

## Design of an Outdoor Impulse Voltage Generator in High Altitude

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**Abstract:** This paper elaborates on a design concept of an outdoor impulse voltage generator test system located on Yangbajing of Tibet, altitude of 4300 meters, mainly focus on the transmission line and insulating characteristics study on high altitude above 4300 meters. The research filled the blank of the ultra high voltage test field in high altitude in the worldwide, especially in the field of discharge characteristics study with long air gap in China, consequently demonstrated the possibility of ultra high voltage transmission in Tibet. The CDY-HW4.2MV/200kJ impulse voltage generator test system can output the standard lightning impulse, switching impulse. The stage voltage of this 4.2MkV/ 200kJ equipment is 200kV and 22 stages for margin consideration. In order to make the transport, installation and long term maintenance convenient, dry capacitors inside and outside protective barrel using once-shaping insulation cylinder with anti-ultraviolet ray coatings are constructed; 4.2MV damped capacitive voltage divider is structured to be an insulating cylinder with compounded silastic covering, the measurement and control system are installed in control room; the whole frame can be fulfilled the requirement of 8 magnitude Seismic fortification. The output voltage of lightning and switching impulse is 2058kV and 1786kV respectively after preliminary commission.



Fig 1: 4.2MV Impulse Generator on set.

### Introduction

The complete 4.2MV/200kJ impulse voltage generator test system is composed of CDY-HW4.2MV/200kJ generator stack, charging unit, 4.2MV damped capacitive divider, CCK-2511 computer control (fibre) and measurement system. The operating of this equipment is satisfactory and can meet all test requirements after preliminary commission.

#### 1. CDY-HW4.2MV/200kJ impulse voltage generator

Impulse voltage generator is an H series structure with epoxy protective covering so as to greatly reduce the workload and

working strength. Large diameter epoxy cylinder with anti-ultraviolet ray coatings can prevent the installation from degradation due to strong ultraviolet in such high altitude. The conjunction of insulating tube between generator and covering and the extruded silastic sheath results the enhanced system stability and reliability. The mechanical construction of the protective covering with 23 meters height, 4030 mm diameter and 30mm thickness is based on the consideration of max 36m/s wind speed,  $3\text{m/s}^2$  horizontal acceleration,  $1.5\text{m/s}^2$  vertical acceleration and 1.5 margin.

The impulse generator adopts same structure of China Electric Power Research Institute 7.2MV impulse generator [1]. The HTMMJ100-1.0 dry capacitor with low inductance is used to reduce volume and weight. To reduce wind resistance, the material of corona shield used stainless steel with the dimension of  $\Phi 7800/1400\text{mm}$ .

For the safety design, the total height of complete 4.2MV impulse generator test system is 24m, the insulating distance between stages is 965mm.

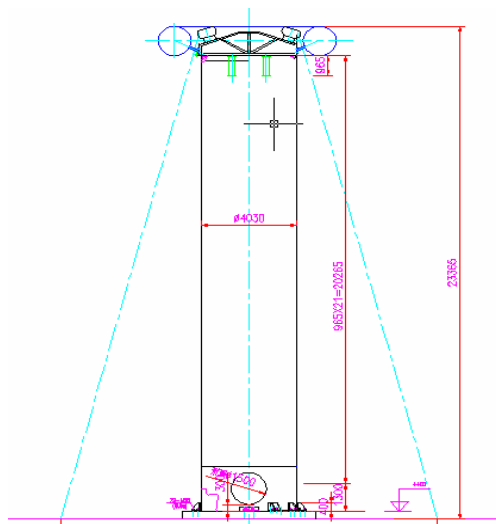


Fig 2 Dimensions of impulse generator

## 2. Charging Unit

Considered the special and multivariant climate of site, the design of charging unit employs symmetric dual side charging mode same as 7.2MV impulse generator supplied to China electric power research institute, The charging unit and generator stack are separated laid up in accordance with site actual situation, the former one is placed in the control room and charged the capacitor through high voltage DC cable. The temperature of control room is kept no less than  $-10\text{ }^{\circ}\text{C}$ , while the minimum surrounding temperature the generator can be operated is  $-40\text{ }^{\circ}\text{C}$ .

## 3. 4.2MV damped capacitive voltage

### divider

The design of 4.2MV damped capacitive voltage divider adopts the same structure and technique of our existing 7.2MV voltage divider, which consists of eight MWF 800-3200 impulse capacitors connected in series. The capacitance of this high voltage arm is 400pF; the secondary arm is composed of parallel connected monolithic ceramic capacitor. Corona shield with the dimension of  $\Phi 7400/1400 \times 2$ ,  $\Phi 4000/600 \times 2$  and 1800/400mm, and insulating rod with extruded silastic sheath are assembled on the top, 2/3 and 1/3 height of the divider which is totally 23meters

## 4. CCK-2511 computer control (fibre) and measurement system

The CCK-2511 computer control and measuring system consists of industrial control computer, programmable logic controller (PLC), thyristor voltage controller, ignition pulse amplifier, digital oscilloscope and printer. The control system adopt fibre transmission to achieve the function of monitoring and measuring the operating, parameters such as charging voltage, charging time, discharge gap, trigger mode and polarity revisal can be set through fibre transmission. The measurement of impulse waveform complied to relevant IEC standard is accomplished through Ethernet communication.

## 5. Installation and test

### 5.1 Installation

The completed 4.2MV impulse generator test system is located at high altitude test lab of Tibet, with the generator and measure voltage divider is outdoor installed, while the high voltage DC charging unit is installed in the first floor of measuring and control building, and the control console is installed in the second floor. Firm connection between impulse generator stack and reinforced concrete ground provide

improved earthing performance.

The structure of outside protective covering of this impulse generator is an epoxy cylinder. The cylinder is hoisted and vertically fixed up on the reinforced concrete ground; the internal components of generator are hoisted and installed by stages, as shown in fig 3 and fig 4. The corona shield is finally hoisted and connected with the covering after last stage is completed. Four insulating rods buried in advance between covering and grounding enhanced the system stability.



Fig 3 Hoisting of impulse generator



Fig 4 Installation of impulse generator

### 5.2 Output voltage of standard lightning impulse

The capacity of output voltage of lightning impulse is tested with no load; the waveform is shown as below:

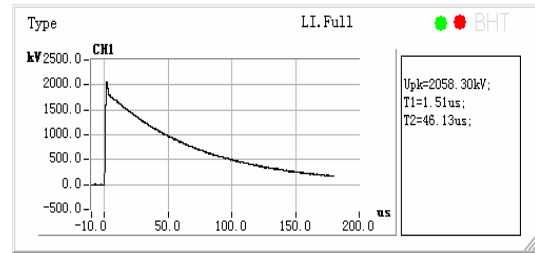


Fig5 voltage waveform of positive lightning impulse

### 5.3 Output voltage of standard switching impulse

For the purpose of test the output voltage of impulse generator switching impulse, a 6 meter metal stick is suspended to the 50m ×50m tower, metal plant electrode is laid under the stick. The conjunction of metal stick and plant to form a discharge gap test surrounding. The distance from the electrode to each side of the tower is more than 20m, and to the ground is 10.5m. The puncture waveform please refer to fig6.:

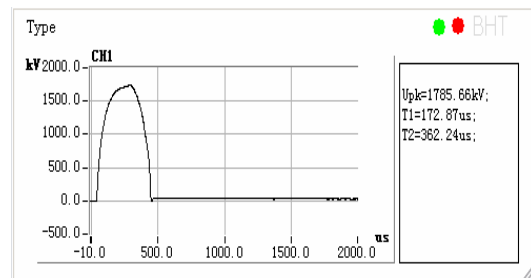


Fig6 Breakdown waveform of positive switching impulse

## 6. Conclusion

6.1 This 4200kV impulse generator is capable of outputting standard full lightning impulse  $1.2 \pm 30\% / 50 \pm 20\% \mu s$  and switching impulse  $250 \pm 20\% / 2500 \pm 60\% \mu s$ .

6.2 The output voltage of lightning and switching impulse is 2058kV and 1786kV respectively after preliminary commission.

## Reference

- [1] Aixiaoyu, AN OUTDOOR 7.2MV IMPULSE GENERATOR, ISH2009