- Choosing the vector potential A^* in the form

$$A^* = A + \int_0^t \nabla\varphi \, dt,$$

we obtain the following <u>vector potential formulation</u> from (6): $v=0$

$$(6)^* \quad \boxed{\operatorname{curl} \nu \operatorname{curl} A^* + \sigma \frac{\partial A^*}{\partial t} + \varepsilon \frac{\partial^2 A^*}{\partial t^2} = \tilde{J}_i} \quad \text{in } \underset{\Omega \times (0,T)}{\underset{\shortparallel}{Q_T}}$$

with $\tilde{J}_i := J_i - \operatorname{curl} \frac{\mu_0}{\mu} M + \frac{\partial P}{\partial t}$.

Once A^* is determined, the magnetic and electric fields can be calculated as follows:

$$B = \operatorname{curl} A^*, \qquad H = \nu B - \frac{\mu_0}{\mu} M,$$

$$E = -\frac{\partial A^*}{\partial t}, \qquad D = \varepsilon E + P.$$

- <u>Boundary Conditions on $\Gamma \times (0,T)$:</u>
  1) Perfect Electric Conductors (PEC)
     $A^* \times n = 0$ on Γ_{PEC} $\quad (\Rightarrow E \times n = 0$ on $\Gamma_{PEC})$
  2) Perfect Magnetic Conductors (PMC)
     $\mu^{-1} \operatorname{curl} A^* \times n = 0$ on Γ_{PMC} $\quad (\Leftrightarrow H \times n = 0$ on $\Gamma_{PMC})$
  3) Impressed surface currents (ISC)
     $\mu^{-1} \operatorname{curl} A^* \times n = -j_{\Gamma,i}$ on Γ_{ISC} $\quad (\Leftrightarrow H \times n = -j_{\Gamma,i}$ on $\Gamma_{ISC})$
  4) Impedance boundary conditions (IBC)
     $H \times n - \varkappa (E \times n) \times n = 0$ on Γ_{IBC}

  etc.

- <u>Initial Conditions at $t = t_0 := 0$:</u>

$$A^*(x,0) = 0 \quad \text{for } x \in \overline{\Omega},$$

$$\frac{\partial A^*}{\partial t}(x,0) \equiv -E(x,0) = E_0(x) \quad \text{for } x \in \overline{\Omega}.$$