POWER COUPLER AND COLD WINDOW FOR SEVEN-CELL SUPERCONDUCTING CAVITY VERTICAL TEST*

Edward R. Gray and George Spalek
Los Alamos National Laboratory

Abstract

For tests of the LANL 805MHz seven cell superconducting cavity[1], we are developing a variable coaxial rf power coupler. Its Q_{ext} will be variable over a range from 10^5 to 10^{12}. It will operate nominally at 3kW CW and 100kW peak for high power processing. The coupler consists of a 3 inch driveline and window, a 3.45 inch T supported by a $\lambda/4$ shorted stub followed by a step transition to a 2 inch coupler port. A $\sim$ 6.6 Ohm impedance choke joint located at the step transition allows the large center conductor travel necessary for the Q_{ext} variation. The folded choke joint is located at a standing wave current node to keep its excitation below the multipacting level even at high power levels. A low contact-pressure sliding rf seal prevents arcing at the choke joints current node during its filling time.

Introduction

Low power CW testing and high peak power conditioning of the 7 cell LANL 805MHz superconducting cavity requires a well matched coaxial coupler with a coupling probe travel of ~11.5cm to achieve a Q_{ext} variation from 10^5 to 10^{12}. Figure 1 shows a simplified sketch of the chosen shorted T design. The drive line and window are 3 inches O.D.. The straight through portion of the T is 3.45 inches O.D. It is shorted on one end near $\lambda/4$ from the T midpoint. On the other end, a step transition to a 2 inch coaxial line provides a convenient place for a choke joint for the movable center conductor (coarse crosshatch). Arcing at the current node of the choke during the rf filling time is prevented by a low contact pressure rf seal. A welded bellows (fine crosshatch) provides a vacuum seal between the movable rf probe and the coupler body. It is not exposed to any rf fields. The figure shows the drive line with a simple illustration of a detachable rf window.

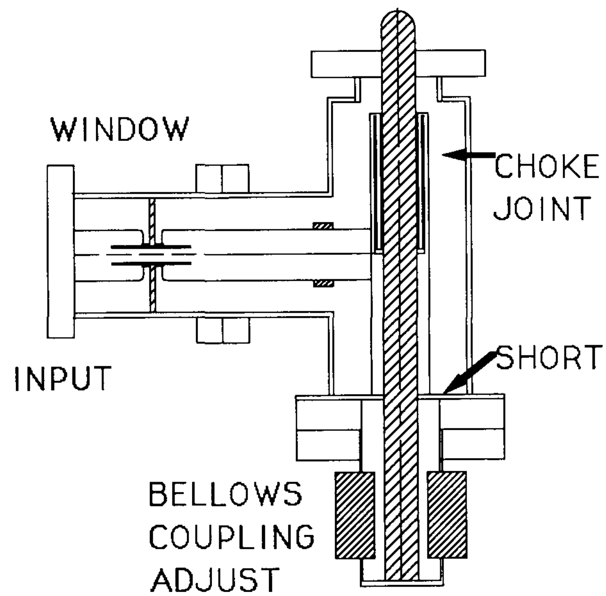

Figure 1: Simplified T Coupler

Choke Joint and Step Transition

The 7 cell cavity will operate overcoupled at a Q_{ext} of $\sim 5\times10^7$. To achieve the design goal of 15MV/m, ~3kW of CW forward power will be required at a cavity power dissipation of ~280W. The step transition (i.e. the choke joint) will be located at a minimum current point of the rf drive line's CW standing wave to minimize its excitation, which corresponds to a traveling wave of ~280W. For the chosen choke joint impedance of ~6.6 Ohms (with a frequency-gap product of ~1,030 MHz-cm) CW multipacting in the choke line can occur only if the rf drive line's standing wave current minimum amplitude corresponds to a traveling wave in the range of 2kW to 10kW, well above the expected 280W. During high peak power pulsed processing, only a small fraction of the choke line has the proper excitation for multipacting for the part of the cavity filling time when the drive line is undercoupled. Once the drive line becomes overcoupled no multipacting is possible. Because of the fast risetimes during pulsed conditioning, multipacting is not considered serious. For a VSWR of 1.01, the choke joint's bandwidth is ~2% or 16 MHz. A low power model of the coupler, choke joint and step transition has been built so that dimensions can be determined experimentally. The step transition from the 3.45 inch line to the 2 inch line must be tuned for a match at the operating frequency by adjusting the longitudinal distance from

*Work supported by the US Department of Energy, High Energy and Nuclear Physics Office.

the center coax step to the outer coax step. Preliminary measurements of the tuned model step indicate that the step transitions 1.05 VSWR bandwidth is ~40MHz or 5% with the step distance being approximately the calculated value. Model measurements of the choke joint bandwidth will be made.

Shorted T Matching

A standard T used as a straight through line is symmetric and the adjustable shorted side line provides a match. Because of the field distortions in the vicinity of the T junction used as a right angle drive line, the T has to be modeled as a junction of three 50 Ohm lines with stray inductances and capacitances. The values of these stray reactances change with frequency because the T dimensions are a considerable fraction of a wavelength at 805MHz. Even though a Time Domain Reflectometer (TDR) measurement excites higher order modes in the T section, it nevertheless has enough information that an equivalent circuit of the junction can be constructed but values of the stray reactances cannot be determined accurately enough. An example of the TDR measurement is shown in Figure 2 for an unmatched T with short. The positive bump is the stray inductive reactance. The stray capacitive reactances are seen in Figure 2 as a single negative bump. Figure 3 shows the location of the equivalent circuit reactances obtained from the TDR measurements. The stray inductance in series with the input port is easily locally compensated for by increasing the center conductor diameter at the stray inductance position. The stray capacitances are, however, almost impossible to compensate for locally because the center conductor diameter cannot be decreased (because of the internal folded choke line and the moveable coupler center probe). The outer conductor diameter is difficult to increase because of mechanical considerations near the location of the stray capacitance.

Even though there are many ways to match the T globally, the method chosen increases the center conductor size near the stray series inductance using a collar to not only locally reduce the inductance but also provide capacitance at an adjustable position that is electrically near $\lambda/4$ from the stray capacitances. The tuning procedure that gives a low T VSWR of $\leq$1.01, consists of:

- An oversize collar is placed near the position of the stray inductance, its rough size is determined from TDR measurements to give a stray capacitance roughly equal to the two stray capacitances in the other legs of the T. (The final collar size will be chosen from cold model measurements.)
- The collar is moved until the VSWR for the T is minimized at a frequency determined by the length of the shorted port.
- The length of the shorted port is trimmed to move the frequency of the VSWR minimum closer to the room temperature compensated frequency of 802.21MHz.

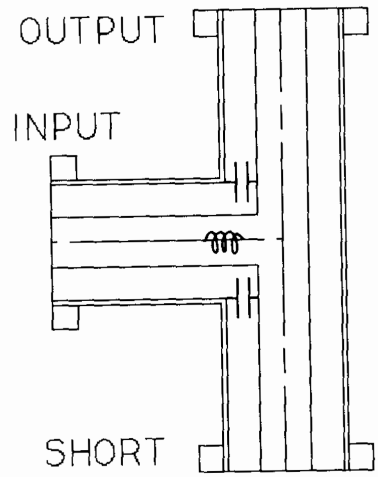

Figure 2: TDR View of Mismatches

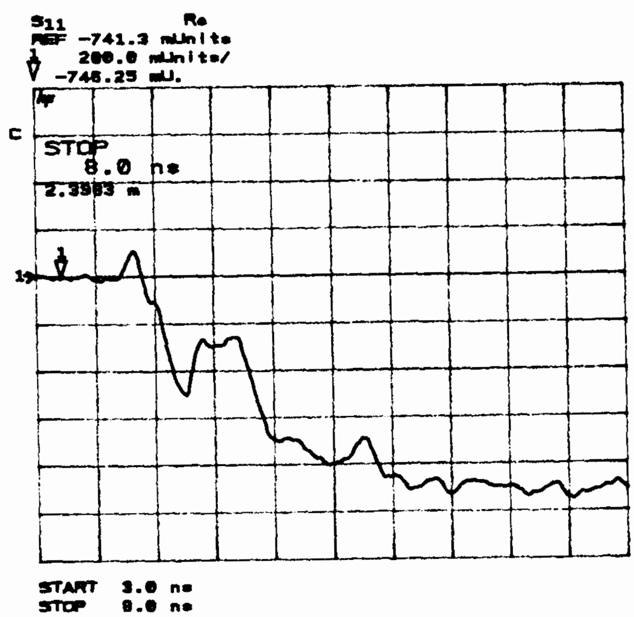

Figure 3: Local Mismatches

- The collar is positioned to minimize the VSWR again and the new frequency compared to the desired value.
- The above process is repeated in small length changes of the shorted port until the VSWR minimum occurs at the desired room temperature frequency of 802.21MHz.

We are in the process of tuning the low power model T , choke joint, and step transition to determine the final dimensions of the high power device.

Conclusion

Calculations and preliminary model measurements indicate that our coaxial right angle shorted T coupler with choke joint and step transition to a 2 inch coupler port will be relatively easy to tune for a VSWR $\leq$1.01. It will also give us a very large range of Q_{ext} adjustment without using bellows exposed to rf, using only low contact pressure rf seals, and with manageable or non-existent multipacting problems. Tuning of the coupler model is well on the way to completion. High power tests of the coupler are planned for the near future.

References

[1]George Spalek and Henry A. Thiessen. "PILAC-A Pion Linac Facility for 1 Gev Pion Physics at LAMPF," in "Proceedings of the 5th Workshop on RF Superconductivity,"(DESY, Augest 1991),p. 95