# CHAPTER 4

# Conclusion

## 4.1 Conclusion

The proposed TSE algorithm of this study uses the transmission line with Bergeron model. The test system is 10 bus and evaluated with different sag levels. The 1%, 2%, 3% of measurement noises are applied and the effect of nonlinear equipment such as saturated transformer is also considered. The results of estimation are shown only %RMSE of phase-A for three-phase and single-phase at bus no.5 and no.7 (fault at phase-A) as figure 4.1-4.4, respectively. Beside, %MAE also has a similar result (not show the picture). These figures show that high noise level reduces the performance of the estimator. For testing with the saturated transformer connected to bus no.7, there are effects that decrease the voltage level and reduce the performance of estimator too.

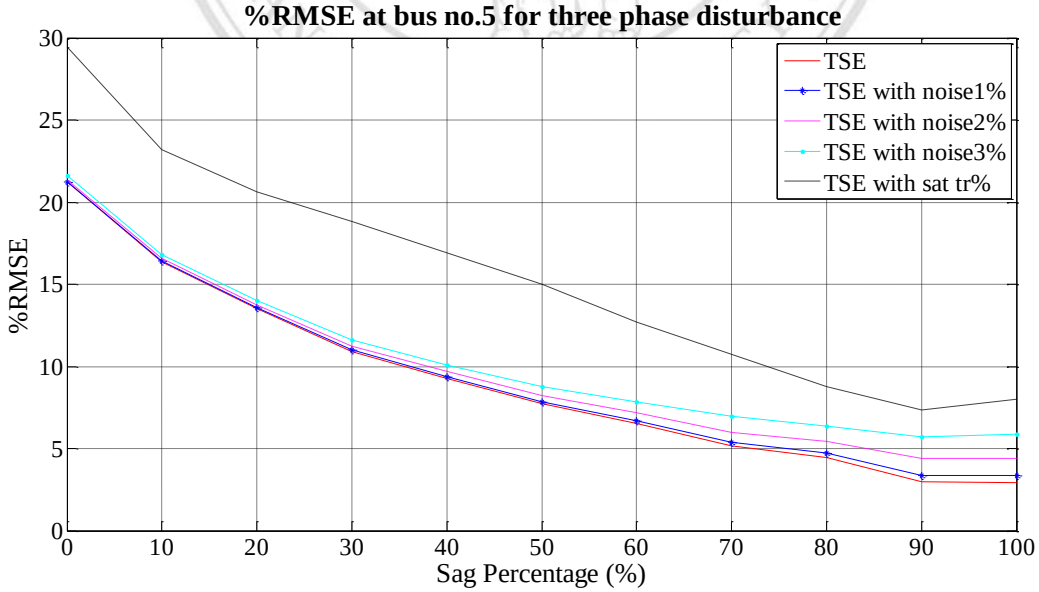


Figure 4.1 %RMSE of phase-A at bus no.5 for three-phase disturbance in each evaluation testing.

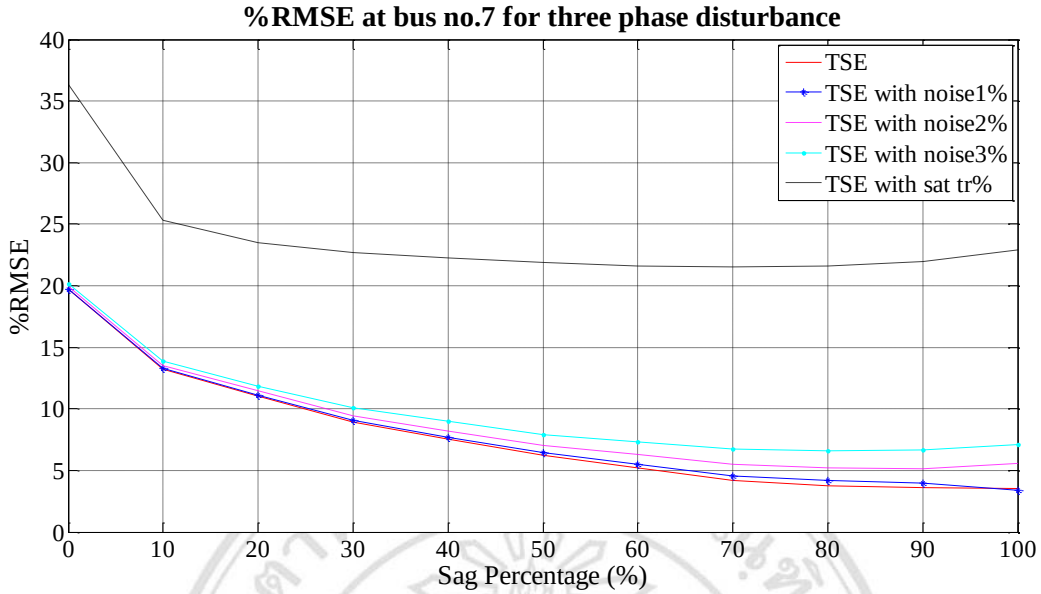


Figure 4.2 %RMSE of phase-A at bus no.7 for three-phase disturbance in each evaluation testing.

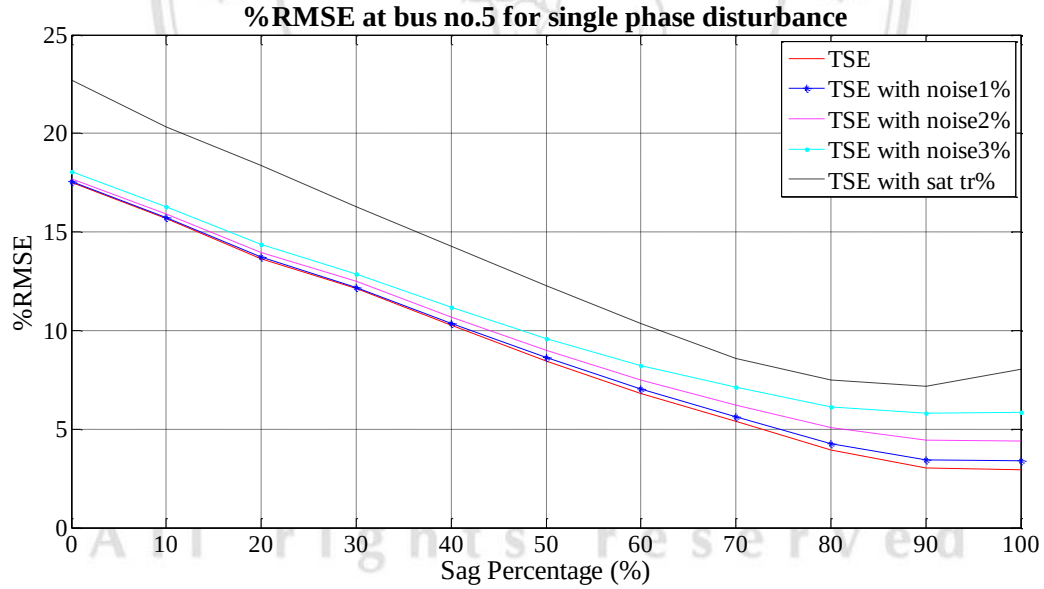


Figure 4.3 %RMSE of phase-A at bus no.5 for single-phase disturbance in each evaluation testing.

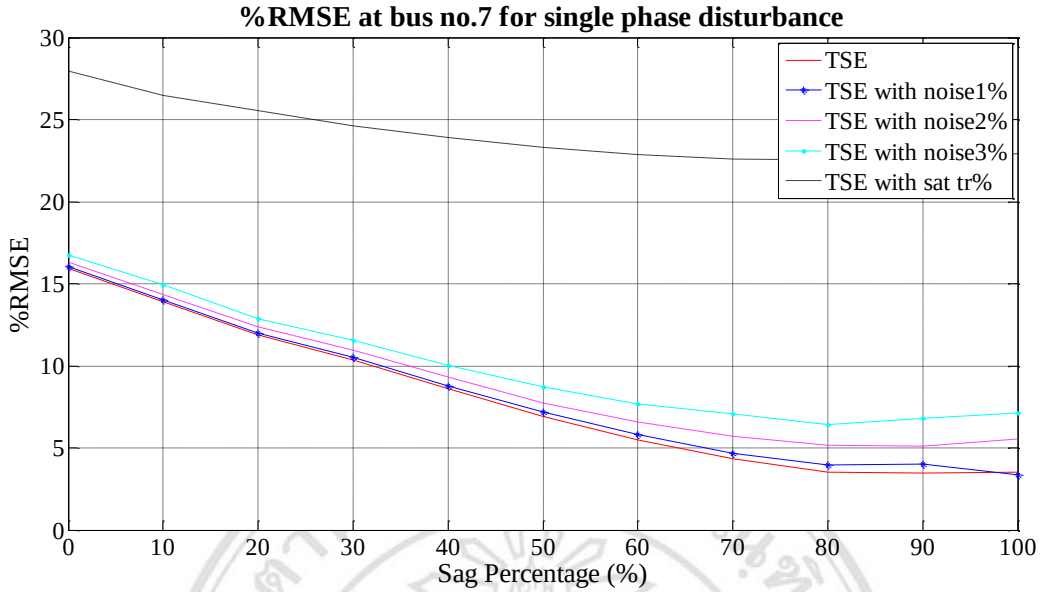


Figure 4.4 %RMSE of phase-A at bus no.7 for single-phase disturbance in each evaluation testing.

Table 4.1 Range of %RMSE of voltage at bus no.5 cause by different sag from high to low level.

| Estimation Testing | Three phase disturbance | | | Single line disturbance (phase A) | | |
|---|---|---|---|---|---|---|
| | phase A | phase B | phase C | phase A | phase B | phase C |
| TSE | 2.92 - 21.21 | 2.86 - 22.21 | 2.86 - 22.10 | 2.92 - 17.50 | 2.86 - 8.09 | 2.86 - 8.60 |
| TSE with noise1% | 3.38 - 21.24 | 3.37 - 22.23 | 3.38 - 22.13 | 3.38 - 17.54 | 3.37 - 8.23 | 3.38 - 8.78 |
| TSE with noise2% | 4.41 - 21.32 | 4.41 - 22.35 | 4.36 - 22.25 | 4.41 - 17.71 | 4.41 - 8.57 | 4.36 - 9.30 |
| TSE with noise3% | 5.85 - 21.59 | 5.68 - 22.55 | 5.81 - 22.41 | 5.85 - 18.04 | 5.68 - 9.23 | 5.81 - 10.03 |
| TSE with saturated transfomer | 8.03 - 29.45 | 8.16 - 34.66 | 8.57 - 26.64 | 8.03 - 22.69 | 8.16 - 10.38 | 8.57 - 12.50 |



Table 4.2 Range of %RMSE of voltage at bus no.7 cause by different sag from high to low level.

| Estimation Testing | Three phase disturbance | | | Single line disturbance (phase A) | | |
|---|---|---|---|---|---|---|
| | phase A | phase B | phase C | phase A | phase B | phase C |
| TSE | 3.54 - 19.68 | 3.41 - 20.88 | 3.40 - 20.92 | 3.54 - 15.95 | 3.41 - 7.36 | 3.40 - 8.10 |
| TSE with noise1% | 3.38 - 19.74 | 3.37 - 20.91 | 3.38 - 20.98 | 3.38 - 16.02 | 3.37 - 7.56 | 3.38 - 8.36 |
| TSE with noise2% | 5.54 - 19.90 | 5.43 - 21.08 | 5.47 - 21.18 | 5.54 - 16.30 | 5.43 - 8.13 | 5.47 - 9.10 |
| TSE with noise3% | 7.11 - 20.18 | 6.94 - 21.40 | 6.95 - 21.42 | 7.11 - 16.75 | 6.94 - 9.01 | 6.95 - 10.06 |
| TSE with saturated transfomer | 22.94 - 36.35 | 22.33 - 26.08 | 22.73 - 35.84 | 22.94 - 27.93 | 22.33 - 18.15 | 22.73 - 29.77 |

The evaluation of each estimate testing in table 4.1 and 4.2 show the range of %RMSE of voltage at bus no.5, no.7 caused by different sag from high level to low level. For three-phase disturbance, the voltages are drop between the times that fault occurred. The %RMSE of TSE with noise and saturated transformer are increase according to the increasing of noise level. While single-phase disturbance, fault happened at phase A, is directly affect to phase A. Moreover, %RMSE for phase A is higher than other phase, especially at low sag level.

## 4.2 Future Work

The TSE algorithm has been developed and implemented for the system that consists of Begeron transmission line model. It is also considered about nonlinear characteristics of equipment such as transformer which is saturated. However, several equipment concerns with nonlinear equipment such as surge arrester represented by the nonlinear variation of the resistance should be studied in the future work.