IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331,
PP 59-63
www.iosrjournals.org

Grid Connected Self-Synchronized Inverter

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Abstract: *The paper discuss the idea of operating an inverter to mimic a synchronous generator(SG).Using such inverters,the theory or algorithms used to control synchronous generators can be used in power systems where a significant proportion of the generating capacity is inverter based.Similar to other grid connected inverters,it needs a dedicated synchronization unit,eg: a phase locked loop(PLL),to provide the phase,frequency and amplitude as references.In this paper ,a radical step is taken to improve the inverter as a self-synchronized inverter by removing the dedicated synchronization unit.Such inverters can automatically synchronize itself with the grid before connection and track the grid frequency after connection.This will considerably improves the performance ,reduce the complexity and computational burden of the controller.*
Keywords: *Grid connection , microgrid , PLL ,renewable energy ,synchronization , Virtual synchronous machines.Distributed generation ,synchronverter,*

I. Introduction

Renewable energy (RE) is the energy which comes from natural resources such as sun, wind ,rain,tides and geothermal heat.These resources are renewable and can be naturally replenished.These resources can be considered to be inexhaustible , unlike decaying conventional fossil fuels.The global energy crisis has provided a renewed impetus to the growth and development of clean and renewable energy sources.Fossil fuels in the world are rapidly decreasing reserves.So another major factor working against fossil fuels is the pollution associated with their combustion.Renewable energy sources are much cleaner and produce energy without the harmful effects of pollution unlike the conventional sources.[1]Distributed generation (DG) systems are one category of the power generation sector where renewable energy technologies can play a vital role.Owing to their installation near load sites, the advantages of DGs are elimination of the need for long distribution infrastructures,raising environmental standards,increasing supply reliability and peak shaving capability. [2][3]
To deliver the power from DG to the national grid ,it should be synchronised with the grid voltage parameters like phase sequence amplitude and frequency.The most widely accepted synchronization solution to a time-varying signal is synchronous frame PLL.It is widely used in three phase systems.In this work a radical step is taken to improve the inverter as a self-synchronized inverter by removing the dedicated synchronization unit.Such inverters can automatically synchronize itself with the grid before connection and they can track the grid frequency after connection.

II. Literature Review

The most important and basic requirement for grid connected inverters is to keep inverters synchronized with the grid so that

1) An inverter can be connected to the grid
2) The inverter can feed right amount of power to the grid even when the grid voltage changes its frequency,phase and amplitude[4-12]

It is a practice to adopt a synchronization unit eg; a phase locked loop(PLL) and its variants[7] to make sure that the inverter is synchronized with the grid.This practically adds an outer loop controller(the synchronization unit) to the inverter controller.

Synchronverters are grid-friendly inverters that mimic synchronous generators [7], [8]. A synchronverter includes the mathematical model of a synchronous machine and behaves within the same manner, mathematically, as a synchronous generator to offer a voltage supply. Its operator is in essence an influence controller with integrated capability of voltage and frequency regulation thus it's ready to win real power control, reactive power management, frequency regulation, and voltage regulation. as a result of the embedded mathematical model, a utility company is in a position to manage a synchronverter within the same manner as dominant synchronous generators, that significantly facilitates the grid affiliation of renewable energy and sensible grid integration.Since a synchronous machine is inherently ready to synchronize with the grid, it ought to be doable to integrate the synchronization perform into the ability controller and create a

synchronverter to synchronize with the grid while not an avid synchronization unit. this might result in a compact management structure.

In this work, the synchronverter strategy is improved to own the aptitude of synchronizing with the grid by itself while not the help of a fervent synchronization unit. This takes away a slow part within the closed loop consisting of the synchronization unit, the electrical converter controller and also the power grid, and removes a significant nonlinear part that affects the speed and accuracy of synchronization. Hence, it widens the system information measure, reduces the time required for synchronization, and improves the accuracy of synchronization, that doesn't solely significantly improve the performance of the system however additionally reduces the complexness of the general controller.

To the most effective information of the authors, no management strategy for gridconnected inverters that don't seem to be equipped with a fervent synchronization unit for synchronization each before association and when association has been reported within the literature. The nearest work on this direction is [6], wherever a further

PLL isn't required throughout traditional operation however a backup PLL continues to be required for synchronization before association (and additionally for things once there ar severe faults on the ac side). Simulation and experimental results ar provided to demonstrate the wonderful performance of the planned management strategy, each below traditional operation and below grid faults.[9][10][11].

The rest of this paper is organized as follows. The original synchronverter is reviewed in Section II. The self-synchronized synchronverter is proposed in Section III, with simulation and results presented in Sections IV and V, respectively, followed by conclusions and discussions made in Section VI.

III. Overview Of The Synchronverter Technology

A synchronverter is an inverter that mimics a traditional synchronous generator [7], [8]. As a result, grid-connected renewable energy and distributed generation will simply participate within the regulation of system frequency and voltage. A synchronverter consists of an influence half, as shown in Fig. 1, and an electronic half, i.e., the controller, as shown in Fig. 2.

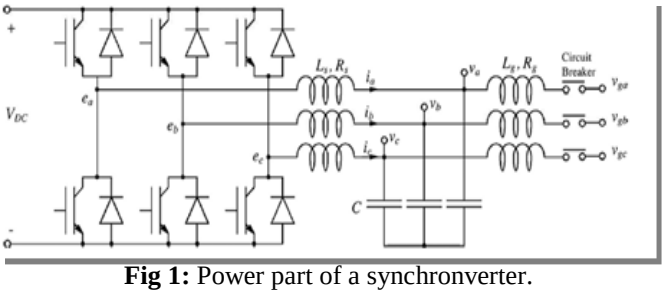


Fig 1: Power part of a synchronverter.

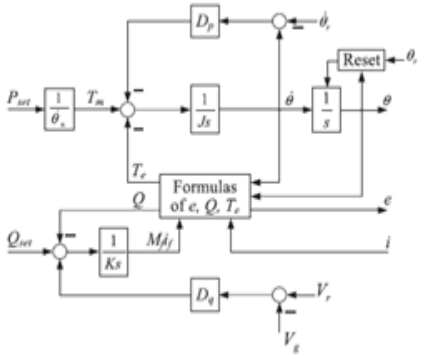


Fig :2 Electronic part (controller) of a synchronverter, where the provision of the frequency reference θ˙r , the phase reference θr , and the voltage reference Vr , normally via a dedicated synchronization unit, is not shown.

It is assumed that the dc bus of the synchronverter is constant.Otherwise, a dc-bus voltage managementler, in conjunction with an energy storage system if required, may be introduced to take care of the dc bus voltage constant, e.g., via control the reference of the important power for the synchronverter or control the facility flow into and out of the energy storage system.The controller includes the mathematical model of a three-phase round-rotor synchronous machine represented by

$$\ddot{\theta} = \frac{1}{J}\left(T_m - T_e - D_p\,\dot{\theta}\right) \quad (1)$$

$$T_e = M_f i_f \langle i, \widetilde{\sin\theta} \rangle \quad (2)$$

$$e = \dot{\theta} M_f i_f \widetilde{\sin\theta} \quad (3)$$

$$Q = -\dot{\theta} M_f i_f \langle i, \widetilde{\cos\theta} \rangle \quad (4)$$

where Tm, Te , e, θ, and alphabetic character square measure the mechanical torsion applied to the rotor, the magnetic attraction torsion, the three-phase generated voltage, the rotor angle, and also the reactive power, severally. J is that the imagined moment of inertia of all the elements rotating with the rotor. I_f is that the field excitation current and M_f is that the most coefficient between the stator coil windings and also the field coil. $\dot{\theta}$ is that the virtual angular speed of the machine and conjointly the frequency of the management signal e sent to the pulsewidth modulation (PWM) generator, and if is that the stator coil current (vector) flowing out of the machine. and outlined as

$$\widetilde{\sin\theta} = \begin{bmatrix} \sin\theta \\ \sin\left(\theta - \frac{2\pi}{3}\right) \\ \sin\left(\theta + \frac{2\pi}{3}\right) \end{bmatrix}$$

$$\widetilde{\cos\theta} = \begin{bmatrix} \cos\theta \\ \cos\left(\theta - \frac{2\pi}{3}\right) \\ \cos\left(\theta + \frac{2\pi}{3}\right) \end{bmatrix}$$

In this paper, it's assumed that the amount of pairs of poles for every section is one and thence the mechanical speed of the machine is that the same because the electrical speed of the magnetic attraction field. Similarly to the management of a synchronous generator, the controller of a synchronverter has 2 channels: one for the important power and also the different for the reactive power. the important power is managed by a frequency droop control loop, mistreatment the (imaginary) mechanical friction constant refugee because the feedback gain.This loop regulates the (imaginary) speed $\dot{\theta}$ of the synchronous machine and creates the point in time θ for the management signal e.

For grid-connected applications, a synchronization unit is required to supply the grid data for the synchronverter to synchronize with the grid before affiliation and for the synchronverter to deliver the required real and reactive powers after connection.

IV. Design And Operation Of A Self-Synchronized Synchronver

The Proposed Controller

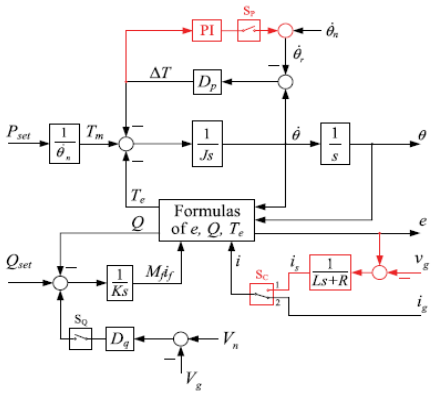


Fig. 3. Proposed controller (electronic part) for a self-synchronized synchronverter

The planned controller for a self-synchronized synchronverter is shown in Fig. 3, when creating some necessary changes to the core of the synchronverter controller shown in Fig. 2. it's able to be connected to the grid safely and to control while not the requirement of an infatuated synchronization unit. There area unit 2 major changes made: 1) a virtual current is generated from the voltage error between e and vg is else and also the current fed into the controller is either is or the grid current immune gamma globulin ; 2) a PI controller is else to control the output ΔT of the frequency droop block displaced person to be zero and to get the reference frequency θ˙r for the initial synchronverter. so as to facilitate the operation of the self-synchronized synchronverter, 3 switches SC , SP , and SQ area unit else to vary the operation mode. once Switch SC is thrown at Position one (with SP turned ON and SQ turned OFF), the synchronverter is operated beneath the set mode outlined in [8]. If Pset and Qset area unit each zero, then the operation mode is named the self-synchronization mode and also the synchronverter is in a position to synchronize with the grid.When it's synchronised with the grid, the breaker within the power half is turned on to attach the synchronverter to the grid. once switch SC is thrown at Position two, the synchronverter is operated in four completely different modes. All the attainable operation modes area unit shown in Table I. so as to safeguard the operation within the self-synchronization mode, SP is turned ON and SQ is turned OFF mechanically whenever switch SC is thrown at Position one. during this paper, solely the characteristics that area unit completely different from the initial synchronverter area unit are represented.

V. Simulation And Results

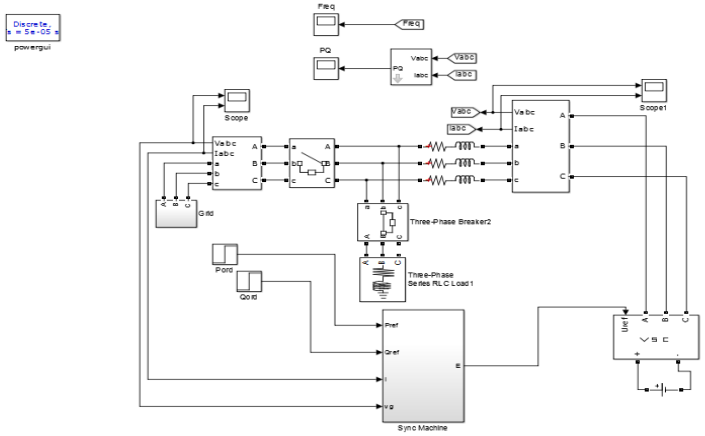
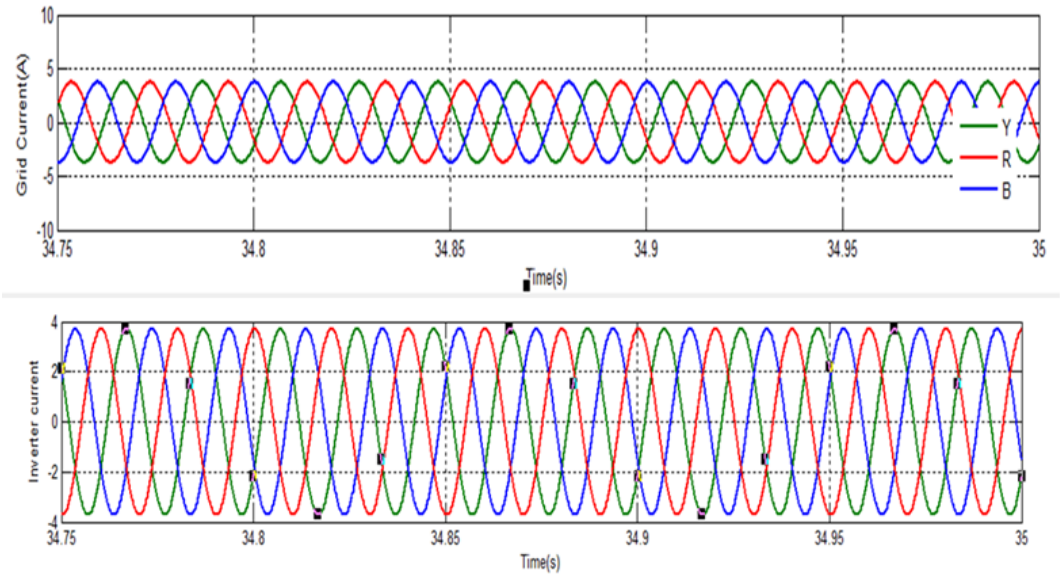


Fig :4 Simulation of synchronverter



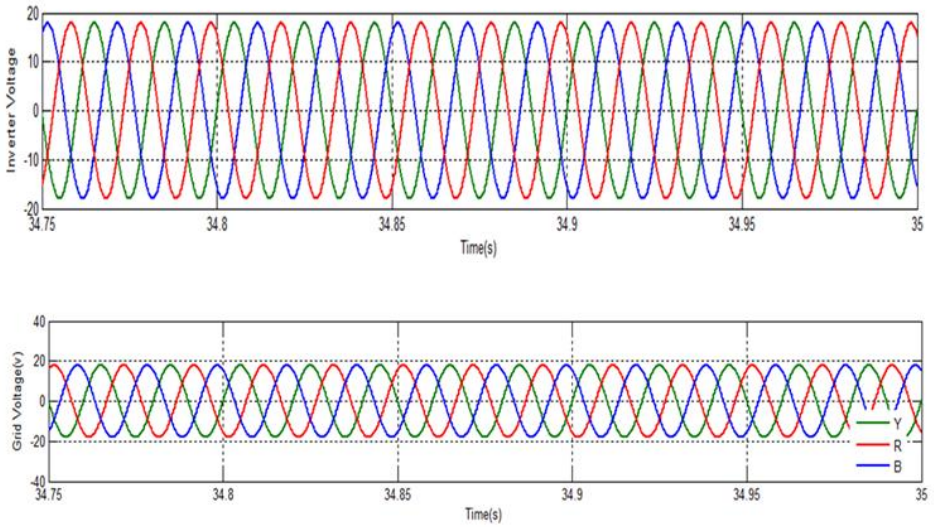


Fig:5 Synchronized Voltages And Currents

VI. Conclusion

A self-synchronized inverter(called synchronverter) has been developed to integrate the renewable energy system to grid system.The need of a phase locked loop is removed by the self synchronization control of grid connected inverter.The problems that are associated with a conventional PLL is eliminated.Thus the difficulty and complexity in tuning the parameters is reduced and also the development cost of PLL is reduced.It is able to synchronize the grid before connection and track the grid frequency automatically after connection.The controller is in principle ,a power controller with integrated capability of frequency and voltage regulation together with self synchronization control.

References

[1]. Q.-C. Zhong and T. Hornik, Control of Power Inverters in Renewable Energy and Smart Grid Integration. New York, NY, USA:Wiley, 2013.
[2]. F. Blaabjerg, R. Teodorescu, M. Liserre, and A. Timbus, "Overview of control and grid synchronization for distributed power generation systems," IEEE Trans. Ind. Electron., vol. 53, no. 5, pp. 1398–1409, Oct. 2006.
[3]. T. Wildi, Electrical Machines, Drives and Power Systems, 6th ed. Englewood Cliffs, NJ, USA: Prentice-Hall, 2005.
[4]. S. Shinnaka, "A robust single-phase PLL system with stable and fast tracking," IEEE Trans. Ind. Appl., vol. 44, no. 2, pp. 624–633, Mar./Apr. 2008.
[5]. P. Rodriguez, J. Pou, J. Bergas, J. Candela, R. Burgos, and D. Boroyevich, "Decoupled double synchronous reference frame PLL for power converters control," IEEE Trans. Power Electron., vol. 22, no. 2, pp. 584–592, Mar. 2007.
[6]. L. Zhang, L. Harnefors, and H.-P. Nee, "Power-synchronization control of grid-connected voltage-source converters," IEEE Trans. Power Syst., vol. 25, no. 2, pp. 809–820, May 2010.
[7]. Q. Zhang, X.-D. Sun, Y.-R. Zhong, M. Matsui, and B.-Y. Ren, "Analysis and design of a digital phase-locked loop for single-phase grid-connected power conversion systems," IEEE Trans. Ind. Electron., vol. 58, no. 8, pp. 3581–3592, Aug. 2011.
[8]. T. Thacker, D. Boroyevich, R. Burgos, and F. Wang, "Phase-locked loop noise reduction via phase detector implementation for single-phase systems," IEEE Trans. Ind. Electron., vol. 58, no. 6, pp. 2482–2490, Jun. 2011.
[9]. http://www.nexoncn.com/read/3c2e2901a276d202421c4566.html.
[10]. https://www.sheffield.ac.uk/polopoly_fs/1.323811!/file/IEEEPE_SelfSynch.pdf
[11]. https://www.slideshare.net/IJMER/d0408-04-2130
[12]. http://docplayer.net/28333431-Ieee-transactions-on-power-electronics-vol-29-no-2-february.html
[13]. http://www.nexoncn.com/read/3c2e2901a276d202421c4566.html
[14]. http://mypages.iit.edu/~qzhong2/IEEEPEM1612_VSM.pdf
[15]. https://www.researchgate.net/profile/Qing-Chang_Zhong/publication/261273868_Synchronverter-based_operation_of_STATCOM_to_Mimic_Synchronous_Condensers/links/559d856f08ae76bed0bb3f0c.pdf?inViewer=true&pdfJsDownload=true&disableCoverPage=true&origin=publication_detail.