Understanding MFJ analyzer readings

ZS6KR

In an older publication of QEX there was a reader's query and explanation regarding the interpretation of MFJ antenna analyzer SWR and impedance readings which I copied and filed at the time.
Rediscovering this, it is worth publishing here with some expanded explanation to clarify why readings sometimes appear untrue though they are not:

MFJ: **Z**=52 Ω, **R**=42 Ω, **X**=32 (sign unknown) SWR=2,0
At first sight this is a good impedance match to a 50Ω system, but SWR=2,0 Why?

For complex loads the magnitude of SWR is NOT=Zload/Zo or Zo/Zload , and we must take into account the reactance as follows using standard theory:

$$SWR = \frac{1+\rho}{1-\rho} = \frac{V_{max}}{V_{min}}$$ where **ρ** is the absolute value of $$\frac{Z_{load} - Z_o}{Z_{load} + Z_o}$$ where either Zload is complex (42±j32).

Squaring the expression gets rid of "j" and results in $$\rho^2 = \frac{(42-50)+32^2}{(42+50)+32^2} = 0,11$$

Thus **ρ** = 0,34 and $$SWR = \frac{1+0,34}{1-0,34} = 2,0$$

The impedance is calculated by the analyzer in the normal way: $\mathbf{Z} = \sqrt{(42^2 + 32^2)} = \sqrt{2788} = 52,8\ \Omega$

It is only for purely resistive loads that SWR=Zload/Zo or Zo/Zload

For instance for a 75Ω dipole in resonance fed by a 50Ω source $$\rho = \frac{75-50}{75+50} = 0,2$$

Thus $SWR = \frac{1+0,2}{1-0,2} = 1,5$ which also tallies with $SWR = \frac{75}{50} = 1,5$

Hence, whenever (assuming your analyzer is properly calibrated) your analyzer indicates considerable reactance, the Z and SWR readings should make sense according to the first example while for X close to zero the figures should make sense according to the second example's simplified expressions.

Now for another erroneous interpretation often done:
Tuning antennas with an arbitrary length of transmission line feeder will not fool the MFJ but you, the operator.
You may tune as much as you like, but the MFJ is looking at the feeder plus antenna and shows the *system impedance.*

How do we truly know what the situation is at the end of the feeder?
By making the feeder of such a length at the frequency of interest that it acts as a 1:1 transformer.

Ever half-wave in a transmission line gives a 1:1 transformation with a phase reversal every time, which for MFJ purposes we can ignore.
The physical length of a half-wave cable = velocity factor x ½ x 300/MHz = ≈67% x 150/MHz ≈ 693mm @ 145MHz

For any installation or test cable thus use any multiple of ≈693mm.

To verify the full cable, short it at the end and check with the MFJ for zero or minimum resistance at the frequency of interest.
Generally it is wise to cut the cable slightly longer and snip little bits off until the correct frequency is reached.

Feeding an HF 10,15,20m tribander is also possible with this philosophy as the three frequencies are harmonically related:

A full wave on 20m = 2 full waves on 10m and 3 half waves on 15m.
Thus making the smallest unit of cable length a full wave on 20m, we get physical length=14,10m for f=14,25MHz

Thus in any installation use any multiple of ≈14,10m and coil up any excess.

Again, verify the correct overall length by shorting the end and checking for R≈0 at the 3 frequencies.
Long cables or moderate lengths of thin cable will of course not show R=0 but a higher minimum reading due to losses.

For an existing installation, proof of a correctly tuned 50Ω antenna can only be found when adding various lengths of cable onto the feedline and verifying that readings remain at R≈50 and X≈0.
