This short article explains how the Monimatch operates and some common circumstances under which it may give misleading information.

One of the most-misunderstood, most-confusing and most-discussed subjects in amateur radio today is the subject of standing-wave ratio. Prior to about 1956, few amateurs had means whereby they could measure the s.w.r. on their antenna transmission lines. The rest of us loaded our rigs into half-wave dipoles fed with 600-ohm open-wire line (perhaps resulting in an s.w.r. of 8:1), and went ignorantly on our ways working everything from AC4s to ZD9s. Everything worked fine, and everyone was happy.

Then Lew McCoy upset this apple cart of ignorant bliss with his description of the Monimatch.[1] The Monimatch was a simple, inexpensive device which indicated s.w.r., consumed negligible power, and could be left in the line during high-power operation. Today we find s.w.r. indicators of the Monimatch or similar design adorning the operating tables of amateurs everywhere. We also find much confusion, consternation and worry when this diabolical device indicates an s.w.r. other than 1:1, or indicates other than zero reflected power.

How does the Monimatch work? What do its readings mean?

One version of the Monimatch is shown in Fig. 1. R.f. power from your transmitter feeds in through the coax connector on the left, and the coax line to your antenna connects to the coax connector on the right. The two pickup wires, W_R and W_F, are equal in length, and are spaced equally from the center conductor. The r.f. voltage at one end of pickup wire W_F is rectified by diode D_F and read on meter V_F. Similarly, the r.f. voltage at the opposite end of pickup wire W_R is rectified by diode D_R and read on meter V_R.

The r.f. voltages, V_F and V_R, are a resultant produced by both capacitive and inductive coupling from the center conductor. When the Monimatch is properly adjusted and terminated in its design impedance (e.g., 50 ohms), the two capacitively-coupled voltages, V_C, and the two inductively-coupled voltages, V_I, are all equal to each other. Fig. 2 shows the way these voltages are combined to produce the measured voltages V_F and V_R. Notice that on pickup wire W_F, the equal voltages V_C and V_I add in phase to give V_F; voltage V_F is an indication of the so-called "forward" power. On pickup wire W_R, the equal voltages V_C and V_I are opposite in phase because the voltage is measured at the end of the wire opposite from that at which the measurement is made on pickup wire W_F. In this case, V_R is the difference between V_C and V_I, and the resultant produces a zero reading at V_R; voltage V_R is an indication of the so-called "reverse" power, and the reverse-power reading is zero when the Monimatch is properly balanced and terminated.

The situation that has just been described is the one that we all strive so hard to achieve: zero reflected power. But notice that a zero reflected-power reading merely indicates that the previously-balanced Monimatch is properly terminated, usually by 50 ohms; without additional information it tells us nothing about what is happening on a transmission line that may be connected to the output end of the Monimatch.

The Monimatch and S.W.R.

BY S. C. SHALLON,* K6CYG

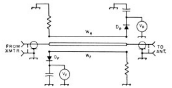

Fig. 1—Basic circuit of the Monimatch.

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[1] McCoy, "The Monimatch," *QST*, Oct., 1956. "Monimatch, Mark II," *QST*, Feb., 1957.

Table I

Monimatch Voltages and Currents with 100 Watts in Load

	A	B	C	D
Load (ohms)	50	100	25	40 + j30
Load Voltage (volts)	70.7	100	50	63.2 + j47.4
Load Current (amperes)	1.41	1	2	1.58
V_C (proportional to load voltage)	70.7	100	50	63.2 + j47.4
V_I (proportional to load current)	70.7	50	100	79.0
$V_F = V_C + V_I$	141.4	150	150	$142.2 + j47.4 = 150 \angle 18.4°$
$V_R = V_C - V_I$ (or $V_I - V_C$)	0	50	50	$-15.8 + j47.4 = 50 \angle 108.4°$
Indicated Forward Power (watts)	100	112.5	112.5	112.5
Indicated Reverse Power (watts)	0	12.5	12.5	12.5

To get a better appreciation of what the Monimatch readings mean, let's assume that we have a transmitter delivering 100 watts through a 50-ohm Monimatch into a 50-ohm load connected directly to the output end of the Monimatch. The load voltage, to which V_C is proportional, is 70.7 volts; for the sake of simplicity, let's say that V_C measures 70.7 units of voltage. The load current, to which V_I is proportional, is 1.41 amperes; this must produce a V_I of 70.7 units of voltage since V_C and V_I are equal when the Monimatch is properly terminated. These voltage and current conditions for a 50-ohm load are tabulated in column A of Table I. Column A also shows that V_F (an indication of forward power) is 141.4, and that V_R (an indication of reverse power) is zero, indicating that there is no reflected power.

Now, let's replace the 50-ohm load with a 100-ohm load; but let's continue to pour 100 watts into it through our 50-ohm Monimatch. The load voltage is now 100 volts, and the load current is one ampere. These values for load voltage and load current produce new values of V_C, V_I, V_F, and V_R, as tabulated in column B of Table I. Since power is proportional to the square of voltage, and since the V_F of 141.4 in column A corresponded to a forward power of 100 watts, the new V_F of 150 must correspond to an indicated forward power of

$$\left(\frac{150}{141.4}\right)^2 \times 100 = 112.5 \text{ watts.}$$

Huh! Is the guy who wrote this article some kind of nut? How can the Monimatch indicate 112.5 watts forward power when we started with only 100 watts? To answer this, let's look at the reflected power. The V_R of 50 corresponds to a reflected power of

$$\left(\frac{50}{141.4}\right)^2 \times 100 = 12.5 \text{ watts.}$$

And it should be obvious that the 12.5 watts of reflected power subtracted from the 112.5 watts of forward power leaves 100 watts, the power we started with.

What this all boils down to is that the "forward" and "reflected" powers are both fictitious powers that help (?) in the understanding of transmission-line phenomena; but the only power that actually exists is the difference between the two, the power delivered to the load. The "reflected" power measured by your Monimatch is not wasted power that is not finding its way to your antenna; it is a fictitious power. If the "reflected" power were an actual power, the extra power would have to come from somewhere. But if you check the input power to your final amplifier, you will find that it is the same as it was when the "forward" power was 100 watts with no "reflected" power.

A 100-ohm resistive load is not the only load that will result in an indication of 112.5 watts of "forward" power and 12.5 watts of "reflected" power. A 25-ohm resistive load will produce the same results, as shown in column C of Table I.

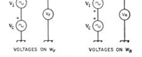

Fig. 2—Diagrams showing the various voltages involved in operation of the Monimatch.

There are infinite combinations of resistance and reactance that also will produce the same results; column D shows the circuit conditions for one such load: 40 ohms of resistance in series with 30 ohms of inductive reactance.

In the above calculations, lumped-constant loads were used at the output of the Monimatch. When the Monimatch is connected instead to a transmission line, the Monimatch readings depend upon the equivalent lumped-constant impedance "seen looking into" the line. The equivalent impedance depends upon the load impedance at the far end of the line, the length of line, and the characteristic impedance of the transmission line. Fortunately, there is a convenient relationship between the transmission-line s.w.r. and the impedance "seen looking into" the line which permits the Monimatch to be used for s.w.r. measurements. However, the Monimatch readings will be correct only if the Monimatch has been calibrated for the impedance of the transmission line with which it is used. To see that this is the case, consider the following situations.

Let's go back to the situation depicted in column A of Table I, in which a 50-ohm Monimatch is terminated with 50 ohms. Now, insert one half wavelength of 200-ohm transmission line between the Monimatch and the load. The s.w.r. on the line is 4:1, but the Monimatch continues to indicate zero reflected power. This is because the impedance seen looking into a transmission line repeats for each half-wavelength increment of line. Thus, it is seen that the Monimatch gives erroneous readings for this situation of mismatch between Monimatch and transmission line.

Suppose we have a Monimatch that is not properly balanced for 50 ohms, but is balanced instead for 40 ohms. If we connect to the output of this Monimatch a length of 50-ohm transmission line feeding a 50-ohm load, the s.w.r. on the line will be unity, but the Monimatch will indicate an s.w.r. of 1.25:1. Again, the Monimatch gives erroneous readings because it is not balanced for the impedance of the transmission line being used.

But let's connect a 50-ohm Monimatch into a 50-ohm transmission line of arbitrary length, and let's suppose that the load at the far end of the line is mismatched so as to produce an s.w.r. on the line of 2:1. Depending upon the load impedance and the length of line, the impedance presented to the Monimatch may be 100 ohms resistive (corresponding to column B of Table I), 25 ohms resistive (corresponding to column C), or a combination of resistance and reactance (such as that in column D); but for all of these cases, the Monimatch forward power readings will be the same, as will the reverse power readings, and the indicated s.w.r. will be 2:1 (in columns B, C, and D of Table I, the forward power of 112.5 watts and reverse power of 12.5 watts correspond to a 2:1 s.w.r.).

Many fables regarding standing-wave ratio are rampant on the ham bands and in the literature. With knowledge of how the Monimatch works, the true facts should be evident:

1) If your Monimatch is properly balanced (and there is no r.f. on the outside of your coax line), the s.w.r. reading should be independent of the length of line. However, if there is a standing wave on the line, your transmitter loading may change as you change the line length because the impedance presented to the transmitter changes.

2) S.w.r. readings do not depend upon the length of coax line between your transmitter and the Monimatch.

3) Reflected power is not wasted power. However, transmission-line loss varies with s.w.r. as described in the *Handbook*. QST