HIGH POWER TEST OF COUPLER WITH CAPACITIVE WINDOW

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Abstract

New type of coupler with capacitive-coupling inner conductor is designed in KEK. This coupler has a module structure, which is convenient for mass-production, assembling and repairing. Four samples of couplers were made and two of them were tested at high power level. The main parameters of the couplers and test results are presented in this paper.

INTRODUCTION

International linear collider, ILC, is probably next main project for high energy accelerators. It is supposed that length of linac will be about 20km long with several thousands of superconductive accelerator cavitis. Each cavity has a coupler to input RF power. Besides power feeding, coupler separates vacuum of accelerator cavity from outside systems. Part of the coupler close to cavity operates at liquid helium temperature, while the other part connected to the power distribution system is located at room temperature. There are two dielectric RF windows for vacuum isolation. Superconductive accelerator cavity requires ultra cleanness during assembling and it should be assembled in spatial clean rooms. Then vacuum sealed cavity is inserted into cryomodul. It means that RF window should be assembled to a cavity and it should be close to the cavity as possible to be easily inserted into cryomodule. Window position close to the cavity means that it is at low temperature during operation. Because power distribution system is air filled, the coupler requires second warm RF window. To decrease cryogenic heat load the coupler should has low ohmic loss and low thermal flow from room temperature part. All of these make coupler rather complicated. Because of big number the relative coupler cost in total cost of ILC is noticeable. Therefore, it is impotent to make the coupler simple and cheaper. To this end, we found an interesting approach with using a capacitive window as cold one. It allows dividing coupler into several modules, Fig.1. It is convenient for mass-production, assembling and repairing. Cold window itself becomes simpler [1].

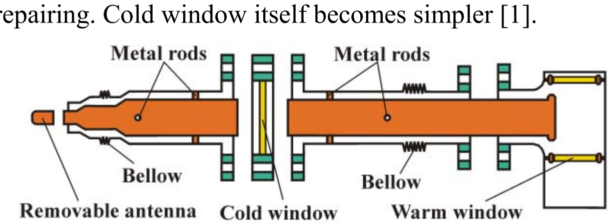

Figure 1: Module structure of coupler with capacitive coupling window.

DESIGN OF COUPLER

Goles of the design were to construct the coupler with as low electric field at dielectric RF windows as possible, electric field in air part less then breakdown limit for full reflection from cavity, and to maximise passband keeping geometry as simple as possible. The same time we posed a requirement that coupler should be interchangeable with TTF-III coupler. Some design parameters of coupler presented in Table 1. Experimental samples of coupler were made by Toshiba Electron Tubes & Devices Corporation. Figure 2 shows assembled coupler. Figure 3 presents measured passband of single coupler.

Table 1: Design parameters of coupler

Frequency	1.3 GHz
Input	Waveguide, WR650
Output	Coaxial, D40mm x D17.4mm
Passband	70 MHz (SWR < 1.2)
Max. E- field ,cold window	11.5 kV/cm (500kW)
Max. E-field , warm window	5 kV/cm (500 kW)
Max. E-field, air	7 kV/cm (500kW)

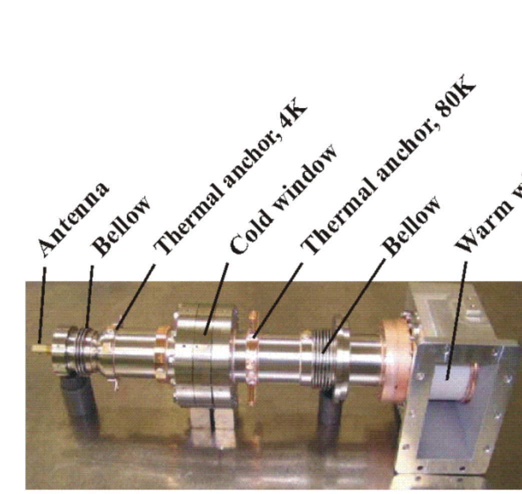

Figure 2: Assembled coupler.

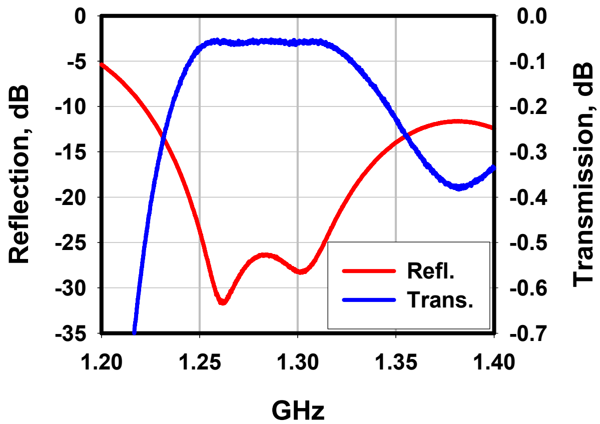

Figure 3: Measured passband of single coupler.

HIGH POWER TEST

Couplers were tested at high power level. The scheme of test stand is shown in Figure 4

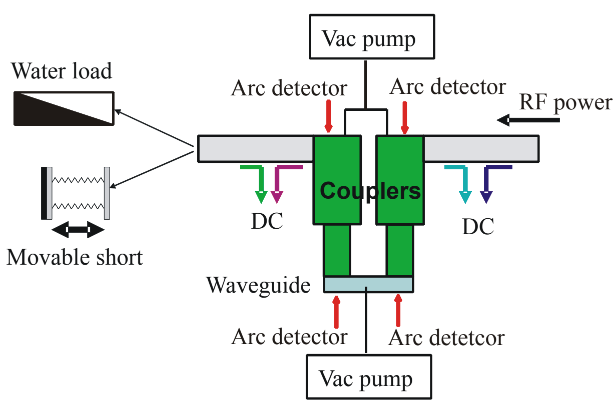

Figure 4: Scheme of high power test.

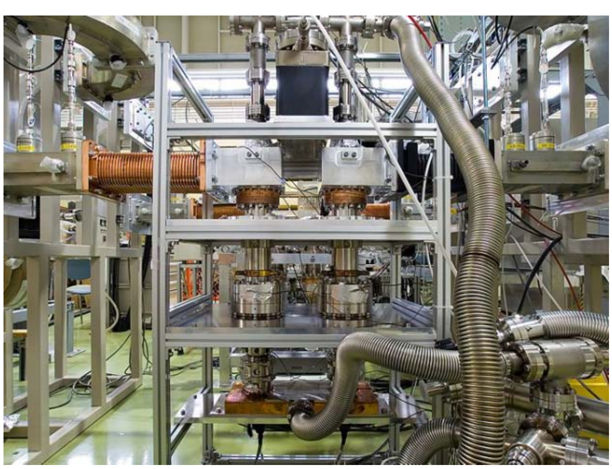

Figure 5: Photo of two couplers installed for high power test.

Figure 5 shows two couplers at high power test stand. We performed two runs. During the first run couplers were processed without backing. After 20 hours of conditioning the power level was reached 2.3 MW x 1.7ms x 5pps. It corresponds to an average power 19.6kW. The vacuum level was about 10^{-6} Torr. After short operation at this power level a one of the warm window was broken due to thermal stress. Loss tangent of present ceramic of warm window is 10-4. In future this ceramic will be replaced by better one with loss tangent 10-5. We think this change will increase the available average power limit.

For the second run the broken warm window was replaces by new one. Before this run the couplers were baked during 100 hours at 120C. The history of conditioning of second run is presented at Fig. 6. During 5 hours power was increased up to 1.2 MW and pulse length was extended to 1.5ms. Then couplers were kept at level 500kW x 1.5ms x 5pps for 8 hours. Then power was increased till 1.MW and coupler were kept at this level for 18 hours. After that power level was set at 2 MW, with the reduced of 3pps and kept for 3.5 hours. The vacuum pressure during second run was not higher then 10^{-7} Torr

As the next step the matching load was replaced by moveable short and the couplers were tested at 500 kW x 1.5ms x 5pps at different short position. Trough this test, the couplers operated normally, and RF pulse were stable.

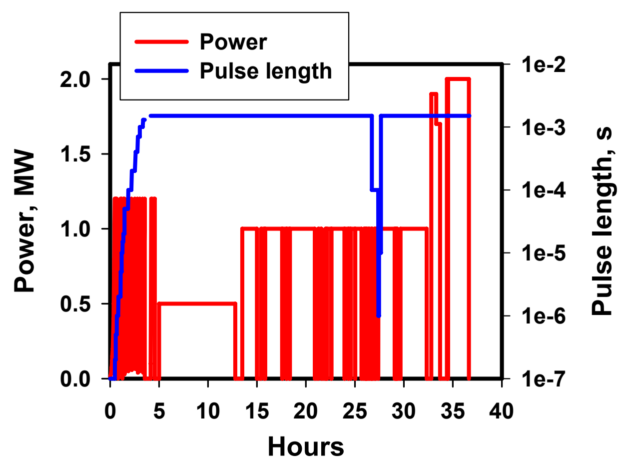

Figure 6: History of couplers conditioning.

During the second run the temperature was monitored at several points of couplers including the surface of ceramic of warm windows. Figure 7 shows difference between temperature of warm window ceramic and input waveguide vs average input power for the case of matched load. Curve is smooth. The nonlinear behavior can be explained by different cooling condition of upper and bottom waveguide walls. Figure 8 shows the same temperature difference vs short position for 500 kW input peak power with terminated by movable short.

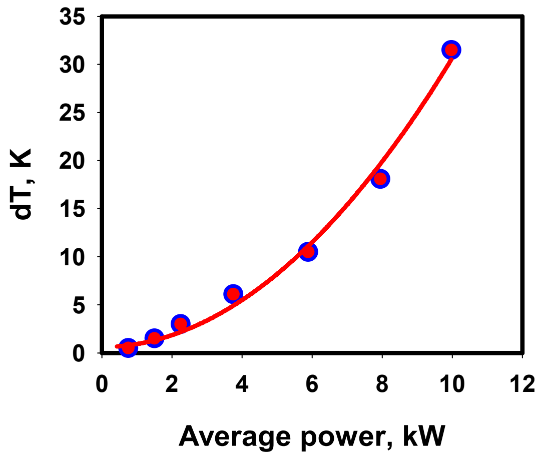

Figure 7: Temperature difference between warm window ceramic and input waveguide vs average power.

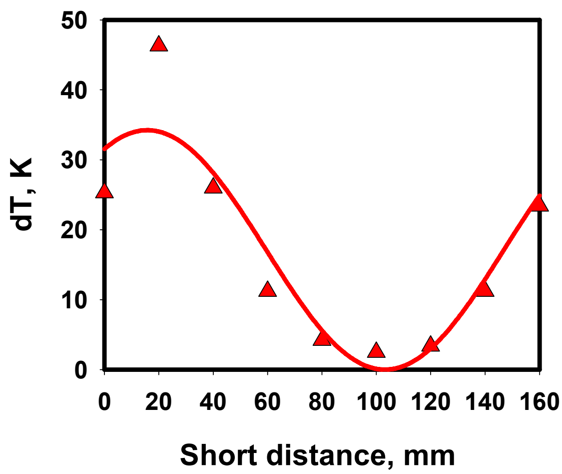

Figure 8: Temperature difference between warm window ceramic and input waveguide vs distance to short. Power is 500kW x 1.5ms x 5pps.

Multipactor

To suppress multipactor the most metal parts of coupler were coated by Ti and surfaces of ceramic window were coated by TiN. During the tests a multipactor effects were rathe weak. In MP regime it appeared as vacuum change, slight change of shape of reflected signal was observed and it was no appearance at transmitted pulse. At power higher 200 kW there was no sign of multipactor. The pulse shape at the beginning of conditioning, multipactor regime is presented at Figure 9. Typical pulse shape after conditioning is in Figure 10.

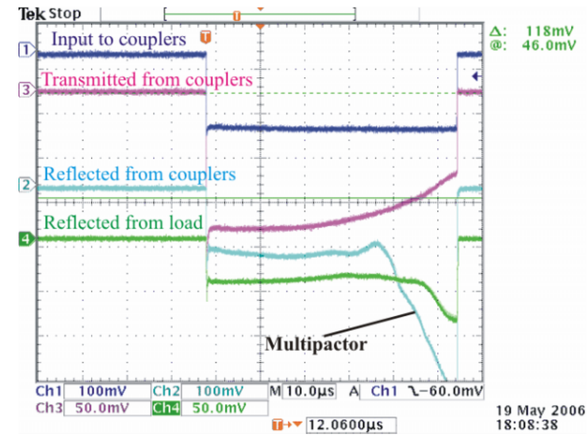

Figure 9: Pulse shape at the beginning of conditioning, multipactor regime.

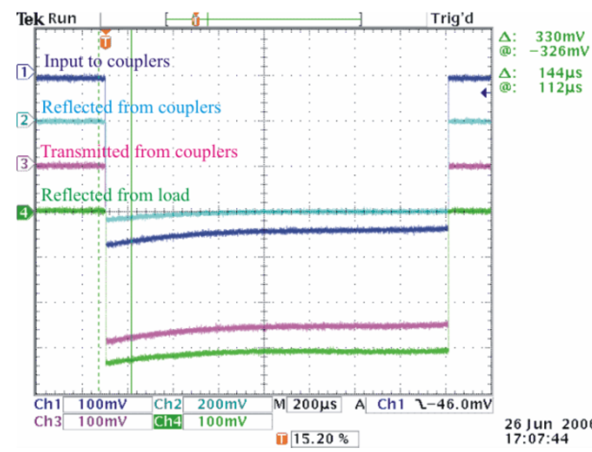

Figure 10: Pulse shape after conditioning, 2MW x 1.5ms x 3pps input pulse.

CONCLUSION

The L-band high-power couplers with capacitive coupling mechanism at the cold window were made for superconductive accelerator cavity. Couplers were tested at high power level. Test demonstrated that couplers can successfully operate with pulse 1MW x 1.5 x 5pps and 2MW x 1.5ms x 3pps with matching load and with pulse 500kW x 1.5ms x 5pps with short. Effect of multipactor is weak. Upper limit of multipactor is about 200 kW. These couplers will be used for STF in KEK.

ACKNOWLEDGMENTS

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REFERENCES

[1] H.Matsumoto, S.Kazakov, K.Saito, “A New Design for Super-conducting Cavity Input Coupler”, Proceedings of 2005 Particle Accelerator Conference, Knoxville, Tennessee, USA, May-2005, p. 4141