Design Challenges for Aerospace and Defense SDR (Software Defined Radio)

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Agenda

► Electronic Warfare Sub-Categories
  ▪ COMINT
  ▪ ELINT

► Next Generation Challenges
  ▪ SWaP (Size, Weight, and Power)

► Novel Electronic Warfare Component
  ▪ ADRV9009

► Conclusion
Electronic Warfare Sub-Categories
Electronic Warfare Sub-Categories

- Attack
- Monitor
- Protect
- C4ISR
COMINT

- SIGINT = Signals Intelligence
- COMINT = Communications Intelligence

- COMINT focuses on collecting and understanding human generated communication
  - GSM, LTE, Wi-Fi, Bluetooth, HAM Radio, MILCOM, Data Links, etc.

- Historically VHF to ~3GHz but rapidly expanding as civilian and defense communications evolve
  - 5G will move COMINT into microwave space

- Receive heavy, often zero or very limited transmit capability

- Blended with ELINT when capabilities like direction finding (DF) are included in a system
ELINT

- SIGINT = Signals Intelligence
- ELINT = Electronic Intelligence

- ELINT focuses on collecting and understanding electronic transmission, usually not communication
  - Ground and air based radar, seekers, beacons, electronic border fence

- Historically 2-18GHz but already transitioning to cover through Ka to V band

- Mix of receive heavy to paired receivers/transmitters – very wide application space and partitioning

- ELINT currently is one of, if not the, largest investment focus for the US department of defense
Next Generation Challenges
Increased Demand for Channel Count and Coverage

- Platforms Moving to Small Form Factors
  - Airborne from fixed wing to UAV
  - Ground from vehicle to dismounted soldier

- Channel Density Increasing
  - Enables simultaneous coverage of more channels
  - Or allows higher order beamforming

- Frequency Ranges Increasing
  - Threats and targets moving to new frequencies
  - Demands EW move to new frequencies as well

- All combine to demand lower SWaP radios!
Traditional Radio Design

- Discrete super-heterodyne – many components
- Heavy filtering to use a real IF ADC/DAC conversion
- Minimal integration, minimal re-configurability
- Large SWaP
- Typically high performance – but many other costs
Low SWaP Radio Design

- Zero-IF removes the real IF sampling of a super-heterodyne
- Mixes directly to IQ baseband
- This simplifies filtering and frequency planning
- ADCs can sample lower for same bandwidth
- Single device contains entire ZIF architecture – low SWaP!
- But…introduces algorithm challenges
ZIF Algorithms

- **DC (Rx) / LO (Tx) Leakage**
  - Because the PLL/VCO is directly on baseband, potential for DC/LO errors to propagate through signal chain

- **Image Rejection**
  - I and Q path ideally the exact same amplitude and exactly 90 degrees offset, but errors exist in real silicon

- **Algorithms needed to resolve both error sources**
  - Modern ZIF transceivers can achieve ~75dB rejection of both image and DC/LO errors
Electronic Warfare Focus Components
ADRV9009 Transceiver

- Integrated Dual Rx and Dual Tx
  - LO Range:
    - $75 \text{MHz} < F_c < 6 \text{GHz}$
  - Max Rx BW = 200MHz
  - Max Tx BW = 200MHz (synth BW 450MHz)

- Integrated Clock Generation
  - Frequency Agile
  - Rx / Tx Local Oscillator
  - Improved Phase Noise
  - RF LO Phase Sync
  - 16 bit ADC/DAC

- Digital Features
  - Rx: DC Offset Correction, QEC, AGC
  - Tx: LO leakage, QEC
  - AGC, Programmable FIR
  - 12.5 Gbit/s JESD204-B interface
  - API Control
ADRV9009 Fast Hopping – PLL & QEC

Analog Demod - Agilent 89600 VSA Software - Press the Mode key to switch applications

Rx Image Rejection With and Without Fast Hop Calibration
Common SIGINT application is scanning receiver
- Goal is to monitor and collect all frequency bands of interest
- Could be contiguous, could be discontinuous
- Coverage time is the critical spec

Coverage time has three inputs
- Instantaneous BW – how many bands can be observed at a time
- Dwell time – how long does a given frequency need to be observed to understand it
- Hop time – how long does it take to go to a new band

Calculations
- Number hops = Total coverage required / instantaneous BW
- Dwell time = Minimum FFT duration / IQ sample rate
- Hop time = Function of the PLL/VCO
- Coverage time = Number_Hops * (Dwell_Time + Hop_Time)
## Transceiver Comparison

<table>
<thead>
<tr>
<th>Parameter</th>
<th>AD9361 w/ Fast Lock</th>
<th>AD9361 w/o Fast Lock</th>
<th>AD9371</th>
<th>ADRV9009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency Coverage</td>
<td>3GHz</td>
<td>3GHz</td>
<td>3GHz</td>
<td>3GHz</td>
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<tr>
<td>Instantaneous BW</td>
<td>40MHz</td>
<td>40MHz</td>
<td>100MHz</td>
<td>200MHz</td>
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<tr>
<td>Hop Time</td>
<td>15us</td>
<td>250us</td>
<td>1ms</td>
<td>70us</td>
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<td>IQ Rate</td>
<td>50MSPS</td>
<td>50MSPS</td>
<td>125MSPS</td>
<td>250MSPS</td>
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<tr>
<td>Number Hops Required</td>
<td>75</td>
<td>75</td>
<td>30</td>
<td>15</td>
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<tr>
<td>Min FFT Size</td>
<td>16384</td>
<td>16384</td>
<td>32768</td>
<td>65536</td>
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<tr>
<td>Dwell Time</td>
<td>328us</td>
<td>328us</td>
<td>262us</td>
<td>262us</td>
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<tr>
<td>Total Coverage Time</td>
<td>25.7ms</td>
<td>43.3ms</td>
<td>37.8ms</td>
<td>5ms</td>
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</tbody>
</table>
Example ADRV9009 Sweep

- Standard eval board, ZC706 connected to PC via Ethernet, ISM band antenna connected to Rx1
- MATLAB used to gather and plot the data, tuning the LO and stitching together a 2GHz sweep
ADRV9009 LO Phase With Phase Sync Disabled

Tx1 Phase (b2) Relative To External Signal Generator (b1)

New Initialization
PLL Frequency Change
RadioOff / RadioOn
LO Phase Is Not Consistent!
ADRV9009 LO Phase With Phase Sync Enabled

Tx1 Phase (b2) Relative To External Signal Generator (b1)

New Initialization
PLL Frequency Change

RadioOff / RadioOn

LO Phase Returns to Same Value!
# ADRV9009/ADRV9008: Design Resources on RadioVerse®

| Evaluation Kits                      | ADRV9009-W/PCBZ—wideband TDD EVB  
|                                      | ADRV9008-1W/PCBZ—wideband Rx EVB  
|                                      | ADRV9008-2W/PCBZ—wideband Tx/Rx EVB |
| Carrier Platforms                    | Xilinx ZC706 (EVAL-TPG-ZYNQ3) |
| Simulation Tools                     | Filter Wizard |
| Software Driver and GUI              | Windows GUI  
|                                      | API library  
|                                      | Linux driver  
|                                      | ADI JESD204B interface framework |
| Customer Support Forum               | ADI EngineerZone®—wideband RF transceivers, API, Linux® drivers, FPGA reference designs |
| Reference Designs and Partners       | Dual ADRV9009 system-on-module (SOM)—Q4  
|                                      | Epiq Sidekik X4 FMC card with dual ADRV9009  
|                                      | Panateq FMC card with single ADRV9009  
|                                      | Intel JESD interoperability report |

Please visit [analog.com/radioverse](http://analog.com/radioverse) for more information.
Introduce ADRV9009 System-on-Module (RF-SOM)

- Supports up to 4× ADRV9009 that can be synced in frequency and phase
- Scalable with multiple RF-SOM’s synced together
- I/O connector: USB 3.0, 10Gb Ethernet, PCIe x8
- Approximate size: 96 mm × 160 mm
- Comes with open source code support package hosted on GitHub

Key Benefits

- Qualified ‘production ready’ module to speed up prototyping and integration into final production
- Allows customers to focus on their own areas of differentiation
- Broad range of applications in cellular infrastructure, radar, portable defence, and instrumentation

Available in 2019
Conclusion
Conclusion

► Electronic Warfare is a complex technology space
► Many sub-categories that often overlap

► New threats continue to emerge, requiring new capability in response
► New capability often demands lower SWaP (Size, Weight, and Power) solutions

► ADRV9009 is ADI’s latest integrated transceiver
► Electronic Warfare focused features
  ▪ Wide bandwidth
  ▪ Frequency hopping
  ▪ LO phase sync
Related Links

► Analog Devices, Inc.
  ▪ www.analog.com

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  ▪ www.analog.com/ADEF

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