Cooking from Scratch:
Designing and Building a Microwave SDR

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Why?

- We do R&D, and we’ve used commercial SDRs for more than a decade for many different projects
  - We’ve been happy with commercial SDRs for the cases they fit
- We designed and built our own 5-20 GHz, 160 MSPS SDR because:
  - We wanted to do things you can’t do with commercial SDR’s
  - We wanted a radio we could customize for different applications
    - Change the frequency band
    - Change the sample rate
    - Build single or multichannel systems
  - We thought it would be interesting and fun
  - We had time and cost estimates that were each about 3 dB low
Our First From-Scratch SDR Design – the VXSDR-20

- We chose to separate the design into 2 sections:
  - Analog board with RF, IF, synthesizers, and converters
  - Digital board with FPGA and network interface
  - Using JESD in between gives us a lot of flexibility to mix and match!

- For our first implementation, we chose these design goals:
  - 5 - 20 GHz (higher than most commercial SDRs)
  - 160 MSPS each way, simultaneously
  - 10 gigabit Ethernet data transfer
  - PPS and 10 MHz synchronization

- 18 months, 2 subsystem prototypes, and 1 design rev later:
  - It works!
  - Specs are given later in the presentation, but we hit our performance targets
VXSDR-20 Boards
VXSDR-20 Boards

**DIGITAL BOARD**
- 10 Gb Ethernet
- Power (12V)
- PPS
- FPGA

**ANALOG BOARD**
- DAC
- 10 MHz
- TX Synth
- TX Mixer
- TX Amps
- RX Synth
- RX Mixer
- RX LNA
- Antialiasing Filters
- MCU
- ADC
Measured Specs

- 5.0 to 20.0 GHz transmit and receive
  - usable to 22.0 GHz in both directions
- Receive noise figure 5 – 9 dB across the band
- Transmit power 15 – 10 dBm across the band
- Both TX power and RX sensitivity are reasonably flat (±3 dB) across the band
- 160 MSPS bidirectional over 10 GbE
- 10 MHz and PPS work as designed
  - can be used standalone if synch not needed
Lessons Learned

• If you’re going to build an SDR, do it to have unique capabilities
  – We can now do things you can’t do with commercial SDRs
  – And we have a base design we can customize for future uses

• Software takes *at least* as much effort as hardware
  – Lessons from other examples during the design process (like UHD)
  – At least fixing software is easier (we spent months fixing hardware problems)

• Don’t do it unless you can tolerate up to 3 dB of cost and schedule increase

• Try not to do it during a pandemic or a global semiconductor supply chain breakdown
Thank You

• We’re here to get feedback from any interested listeners or potential users of a radio like this
• If there were significant interest, we’d be happy to consider a CrowdSupply project to make the radio available
• For questions, comments, or to get more info, you can contact us at vxsdr@vesperix.io
• Questions?