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Jabatan Pengajian Politeknik

COMPACT PHOTOVOLTAIC CONTROL BOX WITH HANDPIECE

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This Report is Submitted in Partial Fulfillment Of The

Requirements For Diploma Electronic Engineering (Medical)

Jabatan Kejuruteraan Elektrik

Politeknik Sultan Salahuddin Abdul Aziz Shah

DIS 2016

ENDORSEMENT

"I hereby acknowledge that I have read this report and I find that its contents meet the requirements in terms of scope and quality for the award of the Diploma in Electronic Engineering (Medical)"

Signature : _____

Name of Supervisor : DR. HJ. ZUNUWANAS BIN MOHAMAD

KETUA PROGRAM

IJAZAH SARJANA MUDA TEKNOLOGI KEJURUTERAAN ELEKTRONIK (ELEKTRONIK PERUBATAN)

POLITEKNIK SULTAN SALAHUDDIN ABDUL AZIZ SHAH

Date : 29/3/17

DECLARATION

"We hereby declare that the work in this report is our own expect for quotation and summaries which have been duly acknowledge"

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ABSTRACT

A dental hand piece is a dental instrument, either air driven electrically driven, that holds various disks, cups or burs, used to prepare a tooth to receive a restoration or to contour, clean or polish a tooth or restoration. Hand piece rotations are measured in rotation per minute. A low speed hand piece is a well-known laboratory instrument for holding dental burs to smooth and polish restorative materials on a denture. Thus, this project is concerned mainly to design and develop a solar powered control box with a low speed dental hand piece which also can be labelled as eco-friendly and user-friendly equipment. The rotation of the bur of the low speed hand piece is controlled by the compact designed control box. The polishing bur can variably rotate from 0 to 27,000 rpm and go forward or reverse. Solar cells (or photovoltaic cells) which are fixed on the control box create solar energy which lengthens the battery life. In addition, it acts as the second alternative power source of the control box. Therefore, this speed controlled hand piece can be used to smooth and polish restorative materials on a denture by using both solar energy and electrical energy.

ABSTRAK

Handpiece adalah instrumen pergigian, ia sama ada didorong oleh udara ataupun elektrik, memegang pelbagai cakera, cawan atau burr, ini semua digunakan untuk menyediakan gigi untuk menerima pemulihan atau untuk kontur, bersih atau menggilap gigi. Putaran handpiece adalah diukur dalam putaran per seminit. Handpiece kelajuan rendah adalah instrumen makmal terkenal untuk mengadakan burs untuk meratakan dan menggilap bahan-bahan pemulihan pada gigi palsu. Oleh itu, projek ini adalah berkenaan terutamanya untuk mereka bentuk dan membangunkan kotak kawalan berkuasa solar dengan handpiece kelajuan rendah yang juga boleh dilabelkan sebagai mesra alam dan peralatan yang mesra pengguna. Putaran bur pada handpiece kelajuan rendah dikawal oleh kotak kawalan padat direka. Bur yang berfungsi penggilap boleh berubah kelajuan ia dengan berputar dari 0 kepada 27,000 rpm dan berputar berikut arah jam ataupun berlawan arah jam. Sel-sel solar yang ditetapkan pada kotak kawalan mewujudkan tenaga solar yang memanjangkan hayat bateri. Di samping itu, ia bertindak sebagai sumber kuasa alternatif kedua untuk kotak kawalan. Oleh itu, kelajuan mengawal handpiece boleh digunakan untuk melicinkan dan bahan-bahan pemulihan menggilap pada gigi palsu dengan menggunakan kedua-dua tenaga iaitu tenaga solar dan tenaga elektrik.

LIST OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction

A dental handpiece is a dental instrument, either air driven electrically driven, that holds various disks, cups or burs, used to prepare a tooth to receive a restoration or to contour, clean or polish a tooth or restoration. It is also a well-known laboratory instrument for holding dental burs to remove tooth structure or to smooth and polish restorative materials on a denture. Handpiece rotations are measured in rotation per minute. It may be powered by electric motor or air turbines and are characterized as high speed or low speed, depending on their rotational speed.

A high speed handpiece operates at speed about 100, 000 to 800, 000 rpm. The high speed or ultra-speed handpiece operates with a water spray and may have a fibre-optic light to facilitate better visibility. A water spray is necessary to reduce the

temperature within the hand piece and surgical site. Nevertheless, a low speed dental hand piece operates at speed about 6, 000 to 80, 000 rpm. Low speed handpieces are used to polish and finish dental procedures. There are also contra-angle dental handpieces and turbine dental hand pieces.

Control box for the hand piece is mainly to control the rotation speed of the handpiece. The electric control box dental controls the spinning of the bur of handpiece which can polish or cut. The polishing bur can variably rotate from 0 to 35,000 rpm and go forward or reverse. It provides a very high torque. Only low speed handpieces can be used in this control box due to its maximum rotation speed. Compact designed control box provide much convenience to the user. Solar cells (or photovoltaic cells) which are fixed on the control box create solar energy. A solar power panel is able to function using the solar energy which is derived from the sun. It acts as the second alternative power source of the hand piece.

1.2 Problem Statement

The problem of dental laboratory micro motor control box (with its handpiece) in use nowadays is less compact. Furthermore, the problem of dental laboratory micro motor control box in use nowadays is difficult and not easy to use as it needs both hand and leg to operate it. An additional foot pedal is used to control the speed rotation of the bur. This additional pedal does not come in handy and it may destruct the user's concentration on shaping or polishing the dentures. This is because the user needs to focus on the foot pedal too for the speed control. This may lead to human error, for example pressing the pedal too much without taking aware of the rotation speed may spoil the dentures shape.

The dental laboratory micro motor uses only dc power as its power source. So, when there is electricity cut off or short circuit occurred in laboratory, this equipment cannot be operated. Moreover, it consumes much electric energy causes this equipment to get hot easily and lead it to help less in saving energy. High temperature and less ventilation in control box causes the equipment to be spoilt with short life span.

1.3 Objective Study

The main objective of this project is to design and develop a solar powered control box with a low speed dental hand piece. The detail objective of this study as follow:

i. To make the handy equipment which is portable to rural areas and countryside.
ii. To create an eco-friendly equipment and support renewable energy by using solar energy
iii. Produce and provide user-friendly device by creating the handpiece which just only need to use hand to operate it.

1.4 Scope of Project

This project scope is in biomedical instrument or device that consist of software and hardware. This project using software Arduino for programming and general component such as resistor, diode, transistor, capacitor and LED. A dental compact photovoltaic control box with handpiece (CPC Hand piece) holds various disks, cups or burs for polishing only dentures not the real teeth. Dental Technician will use this CPCB Hand piece for polishing dentures only. This project provide an eco-friendly that using solar energy and user-friendly device that using only hand to operate by control its speed/rpm.

1.5 Importance of Research

Importance of our project is to help the dental technician reduce the human error which is pressing too much the foot pedal while using it to control the speed and because of that error the dentures will spoil. So, we provide user-friendly device which is just using hand to operate. So it is easier and convenient for dental technician to use. Besides, our project is handy devices which is portable to rural areas and countryside. Then, in order to support renewable energy this project using solar energy that can make the battery last longer to use.

CHAPTER 2

LITERATURE REVIEW

2.1 Dental Anatomy

Dental anatomy is a field of an anatomy dedicated to the study of human tooth structures. The development, appearance, and classification of teeth fall within its preview. (The function of teeth contact one another falls elsewhere, under dental occlusion) tooth formation begins before birth, and teeth's eventual morphology is dictated during this time. Dental anatomy is also a taxonomical science: it is concerned with the naming of teeth and the structures of which they are made.

Usually, there are 20 primary("baby") teeth and 28 to 32 permanent teeth, the last four being third molars or "wisdom teeth", each of which may or not grow in. Among primary teeth. 10 usually are found in the maxilla (upper jaw) and the other 10 in the mandible (lower jaw). Among permanent teeth, 16 are found in the maxilla and the other 16 in the mandible. Most of the teeth have distinguishing features.

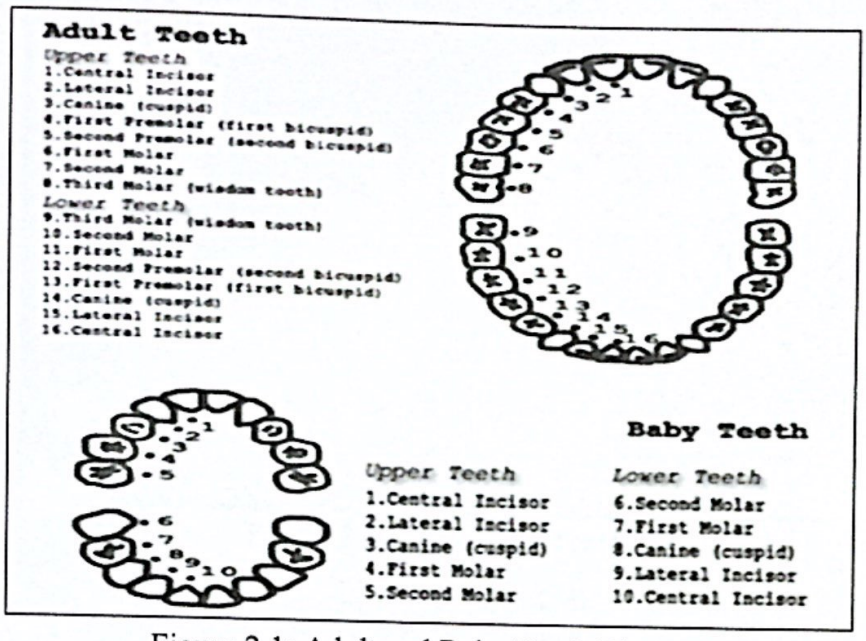


Figure 2.1: Adult and Baby Teeth Diagram

The teeth are the hardest substances in the human body. Besides being essential for chewing, the teeth play an important role in speech. Parts of the teeth include:

i. Enamel: The hardest, white outer part of the tooth. Enamel is mostly made of calcium phosphate, a rock-hard mineral.

ii. Dentin: A layer underlying the enamel. Dentin is made of living cells, which secrete a hard mineral substance.

iii. Pulp: The softer, living inner structure of teeth. Blood vessels and nerves run through the pulp of the teeth.

iv. Cementum: A layer of connective tissue that binds the roots of the teeth firmly to the gums and jawbone.

v. Periodontal ligament: Tissue that helps hold the teeth tightly against the jaw.

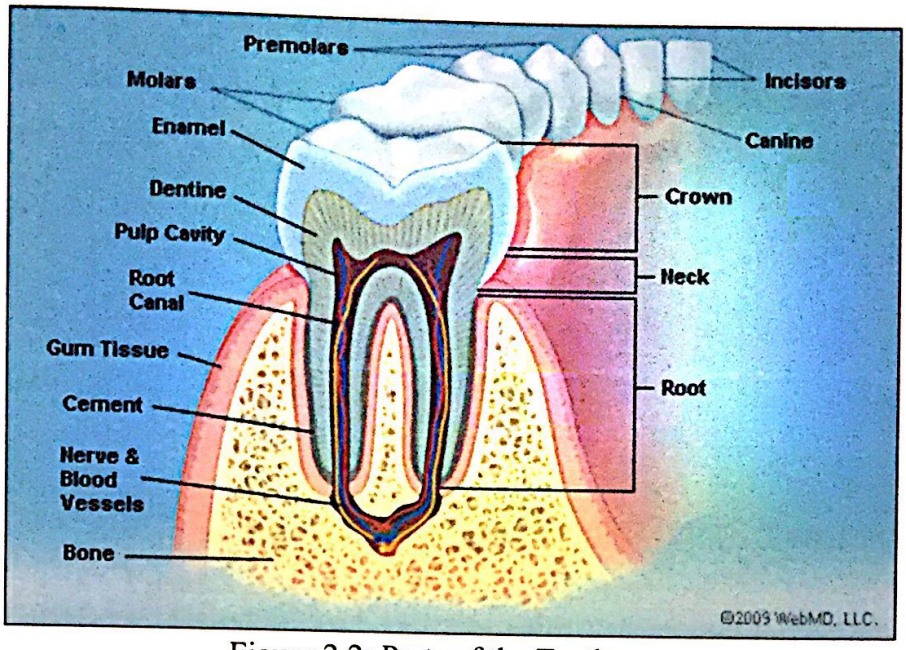


Figure 2.2: Parts of the Teeth

2.2 Dentures (False Teeth)

Dentures are removable false teeth made of acrylic (plastic), nylon or metal. They fit snugly over the gums to replace missing teeth and eliminate potential problems cause by gaps [2]. There are two types – complete and partial dentures. Complete dentures are for patients who are missing all of their teeth, while partial dentures will only replace missing teeth. When missing any teeth, partials play an important role in preventing other teeth from shifting position in the mouth [1].

Typically, patients receive dentures for the following reasons:

i. Partial loss of teeth in an arch
ii. Complete loss of all teeth in an arch
iii. Enhancing smile and facial tissues
iv. Improving chewing, speech and digestion

2 types of dentures:

i. Complete dentures (a full set) – which replace all upper or lower teethes.
ii. Partial dentures – which replace just one tooth or a few missing teethes.

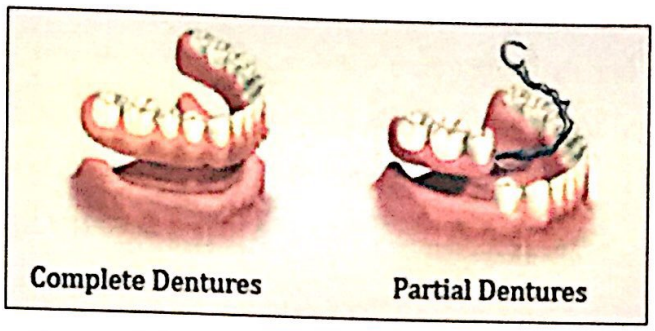


Figure 2.3: A Complete and Partial Dentures

2.2.1 How Dentures are Fitted

Complete dentures

A full denture will be fitted if all upper or lower teethes are removed or having an old complete denture replaced. The denture will usually be fitted as soon as the teeth are removed, which means the person will not be without teeth [2]. The difference between a dentist and a clinical dental technician (in terms of producing dentures) is outlined below.

i. A dentist – will take measurements and impressions (moulds) of the mouth, and then order patient's full or partial dentures from a dental technician.
ii. A clinical dental technician – will provide a full set of dentures directly without having to see the person's dentist (although should still have regular dental check-ups with dentist).

Partial dentures

The dentist can measure the mouth and order a partial denture for the patient, or the person can see a qualified clinical dental technician, who can provide a partial denture in directly first seen the dentist for a treatment plan and certificate of oral health. A fixed bridge is an alternative to a partial denture and may be suitable for some people. Crowns are put on the teeth both side of the gap and joined together by a false tooth that's put in the gap [2].

2.3 History of Handpiece

Since the inception of civilization, there has been evidence of dentistry. In 2006, scientists announced that they unearthed the earliest evidence of drilled human teeth in vivo, which are estimated to be more than 9,000 years old. The handpiece of today is sophisticated combination of precision parts moving in perfect synchronization at extremely high speed. The application places a strain or load, of one kind or another on the internal workings of the handpiece that eventually leads to failure. Chrome-plated outer's sleeves have been replaced with titanium providing a more durable finish.

The finish is less sensitive to the chemicals used during disinfection that may lead to corrosion. When considering an electric handpiece, titanium also provides an ultra-light handpiece are larger at the connector and therefore heavier than their air driven counterparts. Titanium handpiece can demonstrate a 30% decrease in weight compared to chrome-plated handpieces; based on the research review entitled

'Handpiece in Dentistry' by Prashanth Kumar, Sridhar, Malthesh B, Savakanavar and Kiran Murthy D.[3]

Dental handpiece is a tool that is used to drill into certain areas of the tooth with high speed. Also known as dental drill or dental engine, dental handpiece is a small, high-speed drill used during dental procedures, usually to remove decay and shape both structure prior to the insertion of a filling or crown.

Uses of Dental Handpiece:

i. remove tooth decay
ii. shape the tooth prior to any dental procedure
iii. clean and shape root canals
iv. remove old or temporary tooth filling or crown
v. clean the tooth

2.3.1 Types of Handpieces

Types of dental handpieces based on speed, there are two major types of dental handpiece, high speed dental handpiece and low speed handpiece. High speed dental handpiece can rotate at up to 400,000 rpm, and generally use hard metal alloy bits known as burrs. Low speed handpiece is operated by an inbuilt motor and their speed is around 80,000 rpm. [3]

Types of dental handpieces based on design, a dental handpiece can be classified into two, air-driven handpiece and electric handpiece. Air-driven high-speed handpieces contain air-driven turbine inside. This generates the rotational motion of the dental handpiece. Electric handpiece contains an electric motor driving the handpiece.

2.3.2 Low Speed Handpieces

A hand held motor, usually air-driven (can also be electric), that spins a cutting bur or prophy cup at 50,000 rpm or less. Used for removal of caries, refining a cavity preparation, performing prophylaxis, and other endodontic and implant procedures. Straight attachments that use handpiece burs are generally used for trimming prosthetics.

The low speed handpieces are fitted with a quick coupling to an air motor (some units use an electric motor). The burs can rotate at 7650 – 50,000 rpm (rotations per minutes) and they have high torque (power). The motor speed can be adjusted as well as going forward or in inverse.

2.3.3 Features of Low Speed Handpieces

An airline is attached to the back end of the handpiece, similar to a high speed handpiece. When air is introduced into the handpiece (via the chair unit foot pedal), air is forced over the vanes of the rotor (consisting of vanes or blades), which causes it to spin. After the air moves around the rotor, it is forced out through the handpiece's back end exhaust port.

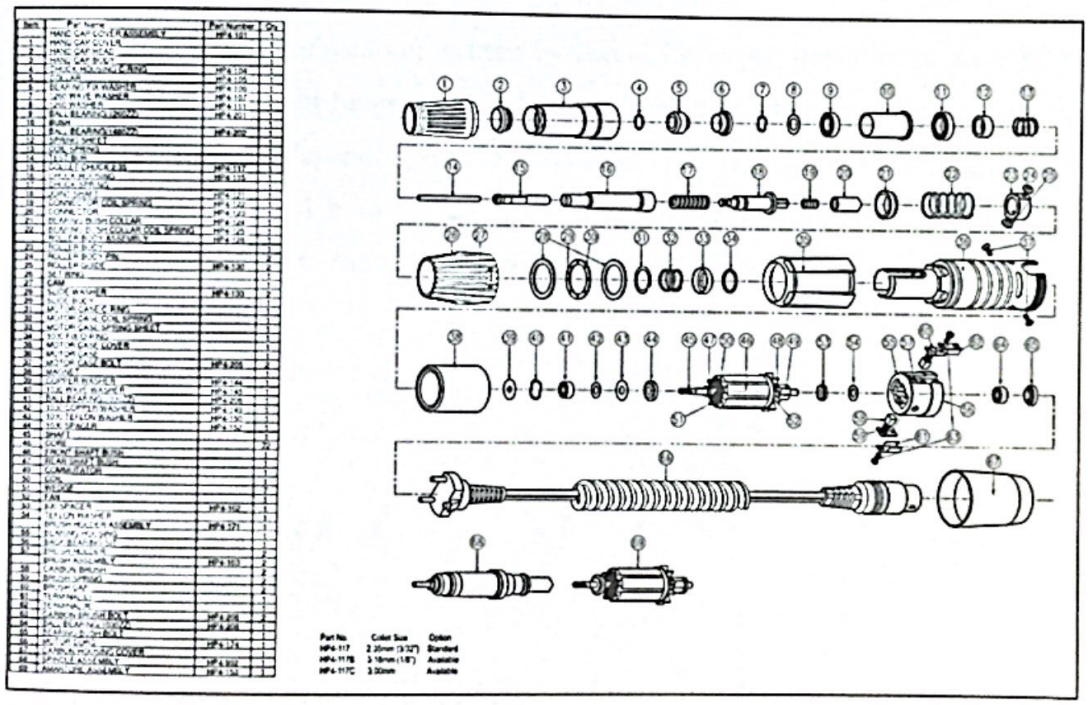


Figure 2.4: Part List of Handpiece and Sequence to Assemble the Handpiece

2.4 Burs

Burs for dental procedures typically are fabricated from tungsten carbide or diamond particle coatings, with ceramic and zirconia burs also available. Bur designs include many configurations and sizes, with bur selection depending on the type of procedure, the clinician's preference and the bur's overall effectiveness. The selection of an appropriate handpiece and appropriate burs is key for the safe and effective removal of dental hard tissues and caries in an efficient manner that also maximizes ergonomics for the clinician and minimizes patient discomfort.

According to a publication written by David Little [4], dental restorative burs are typically made from tungsten carbide or a diamond particle coating of varying degrees of roughness depending on the purpose of the bur, bonded to the underlying metal bur head. Dental burs are designed with different flute angles and cutting characteristics specific to the task for which they are designed.

2.4.1 Speed/ RPM by Burs

The speed at which you use your carbide bur in your rotary tool will depend on the material you're using it on and the contour being produced but it's safe to say you do not need to exceed speeds of 35,000 RPM. The table below shows some approximate speeds.

If the burs are chipping easily this could be due to the speed being too slow. However, it's ideal to start the bur off slow, increasing the speed as you go along. High speeds will prevent clogging in the flutes of your burs.

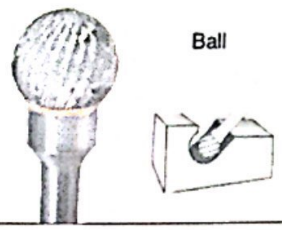
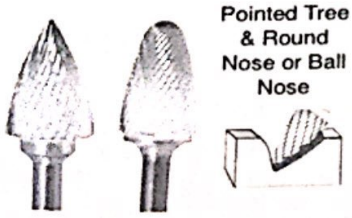
Table 2.1: The Diameter of Burs and Their Speed

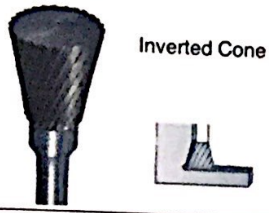
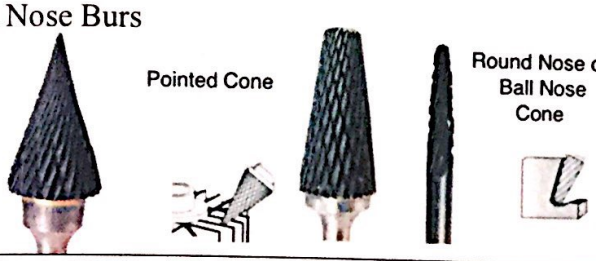
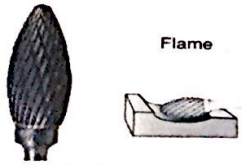
Diameter of Burs	RPM
1.6mm or 1/16"	25,000 - 35,000
2.35mm or 3/32"	17,000 - 26,000
3mm or 1/8"	17,000 - 26,000
6mm or 1/4"	11,000 - 16,500
12mm or 1/2"	8,000 - 12,000
16mm or 5/8"	7,650 - 11,500

2.4.2 Types of Burs

Various bur shapes can be selected, depending on the particular clinical case and the clinician's preference. Shapes include round, inverted cone, straight fissure, tapered fissure and pear-shaped – each available in a variety of diameters or sizes. [6]

Table 2.2: Various Types of Burs and Their Functions

Type of Burs	Functions
Carbide Ball Bur 	To create concave cuts in your material or to shape and hollow out an area.
Carbide Tree Burs 	Use for rounding off edges and making concave cuts. Use the pointed end for cutting in hard to reach areas and acute angled contours.

Carbide Inverted Cone Burs 	Use inverted cone shaped tungsten carbide burrs for making v-cuts and rear side chamfering.
Carbide Pointed Cone & Carbide Round Nose or Ball Nose Burs 	Good for rounded edges and surface finishing in difficult to reach areas or tight and narrow angles and contours. The round nose or ball nose cone are often referred to as a taper shape.
Flame Burs 	A wheel shaped bur with a smooth top and fluted sides. Great for channel work and shaping.

2.5 Handpiece and Bur Maintenance and Repair

Based on Peer-Review Publication written by Tija Hunter [6], dental handpieces have evolved significantly over the years and they remain a vital part of dentistry today. The care and maintenance of these instruments is essential to preserving not only the life of the instrument but its proper function as well. While traditional air driven handpieces are still a mainstay in dentistry, electric handpieces are now being more widely used.

The newest technology takes components from both electric and air driven handpieces. Understanding how to clean and maintain these handpieces and their components properly will help the clinician achieve optimal results. Knowing when to replace or rebuild handpiece turbines and its pros and cons, and knowing who to send the handpiece to for repairs is essential for quality and turnaround times. [5]

2.5.1 Cleaning and Lubricating of Handpiece

Following are the few steps to clean and lubricate handpiece:

1. Remove bur from handpiece.
2. Clean the outside of the handpiece under running water. (Do not clean the handpiece in disinfectant. Do not immerse your handpieces in any chemical solution, which includes water.)
3. Separate head and shank as appropriate.
4. Lubricate the head and handpiece separately With KaV0 Spray and appropriate nozzle. Repeat until clean lubricant appears from the Chuck (Always shake the can prior to use and keep upright when lubricating)
5. Use tissue to clean handpiece of any excess lubricant.
6. Sterilise in autoclave (Remember to change distilled water autoclave on a regular basis. Note: Recommended temperatures must not be exceeded)
7. Upon completion of cycle remove handpiece from chamber as soon as possible and store with head upright, until cool and internally dry.
   (Do not leave handpieces in autoclave)
8. Once dry and cool, handpieces can be stored in a bag, cupboard, drawer or upright on a handpiece stand.
9. Run handpiece briefly before use to clear excess lubricant. (Do not lubricate prior to use)

2.5.2 Replacing Carbon Brushes in Handpiece

1. After turn off the power of the Control Unit, remove the Carbon Housing Cover and the Motor Cord from the rear of the handpiece.
2. Remove worn-out Carbon Brushes after taking off Carbon Brush Bolts using a screwdriver (+).

3. Replace by new ones with observing the Brush Spring should get jammed in the Carbon Brush Holder.
4. Assemble the handpiece.
5. After run the handpiece under no load state about 20,000RPM for 30 minutes, then use.

* Replacing cycle of Carbon Brushes being about one year, can be depending on working hours and loading conditions.

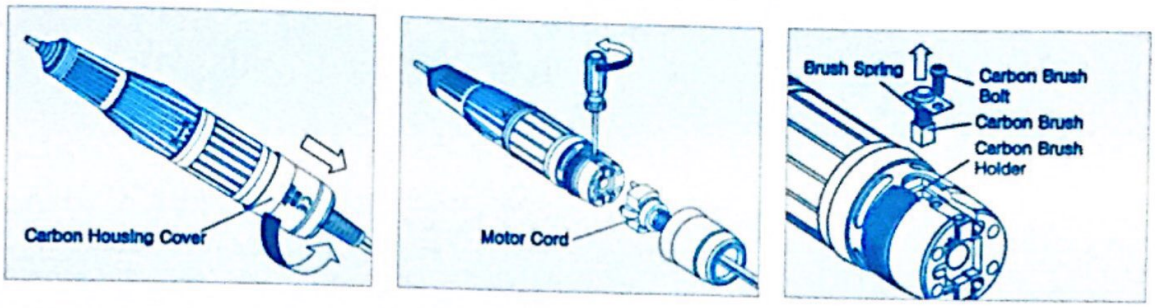


Figure 2.5: The Step Replacing the Carbon Brushes

2.5.3 Replacing Ball Bearings

1. Disjoint the Hand Cap and the Spindle Set.
2. If remove the C Ring from the front of the Chuck Housing, Ball Bearings and other parts are disassembled.
3. After assemble other parts and replace with new Ball Bearings sequentially, install C Ring again.
4. Joint The Hand Cap and the Spindle Set.
5. After run the Handpiece under no load state and confirm something wrong nonexistence, then use.

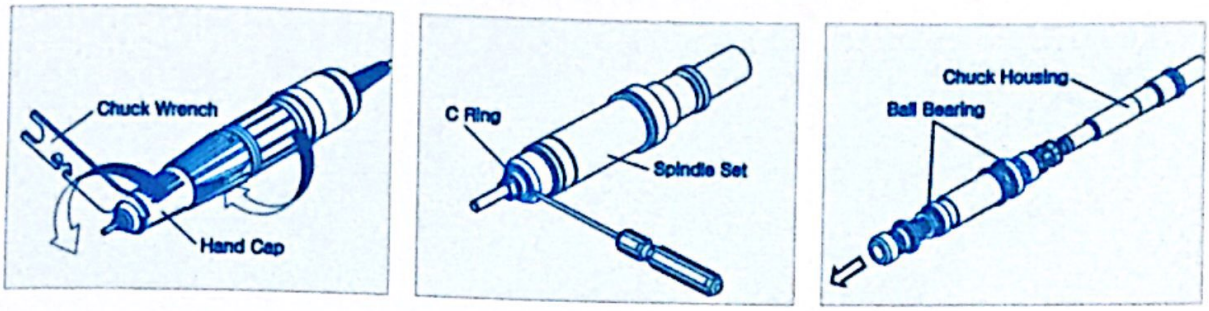


Figure 2.6: The Steps Replacing Ball Bearings

2.5.4 Cleaning and sterilizing burs

Following completion of a patient's procedure, the burs must be examined. Worn or damaged burs and any single-use, disposable burs must be discarded and safely disposed of.

Once it has been determined that burs can be reused, they must be cleaned and then sterilized like the steps stated below:

1. Burs should be pre-soaked in a container of soapy water to loosen debris.
2. Any remaining debris must be brushed away from the bur using a stainless steel wire brush, and the burs then must be rinsed under running water.
3. After rinsing, the burs must be thoroughly dried by placing them on absorbent towels and patting all bur surfaces.
4. Pre-sterilization cleaning of burs can also be performed using a washer-disinfector (found to be more effective than manual cleaning of contaminated dental burs)
5. Heat sterilization of burs can be achieved using a dry heat sterilizer or an autoclave. For dry heat sterilization, the burs should be sterilized at 170°C (340°F) for one hour. (This method, when used according to the manufacturer's instructions, will not corrode or dull carbide burs)

CHAPTER 3

METHODOLOGY

3.0 Introduction

This chapter will cover the details explanation of methodology that is being used to make this project complete and working well. Many methodology or findings from this field mainly generated into journal for others to take advantages and improve as upcoming studies. The method is use to achieve the objective of the project that will accomplish a perfect result. In order to evaluate this project, the methodology generally based on three major step, which is planning, implementing and analysis.

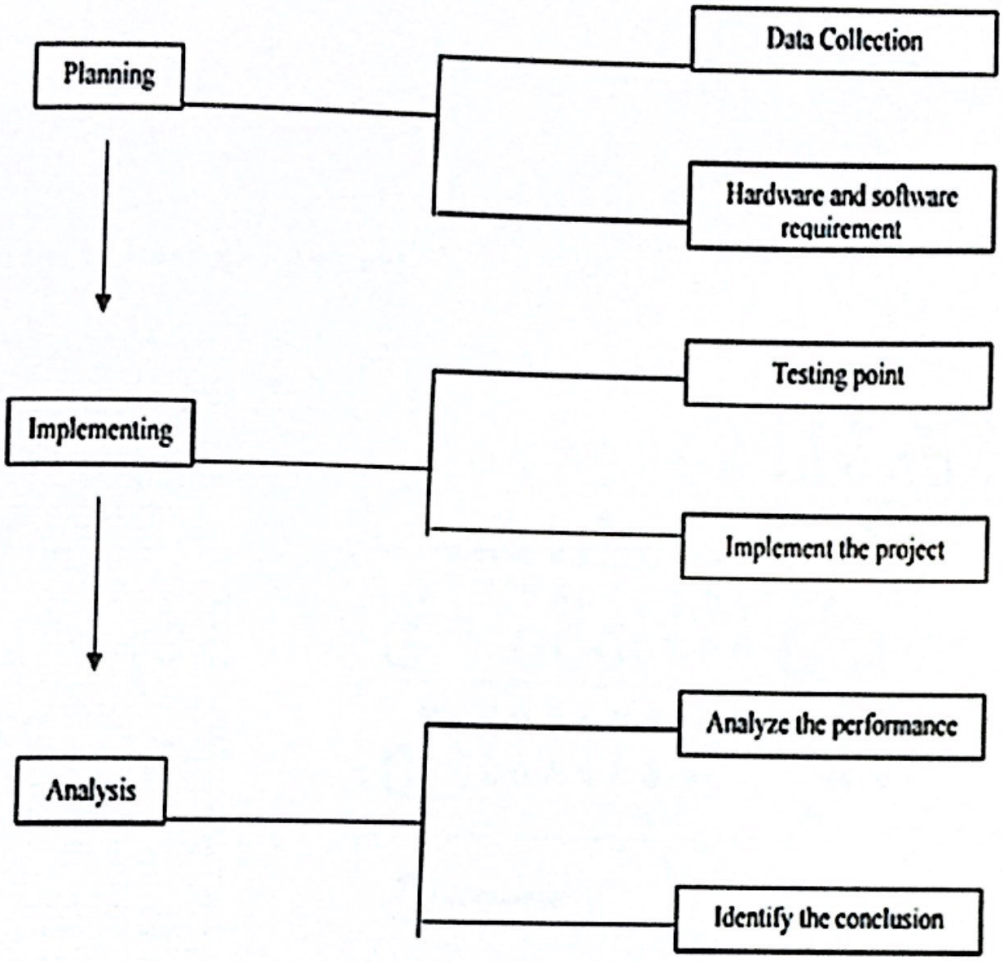
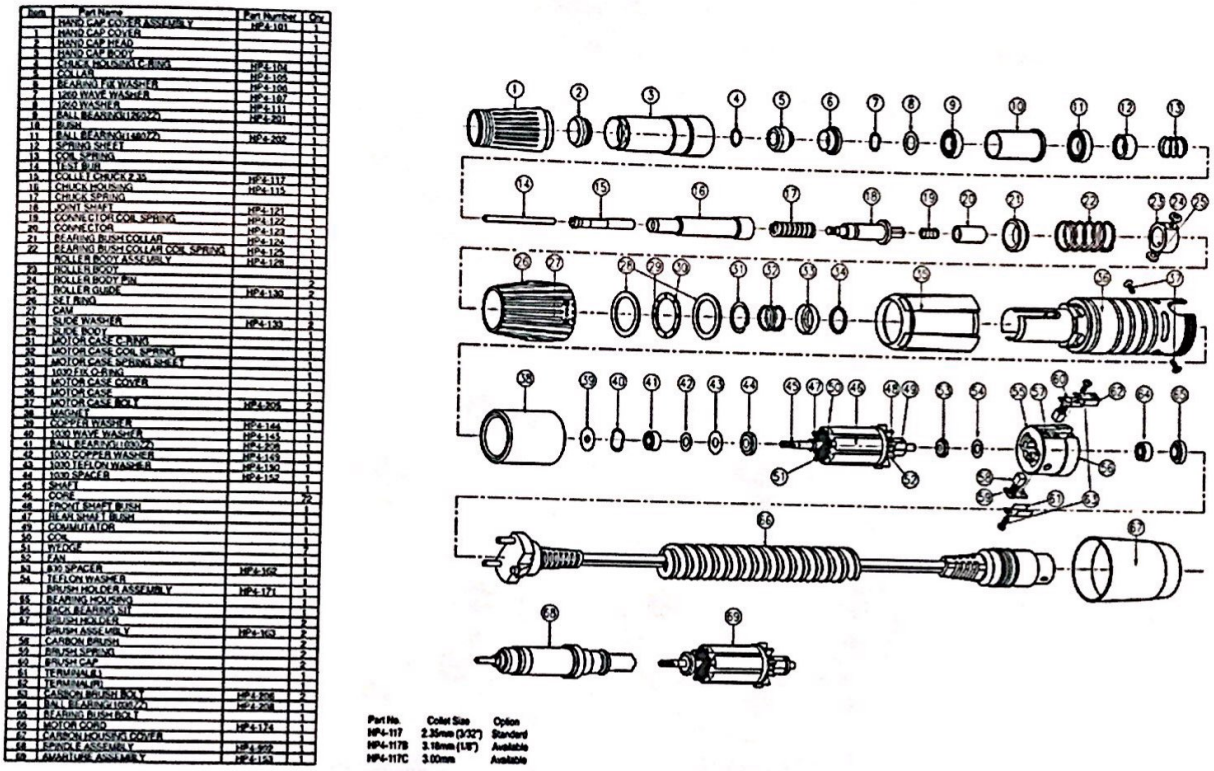


Figure 3.1: Steps of Methodology

3.1 Dental Handpiece

3.1.1 Dental Handpiece Assembly



Item	Part Name	Part Number	Qty
	HAND CAP COVER ASSEMBLY	HP4-101	1
1	HAND CAP COVER		1
2	HAND CAP HEAD		1
3	HAND CAP BODY		1
4	O-RING		1
5	COLLAR HOUSING C-RING	HP4-104	1
6	COLLAR	HP4-105	1
7	BEARING FOR WASHER	HP4-106	1
8	1200 WAVE WASHER	HP4-107	1
9	1200 WASHER	HP4-111	1
10	BALL BEARING(1/8X2X5)	HP4-201	1
11	BUSH		1
12	BALL BEARING(1/4X5X2)	HP4-202	1
13	SPRING SHEET		1
14	COIL SPRING		1
15	TEST BUR		1
16	COLLET CHUCK 2.35	HP4-117	1
17	CHUCK HOUSING	HP4-115	1
18	CHUCK SPRING		1
19	JOINT SHAFT	HP4-121	1
20	CONNECTOR COIL SPRING	HP4-122	1
21	CONNECTOR	HP4-123	1
22	BEARING BUSH COLLAR	HP4-124	1
23	BEARING BUSH COLLAR COIL SPRING	HP4-125	1
24	ROLLER BODY ASSEMBLY	HP4-129	1
25	ROLLER BODY		1
26	ROLLER BODY PIN		2
27	ROLLER GUIDE	HP4-130	2
28	SET RING		1
29	CAM		1
30	SLIDE WASHER	HP4-133	2
31	SLIDE BODY		1
32	MOTOR CASE C-RING		1
33	MOTOR CASE COIL SPRING		1
34	MOTOR CASE SPRING SHEET		1
35	1020 FIX O-RING		1
36	MOTOR CASE COVER		1
37	MOTOR CASE		1
38	MOTOR CASE BODY	HP4-305	1
39	MAGNET		2
40	COPPER WASHER	HP4-144	1
41	1020 WAVE WASHER	HP4-145	1
42	BALL BEARING(1/2X3X7)	HP4-208	1
43	1030 COPPER WASHER	HP4-149	1
44	1030 TEFLON WASHER	HP4-150	1
45	1030 SPACER	HP4-152	1
46	SHAFT		1
47	CORE		22
48	FRONT SHAFT BUSH		1
49	REAR SHAFT BUSH		1
50	COMMUTATOR		1
51	COIL		1
52	RIDGE		7
53	FAN		1
54	830 SPACER	HP4-162	1
55	TEFLON WASHER		1
56	BRUSH HOLDER ASSEMBLY	HP4-171	1
57	BEARING HOUSING		1
58	BACK BEARING SET		1
59	BRUSH HOLDER		2
60	BRUSH ASSEMBLY	HP4-163	2
61	CARBON BRUSH		2
62	BRUSH SPRING		2
63	BRUSH CAP		2
64	TERMINAL(L)		1
65	TERMINAL(R)		1
66	CARBON BRUSH BODY	HP4-306	1
67	BALL BEARING(1/2X5X2)	HP4-209	1
68	BEARING BUSH BODY		1
69	MOTOR CORD	HP4-174	1
70	CARBON HOUSING COVER		1
71	SPINDLE ASSEMBLY	HP4-902	1
72	ARMATURE ASSEMBLY	HP4-153	1

Part No.	Collet Size	Option
HP4-117	2.35mm (3/32")	Standard
HP4-117B	3.18mm (1/8")	Available
HP4-117C	3.00mm	Available

Figure 3.2: Part List of Handpiece and Sequence to Assemble the Handpiece (Source from Sun Burst Company)

To assemble the handpiece, the sequence of the part in the handpiece must be proper based on figure 3.1.1. The burs used in our project is silfradent burs with diameter 2.35 mm.

3.1.2 Male and Female DIN 5/180° Pin Connector

Figure 3.3: Male and Female DIN 5/180° Pin Connector and the Arrangement of the Number of Pin

A DIN connector is an electrical connector that was originally standardized by the *Deutsches Institut für Normung* (DIN), the German national standards organization. DIN connectors are round, with pins arranged in a circular pattern. This type of connector was used widely for PC keyboards, MIDI instruments, and other specialized equipment. In our project, we used male and female 5/180° pin DIN to connect the handpiece and control box. We choose one positive pin and one negative pin to control the output of control box and input for handpiece, while pin 3 has no function in this case.

Table 3.1: Positive Pin and Negative Pin of Both Male and Female 5/180° Pin DIN Connector

Positive pin (+)	Negative pin (-)
1	2
4	5

3.2 Control Box

3.2.1 Schematic Diagram of Control Box

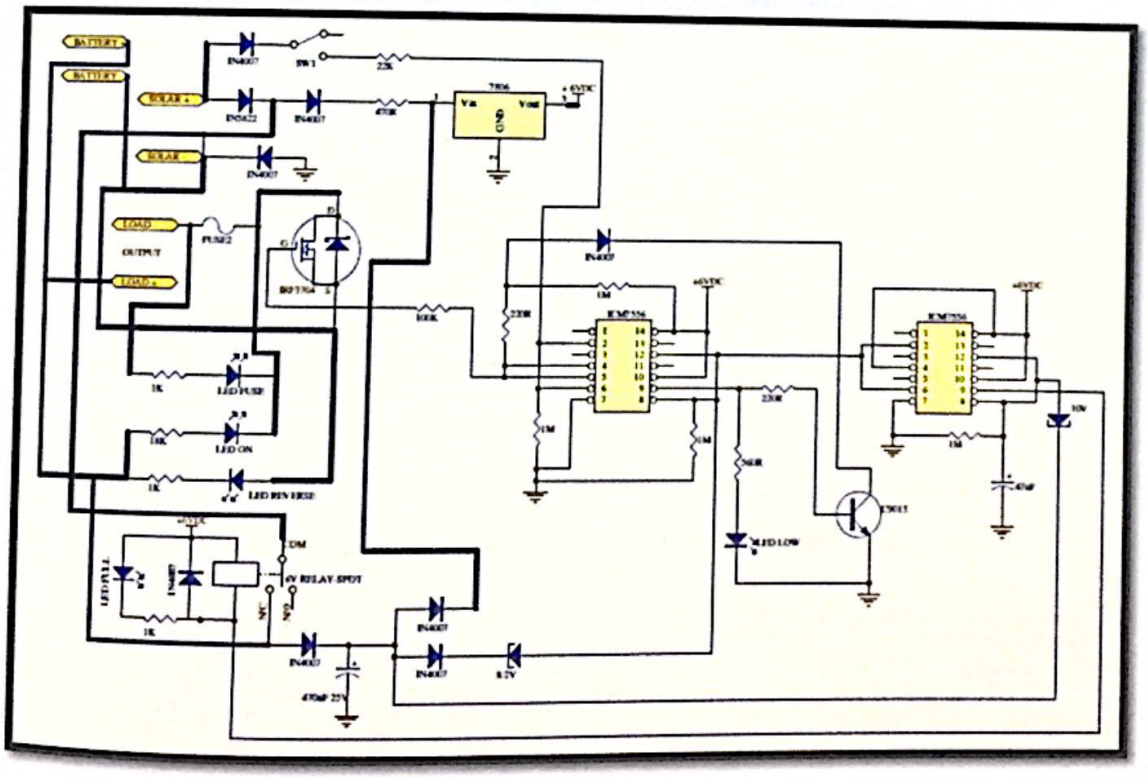


Figure 3.4: Schematic Diagram of Control Box

3.2.2 Block Diagram

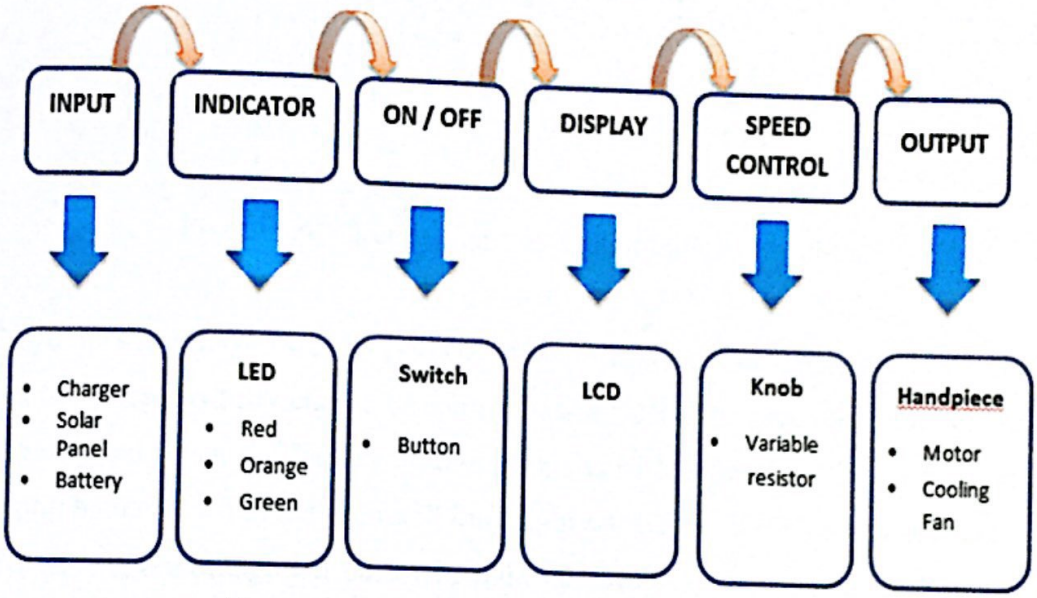


Figure 3.5: Block Diagram of Control Box

3.2.3 Explanation of Circuit Board and Cooling Fan in the Control Box

In our control box, it have four part difference functions but connect each other. Three of these are circuit board and they function is use to control handpiece rotate speed, display speed value when handpiece run, switch on/off for the control box and showing battery level by using different colour of indicator light bulbs. For another part, it is cooling fan and its function is use to cooling the control box.

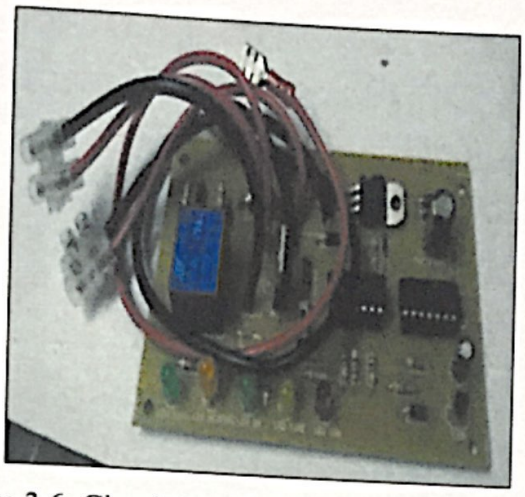


Figure 3.6: Circuit Board of Switch Indicator Light

In this diagram, it have three led, two of led bulb represent different level of battery. When the battery is fully charge or control box is "ON", the green led bulb will only light up. And when the battery storage drops until low level on in the process of charging battery, the red led bulb will only light up. Lastly, if the battery connector is placed invert, the orange led bulb will light up. Besides that, this circuit board also don't have any coding, it just simply use electronic component to control it like IC 7555/NE556 controller IC and Delay Relay Timer Module Trigger Delay Switch (Time Delay Relays).

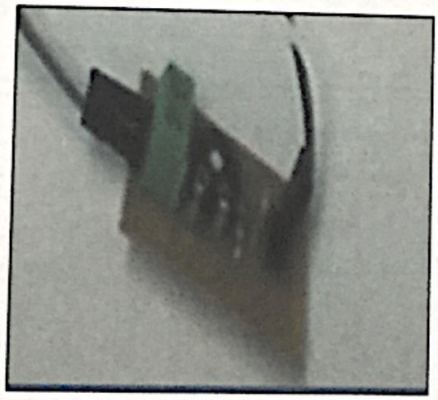


Figure 3.7: Circuit Board of Voltage Measurement Sensor

Table 3.2: Function of each part in Voltage Measurement Sensor

LABEL	FUNCTION
A	Probe (Input sensor for measure voltage)
A1	Probe +ve
A2	Probe GND
B	Preset (Calibration)
C	No Connected(N/C)
D	Signal Output(Analogue Signal)
E	Ground(GND)

Explanation

Function:

i. When input module have a voltage (0V until 30V) this product be produce signal at pin (D) in signal analogue

ii. Adjust VR or preset for calibration to PIC until get the actual voltage from input module

iii. Output Signal need connect to PIC or MCU (Microcontroller) board.

iv. See the illustration A for reference

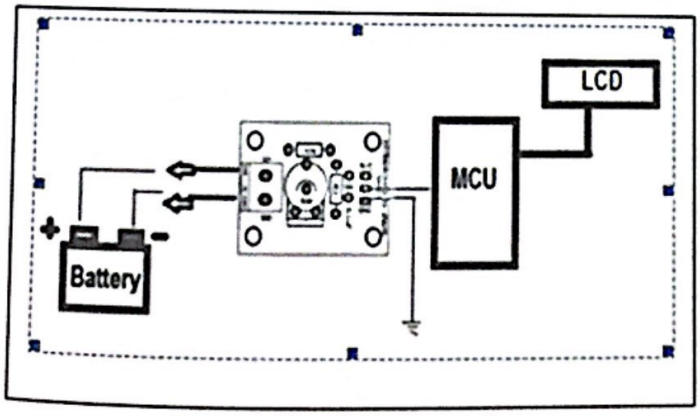


Illustration A

Figure 3.8: Connection between Circuit Board of Voltage Measurement Sensor and other circuit board in control box

*Must be using this product before connect to PIC or MCU (microcontroller) board. Because input voltage PIC board is 0 volt until +5 volt.

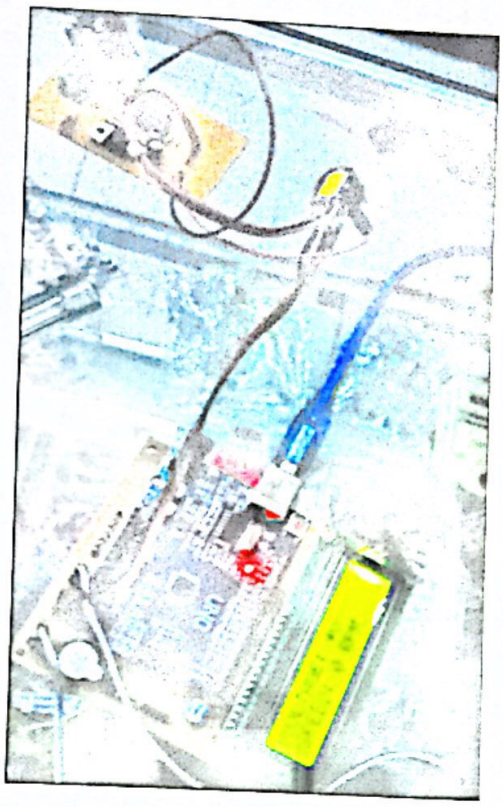


Figure 3.9: Circuit Board and Schematic Diagram of LCD display

In this part, it has LCD Display, speed control knob and place that connection between circuit board and handpiece in our control box. When we choose the speed by rotating the speed control knob, the LCD Display will automatically display the speed value that you chose just now. The speed value display at LCD Display is in RPM unit and the range is between 0rpm until 27000rpm. Besides that, when we rotate the speed control knob, the handpiece will move or run with the speed value we chosen, these three part are working or functioning in the same time.

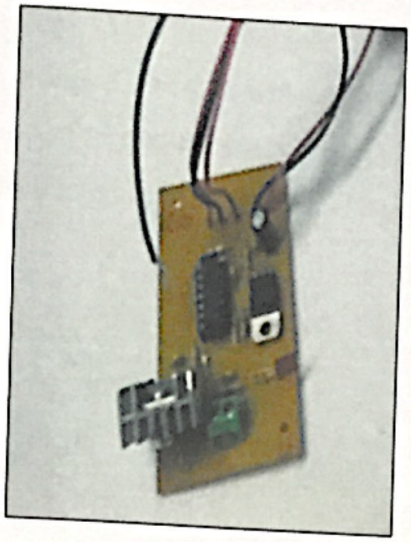


Figure 3.10: Circuit Board of DC Control Speed

For this circuit board, its function is to connect the handpiece to the whole circuit board in the control box. The DIN for this circuit box will connect with the din at the handpiece, so the current/ voltage from the battery can flow to the handpiece via this circuit board.

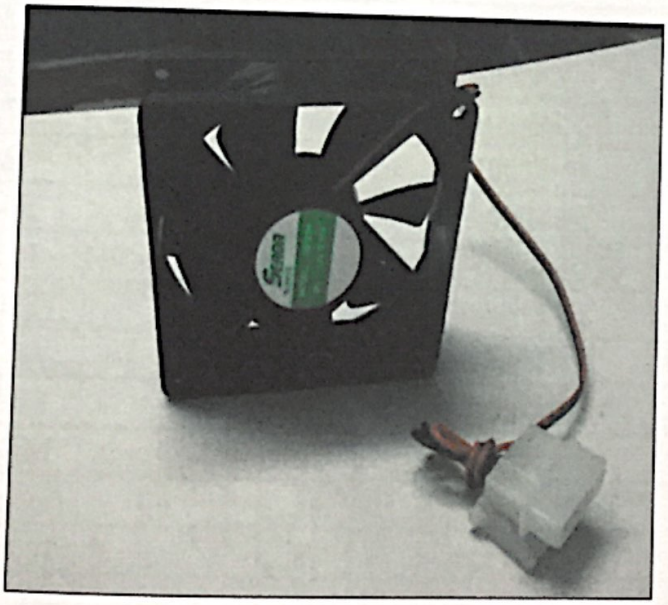


Figure 3.11: Cooling Fan

This cooling fan is same as the computer fan is any fan inside, or attached to, a computer case used for active cooling, and may refer to fans that draw cooler air into the case from the outside, expel warm air from inside, or move air across a heat sink

to cool a particular component. Generally these are found in axial and sometimes centrifugal forms. In our project, the reason why we need to put cooling fan in our control box is because we want to prevent overheating phenomena won't happen in our control box. This will effectively increase the lifespan for our control box and also the whole product.

3.2.4 List Component

Table 3.3: List of Components Used in Control Box

NO	COMPONENT	UNIT	NO	COMPONENT	UNIT
1	Resistor 1.2k	x1	21	Capacitor 47uf	x1
2	Resistor 470	x2	22	Fuse 4A/5A	x1
3	Resistor 1k	x2	23	Reg 7806	x1
4	Resistor 560R	x1	24	Irfz 44	x1
5	Resistor 18k	x1	25	IN5822/IN5804	x1
6	Resistor 100k	x2	26	LED	x5
7	Resistor 22k	x1	27	Relay 6V	x1
8	Resistor 220R	x2	28	Jumper pin(set)	x1
9	Resistor 1M	x4	29	IC 7805	x1
10	Resistor 560R	x1	30	Ic base 14pin	x2
11	Diode IN4001 ~ IN4007	x8	31	IC 7555/NE556	x1
12	Zener diod 6.2V	x1	32	Resistor 3.3k	x2
13	Zener diod 10V	x1	33	Resistor 47k	x1
14	Transistor 9013	x1	34	Resistor 2.7k	x1
15	Capacitor 470uf	x1	35	Capacitor 0.1uf	x4
16	LED (any colour)	x1	36	Capacitor 100uf	x1
17	Ic base 14pin	x1	37	Diode IN4007	x1
18	IC LM324	x1	38	Vibrable Resistor 10k(VR)	x1
19	2way Terminal Blok(for motor)	x1	39	IRFZ34 or IRFZ44	x1
20	PCB	x1	40	Regulator 7809	x1

3.2.5 List of component use in control box

3.2.5.1 IC 7555 /ne556

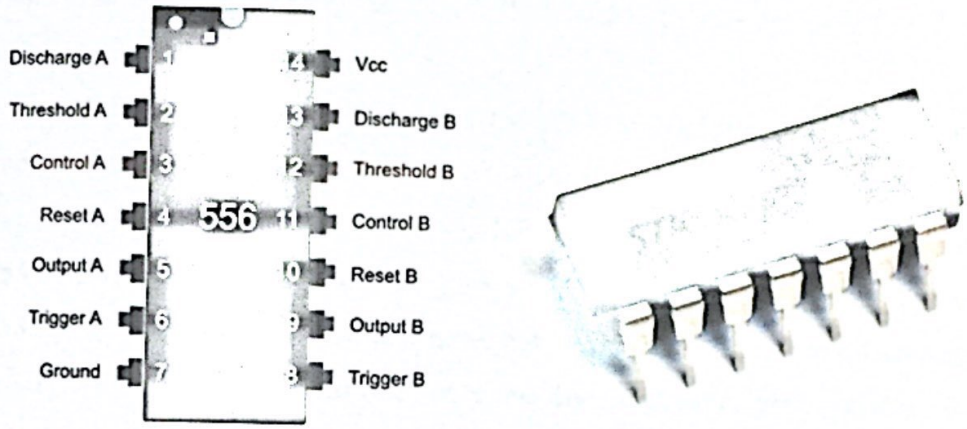


Figure 3.12: IC 7555/ne556

The function of an IC (integrated circuit) chip is to replace many separate electronic components which could possibly have been used to build a particular electronic circuit. Most of those separate components are replaced by just one tiny IC chip that has been manufactured ("fabricated" is the correct technical word) to include extremely miniature circuits which imitate the behaviour of all those separate components.

In our circuit board, we use IC 7555/NE556 or IC base 14pin, this is because the 7555 CMOS device suffers from none of these snags; it can use supplies in the range of 2V to 18V, draws only 100μA quiescent from a 15V supply, and draws a peak spike current of only 10mA when its output transitions from one state to the other, thus generating negligible switching RFI. In our schematic diagram, the pin2 (Threshold) and pin 6 (Trigger) of the IC 7555/NE556 are receive the voltage from the battery after the switch is ''ON''.

Threshold detects the high voltage on the capacitor and makes Discharge and Output go LOW. While Trigger detects the low voltage on the capacitor and makes Discharge and Output go HIGH. For the pin8 (Trigger B) and pin12 (Threshold B), they are connecting to another IC 7555/NE556 as provide power supply. Besides that, they also connect the IC 7555/NE556 to voltage regulator 7806 for stable voltage (or less often current). The pin 7 (ground) will connect the IC 7555/NE556 to the ground. While the pin 4 (Reset A), pin 5(Output), pin10 (Reset B) and pin 14 (Vcc) are connect to the supply voltage of the IC 7555/NE556 to operate.

If it is momentarily grounded, the IC 7555/NE556's operation is interrupted and won't start again until it's triggered again via pin 6. The pin5 and pin9 is output pin, they are connect the IC 7555/NE556 to the led bulbs. For another IC 7555/NE556, the connection of pins are mostly similar with the previous C 7555/NE556 that we mention just now, but only a few of pins are difference, like in this IC 7555/NE556 (second one) only use one output pin- pin9 and this pin is also connect the IC 7555/NE556 to the led bulb.

3.2.5.2 Relay 6V

Figure 3.13: 6V Relay

:

In addition, in circuit board, we also use Relay 6V or normally call as time Delay Relays. It function is control period between the functioning of two events. A Time Delay relay is a combination of an electromechanical output relay and a control

circuit. The control circuit is comprised of solid state components and timing circuits that control operation of the relay and timing range. Time delay relays have a broad choice of timing ranges from less than one second to many days. There are many choices of timing adjustments from calibrated external knobs, DIP switches, thumbwheel switches, or recessed potentiometer.

The output contacts on the electromechanical output relay are direct wired to the output terminals. Time delay relays are simply control relays with a time delay built in. Their purpose is to control an event based on time. The difference between relays and time delay relays is when the output contacts open & close: on a control relay, it happens when voltage is applied and removed from the coil; on time delay relays, the contacts will open or close before or after a pre-selected, timed interval.

3.2.5.3 Liquid Crystal Display (LCD)

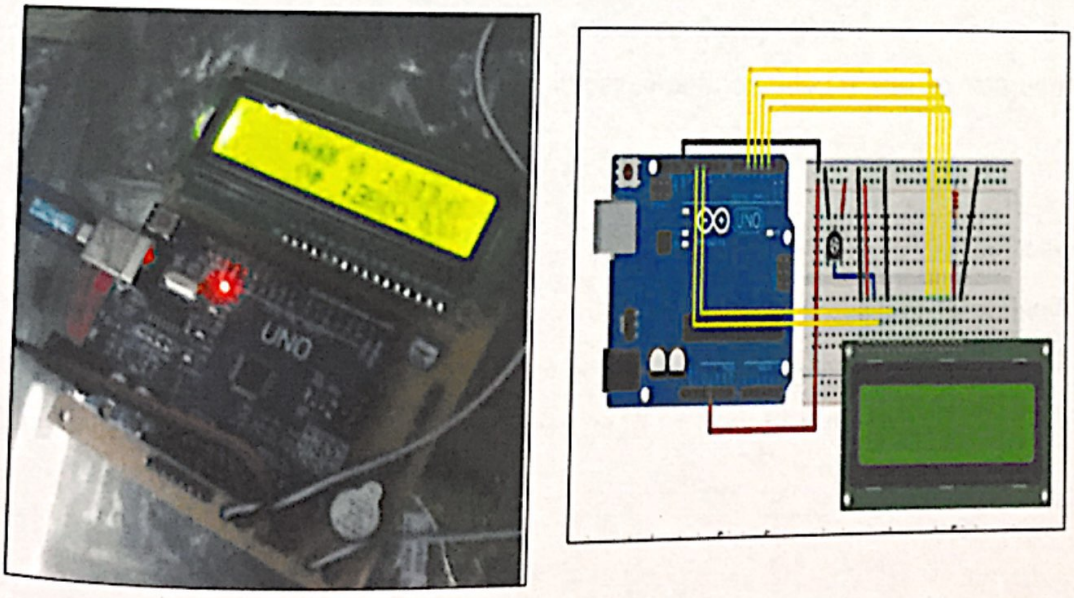


Figure 3.14: LCD and the Connection of LCD with Microcontroller

The LCDs have a parallel interface, meaning that the microcontroller has to manipulate several interface pins at once to control the display. The interface consists of the following pins:

i. A register select (RS) pin that controls where in the LCD's memory you're writing data to. You can select either the data register, which holds what goes on the screen, or an instruction register, which is where the LCD's controller looks for instructions on what to do next.
ii. A Read/Write (R/W) pin that selects reading mode or writing mode
iii. An Enable pin that enables writing to the registers
iv. 8 data pins (D0 -D7). The states of these pins (high or low) are the bits that you're writing to a register when you write, or the values you're reading when you read.
v. There's also a display contrast pin (Vo), power supply pins (+5V and Gnd) and LED Backlight (Bklt+ and BKlt-) pins that you can use to power the LCD, control the display contrast, and turn on and off the LED backlight, respectively.

The process of controlling the display involves putting the data that form the image of what you want to display into the data registers, then putting instructions in the instruction register. The Liquid Crystal Library simplifies this for you so you don't need to know the low-level instructions.

The LCD Display can be controlled in two modes: 4-bit or 8-bit. The 4-bit mode requires seven I/O pins from the Arduino software, while the 8-bit mode requires 11 pins. For displaying text on the screen, you can do most everything in 4-bit mode, so example shows how to control a 2x16 LCD in 4-bit mode.

Circuit

Before wiring the LCD screen to your Arduino or Genuino board we suggest to solder a pin header strip to the 14 (or 16) pin count connector of the LCD screen, as you can see in the image above.

To wire your LCD screen to your board, connect the following pins:

i. LCD RS pin to digital pin 12
ii. LCD Enable pin to digital pin 11
iii. LCD D4 pin to digital pin 5
iv. LCD D5 pin to digital pin 4
v. LCD D6 pin to digital pin 3
vi. LCD D7 pin to digital pin 2

Additionally, wire a 10k pot to +5V and GND, with it's wiper (output) to LCD screens VO pin (pin3). A 220 ohm resistor is used to power the backlight of the display, usually on pin 15 and 16 of the LCD connector.

3.2.6 Solar Panel

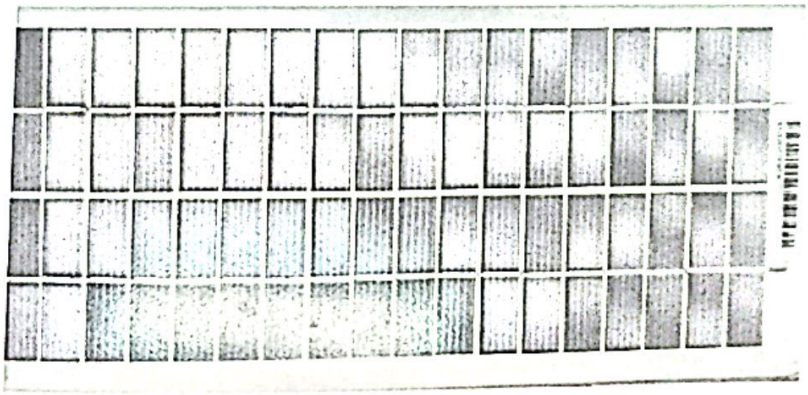


Figure 3.15: Solar Panel

The size of this solar is 160mm (length), 360mm (width), 28mm (depth). The number of cell in this solar panel is 36. Besides that, the max power current (Imp) and max power voltage (Vmp) are 0.3A and 17V, but for the max power voltage actually it can reach until 22V after we tested it under the sunlight. The out peak

3.2.7 Casing Design of Control Box

For the design of the casing, we totally design for twice as we found that the first design was not suitable for solar panel to fix on it. Besides, it is round in shape that not able to stand nicely. For the second design, we modified the round shape control box into a rectangular shape with blunt corner control box which able to fit with the shape of solar panel.

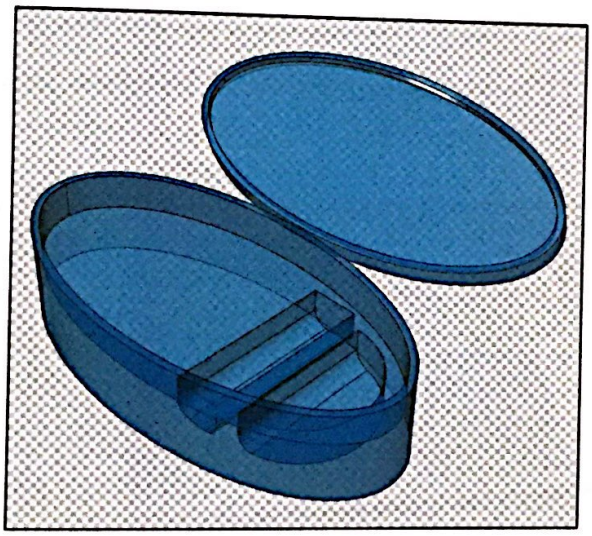


Figure 3.16: First Design of Control Box

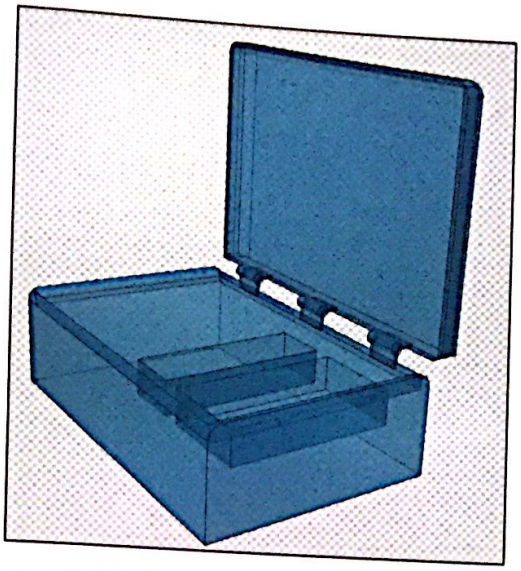


Figure 3.17: Second Design of Control Box

There are 2 partitions (left side) that used to keep the handpiece and the adapter. Another side is to place with knob, LEDs, on and off button, and LCD. This control box has the length of 36.7 cm, width of 22.7 cm, and height of 11.8 cm.

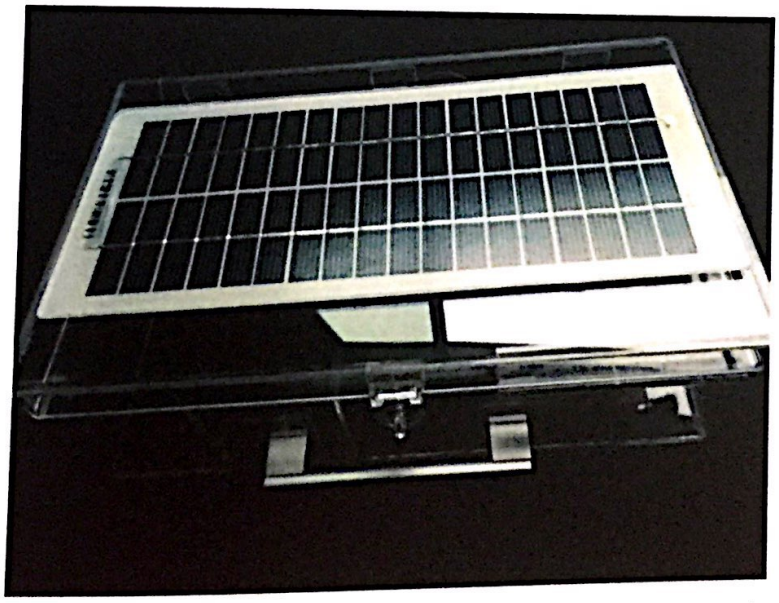


Figure 3.18: View of Control Box when Cover is Closed.

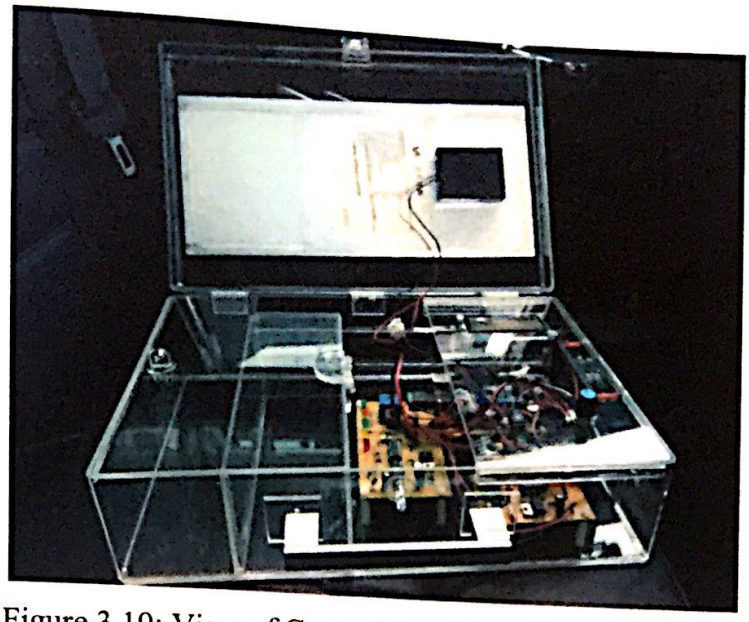


Figure 3.19: View of Control Box when Cover is Opened.

3.3 Programming

3.3.1 Explanation of each parts of flowchart

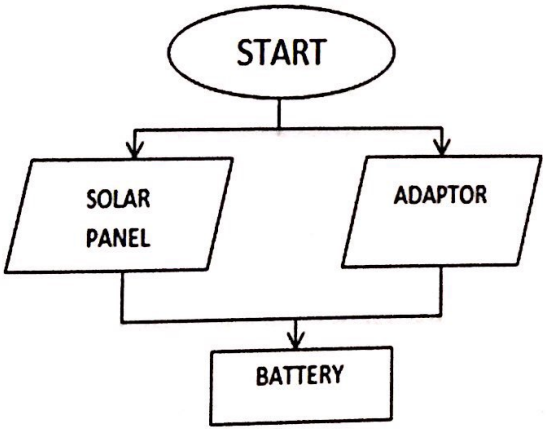


Figure 3.20: Flowchart of input source for the battery

From the beginning, for the input of the battery, we have two choices. One is from solar panel and the other one is from adaptor (that mean from socket). The battery storage is 16V and the solar panel can provide maximum voltage until 22V. So that is conform the concept of solar panel circuit which mean the voltage that provided by solar panel must greater than battery storage.

If not, the solar panel will charge very slowly and this will affect the efficiency of the machine. This situation also happens at adaptor and battery. The output of adaptor must greater/higher than the battery storage. If not, the machine won't function because there is not enough input power supply to support the machine run.

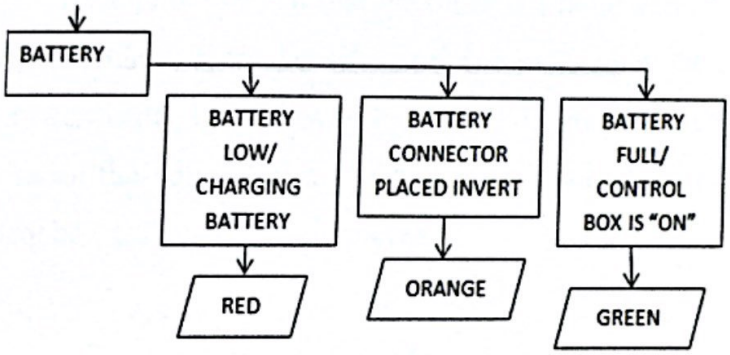


Figure 3.21: Flowchart of Indicator Light and its function

This part is showing the battery level indicator light, but here it doesn't use any coding and just simply used delay to control and manage the battery level indicator light. There have three battery levels respectively low and high. If the battery is fully charge or control box is "ON", the green led bulb will only light up. If the battery storage drops until low level on in the process of charging battery, the red led bulb will only light up. Lastly, if the battery connector is placed invert, the orange led bulb will light up.

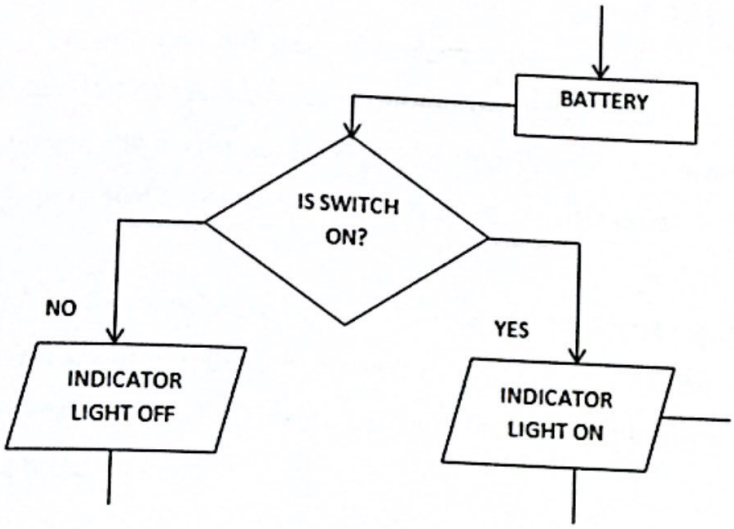


Figure 3.22: Flowchart of switch ON/OFF

Here is the switch that we on or off the control box (another word is whole machine). If the switch is on, the indicator light will also on while if the switch is off, the indicator light will off. Besides that, if the switch is on, that mean the voltage from the battery will start flow into the circuit of the control box and also the handpieces.

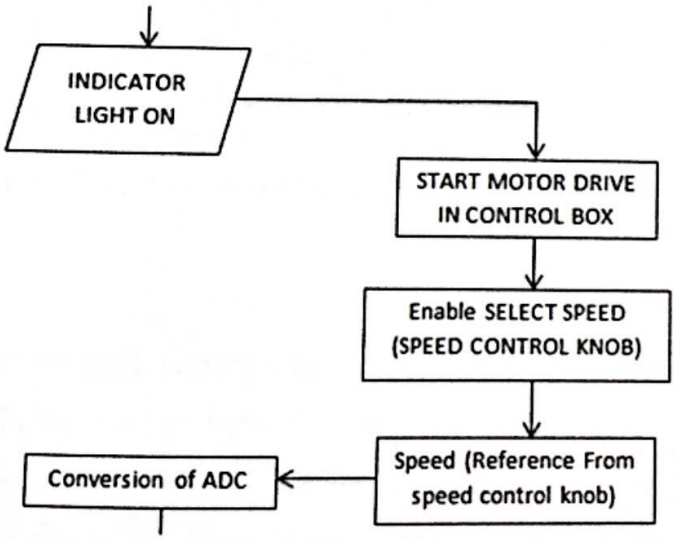


Figure 3.23: Flowchart between Speed Control Knob and ADC converter

When the switch is on, the motor drive or circuit panel in control box will start function automatically. At this time, we can choose the speed that we want for our handpieces at the speed control knob. The minimum speed is 0rpm and the maximum speed is 27k rpm for the handpieces, we can choose any speed that we want by simply rotate the speed control knob.

After we choose the speed value, this analogue signal (from the speed control knob) will directly convert to digital signal by using ADC (analogue-to-digital converter). This digital signal is very useful for the display and can read by handpieces.

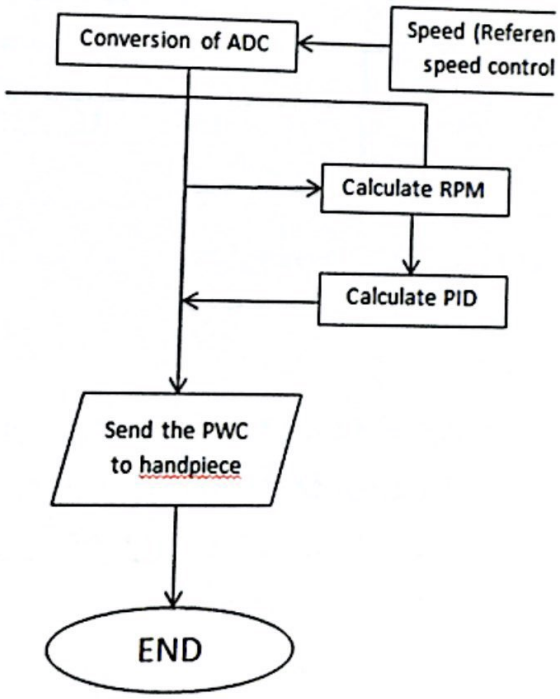


Figure 3.24: Flowchart between PWM and ADC Converter

After the analogue signal convert to digital signal at ADC, then the signal will be counted in RPM form and then send to display. Then, signal will go through the PID after calculated in RPM form. PID controller (proportional–integral–derivative controller) is a control loop feedback mechanism (controller) commonly used in industrial control systems.

A PID controller continuously calculates an error value {\display style e(t)} e(t) as the difference between a desired set point and a measured process variable and applies a correction based on proportional, integral, and derivative terms (sometimes denoted P, I, and D respectively) which give their name to the controller type. After check by PID, send the PWC to the handpiece and let the handpiece start rotate.

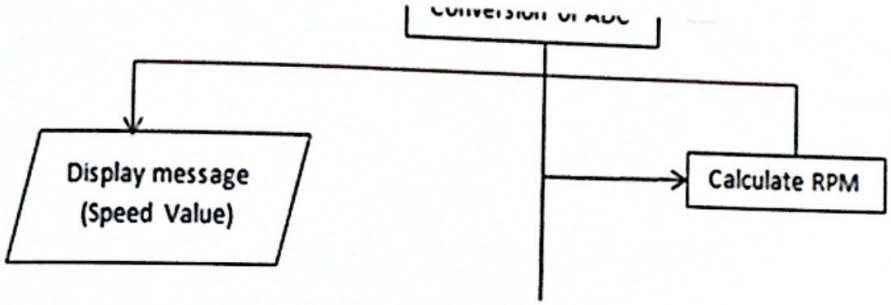


Figure 3.25: Flowchart between RPM and LCD display

In this part, after the RPM have been calculated, then this signal will send to display to shown out the RPM value. RPM is a revolution per minute (abbreviated rpm, RPM, rev/min, r/min) is a measure of the frequency of rotation, specifically the number of rotations around a fixed axis in one minute. It is used as a measure of rotational speed of a mechanical component.

3.4 Analysis

3.4.1 Survey

A field of applied statistics, survey methodology studies the sampling of individual units from a population and the associated survey data collection techniques, such as questionnaire construction and methods for improving the number and accuracy of responses to surveys.

Before proceed this project, questionnaires is given to specific person, who are the users of handpiece, such as technician, dentists and others. Moreover, after the project is done, another questionnaires are given to the students and lecturers in Politeknik Sultan Salahuddin Abdul Aziz Shah. Their answers are classified to speed, safety, and usability of our project. The result is recorded in statistics and graph.

Figure 3.26: Survey on Students and Lecturers PSA after Project is Done

3.4.2 Calculation between Resistance and Speed of Handpiece

According to Ohm's Law, in a linear circuit of fixed resistance, if there is an increase in voltage, the current will goes up, and similarly, if there is a decrease in voltage, the current goes down. This means that if the voltage is high the current is high, and if the voltage is low, the current is low. Likewise, if increase in resistance, the current goes down for a given voltage and if decrease in resistance, the current goes up. Which means that if resistance is high, current is low and if resistance is low, current is high.

Furthermore, the speed of handpiece is also depends on the voltage and current supplied. As an example, if voltage high, current will also high and the speed will increase. If there is a resistance, current will become lower for a given voltage and the speed will decrease.

To calculate the speed based on the resistance of the variable resistor (knob) with the maximum resistance of the variable resistor of 3500Ω and the maximum speed of handpiece of 27000 rpm. Ratios of 3500Ω : 0rpm, 0Ω : 27000rpm:

Speed Produced (rpm) = Maximum speed – [(maximum speed / maximum resistance) x resistance chosen (Ω)]

Example: 27000 – [(27000/ 3500) x 500 = 23143 rpm

Table 3.4: Resistance of Variable Resistor (Knob) and Speed of Handpiece

Resistance (Ω)	Speed of handpiece (rpm)
3500	0
3000	3857
2500	7714
2000	11571
1500	15429
1000	19286
500	23143
0	27000

To make sure the burs not to break or spoil, the resistance and speed is set depend on the range of speed that can withstand by the burs due to its diameter. (Refer Chapter 2)

3.5 Flow Chart of Project Development

A flow chart is a type of diagram that represents an algorithm, workflow or process, showing the steps as boxes of various kinds, and their order by connecting them with arrows. This diagrammatic representation illustrates a solution model to a given problem. Flowcharts are used in analysing, designing, documenting or managing a process or program in various fields.

Besides, flowchart is an excellent way of planning a project. Each stage of the project is set out as a sequence of events. A typical standard flowchart is with the contents of a design folder set out as a number of individual stages. Each stage leads to the next, displaying the sequence of events.

3.5.1 Flowchart Objectives

Following are the objectives of flowcharts:

i. Represent ideas in a graphical manner.
ii. Make us easier to see how complex systems work.
iii. Promote process understanding.

3.5.2 Flowchart of Final Year Project

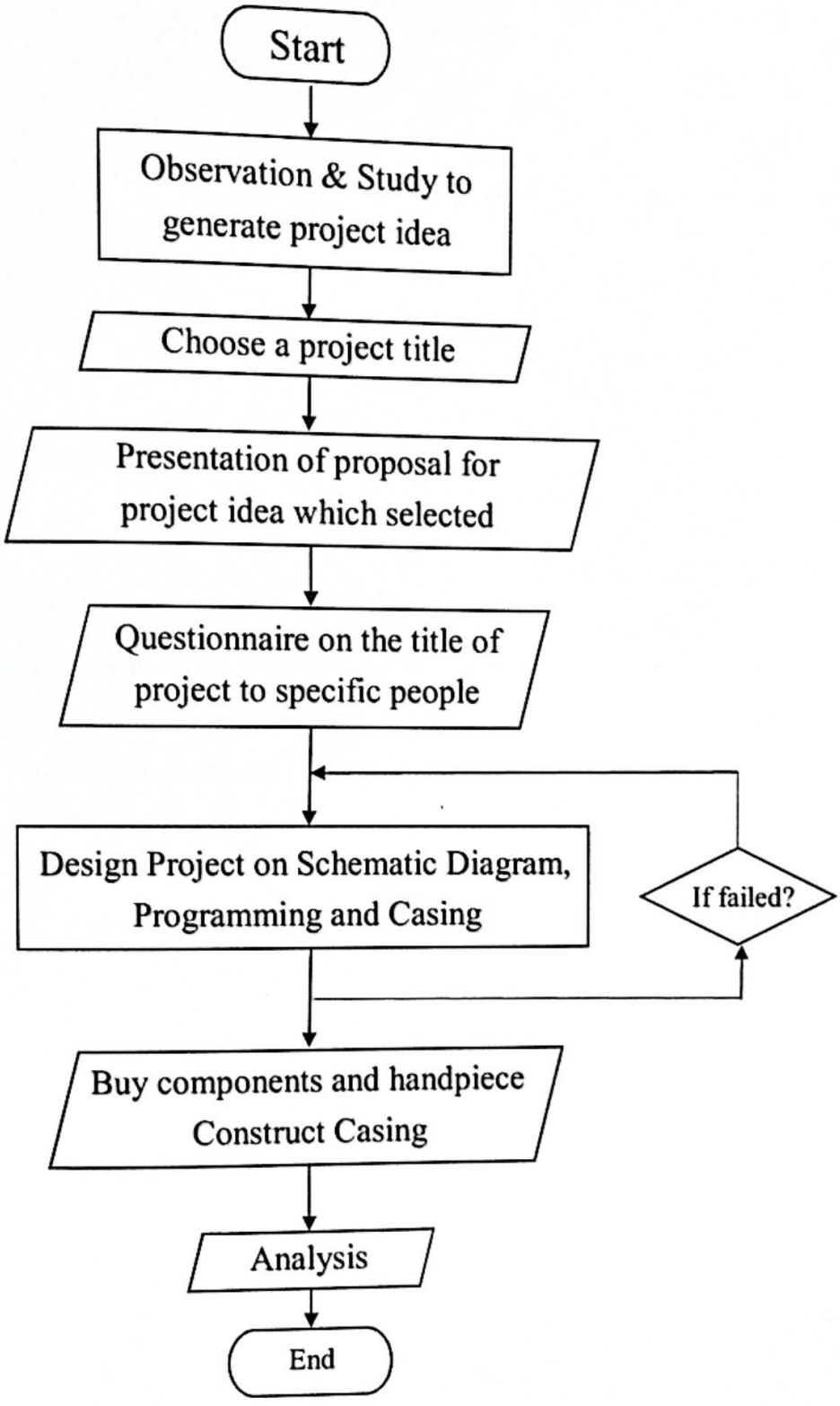


Figure 3.27: Project Planning Flowchart

CHAPTER 4

RESULTS & DISCUSSION

4.1 Survey with Dental Technicians

A survey has been done among a group of dental technicians to gather ideas and reviews on this new innovation. This survey carried out before we start to produce the device. Firstly, objectives and project planning of this project is well described to the dental technicians. This is attributed to further supportive ideas which helped us on planning the project to be more efficient to the user. Especially for dental technicians and biomedical engineers. The survey form is attached as Appendix X.

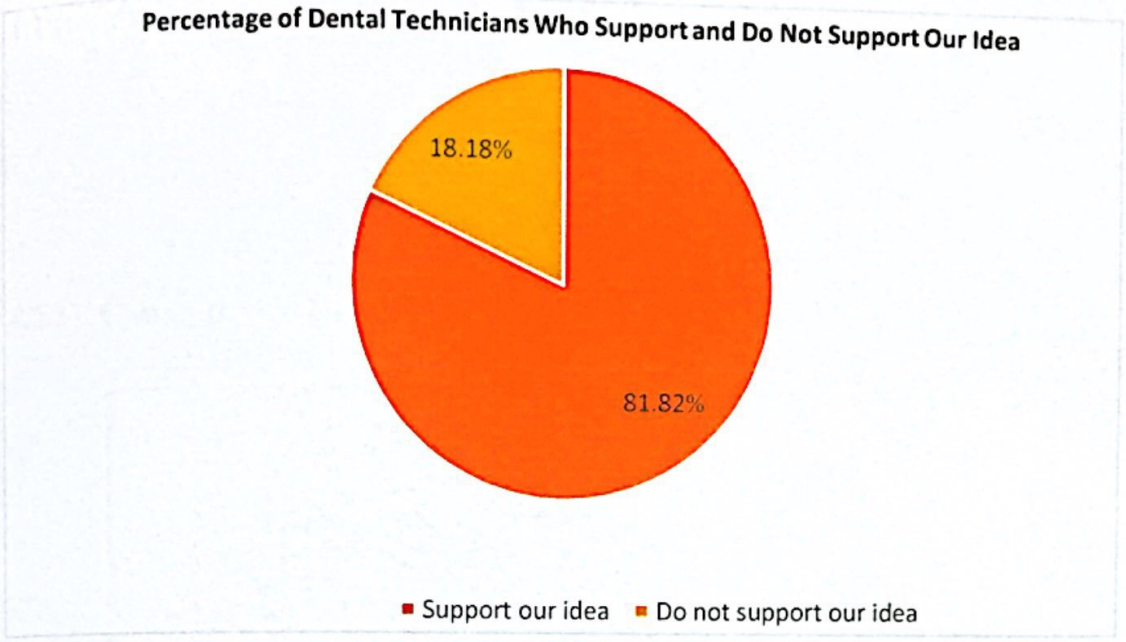


Figure 4.1: Pie Chart on Percentage of Dental Technicians Who Support and Do Not Support Our Idea

Based on the chart shown above, 81.82% of the dental technicians support our idea. Comments and reviews regarding this project is written on the survey form. For example:

i. To make the size of the control box bigger for better cooling system
ii. To make good ventilation system because high temperature causes the device malfunction.
iii. Hand piece damages frequently and the bur loses its grip

However, there are 18.18% of them who do not support the project. This is because they are comfortable and already familiar in using the current model. Furthermore, they commented that they are not having big problems with the current model to support our innovation.

4.2 Results

4.2.1 Casing Design Result

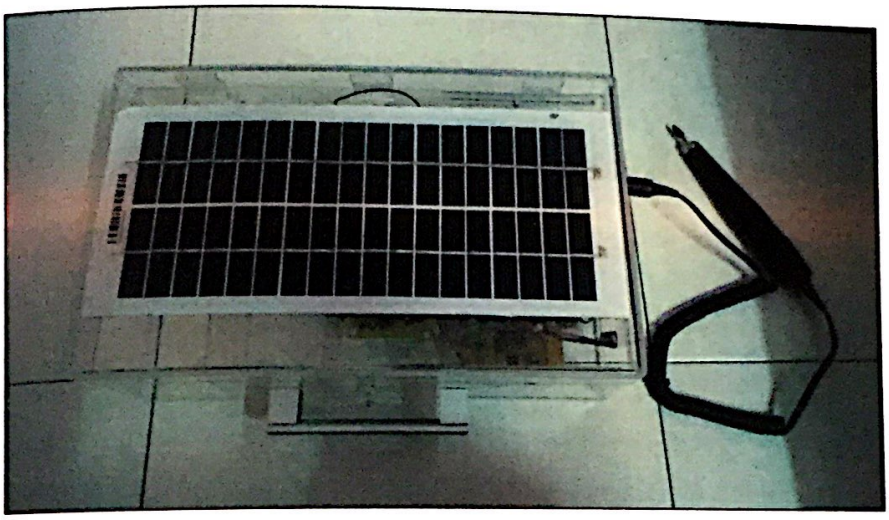


Figure 4.2: The Top View of the Solar Fixed Control Box and Handpiece

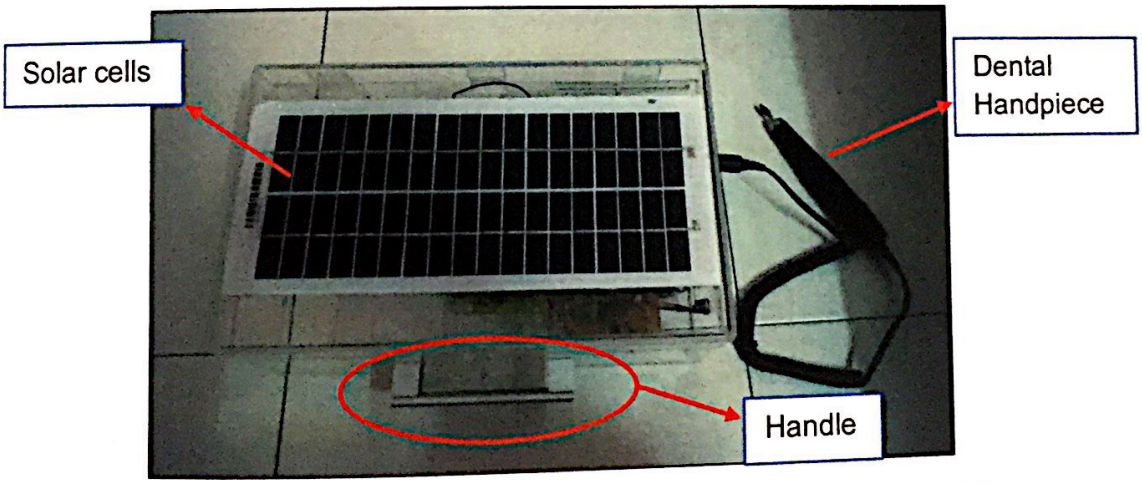


Figure 4.3: The Labelling Of the Solar Fixed Control Box and Handpiece

The solar cells are fixed on top of the casing. This enables the solar cells to receive sunlight easily. A handle is fixed on the side part of the box, so that it can be carried everywhere.

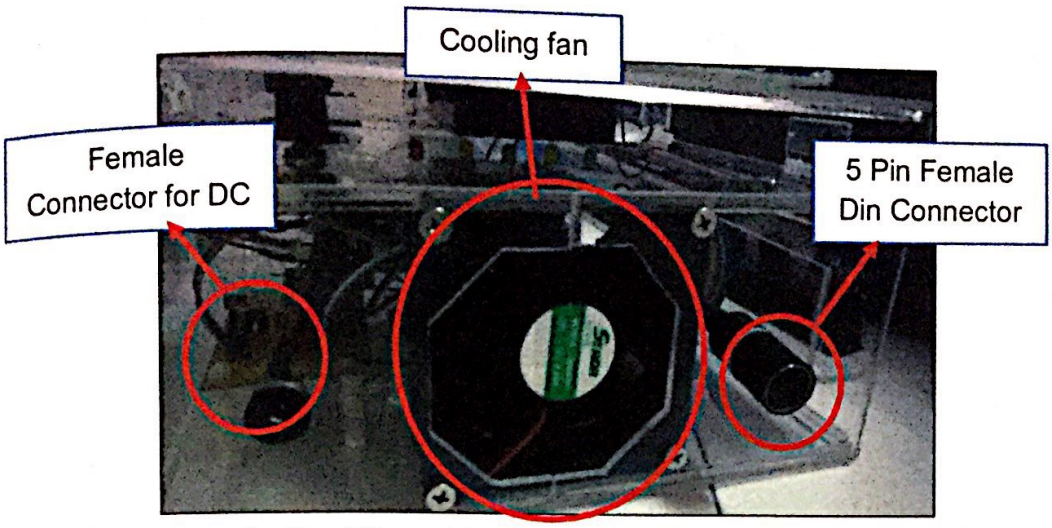


Figure 4.4: The Top View of the Solar Fixed Control Box and Handpiece

A 3 inch size of cooling fan is also fixed on the right side of the box to improve the cooling system which reduces the heat of the components. This is because the components, mainly the circuit temperature rises as the motor functions for a long time. Female connector for DC adapter and 5 Pin Female Din connector is also placed beside the cooling fan to connect the hand piece.

4.2.2 Results on Speed and Resistance

We have tested the resistance of the variable resistor by using multimeter and take the reading of the speed of the handpiece. The resistance of the variable resistor is the manipulated variable which can affect the speed of the handpiece which is the responding variable. However, there is some difference between the calculated result and the result after tested as there is some error in programming and energy loss in the circuit.

Table 4.1: Result of Resistance of Variable Resistor (Knob) and Speed of Handpiece

Resistance (Ω)	Speed of handpiece (rpm)
3500	0
3000	5645
2500	10364
2000	13440
1500	17293
1000	20877
500	24013
0	27059

4.3 Evaluation Survey

The evaluation survey has been done by 30 respondents which consists of 25 engineering students and 5 Lecturers. Students from Mechanical Department (JKM), Electrical Department (JKE) and Civil Department (JKA) and lecturers from Electrical Department (JKE) were involved in this survey. Table below shows the overall results of the survey conducted.

Departments	JKE (10 students)		JKA (9 students)		JKM (6 students)		JKE (5 lecturers)	
Questions/ Respond	YES	NO	YES	NO	YES	NO	YES	NO
Q1	10	0	9	0	6	0	5	0
Q2	10	0	9	0	5	1	5	0
Q3	10	0	8	1	5	1	5	0
Q4	10	0	8	1	6	0	5	0
Q5	10	0	9	0	6	0	5	0
Q6	8	2	9	0	6	0	5	0
Q7	6	4	2	7	2	4	3	2
Q8	10	0	8	1	6	0	5	0
Q9	10	0	9	0	5	1	5	0
Q10	10	0	8	1	6	0	4	1
Total = 30 respondents								

Table 4.2: The Responses for the Evaluation Survey

4.3.1 Analysis on Evaluation Survey

There were 10 questions in the evaluation survey form to evaluate the project. The 'Yes or No' questions were mainly on objectives of the project, user convenience, safety measure, and market potential.

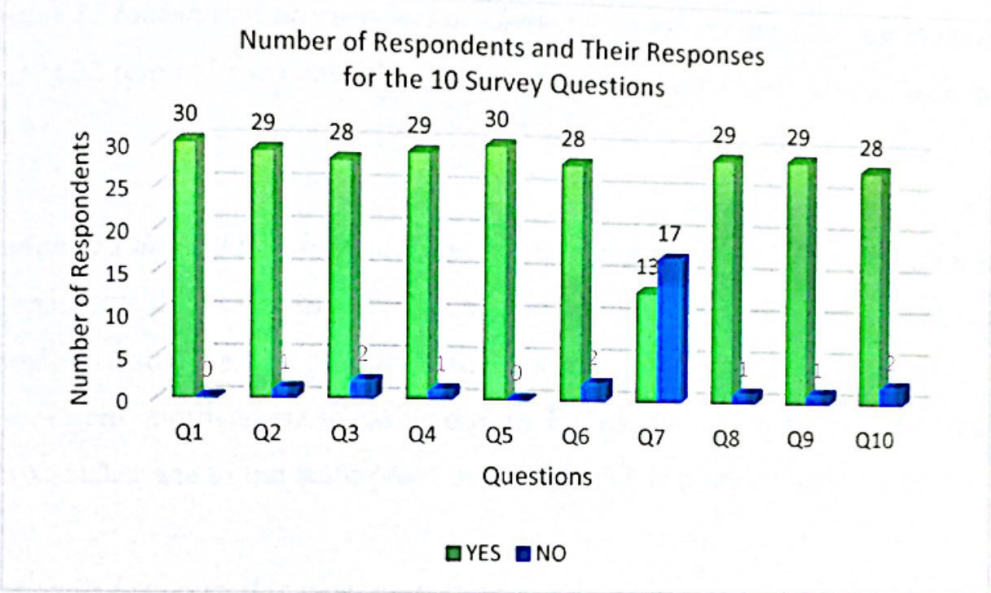


Figure 4.5: The Overall Graph on Number of Respondents and Their Responses for Each Question

Question 1: I think it will help the clinics or laboratories in rural area.

30 out of 30 respondents thinks that this project helps the clinics or laboratories in rural area.

Question 2: It has good design that suitable for clinics, hospitals, or laboratories.

29 out of 30 respondents thinks that this project is suitable for clinics, hospitals or laboratories.

Question 3: I think it can be easily to bring on any transport.

2 out of 30 respondents think that this device/equipment not easy to bring on any transport due to the big and thick sized box which will not be easy to carry on a bike

Question 4: I support this product as an eco-friendly product.

29 out of 30 respondents support this product as an eco-friendly as the box uses solar cells which changes solar energy to electrical energy.

Question 5: I think it is safe to be used.

All of 30 respondents thinks this product is 100% safe to be used.

Question 6: I think that this product are better than others available on the market.

28 out of 30 respondents thinks this product are better than others available on the market.

Question 7: I think that this product need some improvement. If yes, please state.

17 respondents thinks that this product no need some improvement and the others 13 respondents stated that this product need some improvement. All 13 of them stated that they need improvement in casing design. For example, they suggested to make the box smaller and to use waterproof material which is more suitable for rural areas.

Question 8: I support this new innovation.

29 out of 30 respondents support this new innovation.

Question 9: This product is convenient to use because it can control only by hand that use less energy or reduce human error.

29 out of 30 respondents choose agrees that this project is user-friendly as it helps to reduce the human error.

Question 10: The design is futuristic

For the last question, 28 responds agreed that the design is futuristic while 2 of them thinks that we can enhance more futuristic design for a better market potential.

4.3.2 Score Given by Respondents

Score out of 10 given by each respondent for the project to rate the new innovation. This is attribute to a conclusion whether this project is supported or not supported by the people. Meanwhile, it is also easier to decide whether the objectives have been accomplished or no.

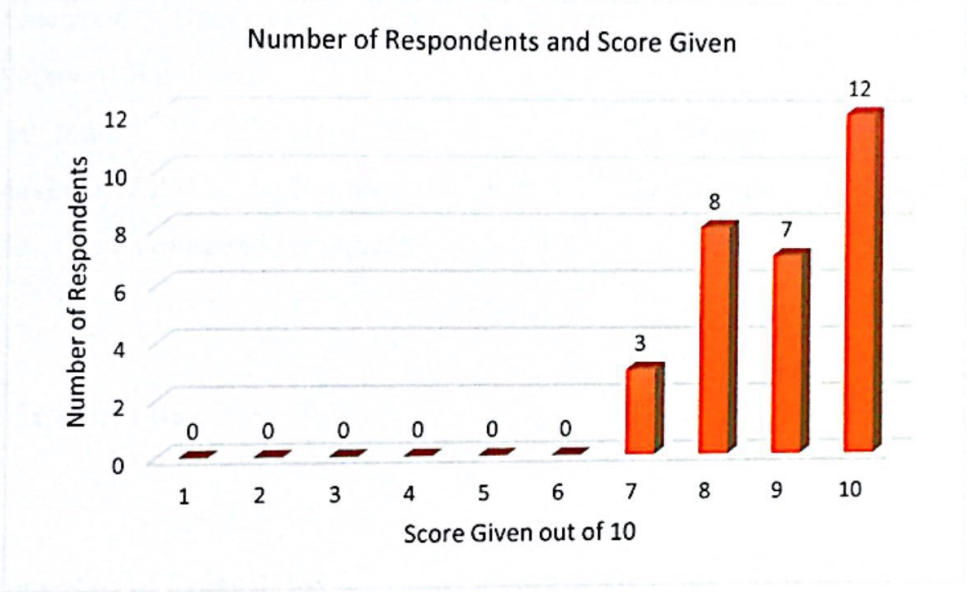


Figure 4.6: Number of Respondents and Score Given By Them Out Of 10

4.4 Technical Data

4.4.1 Handpiece

Dimension of Handpiece : 154.50 mm x 29.4 mm
Weight of Handpiece : 270g
Maximum RPM of the Handpiece : 35 000 rpm
Maximum RPM of the Bur used (Silfradent) : 27 000rpm
Maximum Voltage of Handpiece : 30V

4.4.2 Control Box

Dimension of Control Box : 33.7 cm x 22.7 cm x 11.8 cm
Weight of Control Box :
Voltage Supply (Rechargeable Battery) : 16V
Output Voltage (Rechargeable Battery) : 16V
Current (Rechargeable Battery) : 2200 mAh
Variable Resistance : 0 – 3500 Ω

4.4.3 Solar Panel

Dimension of Solar Panel	: 160 mm x 360 mm x 28 mm
Out Peak Power	: 5 Watt
Power Allowance Range	: ±5%
Max. Power Voltage	: 20V
Max. Power Current	: 0.3 A
Number of Cells	: 36

4.5 Conclusion for Evaluation Survey

Evaluation survey was analysed mainly on objectives of the project, user convenience, safety measure, and market potential. The evaluation of survey was conducted among a group of dental technicians and 30 respondents which consists of students from Mechanical Department (JKM), Electrical Department (JKE) and Civil Department (JKA) and lecturers from Electrical Department (JKE).

As we can see in pie chart 4.1, 81.82% of the dental technicians support our idea of this new innovation. They support our idea and give some comments and recommendation regarding this new innovation such as add the cooling fan to make a good ventilation system and make the size of control box bigger.

The survey among students and lecturers also shows that mostly of respondents support this new innovation. The respondents support this project innovation mainly because it will help clinics or laboratories in rural areas, using solar energy and provide user-friendly device that use less energy and also reduce human error.

For the evaluation of user convenience, some of the dental technicians stated that they already comfortable using current model and they also commented that they are not having big problems with the current model to support our innovation. The figure 4.5 shows mostly the respondents of students and lecturers choose yes to the question about the product is convenient to use as it can control by hand that use less energy.

Next, for the evaluation of safety measure, based on the figure 4.5, all the 30 respondent thinks this product save to be used. The safety of this product already tested by our own. We tested it by using multimeter to ensure that there is no short circuit. We also tested the project with technician to make sure it functioning well.

For the evaluation of the market potential, based on the survey among students and lecturers, 28 of them thinks this product are better than others available on the market. The design of this product also influenced by market potential. 29 out of 30 respondents thinks design of this product is suitable for clinics or laboratory. But, some respondents also comments that the design or casing must do improvement.

According to the chart in Figure 4.6, all 30 respondents have given their scores and (40%) majority of them gave best score which 10/10. In a nutshell, most of them support this project and successfully created a good impression among them.

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

During the development of this project, we have gained a lot of experience and knowledge on programming, creating circuit, assemble components and others. Besides, we have overcome all problems we faced that occurred in the process of completing this project. As example, much progress has been made on writing the programming and etching the printed circuit board (PCB) because we have not enough knowledge on writing program and experience on etching. To overcome this problems, we have referred to lecturers, friends and experienced person.

In conclusion, our 'Compact Photovoltaic Control Box with Handpiece' is a set of device that included dental handpiece which can be used to polish dentures controlled by the compact designed control box that easy to bring to rural areas or countryside due to its size and light weight. Solar cells (or photovoltaic cells) are fixed on the control box able to convert solar energy to electrical energy which will lengthen the rechargeable battery life. Therefore, this is an eco-friendly and user-friendly product which can fulfil the satisfaction of the user.

Moreover, to control the dental handpiece, the user no need to control the speed by using foot pedal which can cause over stepping and break the bur easily. The users are able to set a suitable speed by rotating the knob on the control box

before carry out any work and this can prevent breaking the bur, at the same time reduce human error. Furthermore, our project are safe to be used as the cooling system able to cool down the circuit so that it will not overheated. The objectives of our project are achieved and we are satisfied of the outcomes of this project.

5.2 Recommendations

Our project 'Compact Photovoltaic Control Box with Handpiece' able the user to carry from place to place easier. Besides, it used solar panel which can lengthen the rechargeable battery life. We also added the cooling system that can cool down the circuit so that it will last longer and will not spoil easily. However, this innovation need some improvements.

Based on the questionnaire we have done before, some of the respondents requested to make it smaller so that it will be lighter. Furthermore, some respondents felt that the casing is quite fragile and not waterproof which not suitable to bring to rural areas which need to pass through forests, rivers and so on.

Therefore, to improve the quality of our project, we plan to make it smaller and improve the cooling system so that the heat that produced by the components can be released more efficient. We also want to improve the quality of the casing or cover of our project by using waterproof materials.

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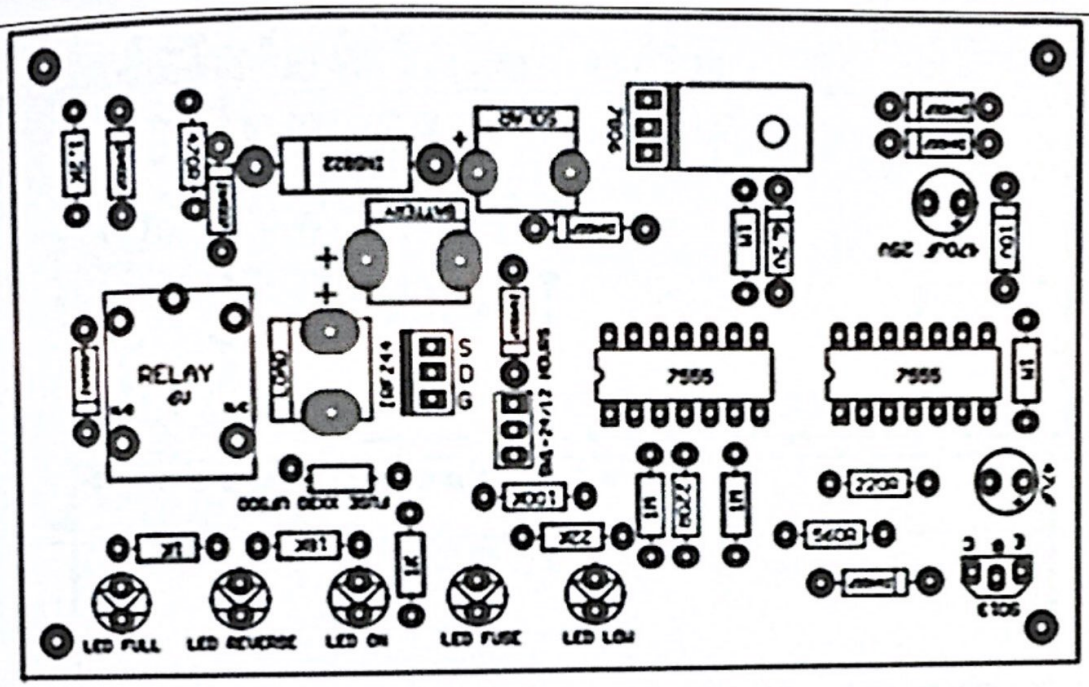
APPENDIX A: PROGRAMMING

```
#include <LiquidCrystal.h>

LiquidCrystal lcd(8, 9, 4, 5, 6, 7);

//----------------------------------------

void setup()

{

 lcd.begin(16, 2);

 lcd.clear();


 lcd.print("MOTOR HANDPIECE ");

 lcd.setCursor(0,1);

 lcd.print("  ");


 delay(3000);

 // Set the clock to run-mode, and disable the write protection


 Serial.begin(9600);
```

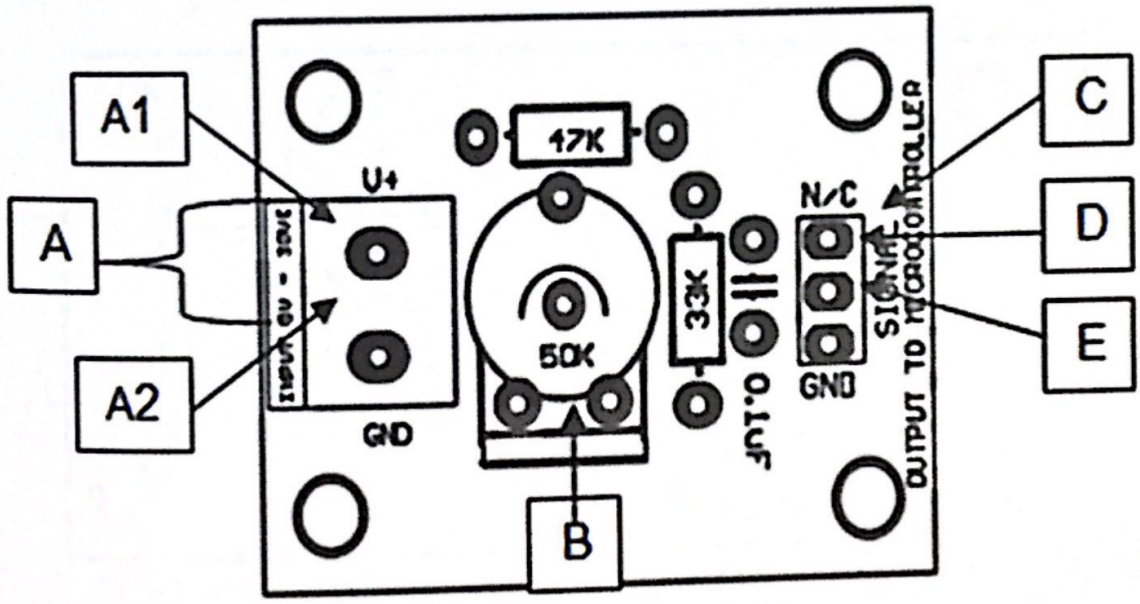
```
}


float SW1;

float SW2;

float SW3;

float SW4;


int SW1Pin = 0;

int SW2Pin = 1;

int SW3Pin = 2;

int SW4Pin = 3;

float VOLT,RPM;

void loop()

{

 // Send Day-of-Week


 //--------------------------------------------------------------------------

  SW1 = analogRead(SW1Pin);          //read the value from the SW1

  SW1 = (5.0 * SW1 * 100.0)/1024.0;

  SW2 = analogRead(SW2Pin);          //read the value from the SW2

  SW2 = (5.0 * SW2 * 10000.0)/1024.0;

  VOLT =SW1;  ///((100.0 - SW1)/25)*180.0;
```

```
RPM=SW2;


Serial.print("VOLTAGE: ");
Serial.print(VOLT);
Serial.print("  RPM:");
Serial.println(RPM);


 lcd.clear();
lcd.setCursor(0,0);
 lcd.print("VOLTAGE: ");
 lcd.print(VOLT,0);
 lcd.print("v");
 lcd.setCursor(0,1);
 lcd.print("SPEED: ");
 lcd.print(RPM,0);
 lcd.print(" RPM");


 lcd.print("  ");
 delay(500);
}
```

APPENDIX B: SCHEMATIC DIAGRAM

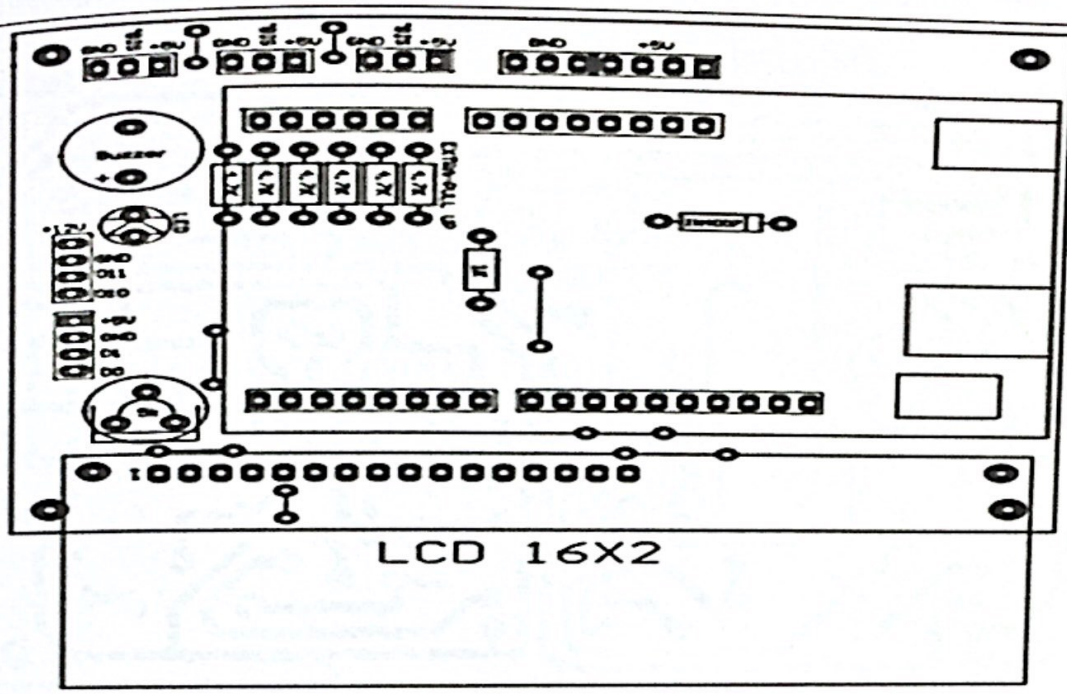


(Schematic Diagram of Switch Indicator Light)

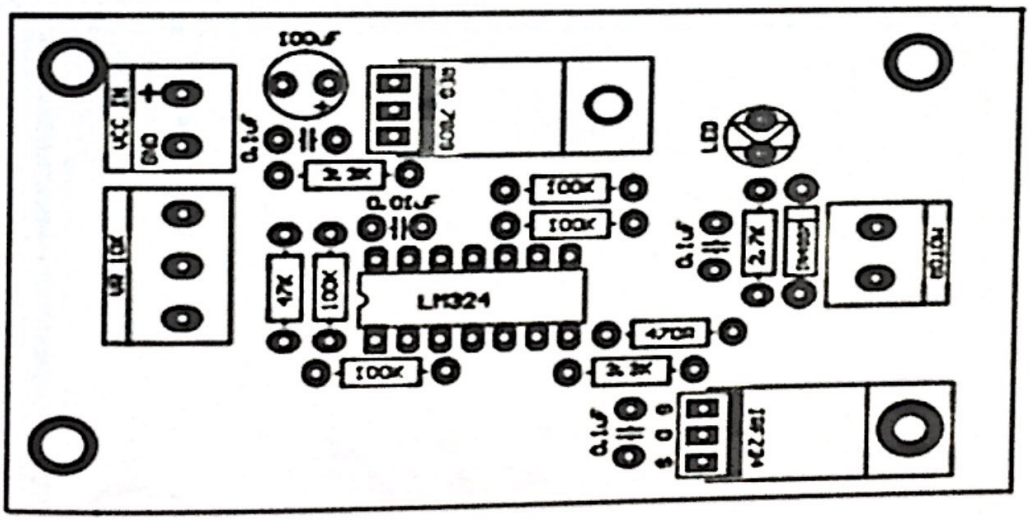


(Schematic Diagram of Voltage Measurement Sensor)

APPENDIX C: SCHEMATIC DIAGRAM

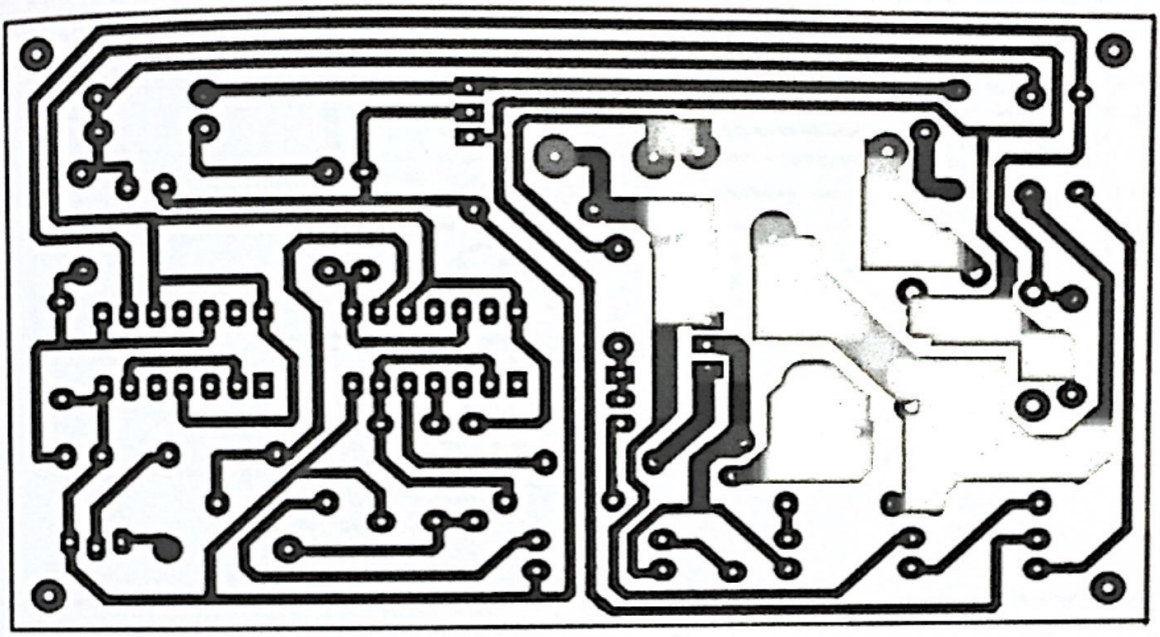


(Schematic Diagram of LCD display)

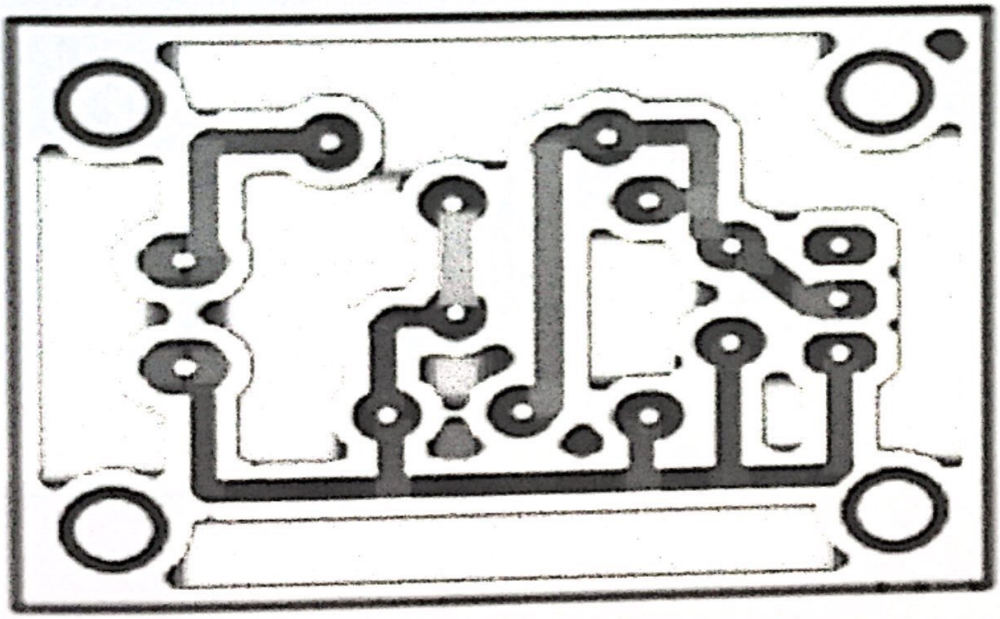


Schematic Diagram of DC Speed Control

APPENDIX D: PCB LAYOUT

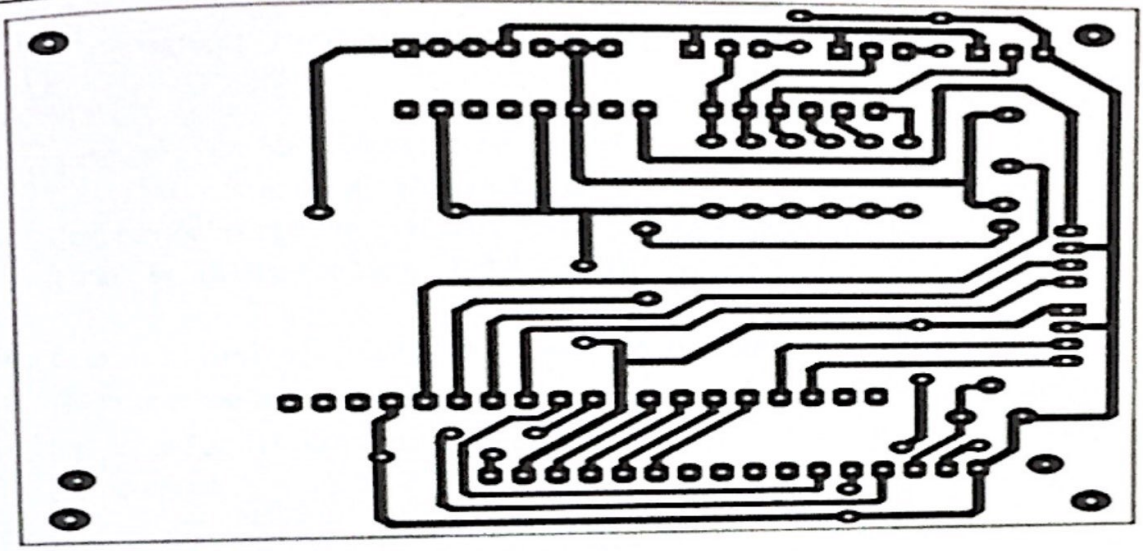


(PCB Layout of Switch Indicator Light)

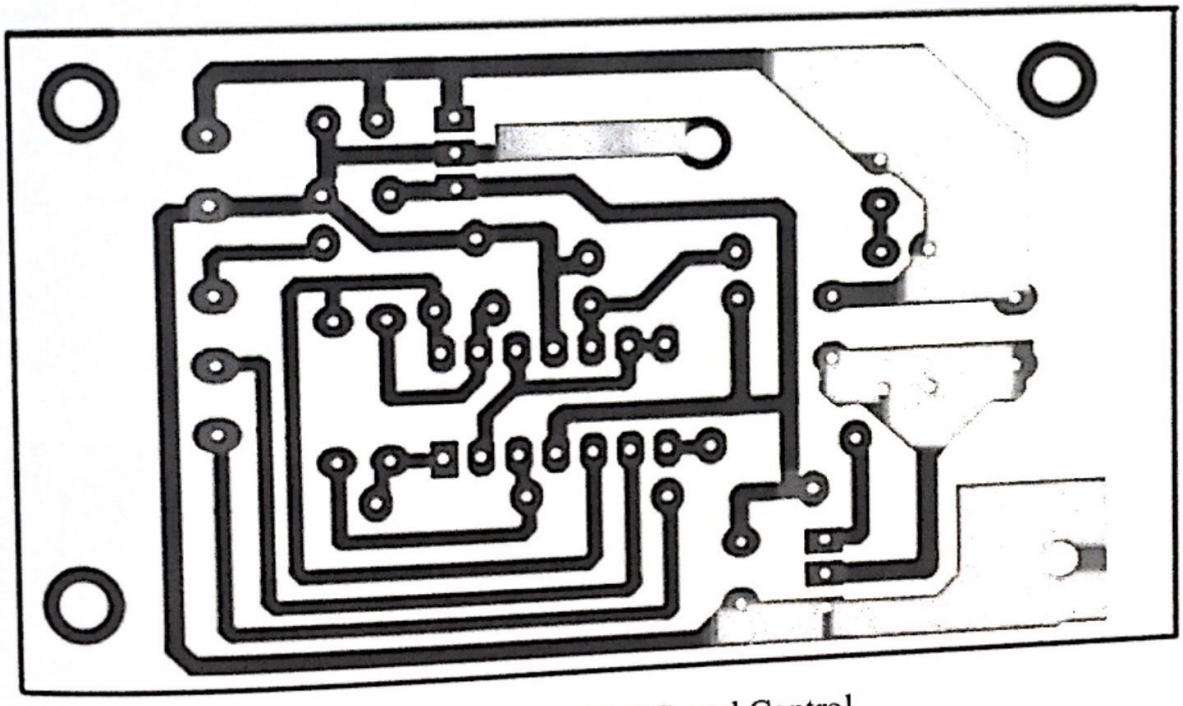


(Schematic Diagram of Voltage Measurement Sensor)

APPENDIX E: PCB LAYOUT



(PCB Layout of LCD diplay)



PCB Layout of DC Speed Control

APPENDIX F: QUESTIONNAIRE (FILL IN BY DENTAL TECHNICIAN)

Hospital / Clinic: _____

Position: _____

COMPACT PHOTOVOLTAIC CONTROL BOX WITH HAND PIECE

Introduction

- ✓ Dental Lab Micro Motor Hand Piece is one of the most used equipment in a dental lab and dental clinic. The dentist or dental technician will use the HAND PIECE for making dental stuff (dentures), polishing surface or cuts. CONTROL BOX is used to control hand piece's speed, rotation, switch on/off and so on. But this device is only use for dentures, not for real teeth.

Objectives

- ✓ To make the handy equipment which is portable to rural areas and countryside
- ✓ To create an eco-friendly equipment and support renewable energy by using solar energy
- ✓ Produce and provide user-friendly device by creating the hand piece which just only need to use hand to operate it.

Questionnaire

There are some questions about our product that need your perspective and comment. Tick (✓) if Yes and cross (X) if No.

1. Do you feel comfortable with the hand piece used in your work place?	
2. Do you agree to use a portable control box with hand piece?	
3. Do you support for an eco-friendly product?	
4. Do you prefer if pedal used from current hand piece model is replaced with a compact speed control box?	
5. Is our product idea is suitable for dentistry in this era?	

6. Do you face any problem with the current hand piece used? If yes, please state the problem.
   _____
7. What kind of damage usually occurs on the current hand piece?
   _____
8. Do you support our new invention 'Compact Photovoltaic Control Box with Hand Piece'? State your reason.
   _____

Comments:

_____

.....
Stamp & Signature

APPENDIX G: QUESTIONNAIRE (FILL IN BY STUDENTS AND LECTERUR IN PSA)

Department: **Occupation:** **Age:**

COMPACT PHOTOVOLTAIC CONTROL BOX WITH HANDPIECE

We developed a Compact Photovoltaic Control Box which used to control the dental Handpiece that used to clean or polish dentures or restoration. The polishing bur can variably rotate from 0 to 27,000 rpm. One of the novelties of our project is we are Green Technology that Solar cells (or photovoltaic cells) are fixed on the control box will convert solar energy to electrical energy which lengthens the battery life. In addition, the adapter is used as the second alternative power source of the control box. This product can able the user to carry from place to place especially rural area.

Questionnaire

There are some questions about our product that need your perspective and comment.

Questions	YES	NO
9. I think it will help the clinics or laboratories in rural area.		
10. It has good design that suitable for clinics, hospitals, or laboratories.		
11. I think it can be easily to bring on any transport.		
12. I support this product as an eco-friendly product.		
13. I think it is safe to be used.		
14. I think that this product are better than others available on the market.		
15. I think that this product need some improvement. If yes, please state. _____		
16. I support this new innovation.		
17. This product is convenient to use because it can control only by hand that use less energy or reduce human error		
18. The design is futuristic		

If you were to review our project, what score would you give it out of 10?

_____

Thank You for Your Cooperation. ☺