MONDAY, MAY 15, 1961
SESSION 2: PARAMETRIC DEVICES

2:00 PM - 4:45 PM
CHAIRMAN: W. W. MUMFORD
BELL TELEPHONE LAB
WHIPPANY, NEW JERSEY

2.4 PRACTICAL DESIGN AND PERFORMANCE OF NEARLY OPTIMUM WIDEBAND DEGENERATE PARAMETRIC AMPLIFIERS*

M. Gilden and G. L. Matthaei
Stanford Research Institute, Menlo Park, California

The design and performance of degenerate parametric amplifiers is described as that in which large bandwidth is achieved through the use of multiple-resonators as suggested by Seidel and Herrmann.[1] However, instead of setting frequency derivatives of the gain function equal to zero,[1] filter-theory design procedures as developed by Matthaei were used.[2] These design procedures have been verified by the authors with a single-diode degenerate amplifier operated with a directional coupler[3,4] and in this paper the work has been extended to include the cases of balanced amplifiers and cascaded balanced amplifiers with contiguous pass bands.[3]

The nearly-optimum wide band performance was achieved by using a two-resonator structure, by resonating the diode in series, by making the resonator elements as nearly lumped as possible, and by using a lightly-coupled pump resonator. Figure 1 shows the stripline circuit which was used.

The frequency response and noise figure of the single-diode degenerate amplifier (Fig. 1) corresponding to operation with an ideal circulator or balanced circuit were obtained. Experimental and theoretical responses of the amplifier, in Fig. 2, shows the significant increase in bandwidth, from 81 to 210 Mc, resulting from the addition of a second resonator and also shows the good agreement between theory and experiment. The measured double-channel noise figure of 1 db agrees with the theoretical value of 0.5 db within the estimated possible measurement error.

An interesting and important effect is the surprising lack of sensitivity to mistuning of the resonators which is shown to be due to a reactance cancellation effect. This effect is demonstrated in Fig. 3 where computed frequency responses are plotted for several values of static diode capacitance. The mid-band frequency does not shift and only the ripple amplitude varies. Also, it was found that shifting the pump frequency causes the mid-band frequency of the amplifier to shift so as to always fall at one-half the pump frequency.

Two single diode amplifiers were connected to a low VSWR 3-db directional coupler as shown in Fig. 4 to form a balanced amplifier. The directional coupler permits optimum gain and noise figure and also provides separate input and output ports. The measured response of the balanced amplifier shown in Fig. 5 is seen to be altered only slightly from that for a single unit, (Fig. 2).

To extend the bandwidth even further two balanced amplifiers with contiguous pass bands were connected in cascade. This connection is practical because each balanced amplifier has unity gain outside its pass band. Although the results became erratic at the higher frequencies because the directional couplers had not been designed for that range, the results indicated that such an interconnection is feasible.

---

*This research was sponsored by Wright Air Development Division, Wright Air Force Base, under Contract AF33(616)-5803.

[1]H. Seidel and G. F. Herrmann, "Circuit Aspects of Parametric Amplifiers," 1959 IRE WESCON CONVENTION RECORD, Part 2, Circuit Theory, pp. 83–90.

[2]G. L. Matthaei, "A Study of the Optimum Design of Wideband Parametric Amplifiers and Up-Converters," IRE Trans. on Microwave Theory and Techniques, Vol. MTT-9, pp. 23–38; January 1961.

[3]M. C. Pease, M. Gilden, G. L. Matthaei, R. C. Honey, and C. W. Barnes, "Application of New Techniques to Low-Noise Reception," Quarterly Progress Report 10 and Final Report, SRI Project 2550, Contract AF 33(616)-5803, Stanford Research Institute, Menlo Park, California (March, 1960).

[4]M. Gilden and G. L. Mattahei, "A Nearly Optimum Wideband Degenerate Parametric Amplifier," To be published in correspondence section of Proceedings of the IRE.

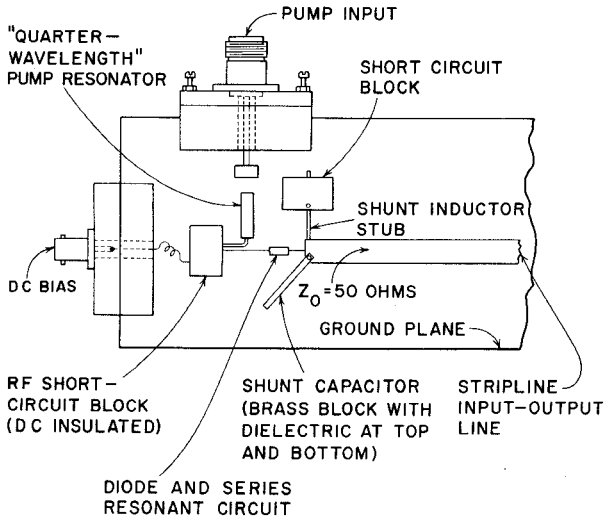

Figure 1 - Construction Details of Double-Resonator Degenerate Parametric Amplifier.

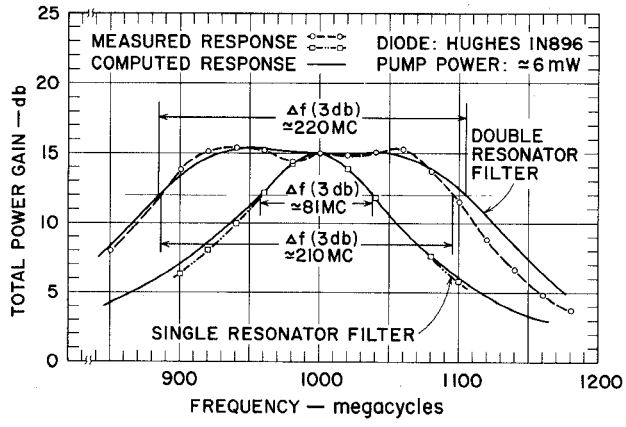

Figure 2 - Frequency Response of the Single- and Double-Resonator Filter Parametric Amplifier.

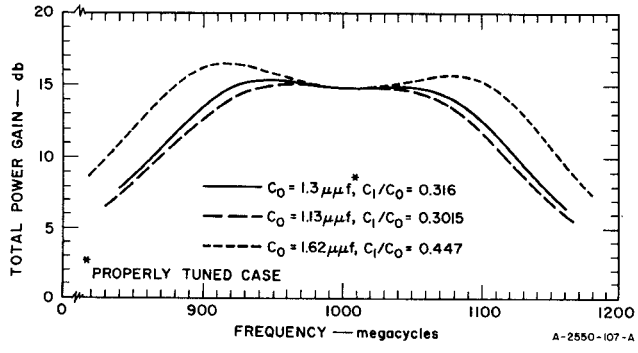

Figure 3 - Computed Frequency Response of Two-Resonator Filter Degenerate Parametric Amplifier Showing Dependence upon Static Capacitance of Diode.

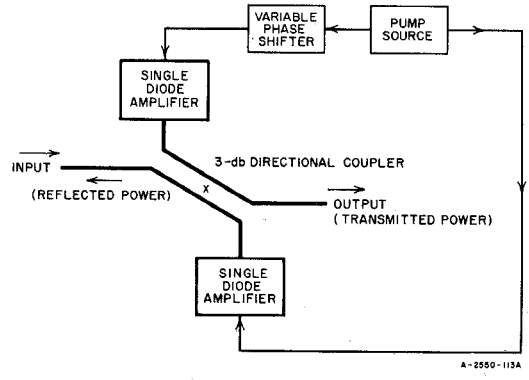

Figure 4 - Balanced Amplifier Using Two Degenerate Parametric Amplifiers and A 3-db Directional Coupler.

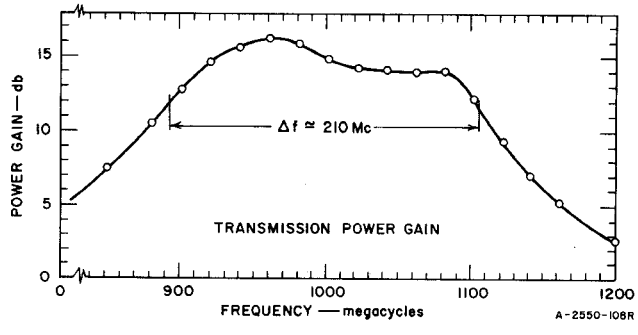

Figure 5 - Measured Frequency Response of Balanced Amplifier Using Two Degenerate Amplifiers and Three-db Directional Coupler.