Electromagnetic Compatibility
Problem Set 6

Problem 1: Evaluation of decoupling capacitors

In the transition phases, the drive current in an integrated circuit is 33 mA during 3 ns. Compute the value of the decoupling capacitor in order to limit the decrease of the supply voltage to 0.01 V. Assuming that the parasitic inductance is 30 nH, compute the resonance frequency.

Problem 2: EM radiation from digital circuits

A 5-MHz clock signal characterized by a rise/fall time of 5 ns circulate in a 1-m long ribbon cable. The two conductors of the cable are separated by a distance of 0.125 cm. The peak current is 25 mA. Compute in $dB_{\mu V/m}$ the radiated electric field at a distance of 3 m from the cable at a frequency of 100 MHz.

Problem 3: Global electric circuit

The earth's surface and the ionosophere form a charged spherical capacitor. The ground is normally negatively charged during fair weather. Positive charge is found in the air between the ground and the ionosphere (the charge would normally be found on the second electrode in a typical capacitor). Negative charge on the ground and positive charge in the air above means that there is a downward pointing, 100 to 300 volts/meter (V/m) electric field (E field) at the ground during normal fair weather conditions. Let us assume that the field is 200 V/m.

a) Calculate the total current flowing between the ionosphere and the earth's surface. The air conductivity is assumed to be $2x10^{-14}$ S/m.
b) Calculate the total charge on the Earth's surface.
c) Using the results obtained under a) and b), calculate the discharge time for the current to neutralize the charge on Earth?
d) What keeps the Earth-Ionosphere charged up?
e) An electric field of 200 V/m means that there is a voltage difference of 400 V between the ground and a point 2 m above it. That would be about 400 V difference between our head and our toes. Why don't we feel this?

Problem 4: Direct lightning on a power line

A direct lightning strikes an overhead power line 50 km from its termination. For simplicity, let us assume a triangular shape of the lightning overvoltage waveform with a risetime of 1 µs and a fall time of 10 µs. The peak current is low (2.5 kA), so that we can neglect any flashovers across insulator strings. The line is terminated on a transformer. For fast transients, a transformer has a capacitive behavior, which, at early times, can be approximated as an open circuit. The characteristic impedance of the line is 400 Ohms. The line is assumed to be enough long so that we do not see the effect of the other termination within the considered time frame.

a) What is the peak value of the overvoltage on the transformer?
b) Assume we install a surge arrester at 300 m from the transformer. Calculate the voltage at the position of the surge arrester prior to its installation. Represent graphically this voltage and the voltage across the transformer.
c) Discuss the impact of the surge arrester assuming it has a residual voltage of 600 kV.