Solar Energyfor Extensionof Endurance for Unmanned Air Vehicle

Sudha[1], Siva Subba Rao Patange[2], Raja S [2], M. Sowmia Devi[2], Raghavendra L[2],Naveenkumar. G. N[1]
[1]CMR Institute of Technology Bengaluru-560037, India
[2]CSIR- National Aerospace Laboratories Bengaluru-560017, India

***Abstract*—At present the Unmanned Air Vehicles (UAV) sustain very short duration flight due to limited on board energy storage capacity (Battery). Battery maintains limited power and it will discharge after certain time while flying an UAV. To increase the operational time of the UAV the energy harvesting elements, such as flexible thin solar cells are used. These solar cells are used to charge the battery, and can be used as wing structures to increase the operational performance. Several approaches have been used for the implementation of MPPT solar system based on the P&O and enhanced P&O algorithms simulation is done using LABVIEW [1]. Energy harvesting system is applied for solar powered flood warning system using P&O algorithm [2]. In this paper, the maximum power point tracking (MPPT) algorithms such as P&O and Incremental conductance methods are used and the simulation results are obtained using MATLAB/Simulink. The maximum power point track is achieved with the help of MPPT incremental conductance algorithmsthe results are observed.**

Keywords— Solar energy; Endurance; MPPT; P&O; Incremental conductance.

I. INTRODUCTION

The Unmanned Air Vehicle is usually called as a drone. It is an aircraft with no pilot. The difference between the manned and unmanned air vehicle is they have similar physical components the main exceptions are the cockpit and control system. UAVs are components of an Unmanned Aircraft System, which include a UAV, and a ground based controller. UAV is defined as a capable of controlled and sustained level flight and it can be powered by a engine. The UAVs are mostly used for military applications and they are used in other applications such as industrial, and agricultural and in aerial photography etc. The UAV is not burdened with physiological limitations of human pilot. The flight duration of the unmanned air vehicle varies widely depending on the aircraft size. The solar electric UAVs used for extension of flight duration. The smaller UAVs use (Li – PO) batteries and the larger UAVs relay on conventional aircraft engine.

II. LITERATURE SURVEY

ERRAHIMI Fatima, GAGA Ahmed [1] has proposed that the design and development of a photovoltaic system based on the enhanced P&O algorithm that improve the efficiency, stability and accuracy of solar systems. The effectiveness of the solar regulator system is verified by the simulation by PowerSim simulator and experimental results under our developed system using two MPPT algorithms, classical P&O and a new enhanced P&O algorithm.

ThanyanutLueangamornsiri [2] has proposed that the solar energy harvesting system applied for the flood warning system. It is a stand-alone system that is used to harvest the maximum energy from the photovoltaic (PV) panel to charge batteries. The Perturb and Observe method (P&O) is used to control converters using for Maximum Power Point Tracking (MPPT). A Three-Stage Charging (TSC) method is used to quickly charge the battery. The power management technique between the maximum power point tracking and the power charging processes is also proposed. The simulation results show that the P&O method can efficiently track the maximum power and the TSC method can properly control the charging process. The MPPT method and optimal charging of the battery can work together with the proposed power management algorithm.

Fangrui Liu, ShanxuDuan [3] has proposed that the Maximum power point tracking (MPPT) techniques are employed in photovoltaic (PV) systems to make full utilization of the PV array output power which depends on the solar irradiation and the ambient temperature. The incremental conductance (INC) algorithm is widely used due to the high tracking accuracy at and good adaptability to the rapidly changing atmospheric conditions. A modified variable step size INC MPPT algorithm is proposed, which automatically adjusts the step size to track the PV array maximum power point. Compared with the conventional fixed step size method, the proposed approach can effectively improve the MPPT speed and accuracy. The theoretical analysis and design principle of the proposed method are provided and its feasibility is also verified by simulation and experimental results.

Saad Mekhilef, Azadeh Safari [4] in this paper the simulation and hardware implementation of the incremental conductance maximum power point tracking (MPPT) algorithm used in solar array power systems with the direct control method. The proposed system to existing MPPT systems includes elimination of the proportional–integral control loop and investigation of the effect of simplifying the control circuit. The system including converter design, system simulation, controller programming, and the experimental setup. The system is capable of tracking maximum power point accurately and rapidly without the steady-state oscillation. The Incremental Conductance algorithm is used to track the maximum power point because it performs precise control under rapidly changing atmospheric conditions. MATLAB

and Simulink platform used for simulation and the Code Composer Studio v3.1 was used to program a TMS320F2812 digital signal processor. The proposed system was developed and tested successfully on a photovoltaic solar panel. Experimental results indicate the improved functionality of the system.

Ahmed K.Abdelsalam, Ahmed M. Massoud [5] has proposed that the Solar photovoltaic (PV) energy has large growth in the past decade. The High-efficiency PV-based micro grids require maximum power point tracking (MPPT) controllers to maximize the harvested energy due to the nonlinearity in PV module characteristics. The Perturb and observe (P&O) techniques have several disadvantages, such as sustained oscillation around the Maximum Power Point, fast tracking versus oscillation tradeoffs and the user predefined constants. In this paper, a modified P&O MPPT technique is presented. The results for the implemented setup at different irradiance levels are illustrated.

Mr. S.Venkatasubramanian, C Anusuya [6] this paper proposed a high step-up for solar power optimizer (SPO) that efficiently harvests the maximum energy from a photovoltaic (PV) panel then outputs energy to a dc-micro-grid. The system enhanced the features of Dual Active Bridge and perturbation and observation (P&O) algorithm for tracking the maximum power for setting the input power. The harvested photovoltaic energy is given to the Dual Active Bridge circuit where it can be stepped up using linear transformer. The linear transformer ratio is 1:4 and this output is given to the converter bridge. The converter changes from AC into DC. The dc power input is given to the dc distribution system. The dual active bridge is simulated using MATLAB/ SIMULINK software for different solar panel power.

Hamdy A. Ziedan and Hammad Abo-Zied Mohammed [7] has proposed that it is aimed for designing and implementing the control circuits for a stand-alone photovoltaic (PV) LED road lighting system. The parts of the control circuit are DC/DC converter and microprocessor control circuit. The Control circuit adjust the Maximum Power Point Tracking (MPPT), which makes the road lighting system operated effectively and adjusts battery charging process. The Control circuit function is considered to automatically switch lights ON at sunset. The simulation study is done by using the PSIM and Simulation of MATLAB software.

N. Sandeep, M. V. Aware and ChoukiBalakishan[8] has proposed that the photovoltaic (PV) system exhibits a nonlinear power attribute which depends on the environmental conditions. To draw the maximum, power the various algorithms are used with PV voltage/current or both as an input for the maximum power point tracking (MPPT) controller. Here a Golden section search (GSS) based MPPT control and its use with the three-level DC-DC boost converter for MPPT are established, the three-level boost converter provides the high voltage transfer which enables the high power photovoltaic (PV) system to work with low size inductors with high efficiency. The simulation of three-level DC-DC converter with GSS algorithm is done with MATLAB/SIMULINK platform. The experiments carried out on hardware prototype of 100W converter with low cost AT'mega328 controller. The experimental results show high performance and a conversion efficiency of 94%.

ShakilAhamed Khan, Mohammad Jakir Hossain and [9] has proposed an intelligent method for maximum power point tracking (MPPT) for a photovoltaic system under variable temperature conditions and conversion of this solar energy intostabilized sine wave having low distortion factor (DF), so that the solar energy can be supplied to grid and can operate the deviceproficiently. The fuzzy logic control algorithm is implemented with the embedded microcontroller for the improved performance. This MPPT controller regulates converter output voltage by varying modulation index of the PWM pattern using MPPT algorithm and maximizes the output power extracted from photovoltaic array. The low-cost implementation of the MPP algorithm in a 8-bit microcontroller to generate optimized real time code in C for ATMega8 microcontroller which will demonstrate how maximum power point tracker might provide elegant and efficient solution for increasing the efficiency of a solar system and connection of the extracted energy to grid which is based on experimental results rather than on mathematical models.

Subramani. M, Dineshkumar. T [10] has proposed that Maximum Power Point Tracking (MPPT) is used to optimize photovoltaic cells power. The Beta algorithm is a type of MPPT algorithm used to track the maximum power point. The Beta algorithm is having fast tracking ability for the different atmospheric conditions. These Algorithms are used to calculate the duty cycle for DC-DC converter. The Calculation of duty cycle is dependent on photovoltaic cells output voltage and current. The DC-DC converter Output power is measured in order to verify the algorithm indifferent irradiation levels of photovoltaic cells. Beta algorithm is compared with different MPPT algorithms.

III. IMPLEMENTATION PROCEDURE

Solar panel:The solar panels are used as a energy harvesting elements to absorb energy from sunlight which will be in terms of heat or electricity.The output power of solar arrays is always changing with weather conditions such as solar irradiation and atmospheric temperature. The thin flexible solar cells are used in this project. These solar cells are used as a multifunctional wing for Unmanned Aerial Vehicle.

MPPT Implementation:

In this paper, the Maximum Power Point Tracking (MPPT) algorithms are used to extract the maximum power from the solar cells to obtain the maximum power point. The MPPT is implemented in photovoltaic systems, this algorithm controls the voltage to ensure that the system operates at peak voltage. The P&O and Incremental conductance MPPT algorithms are used here to track the maximum power.

MPPT ALGORITMS:

A. Perturb and Observe (P&O)Algorithm:

Perturb and observe is the most commonly used MPPT method in this method the controller adjusts the voltage by a small amount from the PV array and measures power. This method can result in oscillations of power output. This algorithm regularly perturbs the operating point of the solar cells by increasing and decreasing the conditional parameters. This algorithm measures the solar cell output before and after the perturbation.

B. Incremental Conductance:

This algorithm is an instantaneous conductance for the solar cells. This algorithm increases or decreases the voltage depending on the result to achieve the maximum power point. The controller measures the incremental changes in PV array current and voltage to predict the effect of a voltage change. This method requires more computation in the controller, but can track changing conditions more rapidly than the perturb and observe method (P&O).

The incremental conductance method computes the maximum power point by comparison of the incremental conductance (I_Δ / V_Δ) to the array conductance (I / V). when these two are the same (I / V = I_Δ / V_Δ), the output voltage is the maximum power point voltage. Until the irradiation changes the controller maintains voltage constant and the process is repeated. The incremental conductance method based on the observation that at the maximum power point dP/dV = 0 and that P = IV.

A. Perturb and Observe (P&O) Flowchart

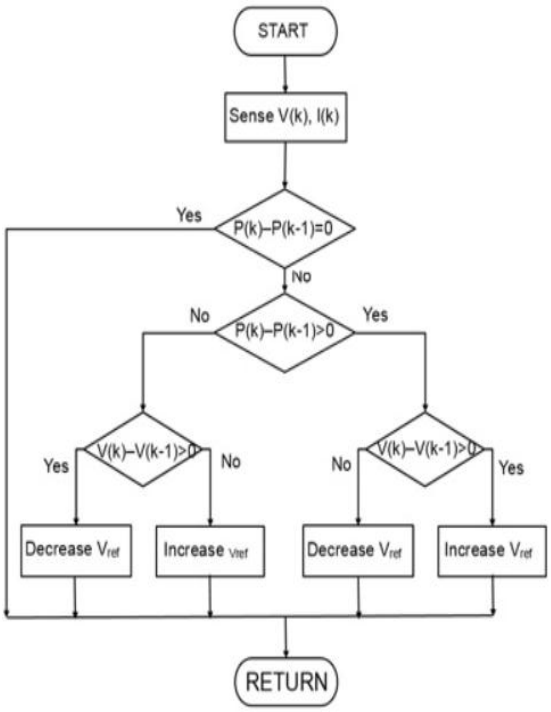

Figure 1:Flowchart of P&O algorithm.

The Perturb and Observe method follows the steps according to flowchart as shown in fig

From the solar panels the current I (k) and voltage V (k) readings are measured. The k value is set to certain point based on these current and voltage values the power can be calculated. If the power of the initial value p (k) and the power of the old value P (k-1) is equals to zero the loop will be completed, if not equals to zero it will check the voltage levels for different conditions. If the voltage of the initial value V (k) and the voltage of the old value V (k-1) is equals to zero the it will decrease the voltage Vref, if not equals to zero increases the voltage Vref.

B. Incremental Conductance Method Flowchart

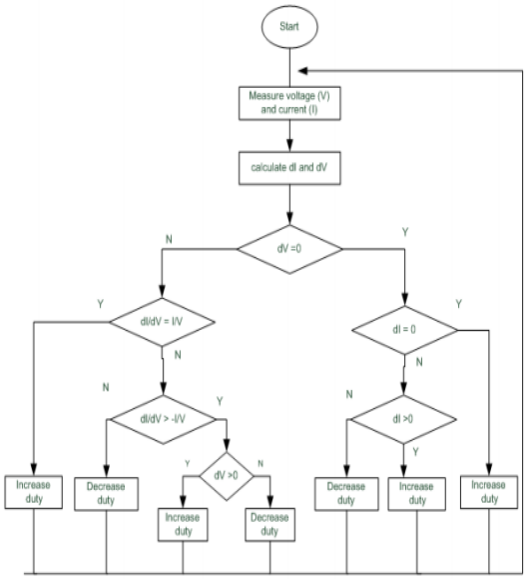

Figure 2: Flowchart of Incremental Conductance algorithm.

The maximum power point (MPP) can be calculated by using the relation between dI/dV and –I/V. If dP/dV is negative then MPPT is lies on the right side of recent position and if the MPP is positive the MPPT is on left side. The equation of incremental conductance (IC) method is

$$\frac{dp}{dv} = \frac{d(VI)}{dV} = I\frac{dV}{dV} + V\frac{dI}{dV} \quad (1)$$

$$= I + V\frac{dI}{dV}$$

MPP is reached when dP/dV=0 and

$$\frac{dI}{dV} = -\frac{I}{V} \quad (2)$$

$$\frac{dp}{dv} > 0 \; then \; Vp < Vmpp \quad (3)$$

$$\frac{dp}{dv} = 0 \; then \; Vp = Vmpp \quad (4)$$

$$\frac{dp}{dv} < 0 \; then \; Vp > Vmpp \quad (5)$$

If MPP lies on right side, dI/dV< -I/V and then the PV voltage must be decreased to reach the MPP. IC methods can be used for finding the MPP, improve the PV efficiency, reduce power loss and system cost. The oscillation around maximum power point (MPP) area also can be suppressed in

trade of with its implementation complexity. Tracking time still not fast since the voltage increment and decrement had been selected manually by trial and error.

IV. RESULTS AND DISCUSSION

In this paper to increase the endurance speed of the Unmanned Air Vehicle the thin flexible solar cells are used. These solar cells are used as multifunctional wings where it can perform multiple functions into a single device. The output of the Solar Energy System has to be controlled hence a MPPT technique has designed to track the maximum power from the solar panel, the design of the MPPT is done by using the MPPT algorithms they are Perturb and observe (P&O) and Incremental Conductance method. In this paper, the incremental conductance method overcomes the disadvantages of P&O algorithm. And it is having the ability to track the maximum power point.The output of the Solar Energy System has to be controlled hence a MPPT technique has designed to track the maximum power from the solar panel. In this paper, the incremental conductance MPPT algorithm is used and the incremental conductance algorithm is implemented in Simulink. Figure shows the plots for incremental conductance implemented in Simulink.

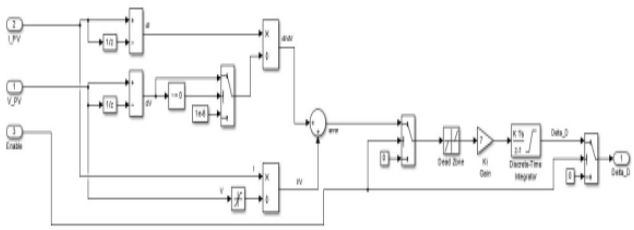

Figure 3:Simulink model of Incremental conductance algorithm.

The solar energy used here to charge the battery to increase the endurance speed of UAV by powering the device. For battery, operated UAVs the endurance speed is less, so the solar panels used to charge the battery to increase the endurance speed of the UAV. The solar panel voltage is 23.68V when it is connected to load it will be 19.55Vand by keeping the 50% throttle, the battery voltage and the panel voltage are checked for every 3 to 5 minutes and the results are plotted with respect to battery voltage. The endurance speed of UAV is extended up to 1hour 7 minutes. And the power obtained from these results is 86.4 Watt.

Fig 4. Shows the output waveforms which are obtained from the solar energy. The first graph shows the output of solar current at maximum peak, the second graph shows the output of solar voltage and the third graph shows the output of solar power at the maximum power point.

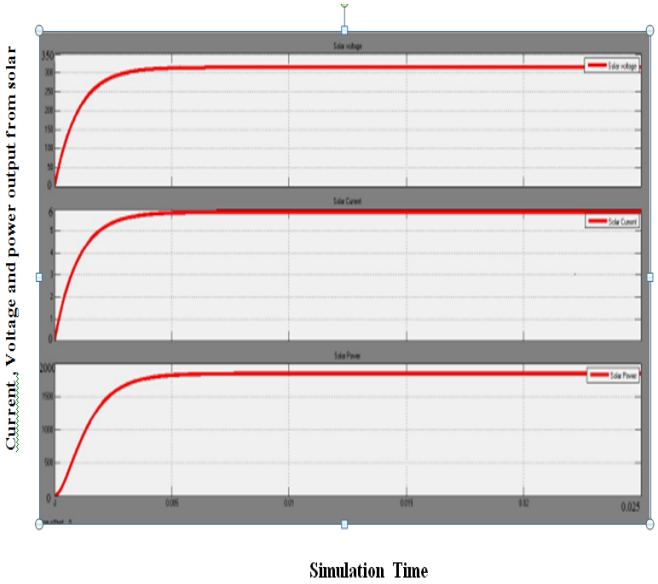

Figure 4:Simululation graph of Incremental conductance algorithm.

V. CONCLUSION

In this paper, the solar cells are used for charging the battery to increase the endurance speed of the UAV. The earlier UAVs are battery operated systems and they had a less endurance speed. The solar cells used here are thin and flexible and low weight films and can be used to charge the battery to power up the device for the extension of endurance. To track the maximum power from the solar cells the MPPT algorithms are used they are the perturb and observe and incremental conductance. The results show that the incremental conductance MPPT algorithm is efficient to track the maximum power from the solar cells compared to P&O algorithm.

ACKNOWLEDGEMENT

The authors would like to thank the Director, CSIR-National Aerospace Laboratories for his persistence to carry out the work. Dr. Satish Chandra, Head Structural Technologies Division (STTD) is profusely thanked for providing all the facilities for completing this developmental work. Special thanks are due to Mr. Aravindu B, Technical Assistant of Structural Technologies Division (STTD), CSIR-National Aerospace Laboratories, for their help.

REFERENCES

[1] ERRAHIMI Fatima, GAGA Ahmed “Design and implementation of MPPT solar system based on the enhanced P&O algorithm using Labview”.
[2] Fangrui Liu, ShanxuDuan,“A Variable Step Size INC MPPTMethod for PV Systems”. VOL. 55,NO. 7, JULY 2008.
[3] SaadMekhilef, Azadeh Safari and “Simulation and Hardware Implementation ofIncremental Conductance MPPT With DirectControl Method Using Cuk Converter” VOL. 58, NO. 4, APRIL 2011.
[4] Ahmed K. Abdelsalam, Ahmed M. Massoud, “High-Performance Adaptive Perturb and ObserveMPPT Technique for Photovoltaic-Based Microgrids” VOL. 26, NO. 4, APRIL 2011.

[5] Mr. S. Venkatasubramanian, C Anusuy"Design and Implementation of Solar Power Optimizer for DC Distribution System using Dual Active Bridge" Vol. 3, Special Issue 1, February 2014.
[6] Hamdy A. Ziedan andHammad Abo-Zied Mohammed "Design and implementation of control circuit for a stand-alone photovoltaic led road lighting system" Vol. 44 No. 2 March 2016 PP. 145 – 157.
[7] N. Sandeep, M. V. Awareand ChoukiBalakishan, "Design and Implementation of Three-Level DC-DC Converter with Golden Section Search Based MPPT for the Photovoltaic Applications" Volume 2015, Article ID 58719.
[8] ShakilAhamed Khan, Mohammad Jakir Hossain and Md. Ismail Hossain "Design and Implementation of MPPT Controlled Grid Connected Photovoltaic System"
[9] SUBRAMANI. M, DINESHKUMAR. T "Design and Implementation Maximum Power Point Tracking in Photovoltaic Cells".
[10] Rafael Diez; Arnold Wiesner; Gabriel Perilla. "Design and implementation of a Buck converter with MPPT for battery charge from solar module".978-1-4799-1007-6/13/©2013