## Preliminary desin on power supply system of superconducting test device based on long pulse signal

by

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### Research Background

- Key technologies of long pulse power supply
- Balance design of three winding phase-shift rectifier transformer
- Analysis of circular array structure of thyristor rectifier
- Design of balance reactor
- Simulation Verification





#### **Research Background**

- Long pulse operation is the main task for CRAFT power supply system.
- The power supply equipment suitable for long pulse operation is the premise to ensure stable operation.
- The power supply design based on long pulse is the main research content of this paper.

	W7-X	EAST	ITER	JT-60SA	CRAFT
Voltage	8kV	2kV	10kV	5kV	250V
Current	20kA	15kA	68kA	25.7kA	90kA
Magnet energy	-	0.4GJ	2.23GJ	1GJ	10GJ





#### **Research Background**



#### Research objective:

- High availability for long pulse operation.
- High reliability for system protection.
- Fast respond and high stability for plasma control.

**CRAFT Structural Layout** 





## Key technologies of long pulse power supply

#### **Research significance:**

High-power converter power supply system is built to meet the requirements of continuous improvement of long pulse parameters, and the power supply system is optimized and analyzed to provide support for the development of fusion reactor.



#### Research difficulties:

- •Thermal stability of power supply system.
- •Structural stability of power supply system.
- •Dynamic performance of power supply system.

#### **Research method:**

The optimized structure is adopted under long pulse.

The multi physical coupling method is used to study the

stability analysis of the system with multiple physical quantities

of electromagnetic, thermal, temperature and structure.



# Balance design of three winding phase-shift rectifier transformer



- Rectifier transformer is an important equipment to convert the grid voltage into the required AC voltage, previous transformer adopts same terminal output structure.
- Copper and symmetrical current output structure impedance consistency(current balance), low conductivity(temperature)

ASIPP



- Thyristor is an important device to convert the AC current and control high power output parameters.
- The current flowing into each thyristor needs to be equal, which is conducive to the stable operation of long pulses.

ASIPP



- A circumferential array thyristor layout is proposed.
- The uniform distribution of current is conducive to heat dissipation and current sharing , structural strength, which provides a reliable guarantee for the stable
  operation of long pulse.



- The overall thermal of rectifier is 49.57°C within reasonable range, compared with traditional structure, it is beneficial to availability.
- The uniform thermal distribution of thyristors is conducive to the structural stability.



- The stress of the current copper bar of the thyristor converter meets the requirements, and the shape variable is very small, so it is a very reliable structural design.
- Excellent structure design ensures stable operation under long pulse.



Maximum deformation at 400kA stress

#### Design of balance reactor

11



- The reactor can balance the current and is an important device for restraining current ripple.
- The current ripple will cause great interference to the equipment, affect the safe and stable operation, even fault, and cannot ensure the stable operation of long pulse.

### **Design of balance reactor**



- The thermal effect of long pulse operation is within the maximum acceptable range, ensuring safety and reliability.
- The reactor has sufficient structural strength to ensure stable operation of long pulse.

#### Simulation verification



- To verify the ability of the system to maintain long pulse operation, a simulation model is built to realize the stable operation of long pulse.
- The output of four converters can meet the requirements of high parameter long pulse.

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#### Summary

#### Content

- The magnet power supply suitable for long pulse operation, combined with multi-disciplinary knowledge, adopts a multi physical coupling analysis method to solve the electromagnetic, structural, thermal, fluid and other problems in the design process.
- The key technologies of transformers, reactors, thyristor converters and other important equipment suitable for long pulse operation are mainly studied.

#### Innovation



A symmetrical busbar structure is proposed to reduce the impedance and improve the response speed.



A topology of circular array thyristors is proposed, which improves the heat distribution, enhances the structural strength and reduces electromagnetic interference.



# Thank You

