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Wavelet based performance analysis of AC transmission systems with unified power flow controller under power quality issues

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ABSTRACT

The developments in power quality are fast and difficult to predict. The majority of power quality issues experienced by industrial customers can be attributed to momentary interruptions, voltage sags or swells, transients, harmonic distortion, electrical noise, and flickering lights, among others. A new device may be invented tomorrow solving power quality problems. The FACTS devices could provide fast control of active and reactive power through a transmission line. The unified power-flow controller (UPFC) is a member of the FACTS family with very attractive features. This device can independently control many parameters, so it is the combination of the properties of a static synchronous compensator (STATCOM) and static synchronous series compensator (SSSC).The performance of AC Transmission system with Unified power flow controller under various power quality problems analysis described. The proposed system is formulated and research work is done by wavelet multi resolution analysis using Bior1.5 mother wavelet with MATLAB/SIMULINK software. It is observed that the effectiveness of AC power transmission through Unified power flow controller under power quality problems of sag, swell, transient, temporary faults and capacitive switching.

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1. INTRODUCTION

Power quality is an issue that is becoming increasingly important to electricity consumers at all levels of power system network. Sensitive and non-linear loads are common place in both the industrial and the domestic applications [1]. Developments in the power quality area will take long time, so that these problems will be around for at least several more years. Power quality problems related to long and short interruptions of power supply. Long interruptions are the most serious voltage quality disturbance. Short interruptions are shown to be due to a combination of automatic reclosing and a system design aimed at limiting the number of reclosers.Automatioc reclosing makes that a long interruption becomes a short interruption and such a mitigation method. Voltage sag is short duration reduction in voltage, caused by short circuits, overloads, and starting of induction motors. As long as voltage is sinusoidal, it does not matter whether rms voltage, fundamental voltage, or peak voltage is used to obtain the sag magnitude.

The interface between the system and the equipment is the most common place to mitigate sag and interruptions. Most of the mitigation techniques are based on the injection of active power, thus compensating the loss of active power supplied by the system. All modern techniques are based on power electronic devices, with the voltage source converters being the building block. A voltage source converter is a power electronic device which can generate a sinusoidal voltage at any required frequency, magnitude, and phase angle. The voltage source converter technology is used for “Flexible AC Transmission systems” and for mitigation of harmonic distortion and voltage fluctuations.

The UPFC consists of shunt and series compensation device is one of the flexible AC transmission system [2]. It can control bus voltage and power flows of a network. This paper presents the complete digital simulation of the configurations of UPFC within the power system is performed in the MATLAB/Simulink environment to handle the power quality issues. The paper proposes a full model comprising of voltage source converter based UPFC is constructed for digital simulation to investigate the performance of the controller on various power quality problems and observed that considerable improvement is identified on 48-pulse Voltage source converter. The control scheme has the fast dynamic response and hence is adequate for improving transient behaviour of power system after transient conditions. When no UPFC is installed, real and reactive power through the transmission line cannot be controlled. A control system which enables the UPFC to follow the changes in reference values like AC voltage, DC voltage and angle order of the series voltage source converter is simulated. In past, the power quality problems are identified by total harmonic distortions, but this method of approach is failed under micro analysis. To overcome the previous analysis, the proposed research work is carried wavelet based performance analysis of ac transmission systems with unified power flow controller under power quality issues. The sum of the detailed coefficients of current and voltage signals are calculated by make use of bior1.5 mother wavelet at each terminal [3, 4]. The analysis can be carried under various power quality problems and it is found that the analysis is superior to existing methods.

2. PROPOSED UPFC CONNECTED TRANSMISSION MODEL

The 48-pulse voltage source converter is composed of three-phase controllable bridges to produce current that is injected into a transmission line using a series transformer. In this UPFC is designed by using series and shunt voltage sourced converters can control active and reactive power flows in a transmission line. The UPFC is a combination of a static synchronous series compensator (SSSC) and static synchronous compensator (STATCOM) coupled through a common DC voltage linking injected voltage in quadrature with current within the power system [5]. The proposed UPFC connected transmission model illustrated in Figure 1.

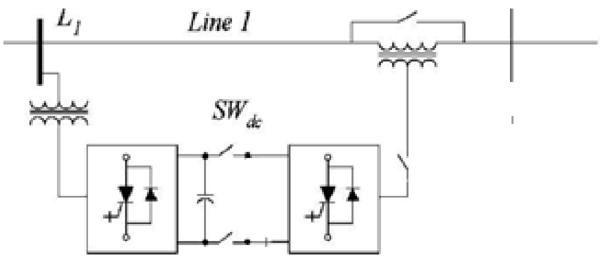

Figure 1. The proposed model of a UPFC connected transmission system

The series VSC blocks are connected in series with the transmission line by a series coupling transformer and it can provide either capacitive or inductive voltage compensation [6]. The converter is operated under fundamental frequency for the main bridges and six time fundamental frequency for the auxiliary circuit. The converter switching loses and switching device dynamic voltage stress is reduced significantly [7].

3. DIGITAL SIMULATION MODEL OF UPFC

The single line diagram representing proposed system model for 60-pulse the UPFC connected transmission system under study is illustrated in Figure 2. The sample system with the Unified power Flow Controller with shunt as well as series VSC controller and its control scheme is connected to four bus system. The feeder network is connected at Bus1 with a 25 kV,100MVA source and 3MW injected load connected at Bus2 , at injected load of 5MW and 2Mvar at bus 3.

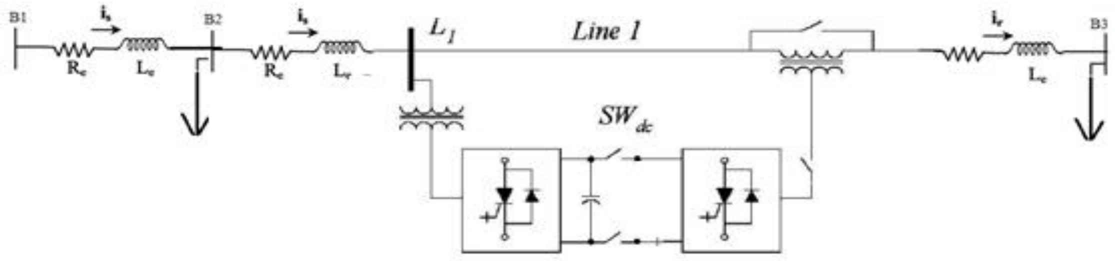

Figure 2. Single line diagram of proposed model with the 48-pulse UPFC between Bus B2 and B3

The UPFC located at the left end of the 10 km feeder from B2. It consists of three 100-MVA, three-level, 48-pulse GTO-based converters, connected as shunt at bus B2. The shunt and series converter can exchange active and reactive power through a common DC bus. The reactive power variation is obtained by varying the DC bus voltage. The digital simulation model comprises of four 12-pulse GTO-converters, phase-shiftedby 〖7.5〗^0from each other and model, can provide the full 48-pulse converter operation. The 48-pulse converter can be used in high-voltage and power applications operation there is no need of any ac filters to control harmonic distortion content on the ac side [8, 9]. The output voltage has normal harmonics n=48r_(+)1, where r=0, 1, 2, 3.

4. RESULTS AND ANALYSIS

The variation of three phase currents and voltages are shown in Figure 3 and Figure 4 under switching transient condition. The current and voltage transients are compensated with UPFC as shown in Figure 5 and Figure 6.

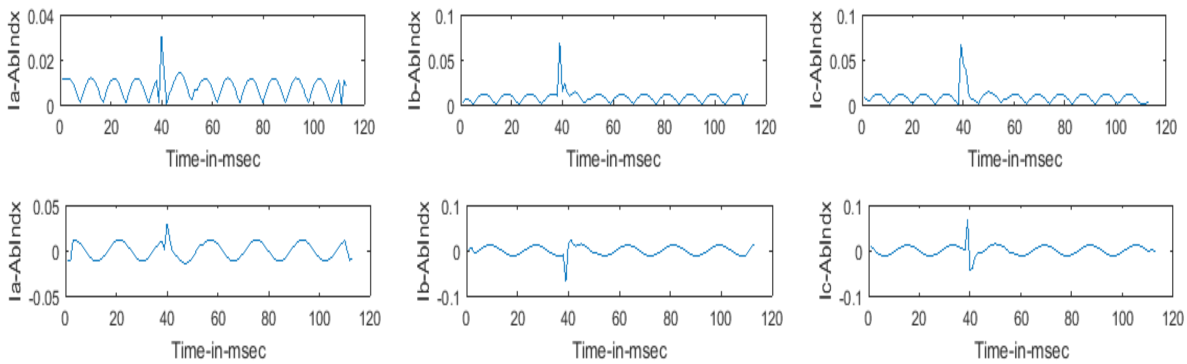

Figure 3. Absolute and detailed index of transient current signal of uncompensated transmission system

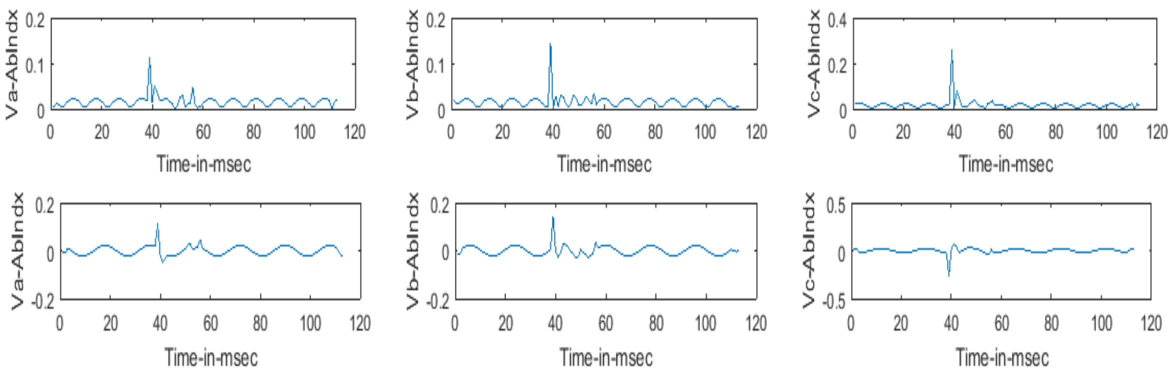

Figure 4. Absolute and detailed index of transient voltage signal of uncompensated transmission system

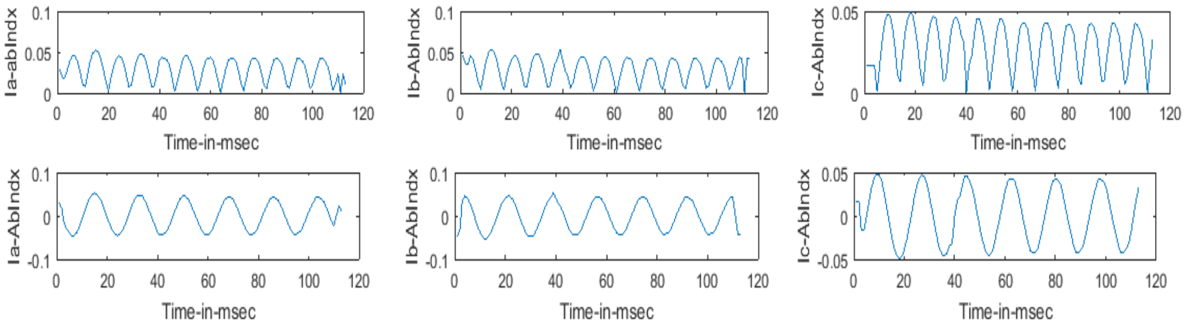

Figure 5. Absolute and detailed index of transient current signal of UPFC Compensated transmission system

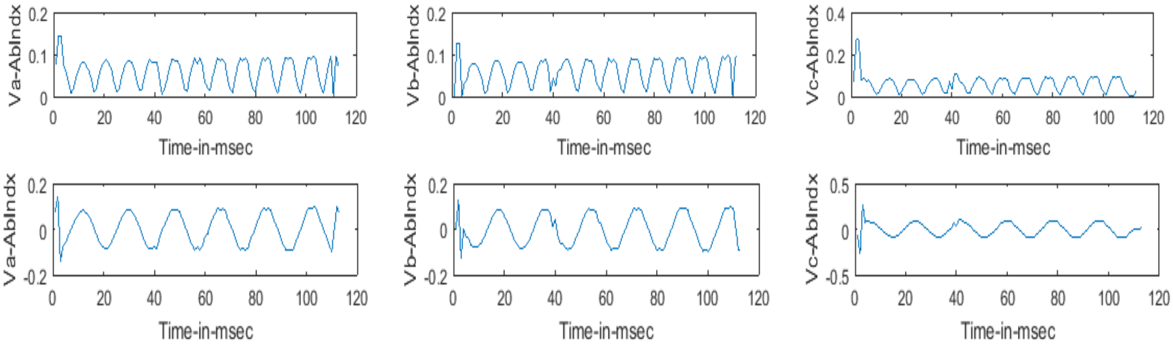

Figure 6. Absolute and detailed index of transient voltage signal of UPFC compensated transmission system

The variation of three phase currents and voltages are shown in Figure 7 and Figure 8 under capacitive reactive load in uncompensated the transmission system, current and voltage distortions are suppressed by Unified power flow condition compensator can be observed and illustrated in Figure 9 and Figure 10.

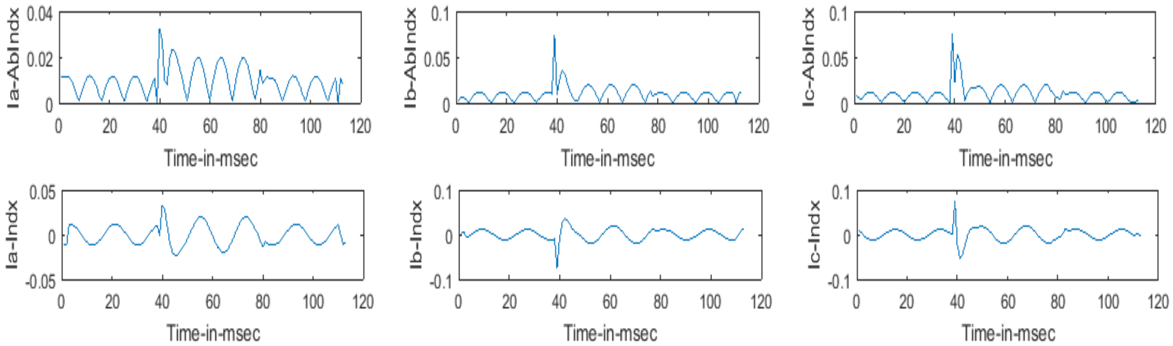

Figure 7. Absolute and detailed index of current signal of uncompensated transmission system under leading reactive power injection

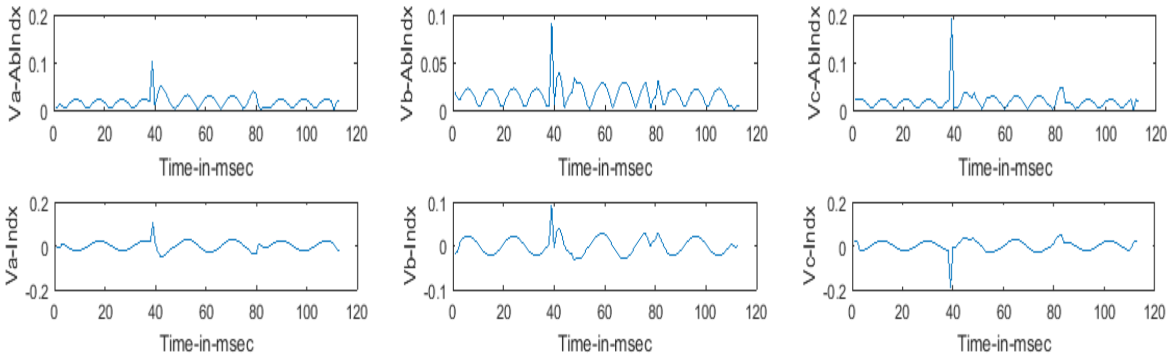

Figure 8. Absolute and detailed index of voltage signal of uncompensated transmission system under leading reactive power injection

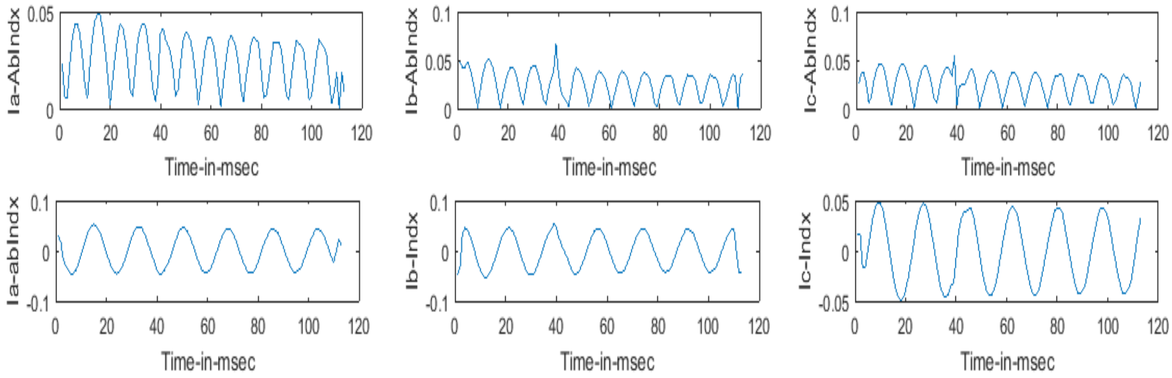

Figure 9. Absolute and detailed index of current signal of UPFC compensated transmission system under leading reactive power injection

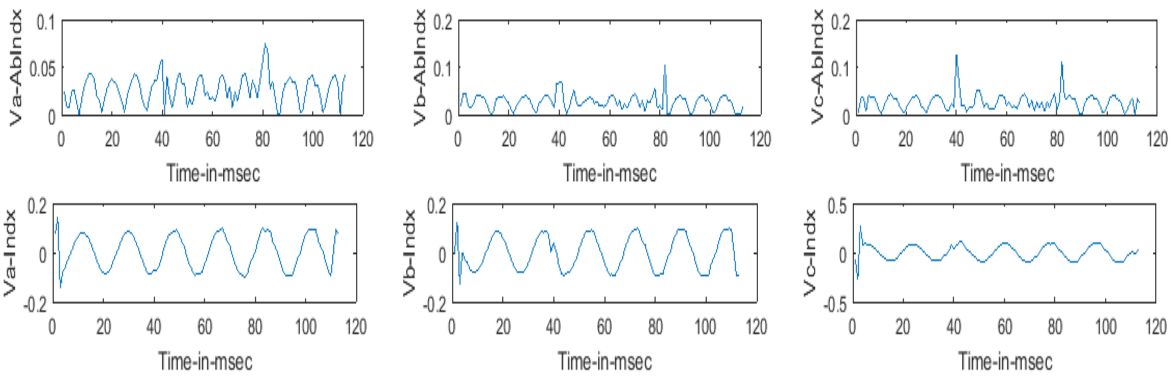

Figure 10. Absolute and detailed index of voltage signal of UPFC compensated transmission system under leading reactive power injection

The variation of three phase currents and voltages are shown in Figure 11 and Figure 12 under sudden load in uncompensated the transmission system, current and voltage distortions are suppressed by Unified power flow condition compensator can be observed and illustrated in Figure 13 and Figure 14.

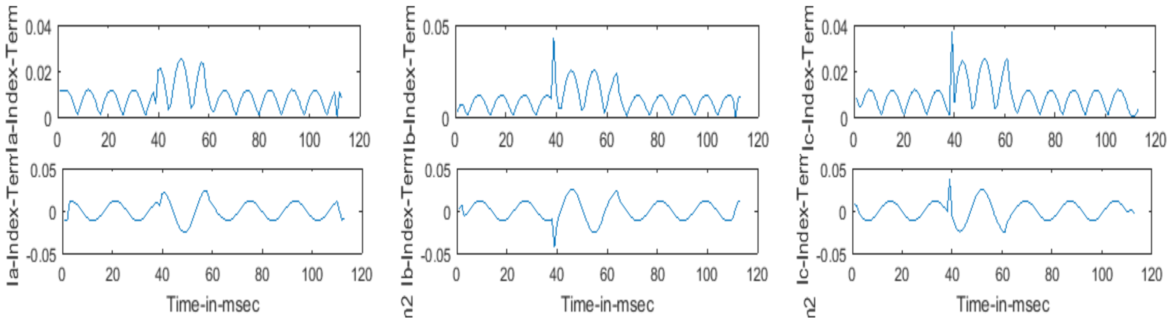

Figure 11. Absolute and detailed index of current signal of uncompensated transmission system under sudden load

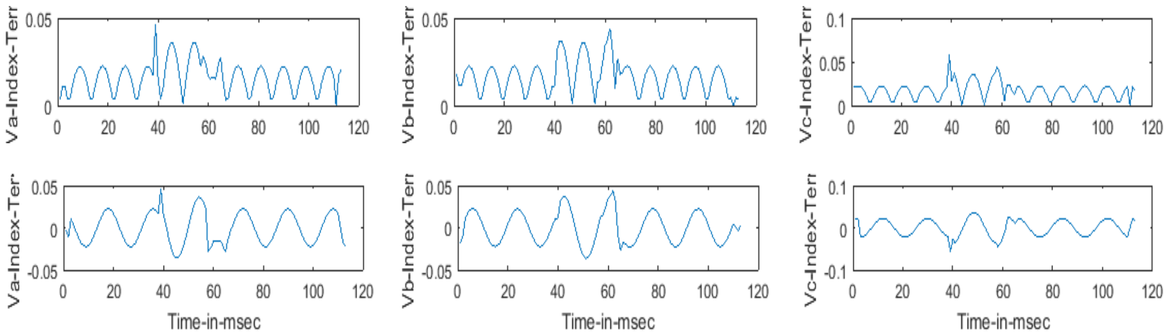

Figure 12. Absolute and detailed index of voltage signal of uncompensated transmission system under sudden load

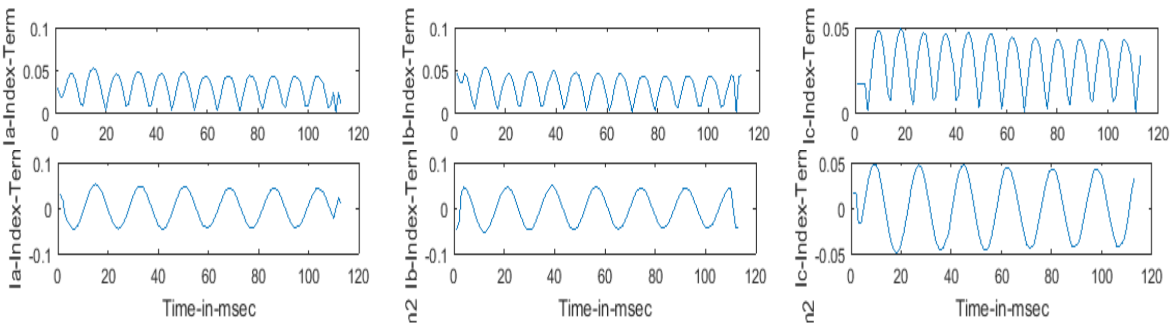

Figure 13. Absolute and detailed index of current signal of UPFC compensated transmission system under sudden load

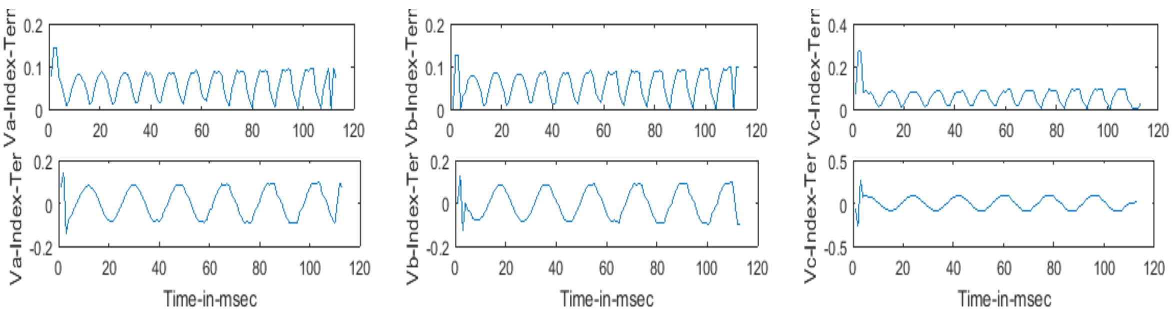

Figure 14. Absolute and detailed index of voltage signal of UPFC compensated transmission system under sudden load

The variation of three phase currents and voltages are shown under single line to ground fault and double line to ground faults are described on uncompensated and compensated system are shown from Figure15 to Figure 22.

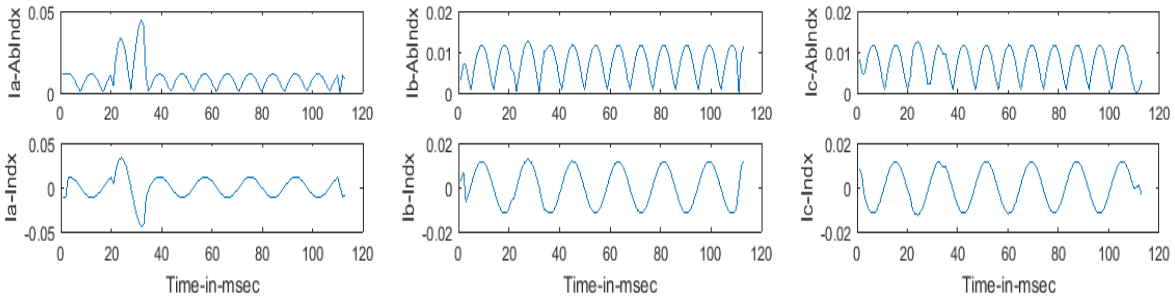

Figure 15:Absolute and detailed index of current signal of uncompensated transmission system under temporary single line to ground fault

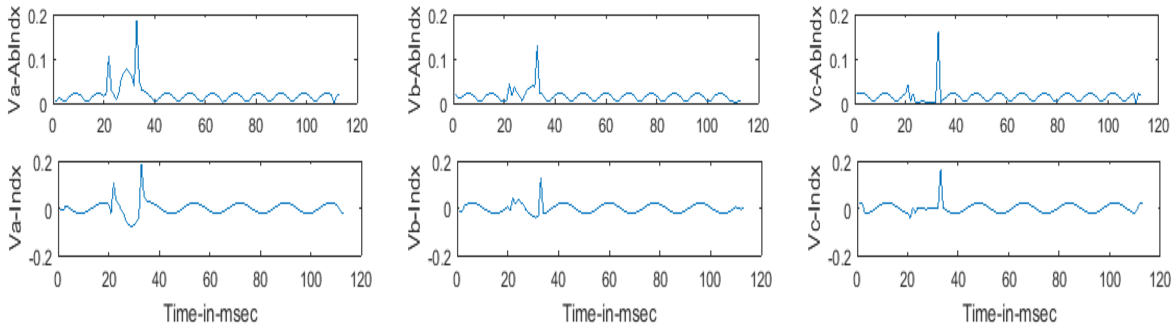

Figure 16. Absolute and detailed index of voltage signal of uncompensated transmission system under temporary single line to ground fault

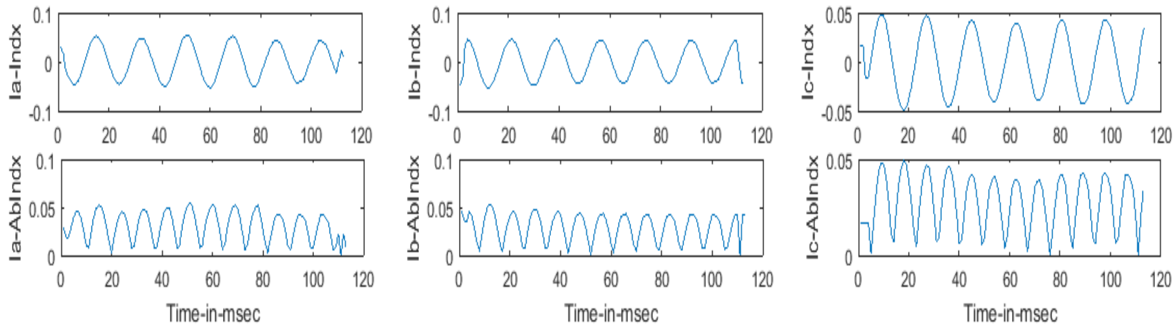

Figure 17. Absolute and detailed index of current signal of UPFC compensated transmission system under temporary single line to ground fault

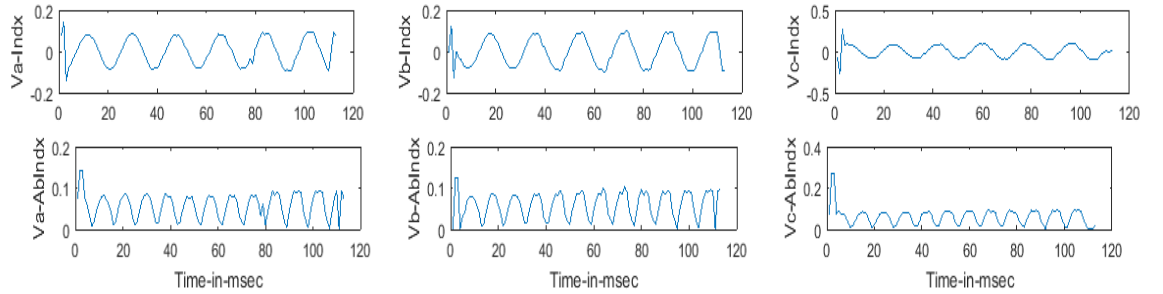

Figure 18. Absolute and detailed index of voltage signal of UPFC compensated transmission system under temporary single line to ground fault

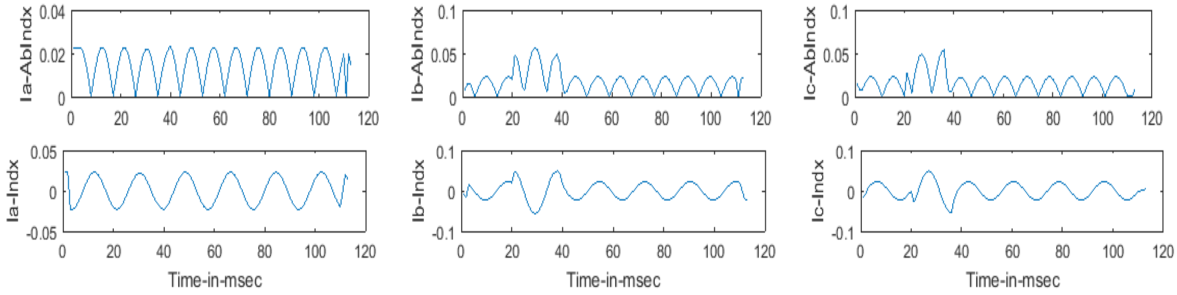

Figure 19. Absolute and detailed index of current signal of uncompensated transmission system under temporary double line to ground fault

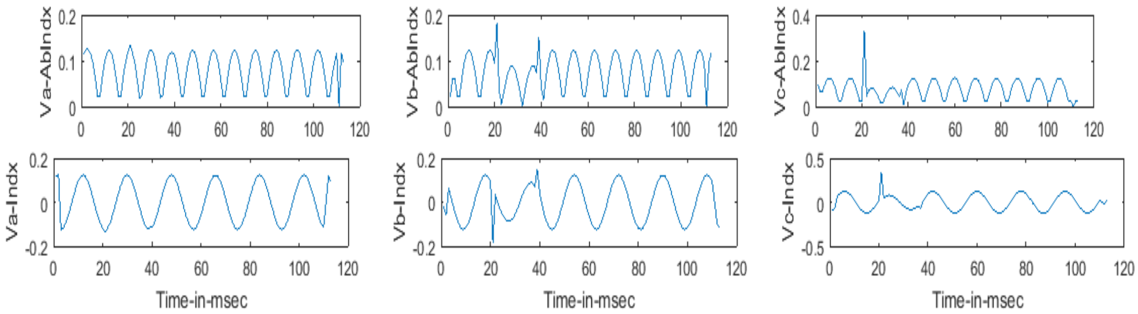

Figure 20. Absolute and detailed index of voltage signal of uncompensated transmission system under temporary double line to ground fault

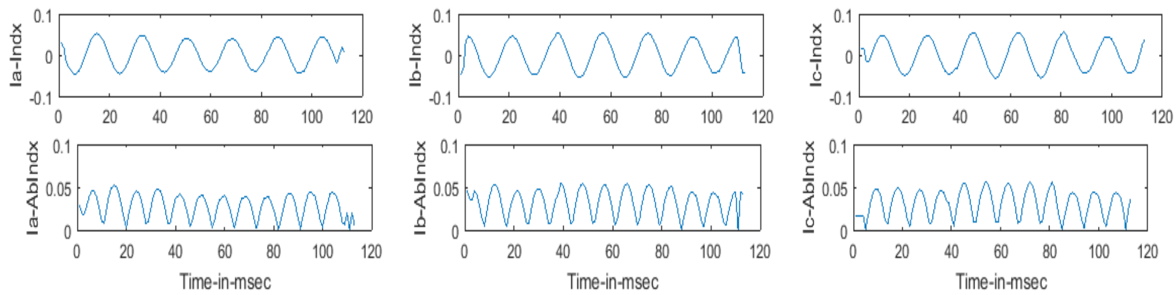

Figure 21. Absolute and detailed index of current signal of UPFC compensated transmission system under temporary double line to ground fault

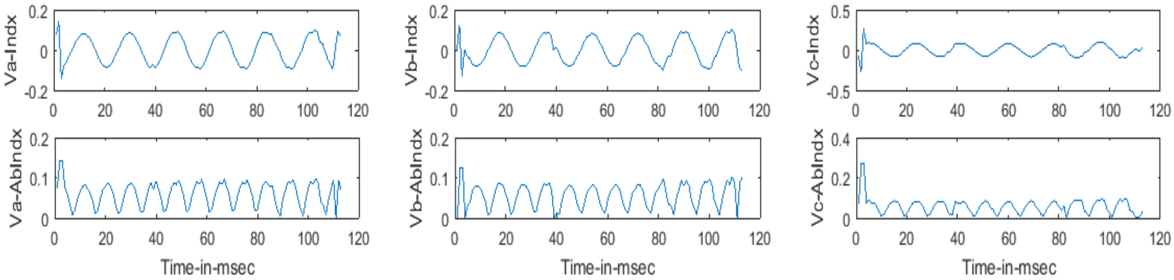

Figure 22. Absolute and detailed index of voltage signal of UPFC compensated transmission system under temporary double line to ground fault

The wavelet approach is more prominent method to analyse the reactive power compensating transmission system with as well as without UPFC under various power quality issues [10].

5. CONCLUSION

The increasing complexities of large inter connected networks had fluctuations in reliability of power supply, which resulted in system instability, difficult to control the power flow, existence of voltage sag, voltage swell, interruptions, harmonic distortions, transients and security problems are analysed. The multiline transmission systems with UPFC is a VSC based controller is developed using the MATLAB/Simulink. For detecting and characterizing disturbances in the transmission system is carried wavelet multi resolution analysis technique is implemented. An operating current signals are identified and then sum of the detailed coefficients are calculated by make use of bior1.5 mother wavelet at each terminal. This is compared to various power quality problems. The proposed model is tested under various power quality problems and found that voltage source converter based UPFC can control power quality issues effectively.

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