

Transformer Directional Coupler

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<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.

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

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

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

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

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

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

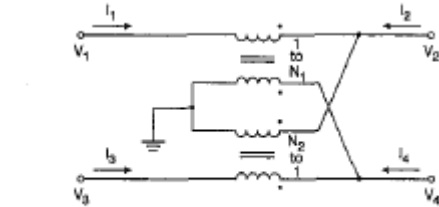
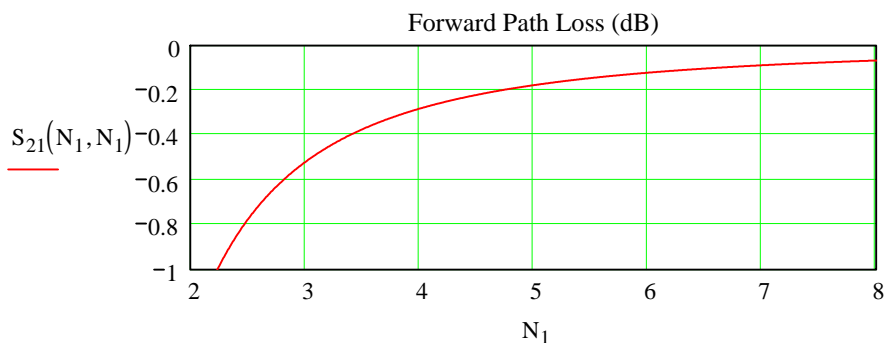
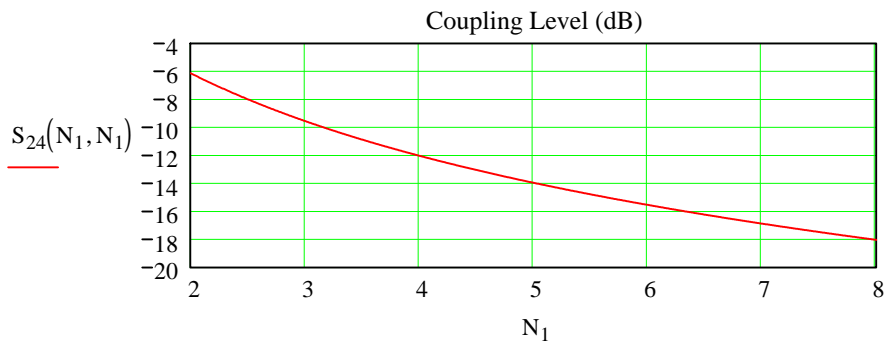
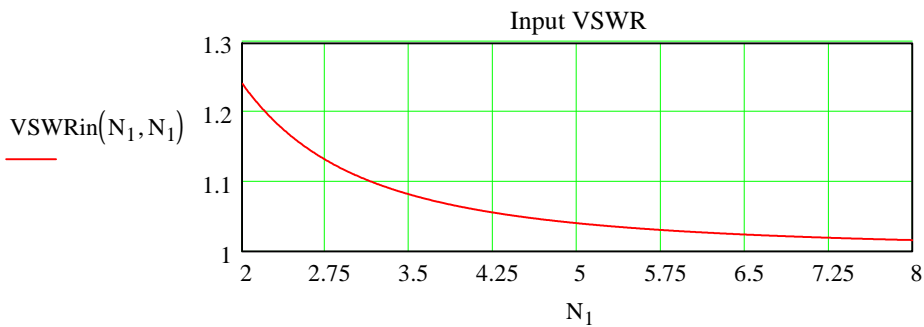


Fig.1 Directional coupler with transformers

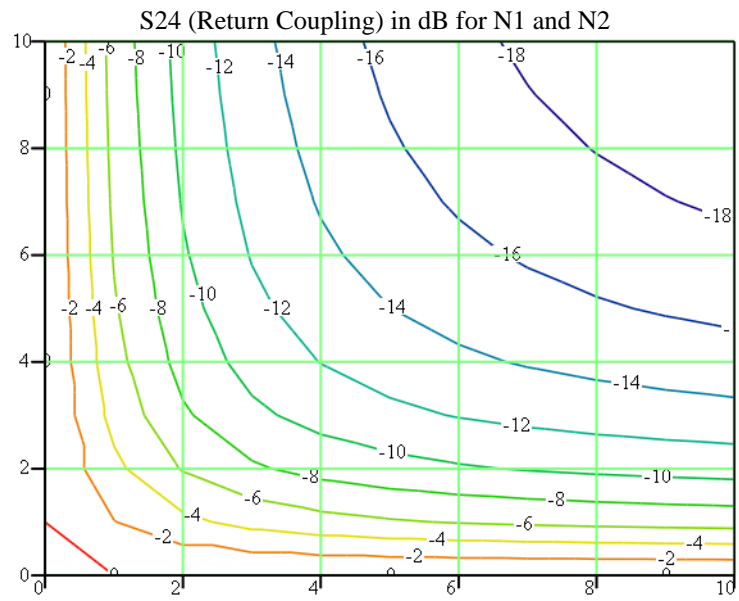


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$N1 := 1, 2.. 10$ $N2 := 1, 2.. 10$

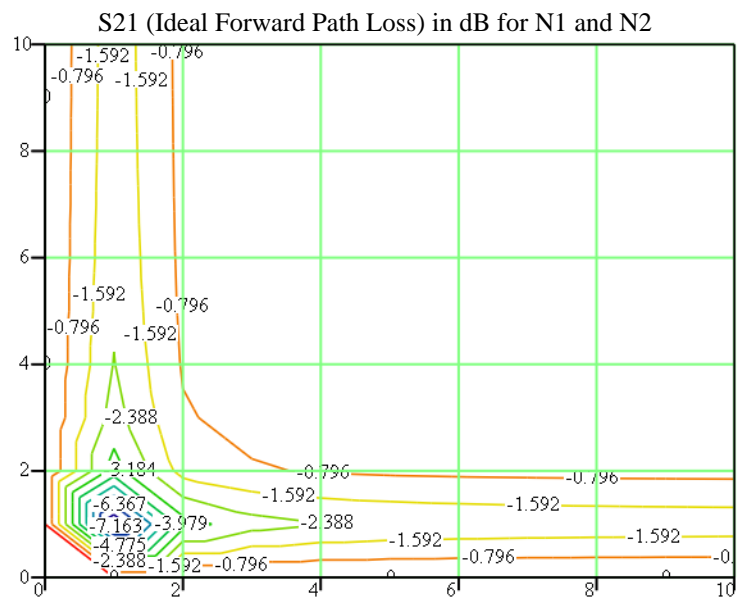
$M_{N1, N2} := S_{24}(N1, N2)$



M

According to the paper the forward and reverse path losses, S_{21} , S_{12} , S_{34} , S_{43} are all equal and calculated above as S_{21} . Shown below dB. Added coil losses make a big difference to this.

$M_{N1, N2} := S_{21}(N1, N2)$



M