PERFORMANCE INVESTIGATION OF ANALYSIS AND DESIG FOR UPFC CONTROL UNDER UNBALANCED AND DISTORTED LOAD CONDITIONS

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ABSTRACT

Disturbances to the electricity grid occur often. System harmonics and oscillations will be generated by these disruptions, triggering the activation of protective relays. As a result, the whole system will crash. These power system oscillations may be mitigated, and power quality improved using a variety of methods and equipment. One such means is the FACT (flexible alternating current transmission system) devices are used. As a result, FACT devices facilitate the administration of power grid operations. Among the most current FACT devices created, the unified power flow controller (UPFC) regulates both the active and reactive power of the power grid. This presentation contains we will describe our work on modelling UPFCs for transmission lines and evaluate their effects on power quality under abnormal situations. Furthermore, models of the UPFC's subsystems are constructed in MATLAB/Simulink in order to provide a transmission line model for use in simulations of the UPFC.

INDEX TERMS: UPFC, FACT, Transmission Line Model.

I. INTRODUCTION

Electrical energy is the most popular kind of energy today, and everyone relies on it. Life is impossible without electricity. Similarly, the efficiency and reliability of the endelectrical user's supply are essential. Power reliability is especially important for commercial and industrial users. Today, maintaining quality is crucial. Electric power quality (PQ) concerns utilities, customers, end-users, and manufacturers. The term "power quality" refers to a collection of metrics that describe the power supply under typical operating circumstances (magnitude, frequency, symmetry, waveform etc.). Power quality (PQ) issues may damage microprocessors, microcontrollers, telecom gear, and delicate computing apparatus. PQ is a major issue for both power companies and their customers. Poor power quality costs around 500 billion Euros each year, or 50% of the worldwide electrical sector's revenue. Poor PQ costs more than electricity for many businesses and is growing. Power electronics devices affect electricity's quality and reliability. Power electronics problems include uninterruptible power, inconsistent voltage, and flashing lights. Problems with power quality include fluctuations in voltage caused by factors such as network outages, lightning, and the switching of capacitor banks. In addition to causing reactive power disruptions and harmonics, non-linear loads may also cause a reduction in efficiency (computers, lasers, printers, rectifiers). These problems, if left unresolved, might spiral out of control. Traditional methods of dealing with reactive power disturbances and harmonics generation included the use of passive filters, Disadvantages include size, resonance, and source impedance. Power filters improve electricity quality. Active power filters are classified by system. Series or shunt-connected active power filters exist. APFs are combined in UPFCs. UPFC removes voltage and current irregularities. A shunt active power filter may enhance harmonics, reactive power, and power factor. An APF stabilizes load voltage. APF-linked transmission line. Back-to-back series and a DC-shunt APF form UPFC. Fuzzy logic and UPFC increase power quality. UPFC employs series/shunt APF. **II Literature survey** [1] Time-frequency analysis is used to build new transient power quality metrics. Transient disturbance time-frequency distribution affects power quality measures. Instantaneous disturbance energy ratio, normalised instantaneous disturbance energy ratio, instantaneous frequency, and instantaneous K-factor measure transient power quality. Timefrequency power quality indexes detect temporary disturbances.

[2] Active power filters regulate reactive power, harmonics, flicker/imbalance, and voltage. Japan's active filters are 50 kVA60 MVA. "Active filters" will have a new meaning. Active filters intended for harmonic solutions can isolate and dampen harmonics in power distribution systems. This page explains active filters based on modern power electronics technology, their future possibilities, and the author's hopes and dreams.

[3] Power electronics are used to create and regulate reactive power in electric power systems for dynamic VAR correction. Dynamic VAR correction enhanced electric power transmission voltage, transient stability, and oscillation damping. Using thyristor-controlled reactors, fixed and thyristor-switched capacitors, or modern gate-turn-off (GTO) power converters, reactive power may be produced and regulated. Summarize power system control structure and functioning.

III. METHODOLOGY

i. UPFC (Unified Power Flow Controller):

UPQC (Unified Power flow conditioner) corrects voltage distortion and imbalance in a power system so load voltage is balanced, sinusoidal, and controlled. It adjusts for load current harmonics so the source current is sinusoidal and devoid of distortions and harmonics. UPFC combines active and shunt filters. A shunt active power filter (APF) cancels out load current to reduce harmonics and distortions in source current. Parallel transmission and APF. Series APF reduces distortions and imbalances on the supply side to balance, control, and sinusoidize the load side voltage. Series transmission line and APF. UPQC is a single-phase, three-phase-threewire, three-phase-fourwire configuration with two voltage source inverters coupled back-to-back by a DC link capacitor. Series APF inverters are variable voltage source inverters. Passive filters for compensating harmonics and voltage distortion are no longer used.

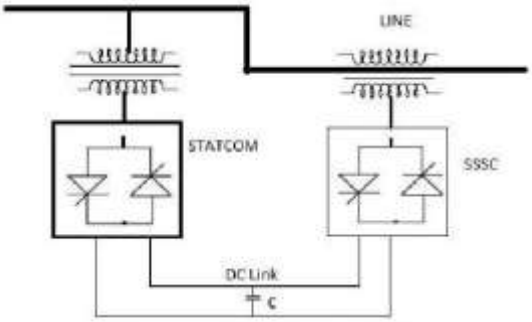

Fig.1: Simple circuit design of UPFC

ii. Series APF:

APF is usually linked in series on transmission lines. Transformer connects it transmission line connection One kind of voltage inverter is the Series APF, which may be linked to an existing transmission line. Disturbances and imbalances in the voltage are restored. The load voltage is regulated by a compensating voltage injected by the series APF, PWM controls series inverter. Hysteresis band PWM is straightforward to implement. Fast response. Details follow. **iii. Shunt APF:** Shunts employ parallel APF connections. APF shunts current-induced distortions and harmonics. Non-linear loads create harmonics in load current; Shunt APF keeps source

current sinusoidal and distortionfree. Shunt active power factor (APF) injects compensatory current for sinusoidal, distortion-free source current. PWM in the hysteresis band regulates shunt APF. In hysteresis band PWM, reference and current vary output current. **iv. DC link capacitor:**
DC capacitor connects two voltage inverters. DC capacitor powers inverter. DC capacitors store energy until required. In steady condition, source power should equal load power + active filter adjustment. Due to load changes, DC capacitor voltage is not the reference value.

v. Design of UPFC Controller: Here, we explore both series and shunt APF control. 3P4W load might imbalance utility current. Single-phase P-Q theory. By assigning each phase of genuine threephase systems 2 lead or 2 lag voltage and current, we may conceptualise a singlephase system as a fictional two-phase system. P-Q theory may be applied to both parts of an imbalanced system using coordinates. On the -axis are voltages and currents at the load and a lag or lead of /2. In this research, each phase of a two-phase system contains /2 lead. P-Q theory fails when input or utility voltages are off. Instead of unbalanced input/utility voltages, series APF uses reference load voltage signals. For series APF, reference load voltage signals are utilised.

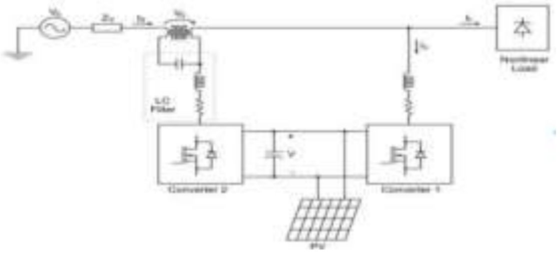

Fig.2: UPFC System

Circuit Description

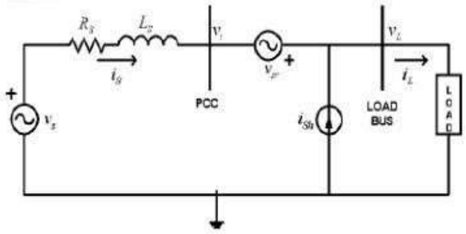

Fig.3: Equivalent Circuit Diagram For UPFC

UPFC configuration:
Connecting UPFC to PCC terminal voltage vt may be done two ways (point of common coupling).

- Left Shunt UPFC, shunt compensator (ic) on left side of series compensator (vc)
- Right Shunt UPFC, shunt compensator (ic) on right side of series compensator (vc).

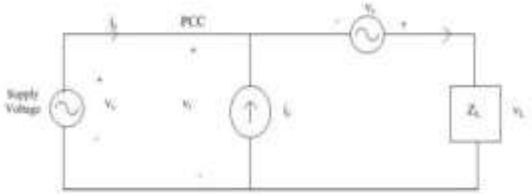

Fig.4: Left shunt UPFC

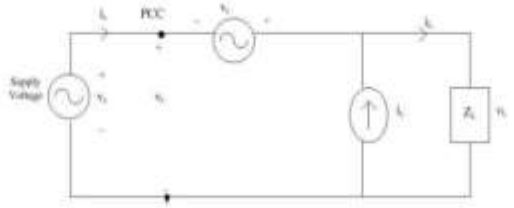

Fig.5: Right Shunt UPFC

As indicated in fig.5, right shunt UPFC performs better than left shunt UPFC. **vi. Power flow analysis of UPFC in steady state**

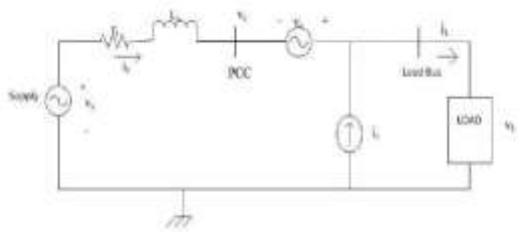

Fig.6: Circuit diagram of UPFC

UPFC eliminates current and voltage harmonics and compensates for reactive power. In UPFC series, APF is employed as a voltage source inverter to balance and sinusoidize load voltage. Series APF injects the difference between source and load voltages. Shunt APF is used to eliminate load current harmonics and compensate reactive power. Shunt APF maintains DC link capacitor value.

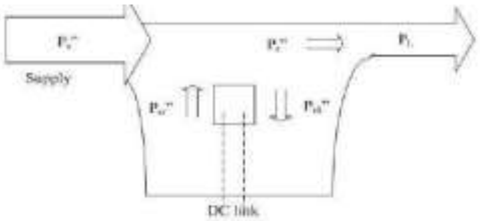

Fig.7: Real power flow during Voltage dip (sag) condition

Real power goes from source to shunt APF, then to series APF through DC link capacitor, and finally to load. So load gets electricity during voltage sag. In this situation, shunt APF power from source equals series APF power to load. Fig.7 illustrates it.

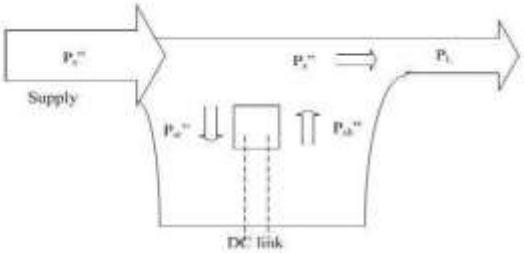

Fig.8: Real power flow during voltage rise condition

vii. Proportional & Integral Controllers: PI controllers were created because systems with type 1 or higher open loop transfer functions had zero steady state error with a

$$\frac{U(s)}{E(s)} = K_P + \frac{K_I}{s}$$

step input.

The PI regulator is

Tuning PI Controllers:

Tuning strategy:

1. No initial gain (TI large)
2. Increase KP till satisfied
3. Integrate (decrease TI) until steady-state error is eliminated

IV. Simulation Results

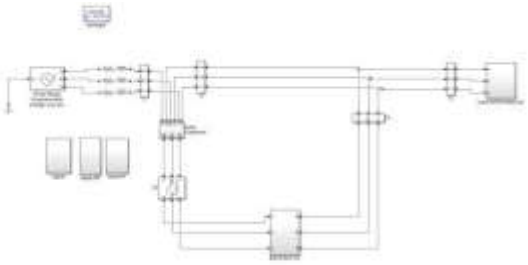

Fig.9: Simulink

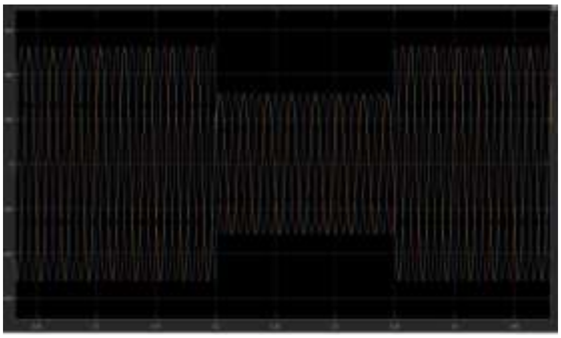

Fig.10: Source voltage sag

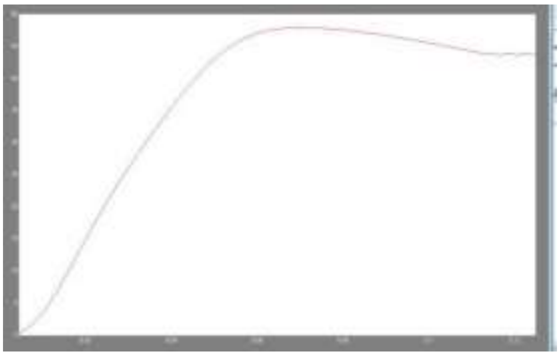

Fig.11: capacitor dc link voltage

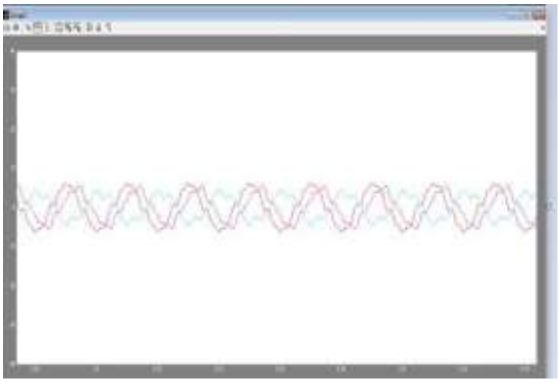

Fig.12: Compensating load current

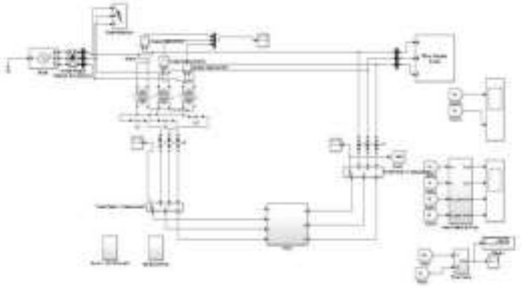

Fig.13: Power quality improvement by using UPFC

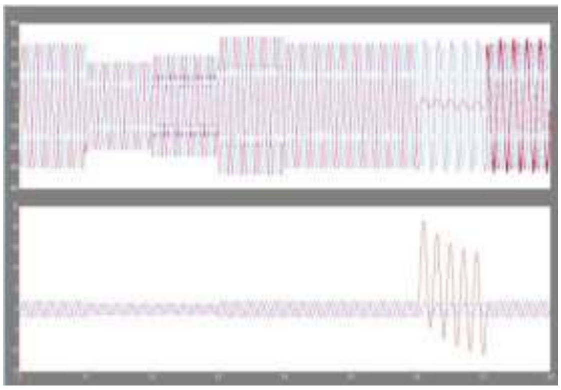

Fig.14: source voltage & current

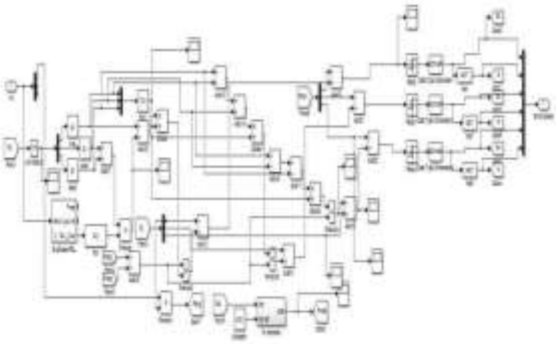

Fig.15: Shunt converter control design

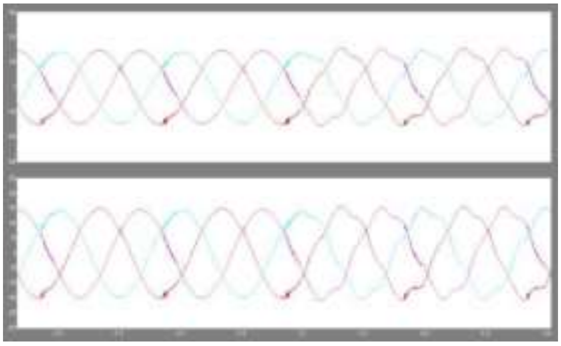

Fig.16: compensating load voltage & current

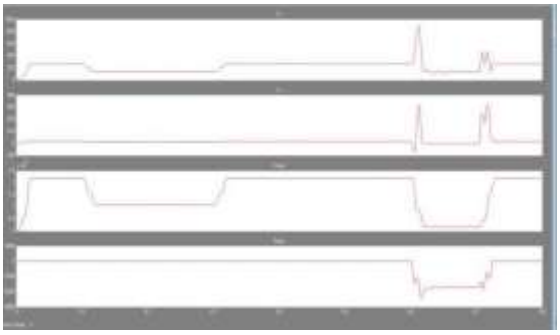

Fig.17: source side i) active power ii) reactive power load side iii) active power iv) reactive power

Fig.18: Power factor

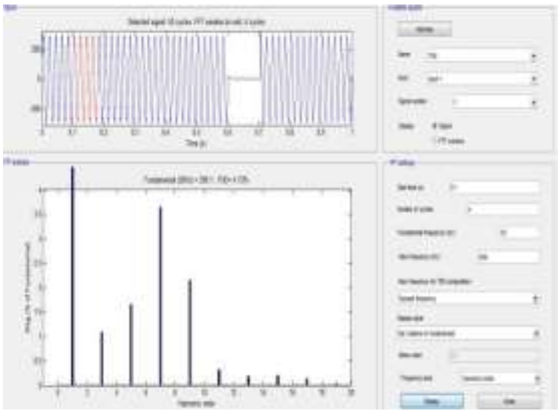

Fig.19: THD OF voltage harmonic

V. CONCLUSION

For better power quality, this project details the operation and results of a UPFC. Research on voltage compensation using UPFC is presented. As the injection angle rises, so do the actual and reactive powers. UPFC's ability to regulate the reactive and actual powers is shown by the simulation findings. It has been shown that the UPFC can solve huge power networks extremely reliably thanks to the modelling and analysis of power systems incorporated with the UPFC. The effects of control parameter changes and UPFC performance on power quality measurements are studied. The results show that the actual and reactive powers along the transmission line improve once UPFC is used. The UPFC system's benefits include its low maintenance requirements and its ability to regulate both actual and reactive powers. This means that the findings from the simulation are consistent with the results from the experiments.

VI. REFERENCES

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