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ORIC RF SYSTEM - PREPARATION FOR HHIRF

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Abstract

The integration of the Oak Ridge Isochronous Cyclotron (ORIC) into the Holifield Heavy Ion Research Facility (HHIRF) requires several RF system modifications to permit injection of ion beams from the 25 MV tandem electrostatic accelerator into ORIC. A new dee eliminates structural interference with the injected beam path and provides an opportunity to improve the mechanical stability of the resonator and to reduce RF voltage gradients in areas susceptible to sparking. Space for structural improvements is realized by reducing the ion beam aperture from 4.8 cm to 2.4 cm. The complexity of the original ORIC RF power system has been substantially reduced. A new broadband solid state driver amplifier between the frequency synthesizer and the main power amplifier eliminates most circuit tuning and permits the use of a new simplified dee RF voltage regulator loop. Most of the remaining instrumentation and control circuitry is TTL compatible and will eventually tie to the ORIC computer control system through a CAMAC interface.

Introduction

The Oak Ridge Isochronous Cyclotron (ORIC) will soon be an integral part of the Holifield Heavy Ion Research Facility (HHIRF).[1] After a long productive career as a multiparticle AVF cyclotron, ORIC is undergoing a variety of alterations which will make it compatible with HHIRF. Most notably, ORIC must accommodate ion beam injection from the 25MV Tandem Electrostatic Accelerator as illustrated in the trajectory diagram in Fig. 1. The beam passes through the RF resonator dee stem and through areas occupied by the dee periphery and the upper tuning capacitor or trimmer. A large steering magnet and other ion optics components will be located inside the dee stem. Other changes including a new broadband RF driver amplifier and a new RF voltage regulator loop with transient protection circuitry are primarily intended for improvements in ORIC's performance and reliability, but HHIRF will especially benefit from the resultant simplification in ORIC's control system.

The New Dee

ORIC's original dee featured a fairly thin walled structure with substantial bracing in the peripheral areas. Since the points at which the injected beam penetrates the periphery are subject to variation as a function of momentum and mass/charge ratio, the cuts required to accommodate all beams would have destroyed the structure. Consequently, a new dee was fabricated with its periphery entirely open except for 2 small corner braces. Past experience with ORIC indicates that its original dee aperture was larger than necessary and that its maximum RF voltage limitations were determined by dee edge geometry rather than by dee to ground clearance. Therefore, the new dee has more structural support in its walls with resultant increase in wall thickness from 1.4 cm to 3.8 cm. While the new dee lacks peripheral structure, it is considerably stiffer than the original.

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*Operated by Union Carbide Corp. for U.S. ERDA.

Some dimensions and characteristics of ORIC's original and new dees are listed in Table 1. The reduced dee to ground clearance adds some capacitive loading which lowers the minimum frequency of the RF tuning range. This increases the number of heavy ion beams which can be accelerated in fundamental mode rather than in 3rd harmonic mode. Since the added capacitance is centered toward the dee stem, it does not affect the upper end of the RF tuning range although it causes a 10% increase in excitation power. Allowable clearances are based upon Cranberg's[2] criteria for voltage breakdown threshold. Surface conditioning should permit considerably higher voltages than the threshold levels. ORIC typically operates with its dee voltage at about 75 kv. The increased dee tip radii should permit somewhat higher dee voltage or smoother operation at voltage levels used in the past.

Considerable effort went into achieving improved cooling so as to prevent dimensional variation with respect to RF power level. The maximum temperature differential from the copper surface to the coolant water will be less than 11°C. In addition to the usual array of copper lines which are brazed to the inside surfaces of the dee walls, the dee edges are formed from heavy walled copper tubing (2.54 cm dia.) which is also part of the coolant loop.

Table 1. Dimensions and Characteristics of the Original ORIC Dee and the New Dee

	Original Dee	New Dee
Max. orbit diameter	178 cm	178 cm
Beam aperture at edges	4.8 cm	2.4 cm
Dee tip (edge) radius	0.32 cm	1.27 cm
Dee-to-ground clearance, (flat surfaces)	3.81 cm	2.54 cm
Dee-to-ground clearance, (edges)	2.54 cm	2.54 cm
RF tuning range, F min.	7.5 MHz	7.0 MHz
F max.	22.5 MHz	23 MHz
Breakdown RF voltage threshold,		
on flat surfaces	78 kV	77 kV
on edges	44 kV	66 kV

The ion beam injection trajectory passes through the upper periphery of the dee; however, for the sake of symmetry the lower periphery is also open. (Fig. 2) The fine tuning capacitors, or trimmers, will also be replaced. Since the upper trimmer is in the beam path, it too is slotted to match the periphery of the dee. Again, the lower trimmer is identical to retain symmetry.

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