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# Augmentation of Real & Reactive Power in Grid by Unified Power Flow Controller

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**ABSTRACT**
In this paper**,** a Power Flow Control in transmission line with respect to voltage condition (L-G, L-L-G, L-L) over come by using unified power flow controller. The existing system employs UPFC with transformer less connection with both series and shunt converter. This converter have been cascaded with multilevel inverters which is more complicated to enhance the performance of UPFC.A proposed system consist of three terminal transformer for shunt converter and six terminal transformer for series converter. Shunt converter & series converter is coupled with common DC capacitor. DC link capacitor voltage is maintained using PID controller and synchronous reference frame theory (SRF) is used to generate reference voltage & current signal. Simulation studies are carried out for (L-G, L-L-G, L-L real & reactive power compensation results will be shown in this paper).

***Keyword****:* SRF- Synchronous Reference Frame theory, UPFC-Unified Power Flow Controller, PID-Proponal Integral Derivative controller, LG-Line to Ground fault, LL-Line to Line fault, LLG-Double Line to Ground fault. ***IndexTerms***- Flexible AC transmission systems (FACTS), unified power flow controller (UPFC), transformers, voltage source converter1, voltage source converter2, and power flow control.

## I. INTRODUCTION

Power Generation and Transmission is a complex process, requiring the working of many components of the power system in tandem to maximize the output. One of the main components to form a major part is the reactive power in the system. It is required to maintain the voltage to deliver the active power through the lines. Loads like motor loads and other loads require reactive power for their operation. To improve the performance of ac power systems, we need to manage this reactive power in an efficient way and this is known as reactive power compensation. There are two aspects to the problem of reactive power compensation: load compensation and voltage support.

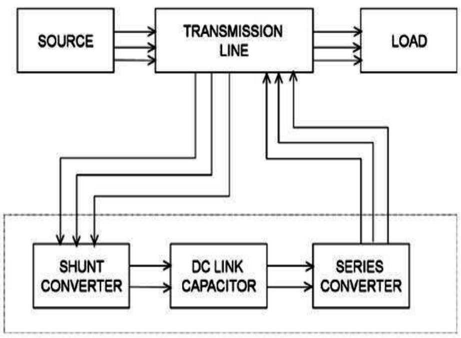


Fig.(a)-block diagram of UPFC

Table III. System Parameters for Test Setup

| Parameter | Value |
|---|---|
| Grid voltage (low voltage side) Vg | 480 V |
| Rated frequency | 60 Hz |
| Sampling frequency | 2.5 kHz |
| Transformer 1 | 480 V/ 4160 V, 75 kVA |
| Transformer 2 | 480 V/ 4160 V, 75 kVA |
| Dc capacitance | 2350 µF |
| Rated line current | 10 A |
| Reactor X1 | 2.5 mH |
| Reactor X2 | 3.2 mH |
| Leakage inductance of Transformer 1 | 35 mH (6% pu) |
| Leakage inductance of Transformer 2 | 35 mH (6% pu) |

Load compensation consists of improvement in power factor, balancing of real power drawn from the supply, better voltage regulation, etc. of large fluctuating loads. Voltage support consists of reduction of voltage fluctuation at a given terminal of the transmission line. Two types of compensation can be used: series and shunt compensation. These modify the parameters of the system to give UPFC compensation.

In recent years, the SSSC & STATCOM compensators like the UPFC have been developed. These quite satisfactorily do the job of absorbing or generating reactive power with a faster time response and come under Flexible AC Transmission Systems (FACTS). This allows an increase in transfer of apparent power through a transmission line, and much better stability by the adjustment of parameters that govern the power system i.e. current, voltage, phase angle, frequency and impedance.

## II. PRICIPLE AND OPERATION OF UNIFIED POWER FLOW CONTROLLER (UPFC)

The UPFC consist of two back to back converters named $VSC_1$ and $VSC_2$, are operated from a DC link provided by a dc storage capacitor. These arrangements operate as an ideal ac to ac converter in which the real power can freely flow either in direction between the ac terminals of the two converts and each converter can independently generate or absorb reactive power as its own ac output terminal.

One VSC is connected to in shunt to the transmission line via a shunt transformer and other one is connected in series through a series transformer. The DC terminal of two VSCs is coupled and this creates a path for active power exchange between the converters.

VSC provide the main function of UPFC by injecting a voltage with controllable magnitude and phase angle in series with the line via an injection transformer. This injected voltage act as a synchronous ac voltage source.

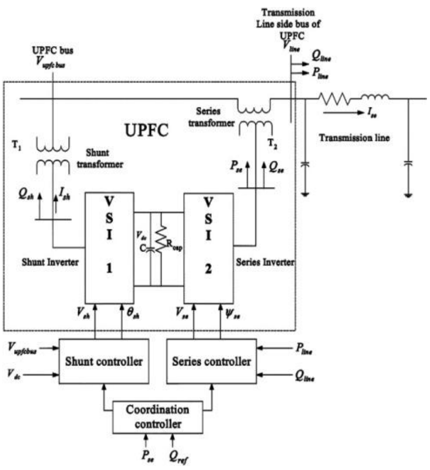


Fig (b)-circuit diagram of UPFC

The transmission line current flows through this voltage source resulting in reactive and active power exchange between it and the ac system. The reactive power exchanged at the dc terminal is generated internally by the converter. The real power exchanged at the ac terminal is converted into dc power which appears at the dc link as a real power demand.

$VSC_1$ is to supply or absorb the real power demanded by converter2 at the common dc link to support real power exchange resulting from the series voltage injection. This dc link power demand of $VSC_2$ is converted back to ac by $VSC_1$ and coupled to the transmission line bus via shunt connected transformer.

In addition $VSC_1$ can also generate or absorb controllable reactive power if it is required and thereby provide independent shunt reactive compensation for the line.

Thus $VSC_1$ can be operated at a unity power factor or to be controlled to have a reactive power exchange with the line independent of the reactive power exchanged by $VSC_1$. Obviously, there can be no reactive power flow through the UPFC dc link.

## III. FUNDAMENTAL OF UNIFIED POWER FLOW CONTROLLER

The unified power flow controller consists of two switching converters operated from a common dc link provided by a dc storage capacitor.converter1 is connected in parallel with a transmission line, and converter2 is connected in series with a line. The converter1 is act as a STATCOM (Static synchronous compensator),and converter2 is act as a SSSC(static synchronous series compensator).

**CONVERTER1**: The converter1 is absorb the real power and absorb, injected the reactive power. The converter section is six MOSFET switches as used in $vsc_1$.the control technique is PWM (pulse width modulation) as been used. The $vsc_1$ is its convert 3 phase AC –DC power supply it act as rectifier.

C**ONVERTER2**: The converter2 to injected the real power and absorb, inject the reactive power. The same six MOSFET switches as used in the $vsc_2$.the $vsc_2$ its convert dc-3 phase ac power supply it act as the inverters. The control technique also same in $vsc_1$ and $vsc_2$.

## IV. CONTROL TECHNIQUES OF UPFC

Control techniques for $VSC_1$: The control techniques as show in fig.(c)

The error signal cannot be measure in critical of the sine waveforms. Its converts to abc to dq0.the direct axis easily find the error signals. So, go for the dq0 conversion. Then low pass filter its cannot allow the low frequency if allow the high frequency of the power system.

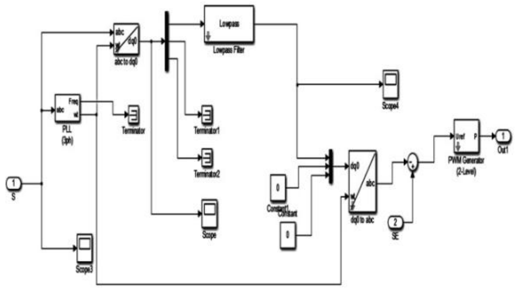

Fig (c)-controller for $vsc_1$

After that MUX is dq0 signal to single output is given to the dq0 to abc conversion. The abc signal and reference signal is compare the comparator finding errors values then PWM is generate the trigger pulse.

Control techniques for $VSC_2$: The control techniques as show in fig.(d)

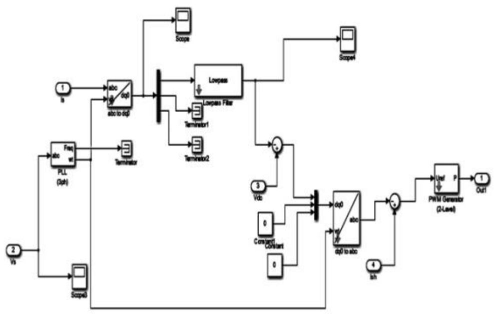

Fig (d)-controller for $vsc_2$

The same function of $vsc_1$ and $vsc_2$ if only difference is $vsc_2$ reference signal is taken by a shunt current. If shunt means voltage is constant current is variable. Then $vsc_1$ reference signal is series voltage is taken. Because series means voltage is variable. dc-link capacitor voltage level should be maintained the some voltage level. The PID controller as to be maintain the capacitor voltage values.

LOADS: Linear loads are AC electrical loads where the voltage and current wave forms are sinusoidal. The current at any time is proportional to voltage. Linear Loads are capacitors, incandescent lamps, heaters etc. Linear load is used in our project to depict the operation of the power system in normal operating conditions.

Non-linear loads are AC loads where the current is not proportional to the voltage. The non-linear loads generate harmonics in the current wave form. This distortion of the current waveform leads to distortion of the voltage waveform. Under these conditions, the voltage waveform is no longer proportional to the current. Non Linear Loads are computers, laser printers, SMPS, rectifier.

## V. EXPERIMENTAL RESULTS OF UPFC

A. Fault analysis of line to ground(L-G) fault: Voltage compensation of L-G fault as shown in fig(e).

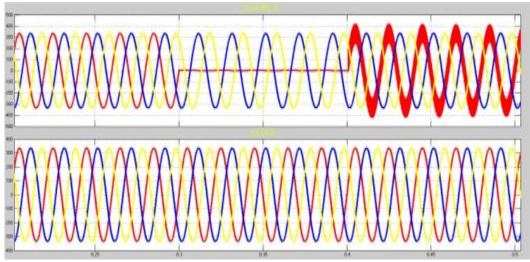

Fig (e)

Current compensation of L-G fault as shown in fig (f)

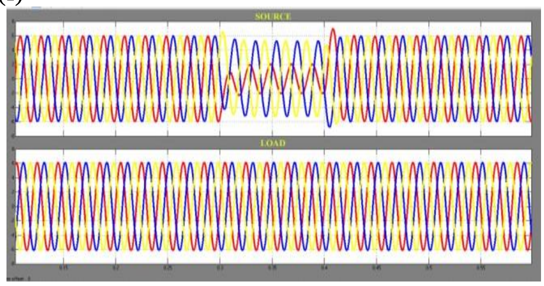

Fig (f)

Real & reactive power compensation of L-G fault as shown in fig (g)

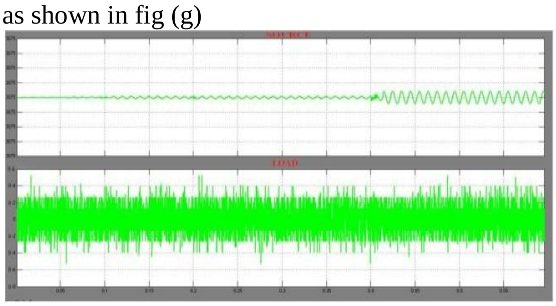

Fig (g)

B. Fault analysis of line to line (L-L) fault: Voltage compensation of L-L fault as shown in fig (h)

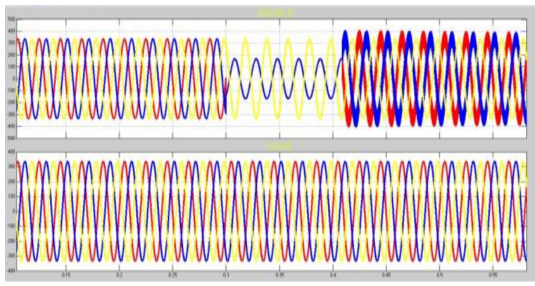

Fig (h)

Current compensation of L-L fault as shown in fig (i)

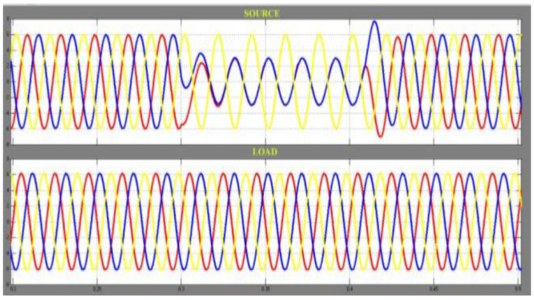


Fig (i)

Real & reactive power compensation of L-L fault as shown in fig (j)

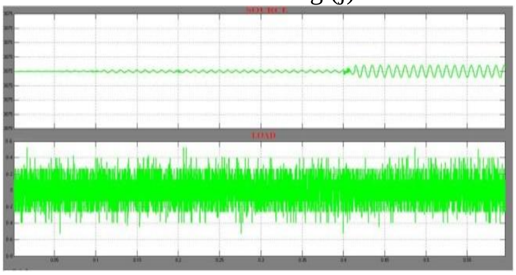

Fig (j)

C. Fault analysis of Double line to Ground (L-L-G) fault: Voltage compensation of L-L-G fault as shown in fig (k)

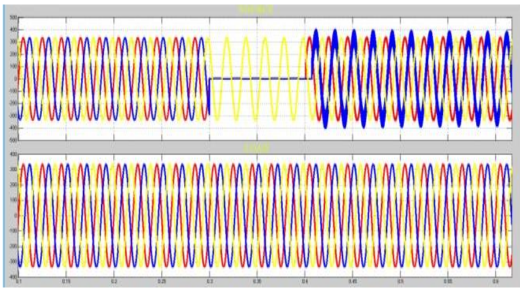

Fig (k)

Current compensation of L-L-G fault as shown in fig (l)

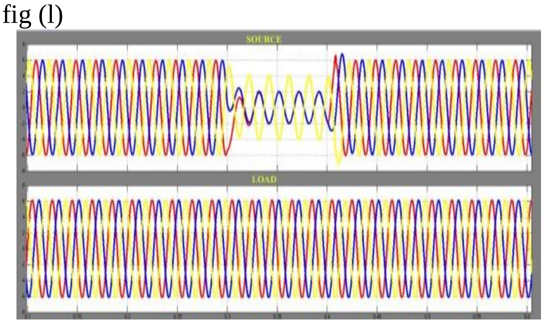


Fig (l)

Real & reactive power compensation of L-L-G fault as shown in fig (m)

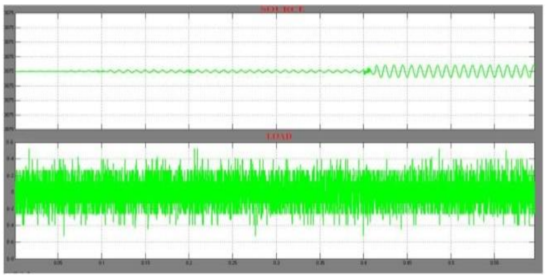

Fig (m)

## VI. VI. CONCLUSION

This project presents power flow control in transmission line with respect to voltage condition (L-G, L-L-G, L-L) over come by using unified power flow controller. The existing system employs UPFC with transformer less connection with both series and shunt converter. This converter have been cascaded with multilevel inverters which is more complicated to enhance the performance of UPFC. A proposed system consists of three terminal transformer for shunt converter and six terminal transformer for series converter. Shunt converter & series converter is coupled with common DC capacitor. DC link capacitor voltage is maintained using PID controller and synchronous reference frame theory (SRF) is used to generate reference voltage & current signal. Simulation studies are carried out for(L-G, L-L-G, L-L real & reactive power compensation)

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