Cost Allocation Of Transmission Line using Fact Devices

K. Sarada, S S Tulasi ram, V. Bala Shweta,

Abstract*: *This paper presents the cost calculation when their cost calculation. Different FACT devices are used to compensate the real power lagging in the available transmission systems. The FACT devices are SVC and UPFC different values are obtained at different placements and loading situations. IEEE- 5 bus system as standard test is used for the study of the reactive power at different situations. Optimisation of power using FACTS devices is easy and the line becomes healthy with less losses. The main impartial ofcurrent study is towards decreasing active power losses, system working cost plus the price of FACTS devices and congestion in transmission system. As cost is main factor to be considerable in all the conditions. It has been observed that by optimal placement of FACT devices with consideration on transformers and different tap changers in the transmission line gives good power flow in the line and the congestion in the lines is controlled.

***Index Terms*: Cost allocation, Static var compensator, Unified power flow controller.**

I. INTRODUCTION

Transmission lines are one the most important element to distribute the required power to the industries and to the household appliances. All the transmission lines are either over loaded or under loaded when considered the line capacity. The causes for over load to the transmission line is may be due to the unplanned generation like sudden political meets in the area or any other procession which starts suddenly. This leads to the transmission congestion and fluctuations in the line and the losses in the line are exceeded. So, to maintain the transmission congestion and the voltage in the line is one of the stimulating tasks. This can be controlled or reduced by reactive power compensation at the weak nodes transmission line. This will improve the profile of line and both the steady state and dynamic conditions are reduced. Flexible AC transmission systems have the capability in the present situation to overcome the problem faced and the loadability of the line is also increased. By employing proper FACTS devices at both ends of the transmission line at both the ends as the power flow in the lines is the function of voltage and the required reactive and active power can be compensated by advanced FACTS devices.

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FACTS were the concept that is first introduced by Hingorani [1]. FACT device is solid-state converters which are proficient of controlling many factors in the transmission lines. In what way the FACT devices can enhance the power flow in transmission line is illustrated in [2]. Secured area is identified and then perceptive based changes are done in the system [3]. The location for the placement of FACT devices is discussed and is given in [4]. FACTs controllers are used to enhance the power flow in the transmission system. Power flow and controlling in the lines is discussed by Goutham and Heyty [5]. Locating the perfect place to place the FACT devices and to reduce maximum cost for system was the main objective of Lie and Degn [6]. Different approaches to find the optimal allocation of the devices was presented by Xiao et al. [7]. Proper placement of FACT devices and minimization of cost was deliberated by Singh and David [8]. Series FACTS controllers can be reused to raise the power transmission capability in a steady state condition [9]. The basic of choice of FACT devices is connected in power network is discussed and the allocation of devices is decided programing based allocation is used [10]. Programing based allocation is optimal assignment for devices is placed in the network [11]. The difficulties in the system were recognized and the optimal placement of UPFC in the system is done [12]. A probabilistic method was used to place the device in the correct place [13]. A relative analysis of different methods was used to place the device at a position according to the sizes and cost [14]. A suitable solution for the placement of UPFC in the network was presented in [15]. Neural losses perfect for the resolve of optimal number and place of FACTS devices labeled by Rahimzadeh et al [16]. This technique is useful for medium and large scale system. Actual coded genetic algorithm (GA) is applied for the optimal locations of FACTS devices in are connected power system for the improvement of available transfer capacity in [17]. UPFC sideways through series and shunt FACTS organizers were to reduce system operation cost in dissimilar reactive loading cases in [18].

II. INTRODUCTION TO SVC AND UPFC

Flexible AC transmission system is used increase the thermal capability of the system. They are used for the better performance of the system. In this we have used FACT devices to enhance the system stability and accuracy. SVC is an automatic device that is designed to bring the system closer to unity power factor. The Static Var Compensators are the most generally introduced FACTS hardware right now.

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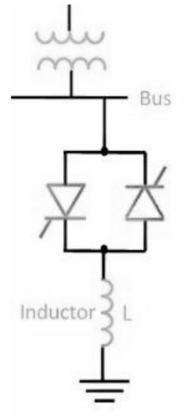
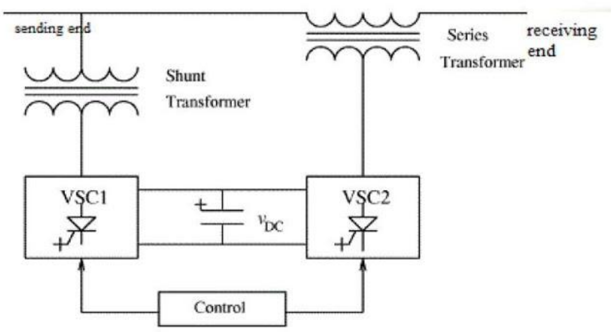
They imitate the working standards of a variable shunt susceptance and utilize quick thyristor controllers with settling times of just a couple of central recurrence periods. From the operational perspective, the SVC modifies its esteem consequently in light of changes in the working states of the system. By reasonable control of it proportionate susceptance, it is conceivable to direct the voltage size at the SVC purpose of association, along these lines upgrading essentially the execution of the control framework. A blend of a static synchronous compensator (STATCOM)
what's more, a static synchronous arrangement compensator (SSSC) which are coupled by means of a regular dc connect, to permit bi-directional stream of genuine power between the arrangement yield terminals of the SSSC and the shunt worked terminals of STATCOM, what's more, are controlled to give simultaneous genuine and responsive arrangement line pay without an outer electric vitality source. The UPFC, by
methods for precise unconstrained arrangement voltage infusion, can control, simultaneously or specifically, the transmission line voltage, impedance and point or on the other hand, the genuine and responsive power stream in the line. The UPFC may likewise give freely controllable shunt-receptive pay. The UPFC which is a standout amongst the most encouraging gadget in the FACTS idea, has been examined and put into viable use (Schauder 1998).

SVC



(a)



(b)

Fig 1: Block diagram of (a)SVC , (b) UPFC

III.PROPOSED METHODS

The goal of the paper is to diminish the dynamic power misfortunes and to limit the cost of the framework by putting the gadgets in the fitting spot in the framework. Moreover, the reason for the ideal routine with regards to responsive power sources beforehand present in the system. Along these lines, the key point of this paper is to limit dynamic power misfortune and all out operational expense under different stacking circumstances by the establishment of FACTS gadgets at various ideal areas in transmission framework which likewise kills clog issues. The choices for which they were put are generally subject to wanted outcome and the highlights of the precise framework. Introducing cost for various FACTS gadgets and the expense of framework tasks in particular, vitality misfortunes costs are joint to shape target work is to be limited, which is likely by administrative receptive age of the generator, administrative transformer tap setting is by the expansion that shunt capacitors at delicate transports. Var days of generators and directorial transformer tap settings inside their unmistakable bounds don't give any expenses to the procedure cost of the framework, later on methodology setting of transformer tap position and receptive age of generators are contained as administrative parameters alongside FACTS gadgets. The areas of transformer tap places and responsive ages of the generators inside determined breaking point are self-administering on the framework's cost, just expense of the FACTS gadgets are to be considered. There psp method is used to find the cost of the system with and without SVC and UPFC. The idea of relative sharing strategy is proposed by Bialek, where the summation of inflows is equivalent to the outpourings at every hub or transport and the every surge is proportionate with the whole of inflows. The point work is to limit the general working expense have two sections. One the expense because of vitality misfortunes credited by dynamic influence loss of framework and other is the expense of the FACTS gadgets. The general target work is

$C_{FACTS} = C_E + {}_{FACTS}$----- (1)

C_E is due to the overall transmission loss in the system. Cost due
to energy loss = 0.06 \$/kWh. CE is the cost due to energy loss (in \$)
where

$C_{FACTS} = C_{SVC} + C_{UPFC}$----- (2)

C_{FACTS} is price due to FACTS devices (\$),is the price due to C_{SVC} is price due to SVC (\$), and C_{UPFC} is price due to UPFC (\$).

Cost role of SVC and UPFC are given by-----(3)–(4) from-----[10]

$C_{SVC} = 0.0003\ SVC_{value}^2 - 0.3051\ SVC_{value} + 127.38$ US/kVAR----- (3)

$C_{UPFC} = 0.0003 UPFC_{value}^2 - 0.2691(UPFC_{value}) + 188.22$ US/kVAR----- (4)

To diminish active power losses in transmission net that can be given by

$$P_{loss} = \sum_{k=1}^{n} gk\left[V_i^2 + v_j^2 - 2v_i \times v_j \times \cos(\partial_i - \partial_j)\right] - (5)$$

g_k is conductance of kth line joined in midst of ith and jth transports of power frameworks. V_i and V_j are voltage extents and δi and δj are voltage stage edges of ith and jth transports. n is absolute number of lines.

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Following limitations are content while limiting principle work for ideal arranging of receptive power bases are -----(1). Voltage greatness have

$V^{min}_{i} \leq V_i \leq V^{max}_{i}$ -----(6)

Reactive generation limit of the generator's

$Q^{min}_{gi} \leq Q_{gi} \leq Q^{max}_{gi}$ ------(7)

Transformer tap setting arrangements

$T^{min}_{i} \leq T_i \leq T^{max}_{i}$ -----(8)

Var output of shunt capacitors

$Q^{min}_{Ci} \leq Q_{Ci} \leq Q^{max}_{Ci}$------(9)

Testing system taken is IEEE 5 bus system. The devices to compensate the reactive power is placed according to the lag in the particular bus and that is called the week bus, and the SVC is placed at the 3^{rd} bus as the number of loads at that bus are more and there is no generator at the bus.

Receptive power planning alongside FACTS gadgets following two disparity imperatives are fulfilled by fair capacity signified by

$C_{Total} = C_E + C_{FACTS}$

in count to gratification of disparity constraints exposed by formulae -----(7)–(15).

Inequality constraint of SVC is given by

$Q_{min}\, SV_{Ci} \leq QSV_{Ci} \leq Q_{max}\, SV_{Ci}$----- (10)

Inequality restraints of UPFC are given below. Voltage magnitude of series and shunt converters limit are to be represented as

$V_{se,min} \leq V_{se} \leq V_{se,\,max}$ ----(11)

$V_{sh,\,min} \leq V_{sh} \leq V_{sh,\,max}$ -----(12)

Voltage angles of the series and shunt converters bounds are signified by

$0 \leq u_{sh} \leq 2_p$ -----(13)

$0 \leq u_{se} \leq 2_p$ -----(14)

UPFC is connected between ith bus and jth bus. Active and reactive power flow equations at i^{th} bus are given by

$Pi + V^2s\, G_{ij} + 2V_iVsG_{ij} \cos(\phi_s - \Theta i) - V_jVs$

$[Gij \cos(\phi_s - \Theta_j) - B_{ij} \sin(\phi_s - \Theta j)] = 0$ (15)

$Qi - V_iIq - V_iVs[G_{ij} \sin(\phi_s - \Theta i) - B_{ij} \cos(s - \Theta i)] = 0$ (16)

Power flow equations for Active and reactive powers are at the jth bus

$P_j - V_jVs[Gij \cos(\phi s - \Theta j) + Bij \sin(\phi s - \Theta j)] = 0$ (17)

$Q_j + V_jVs[Gij \sin(\phi s - \Theta j) - Bij \cos(\phi s - \Theta j)] = 0$ (18)

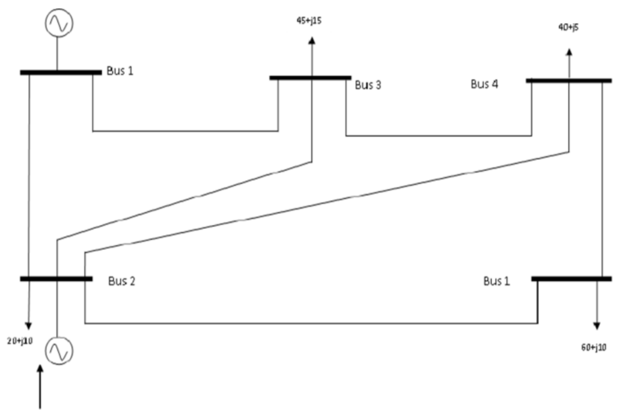

FIG 2: IEEE 5 BUS

IV. PLACEMENT OF FACT DEVICES

Various techniques for definitive the area of FACTS gadgets however the strategy that have been utilized under and control stream in various branches heretofore and a short time later the task of those gadgets. SVCs are there to control responsive vaccinations at weak transports. UPFC's are associated on some positive transports to switch voltage, stage edge identified with those transports and line impedances are adjacent by transports connected with UPFC. Aggregate framework capacity near transmit control, FACTS gadgets are set in a particular way that it can likewise use current creating units. Explanation behind situation of FACTS gadgets in profoundly stacked line is results in reduction of receptive power stream completed these lines. It has an inadvertent impact of redistributing of additional power in different areas of lines of framework in such a strategy, that these lines are likewise not over-burden. In proposed process, two sorts of FACTS controllers: to be specific, UPFC and SVC are utilized. UPFC's areas are come about by recognizing lines conveying high dynamic power, while positions for situation of SVC's are resolved on premise of receptive power move through lines. All through appraisal of unbiased capacity with breaking points connoted by a string as appeared contains of FACTS gadgets alongside VAR ages of generators and transformer tap setting courses of action.

Steps for cost allocation:

Steps for calculation:

1. Run load flow analaysis without FACT devices(SVC,UPFC)
2. Cost allocation (C_E) is done
3. Run load flow installing fact devices at various buses
4. Cost allocation (C_{FACTS}) is done
5. Net cost= C_E+ C_{FACTS}

Where C_{FACTS}

C_{SVC}=0.0003 SVC^2-0.3051*SVC+127.38 $/kvar

C_{UPFC}=0.0003$UPFC^2$-0.2691*UPFC+188.2 $/kvar

V. RESULT

Line Data Of Fig 2:

Sl.No	From_Bus	To_Bus	R	X	B
1	1	2	0.02	0.06	0.03
2	1	3	0.08	0.24	0.025
3	2	3	0.06	0.18	0.02
4	2	4	0.06	0.18	0.02
5	2	5	0.04	0.12	0.015
6	3	4	0.01	0.03	0.01
7	4	5	0.08	0.24	0.025

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Bus data of Fig 2:

Bus No.	Type	Pd	Qd	PG	QG	Q_{max}	Q_{min}
1	Slack	0	0	120	0	300	-50
2	2	0	0	20	0	300	-20
3	1	45	15	0	0	0	0
4	1	40	5	0	0	0	0
5	1	60	10	0	0	0	0

For above power system following FACT devices are located as

(i) SVC is placed at bus 3:

(ii) UPFC is placed between bus 3 and 4.

Table 1 & Table 3 showa the comparision of transmission losses with (SVC, UPFC) and without using FACT devices.

Table 2 shows cost allocation done without FACT devices for inclusion of with and without losses.

Table 4 shows the transmission losses obtained with UPFC.

Table 5 shows the cost allocation done with UPFC device for with and without losses.

Table 1:Transmission losses:

		With SVC		Without FACTs	
From	To	P	Q	P	Q
1	2	2.49	7.46	2.48	7.46
1	3	1.56	4.68	1.39	4.68
2	3	0.36	1.08	0.39	1.08
2	4	0.46	1.39	0.48	1.39
2	5	1.23	3.70	1.19	3.70
3	4	0.04	0.12	0.05	0.12
4	5	0.04	0.12	0.66	0.12
Total		6.19	18.56	6.64	11.26

Table 2:Cost allocation without FACTs in $:

Total power cost allocation with losses to Generators	Total power cost allocation with losses to Demands	Total power cost allocation with out losses to Generators	Total power cost allocation with out losses to Demands
102.7338	0.00	94.0450	0.00
15.2950	0.00	14.7050	0.00
0.00	35.0559	0.00	32.4441
0.00	31.2230	0.00	28.7770
0.00	47.1105	0.00	42.8895

Table 3: Cost allocation with SVC in $:

Total power cost allocation with losses to Generators	Toatal power cost allocation with losses to Demands	Toatal power cost allocation with out losses to Generators	Toatal power cost allocation with out losses to Demands
94.4	0	85.52	0
15.37	0	14.63	0
0	1.04	0	66.46
0	3.62	0	56.38
0	100.34	0	-10.34

Table 4: Transmission losses

		With UPFC		Without FACTs	
From	To	P	Q	P	Q
1	2	2.3	152.3	2.48	7.46
1	3	1.95	18.26	1.39	4.68
2	3	0.19	-1.26	0.39	1.08
2	4	0.11	-3.63	0.48	1.39
2	5	0.92	-0.15	1.19	3.70
6	4	0	3.74	0.05	0.12
4	5	0.16	-1.49	0.66	0.12
Total		4.027	0.0004	6.5	6.64

Table 5: COST ALLOCATION using UPFC in $

Total power cost allocation with losses to Generators	Toatal power cost allocation with losses to Demands	Toatal power cost allocation with out losses to Generators	Toatal power cost allocation with out losses to Demands
94.01	85.99	0.00	0.00
15.31	14.69	0.00	-1.00
0.00	0.00	68.50	59.93
0.00	0.00	0.00	53.58
0.00	0.00	36.42	0.00

VI. CONCLUSION

This paper concludes that using FACT devices the transmission losses are reduced and the cost at different places differs with respect to the device kept. Further, this can be done by using Generic Algorithm.

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