

Ettus Research Products

Overview and Roadmap

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Ettus Research LLC

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Outline

- 1 Overview
- 2 Software
 - GNU Radio
 - Universal Driver
- 3 Hardware
 - Architecture
 - Motherboards
 - RF Daughterboards
- 4 Roadmap
 - Motherboards
 - RF

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History

- GNU Radio software project started in late 2000 or early 2001
 - Host-based signal processing
 - Free Software
- Originally designed the USRP1 in 2003/2004 to “Scratch an Itch”
 - Wanted a cheap platform to experiment with SDR
 - Wanted MIMO
- Ettus Research LLC founded in August 2004
- Acquired by National Instruments in February 2010
 - Operating as a wholly-owned subsidiary of NI

Business Model

- Sell low-cost, easy to use software radio kits
- Live up to the name “Universal Software Radio Peripheral”
- Build a community of users
- Low overhead
- Largest sectors are academic and defense/intelligence

Engineering Model

- Most signal processing done in host computer
- Moderate sized, low cost FPGA
 - User can reprogram, build off of our open-source IP
- Use highly-integrated parts where possible
- Communications-grade, NOT measurement grade

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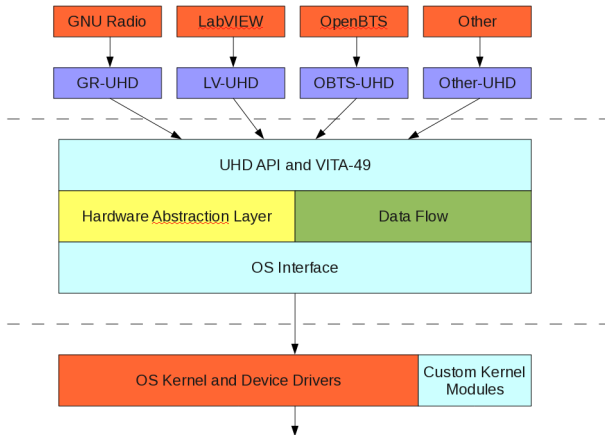
GNU Radio

- A tool for rapid prototyping and deployment of software radios
- A platform for signal processing on commodity hardware
- A tool for digital communications research
- A community for educating and learning
- Free Software (GPL)

GNU Radio Features

- Seamless Multithreading
- Easy to program, object-oriented interface
- Designs written in C++ or Python, or a graphical tool
- Extremely Fast DSP Primitives in C++ and often hand-coded SIMD Assembly
- Built in standard signal-processing constructs
- GUI Integration
- Filter design
- Hides all memory, buffering, scheduling concerns

Universal Hardware Driver (UHD)



UHD

- Have users on Windows, Mac and Linux now
- Development proceeding rapidly
 - Current push is easy to use MIMO
- Using CMAKE for cross-platform build system
 - Everything builds on Windows 7 (Visual Studio) as well as Linux and Mac
 - Can communicate with the USRP2 from Windows, both in a VM and direct
- Alpha released to GNU Radio community on April 15th
- Would like to start transitioning the bulk of users to UHD by the beginning of Q4
- Dual-license model (GPL + Other)

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Architecture

- Motherboard interfaces computer to analog
 - FPGA
 - Dual high-speed ADCs and DACs
 - Low speed ADCs and DACs for RSSI, gain ctrl, etc.
 - Clock generation
 - GPIOs, I2C, SPI
- Interchangeable daughterboards convert analog baseband to RF
 - Quadrature Up/Downconverters
 - VCO/PLL for LO
 - LNA, PA, all filtering

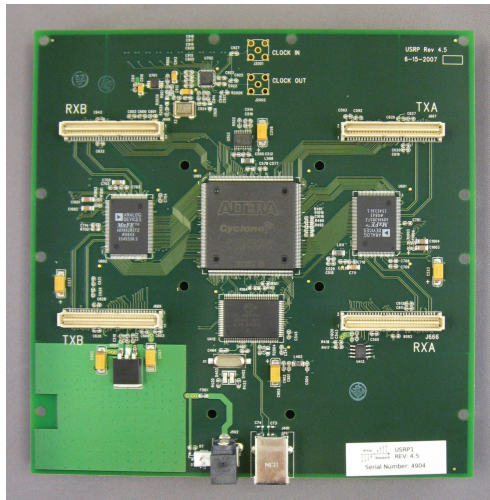
FPGA Design

- Digital up and downconverters
- Decimation and Interpolation
 - CIC and halfband filters
- Data formatting, packetizing, and bus interfacing
- Daughterboard Control
- Precise timing

USRP1

- Introduced in 2005
- USB 2.0 Interface
 - 8 MHz of RF bandwidth at 16 bits per sample
- Altera Cyclone I FPGA
 - No multipliers!
- 64 MS/s 12-bit ADCs, 128 MS/s 14-bit DACs
- 2x2 MIMO capable
- \$700

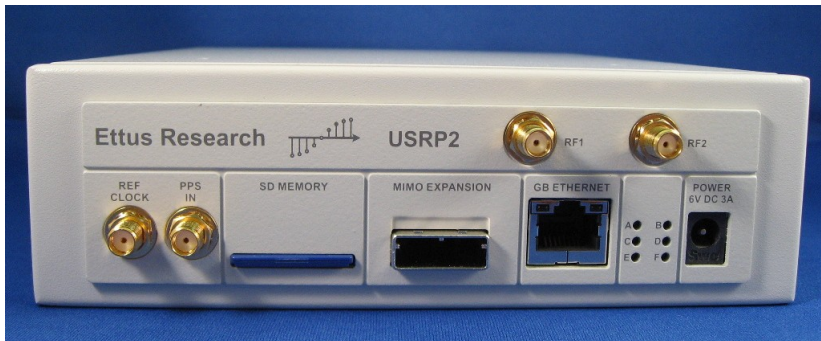
USRP1



USRP2

- Introduced late 2008
- Gigabit Ethernet interface
 - 25 MHz of RF bandwidth at 16 bit samples
- Xilinx Spartan 3-2000 FPGA
- 100 MS/s 14-bit ADCs, 400 MS/s 16-bit DACs
- External 10 MHz reference and PPS input
- MIMO Expansion
- \$1400

USRP2



Simple Daughterboards

- BasicRX and BasicTX (\$75)
 - Transformer-coupled to ADC/DAC
 - Breakout board
- LFRX and LFTX (\$75)
 - DC-30 MHz
- TVRX (\$100)
 - 50 MHz to 860 MHz receive-only
- DBSRX (\$150)
 - 800 MHz to 2.4 GHz receive-only

RFX-Series Transceivers

- \$275 each
- 50-100 mW output power
- Full duplex
- Multiple bands
 - RFX400 – 400-500 MHz
 - RFX900 – 800-1000 MHz
 - RFX1200 – 1100-1400 MHz
 - RFX1800 – 1500-2100 MHz
 - RFX2200 – 2000-2400 MHz
 - RFX2400 – 2300-2900 MHz

Transceivers, II

- XCVR2450 (\$400)
 - 2.4-2.5 GHz, 100mW
 - 4.9-5.9 GHz, 50mW
 - Not full duplex
- WBX (\$450)
 - Introduced in January
 - 50 MHz to 2.2 GHz
 - 50-100mW output power
 - 3-6 dB noise figure
 - +5 to +10 dBm IP3
 - Full duplex

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Market Positioning

3 Separate “lines”

- Low cost
 - USRP2 -> USRP2+ -> USRP3...
- Extremely low cost
 - USRP1 -> USRP1+
- Embedded

USRP1+

- Like USRP1 but
 - Single daughterboard
 - Flexible clocking plus TCXO reference
 - Spartan 3
- Driver work, directly in UHD
 - Adding support for USRP1 to UHD at the same time
- On track to ship by January
- ~\$700

USRP2+

- Like USRP2 but
 - Spartan 3A DSP
 - No SD card
 - TCXO reference
 - Support for in-box GPSDO
 - Minor component changes
- On track to ship by end of year
- \$1500 with S3A-1800, more for S3A-3400

USRP Embedded

- Like USRP1+, but replace USB2 interface with a GUMSTIX SBC
- OMAP3530
 - 600 MHz ARM Cortex with floating point SIMD extensions
 - 520 MHz TI C64x fixed-point DSP
- Spartan 3A DSP-1800 and -3400 versions
- High-speed bus between FPGA and OMAP
- Audio In/Out, HDMI video
- 10/100 Ethernet
- USB Host, USB On The Go, USB console

USRP Embedded Highlights

- Runs REAL Linux
- No need to choose between GPP, DSP, or FPGA processing
- Develop on desktop with USRP1/2, deploy (same code!) on Embedded
- Develop directly on Embedded
- Low power, no laptop
- Extremely low latency with direct bus access

Embedded Usage Model

- Network testbeds
- Wireless sensor nodes
- Public safety nodes
- Picocells

USRP Embedded Status

- Hardware bringup complete on pre-production boards
- Data transfer rates >20 MB/s
 - Enough for WCDMA
- Driver work going directly into UHD
- Kernel module
- On track to ship by November, \$1200-\$1400

Receivers

- DBSRX2 (800 MHz to 2.4 GHz)
 - Replace obsolete part
 - Better performance
 - Works better with USRP2 and new motherboards
 - October release
- TVRX2 (50 MHz to 860 MHz)
 - Dual tuner
 - Replace obsolete part
 - Better performance
 - November Release

Transceivers

- SBX
 - 400 MHz to 4.4 GHz, full duplex
 - ~100mW output power
 - Similar to WBX
 - January Release
- CBX
 - 2 GHz to 6 GHz, full duplex
 - Very similar to WBX and SBX
 - January Release

Miscellaneous

- WBX-GDB for US mobile phone bands
 - 0.5 to 1 Watt TX power on all 3 bands
 - GPS RX port
 - Should be done by end of year, ship Q1-2011
- European/worldwide cellphone bands
 - Coming next once US bands done