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DISTRIBUTED POWER FLOW CONTROLLER FOR VOLTAGE SAG/SWELL DAMPING

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Abstract— Growing demand and aging of network makes it desirable to better control the power flow in power transmission systems. FACTS devices, especially UPFC, provide a fast, smooth control of power system parameters. However, for cost and reliability reasons, the application is limited. This paper presents a new concept for power flow control by distributed UPFC. The system, called distributed power flow controller (DPFC), consists of several low- power series converters and one shunt large-power converter without common dc link. Also new is that the power exchange between the shunt and series parts is through the existing transmission line at a harmonic frequency. This solution enables the DPFC to fully control all power system parameters, and it reduces the cost and increases the reliability of device at the same time

Keywords: FACTS, UPFC, DPFC, Voltage sag & Swell

I. Introduction

Currently, the Unified Power Flow Controller (UPFC) is the most powerful FACTS device. It can control all parameters in a power network at the same time, including line impedance, power angle, and voltage magnitude [1] [2]. Figure 1 shows a simplified schematic of the UPFC. However, due to the expensive cost of such solid-state power flow controllers due to the high voltage isolation, high power rating, and relative low dependability, they are not commonly used. The power electronics determine the UPFC's reliability. If a single component fails, the entire system will shut down.

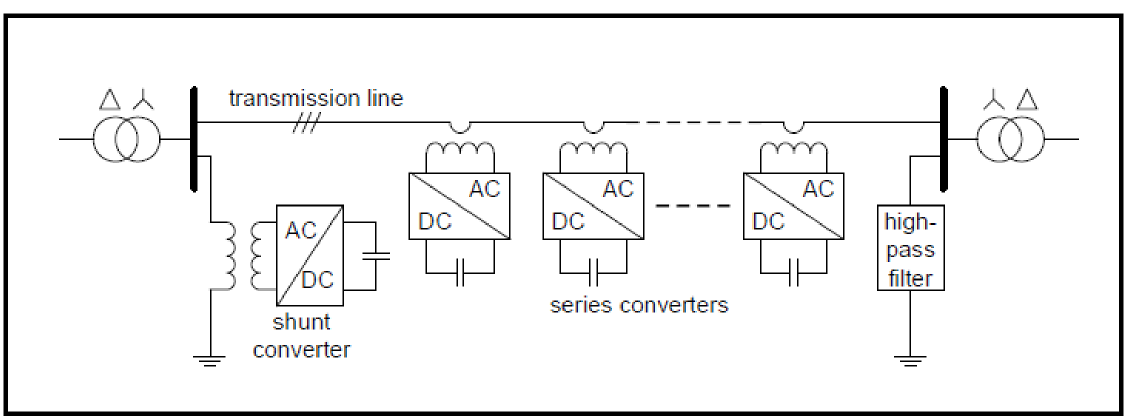

Fig. 1: Simplified representation of a conventional UPFC

The distributed FACTS device (D-FACTS) is an idea that uses single-turn transformers to connect several low-power converters to the transmission line [3]. When compared to traditional FACTS devices, the concept offers various benefits, including lower costs, ease of maintenance and installation, and increased system reliability (one device failure will not lead to the entire system shut down). The Distributed Static Series Compensator (DSSC), shown in Fig.2, is the current D-FACTS device that functions as a controlled variable conductor. Because the DSSC is without a power supply, it can only adjust the line impedance, and is not as powerful as UPFC.

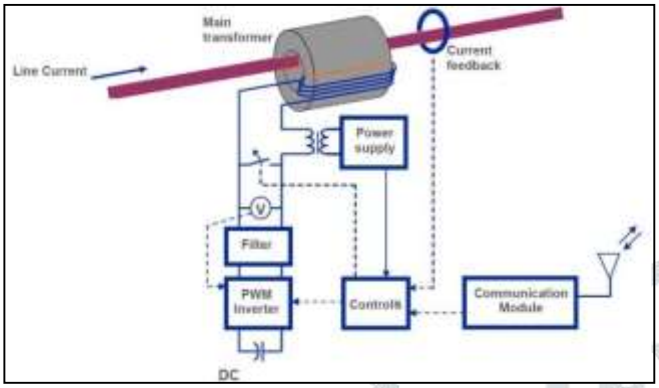

Fig. 2: Distributed Static Series Compensator (DSSC)

This study introduces a new distributed power flow controller (DPFC) concept that incorporates both traditional FACTS and D-FACTS devices. All system parameters, such as line impedance and power angle, can be controlled using the DPFC. At the same time, it has a higher level of reliability and is less expensive.

II. PROPOSED METHODOLOGY

A. MATLAB Simulation model

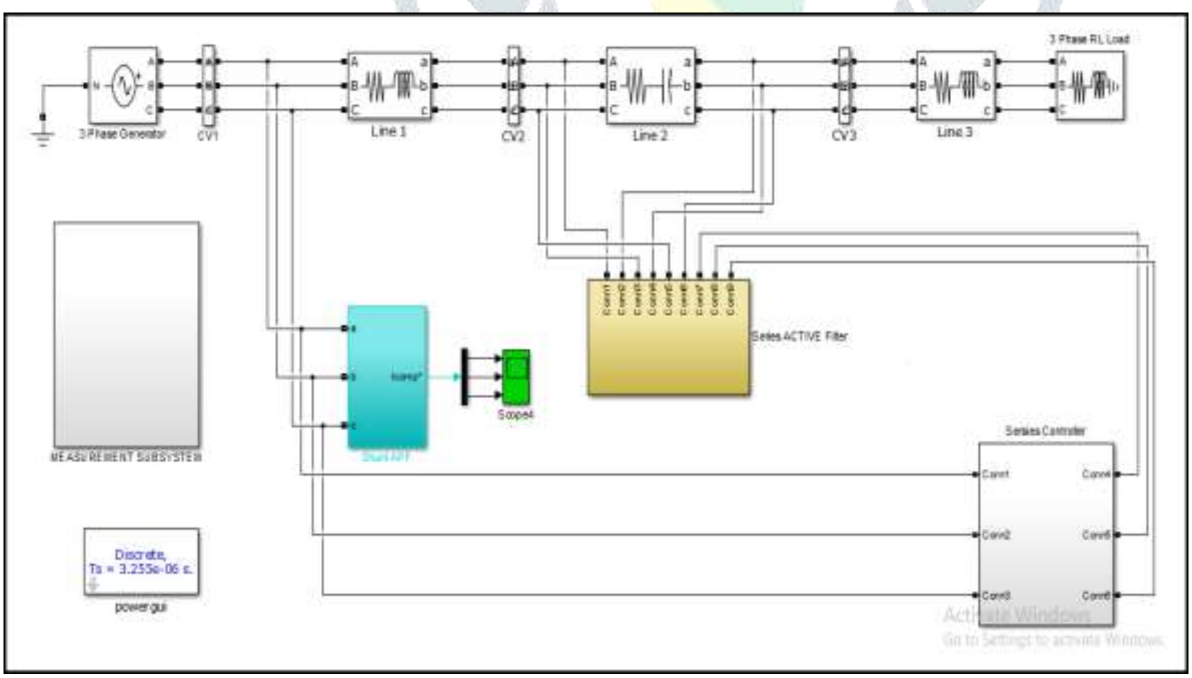

Fig. 3: Block diagram of proposed approach

B. Series controller subsystem

The Series controller is used to compensate the source side disturbances such as voltage sags, swells and also harmonic distortions. In this configuration, the filter is connected in series with the line being compensated. Therefore the configurations are often referred to as a series active filter. The approach is based on the principle of injecting voltage in series with the line through the injection transformer to cancel the source side voltage disturbances and thus it makes the load side voltage sinusoidal.

Fig. 3 shows the MATLAB/ Simulink model of designed system. The main components of the below system are as follows.

- Nonlinear load
- Active Power Filter
- Voltage source inverter
- Interface reactor
- Reference voltage generator
- Hysteresis voltage controller

Table . 1 MATLAB Simulink Model Parameter Specification

Sr No	Name of block	Specification
1	3 phase generator	Three phase to phase voltage = 415 V; Phase angle of phase A = 0 Degree; Frequency of supply = 50 Hz
2	Line 1	Inductance L = 0.5mH; Resistance R = 0.1 Ω
3	Line 2	Capacitance c = 6 µF; Resistance R = 6 Ω
4	Line 3	Inductance L = 1 mH; Resistance R = 50 Ω
5	Three phase load	Nominal phase to phase voltage = 400V; Nominal frequency = 50Hz; Active power = 10 KW; Inductive reactive power = 100 VAr

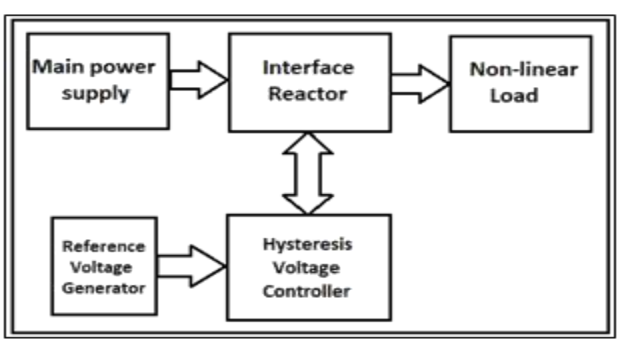

Fig. 4: Block diagram of proposed series active power controller

C Shunt controller subsystem

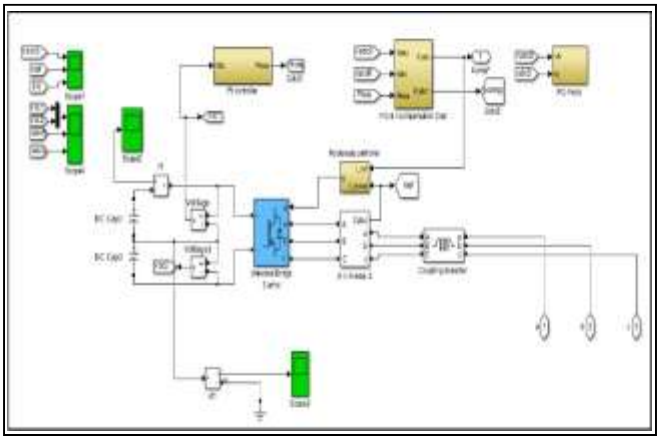

Fig. 5: MATLAB simulation model of shunt controller

Figure 5 shows the matlab simulink model of shunt active power controller. In this universal bridge which is act as inverter which converts the DC link supply into AC output which fed to the transmission line. That controller control the current of transmission line based on firing pulses of inverter. As the voltage of transmission line drops due to high loading then that time controller absorbed the current from transmission line by decreasing pulses rate of inverter. Similarly, for high voltage increases due to highly capacitive load then that time controller insert the current into the transmission line by increasing the pulse rate of inverter.

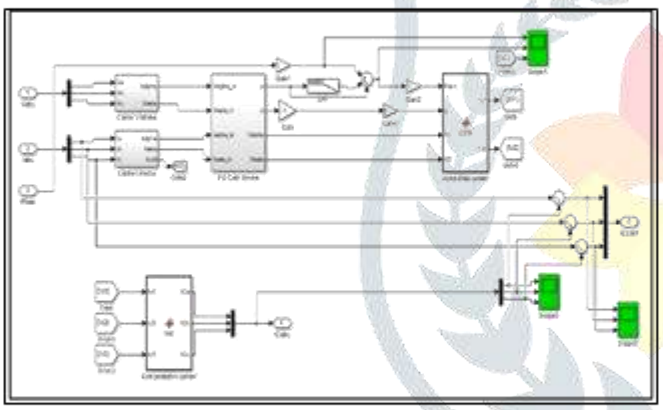

Fig. 6: PQ components calibration subsystem model

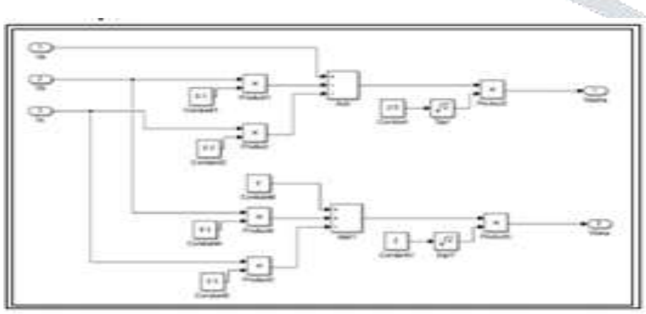

Fig. 7: Clarke transformation for V_{alpha} and V_{beta} Calibration

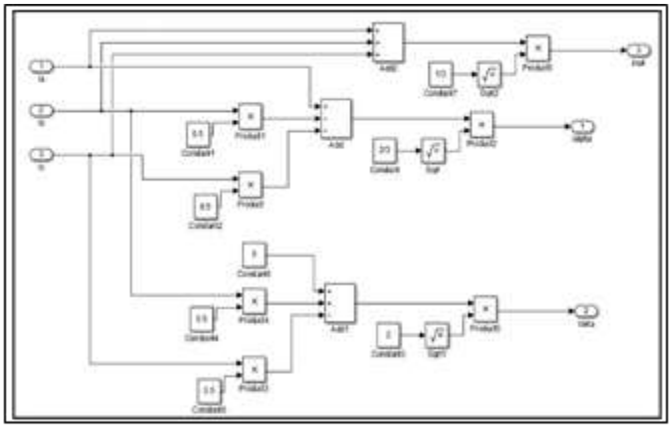

Fig.8 clarke transformation for Ialpha , I beta caliberation

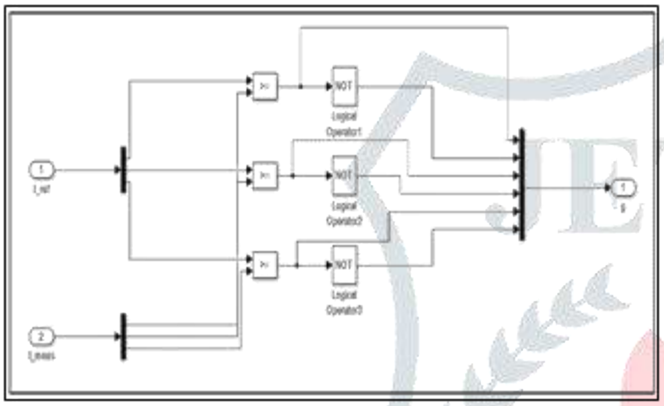

fig. 9: Hysteresis based Ireference and Imean current comparison subsystem model

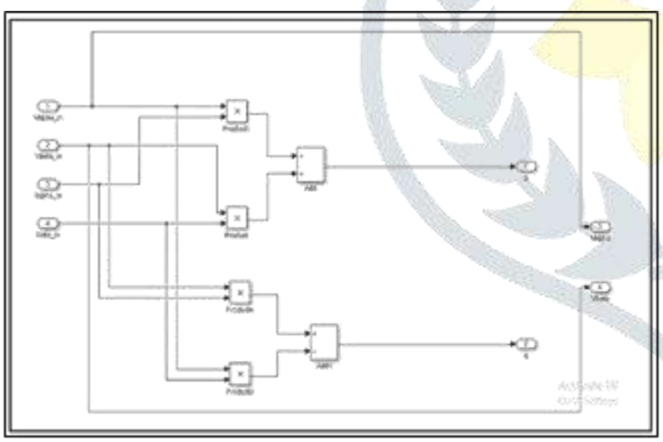

Fig. 10: P and Q components calibration subsystem model

That calibrated Valpha, Vbeta, Ialpha and Ibeta component then transfer to P and Q components calibration subsystem. The complete PQ component calibration subsystem model is shown in figure 9.

III. MATLAB SIMULATION RESULTS

A. With voltage sag and swell condition

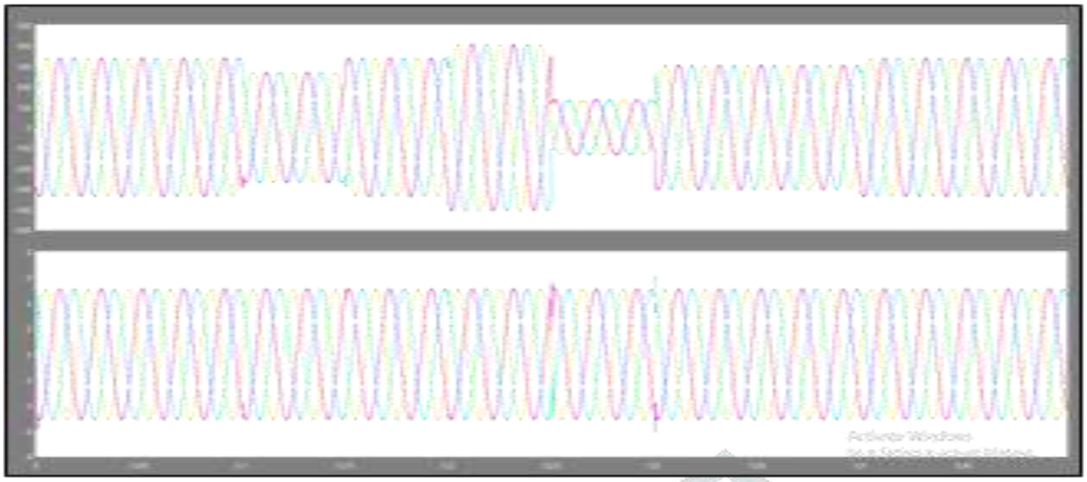

Fig. 11: Sending end three phase voltage and current of transmission line with voltage sag and swell condition

Figure 10 shows the sending end voltage and current of transmission line which contains voltage sag and swell conditions. Total simulation time is 0.5 second in which voltage swell is occurs at 0.1 sec then again voltage becomes normal at 0.15 seconds. Then again voltage well occurs at 0.2 second and then again voltage swell at 0.25 second and so on. Hence voltage fluctuations are present at sending end voltage of transmission line.

Figure 11 shows the transmission line receiving end voltage and current waveform in which x-axis shows the simulation time in second while y-axis shows the voltage and current magnitude. It is shows that transmission line receiving end voltage at transmission line or load side is free from voltage fluctuations due to DPFC controllers.

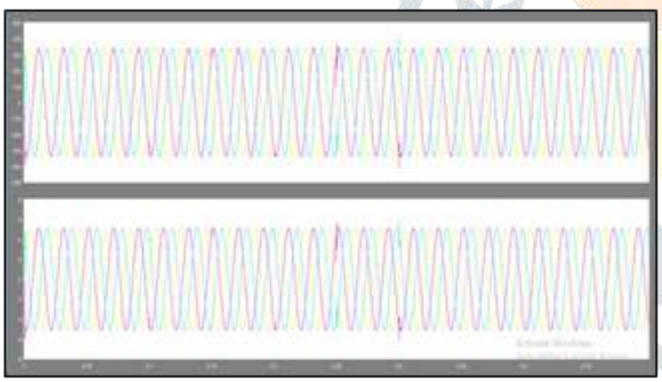

Fig. 12: Receiving end three phase voltage and current of transmission line without voltage swell and sag

B. With harmonics and momentary interruption condition

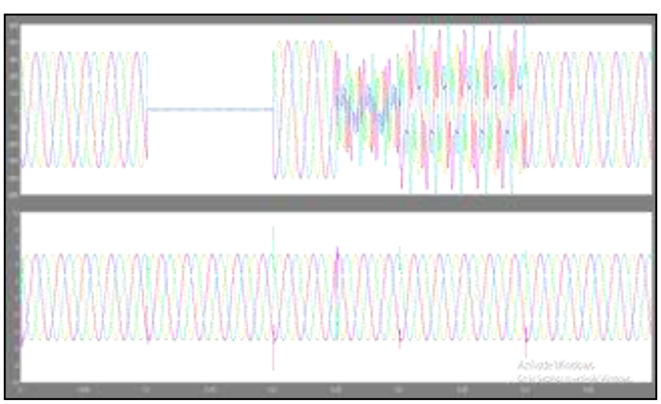

Fig. 13: Sending end three phase voltage and current of transmission line with harmonics and interruption condition

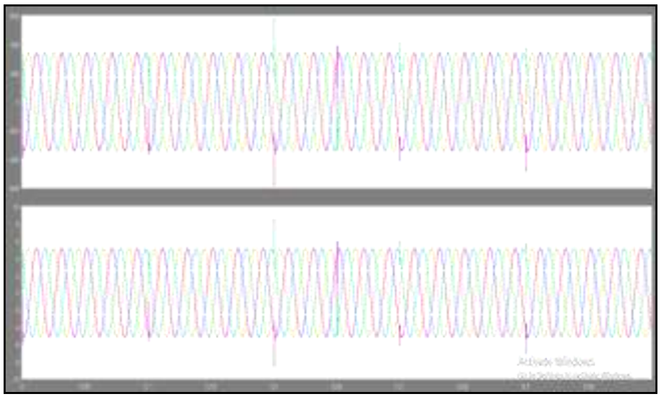

Fig. 14: Receiving end three phase voltage and current of transmission line without harmonics and interruption

III. CONCLUSION

The dynamic model is used to construct the DPFC basic control. The basic control maintains the level of each converter's capacitor DC voltage and guarantees that the converters inject voltages into the network in accordance with the central control's commands. The shunt converter injects a continuous current at the 3rd harmonic frequency, while the fundamental frequency component stabilises the DC voltage. The output voltage at the fundamental frequency is derived from the central control for the series converter, and the DC voltage level is maintained by the 3rd harmonic components. The basic control's control settings are determined. Matlab Simulink is used to verify both the model and the basic control. The dependability issue is important when using DPFC in power systems. To improve system performance during converter failures, the fault tolerance of the DPFC is explored, including the protection strategy for different types of failures and the usage of supplemental controls.

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