Xilinx Kintex Ultrascale+ FPGA Pattern Generator

Scope

Provide a custom high speed FPGA pattern generator with multiple I/O lines for use in a cutting edge quantum computing application.

Solution

Spark Product Innovation created a Printed Circuit Board (PCB) assembly with ultra-high speed differential tracking and carefully designed termination networks, we also created the necessary FPGA firmware to deliver our customer a turnkey solution.

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- High Speed Xilinx Kintex Ultrascale+ FPGA (XCKU5P) with 6.25 GHz I/O lines and FPGA based MicroBlaze microprocessor.

- Analog devices HMC856 wideband 28 Gbps, Digital Time Delay IC with 3pS resolution.

- USB and UART interfaces to allow customization and user programmable patterns.

- High Speed I/O lines available on FMC mezzanine connector to facilitate system testing and commissioning.

- Fully simulated and laboratory tested high speed differential tracking and termination networks.

- Custom 14GHz Firmware

Spark Product Innovation were approached by a quantum encryption communications company that had heard about our high speed digital and FPGA firmware skills by word of mouth.

They needed a bespoke FPGA design to interface and control their proprietary high speed encryption silicon and photonics.

Spark Product Innovation approached this by sitting down with the client and fully understanding their requirements, discussing various options and exploring what is technically feasible is and what is not. A detailed proposal was made and accepted.

The detailed engineering, prototyping, testing and technical demonstrations followed and has now been completed and signed off by the client. Spark Product Innovation is also working with the client on several other electronic and firmware projects.

The design consists of a PCB based around a Xilinx Kintex Ultrascale+ FPGA. This part was selected as it is available on a development kit; taking this approach enabled the FPGA firmware to run in parallel with the electronic development.

In addition to the FPGA the PCB also had a FMC connector for mounting a mezzanine card, power supplies and power sequencing circuits, system clock and timing functions, external interfaces (UARTs, USB etc) as well as high speed AD HMC856 digital time delay ICs. The FPGA also has a "soft" MicroBlaze uP for external control.
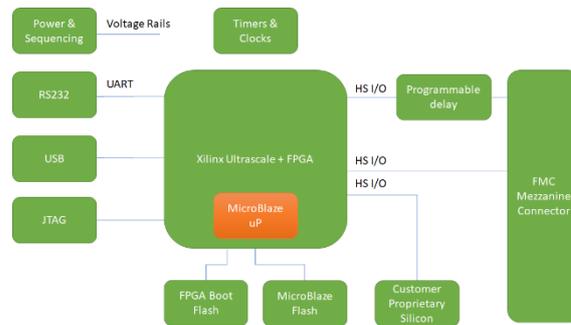
The firmware held a Bit Error Rate (BIR) pattern in RAM memory and had used a custom 14 GHz interface to generate the customers digital signals.

Note: Spark also has other ongoing projects using the Artix-7 FPGA.

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System Architecture

The center of the system is the Xilinx FPGA with a MicroBlaze uP. Around this part there's various connectivity to the outside world including JTAG, USB, RS232 and a FMC Mezzanine connector. Electrically there are carefully designed power supplies with power sequencing for the many FPGA voltage rails, clock and timers, memory, digital delays and the customer's proprietary silicon.
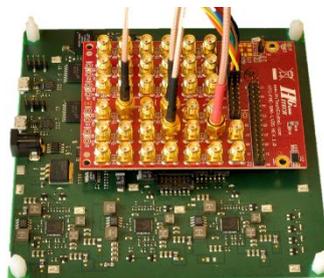
Printed Circuit Board Assembly

FPGA Printed Circuit Board – Front Side

- Major component face
- Mezzanine connector
- Xilinx Kintex Ultrascale+ FPGA
- Analog devices 28 Gbps, Digital Time Delay ICs
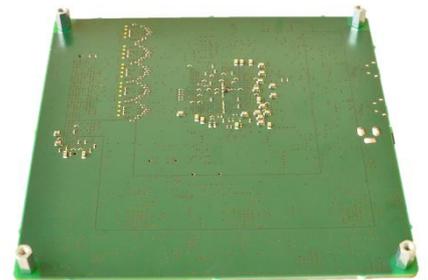
FPGA Printed Circuit Board – Rear Side

- 16 layer design with multiple signal layers and power planes.
- High speed impedance matched differential tracking with a carefully selected termination scheme.

FPGA Printed Circuit Board – With Mezzanine

- FMC Mezzanine with High Speed connectivity to test equipment.
- Off the shelf Mezzanine with custom FPGA PCB to lower total costs

FPGA Printed Circuit Board – pS Signals

- 160pS signals
- Firmware and Hardware multiple customer specific high speed I/O lines.

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