Problem

The input power in a two hole directional coupler is 1mW. the coupler has a coupling factor of 15 dB and a directivity of 30 dB. Calculate the power in all the ports.

Soln

$$C = 10 \log \left(\frac{\text{Input power}}{\text{Coupled o/p power}} \right)$$

$$\Rightarrow C = 10 \log \left(\frac{P_1}{P_4} \right)$$

$$\Rightarrow 15 = 10 \log \frac{P_1}{P_4}$$

$$\Rightarrow \frac{P_1}{P_4} = \text{antilog} \left(\frac{3}{2} \right) = 31.62$$

$$\therefore P_4 = \frac{1\,mW}{31.62} = 0.032\,mW$$
$$= 32\,\mu W$$

$$D = 10 \log \frac{P_4}{P_3} = 30$$

$$\Rightarrow \frac{P_4}{P_3} = \text{Anti log}(3) = 10^3$$

$$\Rightarrow \cancel{P_4 = 10^3 P}$$

$$\Rightarrow P_3 = \frac{P_4}{10^3} = \frac{32\,\mu W}{10^3} = 0.032\,\mu$$

Then power in port 2

P_2 = Input Power − (Power in coupled port + Power in isolated port)

$$= P_1 - (P_3 + P_4)$$

$$= 1 - (0.032 + 0.000032)$$

$$= 0.968\,mW$$

...tion to a Two port ...

(2) The s-parameter of a two port network are given by

$$[S] = \begin{bmatrix} 0.2\angle 0^\circ & 0.6\angle 90^\circ \\ 0.6\angle 90^\circ & 0.1\angle 0^\circ \end{bmatrix}$$

(a) Prove that the network is reciprocal but not lossless.

(b) Find the return loss at Port 1 when Port 2 is short-circuited.

Sol^n

~~Since~~ A reciprocal device has the same transmission characteristics in either direction of a pair of ports & it is characterised by a symmetric scattering matrix;

$S_{ij} = S_{ji} \quad (i \neq j)$ which results $[S]_t = [S]$

Now in given matrix as $[S]_t = [S]$, so it is reciprocal.

but to prove it is lossless, given S-matrix needs to satisfy unitary property;

i.e $\sum_{n=1}^{N} S_{ni} \cdot S_{nj}^* = 1; \quad i = j$ also, $\sum_{n=1}^{N} S_{ni} \cdot S_{nj}^* = 0; \quad i \neq j$

i.e.

$$\left.\begin{aligned} S_{11} \cdot S_{11}^* + S_{12} S_{12}^* &= 1 \\ \& \ S_{21} S_{21}^* + S_{21} S_{21}^* &= 1 \end{aligned}\right\}$$

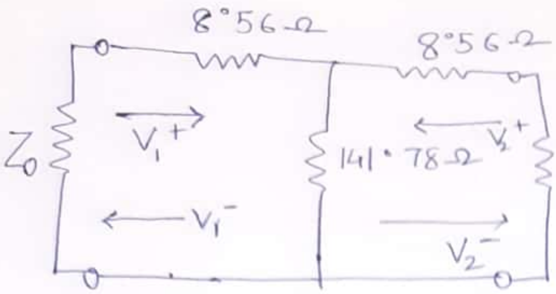
but here, $|S_{11}|^2 + |S_{12}|^2$

$\Rightarrow 0.2^2 + 0.6^2 \neq 1$

Again $0.6^2 + 0.1^2 \neq 1$.

So the network is reciprocal but not lossless (Proved)

Q ①



$Z_0 = 50\Omega$

$$S_{11} = \left.\frac{V_1^-}{V_1^+}\right|_{V_2^+=0} = \frac{b_1}{a_1} = \frac{Z_{in1} - Z_0}{Z_{in2} + Z_0}$$

$$Z_{in1} = 8{\cdot}56 + 141{\cdot}78 \,\|\, (8{\cdot}56 + 50)$$

$$= 8{\cdot}56 + \frac{141{\cdot}78 \times 58{\cdot}56}{141{\cdot}78 + 58{\cdot}56}$$

$$\simeq 50 \text{ ohm}$$

$\therefore S_{11} = 0$.

For symmetry $S_{22} = S_{11} = 0$, $V_1^- = V_2^+ = 0$

$$S_{21} = \left.\frac{V_2^-}{V_1^+}\right|_{V_2^+=0}$$

Now $V_1 = V_1^+ + V_1^- = V_1^+$

$V_2 = V_2^+ + V_2^- = V_2^-$

$(141{\cdot}78 \| (50+8{\cdot}56)$
$= 41{\cdot}44$

$$V_2^- = V_2 = \left\{\frac{V_1}{8{\cdot}56 + 41{\cdot}44} \times 41{\cdot}44\right\} \frac{50}{50+8{\cdot}56}$$

$$= 0{\cdot}707\, V_1 \qquad = 0{\cdot}707\, V_1^+$$

$$\therefore S_{21} = \frac{V_2^-}{V_1^+} = \frac{V_2}{V_1} = 0{\cdot}707$$

$$\therefore [S] = \begin{bmatrix} 0 & 0{\cdot}707 \\ 0{\cdot}707 & 0 \end{bmatrix}$$

Ans

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