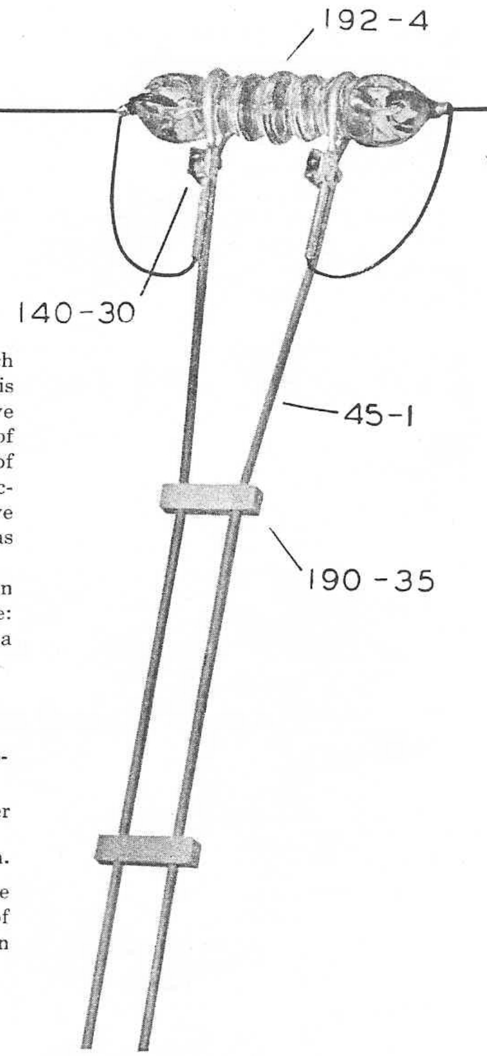
Transmission Line Loss Calculation and Measurement (Continued)



FITTINGS FOR THE CENTER OF THE MULTIBAND ANTENNA

The special clamp (140-30) makes a permanent connection between the line and the antenna wire without soldering. Center insulator (192-4) is also illustrated.

space is 73 ohms, giving a good match with the concentric line. Twisted pair is sometimes used to feed a half-wave doublet. The characteristic impedance of twisted pair may be made in the order of 70 ohms by proper selection of the dielectric. The twisted pair is less expensive than some other types of lines but also has somewhat higher losses.

Considering, first, the two wire line when terminated in its characteristic impedance: at high frequencies the resistance of a circular conductor is:

$$R=\sqrt{\frac{\rho f}{a}}\times 10^{-9}\ \text{ohms/cm*}$$

Where ρ is the resistivity in electromagnetic units.

f is the frequency in cycles per second.

and a is the conductor radius in cm.

This resistance formula neglects the reaction on skin effect of the proximity of the conductors. The following correction may be applied:

$$c=\frac{b}{\sqrt{b^2-4a^2}}\ \dagger$$

Where a is radius of conductors

and b is separation center to center.

This correction may be neglected except for the lines constructed of tubing having close spacing.

From transmission line theory the characteristic impedance and the propagation constant are given by:

$$Z_0=\sqrt{\frac{Z}{Y}}$$

and $\gamma=\sqrt{ZY}$

Where Z is the impedance per unit length.

and Y is the admittance per unit length.

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*(A. Russell Phil. Mag. April, 1909.)

† (S. P. Mead Bell System Technical Journal, pg. 327, 1925.)

For a given line:

$$Z=R+j\omega L$$

and $Y=j\omega C$

neglecting leakage conductance.

Using the fact that for a low loss line $\omega L \gg R$ and the angle of Z is approximately $\pi/2$ gives

$$Z=\omega L\ \underline{/\pi/2-R/\omega L}$$

since for small angles the angle in radians is approximately equal to the tan. of the angle.

Thus $Z_0=\sqrt{L/C}\ \underline{/-R/\omega L}$

and is almost a pure resistance.

Also $\gamma=\omega\sqrt{LC}\ \underline{\left|\pi/2-\frac{R}{2\omega L}\right.}$

$$=\omega\sqrt{LC}\left[\cos\left(\pi/2-\frac{R}{2\omega L}\right)+j\sin\left(\pi/2-\frac{R}{2\omega L}\right)\right]$$

$$=\frac{R}{2Z_0}+j\omega\sqrt{LC}$$

Thus the attenuation per unit length when terminated in Z_0 is $\alpha=\frac{R}{2Z_0}$ nepers or $4.34R/Z_0$ decibels, and the phase shift per unit length is $\beta=\omega\sqrt{LC}$ radians, and the velocity of propagation is $V=\omega/\beta=\frac{1}{\sqrt{LC}}$.

Neglecting the effect of proximity and dielectric constant on capacitance:

$$Z_0=\sqrt{\frac{L}{C}}=276\log_{10}\frac{b}{a}\ \text{ohms}$$

Where b is separation of conductors center to center

and a is radius of conductor

The effect of proximity on capacity does not change the characteristic impedance appreciably. The change is less than one-half of one percent for the case of ¼-inch tubing spaced 1 inch center to center. In air the dielectric constant may be taken as unity.

As an illustrative example of the loss occurring at radio frequencies on a transmission line terminated in its characteristic impedance, the computed loss in decibels per 100 feet has been calculated for three cases:

(1) No. 12 Hard-drawn wire spaced 6 inches with a characteristic impedance of 600 ohms.

(2) ¼ inch copper tubing spaced 1½ inches with a characteristic impedance of 300 ohms.

(3) ¼ inch aluminum tubing spaced 1½ inches.

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