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Smart Grid Power Quality Improvement Using UPQC

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ABSTRACT
This paper is presents smart grid power quality improvement by the use of flexible AC transmission system (FACTS) devices like unified power quality conditioner (UPQC). With the application of UPQC, fault current reduces at a certain level is also investigates. In this paper the fault currents, without UPQC in smart grid at different types of faults (LG, LL, LLG, LLL & LLLG fault) and after integration of UPQC with smart grid fault currents have been calculated. This paper also describes different issues of smart grid such as security and power quality improvements.
The term Smart Grid was coined in year 2005, when it appeared within the IEEE P&E Magazine in an article " Towards a smart Grid " by Amin and Wallenberg. Somehow there is a common belief that the smart grid will revolutionize the electricity business & change the business model that has been in place for the past 75 years and more It is an automated extensively distributed energy transfer network, withtwo-way flow of electricity and informations and it is monitoring and reacting to variations in every parameter from power generations to individual consumer appliances. Although there is no standard definition of Smart Grid & same is still evolving but broadly the term stands for: *'A Power System' that uses some ICT(information and communications technology) tools to improvethe efficiency, economics, sustainability and reliability of the generation, transmission or/and distribution of electricity* In fact, most of the work that has been going on in power system modernization, especially substation and distribution automation, is now being called as smart grid, of course there are few additional capabilities being evolved as well. *Smart Grids are also known as self-healing or self-adaptive grids Or self- healing network. They have Ability to sense, diagnose, isolate, temporarily correct /eradicate a fault or performance condition without human intervention. It conducts Automated objective analysis & the correlation of various type of events enable the utilities to proactively*

UPQC are usually employed to resolve the issues related to flicker, power quality, voltage sag, swell and natural current reduction of distribution system and also it reduces the harmonics into the system.The system model is simulated in MATLEB software & simulation results are discussed.

KEY WORDS: Smart Grid, UPQC(unified power quality conditioner),Power Quality, Faults, MATLAB, Simulink.

I. INTRODUCTION

responds to feederevents ratherthan merely being able to react to them.

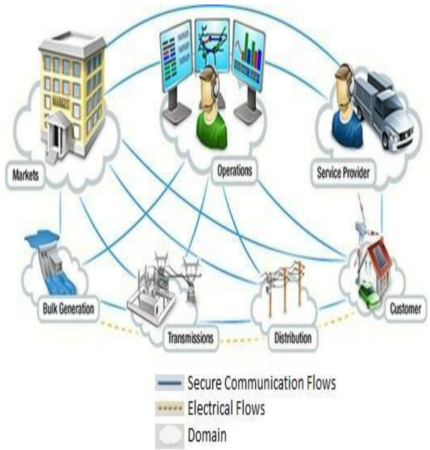


Fig. 1- conceptual model of smart grid

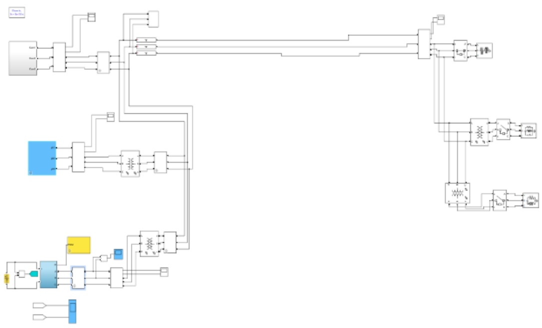
II. CONVENTIONAL GRID VS SMART GRID

1. The conventional grid is equipped with electromechanical sensors & relays & smart grid is completely digital. It uses state of the art digital relays and other sensors.
2. The conventional grid is having one way communication. But smart grid uses two-waycommunication.
3. The conventional grid uses centralized generation &smart grid uses distributed generation.

4. The conventional grid will have limited sensors but smart grid is equipped with sensorsthroughout.
5. The monitoring of power & fault related issues in conventionalgrid is done manually but in smart grid, it is a self-monitoring process.
6. If any fault occurs in conventional grid, we should restore it manually from the control center. whereas in smart grid, it is a self-healing process.
7. If a blackout occurs in conventional grid, it creates a catastrophe. But in smart grid, there's an option for adaptive islanding.
8. Conventional grid is having limited control &smart grid is having pervasive control
9. Conventional grid gives limited choice to customers whereas the smart grid gives multiple opportunities to customers &there are lot of demand response programs created to give incentives to customers if we reduce our power consumption during peak hours.

III. MATLAB SIMULATION AND WAVEFORMS

Smart grid model is simulated in MATLAB using Simulink. The model consists of conventional grid, nonconventional energy sources. on load side different types of fault is simulated. Practical data has been used to obtain simulation results.



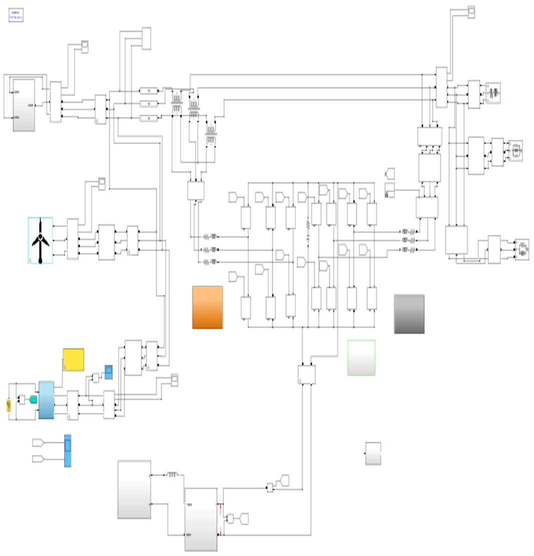
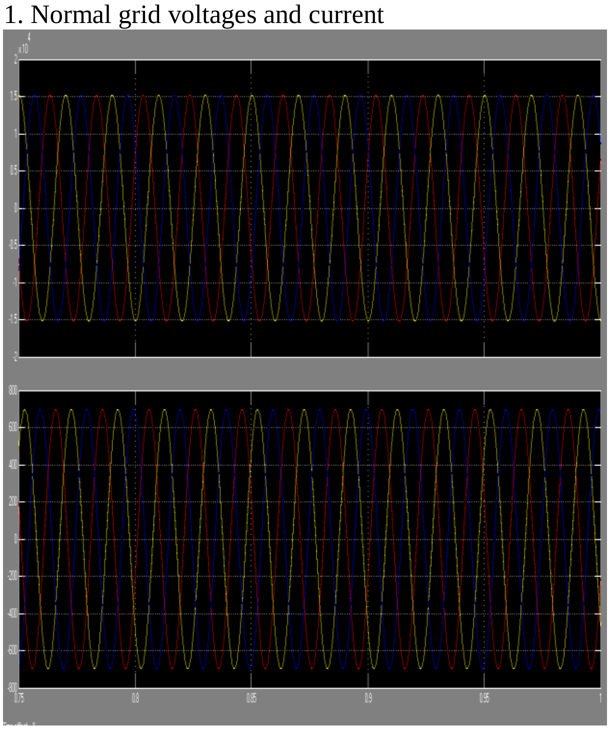


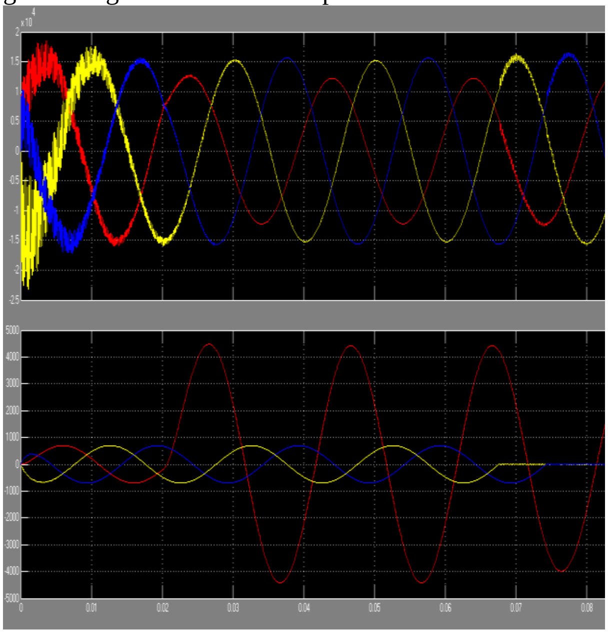
Fig. 2 smart grid without UPQC

Fig.3 smart grid with UPQC

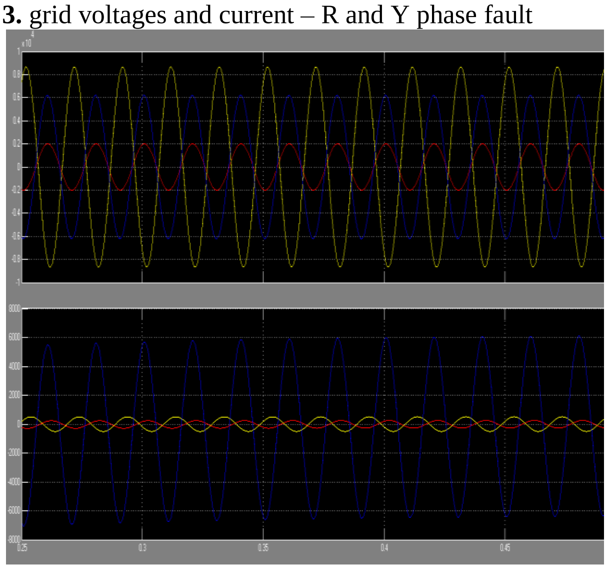
1. Normal grid voltages and current



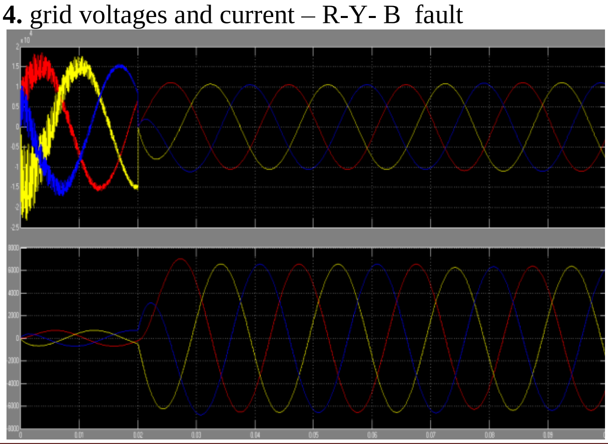
grid voltages and current – R-phase to earth fault



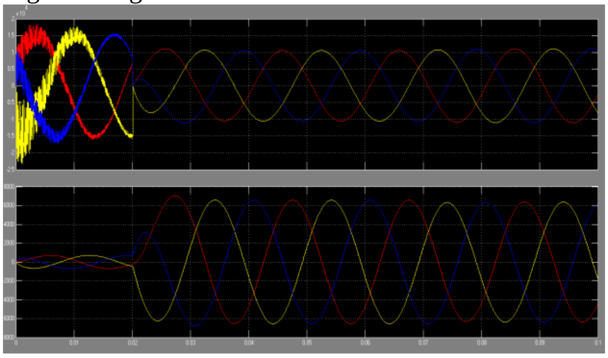
3. grid voltages and current – R and Y phase fault



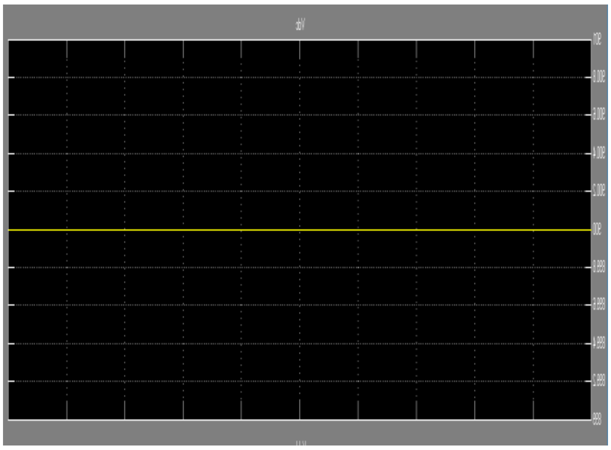
4. grid voltages and current – R-Y- B fault



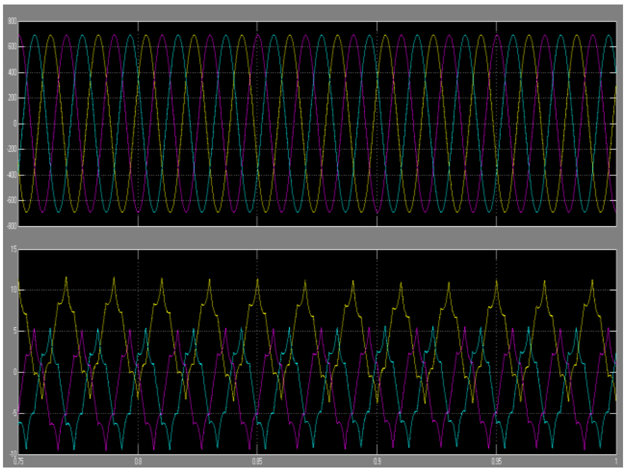
5. grid voltages and current – R-Y- B to earth fault



6. SOLAR D.C.



7.SOLAR A.c.



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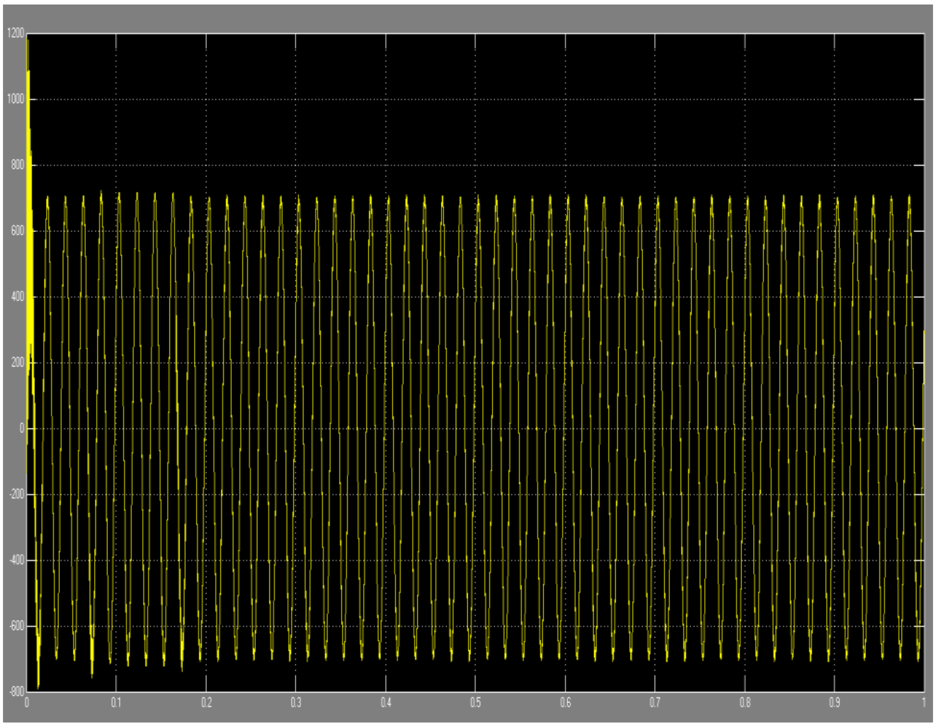
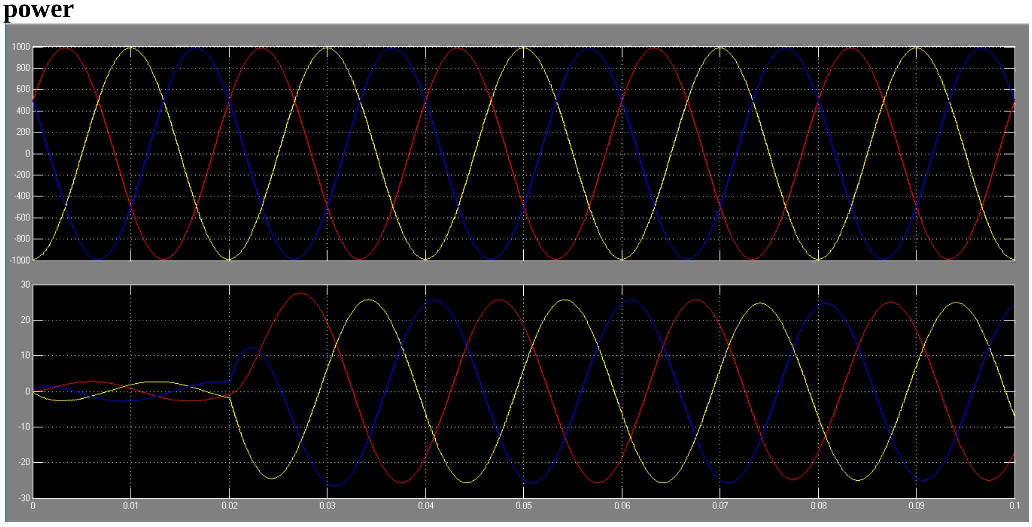
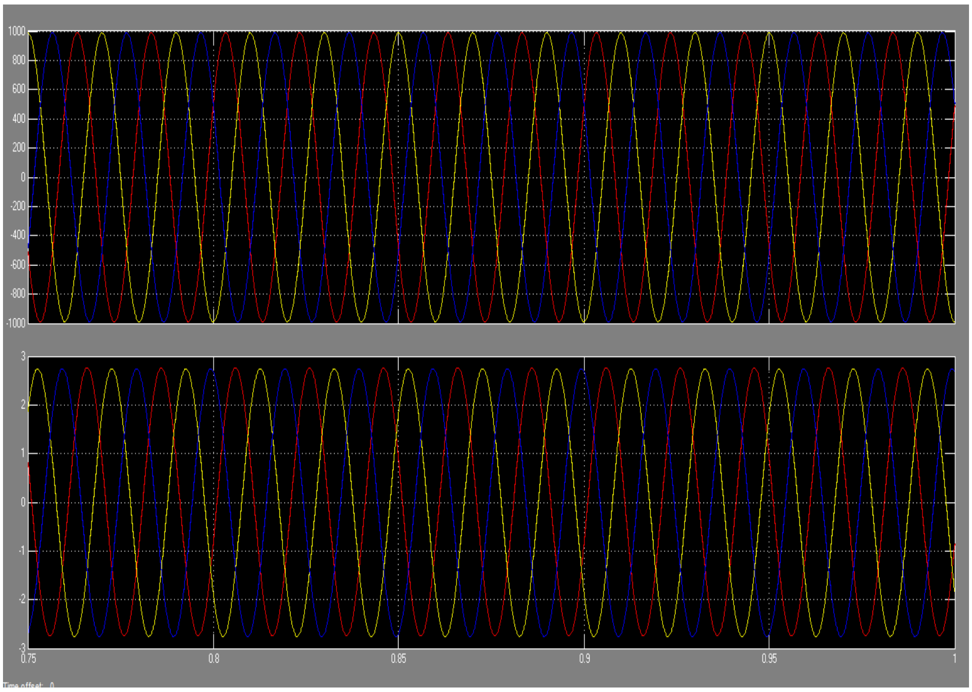
8. solar A.C. current after filter



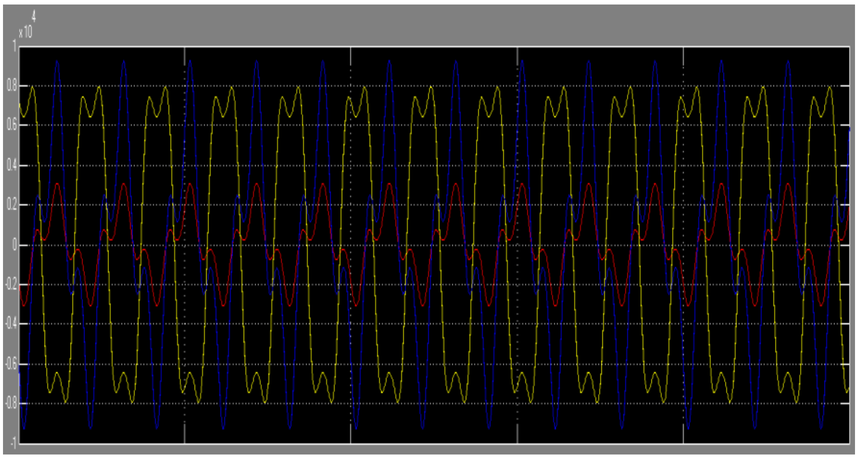
9. wind power





4.3 LOSS REDUCTION
R of line 0.01273 x 10 = 0.1273 OHM
Without UPQC
V*I*t= 11000x 619.3x0.9 x 24x30/1000 = 4414370 kwh per month
WITH UPQC
V*I*t = 11000x450 x 0.9 x 24x30/1000 = 3207600 kwh per month
Total energy saving = 1206770 kwh per month
Considering the cost of energy Rs 3.5 per kwh there is saving of Rs 4223695 per month or Rs 5 crores per annum on one 11 kv line

4.5 HARMONICS REDUCTION:
Generated harmonics waveform at source:



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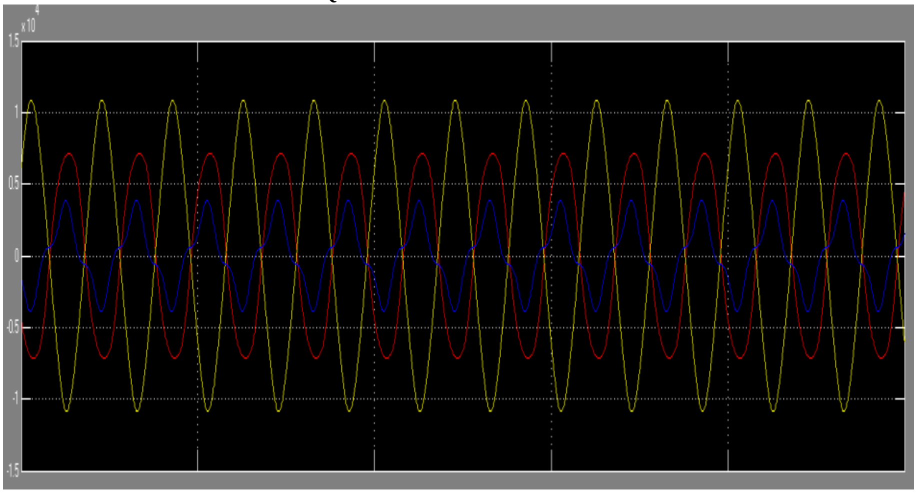
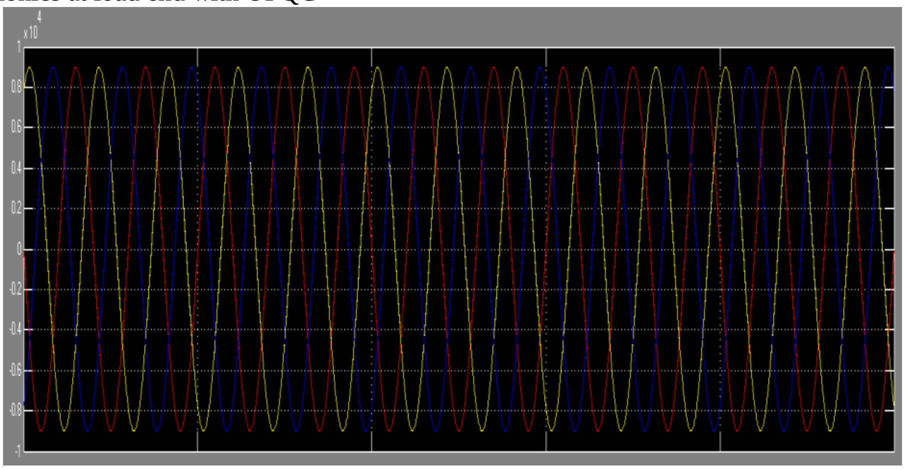
Effect of harmonics at load end without UPQC



Effect of harmonics at load end with UPQC



4.6 STEADY STATE ANALYSIS

Without UPQC

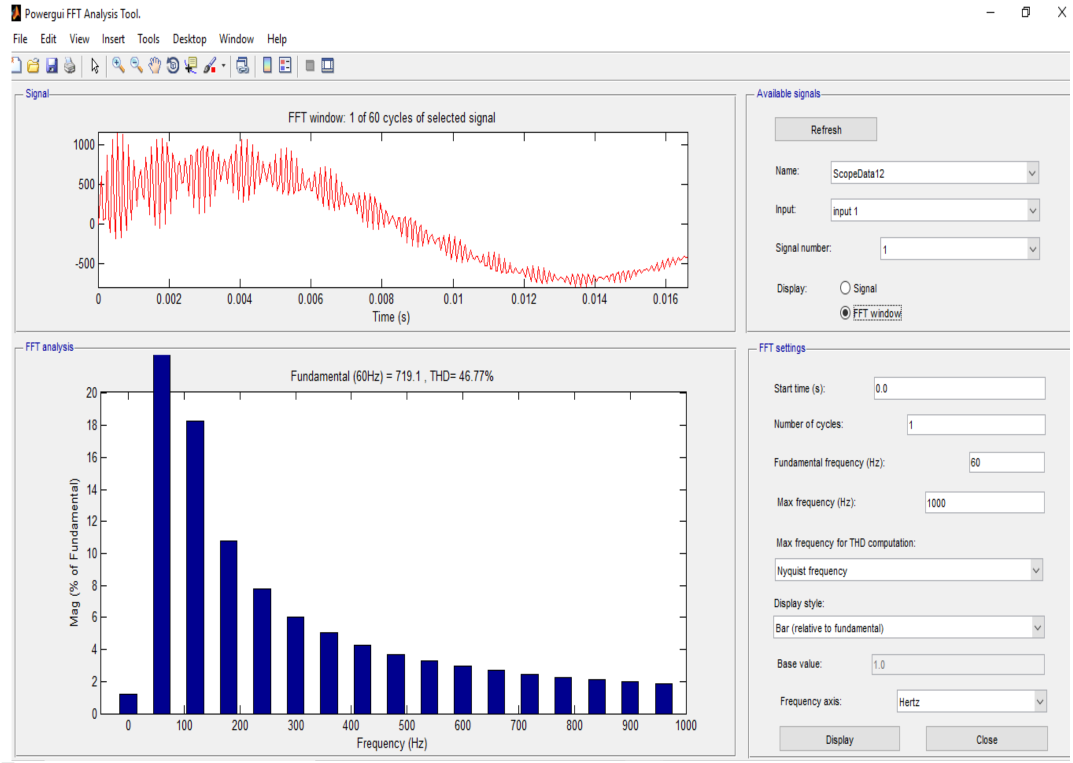
- MEASUREMENTS:
- 1: 'U_Vab_VSC2 ' = 488.84 Vrms 25.81°
- 2: 'U_Vdc ' = 0.00 Vrms 0.00°
- 3: 'U AB: Three-Phase V-I Measurement4 ' = 10350.23 Vrms 12.33°
- 4: 'U BC: Three-Phase V-I Measurement4 ' = 10350.23 Vrms -107.67°
- 5: 'U CA: Three-Phase V-I Measurement4 ' = 10350.23 Vrms 132.33°
- 6: 'U AB: Three-Phase V-I Measurement3 ' = 488.84 Vrms 25.81°
- 7: 'U BC: Three-Phase V-I Measurement3 ' = 488.84 Vrms -94.19°
- 8: 'U CA: Three-Phase V-I Measurement3 ' = 488.84 Vrms 145.81°
- 9: 'U AB: Three-Phase V-I Measurement2 ' = 699.97 Vrms 29.99°
- 10: 'U BC: Three-Phase V-I Measurement2 ' = 699.97 Vrms -90.01°
- 11: 'U CA: Three-Phase V-I Measurement2 ' = 699.97 Vrms 149.99°
- 12: 'U AB: Three-Phase V-I Measurement1 ' = 10755.87 Vrms 25.82°
- 13: 'U BC: Three-Phase V-I Measurement1 ' = 10755.87 Vrms -94.18°
- 14: 'U CA: Three-Phase V-I Measurement1 ' = 10755.87 Vrms 145.82°
- 15: 'I A: Three-Phase V-I Measurement1 ' = 493.84 Arms -17.66°
- 16: 'I A: Three-Phase V-I Measurement2 ' = 1.95 Arms -17.83°
- 17: 'I A: Three-Phase V-I Measurement3 ' = 0.09 Arms -97.83°
- 18: 'I A: Three-Phase V-I Measurement4 ' = 493.92 Arms -17.69°
- 19: 'I B: Three-Phase V-I Measurement4 ' = 493.92 Arms -137.69°

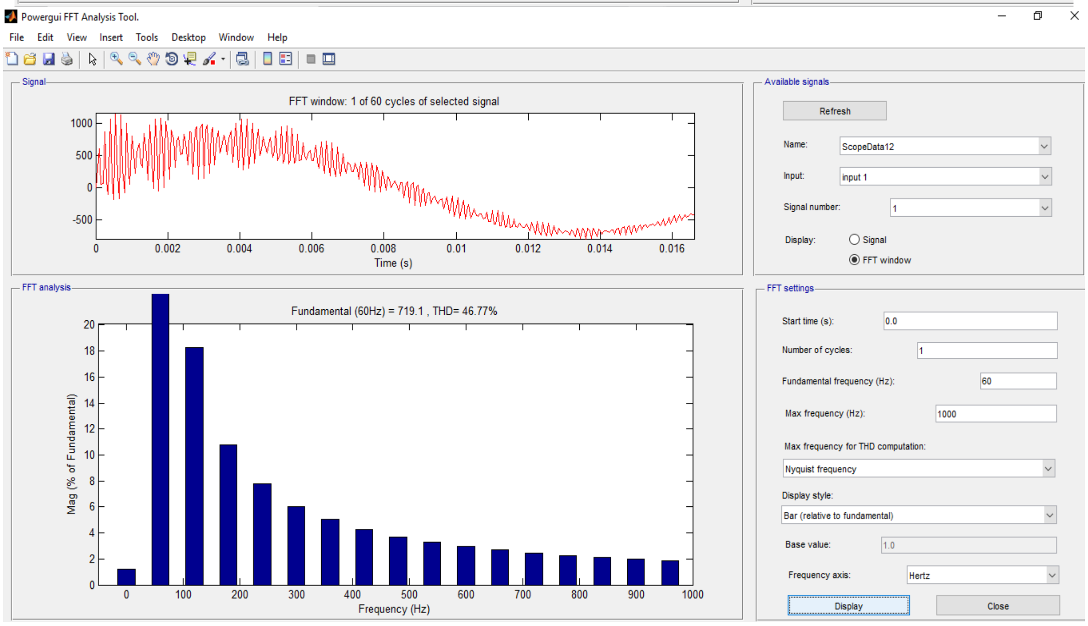
- 20: 'I C: Three-Phase V-I Measurement4 ' = 493.92 Arms 102.31°
- 21: 'I B: Three-Phase V-I Measurement3 ' = 0.09 Arms 142.17°
- 22: 'I C: Three-Phase V-I Measurement3 ' = 0.09 Arms 22.17°
- 23: 'I B: Three-Phase V-I Measurement2 ' = 1.95 Arms -137.83°
- 24: 'I C: Three-Phase V-I Measurement2 ' = 1.95 Arms 102.17°
- 25: 'I B: Three-Phase V-I Measurement1 ' = 493.84 Arms -137.66°
- 26: 'I C: Three-Phase V-I Measurement1 ' = 493.84 Arms 102.34°

WITH UPQC

- MEASUREMENTS:
- 1: 'U_Vab_VSC2 ' = 640.52 Vrms 63.25°
- 2: 'U_Vdc ' = 0.00 Vrms 0.00°
- 3: 'U_Voltage Measurement ' = 0.00 Vrms 60.34°
- 4: 'U AB: Three-Phase V-I Measurement5 ' = 60.88 Vrms 13.63°
- 5: 'U BC: Three-Phase V-I Measurement5 ' = 83.92 Vrms -161.48°
- 6: 'U CA: Three-Phase V-I Measurement5 ' = 23.84 Vrms 31.08°
- 7: 'U A: Three-Phase V-I Measurement ' = 750.08 Vrms 52.90°
- 8: 'U B: Three-Phase V-I Measurement ' = 2796.00 Vrms -113.64°
- 9: 'U C: Three-Phase V-I Measurement ' = 2073.85 Vrms 71.18°
- 10: 'U_100Vdc DC//DC Converter3/Chopper/Voltage Measurement1' = 0.00 Vrms 60.34°
- 11: 'U_100Vdc DC//DC Converter3/Voltage Measurement ' = 0.00 Vrms 60.34°
- 12: 'U A: Three-Phase V-I Measurement1 ' = 1524.44 Vrms 77.08°
- 13: 'U B: Three-Phase V-I Measurement1 ' = 6347.23 Vrms -120.03°
- 14: 'U C: Three-Phase V-I Measurement1 ' = 4582.48 Vrms 79.51°
- 15: 'U A: Three-Phase V-I Measurement2 ' = 340.31 Vrms 2.43°
- 16: 'U B: Three-Phase V-I Measurement2 ' = 404.10 Vrms -120.01°
- 17: 'U C: Three-Phase V-I Measurement2 ' = 375.75 Vrms 115.08°
- 18: 'U A: Three-Phase V-I Measurement3 ' = 124.91 Vrms 77.03°
- 19: 'U B: Three-Phase V-I Measurement3 ' = 520.06 Vrms -120.03°
- 20: 'U C: Three-Phase V-I Measurement3 ' = 375.47 Vrms 79.49°
- 21: 'U AB: Three-Phase V-I Measurement4 ' = 60.88 Vrms 13.63°
- 22: 'U BC: Three-Phase V-I Measurement4 ' = 83.92 Vrms -161.48°
- 23: 'U CA: Three-Phase V-I Measurement4 ' = 23.84 Vrms 31.08°
- 24: 'I_Current Measurement ' = 0.00 Arms -54.89°
- 25: 'I A: Three-Phase V-I Measurement ' = 0.02 Arms 52.90°
- 26: 'I B: Three-Phase V-I Measurement ' = 0.06 Arms -113.64°
- 27: 'I A: Three-Phase V-I Measurement5 ' = 0.00 Arms -6.36°
- 28: 'I B: Three-Phase V-I Measurement5 ' = 0.00 Arms 156.65°
- 29: 'I C: Three-Phase V-I Measurement5 ' = 0.00 Arms -3.87°
- 30: 'I C: Three-Phase V-I Measurement ' = 0.04 Arms 71.18°
- 31: 'I_100Vdc DC//DC Converter3/Chopper/Current Measurement ' = 0.00 Arms 0.00°
- 32: 'I A: Three-Phase V-I Measurement1 ' = 133.85 Arms 77.02°
- 33: 'I B: Three-Phase V-I Measurement1 ' = 3.70 Arms -164.74°
- 34: 'I C: Three-Phase V-I Measurement1 ' = 4265.06 Arms 77.51°
- 35: 'I A: Three-Phase V-I Measurement2 ' = 2092.80 Arms -102.69°
- 36: 'I B: Three-Phase V-I Measurement2 ' = 2.18 Arms -165.10°
- 37: 'I C: Three-Phase V-I Measurement2 ' = 1396.74 Arms 77.26°
- 38: 'I A: Three-Phase V-I Measurement3 ' = 0.86 Arms -37.56°
- 39: 'I B: Three-Phase V-I Measurement3 ' = 3.19 Arms 155.90°
- 40: 'I C: Three-Phase V-I Measurement3 ' = 2.36 Arms -19.27°
- 41: 'I A: Three-Phase V-I Measurement4 ' = 0.98 Arms 27.33°
- 42: 'I B: Three-Phase V-I Measurement4 ' = 4.08 Arms -169.66°
- 43: 'I C: Three-Phase V-I Measurement4 ' = 2.95 Arms 29.83°

4.7 FFT ANALYSIS





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IV. RESULTS

	Without UPQC						WITH UPQC					
	Grid Voltage			Grid Current			Grid voltage			Grid current		
	R	Y	B	R	Y	B	R	Y	B	R	Y	B
NORMAL	11000	11000	11000	618	621	619	11000	11000	11000	450	450	450
R-G FAULT	0	11000	11000	6321	700	700	0	11000	11000	4088	551	549
R-Y FAULT	0	0	11000	5516	5534	700	0	0	11000	4114	4161	700
R-Y-G FAULT	0	0	11000	6105	6119	700	0	0	11000	4211	4189	700
R-Y-B FAULT	0	0	0	6022	6112	6210	0	0	0	4501	4488	4490
R-Y-B-G FAULT	0	0	0	6266	6401	6328	0	0	0	4717	4754	4737

V. CONCLUSION

- It is observed that using UPQS in smart grid fault current reduces to certain extent.
- It is recorded that load current also reduces using UPQC
- It is also observed that due to reduction of harmonicsthe power quality is enhanced
- It is observed that there is reduction in energy Loss using UPQC
- Financial saving also observed up to much extent

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