Development and application of infrared imaging check and evaluation system

Huang Fucu¹, Sui Dongpeng¹*, Zhao Ye², Liu Chang³, Guo Zhinan² and Wang Yanan¹

¹State Grid Electric Power Research Institute of Liaoning Electric Power Co., Ltd., Liaoning, 110006, China.
²LiaoningDongke Power Co., Ltd., Liaoning, 110006, China.

sdp_ldk@ln.sgcc.com.cn suidongpeng.41@163.com

Abstract: According to the parameters of various kinds of infrared imaging equipment was performance full automatic detection and evaluation of research in this paper. The evaluation system will to accuracy, slit function (SRF), minimum resolvable temperature difference (MRTD), minimum detectable temperature difference (MDTD) and noise equivalent temperature difference (NETD) and other parameters as the basis, the establishment of infrared imaging evaluation system database, to convergence of digital interface to realize automatic detection and evaluation of infrared imaging device, solving the technical problem of performance evaluation of grid infrared imaging equipment, ensure the accuracy of condition based maintenance for power transmission system.

1. INTRODUCTION

The wide application of infrared imaging technology is one of the key links to realize the state maintenance of power grid, and the performance evaluation of infrared imaging equipment is also an important guarantee for the safe and stable operation of power grid. At present, the evaluation technology of infrared imaging equipment in Northeast Power System mainly focuses on manual detection, and lacks a full-performance evaluation system for infrared imaging equipment. There are dozens of kinds of infrared imaging equipment in Northeast Power System, all of which adopt different data interfaces. According to the requirements of relevant documents and regulations of State Grid Corporation of China, the infrared imaging equipment needs to evaluate and analyze multiple technical parameters such as MRTD and MDTD to ensure the accuracy of power grid condition maintenance. Due to the large number of applied infrared imaging equipment, a wide range of parts, and the digital interface is not uniform, it is difficult to achieve automatic full performance evaluation.

Therefore, in order to achieve the parameters to the variety of the time-varying analysis, this paper puts forward a set of infrared imaging automation based on time-varying parameter, the performance evaluation system, with high precision of high temperature and low temperature blackbody as control core, the design of the control panel and the control program, implement automatic switch test standard as well as the temperature automatic adjustment function, developing automatic feedback regulating functions, improve the accuracy of the output, through the automatic control and automatic acquisition read measurement value feedback, cohesion and dynamic database software.
2. Infrared evaluation system composition

The system hardware structure diagram as shown in figure 1, the evaluation system with ASP.NET software as the core, through the computer control black body, and the infrared imaging device in the form of digital interface data collection, the blackbody data and infrared imaging devices for gathering information circulation operation for many times, the infrared imaging device MDTD, MRTD, SRF and NETD technology parameters, such as save in dynamic database[3].

![Figure 1. Schematic diagram of system hardware structure](image)

The evaluation system of infrared thermal imager is composed of TCB-2D blackbody, parallel light tube, CTCB controller, runner, a series of targets, etc. Eight targets of different sizes can be installed on the runner, and the target rotation can be controlled by CTCB controller or matching software. By setting the blackbody temperature difference between target and (minimum can reach 0.01 ℃), and use different size of the target (slit 1 mm ~ 15 mm) to test the infrared thermal imager, the infrared thermal imager images through video acquisition card collection, through the software of image analysis can evaluate the some parameter of the thermal imager, MRTD (minimum resolution temperature difference), MDTD (minimum detectable temperature difference), NETD (noise equivalent temperature difference, temperature resolution), SRF (slit response function), the MTF (modulation transfer function), etc.

3. Main performance parameters of infrared thermal imager

The performance parameters of infrared thermal imager are relatively standardized, which can be divided into the following eight aspects: subjective image quality parameters, response parameters, noise parameters, image resolution parameters, geometric parameters, precision parameters, spectral parameters and operational parameters. In this paper, we only discuss how to analyze noise parameters (NETD) and subjective image quality parameters (MRTD, MDTD) using the evaluation system.

3.1 NETD noise equivalent temperature difference

When the thermal imager measures the noise equivalent temperature difference, the infrared filter chooses the appropriate frequency band to measure the uniform target at the ambient temperature at the maximum scanning rate of the infrared thermal imager. The accurate testing process of the noise equivalent temperature difference is shown in Figure 2. Under the background of uniform uniform temperature target, target and background is a standard blackbody, systematically observed in test mode, signal peak voltage Vs and vn is equal to the RMS noise voltage generated by the system, namely the signal-to-noise ratio is equal to 1, measuring the temperature difference between the object and the background environment \( \Delta T \) called NETD noise equivalent temperature difference of the system.
3.2 Minimum resolvable temperature difference (MRTD)
The Minimum Resolvable Temperature Differential Method (MRTD) is used to describe the detection threshold of the observation field by the thermal imager. It reflects the distance at which a target can be detected and observed and also determines the target space frequency. At low spatial frequencies, the observer is affected by noise and false images. At high spatial frequencies, the spatial resolution of the system becomes the main factor affecting the performance of the equipment[4].

4. Test methods and data of infrared imaging evaluation system

4.1 NETD test
The computer collects L frames of images made by the detector through the video acquisition card, and each frame contains M rows and N columns of units. In the testing process, data from the digital output of the detector is always taken.

The $\sigma_{th}$ can be solved, from the equation $\text{NETD} = \sigma_{th} / SITF$ and the SITF obtained, NETD can be obtained.

The test results verified by the consistency test in the laboratory environment are shown in Table 1. It can be seen that the NETD test errors are all less than 5% at different ambient temperatures, showing reliable consistency. The test results also show that the NETD value of the thermal imager varies with the ambient temperature.

| The environment temperature ℃ | Number of tests | SITF count/℃ | 3D noise sound DTVH | NETD value (mk) | The result deviation(σ) |
|-------------------------------|----------------|--------------|----------------------|----------------|------------------------|
| 12                            | 1              | 110.88       | 15.73                | 141.87         | -0.16                  |
|                               | 2              | 112.50       | 15.99                | 142.15         | 0.21                   |
|                               | 3              | 113.52       | 16.10                | 141.79         | -0.15                  |

Figure 2. Schematic diagram of the standard test process for NETD

Figure 3. Measures the positive and negative sides of MRTD four-grid target
4.2 MRTD and MDTD tests

MRTD and MDTD measurements should be made at an ambient temperature of 10-30°C.

1) According to the parameters of the thermal imager to be measured, the test frequency points are determined and the target is installed.

2) Rotate the target with the lowest frequency tested to the position of the test target, adjust the background temperature difference of the target, set the parameters of the measured thermal imager to achieve the best observation effect, and record the parameters of the thermal imager and ambient temperature;

3) Reducing the target background temperature gradually until the target 4 shot is immediately indistinguishable, note the temperature difference at this point $\Delta T_+);

4) Gradually reduce the target background temperature difference until the target 4 shot is immediately indistinguishable, note the temperature difference at this point $\Delta T_-$;

5) The minimum resolvable temperature difference of the thermal imager at this frequency is:

$$MRTD(f) = \frac{\Delta T_+ + |\Delta T_-|}{2}, cor(T_m) \cdot \tau$$

(1)

6) Repeat the steps for the target in another space from low to high spatial frequency 3) ~5);

7) Draw the curve of MRTD(f).

The parameters of the thermal imager were as follows: the working band was 8 ~ 12 m, the field of view was 2×1.5 °, the ambient temperature was 16°C, and the transmittance of parallel light tube was 0.94. By comparing the test results with the manufacturer's test results, the maximum deviation is less than 15%. The specific test results are shown in Figure 4[5-6].

5. Conclusions

This paper mainly completes the research and application of infrared evaluation system, and puts forward the main parameter evaluation steps. In the actual performance comparison of infrared thermal imager, the test results achieve the expected results.
The evaluation system has been applied to the full performance technical evaluation of the infrared imaging equipment of power supply enterprises in Liaoning. The manufacturers have actively rectified or replaced the problems found in the evaluation, effectively avoiding the unqualified infrared thermal imaging equipment to flow into the power system in Liaoning.

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