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Driver Pre-emphasis Techniques for On-Chip Global Buses

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Outline

- > Global interconnects
- > Driver pre-emphasis technique
- > Demonstration

u Single-ended voltage-mode (VM) busu Differential current-mode (CM) bus

> Summary

Global Interconnect: Delay



Global Interconnect: Power



- > 180nm (20K to 70K repeaters, 50W)
 ->50nm (1000K repeaters, 100W/cm²)
- > Power consumption and heat removal have become 1st order limiter to "Moore's Law".

Driver Pre-emphasis Technique



Driver Pre-emphasis Technique



Driver pre-emphasis increases the -3db bandwidth of a distributed RC interconnect channel from 0.5GHz to 1GHz

Driver Pre-emphasis Technique



Driver pre-emphasis decreases the latency of a10mm-long line to 411ps, a 26% and 19% improvement over lines with one repeater and four repeaters, respectively.

Circuit Implementation



Die Photo



Measurement Result



Interconnect with no repeater

with one repeater

with driver pre-emphasis

Power Dissipation



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Differential Current-Mode Sensing

> Current-mode signaling provides higher interconnect bandwidth at the expense of increased DC power



> A pair of differential interconnects with a bridge resistor termination are used to reduce the static current.



RC time constant is the same because of the Vdd/2 virtual ground in the middle of RB.

Circuit Implementation

- > Small power overhead from 6 logic gates and 1 DFF
- > No extra clock period of latency
- > Small drivers save buffer power dissipation and help reduce SSN noise



Bus Structure

- Differential CM bus with driver pre-emphasis only takes 7.9% more bus routing area and saves all of the repeater blockages.
- Single-ended VM bus needs 3xPmin and 2 repeaters to run at the same speed.
- > Coupling capacitance ratio is reduced from 61.2% to 14.4%.



Test Chip



Simulation Results



Crosstalk

- Coupling capacitance is below 1fF from 8-bit full-swing bus
- > Rejected as common-mode noise





Peak Current Reduction

- > Differential bus with driver pre-emphasis reduces the peak current by 63.8%, a result from both the differential signaling and small drivers.
- > The static current for one channel is only 0.52mA, i.e. 1.3pJ/bit at 1Gbs.



Power Dissipation

- Differential bus with driver pre-emphasis reduces power dissipation by 26.0% - 51.2% for data activities above 0.2 at 1Gbs.
- > Differential bus consumes more power only for data activities below 0.1.



Summary

10mm long interconnect	Propagation delay	Delay (+driver +receiver)	Energy/bit (activity >0.2)	Peak current/ bit	Routing area
Repeater insertion	1.07ns	1.72ns	4.51~ 9.25pJ	6.81mA	3xPmin
Driver pre- emphasis (CM)	0.78ns	1.25ns	1.76~ 2.38pJ	2.47mA	+7.9%
Improvement	-27.1%	-27.3%	-26.0% ~51.2%	-63.8%	-Repeater layout blockage

Thank you!