International Journal for Innovative Engineering and Management Research
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IJIEMR Transactions, online available on 11th Jan 2021. Link :http://www.ijiemr.org/downloads.php?vol=Volume-10&issue=ISSUE-01

DOI: 10.48047/IJIEMR/V10/I01/07

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Volume 10, Issue 01, Pages: 44-50

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CONTROL SCHEMES OF VOLTAGE FOR VOLTAGE SOURCE CONVERTER (VSC) BASED DISTRIBUTED GENERATION (DG) USING FUZZY LOGIC CONVERTER IN MICROGRID

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Abstract: This paper introduces a voltage control strategy for an electronically-interfaced DG unit that uses a VSC as the interface medium. It proposes the positive sequence, negative sequence and zero sequence voltage and current control schemes in dq-frame for the VSC based DG units so as to limit voltage instability in microgrid. The main aim of these schemes is to control the positive, negative and zero sequence components (separately and independently) of the voltage at the PCC and the VSC currents to their respective reference commands. Dynamically varying limits have been proposed for the positive and negative sequence references for the current control schemes in order to protect the VSC from overloading and asymmetrical faults. The control scheme should be the same for both the grid connected as well as the islanded modes of operation. The performance of the various control schemes have been employed for controlling the VSC based DG units, and it has been tested on two identical VSC based DG units feeding power to the IEEE 34 node distribution network implemented in MATLAB/SIMULINK.

Index Terms – Distributed Generation (DG), Grid Connected mode, Islanded mode, Microgrid, Voltage Source Converter

INTRODUCTION

The concept of distributed generation (DG) has gained significant acceptance during the last decade due to high cost of energy, environment concerns, and major advances in DG technologies. Most of the renewable energy sources (like PV, FC, etc) generate DC power, and most of the storage systems (like Battery, Super-capacitor, etc) handle energy in the form of DC. These energy sources and storage systems need to be interfaced with the AC Microgrid through Voltage Source Converters (VSC). AC Microgrids are usually low voltage distribution networks with Distributed Generation (DG) units supplying power to the local loads [1] (which are inherently unbalanced). Accordingly the VSCs will be supply unbalanced currents for most of the time and therefore a proper control scheme needs to be chosen for the VSC so that the execution of the VSC doesn’t get drastically affected. Another test including the control of VSCs is in the control schemes for the Grid Connected and the Islanded modes of operation. At the point when the microgrid is in the Grid connected mode of operation, the voltage and frequency of the microgrid will be imposed by the Main Grid, but when the microgrid is in the Standalone or Islanded mode of operation, the VSCs need to set the voltage and frequency of the microgrid.

Accordingly analysts at first proposed separate control schemes for VSCs working in the Grid associated and the islanded modes of operation [2]. A similar idea was reached out in [3] so as to manage unbalanced conditions. Be that as it may, a progress from the grid connected mode to the islanded mode of operation and the other way around will result in constrained exchanging between two arrangements of controllers, which will unmistakably demonstrate the requirement for a quick and a dependable islanding identification. The control structure proposed in [4] aims to control the VSC as a synchronous machine with an assumed virtual inertia constant (H) and a virtual damping constant (KD).Anyway grid faults will make harm to the VSC changes due to over flows. Reference [5] expanded upon the ideas presented in [6] and [7] and proposed a control scheme that is valid for both the grid connected and the islanded modes of operation thereby removing the need for islanding detection. However the Grid connected and the Islanded modes of operation have been considered separately and the positive and negative sequence components of the voltages and furthermore currents in the results have not been expressly displayed. The control schemes proposed in [6], [7] and [11] are strong as long as the system is adjusted, however under unbalanced loading conditions, the voltage at the PCC. In islanded mode where the frequency and voltage are not directed by the grid, the current controlled method for the interface VSC isn't really the ideal decision. The fundamental reason is that it might result in voltage as well as frequency outings that lead to either unsuitable working conditions or unsteadiness.

VSC BASED DG UNIT SYSTM

To describe the proposed control strategy, the study system of Fig. 1 is considered. The system is composed of a DG unit and IEEE 34 Node Distribution Network with PV system and two vscs .In the PV system parallel RLC load, and is required to work either in a grid connected or islanded)mode when switch is shut or open, separately. The DG unit incorporates an essential vitality source and a three-phase VSC. The DG unit is interfaced to the point of common coupling (PCC) through a series filter and a transformer The local RLC load is connected to the PCC. The proposed VSC control , is we control the voltage at the point of common coupling and currents at VSC.

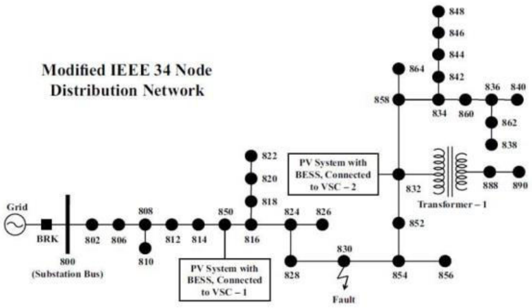

Fig.1. Modified IEEE 34 Node Distribution Network.[4]

A. Open loop VSC Current Control and PCC Voltage Control:

The open loop VSC current control model can be implemented by applying Kirchhoff's Voltage Law across the filter inductor and the VSC switches in the ON state. After rewriting these equations to dq-frame (Positive, Negative and Zero Sequence), the be obtained equations are (which represents the open loop VSC current control model).

$dI^+_d(t)$
L $+ 2R\_)I^+(t) = V^+(t) - V^+(t) +$ $+ \Delta f(t))I^+(t)$
$2\pi L$ (f
$+ R$

f ON td sd f o (1)

dt f q
d
I^+
$(t$
$)$

L q $+ (R + 2R)I^+(t) = V^+(t) - V^+(t) +$ $+ \Delta f(t))I^+(t)$
$2\pi L$ (f

f dt f ON tq sq f o (2)

d

$dI^-_d(t)$
L $+ 2R\_)I^-(t) = V^-(t) - V^-(t) +$ $+ \Delta f(t))I^-(t)$
$2\pi L$ (f
$+ R$

f ON td sd f o (3)

dt f q

L q $+ (R + 2R)I^-(t) = V^-(t) - V^-(t) +$ $+ \Delta f(t))I^-(t)$
$2\pi L$ (f

f dt f ON tq sq f o (4)

d

$dI_{od}(t)$
L $+ R$) $(t) = V$ $(t) - V$ $(t) + 2\pi L$ $+ \Delta f(t)I$ (t)
I (f
$+ R$

f dt f o tod sod f o oq (5)
0 d
N

$dI_{oq}(t)$
L $+ R$) $(t) = V$ $(t) - V$ $(t) + 2\pi L$ $+$ (t)
I (f $\Delta f(t))I$
$+ R$

f dt f o toq soq f o od (6)
0 q
N

sd d_+ $+$ $+ \Delta f(t))V^+(t)$
V
$+$
$($
t
$)$
C $= I(t) - I$
$(t) + 2\pi C$ (f

f dt f o (7)
d s
Ld q
$dV^+(t)$

C sq $= I^+(t) - I^+(t) +$ $+ \Delta f(t))V^+(t)$
$2\pi C$ (f

f o (8)
f dt s
q d
Lq
$dV^-(t)$

C sd $= I^-(t) - I^-$ $+ \Delta f(t))V^+(t)$
$(t) + 2\pi C$ (f

f dt f o (9)
d s
Ld q

$dV_{sq}(t)$
C $= I^-(t) - I^-(t) +$ $+ \Delta f(t))V^-(t)$
$2\pi C$ (f

f dt f o (10)
q s
Lq d

$dV_{sod}(t)$ $(t) -$ $(t) + 2\pi C$ $+$ (t)
C $= I$ I (f $\Delta f(t))V$

f dt od Lod f o soq (11)

$dV_{soq}(t)$ $(t) -$ $(t) + 2\pi C$ $+$ (t)
C $= I$ I (f $\Delta f(t))V$

f dt oq Loq f o sod (12)

$E_1 = E_S - D_q Q$

(13)

$$E_2 = \frac{KQ(Q_{ref} - Q)}{S} \tag{14}$$

The open loop PCC voltage control model can be implemented by applying Kirchhoff’s Current Law at the filter capacitor. After rewriting the equations to dq-frame (Positive, Negative and Zero Sequence), the obtained equations are

A. VOLTAGE CONTROL

The proposed voltage controller for the DG unit of Fig. 1 is shown in Fig. 2. The VSC terminal voltage E is determined by signals $E1$and $E2$

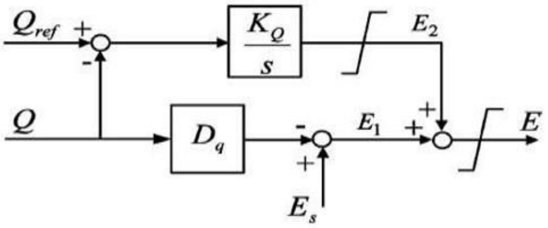

Fig 2 . Block diagram of voltage control of the VSC-based DG unit .

$E1$ is calculated by the voltage droop block where Q is the measured output reactive power of the VSC at PCC, D_Q is a voltage droop constant, and E_S is the reference value of the VSC terminal voltage. Signal $E2$ is the output of the reactive power controller and given by control of Fig. 3. However, in an islanded mode, the DG unit has to supply the load reactive power demand without any reactive power contribution from the main grid.

Therefore, $E2$ of Fig. 2 is set to zero by imposing K_Q=0 during an autonomous mode and only $E1$ remains effective. Therefore, the voltage control strategy should change during the transition process from the grid-connected mode to the autonomous mode. This change takes place after islanding is confirmed based on the inherent islanding detection capability of the proposed controller.

B. Reference commands for the current control loops:

Dynamically varying limits for the positive sequence and negative sequence current references have been chosen in order to minimize the fault current during an unsymmetrical fault, while the limits of the zero sequence current references have been chosen to be fixed for the purpose of simplicity. If the system will be operating on a balanced conditions and the VSC is supplying balanced currents, then the limits of the positive sequence current references can be conveniently chosen as 1 pu, but if the system was operated on a unbalanced conditions then VSC can be possibly subjected to high currents in one of the phases. The most outrageous instance of unbalance that is basically conceivable; when the positive sequence the negative sequence and
the zero sequence are all exactly equal in magnitude. For instance, if the positive sequence, negative sequence and zero sequence components are all equal to 1 pu, then the current in one of the phases will be3.0 pu which will make extensive harm the switches. In this way when the VSC is providing unbalanced flows, it is critical to change the points of the limits for the positive and the negative arrangement sequence references.

III CONTROL STRATEGY

The Active Power Control, Frequency Control and the Reactive Power–Voltage droop control schemes presented in will decide the references for the positive sequence voltage control scheme, while the references of the Negative and Zero Sequence PCC Voltage control schemes have been set at ‘0’ in order to fulfil the objective of maintaining the voltage at the PCC balanced at all times.

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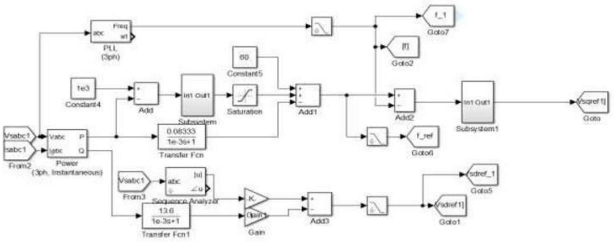


Fig 3 Active and Reactive power control scheme

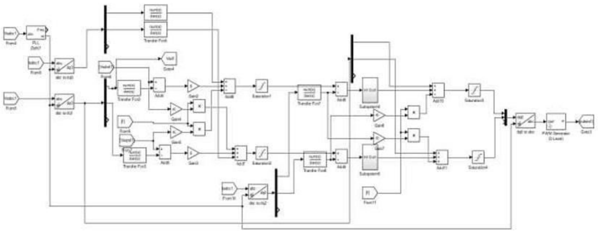


fig4 Control diagram for DG system

IV SIMULATION RESULTS

The modified IEEE 34 node distribution network (which is acting as a microgrid) shown in Fig. 1(b) with two identical VSC based DG units feeding power to the network has been implemented in PSCAD/ EMTDC. The modification that has been done is that the voltage regulators originally present in the network [8] have been removed for the purpose of studying the capability of the VSCs in improving the voltage profile of the feeder in the absence of voltage regulators. The rated capacity of the PV array in each DG unit is 2300 kW at STC, and the reference command for the Active Power Control loop of both the VSCs is 1150 kW.

Transition from the Grid Connected mode of Operation to the Islanded mode of Operation:

The microgrid was working in the Grid Connected mode of operation. The PV arrays of both the DG units were working at the Maximum Power Point (MPP) at STC and were creating 2300 kW each. Both the VSCs were providing 1150 kW to the microgrid (VSC-1 was providing around 200 kVAR and VSC-2 was providing around 320 kVAR to the microgrid). The microgrid was providing around 450 Kw and 150 kVAR to the principle grid as appeared in Fig. 1b (because of the way that the power provided by the VSCs to the microgrid is more than the power devoured by the heap in the microgrid). All of a sudden at t=0.75s, the electrical switch 'BRK' has been opened. In view of the results waveforms clear that the controllers had the capacity to control the voltage and frequency of the VSCs inside the to a consistent working point with no substantial outings in the voltage and frequency. In view of the results displayed in Fig. 1a, 1b and 1c, unmistakably the microgrid is never again synchronized with the principle grid. In view of the results introduced in Fig. 1, unmistakably the controllers had the capacity to control the voltage and frequency of the VSCs . Thusly the microgrid has gone to a consistent working point with no huge journeys in the voltage and frequency .Since the Active Power provided by both the VSCs currently is not exactly the reference direction of 1150 kW (which can be seen in Fig. 1f for VSC-1; not appeared for VSC-2 due to brevity),the P-I controllers of the Active Power control loops of both the VSCs have now become saturated and the droop control schemes have taken charge in deciding the frequency of both the VSCs (which ultimately will decide the frequency of the microgrid). Fig. 1d shows the variation in the frequency of VSC-1 (The variation in the frequency of VSC-2 is similar to that of the frequency of VSC-1 which hasn’t been shown due to brevity). From Fig. 1e it is clear that the BESS has taken care of the difference between the power generated by the PV array and the power supplied by the VSC (the results have been shown for VSC-1). A similar perception is valid for VSC-2.

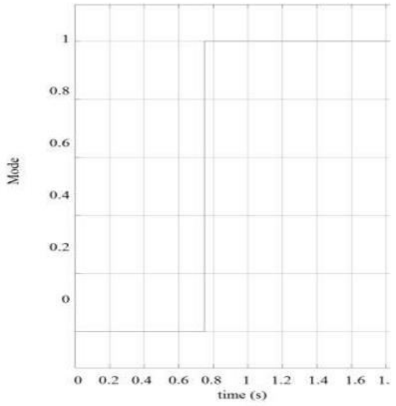


Fig 1a. Mode of operation of microgrid

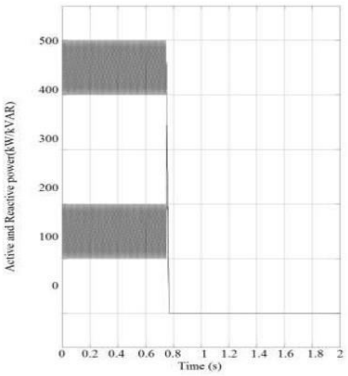


Fig 1b.Active and Reactive power flow from Microgrid to main grid

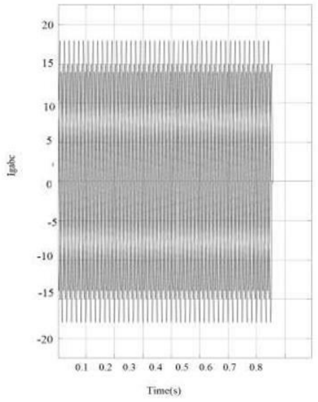


fig 1c . Line currents from the main grid to the microgrid

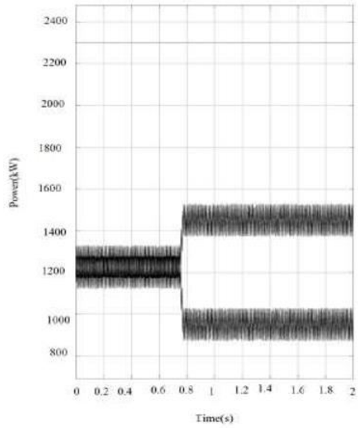
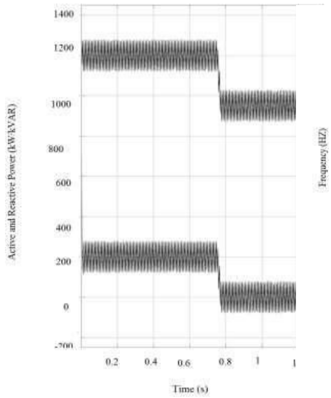


fig 1d.Power flow on the dc side of VSC



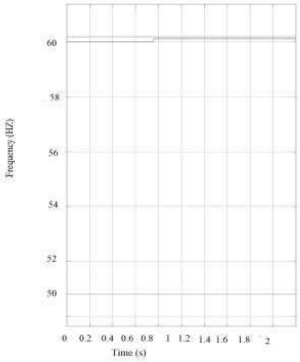


Fig 1e. Active and Reactive power supplied by VSC to

fig 1f.Frequency of VSC the Microgrid

CONCLUSION

The positive, negative and zero sequence VSC current control and PCC voltage control schemes have been tested on two VSC based DG units feeding power to a local distribution network that is acting as a microgrid. The principle of these control schemes is to maintain the voltage at the PCC balanced irrespective of the unbalance in the VSC currents. The Active Powercontrol, Frequency control and Reactive Power–Voltage droop control schemes will decide the references for the positive sequence PCC voltage control scheme. These control schemes reduce the need for knowing the prevailing mode of operation of the microgrid so that the same control scheme can be used for the grid connected and the islanded modes of operation. Dynamically varying limits have been proposed for the positive and negative sequence references for the current control scheme which has played a significant role in minimizing the fault current to less than 1.5 pu. The positive, negative and zero sequence VSC current control and PCC voltage control schemes were able to control the PCC voltage and VSC current to the respective reference commands satisfactorily in the grid connected as well as the islanded modes of operation.

REFERENCES

[1] Nikos Hatziargyriou, “Microgrids Architectures and Control,” IEEE press, John Wiley and Sons, 2014.

[2] H. Karimi, H. Nikkhajoei, R. Iravani, “Control of an Electronically-Coupled Distributed Resource Unit Subsequent to an Islanding Event,” IEEE Transactions on Power Delivery, vol. 23, no. 1, pp. 493–501, Jan 2008.

[3] H. Karimi, A. Yazdani, R. Iravani, “Robust Control of an Autonomous Four Wire Electronically-Coupled Distributed Generation Unit,” IEEE Transactions on Power Delivery, vol. 26, no. 1, pp. 455–466, Jan 2011.

[4] F. Gao, R. Iravani, “A Control Strategy for a Distributed Generation Unit in Grid-Connected and Autonomous Modes of Operation,” IEEE Transactions on Power Delivery, Vol 23, No 2, pp 850–859, Apr 2008.

[5] M. B. Delghavi, A. Yazdani, “A Unified Control Strategy for Electronically Interfaced Distributed Energy Resources,” IEEE Delivery Transactions on Power Delivery vol. 27, no. 2, pp. 803–812, Apr 2012.

[6] A. Yazdani, “Control of an Islanded Distributed Energy Resource Unit with Load Compensating Feed-Forward,” IEEE Power Engineering Society General Meeting, 7 pp. July 20–24, 2008.

[7] M. B. Delghavi and A. Yazdani, “A Control Strategy for Islanded Operation of a Distributed Resource (DR) Unit,” IEEE Power and Energy Society General Meeting, 8 pp. July 26–30, 2009.

[8] L. Meng, F. Tang, M. Savaghebi, J. C. Vasquez, J. M. Guerrero, “Tertiary Control of Voltage Unbalance Compensation for Optimal Power Quality in Islanded Microgrids,” IEEE Transactions on Energy Conversion, vol. 29, no. 4, pp. 802–815, Dec 2014.

[9] D. Sera, L. Mathe, T. Kerekes, S.V. Spataru, R. Teodorescu, “On the Perturb-and-Observe and Incremental Conductance MPPT Methods for PV Systems,” IEE Journal of Photovoltaics, vol. 3, no. 3, pp. 1070–1078, Jul 2013.

[10] A. Camacho, M. Castilla, J. Miret, A. Borrell, L. G. de Vicua, “Active and Reactive Power Strategies With Peak Current Limitation for Distributed Generation Inverters During Unbalanced Grid Faults,” IEEE Transactions on Industrial Electronics, vol. 62, no. 3, pp. 1515-1525, Mar 2015.

[11] N. R. Tummuru, M. K. Mishra, S. Srinivas, “An Improved Current Controller for Grid Connected Voltage Source Converter in Microgrid Applications,” IEEE Transactions on Sustainable Energy, vol. 6, no. 2, pp. 595-605, Apr 2015.

[12] L. Meng, X. Zhao, F. Tang, M. Savaghebi, T. Dragicevic, J. C. Vasquez, J. M. Guerrero, “Distributed Voltage Unbalance Compensation in Islanded Microgrids by Using a Dynamic Consensus Algorithm,” IEEE Transactions on Power Electronics, vol. 31, no. 1, pp. 827-838, Jan 2016.

Noel Richard Merritt, Chandan Chakraborty, Fellow, “New Voltage Control Strategies for