Solar Powered Full Bridge FET SMPS based Pulse Battery Charger with Power Management Using Atmega328

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***Abstract*—This paper aims to build a microcontroller based SMPS full wave bridge power transfer system that will also incorporate some domestic alerting mechanisms, such as security-alert, mail notification, flooding, smoke detection etc. The solar energy is utilized to charge a battery, which in turn will power up the system to drive various modules. This helps the system to be a completely stand-alone device. Along with usage of renewable energy, the paper also aims at protecting the electrical devices in a domestic setting from power-fluctuations or a brown-out.**

***Index Terms* — Full bridge SMPS, Solar cell, MOSFETs, microcontroller, transformer**

I. INTRODUCTION

Today, when the world faces severe dearth of power, it is required that power be conserved at any level possible. Other than conservation, one more solution is to harness power from the infinite sources of energy. Renewable sources of energy are a boon in such times. When a domestic setting is spoken of, the most readily available renewable source of energy is the solar energy. To procure energy from wind and water will require a large set up and huge cost. Not just the set up and cost parameters, the maintenance of such a huge setup is also a major challenge. On the contrary, a solar energy source setup relieves us from the space, maintenance and cost constraints. [5]

Hence use of solar energy after its transformation in to electrical energy is a golden solution. Harnessing of the solar energy requires an initial cost for the solar panel set up and doesn't consume much space. This paper constitutes the use of solar energy to charge up a battery, which on being charged can be used for various purposes as per requirement.

Energy thus obtained can be used in addition to the mains supply [4]. The portability of the smaller panels allows for an ease in setting up procedure and maintenance. The efficient and low cost designs of the panels help to obtain a smoother output that needs to be processed, thus making solar energy a smart choice.

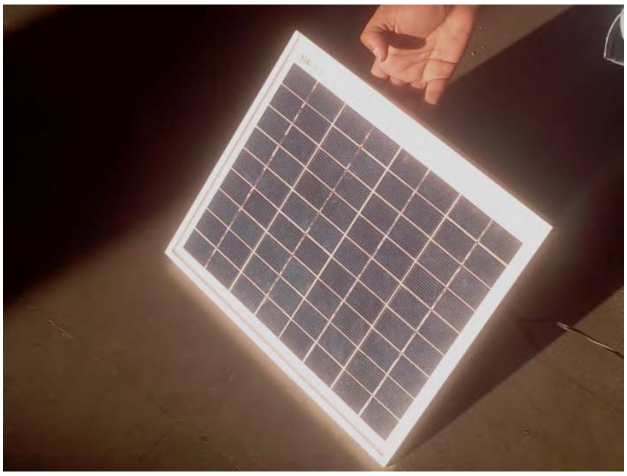

Fig.1. The solar cell used for charging the battery.
(Open Circuit Voltage = 21V,
Short Circuit Current = 0.69 A,
Maximum System Power = 10 W)

II. SOLAR CHARGING

The primary source used to charge the lead acid battery is the energy obtained from the solar cell. Since solar energy is a very promising renewable energy source, it is wise to utilize the same [4]. Solar Panels hence produce a photocurrent on being exposed to the solar radiation. Not only are the solar cells a major source to harness renewable energy, but are also portable power sources [4]. Since the intensity of radiation is variable, the circuit should work with a broad range of voltages above and below the desired voltage. [5]

In order to obtain a potential enough to charge the battery, a sequence of circuits is used in succession to the current produced by the solar cell. The circuit components are listed ahead [3]

(A) Inverter: The DC potential from the solar cell is given to an H-bridge, constituted by MOSFETs [1]. The bridge is controlled by the microcontroller. This bridge converts the DC potential from the solar cell to 60Hz AC [2].

Algorithm: A timer for 8 milliseconds (in order to obtain 60 Hz AC) is set.

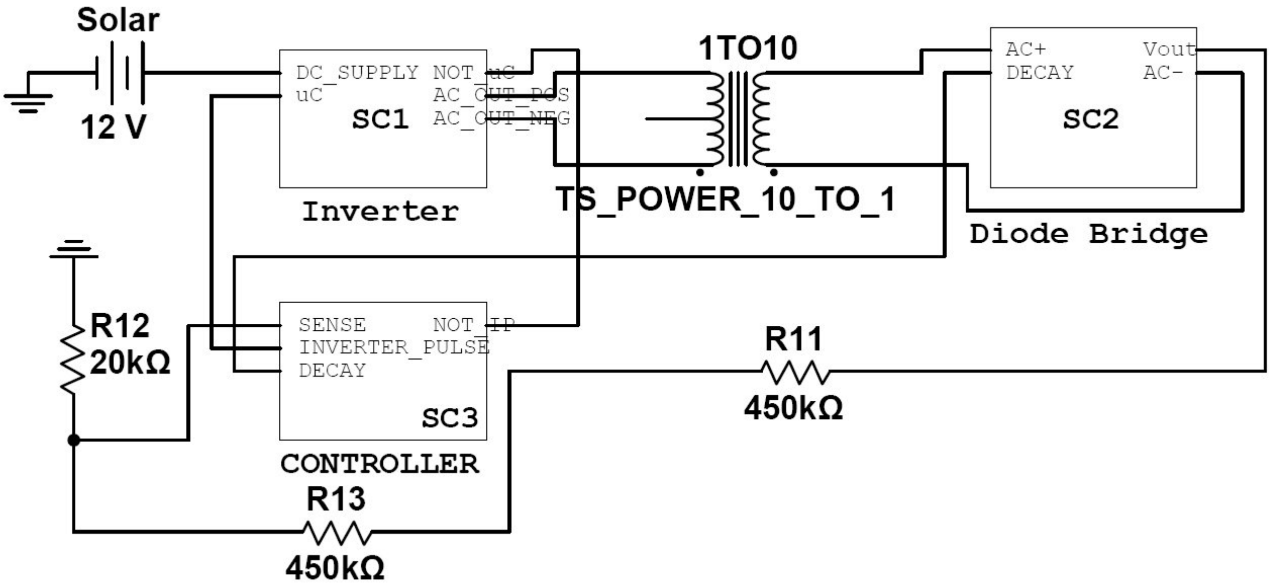

Fig.2 Block diagram of solar charging circuit.

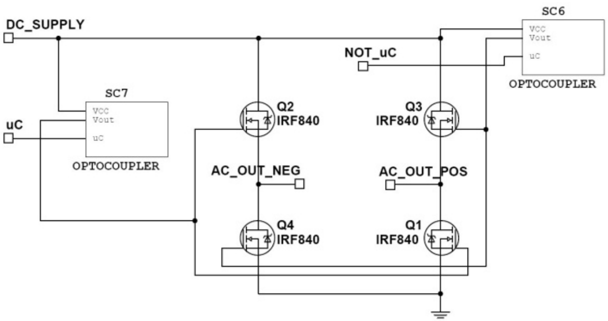

Fig.3. Circuit diagram for the inverter (DC to AC)

(B) *Transformer*: The AC potential hence obtained from the Inverter [1] is stepped up by a transformer of appropriate rating (24V/220V 60Hz).

(C) *Diode Bridge*: For charging purpose, the battery needs a DC supply [1, 2]. But the output obtained from the transformer is still an AC output. So, to convert it back to DC, a diode bridge network, is connected across the output obtained from the transformer. This circuit finally gives DC potential across a 1200uF electrolytic capacitor, thus leading to the charging of the capacitor. This stored charge in the capacitor is used to charge the battery.

(D) *Pulse Charger*: The mode of charging the lead acid battery chosen is pulse charging, for its efficient characteristics. [7] Pulse charging allows for the chemical reactions to settle during the OFF time of the pulse. Having a low percentage of the OFF time of the pulse, a quick charging can still be ensured.

Algorithm: Once the capacitor voltage reaches a limit of around 20V, the discharge MOSFET is triggered until the capacitor voltage falls to 13V after which the cycle is repeated all over again. This causes a series of current pulses into the battery.

Application of the battery thus charged: The battery thus charged is used to drive the circuits and other devices constituting this system, such as IR modules, bridge circuits, alarms and the microcontroller itself. [4]

Note that the battery charging circuit is essentially a full bridge SMPS converter where DC is converted to AC, [1] the AC is stepped up and is rectified using a diode bridge in the process boosting the voltage.

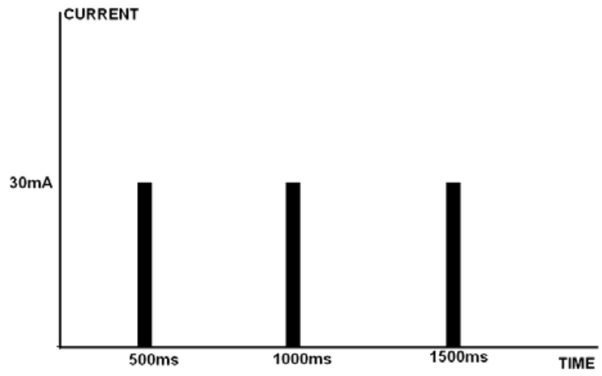

Fig 4. Current pulses plotted up to 1700ms under reasonable illumination.

Without the switching MOSFET, the circuit can still deliver a reasonable amount of current and behaves like a regular full bridge SMPS charger. The circuit is capable of giving excellent performance provided a power transformer with good regulation is used as the power transfer element.

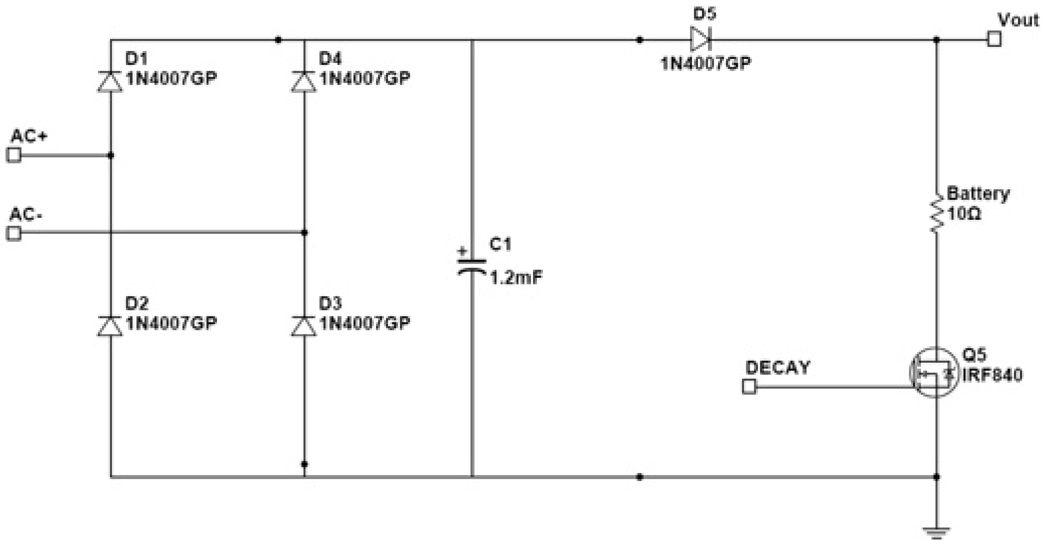

Fig.5. Diode Bridge Circuit

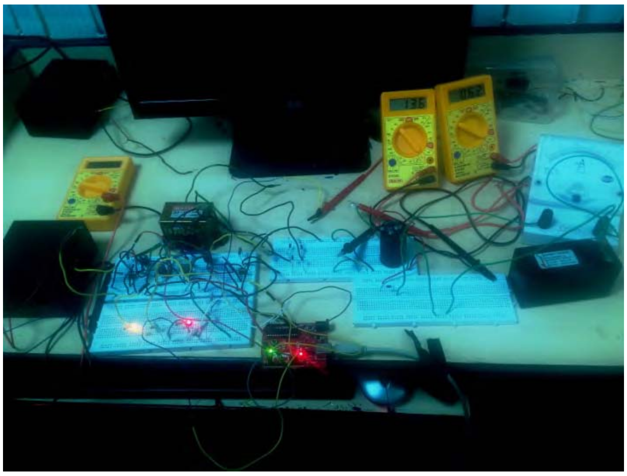

Fig.6. The battery being charged with around 30mA.

III. PROTECTION OF ELECTRICAL APPLIANCES

Often experienced phenomenon, "Voltage Fluctuation" or "Brown-outs" are a common threat to certain electrical appliances with intricate and delicate internal wiring or complex structures. Fluctuations can tamper with their performance or permanently damage a part of these appliances, since the appliances might not be equipped to withstand abrupt voltage changes, which sometimes can go beyond their rating. [2]

So, in order to avoid such a situation, the devices can be protected by various means. One such solution is to completely cut-off the mains power supply when fluctuation is detected. [3]

To achieve this, the mains power supply is stepped down by a transformer of appropriate rating. The stepped down voltage is then converted to DC by the means of a rectifier circuit and then a potential divider, to be fed to the microcontroller.

The microcontroller also detects the device current for the appliance to be protected. Based upon the mains' supply, the device current and the specified rating of the appliance, the microcontroller allows or restricts the mains supply and the supply to the corresponding appliance.

To cut off the power supply to these appliances, regular circuit breakers with relays can be used. The circuit is restored when there is no fluctuation detected and the mains supply is stabilized.

Algorithm: The loads can be classified into three categories called A, B and C. 'A' operates at all voltage ranges, The devices under 'B' operate at a narrower range of voltages and 'C' operates at a strict voltage of 200-220V AC. On the top of Fig 7 is shown one category where a load of 300 ohms is present. The current transformer and rectifier arrangement on the right measures the 220V signal. If the voltage drops, the output of the current transformer and rectifier system drops and when it drops below a set value, the 300 Ohm load shuts off via its dedicated relay. The same relays also doubles up for short circuit protection discussed in the next paragraph. Note that the 'live' relay in series with the 220V source is cut off when a dangerously high current is detected or when the voltage goes higher than normal.

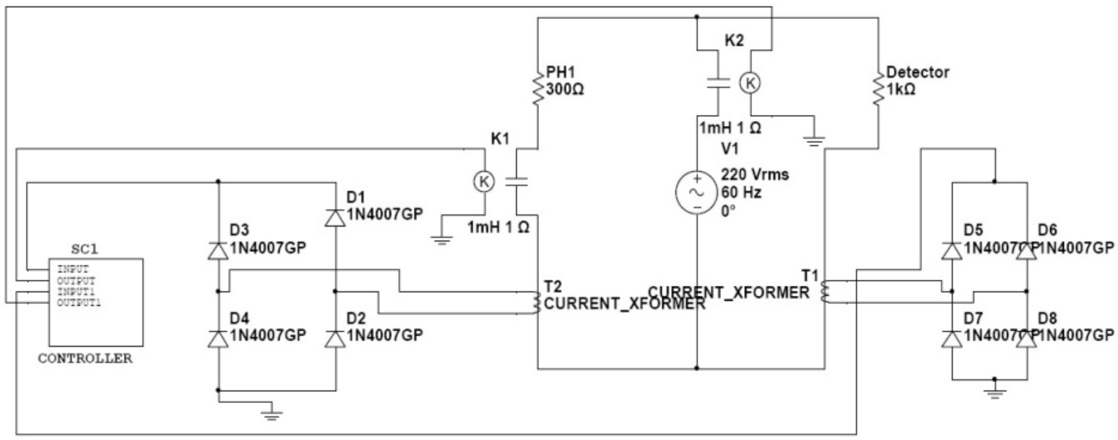

Fig.7. Circuit Diagram for Protection of appliances.

Fig.8. Meter Readings at the time of charging.

If the load shorts, the current transformer and rectifier system outputs a higher voltage which the microcontroller detects and shuts off via the relay.

IV. Salient features & Applications

This paper is unique in some ways that are elaborated below.

- *Technique.* A full bridge SMPS based pulse charging method which provides a 30mA current pulse after a certain interval of time.
- *Input voltage.* A 12V panel can give voltages between 6V and 24V. This design allows the battery to charge by gradually accumulating enough charge on the capacitor and then pushing a part of that into the battery. The time between pulses reduces with an increase in the input voltage.
- *Cost effectiveness.* The setup is low cost and the sum comes to around 1800 INR The cost breakup is shown below,

  IRF840 X 5 ………………………. Rs. 175/-

  *4N25 X 2……………………………..*Rs. 120/-

  *1200uF capacitor………………….*Rs. 90/-

  Atemga328……………………… Rs. 700/-

  24V/220V 60Hz Transformer…….Rs. 700/-

  *Miscellaneous………………………*Rs. 15/-

Some of the applications of this system are:

(A) Smart lighting: In times when power conserved is power produced, it is essential that the power wastage due to forgetful nature of some be stopped. This motive can be achieved by a smart lighting system, where by having the knowledge of the number of people in a room; the electrical appliances in that room can be turned ON or OFF. Output from the IR sensors, at the entry and exit of each room is given to the microcontroller. Based on these outputs, the microcontroller maintains a counter. This counter when reaches a nil value, the microcontroller issues the signal to switch the appliances of that particular room OFF. On the contrary, when the counter has a certain positive value, the basic appliances of the room, such as the tube light and the fan are given ON signals. This can avoid a lot of power loss at the grassroots level.

(B) Security Alert: In a domestic setting, a security alert system can prove to be very useful against thefts or illegal breaking-in. By the use of simple sensor and alarm duo, security alert system can be designed.

When the user leaves the house or locks the entrances, the security alert system activates. An ultrasonic sensor with appropriate placing at the entry, where an intruder can be expected, is placed. This ultrasonic sensor constantly transmits radiation. When the radiation is received back by the receiving end of the sensor, this gives the measure of the proximity of an intruder. On receiving such a signal, the microcontroller gives the alarm system, a high signal, thus completing the process.

(C) Flooding Notification: By the use of a simple mechanical sensor or IR sensor, the microcontroller is given a digital HIGH signal when the water levels of a specific location such as the bathroom or the kitchen reach a certain mark, where these sensors are appointed. The microcontroller informs the user of such a situation, by the means of an alarm. Appropriate measures are then needed to be taken by the user.

(D) Fire Detection: A regular smoke detector is installed to detect the smoke emerging from the source of fire, at locations that are vulnerable to such an incident. This detector is connected to the microcontroller. When the detector gives a high signal or pulse, the controller activates the alarm system, which comprises of a buzzer and a flashing LED in one or more locations. The user is then required to take appropriate action depending upon the intensity of the fire or smoke levels.

(E) Misc.: Other simple yet important applications for a domestic setting are Mail-Notification and Garbage-disposal notification. By installing simple IR Sensor modules at proper heights of the Mail-box and the Garbage container, on receiving of a mail or the garbage level reaching the mark, the sensors are notified.

These sensors then propagate the high signal to the microcontroller, which further notifies the user by the means of buzzers or glowing or flashing of LEDs.

Energy Source: The components mentioned above require a minimum potential to function. This driving potential is provided to them by the Lead Acid battery which is charged by the solar energy, thus making the system self-sufficient.

VI. Conclusion

In this paper, we have demonstrated how a full bridge SMPS battery charging system may be built that can harness solar energy. This design is efficient for a wide range of potential (6V to 24V) from the solar cell, which keeps in consideration the inevitable variability that exists due to natural factors, impacting the intensity of the solar radiation. Also, the use of pulse charging ensures a steadier charging process. We have also gone on to describe some applications that can be driven off this battery.

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