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Performance Evaluation of UPFC under LLLG-Fault Condition in an Interconnected Network

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Abstract:

The Unified Power Flow Controller (UPFC) is the most adaptable and complex power electronic device that has developed for the control and enhancement of power in electrical power transmission framework. This paper introduces a control framework which empowers the UPFC to take after the adjustments in reference qualities like AC voltage and DC join voltage. Operation of UPFC utilizing a SVM procedure. Reenactments were completed utilizing MATLAB/Simulink programming to approve the execution of the UPFC in a transmission line with LLLG inadequacies. Multiplication results show that the proposed control arrangement is effective in damping the power swings in transient states.

Keywords:
power flow, voltage regulation, FACTS, SVM.

I. INTRODUCTION:

THE POWER exchange capacity of long transmission lines is normally constrained by warm ability, dielectric quality and various steadiness issues. Monetary elements, for example, high cost of long lines and income from the conveyance of extra power, give solid impetuses to investigate all financially and in fact plausible method for raising as far as possible. Then again, the advancement of viable approaches to utilize transmission frameworks at their most extreme warm and dielectric capacity has gotten much research consideration lately. Quick movement in the field of force hardware has extraordinary impact on the force business. One immediate result of its impact is the idea of Flexible AC Transmission Systems (FACTS), which enhances solidness to build usable force transmission ability to its warm breaking point. The group of FACTS gadgets makes utilization of door turn-off thyristors (GTOs) in high power converter conurbations that can be controlled to carry on as three stage sinusoidal voltage sources, to give quick control of dynamic and responsive power through a transmission line. The group of FACTS gadgets incorporates the Static Var Compensators (SVCs), Static Synchronous Compensators (STATCOMs), Thyristor Controlled Series Compensators (TCSCs), the Static Synchronous Series Compensators (SSSCs), and the Unified Power Flow Controllers (UPFCs). The UPFC is the most flexible and complex of the FACTS gadgets, consolidating the components of the STATCOM and the SSSC. The UPFC can give synchronous control of all fundamental force framework parameters, viz., transmission voltage, and impedance and stage point.

Most looks into have accentuated the impact of UPFCs on force stream control and security change. Then again, a little writing has been distributed on element execution and transient conduct of UPFCs. This paper introduces a control plan and far reaching investigation for an UPFC through PC reenactment. In this control conspire, the SVM controls the operation of UPFC. The execution of the above said control plan is tried by applying diverse blames over a transmission line to which it is joined. It presumes that the proposed control plan is described by effectively damping force swings in transient states.

II.BASIC OPERATING PRINCIPLE OF UPFC:

A streamlined schematic of an UPFC is demonstrated in Figure-1. The primary components are, it has two inverters, one joined in arrangement with the line through an arrangement insertion transformer and another associated in shunt with the line through a shunt coupling transformer. Fundamentally, the arrangement associated inverter is utilized to infuse a controlled voltage in arrangement with the line and in this way to compel the force stream to a wanted worth.

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All in all, the arrangement inverter may trade both genuine and responsive force while performing this obligation. A voltage sourced-inverter has the capacity produce the required responsive power electronically at its air conditioner terminals, however is unequipped for taking care of genuine force trade unless there is a suitable force source joined with its dc terminals. Therefore the arrangement joined inverter has its dc terminals associated with those of the shunt-joined inverter, which performs its essential capacity by conveying precisely the perfect measure of genuine energy to meet the genuine power needs of arrangement inverter. It gets this genuine force from its association with the air conditioner transport. The shunt inverter can likewise perform an optional capacity by electronically creating responsive force for regulation of the neighborhood air conditioning transport voltage. The UPFC consequently offers the extraordinary capacity of freely controlling the genuine and receptive force streams on the transmission line, while additionally managing the nearby transport voltage.

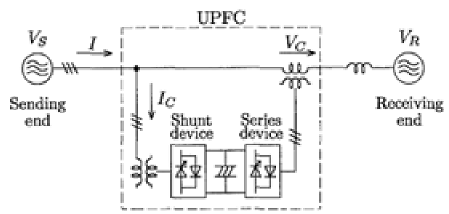


Figure-1. Schematic of UPFC.

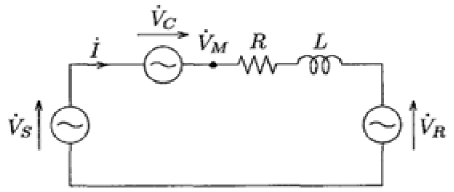
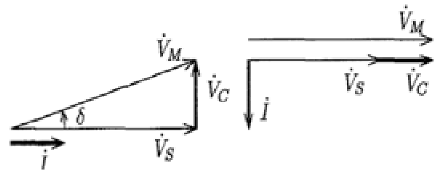


Fig2: Single phase equivalent circuit



(a) Active (b) Reactive

Fig3: Phasor diagrams in case of active and reactive power

III.CONTROL TECHNIQUE FOR UPFC CONVERTERS:

The most popular among the various PWM techniques employed for converters are carrier-based sinusoidal PWM and SVPWM. The major disadvantage of SPWM scheme is lower dc bus utilization. The maximum output voltage from VSI utilizing this scheme is limited to 0.5Vdc (peak) or 0.353 rms. Space vector modulation improves dc bus utilization by 15.15%. Further digital implementation of this scheme is easier. The major advantage of SVWPM stem from the fact that there is a degree of freedom of space vector placement in a switching cycle. This improves the harmonic performance of this method.

PRINCIPLE OF SVPWM:

A three-phase VSI generates eight switching states which include six active and two zero states. These vectors form a hexagon which can be seen as consisting of six sectors spanning 60° each. The reference vector which represents three-phase sinusoidal voltage is generated using SVPWM by switching between two nearest active vectors and zero vectors.

STEPS TO IMPLEMENT SVPWM:

Step-1: Sector identification

By comparing the stationary frame d-q components of the reference voltage vector, the sector where the reference voltage vector is located is identified.

Step-2: Calculating the effective time

Using the d-q components of the reference voltage vector, a sine loop voltage and a dc-link voltage information, the effective times T1, T2 are calculated. Instead of the sine table, to reduce the calculation time, another look-up table which contains the corresponding to each sector number may be used.

Step-3: Determining the switching states

Using the corresponding sector information the actual switching time for each inverter leg is generated from the combination of effective times and zero sequence time by using volt-seconds balance.The principal advantage of the SVPWM over SPWM is that it enhances the DC bus utilization by about 15%.The maximum value of the peak-phase voltage by SVPWM is given by

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$$V_{phpeakmax}=\frac{2}{3}*\frac{\sqrt{3}}{2}*V_{dc}=\frac{V_{dc}}{\sqrt{3}}=0.577*V_{dc}$$

It is known that the maximum value of the peak-phase voltage that can be obtained from a 3-Ph inverter with Sinusoidal Pulse Width Modulation (SPWM) technique is equal to Vdc/2.It is therefore evident that SVPWM achieves a better DC bus utilization compared to SPWM (by about 15.4%).

IV.SIMULATION SETUP

Software employed

Matlab-R2010a.

MATLAB is a software package for computation in engineering, science, and applied mathematics. It offers a powerful programming language, excellent graphics, and a wide range of expert knowledge. MATLAB is published by and a trademark of The Math Works, Inc Simulink (Simulation and Link) is an extension of MATLAB by Math works Inc. It works with MATLAB to offer modeling, simulating, and analyzing of dynamical systems under a graphical user interface (GUI) environment. The construction of a model is simplified with click-and-drag mouse operations. Simulink includes a comprehensive block library of toolboxes for both linear and nonlinear analyses. As Simulink is an integral part of MATLAB, it is easy to switch back and forth during the analysis process and thus, the user may take full advantage of features offered in both environments

Sim-Power Systems-toolbox:

Sim-Power Systems is other product of the Physical Modeling which works together with Simulink® to model electrical, mechanical, and control systems. Sim-Power Systems is a modern design tool that allows scientists and engineers to rapidly and easily build models that simulate power systems. Not only can you draw the circuit topology rapidly, but your analysis of the circuit can include its interactions with mechanical, thermal, control, and other disciplines. This is possible because all the electrical parts of the simulation interact with the extensive Simulink modeling library. Since Simulink uses MATLAB® as its computational engine, designers can also use MATLAB toolboxes and Simulink block sets. SimPowerSystems and Sim Mechanics share a special Physical Modeling block and connection line interface.

System Details

IEEE- 6 Bus System Data
MVA Base=100 MVA
System Frequency = 50 Hz
Bus Nominal Voltage =11KV
Bus Maximum Voltage = 11.5 KV
Bus Minimum Voltage = 10.4 KV

Generation data

G=100MVA 11KV at BUS B2

G=100MVA 11KV at BUS B3
G=100MVA 11KV at BUS B4

Load data

L=20MW 10MVAR at BUS B2
L=30MW 10MVAR at BUS B6
L=40MW 15MVAR at BUS B5

External disturbance condition

LLLG fault(symmetrical type) at BUS 5
Fault resistance=0.001 Ohm
Gnd resistance=0.001 Ohm

Conditions verified

Case-1

Without UPFC : Observe various P Q line flows, Bus voltages

Case-2

Without UPFC : Presence of LLLG fault at BUS-5 after 0.3sec- Observe sudden drops Vbus5 Ibus5 Pbus5

Case-3

With UPFC acted after 0.4sec connected in line-a : Presence of LLLG fault at BUS-5 after 0.3sec -Observe Vbus5 Ibus5 Pbus5 getting restored

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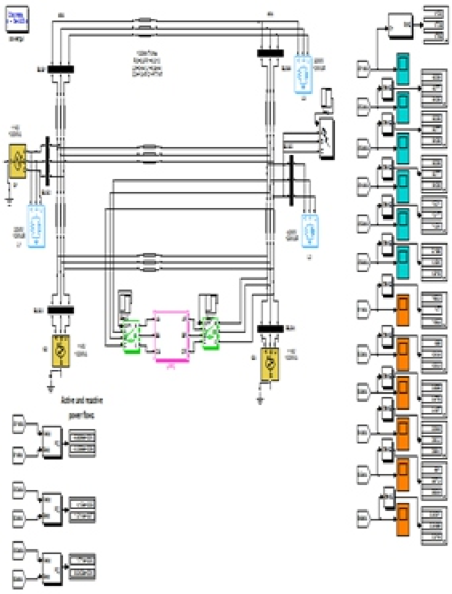


Fig4 : power system with UPFC

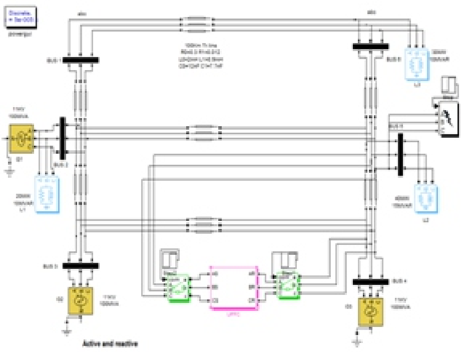


Fig 5:

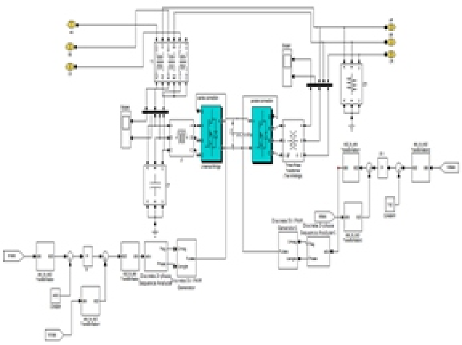


Fig 5: UPFC converter circuit and its controller

For example:

Let Vdc=150V
Then Max value of phase peak voltage from SPWM=0.5* Vdc
=0.5*150
= 75V

Now,
Max value of phase peak voltage from SVPWM= 0.577* Vdc
=0.577*150
= 86.55V
Therefore,Percentage increase in inverter voltage= [(86.55-75)/75]*100
=15.4%

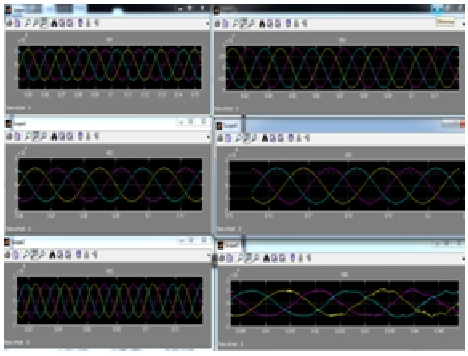


Fig 5: Before fault-various bus voltages

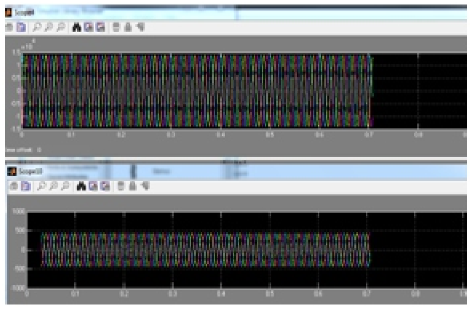


Fig 6: Before fault at BUS-5: VB5abc and IB5abc

Power flows before fault Bus-5
Active pw bus-5 P =8.4MW
Reactive pw bus-5 Q=3.1MVar

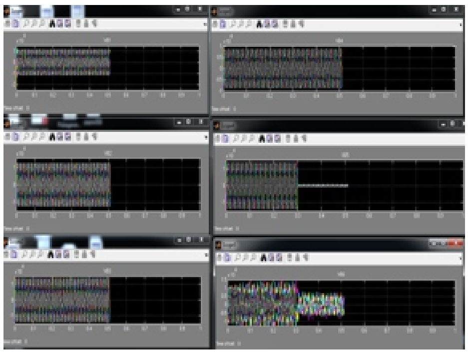


Fig 7: During fault (0.3 sec)-various bus voltages

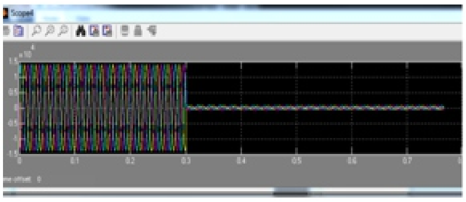
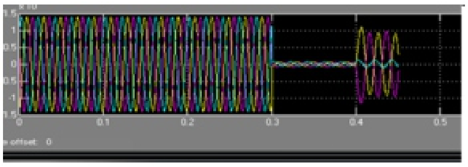
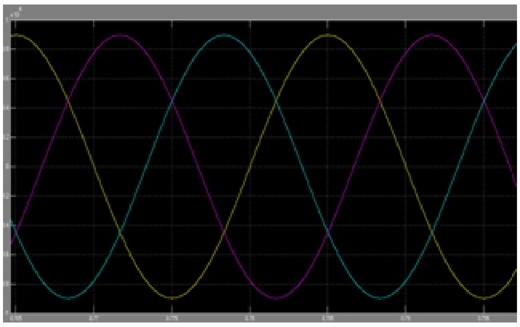


Fig 7: During fault at BUS-5: VB5abc

Power flows during fault at bus-5
Active pw bus-5 P =15KW
Reactive pw bus-5 Q=10KVar
UPFC getting in to action after 0.4 sec



UPFC acted after 0.4sec: VB5abc restoring



Vabc

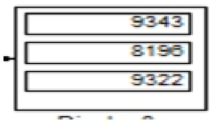
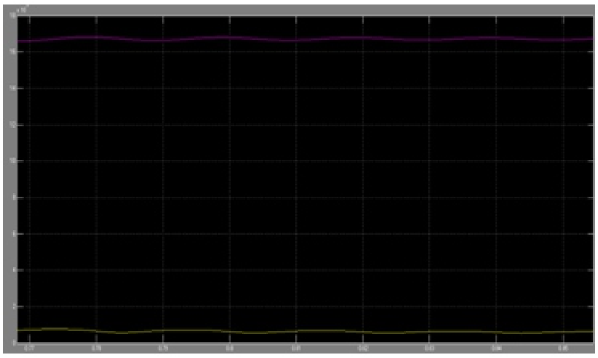


Fig 9: Injected voltages by UPFC in to the system during fault



P and Q

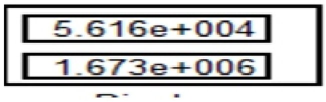


Fig 10: Active and reactive powers delivered by UPFC under fault conditions

Power flows during fault at bus-5 +
UPFC acted after 0.4sec
Active pw bus-5 P =2.6MW
Reactive pw bus-5 Q=0.2MVar

V. CONCLUSION:

This paper introduces a control framework which empowers the UPFC to take after the adjustments in reference qualities like AC voltage and DC join voltage. Operation of UPFC utilizing a SVM procedure is presented here. This utilizes MATLAB/Simulink programming to approve the execution of the UPFC in a transmission line with LLLG inadequacies.

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