PROJET ODRI - Axe 5

Offre de Raccordement Intelligente

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1. Voltage Rise control Block scheme

To control the voltage rise on the higher voltage buses the following block scheme is developed.

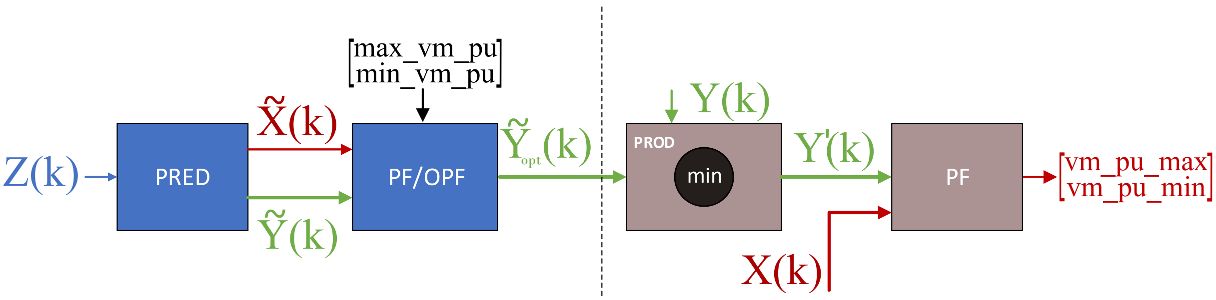

Figura 1: Two Stages Scenario tree

Blocks in blue and grey respectively implement algorithms computed before and after the reality of all the variables are unveiled.

1.1. Variables definition

The variables involved are defined as follows:

$$Y(k) = \begin{bmatrix} P0_1(k) \\ \vdots \\ P0_{m_{HT}}(k) \end{bmatrix}, \quad X(k) = \begin{bmatrix} P_{load}(k) \\ P^{BT}(k) = \begin{bmatrix} P0_1(k) \\ \vdots \\ P0_{n_{BT}}(k) \end{bmatrix} \\ P^{HT}(k) = \begin{bmatrix} P0_1(k) \\ \vdots \\ P0_{n_{HT}}(k) \end{bmatrix} \end{bmatrix}, \quad Z(k) = \begin{bmatrix} \left[X(k-1)^T, \ Y(k-1)^T\right] \\ \vdots \\ \left[X(k-N)^T, \ Y(k-N)^T\right] \end{bmatrix}$$

where :

- $Y(k) \in \mathbb{R}^{m_{HT}}$ is the active power produced by all controllable static generators at period k;

- $\tilde{Y}(k)$ the predicted value of $Y(k)$;
- $\tilde{Y}_{opt}(k)$ the optimal predicted value of $Y(k)$ to respect the voltage rise constraints in the network or the active power demanded by the GRD to the static generators;
- $Y^{'}(k)$ is the actual active power injected into the grid.
- $X(k) \in \mathbb{R}^{(n_{HT}+n_{BT}+1)}$ is the active power produced by the uncontrollable higher and lower voltage generators and the load demand at period k;
- $\tilde{X}(k)$ is the predicted value of $X(k)$
- $Z(k) \in \mathbb{R}^{N*2}$ with N being the total number of past periods or lag is the history of the considered network.

1.2. Algorithms

The algorithms implemented by each block are as follows:

- **PRED**: Prediction. All the prediction algorithms would be implemented here;
- **PF/OPF**: Run power flow and, if needed, optimal power flow.
- **PROD**: Implement a physical constraint. The controllable static generator cannot output more than what is produced at a certain period.
- **PF**: Run a power

1.3. Principle of operation

Lets us divide each instant k into two distinct parts: before (Blue blocks) and after (grey blocks), a command is sent to the controlled HV(s) generator(s). This can also be considered as before and after the unknown variables are reveiled.

1.3.1. Before

The prediction block **PRED** receives an history of the electrical network as $Z(k)$. The history is used to produce both $\tilde{X}(k)$ and $\tilde{Y}(k)$, which are sent to the **PF/OPF** block. Inside this block, a power flow is always executed based on the predicted variables entering. Let $v_{rise}^{max}(k)$ and $v_{rise}^{min}(k)$ be the resulting maximum and minimum voltage detected on the electrical network Hv buses.

Two cases are possibles:

- All voltage rise constraints are respected i.e., $v_{rise}^{max}(k)$ and $v_{rise}^{min}(k)$ are lower and greater than the defined thresholds max_vm_pu and min_vm_pu

$$v_{rise}^{max} \leq max\_vm\_pu$$
$$v_{rise}^{min} \geq min\_vm\_pu,$$

  PF/OPF outputs $\tilde{Y}_{opt}(k) = \tilde{Y}(k)$

- Either of voltage rise constraints is not respected i.e.

$$v_{rise}^{max} \geq max\_vm\_pu$$
$$v_{rise}^{min} \leq min\_vm\_pu,$$

  an optimal power flow is executed to find the optimal value(s) $\tilde{Y}_{opt}$ of the controllable Hv generator respecting these thresholds.

In both cases, the optimal $\tilde{Y}_{opt}$ is sent to the Hv controlled Producers.

1.3.2. After

The block **PROD** at the controllable producers end receives a command $\tilde{Y}_{opt}$ of active power to inject into the electrical grid to satisfy the defined threshold. A minimum operation defined as

$$Y'(k) = min\Big(\tilde{Y}_{opt}(k), Y(k)\Big)$$

implements a physical constraint, i.e. a controllable generator cannot inject more than what is produced at a certain period into the electrical grid.

The block **PF** receives the actual active power injected by the controllable Hv(s) generator(s), i.e. $Y'(k)$, by the uncontrollable higher and lower voltage generators and the load demand, i.e. $X'(k)$. Based on these inputs, a power flow is executed to provide outputs to the user to verify the control implemented effects into the whole process.

2. Robust Voltage Rise control Block scheme

Following the principle of operation described in the previous section, at each instant, the controllable Hv(s) generator(s) will receive a control command $\tilde{Y}_{opt}(k)$ whether or not an exceeding (lower or upper) of the authorised voltage rise occurs. This strategy is not optimal for the GRD or the Hv(s) producer. We developed the Robust Voltage Rise control Block scheme to mitigate this problem.

The new method's robustness consists of only sending a control command to the Hv(s) producer when a violation of the authorised voltage rise is predicted in the block PF/OPF. On the contrary, when the constraints are respected, no command is sent to the controlled Hv(s) producer(s) that can therefore inject all their produced power $Y(k)$ onto the electrical grid.