ECE 6130 ABCD Parameters and TRL Network Calibration

Text Sections 4.4 and pages 217-222

Portfolio Optional
Chapter 4 Repeat Problem 4.18 using ABCD parameters.
Hint: Use table 4.1 to find the ABCD parameters of each single transmission line. Multiply them together to find the series configuration. Convert to S parameters using table 4.2. Compare with results obtained previously.

Transmission ABCD Parameters

Useful for evaluating cascades of networks. Easy to convert to and from S parameters.

V1 = A V2 + B I2
I1 = C V2 + D I2

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix}$$

For a cascade (series) of networks:
VIEWGRAPH FIGURE 4.11

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix}$$

$$\begin{bmatrix} V_2 \\ I_2 \end{bmatrix} = \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_3 \\ I_3 \end{bmatrix}$$

SO

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} V_3 \\ I_3 \end{bmatrix}$$

VIEWGRAPH Table 4.1

TRL Network Analyzer Calibration

Calibration done so far relies on known loads (short, open, matched).
There are always errors in these loads. Matched load, for instance, is only perfectly matched at a single frequency. This is particularly a problem if you need a “holder” for a device under test (DUT) and need to calibrate out the effects of the holder.

Better method: TRL Calibration.

VIEWGRAPH Figures 4.21

THRU: Connect two reference planes exactly . (Or any line integral # of half-wavelengths)

$T11 = b1 / a1$ (when $a2=0$) $= S11 + S22\, S12^2 / (1 - S22^2)$
$T12 = b1/ a2$ (when $a1=0$) $= S12^2 / (1 - S22^2)$

REFLECT: Connect two reference planes with any high-reflection load (open or short)

$R11 = b1/a1$ (when $a2=0$) $= S11 + \Gamma_L\, S12^2 / (1 - S22\, \Gamma_L)$

LINE: Connect two reference planes with any length of line OTHER than 0.5 wavelength multiples. Best results occur when the line is quarter wavelength, but others are OK, too.)

$L11 = b1 / a1$ (when $a2=0$) $= S11 + S22\, S12^2\, e^{-2\gamma L}/ (1 - S22^2\, e^{-2\gamma L})$
$L12 = b1/ a2$ (when $a1=0$) $= S12^2\, e^{-2\gamma L} / (1 - S22^2\, e^{-2\gamma L})$

SOLVE for $e^{-2\gamma L}$ and Γ_L
VIEWGRAPH Equations 4.78 and 4.83

Calibration complete.

Measurement of DUT

VIEWGRAPH equations 4.84