Real-Time State Estimation of Active Distribution Grids using the Kalman Filter

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Background and Challenge
State estimation is performed only in transmission grids using the well-known Weighted Least Squares (WLS) algorithm.

Kalman Filter, although in principle can provide better results, has never been applied to power grids because of:
- its computational complexity and implementation;
- difficulty to define an exact prediction model including its covariance matrix.

Adopted Prediction Model:
Kalman Filter prediction:

\[
\hat{x}_k = \hat{x}_{k-1} + P_{k-1} \hat{y}_k
\]

The adopted Prediction Model is:

\[
\text{ARIMA (0,1,0)}
\]

The covariance matrix \(Q\) represents the uncertainty of the prediction.

Proposed Q Assessment Method:
We assess the matrix \(Q\) on-the-fly using the last \(N\) estimated states:

\[
y_j = \hat{x}_{k-j} - \hat{x}_{k-N} \quad (j = 1, ..., N)
\]

\(Q\) is the sample variance of the vector of the residuals \(y_j\):

\[
Q = \text{var}(y_1, ..., y_N)
\]

Kalman Filter state estimator adapted to active distribution grids

Validation using the EPFL power grid

References