Abstract: The need for energy has increased dramatically throughout the world in recent years. Renewable energy sources such as wind, solar, geothermal, biomass, etc. play a significant role in the sustainable generation of electric power for nations all around the world. Among the various renewable energy resources, the generation of power from wind energy is considered to be more friendly to the environment. The forecast for the installed capacity of the wind energy-based power system for the world is about 839 GW by 2023. Currently, most of the wind energy system in India and the world uses fixed speed type of generators. These fixed speed wind energy conversion system has low energy conversion efficiency when operated under variable wind speed. Moreover, there is a need to have a wind energy conversion system that can support the grid by supplying reactive power and actively participate in frequency regulation of the grid. In order to extract maximum possible energy from the wind, efficient technologies, such as variable speed constant frequency (VSCF) wind energy conversion system (WECS) are needed. The commonly used variable speed generators are doubly-fed induction generator (DFIG), permanent magnet synchronous generator and synchronous reluctance generator. Among these, the DFIG is the preferred for WECS due to its low maintenance and installation cost, and robustness. Furthermore, DFIG offers various features such as four quadrant active and reactive power control, low converter cost, variable speed operation (±33% slip speed variation). The controllers for DFIGs are quite complex, and accurate estimation of rotor position and speed plays a significant role in improving the performance of the controller for sensorless operation. The instantaneous position of the rotor with respect to the stator is required for decoupled control of active and reactive power. In conventional field oriented control schemes, the instantaneous rotor position is estimated by using an absolute encoder fitted to the shaft. A high-resolution position encoder is very expensive as well as reduces system reliability. However, in a DFIG based wind turbine system, the mounting of an encoder is not an easy task. The encoder must be mounted in such a way that the angle between rotor and stator axis can be accessed directly. Sensorless control strategies are usually used to estimate the DFIG flux and rotor position using observer design, which reduces the cost, size, and maintenance of the drive system. Due to the nonlinearity of the wind turbine dynamics and stochastic behavior of the wind, it is not so simple to estimate the rotor position and machine flux over a wide variation of slip. Sensorless control techniques use a model of a DFIG in the synchronous reference frame. Hence, there is a need to transfer the variables to this reference frame. This requires an accurate estimate of the slip position of the rotor or rotor angle. Several estimation techniques, such as flux-based observer and current-based model reference adaptive system (MRAS) observer, high-frequency injection, etc., have been introduced in literature. They have their own advantages and limitations. Rotor flux based MRAS observers show with poor performance when operated close to synchronous speed. This is due to low-level excitation from the rotor side. Stator flux based MRAS observer, on the other hand, comes with inherent integration drift problems. Similarly, stator current based MRAS observers drift to unstable operation when the magnitude of stator current is low. Hence, the accuracy of such observers depends on the load connected to the system, i.e., it gives a more erroneous estimation of rotor position under no-load or light load connected to the system. Whereas, the rotor current based MRAS observer is affected by the variation of parameters, such as stator inductances, and mutual inductances, etc. The present thesis is mainly focused on developing algorithms to mitigate the above limitations. The present thesis work is focused on the design and hardware implementation of robust observers for the slip position and speed of DFIG. The first estimator described in this thesis is a predictor-corrector based closed-loop rotor slip-position estimator is one of the techniques. This method utilizes measured values of the stator voltage, stator current, rotor current, and rotor speed. Further, an analysis of its stability and the range of gain for its convergence is discussed. The next proposed estimator is a new closed-loop adaptive speed and slip position observer (ASSPE) for a standalone DFIG system. This method uses the measured value of the stator voltages, stator currents and rotor currents. The proposed ASSPE requires less number of DFIG parameters as compared to the modelbased observers. The turns ratio and stator leakage inductance are considered to improve the estimation accuracy. This method avoids the stator and rotor flux estimation. Further, a new robust two-stage observer is proposed to mitigate the effects of sudden changes in speed and load, parametric uncertainty, and noise. The proposed observer estimates the rotor slip position and speed of the DFIG accurately. Finally, Extended Kalman Filter (EKF) based observer is proposed. This estimator uses an augmented state model to estimate the rotor position and speed accurately for a grid-connected DFIG system. The aim of the research work presented in this thesis is to model, develop and implement slip position and speed observers. The developed observers are robust to load and speed disturbances, parametric uncertainties, model errors, noise interference, and estimation errors. The performance of these observers are verified through simulation and hardware implementation.