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MATLAB Simulation Based Reasonable Investigation of MPPT Methods for Cuk Converter Established Solar PV System to Connect to Utility Grid

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***Abstract*- In this paper presents a reasonable investigation of Maximum power point tracking system(MPPT) using a perturb and observe algorithm for Cuk DC-DC power converter based solar photovoltaic (PV) system to supply power to on grid.Cuk converter delivers an output voltage that may be less than or greater than input voltage. An imperativeimprovement of Cuk converter is a constant current at both the input and the output of the converter. Drawbacks of the Cuk converter are a high number of reactive components and high current stresses on the switch. The Cuk converter delivers a batter output voltage with reduced ripples and increase efficiency. MPPT methods are used in solar PV systems to extract the maximum power from the PV array under dynamic atmospheric circumstances. The electric power generated by solar panel, this power is regulated and it is required to constant power through the Cuk converter is used for improve to desirable voltage at solar panel. These methods are stimulated by MATLAB/Simulink program.**

***Keywords*- Maximum power point tracking (MPPT), PV, CUK Converter, P&O algorithm.**

I. INTRODUCTION

Renewable sources of energy acquire growing importance due to massive consumption and exhaustion of fossil fuel. Among several renewable energy sources, Photovoltaic arrays are used in many presentations such as water pumping, battery charging, hybrid vehicles, and grid connected PV systems.Maximum Power Point Tracking (MPPT) is used to obtain the maximum power from these systems. Such applications as putting power on the grid, charging batteries, or powering an electric motor benefit from MPPT. In these applications, the load can demand more power than the PV system can deliver.

In this case, a power conversion system is used to maximize the power from the PV system. DC-DC Converter DC-DC converters are electronic devices that are used to change DC electrical power efficiently from one voltage level to another. They are an electronic circuit which converts a DC signal from one voltage level to another level by storing the input energy and realizing that energy to the output at different voltage level.

They use an inductor and a capacitor as energy storage elements so that energy can be transferred from the input to the output. DC- DC converters are widely used in switched-mode power supplies (SMPS) and have a wide range of uses today and are becoming increasingly more important in everyday use. In general, there are two groups of DC-DC step-up converters, the is lated and the non-transformer converters. Isolated converters usually applicable in areas where, an intermediate medium frequency operated transformer is required between the input and output power sides fore special safety purpose.

There are a number of such topologies have been evolved with high voltage gain, but their application is limited to certain areas due to their low efficacy and output stability. The block diagram is shown in Fig.1.1

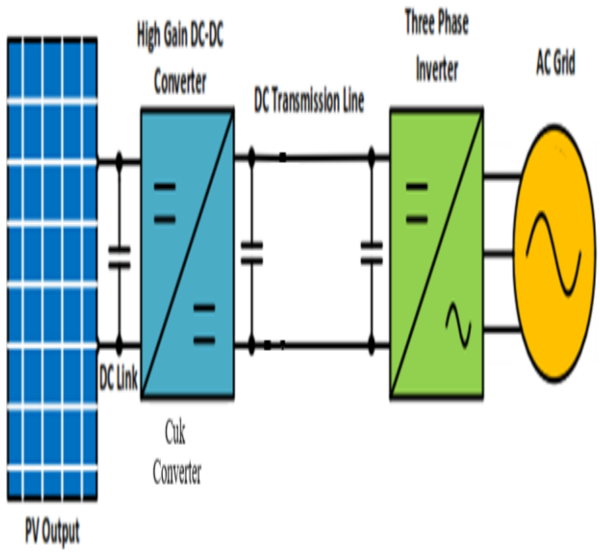

Fig 1. PV Power controlling system block diagram forhigh levelutility Grid power conversionsystems.

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II. DC-DC CONVERTER

Cuk converter is a switching regulator which yields a variable output voltage from a constant dc supply. Its continuous input inductor current gives a relative advantage against its rivals. This converter has been investigated quite extensively in the literature. There several studies related to its modelling, analysis, and control issues.

Descriptive equations of voltage and current for different operational states of a Cuk converter used, when developing the model of the converter, continuous inductor current mode operation. The state space averaged model used to derive the steady-state and the dynamic models of the Cuk converter based on its state space averaged model.

The state space averaging concept provides a means to obtain models for Cuk converter operating in discontinuous inductor current mode. It is used also to analyse the converter response for continuous inductor current mode. Discontinuous inductor current mode operation of Cuk converter at constant duty ratio makes the application of Cuk converter feasible to be used as power-factor pre regulator.

It is stated that by special average current mode control technique, Cuk converter in continuous inductor current mode is applicable as power-factor pre regulator for high power requirements that cannot be provided at discontinuous inductor current mode. The discontinuous inductor current mode of operation, the discontinuous capacitor voltage mode operation makes the application of Cuk converter feasible to be used as power factor pre regulator.Cuk converter is a switched mode converter.

Schematic of the Cuk converter is shown in Fig. 1.2. During the operation the switch S1 switches on and off at a frequency ‘f’s,’ with a period ‘T’ and duty ratio‘k’ within the period T determined by an externally applied control signal.

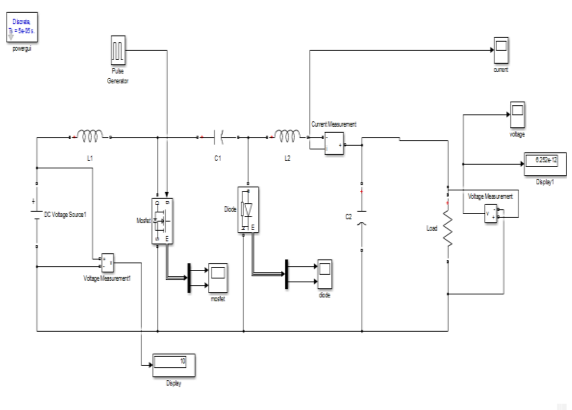

Fig 2. MATLAB Model of Cuk converter.

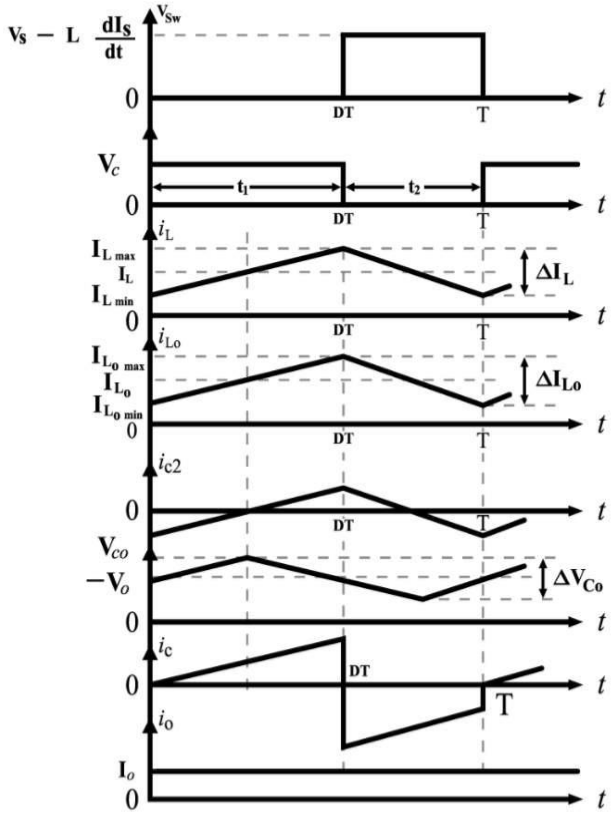

Fig 3. Switch (S) Voltage, Capacitor (C) Voltage, Inductor (L) Current, Inductor (LO) Current, Capacitor (CO) Voltage, Capacitor (C) Current and Load Current respectively for the CUK Converter.

III. SEPARATE ANALYSIS OF TWO STATES

Continuous conduction mode operation implies than inductor currents do not fall to zero at any instant within the period. In the subsequent analysis parasitic resistances are negligibly small, and all elements are supposed ideal.

The operation of the converter within the period T can be divided into two states for continuous conduction mode operation;

State for S1 is ‘on’, when $0<t<T_{on}$

State for S1 is ‘off’, when $T_{on}<t<T$

$$\text{Where } K = \frac{T_{on}}{T} = T_{on} = k_T \text{ and } k' = 1 - k$$

1. State S1‘off’, kT< t < T:

The circuit is divided into two separate meshes as seen in Fig. 1.4. When S1 is off, the energy storage capacitor C1 in the left hand mesh is charged through L1 and D1 in this time interval. Diode D1 common to both meshes is forward biased in this time interval. L2 and Co in the right hand mesh transfer their stored energies, left from the previous time interval during the steady-state operation, to the load R over D1 again. One can write the following equations governing the operation in this state as;

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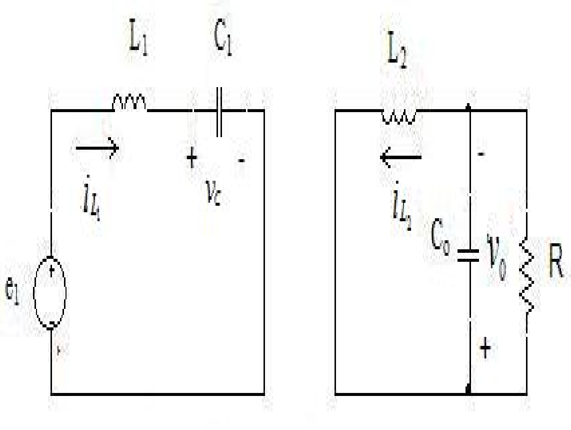

Fig 4. The Cuk converter equivalent circuit in state for S_1 is off.

$$\frac{di_{L_1}}{dt} = \frac{e_1 - V_c}{L_1} \quad (1)$$

$$\frac{dv_c}{dt} = \frac{i_{L_1}}{C} \quad (2)$$

in the left hand mesh,

$$\frac{di_{L_2}}{dt} = \frac{-V_c}{L_2} \quad (3)$$

$$\frac{dv_0}{dt} = \frac{1}{C_0}\left(i_{L_2} - \frac{V_0}{R}\right) \quad (4)$$

in the right hand mesh.

Current passing through D1 is the sum of input and output inductor currents:

$$i_{D_1} = i_{L_1} + i_{L_2} \quad (5)$$

2. State S1'on', 0<t<kT:

In the state S1 is on the converter circuit takes the form shown in Fig.1.5. Similar to the 'off' state equivalent circuit there are two separate meshes again. In theleft hand mesh the input inductor L1 stores energy from the source over S1during the time interval.

The energy storage capacitor C1 is now in the right hand mesh and ittransfers stored energy, over S1, to the load R, and energy storing elements L2 and Co. Due to the inappropriate voltage polarity of the charge on the capacitor C1Diode D1 is reverse biased and therefore off. The common path between the two meshes isprovided by S1 this time. One can write the following equations governing the operation in this state as;

$$\frac{di_{L_1}}{dt} = \frac{e_1}{L_1} \quad (6)$$

in the left hand mesh,

$$\frac{dv_{C_1}}{dt} = -\frac{i_{L_2}}{C_1} \quad (7)$$

$$\frac{di_{L_2}}{dt} = \frac{v_{C_1} - V_0}{L_2} \quad (8)$$

$$\frac{dv_0}{dt} = \frac{1}{C_0}\left(i_{L_2} - \frac{V_0}{R}\right) \quad (9)$$

in the right hand mesh.

Current passing through S_1 is the sum of input and output inductor currents:

$$i_{S_1} = i_{L_1} + i_{L_2} \quad (10)$$

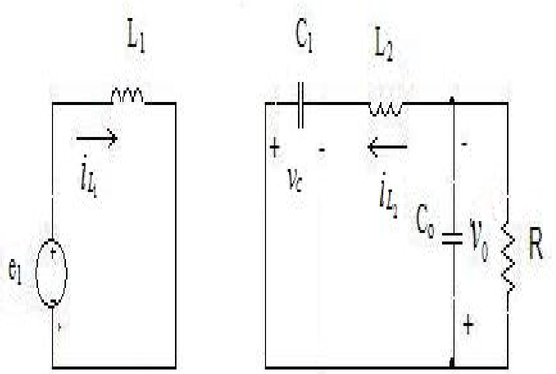

Fig 5. The Cuk converter equivalent circuit in state for S1 is on.

Main energy transferring element in the Cuk converter is the capacitor C1.The terminal of C1 connected to the negative terminal of the supply alternates in eachstate. It is the negative terminal of C1 for the state S1 is off, the positive terminal forthe state S1 is on. It was declared in that this property in the connection of C1isthe cause of the inversion of the output voltage, vo.

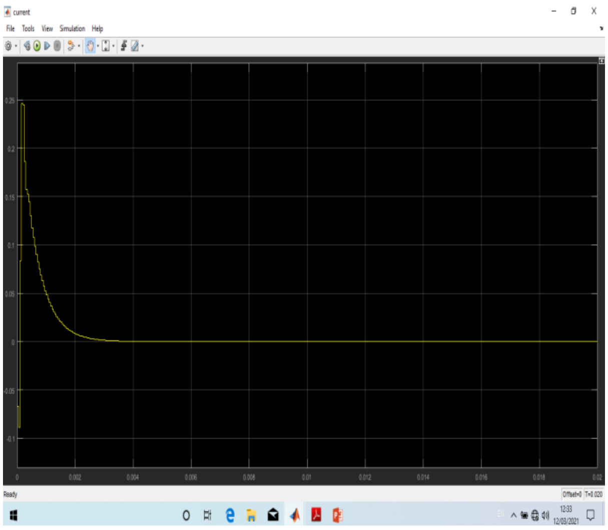

Fig 6. Cuk converter Output Voltage.

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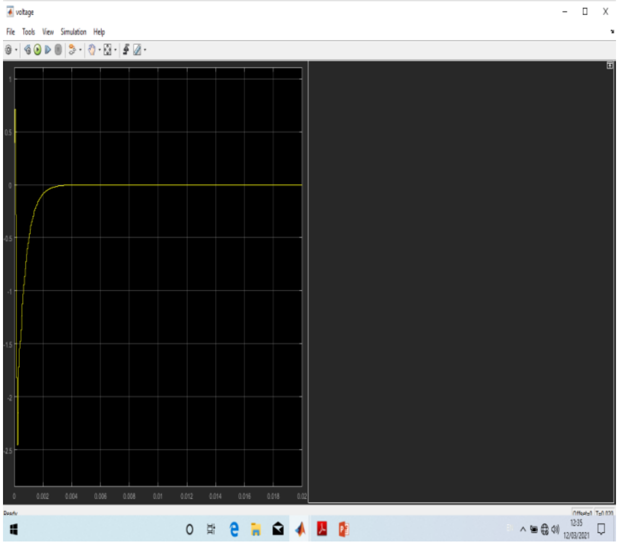

Fig 7. Cuk converter Output current.

IV. RESULT SIMULATION

The PV array input to solar radiation is 1000W/m2 and temp. is 25 deg. C. required for standard atmosphere condition. The PV array has 66 parallel strings and 5 Series connected modules per string the maximum power 305.226 W per panel, 96 cells per module, 64.2Voc, and 5.96 Isc.

The Cuk converter are connected to MPPT controller using pertube and observe technique required data is Duty cycle of Cuk converter value between 0 and 1. Enabled step input is required for MPPT controller, and PV voltage and PV current.

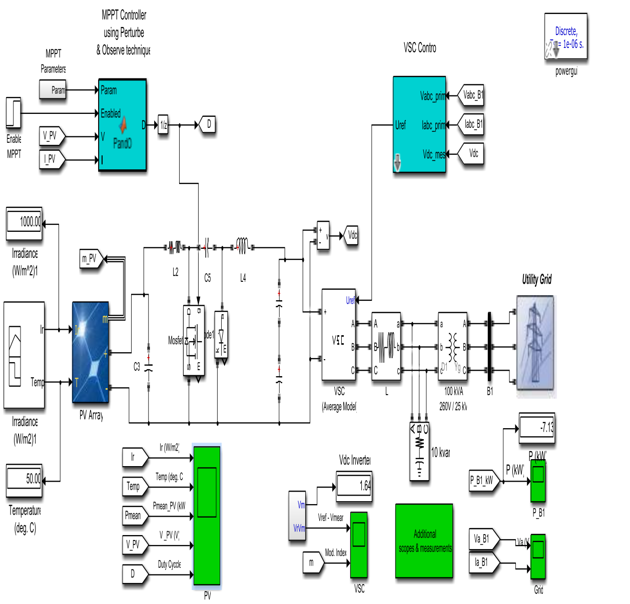

Fig 8. MATLAB Simulation Model for CUK Converter using P&O method.

The voltage source control inverter is used to convert DC to AC supply. The inverter has 3 Universal bridge arms, Average model based VSC power electronic device is used. 3 phase inverter is connected to LRC breach and 100KVA transformer is connected to bus bar and after the electrical power is sifted to utility grid. The MATLAB model for Cuk converter is shown in below fig.1.8 and simulation results is shown in fig. 1.9 to fig. 1.14.

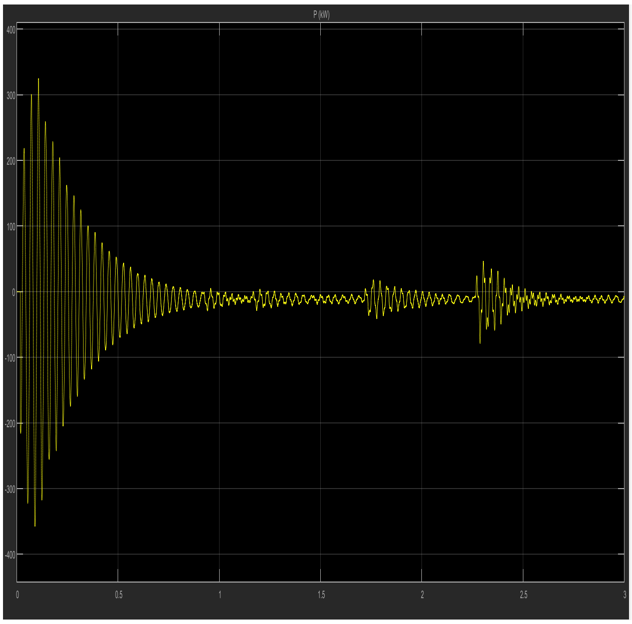

Fig 9. MATLAB Simulation Result for CUK converter power (KW).

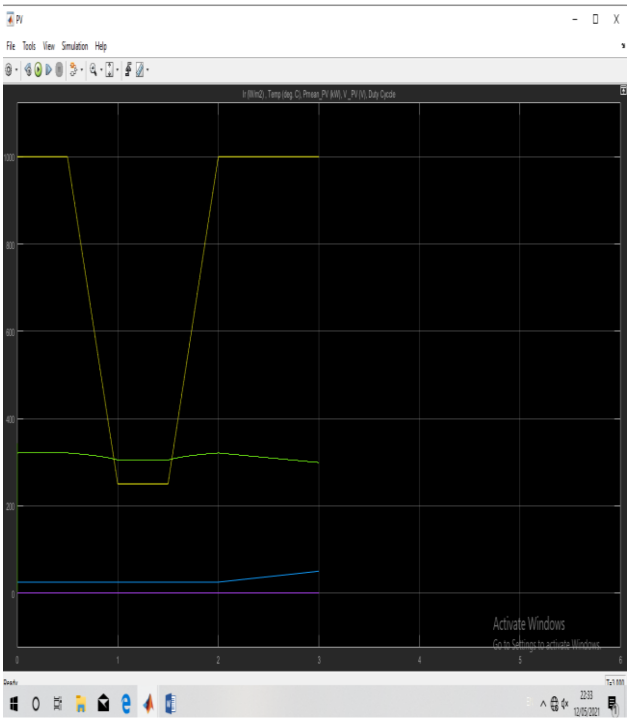

Fig 10. MATLAB Simulation Result for Cuk converter for Ir(W/m^3),Temp.(Deg. C.),Pmean Photovoltaic, Voltage PV, Duty cycle.

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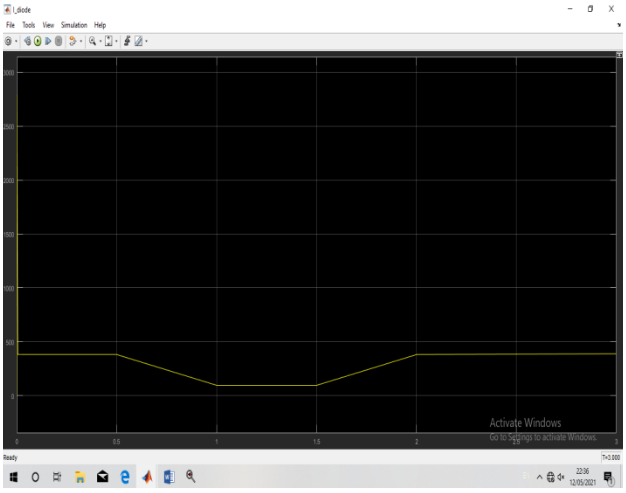

Fig 11. MATLAB Simulation Result for Cuk converter for Diode Current.

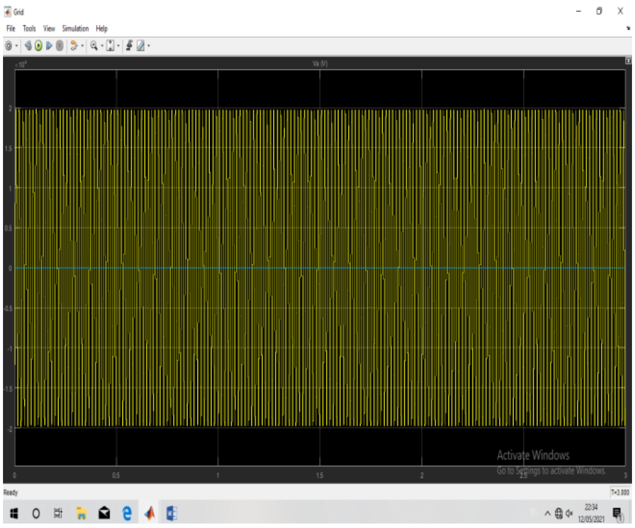

Fig 12. MATLAB Simulation Result for Cuk converter for Grid Voltage (Va)

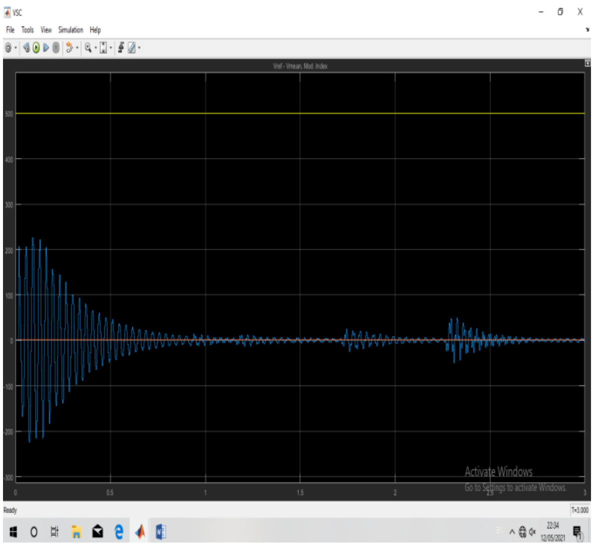

Fig 13. MATLAB Simulation Result for Cuk converter for VSC control DC voltage, Vmean, modulation Index.

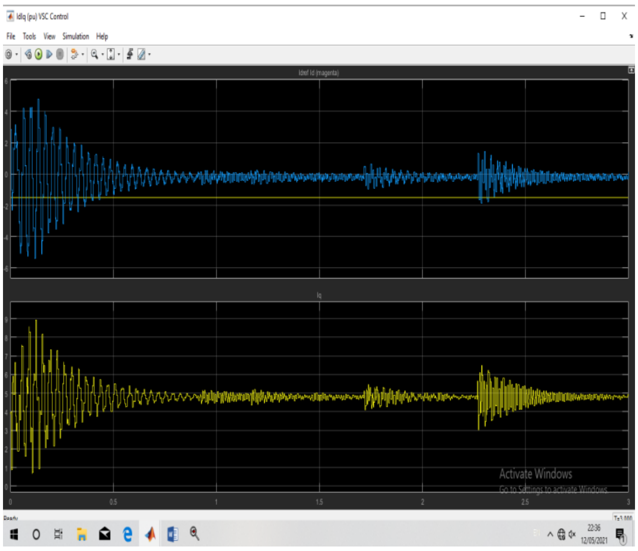

Fig 14. MATLAB Simulation Result for Cuk converter for VSC Control Current IdIq (PU) and Diode current.

V. CONCLUSION

In this paper shown a photovoltaic solar penal Cuk converter with connected to 3 phase Voltage source control inverter voltage 500.05v and inverter power supply to a power utility grid. The result show the power output to the grid is 105.98 KW and solar penal irradiance 1000W/M^2 and solar power temperature 25 Deg. C. Areas on able analysis of most general MPPT algorithms, Perturb & Observe andIncremental Conductance for Cuk converter based solar PV system.

This paper mainly focuses on performance analysis of Cuk converter which is connected with the MPPT controller and a solar panel with standard value of insolation and temperature and it has been included in the simulation circuit. Hence usage of this efficient power converter in solar PV system provides better solution to meet the energy demand.

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