Using SoC to Achieve Low Size, Weight, Power and Cost in an Advanced PNT Module

An Altera SoC Application Case Study

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Spectracom simplifies **Position, Navigation, and Timing** integration into our customer’s systems.

**Bringing Technology to:**
- Military, Aerospace
  - UAV’s
  - Electronic Warfare
  - C4ISR
- High-End Commercial Apps
  - Datacenters
  - Robotics/Telematics
  - IDM
  - GIS Data Mining
Problem Statement

Shrink functionality of two boxes into one small module for UAVs

- Smallest possible PNT device
- Reduce size by 40x
- Reduce weight by 10x
- Reduce power by 10x
- Maintain the same interfaces
VersaPNT – Rugged, Airborne PNT Solution – all in one module

- Fully integrated PNT sensor: 3 main components
  - Embedded GNSS receiver
  - Internal Inertial Measurement Unit (IMU)
  - Precision Clock
- GNSS Receiver
  - Civilian or SAASM
  - Multi-constellations – GPS, GLONASS, Galileo, Beidou
- Inertial Navigation System (INS)
  - Internal MEMS device
  - Optional external IMUs
  - 50+ state Extended Kalman Filter (EKF) processing
- Precision Clock
  - Miniature Atomic Clock or OCXO
  - GNSS disciplined
Why SoC?

- High density, low SWaP (Size, Weight and Power) design
- Multi-processor capability
  - Combining three processors and dedicated FPGA circuitry into a single chip.
- Re-host of established code set and architecture
  - Leveraging proven Navigation and Timing firmware and software
- Wide temperature range, rugged environment
  - MIL-STD-810 requirements
- High reliability
  - Reduced chip count and interconnects increase reliability
  - Targeted for military, security and other mission critical application
- Fast time to market
  - Trial porting of existing codebase during evaluation period proved the feasibility and lowered the project schedule risk
**SoC Block Diagram**

**ARM Cortex A9 Main processor**
- controls network and user interfaces
- General supervisory functions

**NIOS soft core #1**
- Timing function
- Realtime events

**NIOS soft core #2**
- Positioning and Navigation functions
- Interface to GPS
- Interface to IMU
- Interface to other nav sensors
Highlights of Project

- Multi-processor application
- Specialized timing HW and analog circuitry required
- Realtime processing in FPGA

Step 1: Prototype feasibility on Altera development board
  - Head start on SW porting
  - Provided development velocity measurement for project planning

Step 2: Create an evaluation board for development
  - Contains all specialized circuitry
  - Expanded layout for developmental testing

Step 3: Build final form factor HW

Step 4: Product qualification testing
FPGA/SoC Hardware Design Highlights

- We replaced the bus interface between systems in our existing product with the Avalon bus.
- We are re-using all of our existing application-specific FPGA code.
- We have tested our DDR interfaces.
- We have demonstrated that we can use the FPGA-to-SDRAM bridge to execute NIOS code in the memory attached to the HPS.
  - It is our job to make sure the NIOS and HPS don’t stomp on each others’ memory space!
- We have combined a processor module, a second embedded processor, and our FPGA components into one FPGA SoC device.
Straightforward porting of timing software from Coldfire to NIOS
- Software architecture allowed for easy transition
- Software NIOS could be configured to meet software needs.
- Altera NIOS tools and example programs eased the transition

Convert Linux driver from PCI to shared memory
- Previous physically separated processors communicated over PCI
- SOC allowed the for conversion from PCI to shared memory between NIOS and Cortex A9

Challenging port of existing Gentoo Linux system
- Conversion from x86 to ARM needed new development environment
- Difficulty with configuring Kernel and acquiring drivers for our peripherals
- Need to maintain support for grub on x86 while also using u-boot on ARM
Evaluation Board

- PCIe bus for peripheral expansion, future product development
- Interfaces and signal test point breakouts
  - Ethernet
  - VGA
  - USB
  - CAN
- Peripherals
  - Precision clock
  - DDS frequency generation
  - Temp sensors
Altera SoC has been a good choice for our rugged airborne design
- We can meet our low-SWaP requirements
- We can re-use existing code

Still a work in process
- Testing on Evaluation Board now

Design tools are very good
- Bus analyzer is built in the FPGA
- Still need to investigate some purchased debugging tools
- Good support from Altera and Arrow

Lots of Linux kernel learning during the port from x86 to ARM

Altera’s SOC Linux vs. our Gentoo distribution
- Keeping the old distribution is less risky than switching to a new OS
- Using modified Altera kernel from rocketboards.org
Thank You

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