Introduction to SDR Hardware

Paul Sutton

4th March 2014

ICTP School on Applications of Open Spectrum and White Spaces Technologies

Software Radio Systems

CTVR the telecommunications research centre

Outline

- What is Software Radio?
- A Brief History
- Software Radio Today

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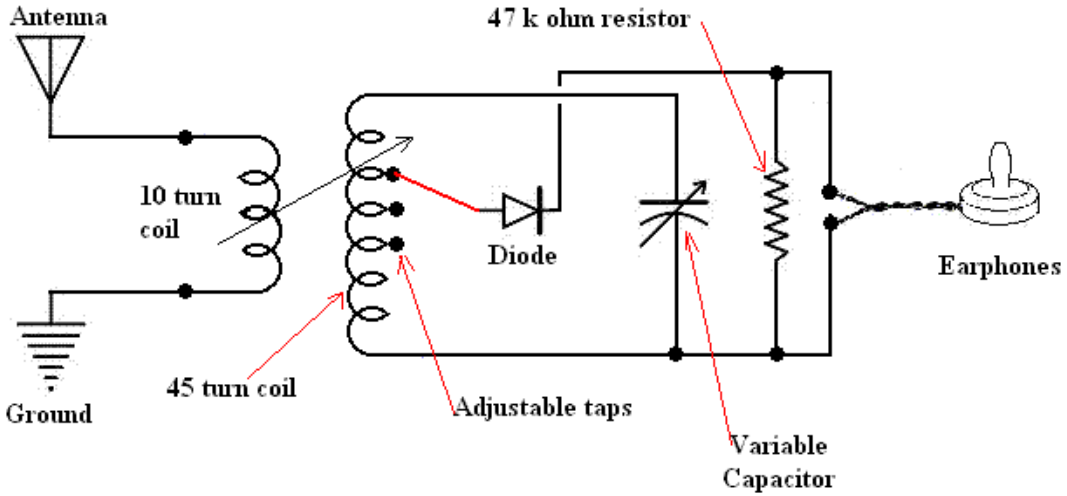
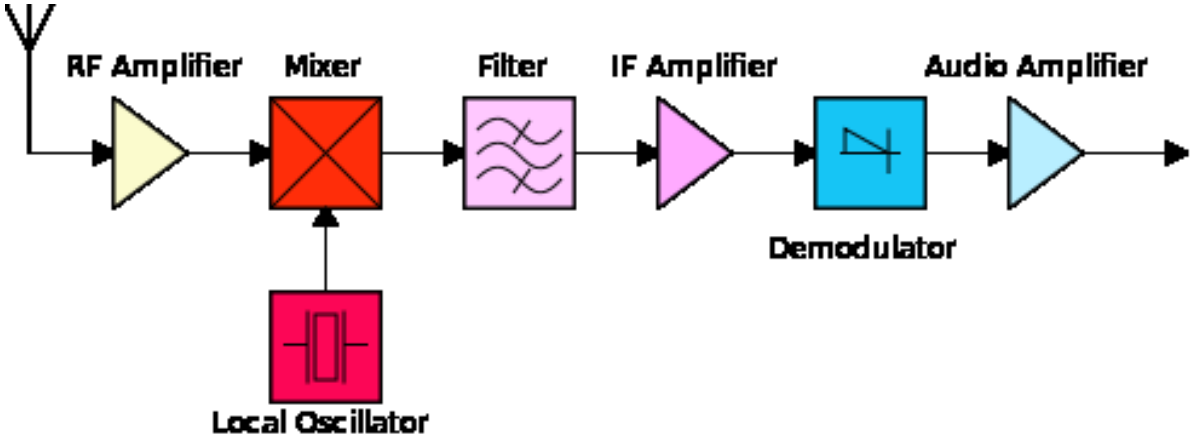
What is Software Radio?

Simple Crystal Radio

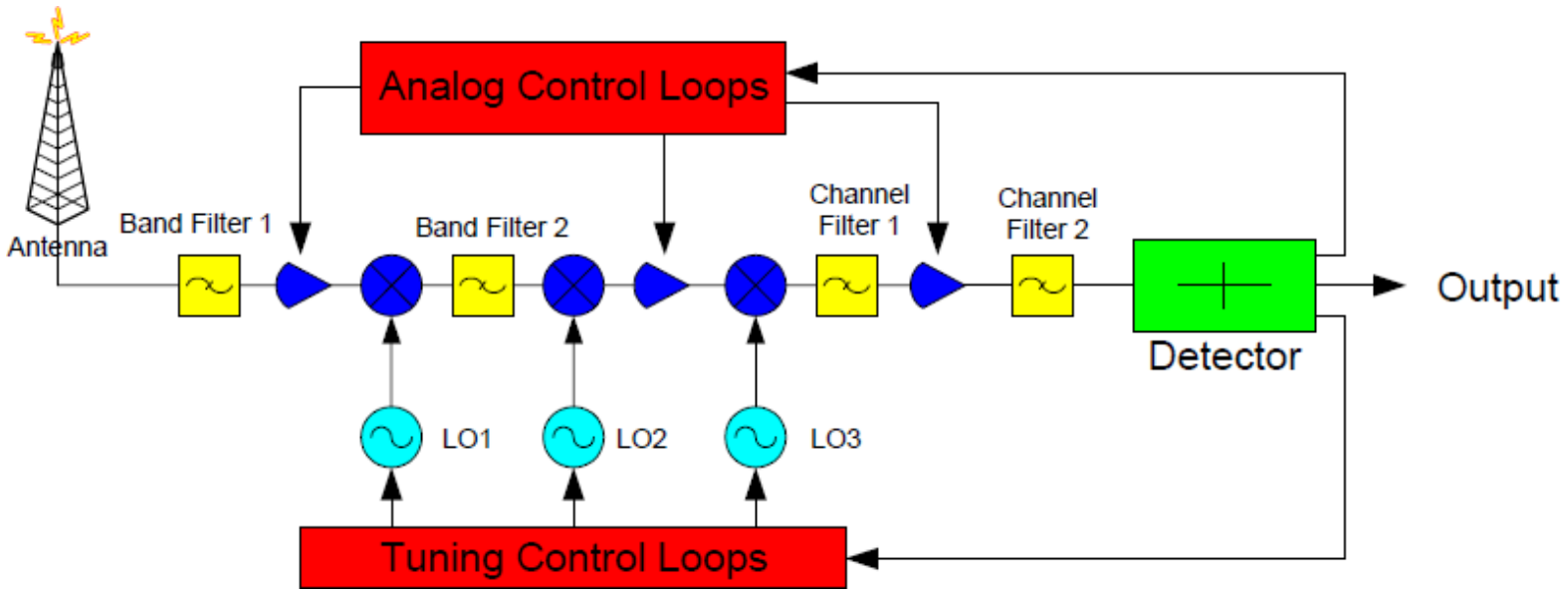


What is Software Radio?

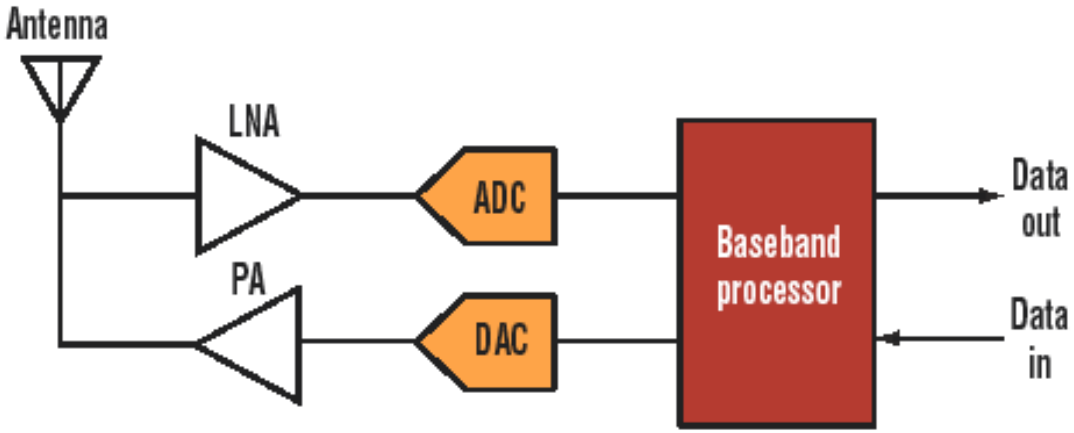
Superheterodyne Receiver



What is Software Radio?



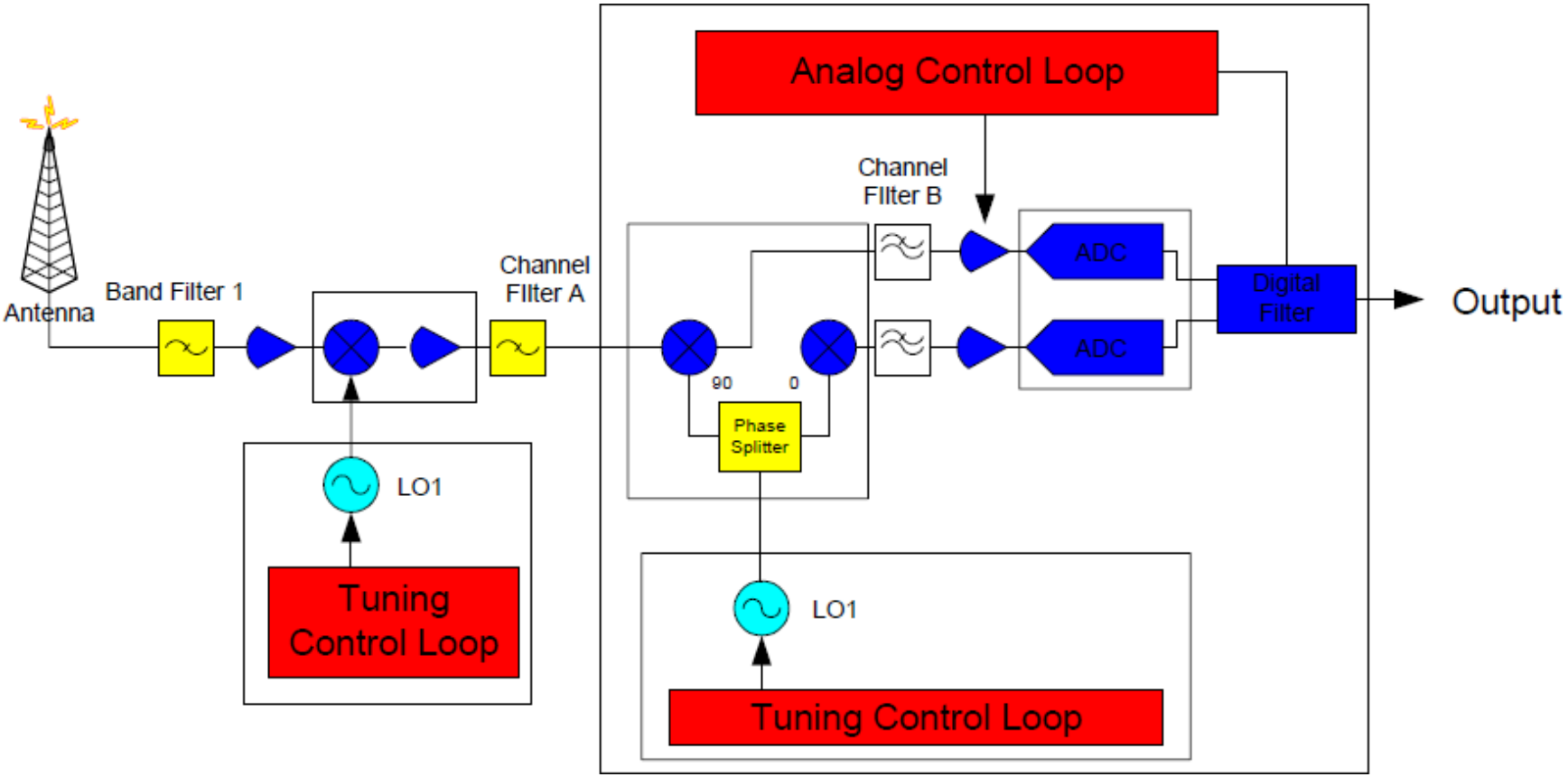
What is Software Radio?



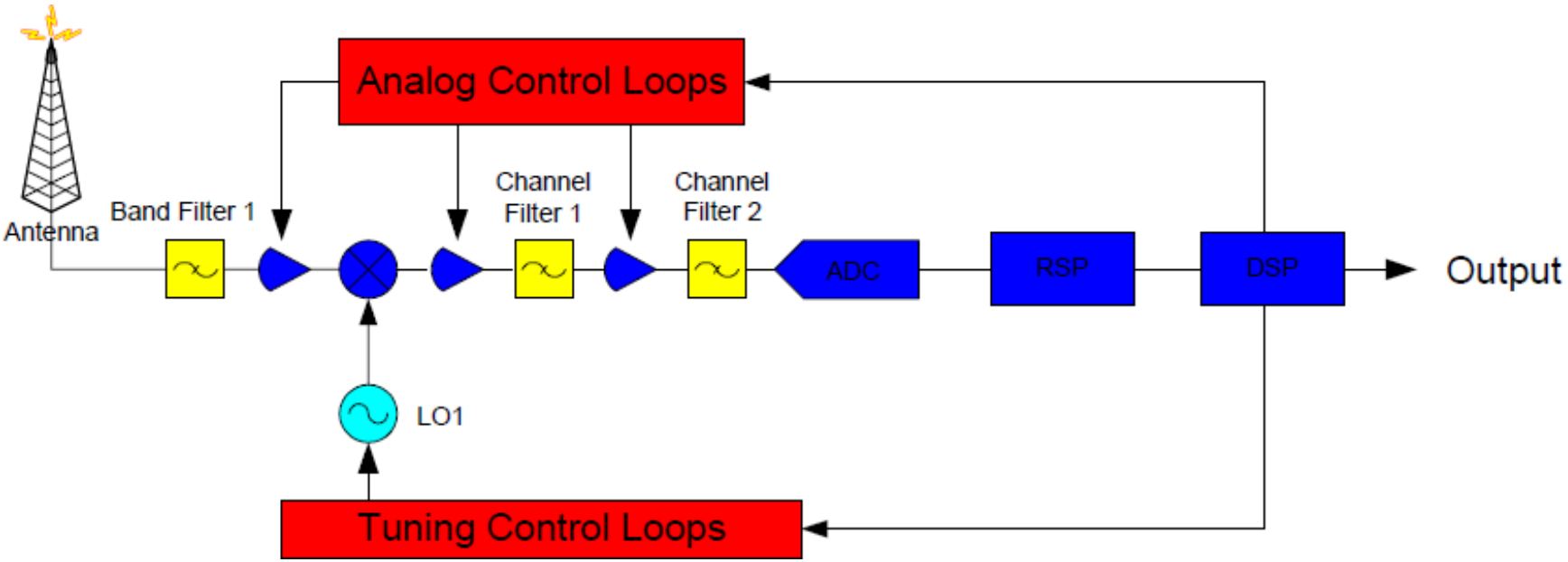
1. In the ideal software-defined radio, the antenna connects directly to the LNA and ADC, or the PA and DAC. The processor handles all radio functions, filtering, up/downconversion, modulation/demodulation, and digital baseband.

Source: http://electronicdesign.com/communications/elusive-software-defined-radio

What is Software Radio?



What is Software Radio?



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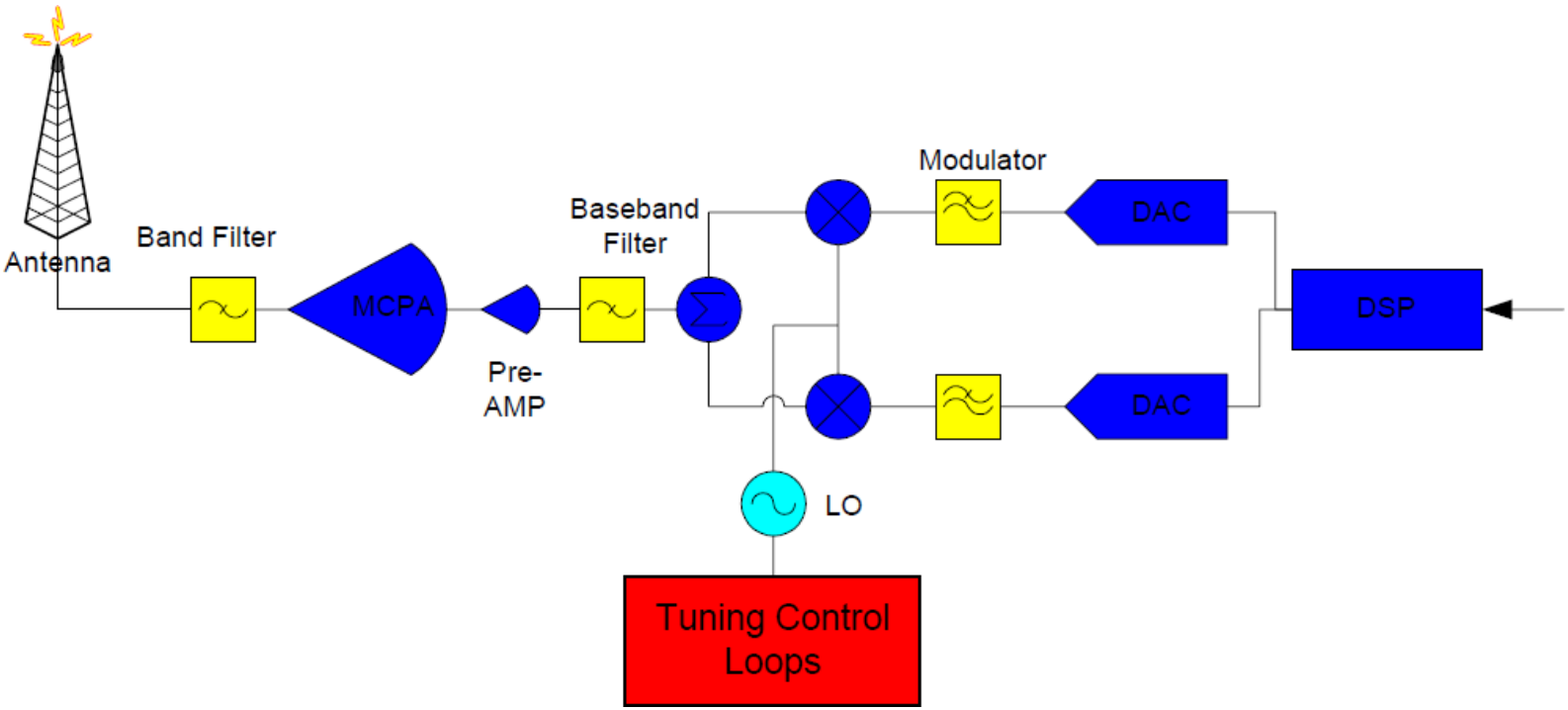

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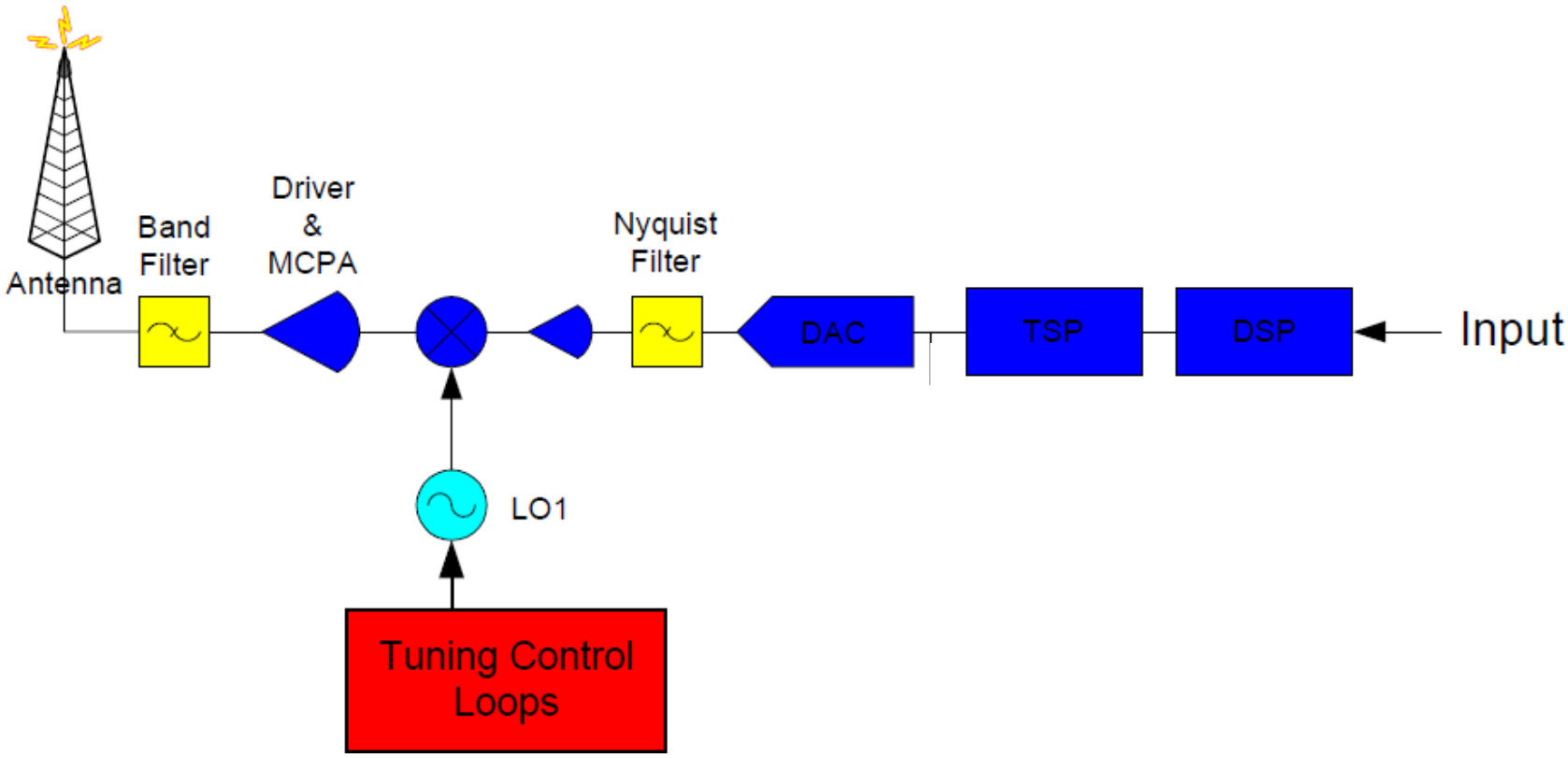
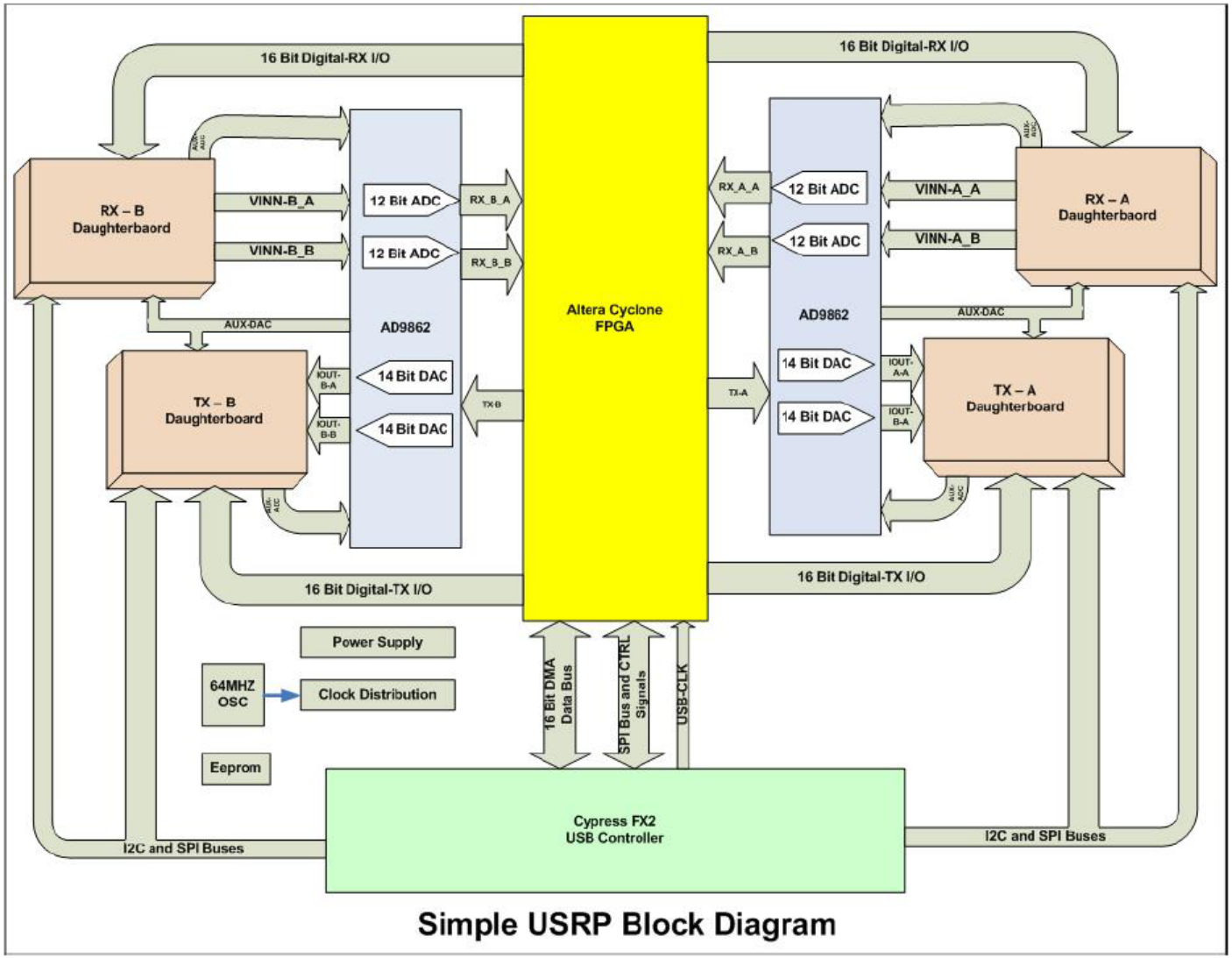
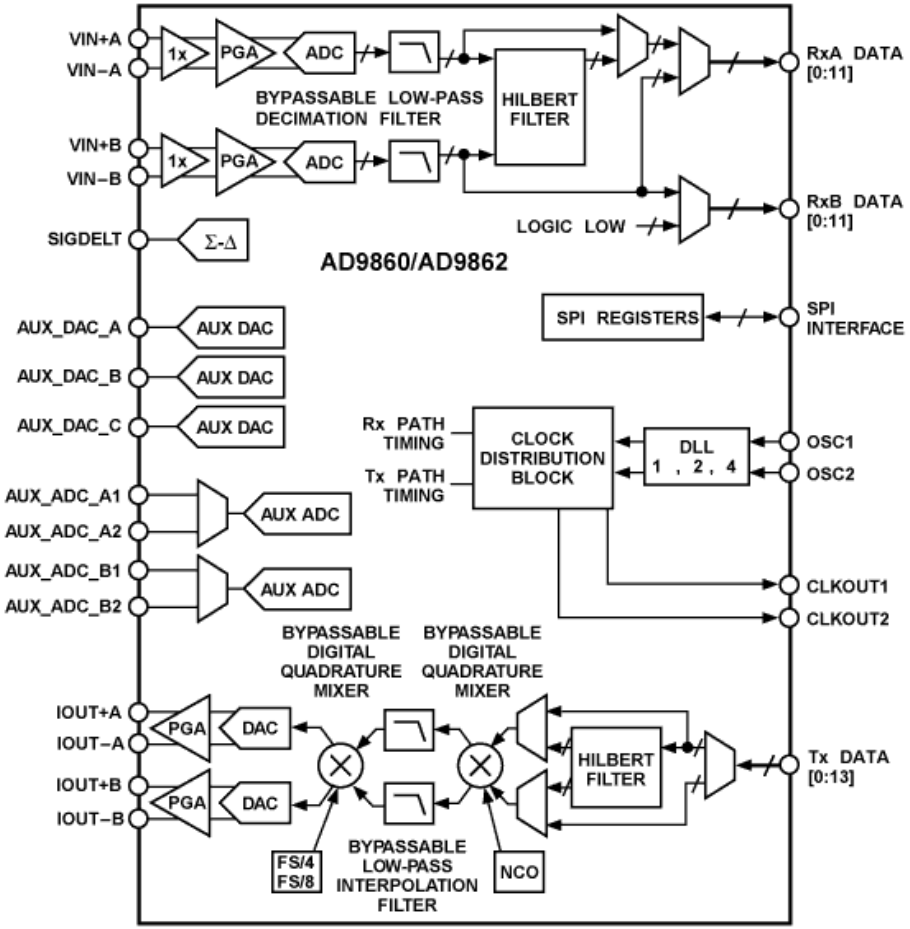


What is Software Radio?



Source: gnuradio.org/redmine/attachments/128/USRP_Documentation.odt

What is Software Radio?



A Brief History

- What is Software Radio?
- A Brief History
- Software Radio Today

A Brief History

Software Radios
Survey, Critical Evaluation and Future Directions

J. Mitola, III
Chief Scientist, Electronic Systems
E-Systems, Melpar Division
11225 Waples Mill Road
Fairfax, VA 22030

ABSTRACT

A software radio is a set of Digital Signal Processing (DSP) primitives, a metalevel system for combining the primitives into communications systems functions (transmitter, channel model, receiver . . .) and a set of target processors on which the software radio is hosted for real-time communications. Typical applications include speech/music, modems, packet radio, telemetry and High Definition Television. Low cost high performance DSP chips promote delivery of enhanced communications services as software radios. Time to incorporate a new service into a product is reduced dramatically using this approach. Low costs and new services will continue to increase demand for software radio tool sets and CAD environments.

This paper relates performance of enabling hardware technologies to software radio requirements, portending a decade of shift from hardware radios toward software intensive approaches. Such approaches require efficient use of computational resources through topological consistency of radio functions and host architectures. This leads to a layered

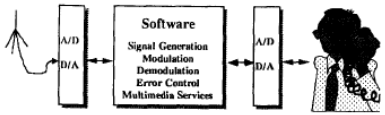


Fig. 1. An Idealized Software Radio

at handset allow all radio transmit, receive, signal generation, modulation/demodulation, timing, control, coding and decoding functions to be performed in software.

This "software" radio of course includes many non-DSP hardware components like RF conversion, RF distribution, anti-aliasing filters, power handling, etc. But the increased performance and continually dropping costs of the enabling technologies of A/D and D/A converters, high speed digital signal distribution, DSP chips and embedded computing are facilitating a shift toward software intensive approaches especially in large scale telesystems applications.

- First IEEE paper
  - Mitola, 1993

The Software Radio Architecture

As communications technology continues its rapid transition from analog to digital, more functions of contemporary radio systems are implemented in software, leading toward the software radio. What distinguishes software radio architectures? What new capabilities are more economically accessible in software radios than digital radios? What are the pitfalls? And the prognosis?

Joe Mitola

We are poised on the threshold of another revolution in radio systems engineering. Throughout the '70s and '80s radio systems migrated from analog to digital in almost every respect from system control to source and channel coding to hardware technology. And now the software radio revolution extends these horizons by liberating radio-based services from chronic dependency on hard-wired characteristics, including frequency band, channel bandwidth, and channel coding. This liberation is accomplished through a combination of techniques that includes multi-band antennas and RF conversion; wideband Analog to Digital (A/D) and Digital to Analog (D/A) conversion (A/D/A conversion); and the implementation of IF, baseband, and bitstream processing functions in general-purpose programmable processors. The resulting software-defined radio (or "software radio") in part extends the evolution of programmable hardware, increasing flexibility via increased programmability. And, in part, it represents an ideal that may never be fully implemented but that nevertheless simplifies and existence of a large commercial base which sometimes fails to emerge in spite of openness. As system complexity increases, architecture becomes more critical because of its power to either simplify and facilitate system development (a "powerful" architecture) or to complicate development and impede progress (a "weak" architecture).

Radio architectures may be plotted in the phase space of network organization versus channel data rate, as shown in Fig. 1. These architectures have evolved from early point-to-point and relatively chaotic peer networks (e.g., citizens band and push-to-talk mobile military radio networks) toward more hierarchical structures with improved service quality. In addition, channel data rates continue to increase through multiplexing and spectrum spreading. In a multiple-hierarchy application, a single radio unit, typically a mobile terminal, participates in more than one network hierarchy. A software radio terminal, for example, could operate in a GSM network, an AMPS network, and a future satellite mobile network. Multiband multimode military radios and future Personal Communications Systems (PCS) that seamlessly integrate multimedia services across such diverse

JOE MITOLA is a consulting scientist with The MITRE Corporation.

SPW is a registered trade-

- IEEE Comms Magazine
  - May 1995
  - Special Issue
  - Mitola Guest Editor

A Brief History

- Initial work on software radio was driven by military applications.

- The need for interoperability between a variety of different communication technologies.

- SPEAKeasy
- JTRS

A Brief History

- On the commercial side, significant initial work was done by the SpectrumWare research group at MIT.

- Commercialized by Vanu Inc.

- Demonstrated GSM basestations powered by Xeon processors in 2003.

A Brief History

Since then....

A Brief History

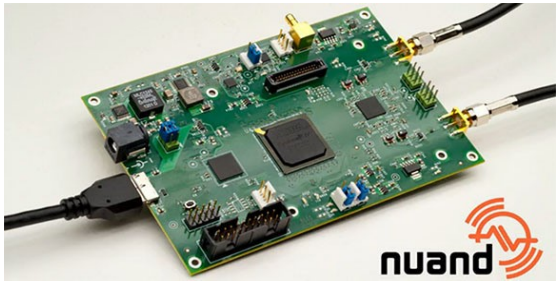
Since then....

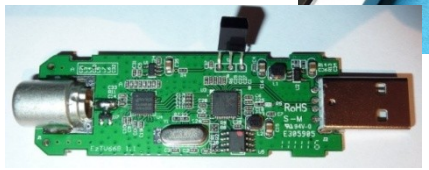
- A vast amount of research

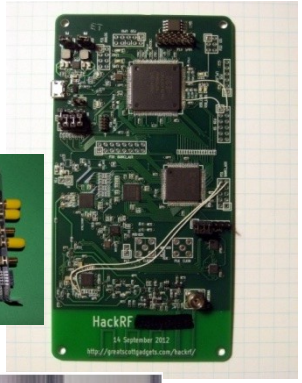
A Brief History

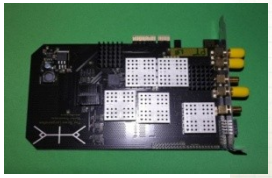
Since then....

- A wide range of RF front-ends





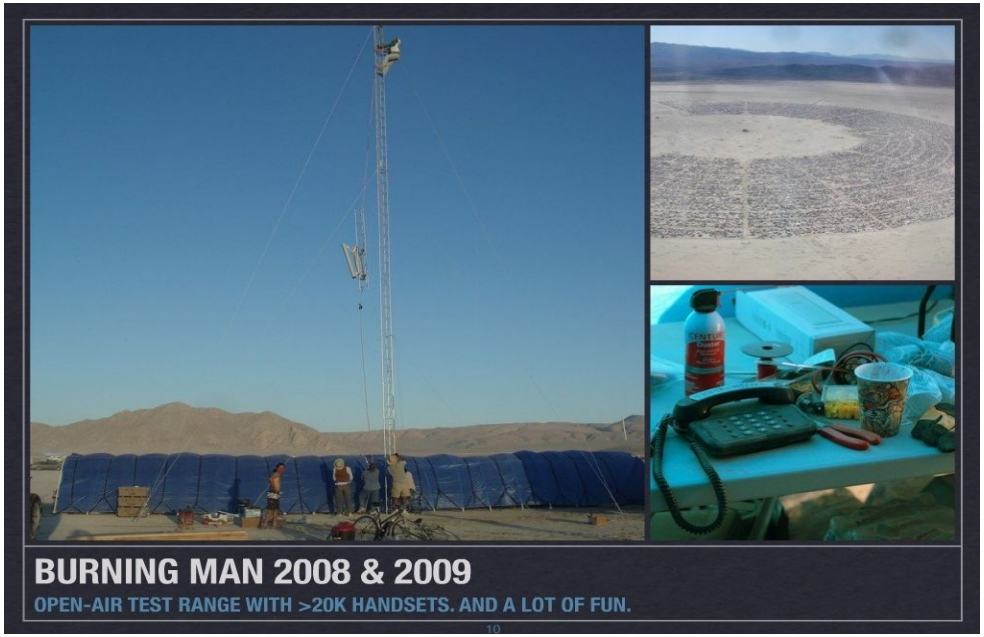




A Brief History

Since then....

- Some advanced projects



osmocom
osmocomBB
osmocomSecurity
osmocomTETRA
osmocomDECT
osmocomOpenBSC

OPEN AIR INTERFACE

amarisoft

OPEN

openLTE Alpha
An open source 3GPP LTE implementation.
Brought to you by: bwojtowi

SRS Software Radio Systems

CTVR the telecommunications research centre

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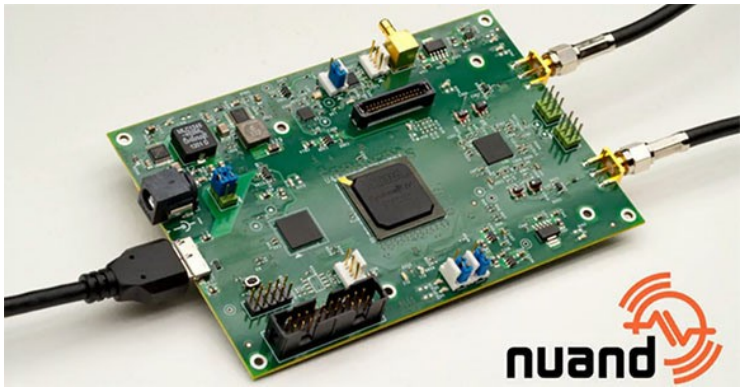
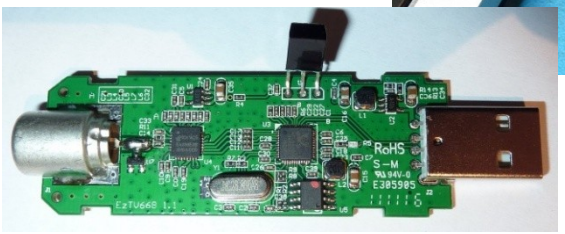
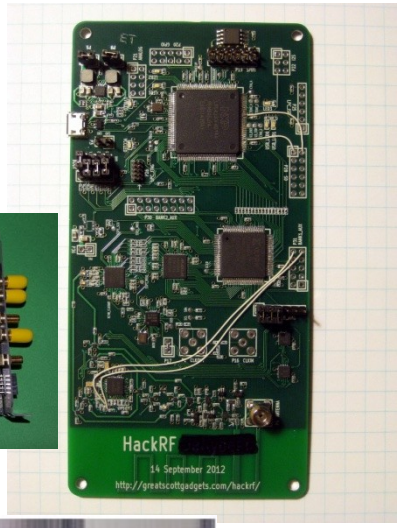
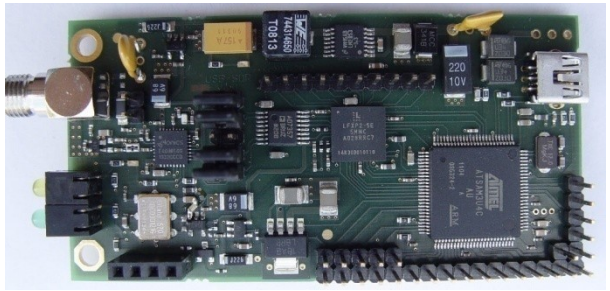
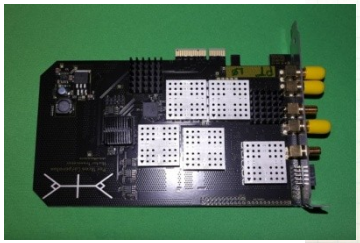
Software Radio Today

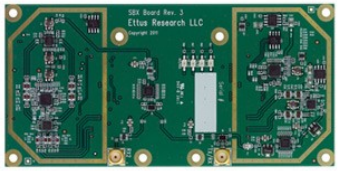












Software Radio Systems

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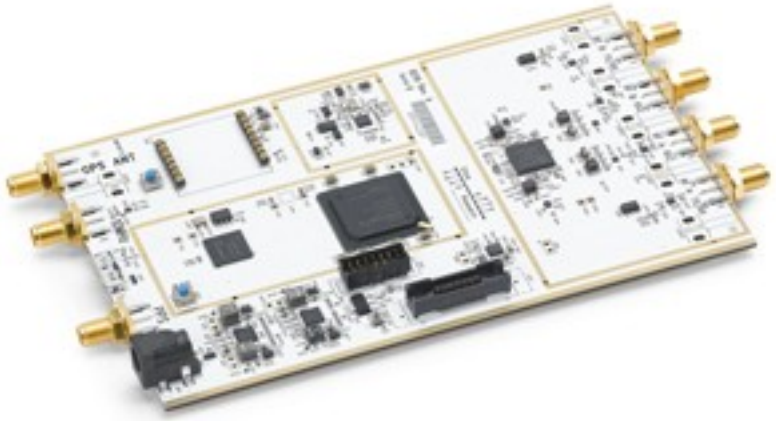
Software Radio Today

Ettus Research



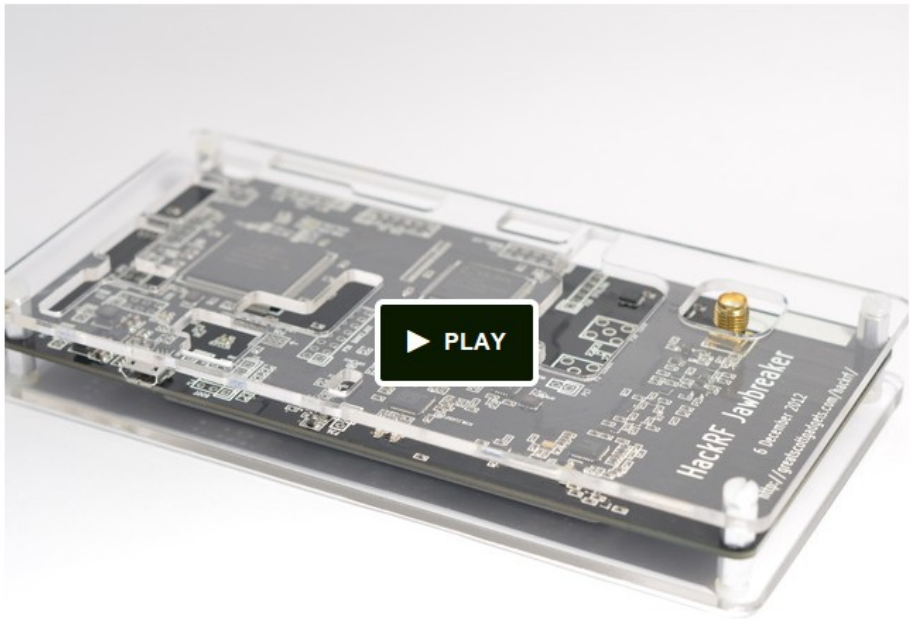
Software Radio Today

HackRF, an open source SDR platform

by Michael Ossmann

Home | Updates 13 | Backers 1,991 | Comments 105 | Evergreen, CO | Hardware

Funded! This project successfully raised its funding goal on Sep 4.



1,991
backers

$602,960
pledged of $80,000 goal

0
seconds to go

Funding period
Jul 31, 2013 - Sep 4, 2013 (35 days)

Project by
Michael Ossmann
Evergreen, CO
Contact me

Software Radio Today

bladeRF - USB 3.0 Software Defined Radio

by Nuand

Home | Updates 31 | Backers 501 | Comments 63 | Santa Clara, CA | Hardware

Funded! This project successfully raised its funding goal on Feb 28, 2013.

501
backers

$191,422
pledged of $100,000 goal

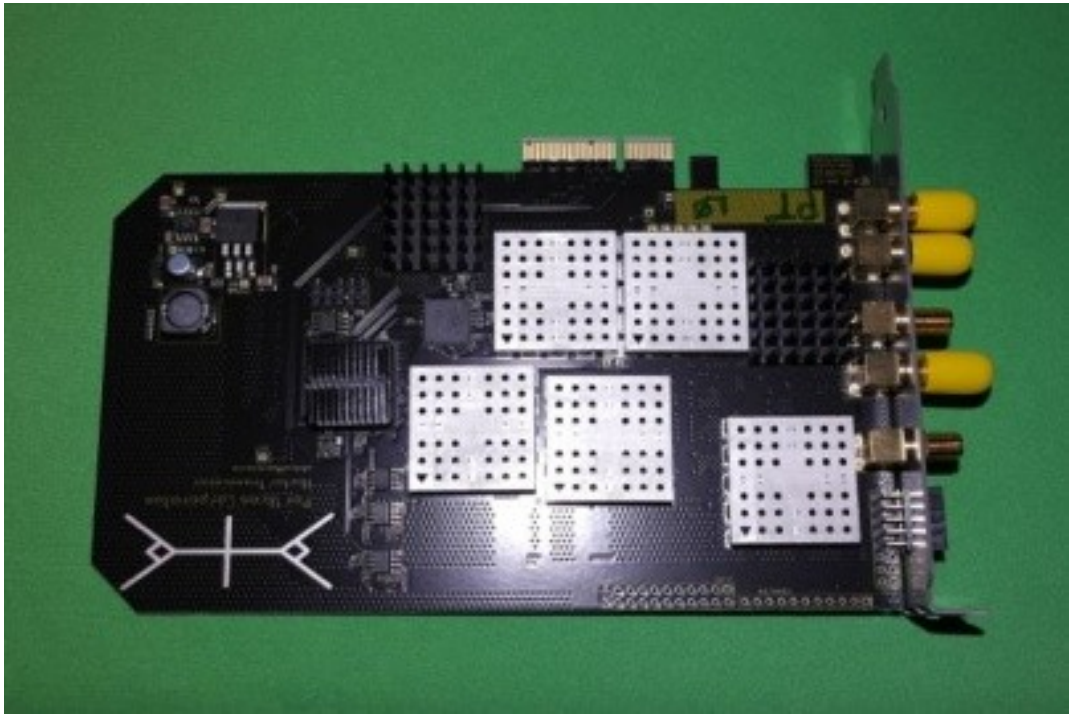
0
seconds to go

Funding period
Jan 29, 2013 - Feb 28, 2013 (30 days)

Project by
Nuand
Santa Clara, CA
Contact me

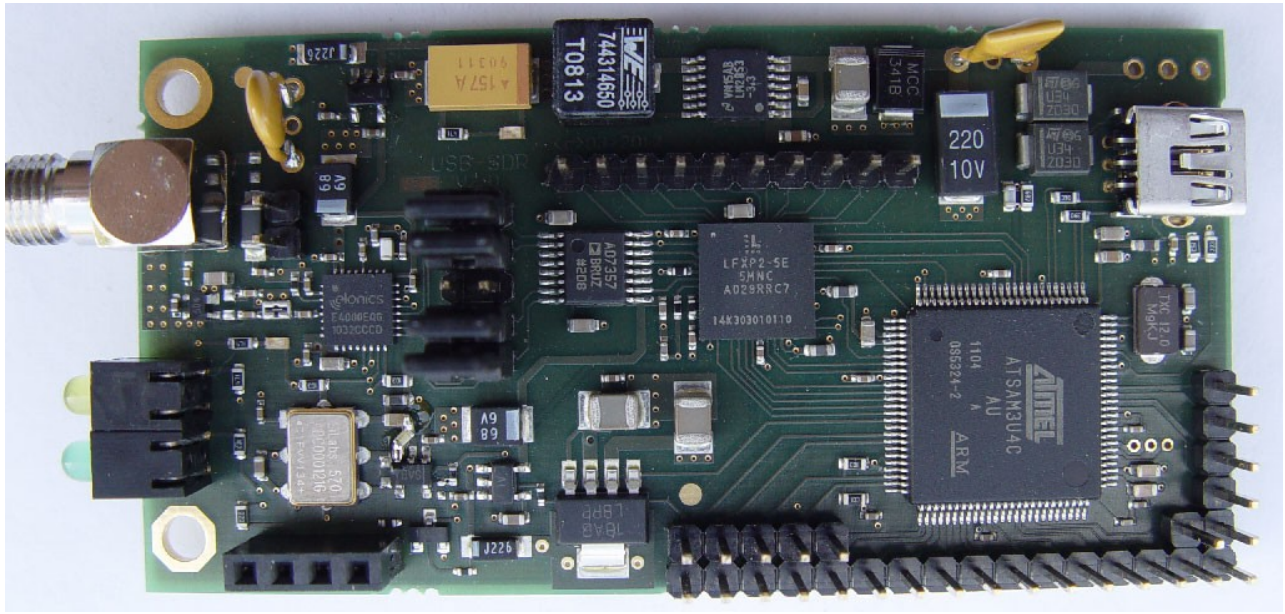
Software Radio Today

Per Vices Corporation



Software Radio Today

osmocomSDR



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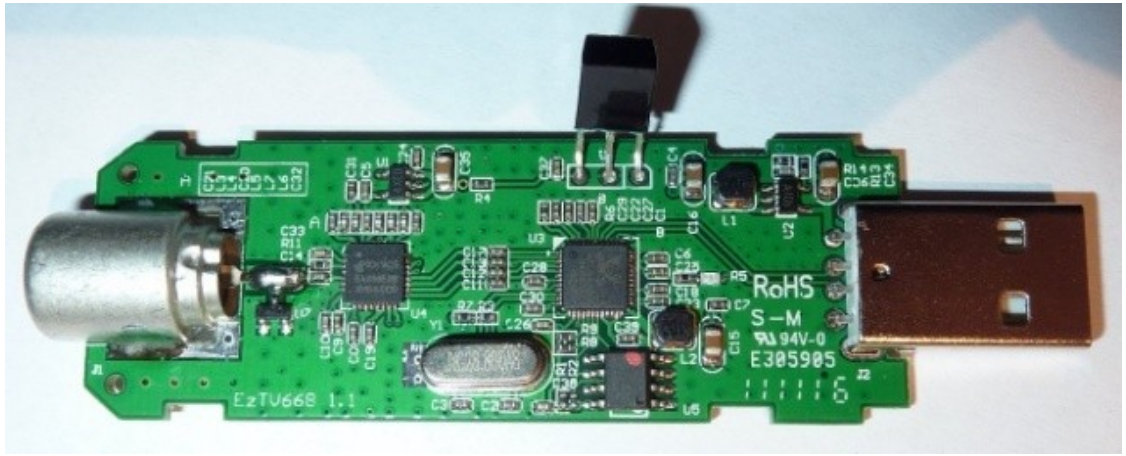

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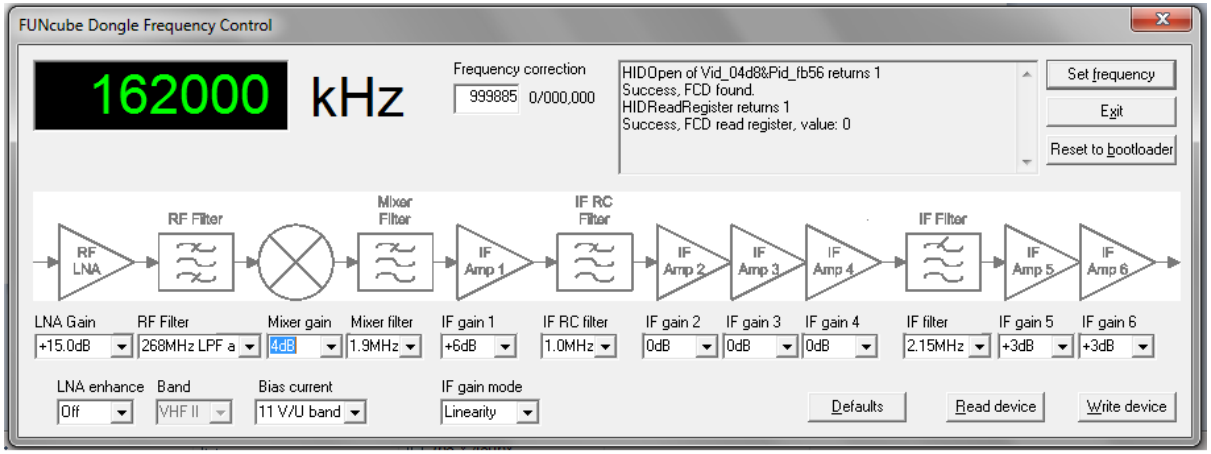

Thanks for your attention

Questions?