Using Electric and Magnetic “Moments” to Characterize IC Coupling to Cables and Enclosures

T. Hubing (1), S. Deng (2), and D. Beetner (3)

(1) Clemson University
(2) Juniper Networks
(3) University of Missouri-Rolla
Introduction

- ICs are often the source of radiated energy, but usually not the “antenna”.

- ICs couple to the structures that serve as antennas conducted, electric-field, or magnetic-field coupling.

- The electric and magnetic field coupling from an IC can be quantified by measurements using a TEM Cell and a hybrid coupler.

- These measurement results can be expressed as electric or magnetic moments that fully describe an ICs ability to couple to nearby objects.
A hybrid can be used to differentiate electric and magnetic field coupling.

The A-B output indicates the amount of magnetic field coupling.

The A+B output indicates the amount of electric field coupling.
Hybrid TEM Cell Electric Field Coupling

\[ |V_{IC}| \omega C_{TEM} \approx \frac{|V_{measured}|}{25} \]
Hybrid TEM Cell Magnetic Field Coupling

(a.)

(b.)

Magnetic Moment

\[ |V_{\text{measured}}| = |I_{IC}| \omega M_{\text{TEM}} \]
Measurement Test Set-Up
Model vs. Measurement
Maximum Emissions Estimate

![Diagram of antenna and frequency response graph with labeled axes and curves indicating emissions levels at different frequencies for various cable lengths.]
Conclusions

- Measurements of an integrated circuit in a hybrid TEM cell configuration can be used to obtain values for the “electric moment” and “magnetic moment” associated with an IC as it is configured on a given circuit board.

- ICs with smaller moments are less likely to couple to other parts of a system resulting in unintentional radiated emissions.

- Electric and magnetic moments can be used in full-wave electromagnetic models of a system, replacing complex IC-package geometries with simple equivalent sources.