# Enhancement of Wind Energy Penetration Levels In Rural Grid By Power Quality Mitigation Using DSTATCOM Controlled by Adaptive Algorithms

*A Thesis submitted by*
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*in partial fulfillment of the requirements for the award of the degree of*
**Doctor of Philosophy**


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*January, 2022*

# 6
# Conclusions and Scope for Future Work

This chapter summarises the proposed research work findings and scope for future work.

## 6.1 CONCLUSIONS

This thesis suggests an additional DSTATCOM infrastructure to enhance wind energy penetration levels into the rural grid by mitigating power quality issues. Three algorithms, namely, ADALINE-LMS algorithm, Least Mean Fourth algorithm, and Delayed Least Mean Fourth algorithm, are proposed to control DSTATCOM, whose parameters are automatically tuned due their adaptive nature based on the changes in system. The proposed methods have been tested under various conditions such as variation in strengths of AC grid, penetration levels, wind speed and load composition in laboratory followed by in MATLAB platform. The proposed adaptive algorithms have established the capability of enhancing the wind energy penetration levels in the rural grid by effectively mitigating the PQ with injecting optimal reactive power. The major observations associated with these algorithms include:

1. Self-tuning of weight components, which helps to adopt the changes in the system such as grid voltage, wind speed, unbalanced and harmonics in the loads.

2. Accuracy in reactive power planning based on the changes in the system, which optimizes the size of DSTATCOM.

3. The simplicity in architecture, simplified calculation, hardware compatibility, PLL-less structure and minor steady-state error.

The summarized achievements are as follows:

**ADALINE-LMS algorithm:** With this algorithm a WE penetration level of 25% into a rural grid of SCR 2.74 in the presence of 25% NL load has been achieved under a wind speed variation ranging 15 m/s and as low as 7.5 m/s. The accurate signal tracking of this algorithm helps in reducing the size of the DSTATCOM up to 70%.

**Least Mean Fourth Algorithm:** With this control algorithm a WE penetration level of 25% into a rural grid of SCR 2.74 in the presence of 40% NL load has been achieved under a wind speed variation ranging 15 m/s and as low as 7.5 m/s. The accurate signal tracking of this algorithm helps in reducing the size of the DSTATCOM up to 80%.

**Delayed Least Mean Fourth Algorithm:** With this control algorithm a WE penetration level of 30% into a rural grid of SCR 2.74 in the presence of 40% NL load has been achieved under a wind speed variation ranging 15 m/s and as low as 7.5 m/s. The accurate signal tracking of this algorithm helps in reducing the size of the DSTATCOM up to 85%.

**All the three algorithms** mentioned above now been successful in achieving grid (SCR = 2.74) synchronization of a DFIG within 0.9 seconds in the presence of non-linear loads.

From the simulation and experimental results, it can be concluded that, the proposed adaptive algorithms have been successful in achieving WE penetration levels as high as 30% into the weak ac grid in the presence of non-linear loads as large as 40% satisfying EN-50160 and IEEE 519-2014 standards.

## 6.2 SCOPE FOR FUTURE WORK

Scope for future work may include further modification of adaptive algorithms such as:

(a) Enhancement of Solar-PV penetration levels using proposed algorithms.

(b) Enhancement of hybrid penetration levels with Solar-PV and WE source.

(c) Testing of proposed algorithms in the presence of induction motors.

(d) Using different convergence factors for active and reactive components of power in proposed algorithms.