Reports & Presentations	25%	25%	25%	25%

Cost

Item	Quantity	Unit Cost (SR)	Subtotal (SR)
Chassis	1	1500	1500
Tires	4	150	600
3- ϕ induction motor	1	4000	4000
Arduino	1	300	300
Inverter	1	1500	1500
Batteries	24	100	2400
Total Cost			10,300

References

- https://ycharts.com/indicators/saudi_arabia_oil_production
- https://www.researchgate.net/publication/266588079_Construction_of_an_Electric_Vehicle_Implemented_in_Egypt
- <https://www.quora.com/What-is-the-difference-between-1-phase-and-3-phase-induction-motors>
- <http://investors.st.com/news-releases/news-release-details/stmicroelectronics-locks-stm32-advantages-new-megabyte-devices>



Thank you

Questions/Suggestions?