Displacement Current :-

Displacement current is the Current that flows through the Capacitor when time varying Voltage is given.

In general, $I_d = \frac{dQ}{dt}$.

$$I_d = \frac{d}{dt}(C.V) \Rightarrow C\frac{dV}{dt} \Rightarrow \frac{\varepsilon A}{d}\frac{dV}{dt}$$

w.k.t $V = |\vec{E}||\vec{d}| \Rightarrow V = E.d.$

$$\therefore I_d = \frac{\varepsilon A}{d}\frac{d}{dt}(E.d).$$

$$\frac{I_d}{A} = \frac{d}{dt}\varepsilon E. = \frac{d}{dt}D. \Rightarrow J_d = \frac{d}{dt}D$$

$$\boxed{\vec{J_d} = \frac{\partial \vec{D}}{\partial t}}$$

According to Ampere's Circuital Law in Magnetostatics

$\nabla \times H = J_c$ $\quad \vec{J_c} \rightarrow$ Conduction Current Density.

Taking Divergence on both sides.,

$\nabla.(\nabla \times H) = \nabla . J_c \Rightarrow 0$ {Divergence of the Curl of any vector field is Zero}

Accordingto Continuity equation;

$$\nabla \cdot \vec{J}_c = \frac{-\partial \rho_v}{\partial t} \neq 0 .$$

→ For Time Varying field; Amperes Circuit Law is Incompatible.

→ Maxwell modified Amperes Circuit Law for time varying field & it is called <u>Modified Amperes Circuit Law.</u>

He Introduced new parameter called <u>displacement current</u> (Depends on changing electric field, D).

$$\Rightarrow \boxed{\nabla \times H = \vec{J}_c + \vec{J}_d}.$$

$\vec{J}_d$ → Displacement Current density.

Taking Divergence on both sides;

$$\nabla \cdot (\nabla \times H) = \nabla \cdot \vec{J}_c + \nabla \cdot \vec{J}_d = 0 .$$

$$\nabla \cdot \vec{J}_d = -\nabla \cdot \vec{J}_c$$

$$= -\left(-\frac{\partial \rho_v}{dt}\right) = \frac{\partial \cdot \rho_v}{\partial t} .$$

w.k.t from Gauss law of Electric field.,

$$\nabla\cdot\vec{D} = \rho_v .$$

$$\Rightarrow \nabla\cdot\vec{J}_d = \frac{\partial}{\partial t}\nabla\cdot\vec{D} .$$

$$\Rightarrow \nabla\cdot J_d = \nabla\cdot\frac{\partial\vec{D}}{\partial t} .$$

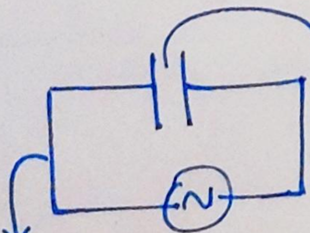
$$\boxed{\vec{J}_d = \frac{\partial\vec{D}}{\partial t}.}$$ ⇒ Displacement Current Density.

$$I_d = \int_S \vec{J}_d\cdot d\vec{s} .$$

$$\left\{ \text{w.k.t.} \quad \oint_L \vec{H} dl = I = \int_S \vec{J}_d d\vec{s} \right\}.$$

$$\boxed{I_d = \int_S \frac{\partial\vec{D}}{\partial t}\cdot d\vec{s}.}$$ ⇒ Displacement Current

w.k.t $J_d = \frac{\partial D}{\partial t}$.



$$\oint_L \vec{H} dl = \int_S \vec{J}_c\cdot d\vec{s} = I_{enc} = I$$

$$\{J_d = 0\}.$$

$$\oint_L \vec{H} dl = I = \int_S \vec{J}_d\cdot d\vec{s}$$

$$= \int_S \frac{\partial D}{\partial t} ds .$$

$$= \frac{\partial}{\partial t}\underbrace{\int \vec{D}\cdot ds}_{Q} \Rightarrow \frac{\partial}{\partial t} Q$$

$$\partial/\partial t(Q) = I$$

$$\{J_c = 0\}$$