ZL2PD Digital Antenna Analyser

Appendix A: Impedance Calculations

The microprocessor directly measures V_{in}, V_{50} and V_L. From the voltage vectors which are shown in Figure 1 above, we can see that:

$V_{RL}^2+V_{XL}^2=V_L^2$ and rearranging, then

$$V_{XL}^2=V_L^2 - V_{RL}^2 \qquad (1)$$

Also, from Figure 1, we can see:

$$(V_{50}+V_{RL})^2 +V_{XL}^2 = V_{in}^2 \qquad (2)$$

Substituting (1) into (2), then;

$$V_{RL} = \frac{V_{in}^2 - V_{50}^2 - V_L^2}{2*V_{50}} \qquad (3)$$

Substituting the calculated value of V_{RL} (determined by using equation (3) and the voltages measured from the bridge) into equation (1) allows us to find V_{XL}^2. Then, by calculating the square root of this value, we can finally calculate the value of $V_{XL.}$

Now, the bridge current passing through the 50 ohm bridge resistor and the load can be calculated from V_{50} since this current equals $V_{50}/50$ ohms. Since we have calculated the individual voltage drops across the resistive (V_{RL}) and reactive (V_{XL}) components of the load impedance, then we can divide these voltages by this bridge current to obtain the values of R and X, as follows:

$$R_L = \frac{V_{RL} * 50}{V_{50}} \qquad \text{and} \qquad X_L = \frac{V_{XL} * 50}{V_{50}}$$

The meter can then show these values on the LCD.

The last step is to determine VSWR.

VSWR = $1+\rho/1-\rho$ where $\rho = (Z_L-50)/(Z_L+50)$

ρ is the reflection coefficient, a parameter representing the mismatch between load and reference impedances, in this case, 50 ohms. Z_L is a complex impedance, so ρ is also a complex number.

While ρ can have negative values, VSWR is calculated using the “absolute value” of "ρ", a number between 0 and 1.

Since we have already determined the values of R_L and X_L, we can calculate ρ from:

$$|\rho| = SQRT\{(R_L-50)^2+X_L^2\}/ SQRT\{(R_L+50)^2+X_L^2\}$$

This last equation, with all of the squares and square roots, can be troublesome when using integer calculations. Careful scaling avoids register overflow and allows us to maintain reasonable accuracy while also minimizing the calculation time.