

Grid Tied RES Source Control Technique to mitigate harmonic and Reactive Power Compensation by using UPQC.

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Abstract: In recent years insufficient energy became greatest hurdle for consumers and generating station due to Scarcity of non-renewable energies, block outs in plants, improper production and supply of requirements Production and supply of energy became a challenging aspect for power Generation, distribution and transmission operators. With the considerations of above a grid connected supply which supported by a Renewable energy source –wind is used to a non-linear load. To obtain power quality here we used a AC-AC link with rectifier and 4-Leg inverter operation at a point of common coupling (PCC).

Key words: PCC (Point of common coupling), RES (Renewable energy sources), P-Q (Power -Quality).

I. INTRODUCTION:

In electricpower systems, distribution utilities mandate the connected loads compliance with the strict power-quality standards. This is to improve the reliability of the distribution system to cater the needs of critical loads and sensitive automation systems. The major challenges to maintain good quality power are:

1. Fundamental reactive power requirements of the connected loads.
2. Voltage sag and swells at the point of common coupling(PCC) due to connection and disconnection of large industrial loads and reactive power compensating capacitors, and
3. Voltage and/or current harmonic distortion due to the presence of nonlinear loads. Active power filters (APFs) are the most promising and widely used solutions for improving the power quality (PQ) at the distribution level [1], [2]. These APFs can be classified as shunt APF, series APF, and hybrid APF. The combination of both series and shunt APFs, to mitigate almost all of the voltage- and current-related PQ problems, is a unified power-quality conditioner (UPQC). Superior performance and the ability to mitigate almost all major PQ problems make UPQC the most attractive solution for PQ improvement despite its high cost, complex structure, and control [1]–[3]. The system configuration of a UPQC is shown Fig. 1. Current trends in the area of UPQC are directed toward operating the UPQC with minimum volt-ampere (VA) loading to reduce the overall system losses [3]–[12]. Generally, the voltage sags and swells are short duration PQ problems. Thus, in UPQC-P and UPQC-Q, series inverter VA loading will only be utilized for short durations. On the other hand, the shunt inverter VA loading is fully utilized throughout the operation, due to continuous load reactive power support and current harmonic compensation. To enhance the utilization of series part of UPQC during steady state, part of load reactive power is supported by the series inverter in UPQC-S [5], [6].

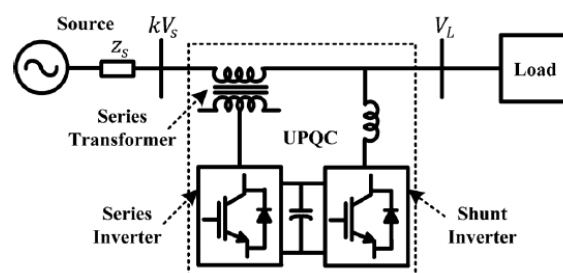


Fig. 1. Schematic diagram of the unified power-quality conditioner (UPQC).

A grid-connected wind turbine can reduce your consumption of utility-supplied electricity for lighting, appliances, and electric heat. If the turbine cannot deliver the amount of energy you need, the utility makes up the difference. When the wind system produces more electricity than the household requires, the excess is sent

or sold to the utility. With this type of grid-connection, note that the wind turbine will operate only when the utility grid is available. During power outages, the wind turbine is required to shut down due to safety concerns.

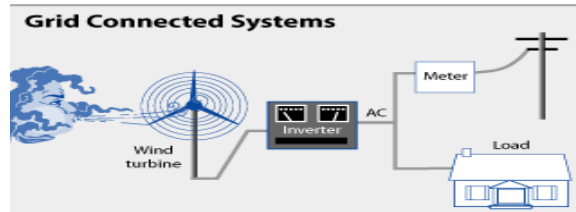


Fig.2. Grid-connected system

Grid-connected systems can be practical if the following conditions exist:

- You live in an area with average annual wind speed of at least 10 miles per hour (4.5 m/s).
- Utility-supplied electricity is expensive in your area (about 10–15 cents per kilowatt-hour).
- The utility's requirements for connecting your system to its grid are not prohibitively expensive.
- There are good incentives for the sale of excess electricity or for the purchase of wind turbines.

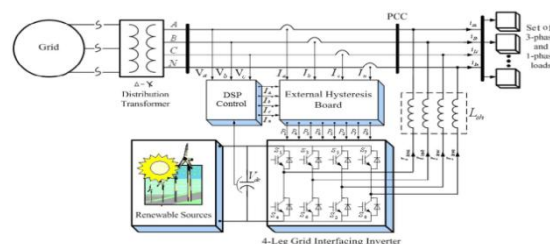


Fig 3: Grid connected RES model

II. SYSTEM MODELING AND OPERATION:

Due to increase of energy utilization supplying of sufficient energy became very nominal. The main theme of the system is to supply sufficient amount of energy to the variable load with RES (Renewable energy Sources) as added plug-in. Where fixed amount of energy is supplied by the input grid to supply to the variable load. If Receiving end voltage is equal to the source voltage due to the effect of losses, harmonics, disturbances will affect the power-quality and it become a hurdle to supply required amount of energy to the variable. These will raises to the utilization of an extra source called RES (Renewable energy source). We have many types of renewable energy sources like Wind, Solar, and Fuel Cell...etc. Recent trends uses Wind in Rigorous usage than Solar due to the disadvantage of low efficiency, high investment cost, limited amount of energy production.etc

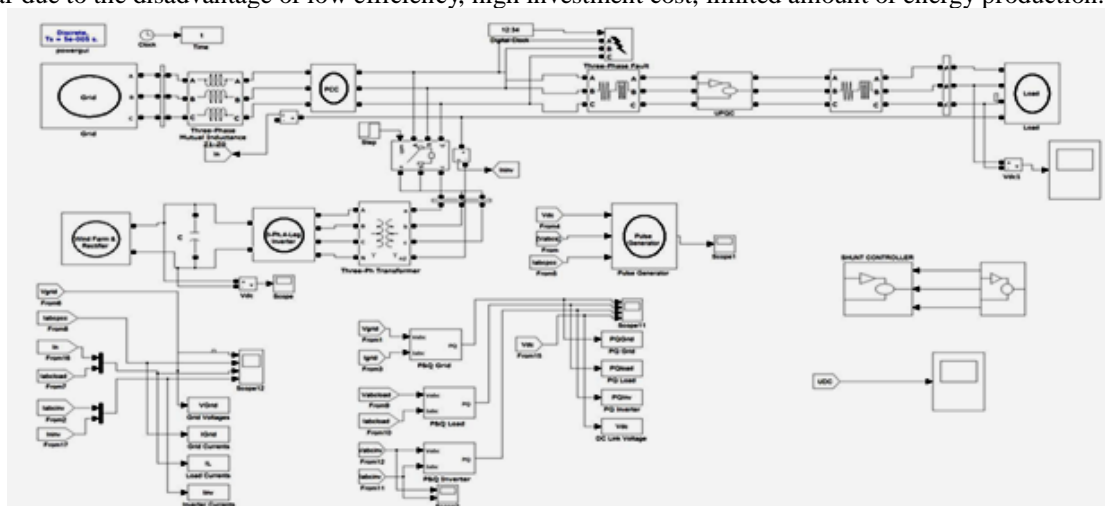


Fig 4 MATLAB/SIMULINK model of Grid-connected RES model

III. CONTROL OF GRID INTERFACING INVERTER

The basic procedure for grid connected Wind/PV source is operated in three modes.

Case 1: $P_{WT}=P_{GRID}$;

An Induction Machine (IM) interfaced Wind Turbine source is the connected to grid where as the basic assumptions of the insufficient source energy feeding to the grid. We depends upon the PV (Photo Voltaic cells) is taken into consideration.

Where $P=1.5MW$, $V_{WT}=575v$, $F=50Hz$ is feeder to the Grid.

2) $P_{RES}<TOTAL\ LOAD\ POWER\ (P_L)$; and

3) $P_{RES}>TOTAL\ LOAD\ POWER\ (P_L)$.

While performing the power management operation, the inverter is actively controlled in such a way that it always draws/ supplies fundamental active power from/ to the grid. If the load connected to the PCC is non-linear or unbalanced or the combination of both, the given control approach also compensates the harmonics, unbalance, and neutral current. The duty ratio of inverter switches are varied in a power cycle such that the combination of load and inverter injected power appears as balanced resistive load to the grid. The regulation of dc-link voltage carries the information regarding the exchange of active power in between renewable source and grid. Thus the output of dc-link voltage regulator results in an active current. The multiplication of active current component with unity grid voltage vector templates (U_A, U_B, U_C) generates

The reference grid currents (I_A^*, I_B^*, I_C^*). The reference grid neutral current (I_N^*) is set to zero, being the instantaneous sum of balanced grid currents. The grid synchronizing angle (θ) obtained from phase locked loop (PLL) is used to generate unity vector template as [9]–[11]

$$U_A = \sin(\theta) \dots \dots \dots (2)$$

$$U_B = \sin(\theta - 2\pi/3) \dots \dots (3)$$

$$U_C = \sin(\theta + 2\pi/3) \dots \dots (4)$$

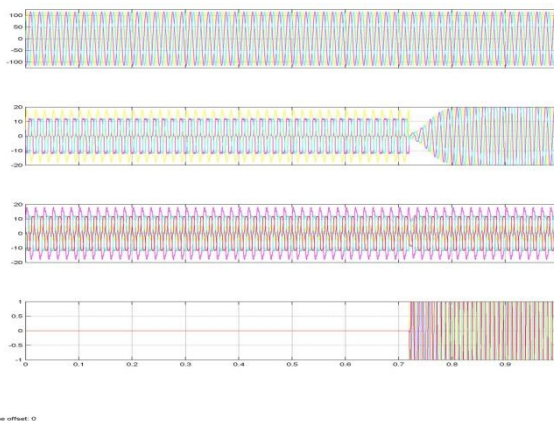


Fig.6.(a). Unbalanced load currents and inverter currents.

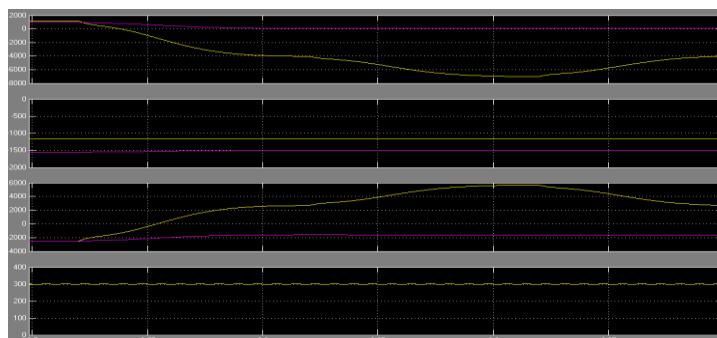


Fig.7.(b) Active-reactive powers across grid, load and Inverter.

IV. Current Harmonic Compensation

Fig. 8 shows the simulation results for UPQC working as current harmonics compensator. In this case, the terminal voltages are assumed pure sinusoidal, the UPQC is put into the operation at instant 0.1sec. Within the very short time period shunt APF maintains the dc link voltage at constant level. In addition to this the shunt APF also helps in compensating the current harmonics generated by the non-linear load. The shunt APF injects a current in such a manner that the source current becomes sinusoidal. At the same time, the shunt APF compensates for the reactive current of the load and improves power factor. The improved source current profile with fault THD is 92.92%.

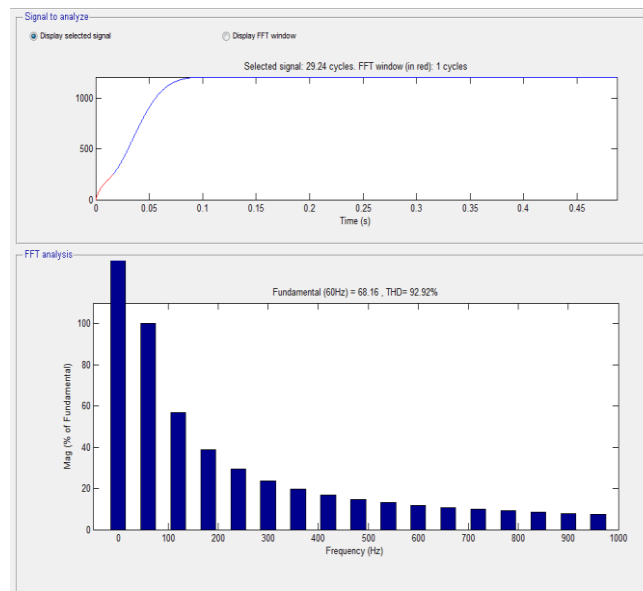


Fig. 8. system is effected with fault is 92.92%

Positive values of grid active-reactive powers and inverter active-reactive powers imply that these powers flow from grid side towards PCC and from inverter towards PCC, respectively. The active and reactive powers absorbed by the load are denoted by positive signs. Initially, the grid-interfacing inverter is not connected to the network (i.e., the load power demand is totally supplied by the grid alone). Therefore, $t=0.72$ s before time s , the grid current profile is identical to the load current profile. At $t=0.72$ s, the grid-interfacing inverter is connected to the network. At this instant the inverter starts injecting the current in such a way that the profile of grid current starts changing from unbalanced non linear to balanced sinusoidal current. As the inverter also supplies the load neutral current demand, the grid neutral current (I_n) becomes zero after s .

Fig. 9 shows the harmonic spectrum of source voltage and load voltage for phase-a after the UPQC is put in operation. THD of source voltage is 24.37%. With the UPQC in operation there is a significant reduction in THD at load side voltage, from 24.37 % to 0.19 %. Series APF is able to prevent the harmonics from disturbing load voltage 0.19 to 0.51%.

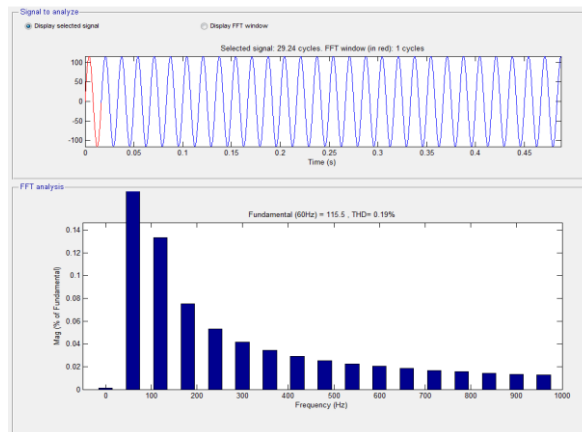


Fig.9.THD of from 0.19 to 0.51%

At $t=0.72s$, the inverter starts injecting active power generated from RES ($P_{RES} \approx P_{INV}$). Since the generated power is more than the load power demand the additional power is fed back to the grid. The negative sign of P_{GRID} , after time 0.72 s suggests that the grid is now receiving power from RES. Moreover, the grid-interfacing inverter also supplies the load reactive power demand locally. Thus, once the inverter is in operation the grid only supplies/receives fundamental active power.

At $t=0.82s$, the active power from RES is increased to evaluate the performance of system under variable power generation from RES. This results in increased magnitude of inverter current. As the load power demand is considered as constant, this additional power generated from RES flows towards grid, which can be noticed from the increased magnitude of grid current as indicated by its profile.

At $t=0.92s$, the power available from RES is reduced. The corresponding change in the inverter and grid currents can be seen from Fig. 7.(a). The active and reactive power flows between the inverter, load and grid during increase and decrease of energy generation from RES can be noticed from Fig. 7.(b). The dc-link voltage across the grid- interfacing inverter (Fig. 7.(d)) during different operating condition is maintained at constant level in order to facilitate the active and reactive power flow. Thus from the simulation results, it is evident that the grid-interfacing inverter can be effectively used to compensate the load reactive power, current unbalance and current harmonics in addition to active power injection from RES. This enables the grid to supply/ receive sinusoidal and balanced power at UPF.

V. CONCLUSION:

This paper has presented a novel control of an existing grid interfacing inverter to improve the quality of power at PCC for a 3-phase 4-wire DG system. It has been shown that the grid-interfacing inverter can be effectively utilized for power conditioning without affecting its normal operation of real power transfer.

The grid-interfacing inverter with the proposed approach can be utilized to:

- i) Inject real power generated from RES to the grid, and/or,
- ii) Operate as a shunt Active Power Filter (APF).

This approach thus eliminates the need for additional power conditioning equipment to improve the quality of power at PCC. Extensive MATLAB/Simulink simulation as well as the DSP based experimental results have validated the proposed approach and have shown that the grid-interfacing inverter can be utilized as a multi-function device.

It is further demonstrated that the PQ enhancement can be achieved under three different scenarios: 1) $P_{RES}=0$, 2) $P_{RES} < P_{LOAD}$, and 3) $P_{RES} > P_{LOAD}$. The current unbalance, current harmonics and load reactive power, due to unbalanced and non-linear load connected to the PCC, are compensated effectively such that the grid side currents are always maintained as balanced and sinusoidal at unity power factor. Moreover, the load neutral current is prevented from flowing into the grid side by compensating it locally from the fourth leg of inverter. When the power generated from RES is more than the total load power demand, the grid-interfacing inverter with the proposed control approach not only fulfills the total load active and reactive power demand (with harmonic compensation) but also delivers the excess generated sinusoidal active power to the grid at unity power factor.

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