CHAPTER 1
INTRODUCTION

1.1 Project Background

The interest in generating electricity from the flow of moving vehicles has existed for many decades. However, designing a device providing a safe and efficient means to convert the energy from moving vehicles to electricity has been elusive. The Highway Power Harvester offers a design that is unobtrusive to the motoring public and efficient at converting the energy of moving vehicles to electricity. It will incorporate safety features for motorcycles, and does not result in a lack of control or comfort to those travelling over it.

The Highway Power Harvester provides a means to produce power 24 hours a day. It can be built to provide small amounts of power for special needs and multiple units can be linked to produce greater quantities of power. The highway in Malaysia served well for providing a means to travel from one place to another. Our roads have millions of vehicles travelling over them, and the energy from these moving vehicles can be effectively harnessed for producing electricity.

Devising a safe, simple and effective means to convert the energy of passing vehicles into electricity would assist in reducing the need for other electricity producing means while providing a cheap, clean and useful source of electricity.

1.2 Problem Statement

Power is needed to support the lighting along highway especially at night. Countries spend a lot of money for maintenance and supply the power to highway. The power supply to the highway can be use to for other purpose id the lighting power can be generated by alternative means.

Other inventions have attempted to harness the energy of motion using treadle plates, pneumatic devices and complicated gearing mechanisms. Although these inventions capture some energy from passing vehicles and convert it into electricity, they have several disadvantages:

1. Some of the previous inventions stand in their ready state of operation as an obstacle protruding in the roadway. This is true for those devices using treadle plates. As motorists are generally accustomed to travelling on smooth roads, obstacles in the roadway would cause a driver to react instinctively by swerving or otherwise trying to avoid running over them.[2]

2. The other inventions do not consider the variety of vehicles on the road ranging from light trailers to motorcycles to large 80,000 lbs trucks. In the case of the inventions using treadle plates some motorcycles or trailers could end up on either side of the plate causing difficulty in balance or control.[2]

3. In other previous inventions, the apparatus for contacting the vehicles as they pass are initially flush with the road surface but then give slightly, are depressed below the road level, or drop slightly in order to trigger a mechanism. This disruption to the vehicle would naturally lead to a sense of loss of control and uncomfortable ride.[2]

1.3 Objective and Scope of study

- To design a system can generate power from moving vehicles
- To analyze the system by Multisim software
- To design a model for highway power harvester.

1.4 Scope of project

The scope of study will involve power analysis related to the power generation and distribution. It also involve the knowledge technology for saving energy such as understanding the principle of the amount of energy that can be captured from the car at the highway and can generate the energy or power to distribute for a lot of uses. This project also needs the knowledge of power electronics that is necessary to build the inverter circuit.

1.4.1 Relevancy of the Project

The purpose of this project is to design a simple prototype highway power harvester. The technology is still infancy in Malaysia.

1.4.2 Feasibility of the Project within the Scope and Time Frame

This project will start by collecting the reading material such as the books, journals, related website and discussion with supervisor. During the time allocated for Final Year Project (FYP) 1, this project target's is to setup the prototype. During the FYP 2 period, the target is to get more data and analysis for different condition of situation.

CHAPTER 2
LITERATURE REVIEW

2.1 Generate Energy from Vehicle

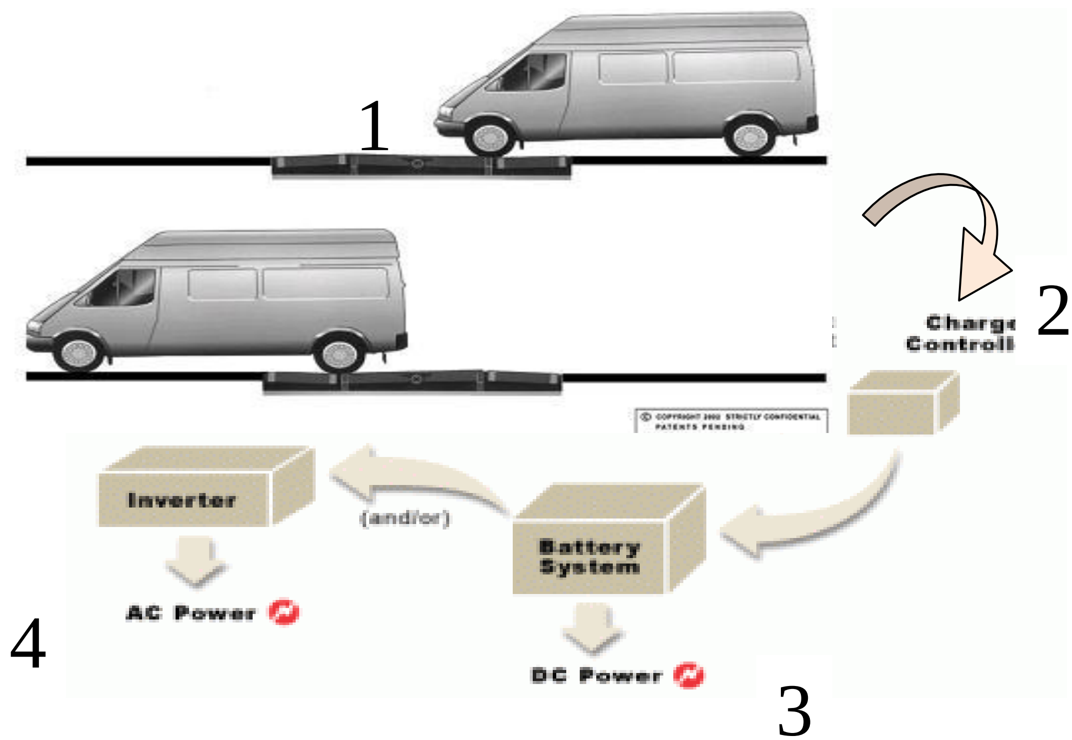

Figure 1: Schematics of energy generators from moving vehicles

The figure 1 shows, progress how the power/energy is generated from moving vehicles. The vehicles pass the soft surface at road and for the same time the piezoelectric becomes active. The force from this moving vehicle will convert to electric energy. The charge controller, battery system and inverter are part of equipment use in this project.

2.2 Piezoelectric

Piezoelectricity is the ability of some materials to generate electricity in response to applied mechanical stress. The effect is closely related to a change of polarization density within the material's volume. If the material is not short-circuited, the applied stress induces a voltage across the material. The word is derived from the Greek piezo or piezein, which means to squeeze or press. The effect finds useful applications such as the production and detection of sound, generation of high voltages, electronic frequency generation, microbalances, and ultra fine focusing of optical assemblies. It is also the basis of a number of scientific instrumental techniques with atomic resolution, the scanning probe microscopies such as STM, AFM, MTA, SNOM, etc., and everyday uses such as acting as the ignition source for cigarette lighters and push-start propane barbecues.[6] Figure 2 shows when piezoelectric have force they will produce a voltage. Figure 3 shows the type of piezoelectric will use in this project.

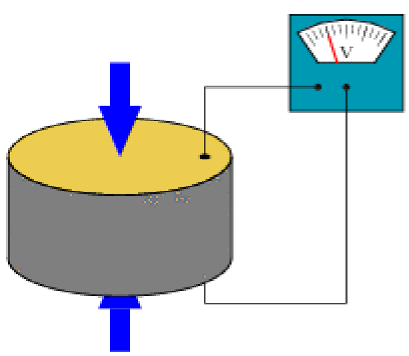

Figure 2: A piezoelectric disk generates a voltage when deformed. [6]

Figure 3: Piezoelectric Component

In theory, the piezoelectric will generate the voltage if there is a force on it. The voltage output from this component is small around 0.0001 volts for 10 Newton of force. If we connect series, the voltage output can be large. For example 100 pieces of the piezoelectric connect in series, the 0.01 volt for 10 Newton. The voltage will bigger when the piezoelectric have big force and the series connection is also one of factor the voltage output increase.[8] The light vehicles are 825kg and heavy vehicles are 5000 kg until 7000 kg.[7] Table 1 show, type force of vehicle and output voltage for using piezoelectric.

Table 1: Calculation based on mass, speed of car and output voltage

Type of vehicle	Mass (kg)	Speed (Km/s)	Force F=ma	Voltage (V)	Voltage if 100 piezoelectric
Light vehicle	825	1 (min)	825 N	0.011 V	1.1V
Heavy vehicles.	5000-7000	1 (min)	7000 N	0.93 V	9.3V

Table 2: Formula of Force and Piezoelectric [8]

Mechanical Force	**Piezoelectric**
F= ma F= Force m = Mass (Kg) a = acceleration (m/s^2)	**q= g33*F q= cv** q= charge v=voltage c= dielectric constants (1800) g33 = 24.0 x 10^{-3} (refer piezo guidelines)

2.3 Charge controller

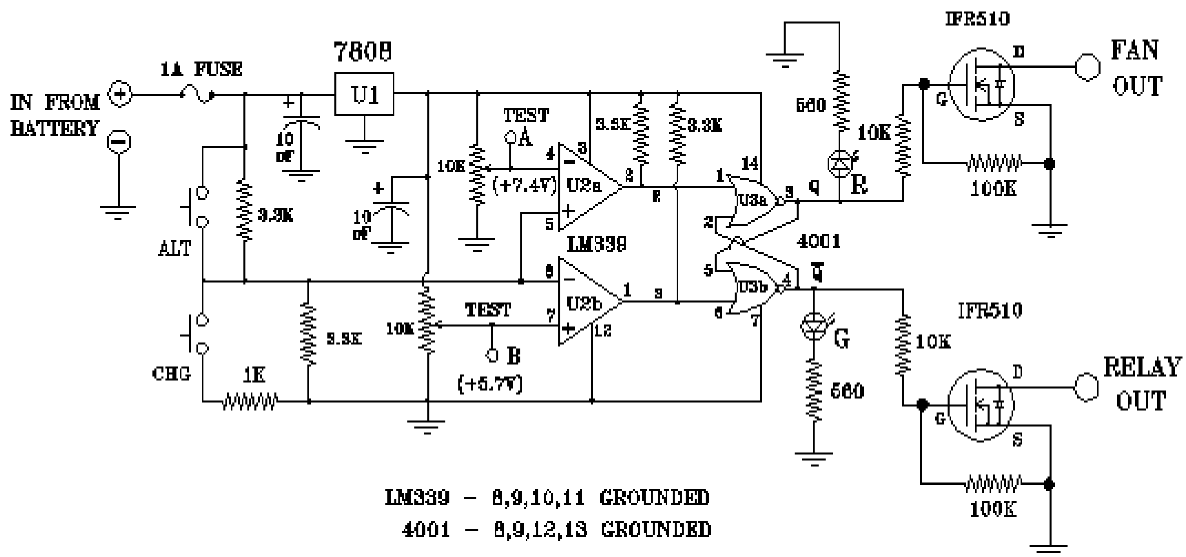

Figure 4: Schematics of charge controller [4]

The schematics show the simple charge controller circuit. The incoming battery voltage is divided half by a pair of 3.3k resistors, so trip points are adjusted to one-half the desired levels. The actual trip points will depend on particular batteries, but a good starting point is 14.5 volts for full-charge and 11.8 volts for discharged. The trimpots should adjust to read 7.4 volts at TP-A and 5.7 at TP-B. [4]

The outputs of the controller are latched, and drive a pair of IFR510 power FETs, which serve as relay drivers. If we use double-throw relay, only one output is necessary, since the relay can switch the incoming power either the batteries or the alternate load as required. The second output can be used to switch a small 12 volt DC muffin fan to vent hydrogen gas from the battery enclosure to prevent the danger of explosion when charging batteries. [4]

2.4 Inverter

The inverter is an electrical device that converts the direct current (DC) to the alternating current (AC). The conversion of alternating current can be done at any voltage and frequency depends on the suitable use of transformer, switching and control circuits. [5]

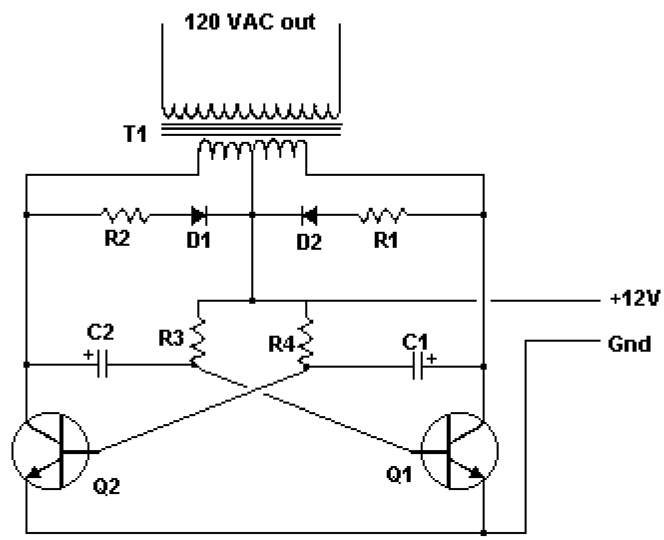

Figure 5: Schematics of Inverter [5]

This inverter takes 12volt dc and step up to 120 volt a.c. The wattage depends on which transistor use for Q1 and Q2 as well as how big transformer use for T1. Transistor (2N3055) and T1 is a 15A transformer; the inverter will supply about 300 watts. The larger transformer and more powerful transistor can be substitute for T1, Q1 and Q2 for more power. [5]

CHAPTER 3

METHODOLOGY

3. Methodology

3.1. Procedure Identification:

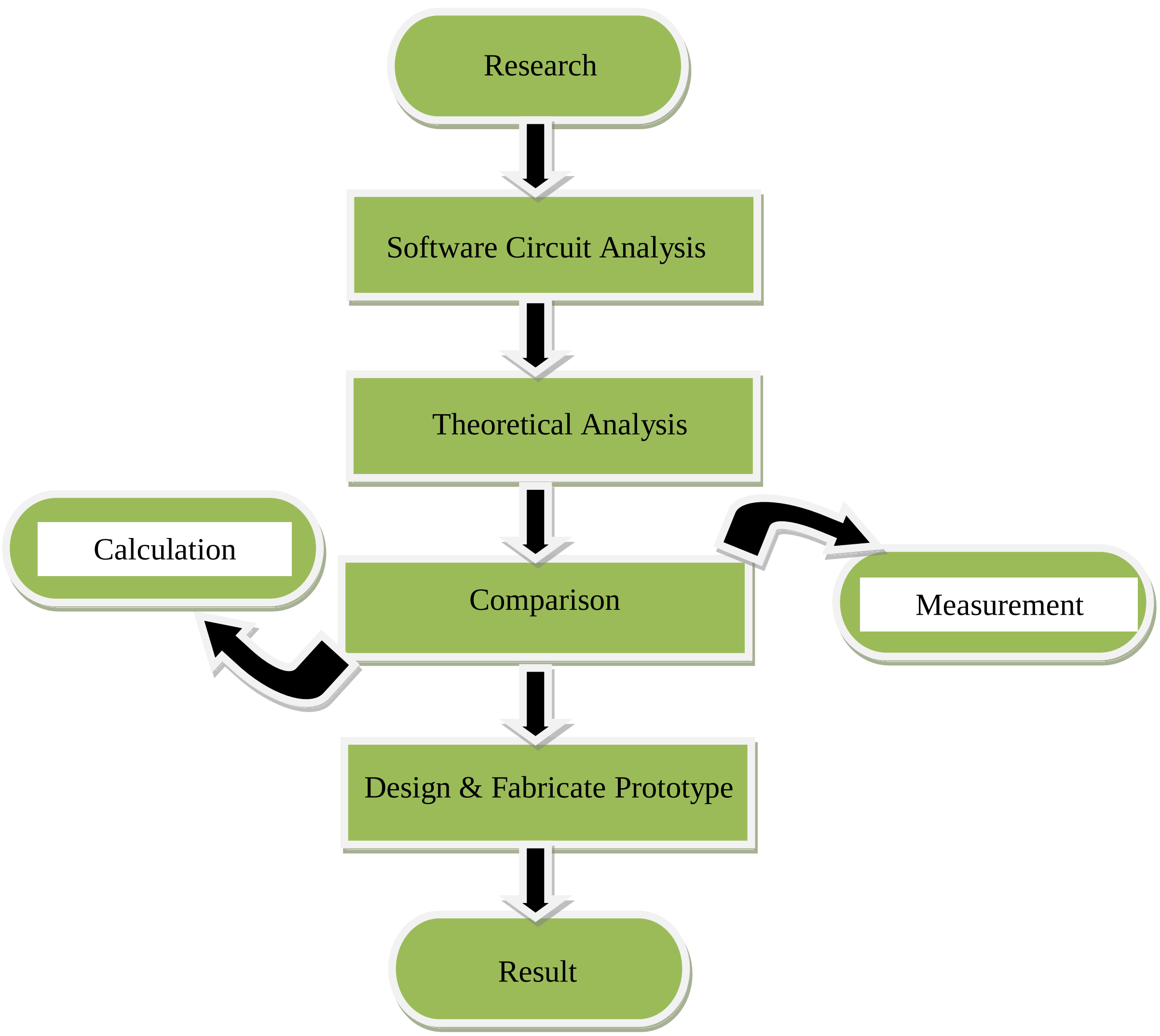

Figure 6: Project flow chart for FYP 1 & FYP 2

The project is kick-started with research to define the problems, to know the subjects, to identify the current issues about available methods of how to generate the power from moving vehicle at highway.

Then, the software that relates to the relevant models and to get familiar with the theoretical part of Multisim software respectively. As discussed with the Supervisor before, it is hoped that a training session to handle neural network using Multisim could be held to analyze the data for generate power. Compare the value of measurement and calculation. Furthermore, design and fabricate the prototype. Lastly, we can get the result from the comparison experiment and the prototype.

3.2 Models Development

As stated, in this project, we try to develop a model using power system techniques. Our main concern is to develop model by using a simple system can generate a power from moving vehicles at highway.

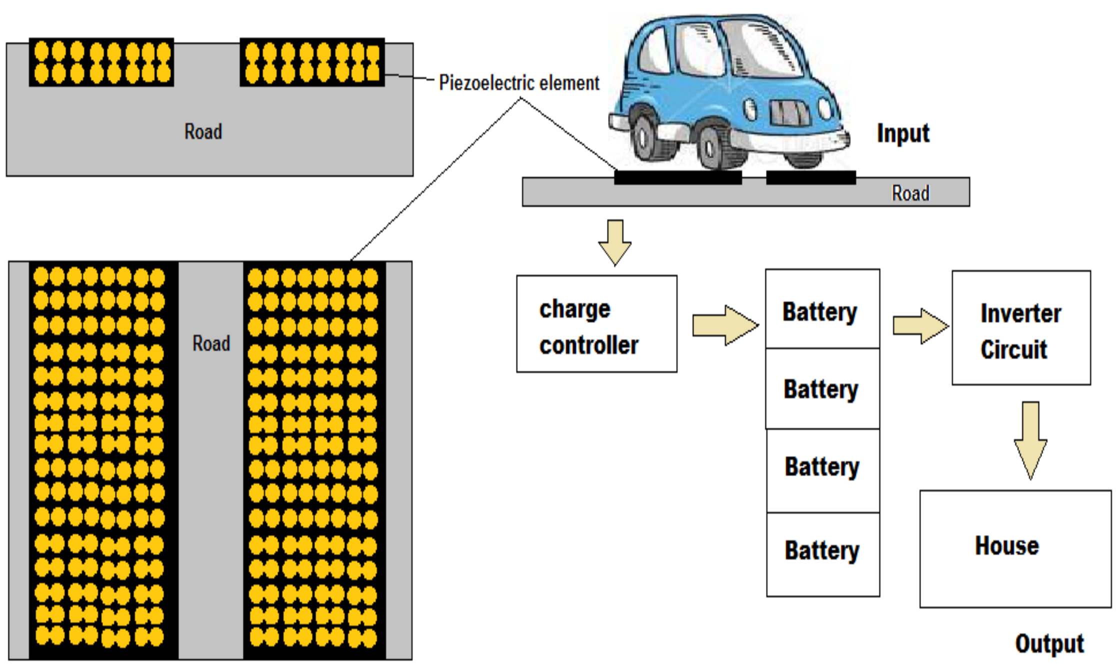

Figure 7: Design Highway Power Harvester

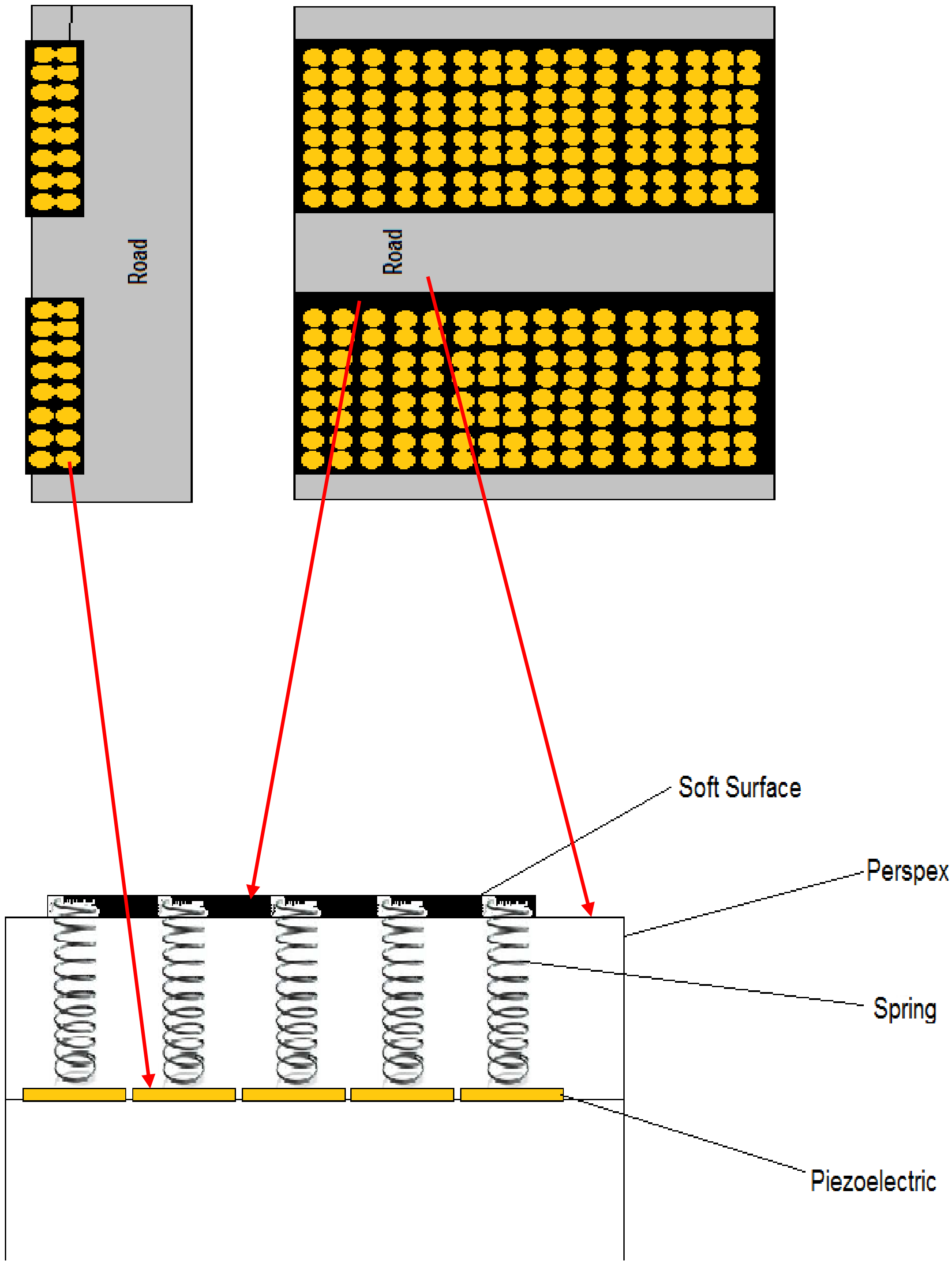

Figure 8: Model Design

Figure 7 show about how the highway power harvester working. The piezoelectric elements are placed inside the road to gain the power from vehicle. The piezoelectric will get force, automatically the battery will be charged and supply the power to any AC or DC supplier. Figure 8 show the model design for this project. The Perspex, spring and the soft surface will be use in this project. The spring will give the force to the piezoelectric component when some force touch the soft surface at the top of the Perspex.

3.3 Tools and Equipments

Hardware:

1) Hand tools
   - In order to build the prototype, proper tools are needed so that the prototype can be built much easier.

2) Electronics tools
   - In order to build the circuit, proper electronic tools are needed so that the circuit can be built and test it much easier.

Software:

1) AutoCAD
   - AutoCAD is a suite of CAD software products for 2- and 3-dimensional design and drafting.
   - In this project, it will be used to design the prototype.

2) MATLAB
   - Simulation the output from the model
   - Analyze the data from the model

3) Multisim

- Mutisim is to design a circuit for power generator
- Simulate the circuit

4) Microsoft Power Point

- Microsoft Power Point is a presentation program which will be used for presentation during the demonstration session.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Piezoelectric simple circuit

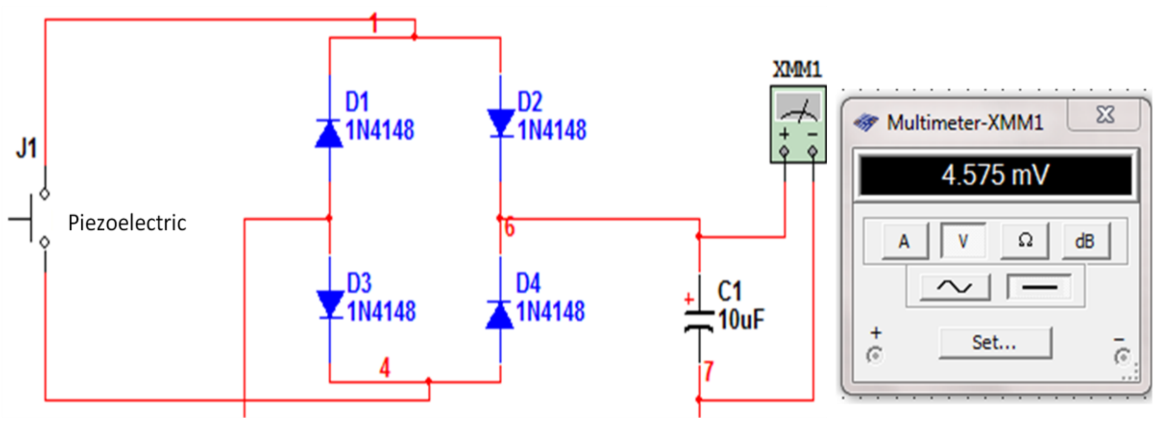

Figure 9: Schematics diagram piezoelectric circuit

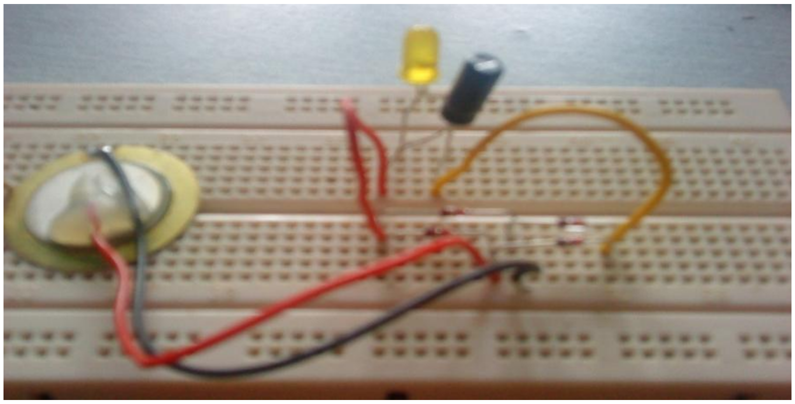

Figure 10: Piezoelectric circuit

The simple circuit is to show how the piezoelectric operations. Figure 9 shows the schematic of the circuit. The piezoelectric is the main voltage input. When we press the piezoelectric component there will be a force and generate some voltage. The diode is a full-wave rectifier. It uses to convert the AC to DC voltage because the piezoelectric components produce AC voltage. The capacitor is for save the charge from output of piezoelectric. The capacitor will save the charge and discharge when the piezoelectric don’t have a force. This is similar with the battery system.

4.2 Comparison voltage measurement and voltage calculation

Table 3: Result of experiment Force vs Voltage

Force (N)	**Voltage measurement (mV)**	**Voltage calculation (mV)**
10	0.08	0.13
100	1	1.3
200	2	2.6
500	4	6
800	8.3	10.6
1000	9.5	13
7000	60	93.3

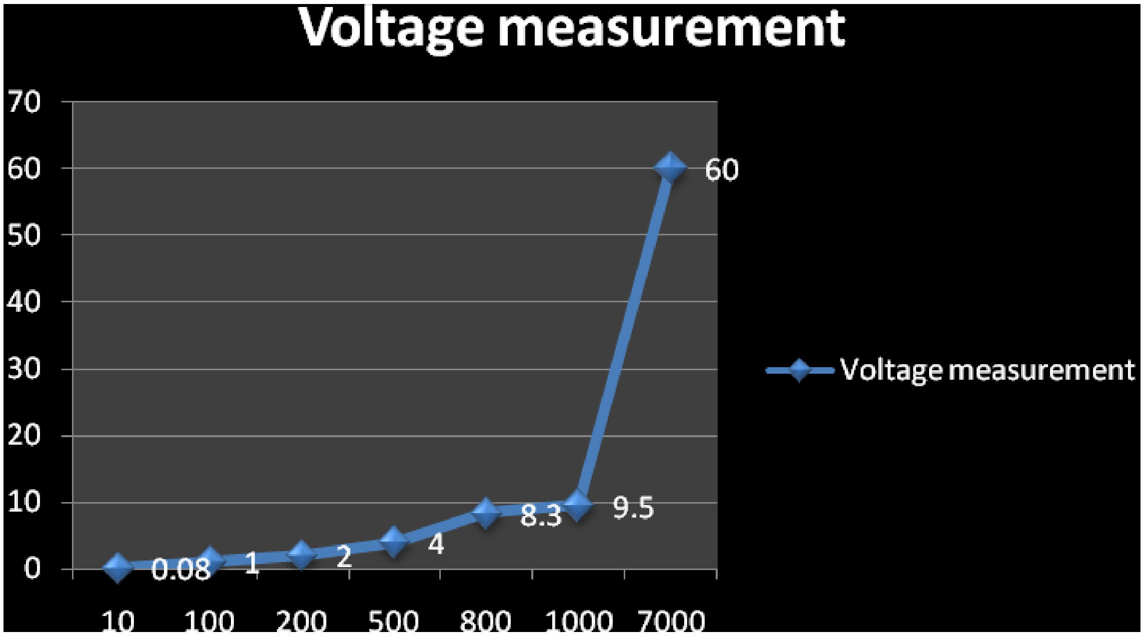

Figure 11: Graph voltage measurement (mV) vs force (N)

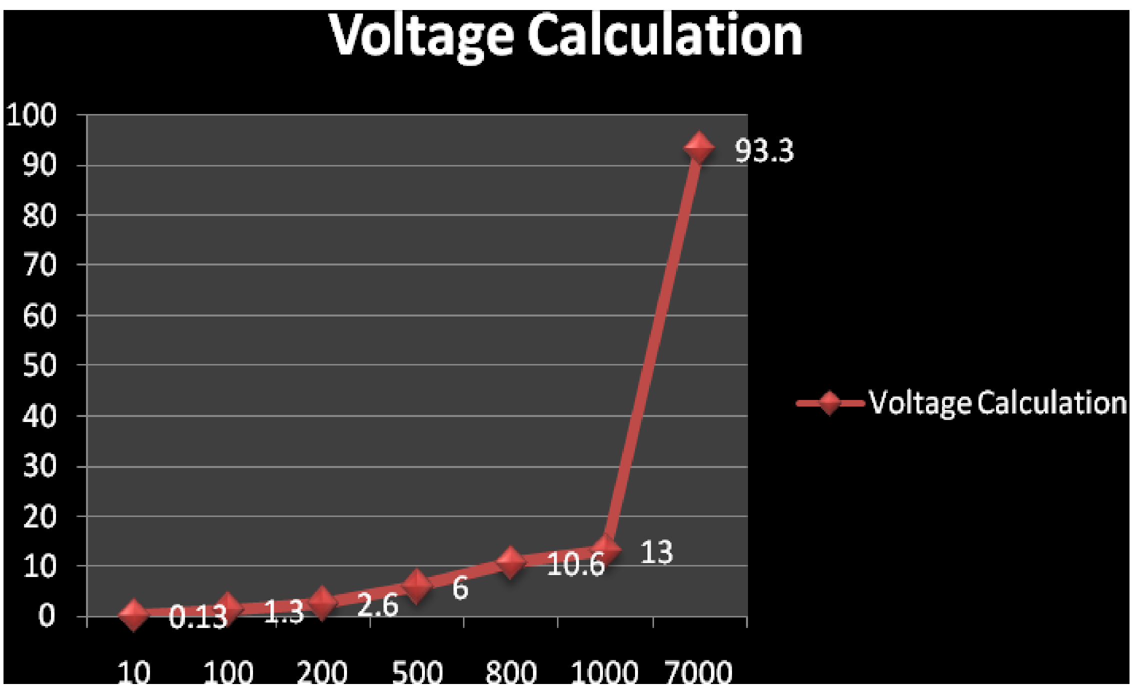

Figure 12: Graph voltage calculation (mV) vs force (N)

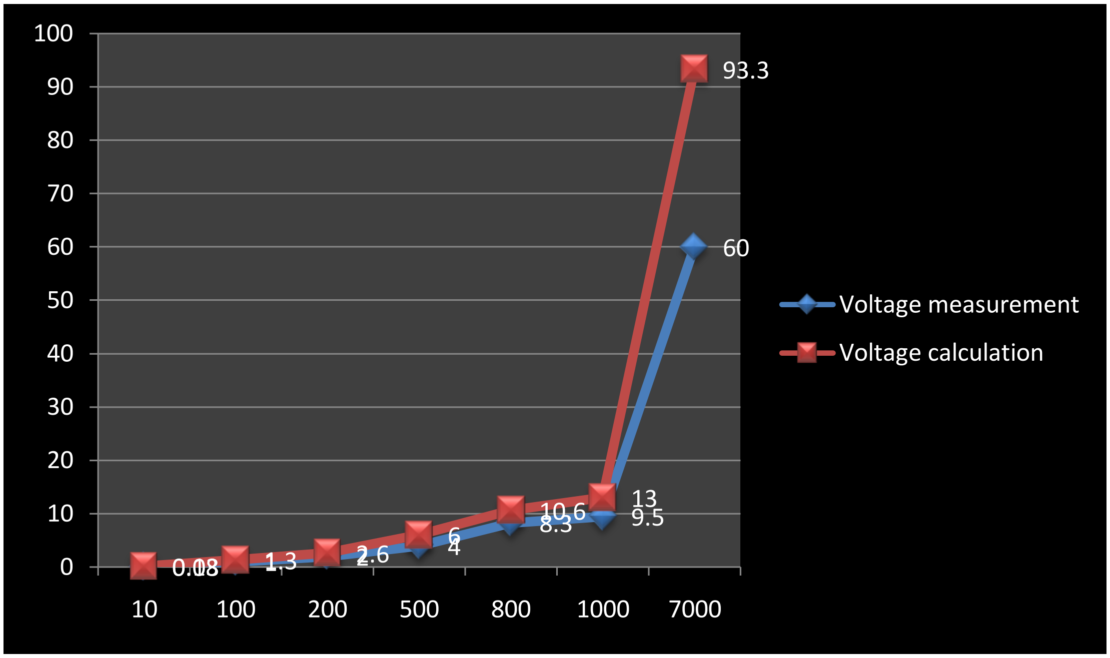

Figure 13: Graph voltage calculation & voltage measurement (mV) vs force (N)

The table and graph from the above show value of the voltage measurement and voltage calculation. There are little different between the measurement and the calculation. The measurements for piezoelectric components are by the force equipment but there are some force limits can be determine by the equipment. The figure 13 shows, the different between the calculation and the measurement. The measurements voltage lower than calculation voltage when the force large. There are a lot of different between the 1000N and 7000N voltage output. In theoretical, the value are around 93.3mv for 7000N force but the measurement just 60mv. The measurement are on 1 (one) piezoelectric only.

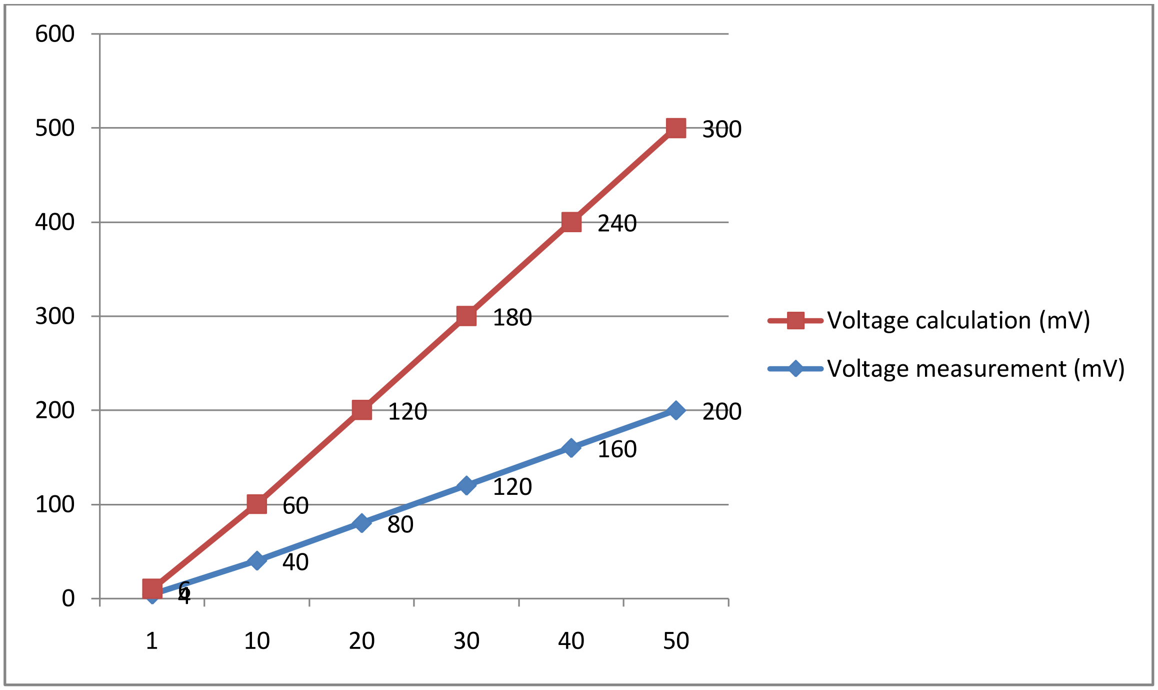

Figure 14: Force 500 Newton for 50 piezoelectric

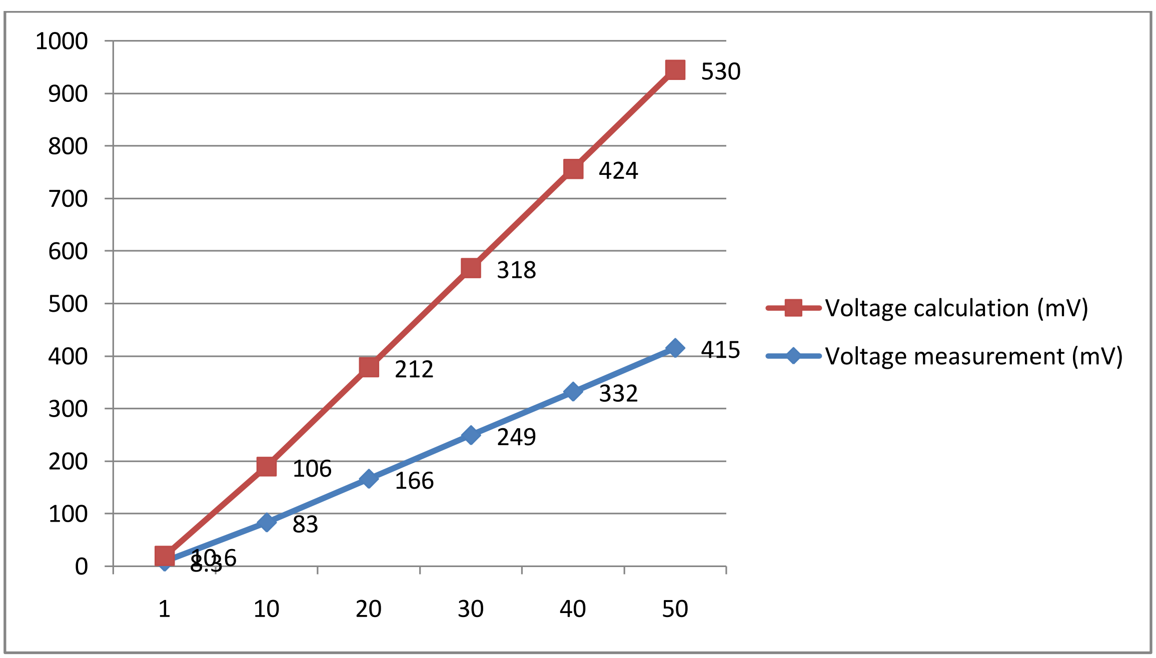

Figure 15: Force 800 Newton for 50 piezoelectric

The graphs from the above show value of the voltage measurement and voltage calculation. The figure 14 show, 50 piezoelectric and had force by 500 N. the voltage measurement still large than voltage calculation. From figure 15 we can see the 800 N forces for 50 piezoelectric. The graph still voltage measurement large than voltage calculation.

4.3 Voltage output for Motorcycle and Lorry

Motorcycle;

Force = 1000 Newton

1 piezoelectric = 9.5 mV (refer table 3)

50 piezoelectric = 475 mV

Table 4: Voltage Output from Motorcycle

No of passing the Piezoelectric surface	Voltage Output (V)
1	0.475
2	0.95
3	1.425
4	1.9
5	2.375
6	2.85
7	3.325
8	3.8
9	4.275
10	4.75

Lorry;

Force = 7000 Newton

1 piezoelectric = 60 mV (refer table 3)

50 piezoelectric = 3V

Table 5: Voltage Output from Lorry

No of passing the Piezoelectric surface	**Voltage Output (V)**
1	3
2	6
3	9
4	12

The table from the above shows the output voltage from the motorcycle and lorry. There are 50 piezoelectric that used for calculate the output voltage for motorcycle and lorry. Table 4 show voltage output from motorcycle. The voltage output increase until 4.75 volt and the piezoelectric still in good condition. Table 5 show the voltage output from lorry. The voltage output increase until 12 volt but the piezoelectric had crack when 4 times it passing through the piezoelectric surface.

4.4 Charger Controller Circuit

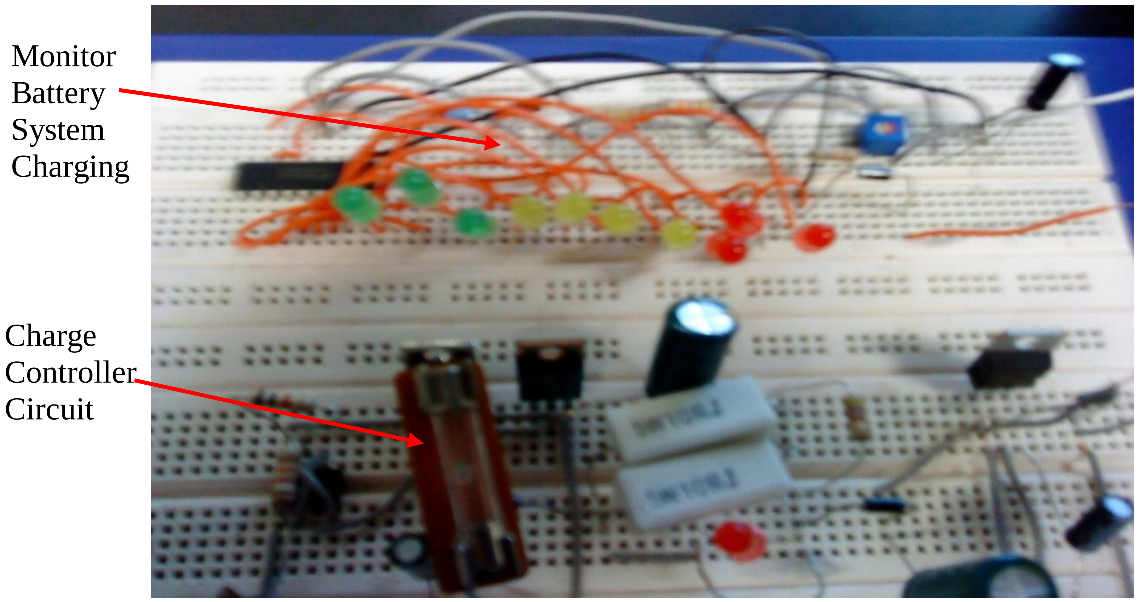

Figure 16: Charge controller circuit and Monitor Battery system

The figure show charge controller circuit and the monitor battery system circuit. The charge controller circuit will control the voltage and current into the battery system from the main source or piezoelectric. It is because without this controller the battery will directly get the source and maybe it will damage the battery. This circuit will charge the battery 0v-12v. The limits of 1 battery are 12 volt. The monitor battery system is to know how much the battery is charge. We can easily monitor how much battery is charging and we can know the battery is full charging by using the led. The red led show battery still week, the yellow led show battery are half charging and when the battery full charge the green led will appear.

4.5 Battery System

Figure 17: Liquid 12 volt 7 Ah battery charge

Figure show the battery that use in this project. This battery can charge until 12 volt. The battery will keep charging when the piezoelectric produce the electricity by the force from other source. This battery use liquid acid to store the voltage.

4.6 Inverter

4.61 Multisim

The intuitive and easy-to-use software platform combines schematic capture and industry-standard SPICE simulation into a single integrated environment. Multisim abstracts the complexities and difficulties of traditional syntax-based simulation, so you no longer need to be an expert in SPICE to simulate and analyze circuits. Multisim is available in two distinct versions to meet the teaching needs of educators or the design needs of professionals.

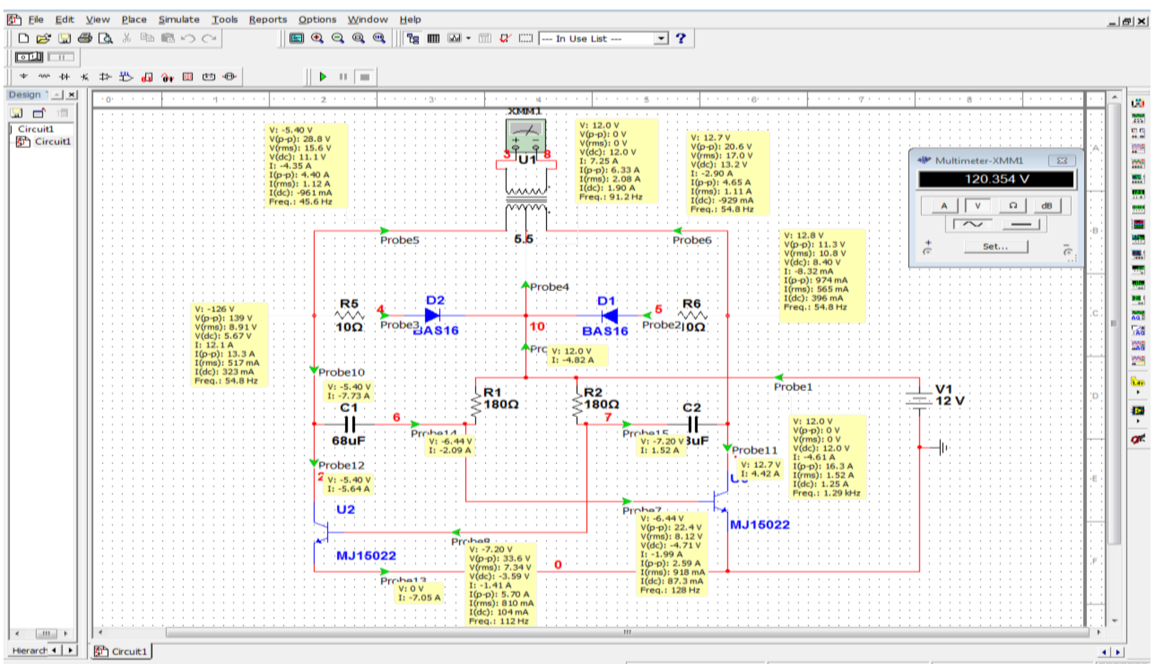

Figure18: Multisim Result for Inverter

Based on the result, the output voltage is 120 volt a.c. The simulation of the inverter circuit is reliable since the inverter will operate from 12V dc to 120V ac.

4.62 Inverter Output

In the electrical system, the inverter circuit is used to convert direct current (DC) at input to the alternating current (AC) at output. After done the fabrication of inverter circuit at project board, the circuit is tested and the output and input result is measured by using the multimeter.

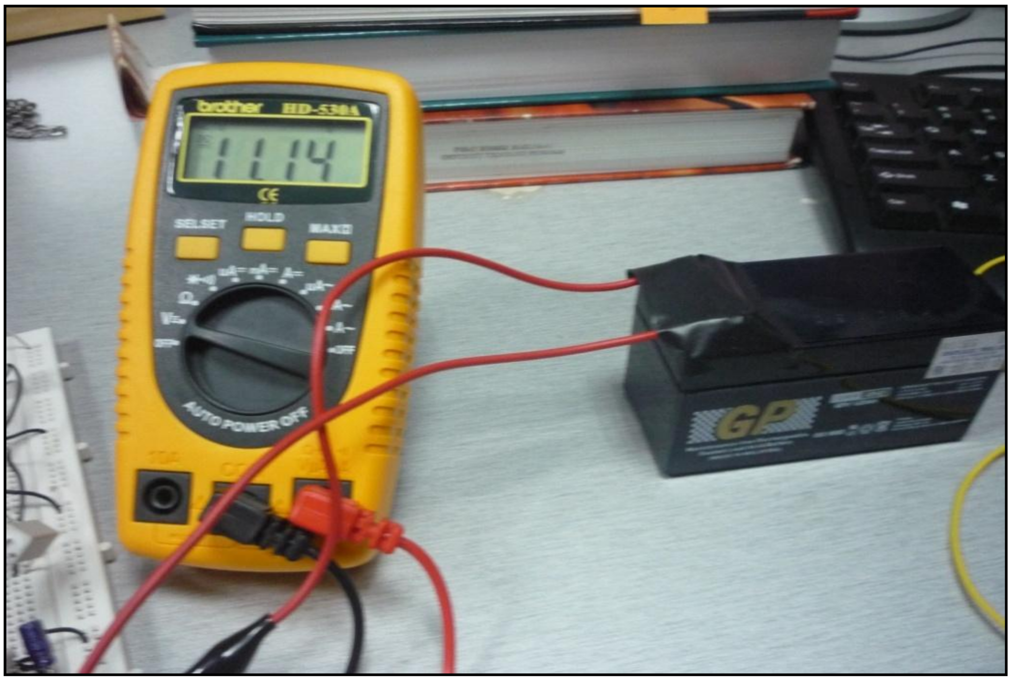

Figure19: Voltage Input

Since the battery has been used several times, the input not exceed 12 volt. However, the circuit can still be run. Then the output voltage is also measured by using the multimeter at the transformer output.

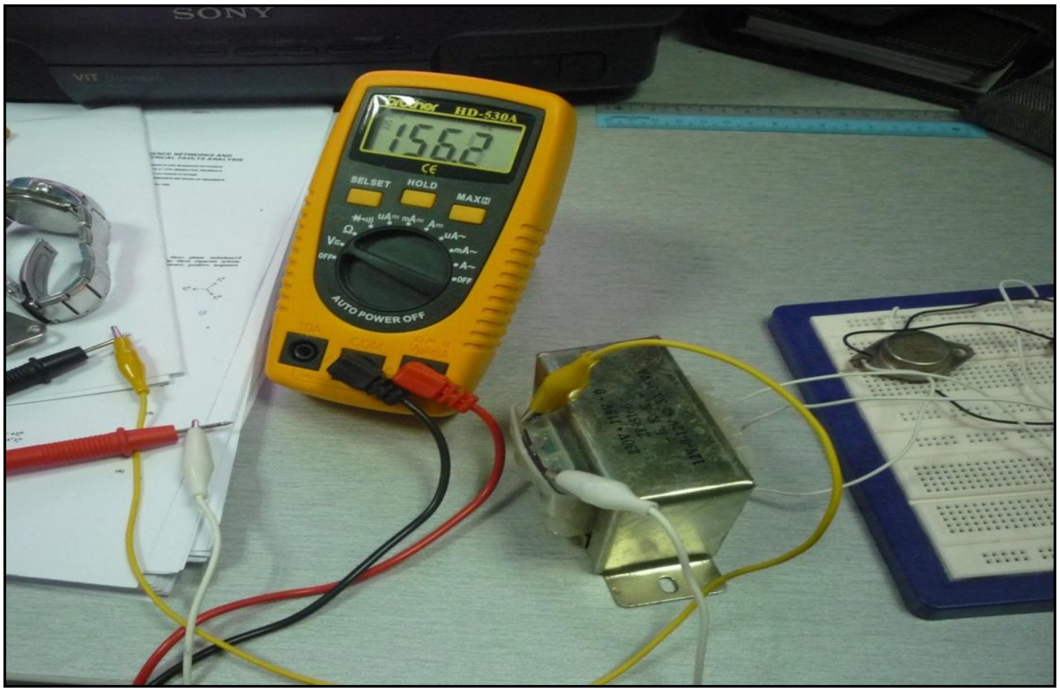

Figure 20: Voltage output

At the output of transformer, the value of the output voltage is about 150 volt only. Based on the theory of this circuit, the output voltage should be 120 volt. Therefore the values not exceed the value that we target.

4.7 Prototype Design

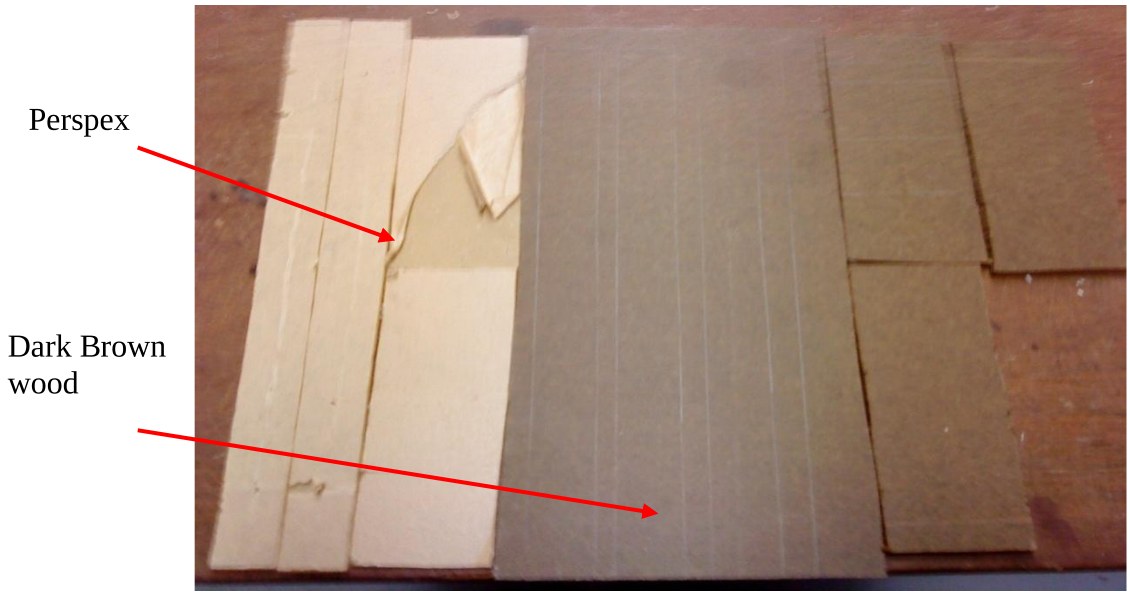

Figure 21: Prototype material

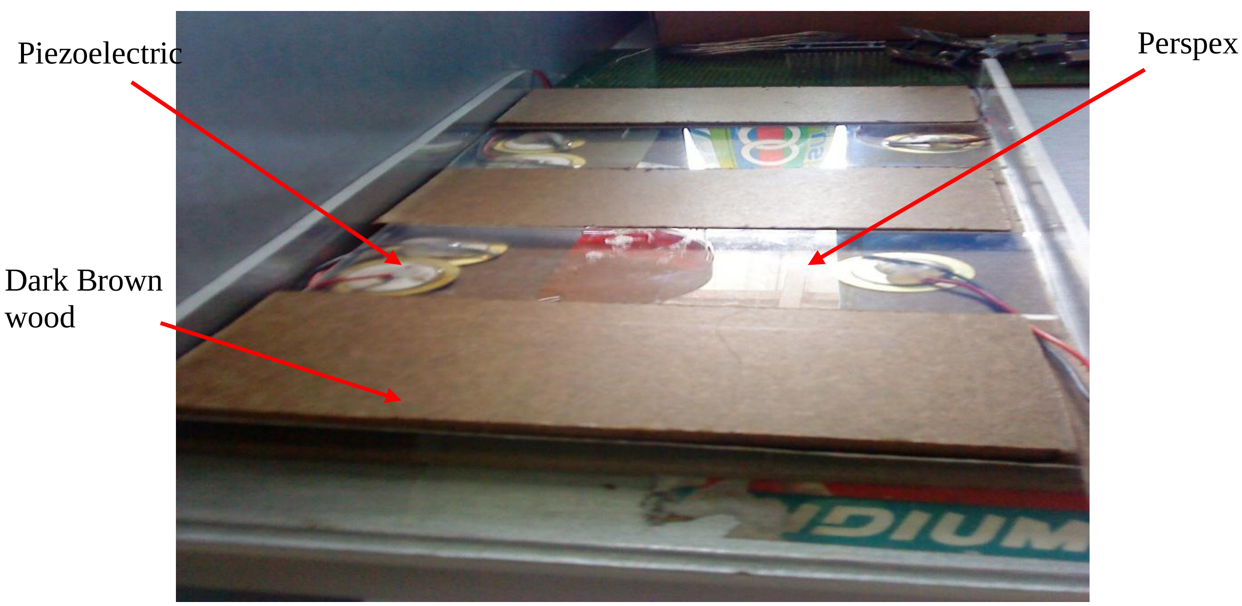

Figure 22: Side view

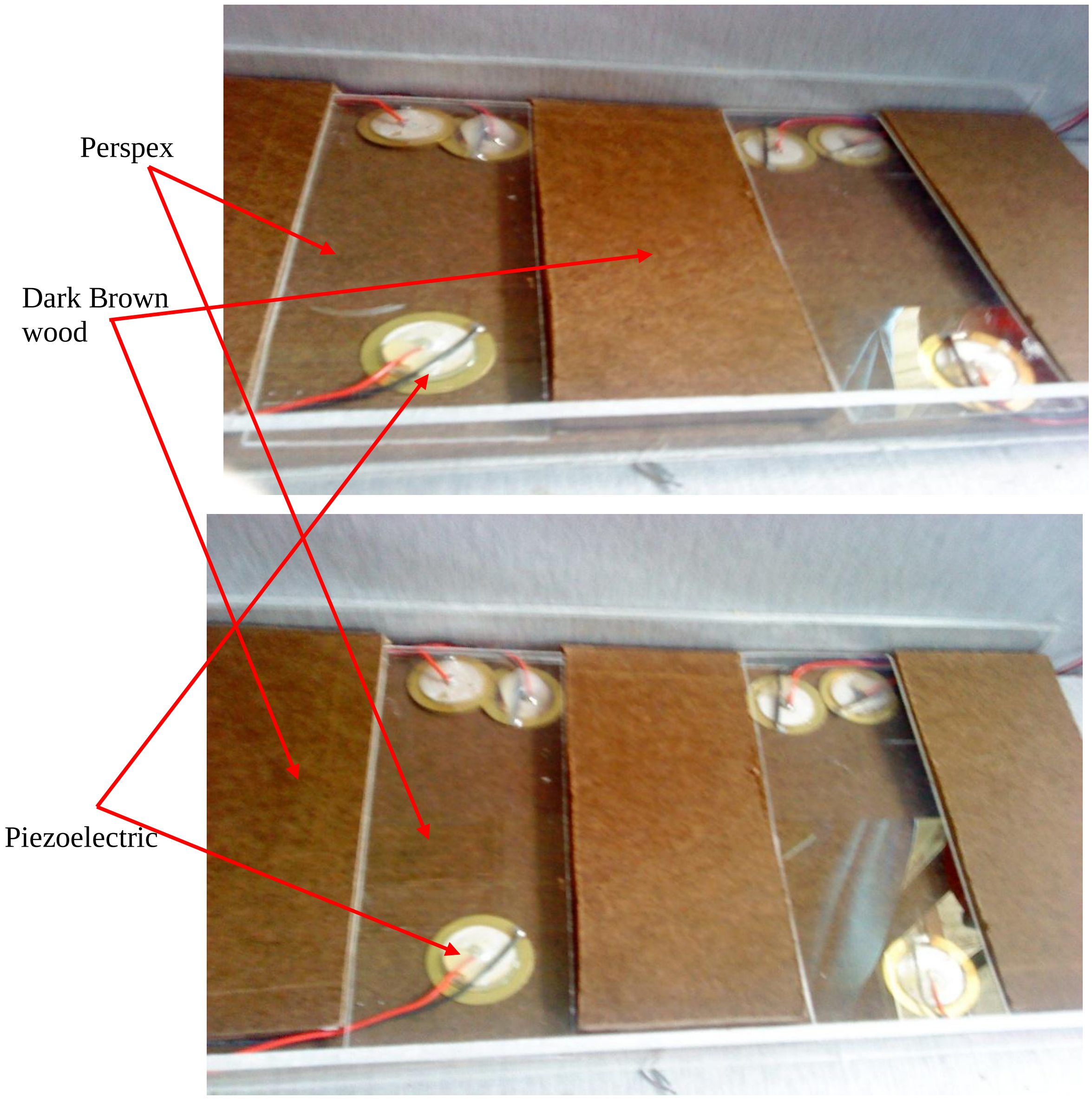

Figure 23: Upper view

CHAPTER 5
CONCLUSIONS & RECOMMENDATION

5.1 Conclusion

In conclusion, the modeling of Highway Power Generator is to generate the energy from moving vehicle at highway. The piezoelectric is the equipment to convert the mechanical energy to electric energy. Furthermore, the piezoelectric will give the system voltage and always supply to the battery system. The inverter can generate more power from AC to DC. The piezoelectric experiment show the force and voltage measurement. It compare with the measurement and calculation. The measurement voltage is almost same with calculation voltage. The charge controller will keep the battery system in good condition because without the controller the battery will not charging with good condition will damage the battery in short term period.

5.2 Recommendation

This project is an ongoing process and necessary approaches shall be taken in the future to improve the material of highway power harvester. There are some of material that can be use to replace this small piezoelectric. Bender piezoelectric maybe the material that can be used in the future project. This component can generate more voltage but the prices are more expensive. Furthermore, the voltage output for piezoelectric is not stable. The stabilizer circuit will need it to stable the voltage from piezoelectric.

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APPENDICES

Appendix A

Project Gantt Chart FYP 2

Activities / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Piezoelectric Experiment														
Design the Prototype														
Preparation for Progress Report 1														
Submission of Progress Report 1														
Build charge controller circuit														
Build the Inverter Circuit														
Testing circuit														
Build the prototype														
Preparation for Progress Report 2														
Submission of Progress Report 2														
Pre-EDX														
Simulate circuit with prototype														
Preparation for Final Report														
Submission of Final Report														
Oral presentation														

Appendix B

Piezoceramics properties (Value to be use as guidelines) [8]

PIEZOELECTRIC			
Piezo Systems' Designation			**PSI-5A4E**
Industry Designations			Navy type II; Industry Type 5A
Composition			Lead Zirconate Titanate
Relative Dielectric Constant (@ 1 KHz)	K^T_3		1800
Piezoelectric "d" coefficients (Strain Produced / Electric Field Applied or the Short Circuit Charge Density Produced / Stress Applied)			
	d_{33}	meter/Volt or Coulomb/Newton	390×10^{-12}
	d_{31}	meter/Volt or Coulomb/Newton	-190×10^{-12}
Piezoelectric "g" coefficients (Open Circuit Electric Field Produced / Stress Applied or the Strain Produced / Charge Density Applied)			
	g_{33}	Volt-meter/Newton or meter^2/Coulomb	24.0×10^{-3}
	g_{31}	Volt-meter/Newton or meter^2/Coulomb	-11.6×10^{-3}
Coupling Coefficient	k_{33}		0.72

	k_{31}		0.35
Polarizing Field	Ep	Volts/meter	> 2 x 10^6
Initial Depolarizing Field	Ec	Volts/meter	~ 5 x 10^5
Coercive Field	Ec	Volts/meter	~ 1.2 x 10^6
MECHANICAL			
Density	δ	Kg/meter^3	7800
Mechanical Q			80
Elastic Modulus	$Y^E{}_3$	Newtons/meter^2	5.2 x 10^{10}
	$Y^E{}_1$	Newtons/meter^2	6.6 x 10^{10}
THERMAL			
Thermal Expansion Coefficient		meters/meter °C	~ 4 x 10^{-6}
Curie Temperature		°C	