EMC

Laboratory exercise 1
Spectrum analysis

Biomedical Engineering
LTH

Laboratory excercise 1: Spectrum analysis

The laboratory exercise is about measurements using a spectrum analyzer, and it is divided into three parts:

- Measurements of pulse-trains.
- Measurements using nearfield-probes at an ”unknown” device.
- Measurements of emissions from various rapid logic circuits.

Below, you are given a mandatory preparatory assignment and a number of tasks to solve/measure and these are to be presented in a laboratory report (see below for details) in order to pass this laboratory exercise.

Readings

Williams, "EMC for product designers"
Chapter 6, pp 118-26, 139
Chapter 10, pp 232-241
Chapter 11, pp 268-287
Chapter 12, pp 288-306
Carlson & Johansson, ”Elektronisk mätteknik” *(in Swedish only, not necessary but useful)*
Chapter 8.2, pp. 423-436

Preparatory assignment

Draw a schematic diagram of the spectrum analyzer. Explain briefly what the functions of the different blocks are, and how they interact with each other.

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 (description of 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.

Equipment

Siglent SSA 3021X spectrum analyzer with built-in tracking generator 9 kHz – 2.1 GHz.
Spectrum analyzer HP 8591 EM
Digital oscilloscope Tektronix 1002 or 2002
5Vpower supply
“unknown” circuit board
Pulse generator with variable rise-/fall-times
Circuit board with 74LS04- respectively with 74F04-inverters (of which at least one with a ground plane, and one without ground plane, in all three circuit boards per group)
Ferrite clamp

Please note!

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

The spectrum analyzer

Before connecting a signal to the spectrum analyzer a 20 dB attenuator must be connected to the input. If this is not done, high voltages may destroy the input stages of the instrument.

1. How are signal levels indicated in the analyzer? Where on the screen is the reference level? Please calculate the maximum allowable voltage level at the input.

2. Connect a 1 MHz square wave from a function- or pulse-generator. How does the filter bandwidth influence the noise level? How is the sweep time altered? How is the width of the peaks altered? Why?

Measurements of pulse-trains

The signal is taken from a pulse-generator with variable rise- and fall times.

3. Make a measurement of a 1 MHz square wave signal, 50% duty cycle and compare the spectra of a 10 ns respectively of a 100 ns rise-/fall time. How is the frequency content changed due to the duty cycle? Compare with the theoretical breakpoints of the spectrum envelope discussed at the lecture. The adjustments of duty cycle, rise- and fall time is best done using an oscilloscope with automatic measurement functions.

Measurements on an "unknown" device using near-field probes

The unknown circuit is connected to a 5V power supply. Connect the near field probes to the Spectrum analyzer without attenuator

4. Measure near-field emission from the board using E-field and H-field probes. Identify the sources of noise and determine which fundamental frequencies that are present. Draw a schematic "map" of the emission from the board. Describe the shortcomings of the design and suggest improvements.

5. Measure the emission from the power supply cables, e.g. close to the power supply unit. Try to attenuate the noise e.g. by a ferrite. Are the emissions of differential mode or common mode type?

Measurement of emissions from differently rapid logic circuits

Two prototypes are available with connection from a gate output to a gate input of inverting TTL-circuits. One of the circuits has two 74LS04 inverters with a rise/fall-times of 9 ns and the other one has two 74F04 inverters with a rise-/fall time of 3 ns. The circuit boards are to be powered by the 5 V power supply.

6. Connect a 1 MHz Clock signal to the first inverter. Study the emitted spectrum. Is it differential mode or common mode? How is the spectrum/noise levels influenced by the layout of the circuit board and routing of the signal? How can the emissions be minimized?

7. Compare the spectra from the two types of ICs (LS and F). Conclusions?

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