Fig. 20.3: Voltage response of the system at bus-25

During the period with a fault applied on the grid at bus-25 at time 15 sec with a time duration of 88 msec of fault, all wind turbines are disconnected at time 15.1 sec due to AC under voltage and no output power is generated due to the lost in the reactive power required during this fault where the power system and capacitor banks are not enough to supply the large amount of reactive power. This is a big problem for a large wind farms and the voltage of the grid increases due to the impact of the reactive power delivered from the capacitor bank. When a STATCOM is connected to the system, it supplies the required reactive power during a fault which is enough to keep the wind farm generating its rated power under a large time duration of high fault.

5. Conclusions

In this work, the wind farm power quality has been improved using FACTS devices such as STATCOM. The dynamic model of the power system has been built using MATLAB/Simulink software. The performance and the impact of STATCOM in static voltage stability margin enhancement has been studied in different fault scenarios. The main effect of STATCOM has been seen when a three-phase fault applied on the grid, as it is a dangerous fault during a long applied fault time duration on the grid. The transferred power and power factor has been improved by using STATCOM. The voltage of the grid is always constant, stable and close to the desired value (1 pu).

Appendix: System parameters of STATCOM and wind turbine

Table 1: System Parameters of STATCOM

Parameter	Value
System Nominal Voltage	25 KV
System Frequency	60 HZ
Rating Power	3 MVA
Capacitor	1125 µF

Table 2: System Parameters of IG and wind turbine:

Parameter	Value
Rating Power	3.33 MAV
Stator Voltage	575 V(rms)
Frequency	60 HZ
Stator Resistance	0.0045 pu
Stator Inductance	0.125 pu
Rotor Resistance	0.0044 pu
Rotor Inductance	0.179 pu

Magnetizing Inductance	6.77 pu
Inertia Constant	5.04 s
Friction Factor	0.01 pu
Pairs of Poles	3 p
Base wind speed	9 m/s
Maximum pitch angle	45 deg
Pitch angle controller gain: [Kp Ki]	[5 25]
Nominal wind turbine mechanical output power	3 MW

References

[1] T. Truong, K. Ro, "Improvement of LVRT characteristic of SCIG wind turbine system by incorporating PMSG," Int. J. Energy, Information and Communications, 3, 3, 2012.

[2] Q. Salem, I. Altawil, "Stability study of grid connected to multiple speed wind farms with and without FACTS Integration", Int. J. Electronics and Electrical Engineering 2, 3, 2014.

[3] B. Pokharel, G. Wenzhong, "Mitigation of disturbances in DFIG based wind farm connected to weak distribution system using STATCOM", North American Power Symposium, 1-7, 2010.

[4] Q. Wei, G. Venayagamoorthy, R. Harley, "Real-time implementation of a STATCOM on a wind farm equipped with doubly fed induction generators industry applications", IEEE Transactions 45, 1, 98-107, 2009.

[5] C. Han, A. Huang, M. Baran, S. Bhattacharya, W. Litzenberger, L. Anderson, A. Johnson, A. Edris, "STATCOM impact study on the integration of a large wind farm into a weak loop power system," IEEE Trans on Energy Conversion, 23, 1, 226-233, 2008.

[6] M. Sheikh, M. Hossain, R. Hossain, "Stability enhancement of a grid connected wind farm by using STATCOM", Int. Conf. Electrical & Electronic Engineering, Bangladesh, 2015.

[7] C. Li, R. Burgos, I. Cvetkovic, D. Boroyevich, "Active and Reactive Power Flow Analysis for STATCOM under Virtual Synchronous Machine Control," Workshop on Control and Modeling for Power Electronics, 2015.

[8] K. Pushpak, B. Kumar, A. Ravi, "Improving transient stability of wind farm using FACTS devices focused on STATCOM", Int. J. Engineering Applied Sciences and Technology, 1, 7, 163-167, 2016.

[9] C. Wessels, M. Molinas, "STATCOM control at wind farms with fixed-speed induction generators under asymmetrical grid faults", IEEE Transactions on Industrial Electronics, 60, 7, 2013.

[10] L. Chi, R. Burgos, I. Cvetkovic, D. Boroyevich, L. Mili, and P. Rodriguez, "Evaluation and control design of virtual synchronous- machine-based STATCOM for grids with high penetration of renewable energy", Energy Conversion Congress and Exposition, 5652-5658, 2014.

[11] G. Elsady, Y. Mobarak, A. Youssef, "STATCOM for improved dynamic performance of wind farms in power grid", Int. Middle East Power Systems Conference, Egypt, 2010, Paper ID 207.

[12] A. Salman, P. Hassan, R. Masoud, "Modeling and simulation of wind farm with STATCOM in MATLAB/Simulink environment", Bulletin Georgian National Academy of Sciences, 9, 2, 2015.

[13] F. Rong, S. Wanpeng, Y. Jian, J. Yapeng, "Study on application of STATCOM in voltage stability of wind farm incorporated system", Chinese control conference, 2013.

[14] Z. Saad, M. Lisboa, J. Kanayake, N. Jenkins, G. Strbac, "Application of STATCOMs to wind farms", IEEE proceedings on Generation, Transmission and Distribution, 145, 5, 2011.