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Co-Simulation of a Avionics Interface Device

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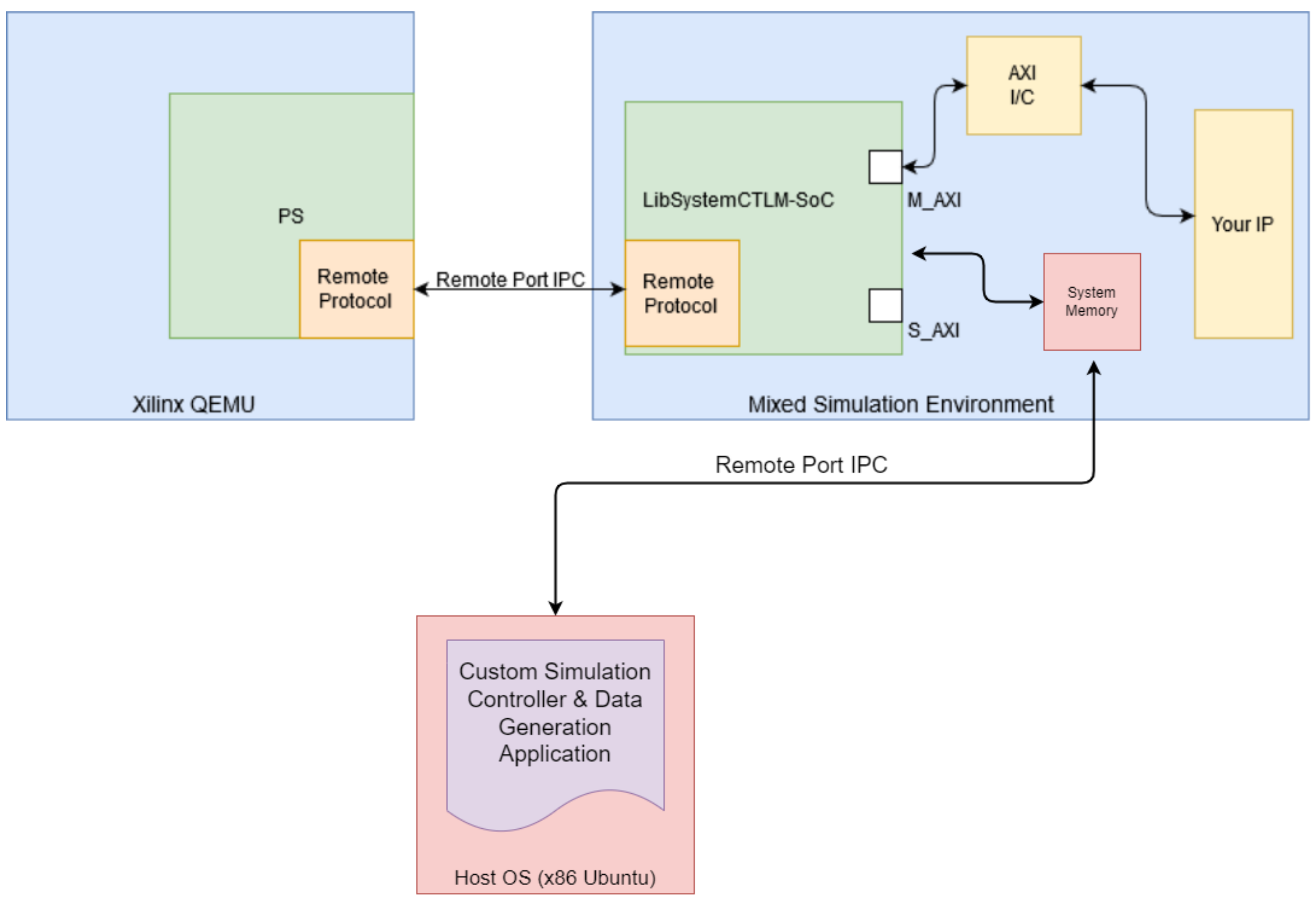
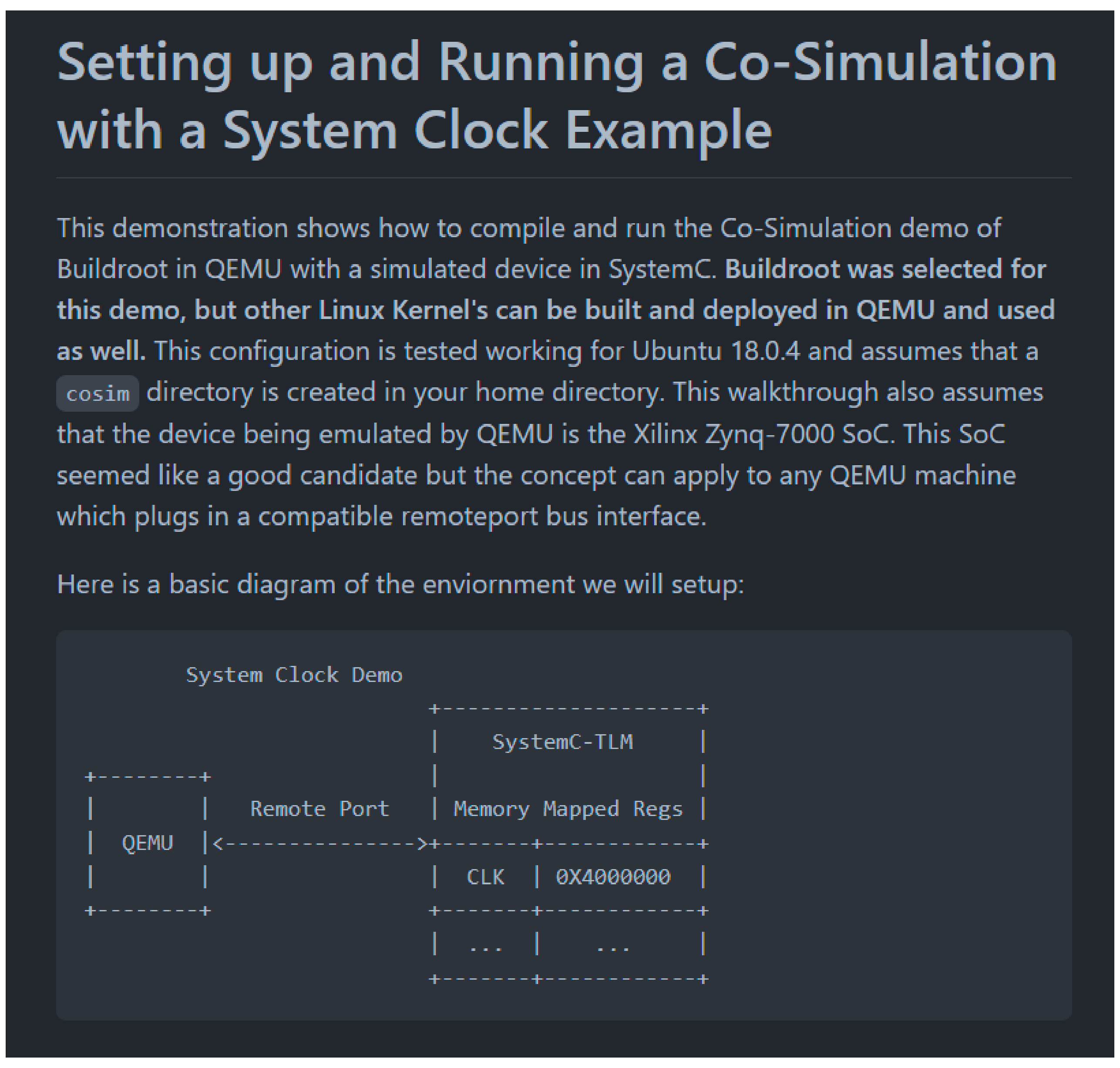
What is Co-Simulation?

The process of simulating a system with multiple different subsystems. This is done at a subsystem level with each subsystem being simulated in parallel to model the system. This can be challenging to perform correctly and efficiently, as simulations can be slow, and the number of simulations being managed and communicating with one another. It is important when creating coupled hardware and software systems in tandem. Without it, hardware and software development teams would be unable to fully test either part without a working or prototype implementations of all other components [3][4].



Example Xilinx Co-Simulation environment containing a QEMU instance running a Linux OS, a Xilinx SoC and our Host device. Our additions are highlighted in Red [5].



Setting up and Running a Co-Simulation with a System Clock Example

This demonstration shows how to compile and run the Co-Simulation demo of Buildroot in QEMU with a simulated device in SystemC. **Buildroot was selected for this demo, but other Linux Kernel's can be built and deployed in QEMU and used as well.** This configuration is tested working for Ubuntu 18.0.4 and assumes that a `cosim` directory is created in your home directory. This walkthrough also assumes that the device being emulated by QEMU is the Xilinx Zynq-7000 SoC. This SoC seemed like a good candidate but the concept can apply to any QEMU machine which plugs in a compatible remoteport bus interface.

Here is a basic diagram of the enviornment we will setup:

```
        System Clock Demo
                             +--------------------+
                             |    SystemC-TLM     |
+--------+                   |                    |
|        |   Remote Port     | Memory Mapped Regs |
|  QEMU  |<----------------->+-------+------------+
|        |                   |  CLK  | 0X4000000  |
+--------+                   +-------+------------+
                             |  ...  |    ...     |
                             +-------+------------+
```

Open source published Xilinx Co-Simulation Getting Started Guide. [1]

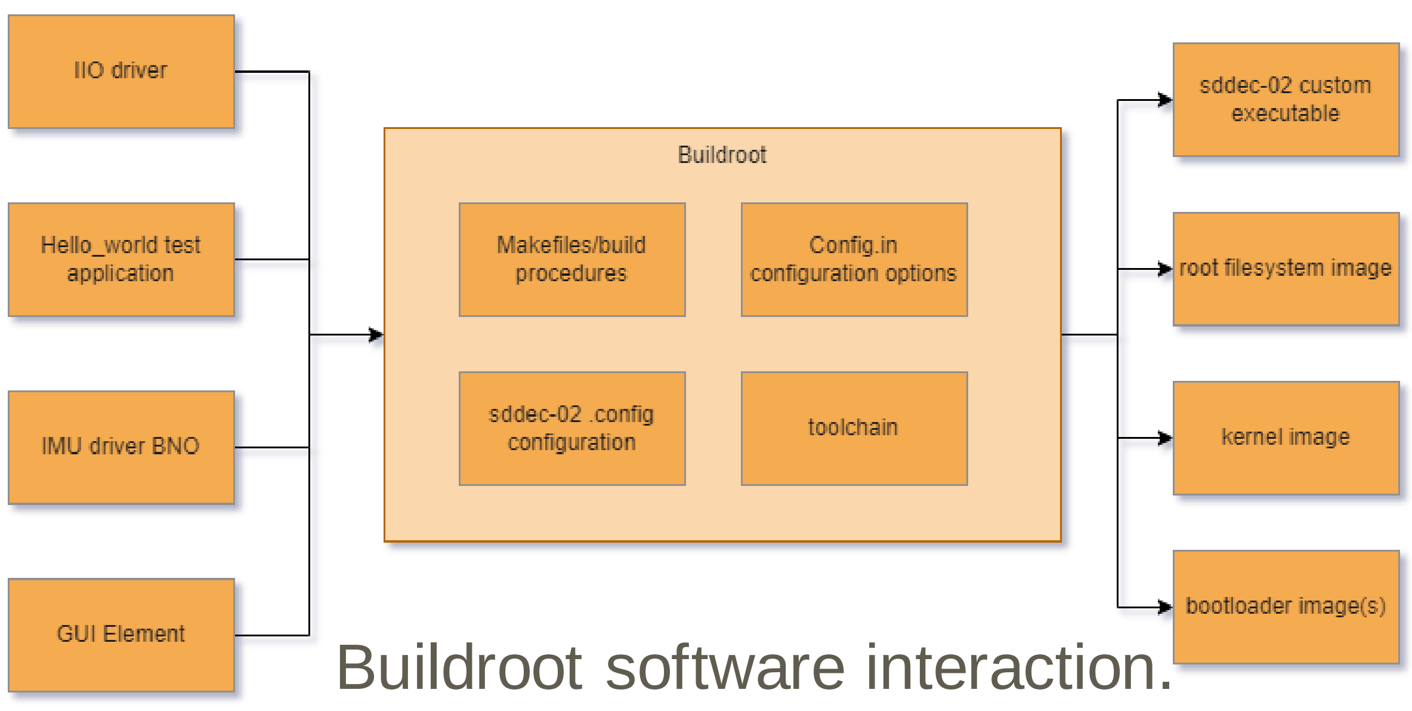
Documentation

One of our primary contributions to the Xilinx co-simulation tool flow was additional open-source documentation. Xilinx Co-Simulation libraries and tools lack documentation almost entirely, as such, authoring documentation is an important first step to gaining greater adoption:

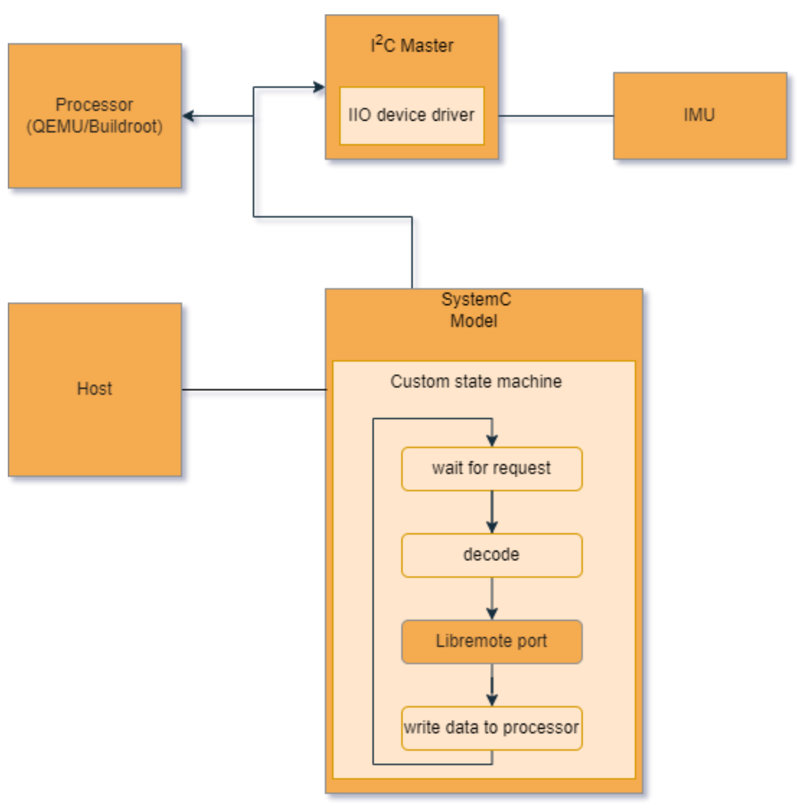
- Xilinx Co-Simulation Getting Started Demo Step-by-step guide [1]
- Remote Port protocol additional documentation
- Xilinx co-simulation SystemC-TLM open-source issue support [2]
- Co-Simulation and Remote Port example implementation diagrams

Implementations

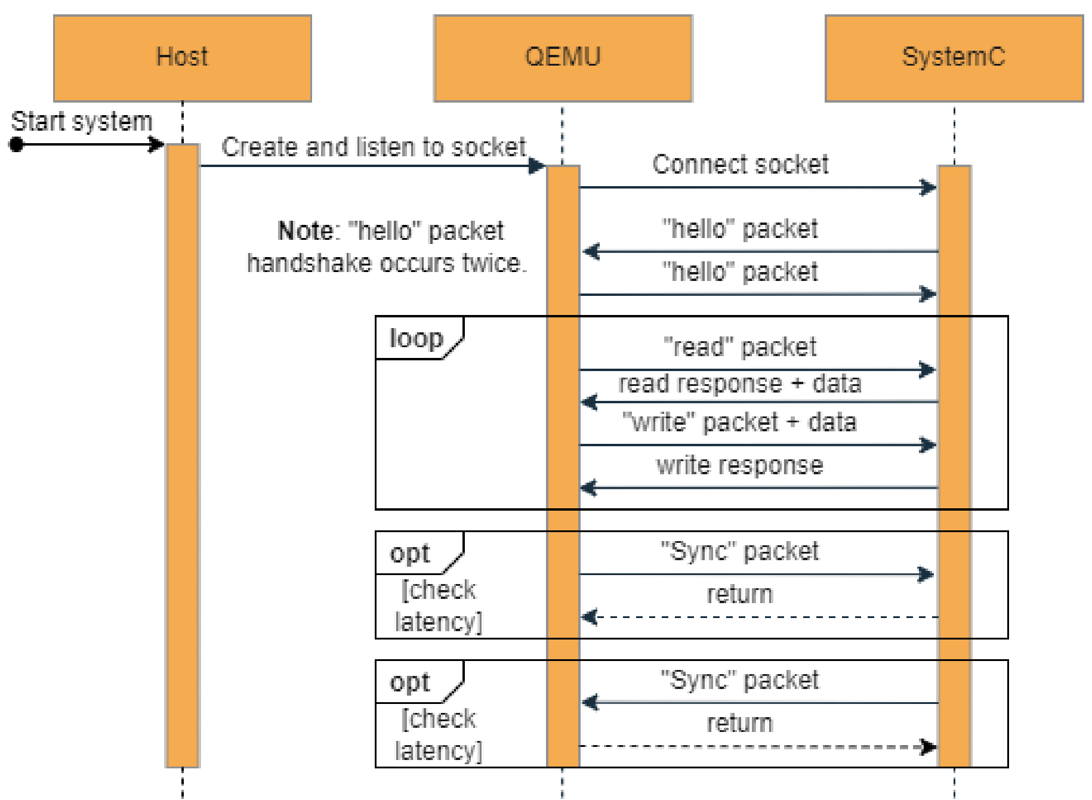
- Remote Port:
  - Create a Unix socket
  - Connect SystemC to the socket
  - Read and decode packets sent from SystemC
- Industrial I/O
  - Moddifed kernel module for reading MMIO
  - Setup a software triggered mock IIO device
  - IIO ssh Oscilloscope example
- PPM SystemC Implementation
  - Demonstrate complex SystemC device
  - Intended for Co-Simulation demo and learning


IIO driver
Hello_world test application
IMU driver BNO
GUI Element
Buildroot
Makefiles/build procedures
Config.in configuration options
sddec-02 .config configuration
toolchain
sddec-02 custom executable
root filesystem image
kernel image
bootloader image(s)

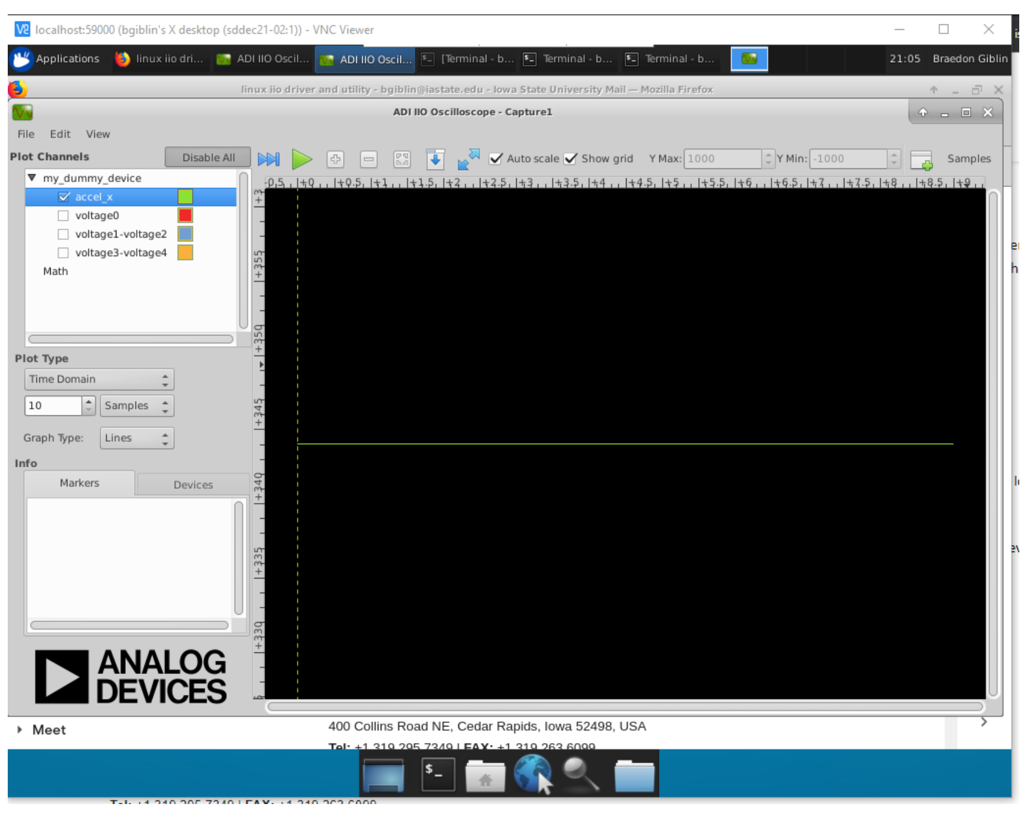
Buildroot software interaction.



System Overview.



Remote Port protocol diagram.



IIO Oscilloscope demo.

Technologies

Project Team

- **Client**
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  - Collins Aerospace
- **Advisor**
  - Dr. Phillip Jones
  - Department of ECpE @ Iowa State
- **Additional Support**
  - Edgar E. Iglesias
  - Francisco Iglesias - Xilinx

References

1. https://github.com/Xilinx/systemctlm-cosim-demo/blob/master/docs/zynq-7000-getting-started-guide.md
2. https://github.com/Xilinx/systemctlm-cosim-demo/issues/23
3. https://xilinx-wiki.atlassian.net/wiki/spaces/A/pages/862421112/Co-simulation
4. https://en.wikipedia.org/wiki/Co-simulation
5. https://sddec21-02.sd.ece.iastate.edu/