DESIGN AND PRODUCTION OF A LOW-POWER HIGH FREQUENCY DOPPLER RADIO SCATTEROMETER (HFDRS) FOR COASTAL ZONE OCEANOGRAPHY

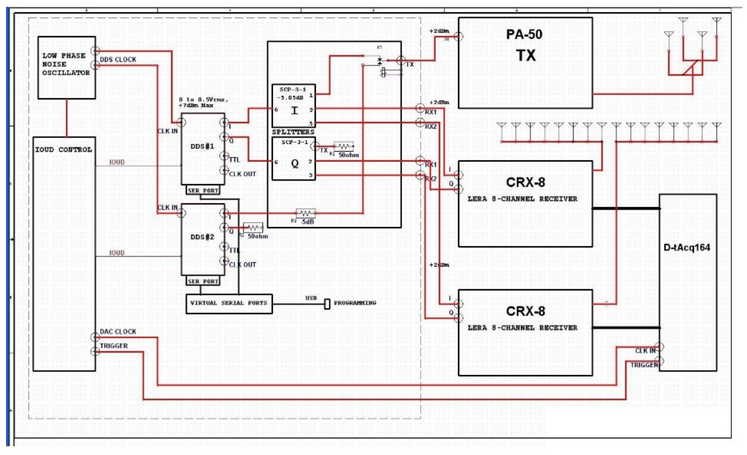
Mael Flament, Dave Harris, Pierre Flament, Ian Fernandez, Ryan Hlivak, Brian Ng, Lindsey Benjamin, Alma Castillo, Charina Repollo, Benedicte Dousset

A new beam-forming HFDRS a.k.a. Doppler Radar has been designed, maximizing commercial-off-the-shelf (COTS) components thus minimizing overall cost, minimizing power consumption thus enabling solar/wind operation in remote areas. For 8 channels, components cost less than k$20 and two man-weeks suffice for assembly, testing and calibration. Power consumption is 120W full duty. It uses frequency-ramped continuous wave signals, and phased-array transmissions to decouple direct path to receivers. Fan-less operation of critical components avoids 60Hz inter-modulation. Five sub-assemblies are controlled by a Linux single-board computer: (I) COTS direct digital synthesis of transmit and orthogonal local oscillator signals, derived from a ultra-low phase noise oven-stabilized crystal; (ii) four distributed 1 W power amplifier, built-in transmit antennas; (iii) lambda/20 compact active antenna monopoles with embedded out-of-band rejection filters; (iv) analog homodyne receivers based on complex demodulation by double-balanced mixers; (v) COTS 24-bit analog-to-digital sigma-delta conversion with 512 oversampling and digital low-pass filter. At 13.5 MHz, 4 W transmit, 15 min averaging, range up to 120 km is achieved. Twenty units have been built, and are being deployed in Hawai'i, Mexico and the Philippines; one is on display at booth 404.

System overview:

- sub-assemblies controlled by Linux server
- ultra-low phase noise oven-controlled crystal for synchronous signal synthesis and A/D conversion (VECTRON OXCO)
- direct digital synthesis of transmit and orthogonal local oscillator signals (ANALOG DEVICES DDS/NOVATECH)
- λ/8 1.5 W active (no PA) transmit monopoles (UH)
- λ/20 active receive antenna monopoles with out-of-band rejection filters (UH/DLWA)
- complex demodulation by double-balanced mixers, homodyne translation of HF spectrum to audio band (UH)
- 24-bit analog-to-digital sigma-delta conversion with 512-oversampling and digital low-pass filter (DTACQ)

Block diagram

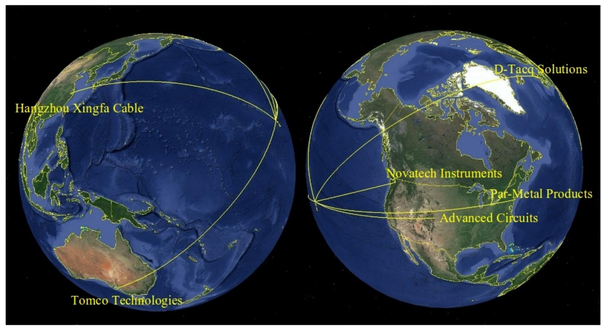


Software solutions:

- Output simple binary files of A/D converter antenna signals
- Simple to process directly in matlab, m-files provided
- Python scripts for spectra, currents under development
- Simple import to all common processing packages:
  - Neptune/Seaview Sensing currents/wave/wind
  - Gurgel/Helzel WERA currents/wave/wind
  - LSET/Broche/Barbin currents

Objectives:

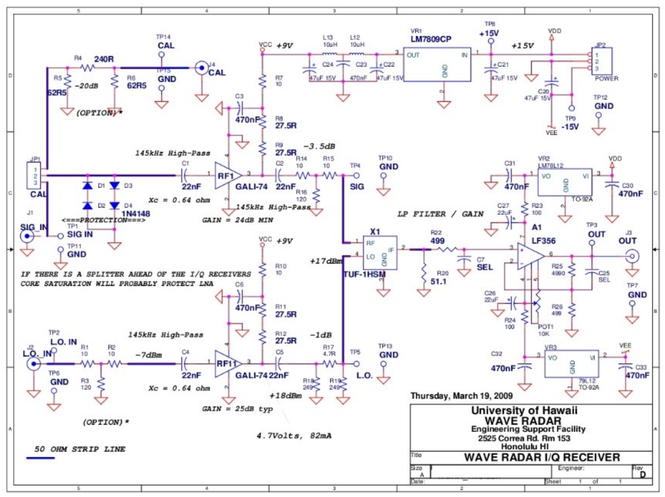
- maximize commercial-off-the-shelf components
- minimize overall cost (non-profit non-subsidized)
- readily scalable to arbitrary number of channels
- minimize power consumption
  120 W AC for 8-channel 5 W RF (continuous)
- solar/wind operation enabled
- fan-less operation of critical components to avoid 50/60Hz inter-modulation



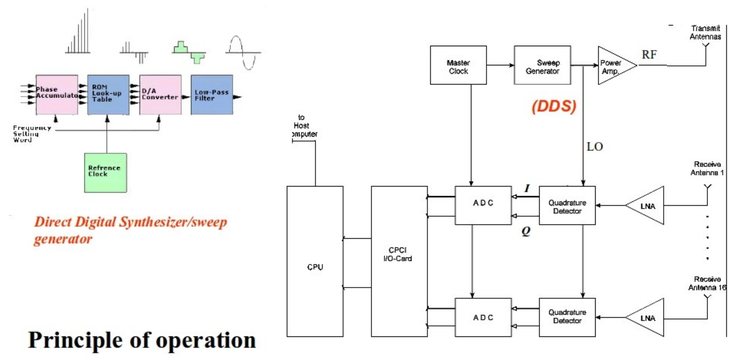
The supply chain... and our industrial partners

System specifications:

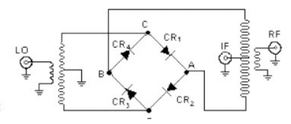
Modulation	FMCW frequency-ramped linear chirp
Operating Frequency	3 MHz to 150 MHz
Transmitted RF-Power	5 Watts, beam-formed towards ocean (+ 6 dB)
Range	typ. 120 km/ 65 NM @ 13 MHz
Range Resolution	depends on bandwidth c/2B 1.5 km @ 100 kHz, 150 m @1 MHz
Azimuthal Resolution	- beam-forming 8 to 16 antennas - direction-finding square array

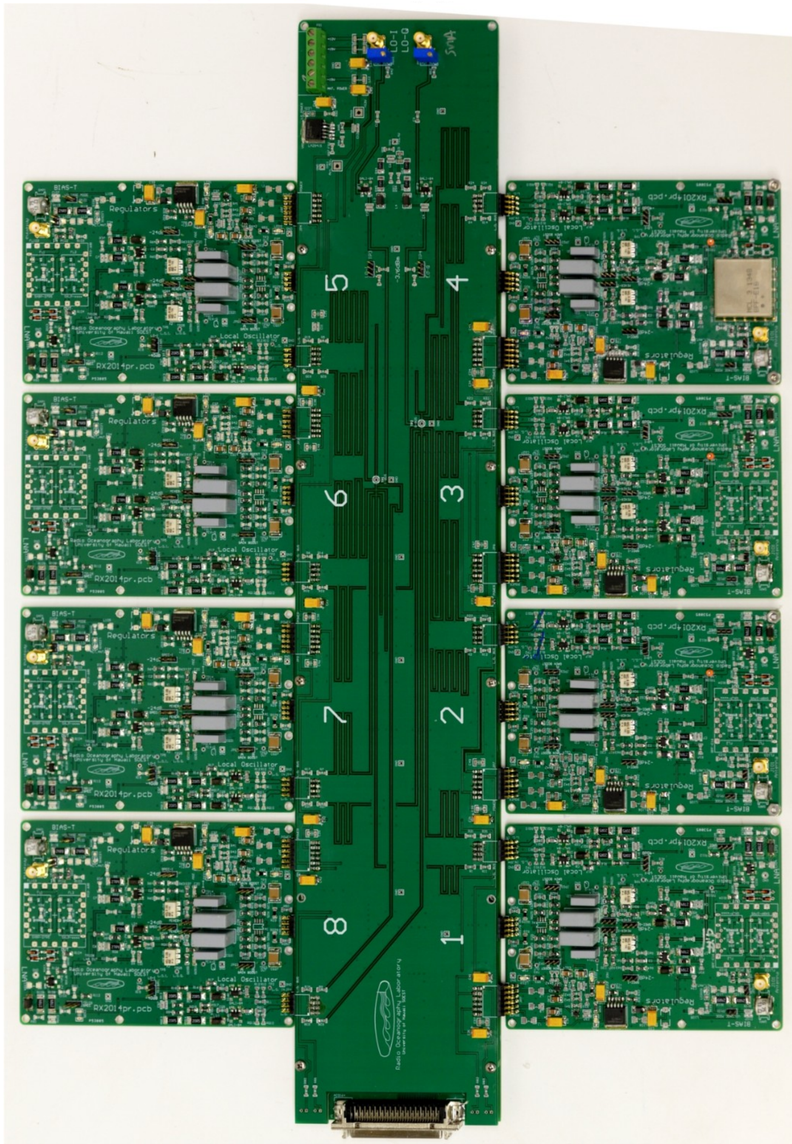


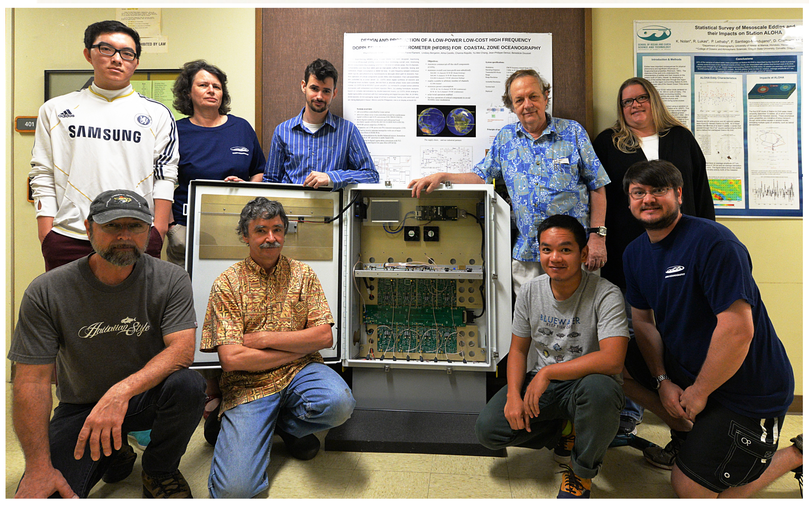
Critical UH-designed circuit: complex demodulator (600 built)



Principle of operation







RADIO OCEANOGRAPHY LABORATORY
SCHOOL OF OCEAN AND EARTH SCIENCE AND TECHNOLOGY
UNIVERSITY OF HAWAI'I AT MANOA