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Simulation Analysis of MPPT Algorithm for a PV System Using a ZSI and Contrast with DC-DC Boosted VSI

Sumalata I.A[1], Nalini.S[2]

Abstract- Energy demand is increasing from past few decades and Renewable energy resources are used for supplying that increasing power demand. So in order to increase the efficiency and power output of PV system MPPT Technique plays a major role. As PV arrays undergoes nonlinear and voltage-current characteristics thus MPPT Algorithm is necessary. Therefore it is necessary to operate the solar panel at its maximum power point tracking to ensure increase in the extraction of power from solar panel. Hence MPPT algorithm is necessary in PV array to maximize its output power. In this Paper a new Converter model named as Impedance(Z) Source Inverter with advanced MPC technique is used for MPPT for Grid connected PV harvesting system. A Single Stage Conversion has been carried out in ZSI for MPPT whereas in Conventional converters like VSI and CSI carries out. The Output of ZSI for PV system is compared with voltage Boosted converter and thus observed that dynamic stability of the system increases, THD reduces, power factor improves and efficiency increases by using ZSI for PV system. Simulation and experimental studies verify the performance of a new proposed control strategy.

Keywords-*MPPT(Maximum Power Point Tracking); MPC(Model Predictive Control); PV(Photovoltaic); P&O(Perturb and Observe); ZSI(Z(Impedance) Source Inverter); Voltage Source Inverter(VSI); Current Source Inverter(CSI);*

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INTRODUCTION

Majority of the power generation is from Solar power systems by reason of its high existence of solar radiations and eco-friendly(ecological) in almost all geological conditions. Solar based power vitality generated by PV systems is reliant on the radiation of the sun, temperature in most of the ambience conditions. Thus to make the utilize of extraction of high accessible energy from the PV board it is need to be operate at its MPPT at any instant. However now Solar power framework is constantly should have been worked in its MPPT for greatest extraction. Generally when it is not made to work in its MPPT implies its effectiveness lessens disregarding its topographical conditions.

Traditional grid connected photo-voltaic systems usually has a two stage power conversion that includes two stages DC/DC Converter which is connected in between PV panel and capacitor(dc link energy buffer) and an DC/AC Inverter which is between capacitor(energy buffer) and AC grid. Figure. 1 shows the schematic diagram of two-stage grid-tied PV system. DC/AC inverter has an inbuilt drawback that is which cannot step up or down the voltage liberally hence two stage power conversion is essential. Usually Traditional(Conventional) inverters are divided as VSI(voltage-source inverter) which buck(step down) the voltage and CSI(current-source inverter) which boost(step up) the voltage.

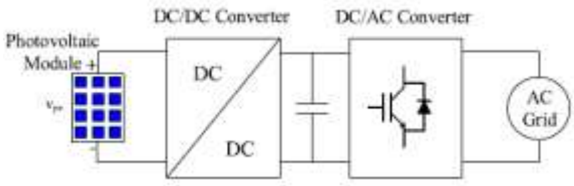

Figure 1 Two-stage grid-tied PV system configuration

The Z-Source inverter has a distinctive impedance(Z) circuit which couples the inverter circuit to the power supply, thus obtaining a unique features which cannot be fulfilled in the conventional voltage-source inverter(VSI) and current-source inverters(CSI) wherein a capacitor and inductor are used, respectively. By regulating the duty cycle(D) which is in shoot through state Z(Impedance) Source Inverter is used to conquer the drawbacks of conventional VSI and CSI.

Maximum Power Point voltage which is tracked it would be greater or lower than the AC grid voltage dependent on climatic condition accordingly to which the topology buck or boost the voltage in a wide range. A new converter model uses a single stage conversion described as Impedance(Z) source inverter which cope up the limitations of VSI and CSI. In this new topology z source inverter can buck(step down) or boost(step up) the voltage freely while in VSI and CSI could perform only one function either step up or step down of voltage. Figure 2 shows the schematic diagram of single stage grid tied PV system.

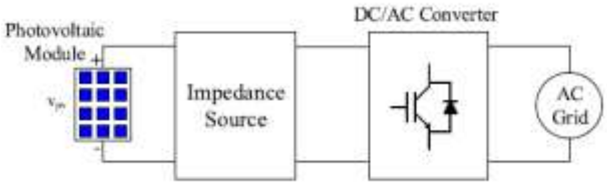

Figure 2 Single-stage impedance-source grid-tied PV system configuration

Z-SOURCE CONVERTER

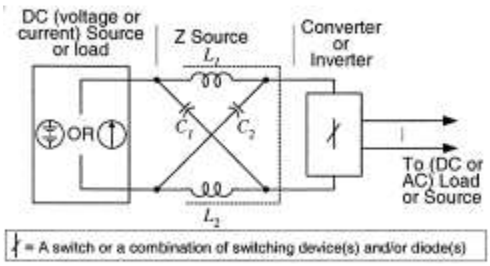

Figure 3 General Structure of Z-Source Converter

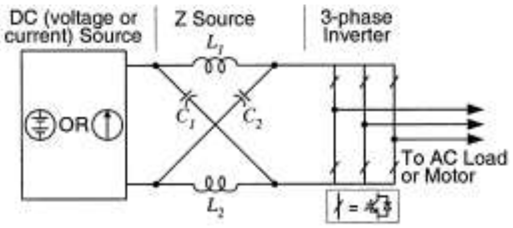

Figure 4 Z-source converter structure using the anti parallel combination of switching device and diode.

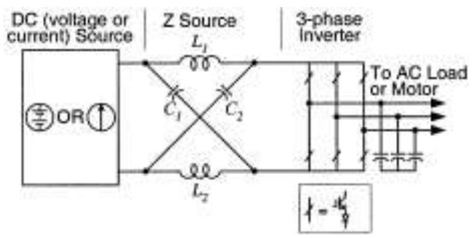

Figure 5 Z-Source converter structure using the series combination of switching device and diode.

Traditional V-Source and I-Source Inverters has drawbacks in order to defeat the difficulties Z-Source(Impedance fed) converters are used. Fig. 3 shows the general structure of Z-source converter proposed. Z source inverter has the specific characteristics which is absent in previous technology i.e voltage fed and current fed inverters. The above mentioned conceptual or theoretical drawbacks are limited by using Z source inverter and provide the dynamic response of the system by providing impedance circuit shown in Fig.3.

Fig. 3 is a two-port network which includes a split-inductor L_1 and L_2 and capacitors C_1 and C_2 which are connected in X shape used to obtain an impedance source (Z-source) coupling the converter (or inverter) to the dc source, load, or another converter. DC source/or load would be either a voltage or a current source/or load. Thus, DC source would be a thyristor converter, diode rectifier, battery or a combination of these. Semiconductor switching device present in the converter circuit with the diode in antiparallel shown in fig 4 and diode in series with the switches shown in fig. 5. Thus Z Source Inverter equivalent circuit diagram is as shown in fig 4 and 5. Inductance is equipped through two slit inductor and two isolated inductors

PROPORTIONATE CIRCUIT, OPERATING PRINCIPLE, AND CONTROL

The exceptional element of the Z-source inverter is that the yield AC voltage can be any an incentive in the vicinity of zero and vastness paying little mind to the power device voltage. That is, Z-source inverter can give an expansive scope of yield voltage and furthermore also act as buck-boost inverter. In any case, such particular elements can't be gotten by customary V-and I-source inverters. The Z Source Inverter control elements can useful to a converters like DC-AC converter, AC-DC converter, AC-AC converter and DC-DC converter

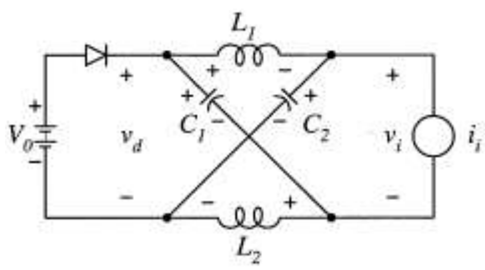

Figure 6 Equivalent circuit of the Z-source inverter viewed from the dc link.

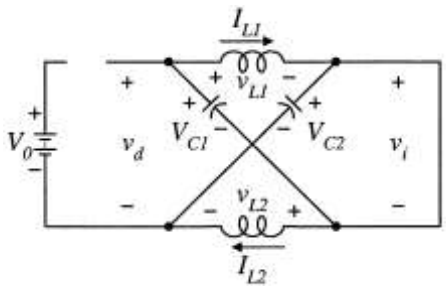

Figure 7 Equivalent circuit of the Z-source inverter viewed from the dc link when the inverter bridge is in the shoot-through Zero State

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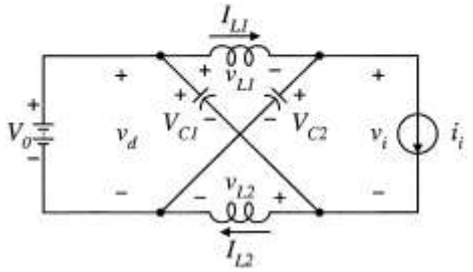

Figure 8 Equivalent circuit of the Z-source inverter viewed from the dc link when the inverter bridge is in one of the eight nonshoot-through switching states.

Z Source Inverter three phase leg includes nine switching vectors(states) but in conventional V-Source and I-Source Inverter has only eight allowable switching vectors(states). That is in traditional Voltage Source Inverter and Current source Inverter has six active states i.e non-shoot through states when dc voltage is used to supply the load and two zero states when either of all the upper three switches or all the lower three switches are gated(switched). But in Z Source Inverter it has one additional zero state which is called as shoot through zero state which is happened due to the gating of the switches of any one leg or comprising of two legs or all the three legs which is possible by seven unique ways. One extra state in Z Source Inverter made it to act as buck-boost inverter. Thus improves power factor of the line and provides fast dynamic response.

Fig. 6 shows the equivalent circuit of the Z-source inverter viewed from the dc link. When the Inverter bridge is in the Shoot through zero state diode is reverse biased it's equivalent circuit is as shown in Fig. 7 and the equivalent circuit of the Z Source Inverter when it is in non shoot through states or in of the six active states when diode is forward biased is as shown in Fig 8. Thus fig. 7 and 8 shows the Z Source Inverter configuration. When it is in one of the two zero vectors it act as an current source with open circuit

CIRCUIT ANALYSIS AND OBTAINABLE OUTPUT VOLTAGE

At first let us consider or expect that the inductors L_1 and L_2 and capacitors C_1 and C_2 have the same inductance(L) and capacitance(C), respectively, the Z-source arrange winds up plainly symmetrical. From the symmetry and the equal circuits, we have

$$VC1=VC2=VC \text{ and } VL1=VL2=VL \qquad (1)$$

Shoot Through Mode

Presently consider that the inverter extension is in the shoot-through zero state for an interim of T_0, amid switching cycle T, The inverter side yield voltage is zero in this state. In this state diode is switch one-sided(reverse biased) and capacitors are utilized to charge the inductors and inductor current increments straightly in this method of operation as appeared in fig 7 and from the equal circuit, Fig..7, one has

$$VL=VC \quad Vd=2VC \quad Vi=0 \qquad (2)$$

Non Shoot Through Mode (Active State)

Given that the inverter leg is in one of the eight non shoot-through states for an interim of T_1, amid the switching cycle, T. In this method of operation diode is forward one-sided(biased) as appeared in fig 8, from the proportional circuit, Fig.8, one has

$$VL=V0\text{-}VC \quad Vd=V0 \quad Vi=VC\text{-}VL=2VC\text{-}V0 \qquad (3)$$

Where V0 is the dc source voltage and T=T0+T1

The average voltage of the inductors over one switching period T should be zero in steady state, from (2) and (3), thus, we have

$$VL=\frac{T0Vc+T1(V0-Vc)}{T}=0 \qquad (4)$$

$$\text{Or} \quad \frac{Vc}{V0}=\frac{T1}{T1-T0} \qquad (5)$$

Similarly, the average dc-link voltage across the inverter bridge can be found as follows

$$Vi=\frac{T0\,.0+T1(2Vc-Vo)}{T}=\frac{T1}{T1-T0}V0=VC \qquad (6)$$

The Peak dc-link voltage across the inverter bridge is expressed

$$Vi=VC\text{-}VL=2Vc\text{-}V0=\frac{T1}{T1-T0}V0=B.\,V0 \qquad (7)$$

$$\text{Where } B=\frac{T}{T1-T0}=\frac{1}{1-2\frac{T0}{T}}>=1 \qquad (8)$$

is the boost factor resulting from the shoot-through zero state. The peak dc-link voltage Vi is the equivalent dc-link voltage of the inverter.

BLOCK DIAGRAM

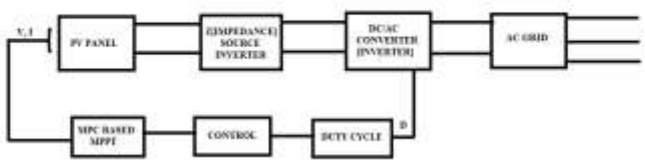

Figure 9 Block Diagram of the Proposed Control System

Due to nature of MPC which predicts the system behavior in a specified time horizon, the most significant advantage of the proposed technique is high accuracy tracking of gradually changing solar irradiance levels, a property present in most well-known MPPT techniques such as P&O. Demonstrate Predictive

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calculation utilized here is Perturb and Observe procedure which gives high control adequacy, quick unique reaction, and diminishes the oscillations around Maximum power point without the need of any exorbitant detecting gadget, it quantifies the sunlight based radiations specifically hence the cost of the framework decreases. There is a test of challenge of determination of huge inductor and capacitor (detached components) esteem in impedance source organize, therefore because of the accessibility of less oscillation on surroundings of MPP subsequently, z source inverter can utilize little estimation of inductor and capacitor. Subsequently ZSI is therefore more favourable contrasted with different converters in this manner the proposed model is utilized with comprise of ZSI on account of its high advantages.

FLOW CHART

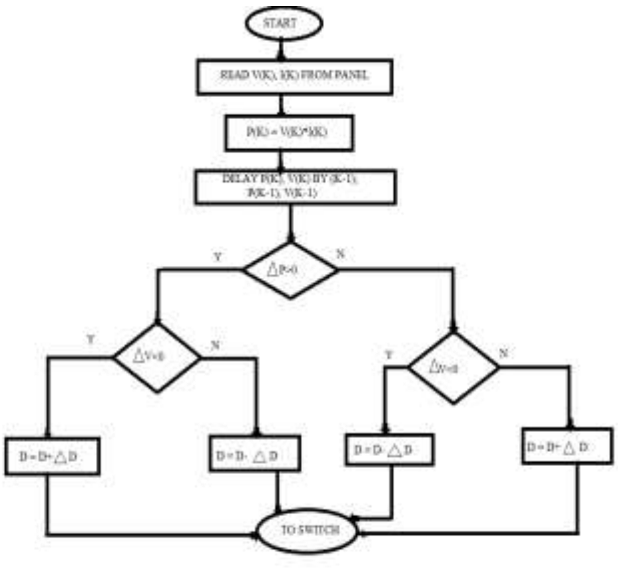

Figure 10 Flow Chart of P&O MPPT Algorithm

Stream outline of P&O calculation is as appeared in Fig. 10. This algorithm relies on upon the mathematical calculation of its yield control(output power) which is gotten by perusing the current and voltage of the PV board. In this MPPT controller past voltage is stored and it is contrasted and the present voltage in like manner the MPPT calculation increment or abatement the voltage. Power is calculated by multiplying voltage and current (P=V*I) and Power is likewise compared from present and past values as needs be MPPT controller increment or lessening the power and get the most extreme power point. This processor happens continuously to acquire MPP.

SIMULATION RESULTS

The Z-source inverter can be operated in both boost and buck operations. In case of Z - source inverter simulation L value is taken as 0.7mH and C value is 1000μF.

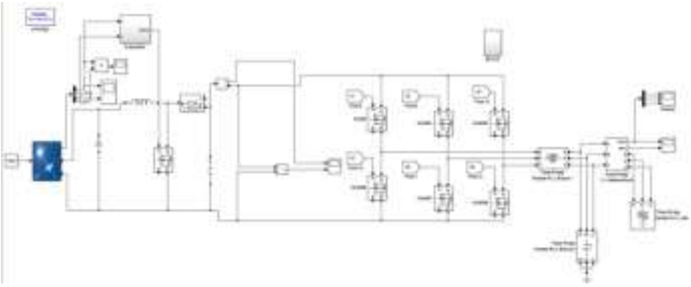

Figure 11 MPC Based MPPT for PV System Using Boost converter

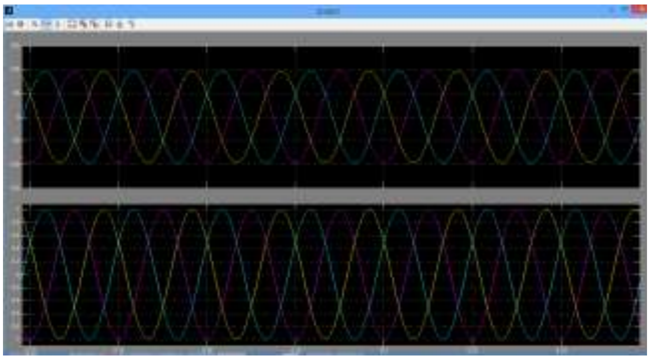

Figure 12 Voltage and Current Waveforms of MPC Based MPPT for PV System Using Boost converter

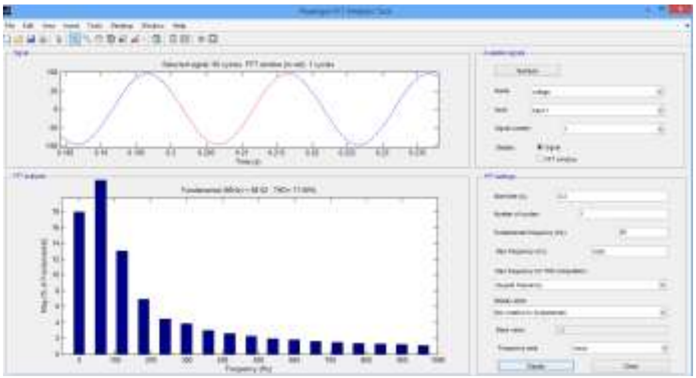

Figure 13 FFT analysis of MPC Based MPPT for PV System Using Boost converter

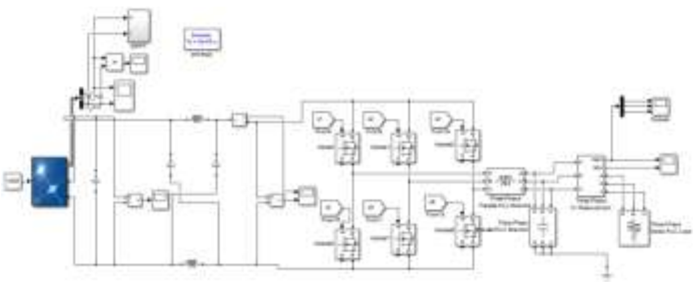

Figure 14 MPC Based MPPT of PV System Using Z Source Inverter with Filter

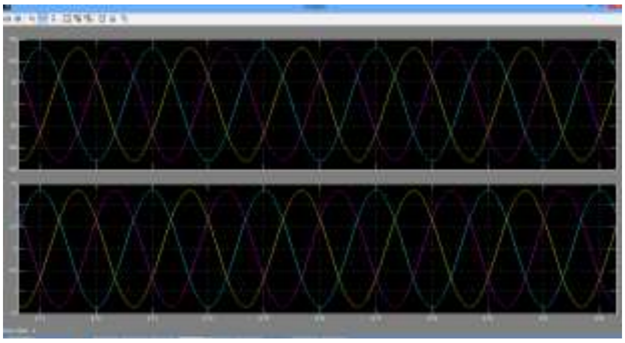

Figure 15 Output Voltage and Current Waveforms MPC Based MPPT of PV System Using Z Source Inverter with Filter

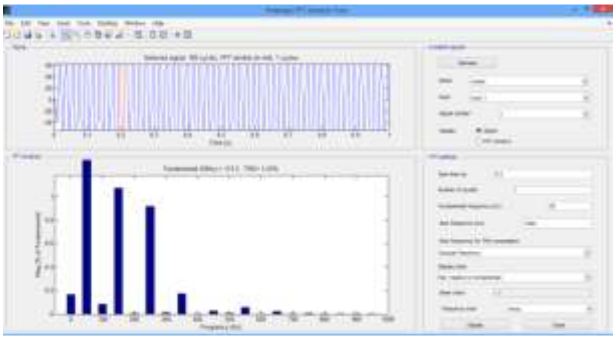

Figure 16 FFT analysis of MPC Based MPPT of PV System Using Z Source Inverter with Filter

COMPARISON OF DC-DC BOOSTED VSI AND Z SOURCE INVERTER

Z Source Inverter has a capacity to buck-boost the input voltage with Single stage transformation just while it would be two stage change in DC-DC boost inverter. Henceforth Boost Converter requires extra cost and the control is perplexing and diminished proficiency where as ZSI requires less cost, increased unwavering quality(reliability), improves power factor, enhances control component and productivity is expanded. Keeping in mind the end goal to change over the DC input voltage into AC voltage, boost converter is associated with VSI(Voltage Source Inverter). Recreation result shows that Total Harmonic Distortion is more on DC-DC supported Voltage Source Inverter(17.19%) where as THD in Impedance Source Inverter is 1.43%.

Table 1 Parameters of MPC Based MPPT for ZSI

Parameters	Values
C1	1000µF
C2	1000µF
L1	0.7mH
L2	0.7mH
Ts	50µs
L(filter)	1mH
C(filter)	720µF
f	1kHz

Table 2 Comparsion of DC-DC Boosted VSI with ZSI

Inverter Type	PV Panel Input Voltage(volts)	Inverter Output Voltage(volts)	Number of Switches Used	Conversion Type
Boosted VSI	45	90	7	Two-Stage Conversion
ZSI	45	110	6	Single Stage Conversion

HARDWARE IMPLEMENTATION

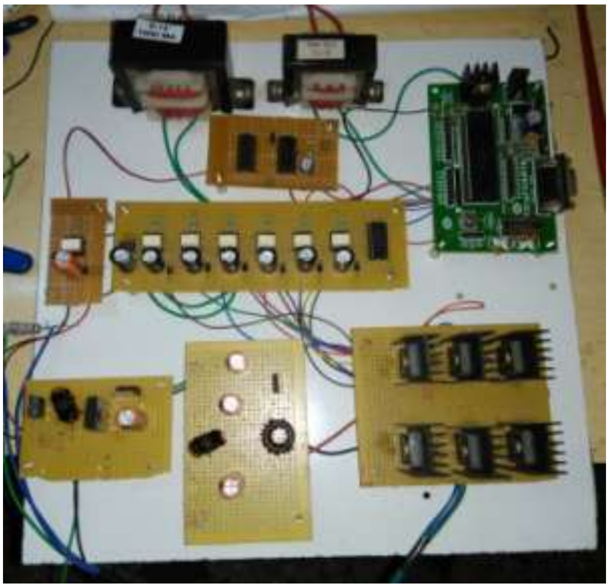

Fig. 17 Prototype of Proposed Model

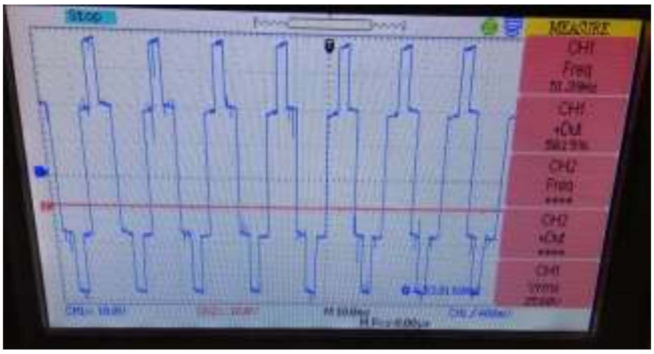

Fig. 18 Output Voltage of Proposed System

CONCLUSION

The proposed technique MPC based MPPT display prescient based greatest power point following for photo-voltaic frameworks has quick unique reaction, quick controllability contrasted with ordinary following frameworks which enhances the unwavering quality, control element and THD. Accordingly MATLAB/Simulink is utilized to simulate and the reproduction result affirms that Z Source Inverter is preferred and more advantageous over the supported VSI. The proposed strategy in

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this venture can be reasonable in any biological conditions and could apply to any sustainable power sources whose yield is ceaselessly changing and also the proficiency of the framework increments

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BIOGRAPHIES

Sumalata I. Amminabhavi: was born in Saundatti, Karnataka, India on 30 January 1994. She has completed her BE Degree in Department of Electrical and Electronics Engineering, Tontadarya College of Engineering, Gadag, Karnataka, India. Presently Pursuing M Tech IV sem in Power Electronics at Dr. Ambedkar Institute of Technology, Bengaluru.
Her areas of Interests are Power system, Energy Management and FACTS

Nalini S: Is presently working as an Associate Professor in the EEE Department of Dr.AIT, Bangalore. She has a total experience of 31 years in Academics. She was born in Bangalore, Karnataka, India on 11th of August, 1962. She completed her BE degree in Electrical Engineering from MSRIT, Bangalore and ME degree in Power Systems from UVCE, Bangalore. She is a member of various professional societies;Viz.MISTE,MIE,BMESI,SESI,etc. Her areas of interest are, Power Systems, Renewable Energy and related fields.