Plane wave illumination effects onto circuit topologies

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Extended Summary

With the increasing use of wireless devices and services, the impact of electromagnetic coupling and interference on active circuits in the presence of ambient radiation should be carefully investigated. This interference can be intentional or unintentional and could result in distortion of the output signal for analog devices and their improper functionality leading to digital circuit logic errors. In this paper, we propose a hybrid finite element boundary integral (FE-BI) method for the analysis of EM coupling from external plane wave on passive circuit elements such as a microstrip interdigital filter and a coupled microstrip line filter. The input and output ports of both the microwave interdigital filter and the coupled microstrip line filters are terminated with 50Ω resistive loads. An induced voltage of 3.65 mV and 13 mV are respectively computed at the output of the microstrip interdigital filter and the microstrip line coupled filter. In both cases, the illuminating plane wave has an amplitude of 1V/m and the resonance, where the maximum induced voltage is computed, is close to the designed resonance of the microwave filter circuits. These induced voltages can therefore be significant when a 100 V/m plane wave intensity is considered.

This analytical study is further extended to a low noise amplifier (figure1) operating with a gain of 11 to 12 dB from 8 to 12 GHz. Induced voltages at the gate and drain terminals of the FET are computed with the FE-BI method at various levels of plane wave illuminations. Next, these voltages are modeled as extraneous sources with a single-tone harmonic balance simulation to evaluate the effect on the LNA gain due to external plane wave illuminations. We observed that as the amplitude of the plane wave increases, the distortion at the LNA output increases. When the LNA is connected to other digital and analog circuits, such EM interference and coupling may therefore result in bit errors at the output. A study on the degree of non-linearity introduced to the LNA circuit is also performed. In this study, the LNA operates at 10 GHz (f_1) while a 9.5 GHz (f_2) 50V/m external plane wave with the same orientation and polarization as before is used to illuminate the LNA. A two-tone harmonic balance simulation using the induced voltages at the gate and drain of the LNA indicates that the plane wave can introduce significant non-linearities within the LNA circuit with an IP3 intercept point at 40 dBm instead of infinity for an ideal linear amplifier (in the absence of radiation).

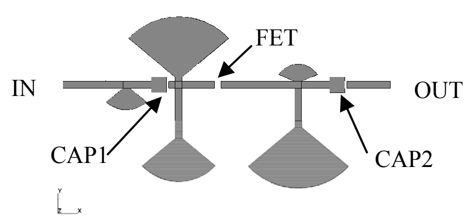

Fig 1: Layout of the LNA used for studying plane wave illumination effects.