



SOFTWARE DEFINED RADIO

USR SDR WORKSHOP, SEPTEMBER 2017

PROF. MARCELO SEGURA

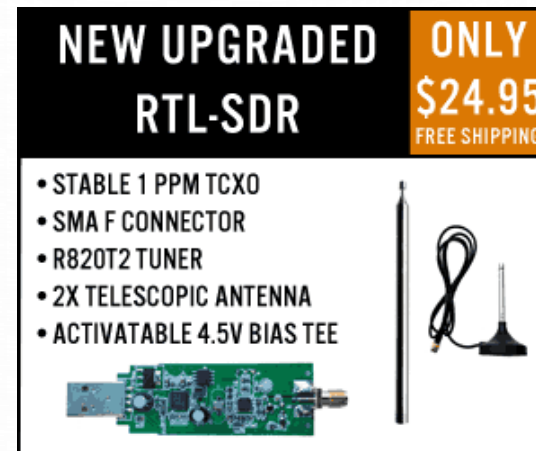
SESSION 1: SDR PLATFORMS

PARAMETER TO BE CONSIDER

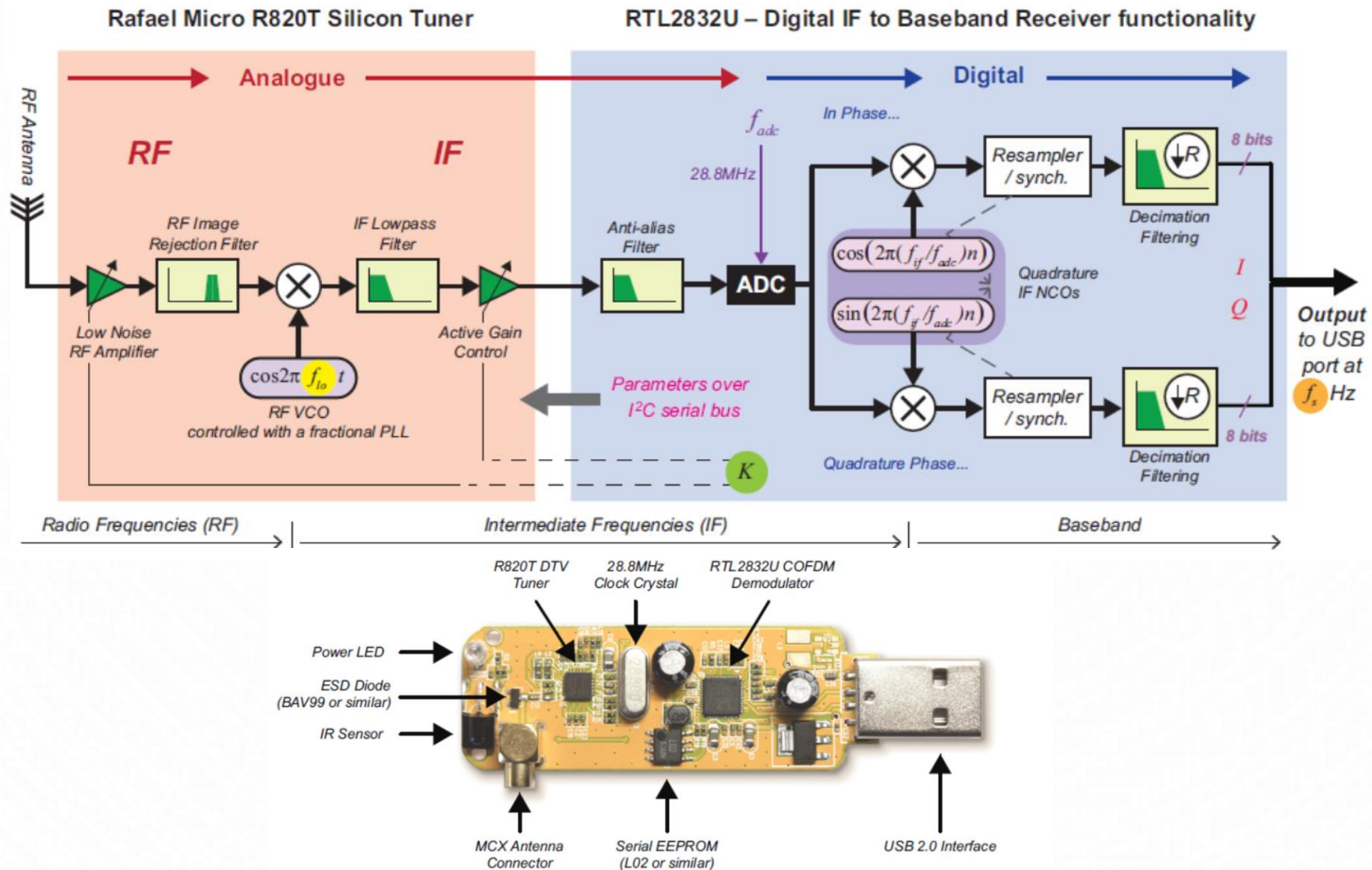
- Bandwidth: bigger band better analysis possibilities.
- Spurious free BW: which is the real band?
- RX sensibility: related with the RF components and ADC capabilities.
- ADC effective number of bits.
- Dynamic range: depend on ADC and will allow to receive small signal over strongest ones (interference)
- Filter capacity: spurious images and aliasing corrupt the received spectrum.
- Phase Noise: depends on oscillator quality, more jitters gives high noise floor so we loss signal.
- Frequency stability: better TCXO.
- General RF design: Filters, amplifiers, amplifiers, AGC, Mixer.

RTL-SDR

- Is one of the cheapest SDR on the market. It use a Realtek TV tuner that gives access to I/Q signals.
- Frequency: 25Mhz-2200Mhz
- Bandwidth: 3,2 Mhz
- ADC: 8 bits, dynamic range ?? 😞
- Duplex: NO, just **RX**
- Interface USB 2.0
- Price 😊
- www.rtl-sdr.com



RTL-SDR



HACKRF

- Frequency: 10 Mhz – 6Ghz
- ADC: 8 bits, dynamic range ??
- Bandwidth: 8 - 20Mhz
- Duplex: HALF duplex TX o RX
- Interface USB 2.0
- Price: 300 USD
- <http://greatscottgadgets.com/hackrf/>



AIRSPY

- Continuous 24 – 1800 MHz native RX range, down to DC with the SpyVerter option
- 3.5 dB NF between 42 and 1002 MHz
- Maximum RF input of +10 dBm
- Tracking RF filters
- 35dBm IIP3 RF front end
- 12bit ADC @ 20 MSPS (10.4 ENOB, 70dB SNR, 95dB SFDR)
- 10, 6 and 3 MSPS IQ output – Optimized for portable and tablets
- Up to 6 MHz panoramic spectrum view
- 0.5 ppm high precision, low phase noise clock
- 4.5v software switchable Bias-Tee 100% Compatible with SpyVerter and High Performance
- IQ or Real, 16bit fixed or 32bit float output streams
- No IQ imbalance, DC offset or 1/F noise at the center of the spectrum that plagues all the other SDRs
- Best software support of all existing SDRs
- No drivers required! 100% Plug-and-play on Windows Vista, Seven, 8, 8.1 and 10, all Linux Flavors, Mac and Android
- Compatible with Raspberry Pi, Odroid, Pine64 and UP boards
- Operating temperature: -10°C to 40°C

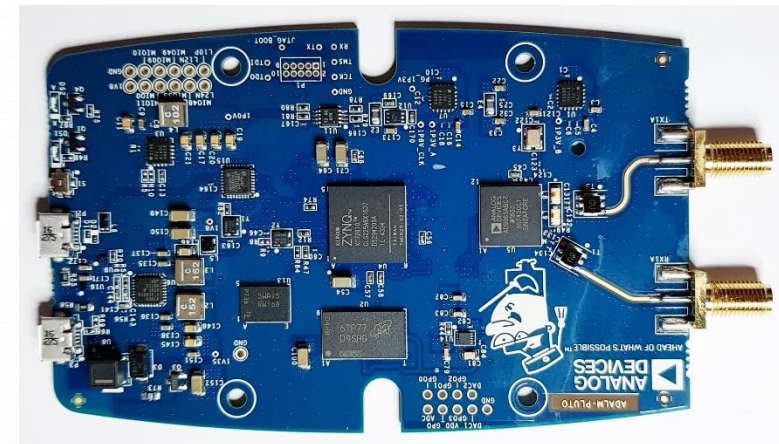
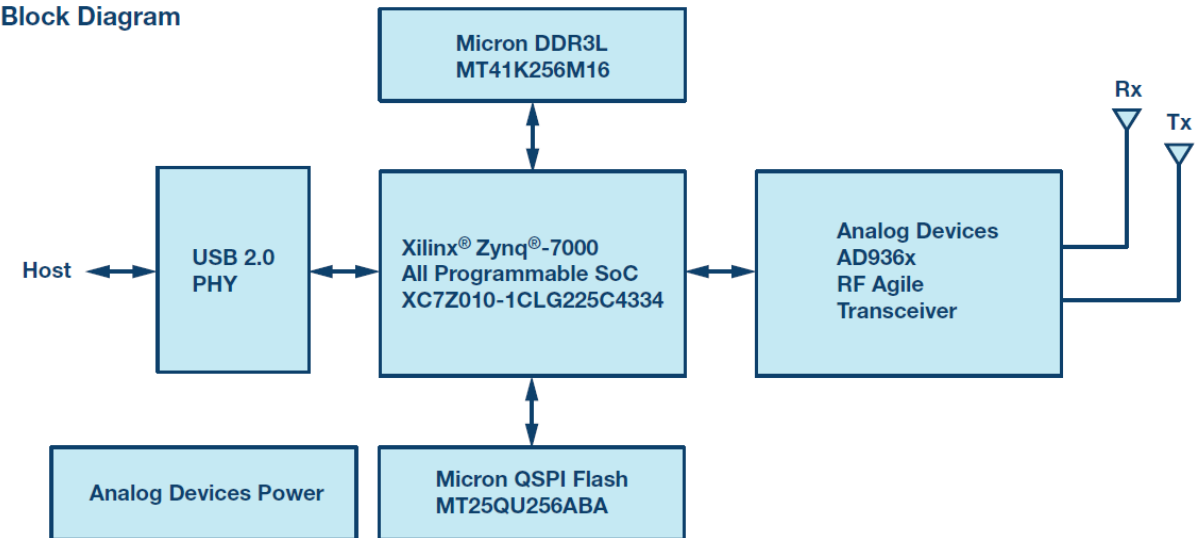
Price: 100 USD



PLUTOSDR

Specifications	Typical
Power	
DC Input (USB)	4.5 V to 5.5 V
Conversion Performance and Clocks	
ADC and DAC Sample Rate	65.2 kSPS to 61.44 MSPS
ADC and DAC Resolution	12 bits
Frequency Accuracy	±25 ppm
RF Performance	
Tuning Range	325 MHz to 3800 MHz
Tx Power Output	7 dBm
Rx Noise Figure	<3.5 dB
Rx and Tx Modulation Accuracy (EVM)	-34 dB (2%)
RF Shielding	None
Digital	
USB	2.0 On-the-Go
Core	Single ARM Cortex®-A9 @ 667 MHz
FPGA Logic Cells	28k
DSP Slices	80
DDR3L	4 Gb (512 MB)
QSPI Flash	256 Mb (32 MB)
Physical	
Dimensions	117 mm × 79 mm × 24 mm 4.62" × 3.11" × 0.95"
Weight	114 g
Temperature	10°C to 40°C

Simplified Block Diagram



Price: 150 USD

Hack?? 6Ghz: <https://wiki.analog.com/university/tools/pluto/users/customizing>

Matlab support

SDRPLAY

KEY FEATURES	RSP1	RSP2
Continuous coverage from 10 kHz to 2 GHz	✓	
Continuous coverage from 1 kHz to 2 GHz		✓
Up to 10 MHz visible bandwidth	✓	✓
Powers over the USB cable with a simple type B socket	✓	✓
12-bit ADC silicon technology (not another 8 bit dongle!)	✓	✓
8 built in front-end pre-selection filters	✓	
10 high-selectivity, built in front-end preselection filters		✓
Software selectable (On/Off) Low Noise Preamplifier	✓	
Software selectable multi-level Low Noise Preamplifier		✓
SDRuno—World Class SDR software	✓	✓
Open API for new apps development	✓	✓
Single SMA antenna socket	✓	
2 x SMA Software Selectable Antenna Inputs		✓
1 x High Impedance Input for long wire antennas		✓
Software selectable MW /FM notch filters		✓
Highly stable 0.5PPM TCXO trimmable to 0.01PPM		✓
24MHz Reference clock input / output connections		✓
4.7V Bias-T (Port B only)		✓
Robust and strong plastic case	✓	✓
RF shielding layer inside case		✓



Price: 170 USD

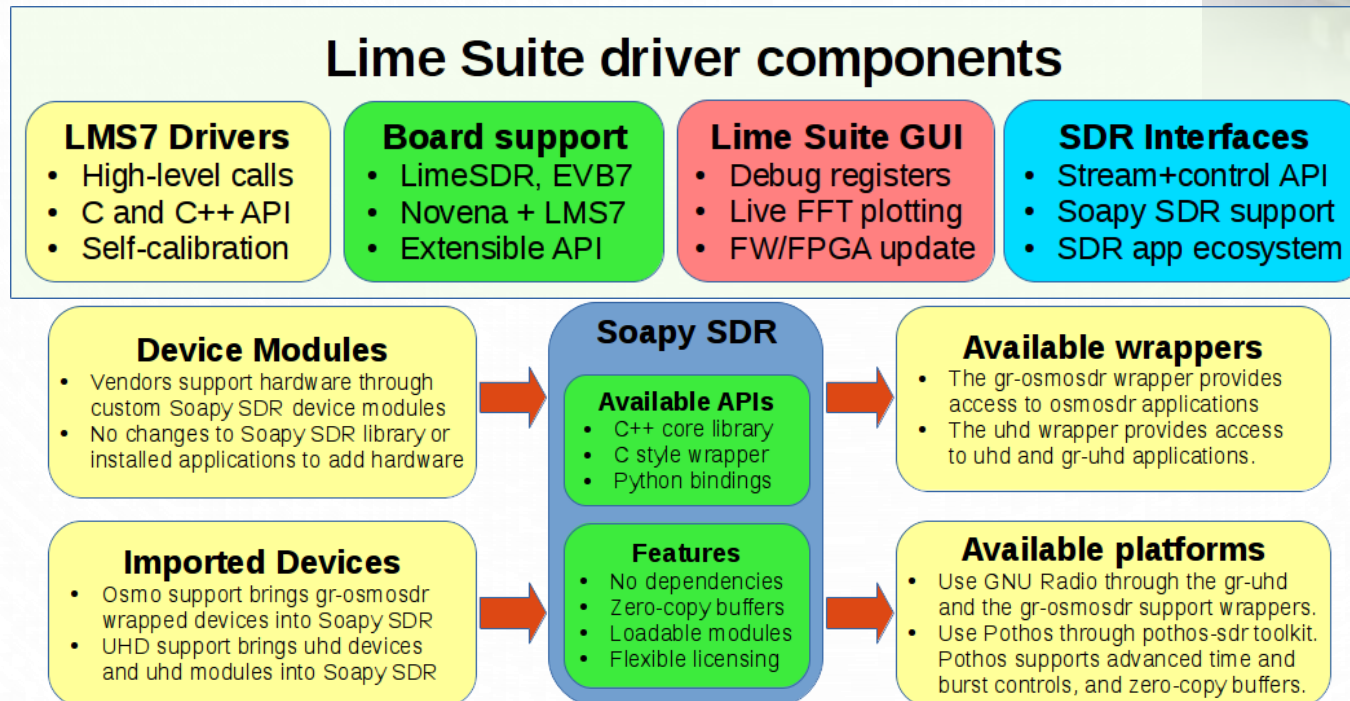
LIME SDR

- RF Transceiver: Lime Microsystems LMS7002M MIMO FPRF
- FPGA: Altera Cyclone IV EP4CE40F23 – also compatible with EP4CE30F23
- USB 3.0 controller: Cypress USB 3.0 CYUSB3014-BZXC
- Continuous frequency range: 100 kHz – 3.8 GHz
- Bandwidth: 61.44 MHz
- Power Output (CW): up to 10 dBm
- Multiplexing: 2×2 MIMO
- Power: micro USB connector or optional external power supply
- Price: \$290
- <https://wiki.myriadrfr.org/LimeSDR-USB>



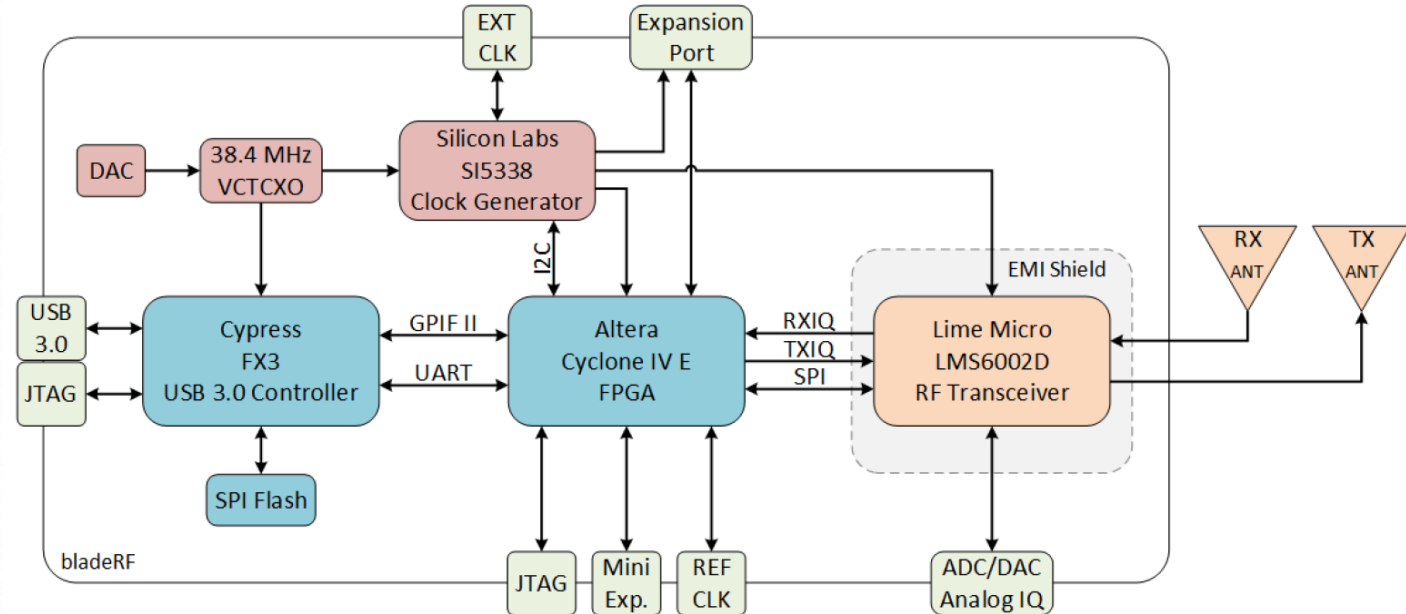
LIME SDR

- LIME NET MINI
 - Intel Core i7-7500U CPU 2 Core 2.7/3.5 GHz
 - 32GB DDR4 2133MHz memory, 512 GB SSD
 - USB 3.1 type C, USB 3.1, 2x USB3.0, Gigabit Ethernet port
- LIME APP STORE



BLADE RF

- Frequency: 300Mhz – 3.8 Ghz
- ADC/DAC: 12 bits 40MSPSP
- Dynamic range: LimeMicro LMS6002D
- Bandwidth: 28 Mhz
- Duplex: YES, Full dúplex
- Interface USB 3.0
- Price: 420 USD
- <http://www.nuand.com/>



ADRV9361

- ANALOG DEVICE: AD9361+ZYNQ FPGA
- MIMO 2X2 70MHZ – 6GHZ
- SYSTEM ON MODULE
- EMBEDDED PROCESING
- PRICE: \$1000 (not available yet)



https://wiki.analog.com/resources/eval/user-guides/adrv936x_rfsom

PICO SDR

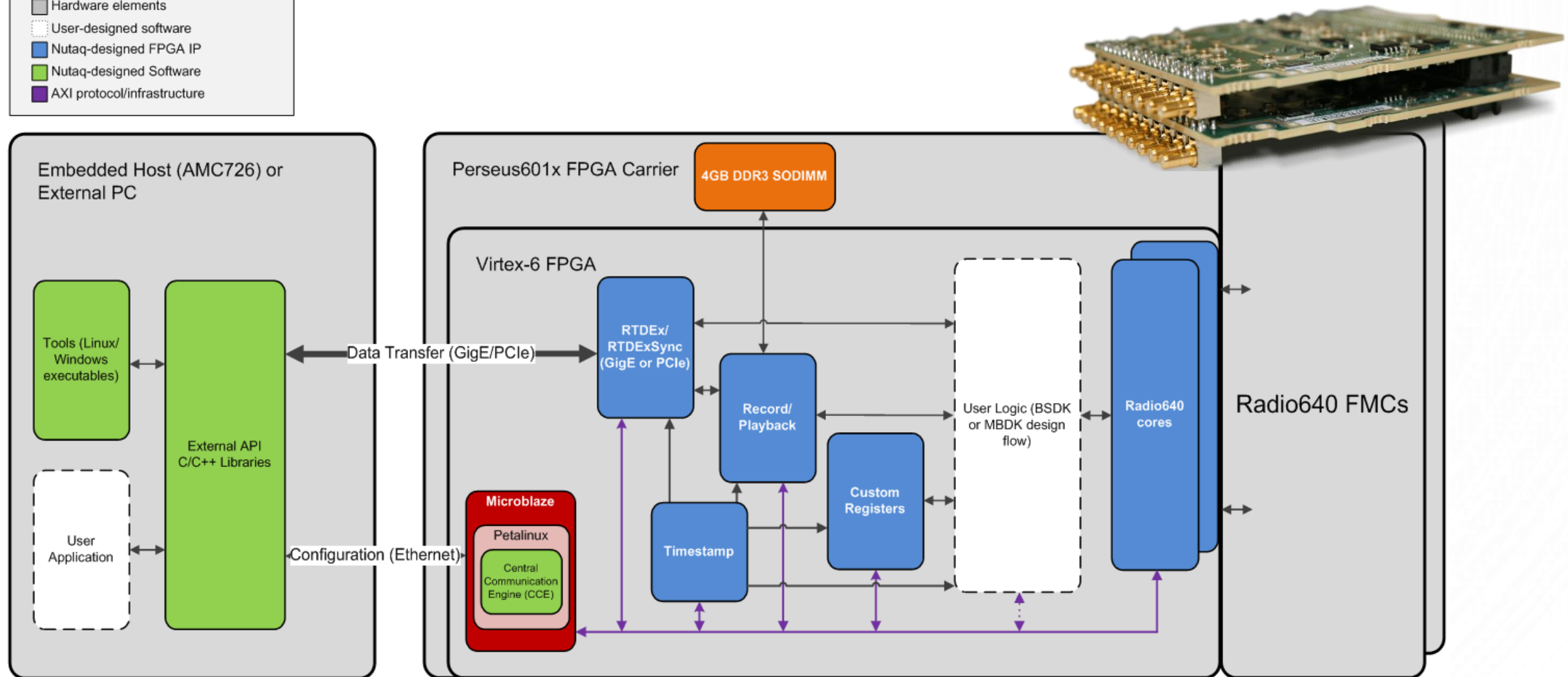
- 4×4 in one single FPGA perfectly synchronized
- Matlab Simulink and Xilinx System Generator
- AD9361 Radio Frequency Integrated Circuit (RFIC)
- Software defined up to 6 GHz and 56 MHz BW
- GNU Radio Support
- Small form factor: 215 mm x 48 mm x 290 mm
- Embedded Linux PC: connect remotely from any computer or run standalone
- Plug-and-play, with Ethernet, PCI Express and VITA-49 Radio Transport Protocol (VRT)
- Low Latency (75 μ s roundtrip) and high speed (10 Gbps) PCIe interface
- QAM64 OFDM Ref Design
- <http://www.nutaq.com/products/picosdr>
- Price: >\$4000



PICO SDR

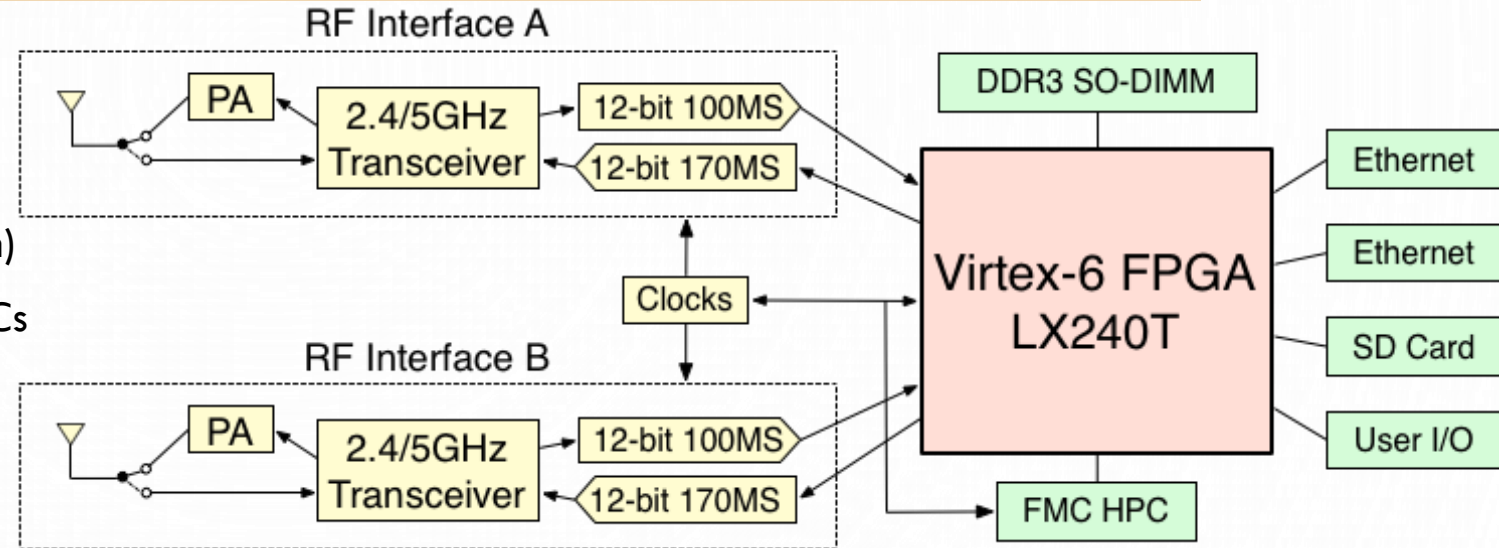
Legend

- Hardware elements
- User-designed software
- Nutaq-designed FPGA IP
- Nutaq-designed Software
- AXI protocol/infrastructure



WARP V3

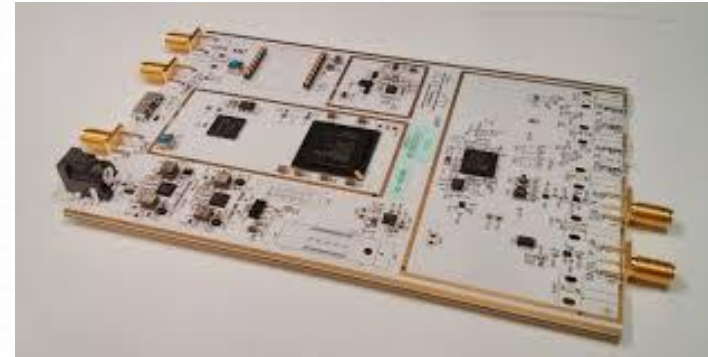
- Xilinx Virtex-6 LX240T FPGA
- 2 programmable RF interfaces, each with:
 - 2.4/5GHz transceiver (40MHz RF bandwidth)
 - 12-bit 170MSps DACs, 12-bit 100MSps ADCs
 - Dual-band PA (20dBm Tx power)
 - Shared clocking for MIMO applications
- FMC HPC expansion slot
- 2 gigabit Ethernet interfaces
- DDR3 SO-DIMM slot
- FPGA config via JTAG, SD card or flash
- User I/O: USB-UART, 12 LEDs, 2 seven-segment displays
- 4 push buttons, 4-bit DIP switch, 16-bit 2.5v I/O header
- <https://mangocomm.com/products/kits/warp-v3-kit>. Price: \$5000



B200 & B200-MINI ETTUS

- **KET FUTURES:**

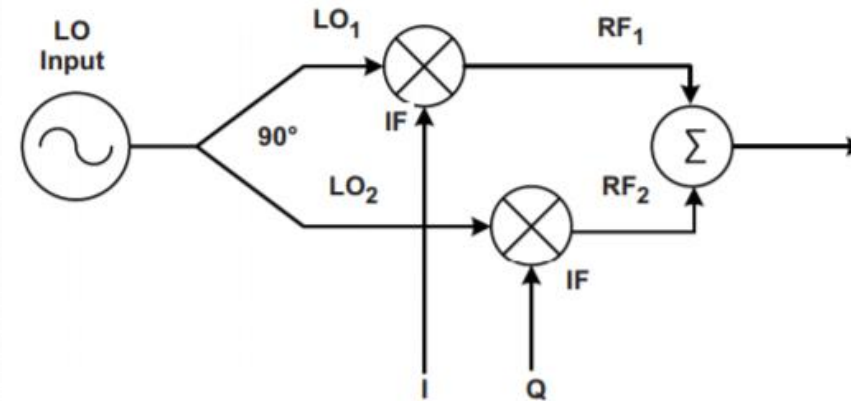
- Xilinx Spartan-6 XC6SLX75 FPGA
- Analog Devices AD9364 RFIC direct-conversion transceiver
- 12 Bits ADC/DAC
- Frequency range: 70 MHz - 6 GHz
- Up to 56 MHz of instantaneous bandwidth
- Full duplex, SISO (1 Tx & 1 Rx)
- Fast and convenient bus-powered USB 3.0 connectivity
- Price: \$800



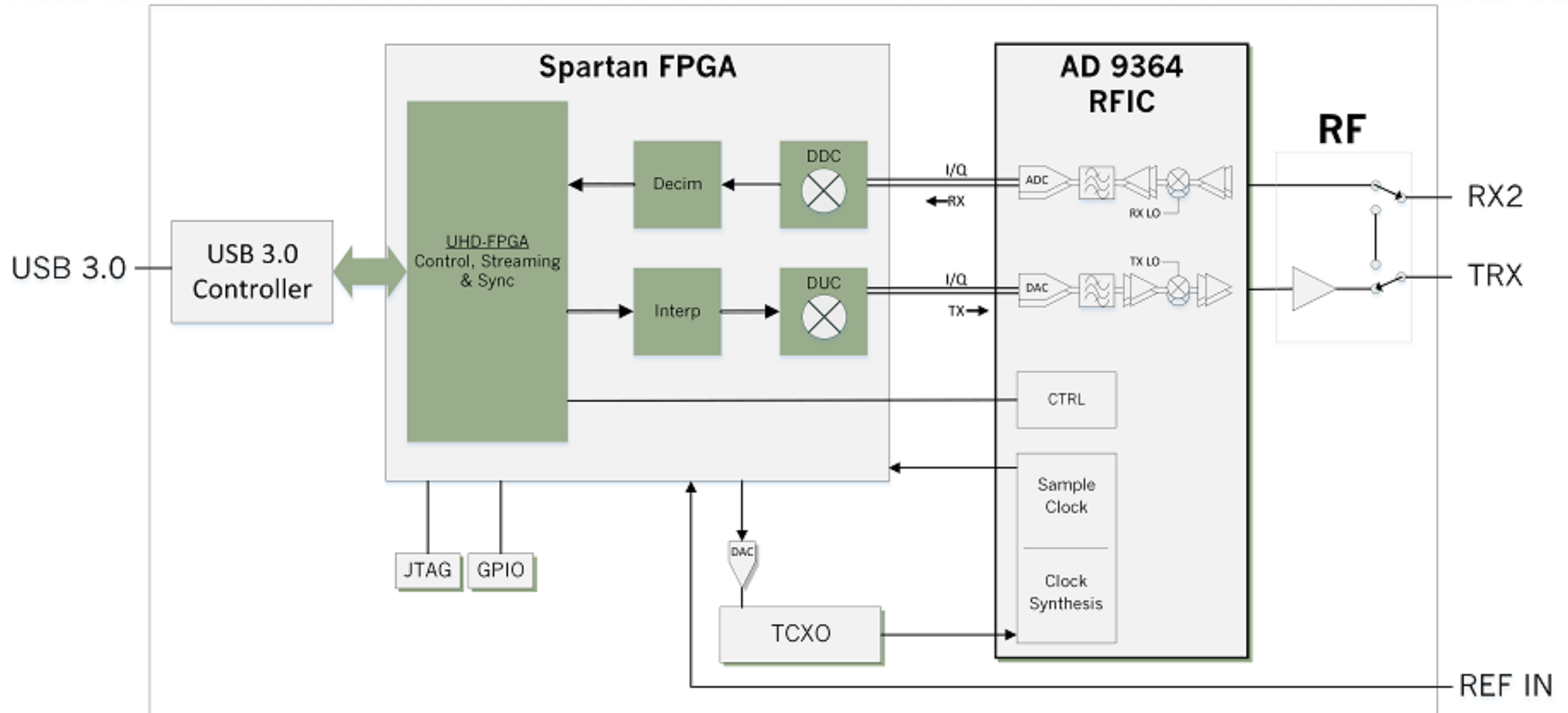
RF PERFORMANCE

• RF Performance

- SSB/LO Suppression -35/50 dBc
- Phase Noise 3.5 GHz 1.0 deg RMS
- Phase Noise 6 GHz 1.5 deg RMS
- Power Output >10dBm
- IIP3 (@ typ NF) -20dBm
- Typical Noise Figure <8dB
- RF Ports matched 50 Ohm,-10dB or better return loss generally.
- Maximum Input Power: 0 dBm



B200: BLOCK DIAGRAM



DR ING MARCELO SEGURA



INDICATORS

Component ID	Description	Details
PWR LED	Power Indicator	off = no power applied on = power applied (external or USB)
TRX LED	TX/RX Activity	off = no activity green = receiving red = transmitting orange = switching between transmitting and receiving
RX2 LED	RX2 Activity	off = no activity green = receiving
S0 LED	Reference Lock	off = no activity green = locked
S1 LED	Reference Present	off = reference level low or not present green = reference level high

CONNECTIONS & SWITCHES

Component ID	Description	Details
USB3	USB Connector	USB 3.0
J1	TRX	TX power +20dBm max RX power -15dBm max
J2	RX2	RX power -15dBm max
J3	External 10MHz/PPS Reference	+15 dBm max

Component ID	Description	Details
J5	JTAG Header	Interface to FPGA for programming and debugging.
J6 ¹	GPIO Header	Header connected to the FPGA for GPIO purposes.
SW1	FX3 Hard Reset Switch	Resets the USB controller / System reset