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Neuro Fuzzy Controller for SVC to Improve the Stability of Power System

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ABSTRACT: In this paper steady-state modelling of Static VAR Compensator (SVC) for power flow studies has been expressed and discussed in details. Firing angle model for SVC was suggested to control the voltage at which it is connected. In same aspect firing angle model for SVC is advised with Fuzzy controller to control active power flow of the line to which TCSC is installed. The advised models take firing angle as state variable in power flow formulation. To validate the effectiveness of the advised models ANN algorithm was refined to solve power equations in presence of SVC. The Case studies are carried out on 9-bus test system to illustrate the performance of the advised models.

KEYWORDS: *SVC, TCSC, Fuzzy Logic, Transient stability.*

I.INTRODUCTION

With the rapid improvement of power system, especially the enlarged use of transmission facilities due to higher industrial output and deregulation, it becomes essential to explore new ways of imcreasing power transfer in existing transmission facilities, while at the same time maintaining the acceptable levels of the network reliability and stability. On the other hand, the fast enhancement of power electronic technology has made FACTS (flexible AC Transmission System) promising solution of future power system. FACTS controllers such as Static Synchronous Compensator (STATCOM), Static VAR Compensator (SVC), Thyristor Controlled Series Compensator (TCSC), Static Synchronous Series Compensator (SSSC) and Unified Power Flow controller (UPFC) are able to change the network parameters in a fast and effective way in order to achieve improved system performance.

These controllers are used for enhancing dynamic performance of power systems in terms of voltage/angle stability while improving the power transfer potentiality and voltage profile in steady-state conditions. Static VAR Compensator (SVC) and Thyristor Controlled Series Compensator (TCSC) are FACTS controllers based on thyristor-controlled reactor (TCRs), the first is a shunt compensator used for voltage regulation which is attained by controlling the production, absorption and flow of reactive power through the network. The latter is a series compensator, which

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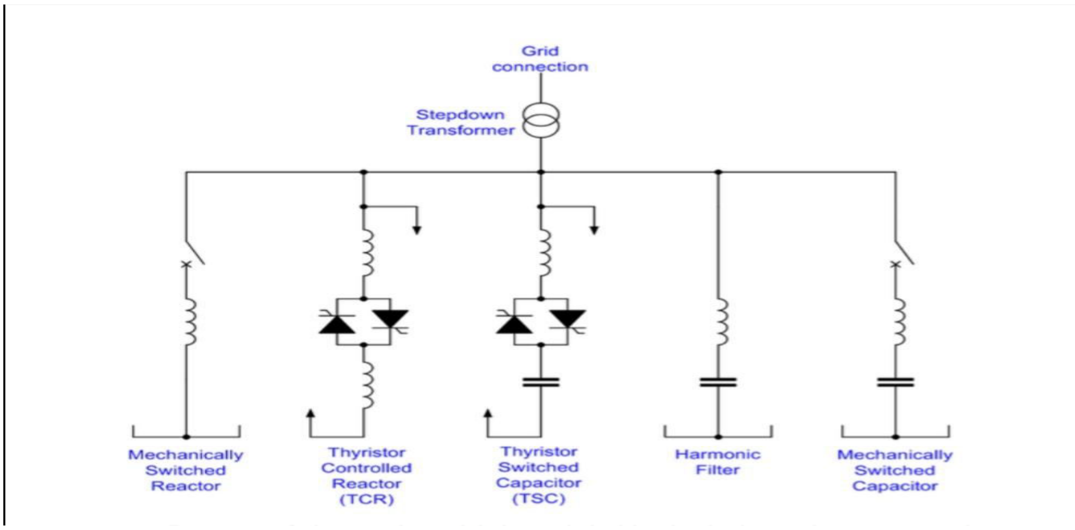
allows fast and continuous changes of transmission impedance, controlling power flow in the line and improving system stability. Now, for maximum utilization of any FACTS device in power system planning, operation and control, power flow solution of the network that consists any of these devices is a fundamental requirement. As a result, many excellent research works have been carried out in the literature for developing efficient load flow algorithm for FACTS devices.

II. STATIC VAR COMPENSATOR

It is a power quality device, which employs power electronics to control the reactive power flow of the system where it is connected. As a result, it is able to provide fast-acting reactive power compensation on electrical systems. In other words, static var compensators have their output adjusted to exchange inductive or capacitive current in order to control a power system variable such as the bus voltage. Moreover, the term static is used to distinguish the SVC from its rotating counter parts like the synchronous generators and/or motors.Typically, an SVC comprises one or more banks of fixed or switched shunt capacitors or reactors, of which at least one bank is switched by thyristor. Elements which may be used to make an SVC typically include: 1. Thyristor controlled reactor (TCR), where the reactor may be air- or iron-cored 2. Thyristor switched capacitor (TSC) 3. Harmonic filter(s) 4. Mechanically switched capacitors or reactors (switched by a circuit breaker).



Smoother control and more flexibility can be provided with thyristor-controlled capacitor switching.
1. Thyristor Controlled Reactor (TCR), shown with Delta connection
2. Thyristor Switched Capacitor (TSC), shown with Delta connection
The thyristors are electronically controlled. Thyristors, like all semiconductors, generate heat and deionized water is commonly used to cool them. Chopping reactive load into the circuit in this manner injects undesirable odd-order harmonics and so banks of high-power filters are usually provided to smooth the waveform. Since the filters themselves are capacitive, they also export MVARs to the power system.

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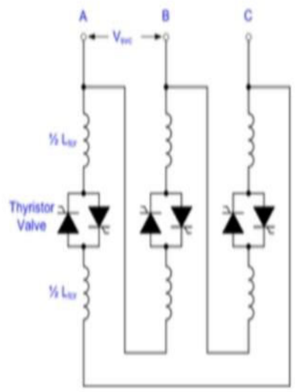
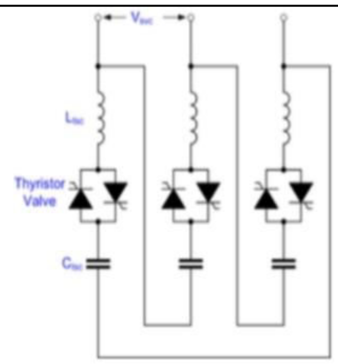


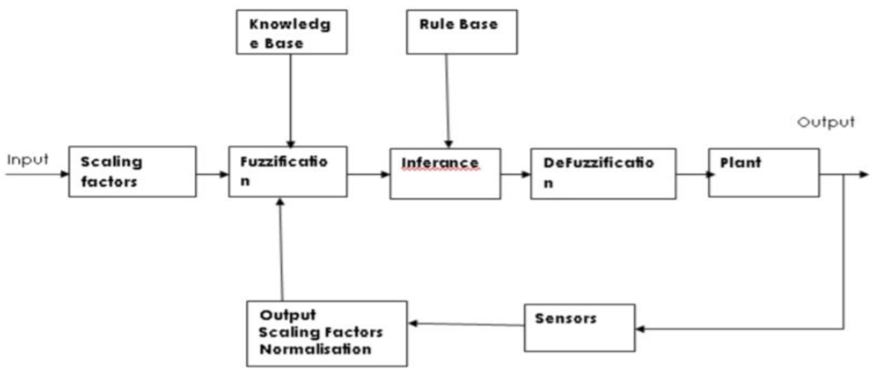
Thyristor Controlled Reactor (TCR)



Thyristor Switched Capacitor (TSC)

III. FUZZY LOGIC CONTROLLER

Fuzzy logic is a fascinating area of research because it does a good job of trading off between significance and precision—something that humans have been managing for a very long time. In this sense, fuzzy logic is both old and new because, although the modern and methodical science of fuzzy logic is still young, the concept of fuzzy logic relies on age-old skills of human reasoning.The knowledge-base module contains knowledge about all the input and output fuzzy partitions. It will include the term set and the corresponding membership functions defining the input variables to the fuzzy rule-base system and the output variables, or control actions, to the plant under control.



The steps in designing a simple fuzzy logic control system are as follows:

1. Identify the variables (inputs, states and outputs) of the plant. Partition the universe of discourse or the interval spanned by each variable into a number of fuzzy subsets, assigning each a linguistic label (subsets include all the elements in the universe).
2. Assign or determine a membership function for each fuzzy subset.
3. Assign the fuzzy relationships between the inputs or states fuzzy subsets on the one hand and the outputs fuzzy subsets on the other hand, thus forming the rule-base.
4. Choose appropriate scaling factors for the input and output variables in order to normalize the variables to the [0, 1] or the [-1, 1] interval.
5. Fuzzify the inputs to the controller.
6. Use fuzzy approximate reasoning to infer the output contributed from each rule.
7. Aggregate the fuzzy outputs recommended by each rule.
8. Apply defuzzification to form a crisp output.

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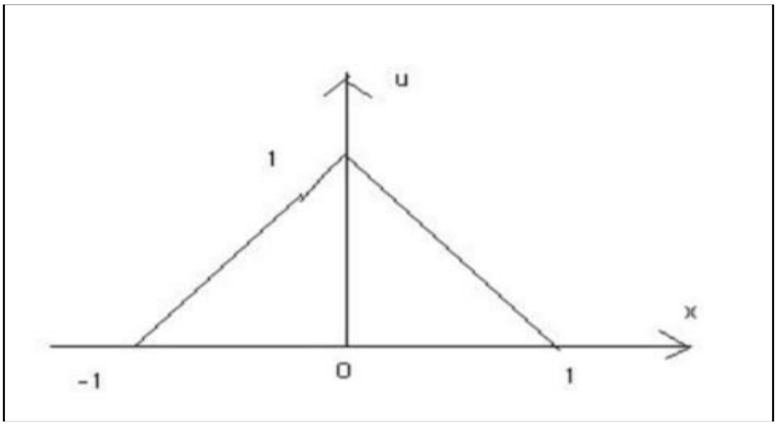
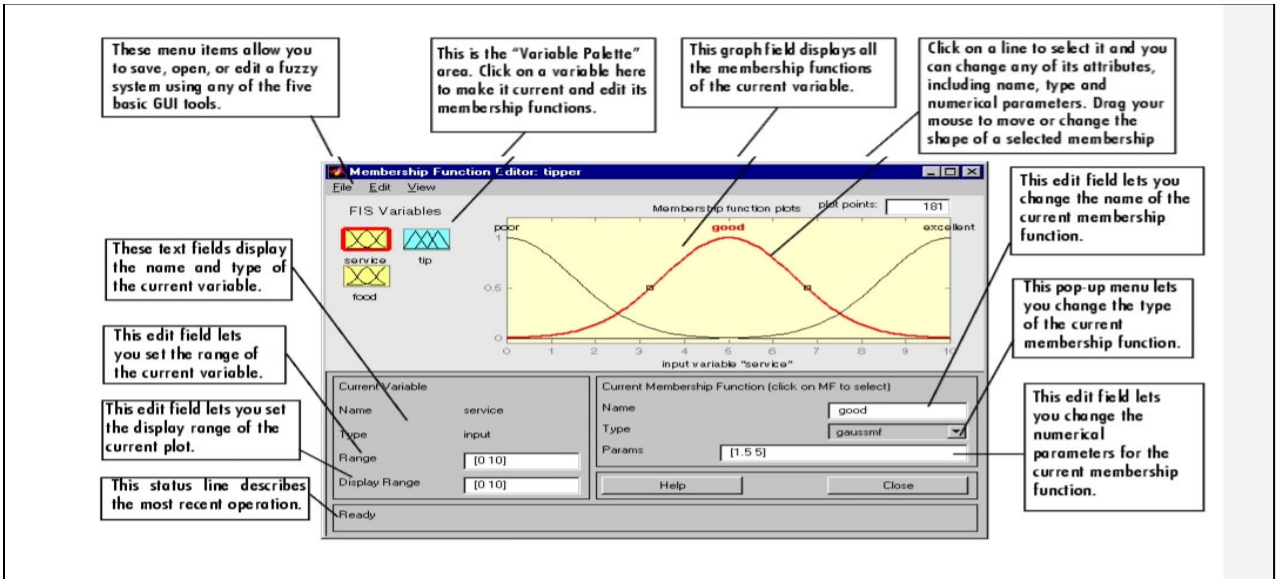
MEMBERSHIP FUNCTIONS:

A graph that defines how each point in the input space is mapped to membership value between 0 and 1. Input space is often referred as the universe of discourse or universal set (u), which contain all the possible elements of concern in each particular application.In this paper, the membership function is considered as a type in triangular membership function.



MEMBERSHIP FUNCTION EDITOR:



FUZZY INFERENCE SYSTEM:

Fuzzy inference is a method that interprets the values in the input vector and, based on user defined rules, assigns values to the output vector. Using the GUI editors and viewers in the Fuzzy Logic Toolbox, you can build the rules set, define the membership functions, and analyze the behavior of a fuzzy inference system (FIS).

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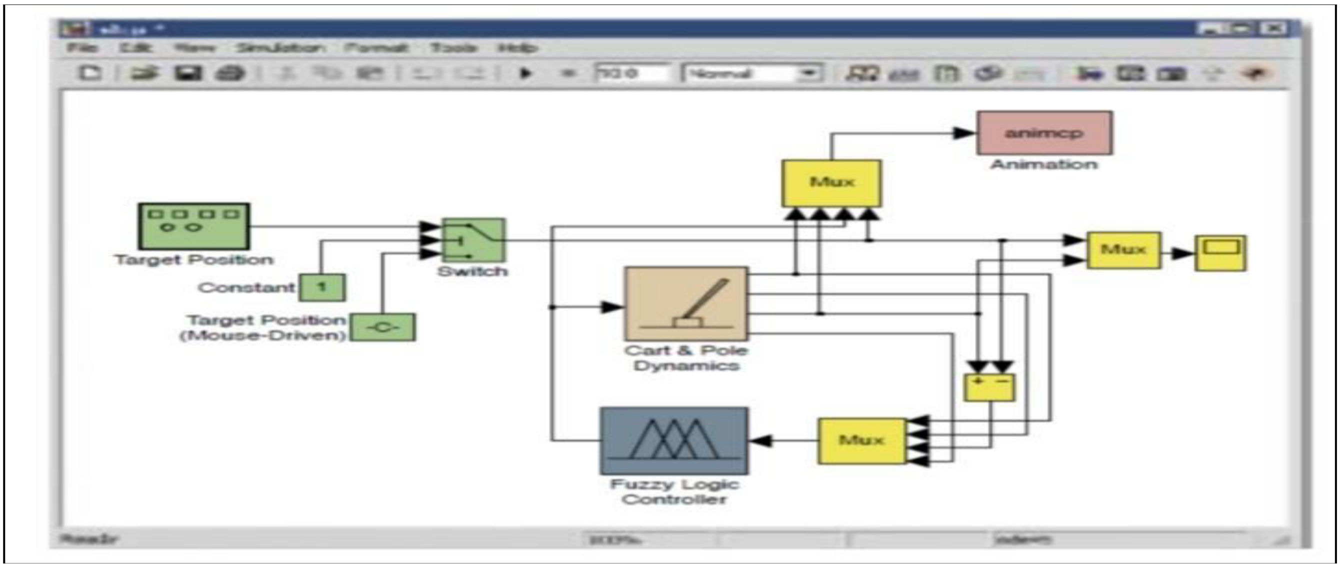
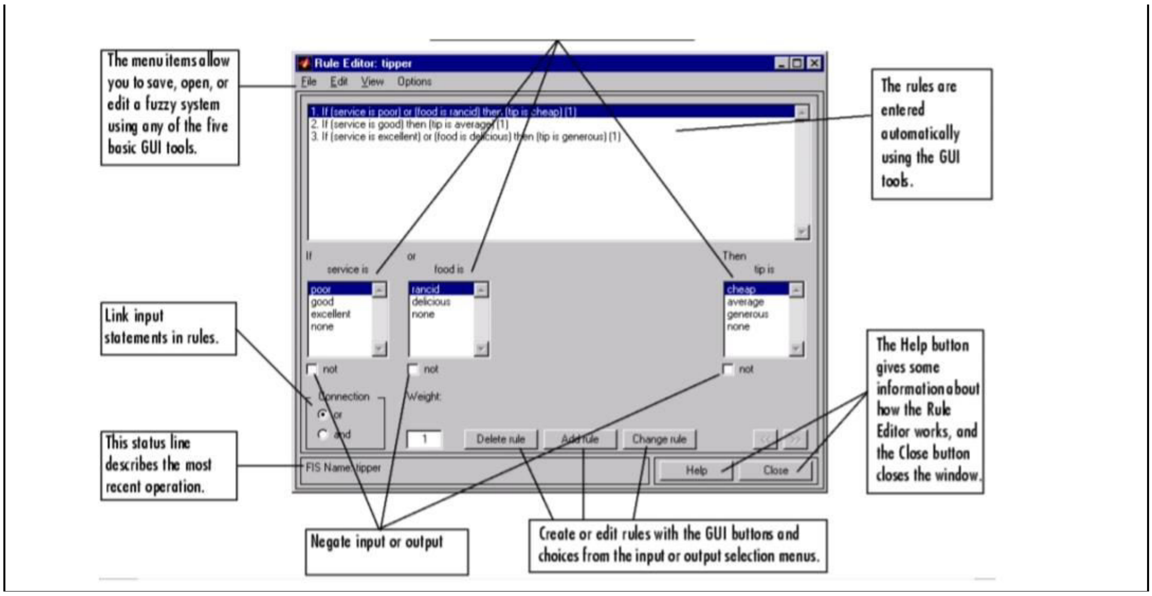


RULE EDITOR:
Constructing rules using the graphical Rule Editor interface is fairly self-evident. Based on the descriptions of the input and output variables defined with the FIS Editor, the Rule Editor allows you to construct the rule statements automatically, by clicking on and selecting one item in each input variable box, one item in each output box, and one connection item. Choosing none as one of the variable qualities will exclude that variable from a given rule.



IV. MATLAB SIMULATION

The integrated multi-machine power system model consisting of 2 generators used for the simulation purposes is shown in the form of a one line diagram (single line diagram) with & without the controllers in the Figs respectively. The generators 1 and 2 are connected to buses 1 and 2. SVC is used for controlling & damping the power system oscillations in the integrated plant. One is connected between bus 9 & 10 Three transformers T1 to T3 are also used in the integrated power system near the generator buses for the power transmission purposes, i.e., for stepping up & stepping down purposes. Transmission lines are connected
between the buses 9-10. Since, we know that the power system is a dynamic one, definitely, it is an on-linear system**.**

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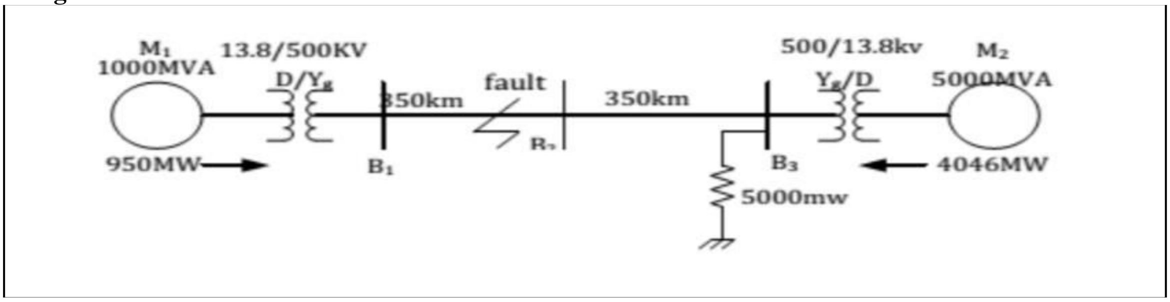
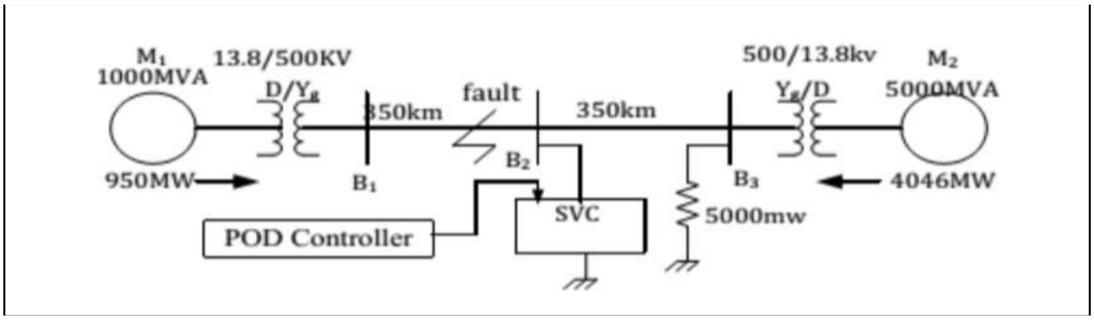
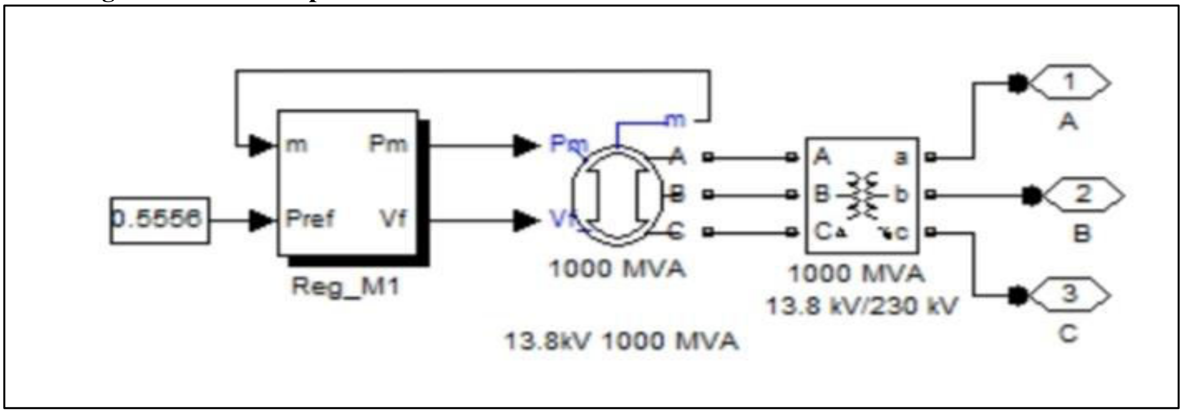
Modelling of 2 machine without controller:



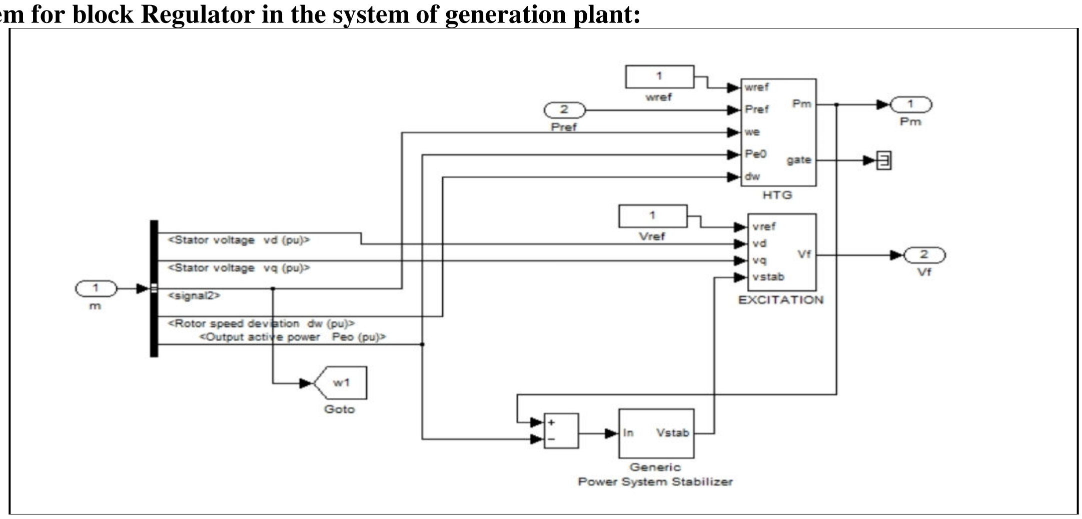
Modelling of 2 machine with controller:



Model of the generation Power plant:



Subsystem for block Regulator in the system of generation plant:



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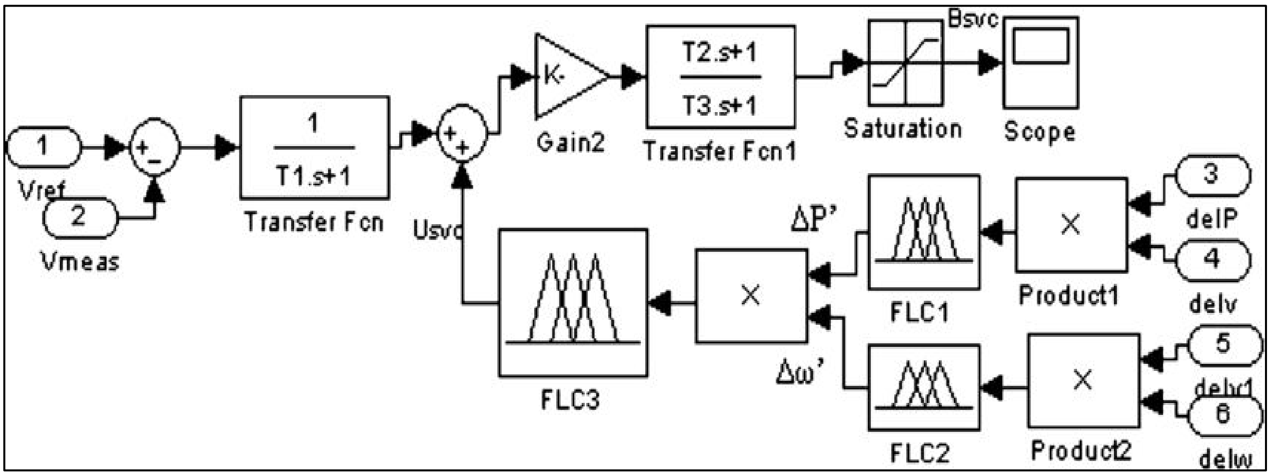
SIMULINK MODEL:



V. RESULTS

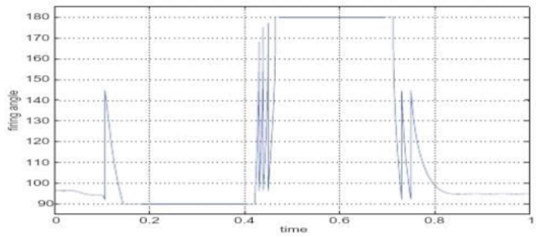


Fig. 13. Firing angle α

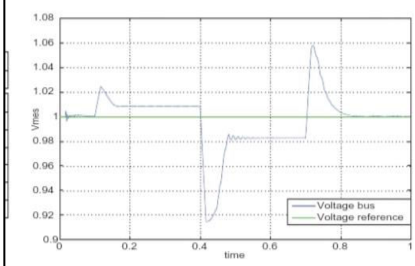


Fig. 9. Voltage bus and Voltage reference

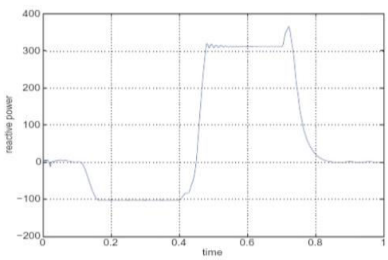


Fig. 10. Reactive power

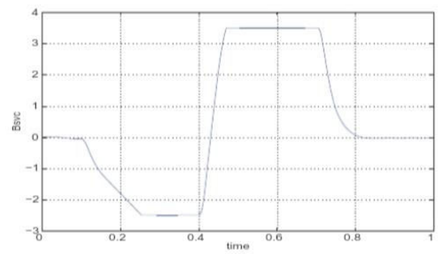


Fig. 11. susceptance B

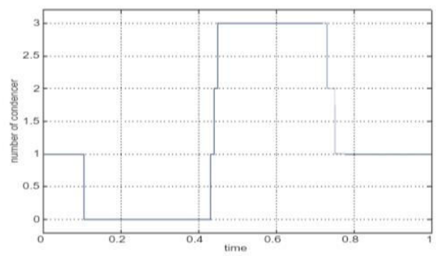


Fig. 12. number of condensers

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VI. CONCLUSION

The paper summarized the following points, mainly quality, reliability and stability issues get generated with the Inter-connection of many distributed generation system in Grid. Power stability issues like voltage frequency and load angle Variation in DG connections. An advanced control device is required for the connection of distributed generation in a network; control device should have a property to secure high reliability and stability of the power system. In this paper, SVC mechanism is controlled with fuzzy logic and ANN based controller. This controller along with SVC improves the voltage profile and the transient stability of buses connected with grid occurred. The designed controller is tested on a 3 machine 5 bus Simulink model in MATLAB. The Simulation tests are performed on buses terminal voltage. The ability of designed controller in contrast with the conventional SVC can be seen that the fuzzy and Ann based controller has enhanced the transmission line power stability during the disturbances whereas the ANN controller provides reliable and stable working.

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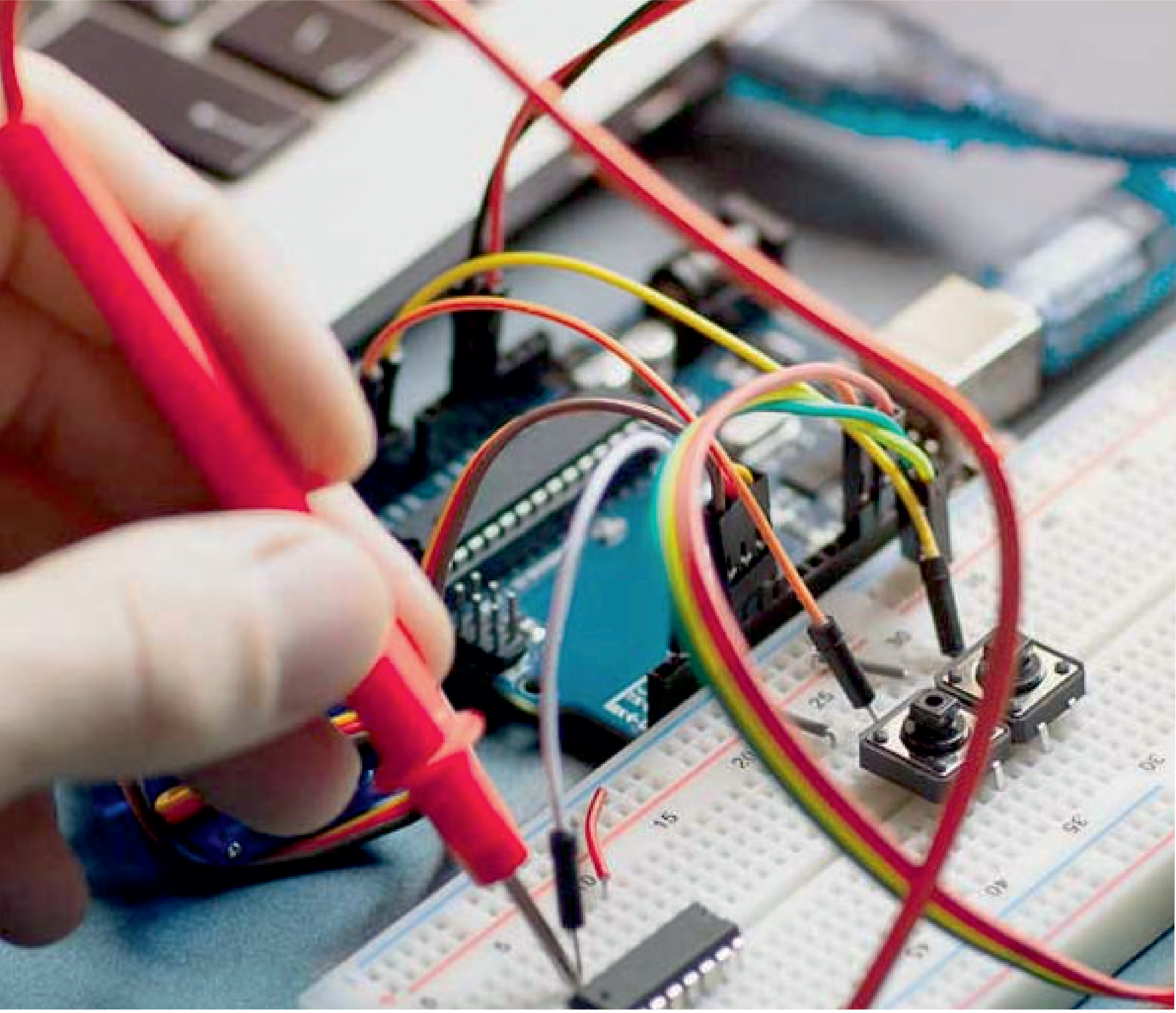

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