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Low Level RF System in the KOMAC/KTF RFQ Linac

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Abstract

The KOMAC Test Facility (KTF) being constructed at Korea Atomic Energy Research Institute (KAERI) will serve as the prototype for the low energy section of the Korea Multipurpose Accelerator Complex (KOMAC). The low-level radio-frequency (RF) control system for the KTF radio-frequency quadrupole (RFQ) proton linac requires the feedback control of the accelerating fields within the cavity in order to maintain field stability within $\pm 1\%$ *amplitude and* 1° *phase. A design of the low level RF system which is able to satisfy these requirements is presented.*

I. Introduction

The linear accelerator for the KOMAC Project [1,2] will include a 350MHz cw RFQ linac which accelerates a proton beam to a final energy of 3.0 MeV. The first phase of the project, KOMAC Test Facility (KTF), is to demonstrate performance of the RFQ [3] plus a coupled-cavity drift-tube linac (CCDTL) [4] to 20 MeV. A basic parameters of the KOMAC/KTF RFQ are follows: type is a 4-vane type, frequency is 350MHz, beam current is 20mA, and length is 324cm. To accomplish proton acceleration the KTF RFQ requires structure and beam power of 417.9kW. From previous experience at CERN, KEK, and ATP, 350MHz 1.0 MW klystron was selected as the generator size for the RF system of the KTF RFQ.

The RF system is composed of master oscillator, klystron amplifier, transmission line, circulator, and low level RF (LLRF) system [5,6]. The LLRF system is an essential component of the RF system for the RFQ cavity. The key issue in the LLRF system is to stabilize the system operation. There are three basic feedback loops to stabilize the system operation : 1) Cavity frequency tuning feedback loop. 2) Amplitude stabilization feedback loop. 3) RF phase stabilizer feedback loop. A block diagram of the LLRF system is shown in Figure 1. Other functions of the LLRF control system are implementation of the local phase control loop of klystron and RFQ resonance condition monitoring. The resonance of the RFQ is controlled by varying cooling water temperature. Because the RFQ will rapidly cool when RF is shutdown, drive frequency agility in the main feedback control subsystem is incorporated to quickly restore the cavity to resonance with RF heating.

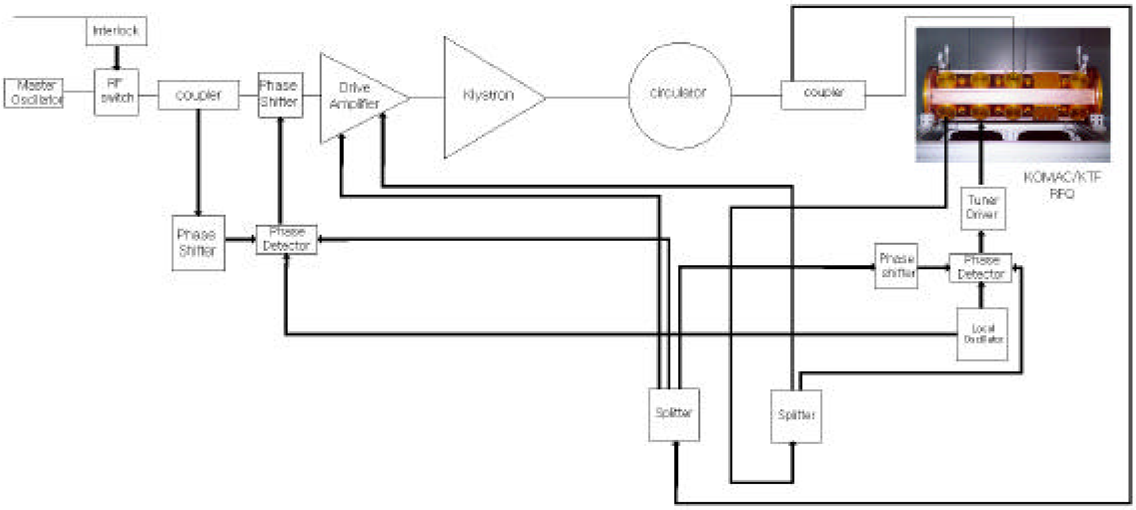

Figure 1. A block diagram of the KOMAC/KFT RFQ RF station.

II. KOMAC/KTF LLRF System Design

A. Tuner Loop

we have to overcome several problems arising from an extremely beam loading on RF cavity. one is the detuning of the cavity due to thermal expansion and to reactive beam loading, the other is an instability of the cavity brought about by an uneven temperature distribution.

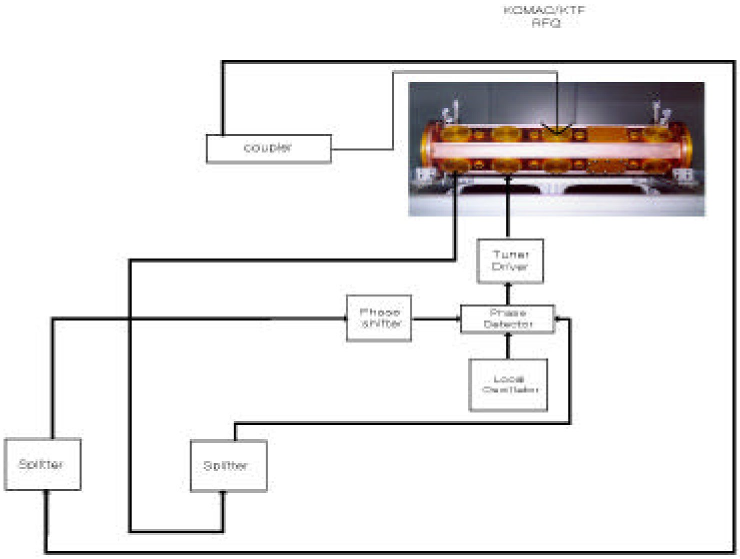

Figure 2. A block diagram of the tuner feedback loop

The first problem is stabilized by a feedback loop controlling the common penetration of the tuners. The second problem can be minimized by the differential positioning of the tuners. The block diagram of tuner feedback loop is illustrated in Fig 2. This feedback loop compares the RF phase of the field in the cavity to the phase of RF signal detector from the coupler forward. The phase comparison is made by down converting both RF signal to 2MHz by way of a mixer, as shown in Fig 3. The same type of phase detectors are also used in the phase stabilization feedback loop and amplitude stabilization feedback loop.

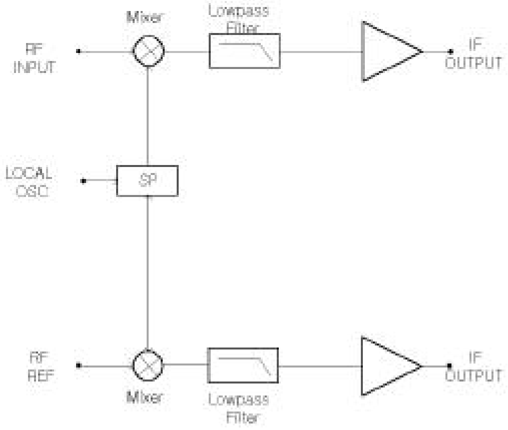

Figure 3. A block diagram of the phase detector

This feedback loop adjusts the tuner in tandem to keep the cavity at the resonant frequency with ±1° under rf heating.

B. Phase Stabilization

The phase lock loop has been designed to maintain a phase stability of the cavity fields. The main function of this loop is to lock the field in the RF cavity to the RF signal generator. This feedback loop maintains field stability within ±1° phase. The RF signal detected from the coupler forward is compared with a reference signal which is derived from the RF generator. Its output signal is used to drive a phase shifter in the RF drive line. The block diagram of phase stabilization feedback loop is illustrated in Fig 4.

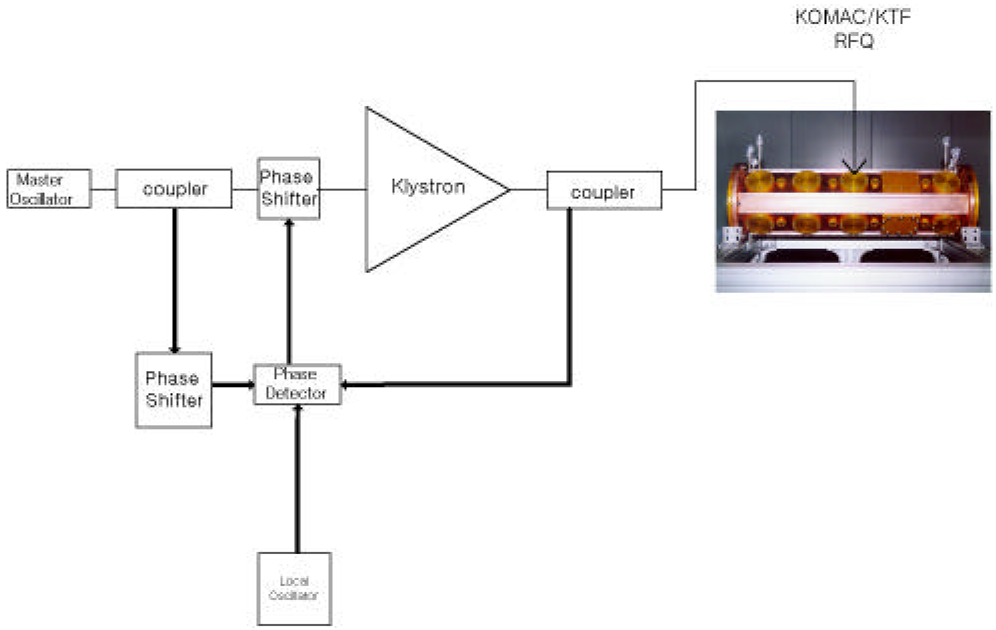

Figure 4. A block diagram of phase stabilization feedback loop

C. Amplitude Stabilization

A block diagram of the amplitude stabilization feedback loop is shown in Fig 5. This feedback loop compares the field amplitude detector from the cavity sampling loop to the coupler forward voltage. The resulting signal is applied to a gain-controlled amplifier in the drive line. This feedback loop maintains field stability within ±1% amplitude

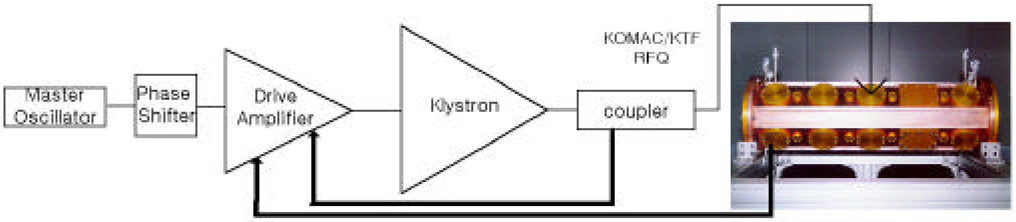

Figure 5. A block diagram of amplitude stabilization feedback loop

III. Conclusion

All low level RF feedback loop perform as designed to stabilize during operation of the RFQ cavity. Therefor It was considered important for the low level RF system to be stable and reliable. Interlocks for the cooling water and cavity vacuum are also provided.

Presently we are modeling the various component of the low level RF system, and schematics and breadboarding are on-going.

Acknowledgment

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