

Research on the electromagnetic disturbance characteristics of lightning GIS equipment intelligent components

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Abstract. In order to improve the reliability of power supply, a large number of GIS equipment and its intelligent components are used in smart substations. In order to further study the electromagnetic disturbance characteristics of intelligent component ports under lightning, we developed a set of GIS device intelligent components port electromagnetic disturbance measurement system. First, the hardware structure of the GIS device and its intelligent component characteristic measurement system is given, and the corresponding software main program structure is given in this paper. Then combined with the engineering practice, the structure of the corresponding test experiment system is given. Using this experimental test system, the lightning electromagnetic disturbance characteristics of GIS equipment and its intelligent components under different conditions are obtained. The results of this study can be used to study the overall lightning stroke characteristics of intelligent substations.

1. Introduction

Gas insulated switchgear, referred to as GIS. GIS has the advantages of small area, high reliability, high security, and small maintenance work. It is one of the important equipment of smart substation.^[1-2]

In order to further study the electromagnetic disturbance characteristics of intelligent component ports under lightning, we developed a set of GIS device intelligent components port electromagnetic disturbance measurement system.

2. Research method

2.1. The hardware composition of the measurement system

The measurement system is developed on the basis of acquisition card and ATX motherboard. It's hardware consists of data acquisition card, high voltage probe, mini-ATX motherboard, DC-ATX power module, lithium battery, fibre transceiver, fan and shielding box.

Figure 1 is a schematic diagram of the structure of the measurement system. Among them, the high voltage probe of the measurement system is connected by a shorter measuring lead and the sensor port. The shielding box between the sensor and the measuring system is connected by a plastic metal hose. The measuring system is supported by the insulation support so that the sensor box and the shield box are shielded as whole and single point grounding. After the signal is divided by the high-voltage probe



and collected by the data acquisition card, the obtained data is processed by the ATX motherboard, and then the result is transmitted to the remote PC through the optical transceiver. In order to further reduce the volume of the device and optimize the heat dissipation, the power supply adopts the combination of DC-ATX module and lithium battery, which can supply directly to the main board without the need of inverting.^[3-5]

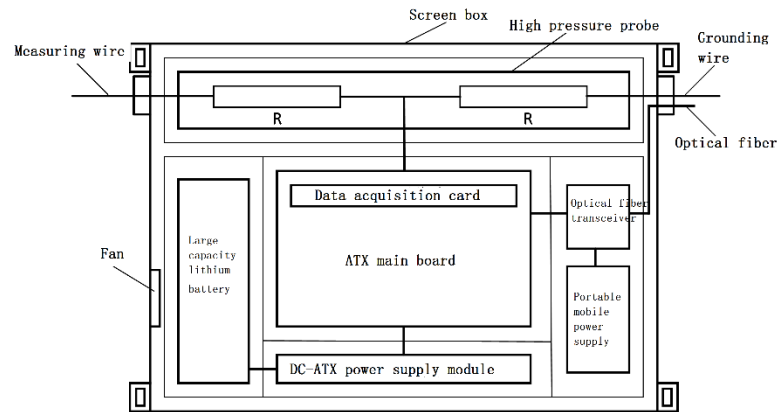


Figure 1. Hardware structure diagram of measurement system

2.2. Software design of measurement system

Figure 2 is the structure diagram of the main program of the data acquisition program in the measurement system. In the main program, you can set the name and location of the waveform storage file.

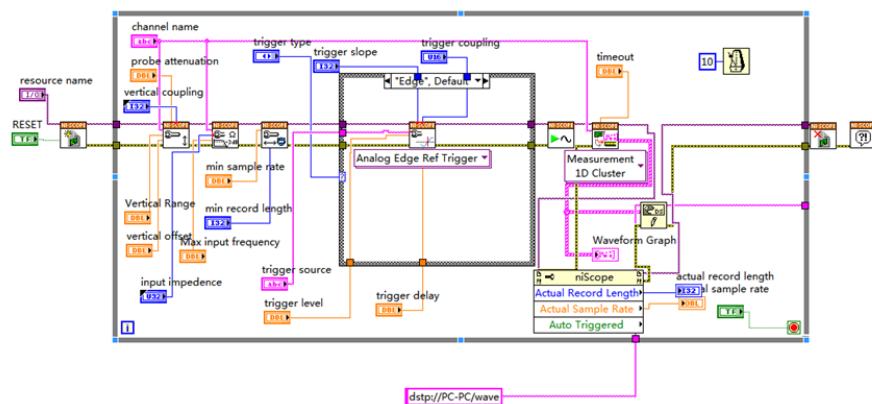


Figure 2. The structure diagram of the main program of the data acquisition program

3. Characteristics Research

3.1. Characteristic test system

Because of the complexity of the electromagnetic environment of the substation, the field measurement is the main means to obtain the electromagnetic disturbance data of the GIS intelligent component port. However, the GIS devices at the substation are usually in a well installed state, and no other access systems can be connected. Although they are not packaged, they are not allowed to be tested directly for safety reasons.

Therefore, this paper proposes a simulation test method for electromagnetic disturbance of GIS device intelligent component port. Without changing the sensor and intelligent components of GIS device, the electromagnetic disturbance level of GIS device sensor and smart component port is studied. A simulation test system is presented in this paper. Its structure is shown in Figure 3. It is

applied to the GIS experimental research platform of North China Electric Power University, and it can get the time domain and frequency characteristics of the voltage waveforms when surge disturbance is applied to different locations of GIS pipelines.

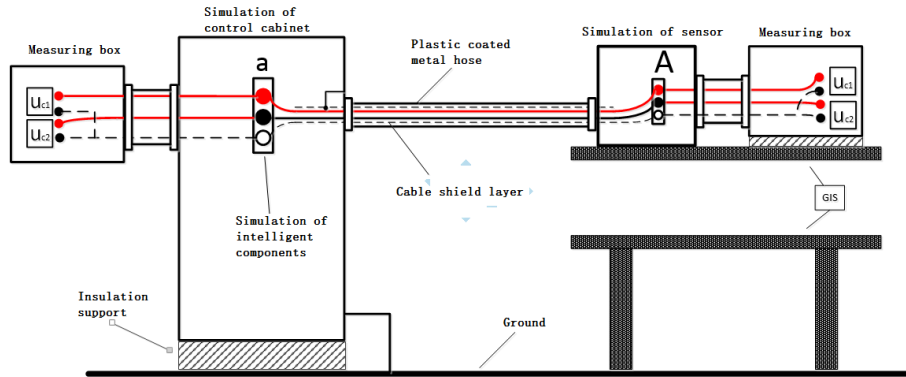


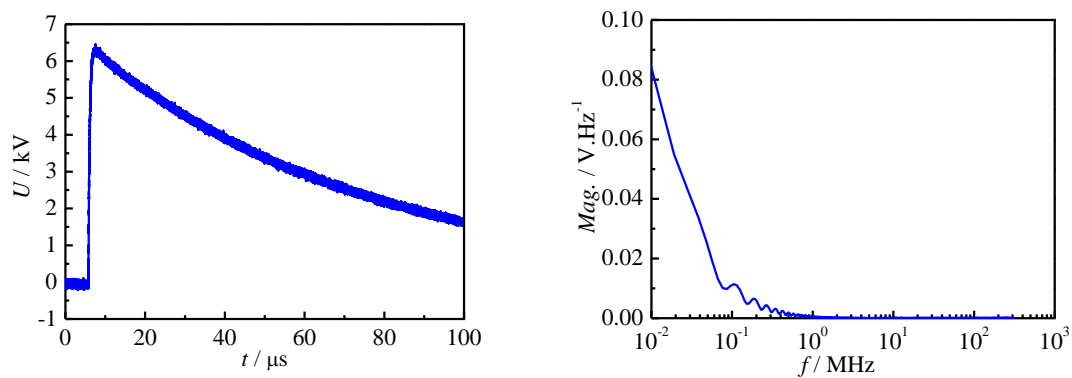
Figure 3. The structure diagram of the characteristic test system

According to the above system arrangement, the characteristic test data for reference can be obtained by using the switch operation of the GIS equipment when the substation is debugged or overhauled.

3.2. Characteristic test results

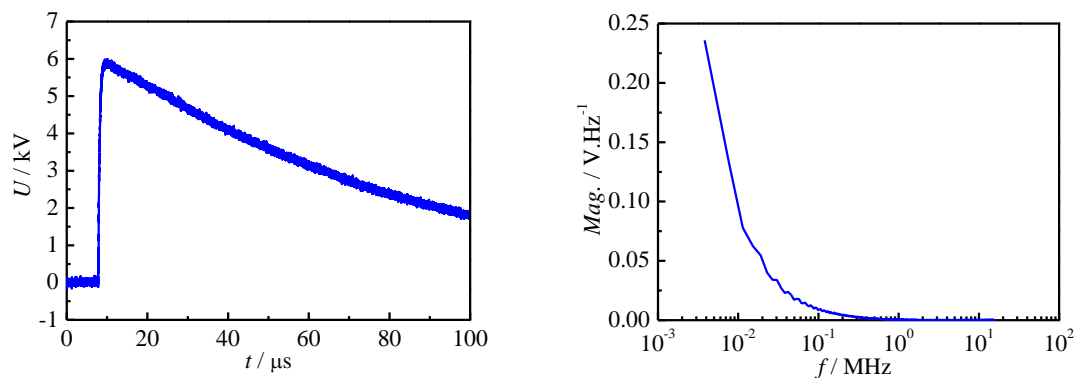
3.2.1. The voltage wave between the central guide rod and the shell at the end of GIS pipe

The excitation source is a lightning wave generator. Figure 4(a) shows the spectral density of the voltage of a lightning wave generator.



(a) the voltage time domain waveform (b) the frequency spectrum density of voltage

Figure 4. The time domain voltage waveform and the frequency spectrum density of the voltage between the central guide rod and the shell at the beginning of the GIS pipe



(a) the voltage time domain waveform (b) the frequency spectrum density of voltage

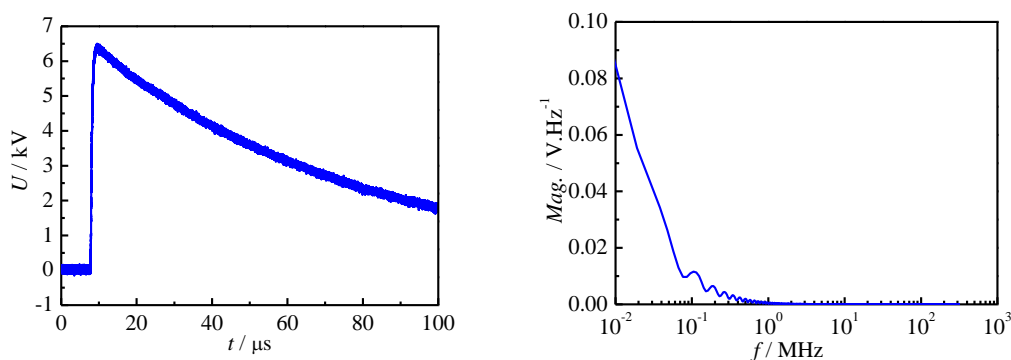
Figure 5. The time domain voltage waveform and the frequency spectrum density of the voltage between the central guide rod and the shell at the end of the GIS pipe

Figure 4(a) is the voltage time domain waveform between the central guide rod and the shell at the beginning of the GIS pipe, that is, the voltage waveform of the source. Figure 5(a) is the voltage time domain waveform between the central guide rod and the shell at the end of the GIS pipe.

As can be seen from Figures 4 and 5, when the excitation source is a lightning wave generator, the amplitude of the voltage between the central guide rod and the shell at the beginning of the GIS pipe is 6.4 kV, the wave front time is $1.3 \mu\text{s}$, and the main frequency range is 0~300 kHz. The amplitude of the voltage between the central guide rod and the shell at the end of the GIS pipe is 6 kV, the wave front time is $1.7 \mu\text{s}$ and the main frequency range is 0~200 kHz. Compared with the beginning end, the amplitude decreases and the frequency band widens.

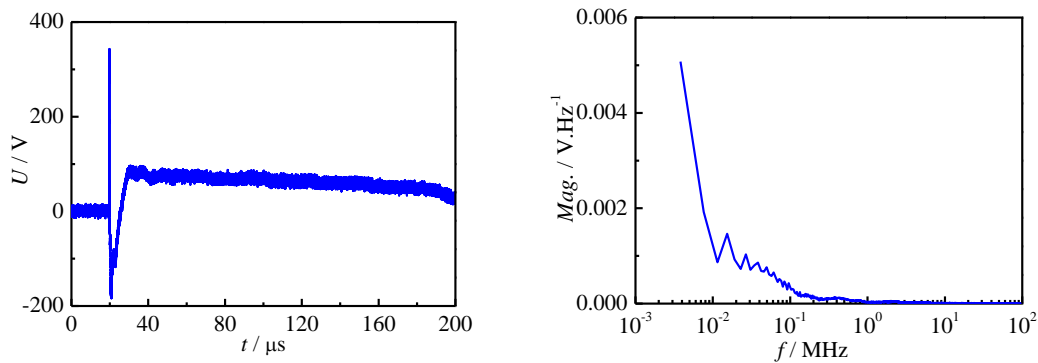
3.2.2. The voltage waveform between the shell and the ground at the end of the GIS pipe

From Figure 6 and Figure 7, we can see that when the GIS shell is not grounded, the voltage amplitude between the central guide bar and the shell of the GIS pipe is 6.5 kV, the wave front time is $1.3 \mu\text{s}$, and the main frequency range is 0~300 kHz. The amplitude of the voltage between the shell and the ground at the end of the GIS pipe is 350 V, and the main frequency range is 0~200 kHz.



(a) the voltage time domain waveform (b) the frequency spectrum density of voltage

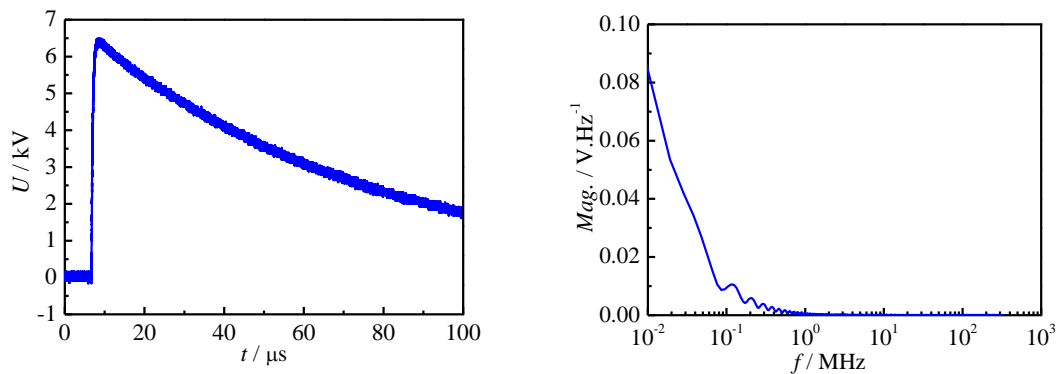
Figure 6. The time domain voltage waveform and the frequency spectrum density of the voltage of the lightning wave generator when the GIS shell is ungrounded



(a) the voltage time domain waveform (b) the frequency spectrum density of voltage

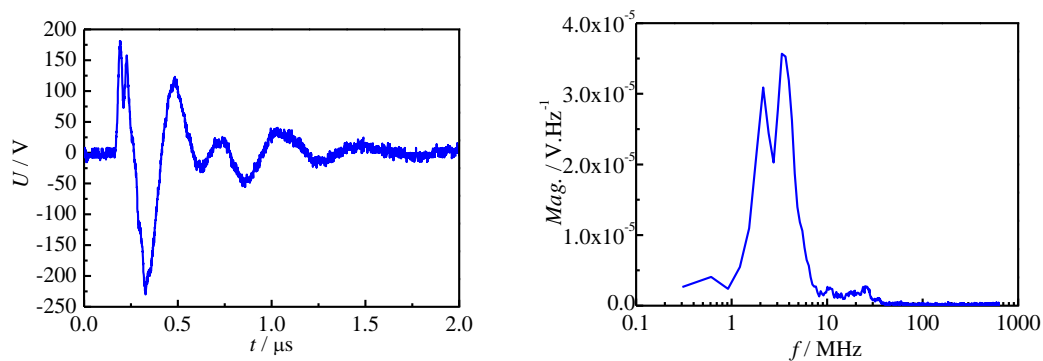
Figure 7. The time domain voltage waveform and the frequency spectrum density of the voltage of between the shell and the ground at the end of the GIS pipe when the GIS shell is ungrounded

From figure 8 and Figure 9, we can see that when the GIS enclosure is grounded, the voltage amplitude between the central guide bar and the outer shell of the GIS pipeline is 6.4 kV, the wave front time is 1.3 μs, and the main frequency range is 0~300 kHz. The amplitude of the voltage between the shell and the ground at the end of the GIS pipe is 250 V, and the main frequency range is 1~10 MHz. Compared with the ungrounded shell, the amplitude of the voltage when the GIS shell is grounded is reduced and the main frequency increases.



(a) the voltage time domain waveform (b) the frequency spectrum density of voltage

Figure 8. The time domain voltage waveform and the frequency spectrum density of the voltage of the lightning wave generator when the GIS shell is grounded

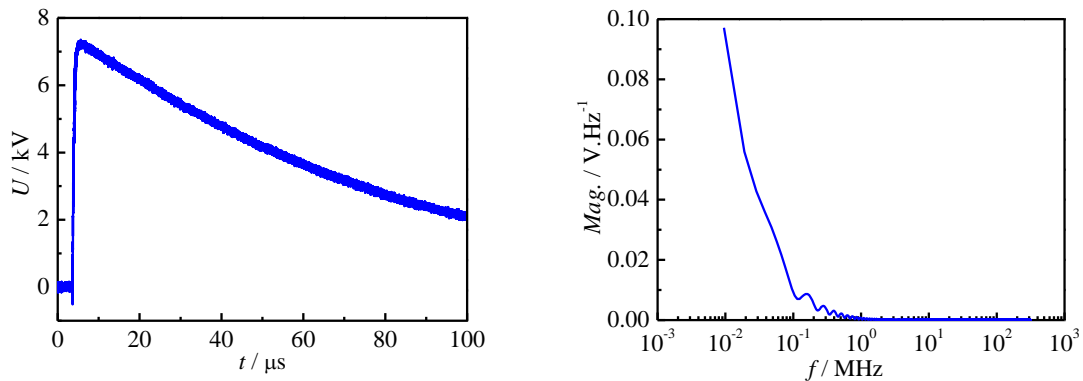


(a) the voltage time domain waveform (b) the frequency spectrum density of voltage

Figure 9. The time domain voltage waveform and the frequency spectrum density of the voltage of between the shell and the ground at the end of the GIS pipe when the GIS shell is grounded

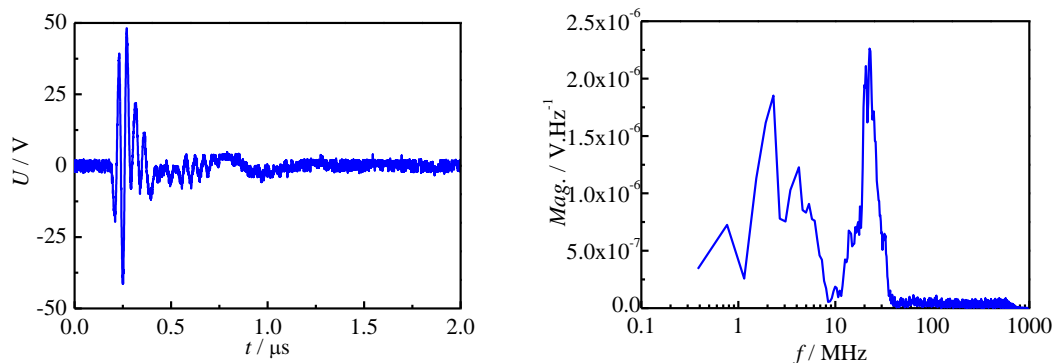
3.2.3. The voltage waveform between the secondary cable core line and the ground at the simulated sensor port

The excitation source is a lightning wave generator. Figure 10 (a) is the excitation source voltage waveform, and Figure 11 (a) is the waveform of the voltage time domain between the secondary cable core line and the ground at the simulated sensor port.



(a) the voltage time domain waveform (b) the frequency spectrum density of voltage
Figure 10. The time domain voltage waveform and the frequency spectrum density of the voltage of the lightning wave generator

From Figure 10 and Figure 11, we can see that when the excitation source is a lightning wave generator, the voltage amplitude between the central guide bar and the outer shell of the GIS pipe is 7.3 kV, and the main frequency range is 0~300 kHz. The voltage amplitude between the two cable core line and the ground of the simulated sensor is 50 V, and the main frequency range is 1~30 MHz.



(a) the voltage time domain waveform (b) the frequency spectrum density of voltage
Figure 11. The time domain voltage waveform and the frequency spectrum density of the voltage of between the secondary cable core line and the ground of the simulated sensor

3.2.4. The voltage waveform between the secondary cable core line and the ground at the simulated control cabinet port

When the excitation source for the lightning wave generator, the voltage between the secondary cable core line and the ground at the simulated control cabinet port is very small, less than the voltage noise, and unable to accurately display the waveform oscilloscope.

4. Conclusion

By the above analysis, it can be known that the electromagnetic disturbance characteristic of intelligent component ports under lightning is researched. In order to study the lightning electromagnetic harassment characteristics of GIS equipment and its intelligent components, the hardware and software system structure of the measurement system was designed. Combined with the

engineering practice, the lightning electromagnetic disturbance characteristics of GIS equipment and its intelligent components under various conditions are analysed.

The results of this study can be used to study the overall lightning stroke characteristics of intelligent substations.

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