# Design Study of Fundamental Power Coupler for Superconducting Half Wave Resonator for KOMAC Proton Accelerator

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## 1. Introduction

A 100 MeV proton accelerator established at Korea Multi-purpose Accelerator Complex (KOMAC) is stably operated. The KOMAC prepares a next phase of the accelerator research. To improve performance of the accelerator and expand an application field, various developing programs are planned and executed. One of these programs is development of a superconducting accelerator. The superconducting accelerator not only raises proton beam energy but also allows other applications. A representative application of the superconducting accelerator is a pulsed neutron source. The fast neutron is generated by a target irradiated by the pulsed proton beam.

When the tungsten target is irradiated 1 kW of 100 MeV proton beam, the neutron yield is estimated about 2.5E13 pps, in previous study [1]. Also, if the proton beam energy increases up to 160 MeV, the neutron yield will be enhanced by 2.5 times. Thus, to improve the proton beam energy within the existing accelerator facility, the superconducting radio-frequency (SRF) cavity has been developed.

A half-wave resonator (HWR) type SRF cavity is selected at KOMAC. To develop superconducting accelerator, several researches on the cavity geometry, characteristics and SRF cryo-module are conducted. This study develops a RF power coupler of QWR.

## 2. Superconducting Accelerator of KOMAC

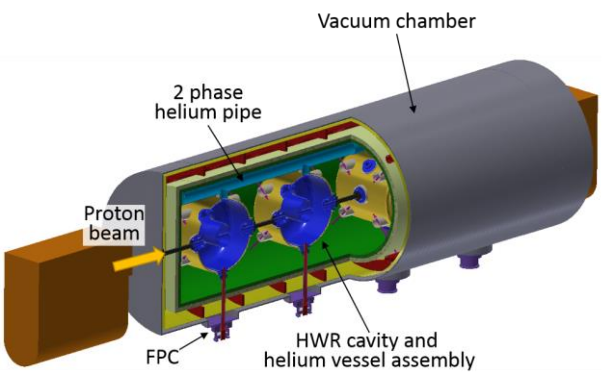


Fig. 1. Cryo-module under-developed at KOMAC

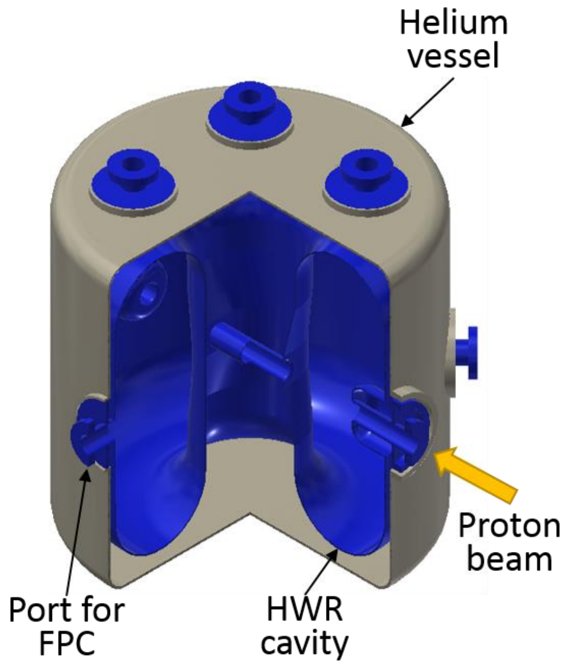


Fig. 2. HWR cavity designed by KOMAC

A key component of the superconducting accelerator is the RF cavity. Since the RF cavity is made by the niobium superconductor and its temperature should be sustained lower than 4 Kelvin by liquid helium, the RF cavity is installed inside the helium vessel. Also, most components of the superconducting accelerator are devoted to sustain the operation temperature and pressure of liquid helium and shield the magnetic field which induces malfunction of the superconductor. The cryo-module under-developed by KOMAC is shown in Fig. 1. One cryo-module consists of 4 HWR cavities, thermal and magnetic shield layers, mechanical support frame, and vacuum chamber.

HWR designed by KOMAC is depicted in Fig. 2. The RF field inside HWR will be excited by a 350 MHz solid state amplifier. Also, 120 kW RF power is supplied to the respective HWR, to maintain 20 mA peak beam current. To accelerate the proton from 100 MeV to 180 MeV, totally 28 cavities are required.

Table 1. Design parameters of HWR.

| Parameter | Unit | Value |
|---|---|---|
| Frequency | MHz | 350.0 |
| Optimum beta, $\beta_{opt}$ | - | 0.64 |
| Geometric beta | - | 0.58 |
| Stored energy | J | 17.728 |
| $V_{acc}$ @ $\beta_{opt}$ | MV | 3.336 |
| $E_{acc}$ | MV/m | 7.212 |
| $E_0$ | MV/m | 8.200 |
| $E_p$ | MV/m | 30.252 |
| $B_p$ | mT | 64.392 |
| $E_p/E_{acc}$ | - | 4.195 |
| $B_p/E_{acc}$ | mT/(MV/m) | 8.928 |
| R/Q @$\beta_{opt}$ | ohm | 285.2 |
| G @ 20 nΩ | ohm | 123.8 |
| $Q_0$ @ 20 nΩ | - | 6.19E+09 |
| Loss @ 20 nΩ | W | 6.38 |
| Aperture | Mm | 35 |
| $L_{eff}$ | M | 0.4625 |

Main designed parameters of HWR cavity are listed in Table 1. Approximated dimension of the cavity is 460 mm in outer diameter and 440 mm in height. Detail description and specific design parameters are presented in previous work [2].

### 3. Design Study Fundamental Power Coupler

A fundamental power coupler (FPC), which delivers the RF power into the cavity, consists of inner conductor, outer conductor, ceramic window, inner and outer conductor extension, as shown in Fig. 3. Also, FPC plays as a vacuum boundary. Therefore, they should be considered that RF power coupling, transmission loss, thermal and mechanical stability, reliability and multifacting, when the FPC is designed with given RF frequency and power.

In this study, RF power coupling is main consideration parameter. Especially, for the various inner conductor length, RF characteristics including power coupling are simulated by CST program.

Based on the RF coupling factor, more detail design work considering the stability and the reliability is followed.

### 4. Summary

The superconducting accelerator is under-developed at KOMAC. The KOMAC will increase the proton beam energy and expand the application field of the accelerator by introducing the superconducting accelerator. This work designs the FPC for HWR cavity. The RF power coupling is the primary constraint to design FPC. Also, based on this work, design optimization will be followed.

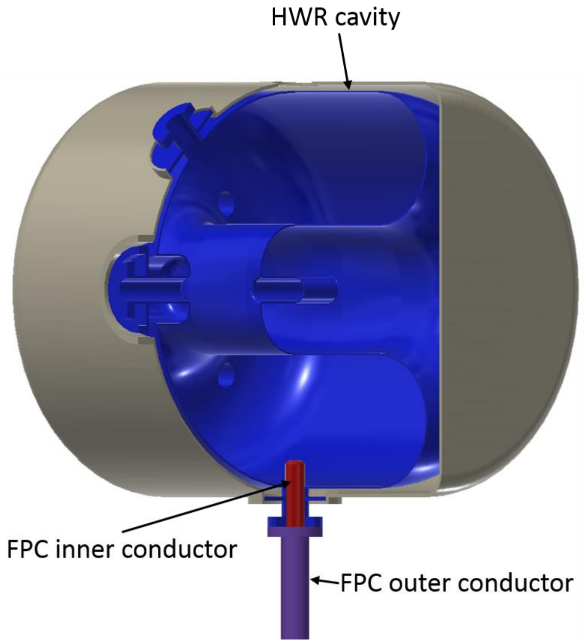


Fig. 3. HWR cavity and FPC assembly

### Acknowledgment

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[2] H.S. Kim, H.J. Kwon, Y.G. Song, S.H. Lee, J.J. Dang, S.P. Yoon, Y.S. Cho, EM Analysis of Superconducting Half Wave Resonator for KOMAC 100-MeV Proton Accelerator Energy Upgrade, Korean Nuclear Society Spring Meeting, May 18~19, 2017, Jeju, Korea