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IMPROVING EFFICIENCY OF SOLAR PV GRID USING MICRO INVERTER AND ITS CONTROL STRATAGIES

Prashant R Gamit[1], Assi.Prof Kishan Thacker[2],
[1]M. E. Electrical Engineering
HJD Institute of Technology & Research

Abstract— ***There is a critical need to make use of renewable energy sources such as solar energy to develop efficient and economical solutions to the energy crisis that many countries are facing. This need is worsened in developing countries by the resented of weak or unreliable electrical grids. A popular solution is the use of solar based single phase micro-inverters feeding AC power to the grid. However, they require a stable grid and input current pulsation at twice the line frequency is an inherent disadvantage.***
This limitation is typically remedied by a large electrolytic input capacitor that increases the cost and reduces the efficiency of the converter. This paper therefore proposes a dual mode fly back based hybrid converter that can support both a grid tied mode and islanded mode operation to extract maximum power from the solar PV source at all times. It is also designed to employ active power decoupling to draw constant input current with reduced filter size at the terminals of the PV panel in both AC and DC output power modes. The ability of the proposed converter to produce both DC and AC output allows flexibility of operation in environments where the grid may not be available for as high as 80% of sunlight hours while maintaining the advantages of micro-inverters. This paper presents the analysis, P-SIM simulation as well as the experimental validation of the proposed converter system on a 240 watt prototype. The results obtained validate that this approach can be applied to large distributed generation networks of micro inverters in weak grid communities

Keywords— ***Micro inverter, solar PV system design, AC Grid***

I. INTRODUCTION

With the increasingly urgent energy issues, the world attaches great importance to begin the development of new energy and related technology. At present, large scale photovoltaic power generation and scale of renewable energy has become parts of development strategy, meanwhile it is the way to guide the development of photovoltaic industry. However, because of its own characteristics different from conventional power generation grid connected PV power station and its security, stability, reliable operation become new challenges which power grid and PV power plant need to face. Grid connected photovoltaic power systems are power system energized by photovoltaic panels which are connected to the utility grid. Grid connected power systems comprise of PV panels

I.MPPT
II. Solar inverters
III. Power conditioning units
IV.Grid connection equipments

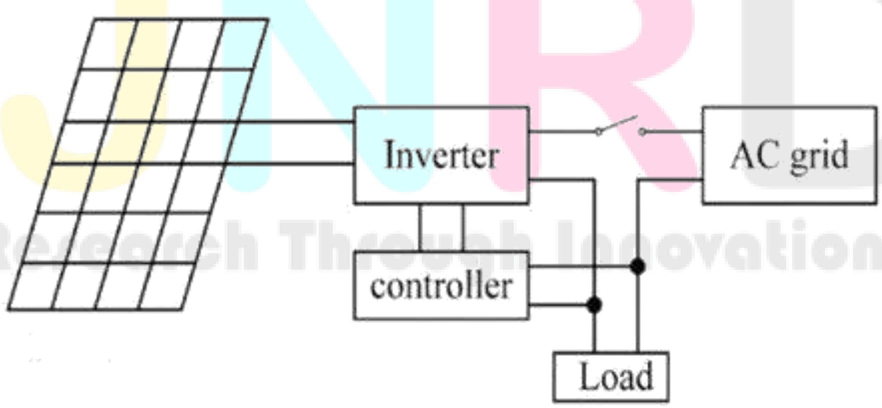


Fig.1.1 Photovoltaic modules or solar panel

i. Solar PV Panel

Photovoltaic cell which produces electricity from the daylight is the main constituent in a PV system. Current and voltage produced depend on the range of the cell. A

13.5‖x13.5‖ size Photovoltaic cell can produce voltage of about 0.55volts and a current density of 30–35mA/cm^2. A solar board is the gathering of this elementary Photovoltaic cell which can be called solar cells. To meet the power necessities of a specific system, a number of panels are linked in the following form;

(1) Series connection is made to increase voltage

(2) Parallel connection is made to increase current

While its groupings form a solar PV array.

ii. MPPT

Solar inverters use maximum power point tracking to get the maximum possible power from PV array. Solar cells have a complex relationship between solar irradiation, temperature and total resistance that produces a non-linear output efficiency known as the I-V curve. It is the purpose of a MPPT system to sample the output of the cells and determine a resistance to obtain maximum power for any given environmental conditions.

iii. inverter

This is also identified as power conditioning component. Most of the appliances work on AC source and battery and panel are DC source. Work of Inverter is to converts DC power into AC power in a solar power generating system.

iv. Load

Load is a Power consumption unit for a PV system to be scheduled. Load may be AC type or DC type. Proper load approximation is essential in designing stand-alone solar power generating system. While designing solar generating power system, the nature of the load may be resistive or it may be inductive. Resistive loads do not require any substantial surge current when it is energized. Like bulb, heaters etc. On the other hand, large amount of surge current is required in inductive load at the time of starting which is normally near around 3.5 times the standard energy supplies such as; electric fan, motor, etc. liable on the load approximation of a structure if correct design can be employed.

II. CALCULATION METHODOLOGY FOR SOLAR POWER GENERATING SYSTEM

This chapter presents explanation of the numerous apparatuses of a standard solar energy system sizing & design containing the panel module, a battery, a charge controller development and load. **A. Determine power demand**

Load speaks of somewhat that uses electricity. By taking an example of a toaster which acts as electrical load draws huge quantity of current whereas an iPhone charger requires less current. We famine to recognize how much energy is important every day, and how rapidly that energy requirements to be distributed. Always work in kilowatt Hours for the quantity of energy desired and kilowatts aimed at the degree at which the energy desires to be delivered. For scheme a Solar generating system, the leading step is to look out total energy and power requirement. Step 1: Calculating overall Watt-hours day meant for every single appliance. First of all to get overall watt-hour for day we require adding all appliances watt-hour requirement. Step 2: Calculating overall Watt-hours day desired from the panel. The losses include wiring and connection losses about 10%, losses in the battery about 20%. Now adding up all losses will be around 30%, hence we essential to produce 30% enough WH/Day including loads to balance the losses. Hence we want to produce 130% of load requirement. Hence multiplying 1.3 time total load we will get total power which is required from the module

B. Calculation of panel requirement

The power produced by different size solar panel is different. Peak-watt for a panel produced is governed by Panel size & weather condition of site. We require studying Panel Generation Factor (PGF) that is dissimilar in each site. For India, the panel generation factor is nearly about 3.8. To find the sizing of PV modules, we need to follow these steps: First step: Calculation of Overall Watt-Peak of Solar Module To acquire the total Watt-Peak of solar module we require dividing the overall Watt-hours each day required from the Panel by 3.8 to operate appliances. Second step: Calculation of quantity of panels for the system. Quantity of panels required for the system can be found by dividing overall watt- peak of solar module which is previously calculated by standard available module rating. If whole number is not obtained, just simply round off it to highest number

C. Calculation of VA rating of the inverter

It is Volt-ampere rating of transformer. The output from inverter will be voltage & current to the apparatus. Ideal transformer efficiency will be percentage. But practical transformer will operate nearly 60 to 80 percentages. Inverter will supply same amount of power as of load when it is cent percentage. Talking practically inverter has to supply 30 % more. Power rating of transformer = total AC load / efficiency or power factor. We will consider efficiency or power factor = 0.7

D. Calculating Panel generation Factor

For my locality month wise Solar Radiation is depicted in table given below

Table 1: Month wise solar radiation of my zone

MONTH	SOLAR RADIATION
1	6.45962286
2	7.0536375
3	7.40845394
4	7.37190723

5	6.81079483
6	5.54507542
7	4.18471956
8	4.74270058
9	6.17625713
10	6.64119911
11	6.12629271
12	5.81129599
Total	74.33195686

Average solar radiation (KWh/m2/day) is (74.33/12) = 6.19. Suppose the lowest month solar has a daily average of 6.19. That is equivalent to 6.19 hours of 1000 W/m2 sunlight every day. Loss calculation for temperature will be 15%, daylight not arresting the panel will be nearly 5%, MPP loss will be nearly about 10%, and dust will add up loss of 5%, aging effect will have loss of 10%. Hence in total overall power = 0.95 x 0.90 x 0.90 x 0.85 x 0.95= 0.62 of original panel rating. PGF= 6.19 x 0.62 = **3.83.**

G. Calculate fix tilt Angle

To calculate fix tilt angle use below given methods to find the finest angle from the plane at which the module should be tilted:

Latitude	**Fix Tilt Angle**
latitude< 25°	Latitude x 0.87
25°<Latitude< 50°	(Latitude x 0.76) + 3.1°

Table 2: Latitude and fix tilt angle relation

III. SOLAR POWER GENERATING SYSTEM SIZING CALCULATIONS Modeling a house which has the following electrical appliance usage:

Table 3: Modeling of household applications

Appliances	**Quantity**	**Rating**	**No. of hours use/day**	**load**
LED mp(AC)	2	9W	4	72W
n(DC)	1	15W	2	30W

A. Determine power consumption demands

Overall appliances used for hours are

= (9W x 4 hrs) + (15W x 2 hrs) Total energy required from the solar panel is

= 102Wh/day =102 x 1.3 =**132.6 Wh/day**.

B. Calculation of panel requirement

Total watt-peak solar panel capacity required is

= 132.6/3.8

=36.83 Wp

Quantity of solar panels required= 36.83/40

=0.9208 modules

=1 module

In Short Panel required to supply load is formulated in table

Table 4: Panel Requirement

No. of Panel required(Minimum)	**Rating of Panel**
1	40Wp

C. Fix tilt angle For my locality:

Latitude 20.83oN Longitude 70.55oE

According to formula we need to multiply Latitude with 0.87 as latitude is below 250. Fix tilt angle= 20.83 x 0.87 =18.12o

So we require fixing our solar module at nearly about **180**.

D. Inverter

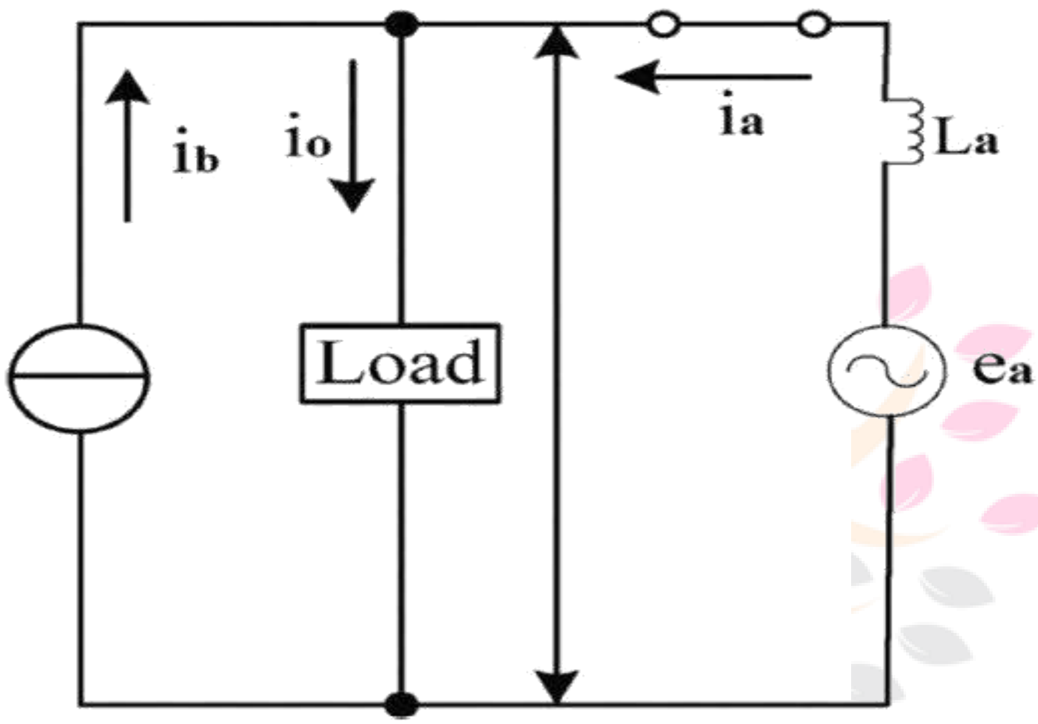
Power of inverter (VA) = 18W/0.7

=26W

So, nearly **26W** inverter is required for AC loads.

IV. Inverter control theory

Inverter can control the switch state of shut and conduct, thus the system may form two different working ways which are parallel operation and independently operation. When the system is working in parallel operation way, the inverter belongs to the current mode. Equivalent circuit of the inverter in parallel operating mode is shown in figure.



Thus the value of the active component received by the ac grid will be controlled by the phase between the output voltage of the inverter and the source voltage.

A. Improved PWM inverter control method

In improved PWM inverter control method the two reverse diodes used in power type PWM is removed. And the setting of the drive voltage phase of the inverter is based on the grid voltage phase which means the output power factor will be kept to a high value. The improved PWM inverter control system also use the outer loop to control voltage and the inner loop to control current which is the same with the voltage source inverter control, and then it tracks the maximum power point after using the output current transforms to a fit type, which can ensure maximum power output of the battery. In this way, the system inverter structure is simpler than the power-type PWM, and ensures the stability of the power output. The improved PWM inverter circuit can realize the following mode. For one thing, work as AC switch.

This improved type PWM inverter control method adopted the isolated transformer to allow the load to achieve the required voltage, which plays an important role of separating AC system from DC system

B. MODELING OF MICRO INVERTER

Solar micro inverter is modeled as per data sheet of Repulse- 250. Micro inverter comprises of fly-back converter and single phase full bridge inverter. Micro inverter schematic diagram is shown in *Fig. 5*. To reduce the size of inverter and introduce high voltage gain a high frequency isolator transformer are used.

From *Fig. 5*, when the switch *Q1* (MOSFET) is ON, energy from PV is stored in magnetizing inductor of transformer. When diode *D1* conducts, stored energy from inductor is transferred to full bridge inverter. In fly back converter, inductor voltage and current are scaled according to 1: *n* turns ratio of the high frequency isolator transformer [6].Turns ratio *n* is calculated by input and output voltages of fly back converter.

The magnetizing reactor is found out considering 1% current ripple and switching frequency 150 kHz. Input capacitor *Cin** is evaluated by taking voltage and current ripple 5% and 1% respectively. DC link capacitor *Cdclink** is calculated considering power transfer to single phase inverter. PI controller is utilized to generate duty ratio from change of input voltage for fly-back converter. Parameters of fly-back converter are given in Table V

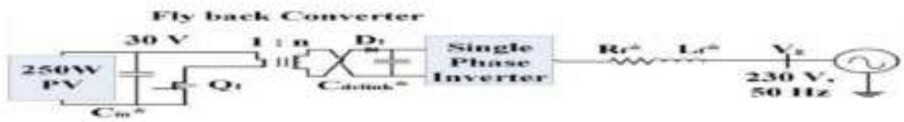
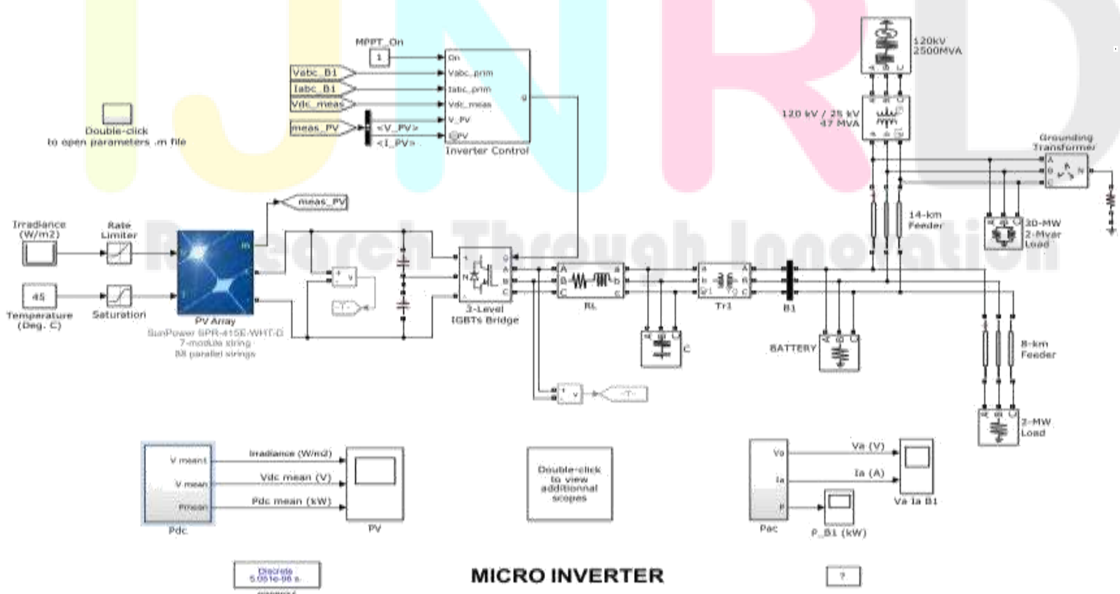


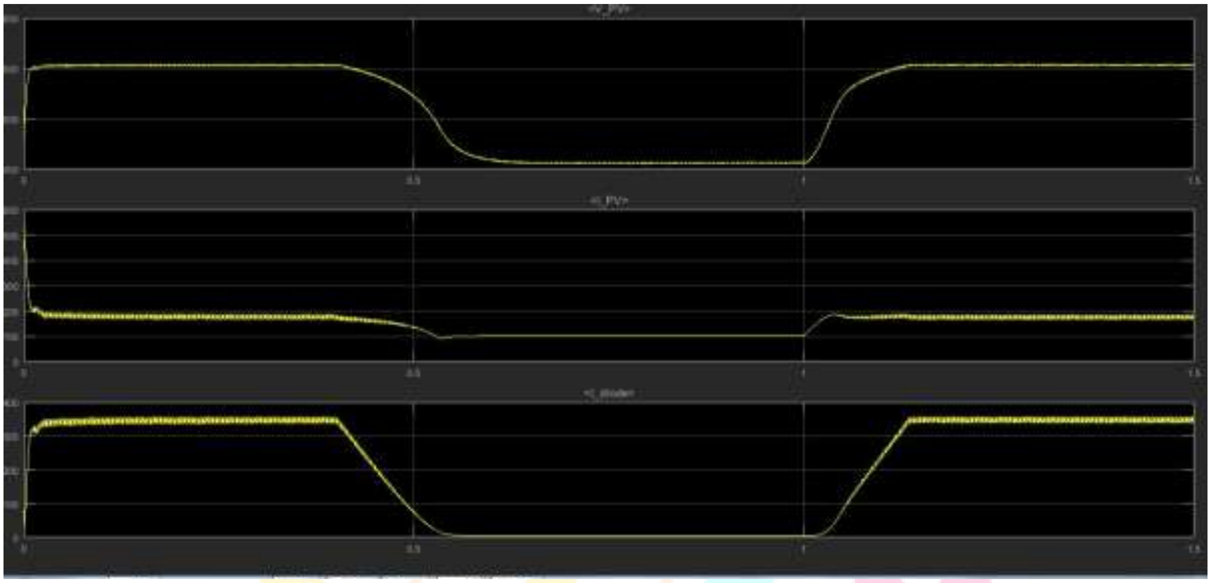
TABLE V. FLY-BACK CONVERTER PARAMETERS

Micro Inverter Parameters	Values
Vin, Photovoltic output voltage	30 Vdc
Vout, DC link voltage	380 Vdc
MOSFET frequency	150 kHz
Cin*, Input capacitor	125 µF
Transformer magnetizing inductor	10.51 µH
Cout*, DC link capacitor	1250 µF
1 : n, Turns ratio	1 : 12
PI controller	$K_p = 1$, $K_i = 0.01$

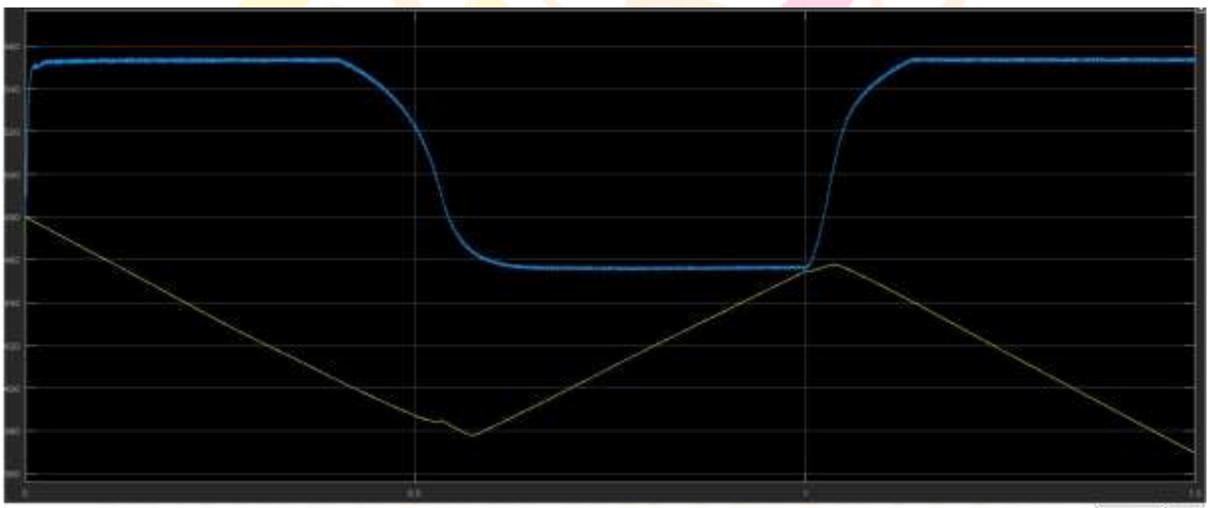
MATLAB SIMULATION CIRCUIT



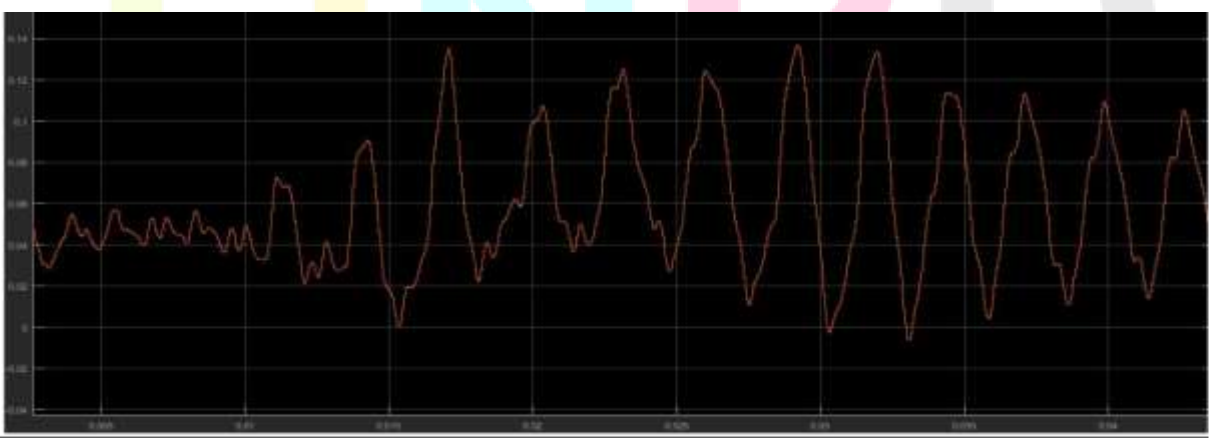
PV



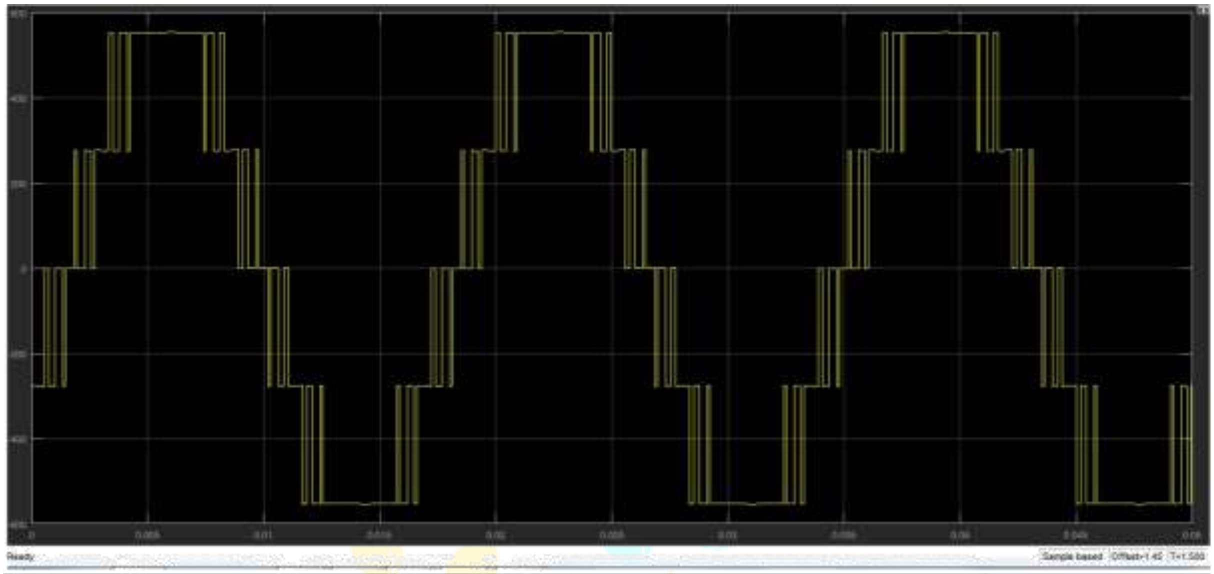
Vdc Reference Mean



Vsc Control



INVERTER



CONCLUSION

The structure of improved PWM inverter control system is very simple which is based on the voltage type control method and the PWM power type control method. From the result of simulation, conclusions are come to as follows. First, the improved PWM inverter control method can make the voltage and the current waveform of the grid tend to sine wave effectively and quickly, and the power factor will reach to one. Second, the power can be sent to the grid or load arbitrary through controlling the PWM regulator, while the control system has a good stability.

Finally, many inverter control systems are used in grid-connected at present, but there are several problems which need be to solved about how to keep a good stability of the power system when the grid changes from island to grid-connected. Today, research of a large number of grid-connected PV generation inverter control system is still very important for everyone

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