EMI Parameters for IBIS

DesignCon 2002

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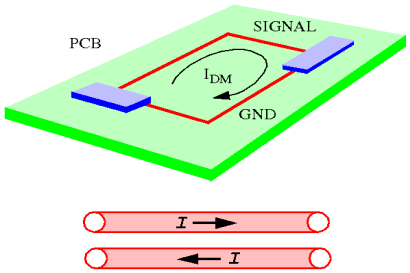
Introduction

- This is part 2 (of 2).
  - Part 1 was given at DAC 2001.
- EMI is too complicated for today's computers to simulate.
  - You can use a Cray and simulate for 10 years, but engineers (and companies) want answers sooner than that, preferably within a few minutes. So some assumptions are necessary.
- Use easily obtainable parameters.
  - Want IC vendors and users to be able to create models easily and quickly.
- All the parameters are optional.
  - The more you have the better the analysis.
  - Some are more important than others.

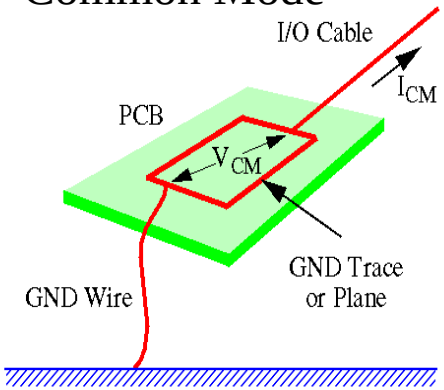
Radiation Modes

Differential Mode



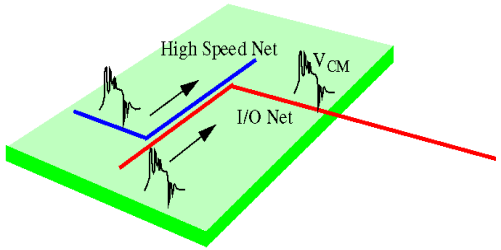
On surface layers, the current loop formed by the signal trace and its associated return path will radiate as a loop antenna.

Current-Driven Common Mode



On surface layers, the return current on a return plane due to a signal current induces a ground voltage differential across the return plane. This *noise* voltage will drive external cables.

Voltage-Driven Common Mode



High frequency voltages on an I/O trace due to X-talk or the I/O signal itself drive the off-board signal wire against GND/PWR plane of a board.

EMI Mechanisms

- Differential Mode
  - Direct radiation from signal loops.
- Current-Driven Common Mode
  - Signal return currents create noise voltages across finite return planes that drive attached cables.
- Voltage-Driven Common Mode
  - Signal voltages and noise voltages due to crosstalk drive attached cables.
- Power Bus
  - Digital switching creates power bus noise.
- Heatsinks
  - Act as antennas driven by potential differences on the return plane.
- Crosstalk
  - Coupling among nearby traces.
- Immunity
  - ESD, Magnetic and Electric Field Susceptibility.

Differential Mode

The differential mode EMI from a net is estimated based on the far field approximation as follows:

$$E_{DM}(f) = \frac{3x10^{-14} I(f) f^2 ls}{r}$$

where I is current, f is frequency, l is trace length, s is signal return distance, and r is antenna distance.

References

[1] J.L. Drewniak, T.H. Hubing, and T.P. Van Doren, "Investigation of Fundamental Mechanisms of Common-Mode Radiation from Printed Circuit Boards with Attached Cables," *Proceedings of the 1994 IEEE International Symposium on Electromagnetic Compatibility*, Chicago, IL, August 1994, pp. 110-115.

[2] C.R. Paul, *Introduction to Electromagnetic Compatibility*, John Wiley Interscience, New York (1992).

[3] D.M. Hockanson, J.L. Drewniak, T.H. Hubing, T.P. Van Doren, F. Sha, C.-W. Lam, and L. Rubin, "Quantifying EMI Noise Sources Resulting from Finite-Impedance Reference Planes," *IEEE Transactions on Electromagnetic Compatibility*, vol. EMC-39, no. 4, November 1997, pp. 286-297.

[4] C.R. Paul, "Printed Circuit Board EMC.", *6th Symposium on EMC*, Zurich, March 1985.

[5] H.W. Ott, *Noise Reduction Techniques in Electronic Systems, 2nd Edition*, John Wiley Interscience, New York (1988).

Proposed (additional) EMI parameters

- Component
  - **Voltage Range**
    Describes the voltage range of a driver (or bi-directional output).
    Note that these voltages are not necessarily the same as the power rails. E.g. for ECL the power rails are 0V and 3.3V, but the voltage range is 1.625V to 2.375V.
  - **Component Type**
    Indicates whether the component is a connector.
  - **Domain**
    Defines whether the component is Analog, Digital or both.
  - **Family**
    Describes the logic family. This can be one of UNDEF, TTL, CMOS or ECL.
- Model
  - **Ferrite**
    Indicates that the model for this pin is a ferrite.

Examples

- Example 1

```
[Component EMI]
Voltage_range       1.625   2.375
Component_type      Active
Domain              Digital
Family              ECL
Cpd                 6.4pF
```

- Example 2

```
[Pin EMI]
 1                  shielded
 4                  type37

[Model EMI]  type37
Model_emi_type      Ferrite
```

What's next?

- Prepare a more detailed specification
  - Need to add more details as to why these parameters are important.
  - How to measure, and where to find, the parameters.

- Submit a Bird
  - Currently in preparation.

INNOVEDA.