

APPENDIX 6 – POWER RELATIONSHIPS ON MISMATCHED TRANSMISSION LINES

The power relationships on a mismatched transmission line may be determined from the following equations.

$$\rho = \text{magnitude of voltage reflection coefficient} = \frac{\text{SWR} - 1}{\text{SWR} + 1}$$

ρ^2 = magnitude of power reflection coefficient (power reflected by mismatched load)

$$(1 - \rho^2) = \text{power absorbed by mismatched load}$$

Example 1

Lossless line (attenuation $\alpha = 0$); line with matched load, SWR = 1:1, $\rho = 0$, $\rho^2 = 0$, and $(1 - \rho^2) = 1$. Transmitter matched to line-input impedance, $Z_c = 50$ ohms. See Apx 6-1A. All the transmitter power, 100 W, is absorbed in the load.

Example 2

As in example 1, a lossless line (attenuation $\alpha = 0$); line with mismatched load, SWR = 3:1, $\rho = (3 - 1)/(3 + 1) = 0.5$. Transmitter initially matched to 50-ohm dummy load, then switched to the mismatched line without retuning and matching. The 3:1 load mismatch referred back to the line input results in a 3:1 mismatch to the transmitter; *transmitter not rematched* to the new line-input impedance. See Apx 6-1B. Here the transmitter reduces its delivered power by the amount of the reflected power, $\rho^2 = 25$ W, due to its mismatch to the line. Note that all the transmitter power delivered, 75 W, is absorbed in the load.

Example 3

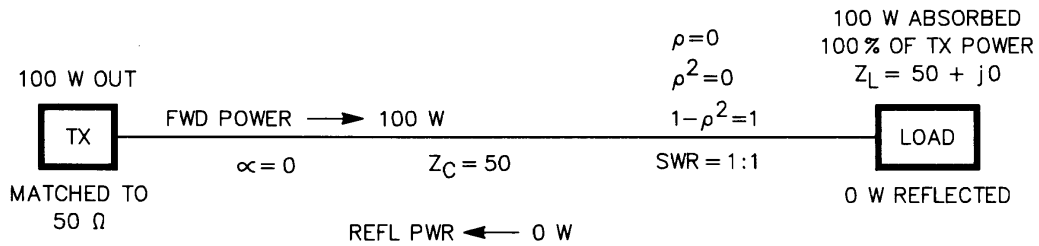
As in example 2, a lossless line (attenuation $\alpha = 0$); line still mismatched with 3:1 SWR, but *transmitter rematched* (conjugate) to new line-input impedance. See Apx 6-1C. The transmitter again delivers 100 W to the line, and 100 W are now absorbed in the Z_c -mismatched, but conjugate-matched load. How is the 133.33 W of forward power obtained? From Eq 6-2 (also Appendix 5), forward power = $1/(1 - \rho^2) = 1/0.75 = 1.3333$ when the mismatch is 3:1. $100 \text{ W} \times 1.3333 = 133.33 \text{ W}$. (See Appendix 7 for explanation of the increase in forward power on line with mismatched load, but conjugately matched at line input by rematching pi-network in the transmitter, or with the use of an antenna tuner.)

Example 4

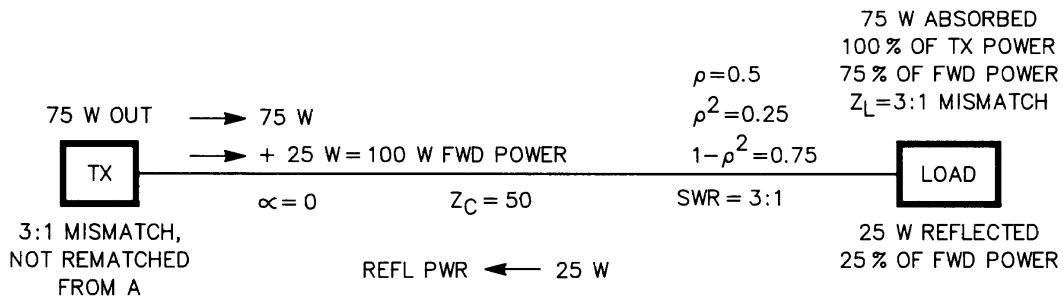
Line with attenuation, $\alpha = 0.5$ dB, such as 87 feet of RG-59 or 175 feet of RG-8 at 4.0 MHz; matched load, as in example 1; SWR = 1:1. See Apx 6-2A. The transmitter is matched to the line-input impedance $Z_C = 50$ ohms. However, 100 W of forward power leaving the transmitter suffers 0.5 dB line attenuation loss; hence, only 89.125 W reaches the load, where it is all absorbed.

Example 5

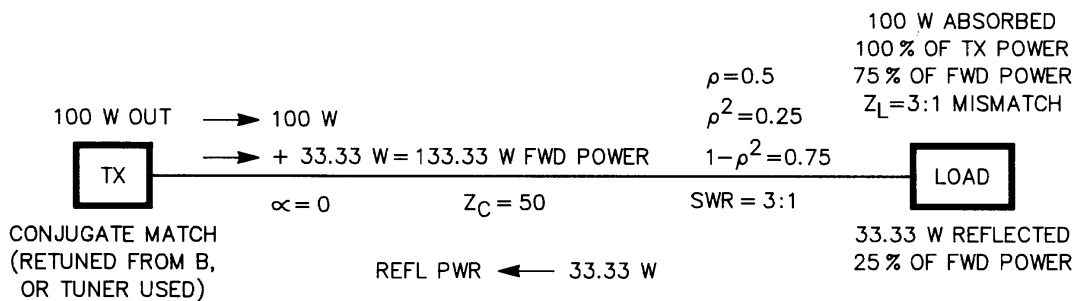
Line with attenuation, $\alpha = 0.5$ dB, such as 87 feet of RG-59 or 175 feet of RG-8 at 4.0 MHz, as in Example 4, but line mismatched with 3:1 SWR at load. See Apx 6-2B. The 3:1 load mismatch referred back to the line input through 0.5 dB of line attenuation results in a 2.61:1 mismatch to the transmitter until matched by retuning, or with a transmatch. The rematched transmitter delivers 100 W to the line. With 0.5 dB of matched-line loss, plus 0.288 dB additional line loss from the 3:1 SWR, the total line-attenuation loss is 0.788 dB. The power lost to line attenuation with the 3:1 mismatch is 16.59 watts, in contrast to 10.87 watts lost when the line is matched (example 4, Apx 6-2A). The forward power, 124.78 W, suffers 0.5 dB loss to 111.21 W during the trip to the load; the reflected power, 27.8 W, suffers 0.5 dB loss to 24.78 W during the return trip to the transmitter, leaving 24.78 W to add to the source power, 100 W. The power absorbed in the load and the power lost in line attenuation account for all the power delivered by the transmitter!



(A)

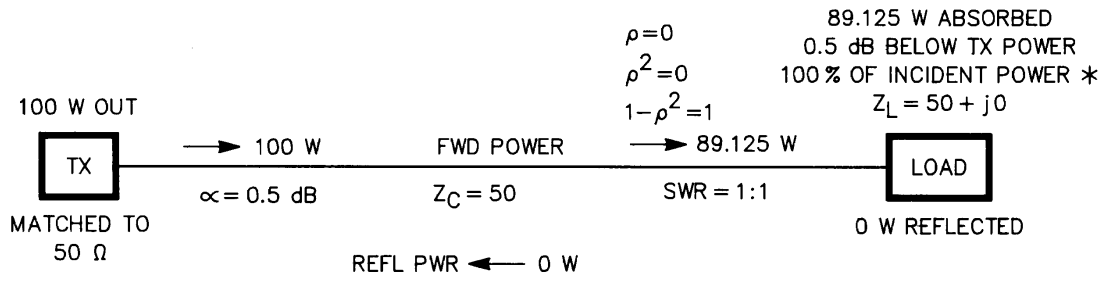


(B)

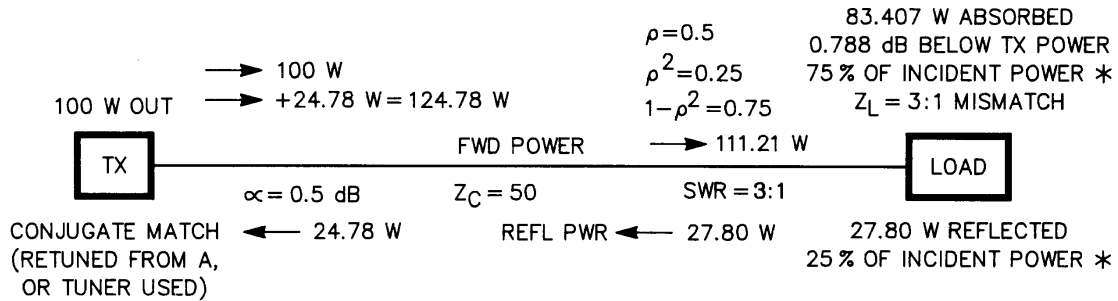


(C)

Fig Appendix 6-1 – Illustrating the transmission-line conditions for a lossless line with different loads and input matching conditions. Drawings A, B and C respectively represent Appendix 6 examples 1, 2 and 3.



(A)



(B)

Fig Appendix 6-2 – Illustrating the transmission-line conditions for a line with 0.5 dB loss having different loads and input matching conditions. Drawings A and B respectively represent Appendix 6 examples 4 and 5. *Incident power is the forward power that reaches the load.