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CONTROL STRATEGY FOR INVERTER BASED MICRO-GRID BY USING RES (PV CELL & WIND TURBINE)

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ABSTRACT:

Demand for electricity is ever increasing. In order to balance the growing needs, distributed generation (DG) can help a large extent. Micro grids (MG), mainly inverter based, are gaining more and more importance as they can accommodate various types of DG effectively and for their superior power quality. A MG can be operated in two modes, grid connected and islanded mode. Each mode has its own control strategy. In this project a control strategy for inverter based MG which can ensure stability and proper power sharing among the inverters, Islanded mode ,is proposed . In a MG the output impedance of an inverter can have much impact on load sharing of inverters. The proposed control scheme uses second order integrator in conjunction with indirect operation of droop method, to enhance the stability and power sharing in MG.

A MG may be treated as a low voltage network of local distributed energy resources (DER) and local loads. The power output of the DER is controlled by a central controller or an individual controller. The increase of MG also reduces the load on conventional power generation plants and help in reducing carbon foot prints in the environment. Inverter based MG plays a critical role in making the system more reliable and more integrated with various types of DER.

In this project, a novel control strategy which uses virtual impedance loop method second order general integrator (SOGI) in conjunction with indirect operation of conventional droop control method is proposed.

Keywords: *micro grid; islanded operation; distributed energy resources (DER)*

(I). INTRODUCTION

A MG may be treated as a low voltage network of local distributed energy resources (DERs) and local loads. The power output of the DERs is controlled by a central controller or an individual controller. Moreover, MGs are usually a small scale power supply networks with total installed capacities around a few hundred kilowatts to few megawatts. The main aim of MG is to power a remote place or a village by utilizing the local resources available, where there is no grid connection and also MG can be designed to provide uninterrupted high quality power to sensitive loads in a certain area. The feature that makes MG a unique power systems is that, although it can be operated in parallel with the grid and it can be automatically transferred to Islanded mode whenever its control systems detects a fault or disturbance in power quality from the grid. When the fault is cleared or the disturbance disappears, the MG can be re synchronized with the main network. The increase of MGs also reduces the load on conventional power generation plants and help in reducing carbon foot in the environment.

Inverter based MG plays a critical role in making the system more reliable and more integrated with various types of DERs. A MG with a proper control strategy can provide plug and play access to the micro resources (MS). The block diagram of inverter based MG is shown in fig 1. The critical parameters that are required to be controlled in a MG are active power dispatch of various micro sources, power sharing among the inverters, voltages and the frequency of the system.

MG has to operating modes, grid connected mode and the other, Islanded mode. When it is connected to grid, control strategy should be able to make inverters to pump the set value of active and reactive powers and here constant current control or PQ control can be implemented. During Islanded mode, control strategy should control the voltage and frequency of the MG in addition to the active and reactive powers and here p-f and Q-V droop methods find their application. This droop method is more suitable for high and medium voltage grids because of their inductive nature.

For low voltage grids, especially MGs, where the sources are resistively coupled, control method opposite to conventional droop methods work more accurately but there are problems related to stability, and only, voltage control is achieved but no power dispatch and proper control over power sharing among the inverters is complex. In order to address these issue, indirect operations of conventional droop or virtual impedance loop methods may be used.

In this project a novel control strategy which uses virtual impedance loop method and second order general integrator (SOGI) in conjunction with indirect operation of conventional droop method is proposed.

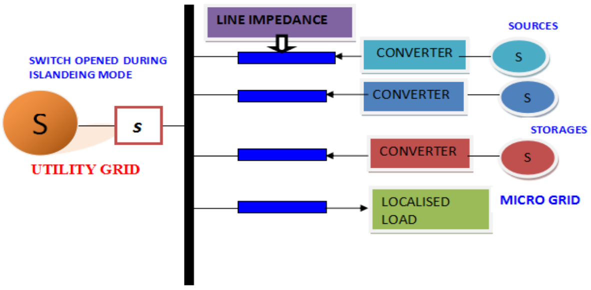


Fig 1 Structure of Micro grid

(II) MG in Grid connected Mode

There are various well established control method to control methods to control the inverters in a MG when it is operating in Grid connected mode . In most cases, either of constant current control or PQ control is used. These two methods are briefly explained below.

(a) Constant Current Control

In this control method, inverters are forced to inject constant current output. The block diagram of this control shown in the fig.2.And its controller is shown in fig.2.

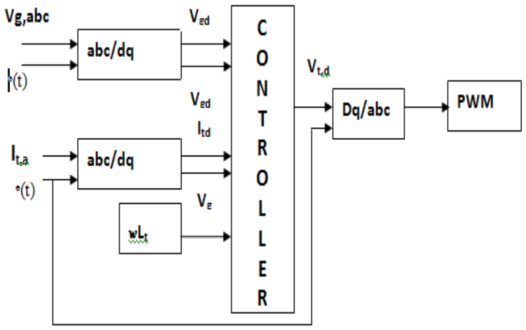


Fig.3.2. Block diagram of Controller

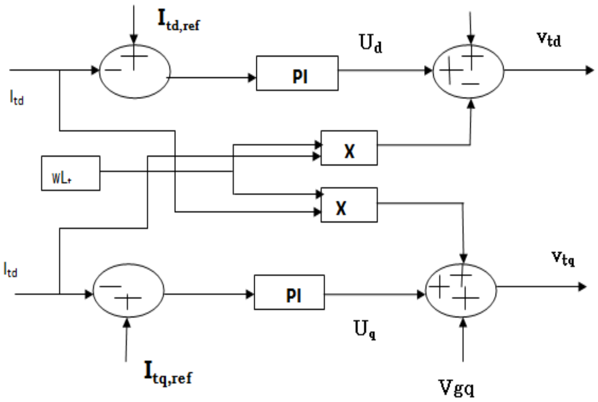


Fig.3 Block diagram of Constant Current Control.

The constant current control measures the load voltage Vgabc and the inverter current Igabc and transfers them to dq frame. The converter quantities Id and Iq are then compared with reference DC quantities It d, ref (active power set point) and Itq,ref(reactive power set point) to obtain error signals. The error signals are then applied to proportional-Integral (PI) controllers to correct the errors and defined the reference voltage signals Vtd and Vtq. These reference voltages are again transformed to three phase quantities and are given to the pulse generator to generate pulses for the inverter. Overall, this process forces the inverter to inject the defined currents and at the same time it regulates the voltage at the connection point as measured from the grid side.

(b) PQ Control Method

The block diagram of PQ control is shown in fig.4. The control structure of this type is quiet similar to the constant current control. The only difference between the two controls is the regulated parameters and they reach the same conclusion, which is output power control, in this control type, the regulated parameters are the active and reactive powers instead of the current.

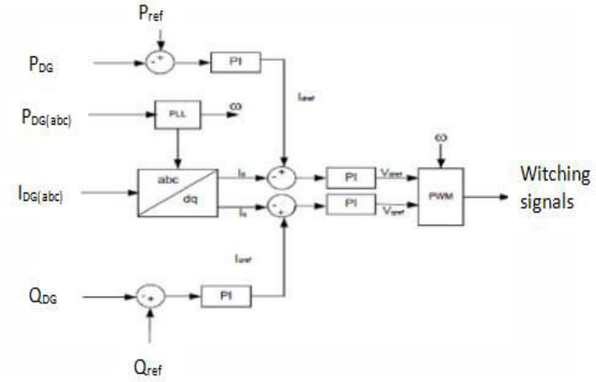


Fig..4.Block diagram of PQ Control

Active and reactive powers are measured at the output terminal of the inverter and then compared with the reference values to obtain the errors. These error signals are then applied to two PI controllers in order to obtain I_{dref} and I_{qref}. the rest of the process is similar to the constant current control technique shown earlier in fig .2 and .3.

(III) Review of Various droop control techniques

(I). Conventional Droop Method

The basic equations that governs transfer of power in conventional power system are given by

$$P = \frac{V_S X V_r}{X}\sin\delta \ldots\ldots\ldots\ldots \quad .(1)$$

$$Q = \frac{VS^2}{X} - \frac{V_S X V_r}{X}\cos\delta \ldots. \quad .(2)$$

From the equations, it is clear that real power is dependent on the phase angle delta or frequency and the reactive power is based on the voltage profile of the system. These relations holds good in inductance dominated networks. Now, many wireless control strategies for inverters in Islanded operation use the various droop methods which are derived from Eq.(1) and Eq.(2)

$$f = f^0 - m_p p \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\mathbf{V = V^0 - m_Q Q} \ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where, f and V are the instantaneous frequency and voltage of the system and f^0 and V^0 are nominal frequency and voltages respectively, and m_p, $m_q$are the droop coefficients of the droop equations (3) and (4) respectively. The block diagram for the droop control is shown in fig.5.

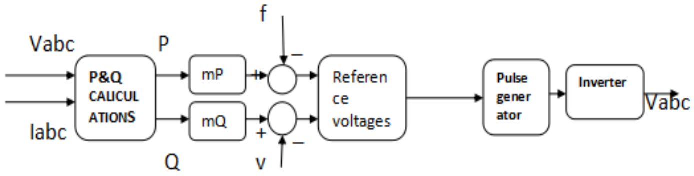


Fig5 Block diagram of conventional droop method

As shown in the fig5, frequency reference is generated by real power Vs frequency droop and The reactive power Vs voltage droop generates the voltage magnitude reference. Now the voltage reference to the pulse generator is derived by using the following equations.

$$\boldsymbol{Va = Vm\sin(\omega t)} \ldots\ldots\ldots\ldots\ldots\ldots.(.5)$$

$$\boldsymbol{Vb = Vm\sin(\omega t - 120^0)} \ldots\ldots..(6)$$

$$\boldsymbol{Vc = Vm\sin(\omega t + 120^0)} \ldots\ldots...(7)$$

The required phase angleωt, can obtained by integrating the frequency ω.

$$\boldsymbol{\omega t = \int \omega dt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots..8)$$

(b) Opposite droop method

In case of MGs where the network is resistive in nature, the basic equations that govern the power flows are given by the following equations.

$$Q = \frac{V_S X V_r}{X}\sin\delta \ldots\ldots\ldots\ldots(9)$$

$$P = \frac{VS^2}{X} - \frac{V_S X V_r}{X}\cos\delta \ldots\ldots..(10)$$

Hence according to the equations the new droop equations (opposite droops) are formulated as follows,

$$\boldsymbol{V = V^0 - m_p P} \ldots\ldots\ldots\ldots.(11)$$

$$\boldsymbol{f = f^0 - m_q Q} \ldots\ldots\ldots\ldots\ldots(12)$$

The block diagram for the opposite droop control method is shown in the fig.6. As shown in the fig.6, real power Vs frequency droop is used to get the reference of voltage magnitude. The comparison between the above two mentioned droop methods is shown in the following table.1.

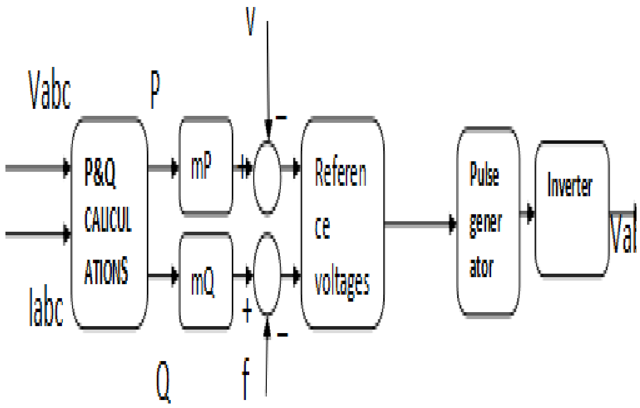
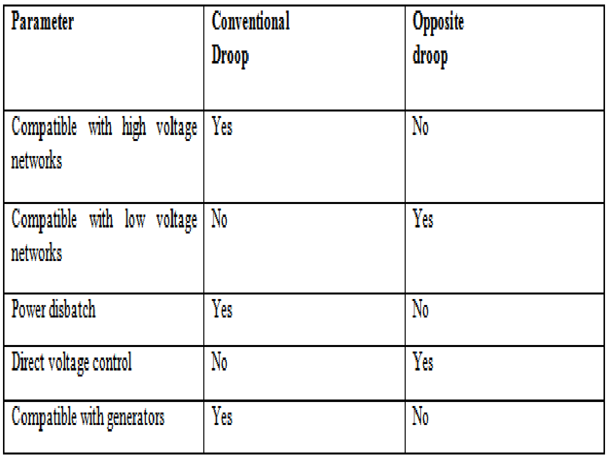


Fig 6 Block diagram of opposite droop method

Hence, from the table I, it is clear that conventional droop method has multiple advantages over opposite droop method. Also the above two mentioned methods cannot make the DERs share load properly if non linear loads are present in the MG.Table1 shows the comparison between the two droop methods

Comparison of various control methods



Parameter	Conventional Droop	Opposite droop
Compatible with high voltage networks	Yes	No
Compatible with low voltage networks	No	Yes
Power disbatch	Yes	No
Direct voltage control	No	Yes
Compatible with generators	Yes	No

Table :1 Comparison of droop methods

(c) Virtual output impedance method

If conventional droop method is used for the control of MG, circulating currents among the inverters will be more and this affects the power sharing accuracy of the control technique and by using virtual impedance loop with conventional droop method this problem can be addressed to some extent. The basic idea behind this control is that, by adding a virtual impedance loop, the impedance seen by the inverter can be increased and hence the circulation currents among the inverters can be limited can be limited to some extent and power sharing may be ensured.

The block diagram of this method is shown in the following fig. 7. Here the method is implemented by drooping the reference voltage proportional to the time derivative of inverter output current and thus increasing the total inverter output impedance.

Virtual impedance method mainly works on to compensate impedance levels of the voltage and currents for different types of loads .And also helps to boot at power sharing of the inverter operation. It will manage with three types of impedance like resistive, inductive &completive.

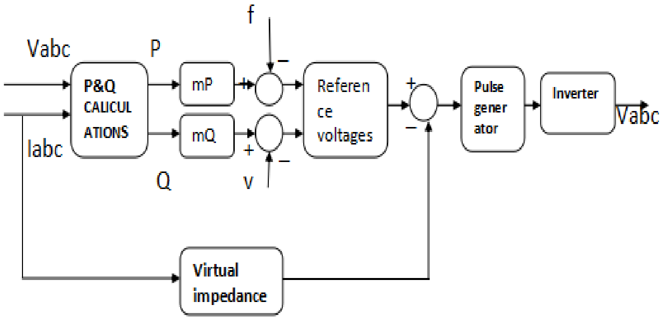


Fig 7Block diagram of virtual impedance loop method

$$V_{ref} = V_{droop} - Z(s)I_0 \quad \ldots\ldots\ldots\ldots..(13)$$

All the above mentioned methods works fine for MGs with predominantly linear loads and if nonlinear loads are present the above methods may not work satisfactorily. So a new control technique which uses a second order general integrator (SOGI) filter with indirect operation of droops is proposed here.

By using this modified droop method proper power sharing among the inverters and stability in the MG can be assured to a good extent.

(IV) Proposed control technique

In virtual output impedance loop method, the derivative of output current may amplify the magnitude of harmonic currents. So this cannot be implemented if the harmonic content in the output current is high. This problem can be addressed by using SOGI. SOGI is basically a Frequency adjustable resonant circuit and it is implemented by connecting two integrators in a cascaded manner to form a closed loop. The block diagram of SOGI is shown in fig.8.

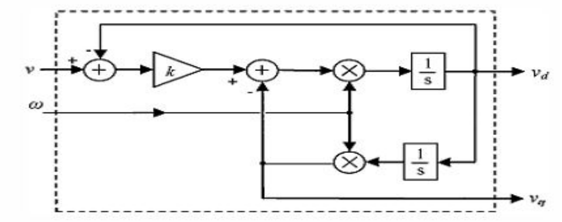


Fig 8 Block diagram of SOGI

SOGI has two inputs; one is actuating quantity, v, and the other, ω frequency and produces two output signals V_d and V_q which will have a phase shift of 90^0. Here in this control, inverter output current is given as actuating input and system frequency, the other input. So if the input to SOGI is I_0=I sin (ωt), then the two outputs are given by the equations,

$$V_d = \sin(\omega t) \text{ ………….(14)}$$

$$V_q = -I_0 \cos(\omega t) \text{…… (15)}$$

Now the virtual impedance loop can be implemented by using these two outputs.

The time derivative of output current is given by,

$$\frac{dI_0}{dt} = \frac{d(I\sin(\omega t))}{dt} = I\omega\cos(\omega t) = \omega V_q \text{ ..(16)}$$

So the virtual impedance can be implemented simply by multiplying impedance values Z(s) with -V_q

$$Z_v(s) = -L_v V_q \text{………(17)}$$

Similarly virtual resistor can be implemented by multiplying virtual resistor value with the output of SOGI V_d.

$$Z_v(s) = -R_v V_d \text{………(18)}$$

The functional diagram of virtual impedance using SOGI is given as

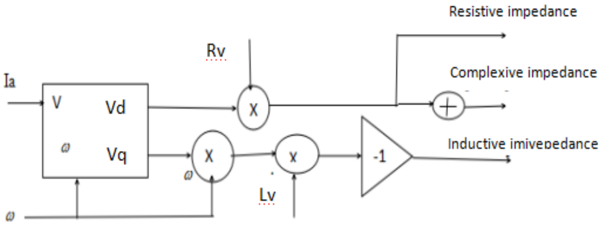


Fig 9 Implementation of virtual impedance using SOGI

Hence it can be observed that the derivative of output current is avoided and thus power sharing and stability in the MG are not affected by the nonlinear loads to a good extent. If SOGI is used in conjunction with indirect operation of droop control method, further more accuracy in power sharing and stability of the MG can be enhanced.

The voltage reference obtained by indirect operation of droop control is modified to achieve accurate power sharing and stability by introducing virtual impedance drop through SOGI, as shown in fig 10. This modified voltage reference is used for pulse generation to trigger the inverters.

Indirect operation can be explained as follows. Here real power depends on the voltage profile and so reactive power is tuned in such a way that the resulting voltage profile satisfies the real power. In the low voltage grid the reactive power is a function of phase angle and this is adjusted with the active power frequency droop. The block diagram of the proposed control is shown in fig 10.

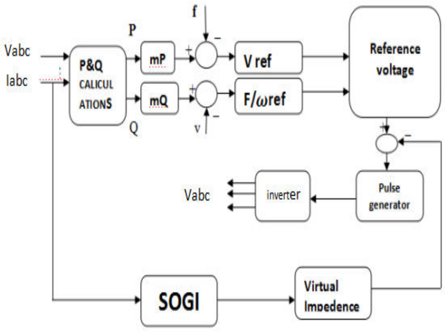


Fig 10 Block diagram of proposed control method using SOGI

The proposed model works with combination of conventional droop method, virtual impedance method in conjunction with second order general integrator.

In droop conventional droop method the calculating currents &switching currents will be effect the power sharing capacity and harmonic content by nominal power sharing technical drop down these issues we tried with opposite drooping model by reversing of v &f , even also we found same problem not up to our expectation.To rectify these &to improve the power quality we proposed the combination of SOGI and Virtual impedance to the droop method. After this combination we reached up to expectation levels at power sharing among the inverters within the controllable limits only.This evaluation can be addressed clearly by using MATLAB /SIMULINK software .And also we can verify with different results to comparison of working models/methods by various simulation circuits.

(V) EXTENSION

“The Extension of this project is adding the RES sources in place of utility grid failure situations (island mode) for uninterruptable power supply to the linear and non linear loads at remote areas”.To meet this level of approach to supply uninterruptable supply we can employ (RES) renewable energy sources like wind energy, solar energy, wave energy, OTECH etc.In this project we proposed the wind energy & photo voltaic cell (solar) to meet the required system expectations towards regular power supply during Islanding mode.

(VI) Matlab/ Simulink circuitry & results:

The Simulink diagram of the closed MG is shown in the fig. It has two DER units interfaced by two inverters ,Inverter 1and Inverter 2 of ratings 15kVA and 10kVA respectively and are connected to load through distribution. In this system there are two critical loads, in which one load is non linear load and the other is a RL load and there is a non critical load and it can be swathed on/off with the help of through circuit breaker which operates based on the situation of MG. The Simulink circuit of proposed control strategy is shown in the fig. Here control circuit for only one inverter is shown. The same circuit can be used for any number of inverters with change in parameters. The parameters used for the simulation are listed in Table 3 and the various wave forms obtained are shown below

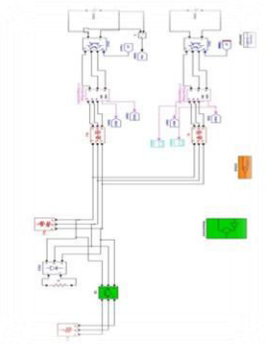


Fig: 11 Simulation Circuit of two inverter controlled micro grid

The control circuit is works based on combination of SOGI second order general Integrator ,Virtual impedance and indirect operation of droop control method

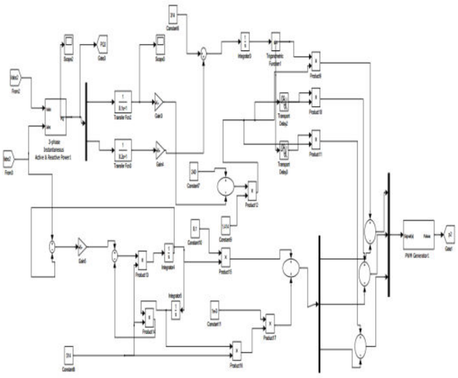


Fig: 12 Simulation control circuit

The scope blocks represent for view the instant results of the particular sequenced blocks. The below fig represent the total scopes of the control & simulation circuits in the simulation, the MG starts as islanded with critical loads and the load sharing among the inverters for both real and reactive powers is shown in fig21: for inverter 1 fig22: shows for inverter 2.It can be seen that the sharing is good, in proportion to the rating of each inverter.

At time =0.05s, the non critical load is introduced into the system and the change in power sharing for the additional increase in power demand can be seen in fig:21&22,and this load is again taken out at time = 0.15s.

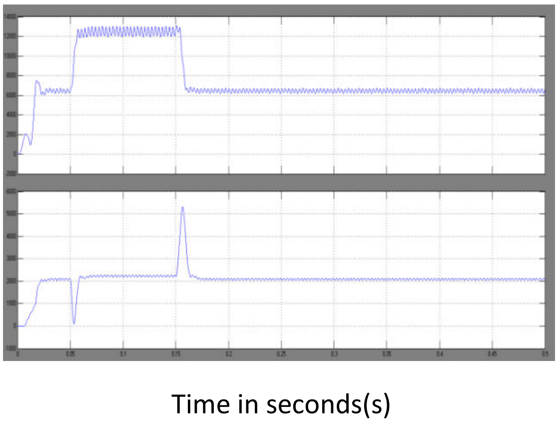


Fig: 13 Active and Reactive voltages of inverter 1(P1&Q1

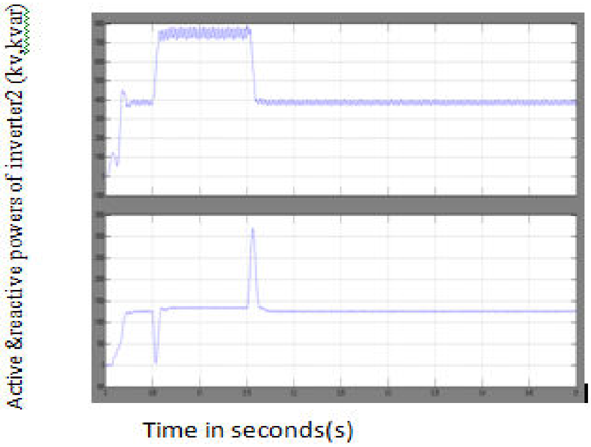


Fig: 14 Active and Reactive voltages of inverter 2(P2&Q2)

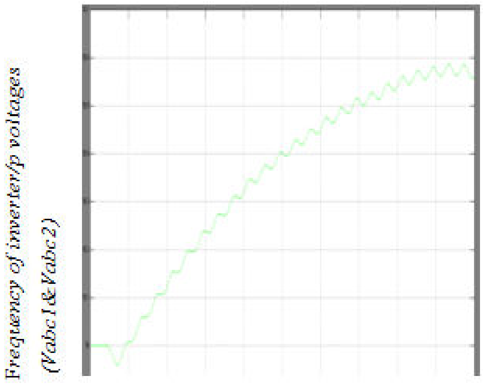


Fig: 15 Frequency of inverters f1&f2 (Vabc1&Vabc2

The above fig: 23 shows the frequencies of the voltages of the two inverters and it can be noticed that both are within the acceptable limits.

This can be achieved from control circuit of droop method by giving frequency reference values for regular system acceptance, and stability of the control system .If the harmonics & circulating currents will minimized the control system to be under stable condition.With given regular supply we have to observe the voltage & currents for acceptance to our existed system. The wave forms of the inverter output voltages and currents and it can be seen that voltages are in allowable limits and also the dynamics in the currents supplied by two inverters can be noticed as the critical load is switched ON/OFF.

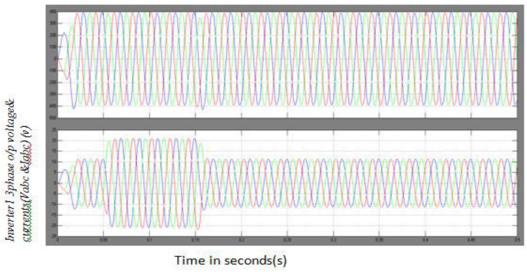


Fig: 16 Three phase voltage &current of inverter 1(Vabc&Iabc)

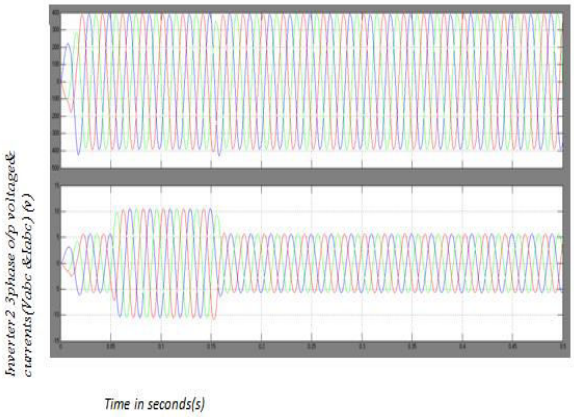


Fig: 17 Three phase voltage &current of inverter 2(Vabc&Iabc)

The power sharing of two inverters for a total load of 12kw and 3.4kVAR(including non linear load) with various control methods is compared in Table:2 ,and the parameters used in this system to get such above results the values tabulated below Table :3.

Control method	P1(kw)	Q1(kVAR)	P2(kw)	Q2(kVAR)
Expected sharing	8	2.2	4	1.2
Conventional droop method	7.6	1.9	3.6	0.9
Opposite droop method	7.68	2	3.85	1
Virtual impedance loop	7.75	2.1	3.85	1
Proposed Method	7.9	2.15	3.92	1.15

Table: 2 Comparison of results of various droop methods P&Q power values

The simulation model parameters taken as below.

Parameter	Value
System voltage	415kv
System frequency	50Hz
Critical load10kw,3Kvar	5kw
Non linear load	1kw
mP,mQ for inverter 1	0.0001,0.00023
mP,mQ for inverter 2	0.00022,0.00025

Table: 3 Simulation parameters

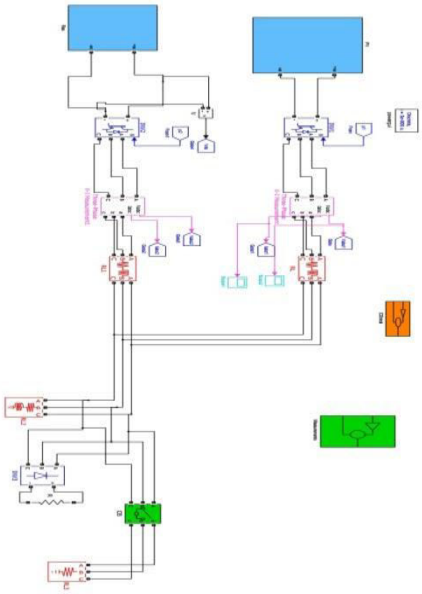


Fig: 18 Simulation circuit of two inverter controlled Micro grid With extension of RES sources

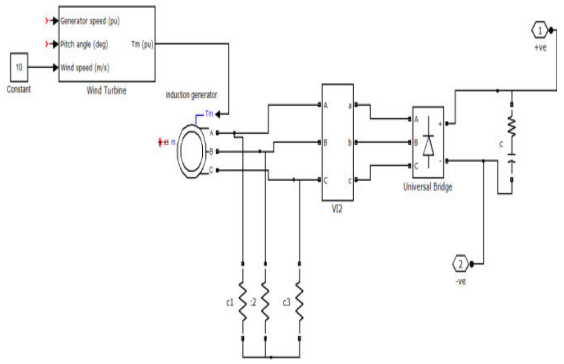


Fig: 19 Simulation circuit of Wind Turbine

The above wind turbine is designed to connect as energy source to supply electricity to the connected loads with following of the inverter switching signal.

Initially the turbine will rotate by wind force and drives the dc generator which produces electricity and supplies to the loads. In this sequence we are utilizing this electricity at required parameters and injecting into the MG grid/proposed model by modifying the power qualities (real & reactive powers) to reach the load demands at low losses. The output results of this circuit are shown in fig:23.

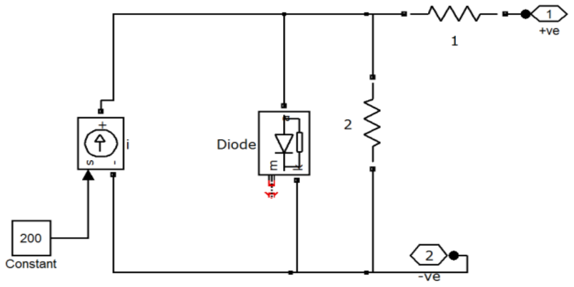


Fig: 20 Simulation circuit of photo voltaic cell

As shown in the above figure we made simulation circuit for photo voltaic cell to connect into the micro grid in Islanding mode of the MG .In this model the parameters taken as per the o/p voltage levels by testing different values.

The photo voltaic cell connected to the control circuit as explained in simulation circuit at desired parameters to meet the expected values. And in Islanding mode the power (P&Q) levels we can observe in the fig: 21

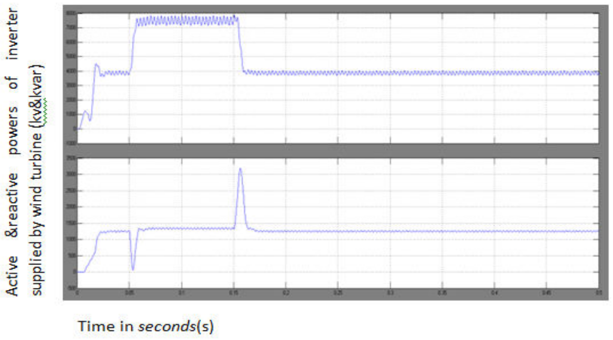


Fig: 21 Real &Reactive power of Wind turbine (P&Q)

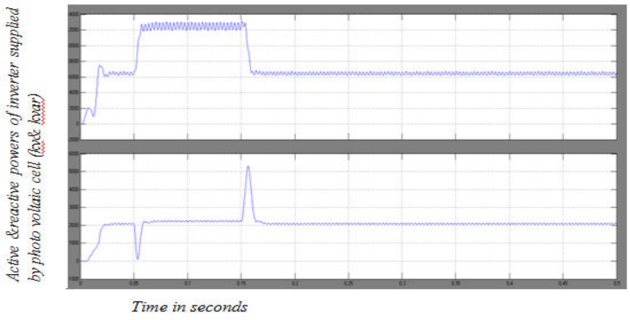


Fig: 22 Real &Reactive power of Photo voltaic cell (P&Q)

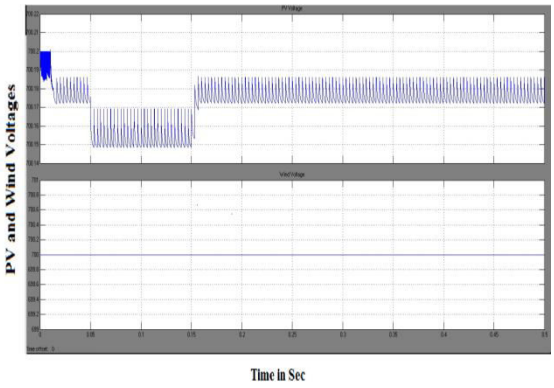


Fig: 23 PV and Wind Voltage outputs

(VII) CONCLUSION

A novel control strategy for inverter based MG operating in Islanded mode has been proposed. The virtual impedance loop with SOGI in conjunction with indirect operation of droop control method can effectively enhance the power sharing ability of inverters and the stability of the MG to a good extent. This type of control method can be used for the MGs which are located at rural or remote place.

DG changes the current flows and shape of the load cycle where they are connected. This could cause thermal ratings to be exceeded. DG can cause system voltage to rise beyond the acceptable limits. DG can contribute to fault level, which can raise the fault level above the rating of network equipment. DG could cause reverse power flows, e.g. power flows in the opposite direction

To which the system has been designed. Reverse power flows can be limited by The design of equipment and can affect automatic voltage control systems.

DG could contribute to harmonics, and raise them above the accepted limits, particularly if a significant number of DG with inverters controllers are present. If there are lots of single-phase generating units, they can cause voltage unbalance which affects power quality. If the output of the DG changes (e.g. from fully on to fully off) rapidly this could cause voltage fluctuation or flicker. Note: The technical terms used above are defined it he glossed on.Islanding occurs when a DG system is still generating power to the distribution system when the main breaker from the Wires Owner is open. In this case, the DG system would be the sole supplier of electricity to the distribution system. This is a concern for several reasons. If the Wires Owner's line workers are not aware that the DG system is still running, they may be electrocuted working on the line or other equipment connected to the line.

If the DG is still generating while the main breaker from the wire owner is open, the voltage and the waveform from the DG may fluctuate and may not meet the acceptable standard. Existing customers who are connected to the distribution line are then fed by very poor quality of power from the DG. As a result, their light fixtures, motors and other electric equipment may be damaged or its life may be shortened. If the situation persists unnoticed for an unacceptably longtime, a fire hazard may exist.

If the DG is still generating while the main breaker from the wires owner is open, the DG equipment may be damaged when the wires owner’s main breaker is closed due to closing out of synchronism.

To ensure the safety of a DG system, EPCOR recommends contracting with an experienced professional engineer registered with APEGGA (Association of Professional Engineers, Geologists and Geophysicists of Alberta) for the design and installation of the system. They will ensure the system is in compliance with provincial and national guidelines and the interconnection guidelines provided by the wires owner.

REFERENCES

[1].J. M. Guerrero, M. Chandorkar, T-L. Lee, and P. C. Loh, "Advanced control architectures for intelligent microgrids-Part II: Power Quality, Energy Storage and AC/DC Microgrids," IEEE Trans. Ind. Electron., vol. 60, no. 4, pp. 1263-1270, Apr. 2013.

[2].M. Popov, H. Karimi, H. Nikkhajoei and V. Terzija, "Dynamic Model and Control of a Microgrid with Passive Loads", IPST Conference Proceedings, 2009.

[3].R. S. Alabri and E. F. El-Saadany, "Interfacing Control of Inverter-based DG Units", ICCCP-2009.

[4].J. M. Guerrero, M. Chandorkar, T-L. Lee and P. C. Loh, "Advanced control architectures for intelligent microgrids-Pqrt I: Decentralized and hierarchial control," IEEE

Trans. Ind. Electron., vol. 60, no. 4, pp. 1254-1262,Apr. 2013.

[5].Xiongfei Wang, Josep M. Guerrero, FredeBlaabjerg, and Zhe Chen, "A Review of Power Electronics Based Microgrids," Journal of Power Electronics, Vol. 12, No. 1, January 2012 [6] "Evaluation of the Local Controller Strategies", microgrids. eu/ micro2000/delivarables/Deliverable DB2. pdf

[6].Xiao Zhao-xia, Fang Hong-wei, "Impacts of P-f & Q-V Droop Control on MicroGrids Transient Stability," Physics Procedia, vol. 24, pp. 276-282, 2012.

[7].Jose Mitas, Miguel Castilla, Luis Garcia de Vicuna, JaumeMiret, "Virtual Impedance Loop for Droop-Controlled Single-Phase Parallel Inverters Using a Second-Order General-Integrator Scheme," IEEE Transactions on Power Electronics, vol. 25, NO. 12, December 2010.