Sensor and Simulation Notes

Note 85

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Division of a Two-Plate Line into Sections with Equal Impedance

by

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Abstract

Curves of the positions of the points which divide a two-plate transmission line into three, four, five or six sections of equal impedance are presented. Approximations to these curves are deduced for the cases where the two plates are either very far apart or very close together.

Acknowledgment

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I. Introduction

A parallel-plate transmission line may be used to simulate the nuclear electromagnetic pulse. The characteristics of such a structure have been described extensively in previous notes in this series.[1,3] In order to excite the parallel-plate simulator by realistic energy sources, some sort of transition section is necessary.[2] This transition section may take the form of a single conical section or several sections in parallel.

A determination of the shape that the multiple-transition sections should take in order to maintain a constant impedance per section as they gradually taper to the sources from the top plate of the simulator has been made.[4] The calculations were based on the assumption that the transition region is an infinite periodic structure. The fact that there are really only a few transition sections can make edge effects important. In particular the sections, when they meet the upper plate of the simulator, should not all be of equal width if the impedance looking into each is to be the same. The reason for this is that the charge distribution on the upper plate of the simulator is non-uniform.

The general problem of determining the proper shape of the transition sections when there are only a finite number of them present is quite complex. This may have to be done in the future if measurements should show serious impedance mismatches. In this note we merely make a first guess at the solution of the general problem by determining where the various sections should meet the top plate in order that they all have the same impedance. This will be done by dividing the top plate into three, four, five and six sections, each section containing equal charge per unit length. Perhaps the data presented here, in conjunction with the information derived from the calculations for the periodic structure,[4] will permit an adequate prescription of the shape of the transition section in the actual case.

A precise statement of the mathematical problem and its solution is given in the next section. Approximations for the cases where the two plates of the transmission line are either far apart or close together are given in the third and fourth sections respectively.

II. A Precise Formulation

A cross-section of the transmission line we wish to study is shown in figure 1. The conformal transformation that implicitly determines the fields in the vicinity of the structure shown in figure 1 is well known. From this transformation, impedance values for the whole structure have beem computed and field plots have been made.[1,3] In this note we merely wish to show how to divide the plates into sections with equal impedance. This can be done by determining, on the cross-section of one of the plates, the points that divide the plate into sections, each of which carries equal charge per unit length.

By symmetry, there is only one significant division point for the three- and four-section lines. We denote the distance of this point from the center of the plate by x_1 . For the three-section line the other division point is, of course, the same distance on the other side of the center point. For the four-section line there is, in addition to this symmetric division point, a division point at the center itself.

Similarly, for the five- and six-section lines there are only two significant division points, the center of the plate being again a division point of the six-section line.

To determine the proper division points in each case we begin with the appropriate conformal transformation. We denote the stream function by u and, using the coordinate system of figure 1, set it equal to zero along the y axis above the upper plate. We denote the potential function by v and set it equal to zero along the x-axis and equal to $K(m_1)$ on the upper plate, where $K(m_1)$ is the complete elliptic integral of the first kind with modulus m_1 , and m_1 will be defined later. With this notation we may write the stream function and potential function as implicit functions of x and y in the form[1]

$$\frac{x}{b} = \frac{2K(m)}{\pi}\left\{E(u|m) - \frac{uE(m)}{K(m)} + \frac{m\ \mathrm{sn}(u|m)\mathrm{cn}(u|m)\mathrm{dn}(u|m)\mathrm{sn}^2(v'|m_1)}{1 - \mathrm{dn}^2(u|m)\mathrm{sn}^2(v'|m_1)}\right\} \tag{1}$$

$$\frac{y}{b} = \frac{2K(m)}{\pi}\left\{E(v'|m_1) - \frac{v'E(m_1)}{K(m_1)} + \frac{\pi v}{2K(m)K(m_1)} - \frac{dn^2(u|m)sn(v'|m_1)cn(v'|m_1)dn(v'|m_1)}{1 - dn^2(u|m)sn^2(v'|m_1)}\right\} \quad (2)$$

where

$$v' = v + K(m_1) \quad (3)$$

$$m_1 = 1 - m \quad (4)$$

and m is defined by the pair of simultaneous equations

$$1 - m \sin^2(\phi_o) = \frac{E(m)}{K(m)} \quad (5)$$

$$\frac{a}{b} = \frac{2}{\pi}\{K(m)E(\phi_o|m) - E(m)F(\phi_o|m)\} \quad . \quad (6)$$

In equation 6, a and b are as shown in figure 1 and ϕ_o is the amplitude of the elliptic integrals. The notation in the above equations is the same as in reference 5.

To be specific, we will consider only the top plate in the following. On the top plate,

$$v = K(m_1) \quad ,$$

hence

$$sn(v'|m_1) = sn(2K(m_1)|m_1) = 0$$

and so

$$x = \frac{2K(m)}{\pi}\left\{E(u|m) - \frac{uE(m)}{K(m)}\right\} \tag{7}$$

From equation 7, if x is zero, u is either zero or $K(m)$. On the upper side of the plate u is zero at $x = 0$ and on the lower side of the plate u is $K(m)$ at $x = 0$. The stream function u increases monotonically from zero to $K(m)$ as the point x moves out along the upper side of the plate until it is equal to a , and then moves back along the lower side of the plate. From the definition of the stream function, the charge per unit length between any two points on the top plate is given by ε_o times the difference in the values of u at the two points. In particular the charge per unit length on half of the top plate is $\varepsilon_o K(m)$. In order to find the point x_1 such that a fraction α of this charge is situated between x_1 and the edge of the plate we write the two expressions for x_1 in terms of u above and below the plate. That is

$$x_1 = \frac{2}{\pi}\left\{K(m)E(u_T|m) - u_T E(m)\right\} \tag{8}$$

$$x_1 = \frac{2}{\pi}\left\{K(m)E(u_B|m) - u_B E(m)\right\} \tag{9}$$

where

$$u_B - u_T = \alpha K(m) \qquad (10)$$

Combining these equations:

$$K(m)[E(u_T + \alpha K(m)|m) - E(u_T|m)] = \alpha K(m)E(m) \qquad (11)$$

or using the definition

$$E(u|m) = \int_0^u dn^2(x|m)dx \quad ,$$

we may rewrite equation (11) as

$$\int_{u_T}^{u_T + \alpha K(m)} dn^2(x|m)dx = \alpha E(m) \qquad (12)$$

For a given m and α , equation (12) is a transcendental equation that can be used to determine u_T . Once u_T is known it can be substituted in equation (8) to determine x_1 . This is, in fact, what was done to obtain the data plotted in the continuous curves in figures 3 through 6. For the three-section line x_1 was determined by setting $\alpha = 2/3$. For the four-section line $\alpha = 1/2$. For the five-section line, $\alpha = 4/5$ determines x_1 and $\alpha = 2/5$ determines x_2 . For the six-section line $\alpha = 2/3$ determines x_1 while $\alpha = 1/3$ determines x_2 . In all cases the relation between m and a/b can be determined from equations (5) and (6). When the numerical calculations were made, actually a pair of equations equivalent to (5) and (6) were used, namely

$$\mathrm{dn}^2(u_o|m) = \frac{E(m)}{K(m)} \tag{13}$$

and

$$\frac{a}{b} = \frac{2}{\pi}\left\{K(m)\int_o^{u_o} \mathrm{dn}^2(x|m)\,dx - u_o E(m)\right\} \tag{14}$$

III. Plates Far Apart

If the plates are very far apart compared to their width the charge density on each plate arranges itself to be quite close to the charge density that would occur if the plate were isolated in free space. This density is well known to be

$$\sigma(x) = \frac{Q}{\pi\sqrt{a^2 - x^2}} \tag{15}$$

where Q is the total charge on the plate. To find the values of x_i that divide the plate into, say, N sections of equal charge, we simply require that x_i satisfies the equation

$$\int_{x_i}^{x_{i+1}} \sigma(x)dx = \frac{Q}{N} \qquad i = -\frac{N}{2} \rightarrow \frac{N}{2} \quad \text{(N even)} \qquad = -\frac{N-1}{2} \rightarrow \frac{N+1}{2} \quad \text{(N odd)} \tag{16}$$

This can easily be solved by setting

$$x = a \sin\theta \tag{17}$$

in equation (16) to obtain

$$\frac{Q}{\pi}\int_{\theta_i}^{\theta_{i+1}} d\theta = \frac{Q}{N} \qquad -\pi < \theta_i < \pi$$

or

$$\theta_{i+1} - \theta_i = \frac{\pi}{N} \tag{18}$$

For N even, (17) and (18) may be combined to give the significant division points as the center point, x_o , and

$$x_i = a \sin\left(\frac{i\pi}{2N}\right) \qquad i = 1 \rightarrow \frac{N}{2} - 1 \tag{19}$$

For N odd the significant division points are again given by (19), but the range of i is from 1 to $(N - 1)/2$. These values are plotted as the horizontal asymptotes in the upper left portions of the curves in figures 3 through 6.

IV. Plates Close Together

For the case where the upper plate, of width $2a$, is several times larger than its height b, we assume that the fields near the center $x = 0$ are not affected by the fringing caused by the edges at $x = \pm a$, i.e., the fields at $x = 0$ are the same as those that would exist if the upper plate were infinite in extent $(-a \to -\infty)$. This assumption allows one to extend the left half $(-a \leq x \leq 0)$ of the upper plate while keeping the right half $(0 \leq x \leq a)$ intact, so that the extended upper plate occupies the region $(-\infty < x \leq a\ ,\ y = b)$ as shown in figure 2a. The charge distribution on the right half of the actual upper plate is assumed to be the same as that on the right half $(0 \leq x \leq a)$ of the extended upper plate.

It is convenient to use the conformal transformation

$$\frac{\pi(z - a)}{b} = 1 + w + \ln w \tag{20}$$

to map the structure depicted in figure 2a from the z-plane onto the w-plane.[6] Transformed onto the w-plane, the structure takes on the simple geometry shown in figure 2b. By substituting $w = re^{i\theta}$ into (20) we obtain

$$\begin{aligned} \frac{\pi(x - a)}{b} &= 1 + \ln r + r\cos\theta \\ \frac{\pi y}{b} &= \theta + r\sin\theta \end{aligned} \tag{21}$$

from which corresponding points on the two planes are readily determined; several important points are labeled in figure 2.

Both the upper and lower surfaces of the right half of the upper plate map onto the w-plane as the line segment ACB which has charge only on its upper surface so that the lines of flux connecting ACB and A'C'B' are semi-circles existing only in the upper half of the w-plane $(0 \leq \theta \leq \pi)$. The potential for the simplified geometry in the w-plane can be written down by inspection, viz.

$$\phi = \frac{(\phi_2 - \phi_1)}{\pi} \theta + \phi_1 \qquad (0 \leq \theta \leq \pi) \tag{22}$$

The charge on the strip ACB , by Gauss's law, is

$$q_{AB} = \varepsilon_o \int_{r_A}^{r_B} \nabla\phi \cdot \underline{u}_\theta \, dr \tag{23}$$

which gives

$$q_{AB} = \varepsilon_o \ln(r_B/r_A) \quad .$$

It is assumed that the total charge on the actual upper plate, of width 2a, is $q_t = 2q_{AB}$. Setting $\theta = \pi$ in (21) and evaluating the result at $x = 0$, we see that the radii r_A and r_B satisfy

$$\begin{aligned} -\frac{\pi a}{b} &= 1 + \ln r_A - r_A \qquad (r_a < 1) \\ -\frac{\pi a}{b} &= 1 + \ln r_B - r_B \qquad (r_B > 1) \end{aligned} \tag{24}$$

We want to divide the upper plate into N sections such that the charge

q_N on each section is the same, viz., $q_N = q_t/N$. Clearly, for the simple case of $N = 2$, dividing the upper plate at $x = 0$ into two halves gives two sections with the same amount of charge. Since the charge on the upper plate is not uniformly distributed but is instead peaked toward the edges, the problem in general is more difficult. In general we want to determine a position x_i such that the charge on the section of the upper plate $(x_i \le x \le a)$ to the right of x_i is $\alpha q_t/2$ while the charge to the left $(-a \le x \le x_i)$ is $q_t(1 - \alpha/2)$. By proper choice of α we can divide the upper plate into as many equally charged sections as we want.

Corresponding to a particular value of α, the radii r_G and r_H in the w-plane satisfy

$$\ln(r_H/r_G) = c_\alpha \tag{25}$$

where $c_\alpha = \alpha \ln(r_B/r_A)$, the radii r_A and r_B being obtained from (24) for each geometry. Using (24) we may write, for the sake of convenience, $\ln(r_B/r_A) = r_B - r_A$ so that $c_\alpha = \alpha(r_B - r_A)$.

In addition to (25), which can be written as

$$r_H = r_G e^{c_\alpha} \quad , \tag{26}$$

the radii r_G and r_H satisfy

$$\frac{\pi(x_i - a)}{b} = 1 + \ln r_G - r_G \qquad (r_G < 1) \tag{27a}$$

$$\frac{\pi(x_i - a)}{b} = 1 + \ln r_H - r_H \qquad (r_H > 1) \quad . \tag{27b}$$

From (27) we obtain $\ln(r_H/r_G) = r_H - r_G$ in which (26) may be substituted to eliminate r_H, giving

$$r_G = \frac{c_\alpha}{e^{c_\alpha} - 1} \leq 1 \quad . \tag{28}$$

For a particular value of c_α we use (28) to compute r_G which, in turn, is used to compute x_i according to (27a)

$$\frac{x_i}{b} = \frac{a}{b} - \frac{1}{\pi}\,(r_G - 1 - \ln r_G) \tag{29}$$

alternatively

$$\frac{x_i}{b} = \frac{a}{b} - \frac{1}{\pi}\,(r_H - 1 - \ln r_H) \tag{30}$$

where

$$r_H = \frac{c_\alpha}{1 - e^{-c_\alpha}} \geq 1 \quad . \tag{31}$$

For geometries with $a/b > 10$ a good approximation for x_i is

$$\frac{x_i}{b} \approx \frac{a}{b} - \frac{1}{\pi}\,(\gamma_i - 1 - \ln \gamma_i) \tag{32}$$

where

$$\gamma_i = \alpha(1 + \pi a/b) \tag{33}$$

This approximation assumes that both r_A and $\ln r_B$ are negligible compared to r_B and that e^{-c_α} is negligible compared to unity.

Equation (29) is plotted in figures 3 through 6 as the curves starting at the point $a/b = 1$. For $a/b > 10$ these curves are indistinguishable from those obtained from the approximate formula (32) and also indistinguishable from their actual values. The horizontal asymptotes at the lower right portions of the curves in figures 3 through 6 are plots of the crude approximation

$$\frac{x_i}{b} = \frac{a}{b}(1 - \alpha) \quad , \tag{34}$$

which is equivalent to dividing the plate into N equal sections.

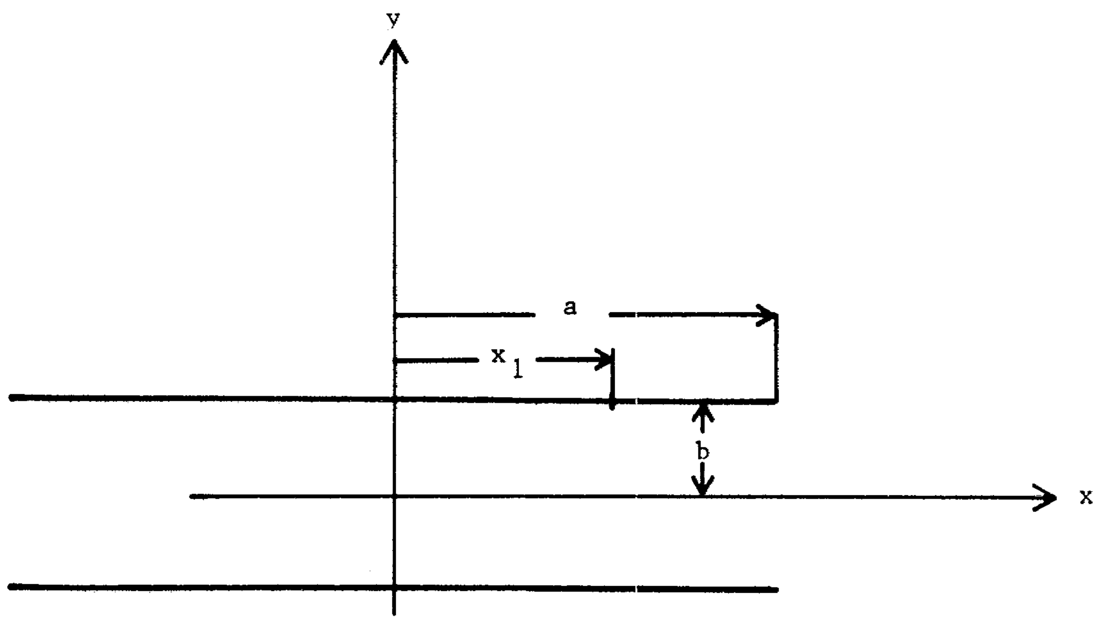

Figure 1a. Division point of 3-section and 4-section lines.

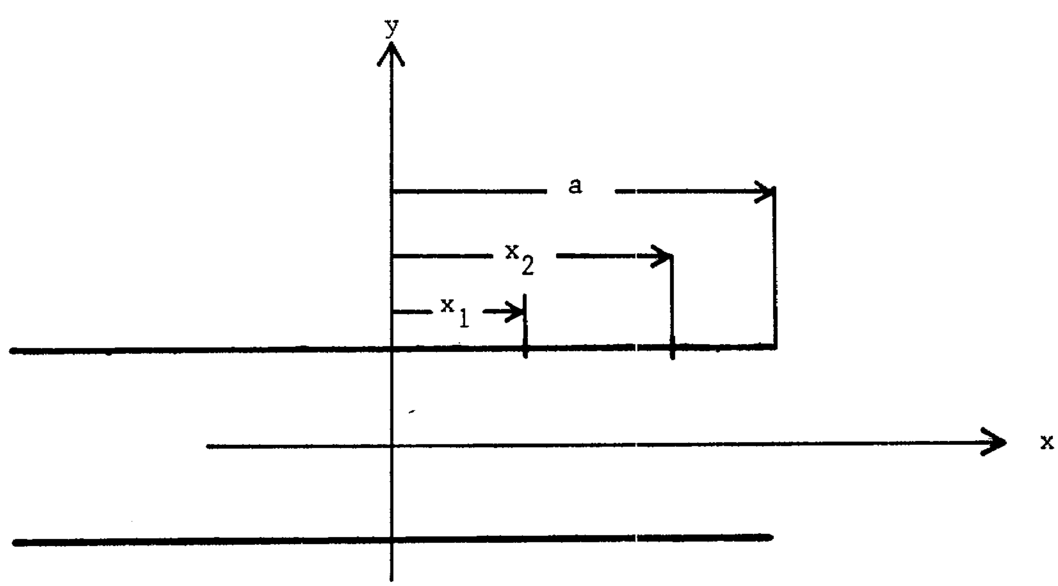

Figure 1b. Division points of 5-section and 6-section lines.

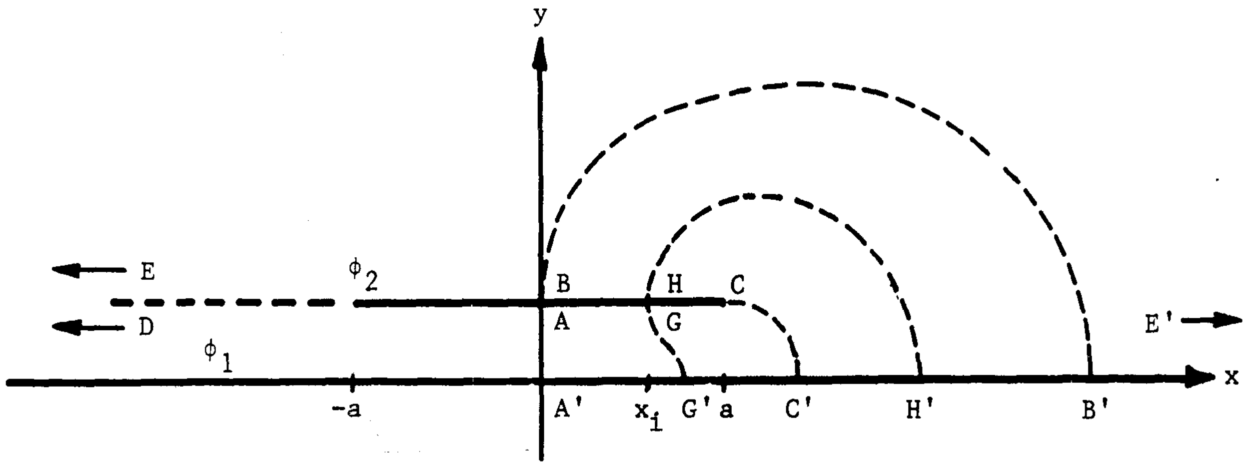

Figure 2a. The z-plane.

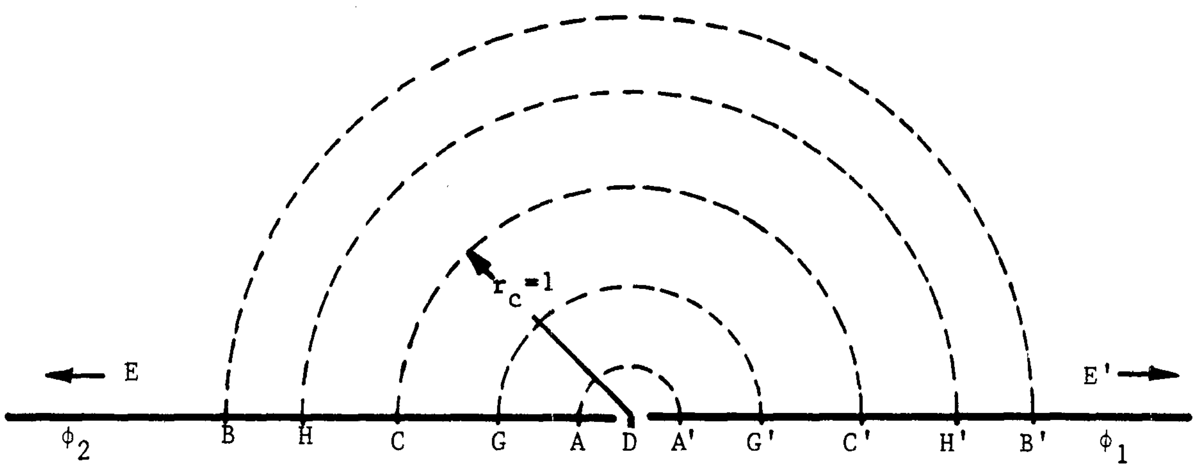

Figure 2b. The w-plane.

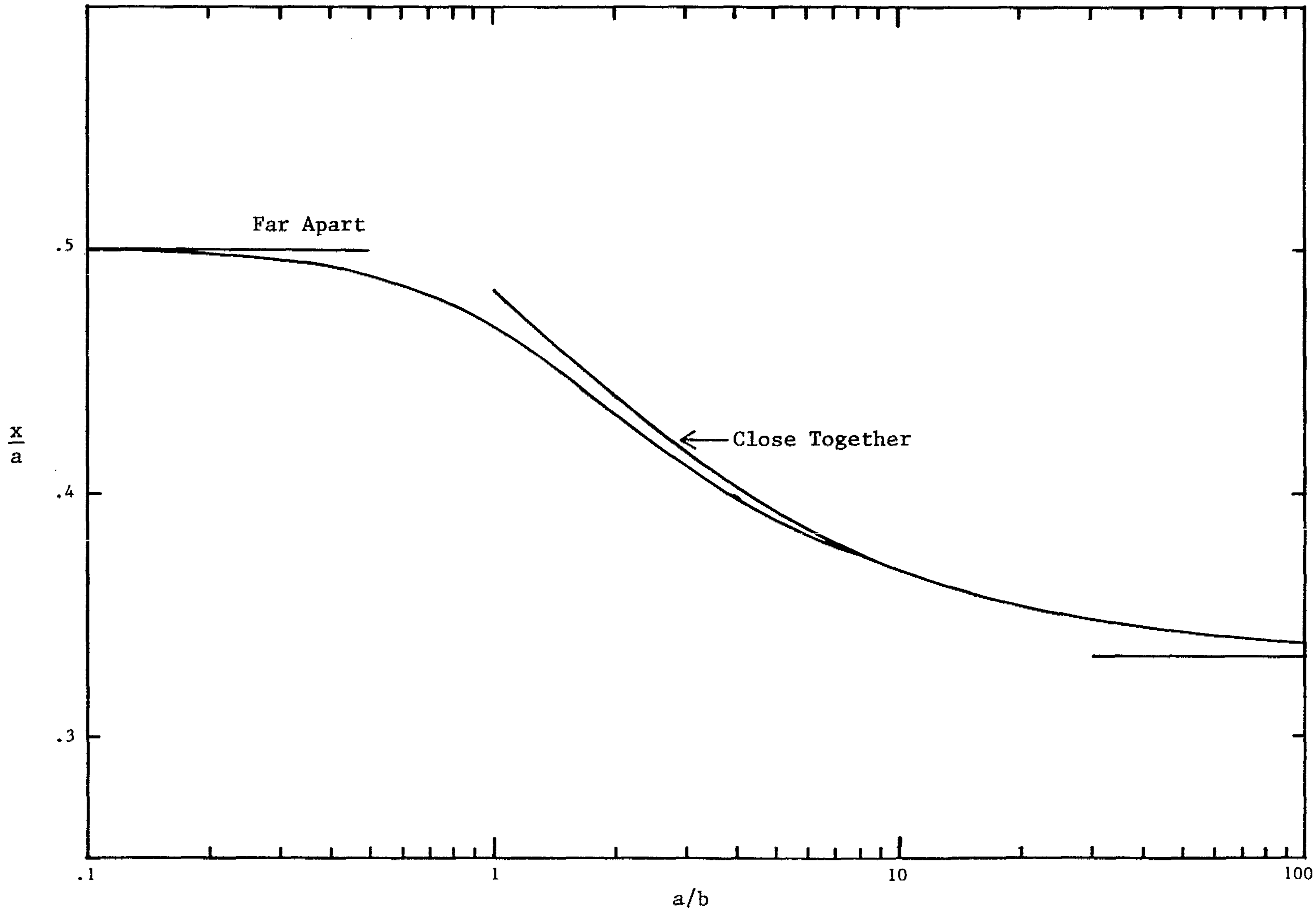

Figure 3. Division point of three-section line.

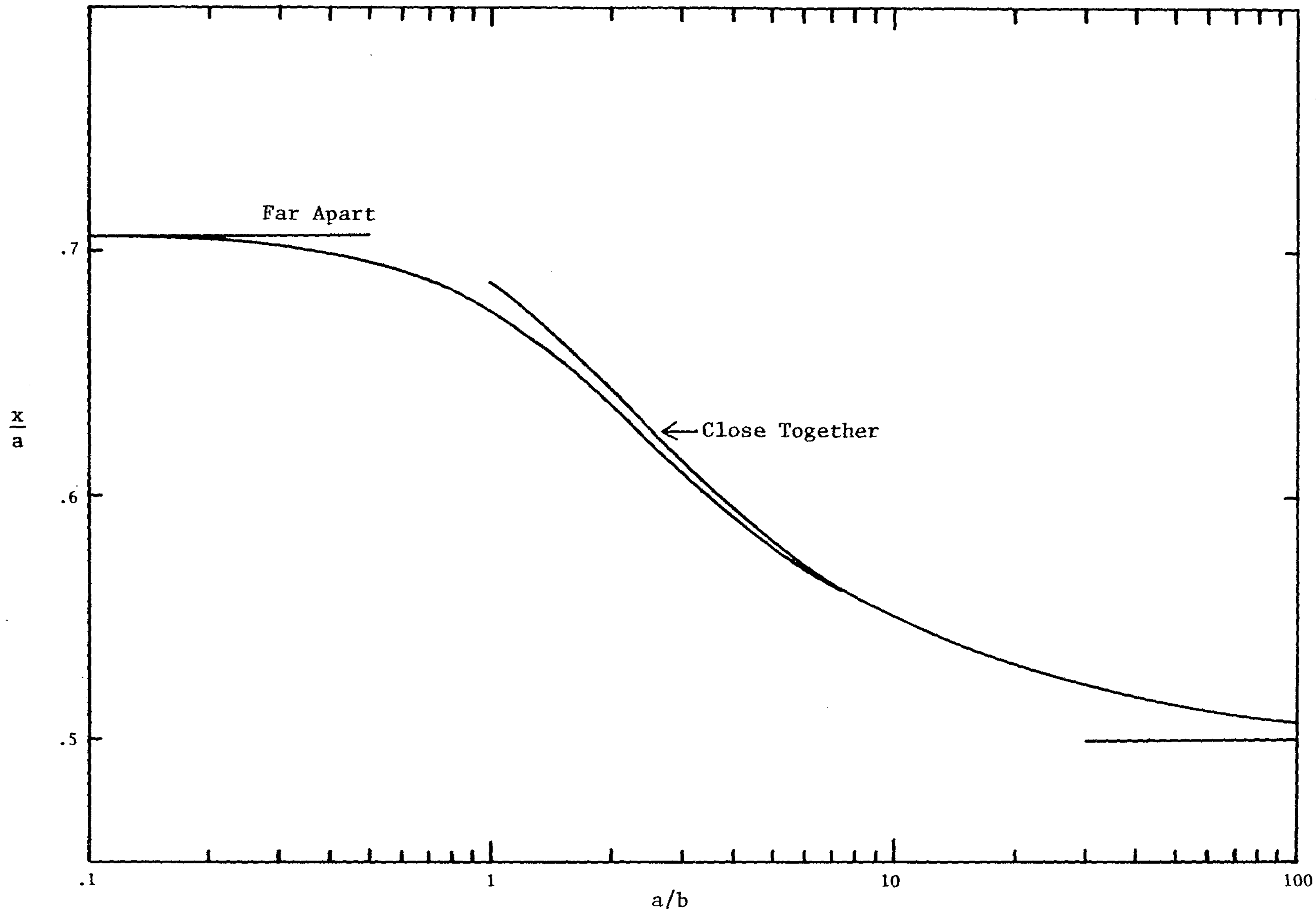

Figure 4. Division point of four-section line.

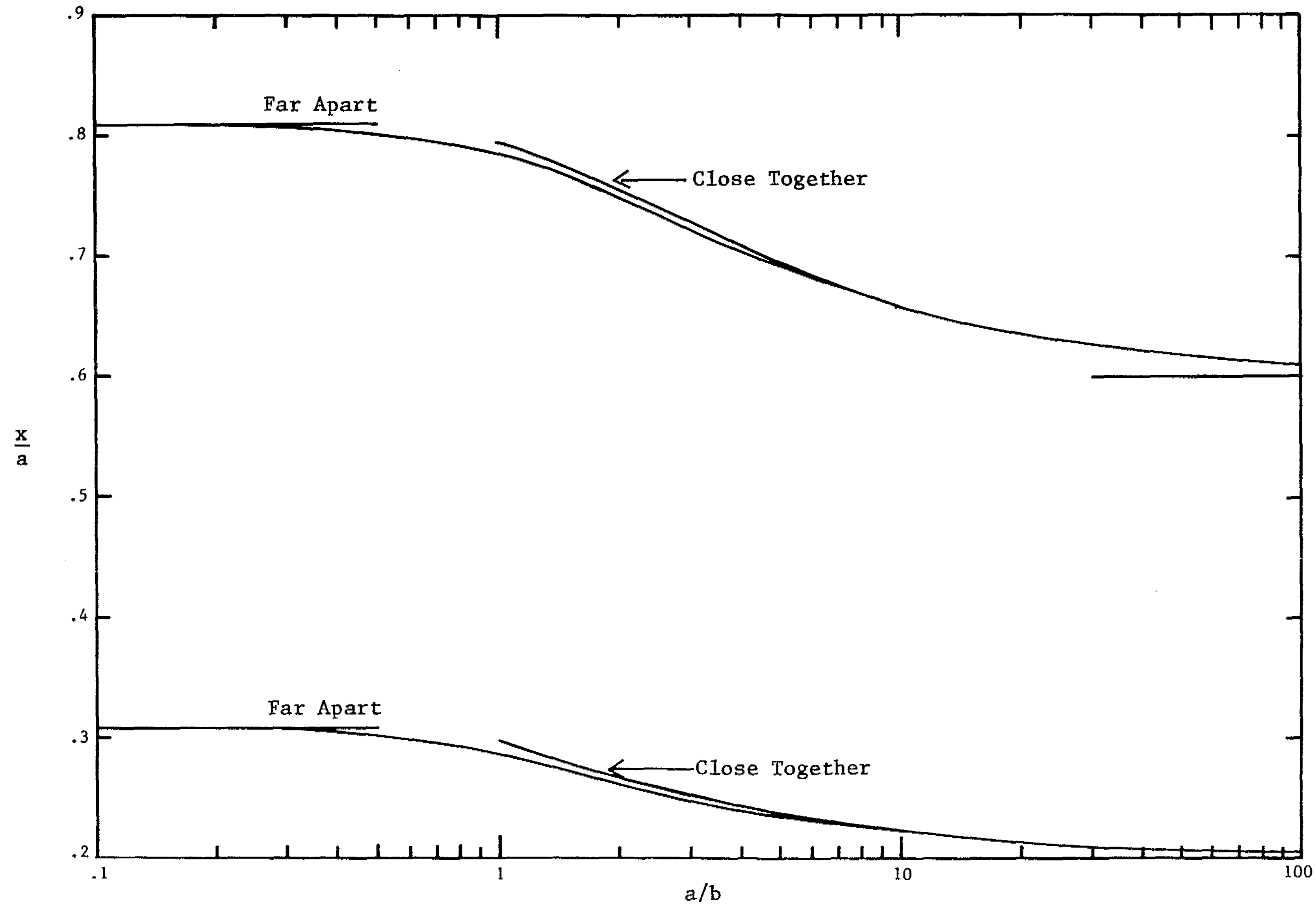

Figure 5. Division points of five-section line.

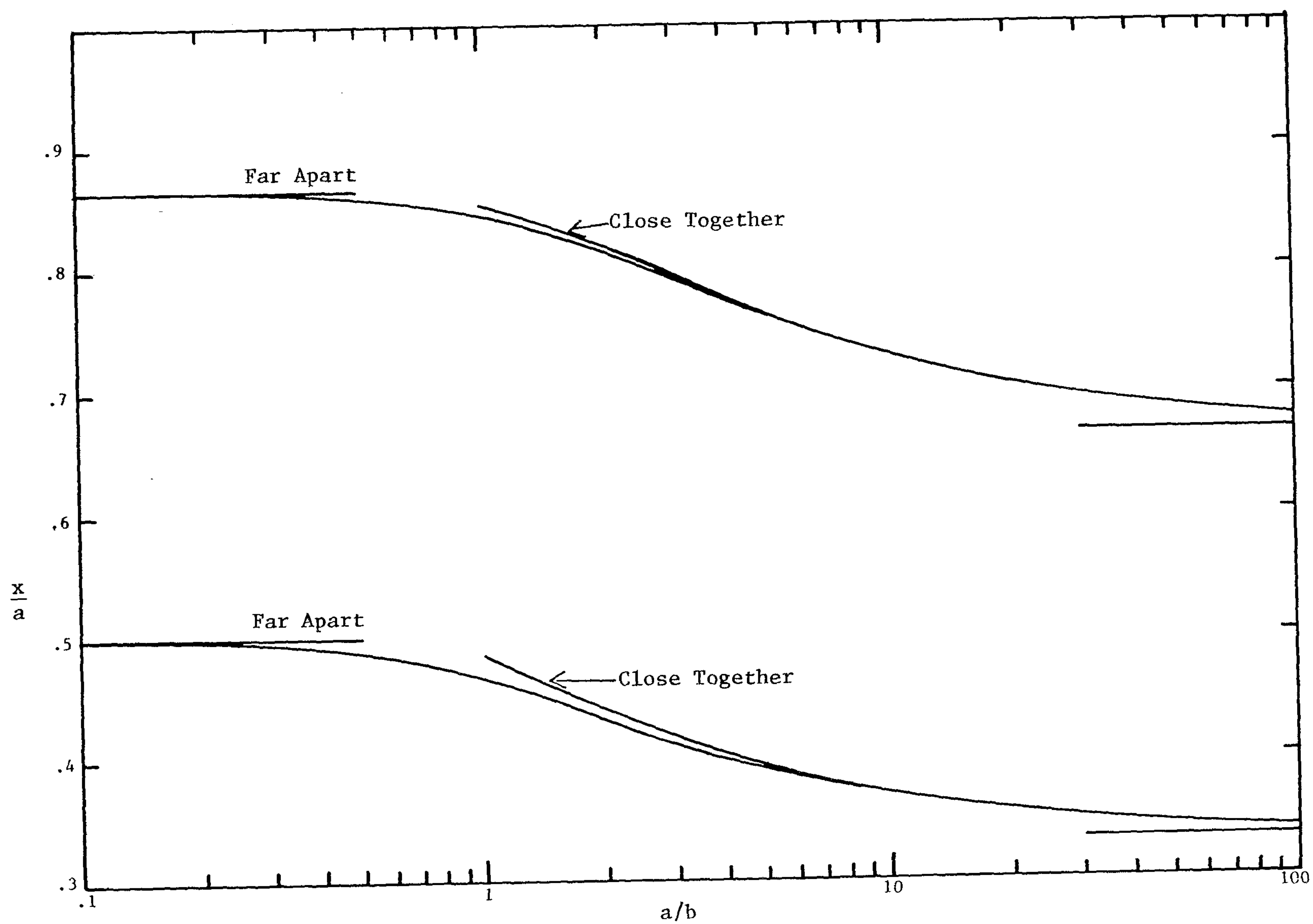

Figure 6. Division points of six-section line.

References

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4. Guy W. Carlisle, Sensor and Simulation Note 54, "Matching The Impedance of Multiple Transitions to a Parallel-Plate Transmission Line."
5. Milton Abromowitz and Irene A. Stegun, Editors, <u>Handbook of Mathematical Functions</u>, National Bureau of Standards, AMS-55, June 1964.
6. F. Assadourian and E. Rimai, "Simplified Theory of Microstrip Transmission Systems," Proceedings of IRE, December 1952, pp. 1651-1657.

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Appendix to Note 85

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In table 1 of this appendix we present again, in a form from which more accurate data can be obtained, the information used to produce figures 3 through 6 of note 85.

For divisions of the two-plate line other than those of table 1, tables 2, 3 and 4 may be useful. The latter tables give the positions of the points (tabulated, as in table 1, as a fraction of the half-width of the plates) that contain a fraction α of the admittance of a half-plate between the tabulated point and the outside edge of the plate.

The numbers presented here are accurate to within ±.0003. Linear interpolation between the entries in tables 2, 3 and 4 will give 3-figure accuracy except for the lowest pair of α's .

TABLE 1: Division Points for Particular Lines

line / a/b	3-section	4-section	5-section		6-section	
	x_1	x_1	x_1	x_2	x_1	x_2
3.0	.4115	.6092	.2471	.7210	.4115	.7909
3.5	.4040	.5997	.2416	.7107	.4040	.7810
4.0	.3983	.5914	.2395	.7028	.3983	.7755
4.5	.3927	.5848	.2355	.6966	.3927	.7685
5.0	.3883	.5795	.2333	.6903	.3883	.7620
5.5	.3860	.5745	.2309	.6860	.3860	.7583
6.0	.3833	.5702	.2299	.6810	.3833	.7532
6.5	.3808	.5666	.2289	.6775	.3808	.7500
7.0	.3783	.5630	.2279	.6739	.3783	.7470
7.5	.3762	.5602	.2269	.6706	.3762	.7435
8.0	.3745	.5580	.2259	.6680	.3745	.7398
8.5	.3728	.5561	.2249	.6652	.3728	.7370
9.0	.3710	.5538	.2239	.6629	.3710	.7340
9.5	.3699	.5523	.2229	.6605	.3699	.7312
10	.3691	.5502	.2221	.6584	.3691	.7292
11	.3666	.5475	.2206	.6546	.3666	.7250
12	.3646	.5446	.2193	.6513	.3646	.7215
13	.3628	.5421	.2181	.6484	.3628	.7185
14	.3612	.5398	.2172	.6459	.3612	.7158
15	.3598	.5378	.2163	.6436	.3598	.7134
16	.3585	.5361	.2155	.6416	.3585	.7113
17	.3574	.5345	.2148	.6398	.3574	.7094
18	.3564	.5330	.2142	.6381	.3564	.7076
19	.3554	.5317	.2136	.6366	.3554	.7060
20	.3546	.5305	.2131	.6353	.3546	.7046
30	.3489	.5224	.2095	.6260	.3489	.6946
40	.3457	.5179	.2076	.6208	.3457	.6891
50	.3437	.5150	.2063	.6174	.3437	.6855
60	.3423	.5130	.2055	.6151	.3423	.6830
70	.3412	.5114	.2048	.6134	.3412	.6811
80	.3404	.5103	.2043	.6120	.3404	.6797
90	.3398	.5093	.2039	.6109	.3398	.6785
100	.3392	.5086	.2036	.6100	.3392	.6775

TABLE 2: Division Points for Fractional Admittances

a/b \ α	.05	.10	.15	.20	.25	.30	.35
7	.9971	.9685	.9275	.8809	.8314	.7799	.7273
8	.9958	.9648	.9222	.8749	.8251	.7735	.7210
9	.9947	.9614	.9177	.8699	.8200	.7685	.7161
10	.9932	.9580	.9136	.8654	.8153	.7638	.7114
11	.9917	.9550	.9100	.8615	.8112	.7597	.7074
12	.9902	.9523	.9067	.8581	.8077	.7562	.7040
13	.9888	.9499	.9039	.8550	.8046	.7532	.7010
14	.9875	.9477	.9014	.8523	.8019	.7504	.6984
15	.9863	.9457	.8991	.8499	.7994	.7480	.6960
16	.9851	.9439	.8970	.8478	.7972	.7459	.6939
17	.9841	.9423	.8951	.8458	.7952	.7439	.6920
18	.9831	.9408	.8934	.8440	.7934	.7421	.6903
19	.9821	.9394	.8919	.8424	.7918	.7405	.6887
20	.9813	.9381	.8904	.8409	.7902	.7390	.6873
25	.9775	.9329	.8846	.8348	.7842	.7331	.6816
30	.9747	.9291	.8804	.8305	.7799	.7288	.6775
35	.9724	.9261	.8772	.8272	.7766	.7257	.6744
40	.9706	.9238	.8747	.8246	.7741	.7232	.6721
45	.9691	.9219	.8726	.8225	.7720	.7212	.6701
50	.9678	.9203	.8709	.8208	.7703	.7195	.6685
55	.9667	.9189	.8695	.8193	.7688	.7181	.6672
60	.9657	.9177	.8682	.8181	.7676	.7169	.6661
65	.9649	.9167	.8671	.8170	.7665	.7159	.6651
70	.9641	.9158	.8662	.8160	.7656	.7150	.6642
75	.9635	.9150	.8654	.8152	.7648	.7142	.6634
80	.9628	.9143	.8646	.8145	.7640	.7135	.6628
85	.9623	.9137	.8639	.8138	.7634	.7128	.6622
90	.9618	.9131	.8633	.8132	.7628	.7122	.6616
95	.9614	.9126	.8628	.8126	.7622	.7117	.6611
100	.9609	.9121	.8623	.8121	.7618	.7113	.6607

TABLE 3: Division Points for Fractional Admittances

a/b \ α	.40	.45	.50	.55	.60	.65
7	.6739	.6194	.5630	.5090	.4533	.3973
8	.6680	.6137	.5580	.5041	.4490	.3934
9	.6629	.6090	.5538	.5000	.4452	.3901
10	.6584	.6048	.5502	.4966	.4420	.3874
11	.6546	.6012	.5471	.4935	.4398	.3848
12	.6513	.5981	.5446	.4908	.4368	.3827
13	.6484	.5954	.5421	.4885	.4347	.3808
14	.6459	.5930	.5398	.4864	.4329	.3791
15	.6436	.5909	.5378	.4846	.4312	.3776
16	.6416	.5890	.5361	.4830	.4297	.3763
17	.6398	.5872	.5345	.4815	.4284	.3752
18	.6381	.5857	.5330	.4802	.4272	.3741
19	.6366	.5843	.5317	.4790	.4261	.3731
20	.6353	.5830	.5305	.4779	.4251	.3722
25	.6298	.5779	.5257	.4735	.4212	.3687
30	.6260	.5742	.5224	.4704	.4184	.3662
35	.6230	.5715	.5198	.4681	.4163	.3644
40	.6208	.5694	.5179	.4663	.4146	.3629
45	.6190	.5677	.5163	.4648	.4133	.3618
50	.6174	.5663	.5150	.4637	.4123	.3608
55	.6162	.5651	.5139	.4627	.4114	.3600
60	.6151	.5641	.5130	.4618	.4106	.3594
65	.6142	.5632	.5122	.4611	.4099	.3588
70	.6134	.5624	.5114	.4604	.4094	.3583
75	.6126	.5618	.5108	.4599	.4088	.3578
80	.6120	.5612	.5103	.4594	.4084	.3574
85	.6114	.5606	.5098	.4589	.4080	.3571
90	.6109	.5601	.5093	.4585	.4076	.3567
95	.6104	.5597	.5089	.4581	.4073	.3564
100	.6100	.5593	.5086	.4578	.4070	.3562

TABLE 4: Division Points for Fractional Admittances

a/b \ α	.70	.75	.80	.85	.90	.95
7	.3410	.2845	.2279	.1709	.1140	.0570
8	.3377	.2817	.2259	.1695	.1131	.0565
9	.3349	.2795	.2239	.1680	.1122	.0561
10	.3324	.2773	.2221	.1667	.1114	.0557
11	.3302	.2755	.2206	.1656	.1105	.0553
12	.3283	.2739	.2193	.1646	.1098	.0549
13	.3267	.2725	.2181	.1637	.1092	.0546
14	.3252	.2712	.2172	.1630	.1087	.0544
15	.3240	.2702	.2163	.1623	.1083	.0542
16	.3228	.2692	.2155	.1617	.1079	.0540
17	.3218	.2683	.2148	.1612	.1075	.0538
18	.3209	.2676	.2142	.1607	.1072	.0536
19	.3200	.2668	.2136	.1603	.1069	.0535
20	.3192	.2662	.2131	.1599	.1066	.0533
25	.3162	.2636	.2110	.1583	.1056	.0528
30	.3141	.2618	.1095	.1572	.1048	.0524
35	.3124	.2605	.2084	.1564	.1043	.0521
40	.3112	.2594	.2076	.1557	.1038	.0519
45	.3102	.2586	.2069	.1552	.1035	.0518
50	.3094	.2579	.2063	.1548	.1032	.0516
55	.3087	.2573	.2059	.1544	.1030	.0515
60	.3081	.2568	.2055	.1541	.1028	.0514
65	.3076	.2564	.2051	.1539	.1026	.0513
70	.3071	.2560	.2048	.1536	.1024	.0512
75	.3067	.2557	.2046	.1534	.1023	.0512
80	.3064	.2554	.2043	.1533	.1022	.0511
85	.3061	.2551	.2041	.1531	.1021	.0510
90	.3058	.2549	.2039	.1530	.1020	.0510
95	.3056	.2547	.2038	.1528	.1019	.0510
100	.3053	.2545	.2036	.1527	.1018	.0509