Start with the general form of Ampere's Law, valid for classical macroscopic media.

$$I = \oint \mathbf{H} \bullet d\mathbf{l} = \iint \mathbf{J} \bullet d\mathbf{s} + \frac{d}{dt} \iint \mathbf{D} \bullet d\mathbf{s}$$

Assume no time varying surfaces

$$I = \oint \mathbf{H} \bullet d\mathbf{l} = \iint \left(\mathbf{J} + \frac{\partial \mathbf{D}}{\partial t} \right) \bullet d\mathbf{s}$$

Assume Ohm's Law at a point

$$I = \oint \mathbf{H} \bullet d\mathbf{l} = \iint \left(\sigma \mathbf{E} + \frac{\partial \mathbf{D}}{\partial t} \right) \bullet d\mathbf{s}$$

Assume static and linear media (note ε_r is relative permittivity)

$$I = \oint \mathbf{H} \bullet d\mathbf{l} = \iint \left(\sigma \mathbf{E} + \varepsilon_o \, \varepsilon_r \frac{\partial \mathbf{E}}{\partial t} \right) \bullet d\mathbf{s}$$

Assume steady state complex sinusoidal fields (also called a Fourier Transform)

$$I_o \, \mathrm{e}^{\mathrm{j}\omega t} = \mathrm{e}^{\mathrm{j}\omega t} \oint H_o \bullet d\mathbf{l} = \mathrm{e}^{\mathrm{j}\omega t} \iint \left(\sigma E_o + \mathrm{j} \varepsilon_o \, \varepsilon_r \, \omega E_o \right) \bullet d\mathbf{s}$$

Express using effective complex conductivity

$$I_o \, \mathrm{e}^{\mathrm{j}\omega t} = \mathrm{e}^{\mathrm{j}\omega t} \oint H_o \bullet d\mathbf{l} = \mathrm{e}^{\mathrm{j}\omega t} \iint \left(\sigma + \mathrm{j} \varepsilon_o \, \varepsilon_r \, \omega \right) E_o \bullet d\mathbf{s}$$

Compare to the result we would have obtained for a pure conductor

$$I_o \, \mathrm{e}^{\mathrm{j}\omega t} = \mathrm{e}^{\mathrm{j}\omega t} \oint H_o \bullet d\mathbf{l} = \mathrm{e}^{\mathrm{j}\omega t} \iint \sigma \; E_o \bullet d\mathbf{s}$$

Here you can see that from a certain point of view, and under specific assumptions (which are very common in real applications), the dielectric effects can be considered to be the complex part of conductivity.

Equivalently, one can think of conductivity as the complex part of permittivity.

Express using effective complex permitivity

$$I_o \, \mathrm{e}^{\mathrm{j}\omega t} = \mathrm{e}^{\mathrm{j}\omega t} \oint H_o \bullet d\mathbf{l} = \mathrm{e}^{\mathrm{j}\omega t} \iint \mathrm{j} \omega \left(\varepsilon_o \, \varepsilon_r - \mathrm{j} \frac{\sigma}{\omega} \right) E_o \bullet d\mathbf{s}$$

Compare to the result we would have obtained for a pure insulator

$$I_o \, \mathrm{e}^{\mathrm{j}\omega t} = \mathrm{e}^{\mathrm{j}\omega t} \oint H_o \bullet d\mathbf{l} = \mathrm{e}^{\mathrm{j}\omega t} \iint \mathrm{j} \omega \varepsilon_o \, \varepsilon_r \, E_o \bullet d\mathbf{s}$$