

# An Improvised power quality of Wind power grid using FACTS Controller System

Kalpana.P#1

# Assistant Professor, EEE, CK College of Engineering and Technology, Cuddalore, India

**Abstract**— In recent years generation of electricity using wind power has received considerable attention worldwide. Induction machines are mostly used as generators in wind power based generations. Since induction machines have a stability problem as they draw very large reactive currents during fault condition, reactive power compensation can be provided to improve stability. This paper deals with stability improvement of a distribution system embedded with wind farms by using power electronics based Flexible AC Transmission Systems (FACTS) reactive power compensator controller. The dynamic behavior of the example distribution system, during an external three-phase fault and under various types of wind speed changes, is investigated. The study is carried out by three-phase, non-linear, dynamic simulation of distribution system component models. Simulation results are presented for different cases such as with and without FACTS and also for different modes of operation of FACTS controller. The effect of constant wind speed and linear change in wind speed on stability is also analyzed. The simulation analysis of stability of distributed system with wind farm is performed using MATLAB/SIMULINK.

**IndexTerms-** *Distributed generation, distribution system, FACTS, reactive power compensation, power system stability, wind*

**turbine induction generator**

## I.INTRODUCTION

The Use of electronic controllers in the electric power-supply gadget has turn out to be very not unusual. These digital controllers behave as nonlinear load and reason critical distortion within the distribution gadget and introduce unwanted harmonics inside the supply system, main to reduced performance of the energy device community and gadget linked within the network [1]. To fulfill the requirements of harmonic regulation, passive and active electricity filters are being utilized in aggregate with the traditional converters [2]. Presently, lively electricity filters (APFs) are getting extra inexpensive because of fee reductions in strength semiconductor gadgets, their auxiliary parts, and included digital manage circuits. Similarly, the APF additionally acts as a power-conditioning device which affords a cluster of a couple of features, such as harmonic filtering, damping, isolation and termination, load balancing, reactive-power manipulate for power-factor correction and voltage regulation, voltage-flicker reduction, and/or their combinations. Resent studies specializes in use of the ordinary strength best conditioner (FACT CONTROLLER) to catch up on electricity-satisfactory issues [3], [4].The performance of FACT CONTROLLER specifically relies upon upon how correctly and quickly reference

alerts are derived. After green extraction of the distorted sign, a suitable dc-hyperlink modern-day regulator is used to derive the actual reference indicators. Numerous control approaches, such as the PI, PID, fuzzy-good judgment, sliding-mode, predictive, unified regular frequency (UCF) controllers, and many others., are in use [5]–[7]. Just like the PI conventional controller, the PID controller requires unique linear mathematical fashions, which can be hard to gain, and fails to carry out satisfactorily below parameter variation nonlinearity load disturbance, etc.

Contemporary manage concept-primarily based controllers are kingdom remarks controllers, self-tuning controllers, and version reference adaptive controllers, and many others. Those controllers additionally want mathematical models and are therefore sensitive to parameter variations [8]. In current years, a major effort has been underway to increase new and unconventional manage techniques which can often increase or replace traditional manipulate strategies. A number of unconventional control strategies have developed, imparting solutions to many tough manipulate issues in industry and manufacturing sectors. In contrast to their traditional opposite numbers, these unconventional controllers (sensible controllers) can study, take into account, and make choices. Synthetic-intelligence (AI) strategies, particularly the NNs, are having a sizable effect on power-electronics applications. Neural-community-based totally controllers provide rapid dynamic reaction even as retaining the stability of the converter machine over a wide operating variety and are considered as a new device to design manipulate circuits for PQ gadgets [9]–[12]. Over the last few years, main studies works had been auto mobileried out on manipulate circuit design for FACT

CONTROLLERS with the goal of acquiring reliable manipulate algorithms and rapid reaction procedures to reap the transfer manage alerts [13]–[15]. On this paper, for improving the performance of a FACT CONTROLLER, a multilayer feed forward-kind FACTS-primarily based controller is designed for the cur- hire control of the shunt energetic clear out in preference to the traditional PI controller. An algorithm for education the FACTS controller is evolved and trained offline. Numerous simulation results are provided and confirmed experimentally, and evaluate the performance of the FACTS controller with traditional PI controller outcomes. A DSP-primarily based microcontroller is used for the actual-time simulation and implementation of the manage algorithm. The machine configuration is defined in phase II, even as PI and FACTS controller design are explained in Sections III and IV, respectively. Simulation and experimental results are mentioned in Sections V and VI, respectively.

**CONFIGURATION**

A conventional FACT CONTROLLER topology consists of the mixing of lively power filters are related lower back to lower back to a commonplace

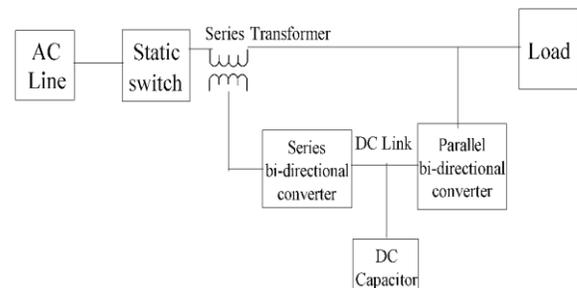


Fig.1.Block diagram of a FACTS CONTROLLER

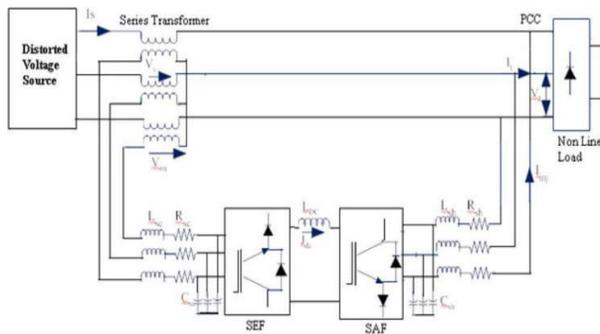


Fig.2.FACT CONTROLLER to polylogy using current-source converters.

Dc-link bus [16]. A easy block diagram of a standard FACT CONTROLLER is shown in Fig. 1.

It is able to be configured both with voltage-supply converters or present day source converters in single section, three-section three- cord, or 3-phase 4-twine configurations. The FACT CONTROLLER with the voltage-source converter (VSC) is most commonplace due to its smaller size and occasional fee. No matter those formerly mentioned advantages, the VSI topology has sluggish manipulate of the converter (LC clear out) output voltage and no quick-circuit/over- current protection. Whilst the lively rectifier within the FACT CONTROLLER is used as a energy factor corrector, dc bus voltage oscillations appear which makes the control of the collection filter output voltage more difficult. The CSI-based FACT CONTROLLER has blessings of excel- lent modern manage capability, clean protection, and excessive reliability over VSI-primarily based FACT CONTROLLER [17]. The primary drawback of the CSI-based FACT CONTROLLER has been to date the shortage of proper switching gadgets and big dc-aspect clear out. The brand new insulated-gate bipolar transistors (IGBTs)

with opposite blockading capability are being launched in the markets which are appropriate for the CSI-primarily based FACT CONTROLLER [18]. With the use of SMES coils, the scale and losses can be decreased substantially [19].A configuration of FACT CONTROLLER the usage of modern-day-supply converters linked again to lower back thru a huge dc-link reactor is proven in Fig. 2.

The overall performance of the FACT CONTROLLER particularly depends on how accurately and quickly the reference signals are derived. After efficient extraction of the distorted sign, a appropriate dc-hyperlink cur- hire regulator is used to derive the actual reference signals. A dc present day regulator will serve as power-loss compensation within the clear out circuits, a good way to take area through the activation of a shunt unit. This regulator will preserve dc-link cutting-edge constant for strong operation of the filter. In the conventional PI controller, the mistake between the real dc-hyperlink current and a reference value, which is generally slightly greater than the height of the dc-hyperlink value, is fed to the PI controller. The output of the PI controller is introduced suitably for the generation of a reference template.

**DESIGN OF THE PI CONTROLLER**

For the reason that dc-hyperlink current is managed with the aid of the shunt filter, the subsequent primary equations are used for designing the manipulate device:

$$P_{ind} = \frac{d}{dt} \left( \frac{1}{2} L_{dc} I_{dc}^2 \right) = L_{dc} I_{dc} \frac{dI_{dc}}{dt} \tag{1}$$

The power input to the PWM converter

$$P_{conv} = 3V_{sh} I_{inj} \tag{2}$$

The average rate of change of energy associated with the

capacitor filter

$$P_{cap} = \frac{d}{dt} \left( \frac{1}{2} C_{sh} V_{sh}^2 \right) \tag{3}$$

Power loss in the resistor Rsh

$$P_{loss} = 3 I_{inj}^2 R_{sh}$$

To be able to manipulate the clear out cutting-edge, the simplest manipulate variable is the duty cycle of the PWM converter. The hassle of control is to decide the obligation cycle in this type of mFACTSer that the dc-link modern stays steady and to provide suitable filter contemporary to cancel the weight modern harmonics. This filter modern-day ought to be contrary of the harmonic modern-day, that is split into additives (i.e., one loss issue plus the reactive aspect and another harmonic issue). The energy transfer to the non-stop facet takes location best on the essential frequency to compensate all of the losses inside the PWM converter). Therefore, it is required to govern outputs, namely and from one control variable (i.e., the obligation cycle of the PWM converter). But, the main goal is to govern the filter contemporary, and the control approach ought to cause specific compensation of the harmonic thing. The price of wishes to most effective be approximately steady and there's no dynamic performance to be attained. The more it's far constant, the more linear the device might be. Subsequently, is controlled circuitously through processing the actual source modern and envisioned reference modern in a hysteresis modern controller. Those reference currents are expected via regulating dc-link current. So one can estimate the consistent-nation errors within the dc-hyperlink current, a PI controller is used. Even though the dynamic reaction of the dc-hyperlink inductor has no effect at the repayment function of the scheme, a mathematical version is required for the

stableness analysis and, as a result, for determining the parameters of the PI controller. The subsequent assumptions are made for deriving the mathematical model of the gadget.

- 1)The voltage at % is sinusoidal and balanced.
- 2)since the harmonic thing does not affect the average electricity stability expressions, handiest the essential component of currents is taken into consideration.
- 3)Losses of the system are lumped and represented by an equivalent resistance related in series with the filter out inductor .
- 4)Ripples inside the dc-hyperlink current are ignored.

The block diagram of the modern-day control loop is shown in Fig. 3, in which advantage of the PI controller; transfer feature of the PWM converter.

A linear version of the PWM converter may be derived through applying a small-sign perturbation technique to achieve its transfer function. In this technique of deriving a linear version,

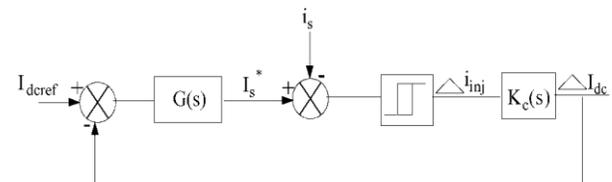


Fig.3.Block diagram of the current control loop.

### DESIGN OF FACTS CONTROLLER

The rapid detection of the disturbance sign with high accuracy, rapid processing of the reference sign, and excessive dynamic reaction of the controller are the top necessities for favored reimbursement in

case of FACT CONTROLLER. The traditional controller fails to carry out satisfactorily under neath parameter variations nonlinearity load disturbance, etc. A recent study shows that NN-based totally controllers offer speedy dynamic response even as preserving balance of the converter device over wide operating range.

The FACTS is made up of interconnecting synthetic neurons. It is essentially a cluster of definitely interconnected nonlinear elements of quite simple form that own the capability to research and adapt. It resembles the brain in two factors: 1) the expertise is acquired by the network via the gaining knowledge of technique and 2) interneuron connection strengths are used to shop the expertise [10]-[11]. These networks are characterized via their topology, the mFACTSer in which they speak with their surroundings, the way in which they're trained, and their ability to method facts. FACTSs are getting used to solve AI problems without necessarily growing a version of a actual dynamic gadget. For improving the performance of a FACT CONTROLLER, a multilayer feed ahead-kind FACTS-based controller is designed. This network is designed with 3 layers, the input layer with 2, the hidden layer with 21, and the output layer with 1 neuron, respectively.

The education set of rules used is Levenberg–Marquardt back propagation (LMBP). The MATLAB programming of FACTS schooling is given as follows:

```
net=newff(minmax(P),[2,21,1],{'tansig',
'tansig','purelin'},'trainlm');
net.trainParam.show=
50;
net.trainParam.lr=
0.05;
net.trainParam.mc=
0.95;
```

```
net.trainParam.lr_inc
=1.9;
net.trainParam.lr_dec
=0.15;
net.trainParam.epochs
=5000;
net.trainParam.goal=
1e-6;
[net,tr]=train(net,P,T)
;
a=sim(net,P);
gensim(net,-1);
```

**SIMULATION RESULTS**

**1) WIND FACT CONTROLLER with current supply inverters**

The machine taken into consideration is 3-phase device and Wind Source is taken as nonlinear load. FACT CONTROLLER consists of series inverter and shunt inverter that are contemporary source inverters. An inductor is taken as taken as a dc link among the inverters.

The parameters of transmission line are taken identical values that are cited layout of PI controller. The simulation diagram is proven in Fig 4.

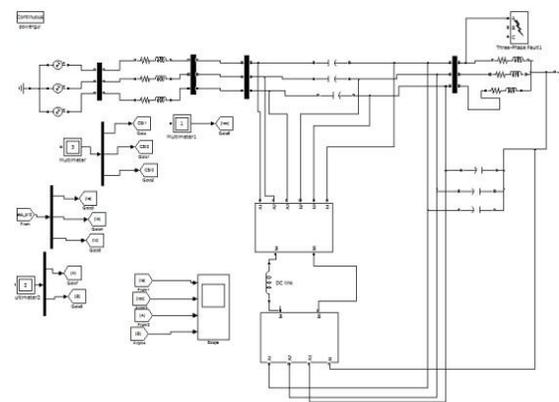


Fig4: Simulation diagram FACT CONTROLLER with Current Source Inverters

The simulation is performed for 0.3

second a disturbance at load is applied for a certain period of time and the performance of PI and FACTS controller are compared.

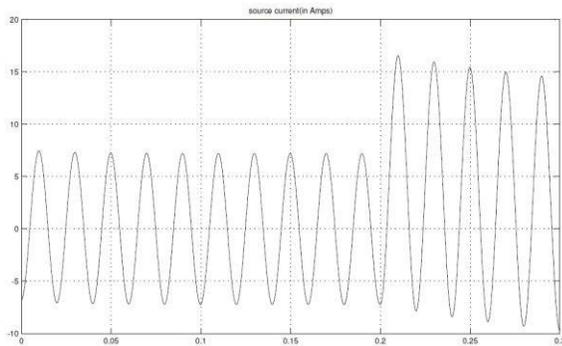


Fig5: Performance of FACT CONTROLLER with PI controller at load per turbations

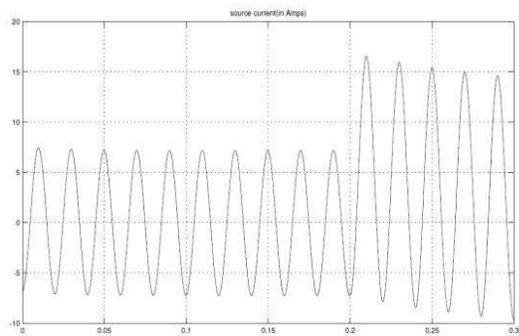


Fig6: Performance of FACT CONTROLLER with FACTS controller at load per turbations

Total harmonic distortion is also taken (0.15sec and 0.25sec). PI and FACTS controller performance is compared

Fig7: Frequency spectrum of the source current at different loading conditions with the PI controller

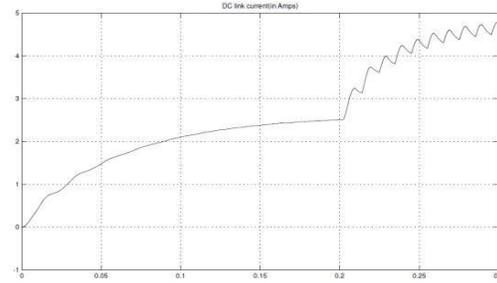
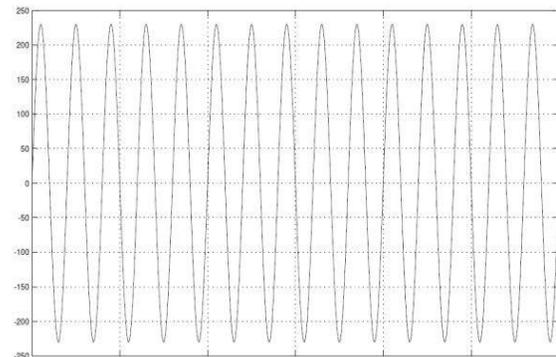


Fig8: Frequency spectrum of the source current at different loading conditions with the FACTS controller.



From figures 5 and 6 the dc hyperlink current is taking more to stabilize at preliminary situations and load perturbations in the case of PI controller and inside the different case of FACTS controller dc hyperlink modern is stabilizing speedy in both conditions as compared to PI controller.

The overall performance of harmonic present day filtration is proven. The load contemporary in both instances is observed to be content material of all unusual harmonic minus triplen, supplying a complete harmonic distortion (THD) of 27.82 %. It's far discovered from the determine that the THD of the supply cutting-edge at 0.15 s is 0.07% within the case of the PI controller while it is 0.06% inside the case of the FACTS controller scheme. Further, the THD of the source modern-day at 0.25 s is 0.95% in case of the PI controller whilst it's miles 0.94% in case of the FACTS controller scheme. At

each instances FACTS controller overall performance is proving better than PI controller.

**2) FACT CONTROLLER with voltage source inverters**

The machine taken into consideration is 3-phase device and load is taken as non linear load. FACT CONTROLLER consists of series inverter and shunt inverter which can be voltage source inverters. A capacitor is taken as taken as a dc link among the inverters.

The parameters of transmission line are taken equal values which are noted design of PI controller. The simulation diagram is proven in figure 9.

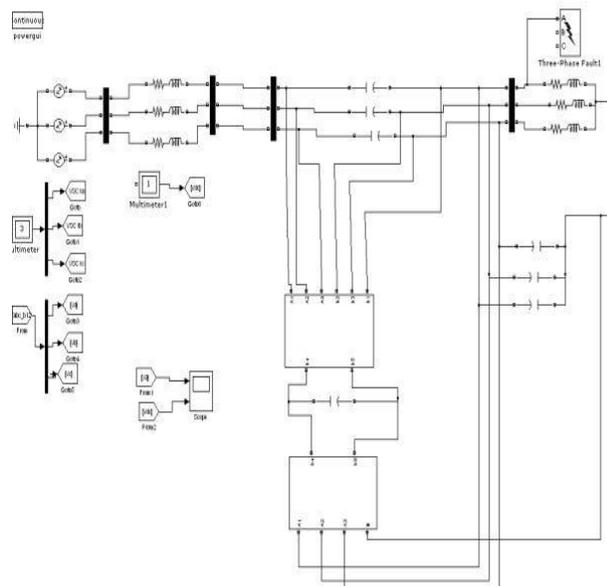


Fig9:Simulation diagram FACT CONTROLLER with Voltage Source Inverters

The simulation is completed for 0.3sec and a disturbance at load is implemented for a sure time frame and the overall performance of PI and FACTS

controller are in comparison

From figures 10 and eleven the dc hyperlink is stabilizing speedy at preliminary conditions with FACTS controller as compared to PI controller. Even at load perturbations there are fewer oscillations happening with FACTS controller in comparison to PI controller. Subsequently FACTS controller is showing a better overall performance in the two cases towards PI controller.

**CONCLUSION**

The performance of the WIND FACT CONTROLLER particularly relies upon how appropriately and quickly reference indicators are derived. There were numerous situations which can be tested. However, the performance of conventional PI controller is not proving higher against proposed FACTS controller in both cases of FACT CONTROLLER (thinking about CSI and VSI inverters). This is proved through simulation results. Subsequently, with FACTS controller there was big improvement inside the reaction time of the manage of the dc-link present day which is the principle issue inside the case of the electricity system community.

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