IN5230 – Mandatory Task 2

EM scanner

In this mandatory task, you will be using the EMxpert scanner to test the Electro Magnetic Interface (EMI) of different printed circuit boards (PCBs). The scanner is located in 5419 and each group will have its test board with the needed equipment. There are 2 lab weeks (??) and each group will be able to use the scanner one day per week (G1 – Mon, G2 – Tue, G3 – Wed, G4 – Thu, G5 – Fri). Don't lose time!

The reports will be handed in as groups. Please be clear in showing the results. With the report, you should also hand in the *.EMX file saved in EMxpert.
Email a zip (named GroupN_user1_user2_Task2_IN5230.zip) with the report in .pdf and the .EMX file to: jonheri@ifi.uio.no and cc joar@ifi.uio.no

Deadlines

The deadlines for handing in the reports is:

To be announced!

Important information

The computer to be used is the HP UiO116420.
The username is *stoy* and the password is *stoystoy*. You can use the Group1-5 folders in 'C:\IN5230stud' to save your project and data. You have read/write permissions on the PC, so PLEASE BE CAREFUL and do not touch/delete other groups' folders.

Bill of Material

In the bag on top of the scanner you fill find all the needed material:

- Demo Board
- 2 COAX cables (short and long)
- USB charger
- Conductive tape
- Aluminium foil
- Paper tape
- Magnets

Please tidy up and place everything back when you are done using the material. Unplug the laptop and switch it off, switch off and unplug the scanner, and unplug the USB charger when you are done.

Setup

1. Power up the EMxpert using its transformer (labelled).

2. Connect the EMxpert to the PC with the yellow ethernet cable.
3. Place the test board on the scanner with the top left point as reference. Fix the board to the scanner with the paper tape so that it is more stable.
4. Power up the board with the mini USB plug from BRD#01/BRD#07 (depending on the exercise) using the charger.
5. Switch on the EMxpert (wait around 1 minute for scanner initialization until front LED becomes green) and open the EMxpert64 program from the Desktop. When the software is connected to the scan it shows the IP address on the lower left window.
6. Change the settings of your Project by right click → settings (settings are hierarchical, so everytime you add a new node to the project node the settings will be inherited.)

Spectral Scan

The spectral scan allows the user scan the PCB at some locations in a wide frequency range. It outputs a spectrum of the EM.
SET *Start frequency = 10MHz*, *Stop frequency = 200MHz*, and *RBW=122.070 kHz* (bandwidth steps).
ENABLE *Interleaved Scan* by selecting the box .
(the scanner has two sets of antennas oriented at 90deg shift. Interleaved scan makes sure that each set of antennas is run on all positions to measure the readings)
Leave everything else as it is (ERX control level is the spatial resolution of the scan).

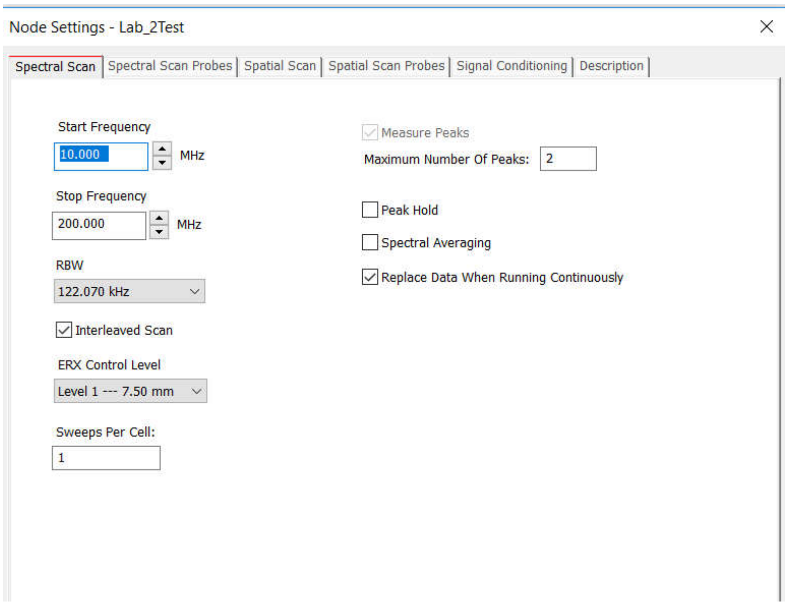

Figure 1 Spectral analysis settings

Spectral Scan Probes

In this section one can configure the points in which the spectral measurements are recorded. As you will analyse different boards separately, CLICK *Select None*.
SET *Overlay editor* to import the demo board image in the program. The image is in *'C:\EMSCAN\IN5230 DemoCard\DemoBoardGerb'*
ADJUST the image so that it corresponds to the same coordinates on the scanner.

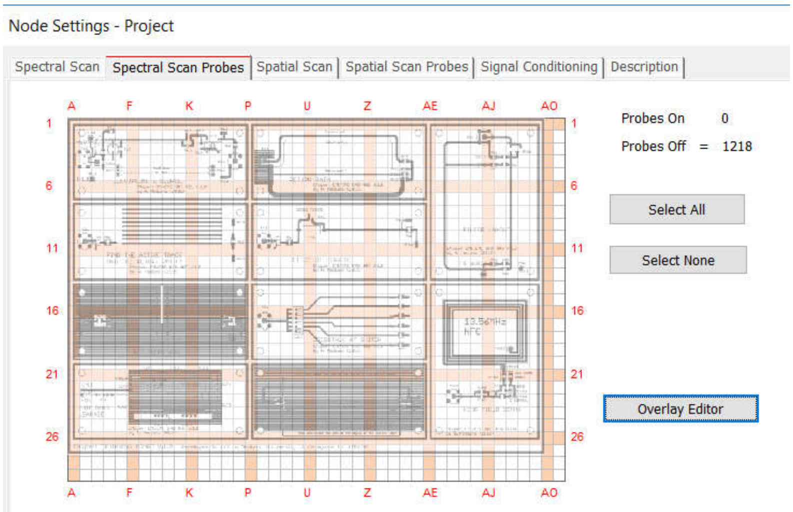

Figure 2 Spectral Scan Probes settings and Overlay Editor

Spatial Scan

The spatial scan allows the user to scan a selection of locations at a certain frequency.
SET *Center frequency = 20MHz.*
ENABLE *Interleaved Scan* by selecting the box.
Leave everything else as it is (ERX control level is the spatial resolution of the scan).

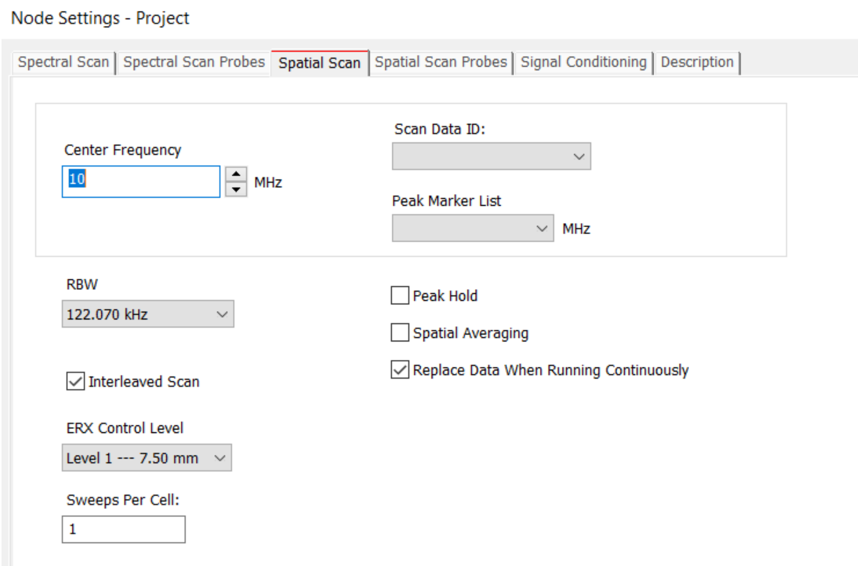

Figure 3 Spatial Scan settings

Spatial Scan Probes

In this section one can configure the points in which the spatial measurements are recorded. As you will analyse different boards separately, CLICK *Select None*.
SET *Overlay editor* to import the demo board image in the program. The image is in *'C:\IN5230stud\Educational Board V.4.0 OVERLAY.jpg'*
ADJUST the image so that it corresponds to the same coordinates on the scanner.

LEAVE the **Signal Conditioning** section as it is and use the **Description** Tab to change the name of the project (and add a description/comments).

For each of the following exercise create a new node (project→right click→add node→module) and change the name in the description to the exercise number. Within each exercise module, you can add a new simulation by creating a new node (e.g. exercise 1→add node→Spectral to create a spectral simulation). The settings are inherited from the project settings, but you have to select the scanning positions for the spectral and spatial probes.

Exercise 1

Before doing any noise measurements, it is a good practice to measure the ambient noise. Unplug the demo board and run a Spectral Scan. Choose a few random points (<10) spread on the board to perform the recordings. How does the noise look like? Are there particular interferences at certain frequencies?

Exercise 2

In this exercise you will be testing BRD#01. This is the schematic of the board.

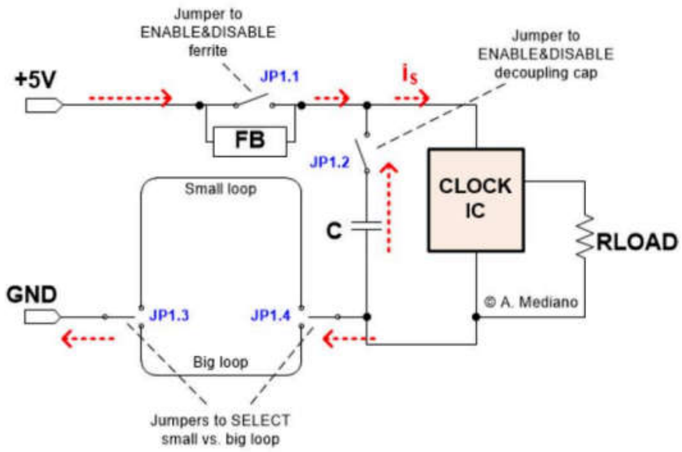

Figure 4 Schematic of board 1

The board contains a 20MHz clock generator (IC1.1). And a decoupling network that can be connected/disconnected using jumpers. Power up the board and probe the clock signal with the oscilloscope at test point TP1.3 (ground is at TP1.4). Set the Spectral Scan Probes and the Spatial Scan Probes as following:

Figure 5 BRD#01 spatial probes

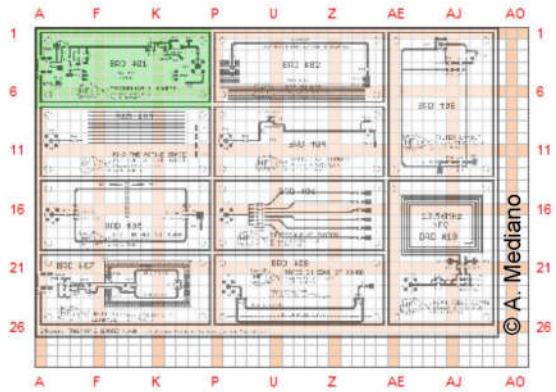

Figure 6 BRD#01 spectral probes

a) Disable the decoupling network made of a ferrite and a capacitor (JP1.1=ON, JP1.2=OFF) and select the BIG LOOP for return current. This is the worst situation in terms of EMI. Run a spectral scan with the probes shown in Figure 5.
How does the spectrum look like? Is it expected?

b) Now focus on a specific frequency based on the spectrum and run a spatial scan. In the Spatial Scan Probes settings select the entire BRD#01 as shown in Figure 6. Zoom in the board by selecting the region of interest. Can you identify the current paths? (A good tool to spatially visualize the noise is the 3D View! You press ctrl and scroll up and down with them mouse). Write down the scale of the noise on the right of the spatial plot.

c) Now activate the decoupling network made of a ferrite and a capacitor (JP1.1=OFF, JP1.2=ON) and run the spatial scan. What is the difference (remember to adjust the scale!)? You can also run a Spatial Comparison (for spatial comparison scanning frequency needs to be equal) by adding the Spatial Comparison node. Then for each previous spatial scan right click→copy scan data and paste them in the comparison window. Use the worst situation as test and the decoupling as reference.

d) Use the SMALL LOOP return path and run the spatial scan. Is the difference large compared to point c)? Is it more relevant to reduce noise to have a proper decoupling network or a well-designed return path?

Exercise 3

For this exercise you will be analysing BRD#05. In this example there are two return paths: one is *clean* and the other has a slot in the ground plane. This is the schematic:

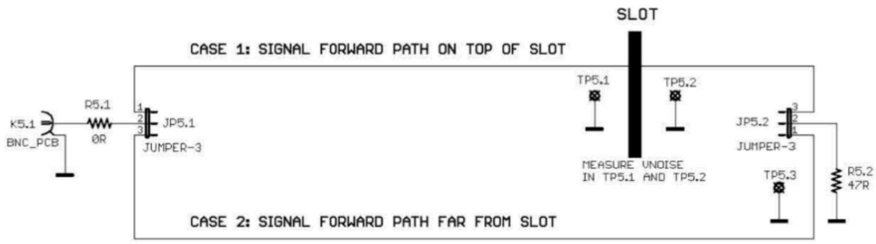

Figure 7 Schematic of board 5

Connect the clock source from BRD#01 to BRD#05 using the short coax cable through the BNC connectors. You should set the spatial scan probes as follows:

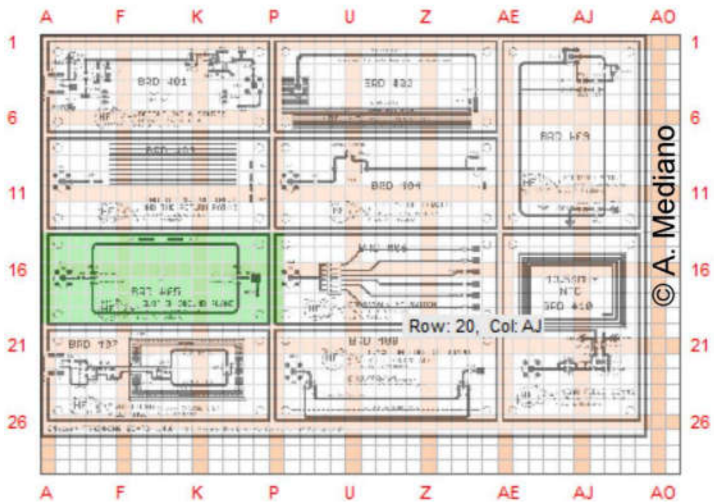

Figure 8 Spatial scan probes for BRD#05

a) Select the return path without the slot using the jumpers. Run a Spectral/Spatial scan. This type of scan combines the spectral and spatial scans and the plot shows the frequency in which the largest noise was found when you pass on it with the cursor. What is the frequency with the largest noise level? Can you identify the return path?

b) Now select the return path with the slot and re-run the spatial/spectral analysis. What is the effect of the slot? Is the noise level increased? Why?

c) This imperfection in the ground plane can be *fixed* using conductive tape. Try to patch the slot (on the bottom of the board) with the provided conductive tape and run the simulation (be careful in flipping the board and applying the tape on the entire slot). Compare the results with a) and b).

Exercise 4

In this exercise you will be testing BRD#07 and the effect of shield leakage. The schematics is:

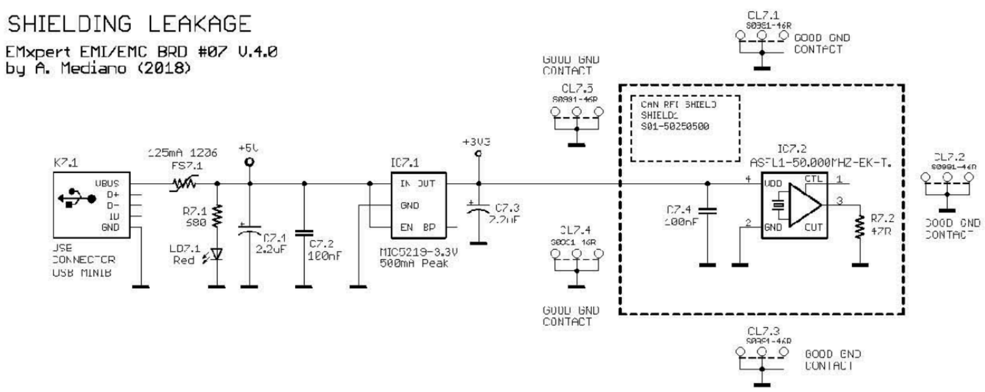

Figure 9 Schematic of board 7

The circuit is powered up by the USB port and it has some protection circuits (FS7.1), a voltage regulator (IC7.1), and a clock generator.

Set the spectral and spatial scan probes as follows:

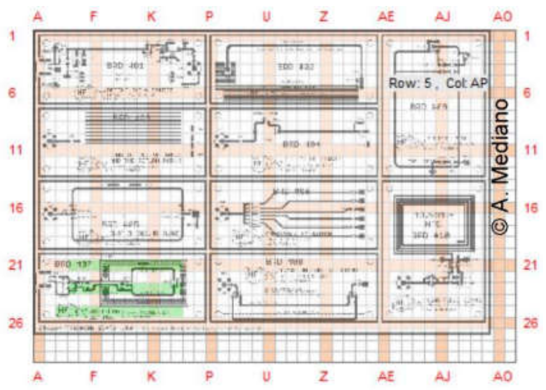

Figure 10 Spectral scan probes for BRD#07

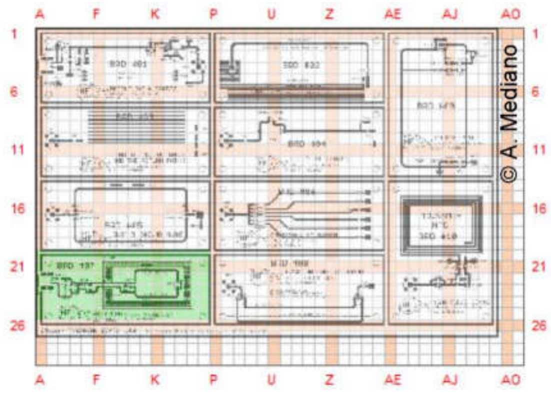

Figure 11 Spatial scan probes for BRD#07

a) Run a spectral scan between 10 and 500 MHz. Where are the main peaks? Can you identify the clock frequency from it?

b) Now run a spatial scan with center frequency at the fundamental frequency of the clock signal. Is the shield doing its job? Can you identify a leakage (Use 3D view!)? Inspect the board for possible sources of the leakage (you can remove the shield with the screwdriver and look at top and bottom layer).

c) Try to fix the leakage (HINT: exercise 3c!). Re-run a spatial simulation and compare with point b).

Exercise 5

In this exercise you will use the EM scanner to test the performance of an NFC antenna (BRD#10). For this task you will need the function generator in the lab. The schematic is:

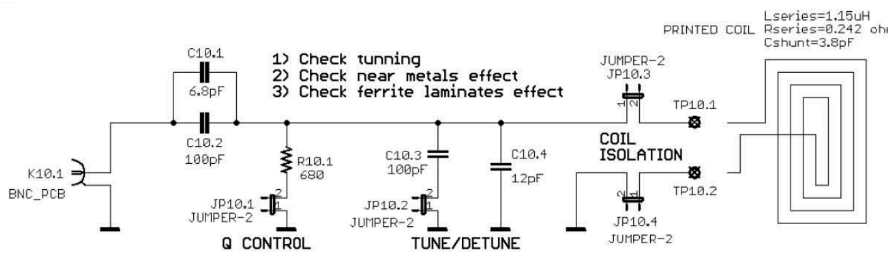

Figure 12 Schematic for board 10

And the probe scans should be set as follows:

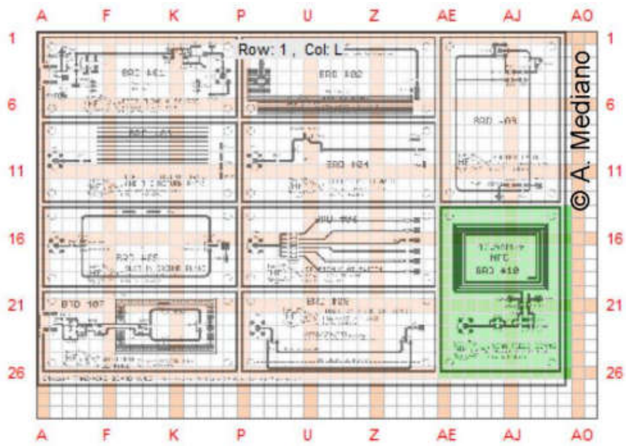

Figure 13 Spatial scan probes for BRD#10

The NFC antenna printed on the board has a center frequency of 13.56MHz. The antenna is connected to a resonant circuit with matching network composed by C10.1, C10.2, C10.3, C10.4, and R10.1. Set up the function generator (HP 33120A) to deliver a sinusoid function at 13.56Hz: select SINUSOIDAL waveform, FREQ=13.56 MHz, and AMPL=3.1 Vpp. Set some global settings for the module: in spectral scan, scan frequency from 13 to 14 MHz with 1.906 kHz RBW. In the spatial scan set the center frequency to 13.56 MHz and RBW to 15.259 kHz. Always make sure that *Interleaved Scan* is selected.

a) Connect the function generator to the board using a long coax cable through the BNC connector. Make sure the coil is connected (JP10.3=ON, JP10.4=ON) and run a spectral scan selecting recording sites close to the antenna: Set the scanning frequency between 13 and 14MHz with a 1.906 kHz step. What do you observe?

b) Now run a spatial scan with center frequency to 13.56 MHz. Set JP10.1=OFF, JP10.2=OFF (JP10.3=ON, JP10.4=ON). What is the result of the simulation? Would you call what you observe *noise* or is it what you expect?

c) Now set the JP10.2=ON, which creates a mismatch in the matching network for the antenna. Repeat the simulation. Do you find any difference? Is it a good or bad situation for an antenna performance?

d) Try to repeat the simulation a), but this time investigate how a conductive foil (aluminium) and small magnets affect the field. You can place foil strips on top of the PCB or on the bottom (WARNING: be careful not to short circuit anything!) and cover different parts of the coil or all of it. Place the magnets on top of the board on different positions. Comment on your results.

Exercise 6 (mandatory for PhD, optional for master)

In this exercise you will use the EM scanner to test the noise implications of PCB design in terms of trace (BRD#08). The schematic of BRD#08 is the following:

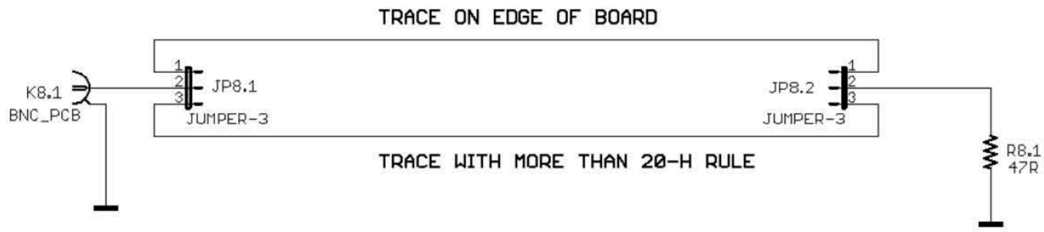

Figure 14 Schematic of board 8

Connect the clock source from BRD#01 to BRD#08 using the short coax cable through the BNC connectors. You should set the spatial scan probes as follows:

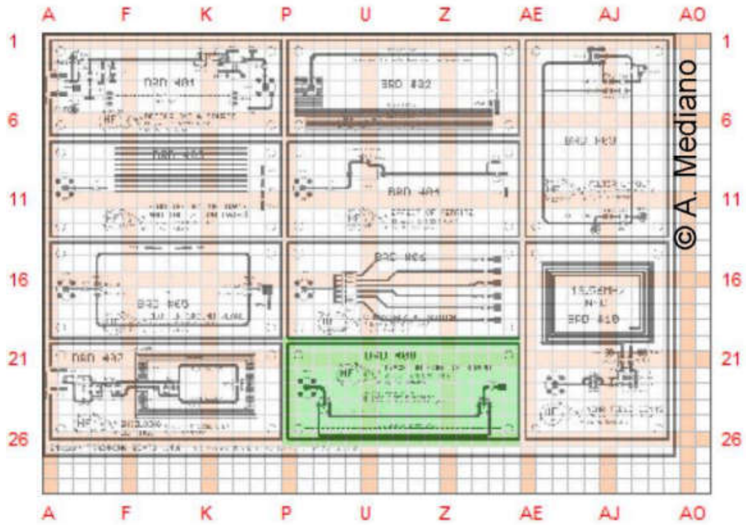

Figure 15 Spatial scan probes for board 8

a) Set the jumpers JP8.1 and JP8.2 to (1). In this configuration the return path is routed close to the edge of the board. What is the effect in terms of EM noise?

b) Now select the jumpers to path (2). In this case the signal is routed far from the edge. Compare with point 1) and explain the difference (HINT: *fringing effect*).