II Международная научно-практическая конференция
«Альтернативная и интеллектуальная энергетика»

Simulation of the Static Synchronous Compensator for the Electrical System with non-Linear Load

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Introduction

The Article presents the STATCOM model in PSIM, which compensate reactive power and current harmonics from the non-linear load, which presented as electric arc furnace. Reactive power consumption and harmonics current of non-linear load given from measurement, presented on figures 3-6. The model of STATCOM is a multi-level voltage inverter. System voltage, power factor and harmonics currents are controlled.




Experiments

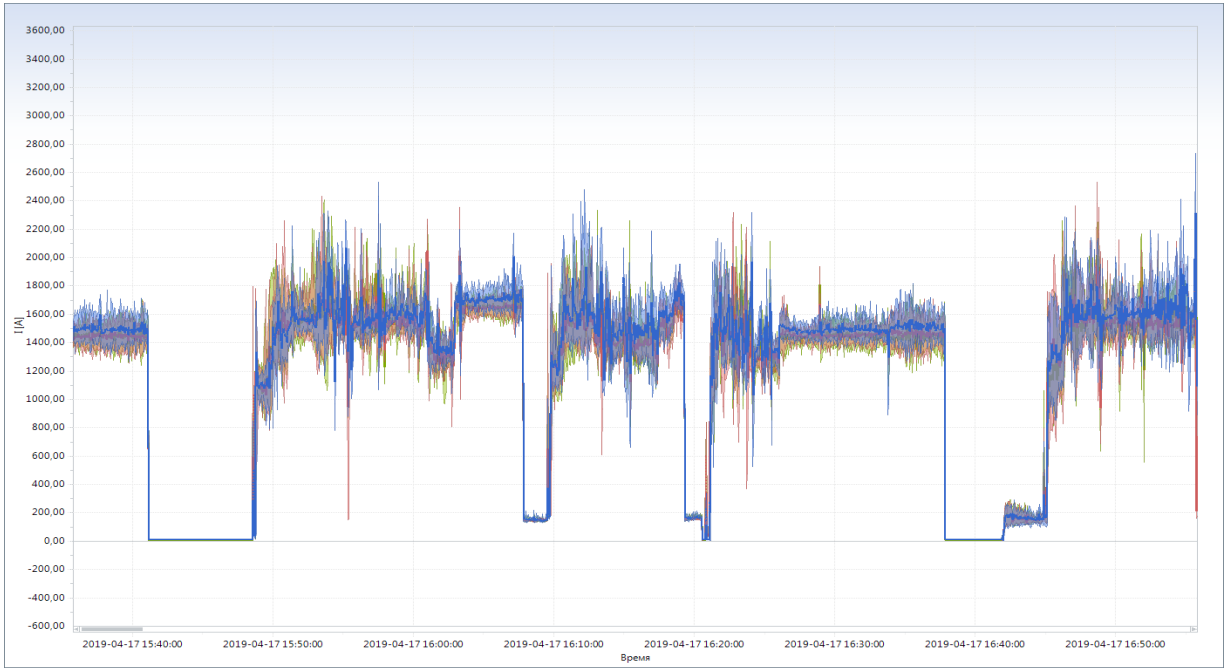


Figure 1. Non-linear load RMS current value, measurement result.




Experiments

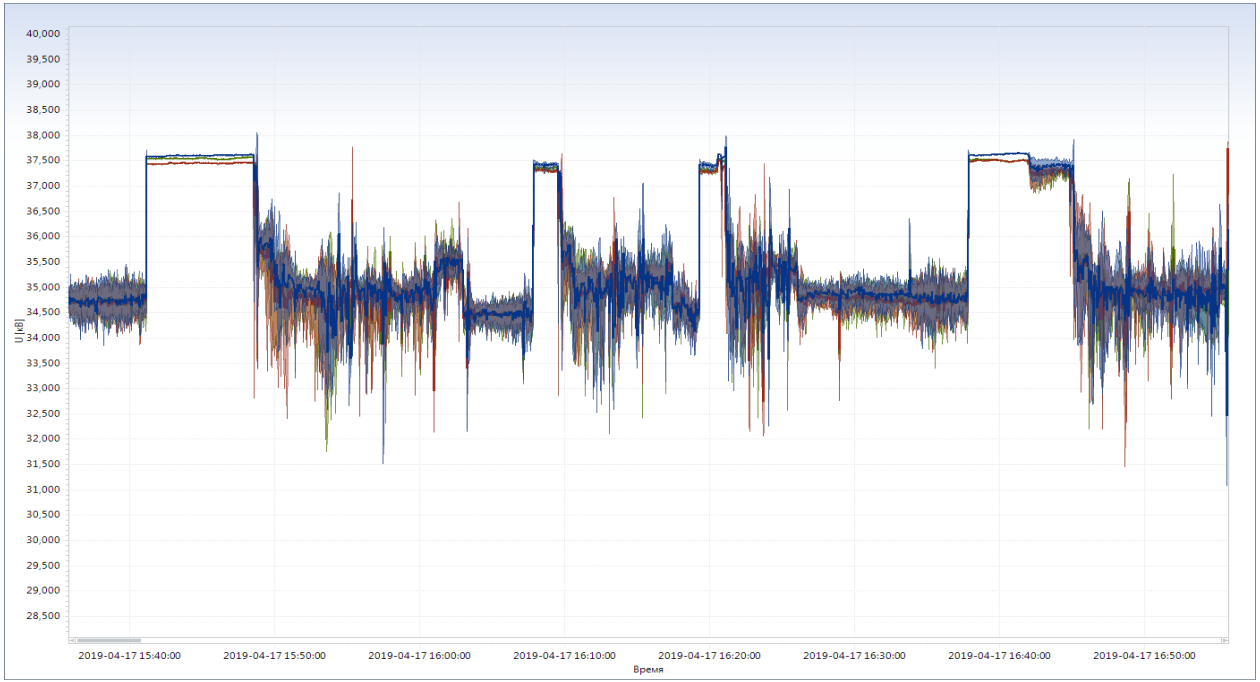


Figure 2. Non-linear load RMS voltage value, measurement result.




Experiments

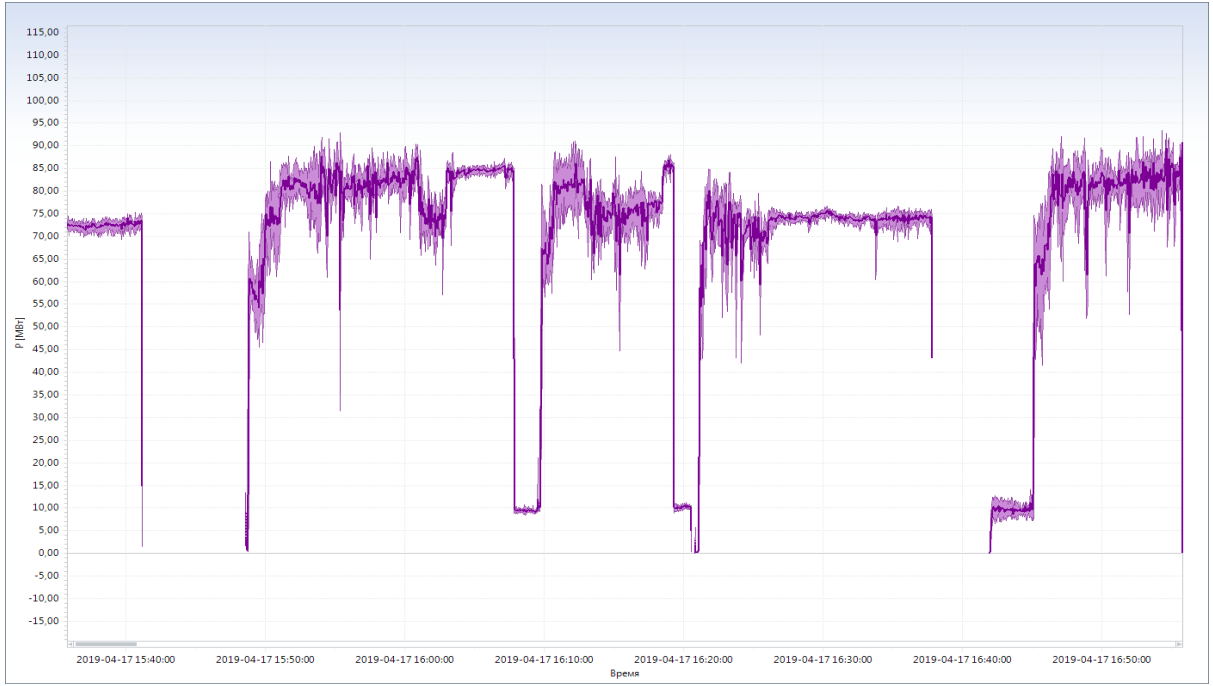


Figure 4. Non-linear active power, measurement result.




Experiments

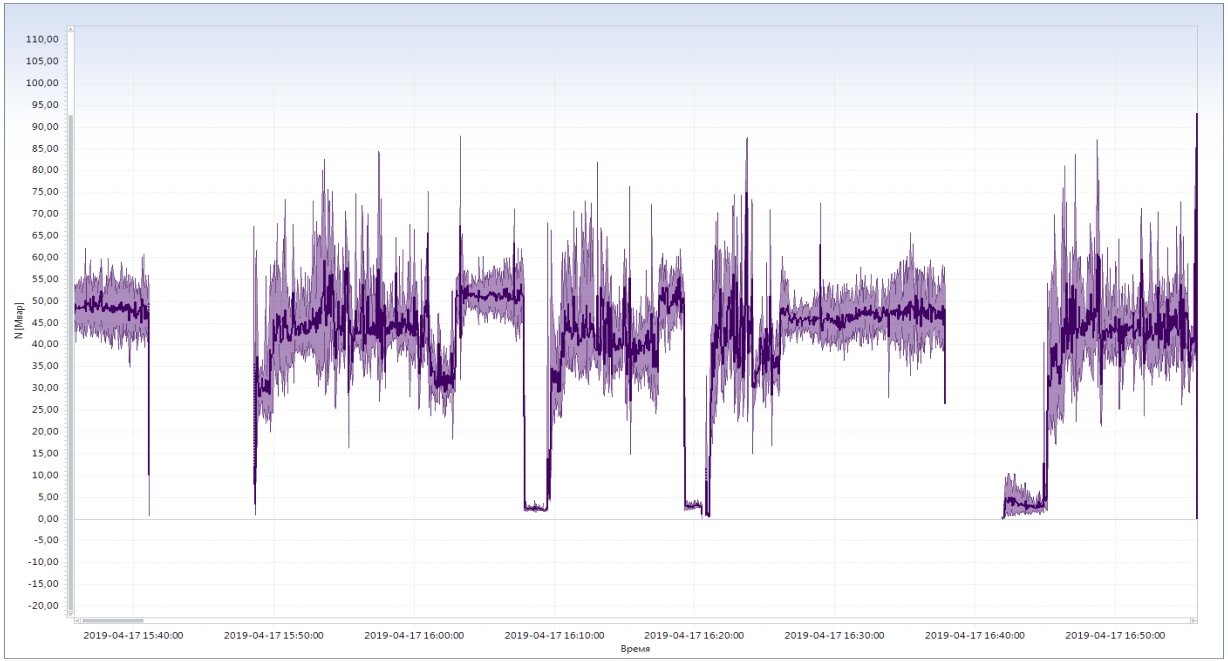


Figure 5. Non-linear reactive power, measurement result.




Experiments

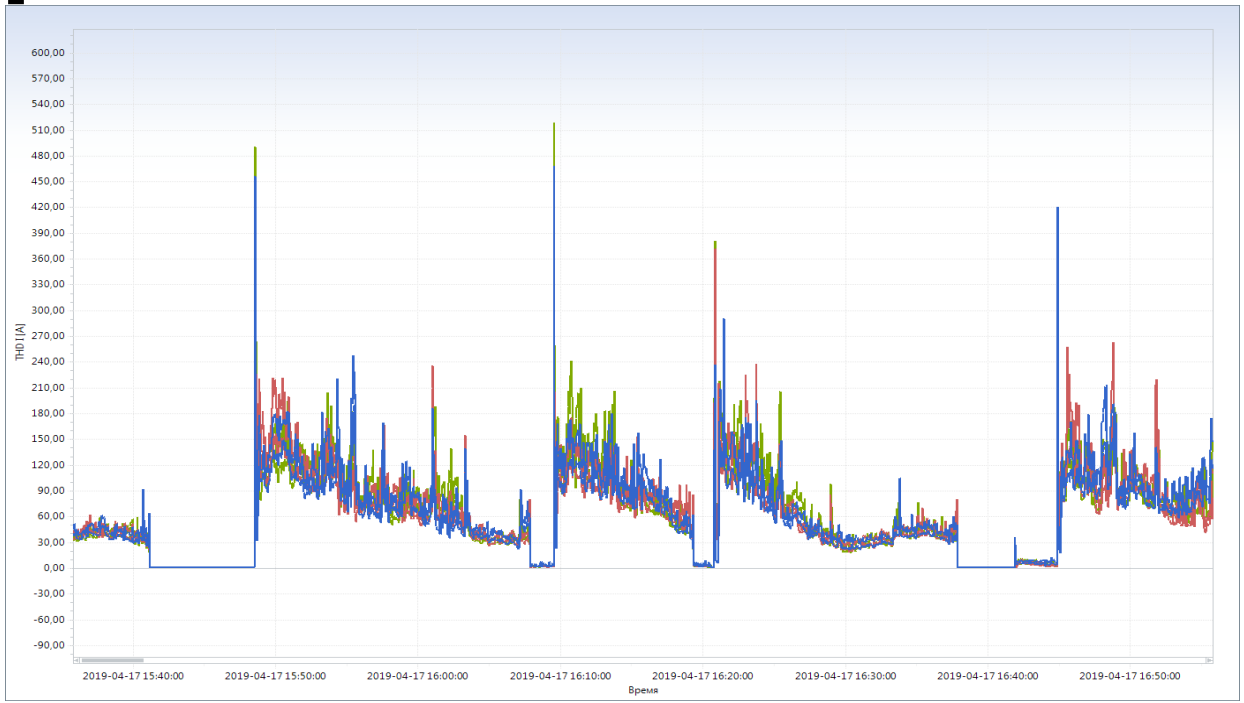


Figure 6. Non-linear total harmonic distortion current, measurement result.

Experiments

The rated voltage of the voltage source is 35kV. The non-linear load is connected to the 35kV bus bar. One set of STATCOM is connected to the same 35kV bus bar

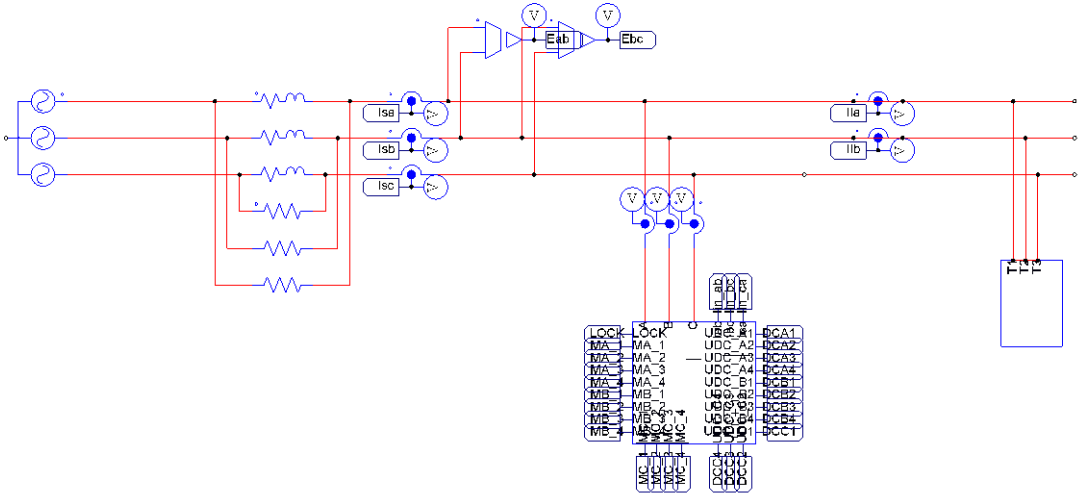


Figure 7. Equivalent electric circuit model with STATCOM and non-linear load.




Experiments

The model of STATCOM is a three phase multi-level voltage inverter, consisted of four series connected power modules. Phases has delta connection

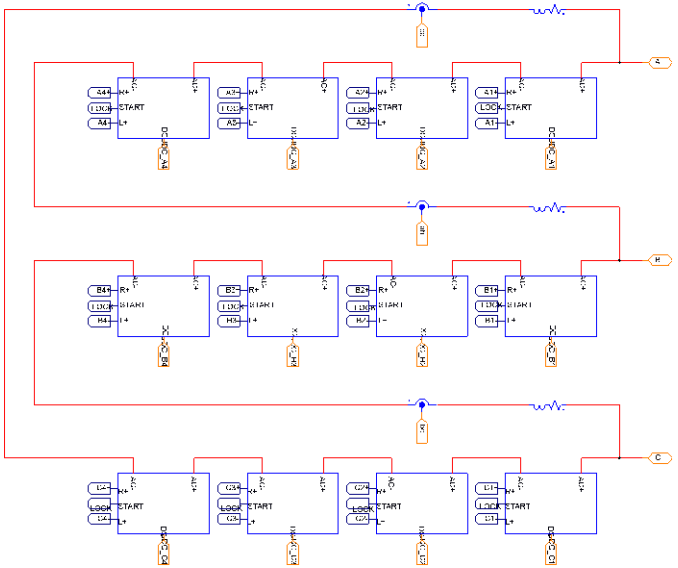


Figure 8. Electric circuit of STATCOM




Experiments

Each power module presented as H-bridge inverter, based on IGBT transistor

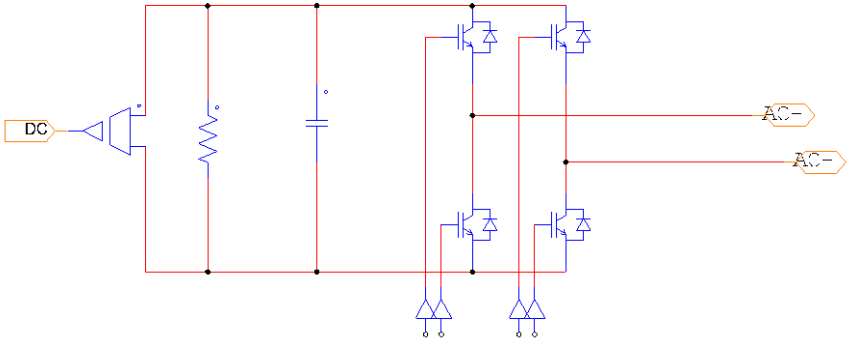


Figure 9. Electric circuit of Power module

Results and Discussion

After analysing the above waveforms, after the STATCOM is put into operation, the reactive power fluctuation becomes smaller, the maximum reactive power is 4.71 Mvar. Average of the load active power before compensation is 105 MW, and after compensation is 119MW.

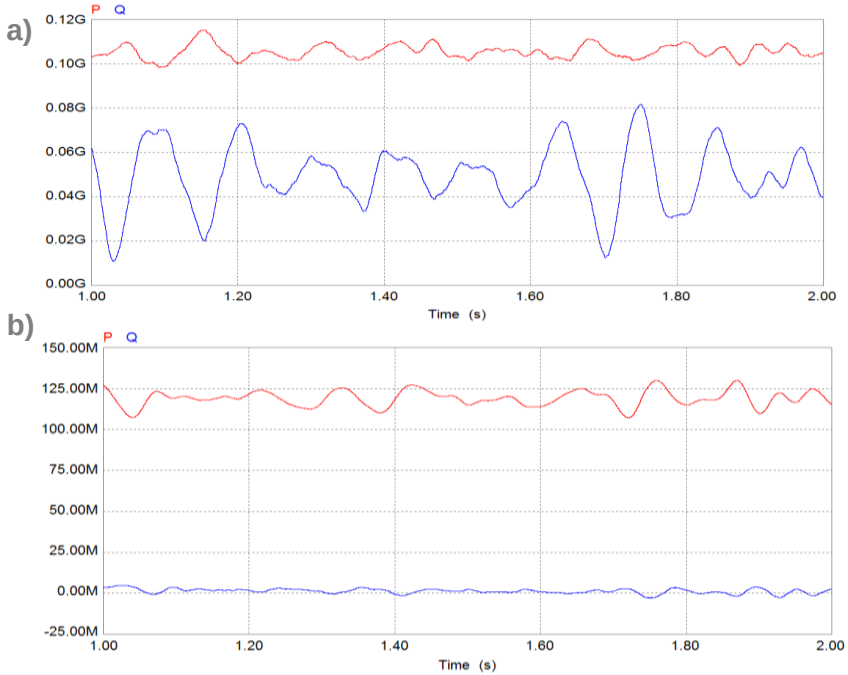
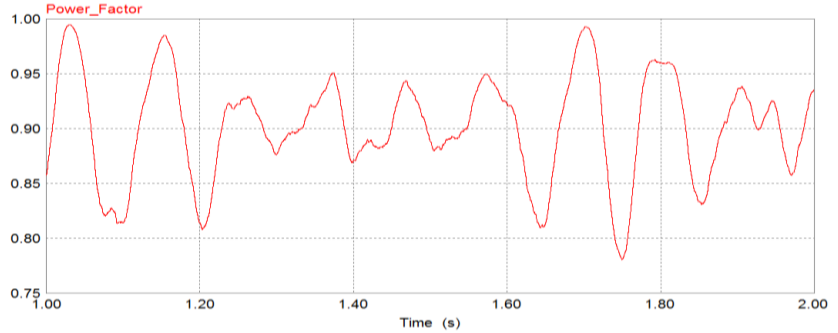


Figure 10. Active and reactive power before a) and after b) compensation

Results and Discussion

Analysis of the above waveforms, the load reactive power fluctuations are large, the instantaneous power factor fluctuates between 0.78 and 0.99. After compensation instantaneous power factor is higher than 0.998

a)



b)

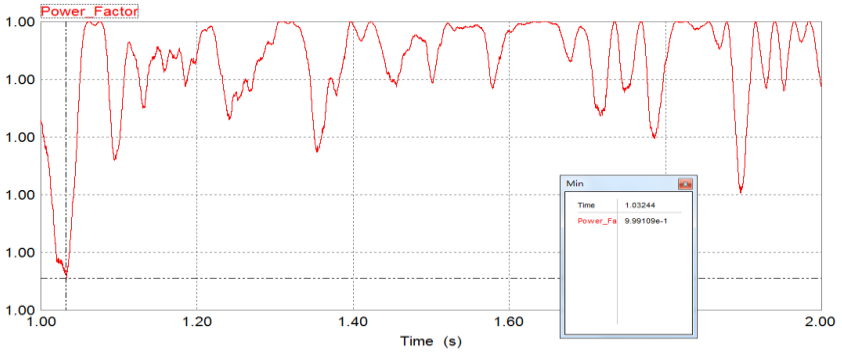


Figure 11. Power factor before a) and after b) compensation

Results and Discussions

The reduction of reactive power results in a significant reduction in grid voltage fluctuations, which in turn leads to an increase in active power and an increase in the active power of 13% for the non-linear load

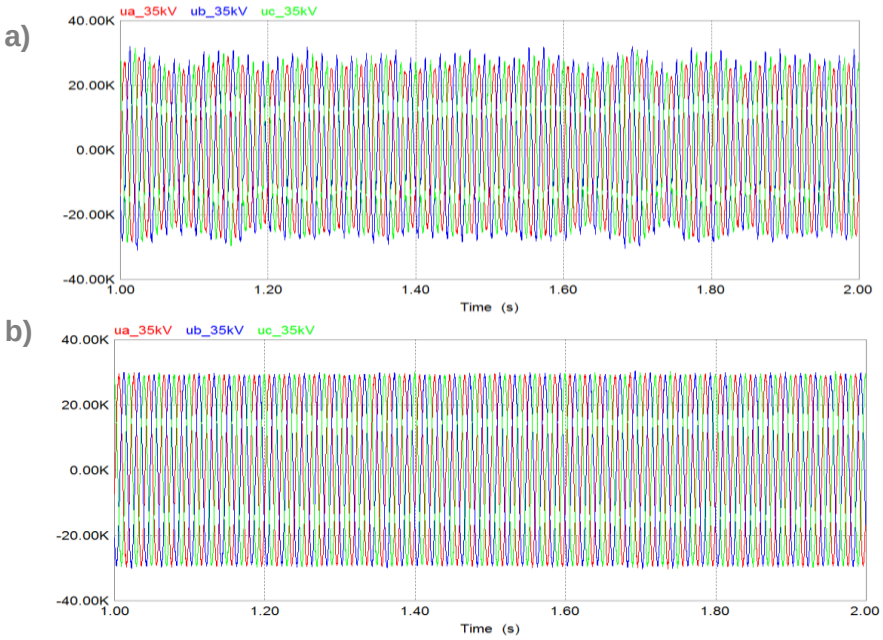


Figure 12. Voltage on 35kV bus before a) and after b) compensation

Results and Discussion

After the STATCOM is started, the harmonic current in the load will be detected, and the currents of the same magnitude and opposite phase are compensated

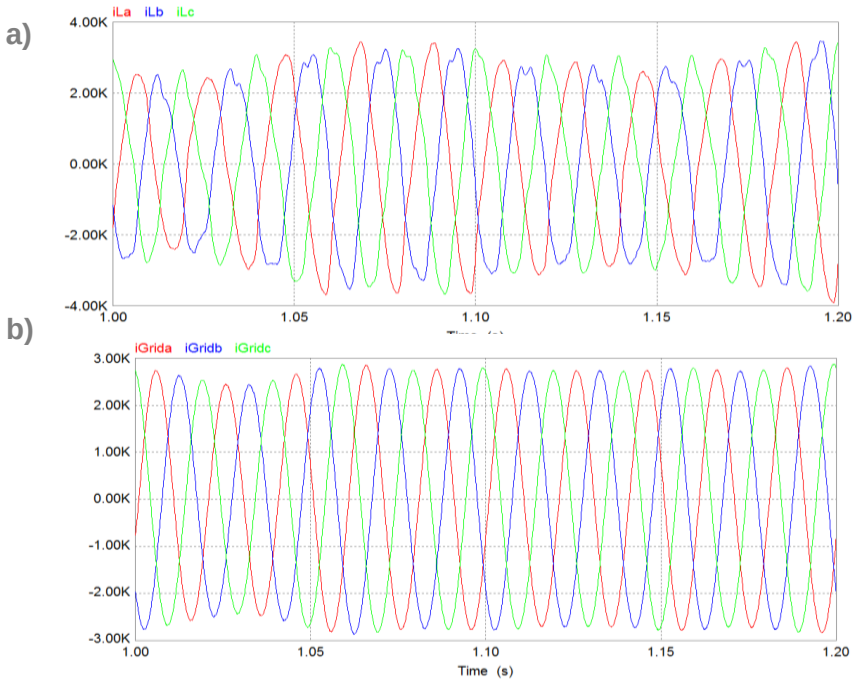
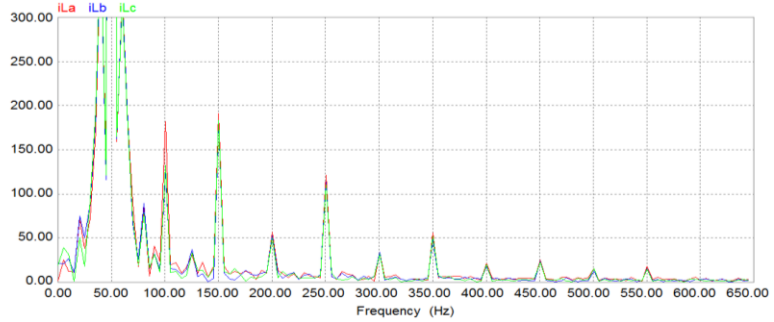


Figure 13. Non-linear load current a) and after b) compensation

Results and Discussion

After the compensation of STATCOM, the harmonic current in the load is basically cancelled, and the harmonic distortion rate of the grid current waveform becomes low

a)



b)

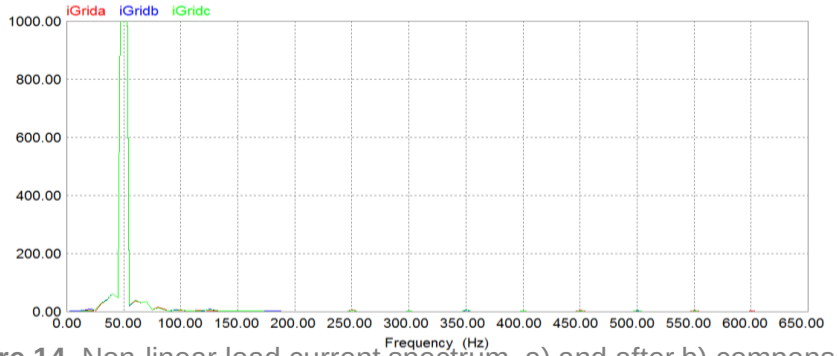


Figure 14. Non-linear load current spectrum a) and after b) compensation

Results and Discussion

After the STATCOM started the operation. However, considering the filter quality factor and the partial harmonic design, the filtering effect is limited, especially for the second harmonic, it is difficult to have a good filtering effect

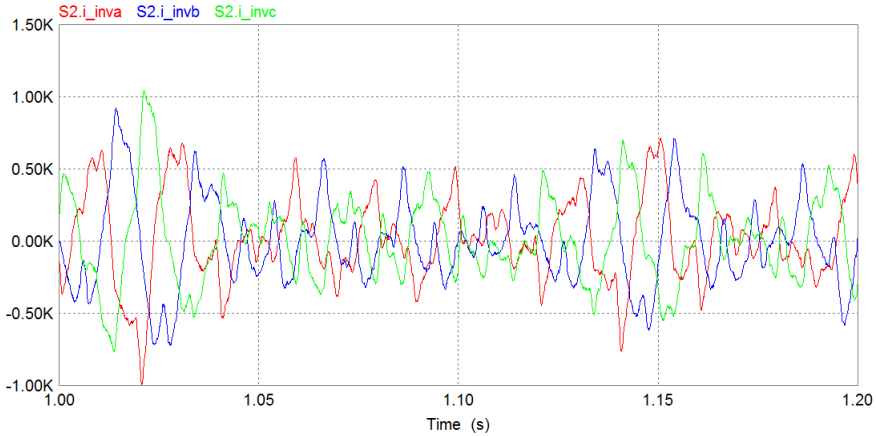


Figure 15. STATCOM current

Conclusion

For operating projects overview with given data from measurement, simulation verification for the two compensation mode of STATCOM is designed. The simulation results indicate that after compensation, the power quality at the STATCOM connected point could meet and exceed the site assessment requirements. The performance indicators that the simulation can achieve are as follows.

- Power factor ≥ 0.995 (before compensation
- Total Harmonic Distortion ≤ 1.8% (before compensation

The simulation shows that after the compensation device is put into operation, the reactive power is reduced, the bus voltage fluctuation is reduced, and the stability of the bus voltage will cause the active power of the system to be improved. Results presents in table1.

Table 1. Comparison electric system parameters before and after compensation

	THDu	Cosϕ	*P*	ΔU
Before compensation	5,5%	0,78	105MW	9,56%
After compensation	1,8%	0,995	119MW	3%

Thank you for attention