

# Research and Design of Smart Grid Online Automatic Control and Evaluate

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State grid dispatch center proposed the foundation of smart grid dispatch technical support system framework. It proposed on how to achieve functional goals of smart grid dispatch technical in the framework of the current scheduling system. PMU can be engineered to have pointed out that remote signalling and remote adjustment function, with the SCADA system and fault recording function. Therefore, completely replace unified data collection grid; noted with PI Database and Oracle database as the dispatch of a unified data platform database to database storage grid PI dynamic data to Oracle database storage grid model and structure, to achieve effective processing power grid information. In the analysis of the functional system based EMS, WAMS system, dynamic warning system, generation security check system, load forecasting system, based on the above noted applications can achieve integration, to achieve all of the above functions in an integrated system, and pointed out that In order to realize the smart grid must be newly developed power grid operation mode pre-arranged power grid economic analysis, ultimate power calculation section line, power supply capability evaluation applications.

## 1. Introduction

With the advancement of the smart grid research and construction work, the need to build a scientific, rational, comprehensive assessment system, namely smart grid evaluation system (Marin-Perianu et al., 2013; Wang et al., 2005). At the macro strategic level, the level of development of intelligent grid to be evaluated for intelligence grid brings safety benefits, economic and social benefits assess and provide scientific guidance for smart grid development planning; process at the micro level, the state of the power grid and weaknesses are analyzed, identifying, for the operation and management of smart grid provided decisions (Spencer et al., 2004). Therefore, the construction of smart grid infrastructure evaluation index system is the smart grid (Sadek et al., 2008; Dong et al., 2016).

Smart Grid is the scientific evaluation system to assess the level and effectiveness of smart grid development, smart grid guide chemotactic excellent carrier operations, is the basis for smart grid construction (Tarighat et al., 2005). Text in the index system is divided into strategic and process indicators index set two levels, which are macroscopic appearance of strategic indicators set smart grid, set the process indicators which characterize the micro factors, the two form a tight chain index (Van de Beek et al., 1995). From smart grid stakeholder needs, creating multiple layers, multi-level needs of architecture, based on a quantification of needs to build a smart grid strategy index set of strategic indicators sets the decomposition and transformation of multi-dimensional formation process index set (Wong et al., 2001). Construction of the index system is layered strong correlation indices in clear, easy to use and so on (Sadek et al., 2007; Shariatzadeh et al., 2015; Zhu et al., 2011; Soungalo et al., 2011).

## 2. CPPS damping control integrated WAN

Because of the vector sorting, packing process is relatively simple, usually do not need at this time to deploy a separate set of towels playing style PDC, but by the PMU complete the corresponding function. However, for the phasor data requires a lot of applications, it is generally designed to be set towel type structure, by one or

more PDC complete phasor data collection, sorting, packaging, process the hair. Centralized CPPS wide area monitoring system level and composition was shown in Figure 1.

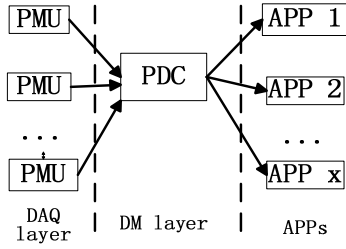


Figure 1: Centralized CPPS level and composition of wide area monitoring system

Considered small, interference, and does not usually lead to structural power system operating point changes. For analysis, the equations describing the system response can be linearized at a specific operating point. Static excitation system for the controlled excitation system and ignore the power unit and the dynamic excitation regulator. The excitation voltage deviation as excitation control input, the first / motor equation can be expressed as:

$$\begin{cases} U_{di} = X_{qi} I_{qi} \\ U_{qi} = E_{qi} - X_{di} \dot{I}_{di} \\ \delta(t) = \omega(t) - \omega_0 \\ \dot{\omega}(t) = (\omega_0/M_i) P_{mi} - (D_i/M_i)(\omega(t) - \omega_0) - (\omega_0/M_i) P_{ei} \\ \ddot{E}_{qi}(t) = -(1/T_{doi}) [\dot{E}_{qi}(t) + I_{di} (x_{di} - \dot{x}_{di})] + (1/T_{doi}) E_{fi} \end{cases} \quad (1)$$

Among them:

$$P_{ei} = [E_{qi}(t) + I_{di} (x_{qi} - \dot{x}_{di})] I_{di} \quad (2)$$

The state as vector:

$$x = [\Delta\delta \quad \Delta\omega \quad \Delta E_q^-]^T \quad (3)$$

For wide area H control, select the controlled output of z (t), and therefore multi-machine power system considered here can be expressed as:

$$\begin{cases} \dot{x}(t) = Ax(t) + Bu(t) + B_2\varepsilon(t) \\ Z(t) = Cx(t) + Du(t) \end{cases} \quad (4)$$

Where C and ε are weighting matrix, M is the state of the measured signal remote PMU linear combinations thereof. Control mechanism often results in periodic communications network of WAMS has a lot of redundant information transmission, thereby increasing the burden of communication, resulting in waste of network bandwidth. It is necessary to introduce a mechanism to determine the status of signal acquisition which is necessary to send to a network for control calculation. Construction data pre-processing unit called event detector in a wide area damping control loop, PDC CPPS state information collected after, if the signal is sent to the WADC, is defined as an event occurs.

For wide-area damping control phasor by the synchronization signal PDC collected by the event detector logic unit according to the current operating state of the power system, according to the event trigger criteria for signal hoof election, will meet the criteria to trigger event signal is sent via a communication network CPPS wide-area damping control towel to heart. Control Center after receiving the updated feedback signals, a specific control law to calculate a control signal, via a wide area communication network under CPPS sent to the controlled unit, perform the appropriate action to complete the closed loop damping control.

### 3. Modeling and description

Wide-area power systems, closed-loop structure WADC CPPS and communication network was shown in Figure 3. The dotted line represents the information link line. PMU output signal X (t) measured

simultaneously, and the sampling data packet  $y(t)$  through the communication network to send periodic WADC. This study is located in WADC controlled object side (or WADC connected via high-speed communications network and actuators, the communication delay can be ignored), that is, the power system to be measured and the controller of the wide area communications network there is only between. This structure can be applied to the additional excitation control, FACTS and HVDC additional damping of the remote-control signal designs. Figure 3 shows the CPPS linear model is expressed as:

$$\begin{cases} \dot{x}(t) = Ax(t) + Bu(t) \\ y(t) = Cx(t) \end{cases} \quad (5)$$

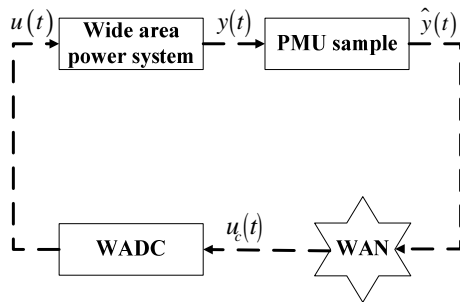


Figure 2: The general structure of CPPS wide area damping control system

PMU preclude the collection of synchronized phasor data packets transmitted between the controller and the remote object, in addition to the calculation processing time controller, but also produce network-induced delays. To simplify the analysis, different communication channels is assumed here that the delay is the same; as compared with the transmission delay of the processing time of the controller is small, ignoring its effects. In addition, behind the theoretical derivation we need to use a few common assumptions analysis of network control system is as follows.

### 4. Experiment and results

#### 4.1 Simulation analysis

Performance indicators to assess a wide area damping controller H includes: dynamic response overshoot, settling time and steady-state error, the number of transmissions of a certain kind of status signal simulation time. The maximum allowable delay (Delay stability margin), as well as  $\gamma$  disturbance rejection index and so on. Two districts and four the next system will be shown in Figure 4, for the study to verify the proposed event trigger mechanism having a wide area damping controller design methods, and focus on performance indicators and the above-mentioned event trigger parameters b and disturbance rejection relationship between the level of parameters to be able to guide the event trigger parameters  $\gamma$  and  $\sigma$  disturbance rejection level parameter set selection.

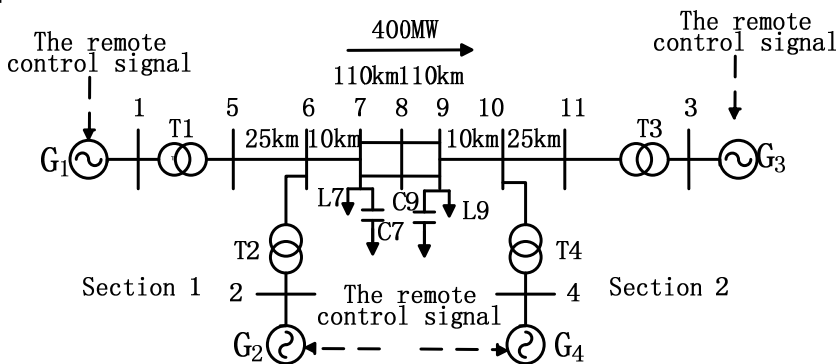


Figure 3: Two districts and four one-line diagram system

Since the controlled rectifier bridge shoes static excitation system, as expected while off pipe conducting real-time interval exists, leading to periodic fluctuations in the output voltage of the DC excitation occurs. To simplify the analysis, considered the disturbance expressed as:

$$\varepsilon_i(t) = \begin{cases} 0.1 \text{sign}(\sin t) & t \in [0, 5] \\ 0, & \text{others,} \end{cases} \varepsilon_i(t) = 0, i = 2, 3, 4. \quad (6)$$

The system dynamic response curve was shown in Figure 5. In order to evaluate changes in the system dynamic response, this paper introduces two performance indicators: conditions under periodic system response and send event-triggered mechanism IAE system response time, as well as time-triggered and event-triggered two mechanisms under dynamic response bias:

$$IAE = \int_0^t |x_{\text{time-based}}(t) - x_{\text{event-triggered}}(t)| dt \quad (7)$$

$$TRE = x_{\text{time-based}}(t) - x_{\text{event-triggered}}(t) \quad (8)$$

Stable operation of power system, the frequency of the whole system is kept within a permissible range. Frequency stability is the stability of the power system in the frequency of this variable. It refers to the failures that result when subjected to severe load output and a larger imbalance power system ability to maintain a stable frequency operation. Active Power System output and load balance between consumption is a prerequisite for maintaining a constant frequency. Often lead to system instability frequency current, voltage, and substantial changes in other variables, causing the system control and protection action, so that more load is removed.

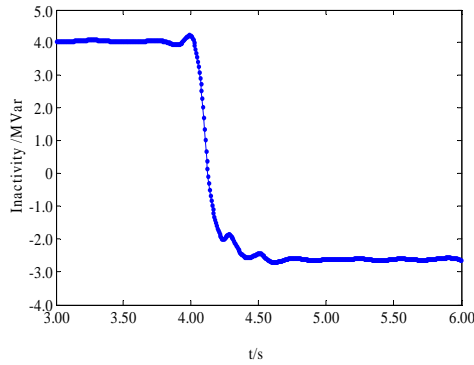


Figure 4: The system dynamic response curve

Simulation study in the next, CPPS state-space description is based on the relative power angle synchronous reference frame model. At selected operating point linearization obtained. For ease of control design, state variable reordering is:

$$x = [\Delta\omega_1 \ \Delta\delta_{14} \ \Delta\omega_2 \ \Delta\delta_{24} \ \Delta\omega_3 \ \Delta\delta_{34} \ \Delta\omega_4 \ \Delta E'_{q1} \ \Delta E'_{q2} \ \Delta E'_{q3} \ \Delta E'_{q4}]^T \quad (9)$$

For controlled output, select weighted matrix:

$$C = \{10, 1.0, 10, 1.0, 10, 1.0, 0.5, 0.5, 0.5, 0.5\} \quad (10)$$

$$D = \begin{bmatrix} 0_{7 \times 4} \\ I_{4 \times 4} \end{bmatrix} \quad (11)$$

From the introduction of each generator field winding disturbances, and B2 = D.

#### 4.2 Index system construct

Smart grid core values rely on high-performance operation of various departments, personnel, equipment and automation systems, either part of the problem. It will have an impact on the grid. Therefore, strategic indicators reflect the outcome (lagging indicators), macro characterization process indicators, and process indicators reflect the reason (leading indicators), is a factor of strategic indicators, process indicators by

different operating mechanism inside the grid layer progressive, joint action on strategic targets. Relationship between tree or mesh may be used to characterize the chain indicators, as shown in Figure 5-6.

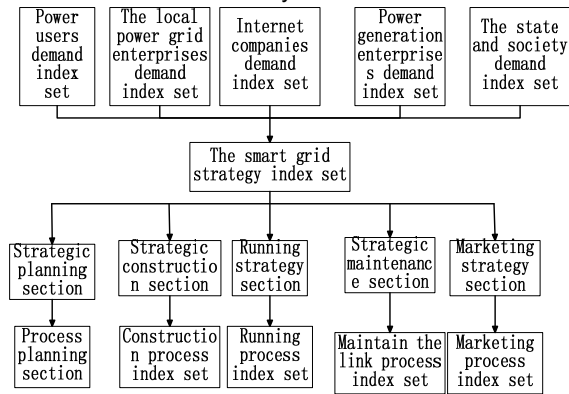


Figure 5: Relationship strategic indicators and process indicators

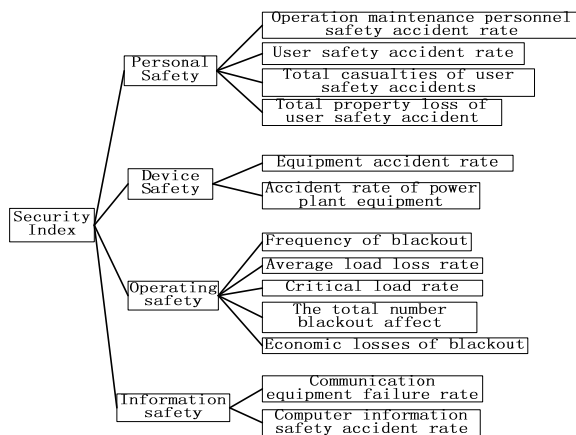


Figure 6: Smart Grid strategy index set

### 4.3 The quantization error of the AD converter

AD output can only be finite word length. Suppose we are using AD output is 8, then a unit of AD represent values are:

$$LSB = \frac{q}{2^b} \tag{12}$$

The significance of this is that the output value represents the value of the ADC LSB is an integer multiple of the lowest level since AD is not the component, the output value of AD is not continuous. In this process, the error is generated in the quantization error. FWL not represent a number or a signal AD conversion, the smaller word length calculation accuracy less accurate, the more serious problem of the quantization error with infinitely precise digital. For example, suppose that AD converter LSB is 50mV, after following the analog signal AD conversion, quantization error in Figure 7 below:

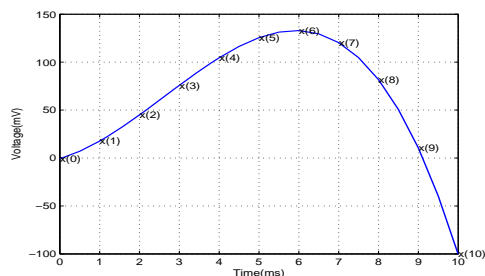


Figure 7: Random signal quantization result

AD output SNR:

$$SNR_{A/D} = 10 \lg \frac{\sigma_{input}^2}{\sigma_{A/Dnoise}^2} \quad (13)$$

Wherein  $\sigma_{input}^2$ -Input signal variance

$\sigma_{A/Dnoise}^2$ -AD Quantization noise variance

In practice, AD converter, you can easily calculate the maximum signal to noise ratio by the above formula AD conversion, which is the actual AD converter maximum SNR in the practical application of the continuous signal is not always necessary use a lot bigger than its own SNR a / DSNR, under normal circumstances, will assume AD converter SNR ratio a DSNR small 3-6dB.

Conclusions

In this paper, smart grid scheduling technology support system construction framework objectives national electric power dispatching center to build. It combined with the current provincial companies electric power dispatching and communication center actual production operation of the system will be a combination of both. We proposed smart grid scheduling support system construction data integration, platform integration and functional integration implementations. Construction and application of smart grid also needs further exploration in the practice run, but also with the smart grid development and application of new technologies and progressive development.

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