

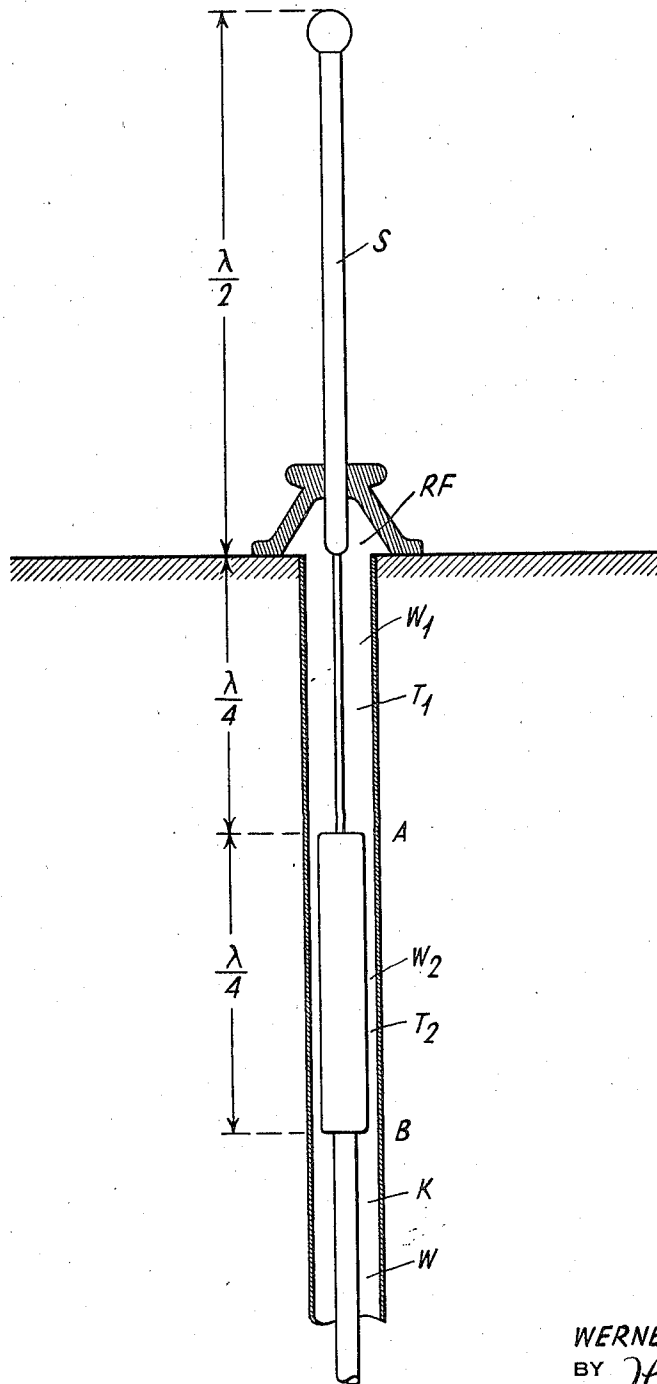
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ARRANGEMENT FOR MATCHING A HIGH FREQUENCY RADIATOR TO A TRANSMISSION LINE

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ARRANGEMENT FOR MATCHING A HIGH FREQUENCY RADIATOR TO A TRANSMISSION LINE

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There is a long known effort, to replace the quarter wave antenna, frequently used because of its simple and direct match to a 36.6 ohm cable, by a halfwave antenna, possessing better radiation characteristics (greater horizontal field strength at same expenditure of power). The reason for the uncommon use of this antenna shape even in simple antenna arrays is to be attributed to the high base impedance of the half-wave radiator, which even when using shapes which give the lowest possible characteristic impedance can hardly be brought below 2,000 ohms and with power used in simple wire antennae, it can easily reach values of 5,000 to 6,000 ohms. Because it is not practical to construct concentric lines having a characteristic impedance of more than 200-250 ohms, it is, therefore, impossible to apply the known transformation means through a quarter-wave line, whose characteristic impedance is equal to the geometric mean of the antenna and cable impedance combined, because the characteristic impedance of the transformer device would still lie beyond the practical limits.

According to the invention, these disadvantages may be overcome by employing two or more series connected transformation lines whose length is any odd multiple of a quarter wavelength and where the characteristic impedances are in such relation that a perfect matching is obtained.

In the diagram a halfwave antenna S is illustrated which is energized through a cable K having a characteristic impedance W. R_F marks the impedance at the base. If a quarter wave line is connected in a known manner between the cable and the antenna its characteristic impedance W_1 must be equal to the geometrical mean between R_F and W, that is,

$$W_1 = \sqrt{R_F \cdot W}$$

with a normal base impedance of a halfwave antenna around 3600 ohms, for example,

$$W_1 = \sqrt{3600 \cdot 60} = 464 \text{ ohms}$$

which cannot be attained in practice. If pursuant to the invention, two transformation lines instead of one (T_1 and T_2 in the diagram) having

characteristic impedances W_1 and W_2 , the following ratios will be obtained:

At point A will appear the impedance

$$R_A = \frac{W^2}{R_F}$$

At point B will appear the impedance

$$R_B = \frac{W^2}{R_A} = R_F \cdot \frac{W^2}{W_1^2}$$

When the normal cable K having characteristic impedance W is attached at B a matching exists when $R_B = W$. The condition for a perfect matching of the antenna to the cable then is

$$\frac{W_1}{W_2} = \sqrt{\frac{R_F}{W}}$$

Contrary to the previously known arrangements, it is not necessary that the characteristic impedance of the transformation section have a certain predetermined value which under the circumstances can not be obtained, but it merely determines the ratio of two characteristic impedances, which can always be arranged at will, because in the range met with in practice, no low limit is set. In the aforementioned example with $R_F = 3600$ ohms and $W = 60$ ohms by the use of two transformation lines, the ratio becomes:

$$\frac{W_1}{W_2} = \sqrt{\frac{3600}{60}} = 7.74$$

a condition which can be easily realized. If, for example, the characteristic impedance of one of the transformation lines is $W_1 = 180$ ohms then the characteristic impedance of the second line must be $W_2 = 23.2$ ohms, both of which are not difficult with concentric lines.

If the ratio of the characteristic impedance of the two systems to be matched is still greater, giving an even greater ratio of characteristic impedances of the two transformation lines, then it is recommended to use more, for example, four transformation lines. Designating again the base impedance by R_F and the characteristic impedances of the four quarterwave lines, by W_1, W_2, W_3, W_4 and designating by W the characteristic impedance of the cable to be matched, by simple

extension of the former ratios the following equations are obtained:

$$\sqrt{\frac{R_F}{W}} = \frac{W_1 W_3}{W_2 W_4}$$

which changes to equation

$$\sqrt[4]{\frac{R_F}{W}} = \frac{W_1}{W_2}$$

when the values are so chosen that $W_1=W_3$ and $W_2=W_4$. With values given in the foregoing example solved, for four transformation lines, we obtain the value

$$\frac{W_1}{W_2} = \sqrt[4]{\frac{3600}{60}} \approx 2.8$$

Employing between the antenna with $R_F=3600$ ohms and the cable with $W=60$ ohms four quarter wave lines having characteristic impedances $W_1=W_3$ and $W_2=W_4$, then the impedance ratio between the two kinds of transformation lines, that is, between W_1 and W_2 must be equal to 2.8 which does not offer the slightest constructional difficulties.

If a still larger number of transformation lines is used, for example, an even number n and selecting their characteristic impedances to have alternately the same values, that is,

$$W_1=W_3=W_5=W_7 \dots = W_{n-1} \text{ and } W_2=W_4=W_6 \dots = W_n$$

we get the general formula

$$\frac{W_1}{W_2} = \sqrt[n]{\frac{R_F}{W}}$$

with the number of transformation lines increasing, the impedance ratio becomes lower, as can be readily seen from the last equation.

Naturally it is also possible to insert in a well known manner between an even number of transformation lines and the cable, a single quarter wave section whose characteristic impedance must then be accurately determined.

A very close equalization and thereby a better match can be easily attained, by making the inner lead of one or more transformation lines variable so that from its concentric position it can be changed into an eccentric one. Since the characteristic impedance of a tubular conductor with air as a dielectric is in the neighborhood of

$$= \frac{3000}{C} \text{ ohms}$$

where C is the capacity of the conductor in cm./meters, it can be easily seen, that the eccentric position of the inner conductor only affects the characteristic impedance but otherwise has no other effect. The variability of the inner

conductor may be carried out in any known constructional form. Furthermore, it is advantageous to fill the transformation line with oil or, preferably, that portion which has a low characteristic impedance, to avoid impractical diameter ratios of the conductors at the required values of characteristic impedances. In doing so it is necessary to bear in mind the shortening of the wave.

These foregoing considerations only apply to a single fixed frequency. It lies within the field of this invention, however, to develop the construction of transformation lines in such a manner, that with the changing of antenna length, the length of the individual transformation lines can be changed simultaneously, which presents no particular difficulties especially when only two transformation sections are used.

Nor is the invention limited to matching an antenna to a cable, but can find general application wherever a high frequency radiator is connected to a source without reflection, where the impedance of the source and the impedance of the radiator are different.

I claim:

1. Means for matching a high frequency radiator to a transmission line having a characteristic impedance differing from the radiation resistance of said radiator comprising a plurality of transformation sections connected in series between said radiator and said transmission line, each of said sections having a length equal to a quarter of the length of the operating wave, the impedance ratio between said sections being equal to the square root of the impedance ratio between the radiator and the transmission line and means for making a close adjustment of said impedances including means for varying the capacity of said sections.

2. Means for matching a high frequency radiator to a transmission line having a characteristic impedance differing from the radiation resistance of said radiator comprising a plurality of concentric cable transformation sections connected in series between said radiator and said transmission line, each of said transformation sections having an outer sheath and an inner conductor and having a length equal to one-quarter of the length of the operating wave, the impedance ratio between said sections being equal to the square root of the impedance ratio between the radiator and the transmission line, said inner conductors being movable diametrically with respect to said shells whereby a close adjustment of the impedances of said sections may be made.

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