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Solar Energy-Powered Multiple Cellphones Charging (Booth)

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ABSTRACT: The work present the development and implementation of a solar powered multiple cell phones charging system (booth) for 50 cell phones that is capable of charging multiple phones including laptops 24 hours without supply from the main grid. The work is a stand-alone solar renewable energy system that can be used in urban and rural areas with the aim of solving the problem of phone as at when due, due to power failure from main grid or where there is no electricity at all. The system hardware is consists of Solar panel, charge controller, deep circle battery, inverter and multiple charging outlets. The solar panel converts the sun energy to direct current electrical energy to charge the battery through the charge controller. The charge controller controls and regulates the voltage from the solar panel to the battery and also monitors the charging process to avoid over charging of the battery. The battery stores the energy from the sun and supplies it to the input of the inverter. The inverter inverts or converts the direct current (DC) to an alternating current (AC). The 220VAC at the output of the inverter is connected to the multiple socket outlets where phones and laptop is connected for charging.

KEYWORDS: Solar energy, charging system, renewable energy, inverter

I. INTRODUCTION

Solar energy is the energy available from the sun which can be collected by solar panel and concentrated on water to produce steam to drive turbine and for domestic heating purposes. It can also be converted to electricity for lighting our home and streets. Solar energy is the energy available from the sun. The sun is the ultimate energy resources available to man. Its energy does not deplete, it cannot be used by green plants in the process of photosynthesis. Solar energy can be converted to electrical energy using photocells. Solar radiation can be converted to chemical energy by photochemical process. Solar panel can be used for heating homes and boiling water.

Solar energy is of extreme importance in the development of any society. It is the engine that makes the society to function. Developed countries are those whose energy resources are being put into efficient and maximum use in improving the social and economic life of the their society.

The aim of this work is to develop and implement an efficient and economical 2.5kw solar inverter that will utilize the appropriate use of office electrical appliances.

The objectives are as follows: -

- ✓ To develop a model based on solar energy for stead use of power supply, by ensuring continuous availability of power supply in the cause of main outage during an execution of an important or urgent assignment. Thereby enabling the industrial meet up with its office duties even when central power is not available.
- ✓ Solar energy can help to **reduce the cost of electricity**, contribute to a resilient electrical grid, create jobs and spur economic growth, generate back-up power for night-time and outages when paired with storage, and operate at similar efficiency on both small and large scales.
- ✓ Reduce load on the transmission network will bring about reduction in fuel cost in the generation of power. This would amount to significant financial saving for utilities.
- ✓ Reduction in the quantity of power available from the transmission network will bring about decrease in a customer utility bill on energy utilization because of its non-fuel consumption which will cause low price and maintenance cost as compared to the convectional sources of power supplies within urban and local region.
- ✓ Again, reduction in carbon dioxide which is thought to be responsible for some fraction of the rapid increase in global warning seen especially in increasing temperature records observed all over the world.

Furthermore, load reduction has significance in keeping the power system operating within its thermal limits. Keeping the power system within thermal limit helps in keeping generation and transmission infrastructure at top performance, it wills also reducing the aging processes of the generation and transmission equipment in the system.

The proposed work will be capable of charging 50 cell phones simultaneously, It must have a source, a function and also an output. For our source we will be using solar panel. The system will contain the charge controller for preventing the battery from over charging.

It has been in focus worldwide and solar installations of capacities in megawatts order are reality today. The magnitude of the solar panels remains low even today and the requirement of ensuring highest intensity output of the panel remains strong. Thanks to this, several techniques have been deployed to harness the maximum energy, Maximum Power point tracking being one of them. The devices typically need few watts and many of these devices/gadgets now use USB port for charging. The standardization to USB voltage presents opportunity to design more and more chargers that conform to this form factor and voltage requirements. All gadgets are charger typically with a 5V to 5.5V source.

PROCESS OF CONVERSION OF SUN ENERGY

Two methods are usually considered when harnessing sun energy. We can use Photovoltaic Cells or Solar thermal technology.

RADIATION

Is general term for the electromagnetic radiation emitted by the sun? Three major types of solar radiation: (1) visible light (2) infrared light (3) ultraviolet light

RADIATION AND THE VISIBLE SPECTRUM

We are aware of solar energy arriving at the Earth in the form of visible light. To understand light, scientists generally take two basic approaches:

- ✓ Geometric optics is used to examine the light falling on a solar collector as well as the shading and design of passive solar system.
- ✓ Quantum mechanics is used to understand the interaction between a solar collector and the incident light impinging on it.

TYPES OF RADIATION

Direct Radiation

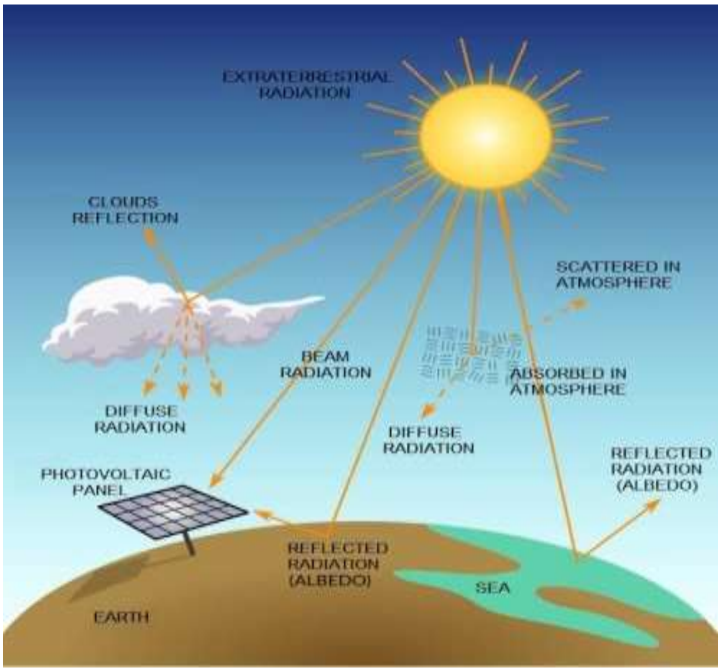
Radiation that reaches the earth's surface instead of being reflected or scattered in the atmosphere .In other words, the radiation from the sun, which is not blocked by clouds.

Diffuse Radiation

Radiation that reaches the earth's surface but is first scattered by naturally occurring gases in the atmosphere (mostly nitrogen and oxyge) , clouds, dust, smoke etc. This type of radiation is why the sky appears blue or the clouds white.

Reflected Radiation

Radiation that reaching the earth's surface after reflection from objects not in the atmosphere such as the ground or snow.



SOLAR POWER (Irradiance)

Solar radiation is power and the unit for measuring power is the watt (W). The term irradiance is used when describing solar radiation as a source of power. The symbol for irradiance is 'E'. However as the irradiance depends on the surface of impact it has to be defined in W/m^2

On a cloud free day in northern Nigeria, the solar irradiance can reach values of 1KW/m^2 .

SOLAR ENERGY (Irradiation)

Irradiation is the amount of light energy from one thing hitting a square of another each second. Photons that carry this energy have wavelengths from energetic X ray and gamma rays to visible light to the infrared and radio.

PHOTOVOLTAICS

Photovoltaic cell consists of different layers of different materials which aid the successful converting of sun energy. The cell absorbs photon from the sun, and with proper wiring, electricity is generated. This method is widely used and economic friendly since it emits less or no greenhouse gas. Thus, this technology is referred to as greenhouse technology.

During my industrial training exercise, I was exposed to the working principle of PV system. And also, the various ways this system can be set up.

Photovoltaic is simply the conversation of light from the sun (**photon**), into electricity **(Voltage).** The process of this conversion is known as **Photovoltaic effect.**

The process of converting solar energy into electricity is when the sun shines onto a solar panel; energy from the sunlight is absorbed by the PV cells in the panel. Include

- Absorption of energy carrying particles in suns ray called photons.
- Photovoltaic conversion, inside the solar cells.
- Combination of current from several cells. This step is necessary, when a single cell has a voltage of less than 1.5 V.
- Conversion of the resultant DC to AC is known as a an inverter.
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PHOTOVOLTAICS EFFECT: the appearance of a potential difference (voltage) between two layers of a semiconductor slice in which the conductivities are opposite, or between a semiconductor and a metal, under the effect of a light stream.

A photovoltaic cell is made of semiconductor materials that**absorb the photons emitted by the sun and generate a flow of electrons**. Photons are elementary particles that carry solar radiation at a speed of 300,000 kilometers per second.

DEVELOPING A SOLAR PANEL

Solar energy can help to **reduce the cost of electricity**, contribute to a resilient electrical grid, create jobs and spur economic growth, generate back-up power for nighttime and outages when paired with storage, and operate at similar efficiency on both small and large scales.

Types of photovoltaic cells

The Photovoltaic technology utilizes two technologies; crystalline form and the amorphous silicon. The amorphous is still a new exploration and may take longer to achieve optimal performance.

CRYSTALINE CELLS

A monocrystalline solar panel is a solar panel comprising monocrystalline solar cells. These cells are made from a cylindrical silicon ingot grown from a single crystal of silicon of high purity in the same way as a semiconductor. The cylindrical ingot is sliced into wafers forming cells.

AMORPHOUS CELLS

Amorphous silicon solar panels (also known as thin-film solar panels) are **created by depositing thin layers of photovoltaic silicon on a suitable substrate such as plastic, stainless steel, glass, or another transparent material**.

Concept of Cell Phones

Is a portable usually cordless telephone for use in a cellular system.

A cellphone is simply a telephone that doesn't need a landline connection. It enables the user to make and receive phone calls. Some cellphones also offer text messaging. A smartphone has more advanced features, including web browsing, software applications and a mobile OS.

A microchip in the phone modulates (or varies) a radio wave using the electrical signal. The radio wave travels through the air to a nearby cell tower; the tower sends your voice to the person you are calling and the process is reversed so that the person on the other end can hear your voice.

Hardware Components of a cell phone

Hardware: A Smartphone is, at heart, a miniature computer and thus it shares many similar components with computers – such as processors and memory. These components are constantly upgraded in new generations of phones and it's important to consider how to balance the demands you place on this hardware.

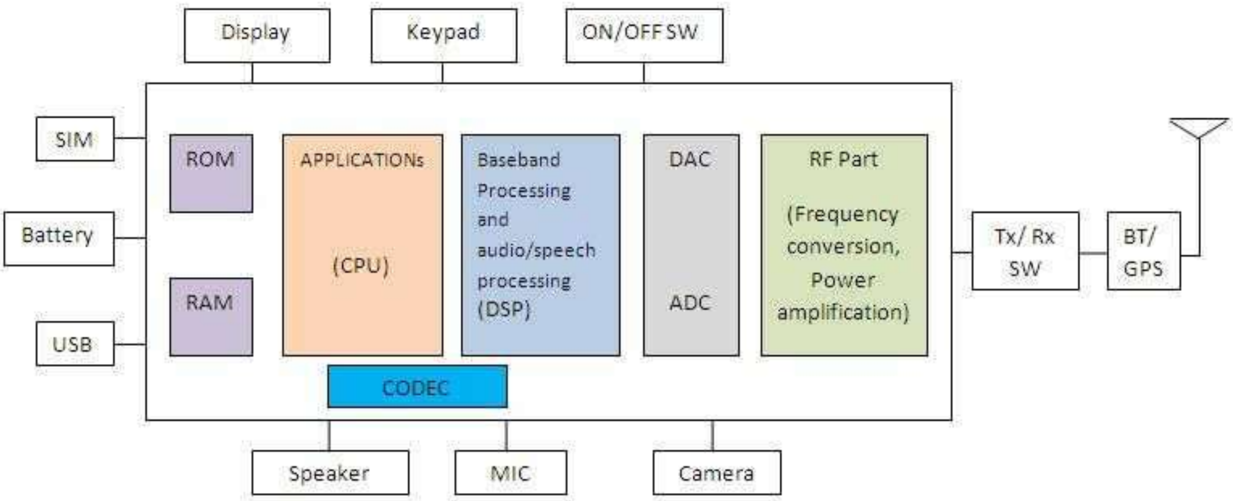

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Figure 1.0: depicts GSM cell phone block diagram

Typically hardware components of a mobile phone include display (LCD, touch screen), keypad, microphone, speaker, SIM card, battery, USB port, antenna, memory unit(RAM,ROM), camera, CODEC, RF part, DAC/ADC, baseband part (L1/Layer1/physical layer) running on DSP, Application/protocol layers running on CPU, ON/OFF ...

Uses of cell phones

1. Sending texts
2. Receiving texts
3. Reading email
4. Surfing the internet
5. Using it as an alarm clock
6. Making Calls
7. Sending emails
8. Checking the time
9. Using the calculator
10. Checking Facebook

III. EMPIRICAL /HISTORICAL STUDIES

I will begin with literary review of inverters from its origin till date. In the book “ORIGIN OF PULSE WIDTH MODULATED POWER INVERTER: OWEN EDWARD” showed that from the late nineteenth century through the middle of the twentieth century, D.C. to A.C power inversion was accomplished using rotary inverters or Motor-Generator sets (M-G sets). In the early twentieth century, vacuum tube and gas filled tubes began to be used as switches in inverter circuits. The most used type of tube was the thyratron.

According to the authoritative dictionary of IEEE standards, The origins of electromechanical inverters explain the source of the term inverter. Early AC-to-DC converters used an induction or synchronous AC motor direct-connected to a generator (dynamo) so that the generator's commutator reversed its connections at exactly the right moments to produce DC. A later development is the synchronous converter, in which the motor and generator windings are combined into one armature, with slip rings at one end and commentator at the other end and only noel frame. The result with either A.C. in D.C. out with an M-G set, the D.C. can be considered to be separately generated from the A.C. to D.C converter with a synchronous converter, in a certain sense it can be considered to be “mechanically rectified A.C to D.C converter to Given the right auxiliary and control equipment, an M-G set of rotary converter can be “run backward” converting D.C to A.C. Hence, an inverter is an inverted converted. It should be noted that since 1954 there have been many high voltage D.C transmission system implemented around the globe with the advent of DC/AC converters; allowing the easy stepping up and down of D.C voltage. Like D.C power, there exist many devices such as power tools, radio and TVs that run OFF of A.C power. It is therefore crucial that both forms of electricity transmission exist; this world cannot be powered with one simple form. It then becomes a vital matter for there to exist easy ways to transform D.C to A.C power and vice versa in an efficient manner.

C. J. HATZIADONIU member, IEEE and F. POURBOGHAT member IEEE from their studies have shown that inverter system is the way out. They were able to show that the inverter system like the 1500w, 220-240v inverter and other inverters can be used to provide the grid interface and the power conditioning of certain disturbed generators and energy storage system.

A Nigerian electronics engineer SAMUEL WILLIAMS, IEEE member, in his studies has shown that inverter system has a lot of applications in the world of electronics. An inverter system converts the D.C electricity from sources such as batteries, solar panels or fuel cells to A.C electricity. In the same sense, BEDFORD B. D. HOFT (1964) in his book “Principles of electronics” shows that this system can also be applied in uninterrupted power supply, induction heating variable – frequency drives, electric drives etc.

RODRIGUEZ JOSE (Aug. 2002) explain in his book, “multilevel inverters” how an inverter D.C to A.C. This is more than one technique. The most common is to use an electronic switch to convert the D.C into a square wave. The square wave is filtered to make it a rough sine wave. This can then be passed through a transformer to the desired voltage. The advantage of this system is that it is very efficient. The disadvantage is that the sine wave produced is not all that good a sine wave and some devices (A.C motors) for examples sometimes problems when being powered by inverters.

BOB MARTY AND JOHN SCOTT, N.Y U.S.A in their book “General electric” pp 236 – 239; described the basic design of an inverter circuit. This show that in one simple inverter which uses minimum number of components for converting a 12V DC to 230V AC. 50Hz inverter, D.C power is connected to a transformer through the tap changer of the primary winding. Switches can be used to switch a low voltage DC device (e.g. LEDs) ON or OFF using saturation region or cut off state. The alternation in the direction of current in the primary winding of the transformer produces alternating (A.C) current in the secondary circuit.

MARK THMPSON, CEO of Fairchild semiconductor described controlled rectifier inverters since early transistors were not available with sufficient voltage and current ratings for most inverter applications. It was the 1957 introduction of the thyristor or silicon-controlled rectifier (SCR), the gas-filled tubes used previously were difficult to operate and unreliable. The symmetrical alternating current switch (TRIAC), the gate turn-off thyristor (GTO), and the large integrated gate-commutated thyristor (IGCT) evolved from the SCR.

SHAM CHOUDURY, member IEEE describes the MOSFET INVERTER GATE DRIVE. An inverter for producing A.C from a source of D.C electric power is analyzed. The power circuit includes the power transformer with the current flow through the two halves of the primary winding. It’s being controlled by a pair of power MOSFETS. A gate driver circuits which includes a driver transformer produces control signals which are substantially 180^0 out of phase across the center tapped secondary winding of the driver transform. A pair of Fast and slow oscillator circuit on coupling circuits consisting of a diode connected in parallel with a resistor couples gate control signals to the gates of the power MOSFETS. Each coupling circuit is effectively in series with one of pair current limiting off-time resistors, the latter being connected in series with the two halves of the primary winding of the gate driver circuit control transformer. The relationship of resistances of the resistors of the coupling circuits to the resistances of the current limiting resistors of the gate driver circuit determines the differences between the turn-off times of the MOSFET. The current limiting resistors prevent burnt out of the gate driver contact transformer and the gate control transistors.

Review of relevant concepts/themes

Solar powered phone charging booth

LONDON (Thomson Reuters Foundation) - Some of London's famous red telephone booths are going green, transformed into free, solar-powered mobile chargers to provide a carbon-neutral source of energy in the city. The "solarbox", unveiled on Wednesday, was invented by two graduates from the London School of Economics (LSE) and can be used to charge phones, tablets, cameras and other devices. The first solar powered phone booth" was opened for public use in Tottenham Court Road in London's main central shopping district 2014 and is equipped with a solar panel which provides a clean, carbon-neutral source of energy. A second solar powered phone booth was opened in 2015 while more will follow. Organizers did not put a number on how many of London's red phone boxes, which are increasingly unused, will be converted into solar boxes. Costs for the green box that can be used free of charge are covered through in-kiosk advertising. The brains behind the solar powered phone charging booth, Kirsty Kenney and Harold Craston, won 5,000 pounds ($8,000) funding for the project from the Mayor of London, Boris Johnson, in his 2014 Low Carbon Entrepreneur competition this summer. "In our modern world, where hardly any Londoner is complete without a raft of personal gizmos in hand, it's about time our iconic boxes were update for the 21st Century, to be useful, more sustainable," Johnson said in a statement (1 US dollar = 0.6174 British pound).

IV. MATERIAL AND METHOD

The key focus on this work in term of method is to develop a model based on solar energy for stead use of power supply, by ensuring continuous availability of power supply in the cause of main outage during an execution of an important or urgent assignment. Thereby enabling the industrial meet up with its office duties even when central power is not available. Solar energy can help to **reduce the cost of electricity**, contribute to a resilient electrical grid, create jobs and spur economic growth, generate back-up power for night-time and outages when paired with storage, and operate at similar efficiency on both small and large scales.

Reduce load on the transmission network will bring about reduction in fuel cost in the generation of power. This would amount to significant financial saving for utilities.

The proposed work will be capable of charging 50 cell phones simultaneously; it must have a source, a function and also an output. For our source we will be using solar panel. The system will contain the charge controller for preventing the battery from over charging.

Material and Equipment.

The following materials and Equipment used for the work implementation is listed below.

1. Solar panel
2. Charge controller
3. Deep cycled Battery
4. Inverter
5. Angle Bar
6. Metal pipe
7. MBF wood
8. Tyre
9. Solar to battery cable
10. Output socket wire
11. Cable clip
12. 13 amps socket
13. Screw nail

Description of materials

Angle Bar: An angle bar also referred to as an angle iron or L-bracket, is a finished metal part in a right angle shape, with perpendicular legs that may be equal or unequal in length. I

Metal pipe: Steel pipes are cylindrical tubes made from steel that are used many ways in manufacturing and infrastructure. The primary use of pipe is in the transport of liquid or gas underground—including oil, gas, and

MBF wood:_ MBF means "thousand board feet" and refers to the yield of board feet, in thousands, that can either be found in a quantity of sawn lumber or that can reasonably be derived from logs or standing timber.

Tyre: The tyre is a rubber ball with bearing at the centre with a rod in between just to reiterate, spherical, which means they offer drivers true 360-degree motion. The tyre enables the phone booth to be moveable.

Solar panel to battery cable: the solar to battery cable is a 4mm twin copper cable that is connected to the output of the solar panel to conduct current from the panel to the charge controller PV input.

Output socket wire: the output socket wire is a 1mm wiring cable that is connected to the 220V output of the inverter and to the entire 13amps socket where the phones and laptop will be charged.

Cable clip: the clip is a tower clip used in clipping both the output socket wire and the solar panel to battery cable.

13 amps socket: 13 amps socket is the 220V outlet where the phone users can plug their phone or laptop to be charge.

Screw nail: the screw nail is a metal screw about one inch that is used to fasten the MBF wood to the angle iron.

Experimental Method

The solar powered multiple phones booth was design and construction with the following method.

A photovoltaic (PV) cell is an energy harvesting technology that converts solar energy into useful electricity through a process called the photovoltaic effect. There are several different types of PV cells which all use semiconductors to interact with incoming photons from the Sun in order to generate an electric current. A solar cell consists of a layer of p-type silicon placed next to a layer of n-type silicon(Fig. 1). In the n-type layer, there is an excess of electrons, and in the p-type layer, there is an excess of positively charged holes (which are vacancies due to the lack of valence electrons). The panel produces 31VDC/8.4 amps at the output once it is exposed to the sun when the sun is at it peak. The positive output terminal of the solar panel is connected to the positive PV input of the charge controller while the negative output terminal of the solar panel is connected to the negative PV input of the charge controller. The battery terminals are connected to the charge controller output where the battery symbol is drawn according to their rightful polarity. Once the charge controller picks the 12VDC signal of the battery it will automatically adapt its charging voltage to suit the battery voltage. The battery is connected first to the charge controller before the solar panel. The same positive terminal of the battery that is connected to the charge controller is connected to the positive input cable of the inverter, while the negative terminal of the battery is connected to the negative input cable of the inverter. The 12VDC/100AH from the battery is been supplied to the inverter input, while the inverter converts the 12VDC/100AH to an alternating current with voltage rating of 220V and capacity rating of 2KVA. The output of the inverter is connected to all they socket through a 1mm copper cable.

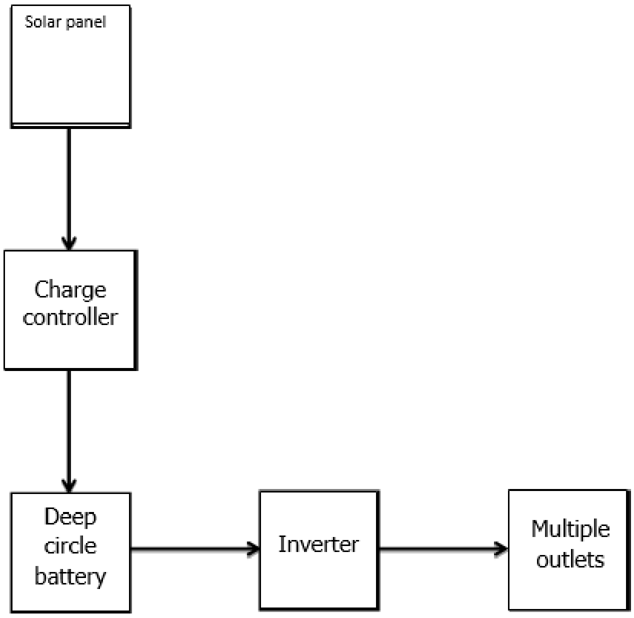

Figure 1.0: The system block diagram

Inverter design.

i. Oscillator Design:

A. SG3524 pin description: SG3524 is a 16 pin PWM (Pulse Width Modulation) controller IC. It is a very common IC in "MOSFET based Inverter device. This IC contains various sections such as oscillator, output, error amplifier, shutdown and +5V regulator. All these sections are used to control the Inverter. Pin description of 1C SG3524 is given below:

Pin-1 – are used for offset voltage in op-amp IC 741. Because of the higher voltage gain of op-amp IC 741, even minimal variation of voltage at inverting and non-inverting inputs caused due to abnormalities in construction procedure or other external disturbances can influence the output voltage. This pin given the operational amplifier inverting input receives feedback from the output of the amplifier.

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Pin-2: This is the voltage supply pin of the display, used to connect the supply pin of the power source.

Pin-3 – A regulator of auxin efflux and involved in differential.

Pin-4 - This pin is related to amplifier section.

Pin-5 – accesses an internal node that is obtained from the supply/ground pins via a voltage divider. This node establishes the reference voltages for the comparators. Adding a capacitor stabilized the voltage by suppressing the high frequency noise.

Pin-6 – Detects when the voltage on the timing capacitor rises above 0.66 Vcc and resets the output when this happens.

Pin-7 –Provides a discharge path from the timing capacitor to ground when the output is low.

Pin-8 – Positive power supply voltage.

Pin-9 – It is a RESET pin, which is used to reset the microcontroller to its initial values.
Pin-10 - Shutdown input. More than 0.66V to this pin shuts Down, the oscillation section inside the IC,
Pin-11 – is TXD (serial data transmit pin) which is serial output pin. Through this output signal microcontroller transmits data for serial communication.
Pin-12 - Positive supply for oscillator section.
Pin-13 - Positive supply for oscillator section.
Pin-14 – There are 7 pins on each side, 14 pins total. ICs in this form are called Dual In line Package (DIP). When an IC has only one row of pins, it os called a Single In line Package (SIP). The number of pins changes depending on the function of IC. At the bottom left is an IC socket for use with 14 pin DIP ICs.
Pin-15 - Positive supply for IC,
Pin-16 - Output of voltage regulator. A constant, regulated +5V is output from this pin.
RT (R8 + R9) and C1 connected at pin 6 and pin 7 of the IC SG3524 respectively determine the frequency of oscillation. Using equation below we determine the value of the unknown parameter.

$$F = \frac{1.18}{C_I C_T} \quad \text{.......................... (1)}$$

Assume $\boldsymbol{C_1}$= 0.1 x 10^{-6}F and the required frequency f = 50Hz

Therefore, $F = \frac{1.18}{0.1\times 10^{-6}\times 50} = 236K\Omega$

The IC SG3524 is used in the oscillation section of this inverter. This IC is used to generate the 50Hz frequency required to generate AC supply by the inverter. The battery supply to the pin 15 of the SG3524 chip offers improved performance and requires less external parts while building swithing power supplies. In the circuit diagram of pin 11 and pin 14 are connected to the TIP41 high power NPN transistors for driving the step up transformer. D3 at the base of Q3 as shown in Figure below is use to regulate the IC SG3524 supply voltage. The pin 8 is connected to the negative terminal of the battery. The pins 6 and 7 of the IC are the oscillation section pins. The frequency produced by the IC depends on the value of the capacitor and resistor connected at these pins. The capacitor (0.1 µF) is connected to pin 7. This capacitor decides the 50Hz frequency output by the IC. Pin 6 is the timing resistance pin. The resistance at this pin keeps the oscillator frequency constant. A pre-set variable resistor (20K) is connected to ground from pin 6 of the IC. This pre-set is used so that the value of the output frequency can be adjusted to a constant 50Hz. A fixed resistance of 220K is connected in series with the variable resistor as shown figure. 3. by the relation:

$$F = \frac{1.30}{C_1 C_2} \quad \text{............................. (2)}$$

Where F is the frequency in KHz, $\boldsymbol{R_T}$is the total resistance at pin 6, and $\boldsymbol{C_T}$is the total capacitance at pin 7. Therefore, to obtain a frequency of 50Hz,
Given $\boldsymbol{C_T}$= 0.1µF

$$F = \frac{1.30}{50\times(0.1\times10^{-6}} = 260K\Omega$$

Therefore, $\boldsymbol{R_T}$must be varied at 100K to obtain a frequency of 50Hz. In our design, we used a fixed resistor of 200K and a variable resistor of 100K.
Signals generated at the oscillator section of the IC reach the flip-flop section of the IC. This section converts the incoming signals into signals with changing polarity. In this signal, changing polarity means when the first signal is positive, the second would be zero and when the first signal becomes zero, the second would be positive. Therefore, to achieve a frequency of 50Hz, this process most repeat every 50 times per second i.e. a pulsating signal with 50Hz frequency is generated inside the flip-flop section of the IC.
This 50Hz frequency alternating signal has an output at pins 11 and 14 of the IC.
This pulsating signal may also be known as the MOS drive signal. This MOS drive signal at pins 11 and 14 is between 4.6 - 5.4V
Voltage at these pins should be same, because any variation in the voltage at these pins could damage the MOSFET at the output.
Since the reference voltage for the error amplifier (pin 2) is set to be 2.5v using voltage divider. Therefore voltage supplied to pin 1 said to be 2.5v.
Using voltage divider:
Assume $\boldsymbol{R_4}$= 4700Ω

$$\boldsymbol{V_{pin1}} = \boldsymbol{V_{ref}} \times \frac{R_4}{R_4 + R_3} \quad \text{..................... (3)}$$

$\boldsymbol{V_{pin1}}$ = 2.5v

$$2.5v = 5 \times \frac{4700\Omega}{4700\Omega + R_3}$$

$\boldsymbol{R_3}$ = 4700Ω or 4.7KΩ

$$V_{pin2} = V_{out} \times \frac{R_S}{R_S + R_5} \quad \text{............................ (4)}$$

$\boldsymbol{R_S} = R_6 + R_7$ note that V_{out} is positive value which is equals to 14.5v in our design. Required voltage at pin 2 is equal to 2.5v.
Assume $\boldsymbol{R_5}$= 100 KΩ

$$R_S = \frac{V_{pin2} \times R_S}{V_{out} + V_{pin2}} \quad \text{.................................... (5)}$$

$$R_S = \frac{2.5 \times 100\,000}{14.5V - 2.5V} = 20.833K\Omega$$

Taking pre-set $\boldsymbol{R_6}$as 20k then $\boldsymbol{R_7}$ = 0.83 KΩ

$V_{pin15} = V_{D3} - V_{BE(Q3)}$

V_{pin15} = 13 – 0.7 = 12.3V

ii. MOSFET power switch:
When large amount of power is needed, the MOSFETS is cascaded to get the amount of power required. The power to be generated depends on the capacity of the MOSFET and the rating of the transformer. The circuit diagram is shown as in figure 5.
The power output for the design is 2KVA (2000VA) by using a power factor of
0.8×P (.VA) = 0.8×2KVA (2000VA) = 1600Watts.
I = P (w)/V (v) = 1600/12(using 12v battery)
= 133.33A

This implies that the load must have a current handling capacity in excess of 133.33A. Since the maximum AC power for a class B amplifier (switching circuit) is given as:

Pac = V**cc** × Imax/2 = 12×133.33/2 = 800W

The power dissipation of the circuit is given by

P**dis** = 2× **Pac**/2π

= 2 × 800/2*3.142

= 278.485W

≈ 278.5W

This means that energy dissipated as heat on the MOSFET on full load will be appropriately 278.5W.

This choice of MOSFET selection depends on max current and power dissipation of the project; IRFP260N MOSFETs were used. The IRFP260N has the required specifications of power dissipating of 280watt Continuous source current of 50amp.

Since the power dissipation of the MOSFET is greater than the expected power dissipation of the circuit, the MOSFET will work perfectly. Each channel of the switching unit consist of five MOSFET, the maximum heat that will be dissipated by the MOSFET is shown in the calculation below,

Max power for MOSFET $= \frac{278.485}{5} = 55.7$ watts

From the calculation shown the power that will be dissipated by each MOSFET is 55.7 watt.

iii. Transformer Design:

A transformer is a device that couples two AC circuits magnetically and provides electrical isolation between the circuits while allowing a transformation of voltage and current from one circuit to another i.e. it is mainly used for voltage and current transformation and hence we made use of current voltage transformers in this project.

The E.M.F in a Wounded Transformer: Consider an alternating voltage is applied across the primary winding of the transformer and the frequency of the supply voltage is f. This applied voltage produces a sinusoidal flux φ in the core of the transformer, which is given by, $\varphi = \varphi_m \sin\omega t$. In a transformer, source of alternating current is applied to the primary winding. Due to this, the current in the primary winding (called as magnetizing current) produces alternating flux in the core of transformer. This alternating flux gets linked with the secondary winding, and because of the phenomenon of mutual induction an emf gets induced in the secondary winding. Magnitude of this induced emf can be found by using the following EMF equation of the transformer.

EMF Equation Of The Transformer

Let,

N_1 = Number of turns in primary winding

N_2 = Number of turns in secondary winding

Φ_m = Maximum flux in the core (in Wb) = (B_m x A)

f = frequency of the AC supply (in Hz)

the flux rises sinusoidally to its maximum value Φ_m from 0. It reaches to the maximum value in one quarter of the cycle i.e in T/4

sec (where, T is time period of the sin wave of the supply = 1/f).

Therefore,

average rate of change of flux = $\Phi_m / (T/4)$ = $\Phi_m / (1/4f)$

Therefore,

average rate of change of flux = 4f Φ_m .... (Wb/s).

Now,

Induced emf per turn = rate of change of flux per turn

Therefore, average emf per turn = 4f Φ_m ....(Volts).

Now, we know, Form factor = RMS value / average value

Therefore, RMS value of emf per turn = Form factor X average emf per turn.

As, the flux Φ varies sinusoidally, form factor of a sine wave is 1.11

Therefore, RMS value of emf per turn = 1.11 x 4f Φ_m = 4.44f Φ_m.

RMS value of induced emf in whole primary winding (E_1) = RMS value of emf per turn X Number of turns in primary winding

$E_1 = 4.44f N_1 \Phi_m$ .... eq 1

Similarly, RMS induced emf in secondary winding (E_2) can be given as

$E_2 = 4.44f N_2 \Phi_m$. .... eq 2

from the above equations 1 and 2,

Now rate of change of flux per turn means induced e .m .f in Volt

Thus Average e.m. f /turn =4 x F x max. Flux

Since the flux is sinusoidal, r.m.s = form factor x Average e.m.f /turn.

But form factor = r.m.s value /Average value =1.11, Then r.m.s value of E.m.f = 1.11 x 4F x max. Flux = 4.44F x max. Flux, But max .flux = Bm x A

NOTE: Bm is assumed to be 15000Wb/m. F = 50 Hz,

the stacking factor f is calculated as follows: **A pressure of 1 N/mm2 is exerted on the stack, and the stack height is measured**: A stacking factor of 0.97 means that 97% of the stack consists of electrical steel.

TP factor= 11 to 13.5 sec and INRs of 0.8 to 1.1.

The power Rating for the Inverter transformer (KVA) = 2KVA, E2= 24V Assuming the efficiency of transformer =85%

Then Input rating =output /Efficiency=1600VA/0.85=1882VA

Ip = PI / VP

VP = 260V

Ip = 1882/ 260 = 7.23A

Is = Po / Vs

Vs = 12V

Ip = 1600 / 12 = 83.3A

For practical design of inverter transformer Number of turns per volt for both primary and secondary winding is given by;

NT.V-1= 7/A

Where A is **0.45** the net core area for the square core transformers. 0.56 is the core area for cruciform or stepped core transformers.

NT.V-1= 7/3.45=2.03

NT.V-1 = 2 (approximate value).

Primary Winding: tapping changer winding turns is to **regulate the output voltage of a transformer**. It does this by altering the number of turns in one winding and thereby changing the turns ratio of the transformer.

Np1= NT.V-1 x E1 E1=220V

Np1 = 2 x 220 = 440turns

Inverter (out) tapping winding turns

NS2= NT.V-1 x E3

E3=260V

NS2 = 2 x 260= 520turns

Difference of Inverting and Charging turns = 520 - 440 = 80turns.

For the primary windings, tap changer is brought out after 440 turns and an addition 80 turns is

to regulate the output voltage of a transformer. It does this by altering the number of turns in one winding and thereby changing the turns ratio of the transformer. There are two types of transformer tap changers: an on-load tap changer (OLTC) and a deenergised tap changer (DETC).

Secondary Winding:

Secondary turns Ns= NT.V-1 x E2 E2 = 12V

Ns= 2 x 12= 24turns. (Bifilar winding)

SWG Estimation:

Standard Gauge Weight, SGW, can be estimated as follow; **the density of current flow in some conductor** J (with fixed value of 2.5A/mm2) and windings coil current.

For Ip = 8.5A, the corresponding gauge from tables is 17SWG and

For Is = 166.3A, the corresponding gauge from tables is 11SWG

Complete circuit diagram

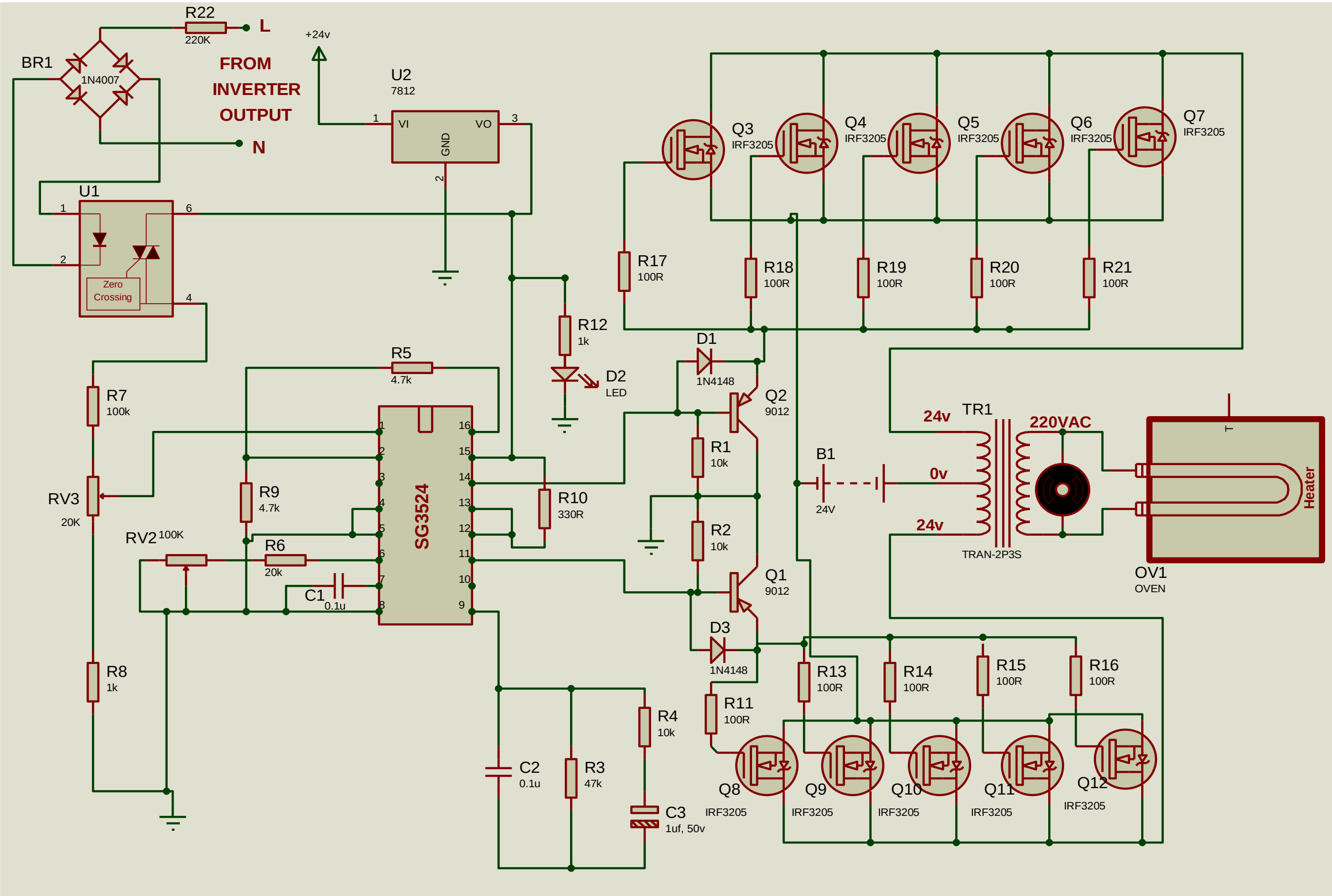

Figure.1.1: the system complete circuits diagram

V DISCUSSION AND RESULT

Results

After the development and implementation phase, the inverter has to be tested for Durability, Efficiency, and Effectiveness and also ascertain if there is need to modify the development. The components were first assembled in a breadboard for proper circuit testing. All components were properly inserted into the breadboard for building temporary circuits and tests were carried out at various stages, To ensure proper functioning of components' that help the system to manage system different areas of the design, the components were tested using a digital millimeter (DMM).

Testing plan and testing data

The testing is done to ensure that the circuit is functioning properly as expected thereby enabling the user to control the circuit for which the paper was targeted for and appreciate its implementation and equally approaches used in the design and integration of the various units of the project. However, this involves checks the component to ensure that all the various units and subsystems function adequately. Also there has to be a good interface existing between the input/output unit subsystems. When the totality of each unit (solar panel, charge controller, battery and inverter) was integrated together, the system was created and all the units responded to the circuit design through which the power supply delivered into the circuit.

Components test

Similar components like resistors were packed together. Other components include capacitor, circuit breaker, transformer, diodes (rectifier), etc**.** Each resistor was tested and the value read and recorded. Also for transistor test the DMM was switched to the diode range with the symbol. The transistor was tested in the following order. The collector, emitter and base pins were gotten from the data analysis on power transistor.

Packaging

The electronic industries nowadays are faced with competitions, each trying in one way or the other, to out match their competitors. To this end, a well thought out packaging not only uplifts the image of a firm but also have attractive luster attached to it. People attached great importance to the shape and design of the casing without considering the contents. In this project, the casing was built in such a way that the components are easily accessible in terms of maintenance and repairs. The casing has screw able cover and the provision for components or circuit fittings are made. The tracks and wires on the strip board do not touch the metal case. In preparing the casing, a plain sheet of metal is obtained and a given dimension measured out with the measuring tape. The dimensions are marked out with a scriber and then cut with a cutting machine to the dimensions marked on the metal. The whole centers were punched with the centre punch and drilled into appropriate size with the drilling machine. After this, the metal was bent with the help of a vice, hammer and some other small accessories. Finally, screw nails were used to screw the necessary junctions together to place the casing intact.

Findings and Results

Some findings and results that were obtained during the testing of the project work.

Battery charging time.

Charging Time of battery = Battery Ah / Charging Current

Formula:

T = Ah/A

So charging current for 100Ah Battery = 100 x (10/100) = 10 Amperes.

If 10A is used for charging of 100A battery then charging time for 100Ah battery = 100 / 10 = 10Hrs.

4.3.2. Battery running time

In the ideal/theoretical case, the battery running time would be

Time (H) = Capacity (Ah)/Current (A).

If the capacity of the battery is in amp-hours and current in amps, time will be in hours (charging or discharging).

Performance evaluation

The inverter was tested on a section by section basis. The output voltage of the stable oscillator was obtained to be 4.24volts at a constant amplitude and frequency. The other unit could not be tested until the final coupling had been done. The battery overcharging protection unit, low battery cut off unit, low and high voltage surge protection as well as the time delay units, feedback unit and the overload and short circuit protection unit were all tested by varying the potentiometer associated with each of them and observing the response through the displays. The list of various settings on the inverter is listed in table 1.0;

Table 1.0.Settings on the Inverter

300 watts	225 V
500 watts	220 V
800 watts	220 V
1200 watts	220 V
1600 watts	220 V

After all the experiment was done, the effect of loading was carried out in the INVERTER system and the load test results are listed table 1.1.

Table 1.1: Load Test

POWER (WATTS)	VOLTAGE (V)
Inverter output voltage	220 V
Inverter frequency	50 HZ
Minimum battery voltage	10V
Maximum load capacity	2000 WATTS
Maximum battery voltage	13.8 V
Inverter input voltage	12V
Inverter efficiency	88%

It was discovered that when, the INVERTER was supply to the output voltage, the voltage start to drop and then return to itself back to 220V. This is due to the feedback action (automatic regulation action) of the IC, SG3524, used as the oscillator.

DISCUSSION

The following maintenance practices and safety precautions are suggested to improve the life span of the system and prevent hazards to the users.

1. Dead batteries should not be used with the inverter
2. The battery terminals should not be switching ON or OFF too often, When it is OFF, the will be polarity must be ensured.
3. The inverter must be put in a moderate temperature environment.
4. The inverter should be switch off when is not use
5. The inverter should always be partially loaded (not more than 80% of its maximum capacity will be enough).
6. The used of refrigerator, induction machine in the inverter should be avoided.
7. The input plug of the inverter should be plugged to a three-pin, properly earthed socked.
8. The surface of the solar photovoltaic cell panel must always be clean of dust for a perfect sun attraction.

CONCLUSION

The work (solar powered multiple phones booth) was finally designed and constructed and is capable of charging multiple phones including laptops 24 hours without supply from the main grid. The work is a stand-alone solar renewable energy system that can be used in urban and rural areas. The system is implemented to solve the problem of phone and laptop user not able to charge their phones or laptops as at when due, due to power failure from main grid or where there is no electricity at all. The system hardware is consisting of the following: Solar panel, charge controller, deep circle battery, inverter and multiple charging outlets. The solar panel converts the sun energy to direct current electrical energy to charge the battery through the charge controller. The charge controller controls and regulates the voltage from the solar panel to the battery and also monitors the charging process to avoid over charging of the battery. The battery stores the energy from the sun and supplies it to the input of the inverter. The inverter inverts or converts the direct current (DC) to an alternating current (AC). The 220VAC at the output of the inverter is connected to the multiple socket outlets where phones and laptop is connected for charging.

RECOMMENDATIONS

This work (The development and implementation of a solar powered multiple phone charging booth) is highly recommended for both commercial and domestic use, like hotels and homes. It can be used by firm especially in Nigerian where power supply from main grid is a challenge. It is cost effective, noiseless and dependable. It does not consume fuel and it is environmental friendly. The solar power system is a convenient way of producing an alternative means of power supply to supplement the mains failure. It is an advantage to the user who could afford its initial cost of installation. I would also recommend for expansion in the system usage capability and possibly take this work on at a larger scale. Also investigate other energy storage solutions which may be lower in price and could be much more compact.

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