Automatic Lawn Mower using Green Energy Sources

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Abstract: An automatic lawn mower is a device or robot that help human to cut grass automatically. It will allow the user to cut their grass with minimal effort. The proposed robotmove on the grass of the garden, within a defined area thereby completes the task automatically. The electrical power required to energies the proposed system is provided from the solar panel. Single-Ended Primary-Inductor Converter (SEPIC)with Maximum Power Point Tracking (MPPT) algorithm and Fuzzy logic controller (FLC) is used at output of solar panel to improve the overall efficiency. The movement or the path of the automatic lawn mower is based on a path planning technique. Sensors are used to provide feedback from obstacles. Every action of the lawn mower is monitored by the PIC microcontroller with the help of the sensor. Unlike other robotic lawn mowers on the market, this design requires no perimeter wires to maintain the robot within the lawn. Through sensor arrangement, the proposed lawn mower avoidsobstacles and humans. A hardware prototype is implemented and successfully tested in the lawn.

Keywords: *Lawn mower, SEPICconverter, PIC microcontroller,FLCand MPPT*

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I. INTRODUCTION

An automatic lawn mower, powered with solar energy is the best option for cutting the grass in the garden as compared with the commercial cutters [1]-[4]. Furthermore, the amount of solar energy required to run the system is essential while designing a lawn mower. In order to accomplish the requirement, the whole surface except the sides of the robot iscoveredwithsolar panels which also act as shield to the robot.Most research on the robot path planning techniques is used mainly to aim for the shortest path and for consuming less energy [5].

As many gardens are in shade, or not directly hit by the sun, the amount of solar energy available at the site will be less. Also, the solar irradiation will vary with theatmosphere condition. As a result,the extraction of energyto the system gets reduced. Nevertheless the maximum power tracking technique combined with an accumulator capable of storing energy solves the aforementioned problem [6]-[7]. The battery works as a buffer and accumulating energy when solar power is plenty. From this point of view lead batteries are the most suitable ones. In full sun, the solar panel is capable of recharging the internal battery with a current at about 6A, totalling about 8W, and well under the power used by even the most efficient electric lawn mower, powered at 230V A.C. The proposed robotic lawn mower can be used for a continuous and steady mowing in the lawn.

In the present scenario where technology is merging with environmental awareness, consumers are looking for the ways to contribute in the relief of their own carbon footprints. Pollution is man-made and can be seen in the daily lives, more specifically in homes. Gas powered lawn mower are approximately 90% in United States (U.S) home and they create 5% of the total U.S. pollution. Green technology initiatives are being support by both the government and cooperates business.

This research workwill relievethe consumer from mowing their own lawns and will reduce both environmental and noise pollution. This design is meant to be an alternate green option to the popular and environmentally hazardous gas powered lawn mower.

II. PROPOSED METHOD

The input from the PV panel is fed into the SEPIC converter in order to obtain the desired output voltage. The extraction of maximum power from the solar panel is achieved through MPPT method. The required algorithm is generated and loaded in the PIC16F887 microcontroller. The feed forward system senses the instantaneous voltage and current which is fed into the microcontrollerfor attaining the maximum power. The perturb and observe MPPT algorithm based on fuzzy logic controllerdetermines the output voltage at which maximum power is obtained. The duty cycle of the converter corresponding to the output voltage is computed by the microcontroller with the predefined program and is applied to the SEPIC converter through the gate driver circuit. The output voltage of the converter is stored in the battery for more reliable operation of the robot.

The obstacle in the lawn is detected by the infrared (IR) sensor provided in front of the robot. According to the information from the sensor,microcontroller sends the signals

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to the motor drive of the lawn mower through relay. The block diagram of the proposed system is shown in the figure 1.

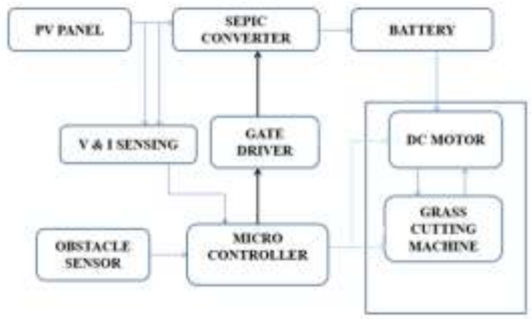

Figure 1.Block diagram of the proposed system.

For achieving the maximum efficiency, MPPT algorithm and Fuzzy logic control is used in the proposed system. The block diagram of the SEPIC converter with FLC controller and MPPT algorithm is shown in figure 2.

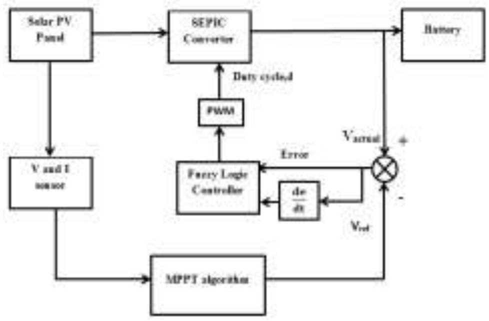

Figure 2.SEPIC converter with FLC controller and MPPT algorithm

III. SEPIC CONVERTER

The SEPIC is a DC-DC buck- boost converterand has the advantage of non- inverted output voltage. It consists of series of capacitors to transfer input energy to output. The schematic diagram of a SEPIC converter is shown in figure 3.

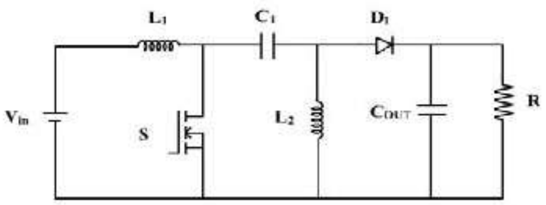

Figure 3.Circuit Diagram of SEPIC converter

All dc-dc converters operate with high frequency MOSFET switches. Inductor L_1 charges when the switchcloses and L_2 charges by the capacitor C_1. The output voltage is the voltage across the capacitor C_2. When the diode is under ON condition, the output voltage is maintained by C_2.

When the switch is open, the capacitors are charged by the inductor current and the load voltage is availed through the diode. High output voltage can be obtained by increasing the duty cycle. Nevertheless very high duty cycle will fail to charge the capacitor and thereby output. Consequently, tradeoff has to be taken while selecting the duty cycle.

IV. MAXIMUM POWER POINT TRACKING ALGORITHM

The direct charging of battery from the panel without any controller leads to premature battery failure.Moreover, this will result in higher equipment cost and the costs will increase due to subsequent equipment failure. MPPT method is used to save the power without which many number of solar panels would be required for the operation. Maximum power point of the solar panel varies as the temperature and irradiation. So tracking method for obtaining maximum power from solar panel is required. Perturb and Observe (P&O) method is used to achieve MPPT. The P&O algorithm for the implementation of MPPT method is shown in figure 4.

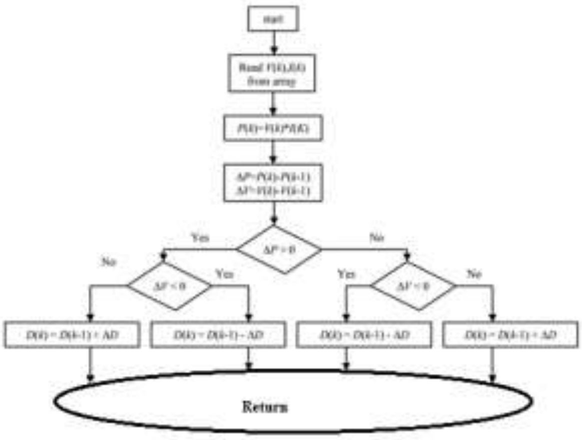

Figure 4.The flowchart of the Perturb and Observe Algorithm.

The maximum power point of a solar panel increases as increase in irradiation which is shown in figure 5.

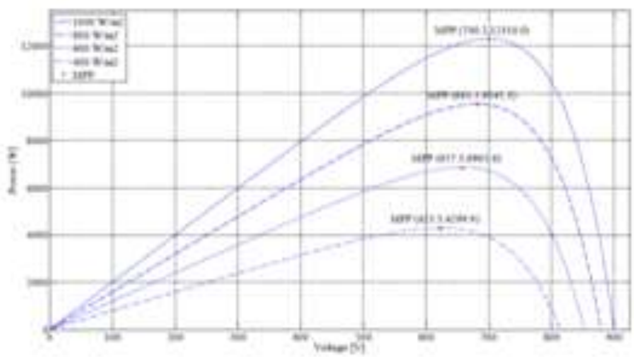

Figure 5.P-V curve depending on the irradiation

Fuzzy Logic controller

Fuzzy Logic controller (FLC) is best suitable for nonlinear system since it does not require any mathematical model of the system. Hencethe implementation of fuzzy controller is easy as

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compared to other controllers. In FLC, artificial intelligence technique is used based on expert knowledge of the system. Fuzzification unit is converting crisp set values into linguistic variables. The reference voltage is decided by MPPT algorithm. The FLC consists of five main blocks. (1) Fuzzifier converts its two inputs such as voltage error (e) and change in voltage error (de/dt) into information and sent to decision making mechanism which can utilize to apply rules. (2) Rule base which consists of the expert's linguistic explanation to obtain the best control. (3) The data base keeps all the description of the membership function required for fuzzifier and defuzzifier. (4) Decision making mechanism evaluates the preferred control rules suitable for the present situation. (5) Defuzzifier block converts the result from decision making mechanism into duty cycle to the plant. Error and change in error is generated based on reference voltage and actual output voltage of the SEPIC converter. The inference mechanisms available for evaluating the control rules are Mamdani and Sugeno Fuzzy Inference System (FIS). The consequent of the fuzzy rules can be obtained by either of these two methods. Fuzzy Logic Controller is designed for the proposed system in Matlab using Mamdani style. The membership function of error and change in error is shown in Figure 6 and 7.

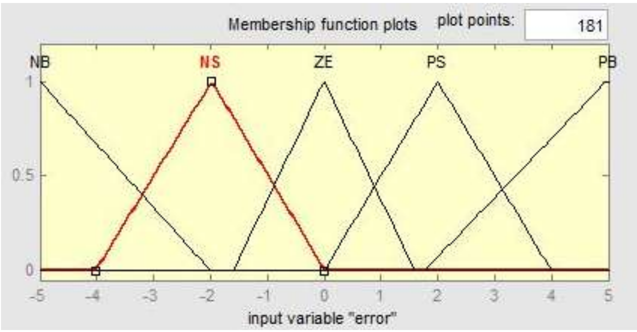

Figure 6. Membership function of error

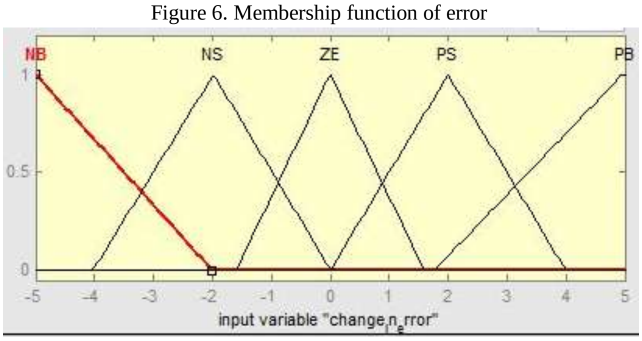

Figure 7.Membership function of change in error

Fuzzy sets are defined for all input and output variables. Five fuzzy subsets which are used for the rules are, PB (Positive Big), PS (Positive Small), ZE (Zero), NS (Negative Small) and NB (Negative Big). The same subsets are used for the two inputs and one output. The rule base is created from the general information about the SEPIC Converter and calculated based on the simulation results. A 5*5 rule base is developed and tabulated and shown in the table1.

TABLE 1. RULES OF FLC

Error / CE	NB	NS	ZE	PS	PB
NB	ZE	NE	PB	PB	PB
NS	NS	NS	PS	PS	PB
ZE	NB	NB	ZE	PS	PB
PS	NB	NS	NS	ZE	**PS**
PB	NB	NB	NB	NS	ZE

V. SIMULATION RESULTS AND DISCUSSION

The simulation using Matlab for the proposed system is shown in figure 8. Voltage and current from the solar panel is measured by the sensors and fed to the MPPT algorithm from where the voltage required for the maximum power is calculated using P&O method. This voltage is considered as the reference voltage to the SEPIC converter. The error and change in error between the actual output voltage and reference voltage for each step is compared and the desired output is achieved through FLC and stored in the battery. The input and output voltage of the SEPIC converter is shown in figure 9.

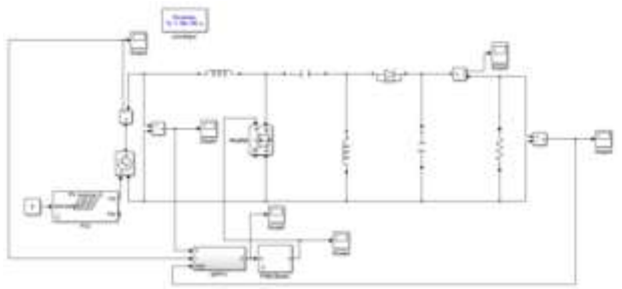

Figure 8. Simulink Model

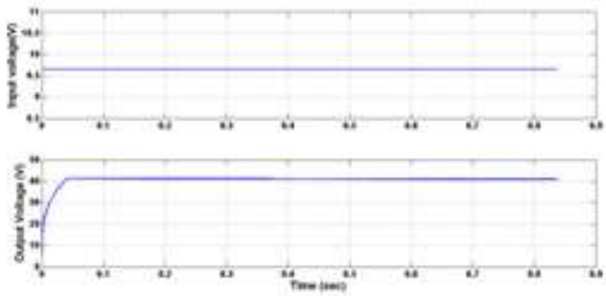

Figure 9. Input and output voltage of SEPIC converter

VI. HARDWARE RESULTS

The main hardware parts include the solar panel, SEPIC converter, microcontroller, IR sensor, motors, grass cutting blades, wheels and battery. The working of the device is all dependent on the electronic circuitry that is designed.

The obstacles present in the path of device are obtained with the help of sensors. The perimeter of the lawn should be covered with either wall or obstacle. The robot will move till the obstacle is detected and takes different direction as per the predefined program in the microcontroller. This mechanism is to be used to cut the grass, which is the primary function of the lawn mower. It is to be achieved with help of a grass cutter and a motor to run this cutter. The number of cutters can be more than one depending on the design of the mower. Also the motion of the cutter can be controlled with help of timer as to when to switch it off. The front and top view of the hardware setup is shown in figure 10 and figure 11.

Figure 10: Front View of the Hardware setup

Figure 11: Top View of the Hardware setup

VII. Conclusion

The proposed lawn mower is designed to achieve less working time, low cost and minimum energy consumption. The proposed green energy mower reduces the pollution and attains maximum efficiency. Fuzzy logic controller combines with MPPT algorithm improve the efficiency of the solar panel by extracting the maximum power. The adjustable blade system can increase the efficiency and also reduce the operating time. The structure is user friendly, economic and achieving the objectives.

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