電磁波實驗：實驗二

功率計使用及衰減器與T型管量測

2

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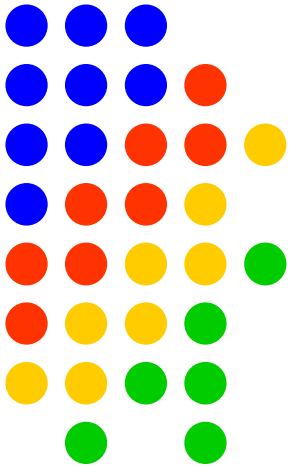
日期：107/3/13,16

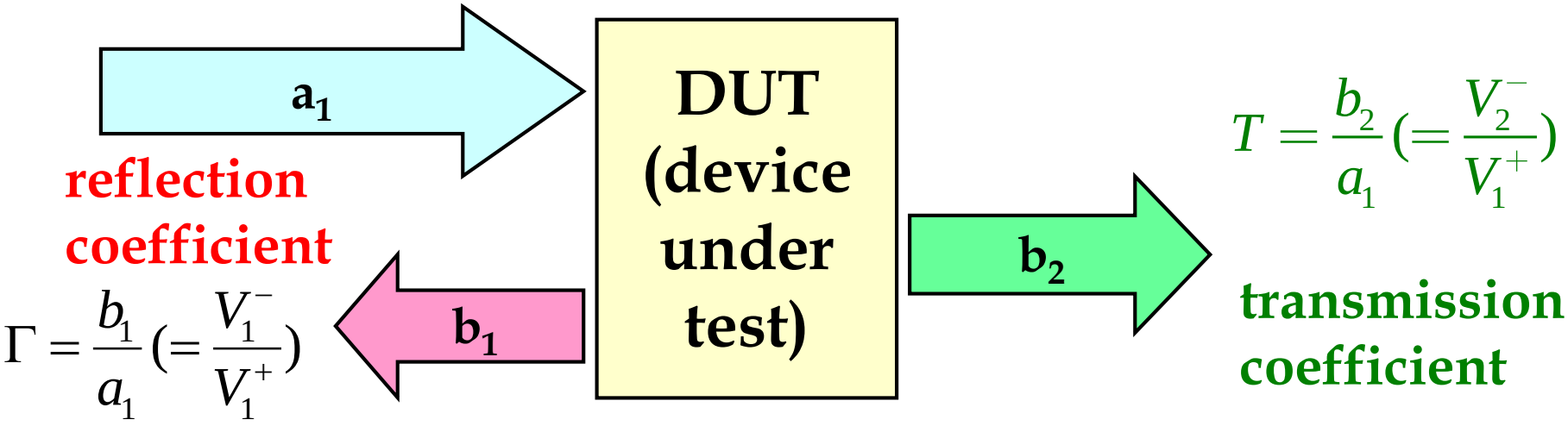


實驗目的

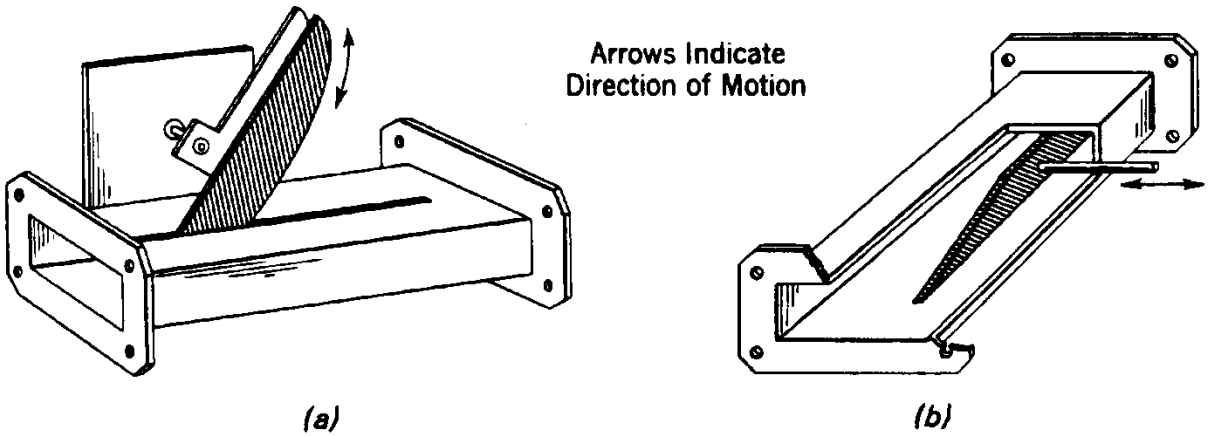
- 熟悉功率計之基本操作及瞭解功率衰減效應。
- 瞭解T形管之功用及其工作原理，並驗證各支臂間輸入功率與輸出功率關係。

穿透係數（Transmission Coefficient）

- 穿透係數：
  - 透射波電場強度與入射波電場強度比值
  - 元件本身造成損耗（濾波器、傳輸線……）
    - 穿透損耗（insertion loss）
  - 刻意製造損耗（衰減器）
    - 衰減量（attenuation）



可調式衰減器

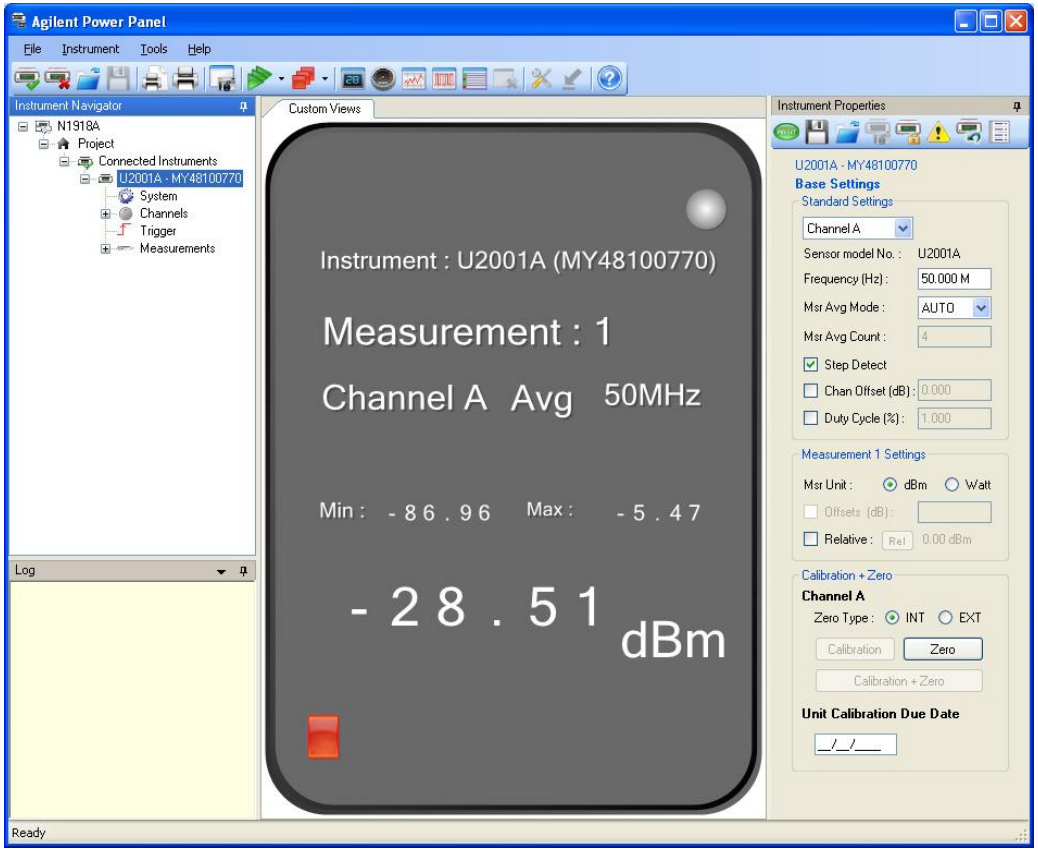


Variable Attenuators (a) Flap Type (b) Laterally Moving Type

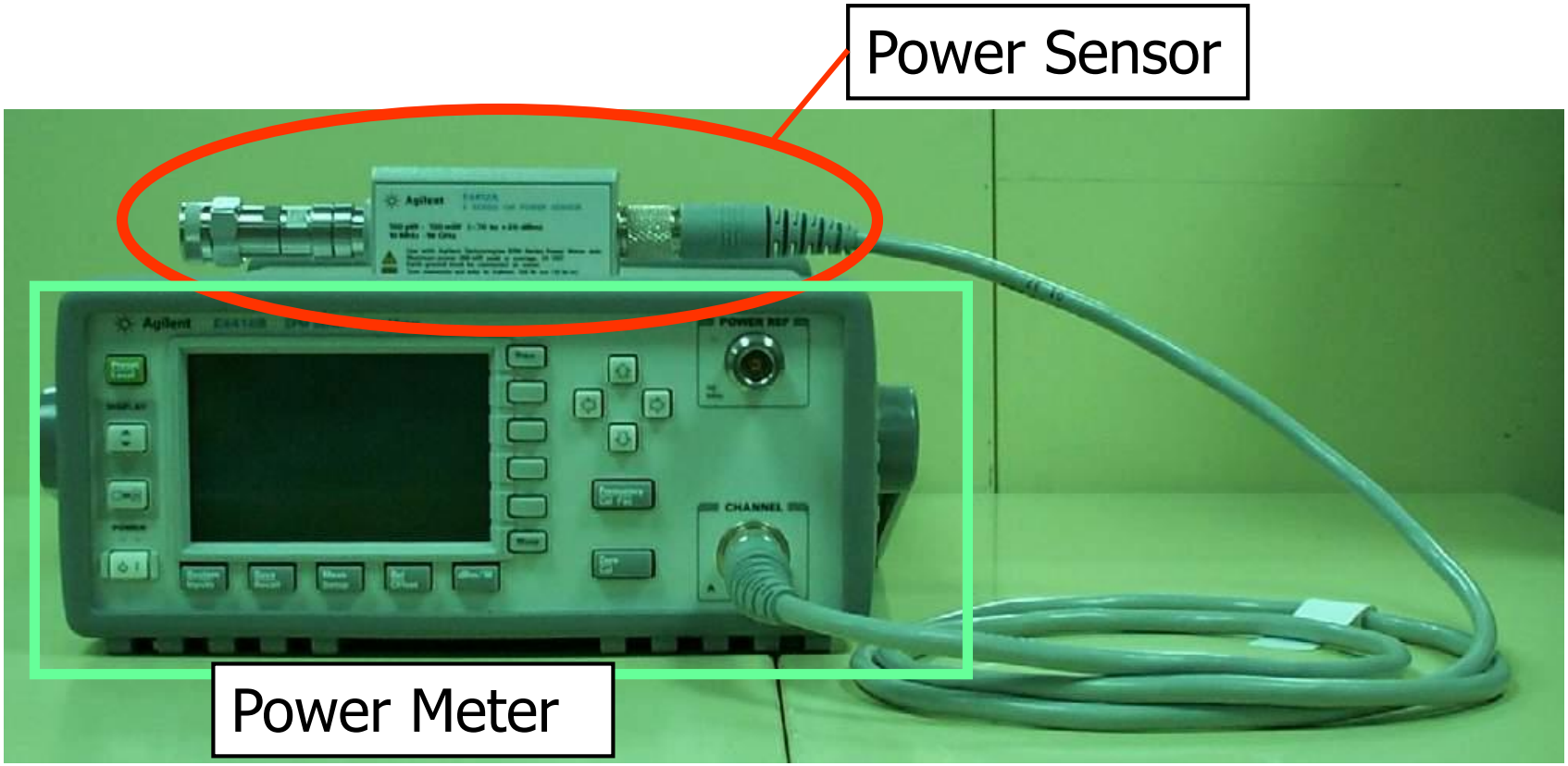
$$Attenuation(dB) = 10\log\left(\frac{P_{in}}{P_{out}}\right)$$

兩種衰減器皆由電阻性材料所構成。固定式衰減器的電阻值固定，而可調式衰減器可藉由調整電阻值之大小，達到功率衰減目的。

功率計（Agilent U2000A）

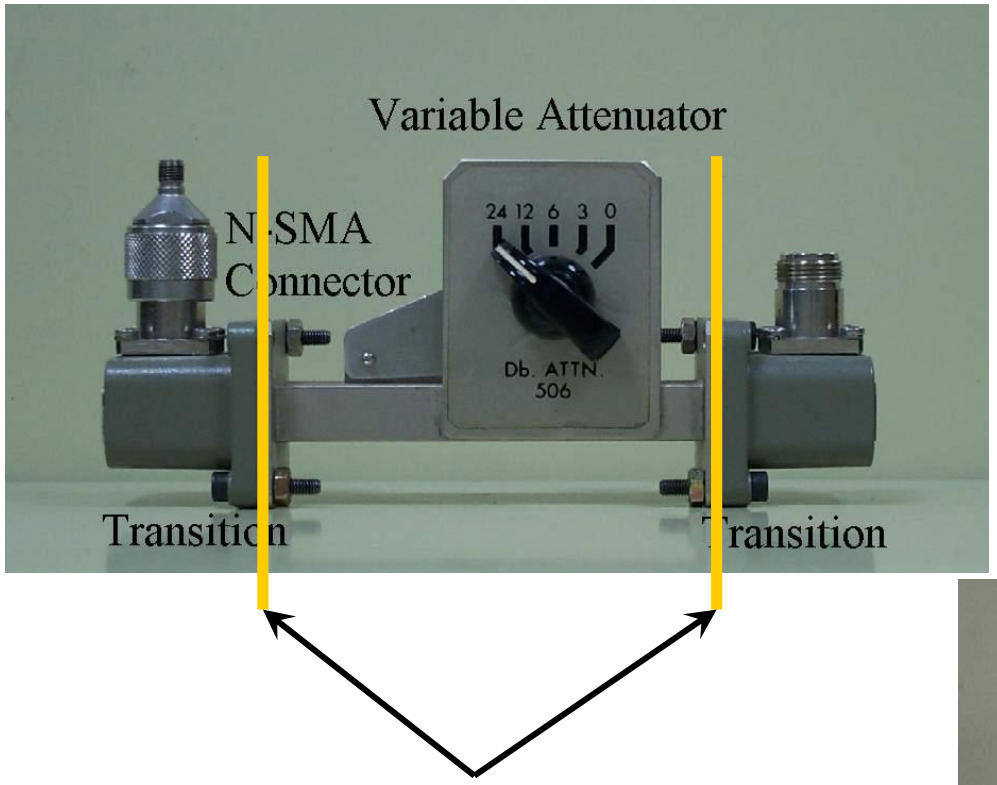


功率計（Agilent 4416A/4418B）

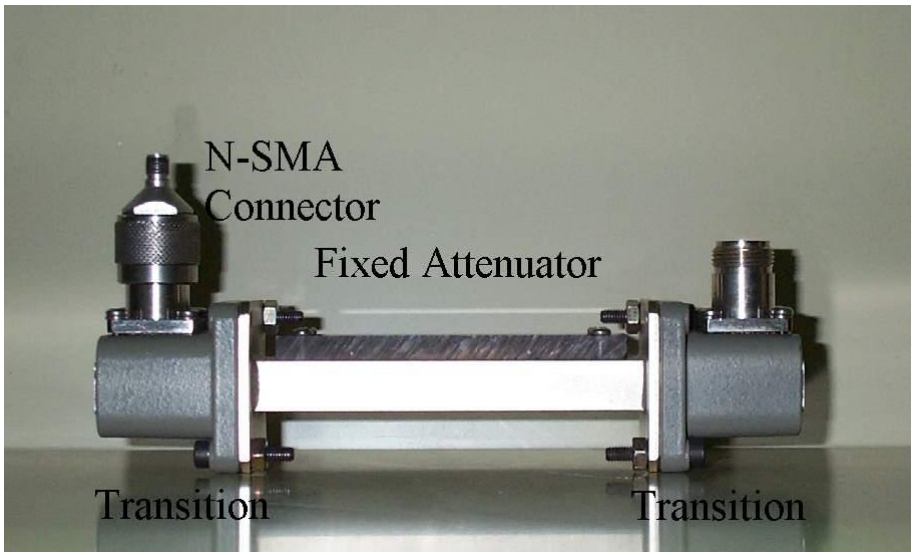


Agilent Fundamentals of RF and Microwave Power Measurements, Application Note 64-1C.

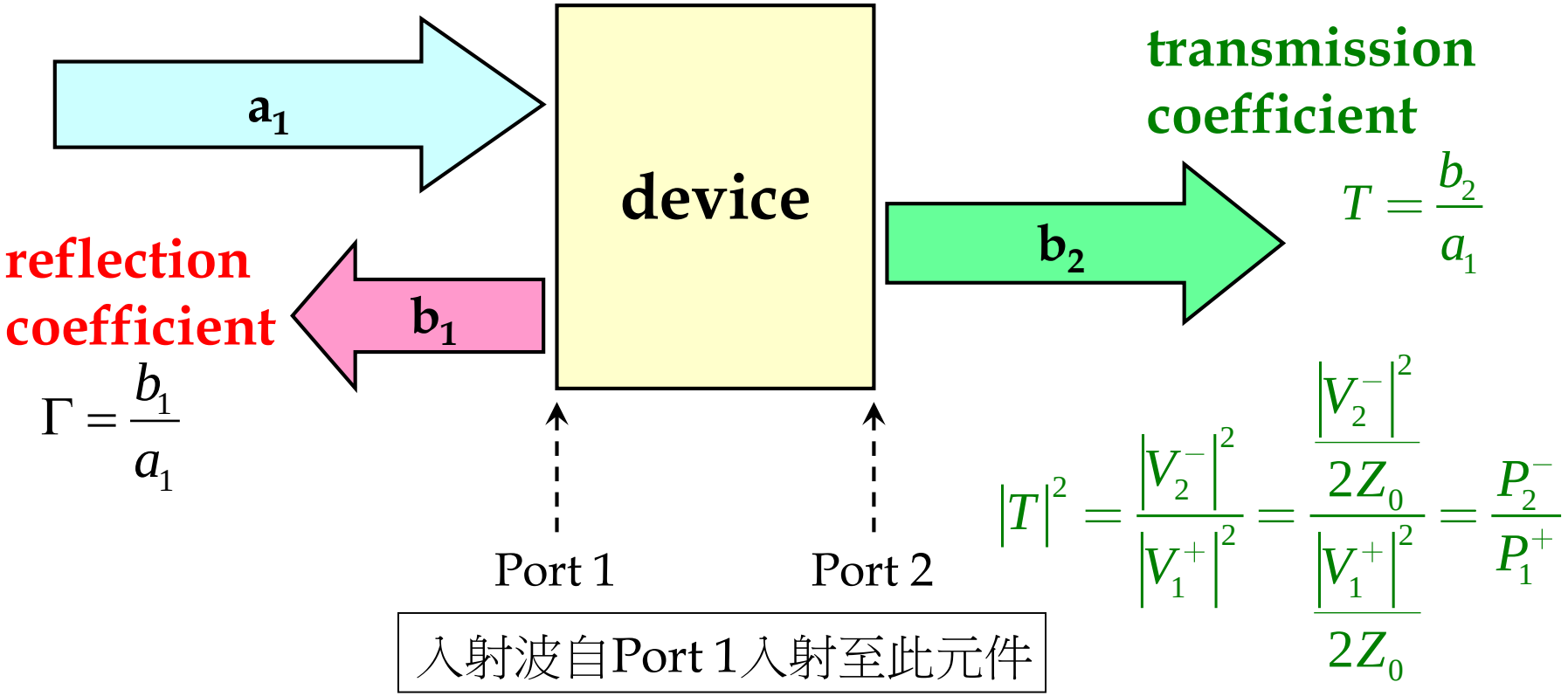
衰減量量測



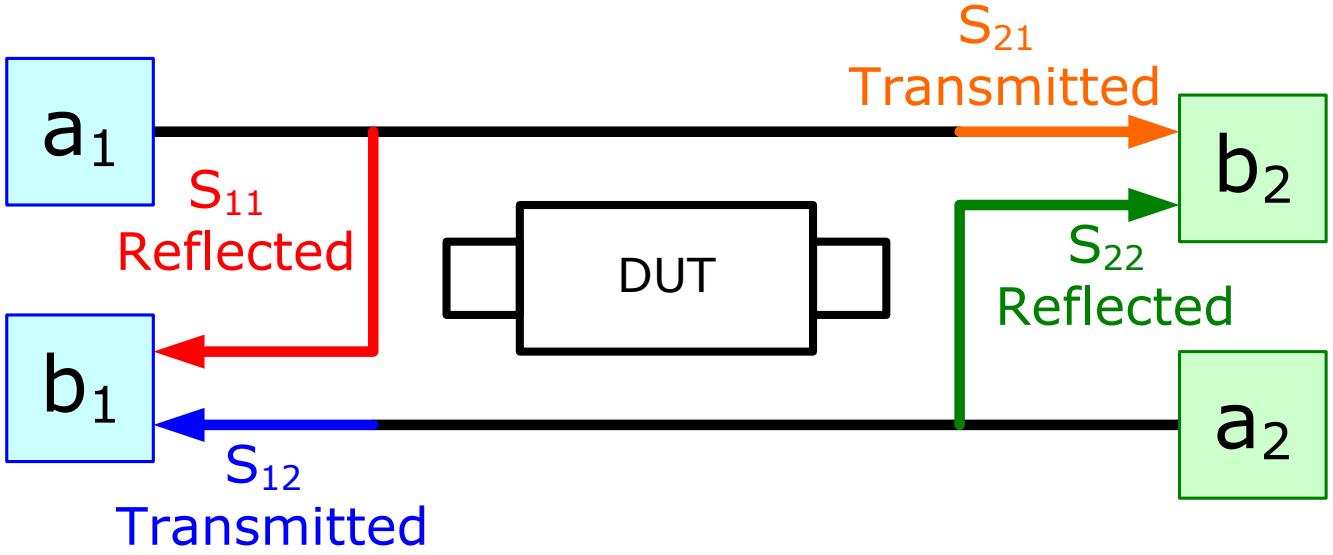
注意量測平面的觀念

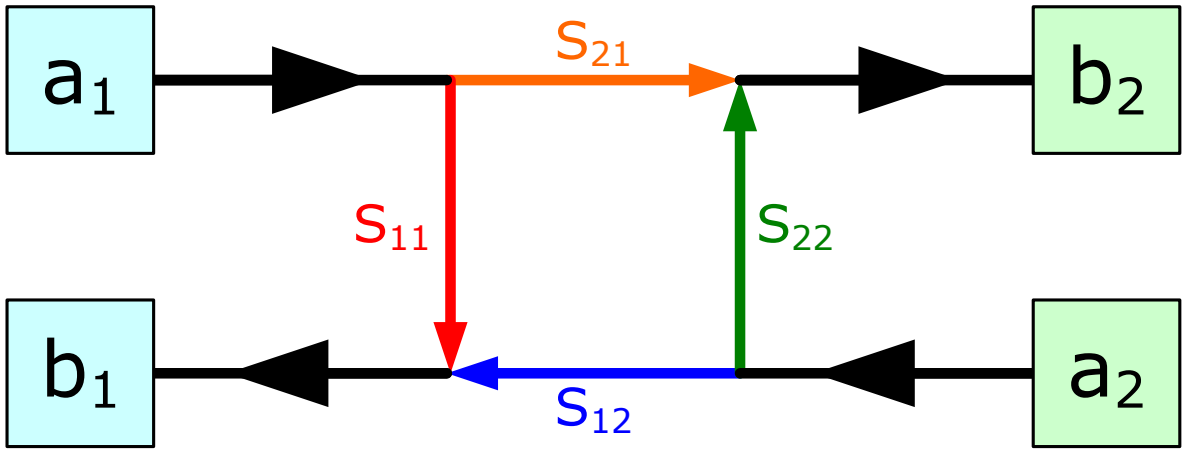


散射參數（Scattering Parameter）

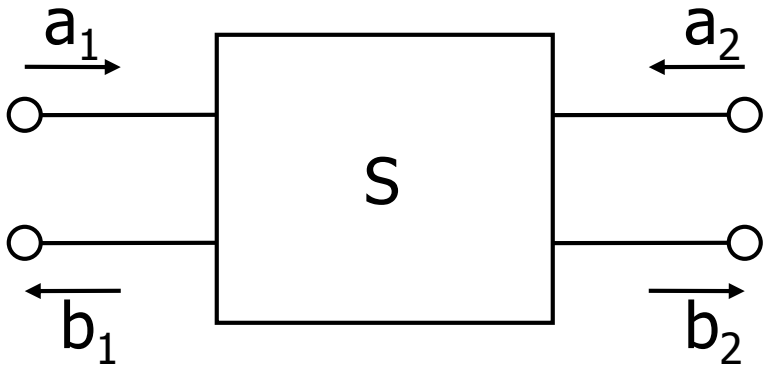


散射參數（Scattering Parameter）





散射參數（Scattering Parameter）



$$b_1 = S_{11}a_1 + S_{12}a_2$$
$$b_2 = S_{21}a_1 + S_{22}a_2$$

$$\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$$

穿透係數

$$S_{11} = \left.\frac{b_1}{a_1}\right|_{a_2=0} \qquad S_{12} = \left.\frac{b_1}{a_2}\right|_{a_1=0} \qquad S_{21} = \left.\frac{b_2}{a_1}\right|_{a_2=0} \qquad S_{22} = \left.\frac{b_2}{a_2}\right|_{a_1=0}$$

反射係數

散射參數（Scattering Parameter）

$$b_i = \sum_{1}^{n} S_{ij} a_j \qquad i = 1,2,3,\ldots,n$$

$$b_1 = S_{11}a_1 + S_{12}a_2 + \cdots + S_{1n}a_n$$

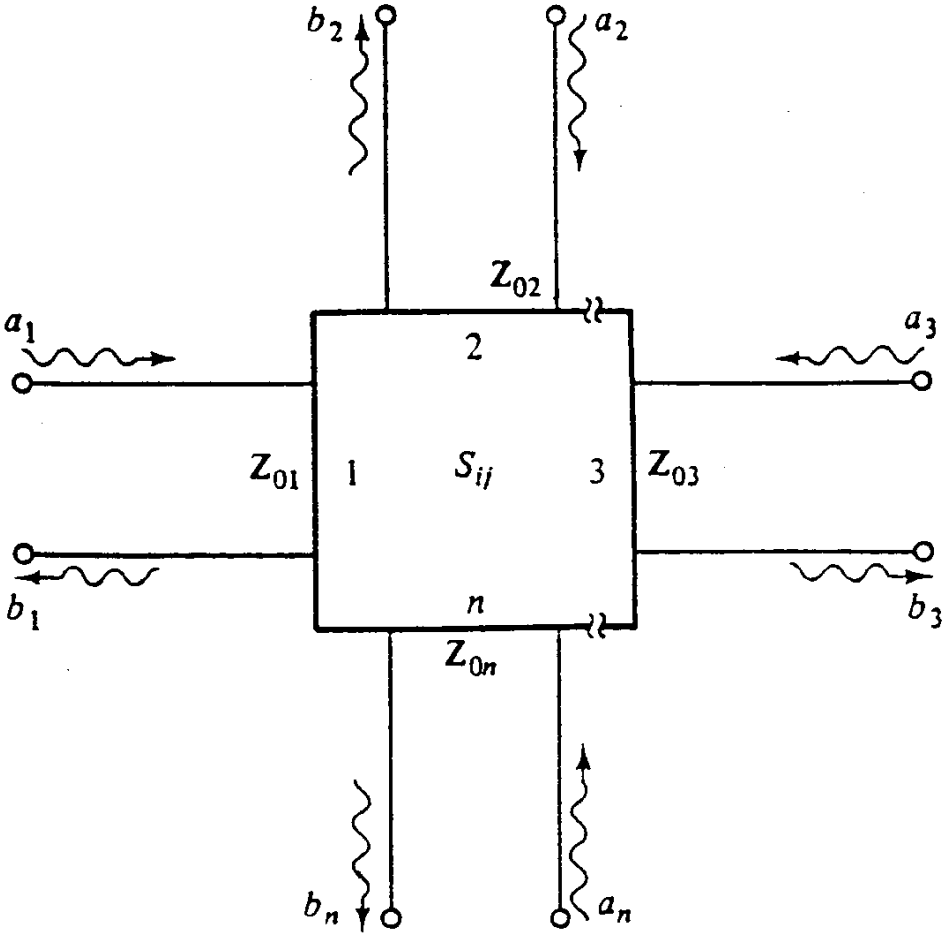
$$b_2 = S_{21}a_1 + S_{22}a_2 + \cdots + S_{2n}a_n$$

$$\vdots$$

$$b_n = S_{n1}a_1 + S_{n2}a_2 + \cdots + S_{nn}a_n$$

$$[b] = [S][a]$$

$$S = \begin{bmatrix} S_{11} & S_{12} & \cdots & S_{1n} \\ S_{21} & S_{22} & \cdots & S_{2n} \\ & & \vdots & \\ S_{n1} & S_{n2} & \cdots & S_{nn} \end{bmatrix}$$



散射參數（Scattering Parameter）

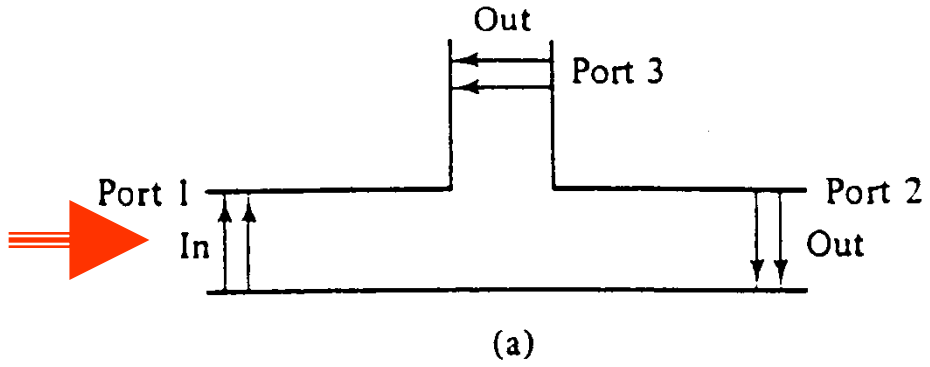
- 散射參數：
  - 使用矩陣表示反射係數與穿透係數。
  - Ｎ埠元件可以使用Ｎ×Ｎ矩陣清楚描述。
  - Reciprocal元件：散射參數為對稱矩陣（對稱性）。
  - Lossless元件：散射參數為unitary矩陣。
  - 若改變Port的平面位置，會使散射參數多乘上一個位移因子（相位移）。

$$\text{symmetric matrix}: [S] = [S]^t$$

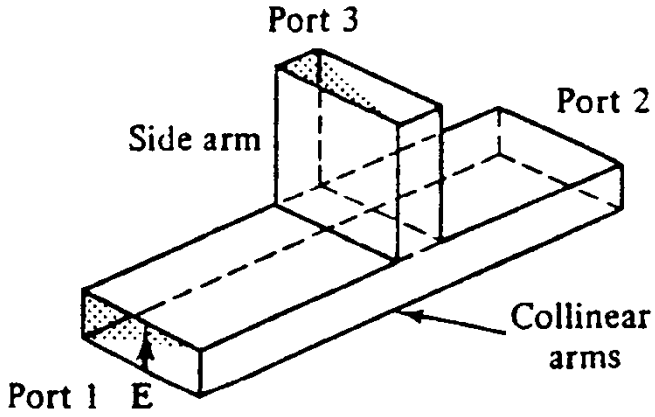
$$\text{unitary matrix}: [S]^t [S]^* = [I]$$

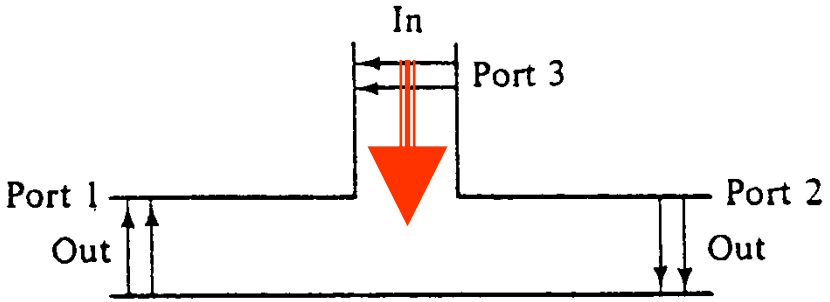
電場平面T形管

$$S = \begin{bmatrix} 0 & S_{12} & S_{13} \\ S_{12} & 0 & -S_{13} \\ S_{13} & -S_{13} & 0 \end{bmatrix}$$



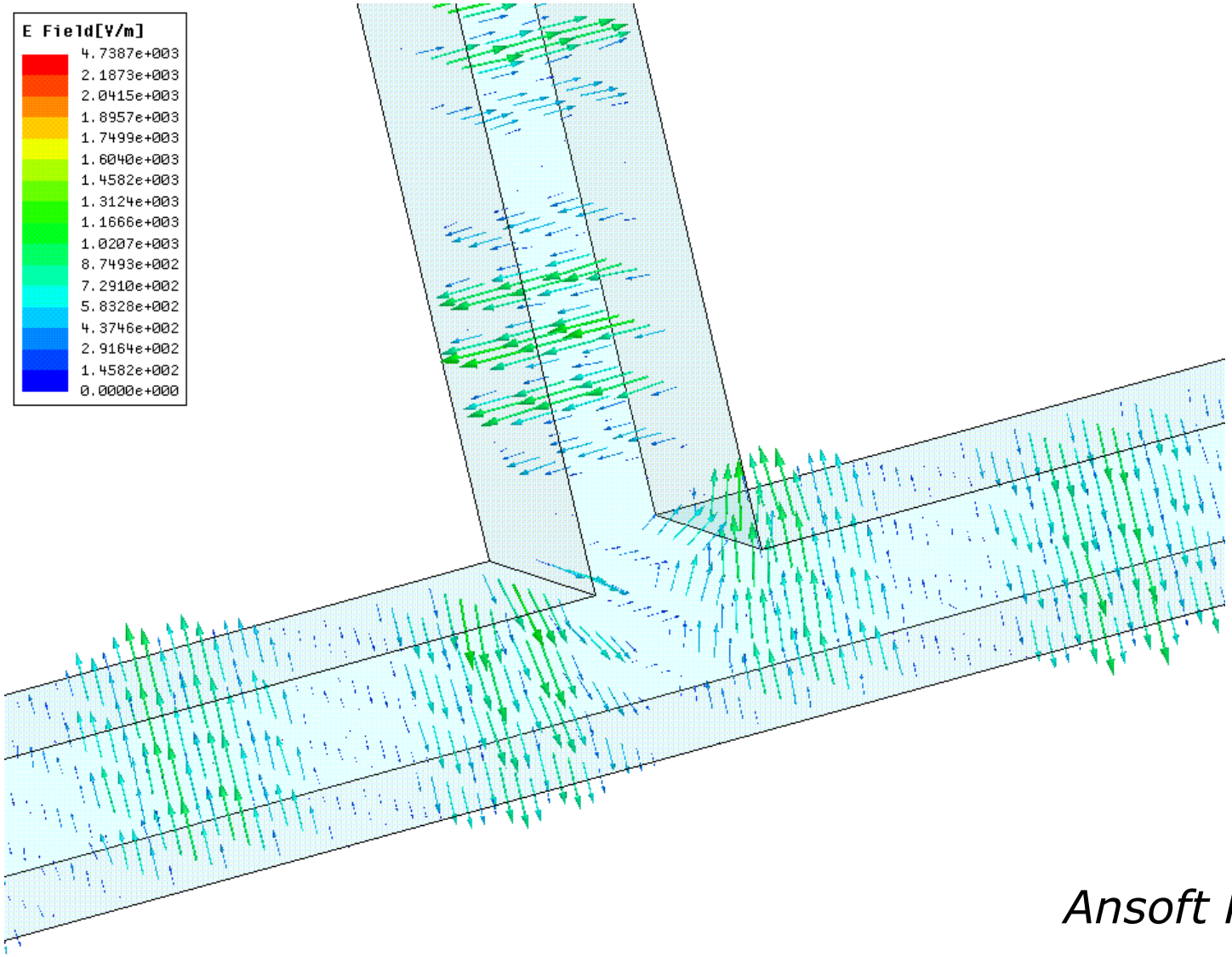
(a)





(b)

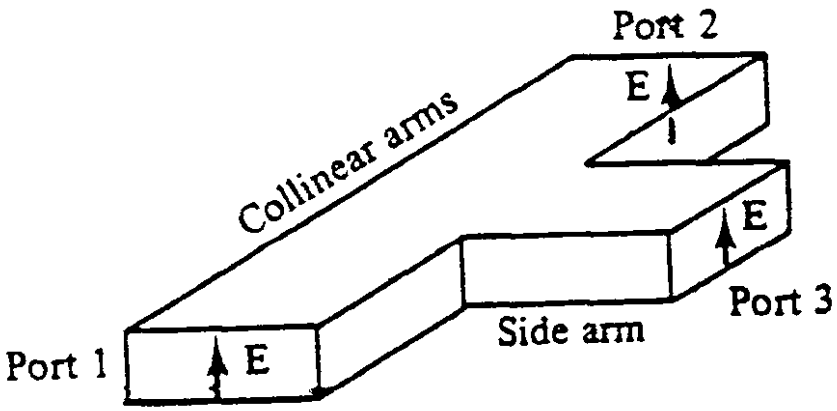
電場平面T形管



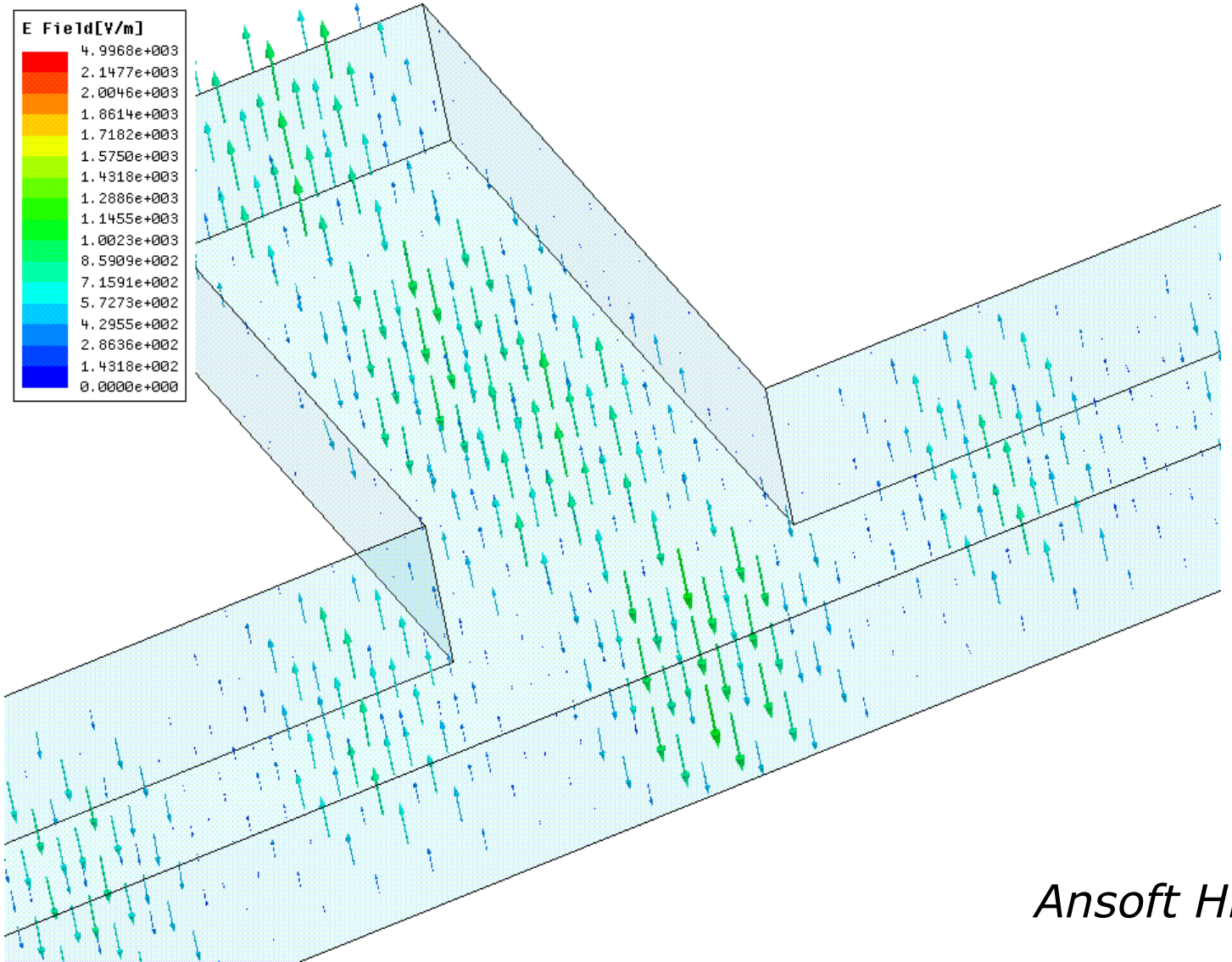
Ansoft HFSS v.10

磁場平面T形管

$$S=\begin{bmatrix} 0 & S_{12} & S_{13} \\ S_{12} & 0 & S_{13} \\ S_{13} & S_{13} & 0 \end{bmatrix}$$



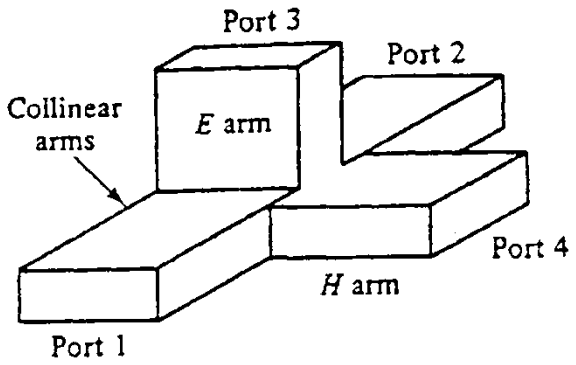
磁場平面T形管

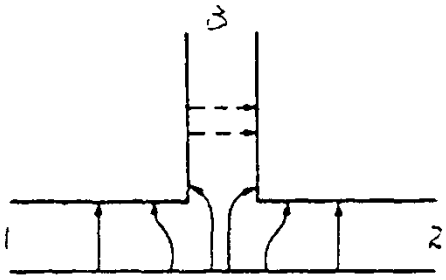


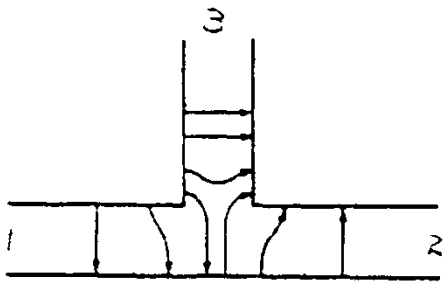
Ansoft HFSS v.10

神奇T形管（Magic Tee）

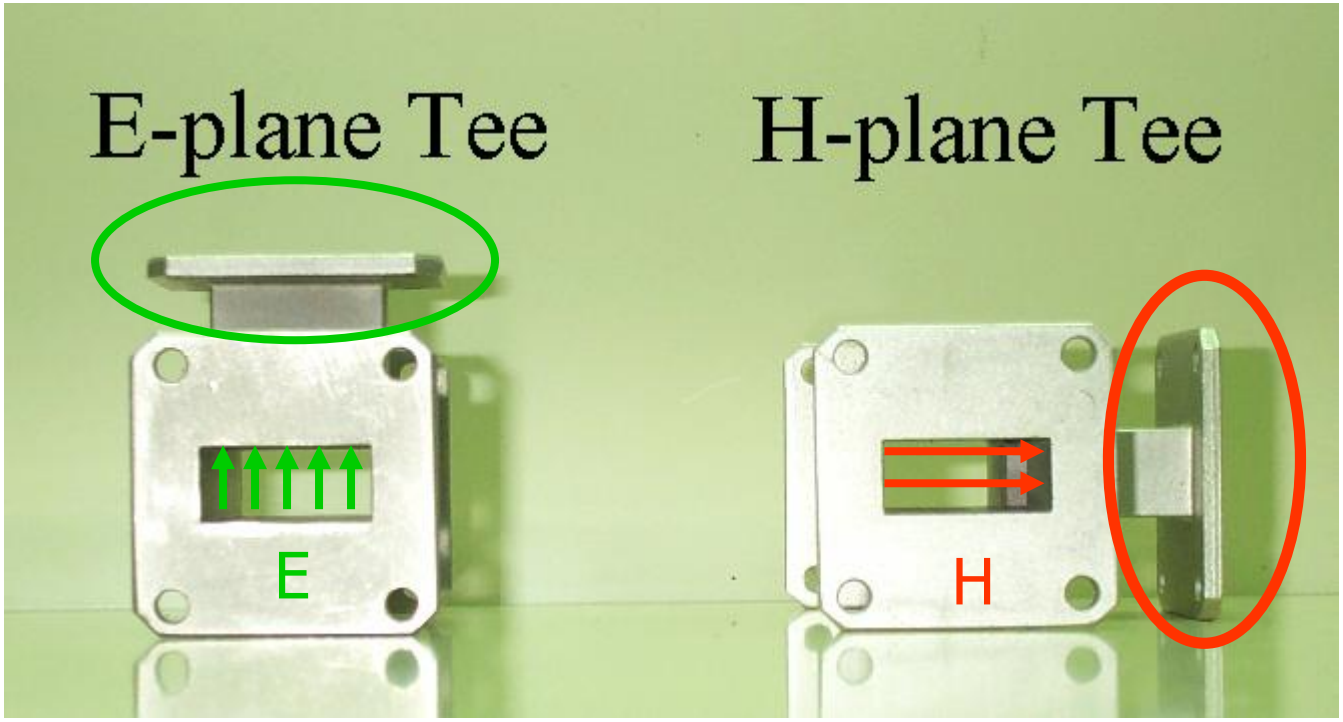
$$S=\begin{bmatrix} 0 & 0 & S_{13} & S_{14} \\ 0 & 0 & -S_{13} & S_{14} \\ S_{13} & -S_{13} & 0 & 0 \\ S_{14} & S_{14} & 0 & 0 \end{bmatrix}$$







判斷T形管



其他事項

- 下周(3/20,23)因事，實驗暫停一次。