I. INTRODUCTION

Accurate broadband information on the complex permittivity (ε) and permeability (µ) of ferrite powders is scarce because (1) ferrite powders had limited applications in which they were exposed to external electromagnetic waves, (2) accurate measurement techniques that could handle powdered materials were few.

Recently however, ferrite powders have been investigated for the advantages they provide in the manufacture of very small magnetic recording tapes. Because of this, it is necessary to determine their complex permittivity and permeability over a broad spectrum accurately. This paper presents first data for two ferrite powders, BaFe$_{12}$O$_{19}$ and SrFe$_{12}$O$_{19}$, from 8.0 – 26.5 GHz obtained via the transmission-reflection (TR) technique and cavity resonator (CR) technique.

II. EXPERIMENTAL

TRANSMISSION REFLECTION

In this technique [2,4], the sample is inserted within a waveguide shim and the reflection and transmission coefficients are measured via a Network Analyzer (HP8510C) (see Fig. 1). ε and µ are then determined analytically from Weir’s equations [2] using a specially written program.

CAVITY RESONATOR

Powders are inserted in a fine capillary tube and slotted in a waveguide resonator (see Fig. 2). The center frequency($f_0$) and 3-dB bandwidth ($Q_0$) of the resonant peaks are disturbed. The formulations [3,4] given below were then used to determine the complex ε and µ from the change in $f_0$ and $Q_0$.

Equations

\[
\frac{1}{X'} = \frac{1}{\lambda_0^2} \ln \left( \frac{1}{P} \right)
\]

\[
\mu' = \frac{1}{\lambda_0^2 - \lambda_s^2} - \frac{f_s - f_0}{V_s}
\]

III. RESULTS

The microwave frequency spectrum of ε and µ for the two hexaferrite powders, packed at a homogeneous density of 1.300 g/cm$^3$ are shown in Figs. 3 and 4. Results show that at 25°C and at air humidity <75%:

1. They are both very weak dielectric and magnetic absorbers.
2. ε’ barium hexaferrite rises gently from 2.50 to 2.60 from 8.0-26.5 GHz
3. ε’ strontium hexaferrite varies negligibly around 2.60
4. µ’ shows little variation at about 1.0 for both powders.

IV. CONCLUSION

With a resonator length of 89.8 mm, four resonant peaks were obtained within the X-Band range at 8.281, 9.385, 10.644 and 12.002 GHz. The real permittivity and permeability measured at those frequencies are shown in Figs. 5 and 6 and Table 1 below.

From Figs. 5 and 6, it can clearly be seen that the two methods agree well within the X-Band. In Table 1, the results in the CR method are compared with the values obtained via the TR method at the four above-mentioned frequencies. The percentage discrepancy between the two methods is shown in the last column.

A worst percentage discrepancy of 8.68% is registered in the measurement of the real permittivity at 8.281 GHz in Strontium ferrite powder.

Table 1: Percentage uncertainty for ε and µ measured via TR and CR techniques in the X-Band

<table>
<thead>
<tr>
<th>Frequency (GHz)</th>
<th>TR</th>
<th>ε'</th>
<th>µ'</th>
<th>CR</th>
<th>ε</th>
<th>µ</th>
<th>% discrepancy</th>
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<td>8.281</td>
<td>2.524</td>
<td>1.061</td>
<td>2.590</td>
<td>1.151</td>
<td>-2.60</td>
<td>8.51</td>
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<td>2.544</td>
<td>1.054</td>
<td>2.557</td>
<td>1.097</td>
<td>-2.50</td>
<td>8.64</td>
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<td>2.507</td>
<td>1.062</td>
<td>2.492</td>
<td>1.000</td>
<td>0.60</td>
<td>5.84</td>
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<td>12.002</td>
<td>2.543</td>
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<td>2.598</td>
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<td>6.54</td>
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<td>2.590</td>
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V. REFERENCES