

EMC problems, Decoupling Capacitors & Discontinuities

1. Objectives

Getting acquainted with the operation of the VNA (Vector Network Analyzer);
Understanding the properties of a capacitor as a filtering/decoupling element;
Understanding the importance of line matching in RF circuits.

2. Components and instrumentation.

VNA working up to 6 GHz is used in the exercise. One of the goals of the exercise is to learn its basic properties through trial and error.

3. Preparation.

Estimated preparation time for classes is 2 to 6 hours.

3.1. Reading

[1] Understanding Electromagnetic Effects using PCB demos.pdf; chapters 8,7,9,11.

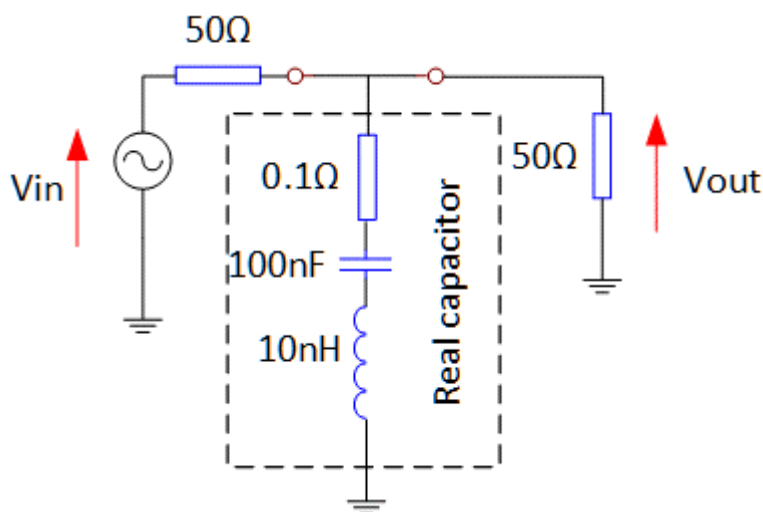
[2] What Are Vector Network Analyzers VNAs Explained Tektronix.pdf

3.2. Problems

1. What is the general idea of VNA operation principle ? ?
2. What is the equivalent circuit of real capacitor ?
3. What is the input impedance of transmission line (open, shorted, matched) ?

3.3. Detailed preparation

Analyze in LTspice (or like program) the circuit in Fig. below. Calculate the transfer function $|V_{out}/V_{in}|$ (in dB vs. frequency in log scale). Figure out the relationship between the shape of transfer function and real capacitor parameters ESR and ESL.



4. Contest of rapport

4.1. *Discontinuities – Stubs (chapter 11 in [1])*

- Make screenshots for every case of transfer function of “track PCB”;
- Compare attenuation for matched and unmatched tracks;
- Answer the questions (floating tracks):
 - How to avoid resonances ?
 - What is relationship between resonant frequencies and lengths of floating tracks ?
 - Results put into a table:

Length of floating track [mm]	Resonant frequency [MHz]

4.2. *Board (chapters) 8 - ESL and ESR of capacitors.*

- Make plots of capacitors impedance (transfer function of the circuit vs. frequency (logarithmic scale).
- Calculate ESR and ESL for every capacitor (except of electrolytic);
- Answer the questions:
 - For what frequencies the capacitor is good to be used as decoupling element ?
 - Is there any relationship between ESL and PCB assembling ?
- Results put into a table:

Capacitor (value and description)	Resonance frequency [MHz]	ESL [nH]	ESR [mΩ]	Decoupled frequency band (capacitor is good as decoupling element) [MHz]