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CEPC Megawatt-level High Power Density High Voltage Power System

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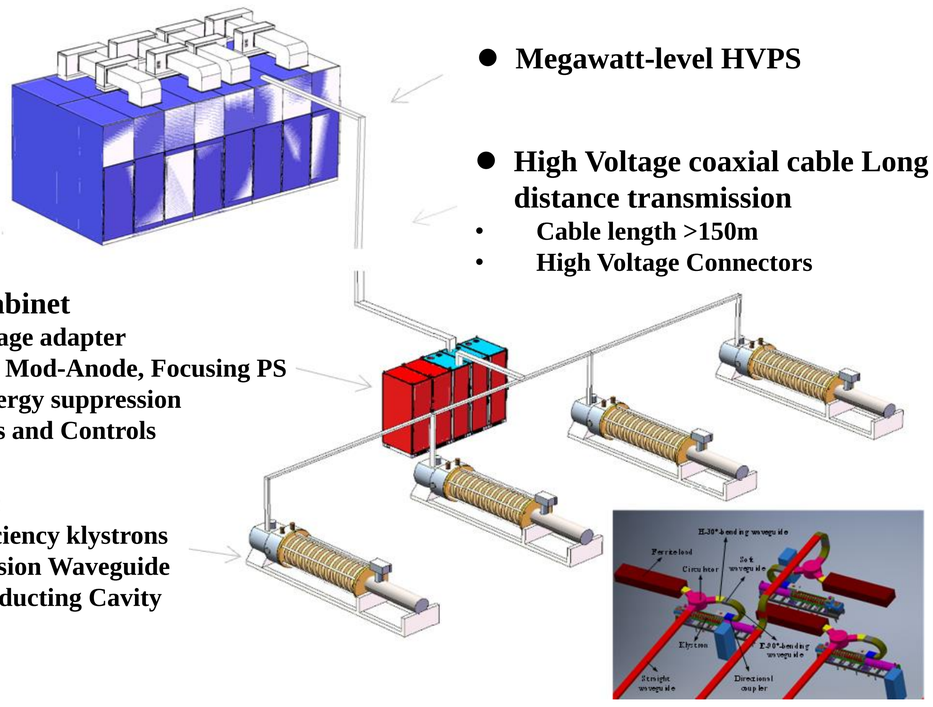
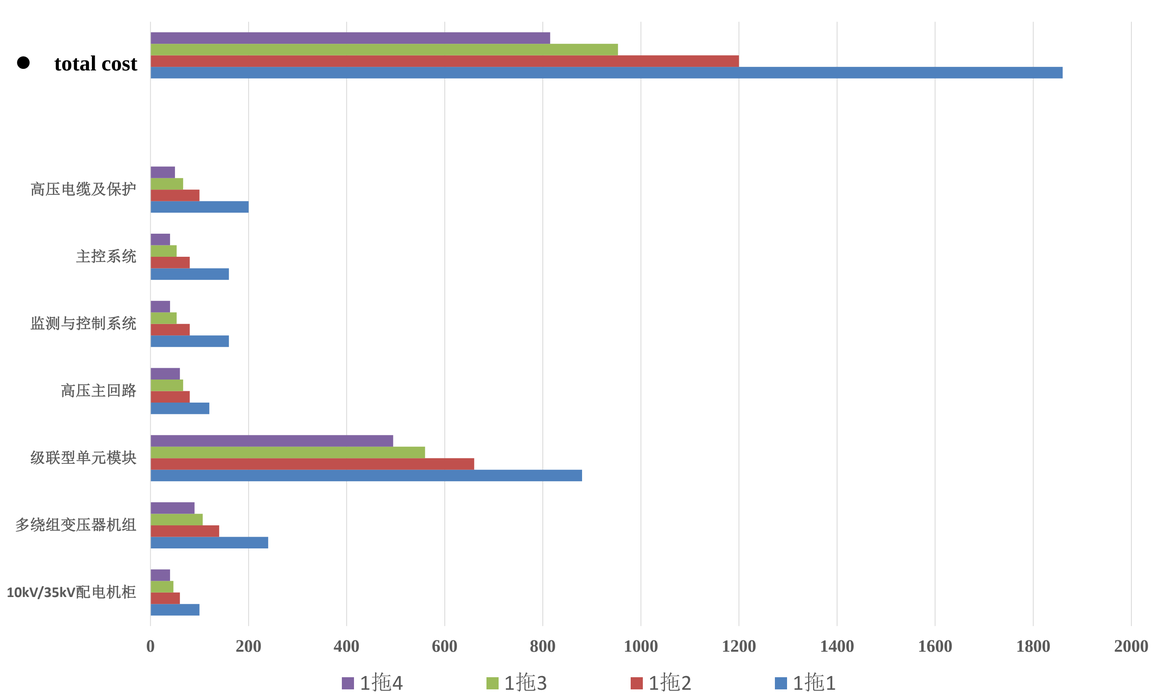
INTRODUCTION

The cost of large particle accelerator devices is expensive (up to billions), and the operating energy consumption is huge (hundreds of megawatts). Green, environmental economics and sustainability are hot topics in accelerator research. For the CEPC CDR/TDR, a high-efficiency RF power source system is planned. This system adopts a 1-to-1 scheme, necessitating 96 sets of 650MHz 800kW high-efficiency klystrons and PSM (Pulse Step Modulation) high-voltage power supply systems. This paper introduces a novel design scheme for high-voltage power supplies (HVPS) and explores the feasibility of using a 1-to-2 or 1-to-4 configuration, where a single megawatt high-power HVPS could drive multiple klystrons. The proposed design features high power density and hybrid modulation methods.



RF Power System Megawatt-level HVPS to Klystron with 1 to 2 or 1 to 4 Layout Schematic



Estimated cost of one high-voltage power supply/total cost for different scheme

The key advantages of this scheme include:

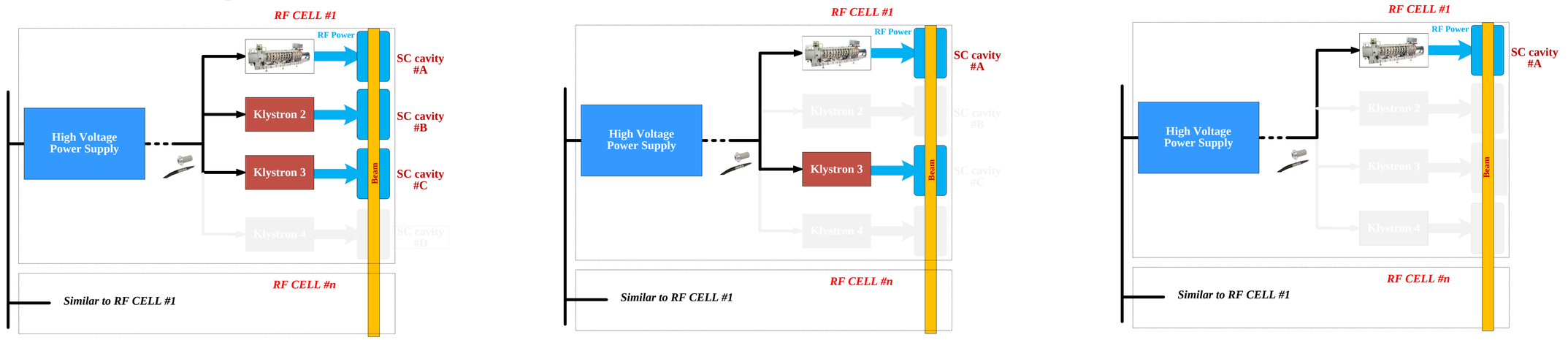
1) Cost Reduction: The new design is expected to cut project costs by 50%, making it a more economical choice for large-scale accelerator projects.

2) Improved Reliability: By increasing the Mean Time Between Failures (MTBF), the system's overall reliability is significantly enhanced.

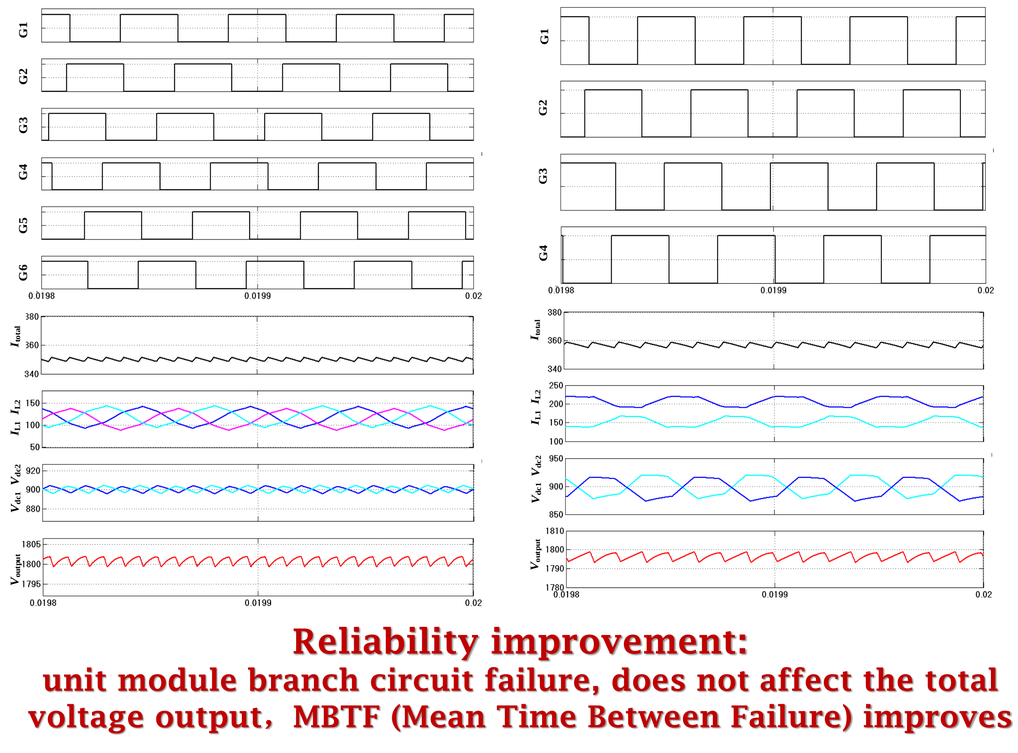
3) Enhanced Performance: The power supply performance for continuous-wave applications is improved, ensuring more stable and efficient operation.

4) Additionally, this new HVPS scheme can be utilized for power factor correction in large power grids. It offers a reactive power compensation capacity ranging from 2.19 to 5.475 Mvar（User-defined）, potentially reducing annual operating expenses by 15.33 to 38.32 million RMB.

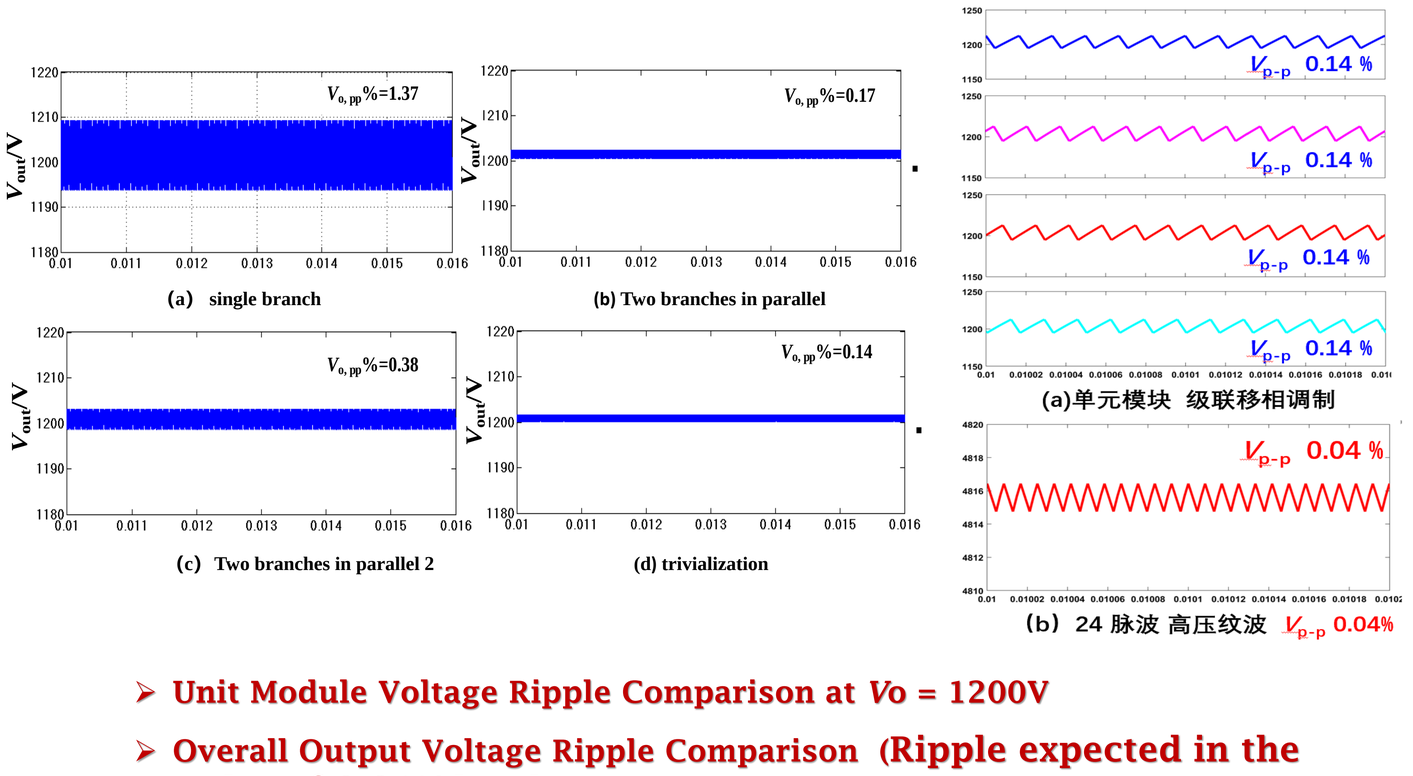
The proposed design scheme not only supports the green, energy-saving, and sustainable development of CEPC, but also applicable to others projects such as the Compact Linear Collider (CLIC) and the Future Circular Collider (FCC).



1 to 4, 1 to 3, 1 to 2, 1 to 1, can be customizable configured for redundancy



Reliability improvement:
unit module branch circuit failure, does not affect the total voltage output，MBTF (Mean Time Between Failure) improves



- **Unit Module Voltage Ripple Comparison at *Vo* = 1200V**
- **Overall Output Voltage Ripple Comparison (Ripple expected in the order of 0.01% level, 1% for conventional HVPS)**

REFERENCE

[1] Gao, J. CEPC Technical Design Report: Accelerator. Radiat Detect Technol Methods 8, 1–1105 (2024). https://doi.org/10.1007/s41605-024-00463-y