Benchmarking Reconfigurable Architectures in the Mobile Domain

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Motivating FPGAs in mobile domain

- The good:
  - Performance
  - Flexibility
    - Logistics
    - Standards
    - Pin expansion
- The bad:
  - Silicon Area ($)
  - Power consumption

Energy problem

- Power's the problem, but there's a huge market

Where is the research?

Need an idea of where to look

- Motivate and evaluate the problem with…

BENCHMARKS

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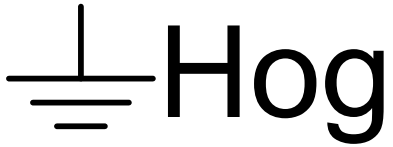
Existing benchmarks: Challenges

- Hard to compare different architectures
  - DSP Processors vs. FPGA
- May not include input stimuli (intermittent)
- Don’t specifically target mobile applications

GroundHog 2009

- Benchmark suite for reconfigurable architectures targeting the mobile domain



Fundamental goals

- Mobile vendors
  - evaluate reconfigurable architectures
- Researchers
  - help drive low power device research

Basic details of GroundHog 2009

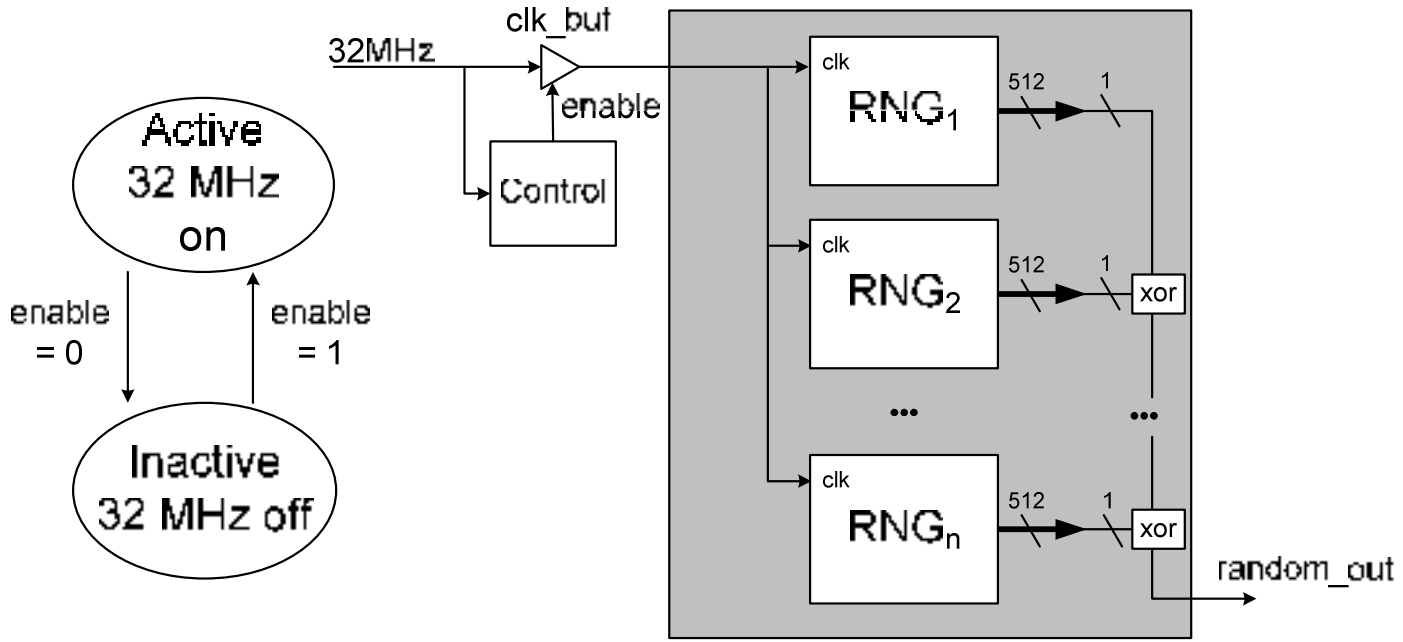
1. Fabric Analysis
   - evaluate fine-grain FPGA logic fabric energy consumption
2. 6 designs
   - applications in mobile domain
3. Tools to help build test benches and verification

1. Fabric analysis

- Fine-grain FPGA logic fabric power analysis
  - Stress test of logic fabric (logic + wires)
  - Quick analysis
  - Indicator of current state of the art

How?

- Use random number generation cores as worst case for device activity [D.Thomas]



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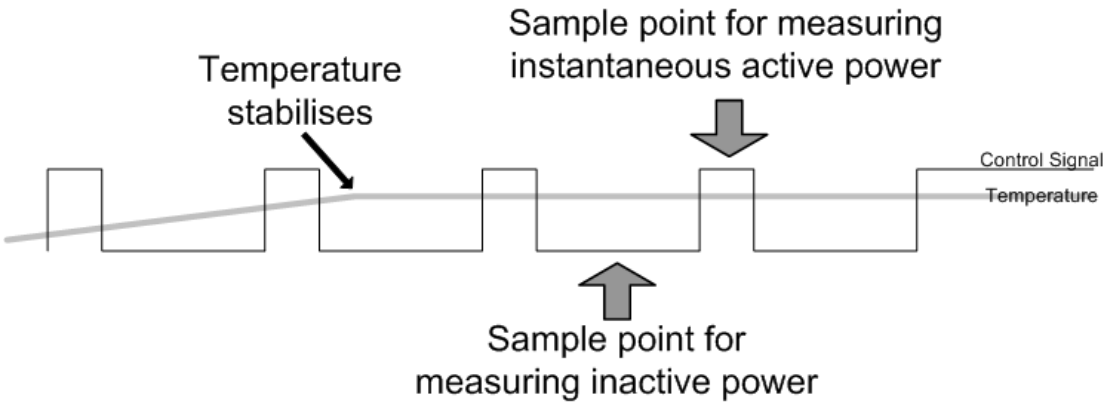
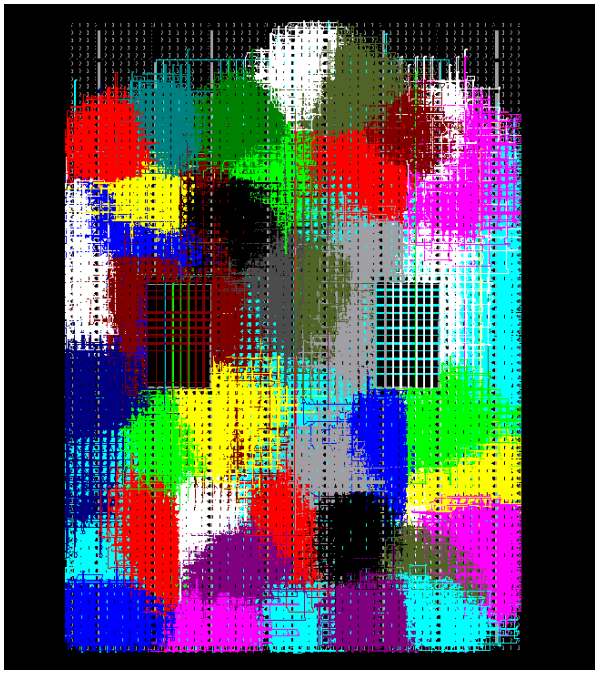
Basic idea

- Fill the FPGA with RNGs – 60%
- Clock X MHz, duty cycle 1%-100%
  - measure power and temperature over duty cycle





- Xilinx Virtex-II Pro 30
  - 48 RNGs, ~90% logic utilisation

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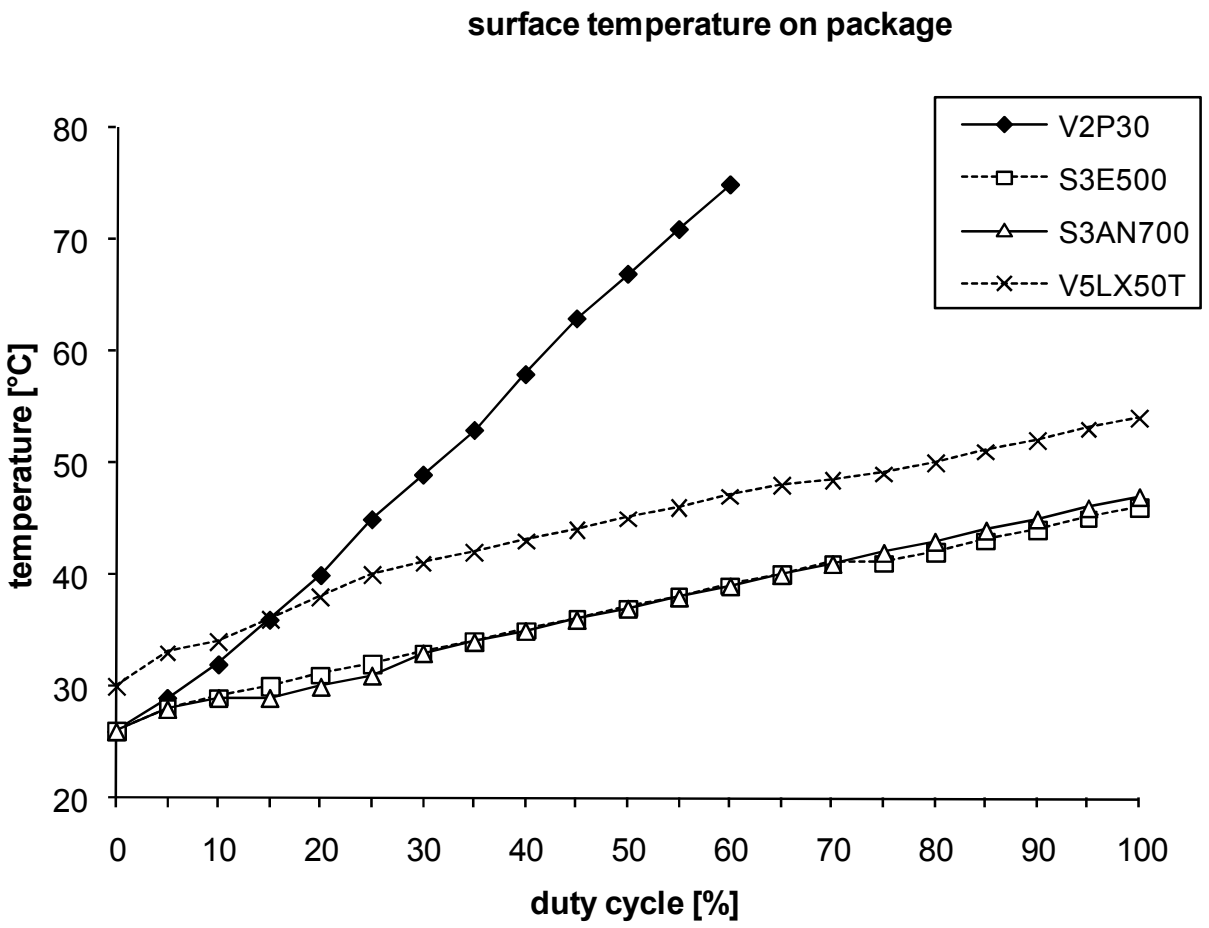
Measured FPGAs

XILINX

FPGA	Process Technology	Number of RNGs	Logic Utilisation
Virtex-II Pro	130nm	48	89.7%
Spartan-3E	90nm	16	88%
Spartan-3AN	90nm	21	91.3%
Virtex-5	65nm	50	88.8%

Temperature of FPGAs



- 100MHz clocks

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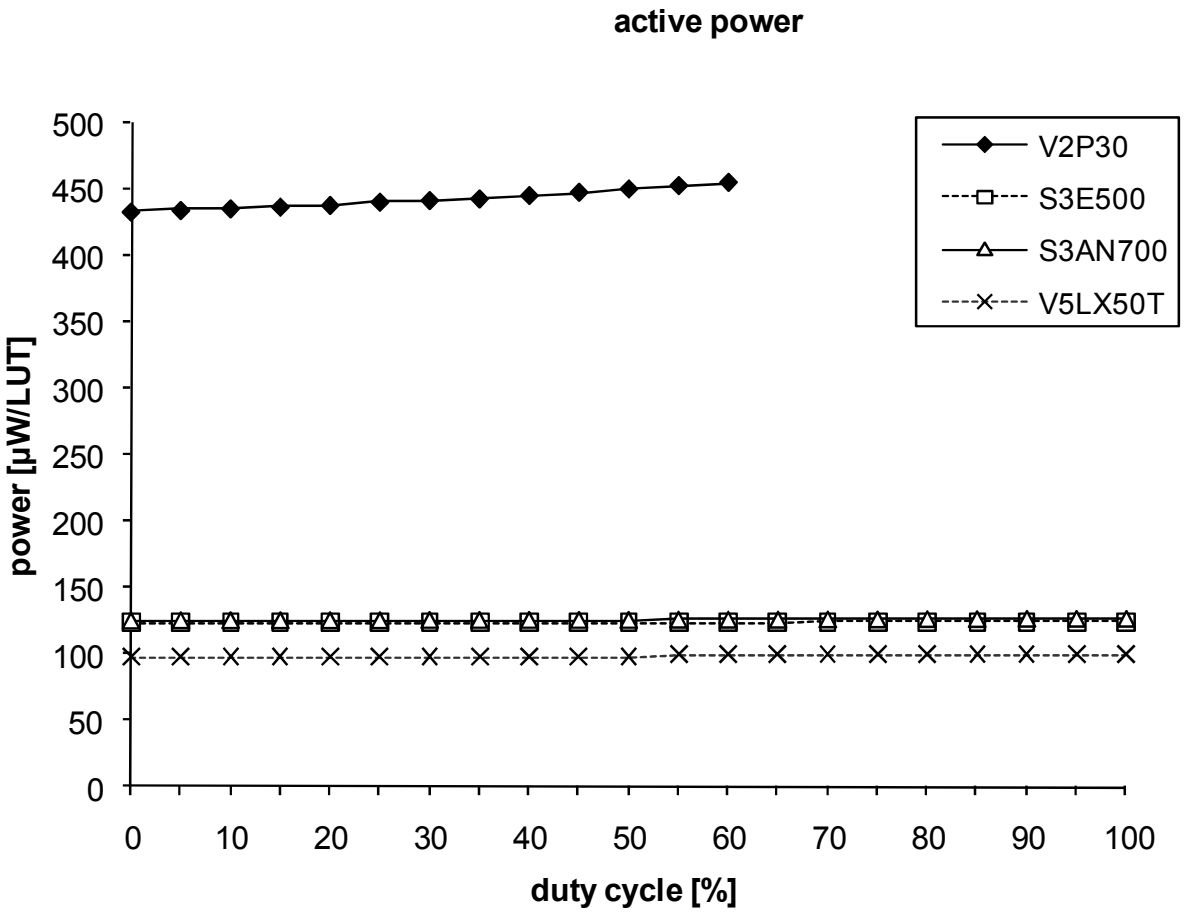
Active power of FPGAs



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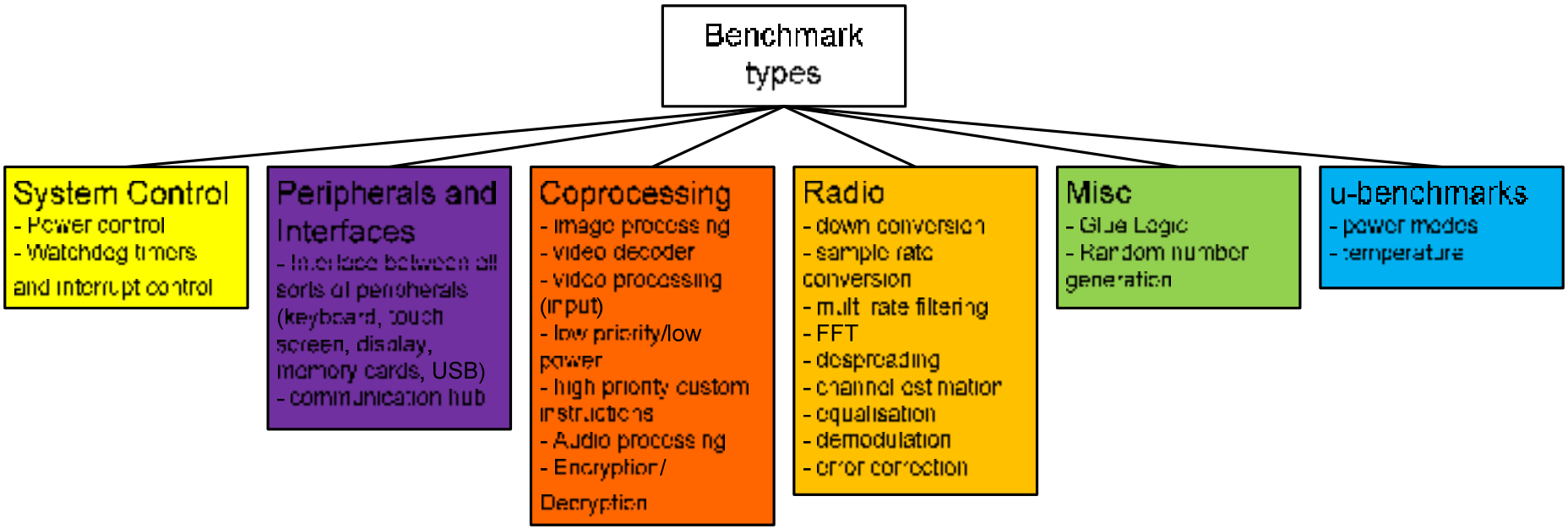
2. Six designs - possible benchmarks



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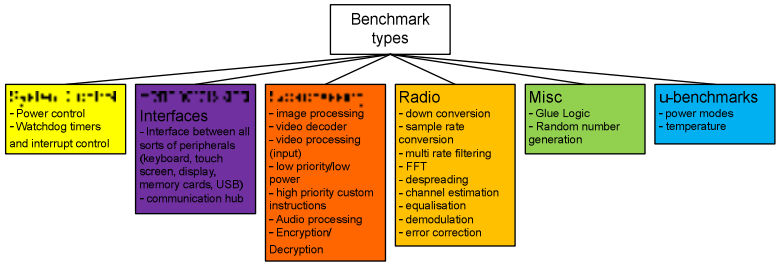
Six current designs



- GH09.B.1 - Port Expander and Keypad Controller
- GH09.B.2 - Glue Logic
- GH09.B.3 - Cryptography
- GH09.B.4 - Data Compression
- GH09.B.5 - Bridge Chip
- GH09.B.6 - 2D convolution

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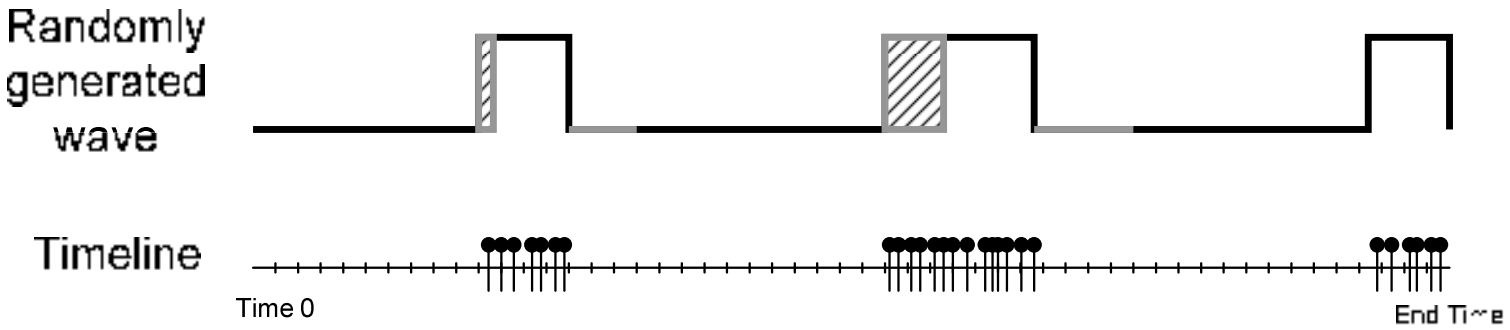
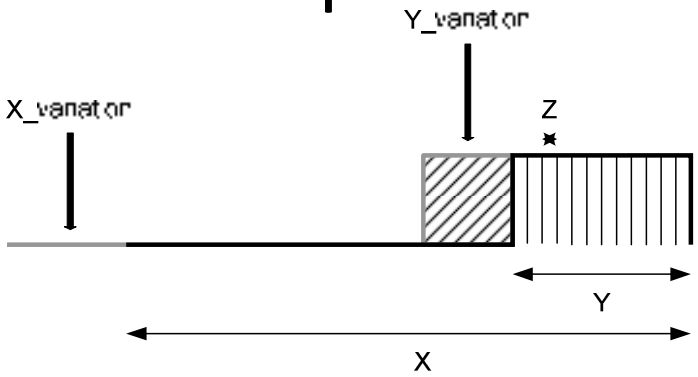
3. Tool for synthetic generation of Input Stimuli

- Workload - Timeline of input stimuli
  - Per benchmark modelling of events



- software tool -> user parameters



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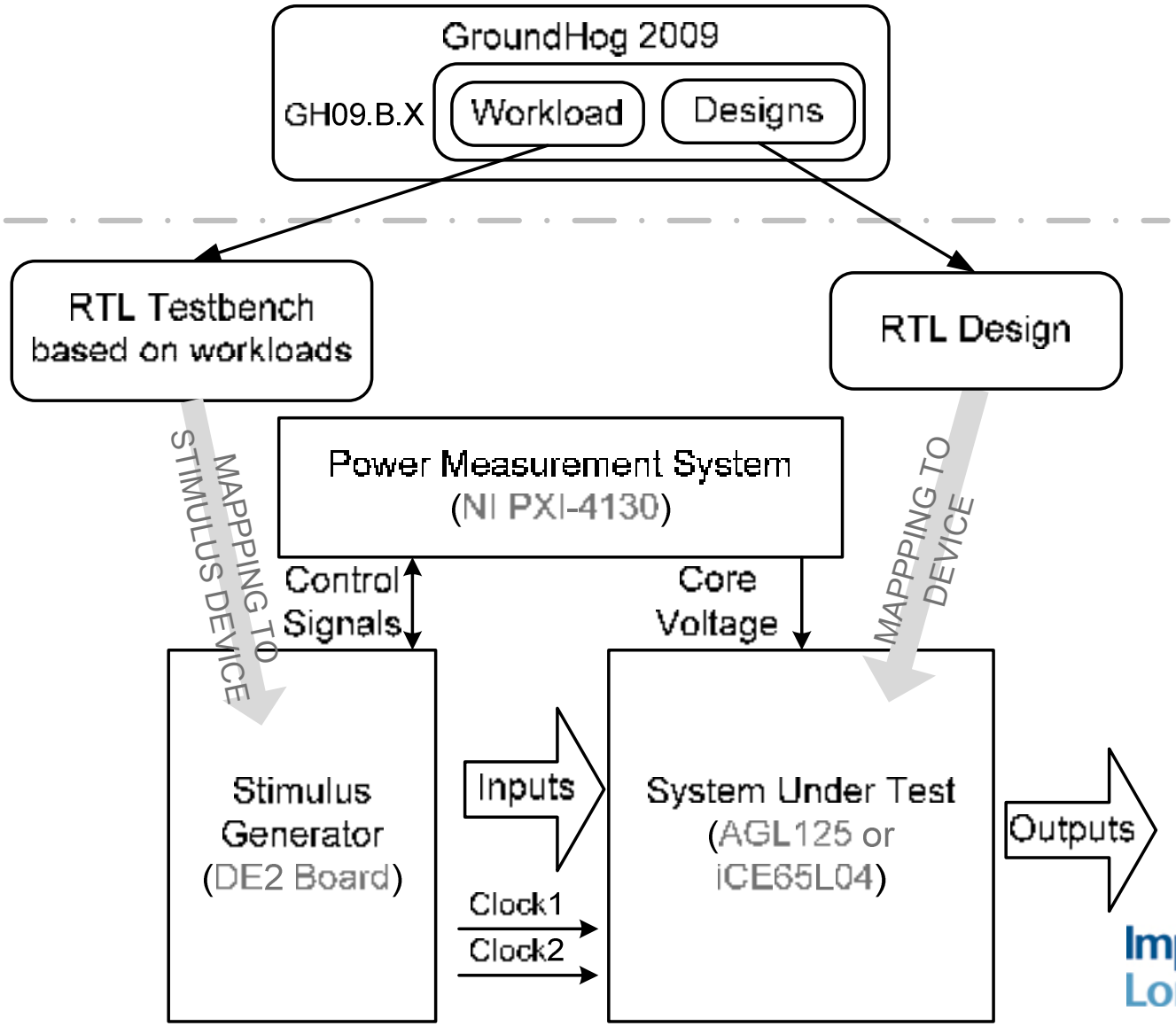
Actual use of this benchmark



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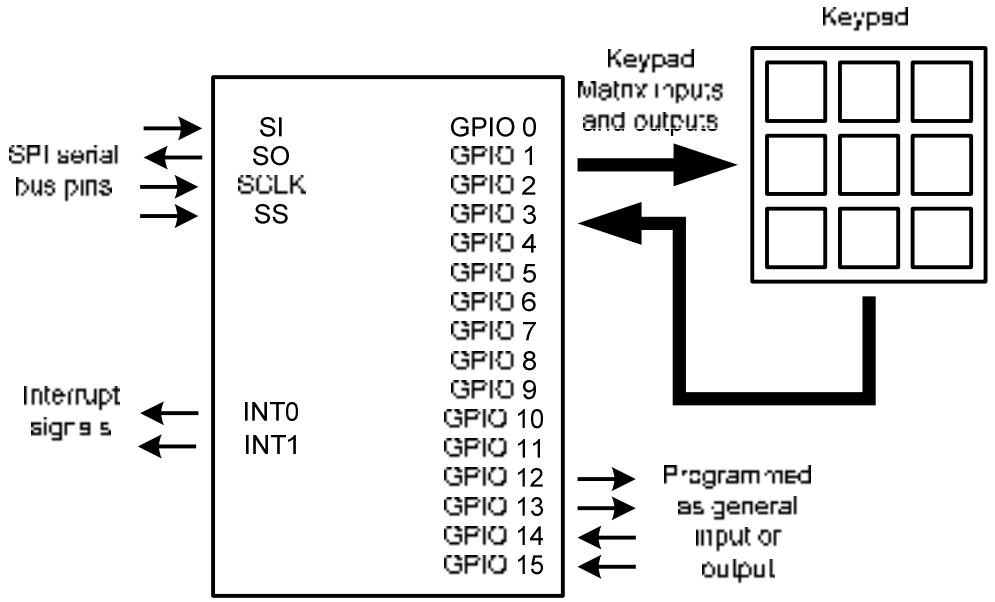
Measuring GH09.B.1

- Port Expander and Keyboard controller
  - General purpose I/Os



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GH09.B.1 as 7x8 keypad

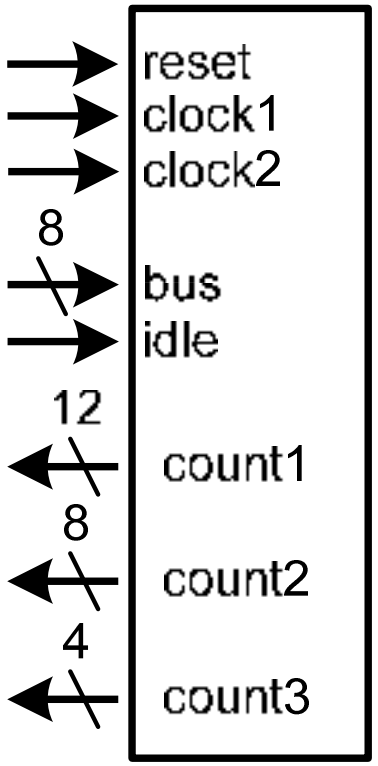
Actel POWER MATTERS

FPGA	Logic Utilisation	Operating Frequency	V_{cc} (V)	I_{avg} (mA)	P_{avg} (mW)
AGL600	10%	32 MHz	1.5	3.751	5.628
AGL600	10%	32 MHz	1.2	2.951	3.541
AGL600	10%	150 KHz	1.5	0.091	0.137
AGL600	10%	150 KHz	1.2	0.059	0.071

- Synthetically generated input (Z=25ms, Y=500ms, X=1000ms) and total time is 5 minutes

Measuring GH09.B.2

- GH09.B.2 - Glue Logic
  - State Machine controls 3 adders
  - State Machine controlled by bus
  - Adders are each clocked by one of
    - No clock (idle)
    - Slow clock (150 KHz)
    - Fast clock (35 MHz)



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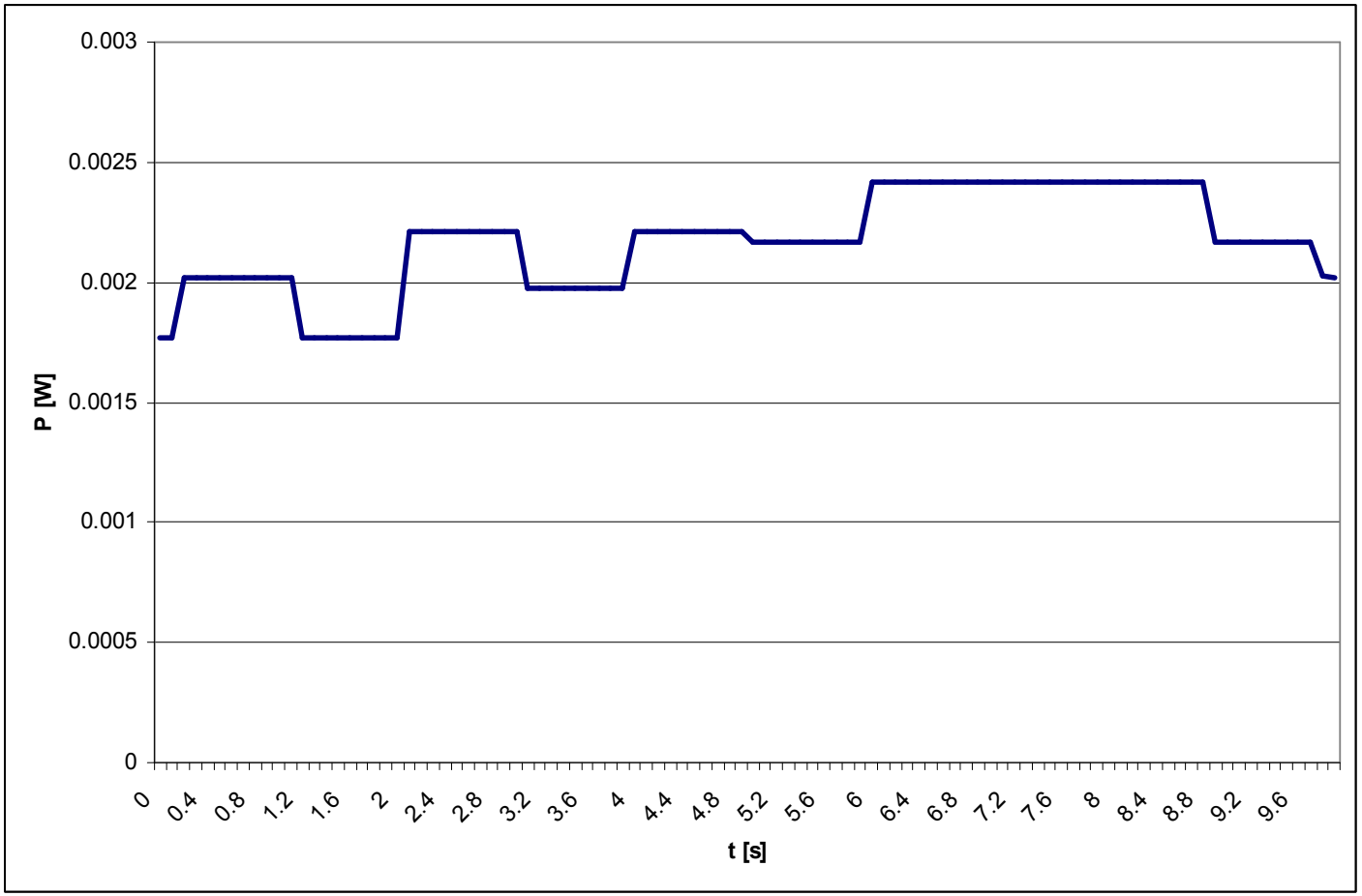
GH09.B.2 measurements over 10s



- Actel FPGA (AGL125), 1.2 V, 35 MHz

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GH09.B.2 over 5 minutes

SiliconBlue

FPGA	Logic Utilisation	Operating Frequency	V_{cc} (V)	I_{avg} (mA)	P_{avg} (mW)
iCE65L04	4%	32 MHz	1.2	1.46	1.75

- Synthetically generated input (Z=1ms, Y=10ms, X=1000ms) and total time of 5 minutes

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Conclusion

- Join the fun!
  - Download the suite including tools
    - http://cc.doc.ic.ac.uk/projects/GROUNDHOG/
  - Repository for communities designs
    - http://www.opencores.org/?do=project&who=groundhog2009_repository
- Measured a range of devices

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