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GRID CONNECTED BOOST HALF BRIDGE PHOTOVOLTAIC MICRO INVERTER SYSTEM USING NEURO FUZZY CONTROLLER

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ABSTRACT

With the rapid development of large scale renewable energy sources and HVDC grid, it is a promising option to connect the renewable energy sources to the HVDC grid with pure DC system, in which high-power high-voltage step-up DC-DC converters are the key equipment to transmit the electrical energy. This paper proposes a resonant converter which is suitable for grid-connected renewable energy sources. The converter can achieve high voltage gain using LC parallel resonant tank. It is characterized by zero-voltage- switching (ZVS) turn-on and nearly ZVS turn-off main switches as well as zero-current-switching (ZCS) turn-off of rectifier diodes, moreover, the equivalent voltage stress of the semiconductor devices is lower than other resonant step up converters. The operation principle of the converter and its resonant parameter selection is presented in the paper. The operation principle of the proposed converter has been successfully verified by simulation and experimental results.

Keywords*:* Resonant converter, Voltage step-up, Renewable energy, Soft Switching, Voltage Stress.

INTRODUCTION

This paper presents a novel grid-connected boost half-bridge photovoltaic (PV) micro inverter system and its control implementations. In order to achieve low cost, easy control, high efficiency, and high reliability, boost-half-bridge dc–dc converter using minimal devices is introduced to interface the low-voltage PV module. A full-bridge pulse width-modulated inverter is cascaded and injects synchronized sinusoidal current to the grid. Moreover, a plug-in repetitive current controller based on a fourth-order linear phase IIR filter is proposed to regulate the grid current. High power factor and very low total harmonic distortions are guaranteed under both heavy load and light load conditions. The grid connected PV system includes two power processing stages: a high step-up boost half bridge converter for boosting a low voltage of PV array up to the high dc-bus voltage, which is not less than grid voltage level; and a full-bridge inverter for inverting the dc current into a sinusoidal waveform synchronized with the utility grid. The neuro fuzzy controller is used to control the input voltage level. Moreover, the dc–dc conversion stage needs more difficult control techniques to satisfy the grid current regulation demand. Therefore, in terms of the MPPT performance and output current quality, the primary class of PV micro inverter is a

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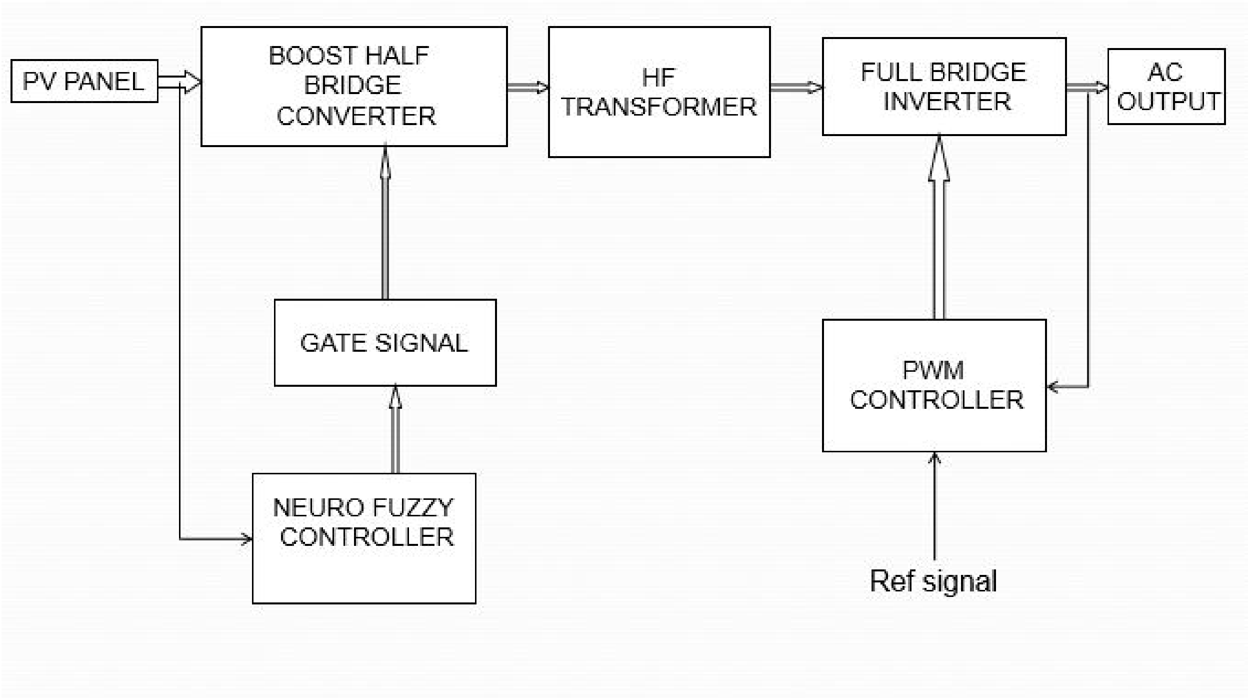
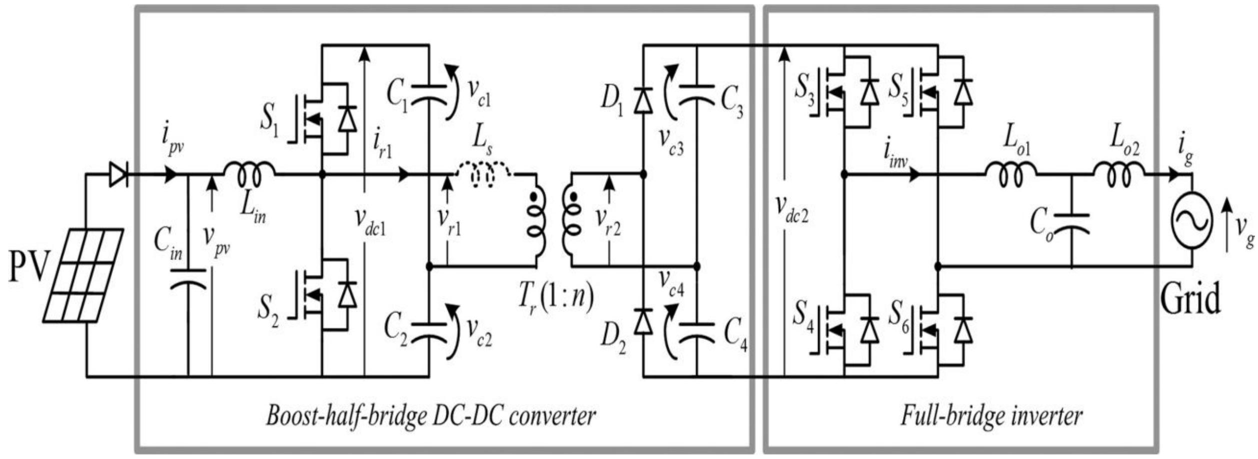
lot of applicable and can be adopted during this paper.

BLOCK DIAGRAM

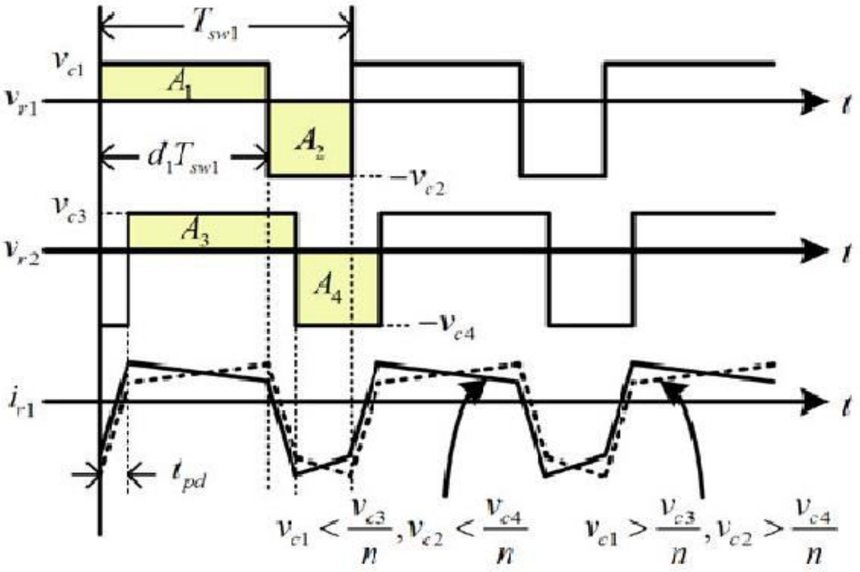


CIRCUIT DIAGRAM



The boost-half-bridge microinverter topology for gridconnected PV systems is depicted in Fig. It is composed oftwo decoupled power processing stages. In the front-end dc–dcconverter, a conventional boost converter is modified by splittingthe output dc capacitor into two separate ones. *C*inand *L*indenote the input capacitor and boost inductor, respectively. Thecenter taps of the two MOSFETs (*S*1 and *S*2) and the two outputcapacitors (*C*1 and*C*2) are connected to the primary terminals ofthe transformer *Tr*, just similar to a half bridge. The transformerleakage inductance reflected to the primary is represented by*Ls*and the transformer turns ratio is 1 :*n*. A voltage doublercomposed of two diodes (*D*1 and *D*2) and two capacitors (*C*3and *C*4) is incorporated to rectify the transformer secondaryvoltage to the inverter dc link. A full-bridge inverter composedof four MOSFETs (*S*3–*S*6) using synchronized PWM controlserves as the dc–ac conversion stage. Sinusoidal current with aunity power factor is supplied to the grid through a third-order*LCL* filter (*Lo*1 ,*Lo*2 , and *Co*).

BOOST-HALF-BRIDGE-PV-MICROINVERTER



When viewing from the full-bridge electrical converter, the boost-halfbridge converter simply operates identically as a conventional boost converter, however with the additional options of the galvanic isolation similarly because the high change of magnitude quantitative relation.

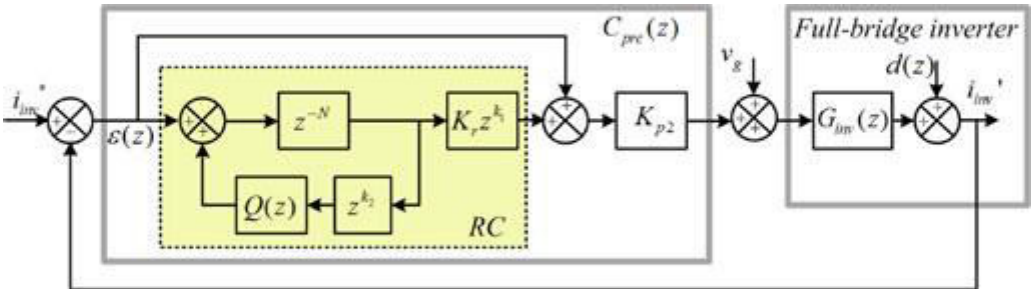
The simple circuit topology with lowest use of semiconductor devices exhibits low total price and sensible responsibility.

SYSTEM CONTROL DESCRIPTION:

An all-digital approach is adopted for the control of the boosthalf-bridge PV microinverter system, as shown in Fig. 3. ThePV voltage vPVand current iPVare both sensed for calculationof the instantaneous PV power PPV, the PV power variationΔPPV, and the PV voltage variation ΔvPV. The MPPT function block generates a reference $v*$PVfor the inner loop of the PVvoltage regulation, which is performed by the dc–dc converter.At the inverter side, the grid voltage vg is sensed to extract theinstantaneous sinusoidal angle θg, which is commonly knownas the phase lock loop. The inverter output current $i$invis prefiltered

by a first-order low-pass filter on the sensing circuitry toeliminate the HF noises. The filter output i_invis then fed backto the plug-in repetitive controller for the inner loop regulation.Either $v$dc1 or $v$dc2 can be sensed for the dc-link voltage regulationas the outer loop. In practice, the LVS dc-link voltage$v$dc1 is regulated for cost effectiveness. The grid current and theLVS dc-link voltage references are represented by respectively.

$\omega r=r1r2Co \quad + \quad Lo1 \quad + \quad Lo2Lo1Lo2Co$



In order to achieve fast dynamic responses of the grid currentas well as the dc-link voltage, a current reference feedforwardis added in correspondence to the input PV power *P*PV.

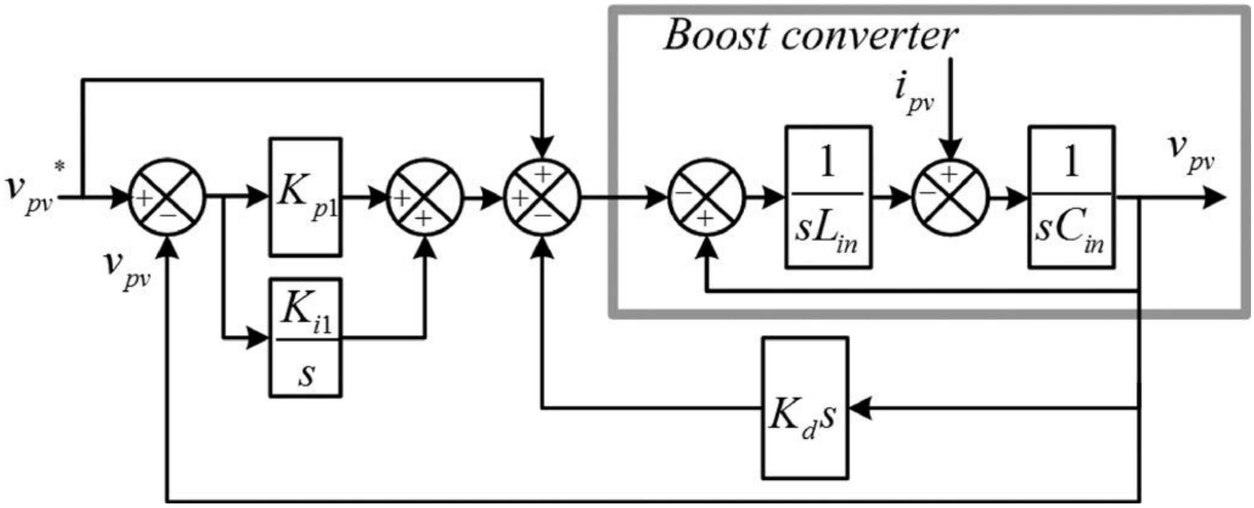
PLUG-IN REPETITIVE CURRENT CONTROLLER

So far, using an *LCL* filter in a grid-connected inverter systemhas been recognized as an attractive solution to reduce currentharmonics around the switchingfrequency, improve the systemdynamic response, and reduce the total size and cost [44]. Typically,an undamped*LCL* filter exhibits a sharp *LC* resonance

peak, which indicates a potential stability issue for the currentregulator design. Hence, either passive damping or active dampingtechniques can be adopted to attenuate the resonance peakbelow 0 dB [45], [46]. On the other hand, a current regulatorwithout introducing any damping method can also be stabilized, as long as the *LCL* parameters and the current sensor locationare properly selected [47]. In this paper, the *LCL* parameters areselected by following the guidelines provided in [44] and [47].The current sensor is placed at the inverter side instead of thegrid side. Resultantly, no damping techniques are needed suchthat the current control is much simplified.

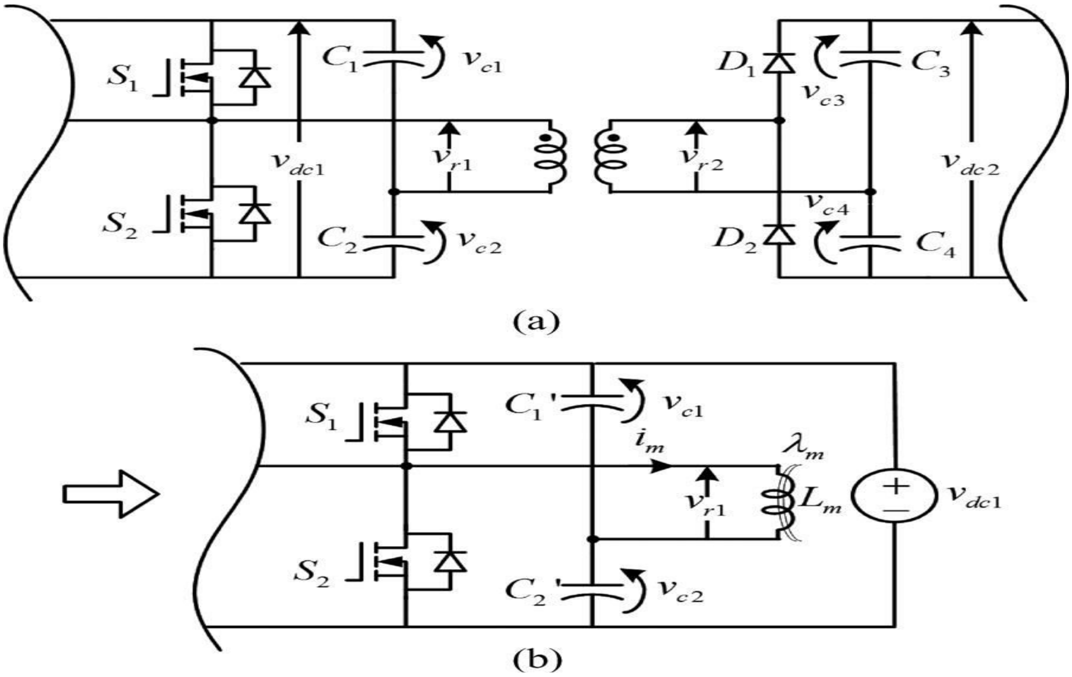
BOOST-HALF-BRIDGE CONVERTER CONTROL

The boost-halfbridgedc–dc converter. As aforementioned, the PV voltage isregulated instantaneously to the command generated by theMPPT function block. The continuous-time control block diagramis shown in Fig. 8. High bandwidth proportional-integralcontrol is adopted to track the voltage reference *v*∗PV and to minimizethe double-line-frequency disturbance from the LVS dclink.

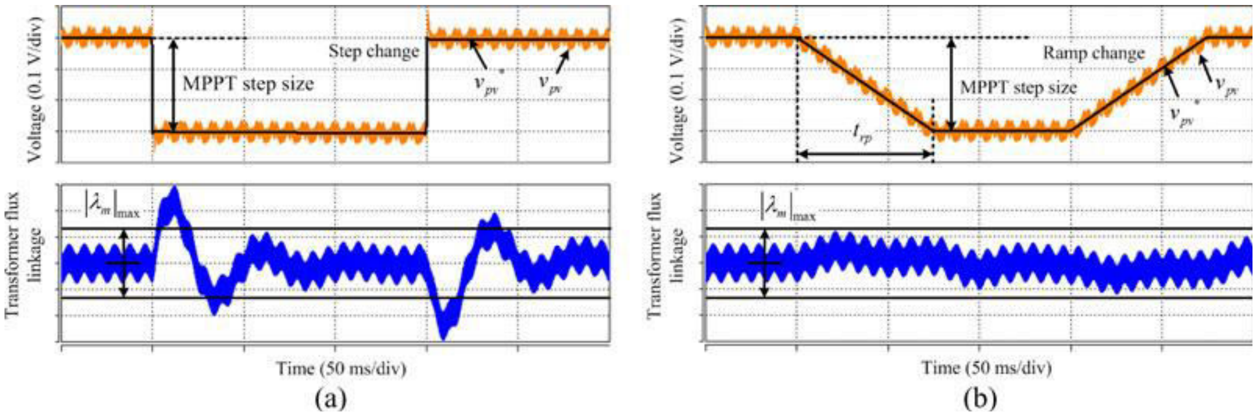


The capacitor voltage differential feedback is introducedfor active damping of the input *LC* resonance [48].Typically, the MPPT function block in a PVconverter/invertersystem periodically modifies the tracking reference of the PVvoltage, or the PV current, or the modulation index, or the converterduty cycles. In most cases, these periodic perturbationsyield step change dynamic responses in power converters. Ifthe converter dynamics are disregarded in the MPPT control,undesirable transient responses such as *LC* oscillation, inrushcurrent, and magnetic saturation may take place. Consequently, the conversion efficiency can be deteriorated or even malfunctionof the converter may occur.Equations (1) and (2) indicate that $vc1-vc4$ are changing dynamically

in accordance with $d1$.



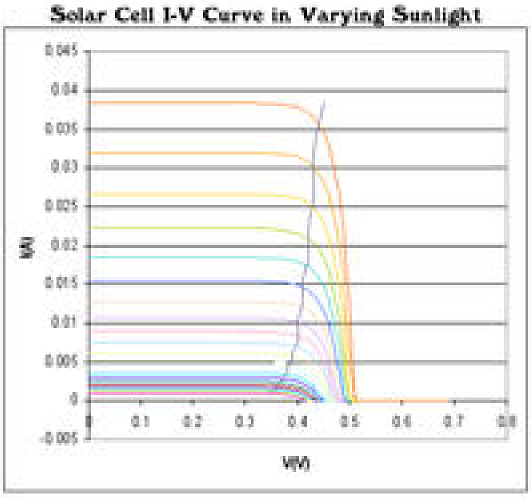
It is worth noting that thecharge and discharge of $C1-C4$ caused by the uneven voltagedistribution on the upper capacitors ($C1$ and $C3$) and thelower capacitors ($C2$ and $C4$) can only be conducted throughthe transformer magnetizing inductor. As a result, at any time,the charge and discharge rate of $C1-C4$ must be limited suchthat the transformer flux is not saturated. Intuitively, this canbe done by either introducing the transformer flux as a statevariable into the inner PV voltage regulator or designing theouter MPPT block adaptively.



(a) (b)

Maximum power point tracking (MPPT) is a technique that grid connected inverters, solar battery chargers and similar devices use to get the maximum possible power from one or more photovoltaic devices, typically solar panels, though optical power transmission systems can benefit from similar technology.[2] Solar cells have a complex relationship between solar irradiation, temperature and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve. It is the purpose of the MPPT system to sample the output of the cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions. MPPT devices are typically integrated into an electric system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors.

I-V curve



SIMPLEARTIFICIALNEURALNETWORK (ANN)

An artificial neural network is a powerful technique which is capable of representing complex input/output relationship. It consists of a large number of interconnected processing elements called neurons. ANN's behavior is characterized by its ability to learn recollect and generalize the training patterns or data similar to that of a human brain.

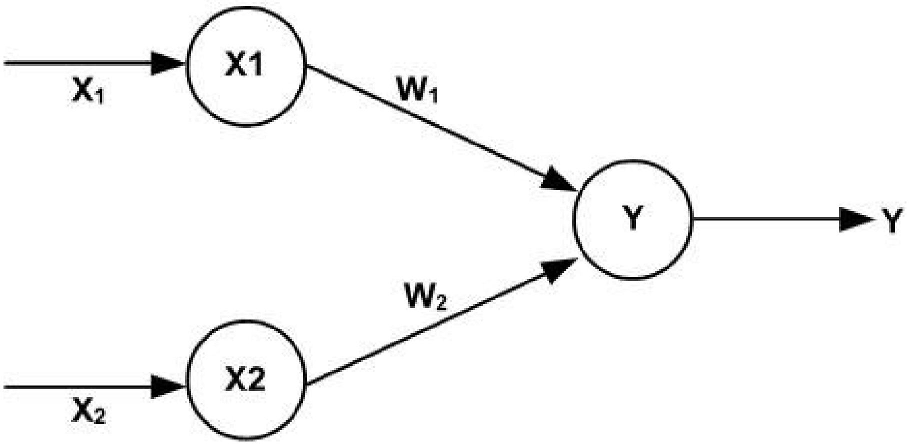


Fig No 1 Architecture of a Simple Artificial Neural Network

Each neuron has its own internal state which is called as the activation of the neuron. A neuron can send only one signal at a time and it can be received by many neurons.

The algorithm for the training is as follows:

Step-1: The input patterns are presented to the network.

Step-2: The inputs are sent to the hidden eurons with strength of Wij. For the net sumtan sigmoidal activation function is applied.

Step-3: The signals from the hidden units are sent to the output layer with a strength of Vjk. Linear activation function is applied and the final outputs available at the output neuron.

Step-4: The output is compared with the target and error generated is calculated.

Step-5: The changes in the hidden to output weights calculated and then the changes in the input to hidden weights Wij are calculated.

Step-6: The weights are updated using the formula

$$Wjk = Wjkold + \mathring{a}Wjk$$

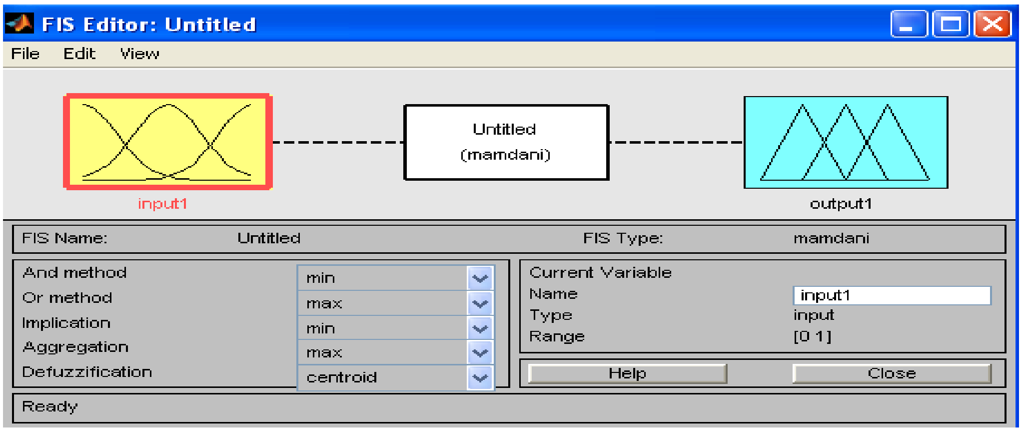
Wij new = Wij old + Wi

FUZZY LOGIC CONTROLLER

Fuzzy logic is a complex mathematical method that allows solving difficult simulated problems with many inputs and output variables. Fuzzy logic is able to give results in the form of recommendation for a specific interval of output state, so it is essential that this mathematical method is strictly distinguished from the more familiar logics, such as Boolean algebra. This paper contains a basic overview of the principles of fuzzy logic. Today control systems are usually described by mathematical models that follow the laws of physics, stochastic models or models which have emerged from mathematical logic. A general difficulty of such constructed model is how to move from a given problem to a proper mathematical model. Undoubtedly, today's advanced computer technology makes it possible; however managing such systems is still too complex.

These complex systems can be simplified by employing a tolerance margin for a reasonable amount of imprecision, vagueness and uncertainty during the modelling phase. As an outcome, not completely perfect system comes to existence; nevertheless in most of the cases it is capable of solving the problem in appropriate way. Even missing input information has already turned out to be satisfactory in knowledge-based systems.

Fuzzy logic allows to lower complexity by allowing the use of imperfect information in sensible way. It can be implemented in hardware, software, or a combination of both. In other words, fuzzy logic approach to problems' control mimics how a person would make decisions, only much faster.



FIS Name: Untitled

FIS Type: mamdani

And method: min

Or method: max

Implication: min

Aggregation: max

Defuzzification: centroid

Current Variable

Name: input1

Type: input

Range: [0 1]

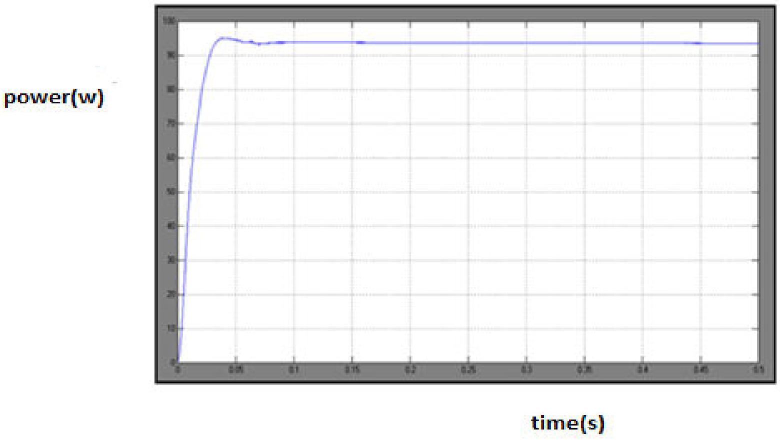
Ready

Fig no 2 fuzzy logic analysis and control

The fuzzy logic analysis and control methods can be described as:

MATLAB:

PV output volt



CONCLUSION

This paper presents a grid-connected PV power system with high voltage gain. The proposed PV system employs a high step-up Boost half bridge converter with MPPT and neurofuzzy control circuits as the first power-processing stage, and high voltage gain is obtained by the turn's ratio selection of winding-coupled inductors. In conventional system a single PV cell is connected to a dc - dc converter and the output of the dc – dc converter is connected to the inverter finally inverter feeds the power into the grid. In this system inverter and DC - DC converter are rated for grid voltage, so the cost of the whole system is high and reliability is low.

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