Misc Topics

98-154/18-224/18-624: Intro to Open-Source Chip Design

More on Verification

- Previously talked about “conventional” verification methods
  - Writing testbenches using Verilog and/or a software-language
- There exist many other methods including formally-proving your design, verifying the correctness of your testbench, etc.

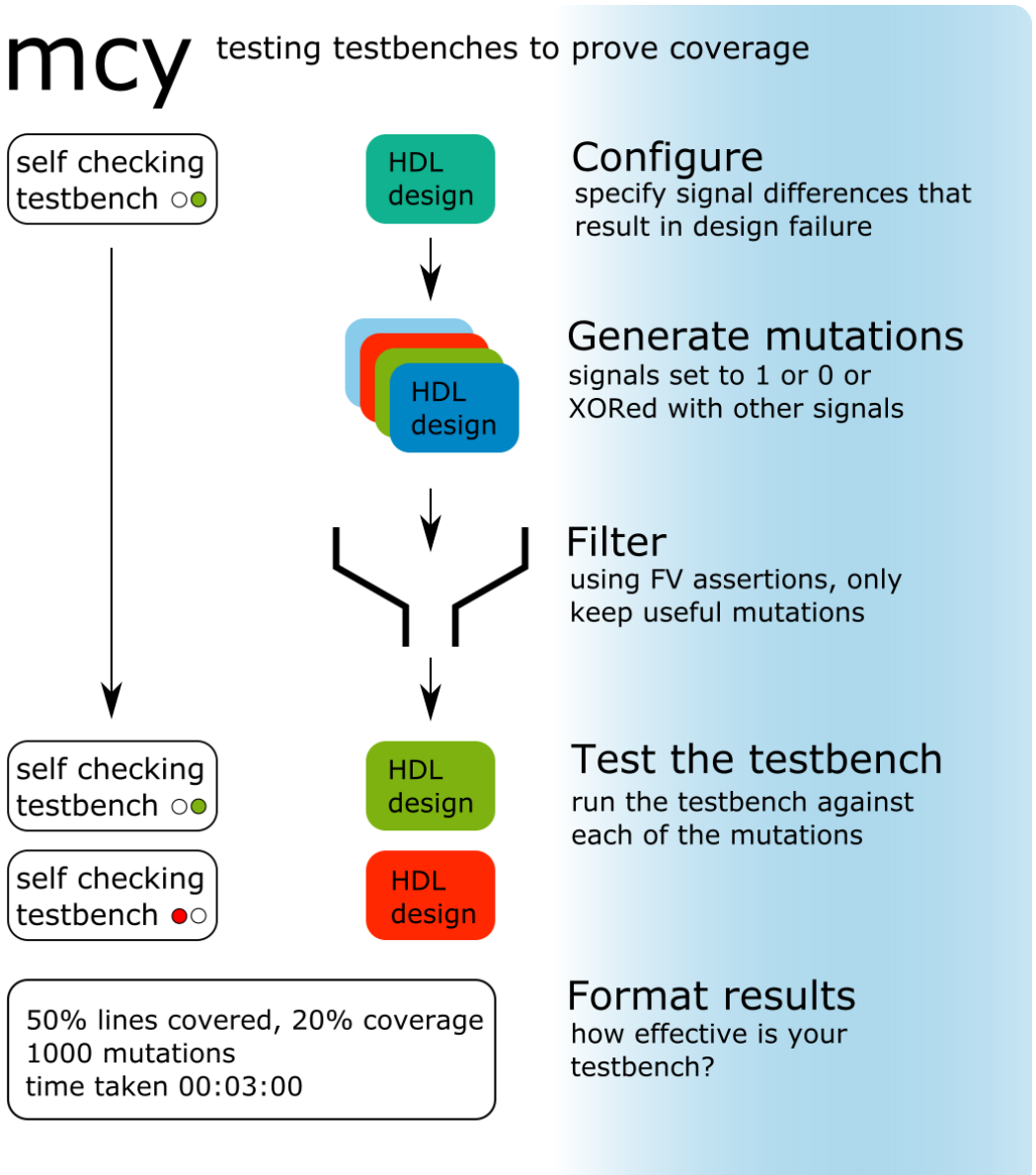
Alternative Verification Methods

- Assertions-Based: Write ‘invariants’ about the design, generate large amount of inputs, verify that invariants always met
- Formal Verification: Use a logic-solver to “prove” the invariants about your design will always hold, w/o generating every input
- Mutation-Based: Verify that your testbench is actually testing what you think it is testing
- Design for Test (DFT): Make it easy to test design and find bugs after tapeout

Mutation Cover

- Easy to write a testbench, hard to know whether the testbench is testing anything useful
- MCY synthesizes the DUT and inserts errors into it, to see if the testbench is always able to catch the errors
- Uses formal methods to figure out whether the testbench should succeed or fail on the mutated design

Mutation Cover



What next?

- If you found this stuff interesting and want to learn more:
  - Buy or borrow a cheap FPGA board
  - Build small personal projects (great chance to try new languages and tools, and build up a GitHub portfolio)
  - Interact with the community (IRC channels, Discord servers, Gitter chats, GitHub issues/PRs)
  - Submit to future Open-MPW tapeouts

FPGA Boards

- Lots of cool boards out there
  - Recommend getting something with lots of peripherals built-in, gives flexibility for future projects
  - Some parts include dedicated ARM CPU, adds cost but lets you use the ARM core for debugging / interfacing with FPGA
  - Avoid older FPGAs (i.e. Xilinx 6-series or older, Cyclone III or older); their toolchains are hellish to use

FPGA Boards

These boards have Lattice parts with Yosys+NextPNR support

- ULX3S (Lattice ECP5, 25-85K LUTs, $100-150)*
- OrangeCrab (Lattice ECP5, 25-85K LUTs, $120-180)
- iCEBreaker (Lattice iCE40, 5K LUTs, $80)*
- iCE40UP5K-B-EVN (Lattice iCE40, 5K LUTs, $60)*
- FOMU (Lattice iCE40, 5K LUTs, $50)

FPGA Boards

These boards don't have open-source toolchains (yet) but are still very nice to work with

- Terasic DE0-CV (Altera Cyclone V, 49K LUTs, $140)
- Terasic DE1-SoC (Altera Cyclone V + ARM CPU, 85K LUTs, $322)*
- Pynq-Z2 (Xilinx Zynq-7020 + ARM CPU, 50K LUTs, $140)*
- Arty A7 (Xilinx Artix 7A35T, 30K LUTs, $160)
- Cmod A7-35T (Xilinx Artix 7A35T, 30K LUTs, $99)

Project Ideas

- Interfacing with peripherals: PS2, UART, VGA, SPI, I2C are all easy to work with
- Build and synthesize a small CPU, use it to control peripherals
- Accelerate some kind of math or cryptographic function
- Find modules on GitHub and try to integrate / build on them
- Develop something using an alternative HDL
- Digital signal processing (audio input/output)
- Control huge LED matrices

Online Community

Very vibrant online community around open-source hardware

- Discord servers: Digital Design HQ, 1BitSquared, KiCad official, etc.
- Slack channels: Open-Source-Silicon.dev, YosysHQ official, conference chats, etc.
- Gitter chats (associated with many Git repos)
- IRC channels: many projects have chats on Libera.Chat
- GitHub: open-source projects are usually very responsive to their GitHub community (issues and pull-requests)