JUAS 2016 – RF Tutorial

$\mu = \mu_0 \, \mu_r$

$\mu_0 = 4\pi \cdot 10^{-7}$ Vs/(Am)

$\varepsilon = \varepsilon_0 \, \varepsilon_r$

$\varepsilon_0 = 8.854 \cdot 10^{-12}$ As/(Vm)

$c_0 = 2.998 \cdot 10^{8}$ m/s

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Cavity Equivalent Circuit

Exercise 1:

A low-Q cavity resonator has an equivalent parallel RLC circuit with an inductance L = 15.915 nH, a capacitance C = 1.5915 pF, and a shunt (parallel) impedance of R = 1 kOhm.

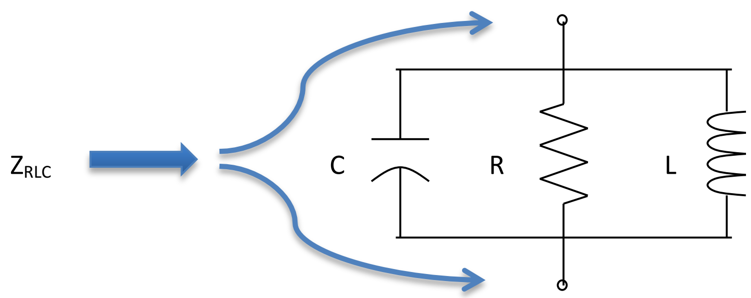
Questions:

Determine some of the relevant parameters of this parallel equivalent circuit of the cavity resonator:

1. the resonant frequency f_{res}.
2. the characteristic impedance R/Q.
3. the quality factor Q.
4. the 3-dB bandwidth.

Exercise 2:

Given is the low-Q cavity with the equivalent RLC parallel circuit and the values from Exercise 1.



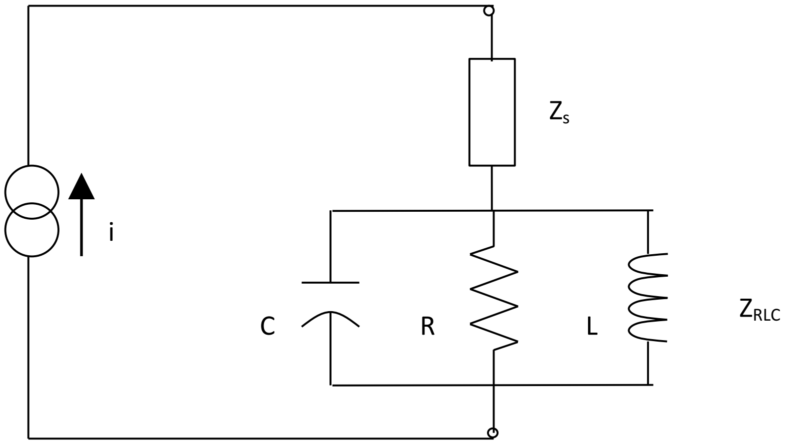
Questions:

1. Plot the impedance of the equivalent parallel circuit of the resonator as locus curve in the complex plane.
   (Use paper, triangle ruler and a pair of compasses. Scale: e.g. 100 Ohm ➔1 cm).
2. Indicate the 3-dB bandwidth points, and measure $|Z_{-3dB}|$ by using a ruler.

Exercise 3:

Now the cavity resonator with the above RLC equivalent parallel circuit is driven by an ideal current source i, i.e. a generator with an infinite high impedance. In series an impedance is added to the RLC parallel resonator, the total impedance Z_{tot} is given by the series impedance Z_s in series to the impedance of the RLC parallel resonator Z_{RLC} . For the Z_s assume three cases:

- a pure resistive impedance R_s = 200 Ohm (e.g. due to cable losses)
- a pure inductive impedance L_s = 31.831 nH (e.g. inductive coupling)
- a pure capacitive impedance C_s = = 0.7958 pF (e.g. a defect of the cable or connector)



Questions:

1. Plot the locus curve of the total impedance $Z_{tot} = Z_{RLC}+Z_s$ in the complex plane (assume a constant frequency $f \cong f_{res}$ for the series impedance).
2. How does the series impedance Z_s affect the locus curve of the overall impedance Z_{tot} for the 3 cases?
3. Now assume the resistive series impedance R_s, is the internal source resistor of a voltage source generator, which is the more typical case.
   What is the effect on the RLC resonator?
   Plot the Z_{tot} in the complex plane for R_s = 200 Ohm

Exercise 4: http://www.amanogawa.com/index.html (for home)

Open the above website and locate
"Circuits -> Java™ Applets browser window -> Parallel Resonant Circuit"

- Verify the Java applet starts
- Make yourself familiar with the settings (it will be difficult to exactly set the parameters of the above example)
- Notice the settings for "Impedance" and "Generator"!
- Find an Impedance setting similar to Exercise 1,
  e.g. L = 15.915 nH, C = 1.592 pF, R = 1 kOhm, f = 1 GHz
- Find a Generator setting which approximates a high impedance source such that unloaded and loaded Q have similar value.
- Check the "Resonance Data", and verify f_{res}, Q, and BW
- Modify the Generator settings and observe the changes on the Resonance Data. Notice the change of loaded Q and f_{res} while changing Z_G which is here a current source parallel to the cavity equivalent circuit.