OPTIMAL DESIGN OF CONVERTER CIRCUIT SUITABLE FOR INDUCTION HEATING

A PROJECT REPORT

submitted by

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to

the APJ Abdul Kalam Technological University
in partial fulfillment of the requirements for the award of the Degree

of

Master of Technology
in
Electrical and Electronics Engineering
with specialisation in
Industrial Instrumentation and Control

Department of Electrical and Electronics Engineering

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DECLARATION

I undersigned hereby declare that the Project report entitled "**Optimal design of converter circuit suitable for Induction heating**", submitted for partial fulfillment of the requirements for the award of degree of Master of Technology in Electrical and Electronics Engineering with specialisation in Industrial Instrumentation and Control, of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under the supervision of *Dr. Sheeba R*, Project Supervisor/ Guide, Professor, Department of Electrical and Electronics Engineering, *Prof. AMAL A*, Project Co-ordinator, Assistant Professor, Department of Electrical and Electronics Engineering. This submission represents my ideas in my own words and where ideas or words of others have been included. I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

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CERTIFICATE

This is to certify that the report entitled " **Optimal design of converter circuit suitable for Induction heating** " submitted by **Resma Radhakrishnan** , **(Reg. No. TKM21EEII09)** of fourth semester to the APJ Abdul Kalam Technological University in partial fulfillment of the requirements for the award of the Degree of Master of Technology in Electrical and Electronics Engineering with specialisation in Industrial Instrumentation and Control, is a bonafide record of the Project work done by her under our guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

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ABSTRACT

Increased energy requirements demands photovoltaic systems to be linked into the grid so as to contribute to the overall power generation. Maximum Power Point Tracking (MPPT) is a technique used by variable power source for extracting maximum power. For tracking maximum power one of the most trustworthy technique is Incremental conductance (INC) MPPT method. However conventional INC algorithm is unable to track maximum power with altering step size. So a novel Incremental Conductance approach using a Fuzzy Logic controller (FLC) is implemented in which a fuzzy logic algorithm is used to vary the step size. The fuzzy logic system is developed by location of fuzzy inputs regarding different regions. The fuzzy inputs are obtained from the slope of power voltage relation. Using the current voltage ratio and its derivatives membership functions and rules are designed. A solar PV system is implemented using the INC and FLC methods and is simulated in Matlab. The simulation findings show that using the FLC approach increases the system's ability to respond to dynamic changes by boosting its dc output power and cutting down on the time it takes to reach the steady state when compared to the conventional INC method.

We use a solar-powered induction cooker to reduce the issue with utility during peak hours. Due to its high efficiency and gentle switching capabilities, a Full bridge resonant converter is developed to satisfy the need. Full bridge series resonant circuit is used for the heating purpose where the circulating magnetic fields induces an eddy current which induces heating. The Matlab or simulink platform is used to simulate the developed FLC method in conjunction with the full bridge resonant converter. The outcomes shows that the system is more effective in terms of output power.

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ABBREVIATIONS

PV	Photovoltaic system
MPP	Maximum power point
FLC	Fuzzy logic control
INC	Incremental Conductance

NOTATIONS

V	Voltage
I	Current
F	Switching Frequency, Hz
D	Duty Ratio
R	Resistance
L	Inductance
C	Capacitance
G	Irradiance
t_c	Cell Temperature

Chapter 1

INTRODUCTION

1.1 GENERAL BACKGROUND

In order to increase the contribution of PV generation to the total global power generation, Photovoltaic (PV) systems are increasingly being integrated into the grid on a global scale. Reduced emissions of CO2 and other hazardous gases from fossil fuels are possible with the help of renewable energy sources including wind, biomass, geothermal, and photovoltaic (PV). The annual growth rates of solar energy generation have significantly grown recently, reaching a total generation of 849 GW in 2021 as opposed to a overall generation of 788 GW in 2020. By 2030, it's anticipated that PV generation penetration levels will continue to rise and reach 2500 GW or more. The widespread use of PV has been made possible by its accessibility, ongoing wattage cost reduction, and environmental friendliness. To increase their power output and lower the cost of producing each kilowatt-hour they generate, energy efficiency concerns and better energy harvesting have emerged. The maximum power point tracking (MPPT) control is the most well-known and efficient method for increasing the energy efficiency of PV systems. This results from the PV generation's variable nature. PV system output is strongly influenced by the temperature and irradiance conditions Because solar radiation is dynamic, power production is unsteady all day long. Additionally, the incorporation of power electronic devices with the renewable energy sources and partial shading of panels results in numerous losses that are significant enough to take into account even during the design stage for driving a specific load.

1.2 OBJECTIVES

Design and Develop a converter circuit suitable for induction heating. The application of this Maximum power point tracking concept is used to improve the converter performance during the constant environmental conditions (static performance) and during the switching of the environmental conditions (dynamic performance).

1.3 SCOPE

For a PV system to operate at its best, efficiency must be increased. This benefit can be attained by continuously drawing the greatest power possible from the PV arrays as the outside conditions change. In order to operate PV arrays in a more efficient way, maximum power point tracking (MPPT) is crucial. The change in environmental circumstances over the course of a day is thought to be represented by the solar irradiation (G) and the cell temperature (Tc). The PV array voltage and power deviate from the ideal point as G and Tc change. Therefore, the PV array voltage is changed to correspond to the highest output power. The DC-DC boost converter's duty cycle can be changed often in order to change the PV voltage.

The incremental conductance (INC), perturb-and-observe, fractional short-circuit current, fractional open circuit voltage, and hill climbing are the most popular MPPT techniques. Numerous variations are used as control approaches for the MPPT for PV systems as a result of improvements in artificial intelligence technology. Artificial neural networks and fuzzy logic control, which are reliable, accurate, and quick procedures, are frequently utilised in MPPT. The MPPT accuracy is improved using optimization approaches including genetic algorithms, ant colony optimization, and particle swarm optimization.

Due to its general nature and easyness, the PO method is the one that is most commonly utilised. When determining the right step size for the PO approach, quick tracking must be sacrificed in order to account for steady state changes. In general, fixed step size MPPT algorithms must take the trade-off conditions into account. When working environmental conditions, such as sun irradiance and ambient temperature, fluctuate quickly and continuously, the situation deteriorates.

1.4 SCHEME OF WORK

The organization of the report is as follows. Chapter 1 deals with the Introduction, it's main objectives and chapter 2 is literature review. The proposed methodology is discussing in Chapter 3. Chapter 4 deals the system description and chapter 5 deals with results and chapter 6 the conclusions of the report.

Chapter 2

LITERATURE REVIEW

Maximum power point tracking is nowadays one of the most important techniques that is used to improve the efficiency of the system. A fuzzy based MPPT method is used to track maximum power point in [1].The system is modelled and analyzed in MATLAB/SIMULINK. Simulation results showed that fuzzy based MPPT has better performance and more power is produced from solar panel.

Many methods to track Maximum Power Point (MPP) for PV arrays have been discussed in [2][3]. It comprises of all the techniques implied in this field and a comparative review of various method is carried out. [4] shows Hybrid MPPT method for grid connected photovoltaic systems under rapidly changing atmospheric conditions.

A method for MPPT tracking named CVT (Constant Voltage Tracking) is proposed by [5] and analysis of its characteristic curve and operation of PV array have been discussed. A power photovoltaic (PV) system with simple structure is designed in [6][7]. This method is tested by PV charging system and its output depicts that MPP of PV array can be tracked more easily by applying the charger controller.

Literature [8] has developed a new Maximum Power Tracking (MPT) algorithm for tracking Maximum Power Operating Point (MPOP) and carried out by comparing the incremental and instantaneous conductance of the PV array. The drawbacks of Perturb and Observe method were analyzed and it was found that the Incremental Conductance algorithm tracks the MPOP even when atmospheric conditions changes rapidly. The work was done by both simulation and graphs. [9] deals with a combination of particle swarm optimization and perturb and observe method for MPPT in PV systems carried out under partial shading conditions.

A solar based induction cooker is being designed in [10] in which a battery setup is also used to store the energy for further use. Hardware implementation of the proposed system is also done. [11] has developed a half bridge series resonant converter with a thyristor controlled reactor for the purpose of domestic heating. [12] proposes a perturb and observe MPPT technique and a PI controller is used for power control so as to obtain highly efficient voltage control.

A resonant converter based on LLC configuration is developed in [13] for high power induction heating applications. This has an added advantage of preventing short circuit current in case if any fault occurs. [14] comprises of a study on various type of power electronic converters used for the optimal operation of induction heating applications. [15][16] provides an idea of a series resonant converter that is used even in zero voltage switching applications and inherent short circuit conditions.

A low profile and improved efficiency resonant converters using class E resonant converters are developed in [17][18]. To improve the efficiency of a zvs switching half bridge resonant converter a variable frequency duty cycle is implemented and efficiency is analysed using the optimum operating point in [19]. [20] proposes a novel design of an MPPT control strategy like hill climbing method and is implemented by using microcontroller in an induction heating system to find the operating frequency corresponding to MPPT.

2.1 SUMMARY

This chapter deals with the various papers related to the work. Various literature are used to get an idea about the former development in this field and studied about the new scope or improvements that can be brought to make the work effective.

Chapter 3

METHODOLOGY

The standard MPPT approach is enhanced by using a new design for adjusting the voltage step size. The slope of power-voltage relation affects on the functioning of MPPT. The output voltage and current from the PV module is fed to a boost converter which boost the output of PV and is given as input to the resonant converter which serves the purpose of induction heating.

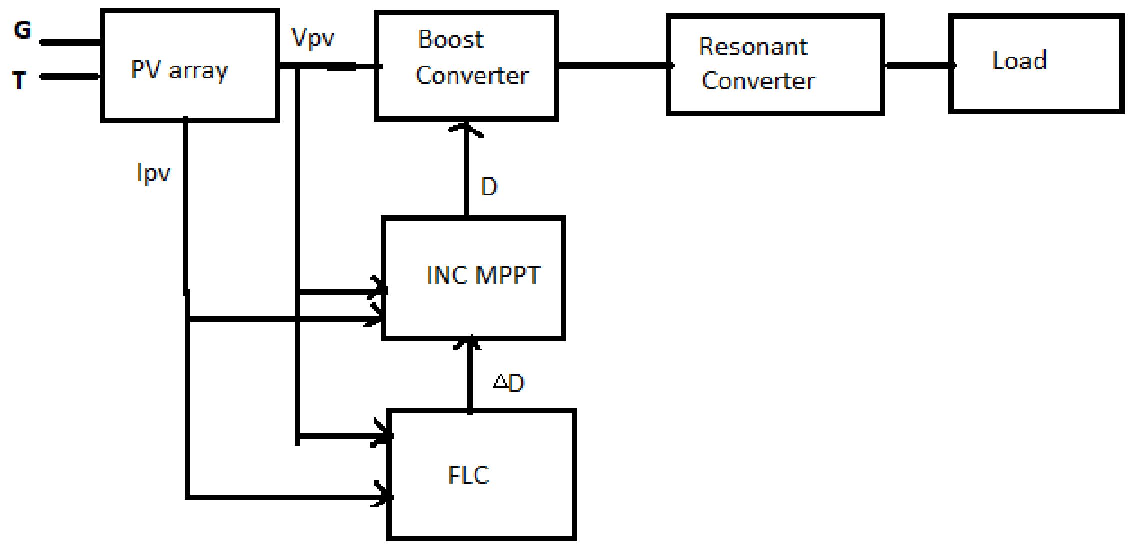


Figure 3.1: Block diagram of proposed system

Maximum power point is obtained by using an Incremental conductance MPPT technique which tracks the maximum power. But conventional MPPT INC technique has a drawback in which tracking of power is difficult in varying conditions like temperature and irradiance. To overcome this a Fuzzy logic controller is implemented to improve the INC method in which FLC outputs a variable step size which controls INC. The ouput of INC is the duty cycle which is given to the boost converter.

3.1 MODELLING OF PV

Solar PV system consist of PV panels, which contains PV cells that are connected in series or parallel to obtain the voltage, current and power that is required. Series connection increase the voltage of the module and parallel connection of cells increases the current of the PV module.

A solar cell is modelled by a current source parallel to that of an inverted diode. The series resistance occurs due to the hindrance in the flow of electrons and parallel resistance is due to the leakage of current.

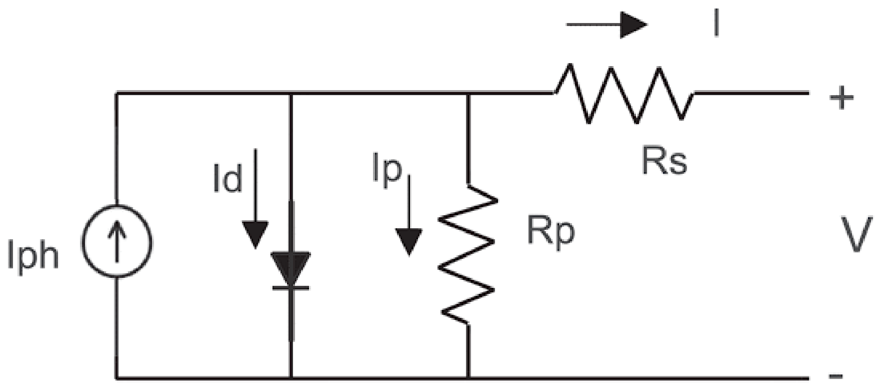


Figure 3.2: single diode model of a cell.

To illustrate the effect of changes in environmental conditions (G and T) on the maximum power point, a PV array is simulated using Matlab.

The array used for simulation is a 1 KW PV array, which is composed of 1 parallel string consisting of 5 series 213.15-P panel, which has 60 cells per module.

The current-voltage and power-voltage is obtained as shown in figure:

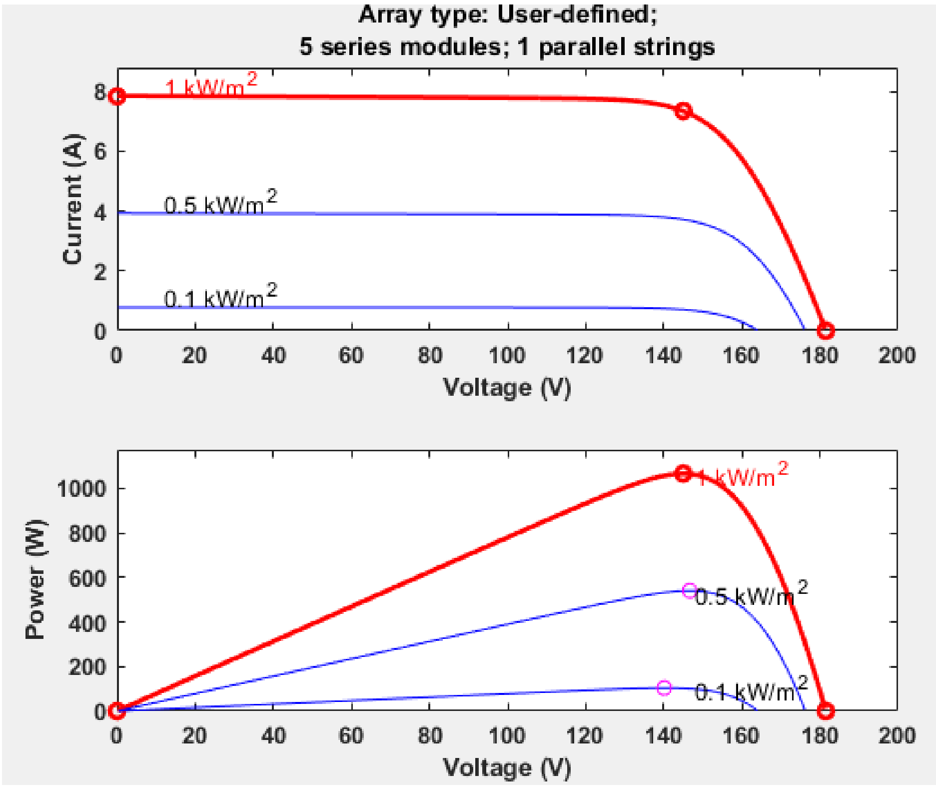


Figure 3.3: PV characteristics

Table 3.1: Parameters of PV module

Parameter	**Value**
Open circuit voltage Voc	36.3 V
Short circuit current Isc	7.84 A
Voltage at maximum power point Vmp	29 V
Current at maximum power point Imp	7.35 A

3.2 BOOST CONVERTER

A boost converter is a DC-to-DC power converter that increases voltage from its input to its output with decreasing current. This is a type of switched-mode power supply having two semiconductors at the less and have one energy storage component, such as a capacitor or an inductor. In order to reduce voltage ripple, filters built of capacitors are typically attached to the converter's input and output.

In order to provide efficient voltage regulation with significant load variations, a wide range of linear and nonlinear control strategies have been investigated. Boost converters are extremely nonlinear systems. Any acceptable DC source, like batteries, solar panels etc can provide energy for the boost converter. DC to DC conversion is the process of converting one DC voltage to another DC voltage. Any DC to DC converter with an output voltage higher than the source voltage is referred to as a boost converter. Since a boost converter "steps up" the source voltage, it is sometimes referred to as a step-up converter. The output current is lower to conserve the power.

The boost converter is the first stage, in which the PV module's greatest amount of energy is gathered. The advantages of the boost converter are voltage enhancement, reduced component count, and continuous current on the solar PV panel side. The MPPT and PWM modulator, which convert the MPPT signal to boost converter gating pulses, make up the control of this step.

The photovoltaic solar panels serve as a source of dc voltage for it. The power semiconductor MOSFET device's duty cycle, which is controlled by pulse-width modulation, determines the output of the circuit. The most crucial factor in choosing the boost converter components and managing the dc-dc power converter to maximise the output power of the solar PV system is the duty cycle of the converter.

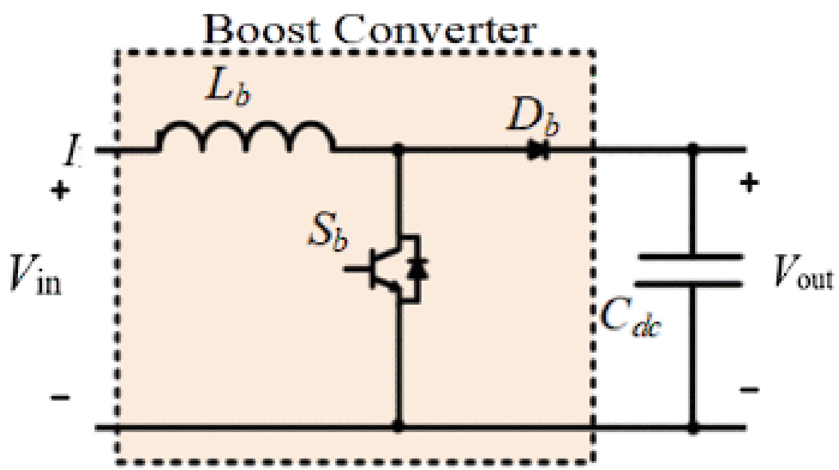


Figure 3.4: Boost circuit.

Table 3.2: Parameters of Boost Converter

Parameter	**Value**
Input Voltage V	180 V
Input current I	7.8 A
Output Voltage V	380 V
Output current I	2.63 A
Power P	1KW
Duty ratio D	0.5
Resistance R	144 Ohm
Inductance L	3.2 mH
Capacitance C	5 uF

3.3 SUMMARY

The chapter discusses about the methodology that is proposed. Photovoltaic systems are currently gaining demand as the surge of electricity usage is being increasing worldwide. So the implementation of maximum power point tracking techniques became more important.The chapter discusses about the method which tracks maximum power so as when connected to meet any requirement it provides maximum output which is used for serving demand.

Chapter 4

SYSTEM DESCRIPTION

4.1 MAXIMUM POWER POINT TRACKING(MPPT)

A technique used by variable power sources to increase energy extraction as with changing conditions is called maximum power point tracking (MPPT), or it is just referred to as power point tracking (PPT). The method can be applied to optical power transmission, wind turbines, and photovoltaic (PV) solar systems in addition to the more popular PV solar systems.

Different inverter systems, grids, battery banks, and other loads interact differently with PV solar systems. The main issue that MPPT attempts to solve is the fact that the efficiency of power transmission in a solar cell is dependent on the quantity of sunlight, the amount of shade, the temperature of the solar panel, and the electrical characteristics of the load.

The load characteristic that provides the maximum power transmission changes when these variables change. To maintain the best efficiency of power transfer as the load characteristic changes, the system have to be optimised. The maximum power point refers to this ideal load property (MPP). The MPPT method involves modifying the load characteristic as the environment changes. Circuits can be created to provide solar cells with the best loads possible before converting the voltage, current, or frequency to suit other systems or devices.

The current-voltage (I-V) curve and the power-voltage (P-V) curves can be used to study the non-linear relationship between temperature and resistance in solar cells. For maximum power, MPPT samples the output of the cell and applies the appropriate resistance.

The majority of the time, MPPT devices are built into an power converter system, which provides voltage or current conversion, filtering, and regulation for powering a variety of loads, such as batteries, power grids etc. Solar inverters utilise MPPT when they convert DC power to AC power.

Various MPPT techniques are:

1. Perturb and observe method

In perturb and observe method the array voltage is adjusted by small amount and measures power. It is also known as hill climbing method as it depends on the rise and fall of power with respect to voltage considering MPP. This method is very efficient providing accurate tracking of power but has a disadvantage of obtaining oscillations in the output power.

2. Incremental conductance method

In Incremental conductance method the effect in voltage change is predicted by measuring the incremental variations in current and voltage. This method is very helpful in tracking varying environmental conditions rather than as in perturb and observe method. oscillations are not encountered in the power output.

3. Current Sweep :

A sweep waveform is required for the measurement of the current- voltage characteristics of PV array which needs to be updated at regular intervals. The MPP voltage is obtained from the characteristic curves at regular intervals.

4. Constant Voltage :

In this method the output voltage is maintained at a constant value or the output voltage is modified on the basis of a constant ratio to measured open circuit voltage also termed as open voltage method.

4.2 INCREMENTAL CONDUCTANCE MPPT

Incremental conductance method is one among the maximum power point tracking method in which to track the maximum power it compares the incremental and instantaneous array conductance. This method depends on the slope of power- voltage. Maximum power occurs at zero slope and if the slope is positive the voltage needs to be incremented and if negative the slope the voltage is to be decremented.

$$P = VI \tag{4.1}$$

$$I + V\frac{d_i}{d_v} \tag{4.2}$$

Where P is the output dc power.

$$\frac{dP}{dV} = \frac{d(I * V)}{dV} \tag{4.3}$$

$$\frac{dP}{dV} = I + \frac{dI * V}{dV} \tag{4.4}$$

When dP/dV is greater than zero voltage should be incremented and if less than zero voltage should be decremented. At Maximum power point dP/dV is zero.

$$\frac{\Delta I}{\Delta V} = -\frac{I}{V}$$ At MPP

$$\frac{\Delta I}{\Delta V} > -\frac{I}{V}$$ To left of MPP

$$\frac{\Delta I}{\Delta V} < -\frac{I}{V}$$ To right of MPP

A flow chart of the incremental conductance method for MPPT is given. For the conventional INC method, a small amount of voltage is fixed for increment or decrement.

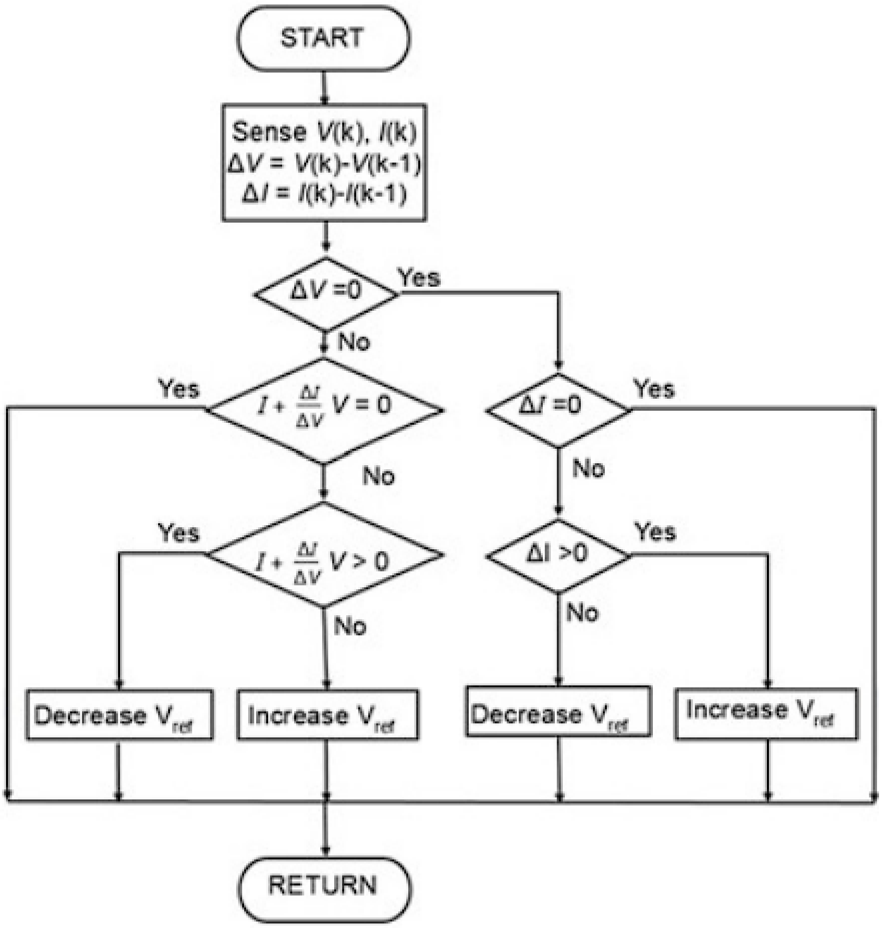


Figure 4.1: Flow chart of INC method

4.3 FUZZY LOGIC CONTROLLER

A Fuzzy logic control is an intelligent technique in which controllers can attain high efficiency without considering of the certainity of the informations. FLC is advantageous over other methods into two ways:

1. No exact mathematical model is required

2. Human expertise is utilised as the main component in designing fuzzy rules.

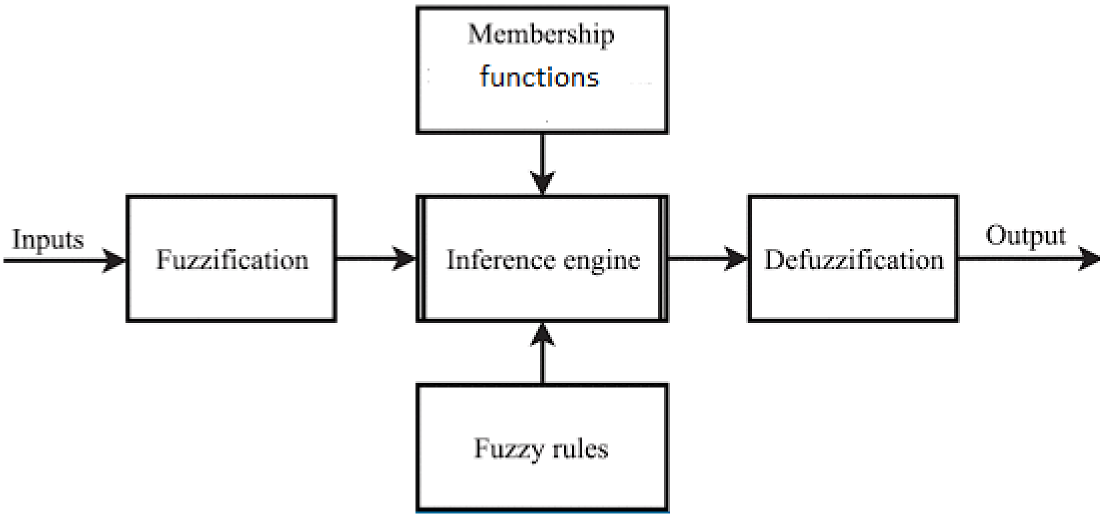


Figure 4.2: Block diagram of a FLC

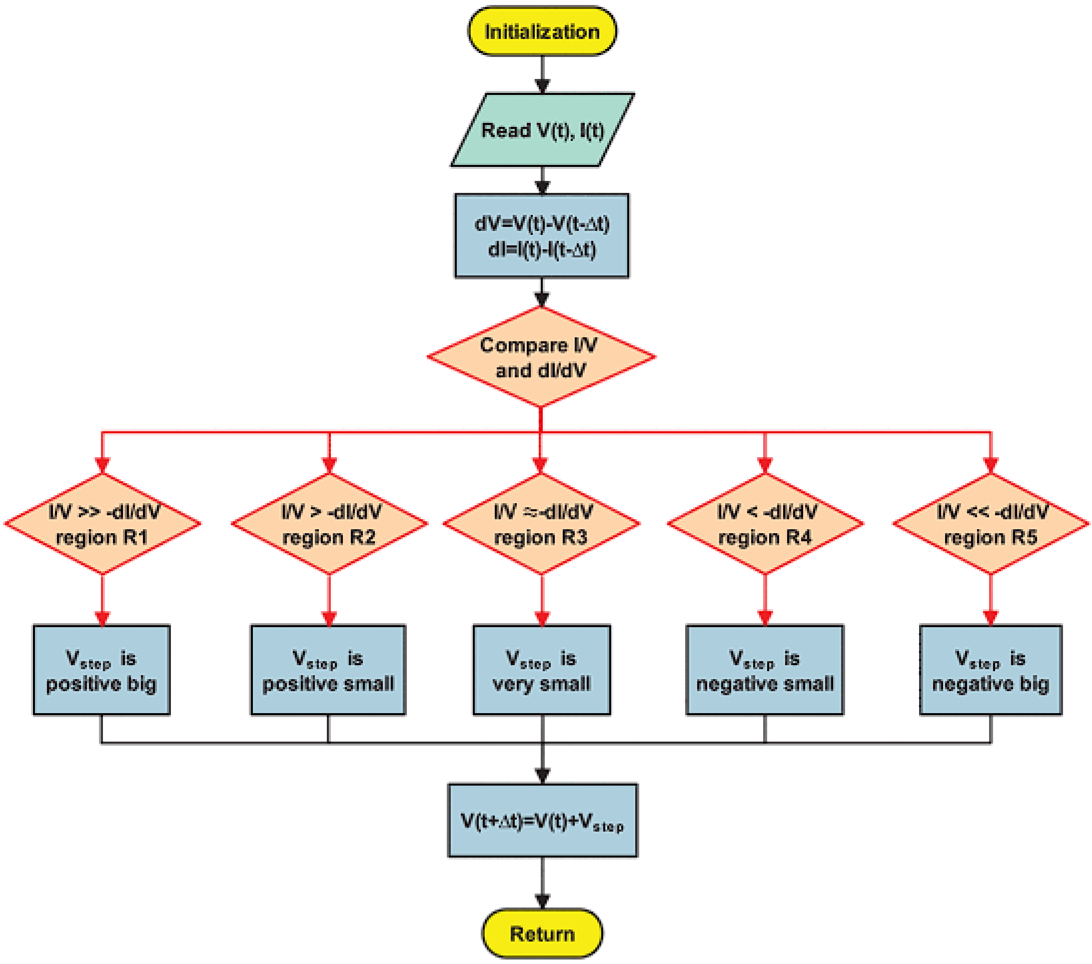
The crisp inputs are converted into Fuzzy inputs by the process of fuzzification. The fuzzy outputs are generated by the inference engine where the fuzzy inputs are converted to fuzzy outputs based on the membership functions and the rule base. Defuzzification is the inverse process of fuzzification in which the fuzzy outputs are converted into crisp output using various methods.

The rule base is the core part of the FLC. The working of FLC is continuous change in the D of converter obtained as a change in error of the voltage encountered in the panel and the maximum voltage of the panel.

4.4 FUZZY LOGIC VARIABLE STEP INC MPPT

The INC MPPT method uses the FLC to adjust the step size of voltage increment or decrease. Five zones are assigned by the algorithm based on where they are in relation to the point of maximum power. The five regions on the power-voltage and current-voltage relations under typical test conditions are essentially represented by the letters R1, R2, R3, R4, and R5.

- The voltage range, which is substantially lower than MPP, is represented by region R1.
- The voltage range lower than MPP is represented by region R2.
- The range close to MPP is represented by Region R3.
- The reverse of regions R2 and R1 on the other side of MPP is represented by regions R4 and R5, respectively.



Based on the algorithm fuzzy Rules for the INC Method's Variable Step Duty Cycle Generation are given in the table.[1]

The fuzzy inputs are ratio between PV current and PV voltage (I/V) and ratio between their derivatives (dI/dV). The output obtained is the variable step size. This variable step is given as the duty cycle of the boost converter.

dI/dV I/V	VL	L	VC	H	VH
VL	PB	PS	PS	VS	NS
L	PB	PS	VS	NS	NB
VC	PB	PS	VS	NS	NB
H	PB	PS	VS	NS	NB
VH	PB	PS	PS	NS	NB

Figure 4.3: Fuzzy rules for varying the duty cycle

The membership functions for the corresponding rules are given as:

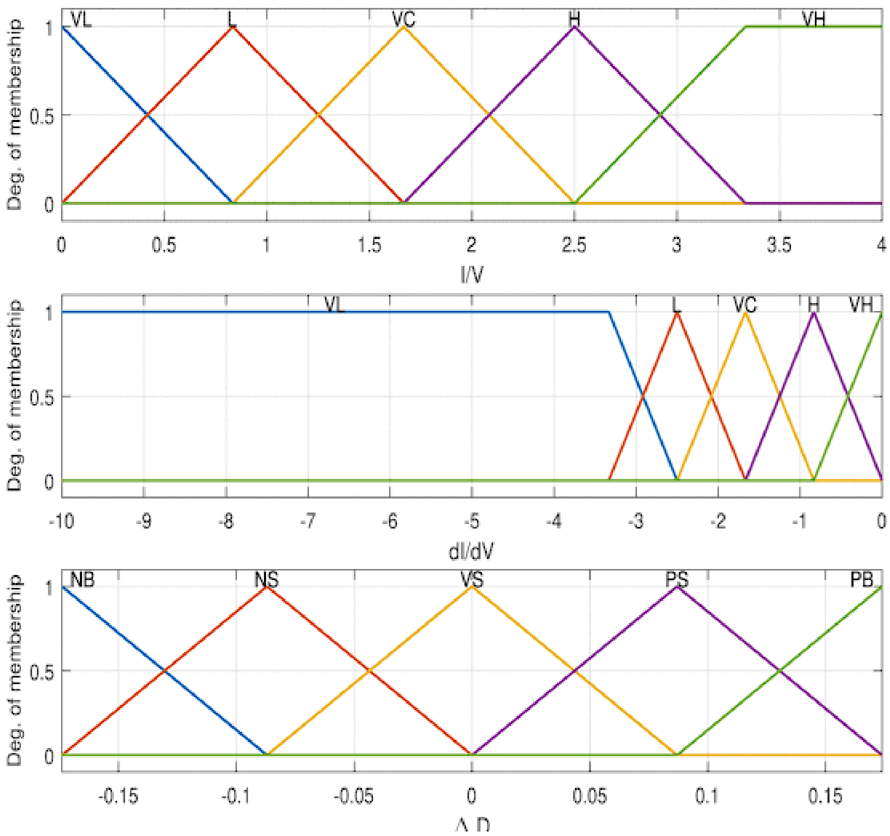


Figure 4.4: Membership functions for varying the duty cycle

The abbreviations in table denotes:

VL: very low, L: low, H: high, VH: very high, VC: very close.

The fuzzy logic controller uses the corresponding rules and membership functions to produce a fuzzified output which is later converted into a crisp input by means of defuzzification.

4.5 INDUCTION HEATING

Induction heating is a technology that uses electromagnetic induction to heat materials. This technique requires high frequency current supply that is capable of inducing high frequency eddy currents in the work piece which results in the heating.

According to Faraday's law of electromagnetic induction, When a current passes through the heating coil a magnetic field will get generated around it which produces the effect of heating.

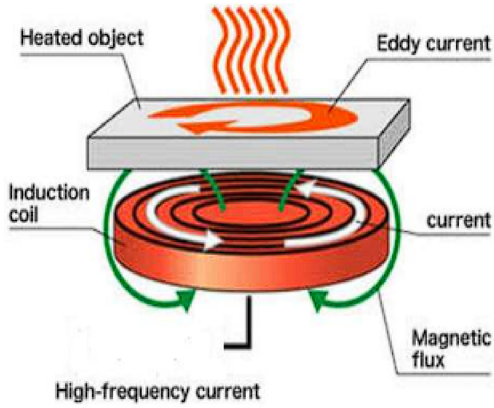


Figure 4.5: Induction working

In case of cooking, the developed alternating magnetic field in the induction coil induces eddy current into the cooking pan or utensil when placed close to the coil.

Advantages of induction heating:

- Efficiency in heat generation and transfer of heat.
- Coil is safe relieving the possibility of shock hazards.
- Lower electricity bills.
- output power stands constant.

• Flexibilty in controlling temperature.

4.6 RESONANT CONVERTER

Resonant converters are devices which are designed to produce zero voltage or zero current switching . These converters are basically electric power converters that contain a network of inductors and capacitors that is specifically tuned to resonate at a particular frequency.

Resonant converter consist of 3 sections:

1. Switch network - produces pulsating voltage and current from dc sources.

2. Resonant tank - performs action of modulating the signal and consist of combination of inductor and capacitors.

3. Rectifier network - rectifies pulsating dc into dc voltage or current.

A full bridge series resonant converter topology is used considering the electrical requirements of the converter and its simplicity. The power flow is continuous in a full bridge circuit so results in higher output power.

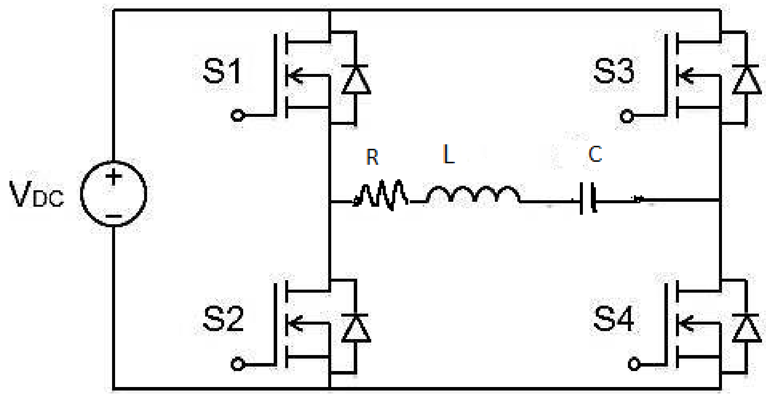


Figure 4.6: full bridge resonant converter

The dc input powers the switches of the converter which simultaneously turn on and off to produce the required output. A resonant tank consisting of L and C generates sinusoidal voltage and current. During resonance the impedance of inductance will be equal to that of the capacitance producing resonant frequency. The output obtained across the load is taken to get the desired output.

The input dc voltage is obtained from the boost converter where the maximum pv output is obtained by the INC and FLC MPPT methods. The fuzzy logic controller inputs the variable step size to the INC which is used to control the duty cycle of the boost converter. This output is given as the input to the resonant converter where in this input is used for the heating purpose.

Determination of design parameters [17]:

The full load Resistance is

$$R_L = \frac{8Vin^2}{(\pi^2 + 4)P} \tag{4.5}$$

The Quality factor [19] is assumed to be 1.6

$$Q = \frac{wL}{R} \tag{4.6}$$

The value of inductance can be obtained as

$$L = \frac{QR}{w} \tag{4.7}$$

The value of capacitance can be obtained as

$$C = \frac{1}{(2\pi F_o)^2 L} \tag{4.8}$$

Table 4.1: Parameters of Resonant converter

Parameter	**Value**
Resistance R	18.6 Ohm
Inductance L	23 uH
Capacitance C	6.8 nF
Switching Frequency F	20 KHZ

4.7 SUMMARY

The chapter discusses about the system used for maximum power point tracking. The Fuzzy logic method used for varying the step size of incremental conductance method tracks maximum power even under varying environmental conditions so as when connected to Resonant converter it provides maximum output which can be used for connecting energy demands such as induction heating, cooking etc.

Chapter 5

RESULT ANALYSIS

A modified MATLAB model of a 1-kW PV array is used to apply the proposed variable step INC MPPT method with the two Inputs I/V and dI/dV. This model is made up of a parallel string, consisting of 5 series panels of 213.5W each. The PV array, the DC-DC boost converter, the variable step INC MPPT, the resonant converter with load are simulated. The duty cycle needed to optimise the PV voltage is generated by the FLC INC MPPT.

For the simulation purpose, the environmental variables taken into consideration are the solar irradiation (G) and the cell temperature.

5.1 STEP VARIATIONS OF G AND T

The step variations are used for testing the proposed variable step INC MPPT method.The first plot shows the irradiance (G) which is varied on the basis of the solar input and usually measured by varying the step when considering varying nature. The second plot shows the temperature and normally it is held to a constant temperature.

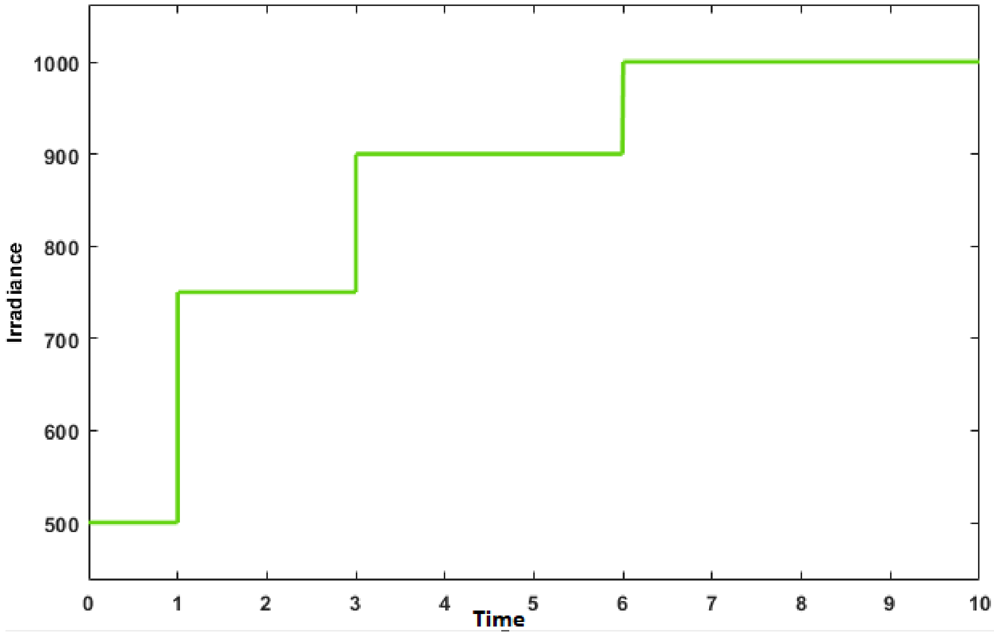


Figure 5.1: Irradiance

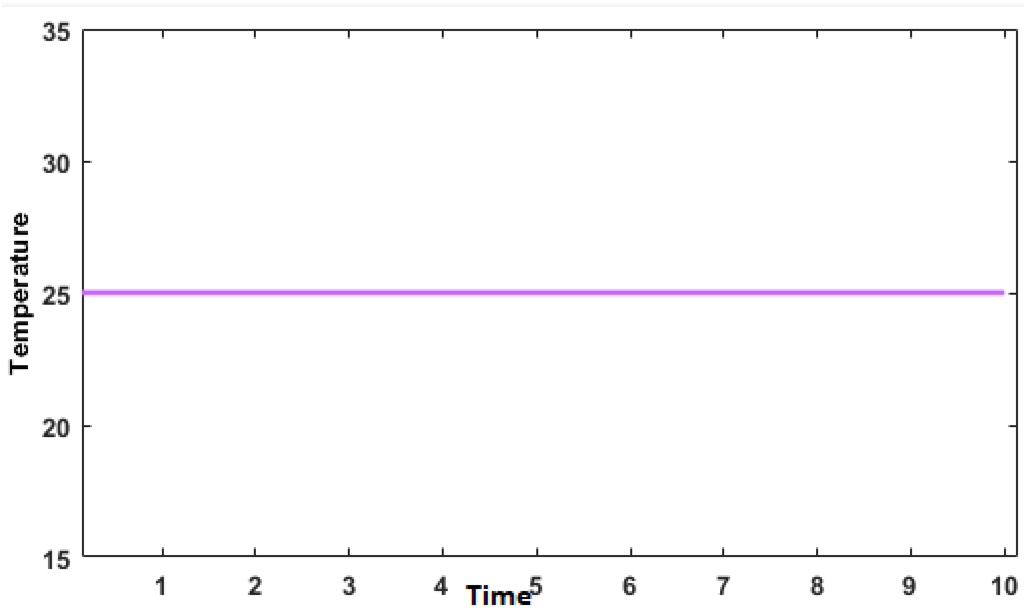


Figure 5.2: Temperature

5.2 PV OUTPUT

The maximum power point changes continuously as the environmental conditions change. Therefore, it is indispensable to use MPPT systems to keep extracting the maximum power of PV panels/arrays. The figure depicts the voltage and current of a PV output that is obtained for the proposed temperature and irradiance.

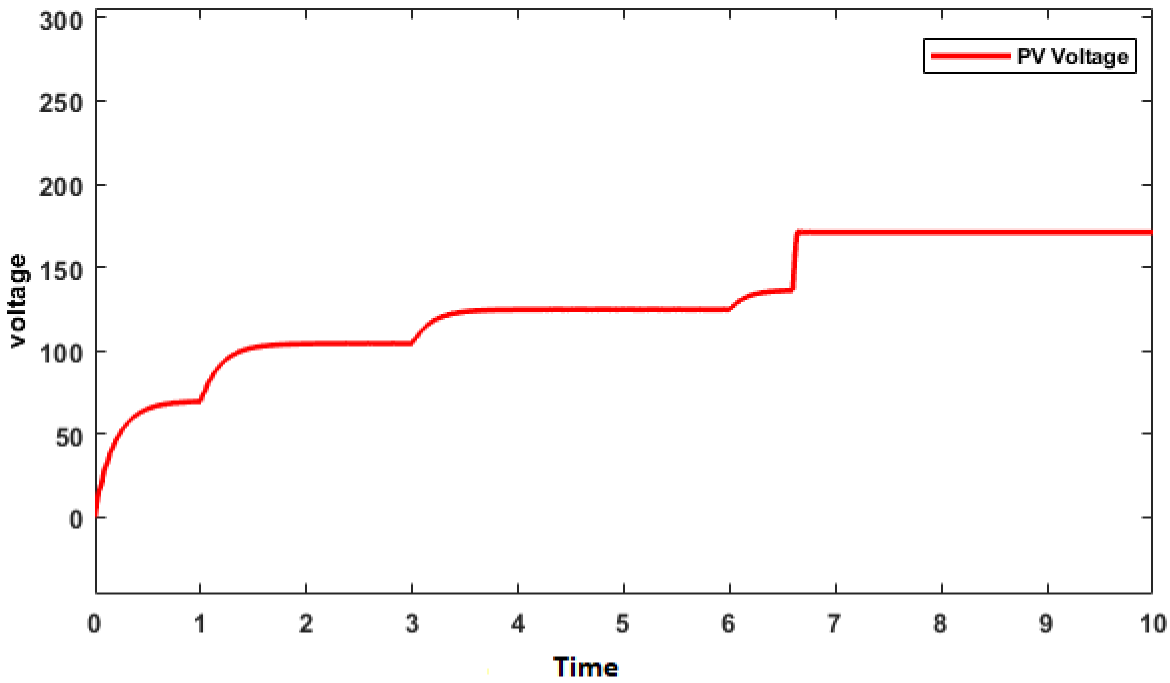


Figure 5.3: Voltage output of PV

Here the voltage and current changes with respect to the time based on the changes in the irradiance and temperature. The obtained value is then fed to the boost converter so as to obtain an increased output.

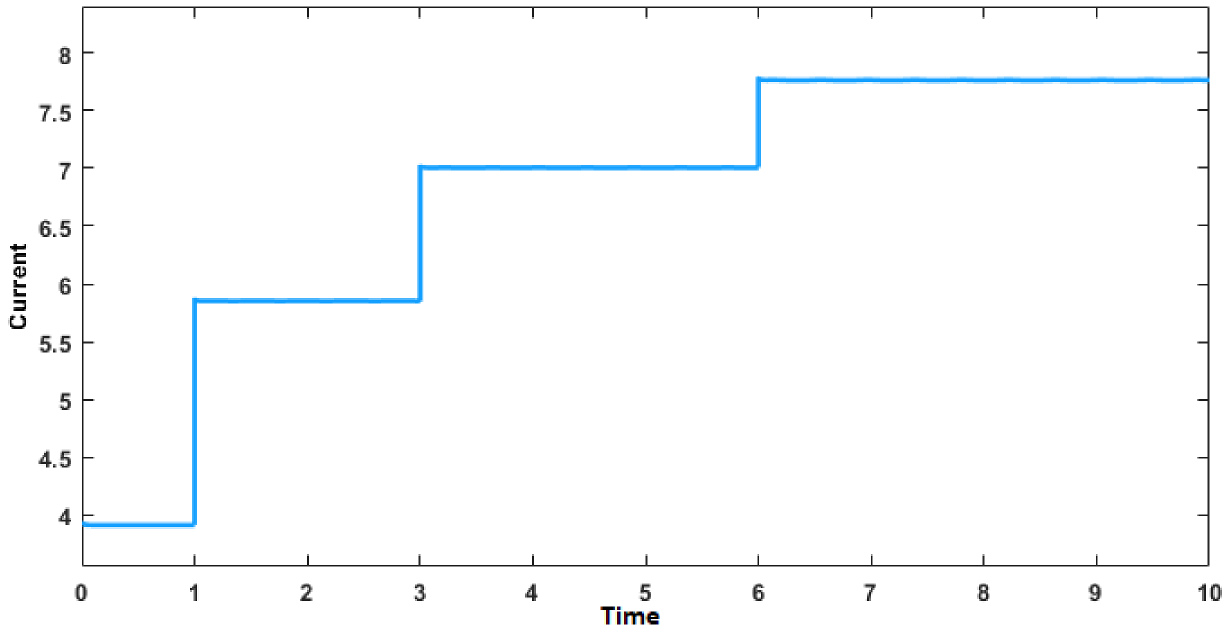


Figure 5.4: Current output of PV

5.3 BOOST CONVERTER OUTPUT

The output of the PV is fed as input to the boost converter. The boost converter boosts the input current and voltage to the designed value which is the input of the resonant converter. The output of boost converter gives the output power which is the product of current and voltage to give the maximum power. Here the boost converter duty cycle is obtained from the incremental conductance MPPT control in which the fuzzy logic controller outputs a variable duty cycle to INC MPPT which makes it a variable in nature. This is given as the duty cycle of the boost converter.

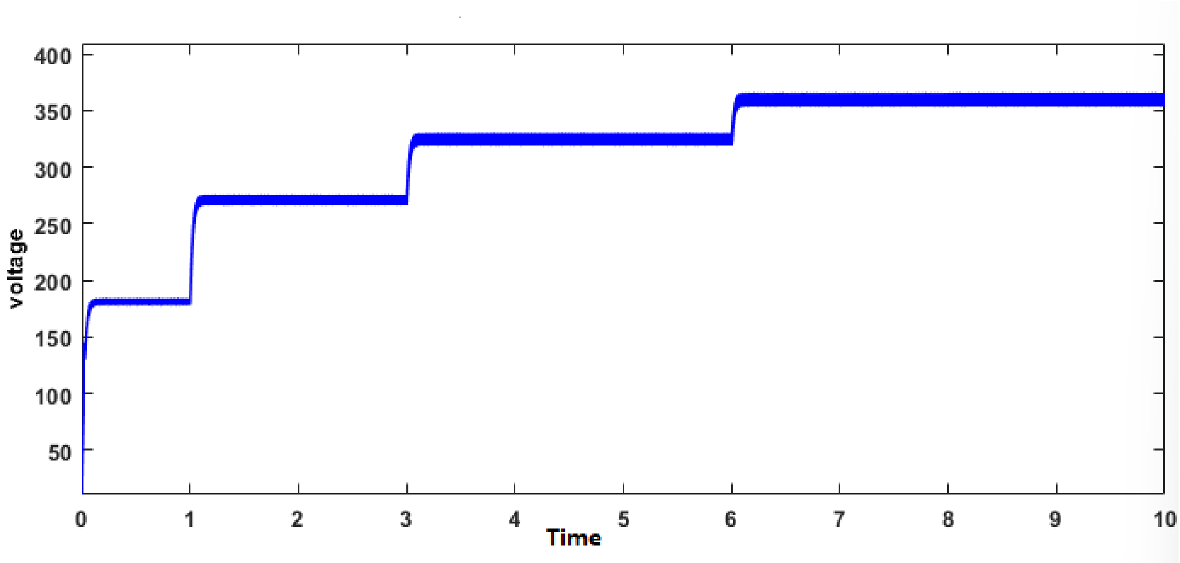


Figure 5.5: Output voltage of Boost converter

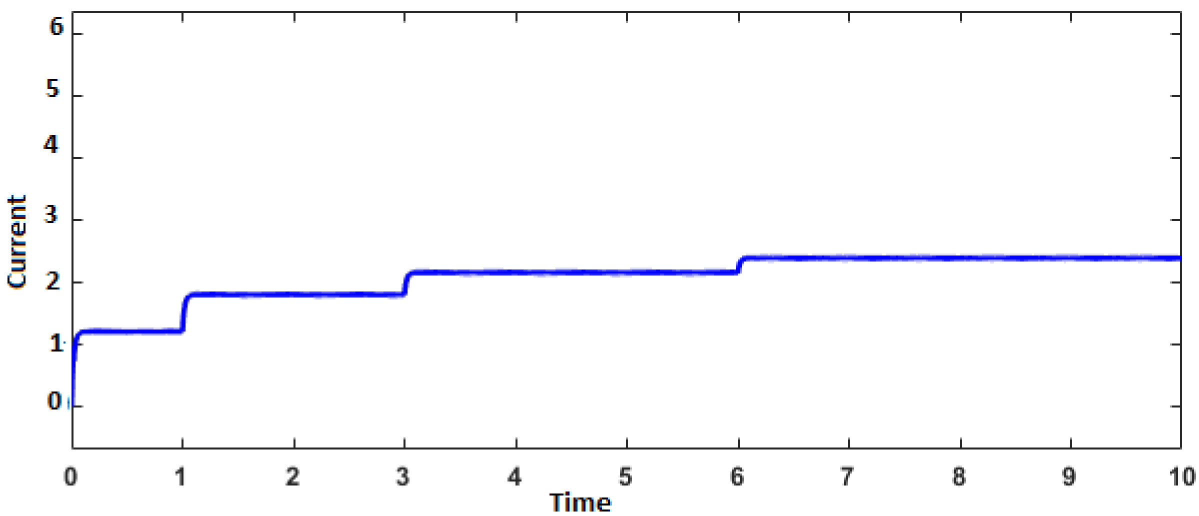


Figure 5.6: Output current of Boost converter

5.4 RESONANT CONVERTER OUTPUT

The boost converter inputs the resonant converter. The power output is obtained across the load. The power output depicts that on applying an FLC based INC method the proposed system tracks the required power rather than normal INC or FLC method which tracks power not upto MPP and it takes more time for converging.

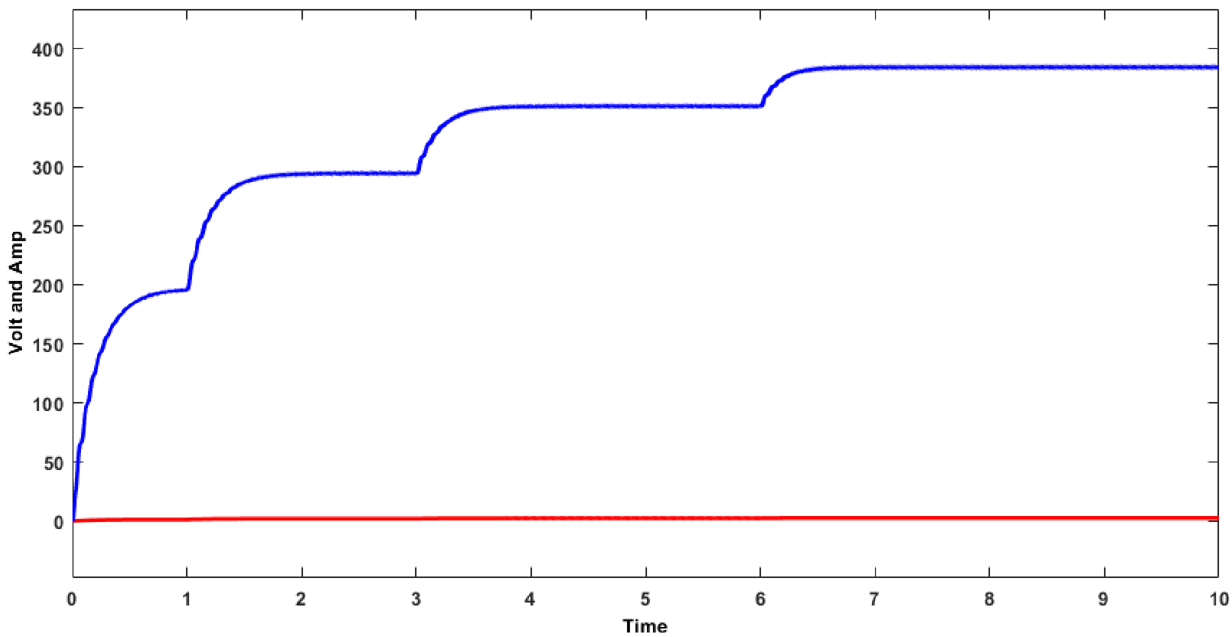


Figure 5.7: Output voltage and current of Resonant converter

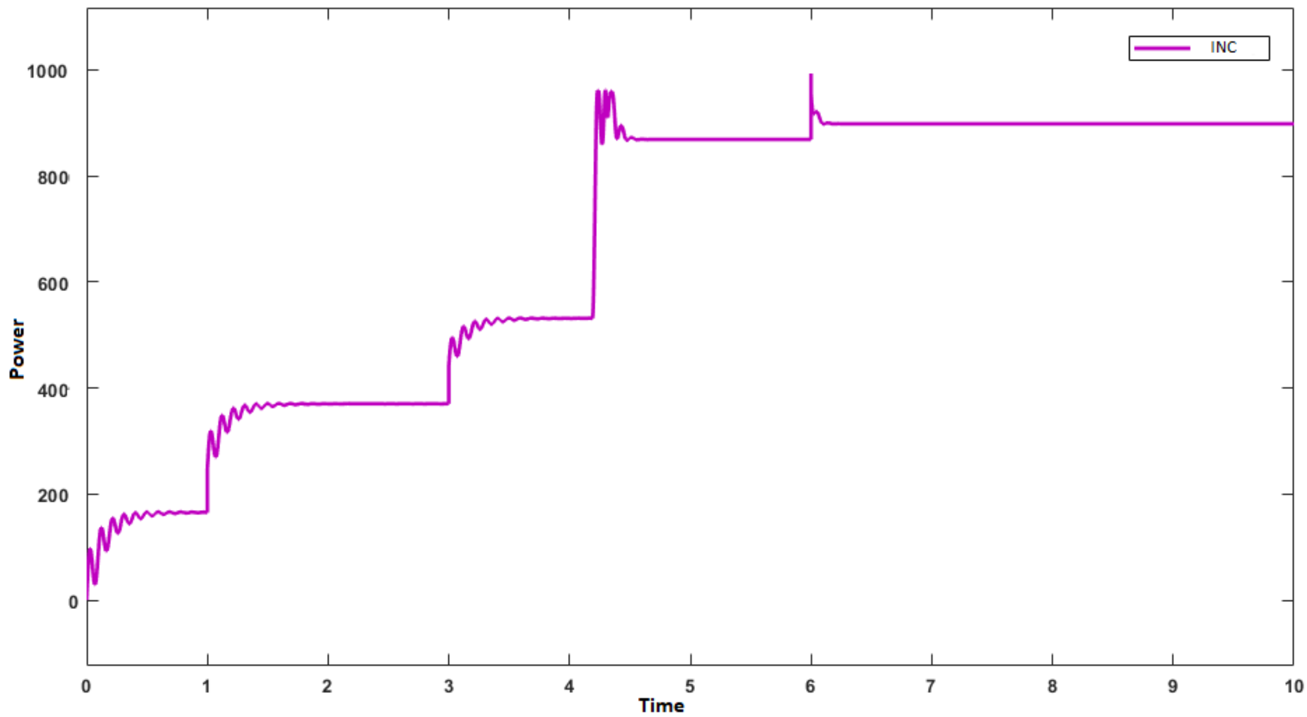


Figure 5.8: Output Power of converter

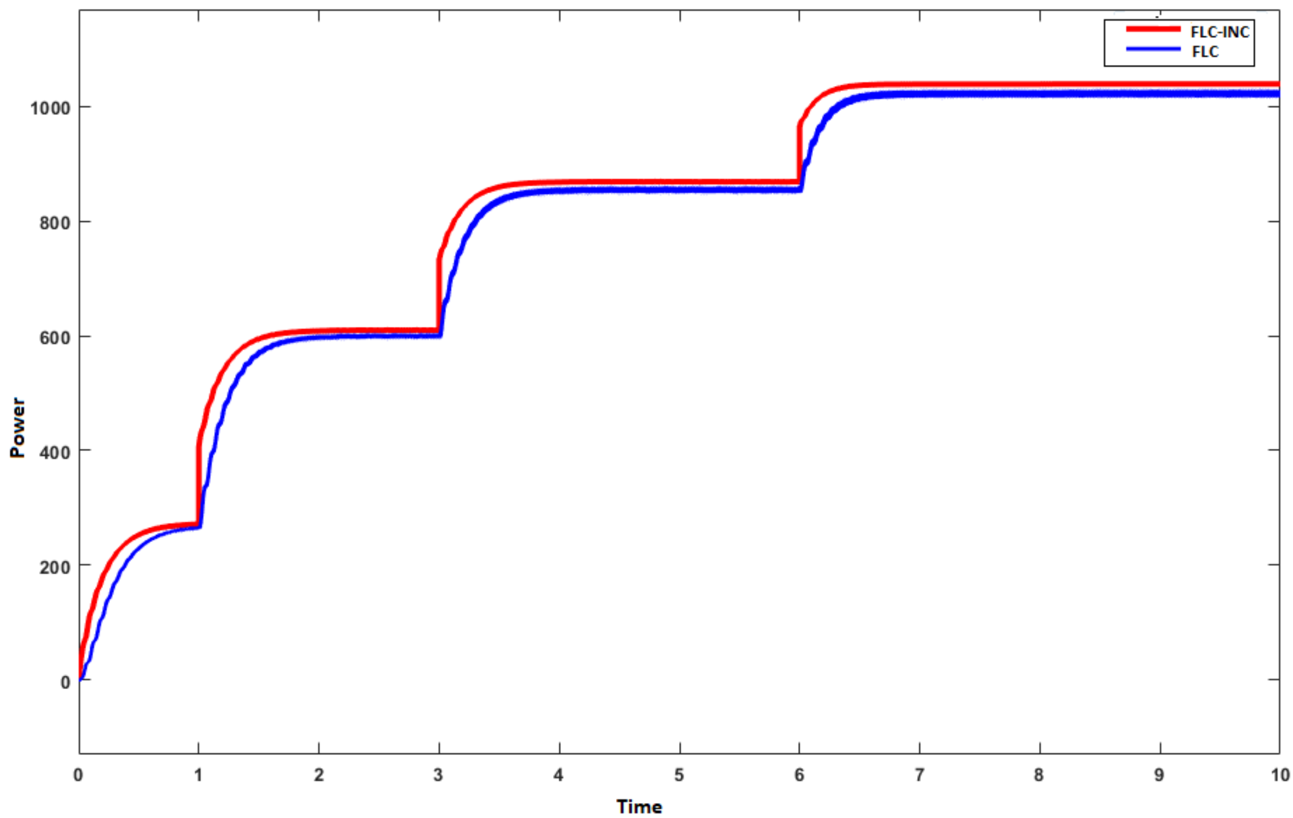


Figure 5.9: Output Power of resonant converter

Table 5.1: Comparison of power output

MPPT methods	Power	Remarks
INC MPPT	900W	not able to track changing G accurately
FLC MPPT	994.5W	tracks changing G
FLC-INC MPPT	1000W	tracks maximum power and less convergence time

Table 5.2: Comparison of Resonant converter output with different loads

Load	Values	Power
RL load	R= 18.6, L=23mH	1000W
R load	R= 18.6	1000W

5.4.1 Cost Analysis

Table 5.3: Various components required for the implementation

Components	cost
PV	48000
H bridge PCB	1250
coil	800
IGBT 4 no.s	600
controller card	1500
5uf AC capacitor	50
sensor and display	750

5.5 SUMMARY

MATLAB simulation is done and obtained the results which shows the maximum power. By using the incremental conductance with Fuzzy logic MPPT the required power output is obtained with less time of convergences which makes it suitable for Induction heating applications.

Chapter 6

CONCLUSION AND FUTURE SCOPE

The grid-connected PV systems' performance is measured using the PV system efficiency, where the MPPT performance is a critical factor. Although the traditional MPPT approach is frequently utilised, it lacks some accuracy and convergence speed. To address this issue, new or improved techniques for producing energy from solar modules are created. These approaches involve decreasing or increasing the duty cycle of the dc-dc boost converter. When changing the ambient circumstances, MPPT increases the output dc power and decreases the time it takes for convergence to achieve the steady state.This ability can be made use in various applications which requires electrical power as in the case of the proposed induction heating. This may paves way to the production of power from renewable energy sources more economically to meet the ongoing consumption. In future, the experimental analysis of various other controllers along with the current MPPT can be used in a grid-connected PV systems. A storage mechanism can also be implemented which can be extended for further improvements while considering demands of electricity.

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