EMC

Laboratory exercise 3
Passive components

Biomedical Engineering
LTH

Laboratory exercise 3: passive components

This exercise deals with the frequency properties of passive components. The measurements are made using a spectrum analyzer (with built-in tracking generator), and with an impedance analyzer.

Below is a mandatory preparatory assignment and a number of tasks/measurements to do, and these are to be accounted for in a written laboratory report in order to pass the exercise (see below for details).

Readings

Williams, "EMC for product designers"
pp 357-366.

Preparatory assignment

Draw equivalent diagrams of resistors, capacitors and coils as described in the book. Make sure that you understand how to interpret the different models of these components.

Laboratory report

In the report, both the answers for the preparatory assignment as well as the results and conclusions of the measurements are to be presented (methods or list of equipment are not necessary). The report is written in groups and is to be 2-4 pages long, in addition to a cover page (where your names, the name of the exercise and the tutor's name are listed). Academic accuracy concerning references is assumed.

To bring to the laboratory exercise

One person in the group should bring a USB-stick in order to save the results of the measurements for the laboratory report (the computer in the lab does not have an Internet connection).

Equipment

Siglent SSA 3021X spectrum analyzer with built-in tracking generator 9 kHz – 2.1 GHz.
HP 4194A impedance analyzer with computer controlling (LabView)
Ferrites
- FB-43-101
- FB-61-101
- FB-75-101

EMI-filter
- Murata 222 (2,2nF)
- T-filter using discrete components

Coils
- 15 µH
- 47 µH
- 220 µH

Capacitors
- 4,7 nF polyester (mylar)
- 4,7 nF ceramic
- 4,7 nF mica
- 47 nF polyester (mylar)

Resistors
- 3,3 Ω
- 100 Ω
- 10 kΩ

Part 1: the frequency properties of passive components

Please note!
Discharge yourself to ground in the beginning of the laboratory exercise before touching the input connector of the spectrum analyzer!

Siglent SSA 3021X
When you have turned the spectrum analyzer on, adjust for a frequency range up to 1 GHz and perform the measurements as described below. Depending on the results and the specifications of the components (devices under test), chose a suitable frequency span for the actual measurements. The tracking generator is activated using the button marked "TG".

1. Study the attenuation of a ferrite bead when it is applied to a wire. There are three different ferrite materials. In which frequency ranges are they active? Why? What happens if two or more beads are applied? Do you see any relationship between the relative permeability of the ferrite material (see data sheets), and what frequencies are attenuated.

2. Study the attenuation of a EMI-filter, type Murata, 2.2 nF. Compare to a similar one consisting of discrete components, 2.2 nF, 2 x 470nH.

3. Suggest some own designs and study the effects using a prototype board. Consider what frequencies are affected, and what frequency range is suitable for the measurements. Does the actual frequency properties of your filter correspond to the theoretical ones, if not: why?
   Hint: feel free to try the filter simulator at (for example) http://sim.okawa-denshi.jp/en/Fkeisan.htm

Part 2: impedance analysis of R, L and C

HP impedance analyzer with computer control

The components which you are to examine are clamped to the test fixture, which is attached to the impedance analyzer. As you start the measurement procedure, the impedance analyzer performs a four-terminal measurement, meaning that current is conducted through the component while voltage and phase-shift between current and voltage is being measured.

The Labview-program in the computer controls the impedance analyzer and retrieves the results which are plotted on the computer. The measurement is started by clicking on the icon with the arrow pointing right. The results of the measurements are then saved as Matlab-files. Please note that each measurement generates three different files, which have to be saved under different names. When the software has started a measurement, the keypad of the impedance analyzer will lock. To reactivate the keypad, press "LCL" (Local) on the impedance analyzer.

4. Measure the frequency behavior of metal film resistors of 3.3 Ω, 100 Ω and 10 kΩ. What properties do the components show at higher frequencies? How much is the change in percentage? Why are the impedances altered?

5. Measure the frequency behavior of a 4.7 nF and a 47 nF polyester (mylar) capacitor. What are the resonance frequencies and the impedance at those? Compare with a 4.7 nF ceramic capacitor and a 4.7 nF mica capacitor. Compare the loss factors D[1] (D=ESR/Xc) at 1 MHz, 5 MHz and 10 MHz for the 4.7 nF capacitors. Conclusions? Which of the capacitors is the 'best' one?

6. Measure the frequency behavior of a 15 µH, 47 µH and a 220 µH inductance (the latter one can easily be mistaken for a resistor). What are the resonance frequencies and the impedance at those? How is the resonance frequency calculated for an LC-circuit? Does the ratio between the resonance frequencies seem to be correct?

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[1] The loss factor is denoted as the D-factor as an abbreviation of *Dissipation factor*, hence the D. The D-factor is the inverse of Q, i.e. D=1/Q. ESR = Equivalent Series Resistance.