EE540 Advance Electromagnetic Theory & Antennas

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Electromagnetic Theorems and Concepts

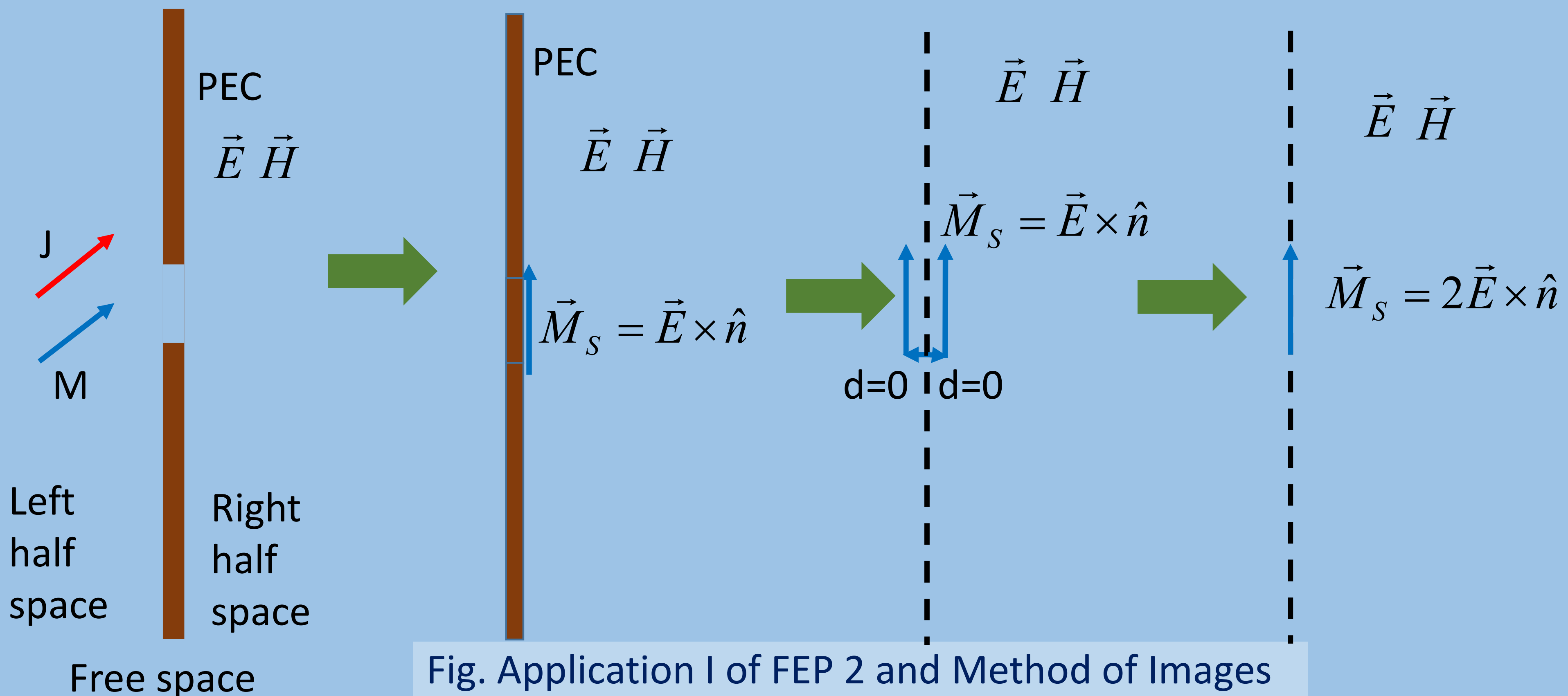

Fig. Application I of FEP 2 and Method of Images

Electromagnetic Theorems and Concepts

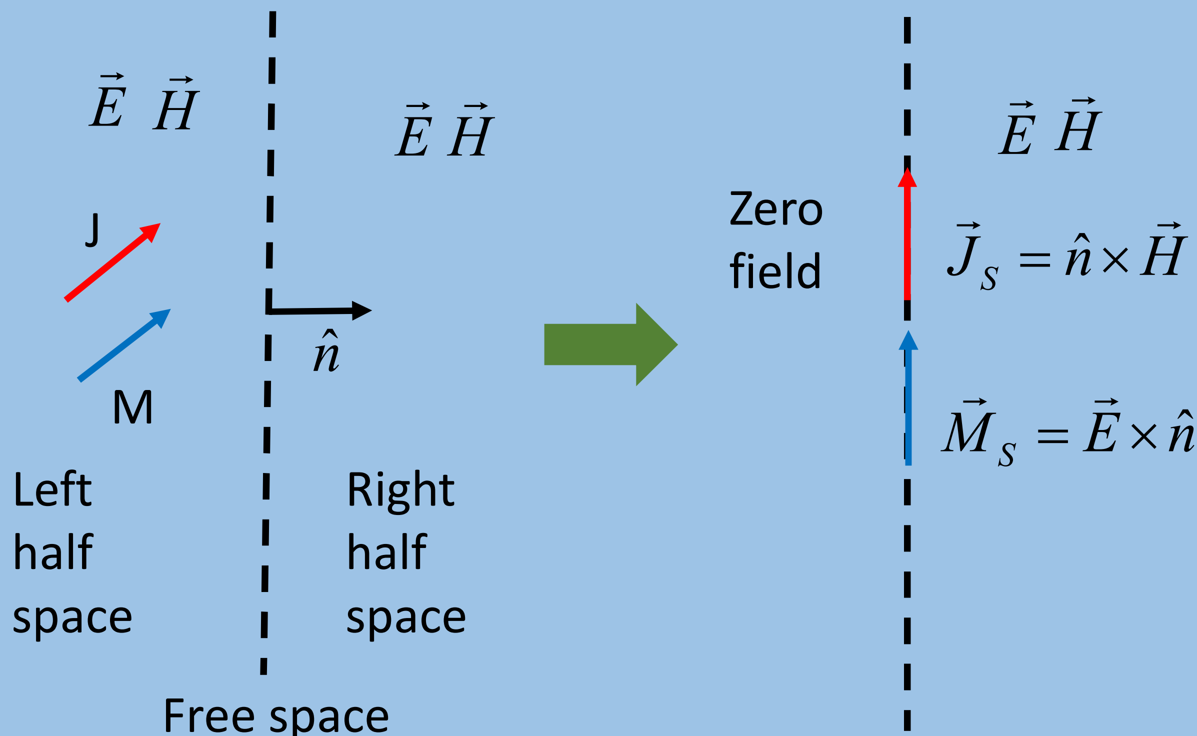

Fig. Application II of FEP 1

Electromagnetic Theorems and Concepts

- **Reciprocity:**
- It basically means
  - fields and sources can be interchanged in
    - an EM problem or experimental set-up
    - without affecting the system's response
- *In the context of antennas: reciprocity*
  - Case I: if an emf is applied at the terminals of an antenna A
    - and the current is measured at the terminals of another antenna B
  - Case II: if the same emf was applied to the terminals of antenna B
    - current will be measured at the terminals of antenna A
  - Currents in case I and Case II will be equal
  - Assumptions made:
    - emfs are of same frequency
    - medium is linear, isotropic and passive

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Electromagnetic Theorems and Concepts

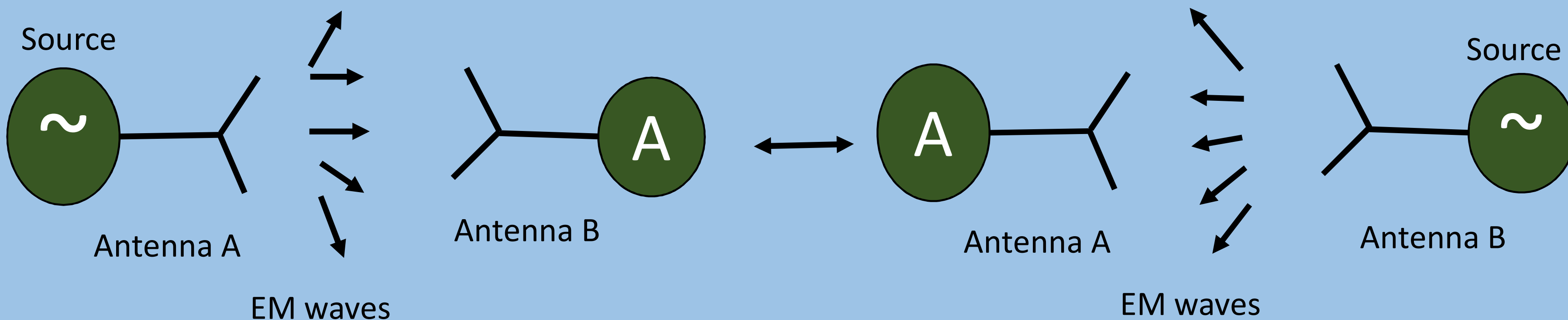

Fig. Reciprocity for antenna

Electromagnetic Theorems and Concepts

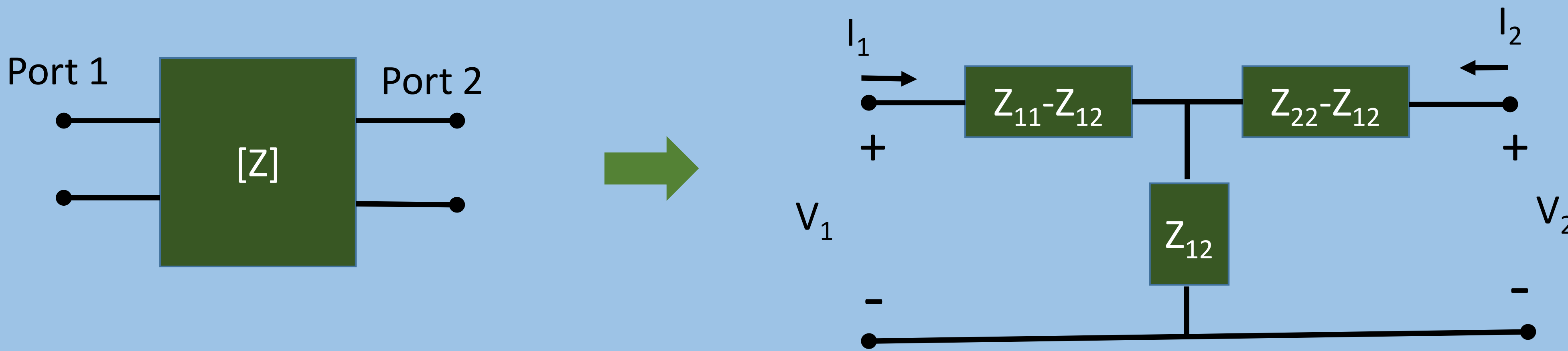

Fig. A two-port network and its T-equivalent circuit representation

Electromagnetic Theorems and Concepts

- *Reciprocity: Explanation from circuit theory*
- Consider a two port network
  - with the excitation as port 1
  - and the measurement terminal as port 2
- The voltage [V] and current [I] of a two port network is related by
  - Matrix relation $[V] = [Z][I]$
  - Component-wise relation $\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$
  - Port-wise relation:
    - Port 1: $V_1 = Z_{11}I_1 + Z_{12}I_2$
    - Port 2: $V_2 = Z_{21}I_1 + Z_{22}I_2$

Electromagnetic Theorems and Concepts

- We can find the short-circuit current I_2 at port 2
  - after applying a voltage V_1 at port 1
    - $\left.\frac{V_1}{I_2}\right|_{V_2=0} = \frac{Z_{12}Z_{21}-Z_{11}Z_{22}}{Z_{21}}$ (Equation I)
  - Similarly,
    - we can also measure short-circuit current I_1 at port 1
    - after applying a voltage V_2 at port 2
      - $\left.\frac{V_2}{I_1}\right|_{V_1=0} = \frac{Z_{12}Z_{21}-Z_{11}Z_{22}}{Z_{12}}$ (Equation II)
  - From the reciprocity theorem, these two ratios in equation (I) and (II) are equal
    - hence $Z_{12}=Z_{21}$
  - If the applied voltages are same $V_1=V_2$,
    - we will have $I_2=I_1$