International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

COPY RIGHT

ELSEVIER SSRN

IJIEMR Transactions, online available on 10th Apr 2023. Link :http://www.ijiemr.org/downloads.php?vol=Volume-12&issue=Issue 04

10.48047/IJIEMR/V12/ISSUE 04/79

Title **STATCOM BASED ON PI CONTROLLER AND PLL USING MATLAB SIMULINK**

Volume 12, ISSUE 04, Pages: 652-658

Paper Authors
A.SAI ANUSHA, M.Venkata Nithin, P. Harika Chowdary, Sk.Jasmine, V.Harshini

USE THIS BARCODE TO ACCESS YOUR ONLINE PAPER

To Secure Your Paper As Per UGC Guidelines We Are Providing A Electronic Bar Code

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

STATCOM BASED ON PI CONTROLLER AND PLL USING MATLAB SIMULINK

A.SAI ANUSHA, Asst. Prof. Department of EEE,
Vasireddy Venkatadri Institute of Technology, Nambur, Guntur Dt., Andhra Pradesh.

M.Venkata Nithin, P. Harika Chowdary, Sk.Jasmine, V.Harshini
UG Students, Department of EEE,
Vasireddy Venkatadri Institute of Technology, Nambur, Guntur Dt., Andhra Pradesh.
movvanithin20@gmail.com, harikapedavalli.07@gmail.com,
jasmine20shaik@gmail.com,vuyyuruharshini.14@gmail.com

Abstract: A regulating component known as a static synchronous compensator (STATCOM) is used as a source or sink of reactive power in AC transmission networks. The STATCOM is most commonly used to improve transmission system voltage stability. A Static Compensator, often known as StatCom, is a tool that may provide reactive assistance to a bus. On one side, voltage source converters link to the power system, and on the other, an energy storage device. This research examines numerous feedback control methods with the standard PI control approach. A Phase Locked Loop was used to reduce the phase difference (PLL). The techniques under ideal and realistic conditions were compared using a three-phase grid with a non-linear load that is imbalanced and with a significant amount of line impedance.

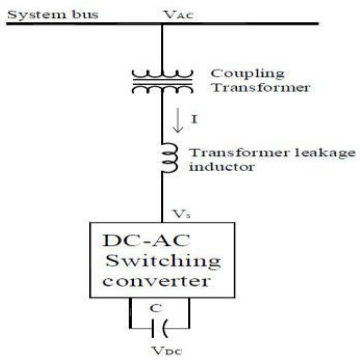
Keywords: STATCom; PLL; PI Controller; LCL Filter; PWM Inverter.

Introduction:

Electricity transmission and generating is a challenging business. The performance of various power system components must be coordinated in order to maximise output. One of the crucial elements that is crucial to the system is the reactive power. Voltage must be kept constant in order to transmit active power via wires. Reactive power is necessary for the operation of motor loads and other types of loads. Reactive power management, also known as reactive power compensation, is necessary to improve the operation of ac power systems. Voltage support and load compensation are the two components of the reactive power compensation issue. For highly fluctuating loads, load compensation can take the form of increased power factor, stabilizing of actual power used from the source, improved voltage management, etc.

Reduced voltage fluctuation at a certain transmission line terminal is what voltage support entails. The two different compensators that may be used are series and shunt. They alter the system's parameters to deliver better V AR correction. Recently developed static V AR compensators include the STATCOM. They fall under FACTS and do a reasonably good ability of create or absorb reactive power with a quicker time reaction. It is possible to increase the apparent power flows through a transmission line and noticeably enhance stability by modifying the factors that control the power system, such as current, potential difference, power factor, frequency and impedance. Transformer leakage reactance caused by the AC voltage difference across it is what causes the reactive power compensation by STATCOM to the grid.

STATCOM:



STATCom is a shunt device that regulates power flow and enhances transient stability on electrical power networks using force-commutated power electronics. (i.e., GTO, IGBT). It is a member of the class of gadgets referred to as the Flexible AC Transmission System (FACTS). While essentially fulfilling the same function as static var compensators, the STATCOM has a number of advantages. The title "Static Synchronous Compensator" was developed due to similar to rotating synchronous compensators in terms of both capabilities and operation.

Multi-level VSCs works with IGBTs, phase reactors & step-up transformers make up a common STATCOM design. The grid is shunt-connected to it. By creating a regulated internal voltage waveform, the reactive current is either supplied or absorbed. The majority of STATCOMs available today operate as GFCs and need a grid voltage function reference (with a certain grid strength). In response, the altered voltage waveform taking into account the voltage at the junction of the grid.

The STATCOM is generally Alternating current controlled device, but the output current is controlled by modulating The internal voltage of the STATCOM (behind the phase reactor), which forms a nearly 90-degree angle with voltage at the grid connection point. Capacitive reactive electricity is supplied to the grid if the STATCOM voltage amplitude is greater than the system voltage amplitude.

Inductive reactive power is created if the current flows in the opposite direction, to the STATCOM from the system. The reactive current, which is influenced by the voltage difference and the transformer short circuit reactance, reaches the thermal limits of the IGBTs.

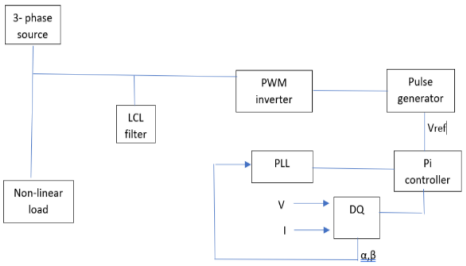
International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

Both voltage amplitudes are equal, the system voltage is within predefined limits, and no reactive power is exchanged with the grid. during normal operation. An established control is for the STATCOM to function as an inductive element and absorb reactive power from the grid if the grid voltage is higher than the threshold value. by lowering the STATCOM voltage waveform's amplitude.

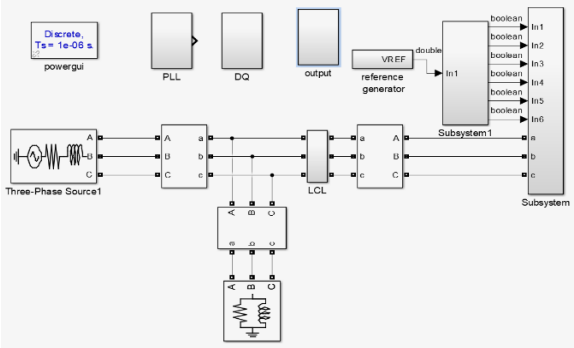
The voltage waveform's size will grow as the grid voltage rises beyond the threshold level, turning the STATCOM into a capacitive component and sending grid-supplied reactive current.

Current designs guarantee the complete necessary dynamic and steady state rating because to their high levels of adaptability, modularity, and scalability. A pure STATCOM device's symmetrical output range can be altered using shunt components to satisfy non-symmetrical performance needs.On the one hand, Thyristor-switched reactors and capacitors can be used in tandem to provide hybrid choices when a quick non-symmetrical dynamic range is required. When necessary, such as by usual intra-day load flow changes, mechanically switched reactors and capacitors can be added to increase slow reaction performance and provide more steady-state capacity.

This block diagram shows the complete working of the Statcom.



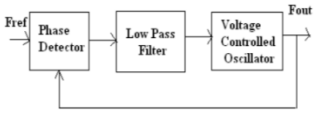
The simulation of the above block diagram as follows:



Direct axis and quadrature axis components of any signal can be produced using the "abc-dq0" block in DQ analysis, or the signal can be transformed into alpha-beta components first using the "abc-"block and then into dq0 components using the "'-dq0"block.

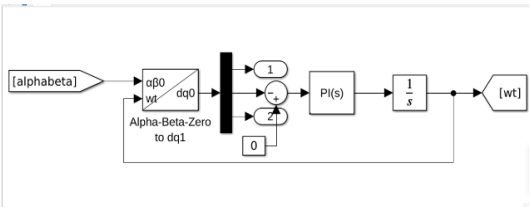
PLL:

A voltage- or voltage-driven oscillator in a phase-locked loop (PLL) electrical circuit continuously adjusts its frequency to match an input signal.



The simulation of the above block diagram as follows:

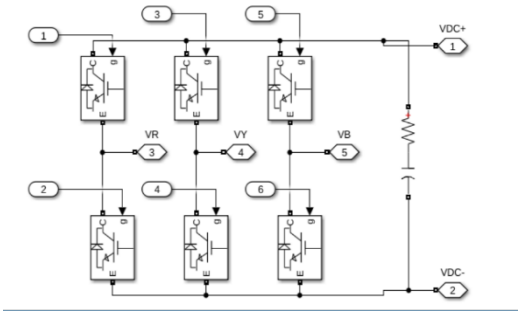
International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org



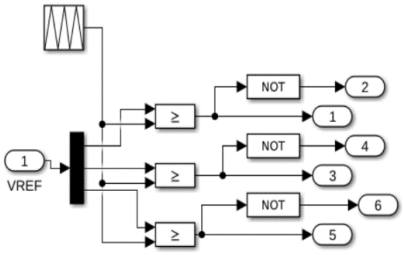
PWM Inverter:

PWM, or pulse width modulation, is a term. Variations in pulse width are made while keeping the input's immediate magnitude constant. PWM is a switching mechanism that adjusts switches between supply and load to regulate pulse width. When the switching process occurs at a very high frequency, the load is unaffected. Because of this, PWM is the approach that works best with inertial loads (motor).

When compared to other conventional switching approaches, PWM is stronger. The PWM approach has the benefit of allowing us to change the output voltage's amplitude and frequency without adding further stages. As a result, it is possible to remove some of the lower order harmonics, which enhances the output waveform's quality and reduces the need for filtering.



IGBTs are used for switching, and capacitors are used to supply the DC voltage. Switching pulses are produced by comparing the repeated sequence with the controller's reference signal.



Positive wave switching pulses are produced via zero crossing detection, while negative wave switching pulses are supplied by complement of these signals.

PI Controller:

A form of feedback management is PI control. Combining proportionate action results in a faster reaction time than I-only control. The system can be brought back to its fixed position via PI control, which also prevents the system from oscillating. Examples of PI-control behaviours in mathematics.

$$c(t) = K_c(e(t)+1T_i \int e(t)dt) +C$$

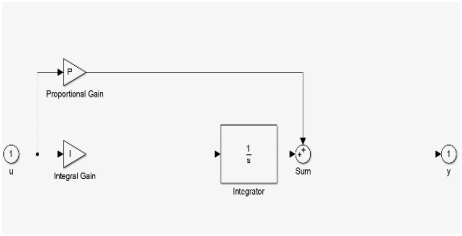
c(t)-- is the controller output,

K_c -- is the controller gain,

T_i --is the integral time,

e(t) -- is the error, and

C -- is the initial value of the controller

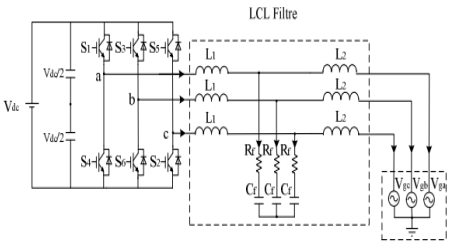


The MATLAB Simulink's internal PI controller block is depicted in the image above, and we have provided both proportional and integral values for it.

The discrepancy between the real signal and the reference signal is progressively reduced by the PI controller, which also lowers fluctuations.

LCL Filter:

The inverter output requires the use of a filter. Just the amplitude is enhanced since the inverted signal is simply the DGM signal once more. Similar to how overtones exist for the switching frequency and its multipliers, so does this signal. The inverter output makes use of the LCL filter. The main criteria that should be taken into account when selecting a filter include the capacity to operate advantages in filter size over standard "L" and "LC" filters, reduced voltage drop, and improved damping over typical "L" and "LC" filters at low switching frequencies.



Higher-order harmonics are produced when Pulse width modulation replaces the output current of the grid-connected inverter. The L filter is therefore frequently used between the converter and the grid. However, the existing overtones are muted by the L filter. L filters are incredibly expensive and, when used in high power situations, have a slow system dynamic response. Additionally, the voltage drops significantly in the L filter. Instead of the advanced In order to rectify the output currents of the voltage source converter, L-filter, a high-order LCL filter, was used. It is well known that the LCL filter performs better than the L filter at reducing switching harmonics.

MATLAB code that contains formulas for the capacitance and inductance values can be used to create an LCL filter.

clc;

k=0.9;

f_1=50;

f_s=4000;

v_0=400/sqrt (3);

v_{oh}_avg=2;

i_0=20;

v_{dc}=800;

a = k^2;

b = (15/4) *k^4;

c =(64/(5*pi)) *k^5;

d = (5/4) *k^6;

k_e =sqrt((a-b+c-d)/1440);

aa =k_e*(v_{dc}/v_{oh} avg);

bb =v_0/(i_0*f_s);

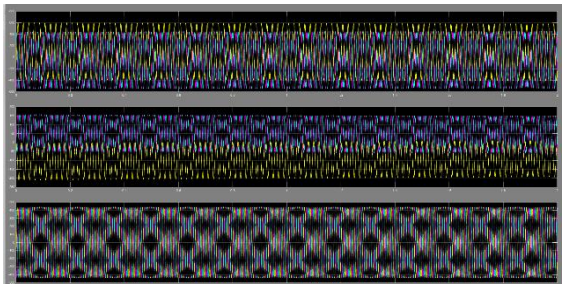
cc =f_1/f_s;

L_f =bb*sqrt(aa*(1+4*pi^2*cc^2*aa))

C_f =k_e*v_{dc}/(L_f*f_s^2*v_{oh}_avg)

The filter's necessary parameters are provided by the MATLAB code above.

SIMULATION RESULTS:



The source current appears as the first wave. The nonlinear load caused it to be erratic. The inverter current is the second wave. Since the STATCom was out of step with the source current, it had to be corrected by gradually bringing the source current back to a balanced state. The third pulse clearly shows the load current. The STATCom claimed that throughout the entire operation, everything stayed stable.

CONCLUSION:

The STATCOM device is more dependable than a shunt capacitor reactive power compensator and can be utilised for reactive power compensation and power factor correction in the industrial network grid. In terms of dynamic load fluctuations, grid voltage variations, and harmonic distortion, STATCOM performs better than shunt capacitors, however both technologies increase the power transmission capacity and static voltage stability margin. Even though STACOMs are quite expensive, their use is warranted because each shunt capacitor battery has a separate LCL filter installed in series with it to ensure that its rated current is kept within limits when the mains voltage is distorted.

References:

1.Thakur P. Load Distribution and VFD Topology Selection for Harmonic Mitigation in an Optimal Way. IEEE Trans. Ind. Appl. 2020; 56:48–56. doi: 10.1109/TIA.2019.2946111. [CrossRef] [Google Scholar]

2. Xu Y., Xiao X., Liu H., Wang H. Parallel Operation of Hybrid Active Power Filter with Passive Power Filter or Capacitors; Proceedings of the 2005 IEEE/PES Transmission & Distribution Conference & Exposition: Asia and Pacific; Dalian, China. 18 August 2005; pp. 1–6. [CrossRef] Google Scholar]

3. Arritt R.F., Dugan R.C. Distributed Generation Interconnection Transformer and Grounding Selection; Proceedings of the 2008 IEEE Power and Energy Society General Meeting—Conversion and Delivery of Electrical Energy in the 21st Century; Pittsburgh, PA, USA. 20–24 July 2008; pp. 1–7. [CrossRef] [Google Scholar]

4. Baghzouz Y., Gong X. Analysis of Three-Phase Transformer No-Load Characteristics. IEEE Trans. Power Syst. 1995; 10:18–26. doi: 10.1109/59.373923. [CrossRef] [Google Scholar]

5. Sanjay J.S., Misra B. Power Quality Improvement for Non6. Phannil N., Jettanasen C., Ngaopitakkul A. Harmonics and Reduction of Energy Consumption in Lighting Systems by Using LED Lamps. Energies. 2018; 11:3169. doi: 10.3390/en11113169. [CrossRef] [Google Scholar]

7. Goschler C., editor. Compensation in Practice: The Foundation 'Remembrance, Responsibility and Future' and the Legacy of Forced Labour during the Third Reich.

1st ed. Berghahn Books; New York, NY, USA: 2017. [CrossRef] [Google Scholar]

8. Hansen S., Nielsen P., Blaabjerg F. Harmonic Cancellation by Mixing Nonlinear Single-Phase and Three-Phase Loads. IEEE Trans. Ind. Appl. 2000; 36:152–159. doi: 10.1109/28.821810. [CrossRef] [Google Scholar]

9. Rastogi M., Mohan N., Edris A.A. Hybrid-Active Filtering of Harmonic Currents in Power Systems. IEEE Trans. Power Deliv. 1995; 10:1994–2000. doi: 10.11

10. Akagi H. Active Harmonic Filters. Proc. IEEE. 2005; 93:2128–2141. doi: 10.1109/JPROC.2005.859603. [CrossRef] [Google Scholar] Linear Load Applications Using Passive Filters; Proceedings of the 2019 3rd International Conference on Recent Developments in Control, Automation & Power Engineering (RDCAPE); Noida, India. 10–11 October 2019; pp. 585–589. [CrossRef] [Google Scholar]

11. Duda T. Ph.D. Thesis. Vysoká Škola Báňská-Technická Univerzita Ostrava; Ostrava, Czech Republic: 2015. Robust Algorithms for Control of Dynamic Systems. [Google Scholar]

12. Chamrád P. Ph.D. Thesis. Vysoká Škola Báňská-Technická Univerzita Ostrava; Ostrava, Czech Republic: 2019. Optimalization of Parameters of MRAS Observer for Sensorless Control of Asynchronal Motor. [Google Scholar]

13. Massoud A., Finney S., Williams B. Review of Harmonic Current Extraction Techniques for an Active Power Filter; Proceedings of the 2004 11th International Conference on Harmonics and Quality of Power (IEEE Cat. No.04EX951); Lake Placid, NY, USA. 12–15 September 2004; pp. 154–159. [CrossRef] [Google Scholar]

14. Abu Hasim A.S., Talib M.H.N., Ibrahim Z. Comparative Study of Different PWM Control Scheme for Three-Phase Three-Wire Shunt Active Power Filter; Proceedings of the 2012 IEEE International Power Engineering and Optimization Conference; Melaka, Malaysia. 6–7 June 2012; pp. 119–123. [CrossRef] [Google Scholar]

15. Kim H., Blaabjerg F., Bak-Jensen B., Choi J. Instantaneous Power Compensation in Three-Phase Systems by Using p-q-r Theory; Proceedings of the 2001 IEEE 32nd Annual Power Electronics Specialists Conference (IEEE Cat. No. 01CH37230); Vancouver, BC, Canada. 17–21 June 2001; pp. 478–485. [CrossRef] [Google Scholar]