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Research Article

UPFC Compensated EHV Transmission Line Analysis for Higher Reliability

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ABSTRACT

Flexible AC Transmission System (FACTS) shown that Thyristor Controlled Series Capacitor (TCSC) affects the protection of line and protects the transmission line. The analysis first done analytically using simplified models, then the simulation results for protection of transmission line and protection relays in Real Time Digital Simulator (RTDS) are used. Finally, the simulation results verified using a commercial relay. The effects of fault resistance studied for UPFC compensated lines. Analysis of harmonic contents also done for UPFC compensated lines.

Keywords: Unified Power Flow Controller (UPFC), Flexible AC Transmission System (FACTS), Thyristor Controlled Series Capacitor (TCSC), Real-Time Software Components (RTSC), Real Time Digital Simulator (RTDS)

Introduction

Protection of aerial lines is one of the important area of power system. Due to increase in demand over the lines are heavily loaded because of which the margin between load and fault current is often small. Sometimes the magnitude of fault current may be less than the maximum full load current in the line. Transmission line can also protected by a coregroup of protective elements. These elements must be dependable and safety for all the power system weakness can cause problems with a relaying scheme. The distance relay are operating a normal speed and when fault[2,3] occurs element under, over reach, out-of-step (OOS) condition and Capacitive Voltage Transformer (CVT) transients. A major project to create a new mechanism for develops a new mechanism to help protection of the total transmission system. In this paper along with SSSC output and UPFC output [14], effect of source impedance and effect of fault location been shown.

Model Description

The Unified Power Flow Controller (UPFC)[9,[10] is helpful for control the power flow in a 500 kV transmission system. The UPFC located at the left end of the 100 km line L2, between the 500 kV buses B1 and B2, is used to control the active and bus B2 reactive powers is flow through while controlling voltage at bus B1. It consists of two 100 MVA, three-level, one connected in shunt at bus B1, 48-pulse GTO-based converters and one connected in series between buses B1 and B2. The series and shunt converters can interchange power through a DC bus. The series converter can inject a maximum of 9.9% of line-to-ground voltage (27.89 kV) in series with line L2 (Figure 1).

Presence of Facts Devices in Transmission Line

FACTS devices used for increased stability, improved voltage regulation, improved reactive power balance and improved load sharing between parallel ac transmission lines. The power flow through a given transmission line depends on three key parameters: (i) Voltage at both ends of the line (ii) the reactance of the line (iii) phase angle difference between sending and receiving end voltage. The recent FACTS technology controls the key parameters by fast acting switches. A Unified Power Flow Controller which combines the Static Compensator and Static Synchronous

Series Compensator represents the third generation of FACTS controller. It will have the unique ability to control all the three parameters voltage, line impedance and phase angle simultaneously.

Case Study and Test Result

Line Model Without UPFC

The line model without UPFC is illustrated shown in Figure 2.

Line data

- R1=0.01537 (Ω/Km) : Positive sequence resistance
- R0=0.04612 (Ω/Km): Zero sequence resistance
- L1=0.8858×10^{-3} (H/Km): Positive sequence inductance
- L0=2.654×10^{-3} (H/Km): Zero sequence inductance
- C1=13.06×10^{-9} (F/Km): Positive sequence capacitance
- C0=4.355×10^{-9} (F/Km): Zero sequence capacitance
- V1=500KV δ_1° (Substation-1)
- V2=500KV δ_2° (Substation-2)

Source data

- 3 Phase voltage source in series with RL branch
- Phase to phase rms voltage =500000V
- Phase angle of phase A= 12 degree
- Frequency= 50Hz
- Internal connection= Yg
- 3 phase short circuit level at base voltage (VA)=15000e6
- Base voltage (Vrmsph-ph)=500e3
- X/R ratio=20

Line Model With UPFC

The detailed line model without UPFC (48-Pulse, GTO-Based unified Power Flow Controller (500KV, 100MVA)) is presented in Figure 3.

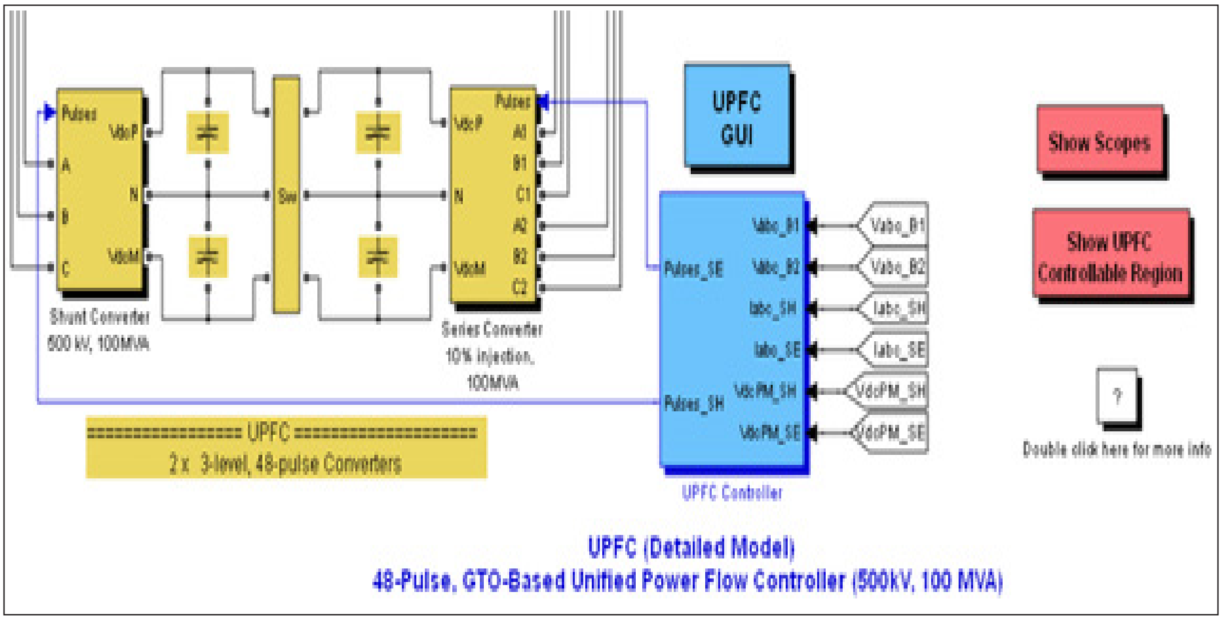

Figure 1.Detailed Model of UPFC

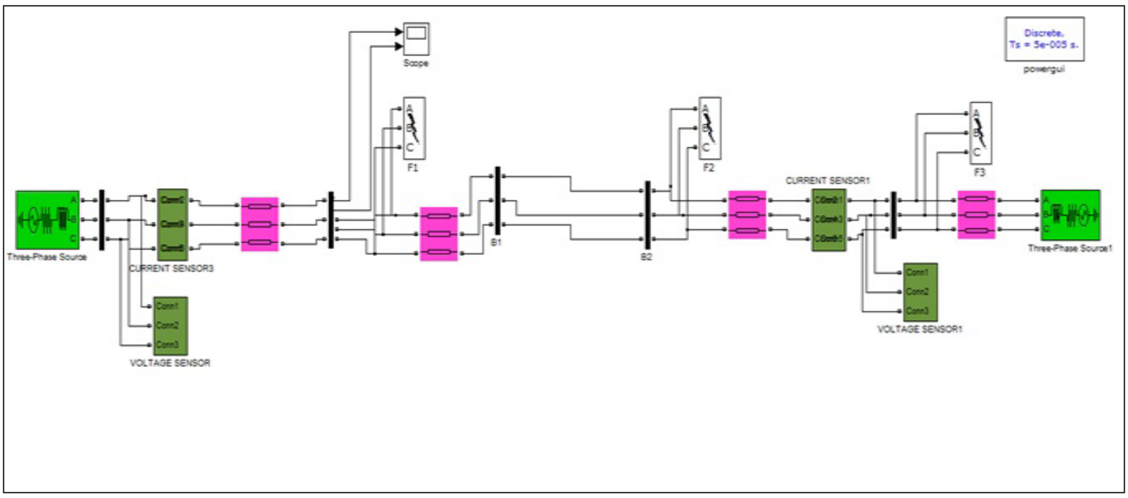

Figure 2.Line Model Without UPFC

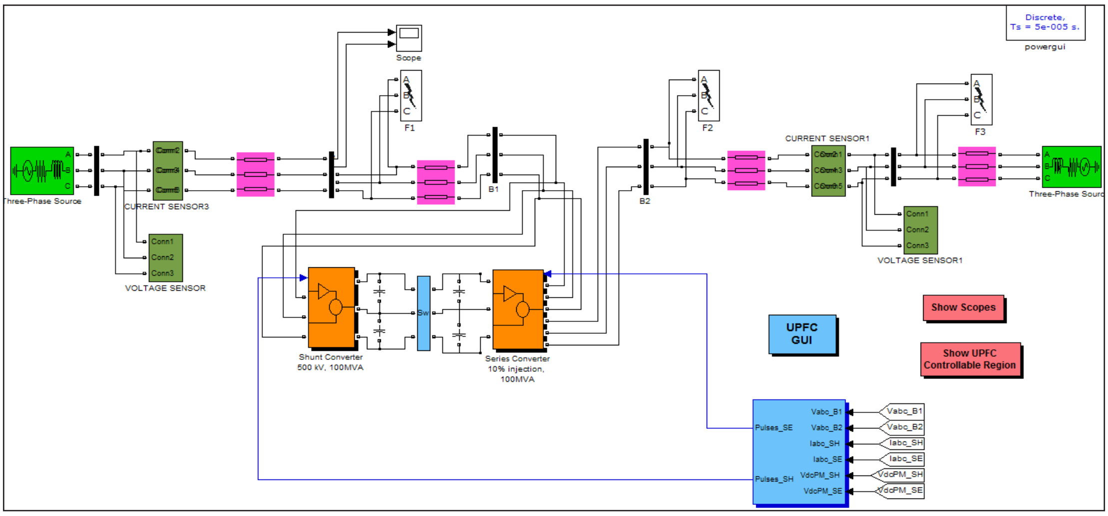

Figure 3.Detailed Line Model Without UPFC (48-Pulse, GTO-Based Unified Power Flow Controller (500KV, 100MVA)

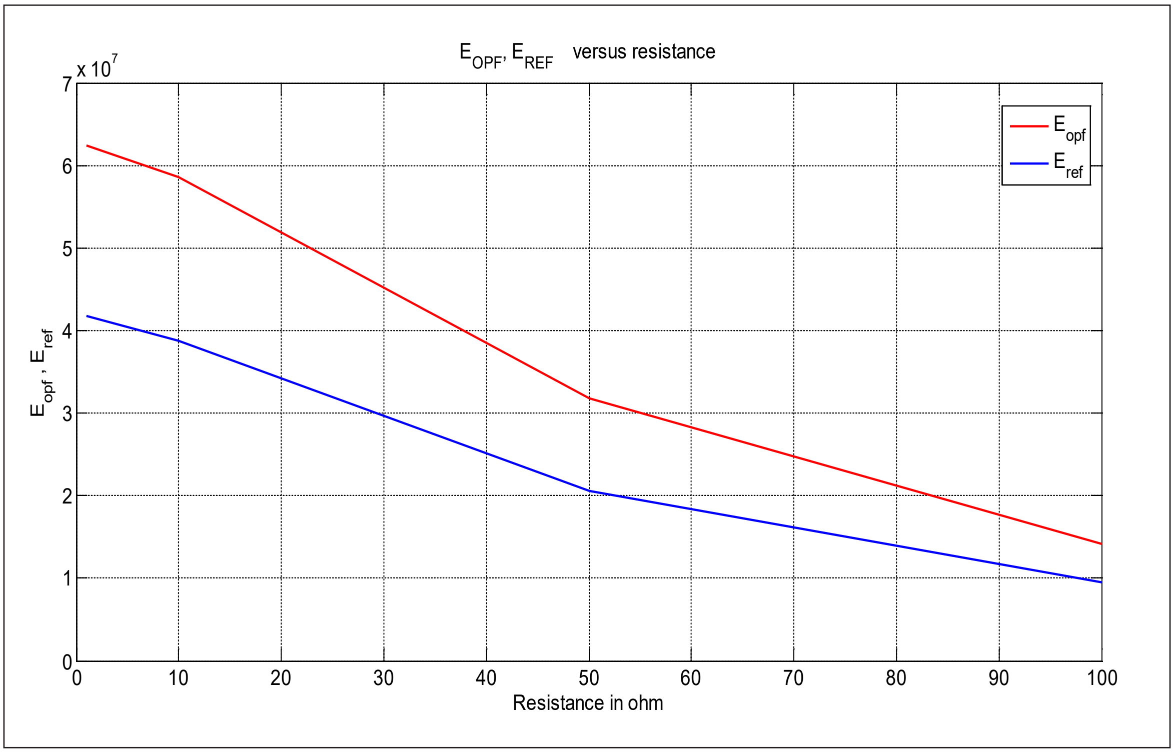

Figure 4.Spectral Energies for Fault Resistance

Effect of Fault Resistance With UPFC Compensated Line

Spectral energies for different values of fault resistance i.e. for 1 ohm,10 ohm,50 ohm,100 ohm for an A-G fault at 100 km from sending end is shown in the Figure 4.

Calculation of Harmonic Content Without UPFC Compensated Line

This is explained through Figures 5, 6 and the calculations are as given below:

f = 50Hz T =1/50 =20ms or 0.02sec

Ns (number of samples per cycle) = T/Ts = 0.02/ 0.00005= 400 samples

Ts = sampling time, total samples = 0.5/ 0.00005 = 10,000

Line model without UPFC – 0.3-0.5 sec THD= 2.68%

0.1-0.3sec (10cycles) THD = 0.10%

Line model with UPFC – 0.7-0.9sec THD = 13.34%

0.1-0.3sec THD = 2.20%

Calculation of Harmonic Content With UPFC Compensated Line

This is explained through Figures 7 (a) and (b).

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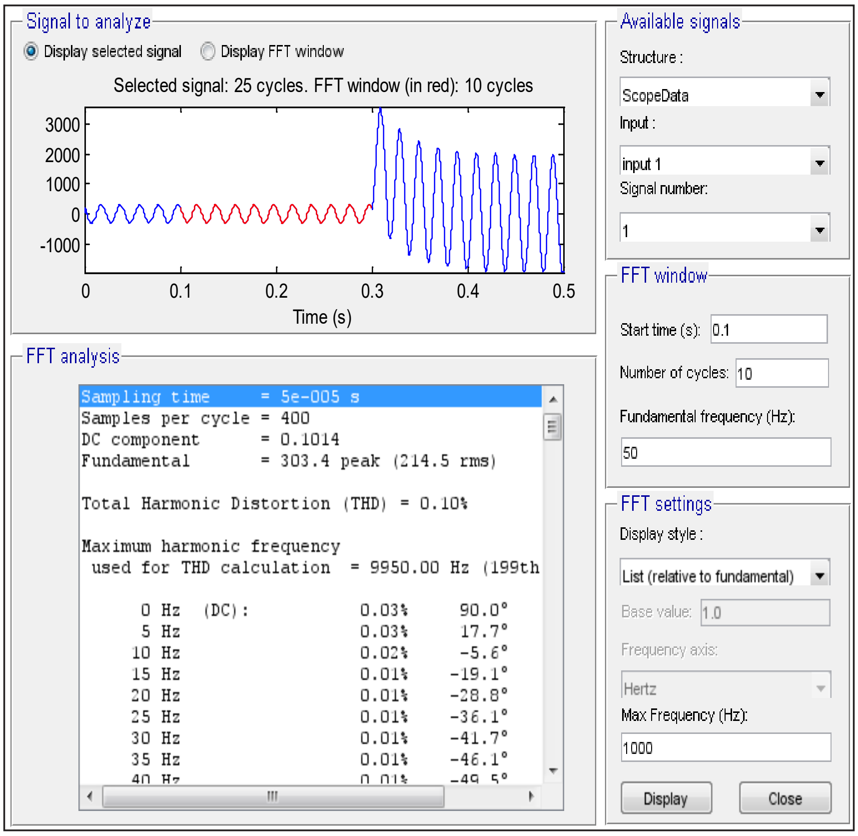


Figure 5.Calculation of Harmonic Content without UPFC Compensated Line

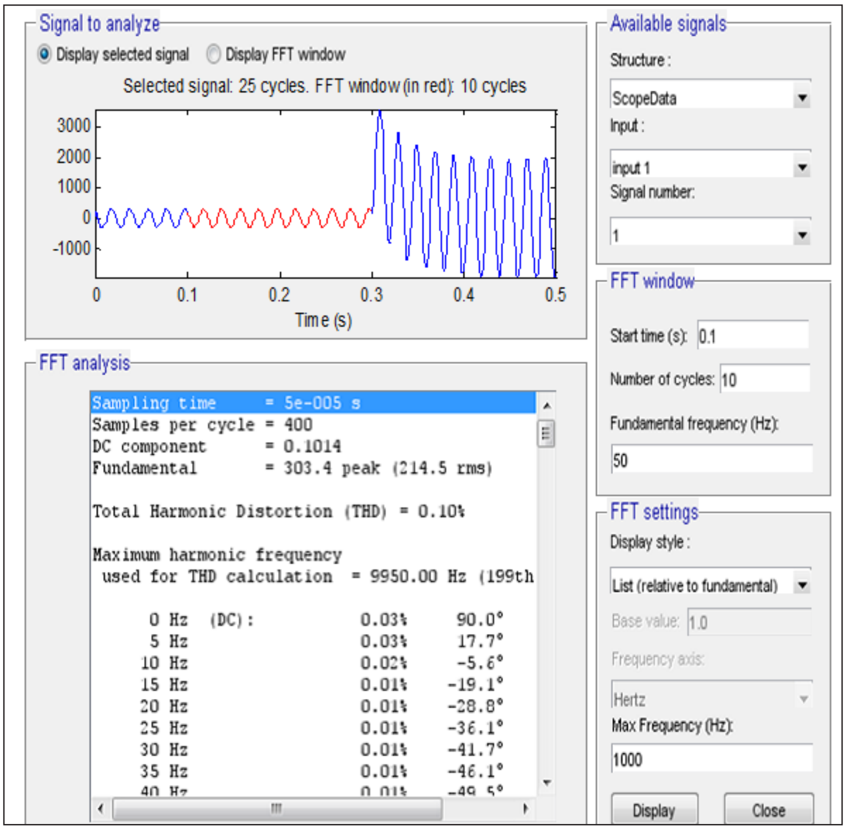
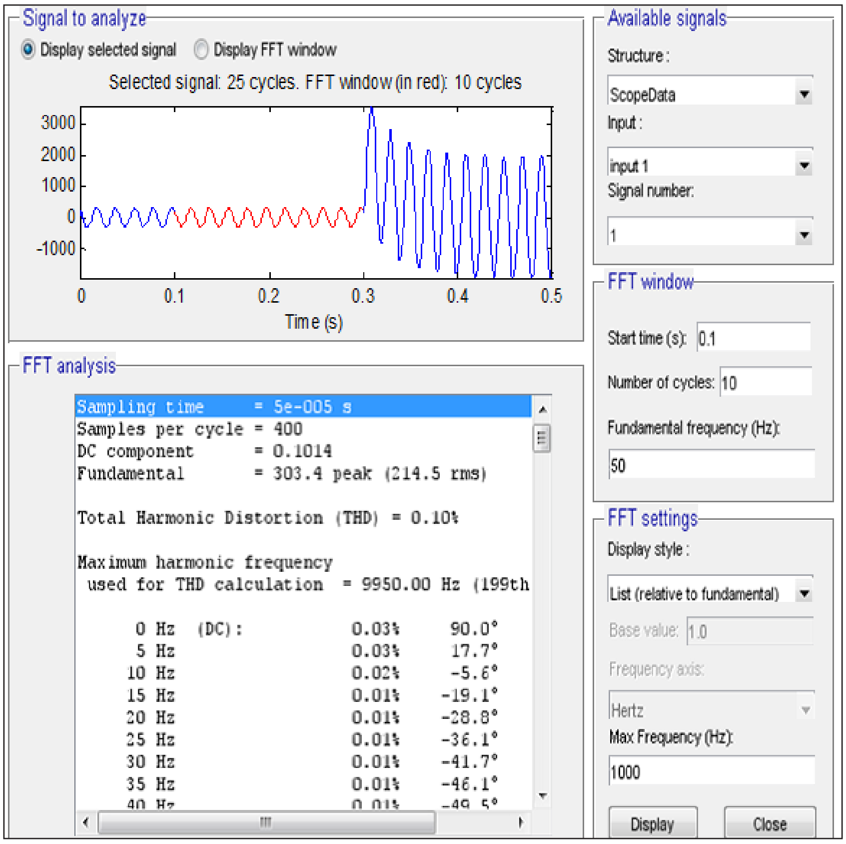


Figure 6.Calculation of Harmonic Content without UPFC Compensated Line (Line Model with UPFC 0.7-0.9sec THD = 13.34%)



(A)

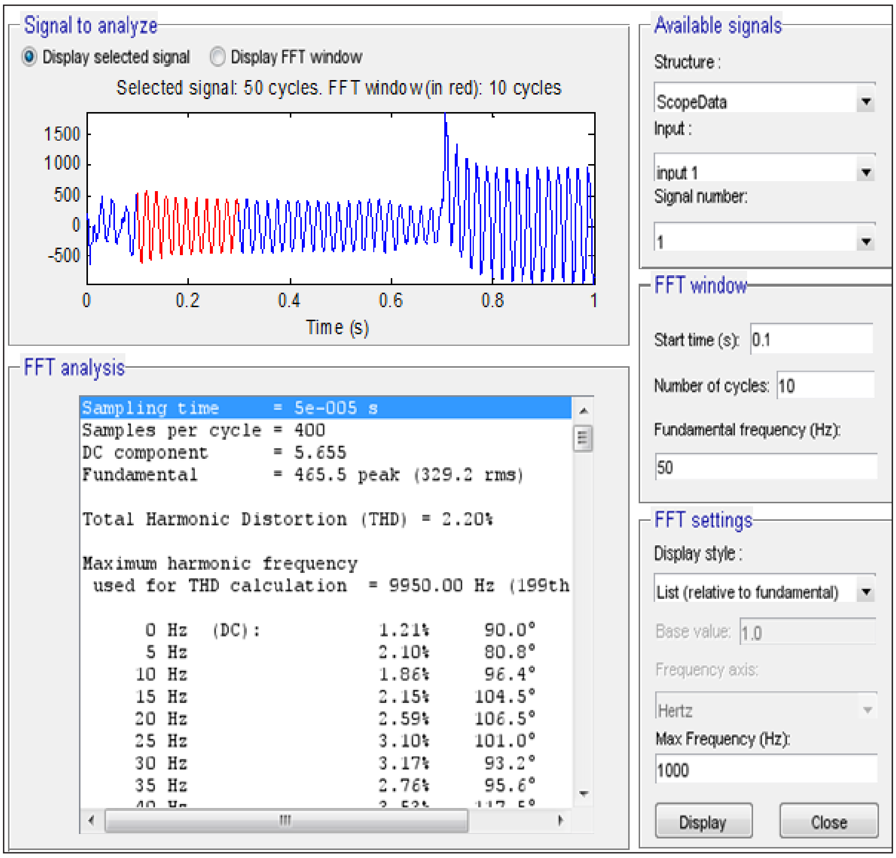


Figure 7(a), (b).Calculation of Harmonic Content with UPFC Compensated Line

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Conclusion

The proposed ccheme provides discrimination between external and internal faults at all operating conditions like fault elements, fault location area, fault resistance, fault inception angle, impedance variation and reverse power flow without incorporating UPFC in Transmission Line. Total harmonic Distortion is increasing in case of UPFC compensated line. Proposed technique works on the energy content of the signals at different substations , only communication link is required to perform the relaying task at a particular substation and thus reducing the cost of time-synchronization of the signals (error introduced due to phase angle difference are minimized) at all substations

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