DISPLACEMENT CURRENT

$$\nabla \times H = J + \frac{\partial D}{\partial t} \rightarrow (1)$$

$$\int (\nabla \times \vec{H}) \cdot d\vec{s} = \int_s \vec{J} \cdot d\vec{s} + \int \left(\frac{\partial \vec{D}}{\partial t}\right) \cdot d\vec{s} \rightarrow (2)$$

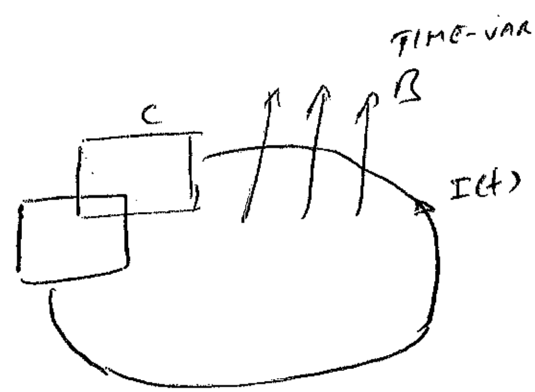
APPLYING STOKES' THEOREM,

$$\int_s (\nabla \times \vec{H}) \cdot d\vec{s} = \oint_L H \cdot dL = I + I_d \rightarrow (3)$$

$I_d = \int \frac{\partial \vec{D}}{\partial t} \cdot d\vec{s}$ IS THE DISPLACEMENT CURRENT

$I = \int \vec{J} \cdot d\vec{s}$ IS " CONDUCTION CURRENT

EXAMPLE :



CONSIDER A CIRCUIT CONSISTING OF A CAPACITOR CONNECTED BY AN IDEAL CONDUCTOR. DUE TO A TIME-VARYING MAGNETIC FIELD, LET THERE BE EMF ABOUT THE CLOSED PATH,

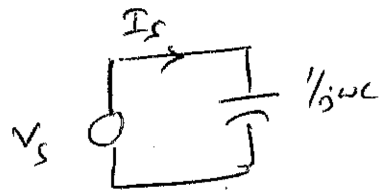
$V(t)$ ~~$= V_0$~~

$$V(t) = V_0 \cos(\omega t) \rightarrow (4)$$

USING THE PHASOR NOTATION,

$$V(t) = \mathrm{Re}\{V_s e^{j\omega t}\}$$

$$V_s = V_0 \angle 0^\circ$$



$$I_s = V_s j\omega C = V_0 \omega C e^{j\pi/2}$$

$$I(t) = \mathrm{Re}\{V_0 \omega C \cdot e^{j(\omega t + \pi/2)}\}$$

$$= -V_0 \omega C \sin \omega t \rightarrow (5)$$

EQ. (5) DESCRIBES THE CONDUCTION CURRENT ~~~~ IN THE CIRCUIT OUTSIDE THE CAPACITOR. BETWEEN THE CAPACITOR PLATES, THERE IS NO CONDUCTION CURRENT, BUT DISPLACEMENT CURRENT,

$$I_d = \int_S \frac{\partial \vec{D}}{\partial t} \cdot d\vec{s}$$ where S is the SURFACE OF CAPACITOR PLATE

BETWEEN THE CAPACITOR, E IS CONST. (AS A FUNCTION OF SPACE)

$$E(t) = \frac{V(t)}{d}$$

WHERE d is the distance between plates.

$$D = \epsilon E = \frac{\epsilon V_0 \cos(\omega t)}{d}$$

$$\frac{\partial \vec{D}}{\partial t} = \frac{-\omega \epsilon V_0 \sin(\omega t)}{d}$$

$\vec{D}$ IS DIRECTED $\perp^r$ TO CAPACITOR ~~PLAT~~ PLATE &

IS CONST. (AS A FUNCTION OF SPACE)

$$\therefore \int_S \frac{\partial \vec{D}}{\partial t} \cdot d\vec{S} = -\omega V_0 \left(\frac{\epsilon S}{d}\right) \cdot \sin(\omega t) \quad \left(\frac{\epsilon S}{d} \to C\right)$$

$$= -\omega V_0 C \sin(\omega t) \rightarrow (6)$$

COMPARING EQS. (5) & (6), WE SEE THAT THE DISPLACEMENT CURRENT ~~ICAL~~ BETWEEN THE PLATES IS THE SAME AS THE CONDUCTION CURRENT OUTSIDE THE PLATE.

NOTE THAT BETWEEN THE PLATES, IT IS OPEN CIRCUIT & YOU MIGHT WONDER ~~HOW~~ HOW THE CIRCUIT WORKS DESPITE OF THE OPEN CIRCUIT. IT IS THE DISPLACEMENT CURRENT THAT IS RESPONSIBLE FOR THE CURRENT CONTINUITY. IF THE CHARGE ON ONE OF THE PLATE DROPS FROM 4 C TO 0, THE CHARGE ON THE OTHER PLATE DROPS FROM -4 C

TO 0 ALMOST INSTANTLY (ACTUALLY AT THE SPEED OF LIGHT) ALTHOUGH THERE IS NO CHARGE FLOW BETWEEN THE PLATES.