EE540 Advance Electromagnetic Theory & Antennas

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Electromagnetic Theorems and Concepts

- **Maxwell's equations (revisited):**
- Let us introduce fictitious magnetic currents $\vec{M}$ and charges (ρ_m) in Maxwell's equations
  - Fictitious equivalent sources are useful in mathematical models of EM problems
- Gauss's law for electric field $\nabla \bullet \vec{D} = \rho_v$
- Gauss's law for magnetic field $\nabla \bullet \vec{B} = \rho_m$
- Ampere-Maxwell law

$$\nabla \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$$

- Faraday's law

$$\nabla \times \vec{E} = -\vec{M} - \frac{\partial \vec{B}}{\partial t}$$

Electromagnetic Theorems and Concepts

- **Fields boundary conditions (revisited):**
- Let us introduce fictitious magnetic currents $\vec{M}$ and charges (ρ_m) in Boundary conditions
- First electric boundary condition $\hat{n} \times (\vec{E}_1 - \vec{E}_2) = -\vec{M}_S$
- Second electric boundary condition $\hat{n} \bullet (\vec{D}_1 - \vec{D}_2) = \rho_s$
- First magnetic boundary condition $\hat{n} \times (\vec{H}_1 - \vec{H}_2) = \vec{J}_s$
- Second magnetic boundary condition $\hat{n} \bullet (\vec{B}_1 - \vec{B}_2) = \sigma_m$

Electromagnetic Theorems and Concepts

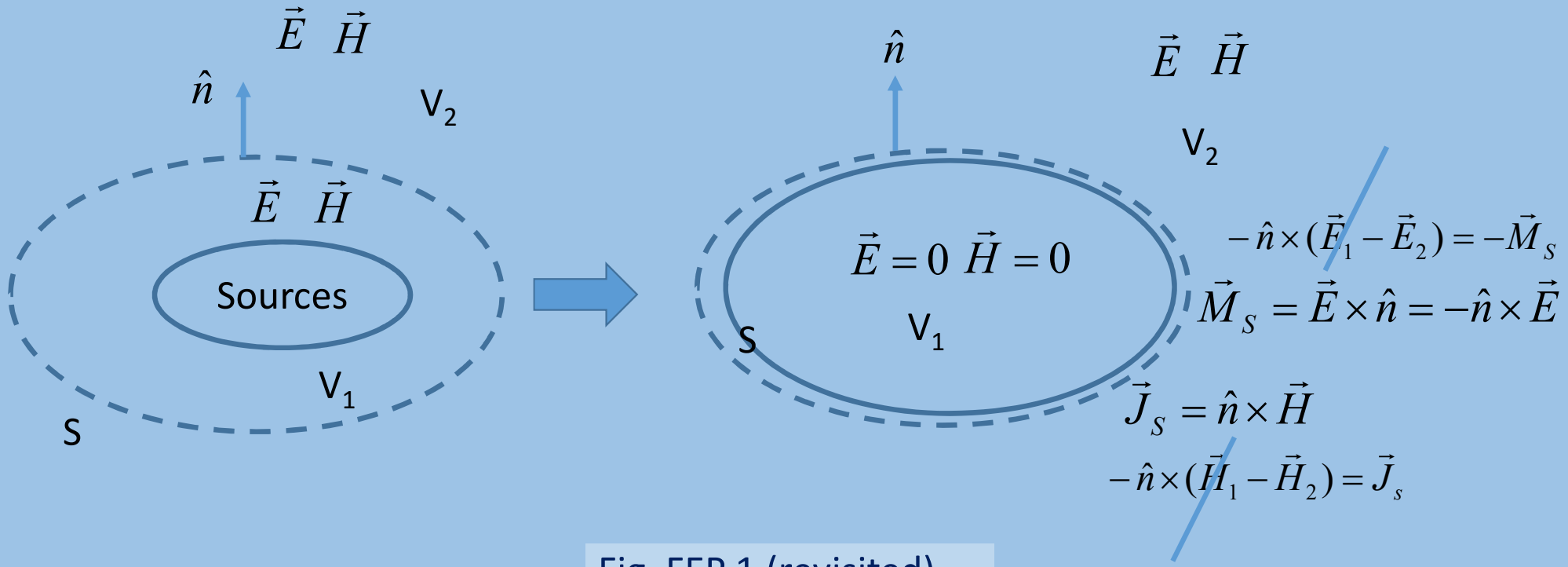

Fig. FEP 1 (revisited)

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- Most often either electric or magnetic field
  - is available with reasonable accuracy
- If the tangential electric field is known on S, we can use
  - **FEP 2:**
- Let us assume that the fields in volume V_2 are the same as before
  - and V_1 is filled with PEC, which makes the fields zero in V_1
- The conducting material forces the tangential electric field zero on surface S
  - Therefore to keep the fields in V_2 the same as before
  - We introduce a magnetic surface current density $\vec{M}_S = \vec{E} \times \hat{n} = -\hat{n} \times \vec{E}$
    - Just outside the surface S in V_2

Electromagnetic Theorems and Concepts

- This will restore the tangential electric field
  - to the same value as before
- Since the tangential electric field is the same on surface S
  - the fields in V_2 are unique
  - according to Uniqueness theorem
- A similar proof can be done for
  - **FEP 3**

Electromagnetic Theorems and Concepts

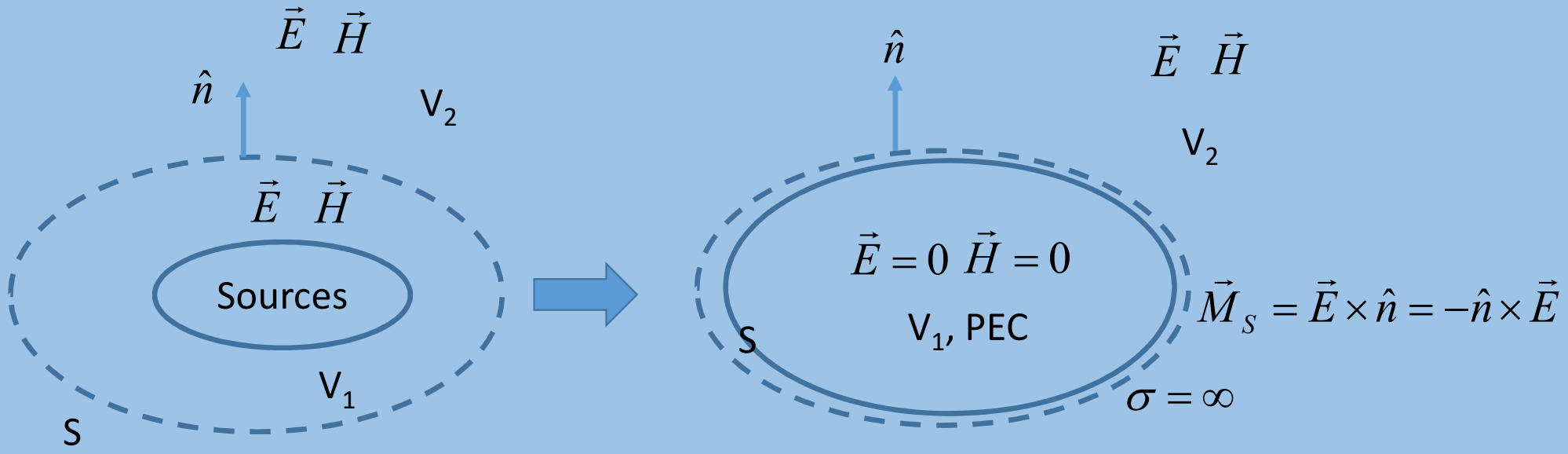

Fig. FEP 2 (Magnetic surface current density alone on the surface S which is PEC)

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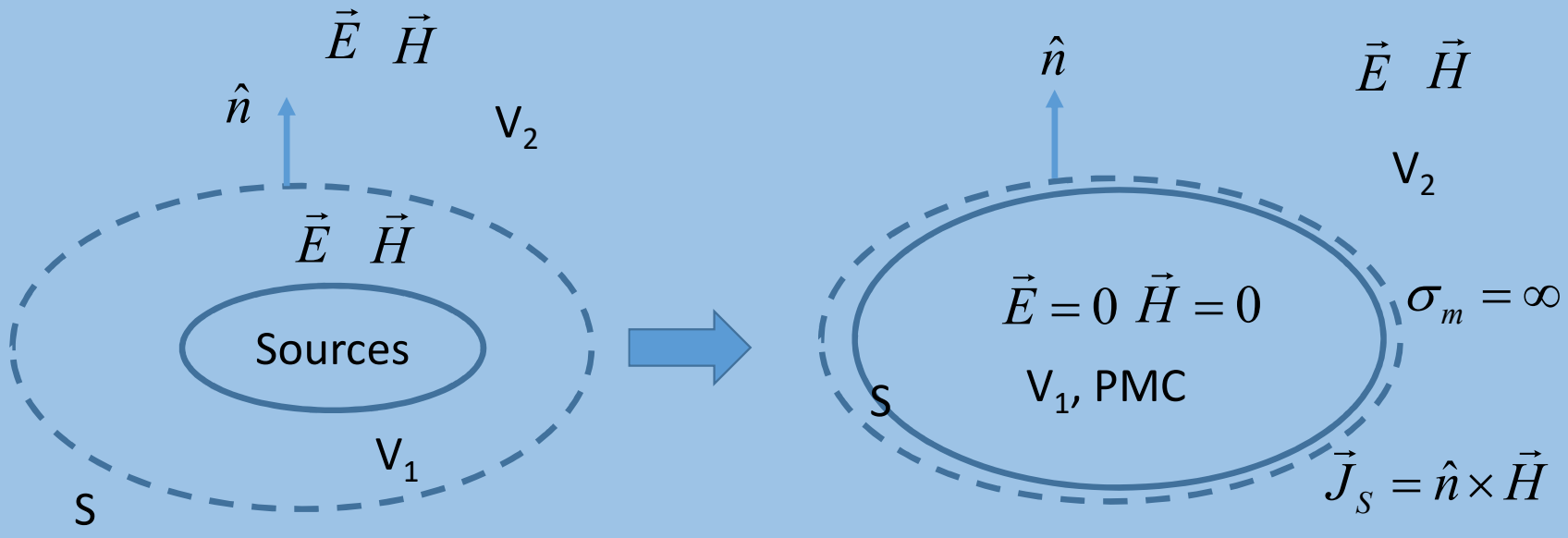

Fig. FEP 3 (Electric surface current density alone on the surface S which is PMC)