Research on the visual detection device of partial discharge visual imaging precision positioning

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Abstract. Electrical equipment is composed of the basic components of the power system, and its performance has a direct impact on the safety and reliable operation of the system, whether it is large equipment such as generators, transformers, or small equipment such as power capacitors, insulators, etc, if equipment problems, not only affect the normal supply of electricity, more likely to cause major accidents. And electrical equipment manufacturing, transportation, operation and maintenance process will inevitably exist latent defects in the long-term environmental impact and high voltage, high field effect, dielectric will gradually damp, aging and deterioration affects the safety of electrical equipment run. Partial discharge mainly in the AC sinusoidal voltage generated directly endanger the normal operation of the insulation, the insulation of electrical equipment to strengthen the partial discharge detection equipment and to ensure the safe operation of the system is significant.

Introduction

Partial discharge measurement and diagnosis has become an important method for the assessment of high voltage electrical equipment operating status. From the mid-20th century, various countries on the mechanism of partial discharge of electrical equipment to do a lot of research, and has made great progress. Existing detection methods can be put through physical testing to determine whether the game has occurred inside the device PD, PD power for accurate positioning is currently developing a direction. Currently there are positioning method for locating cable discharge pulse reflection localization method, the internal power transformer for - acoustic detection and localization method for GIS internal discharge Electro acoustic positioning method. Partial discharge detection insulated substation equipment more and more attention, and the current lack of an internal discharge for equipment insulation, safe, large-scale, fast and intuitive ease of operation of the charging means of detection.

Research on wavelet threshold de-noising

Specific processes wavelet threshold shrinkage denoising method is: the noisy signal on each scale wavelet decomposition, set a threshold, below the threshold amplitude wavelet coefficients set to 0, the threshold is higher than the wavelet coefficients or completely retained, or do the corresponding "contraction (shrinkage)" treatment. Finally, the wavelet coefficients obtained after treatment reconstructed using inverse wavelet transform, image denoised. In the wavelet thresholding denoising, according to the following formula for the global threshold is estimated that the threshold of wavelet coefficients are equal on each scale, and its expression is:

$$\lambda = \sqrt{2\ln(n)} \quad (*) \qquad (1)$$

(*) In the formula, n is the signal length. This method estimates the wavelet decomposition scale λ is independent on all scales, using the same threshold of wavelet coefficients shrink treatment. Thresholding wavelet coefficients, divided into soft threshold and hard threshold method[1-3]. Hard threshold method to retain only the absolute value greater than the threshold λ wavelet coefficients and wavelet coefficients are retained the same as the original coefficient, namely:

$$\eta_h(w_{j,k},\lambda)=\begin{cases} w_{j,k} & |w_{j,k}|\geq\lambda \\ 0 & |w_{j,k}|\geq\lambda \end{cases} \quad (2)$$

For soft thresholding wavelet coefficients less than the absolute value of λ is taken to zero, the absolute value is greater than the value of the wavelet coefficients λ with λ to shrink. Namely:

$$\eta_s(w_{j,k},\lambda)=\begin{cases} w_{j,k}-\lambda & w_{j,k}\geq\lambda \\ 0 & |w_{j,k}|<\lambda \\ w_{j,k}+\lambda & w_{j,k}\leq-\lambda \end{cases} \quad (3)$$

In view of the above drawbacks wavelet de-noising method, the project team made an estimated optimal threshold based on genetic algorithms.

Plane Coordinate System

Like the physical center of the image plane coordinate system is a coordinate origin of the coordinate system, as shown in Fig1.

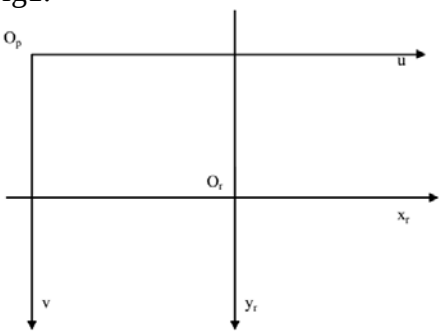

Fig. 1 As the physical plane coordinate system schematic

Fig1 Op-uv coordinates of the pixel plane coordinate system, Or-xr-yr physical plane coordinate system. That plane coordinate pixel rows of pixels Coordinate columns identified, as shown in Figure 2.

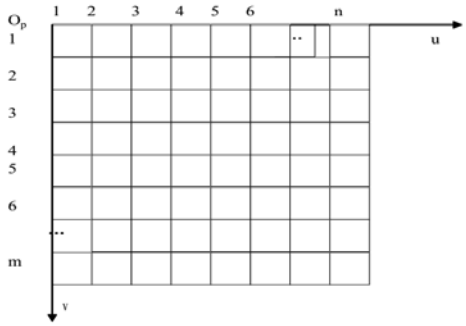

Fig. 2 Pixel plane coordinate system schematic

Wherein each pixel is represented as rows of the matrix, the number of columns, such as (u, v) = (1, 1) represents a first row and first column of pixels.

Visualization detector PD

After analysis and discussion, the project team will design PD visual detection device consists of two parts, the first part of the sensor system, mainly by 4 are mounted on the head of the sensor antenna and a camera mounted on the head of the composition position 4 sensor antenna and a relatively fixed cameras for video and discharge signal acquisition, the second part is the operation control system, the system is mainly used for a variety of control functions, and collected video and discharge signal processing operation, the final discharge synthesized image. Overall design of the apparatus shown in Figure 3. Camera: The main function is to capture the same direction with the

antenna real-time video image, and digitally processed for transmission to the host computer discharge imaging operation [4-6]. Signal acquisition system: The main function is to collect the UHF antenna signal for further processing (including frequency-selective filtering, amplification, noise reduction). The data processing system: The main function is to analog four antennas to form after treatments generate data transmission to the host computer for calculation.

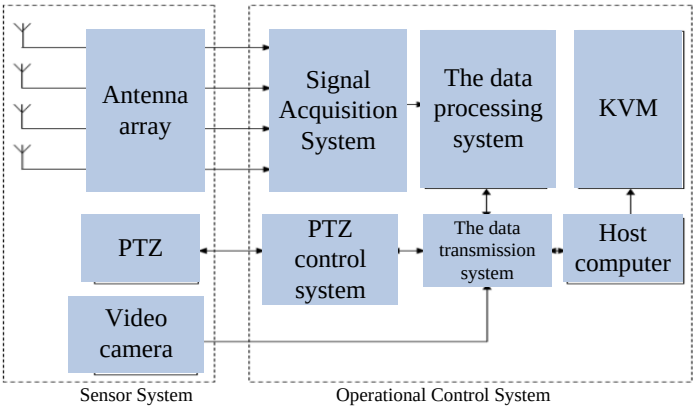

Fig. 3 PD overall design diagram visual detection device

Host computer and KVM: The main function is to control the operation of each device, the digital information signal after the reception processing and discharge, and calculates the spatial position of the discharge signal, and with the camera to capture the image projection operation, and finally form a discharge image, and through KVM displayed. PTZ control system: The main function is to receive control commands the host computer and compiled after transmission to each head, so head movement by command, and after receiving head angle data compiled backhaul back to the host computer deal with.

Research status

Partial discharge measurement and diagnosis has become an important method for the assessment of high voltage electrical equipment operating status. From the mid-20th century, various countries on the mechanism of partial discharge of electrical equipment to do a lot of research, and has made great progress. Existing detection methods can be put through physical testing to determine whether the game has occurred inside the device PD, PD power for accurate positioning is currently developing a direction. Currently there are positioning method for locating cable discharge pulse reflection localization method, the internal power transformer for - acoustic detection and localization method for GIS internal discharge Electro acoustic positioning method. The basic idea of GIS internal discharge Electro acoustic positioning method is to first use of UHF sensors positioned once GIS analysis to determine the approximate range of insulation defects, and while using UHF sensors and ultrasonic sensors for secondary location analysis, to achieve insulation accurately locate defects. Electro acoustic positioning method due to the simultaneous detection of partial discharge of electromagnetic signals and ultrasonic signals, so by the two sensor signals to be analyzed more effectively ruled site interference and improve the positioning accuracy of the partial discharge and defect type recognition accuracy, conducive to discover and identify insulation defects, security maintenance of GIS.

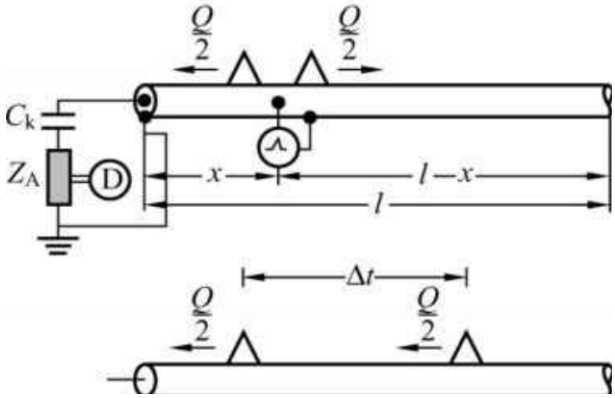

Figure 4 The principle of pulse-echo location in the cable schematic

Testing a cable length l, assuming x occurs at the end away from the partial discharge test, the pulse propagation along the cable to the two opposite directions, wherein a test pulse after the time t1 reaches the end; the other end to end to the test pulse propagation, and in peer communication to the test side after reflection, time t2 to reach the test side. According to two pulse arrival time difference between the tests side Δt, calculate the position of the partial discharge occurs. Internal electrical transformer - acoustic detection principle location method is installed in the transformer tank wall outside a plurality of ultrasonic sensors to partial discharge pulses of electricity as a trigger reference signal, and record the electrical pulse signal and n-way ultrasonic signals, and compared to the measured time delay t and the ultrasonic signal as an electric signal arrives from the point of partial discharge propagation time of each sensor; equivalent to the speed of sound v obtained by multiplying the time delay t from the discharge point to the space of each sensor, in order to solve equation column, thereby considered discharge location.

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Overall program of study

Verified by theoretical frequency antenna selection 20M to discharge points positioned by 8 antenna arrays, the 8 in the same plane of the directional antenna with 45 degrees in one direction a, surrounded by a ring 360, a when the direction of discharge, the sensor facing the antenna received the strongest signal, while each of the other direction of the antenna sensor signal received will gradually decrease, in order to confirm the discharge point of the horizontal direction, then the sensor array to the vertical plane adjusting direction and then conduct a test to determine the direction perpendicular to the direction of the results of the cross discharge point, horizontal, vertical directions after the discharge point is, finally the camera at the direction of the formation of discharge visualization. This method is relatively easy to implement, but only set the direction of the discharge point, and measurement error will cause large deviation discharge position display, so the project team decided to switch after a demonstration more complex and difficult to locate space delay methods to achieve the positioning of the discharge point.

Delay space positioning method is by comparing four receive antennas in the same discharge sensor signal time difference of arrival of each sensor, and then through the spatial geometry of the equation to solve the three-dimensional coordinates of the discharge location space, in order to achieve the purpose of positioning, then this coordinate projection onto a video picture in order to achieve real-time visual effects discharged, this method will achieve a more accurate positioning and enhanced ease of use, and ultimately determine the system works as shown in Figure 5.

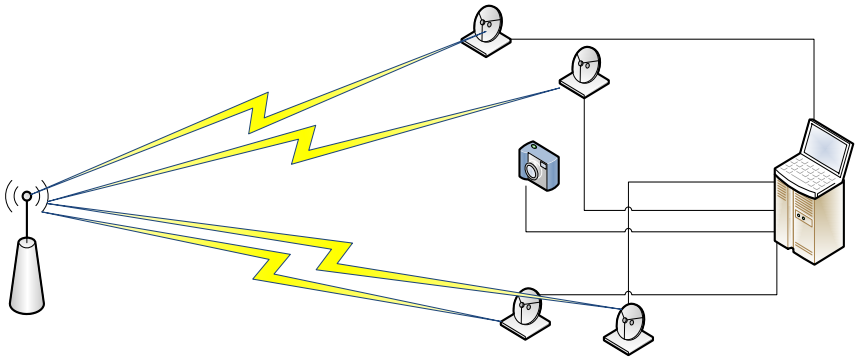

Figure 5 determine the system schematics

Methods sensor system antenna

Initial selection of Omni-directional antenna is because the scene of the discharge signal may come from various directions, the unidirectional antenna can receive signals in all directions of the discharge, is conducive to the discharge point of the detection field, its frequency is 300-600M, is detected discharge UHF the most classic of frequency, bandwidth and 300M for more discharge UHF signal energy, but also help to improve the detection sensitivity. Through simulation testing after discharge, found that there are two questions to the whole antenna: one sensor antenna is often triggered by foreign (non-discharge point) signal, a signal discharge points were covered and do not show up and really come from; Second, the sensor antenna received signal quality is poor, often appear as clutter waveform, rather than the real discharge pulse waveform.

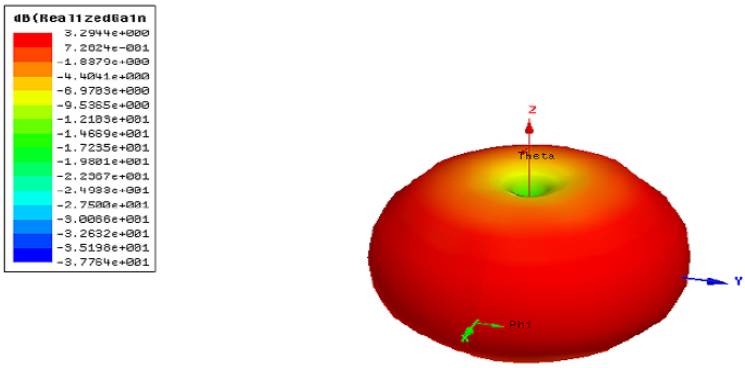

Fig. 6 Omni directional antenna gain patterns in three dimensions

After analyzed, the project team considered Omni directional antennas affects the measurement result, because the unidirectional antenna can receive signals in all directions, so the possibility of being affected by the interference signal is very large, although the bandwidth of the sensor can be improved antenna 300M detection sensitivity, but it also receives the interference signal more frequencies, additional unidirectional antenna ground reflected wave is affected by the discharge waveform of the measured signal quality is poor, difficult to identify.

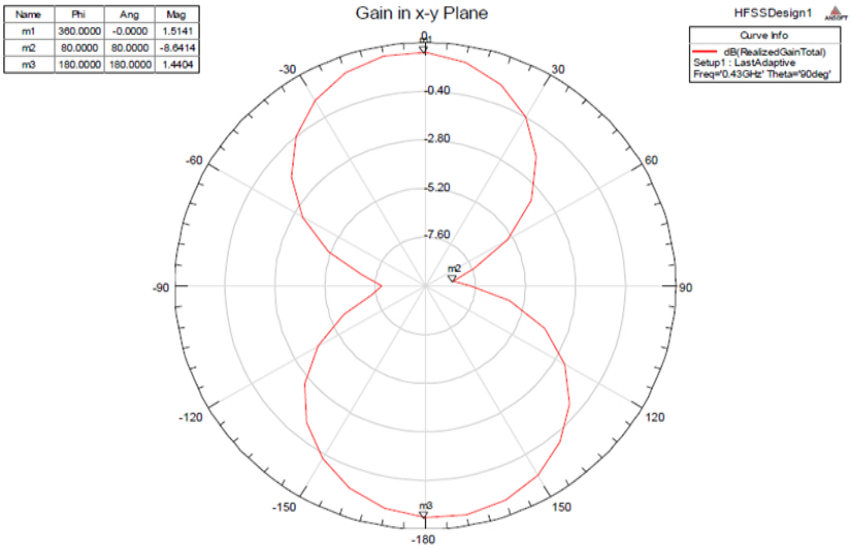

Fig. 7 wideband planar antenna gain patterns horizontal

After testing, the small size of the sensor array to solve the problem of mutual occlusion signal, but the signal quality is still not ideal, analyze the reasons: the gain from the antenna can be seen, although this may reduce interference on both sides, but the positive direction of the interference still exist, especially in the reflection interference from the ground, seriously affecting the received signal waveform quality discharge, unable to achieve the project requirements.

Summary

PD visual detection device currently there are some errors in the visual image positioning accuracy, mainly because the sensor antenna array is currently placed in the way of artificial structures, spatial coordinate system input bias will be to develop relevant bearing means to achieve retractable sensor array in a fixed position, is moved manually so as to generate coordinate offset.

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