# Correspondence

## A Resonator Technique for Studying Dispersion in Longitudinally Magnetized Plasma Guides

A resonator technique has been developed for experimentally studying the dispersion characteristics of the angular symmetric modes with one and two radial variations in a circular, longitudinally magnetized plasma column.[1,2] The resonator was made to resonate for both modes by varying the magnetic field, thus making an independent measurement of plasma density unnecessary for verifying theoretical calculations. A detailed cutaway cross-sectional drawing of one of the resonators is shown in Fig. 1. The plasma was formed by pulsing the cathodes negative with a 2-kilovolt pulse of 5 microseconds duration applied at a repetition rate of 60 cycles per second. The plasma thus formed decayed completely between successive pulses. A CW probing microwave signal was applied to one end of the resonator and the resonance was detected in the decaying plasma either by monitoring a sharp decrease in the reflected power or an increase in the transmitted power when the plasma density decayed to a value that caused the column to resonate. The oscilloscope traces of reflected power shown in Fig. 2(a) and (b), in which time increases from right to left, are illustrative examples of the resonances obtained in such a resonator for modes with one and two radial variations, respectively. The second dip corresponds to a resonance; the one near the beginning of the trace, which is independent of magnetic field, has not been fully explained.

The experimental results obtained from a resonator similar to the one shown in Fig. 1 having a cathode radius of 1.5 cm, a length of 1.43 cm, and an outer glass wall radius of 4 cm are presented in Fig. 3. The resonator was filled to one torr with Argon, the probing signal was CW at 9.6 Gc/s and the magnetic field was varied from zero to about 5 kilogauss.

A theoretical plot of normalized cyclotron frequency vs. normalized plasma frequency is shown in Fig. 4 for the axially symmetric modes with one and two radial variations.[2,3] These modes which are represented here in parameter space correspond to the so-called backward wave or cyclotron wave when represented on a Brillouin plot.

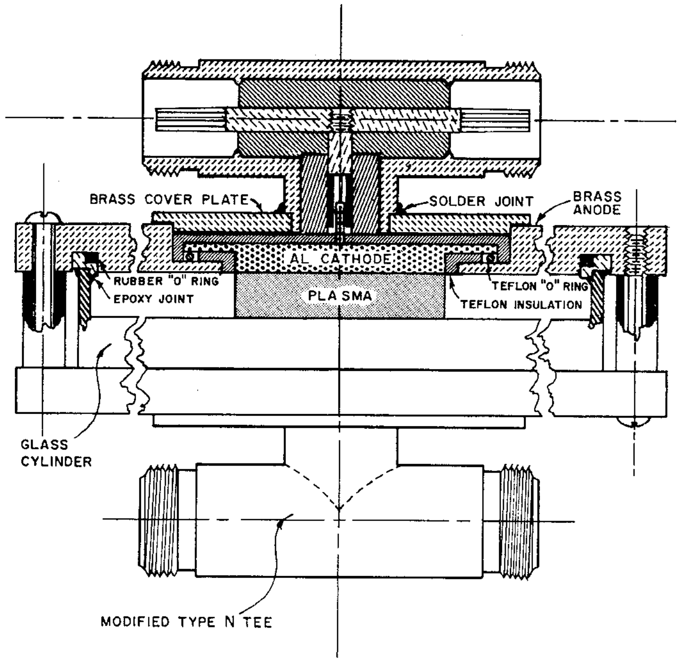
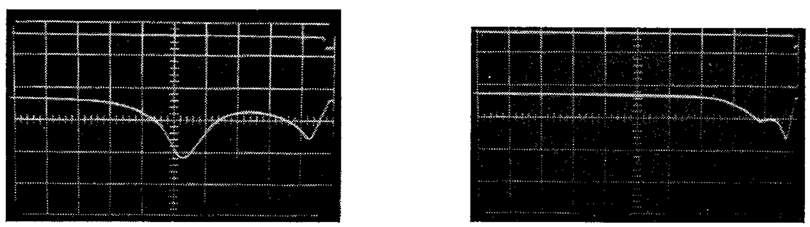



Fig. 1. Cutaway cross-sectional drawing of a plasma resonator.



(a) (b)

Fig. 2. Oscilloscope traces of reflected power from plasma resonator. (a) Mode with one radial variation; sweep speed is 20 μs/cm. (b) Mode with two radial variations; sweep speed is 50 μs/cm.

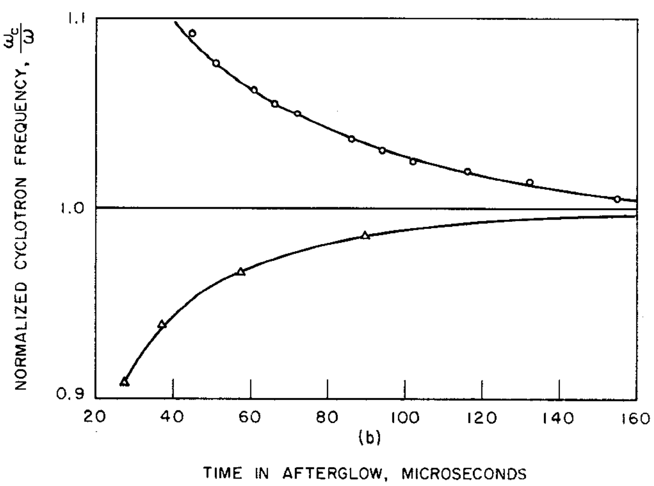



Fig. 3. Experimental data from plasma resonator experiment.

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[1] J. J. Stafford, "Resonant electromagnetic modes in gyroelectric plasmas," Elec. Engrg. Research Lab., University of Ill., Urbana. Tech. Rept. 5, Contract At(11-1)-392, March 1961.

[2] R. K. Likuski, "Free and driven modes in anisotropic plasma guides and resonators," Elec. Engrg. Research Lab., University of Ill., Urbana, Tech. Rept. AL-TDR-64-157, July 1964.

[3] V. L. Granatstein and S. P. Schlesinger, "Electromagnetic waves in parameter space for finite magnetoplasmas," *J. Appl. Phys.*, vol. 35, no. 10, pp. 2846–2855, October 1964.

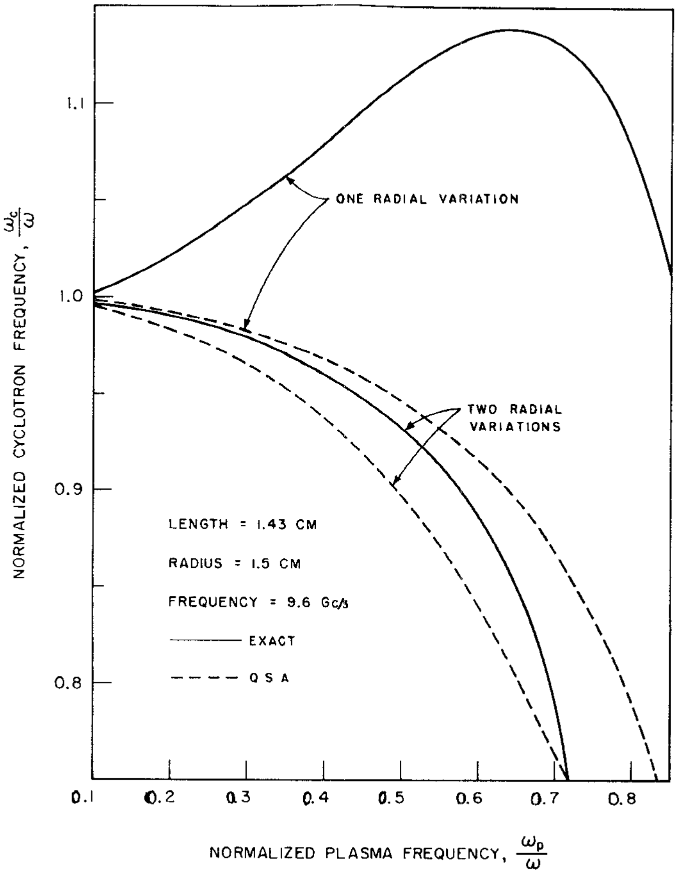


Fig. 4. Theoretical curves for plasma resonator experiment.

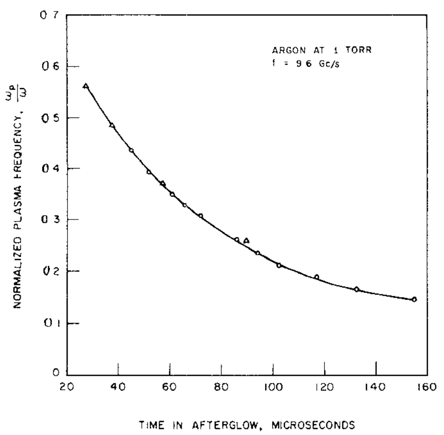


Fig. 5. Experimental plasma decay characteristics. The circular data points represent resonances with one radial variation, while the triangles represent resonances with two radial variations.

The model for these calculations consisted of a circular cylindrical, unclad plasma column; the plasma was considered to be cold, collisionless and homogeneous within the column. Solid lines are used to illustrate solutions obtained through an exact solution of Maxwell's equations while the dashed lines are used for solutions obtained through use of the quasi-static approximation. Both sets of curves are presented to illustrate the discrepancies that would arise if the quasi-static solutions were used to reduce the experimental data.

A plasma decay curve, obtained by reducing the experimental results of Fig. 3 through the use of the exact curves of Fig. 4, is shown in Fig. 5. Good correlation exists between the decay characteristics obtained through the use of the mode with one radial variation and those obtained through the use of the mode with two radial variations. Some discrepancies should exist, since the theoretical model consisted of a lossless, homogeneous plasma while the experimental plasma was lossy, as is apparent from the width of the resonances, and must have had large longitudinal gradients because of diffusion to the cathodes along the magnetic field lines.

An examination of Fig. 4 shows that in the region of parameters for which the experiment was performed, the resonance is very sensitive to small changes in magnetic field, but relatively insensitive to changes in plasma density. It would thus be expected that rather large spatial inhomogeneities could exist in the plasma without destroying the resonance, but small inhomogeneities in the magnetic field would seriously deteriorate the resonance. This was found to be the case experimentally.

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# A Parallel-Strip Point-Contact Diode Mount for Video Detection of Millimeter Waves

This correspondence presents measurements of the performance of an experimental parallel-strip transmission line mount for point-contact diodes (see Fig. 1). These results are an extension of work reported previously [1]. The mount has been used with tunnel-diode, back diode, and ordinary diode detectors at wavelengths of 3.3, 2.1, and 0.84 mm. The sensitivities of the diodes in the new mount compare favorably with reported results for in-line waveguide diodes [2]–[4]. As the signal wavelength decreases, the fabrication of waveguide diode mounts becomes increasingly difficult; therefore, the parallel-strip mount does effect some construction and experimental advantages over such waveguide structures. A detailed description of the parallel-strip mount is given in Gerdine and Barnes [6].

The most comprehensive measurements were made at 3.3 mm because of the availability of laboratory components. A block diagram of the experimental circuit is shown in Fig. 2 and it should be noted that the diode mount was enclosed in a metal box to eliminate background ac pickup. The reference input power for the sensitivity ratings is the input power to the sending horn. The power from the horn was coupled by a dielectric lens to the diode mount input and the spacing between horn and lens was approximately 4 inches. The spacing between the lens and diode mount was adjusted for maximum video output.

The results for different type diodes mounted in the parallel-strip mount are shown in Table I. The tangential sensitivity (TSS) is defined in the standard manner, and the nominal detectable signal (NDS) is defined as the input power required to raise by 3 dB the video output power for no input signal.

Included for comparison, the 1N53 sensitivity measurements were made by replacing the parallel-strip mount and dielectric lens combination by a phase-corrected dielectric lens horn and a waveguide detector mount having a variable tuning termination. The tunnel diodes tested had peak currents in the range from 0.5 mA to 1.5 mA with the most typical values being approximately 1 mA. The peak voltage was typically 0.25 to 0.3 volt. Three to one was the typical peak-to-valley current ratio. Diodes with peak currents ranging from 0 to 0.1 mA were classified as back-diodes and were fabricated from semiconductors doped less heavily than the material used for tunnel-diodes. The silicon used for the point-contact diodes was obtained from 1N53 cartridges.

The results show that the silicon-tungsten point-contact diodes give the best tangential sensitivity for a high impedance video preamplifier, while the gallium arsenide tunnel-diode was most sensitive for the low impedance input into the VSWR amplifier. The principal reason for this is the

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