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APPLICATION OF FACTS DEVICES FOR POWER QUALITY IMPROVEMENT IN POWER TRANSMISSION SYSTEM

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ABSTRACT

Today in the modern era the energy is generated via different mediums and their transmission is dependent upon the way the next other side wants the signal. When transmitting the signal, the signal can be distorted because of the many power and transmission quality problems. Due to this, drop in the voltage occurs in the line which creates an oscillating wave that results to reduce the PF (power factor). The FACTS devices are used to solve this problem earlier. But drawback also occurs while injecting the voltages in the power lines. At this time different hybrid combinations of FACTS devices can be used to make the transmission more secure and can cross long distances. In this research work, the STATCOM and IPFC controller are used for making the power constant even after the long transmission and dropouts in voltage. The main goal is to maintain the voltage regulation in the power line which increases the performance and thus power factor also increases. Various FACTS device (STATCOM and IPFC) can be used to maintain the constant electricity transmission without the slur, degradation or low power factor. Hence the FACTS devices can be used to make power travel over a long distance in the transmission medium. The main goal of this research is to study and analyze the FACTS devices and then control power flow. Three transmission lines are used of various lengths and different load is attached with the individual line. The model is designed in the SIMULINK MATLAB tool. The parameters such as voltage and power loss (reactive power and active power) are measured with optimization and without optimization. Here, we are applying Genetic algorithm to reduce the fluctuations in the voltage and obtained constant voltage.

Keywords: FACT devices, STATCOM, IPFC, SIMULINK, GA.

I. INRTODUCTION

There are several problems with the expansion of the power transmission network. Therefore, the interest in making better use of the available power system capacity is increasing through the installation of new devices such as FACTS (Flexible AC Transmission System) [1]. FACTS equipment can reduce the power flow in heavily loaded lines, thereby, increasing load capacity, reducing system losses, improving network stability, and reducing production costs [2].

More interest in these devices is mainly due to two reasons. First, the recent development of high-power electronics has made these devices cost-effective; second, the increase in power system load coupled with deregulation in the power industry has prompted the use of power flow control as a very cost-effective means of scheduling specific power transactions [3]. Numerous emerging issues in the competitive power market, such as, congestion management, system security and availability of transmission capabilities, transmission prices, etc., have always limited the free and fair trade of electricity in the open electricity market. FACTS equipment can play an important role in these issues [4]. In addition, the location of these devices is important because they are expensive. Devices of FACTS controller family are STATCOM (Static compensator), SSSC (Static synchronous series compensator), GUPFC (Generalized unified power flow controller) and IPFC (Line flow controller).The principle of FACT devices is mainly depends upon the three parameters namely magnitude of voltage, phase angle and the reactance of transmission line in the actual time and the power of transmission line is varied as per the condition of system [5].

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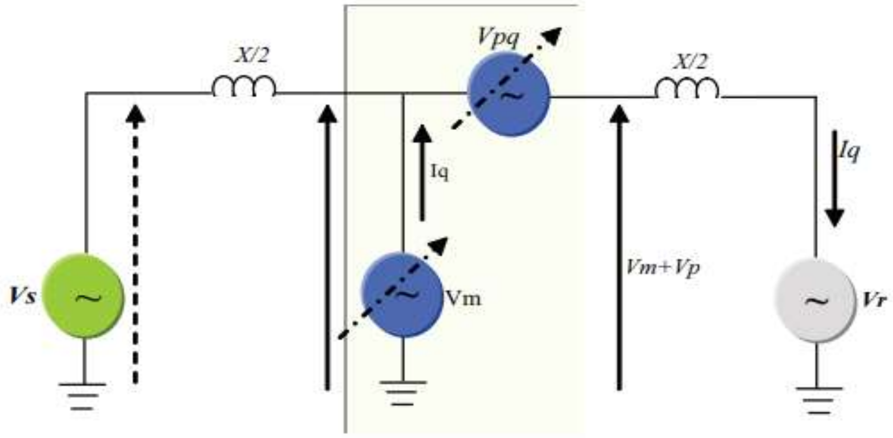

Figure 1: FACT practical network

Today in the modern era the power is generated via different mediums and their transmission is dependent upon the way of selection of transmitting elements [6]. When the transmission line is largethen the probability of power losses is high and the output quality of system is degraded. Power quality issue plays a very essential role in power transmission system and it is important to monitor and create power supply of high quality. Power quality issue mainly occurs due to the large transmission rage, which results in the damage of electrical devices and reduces power quality. The power also reduces due to the large flow of current [7].

The small power quality, produce poor voltage regulation and reduce power handling ability of power transmission system [8]. The Power Quality is a mixture of Voltage and frequency of the signal. It may be defined the rate to which the power supply reaches for the ideal case of constant, distortion and fluctuation free supply. The FACTS devices are used to solve the above mentioned problems in power transmission system. But drawback also occurs while injecting the voltages in the power lines [9]. At this time different hybrid combinations of FACTS devices can be used to make the transmission more secure and can cross long distances. In this research, the STATCOM and IPFC controller are used for making the power constant even after the long transmission and dropouts in voltage using the optimization technique with optimal objective function. In this research, we are using Genetic algorithm as an optimization technique is used to enhance the power quality of the transmission system [10].

II. RELATED WORK

A lot of work has been executed in the field of power improvement by means of FACT devices with their controllers. This section describes the traditional work in the similar field.

João I. Yutaka Ota et al. presented and discusses a phase shifted-PWM distribution static synchronous compensator (D-STATCOM) using the modular multilevel cascade converter based on single-star bridge cells (MMCC-SSBC). Two phase-shifted PWM methods, which are named as one-cell and all-cells update methods, are theoretically and experimentally compared. The all-cells update method can reduce the inherent time delay, thus resulting in a faster and more stable system response than the one-cell update method. **J. Monteiro et al.** presented the design and compare the performance of linear, decoupled and direct power controllers (DPC) for three-phase matrix converters operating as unified power flow controllers (UPFC).Linear controllers show acceptable steady state behaviour but still exhibit coupling between P and Q powers in transient operation. DLC are free from cross coupling but are parameter sensitive. Results obtained by DPC show decoupled power control with zero error tracking and faster responses with no overshoot and no steady-state error. **Guanjun Ding et al.** has analyzed and calculated in detail inductive and capacitive operation modes, including the AC, DC current and DC capacitor voltage in one period for Static Synchronous Series Compensator. The expressions for them are derived in order to assess the compensator performance. The SSSC based on six-pulse VSC is specially studied because it gives an insight into the study of the more complex configurations. On the basis of calculations and simulations in PSCAD/EMTDC, the impact of current on DC capacitor charge and discharge is analyzed thoroughly. A methodology for the capacitor voltage control of SSSC is obtained. **S.Selvakumaran and S.M.Kalidasan** has analyzed that the transmission and the reactive power should be maintain for better

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voltage regulation thus increase the performance and to avoid the power oscillations in the systems .In this research, the performance of the various FACTS devices had analyzed voltage can be injected or absorbed by using STATCOM device. UPFC device is used for the control of active and reactive power. SSSC device is used to inject the voltage in series in the transmission system. **Sarkar, Mithu** has focused on the improvement of the bus voltage and on the reduction of the active and reactive power losses in the transmission lines incorporating steady state model of UPFC in Newton-Raphson (NR) power flow algorithm. The steady state model of the UPFC, derived from two voltage source representation, is presented and analyzed in detail. A MATLAB program is executed to incorporate the UPFC model in NR Load flow algorithm. For determining the steady state performance of the UPFC in the load flow studies, a IEEE 30 and IEEE-14, IEEE-5 bus systems has taken. **Norouzi et al.** has presented an in-depth investigation of the dynamic performance of the Static Synchronous Compensator (STATCOM) and the Static Synchronous Series Compensator (SSSC) theoretically and by exact digital simulation. A 24-pulse GTO dc-ac converter model is designed to represent the operation of the STATCOM and SSSC within a power transmission system. Two major factors of the STATCOM instability are analyzed and a new Automatic Gain Controller (AGC) is proposed to ensure the stable operation of the STATCOM under various load conditions. It is shown that the Phase-Locked Loop (PLL) inherent delay has a great effect on the dynamic operation of the SSSC and a new auxiliary regulator is proposed to enhance the dynamic performance of the SSSC. The proposed control schemes are validated by digital simulation.

III. SIMULATION MODEL

This research has dealt with the execution of analyze power quality improvement in transmission system using FACT devices. Genetic algorithm has been used with FACT devices in transmission system to reduce power losses. The simulation model of the work is defined below.

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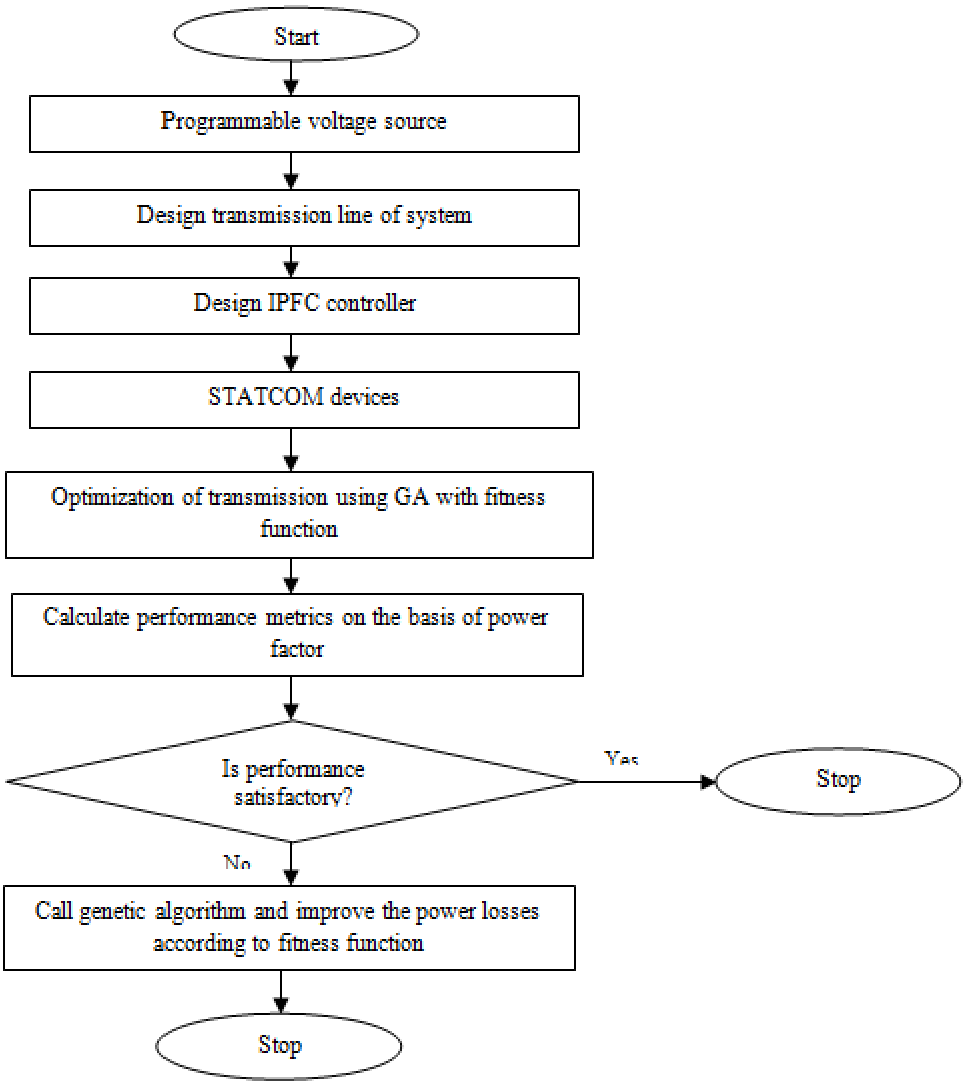

Figure 2: Proposed workflow

Step1: Initialize the programmable voltage source to provide the input voltage to the designed transmission line.
Step2: Transmission line for the system is designed at different distance and load is attached to every line.
Step 3: An Interline power flow controller is designed in order to control the power flow of the transmission line, which occurred due to the fluctuation of load.
Step 4: Initialization of STATCOM devices. This is used to control the fluctuation of frequency occurred in the transmission line.
Step 5: Apply genetic algorithm to optimize the transmission line with the help of fitness function.
Step6: Power factor is calculated on the basis of power loss.
Step 7: If performance of the transmission line degraded, call for genetic algorithm. GA increases the performance of the designed model by using fitness function.

IV. RESULT AND ANALYSIS

This section defines the results obtained after the simulation of the proposed work.

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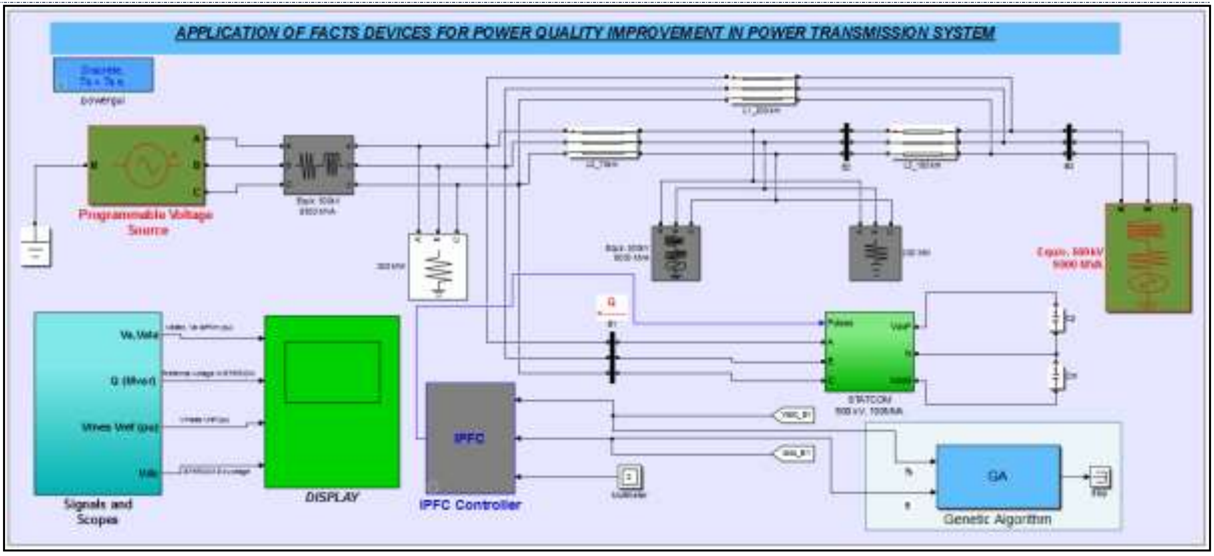

Figure 3: Simulator of proposed work

In the above figure, working after the pressing on the start button is shown. In this the errors in the transmission of the electricity is analysed using the FACTS device. The simulation model of the proposed work is shown in figure above. The input voltage is providing to the circuit by using 3 –phase programmable voltage source controller. The voltage source controller produces voltage of 500KVA, 850MVA. The simulation model is designed to analyze the power losses in the transmission line when the power is transmitted from one place to another place. It is analyzed that as the length of the transmission line is large the power loss is more. The transmission line used in the simulation work is denoted by L1, L2 and L3 of length 200KM, 75 Km and 180 Km respectively. The load is attached to the transmission line L1, L2 and L3.

IPFC controller is connected between transmission line and ground to control the flow of power in multi transmission line. Additionally, it has shunt converter that is linked among a transmission line and ground. The converters are linked via general DC links for exchanging active power. The series converter may give independent reactive compensation of personal transmission line. If the shunt converter is concerned in the system, than the series converter may give independent active compensation, or else, not the series converter may give independent active compensation for its own line. The STATCOM controller is also used to control the frequency fluctuation in the power that occurs due to the variation of load. The box in the green color represents the display of the waveforms observed during the simulation of the work.

The proposed model is divided into two parts named as the model without optimization and the model with optimization. In the optimization part we use genetic algorithm to improve the quality of power during the transmission of voltage and current. In the simulator, if we select normal that represents the simulation without genetic algorithm and genetic for simulation using genetic algorithm.

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Proposed Model without Optimization

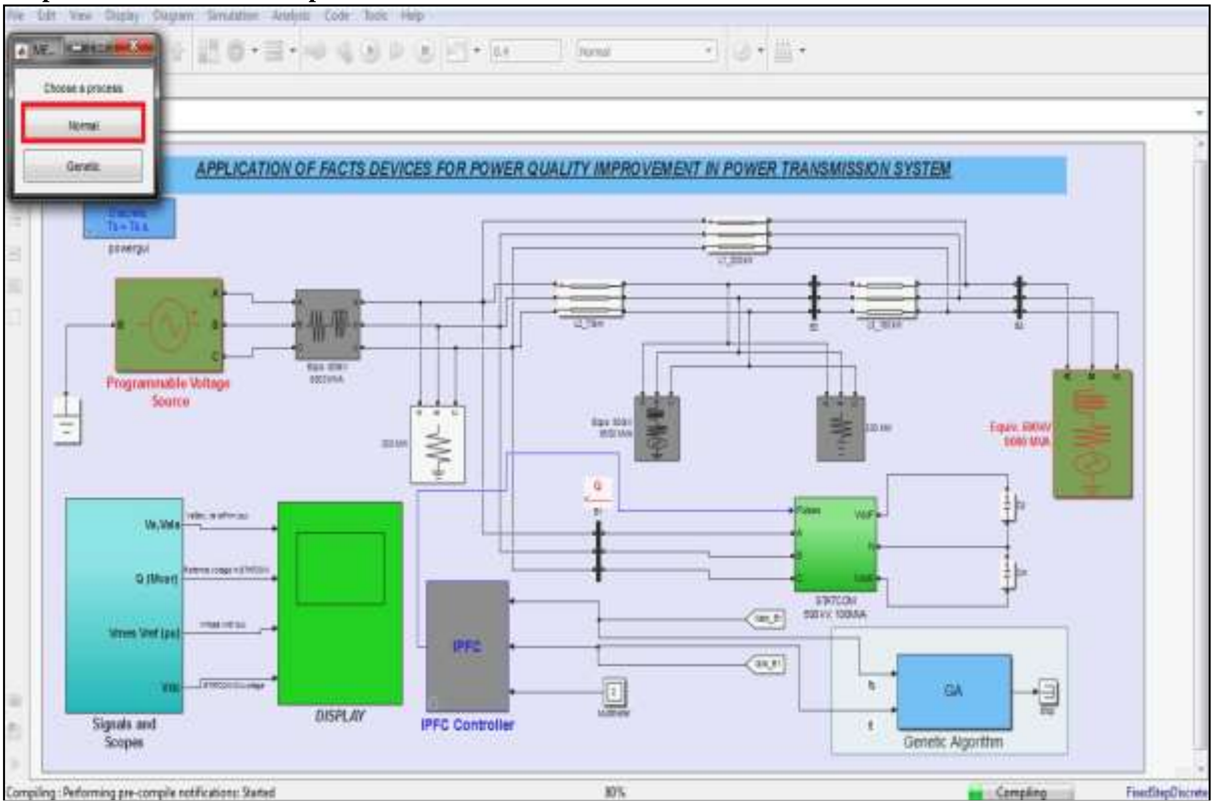

Figure 4: Simulation without GA

The above figure represents the simulation model designed without optimization algorithm for transmission of current and voltage. The results obtained after simulating the model are discussed below.

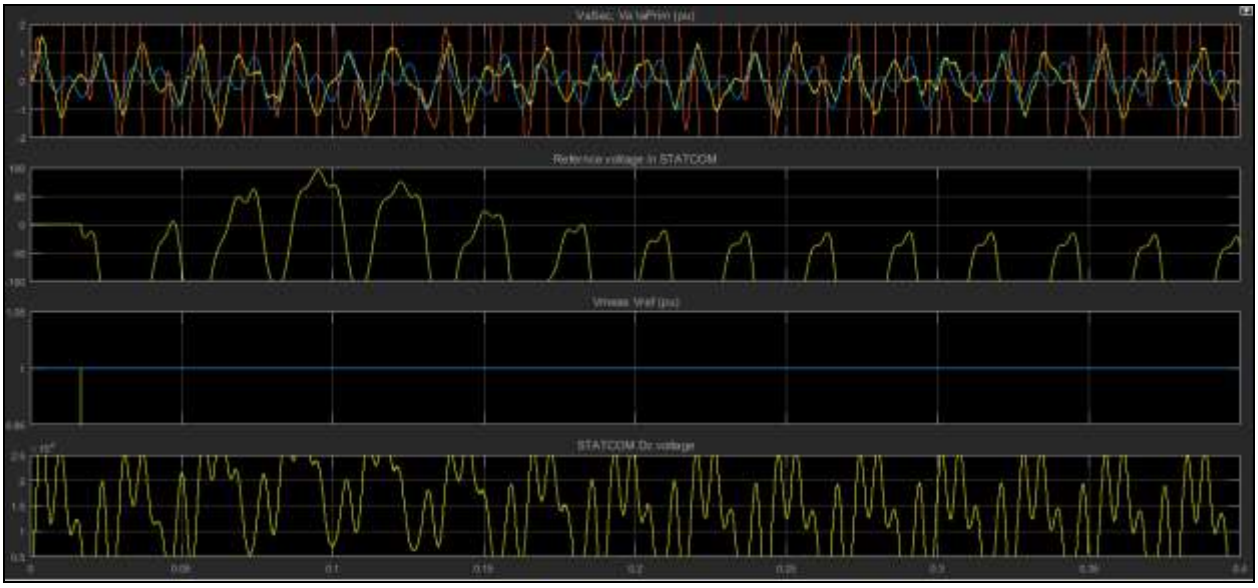

Figure** Error! No text of specified style in document.**: Voltage analysis of simulator

In the first part of figure, there are three signals which represent the current with primary and secondary voltage. The reference voltage of STATCOM is shown in the 2nd part of figure and it is use as a reference voltage which helps to STATCOM. The third part of figure is show the mean voltage with mean of reference voltage and at the last STATCOM voltage is given with more fluctuations.

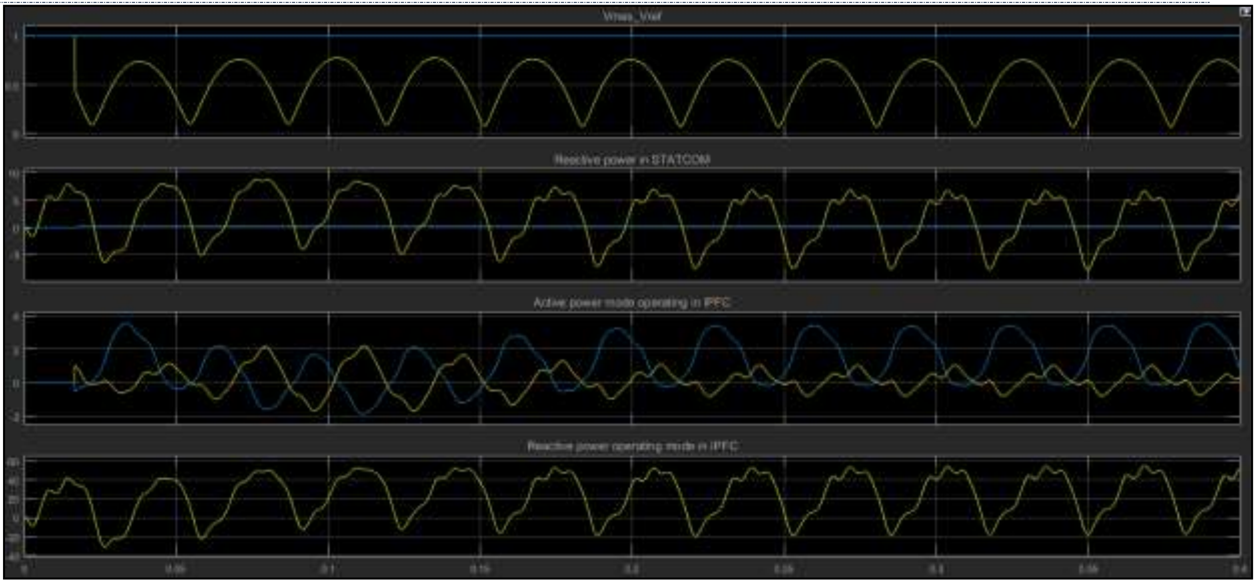

Figure 6: Power analysis of simulator

In the above figure, there are four parts and first is same as mentioned in previous figure. The third part of figure is show the mean voltage with mean of reference voltage. The second part of figure represents the reactive power of STATCOM and form the observation the variation is more in case of without optimization. In the third part of figure, this represents the active power of IPFC and fourth part show the reactive power of IPFC with fluctuations.

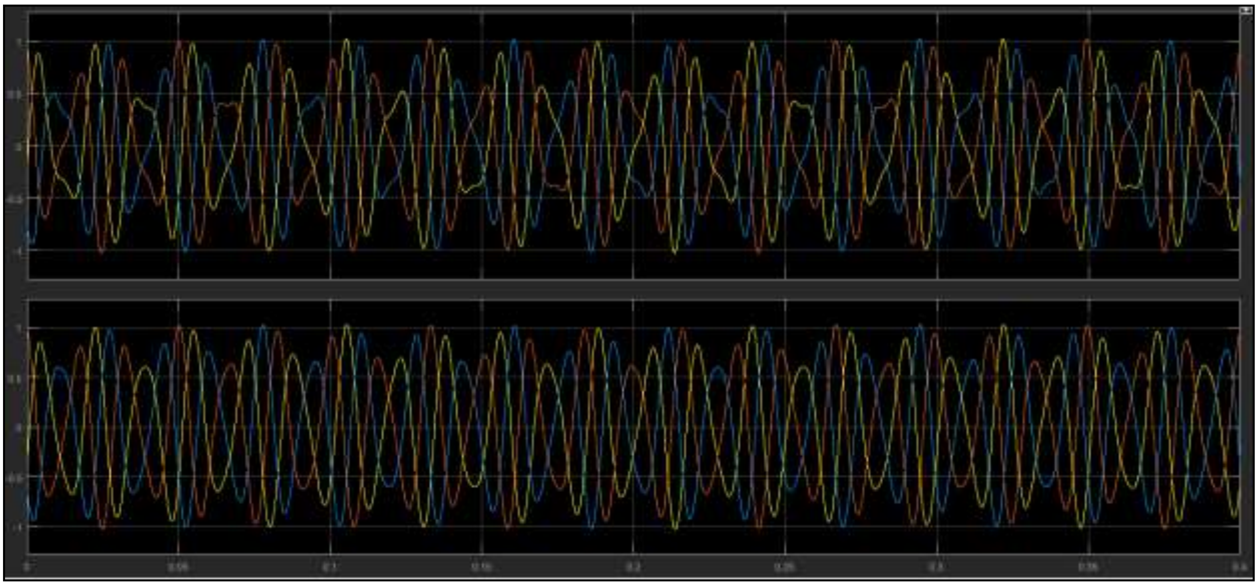

Figure 7: Performance analysis of simulation

Above shown figure represents the change in voltage with time and the fluctuation in voltage is large in case of without optimization. If we apply genetic algorithm with simulation model then we reduce the fluctuations in current, voltage and power and achieve a better performance of simulator.

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Proposed Model With Optimization (GA)

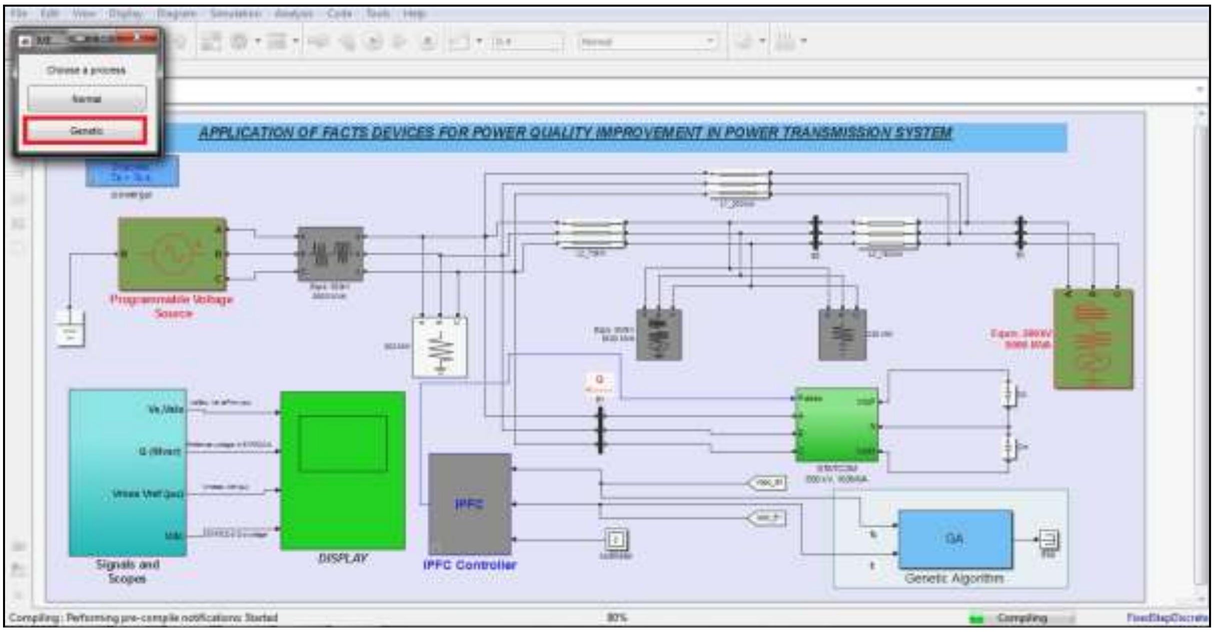

Figure 8: Simulation with GA

The simulation model using Genetic algorithm (GA) is shown in figure above.
The results obtained after the simulation are discussed below.

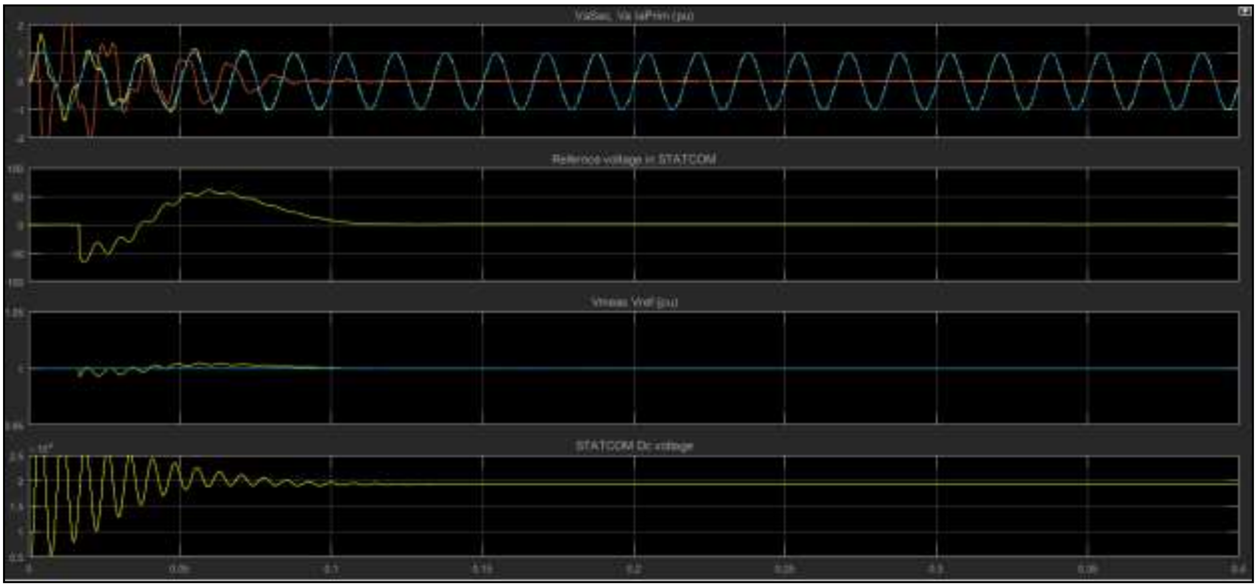

Figure 9: Voltage analysis of simulator

In the first part of figure, there are three signals which represent the primary and secondary voltage of STATCOM. The reference voltage of STATCOM is shown in the 2nd part of figure and it is use as a reference voltage which helps to STATCOM. The third part of figure is show the mean voltage with mean of reference voltage and at the last STATCOM voltage is given with more fluctuations. From the above figure it is clear that when genetic algorithm is applied the fluctuation in the voltage become stable.

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CODEN: IJESS7

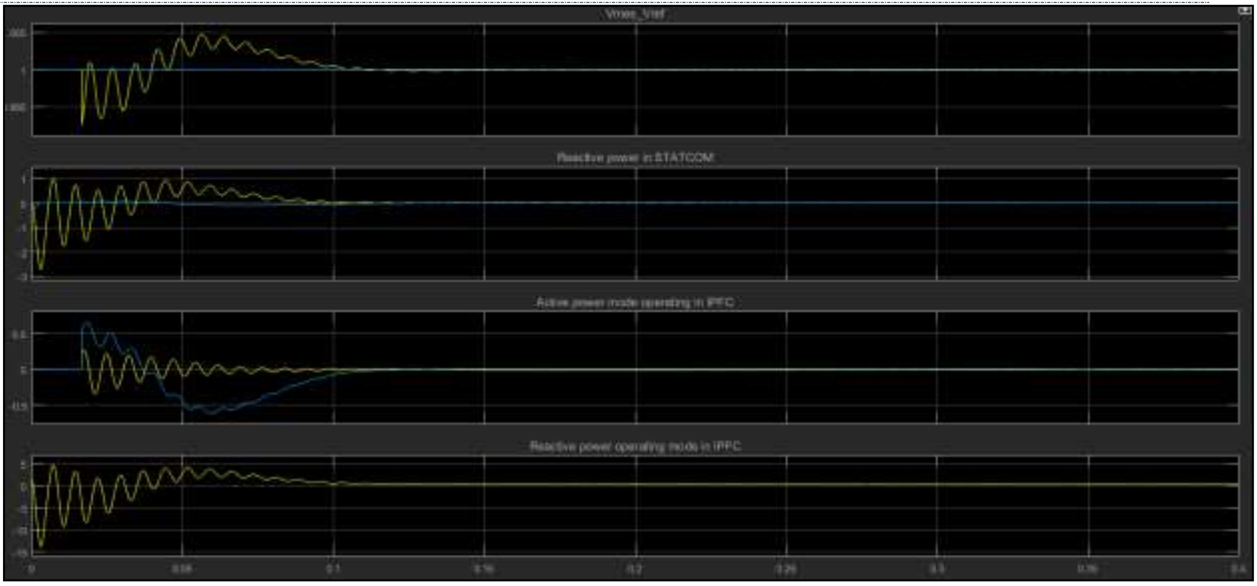

Figure 10: Power analysis of simulator

In the above figure, there are four parts representing Vmesh, Vref, reactive power in STATCOM, active power in IPFC and reactive power in IPFC. After time t=0.1 sec reference voltage become constant which is equal to 1 V. Reactive power measured for STATCOM is nearly equal to 0 volt. Active and reactive power of IPFC also becomes zero.

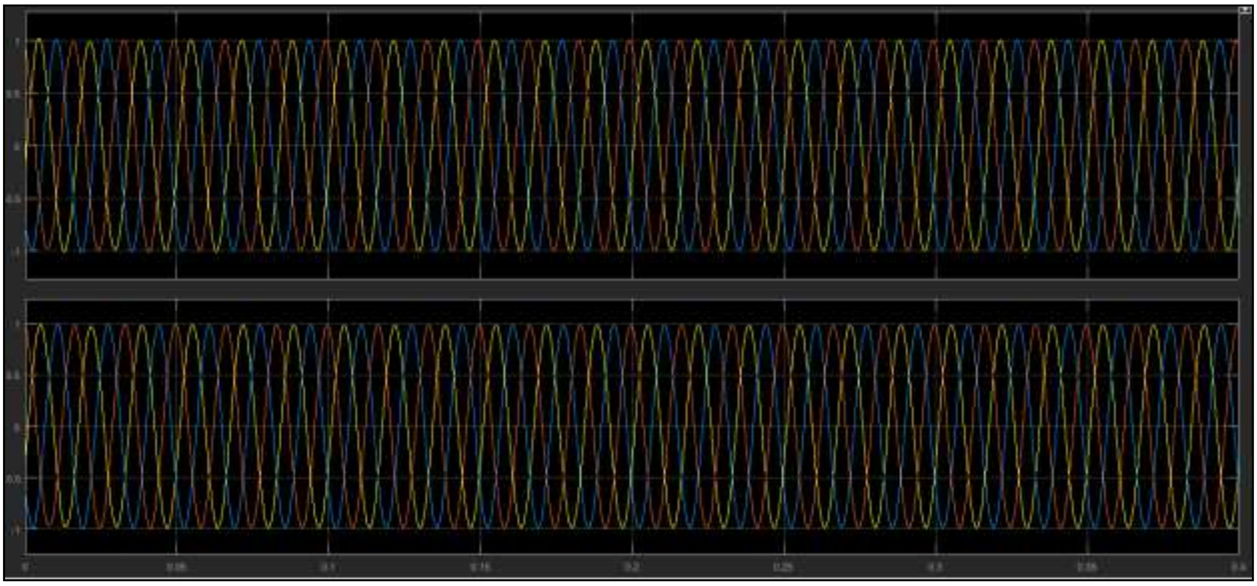

Figure 11: Performance analysis of simulation

Above shown figure represents the change in voltage with time and the fluctuation in voltage is reduced when genetic algorithm is applied in the designed model and the performance of the simulator is increased.

V. CONCLUSION

Different FACTS device scan be used to maintain the constant electricity transmission without the slur, degradation or low power factor. Hence the FACTS devices can be used to make power travel over a long distance in the transmission medium. In this research work, mainly two FACT devices named as STATCOM and IPFC are used to control the fluctuation of voltage and frequency which is varied due to the change in the load in the transmission line. To know the power loss three transmission lines are designed of different length. Simulation results depicts that the designed model is acceptable for the test system. It has been analyzed that after using the FACT devices (STATCOM, IPFC) the power loss in the transmission line decreases and the quality of power flow has been enhanced. In this research the FACT devices are positioned to the transmission loss test in order to minimize the active, reactive power loss and to achieve lowest voltage fluctuation. It has been concluded that the proposed model resolves the problem of power loss efficiency and thus increase the voltage profile.

With the use of the STATCOM and the IPFC controller the power line remained constant which is shown in the simulation results. The value of the active and the reactive power along with the voltage magnitude are shown. The outcome in the power quality graph showed that the performance of the STATCOM and the IPFC controller is much better and improve the power in accurate manner. To enhance the performance an evolutionary algorithm named as Genetic algorithm has been used. This reduced the power loss in the transmission line and increases the voltage level.

In the future different combination of the devices can be used to make the power in constant after the transmission. We can check the power losses in the transmission line by increasing the length of the transmission line and increasing the load.

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