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Improve Power Quality of Grid Connected PV System with PI Controller

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ABSTRACT

In this article investigates the power quality (PQ) of Grid Connected solar energy conversation systems (SECS) based on PI Controller when non linear loads are connected in distribution network. When non linear loads such as three Phase Bridge rectifiers are connected in the network, because of its switching operation harmonics are generates in the network it may lead to generate voltage sags and swells in the network. This PQ problems are severe impact on dynamic performance of the SECS, this are solved by employing PI controller based voltage source converters. Verified simulation results in MATLAB satisfactory results are obtained.

Keywords*: SECS, PQ, PI controllers.*

I. INTRODUCTION

Since a decade power generation through renewable energy sources are rapidly growing because of its numerous features such as free from green house problems, environmental friendly, and no acid rain and doesn't create any problem to ozone layer. Various types of RES are available like solar, wind, geothermal and wind etc, in these solar is more dominant to adopt distribution power generation because it doesn't contains rotating parts to generate power. Absence of mechanical parts PV power generation, it is more economical and more efficiency. From a survey PV power production in 2013 is 40,000MW this may prove the utilization of solar.

SECS are broadly classified into Stand-alone PV systems and the grid-connected PV systems, categorises [1-5]. The major differences between these two SECS are that in stand-alone systems the PV output is equally balanced with the load demand, Grid connected SECS both PV and grid are responsible for to achieve the load demand. When non linear loads such as three phase bridge rectifier is connected in the circuit grid connected PV systems are suffered with power quality issues as harmonics, voltage sags, voltage swells etc. This power quality problems are occurred due presence of non linear loads in the distribution (load).

Voltages generated from the PV arrays are stored in battery [6-7]. Voltage and current rating of solar cell is enhanced by connecting, solar cell leads in series and parallel combinations. Solar doesn't have storage capability; produce electricity from solar is stored in batteries. The industrial and commercial rating of solar power generation voltage rating is from 300-1000 V and current rating is in the range of 5-10 A.

Power quality improvement of grid connected solar system is already described by various authors, That details discussed as follows. Ramakishan [8] has discussed simulation of cell modelling with single diode model and verified simulation results in MATLAB. Detailed information about implementation of maximum power tracking method gave by Xuosong zhou [9]. Design of voltage source converter with fuzzy logic controller is mentioned by Kelesidas.K [3] discussed about the p-q based reactive power compensation theory.. This theory contains information reactive power compensation, current harmonics mitigation and power factor improvement for linear and non linear loads. The filtering of harmonics generated in load side for nonlinear loads eliminated using filtering Jinjun et. al [4],gives the filtering circuit for the elimination of harmonics. The Maximum power point tracking using perturb and observe method is simulated by taking reference B.Subuddi [1] give the brief description of different types of mppt techiniques, Various PI control tuning reported earlier to control switching pattern of voltage source converter [10-13]

The main focus of this article is investigates demand for the electrical energy increasing every day, and the availability of fossil fuel sources declining day by day, this made me to think about alternative energy source solar energy. An active research is being going on this area, but still the effective utilization of solar energy is not happening. The schematic diagram of grid connected SECS system with PI control scheme is shown in figure.1.

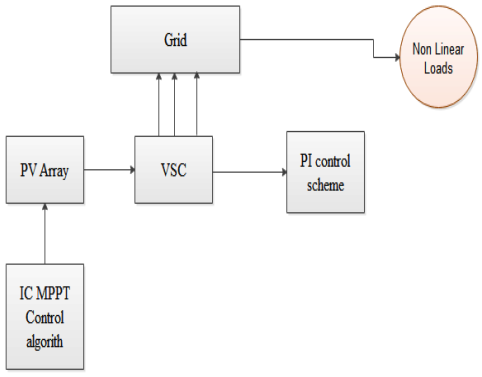

Fig.1. Grid connected SECS system with PI control scheme

The next sessions of this paper is organised as follows, grid connected SECS system configuration section –II, Proposed PI controller approach in section III, discussed MATLAB simulation results in Section IV and summarized/concluded in section.

II. GRID CONNECTED SEC CONFIGURATION

PV thermal technologies, solar irradiation are converted as heat energy. There are various approaches are available to produce heat energy and utilisation. An absorber surface could be a flat surface made of metal, which absorbs the light and transfers the heat to a fluid like water or air as in flat collectors of solar water heater. The flat collectors are simple in design, but cannot provide high temperatures. Higher temperature (optics) gives more electrical energy. The complete block diagram of grid connected SECS with non linear loads is shown figure.2 below.

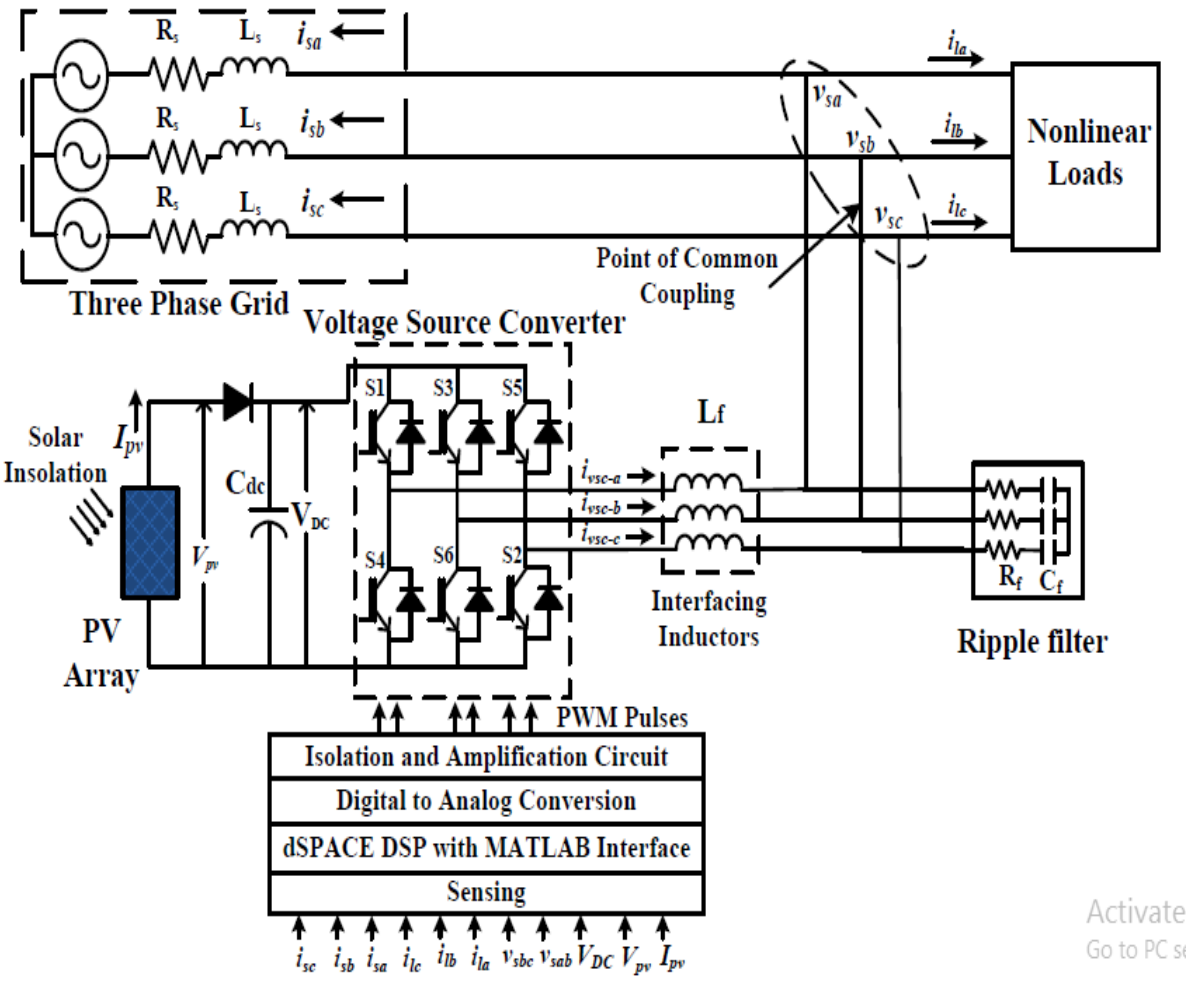

Fig.2. Block diagram of Grid connected SECS with Non linear loads

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A. MODELING OF PV ARRAY:

Solar cell idyllically treats as a current source (Iph) in analogous with uncontrolled switch (D), Shunt resistance (Rsh) and series resistance (Rse). Voltage and current profile of PV depends on Atmosphere temperature (T), and irradiance (S).

The yield power of PV is given by

P=V x I watts

The light generated current of Photo voltaic cell depends on the solar irradiation and the temperature is given an equations. Current produced in PV cell is given as

$$\mathrm{I} = I_{ph} - I_s\left(\exp q\frac{\left(v + R_s I\right)}{NKT}\right) - 1 - \left(\frac{v + R_s I}{R_{sh}}\right)$$

Where

Iph = photocurrent

Is = reverse saturation current

q = electron charge,

V = voltage across the diode,

K is the constant that is Boltzmann's,

T = temperature of the juction,

N is denotes the ideality factor of diode.

To get the desired voltages and currents n no.of PV modules are connected in series or shunt manner.

The voltages produced in n no.of PV modules, in series are given as:

$V_{series} = \sum_{j=1}^{n} V_j = V_1 + V_2 + \ldots\ldots\ldots + V_n$ for I > 0

$V_{seriesoc} = \sum_{j=1}^{n} V_j = V_{oc1} + V_{oc2} + \ldots\ldots\ldots + V_{ocn}$ for I = 0

The current and voltage for m no.of PV modules in parallel is given as:

$I_{parallel} = \sum_{j=1}^{n} I_j = I_1 + I_2 + \ldots\ldots\ldots + I_n$

$V_{parallel} = V_1 = V_2 = \ldots\ldots\ldots = V_n$

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B. MPPT ALGORITHM

To get maximum power from sun we will adopts maximum power tracking methods such as perturb and observation (P&O), neural network (NN), estimated perturb and observation (EPO), Incremental inductance (IC) method etc. In this article used IC based MPPT algorithm and flow chart shown in below figure.3

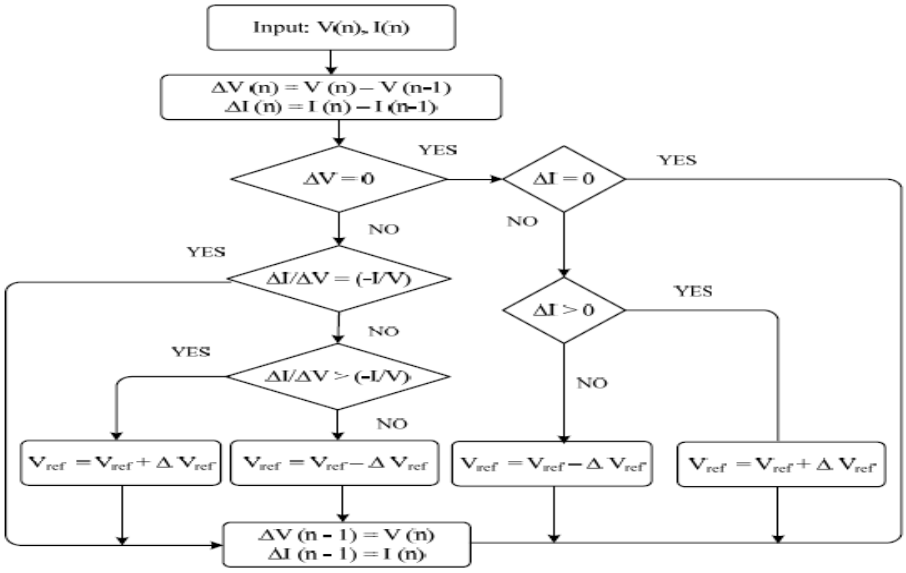

Fig.3. Flow chart diagram for incremental conductance method

III. PROPOSED CONTROL APPROACH

To operate voltage source inverters (switch pattern) design controllers like sliding mode controller, cascade controllers, μ- synthesis method, model predictive power control (MPTC), adaptive control and direct power control (DPC). To implement these controller methods requires a lot of process knowledge design PI controllers. It much depends on the proportional gain (K_P) value. Still the research is going on this era because in numerous cases intend of PID controllers are inadequately tuned, so as a result a few controllers are too destructive and some controllers are giving not acceptable response. In present decade modern control theory, PID control strategies are replaced with sophisticated control techniques such as model predictive control, are built as a supervisory control algorithm, which gives set points to PID controller. The complete block diagram of grid connected SECS system with employing PI control scheme is as shown in blow figure.4.

IV. RESULTS DISCUSSION

Here. Summarized Simulation results of grid connected SECS with unbalanced loads is in figure 5a. and figure 5b figure 5c.

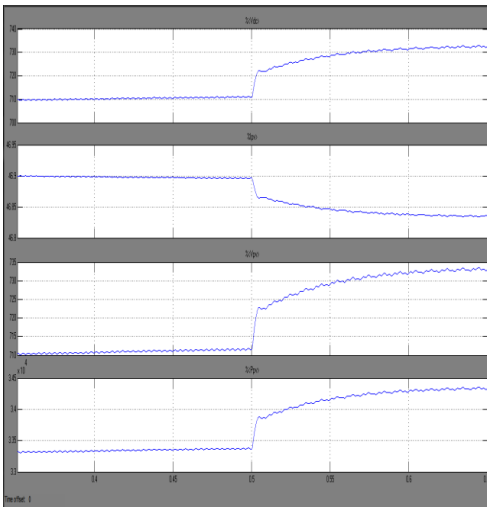

Fig.5a. Vdc – DC Bus-voltage, Ipv – PV current, Vpv – PV voltage, Ps – Real Power produced of grid

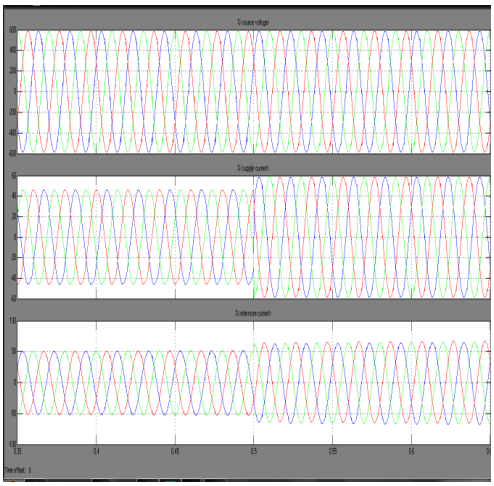

Fig.5b. Vs – Three phase grid voltages, Is – three phase grid currents, Vinv – VSC converter output

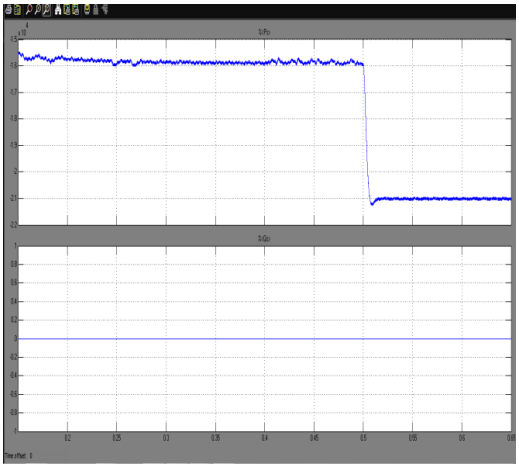

Fig.5c. Variation of grid active power and reactive power when unbalanced load are connected in after 0.5sec

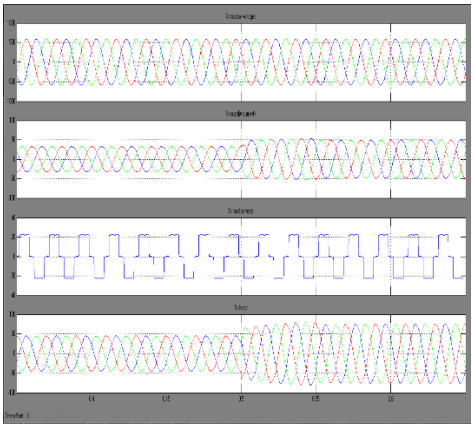

Fig.6a. Vsabc – Grid voltages, Isabc – Grid currents, IL – load current and IVSC – VSC output

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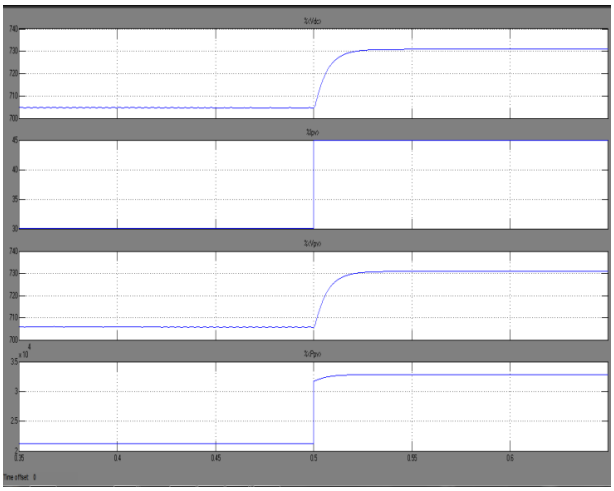

Fig.6b. *Insolation, DC bus voltage, PV voltage, PV real Power*

Simulation time consider up to 0.65 sec non linear load is inserted in the network at the time of 0.5 secs. So after 0.5secs variation of Vdc, Ipv, and Ps

Simulation results of Performance of grid connected SECS system with unbalance and PI contollers is shown in fig.6a. and fig.6b. When at 0.5 secs non linear load connected to the network PV power production is increses and balance the network.

V. CONCLUSION

Dynamic and steady state performance of grid connected SECS with employing PI controller based switching operation of VSC is studied. Obtained simulation results are proven adopting PI controller PQ issues are solved and pure sinusoidal voltages and currents are feed to the load. In this paper mainly focused on, how distribution network act when non linear are connected and it's PQ problems solution.

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