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Development and Implementation of an Automatic Solar/Ac Power Supply Unit for a Refrigerator

Chukwuagu M.I.[1], Aneke E.C.[2]
[1,2] Caritas University Amorji Nike, Emene, Enugu and Nnamidi Azikiwe University (UNIZIK) Awka, Nigeria

ABSTRACT: This work focuses on a solar and AC power supply unit for a refrigerator. The two sources of power supply, an alternating current power supply and solar power supply, each connected to an automatic changeover used to switch power supply to the refrigerator unit. The alternating current power supply and solar power supply both charge the battery interchangeably through the inverter depending on the power source in use. The inverter unit consists of a battery used to store the solar energy needed to keep a constant supply of refrigeration to the refrigerator unit even when there is no alternating current power supply; a transformer which is used to step up the voltage supplied by the battery to match the voltage needed by the refrigerator unit to work properly and also an oscillator which is used to convert the direct current voltage supplied by the battery into alternating current voltage. This aims at maintaining constant operation of the refrigerator unit.

KEYWORDS: MOSFET, Inverter unit, Charge controller, Oscillator, Solar panel units

I INTRODUCTION

A refrigerator is one of our most valuable household appliances. It usually by electricity, so that the food and drinks in it stays fresh and cool, by pushing a liquid refrigerant through a sealed system, which causes it to vaporize, and draw heat out of the fridge. The vaporized refrigerant then is passed through coils outside the fridge (at the back or the bottom). This warms up the vapour, and changes it back into a liquid.

A **freezer** is a special type of refrigerator that stores food at freezing temperatures. Inside a freezer, it is normally −18 °C (0 °F). Freezers can be found in household refrigerators, as well as in industry and commerce. When stored in a freezer, frozen food can be stored safely for a longer time than storing at room temperatures.

Domestic freezers can be a separate compartment in a refrigerator, or can be a separate appliance. Household refrigerators usually have a separate compartment where the heat pump is used to pump even colder temperatures to the contents. Most household freezers maintain temperatures from −23 to −18 °C (−9 to 0 °F). Some freezer-only units can achieve −34 °C (−29 °F) and lower. Most household refrigerators generally do not achieve a temperature lower than −23 °C (−9 °F), because it is difficult to control the temperature for two different compartments. This is because both compartments shares the same coolant loop.

Figure 1.0: Image of a fridge

Standard refrigerator sizes range from around **24 to 40 inches in width, 62 to 72 inches in height and 29 to 36 inches in depth**. Moreover, the side-by-side refrigerators will be larger in width and height, though counter-depth models are frequently available in these two configurations.

II. BACKGROUND OF SOLAR PANEL UNIT

A solar panel is a device that converts light into usable energy. It is called a "solar" panel because the most powerful source of light in any instance is the sun, which was named "Sol" by Astronomers, which means solar panels are used in conjunction with the sun in order to gather adequate energy. Solar panels are sometimes referred to as photovoltaics, which means "light-electricity."

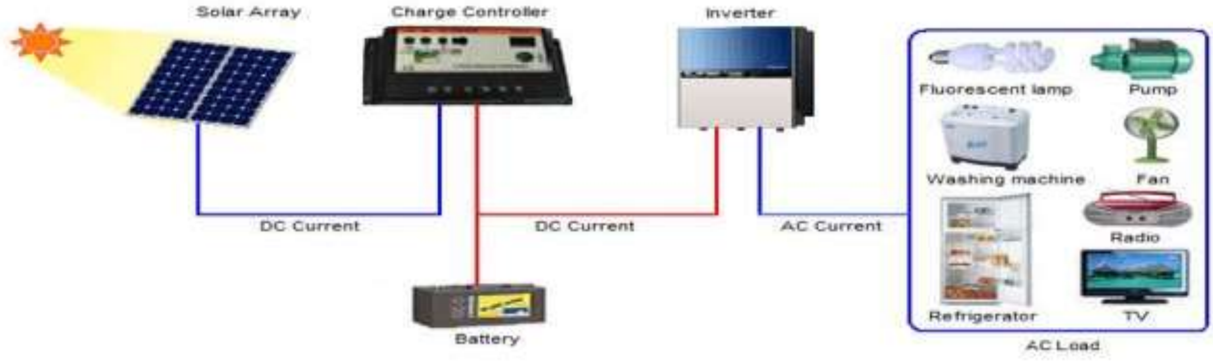


Figure 1.2: solar panel units

A number of solar cells are used to build a single solar panel. These cells is actually a collection of solar (or photovoltaic) cells, which can be used to generate electricity through photovoltaic effects. Solar panels are electricity generating structures that work through the photo electric effect. solar panels is that they **absorb the sunlight and convert it into power** that can be used for many different applications (street lighting, heating systems, machine installations, charging of phones, cameras, signage and many other energy driven devices).

III. BACKGROUND OF AN INVERTER UNIT

An inverter is a device for converting frequency. The technology is used in many home appliances and controls electric voltage, current and frequency. Inverter air conditioner vary their cooling\ heating capacity by adjusting the power supply frequency of their compressors.

The basic function of an inverter is to convert the direct current power that solar panels generate to alternating current power that is usable in appliances, homes and businesses. Fundamentally, invertebracy accomplishes the DC-to-AC conversion by switching the direction of a DC input back and forth very rapidly. This conversion process can be done with the help of a set of insulated gate bipolar transistors. When these solid-state devices are connected in the form of H-bridge, then it oscillates from the DC power to AC power. A step-up transformer is employed so that the AC power can be obtained and be fed to the grid. As a result, a DC input becomes an AC output. This is done because appliances at home run on AC power which is why the inverter must change the DC output that is collected by the solar panels.

Figure1.2: Image of an inverter

IV. BACKGROUND OF AN AUTOMATIC CHANGEOVER SWITCH

The automatic changeover or transfer switch is used to control the transfer of power from the main source (AC power supply) to the backup source (solar power supply) . The automatic changeover monitors the supply of voltage from a single-phase line and a generator supply. It then bases its control operation on the availability or unavailability of power supply from either source. It consists of a series of relays, contactors and protective devices that help form the control circuit of the automatic changeover. The automatic changeover system can be divided into four main functional blocks namely; the relay switching block, timer relay block, the contactor switching block and the Digital Multimeter (DMM) Unit.

Figure1.3: Image of an automatic changeover switch

V. BACKGROUND OF AN AUTOMATIC SOLAR AND AC POWER SUPPLY UNIT FOR A REFRIGERATOR

Throughout developed countries, photovoltaic refrigerators are most widely used to further reduce carbon emissions. These refrigerators are capable of storing perishable items such as medications and vegetables in hot weather by using energy from the sun and are used to maintain much-needed vaccines and other perishable goods at their proper temperature to avoid spoilage. The proposed compact refrigerator can be made with basic components and is suitable for places where energy is poor or non-existent in developing countries. The solar cooling system is operated using electricity generated directly from the sun by photovoltaic cells or solar heat collected from the sun by various kinds of solar collectors and also operates on the electricity generated from a direct power supply such as utilities (power distributor) or generators.

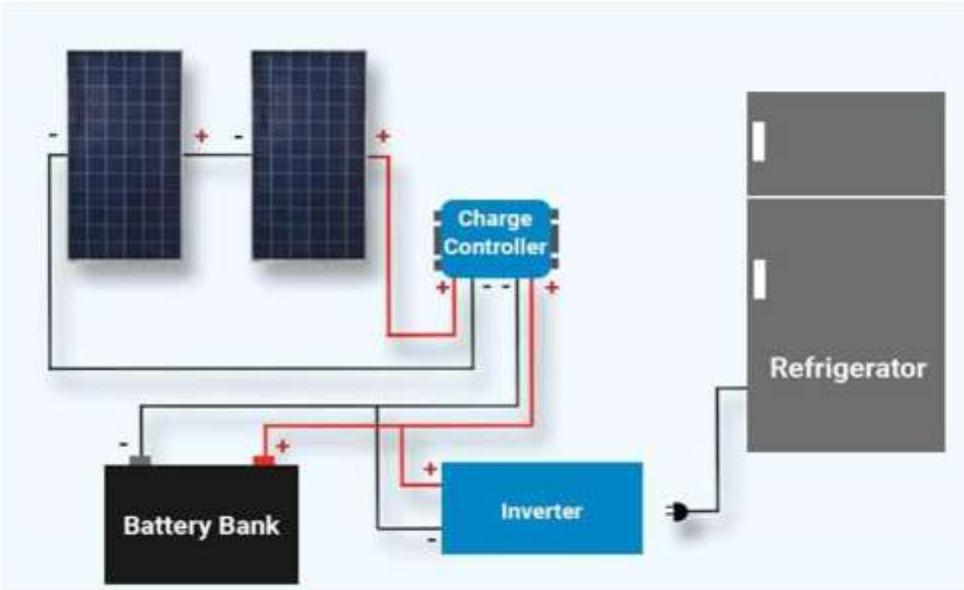


Figure1.4: Working principle of a solar power supply unit for a fridge

In our country today, interrupted power supply has been a serious issue and it makes life difficult and unbearable because people in firms, industries, churches, shopping malls, school, and even business centers depend on power supply for the day-to-day running of their activities. In households, refrigerators are necessary for preserving food stuffs, which need constant power supply to maintain a particular temperature to prevent the spoilage of food stuffs in the home. However, if constant supply of electricity is ensured for constant refrigeration, all the setback would be forestalled..

The main purpose of this work is to construct an automatic dual supply unit that can power a refrigerator in the presence of the AC power supply (main power source) and also in its absence using the solar power supply (backup power source) and also with the use of the inverter unit and an automatic changeover to preventloss of power and to ensure consistent and stable cooling by the refrigerator.

The aims of the work are the develop and implement of the various units;

- Solar panel unit
- Inverter unit
- Automatic changeover

The work will cover the selection of solar charge controller, transformer, battery, inter-connectors (cables) based on the requirement of the system and the refrigerator unit based on the wattage (energy consumption).

This work will also determine the amount of power needed by the solar power system to kick-start a refrigerator and maintain a constant supply of power over a certain period of time; design analysis of the solar panel unit, inverter unit and the refrigerator unit.

- Cost of equipment and components required for the construction of the various units of the system.
- Lack of time to undergo deeper and proper research and analysis.
- Lack of reference points to aid with the research made.

VI. REVIEW OF RELATED LITERATURE

The first instance of artificial refrigeration was demonstrated by Scottish physician and professor William Cullen. In 1748, he observed and demonstrated the cooling effect of rapidly evaporating a liquid into gas, but did not put this method into practical use. The modern mechanical refrigeration process we know today grew from the work of numerous inventors in the 1800s. The chemical refrigerator was developed nearly a century later and brought to the commercial market in 1834. Ferdinand Carré made further refinements in 1859 but, at this time, refrigerators were definitely not a standard feature in private homes. People still tended to rely on blocks of ice for cooling food, storing food in a simple wooden crate containing pieces of wood and insulation materials. This explains the origin of the term ‘ice box’, which some still use today to refer to refrigerators. In 1876, households were revolutionised by Carl von Linde, who played a key role in the development of the refrigerator, and later technical and chemical advances saw refrigerators becoming a standard feature in American private households by the 1930s.

VII. HISTORICAL BACKGROUND OF SOLAR PANEL UNIT

Long before the first Earth Day was celebrated on April 22, 1970, generating awareness about the environment and support for environmental protection, scientists were making the first discoveries in solar energy. It all began with Edmond Becquerel, a young physicist working in France, who in 1839 observed and discovered the photovoltaic effect— a process that produces a voltage or electric current when exposed to light or radiant energy. A few decades later, French mathematician Augustin Mouchot was inspired by the physicist’s work. He began registering patents for solar-powered engines in the 1860s. From France to the U.S., inventors were inspired by the patents of the mathematician and filed for patents on solar-powered devices as early as 1888. Take a light step back to 1883 when New York inventor Charles Fritts created the first solar cell by coating selenium with a thin layer of gold. Fritts reported that the selenium module produced a current “that is continuous, constant, and of considerable force.” This cell achieved an energy conversion rate of 1 to 2 percent. Most modern solar cells work at an efficiency of 15 to 20 percent. So, Fritts created what was a low impact solar cell, but still, it was the beginning of photovoltaic solar panel innovation in America. Named after Italian physicist, chemist and pioneer of electricity and power, Alessandro Volta, photovoltaic is the more technical term for turning light energy into electricity, and used interchangeably with the term photoelectric. Weston proposed, “to transform radiant energy derived from the sun into electrical energy, or through electrical energy into mechanical energy.” Light energy is focused via a lens (f) onto the solar cell (a), “a thermopile (an electronic device that converts thermal energy into electrical energy) composed of bars of dissimilar metals.” The light heats up the solar cell and causes electrons to be released and current to flow. In this instance, light creates heat, which creates electricity; this is the exact reverse of the way an incandescent light bulb works, converting electricity to heat that then generates light.

VIII. HISTORICAL BACKGROUND OF INVERTERS

The first known use of the term “inverter” was in 1925 by engineer David Prince. He published an article in the GE Review in which he wrote: “the author took the rectifier circuit and inverted it, turning in direct current at one end and drawing out alternating current at the other’ So, a solar inverter is called an inverter because it reverses, or ‘inverts’ a rectifier’s operation. Charles S. Bradley invented the rotary converter in 1888. At the time most appliances and machinery operated on DC power, but AC transmission was quickly becoming dominant. There was a pressing need to convert the transmitted AC power into DC that the appliances could use. Rotary converters and also motor-generator sets did this job from the late nineteenth century until the mid-twentieth century. Now when we talk about power converters like this – that convert AC to DC – we usually just call them ‘rectifiers’. By the 1950s inverters moved from being mechanical devices to ones with solid-state circuits. This was made possible by the dawn of a new field of engineering called ‘power electronics’.

IX WORKING PRINCIPLE OF AN AUTOMATIC SOLAR AND AC POWER SUPPLY FOR A REFRIGERATOR

The develop and implement of an automatic solar and AC power supply unit for a refrigerator composed of these parts;

i) the cooling unit (refrigerator),
ii) the energy production unit (PV panels and Utility power supply),
iii) the energy control unit, (the inverter) and s
iv) The automatic changeover
v) The charge controller

The automatic solar and AC power supply unit for a refrigerator works on the principal of two different power supplies one being the AC power supply and the other, the solar power supply, which is switched automatically in the absence of the AC power source. In this system, the refrigerator is powered by AC voltage. The DC voltage supplied by the solar panel to the inverter is converted to AC voltage by the oscillator found in the inverter and is stored in the battery for future use. The idea behind this design is to ensure constant cooling of contents in the refrigerator.

As stated above the automatic solar and AC power supply unit for a refrigerator comprises of four parts; the refrigerator unit which is used to preserve foodstuffs in households and vaccines in labs or hospitals, the solar panel and AC power supply as the generating source used to power the refrigerator and also charge the battery, the inverter unit which consists of a transformer used to step-up the supplied voltage to match the required voltage, the oscillator used to convert DC voltage to AC voltage and the automatic changeover used to switch the power supplied to the refrigerator from the AC power supply to the solar power supply (backup) in its absence, the battery bank which is used to store power from both energy sources for future use and the charge controller used to regulate the power supplied to the battery, used to ensure the battery receive power when it has not been charged fully and also to stop power from reaching the battery when it is fully charged.

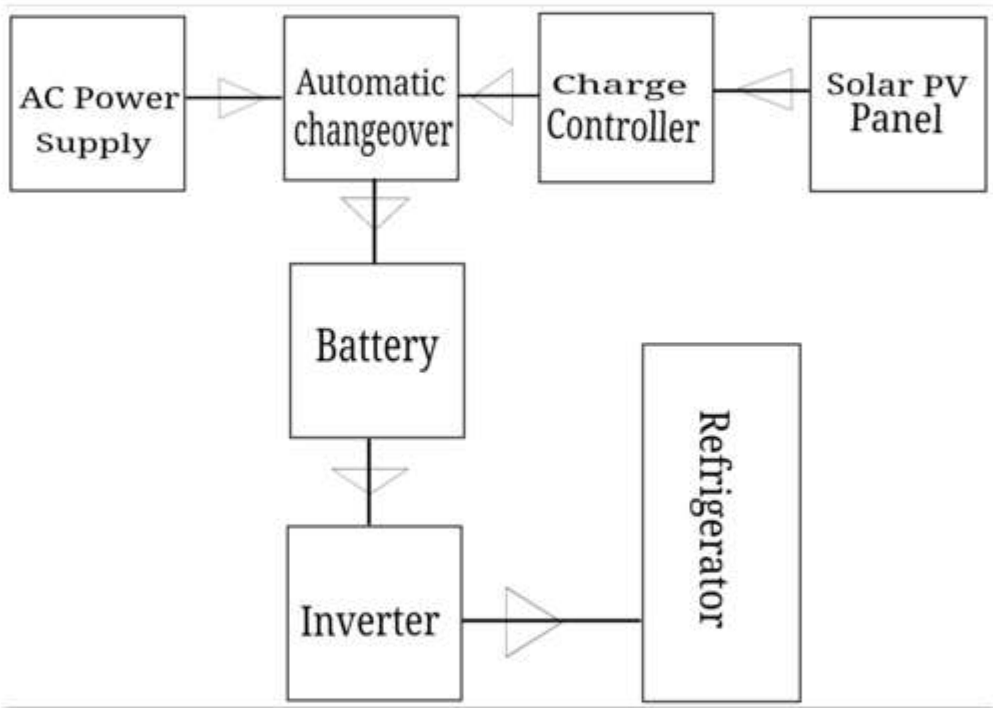


Figure1.5: Working principle of an automatic solar/AC power supply unit for a refrigerator

X. EMPIRICAL STUDY

The system is developed by integrating solar and cooling components such as a refrigerator unit, a solar panel unit, a 300watt inverter, a charge controller and a 12v DC battery. The Power Unit consists of a solar panel connected to a charger controller with an integrated inverter that ensures that the battery is properly charged while converting the DC voltage of the battery to an AC voltage that is useful to the refrigerator. While the charge controller ensures that the battery is not drained, it also means that the refrigerator unit only retains the voltage and current accepted. In the absence of AC power supply, the automatic changeover switches to the solar power supply whereby the inverter is used to power the refrigerator unit.

Various calculations were made to determine the following parameters:

- The starting current given as 8.33A
- The running current given as 2.8A
- Maximum power of the inverter 300 watts

XI. SUMMARY OF REVIEW OF RELEVANT OR RELATEDLITERATURE

Fakeha Sehar, et al.: In this study, the impact of ice storage systems on the chiller energy consumption for large and medium-sized office buildings in diverse climate zones has been investigated. The various studies indicated that the systems with ice thermal storage (ITS) have chiller energy consumptions than the conventional non-storage systems because of the day and night operation of the chiller.

Mehmet Azmi Aktacir: In this study, a PV-powered multi-purpose refrigerator system has been erected to investigate experimentally its daily and seasonal operating performances based on semi-arid climatic conditions of Sanliurfa province in Turkey. It is one of the sunniest rural regions in the world and hence the need for refrigeration is critical. The overall results revealed that PV-refrigerator system can be reliably used in places where the local grid was unreliable and the refrigeration need is critical.

Sanford A. Klein and Douglas T. Reindl: In this study, it was stated that the energy use associated with refrigeration system operation and the environmental impacts associated with its generation and distribution often outweigh the choice of friendly environmental refrigerants. In this article, three approaches to use solar energy for refrigeration at temperatures below 0C were reviewed and their operating characteristics were compared. The coefficient of performance of all the three refrigeration cycles. The PV system was most viable of all other systems especially for small capacity portable systems whereas the absorption systems were more feasible for large stationary refrigeration systems.

Todd Otanicar, et al.: In this study, a variety of solar cooling schemes have been economically and environmentally analyzed to reveal some key details regarding system choice. For solar electric cooling the system, the cost is highly dependent on the system COP when PV prices remain at the current levels but when prices are lowered the impact of COP on cost diminishes. One additional favourable aspect to solar electric cooling systems is the collector area foot print i.e. for solar PV systems, expected sizes in 2010 were between 24 and 48 m² as compared to 78 and 106 m² for solar thermal systems depending on the system COP.

XII. MATERIALS AND METHOD

In the implementation of an automatic solar and AC power supply unit for a refrigerator, the following units are taken into consideration;

- Refrigerator unit
- Solar panel unit
- Inverter unit
- Battery
- Charge controller and
- Automatic changeover

SOLAR PANEL UNIT

Solar panels are those devices which are used to absorb the sun's rays and convert them into electricity or heat**. Description: A solar panel is actually a collection of solar (or photovoltaic) cells, which can be used to generate electricity through photovoltaic effect. When the sun shines onto a solar panel, energy from the sunlight is absorbed by the PV cells in the panel. This energy creates electrical charges that move in response to an internal electrical field in the cell, causing electricity to flow.**

Solar panels use sunlight as a source of energy to generate direct current electricity. They are three types of solar panels namely;

- Polycrystalline solar panel
- Monocrystalline solar panel
- Thin-film solar panel

INVERTER UNIT

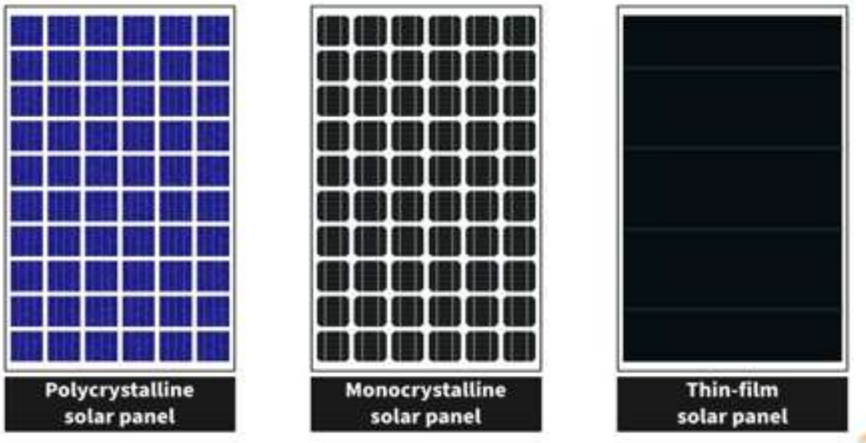


Figure1.6: Images of the types of solar panels

An inverter is **energy saving technology that eliminates wasted operation in air conditioners by efficiently controlling motor speed**. Air conditioners maintain set temperature by cooling when room temperature rises above the set temperature and heating when the room temperature falls below the set temperature.

Figure1.7s: Image of an inverter

The inverter unit comprises of the following components;

- Oscillator
- Transformer
- MOSFET
- Diodes
- Vero board

Figure1.8: Images of an oscillator

OSCILLATOR An oscillator is **a type of circuit that controls the repetitive discharge of a signal**, and there are two main types of oscillator; a relaxation, or an harmonic oscillator

TRANSFORMER

Inverter transformers are voltage-fed type of power transformers. They are often known as electronic transformers due to their application in low scale power conversion. These inverter transformers are used where the DC power supply is available but AC input is required for a power-driven device..

The transformer consists of two types of coils namely;

- Primary coil
- Secondary coil

Figure1.9: Images of a transformer

MOSFET

A field-effect transistor in which there is a thin layer of silicon oxide between the gate and the channel.

DIODE

A diode is **a semiconductor device that essentially acts as a one-way switch for current**. It allows current to flow easily in one direction, but severely restricts current from flowing in the opposite direction.

Figure2.0: Image of a MOSFET

Figure2.1: Image of a diode

VERO BOARD

Figure2.2: Image of a vero board

A brand of stripboard, a pre-formed circuit board material of copper strips on an insulating bonded paper board.
This board houses the following components;

- MOSFET
- Diodes
- C9014
- BC557
- Connecting wire
- Reset button

BATTERY

A solar battery is a device that you can add to your solar power system to store the excess electricity generated by your solar panels.

Figure2.3: Image of an inverter battery

CHARGE CONTROLLER

A charge controller or charge regulator is basically a voltage and/or current regulator to keep batteries from overcharging.

Figure2.4: Image of a charge controller

AUTOMATIC CHANGEOVER

An automatic changeover over also known as an automatic transfer switch (ATS) is a device that automatically transfers a power supply from its primary source to a backup source when it senses a failure or outage in the primary source.

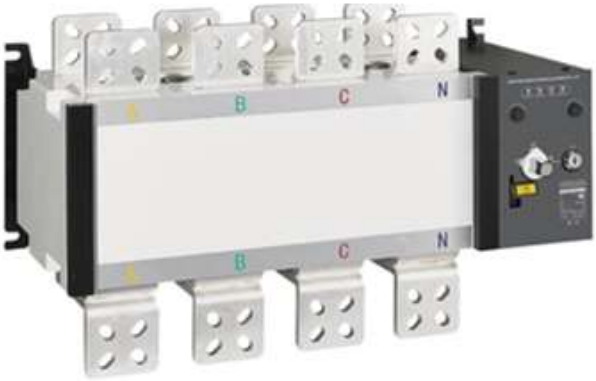
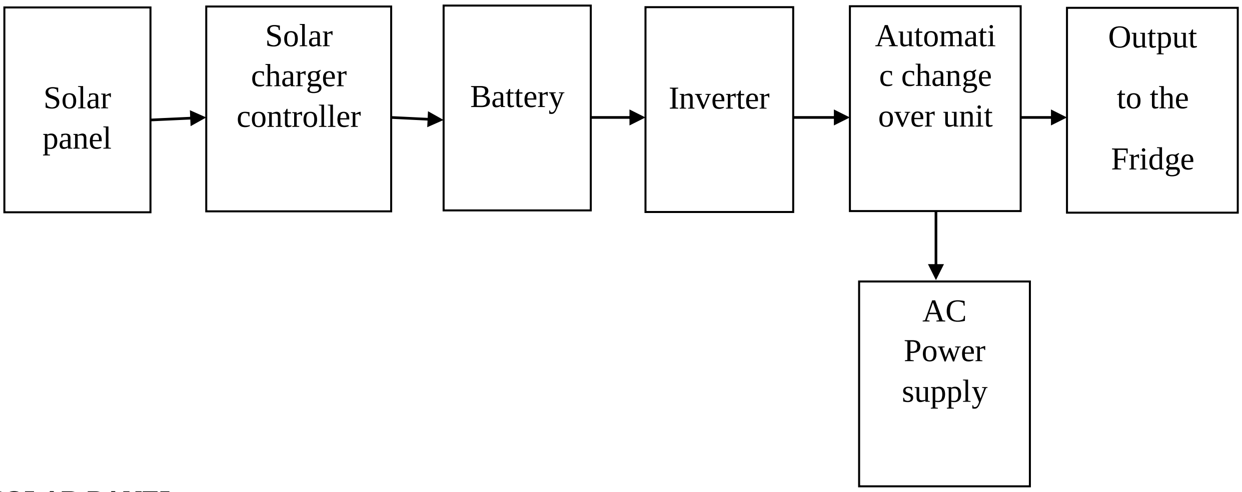


Figure2.5: Image of an automatic transfer switch

XIII. DEVELOPMENT AND CALCULATIONS



SOLAR PANEL

Solar panel is made up of a photo voltaic cell which has ability to convert sun light to voltage. Solar panel is of different types based on the cell's arrangement and the nature of the output.

Types of solar panels:

1. Monolitic solar panel
2. Polycrystalline solar panel
3. Thin-film solar panel

The most effective one out of all solar panels is monolithic solar panel and that is the one we use. Solar panels often come's in 12v/24v. The ones we used are two 12v connected in parallel. The series connection is for as to increase charging current is use a constant 12v.

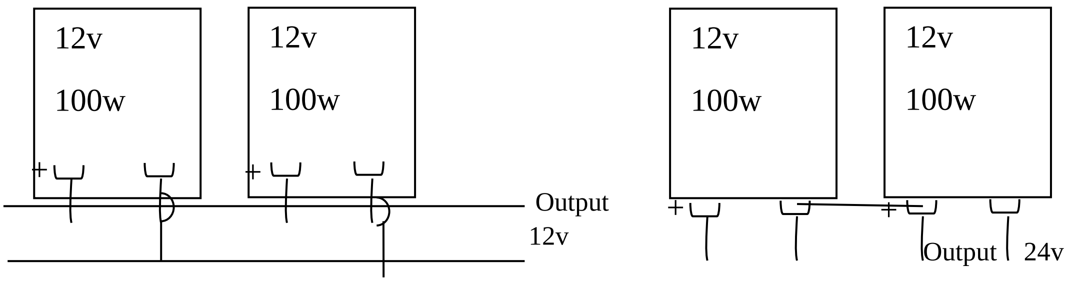
1. If the two solar panels are connected in series the output will be = 24v by 100w. to know the current we apply - P = IV

$$I = \frac{P}{V}$$

$$I = \frac{100}{24} = 4.17A$$

2. If the two panels are connected in parallel it will produce;

Parallel connection series connection



$P = IV$

$I = \frac{P}{v}$ where $p = 100w$

$v = 12v$

$I = \frac{100}{12} = 8.33A$

$P = IV$

$I = \frac{P}{v}$ where $p = 100w$

$v = 24v$

$I = \frac{100}{24} = 4.17A$

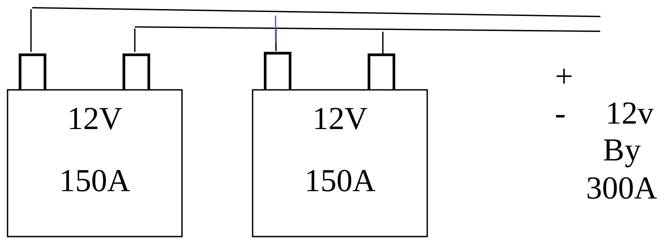
The parallel connection is better to increase the output current for fast charging of the battery.

CHARGE CONTROLLER

The solar charger controller used was 30A charger controller because the battery used was 150A by 12v which require 15A current for effective charging of the battery as the $\frac{1}{10}$ of the batteries total current as stated by IEEE as the required current for the battery to maintain the unit spare of the manufacturer.

BATTERY

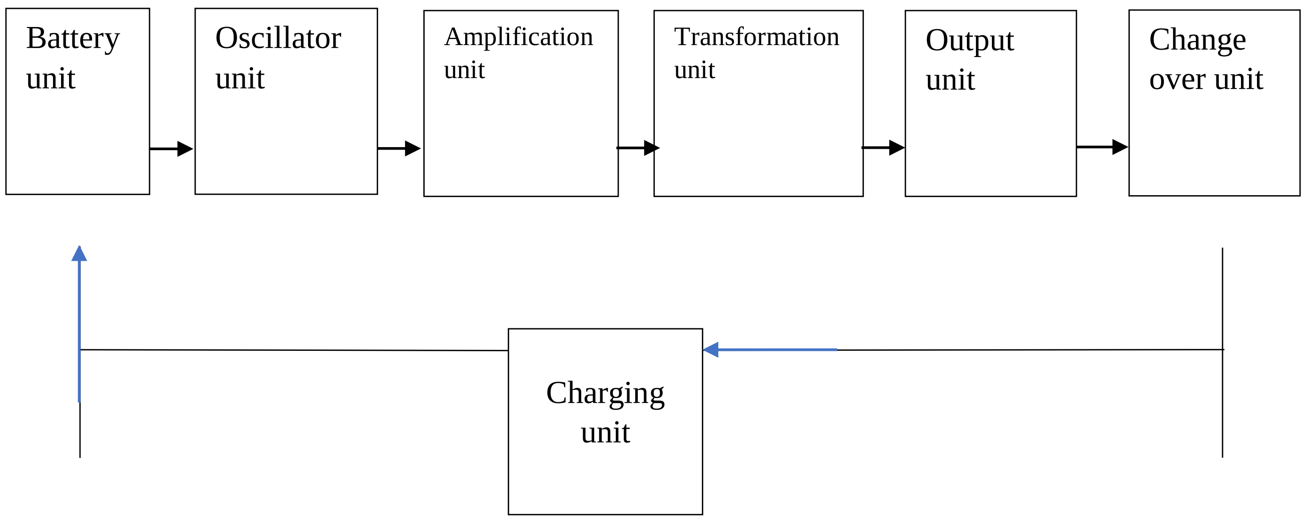
The battery used is a 12v by 150A which can last longer to sustain the systems operation in case of the periods when it may rain for 2 to 3 days and the public supply is not available. The battery used was two 12v connected in parallel.



Battery Unit: 12v D.C

INVERTER UNIT

The inverter system is of different units as specified below:



3.2.4.1 Oscillator Unit:

The time for high output

$TH = 0.7 \times R_1 \times C_1$

Period out the output = TH + TL

Frequency = $\frac{1}{T}$

On time = $\frac{TH = st_1 + st_2 + st_3}{3}$

$St_1 = 3.23$, st2 = 3.23, st3 = 3.31

TH = 3.23 + 23 + 3.31 = 3.26 sec

Off time = TL = $\frac{st_1 + st_2 + st_3}{3}$

$= \frac{1.98 + 1.99 + 2.01}{3}$

= 1.99 sec

Period TH + TL= 3.26 +1.99

= 5.25

Frequency = $\frac{1}{T}$

$$f = \frac{1}{5.25} = 0.1905HZ$$

Amplification Unit:
The transistor used for the amplification unit is MOSFET 3205 which can handle 29v by 100A.
Then we connected three (3) in parallel.

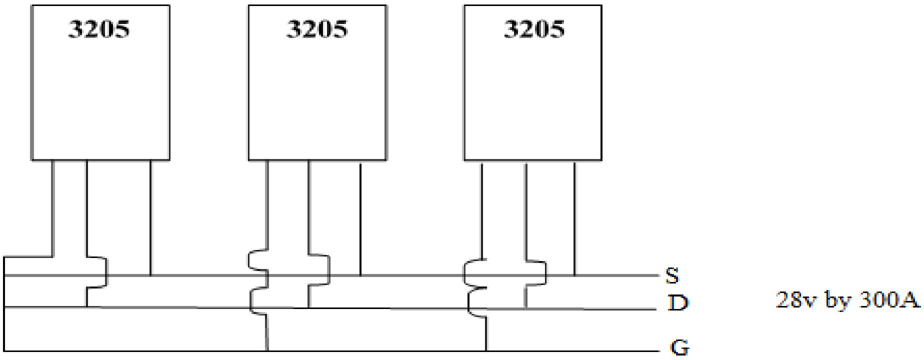


Figure2.6: Diagram of three transistors connected in parallel

Transformer Unit:

$$\frac{Np}{Ns} = \frac{Vp}{Vs}$$

Where; Np = No of turns in primary coil
Ns = No of turns in secondary coils
Vp = Primary voltage
Vs = Secondary voltage
This formula will not work because only 2 parameters are known which are Vp and Vs.
Vp = 12V and Vs = 220v
Using the transformer winding theory
Which states that:
3T = 1V
Applying it to our design to will help determine the number of turns in both primary and secondary winding.
For the primary side
3T = 1V
X = 12
$X \times 1 = 3 \times 12$
X = 36T
For secondary side
3T = 1V
X = 220v
$X \times 1 = 3 \times 220$
X=660T

XI. HOW TO DETERMINE THE COIL SIZE NEEDED FOR THE TRANSFORMER

We first calculate the current that can pass through the primary and secondary sides of the transformer. For the primary side
P = IV
P = 300W; V = 12V; I =?
$I = \frac{P}{V} = \frac{300}{12} = 25A$
For the secondary side
P = 300W; V = 220v; I =?
$I = \frac{P}{V} = \frac{300}{220} = 1.36A$

Using American standard wire gauge table to determine the coil sizes that can handle 42A for primary winding and 2A coil for the secondary side and use them for the transformer winding.
Transformer diagram with calculated parameters

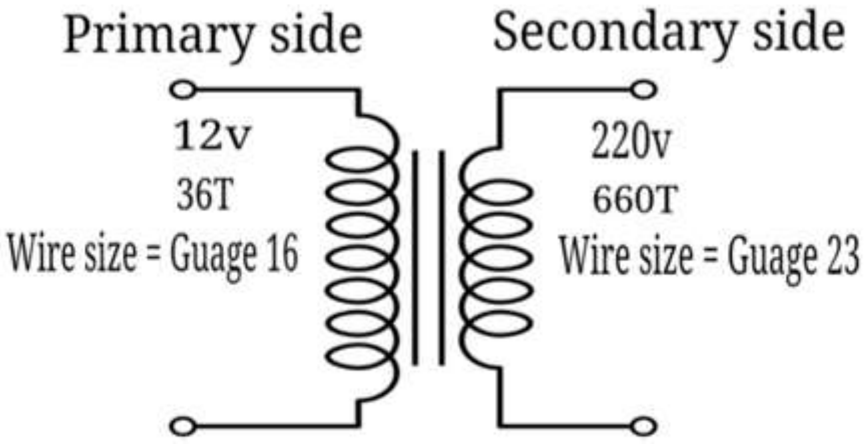


Figure 18: Diagram of a transformer with its calculated parameters

CALCULATION FOR THE STARTUP CURRENT OF THE REFRIGERATOR

1. Power input of the refrigerator = 85W

Voltage frequency = 240V
Current = 0.73A

P = IV CosØ
0.73 x240 = 175.21W

2. Output Unit: The output is 220v 1.t the output value of the transformer unit.

XV. AUTOMATIC CHANGEOVER SWITCH

This automatic transfer switch design is for a single-phase supply. The circuit can be divided into two major parts namely;

- The Power circuits
- The Control circuits

Though these two circuits work hand in hand, the control circuit is the brain box of the device that 'gives the orders. The design is an adaptation from some already existing designs but some modifications have been carried out on it to ensure that it takes care of some issues not considered in previous designs. The circuit for this project work is therefore designed to perform the following functions.

1. Ensure that both sources of power do not supply at the same time and this is ensured through its electrical interlocks.
2. It ensures that when primary supply (AC power supply) is restored, it is monitored and confirmed that it is not just momentary or a surge before it stops the generator and connects it to load.
3. Ensures that the whole installation i.e., the device and the load is well protected with the use of miniature circuit breakers

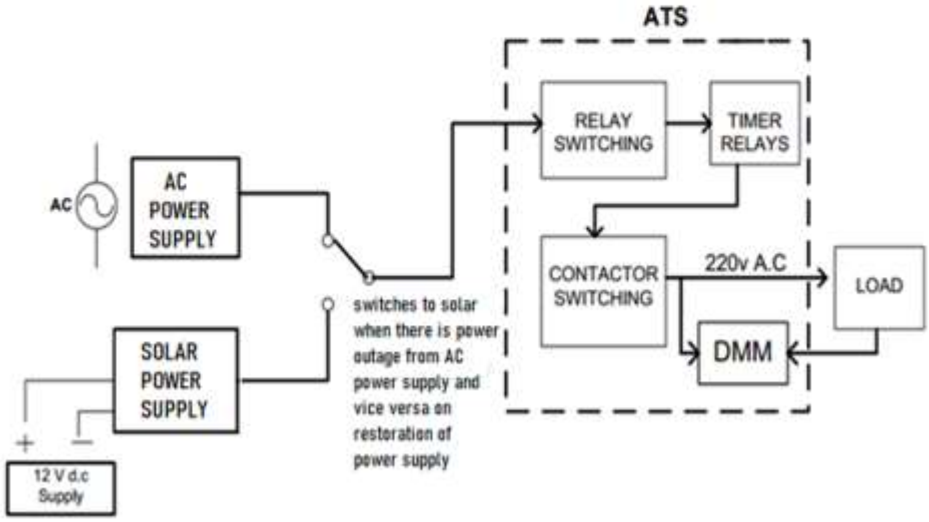


Figure 2: Working principle of an automatic transfer switch

XVI EXPERIMENTAL METHODS

After the develop the system experimental exercise was carried out step by step according to the block diagram.

The first step was procurement of the required solar panel according to the values obtained from my design which was 100W by 12v to increase charging speed, I made it two to reduce the charging time for satisfactory performance. The panel output, read the value obtained is as listed below: -Table 1.0 : experimental methods

S/N	Time (s)	Voltage (v)	Current (I)
1.	8:00am	5v	1A
2.	10:00am	8 v	3A
3.	11: 00am	10 v	5A
4.	01: 00pm	12 v	8A
5.	02: 00pm	13 v	8.4A

The second step was to connect the solar panel with the controller.

Table 1.1: EXPERIMENT 2

S/N	Time (s)	Controller Voltage (v)
1.	5:00Am	00.00v
2.	7:00Am	05:00v
3.	10:00Am	10:00v
4.	12:00Am	12:00v
5.	02: 00Am	13.50 v
6.	7:00pm	00:00v

The third step was connecting solar panel, controller and battery

Table 1.2 : EXPERIMENT 3

S/N	Battery voltage	Time (s)
1.	8.80v	7:00Am
2.	10:50v	9:00Am
3.	11:11v	11:00Am
4.	12:00v	12:30pm
5.	13:00	3:00pm

The fourth step was on inverter implementaion.

The transformer was found with the parameters from my design and calculation as stated above.

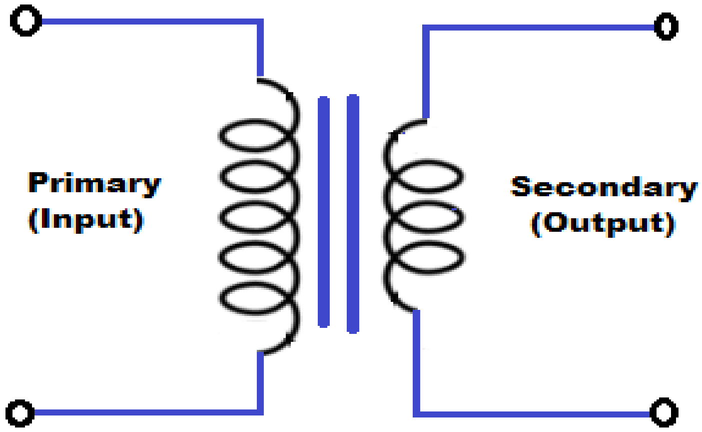


Figure 3: Diagram of a transformer

After winding the resistance of the primary and secondary was read and recorded as below: -:
Primary side resistance = 160*Ω* secondary side resistance = 286 *Ω*.
Resistance of the primary side was lesser because the coil at the primary is bigger and with lesser resistance while the resistance of secondary is higher due to the coil used at the secondary is thinner and with high resistance. After testing resistance and it was ok, the transformer was supply with 220v at the output and the value of the opposite side was 12v which show that the transformer is ok.

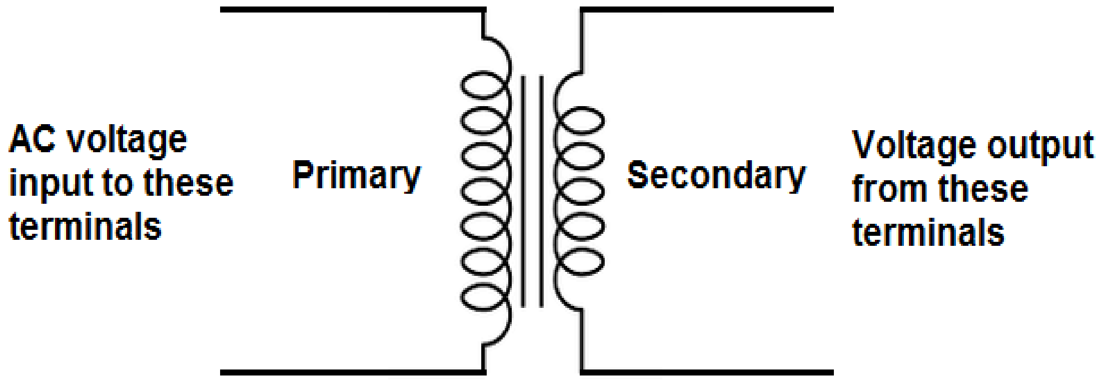


Figure2.7: Diagram of a transformer with the voltage supplied by the primary and secondary coil

In fig 21 above, the following sides has its parameters given as;
1. Primary side: Has an input voltage = 12v
2. Secondary side: Has an output voltage(power supply) = 220v

The fifth step was on automatic changeover switch construction.
The automatic changeover switch is made up of two sections namely;
1. THE POWER SECTION: The power section of that the is responsible for the switching between generator and primary source of supply. The circuit diagram for this is shown in the figure below;

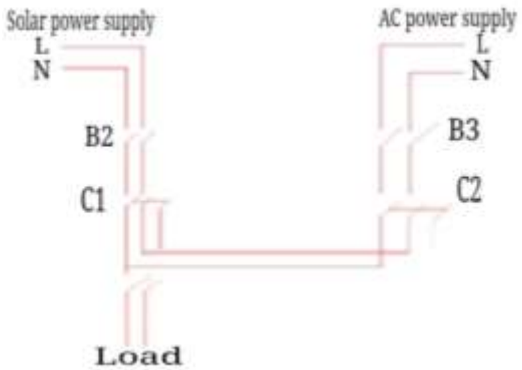


Figure2.8: Diagram of the power section of an ATS

The miniature circuit breakers, B2, and B3 are meant for isolation and protection of various parts of the circuit. The contactors C1 and C2 are the generator and primary source contactors respectively. The control circuit send signals to this circuit on when to switch and to which supply to switch.
2. THE CONTROL SECTION: This is the brain box of the device. It controls everything that goes on in the entire ATS and ensures that the circuit works exactly the way it is configured. This section can be divided into two parts which are the auto – start section and the auto – transfer section. The auto – transfer section can be further divided into two circuits namely the generator auto – transfer circuit and the primary source (PHCN) auto – transfer circuit.

XVII. RESULTS AND DISCUSSION

After the development and implementation phase, the system has to be tested for durability, efficiency, and effectiveness and to also ascertain if there is need to modify this development. The system was first tested on the computer where it was simulated and then assembled physically on a printed circuit board (PCB). All components were properly inserted into the breadboard where some tests were carried out at various stages. To ensure proper function of components' expected data, the components were tested using a digital multimeter (DMM). Resistors were tested to ensure that they were within the tolerance value. Faulty resistors were discarded. The MOSFETS were also tested for continuity after been connected in parallel to ensure its adequate function, after which the transformer was connected to a power source of 220VAC and the primary side was tested to be 12VDC.

DISCUSSION OF RESULTS

It is proper that after implementation that careful testing of the output of each stage is carried out. This is to confirm that it conforms to the expected output and the test carried out is the continuity test. The transformer used was also tested to make sure it conforms to the expected output voltage as well. The system was powered and operated upon using several possibilities. These include loading the inverter and noting the output responses of the system hardware. The system worked well and the inversion of battery voltage to 120-220v AC which is the objective of this project was achieved. The inverter delivered a maximum power of 300w when the required rated battery was used. For the refrigerator

Table 1.4: The system result

Input voltage	Output voltage on full load	Frequency
12V DC	220v ac	50HZ

XIX. CONCLUSION

This work has given us a better understanding of the practical aspect of our course of study (Electric/ Electronics Engineering).It also enables us to acquire more practical skiskillsll and knowledge. The completion of this work of AC/solar powered refrigerator with 300W/12v inverter has given expected results after different tests were carried out on each stage which gave durable and accurate result. The inverter in the refrigerator was able to convert on input voltage of 12V Dc source into an output voltage of 220V Ac power supply and a frequency of 50Hz and it was able to power the refrigerator and can also reduce family spending on energy utilization because of its non- fuel consumption, low price and maintenance cost as compared to the other refrigerator in the market. This volume describes the recent advances and current status of a wide range of approaches to capturing and explicating solar energy to serve the humanity's needs.

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