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Enhancement of Atbra –Port Sudan Transmission Line Using SVC and TCSC

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***Abstract**: Due to the ever increasing demand for power, economic and environmental constraints that limit the expansion and restructuring transmission networks, the transmission lines are prone to be operated under harsh conditions, and power systems to operate near peak limits. This research investigates different scenarios to enhance the power transfer capability of (Atbara-Port Sudan) transmission line as one of the national grid problems. Simulation was conducted using NEPLAN software, based on data given from Load Dispatch Center (LDC) in Sudan. National grid has been studied in peak and off-peak cases, to clearly represent the issue. All the results presented in comparison form to figure out the best case. Power transfer capability of (Atbara-Port Sudan) enhancing up to 50% of existing load by using TCSC beside SVC installed in Port Sudan.*

Keywords— SVC, TCSC, Atbra –Port Sudan Transmission Line, NEPLAN.

1. INTRODUCTION

Over the years the power consumption is increasing continuously due to population and industrial growth. To meet the predicted and un-predicted load demand; countries are more concentrated on installation of new power plants and associated transmission network for delivering electric power to the tail end for safe dispersal of electric power from supply to the load centers; stable transmission network is required[1]. Despite a good transmission lines, there are some serious problems relating to voltage, power factor and line losses owing to long line lengths and over loading. always voltage and Reactive power are directly proportional and therefore reactive power compensation is required to enhance system bus voltages, in addition power factor at various parts of the network is altered resulting in minimized the losses[2].Electricity is been generated from the generation station, needs to be transmitted to the consumers, through transmission and distribution lines [3]. There are no lossless transmission lines, but the capacity to transmit at minimal losses is what this paper concerns.

2. PROBLEM STATEMENT:

Supplying power from sources to consumer points produce loss in supplied power, especially when transport over long distances in addition to the high cost of construction line long distance transport.

Atbara – Port Sudan is a single circuit transmission line with a length of 448.92km and voltage level of 220kV.This line has witnessed considerable voltage drops leading to a decrease in the voltage at receiving ends in Port Sudan to about 20% below to rated voltage in addition to loss of power.

3. METHODOLOGY:

In order to achieve paper objectives NEPLAN simulation program has been used to cover the system before & after analysis of FACT devices (SVC and TCSC).

Static VAR Compensator (SVC):

The SVC built of a TCR in shunt with a bank of capacitors[4]. From the fundamental operational view, the SVC seems like a shunt-connected variable reactance, which either generates or absorbs reactive power to regulate the voltage value at the point of connection to the AC network[5]. It is extremely used to provide fast reactive power and voltage regulation support [6]. The firing angle control of the thyristor allows the SVC to maintain instantaneous speed of response [7].

SVC is based on thyristor without the gate turn-off capability. It includes separate equipment for leading and lagging vars; the thyristor controlled or thyristor- switched reactor for absorbing reactive power and thyristor-switched capacitor for supplying the reactive power.

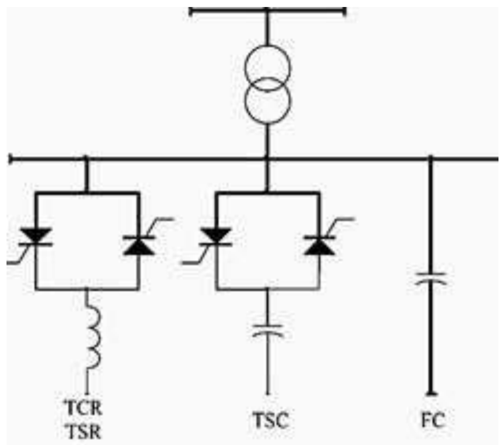

Figure 1: A schematic diagram of SVC.

Thyristor Controlled Series Compensator (TCSC):

It is designed depend on the thyristor based FACTS technology that has the ability to control the line impedance with a thyristor-controlled capacitor connected in series with the transmission line [8]. It is used to increase the transmission line capability by adding a series capacitor that mimize the total series impedance thus allowing more power to be transferred [8]. Thyristor Controlled Series Capacitor is a series compensation device which consists of a series capacitor bank in parallel with thyristor controlled reactor [9]. The fundamental idea beyond power flow control with the TCSC is to minimize or maximize the overall lines effective series transmission impedance, by inserting a capacitive or inductive reactive correspondingly. TCSC is one of the most effective FACTS equipment which offer soft and flexible control of the line impedance with quick response compared to the classical control devices [10]. TCSC can also improve the stability, the dynamic behaviors of power system, and increase the transmit capability of transmission line by reducing the transfer reactance among the buses in where the line is connected [11, 12]. However, to gain the above mentioned merits, the TCSC should be properly conducted in the grid with suitable parameter settings [10].due to that, some performance indicators must be attained, following factors can be considered in the optimal conduction of TCSC, the structure of the network, the stability margin enhancement [10], the power transmission capacity rising, and the power blackout protection [13].Figure 3.1: A schematic diagram of SVC.

4. SIMULATION AND RESULTS

- Case study description:

The Linkage system used in all Sudan electrical networks is high voltage alternating current transmission system. The link transmission system between Atbara station and Port Sudan Station of the longest distance lines (450 Km) in Sudan Electrical network and this is the main reason for the high losses in line; in addition the three-phase transmission line which connects between them consists of just one circuit.

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Figure 2:shows thetransmission line from Meroe Dam

Table 1: shows Atbara Port Sudan transmission line data.

Name	Length (km)	Nominal Voltage (kV)	Resistance (Ω/km)	Reactance (Ω/km)	Capacitance (μF/km)	Susceptance (μS/km)
ATB-POR	448.92	220	0.076	0.403	0.00902	2.834

- Simulation program:

NEPLAN program is one of the programs used to simulate power systems, and it was used to simulate the drop voltage and power loss at Atbara-Port Sudan transmission line exactly at load bus bar in Port Sudan station and it give us the result of adding FACT devices (SVC and TCSC).

- Atbara -Port Sudan Substation:

It consists from three transformational zones:

First zone fed directly from Marawe Dam by 500KV and convert it to 220 KV and second zone from 220KV to 110KV and the third one from 110KV to 33KV,and we are going to set (SVC) station at load bus.

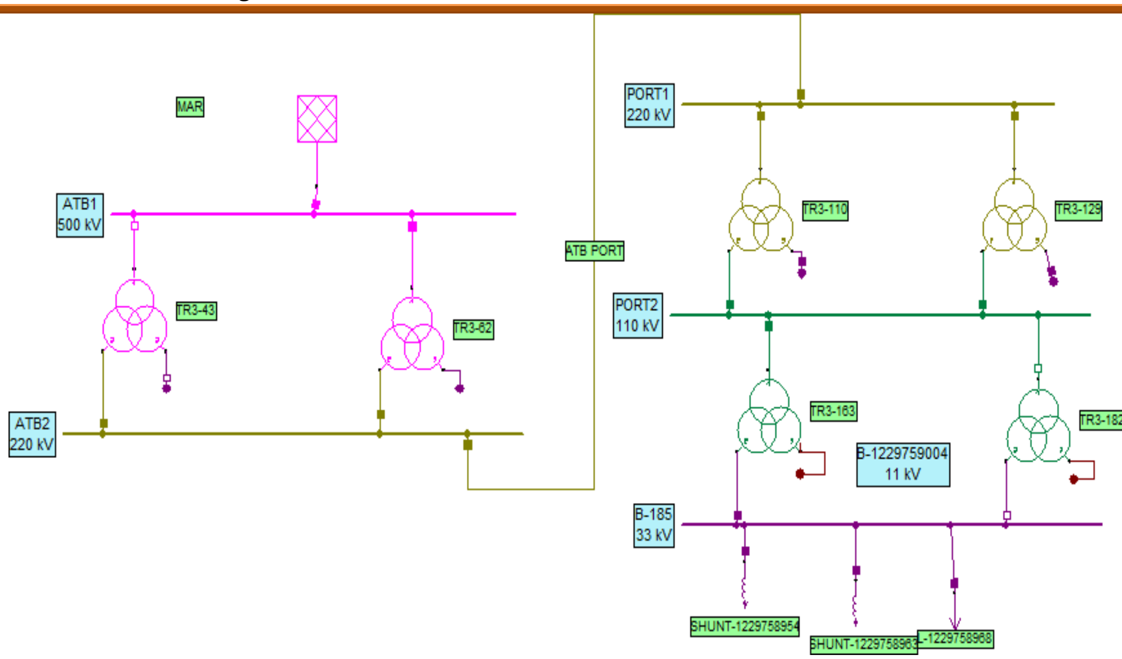

Figure 3: shows single line diagram of Atbara and Port Sudan substations, with ATB-POR transmission line

- The Results:

i. Atbra- Port Sudan transmission line during (light-load):

Program is used to simulate load flow during light load, the simulation is run and gives data in tables below.

Table 2: Atbara-Port Sudan Load Flow Results

BUS	PMW	Q(MVAR)	I(KA)
ATB220	62.78	-38.841	0.183
POR220	60	10	0.166
Ploss(MW)	2.78		
Q loss(M VAR)		- 8.841	
Loading%	19.52%		

Table 3: Voltage Profile

VOLTAGE		
ATB220	POR220	POR110
219.963	215.87	106.603

ii. Atbara-Port Sudan transmission line during maximum existing operating load:

Program is used to simulate load flow during maximum existing operating load, the simulation is run and gives data in tables below.

Table 4: Atbara-Port SudanLoad Flow Results

BUS	PMW	Q(MVAR)	I(KA)
ATB220	86.12 3	34.889	0.228
POR220	80	10	0.255
Ploss(MW)	6.123		
Q loss(M VAR)		- 4.545	
Loading%	29.98%		

Table 5: Voltage profile

VOLTAGE		
ATB220	POR220	POR110
217.915	188.854	92.365

As shown in Table 3 and 5 the voltage at POR bus is below the nominal value.

Proposed Solutions in case of maximum existing operating load:

- Install SVC at Port Sudan 110kVBus:

SVC unit is already installed and connected to Port Sudan 110kV bus through (33/110 kV) transformer. Program is used to simulate load flow after using SVC, the simulation is run and gives data in tables below.

Table 6: Atbara-Port Sudan load flow results

BUS	PMW	Q(MVAR)	I (KA)
ATB220	97.883	39.297	0.26
POR220	90	15	0.282
Ploss(MW)	7.883		
Q loss (M VAR)		8.931	

Loading%	33.21%

Table 7: Voltage profile

Voltage		
ATB220	POR220	POR110
217.683	187.508	92.404

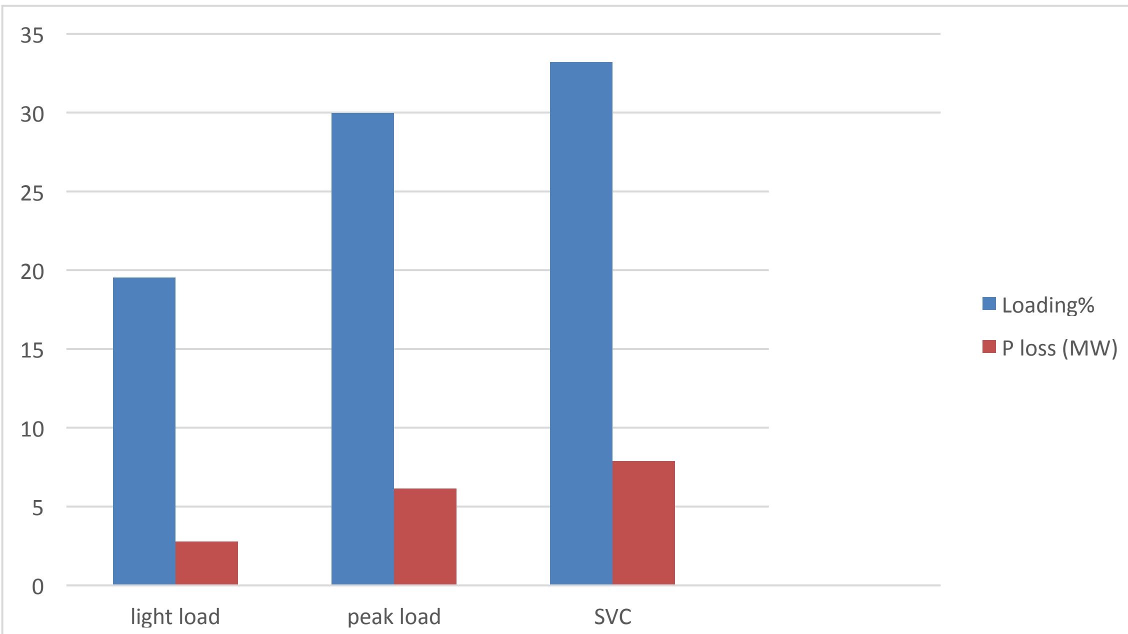

Figure 4: the line loading and ATB-POR transmission loss

- Install TCSC at ATB-POR T.L. Besides SVC:

One of the options to improve Atbara – Portsudan transmission line carry-ability is using of TCSC in the mid of the line beside SVC at Portsudan 110kV bus. The simulation is run and gives data in Tables 8and 9 show, load and losses and steady-state voltages, load in case of SVC plus TCSC.

Table 8: Atbara-Portsudan load flow results.

BUS	PMW	Q(MVAR)	I (KA)
ATB220	96.544	4.102	0.264
POR220	90	15	0.239
P loss (MW)	6.544		
Q loss (M VAR)		- 12.459	

Loading%	28.1%

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Table 9: Voltage profile

VOLTAGE		
ATB2 20	POR220	POR110
219.796	217.636	109.288

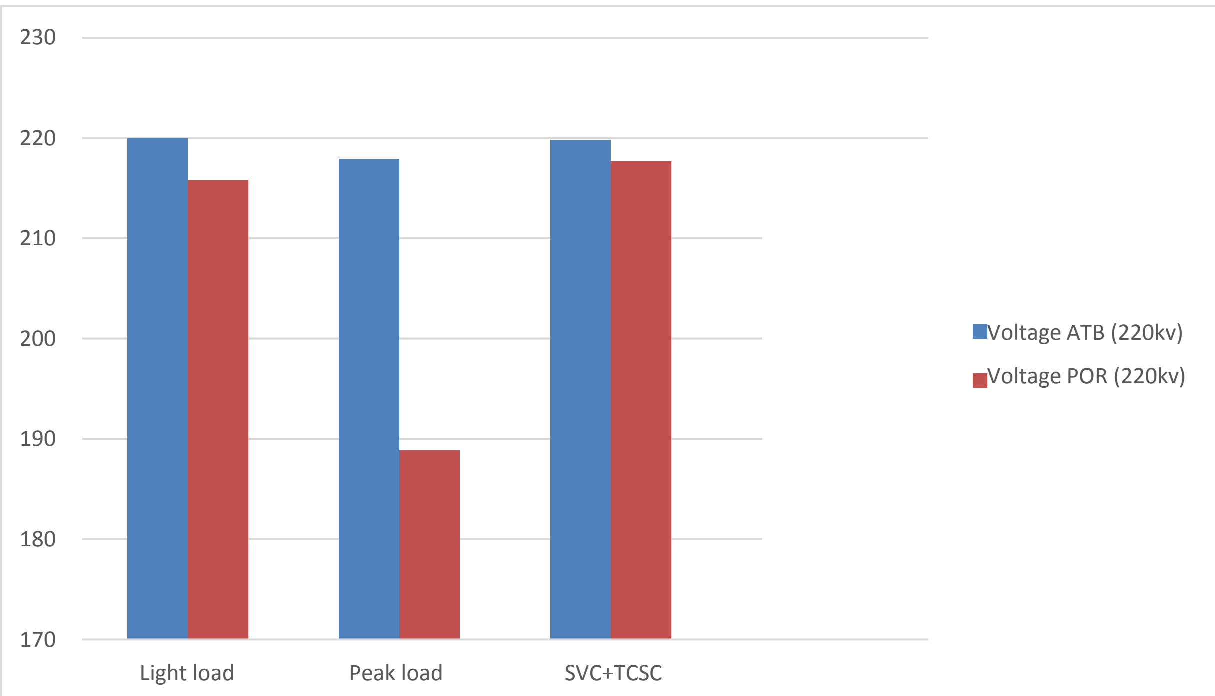

Figure 5: voltage profiles of ATB & POR.

5. CONCLUSION

This paper carried out extensive studies to Atbara - Port Sudan transmission line and explore the impacts of using SVC and SVC with TCSC , and attained the following: Reduce transmission loss, Enhance voltage regulation and Economic solution. sInclusion of FACT devices in ATB-POR transmission line increase the line carry-ability and improve the voltage profile at receiving end in Port Sudan.

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