TABLE 1-6 Relations between time-harmonic electromagnetic field and steady-state a.c. circuit theories

Field theory	Circuit theory
1. $\mathbf{E}$ (electric field intensity)	1. v (voltage)
2. $\mathbf{H}$ (magnetic field intensity)	2. i (current)
3. $\mathbf{D}$ (electric flux density)	3. q_{ev} (electric charge density)
4. $\mathbf{B}$ (magnetic flux density)	4. q_{mv} (magnetic charge density)
5. $\mathbf{J}$ (electric current density)	5. i_e (electric current)
6. $\mathbf{M}$ (magnetic current density)	6. i_m (magnetic current)
7. $\mathbf{J}_d = j\omega\varepsilon\mathbf{E}$ (electric displacement current density)	7. $i = j\omega C v$ (current through a capacitor)
8. $\mathbf{M}_d = j\omega\mu\mathbf{H}$ (magnetic displacement current density)	8. $v = j\omega L i$ (voltage across an inductor)
9. *Constitutive relations*	9. *Element laws*
(a) $\mathbf{J}_c = \sigma\mathbf{E}$ (electric conduction current density)	(a) $i = Gv = \frac{1}{R}v$ (Ohm's law)
(b) $\mathbf{D} = \varepsilon\mathbf{E}$ (dielectric material)	(b) $Q_e = Cv$ (charge in a capacitor)
(c) $\mathbf{B} = \mu\mathbf{H}$ (magnetic material)	(c) $\psi = Li$ (flux of an inductor)
10. $\oint_C \mathbf{E} \cdot d\boldsymbol{\ell} = -j\omega \iint_S \mathbf{B} \cdot d\mathbf{s}$ (Maxwell–Faraday equation)	10. $\sum v = -j\omega L_s i \simeq 0$ (Kirchhoff's voltage law)
11. $\oiint_S \mathbf{J}_{ic} \cdot d\mathbf{s} = -j\omega \iiint_V q_{ev} dv = -\frac{\partial Q_e}{\partial t}$ (continuity equation)	11. $\sum i = -j\omega Q_e = -j\omega C_s v \simeq 0$ (Kirchoff's current law)
12. *Power and energy densities*	12. *Power and energy* (v and i represent peak values)
(a) $\frac{1}{2}\oiint_S (\mathbf{E} \times \mathbf{H}^*) \cdot d\mathbf{s}$ (complex power)	(a) $P = \frac{1}{2}vi$ (power-voltage-current relation)
(b) $\frac{1}{2}\iiint_V \sigma\lvert\mathbf{E}\rvert^2 dv$ (dissipated real power)	(b) $P_d = \frac{1}{2}Gv^2 = \frac{1}{2}\frac{v^2}{R}$ (power dissipated in a resistor)
(c) $\frac{1}{4}\iiint_V \varepsilon\lvert\mathbf{E}\rvert^2 dv$ (time-average electric stored energy)	(c) $\frac{1}{4}Cv^2$ (energy stored in a capacitor)
(d) $\frac{1}{4}\iiint_V \mu\lvert\mathbf{H}\rvert^2 dv$ (time-average magnetic stored energy)	(d) $\frac{1}{4}Li^2$ (energy stored in an inductor)

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