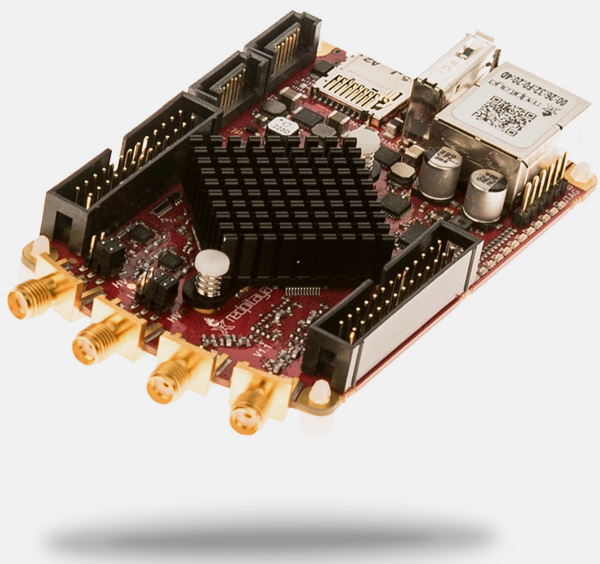
STEMlab



Ultimate open source teaching, learning and development platform for:

- Circuits and electronics
- Measurement and instrumentation
- Wireless communications
- FPGA programming
- Microprocessor programming

redpitaya

STEMlab

Powerful compact HW platform built around the latest technologies

ANALOG DEVICES

XILINX®

Specifications

redpitaya

	STEMlab 125-10	STEMlab 125-14
Basic		
Processor	Dual Core ArmCortex A9	Dual Core ArmCortex A9
FPGA	Xilinx Zynq 7010	Xilinx Zynq 7010
RAM	256 MB (2Gb)	512 MB (4Gb)
Connectivity		
Ethernet	1Gbit	1Gbit
USB	USB 2.0	USB 2.0
WIFI	With Wi-Fi dongle	With Wi-Fi dongle
Synchronisation	Not possible	With dasy chain connectors
RF Inputs		
Channels	2	2
Sample rate	125 MS/s	125 MS/s
ADC resolution	10 bit	14 bit
Ful scale voltage range	1MOhm/10pF	1MOhm/10pF
Absolute Max. Input volt range	30 V	30 V
Input ESD protection	Yes	Yes
Overload protection	Protection diodes	Protection diodes
RF Outputs		
Channels	2	2
Sample rate	125 MS/s	125 MS/s
DAC resolution	10 bit	14 bit
Voltage range	+- 1V	+- 1V
Load Impedance	50 Ohm	50 Ohm
Output slew rate	200V/us	200V/us
Short circuit protection	Yes	Yes
Extension connector		
Digital Ios	16	16
Analog Inputs	4	4
Analog inputs voltage range	0-3,5 V	0-3,5 V
Sample rate	100 kS/s	100 kS/s
Resolution	12 bit	12 bit
Analog Outputs	4	4
Analog Outputs voltage range	0-1,8V	0-1,8V
Communication interfaces	I2C, UART, SPI	I2C, UART, SPI
Available voltages	+5V, +3,3V, -4V	+5V, +3,3V, -4V

redpitaya

STEMlab

Applications

From Test & Measurement, DAQ to
Software Defined Radio (SDR)

Applications

Official - developed by Red Pitaya company	Contributed - developed by community members
Oscilloscope	SDR Radio
Signal Generator	Network vector Analyzer
Spetrum Analyser	PID controller
LCR meter	Radio Box
Logic Analyzer	LTI DSP Work Bench
Bode Analyzer	Frequency Response Analyzer
	Teslameter
	Impedance Analyzer
	...

Oscilloscope & Signal Generator

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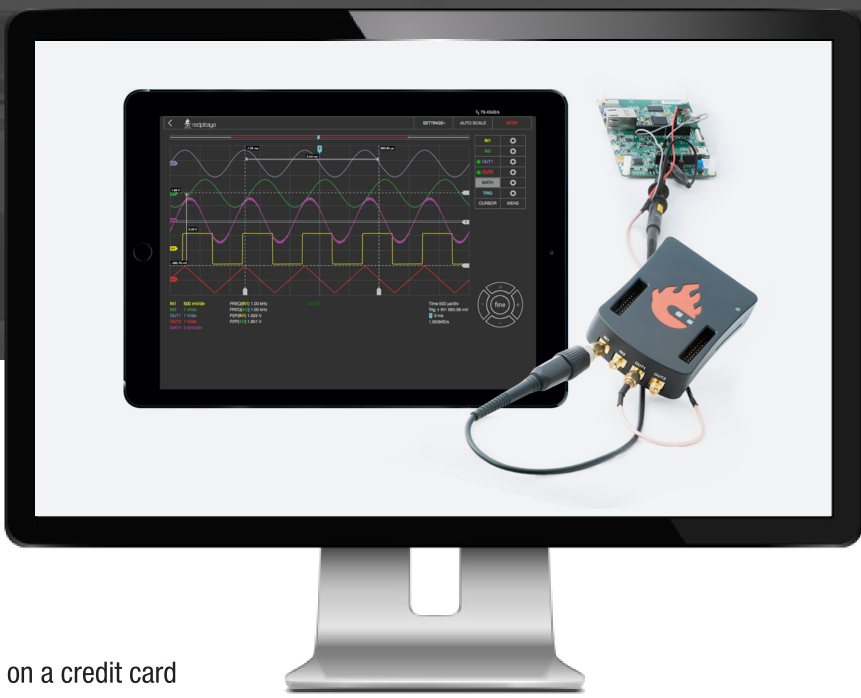
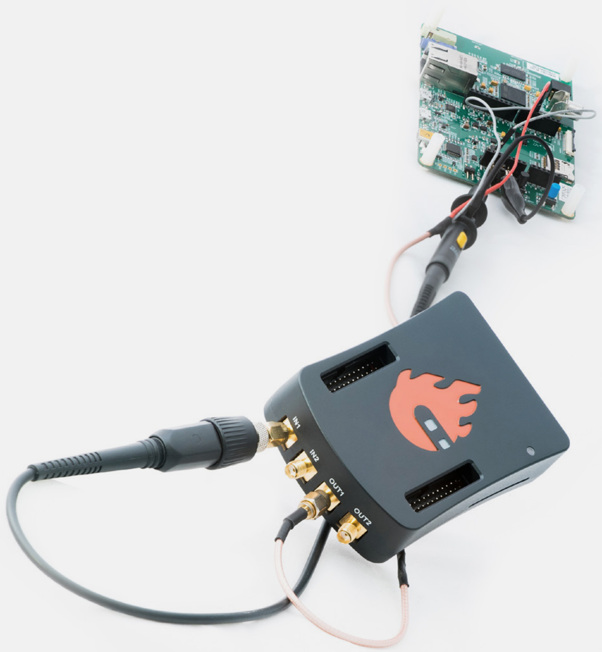


STEMlab

Test & Measurement applications running on a credit card sized SoC (FPGA+CPU) based Open SW source **DAQ platform**

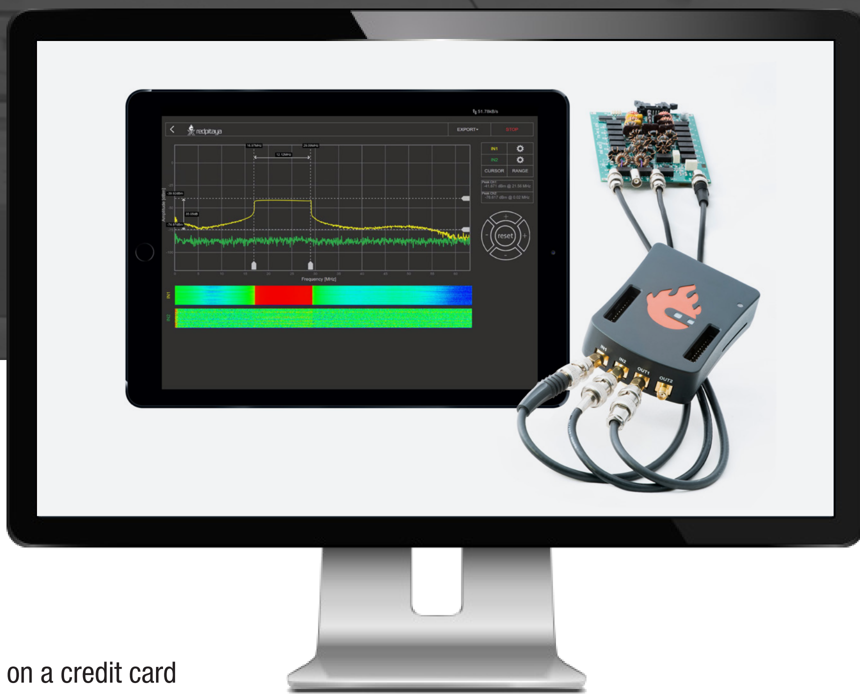
LabVIEW   open source   python



- 2 channel Oscilloscope
- 50MHz of Bandwith
- 14/10 bits of resolution
- 16k samples memory depth
- +-1V to +-20V input range
- DC Input coupling
- External trigger

Spectrum Analyzer

redpitaya



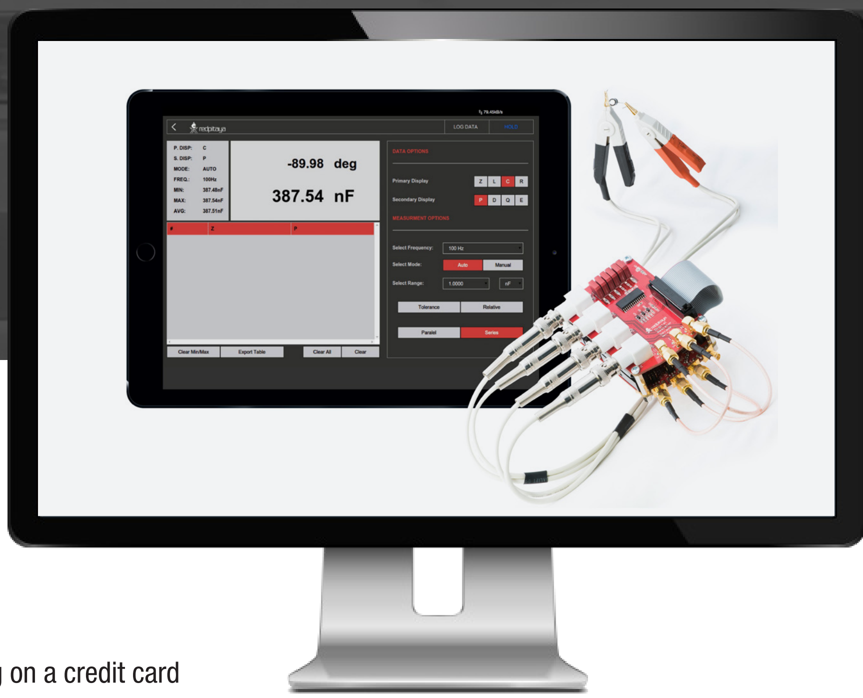
STEMlab

Test & Measurement applications running on a credit card sized SoC (FPGA+CPU) based Open SW source **DAQ platform**

LabVIEW open source python™

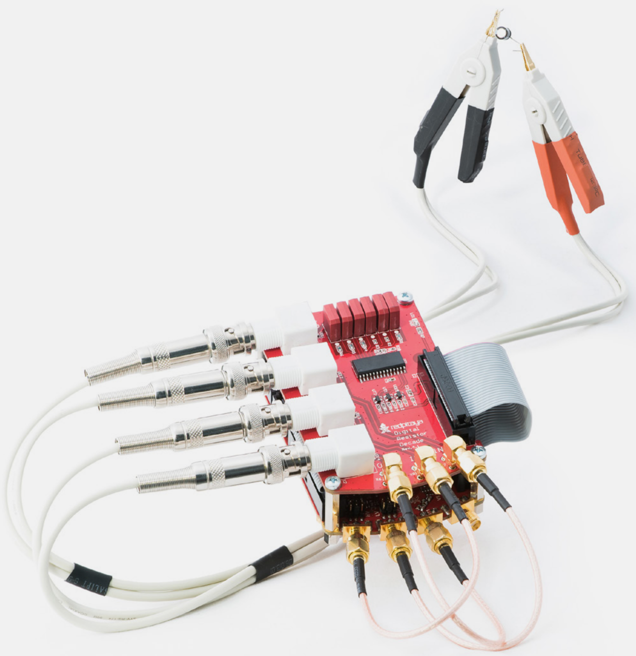
- 2 channel
- 50/62,5MHz of Bandwith
- 14/10 bits of resolution
- 16k DFT buffer
- Dynamic range -70/80 dBm
- Inputs noise level
- <-100/-119 dBm
- DC Input coupling

LCR meter



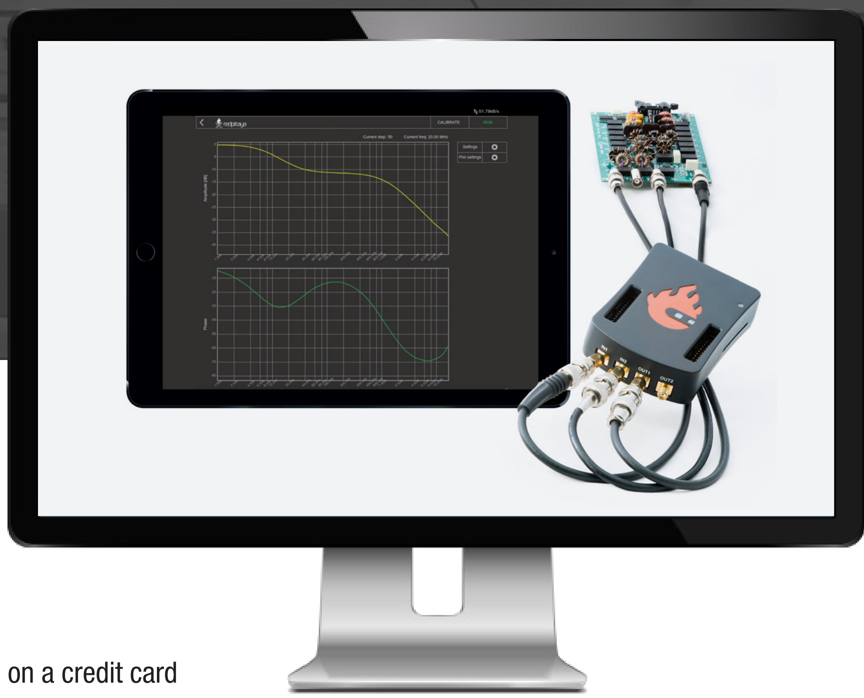
STEMlab

Test & Measurement applications running on a credit card sized SoC (FPGA+CPU) based Open SW source **DAQ platform**



- Primary parameters: Z, L, C, R
- Secondary parameters: P, D, Q, E
- Selectable freq: 100Hz, 1kHz, 10kHz, 100kHz
- Impedance range: 1Ohm- 10MOhm
- DC Bias: 0.5 V
- Basic accuracy: 1%
- Input protection: Yes

Bode Analyzer



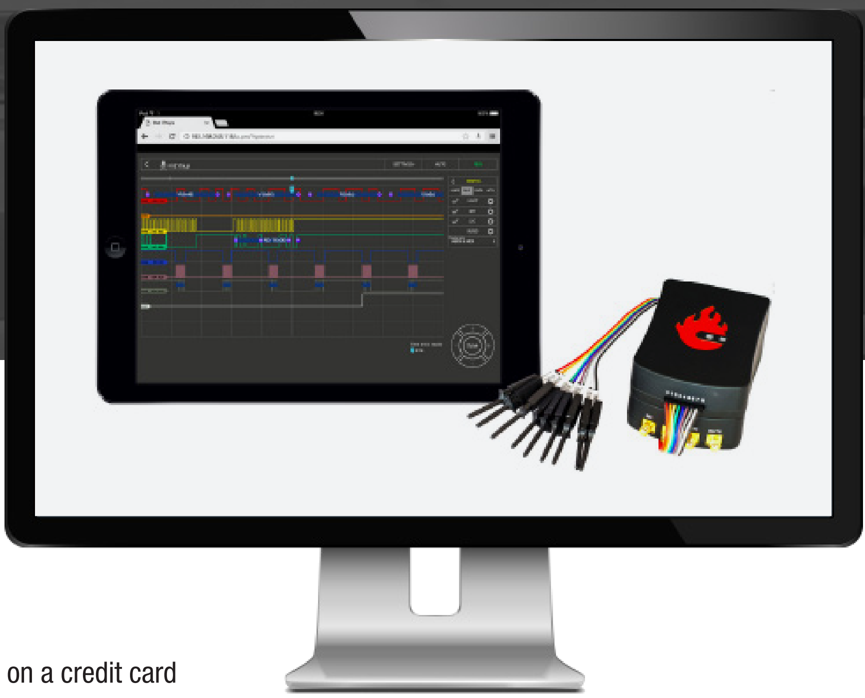
STEMlab

Test & Measurement applications running on a credit card sized SoC (FPGA+CPU) based Open SW source **DAQ platform**

LabVIEW open source python™

- Frequency span: 1Hz-50MHz
- Frequency resolution: 1Hz
- Excitation signal amplitude: 0-1V
- Excitation signal DC bias: 0-0.5V
- Resolution: 10/14 bit
- Max. Nr. Of steps/measurement: 1000
- Max. In. Amplitude: +-1V/+-20V

Logic Analyzer PRO



STEMlab

Test & Measurement applications running on a credit card sized SoC (FPGA+CPU) based Open SW source **DAQ platform**

- Channels: 8
- Sampling rate (Max): 125Msps
- Max. Input freq: 50MHz
- Supporte bus protocols: I2C, UART, SPI
- Input voltage: 2.5V – 5.5V
- Overload protection: integrated
- Trigger types: Level, Edge, Pattern
- Level tresholds: 0.8V (low), 2.0V (high)
- Input impedance: 100k, 3pF

redpitaya

Software Defined Radio

STEMlab

Test & Measurement applications running on a credit card sized SoC (FPGA+CPU) based Open SW source **DAQ platform**

LabVIEW

open source

python

- Transciever (2RX and 2TX Channels)
- RX frequency range: 25KHz – 62,5MHz
- TX frequency range: 1MHz – 62,5MHz
- Compatible with many open source SDR radios: HDSDR, Gqrx, GNU Radio, Pothos

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STEMlab

Open Source platform with powerful Community Support

Open Source

STEMlab

All sources can be downloaded from our Github

https://github.com/redpitaya/

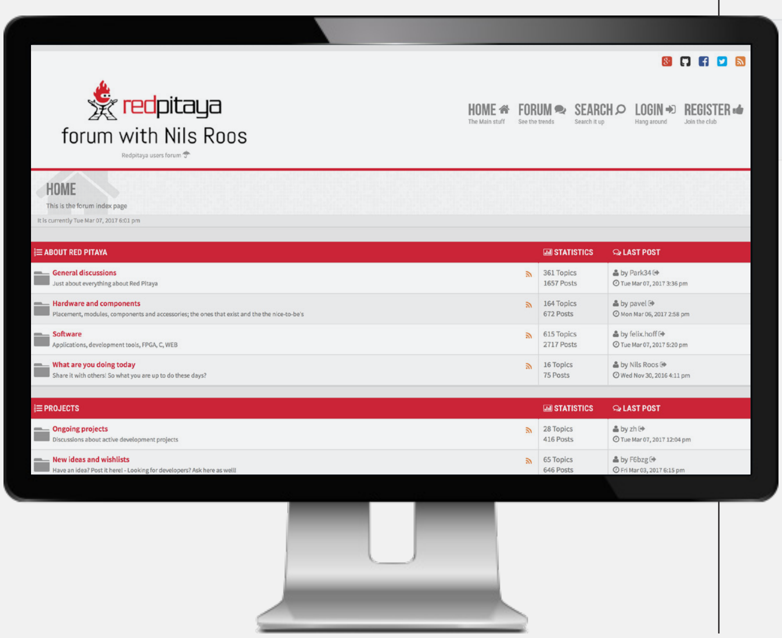
All sources here:

LabVIEW

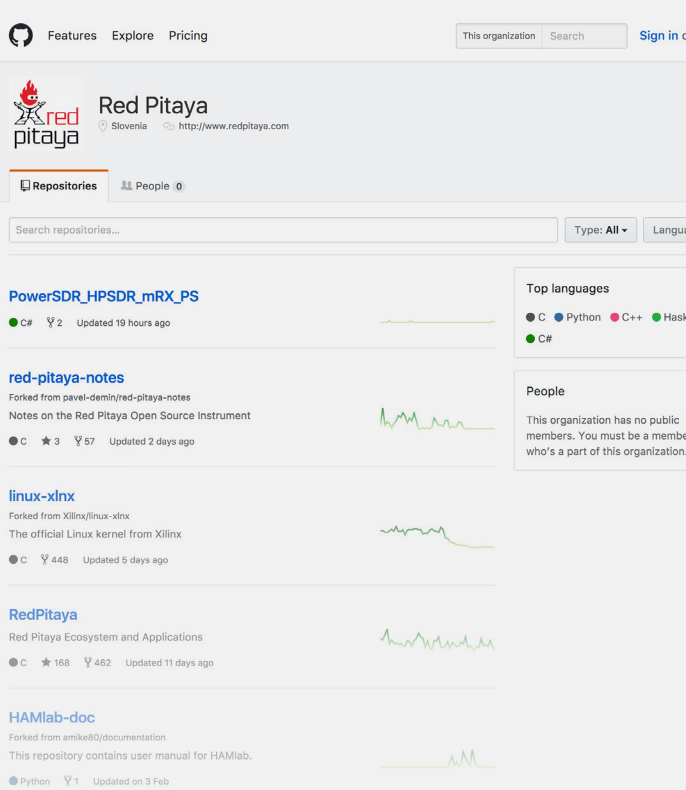
open source

python

SUPPORT - FORUM



GITHUB



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STEMlab

Literature and documentation

Literature

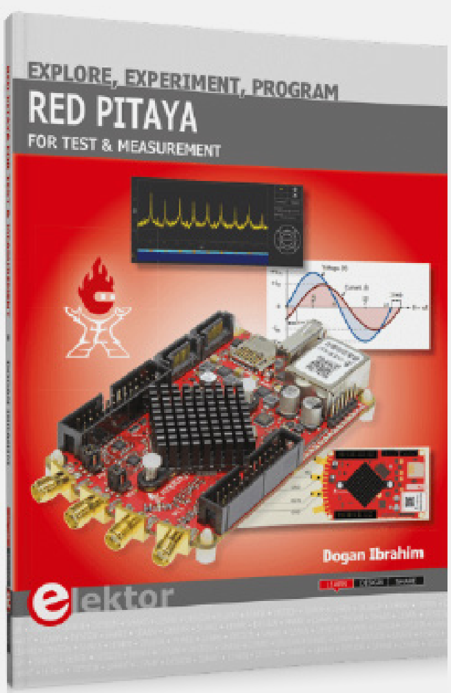
Elektor Magazine book available

http://redpitaya.readthedocs.io/en/latest/doc/appsFeatures/remoteControl/remoteControl.html#examples

STEMlab

Free examples:

Elektor Magazine:



SCPI CONTROLS AND EXAMPLES

Possibility to control STEMlab over SCPI commands through:

- LabView
- Matlab
- Scilab
- Phyton

Examples:

- http://redpitaya.readthedocs.io/en/latest/doc/appsFeatures/remoteControl/remoteControl.html#examples

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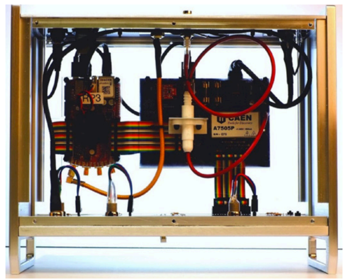
STEMlab

Community projects

Red Pitaya STEMlab board integrated into an open hardware computing platform for nuclear warhead verification

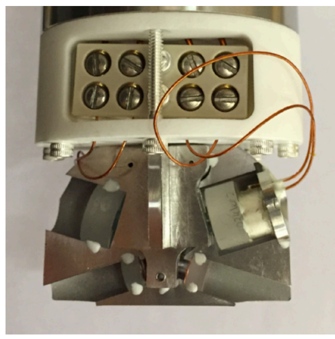
Princeton University, USA

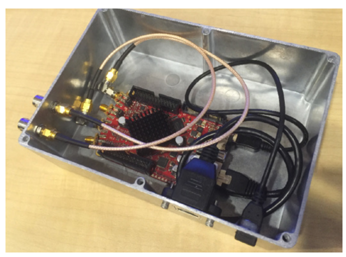


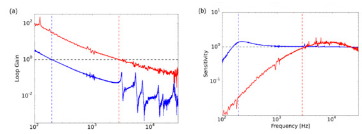
Trusted inspection systems are critical for the verification of future arms control treaties involving measurements on nuclear warheads or classified nuclear warhead components. Over the years, several research efforts have produced a number of prototype systems exploring a range of different technologies and conceptual approaches to accomplish this task. In general, these systems rely on unique hardware and software. In order to authenticate inspection systems, however, it would be beneficial to use a common, intensively tested hardware and software toolkit—possibly even use the same platform for different measurement types and verification tasks. Here, we propose and examine an inspection system based on a particularly versatile single-board computer, the Red Pitaya STEMlab board.

Active Cancellation of Acoustical Resonances using Red Pitaya STEMlab board

James Franck Institute and the Department of Physics
at the University of Chicago





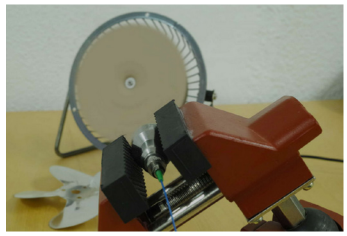


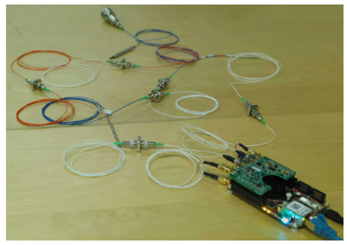
Red Pitaya's STEMlab board is used in a novel approach to enhancing the bandwidth of a feedback-controlled mechanical system by digitally canceling acoustical resonances (poles) and anti-resonances (zeros) in the open-loop response via an FPGA FIR filter. By performing a real-time convolution of the feedback error signal with an inverse filter, we can suppress arbitrarily many poles and zeros below 100 kHz, each with a linewidth down to 10 Hz. We demonstrate the efficacy of this technique by canceling the ten largest mechanical resonances and antiresonances of a high-finesse optical resonator, thereby enhancing the unity gain frequency by more than an order of magnitude. This approach is applicable to a broad array of stabilization problems including optical resonators, external cavity diode lasers, and scanning tunneling microscopes, and points the way to applying modern optimal control techniques to intricate linear acoustical systems.

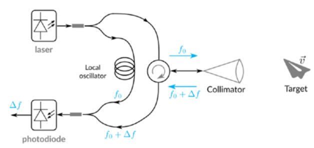
Red Pitaya STEMlab Doppler LIDAR (Light Detection and Ranging) velocimeter

Science Faculty of Paris, Centre scientifique d'Orsay

Let's start with a quick explanation of the Doppler effect. We often experience it when hearing the siren of a moving vehicle: the tone gets higher when the vehicle is approaching. The frequency of the acoustic wave emitted by the siren is affected by the movement of the vehicle. This effect is not only true for sounds but also for optical waves: when a laser beam with the frequency f0 is reflected off a moving target with velocity v, its frequency is shifted of a certain quantity. This frequency shift can be measured and therefore a velocity v off a moving target can be calculated. In this experiment we are using the Red Pitaya STEMlab board and the Laser Development Kit in order to measure the custom USB fan velocity.



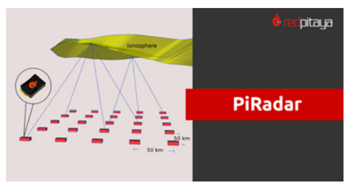


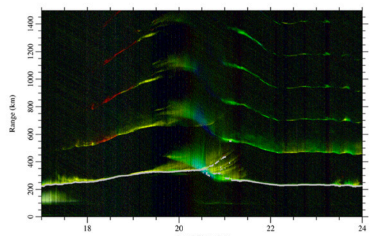


Dense Network of dual-mission HF radars based on Red Pitaya STEMlab and Raspberry Pi boards

Boston University, USA

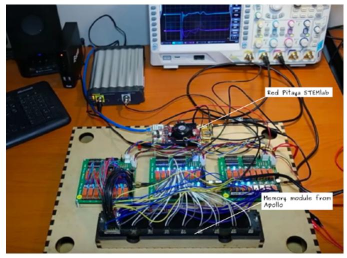
Prof. Michael Hirsch and his team from Boston University are working on a dense network of dual-mission HF radars based on Red Pitaya STEMlab and Raspberry Pi boards: to improve ionospheric models, for 4-D imaging of the Earth's atmosphere/ionosphere, solar storm impact detection and quantification.



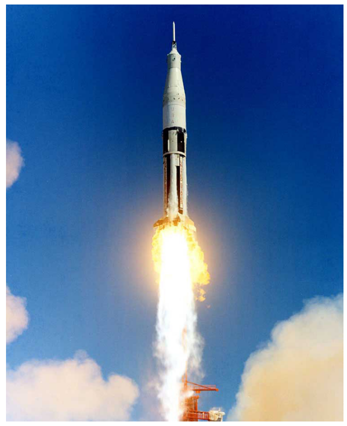


Extracting one of the first lines of “space code” from Rope Memory Modules of the Apollo Guidance Computer used in Flight AS-202

Francois Rautenbach, South Africa



Meet the Indiana Jones of Programming and Electronics. How far, and I literally mean far, software code can go. Well, the most “distant” piece of code is somewhere beyond our solar system happily running on the Voyager spacecraft. But during the Apollo flights in the late 1960s, some of that “space code” returned back to Earth. More specifically, on 25 August 1966 NASA launched and successfully performed Flight AS-202. After the flight, the rocket was disassembled and forgotten about. A half century later, our Indiana, Mr. Francois Rautenbach, while searching for electronic treasures, stumbled upon the Rope Memory Modules of the Apollo Guidance Computer used in Flight AS-202 fifty years ago - this was the first embedded (micro)computer ever. His goal was to track them down and extract from them one of the first lines of “space code”. Everything is possible for experts such as Indiana - of course with his trusty Red Pitaya STEMlab in the pocket.



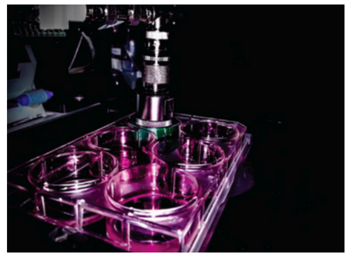
Frequency Counter FPGA project using Red Pitays STEMlab board

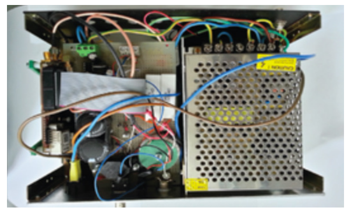
ETH zürich | Anton Potočnik, ETH Zurich, Switzerland

User of the Red Pitaya STEMlab board, Dr. Anton Potočnik sharing his thoughts on Red Pitaya STEMlab board. “What makes Red Pitaya STEMlab boards even better are two fast ADCs, two fast DACs and, most of all, the programmable logic or field-programmable-gate-array (FPGA). With on-chip FPGA Red Pitaya could be used for high performance computing, state-of-the-art measurement system, signal processing and much more.” On the way to powerful acquisition systems let us make a quick detour and create a useful and simple project – the Frequency Counter. The frequency counter will be implemented in the reciprocal counting scheme where the time of a predefined number of signal oscillations is measured and then properly inverted. Such a scheme can have much better frequency resolution, especially for low frequency signals, compared to the conventional method where number of signal cycles are counted in a predefined gate time.

LabVIEW open source python™

Generating ultrasonic power pulses for cell stimulation using Red Pitaya STEMlab board





University of Ljubljana, Slovenia

For the generation of specific shapes of ultrasound pulses researchers usually use a setup consisting of two signal generators (one for switching on and off the train of US pulses and the other one to produce the sinusoidal signal of suitable frequency). This signal is further fed to the amplifier and then to the ultrasonic transducer. Furthermore, an ultrasonic sensor is required to evaluate and control the magnitude of the ultrasound. Usually a hydrophone is used in combination with an amplifier and an oscilloscope. This setup is complex to establish and difficult to use. Therefore, the goal was to develop a device based on Red Pitaya STEMlab, which would be capable of providing appropriate signals required to perform specific ultrasonic experiments in a single apparatus and as such easy to use.

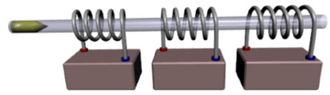
http://2016.igem.org/Team:Slovenia/Hardware

Measuring mechanical resonance of ball bearing using Red Pitaya STEMlab board.

National High Magnetic Field Laboratory,
Los Alamos, USA

The Red Pitaya STEMlab board and an additional customized front end were used in the ball bearing mechanical resonance characterization. The ball bearing is placed between two piezo transducers controlled by the Red Pitaya STEMlab board. The ball bearing was excited with a piezo transducer connected to the STEMlab output channel. The frequency response is measured with the second piezo transducer connected to the STEMlab input channel. In this setup a frequency sweep is performed where the mechanical resonance response of the ball bearing was measured.

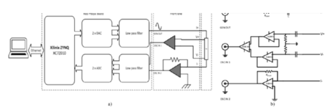
Guided Electromagnetic Gun using Red Pitaya's STEMlab

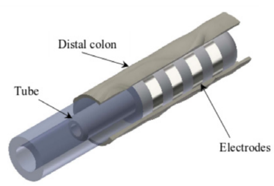


Zavod 404, Slovenia

Electromagnetic guns are simply one of the most awesome DIY projects out there. Constructing an electromagnetic gun is fairly simple but in order to get maximum performance, some additional work is needed. A team of students from Zavod 404 is building a controllable electromagnetic gun. During the firing stage, the position of the bullet is constantly being measured. Depending on the bullet position, an array of acceleration coils is driven. The bullet position and coil control is performed with the Red Pitaya STEMlab board. High speed acquisition and processing is necessary for an optimal control and bullet position measurement. The position of the bullet will be measured by a laser sensor connected to the STEMlab input channel. Control logic and regulation will be implemented in the FPGA to achieve minimal delays and maximal accuracy. The next step of this project will be a full control of the acceleration and the position of the bullet.

A Portable Bioimpedance Measurement System Based on Red Pitaya for Monitoring and Detecting Abnormalities in the Gastrointestinal Tract





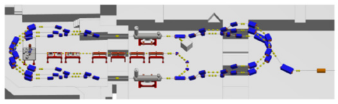
The Medical Device Research Institute Flinders University
Adelaide, Australia

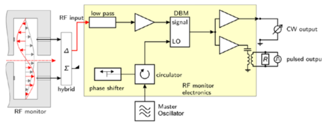
A mobile and low cost 4-terminal bioimpedance measurement system, consisting of a Red Pitaya board and a front-end, for understanding gastrointestinal physiology and exploring new applications for bioimpedance spectroscopy in gastroenterology.

TESTING A DIGITAL BEAM POSITION STABILIZATION FOR THE P2-EXPERIMENT AT MESA using Red Pitaya STEMlab board

JOHANNES GUTENBERG UNIVERSITÄT MAINZ | JG|U

Institut für Kernphysik, Universität Mainz, Germany



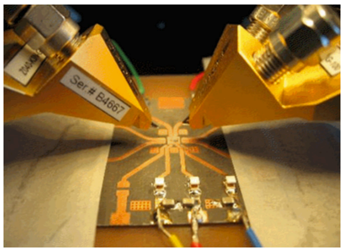


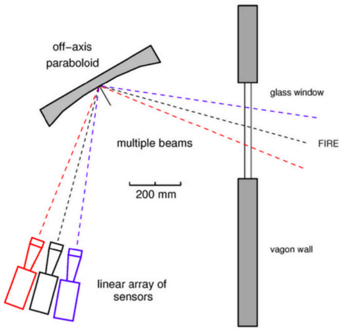
The Mainz Energy-recovering Superconducting Accelerator (MESA) will be built at the Institute for Nuclear Physics at Mainz University. Besides the multi-turn energy recovery mode an external beam mode is foreseen to provide 155 MeV electrons of 85% polarization at 150 µA for parity violating experiments. To achieve the required stability of the main beam parameters a dedicated digital position stabilization is currently developed and tested at the Mainz Microtron (MAMI).

Microwave Radiometers for Fire Detection in Trains: Theory and Feasibility Study

UNIVERSITÀ DEGLI STUDI DI PERUGIA

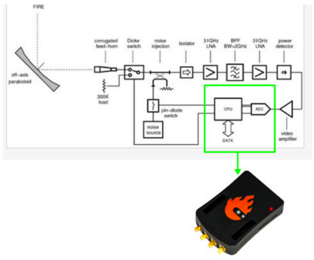
Department of Engineering, University of Perugia, Italy





This work introduces the theory of fire detection in moving vehicles by microwave radiometers. The system analysis is discussed and a feasibility study is illustrated on the basis of two implementation hypotheses. The basic idea is to have a fixed radiometer and to look inside the glass windows of the wagon when it passes in front of the instrument antenna. The proposed sensor uses a three-pixel multi-beam configuration that allows an image to be formed by the movement of the train itself. Red Pitaya STEMlab board is used for signal acquisition and data processing.

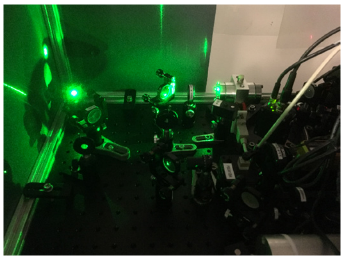
http://www.mdpi.com/1424-8220/16/6/906/htm

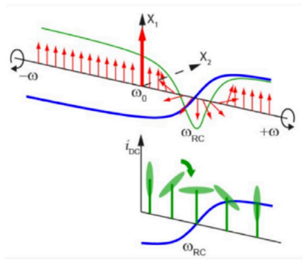


LabVIEW open source python™

Frequency Dependent Squeezed Light in Optomechanical Systems

University of Colorado, USA

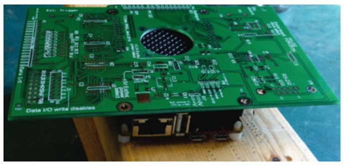




PyRPL is a software package used for implementing feedback loops and diagnostics on Red Pitaya STEMlab boards. PyRPL was created by the Optomechanics and Quantum Measurements group at LKB and is still in active development. PyRPL creates feedback control loops by utilizing different modules such as PID controllers, IIR filters, and IQ quadrature modulation/demodulation. PyRPL also allows the FPGA to function as many different laboratory instruments simultaneously, such as an oscilloscope, arbitrary signal generator, spectrum analyzer, and network analyzer. A major component of this project was using PyRPL to lock several optical cavities to a reference laser using different control schemes. The vast majority of data in this project was also digitally acquired using PyRPL.

http://www.lkb.upmc.fr/optomecanics/wp-content/uploads/sites/19/2015/10/IREU_final.pdf

Industrialisation of Cavity BPMS

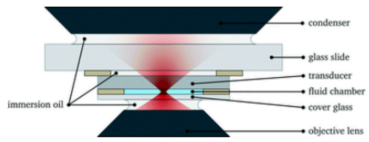


John Adams Institute at Royal Holloway, University of London, Egham, UK S. Syme, FMB Oxford, Oxford, U

The industrialisation project of a cavity beam position monitor (CBPM) has been commissioned aiming at providing reliable and economical CBPM systems for future Free Electron Lasers (FEL) and similar linac-based facilities. The first prototype of a CBPM system was built at Versatile Electron Linear Accelerator (VELA) in Daresbury Laboratory. We report on the measurement results from the first prototype of our system at VELA and current developments of CBPMs, down-converter electronics and Data Acquisition (DAQ) system. In this project two Red Pitaya STEMlab boards are deployed as DAQ systems.

Measuring the electrical impedance of the piezo transducer using Red Pitaya STEMlab board

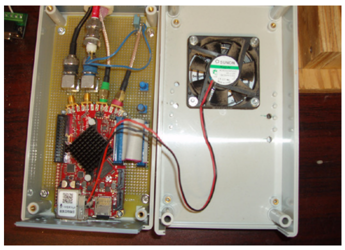
Division of Biomedical Physics, Medical University Innsbruck, Austria, Division of Cancer Research, School of Medicine, University of Dundee, Dundee, UK



As an electrical signal source and for measuring the electrical impedance of the transducer we use a Red Pitaya STEMlab device. It offers two analog outputs and inputs, digitally sampled at 125 MHz rate. Both output channels are summed and amplified by a power amplifier (ADA4870 from Analog Devices on evaluation board, RS 836-8714), to which the transducer is connected by a pair of 20 cm long wires. The voltage at the power amplifier output and across a 10 Ω shunt resistor (in series with the amplifier output) is fed back to the analog inputs of the Red Pitaya device, providing information about the (complex) electrical impedance of the transducer (including the contribution of the wires). Signal generation, data acquisition and subsequent analysis is controlled by a custom Python program, running on the embedded processor of the Red Pitaya device under a Debian Linux operating system. This setup provides a versatile and powerful solution for signal generation and impedance measurement at low cost (approx. € 300).

Red Pitaya STEMlab as a digitizer for pulsed radar in radR project

John Brzustowski, Acadia University,Wolfville, Canada



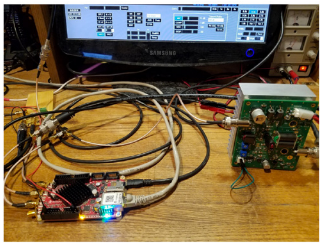
Red Pitays STEMlab board is adapted to work as a digitizer for pulsed radar in radR project. Program radR is an open source software tool for the acquisition, storage and analysis of data from marine radars operating in surveillance mode. radR takes time series data with a two-dimensional spatial component as input from some source (typically a radar digitizer) and extracts and retains information of biological relevance (i.e. moving targets). Low-level data processing is implemented in “C” code, but user-defined functions written in the “R” statistical programming language can be called at pre-defined steps in the calculations. We also provide an overview of the basic considerations of setting up and running a biological radar study. Radar digitizers are ideal tools for capturing and creating radar signals. As such, they can play an important role in the development, testing and operation of radar systems and their key components.

https://radr-project.org/03_-_Current_Features_and_Plug-ins/Red_Pitaya_-_preliminary_work

https://github.com/jbrzusto/digdar/tree/digdar/Applications

Various SDR projects from the Amateur Radio community.

Red Pitaya's STEMlab board is used in many SDR projects. Our SDR community is constantly working and experimenting with Red Pitaya STEMlab boards. RX and TX filters as well as different amplifiers (from 10W to 2kW) were added to the STEMlab in order to achieve the best Ham Radio experience. STEMlab is a very affordable replacement for traditional radio stations as well as for expensive SDR radios. The open source FPGA code enables more complex SDR-related projects/exercises, such as signal modulation, demodulation and similar.



Community Applications available for official OS

Vector Network Analyzer I Power analyzer I RadioBox + many others

The Red Pitaya Marketplace contains applications that were developed by the Red Pitaya community. We are constantly in contact with the application developers and we strive to make these applications work in the best possible way. What do I need to use the Marketplace? To use the Red Pitaya STEMlab Marketplace only one version of the Red Pitaya STEM board is needed (STEM 125-10 or STEM 125-14). Some applications may require additional hardware/software. For additional guidance and information get in touch with the Red Pitaya community via the forum.

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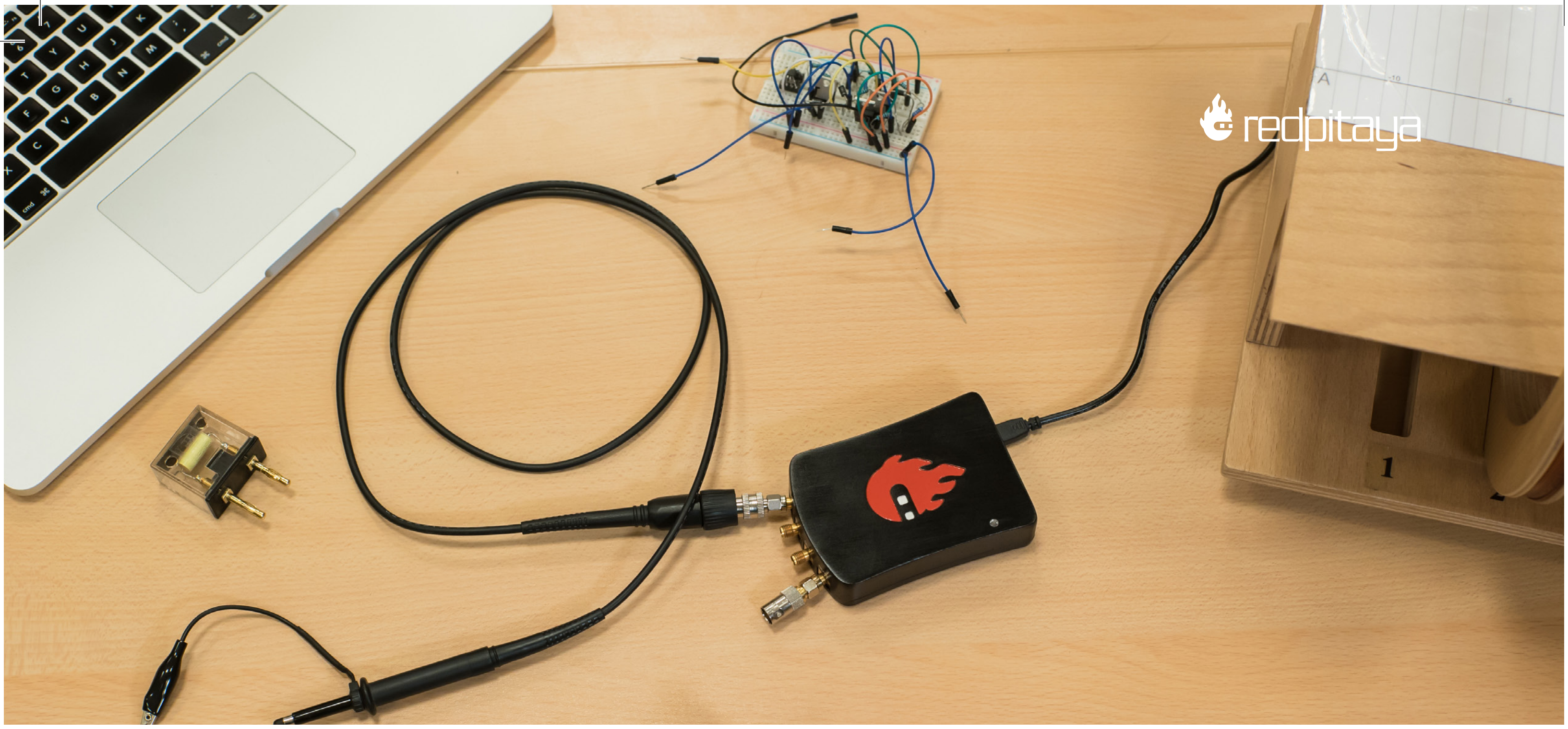
Awards

FROST & SULLIVAN

XILINX®



Red Pitaya was awarded by Frost&Sullivan in 2014 as the best-in-class performance in Electronic and Test and Measurement Tools category.

Placed among Xilinx university boards partners list