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Grid Integrated Micro Inverter for PV Module with Anti -Islanding and MPPT Schemes

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Abstract: From the economic perspective, densely populated areas can generate great amounts of electric power by installing PV panels on its rooftops and it can be fed in to the grid. In this paper describes a grid tied micro inverter for photovoltaic applications. The system consists of a Cuk converter connected with a full-bridge current source inverter. The connection of micro inverter systems to the grid can raise several challenges, as the islanding detection and extracting maximum available power from PV module. In this sense, if the system is unable to detect the islanding situation, it may cause power quality degradation, electrical safety threats to maintenance crews, and damage to the devices that connected at the same power grid .In order to maximize the power extraction from the photovoltaic module it is mandatory, to make use of a MPPT algorithm

Keywords: photovoltaic, Distributed Generation Systems (DGS)

I. INTRODUCTION

Among the variety of renewable energy resources, the most popular among them are undoubtedly solar. The use of photovoltaic (PV) energy has exponentially increasing day by day. It is mainly due to it comes directly from the primary energy source of the solar System, the sun itself. The micro generation technologies can offer benefits to both electric distribution and consumers. This is especially true for PV generators. Highly populated areas can generate great amounts of power by installing, PV panels on rooftops .so the consumers are becomes the part of producing electricity. The main objective of this paper is to design a micro inverter based on the Cuk converter, to enable the effective use of the power generated by the PV module, into the commercial power grid, in low voltage. In order to achieve this goal a micro inverter system must integrate with three key algorithms, which are anti-islanding, Maximum Power Point Tracking (MPPT) and synchronization with grid. When we connect the distributed generation systems (DGS) to the power grid a set of control measures must be taken. Islanding is the situation, where the grid is get offline for certain reason like maintenance but the DGS still feeds to the grid, it causes serious problems To avoid such unsafe conditions, the DGS must sense when then grid is Disconnected .So anti-islanding protection scheme must be used so as to avoid this unsafe condition, it effectively protecting the personnel and equipment of the system [1].In this paper, a micro inverter based on Cuk converter is proposed. This converter was chosen because it presents current source behaviour in its input and output. The presence f the output inductor gives to this circuit a current source Characteristic, which turns out to be suitable for connection to the power grid, which has voltage source characteristics, as is well known [3].

II. MICROINVERTER TOPOLOGY

A grid tied micro inverter is develop inorder to perform three task those are to track or extract maximum available power from the PV module, to convert the dc power from the PV module to ac power with high efficiency ,and to inject into the power grid and finally to detect islanding condition to provide protection to the micro inverter The micro inverter topology consist of a PV module from which power is extracted ,the dc output from the PV module is fed to a dc to dc converter here we use Cuk converter for this function this dc output is fed to dc to ac converter this action is performed by a full bridge current source inverter .

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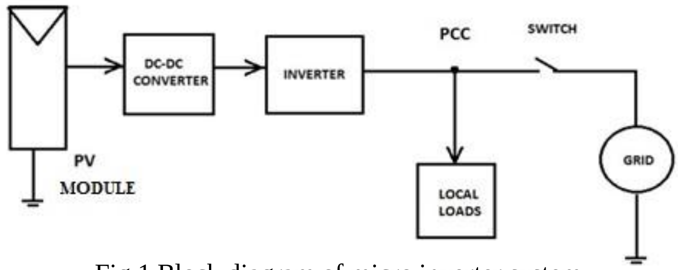

Fig.1 Block diagram of micro inverter system

The output from the micro inverter is fed to the utility grid, there is local loads are provided for domestic needs the interconnection point between microinverter and grid is called PCC point of common coupling. figure (1)shows the basic block diagram of micro inverter topology

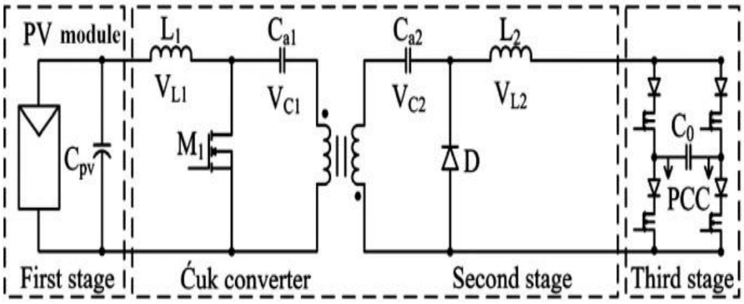

Fig.2 Circuit diagram

The micro inverter topology can be divided in to three stages. The first stage consists of PV panel which is connected in parallel with a decoupling capacitor (C_{PV}), whose function is storing energy arising from the PV modules [4]. The second stage a DC-DC converter is implemented, due to topological simplicity and capacity to synthesis a rectified sinusoidal current waveform through simple variation of duty cycle. It reduces switching components and ripple, the cuk converter is provided with galvanic isolation with gives a physical barrier inorder to withstand with high voltage Isolation of cuk converter is obtained in different manner .capacitor is split in to series capacitors then a transformer is inserted between these capacitors .having capacitors in series with transformer ensures no dc voltage applied to transformer .The third stage consists of a full bridge current source inverter, where the cuk converter is cascaded with the current source inverter .it produces a sinusoidal current waveform which is synchronized with power grid[2] Fig.2 shows thecircuit diagram of microinverter.

III .DESIGN CRITERIA FOR CUK CONVERTER

A simplified topology of the Ćuk converter shown on Fig (1) and it works in discontinuous conduction mode, it presents three stages of operation. In the first stage, the main switch is on condition. In the second and third stages, it remains off. The diode of cuk converter conducts only on the second stage, when it is forward biased dmax value can be determined from the converter static gain

where dmax is the maximum value of the duty cycle,
V2 is the mains rms value,
V1 is the PV maximum power point voltage.

$$d_{max} = \frac{\sqrt{2}V_2}{V_1+\sqrt{2}V_2} \quad (1)$$

The equivalent inductance (Leq) is determined from the Cuk converter gain in DCM

$$L_{eq} < \frac{V_1^2 V_2^2}{2Pf_s\,(V_1+\sqrt{2}V_2)^2} = \frac{L_1\,L_2}{L_1+L_2} \quad (2)$$

fs is the switching frequency and P is the output power.

IV. IMPLEMENTATION OF MPPT ALGORITHM

In order to increase the efficiency of the PV system, it is important to use an MPPT algorithm MPPT algorithms are, employed to extract maximum available power from the PV .Among the various MPPT algorithms, the P&O method is one of the earliest and simplest method .The P&O method is based on perturbing the system and observing the response to perturbation to find the maximum power point (MPP). The acquisition of current (I_{PV}) and voltage samples (V_{PV}) from PV panels allows the instantaneous power extracted from the panel to be calculated. Then, the algorithm compares the calculated value of the instantaneous power at the present moment with the value obtained at the immediately preceding instant to determine if the maximum power available was achieved [5]

V. ISLANDING DETECTION METHODS

Islanding is one of the main technical issues in the case of grid connection. Islanding occurs when power supply from the grid is off but the DGS keeps supplying power into distribution networks. The fault should be detected by using a protection system and tripped before an island can occur. It is necessary to predict the possibility that islanding occurs evaluating the probability of line disconnection. Many islanding detection methods are available for grid-connected PV inverters. These methods can be divided into three categories: passive methods, active methods. Passive islanding detection methods basically monitor .Active islanding detection methods are based on injecting disturbances in the output of the inverter in order to affect a certain parameter that comes out of range in an islanding situation [6]

VI. SIMULATION RESULTS

A micro inverter prototype was built using the proposed design criteria and in view of the design conditions shown in Table. I for the Cuk converter working in DCM [1].The output waveform obtained from the microinverter is shown in the figure.3

TABLE I. MICROINVERTER PARAMETERS

parameters	value
Input voltage (V_{in})	30V
Inductor (L_1)	.029H
Inductor (L_2)	.921mH
Capacitor (C_a)	37.8µF
Capacitor (C_b)	31µF
Output voltage (V_o)	120
Switching frequency (f_s)	25KHz

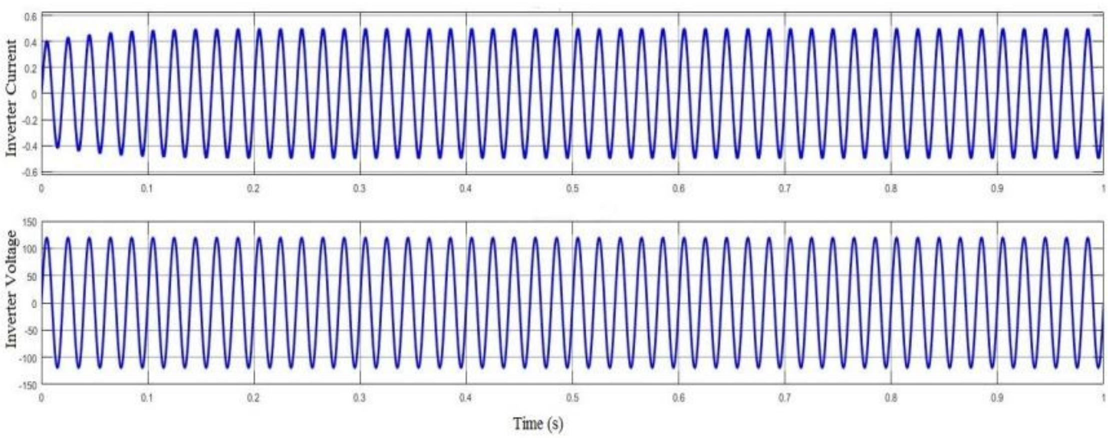

Fig.3 Waveform of inverter voltage and inverter current.

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A. Implementation of the MPPT Algorithm

The MPPT algorithm was implemented in MATLAB/Simulink software. Maximum available power (MPP) and the power tracked by the P and O algorithm (MPPT) versus time, in the terminals of two PV panels connected in series. This result was obtained from the solar irradiance profile solar irradiance profile amplitude from 200 to 1000 W/m^2 . Extracted power levels from 50W to 210 W, according to the characteristics of the PV panels. The extracted power is close to the maximum available power in the PV panels.

TABLE II .PV MODULE SPECIFICATION

PARAMETERS	VALUE
Rated power, P_{max}	213W
open circuit voltage , V_{oc}	36V
short circuit current , I_{SC}	7.84A
voltage at MPP , V_{MPP}	29V
current at MPP , I_{MPP}	7.35A

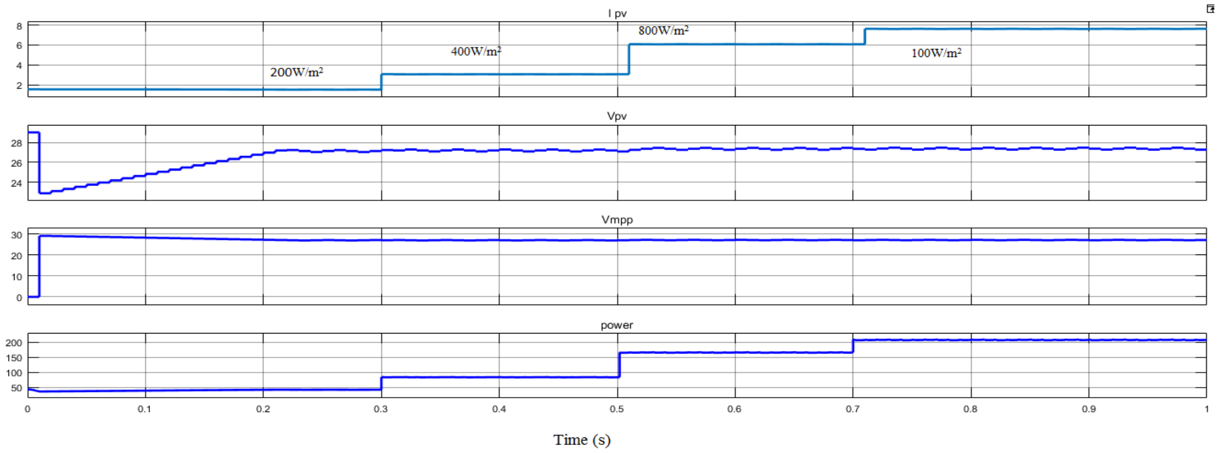

Fig.4 Output waveforms of P&O algorithm with variying irradiation

B. Implementation Of The Anti-Islanding Algorithm

Active anti-islanding methods try to disturb electrical magnitudes on PCC by injecting disturbance at the inverter output. So power grid can effectively reject these type disturbances generated by the inverter. If the impact of the anti-islanding algorithm has no effect on PCC, it means that the power grid is on condition. if the impact of the perturbation in the is significant, a power failure is assumed and the inverter is disconnected

TABLE IV IEEE 929 STANDARD – RESPONSE TO ABNORMAL VOLTAGE

Voltage (at the PCC)	Maximum Trip Time
$V < 50\,\%$	0.1 s
$50\,\% \leq V < 88\,\%$	2.0 s
$88\,\% \leq V \leq 110\,\%$	Continuous operation
$110\,\% < V < 137\,\%$	2.0 s
$137\,\% \leq V$	0.03 s

So active islanding method is implemented in the converter, where the passive methods are not effective when balanced load is connected. The algorithm consists of generating periodic signals, which is obtained by reducing the d max by fifty percentage. every second the perturbation is given to the output voltage .if the voltage disturbance is appear occurs in the point of common coupling or the voltages get out of bound specified in the table occur ,the inverter is suddenly disconnected. For simulation, the disturbance is given to every 0.1s with 0.01 duration. The absence of grid is detected using the algorithm and the inverter is disconnected from the grid within 0.35 s. Fig.5 shows voltage at PCC when the grid is offline from 0.2 s to 0.6s

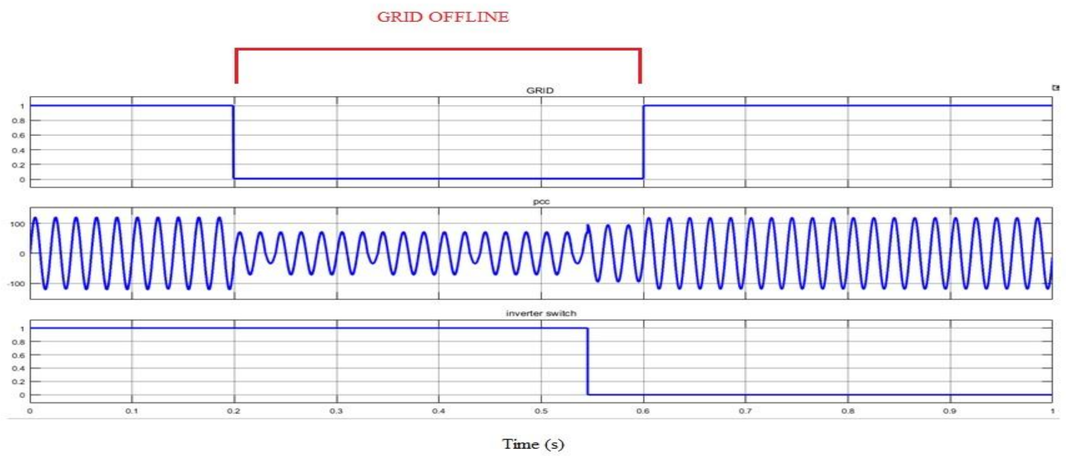

Fig.5 Voltage at PCC when the grid is offline from 0.2 s to 0.6s

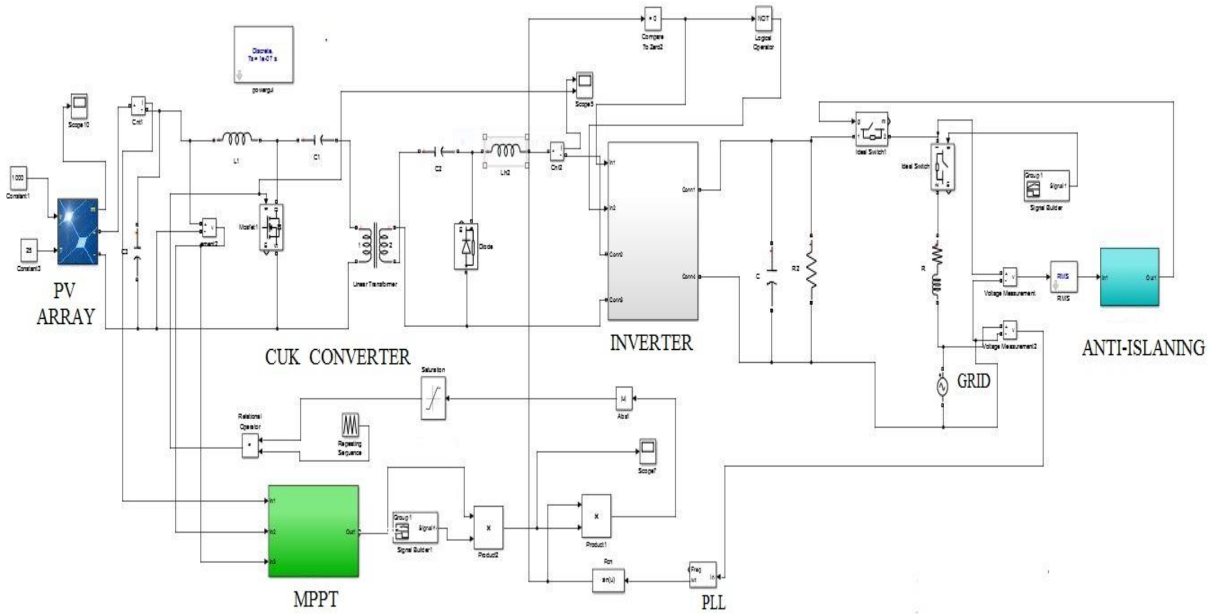

Fig.6 Simulation diagram of the microinverter system with MPPT and Anti-islanding.

VII. CONCLUSION

The implementation of a microinverter, based on the Cuk converter working on DCM is done. The microinverter is powered by a set of PV module. For maximum power extraction P & O algorithm is used because of its simplicity .for islanding protection active method is implemented. Active anti-islanding methods try to disturb electrical magnitudes on PCC by injecting disturbance at the inverter output. So power grid can effectively reject these type disturbances generated by the inverter. If the impact of the anti-islanding algorithm has no effect on PCC, it means that the power grid is on condition. if the impact of the perturbation in the is significant, a power failure is assumed and the inverter is disconnected

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