TI's latest high-speed ADC "winning combo" for defense radar applications

Prepared for BAE Systems

September 2014

Reliable technologies, long-term commitment.

Key parameters: Defense radar designs

Analog to digital converter (ADCs)

- Higher sample rate → higher signal bandwidth → more range resolution (dR~c/(2*BW)
- Highest possible SNR for bandwidth required enables higher object discrimination
- SDR of 90dBc or better (16b), 65dBc or better (12b, >1GHz signal BW)
- Multi-channel ADCs if system is designed as a phased array or active scanning element array (ASEA)

IF digital variable gain amplifier (DVGA)

- Multi-channel solutions for driving multi-channel ADCs
- Low noise with gain range to enable higher system dynamic range
- Higher linearity – greater than 35dB OIP3 at typical ADC IFs (150 – 350 MHz)

LO synthesizer (PLL/VCO)

- Low phase noise, both close in (10KHz) and far out (20MHz)
- Low spur count and energy
- Multiple outputs for driving multiple mixers on RX and TX elements

Transmit digital to analog converter (DACs)

- >70 dBc SFDR across TX bandwidth for pure chirp / pulse generation
- >500MHz of signal bandwidth
- Multi-DAC and multi-chip synchronization for element-to-element phase control

Clocking

- <100 fs additive jitter for clocking receive ADCs
- Fine analog delay adjustments to support JESD data converters
- Multiple outputs for clocking ADCs, DACs, FPGA/DRE and providing RF references from one source

Power

- High PSRR, especially at 1MHz to filter out DC/DC switching noise
- Low output noise to decrease size of spurs in sensitive RF components

ADC12J4000 family

Single, 12-bit, 4.0/2.7/1.6 GSPS JESD204B ADCs

Why were these parts developed?

The ADC12J4000 devices were developed to provide the widest bandwidth sampling capabilities with low power, high speed serialized data output rates and integrated signal processing (DDC), all of which provide design flexibility that can reduce design time and cost.

What makes these parts unique?

The ADC12J4000 is the fastest 12b ADC on the market. This device provides >3.0GHz of input bandwidth, frequency conversion, filtering, and sample rate down conversion in one device. The ADC12J4000 and speed variants utilize the JESD204B serial interface, which can output data on 1 to 8 lanes depending on the decimation and link output rate settings.

ADC12J4000/J2700/J1600 (& LM15851)

Single, 12-bit, 4.0/2.7/1.6 GSPS JESD204B ADC

Samples available

Features

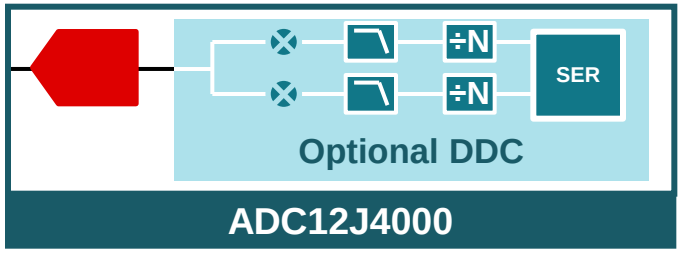
- Buffered input
- Power (1.2/1.9V supplies) at 4 GSPS
  - With DDC: 2W
  - Bypass DDC: 1.8W
- Noise floor: -149 dBFS/Hz
- IMD3 (2.1 GHz, -13dBFS ea): -64 dBc
- JESD204B (DX)
  - Supports Subclass 1
  - Up to 8 lanes at 10 Gbps (max)
- DDC (digital down-converter)
  - Complex decimation: 4/8/10/16/20/32x stop-band suppression: 80 dBc @ 80%
  - NCO frequency resolution: 32-bit
- Package: 68-pin QFN

Benefits

- Optional DDC greatly reduces output data rate, simplifying receiver requirements, reducing FPGA gates
- Excellent performance beyond 3 GHz allows RF-sampling for 3G/4G BTS and other applications, saving size, weight, and power and greatly increasing flexibility
- JESD204B interface minimizes output lanes, simplifies system, enables deterministic latency across multiple lanes and multiple chips
- Low power dissipation and small package reduce system size and complexity

Applications

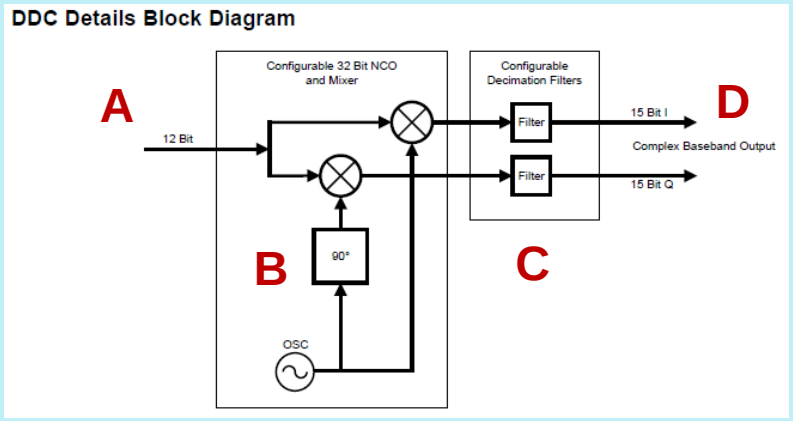
- Wideband communications, 3G/4G receive and DPD
- Military radar, communications, EW and SIGINT
- Test & measurement, data acquisition, spectrum analyzer



Part Number	Sampling Rate	Power	DDC
ADC12J4000	4Gsps	2.0W	Optional
ADC12J2700	2.7Gsps	1.8W	Optional
ADC12J1600	1.6Gsps	1.6W	Optional
*LM15851	4GSPS	2.0W	Required

**Does not require US export license*

Why the digital down converter (DDC)?



A

- 12-bit digital word comes from the ADC after sampling, assume with digitized RF carriers at a digital IF (intermediate frequency)

B

- 32-bit NCO (numerically controlled oscillator) is similar to an analog LO (local oscillator) analog frequency mixing
- Complex down-converting digital mixer is used to shift the carriers, usually to baseband (0 Hz), with the NCO as the 'LO'

C

- Configurable decimation filters reduce the sample rate, depending on the bandwidth of carriers wanted at baseband
- Processing is > 12-bits to preserve processing gains

D

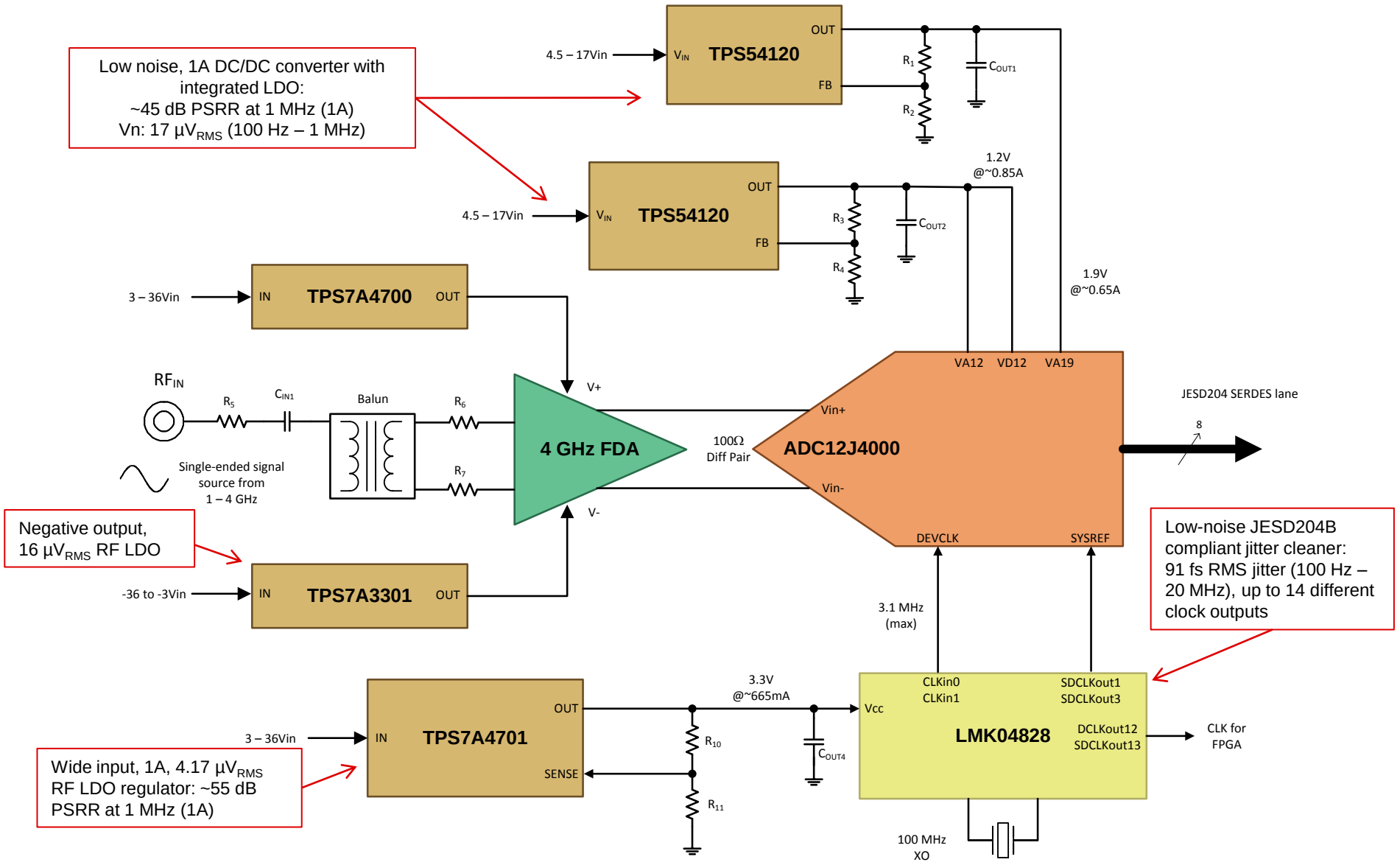
- 15-bit I and Q (complex) data is sent to the JESD204B serialization block for output to the FPGA/ASIC

ADC12J4000 versus current ADC12Dxx00RF

Key Product Improvements

1	>7 dB distortion improvement	Increased performance margin
2	60-70% power reduction	Lower power than IF/ZIF-sampling solutions
3	JESD204B outputs	Simplified interface to FPGA/ASIC/DSP
4	Integrated digital processing	Minimize output data rate
5	Smaller, standard plastic pkg	Smaller size, easier to design board
6	Background calibration	Maintain performance over temperature

Radar “winning combo”: Block diagram



Benefits of TI's radar "winning combo"

- ADC12J4000 allows for direct sampling in the L-band (1-2GHz)
  - Nearest known competitor is sampling at 1.5 GSPS (@ 12-bits)
  - ADC12J4000 EVM tool and ADC12J4000EVM GUI available for evaluation today
- JESD204B interface decreases the overall board size
- Full clocking solution for JESD204B decreases clocking complexity of this interface to an FPGA
- TI clocking solution provides low jitter for maximum ADC SNR performance
  - LMK04828: 88 fs RMS jitter (12 kHz – 20 MHz)
  - Highest-performing clocking solution available today for JESD204B interfaces
  - Higher SNR enables higher object discrimination
- Low output noise voltage and high PSRR from TPS54120 and TPS7A4701 ensure smaller spurs and higher ADC performance
  - TPS54120: Vn: 17 µVRMS at 100 Hz – 1 MHz, PSRR: 45 dB at 1 MHz
  - Ideal for space constrained, power conscious, low noise applications

Additional tools & resources

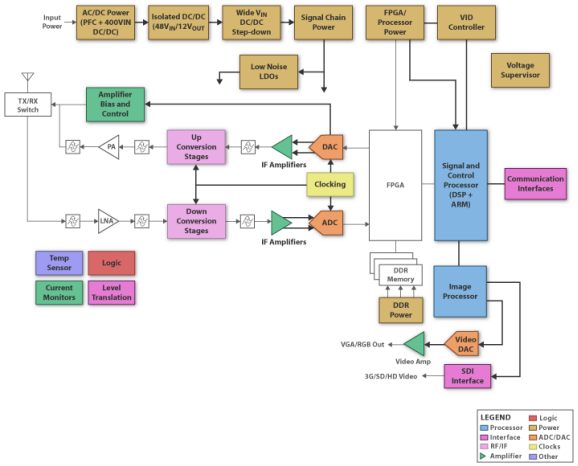
Product Info:

- Product folder: ADC12J4000
- Support (E2E): High speed converters forum
- Evaluation modules: ADC12J4000EVM
- Evaluation software: ADC12J4000EVM GUI

TIDesigns

Additional resources:

- TSW14J56EVM JESD204B capture/generator card
- JESD204B data converters and clocking information
- Radar/electronic warfare SBD information
- High speed data converter pro software



Thank you! For questions or sample/tool requests, please contact:

Leslie Cramer
TI account lead for BAE Systems
lcramer@ti.com
908-626-8719

Reliable technologies, long-term commitment.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265