

NSF PI Meeting: Houdini Platform

Why? What? Who? How? When?



RICE

UC San Diego



TEXAS

The University of Texas at Austin



UNIVERSITY OF
NOTRE DAME

28 September 2026

(Why?) Evolving Research Agenda of the Community

Sub-6GHz

FR3

mmWave

- **Most communications systems are multi-band, with 6G targeting FR3 (8-24GHz).**
- **Wireless sensing has emerged as a dominant point of discussion, so full-duplex operation to enable monostatic radar operation is a new requirement. Multi-static radar is emerging as an important modality.**
- **New emerging area of “wireless imaging” - to go beyond sensing targets**
- **Multi-band datasets to empower learning-based methods**

(Why?) The Need for a NEW Research Platform

Sub-6GHz

FR3

mmWave

- **Novel research is posing new needs**
 - Ability to access *all* spectrum *simultaneously*
 - Ability to use in multiple modes to advance networking, sensing and imaging
 - Scale degrees of freedom - number of antennas & bandwidth
- **Dissemination models**
 - Allow researchers to adapt & built on the base platform
 - Work with PAWR platforms to deploy on public platforms
 - Release open-access datasets

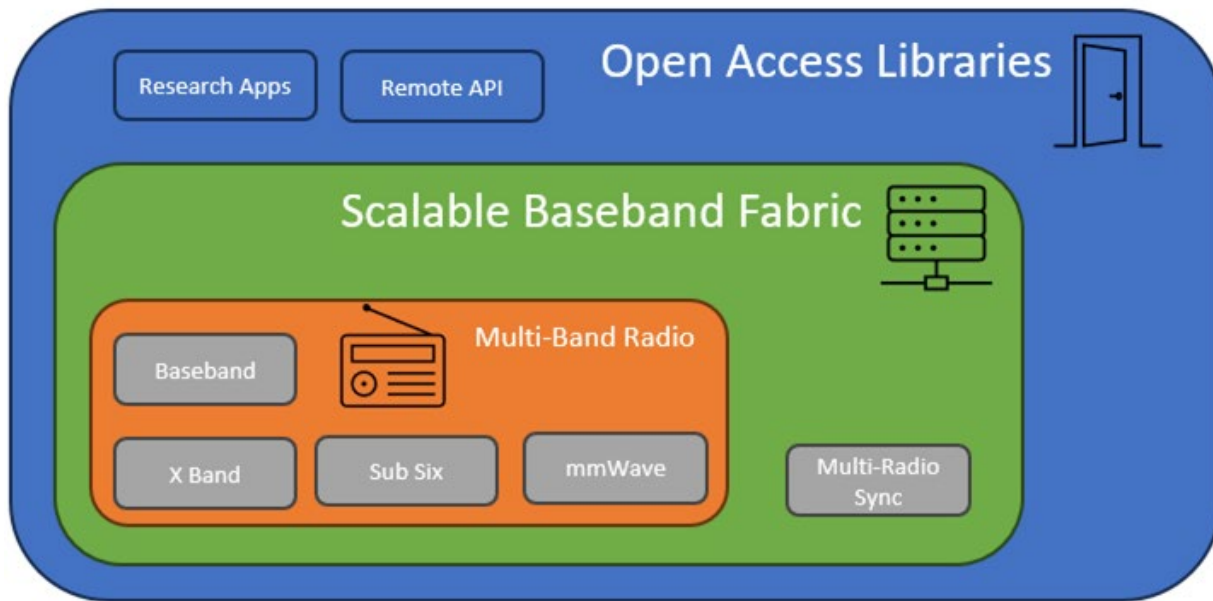


Houdini



Software-defined radio system to

- support emerging bands
- enable simultaneous access to multiple bands of interest
- empower research communities in wireless networking, sensing and imaging
- enable diverse datasets to support advanced AI/ML research



(Who?) The Team



Ashutosh Sabharwal
Joseph Cavallaro
Rahman Doost-Mohammady
Andrew Sedlmayr

UC San Diego

Xinyu Zhang
Wuqiong Zhao



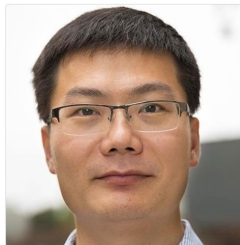
Kaushik Chowdhury
Nicholas Borda



Nick Laneman
Domenic DiGiovanni



Ashutosh Sabharwal
Project Lead



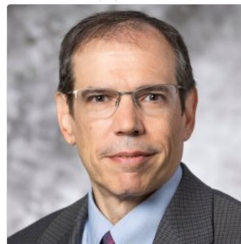
Xinyu Zhang
Co-PI



Kaushik Chowdhury
Co-PI



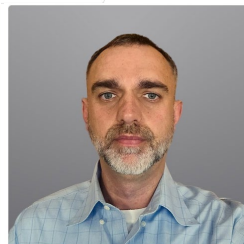
Nick Laneman
Community Outreach Director



Joe Cavallaro
Co-PI



Rahman Doost-Mohammady
Co-PI



Andrew Sedlmayr
Project Manager



Wuqiong Zhao



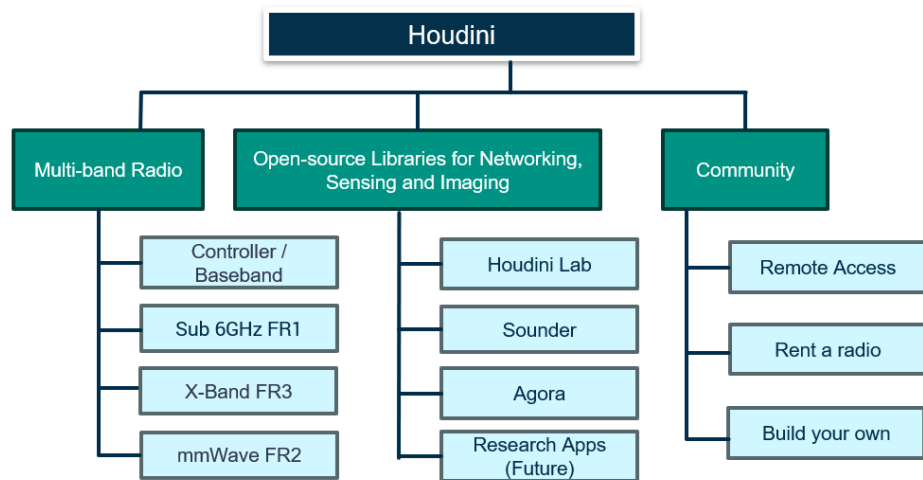
Nicholas Borda



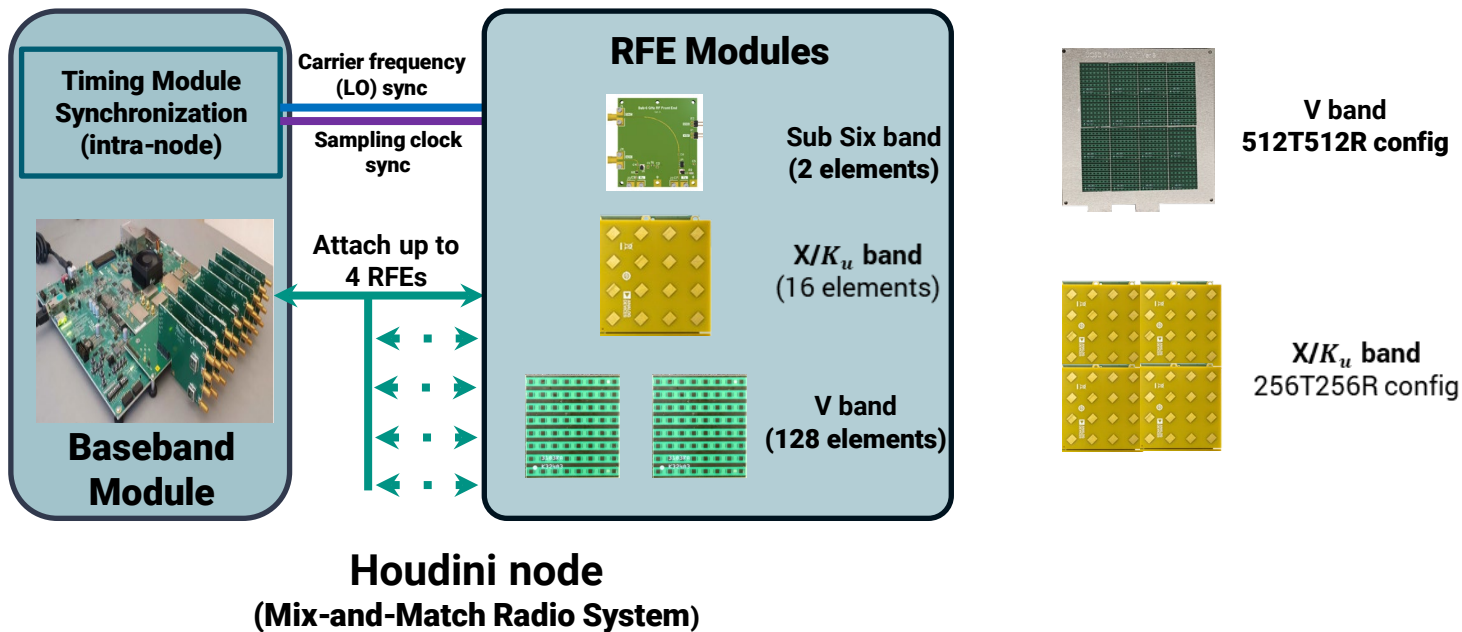
Domenic DiGiovanni

(What / How) The Key Pieces

- **Radios**
 - V-band (57-71 GHz)
 - Directly Sampled (DC-6 GHz)
 - X-band (8-12 GHz)
- **Baseband**
- **Open-Source Libraries and Ecosystem**
- **Remote Access**
- **Dissemination**
- **Coming Soon**

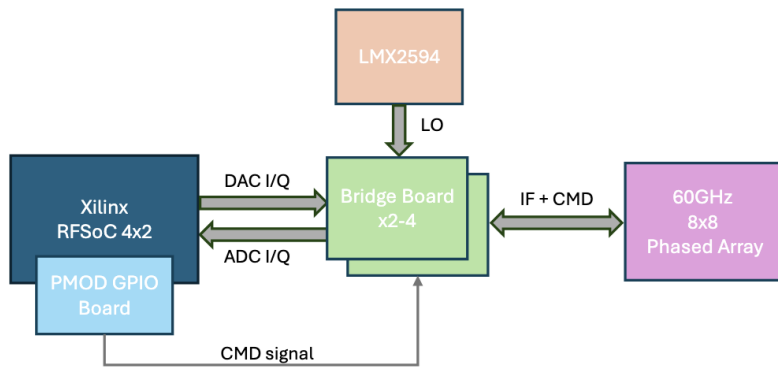


Houdini: Mix-and-Match Radio System

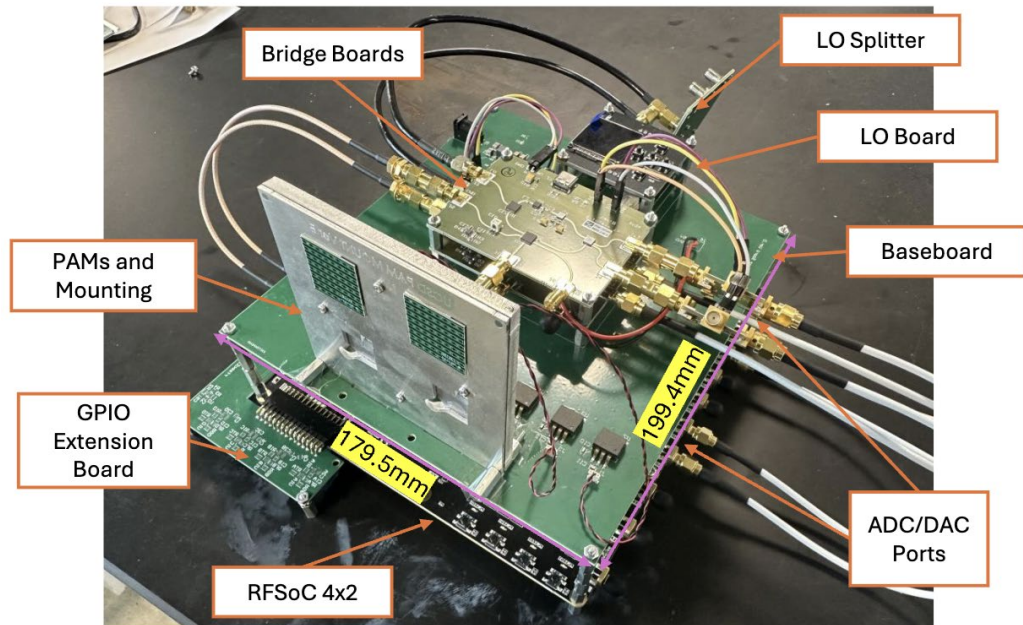
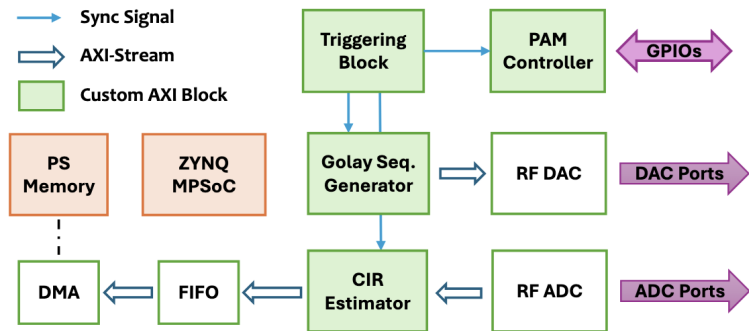


mmWave FR2: Architecture

mmWave SDR module Architecture



mmWave FPGA Baseband Architecture

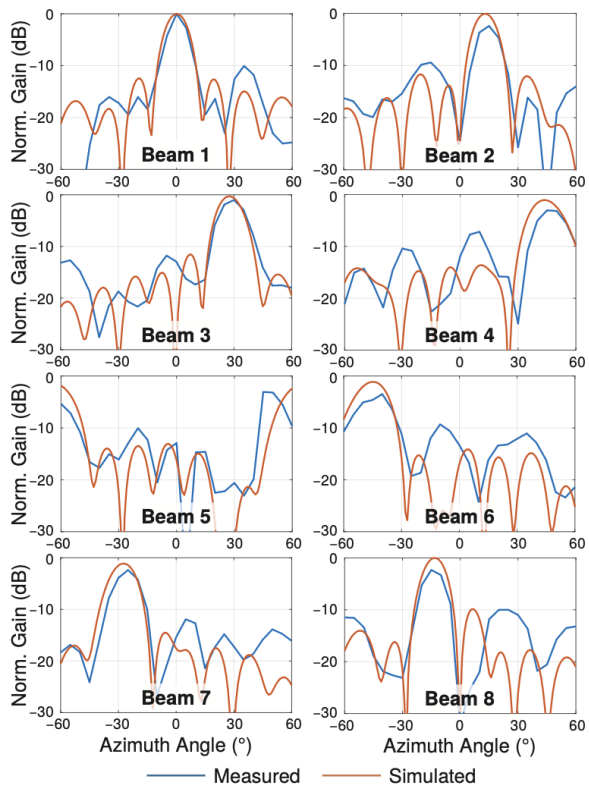


Repurposed Phased Arrays from low-cost 802.11ay 60 GHz Routers

mmWave FR2: Feature Comparisons

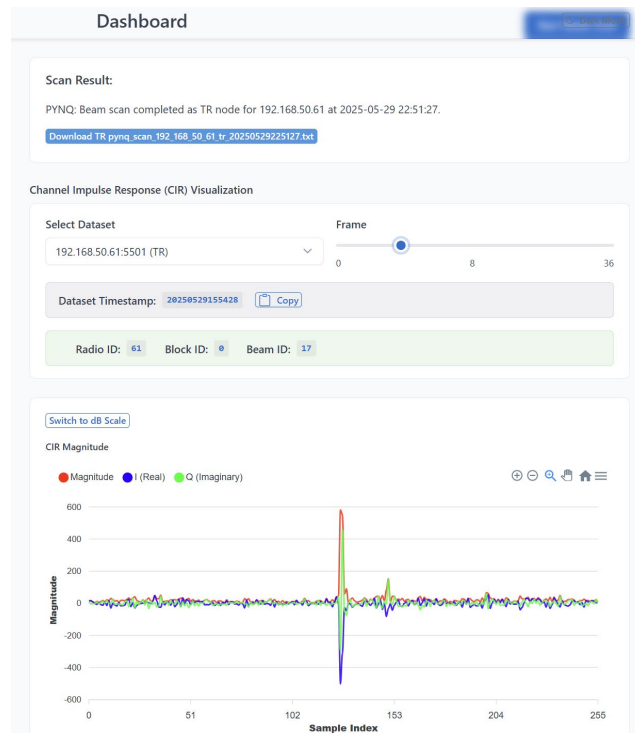
Feature	M-Cube	Sivers	Houdini FR2
Phased arrays	 6×6	 1×16	 8×8 2-bit phase 1-bit amp.
mmWave frequency	57-64 GHz	57-64 GHz	42-77 GHz
Instantaneous bandwidth	4 GHz	2 GHz	Up to 10 GHz
RF / beam control	COTS radio / NIC dependent	Real-time FPGA control	Direct FPGA control of beam + LO
Listed cost	\$15k	\$20k	\$7.2k (2T-2R)

mmWave FR2: Prelim Testing Results



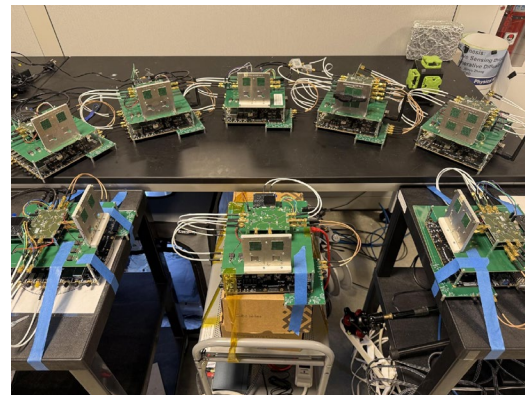
- Beamforming (DFT codebook) showing good match between measurement and simulation. [Left]

- Channel Impulse response estimation in the dashboard showing multi-path. [Right]



mmWave FR2: Status

- **Hardware Design:**
128T128R setup is stable and ready for replication
- **Multiple Nodes Forming a Network:**
Distributed communication and multi-static sensing;
All nodes controllable by a remote server.
- **mmWave SDR on a Drone:**
FR2 module mounted on a drone for aerial
communication/sensing use cases.



mmWave FR2: Ongoing development

Hardware

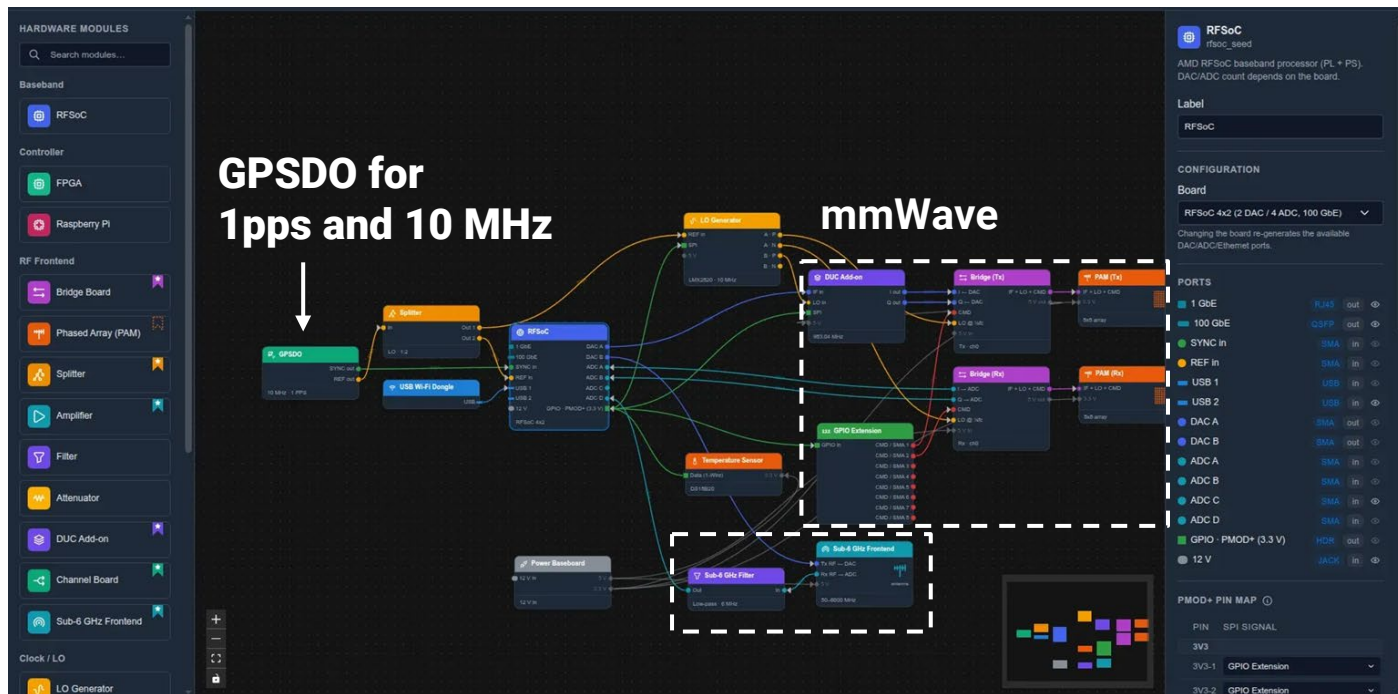
- Scalable Array of Subarrays:
Scaling to 512T512R antenna elements
- Distributed MIMO:
Carrier-synchronized nodes for distributed MIMO communication/sensing

Applications and Reference Designs

- Integrated sensing and communication
- Distributed interference mapping
- mmWave aerial communication and sensing

Configuration / Compiler Technology

Automatic generation of FPGA design & software driver given hardware configurations:



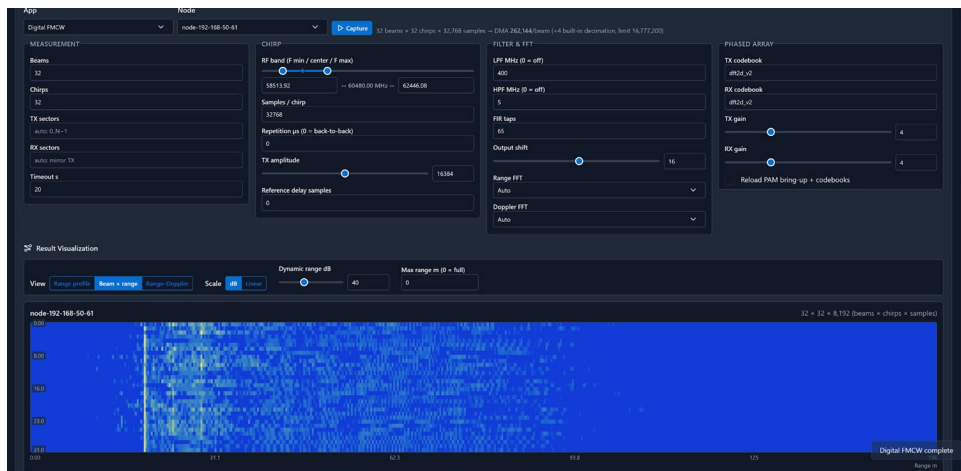
TOML
Config File

PL (FPGA)
.v & .tcl

PS (CPU)
.py

mmWave Demo

Digital FMCW sensing



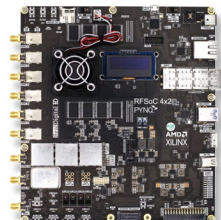
mmWave + sub-6 GHz channel estimation



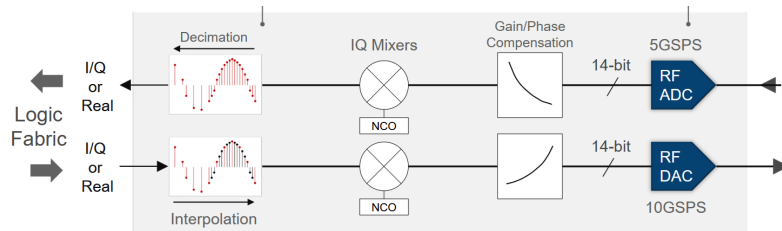
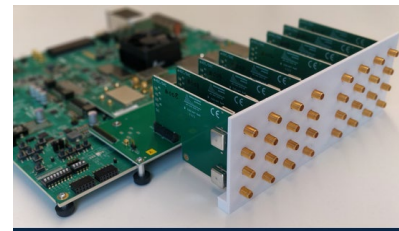
Houdini - [4,16]: Baseband

- 6GHz of analog bandwidth for full direct-RF support of sub-6GHz bands
- Signal Conditional after sampling, in the digital domain
 - Channel Selection, filtering, DDC, equalization, etc
- Network Interface: 100Gbps
- 14-Bit RF-ADCs: 2.5/5.0 GSPS
- 14-Bit RF-DACs: 9.85 GSPS
- Processing subsystem: Quad-core A53
- DDR4: 4GB PS / 4GB PL

- Houdini - 4
 - RFSoc 4x2
 - 2x4 TRX

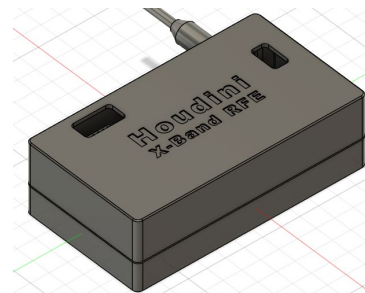
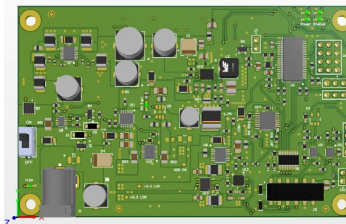
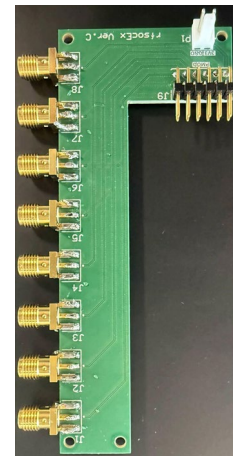
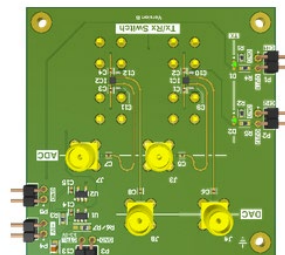
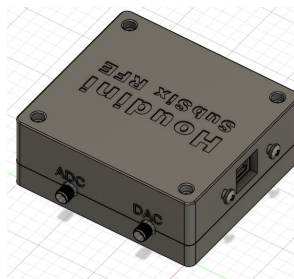
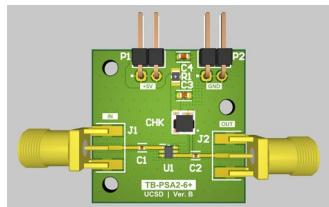
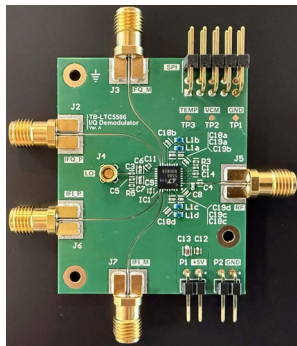
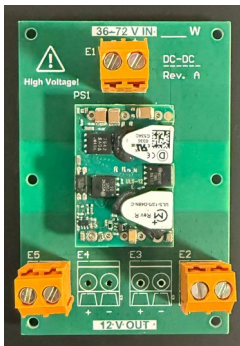


- Houdini - 16
 - ZCU216
 - 16x16 TRX



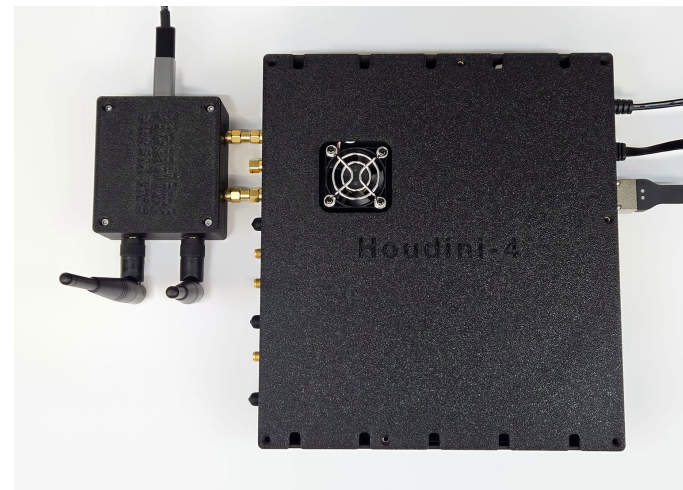
Accessories

- Sub Six TX / RX
- IQ Modulator / Demodulator
- GPIO Extender
- X-Band Power Board
- GPS DIO Support
- Drone Power Adapter
- Enclosures



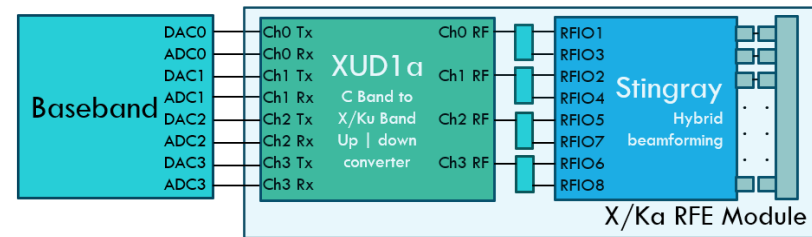
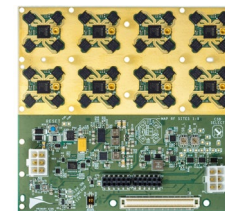
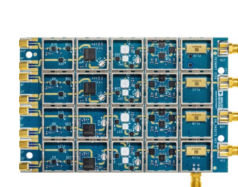
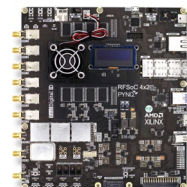
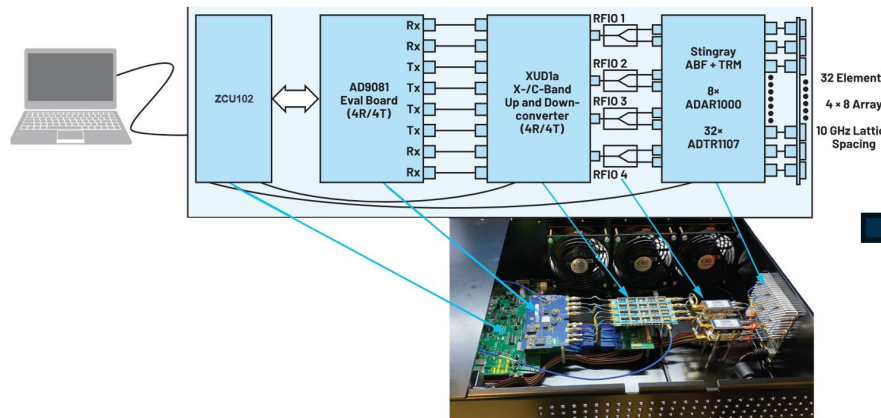
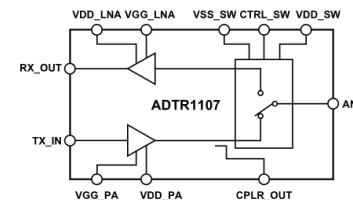
Sub 6 GHz FR1: Directly Sampled

- **Integrated Mixers for both I/Q and Real**
 - **Signal Conditional after sampling, in the digital domain**
 - **Wideband coverage with one architecture**
 - **Discrete external components widely available for bands of interest (ISM, etc).**
- **Example**
 - **100Mhz 64 QAM**
 - **SCS = 30 KHz**
 - **Internal PLL = 491.52 Mhz**



X-Band FR3: Architecture

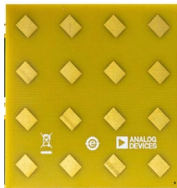
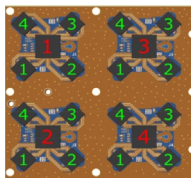
- **ADXUD1AEBZ** : X to C band updown converter
 - 4 channels capable of up and down conversion over a RF frequency band from 8 GHz to 12 GHz and IF frequency band from 4.2 GHz to 6.3 GHz.
- **STINGRAY**
 - ADAR1000 4 channel 8-16 GHz analog beamformer
 - ADRT1107 6-18 GHz Front-End Transmit/Receive Module
- **Evaluating alternative lower cost configurations**
 - Houdini - 4 -> XUD1A -> 2x ADTR1107-EVALZ (See demo!)
 - Low cost Up/Down converter in consideration 6 → 18 GHz



X-Band FR3: Specifications

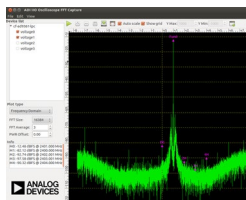
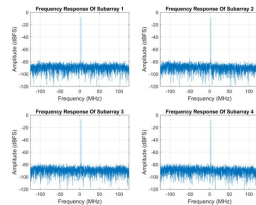
Radio Front End - Key capabilities

- F_c : 10 GHz (8-12GHz, limited by UP/DOWN Conv)
- Bandwidth: 4 GHz.
- Number of antennas: 4 per channel, digital and analog beamforming.
- Scalability: 16 Elements per Houdini RFE Slot (64 max)

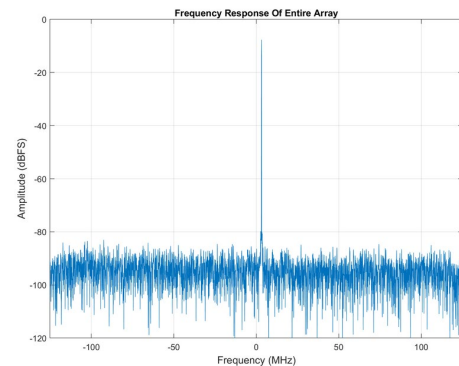


Baseband

- Software: Matlab, iiooscilloscope, iio device drivers



Usage Example
Output



X-Band FR3: Prelim Testing Results

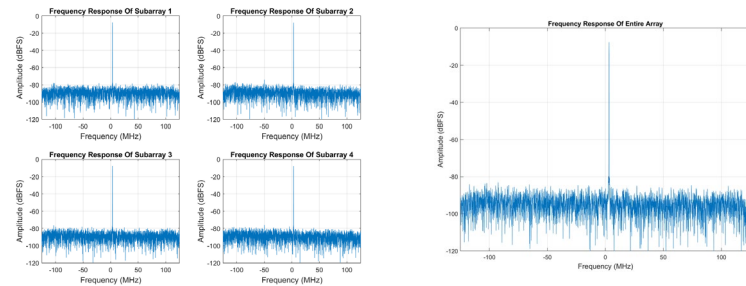
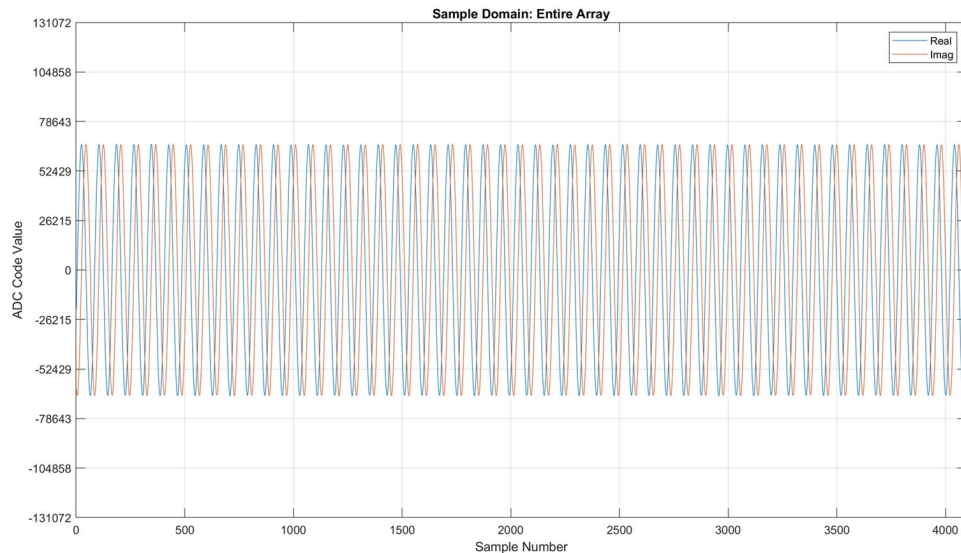
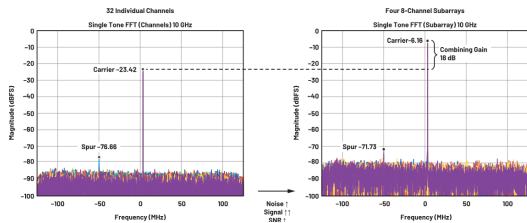
- Controlling X-Band with MATLAB

- NCO Frequency
- NCO Phase
- Per Channel Analog Gain
- Per Channel Analog Phase
- Per Channel Analog Attenuation
- Capture Settings
- Beam Steering
- Beam Taper

SimpleTx Examples

SimpleRx Examples

Single Tone FFT



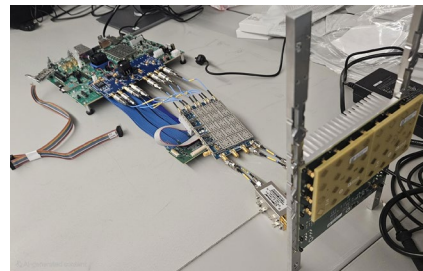
X-Band FR3: Status

Hardware / Software

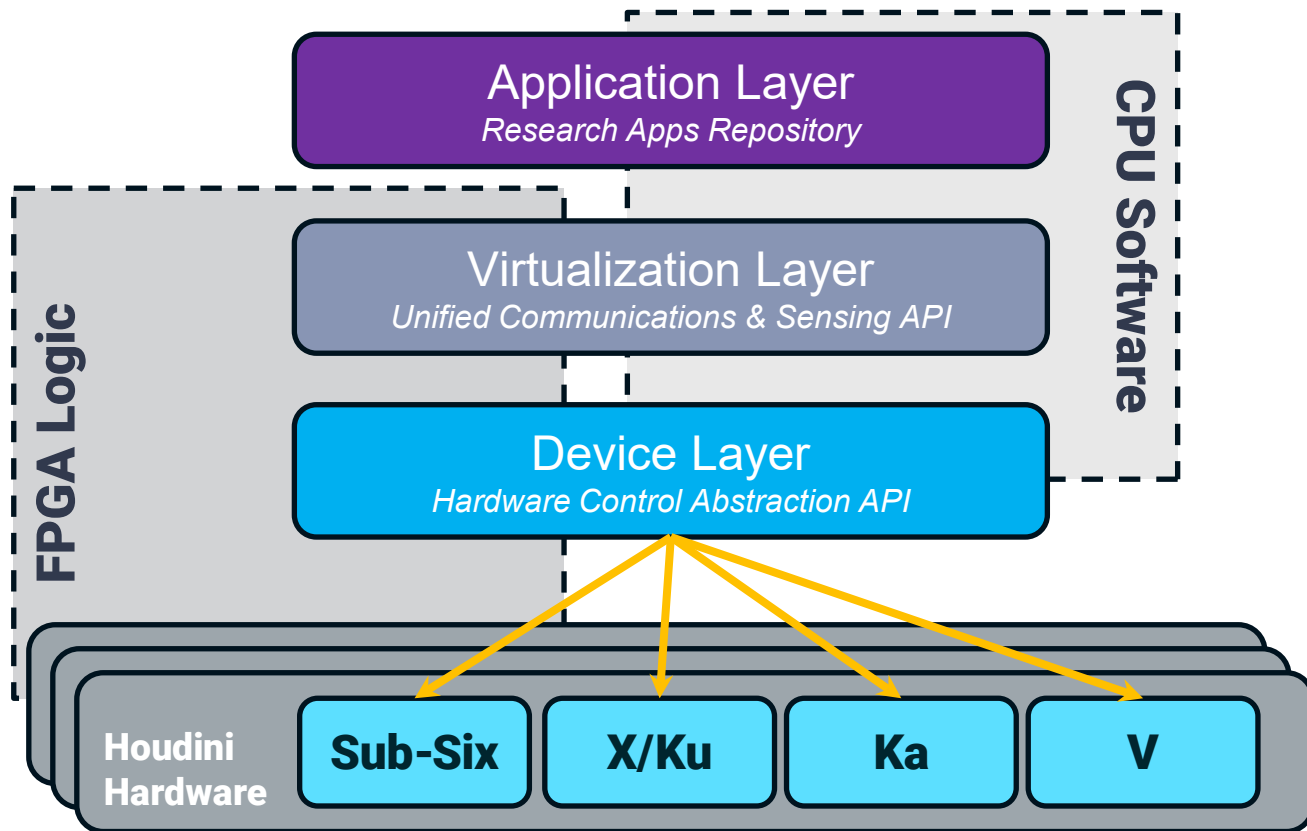
- **Phase 1 standalone system complete - ZCU102 based**
- **Functional Migration from ZCU102 to Houdini-4**
 - Low cost alternative released
 - Driver migration to Houdini multiband
 - MFE to AMD RFDC replacement drivers
 - Linux industrial io device library support (coming soon)
- **Command and Control interface redesign for cable management and interoperability**

Applications

- **Monostatic and Bistatic Radar**



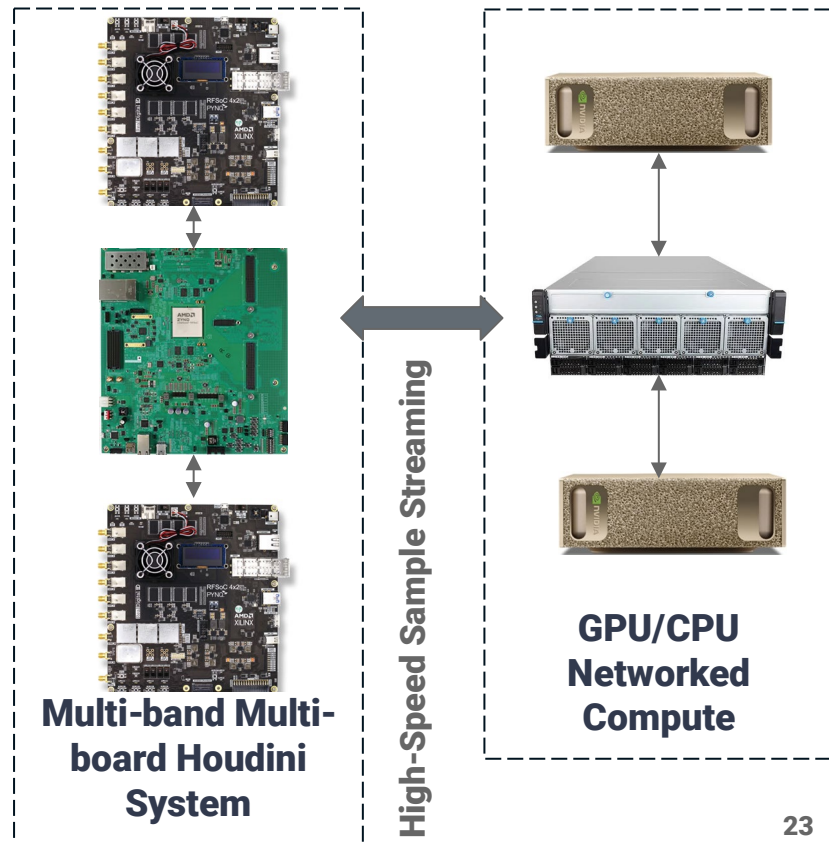
Software Development



Houdini: Scalable Compute Fabric

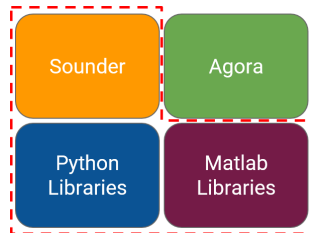
Enabling scalable baseband processing through distributed CPU/GPU servers

- High-speed sample streaming
 - 100G link Host
 - More optimization and rate testing
- Synchronization between Houdini boards (in band and out of band options available)



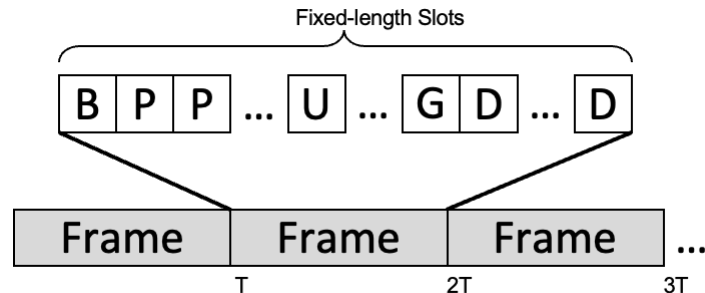
Open-source software

- **High-speed sample streaming enables existing open-source software on Houdini**
 - **Agora: a scalable baseband processing software with massive MIMO and mmWave baseband processing capability**
 - **RENEWLab → HoudiniLab: A python/MATLAB interface library for easy sample collection and algorithmic testing**
 - **Channel Sounder: a highly configurable environment for channel sounding and dataset collection**
- **Future Releases**
 - **5G Stacks: Integration of srsRAN and OAI through enabling a Houdini SDR interface (based on SoapySDR).**
 - **GPU-based Baseband: Integration of existing GPU SDR library, e.g. Sionna RK, and cuSignal**



Software/Firmware Features

- **FPGA-enabled TDD/FDD Framing Features**
- **Additional FPGA Processing (Akin to FH7.2)**
- **Fast Comms/Radar Beamsweeping**
- **FPGA-based Radar Processing**
- **Software DPDK support**
- **Direct sample streaming to GPU (GPU Direct)**
- **Channel Sounding**
 - **Dataset Collection**
 - **HDF5 Format**
 - **Pilot / Uplink / Downlink Groups**
 - **Data Inspection and Verification**



B: Synchronization Beacon Signal

P: Uplink Pilot Signal

U: Uplink Data Signal

D: Downlink Data Signal

G: Guard Interval (No Tx/Rx)

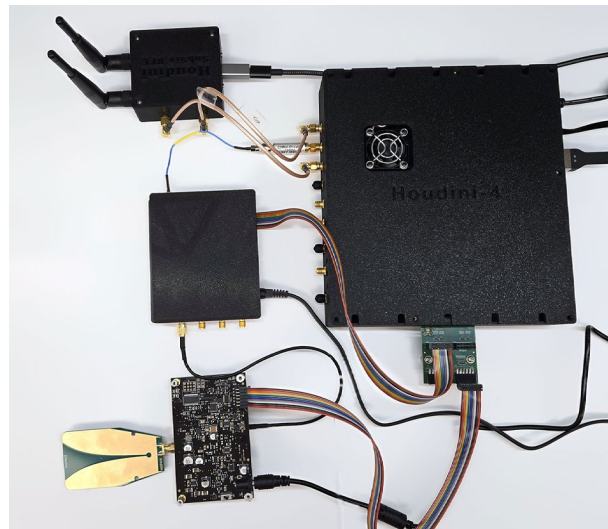
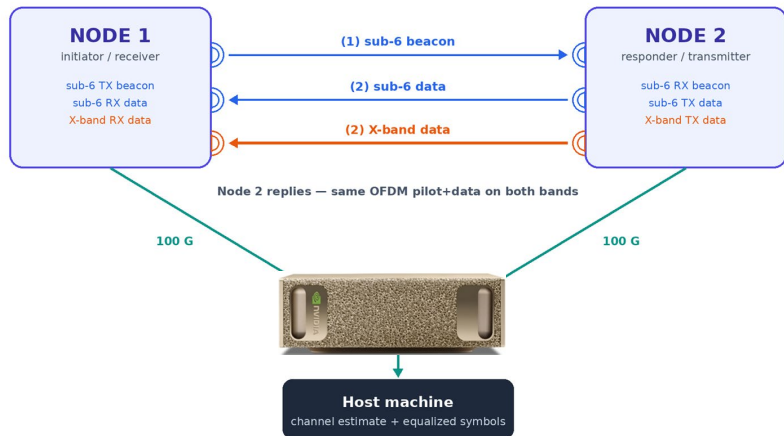
Multi-band channel-sounding demo

Two identical Houdini nodes run a beacon-triggered, multi-band channel sounding experiment. Tangible proof of Houdini's streaming, multiband capability.

- Node 1 transmits a beacon in the 0.915GHz ISM band using a TDD schedule
- Node 2 receives the beacon, aligns and tracks then replies with the SAME OFDM pilot+data symbols on both bands at once with a repeating frame schedule on two bands 0.915 / 10 GHz.
- Node 1 receives both, estimates each channel, equalizes the symbols, and then a Host gui displays them side by side.

Two-Node Multi-Band Channel-Sounding Demo

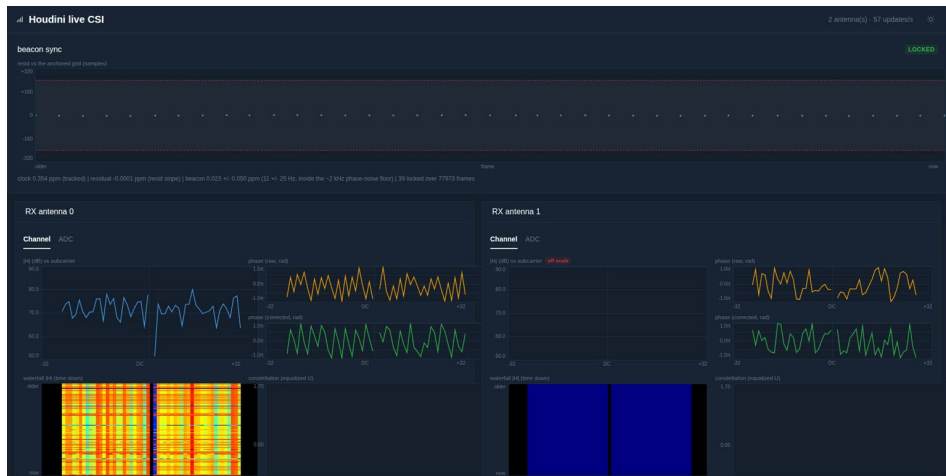
Identical RFSoc 4x2 nodes · sub-6 beacon triggers a dual-band response · 100 G to host



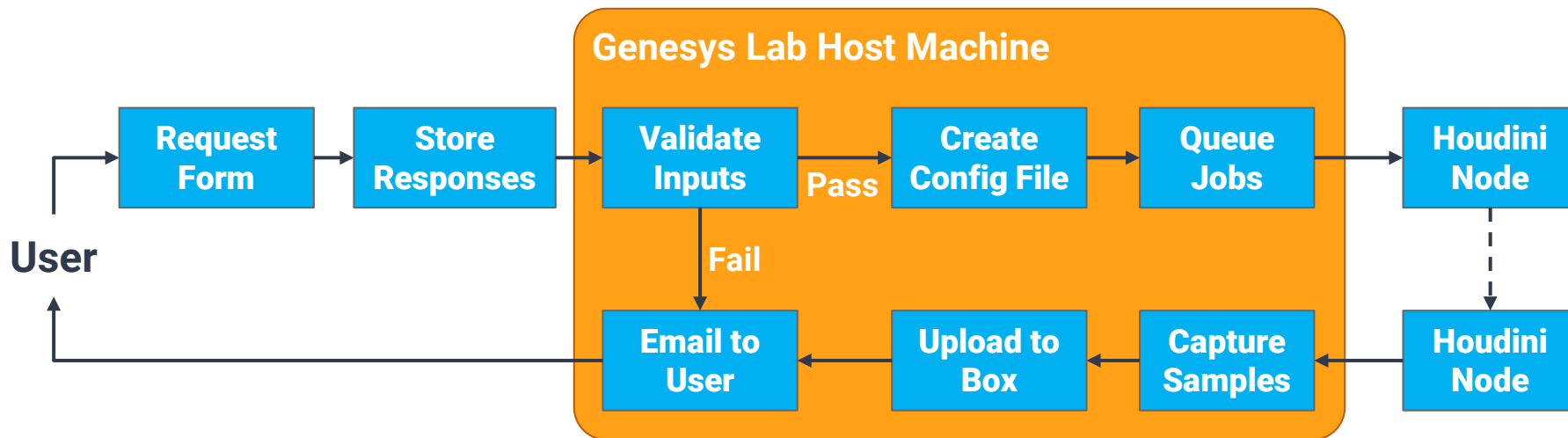
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Remote Access



Remote Access

Houdini Radio

Request the Houdini team to

[Switch to](#)

The name, email, and photo as

upload files and submit this f

User Information

Used to identify you and send

First Name

Your answer

Last Name

Your answer

Institution

(university/department, comp

Your answer

Email

Experiment results will be sto

Your answer

Next

houdinisdr.noreply@gmail.com

Your Houdini radio results — Jane Doe

To: Nicholas Borda

Hello Jane,

Your experiment has finished running on the Houdini software-defined radio.

Below is a copy of your submission and links to both waveforms.

YOUR SUBMISSION

Name	Jane Doe
Institution	UT
Email	ntb633@eid.utexas.edu
Submitted	8/28/2026 16:52:45

TRANSMIT SETTINGS (BAND_1)

Sample rate	61.44 MHz
Center frequency	530 MHz
Requested power	10 dBm

RECEIVE SETTINGS (BAND_1)

Sample rate	61.44 MHz
Center frequency	530 MHz
Duration	40 ms

YOUR FILES

TRANSMITTED — the waveform you supplied

This is the signal the radio's transmitter played.

[Download the transmitted waveform](#)

RECEIVED — the capture the radio recorded

This is what the radio's receiver captured off the air. Format: complex64, interleaved float32 I/Q, no header.

[Download the received capture](#)

Also attached to this email.

[Time domain image](#)

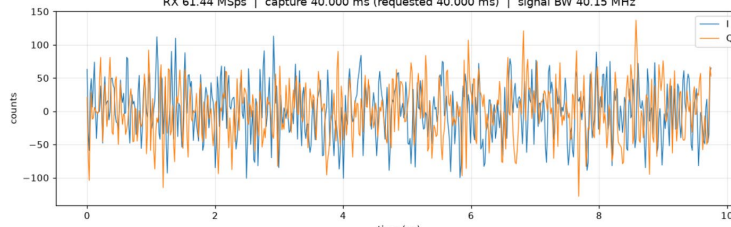
[Frequency domain image](#)

[Spectrogram](#)

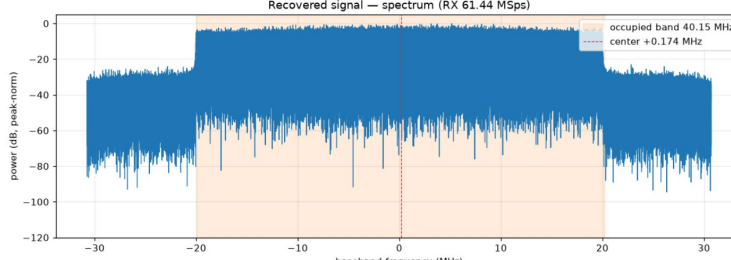
Customize Receiver

Recovered signal — time domain (first 600 of 2457600 samples)

RX 61.44 MSps | capture 40.000 ms (requested 40.000 ms) | signal BW 40.15 MHz



Recovered signal — spectrum (RX 61.44 MSps)



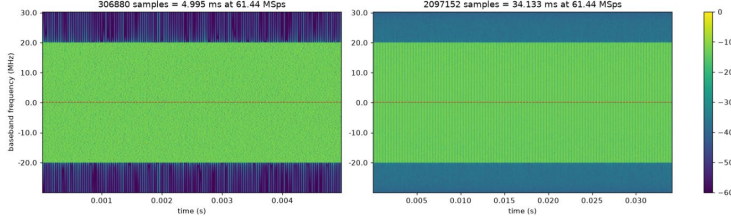
Spectrograms — carrier 530.000 MHz | NFFT 2048 (30 kHz bins), 88% overlap | red = measured centre +0.174 MHz

Transmitted (the waveform fed to the DAC)

306880 samples = 4.995 ms at 61.44 MSps

Received (captured off the ADC)

2097152 samples = 34.133 ms at 61.44 MSps



The above links are from Box — anyone with the link can view or download it.

Community and Dissemination

Building Community

- **Open Access Designs (hardware and software)**
 - **Remotely Accessible**
 - **Rent-to-use**
 - **Build-your-own**
- **User Support and Community Input**
- **Education material**
- **RF Datasets**
- **Frequency Support (FR1, FR2, FR3)**
- **Near Realtime I/Q Streaming**

Coming soon

Q2: X-band 16 element array fully hosted on the Houdini - 4 baseband

Q3: Houdini - 16 with concurrent multi-band streaming and compute

Q4: First integrated software and dataset release

Q4: Houdini-16 tri-band node demonstration and Lead User onboarding

Learn more and join the community



- **Community Resources**

- Website: <https://houdini-sdr.org/>
- Wiki: <https://wiki.houdini-sdr.org>
- Slack workspace: **houdini-sdr**
- Email: info@houdini-sdr.org
- Github: <https://github.com/Houdini-sdr>
- Community Survey: <https://houdini-sdr.org/pages/survey.html>

- **For further information and discussion come see our live demo and display at the poster session.**

