MODELING OF FACTS DEVICES BASED ON SPWM VSCS

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ABSTRACT: Electrical distribution system suffers from various problems like reactive power burden, unbalanced loading, voltage regulation and harmonic distortion. Though UPFC are ideal solutions for such systems, they are not popular because of the cost and complexity of control involved. Phase wise balanced reactive power compensations are required for fast changing loads needing dynamic power factor correcting devices leading to terminal voltage stabilization. Unified power flow controllers (UPFC) remain ideal choice for such loads in practice due to low cost and simple control strategy. These UPFCs, while correcting power factor, inject harmonics into the lines causing serious concerns about quality of the distribution line supplies at PCC. This paper proposes to minimize the harmonics injected into the distribution systems by the operation of UPFC used in conjunction with fast changing loads at LV distribution level. Fuzzy logic system is used to solve this nonlinear problem, giving optimum triggering delay angles used to trigger switches in TCR. The scheme with Fuzzy logic system is attractive and can be used at distribution level where load harmonics are within limits.

I INTRODUCTION:

Flexible AC Transmission Systems, called FACTS, got in the recent years a well known term for higher controllability in power systems by means of power electronic devices. Several FACTS-devices have been introduced for various applications worldwide. A number of new types of devices are in the stage of being introduced in practice. In most of the applications the controllability is used to avoid cost intensive or landscape requiring extensions of power systems, for instance like upgrades or additions of substations and power lines. FACTS-devices provide a better adaptation to varying operational conditions and improve the usage of existing installations. The basic applications of FACTS-devices are:

- Power flow control,
- Increase of transmission capability,
- Voltage control,
- Reactive power compensation,
- Stability improvement,
- Power quality improvement,
- Power conditioning,

• Flicker mitigation,

• Interconnection of renewable and distributed generation and storages.

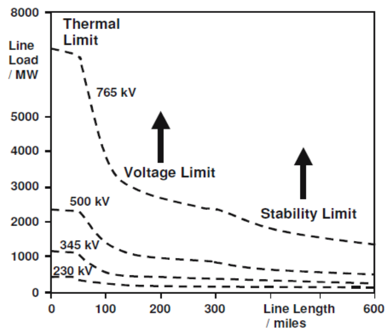


Fig. 1.1. Operational limits of transmission lines for different voltage levels

The influence of FACTS-devices is achieved through switched or controlled shunt compensation, series compensation or phase shift control. The devices work electrically as fast current, voltage or impedance controllers. The power electronic allows very short reaction times down to far below one second. The development of FACTS-devices has started with the growing capabilities of power electronic components. Devices for high power levels have been made available in converters for high and even highest voltage levels. The overall starting points are network elements influencing the reactive power or the impedance of a part of the power system.

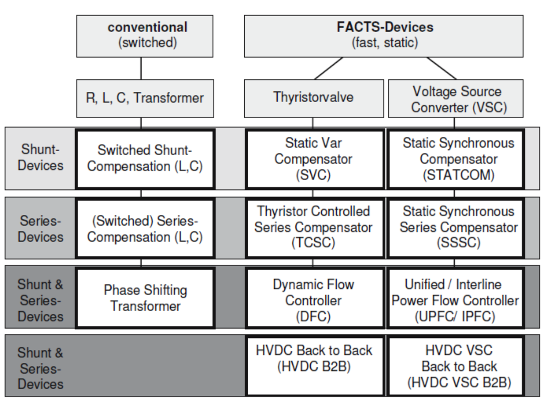


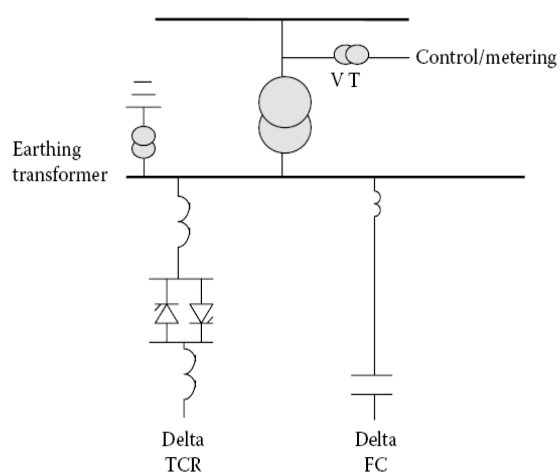
Fig. 1.2. Overview of major FACTS-Devices

SVC:

Electrical loads both generate and absorb reactive power. Since the transmitted load varies considerably from one hour to another, the reactive power balance in a grid varies as well. The result can be unacceptable voltage amplitude variations or even a voltage depression, at the extreme a voltage collapse. A rapidly operating Static Var Compensator (SVC) can continuously provide the reactive power required to control dynamic voltage oscillations under various system conditions and thereby improve the power system transmission and distribution stability.

SVC USING A TCR AND AN FC:

In this arrangement, two or more FC (fixed capacitor) banks are connected to a TCR (thyristor controlled reactor) through a step-down transformer. The rating of the reactor is chosen larger than the rating of the capacitor by an amount to provide the maximum lagging vars that have to be absorbed from the system. By changing the firing angle of the thyristor controlling the reactor from 90° to 180°, the reactive power can be varied over the entire range from maximum lagging vars to leading vars that can be absorbed from the system by this compensator.



1.1.STATCOM:

The STATCOM has a characteristic similar to the synchronous condenser, but as an electronic device it has no inertia and is superior to the synchronous condenser in several ways, such as better dynamics, a lower investment cost and lower operating and maintenance costs. A STATCOM is build with Thyristors with turn-off capability like GTO or today IGCT or with more and more IGBTs. The static line between the current limitations has a certain steepness determining the control characteristic for the voltage. The advantage of a STATCOM is that the reactive power provision is independent from the actual voltage on the connection point. This can be seen in the diagram for the maximum currents being independent of the voltage in comparison to the SVC. This means, that even during most severe contingencies, the STATCOM keeps its full capability.

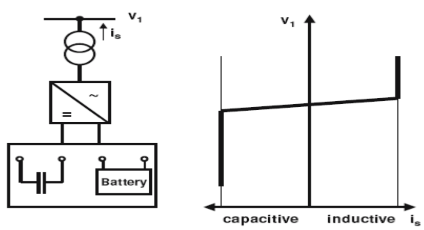
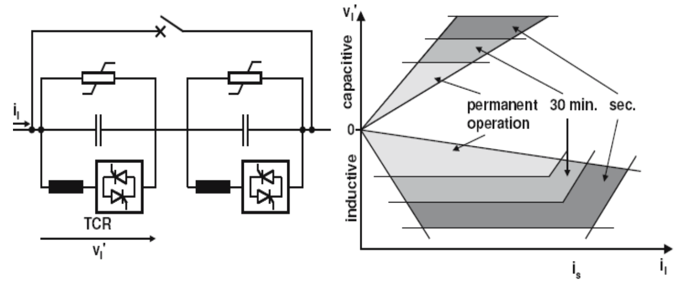


Fig: STATCOM structure and voltage / current characteristic

TCSC: Thyristor Controlled Series Capacitors (TCSC) address specific dynamical problems in transmission systems. Firstly it increases damping when large electrical systems are interconnected. Secondly it can overcome the problem of Sub Synchronous Resonance (SSR), a phenomenon that involves an interaction between large thermal generating units and series compensated transmission systems.



Unified Power Flow Controller:

The UPFC is a combination of a static compensator and static series compensation. It acts as a shunt compensating and a phase shifting device simultaneously.

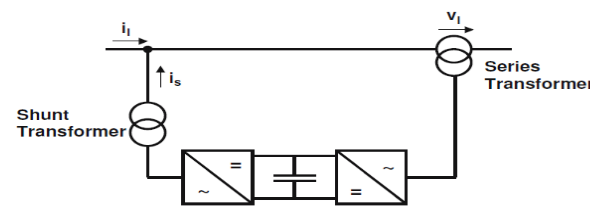
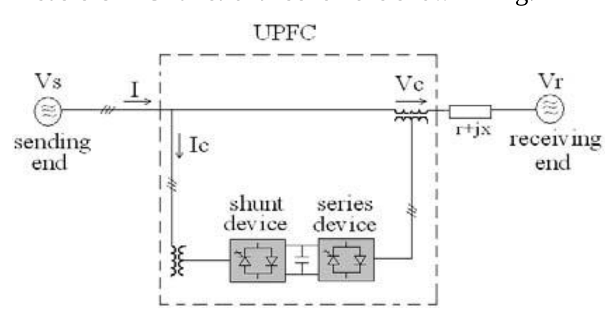


Fig1.21. Principle configuration of an UPFC

OPERATING PRINCIPLE OF UPFC:

The basic components of the UPFC are two voltage source inverters (VSIs) sharing a common dc storage capacitor, and connected to the power system through coupling transformers. One VSI is connected to in shunt to the transmission system via a shunt transformer, while the other one is connected in series through a series transformer.

A basic UPFC functional scheme is shown in fig.1



PROPOSED TECHNIQUE:

FUZZY LOGIC:

Fuzzy logic has two different meanings. In a narrow sense, fuzzy logic is a logical system, which is an extension of multivalve logic. However, in a wider sense fuzzy logic (FL) is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with unsharp boundaries in which membership is a matter of degree. In this perspective, fuzzy logic in its narrow sense is a branch of fl. Even in its more narrow definition, fuzzy logic differs both in concept and substance from traditional multivalve logical systems.

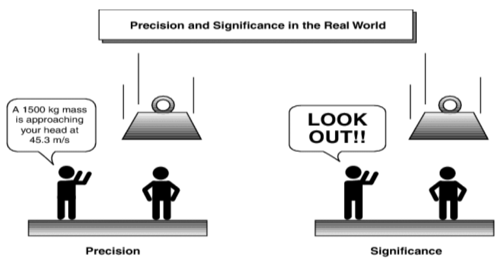


fig 5.1 fuzzy description

Building a 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). The following editors and viewers are provided.

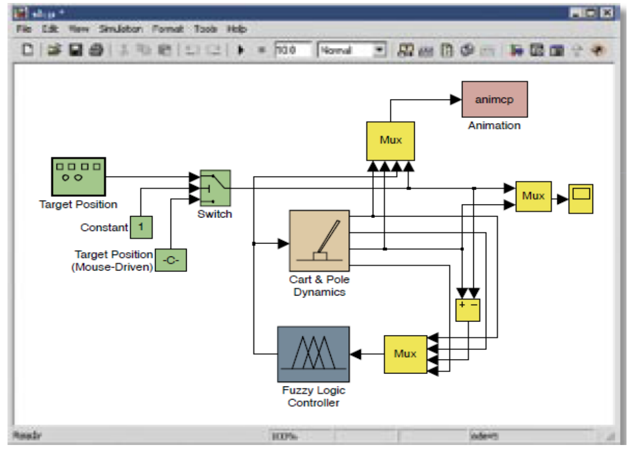


fig 5.2 fuzzy interference system

The FIS editor:

The FIS Editor displays general information about a fuzzy inference system. There's a simple diagram as shown in Fig.3 that shows the names of each input variable on the left, and those of each output variable on the right. The sample membership functions shown in the boxes are just icons and do not depict the actual shapes of the membership functions.

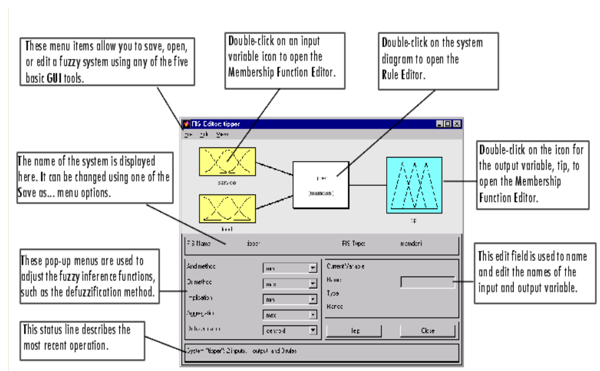
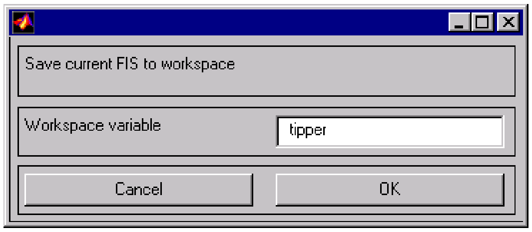


fig 6.3 The FIS Editor

You will see the diagram updated to reflect the new names of the input and output variables. There is now a new variable in the workspace called tipper that contains all the information about this system



'Save to workspace as...' Window

By saving to the workspace with a new name, you also rename the entire system. Your window will look like as shown in Fig.5.

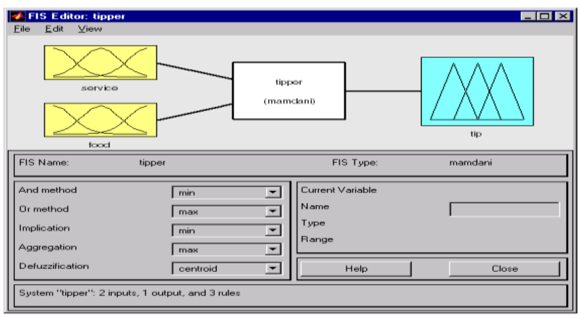
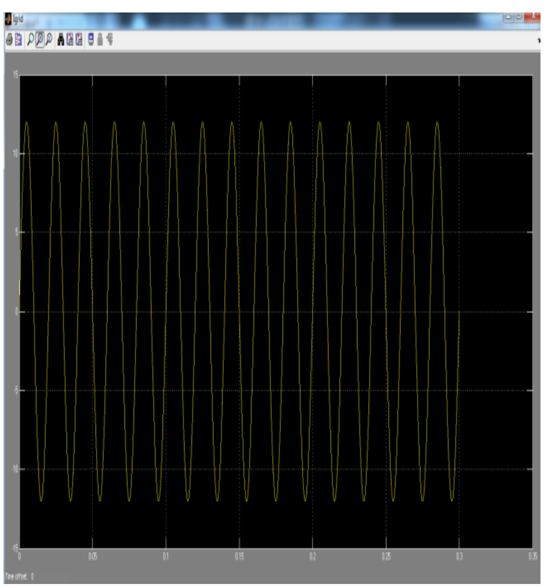


fig 6.5 The updated FIS Editor

RESULT:



CONCLUSION:

Two efficient VSC models based on Fourier series approach and hyperbolic tangent have been proposed for the six-pulse converter. The proposed models have been used for the computation of the solution of FACTS devices connected to a power network. It has been shown that the proposed models can be used to compute both the transient and the periodic steady-state solution of a power network containing VSC-based FACTS. The response given by the proposed methods has been successfully validated against the solution obtained with the widely accepted digital simulators Simulink and PSCAD/EMTDC, respectively, in all the cases the obtained results were in excellent agreement. In addition, it has been shown through simulations that the proposed models allow significant larger integration steps, as compared with the ideal switch model approach, e.g., for the conducted studies, more than 800 times the integration step needed by Simulink and PSCAD/EMTDC when the Fourier approach was used, and at least 300 times when the hyperbolic tangent method was applied. The proposed VSCs models have been only implemented in a network including FACTS devices; however, these models can be used in any power-electronic device based on SPWM six pulse converters, or even for multilevel converters based on arrangement of six-pulse converters.

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