of the cascaded C-sections. Further study has since shown that it is unnecessary to solve, or even ascertain, the aforementioned set of simultaneous equations; that the essential information for the synthesis procedure is contained in the coefficients of the phase function, itself. The phase function β for cascaded C-section all-pass networks is given by [1]

$$\beta = 2 \angle F_n(s) = 2 \angle [N_n(s) + D_n(-s)], \quad (1)$$

where the symbol $\angle$ stands for "the angle of"; the subscript n is the number of cascaded sections; and $N_n(s)$ and $D_n(s)$ are the numerator and denominator, respectively, of the reflection coefficient of the corresponding transformer prototype, terminated in a 1-ohm resistor. It can be shown that

$$N_n(s) + D_n(-s) = F_n(s) = 2(A - C), \quad (2)$$

where A and C are the even and odd polynomials, respectively, that constitute the A and C components of the overall ABCD-matrix for the transformer prototype. Hence,

$$A \doteq \text{Even part of } F_n(s) = F_e(s) \quad (3)$$

$$C \doteq -\text{ Odd part of } F_n(s) = -F_0(s). \quad (4)$$

In the case where the transformer prototype is terminated not in a 1-ohm load but in an open circuit, the input impedance is given by

$$Z_{\text{in}}(s)\,|_{R_L=\infty} = A(s)/C(s) = -F_e(s)/F_0(s). \quad (5)$$

Thus, the even-mode impedances of the cascaded C-sections may be extracted from (5) directly, without resorting to the solution of the aforementioned simultaneous equations. The realization of the reactance function of (5) in a cascade of commensurate transmission lines terminated in an open circuit is guaranteed by a theorem of Richards [2].

To illustrate the use of (5), we use the phase function $F_3(s)$ which was previously presented [1] in the design of a 3-section 90° phase shifter.

$$F_3(s) = 1 - 1.8s + 1.57256s^2 - 0.41763s^3. \quad (6)$$

By (5), one finds directly

$$Z_{\text{in}}(s)\,|_{R_L=\infty} = \frac{1 + 1.57256s^2}{1.8s + 0.41763s^3}. \quad (7)$$

The line impedances may be extracted by the procedure of Richards [2] yielding the same values as previously found [1].

Also in this correspondence, we wish to emphasize that the restrictions on the coefficients of the phase function (see (38) and (39) of [1]) are necessary but not sufficient (except for the case $n=1$) to realize cascaded C-sections with even-mode impedances greater than 1. For two sections necessary and sufficient conditions have been found to be

$$\left.\begin{array}{ll} & 0 < B_1 \le 2 \\ \text{For} & 0 < B_1 \le 1, \quad B_2^2 \text{ unrestricted} \\ \text{For} & 1 \le B_1 \le 2 \\ & B_1 - 1 \le B_2^2 \le \dfrac{1}{B_1 - 1}. \end{array}\right\} \quad (8)$$

For more than two sections sufficient conditions have not been determined. Nevertheless, in most cases of practical interest, it is believed that the synthesis method will yield even-mode impedances greater than one. In this respect the situation is analogous to that encountered in the synthesis of directional couplers from prescribed insertion loss functions. There, also, it is not known beforehand which insertion loss functions will realize even-mode impedances greater than one.

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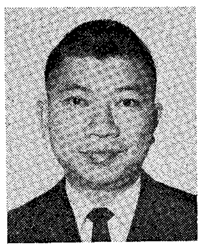

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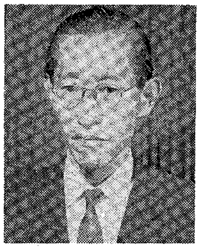

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