Improving The Quality Of Energy Using Phase Shifting Transformer PST

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Abstract – the power flow is importing in transport of energy the transient stability. Power flow control of energy in system transmission have many problem ;a novel technologies are introduced. Flexible AC transmission systems (FACTS); like Phase shifting transformer (PST). PST aims at introducing voltage phase shift between sending and receiving of transmission line; the voltage phase shift is controlled by adding to the voltage of one end of transmission line a quadrature voltage component. In this paper we improving the quality and power flux by controlling the phase shifting between sending and receiving voltage bus; using PST controlling with thyristors (TCPST).we evaluate the control to obtain the max power flow in different status in network. For get optimal control we put our TCPST in a single-machine infinite-bus (SMIB) system. The results of different simulations realized under the MATLAB / Simulink.

Keywords — Phase Shifting Transformer, FACTS, Power Flow and Energy Quality, PWM-control, SMIB.

1 INTRODUCTION

The most importing in electrical network transmission to carry the max power this idea was developed by using flexible AC transmission systems FACTS devices. In the late 1980s, the Electric Power Research Institute (EPRI) introduces a new approach to solve the problem of designing, controlling and operating power systems: the proposed concept is known as Flexible AC Transmission Systems (FACTS)[1]. It is reckoned conceptually a target for long term development to offer new opportunities for controlling power in addition to enhance the capacity of present as well as new lines [2]in the coming decades. Its main objectives are to increase power transmission capability, voltage control, voltage stability enhancement and power system stability improvement.

This paper examines improvement of power flow system by use of thyristor controlled phase shifting transformer (TCPST); it is true that it is unusual to use TCPSTs in such a way, but if TCPSTs are already present in the system for other reasons (like the redirection of power flows according to agreements in deregulated markets) it possible to add a "transient-stability enhancement" module to the TCPST controller and in this way increase the transient-stability margin. The development of power electronics such thyristors, GTO………., could provide fast control of the active power through a transmission line . implies the potential application of these devices for damping of power system electromechanical oscillations. For a phase shifting transformer, the inserted voltage is in quadrature to the source voltage. By the development   of   thyristors   with   current extinguishing   capability,   all   solid   state implementation of power flow controllers could be

realized .TCPST have advantage to controlling power flow by adjusted phase shifting between voltage sending and receiving ; for more study our apparatus we introduces him in single machine in infinite bus (SMIB) .for the small signal stability studies of (SMIB) power system, the linear model of Phillips-Heffron has been used for years, providing reliable results [3]-[4].in this survey we look for the optimal max power flow and stabilization by using our system and controlling him. The proposed approach is illustrated through corrective action plan for a few harmful contingencies in SMIB system.

2 SMIB SYSTEM

The single machine in infinite bus system model developed by Heffron-Phillips

$$\frac{d\delta}{dt} = w_B(S_m - S_{mo}) \tag{1}$$

$$\frac{dS_m}{dt} = \frac{1}{2H}[-D(S_m - S_{mo}) + T_m - T_e] \tag{2}$$

$$\frac{dE_q'}{dt} = \frac{1}{T_{do}'}[-E_q' + (x_d - x_d')i_d + E_{fd}] \tag{3}$$

$$\frac{dE_q'}{dt} = \frac{1}{T_{do}'}[-E_q' + (x_q - x_q')i_q] \tag{4}$$

Electrical equation :

$$T_e = E_d' i_d + E_q' i_q + (x_d' - x_q')i_d i_q \tag{5}$$

Lossless network :

$$E_q' + x_d' i_d = v_q \tag{6}$$

$$E_d' + x_q' i_q = v_q \tag{7}$$

$$v_q = -x_e i_d + E_b \cos\delta \tag{8}$$

$$v_d = -x_e i_q + E_b \sin\delta \tag{9}$$

Park transformation :

$$i_d = \frac{E_b \cos\delta + E_q'}{x_e + x_d'} \tag{10}$$

$$i_q = \frac{E_b \sin\delta + E_q'}{x_e + x_q'} \tag{11}$$

3 Network Active And Reactive Power Transmission

Establishing the expression of power between two points 1 and 2 depending on the modules and phases of voltage and for the generalized case very beings

consider tita deferential zero $\emptyset = 0$.

$$P_{12} + jQ_{12} = \bar{V}_1 \bar{I}^* = \bar{V}_1 \frac{\overline{V_1^*} - \overline{V_2^*}}{R - jX} =$$
$$\frac{[V_1^2 - V_1 V_2 \cos(\emptyset_1 - \emptyset_2) - j\sin(\emptyset_1 - \emptyset_2)](R + jX)}{R^2 + X^2} \tag{12}$$

Expanding the numerator and matching real and imaginary parts of both sides, we obtain the desired relationship:

$$P_{12} = V_1^2 \frac{R}{R^2 + X^2} - V_1 V_2 \left[\frac{R}{R^2 + X^2} \cos(\emptyset_1 - \emptyset_2) - \frac{X}{R^2 + X^2} \sin(\emptyset_1 - \emptyset_2) \right] \tag{13}$$

$$Q_{12} = V_1^2 \frac{X}{R^2 + X^2} - V_1 V_2 \left[\frac{X}{R^2 + X^2} \cos(\emptyset_1 - \emptyset_2) + \frac{R}{R^2 + X^2} \sin(\emptyset_1 - \emptyset_2) \right] \tag{14}$$

By simple permutation of the indices 1 and 2, we obtain the expression of power entering the line side of Node 2:

$$P_{21} = V_2^2 \frac{R}{R^2 + X^2} - V_2 V_1 \left[\frac{R}{R^2 + X^2} \cos(\emptyset_2 - \emptyset_1) - \frac{X}{R^2 + X^2} \sin(\emptyset_2 - \emptyset_1) \right] \tag{15}$$

$$Q_{21} = V_2^2 \frac{X}{R^2+X^2} - V_2V_1 \left[\frac{X}{R^2+X^2} \cos(\emptyset_2 - \emptyset_1) + \frac{R}{R^2+X^2} \sin(\emptyset_2 - \emptyset_1) \right]$$

(16)

As $X \gg R$

$$P_{12} = \frac{V_1 V_2 \sin(\emptyset_1 - \emptyset_2)}{X}$$

(17)

$$Q_{12} = \frac{V_1^2 - V_1 V_2 \cos(\emptyset_1 - \emptyset_2)}{X}$$

(18)

$$P_{12} = \frac{V_2 V_1 \sin(\emptyset_2 - \emptyset_1)}{X}$$

(19)

$$Q_{12} = \frac{V_2^2 - V_2 V_1 \cos(\emptyset_2 - \emptyset_1)}{X}$$

(20)

4 Phase Shifting Transformer Basic Principle

Considering an ideal PST shown in Figure 1. The transformation ratio is a complex quantity

$$a = e^{j\emptyset}$$

$\emptyset$ or phase angle created by the PST[5].
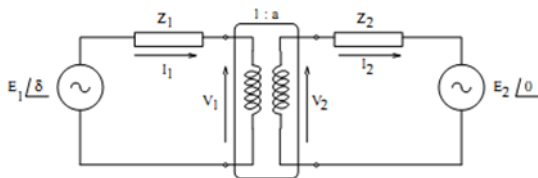
Fig. 1 PST connected to networks

From "fig.1" we have:

$$V_2 = aV_1 \; ;$$

$$I_1 = a^* I_2 = e^{-j\emptyset} I_2$$

(21.1)

(Note: the loss of power (active and reactive) without zero in the ideal transformer)

$$V_1 I_1^* = V_2 I_2^*$$

(21.2)

$$I_2 = \frac{V_2 - E_2}{Z_2}$$

(21.3)

From the equations (21.1) et (21.2) :

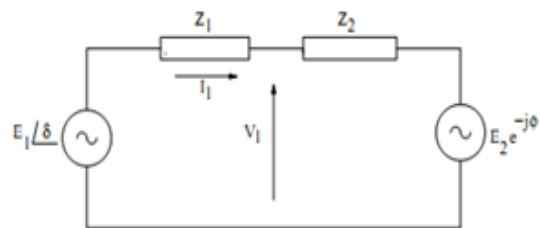$$I_1 = \frac{a^*(aV_1 - E_2)}{Z_2} = \frac{V_1 - a^* E_2}{Z_2}$$

(21.4)

Fig. 2 Equivalent circuit returned to the primary

Equation (21.4) shows the equivalent circuit of "Fig.2" If the power losses are negligible in the circuit.

$$Z_1 = jx_1 \quad , \quad Z_2 = jx_2$$

The transmission of power flow control and can increase using the equation:

$$P = \frac{E_1 E_2}{x_1 + x_2} \sin(\delta + \emptyset)$$

(21.5)

The rang of variation of $\emptyset$ PST

$$\emptyset_{min} < \emptyset < \emptyset_{max}$$

(21.6)

Generally limit $\emptyset$ without symmetrical around zero

$-\emptyset_{min} = \emptyset_{max}$, then then the limits are related to the transformation ratio of PST.

Consider that :

$$e^{j\emptyset} \simeq 1 + j\emptyset \qquad (21.7)$$

The electronics power development and the combination with hardware network makes the control of PST can realize with a thyristor TCP ST see "Fig.3" (thyristor controlled phase shifting transformer) ,
the control of phase shift to follow the load change and get max of active power.
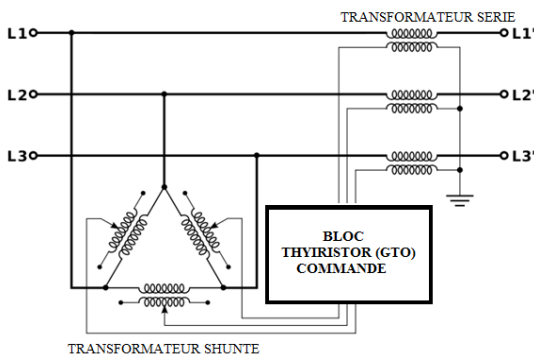

Fig. 3 TCPST

5 Methodology Of The Study

In this search after modelling the phase shifting transformer, installed and studied in SMIB with different angles[8] .since the analysis of IEEE 14 bus network voltages, phases and power flow indicated in "Fig. 3", "Fig. 4","Fig. 5","Fig. 6" and "Table. I " we try to introduce phase shifting transformer in network In order to improve their behavior of active power side.

In this study, a 7% nominal impedance of the phase shifting transformer was used. The transformer size was 50MVA which was based on the maximum power expected to flow through the 110kV line 3_4. This power takes into account the future loads during the normal as well as the abnormal or contingency

Operations[6]-[7].

TABLE I

PHASE SHIFT IN BUSES

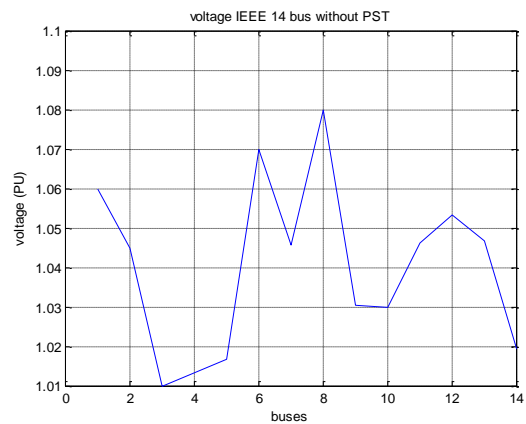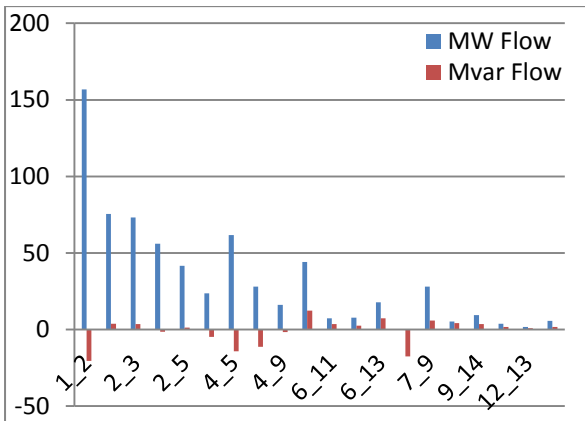| BUS	ANGLE DEGREE
1	0
2	-4.9891
3	-10.242
4	-10.242
5	-8.7601
6	-14.4469
7	-13.2368
8	-13.2368
9	-14.8201
10	-15.0360
11	-14.8581
12	-15.2973
13	-15.3313
14	-16.0717

Fig. 4 Bases voltage (pu)
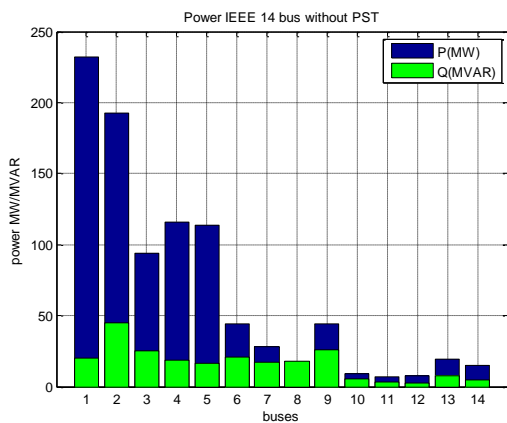
Fig. 5 Power flow in IEEE 14 bus (branch)

Fig. 6 Active and reactive power in buses

6 Result And Discussion

The results of the network studies are discussed in this section and displayed in a graph format. Application of different phase shift in our system introduced several result of power transmission impact. The first phase shift applied is 8° the active power increased in majority buses but in 1,2,7 active powers are low than without PST, this leverage isn't handsome for our system this test is showing in

"fig. 7".

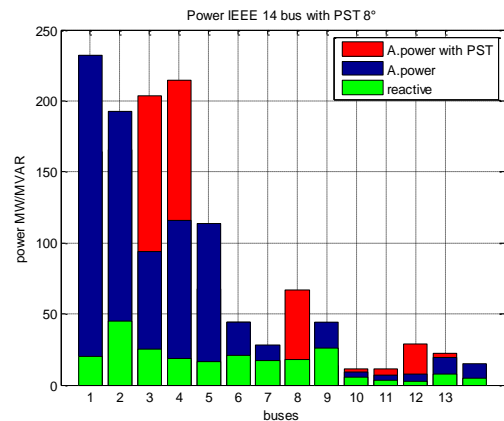Before starting we consider : voltages stable and their module steady.

Fig. 7 Active power with PST 8°

A-PST in system with 8°

The first observation the active powers in buses 3 and 4 were PST installed are increasing and also sway at other buses. Therefore they are grow more than 50% in branch 3_4 of initial value.

B-PST with different phase shift

To better understand our system the next experience offered in this section.
Different phase shift in order to get optimal PS (phase shift) and also set the command variation rang to this network.
This experiment showing in "fig. 8".In our case when PS positive the power broad than initial state by cons in opposite case (PS negative) powers less than pervious case. When PS = 2° for this state network was the optimal point regulation "fig. 9".
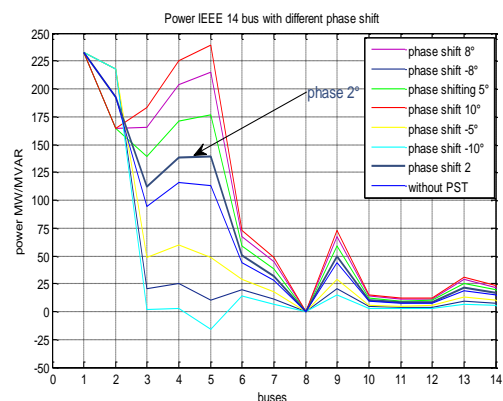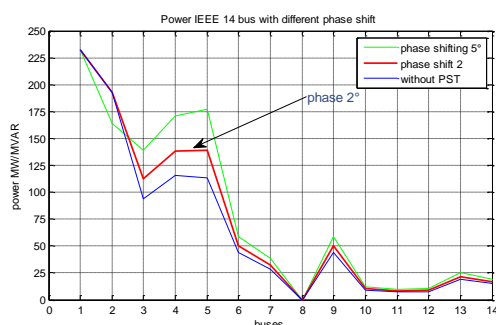

Fig. 8 Different phase shift

Fig. 9 Optimal regulation of PST

7 Conclusion

The results of study shows that the phase shifting transformer can be used to increase and low the active power transmission in network.

The angle that phase shifting transformer exploits at should cautiously be picked since the more power that is permissible to pass via the transformer will worsen the voltage on the primary side of transformer and destroy equipment.

The phase shifting transformer ought not be connected where the primary side is directly purveyance customs.

Even though the phase shifting transformer can improving power flow attentive account should be wrought when selecting the rang of the phase angle a some angle may break down the active power of network.

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