Lab inf5460 – Mandatory Task 2

Measuring the absorption of noise in different cables with varying termination.

Deadline

Deadline for delivery: Monday 10 of October at 12:00.
Assessment: Approved/Not approved.

Layout

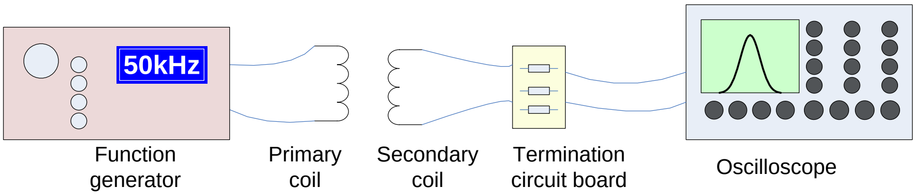

Figure 1: Setup

Primary coil connected to the output of the function generator.
Secondary coil connected to the oscilloscope via a terminal box.

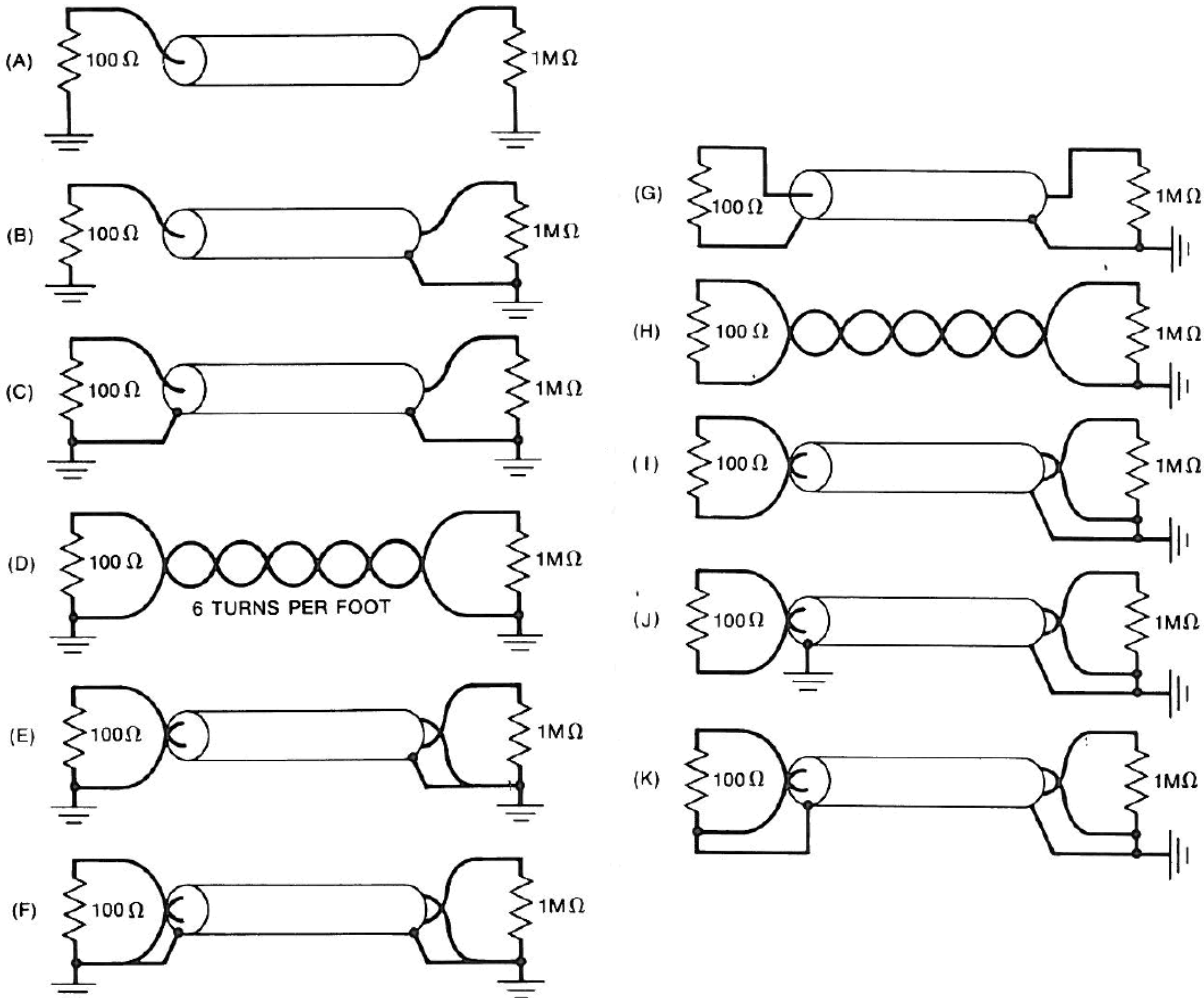

Figure 2: Terminations (Ref: Noise reduction in electronic systems, second edition, pp 58, 59).

In this experiment we will use termination cards designed so that the secondary coil is terminated in accordance with Figure 2 if you use the correct cable. Each termination cards has its own box.

Equipment:

- HP 33120A Function generator (FG) [Functions generator]
- Agilent 54622D Mixed Signal Oscilloscope [Oscilloscope]
- Primary coil: 9" diameter , 12 turns, 20AWG
- Secundary coil(s): 7" diameter, 5 turns:
  - Shielded wire pair (speaker cable)
  - CAT5e (twisted pair) (with 3 connectors)
  - Twisted pair data cable (TP)
  - Shielded twisted pair (STP) (45 Ω)
  - Coax (75 Ω)
- Termination boxes (A-K) with termination card and aluminum shield for connecting the secondary coil and the oscilloscope.
- Coax cables to connect function generator to the primary coil and termination card for oscilloscopes.
- BNC-T-joints

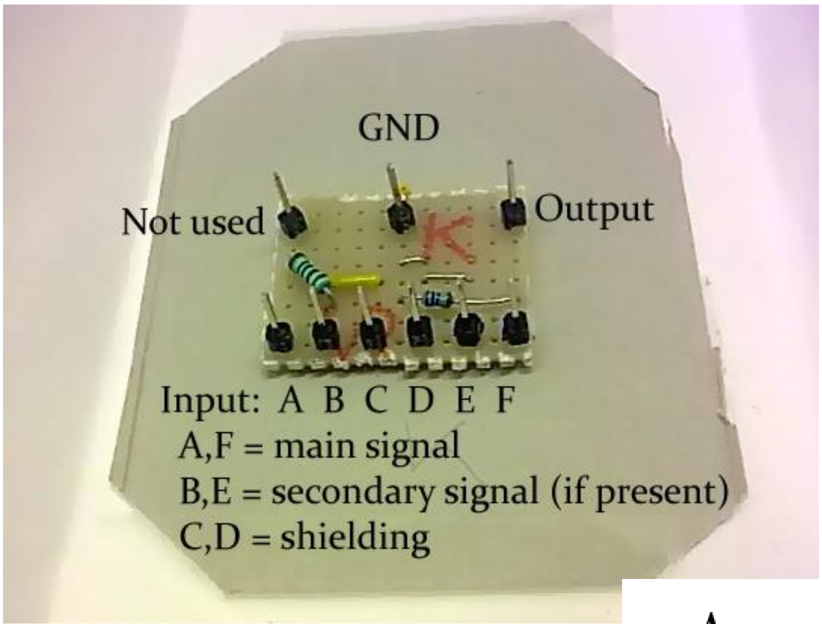

Figure 3: Inside of a termination box. Any termination cards have wire slots that follow the rows of holes perpendicular to the figure (for example. "F" and "Output" is connected together in a groove). Pins and resistors are soldered onto the back, all links between tracks are on the upper side. The cards are ground connected to the aluminum foil enclosing box.

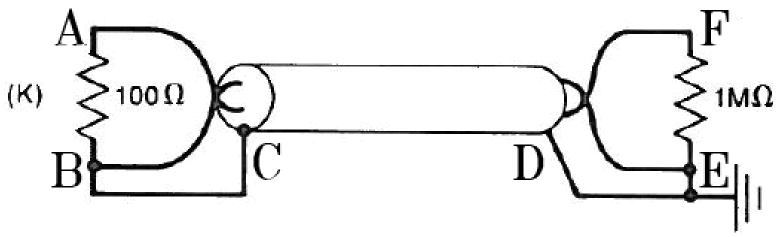

Figure 4. How cables are connected to termination card
A and F are connected to each end of the signal conductor, while B and E connected to the second wire pair in a twisted pair. C and D connected to the cable shielding.

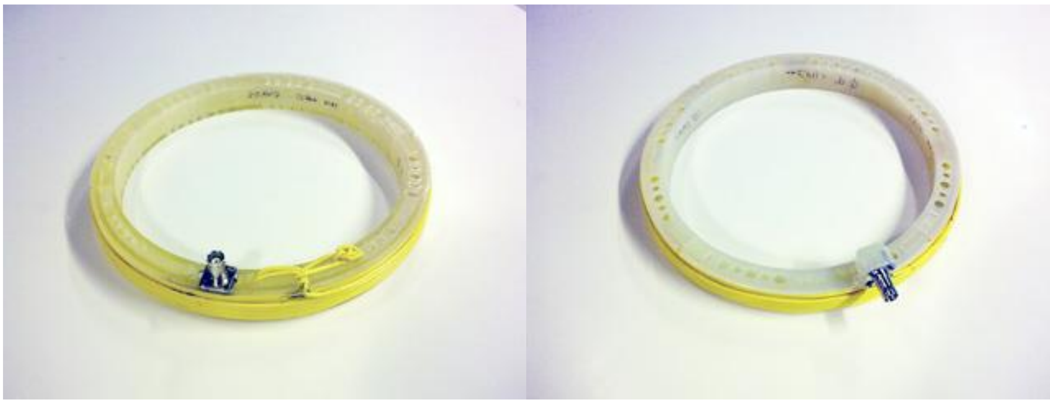

Figure 5 Primary coil

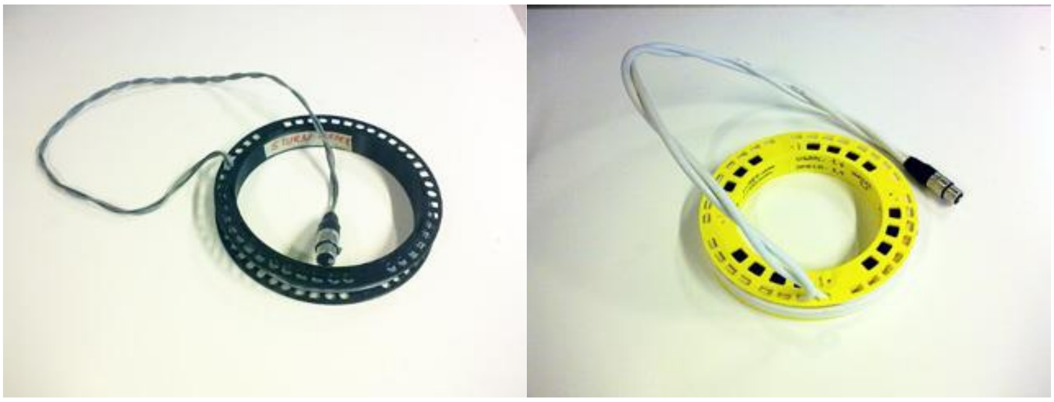

Figure 6 Secundary coil

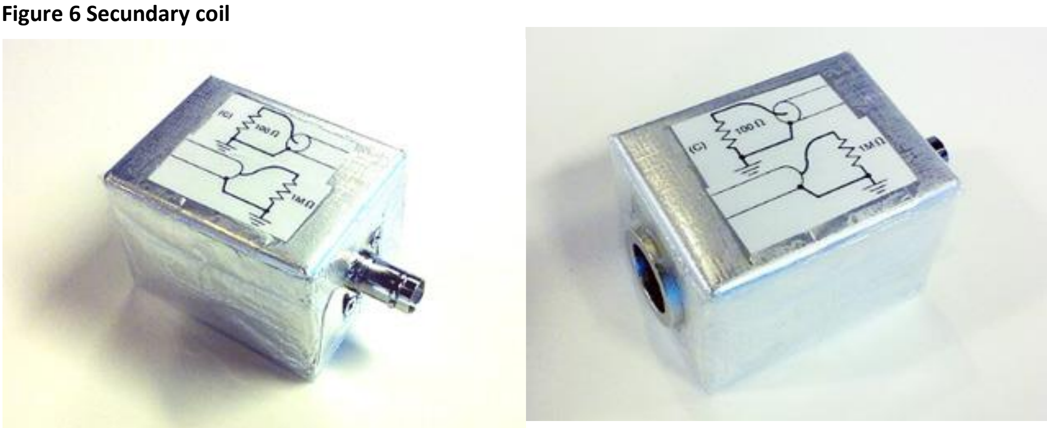

Figure 7 Termination box

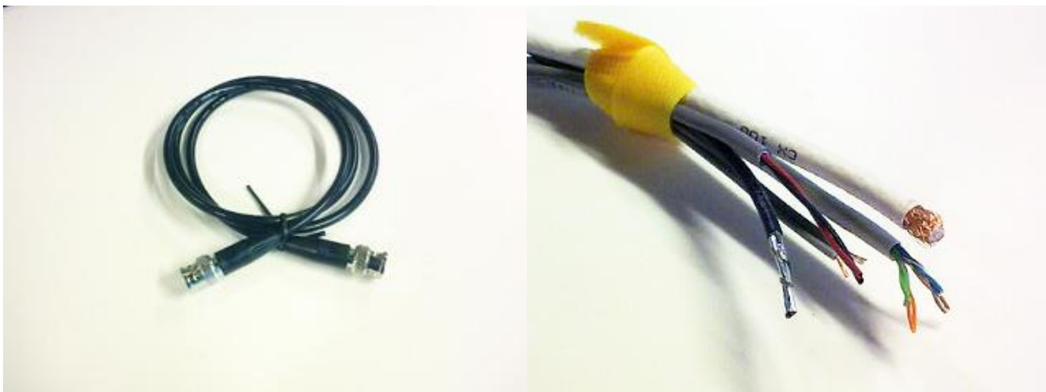

Figure 8 Coax cable and cross section of the cables to the coils

Figure 9 Wiring

Wiring

NB: USE ONLY cables from INF5460 box. Remember to put them neatly in place after use! ☺

1. Connect the primary coil to function generator with a coax cable.
2. Set the function generator to produce a sinusoidal signal with::
   i. Frequency: 50kHz
   ii. Offset 0V
   iii. Amplitude: 10V pp (maximum output, we do not necessarily 10Vpp out).
3. Connect the secondary coil into a termination box (A-K) with XLR connector
4. Add secondary coil inside the primary coil (as shown in Figure 9 Wiring Figure 9)
5. Connect the oscilloscope to the desired card (A-K) with a coax cable to input 1.
6. Connect sync signal from the function generator to input 2 of the oscilloscope with a coax cable.
7. Turn on the oscilloscope and **run autoscale** *NB: this is done to correct the gain of the input signals. Error amplification of the input signal will result in wrong FFT values. Amplification can be later adjusted manually, to prevent FFT settings are changed.*
8. Follow the recipe at http://nano.wiki.ifi.uio.no/Oscilloscopes to find the signal strength of the terminal box with an FFT measurement with external trigger.
9. For each change of termination, you must adjust the gain on channel 1, so that the signal covers as much as possible of the window, without going outside. (For the best quality of reading FFT value).
10. Use the run / stop for each new measurement if you do not want to wait 3 minutes for the next reading

General Information about the Task

- The report should be written so that it can be read and repeated without carrying the text. [1]
- Note who you have worked with.
- Record all test results and describe what you see and do.
- Explain your answers based on the theory you have learned.
- Provide references to theory you used. *Have you used Wikipedia? Refer to the Wikipedia article, or the lecture notes, give reference about the lecture, etc..*
- Make note of which STP cable and the primary coil using. *Even coils that appear to be identical could not identical responses. For weak signals, even small changes in position could lead to noise changes to a few decibels. Weaker signals than -40 dB should thus be rounded to whole decibels.*
- Try to avoid moving the layout more than necessary and avoid loops on the cables. *Moving and tangling cables can give rise to differences that make it difficult to distinguish between setups that have fairly similar results.*
- Ensure that the results are stable. If touching a cable make huge differences, something is wrong.

[1] It gives good readability pasting task text for each answer, and then the answer.

Part 1, before lab

This section should be done before the lab, and brought to the lab, so you have a basis to understand the context of the results you get and can get early feedback on comprehension.

Figure 10 is a proposal for a schematic representation of termination A. The shield and the wire are portrayed as coils precisely because that is what they are in our experiment. The capacitor Csw represents the capacitive coupling between the shield and the wire. Since we have no grounding of the shield there is no effect of the capacitive coupling of A (we will not get any circuit with shield and wire together). Bondings at each end of the cable are physically the same point in our layout, so the wire forms a circuit itself can be inductively coupled. The test point in the experiment is always R2.

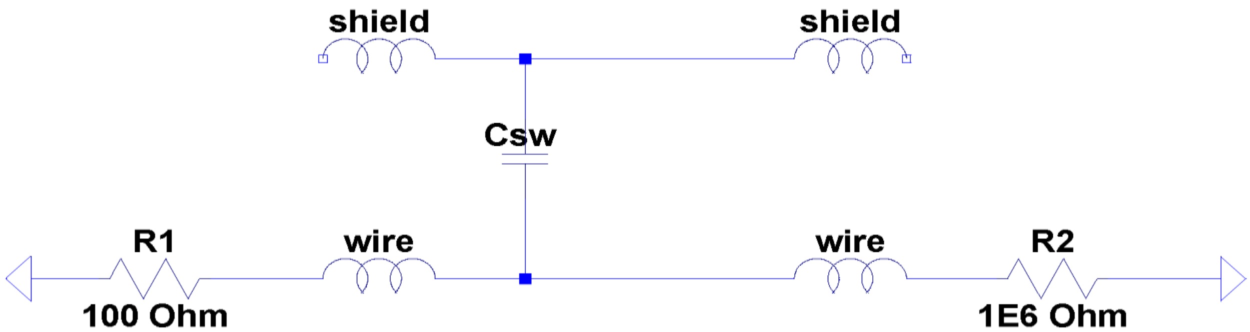

Figure 10: Schematic representation of a connection with termination A.

1. Try to draw the equivalent form for the rest of the 11 different terminations (B-K). Use names here: For TP and STP cable, first and second conductor called 1.wire and 2.wire and capacitance between these called C12. Use CS1 and CS2 for capacitances between shield and 1./2. wire.

2. In this experiment, we use a lot the decibel scale. $Vdb = 20\log(\frac{Vpp}{\sqrt{2}})$ [2]

What describes the greatest change:

- Going from -21 to -23 dB, or to go from -72 to -78dB? (Calculate and explain).

Part 2 Lab

Connect up as indicated in the setup and connection. Set the function generator at 50kHz sine, 10Vpp.

3. Use termination card A together with all cables. Write down the results.
   a) Does shielding have something to say with this assignment? Explain.
   b) What factors are causing the results to be not exactly identical for the cables? Explain your answer.

4. Use termination card A with one of the cables.
   a) Place a sheet of aluminum foil under the coils. How does this affect the result? Explain.
   b) On the bench there is probably other objects that may affect the results, and to some extent can bench itself affect the result. Try to move around a bit on the measurement configuration. Identify three objects or factors affecting measurement results, and explain how they affect.

[2] Note that $\frac{Vpp}{\sqrt{2}}$ is RMS value of a perfect sinusoid. $Vrms = \sum\sqrt{\frac{Vi}{n}}$, that the oscilloscope uses, may differ slightly.

In the next task we will investigate the properties of the terminals A-F. To get comparable results we shall first use only wire with a shielded twisted pair (STP). It is also important that the layout is most similar between each measurement. Enter the primary and secondary coils you are using and use the same primary and secondary coil throughout the experiment. Enter the sample frequency and measure the signal strength of the function generator while it is connected to the primary coil for each frequency (use T-connectors at the coil).

5. Measure the signal strength of the 50kHz signal for terminals A-F. Record the results in a table.
   a) Is the inductive or capacitive noise that dominates for these terminations? Explain.
   b) Describe how the terminals A-F acts in relation to each other and how the differences between them are involved.

6. Measure the signal strength of 50kHz signal in junction G-K. Record the results in a table.
   a) Is the inductive or capacitive noise that dominates for these terminations? Explain.
   b) What is the biggest difference between the links in the C-F and G-K? Explain.
   c) Describe how the terminals G-K work and how the differences between them are involved.

7. This lab assignments largely follows an attempt made by Ott in the 70s.
   a) Unlike Ott we have more turns on the coils. How will it affect measuring our performance compared to capacitive and inductive noise transmitted? Explain your answer.
   b) The results Ott obtained were respectively: 0, 0, 27, 13, 13, 28, 80, 55, 70, 63 and 77 dB attenuation of link A-K, relative to the connector A. The values we measure will vary somewhat in relation to Ott. To what extent the values vary between the terminals? Compare the results you got with the Ott's ones. Do the results seem reasonable? Can you point out possible causes of the differences that you find? (is the tendency the same, or is there a discrepancy? Explain any discrepancies.)

8. Measure the signal strength for type A-K at 20kHz, 500kHz and 2MHz. Record the results in a table and create a graphical representation of the development.
   a) How does the voltage of the function generator change for the different frequencies? (HINT: is the voltage source ideal or is there an internal resistance…?)
   b) How does the ratio between inductive and capacitive noise change with frequency? Explain.
   c) Some of the terminals perform worse in comparison to the others at high frequencies, while some are apparently better. What could be the reason? (Comment the special relationship between H and J).
   d) Compare these results with those from 50 kHz and those that Ott did. How and why do the characteristics of the various cables and termination types themselves change at higher frequencies?

9. Measure the signal strength at 20, 50 and 500 kHz and 2MHz for termination A, C and G with the pure coax cable. Put these results in a table together with the results for STP cable from the task 5 and 8. (In addition to measurement data you should make a row / column where you normalize with respect to A for each cable at the current rate).
   a) Which of the links G / C tells us most about the impedance of the shield being high or low? Explain your answer.
   b) Which of the cables (pure coax vs STP) has the lowest impedance in the shield? Explain the basis of your results.
   c) In the data sheet for STP cable is given a lead to lead capacitance of 112pF / m and capacitance between wire to shield of 220pF / m, while Coax have a capacitance of 54pF / m between wire and shield. How well does this fit with the measured results? Explain.

10. Measure the signal strength at 20, 50 and 500 kHz and 2MHz for termination A, D and H twisted pair (TP) - and speaker (HTT) cables. Write down the results. Make a table where you normalize the results with respect to A for each frequency and cable.

a) Should coupling D or H tell us most about the effect of twisting? (Explain your answer)
b) Have twisting any appreciable effect in this case, or are there other characteristics of cables that are more applicable here? Explain. (Hint: dielectric properties ...)

11. For cat5e cable, there are three pairs.

    a) Can you rank the green (white sleeve – pair 3), orange (yellow sleeve – pair 2) and brown (red sleeve – pair 4) wire pairs according to which has more twist per meter, only based on measurements of noise? Explain the termination card and frequency (s) you want and why you want to use these. Write down the results of the measurements and explain your findings.
    b) See "cat5e" in Wikipedia. (Http://en.wikipedia.org/wiki/Category_5_cable) Compare this result with your table "Individual twist lengths" from Wikipedia. Are the results in disagreement? Explain.
    c) The white sleeve contains both the green (pair 3) and blue (pair 1) pairs. Let's consider the shielding properties of the cables by using termination H and I. Measure the noise level using the two terminations for 20kHz, 50kHz, 500kHz, and 2MHz.
        a) Does the blue pair act as shield for the green pair? What shield effect can we see here?
        b) Compare this result with the difference between H and I in task 5 and 8. Explain any differences and similarities.

Pin	Pair	Wire	Color
1	2	1	white/orange
2	2	2	orange
3	3	1	white/green
4	1	2	blue
5	1	1	white/blue
6	3	2	green
7	4	1	white/brown
8	4	2	brown

Eating and drinking are not allowed in the lab!

Tidy up when you're done!

The lab should be left exactly as you found it:

- Ensure that all cables, terminal boxes and coils for this experiment are back in their box.
- Ensure that the oscilloscope is connected to the same probes as it was.
- Make sure that you did not leave anything!
- Turn off the function generator and oscilloscope.

☺ Takk! ☺

	Oscilloscope:
	Primary coil:

		Frequency			
		20kHz	**50kHz**	**500kHz**	**2Mhz**
	span				
	sampling freq.				
Cable	**Terminal**				

Table 1 Measured data

Tips: Insert all the results into a spreadsheet at once.