center frequency of the coupler. The exact role that each of these elements plays in the final, fully compensated configuration is difficult to assess, and no attempt at a detailed analysis has been made.

In summary, a solution to the problem of anisotropy drift in a YIG single crystal gyromagnetic coupler has been achieved through the appropriate orientation of the YIG coupling element. A solution to the external source of instability has been achieved through the use of a magnetic shunt of Carpenter Temperature Compensator. The end product is a well shielded gyromagnetic coupler, tunable from 5.4 to 5.7 Gc, free from anisotropy drift affects with up to 1 watt average power input, and temperature stabilized to less than ±2 Mc through an ambient change from −20°F to 150°F.

ACKNOWLEDGMENT

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An S-Band Wide-Band Degenerate Parametric Amplifier*

This communication reports some experimental results for an S-band wide-band degenerate parametric amplifier designed with a method earlier described by the author.[1]

We represent the varactor by a nonlinear capacitance in series with a loss resistance R and an inductance L_s and write the pumped capacitance as

$$C = C_d[1 + 2\alpha \cos \omega_p t]. \quad (1)$$

Then the signal voltage gain G of a degenerate circulator operated amplifier can be written as

$$\begin{cases} |G| = \dfrac{1 + |\rho|^2}{2|\rho|} \\ \rho = \dfrac{Z_s - Z_d}{Z_s + Z_d} \end{cases} \quad (2)$$

Z_s is the signal circuit impedance, including varactor reactances, as seen from the varactor end. Z_d is a modified signal-idler coupling impedance

$$\begin{cases} Z_{d0} = \dfrac{\alpha}{\omega_{s0}(1 - \alpha^2)C_d} \\ Z_d = \sqrt{Z_{d0}^2 + \dfrac{R^2}{G_0^2 - 1}} - R\dfrac{G_0}{\sqrt{G_0^2 - 1}} \end{cases} \quad (3)$$

* Received May 24, 1963.

[1] B. T. Henoch, "A new method for designing wide-band parametric amplifiers," IEEE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-11, pp. 62–72; January, 1963.

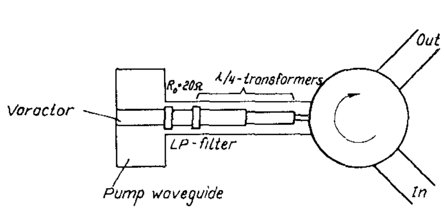

Fig. 1—Configuration of a single-tuned amplifier.

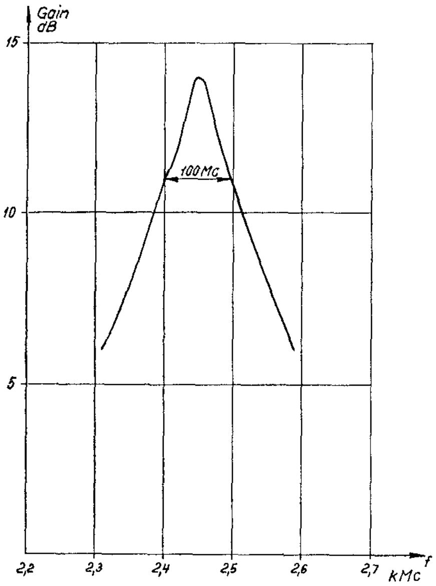

Fig. 2—Double sideband gain as a function of frequency for the single-tuned amplifier.

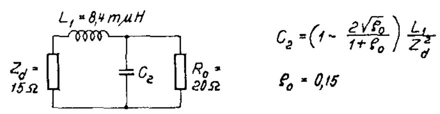

Fig. 3—Low-pass equivalent of the matching circuit.

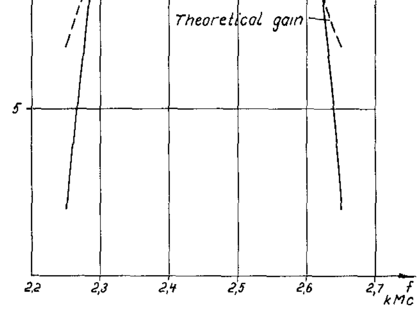

Fig. 4—Double sideband gain as a function of frequency for the double-tuned amplifier.

The wide-band design problem now is reduced to a problem of matching the modified coupling impedance Z_d into the amplifier source impedance R_0.

The experimental amplifier uses a GaAs varactor with a zero-bias capacitance of 0.5 pf, cutoff frequency 100 kMc and series-resonance frequency 6 kMc. The varactor is mounted in a pump waveguide according to Fig. 1.

The signal frequency is chosen so that the waveguide inductance resonates the varactor and the amplifier source impedance R_0 is chosen to 20 Ω.

The double sideband gain is measured by using a swept frequency generator and a broad-band detector which displays the gain curve on an oscilloscope. The gain vs frequency for the single-tuned amplifier is shown in Fig. 2.

The measured gain curve corresponds to $C_d = 0.5$ pf, $Z_d = 15$ Ω and $\alpha = 0.15$. The inductance L_1 in the series resonator is $L_1 = 8.4$ mμh.

To get a double-tuned wide-band amplifier a parallel resonator is inserted between the series-tuned varactor and the amplifier source impedance R_0 and designed to match Z_d maximally flat into R_0. The low-pass equivalent of the matching circuit is shown in Fig. 3.

Practically, a low impedance section, half a wavelength long at ω_{s0}, is used as a parallel resonator. From a linear approximation around ω_{s0} the impedance Z_p of the low impedance section can be determined.

$$C_2 = \frac{1}{2}\frac{\pi}{\omega_{s0}}\left[\frac{1}{Z_p} - \frac{Z_p}{R_0^2}\right]. \quad (4)$$

This determines Z_p to 7 Ω. Plotting in a Smith Chart shows that the optimum Z_p will be somewhat lower than given by (4). Reactive parts in the source impedance R_0 might modify the length of the low impedance section.

With a low impedance section of impedance 5.5 Ω and electrical length 170° at ω_{s0} the gain curve shown in Fig. 4 is measured. The measured gain curve is compared with a theoretical gain curve obtained from the concentrated element equivalent.

Point measurements of the double sideband noise figure give noise figures of 1.5–2.0 db.

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Phaseshift of Electromagnetic Waves Propagating Through Waveguide Junctions*

This work was activated by the lack of information in literature about the effect of an H-plane branch upon electromagnetic waves traveling through the collinear arms of the branch. Most literature about the sub-

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