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A SIMPLE STRIPLINE DESIGN FOR UNEVEN POWER SPLIT

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SUMMARY

A simple technique is described for the design of stripline or microstrip power dividers for unequal, but in-phase, power split. The output power ratio is determined by selecting the location of the input port in a manner analogous to the tap point for an electric power transformer.

INTRODUCTION

Corporate feed networks for antenna arrays often require unequal power dividers in order to excite the array with a nonuniform amplitude distribution. Depending upon the degree of amplitude taper, the number of elements, and the conceptual design of the network, the required ratio of power split may not be the same for all power dividers and may vary over a wide range of values. Branch guide couplers, broadside-coupled quarter-wave sections, and in-line dividers can be designed and implemented in stripline or microstrip for unequal power split; however, if the ratio of the power split is greater than about 8dB, the narrow line widths due to the required high line impedances can become impractical to construct. For power splits exceeding 10dB, side-coupled quarter-wave lines can be used, although they require multilayered construction. In the design of a power distribution network, which includes a wide range of power divisions, a variety of unequal power dividers, line widths, and line spacings may be required. This paper describes a simple power divider which can be designed for power splits ranging from equal split to as large as required, with the advantage of utilizing the same line impedances and line spacings for all values of power split.

DESIGN

A schematic of the unequal power divider is illustrated in fig. 1. The unequal power split is obtained by exciting both input ports of a quadrature hybrid with equal amplitudes but different phases. The signals at the two output ports will then be the superposition of the response of the hybrid to two input signals. By properly selecting the phase difference between the input signals, the signals will combine at the output ports such that the output amplitude ratio can be any value desired, while maintaining an in-phase relationship at the output.

A simple way to excite the two input ports of the hybrid in this manner is illustrated in fig. 1. A simple TEE equal power divider is connected to the inputs of the hybrid by unequal line lengths to produce the phase difference at the inputs to the hybrid. In the configuration of fig. 1, the power ratio at the output of the unequal power splitter will be

$$\frac{P_1}{P_2} = \frac{\cos^2 (2\pi(b-a)/\lambda)}{\cos^2 (2\pi a /\lambda)} \qquad (1)$$

which is independent of the line length, c.

At the center frequency of the hybrid, $b = \lambda/4$, equation 1 can be rewritten as

$$\frac{P_1}{P_2} = \tan^2((\pi/2)(a/b)) \tag{2}$$

Therefore, for the configuration of fig. 1, the ratio of the output power split is determined by the position of the input port (i.e. the ratio a/b) in a manner analogous to the tap point for an electric power transformer. Since the power split depends only upon the ratio a/b, once the physical parameters (dielectric constant, dielectric thickness, line widths, and line lengths) have been established for an equal power divider and a quadrature hybrid at the design frequency, all unequal power dividers for a distribution network can be designed by simply selecting the input tap point such that

$$a/b = (2/\pi) \arctan(\sqrt{P_1/P_2}) \tag{3}$$

RESULTS

Three experimental unequal power splitters were designed for output power ratios of 0.5, 0.25, and 0.1 (-3dB, -6dB, and -10dB) at 1413 MHz and fabricated in stripline as shown in fig. 2. A quarter-wave transformer was included in the input line for impedance matching;

however, no attempt was made to optimize the parameters of the hybrid or the input power divider. The purpose of the three designs was to verify the concept for obtaining unequal power split according to equation 3.

The measured power split is plotted in fig. 3 along with the calculated result from equation 1. At the design frequency (1413 MHz), the measured power split agrees with the design values within the accuracy of the network analyzer system used to make the measurements. Fig. 4 shows the difference in phase at the output ports of the three unequal power splitters.

Although the power split and phase vary with frequency, the usable bandwidth is adequate for some applications. For example, the frequency band (1363-1463 MHz) indicated in fig. 3 and 4 has been allocated for an L-band radiometer phased array with a cosine distribution, which is presently being designed and built. The simplicity of the design of the unequal power splitter makes it attractive for such narrow band phased array applications where a tapered amplitude distribution is required for sidelobe reduction.

CONCLUSION

A simple technique for the design of unequal power dividers for a wide range of power splits is described. The simple technique yields a usable bandwidth of about 7 to 8 percent and is attractive for tapered amplitude distribution networks for narrow band phased arrays.

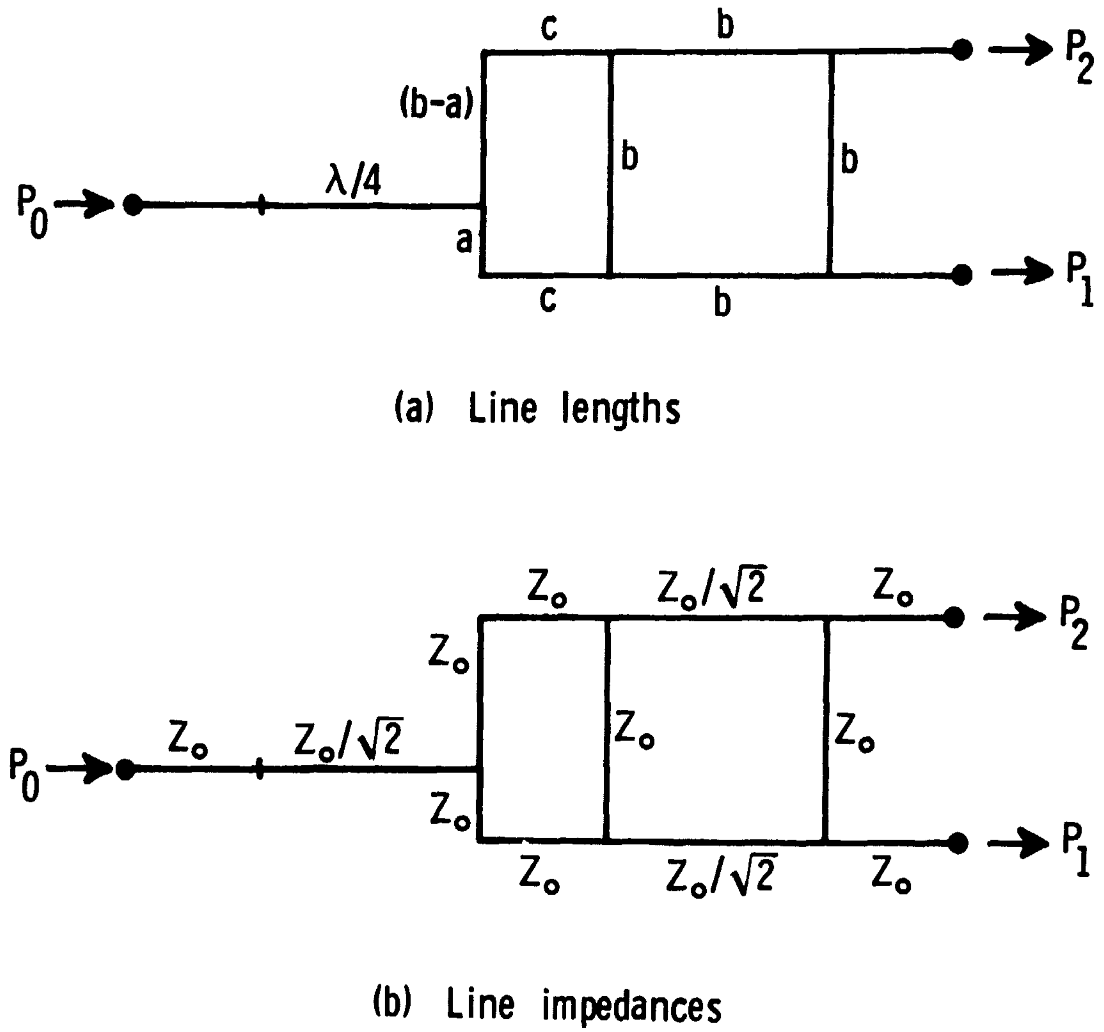

Fig. 1. Schematic of unequal power splitter.

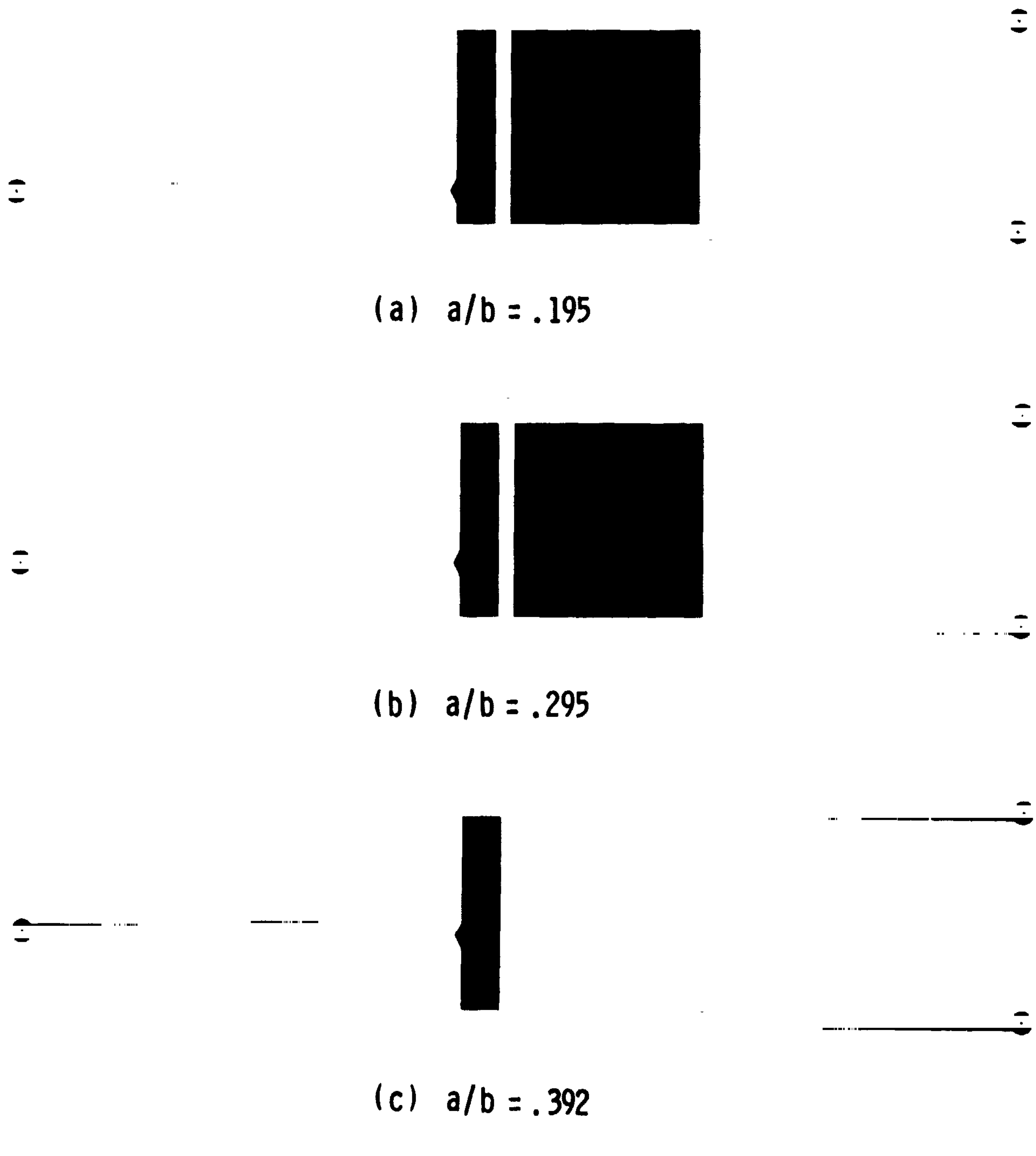

Fig. 2. Center conductor for experimental stripline unequal power splitters designed for output power ratios of 0.1, 0.25, 0.5 at 1413 MHz using 1/8 inch thick stripline, dielectric constant of 2.5 and Z_o=50 ohms.

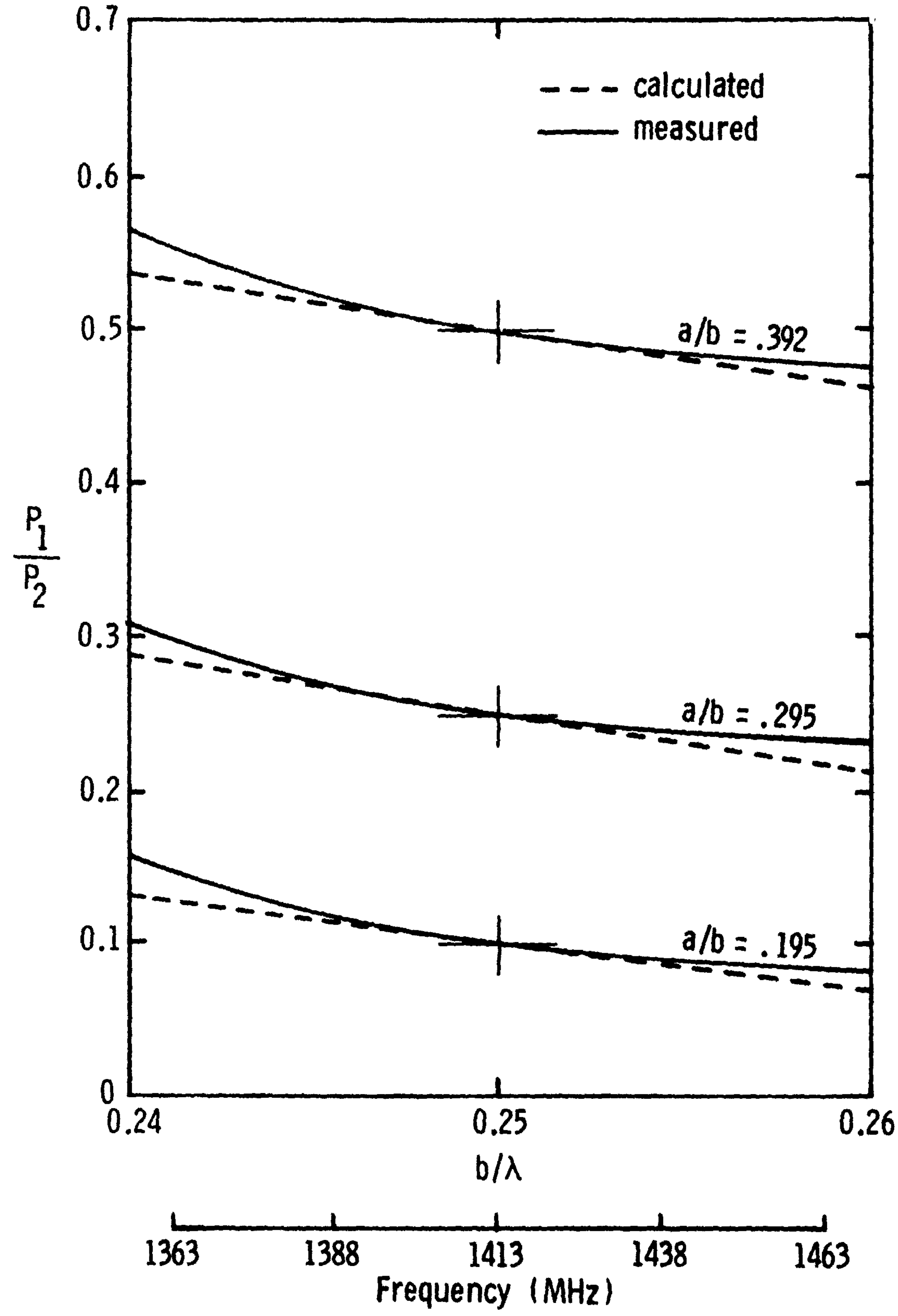

Fig. 3. Output power ratio versus frequency for unequal power splitters of figure 2.

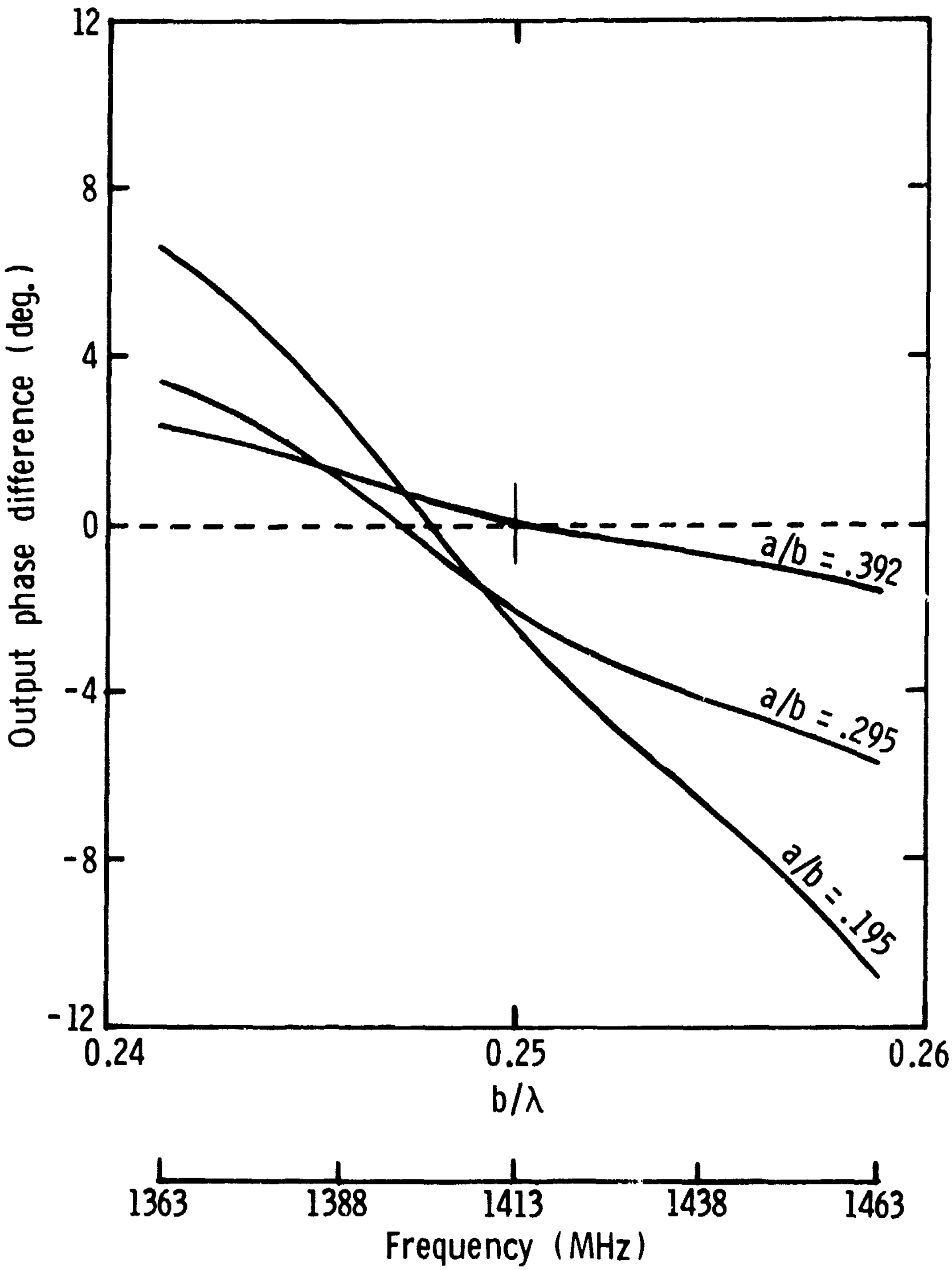

Fig. 4. Output phase difference versus frequency for unequal power splitters of figure 2.