A Review on Induction Heating System by Solar Energy

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***Abstract*—Induction Heating system utilizes electricity for the generation of heat, whereas solar energy is largely available energy source for generation of heat. Combining solar energy with induction heat generation technique is the efficient solution for the heat generation application. The proposed system presents an effective control scheme incorporated in half bridge series resonance induction heating by using solar energy. Pulse width modulation technology is used for charging the battery from photovoltaic array. The simulation and implementation of system is done and presented in this paper. The experimental result of conventional solar heating and solar induction heating are compared. It shows that proposed system, improvises heating performance compared to conventional solar heating system**

IndexTerms—Solar system, Half bridge topology, Solar cooker, Induction heating, Embedded system tem with shows

I. Introduction

One of the most serious problems that we are witness is the increasing cost and scarcity of cooking gas. An alternate method is to use electricity for the purpose. But the extensive upsurge in the price of electricity and the lack of availability of large amount of electricity forces us to think about yet another alternative.On the other hand solar energy is the largely available source which we can use for cooking but this energy is not available 24 hours so it is not possible to use it in the night. So this energy has to be stored in the battery. This stored energy can be use to produce the electricity and further for induction heating.

Induction cooking is the highly efficient technique for the cooking purpose, when it combines with solar system it will provide the future solution for the cooking technology. Although solar based cooking may have high initial cost, but over a long term it is cost effective solution. Induction heating is a well known technique to produce very high temperature such as in melting steel. The technique requires high frequency current supply that enables to induce high frequency eddy current circulating in the target object.

In general, two methods are used to generate high frequency current namely hard switching and soft switching technique. Hard switching has disadvantage of the higher power frequency in the LC circuit and it produces positive cycle as switching losses in the switching devices. Using power MOSFET can solve this problem [6]. Soft switching or sometime called resonant technique reduce those switching losses. However, it requires devices with low on state power losses. So MOSFET is preferred for switching operation.

II. Literature Survey

The most popular types of electric heating can be classified mainly into two types. First one is resistance heating and second one is induction heating. Resistance heating has the advantages of low cost and easy maintains but, the disadvantage is its low efficiency. Considering induction heating, an inverter topology supplies a high frequency current to an induction coil, producing an alternating magnetic field. If this field is applied to a ferromagnetic pan, it produces eddy currents, and magnetic hysteresis, which heat up the pan. Recently, domestic induction hobs have become increasingly popular owing to their specifications such as quick warming, energy saving and high efficiency [1]. Consequently, the research on induction cookers has attracted the attention of theory specialists and practical engineers. For increasing the efficiency and reducing the switching loss and power factor class E resonant inverter is used for the induction cooker, in which only single IGBT is used for reducing the cost

The effort to increase the efficiency and the energy saving during a cooking process using an induction hob has been mainly focused on providing to the pot the maximum power in the more efficient way [2], for instance, designing highly efficient resonant inverter topologies, modulation strategies, and inductors. By controlling the Pulse Width Modulation using micro controller the temperature of the induction is control

It is important to know that the heating efficiency of induction cooker is usually from 80% to 90% or above, which is significantly energy saving comparing to the gas burner. Furthermore, the electricity for the operation of the induction cooker can be generated by sustainable energies such as solar and wind. The domestic and commercial induction cooker systems are similar in the operation theory as well as the configuration. Using the maximum power point tracking algorithm [3] the system is used to charge the battery from solar panel and this energy can be used for generating the electricity for the induction cooker. The half bridge series resonant inverter[4] is the most employed topology due to its simplicity, its cost effectiveness, and the electrical requirements of its components. The resonant tank consists of the pan, the induction coil, and the resonance capacitor. Induction coil and pan coupling is modeled as a series connection of an inductor and a resistor, based on the analogy of a transformer. The inverter section is design for maximum efficiency and minimum switching losses which takes power from solar panel. Power switching components such as MOSFETs and IGBTs [5], are used in high frequency resonant inverters to reduced overall size and switching losses can be reduced as well by means of soft switching technique.

III. METHODOLOGY

The primary input to the system is solar energy coming from the sun; it is received by the array of photovoltaic cell and further converted into electric energy. System block diagram is shown in Fig 1.This electric energy is utilised to charge the rechargeable lead acid battery bank. The charging of the battery must be monitor and control to avoid the overcharging and to indicate the low voltage condition of the battery for that charge control unit is necessary. Pulse width modulation technology is used in solar charge control unit. The stored electric energy is in the DC voltage form is further converted into high frequency(kHz) AC voltage to generate electromagnetic field in the induction coil which generate the heat. MOSFET is used as switching device for generating the AC voltage. Temperature of the generated heat is control by the pulse width modulated signal given to the gate ofMOSFET throughthe controller. Front end is provided with keys to control and change the temperature of the induction cooker. Different LEDs are used at the front end for indicating the battery as well as solar panel voltage conditions.

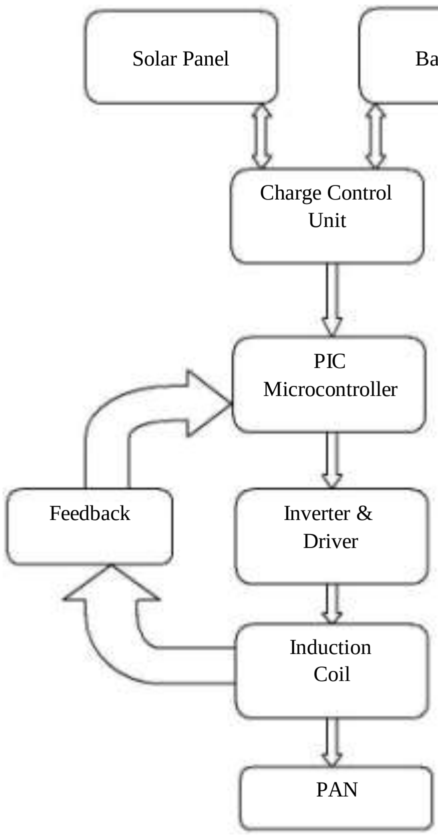


Fig. 1 System block diagram

IV. ALGORITHM

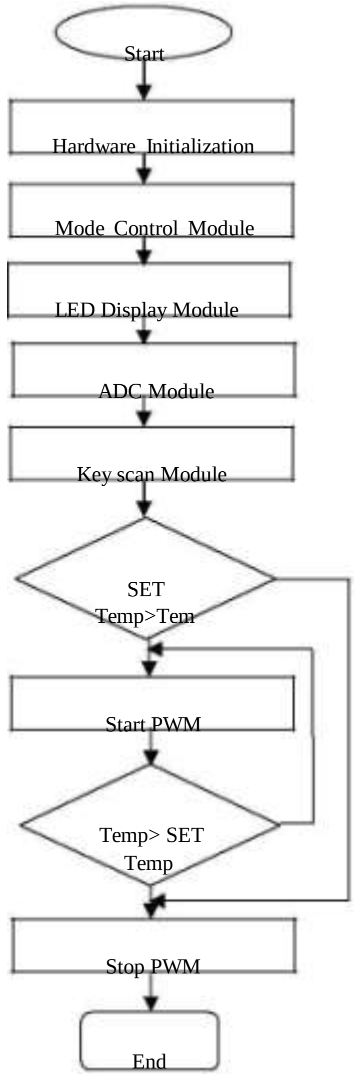


Fig. 2 Algorithm for heat control

Fig. 2 shows the algorithm for heat control of the system, it is explain below.

- First it initialises the port of PIC controller PIC 18F4520
- Assign logic ‘1’ value as input and logic ‘0’ value as output.
- Checking of the ADC bit for the battery, solar and temperature sensor.
- Display the status of the battery and solar voltage by LED.
- Display the temperature of the LCD.
- Checking of the push button status.
- Variation of the PWM signal as per push button signal.
- Fan and buzzer control as per the temperature setting.
- Stop

V. Detailed Description

Induction cooker works on the same principle as that of the transformer. The electromagnetic field generated at primary induction coil produces same amount of the electromagnetic field at the secondary side. The secondary side is the ferromagnetic pan used for cooking. The conversion of the battery D.C. voltage into high frequency A.C. voltage is done with the help of inverter section. The switching device MOSFET IRF3210 is control by giving the pulse width modulation signal coming from the controller. Half bridge series resonant topology is used for heat generation. The frequency of the topology is selected as 25 kHz for achieving maximum efficiency. The width of the signal is control according to user requirement through push buttons. For the protection of the controller section from high current power section TLP250 isolator is used.

The controller section of induction cooker is the main controlling element for the induction cooker. Various control of the induction cooker from varying the temperature to control for the cooling system (fan) is done by the controller. Input to the controller is given through the front end keys and output is display by using the LCD and LED indications. The main function of the controller is to generate the PWM signal for controlling of the temperature as per requirement.

mps so 26 Ahr capacity battery is selected. Solar panel power is calculated using the formula (1).

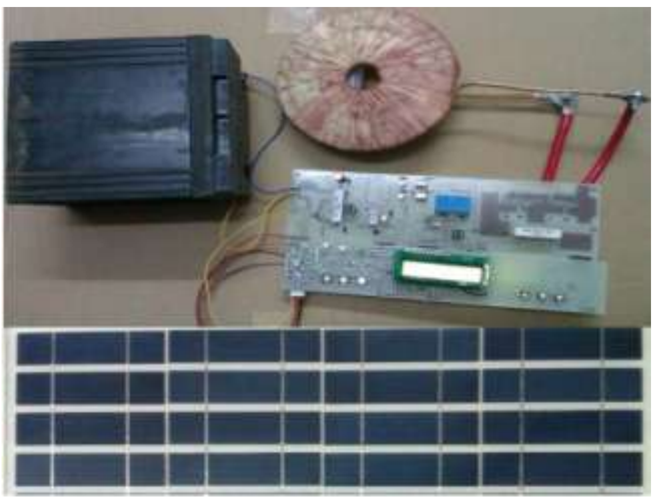
$$Pt = Ps \times 8 \times 0.85 \quad (1)$$

Where; Pt = total power of system,
Ps= solar panel capacity.

The power needed to heat a work piece to desired temperature is calculated using the formula (2).

$$Pw = mc(Tfinal - Tinitial)/t \quad (2)$$

Where; Pw= the work piece power,
m = mass of the work piece,
T final = average values of final temperatures,
T initial = average values of initial temperatures.
c = the average value of the specific heat of the material.
t = the required heating time.



VI. Results

This proposed system of solar based induction cooker is implemented for 500 watts power. Input to system is solar energy which is used to charge two 12 volts batteries using PWM boost converter. Stored DC energy is converted to 25 kHz AC voltage using half bridge series resonant topology.It is efficient technique for the control of the temperature and for the solar charge control of the battery.

Comparing conventional solar heating system with solar induction system hasvarious advantages such as performance in terms of time. For heating 200ml water conventional solar system takes 15 min,whereas it can be done within 5 -6 min using solar induction heating system. System has half bridge series resonance topology due to which it has 80 %.

efficiency. Conventional solar heating system has only 50% efficiency. This system is easy to clean and having thermal safety. This system can be utilized during the day as well as night time. Also, it hasoptional electric charging system so that it can be used during rainy season

Fig 6(a) shows two complimented PWM signal of 25k Hz, given to the base of the MOSFETs. In Fig 6(b) AC signal of 25k Hz generated across heating coil is shown. Result of solar panel at various sunny conditions is observed as shown in table I. It shows that PWM charging technology is the most effective for constant voltage battery charging method. It gets 20% to 30% more energy from solar panel for charging the battery. Another advantage is that it reduces battery heating and increases the life span of the battery.

TABLE I. Result of PWM Solar Charge System.

Test No.	Solar Panel Voltage	Battery Voltage(2 in series)	Boost Voltage	LED
1	19 V	24 V	28 V	Green
2	16 V	24 V	28 V	Green
3	14 V	24 V	28 V	Green
4	18 V	22 V	28 V	Green
5	17 V	28 V	0 V	No LED
6	10 V	21 V	0 V	Red

VII. Conclusion

After implementation of solar induction heating prototype and comparing it with conventional solar heating system following conclusions are drawn.

- Proposed System has 80% efficiency due to half bridge series resonance topology as compare to 50% that of conventional solar heating system.
- System can be used during day as well as night time.
- System can be used in rainy season by using electrical charging option.

The proposed system can be extended to higher power rating and used for commercial heating applications such as water heating for industrial purpose, for food cooking in hotels as well as in households.

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