Letters to the Editor

An Extremely Wideband QRP SWR Meter (Jan/Feb 2014)

Hi Larry,

With regard to my article in the Jan/Feb 2014 issue of *QEX*, Glenn Pederson, WB9QIQ, brought an obvious error to my attention. In the section titled "The Math," I incorrectly stated:

We square the power reflection coefficient to get the voltage reflection coefficient, because we ultimately want the Voltage Standing Wave Ratio. That's the "V" in VSWR. Since we're still dealing with the logarithms, we obtain the square by multiplying the logarithm of the power reflection coefficient by 2.

Glenn caught the obvious error. Actually the voltage reflection coefficient is the square root of the power reflection coefficient.

I overlooked this fact because the equation was obviously correct, as it gave exactly the correct answer in all test cases. It is my simplistic explanation that is in error. I herewith correct that error with way too much math. Sorry, this is as simple as I can make it. Other approaches require manipulation of exponents. The original equation was correct simply because the reciprocal of the slope of the log detector response is exactly 40. Talk about serendipity.

Here is a corrected version of "The Math" section of my article. My thanks to Glenn for bringing this error to my attention, and subsequently checking my math.

The Math

The outputs of the coupler board are two voltages that indicate the logarithms of the forward and reflected powers from the two couplers.

The linearized logarithmic detector response from Figure 4 is given by Equation 1.

$$V = (0.025\ \mathrm{V / dB} \times 10 \log \text{Power in dBm}) + 2.15\ \mathrm{V} \qquad \text{[Eq 1]}$$

The reflection coefficient, traditionally represented as the Greek character rho (ρ) is a ratio of reflected signal level compared to forward signal level. In terms of reflected and forward power, and remembering that dividing numbers is the same as subtracting their logarithms, we obtain Equation 2.

$$\rho_{\text{power}} = \frac{P_r}{P_f} \qquad \text{[Eq 2]}$$

or

$$10 \log \rho_{\text{power}} = 10 \log P_r - 10 \log P_f \qquad \text{[Eq 2A]}$$

VSWR meters measure voltages corresponding to the reflected and forward powers to calculate reflection coefficient and then VSWR. The simplest way I can explain this is to start with the difference between these voltages, which is a ratio of the reflected power to the forward power, and which is in turn, the power reflection coefficient, ρ_{power}. So, we can write Equation 3.

$$\left(V_r - V_f\right) = \left[0.025 \times \left(10 \log P_r\right) + 2.15 - 0.025 \times \left(10 \log P_f\right) - 2.15\right] \qquad \text{[Eq 3]}$$

This conveniently simplifies to Equation 4.

$$\left(V_r - V_f\right) = \frac{\left(10 \log P_r - 10 \log P_f\right)}{40} \qquad \text{[Eq 4]}$$

Equation 4 can be further simplified to Equation 5.

$$\left(V_r - V_f\right) = \frac{\left(\log \dfrac{P_r}{P_f}\right)}{4} = \frac{\left(\log \rho_{\text{power}}\right)}{4} \qquad \text{[Eq 5]}$$

or

$$\left(\log \rho_{\text{power}}\right) = 4 \times \left(V_r - V_f\right) \qquad \text{[Eq 6]}$$

Take the square root of the power reflection coefficient to get the voltage reflection coefficient, ρ_{voltage}, because we ultimately want the Voltage Standing Wave Ratio. That's the "V" in VSWR. Since we're still dealing with logarithms, we obtain the square root by dividing the logarithm of the power reflection coefficient by 2.

$$\log\left(\rho_{\text{voltage}}\right) = \frac{\left(\log \rho_{\text{power}}\right)}{2} = 2 \times \left(V_r - V_f\right) \qquad \text{[Eq 7]}$$

So far, we've taken the two voltages, subtracted them, and multiplied by 2. Then we obtain ρ by raising 10 to the power log ρ_{voltage}. Finally we obtain the VSWR from Equation 8.

$$VSWR = \frac{1 + \rho_{\text{voltage}}}{1 - \rho_{\text{voltage}}} \qquad \text{[Eq 8]}$$

All this is just a few lines of code in a high level language, as Figure 6 in the original article shows.

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Code Listing

```
#include <LiquidCrystal.h>
// initialize the library with the numbers of the interface pins
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);

int sensorPin0 = A0, sensorPin1 = A1;
float a,b,c,d,e,f;
float sensorValue0 = 0, sensorValue1 = 0;  // store values from sensors
float fudge = 2.40/1024 ; // for External 2.4 V reference

void setup() {
lcd.begin(16, 2);    // set up the LCD's number of columns and rows:
analogReference(EXTERNAL);
}

void loop() {
sensorValue0 = analogRead(sensorPin0);
sensorValue1 = analogRead(sensorPin1);

lcd.setCursor(0, 0) ;
//  lcd.print("W0PCE  QRP Meter  "); // normal operation
a=sensorValue0*fudge ;
b=sensorValue1*fudge ;
lcd.print("Vf=");    lcd.print(a); // diagnostic operation
lcd.print("  Vr=");  lcd.print(b);

lcd.setCursor(0, 1) ;
c=2*(b-a) ;
d=pow(10, c);
e=(1+d)/(1-d) ;
lcd.print("  SWR = ");  lcd.print(e);
delay(500);
}
```

Figure 6 — Arduino code performs WØPCE QRP SWR Meter functions.