

# EE 3113

# INTRODUCTION INTO RF

# CIRCUIT DESIGN

Lecture Notes for A-term 1999

## LECTURE 14

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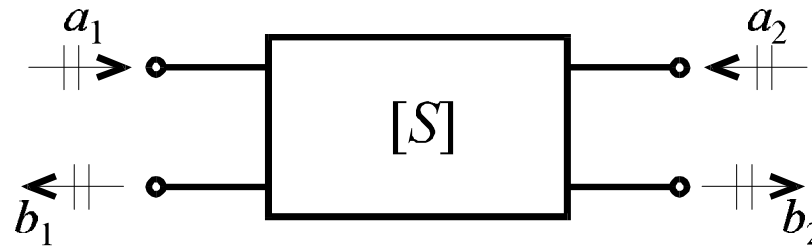
# Scattering parameters

- There is a need to establish well-defined termination conditions in order to find the network descriptions for **Z**, **Y**, **h**, and **ABCD** networks
- **Open** and **short** voltage and current conditions are **difficult to enforce**
- RF implies forward and backward traveling waves which can form **standing waves** destroying the elements

# Solution: S-parameters

- Input-output behavior of network is defined in terms of normalized **power waves**
- Ratio of the power waves are recorded in terms of so-called **scattering parameters**
- S-parameters are measured based on properly **terminated transmission** lines (and not open/short circuit conditions)

# Basic configuration



$$S_{11} = \frac{b_1}{a_1} \Big|_{a_2=0} = \frac{\text{reflected power wave at port1}}{\text{incident power wave at port1}}$$

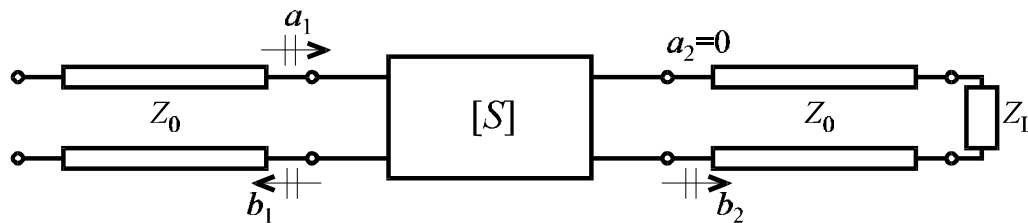
$$S_{21} = \frac{b_2}{a_1} \Big|_{a_2=0} = \frac{\text{transmitted power wave at port2}}{\text{incident power wave at port1}}$$

$$S_{22} = \frac{b_2}{a_2} \Big|_{a_1=0} = \frac{\text{reflected power wave at port2}}{\text{incident power wave at port2}}$$

$$S = \frac{b_1}{a_2} \Big|_{a_1=0} = \frac{\text{transmitted power wave at port1}}{\text{incident power wave at port2}}$$

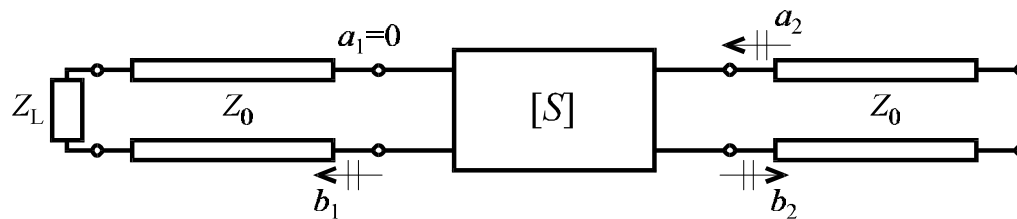
## Set-up for measuring S-parameters

- Properly terminated output



Load impedance =  
line impedance

- Properly terminated input side



input impedance =  
line impedance