EQUATIONS FOR IMPEDANCE OF COUPLED ANTENNAS

□ Alan Harbach's item (Oct. 1983 *QST*, p. 47) regarding the impedance of a dipole above ground provided an accurate explanation of a commonly observed and misunderstood phenomenon. However, some readers may mistakenly attempt to apply the equation and/or results to more general cases of phased antennas.

In the general case, the feed-point impedance of an element in an array is affected not only by the element self-impedance and the mutual impedance between it and the other array elements, but also by the magnitudes and phase angles of currents flowing in the other elements. For two elements, the general equations used to find feed-point impedance are:

$$R_1 = R_{11} + M_{12} (R_{12} \cos \mu_{12} - X_{12} \sin \mu_{12}) \quad \text{Eq. (1)}$$

$$X_{\acute{1}} = X_{11} + M_{12} (X_{12} \cos \mu_{12} + R_{12} \sin \mu_{12}) \quad \text{Eq. (2)}$$

$$R_2 = R_{22} + M_{21} (R_{21} \cos \mu_{21} - X_{21} \sin \mu_{21}) \quad \text{Eq. (3)}$$

$$X_2 + X_{22} + M_{21} (X_{21} \cos \mu_{21} + R_{21} \sin \mu_{21}) \quad \text{Eq. (4)}$$

where

$R_{11} + jX_{11}$ = the self-impedance of element 1

$R_{22} + jX_{22}$ = the self-impedance of element 2

$R_1 + jX_1$ = The feedpoint impedance of element 1

$R_2 + jX_2$ = The feedpoint impedance of element 2

$R_{12} + jX_{12}$ = The mutual impedance between elements 1 and 2[2]

$R_{21} + jX_{21}$ = The mutual impedance between elements 2 and 1

$M_{12} = \frac{1}{M_{21}}$ = Magnitude of current in element 2 relative to that in element 1

$\mu_{12} = -\mu_{21}$ = Phase angle of current in element 2 relative to that in element 1

These equations were derived from those found in the texts quoted by Harbach.

For the special case of an antenna parallel to a reflecting surface (ground), the currents are equal ($M_{12} = M_{21} = 1$) and of opposite phase ($\mu_{12} = \mu_{21} = 180°$). In this case, Eq. 1 through Eq. 4, above, reduce to Eq. 4 in Harbach's letter. Other combinations of current balance and phasing lead to quite different results. — *Roy W. Lewallen, W7EL, Beaverton, Oregon*

[2]$R_{12} = R_{21}$ and $X_{12} = X_{21}$ only when the two elements are identical.

TVI & VHF RIGS

□ I read with interest the letter (Technical Correspondence, Dec. 1983 *QST*) from Robert Findlay, W6NZX, that describes his TVI problem and the RF susceptibility of his 2-meter radio. I am sure many others have also encountered a similar situation. After many hours of "TVI proofing" my SB-230 amplifier, so that it is "clean" when connected to a dummy load, I was dismayed to find that there was still severe TVI when an antenna was attached. This was true despite a multisection low-pass filter installed at the amplifier output. In my case, the 2-meter antenna is approximately 15 ft below the HF antenna.[3] Even so, sufficient RF from the HF radio entered the VHF transceiver to cause interference to nearby television receivers.

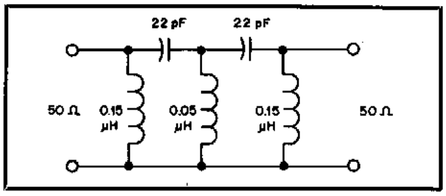

Fig. 2 — Schematic of a high-pass filter to reduce HF signals entering a 2-meter radio.

Findlay suggests using a circulator on the VHF-radio input to eliminate the problem; most circulators I know of are devices of relatively narrow bandwidth, and their reverse isolation at HF isn't very good. Circulators are also fairly expensive devices. The normal TR functions of the VHF radio must be accounted for with such a solution and may require external, nontrivial, switching logic. Disconnection of the VHF antenna may not be possible if one wishes to simultaneously monitor VHF and HF.

Addition of a high-pass filter (Fig. 2) to the RF input of the VHF radio is a much more straightforward solution to the problem. The basic design is a 5-pole Butterworth high-pass filter with a cutoff (3-dB) frequency of 86 MHz. In my particular case, the TVI was eliminated when the filter was placed in the transmission line of the VHF rig. — *Bob Loving, Jr., K9JU, Streamwood, Illinois*

[3]m = ft × 0.3048

FEEDING YOUR STATION

□ DeMaw's article on feed lines, "Feeding Your Station" (Dec. 1983 *QST*), is one of the better articles for beginners that I have read in some time. However, I disagree with his last statement. Foam-dielectric coax cables and open-wire lines are not the answer to the average ham's feed-line requirements.

As a supplier in the marine communications field, I find foam-dielectric coax cables totally unacceptable for commercial or private applications. If you have a spare piece of foam coax, a little experiment will make my point: Cut several small pieces from the sample. You will find that the center conductor is rarely in the exact center of the cable. I believe this condition is created at the time of cable manufacture and is worsened with each handling. This causes hot spots, which are irregularities in the cable impedance. At high power, I have seen these spots get hot to the touch and short out. At VHF, losses are greater than you would believe. Also, foam cables readily accept any moisture offered through poorly sealed connections. (This is a problem in both interior and exterior installations.)

Open-wire lines are indeed (in theory) low-loss feed lines. With today's automated equipment (from TVs to computers, and so on) in homes, however, a novice is foolish to use open-wire line without consideration of the RF radiation along its length — starting in the shack! The article said little about proper installation of the line, and did not show what measures are required to achieve this remarkable low-loss condition. [Installation details appear in Chapter 8 of *The ARRL Antenna Book* — Ed.] Personally, I love open-wire line — when there is no rain.

Good compromise feed lines for those who cannot afford (or justify) a hardline or Heliax™ are: RG-213/U, RG-214/U, 8237, 8213 or any good solid-dielectric RG-8/U with a noncontaminating cover and a minimum of 95% shield coverage. My years of wiring office buildings for limited coast station 1000-W HF systems (in an environment where RF is not considered in design of telephone or computer systems) has shown that 8237 cable (RG-2136) will generally keep RF where you want it. It also holds up well in that severe environment; if it works there, it will work anywhere. Also, don't buy cheap "bargain" coax. There is *no* bargain cable, unless you are fortunate enough to receive a good used section of Heliax or military large-diameter (1 inch or greater) coax.[4] Save your money for quality cable that will bring years of good service with little trouble.

I made believers recently of all the hams present at a local amateur's home. The large majority of TVI from his station was cured by elimination of foam-dielectric cables — this was an extreme case.

I hope *QST* publishes more articles of this quality. There are just as many "experienced" hams as beginners who can profit from such writing. — *Clifford R. Ward, WA5LVG, Spring, Texas*

[4]mm = in × 25.4

Feedback

□ Joseph Worrall, KL7T, informs us of an error in Table 1 (p. 22) of "Feeding Your Station" (Dec. 1983 *QST*). The capacitance of RG-11A/U is 20.5 pF/ft, not 0.5 pF/ft as shown.

□ There are several errors in "Introducing the PS5 — A Dependable, 5-A Portable Power Supply" (June 1983 *QST*). R2 should be connected from pin 3 of U2 to the single ground point, not to the "+" output. Also, there should be a connection dot where the leads from the 2-µF capacitors cross the "common" lead (pin 4) of U2.

In the text on p. 20, under "Operation," the formula for dissipated power should read:

$$P_D = I_{load} \times (V_{in} - V_{out})$$

□ The Hints and Kinks column in this issue contains a correction to a serious ac-power wiring error that appeared in the January *QST* article, "Getting into Amateur Radio Electronics."

□ Here are a few corrections to the February 1984 Hints and Kinks article, "A Two-Transistor Transmitter for 30 Meters." The parts-placement diagram shows 300-pF capacitors in the output network, instead of the 330-pF values shown on the schematic diagram. Either value appears to work. If you use point-to-point wiring, as shown in Fig. 2, it may be necessary to reduce the value of the 130-pF silver-mica capacitor. The author used a value of 82 pF in his original design. The value of L1 is 0.8 µH, not 0.08 µH. The winding information given for this coil is correct.