

DEVELOPMENT OF AN S-BAND PULSE COMPRESSOR*

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Abstract

We designed a pulse compressor for S-band high-power test stand at Tsinghua University. This pulse compressor is made up of a spherical resonant cavity with quality factor of 100,000 and an RF polarizer. It has the ability of compressing a pulse from 3.6 μ s to 300 ns with the power gain of 7. A short description of the pulse compressor is presented, together with the RF design.

INTRODUCTION

Pulse compressors have been widely used in many large research facilities, such as FELs and injectors of circular accelerators [1, 2]. These pulse compressors have ability of increasing the input power by several times, which reduce the demand of RF sources. Klystrons usually work as RF sources in accelerator field. In many cases, a pulse compressor compresses a pulse from a klystron and generates a shorter pulse with high peak power, powering several accelerating structures. This arrangement of klystron and pulse compressor reduces the number of RF sources and simplifies the RF system.

There are many kinds of pulse compressors. Some of them are passive and some are active. Comparing with active pulse compressors, passive ones are more stable and easier to fabricate. SLAC energy doubler (SLED), Barrel Open Cavity (BOC) and resonant delay line pulse compressor (SLED-II) are passive compressors with different RF components [3-5]. SLED and BOC use resonant cavities to store the energy of RF pulse, while SLED-II use long delay line to do the same thing. Recently a pulse compressor based on RF polarizer is designed by SLAC [6]. This pulse compressor is compact with only one resonant cavity.

At Tsinghua University, an S-band high-power test stand was constructed [7]. This test stand mainly consists of two 50 MW S-band klystrons, a SLED-type pulse compressor and two high power stainless steel loads. A 3 dB hybrid combines the powers from two klystrons into one, which is compressed by the pulse compressor. We design a new pulse compressor for this high-power test stand. The new pulse compressor is more compact with one resonant cavity and an RF polarizer. The RF design and the main parameters of the pulse compressor are described in this note.

MAIN PARAMETERS

The SLED-type pulse compressor to be replaced in the high-power test comprises of two identical cylinder reso-

nant cavities and a 3 dB hybrid. After combining the power from two klystrons, the input pulse length is 3.6 μ s, being compressed to 300 ns with compression ratio of 12. With this compression ratio, the coupling factor of the pulse compressor was designed to 5 with peak power gain of 5.6. The coupling of the new pulse compressor is optimized to 8 to obtain higher peak power and efficiency. This modification of coupling factor increases the peak power and the efficiency, as shown in Fig. 1. Figure 2 shows the waveforms of the old and new pulse compressors. With the same input pulse, the new pulse compressor generates a pulse with peak power of 7 and average power gain of 5.2. Table 1 shows the main parameters of the new pulse compressor.

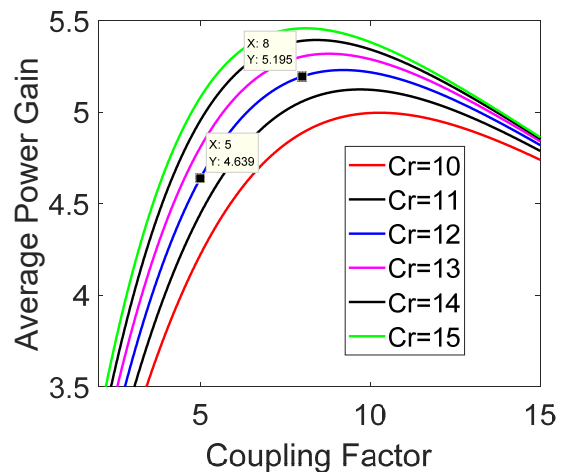


Figure 1: Average power gain of coupling factor with different compression ratio (Cr).

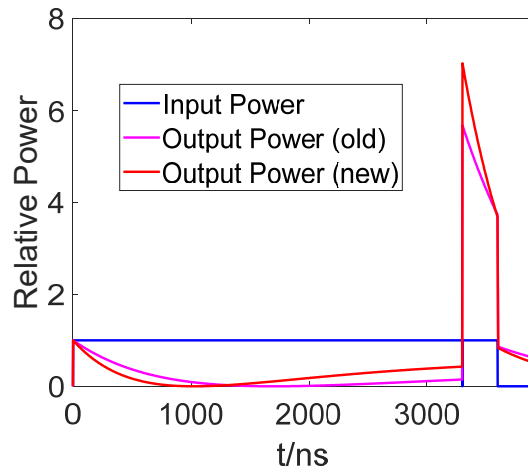


Figure 2: Input and output waveforms of the old and new pulse compressors.

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Table 1: Main Parameters of the Pulse Compressor

Pulse compressor	Parameter
Frequency	2.856 GHz
Unload quality factor	100,000
Coupling factor	8
Compression ratio	12
Input pulse length	3.6 us
Output pulse length	300 ns
Efficiency	41.6%
Peak power gain	7
Average power gain	5.2
Weight	55 kg

RF DESIGN

The new pulse compressor consists of a spherical cavity and an RF polarizer. This design benefits from the RF polarizer and can work with only one resonant cavity.

Spherical Resonant Cavity

The spherical resonant cavity is of high unload quality factor with two orthogonal resonant mode TE₁₁₂. Figure 3 shows the quarter of the spherical cavity with electric field or magnetic field. The fields inside the cavity is much larger than that on the surface. This feature of the field reduces the loss on the surface, which leads to large unload quality factor of 100,000 with the spherical radii of 130 mm. A cylinder waveguide with a taper connects with the spherical cavity. By changing the geometry of the taper, the coupling factor can be tuned to the designed value. Figure 4 shows the reflection coefficient curve of the spherical cavity. Within 200 MHz frequency span, there is only resonant peak and there are no other modes influencing the pulse compressor.

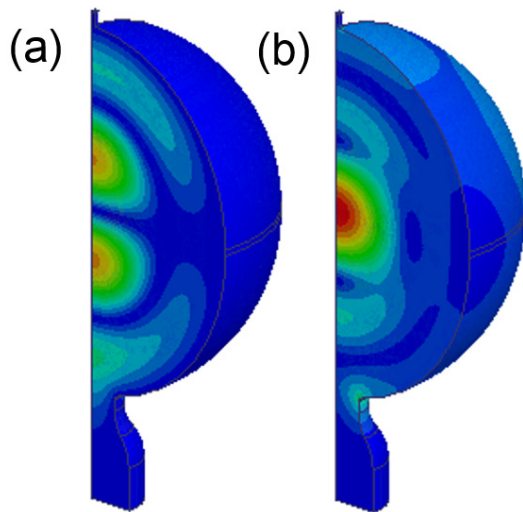


Figure 3: Quarter of spherical resonant cavity and its electric (a) and magnetic (b) fields.

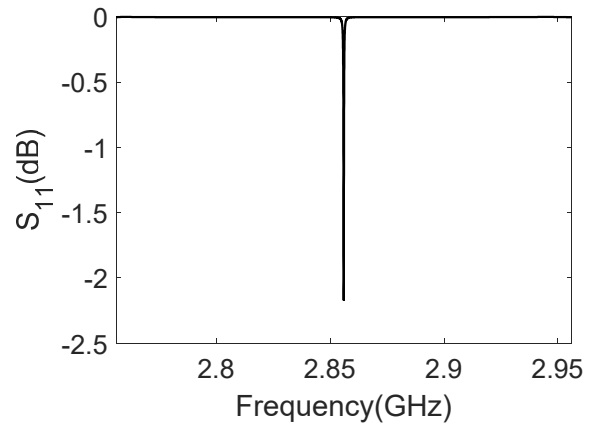


Figure 4: Reflection coefficient curve.

RF polarizer

The RF polarizer is key part of the pulse compressor. Such an RF component has the same function as a 3 dB hybrid, even it has three physical ports. From the perspective of microwave, there are 4 modes with the circular port having two orthogonal TE₁₁ modes. Figure 5 shows the optimised s-parameters of the polarizer. The reflection of input power is below -45 dB and the isolation between port 1 and port 2 is larger than 50dB. Figure 6 and Figure 7 show the electric and magnetic fields of the polarizer

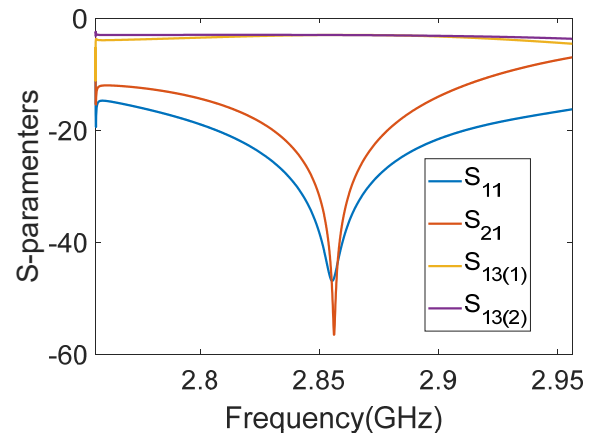


Figure 5: S-parameters of the RF polarizer.

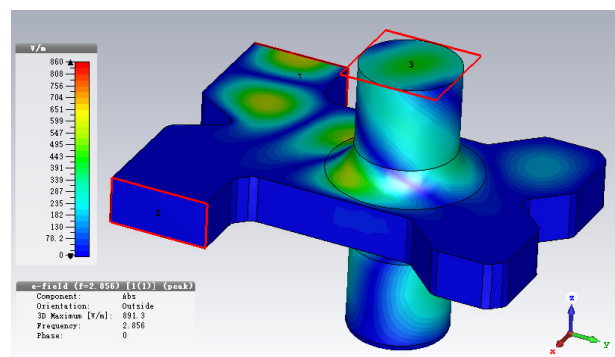


Figure 6: E-field of EF polarizer with input power of 1 W.

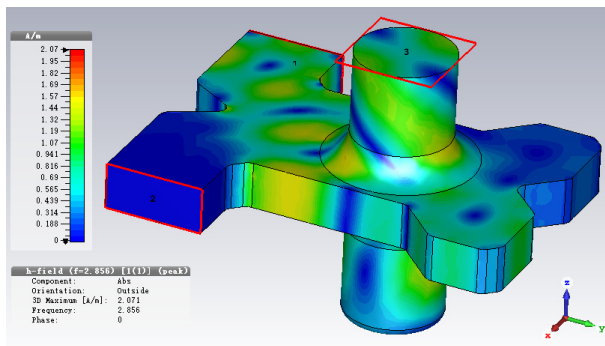


Figure 7: H-field of EF polarizer with input power of 1 W.

Figure 8 shows the full RF design of the pulse compressor. At any time, there are two orthogonal TE_{112} modes inside the spherical cavity. As the phases of the two modes vary with time, the fields rotate inside the cavity. This rotating feature is same as that of the BOC, another kind of pulse compressor with only one resonant cavity, and is the essential reason why a single cavity can work as a pulse compressor [4]. The length of the circular guide connecting the RF polarizer with the spherical cavity should be long enough to make sure the RF polarizer works well.

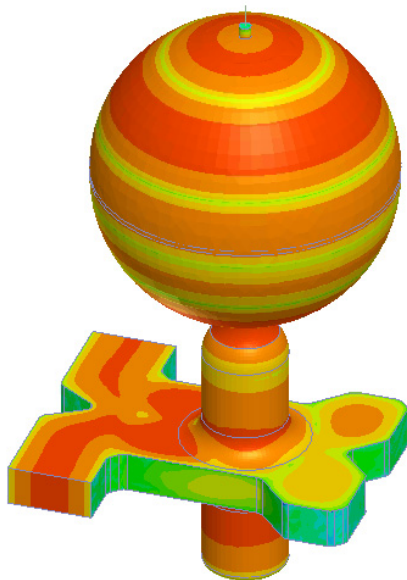


Figure 8: Full RF design of the pulse compressor and its electric field on the surface.

MECHANICAL DESIGN

Figure 9 shows the mechanical design of the pulse compressor. The cooling pipes are arranged on the surface to reduce the weight of the pulse compressor. The weight of the pulse compressor is 55 kg.

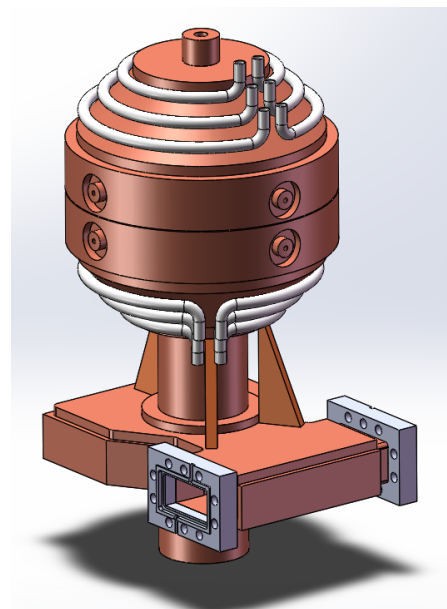


Figure 9: Mechanical design of the pulse compressor.

CONCLUSION

We designed a new pulse compressor for S-band high-power test stand at Tsinghua University. The RF and mechanical designs of the pulse compressor are described. It consists of an RF polarizer and a spherical cavity with TE_{112} mode. The pulse compressor is being fabricated at Tsinghua University. Tuning, low-power RF measurement and high-power test will follow in the future.

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