

Optimal Placement of STATCOM Using IEEE 5 Bus System

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Abstract

Power framework improvement is the most noticeable and advanced errand at any point looked by the power engineers. Many researches have been completed all through the world for ideal situation of the STATCOM in the power organize. It likewise decides the measure of genuine and responsive power imparted between the two frameworks. This paper exhibits a 9 transport power framework demonstrate and the centre is to limit the heap stream, in this way an advanced feed forward calculation has been connected to unravel the power stream. In the second section a preparation technique dependent on Machine Learning has been completed for fast infusion of Voltage amid power framework unbalance because of flooding of Reactive Power. A Matlab Simulink Model has been created considering the IEEE 5 transport frameworks for exhibiting the vigorousness of the controller

Index Terms: IEEE 5 Bus System, STATCOM, Regression Analysis

1. INTRODUCTION

Any nation's monetary and social development to a great extent relies on the electricity and the power framework arrange. Hence it is required to give a security framework to the current power framework arrange for its unwavering quality and compelling utilization of the framework at constantly. However, expanding in the land business and changing way of life of the nation makes a testing work just as an undesirable framework for power architects to deal with the foundation of the nation. It very well may be seen that cell framework has defused various nonlinear burdens into the conventional matrix along these lines making it temperamental for voltage and associated burdens perspective. These huge no. of nonlinear burdens makes control framework precariousness regarding both consistent state and dynamic dependability. Modern burden are associated with synchronous condenser for revising their capacity factor and just as adjusting the receptive power produced by them. Anyway it isn't suggested for utilization of synchronous condenser for house hold framework. In this manner examine has been completed for improving the power factor either by keep up the receptive power or by changing the attributes of Transmission lines.[1]

A group of Power Electronic gadgets which can control the infusion of receptive power and keeps up an appropriate voltage at the terminal of the PCC falls under the classification of Flexible AC Transmission System or essentially FACTS. These power electronic gadgets are fit for changing the dynamic attributes of Transmission lines and consequently contributing in the control of receptive

power in the power framework. Among the distinctive kinds of FACTS controller in this present research Static Synchronous Compensator or STATCOM has been considered. A STATCOM is utilized to control the transport voltage and in this way can be assigned as responsive power compensator. As the essential target of the controller is to control the transport Voltage consequently it is generally associated in shunt with the Transmission lines.[2]

The STATCOM when utilized in the Transmission line, draws an equal measure of responsive current from the transport to which it is associated. In this way keeping it in view and the expense and intricacy engaged with its execution requires ideal and precise spot of establishment. At the point when introduced in the best possible perfect position can improve the framework execution altogether. So FATCS are normally associated in the heap transport and not in the generator transport as the generator transport does not require the voltage guideline. It is qualified to make reference to here that the STATCOM must have lower request consonant remuneration office for illustration additional measure of responsive current from the network.[3]

Legitimate Power framework arranging, control and support requires composed stream of intensity in the power framework and in this way establishes the essence of any power framework arranging and displaying. Various researches has been completed by numerous analysts to settle the power framework load stream issues with limit esteemed condition or emphasis for its viable execution and arrangement. At a specific moment of time the power framework organizes encounters various

insecurities and accordingly includes a no. of complex conditions which requires a significant PC memory control for its answers. Among different sorts of burden stream systems Newton Raphson strategy is typically utilized due to its simple union with quadratic advantage. Anyway this technique does not portray about the conduct of burden stream arrangement within the sight of STATCOM or some other FACTS gadgets. In the present research a heap stream arrangement with STATCOM dependent on Machine Learning Algorithm has been introduced here for demonstrating the power of the controller.[4]

Independent of the upsides of the Newton-Raphson strategy it is as yet mind boggling and muddled due to its prerequisite of substantial memory power and abilities for the arrangement. In a fast changing force framework where it is required to gather the power framework information and burden stream examination in each 5 to 15 minute it turns out to be hard to break down the power framework issue with customary streamlining issue with FACTS gadgets. Thusly in this paper another streamlining strategy dependent on the Artificial Intelligence or Machine Learning has been proposed which when kept running alongside the conventional advancement methods can improve the power framework soundness by constraining the trading of responsive current between the lattice and FACTS gadgets.[9]

In this present paper the AI is utilized to compute and foresee three number of information, for example, voltage at the terminal of STATCOM, stage edge to be presented with the voltage for expanding the strength of the framework and that of the receptive current to be drawn from the lattice for successful utilization of the STATCOM and its related gadgets. Profound Learning Algorithm, for example, relapse with R circle has been presented in this paper.[6]

2. POWER SYSTEM WITH STATCOM

As of now notice the primary reason for STATCOM in the transmission and dispersion framework is to control the accompanying parameters, at that point

- i. Improvement in the Transient solidness of the framework
- ii. Providing remuneration against Thyristor Compensation and control
- iii. Reduction in the Over overwhelmed responsive forces present in the Power framework Network
- iv. Compensation against Domestic purchaser gadgets.

To comprehend the working standard of STATCOM, we'll first have a look at the responsive power exchange condition and enable us to consider two sources V1 and V2 territory unit associated through an electrical wonder $Z = R_a + jX$. From the power point condition, edge δ is that the edge somewhere in the range of V1 and V2. Consequently on the off chance that we tend to keep up edge $\delta = \text{zero}$, at that point Reactive power stream can progress toward becoming [6]

$$Q = (V2/X)[V1-V2]$$

Furthermore, dynamic power stream can move toward becoming

$$P = V1V2\sin\delta/X = 0$$

To condense, we can say that if the edge somewhere in the range of V1 and V2 is zero, the stream of dynamic power winds up zero and furthermore the stream of responsive power relies upon (V1 – V2). Thusly for stream of responsive power there square measure 2 prospects.

- 1) If the extent of V1 is over V2, at that point responsive power can be expected supply V1 to V2.
- 2) If the greatness of V2 is over V1, receptive power can be expected supply V2 to V1.

This standard is utilized in STATCOM for receptive power the executives.[7]

Presently we will see anyway the STATCOM works those we have referenced the central in activity rule of STATCOM. As are frequently observed from the figure over, supply V1 speaks to the yield voltage of the STATCOM. Just if there should be an occurrence of receptive power request will increment inside the framework, STATCOM will build its yield voltage V1 while keep up the part qualification somewhere in the range of V1 and V2 to zero (it will be noted here that there'll perpetually exists modest stage somewhere in the range of V1 and V2 to cook for the hole obstruction stopped by the interconnecting electrical gadget). As $V1 > V2$, responsive power can result STATCOM to the capacity framework. Subsequently STATCOM gives receptive power and goes about as responsive power generator. Addition, if the voltage of intensity network increment on account of burden mislead, STATCOM can curtail its yield voltage V1 and in this manner can ingest responsive capacity to settle the voltage to conventional cost.[8] The higher than method of activity of STATCOM is named Voltage Regulation Mode. Be that as it may, as

we as a whole realize every instrumentation has their very own restrictions, along these lines STATCOM ought to try and have some constraint of action or entrancing receptive power. Indeed, there exists a confinement and this constraint is mandatory by the present conveying ability of power commutated gadgets like IGBT, GTO and so forth. Thusly, if the task of STATCOM achieves their confinement, it doesn't more will increment or diminishes its yield voltage V_1 rather it gives or retains mounted receptive power satisfactory to its restricting cost at a set voltage and current and acts like steady current supply. This method of activity of STATCOM is named power unit the executives Mode.[14]

Every office comprises of numerous transports interconnected with each other through transmission lines. The transports will either be burden or generator transports. The interconnection of various transports is portray by the induction grid or the Y -lattice. The Y -lattice might be a higher representation of the transmission lines because of the greater part of the sections amid this grid are zero, when contrasted with the electrical wonder framework. In any case, the Y -lattice doesn't fuse the permissions related with the heap associated with the transports and STATCOM controller. This outline is appeared in Figure one. The consistent state model of the framework is depicting by the static burden stream conditions for the \$64000 and receptive forces of the transports on with the balance limitations of the transmission organize. [10] The static burden stream conditions of a chose transport are written as far as voltage extents and part edges of the considerable number of transports associated with the present transport. That is, the heap stream conditions without a doubt (P_i) and responsive power (Q_i) of transport " i " are composed as

$$P_i = \sum_{k=1}^n |Y_{ik} V_i V_k| \cos(\theta_{ik} + \delta_k - \delta_i)$$

$$Q_i = -\sum_{k=1}^n |Y_{ik} V_i V_k| \sin(\theta_{ik} + \delta_k - \delta_i)$$

In these equations, $|V_i|$ is that the magnitude of the voltage at bus " i " and $|V_j|$ is that the voltage magnitude of " j th" bus connected to the bus " i ," whereas " δ " represents the corresponding part angle of the voltage and N is that the total variety of buses in the system. $|Y_{ij}|$ and ij area unit magnitude and point of the admittance between buses " i " and " j ". Y_{ij} is calculated from the admittance matrix Y_{Bus} of the bus system, which is given as

$$Y_{BUS} = \begin{pmatrix} Y_{11} & Y_{12} & \dots & Y_{1n} \\ Y_{21} & Y_{22} & \dots & Y_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ Y_{n1} & Y_{n2} & \dots & Y_{nn} \end{pmatrix}$$

3. ARTIFICIAL NEURAL NETWORK

ANN is an awesome AI rule for the relapse and order issues, which may evaluate the information by imitating the common sense of human mind—it works in various layers each with bound assortment of neurons and loads. The ANN will be wont to gauge frameworks even once the PC record is refined and contains excess and degenerate information. Because of its no algorithmic nature, ANN does not attempt and surmised the arrangement simply like the standard systems that are utilized for fathoming the heap stream conditions. A neural system comprises of hubs known as neurons, at everything about the contributions from past layers are aggregated while being expanded with a few loads. The neurons are the essential procedure units that are interconnected with each other amid a bound example. The human cerebrum incorporates trillions of interconnections between the neurons. It's measurable that there are ten billion neurons blessing that are interconnected through 1014 connections. Partner degree confined immaterial physical cell turns out to be incredible once interconnected with various neurons inside the system. Along these lines, Artificial Neural Networks are involved interlinked neurons, whose course of action relies upon the kind of use. Each neural system has the ensuing fundamental layers. [11] Info Layer. This layer incorporates aloof hubs whose sole employment is to transmit the contribution to succeeding layer thus the quantity of hubs amid this layer is proficient the measure of contributions to the system. Each hub conveys explicit weight factor, which is duplicated with each info worth. The quantity of neurons inside the information layer is drawn as network with number of lines decided unpredictably in accordance with the dataset and assortment of sections being skilled the measure of information choices concealed layer. This is the most essential layer of the system which comprises of eccentric assortment of sub layers, each containing distinctive assortment of neurons. This layer forms the information from the information layer by increasing it with the weight factors.

One important issue inside the style of ANN is that the assortment of concealed layers and neurons in each layer. While the information layer and yield layer topology depend generally on the info and yield, severally, concealed layer's topology might be balanced. Lower assortment of shrouded neurons may result in poor

estimation of the work, while over required assortment of neurons would potentially finish in over fitting of the system on the preparation dataset and may likewise join the outcomes of commotion, aside from expanding the calculation time.[12] Consequently, the ideal assortment of neurons ought to be chosen Associate in nursing experimental premise. Generally to decide ideal shrouded neurons is to present self-adjustment inside the system, while the quantity of concealed layers is some of the time discovered adequate and limited to something like one in the vast majority of the writing. A neural system ought to be prepared for the specific dataset before embarking to make its very own choices. The training of the neural system suggests tweaking of the loads in each layer, determined it's prepared to turn out the normal yield with least blunder. Along these lines, ANN works in 2 sections: (I) was preparing and (ii) testing. In instructing section, a piece of the dataset is nourished to the ANN together with the decided yield. The yield got from the neural system is contrasted and the first yield (additionally alluded to as target) and hence the mistake is encouraged back to the system to direct the loads thusly. The execution of the framework is determined utilizing battery associated burden under both AC and DC System [16]. At the point when the loads turn out ideal outcome, with least mistake, the ANN is set up to be tried.

The neural systems are in some cases prepared exploitation Back-Propagation method that might be a variation of the littlest sum Mean Squares procedure on account of its initiation play out that is scientific constant performs. The Back-Propagation strategy depends on steepest-plunge algorithmic program that looks to seek out the base mistake by changing loads inside the course of most minimal blunder. The blunder is taken and back-determined to merge to the ideal goals. Consequently, generally, the mistake engenders inside the regressive heading which is the reason it's gotten back to Propagation strategy.

Be that as it may, Back-Propagation commonly stalls out inside the local least. One goal is to utilize this strategy with various strategies like the one anticipated in. Another goal is to utilize met heuristic approaches to tweak the neural systems. Another vital inquiry is that the legitimacy of the work of ANN over Newton-Raphson strategy.[13] The primary preferred standpoint of ANN over NR is that NR is a reiterative strategy that sets aside profitable amount of your opportunity to unwind the obscure factors in the framework. The obligatory part of NR strategy is Jacobian lattice, whose measurements develop on the grounds that the framework factors increment. As referenced previously, the monstrous power frameworks are dynamic in nature and hence load stream examination is urgent once every jiffy to few moments. The utilization of NR might be overwhelming

since it expends time and calculation control. In refinement, the ANN has the favourable position that it's measurement and accommodating in demonstrating nonlinearities. In addition, they will be with effectiveness upheld on advanced PC designs on account of their tendency thus they can radically downsize the interim . Having said this, it should be referenced that interim and power in ANN is required exclusively all through the instructing some portion of the system. When the ANN is prepared, it will evaluate the required yield while not a great deal of exertion and this is frequently the essential favourable position of exploitation ANN in situ of NR in burden stream examination.

4. RESULT ANALYSIS

A typical 5 bus system is shown in figure.1, where there are two load bus and three generator bus along with a slack bus.

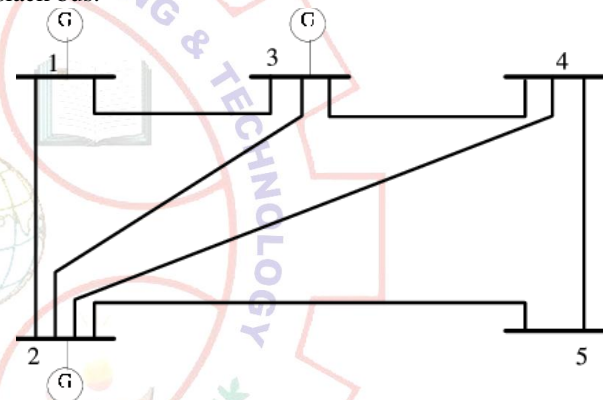


Figure-1:- IEEE 5 Bus system

Bus	Voltage	Generation		Load	
		MW	MVAR	MW	MVAR
1	1.06+j0	0	0	0	0
2	1.0+j0	40	35	21	10
3	1.0+j0	0	0	25	10
4	1.0+j0	0	0	40	5
5	1.0+j0	0	0	50	20

Table.1 Bus data for IEEE 5 Bus System

Bus Code	Line Impedance Z_{eq}		Line Charging
	R per Unit	X per Unit	
1-2	0.02	0.06	NA
2-3	0.06	0.25	0.0+j0.25
3-4	0.01	0.03	0.0+j0.010
4-5	0.08	0.04	0.0+j0.025
5-2	0.03	0.07	0.0+j0.03
2-4	0.02	0.07	0.0+j0.025
1-3	0.02	0.08	0.0+j0.010

Table.2 Line Data for IEEE 5 Bus System

Table 1 and Table-2 shows the Bus data and Line Data respectively. Therefore it can be easily found that the maximum loading of the data is in between 0.7 to 0.92 MW (PU).

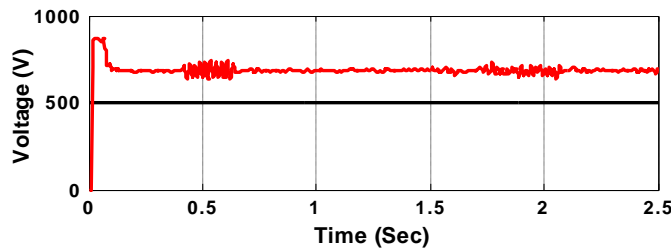


Figure-2:- Reference Voltage of STATCOM at Location.1

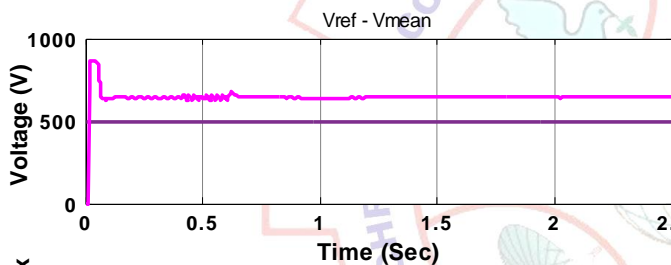


Figure-3:- Reference Voltage of STATCOM at Location.2

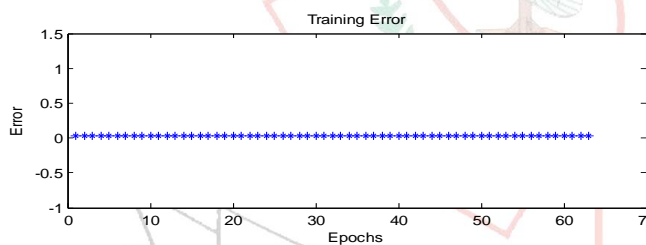


Figure-4:- Error present between the Two STATCOM references Voltage

By comparing the Figure.2 with figure.3 it can be found that the error present between the two locations is in between 5% and that of the reference voltage present at location 2 is found to be suitable for better result and location.

4. CONCLUSION

In this paper the ideal situation of STATCOM has been shown with a MATLAB Simulink display, where both ANN and Machine Learning has been connected better execution. The Matlab based outcome in this manner got for two diverse controllers has been

depicted independently. So as to have a similar investigation among both the controller same stage has been kept up for both controllers.

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