R-SQUARE IMPEDANCE OF ERL FERRITE HOM ABSORBER

BROOKHAVEN NATIONAL LABORATORY

ERL

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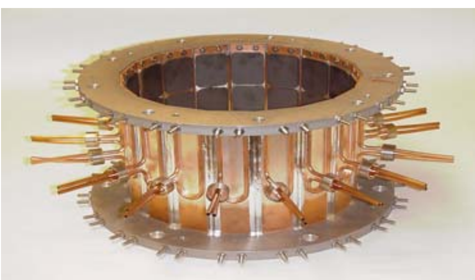
Abstract

An R&D facility for an Energy Recovery Linac (ERL) intended as part of an electron-cooling project for RHIC is being constructed at this laboratory. The center piece of the facility is a 5-cell 703.75 MHz super-conducting RF linac. Successful operation will depend on effective HOM damping. It is planned to achieve HOM damping exclusively with ferrite absorbers. The performance of a prototype absorber was measured by transforming it into a resonant cavity and alternatively by a conventional wire method. The results expressed as a surface or R-square impedance are presented in this paper

INTRODUCTION

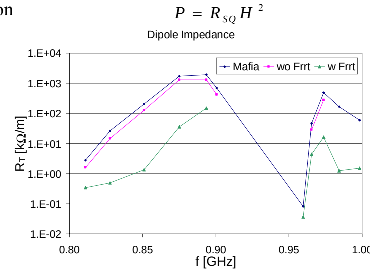
A superconducting (SC) cavity for an Energy Recovery Linac (ERL) is being constructed at this laboratory. The performance of the SC cavity can be severely impacted by the presence of higher order modes (HOM). A carefully chosen design minimizes their presence and remaining HOMs must be damped by HOM couplers attached to the cavity located in the liquid helium or by ferrite absorbers at room temperature. The ERL cavity will rely completely on ferrite absorbers.



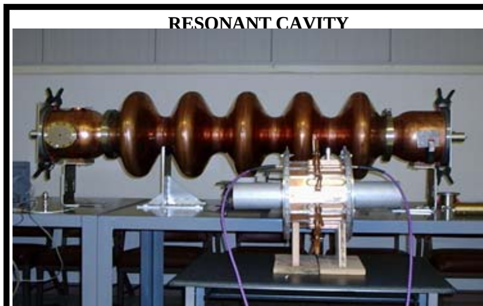
The production ERL HOM absorber is obtained from ACCEL, using the nickel-zinc ferrite C-48 produced by Countis Industries. The ferrite blocks are cooled by water flowing through the copper tubes brazed onto the surface of the heat sink of the ferrite. The ERL test porcupine used for the HOM measurements in the copper cavity is shown in the above Fig. The unit has 18 sections in the 25 cm diameter spool, each assembled of two tiles with 2X1.5X0.125 in. dimensions. A smaller 20 cm diameter unit with 8 tiles was also available for the R-square measurements.

The dipole modes were measured in the ERL copper prototype cavity both with and without the ferrite absorber. The measured data are compared with the Mafia predictions in the Figure below. The dominant dipole modes are found around ~900 MHz so that the absorber properties need to be measured primarily in the frequency range around this strong dipole mode. The measurement of RF properties of the ERL absorber are presented in the convenient form of a R-square impedance which provides the power loss per unit area by the relation

$$P = R_{SQ} H^2$$

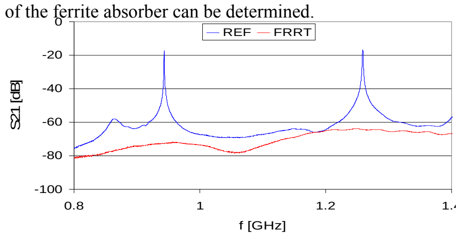


RESONANT CAVITY



The ferrite absorber is transformed into a resonant cavity by attaching shorting end plates and then is compared with a reference cavity of the same dimension. The reference cavity has an inner radius of a = 12.5 cm and a length d = of 18.6 cm. The end plates have stubs, 15 cm long with 4.8 cm i.d., to allow bead pulling for use in other experiments. The ferrite is treated as a thin layer on the same inner radius but covering axially only dFe=10 cm (4 in.) of the cylinder.

The cavity is excited by two equal loops located in the shorting plates at the upper most radial position. The primary measurement of frequency and quality factor of a resonance is by means of the transmission coefficient S21 with a network analyzer. The S21 for the reference and the ferrite absorber cavity are shown in the Fig. The two resonances at 943 and 1257 MHz have been identified as that of the TM010 and TM011 mode respectively for which the R-square impedance of the ferrite absorber can be determined.



In view of considerable measurement errors and for the sake of simplicity, the interpretation of the experimental data will be based on a pill box geometry

$$G = \frac{d}{2d_{Fe}} Z_0 j_{01} \approx 838\Omega$$

The ferrite at the resonance frequencies, 955 MHz

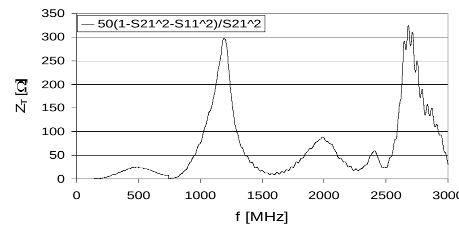
Summarizing the measurements on the ferrite absorber, one can take <Q>≈ 8 from which follows the R-square impedance at 950 MHz as 100 ± 35 Ω, indeed an increase of 4,500 over copper.

The ferrite at the resonance frequencies, 1255 MHz

Fitting of the curves at -3 dB yields a quality factor of Q ≈ 7.4 ± versus the instrument value of 6.3 leading to the R-square impedance 113 20 Ω at 1.255 GHz

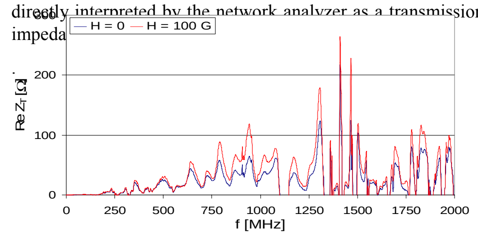
COAXIAL CAVITY

Measurements over a broad frequency range are made with a cavity with center conductor, 2 mm thick. The network analyzer provides the scattering coefficients S21 and S11, which together define the losses within the absorber cavity. The losses for the absorber and reference cavity are shown below. Interpreting the cavity as a lumped element leads to the loss impedance shown here



TRANSMISSION LINE

Conventional transmission line measurements of the ferrite absorber losses are performed by assembling the small 8-tile "porcupine" between coaxial lines, formed from long tubes and a 2 mm center conductor. The ratio of the forward scattering coefficients of the device and of a metal spool is directly interpreted by the network analyzer as a transmission impeda



This measurement established the sensitivity of the ferrite to a magnetic field. A solenoid coil was wound over the cavity and H applied from 0 to 100 G. The losses increased in the present of a magnetic field, a welcome result, since no special absorber shielding will be required.

$R_{SQ} \geq 500\Omega$

A is needed but the experimental results hint that the e. m. waves are not sufficiently damped by one ferrite ring and propagate beyond the absorber.