Exercise 1 "Normalized Transfer Impedance of an Eddy Current"

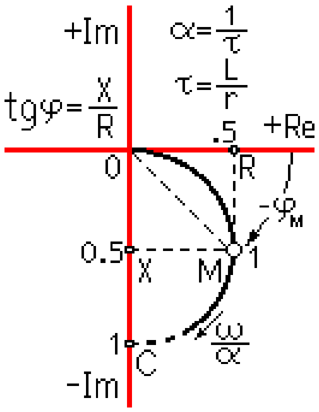

Fig. 3. Normalized transfer impedance of sensing network in complex plane if the target is a slender bracelet made of nonferrous metal

The maximal magnitude is 1 or 100% or 0dB.
α is the cutoff frequency (radians/s),
τ is the timeconstant (s),
ω is the TX frequency (radians/s).
Point M represents relative cutoff frequency or relative frequency ω/α=1. Note that the phase lag φ at cutoff frequency is 45 deg.

FIG. 3 shows transfer impedance of an eddy current in normalized scale. The target may be a slender bracelet made of nonferrous metal. The term "normalized" means that the magnitude is nondimensional and its maximal value is assumed to be 1 or 100%. In decibels that means 0dB because lg1=0. The frequency, in normalized plot, is also nondimensional because it is relative to cutoff frequency. If the sensing network is linear, the shown normalized impedance is independent of:
- diameter of bracelet,
- conductivity of metal,
- distance between sensor and bracelet,
- ampereturns of TX current,
- turns of RX winding.

In the next exercises we will use this normalized transfer impedance for calculation of more complicated impedances.

For now, in this exercise, you should solve following problems and answer to following questions:

1. Plot in normalized form frequency functions in Cartesian coordinates **Re(f)** and **Im(f)**.
HINT: You can find these functions in [6,7, 8 and 10].
2. Plot in normalized form frequency functions in polar coordinates: Magnitude vs. frequency and Phase vs. frequency:
a) in linear scale
b) in log – log scale,
c) approximate log – log scale as Bode plot.
3. Show and explain with Bode plot what is cutoff frequency, HF region and LF region of transfer impedance.
4. What means the term "First order high pass filter"? Write the differential equation of sensing network with an object having single timeconstant (slender bracelet).
5. Simulate with SPICE the transfer admittance of an eddy current. Solve problems 1 and 2 with SPICE.
HINT: If you simulate the circuit diagram shown in FIG. 4, the SPICE should show only a part of sensing network : "First order low pass filter". Afther twice differentiation, you will get the normalized impedance shown in FIG. 3.

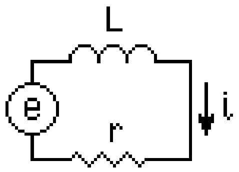

Fig. 4. Equivalent circuit diagram of an eddy current
For SPICE simulation of transfer admittance, you should connect a ground and a signal generator for AC analysis instead EMF "e".

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