Time Series Modeling for Data Driven Supervised Learning in Power System Applications

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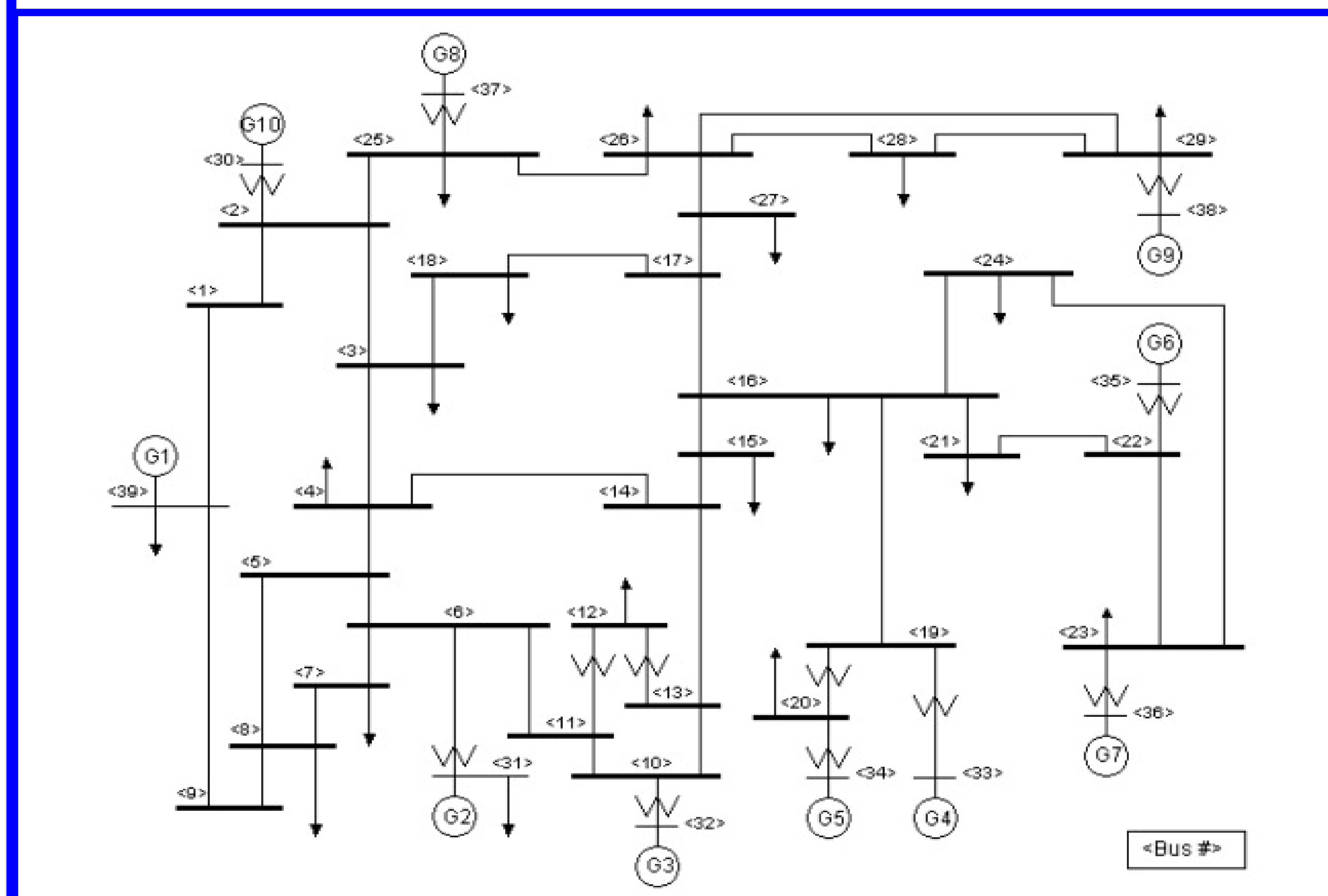
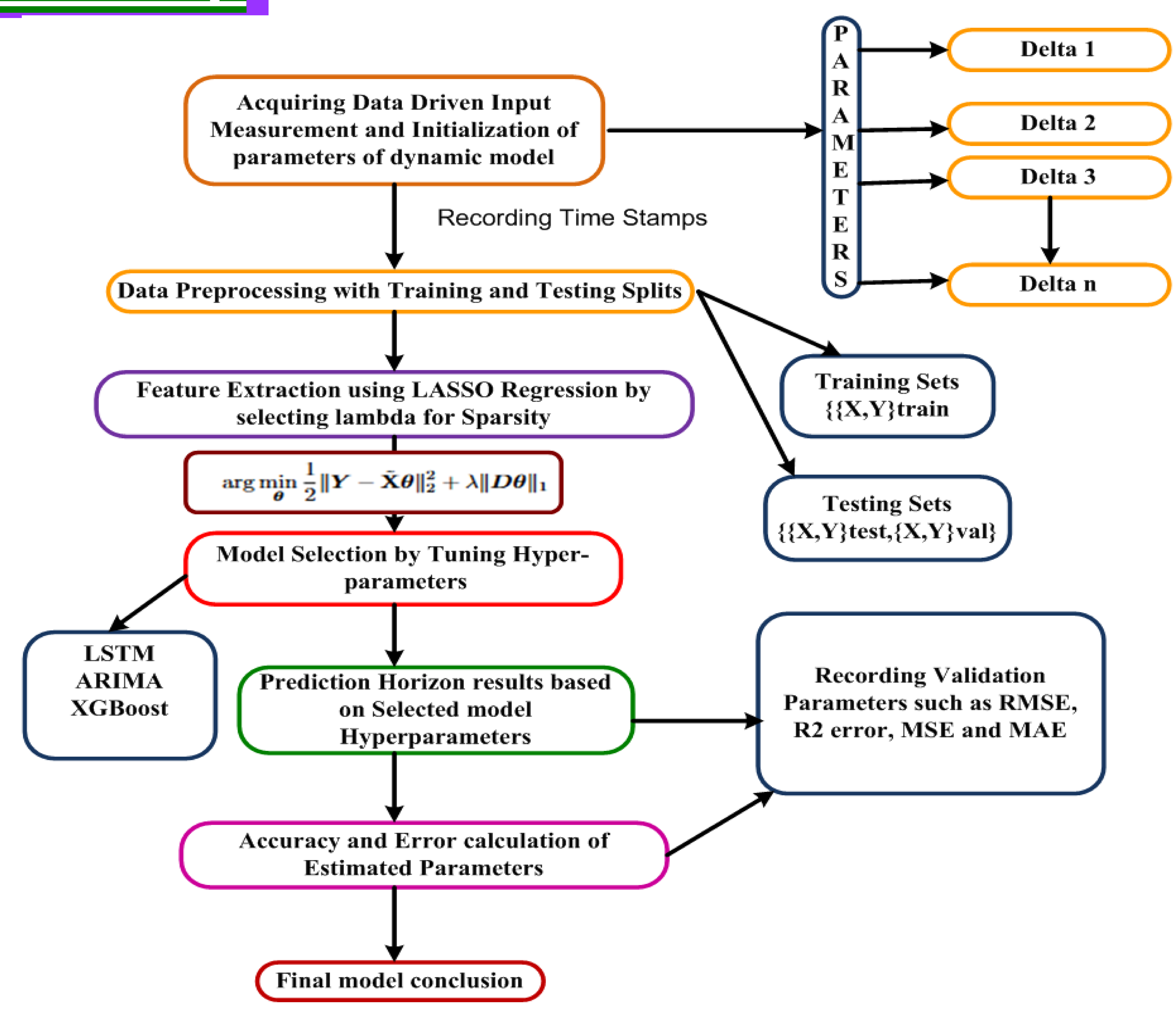
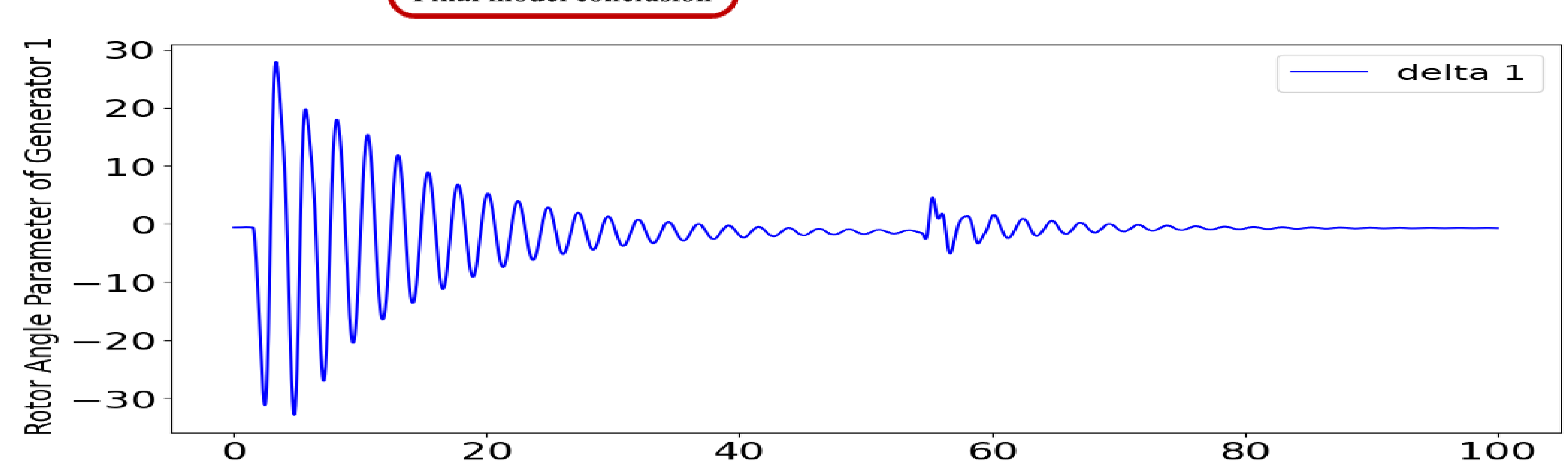
Abstract:

- **Data-Driven Approach**: Demonstrated on multiple synchronous generator models for power system applications.
- **Sparsity-Based LASSO Regression**: Extended to nonlinear dynamics in DAE-based generator models used for transient stability analysis.
- **Dimensionality Reduction**: LASSO's sparse feature extraction lowers model complexity and boosts computational efficiency.
- **Time Series & ML Methods**: ARIMA, LSTM, and XGBoost predict rotor angle measurements, critical indicators of stability and performance in synchronous machines.



Mind-Map





Results:

VALIDATION PARAMETERS FOR DATA DRIVEN MODELS USED IN THE PROPOSED SYSTEM WITHOUT NOISE

Models	RMSE	R2	MSE	MAE	MAPE
LSTM	0.773	0.677	0.285	0.597	209.05
XGB	0.886	0.059	0.785	0.7284	344.399
ARIMA	1.872	-3.1998	3.504	1.547	367.41

VALIDATION PARAMETERS FOR DATA DRIVEN MODELS USED IN THE PROPOSED SYSTEM WITH NOISE.

Models	RMSE	R2	MSE	MAE	MAPE
LSTM	1.492	-1.667	2.226	1.339	523.655
XGB	0.988	-0.1 704	0.976	0.790	370.0
ARIMA	1.872	-3.1998	3.504	1.547	367.41

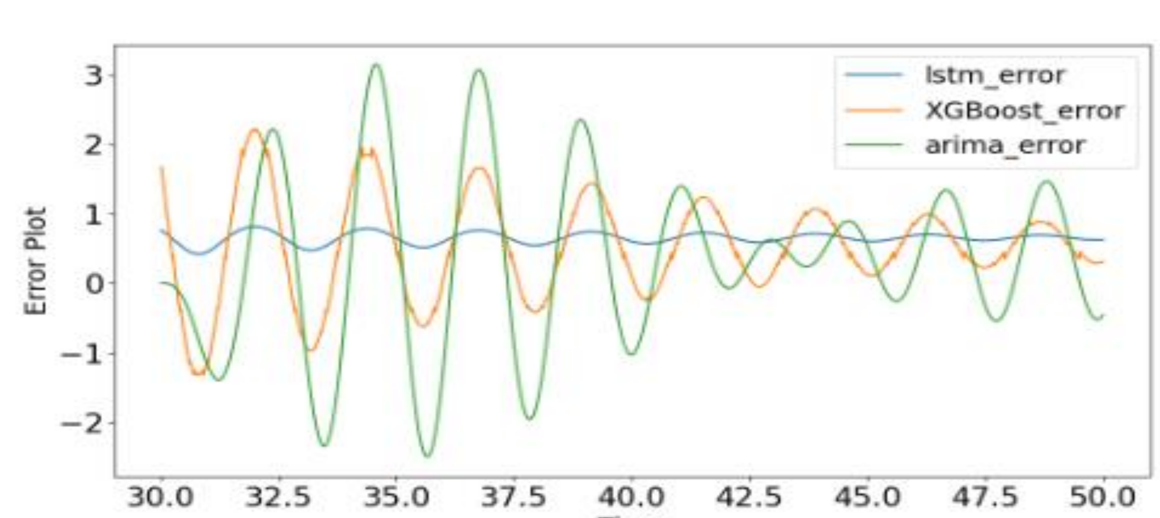


Fig. 10. Error plot of models without noise

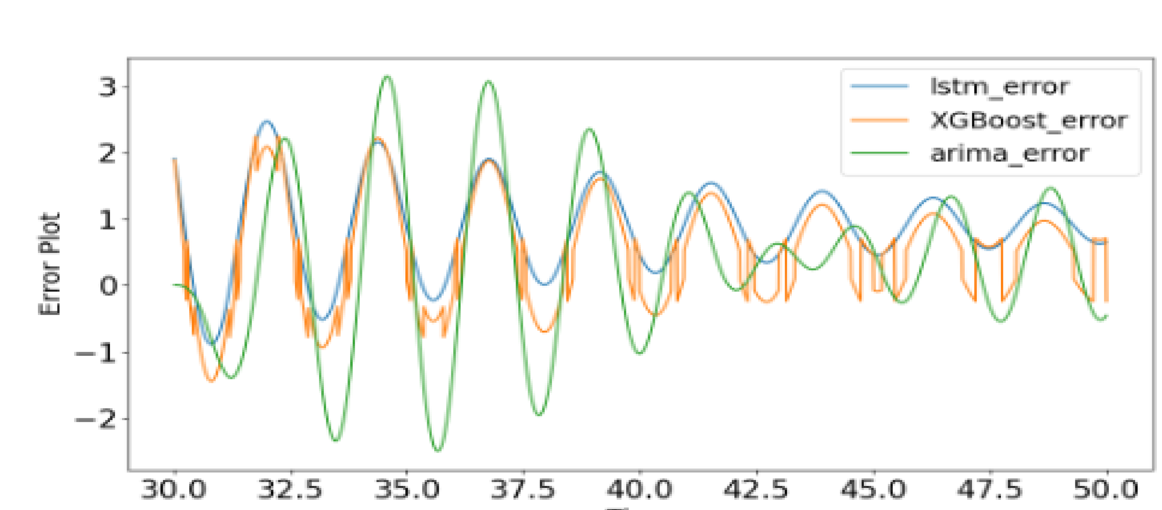


Fig. 11. Error plot of models with noise

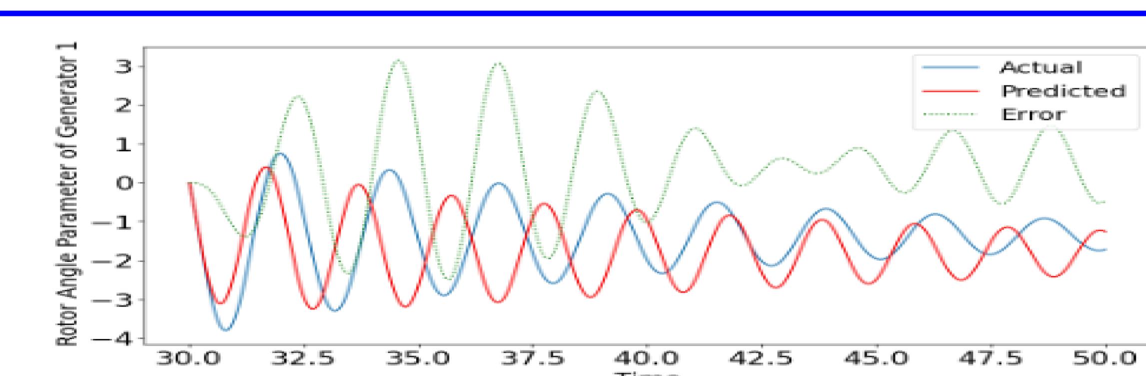


Fig. 9. Actual vs Predicted plot of test data using ARIMA model (3,0,2) for with and without noise condition

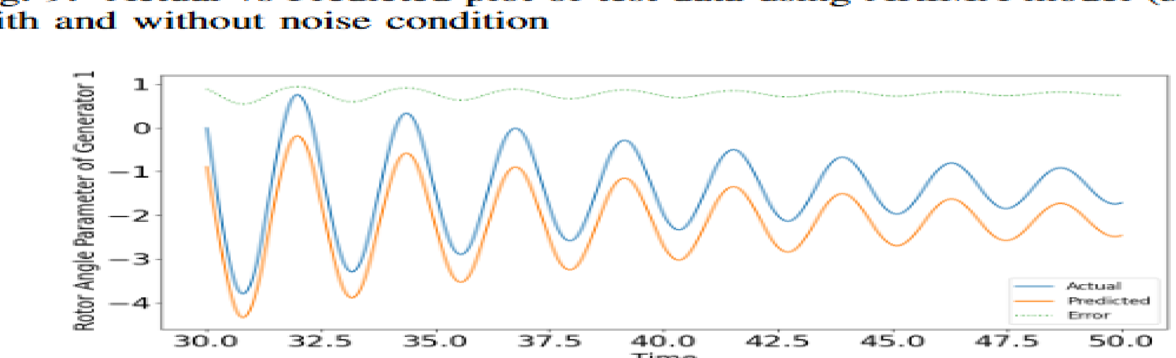


Fig. 4. Actual vs Predicted plot of test data using LSTM model along with error plot without Noise

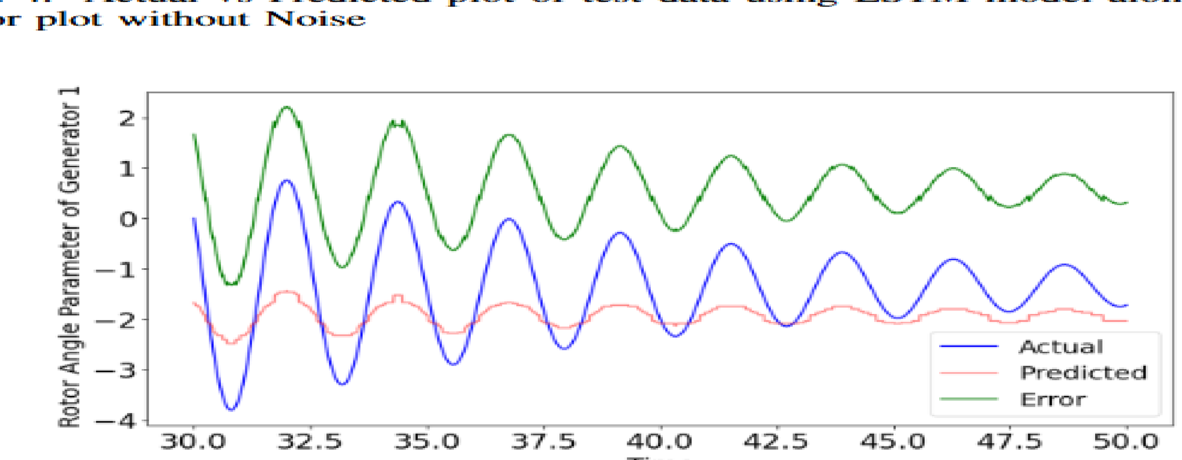


Fig. 6. Actual vs Predicted plot of test data using XGBoost model along with error plot without Noise

Conclusions:

- **LASSO Regression Application**: Demonstrates sparsity-based dimensionality reduction and compressive sensing for transient stability prediction in large power systems.
- **Extended to ML Algorithms**: LASSO is integrated with LSTM and XGBoost, alongside the classical ARIMA model.
- **Comparative Study**: Evaluates ARIMA, LSTM, and XGBoost for time series prediction under various disturbances.
- **Robustness**: ARIMA fails under large disturbances, indicating limited robustness. In contrast, LSTM and XGBoost handle rotor angle prediction effectively.
- **Sparse Feature Extraction**: Offers a more robust, dimensionally reduced, and optimal strategy for power system time series data.

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