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Technical Note 1965-33

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Fringing Capacitances for Offset Coupled Strips in Shielded Strip Line

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Group 46

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ABSTRACT

Even- and odd-mode fringing capacitances are presented for a widely used strip-line configuration that consists of two overlapping thin strips parallel to but not centered between ground planes. All the fringing capacitances are presented in terms of a single function, which is plotted for convenience.

Accepted for the Air Force
Stanley J. Wisniewski
Lt Colonel, USAF
Chief, Lincoln Laboratory Office

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The coupled, thin-strip, shielded strip line shown in Fig. 1 has proven to be a practical configuration for obtaining close coupling which results from the overlap of the center conductors. The information presented here on fringing capacitances for this structure, along with well-known techniques(1) for the use of such capacitances, allows the strip-line component designer to relate required even- and odd-mode capacitances to physical dimensions of the structure with very little error.

It should be observed that the lack of symmetry of either center conductor with respect to the ground planes allows radiation at any discontinuity generating an unbalanced current component normal to the ground planes; but this radiation can usually be controlled by appropriate shielding. A symmetrical thin-strip configuration(1) that also achieves close coupling by overlapped center conductors has been described and it does not require shielding. However, since most strip-line components are shielded regardless of need, the simplicity of the configuration of Fig. 1 has often justified its use.

The use of even- and odd-mode fringing capacitances in designing strip-line components has been described many times before (see Ref. 1) and so only necessary definitions and results will be given here.

Figure 1 shows the cross section and defines the geometry of the configuration. It is assumed that the two strips are of equal width, but this is not a necessary assumption. Figure 2 indicates the various fringing capacitances, denoted by primes, and parallel-plate capacitances, denoted by subscript p. Figure 3 is a generalized schematic diagram showing total capacitances formed of the fringing and parallel-plate capacitances.

(1) W. J. Getsinger, "A Coupled Strip-line Configuration Using Printed-Circuit Construction That Allows Very Close Coupling," IEEE Trans. MTT-9, 535 (November, 1961).

The parallel-plate capacitances indicated in Fig. 2 are defined as follows:

$$C_{p1}/\epsilon = 2\,\frac{c/b}{1 - s/b} \quad ,$$

$$C_{p2}/\epsilon = 2\frac{c/b - d/b}{1 + s/b} \quad , \qquad (1)$$

$$C_{p3}/\epsilon = d/s \quad .$$

It is interesting that the fringing capacitances can be expressed in terms of a single function, F(x), defined by

$$F(x) = -\frac{1}{\pi}\,[(1-x)\,\ell n\,(1-x) + x\,\ell n\,x] \quad . \qquad (2)$$

This function is plotted in Fig. 4. Since F(x) is an even function about x = 0.5, the abscissa can be read as either x or 1-x. The function is related to the structure by letting

$$x' = 2\,\frac{s/b}{1 + s/b} \quad . \qquad (3)$$

and

$$x'' = \frac{1}{2}\,(1 - x/b) \quad .$$

Then the fringing capacitances arising at the overlap are

$$C_1'/\epsilon = \frac{x'}{1 - x'}\;F(x') \quad ,$$

and

$$C_2'/\epsilon = \frac{F(x')}{x'} \quad . \qquad (4)$$

The fringing capacitance to both ground planes from the outer edge of either strip is

$$C_f'/\epsilon \;=\; \frac{F(x'')}{x''(1 - x'')} \;\approx\; \ln 2 \;=\; 0.882 \text{ for } s/b \text{ small.} \tag{5}$$

The total even- and odd-mode capacitances C_e and C_o of a single strip as shown in Fig. 3 are

$$\begin{aligned} C_e &= C_f' + C_1' + C_{p1} + C_{p2} \quad , \\ C_o &= C_e + 2C_{p3} + 4C_2' \quad . \end{aligned} \tag{6}$$

The interstrip capacitance, ΔC, shown in Fig. 3, is given by

$$\Delta C \;=\; \frac{1}{2}\,(C_o - C_e) \quad . \tag{7}$$

Limitations on the accuracy of the curve and formulas require that the strips must be thin, that a positive overlap exist such that $d/s \geq 0.6$, and that the strips be sufficiently wide so that

$$\frac{c - d}{b} \geq 0.35, \text{ approximately.}$$

The above results were derived by conformal mapping using strips extending to infinity from the coupling region.

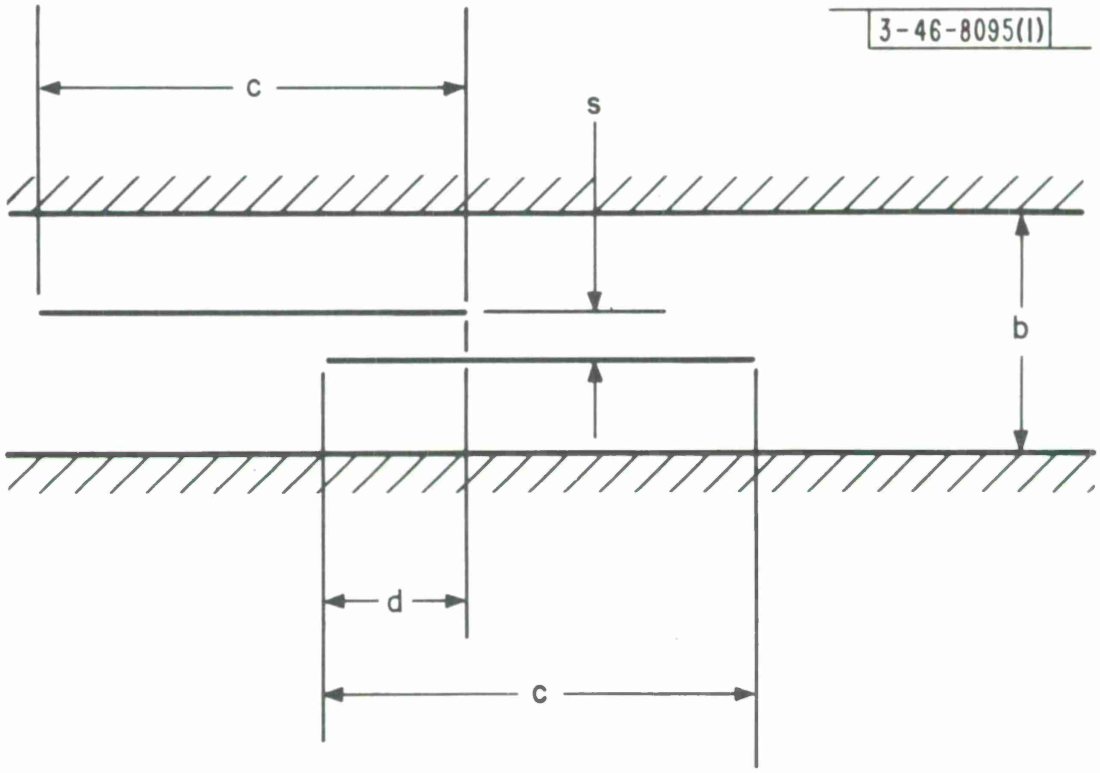

Fig. 1 Offset coupled strips between parallel plates.

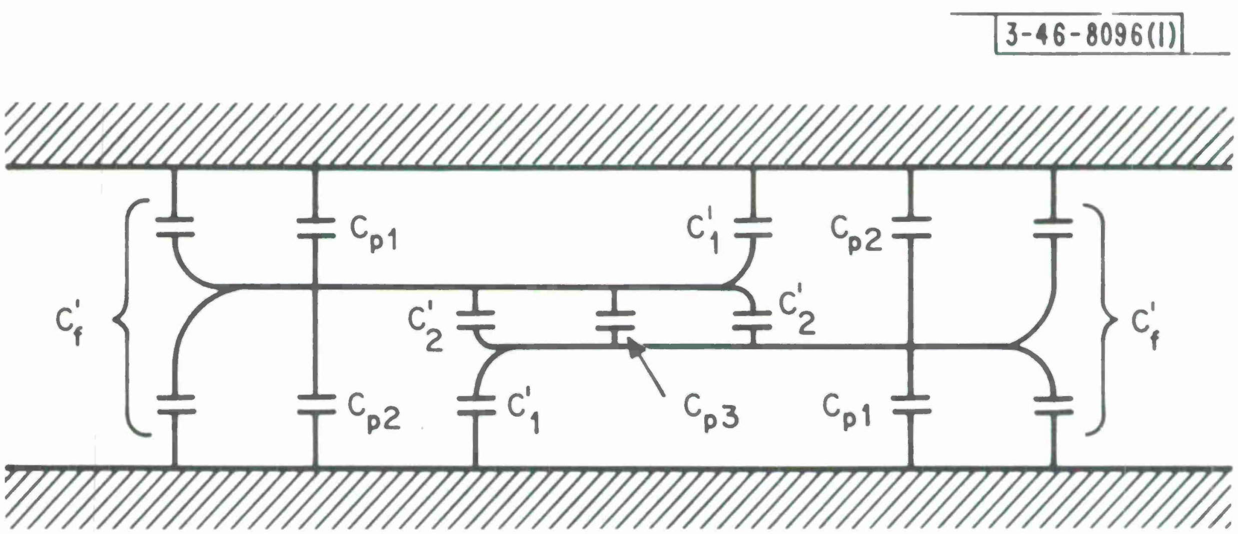

Fig. 2 Capacitances for offset coupled strips.

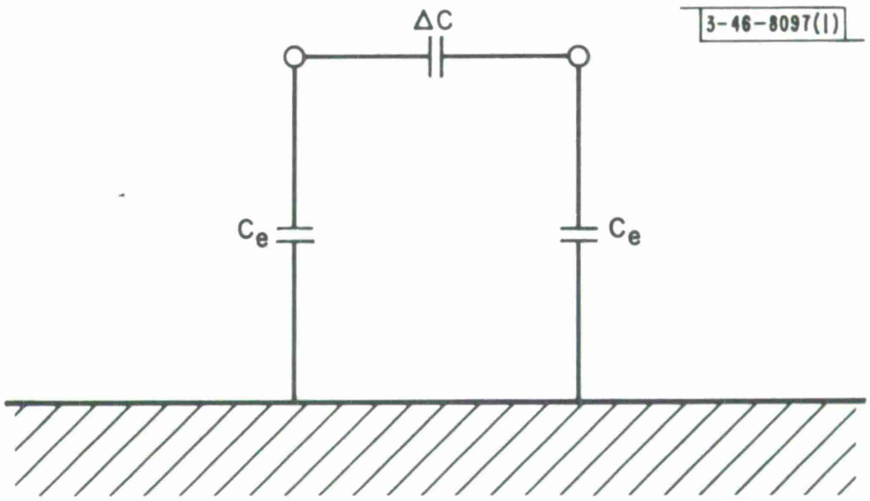

Fig. 3 Schematic diagram for coupled strips.

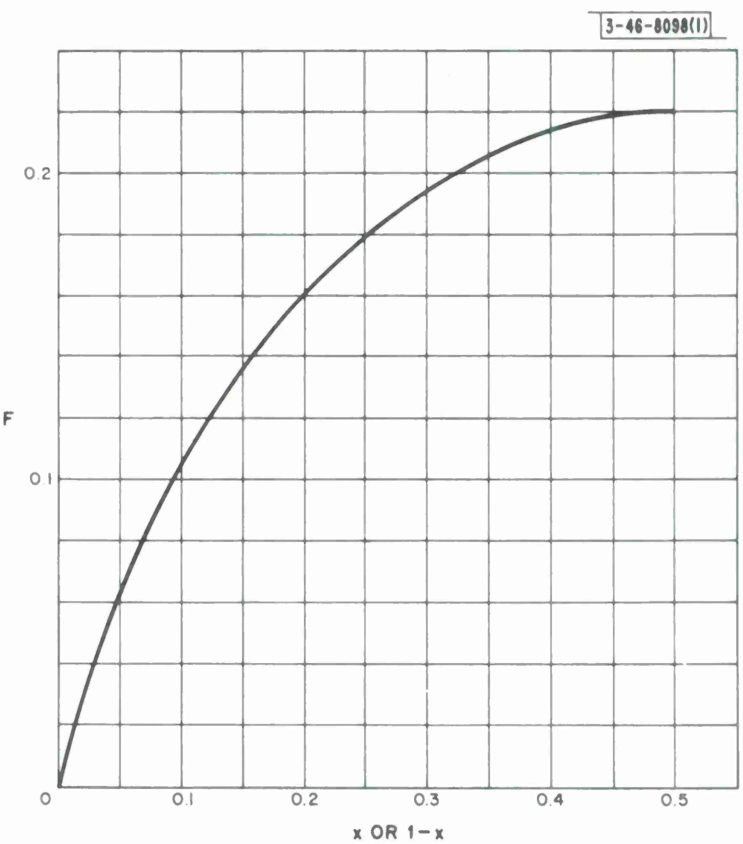

Fig. 4 Capacitance function F for offset coupled strips.

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