A Four-Way Distribution Amplifier for Reference Signal Distribution

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This article presents the design and construction of a four-way distribution amplifier. It has 100 dB isolation between any two output ports, and it will be used to distribute multiple reference signals.

I. Introduction

A four-way distribution amplifier with up to 100 dB isolation and with low phase noise of −140 dBc in a 1 Hz bandwidth 10 Hz from a 100 MHz signal has been developed. It will be used in the stabilized optical fiber distribution system (Ref. 1) to provide multiple outputs.

This article describes the design and overall construction of the amplifier. Optimizing techniques and performance are discussed.

II. Description

As shown in the block diagram (Fig. 1), the distribution amplifier consists of five isolation amplifiers (Ref. 2), one power amplifier, a matching network and one four-way power splitter. The matching network is used to maximize isolation.

The isolation amplifier (Fig. 2) is an in-house design. It contains a complementary common emitter stage followed by a complementary emitter follower. This combination provides maximum output to input isolation for a two-stage amplifier, and better efficiency than can be obtained with a single-ended design. Input and output ports of the isolation amplifier are capacitively coupled, and the impedances are adjusted to 50 Ω.

The power stage is a commercial wideband amplifier with output power up to 22 dBm. It has a gain of 10 dB. Input and output VSWR are typically better than 1.5:1. DC power consumption is about 1.32 watts.

The power splitter is also a commercial unit chosen to achieve the maximum isolation between different output ports. It has a bandwidth of 200 MHz.

III. Isolation

Maximum isolation between output to output and output to input ports of any power splitter can be achieved by providing the optimum impedance at the input port. With the four-way power splitter connected as shown in the block diagram (Fig. 1), tests have demonstrated that 100 dB isolation is obtainable between either the opposite or the adjacent output ports, but not both simultaneously.

In order to obtain 100 dB isolation between all four output ports, a four-way power splitter can be made out of three two-way power splitters, and then an optimum input match can be provided for each of them. A single four-way power splitter was used in the prototype amplifier and the output to output isolation was compromised by adjusting the input impedance of the power splitter until the same isolation is obtained between all output ports. The isolation is thus reduced to -92 dB, and this method requires fewer components than the use of three two-way splitters.

The particular power amplifier used was chosen for its low VSWR and small reactance at its output port. Consequently, a low Q matching-circuit (Fig. 3) can be constructed which will transform the power amplifier output impedance to the optimum input impedance of the power splitter.

In order to determine the optimum matching impedance for best isolation, a tunable matching network was designed to match a 50 Ω source to a range of load impedances. This matching network was applied between the four-way power splitter and the power amplifier. The tuning elements were adjusted for best isolation over a small bandwidth at the desired frequency. In order to get a wideband isolation characteristic, a low Q circuit was substituted for the tunable matching network.

IV. Tests

Tests to determine isolation, gain, VSWR, phase noise and maximum power output have been conducted on the amplifier. The results of these tests are shown in Figs. 4 through 9.

The distribution amplifier has an isolation of 92 dB between any two output ports. It has an isolation of 132 dB from any one output port back to the input. A 3 dB gain is obtained over a bandwidth of 250 MHz. The input and output VSWRs are optimized at 100 MHz. Power spectral density of phase noise (Ref. 3) is -140 dBc in a 1-Hz bandwidth, 10 Hz from a 100 MHz signal. Power output at 5% harmonic distortion is 14 dBm. The total dc power consumption is 4 watts.

V. Conclusion

The distribution amplifier described has excellent isolation, low phase noise, low VSWR, wide bandwidth, and good efficiency. It is well-suited to distribute ultra-stable reference frequencies to multiple users. The techniques described may be useful in other applications requiring high isolation, wide bandwidth and low phase noise.

References

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3. Meyer, R., and Sward, A., "Frequency Generation and Control: The Measurement of Phase Jitter," in The Deep Space Network, *Space Programs Summary 37-64*, Vol. II, pp. 55-58, Jet Propulsion Laboratory, Pasadena, California, August 31, 1970.

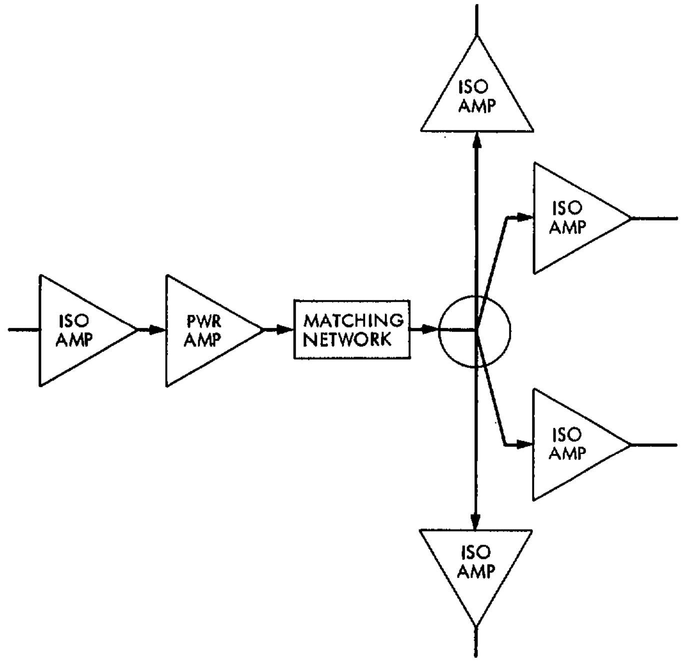

Fig. 1. General block diagram of the distribution amplifier

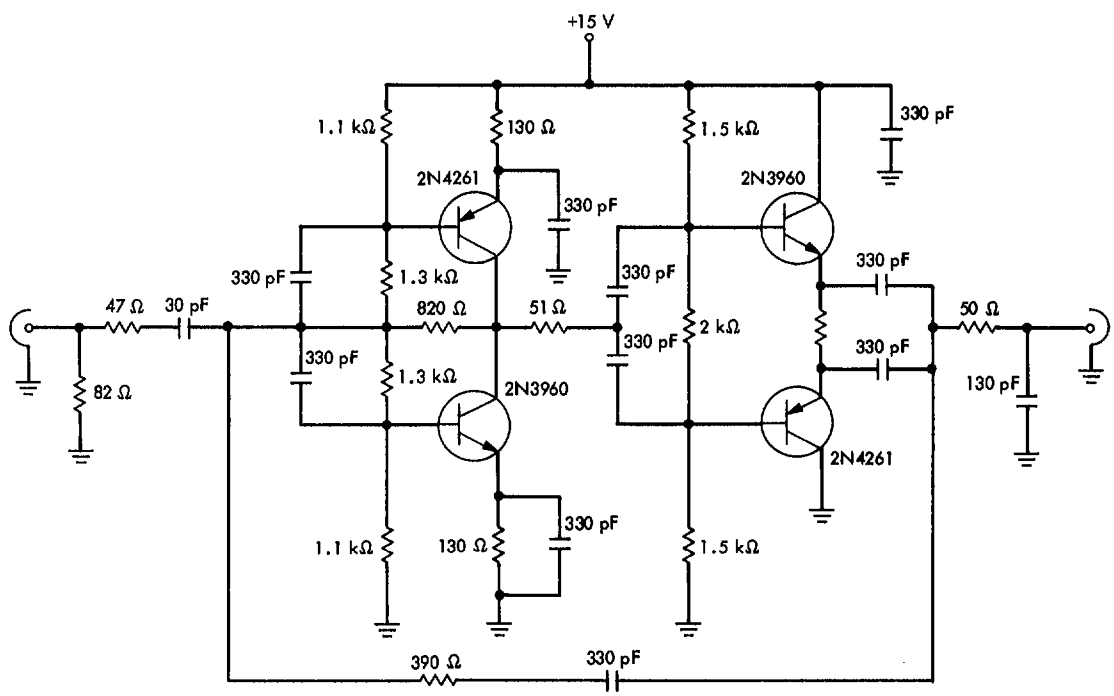

Fig. 2. Isolation amplifier

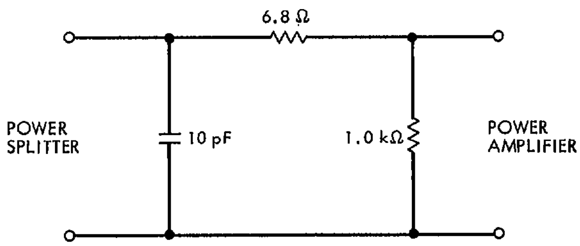

Fig. 3. Matching network

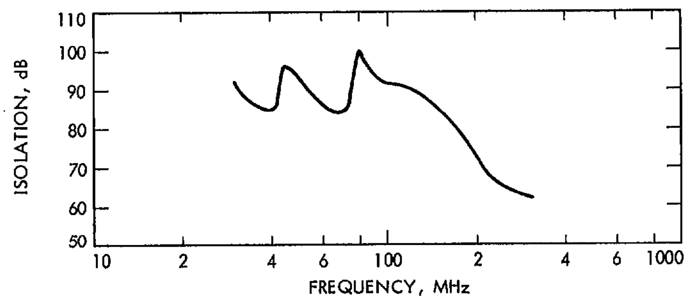

Fig. 4. Typical isolation characteristic of the distribution amplifier (between any two output ports)

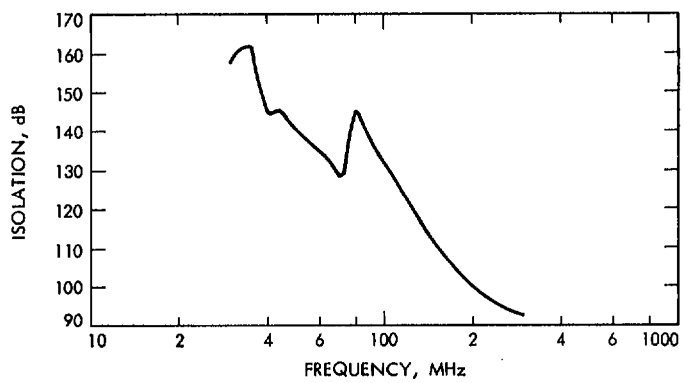

Fig. 5. Typical isolation characteristic of the distribution amplifier (from any one output port to input)

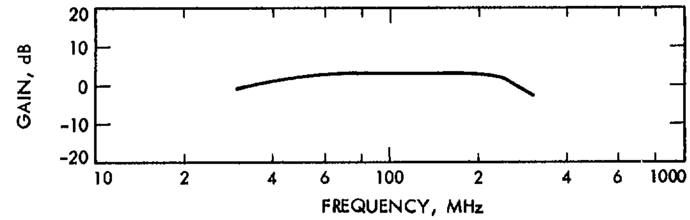

Fig. 6. Gain characteristic for the distribution amplifier

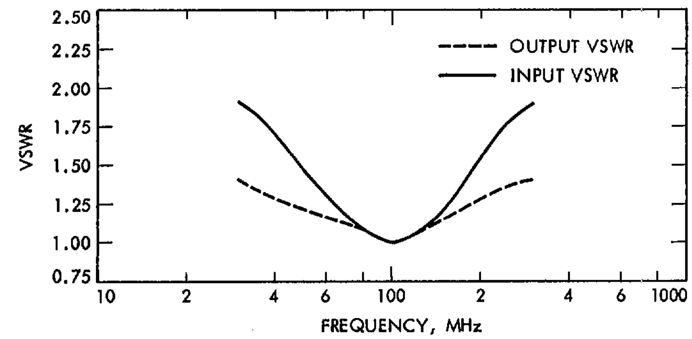

Fig. 7. Input and output VSWR of the distribution amplifier

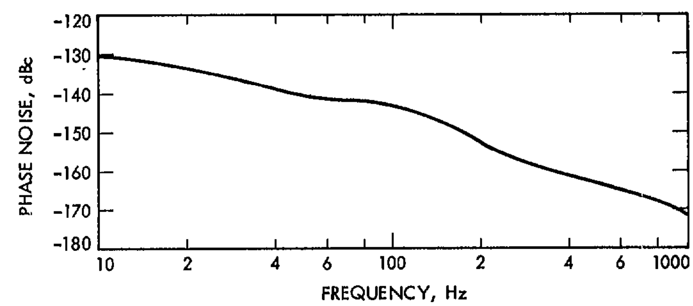

Fig. 8. Power spectral density of phase noise vs frequency of the distribution amplifier (single side band)

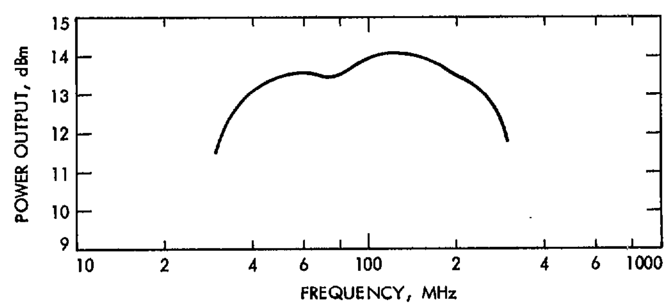

Fig. 9. Power output corresponding to 5% harmonic distortion for the distribution amplifier