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Research paper



Mitigation of Harmonics using Dstatcom with Renewable Energy Sources for Enhanced Power Quality with Intelligent Controller

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Abstract

In this paper, distributed static compensator (DSTATCOM) is used to mitigate of the harmonics show in the source streams on account of non-linear and unbalanced burdens. Here a Photovoltaic (PV cell) based inverter is used as a parallel active filter for the balance of the present harmonics. A unit vector control hypothesis is used to deliver 3-ϕ (three phase) reference source streams. Hysteresis current controller is utilized for restricting the changing recurrence and to deliver characterized harmonics. In this paper, a correlation of total harmonic distortion of an appropriated system is completed with and without DSTATCOM. A fuzzy logic controller is acquainted into the system with enhance the power quality of the dispersed system. The whole procedure was done on MATLAB/SIMULINK to acquire the coveted outcomes.

Keywords: *D-STATCOM, Harmonic mitigation, PV-cell, Total Harmonic Distortion (THD), fuzzy logic controller, Power Quality, Wind energy*

1. Introduction

Sustainable power sources are those sources which are inexhaustable and endless. The most widely utilized inexhaustible sources are sun based energy, Wind Energy, Tidal Energy, Geo warm energy, Hydro electrical power et cetera. These energy sources are used to decrease the use of non-regular sources and diverse procedures like biological hydrogen creation, anerobic absorption and geothermal warming procedure are utilized to improve the utility of the sustainable power sources.

In the midst of all the sustainable sources, tests are generally done on wind and sun oriented energy in view of its bottomless accessibility. Wind is moving air and is caused by contrasts in pneumatic worry inside our atmosphere. Wind is made when changes in temperatures influence air to move from high to low weight zones. Air under high weight pushes toward regions of low weight. The more conspicuous the refinement in weight, the speedier the wind streams.

Display days wind creating system is drawing in exceptional enthusiasm of the researchers because of its gigantic points of interest. For the most part, acceptance machines are utilized as generators and to expand the yield power quality it's smarter to utilize a perpetual magnet AC-DC-AC transformation. A variable speed lasting magnet synchronous generator is utilized in this model to expand the power quality.

A substantial bit of the worldwide benchmarks/looks into portray power quality as the physical traits of the electrical supply gave under standard working conditions that don't resentful or irritate the customer's procedures. Consequently, a power quality issue exists if any voltage, current or repeat deviation achieves a disappointment or disappointment of customer's equipment gear. Regardless, anyway the power quality supply recommends basically supply dependability and voltage quality of the system. Voltage quality issues relate to either disappointment or non-usefulness of the hardware on account of deviations of the line voltage from its said attributes, and the supply dependability is depicted by its adequacy (ability to supply the associated full load), security (ability to stay unaffected for the sudden system deficiencies/shortcircuits) and availability (for the most part for long interferences).

For the most part, the power quality issues at the client end will happen because of the little unsettling influences like sudden exchanging activity, startling increment in the heap. The most serious power quality issues in business, modern and utility systems are voltage sags and swells. Because of these power quality issues the profitability at the client end got influenced.

Thus to build the power quality and efficiency of the system diverse procedures are produced. Nonetheless, for any situation, with the diverse power quality courses of action available, the irrefutable request for a client or utility defying a particular power quality issue is which equipment gives the better game plan.

2. D-Statcom:

i. Construction of DSTATCOM

On a very basic level, the DSTATCOM comprises of three standard parts: a Voltage Source Converter (VSC), a game plan of coupling reactors and a controller. A DSTATCOM is a repaying gadget which is associated in shunt (parallel) to the line for the pay of reactive power and for voltage direction. It can ready to remunerate either line current or transport voltage of the system.

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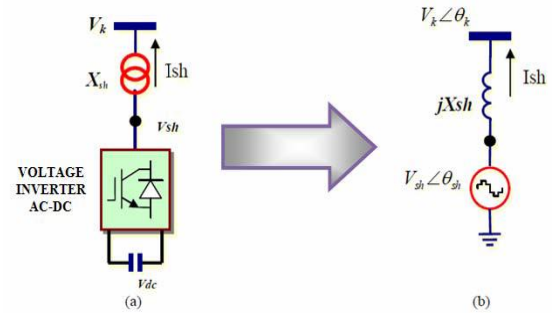


Figure: (a) Circuit diagram of DSTATCOM (b) Equivalent circuit of DSTATCOM

A DSTATCOM is utilized to create controllable voltage source by a VSI(voltage source inverter) and storage device of energy(DC capacitor).
The essential components of DSTATCOM are:

1. To alleviate the impact of voltage plunges and swells on the sensitive burdens.
2. To direct the voltage (voltage control).
3. Harmonic current rectification.
4. Reactive power control.
5. Mitigation of voltage gleaming.
6. Uninterrupted power supply when an storage device of energy is associated furthermore.

(i) Working principle of DSTATCOM:

For the above DSTACOM considered, V_{sh} is the stage voltage and V_t is the line voltage. In the previously mentioned circuit, there is no energy trade with the dynamic system.

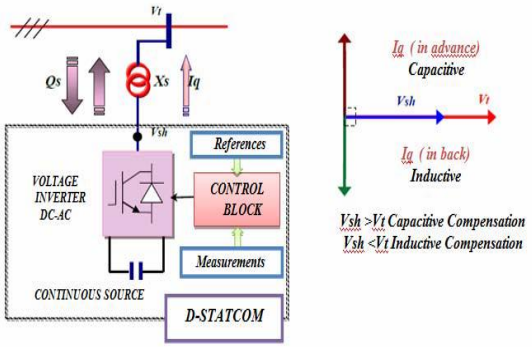


Figure: Basic model of DSTATCOM connected to the network

The DSTATCOM is having three operating modes.
a. If Vt<Vsh : The stage edge of Vt is lagging by 90 degrees regarding Iq;therefore the DSTATCOM is in capacitive mode and the reactive power streams from the DSTACOM.
b. If Vt >Vsh : The stage edge of Vt is leading by 90 degrees regarding Iq;hence the DSTACOM is in capacitive mode and the reactive power is devoured by the DSTACOM.
c. Is Vt =Vsh: The stage edge of Vt is in stage with Iq;in this manner no reactive power introduce in the system.
The voltage source converter VSC (voltage inverter DC-AC) of DSTATCOM is associated with the point of common coupling (PCC) with a spillage inductance of leakage or channel inductance of the coupling transformer. The capacitor associated with the VSC is charged by an outer source i.e.,a battery or charged independent from anyone else. A DSTATCOM for voltage control at PCC,it ought to be worked in inductive mode and in this manner supply current leads the supply voltage by 90˚. In any case, for the power factor correction,both the supply voltage and supply current are in stage with each other.
Therefore in this paper diverse control methodologies are utilized for power factor adjustment, voltage direction and harmonic mitigation of a DSTATCOM.

3. System Description:

The outlined system comprises of photograph voltaic cell as sustainable power source which is associated with the disseminated system with a DC link.

(i) Photo voltaic energy cell:

A photograph voltaic cell is a semiconductor diode which goes about as an energy change gadget to change over daylight i.e., sunlight based energy into electrical energy.

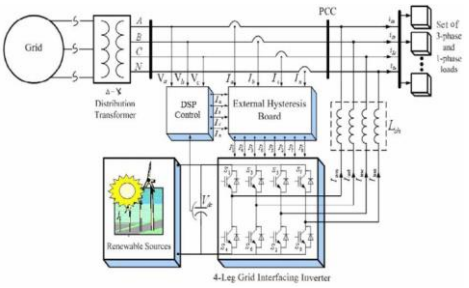


Figure: Schematic diagram of the distribution system with renewable energy sources

The measure of electrical energy delivered from PV cell relies upon the radiation of the sun and its temperature. Sunlight based energy is changed over into electrical energy with a procedure called as photograph voltaic impact and the electrical energy delivered is immediate current which can be put away in the battery.

(ii) Voltage source inverter:

A voltage source inverter is a power electronic gadget which is associated in parallel to the circulated system. It is associated in the system inorder to change over DC voltage into three stage proportionate AC voltage. An exchanging gadget,IGBT is utilized to turn on and off(switching activity) at consistent interims to create rectangular beats of voltage at each stage.

(iii)Control Technique:

As an switching gadget is utilized to turn ON and OFF of the VSI,these moments ought to be so that the associated RES and load ought to show up as a proportional load to the disseminated system. For Such sort of control, the yield of the DClink capacitor is observed constantly and is contrasted and the source voltage Vdc. The distinction estimations of source voltage and genuine voltage will encounter a voltage controller, whose inevitable yield gives a functioning current part Im. By duplicating the unit sine vectors Ua,Uh and Uc with the dynamic current part Im, the reference streams la*, Ib* and Ic* are produced. In the above circuit, the reference matrix current In is considered as zero as it is the immediate total of the framework streams. The stage edges of unit sine voltages are taken as:

$$U_a = \sin(\theta) \quad (1)$$

$$U_b = \sin(\theta - \frac{2\pi}{3}) \quad (2)$$

$$U_c = \sin(\theta + \frac{2\pi}{3}) \quad (3)$$

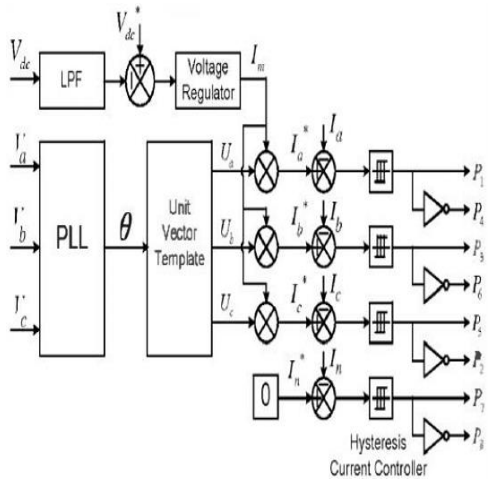


Figure: Block diagram of grid connected inverter Control.

In the grid,the reference and neutral currents are considered as follows:

$$I_a^* = I_m * U_a \quad (4)$$

$$I_b^* = I_m * U_b \quad (5)$$

$$I_c^* = I_m * U_c \quad (6)$$

$$I_n^* = 0 \quad (7)$$

The real lattice streams (la, Ib and Ic)and the reference framework ebbs and flows (la*, Ib* and Ic*) are contrasted and each other and in this way the blunder in current esteem is computed as:

$$I_{aerr} = I_a^* - I_a \quad (8)$$

$$I_{berr} = I_b^* - I_b \quad (9)$$

$$I_{cerr} = I_c^* - I_c \quad (10)$$

(iv) Hysteresis current control:

Hysteresis band PWM control is basically a brisk information current control methodology for PWM,i.e., PWM control technique is a criticism current control strategy where the genuine current diligently tracks the charge current inside a hysteresis band. Here the correlation of the reference singe wave is finished with the waveform of the real present. At the point when the current overwhelms a prescribed hysteresis band, the lower switch in the inverter is turned on and the upper switch in the inverter connect is killed, and thus the present begins to bit by bit decrease.

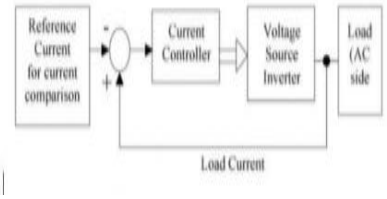


Figure: Block Diagram of Hystersis current control Technique

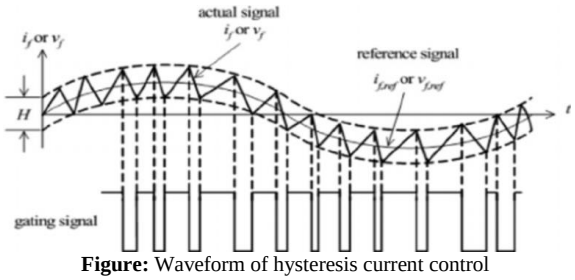


Figure: Waveform of hysteresis current control

The real current is constrained to track the sine reference inside the hysteresis band by forward and in reverse (or impact) trading of the upper and lower switches. The inverter by then essentially transforms into a present source with crest to top current swell, which is controlled inside the hysteresis band, which makes the source current to be sinusoidal.

Here the considered system comprises of hysteresis controllers for each stage(totally three hysteresis controllers) to picture the exchanging task at the coveted time. Each controller chooses the exchanging condition of every inverter of half scaffold with the end goal that the relating currents kept up in the hysteresis band as it were.

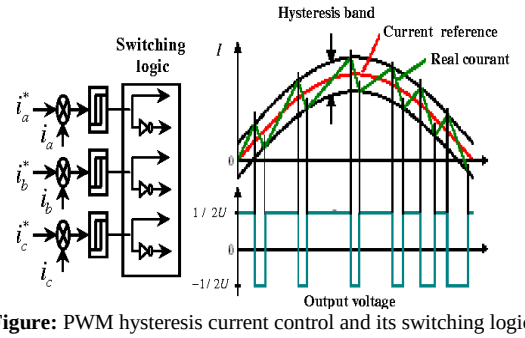


Figure: PWM hysteresis current control and its switching logic

To grow stage current, the associated stage to impartial voltage is proportionate to the half of the dc transport voltage until the point that the most extreme positive esteem is come to. By then, the negative dc busvoltage - ½Udc associated as long quite far is come to. More modern hysteresis PWM current control systems in like manner exist before long, e.g. hysteresis current vector control relies upon controlling the phasor of current in a α/β - reference diagram. These changed systems are produced to takecare of the three stage communication in the system. Unquestionably, the dynamic execution of such an approach is inconceivable since the most extreme voltage is connected until the point that the present blunder is in reach of proposed limits. Because of the extra current controller disposal, the reliance of engine parameter is enormously decreased. All things considered, there are some inherent disadvantages.

- The recurrence of PWM isn't settled.
- Zero voltage phasors can't be produced since there is no collaboration between the phasors.
- Lagging of crucial current with the expanding recurrence.
- The current mistake in the system can't be controlled entirely since the flag may leave the hysteresis band caused by other two stage voltages.

In view of the exchanging misfortunes show in the hysteresis current control,its application is simply restricted to bring down power levels. As the engine parameters are autonomous, hysteresis current control is utilized for the uses of stepper engines, for the activity of high performed based control systems an extra current control circle is included for the count of reference voltages.

4. Wind Energy System:

The accessibility of wind is sufficient wherever of the world. Wind sources are constantly accessible because of the uneven conveyance of air on the earth surface and the persistent pivot of

the Earth. Presently a days, examines are generally going on RES utility inorder to lessen the Green house impact and to dodge the consumption of the ozone layer in light of extensive amounts of carbon dioxide which are discharged into the air when non customary sources like coal,natural gas, oil and so forth are broadly utilized.

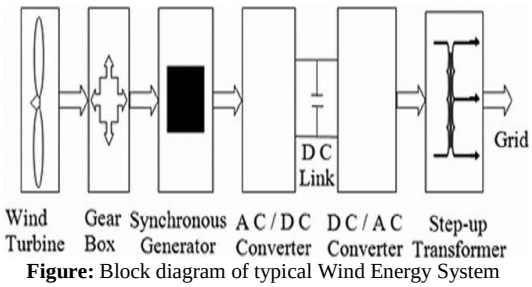


Figure: Block diagram of typical Wind Energy System

Wind energy systems are generally utilized for the age of power as a result of its plentiful accessibility and cost adequacy i.e., shabby when contrasted with the non-sustainable power sources.
A Wind energy system fundamentally comprises of wind turbine,synchronous generator, converter and the transformer as appeared in the figure. Winds turbines can be ordered into the vertical hub compose and the flat pivot composes. Among these two sorts, the vast majority of the wind turbines are of flat pivot compose with a few sharp edges and uses both up-wind and down-wind. As the speed of wind is shifting continuously,wind turbines are planned so that they can work for both variable speed and consistent speed which inturn gives high unwavering quality and ease.

5. Fuzzy Logic Controller:

Fuzzy logic is most widely utilized in machine control. In fuzzy logic, the calculation of the outcomes depend on "level of truth" rather than saying "genuine" or "false". Contrasted with ordinary controllers: these controllers are less expensive to create,having huge scope of working conditions and all the more promptly discover the arrangement of the issue with human activities. In this manner it makes less demanding to prepare it to the undertakings that are effectively completed by people.

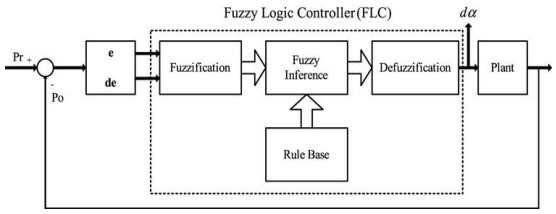


Figure: Fuzzy Logic Controller

6. Matlab/Simulation Results:

A. Balanced Nonlinear Load

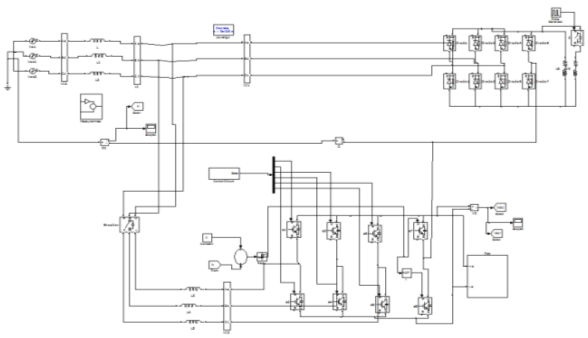


Figure: Simulink Model of balanced non-linear load.

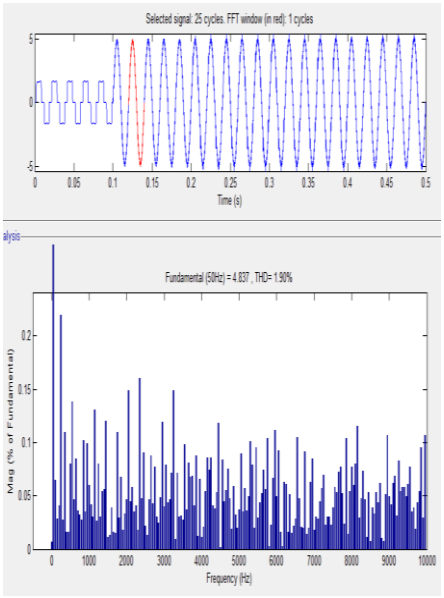


Figure: THD of the source after compensation

B. Unbalanced Non-linear Load:

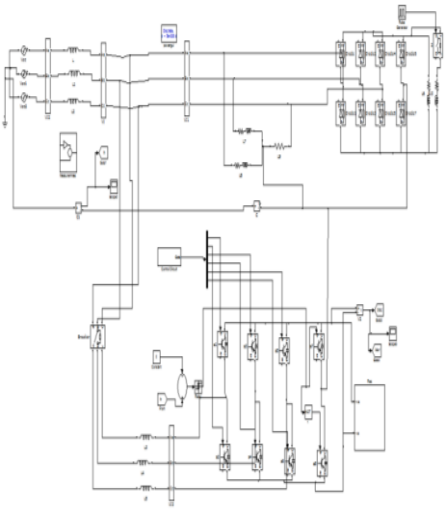


Figure: Simulink Model of unbalanced non-linear load.

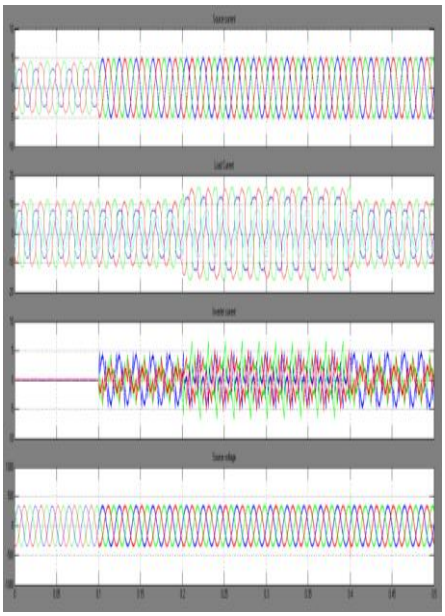


Figure: results of unbalanced Non-linear Load Source current, Load current, Inverter current and source voltage.

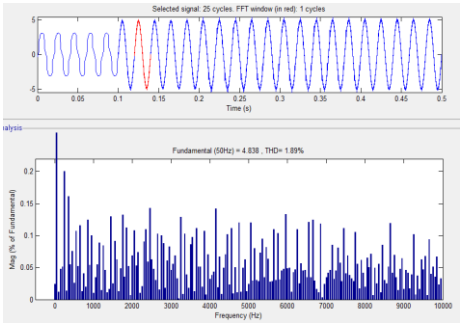


Figure: THD of the source after compensation.

C. Unbalanced Non-linear Load with fuzzy logic controller:

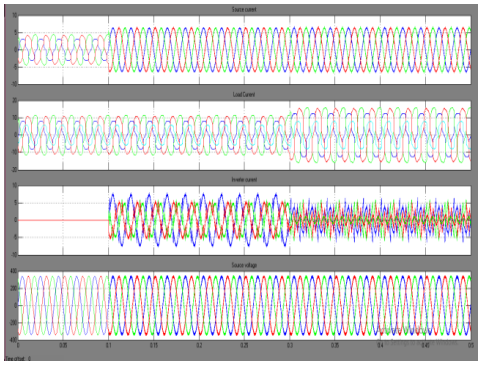


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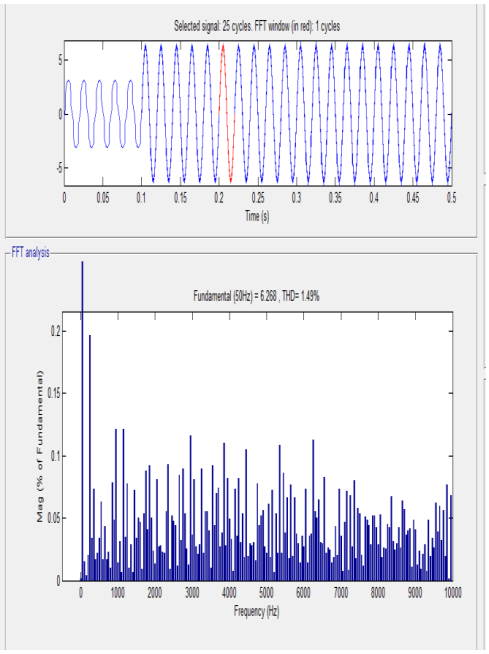


Figure: THD of the source after compensation with fuzzy logic controller.

7. Conclusion

The DSTATCOM infused the required source voltage part rapidly with the adjustments in the load voltages with no trouble. Under different load conditions, the task of the shunt active filter channel is inspected and it affectively repaid the present harmonics and unbalanced streams. The switching beats for the entryway drive in grid inverter are created by the hysteresis controller.

As the sustainable power sources are utilized, the proposed conspire is further developed than customary control strategy because of its cost viability, energy sparing and dynamic execution. By utilizing fuzzy logic controller for the circuit, THD is viably diminished contrasted with traditional PI controller.

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