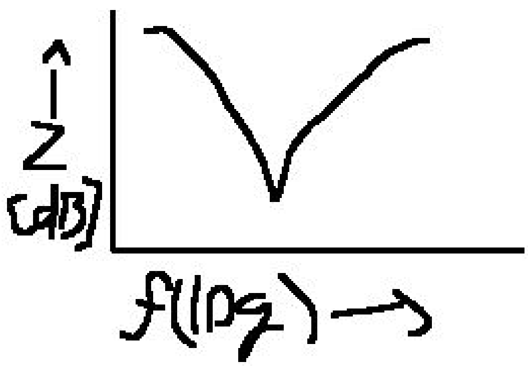
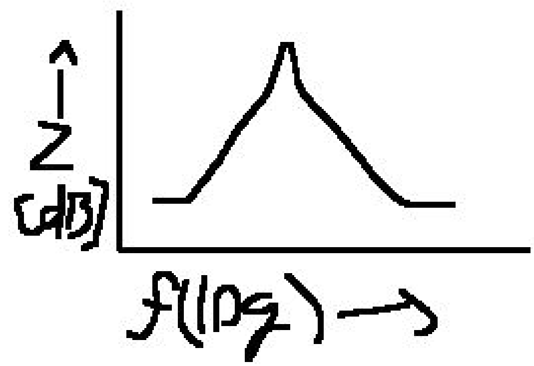
EMC exam 15-04-19 reconstructed

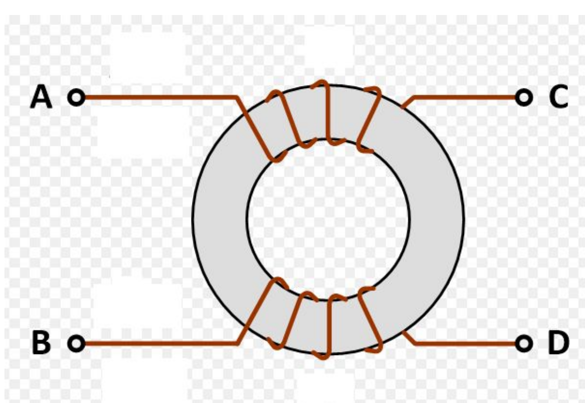
1. Filters

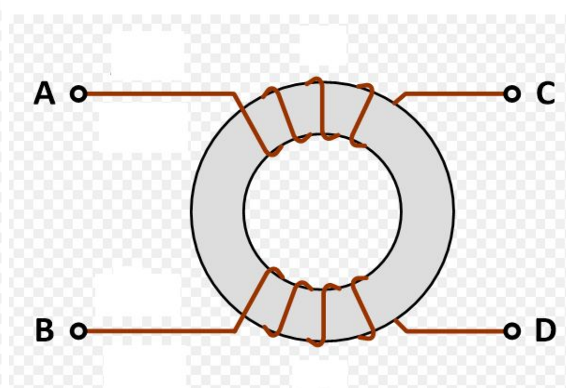
a) Give the equivalent circuits fitting to the following impedance - frequency curves and explain what type of components are measured. Assume constant slopes are 20 dB / dec



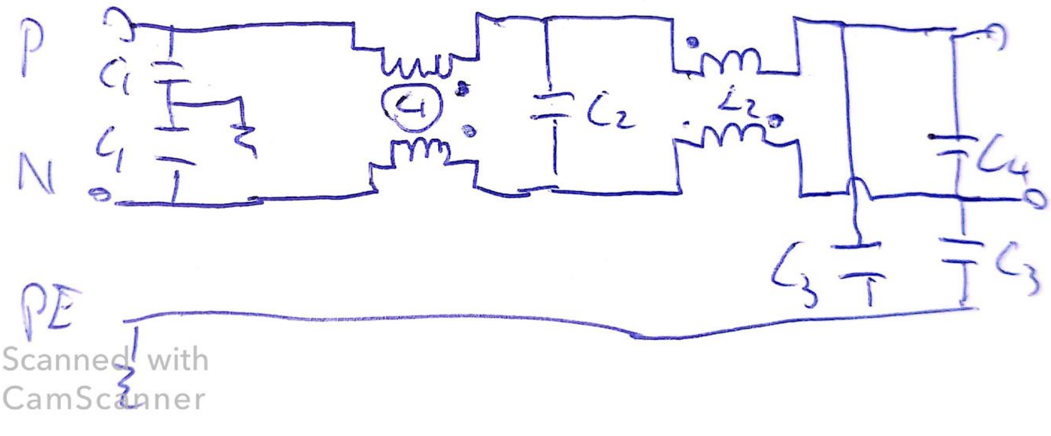


b) For the following two images of a common mode choke, draw the directions of current and the fields for both a DM and a CM case. Explain how it works.





c) Draw equivalent circuits for CM & DM cases, describe what type of filters are implemented for both cases

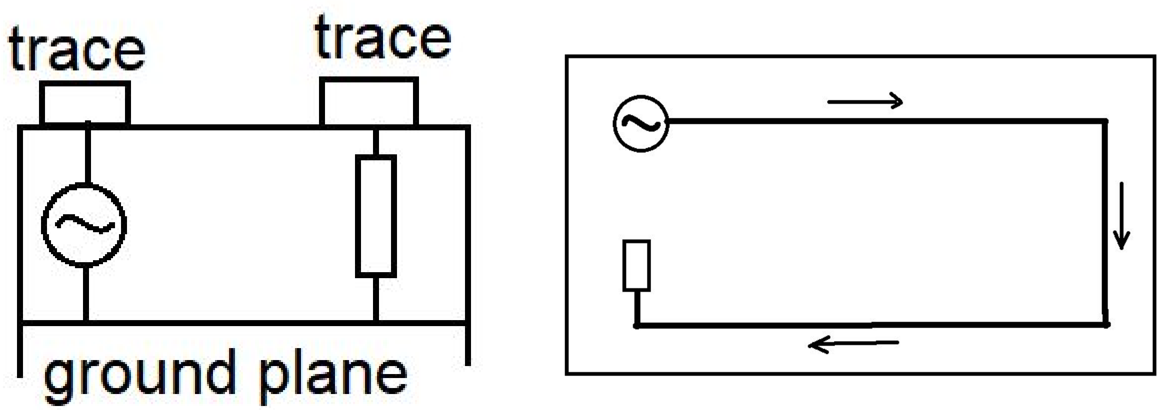


d) For the “ideal components” filters above, draw a circuit with non-ideal components for either the CM or DM case.

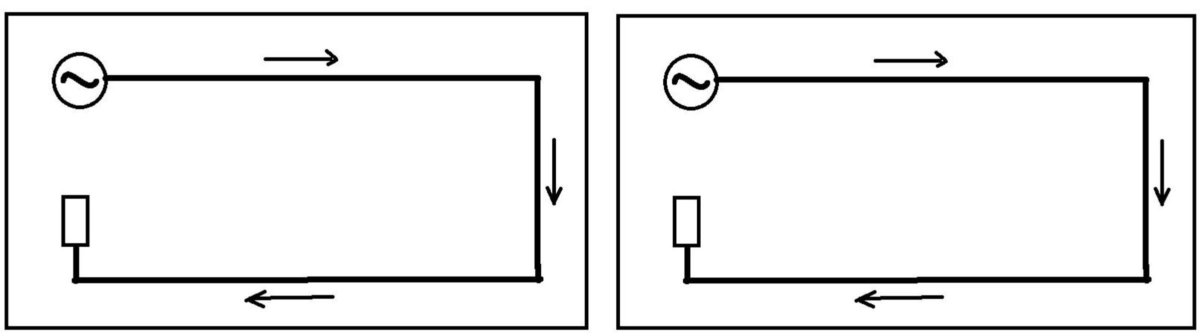
e) For high frequency current (f > resonance frequency) draw the current path & describe what happens to the transfer function / what effect it has on performance

2. Return path

A PCB is made shown below with an uninterrupted ground plane underneath. The traces are made up of copper.



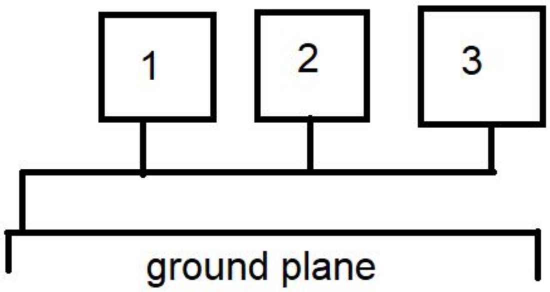
a) Draw below where the current is flowing for the cases 1) a DC current flows 2) a high frequency (f>100kHz) is flowing

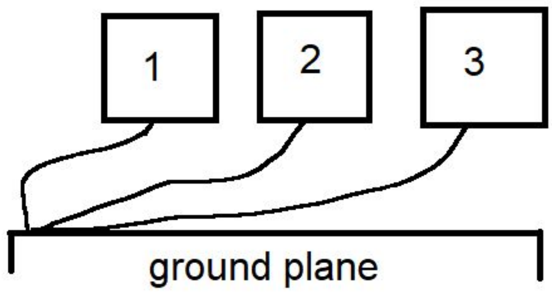


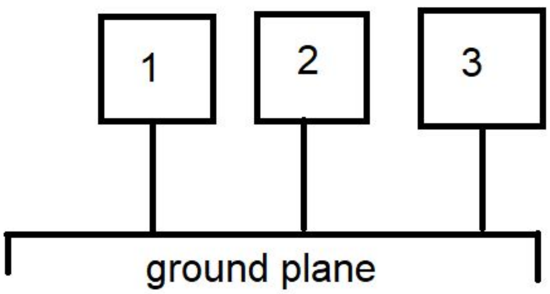
b) What if the conductors were PEC instead?

3. Grounding

a) For each of the images below, what is the type of ground scheme? Assume a perfect ground plane



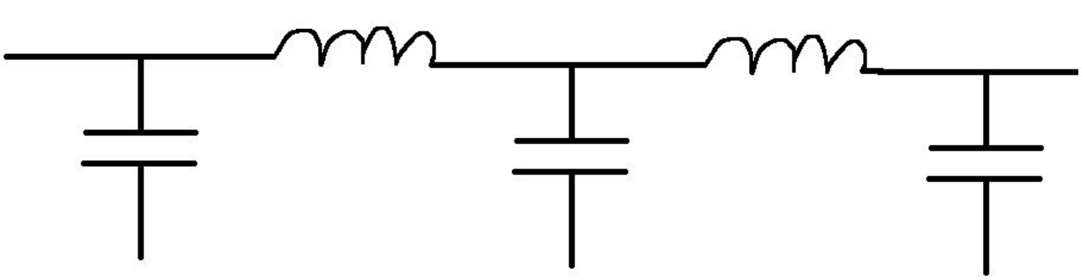




b) Assume the wires have an impedance and make equations for V at the sire of each device (1, 2 and 3) as a function of the wire impedances and I_i for each device for each grounding scheme (so three equations per grounding scheme)

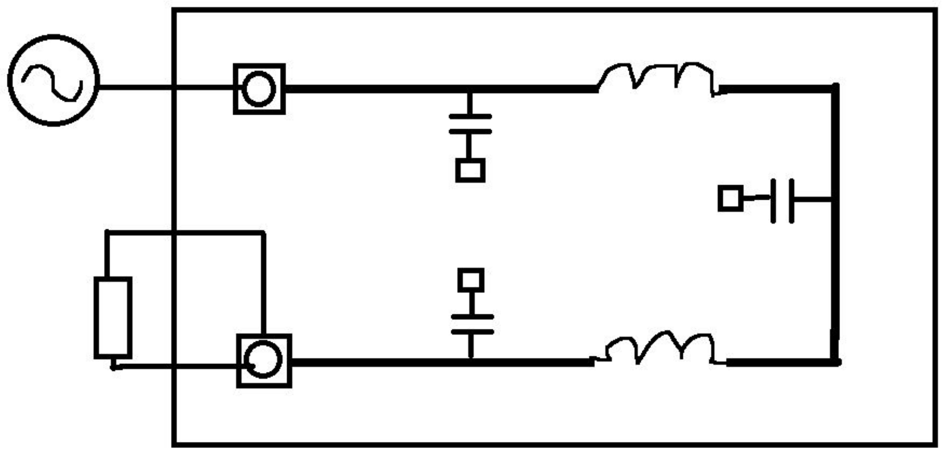
c) For the second grounding scheme, draw a realistic and practical situation by including possible parasitics, indicate the path of high frequency currents. How does this compare to the designed ground scheme (which I think is ground scheme 1?)

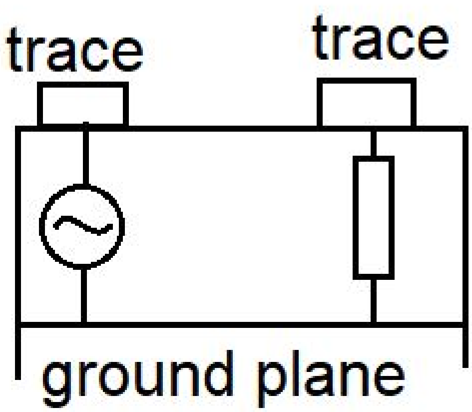
d) Explain which grounding scheme is best for the filter shown below:



4. Design

a) For the image shown below, which grounding scheme would be best.

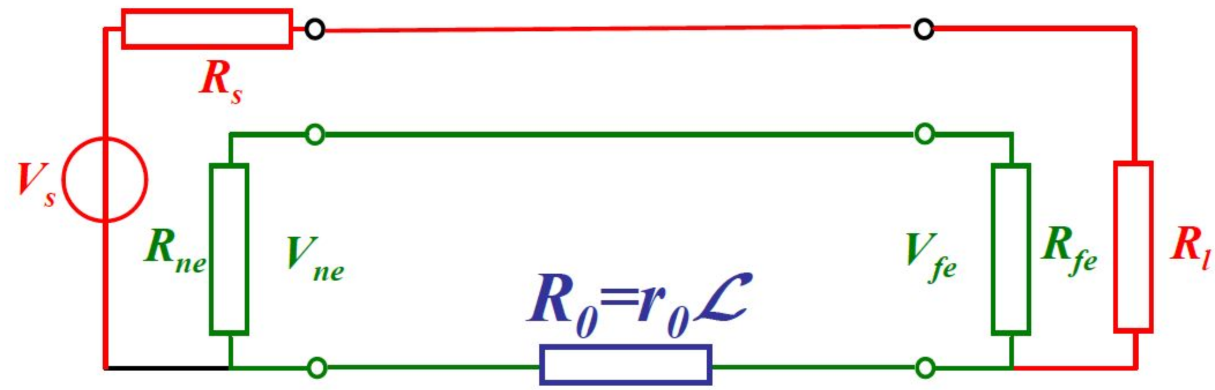




b) draw your own design to maximise the effectiveness of the filter shown in the circuit while minimising the effects of parasitics, x-talk etc.

c) explain the choices by comparing your new design to the original design

5. Crosstalk



Frequency dependent near end crosstalk when the common impedance is neglected can be described as:

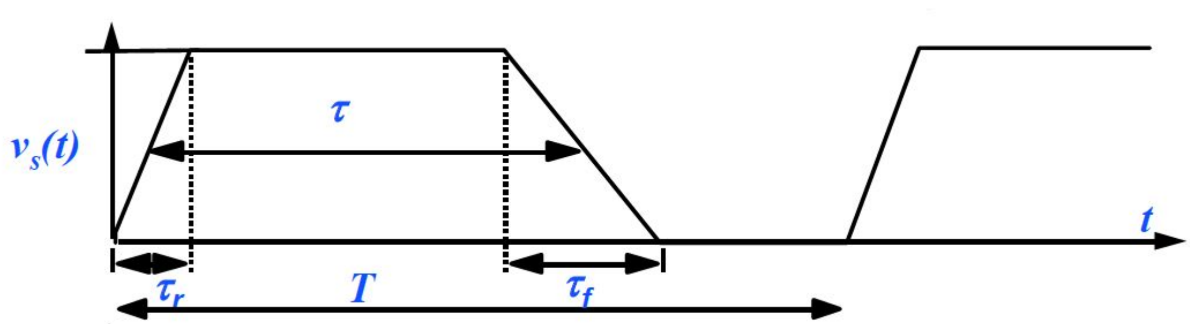
$$\gamma_{NE,ind} = j\omega l \frac{\mu_o}{8\pi R_{c,c}} ln(1 + \frac{4h^2}{d^2}) \quad \gamma_{NE,cap} = \frac{1}{2} j\omega l \frac{\varepsilon_o \pi R_{C,V} ln(1+4h^2/d^2)}{ln^2(2h/r) - ln^2\sqrt{1+4h^2/d}}$$

With Length l = 50 cm, radius of the copper r = 0.5mm, height from ground plane h = 1 cm. Seperation of the two wires s = 5 cm the characteristic impedances (R_{cc} and R_{cv}) = 500Ω

$$\gamma_{NE,xx} = \frac{V_{NE,xx}}{V_s}$$

a) which type of crosstalk is dominant for this system?

b) A 10 MHz clock signal is applied to V_s with a rise & fall time of 1 ns and a duty cycle D = 80%. Sketch the envelope of the functional spectrum of V_s against frequency.



c) Sketch the near end crosstalk in time domain in the figure above.

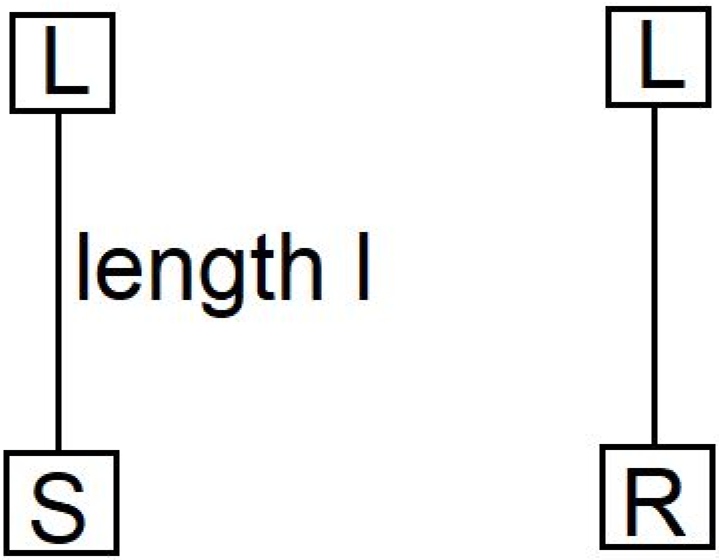
d) Sketch the spectrum of the EMI

e) with respect to EMI generated in the receptor, describe several possibilities for reducing it and which are preferred for what reason

f) the common impedance is now included. The common mode impedance = 0.1mΩ and the max crosstalk due to long line effects is -10 dB. Sketch the new crosstalk curve together with single sided magnitude spectrum of EMI generated at the near end in the victim receptor (note: use 20log(Z) for dBΩ)

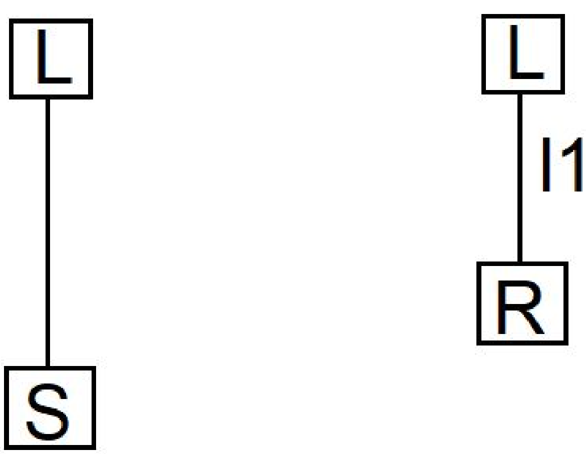
6 Radiated

These two systems are some large distance away.

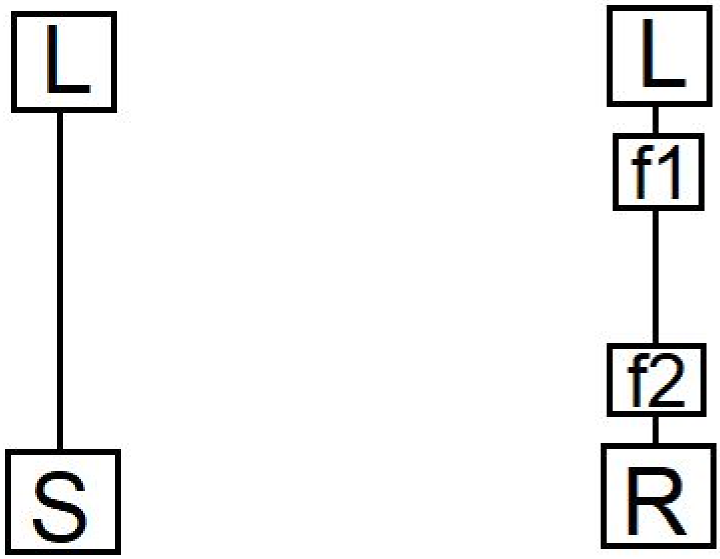


S= source
L= load
R= receiver
Length l = 20cm, source generates two frequencies: f1 = 500MHz, f2 = 1.5GHz.
Describe EMI coupled to receiver in cases of the various mitigation techniques shown below.
Discuss possible effects.

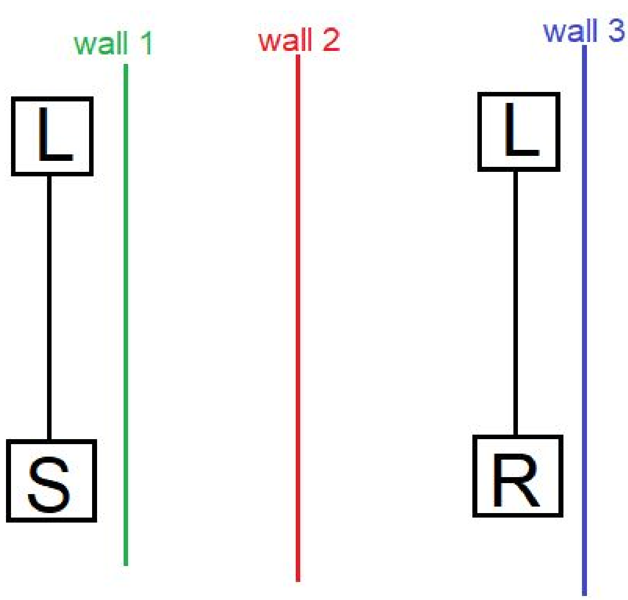
a) l1 = 10 cm



b) Is ferrite on location f1 or location f2 preferred? What is the effect?



c) The effect of a 1mm thick copper plate at three different locations:
Wall 1: 5 cm from source system
Wall 2: far from both systems
Wall 3: 5 cm from receiver system
What other material would be more suitable in each case?



d) what is the effect of placing system 2 in a 1 mm thick copper case with a diameter of d = 10 cm?