Thesis paper

on

Study of a low cost Electro Surgical Diathermy Machine

This thesis is submitted to the department of electrical & electronic engineering, daffodil international university, for partial fulfillment of the requirement for the degree of bachelor of science in electrical and electronic engineering.

Submitted by

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Letter of transmittal

May 24, 2014

To

Prof. Dr. M. Shamsul Alam

Dean, FE

Daffodil International University

Dhaka, Bangladesh.

Subject: Submission of Thesis paper.

Dear Sir,

We are pleased to inform you that we have completed our undergraduate thesis on "**Study of a low cost Electro Surgical Diathermy Machine**". Please find the thesis paper attached herewith. It was indeed great pleasure to work on such an important topic. In carrying out the study we have followed your valued advice and collected facts from text books, reference books, web sites and different others sources. As students of undergraduate program, we tried our level best to accomplish the assignment and hope that our effort would serve the purpose optimally. We think you would find it interesting and informative.

We would be glad to furnish you with further explanations/ clarifications if you feel necessary.

Sincerely yours

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Declaration

We do solemnly declare that the work presented in this thesis entitled "Study of a low cost Electro Surgical Diathermy Machine" was carried out by us and was not previously submitted to any other University for an academic qualification/certificate/ Degree.

We hereby warrant that the work has been presented does not breach any existing copyright.

We further have undertaken to indemnity the University against any loss or damage arising from breach of the forgoing obligations.

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Acknowledgement

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We take the opportunity to express our deep indebtedness to our thesis supervisor, honorable teacher and guide Prof. Dr. M. Shamsul Alam Dean (FE), DIU for his valuable continuous guidance, helpful suggestion and constant encouragement throughout the whole thesis.

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Finally, our cordial thanks to all the teachers of EEE Department, Daffodil International University who have directly or indirectly helped us in this thesis.

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Executive summary

Medical treatment is one of the five basic needs of human being. From the very beginning of the world people learned about medical treatment from nature. Now a days it has been upgraded to the most modern stage. Many electrical/electronic devices are being used for diagnosis and cure from different diseases. In the age of advanced science electro surgical diathermy (ESD) machine is one of the essential device in medical science. Electro surgical diathermy (ESD) machine brings blessing in our life to stop bleeding during surgical operation. Monopolar and bipolar electro surgery are two distinct methods of electro surgery. Some imported ESD machines do not have bipolar option and they are expensive. Considering necessity and cost we have developed monopolar and bipolar electro surgical diathermy machine having both hand and foot operation facilities. DC & low frequency ac current damage the biological tissues due to ion shifts occur in the tissue. when a frequency of 20KHz or higher frequency(HF) alternating electrical current pass through the body, it simply generates heat within the tissue but it does not create muscle stimulation, because the direction of movement of the ions keep reversing with the frequency of the current. Electro surgical diathermy produces HF alternating current (0.3MHz to 3MHz) which passes through the body to achieve a desired surgical effect. It helps to stop bleeding during surgical operation by providing electron flow through the body.

The design of ESD is based on spark gap oscillation for coagulating of blood vessels and the use of thermionic valve oscillation for cutting tissue. Basic components of the designed ESD are: micro-controller, integrating circuits (ICs), optocoupler, resistors, capacitors, diodes, voltage regulator, MOSFET, bridge rectifier, relay, transistor, transformer, potentiometer, receptacle, heat

sink etc. The design of ESD machine is based on micro-controller and output power is 300 watts. The use of micro-controller and MOSFET in the design work of ESD have enhanced safety aspect and all the relevant options with high quality performance. Currently ESDs are not being used in hospitals or clinics of Bangladesh because of its high price. ESD machine is useful for some particular operations like Laproscopy, Urological, Neuro, ENT and spine surgery. It is also commonly used in Dermatological, Cardiac, Ocular Maxillofacial, Orthopedic, Ophthalmic and Burn etc.

Designed ESD machine is cheaper as compared to the imported ESD produced by overseas manufacturers. The cost of the components in Bangladeshi Tk. is 25,000 and assembling cost is Tk. 15,000. So, If we add a profit of Tk. 10,000 the market price of this designed ESD will be Tk. 50,000. Price of ESDs machines manufactured by overseas companies are as follows: Germany ESD machine's price is from Tk. 2,50,000 to 3,00,000. Italian ESD machine's price is from Tk. 1,50,000 to 2,50,000. Korean ESD machine's price is from Tk. 1,50,000 to 2,00,000. China's ESD machine's price is from Tk. 1,00,000 to 1,50,000. Indian ESD machine's price is from Tk. 8,00,000 to 1,00,000. So, the developed ESD machine is cost effective in comparison with the ESD of developed countries.

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CHAPTER-1

1.1 BACKGROUND

The techniques of electro surgery used today were developed in the early part of the 20th Century, although the history of the technique goes back as far as the early 19th Century, when the French Physicist Becquerel, first demonstrated electrocautery, using electricity to heat a wire needle. The principle of cauterising wounds to stop bleeding was known to Hippocrates and the early Greeks (circa 460 – 370 BC).

One important event in the development of electro surgery was when, in 1891d'Arsonoval discovered high frequency alternating electrical current could be passed through the body without causing electrical shock. At a frequency of 20kHz and higher, alternating electrical current passing through the body simply generates heat within tissues and does not create muscle stimulation. In 1909 Nagelschmidt discovered the heating effect of high frequency current could be used for therapeutic purposes and coined the phrase 'diathermy', based on the Greek meaning 'heating through'. A year later Czerny described the use of 'diathermy' for cutting tissue. In 1909 an Italian surgeon, Pozzi described the process of tissue destruction by electrical sparking, and called it 'fulguration'. By the late 1920s two Americans, Bovie and Cushing had developed a more sophisticated type of electro surgery unit.

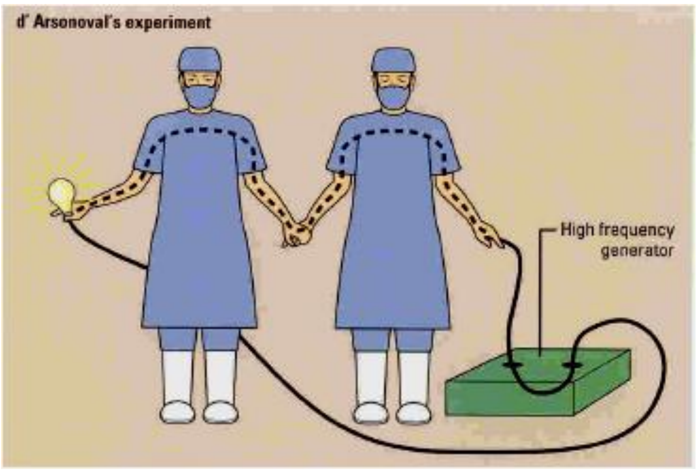


Fig 1.1- HF alternative current passing through the body

The next significant improvement in the design of electro surgery units was the use of spark gap oscillator and thermionic valve oscillators in the late 1930s. These valve type generators were capable of producing a continuous wave output at higher power levels and were therefore good for cutting. With the 1960s came the advent of solid state electronics with transistors and printed circuit boards. This improved technology, combined with the advances in surgical techniques and increased demands for safety and performance, contributed to the rapid development of electrosurgery units. Electro surgical diathermy is essential for some particular operations such as Laproscope, Urological, Neuro, ENT, Spine surgery. It is commonly used in Dermatological, Cardiac, Ocular Maxillofacial, Orthopedic , Ophthalmic, Burn etc. Currently, the design of ESD machine is based on micro-controller and output of this machine can be controlled by hand or leg operator. Mode of this ESD can be changed during surgery. Electro Surgical diathermy is usually better known as "electro surgery." Electro surgery and surgical diathermy involve the use of high frequency alternating current in surgery as either a cutting modality, or else to cauterize small blood vessels to stop bleeding. Electro surgical units (diathermy machines) were first introduced during the early twentieth century to facilitate haemostasis and/or the cutting of tissue during surgical procedures. This is achieved by passing normal electrical current via the diathermy machine and converting it into a high frequency alternating current (HFAC). This HFAC produces heat within body tissues to coagulate bleeding vessels and cut through tissue. Electrosurgery is performed using an electrosurgical generator (also referred to as power supply or waveform generator) and a hand piece including one or several electrodes, sometimes referred to as an RF Knife. The apparatus when used for cutting or coagulation in surgery is still often referred to informally by surgeons as a "Bovie," after the inventor. There are 2 different types of electrosurgery: Monopolar and Bipolar. Monopolar electrosurgery is the emitance of the HFAC from the diathermy via an active electrode through the patient’s body tissues and then returned back to the diathermy machine via a Return electrode (patient return pad). Bipolar electrosurgery is the emitance of the HFAC from the diathermy machine down one prong of a bipolar forcep through the tissue that has been placed between the forcep tips and returned to the diathermy machine via the second prong. Bipolar diathermy does not require a Return electrode (patient return pad).

1.2 OBJECTIVES

The purpose of this thesis is to study on Medical Equipment (**Electro surgical diathermy machine)** including its constructions, principle of operation, preventive maintenance, operating system, advantages & disadvantages. To know the sterilization and calibration of the medical equipment. Proper maintenance of medical equipment is essential to obtain sustained benefits and to preserve capital investment. Medical equipment must be maintained in working order and periodically calibrated for effectiveness and accuracy.

1.3 METHODOLOGY OF THE DESIGN

1. For theory and basic principle followed by the text books, websites & Journals.
2. For design- operation, calibration and preventive maintenance followed the guidelines of the manufacturer as printed in the manual, leaflet, technical documents etc.
3. Have gather-working experience on Electro surgical diathermy machine from MCI Electronic. The company design, manufacture and market different type of Medical equipment in Bangladesh.

CHAPTER-2

Introduction

Electrosurgical diathermy machine

Fig 2.1- Electrosurgical diathermy machine

2.1 THEORY OF ELECTRICITY

In order to understand how electrosurgery works, it is essential to have an understanding of electricity. Electricity exists due to electrons, protons and neutrons, which together create atoms. Atoms, which have the same number of protons as electrons, have a neutral charge. Atoms with more protons than electrons have a positive charge and are called positive ions. Atoms with more electrons than protons have a negative charge and are called negative ions. Should electrons leave their base atom and move to another, the charge on the base atom changes. During these changes unlike charges attract each other and like charges repel. When charged particles flow through a conductor an electrical current is formed.

The flow of electricity is called the **current** and is measured in amps. There are two types of electrical current, alternating current (a.c.), which alternates the flow of the electricity back and forth, and direct current (d.c.), where the electricity flows in one direction only. The **frequency** of this flow is measured in hertz (Hz) where one hertz is one cycle per second Batteries have direct currents (d.c.) and therefore have a frequency of zero Hz, (the current flows in one direction only). Most household mains supplies have alternating currents (a.c.).

In Europe the frequency is 50Hz and in USA the frequency is 60Hz. The pathway around which the current flows, is called the circuit.

Opposition to the flow of alternating current is called **impedance**. Impedance is the sum of two quantities called resistance and reactance. Reactance depends upon frequency, whereas resistance is independent of frequency. Only the resistive part of impedance can dissipate power and hence produce heat. Resistance is measured in ohms. The 'pressure', which forces current to flow through impedance, is called **voltage**. This is measured in volts. The energy produced per second by a current flowing through a resistance is called **power** and is measured in watts. Power dissipated in a resistance produces heat.

2.2 THE EFFECT OF ELECTRICITY ON TISSUE

At low frequencies alternating current (a.c.) causes a dangerous shock but with frequencies above 20kHz, muscular contraction stops, pain stops and the only detectable effect, is heat generation within the tissue. In practice, frequencies of 250kHz or higher are used in electrosurgery units to avoid 'arc rectification' which is low frequency current caused by sparking. This 'arc rectification' is avoided by including a suitable value of capacitance in series with the output. The simplest way to get sufficient power delivered to the patient via this capacitance is to use frequencies of 250 kHz or above.

Note: A capacitor will pass high frequency electrical current but not low frequency electrical current. It is the low frequency electrical current that causes muscle stimulation. Should arc rectification occur, low frequencies will also be generated through sparking. These low frequencies will cause muscle stimulation if they are not blocked by suitable capacitors.

The intensity and spread of heat through the tissue can be altered in various ways to provide the coagulating or cutting power needed in electrosurgery. The objective of electrosurgery is to deliver the optimum power (watts) into a specified electrical resistance as safely and effectively as possible.

The most common range of electrical resistance into which a surgeon operates is between 100 and 1,000 ohms. Different tissues have different ranges of resistance, due to their differing conductivity. Also the total resistance between the active electrode and patient plate electrode depends to a large extent on the size, shape and contact pressure of the active electrode and the distance between the two.

Examples of resistivity and conductivity of tissue

Tissue type	Resistance (Ohms / Ω)	Conductance (Siemens / S	Conductance (millisiemens/mS)
Muscle	110	0.00909	9.090
Kidney	126	0.00794	7.940
Heart	132	0.00758	7.580
Spleen	256	0.00391	3.910
Skin	289	0.00346	3.460
Liver	298	0.00336	3.360
Fat	2180	0.000459	0.459

These resistances and conductances were measured in a conductivity cell.

(Reference: Mitchell, Lumb and Dobbie, A handbook of surgical diathermy (1978). Bristol: J Wright & Sons.

Note:

a. The resistivity of a particular type of tissue is the resistance of the sample of tissue in the conductivity cell multiplied by the cross-sectional area of the conductivity cell and divided by the length of the conductivity cell.
b. Resistivity is normally expressed in "ohm centimeters" (W cm) or "ohm meters" (W m)
c. The conductivity of a particular type of tissue is the conductance of the sample of tissue in the conductivity cell multiplied by the length of the conductivity cell and divided by the cross-sectional area of the conductivity cell.
d. Conductivity is normally expressed in "siemens per centimeter" (S/cm) or "siemens per meter" (S/m).
e. Resistance is voltage divided by current. Conductance is current divided by voltage.
f. Conductance is, therefore, the reciprocal of resistance

2.3 CONCEPT OF ELECTRO SURGICAL DIATHERMY

Electro Surgical diathermy is usually better known as "electro surgery." Electro surgery and surgical diathermy involve the use of high frequency alternating current in surgery as either a cutting modality, or else to cauterize small blood vessels to stop bleeding

Electro surgical units (diathermy machines) were first introduced during the early twentieth century to facilitate haemostasis and/or the cutting of tissue during surgical procedures. This is achieved by passing normal electrical current via the diathermy machine and converting it into a high frequency alternating current (HFAC). This HFAC produces heat within body tissues to coagulate bleeding vessels and cut through tissue.

Electrosurgery is performed using an electrosurgical generator (also referred to as power supply or waveform generator) and a hand piece including one or several electrodes, sometimes referred to as an RF Knife. The apparatus when used for cutting or coagulation in surgery is still often referred to informally by surgeons as a "Bovie," after the inventor.

There are 2 different types of electrosurgery: Monopolar and Bipolar.

Monopolar electrosurgery is the emitance of the HFAC from the diathermy via an active electrode through the patients body tissues and then returned back to the diathermy machine via a dispersive electrode (patient return pad)

Bipolar electrosurgery is the emitance of the HFAC from the diathermy machine down one prong of a bipolar forcep through the tissue that has been placed between the forcep tips and returned to the diathermy machine via the second prong. Bipolar diathermy does not require a dispersive electrode (patient return pad).

2.4 PRINCIPLES OF ELECTROSURGERY

DEFINITION OF ELECTROSURGERY

ELECTROSURGERY can be defined as use of high frequency electric current to severe tissue or achieve homeostasis. This is achieved with the intrinsic thermal effect of the electric current.
A low frequency below 100 kHz can stimulate muscles and nerves. Putting it another way a low frequency current can electrocute the patient.

Although the generator could perform electro surgery quite well at frequencies up to 4 MHz, reactive phenomena, capacitance and inductance become quite prominent at such high frequencies and it becomes difficult to confine these high frequency currents to wires.

For these reasons, Opera works at 350 kHz which is a compromise between these two extremes.

PRINCIPLES OF ELECTROSURGERY

When electric current flows through the biological tissue, the following can be observed.

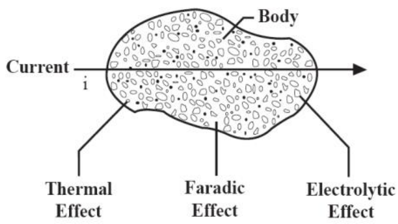


Fig 2.2 - Electric current flows through the biological tissue

2.4.1 THE ELECTROLYTIC EFFECT

Electric current causes ion shifts to occur in biological tissue. With direct current, positively charged ions would be shifted to the negative pole, the cathode, and the negatively charged ions to the positive pole, the anode, and their increased concentration at these points would cause electrolytic damage to the tissue. But when the alternating current is used, the direction of movement of the ions keeps reversing with the frequency of the current. If frequency is above 300 kHz, electrolytic effect is not present.

2.4.2 THE FARADIC EFFECT

Electrically sensitive cells, such as nerve and muscle cells, are stimulated by electric current. This effect, called faradic effect, is undesirable when performing radio-frequency surgery and a way of avoiding it has been devised. When an alternating current of sufficiently high frequency is used for electro surgery, the faradic effect no longer occurs. This is the reason that an alternating current with a frequency of at least 300 KHz is used in what is henceforth referred to as high frequency surgery.

When using alternating current of sufficiently high-frequency, the direction of movement of the ions is repeatedly reversed in accordance with the frequency of the current, so that the ions virtually oscillate to and fro at the frequency of the electric current. This is also a reason for the use of high-frequency alternating current in electro surgery.

2.4.3 THE THERMAL EFFECT

The tissue is heated by the electric current, in which the heating is dependent on the specific resistance of the tissue as well as on the current density and the duration of application. This effect is desirable in electro surgery.

2.5 USE OF THE THERMAL EFFECT IN ELECTRO SURGERY

In electro surgical cutting, the objective is to heat the tissue so rapidly that the cells explode into steam leaving a cavity in the cell matrix. The heat is dissipated in the steam and therefore it does not conduct through the tissue or dry out adjacent cells. When the electrode is moved and the fresh tissue is contacted, new cells are exploded and the incision is made

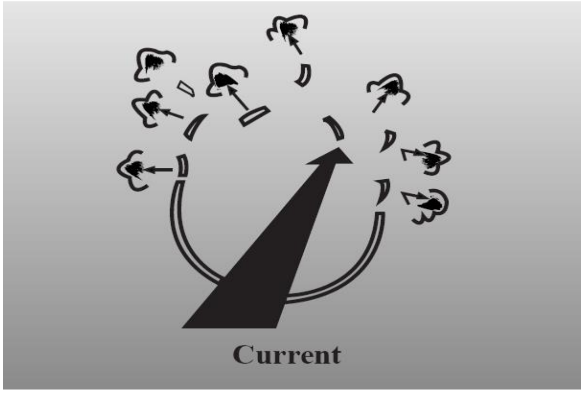


Fig 2.3 - Thermal effect in electro surgery

Biological tissue can only be cut when the voltage between the cutting electrode and the tissue to be cut is sufficiently high to produce electric arcs between them, effectively concentrating the HF electric current onto specific points of the tissue.

A peak voltage of approximately 200 V is required to produce the electric arc between the tissue and the electrode. If it is greater than 200 Vp, the arcs increase in proportion to the voltage, thereby increasing the depth of coagulation along the cut. This relationship between the depth of coagulation and the electric voltage or intensity of the electric arcs between active electrode and biological tissue has for decades been used in the practical application of conventional high frequency equipment. Unmodulated voltages with relatively small peak value Vp are used to produce cuts with the least possible coagulation necrosis, while voltages with greater or lesser amplitude modulation and a relatively high peak value Vp are used for cuts with a greater or lesser depth of coagulation.

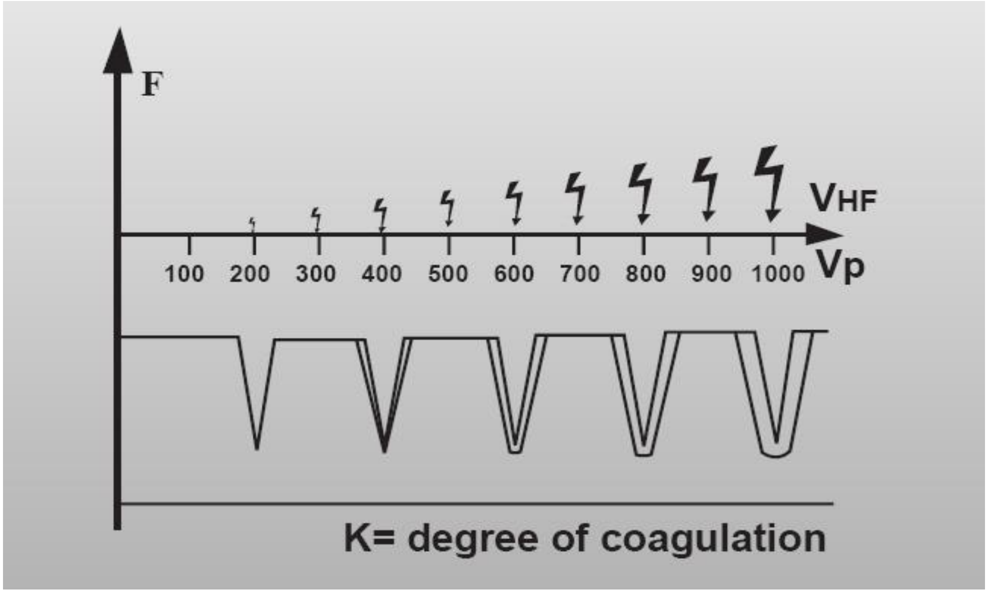


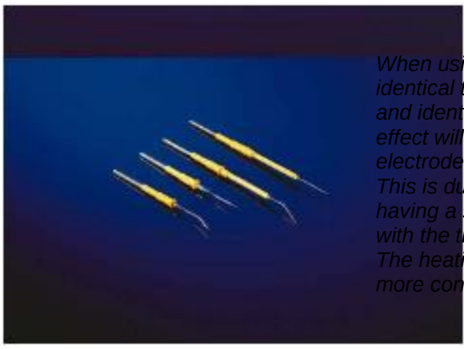
Fig 2.4 - Electrical degree for coagulation of electro surgical diathermy machine.

2.6 THE HEATING EFFECT

This heating effect depends on 4 factors:

Factor 1 - The current density (current divided by area)

a. The greater the current through a particular area, the greater the heating effect.
b. The smaller the area through which a particular current flows, the greater the heating effect.



When using identical power settings identical tissue with identical resistance and identical conductivity, the heating effect will be greater with the needle electrode than with the ball electrode. This is due to the needle electrode having a smaller surface area in contact with the tissue than the ball electrode. The heating effect will therefore be more concentrated.

Fig 2.5 - Different type of electrode

Factor 2 - The conductivity of the tissue

Different types of tissue have different electrical resistances. Fat is a poor conductor (with a relatively high resistance) and muscle is a good conductor (with a relatively low resistance).

Factor 3 - The type of current used

There are distinct differences in the waveforms of currents produced by electro surgery units and these currents produce different effects in the tissues. For example cut has a continuous waveform as opposed to the coagulation waveform, which is not continuous (see the picture Fig-2.6).

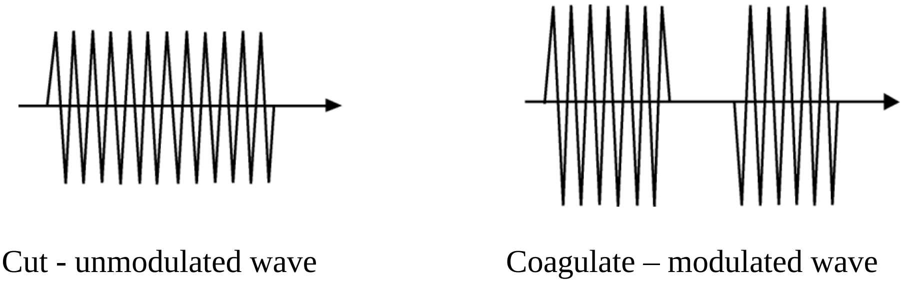


Fig 2.6 - Modulated and un-modulated wave

Factor 4 - The size of the electrode

If the electrodes used are flat plates of equal size, the heating effect produced at both electrodes will be of equal intensity. Maximum heat intensity will be at a depth of approximately 1 cm from the skin surface. This is the type of effect produced by medical diathermy used in physiotherapy departments.

If one of the electrodes is reduced in size, the current at both electrodes will be almost equal but the current density will increase at the smaller electrode and the heating effect produced by that electrode, will be concentrated. Eventually, if the size is reduced even further, the heat will become intense enough to produce a burn. This is the type of effect produced by surgical diathermy otherwise known as electrosurgery. It follows therefore, that if both electrodes were reduced in size, a burn would result from both electrodes. In monopolar electro surgery, one small electrode is used to produce

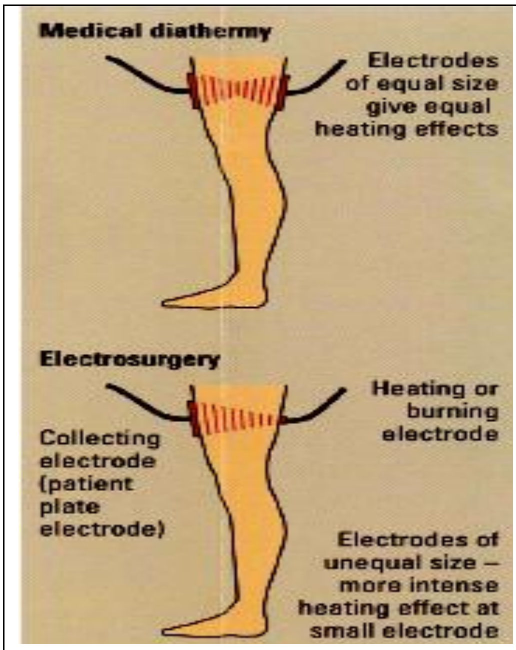


Fig 2.7 - The size of the electrode

the heating effect and one large electrode (the patient plate electrode) to collect the current and return it safely to the electrosurgery unit.

The conductivity of the tissue: Different types of tissue have different electrical resistances. Fat is a poor conductor (with a relatively high resistance) and muscle is a good conductor (with a relatively low resistance).

2.7 Use of electrode cutting needle of electrosurgical diathermy machine:

Fig 2.8- Active electrode of cutting needle

For some surgical procedures the surgeon desires pure cutting, for some other, cutting with more or less coagulation. The following rule needs to be taken into account while performing the surgery with the HF surgical equipment.

- The shape of the cut electrode used
- The speed at which the incision electrode is used to cut through the tissue.
- The intensity of the HF current or HF power.
- The tissue properties
- The characteristics of the HF current waveform

THE SHAPE OF THE CUT ELECTRODE USED

The thinner the incision electrode is, the less is the coagulation at the surface of the incision. A lancet shaped incision electrode, for example, produces greater coagulation of the incision surfaces than a thinner blade incision electrode. Examples of incision electrodes with coagulation are: lancet electrode and needle electrode.

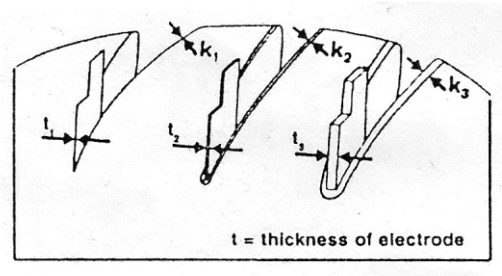


Fig 2.9- shape of the cut electrode used

Examples of less coagulating or non-coagulating incision electrodes are: tape loops or thin wire loop electrode or knife electrode.

The Speed at Which the Incision Electrode Is Used To Cut Through the Tissue.

The degree of coagulation of the incision surfaces is also dependent on the speed with which the incision is made. The slower the incision electrode is moved through the tissue, the greater is the degree of coagulation of the surfaces of the section.

Electrode Is Used To Cut Through The Tissue:

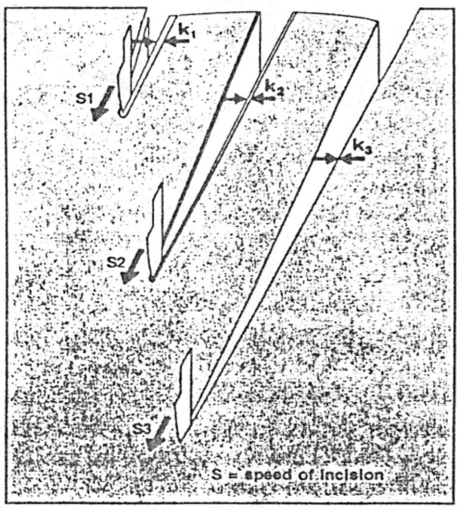


Fig 2.10 - Electrode is used to cut through the Tissue of the system.

2.8 THE INTENSITY OF THE HF CURRENT OR HF POWER

When the intensity is too low, the incision can only be made slowly. Coagulation of the surfaces of incision is then relatively more.

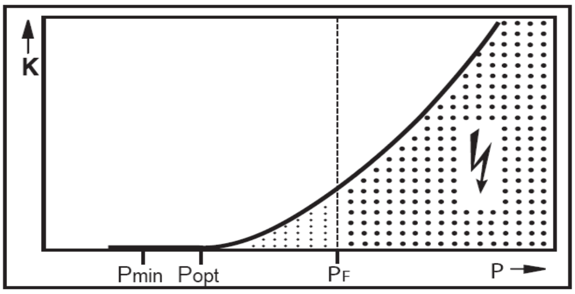


Fig 2.11 - Intensity HF current or HF power.

When the intensity is too high P>Pf, sparks occur between incision electrode and tissue which, as'a result of the high temperature, coagulate the incision surface to the point of burn. The optimum intensity Popt is that at which the degree of coagulation is minimum.

2.9 THE CHARACTERISTIC OF THE HF CURRENT WAVEFORM

The degree of coagulation of the surfaces of the section during incision can be influenced by modulating the amplitude of the current. The degree of coagulation increases with the degree of modulation. The degree of modulation can be mathematically described by the crest factor C. Here the crest factor C is the ratio of the peak value of the current Ip (maximum amplitude) to the root mean square value of the current, Irms.

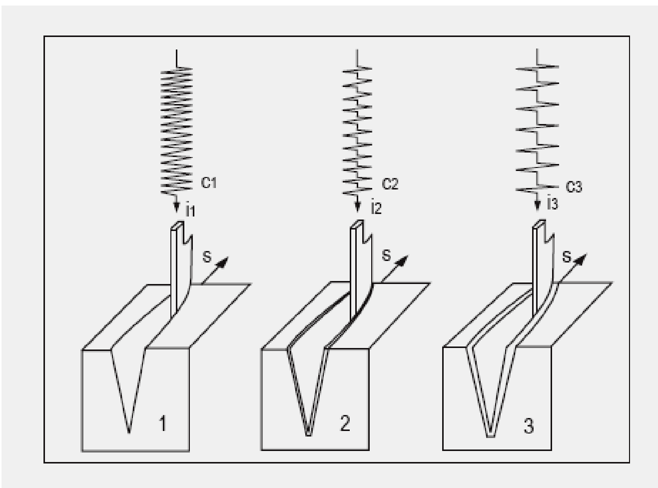


Fig 2.12 - HF current waveform

He essential characteristic of the blended cut waveform is that it is pulse modulated RF current.

For some surgical procedures the surgeon desires pure cutting, for some other cutting with more or less coagulation. The following rule must be taken into account while performing; the surgery with the HF surgical equipment.

A pure cut is obtained by:

1. Using the thinnest possible cutting electrode.
2. Using the smallest possible unmodulated wave.
3. Cutting as rapidly as possible, the full depth of the cut being obtained in a single pass rather than in a number of shallow passes.

A deeper coagulation is obtained by:

1. Using the thickest possible cutting electrode,
2. Using the highest possible HF voltage,
3. Cutting as slowly as possible.

2.10 HF (HIGH FREQUENCY) SURGICAL TECHNIQUES

Monopolar and bipolar electrosurgery

Monopolar and bipolar electrosurgery are two distinct methods of electrosurgery. The fundamental difference between the two is how the electrical circuit is completed.

2.10.1 MONOPOLAR ELECTROSURGERY

With monopolar electrosurgery the patient forms a major part of the electrical circuit. An active cable from the electrosurgery unit carries current to the active monopolar electrode. Current then spreads through the tissue to be collected and returned to the electrosurgery unit by a ‘patient plate electrode’ attached to the patient. There are no intended thermal tissue effects at the plate electrode, since the current is less concentrated. (The patient plate electrode is also known as dispersive, neutral, passive or return electrode).

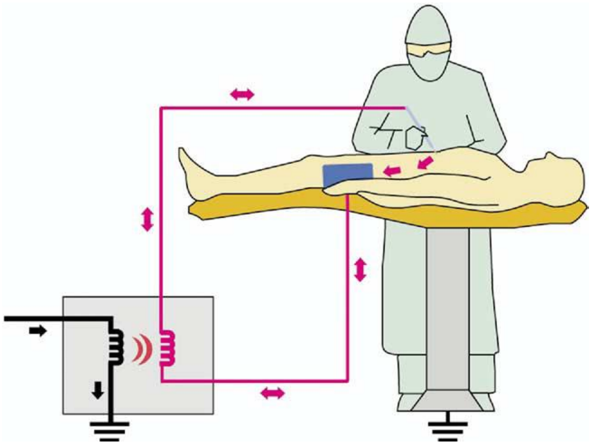


Fig 2.13 - Monopolar surgery techniques

Monopolar active electrodes have a single active pole delivering the current. This current then returns through the patient's body to the patient plate electrode.

Monopolar electrodes are available in an assortment of tips:

Loops to Cut and fulgurate

Ball electrodes for desiccation (contact coagulation) and fulguration (non contact coagulation)

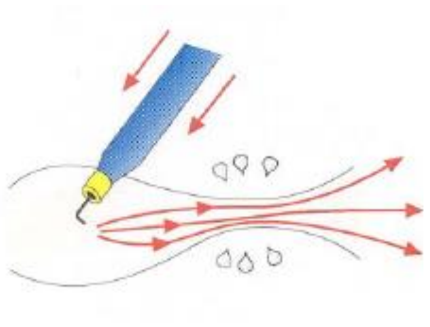
Needles to cut and coagulate

Blades to cut and coagulate

Fig 2.14 - Different type of monopolar electrodes

Monopolar electrosurgery should not be used in areas where the target tissue is connected to adjoining tissue via small delicate structures. Should monopolar electrosurgery be used in this situation, the electrical current can pass through these structures which, if sufficiently small and the current sufficiently concentrated will heat this structure to the extent that tissue damage can occur, resulting in partial or total occlusion of the vessel lumen. This effect is known as ‘channelling’ or the ‘pedicle effect’ (illustrated right)

When using monopolar electrosurgery, the active electrode which delivers power to the surgical site can either be hand or foot activated.



2.10.2 BIPOLAR ELECTROSURGERY

Unlike monopolar electro surgery where the patient’s body forms a major part of the electrical circuit, with bipolar electro surgery only the tissue grasped between the tips of a pair of bipolar forceps forms part of the electrical circuit. These bipolar forceps incorporate two active electrodes, which also return the current, the same as a patient plate electrode in monopolar electro surgery. Both electrodes are isolated in respect of earth and are routed directly to the site of the operation. Bipolar electro surgery typically uses a frequency between 250 kHz and 1 MHz. When using bipolar electro surgery, the active electrodes delivering power to the surgical site, can either be hand or foot activated.

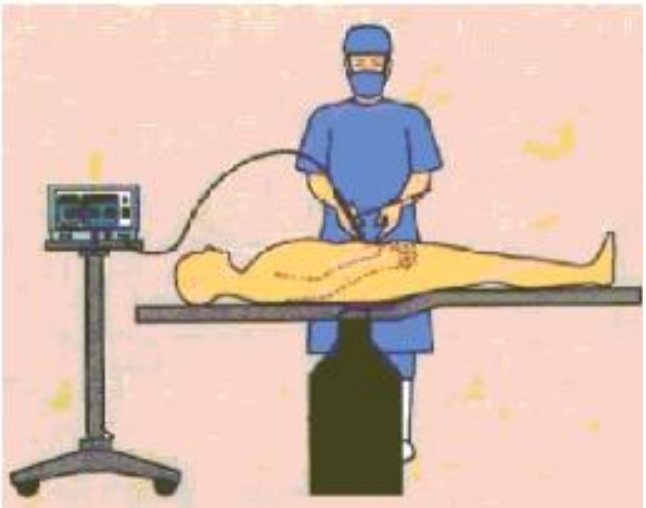


Fig 2.15 - Bipolar surgery techniques

The advantages of bipolar electro surgery are as follows:

Reduced risk to the patient: The intended current does not pass through the body of the patient, only through the tissue grasped between the tips of the forceps.

Reduced damage to surrounding tissue: Bipolar electro surgery has a localised effect on tissue, which is precise. It suits delicate surgery such as ophthalmic, maxillofacial, neurosurgery, vascular and tubal surgery in gynaecology. It is also widely used in orthopaedics where nerves of digits are involved and is particularly suited to paediatric surgery e.g. tonsillectomy and circumcisions.

Greater efficiency: The pressure exerted on a blood vessel by forceps increases heat dissipation and desiccation, causing a 'spot welding' effect that improves coagulation efficiency.

The disadvantages of bipolar electro surgery are as follows:

Electrode adherence: The close contact between the forceps and tissue can cause adherence in "dry tissue", often caused by squeezing the tips of the forceps too tightly on the tissue. This can also result in the loss of current flow.

Low cutting power: The low bipolar output of typical electro surgery units makes them less effective as cutting devices. Also, bipolar cutting instruments need special design in order to cut and not coagulate.

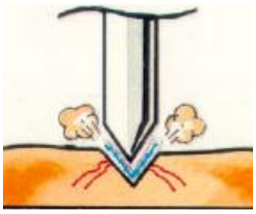
Slower: Because of its precise nature, each vessel has to be grasped and coagulated separately (the size of the blood vessel will also have a bearing on power needed).

2.11 ELECTRO SURGERY MODES

2.11.1 CUTTING (PURE & SPECIALIST)

This is a diagram of a cutting current which has a continuous waveform. Because the delivery of the current is continuous, much lower voltages are required to achieve tissue vaporization.

The Pure cut mode is suitable for a wide range of operations where a scalpel would otherwise be used.

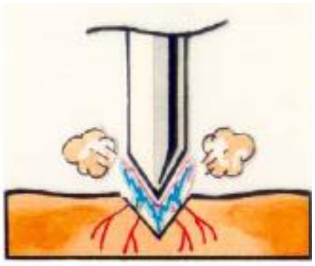


With the cutting modes, the electrode is held over the tissue and a small continuous arc is formed between the electrode and the tissue. This in turn causes rapid cell destruction followed by the complete explosion of the cell.
It ‘blows away’ cell debris achieving a clean cut. Should the electrode be placed directly on the tissue and the cut waveform used, some coagulation will be achieved, this effect is called desiccation. Desiccation can be more effective when using the relevant coagulation mode.

The Specialist cut mode is specifically designed for operations in wet fields (fluid), which have increased levels of conductivity due to the wet environment. This mode delivers more power into higher resistances and is particularly suitable for urology and gynecology.

2.11.2 BLEND

This is a diagram of a blend current, which is not a continuous waveform. Because the delivery of the current is not continuous, higher voltages are required to achieve some coagulation.



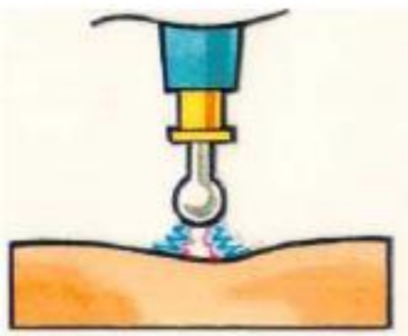
The Blend mode is a function of the cut mode and provides coagulation at the same time as cutting. Because the waveform is not continuous, (needed to enable some coagulation to occur), it employs higher voltages than the other cutting modes, which are designed to cut only. All electro surgery cut modes are colour coded yellow. This requirement is in accordance with IEC 60601-2-2:1998

2.11.3 COAGULATION MODES

This is a diagram of a coagulation current which does not have a continuous waveform. Because the delivery of the current is not continuous and is 'off' for longer periods of time than it is 'on', much higher voltages are required to achieve tissue coagulation.

Desiccation (otherwise known as pinpoint coagulation or contact coagulation) creates rapid localized heat at the end of the blood vessel causing contraction with eventual occlusion of the lumen. This creates precise coagulation of the tissue.

Spray coagulation mode (otherwise known as fulguration) employs higher voltages. This is because the waveform is off for longer periods of time than any other mode, and because the electrode is not in contact with the tissue (held approximately 2 - 4mm away). This therefore, creates an air gap across which the current must jump. The spray coagulation mode creates a more widespread coagulation than the other coagulation modes and due to the higher voltages employed, should not be used in laparoscopic or endoscopic surgery, where the voltages could break down the insulation of the instruments used.



2.12 RISKS AND SAFETY DURING HF SURGERY

CAUSES AND PREVENTION OF BURNS DURING ELECTRO-SURGERY

During the application of electro surgery there is the danger of minor or major patient burns, but these burns can be prevented by knowing the causes. There are three main causes:

1. Endogenous burns
2. Exogenous burns
3. Pseudo burns

1. Endogenous burns

It always results from a too high current density in the patient's tissue. At the active electrode there is a need for high current density in order to cut or coagulate the tissue but at the patient plate or at areas where the patient comes into contact with electro-conductive parts, the current density must not be so high as to burn the patient's tissue.

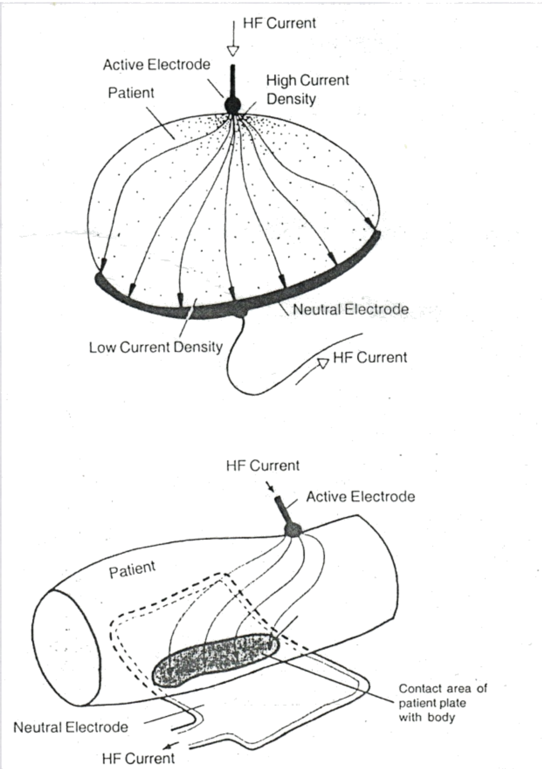


Fig 2.16- prevention of burns during electro-surgery

2. Exogenous burns

They are caused from the heat of burning substances such as skin-cleansing lotions, degreasants and disinfectants also anesthetics, which have been ignited by sparks between the active electrode and the patient's tissue.

Warning: During electro surgery, sparks always exist between the Active electrode and the patient's tissue. Therefore do not use flammable or explosive substances. These must be completely removed before activating the electrosurgical unit.

Fig 2.17- Flammable or Explosive Substances (Do not use).

Warning: Alcohol solutions usually burn as invisible flames, which can cause burns to the patient.

3. Pseudo burns:

From time to time minor or major necrosis are found with patients and are regarded as burns but without finding any explanation or reasons of how these burns are caused.

Endogenous burns can be excluded when the patient did not have contact with electro conductive parts at the area where the necrosis is found.

Exogenous burns can also be excluded when before or during electro surgery no flammable substances were used.

The causes of these burns must be found out by differential diagnosis.

NECROSIS CAUSED BY PRESSURE TO THE PATIENT'S TISSUE

During long operation procedures, pressure to the patient's tissue can cause necrosis, e.g., during heart surgery when the patient is hypothermed a large tissue necrosis was found post-operative.

Primarily this necrosis was claimed to be an endogenous burn caused by high frequency current. But since this type of burn was also found in the same operating they are by other patients where only bipolar coagulation was used, the claim of endogenous or exogenous burns was dismissed. Finally, this "burn" was found to be necrosis caused by enssure to the patient's tissue from the operating table.

High frequency surgery always entails current risk for the patient, operator the surrounding. So one should be aware of their existence & follow certain rules to prevent damages. The Opera provides some features to overcome these hazards an the rest of it has to be dealt with caution.

Warning: Disregard of these instructions, may result in serious injuries
Accidental burns due to HF leakage current

The patient inevitably conducts HF electrical voltage to ground during HF sur^HA which may in turn cause thermal necrosis.

Warning: Do not allow metal objects or wet and damp clothes on the patient's body to connect to the ground

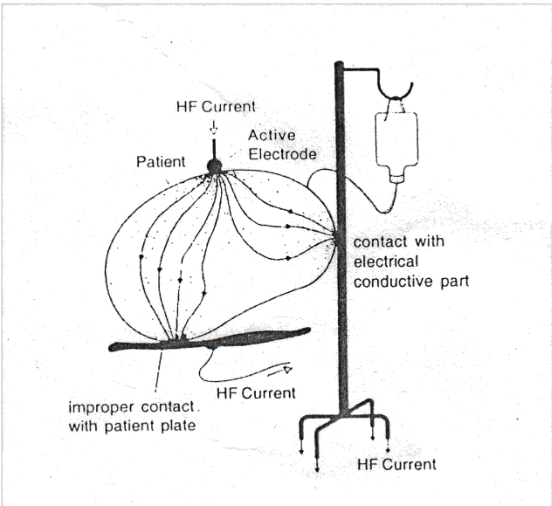


Fig 2.18- Contact with electrical conductive part.

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In Opera, if the leakage current goes above 150 mA, the HF leakage LED glows. The system is shut down along with an audio indication if the HF leakage current exceeds 300 mA.

Accidental burns due to improper use of HF surgery.

Bipolar coagulation should be given preference over monopolar coagulation techniques especially in cases where the HF current has to flow through long stretches of organs with thin cross sections.

Accidental burns due to improper use of neutral electrode

If the neutral electrode is not used correctly or is not used at all, there is a very high risk of burns at the point of application of the neutral electrode and at other points on the patient's body. So the user is advised to check for proper contact between neutral electrode and the patient.

Warning: The effective contact area of the neutral electrode with the patient's skin during HF surgery must be adequate for the HF output used.

The following diagram contains guideline values for the requisite minimum contact area A of different patient plates:

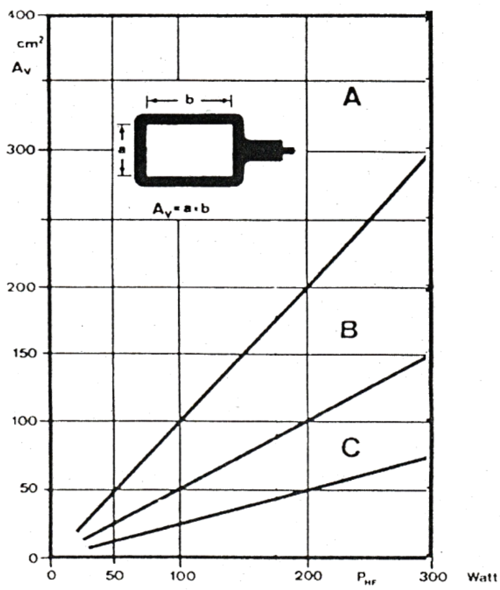

Fig 2.19 - Use of neutral electrode.

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Minimum contact area A_v of different patient plates as a function of the HF output power and of thermal and electrical characteristics of the contact surface.

A = Patient plate of electrically conductive silicone.

B = Patient plate of sheet metal without conductive gel.

C = Patient plate of sheet metal with conductive gel.

NOTE: Metal Patient Plate

If gel patient plates are used, it is most important that the gel is evenly applied over the entire conductive area of the patient plate.

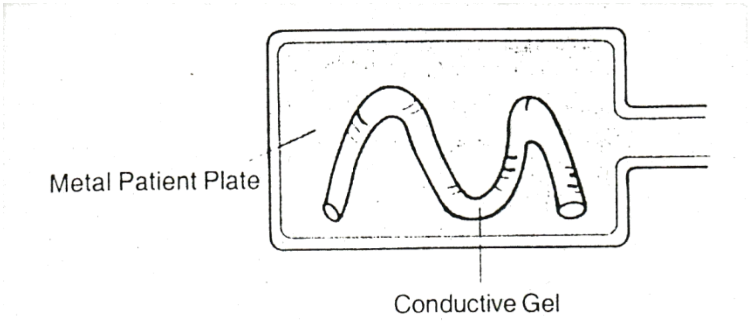


Fig 2.20 -Metal plate and conductive gel.

ATTENTION

.While operating with Bipolar mode, take extra care regarding isolation from earth (like, touch contacts with earth directly or indirectly), since there is no patient plate used.

In opera, an indicator led as well as an audio signal indicate the absence of neutral electrode, when the monopolar channel is activated.

POSITIONING OF PATIENT PLATE

The diagram shows the most suitable points of application on the upper arms or thighs for the appropriate operating areas.

Accidental burns due to use of unsuitable and / or defective accessories.

It must be ensured that only accessories tested by the manufacturer within the framework of type test are used. The insulation on electrodes, electrode cables, connectors etc must be checked for perfection.

Warning: Damaged electrodes, electrode cables, connectors and other defective accessories can cause serious burns to the patient.

2.13 ACCIDENTAL BURNS DUE TO INATTENTIVENESS

The careless positioning of electrode handles or coagulation forceps on or beside the patient can pierce the patient's or other people's skin.

Warning: Burns to surgeon's hands are possible in most clinical situations if a monopolar active electrode is touched to a metal in hands, during activation.

The tip of the bipolar forceps if in contact with anybody when power is switched ON, can cause burns.

ACCIDENTAL BURNS DUE TO OUTPUT ERRORS.

The output intensity selected for coagulation or cut should not be more than what is required for the momentary purpose and should not be switched ON for longer than necessary.

Opera provides a facility by which the duration of activation is monitored. An LED indication is given after 10 seconds of activation and the system will be shut down along with an audible alarm after 15 seconds of activation.

Attention: Inaccurate output power can also result from wear and tear of the equipment.

he problems due to wear and tear of the equipment can be avoided if the equipment is undergoing periodic maintenance and testing by authorized personnel.

ACCIDENTAL BURNS DUE TO UNINTENTIONAL ACTIVATION OF THE HF-GENERATOR

Unintentional activation of the unit can lead to patient burns when the active electrode touches the patient directly or indirectly through electrically conductive objects or wet clothes.

Warning: Unintentional activation of the HF generator can cause serious damages to the patient if the electrode is directly or indirectly in contact with the patient.

Unintentional activation can be caused by:

— Unintended depressing of footswitch

— Unintended depressing of button on electrode handle

— Short circuit within the cable of electrode handle

— Penetration of electrically conductive fluids into a finger switch

At start up, Opera detects any kind of short circuits in the footswitch or in the activation Electrodes and display it as ERROR messages.

The equipment can detect the short circuits only at the start up.

Caution: The user is instructed to connect the electrodes to the equipment before the power is switched ON, to make possible the self check when the power is switched ON.

Warning: The operator is instructed to check for any kind of short
Circuits in foot or hand switches.

UNINTENDED BURNS CAUSED BY HOT ELECTRODES

Warning: Electrodes become hot indirectly from the heated tissue and from the electric arcs caused during cut or coagulation. So the tissue can get burned if these electrodes are still in contact with the tissue. This has to be taken care especially in cases of endoscope where the electrode may be kept in contact with the tissue for long.

ACCIDENTAL BURNS DUE TO IGNITION OF FLAMMABLE LIQUIDS, GASES, AND/OR VAPOURS

Sparks are always produced at the active electrode when surgical units are in operation. So particular care must be taken during surgery to ensure that anesthetics, skin cleansers, degreasing agents and disinfectants are neither FLAMMABLE nor EXPLOSIVE. At the i least, they must be highly volatile.

HF surgery should not be done in gastrointestinal tract since endogenous gases present a j potential explosion hazard. It can be solved by eliminating these gases from the organs, | for instance by flushing with inert gases before and during the HF surgery.

Warning: It is not advisable to activate the generator in the presence of flammable or explosive gases because it can result in serious explosions.

STIMULATION OF MUSCLES AND NERVES

The low frequency currents originating either in low frequency sources or in electric arcs | between the patient and the active electrode can stimulate the muscles and nerves. However the electric arcs produced causes parts of the high frequency alternating current to be I rectified, thus producing more or less strongly modulated low frequency currents which l! can lead to twitching and/or muscular contractions.

Attention: Muscular contractions could be expected if HF surgery is done on structures capable of electrical stimulation, for example, during endoscope surgery in urinary bladder, near the obturator nerve.

CHAPTER-3

DESIGN CRITERIA OF ELECTRO SURGICAL DIATHERMY

3.1 FUNCTIONAL BLOCK DIAGRAM OF ELECTRO SURGICAL DIATHERMY MACHINE

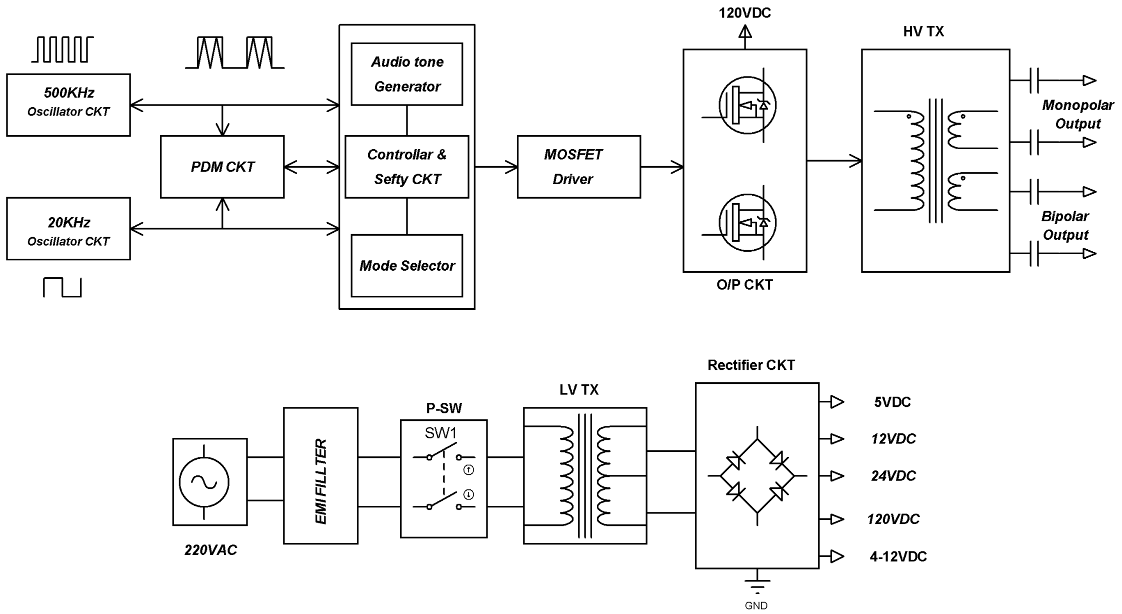


Fig 3.1 - Functional Block diagram of ESD machine

20 KHz oscillator circuit generates 20 KHz modulated signal and 500 KHz oscillator circuit generates 500 KHz PWM signal. 500 KHz PWM signal can adjust ON time and OFF time. These signals are fed to Pulse-duration modulation (PDM) circuit to generate PDM signal for micro controller. Control and safety Circuit generates two types of audio tones as cutting and coagulation. It controls different modes of ESD, also output power by hand or foot switch with safety of return electrode. MOSFET driver drives output circuit to produce 500 KHz alternative current which is feed to “HV output transformer”. We get desired HF alternative current from secondary of “Output transformer”. DC power supply unit generates five types of DC voltages (120 V DC, 24 V DC, 12 V DC, 5 V DC and 4 to 12 V regulated DC).

3.1.1 CIRCUIT DIAGRAM OF ESD MACHINE

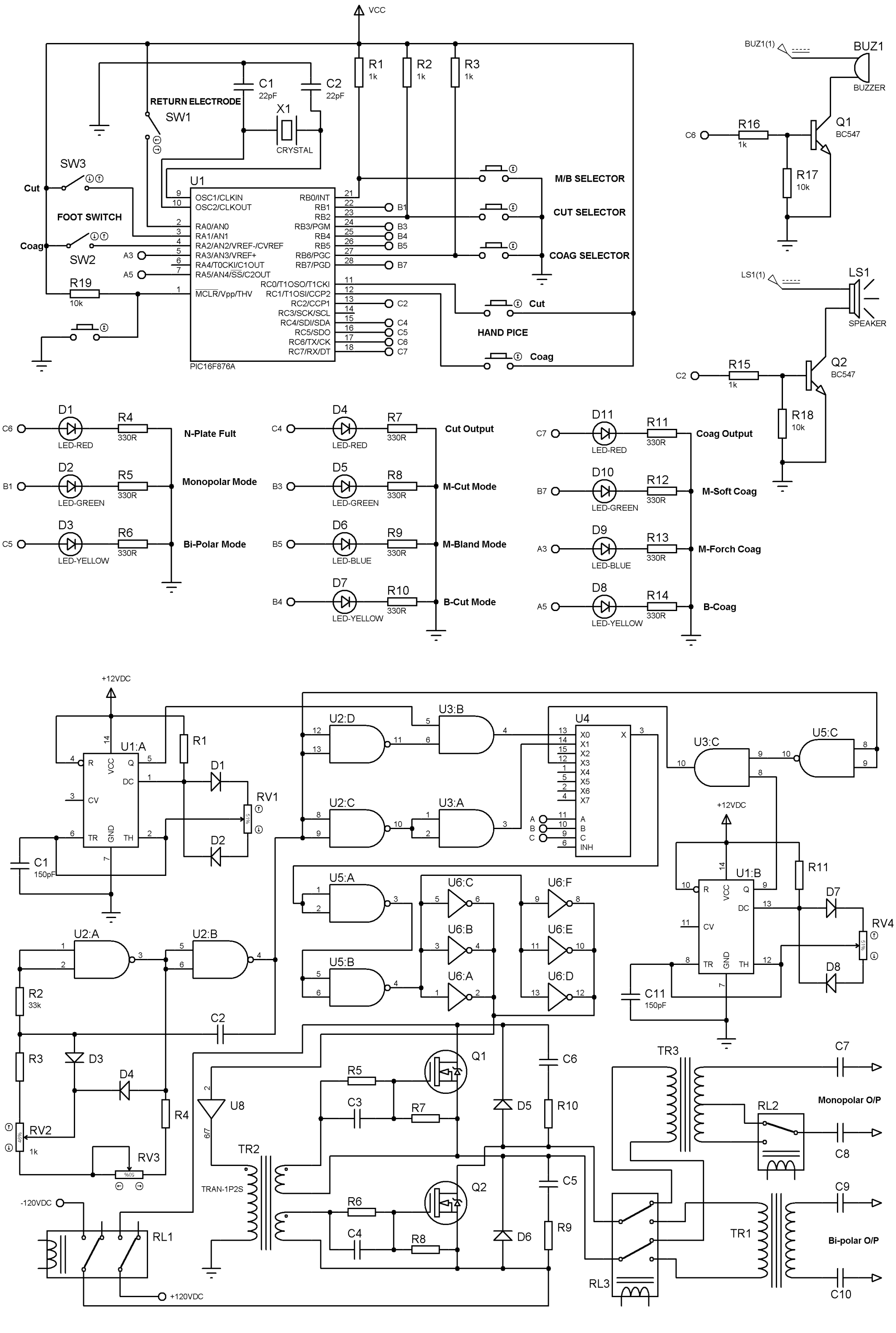


Fig 3.2 - Circuit diagram of ESD machine

Electrosurgical diathermy consists of:

1. 20 KHz Oscillator Circuit
2. 500 KHz PWM Oscillator Circuit
3. Pulse-duration modulation (PDM) Circuit
4. Audio ton generator & Patient plate safety circuit.
5. Controller Safety Circuit
6. Mode Selector Circuit
7. MOSFET Driver Circuit
8. HF Output Circuit
9. Isolation of Output
10. DC Power Supply Circuit

3.2 DESCRIPTION OF THE COMPONENTS

3.2.1 20KHZ OSCILLATION CIRCUIT:

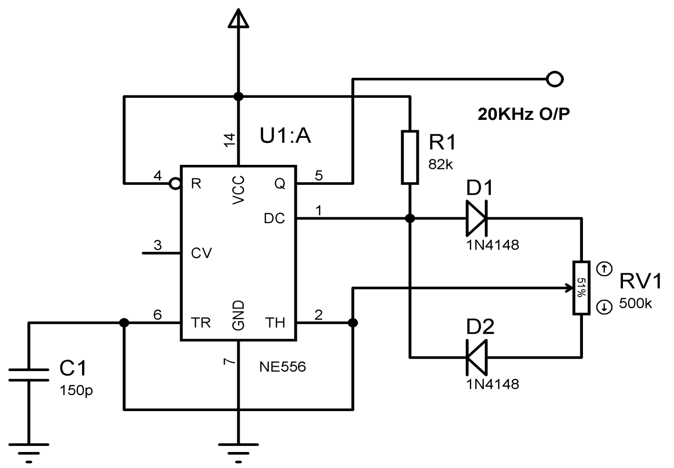


Fig 3.3 - 20KHz oscillator circuit

From this CKT we get desired 20 KHz Oscillation at pin no 5. We can adjust ON time or OFF time of the oscillation by using the variable resistor RV1. NE556 is the most popular IC to make timer or Oscillator circuit.

The NE556 dual monolithic timing circuit is a highly stable controller capable of producing accurate time delays or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200mA. From this circuit we get desired 20 KHz 0scillation at 5 no pin. We can adjust ON time or OFF time of the oscillation by using the variable resistor RV1. NE556 is the most popular IC to make timer or Oscillator circuit.

3.2.2 500 KHZ OSCILLATION CIRCUIT

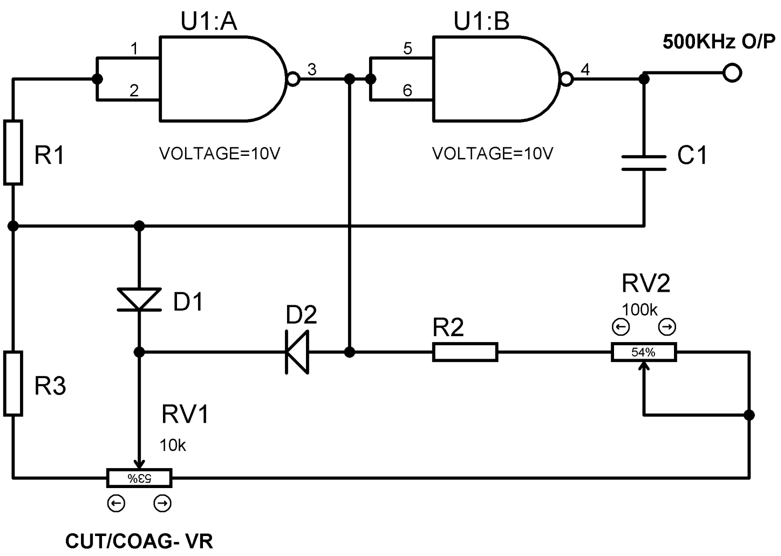


Fig 3.4 - 500KHz oscillation circuit

From this circuit, we get desired 500KHz Oscillation by using NAND gate. We can adjust ON time or OFF time of the oscillation by using the variable resistor RV1. NAND gate is the most popular to generate high frequency Oscillation.

The Pulse Width Modulator (PWM) is a very useful circuit that outputs a variable duty cycle at a fixed frequency (duty cycle is usually controlled using external control signal, potentiometer or using numerical control). The PWM is very useful in applications like wave generation, motor control, DC power controlling systems and Electro surgical diathermy output power controlling. The PWM switching frequency has to be much faster than what would affect the load, which is to say the device that uses the power. Typically switching have to be done several times a minute in an electric stove, 120 Hz in a lamp dimmer, from few kilohertz (KHz) to tens of KHz for a motor drive and well into the tens or hundreds of KHz in audio amplifiers and 200KHz to 3MHz for Electro surgical diathermy. The term duty cycle describes the proportion of 'on' time to the regular interval or 'period' of time; a low duty cycle corresponds to low power, because the power is off for most of the time. Duty cycle is expressed in percent, 100% being fully on. We get desired 500 KHz Oscillation by using NAND gate. We can adjust ON time or OFF time of the oscillation by using the variable resistor RV1. NAND gate is the most popular to generate high frequency Oscillation.

3.2.3 PULSE DURATION MODULATION CIRCUIT

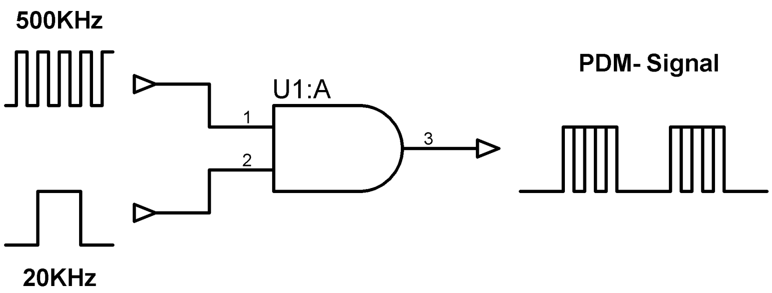


Fig 3.5 - Pulse duration modulation circuit

Pulse-width modulation (**PWM**), or **pulse-duration modulation** (**PDM**), is a modulation technique that conforms the width of the pulse, formally the pulse duration, based on modulator signal information. Although this modulation technique can be used to encode information for transmission, the average value of voltage (and current) fed to the load is controlled by turning the switch between supply and load on and off at a fast pace. The longer the switch is on compared to the off periods, the higher the power supplied to the load. Pulse duration modulation circuit is to control output power of Electro surgical diathermy. The main advantage of PWM is that power loss in the switching devices is very low. When a switch is off there is practically no current, and when it is on, there is almost no voltage drop across the switch. Power loss, being the product of voltage and current, is thus in both cases close to zero. PWM also works well with digital controls, which, because of their on/off nature, can easily set the needed duty cycle.

3.2.4 CONTROL AND SAFTY CIRCUIT WITH AUDIO TONE GENERATOR AND MODES SELECTOR

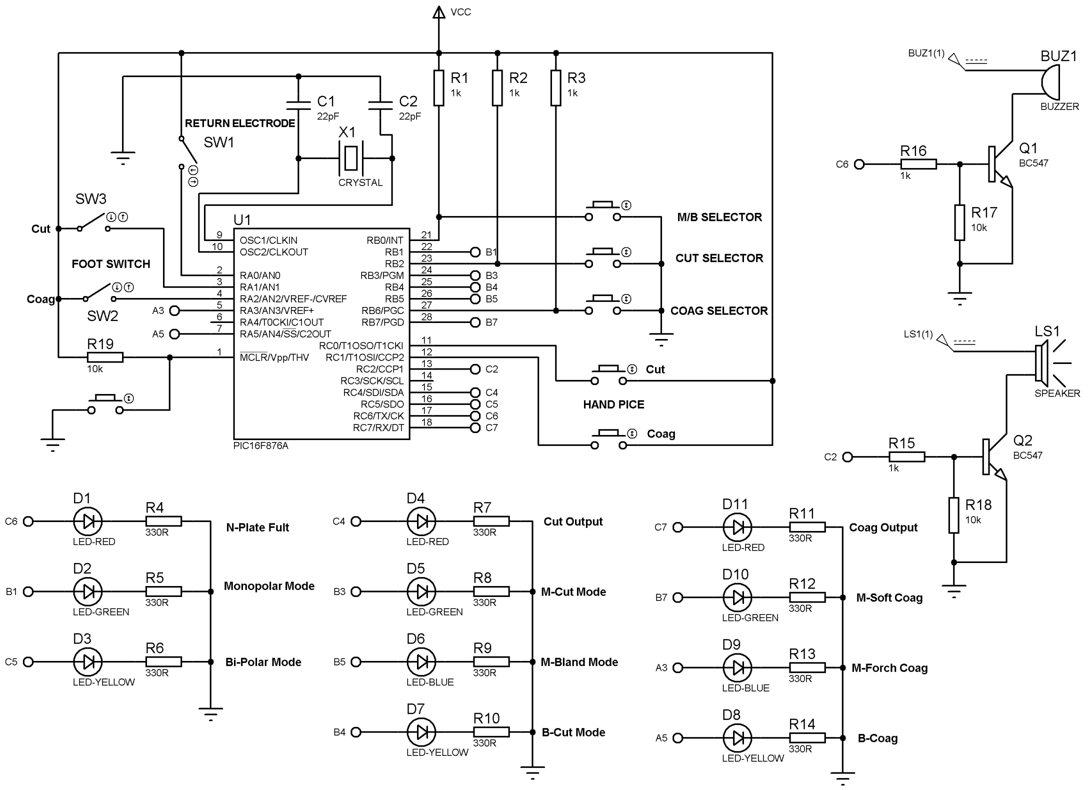


Fig 3.6 - Control and safety circuit with audio tone generator and modes selector.

Control and safety circuit: If return electrode is not connected properly with patient body or return electrode of ESD fails, switch (SW1) is closed to glows LED D1. As a result BUZ1 is generated beef audio tone for alarm at 1 Hz and cut off output power of ESD.

Electro Surgical Diathermy operated by foot switch or hand switch to control output power. Foot switches 'SW3' use for cutting and 'SW2' use for coagulation output ON. If SW2 and SW3 become ON at a time the output power of ESD is cutoff.

Duel hand switches: Any one of two switches (SW4 or SW5) ON we get cutting output power of ESD. When both switches (SW4 and SW5) become ON at the same time then we get coagulation output power of ESD.

During working foot or hand switches generate two types of audio tone for cutting at 200 Hz and coagulation at 100 Hz.

Mono-polar or Bi-polar mode is selected by using SW6 switch. SW7 and SW8 switches are used for only mono-polar mode. SW7 switch use selections of mono-polar cutting and blending mode. SW8 switch use to selections of mono-polar soft coagulation and force coagulation mode.

3.2.5 HF ALTERNATING CURRENTPOWER OUTPUT CIRCUIT

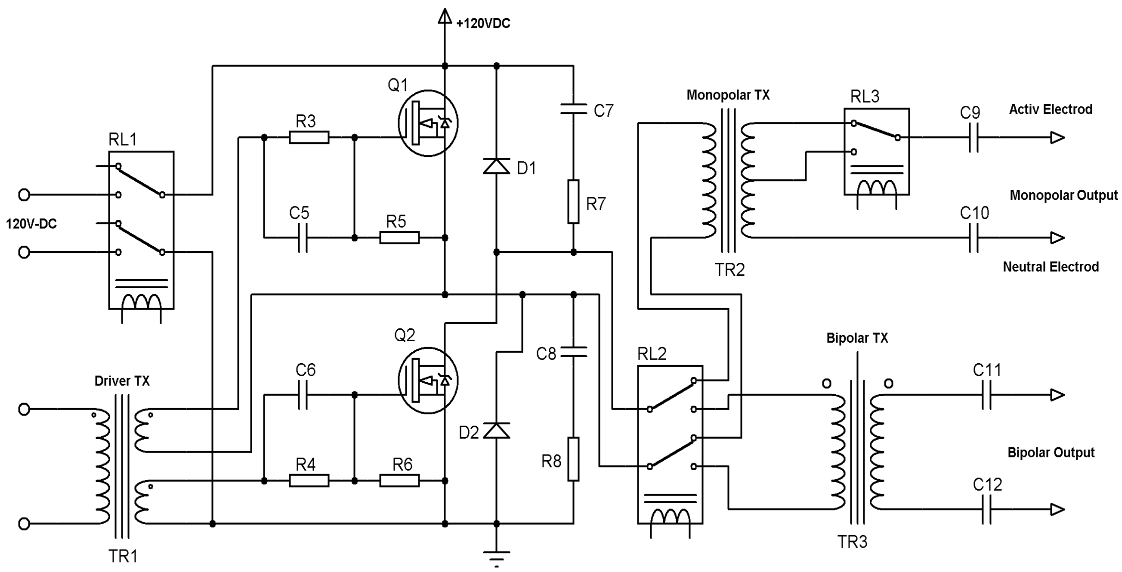


Fig 3.7 - HF Alternating Current Output Circuit

The main part of the HF alternating current output circuit is made of two power MOSFET Q1 & Q2 operating in fly back oscillation. It converts 120VDC to HF alternating current, which is applied at primary side of the mono or bi-polar output Transformer. The secondary voltage of the Transformer is 400V to 2200V in different modes.

3.2.6 MOSFET DRIVERS

When utilizing N-Channel MOSFETs to switch a DC voltage across a load, the drain terminals of the high side MOSFETs are often connected to the highest voltage in the system. This creates a difficulty, as the gate terminal must be approximately 10V higher than the drain terminal for the MOSFET to conduct. Often, integrated circuit devices known as MOSFET drivers are utilized to achieve this difference through charge pumps or bootstrapping techniques. These chips are capable of quickly charging the input capacitance of the MOSFET (Cgiss) quickly before the potential difference is reached, causing the gate to source voltage to be the highest system voltage plus the capacitor voltage, allowing it to conduct. A diagram of an N-Channel MOSFET with gate, drain, and source terminals is shown in Figure. There are many MOSFET drivers available to power N-Channel MOSFETs through level translation of low voltage control signals into voltages capable of supplying sufficient gate voltage. Advanced drivers contain circuitry for powering high and low side devices as well as N and P-Channel MOSFETs. In this design, all MOSFETs are N-Channel due to their increased current handling capabilities. To overcome the difficulties of driving high side N-Channel MOSFETs, the driver devices use an external source to charge a bootstrapping capacitor connected between Vcc and source terminals12. The bootstrap capacitor provides gate charge to the high side MOSFET. As the switch begins to conduct, the capacitor maintains a potential difference, rapidly causing the MOSFET to further conduct, until it is fully on. The name bootstrap component refers to this process and how the MOSFET acts as if it is “pulling itself up by its own boot strap”

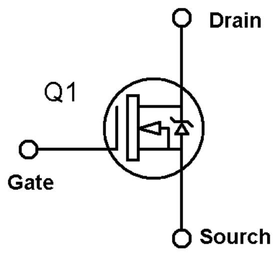


Fig 3.8 - N Channel MOSFET driver.

IC DRIVERS: Although there are many ways to drive MOSFET/IGBTs using hard-wired electronic circuits, IC Drivers offer convenience and features that attract designers. The foremost advantage is compactness. IC Drivers intrinsically offer lower propagation delay. As all important parameters are specified in an IC Driver, designers need not go through time consuming process of defining, designing and testing circuits to drive MOSFET/IGBTs. Another advantage is repeatability and predictability of performance, which can’t be easily achieved in hardwired driver circuits.

3.2.7 ISOLATED PATIENT CIRCUIT

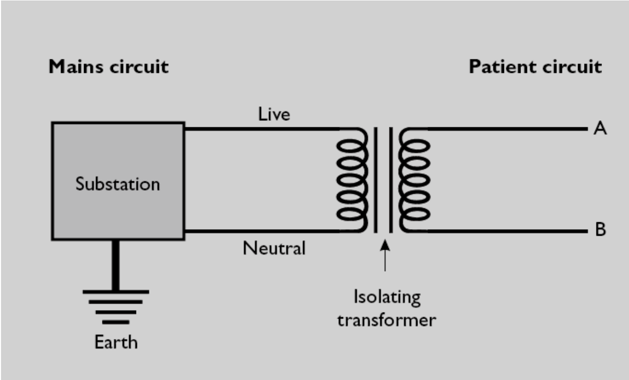


Fig 3.9 - Isolated patient circuit

Isolated or floating circuits provide a circuit whereby a connection between the electrical source and earth does not allow current to flow. They are created by the use of an isolating transformer which consists of 2 coils electrically insulated from each other. When alternating current flows through the mains or primary coil, it produces a changing electromagnetic field around it. This induces a current in the patient or secondary coil. The mains circuit is earthed but, importantly, the patient circuit is not earthed (hence floating). Therefore, to form part of this circuit one must connect wires A and B . Even if you are earthed, contact with wire A or B alone does not complete a circuit and so current cannot flow. These floating circuits can be used to isolate an entire operating theatre. However, if a fault occurs in one piece of equipment, power may be lost to the entire theatre. In the UK, a floating circuit is generally used to isolate individual instruments.

3.2.8 CIRCUIT PROTECTION AND SNUBBERS

One of the major factors in any electronic device is its ability to protect itself from surges that could damage the circuitry. In the case of the inverter, inductive loads can cause special problems because an inductor cannot instantly stop conducting current, it must be dampened or diverted so that the current does not try to flow through the open switch. If not dampened the surges can cause trouble in the MOSFETs used to produce the output sine wave; when a MOSFET is turned off the inductive load still wants to push current through the switch, as it has nowhere else to go. This action can cause the switch to be put under considerable stress, the high dV/dt, dI/dt, V and I associated with this problem can cause the MOSFETs to malfunction and break.

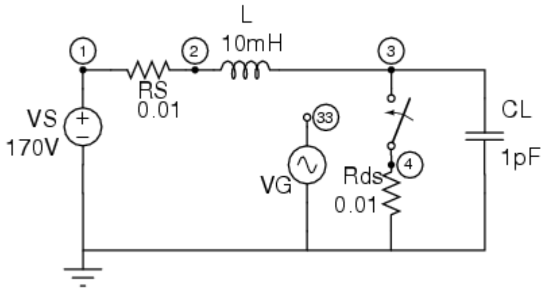


Fig 3.10 - Inductive Load Circuit

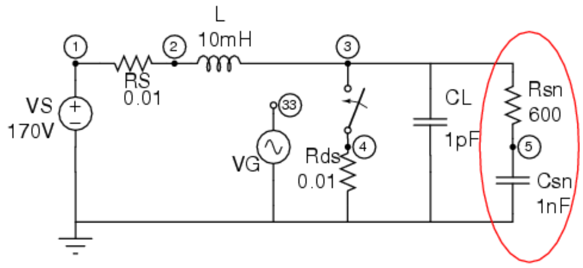


Fig 3.11 - Inductive Load Circuit with Snubber

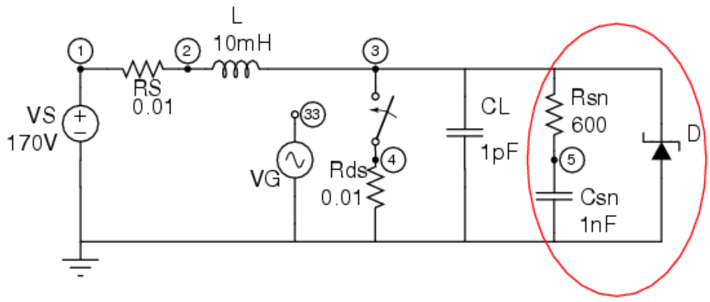


Fig 3.12 - Inductive Load Circuit with Snubber and Zener Diode

To combat this problem snubber circuits can reduce or eliminate any severe voltages and currents. Composed of simply a resistor and capacitor placed across each switch it allows any current or voltage spikes to be suppressed by critically dampening the surge and protecting the switch from damage. The snubber can become more effective by the addition of a zener diode so that any large current surge the resistor capacitor snubber cannot handle gets passed through to ground by the zener diode. The diagram in Figure 3.10 shows a simple representation of an inductive load (L) over a switch representation, Figure 3.11 and Figure 3.12 show how snubbers can be implemented so that a surge will be suppressed.

3.2.9 DC POWER SUPPLY CIRCUIT

This circuit produce four types of dc voltage, which use in this machine

DC 24 Volt 1Amp: The secondary voltage of TR1 is 32V ac and 18V ac. 32V ac is rectified by full-wave bridge rectifier BR1. The C1 converts the full-wave rippled output of the rectifier into a smooth dc output voltage. This voltage is fed to LM7824 input terminal. LM7824C monolithic 3-terminal positive voltage regulators employ internal current-limiting, thermal shutdown and safe-area compensation, making them essentially indestructible. If adequate heat sink is provided, they can deliver over 1.0A output current. They are intended as fixed voltage regulators in a wide range of applications including local (on-card) regulation for elimination of noise and distribution problems associated with single-point regulation. LM7824 deliver 24V dc 1Amp.

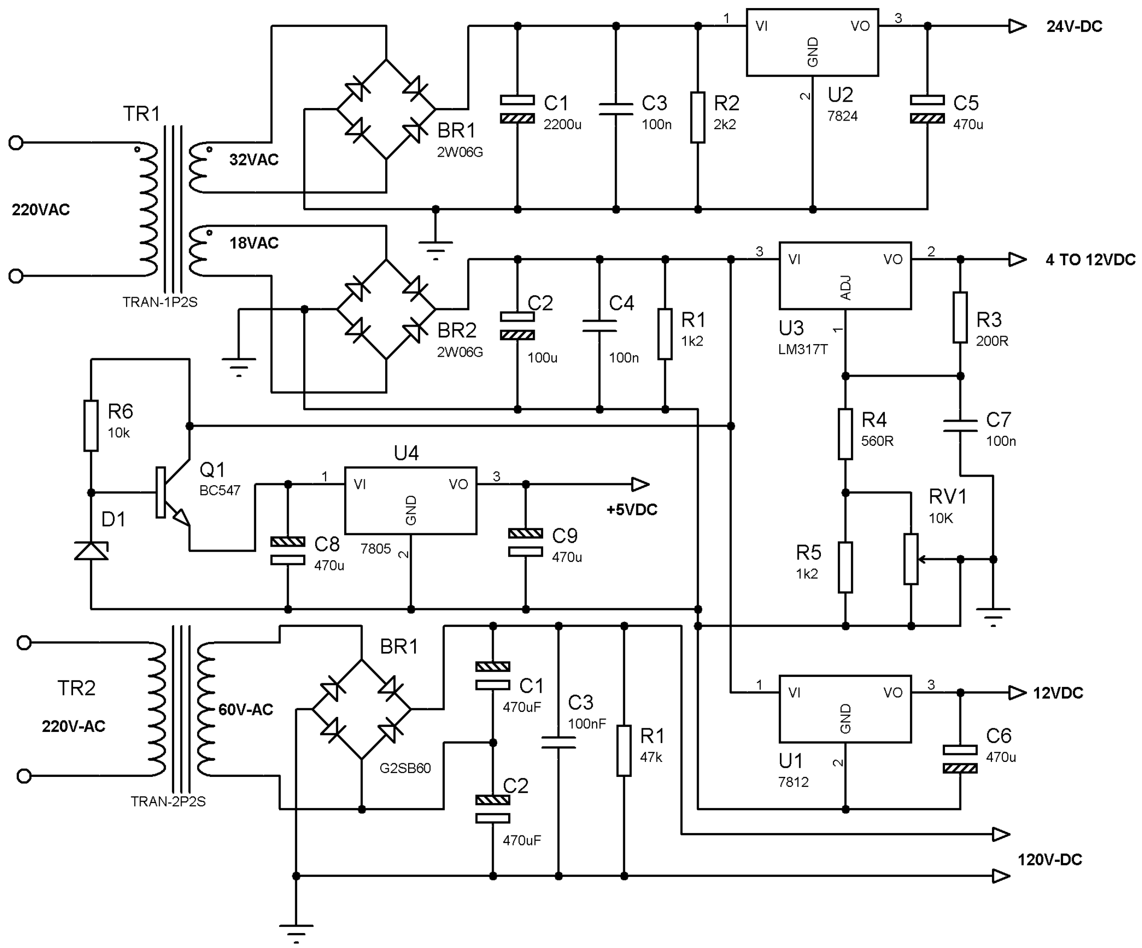


Fig 3.13 - DC power supply circuit.

DC 12 Volt 1Amp: The secondary voltage of TR1 are 32V ac and 18V ac. 18V ac is rectified by full-wave bridge rectifier BR2. The C4 converts the full-wave rippled output of the rectifier into a smooth dc output voltage.. This voltage is fed to LM7812 input terminal. LM7812 deliver 12V dc 1Amp.

DC 5 Volt 1Amp: The secondary voltage of TR1 are 32V ac and 18V ac. 18V ac is rectified by full-wave bridge rectifier BR2. The C4 converts the full-wave rippled output of the rectifier in to a smooth dc output voltage. 18 volt dc convert to 9.1 volt dc by using Q1 and D1. This voltage is fed to LM7805 input terminal. LM7805 deliver 5V dc.

DC 4 to 12 Volt 1Amp: The secondary voltage of TR1 are 32V ac and 18V ac. 18V ac is rectified by full-wave bridge rectifier BR2. The C4 converts the full-wave rippled output of the rectifier in to a smooth dc output voltage. This voltage fed to LM317 input terminal.
LM317 are monolithic integrated circuit in TO-220, ISOWATT220, TO-3 and D2PAK packages intended for use as positive adjustable voltage regulator. They are designed to supply more than 1.5A of load current with an output voltage adjustable over a 1.2 to 37V range. The nominal output voltage is selected by means of only a resistive divider, we can select lowest output voltage 4V dc by R4 and 4 to 12 V dc regulate by VR1.

DC 120 Volt 3Amp: The secondary voltage of TR2 is 60V ac and is rectified by full-wave bridge rectifier BR3. The C7 and C8 convert the full-wave rippled output of the rectifier in to a smooth dc output voltage. Two capacitors C7 & C8 each gives 60V dc in additive polarity which results 120V dc across R7 or C9.

3.3 TRANSFORMER DESIGN

The power transformer is basically a voltage-changing device which supplies operating voltages at right levels in radio and television receivers and other electric and electronic equipment. It is usually the heaviest piece of equipment.

Typically, a power transformer may have a primary winding (some times with taps for voltage adjustments or for 115/230V working), and one or more secondary windings. The primary winding receives ac power from the supply mains and the secondary windings supply different voltages and currents to the load circuits. The size of each winding bears a very definite relationship to the current drawn through it, the number of turns controlling the voltage and the resistance. The number of turns varies inversely as the size of the core, while the weight and bulk of the transformer are proportional to the power handling capability of a transformer.

Although a wide variety of power transformers are readily available in the market, it is often necessary to design and construct a transformer to suit one's own needs. It is also very tempting to reuse the materials many amateurs already have, not only with conservation in mind, but also from the cost point of view. For this, a working knowledge of the designing of transformers is needed. We shall now therefore discuss step-by-step procedures for designing small power transformers. The construction will be described in latter chapters.

Efficiency and Regulation

The total power delivered by the secondary or secondary of a transformer to the load circuit is always less than that drawn from the mains by its primary. The ratio between the power delivered and power drawn is called the *efficiency of a* transformer. Small transformers operate at efficiencies of 80 to 90 percent. The smaller the size, the lower is the efficiency. If a transformer with an efficiency of 0.9 (i.e., 90 percent) draws 100 watts from the mains, it will deliver only 90 watts to the load. The remaining 10 watts will be dissipated in the transformer as heat. Well designed transformers with good efficiency warm up only slightly, even if they are operated continuously. Small transformers for intermittent use are usually designed to work under overload conditions for reasons of economy. Such transformers, if operated continuously, heat up a lot, and eventually get burnt out. Poorly designed transformers for continuous load also behave in a similar manner.

Another important factor in the transformer design is its voltage regulation which is the virtue of its having only a small variation in output voltage with varying amounts of load currents. The voltage regulation of a transformer depends on the iron of the core, the shape of the core and the filling of the window space with windings, there being no large gap between the last layers of wire and the outside limbs. The core must be large enough and wire diameter fully adequate to handle the expected load currents.

Volt-amperes versus Watts

Transformer power ratings are nearly always stated in volt-amperes rather than watts, although both are given by multiplying volts and amperes. But 'volt-amperes' is not the same thing as 'watts'.

If a load is a pure resistance, then the current in the load is in phase with the voltage across it and the voltage across it multiplied by the current is the load in watts. This power is often referred to as true power. If, however, the load is a pure inductance, the voltage drop across it is not in phase with the current through it. In the case of an inductor, plotting voltage and current against time produces two curves as shown in Figure 3.14. If the power curve is developed from this by multiplying their instantaneous values of voltage and current are plotted, the curve shown as the dotted line is obtained. The dotted line shows that power is consumed in the first quarter cycle of current to build up the magnetic field, and then that power is returned to the unit in the next quarter cycle. Since the power swings positive and negative in one half of the current cycle and then repeats this pattern for the second half of the current, the net power consumed is zero.

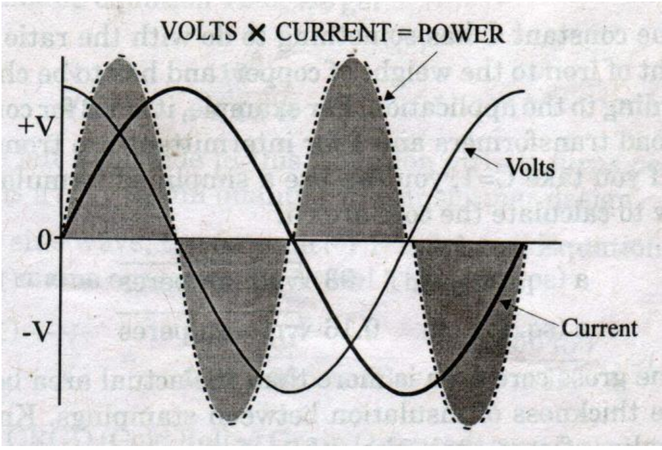


Fig 3.14 - The net power consumed in an inductance is zero

The primary of a transformer behaves like an inductor with a resistance and the current drawn by it is not in phase with the voltage. The phase angle varies with load. Power transformer's ratings are therefore given in volt-amperes. There is a tendency in transformer designers to use the terms 'watts' and 'volt-amperes' interchangeably, but the distinction between the two terms should be kept in mind if light reactive loads are involved because the actual power consumed is equal to ExIcosΦ and Φ can vary with load.

Core Area

The size of the core in a transformer depends on its volt-amperes, i.e., the larger is the volt-ampere rating, the bigger is the core size needed. The relationship between the area of cross-section of the center limb in an E-I type core and that of one limb in U-I type core is given by the equation:

$$\text{Core area a (sq. cm)} = C\sqrt{VA} \quad \text{- ------- 3-1}$$

where

a is the area of cross-section of core in sq. cm

VA is the volt-ampere rating of the transformer and

C is a constant (number). It lies between 1 and 1.25

The constant C has something to do with the ratio of the weight of iron to the weight of copper, and has to be changed according to the application. For example, it is 1.2 for constant full load transformers and 1 for intermittent use transformers. If you take C=1, you can use a simplified formula given below to calculate the core area a:

$$a\ (\text{sq. cm}) = 1.03\sqrt{volt - amperes} \text{ ------------3-2A}$$

$$a\ (\text{sq. in}) = 0.16\ \sqrt{volt - amperes} \text{ ------------3-2B}$$

The gross core area is more than the actual area because of the thickness of insulation between stampings. Knowing the value of core area, the value of gross core area can be calculated by taking into account the stacking factor.

Gross area A = a/stacking factor -------------- 3-3

Basic Transformer Equations

The basic transformer equation that is given below appears rather complicated because of too many symbols involved, but in reality, it is quite simple.

$$V = 4FfaNB \times 10^{-8} \quad \text{----------------- 3-4}$$

Where

V is the voltage across the winding in volts r.m.s.
F is the form factor of the a.c. waveform
f is the frequency in Hz
a is the cross-sectional area of the core
N is the number of turns on the considered winding and
B is the flux density in Maxwell's per unit area

In this equation, if a is in square centimeters, B must be in gauss (maxwells or lines per square centimeter), and if a is in square inches, then B must be in maxwells per square inch. In short, the units must be compatible.

Transformer Calculations

Rearranging equation 3-3, we get:

$$\frac{N}{V} = \frac{10^8}{4FfaB} \text{--------------} \quad 3\text{-}5$$

The left hand side in this ' Equation gives a *turns per volt* which is a very useful quantity in transformer design.

For sine wave, the form factor F is 1.1 (see Equation 3-6), and for mains operation f = 50 Hz. That gives:

$$\frac{N}{V} = \frac{10^8}{4.44 \times 50 \times a \times B} = \frac{450450}{aB} \text{---------} 3\text{-}6$$

For CRGO (Cold Rolled Grain Oriented) core metal stampings, we can take B as 11,500 lines per sq. cm. Hence:

$$\frac{N}{V} = \frac{450450}{11500 \times a} = \frac{39}{a} \text{---------------} \quad 3\text{-}7$$

In case you prefer to take a in square inches, you can use the modified formula

$$\frac{N}{V} = \frac{6}{a} \text{----------------------} 3\text{-}8$$

Equation 12-7 shows that, if the core area is one square inch, you have to wind 6 turns for each volt. This formula makes it easy to find out the actual number of turns. Instead of making calculations, you may find it more convenient to use the number of turns formula.

Now the number of turns in all the windings can be calculated easily. It is a common practice to add about 5 to 10 percent more to the number of turns given by this formula in the secondary winding turns to ensure good regulation.

Example 1

Let us suppose that we want to design a transformer having high and low voltage windings with the following specifications:

Primary Secondary 1 Secondary 2 Secondary 3	230V a.c. 350-0-350V a.c. at 120 mA 12.6V a.c. at 1.5A 5V a.c. at 2A

The center tapped secondary in this transformer is to be used for full wave rectification, only one half of the winding supplies current at a time.

The power consumption in the secondary's are:

350V $\times$ 120mA 12.3V $\times$ 1.5A 5V $\times$ 2A Total	= 42 watts = 18.9 watts = 10 watts = 70.9 watts

We take the efficiency of the transformer as 90 percent.

Hence:

Volt-amperes needed 70.9/0.9 = 79

Primary current 79/230 = 0.343A

Presuming that the transformer will operate continuously, we take the value of C as 1.2. This gives:

$$a \text{ (sq. cm)} = 1.2\sqrt{79} = 10.7 \text{ sq. cm}$$

This is the actual area of iron needed. Since there is space left between the stampings during assembly, the gross area needed would be more. Taking stacking factor of 0.9 we have:

Gross core area A = 10. 7/0.9 = 12 sq. cm

Though not necessary, a square cross section of core is best because iron and copper losses are small. The with of this core is therefore equal to $\sqrt{12}$ = 3.47 cm. Now you can choose the nearest tongue width from the commonly available stamping sizes and then calculate the slack height actually needed to get the required area.

Number of turns per volt = 39/10.7 = 3.65

Hence:

Number of turns in primary	= 3.65x230 = 840
Number of turns in secondary 1A	= 3.65x356 + 10% = 1278 + 127 = 1405
Number of turns in secondary 1B	= 3.65x350 + 10% = 1278 +127 =1405
Number of turns in secondary 2	= 3.65x12.5 + 10% = 45 +4.5 = 50
Number of turns in secondary 3	= 3.65x5 + 10% = 18.2+1.8 = 20

To complete the transformer design, it is only necessary to compute the wire sizes and the window area needed. Note that the secondary 1 will have 1405 + 1405 = 2810 turns with a center tap. The wire size will be chosen for 120/2 = 60 mA

Primary wire gauge for 0.343A	= 26 SWG
Secondary I wire gauge for 60 mA	= 36 SWG
Secondary 2 wire gauge for 1.5 A	= 19 SWG
Secondary 3 wire gauge for 2 A	= 18 SWG

For intermittent operation, higher current densities (thinner wires) may be used (see Appendix G).

Once wire sizes have been determined, the window area can be calculated form data in Tables in Appendix G.

Area occupied by primary	= 840/115 = 2.04 sq. cm
Area occupied by secondary 1	= 2810/2286 = 1.23 sq. cm
Area occupied by secondary 2	= 50/87.4 = 0.57 sq. cm
Area occupied by primary	= 20/60.8 = 0.33 sq. cm
Total area occupied by windings	= 4.17 sq. cm

If the window of the core has enough space to accommodate all these windings plus insulation and bobbin size, the design is ok. Otherwise, either select a, bigger core or use a little thinner wire size and repeat the calculations.

3.4 RISKS AND SAFETY FOR DESIGN OF ESD

The operating theatre is unusual as there are numerous examples of the deliberate application of electrical equipment to the human body. This article will review the potential dangers associated with this, how they occur and how they can be prevented.

Electrical supply

In the UK, mains electricity is supplied as an alternating current, which scillates at a frequency of 50 Hz. It travels from the substation to its destination in two conductors – the live and the neutral wire. The live wire is at a potential of 240 V, whilst the neutral wire is connected to the earth at the substation and is thus kept at approximately the same potential as earth. These are analogous to the positive and negative wires used with direct current. If a connection is made between the live wire and earth, electricity will flow through that connection to earth. The problems arise when this connection is a patient or member of staff.

How does electricity damage the body?

Electricity can cause morbidity or mortality by one of three processes: (i) electrocution; (ii) burns; and (iii) ignition of a flammable material, causing a fire or explosion. Electrocution The effects produced by electrocution are

dependent upon 4 factors: (i) the amount of electricity that flows (current); (ii) where the current flows (current pathway) and its density; (iii) the type of current (direct or alternating); and (iv) current duration.

Current

The word ‘current’ comes from the Latin currere, meaning to run or flow. In electrical terms, it means the flow of electrons. It is measured in the SI unit ampere (A); 1 A represents a flow of 6.24 × 1018 electrons (1 coulomb of charge) past a specific point in 1 sec. The size of any current is determined by

two factors (Ohms law):

Current = Voltage/Resistance

Thus, the current will be greatest if the voltage is high or the resistance is low. Strictly speaking, Ohms law applies to the voltage and direct current across a resistor. Alternating current not only flows through resistors but also across capacitors. To take account of this, the term impedance is substituted for resistance.

Current pathway and density

The pathway that current takes through the body will determine which tissues are damaged. For example, current passing through the chest may cause ventricular fibrillation or asphyxia due to tetany of the respiratory muscles,

whilst a current passing vertically through the body may cause loss of consciousness and spinal cord damage. The effect of the size of current and current pathway can be considered together as current density. This is the amount of current flowing per unit area. For example, a 50 Hz alternating

current flowing between each hand would have the following effects:

1 mA Tingling sensation

15 mA Muscle tetany, pain and asphyxia

75 mA Ventricular fibrillation

In this example, the current has passed through the whole of the trunk with only a small part of it passing through the heart, *i.e*. the myocardial current density is relatively low. However, if the current flows directly into the myocardium (or in very close proximity to it), for any given current, the current density will be much greater. In these circumstances, a substantially smaller current (50 μA at

50 Hz) can cause ventricular fibrillation. This is known as microshock**.** Examples of equipment that may allow microshock include central venous catheters, intracardiac pacemakers with an external lead and, to a lesser extent, a temperature probe placed in the oesophagus immediately behind the left atrium.

Type of current

Direct and alternating currents have different effects on the body; alternating current at 50 Hz is the most dangerous. The myocardium is most susceptible to the arrythmogenic effects of electric currents at this frequency and muscle spasm prevents the victim letting go of the source. As the frequency increases to > 1 kHz, the susceptibility decreases dramatically. At higher frequencies (MHz range), use can be made of its heating properties (diathermy).

Current duration

Finally, damage caused by electrocution is dependent upon the duration of time for which the current flows. The shorter the duration, the higher the current required before damage is done.

Burns

When an electric current passes through any substance having electrical resistance, heat is produced. Whether or not this produces a burn depends on the current density. Skin (especially when dry) has a high electrical resistance compared with the moist tissues beneath. Thus, electrical burns are generally
most marked on or near the skin. Fires and explosions Sparks caused by switches or plugs being removed from wall sockets can ignite inflammable vapours. This is prevented by the use of spark proof switches and electric socket outlets which prevent the plug from being withdrawn whilst the
switch is turned on.

How might electricity flow through the body?

There are two ways by which the body can form part of an electrical circuit – resistive or capacitive coupling. When the body provides a direct physical connection, this is said to have been made by resistive coupling.

Resistive coupling

The body can act as a connection if it comes into contact with the source of electricity and the earth directly or by touching an earthed object such as drip stand. There are two potential sources of this electricity – faulty equipment and leakage currents. Faulty equipment may allow contact with a live wire if it touches the equipment casing. Leakage currents arise because electrical equipment is at a higher potential than earth. Given an adequate connection, some current will flow to earth, even if the equipment is well insulated, since there is no such thing as perfect insulation or infinite resistance. Although these currents are normally small, they can be fatal (microshock). Modern equipment
is designed to limit this hazard.

Capacitive coupling

The body can also form a connection between an electrical source and earth by acting as one plate of a capacitor (capacitive coupling). In their simplest form, capacitors consist of two conducting plates separated by an insulating material
(dielectric). They allow the storage of electrical charge. The amount of charge a capacitor can store is described in terms of its capacitance, which is measured in the unit farad. If direct current is applied to a capacitor, current flows for only the very brief period until the positive plate is charged to the same potential as the electrical source. Thereafter, the current ceases. If alternating current is applied across a capacitor, its plates change polarity at the same rate as the alternating current. The capacitor will then continually charge and discharge and the electrons rush back and forth from plate to plate causing a current to flow in the circuit. This is the reason why the term impedance should be substituted for resistance when discussing alternating currents. The impedance of a capacitor can be expressed by the equation:

$$\text{Impedance} = \frac{\text{Distance between plates}}{\text{Current frequency} \times \text{Plate area}}$$

Thus, the connection becomes increasingly likely as the frequency of the electrical source and area of the plates increase and the distance between them decreases. An example of capacitive coupling in the clinical setting occurs in the MRI scanner. The scanner creates a changing electromagnetic field that can induce currents in conductors such as the wires or metal of a standard pulse oximeter probe. Although the patient may not be in direct contact with these conductors, capacitive coupling allows the patient to become part of an electrical circuit which may cause a burn.

How can we prevent electrocution?

Methods of reducing the risk of risk electrocution can be broadly classified as: (i) general measures; (ii) equipment design; (iii) equipotentiality; (iv) isolated circuits; and (v) circuit breakers.

General measures

Several simple measures can reduce the risk or effect of electrocution. These include adequate maintenance and regular testing of electrical equipment, ensuring the patient is not in contact with earthed objects and the wearing of antistatic shoes, whose high impedance will reduce any current flowing through the body.

Equipment design

We try to fulfill all requirements of ESD design according to the British standard 5724 safety of medical equipment which was revised in 1989 by IEC601 (International electro-technical committee) British Standard Symbols used on medical equipment are shown in Figure 1.

These protective methods can be best considered by describing the classification of equipment according to their means of protection.

Class I

Any conducting part of Class I equipment accessible to the user, such as the metal casing, is connected to earth by an earth wire. This wire becomes the third pin of the plug connecting the equipment to the mains socket. If a fault occurs which allows the live supply to come into contact with an accessible part, current flows down the earth wire. This new circuit has a lower resistance, resulting in an increased current which melts the protective fuses and breaks the circuit, removing the source of potential electrocution. In addition to the fuse in the mains socket, Class I equipment should have fuses at the equipment end of the mains supply lead, in both the live and neutral conductors so that this protection is operative even if the equipment is connected to an incorrectly wired socket outlet.

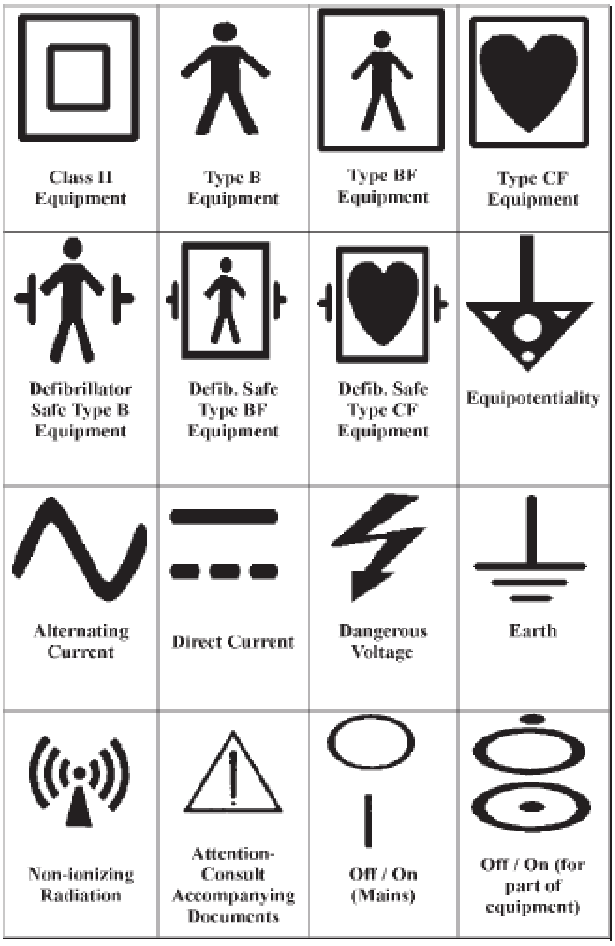


Fig. 1 British Standard Symbols used on medical equipment.

Class II

Any accessible conducting parts of Class II equipment are protected from the live supply by either double or re-inforced insulation. This should prevent any possibility of an accessible part becoming live and so an earth wire is not required.

Class III

Class III equipment provides protection against electric shock by using voltages no higher than safety extra low voltage (SELV). SELV is defined as a voltage not > 25 V AC or 60 V DC. In practice, such equipment is either battery operated or supplied by a SELV transformer. It is unlikely that these voltages will cause electrocution. However, the danger of microshock persists and the latest standards relating to medical electrical equipment do not recognise Class III, since limitation of voltage alone is not sufficient to ensure the safety of patients.

Type designation

We have seen that the class to which a piece of equipment belongs describes the method by which it protects against electrocution. The degree of protection for medical electrical equipment is defined by the type designation and is based on
the maximum permissible leakage currents:

Type B

The equipment may be of Class I, II or III but the maximum leakage current must not exceed 100 μA. It is therefore not suitable for direct connection to the heart.

Type BF

As for type B, but uses an isolated (or floating) circuit (see below).

Type CF

These provide the highest degree of protection, using isolated circuits and having a maximum leakage current of < 10 μA. They are suitable for direct cardiac connection, *e.g*. ECG leads, pressure transducers and thermodilution
computers.

Equipotentiality

Different pieces of equipment may be at different potentials relative to earth. If they are in close proximity, a connection may be made between them by the user. A current may then

flow from the higher to lower potential via the user. To avoid this, the terminals of each piece of equipment in a stack can
be connected to each other bringing them all to the same potential.

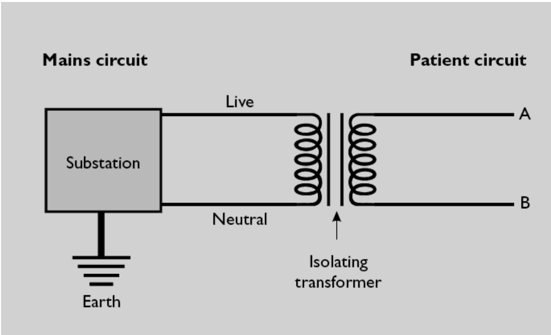


Fig 3.15 - Isolated patient circuit.

Isolated (floating) circuits

Isolated or floating circuits (Fig 3.15) provide a circuit whereby a connection between the electrical source and earth does not allow current to flow. They are created by the use of an isolating transformer which consists of 2 coils electrically insulated from each other. When alternating current flows through the mains or primary coil, it produces a changing electromagnetic field around it. This induces a current in the patient or secondary coil. The mains circuit is earthed but, importantly, the patient circuit is not earthed (hence floating). Therefore, to form part of this circuit one must connect wires A and B (Fig 3.15).

Even if you are earthed, contact with wire A or B alone does not complete a circuit and so current cannot flow. These floating circuits can be used to isolate an entire operating theatre. However, if a fault occurs in one piece of equipment, power may be lost to the entire theatre. In the UK, a floating circuit is generally used to isolate individual instruments.

Circuit breakers:

Current-operated earth leakage circuit breakers (COELCB), also known as an earth trip or residual current circuit breakers, consist of a live and neutral wire with the same number of windings around the core of a transformer. A third winding connects these to the coil of a relay that operates the circuit breaker. If the current in the live and neutral conductors is the same, the magnetic fluxes cancel themselves out. However, if they are different (due to excessive current leakage) there is a resultant magnetic field. This induces a current in the third winding causing the relay to break the circuit. A difference of as little as 30 ma can trip the COELCB in a very short period of time (milliseconds). This greatly reduces the possibility of a serious electrical shock.

3.5 PCB Design

In the picture of (Fig 3.16, Fig 3.17) shown as PCB Design that is done in protel design system and PCB are design in dual layer. In Bangladesh, there is no such a company or industry that design PCB with dual layer. For this reason, manufacture this dual layer PCB from Supreme Circuit, New Delhi, India.

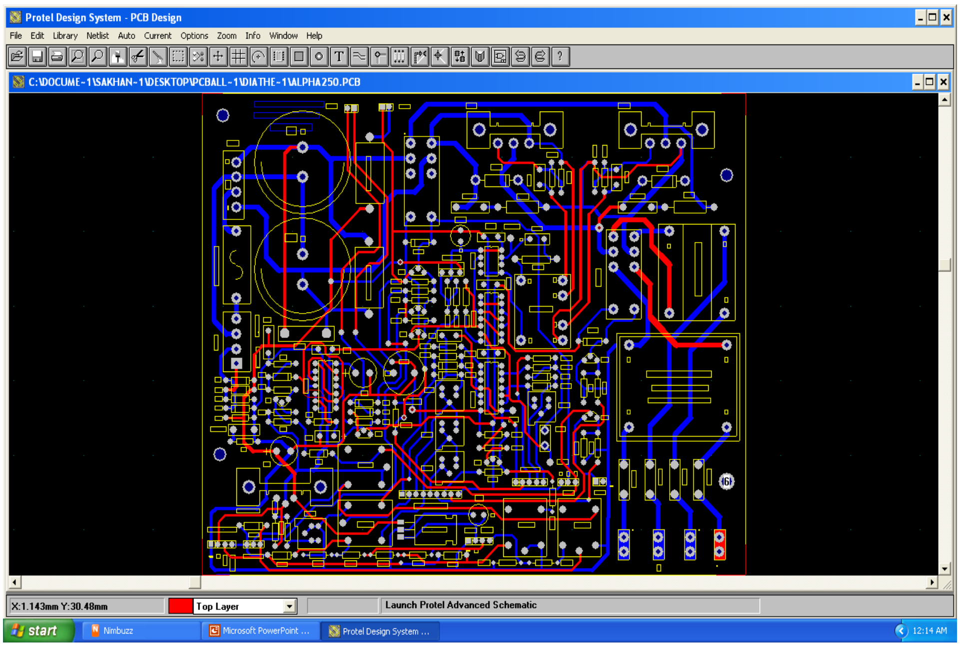


Fig 3.16 - Main PCB of Electro Surgical Diathermy

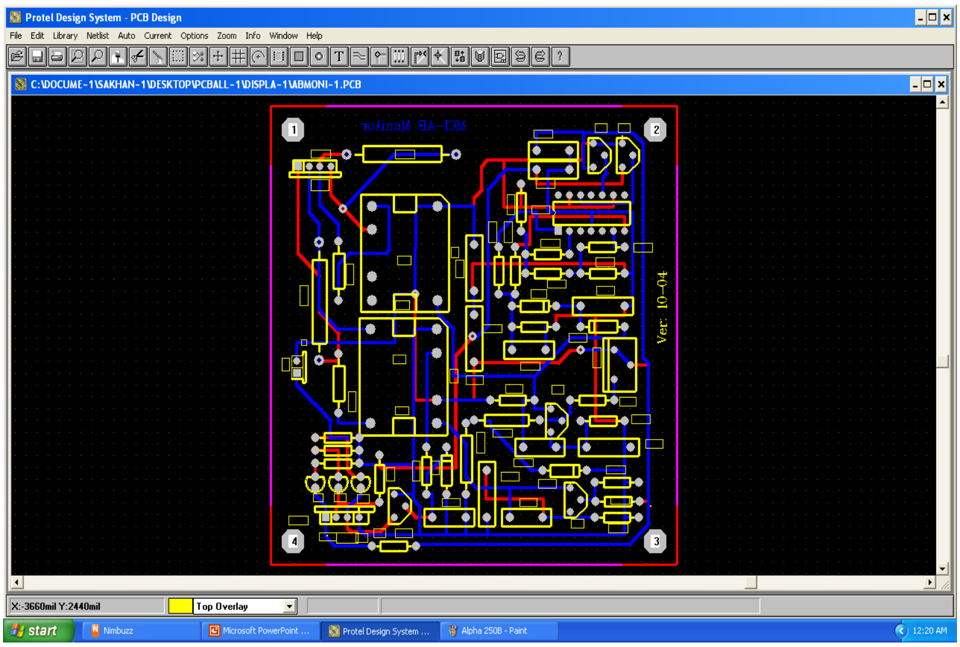


Fig 3.17 - PCB design Of 3 pin hand piece control circuit

3.6 Construction of Electro Surgical Diathermy

In the picture of (Fig 3.18, Fig 3.19), there is shown top and Bottom side of electrosurgical diathermy PCB without component.

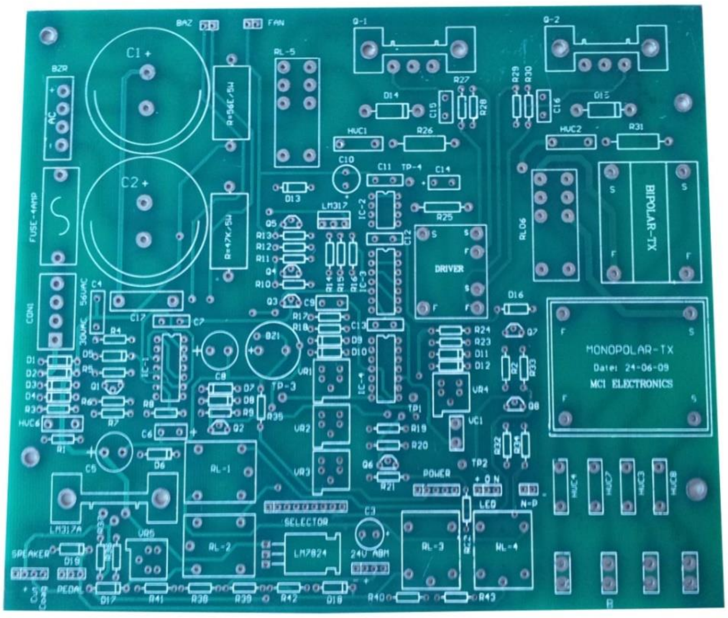


Fig 3.18 - Top Side of Electro Surgical Diathermy PCB

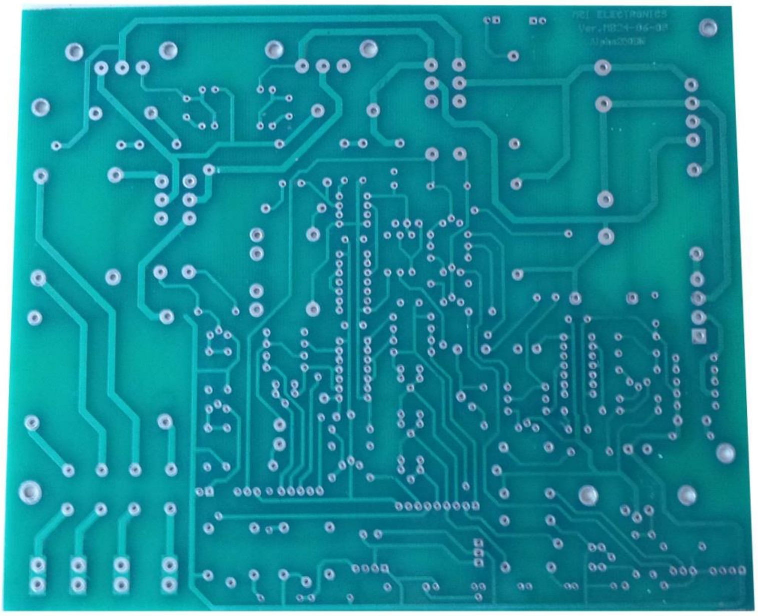
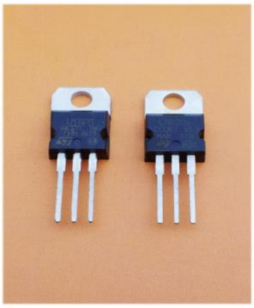
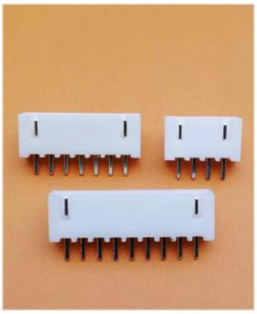
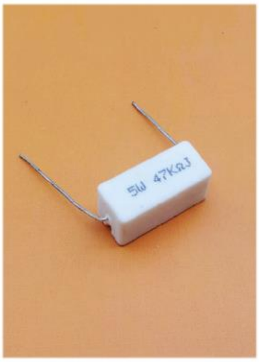


Fig 3.19- Bottom Side of Electro Surgical Diathermy PCB

3.7 Major component of Electro Surgical Diathermy PCB

Those major components are use in load or assembling in electrosurgical diathermy, picture of components and name are given below-

			
Voltage Regulator	Test pin	Heat sink	IC socket
			
CPU connector	Ceramic Capacitor	Buzzer	Tantalum Capacitor
			
Resistor 5Watte	Potentiometer	HV-Capacitor	Switching diode
			
Output Terminal	Electrolytic Capacitor	Driver TX	Bridge Rectifier

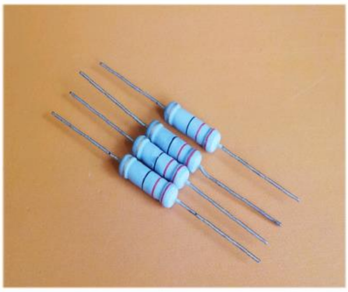
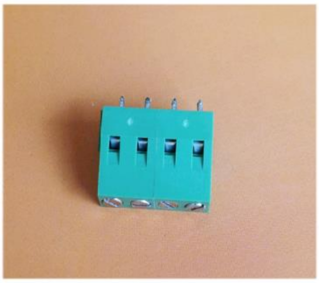
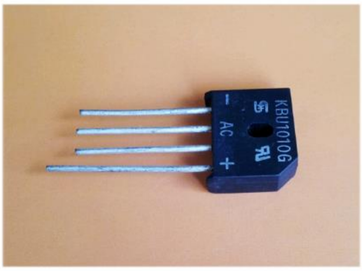
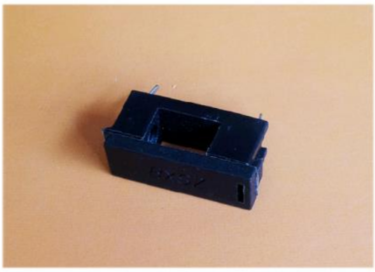
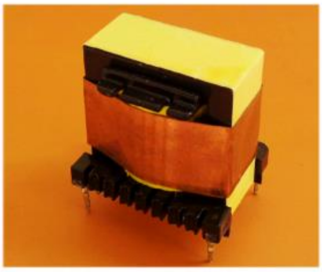
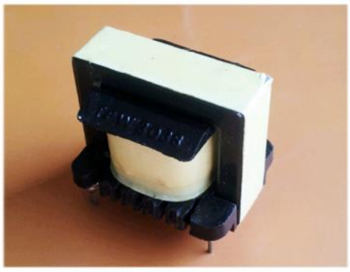
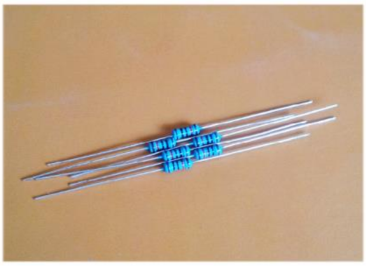
		
Resistor 2 W	5 Pin Relay	PBT Cunnector
		
Bridge Rectifier	Fuse Holder	Monpolar O/P TX
		
8 pin Relay	Varibal Capacitor	Tanasistor
		
Bi-polar O/P TX	Resistor 0.6 W	Normal Diode

Fig 3.20 - Major component of Electro Surgical Diathermy PCB

In the picture of (Fig 3.21) shown as Component Loaded Electro Surgical Diathermy PCB

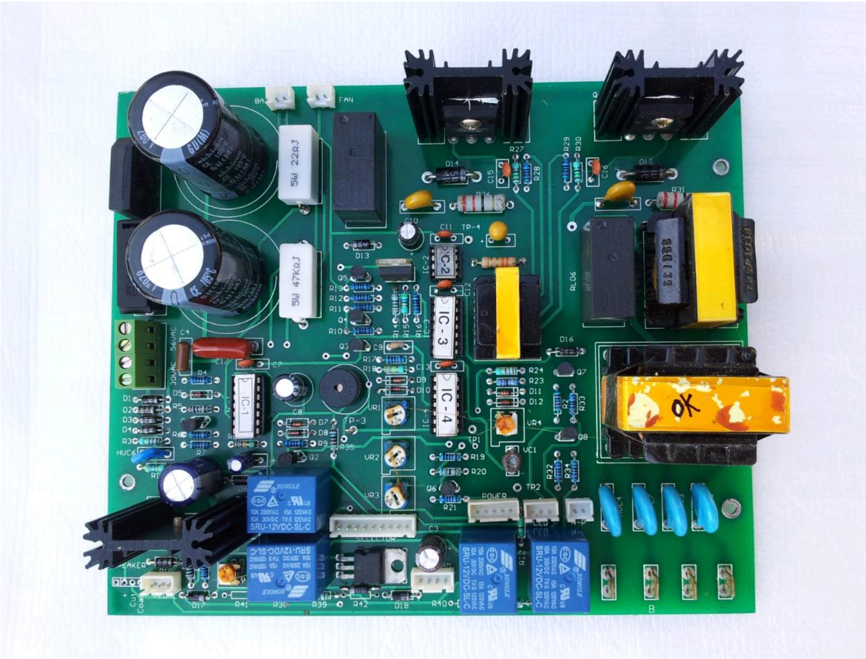


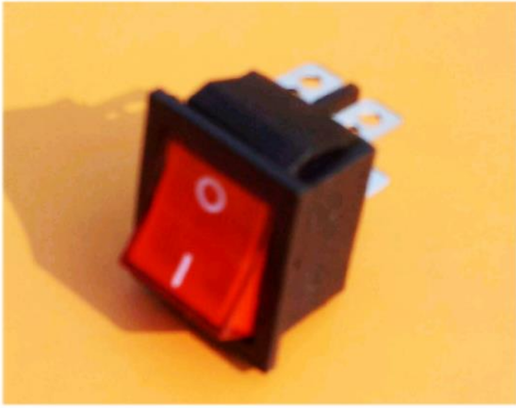
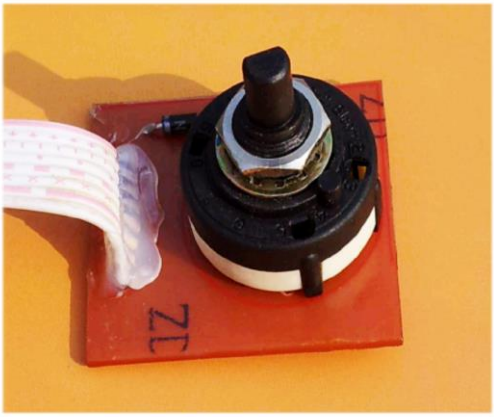
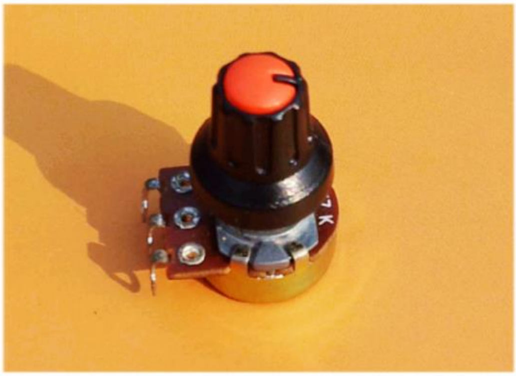
Fig 3.21 - Component Loaded Electro Surgical Diathermy PCB

Fig 3.22 - Electro Surgical Diathermy box without box fittings

Here, Blank box without box fitting have shown of ESD. thus box fitting's are added, that are given below with picture and name-

Box fittings of Electro Surgical Diathermy

	
Monopolar O/P Socket	Power & Selector Knobs
	
Box Lag	EMI Filter
	
LED PCB	Bi-polar O/P Socket

	
Power Switch	Selector Switch
	
Fuse Holder	Buzzer Adj Knob
	
PCB Hide	Power VR

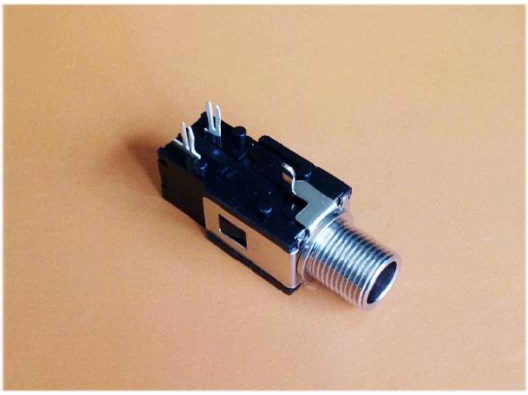
	
Cable Connector	Cooling Fan
	
RC Socket	AV Socket
	
Low Voltage Transformer	RC Socket With Switched

Fig 3.23 - Box fittings of Electro Surgical Diathermy

In the picture of (Fig 3.24) shown as Electro Surgical Diathermy Box with box fittings

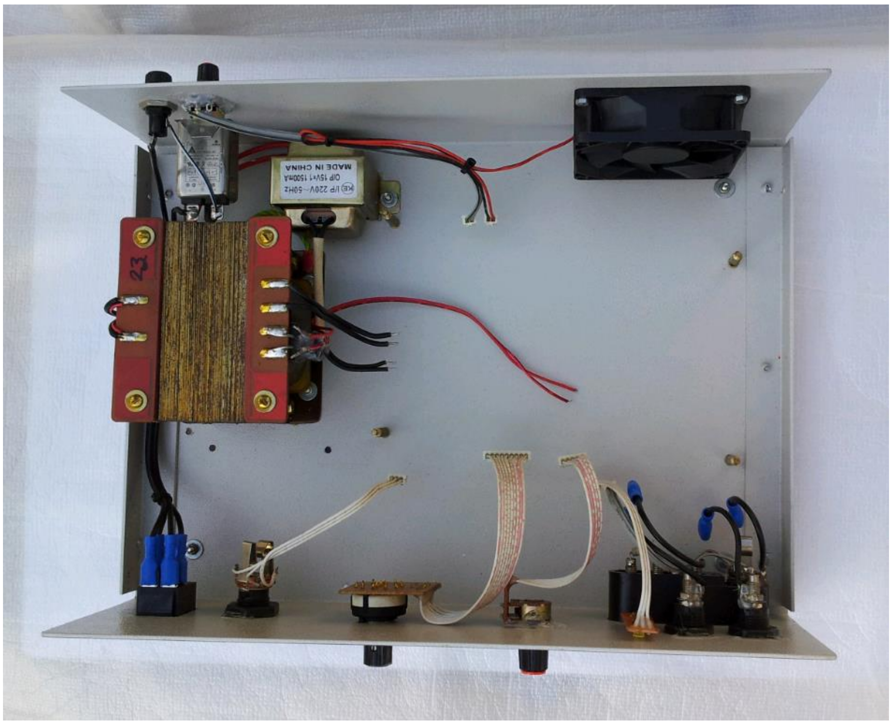


Fig 3.24 - Electro Surgical Diathermy Box with box fittings

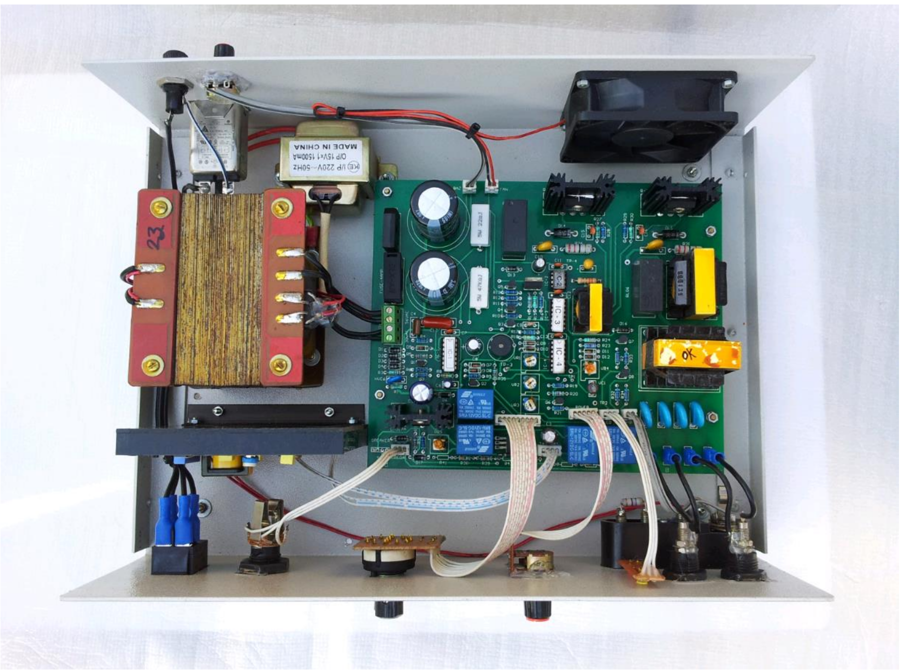


Fig 3.25 - Complete Electro Surgical Diathermy Machine

Here, Electro Surgical Diathermy Box fitting with component load PCB and full connection are shown in picture

Electro Surgical Diathermy Accessories

Those accessories are need to Electro Surgical Diathermy operation, that pictures with names are given below-

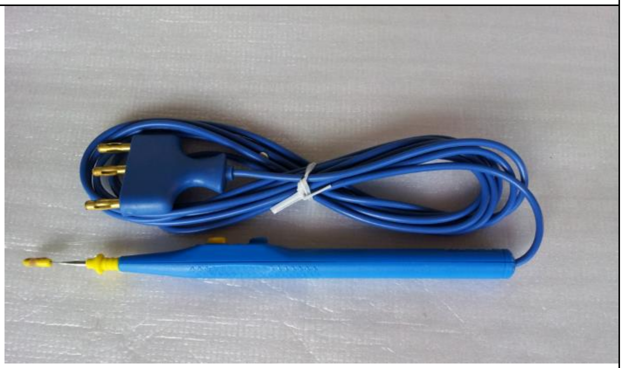
	
Duel Foot Switch	Neutral Electrod
	
Bipolar Furchap	Bipolar Furchap Cable
	
AC coat	3 Pin Hand Piece

Fig 3.26- Electro Surgical Diathermy Accessories

3.8 LIST OF COMPONENTS WITH PRICE

Description	Amount(Tk.)
1. Microcontroller	220
2. Integrating circuit (IC)	200
3. Optocouplar	100
4. Resistor .6W	95
5. Resistor 2W	20
6. Resistor 5W	10
7. Capacitor ceramic	20
8. Capacitor electrolytic	300
9. Capacitor tantalum	25
10. Hi-voltage Capacitor	200
11. Variable Capacitor	50
12. Switching diode	10
13. Ultra fast diode	50
14. Normal diode	10
15. Voltage regulator 5V, 12V, 24V and LM317	50
16. N Channel MOSFET	600
17. Bridge rectifier	25
18. Buzzer	10
19. Relay 12vdc 5 pin	40
20. Relay 12vdc 8 pin	140
21. IC Socket	60
22. Heat sink	100
23. Fuse Holder	20
24. Potentiometer	50
25. Transistor	10
26. Crystal 4MHz	10
27. Speaker 0.5 watts	50
28. Micro Switch	15
29. LED	25
30. Driver Transformer	25
31. Monopolar output Transformer	200
32. Bi-polar output Transformer	140
33. CPU Connector	250
34. PBT Connector	20
35. Other Connector	20
36. PCB	950
37. ESD Box	1200
38. ESD Front starker	100
39. Monopolar output socket	450
40. Bi-polar output socket	100
41. Box lag	20
42. EMI Filter	100
43. Power switch	20
44. Fuse Holder	10
45. Buzzer adjust knob	10

46. Cable connector	60
47. Cooling fan	60
48. RC socket	20
49. AV socket	50
50. Low Voltage Transformer	1500
51. RC socket with switch	30
52. Dual Foot switch	2500
53. 3pin Hand pice	4500
54. Return electrode	1500
55. Bi-polar furchap	5000
56. Bi-polar furchap cable	3500
57. 3 pin AC coat	150
Total Components cost:	**Tk. 25,000/=**

The designed ESD machine is cheaper as compared to the similar machine produced by overseas manufacturers. The cost of the components in Bangladeshi Tk. is 25,000 and assembling cost is Tk. 15,000. So, If we add a profit of Tk. 10,000 the market price of this designed ESD machine will be **taka 50,000**.

3.9 COMPARISON OF ADVANTAGES PROVIDED BY THE DESIGNED ESD MACHINE

Imported ESD machine	Local ESD machine
Imported ESD is very high price.	Local ESD is very low price.
Maintenance cost very expensive.	Maintenance cost low expensive.
After sales service for imported ESD requires a lot of time.	After sales service for local ESD requires a very short time
It does not create job market.	It creates job market.
Imported ESD involves a lot of foreign exchange.	It can save foreign exchange.
Imported ESD do not make skilled manpower.	Local ESD make skilled manpower.

CHAPTER -4

Operation of Electro Surgical Diathermy

4.1 TECHNICAL SPECIFICATION OF ESD

01. Mains And Absorption	: 220VAC, 50Hz, 350VA
02. Frequency	: 500KHz ±5%
03. Output Circuit	: Floating protected against defibrillator Discharge.
04. Cooling	: Convection cooling with Heat Sink.
05. Adjusting and reading of Power	: By Variable Resistor with rotation and fast Changing.
06. Neutral electrode safety	: Cable continuity failure is signaled by both acoustic and visible red LED alarms, with cut off O/P power.
07. Running controls	: By foot pedal or finger switch with acoustic & Visible alarms
08. Maximum output power	Cut: 250W RMS at 500 Ohms Bland: 180W RMS at 500 Ohms Coag: 125W RMS at 500 Ohms Micro: 70W RMS at 500 Ohms Bipolar Coag: 50W RMS at 200 Ohms
09. Dimensions and Weight W×H×D, & Kg.	: 335mm×120mm×280mm.

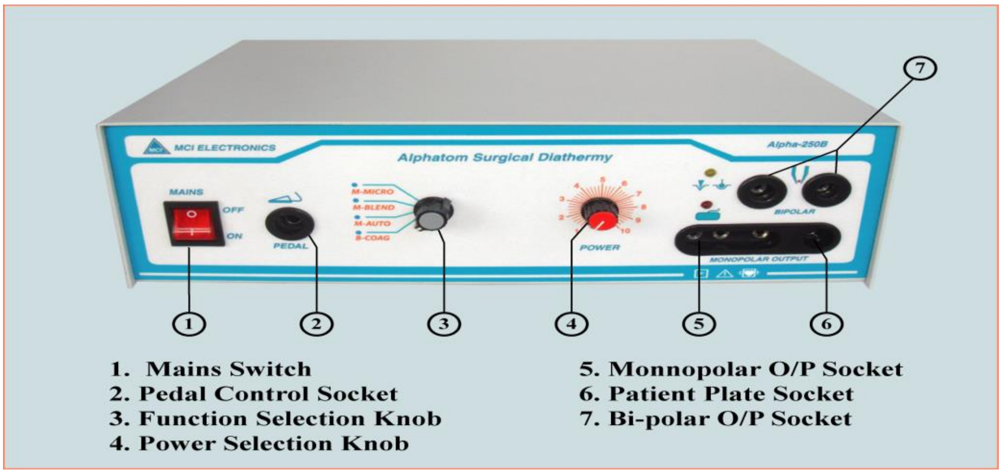


Fig 4.1 - Front side of ESD

4.2 NAME AND FUNCTION OF THE OPERATIONAL PANEL

1. **Maine Switch:** This switch is controls mains power of machine
2. **Pedal Control:** Control the Output power ON/OFF
3. **Function Selection Knob:** This knob is selection deferent type of monopolar mode and Bi-polar mode.
4. **Power Selection knob:** Chang the output power.
5. **Patent plate:** Patent plate or Neutral electrode needs to be applied for using monopolar modes. The unit is equipped with return electrode safety system (RESSY) which monitors electrical connectivity between Neutral electrode and equipment. If there is any loss of continuity an LED illuminated an acoustic alarm sounds, which informs user of the above condition and on output power is delivered.

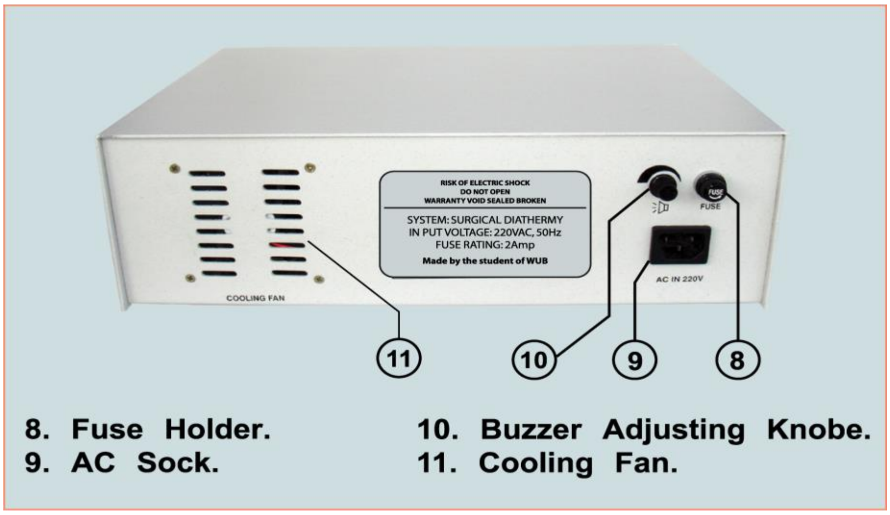


Fig 4.2 - Back side of ESD

6. **Monopolar Output Socket:** This output socket is only use to connected the three pin hand piece.
7. **Bi-polar Output Socket:** This output socket is only use to connected the bipolar forceps.
8. **Fuse Holder:** This unit is protected with 2 main fuses. One place machine back side (1.5 Amps) other place is main PCB 4 Amps.
9. **AC Socket:** 230VAC, ±10% 50Hz power to be fed to this socket.
10. **Buzhear Adjusting knob or Volume control:** A Volume control knob is provided to control the Buzhear volume.
11. **Cooling Fan:** cooling output circuit.

4.3 HOW CAN OPERATED THE EQUIPMENT

<u>Mode-1</u>

<u>M-Auto (Monopolar Cut & Monopolar Coag), Monopolar Bland, Monopolar Micro mode.</u>

1. Set the Power switch off, Intensity control knob set low and connects to the power cote after observing the regular voltage and proper earthing.
2. Contact the Neutral electrode (Patient plate) plug to the patient plate socket.
3. Contact the three pin hand piece plug to the three pin hand piece output socket.
4. Contact the pedal control switch connecting plug to the pedal control socket.
5. Set the function selection knob a desired mode
6. Set the output intensity in the low in a counter clockwise.
7. Then the power switch ON, press the pedal and turn the set output intensity regulator in a clock handed and chose the desired output power /intensity.

Not: Double Foot-Switch and Three pin hand piece only working in

M-Auto (Monopolar Cut & Monopolar Coag), mode

Mode-2

Bi-polar coagulation mode.

1. Set the Power switch off, Intensity control knob set low and connects to the power cote after observing the regular voltage and proper earthing.
2. Contact the Bi-polar forceps plug to the Bi-polar forceps socket.
3. Contact the pedal control switch connecting plug to the pedal control socket.
4. Set the function selection knob Bi-polar Coagulation mode.
5. Set the output intensity in the low in a counter clockwise.
6. Then the power switch ON, press the pedal and turn the set output intensity regulator in a clock handed and chose the desired output power /intensity.

4.4 MAINTENANCE AND CARE

a) Preventing damage to the unit

Apart from proper operation and maintenance, effective protection of the unit against damage is achieved by secure positioning of the unit. This involves not only securely mounting the HF unit, but also protecting it against damp, contamination and contact with flammable and explosive substances. In order to ensure good dissipation of the heat generated, allow ample room around the unit.

b) Preventing damage to the accessories

In order to protect accessories from wear and tear, the following instructions should be followed.

- The electrodes must be handled properly so that the tips and the cables are not damaged.
- The legs of the bipolar forceps must not be forced apart, since this can chip the insulating layer.
- Do not wrap the cable of the electrode handles around the handles, since this will deform the cable.
- Patient plates of metal must not be bent excessively or kinked.

- Do not carry the footswitch by the cable. Do not wind the cable tightly around the footswitch.
- Do not coil the cable too tightly.
- Unplug the plugs unit sockets and accessories by gradually pulling on the plug shaft and not by vigorously tugging on the cable.

c) Cleaning, disinfecting and sterilizing of the unit and accessories.

Cleaning and disinfecting of the unit:

These operations should be done only with non-flammable and non-explosive agents. Make sure that no moisture or detergent enters the unit.

Attention: Alcohol must never be used to clean and disinfect the front panel.

Cleaning, disinfecting and sterilization of the accessories

1. Monopolar and bipolar electrodes Cleaning

Tissue residue can be removed from the active electrode with a sterile, moist cloth, steel, or copper wool. No pointed objects should be used to clean, since they will damage the electrode surface. Such damage can increase adhesion of tissue to the electrode.

Disinfecting

Always clean and disinfect the electrodes in a disinfecting solution prior to sterilizing them.

Sterilization

(Follow the manufacturer's instructions)

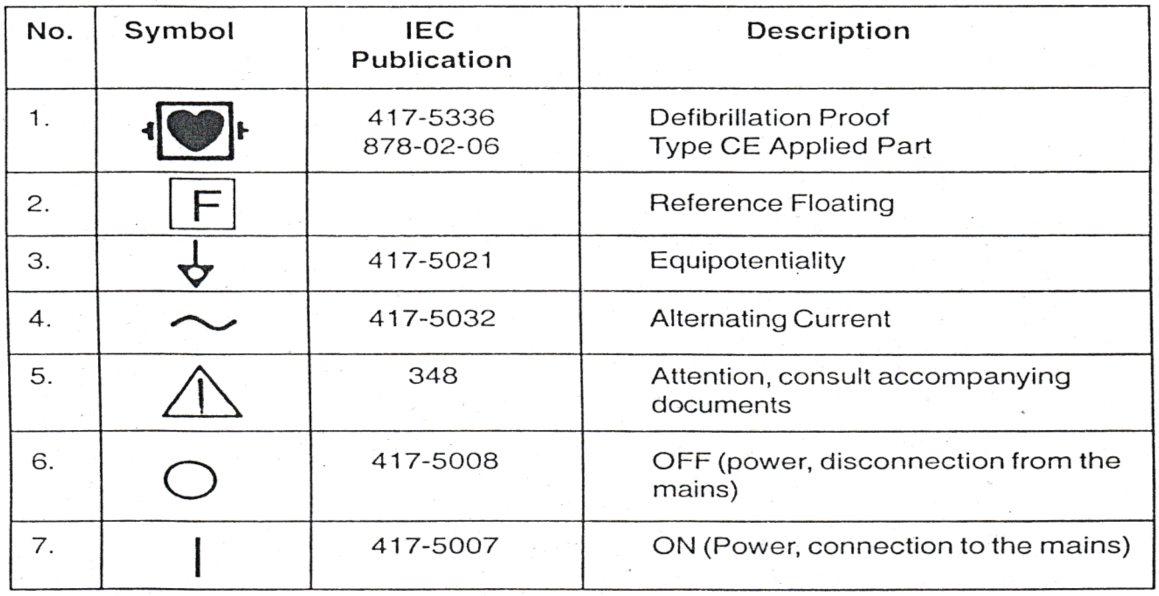
2. Electrode handles with cables and plugs

These accessories also must be cleaned and disinfected as per the manufacturer's instructions. Always make sure that disinfectant or whatever liquids used must be thoroughly rinsed off the accessories.

3. Patient plates with cables, plugs and rubber straps. Patient plates with cables, plugs and rubber straps should be cleaned disinfected, before and after use.

Foot switches and footswitch boards.

Non explosion protected footswitches must not be cleaned with flammable or explosive agents because of the existing fire and explosion hazards.



No.	Symbol	IEC Publication	Description
1.		417-5336 878-02-06	Defibrillation Proof Type CE Applied Part
2.	F		Reference Floating
3.		417-5021	Equipotentiality
4.	~	417-5032	Alternating Current
5.		348	Attention, consult accompanying documents
6.		417-5008	OFF (power, disconnection from the mains)
7.	|	417-5007	ON (Power, connection to the mains)

4.5 APPROVED ACCESSORIES LIST

List of accessories approved by L&T are as follows:

Sr. No.	Accessory	L&T Cat No.	Make	Cat. No.
1.	3 pin Electrode Handle-Disposable	3-10-390-0078-36	ERBE Prima	20190-80 PMS250 (Single Use Fl)
2.	Two pedal foot switch (EP)	3-10-390-0006-58	L&T	
3.	Patient Plate Silicon Rubber 17.5x29. 5 cm	3-10-190-0034-39	ERBE	20193-008
4.	Bipolar Forceps - Bayonet 19.5cm, 1 mm tip, pointed	3-10-190-0070-28	ERBE	20195-008
5.	Bipolar Forceps - Straight 19.5cm, Blunt tip, 1 mm	3-10-190-0037-30	ERBE	20195-000

Caution: Use of unapproved accessories may result in the malfunction of the equipment.

Attention: Disposable handles are meant for single use o

CHAPTER-5

5.1 DISCUSSION

Electro surgical diathermy machine (ESD) produces high frequency alternating current (0.3MHz to 3 MHz) which passes through the body of patient to achieve a desired surgical effect. It cuts and stops bleeding during all operation by passing electron through the body. The only limitation is that, it generates heat in the tissue. This ESD ensures the quality and provides all facilities for all surgical procedures.

Currently ESDs are not being used in all hospitals or clinics in Bangladesh because of its high price. ESD imported from technologically developed country are costly due to high technology's establishment cost, freight and custom duty. Even in many operation theatres surgical knife are used instead of ESDs. Sometimes it leads patient to critical condition causing loose of blood by additional bleeding. ESD helps to avoid this situation by removing loss of extra blood.

ESD is essential for some particular operations such as Laparoscopy, Urological, Neuro, ENT and spine surgery. It is also commonly used in Dermatological, Cardiac, Ocular Maxillofacial, Orthopedic, Ophthalmic and Burn etc.

The design of ESD machine is based on micro-controller and it's output power is 300 watts. There are two types of ESD machine; namely; monopolar and bipolar machine. Generally monopolar machine performs in four modes. They are: monopolar cut ,monopolar blend, monopolar soft coagulation, monopolar force coagulation etc. Bipolar machine has two modes. They are: bipolar cut, bipolar coagulation. The output power of this machine can be controlled by hand or foot of operation as an additional feature. Mode of the ESD can be changed during surgery depending on the requirement.

Designed ESD machine is cheaper as compared to the imported ESD produced by overseas manufacturers. The cost of the components in Bangladeshi Tk. is 25,000 and assembling cost is Tk. 15,000.So, if we add a profit of Tk. 10,000 the market price of this designed ESD machine will be Tk. 50,000. The price of ESDs developed overseas technologically manufactures are much higher than ours. Local customers can get ESD with same quality by fewer prices. Price of ESDs manufactured by overseas companies are as follows: Germany ESD machine's price is from Tk. 2, 50,000 to 3, 00,000. Italian ESD machine's price is from Tk. 1, 50,000 to 2, 50,000. Korean ESD machine's price is from Tk. 1, 50,000 to 2, 00,000. China ESD machine's price is from Tk. 1, 00,000 to 15, 0,000. Indian ESD machine's price is from Tk. 8, 00,000 to 1, 00,000. So, the design of our ESD is efficient and cost effective in comparison with the ESD of developed countries.

Most of the hospitals and clinics are using Indian and Chinese electro surgical diathermy which involves a lot of foreign currency. Many of these ESD do not ensure appropriate safety requirements. Our ESD ensures all the safety requirements. By producing electro surgical diathermy we can save foreign exchange, extend job market through skilled manpower.

Basic components of ESD are given as micro-controller, integrating circuits (ICs), opt-coupler, resistors, capacitors, diodes, voltage regulator, MOSFET, bridge rectifier, relay, transistor, transformer, potentiometer, receptacle, heat sink etc.

To ensure appropriate safety requirements ESD has been designed according to the British standard 5724 safety of medical equipment which was revised in 1989 by IEC 601.

Isolated or floating circuits provide a circuit whereby a connection between the electrical source and earth does not allow current to flow. This floating circuit can be used to isolate an entire operating theatre. Current operated earth leakage circuit breakers consist of a live and neutral wire. A third winding connects these to the coil of a relay that operates the circuit breaker. Due to excessive current leakage there is a resultant magnetic field. This induces a current in the third winding causing the relay to break the circuit to reduce the possibility of a serious electrical shock. So, ESD has been designed to limit potential hazard.

5.2 CONCLUSIONS

The designed ESD machine have ensured the safety of patients using output transformer and designed of a low cost with high quality performance ESD machine. By producing electro surgical diathermy (ESD) machine commercially we can save foreign currency.

5.3 RECOMMENDATIONS

As a developing country Bangladesh should try to manufacture or assemble this Electro surgical diathermy machine. Government should take proper steps to introduce ESD machine in all the hospitals and clinics for mass use.

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