3.4.2 Summary to: Dynamic Properties - Dielectric Losses

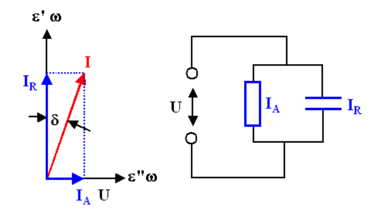
- The frequency dependent current density j flowing through a dielectric is easily obtained. ⇒
  - The in-phase part generates active power and thus heats up the dielectric, the out-of-phase part just produces reactive power
  - The power losses caused by a dielectric are thus directly proportional to the imaginary component of the dielectric function

$$j(\omega) = \frac{dD}{dt} = \epsilon(\omega) \cdot \frac{dE}{dt} = \underbrace{\omega \cdot \epsilon'' \cdot E(\omega)}_{\text{in phase}} + \underbrace{i \cdot \omega \cdot \epsilon' \cdot E(\omega)}_{\text{out of phase}}$$

$$L_A = \begin{array}{l}\textbf{power turned}\\ \textbf{into heat}\end{array} = \omega \cdot |\epsilon''| \cdot E^2$$

- The relation between active and reactive power is called "tangens Delta" (**tg(δ)**); this is clear by looking at the usual pointer diagram of the current

$$\frac{L_A}{L_R} := \operatorname{tg}\delta = \frac{I_A}{I_R} = \frac{\epsilon''}{\epsilon'}$$



  - The pointer diagram for an *ideal* dielectric **σ(ω = 0) = 0**can always be obtained form an (ideal) resistor ***R***(ω) in parallel to an (ideal) capacitor ***C***(ω).
  - ***R***(ω) expresses the apparent conductivity $\sigma_{DK}(\omega)$ of the dielectric, it follows that

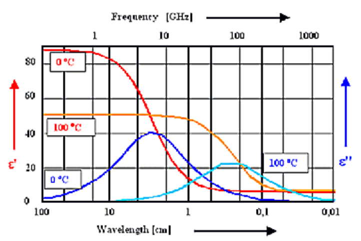
$$\sigma_{DK}(\omega) = \omega \cdot \epsilon''(\omega)$$

- For a *real* dielectric with a non-vanishing conductivity at zero (or small) frequencies, we now just add another resistor in parallel. This allows to express *all* conductivity effects of a real dielectric in the imaginary part of its (usually measured) dielectric function via

$$\epsilon'' = \frac{\sigma_{total}}{\omega}$$

  - We have no *all* materials covered with respect to their dielectric behavior - in principle even metals, but then resorting to a dielectric function would be overkill.

- A good example for using the dielectric function is "dirty" water with a not-too-small (ionic) conductivity, commonly encountered in food.
  - The polarization mechanism is orientation polarization, we expect large imaginary parts of the dielectric function in the **GHz** region.
  - It follows that food can be heated by microwave (ovens)!



Questionnaire

Multiple Choice questions to all of 3.4