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Enhancement of Power Quality in Transmission Network Using TCSC

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Abstract

The thyristor-connected series capacitor (TCSC) lowers transmission losses, boosts functional potential, and boosts the transmission community's overall power. In this post, the transmission group of the strength system is equipped with a thyristor switched collection capacitor. The system's performance in the presence of TCSC was investigated using a variety of strength machine fluctuations, such as voltage amplitude variance, weight turning off and on, output and synchronization of the generator with the grid, as well as voltage, energy glide, and impedance are taken as the variables. The tests are checked in the MATLAB/Simulink setting using a review gadget that is integrated with the TCSC. In the proposed method of TCSC the results are demonstrated the usefulness of this proposed TCSC method.

Keywords: Overhead Line, Stability of the Voltage, Active Control, TCSC, Power Device Network.

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1. Introduction

To meet rising demand of power, FACTS devices are introduced in the transmission line to enhance its power transfer capability either in series or in shunt. The series compensation is an economic method of improving power transmission capability of the lines. Series compensation will increase power transmission capability, improve system stability, reduce system losses, improve voltage profile of the lines, and Optimize power flow between parallel lines. To improve the energy transfer capability, a thyristor-controlled series capacitor is used to compensate for the inductive reactance of EHV/UHV transmission strains. It can also be hired to assist with voltage support, improving short balance, damping energy oscillations, energy waft manipulation, and sub synchronous resonance in the operation and control of strength devices. Mitigation, and a slew of other stuff [1][2]. In today's fashion, the line's reimbursement limit is somewhere between 25% and 75%. Multi-resonance issues can be avoided by selecting the appropriate level of reimbursement and TCSC parameters [3]. TCSC's main module. It has a parallel capacitor aggregate and a TCR department. The TCR branch is made up of a collection thyristor valve and an inductor. Anti-parallel related thyristors are used in the thyristor valve, allowing for bi-directional functionality. A transmission line is linked in series with the TCSC module [4].

Thyristor-controlled series capacitors (TCSC) is also a type of series compensator, can provide many benefits for a power system including controlling power flow in the line, damping power oscillations, and mitigating sub synchronous resonance [5]. The multifunctional capabilities of Flexible AC Transmission System (FACTS) devices paved new paths for controlling and enhancing the power transfer and usable capacity of transmission lines. The ability to enhance power transfers lead to their applications in a multi machine power system for the purpose of an overall reduction in power generation cost, among the others [6].

The optimal location and the parameters of Unified Power Flow Controllers (UPFCs) in electrical power systems. The UPFC is one of the most promising FACTS devices in terms of its ability to control power system quantities. Shunt FACTS devices are used for controlling transmission voltage, power flow, reducing reactive losses, and damping of power system oscillations for high power transfer levels [7]. In countries like India with fast growing demand of electric power it is difficult to extend the transmission system in time by either building new lines or by introduction of a new voltage level. Power is therefore transmitted through weak system leading to unsatisfactory quality and reliability of power supply. To achieve satisfactory quality and operational reliability of power, it has become clear that more efficient utilization and control of the existing transmission system infrastructure is required. Improved utilization of the existing power system is provided through the application of advanced control technologies. Power electronics-based equipment, or

Flexible AC Transmission Systems (FACTS), provide proven technical solutions to address these new operating challenges which are being presented today [8].

Transient stability and power flow models of Thyristor Controlled Reactor (TCR) and Voltage Sourced Inverter (VSI) based Flexible AC Transmission System (FACTS) Controllers. Models of the Static VAR Compensator (SVC), the Thyristor Controlled Series Compensator (TCSC), the Static VAR Compensator (STATCOM). The Static Synchronous Source Series Compensator (SSSC), and the Unified Power Flow Controller (UPFC) appropriate for voltage and angle stability studies [9]. Optimal power flow (OPF) model has been developed and analyzed with Thyristor Controlled Series Compensator (TCSC) for practical power networks using Newton's optimization technique. The minimization of total system real power losses is an objective with controlling the power flow of specified transmission lines.

This model has considered the optimal settings generators, transformers and TCSC devices. The optimal transmission losses and corresponding generation schedules with optimal TCSC setting parameters for different case studies have also been reported [10]. Modeling of the load has a significant effect in electrical power systems. The paper presents the effect of different static load models on the location of SVCs. Static load types, in which active and reactive powers vary with voltage in an exponential form, are used. The effect on voltage control of the appropriate location of the SVC for variable load conditions is investigated. For this purpose, each load is varied as a staircase and voltages are controlled at the desired levels by using the minimum number of SVCs [11].

FACTS devices are power electronics-based shunt or series devices that are connected to the power network and can improve the system performance and the quality of supply [12]. Proper placement of static VAR compensator (SVC) and thyristor-controlled series compensator (TCSC) reduces transmission losses, increases the available capacity, and improves the voltage profile [13]. Emplacement of the compensating FACTS (Flexible alternating current transmission system) device improves the existing power line performance. The transmission line parameters have been obtained and analysis has been done on that parameter. The results reveal that: The transfer capability of power and the profile of power line voltage are improved with compensating device [14]. The UPFC (unified power flow controller) is the most flexible and complicated tool in the power electronic. This has come out for controlling and optimizing the power flow in the electrical power system [15].

The word "custom power" refers to the use of power electronics controllers in a distribution system, for example, Flexible AC Transmission Systems (FACTS) for transmission systems. Specifically, to address a variety of power quality issues. Custom power ensures consumers receive pre-specified consistency and reliability of supply, just as FACTS increases power transmission capabilities and stability margins. Low phase unbalance, no power interruptions, low flicker at the load voltage, low harmonic distortion in the load voltage, magnitude and length of overvoltage and undervoltage within defined limits, acceptance of fluctuations, and weak factor loads without significant impact on the terminal voltage are all examples of pre-specified efficiency. Custom Power devices come in arrange of shapes and sizes [16].

By proper placement of the thyristor-controlled series capacitor (TCSC) in the transmission line regulates the power flow [17]. This represented the applications of the particle swarm optimization (PSO) to find the proper placing of FACTS devices to reach the maximum system load ability [18]. It presents the design of the TCSC regulator to regulate the shunt and series impedance, power and phase angle [19]. The detailed study of this simulation of FACTS devices stated in the power systems. For controlling of the active power and reactive power flow, the UPFC, SVC, TCSC and the phase shifter has been studied [20].

Some of the devices include the Active Power Filters (APF), Battery Energy Storage Systems (BESS), Distribution Static synchronous Compensators (DSTATCOM), Distribution Series Capacitors (DSC), Dynamic Voltage Restorer (DVR), Surge Arresters (SA), Super conducting Magnetic Energy Systems (SMES), Static Electronic Tap Changers (SETC), Solid-State Transfer Switches (SSTS), Solid-State Fault Current Latch (SSFCL). This paper is divided into five segments. In segment II the study of the test system has been studied. In segment III TCSC basics are specified. In segment IV the discussions about the simulation results. Finally, in segment V conclusion has been stated.

2. System Parameters

The flow diagram for testing the system which is used in the proposed study is shown in Fig. 1. These conventional generators are shown by the letters G1and G2. The G1 generator is attached to the bus bar line of B1 and the G2 of the generator has been attached to the bus bar line of B4. The T is the representation letter for the transformer in this figure. The table I gives the information of data for the transformer. The TRL1 and TRL2 are the two transmission lines which are connected in between the two different bus bar lines B1B2 and B3B4 respectively. The two-sequence impedance for the positive and zero are (0.1153+j0.3958) Ω/km and(0.4130+j1.2516) Ω/km respectively. The power transmission lines length are taken as 14 kilometers. The L1 and L2 are the two loads which are connected to two different systems through the different bus bars B4 and B5 respectively. The table II gives the information of data for the load. In between the two bus bar lines B2 and B3 the TCSC (Thyristor controlled series capacitor) has been attached.

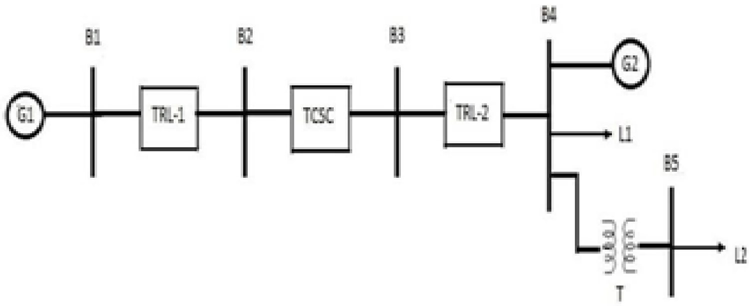

Fig:1.Flow diagram of the proposed test system.

TABLE I. TRANSFORMER DATA

Transformer	MVA	KV-High	KV-Low	HV winding		LV winding	
				R(Ω)	X(Ω)	R(Ω)	X(Ω)
XFM	100	550	33	0.3807	0.002	0.3807	0.002

TABLE II. LOADING STATUS

Load	KW Rating	KVAr Rating
L1	30	1
L2	30	1

3. Thyristor Regulated Series Capacitor

The TCSC (Thyristor controlled series capacitor) is a real-world method for changing the transmission line impedance quickly and continuously. It could be used to precisely regulate energy float on a transmission line, dampen inter- place intensity oscillations, mitigate sub synchronous resonance (SSR), and improve brief balance. The thyristor - controlled reactor (TCR) issued in parallel with the capacitor segments of the array capacitor bank by TCSC controllers.

Thyristor regulated series capacitor is a FACTS device which permits the gradual and continuous change in the impedance of the power system line. This has the prospective applications of precisely controlling the progress of power in the transmission line, power oscillations of dampening inter area, reduce the SSR (sub synchronous resonance) and increasing the stability of transient systems. The controllers of the TCSC use the TCR (Thyristor controlled reactor) in parallel with that of the capacitor sections of the capacitor banks which are in series with that section. Schematic figure of thyristor regulated series capacitor is displayed in the Fig.2. These integrations of the TCR with that of capacitor allows that capacitive reactance to provide the smooth control around the large range that switches the direction to the state from there the double direction thyristor pair conducts continuously and the inductive reactance is inserted into the line. The Thyristor controlled series

Capacitor is the capacitive reactance compensator which consists of the series capacitor bank shunted by the TCR in order to provide the smooth control variations in series capacitive reactance. Thyristor regulated series capacitor controller uses the thyristor-controlled regulator coordinates with different sections with the sequence of capacitor bank. These combinations which belongs to the TCR (Thyristor controlled regulator) and the capacitor which allows the reactance of the capacitance to be evenly operated across the large range from that they changed over the charge to the state. From that location the bi-directional thyristor pair conducts endlessly which is inserted into the suitable reactance to the transmission line. These units entitled in the TCSC are applied for the review purpose: The inductance of the TCR, the capacitance of the TCSC, the quality factor, the snubber reactance of the thyristor and the capacitance are gives as 0.043 H, 21.977e-6F,500, 5000ohm and50e-9F respectively.

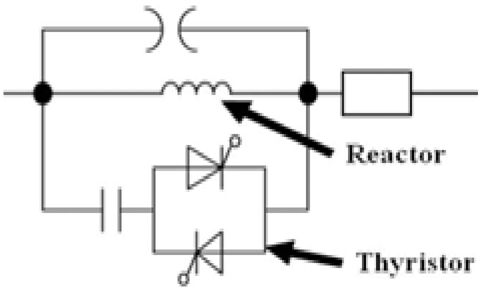

Fig:2. Schematic figure of the TCSC

4. Discussions About Simulation Results

These are the results of simulation which are related to the TCSC (Thyristor switched series capacitor) to increase the enforcement in power line network has been represented in these segments.VA is the voltage at phase-A, IA is the current at phase-A, PTCSC is the TCSC power flow, ZTCSC is the representation for the impedance of TCSC, VTCSC is the voltage over TCSC and Alpha is angle of the TCSC. In observation with these executions of TCSC these components are utilized. The components such as VA, IA, VTCSC, PTCSC, ZTCSC and Alpha are utilized in the graphical points with their unit representation. During the study of different cases these results are determined in the successive subsegments.

1). TCSC in Good Condition

This flow system that has been figured in fig.1 is replicated in the system in the absence of any type of disturbances. In the phase – A the voltage and current, in the TCSC the power flow, impedance, voltage and angle are displayed from map.3. The observations from map.3 are with zero disturbances for potential difference, electric current and the energy flow. These TCSC impedances tracks impedance is consistently trace the source impedance displayed frommap.3 (V). These graphical systems are displayed for map.3 will act as the source graphical systems to examine behavior of structure in different disturbances.

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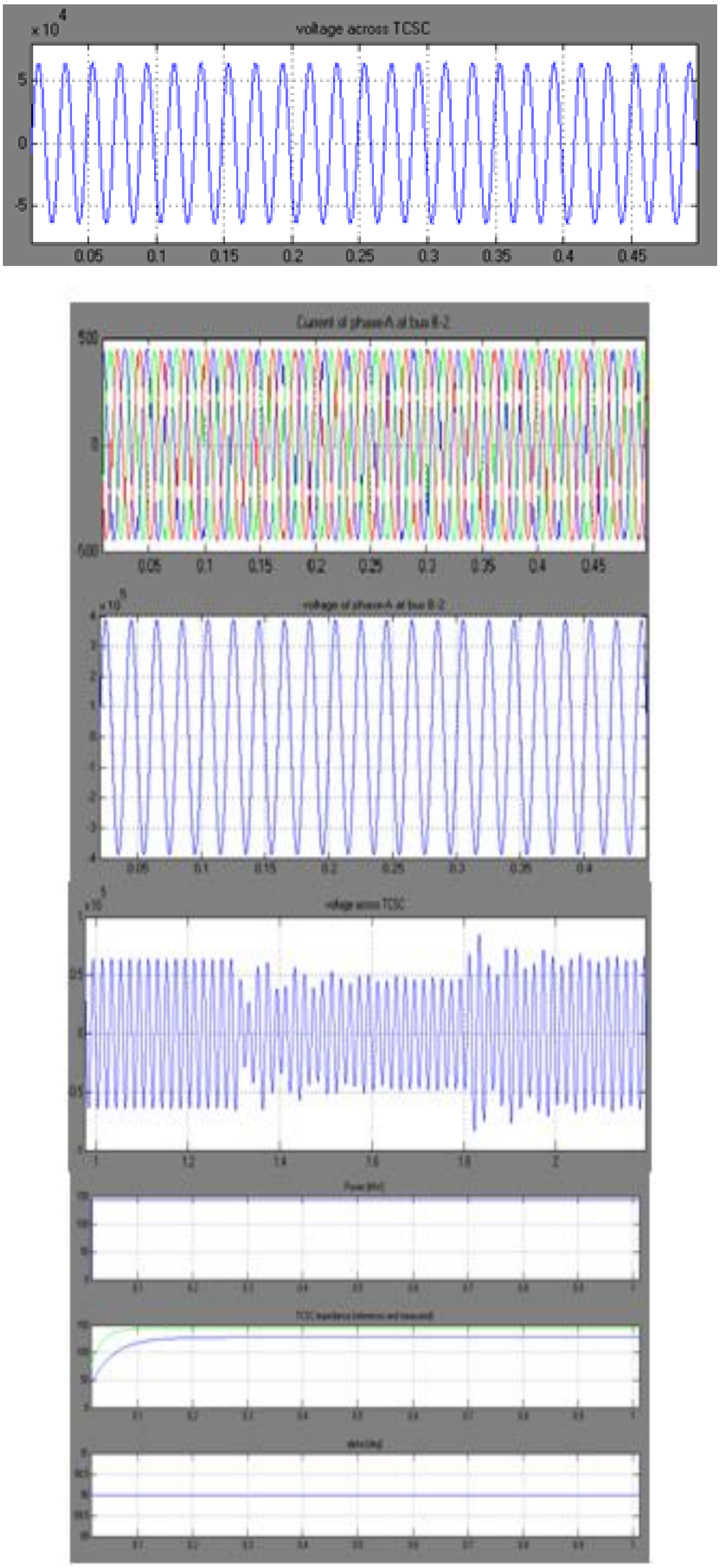
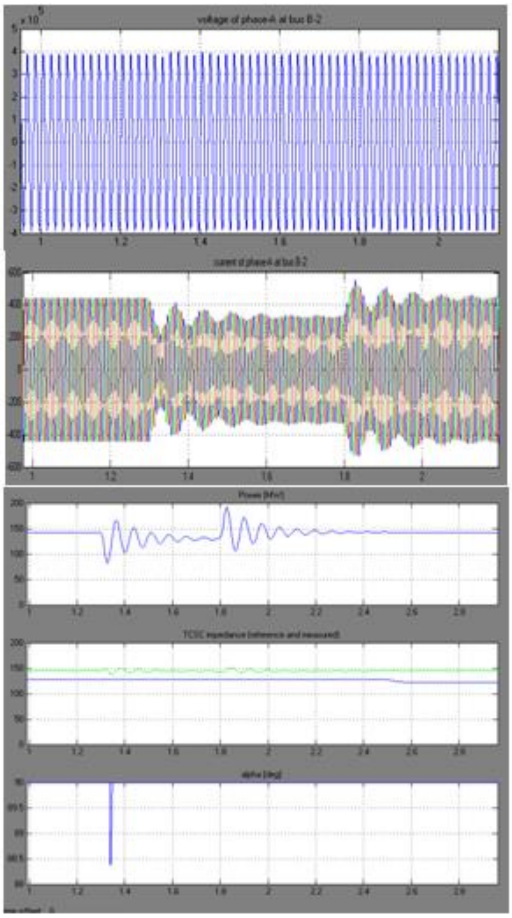


Map: 3. TCSC in Good Condition: (I) phase – A voltage at Bus bar B - 2, (II) phase – A current at Bus bar B – 2, (III) TCSC potential difference, (IV)TCSC power flow, (V) TCSC impedance and (VI) TCSC angle.

2). Variations of Generators Potential difference in Amplitude

These voltage amplitudes for generator G-1 changed in accordance with the sequence of time [1 1.3 1.8] that for magnitude of [1 0.96 1]. In the phase – A the voltage and current, in the TCSC the power flow, impedance, voltage and angle with that of variations in time of amplitude aredisplayedfrommap.4. From map.4 (V), we have to notice that the change of time in the amplitude and impedance converts but this TCSC regulates the impedances and lastly this impedance becomes identical with source impedance. This follows for controlling the flow of active and the reactive powers in the power line. From map.4 (IV) it has been observed that the variations in amplitudes are regulated by TCSC and uninterrupted power has flow in the network for maintenance. All these phase voltages that maintain the reference points, they are displayed by graphical systems of phase – A voltages are displayed for map.4 (I). These power system parameters are controlled as a manner in which the voltage across the TCSC changes. This below figure shows the potential differenceoverthyristorinmap.4 (III). To maintain this system Parameter the TCSC's angle regulates is as shown in themap.4 (VI).

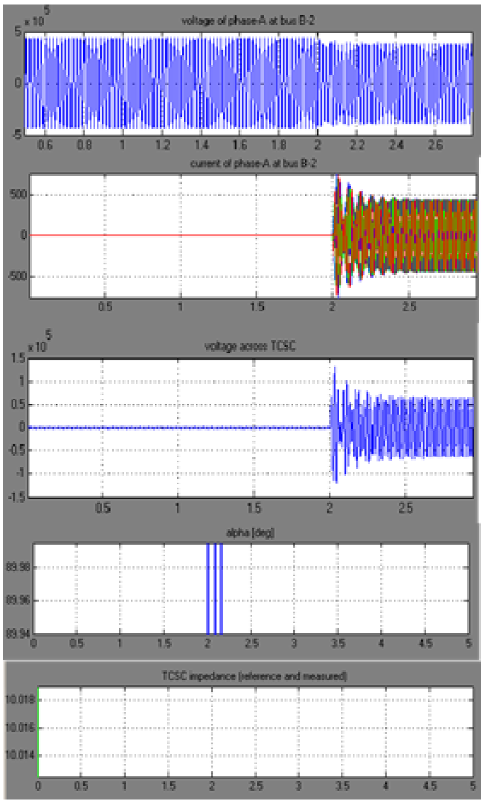


Map: 4. Variations of Generators Potential differences in Amplitude are:(I) phase – A voltage at Bus bar B - 2, (II) phase – A current at Bus bar B – 2, (III) TCSC power flow, (IV) TCSC impedance and (V) TCSC angle.

3). The output for Generator

From the start of the simulation at the 20th cycle the generatorG2 has been detached from bus bar B-4. The parameters like the phase – A the voltage and current, in the TCSC the power flow, impedance, voltage and angle with different variations in the time amplitude as displayed in map.5. Below map.5 (V), output of time has noticed for generator G-2 the changes for the impedances thus it is controlled by the TCSC and lastly impedances become identical for source impedances. These are the outputs that control the regulated movement for the active and reactive powers in the power line system. This extra power that is required to supply through the TCSC due to the output of the generator G-2. It has been seenfrommap.5 (IV)the extra power that is supplies throughout

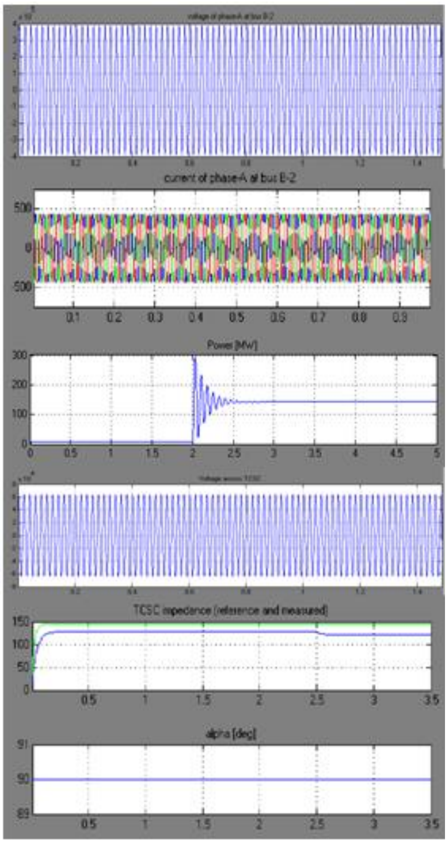
TCSC takes place immediately after output of generator occurs. In presence of TCSC these variations in the energy are unidentified. Thus, output for generator has low in magnitude voltage swells have seen and this is represented by the graphical systems of phase – A voltage is displayed in map.5 (I). To control these power system parameters likely voltage across the TCSC substitutes in such way. From the map.5 (III) it has been observed that these are the dissimilarities for potential difference over the thyristor. To maintain the system parameters like angle of the TCSC is also changes for the TCSC is also changes for the short duration that has been observed and shown in the map.5 (VI).



Map: 5. Output for generator (I) phase – A voltage at Bus bar B - 2, (II) phase – A current at Bus bar B – 2, (III) TCSC potential difference, (IV)TCSC power flow, (V) TCSC impedance and (VI) TCSC angle.

4). Turning the Load to the off state

In the loads of L-1 which is attached to bus bar B-4 that has been turned to the off state after the 20th rotation. The map.6 shows that the parameters like the phase – A the voltage and current, in the TCSC the power flow, impedance, voltage and angle with that of variations in time of amplitude are displayed from map.6. It has been observed from the map.6 (V) that the heavy substitutes take places in measure with impedances due to the output of load but these impedances have been controlled by the TCSC and lastly this impedance becomes identical for source impedances. These are the regulated outputs of active and reactive powers in the power system lines. The turning off of the load results in the energy flowing throughout TCSC a substitute for small durations, the identical is regulated by TCSC is displayed in map.6 (IV). From the map.6 (I), it shows that the potential difference for different cases regulated at their standards as displayed for graphical systems of phase – A voltage. In order to control these power system parameters, the potential difference over the TCSC substitutes identically. From the map.6 (III) it has been shown that the magnitudes with minimized variations in potential difference over the thyristor turning off of the load. To maintain this system parameters angle of TCSC substitutes for very less time 00 as displayed in map.6 (VI).



Map: 6. Turning the load to the off state (I) phase – A voltage at Bus bar B - 2, (II) phase – A current at Bus bar B – 2, (III) TCSC potential difference, (IV)TCSC power flow, (V) TCSC impedance and (VI) TCSC angle.

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5). Turning load to off state supplied through transformer

loads of L-2 which is attached to bus bar B-5. That bus bar B-4 attached along the transformer of symbol T that has been turned to the off state after the 20th rotation. From map.7 it notices that the parameters with the variations with the time of amplitudes for the phase – A the voltage and current, in the TCSC the power flow, impedance, voltage and angle are displayed. From map.7 it notices that different graphical systems in the transformer existence the significant changes may not see in the system parameters. This is an inductive element and capable of absorbing the transient components.

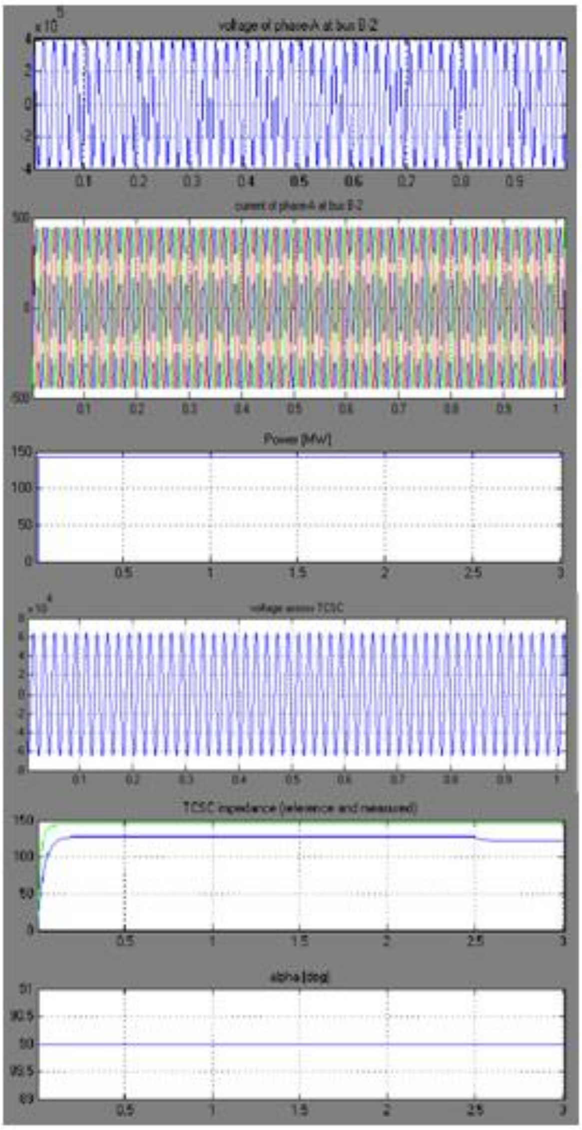
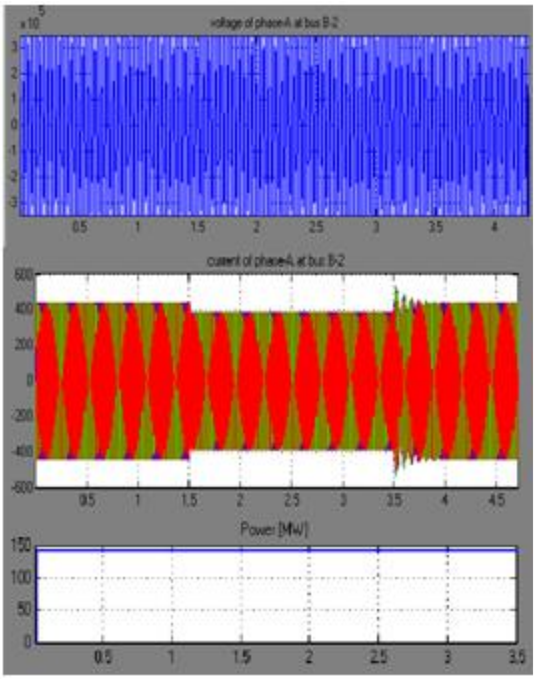


Fig:7. Turning load to off state supplied through the transformer (I) phase – A voltage at Bus bar B - 2, (II) phase – A current at Bus bar B – 2, (III) TCSC potential difference, (IV)TCSC power flow, (V) TCSC impedance and (VI) TCSC angle.

6). Switching on the Generator

The test system at the 20th cycle the generator G-2is connected and then bus bar B-4 is detached and recombined on the bus bar B-4 of the system from the start of the simulation. From the map.8 it has been observed that the parameters with the variations in time of the amplitude are the phase – A the voltage and current, in the TCSC the power flow, impedance, voltage and angle. The impedance changes for the long durations that at the time of switching on the generator G-2 this have been observed from the map.8 (V). Anyway, the impedance is controlled by the TCSC and lastly this impedance becomes equals to the reference impedance. This results in the regulated flow of the active power and the reactive power in the transmission line.

The generator G-2 has been switched on and that the power required by the loads L-1 and L-2 is supplied through the generator G-2. From the map.8 (IV) it has been observed that the power supplied through the TCSC decreases. Anyway, these variations in the power are observed for the longer durations. From the map.8 (I) the voltage variations are observed as indicated by the plot of the voltage of phase – A. To control the power system parameters the voltage across the TCSC changes in such a manner. From the map.8 (III) it has been shown that the variations in the voltage across the thyristor. Due to the switching's of the generator the TCSC angle also changes for the longer durations due to the large disturbances in the power system are as shown in the map.8 (VI).



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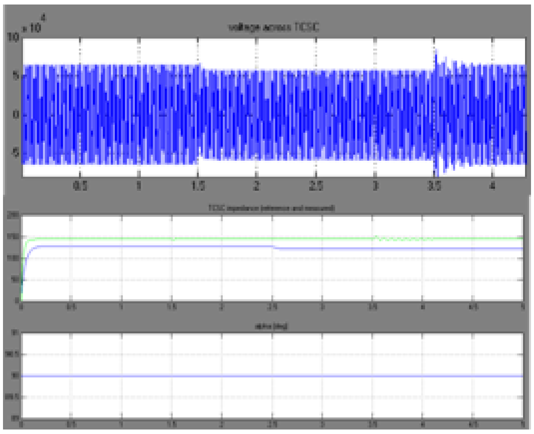

Map: 8. Turning on the generator (I) phase – A voltage at Bus bar B - 2, (II) phase – A current at Bus bar B – 2, (III) TCSC potential difference, (IV)TCSC power flow, (V) TCSC impedance and (VI) TCSC angle.

5. Conclusion

The use of a thyristor switched collection capacitor to improve the transmission network's electricity efficiency is described in this paper. The TCSC is connected to the transmission line's two components in a series configuration. Various types of strength system disturbances, such as loads witching on and off, outage, and generator grid synchronization, have been developed, and the parameters, such as voltage, electricity flow, and impedance, have been discovered. The existence of TCSC has been discovered to regulate the strength system parameters in order to make the gadget more durable. The simulation results show that the proposed TCSC is accurate.

The presentation of this paper is about the enhancement of the power quality in transmission system network of the power system. Thyristor controlled series capacitor has been incorporated in series with the double parts of the transmission line. The different types of power system disturbances such as turning on and off of the loads the generator output and the synchronization of grid been created. The parameters that have been observed are the voltage, the current, the power flow, impedance and the angle. Here, the TCSC controls the power system parameters. Because of this the system maintains more stable. The effectiveness of the proposed method is shown in the simulation results.

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