HUMAN POWERED LED TORCHES

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This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor Degree of Electrical Engineering (Power System)

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26 NOVEMBER 2007

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Electrical Engineering (Power System)

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Date : 26 November 2007

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Signature : ______________________________

Author : AHMAD ZARIR BIN MOHAMAD

Date : 26 NOVEMBER 2007

DEDICATION

Specially dedicate to

To my beloved father and mother

Mohamad bin Hj Abdullah

and

Zawiah binti Ibrahim

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Alhamdulillah, the highest thanks to God because with His Willingness I possible to complete the final year project in time. I would like to take this opportunity to extend my deepest gratitude to the following persons who have helped me a lot in this project, which enabled me to complete the research project in time as a partial fulfillment of the requirement of the degree of Bachelor Engineering (Power System).

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ABSTRACT

This project's purpose is to make the torches that can operate in two modes which are based on mechanical source (using stepper motor) and battery source. User can choose which mode they wanted to. This project is modifications from the existed product exist in the market. These human-powered LED torches have some really good emergency applications. WE can use this torch whenever we out of battery. The objective of this project is to produce a torchlight which can operate without or with battery. To save energy used by using mechanical application. For part 1 which is, this project just need a basic component to operate first is stepper motor which generates the power to run thing, second is rectifier which to converts AC to DC and capacitor which is to store the power and finally the LED itself to produce lights. Part 2 is a low battery detector circuit which is detect and sound an alarm when battery is low. And lastly is part 3, DC charging circuit, whereas to charging the battery. As a result, LEDs will produce a light by those two modes and user can choose which one they need. This project will give a benefit to user in any way whether mechanical part or using battery mode part.

ABSTRAK

Tujuan projek ini adalah untuk menghasilkan lampu suluh yang boleh beroperasi berdasarkan dua pilihan iaitu berdasarkan kuasa bateri dan kuasa mekanikal. Pengguna boleh memilih mana mana pilihan yang ada. Projek ini juga merupakan penambahbaikan terhadap produk yang sedia ada di pasaran. Objektif projek ini adalah untuk menghasilkan cahaya apabila pengguna memutar 'stepper motor' dan sekaligus menjimatkan penggunaan bateri. Untuk bahagian pertama iaitu bahagian mekanikal, ianya hanya memerlikan komponen yang ringkas sahaja seperti motor gerakan untuk menghasilkan kuasa, pengubah untuk mengubah arus ulang alik ke arus terus. Kapasitor pula untuk sebagai tempat simpanan cas dan LED untuk menghasilkan cahaya. Bahagian kedua pula ialah alat yang dapat mengesan apabila bateri kering atau kehabisan. Dan yang paling terakhir iaitu, pengecas bateri untuk mengecas bateri apabila bateri cas kehabisan tenaga. Dan keputusannya, LED akan menghasilkan cahaya melalui kedua dua pilihan yang ada.

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LIST OF ABBREVIATION

VDC	-	Voltage Direct Current
VAC	-	Voltage Alternate Current
T_H	-	Time High
T_L	-	Time Low

CHAPTER 1

INTRODUCTION

This chapter mainly will discuss about the human powered LED torches in briefly. Also, the problem occurs in daily life that contributes to the invention of this project.

1.1 Overview

The purpose of this project is to make a torch that can operate in two modes which is based on mechanical source (using stepper motor) and battery source. This torch can be divided to 3 main parts. This project just needs a basic component to operate. First, a stepper motor, which generates the power to run the thing by cranked the motor. Second a rectifier, which converts the AC (alternating current) from the stepper motor into DC (direct current), which the LED needs. Capacitors, which store the power and also smooth the current and finally the LED itself, which produces the light. This torch has a three major part that is mechanical part, charging part and low battery detector. Low battery detector detects a low battery by creating a sound from the speaker or displays a light from LED. It can operate when in emergency especially in the jungle where we are running out of battery and no electrical source. This torch enables us to use mechanical sources instead of using battery. By using this torch we can create a several option to us with these two modes and is better than other conventional torch available in market. This low battery detector application is the most difficult part to do it rather than other two parts. With this application, we able to charging the battery after know the battery is weak. This is how the charger system and low battery detection connected.

1.2 Objective

Every project has its own objective. Below are the objectives of this project:

1.2.1 Develop a Torch by Using a Stepper Motor.

This main objective of this project is to design a circuit that can operate very well and fully function. This part also can cooperate with other part which will be mention after this. Able to produce light by cranked the shaft of the stepper motor.

1.2.2 To Develop a Low Battery Detector Circuit.

This circuit is able to sound an alarm when the circuit will detect a low battery. The speaker should generate a tone to remind user that battery was weak. Speaker act as an indicator.

1.2.3 Design a Battery Charger

The concept of power supply used here. The basic concept are been studying to achieve this objective. Application of analog circuit is been used.

1.3 Scope Of the Project

Scope of the project is what we want achieve in this project and what component to be used. So, scope of this project is given below.

1.3.1 Hardware Design

The first element need to be considered for this project is hardware part. The main contribution for hardware in this project is stepper motor. This is the heart of the project. Whatever the objective is, the used of stepper motor must be utilize to its maximum.

Since this project is totally hardware, the second element also hardware. The used of LM339 and 555 timer must be fully utilize. Calculation need to be done to get the desired output. This detector must indicate when battery is low. Indicator is speaker or LED. As long as, user understand the meaning of the indication.

1.4 Problem Statement.

Before designing this project, there are several problems occur in my daily life that contributes to the invention of this torch. Below is the statement about problem faced by me.

1.4.1 Emergency Application of the Torch.

As we all know, there are a lot of torch's design available in the current market. But, not all of that torch will satisfy us. But, most torchlight available in market right now is using battery. So, we spend a lot of money to buy new battery to replace with the new one. This will waste our money. Even though there is torch with rechargeable battery application outside there. The other problem will come, when there is blackout and that blackout is occur on 3.00 AM, we cannot charging the battery without electricity and shop is already closed. So, how can we use torchlight? The answer is, we generate our own electricity without using utility supply. How is that possible? By using a stepper motor, we also can generate electricity. The idea of joining of this application is when I had this bad experience recently.

1.4.2 Human Mistake

Human always forgot. Even though we already have the battery, we still forgot to charge the battery. When we want to use the battery at most critical time, we find that battery is empty. So, with low battery detector invention, hope it can help people which had problem with their memory.

1.5 Thesis Outline

Chapter 1 will briefing about the project. These chapters also discuss about objective, scope and problem faced that led to creation of this project.

Chapter 2 will discuss a literature review. This chapter is about what element, what is the component will be used.

Chapter 3 is discuss about methodology used in design and construct this project. This chapter also will tell about the application, method used. Mostly, this is the important chapter in order to make sure people understand the flow of this project.

Chapter 4 is a result that we get from this project. And analysis done based on the output of this project.

Chapter 5 will conclude anything about this project. This chapter also discuss about the commercialization and future development that can be added.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

2.2 Mechanical Part

A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements. Stepping motors can be viewed as electric motors without commutators. As with a DC permanent magnet motor, driving the motors shaft make it work as a generator. The developed current is AC, going positive as a magnet pole approaches a coil and then negative as it goes away again. The most common type of stepper motor has six wires coming out. The six wires stepper motor is actually two motors on one shaft, so the six wires motor can immediately be separated into two groups of three. Each group will have some connection to each other group. It has full torque at standstill and there are no maintenance needed [1]**.** Figure 2.1 show design of the stepper motor.

Figure 2.1 Stepper motor.

Stepper motors have been successfully applied in many applications such as computer peripherals (e.g., disk drives, pen plotters, and printers), office machines (e.g., copiers, scanners), automotive (e.g., seat positioning, speed control), aerospace (e.g., flap control, starter-generators), and industrial (e.g., robots, scanners, machine tools), to name a few. The benefits offered by stepping motors include:

- A simple and cost effective design.
- high reliability
- maintenance free (no brushes)
- open loop (no feedback device required)

There are basically three types of stepping motors, variable reluctance, permanent magnet and hybrid [1]. They differ in terms of construction based on the use of permanent magnets and or iron rotors with laminated steel stators.

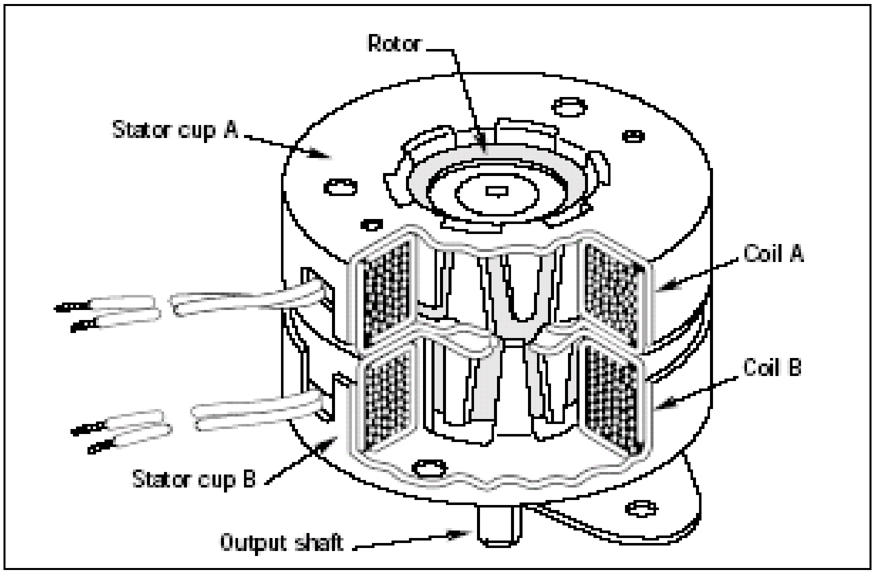

Figure 2.2 Cut view of stepper motor

2.2.1 Definition of rectifier

Rectifier that will be used in this project is full wave bridge rectifier, why I didn't use half wave rectifier. This is because half wave is not practical because of high distortion supply current' [1]. While the objective of a full wave rectifier is to produce a voltage or current which is purely DC' [2]. The output of full wave rectifier is more inherently is fewer ripples than half wave.

This is circuit design of the normal full wave rectifier in Figure 2.4 and Figure 2.3 show the rectifier design available in the market.

Figure 2.3 Rectifier

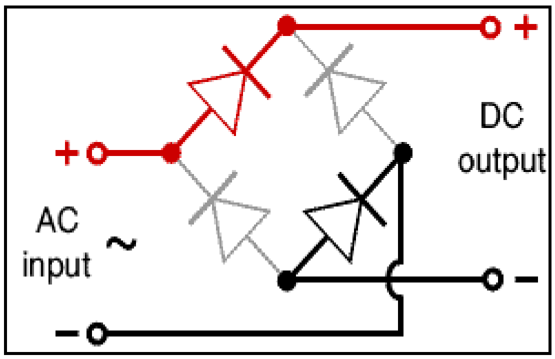

Figure 2.4 Bridge rectifiers.

2.3 Low Battery Detector

This part is the most crucial, since there is operation with using battery, this part becoming very important. In my research, the most important is used of comparator. Zener diode is different from normal diode. The difference is the conduction time. 'For the Zener diode the direction of conduction is opposite to that of the arrow in the symbol....' [3]. 555 timer also important, this unit are use to produces pulse generator which is needed by speaker.

2.3.1 Comparator unit Operation

The comparator circuit is one to which a linear input voltage is compared to another reference voltage .The output swings from maximum to minimum voltage when the input is greater or less than a reference. [4]. the output is always in square wave as shown below. Figure 2.0 shows the design of comparator. There are 4 op-amps inside the one IC and user free to choose which one they need to. And Figure 2.7 describes everything inside the LM339 comparator.

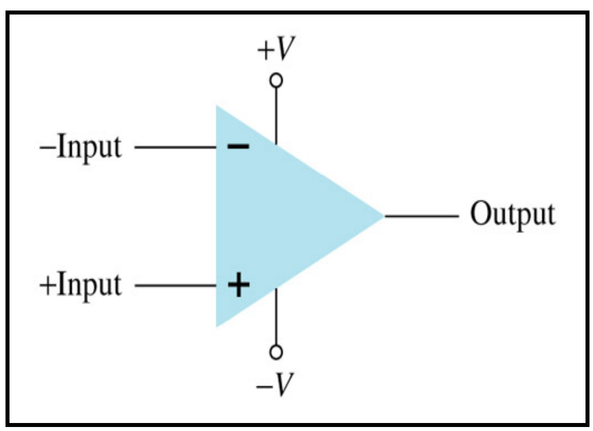

Figure 2.5 Comparator Design

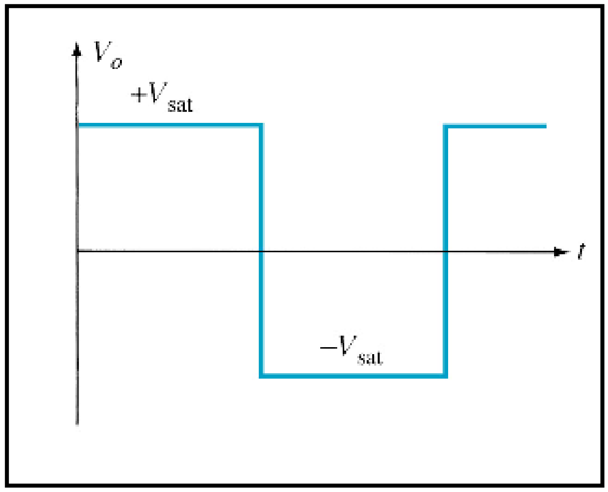

Figure 2.6 Comparator output

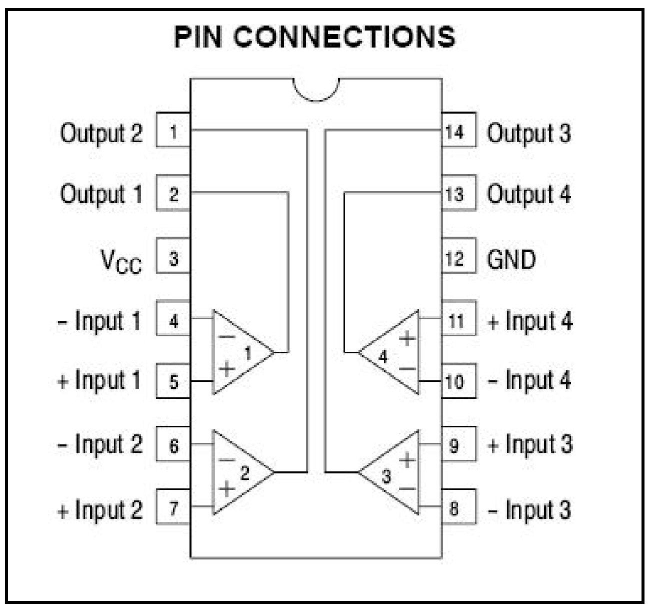

Figure 2.7 Comparator configuration

Rating		Symbol	Value	Unit
Power Supply Voltage		V_{CC}		Vdc
	LM239/LM339/LM2901, V		+36 or ±18	
	MC3302		+30 or ±15	
Input Differential Voltage Range		V_{IDR}		Vdc
	LM239/LM339/LM2901, V		36	
	MC3302		30	
Input Common Mode Voltage Range		V_{ICMR}	−0.3 to V_{CC}	Vdc
Output Short Circuit to Ground (Note 1)		I_{SC}	Continuous	
Power Dissipation @ T_A = 25°C		P_D		
Plastic Package			1.0	W
Derate above 25°C		$1/R_{\theta JA}$	8.0	mW/°C
Junction Temperature		T_J	150	°C
Operating Ambient Temperature Range		T_A		°C
	LM239		−25 to +85	
	MC3302		−40 to +85	
	LM2901		−40 to +105	
	LM2901V, NCV2901		−40 to +125	
	LM339		0 to +70	
Storage Temperature Range		T_{stg}	−65 to +150	°C
ESD Protection at any Pin (Note 2)		V_{ESD}		V
Human Body Model			1500	
Machine Model			200	

Figure 2.8 LM339 datasheet

2.3.2 Timer IC unit operation

In low battery detector circuit, 555 timer is almost important as comparator, 555 timer create a repetitive pulses. The IC is made of a combination of linear comparators and digital flip flops [4]. To generate a frequency, there are two options available. First is astable multivibrator and monostable operation. The timer configuration is shown below in figure 2.9.

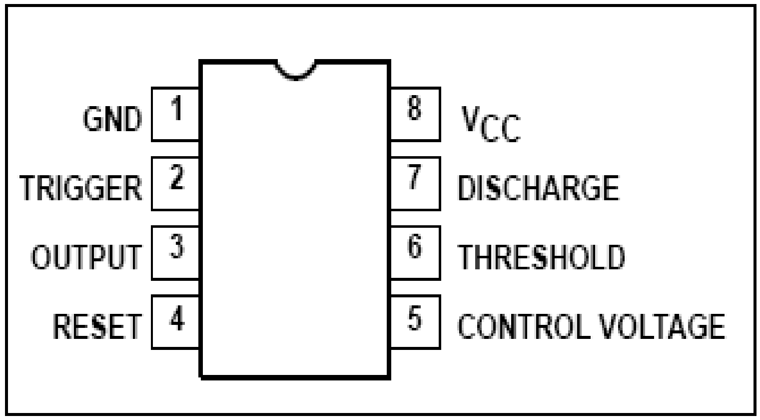

Figure 2.9 555 Timer configuration

2.4 Battery charger

The study of the power supplies lead to this part, the battery charger part. The component used is most basic which contain transformer, voltage regulator and filter.

2.4.1 Transformer

Transformer is the component that converts higher AC voltage to required level. For this part, the transformer used is 200mA rating and 12V. There are several wire configurations. The connection must be right in order to get the desired value. The design of transformer is shown below in Figure 2.10.

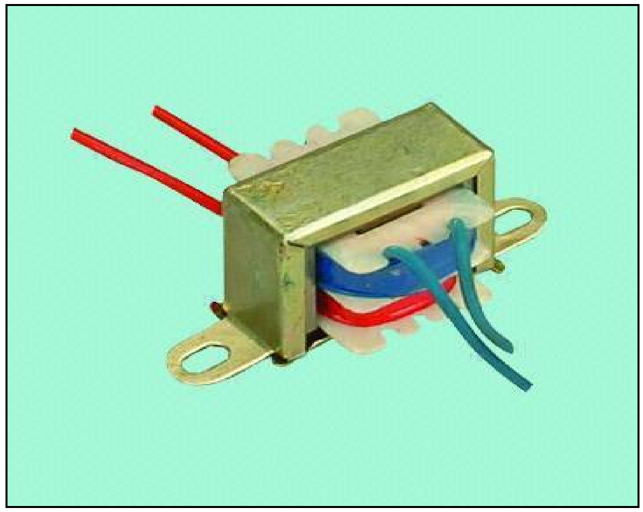

Figure 2.10 Transformer design

2.4.2 Voltage Regulator

Voltage regulator comprises a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device and overload protection [4]. Below is Figure (2.11) of voltage regulator. The rating for regulator is shown in data sheet below in Fig 2.12.

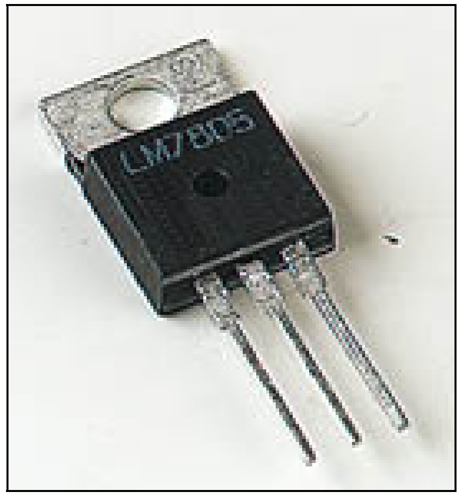

Figure 2.11 Voltage regulator

CHARACTERISTIC	SYMBOL	TEST CIRCUIT	TEST CONDITION		MIN.	TYP.	MAX.	UNIT
Output Voltage	V_{OUT}	1	T_j=25℃, I_{OUT}=100mA		9.6	10.0	10.4	V
Input Regulation	Reg line	1	T_j=25℃	12.5V ≦ V_{IN} ≦ 27V	-	8	200	mV
				14V ≦ V_{IN} ≦ 20V	-	2.5	100	
Load Regulation	Reg load	1	T_j=25℃	5mA ≦ I_{OUT} ≦ 1.4A	-	12	200	mV
				250mA ≦ I_{OUT} ≦ 750mA	-	4	100	
Output Voltage	V_{OUT}	1	12.5V ≦ V_{IN} ≦ 25V 5.0mA ≦ I_{OUT} ≦ 1.0A, Po ≦ 15W		9.5	-	10.5	V
Quiescent Current	I_B	1	T_j=25℃, I_{OUT}=5mA		-	4.3	8.0	mA
Quiescent Current Change	ΔI_B	1	12.5V ≦ V_{IN} ≦ 27V		-	-	1.0	mA
Output Noise Voltage	V_{NO}	1	Ta=25℃, 10Hz ≦ f ≦ 100kHz I_{OUT}=50mA		-	80	-	μV_{rms}
Ripple Rejection Ratio	RR	1	f=120Hz, 13.5V ≦ V_{IN} ≦ 23.5V I_{OUT}=50mA, T_j=25℃		55	72	-	dB
Dropout Voltage	V_D	1	I_{OUT}=1.0A, T_j=25℃		-	2.0	-	V
Short Circuit Current Limit	I_{SC}	1	T_j=25℃		-	0.9	-	A
Average Temperature Coefficient of Output Voltage	TC_{VO}	1	I_{OUT}=5mA, 0℃ ≦ T_j ≦ 125℃		-	-1.3	-	mV/℃

Figure 2.12 Datasheet of voltage regulator LM7810

CHAPTER 3

METHODOLOGY

This project consists of 3 main parts. Firstly is mechanical part, secondly is low battery detector part and thirdly is battery charger part. Every part will be discussed detailed after this.

3.1 Introduction

This chapter presents the methodology of this project. It describes on how the project is organized and the flow of the steps in order to complete this project. The methodology is diverged in three parts; first part is mechanical part which is using stepper motor as a generator to generate electricity, secondly is low battery detector and thirdly is battery charger (supply unit).

3.2 Methodology

There is few mains method in order to develop this project. Before assemble the component on proto board, circuit must be test on bread board. It is for our safety and to avoid from wasted component.

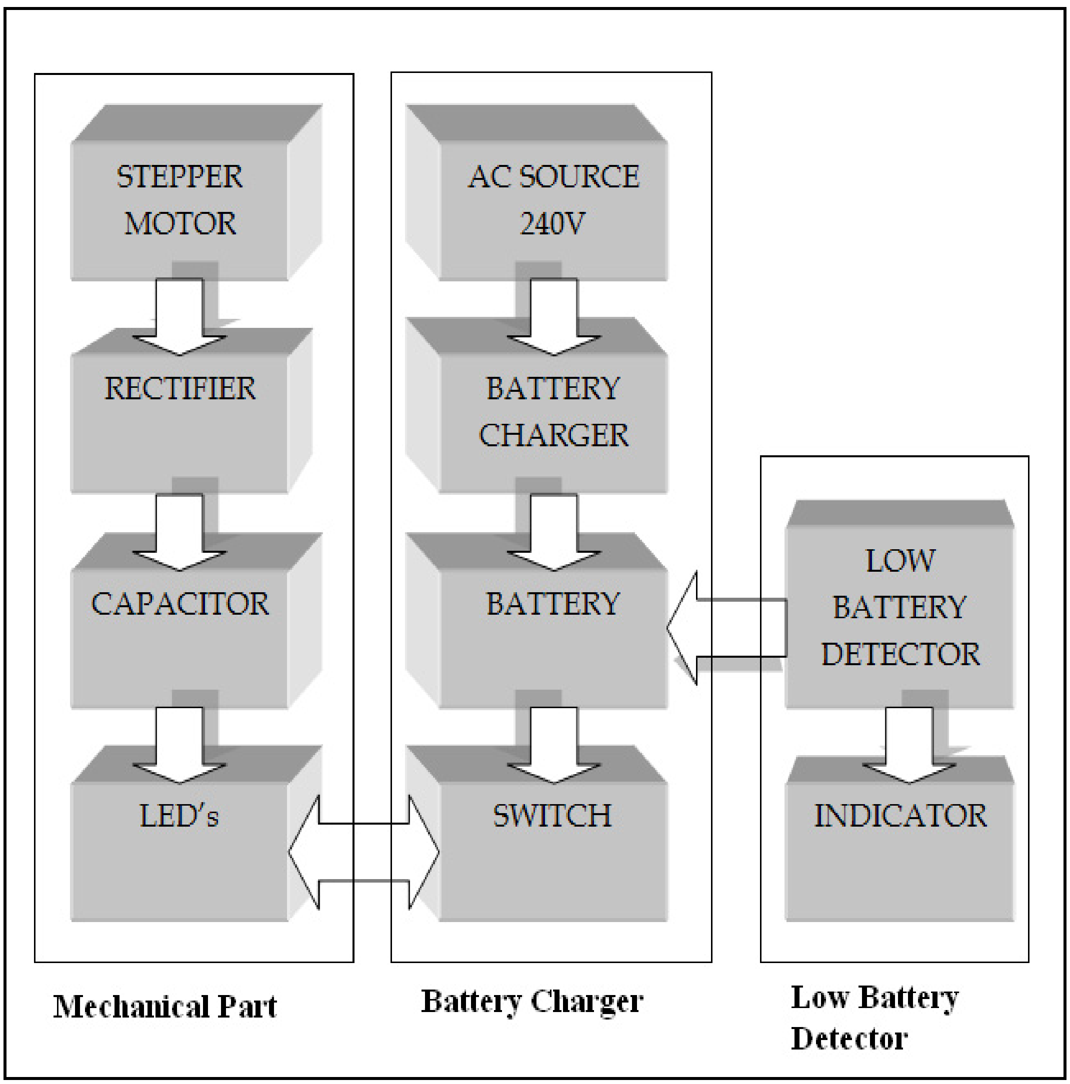

Figure 3.1 Project diagram

3.2.1 Mechanical Part

Firstly, user needs to give input by spinning the stepper motor and this mechanical movement will be converted to electrical energy which is AC. Since our goal is to use LEDs for generate the lights we need to use rectifier to convert from AC to DC voltage/current. But, the output that we get is not purely DC, and we need to use capacitor in order to smoothen the DC by reduced the noise and with this we will get smooth and purely DC to LEDs. In this case, we are using white LEDs because we want the intensity of the light is high. The voltage needed to supply LEDs is about 3.0V and maximum voltage can be achieved by LEDs is about 4.3V.Below is Figure 3.2 of the process of the torchlight.

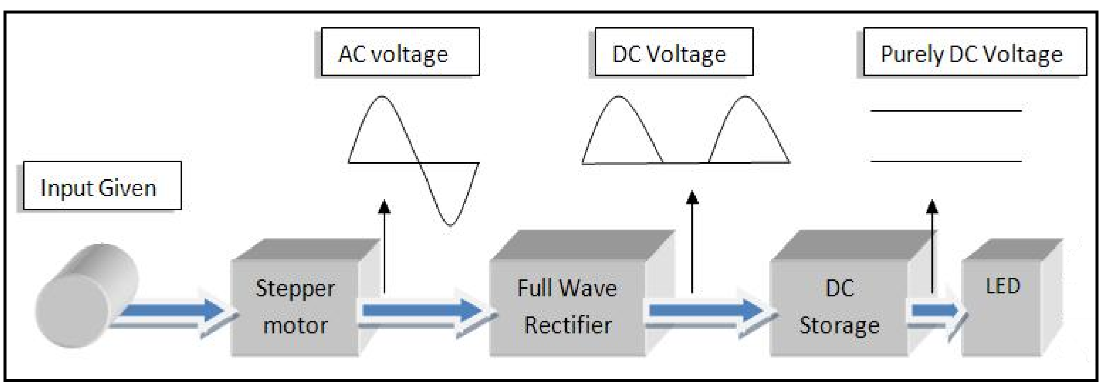

Figure 3.2 Human powered LED torches flow

The voltage output from the stepper motor is about 1.5~2.5Vac. This is the required and most suitable voltage for LEDs.

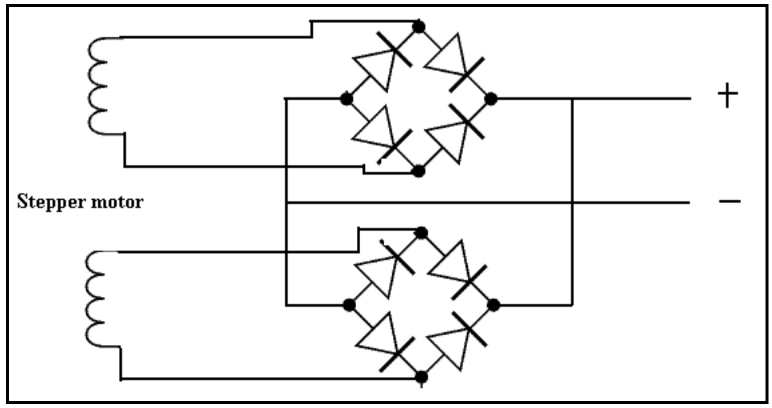

Figure 3.3 Circuit with two bridge rectifier.

3.2.1.1 Organizing the Project

Before start to organizing this project, there is a flow needed to follow. The first step is to find a suitable stepper motor that can be used to generate electricity to LED needs. There are variety of stepper motor available either small or big. The big one will produce higher power. To choose design circuit, we need to choose the circuit with two rectifiers for generate a higher voltage as in figure 3.2. After that is capacitor energy storage. The low current draw of the LED makes the LED beam only a while. So the solution is using capacitor. It serves two functions; First is, it smoothes out the pulsing coming from alternator and second is, it allows the LED to stay on for a short time after stop cranking. How long LED stays is depend on how much capacitors storage. In this project, the capacitor used is 1000µF 16V electrolytic. Total up is 4000µF. typically give us 1~2 second beam after stop cranking. Basically, the more capacitance is the longer LED will glow.

3.2.1.2 Stepper Motor

Before circuit connected with the stepper motor, there are several procedures needed. The majority of stepper motors are six wires. The six wire stepper is actually two motors on one shaft, so the six wires can be separated into two groups of three. Each group will have some connection to each other, but no connection to any of the other group. In each group, one wire is the common. And the other two are the opposite ends of a winding which will give out oppositely-phased AC. Figure 3.4 shown below describe how stepper motor can generate AC voltage.

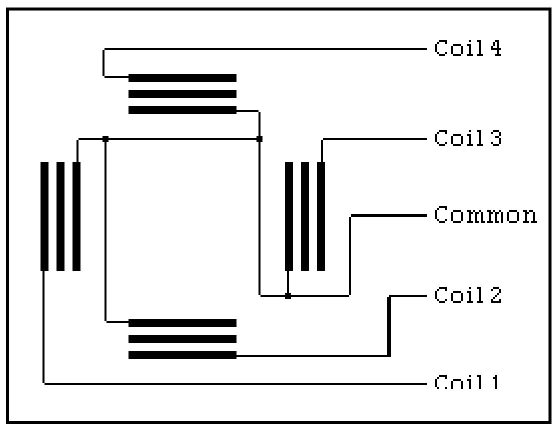

Figure 3.4 Coil in stepper motor

There are six wires emerging from the stepper motor: two red, two yellow, and two greys. One red, one grey, and one of the yellow wires have a dark mark on them, the other wires are clean. Therefore we can use that to individually identify the wires. If the wires all looked the same, then we would have individually identified them with small pieces of labelled tape. We will call the wires R1, Y1, G1, R2, Y2, and G2 where the letter is the first letter of the wire's colour, and the number 1 or 2 identifies if the wire was clean its 1, if the wire was dark mark no 2. But, it depends on the stepper motor. Every stepper has its own wire colour design.

To determine the connection between wires, there is a way to do so. Systematically use a multimeter to measure the resistance between different pairs of wires. All four coils will have near identical resistances, if they did not the motor would not function properly. Therefore if the pair of wires being measured are both live, the resistance measured will be double that measured if one of the wires is a common. Because two live wires have two coils between them whereas a common and a live have just one coil between them. Table 1 below shows the result from the measurement taken. All measurement is in Ω.

Table1 Stepper motor connection measurement

Colour	R1	R2	G1	G2	Y1	Y2
Red 1/R1		__	117	__	117	__
Red 2/R2	__		__	117	__	117
Grey 1/G1	117	__		__	234	__
Grey 2/G2	__	117	__		__	236
Yellow1/Y1	117	__	234	__		__
Yellow2/Y2	__	117	__	234	__	

From table above, we can make an analysis about the measurement taken above. When the resistance between two wires is infinite, we know there is no connection between those two wires within the stepper motor. For example, between R1 and R2 or G1 and G2, we have two different values of resistance between the other wires which is 117Ω and 234 Ω with one being half of the other. This is because this stepper motor has four phases and therefore four identical coils. When the resistance measured between two wires is 117 Ω, the wires are connected across one coil, and when the resistance is 234 Ohms the wires are connected across two coils. R1 is connected to G1 and Y1 across one coil. R2 is connected to G2 and Y2 across one coil. G1 and Y1 are connected across two coils, and G2 and Y2 are connected across two coils. None of the 2's are connected to any of the 1's. Therefore we can draw the following simple diagram of the wiring of this stepper motor as shown in Figure 3.5. The result of this circuit is shown in Figure 3.6.

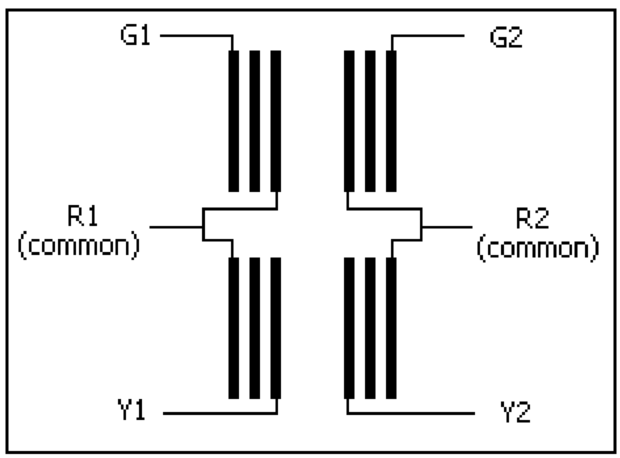

Figure 3.5 Stepper motor wiring diagram

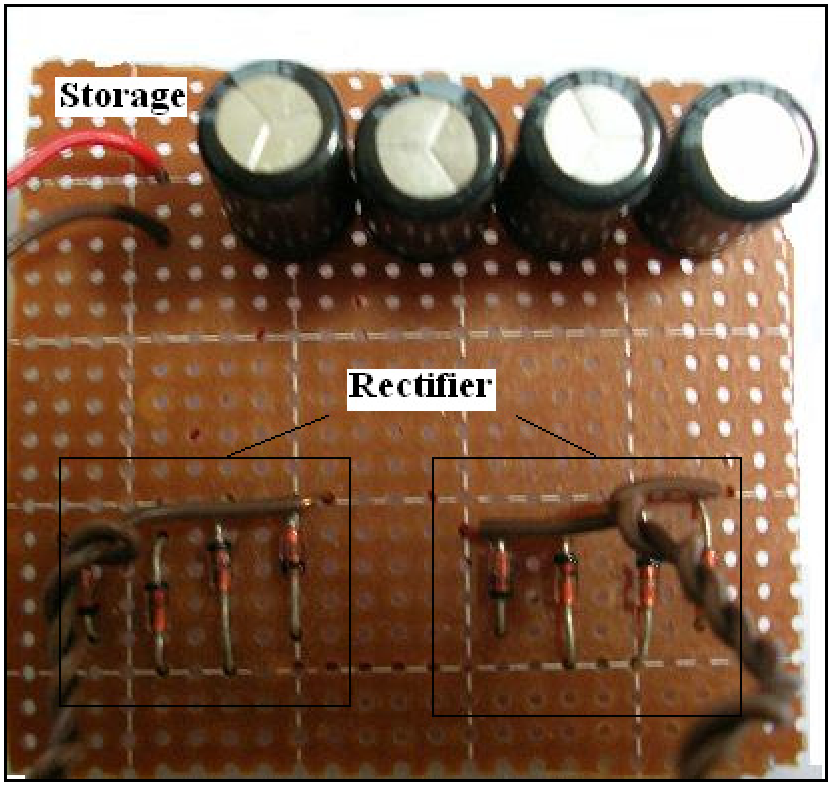

Figure 3.6 Circuit design of mechanical part

On Figure 3.6 above, the capacitor is place on top of the figure. Also, there are two bridge rectifiers on that figure. Both rectifiers are connected to the stepper motor. Connection to the stepper motor is already discussed in chapter 3. The output from the stepper motor is AC voltage.