APPENDIX 8 – DETERMINING ADDITONAL POWER LOST IN LINE DUE TO REFLECTIONS AND SWR

(A calculator program for solutions using this procedure appears in Appendix 8a.)

When using an antenna tuner with coaxial transmission lines to match the input impedance of the line to the transceiver, we often want to know how much additional power we will lose to line attenuation for a given value of SWR, over and above the power lost when the line is matched. Calculations to determine the additional power lost due to SWR are easy to perform using the reflection coefficient ρ, obtained by substituting the value of SWR in the following expression.

$$\rho = \frac{SWR - 1}{SWR + 1} \qquad \text{(Eq 3-2)}$$

It should be kept in mind that, since standing waves result from reflections, the value of SWR is determined by the reflection coefficient. The scale of the SWR meter is designed to indicate SWR, but its needle deflection is determined by the reflection coefficient, which for an SWR of 3:1, reflection coefficient $\rho = 0.5$. Thus, the meter needle will be at half scale (0.5) for an SWR of 3:1. It is important to become familiar with using the reflection coefficient, because the entire procedure for calculating the additional power lost due to SWR will be with the reflection coefficient.

This procedure requires determination of the power transmission coefficients, $(1 - \rho^2)$, at both the load and input ends of the transmission line. The difference between the two transmission coefficients gives the information we need to determine the amount of additional lost power. The power transmission coefficient at the load is determined from the reflection coefficient ρ at the load, and that at the input is determined by reducing the load ρ by the amount of the line attenuation α in decibels. Thus ρ represents the reflection coefficient at the load, and we will let ρ' represent the reduced reflection coefficient at the input. Consequently, the power transmission coefficient at the load is $(1 - \rho^2)$ and that at the input is $(1 - \rho'^2)$.

We first convert attenuation α in decibels to its decimal value α_{DEC}, using the expression

$$\alpha_{DEC} = \text{anti}\log_{10}^{-1}\frac{\alpha}{10}.$$

(Details for using this expression appear in Appendix 7.)

Next, we multiply ρ by α_{DEC} to obtain ρ' at the line input to include the effect of the line attenuation, and then substitute ρ and ρ' in the power transmission coefficients $(1 - \rho^2)$ and $(1 - \rho'^2)$, respectively. Due to the line attenuation, the power coefficient $(1 - \rho^2)$ at the load is less than coefficient $(1 - \rho'^2)$ at the input. The difference between the two power coefficients in dB gives us the amount of power lost because of the SWR.

We will now illustrate the procedure with an example, using the same values as in Chapters 3 and 9 (also Appendices 6 and 7). In those examples we used a transmission line having attenuation $\alpha = 0.5$ dB, terminated with a mismatched load that gives rise to reflections with the reflection coefficient $\rho = 0.5$, for an SWR of 3:1. Therefore, the power *reflection* coefficient at the load is $\rho^2 = 0.25$, and the power *transmission* coefficient at the load is $(1 - \rho^2) = 0.75$. Before we can determine the value of ρ' at the input, we must first calculate the decimal value of line attenuation α, using the expression repeated from above,

$$\alpha_{\mathrm{DEC}} = \text{anti}\log_{10}^{-1}\frac{\alpha}{10}.$$

Using the values obtained in the example appearing in Appendix 7, we find $\alpha_{\mathrm{DEC}} = 0.89125$. Multiplying $\rho \times \alpha_{\mathrm{DEC}}$ we get $\rho' = 0.44563$, which, after squaring, the power *reflection* coefficient at the input is $\rho'^2 = 0.19858$. Therefore, the power *transmission* coefficient at the input is $(1 - \rho'^2) = 0.80142$. To find the difference between the two power transmission coefficients in dB, we perform the following division to find the decimal value of the loss,

$$\frac{(1-\rho^2)}{(1-\rho'^2)} = \frac{0.75}{0.80142} = 0.93548,$$

which equals –0.288 dB, the additional power lost due to an SWR of 3:1 on a transmission line having an attenuation of 0.5 dB. The total loss includes the matched loss of 0.5 dB plus 0.288 dB due to SWR, which equals 0.788 dB. You may now find it interesting to review Example 5 in Appendix 6.

By using the procedure just described, the additional power lost to SWR can be found for any transmission line, once its matched-line attenuation and SWR are known.