Research on Verification of 10kv High Voltage Digital Electric Energy Measurement based on RF Synchronization Technology

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Abstract: With the deepening of power system reform, great attention has been paid to the economic benefits of power, among which the accurate measurement of electric energy is the key. In order to improve the economic benefit and stability of power grid operation, the verification of electric energy measurement is studied. The traditional high-voltage digital power metering calibration method has not been optimized, which leads to large error. Therefore, a 10kv High-voltage digital power metering calibration method based on RF synchronization technology is proposed. The analysis model of high-voltage digital power parameters is constructed. The RF synchronous technology is used to collect high-voltage digital power parameters. The offset compensation method of average current period is used to adjust the compensation and feedback of high-voltage digital power parameters. The steady-state gain regulation model of high-voltage digital power transmission is constructed, and the RF synchronous control method is used to complete the model prediction and parameter estimation in the process of high-voltage digital power measurement. Combined with the deep learning method, the optimization control in the verification process of high-voltage digital power measurement is realized. The parameters such as electric power, working voltage and output power gain are taken as constraint variables, and the power consumption is calculated by the power synchronization method The method of upper limit compensation and error factor adjustment is used to realize 10kv High-voltage digital energy metering verification. The simulation results show that the improved piezoelectric digital energy metering method has higher accuracy and better application performance.

1 INTRODUCTION

10KV High-voltage power transmission has become the main operation mode of power transmission in the future. In the process of high-voltage power transmission, it is disturbed by the environmental disturbance and oscillation factors of the line, resulting in the low accuracy of electric energy measurement of high-voltage power transmission. It is necessary to build an optimized 10KV High-voltage digital electric energy measurement verification method and control the verification results of 10KV High-voltage digital electric energy measurement in combination with RF synchronous control technology so as to improve the output stability and reliability of electric energy measurement (Jing, 2019, Chen, 2019, Tan, 2019, Wang, 2019). The related research on 10KV High-voltage digital electric energy measurement verification method has a wide application value in high-voltage transmission and digital electric energy measurement.

At present, in the existing research, the more typical power metering verification method is the implementation scheme of remote online verification of digital metering secondary equipment proposed in document (Yu, 2019, Bai, 2019, Zhou, 2019, et al). In this study, the device communication modeling is carried out based on the electric energy metering model of IEC 61850 project. The special logic node MSCN for metering verification is used to accumulate the measured electric energy value, transmit the verification data to the station control layer through MMS service, and complete the non-invasive verification based on the clock synchronization of the metering equipment in the station. There are two verification implementation modes of "local verification" and "background verification". The design route of this method is

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feasible, but in practical application, its timeliness and accuracy need to be further improved.

Aiming at the disadvantages of traditional methods, a 10KV High voltage digital electric energy measurement verification method based on RF synchronization technology is proposed in this paper. The simulation test results show that this method has superior performance in improving the verification accuracy of 10KV High voltage digital electric energy metering.

2 10KV HIGH VOLTAGE DIGITAL ELECTRIC ENERGY METERING COEFFICIENT COMPENSATION

2.1 Electric Energy Measurement Information Acquisition Based on RF Synchronization Technology

The RF synchronization technology (Newsham, 2019, Li, 2016, Du, 2016, Zhu, 2016) is introduced to build the RF information acquisition model of 10KV High-voltage digital electric energy metering. Based on the planning and measured data of power grid, it is obtained that the correlation fusion time T of 10KV High-voltage digital electric energy is:

$$T = \frac{N*(o_i + o_i')}{t_i} + y_i \qquad (1)$$

In it, N is the sequence length of 10KV High voltage digital electric energy coefficient (Jin, 2018, Song, 2018, Gong, 2018, et al), i.e. 32; The 10KV High voltage digital electric energy coefficient component t_i collected at the sampling time point i represents the distance from the origin of the time axis $\bar{t} = \sum_{i=1}^{N} t_i \Big/ N$; 10KV High voltage digital electric energy coefficient distribution value y_i collected for the i RF tag; And o_i and o_i' are the adjacent samples of 10KV High-voltage digital electric energy coefficient measurement, and their mean values can be expressed as $\bar{y}$ (Dong, 2015, Li, 2015). The least square estimation value of RF information of 10KV High-voltage digital electric energy measurement is obtained by using the method of optimal decision-making of comprehensive benefits (Wu, 2017, Peng, 2017, Wang, 2017, Zhang, 2019, Zhao, 2019, Zhang, 2019). The symbolic value of RF information of 10KV high-voltage digital electric energy measurement is obtained by scalar time series analysis:

$$b(m) = \cos T + [y' + N] + \bar{y} \qquad (2)$$

Through the grouping detection method, the RF synchronous control model of 10KV High-voltage digital electric energy metering is constructed. And the expression of the electric energy consumption model of the electrolytic cell is obtained as follows:

$$p(a_v) = \sum_{m=1} b(m) + s_{jk} + y' \qquad (3)$$

Among them, s_{jk} is the RF identification information of 10KV High-voltage digital electric energy metering collected in section j and section k. According to the increase amplitude of electric heating power, the RF information acquisition model of 10KV High-voltage digital electric energy metering is constructed by using the constraint method of heat storage and heat release power, as shown in Figure 1.

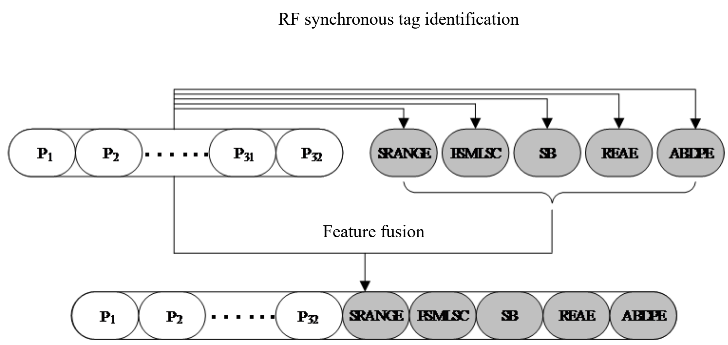


Figure 1: RF information acquisition model for 10kV High voltage digital electric energy metering.

2.2 Realization of Electric Energy Metering Coefficient Compensation

The RF synchronization technology is used to collect 10KV High-voltage digital electric energy coefficient, and the offset compensation method of current cycle average value is used for 10KV High-voltage digital electric energy coefficient compensation and feedback adjustment (Guo, 2020, Li, 2020, Zhou, 2020, Wang, 2020). The spatial distribution coordinate of 10KV High-voltage digital electric energy coefficient compensation is defined as $\left\{\left[\sum_{i=n_1}^{n_1+7} t_i \Big/ 8\right], \left[\sum_{i=n_1}^{n_1+7} y_i \Big/ 8\right]\right\}$. The value of 10KV High-voltage digital electric energy coefficient collected in each section is n_1, and the values are 1, 4, 14 and 24 respectively; M is the mean square error value of the least square estimation of 10KV High voltage digital electric energy coefficient compensation; the covariance error M_{jk} of 10KV High voltage digital electric energy coefficient fusion from the sampling points of section j and section k is obtained. Using the least square programming design method, the equivalent constraint coefficient of 10KV High-voltage digital electric energy coefficient compensation meets the minimum $\|\omega\|$. Using the polynomial fitting method, the regression analysis term of electric energy coefficient $\xi_i(\xi_i > 0)$ is obtained. And the three-phase stator current waveform is constructed to obtain the constraint coefficient C. The quadratic programming problem of 10KV High-voltage digital electric energy metering is as follows:

$$U(w) = \left(b(m) + \|\omega\|\right) \cdot p(a_v) \quad (4)$$

Lagrange multiplier $(a_i, i = 1, 2, ..., l; a_i \geq 0)$ is introduced to construct the Lagrange function solution model for 10KV High voltage digital electric energy measurement and verification. The dual problem of 10KV High voltage digital electric energy measurement and verification is as follows:

$$d_v(a) = \int_{w=1} U(w)dw + \|\omega\| \quad (5)$$

The steady-state gain regulation model of 10KV High-voltage digital electric energy transmission is constructed. The RF synchronous control method is used for model prediction and coefficient estimation in the process of 10KV High-voltage digital electric energy metering (Zhan, 2018, Hu, 2018, Wei, 2018). Combined with nonlinear transformation and relevant theories of functional theory, the optimization model of 10KV High-voltage digital electric energy metering process is obtained, which is expressed as:

$$M_s = \frac{s(e) + a(l)}{g} \cdot \phi(M_s) \quad (6)$$

Among them, g is the RF synchronous control coefficient and the new quadratic programming objective function for 10KV High voltage digital electric energy metering verification is $s(e)$. The bias of current is processed (Zhu, 2020, Zhang, 2020, Cao, 2020) to solve the classification decision function $a(l)$ of dual inverter winding control.

The kernel function fuzzy decision method is adopted to obtain the support vector machine (SVM-RBF) control chart model for 10KV High voltage digital electric energy metering verification, which is shown as follows:

$$D(e_g) = \gamma * (M_s + s(e)) \quad (7)$$

Where, y is the coefficient of radial basis kernel function. Therefore, a 10KV High voltage digital electric energy metering coefficient compensation model is constructed (Yin, 2020, Guo, 2020, Wang, 2020, Wang, 2020, Pan, 2020).

3 10KV HIGH VOLTAGE DIGITAL ELECTRIC ENERGY METERING VERIFICATION

3.1 Power Metering Verification Weight Acquisition

Based on the compensation results of 10KV High voltage digital electric energy metering coefficient, the fuzzy iterative phase coefficient of high voltage digital electric energy metering is identified. The phase estimation $\bar{\theta}_r$ of multi-phase electric energy digital measurement is:

$$\bar{\theta}_r = v_Q(n) + v(n) \quad (8)$$

Among them, $v(n)$ is the disturbed white noise of high-voltage digital electric energy measurement and verification. $v_Q(n)$ is the imaginary part of the disturbed white noise $v(n)$ of 10KV High-voltage digital electric energy measurement and verification.

The first point of the 10KV High-voltage digital electric energy metering verification sequence $r(n)$ is adopted to make the sequence length even $N-1$. The iterative model R of 10KV High-voltage digital electric energy metering is obtained by using phase space reorganization technology:

$$R=r(n)+\frac{\bar{\theta}_r}{s_{jk}} \tag{9}$$

The power consumption s_{jk} of RF information is:

$$p(s_{jk})=\frac{R+\left[A_k+s_{jk}\right]}{\varphi_k} \tag{10}$$

Among them, the amplitude term and phase term of 10KV High voltage digital electric energy measurement and inspection are A_k and φ_k respectively.

Build the weight calculation model of 10KV High voltage digital electric energy metering. It is set k_0 as the discrete spectrum component of electric energy. And the sum φ_1 and φ_2 is used to represent the 10KV High-voltage digital electric energy transmission sequence $R_1(k)$ and the phase $R_2(k)$ at the maximum spectrum line respectively. Then the calculation model of electric energy metering weight is as follows:

$$\eta(t)=\frac{p(s_{jk})\cdot(\varphi_1+\varphi_2)}{k_0}+\left|R_1(k)+R_2(k)\right| \tag{11}$$

3.2 10kV High Voltage Digital Electric Energy Metering Verification

Based on the power metering weight calculated above, combined with the deep learning method, the optimization of 10KV High-voltage digital power metering verification is realized.

Taking the coefficients of electric power, working voltage and output power gain as constraint variables (Yang 2018, Zhang 2018, Wang 2018), the independent variables of the verification constraint of high-voltage digital electric energy metering K' are corrected. The verification constraint is:

$$K'=\Phi_{un}(n)+[F+\varepsilon] \tag{12}$$

The winding phase of the output power gain $\Phi_{un}(n)$ is obtained by taking the electric power, working voltage and output power gain as the constrained characteristic component (Wang 2019, Gao 2019, Wei 2019). When the unwinding is correct, the output power gain control coefficient is $\Phi_{un}(n)=\Phi(n)$ or $\Phi_{un}(n)=\phi(n)+\phi(-n)$. For phase estimation ε, the estimated value can be calculated according to the verification results of the three port electronic system.

Based on the estimation of independent DC coefficient of multi- energy storage,the verification steady-state coefficient $q(w)$ of 10KV High-voltage digital electric energy metering is as follows:

$$q(w)=\left\{K'+g_n(u)\right\}+Y_s^{(i,t-1)} \tag{13}$$

In it, $Y_s^{(i,t-1)}$ represents the value of 10KV High-voltage digital electric energy metering verification coefficient detected at time $t-1$, and $g_n(u)$ is the feedback coefficient of 10KV High-voltage digital electric energy metering verification output.

Considering the difference of 10KV High voltage digital electric energy metering verification, likelihood estimation of steady-state coefficient for verification of 10KV High voltage digital electric energy metering is like this:

$$A(x)=\frac{f(z)}{i_n}+\sum_{w=1}q(w) \tag{14}$$

Using the similarity fusion method, the dynamic adjustment coefficient of 10KV High voltage digital electric energy metering output is obtained as i_n . $f(z)$ is the 10KV High voltage digital electric energy metering output after the t+ 1 iteration (Wang, 2019, Chen, 2019, Zeng, 2019).

At this time, the response expression of 10KV High voltage digital electric energy verification is:

$$I=M\in R^{3\times3}+\left[J+A(x)\right] \tag{15}$$

The optimized characteristic solution is:

$$M=\frac{J+I}{e(x_t)} \tag{16}$$

In it, $M\in R^{3\times3}$ is the positive definite matrix of 10KV High voltage digital electric energy metering verification; J is a constant; $e(x_t)$ is the guide error vector of 10KV High voltage digital electric energy metering.

To sum up, the verification of 10KV High voltage digital electric energy metering is realized. The implementation structure block diagram of the verification device is shown in Figure 2.

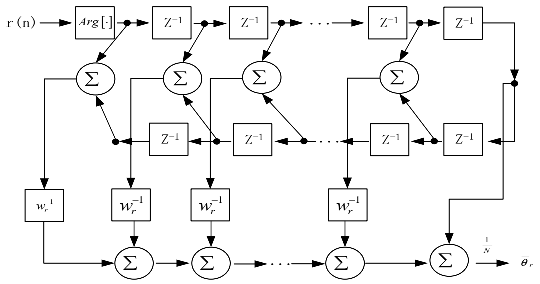
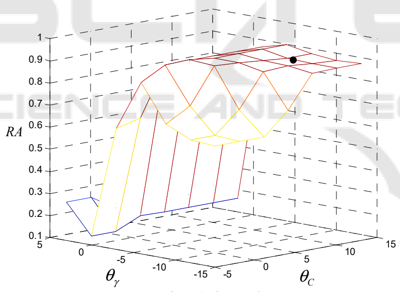


Figure 2: Realization structure diagram of 10kV High voltage digital electric energy metering verification device.

4 EXPERIMENTAL TEST AND ANALYSIS

In the experiment, the terminal voltage gain of 10KV High-voltage digital electric energy metering is set to be 7KV to 10V. The output power of high-voltage digital electric energy metering device is 120W, and the maximum power point voltage offset is 15V. The output gain distribution curve of 10KV High-voltage digital electric energy metering inspection under different variable coefficients is obtained, as shown in Figure 3.

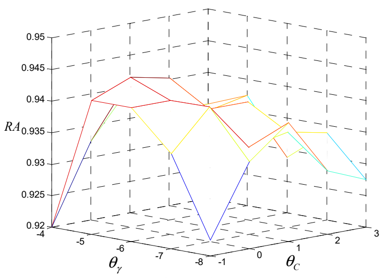


$\theta_C = 1, \theta_\gamma = -6$

$C = 2, \gamma = 0.015625$

$RA = 0.93875$

(a)

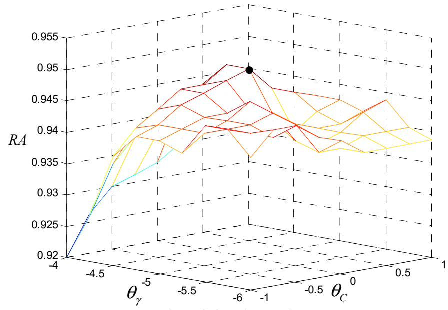


$\theta_C = 0, \theta_\gamma = -5$

$C = 1, \ \gamma = 0.03125$

$RA = 0.94375$

(b)



$\theta_C = 0.25, \theta_\gamma = -4.75$

$C = 1.189207, \ \gamma = 0.037163$

$RA = 0.94875$

(c)

Figure 3: Output gain distribution of 10kV High voltage digital electric energy metering verification.

According to the analysis of Figure 3, the output gain and stability of 10KV High-voltage digital electric energy metering verification by this method are large. The output root mean square error of 10KV High-voltage digital electric energy metering is tested, and the comparison results are shown in Figure 4.

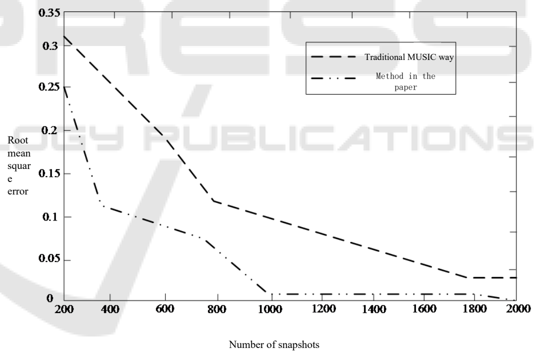


Figure 4 Comparison of output error of 10kV High voltage digital electric energy metering calibration.

According to the analysis of Figure 4, the output root mean square error of 10KV High-voltage digital electric energy metering verification by this method is low.

5 CONCLUSION

A verification method of 10KV High voltage digital electric energy measurement based on RF synchronization technology is proposed. Based on the planning and measured data of power grid, according to the increasing amplitude of electric heating power, the RF information acquisition model of 10KV High-voltage digital electric energy measurement is constructed. And a new quadratic planning objective function for the verification of 10KV High-voltage digital electric energy measurement is obtained to realize 10KV High-voltage digital electric energy measurement. It is concluded that the output error of 10KV High voltage digital electric energy measurement verification by this method is small and the stability is high.

REFERENCES

Dong Xianlun, Li Xueqing. A Novel distributed database solution based on MySQL[C]//Proceedings of the 2015 7th International Conference on Information Technology in Medicine and Education. Huangshan: I EEE, 2015:329-333.

Guo Zun, Li Gengyin, Zhou Ming, Wang Jianxiao. Decentralized coordinated robust optimal scheduling model for wind power consumption [J]. Chinese Journal of electrical engineering, 2020, 40 (20): 6442-6454.

Jin Jiahui, Song Aibo, Gong Huan, et al. Distributed storage system for electric power data based on HBase[J]. Big Data Mining and Analytics, 2018, 1(4): 324-334.

Jing Chaoxia, Chen Dapeng, Tan Huijuan, Wang Hongyi. Improved benders algorithm for maximum power supply capacity of urban transmission network [J]. Chinese Journal of electrical engineering, 2019, 39 (15): 4373-4384.

Li Bin, Du Mengyuan, Zhu Yun, et al. Intelligent distribution network state estimation based on quasi real-time data [J]. Journal of electro-technics, 2016,31 (1): 34-44.

Newsham G R. Measurement and verification of energy conservation measures using whole-building electricity data from four identical office towers[J]. Applied Energy, 2019, 255(Dec.1):113882.1-113882.18.

Wang Cheng, Gao Rui, Wei Wei, et al. Risk-based distributionally robust optimal gas-power flow with Wasserstein distance[J]. IEEE Transactions on Power Systems,2019,34(3):2190-2204.

Wang Yuhong, Chen Yang, Zeng Qi, et al. Research on contribution ranking and suppression method of ultra-low frequency oscillation of hydro-power units [J]. Electrical measurement and instrumentation, 2019,56 (7): 7-14,29.

Wu Qingxi, Peng Hui, Wang Jin, et al. Design and key technology of distributed real-time database for power grid regulation cluster [J]. Power system automation, 2017,41 (22): 89-95.

Yang Jingwei, Zhang Ning, Wang Yi, et al. Multi energy system for renewable energy consumption: review and prospect [J]. Power system automation, 2018,42 (4): 11-24.

Yin Rui, Guo Jiangtao, Wang Xiaolei, Wang Tianjun, pan Jianli. Design of association rule mining algorithm for smart grid [J]. Microcomputer application, 2020,36 (05): 85-88.

Yu Chunping, Bai Jingfen, Zhou Jianbo, et al. Remote calibration technology of digital electric energy metering secondary equipment based on IEC 61850 [J]. Electrical measurement and instrumentation, 2019.

Zhan Side, Hu Wei, Wei Zhinong, et al. Stochastic optimal power flow of electricity gas interconnected integrated energy system based on opportunity constrained programming [J]. Power automation equipment, 2018,38 (9): 121-128.

Zhang Lingtao, Zhao Lin, Zhang Liang, et al. Load balancing framework for distributed computing cluster with power big data [J]. Power grid technology, 2019,43 (1): 259-265.

Zhu Xingyu, Zhang Qianwu, Cao Bingyao. Design of traffic test platform based on dpdk [J]. Microcomputer application, 2020,36 (05): 99-102.