Transformer Directional Coupler

Chris Haji-Michael
http://www.sunshadow.co.uk/chris.htm

This mathcad document is to design a directional coupler using transformers. The equations are from IEE Microwave Antennas and Prop, Vol 14, August 1999. The equations assume tight transformer coupling from 1 to N and are therefore this is only a starting point for a circuit built on a chip.

$$d(N_1, N_2) := 4 \cdot N_1^{\,2} \cdot N_2^{\,2} + 1 + (N_1 - N_2)^2$$

$$S_{11}(N_1, N_2) := \frac{1}{d(N_1, N_2)}\left(-N_1^{\,2} + N_2^{\,2} - 2 \cdot N_1 \cdot N_2 + 1\right)$$

$$S_{22}(N_1, N_2) := \frac{1}{d(N_1, N_2)}\left(-N_1^{\,2} + N_2^{\,2} + 2 \cdot N_1 \cdot N_2 - 1\right)$$

$$S_{21}(N_1, N_2) := 20 \cdot \log\left[\frac{2 \cdot N_1 \cdot N_2}{d(N_1, N_2)}(2 \cdot N_1 \cdot N_2 - 1)\right]$$

$$S_{24}(N_1, N_2) := 20 \cdot \log\left[\frac{2 \cdot N_1 \cdot N_2}{d(N_1, N_2)}(N_1 + N_2)\right]$$

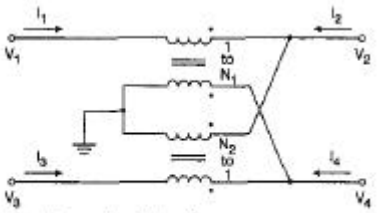

Fig.1 *Directional coupler with transformers*

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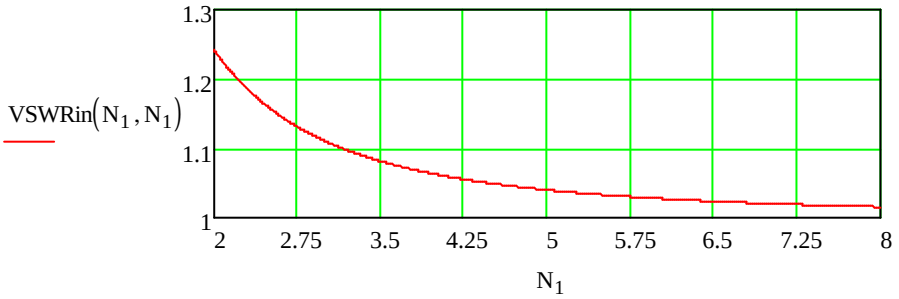
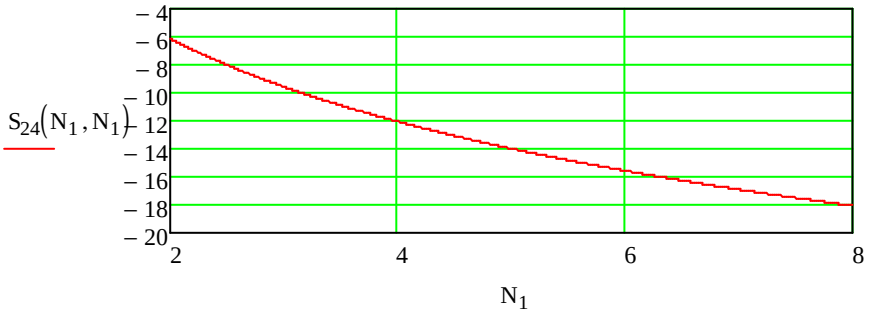
$$VSWRin(N_1, N_2) := \frac{1 + |S_{11}(N_1, N_2)|}{1 - |S_{11}(N_1, N_2)|}$$

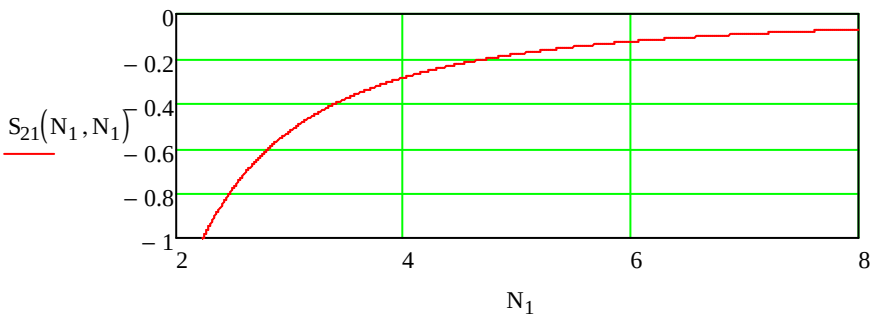
Input VSWR



Coupling Level (dB)



Forward Path Loss (dB)



Simulation with N1=2 and N2=6
S24 = S41 = -9.795dB
S21 = S43 = -0.622dB

$S_{24}(2,6) = -9.795$

$S_{21}(2,6) = -0.622$