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Design and Manufacture of 10 kW, 83.2 MHz 4-way power Combiner for solid state amplifier

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Abstract

The purpose of this study is to improve the insertion loss of a 20 kW solid-state RF power amplifier and the power coupling efficiency by reducing reflected power. For this purpose, a power combiner, which is a core component of a solid-state RF power amplifier, was designed and fabricated. The 4-way power combiner employs the Wilkinson type, which has excellent power coupling efficiency and isolation, and operates at 83.2 MHz. This paper covers the design and cold test results

RF cavity Feature

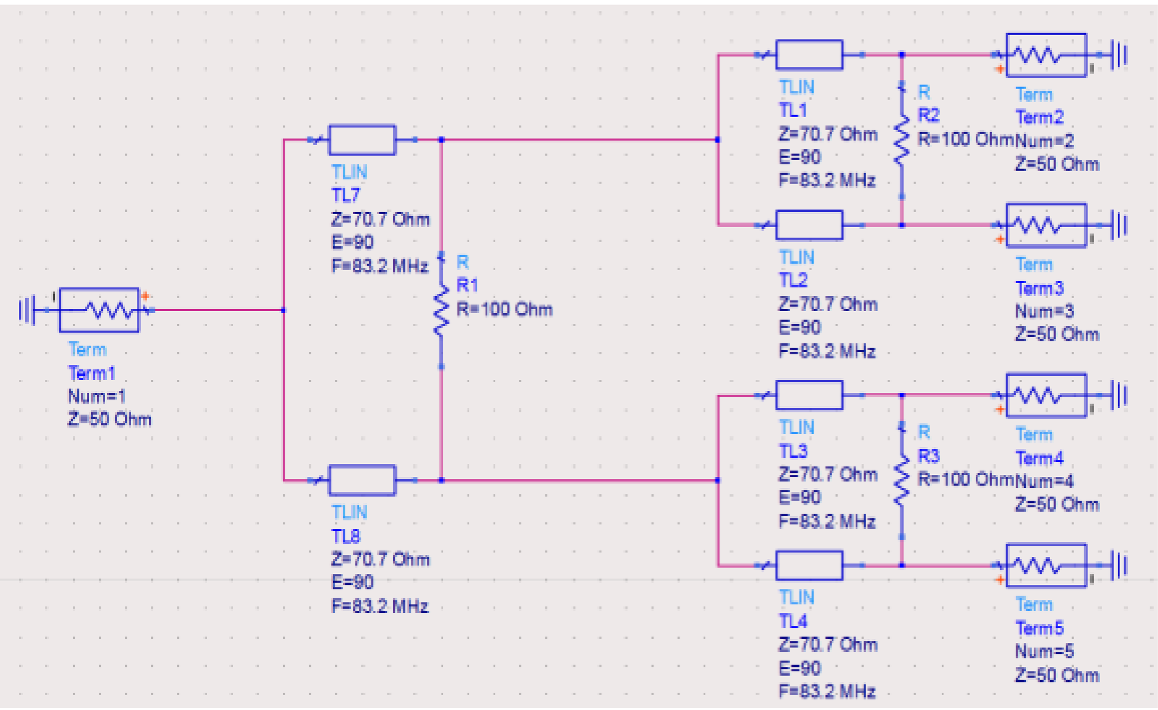


Figure 1 Ideal 4-way Wilkinson power combiner matched at 83.2 MHz

- Fig 1(A) shows fabricated X-band linac cavities.
- Fig 1(B) how small the x-band cavity is.
- In order to get a sufficient surface roughness as shown fig 1(C) of the copper device, use single crystal diamond tool to fabricate copper bulk.
- Table 1 shows specification of X-band linac cavity.

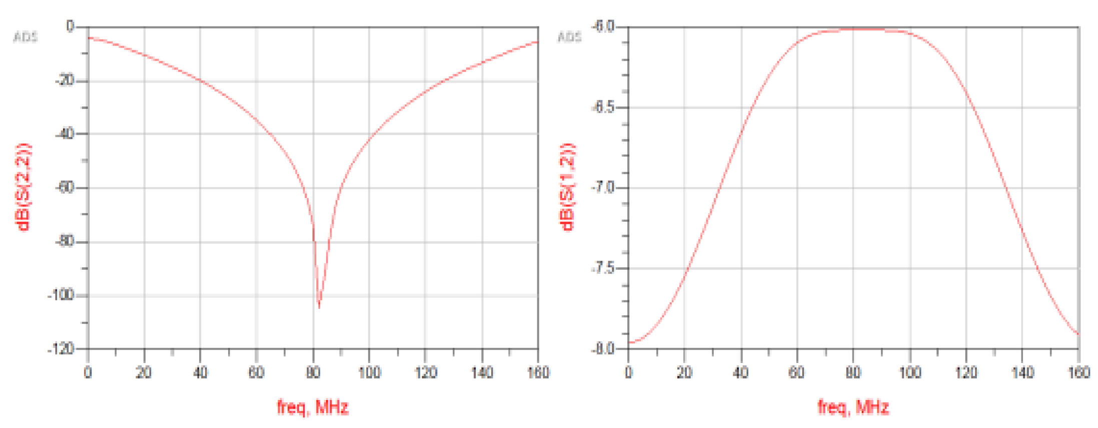


Table 1: S-parameter simulation results S(2,2), S(1,2)

Simulation

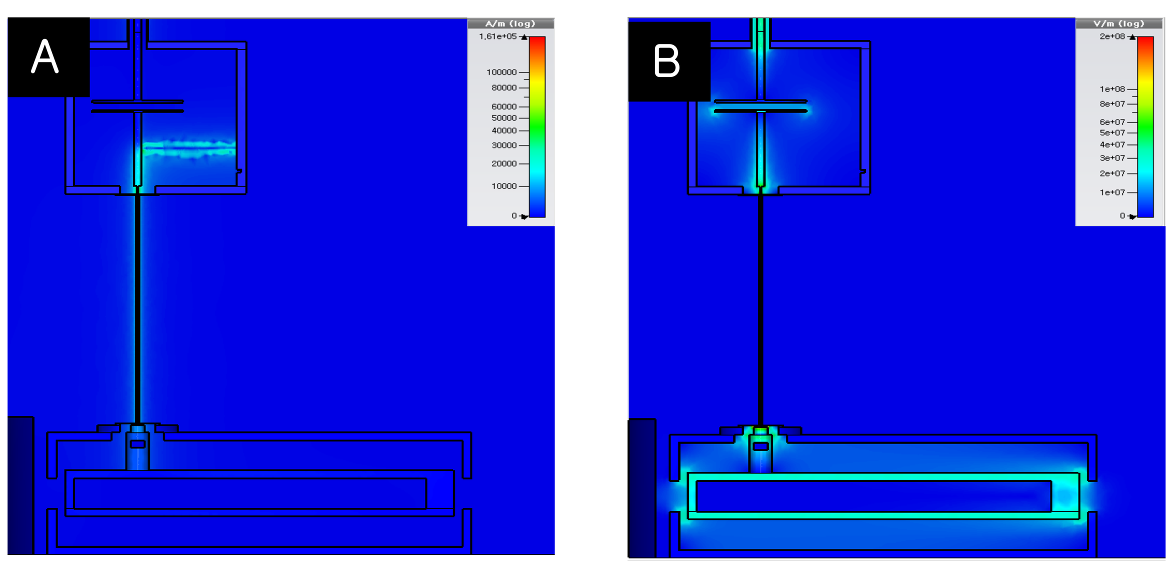
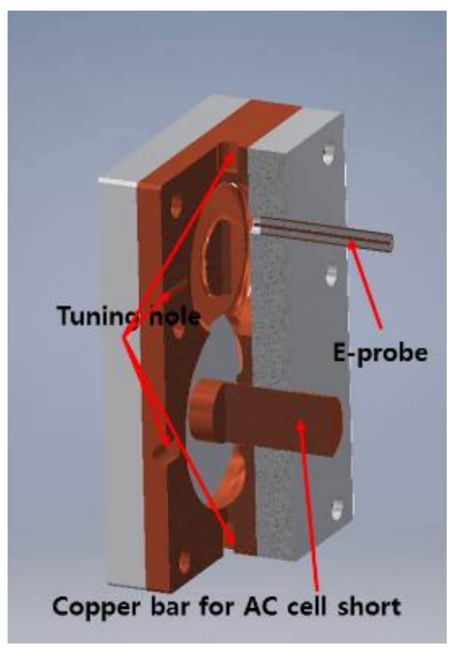


Figure 2: (A)H-field, (B)E-field

- Fig 2 shows design step for removing stop-band.
- The boundary conditions were selected so that the electromagnetic fields of pi / 2 mode were generated in AC and SC.



- E-probe consists of inner-conductor and outer-conductor and material is annealed copper.
- The material between Inner and Outer is generally used as Teflon (Epsilon = 2.1)
- The probe was inserted 0.5 mm away from the aluminum jig surface

Figure 3: Device for measurement of each cell

- Fig 3 shows each cell measurement system in Sungkyunkwan university.
- Tuning was carried out by putting a bead in the tuning hole and pushing a bead into cavity wall.
- The resonant frequency can be changed from 0 to 10 MHz in one hole. There are 6 tuning hole of each cell(AC: 3, SC: 3) except coupler cell(AC:2,SC:3) because of coupling hole

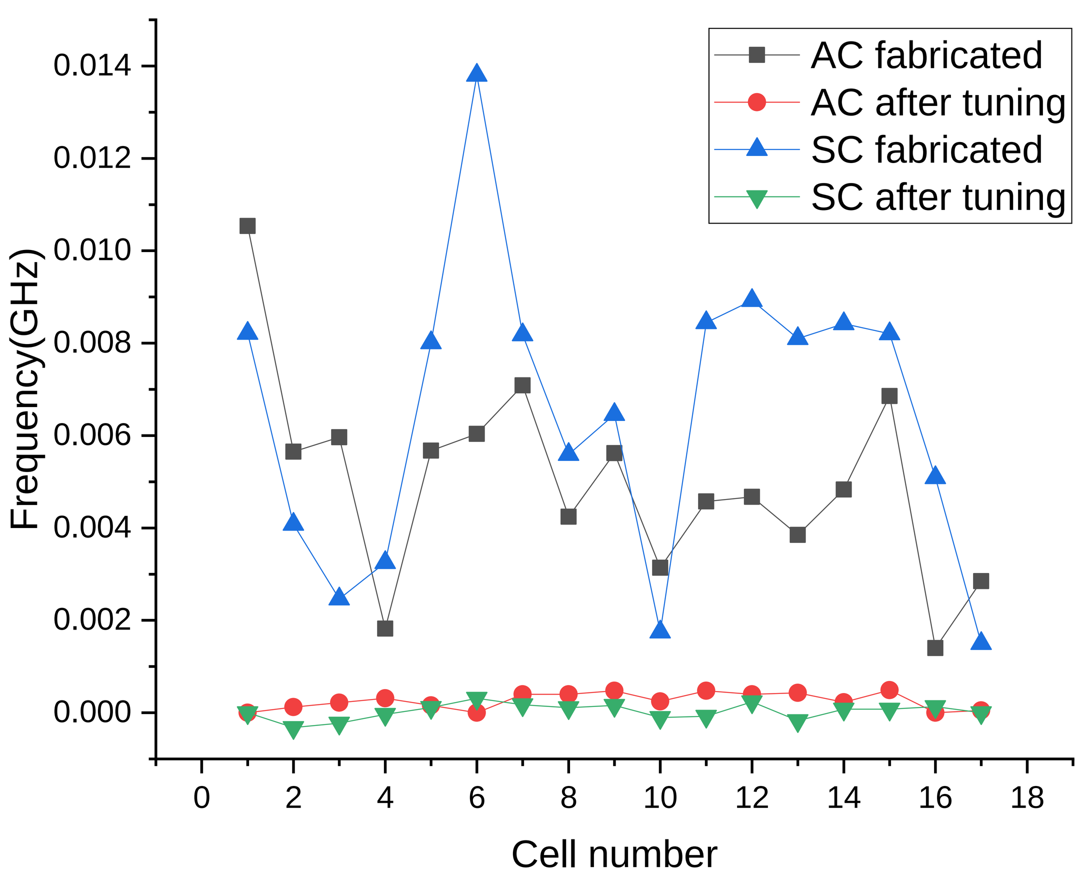


Figure 4: resonant frequency before and after tuning

- Fig 4 shows the resonant frequency before and after tuning.
- Before the tuning, it has a difference of 0 ~ 15 MHz from the reference frequency.
- After tuning, There are a difference of -0.5 ~ 0.5 MHz.
- It means that the resonance frequency of AC and SC are equal.

Bead-pull measurement

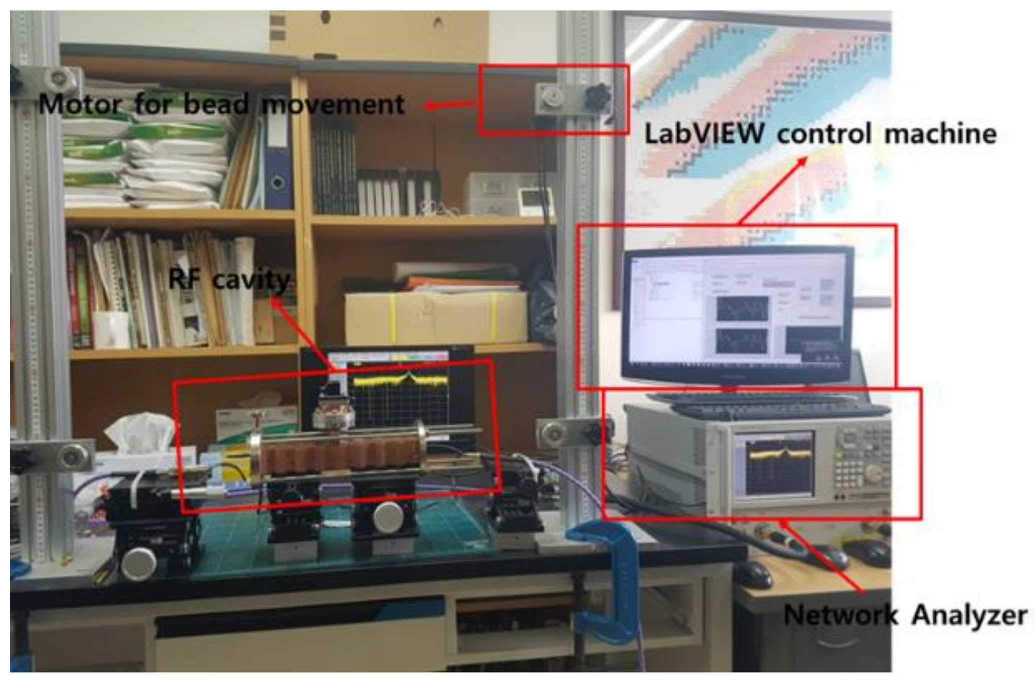


Figure 5: bead-pull system

- Fig 5 shows bead-pull system of Sungkyunkwan university.
- In the software, LABVIEW code was used.
- The developed LABVIEW code consists of reading field map data, storing data, and processing data.
- In the hardware, supporters, motors, and fishing lines were used.

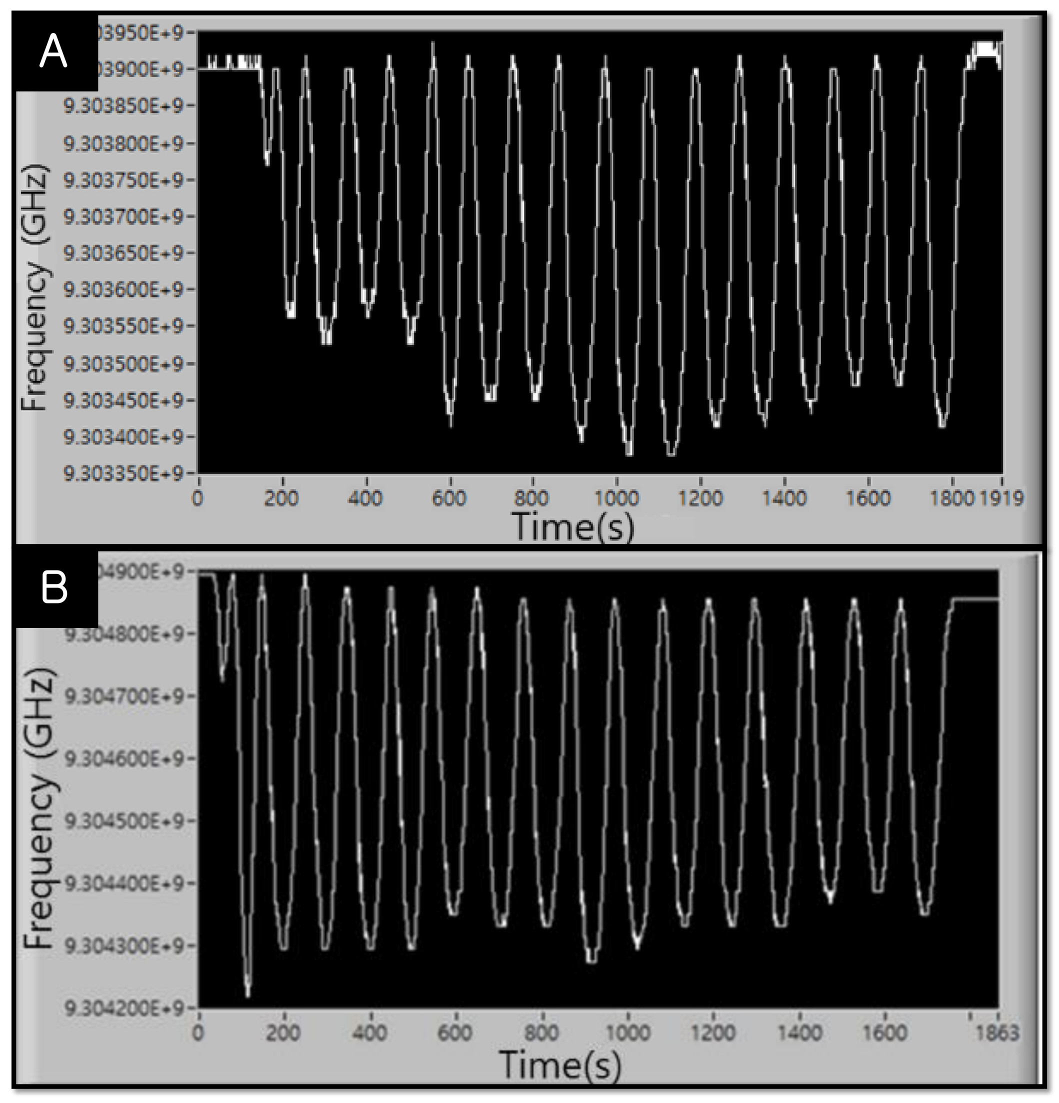


Figure 6: electric field map in cavity ((A) initial state of field map, (B) field map after tuning)

- Fig 6 shows the electric field distribution in cavity.
- In the initial state of cavity, the difference between the maximum peak and the minimum peak was more than 30%.
- After the tuning using the bead pull system, it was less than 9%.
- Through the data obtained after tuning, we verified through ASTRA simulation code and confirmed that the beam accelerates to 6 MeV

Conclusion

- In this study, electric field distribution measurement and tuning of the fabricated 6 MeV electron accelerator was verified.
- In each cell measurement and tuning process, various variables (temperature, e-probe depth, surface roughness and so on) were simulated by CST microwave studio code before application.
- To measure the electric field distribution and obtain the required field flatness, bead-pull system based on perturbation theory was used.

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