



Enhancing power quality using Unified Power Flow Controller (UPFC)

A.Suganya

*Department of Electrical & Electronics Engineering
Dr Mahalingam College of Engineering &
Technology
Pollachi, Coimbatore, Tamilnadu-642003*

Sivasankari A, Srinivasan R, Barathvaaj T

*Department of Electrical & Electronics Engineering
Dr Mahalingam College of Engineering
&Technology
Pollachi, Coimbatore, Tamilnadu-642003*

Abstract- One of the main issues with the operation of the power system is power system harmonics. A disruption in the delivery of electricity might result from harmonics' ability to increase and decrease transmission line capacity. To lessen these harmonics, devices known as flexible Alternating Current Transmission system (FACTS) are used. The newest fact device, the unified power flow controller, combines the characteristics of a shunt and series compensator to regulate the reactive and active power of transmission lines. The most adaptable FACTs device to develop for the reduction of harmonic in the power system is the unified power flow controller (UPFC), while there are several other variants as well. Controlling the performance of a PWM-based UPFC based on harmonic reduction is the primary goal of this study. MATLAB software is used to validate the planned work.

Keywords- FACTS, UPFC, linear load, non-linear load

1. INTRODUCTION

A massive, complicated network with several generators, transformers, transmission lines, and various load types, including nonlinear and linear loads, makes up an electric power system. Rapid increases in power consumption are accompanied with regulated transmission and generation development and a restricted supply of devices. Compared to earlier times, electricity systems are far more burdened nowadays. Power systems are forced to run close to their stability limitations as a result. The environment and energy problems make it exceedingly challenging to design new power plants and transmission systems. Therefore, rather than building new lines, it is important to boost the power flow capability to execute the gearbox line itself. The most adaptable high power semiconductor devices have recently been employed in power systems applications for safe loading, power flow control, and oscillation in flexible AC transmission systems (FACTS). The idea behind FACTS is to increase the transmission line's actual capacity without building new transmission



lines. The unified power flow controller (UPFC) is the most adaptable FACTS device available for enhancing system stability. The two voltage source converters (VSC) that make up the unified power flow controller (UPFC) allow it to provide and absorb both active and reactive power. The parallel coupling transformer is linked to one of the two voltage source converters (VSC) while the series coupling transformer is connected to the other voltage source converter (VSC). A DC storage capacitor, which supplies the DC voltage needed for the VSC operation, connects the two VSC. The two VSCs linked in series and shunt in the transmission line to the DC capacitor have a power equilibrium. By exchanging active power with the gearbox line and injecting a voltage with varying amplitude and phase angle, the series VSC of UPFC enhances the harmonic. The power system and the UPFC shunt VSC exchange a current with a controlled phase angle and amplitude. The active power injected or submerged in the power system was balanced by the UPFC. This study examines the electric power system's harmonics for both linear and dynamic non-linear loads, both with and without UPFC.

2. BLOCK DIAGRAM

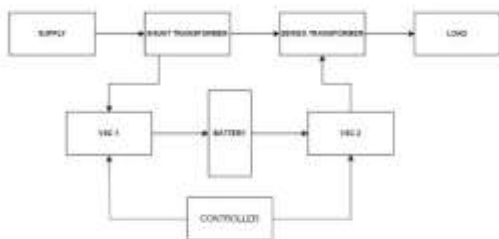


Fig. 2 Block diagram

2.1 UPFC CONTROLLER DESIGN

The configuration of the UPFC, which consists of two VSC, a coupling transformer, and a DC storage capacitor, is shown in Fig. 1. A balanced set of voltage and current is produced at the two VSCs. fundamental frequency will enable concurrent control of the voltage, amplitude, and phase angle of the power system. A common DC voltage connection connects a static synchronous compensator (STATCOM) and a static synchronous series compensator (SSSC), which together form the UPFC.

A UPFC functions primarily in two modes: Power Flow Control Mode modifies the phase angle and amplitude of the injected voltage to affect power flow, and Voltage Regulation Mode modifies voltage by exchanging reactive power.

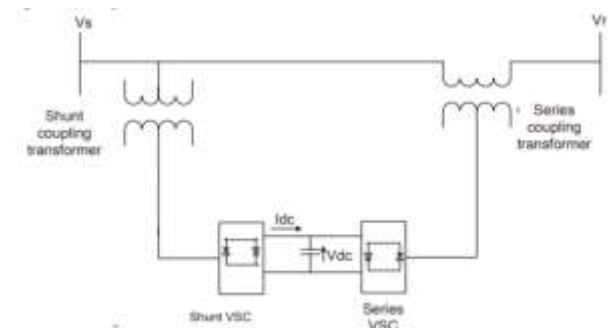


Fig. 2.1 Unified Power Flow Controller

The shunt controller manages reactive power and supplies the DC power required for integrated converters, while the series converter regulates the phase angle and voltage magnitude in series with the transmission line. Voltage is primarily introduced in series with the line by the UPSFC. Phase angle and voltage magnitude can vary from 0 to 2π in relation to the terminal voltage and from 0 to the



maximum value that has been established, respectively. There are two possible UPFC modes: automated voltage control and VAR control. The goal of the automated voltage control mode is to keep line voltage at the connection point to a reference value using an inductive or capacitive reference input in the first control mode.

2.2 PULSE WITH MODULATION

Pulse-width modulation commonly known as PWM, is a modulation method that changes the pulse signal's width in electrical systems to regulate the average power supplied to a load. A signal that changes the pulse width is made with the help of a comparator. The modulating signal is one of the inputs to the comparator; the other input is either a sawtooth wave or a wave that is not sinusoidal. After comparing two signals, the comparator generates a PWM signal's output waveform. Some important features like, Duty cycle: A duty cycle is the time period of a system or signal that it is operational. Most of the time, a duty cycle is expressed as a percentage or a ratio. A period is the time it takes for a signal to complete an ON-OFF cycle. Frequency: The frequency of something is the rate at which it recurs or occurs over a given time period. Output voltage of PWM signal: The frequency of something is the rate at which it recurs or occurs over a given time period.

2.3 PI CONTROLLER

A P.I Controller is a feedback control loop that takes the difference between a system's output and its set point to calculate an error signal. In this case, the difference is the power drawn from the battery. Due to

its capacity to effectively regulate and stabilize system parameters, a PI (Proportional-Integral) controller is frequently utilized in power quality enhancement. Stable voltage and current levels are essential for ensuring good power quality in power systems. In the event of deviations from the desired value, the proportional part of the PI controller provides an immediate response. It helps to reduce voltage and current deviations by allowing power systems to quickly respond to changes in load or disturbances.

2.4 IGBT-INSULATED GATE BIPOLAR TRANSISTOR

IGBTs can turn on and off quickly, usually within a few microseconds. They are suitable for voltage regulation and harmonic mitigation applications that require dynamic response to changes in load or grid conditions due to their fast - switching capability. IGBTs are suitable for power electronics applications where substantial power levels must be controlled because they can handle high currents and voltages. IGBTs are frequently utilized in voltage source converters (VSCs) or active power filters of power quality enhancement systems to control voltage levels, compensate for reactive power, or reduce harmonic distortion. When compared to other power semiconductor devices like thyristors or diodes, IGBTs have relatively low conduction losses.

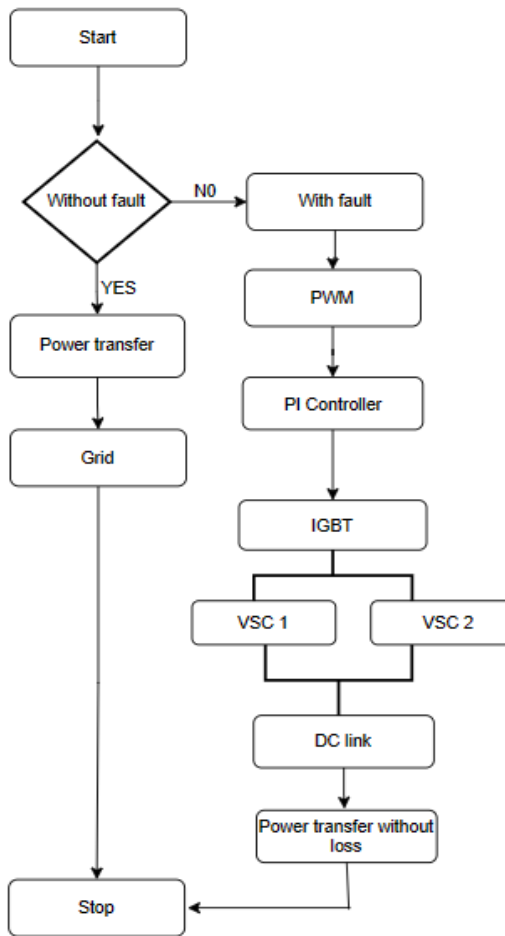


Fig. 2.2: Flowchart

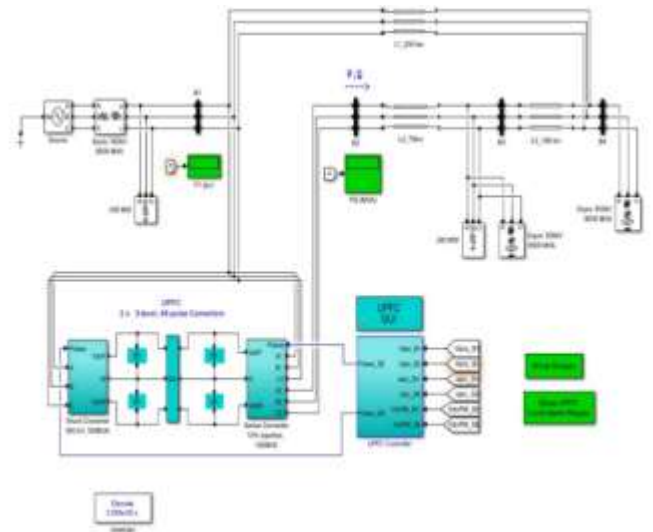


Fig. 3.1 CIRCUIT DIAGRAM

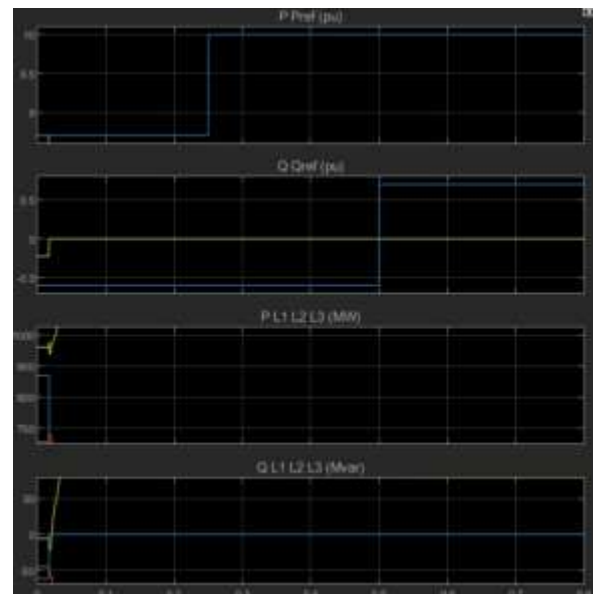


Fig. 3.2 Output waveform

3.SIMULATION DIAGRAM AND RESULT DISCUSSION

The recreation is finished in MATLAB Simulink programming furthermore, perception is finished under the various circumstances.

The idea of the framework under the different condition is seen which are made sense of underneath.



Case 1: Under the typical working condition without UPFC with straight burden Voltage across transports B1, B2 and B3. The voltage across transports is in per unit (PU) and the second bend is of straight power in MW. Sounds across three transports voltage. As there is realized non-straight burden is available in the framework just direct burden is available. The voltage across every three transports and the line power are at required esteem which are giving the steady outcomes. Comparably the quick Fourier change examination of the model and view as the sounds across every three transports voltage are likewise in results as there is typical condition. The complete music twisting (THD) of straight burden is 63.53%.

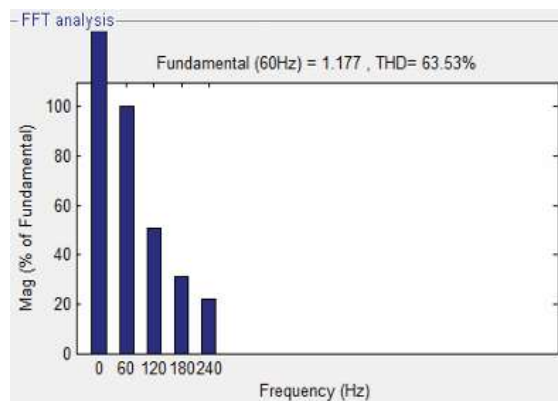


Fig. 3.3 Simulation result of harmonic without UPFC with linear load

Case 2: Under the typical working condition, without UPFC with dynamic non-straight burden. In the second case we have taken is when there is no UPFC except for dynamic non-direct burden is associated into the framework model. When the unique non-straight burden are associated in the framework model the consonant of the framework is increments (i.e., complete consonant bending (THD) is 81.83%) is displayed in recreation results. The voltage

across three transports are too impacted, and the power nature of the framework is decreased which are displayed in figure. Presently next task is to decreased these symphonious brought about by the powerful non-straight burden which done in next case.

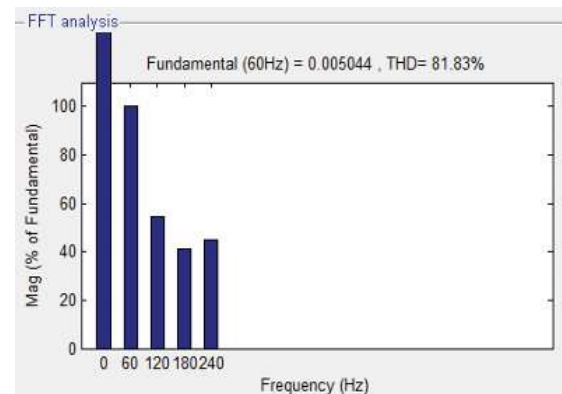


Fig. 3.4 Simulation result of harmonic without UPFC with Non-linear load

Case 3: With UPFC under normal operating conditions and linear weight. In the third scenario, UPFC has a linear load, which connected to the system model of the two machines. The simulation model displays the outcomes, where the harmonic The unified power reduces the effects of the linear load. The FACTs flow controller was installed in the two machines' system. model. The system model's harmonic is reduced to the bar diagram depicts 61.88 percent. As a result, the effect of the outcome of the simulation demonstrates UPFC. which have decreased the harmonics.

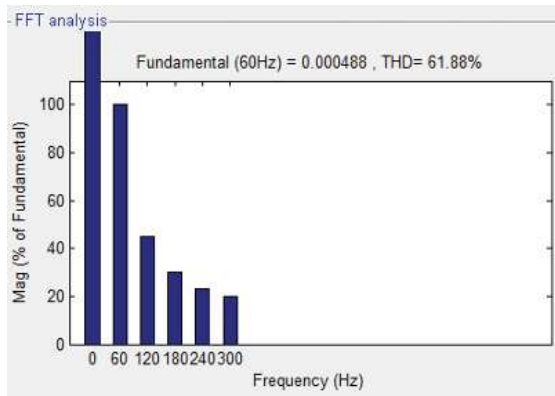


Fig. 3.5 Simulation result of harmonic with UPFC and with linear load

Case 4: With UPFC under normal operating conditions and non-linear and dynamic load. In the fourth scenario, dynamic nonlinear loads, or UPFC, take the place of linear loads. connected to the system model of the two machines. Where the harmonics are, the simulation model results are displayed. which was brought on by the second case's dynamic non-linear load. are decreased by the FACTS of the unified power flow controller. device was added to the system's model. Rapid Fourier the system through a transformation (FFT) analysis and locate the system's harmonics. In comparison, the harmonic is reduced. FFT (i.e. total harmonic) for the second case harmonics The bar diagram below depicts distortion (THD) at 79.66 percent.

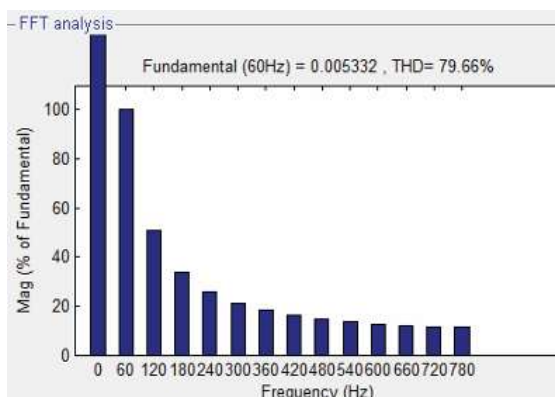


Fig. 3.6 Simulation result of harmonic with UPFC and with non-linear load

5.CONCLUSION

The issues with power quality have been discussed in this paper, such as for the performance, harmonics unified power flow controller enhancement of the electric power system for loads that are not linear. MATLAB was used to put the UPFC detail model through its paces. Software called Simulink behaviour is depicted by the two-machine system. is observed with UPFC and under a variety of conditions. minus UPFC. The bus represents the observed behaviour parameters. harmonics and voltages per unit (PU) of the system model. The two machine transmission systems with UPFC installed are analysed in this paper, with the following conclusion: If the harmonics of the system are greater than those of the linear load, the harmonics of the system are put into dynamic non-linear load is increases.

REFERENCE

- [1] Devendra M. Holey, Vinod Kumar Chandrakar , “Dynamic Harmonic Domain Modelling of Space Sector based SSSC” ,Energy and power Engineering,2016, 8 , 152-160.
- [2] Modelling and Simulation of UPFC to improve power quality, Prachi Sharma, Member, IEEE, 2022.
- [3] Controlling transmission line power parameters by using UPFC, Manish Srivastava , Member , IEEE. Prakhar Singh, Member , Member , IEEE, 2021.



- [4] Analysis of UPFC Installation effect on Power Flow, Rahmat Akbar, Fellow, IEEE, 2021.
- [5] Devendra Manikrao Holey, Vinod Kumar Chandrakar, "Harmonic Domain Modelling of Space Vector Based STATCOM", Energy and Power Engineering, 2016, 8, 195-203
- [6] L.Gyugyi, N. G. Hingorani, P.R. Nannery and N. Tai, "Advanced Static VAR Compensator Using gate Turn-off Thyristor for Utility application.
- [7] C.D.Schauder and H.Mehta, "Vector Analysis and Control of Advanced Static VAR Compensator".
- [9] L. Gyugyi, C.D.Schauder and K.K.Sen, "Static Synchronous Series Compensator:", IEEE PES Winter Meeting.
- [10] M.A .Abido, A.T.AI-Awami, Y.L. Abdel- Magid, "Analysis and design of UPFC Damping Stabilizers for Power System Stability Enhancement", IEE ISIE.
- [11] Ravill Madhusudan, G. Ramamohan Rao, "Modelling and Simulation of Distribution STSTCOM for Power Quality Problems-Voltage Sag and Swell Based on Sinusoidal Pulse Width Modulation", International Conference on Advances In Engineering, Science and Management (ICAESM).
- [12] N.G.Higoran, "Flexible AC Transmission", IEEE Spectrum.
- [13] A.Arab, P.Kundur, "A Versatile FACTS Device Model For Power flow and Stability Simulations," IEEE Transactions on Power Systems, Vol. 11.
- [14] H.F-Wang. "Damping Function of a Unified Power Row Controller" IEEE proceedings-Generation, Transmission and Distribution, VOL 144.
- [15] K-R-Padiyar, K.Uma Rao, "Modelling and Control of Unified power flow controller for Transient stability" Electrical Power & Energy Systems, Vol.2