★★★ DECEMBER, 1935

COLLINS SIGNAL

PUBLISHED BY COLLINS RADIO COMPANY CEDAR RAPIDS, IOWA, U. S. A.

Multiband Antenna for High Frequencies

Section I. Practical Data:

A HIGH FREQUENCY antenna and associated transmission line, capable of efficient operation over a wide range of frequencies, has been urgently needed. Amateurs are rarely fortunate enough to have sufficient space for erecting more than one antenna, and commercial high-frequency stations are also frequently located in restricted quarters where separate antennas for each channel cannot be used.

The ordinary high-frequency antenna consists of a doublet operated at its fundamental (the length equal to one-half wave length) or at a harmonic. Such antennas are popularly classified by the type of feeder system employed, such as "Center Fed," "End Fed or Zeppelin," "Single-wire Hertz," "Matched Impedance with Y connected feeders," etc. Only by connecting the feeders into the center of the doublet can the antenna and feeder system be kept electrically symmetrical as the frequency is varied. Unfortunately, the impedance at the center of the antenna changes with the frequency, and any ordinary arrangement for matching the transmission impedance to the antenna impedance can be effective at only one frequency. Furthermore, the effective electrical height (which may be different from the physical height above ground) has a marked effect upon the antenna resistance, and an impedance matching system which is effective at only one value of antenna impedance cannot be counted on to give correct energy transfer to the antenna unless it is adjusted for each particular installation.

The problem, then, resolves itself into the designing of a transmission line which operates efficiently over a wide range of terminating or antenna impedances. The usual two-wire line, constructed of two No. 12 wires spaced about six inches and having a characteristic impedance of about 600 ohms, is not satisfactory for this purpose. For example, such a line one-quarter wave length long connected to the center of a one-half wave length doublet will not be terminated in its characteristic impedance of 600 ohms, but in the antenna resistance of about 75 ohms, and due to the properties of such a line the input impedance at the transmitter end will be about 5,000 ohms (mathematical study will be reserved for the second section of this article and is not essential for a practical understanding of the system). An input impedance as high as 5,000 ohms is undesirable because it is difficult to transfer power to it, because a slight capacity unbalance will cause serious radiation from the line, and because line losses are high due to poor power factor, i. e., pronounced standing waves.

In practice the impedance at the center of a horizontal antenna varies between about 75 ohms and 1200 ohms as the frequency is varied. The lower values occur when the antenna length is one-half wave length, three one-half wave lengths, five one-half wave lengths, etc., and the impedance is highest for frequencies making the antenna length one or more full wave lengths long. If a transmission line with a characteristic impedance of 300 ohms (the geometric mean between 75 and 1200) is used, the standing waves will be a minimum at all frequencies, and the input impedance will remain at all times a manageable value not exceeding 1200 ohms. A 300 ohm line can be constructed of two ¼ inch tubes spaced 1½ inches by means of ceramic blocks at intervals of about 20 inches. The blocks can be located by crimping the tube slightly on either side of the block. A 50 foot copper line of this type weighs 10.9 pounds and is not difficult to support from the center of the antenna. If necessary, aluminum instead of copper tubing may be used to reduce the load on the antenna supports when the vertical part of the transmission line is greater than 50 feet. A line so constructed has surprisingly low loss. Figures 1 and 4 show the actual data, but the following excerpts indicate the minimum efficiency obtained for a line 100 feet long terminated in either 70 or 1200 ohms.

Frequency	Efficiency
3000 kc.	98.5%
7000 kc.	98 %
14000 kc.	97 %

By way of comparison it is interesting to note that a 100 foot twisted pair transmission line of popular make has the following efficiency when terminated in its characteristic impedance:

Frequency	Efficiency
3000 kc.	95%
7000 kc.	84%
14000 kc.	68%

Of course, an antenna with twisted pair feeders can only be used on one band.

A 600 ohm two-wire line 100 feet long terminated in 70 ohms has the following efficiency when **properly balanced:**

Frequency	Efficiency
3000 kc.	94%
7000 kc.	92%
14000 kc.	89%

In practice, slight unbalances in a 600 ohm line materially reduce the efficiency, whereas the 300 ohm line is not so susceptible to loss in efficiency.

In view of the above information it is seen that an antenna can be made to work very efficiently over a wide frequency range and with any antenna im-