HIGH POWER TESTING RF SYSTEM COMPONENTS FOR THE CORNELL ERL INJECTOR*

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Abstract

There are two high power 1300 MHz RF systems under development for the Cornell University ERL Injector. The first system, based on a 16 kWCW IOT transmitter, will provide RF power to a buncher cavity. The second system employs five 120 kWCW klystrons to feed 2-cell superconducting cavities of the injector cryomodule. All components of these systems were ordered and some have already been delivered, including the IOT transmitter (manufactured by Thales Broadcast & Multimedia), 20 kWCW AFT circulator, one 170 kWCW circulator (the Ferrite Co.) and two prototype input couplers for superconducting cavities manufactured by the Beverley Microwave Division of CPI. A special liquid-nitrogen-cooled cryostat has been designed and built for testing/processing the input couplers. The results of the first high-power tests are presented.

1 DESCRIPTION OF THE ERL INJECTOR RF SYSTEMS

The ERL injector [1], under construction at Cornell University, has two distinctly different RF systems [2]. The buncher cavity RF system consists of the normal-conducting buncher cavity [3], waveguide transmission line components and an IOT-based, 1.3 GHz, 16 kWCW High Power Amplifier (HPA). The HPA is manufactured by Thales-BM; A 20 kWCW circulator is supplied by AFT, the standard waveguide components – by MEGA Industries. The diagram of this system is shown in Figure 1.

The injector cryomodule RF system has five identical channels. Each channel consists of a two-cell superconducting cavity [4] with twin input couplers [5], waveguide transmission line components and a klystron-based transmitter. The 120 kWCW klystron is being fabricated by e2v. A 170 kWCW circulator is supplied by the Ferrite Co., the standard pieces of the transmission line system – by MEGA Industries. Figure 2 represents the diagram of one channel.

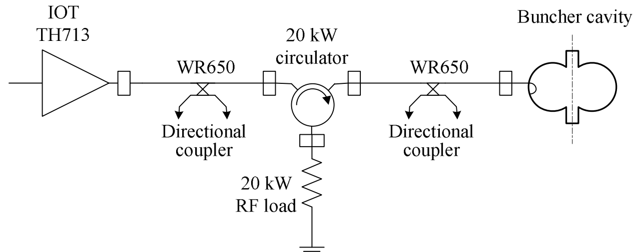

Figure 1: Configuration of the buncher cavity RF system.

2 TESTING COMPONENTS OF THE BUNCHER RF SYSTEM

An IOT-based high power amplifier was chosen as an RF power generator for the buncher cavity. The HPA was manufactured by Thales-BM. The system includes a 16 kWCW tube TH 713 (Thales-ED) incorporated into a modified version of the Thales DCX SIIA broadcast transmitter system (Figure 3). The high voltage power supply is manufactured by NWL.

During the factory acceptance test the HPA has reached the design output power level of 16 kW with efficiency of 60% and gain of over 21 dB. The amplitude and phase ripple noise rms values were measured to be 0.13% and 0.5° respectively. The system was subjected to a 24 hour endurance run with zero faults observed. Upon receiving

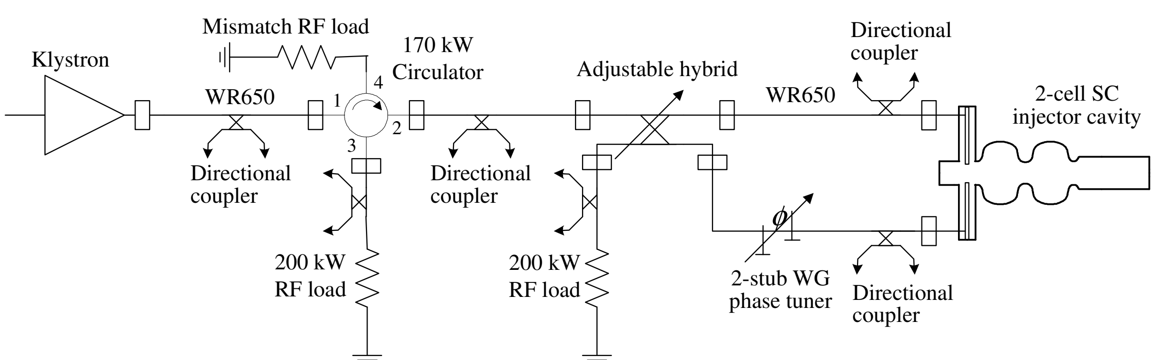

Figure 2: One channel of the injector cryomodule RF system.

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Figure 3: TH 713 IOT inside the transmitter.

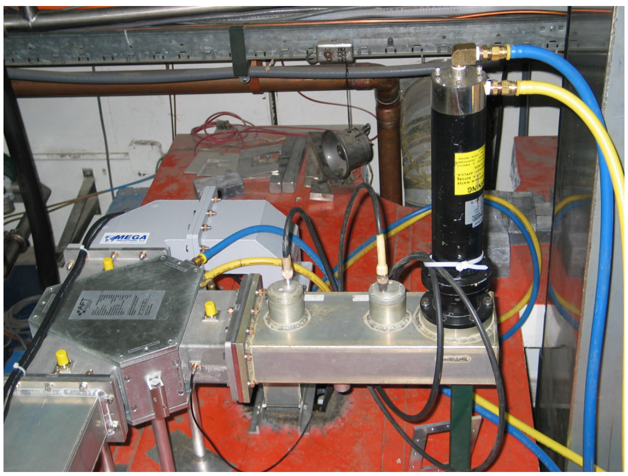


Figure 4: 20 kWCW AFT circulator with RF load.

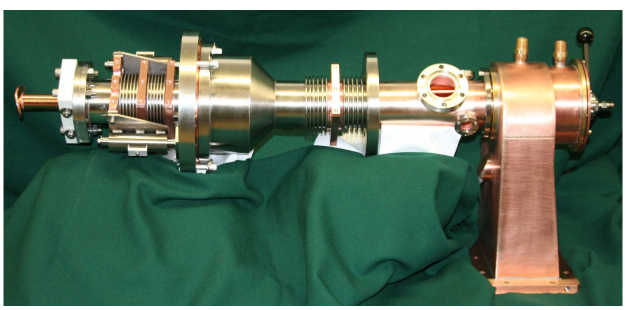
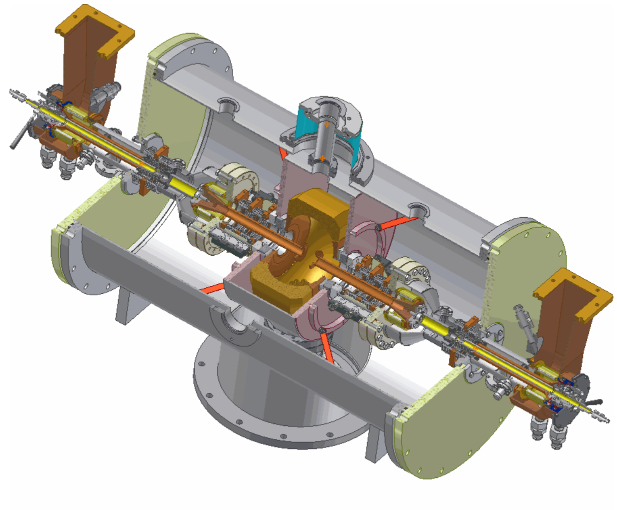


Figure 5: ERL injector cryomodule input coupler.

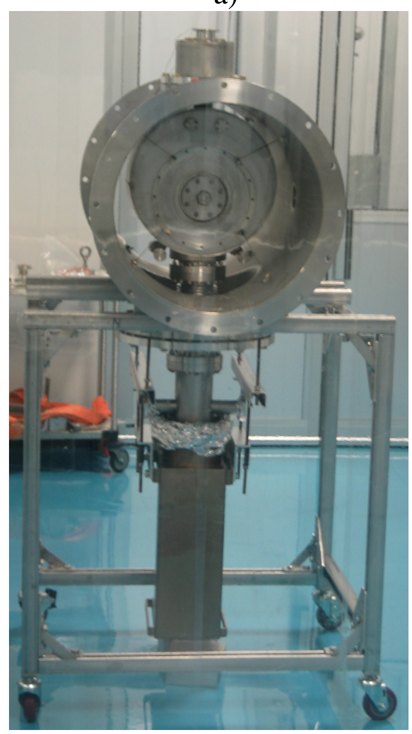
the HPA at Cornell, it was installed in a temporary location and tested again. The tube has quickly reached the nominal output level though there were several crowbar events. The IOT behavior has improved after subsequent high-potting. The 20 kWCW AFT ferrite circulator (Figure 4) was tested up to 16 kW in traveling wave mode and up to 12 kW at full reflection. The system is now fully operational and will be used as part of the input coupler test set up.

3 INPUT COUPLER TEST SET UP

A 75 kWCW input coupler (Figure 5) was designed for superconducting injector cavities [4]. The two prototype



a)



b)

Figure 6: a) 3D view of the input coupler test cryostat with coupling cavity and two couplers; b) the cryostat being assembled in the clean room.

couplers have been ordered from CPI/BMD and have been delivered recently. Ten more units will be ordered after high power testing of the prototypes.

The ERL injector input couplers can transmit high average RF power only with adequate cooling, we plan to process couplers in conditions close to those in a cryomodule. For this purpose a liquid-nitrogen cryostat with a copper coupling cavity inside was designed and built at Cornell. The whole cold part of couplers will be cooled to 80 K. Figure 6a shows the assembly of this cryostat with a coupling cavity and two couplers. One coupler will be connected to the high RF power source and a water cooled load will be attached to the other coupler. The high power test of two prototype couplers will begin in July of 2006.

As the high power klystron (see next section) will not be available by the time of the first coupler test, the 16 kW IOT transmitter will be used. To boost the RF power to the desired level of up to 75 kW, a resonant ring set-up will be build and the two couplers assembly will be inserted into the ring. A power gain of 40 is expected in the ring.

4 STATUS OF THE INJECTOR CRYOMODULE RF SYSTEM

The cryomodule RF system will utilize 120 kWCW klystrons K3415LS manufactured by e2v (Figure 7). This is a 7-cavity tube with designed saturated output power of 160 kWCW. To provide very stable regulation of the cavity field, the klystron must have a non-zero gain and therefore cannot operate in saturation. The maximum useful output power for this tube was defined as a power with gain of 0.5 dB/dB of drive and specified to be no less than 120 kWCW. At this power level the efficiency should be at least 50%. The first klystron is in the final stage of production and will be delivered to Cornell in late July'2006. Five more tubes are on order.

The twin-coupler cavity design requires a rather complicated RF power delivery system [6]. The key components in the power split, an adjustable short slot hybrid and a motorized 2-stub waveguide phase tuner, have been designed. A 3-stub version of the waveguide tuner has been manufactured for use in the resonant ring. Other critical components – 170 kWCW circulators – have been ordered from the Ferrite Co. The first unit (Figure 8) is delivered; manufacturing of five more will be complete soon.

Figure 7: K3415LS klystron.

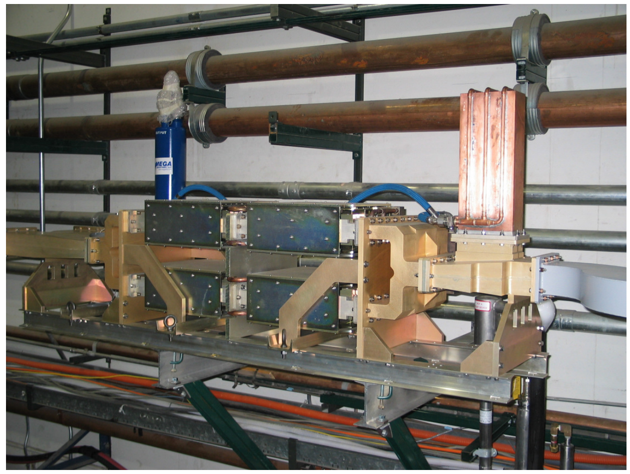


Figure 8: 170 kWCW circulator (the Ferrite Co.) with RF loads.

5 SUMMARY AND FUTUTE PLANS

All components of the buncher cavity RF system have been successfully tested and are fully operational. The two prototype input couplers for the ERL injector cryomodule have been delivered and will be high-power tested using the IOT transmitter and resonant ring in July of 2006. Ten more couplers will be ordered after that test with expected delivery in early 2007. The high power klystrons for the superconducting cryomodule RF system are on order and the first unit will be shipped to Cornell in July of 2006. All long-lead-time waveguide parts for this system have been ordered. In one year we expect to receive and test all RF components necessary to complete RF systems of the Cornell ERL injector.

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