Research on Induced Voltage and Operating Overvoltage of EMU

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Abstract

At present, EMU trains mostly use electronic voltage transformers for real-time monitoring of contact network voltage. Electronic voltage transformers have advantages such as small size, light weight, and excellent electromagnetic interference resistance. When a train passes through the AC-AC phase separation zone, the voltage transformer may be subjected to high-frequency and high-voltage impacts due to the Induced Voltage or VCB operation, which seriously affects the stable operation of the train. This article designs a testing plan for electronic voltage transformers and conducts actual measurement verification during the main line operation of the train. The testing results show that the impact amplitude of the PT power supply incoming line during VCB operation of the vehicle is 216V.

Keywords

EMU; Electronic Potential Transformer; VCB; Overvoltage; High-Frequency Percussion.

1. Introduction

Many scholars have conducted extensive research on the surge overvoltage and switching overvoltage of the body lifting pantograph on trunk railways. During the VCB closing and breaking operation[1], the magnetic field and electrical energy stored by the capacitors and inductance components in the train traction power supply circuit will rapidly convert into each other[2], forming electromagnetic oscillations, resulting in operating overvoltage surges several times the rated voltage in the traction power supply circuit[3]. When the circuit breaker is operated, due to the working status of the high-voltage components of the traction power supply system, the operating overvoltage will propagate in the traction system[4], causing the high-voltage components that are electrically connected to the circuit breaker to be impacted by the operating overvoltage[5], accelerating the insulation aging of the roof high-voltage components. Literature [6] established an equivalent circuit for the joint electrical phase division of the anchor segment, and obtained the relationship between the voltage phase of the power supply and the neutral overvoltage through simulation analysis. Literature [7] has analyzed the common overvoltage of overhead contact line. Literature [8] proposed two suppression methods for the surge overvoltage of the train lifting bow body.

2. Influence of Induced Voltage

According to the Maxwell equations, not only can conducting current generate a magnetic field, but also the changing electric field can generate a magnetic field[9], and the changing magnetic field also generates an electric field. During the operation of transmission lines and electrical equipment in the power system, due to the continuous changes in current, a changing magnetic field will be generated around it. When the changing magnetic field encounters a conductor[10], it will induce electric potential. This process of generating electric potential is called electromagnetic induction. The voltage generated by electromagnetic induction and electrostatic induction on conductors near power lines and electrical equipment is called induced voltage. Induced voltage can cause harm to personnel when forming a conductive circuit; If a conductive circuit is not formed, there is a safety hazard. The induced voltage should be limited to a certain range.

For the induced voltage, this article has designed a relevant testing plan. The neutral section on the debugging line is divided into two sections through three segmented insulators[11], near the AC side neutral section and near the DC side neutral section. The testing process is to first power on the AC side contact network and then power on the DC side contact network, and then power off the AC side contact network and then the DC side contact network. The test wiring schematic and actual wiring are shown in Figure 1.

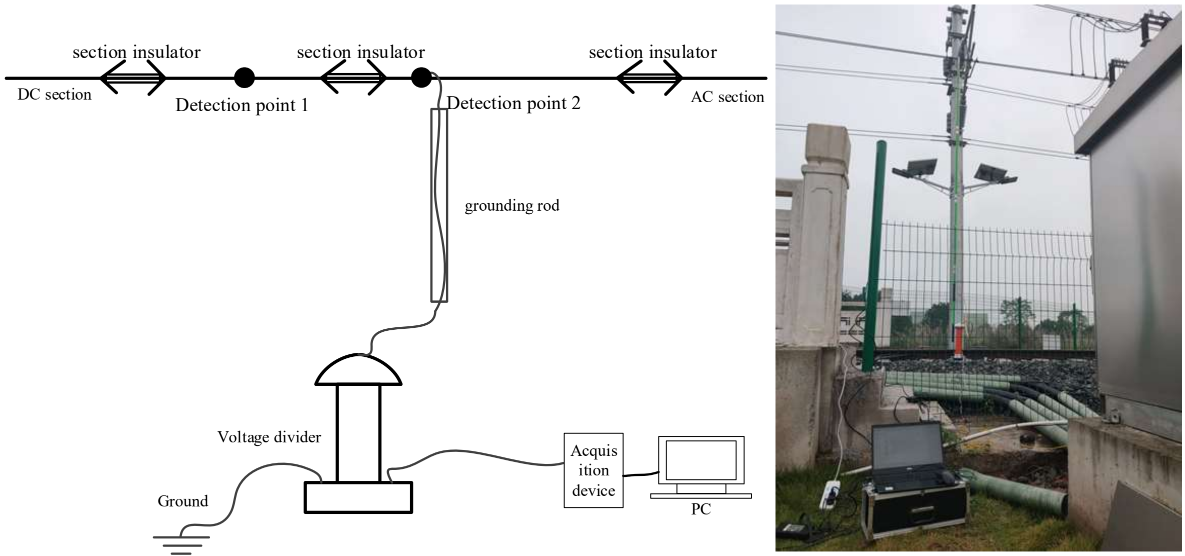

Figure 1. Picture of wiring principle and actual test

The waveform of the induced voltage near the neutral section of the AC side is shown in Figure 2. According to the analysis of measured data, when the contact network is powered on, the induced voltage near the neutral section of the AC side will undergo a brief oscillation process, during which the maximum induced voltage can reach 6000V. After the induced voltage waveform stabilizes, its effective value is 3890V. After the power outage of the AC testing contact network, the induced voltage near the neutral section of the AC side will gradually decay to the level before the test after about 17 seconds, while the power outage of the DC side contact network has no significant impact on the induced voltage near the neutral section of the AC side.

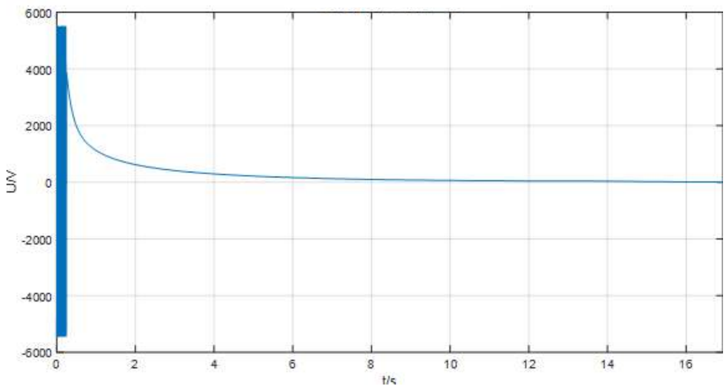

Figure 2. Induced voltage waveform

ISSN: 2414-1895 DOI: 10.6919/ICJE.202312_9(12).0018

3. Influence of Switching Overvoltage

In AC operation mode, the power supply unit is powered by the pantograph and supplied to the motor through the vehicle Vacuum Circuit Breaker (VCB), transformer and corresponding AC/DC converter. In the DC operation mode, the power supply unit is taken by the pantograph and directly fed to the DC link of the AC converter, and after inverting, it supplies power to the traction motor. When EMU trains enter the phase separation zone, the VCB is disconnected and closed after leaving the phase separation zone, the operating overvoltage will be generated, and the operating overvoltage is a high-frequency signal, which will be coupled to the shielding layer through the wire core of the high-voltage cable and transmitted to the vehicle body from the grounding point of the cable shielding layer, resulting in the surge overvoltage of the vehicle body.

The overvoltage waveform generated by the first time the train passes through the split phase network voltage and VCB operation is shown in Figure 2. According to the analysis of measured data, the overvoltage amplitude caused by opening the VCB operation in the split phase zone can reach 37.3kV, and the overvoltage amplitude caused by closing the VCB operation when leaving the split phase zone can reach 44.9kV.

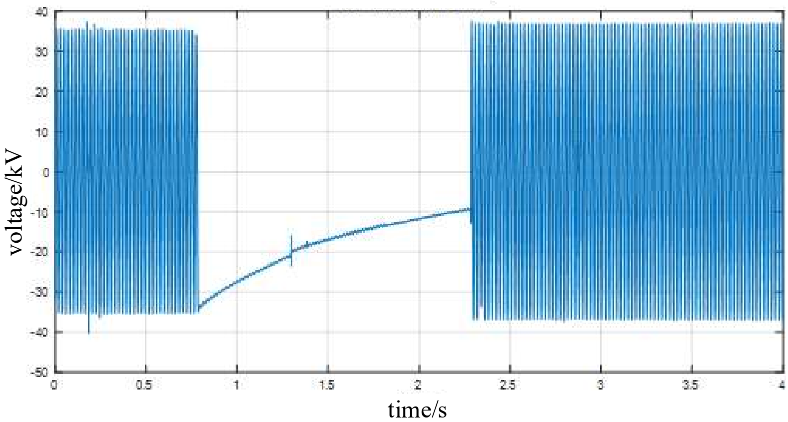

Figure 3. The first Operating overvoltage voltage waveform

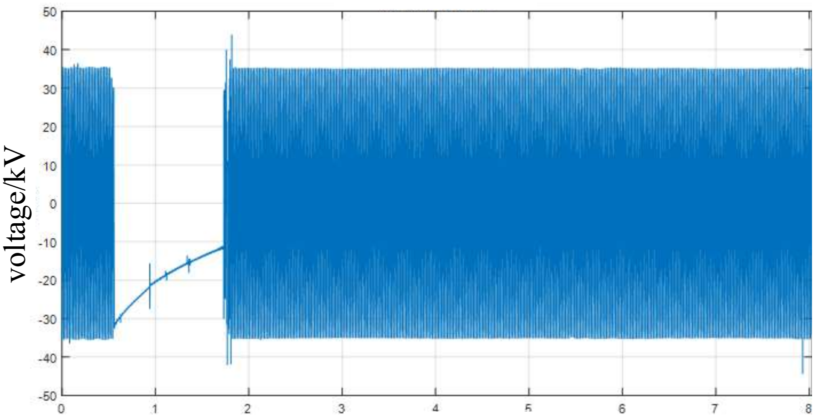

Figure 4. The second Operating overvoltage voltage waveform

The overvoltage waveform generated by the second time the train passed through the split phase network voltage waveform and VCB operation is shown in Figure 4. According to the analysis of measured data, the disconnection of VCB operation into the split phase zone did not generate

ISSN: 2414-1895 DOI: 10.6919/ICJE.202312_9(12).0018

overvoltage. The overvoltage of around 40-44kV that occurred during the phase transition process was caused by the arc generated by the pantograph sliding through the device type insulation joint in the phase zone. The overvoltage amplitude caused by closing VCB operation after leaving the split phase zone can reach 44.4kV. Check the work log of the voltage transformer and it was found that the transformer did not experience a restart fault.

4. Conclusion

The voltage surge generated by train closing and breaking VCB is accidental, and whether overvoltage can be generated is related to the voltage phase at the time of closing VCB. In dynamic testing, there was no significant overvoltage surge generated by closing the VCB, while the maximum overvoltage generated by opening the VCB was 44.2kV. The frequency of impact on the power supply of the network voltage transformer caused by VCB operation of the train is extremely high. Due to the logic of restarting the power supply of the train's network voltage transformer being 145V and lasting for more than 1ms, the maximum power impact caused by VCB operation of the train in this test reached 216V, but the duration was much less than 1ms (less than 10 seconds μ s) Therefore, the network voltage transformer did not experience a restart fault.

Acknowledgments

Sichuan University of Science and Engineering Graduate Student Innovation Fund (Y2022152).

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