Wideband RF Signal Processing Solutions from ADI

When GHz Signal Acquisition and Conversion Are Critical, ADI Has the Answer

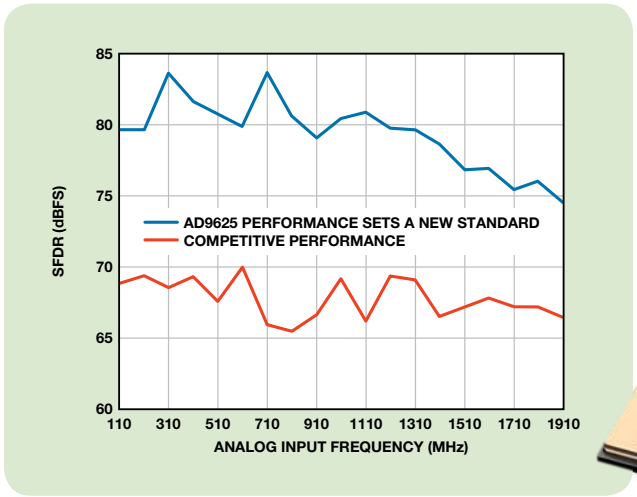
The wideband RF signal processing receiver is driven by the need to acquire, convert, and transfer GSPS data to a digital processor as quickly and accurately as possible. In many defense electronics applications, lives literally depend on the speed of this function. As a result, the desire of system architects is to place the point of signal conversion as close to the antenna, sensor, probe, or transducer as is technically feasible. But even at low GHz analog input bandwidths, serious data conversion design barriers begin to present themselves, and ADI has solved those problems. Specifically:

- While ultrahigh speed GSPS analog-to-digital converters (ADCs) have been available for some time, their Nyquist band linearity and wideband noise performance have been insufficient for most demanding applications. The solution: ADI has introduced a new family of wideband performance optimized 12- and 14-bit, 2.5 GSPS/1.0 GSPS (respectively) ADC cores that provide up to 80 dB of wideband dynamic range at 1 GHz A_{IN}. Likewise, our quad, 16-bit, 2.8 GSPS, digital-to-analog converter (DAC) provides signal synthesis capability with industry-leading performance.
- Achieving "data sheet" converter performance in the production system at GHz bandwidths requires particular attention to interface, frequency planning, PCB layout, noise and thermal management, support components, and just about everything else, or unwanted design cycles can occur that impact time to market (TTM). Solution: ADI delivers its wideband RF conversion technology on both performance evaluation boards and rapid system prototyping FMC modules containing critical signal chain components such as driver amplifiers, clocks, and power management. These modules come with full production ready operating software and serve as known good system reference designs that greatly diminish risk and TTM.

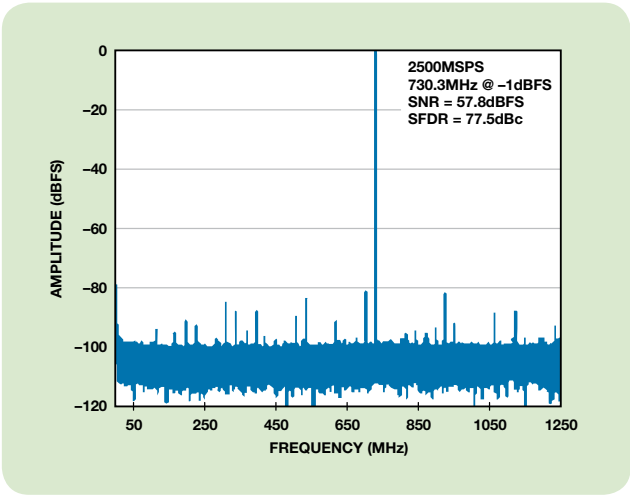
This brochure provides an overview of ADI's game changing wideband RF signal processing solutions for performance critical applications such as exist in defense electronics, RF instrumentation, and communications infrastructure. Take a look at our compelling technology, and we believe that you'll agree: the time has come to incorporate wideband RF signal processing into your system design.

ADI Has Shattered the GHz Signal Conversion Performance Barriers

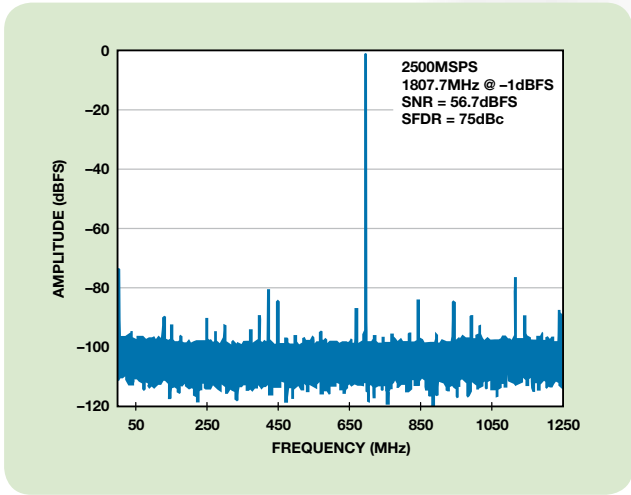
Drawing on the strength of more than 45 years of industry-leading innovation in data conversion technology, ADI engineers have developed breakthrough 12-bit, 2.5 GSPS, and dual 14-bit, 1.0 GSPS, ADC cores that shatter existing performance limitations in GHz bandwidth signal conversion. This new level of dynamic and noise performance is poised to usher in the next generation of advanced RF and high IF sampling architectures that enable significant increases in end system sensitivity, functionality, configurability, and improved response times.



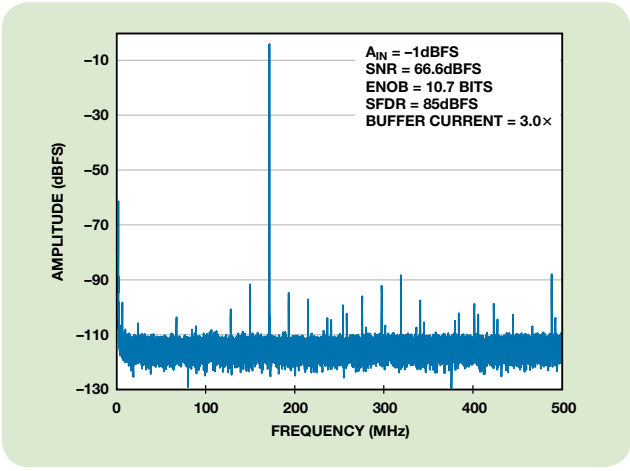
AD9625 SFDR vs. frequency (2.5 GSPS).



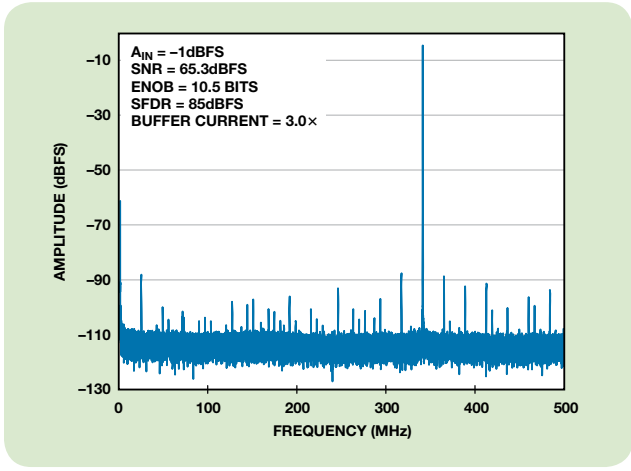
AD9625 spectrum with 730 MHz A_{IN}, 2.5 GSPS.



AD9625 spectrum with 1.8 GHz A_{IN}, 2.5 GSPS.



AD9680 spectrum with 170.3 MHz A_{IN}, 1.0 GSPS.



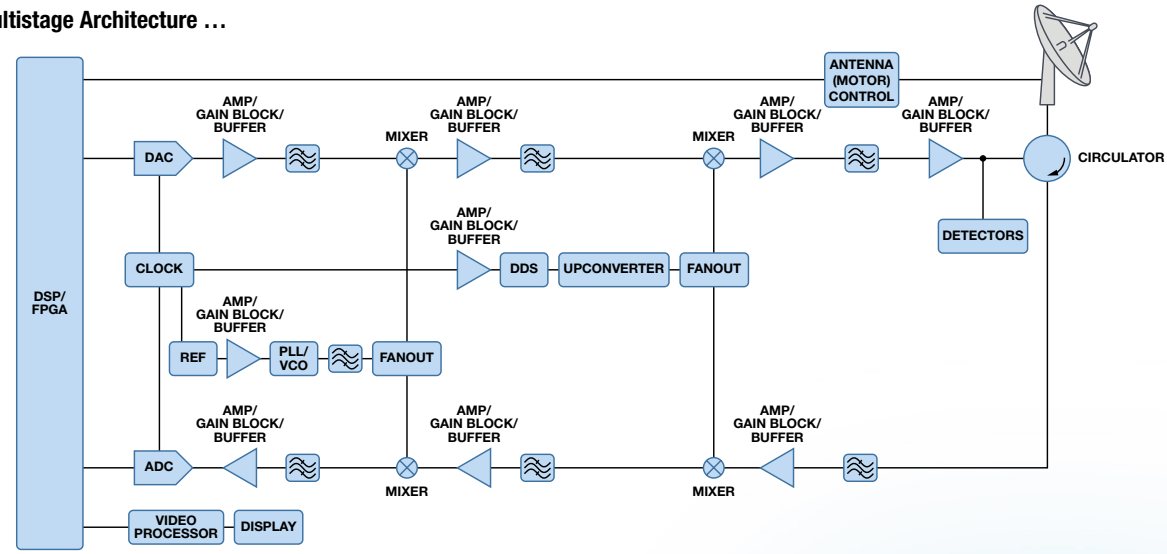
AD9680 spectrum with 340 MHz A_{IN}, 1.0 GSPS.

Superior Dynamic Range and Noise Performance in Wideband RF Signal Conversion Can Simplify Architectures

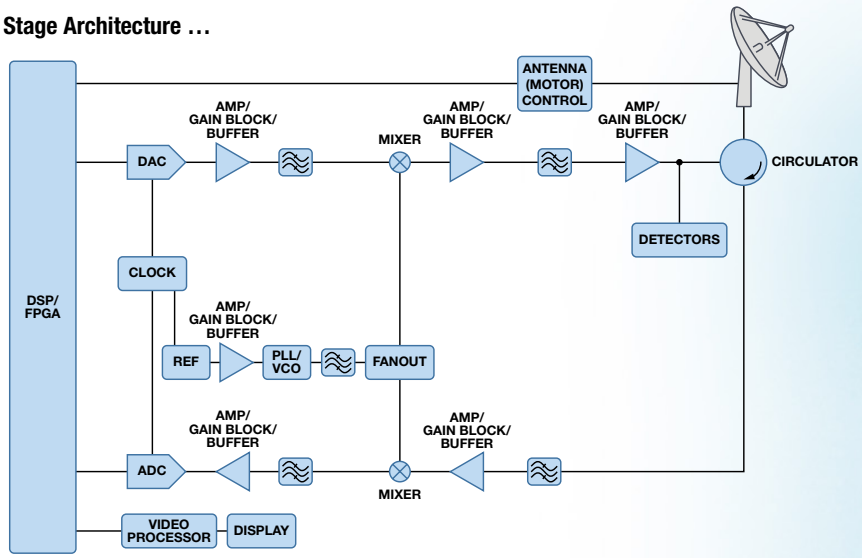
ADI's breakthrough in GHz data converter performance has enabled the point of signal conversion in many architectures to be moved closer to the antenna, thereby eliminating downconversion stages that add noise, complexity, and cost to end system designs.

Real-World Example: High Performance GSPS Converters Driving the Evolution of X-Band Radar Architecture

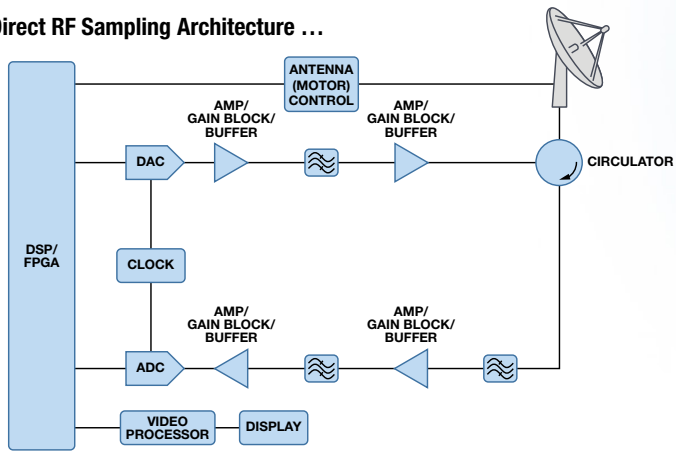
From a Multistage Architecture …

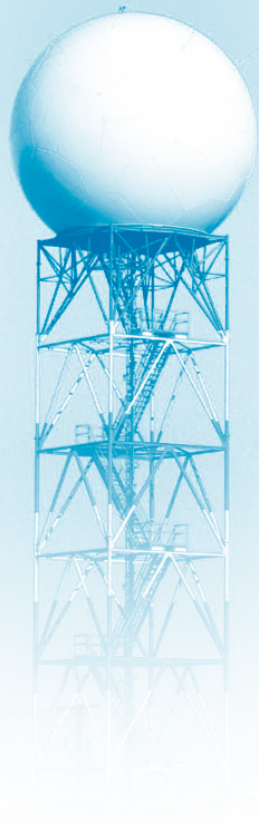


To a Single Stage Architecture …



To Even a Direct RF Sampling Architecture …





New Tool for Prototyping and Designing with State-of-the-Art Data Conversion Technology

ADI now offers this breakthrough and enabling wideband RF signal processing technology on standardized platforms that seamlessly connect to the FPGA prototyping ecosystem; in other words, the way you actually design your system!

AD-FMCDAQ2-EBZ FMC module comprised of: AD9680—dual, 14-bit, 1.0 GSPS ADC; AD9144—quad, 16-bit, 2.8 GSPS TxDAC+.®

AD-FMCDAQ2-EBZ connected to Xilinx® VC707 FPGA development platform for rapid prototyping and system development.

ADI collaborates closely with our platform partners to verify connectivity, interoperability, and performance of hardware, software, and design tools.

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A Closer Look at ADI's Premiere Wideband RF Signal Conversion IC Technology and FMC Module Solutions

AD9680 Dual-Channel, 14-Bit, 1.0 GSPS Analog-to-Digital Converter IC

The AD9680 is a dual, 14-bit, 1 GSPS analog-to-digital converter (ADC). The device has an on-chip buffer and sample-and-hold circuit designed for low power, small size, and ease of use. This device is designed for sampling wide bandwidth analog signals of up to 2 GHz. The AD9680 is optimized for wide input bandwidth, high sampling rate, excellent ac linearity, and low power in a small package. Applications for the AD9680 include diversity multi-mode, multiband digital receivers, defense electronics, and RF instrumentation.

- SFDR = 85 dBFS at 340 MHz, 80 dBFS at 1 GHz
- SNR = 65.3 dBFS at 340 MHz (A_{IN} = –1.0 dBFS), 61.4 dBFS at 1 GHz
- ENOB = 10.8 bits at 10 MHz
- Noise density = –154 dBFS/Hz at 1.0 GSPS
- JESD204B (Subclass 1) coded serial digital outputs

AD9625 Single-Channel, 12-Bit, 2.0 GSPS/2.5 GSPS Analog-to-Digital Converter IC

The AD9625 is a 12-bit ADC that operates at conversion rates of up to 2.5 GSPS and is designed for sampling wide bandwidth analog signals up to the second Nyquist zone. The combination of wide input bandwidth, high sampling rate, and excellent ac linearity makes the AD9625 ideally suited for spectrum analyzers, data acquisition systems, and a wide assortment of military electronics applications, such as radar and jamming/antijamming measures.

- SFDR = 79 dBc, A_{IN} up to 1 GHz at –1 dBFS, 2.5 GSPS
- SFDR = 75 dBc, A_{IN} up to 1.8 GHz at –1 dBFS, 2.5 GSPS
- SNR = 57.6 dBFS, A_{IN} up to 1 GHz at –1 dBFS, 2.5 GSPS
- SNR = 56.7 dBFS, A_{IN} up to 1.8 GHz at –1 dBFS, 2.5 GSPS
- Noise spectral density = –150 dBFs/Hz at 2.5 GSPS
- Two independent decimate by 8 or decimate by 16 filters with 10-bit NCOs
- High speed 6-lane or 8-lane JESD204B serial output with 6.25 Gbps at 2.5 GSPS
- Subclass 1 deterministic latency

AD9144 Quad-Channel, 16-Bit, 2.8 GSPS TxDAC+ Transmit DAC

The AD9144 is a quad, 16-bit, high dynamic range digital-to-analog converter that provides a maximum sample rate of 2.8 GSPS, permitting a multicarrier generation up to the Nyquist frequency. The AD9144's >1 GHz ultrawide complex signal bandwidth enables emerging wideband and multiband wireless applications. Advanced low spurious and distortion design techniques provide high quality synthesis of wideband signals from baseband to high intermediate frequencies.

- Low spurious and distortion design
  - 6-carrier GSM IMD = 77 dBc at 75 MHz IF
  - SFDR = 82 dBc at dc IF, –9 dBFS
- Flexible 8-lane JESD204B interface
- Supports input data rate >1.0 GSPS
- Support dual DAC mode at 2.8 GSPS
- Multiple chip synchronization

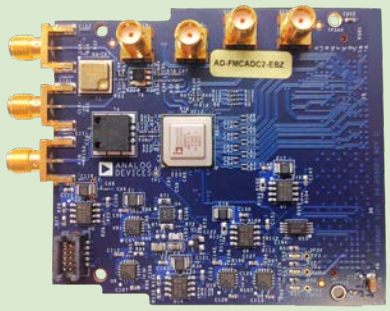
AD-FMCDAQ2-EBZ Rapid Prototyping and Development Board Incorporating the AD9680 ADC and the AD9144 DAC

The AD-FMCDAQ2-EBZ rapid development and prototyping board is a high speed analog module, incorporating the AD9680 dual-channel, 14-bit, 1.0 GSPS ADC and the AD9144 quad-channel, 16-bit, 2.8 GSPS TxDAC+ transmit DAC (configured as a dual-channel). This FMC module seamlessly connects to and operates within the Xilinx FPGA development platform ecosystem. This board is a 2 × 2 RF configuration, which is fully customizable by software without any hardware changes. It comes with downloadable Linux® drivers and bare metal software drivers, schematics, board layout, and design aid reference materials on the Analog Devices wiki site.

- Completely self-contained data acquisition and signal synthesis platform—capable of operation with no external inputs
- Includes schematics, layout, BOM, Gerber files, HDL, Linux drivers, IIO Oscilloscope, VisualANALOG,™ and application software
- FMC-compatible form factor
- Powered from single FMC connector
- Provides two channels of 14-bit, 1 GSPS analog-to-digital conversion and two channels of 16-bit, 2.8 GSPS digital-to-analog conversion with full synchronization capabilities

Visit the resource wiki page for the AD-FMCDAQ2-EBZ at
http://wiki.analog.com/resources/eval/user-guides/ad-fmcdaq2-ebz

AD-FMCADC2-EBZ Rapid Prototyping and Development Module Incorporating the AD9625 ADC



The AD-FMCADC2-EBZ is a data acquisition and signal processing platform that contains a complete signal chain for digitizing wideband RF signals for a variety of high performance applications. The board has operating software and drivers for seamless connectivity within the Xilinx FPGA development platform ecosystem. This board is comprised of the AD9625.2.5 12-bit, 2.5 GSPS JESD204B ADC, input balun, clock oscillator, and critical power management components.

- Module comprises the AD9625, 12-bit, 2.5 GSPS JESD204B ADC IC with input BALUN, clock oscillator, and power management
- Includes schematics, layout, BOM, HDL, Linux drivers and application software
- FMC-compatible form factor
- Powered from a single FMC connector

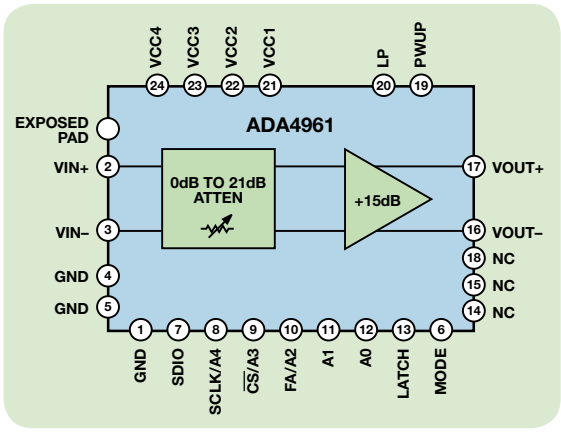
Visit the resource wiki page for the AD-FMCADC2-EBZ at
http://wiki.analog.com/resources/eval/user-guides/ad-fmcadc2-ebz

High Performance Companion Components Are Critical in Optimizing Wideband RF Signal Conversion Performance, and ADI Has the Solution

ADA4961 Driver Amplifier

The ADA4961 is a high performance BiCMOS RF differential amplifier (DGA) optimized for driving heavy loads out to 2.0 GHz and beyond. Typically, achieving −90 dBc IMD3 performance at 500 MHz and −85 dBc at 1.5 GHz, this device enables GHz converters to achieve their optimum performance with minimal limitations of the driver amplifier or constraints on overall power that typically result from GaAs amplifiers. This product can easily drive 10-bit to 16-bit high speed ADCs.

- High speed
  - −3 dB bandwidth: 2.5 GHz
  - −1 dB bandwidth: 1.8 GHz
- Low distortion
  - IMD3 at 1 GHz: −90 dBc
  - HD3 at 500 MHz: −82 dBc
  - HD3 at 1 GHz: −80 dBc
  - HD3 at 1.5 GHz: −75 dBc
- Digitally adjustable gain
  - Voltage gain: −6 dB to +15 dB
  - Power gain: −3 dB to +18 dB



Low Jitter Data Converter Sampling Clocks

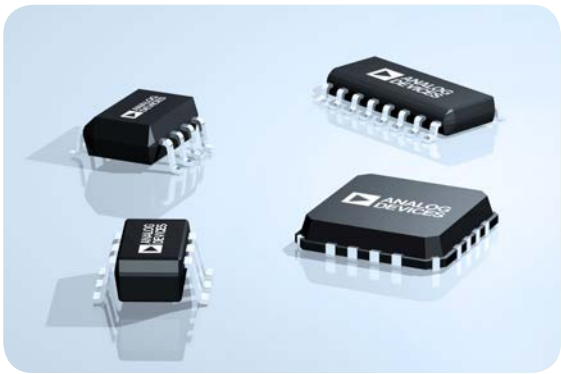
The AD9525 clock provides a low power, multioutput, clock distribution function with low jitter performance, along with an on-chip PLL that can be used with an external VCO or VCXO. The VCO input and eight LVPECL outputs can operate up to a frequency of 3.6 GHz.

The AD9523 provides a low power, multioutput, clock distribution function with low jitter performance, along with an on-chip PLL and VCO. The AD9523 has 14 outputs configurable for LVPECL, LVDS, HSTL, and LVCMOS, and supports output frequencies of <1 MHz to 1 GHz.

Power Solutions

ADI offers a wide portfolio of power supply and management ICs that support the critical requirements of wideband RF signal conversion applications. Examples of power ICs utilized on ADI's rapid prototyping and development FMC modules include:

- ADP1740: 2 A, low V_{IN} dropout, linear regulator
- ADP150: Ultralow noise 150 mA LDO
- ADP2384: 20 V, 4 A, synchronous step-down dc-to-dc regulator
- ADP1753: 800 mA, low V_{IN}, adjustable V_{OUT} LDO regulator
- ADP7104: 20 V, 500 mA, low noise, CMOS LDO



Antenna to Bits and Back

The combined RF and microwave portfolios from Analog Devices and Hittite Microwave include more than 2000 high performance products from functional blocks to highly integrated solutions. Complemented by the world's leading data converters, Analog Devices is the only single source supplier to cover the entire signal chain, from antenna to bits and back, across the entire frequency spectrum up to 110 GHz.

Selection Tables

Key Wideband RF Signal Processing Solutions for the GSPS Data Conversion Stage Signal Chain Design

Part Number	Description	Attribute
Data Converter ICs		
AD9625	12-bit, 2.0 GSPS/2.5 GSPS JESD204B ADC with dual downconverters	SFDR of 79 dBc @ 1 GHz A_{IN}, and 75 dBc @ 1.8 GHz A_{IN}
AD9680	Dual, 14-bit, 1.0 GSPS JESD204B ADC with digital downconverters	SFDR 0f 85 dBFS @ 340 MHz A_{IN}, and 80 dBFS @ 1 GHz A_{IN}
AD9144	Quad, 16-bit, 2.8 GSPS JESD204B TxDAC+ transmit DAC	82 dBc SFDR to Nyquist, −164 dBm/Hz noise spectral density
FMC Modules		
AD-FMCDAQ2-EBZ	FMC module comprised of AD9680, dual, 14-bit, 1.0 GSPS ADC, AD9144 quad, 16-bit, 2.8 GSPS DAC, AD9523-1 clock, power management, and operating software	Enables rapid prototyping of dual synchronized 14-bit wideband RF data acquisition and 16-bit signal synthesis channels, and JESD204B interface
AD-FMCADC2-EBZ	FMC module comprised of AD9625, 12-bit, 2.5 GSPS ADC, clock oscillator, power management, and operating software	Enables rapid prototyping of dc to 1.8 GHz, 12-bit wideband RF data acquisition channel and JESD204B interface; module is configured for synchronization of multiple ADC2 boards
Driver Amplifier		
ADA4961	Low distortion, dc to 2.5 GHz ADC driver amplifier	−90 dBc IMD3 performance at 500 MHz and −85 dBc at 1.5 GHz
Converter Clocks		
AD9523-1	Low jitter clock generator with 14 outputs	Output frequency: <1 MHz to 1 GHz, on-chip PLL and VCO with two VCO dividers
Power Supplies		
ADP5040	1.2 A buck regulator and dual 200 mA LDOs	High switching frequency of the buck regulator enables the use of tiny multilayer external components and minimizes board space
ADP2384	20 V, 4 A, synchronous step-down dc-to-dc regulator	This device uses a peak current mode, constant frequency pulse-width modulation (PWM) control scheme for excellent stability and transient response
ADP7104	20 V, 500 mA, low noise, CMOS LDO	Using an advanced proprietary architecture, it provides high power supply rejection and low noise, and achieves excellent line and load transient response with just a small 1 µF ceramic output capacitor
ADP1740	2 A, low V_{IN} dropout, linear regulator	This low V_{IN}/V_{OUT} LDO is ideal for regulation of nanometer FPGA geometries operating from 2.5 V down to 1.8 V I/O rails, and powering core voltages down to 0.75 V
ADP150	Ultralow noise 150 mA LDO	Using an innovative circuit topology, the ADP150 achieves ultralow noise performance without the necessity of an additional noise bypass capacitor, making it ideal for noise sensitive analog and RF applications

Wideband RF Signal Processing Solutions for the Complete Antenna to Bits and Back RF Signal Chain Design

Part Number	Description
RF Amplifiers	
ADL5601, ADL5602	50 MHz to 4 GHz broadband 20 dB linear amplifiers providing the highest dynamic range available from an internally matched gain block.
ADL5320	400 MHz to 2700 MHz, ¼ W RF driver amplifier with a dynamically adjustable biasing circuit that allows for the customization of OIP3 and P1 dB performance from 3.3 V to 5 V without the need for an external bias resistor.
ADL5604	700 MHz to 2700 MHz, 1 W RF driver amplifier that is highly linear and has a very low power consumption, enabling the driver to be packaged in a compact 16-lead, 4 mm × 4 mm LFCSP.
ADL5610, ADL5611	30 MHz to 6 GHz RF/IG gain block for high performance applications, providing a low noise figure of 2.2 dB with a very high OIP3 of more than 38 dBm simultaneously, which delivers a high dynamic range.
ADL5544, ADL5545	Single-ended RF/IF gain block amplifier for low power applications that provides broadband operation from 30 MHz to 6 GHz. Provides over 34 dBm of OIP3 using only 55 mA from a 5 V supply.
Low Noise Amplifiers	
ADL5523, ADL5521	400 MHz to 4000 MHz low noise GaAs pHEMT amplifier providing high gain and low noise figure for single downconversion IF sampling receiver architectures as well as direct downconversion receivers.
Power Detector	
ADL5501	50 MHz to 6 GHz TruPwr™ detector for true power measurement of simple and complex waveforms. The device is particularly useful for measuring high crest factor (high peak-to-rms ratio) signals, such as CDMA-, CDMA2000-, W-CDMA-, and QPSK-/QAM-based OFDM waveforms.
PLLs	
ADF5355	Wideband synthesizer with integrated VCO has a fundamental output frequency ranging from 3.5 GHz to 7 GHz, and divide-by-1/-2/-4/-8/-16/-32/-64 circuits allow the user to generate RF output frequencies as low as 55 MHz.
ADF4351, ADF4355-2	Wideband synthesizer with integrated VCOs has fractional-N or integer-N phase-locked loop (PLL) frequency synthesizers if used with an external loop filter and external reference frequency.
HMC703	8 GHz fractional-N PLL with sweeper, dc to 8 GHz RF input, exhibits the best phase noise and spurious performance in the industry enabling higher order modulation schemes while minimizing blocker effects in high performance radios.
Wideband Mixer	
HMC170	2.5 GHz to 4 GHz mixer can handle larger signal levels than most active mixers due to the high third-order intercept. MMIC implementation provides exceptional balance in the circuit, resulting in high LO/RF and LO/IF isolations and unit-to-unit consistency.

Online Tools And Resources

Visit the Wideband RF Signal Processing Resource Website at
www.analog.com/widebandrf

You'll find resources and technical information relating to every stage of your wideband RF signal chain design journey:

- Technical articles
- Webcasts
- Videos
- Product information
- Support resources
- And more …

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