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Optimal Location of TCSC Device for Congestion Management using Fuzzy Logic

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Abstract —In modern world, congestion is one of the challenging task in power system deregulated market. In transmission line, congestion occurs due to the insufficient capacity to satisfy all constraints for transmission line. In this paper non cost free method is used to relieve congestion management using TCSC (FACTS) devices. TCSC devices improves stability of power system network, controlling power flow & reduces the cost. In this paper Fuzzy logic optimization technique used for the location of TCSC (FACTS) device, their type & rated value of the devices. load flow study performed on IEEE 14 bus system using N-R method

Keywords-. Congestion Management, Deregulated electricity market, TCSC Device, N-R Method, Fuzzy Logic.

I. INTRODUCTION

Congestion occur in transmission line due lack of coordination between generation & transmission line utilities. In recent area, there is more expansion & increasing demand of electricity. Electrical Power generation has a bigger challenge to meet the growing demand for more power. To meet the increasing demand ensuring adequate availability and reliability with safety. Congestion Management is the process to relieve congestion in transmission line.

There are two types Methods are used to relieve congestion:

A) Cost free method:

- Out-ageing of congested lines
- Operation of transformer taps/phase shifter
- Operation of FACTS devices

B) Non Cost Free Method:

- Re-dispatching the generation amounts. By using this method, some generators back down while other increase their output. The effect of re-dispatching is that generators no longer operate at equal incremental costs.
- Curtailment of loads and the exercise of load interruption options

Among two methods we are using Cost free method. In this method GENCO & DISCO will not be considered.

This Paper objectives is the optimal location of TCSC device for relieve congestion management in deregulated market. The sensitivity factor to be considered to location of TCSC device using Fuzzy logic. Fuzzy logic applied to range of optimization & learning problems in domain.

II. TCSC Device

The Thyristor Controlled Series Capacitor (TCSC) belongs to the Flexible AC Transmission Systems (FACTS) group of power systems devices. A TCSC is a series-controlled capacitive reactance that can provide continuous control of power on the ac line over a wide range. The principle of variable-series compensation is simply to increase the fundamental-frequency voltage across an fixed capacitor (FC) in a series compensated line through appropriate variation of the firing angle α.

A TCSC consists of a fixed capacitor in parallel with a variable inductive reactance as shown in Fig. 1. This variable inductive reactance is obtained by connecting back to back thyristors in series with a fixed-reactance inductor, and is known as a Thyristor Controlled Reactor or TCR. By controlling the trigger angle of the back to back thyristors

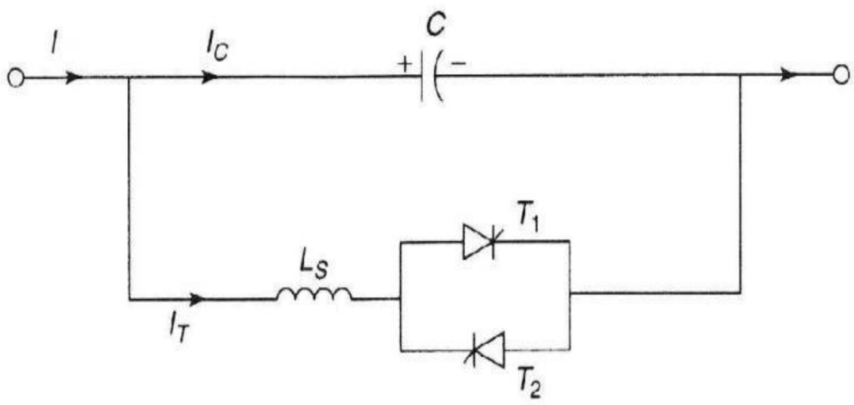

Figure 1 TCSC scheme

The variable inductive impedance XL(α):-

XL(α) =XL 180/(180-2 α- Sin2(α)) , XL ≤ XL(α) ≤ α.

The impedance of TCSC:-

XTCSC(α) = XL(α)*Xc/(XL(α)-XC)

The effective reactance of TCSC operates in three region:-

1. Inductive region:- 0 ≤ α ≤ αLlim.
2. Capacitive region:- αClim ≤ α ≤ 90.
3. Resonance region:- αLlim ≤ α ≤ αClim.

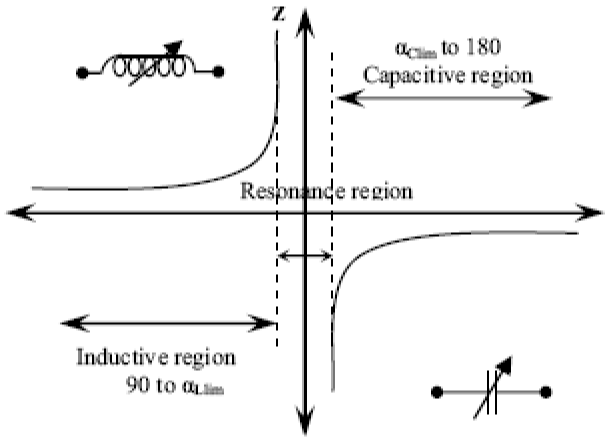

Fig.2 impedance characteristic

III. Modelling of TCSC device

Power Injection Model can be used for congestion management using FACTS devices. a device that injects a certain amount of active and reactive power to a node, so that the FACTS devices are presented as PQ elements. A transmission line represented by its lumped equivalent parameters connected between bus-i and bus-j. Let complex voltages at bus-i and bus-j with angle are and, respectively.

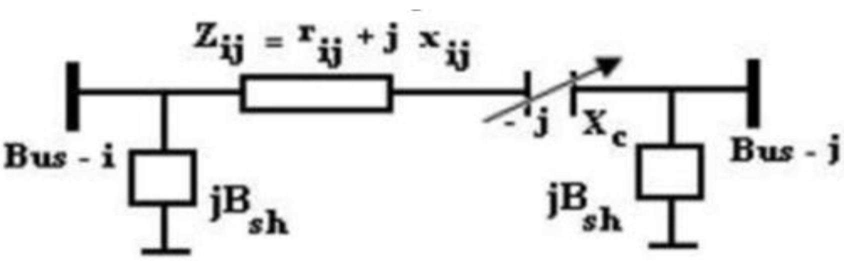

Fig.3 Modelling Of TCSC

Model transmission line with tcsc device between bus i to bus j

Pij = V^2 i *Gij' –Vi Vj [Gij' cosδij + Bij' sinδij] (1)

Qij = -V^2j *(Bij'+Bsh) –Vi Vj [Gij' sinδij –Bij' cosδij] (2)

Where,

Gij=rij/(rij^2+(Xij+Xc))^2

Bij= -(Xij-Xc)/(rij^2+(Xij+Xc))^2

TCSC Steady State Model

Thyristor Controlled Series Capacitor (TCSC) is an important FACTS component that is able to alter the value of the transmission line reactance by adding either a capacitive or inductive component to the main transmission line reactance as shown in Figure 2. In this study, the reactance of the transmission line is adjusted by TCSC directly. The rating of TCSC depends on the reactance of the transmission line where the TCSC is located.

XTCSC =rTCSC .XLine

where XLine is the reactance of the transmission line and **r**TCSC is the coefficient which represents the degree of compensation by TCSC. To avoid overcompensation, the working range of the TCSC is chosen between **(-0.8X line and 0.2X line**). By optimizing the reactance values between these ranges, Optimal setting of reactance value can be achieved

IV. N-R Method load flow study

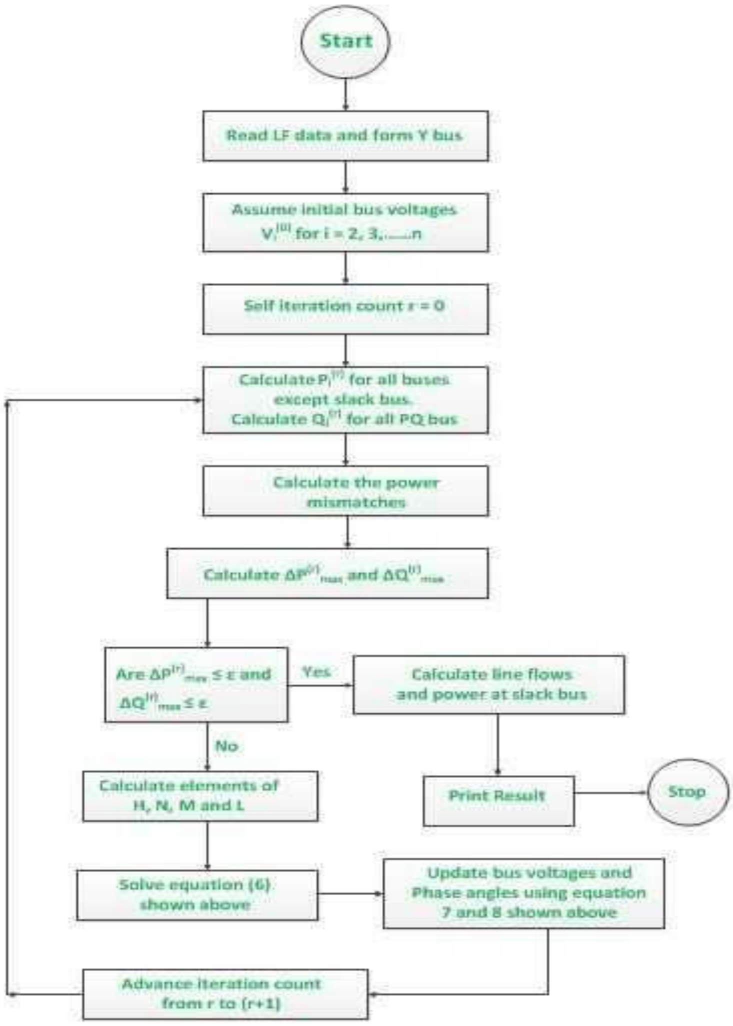

Fig.4 Flowchart N R method

V. Case Study

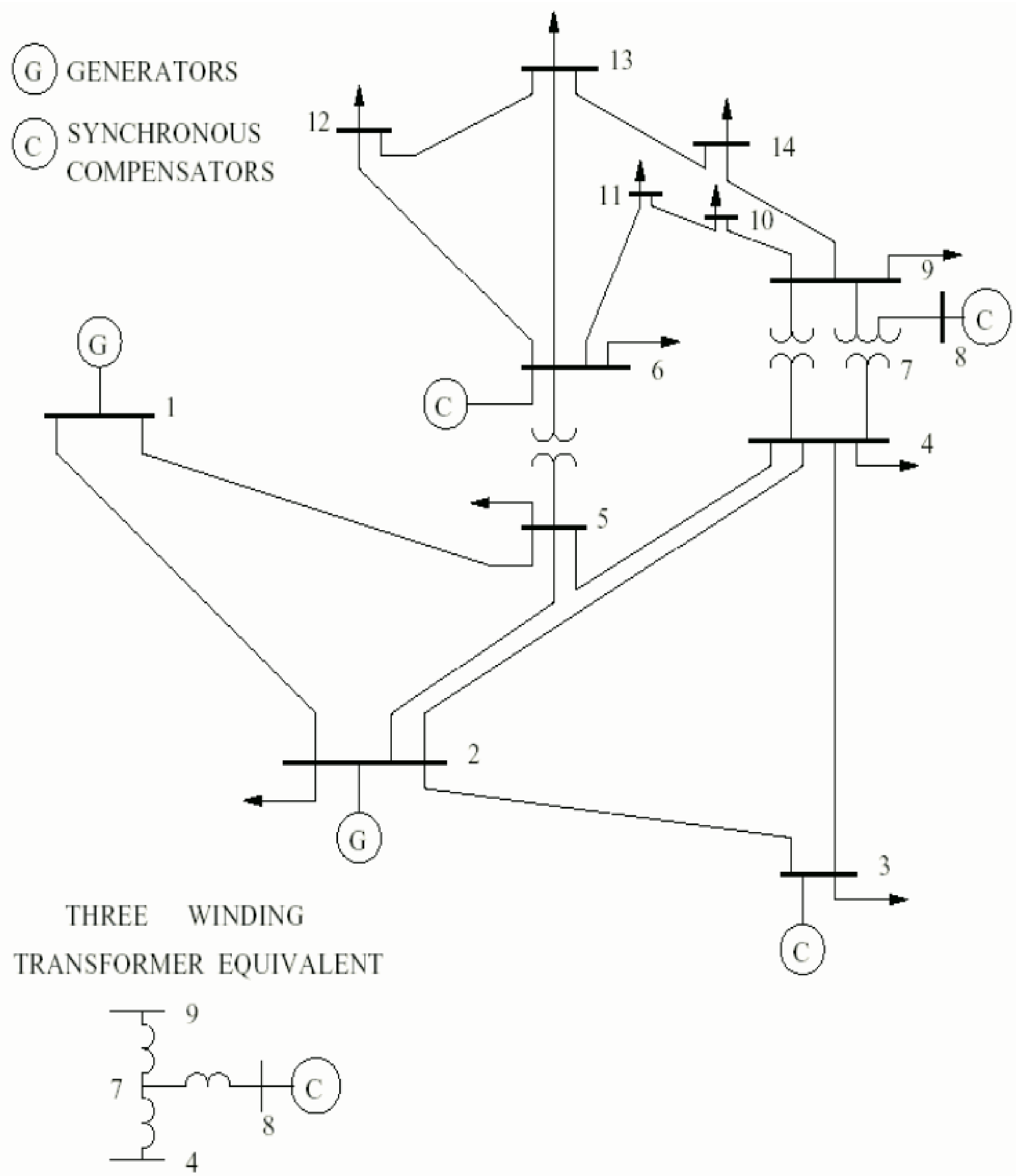

Figure 5 IEEE 14 bus

Consideration & calculation to decide voltage sensitive bus

The term voltage sensitive is with regards to voltage stability. For the selected IEEE 14 bus system it is to be decided now which are most sensitive? To decide voltage sensitivity of the busses, the load bus increases from base load to 2 times the base load (**P**load & **Q**load are increases)

Table.1 Without TCSC device

Bus N0.	Active power	Reactive power	Voltage	Theta
1	4.937229	-0.38901	1.06	0
2	-0.034	1.298224	1.045	-11.1469
3	-1.884	0.695891	1.01	-27.1395
4	-0.956	-0.078	0.989139	-20.8648
5	-0.152	-0.032	1.000629	-17.7372
6	0.177	0.83014	1.07	-26.6582
7	0	0	1.008438	-26.3846
8	0	0.504698	1.09	-26.3846
9	-0.57	-0.332	0.971348	-29.3365
10	-0.18	-0.116	0.97223	-29.4535
11	-0.07	-0.036	1.012416	-28.2624
12	-0.122	-0.032	1.034073	-28.5438
13	-0.27	-0.116	1.018076	-28.7353
14	-0.298	-0.1	0.95198	-31.3634

VI. Fuzzy Logic

Fuzzy logic was created by Lotfi Zadeh in the 1960s (Zadeh 1965). Fuzzy Logic represent the knowledge using a linguistic or verbal form, but at the same time to be operationally powerful so that computers can be used. According to the situations, rules are established and necessary actions to a solution are determined The relationship functions of these variables are shown in Table.

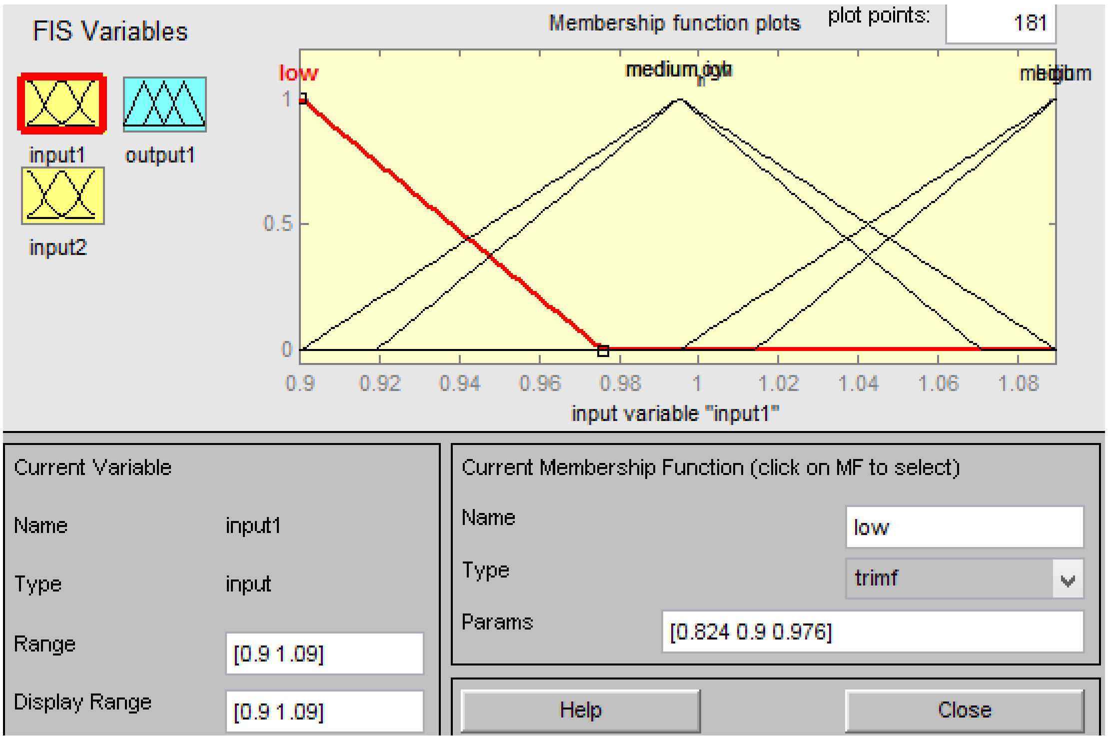

Fig.6 Fuzzy Logic Simulink model

Those variables indicate lack of FACTS devices in the power system network and determine the allocation sensibility degree of each bus.The fuzzy rules are established by considering first two extreme situations

1. If low bus voltage and high Power loss, where FACTS devices essential.
2. If high voltage and low power loss, where FACTS devices low attribute.

Fuzzy Logic approach for FACTS device location

1. Calculate bus voltages, power considering power system without FACTS device using N R method.
2. Bus voltage (BV) is defined for each bus and power loss(PL) is determined
3. Apply fuzzy logic to determine the subgroup of bus in which the FACTS device locations have more advantages.

Table No.2 Fuzzy Rules

Voltage / Power loss	low	Medium low	medium	Medium high	high
Low	medium low	medium low	low	low	low
Medium low	medium	medium low	medium low	low	low
Medium	medium	medium	medium low	low	low
Medium high	medium high	medium high	medium	medium low	low
High	high	medium high	medium	medium low	medium low

VII. Results

The optimal placement of tcsc device on sensitive bus voltage no.4 & line between 2&4.

& also sensitive bus no. 14 & line between 13 & 14. By using fuzzy logic tahe tcsc device value should be -0.437 & -.0567 respctively**.**

Table 3 comparison between without TCSC & with TCSC

	Without TCSC Device	**With TCSC device**
Voltage (bus .4)	**0.983**	**0.9921**
Voltage (bus.14)	**0.95198**	**0.9718**
Total power loss	**0.577**	**0.523**

VIII. Conclusion

Congestion management is an important issue in deregulated power systems. FACTS devices such as TCSC by controlling the power flows in the network can help to reduce the flows in heavily loaded lines & reducecost of the power system Network. The power flow control with the TCSC is to increase or decrease the overall series transmission line impedances.for facts devices location to relieve congestion using fuzzy logic results of tcsc device parameters. Test results should be IEEE 14 data. Optimise determined by Fuzzy logic tool in MATLAB.

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