

Analysis & control strategy of first swing stability using shunt fact devices

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Abstract —The purpose of this paper is to control with new tactic of FACTs device to expand the first swing stability of power system. Generally, the speed based control technique (e.g. Bang -bang control) is used but this scheme is not able to use complete decelerating area to maintain stability. In SMIB system normally proposed control strategy is applied to SVC. It is found that this policy can provide expressively huger stability limit then that of the bang-bang control method.

Keywords- Equal area criterion (EAC), Flexible ac transmission system (FACTS), Static var compensator (SVC), Single machine with infinite bus (SMIB)

I. INTRODUCTION

In the analysis of power system, generally voltage, frequency & transient stabilities are the main types of stability which limits the power transfer capability. Improvement in transient stability is now engaging more importance for first swing stability scrutiny. A power system can be considered as first swing stable if it is going to fulfill equal area criteria (EAC) in SMIB system. This paper offers a new-fangled controller strategy of shunt FACTs policies to progress first swing stability limit by take full advantage of the decelerating area by using SVC in SMIB system.

II. EQUAL AREA CRITERIA

This section provides the basis of EAC of a SMIB system. The accelerating power in swing equation will have sine term. Therefore, the swing equation is non-linear differential calculation and obtaining its solution is not that meek. For two machine systems and one machine connected to infinite bus bar, it is possible to say whether a system has transient stability or not, without solving the swing equation. [1] Such criteria which decides the stability, makes use of equal area in power angle diagram and hence it is known as Equal Area Criterion. So, the opinion by which stability under transient conditions is strongminded without solving the swing equation, but makes use of areas in power angle diagram, is called the EQUAL AREA CRITERION. The dynamics of the system in SMIB model, can be define as

$$M * (d\omega / dt) = (P_m - P_e) = P_a \dots\dots\dots(1)$$

Here, M = moment of inertia, P_m = input mechanical power, P_e = electrical power output, P_a = accelerating power.

In SMB system generally continuous and discontinuous types of controls are used for improving the transient stability and damping control with shunt FACTs devices. [3,4] The continuous strategy is not able to use the full capacity of the device. where the other one method can control at full rating with maximum benefit. The continuous strategy is very helpful in dynamic stability problems which is produced by transient disturbance.

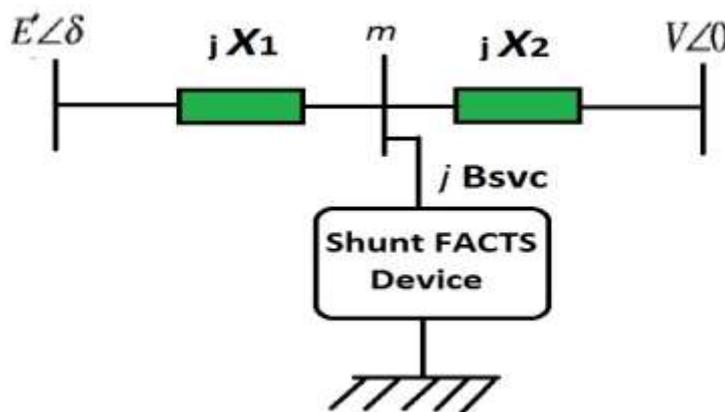


Fig. 1 A SMIB system with SVC device

III. ANALYSIS OF FIRST SWING STABILITY CONTROL

In SMIB system with a shunt FACTS devices as shown in Fig. 1. The corresponding circuit of the system is signifying the machine inner voltage and infinite bus voltage, respectively. In this system power angle graph of the system with SVC is described. [1,3] When a transient fault is happening, there is sudden decreasing in electrical power from point to point & thus machine starts accelerating. Currently the SVC operates in capacitive mode (During the time of fault Clearing). when SVC reaches to its maximum point, machine starts decelerating but angle continuous increase up to maximum point so this up to stable point area is known as decelerating area. The electrical output power of the machine is defined as

$$P_e = (E * V / X) * \sin\delta \dots\dots\dots(2)$$

Here, E = Sending end voltage, V = Receiving end voltage, Pe = Electrical output power

In BBC control strategy, during the mode of operation of SVC if the angle reaches to the maximum point it would not allowed to utilize the over all area of decelerating to balance the accelerating area. So, there is another control strategy is used to maximize the first swing stability. [6] This operation requires continuous operation of SVC with full capacitive mode till the system speed reaches with reasonable negative value during the first return path. Such type of control is calculated by following equation,

$$\int_{\delta_0}^{\delta_c} (P_m - P_{cf}) d\delta = \int_{\delta_c}^{\delta_m} (P_{ep} - P_m) d\delta \dots\dots\dots(3)$$

Here, Pm = mechanical input power, Pep = Power after fault, δ0=angle at fault occurs, δc=angle at fault cleared δm =maximum angle

In SMIB system This needs remaining the operation of SVC at its full capacitive mode until the machine speed reaches a reasonable negative value during the first return journey. In 3 machine 9 bus system near bus 8 fault is considered .and SVC is connected near bus 8. As per the equity area criteria critical clearing time is calculate through various rating of SVC . Table I is the assessment between Dissimilar CCT at dissimilar ratings of SVC. It is measured that the shunt FACTS plansfunction at full capacitive rating in initial part of the post-fault period to exploit the decelerating area and then the entire decelerating area is used in correcting the accelerating area. Resultsof Table I indicate that the CCT of the fault, without a shuntFACTS device is only 92ms and it increases as the rating the device is increased. Though, at aadvanced angle, decreases pointedly and thusUPFC also injects more reactive power (or handoversextra activepower finished the line) than that of a SVC of parallel ratingThat is why a SVCmay provide higher valuesof CCT than without SVC (see Table I).The CCTs of the responsibility are also strongmindedfinished repetitive time domain replications of scheme dynamic equations withthe proposed control strategy and the falloutscrate are detected to be in exact agreement with those given in Table I. Fig. 2 shows the swing curve of the mechanism for critically stable (ms) and unstable (ms) situations with a SVC of pu. The variation of machine speed and SVC susceptance, for critically stable case, is shown in Fig. 2. Unlike the BBC, the proposed control functions the SVC at its complete capacitive rating beyond the zero speed [see Fig. 2]

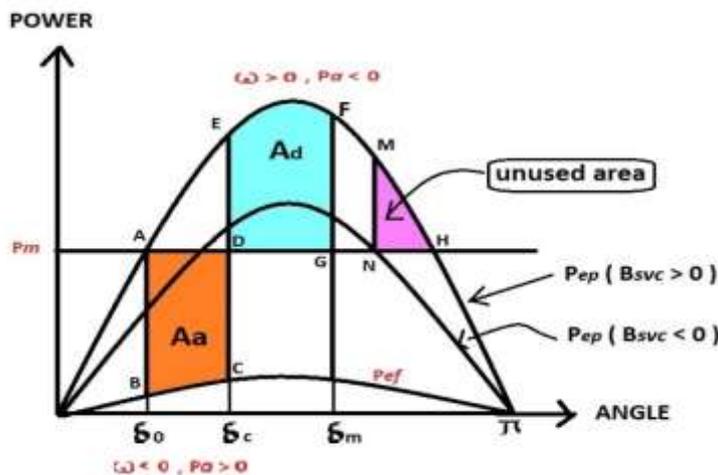


Fig. 2 Power -angle curve

A 3-phase fault on line near bus 8 is painstaking and it is cleared by opening the line at both ends. First the critical clearing time of the fault is strongly minded concluded Equal Area Criteria for numerous ratings of shunt FACTS devices and the outcomes found are given in Table I. In defining the CCT, it is considered entire decelerating area.

Result of SVC	
Bsvc (pu)	CCT (ms)
0.25	92
0.40	104
0.60	116
0.80	127

Table 1. CCT for various ratings of SVC

Later, the modification is swapped to unremitting type to improve damping and which depends on the value of used Fig. 2 shows the swing curve of the mechanism for critically stable case for different values of and it indicates that the system damping improves as the value of is increased. When the BBC is functional, the CCT of the fault is found as 315-316ms (with pu) and which is 50ms lower than that gained with the proposed control. Fig. 2 shows the curve and swing curve of the machine for 20ms. Some chattering actions of machine output power around the maximum angle can be observed in Fig. 4. Such changes in output power cause to operate the machine around the unbalanced evenness point (UEP) for a long time.

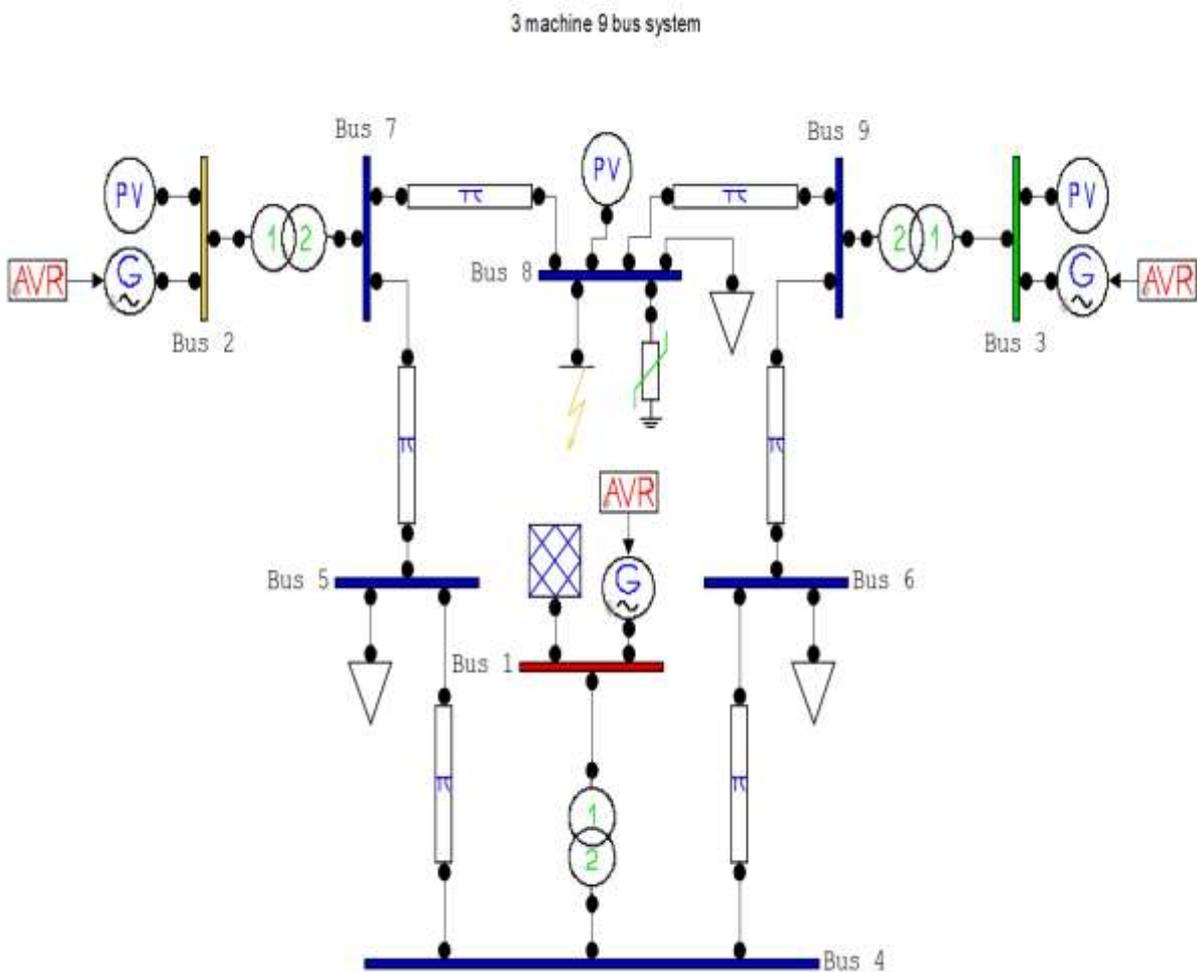


Fig. 3 Three machine nine bus system with SVC

IV. SIMULATION RESULTS

In 3 machines 9 bus system we have taken two situations for comparison. For first condition we took fault location at bus 8 and fault time is at 0.1 s. so at that time without SVC condition system is going to unstable at 366ms. So by this result we can get our CCT is 266 ms. But for second conation with using SVC, we get our critical clearing time 316ms. So the Simulation results are as below,

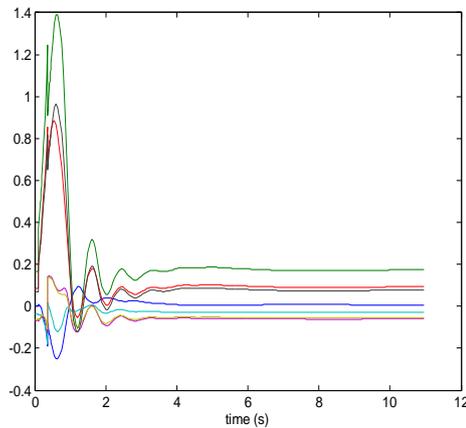


Fig 4.1 [wave form upto t = 0.415 s system is stable]

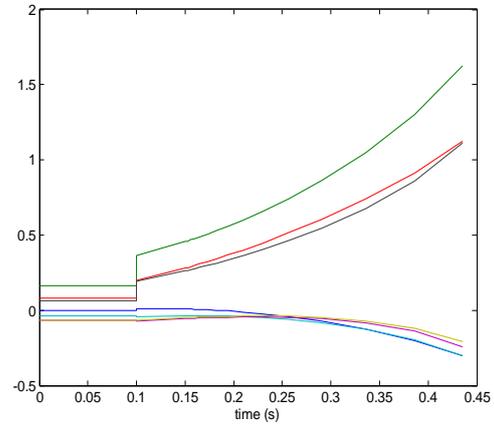


Fig 4.2 [wave form at t = 0.416 s system is unstable]

Fig. 4 Three machine nine bus system with SVC

FAULT LOCATION ON BUS NO	WITH OUT SVC			WITH SVC			INCREASING IN Tcr [ms]
	FAULT TIME @ [sec]	SYSTEM STABILITY TIME [sec]	Tcr [ms]	FAULT TIME @	SYSTEM STABILITY TIME	Tcr [ms]	
4	0.1	0.389	289	0.1	0.434	334	45
5	0.1	0.376	276	0.1	0.413	319	43
6	0.1	0.365	265	0.1	0.405	305	40
7	0.1	0.374	274	0.1	0.413	313	42
8	0.1	0.366	266	0.1	0.416	316	50

Table 2. comparison of CCT with or without SVC

As per above result, by using different fault location at different bus ,the critical clearing time is going to increase when SVC is connected in the system so over all stability of system is increased with SVC and the value of Tcr is increased. For further expansion or improvement purpose we can use STATCOM or UPFC for better result.

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