PPU College of Engineering and Technology

The Home of Competent Engineers and Researchers

Electrical and Computer Engineering Department

Biomedical Engineering Program

Bachelor Thesis

Graduation Project

Biomedical Solar Autoclave

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OUTLINE

Abstract:

To protect the environment from pollution the solar energy will be used as alternative source of energy. Solar energy is considered clean, economic and sustainable source of energy. In this project it will be hired in building biomedical autoclave by using photo-voltaic cell to accomplish sterilization process under 2 bar steam pressure at temperature of 120 °C within 15 minutes. The output of the PV-cell is a constant current, this current will be used to charge a two series 12Vdc batteries. Charger-controller is utilized to control the charging and discharging cycles of the series batteries. Autoclave is important device used to sterilize medical tools to prevent infection.

ملخص المشروع:

للحفاظ على البيئة من التلوث ،سيتم استخدام الطاقة الشمسية كمصدر بديل للطاقة،حيث تعتبر الطاقة الشمسية طاقة نظيفة ،اقتصادية وستدامة،لذلك في مشروعنا هذا سوف يتم بناء جهاز تعقيم يعمل باستخدام الواح الطاقة الشمسية لتحقيق عملية تعقيم تحت ضغط 2 بار ودرجة حرارة 120 سيلسيوس خلال فترة زمنية ربع ساعة وذلك بهدف تعقيم الادوات الطبية وقتل الجراثيم.

ان الالواح الشمسية سوف تزودنا بتيار ثابت سيتم استخدامه لشحن بطاريتين على التوالي كل منهما 12 فولت ،بالإضافة الى ذلك سيتم استخدام منظم للشحن من اجل تنظيم عملية الشحن والتفريغ في البطاريات.

1

Introduction

Chapter one

Introduction

1.1. Over view:

Sterilization is a recommended method for processing instruments and other items that will come in contact with the blood stream or tissues under skin. Instruments and other item can be sterilized by steam under pressure (Autoclaving or moist heat).

Sterilization - eliminates all microorganisms (Bacteria, Viruses, Fungi and Parasites). Including bacterial End spores .One method of sterilization is autoclave which a device that maintains saturated steam for period of time at high temp & under pressure.

The proposed technique is to design an autoclave working on solar system instead of electricity. Our aim is to utilize solar energy for solar thermal conversion. The produced heat can be used for different purposes such as operating medical devices and devices in many fields instead of operating them using electricity .

A solar autoclave is an autoclave working on solar system that uses sun's radiations to operate the device , by using photo-voltaic cell which used to convert solar energy to electrical energy (dc). Several control parameters are needed for designing the biomedical solar autoclave: pressure control circuit, temperature controller. For Pressure circuit the pressure will not exceed 2 bar .

1.2. Literature view:

1- USE OF THE SOLAR PANEL COOKER FORMEDICAL PRESSURE STEAM STERILIZATION.

Ms. Barbara Prosser Kerr& Mr. James Scott ,Kerr-Cole Sustainable Living Center, USA.

This paper describes the adaptation of a large, simple, low cost panel cooker to greatly reduce the reliance on conventional heat sources. The hybrid apparatus integrates propane for backup in case the available sunlight is insufficient. In good sunlight, sterilization runs can be completed on solar power alone. The efficient design also reduces fuel use even when no sunlight is available. The concept and operating guidelines for practical clinical use draw on the principal author's experience as a surgical nurse. Described are the principles of operation, design, construction and experimental results for a prototype unit – including verification of sterilization. The apparatus is also highly effective for general cooking, pressure-cooking and pressure food preservation ("canning"). The wind and rainproof design allows efficient and reliable operation under all weather conditions.

2-PORTABLE SOLAR-POWERED AUTOCLAVE

Adapted from the entry by: Rhys Hardwick Jones, Iain Brown, Joshua Przybylko, Sandra Fisher, James Tracey, and Nicholas Russell – Sydney University, Australia.

This design depend on designing prototypes and it's concept is a completely solar-powered autoclave-style sterilizer, which provides cheap, non-burn, portable sterilization to rural areas, and operates in both sunny and cloudy conditions. Prototypes using this design have been successfully built and tested by research teams at Sydney University. One prototype is much larger, with a capacity of 14 liters per batch. The other version is more portable, and has a capacity of just 1.5 liters per batch. Both prototypes utilize the same technology .

3-Solar Cooker for Evening / Night Cooking Using Solar Heat Storage Materials

Someshwer Dutt Sharma,CSEM – UAE Innovation Center, Energy & Water Sector, Ras AlKhaimah, UAE.

In this paper, Use of Phase Change Materials (PCMs) for evening / night cooking is discussed. The use of a solar cooker is limited because cooking of food is not possible due to frequent clouds in the day or in the evening. If storage of solar provided in a solar cooker, then there is a possibility of cooking food energy can be during clouds or in the evening, and the storage will increase the utility and reliability of the solar cookers. Hence, PCM is the best option to store the solar energy during sun utilized for cooking in late evening/night time Phase Change shine hours and is Materials (PCM) are latent heat storage materials. As the source temperature rises, the chemical bonds within the PCM break up as the material changes phase from solid to solid-liquid PCMs, which are of particular interest here). The liquid (as is the case for phase change is a heat-seeking (endothermic) process and therefore, the PCM absorbs heat. Upon storing heat in the storage material, the material begins to melt when the is reached. The temperature then stays constant until the phase change temperature melting process is finished. The heat stored during the phase change process (melting process) of the material is called latent heat. Latent heat storage has two main large amounts of heat with only small temperature advantages: (i) it is possible to store changes and therefore to have a high storage density; (ii) because the change of phase at a constant temperature takes some time to complete, it becomes possible to smooth comparison between latent and sensible heat storage shows temperature variations. The that using latent heat storage, storage densities typically 5 to 10 times higher can be reached.

1.3.Project Objectives:

1.Use alternative energy source which is solar energy in operating biomedical autoclave

2. To reduce pollution and reduce electricity consumption.

3.Apply this design in medical field by designing biomedical autoclave.

4.Achieve sterilized medical tools and equipments.

1.4.Project importance:

This project is providing a new field of employment of solar energy in medical application. Solar energy source is considered an economical and sustainable source. The proposed design is more important for use and ambulatory dental clinic or ambulances or when electricity is interrupted. The sterilization is a vital factor in health care sectors and institutions (laboratories, operating rooms and others hospital departments) as the humans health is the primary goal.

1.5.Report content:

Our project is divided into four chapters; these chapters could be described as follow:

Chapter 1: Introduction

This chapter presents overview, project objectives, project scheduling, estimated cost, and report contents.

Chapter 2: Solar Energy

This chapter discuss types of energy sources and storage of energy ,and solar energy and it's applications .

Chapter 3: Sterilization

This chapter discusses the sterilization and sterilization techniques , types of sterilization, autoclave in details.

Chapter 4: Project Design

This chapter talks about the block diagram , calculations, circuit, stimulation of the circuit

Chapter 5: Testing Implementation and testing

This chapter discuss the system implementation and the results of testing.

Chapter 6: Conclusion and recommendations

This chapter talks about conclusion of the system and recommendations .

1.6.estimated cost :

Component	Cost	Notes
Stainless steel box	400 NIS	
Water tank	50 NIS	
Temperature Sensor & Temperature controller	330NIS	
Pressure guage	30 NIS	
Heater	450NIS	
chamber & refinery	550NIS	
Valves (3)	350NIS	
Timer (2)	150 NIS	
Switch ON/OFF (2)	70 NIS	
Micros witch	25NIS	
buzzer	35 NIS	
Battery (2)	300 NIS	
Charger Controller	700 NIS	
Printing and internet	300NIS	
Transportation	300NIS	
Photovoltaic cell costs	3500	Available in the university
Working of team	0	
Turning cost	320NIS	
Total:	7860NIS	

1.7.scheduling table :

Week / Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Gives Idea	■	■	■	■											
Collection Data	■	■	■	■	■	■	■	■	■						
Make Design							■	■	■	■					
Analysis Design										■	■	■	■		
Writing the documentation					■	■	■	■	■	■	■	■	■	■	
Printing Hard copy															■

Week / Task	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Preparing the project parts	■	■													
Hardware implementation			■	■	■	■	■	■	■						
Analysis Design								■	■	■	■	■			
Testing design												■	■		
Writing the documentation							■	■	■	■	■	■	■	■	
Printing Hard copy															■

2

Solar energy

2.1-Convevtional energy sources:

2.1.1-Fossil fuel.

2.2-Renewable energy source.

2.2.1-Hydropower energy.

2.2.2-Wind energy.

2.3.3-Tidal energy.

2.2.4-Solar energy.

2.3-Energy storage.

2.3.1-Storing of mechanical energy.

2.3.2-Storing of hydropower energy.

2.3.3-Storing chemical energy.

2.3.4-Storing thermal energy.

2.4-Solar energy.

2.5-Solar power.

2.6-Solar heating system.

2.7-Solar water heaters.

2.8-Direct conversion of solar energy (Photovoltaic Cell).

2.9-Some application of solar energy.

2.10-Traditional application.

2.11-Solar cooker.

2.12-Description of solar thermal system.

Chapter Two
Solar Energy

Introduction

First human discovers many resources of energy such as fire by friction of stones for cooking, heating and lighting . Then he discovers coal as potential source of heat energy . Also he utilize wind power to drive ships. With the development of human beings petrol was discovered and scientists discover the power of nuclear materials resulted from fusion of atoms and they benefit from conversion of this power to produce useful energy, such as electricity.

With the passage of time this sources of energy starts to pollute environment ; air ,water and soil .As a result scientists start to this about alternative energy sources reduce harm done to the biosphere. some of these sources are renewable ,such as solar energy, wind energy,hydrological power .

In Palestine, for example , solar energy has been used in providing domestic heating means to heat water.It is estimated that more than 75% of households are equipped with solar hot water heating systems .

Because the weather in Palestine is so encouraging for using solar energy as alternative source of energy because it is sunny in most days of the year even in winter there is days the sun rise .

There is five months of the year in Palestine has a strong sun from May to August and the rest of the months there is poor sun .

There are two types of energy sources : conventional energy sources and renewable energy sources

2.1. Conventional energy sources :

2..1.1.fossil fuel :

fossil fuel was formed millions of years ago from organic substances buried under ground subjected to high temperature and pressure,Fossil fuel consist of the following sources:

a-Petroleum and natural resource:

The first petrol well discovered in 1859 in USA.In1860 one million barrel of petrol, were extracted in the USA.After only ten years,more than 4.2 million barrels were extracted.

b-Coal Resources:

As another fossil sources coalmines can be estimated with moderate accuracy because they are found in Earth's layers,that are easily mapped.Before discovering coal Wood was the first sources of energy used to produce heat.The discovering of petroleum.

c-Natural Gas:

At first natural gas was burnt to reduce pressure exerted at top of the well were petroleum stored.Storing natural gas is one of the most important disadvantages to utilizing this source of energy.Another disadvantage is the liquefying processes which still not feasible .Today gas is (Kerosene, Benzene, ... etc).

Natural gas processed was used in producing the following commercial gas products:

Propane .

Ethylene.

Ethane.

Methane

2.2. Renewable energy sources:

These are sources that are not going to dwell in the foreseen future such as Hydrology power,wind energy and solar energy.
The major types of renewable energies are:

2.2.1. Hydropower energy:

The impact of mass of water,driven by the level deference(Head),on a vane of a rotor will produce mechanical torque.The mechanical energy produced can be converted to another types of energies, e.g. electrical energy.The energy produced depends on the available head and the fluid kinetic energy generated.Tow types of hydraulic machines(turbines) can be utilized in hydropower energy,the reaction type turbines such as Francis and the impulsive A. Hydropower need large amount of water sources which not found in Palestine or it is out of reach .

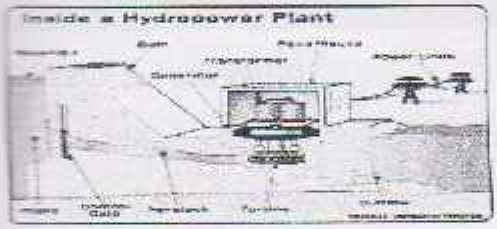


Fig2.1: Hydropower energy[11]

2.2.2. Wind energy:

Wind has been used for centuries to provide power for various tasks,such as pumping water and milling grain.The principle used to convert wind energy into other type of energy is the use of impulsive action.

Different type of wind turbines are available: two blades type,darius type and other commercial type.The operation principles are the same. This type of energy has disadvantages,it is noisy because of the sound of motors used,needs large area,costly and it is not safe for using large and heavy equipments .

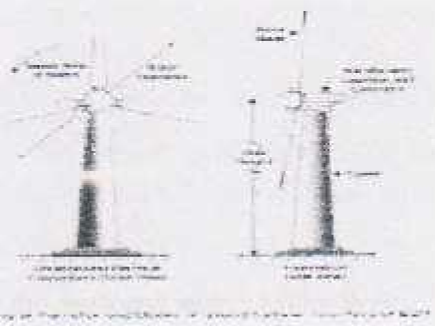


Fig2.2: Wind energy[12]

2.2.3. Tidal energy:

The gravitational forces exerted on the earth by the sun and moon cause a displacement of the ocean water of the earth,as the earth rotates,the surface of the ocean water alternately rises and falls at a particular location, during the rise of the water, the tide is designated as the flood tide, and during the flood of the water

The variation in the water level between high and low tide will depend upon the relative positions of the sun and the moon, when the moon is new or full, the tidal range is unusually high. and when the moon is at the first or third quarter, the tidal range is unusually low.

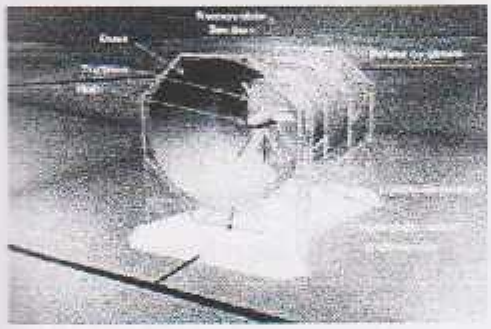


Fig2.3: Tidal energy[13]

2.2.4.Solar energy:

The sun is the source of all forcing and energies over the earth and within Milky Way. Solar radiation consist of photons of heat energy. When fall over surface radiation energy is transferred into heat energy. Heat energy can be converted into many other types of energy. There are several applications that can be used with local technology to utilize solar radiation such as: heating of water for domestic, commercial and industrial usage, space heating ,solar ponds, warming up water in swimming pools, water desalination and many other application.

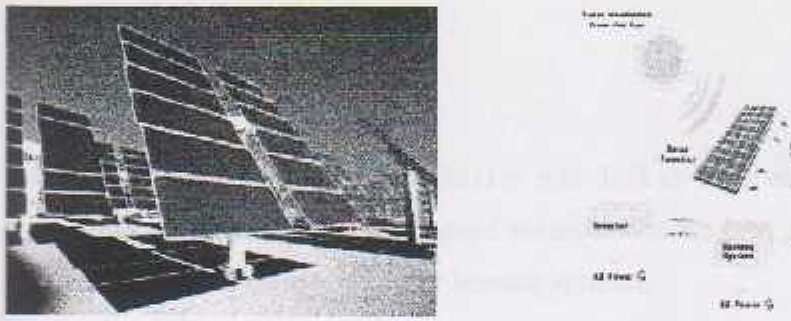


Fig2.4: Solar energy[14]

2.3.Energy Storage

There are several types technology used to store energy.

2.3.1.Storing of Mechanical Energy

Flywheel is the device used to store mechanical energy. Rotational motion or mechanical energy can be stored in weighing disc. This method is used in internal combustion engines to store energy produced from expansion stroke.

2.3.2.Storing of Hydropower Energy

Pumped hydro storage is an important possibility for solar electrical power system located in terrain suitable for storing large amounts of water at elevations differing by at least 30.5 m.

2.3.3.Storing Chemical Energy

Fuel tank (storage) in vehicles is considered a good example for chemical energy storage. Another example is the chemical energy stored in batteries where two poles are presented: cathode(negative pole), and anode (positive pole).

2.3.4.Storing Thermal Energy

The thermal storing medium can be fluid or non-fluid as in the case of thermal baked brick. The passive solar energy application are good examples for this type of storage. An example of these application is the domestic hot water heating systems.

2.4.Solar Energy

In the last three decades large number of programs and projects have been initiated for examining the feasibility of solar energy for heating,air conditioning, and production of electric power.

The availability of solar radiation depends mainly on the geographical location (longitude-latitudes) of the site, the season and time of the day within sunrise-sunset span and also the condition of the sky.

Every second, the sun generates immense amounts of energy called solar radiation. The energy is radiated in to space as sunlight (47%), ultraviolet ray's (7%) and infrared radiation or heat(46%). Only small portion of emitted radiation intercepts the earth. Although this portion is very small compared to the emitted energy, but it is enormous in terms of holding the atmospheric physical layer,i.e. the biosphere, in its shape as safe heaven for the living creatures.

There are still a few major constraints that limit the use of renewable source of clean energy. First: the availability of solar energy that should be considered in building any utilizable system. And second: the storing of solar energy either as heat (thermal storage) or other types of energy (e.g. electrical).

2.5.Solar Power

There are several advantages that make the use of solar power (energy) feasible.
The two major advantages are:

a-Economics

The price of a solar heating system can range from a few hundred dollars for a simple home-built system for heating water at a summer cottage to several thousand dollars for a commercial package designed to heat half the hot water used by a family. In some cases the cost of the equipment is far greater than the cost of the energy saved. Experience has shown that, in Manitoba, solar energy is not cost –effective for hot water or space heating system where low- cost electricity or natural gas is available. Using solar energy for heating a swimming pool or heating water at remote cottage, without electricity , can be considered when the other possibility, such as

b-Environmental Considerations

Solar heating systems are clean, non-polluting and can help reduce dependence on non-renewable energy resources. Care must be taken to ensure that the heat transfer liquid is non-toxic and thy systems conform to all local and provincial building codes.

2.6.Solar Heating System

Solar heating systems can be divided into two groupies these are:

1-Passive Solar Heating

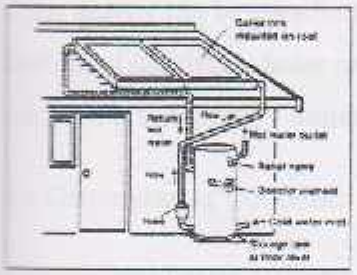
Passive solar heating systems collect and store solar energy primarily by using natural heat flow processes. These systems are relatively maintenance-free because they do not use any controls, pumps, fans, sensors or other mechanical parts. Because of their simplicity, passive,systems tend to be very reliable and can also cost very little to install

2-Active Solar Heating Systems

A solar heating system that moves heated air with a fan or a heated liquid using a pump is known as an active solar heating system.
One form of active solar heating system uses a fan to move air from the collectors (where it is heated by the sun) to a storage unit (usually an enclosed bin full of rocks) until it is needed . Because active systems use a number of high performance components such as pumps, fane, thermostats, automatic valves and other devices, they tend to require more maintenance and be more expensive to install than passive systems.

2.7.Solar Water Heaters:

These system utilize solar energy by absorbing the available solar radiation and use it heat up a working fluid.The system consists mainly from a collecting surface which collects solar rays and pass it to an absorber. The larger collector area,the energy collected is large.It is also obvious large heat absorption are means large heat gained.
Solar heating system have been used in many countries for provide in hot water for domestic and commercial needs. Solar water heater avoid the harmful greenhouse gas emissions associated of electricity production.



2.8.Direct Conversion Of Solar Energy (photovoltaic cell):

Photovoltaic cell or solar cell is the direct transform of sunlight to electricity. Silicon is a semiconductor that is neither a good nor a bad conductor of electricity.

A pure crystal of silicon can be doped with a few atoms of another substance to make either p-type or n-type silicon.P-type is a doped with acceptor atoms and n-type is a doped with donor atoms

Each donor atom has an extra electron to donate that becomes free to move around in the crystal,each acceptor atom has an empty space that would accept an electron if one where available, this space is called hole, like electrons, are free to move around in crystal of silicon, a hole moves as an acceptor atom grabs an electron from neighboring silicon atom.

Now it is the silicon atom that has the hole and it can pass the hole a long by garbing and electron from another silicon atom, silicon can have four kinds of charged particles in it.

Where the p-region meat the n-region we have p-n-junction .In the area around the p-n-junction there is a strong, permanent electric field that is vital to the operation, because of the natural electric field near the p-n-junction, the electron and the hole are forced a part, and an electron potential is created.

2.9.Some Application Of Solar Energy:

Solar energy can be transformed into useful forms of energy .Solar energy can be applied in space heating of buildings. Solar space heating will reduce the world's dependence on supplies of oil and coal that are inherently limited.

1)- Concentrating Collector:

Concentrating solar collector are light to heat energy transformers.The best ways to generate high temperatures from sunlight is to concentrate the light; that is to use a lens or mirror to focus a large area of sunlight into a small receiving surface. The ratio of concentration is measured of how large area of collected sunlight is in relation to area of small receiver.We have some basic types of concentrating collectors. The circular concentrator is used to generate extremely high temperature. A parabolic curve gives the most precise focus, but many other shapes can be used.

2)-Solar Trough Systems:

These system provide large scale power generation from the sun. trough systems predominate among today's commercial solar power plants. These plants have a combined capacity of 345 megawatts (MW) and today generate enough electricity to meet the needs of approximately 500,000 people. Trough system is converted the heat from the sun into electricity.Because of parabolic shape ,trough can focus the sun at 30 to 60 times its normal intensity on a receiver pipe located a long the focal line of the trough.

2.10.Traditional Applications:

For year solar energy has been used to heat water and to cook and dry food. perhaps the most widely used alternative application of solar technology is domestic water heating, which is seminar to space heating in concept and has become at least as popular.

1)- Solar water heating:

Solar water heating system usually resemble small liquid type space heating systems in both appearance and performance. In passive,thermosiphone types natural convection provides circulation, and in active type a pump circulate the water. Both passive and active heating systems must provide some hot water storage.

A)-Thermosiphone water heaters:

The most common type of solar water heater is Thermosiphone water heater.The water in the collector heats it becomes less dense and rises.Cold water from the bottom of the storage unit enters the bottom of the collector and heated water from the top returns to the storage tank. If it is impossible to place the storage tank above the top of the collector, a check valve may be installed to prevent reverse thermo siphoning.

B)-Active Water Heater:

The active hot water circulates water through the collector and has two storage tanks connected in series. The first larger tank preheats the water,the hot test of which enters the second tank,which is a conventional water heater. if the solar heated water is not enough to use, the backup water heater to the proper temperature heats it

2)- Swimming Pool heating:

Swimming pool is reducing the heat road.For swimming pool the heat load depends on the heat loss of the pool. Conduction to ground, radiation to the sky, convection and evaporation of the water lose heat.

2.11.Solar Cooker

The closest model to the solar autoclave is the solar cooker.two basic methods for cooking with solar energy corresponds to cooking with a conventional stove and oven. The solar often is an insulated box with a window top and side reflectors. Their position has to be readjusted every 15-20 min. to follow the sun. Most solar ovens are basically well insulated boxes with glass or plastic-top that admits solar radiation.

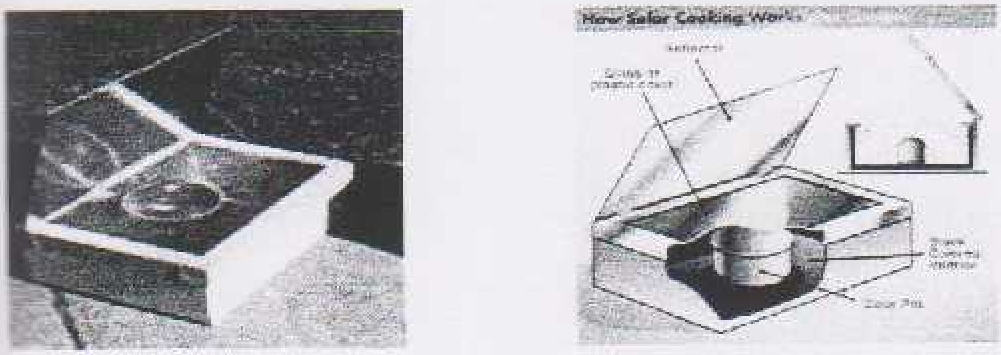


Fig2.6: Solar cooker[16]

In this project solar energy will be utilized for providing an biomedical autoclave using solar energy for supplying the heater to heat water for sterilization process instead of using conventional source (electricity) for supplying the heater.

2.12.Description Of Solar Thermal System

The solar heating system consists of collectors ,storage unit ,circulation system and control mechanism.The most important one is the collector,it is used to absorb the maximum incoming solar energy and transfer it into to heat transfer medium with least loss due to reflection, conduction, and re-radiation.

The solar collector is the heart of most solar energy systems. It absorbs the sun's light energy and converts it to many forms like electricity ,heat and thermal energy. Other solar collectors generate electrical energy for buildings through the use of photovoltaic(PV)systems.

All types of solar heating systems have a circulation system to keep the heat-transfer medium continually moving from collector to storage unit. This flow is done by natural convection, or a fan or pump is needed to force the heat –transfer medium on its way.The fan or the pump is turned on or off by a control unit with a temperature sensor to maintain the needed temperature in the system.

3

Sterilization

Chapter three
Sterilization

3.1 Sterilization

3.1.1 Sterilization Definition

Eliminates all microorganisms (Bacteria, Viruses, Fungi and Parasites)by physical (ex:heat) or chemical (ex: paracetic acid) means. It is the recommended method for processing instruments and other items that will come in contact with the blood stream or tissues under skin.

3.1.2 Types of Sterilization

3.1.2.a Dry heat sterilization (electric oven)

The method of sterilization that requires heat for specific period of time. For dry heat to be achieved a constant supply of electricity is necessary. Only glass or metal objects can be sterilized by this method, because high temperature is necessary.

30 – 300 C Use for drying and sterilizing

Table 3.1:stander time with temperature.

Temp.	Time
170°C (340 °F)	1 Hour
160°C (320 °F)	2 Hours
150°C (300 °F)	2½ Hours
140°C (285 °F)	3 Hours

Advantages

- Better for some products (Powder).
- Does not erode glass
- Minimal rusting effect.
- Reaches some parts of instruments by conduction.

Disadvantage

- Long exposure times.
- Heat penetrates slowly and unevenly.
- Damages some rubber goods and burns fabric or, paper packages.

3.1.2.b Steam sterilize (Autoclave)

The method of sterilization that requires moist heat under pressure. For steam to be produced there must be sources of both water and heat. A heat source in necessary to maintain the required temperature and pressure.
Heat can be provided by electricity or any other fuel source.
* The temperatures required for steam sterilization is lower than those for heat sterilization are because moist heat under pressure allows for more efficient destruction of microorganisms.

Advantages

- Very effective. because saturated steam carries seven times as much available heat as air at the same temperature.
- Least expensive method of sterilization.
- Relatively low temperature requirements (compared to dry heat sterilization).
- Speed, process simplicity.
- Lack of toxic residues when compared to methods such as ethylene oxide sterilization.
- Since moist heat sterilization is performed in a pressurized environment, it can also be used to sterilize liquids.

Disadvantages

- The disadvantage of moist heat sterilization comes from the presence of water and the use of elevated temperatures.
- Unsuitable for plastics with low melting points, powders, labile(unstable) materials, anhydrous oils (oils free of water) or synthetic and natural polymers that are readily degraded by hydrolysis.

3.1.2.c Radiation Sterilization

Many types of radiation are used for sterilization like electromagnetic radiation (e.g. gamma rays and UV light), particulate radiation (e.g. accelerated electrons).
The major target for these radiation is microbial DNA. Gamma rays and electrons cause ionization and free radical production while UV light causes excitation.
Radiation sterilization with high energy gamma rays or accelerated electrons has proven to be a useful method for the industrial sterilization of heat sensitive products.
But some undesirable changes occur in irradiated products, an example is aqueous solution where radiolysis of water occurs.
Radiation sterilization is generally applied to articles in the dry state; including surgical instruments, sutures, prostheses, unit dose ointments, plastic syringes and dry pharmaceutical products. UV light, with its much lower energy, and poor penetrability finds uses in the sterilization of air, for surface sterilization of aseptic work areas, for treatment of manufacturing grade water, but is not suitable for sterilization of pharmaceutical dosage forms.
a. Gamma ray Sterilizer: Gamma rays for sterilization are usually derived from cobalt-60 source, the isotope is held as pellets packed in metal rods, each rod carefully arranged within the source and containing 20 KCi of activity. This source is housed within a reinforced concrete building with 2 m thick walls. Articles being

sterilized are passed through the irradiation chamber on a conveyor belt and move around the raised source.

b. Ultraviolet Irradiation: The optimum wavelength for UV sterilization is 260 nm. A mercury lamp giving peak emission at 254 nm is the suitable source of UV light in this region.

Advantages

- useful method for the industrial sterilization of heat sensitive product

Disadvantages

- Undesirable changes occur in irradiated products ,an example is aqueous solution where radiolysis of water occurs

3.1.2.d Liquid Chemicals

Several FDA-cleared liquid chemical sterilant include indications for sterilization of medical devices (Tables 4 and 5)[69]. The indicated contact times range from 3 hours to 12 hours. However, except for a few of the products, the contact time is based only on the conditions to pass the AOAC Sporicidal Test as a sterilant and not on simulated use testing with devices. These solutions are commonly used as high-level disinfectants when a shorter processing time is required. Generally, chemical liquid sterilant cannot be monitored using a biological indicator to verify sterility[899, 900].

The survival kinetics for thermal sterilization methods, such as steam and dry heat, have been studied and characterized extensively, whereas the kinetics for sterilization with liquid sterilant are less well understood[921]. The information that is available in the literature suggests that sterilization processes based on liquid chemical sterilant, in general, may not convey the same sterility assurance level as sterilization achieved using thermal or physical methods[823]. The data indicate that the survival curves for liquid chemical sterilant may not exhibit log-linear kinetics and the shape of the survivor curve may vary depending of the formulation, chemical nature and stability of the liquid chemical sterilant. In addition, the design of the AOAC Sporicidal Test does not provide quantification of the microbial challenge. Therefore, sterilization with a liquid chemical sterilant may not convey the same sterility assurance as other sterilization methods.

One of the differences between thermal and liquid chemical processes for sterilization of devices is the accessibility of microorganisms to the sterilant. Heat can penetrate barriers, such as biofilm, tissue, and blood, to attain organism kill, whereas liquids cannot adequately penetrate these barriers. In addition, the viscosity of some liquid chemical sterilant impedes their access to organisms in the narrow lumens and mated surfaces of devices. Another limitation to sterilization of devices with liquid chemical germicides is the post-processing environment of the device. Devices cannot be wrapped or adequately contained during processing in a liquid chemical sterilant to maintain sterility following processing and during storage. Furthermore, devices may require rinsing following exposure to the liquid chemical sterilant with water that typically is not sterile. Therefore, due to the inherent limitations of using liquid chemical sterilant, their use should be restricted to reprocessing critical devices that are heat-sensitive and incompatible with other sterilization methods.

Advantages

- Effective for heat sensitive instruments.

Disadvantages

- Long immersion time.
- Difficulty in determining effectiveness.
- Fresh solutions may be needed for each load.
- Health risks to those handling the solution.
- High toxicity for biologic materials.

3.1.2.e Gaseous Sterilization

The chemically reactive gases such as formaldehyde, (methanol, H.CHO) and ethylene oxide $(CH2)2O$ possess biocide activity. Ethylene oxide is a colorless, odorless, and flammable gas. The mechanism of antimicrobial action of the two gases is assumed to be through alkylation's of sulphydryl, amino, hydroxyl and carboxyl groups on proteins and amino groups of nucleic acids.

The concentration ranges (weight of gas per unit chamber volume) are usually in range of 800-1200 mg/L for ethylene oxide and 15-100 mg/L for formaldehyde with operating temperatures of 45-63°C and 70-75°C respectively.

Both of these gases being alkyl ting agents are potentially mutagenic and carcinogenic. They also produce acute toxicity including irritation of the skin, conjunctiva and nasal Mucosa.

a. Ethylene oxide sterilizer: An ethylene oxide sterilizer consists of a chamber of 100-300 Liter capacity and surrounded by a water jacket. Air is removed from sterilizer by evacuation, humidification and conditioning of the load is done by passing sub-atmospheric pressure steam, then evacuation is done again and preheated vaporized ethylene oxide is passed. After treatment, the gases are evacuated either directly to the outside atmosphere or through a special exhaust system. Ethylene oxide gas has been used widely to process heat-sensitive devices, but the aeration times needed at the end of the cycle to eliminate the gas made this method slow.

b. Low temperature steam formaldehyde (LTSF) sterilizer: An LTSF sterilizer operates with sub atmospheric pressure steam. At first, air is removed by evacuation and steam is admitted to the chamber.

Advantages

- Penetrating ability of gases.

Disadvantages

- Gases being alkyl ting agents are potentially mutagenic and carcinogen

3.1.3 Filtration with sterilization:

Certain media components are sensitive to heat; it is going to be damaged if it is heated, also some liquids would be damaged by heat, irradiation, and chemical sterilization; so they can be sterilized using mechanical filtration, a filter with pore size 0.2 μm will effectively remove bacteria. If viruses must also be removed, a much smaller pore size around 20 nm is needed. Normally filtration of media is used instead of sterilized media with an autoclave. To filter sterilized media, filter the water using a 0.45μm pore size filter, before using a 0.22μm pore size filter for final sterilization. This method is commonly used for sensitive pharmaceuticals and protein solutions in biological research.

3.1.4 Monitoring of sterilization:

The following two methods are used to monitor the effectiveness of sterilization:.

1. Chemical indicators

Internal and external, use sensitive chemicals to assess physical conditions such as temperature during the sterilization process. Chemical indicators such as heat sensitive tape change color rapidly when a given parameter is reached. An internal chemical indicator should be placed in every sterilization package to ensure the sterilization material and actually reached the instruments inside. An external indicator should be used when the internal indicator cannot be seen from outside the package.

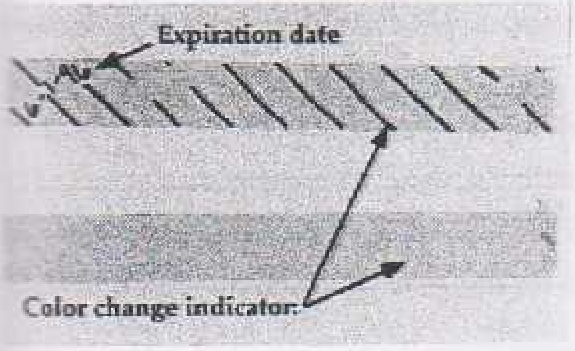


Figure 3.2: Color Change of Sterilization Indicators [18]

2.Biological indicators (BI)

Biological indicators are used to demonstrate that sterilization has occurred. Biological monitors consist of tubes or paper strips containing "known" amounts of bacterial spores; these spores are deactivated during a successful sterilization process.

3.2 Autoclave

3.2.1 Steam sterilize (Autoclave)

The method of sterilization that requires moist heat under pressure. For steam to be produced there must be sources of both water and heat. A heat source in necessary to maintain the required temperature and pressure.

* Heat can be provided by electricity or any other fuel source.
* The temperatures required for steam sterilization is lower than those for heat sterilization are because moist heat under pressure allows for more efficient destruction of microorganisms.
*Used to sterilize lab equipment and materials by destroying potentially infectious agents.

3.2.2 History of Autoclave

Autoclave passed through several stages of development, side by side with the development in medical field, the following table summarizes autoclave development hierarchy.

Table 3.2: Historical background about autoclaves

Development	Year
Hippocrates poured boiling water onto surgical instruments to clean them.	460-377 B.C.E
Denis Papen's, invented the early version of autoclave called the steam pressure cooker	1681
Lazzaro Spallanzani discovered that it took 30 minutes to kill bacteria by heating them in sealed glass flasks	1768
Pasteur sterilized using boiling water at 15 pounds pressure for 15 minutes (commonly called "15 pounds for 15	1862
Charles Chamber land finalized The current design of the	1880
The first commercial steam sterilization system intended for use on medical products	1889

3.2.3 Theory of Operation

After the instruments and tools are packaged and inserted inside the chamber and close the door, the chamber will be filled with water to determined level, and then heaters will start heating till the sterilization temperature, this temperature will be fixed for specific period of time depend on that temperature, after that the steam will be expelled out the chamber and finally drying will begin. The following graph shows the stages of sterilization process.

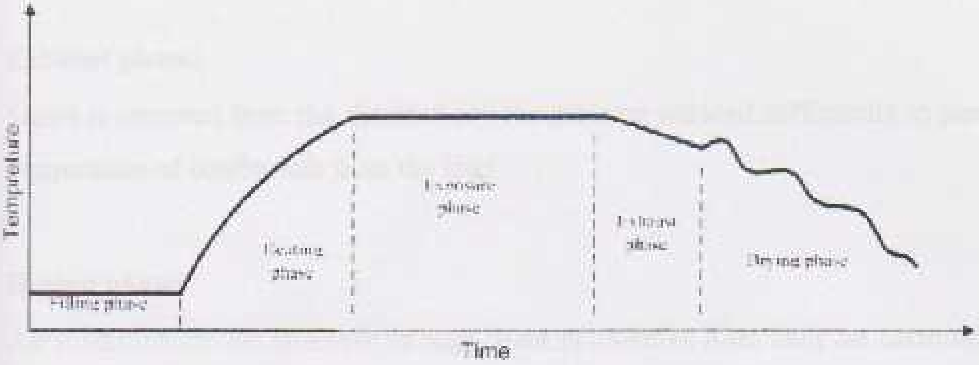


Figure 3.3: Sterilization Phases[19]

Filling phase:

Sufficient air should be removed from the chamber and load to permit the attainment of sterilizing conditions.

Heating phase:

Steam is admitted to the chamber until the sterilizing temperature is attained through out the load.

Exposure phase:

Sterilizing temperature must be maintained through the chamber and load.

Exhaust phase:

Steam is removed from the chamber and the pressure reduced sufficiently to permit the evaporation of condensate from the load.

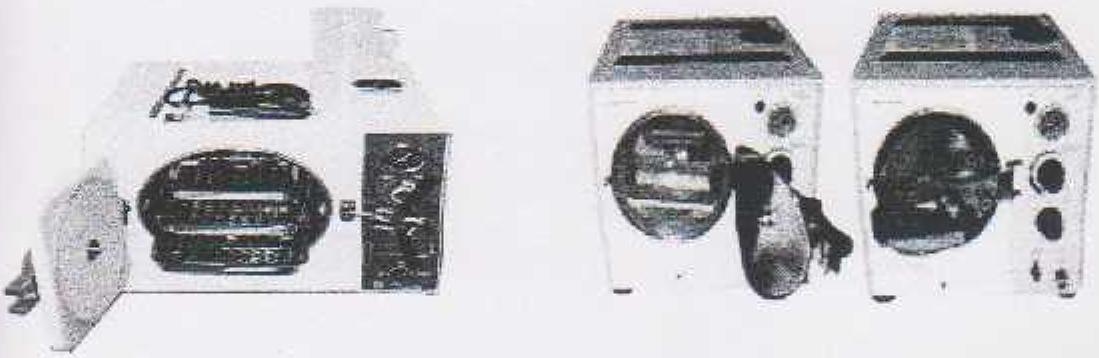
Drying phase:

Air is admitted to the chamber through bacteria retentive filter until the chamber reach atmospheric pressure.

3.2.4 Types of Autoclaves

There are many different types of autoclaves, and they vary in details how they are constructed, heated and controlled.

1. Front Loading (Table-Top) Autoclave



2. Stove Top Autoclave

Figure 3.5: Stove Top Autoclave [20]

4

project design

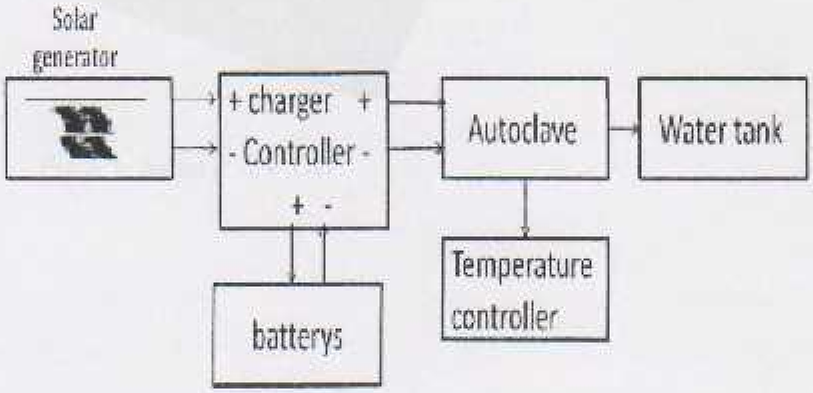
4.1. block diagram

4.2.Project calculations

Chapter four

Project design

4.1.Bock diagram of the project:



*PV panel receives sun shine and converts to DC voltage.

*The DC voltage is transfer through charge controller charge batteries.

*After charging process is completed, the batteries supply dc voltage to the heater.

Batteries:

Battery is a device used to store electrical energy to use it later when needed.
They are many type of batteries depending on voltage, current per hour, time for charging and discharging, the physical component, and the size and weight. Batteries can be divided into two parts, liquid batteries and dry batteries. In this project we need special batteries to do work effectively with PV.
Tow batteries in series will be used each 12V , 40 A.

Fig 4.1: battery 12V DC

Charger controller:

The charger controller is used to organize charging operation and to protect the battery from over charging and discharging.

There are two main types of charge controller:

1- Series charge controller or series regulator disables further current flow into batteries when they are full.

2- Shunt charge controller: shunt charge controller or shunt regulator diverts excess electricity to auxiliary or " shunt" lode, such as an electric water heater, when batteries are full.

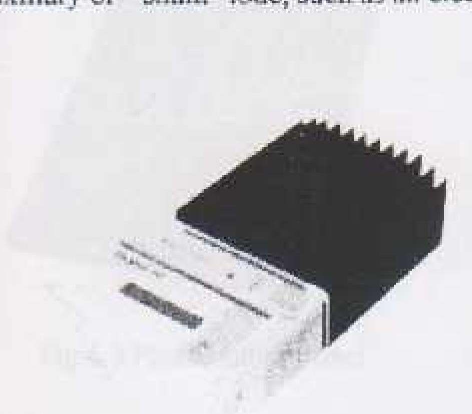


Fig.4.2:charger controller 24V DC

Photovoltaic cell:

Photovoltaic systems are solar system that produce electricity directly from sunlight. The term "photo" comes from the Greek "phos" meaning light. "Voltaic" is named for Alessandro Volta, a pioneer in the study of electricity for whom the term "volt" was named. Photovoltaic then means "light electricity". Photovoltaic systems produce clean, reliable electricity without consuming any fossil fuels. They are being used in a wide variety of applications, from providing power for watches, highway signs, and space stations, to providing for a motor pump needs.

The difference between "solar energy" and photovoltaic.

Photovoltaic is one form of solar energy. The term solar energy can refer to something as simple the energy gathered in your parked, sealed car (your solar collector) and converted into heat. Solar energy is often used to heat houses directly through passive means (sun enters window, room warms). Solar energy is also often used to heat water (a solar collector is mounted in direct sunlight, which warms a heat transfer fluid, which in turn heats the water in your hot water tank). Photovoltaic refers specifically to the practice of converting suns energy directly into electricity using photovoltaic cells. Photovoltaic cells are often referred to as PV cells or solar cells.

Fig.4.3 Photo voltaic panel

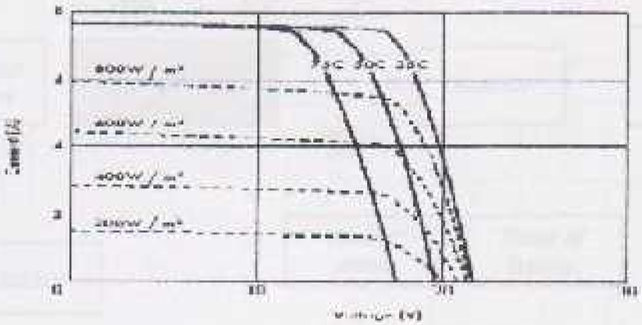


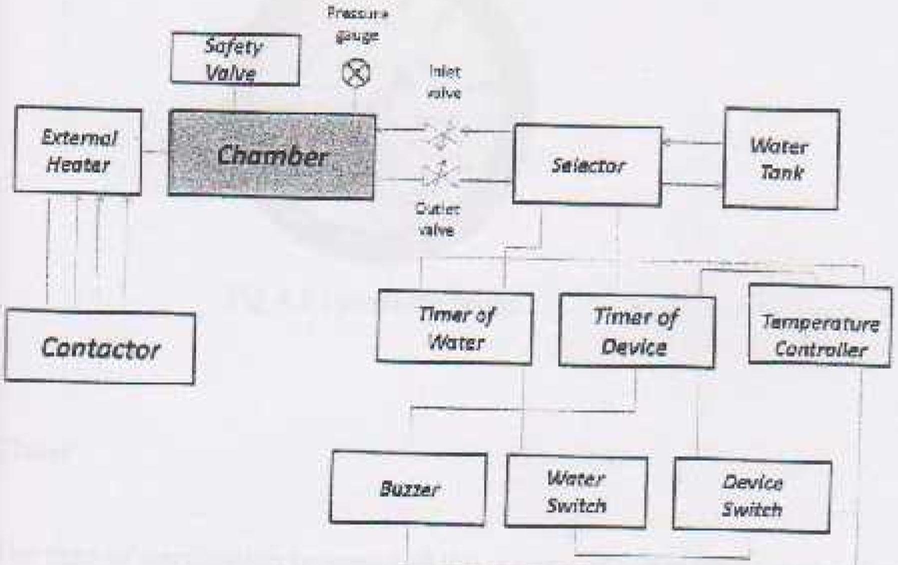
Fig 4.4: Different IV Curves. The current (A) changes with the irradiance, and the voltage (V) changes with the temperature

Heater

The heater is the source of heat used during the sterilization process to heat the water and transform it to steam, it is steam- water heater and placed outside the chamber so that to complete the drying phase and the sterilization process.

24 V DC , 800 W .

Functional block diagram of autoclave :



Pressure Gauge

Instrument for displaying the pressure inside the chamber in P.S.I or Bar.
used for measuring the condition of a fluid (liquid or gas) that is specified by the force the fluid would apply, when at rest, to a unit area, such as pounds per square inch (p.s.i) or Pascals (Pa).

The reading on the gauge, called the gauge pressure, is always the difference between two pressures. When the lower of the pressures is that of the atmosphere, the total (or absolute) pressure is the sum of the gauge and atmospheric pressures.

In our design it will display 1Bar inside the chamber plus the atmospheric pressure which is 1 Bar,so this will give the desired pressure which is 2 Bar.[8]

Fig 4.5 : pressure gauge

Timer

The time of sterilization process and the amount of water filling in the chamber will be controlled using two timers. The first timer used for calibrating the 15 minutes the sterilization process time . the second timer used to calibrate the time to fill the chamber with 25ml water from the tank . by trials we found that it is need 12 sec to fill this quantity of water

Principle of operation:

The time delay period begins when power is applied to the input terminals of the relay. When the time delay has completed, the contacts of the relay will switch to the energized position. The relay contacts will remain in the energized position until power is removed. The contacts of the relay transfer to the unenergized position upon removal of power. The time delay of the relay will reset if power is removed before the delay has completed.

Fig.4.6: timer

Contactor

contactors are designed to be directly connected to high-current load devices. It is used here because the ampere passing through temperature controller is low so the contactor will increase current that going to the heater .

principle of operation :

When current passes through the electromagnet, a magnetic field is produced, which attracts the moving core of the contactor. The electromagnet coil draws more current initially, until its inductance increases when the metal core enters the coil. The moving contact is propelled by the moving core; the force developed by the electromagnet holds the moving and fixed contacts together. When the contactor coil is de-energized, gravity or a spring returns the electromagnet core to its initial position and opens the contacts.


Fig.4.7:contactor

Temperature controller

It is a temperature clock ,which is used for reading the average of temperature in side the autoclave machine by using sensor which is joined to PT100.

Principle of operation:

We measure a set value for the temperature with the value of max 120C, and the PT100 will read the temperature inside the autoclave. When it reaches to 120C there will a separation from the circle and the circle will be opened ,this mean become "normal open".By this way we can control the temperature with 120C .This clock will be programmed handily by using a button which is found in the front of the clock.

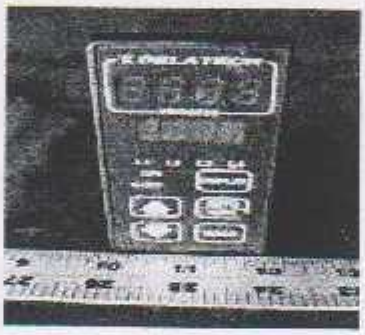


Fig 4.8: Temperature controller

Solenoid Valves

A solenoid valve is an electromechanical valve operated by a built-in actuator in the form of an electrical coil (or solenoid) and a plunger. This controls the flow of liquids, gases, and steam. This valve is controlled by the passage of electric current in the solenoid (which is a coil of wire), when electrically energized they either open or close causing the flow of liquids or not

A solenoid valve has two main parts: the solenoid and the valve. The solenoid consists of a coil of wire of cylindrical shape around the bobbin. When it is energized by an electrical signal, a magnetic field builds up which attracts the movable plunger to the pole piece, against the tension of the main plunger spring

When de-energized, the magnetic field dissipates and the plunger returns to its original position, under the action of the main plunger spring. So the solenoid converts electrical energy into mechanical energy using magnetic effect which opens or closes the valve mechanically

Solenoid valves are produced in two modes normally open or normally closed (referring to the state when the solenoid is not energized).

Outlet valve: I t is used to allow the steam go outside the chamber.
It is used to control the passage of steam from the chamber to the reservoir tank after completing the sterilization.

Inlet valve: It is used to allow the water to flow inside the chamber.

Chamber

The enclosed box where the medical tools are placed, and provide the suitable environment for sterilization.It is made from aluminum.The chamber edges must be curved so that effect of high pressure is reduced.It is cylindrical shaped of approximately 25cm diameter and 39cm depth.

Safety valve

It will work if the pressure increases to the maximum pressure; it opens allowing steam get out the chamber

Temperature Sensor

Temperature sensor is used to convert the temperature to electric current.
It is a PT100 temperature sensor

water tank

- It reserves water to be used in sterilization to produce needed steam.
- It is used to condense the steam after completion of sterilization process.
- 0.25 Liter water volume.

Selector

Instrument used to connect the inlet and outlet valves to the chamber. It has two ways one for letting the water to come inside the chamber and the other to let the steam go outside
The chamber .

Platinum resistance thermometers (PT100):

Excellent accuracy over a wide temperature from (-200 to 800C).Standard sensors are available from many manufactures with various accuracy specification and numerous packaging options to suit most application.

The principle of operation is to measure the resistance of a platinum element .The most common type (PT100) has a resistance of 100ohms at 0C and 138.4 ohms at 100C .

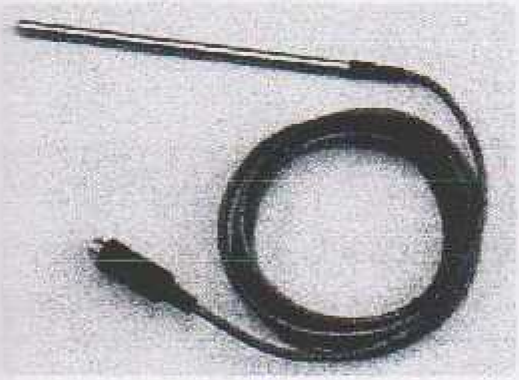


Fig4.9: temperature sensor PT100

4.2.Project circuit and calculations:

Heater:

Some general guidelines. Here are some recommended times for autoclaving liquids of thefollowing volume per container:

75- 200 ml	20 minutes	[26]
200- 500 ml	25 minutes	
500- 1000 ml	30 minutes	
1000- 1500 ml	35 minutes	
1500- 2000 ml	40 minutes	

1. $$Q_1 = M_{tot} \bullet C_v \bullet \Delta T \text{.....................}(4.1)[8]$$

$Q_1 \Rightarrow$

$Q_2 \Rightarrow$

amount of heat required to convert 2/3 of water to vapor

$M_{tot} \Rightarrow$ total mass of water

$C_v \Rightarrow$ specific heat

$\Delta T \Rightarrow$ Temperature ($T_f - T_i$)

$M_{tot} = \rho . v$

Where: $\rho \Rightarrow$ density of water

$v \Rightarrow$ volume of water

$$M_{tot} = (997 \frac{kg}{m^3})(\frac{0.25}{1000} m^3)$$

$= 0.249\ kg$

$C_{v\ (H2O)}$ at 25 C° = 4.18 kJ / kg .k

$C_{v\ (H2O)}$ at 120 C° = 4.22 kJ / kg .k

$$C_{v\ (H2O)} = \frac{4.18 + 4.22}{2} = 4.2\ kJ / kg.k$$

$$Q_1 = M_{tot} \bullet C_v \bullet \Delta T$$

= (0.249) (4.2) (120-25)

= 99.35 kJ

2. $Q_2 = m_g \bullet \Delta h$..................(4.2)[8]

$= m_g \cdot (h_{av} - h_f)$

How to calculate x ⇒

$m_g \Rightarrow$ mass of Vapor

$m_f \Rightarrow$ mass of liquid

$$X = \frac{mg}{M_{tot}} = \frac{m_g}{m_g * m_f} \text{ ....(3)[28]}$$

$$m_g = \frac{2}{3} * M_{tot}$$

$$= \frac{2}{3} * 0.249$$

$\cong$ 0.166 kg

$$X = \frac{mg}{M_{wt}} = \frac{0.166}{0.249} = 0.66$$

To calculate h_{sv} $\Rightarrow$

$$X = \frac{h_{sv} - h_f}{h_g - h_f}$$

$$h_{sv} = X(\ h_g - h_f) - h_f$$

From table A.4 from thermo dynamic appendix

$\Rightarrow$ at 120 C° sat liquid

$h_f \Rightarrow$ heat at saturated liquid = 503.81 kJ / kg

$h_g \Rightarrow$ heat at saturated vapor = 2706.0 kJ / kg

$h_{fg} \Rightarrow$ latent heat of evaporation = 2202.1 kJ / kg

$\therefore$ h_{sv} = 0.66 (2202.19) + 503.81

= 1957.25

$$Q_2 = m_g \bullet \Delta h$$

= (0.166) $(h_{sv} - h_f)$

= (0.166) (1957.25 - 503.81)

= 241.27 kJ

Amount of heat required to raise the temp of the pot body from 25 c to 120 c can be estimated as follows :

$$Q_3 = \Delta U$$

$$= M\Delta u$$

$$= \rho v C_p \Delta T$$

Where :

Q = The amount of heat that is needed to raise the temp of the pot (kJ).

ΔU = Total internal energy change (kJ) .

M = mass of the pot (kg).

ΔU = internal energy change of the pot per unit mass (kJ / kg).

ρ = Density of Aluminum (kg / m^3)

= 2771 (kg / m^3)

V = volume of the pot (m^3)

C_p = Specific heat of Aluminum ($\frac{kJ}{kg \cdot C^{\circ}}$)

= 1.005 ($\frac{kJ}{kg \cdot C^{\circ}}$)

ΔT = Temperature rise ($120 C^{\circ} - 25 C^{\circ}$)

$$Q_3 = \Delta U$$

$$= M\Delta U$$

$= M c_p \Delta T$

$$M = \rho v$$

$$V = \pi (r_2^2 - r_1^2) * L + 2\pi r_2^2 . W$$

$= \pi ((0.248^2) - (0.245^2)) * 0.26 + 2\pi (0.248^2)(0.003)$

$= 0.0025\ m^3$

$$Q_3 = M c_p \Delta T$$

$= \rho v c_p \Delta T$

$= (2771 \frac{Kg}{m^3})(0.0025\ m^3)(1.005 \frac{kj}{kg.C^{\circ}})(120\ C^{\circ} - 25\ C^{\circ})$

$=404$ kJ

$$Q_{tot} = Q_1 + Q_2 + Q_3$$

$= (99.35) + (241.27) - (404)$

$= 744.62$ kJ

$Q_{tot} = 744.62$kJ

⇒ For heating time of 0.25 hr

t = (0.25) (60) (60) = 900 sec

$$P = \frac{Q_{tot}}{t} \text{....................}(4.3)[8]$$

$$= \frac{744.62kJ}{900\sec} = 827.4\text{w}$$

** Calculation for PV:

TCH $\Rightarrow$ Total charging energy.

$V_B \Rightarrow$ Battery voltage.

$I_B \Rightarrow$ Battery current.

$\}_B \Rightarrow$ Battery charging efficiency.

SOC $\Rightarrow$ State of charge.

$I_{dis} \Rightarrow$ Discharging current.

TCD $\Rightarrow$ Discharging energy(energy capacitance).

$\}_{cont} \Rightarrow$ Controller efficiency .

$P_{array} \Rightarrow$ Array power.

$t_{sunny} \Rightarrow$ Total sunny hour.

TCH = 830 w * 1 h = 830 w.hr

V_B = 24 v

$$I_B = \frac{830whr}{24v} = 34.58 \text{ A.hr}$$

$\}_B$

= 0.98

SOC = 0.8

$$I_{dis} = \frac{I_B}{\}_B SOC} = \frac{34.58}{0.98 * 0.8} = 44.11 \text{ A}$$

TCD = TCH * operating time

= 830 w.hr * 0.25

= 207.5 w.hr

Conductor Losses ⟶ 2 %

Voltage drop (Discharge) ⟶ 10 %

$\}_{dis} = 1 -$ voltage drop

$$\text{TCT} = \frac{TCD}{\eta_{losses} \cdot \eta_{dis}}$$

$$= \frac{207.5}{0.98 * 0.9}$$

= 235.261 w

$$\text{Total PV power} = \frac{TCT}{\eta_{ch} \cdot (1 - \Delta P_{loss})}$$

$$= \frac{235.261}{0.96 * 0.88}$$

= 278.48 w.hr

η_{cont} = 0.96

Voltage drop = 12 %

$$P_{array} = \frac{TotalPV}{t_{sunny}} = \frac{278.48 w.hr}{4hr} = 69.62 \text{ w}$$

t_{sunny} = 4 hours / January (cloudy weather)

$$Number\ of\ PV = \frac{69.62}{110w} = 0.633 \approx 1 \text{ Pannel}$$

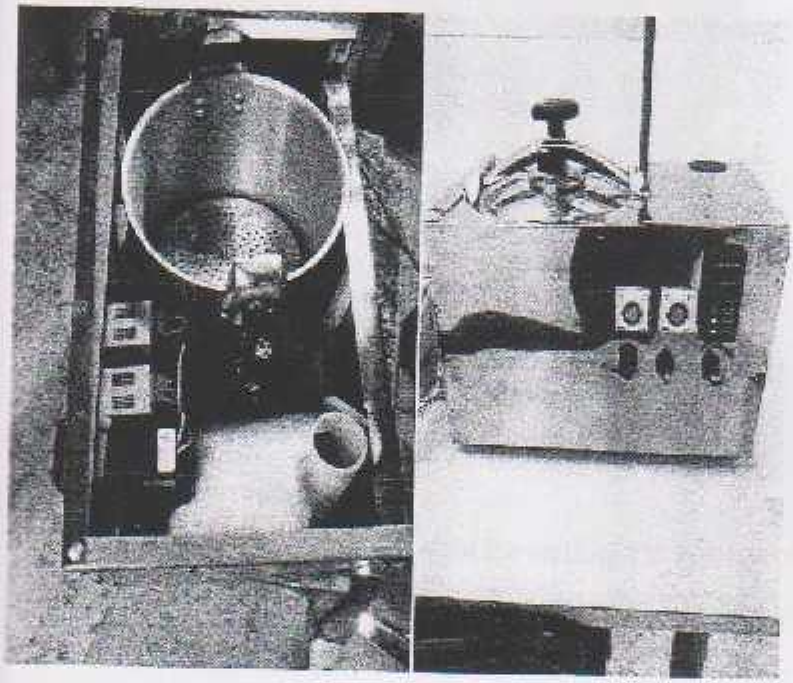
5

System Implementation and Testing

This chapter demonstrates the parts used to implement, test, and examine the system operation and behavior. System testing is an important step in implementing whole system.

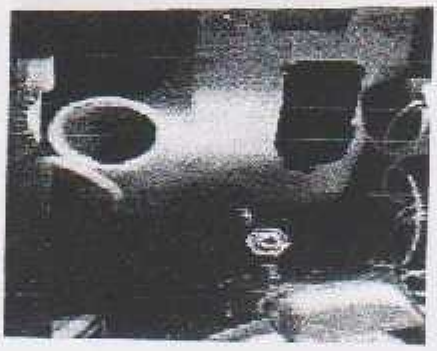
Mechanical system implementation

The mechanical system implementation includes combining the chamber with water tank, safety valve, solenoid valves, pressure gauge, temperature controller, timer, switch, buzzer, selector, contactor. The heater is placed outside the chamber. The following picture shows mechanical system implementation.



Water tank

It is used to reserve water to be used in sterilization to produce needed steam.



Pressure Gauge

Instrument for displaying the pressure inside the chamber in Bar.

Temperature controller

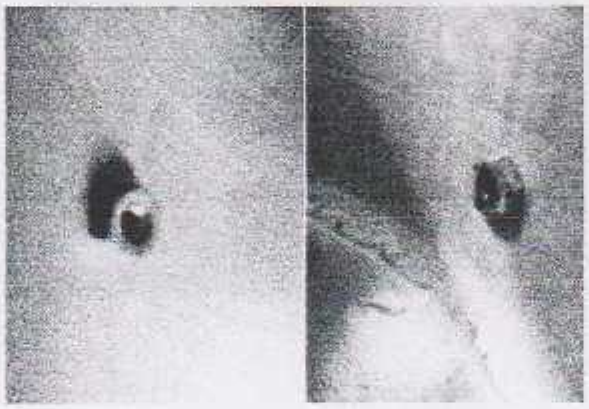
It is a temperature clock ,which is used for reading the average of temperature inside the autoclave machine by using sensor which is joined to PT100.

Solenoid valves

Outlet valve: -I t is used to allow the steam go outside the chamber

- It is used to control the passage of steam from the chamber to the reservoir tank after completing the sterilization

Inlet valve: It is used to allow the water to flow inside the chamber



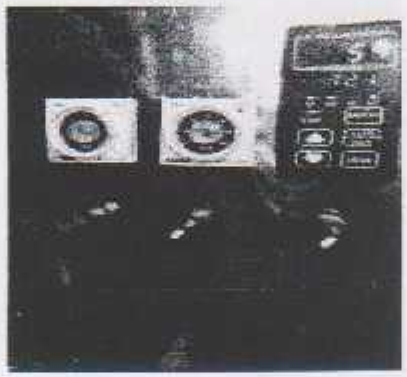
Selector

Instrument used to connect the inlet and outlet valves to the chamber. It has two ways one for letting the water to come inside the chamber and the other to let the steam go outside The chamber .

Timer

Two timers are used. The first timer used for calibrating the 15 minutes the sterilization process time . the second timer used to calibrate the time to fill the chamber with 25ml water from the tank .

by trials we found that it is need 12 sec to fill this quantity of water.



Safety valve

It will work if the pressure increases to the maximum pressure; it opens allowing steam get out the chamber

Switch

Tow switches are used the first start the device and the operation of sterilization, it is connected to the time timer. The other switch starting the filling of water ,it is connected to the second timer.

Buzzer

Instrument used to give a sign when the process complete.

Testing

the system tested several times and the results was near the desired one .

the first reading is 1.8 bar and 115 C^0 .

The second reading is 1.4 bar and 100 C^0 .

6

Conclusion and Recommendations

6.1 Conclusions

6.2 Recommendations

Chapter Sex

Conclusion and Recommendations

6.1 Conclusions

1. Our project use solar energy to achieve the sterilization process instead of electrical energy.
2. This project will sterilize the medical tools using steam under pressure as sterilizing agent.
3. This device will be suitable for ambulatory dental clinic or ambulances or when electricity is interrupted and operation room, emergency room, and clinics.

6.2 Recommendations

Future modifications can be carried out so system performance and efficiency is improved, these modifications include:

1. Use the stainless box that can withstand high temperature and high pressure such as old autoclaves
2. Rebuild the system by adding a system to open and close door automatically (for safety).
3. Adding printer to print a report about sterilization.
4. avoid using pressure cooker to implement the device .

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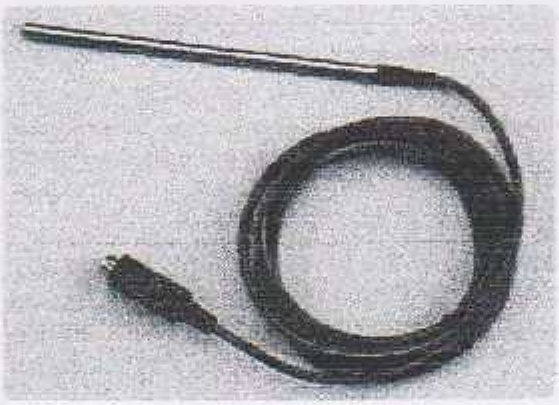
Appendix's

Platinum resistance thermometers (PRTs) offer excellent accuracy over a wide temperature range (from -200 to +850 °C). Standard Sensors are available from many manufacturers with various accuracy specifications and numerous packaging options to suit most applications. Unlike thermocouples, it is not necessary to use special cables to connect to the sensor.

The principle of operation is to measure the resistance of a platinum element. The most common type (PT100) has a resistance of 100 ohms at 0 °C and 138.4 ohms at 100 °C. There are also PT1000 sensors that have a resistance of 1000 ohms at 0 °C.

The relationship between temperature and resistance is approximately linear over a small temperature range: for example, if you assume that it is linear over the 0 to 100 °C range, the error at 50 °C is 0.4 °C. For precision measurement, it is necessary to linearise the resistance to give an accurate temperature. The most recent definition of the relationship between resistance and temperature is International Temperature Standard 90 (ITS-90).



This linearization is done automatically, in software, when using Pico signal conditioners. The linearization equation is:

*Rt = R0 * (1 + A* t + B*t2 + C*(t-100)* t3)*

Where:

Rt is the resistance at temperature *t*, *R0* is the resistance at 0 °C, and
A= 3.9083 E-3
B = -5.775 E-7
C = -4.183 E -12 (below 0 °C), or
C = 0 (above 0 °C)

For a PT100 sensor, a 1 °C temperature change will cause a 0.384 ohm change in resistance, so even a small error in measurement of the resistance (for example, the resistance of the wires leading to the sensor) can cause a large error in the measurement of the temperature. For precision work, sensors have four wires- two to carry the sense current, and two to measure the voltage across the sensor element. It is also possible to obtain three-wire sensors, although these operate on the (not necessarily valid) assumption that the resistance of each of the three wires is the same.

The current through the sensor will cause some heating: for example, a sense current of 1 mA through a 100 ohm resistor will generate 100 µW of heat. If the sensor element is unable to dissipate this heat, it will report an artificially high temperature. This effect can be reduced by either using a large sensor element, or by making sure that it is in good thermal contact with its environment.

Using a 1 mA sense current will give a signal of only 100 mV. Because the change in resistance for a degree Celsius is very small, even a small error in the measurement of the voltage across the sensor will produce a large error in the temperature measurement. For example, a 100 µV voltage measurement error will give a 0.4 °C error in the temperature reading. Similarly, a 1 µA error in the sense current will give 0.4 °C temperature error.

Because of the low signal levels, it is important to keep any cables away from electric cables, motors, switchgear and other devices that may emit electrical noise. Using screened cable, with the screen grounded at one end, may help to reduce interference. When using long cables, it is necessary to check that the measuring equipment is capable of handling the resistance of the cables. Most equipment can cope with up to 100 ohms per core.

The type of probe and cable should be chosen carefully to suit the application. The main issues are the temperature range and exposure to fluids (corrosive or conductive) or metals. Clearly, normal solder junctions on cables should not be used at temperatures above about 170 °C.

Sensor manufacturers offer a wide range of sensors that comply with BS1904 class B (DIN 43760): these sensors offer an accuracy of ±0.3 °C at 0 °C. For increased accuracy, BS1904 class A (±0.15 °C) or tenth-DIN sensors (±0.03 °C). Companies like Biotech can provide standards with 0.001 °C accuracy. Please note that these accuracy specifications relate to the SENSOR ONLY: it is necessary to add on any error in the measuring system as well.

Related standards are IEC751 and JISC1604-1989. IEC751 also defines the colour coding for PRT sensor cables: the one or two wires attached to one end of the sensor are red, and the one or two wires at the other end are white.

Type	Terminal	Contact form	Model			
			Single contact		Bifurcated contact	
			Standard bracket mounting	Upper mounting bracket	Standard bracket mounting	Upper mounting bracket
o-test	Plug-in/solder	SPDT	LY1I4	—	—	—
		DPDT	LY2I4	—	LY2ZI2	—
		3PDT	LY3I4	—	—	—
		4PDT	LY4I4	—	—	—
dicator and o-test button	Plug-in/solder	DPDT	LY2I4N	—	LY2ZI2N	—
		4PDT	LY4I4N	—	—	—

1. Types with specifications other than those listed are available. Contact your Omron Sales representative.
2. To order connecting sockets and mounting tracks, see "Accessories" section.

ccessories

nnecting Sockets

der: Select the appropriate part numbers for sockets, clips, and mounting tracks (if required) from the following charts.

k Mounted Sockets

Relay	Socket*	Relay hold-down clip		Mounting track
		Standard	RC circuit	
	PTF08A-E	PYC-A1	Y92H-3	PFP-100N/PFP-50N & PFP-M or PFP-100N2 PFP-S (Option spacer)
	PTF11A			
	PTF14A-E			

mounted socket can be used as a front connecting socket.

k Connecting Sockets

ay	Solder terminal socket	Wire wrap terminal socket	Relay hold-down clip				Socket Mounting Plate			
			Standard	Push-to-test	RC circuit	Mtg. plate	1	10	12	18
	PT08	PT08QN	PYC-P	PYC-P2	PYC-1	PYC-S	PYP-1	–	–	PYP-18
	PT11	PT11QN					PTP-1-3	–	PTP-12	–
	PT14	PT14QN					PTP-1	PTP-10	–	–

Types PYP-18, PTP-12 and PTP-10 may be cut to any desired length.

Relay	PC terminal socket	Relay hold-down clip		
		Standard	Push-to-test	RC circuit
	PT08-0	PYC-P	PYC-P2	PYC-1
	PT11-0			
	PT14-0			

Specifications

Contact Data

Load	Single contact				Bifurcated contact	
	SPDT		DPDT, 3PDT, 4PDT		DPDT	
	Resistive load (p.f. = 1)	Inductive load (p.f. = 0.4) (L/R = 7 ms)	Resistive load (p.f. = 1)	Inductive load (p.f. = 0.4) (L/R = 7 ms)	Resistive load (p.f. = 1)	Inductive load (p.f. = 0.4) (L/R = 7 ms)
Rated load	15 A at 110 VAC 15 A at 24 VDC	10 A at 110 VAC 7 A at 24 VDC	10 A at 110 VAC 10 A at 24 VDC	7.5 A at 110 VAC 5 A at 24 VDC	5 A at 110 VAC 5 A at 24 VDC	4 A at 110 VAC 4 A at 24 VDC
Contact material	Ag-Alloy					
Carry current	15 A		10 A		7 A	
Max. operating voltage	250 VAC 125 VDC					
Max. operating current	15 A		10 A		7 A	
Max. switching capacity	1,700 VA 360 W	1,100 VA 170 W	1,100 VA 240 W	825 VA 120 W	550 VA 120 W	440 VA 100 W
Min. permissible load	100 mA, 5 VDC				10 mA, 5 VDC	

Coil Data

1- and 2-pole Types – AC

Rated voltage (V)	Rated current (mA)		Coil resistance (Ω)	Coil inductance (ref. value) (H)		Pick-up voltage	Dropout voltage	Maximum voltage	Power consumption (VA, W)
	50 Hz	60 Hz		Armature OFF	Armature ON	(% of rated voltage)			
6	214.10	183	12.20	0.04	0.08	80% max.	30% min.	110%	Approx. 1.00 to 1.20 (60 Hz)
12	106.50	91	46	0.17	0.33				
24	53.80	46	180	0.69	1.30				
50	25.70	22	788	3.22	5.66				
100/110	11.70/12.90	10/11	3,750	14.54	24.60				Approx. 0.90 to 1.10 (60 Hz)
110/120	9.90/10.80	8.40/9.20	4,430	19.20	32.10				
200/220	6.20/6.80	5.30/5.80	12,950	54.75	94.07				
220/240	4.80/5.30	4.20/4.60	18,790	83.30	136.40				

1- and 2-pole Types – DC

Rated voltage (V)	Rated current (mA)	Coil resistance (Ω)	Coil inductance (ref. value) (H)		Pick-up voltage	Dropout voltage	Maximum voltage	Power consumption (VA, W)
			Armature OFF	Armature ON	(% of rated voltage)			
6	150	40	0.16	0.33	80% max.	10% min.	110%	Approx. 0.90
12	75	160	0.73	1.37				
24	36.90	650	3.20	5.72				
48	18.50	2,600	10.60	21				
100/110	9.10/10	11,000	45.60	86.20				

Note: 1. The rated current and coil resistance are measured at a coil temperature of 23°C (73°F) with tolerances of +15%, -20% for AC rated current, and ±15% for DC rated coil resistance.

2. The AC coil resistance and inductance are reference values at 50 Hz.

3. The performance characteristics are measured at a coil temperature of 23°C (73°F).

4. Class B coil insulation is available.

ole Type – AC

ated ge (V)	Rated current (mA)		Coil resistance (Ω)	Coil inductance (ref. value) (H)		Pick-up voltage	Dropout voltage	Maximum voltage	Power consumption (VA, W)
	50 Hz	60 Hz		Armature OFF	Armature ON	(% of rated voltage)			
	310	270	6.70	0.03	0.05	80% max.	30% min.	110%	Approx. 1.60 to 2.00 (60 Hz)
	158	134	24	0.12	0.21				
	80	67	100	0.44	0.79				
	38	33	410	2.24	3.87				
110	15.90/16.30	13.60/15.60	2,300	10.50	18.50				
	17.30	14.8	2,450	11.50	20.60				
220	10.50/11.60	9.00/9.90	8,650	34.80	59.30				
	9.40	8	10,400	38.80	74.60				

ole Type – DC

ated ltage (V)	Rated current (mA)	Coil resistance (Ω)	Coil inductance (ref. value) (H)		Pick-up voltage	Dropout voltage	Maximum voltage	Power consumption (VA, W)
			Armature OFF	Armature ON	(% of rated voltage)			
	234	25.70	0.11	0.21	80% max.	10% min.	110%	Approx. 1.40
	112	107	0.45	0.85				
	58.60	410	1.89	3.87				
	28.20	1,700	8.53	13.90				
110	12.70/13	8,500	29.60	54.30				

ole Type – AC

ated ge (V)	Rated current (mA)		Coil resistance (Ω)	Coil inductance (ref. value) (H)		Pick-up voltage	Dropout voltage	Maximum voltage	Power consumption (VA, W)
	50 Hz	60 Hz		Armature OFF	Armature ON	(% of rated voltage)			
	366	330	5	0.02	0.04	80% max.	30% min.	110%	Approx. 1.95 to 2.50 (60 Hz)
	199	170	20	0.10	0.17				
	93.60	80	78	0.38	0.67				
	46.80	40	350	1.74	2.88				
110	22.50/25.50	19/21.80	1,800	10.50	17.30				
	19.00	16.40	2,200	9.30	19				
220	11.50/13.10	9.80/11.20	6,700	33.10	57.80				
	11.00	9.50	9,000	30.20	53.40				

ole Type – DC

ated ge (V)	Rated current (mA)	Coil resistance (Ω)	Coil inductance (ref. value) (H)		Pick-up voltage	Dropout voltage	Maximum voltage	Power consumption (VA, W)
			Armature OFF	Armature ON	(% of rated voltage)			
	240	25	0.09	0.21	80% max.	10% min.	110%	Approx. 1.50
	120	100	0.39	0.84				
	69	350	1.41	2.91				
	30	1,800	6.39	13.60				
110	15/15.90	6,900	32	63.70				

1. The rated current and coil resistance are measured at a coil temperature of 23°C (73°F) with tolerances of +15%, -20% for AC rated current, and ±15% for DC rated coil resistance.
2. The AC coil resistance and inductance are reference values at 60 Hz.
3. The performance characteristics are measured at a coil temperature of 23°C (73°F).
4. Class B coil insulation is available.

TABLE A-3

Properties of common liquids, solids, and foods

(a) Liquids

Substance	Boiling data at 1 atm: Normal boiling point, °C	Boiling data at 1 atm: Latent heat of vaporization h_{fg}, kJ/kg	Freezing data: Freezing point, °C	Freezing data: Latent heat of fusion h_{if}, kJ/kg	Liquid properties: Temperature, °C	Liquid properties: Density ρ, kg/m^3	Liquid properties: Specific heat c_p, kJ/kg · K
Ammonia	−33.3	1357	−77.7	322.4	−33.3	682	4.43
					−20	665	4.52
					0	639	4.60
					25	602	4.80
Argon	−185.9	161.6	−189.3	28	−185.6	1394	1.14
Benzene	80.2	394	5.5	126	20	879	1.72
Brine (20% sodium chloride by mass)	103.9	—	−17.4	—	20	1150	3.11
n-Butane	−0.5	385.2	−138.5	80.3	−0.5	601	2.31
Carbon dioxide	−78.4*	230.5 (at 0°C)	−56.6		0	298	0.59
Ethanol	78.2	838.3	−114.2	109	25	783	2.46
Ethyl alcohol	78.6	855	−156	108	20	789	2.84
Ethylene glycol	198.1	800.1	−10.8	181.1	20	1109	2.84
Glycerine	179.9	974	18.9	200.6	20	1261	2.32
Helium	−268.9	22.8	—	—	−268.9	146.2	22.8
Hydrogen	−252.8	445.7	−259.2	59.5	−252.8	70.7	10.0
Isobutane	−11.7	367.1	−160	105.7	−11.7	593.8	2.28
Kerosene	204–293	251	−24.9	—	20	820	2.00
Mercury	356.7	294.7	−38.9	11.4	25	13,560	0.139
Methane	−161.5	510.4	−182.2	58.4	−161.5	423	3.49
					−100	301	5.79
Methanol	64.5	1100	−97.7	99.2	25	787	2.55
Nitrogen	−195.8	198.6	−210	25.3	−195.8	809	2.06
					−160	596	2.97
Octane	124.8	306.3	−57.5	180.7	20	703	2.10
Oil (light)					25	910	1.80
Oxygen	−183	212.7	−218.8	13.7	−183	1141	1.71
Petroleum	—	230–384			20	640	2.0
Propane	−42.1	427.8	−187.7	80.0	−42.1	581	2.25
					0	529	2.53
					50	449	3.13
Refrigerant-134a	−26.1	217.0	−96.6	—	−50	1443	1.23
					−26.1	1374	1.27
					0	1295	1.34
					25	1207	1.43
Water	100	2257	0.0	333.7	0	1000	4.22
					25	997	4.18
					50	988	4.18
					75	975	4.19
					100	958	4.22

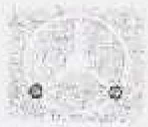
* Sublimation temperature. (At pressures below the triple-point pressure of 518 kPa, carbon dioxide exists as a solid or gas. Also, the freezing-point temperature of carbon dioxide is the triple-point temperature of −56.5°C.)

TABLE A-4

Saturated water—Temperature table

		Specific volume, m³/kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg · K		
Temp., T °C	Sat. press., P_{sat} kPa	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
0.01	0.6117	0.001000	206.00	0.000	2374.9	2374.9	0.001	2500.9	2500.9	0.0000	9.1556	9.1556
5	0.8725	0.001000	147.03	21.019	2360.8	2381.8	21.020	2489.1	2510.1	0.0763	8.9487	9.0249
10	1.2281	0.001000	106.32	42.020	2346.6	2388.7	42.022	2477.2	2519.2	0.1511	8.7488	8.8999
15	1.7057	0.001001	77.885	62.980	2332.5	2395.5	62.982	2465.4	2528.3	0.2245	8.5559	8.7803
20	2.3392	0.001002	57.762	83.913	2318.4	2402.3	83.915	2453.5	2537.4	0.2965	8.3696	8.6661
25	3.1698	0.001003	43.340	104.83	2304.3	2409.1	104.83	2441.7	2546.5	0.3672	8.1895	8.5567
30	4.2469	0.001004	32.879	125.73	2290.2	2415.9	125.74	2429.8	2555.6	0.4368	8.0152	8.4520
35	5.6291	0.001006	25.205	146.63	2276.0	2422.7	146.64	2417.9	2564.6	0.5051	7.8466	8.3517
40	7.3851	0.001008	19.515	167.53	2261.9	2429.4	167.53	2406.0	2573.5	0.5724	7.6832	8.2556
45	9.5953	0.001010	15.251	188.43	2247.7	2436.1	188.44	2394.0	2582.4	0.6386	7.5247	8.1633
50	12.352	0.001012	12.026	209.33	2233.4	2442.7	209.34	2382.0	2591.3	0.7038	7.3710	8.0748
55	15.763	0.001015	9.5639	230.24	2219.1	2449.3	230.26	2369.8	2600.1	0.7680	7.2218	7.9898
60	19.947	0.001017	7.6670	251.16	2204.7	2455.9	251.18	2357.7	2608.8	0.8313	7.0769	7.9082
65	25.043	0.001020	6.1935	272.09	2190.3	2462.4	272.12	2345.4	2617.5	0.8937	6.9360	7.8296
70	31.202	0.001023	5.0396	293.04	2175.8	2468.9	293.07	2333.0	2626.1	0.9551	6.7989	7.7540
75	38.597	0.001026	4.1291	313.99	2161.3	2475.3	314.03	2320.6	2634.6	1.0158	6.6655	7.6812
80	47.416	0.001029	3.4053	334.97	2146.6	2481.6	335.02	2308.0	2643.0	1.0756	6.5355	7.6111
85	57.868	0.001032	2.8261	355.96	2131.9	2487.8	356.02	2295.3	2651.4	1.1346	6.4089	7.5435
90	70.183	0.001036	2.3593	376.97	2117.0	2494.0	377.04	2282.5	2659.6	1.1929	6.2853	7.4782
95	84.609	0.001040	1.9808	398.00	2102.0	2500.1	398.09	2269.6	2667.6	1.2504	6.1647	7.4151
100	101.42	0.001043	1.6720	419.06	2087.0	2506.0	419.17	2256.4	2675.6	1.3072	6.0470	7.3542
105	120.90	0.001047	1.4186	440.15	2071.8	2511.9	440.28	2243.1	2683.4	1.3634	5.9319	7.2952
110	143.38	0.001052	1.2094	461.27	2056.4	2517.7	461.42	2229.7	2691.1	1.4188	5.8193	7.2382
115	169.18	0.001056	1.0360	482.42	2040.9	2523.3	482.59	2216.0	2698.6	1.4737	5.7092	7.1829
120	198.67	0.001060	0.89133	503.60	2025.3	2528.9	503.81	2202.1	2706.0	1.5279	5.6013	7.1292
125	232.23	0.001065	0.77012	524.83	2009.5	2534.3	525.07	2188.1	2713.1	1.5816	5.4956	7.0771
130	270.28	0.001070	0.66808	546.10	1993.4	2539.5	546.38	2173.7	2720.1	1.6346	5.3919	7.0265
135	313.22	0.001075	0.58179	567.41	1977.3	2544.7	567.75	2159.1	2726.9	1.6872	5.2901	6.9773
140	361.53	0.001080	0.50850	588.77	1960.9	2549.6	589.16	2144.3	2733.5	1.7392	5.1901	6.9294
145	415.68	0.001085	0.44600	610.19	1944.2	2554.4	610.64	2129.2	2739.8	1.7908	5.0919	6.8827
150	476.16	0.001091	0.39248	631.66	1927.4	2559.1	632.18	2113.8	2745.9	1.8418	4.9953	6.8371
155	543.49	0.001096	0.34648	653.19	1910.3	2563.5	653.79	2098.0	2751.8	1.8924	4.9002	6.7927
160	618.23	0.001102	0.30680	674.79	1893.0	2567.8	675.47	2082.0	2757.5	1.9426	4.8066	6.7492
165	700.93	0.001108	0.27244	696.46	1875.4	2571.9	697.24	2065.6	2762.8	1.9923	4.7143	6.7067
170	792.18	0.001114	0.24260	718.20	1857.5	2575.7	719.08	2048.8	2767.9	2.0417	4.6233	6.6650
175	892.60	0.001121	0.21659	740.02	1839.4	2579.4	741.02	2031.7	2772.7	2.0906	4.5335	6.6242
180	1002.8	0.001127	0.19384	761.92	1820.9	2582.8	763.05	2014.2	2777.2	2.1392	4.4448	6.5841
185	1123.5	0.001134	0.17390	783.91	1802.1	2586.0	785.19	1996.2	2781.4	2.1875	4.3572	6.5447
190	1255.2	0.001141	0.15636	806.00	1783.0	2589.0	807.43	1977.9	2785.3	2.2355	4.2705	6.5059
195	1398.8	0.001149	0.14089	828.18	1763.6	2591.7	829.78	1959.0	2788.8	2.2831	4.1847	6.4678
200	1554.9	0.001157	0.12721	850.46	1743.7	2594.2	852.26	1939.8	2792.0	2.3305	4.0997	6.4302

Photovoltaic Module
Installation and care



Option 1 - **JUNCTION BOX**

Cable glands must be placed in one of the 6 positions provided. Punch out the circle of thinner plastic in the chosen hole with a screwdriver or similar instrument. ⇒

Do not push on the center of the circle or touch the backside of the module.

Use suitable cables for outdoor use (Ø : between 7 and 12.5 mm).

Connect (+) to terminal 0 and (-) on terminal 6. For a 24V use connect terminals 2/4 together, otherwise (12V use) connect together terminals (+) 0/4 and (-) 2/6 together. ⇒

After the connectings coat metal parts with silicone grasse.

For a watertight assembly, put an O-ring in the cover groove and place 2 more screws (however, it is better to allow a proper ventilation by free flow of air in order to avoid moisture).

Option 2 - **CABLE JUNCTION**

Connectors used are manufactured by Multi-Contact. ⇒

Option 1 - **BOITE DE CONNEXION**

Placer les presse-étoupe de passage des câbles dans l'un des 6 emplacements prévus. Oter l'opercule à l'aide, par exemple, d'un tournevis. ⇒

Ne pas presser au centre du cercle ou toucher l'arrière du module.

Employer des câbles prévus pour une utilisation extérieure (Ø de 7 à 12,5 mm).

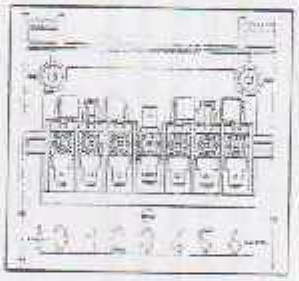
Raccorder le (+) à la borne 0 et le (-) à la borne 6. Pour un fonctionnement en 24V relier les bornes 2/4 ensemble, sinon (12V) relier entre elles les bornes (+) 0/4 et (-) 2/6 ⇒

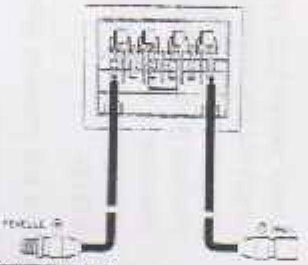
Après raccordements, enduire les parties métalliques avec la graisse silicone fournie.

Pour un montage étanche, placer un joint torique dans la gorge du couvercle et mettre 2 vis supplémentaires (Il est toutefois préférable de laisser une circulation d'air dans la boîte afin d'évacuer l'humidité.)

Option 2 - **SORTIES PAR CABLES**

Les connecteurs utilisés sont fabriqués par Multi-Contact. ⇒





Electrical ratings		PW500 - PWX500			PW1000					
			12 V			24 V			12 V	
Typical power	[W]	45	50	55	100	105	110	100	105	110
Operating voltage	[V]	16.9	17.2	17.3	34.4	34.6	34.8	17.2	17.3	17.4
Current at op. voltage	[A]	2.65	2.9	3.2	2.9	3.05	3.15	5.8	6.1	6.3
Short circuit current	[A]	2.95	3.1	3.45	3.1	3.2	3.4	6.2	6.4	6.8
Open circuit voltage	[V]	21.6	21.6	21.7	43.2	43.4	43.6	21.6	21.7	21.8
Minimum power	[W]	40.1	45.1	50.1	95.1	100.1	105.1	95.1	100.1	105.1
Maximum syst. Voltage	[V]		600 V			600 V			600 V	
Serie fuse			6 A			6 A			12 A	

Electrical ratings		PW850 - PWX850			PW1250			PW1650					
			12 V			18 V			24 V			12 V	
Typical power	[W]	75	80	85	115	125	135	155	165	175	155	165	175
Operating voltage	[V]	17.0	17.3	17.6	25.4	25.7	25.9	34	34.4	35	17	17.2	17.5
Current at op. voltage	[A]	4.4	4.6	4.8	4.5	4.8	5.1	4.6	4.8	5	9.2	9.6	10
Short circuit current	[A]	4.7	5.0	5.2	4.7	5.0	5.3	4.8	5.1	5.3	9.6	10.2	10.6
Open circuit voltage	[V]	21.5	21.6	21.6	31.9	32.0	32.1	43	43.2	43.4	21.5	21.6	21.7
Minimum power	[W]	70.1	75.1	80.1	110	120	130	150	160	170	150	160	170
Maximum syst. Voltage	[V]		600 V			600 V			770 V			770 V	
Serie fuse			8 A			8 A			8 A			16 A	

Electrical ratings		PW6-110	PW6-123	PW6-230	
		12 V	12 V	24 V	12 V
Typical power	[W]	110	123	230	230
Operating voltage	[V]	17.2	17.9	34.9	17.45
Current at op. voltage	[A]	6.4	6.85	6.6	13.2
Short circuit current	[A]	6.8	7.6	7.2	14.4
Open circuit voltage	[V]	21.7	21.9	43.6	21.8
Minimum power	[W]	106	119	223	223
Maximum syst. Voltage	[V]	770 V	770 V	770 V	770 V
Serie fuse		10 A	10 A	10 A	20 A

Values prone to evolution / Valeurs sujettes à évolution

Measuring uncertainty 5%, including 2.5% uncertainty on the reference module tested by an internationally recognized laboratory.
Incertitude de mesure 5 %, dont 2,5 % dus au module de référence qualifié par un laboratoire international [illegible].

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Example Network #1

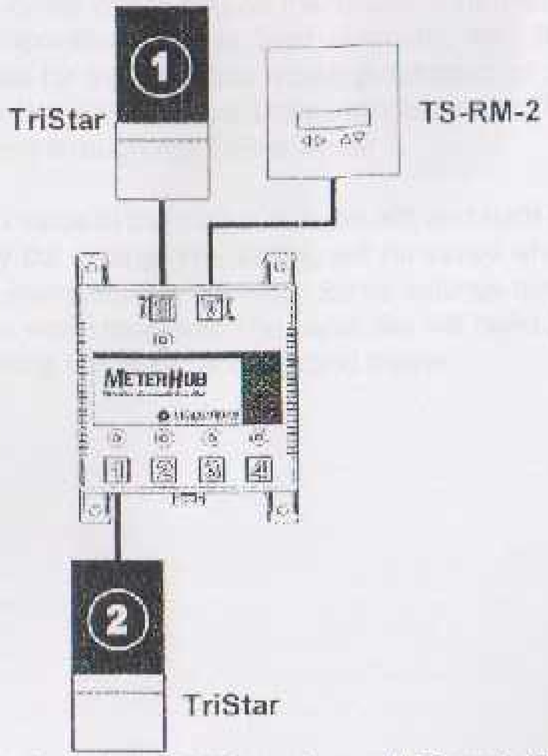


Figure 3-2. A simple two TriStar system with Remote Meter.

- TriStar 1 provides power both to a hub and to a single Remote Meter connected to Output Power Port A.
- TriStar 2 is connected to Port 1 on the Hub and is electrically isolated from TriStar 1.

NOTE:
Electrical isolation protects controllers, cables, and other system equipment from damaged due to poor or disconnected system grounds.

Example Network #2

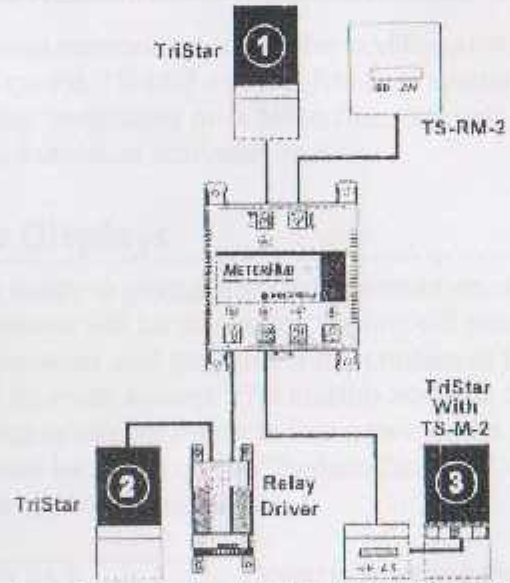


Figure 3-3. A medium-sized network with 3 TriStars, 2 meters, and a Relay Driver.

- TriStar 1 provides power to the hub and Remote Meter.
- TriStar 2 powers the Relay Driver and TriStar 3 powers the Local Meter. It is good practice to distribute the network meters and Relay Driver as shown to avoid loading a single TriStar with all of the network accessories.
- All three TriStars are isolated from each other in this system.

NOTE:
Information is shared across the entire MeterBus network. A meter can be connected anywhere in the system and will always show full aggregate system information as well as information about each controller on the network. This is true regardless of the meter model (TS-M-2 / TS-RM-2).

The setting values displayed in the Advanced Setup menu screens varies depending on the TriStar controller model and mode of operation (charge, load, diversion, etc). Refer to the meter map for the particular model purchased for detailed display information. Not all TriStar models support settings adjustment through the TriStar Meter 2.

For each value in the menu, use the left and right pushbuttons to modify the setting. The setting will be saved when the up or down pushbutton is pressed. Some settings may fault the controller when modified. The controller will need to be reset by removing and then reconnecting power.

4.3 TriStar MeterBus Networks

The following section describes the additional meter screens displayed on the TS-M-2 and TS-RM-2 in systems with two or more TriStar controllers on a MeterBus network. Section 4.2 covers the individual controller menus.

Startup Displays

When the meter is plugged in and powered on, a sequence of startup screens will be displayed. Figure 4-8 below shows the startup sequence and provides a description of the information displayed on each screen. The startup screens are only displayed once when the meter is first powered on. This information can also be found under "System Settings" in the System menu during normal operation.

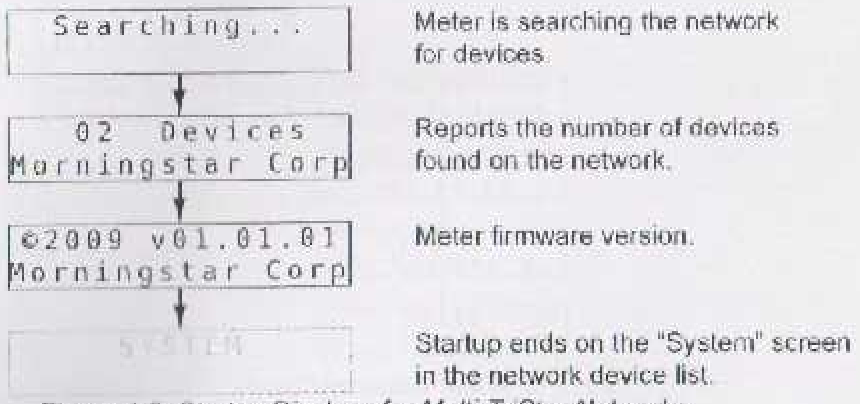


Figure 4-8. Startup Displays for Multi-TriStar Networks

Network Device List

The Network Device List is a top level menu that contains a screen for each controller on the network. There is also an additional "SYSTEM" screen that provides system-wide information.

An example Network Device List is shown in figure 4-9 below. The example system has two controllers: a charge controller and a TS-45 in Load mode.

Figure 4-9. Network Device List

Each device screen displays the model number, the mode of operation, and the MeterBus address. Pressing the down button on any of the device screens will advance to the controller information menu. The information menu varies depending on the TriStar controller model and mode of operation (charge, load, diversion, etc). The structure of the controller information menus is described in Section 4.2. Refer to the meter map for the particular model purchased for detailed display information.

Pressing the down pushbutton on the "SYSTEM" screen will advance to the System Information menu. The System Information menu is a special menu that is described in the next topic.

System Information Menu

The System Information menu displays the following:

- Operating Displays show aggregate system data
- Manual Operation screens for system-wide control
- System Settings menu to adjust meter settings

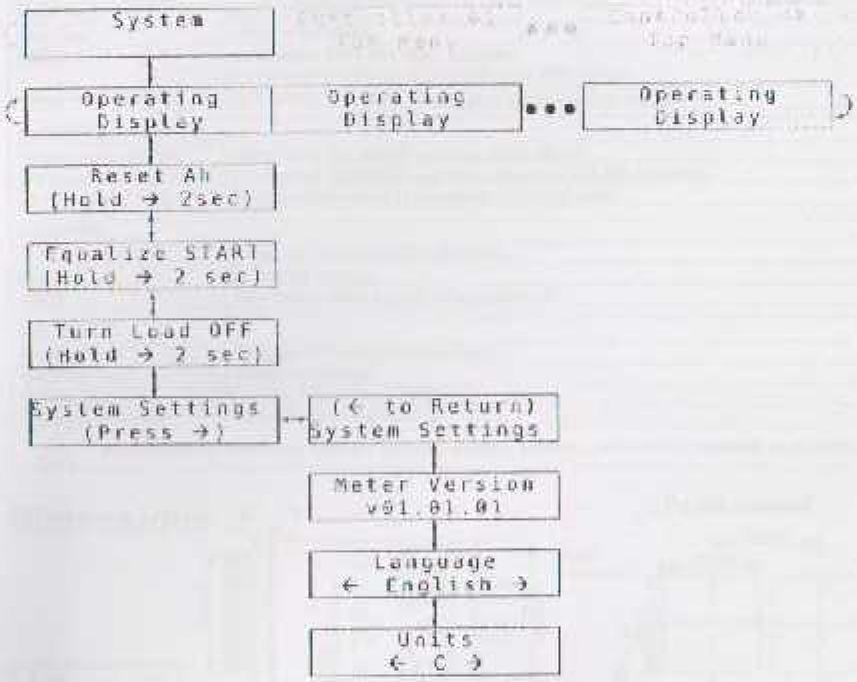


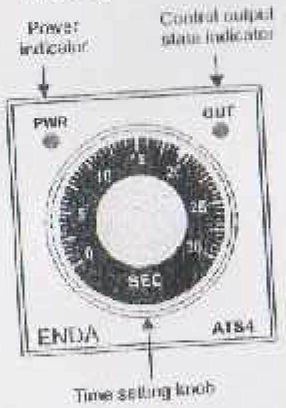
Figure 4-10. System Information menu.

Read this document carefully before using this device. The guarantee will be expired by damaging of the device if you don't attend to the directions in the user manual. Also we don't accept any compensations for personal injury, material damage or capital disadvantages.

ENDA ATS4 ANALOG TIMER

Thank you for choosing ENDA ATS4 analog timer.

CE



* 48*48mm sized.
* Start by supply voltage.
* Control output for timing funciton (A mode) with on-delay operation (OUT).
* 8 pin octal connector or screw-terminal connection.
* CE marked according to European Norms.

Order Code : ATS4-☐-☐☐☐☐-☐☐
1 2 3

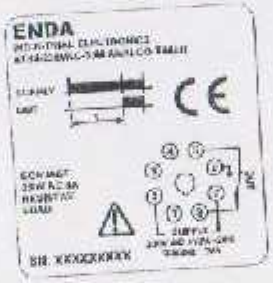
1 - Connection Type
K.........Screw Terminal
None...Octal Connector

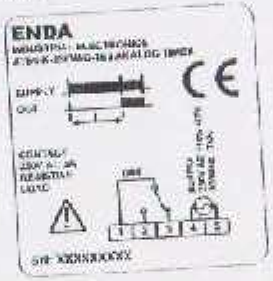
2 - Supply Voltage
230VAC...230V AC
24............24V AC/DC

3 - Time Ranges
1S2.....0 .. 1.2 seconds
3S.......0 .. 3 seconds
12S.....0 .. 12 seconds
30S.....0 .. 30 seconds
60S.....0 .. 60 seconds
3M......0 .. 3 minutes
12M....0 .. 12 minutes
30M....0 .. 30 minutes
60M....0 .. 60 minutes
3H.......0 .. 3 hours
12H.....0 .. 12 hours

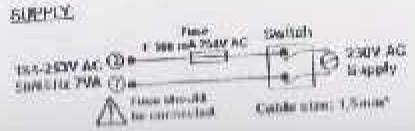
Connection Diagram

ENDA ATS4 is intended for installation in control panels. Make sure that the device is used only for intended purpose. The electrical connections must be carried on by a qualified staff and must be according to the relevant locally applicable regulations. During an installation, all of the cables that are connected to the device must be free of energy. The device must be protected against inadmissible humidity, vibrations, severe soiling and make sure that the operation temperature is not exceeded. All input and output lines that are not connected to the supply network must be laid out as shielded and twisted cables. These cables should not be close to the power cables or components. The shielding must be grounded on the instrument side.





NOTE :
SUPPLY



NOTE: 1) Mains supply cords shall meet the requirements of IEC 60730 or IEC 60245.
2) In accordance with the safety regulations, the power supply switch shall bring the identification of the relevant instrument and it should be easily accessible by the operator.

Technical Specifications

ENVIRONMENTAL CONDITIONS		
Ambient/storage temperature	0 ... +50°C/-25 ... 70°C	
Max. relative humidity	80%, up to 31°C decreasing linearly 50% at 40°C	
Rated pollution degree	According to EN 60529	Front panel : IP50 Rear panel : IP20
Height	Maximum 2000m	

⚠ Do not use the device in locations subject to corrosive and flammable gasses.

ELECTRICAL CHARACTERISTICS	
Supply voltage	230V AC +10% -20%, 50/60Hz or 24V AC/DC ±10%, 50/60Hz
Power consumption	Maximum 7VA
Connection	8-pins octal connector or 2.5mm² screw-terminal connections.
Scale	1.2, 3, 12, 30, 60 seconds; 3, 12, 30, 60 minutes; 3, 12 hours.
Reset time	Max. 0.5 seconds
Accuracy	±10% (of full scale)
EMC	EN 61326-1: 1997, A1: 1998, A2: 2001 (Performance criterion B is satisfied for EMC tests.)
Safety requirements	EN 61010-1: 2001 (Pollution degree 2, overvoltage category II)

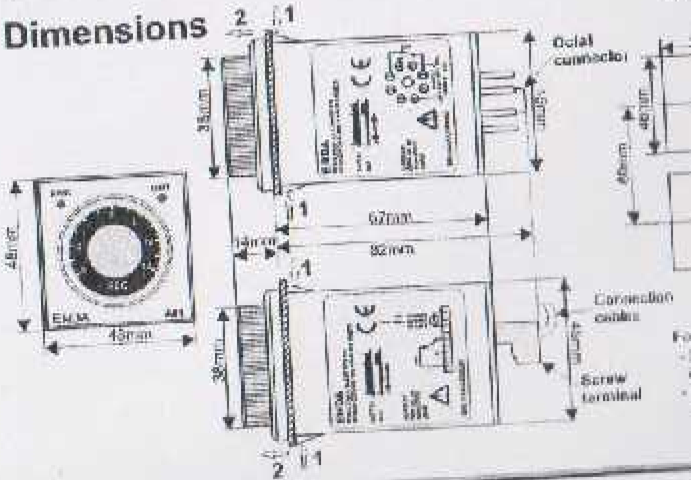
OUTPUTS	
Control output (OUT)	Relay: 250V AC, 3A (for resistive load), NO+NC
Life expectancy for relay	Mechanical 30.000.000 operation; electrical 300.000 operation
Control output state	While control output is energized OUT LED is on.

CONTROL	
Timing function	Power on-delay operation (A mode)
Start	By supply voltage.
Reset	Time resets when supply voltage goes off.

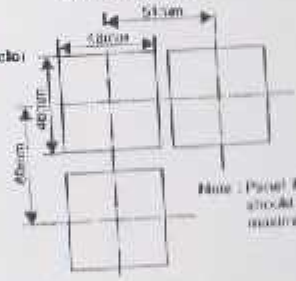
HOUSING	
Housing type	Suitable for flush-panel mounting.
Dimensions	W48xH48xD82mm
Weight	Approx. 80g (after packing)
Enclosure material	Self extinguishing plastics.

⚠ While cleaning the device, solvents (thinner, benzine, acid etc.) or corrosive materials must not be used.

Dimensions



Panel cut-out



Note : Panel thickness should be maximum 9mm

For removing the device from the panel:
- Push to the mounting clamps in direction 1 as shown below.
- Then, pull out the device in direction 2

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