I. EMC ISSUES

EMC ISSUES

EMC OF ICS IS 50 YEARS OLD
Air Force Weapon Laboratory, USA
SPECTRE

- Effects of the electromagnetic fields trigged by nuclear explosions on electronic devices
- Simulation software developed at IBM (Sedore, 1965)
- Correlate simulations and experimental measurements obtained on an electromagnetic impulse test-bench.

I. EMC ISSUES

II. EVOLUTION OF ICS AND CONSEQUENCE ON EMC

III. MEASUREMENT OF IC EMISSION AND SUSCEPTIBILITY

IV. MODELS FOR EMC SIMULATION

V. DESIGN GUIDELINES FOR IMPROVED EMC

VI. CONCLUSION

SUMMARY

1. EMC ISSUES

2. EVOLUTION OF ICS AND CONSEQUENCE ON EMC

3. MEASUREMENT OF IC EMISSION AND SUSCEPTIBILITY

4. MODELS FOR EMC SIMULATION

5. DESIGN GUIDELINES FOR IMPROVED EMC

6. CONCLUSION

TOULOUSE

Airbus A380 (heavy airplane)

Cassoulet (heavy food)

Rugby (heavy efforts)

TOULOUSE

Founded in -120 B.C (heavy history with 4 golden periods)

Best place to study in France (2011-13 rankings)

(heavy responsibility)

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SUSCEPTIBILITY

EMISSION
III. MEASUREMENT OF IC EMISSION & SUSCEPTIBILITY

STANDARD EMISSION MEASUREMENT METHODS

- IEC 61967-2 (TEM : 1 GHz)
- IEC 61967-3/6 (Near-field Scan, 5 GHz)
- IEC 61967-4 (1/150 Ω, 1 GHz)
- IEC 61967-8 (Mini-stripline)
- IEC 61967-7 (Mode Stirred Chamber : 18 GHz)
- Ext : IEC 61967-2 (GTEM 18 GHz)

MEASUREMENT OF EMISSION

A Zoom on Near-field Scan

SMALL MAGNETIC PROBE (IEC 61967-3, -6)

MEASUREMENT OF SUSCEPTIBILITY

IEC STANDARDS FOR SUSCEPTIBILITY

SUSCEPTIBILITY CHARACTERIZATION

Much more complex and time consuming than emission: example of one DPI

ZOOM ON DPI

ZOOM ON NEAR-FIELD IMMUNITY

SUSCEPTIBILITY CHARACTERIZATION

Near-field immunity coupling up to 6 GHz using a small loop (IEC 62132-9)
IV. MODELS FOR EMC SIMULATION

IBIS – ELECTRICAL IC BEHAVIOUR FOR SIGNAL INTEGRITY

Parameters

IBIS – LINK TO EMC

IBIS – LINK TO EMC

IEC STANDARD MODEL APPROACH

IEC 62 433 – EMISSION (ICEM) AND IMMUNITY (ICIM) MODELS

EMC SIMULATION FLOW AT IC LEVEL

The DUT is isolated on a simple EMC board to minimize modeling effort.
EMISSION CASE STUDY

INFINEON TRICORE™ - TEM CELL MODEL
Capacitance coupling to the TEM cell

Conversion to Win-SPICE
Analogue Time Domain Simulation
Fourier Transformation
dB vs Freq (log conversion)

Core current model

EMISSION CASE STUDY

INFINEON TRICORE™ - TEM CELL EMISSION
Infineon TriCore™ measurement/simulation comparisons

Radiated noise in GTEM cell (dBµV)

Correct envelop
Reasonable match
Simulation 15 dB above measurement starting 700 MHz
Manual fit leads to 5 dB max difference

IEC STANDARD MODEL APPROACH

IEC 62433-4 – “ICM CONDUCTED IMMUNITY”
Based on ICEM, add non-linearities

Close to ICEM
Add Diodes (camp, back-to-back, ESD, ESD)

Close to ICEM
New!

IMMUNITY SIMULATION

S12X CASE STUDY – DPI ON AN INPUT

• 16 bit micro-controller
• Direct power injection
• Input buffer aggression
• Sinusoidal mode
• Simulation criterion: Logical change of input buffer

From A. Boyer’s PhD, INSA, 2007

DOWN-SCALING TO MULTI-DIES

VI. DESIGN GUIDELINES FOR IMPROVED EMC
Why: because inductance is a major source of resonance
Where is the inductance: in each conductor, worst is far from ground

GUIDELINE 1: REDUCE THE INDUCTANCE

GUIDELINE 2: PLACE VDD/VSS CLOSE TO STRONG DI/DT

Tools required to forecast strong di/dt effects

GUIDELINE 3: PLACE VDD-VSS CLOSE

- to reduce current loops that provoke magnetic field
- to increase decoupling capacitance that reduces fluctuations

GUIDELINE 4: USE ONE VDD/VSS FOR 10 I/Os

FPGA CASE STUDY

Good design: moderate noise during IO switching

Poor design: x 5 mode switching noise

© Dr. Howard Johnson, “BGA Crosstalk”, www.sigcon.com
DESIGN RULES

GUIDELINE 5: BALANCE VDD/VSS PINS

Fail
Correct

Fail

Fail

Correct

• 1nF added close to the core
• More than 15 dB noise reduction

B. Vrignon CIESAR test-chip IEEE Trans EMC 2006

GUIDELINE 5: PLACE ON-CHIP DECOUPLING CLOSE TO STRONG DI/DT

GUIDELINE 6: ADD JITTER ON THE CLOCK

RC filtering works both for emission and immunity

Ali ALAELDINE, PhD Eseo France

GUIDELINE 7: ADD RC FILTERING AT WEAK POINTS

LOW ENERGY EMI

• 1000 V/m, 1 cm antenna
• 10 V RFI
• Diodes turned on
• Parasitic currents
• Signal faults
• Thermal effects
• Minor instability
GUIDELINE 9: NEVER TRUST YOUR R,L,C DESIGN RULES

- Higher complexity and frequencies, technology scale down make EMC more and more challenging
- EMC starts to be investigated in the design flow
- Mature standard measurement methods dedicated to ICs
- New standards for EMC modeling at IC level
- Good prediction of emission and susceptibility up to 2 GHz
- Research need to extend these methods to 18 GHz

CONCLUSION

Standards www.iec.ch
- IEC 61967, 2001, Integrated Circuits emissions
- IEC 62132, 2003, integrated circuits immunity
- IEC 62433, 2006, Integrated Circuit Model
- IEC 62215, 2009 Transient immunity

Books
www.springeronline.com
www.emccompo.org
EMC Compo in Dec, 2013 Nara Japan

Tools
www.ic-emc.org

REFERENCES

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