Multi - agent system based Energy Management of Distributed power sources in Domestic Cooking

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Abstract.

As we are using many homes appliances day by day, the energy consumption is increasing. As Fossil fuels are depleting and demand is increasing, it is important to move towards Renewable Energy even in domestic areas. Energy used for Cooking is in large amount in developing countries. Almost 80% of energy which among household is used as cooking energy in rural areas. Biofuels such as fuel wood, charcoal, agri-residues, and dung cakes are used to replace this requirement for cooking. In India, several attempts have been made to utilise biofuels and renewable energy for home cooking. In this project, solar power is used to power an induction cooktop. Because of its excellent efficiency and safety, the induction stove has been more popular in recent years. The concept of Electromagnetic Induction is used in induction cooking. The coil is stimulated in the ferromagnetic material by creating eddy currents in the coil, which causes heating [1]. An induction cooktop driven by solar panels and supplemented by mains electricity is being developed utilising a half bridge design. The operating frequency may be changed in simulation and in hardware, allowing for more control over power output.

Keywords: *Microprocessor-controlled induction cooking, solar power, a half-bridge circuit with microcontroller, and a battery charging circuit MATLAB-SIMULINK, PROTEUS.*

1. INTRODUCTION

Solar Energy is a clean form of energy that will help the globe avoid using non-renewable energy sources such as coal and other fossil fuels. Induction heating is commonly employed in domestic applications. It's also eco-friendly, efficient, low-cost, and results-oriented [2]. Induction heating is mostly utilised in the manufacturing industry for melting, brazing, and hardening [3]. Solar cookers are now the only household cooking option. Even though many research papers have reported, biogas plants and cookstoves with new features are still far away from their respective potential. Solar cookers are also contributing their part inmeeting domestic needs. It is ideal to improve the technology of solar cooker as India is blessed with sunshine and can meet the requirements of energy. An effort has been made in this reference to assess the technology's potential for use in household cookery in India, which helps in assessment of their future potential of planning energy sector in country. It's memorable's pivotal that as the quantity of homes in the nation develops and as biomass feedstock and other inexhaustible assets become all the more promptly accessible, the genuine capability of environmentally friendly power gadgets for home cooking might change.

In general, low temperatures are required for the majority of the cooking energy. So solar cookers are known to be very good source of having low thermal energy. The yearly mean daily sun radiation received by average nations is in the range of 5- 7kwm2/day [9]. The box type solar cooker is the one that is specified [8] in India for boiling and baking meals.

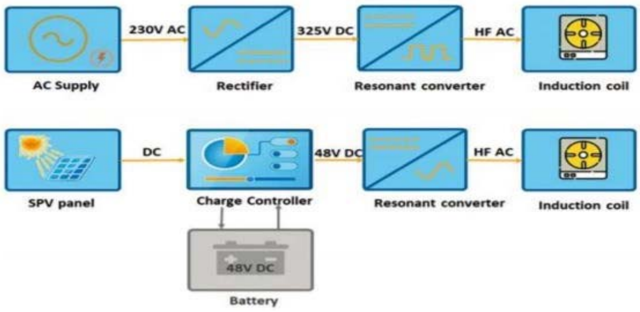

Fig. 1: Number of box-type solar cookers in use throughout time in a given nation

In this article, a few homes are assumed to be using a box type solar cooker for domestic cooking. The following calculation is based on the assumption that although solar cookers cannot totally replace current cooking alternatives, they may save a significant amount of fuel when utilised for home purposes. In other words, it is expected that if all of the above-mentioned cooking equipment criteria are met, solar cookers will be possible consumers.

2. INDUCTION HEATING

Induction heating is being used now a days for domestic appliances, as it is clean, gives high efficiency and is low-cost advanced semiconductor device, it gives high performance [6]. Enlistment warming is utilized for brazing, solidifying, and dissolving in industry [7]. 80% of the attractive field produced between the loop and the skillet is moved to the curl. Domestic and commercial cooker will give quick warming by saving energy with different range of temperatures [9]. Induction heating is done by electromagnetic induction in which the ferromagnetic materials are heated electrically. Cooking is one of the numerous uses for Induction. Induction cooking works on the concept of magnetic induction, in which eddy currents are created in the coil, which then stimulates the ferromagnetic materials, causing them to heat up. Many converter topologies are their which can efficiently produce time varying magnetic field that is needed for induction heating.

In this paper, principle of working of induction heaters/cookers is presented. Different topologies of solar electricity-based DC induction cookers like resonant converter and the voltage source inverters of full bridge inverter, and quasi resonant topology has been reviewed.

3. PRINCIPLE OF OPERATION OF SOLAR INDUCTION

A solar panel charges the battery by providing fluctuating DC to the solar induction cooker. The DC from the battery is transformed to high frequency AC power with the help of an inverter circuit. The alternating flux created in the magnetic core causes eddy currents and hysteresis losses. Induction cooking is becoming more popular due to its great efficiency and safety.

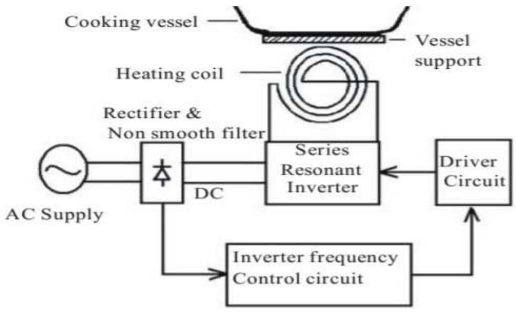

Fig 2: Basic circuit of Induction cooking

Induction cooker is initially supplied with energy as fuel from solar panel and solar panel is controlled using a controller. The energy from Solar panel can be used immediately for induction cooker or store in the form of DC for future use. To utilise the conserved energy later, the stored energy may be transformed into high frequency AC form using an inverter. There is an exchanging attractive field produced by this high recurrence current in the enlistment loop. Inducing eddy current in a pan by positioning it near to an induction coil. This results in production of heat on pan surface. In this way internal resistance of the pan will result in dissipation of heat. Finally, it is the pan which helps in heating and cooking process but not the heater.

Benefits of Using an Induction Cooker:

- The sole source of heat radiation is an induction cooker
- Coil stays cool, so it will be safer
- High efficiency, so gives low electricity bills
- Gives constant power output
- No danger of electric shock in cooking pan
- Has flexible temperature control
- When compared with microwave-oven induction cooker is cheaper
- No need of any special utensils, regular kitchen steel utensils are enough

4. ENERGY MANAGEMENT SYSTEM OF SOLAR INDUCTION COOKER

There are three different kinds of cooktops on the market: Gas, electricity, and induction are all options.

• Gas: It features a burner on top that burns gas (LGP or PNG) to create a flame that cooks food.

• Electric: A coil warms up as a result of resistance. It heats and cooks food by generating energy.

• Induction: This method utilises electricity and the magnetic properties of steel to heat the cooking pots directly.

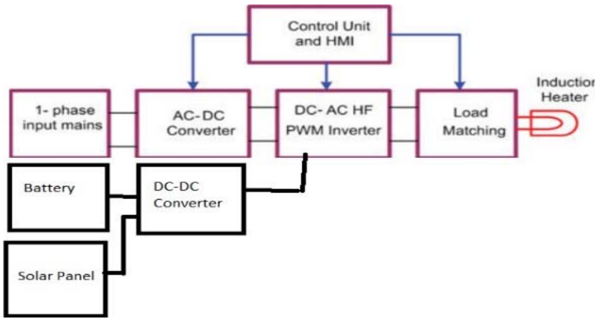

Fig 3: Solar Induction Cooking Block Diagram

In this paper, it is also explained regarding the thermal storage, which is present in food also, even if battery is not used. As a result, the chef may use the kitchen equipment inside the home as well. As a result, even without a battery, the solar e-cooker system offers several benefits over a traditional solar cooker.

The expenses of 500 Wp roof top panel with its fitting and fixing

$$C(PV) = 300[0.1/ (1 - (1 + 0.1)^{-20}) + 0.05] = \text{Rs } 3500 \text{ per year (approx.)} \quad (1)$$

Amount of energy generated by a panel over a daily insolation average of 4.5 kWh/ m^2 (assumptions of insolation are considered from paper studies) is 821.25 × 0.8 = 657 kWh

Cost of energy is approximated to

$$C \text{ (solar PV electricity)} = 50.23/657 = \text{Rs } 5.355 \text{ /kWh} \quad (2)$$

The cost of energy production will depend on sunshine and interest rate. Cooking is supposed to take 4 hours a day on average, for cooking, the monthly expenditure of energy is estimated to be about 300 watts on an average

$$C(cooking) = 0.0765 \times 0.3 \times 4 \times 30 = \text{Rs } 192.78 \text{ /month} \quad (3)$$

5. SIMULATION MODEL AND RESULTS

The essential goal of this exploration is to create a multi-specialist framework for family cooking energy the executives utilizing environmentally friendly power . Many problems that a single agent or monolithic system cannot address may be solved with the help of multi-agent systems. Intelligence strategies for forming decisions include procedures such as algorithmic search and reinforcement learning.

The major goal of this project is to create an intelligent habitat system by determining which components will be able to make choices and optimise energy use through intercommunication. The method should not affect the inhabitant comfort with respect to the application.

In addition, the use of a Multi Agent System (MAS) as a crucial technology for providing distributed adaptable micro-network control was examined. Each function of the system will be allocated to a different agent in the multi-agent approach, which allows more flexibility and autonomy than the typical solar-based induction cooking system. These agents will closely link and communicate with each other.

The initial analysis of the solar based cooking system is done by using 555 timers. The driver circuit for induction cooking is also developed with the help of the same 555 timer. Simulation of driver circuit using 555 timer is done by MATLAB-Simulink.

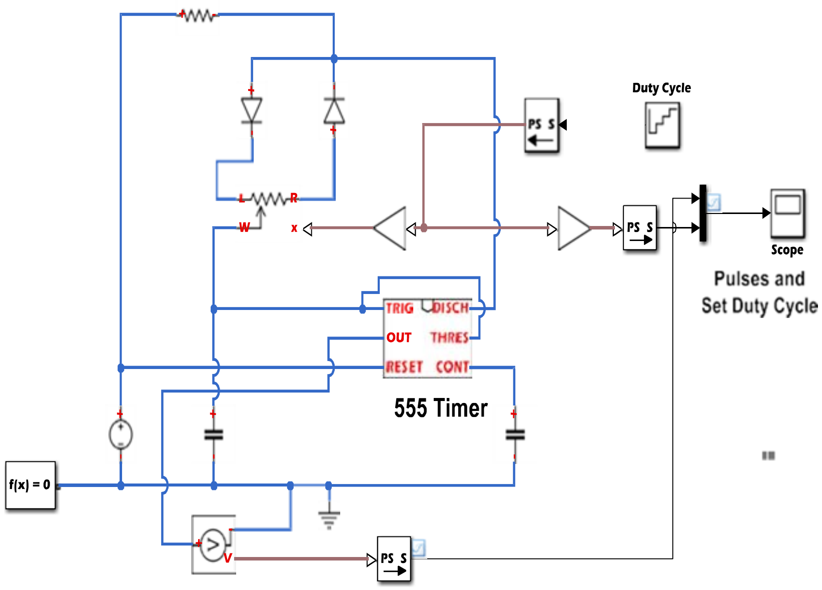

Fig 4: 555 Timer circuit diagram to generate PWM pulses

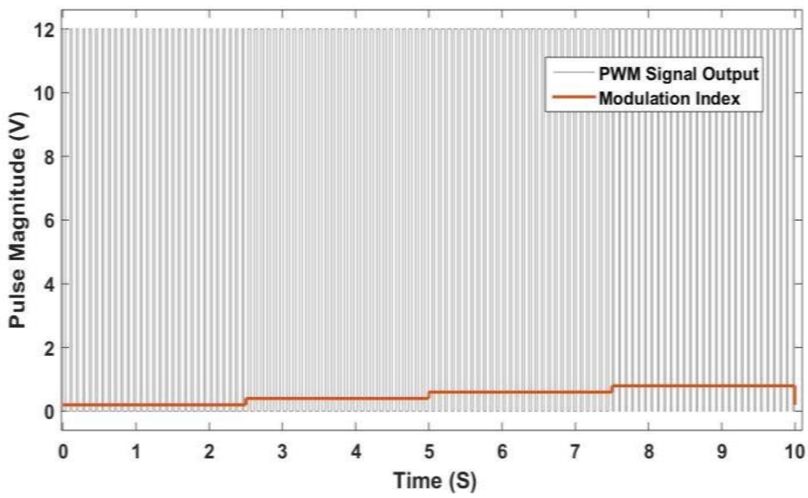

Fig 5: 555 Timer PWM pulses for different Modulation Index.

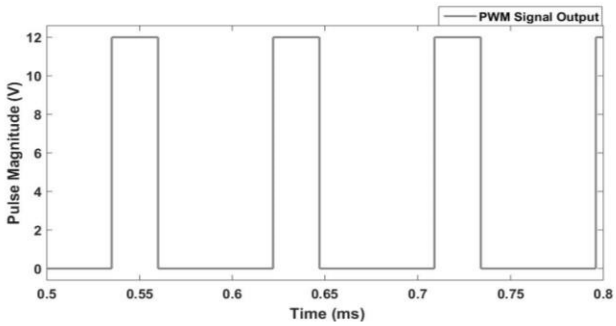

Fig 6: 555 Timer PWM pulses for 25% Modulation index.

The MOSFET will be ON for 20% of the cycle and OFF for 80% of the cycle. The graph is recorded for every 20Khz frequency. The simulation results of Multi Agent System is shown below. The main circuit is simulated with three sources solar battery and a adopter, which are used for domestic cooking purpose.

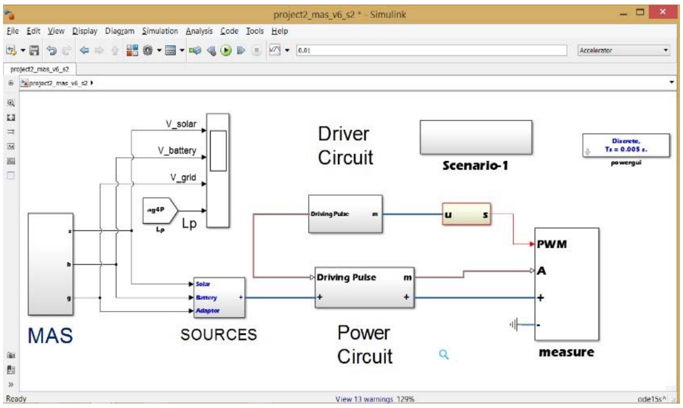

Fig 7: Main Circuit

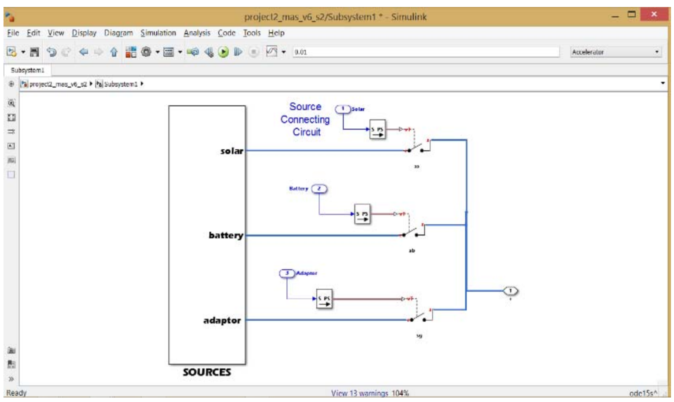

Fig 8: Connection of sources to main power circuit

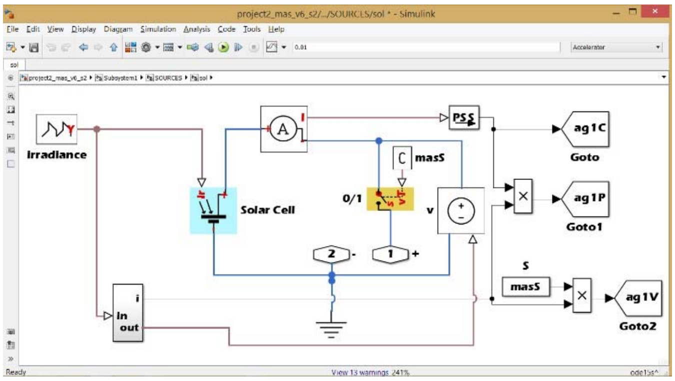

Fig 9: Subsystem of Solar source

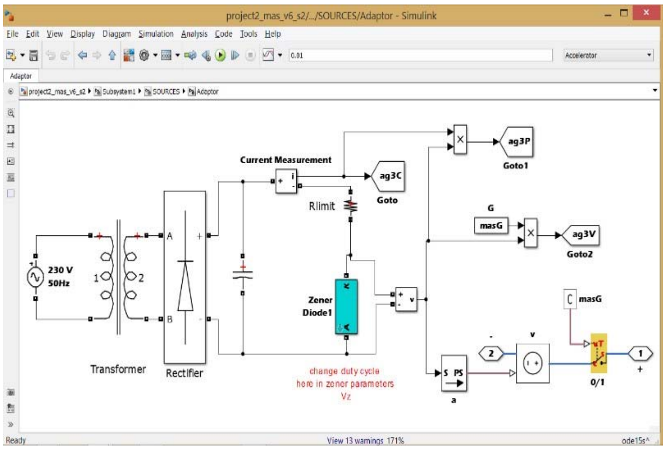

Fig 10: Subsystem of adaptor circuit

Considering load is constant at 4000 watts as peak, also grid is not available, solar power and battery are available. A threshold value of 5000-watt peak is considered and categorized as low power and high power (If the value is less than or equal to 5000 peak then it is low power, if value is more than 5000 peak then consider it as high power).

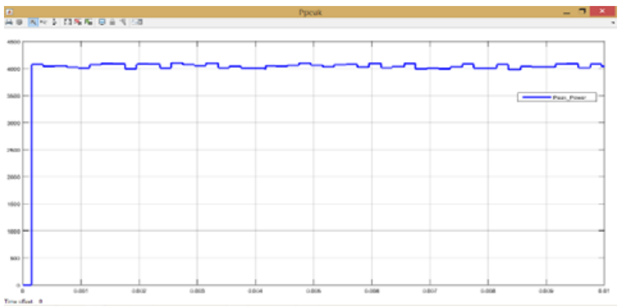

Fig 11: Load power requirement

Solar power has been delivered at 48V and battery also has the terminal voltage at 48V whereas grid voltage is zero as it is not considered in this scenario. Fig 11 shows the load response to the first case executed in the simulation.

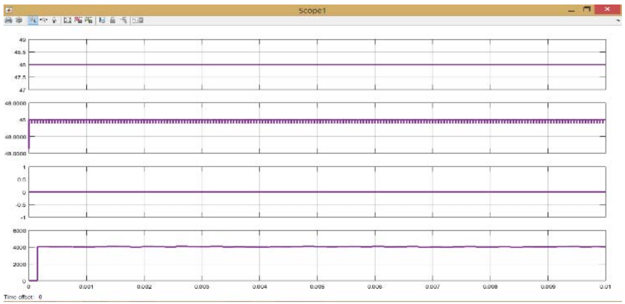

Fig 12: Voltage profile of sources and load power

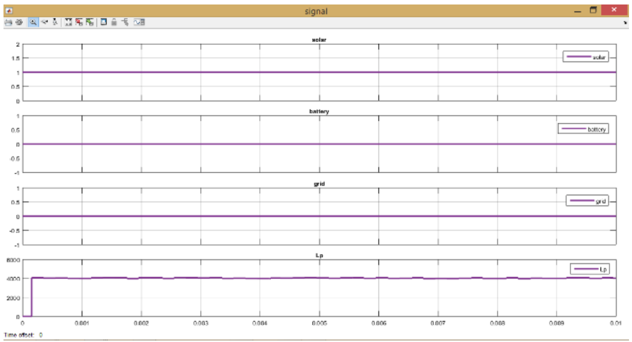

Fig 13: Load Response to first case executed in the simulation

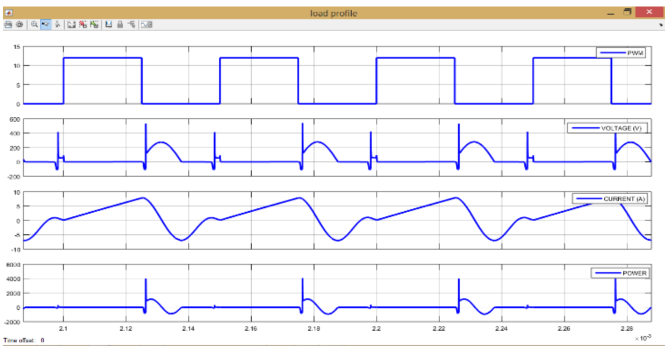

Fig 14: MAS output, switching ON/OFF sources

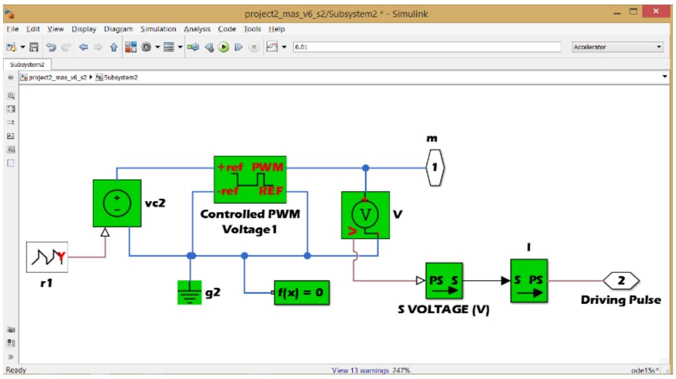

Fig 15: Driver circuit

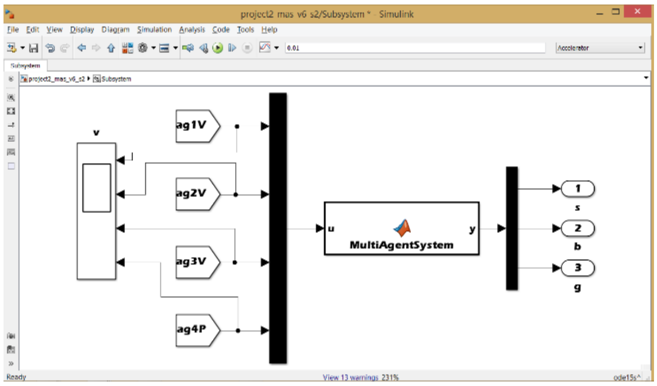

Fig 16: Multi Agent System Central Controller

Input information is taken by Multi Agent system and given to the central controller. The central controller unit will take decision depending on the algorithm output. The decision will be in the form of turning a particular source as ON/ OFF.

Table 1: Solar parameters

From time (ms)	To time (ms)	Insolation (H in Watts/m^2)
0	3	500
3.01	6	1000
6.01	10	1000

Solar source parameters (1=ON or 0=OFF)

MAS to Solar=1; MAS to Battery=1; MAS to GridG=1

Table 2: Drive Duty cycle parameters

From time (ms)	To time (ms)	Duty Cycle (%)
0	3	75
3.01	6	50
6.01	10	75

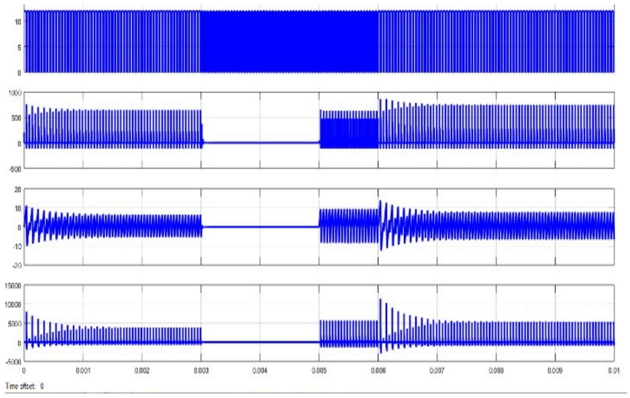

Fig 17: Voltage, Current and Power at the load side.

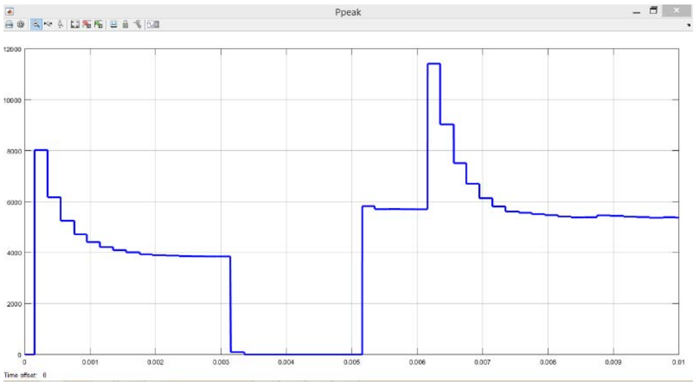

Fig 18: Load power vs Time

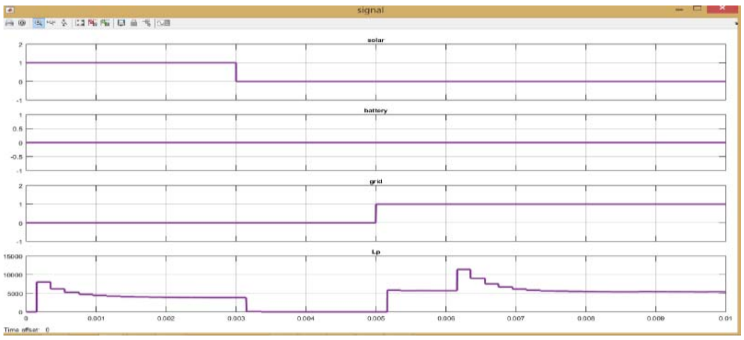

Fig 19: MAS decision making output: sources

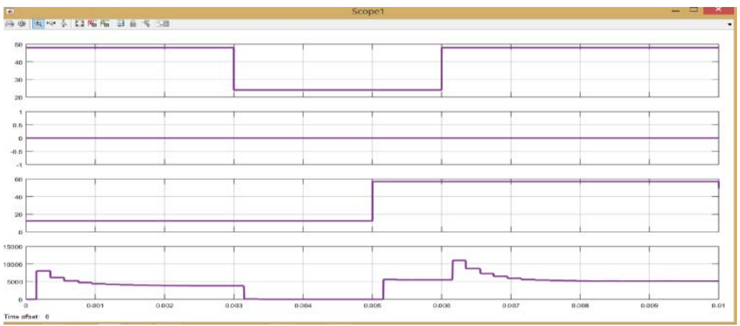

Fig 20: Voltage levels of sources connected to the system

Table 3: Solar parameters

From time (ms)	To time (ms)	Insolation (H in Watts/m^2)
0	3.33	1000
3.33	6.66	1000
6.66	10	500

Solar Control parameters (1=ON or 0=OFF) MAS to Solar =1;

MAS to Battery=1; MAS to Battery =1; MAS to GridG = 1;

Table 4: Driver- Duty cycle parameters

From time (ms)	To time (ms)	Duty Cycle (%)
0	3.33	50
3.33	6.66	75
6.66	10	50

During the time t=0 to 0.006s, it is observed that solar power which is generated is sent to the load, as the requirement are below the threshold values in 5000 watts type. In this period the input to solar PV is kept at 1000 watts per meter.

At time t is equal to 0.006S solar insolation level drops to 500 watts per meter square and hence power needed by the load cannot be generated, the same is communicated to central Multi Agent system. The grade is used as second option in Multi Agent System, the volage across the adapter will cross the threshold limit of 47V. The power levels will increase because the adapter output is 52V, it means more power can be generated from the source.

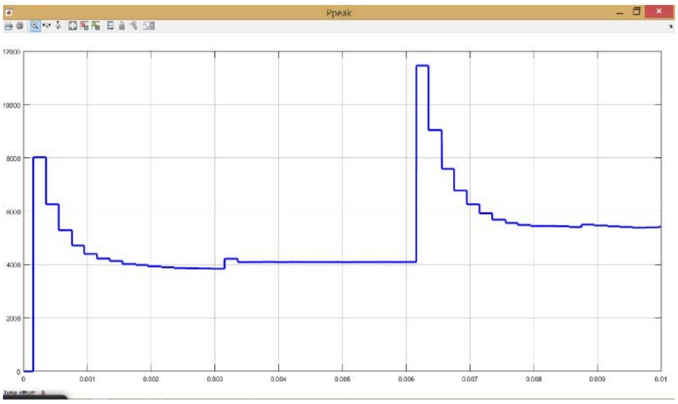

Fig 21: Power requirement of load

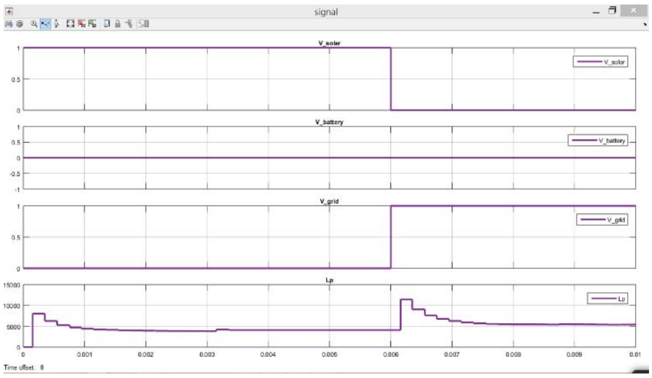

Fig 22: MAS based decision made, based on source availability and load power required

6. CONCLUSIONS

The key issues of solar e-cooking in terms of energy costs, usage, and conservation are discussed in this research. The energy cost for cooking is very low in insulated stoves and pans and these can be used in applications of both grid and off-grid case. Cooking meals with minimal power and in an acceptable amount of time is the key technological difficulty for this study, as well as the problem of changing cooking habits. Rice, vegetables, and meat can all be cooked the same way, based on what we've learned, but frying is going to be more difficult because of our limited understanding. For sun oriented e-cooking, expanding the size of the PV board and the battery might be more financially savvy, as indicated by this expense research. Furthermore, boosting the solar home system's power capacity allows homes to utilise additional equipment, such as fans for cooling, tiny freezers, and so on. This enhances the quality of life of users. The results obtained are verified with compact and low cost efficient 500watts prototype design. In the comparison process it is found that efficiency of the proposed converters exceeds more than 92% with full load condition due to reduction in THD.

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