Enhanced Bad Data Processing by Phasor-Aided State Estimation

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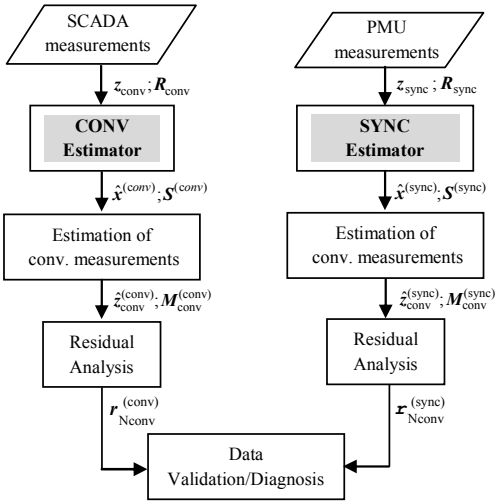
Abstract: This work presents a novel way of processing BD, whose features are similar to those found in the data validation routines of FASE. The proposed PHASE approach has the advantage of leaving the existing SE application software intact, complementing it with an extra estimation module, capable of processing phasor measurements separately and judging whether the measurement set contains anomalies. The results of a proof of concept study performed on the IEEE 14-bus benchmark system demonstrate the application of the proposed methodology. Also, PMU-observability issues are addressed and illustrated through simulation studies conducted on the IEEE 118-bus system.

Fundamentals:

- *existent SCADA estimator is preserved;*
- *independent estimators are used to process separately con-ventional and synchrophasor measurements;*
- *smearing effect of BD is eliminated, which allows their block identification and replacement;*
- *conventional and phasor measurement gross errors are ade-quately processed;*
- *data validation is possible even under critical conditions for observability;*
- *final state estimate is obtained only after the measurements are given as valid.*

Methodology:



$$M^{(conv)}_{conv} = [H^{(conv)}_{conv}]S^{(conv)}[H^{(conv)}_{conv}]^t$$

$$M^{(sync)}_{conv} = [H^{(sync)}_{conv}]S^{(sync)}[H^{(sync)}_{conv}]^t$$

$$V = R + M$$

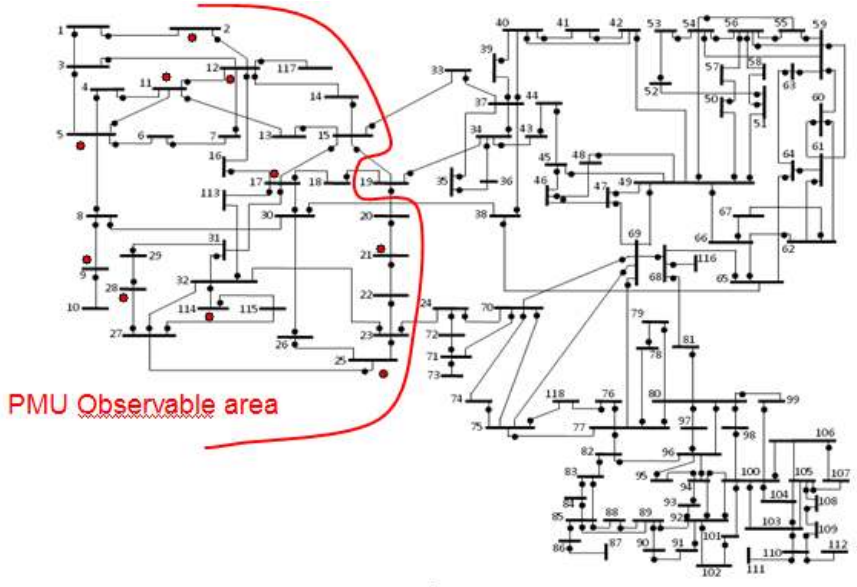
$$r_N(i) = |r(i)| / \sigma_V(i) \leq \text{threshold}$$

$$\sigma_V(i) = \sqrt{V(i,i)}$$

Threshold Violations		Diagnosis
$r^{(sync)}_{Nconv}$	$r^{(conv)}_{Nconv}$	
Yes	Yes	BD in SCADA meas. Inside PMU area
Yes	No	BD in PMU measurements
No	No	no BD
No	Yes	BD in SCADA meas. Outside PMU area

Results:

IEEE 118 – Partial PMU Observability Case



BD on RTU 17 – CASE 5
Violations on 14 measurements with Hybrid SE
PHASE aproach completely supressed the smearing effect

BD on RTUs 17 and 19 – CASE 6
Violations on 33 measurements with Hybrid SE
PHASE aproach completely supressed the effect of RTU 17 and reduced 50% the smearing effect of RTU 19
(13 violations only)

Conclusions

- ***identifying all at once bad data in conventional measurements***
- ***identifying all at once bad data in synchrophasor measurements,***
- ***avoiding the tedious and inefficient combinatorial identification process***
- ***If limited PMU measurements, reduces the Smearing Effect***