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White Paper

Highly integrated transceiver with RF front end reduces design time and development resources

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Engineers are constantly under pressure to design smaller, lower-power and higher-performance devices. A lack of time and resources are often also part of the challenge. Richardson RFPD engineers and others have teamed with Analog Devices to introduce a new, highly integrated transceiver and have built SoMs and RF front ends to interface with it. Our collective goal is to provide engineers with small, low-power, high-performance starting points for their own projects that will reduce design time and the amount of needed resources.

RF Integration

The factors driving RF integration include requirements for smaller components with ever-increasing performance and complexity—at ever-decreasing power usages. The motivations span an array of needs, from making end-user customer lives easier, to adapting existing designs for new applications, creating military versions, and simply improving performance.

Integrated Transceivers

RadioVerse™ Integrated Transceivers

Analog Devices has a line of integrated transceivers that focus on high performance in a very small size. These RadioVerse SDR Integrated Transceivers offer highly integrated, carrier-grade radio system-on-chip (SoC) solutions that support communications, aerospace and defense, and high-speed instrumentation applications. In addition to reduced size, weight and power (SWaP) these devices are versatile and can be used as a common design platform across multiple designs and variants.

As you can see in Figure 1, below, ADI's high-performance integrated transceiver portfolio started with the AD9361 and its variants. It was followed by other parts that could be used for many applications but were primarily focused on cellular infrastructure.

The newly announced ADRV9002 is the first high-performance integrated transceiver that can be used for cellular infrastructure applications but is primarily focused on everything else. Device highlights include extending low frequency coverage down to 30 MHz, as well as its focus on more narrowband modulation signals. Because it was made on a 28 nm CMOS process, it is a very low power device.

These devices are versatile— they can be used as a common design platform across multiple designs and variants.

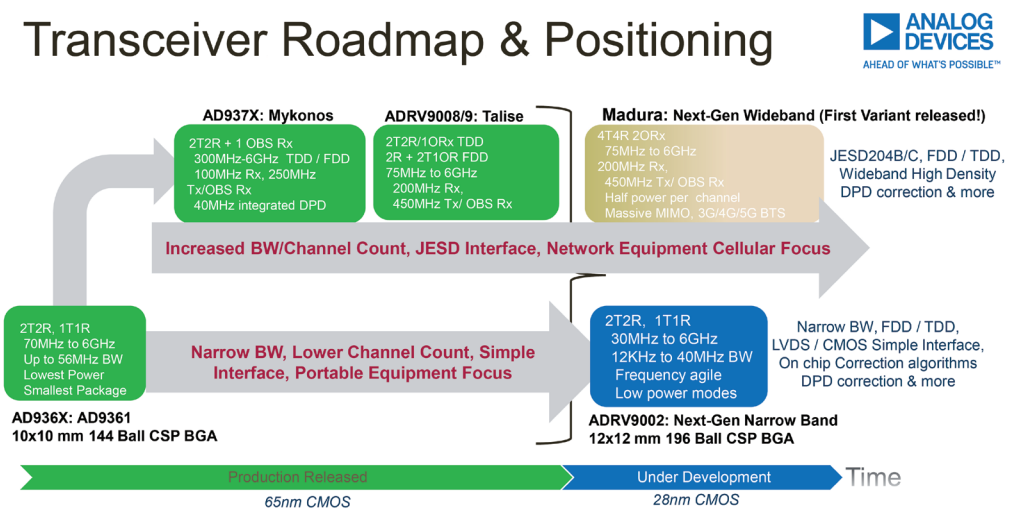

Figure 1: Roadmap of Analog Devices' RadioVerse™ Integrated Transceivers

The ADRV9002 has two transmit channels, two receive channels, and two synthesizers that can be muxed to any combination of the transmit and receive chains, allowing it to be used for FDD or TDD applications. Alternatively, one of the RX paths can function as a sniffer while the rest of the system is turned off, to determine which frequency bands are not being used; then the whole system can be switched to that empty frequency band. It has various low power modes, the ability to do fast frequency hopping, and digital pre-distortion (DPD). (It may actually be the first open market DPD that works for very narrowband applications). It also has a SPI or LVDS digital interface, which allows it to be used with an inexpensive processor or FPGA.

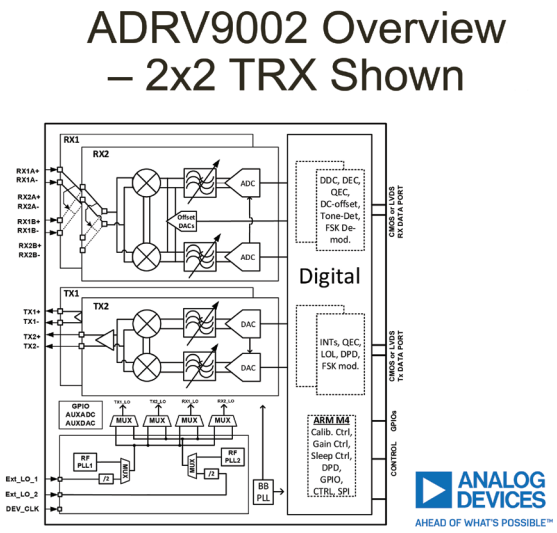

Figure 2: ADRV9002 Overview – 2×2 TRX shown

The ADRV9002 also has various digital functions like digital down converters and FIR filters, and multiple ADRV9002s can be synched for MIMO type applications. The following is an overview of ADRV9002 features:

- Highly integrated Transceiver (RF to Digital)
  - Single and Dual channel Transceivers (2Tx 2Rx & 1Tx 1Rx)
  - Dual flexible fully integrated RF LOs on chip
  - Direct conversion architecture with correction algorithms for QEC/LOL, DC offset

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- Operating Frequency Bands
  - 30MHz to 6GHz Operating bandwidth
  - 12.5KHz to 40MHz Instantaneous bandwidth
- Digital functions
  - Integrated digital downconverter (DDC) for NB IF operation
  - 128 taps Rx/Tx programmable FIR filters
  - Automatic and manual gain control
  - Digital Pre-Distortion (NB/WB)
- Interface modes
  - Flexible multi-protocol data interface, LVDS / SSI digital interface
  - SPI for AuxDAC, AuxADC, GPIO, Tx/Rx enable control
- System functions
  - Low power auxiliary monitor functions
  - Fast profile switching
  - Fast frequency hopping
  - PA ramp control and PA protection
  - Flexible power vs. performance modes
- Package: 12 × 12 mm 0.45 Ball Diameter,196 Ball CSP BGA

BytePipe: 0.03–6 GHz Transceiver with FPGA SoM (ADI ADRV9002) – NextGen RF

The BytePipe is a 30 MHz to 6 GHz RF transceiver with FPGA System on Module that uses the Analog Devices ADRV9002 and Xilinx XCU3EG. It supports most of the functionality of the ADRV9002, including DPD, multi-board synchronization, fast frequency hopping and instantaneous bandwidths of 12 KHz to 40 MHz, and it will greatly reduce engineering time and costs of implementing the ADRV9002 and FPGA into a design.

vPROTEAN: 0.03–6 GHz Transceiver with FPGA SoM (ADI ADRV9004) - Vanteon

The vPROTEAN is a 30 MHz to 6 GHz RF transceiver with FPGA System on Module that uses the Analog Devices ADRV9004 and Xilinx Zynq Z-7020. It includes an LNA on the RX and gain block on the TX and most of the functionality of the ADRV9004. It will greatly reduce engineering time and costs of implementing the ADRV9004 and FPGA into a design.

RF Front Ends

Richardson RFPD has designed several RF Front Ends specifically to work with the ADRV9002.

The **DE705 Doherty *Accelerator*** is a complete RF front-end evaluation platform for FDD operation in LTE Bands 14 and 28. The platform uses components with universal footprints that allow the same PCB to be used for all sub 1 GHz LTE bands.

The platform features a single channel transmitter and a single channel receiver with a swappable ceramic duplexer that will allow configuration for band 14 or band 28. Included in the TX circuitry is a high performance 2-stage LDMOS PA implemented as an asymmetrical Doherty amplifier for optimum TX efficiency and linearity performance. An onboard bias generation IC and an Advanced Doherty Alignment Module (ADAM) IC with SW control provide for additional levels of configuration.

The DE705 RFFE has a 45% efficient 9 W power amplifier for the transmit, and a 2.5 dB noise figure for the receive.

Richardson RFPD's **RadioCarbon Design Accelerators** consist of 3 designs, covering frequency ranges of 1.35-2.7 GHz (RFPD-RC-1327-50 and RFPD-RC-1327-20) and 4.4-5 GHz (RFPD-RC-4450-50). They include a full RF front end, transmit and receive that can be used for either TDD or FDD applications. Output powers are 40W or 20W PSAT and 2W or 1W linear, assuming a 10 dB peak to average signal. The boards can be used with any transceiver that has DPD through SMA connectors, but they were specifically designed to work with the BytePipe SoM and ADRV9002 evaluation board.

These boards are ideal for designers working on military communications, SATCOM, troposcatter, NLOS backhaul, and 5G applications, although they can be modified to work in other frequency bands.

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Demonstrations

The RFPD-RC-4450-50 (4.4-5 GHz) RadioCarbon board was demonstrated at IMS2021, as shown in Figure 3, right. Transmit had about 35 dB of gain and a 40W PSAT or 2W linear at the antenna (assuming a 10 dB peak to average signal). The receive had 24 dB max gain and a 1.75 dB system noise figure, but the second stage LNA can be bypassed if there is a jammer.

Figure 3 shows a picture of the board being tested. Note that the BytePipe SoM can be mounted directly on the RadioCarbon board; however, if a different transceiver board were used, the BytePipe would not be installed, and the transceiver board would be connected via the SMA connector. The BytePipe is only 37mm x 61mm, and overall the whole board is small, especially considering there are no components on the back side.

The RadioCarbon board, combined with the BytePipe, supplies most of the hardware necessary to make a complete radio. The transmitted signal is streamed through the FPGA, continues through ADI's ADRV9002s and various gain stages on the RadioCarbon board to where it is fed through two combined Wolfspeed GaN power amplifiers that are linearized by the ADRV9002 to provide a high-power linear transmit to the antenna output of a circulator.

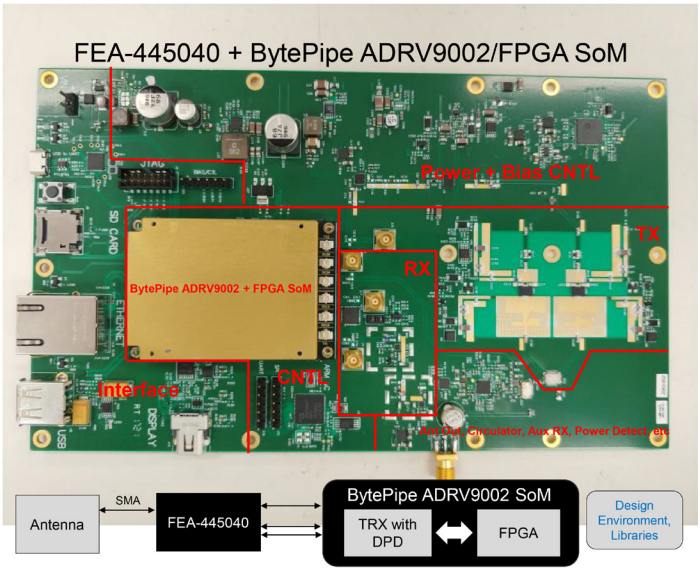

Figure 3: Demo: 4.4-5 GHz, 2W Linear Radio

An LTE data file provided by Analog Devices was leveraged for this demonstration. The LTE waveform was wideband (10 MHz), with a sample rate of 15.36 Msps. TX2/RX2 were configured for transmit and receive, with the carrier frequency set up for 4.75 GHz. As you can see from the spectrum analyzer plot shown in Figure 4, below, there is approximately 20 dB of improvement in the ACPR performance with DPD at ~2W RMS.

- WB LTE (10MHz)
- Center Frequency = 4.75GHz
- ~2W Linear

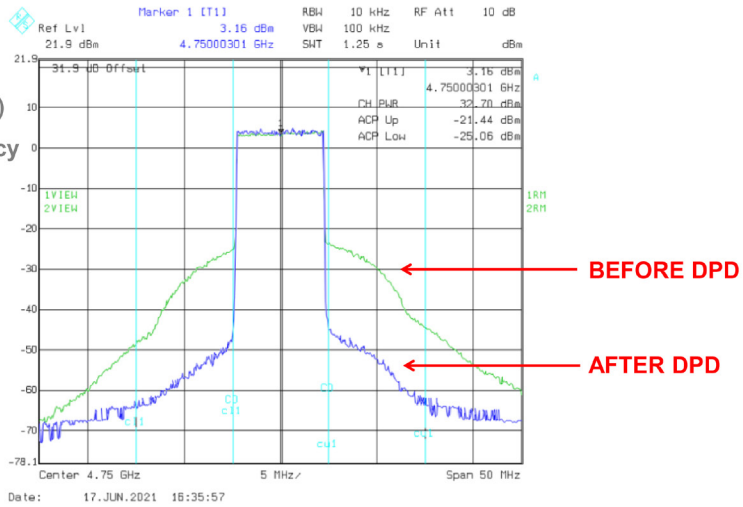

Figure 4: Demo: 4.4-5 GHz, 2W Linear Radio

The RX side includes a very low noise Guerrilla RF LNA and LNA with bypass, followed by an Analog Devices tuneable filter that can be customized to fit many different applications, and the BytePipe ADRV9002 SoM.

A demonstration of the ADRV9002 was also presented at IMS2020 and is available here.

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About Richardson RFPD

Richardson RFPD, an Arrow Electronics company, is a global leader in the RF, wireless, IoT and power technologies markets. It brings relationships with many of the industry's top radio frequency and power component suppliers. Whether it's designing components or engineering complete solutions, Richardson RFPD's worldwide design centers and technical sales team provide comprehensive support for customers' go-to-market strategy, from prototype to production. More information is available online at www.richardsonrfpd.com.

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