



Electromagnetics:
Electromagnetic Field Theory

Power in Conductors

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Joule's Law

Joule's law calculates the power dissipated by a conducting medium.

$$P = \iiint_v (\vec{E} \cdot \vec{J}) dv \quad \text{This is equivalent to } P = VI \text{ in circuit theory.}$$

From this, the power density p_d in a conductor is extracted.

$$p_d = \vec{E} \cdot \vec{J}$$

Applying Ohm's law for electromagnetics $\vec{J} = \sigma \vec{E}$ gives

$$\begin{aligned} p_d &= \vec{E} \cdot \vec{J} \\ &= \vec{E} \cdot \sigma \vec{E} \\ &= \sigma |\vec{E}|^2 \end{aligned}$$

$$P = \iiint_v \sigma |\vec{E}|^2 dv$$

Most common form for power dissipated in a conductor.

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