Conquering Your Electronic Countermeasures and Surveillance Design Challenges

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Agenda

- Overview of Electronic Countermeasures, Protection and Surveillance Systems
- RF Tuners & Analog Downconverters
  - 2-18 GHz Implementation Example
- ADI Power Amplifiers
  - Complement to Upconverter Signal Chains
  - GaN & HPA Solutions
- Digitizing the Spectrum
  - Converter Implementation Examples
- Questions & Answers

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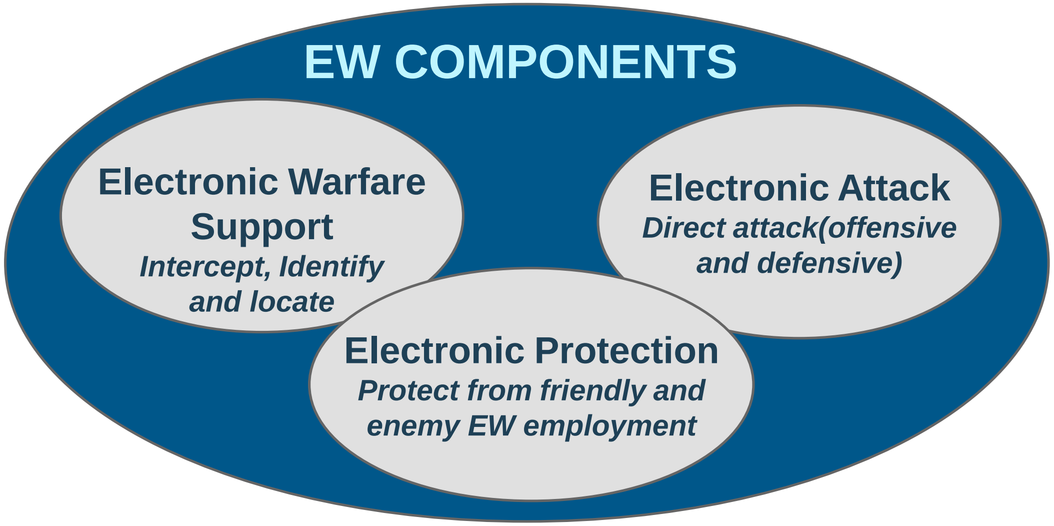
EW Overview

EW Components



- EA is the component of EW involving the use of electromagnetic, directed energy, or anti-radiation weapons to attack personnel, facilities, or equipment with the intent of degrading, neutralizing, or destroying enemy combat capability
- EP includes the actions taken to protect personnel, facilities, and equipment from any EW employment that may degrade, neutralize, or destroy friendly combat capability
- ES responds to taskings to search for, intercept, identify, and locate sources of intentional and unintentional radiated electromagnetic energy for the purpose of threat recognition

SIGINT Systems

- Signals intelligence (SigInt) is the general term which refers to intelligence gathering or intercepting signals.
- Systems normally include
  - surveillance – to scan and detect signals in the EM spectrum
  - Recording of signals for later processing
  - Real-time demodulation and decoding

ELINT & COMINT

ELINT – Electronic Intelligence

- Typical Specifications
  - Surveillance from 2-18 GHz (sometimes as low as 500 MHz & upwards of 30 GHz)
  - Single or multiple antenna feeds
  - Instantaneous BW of 500 MHz or higher
  - Airborne and Naval applications

- COMINT - Communications Intelligence
  - Historically this was focused on battlefield and diplomatic communications
    - The interception of tactical radios – i.e. military communications & radios
      - Frequency hopping, encrypted transmissions
    - Satellite transmissions between countries

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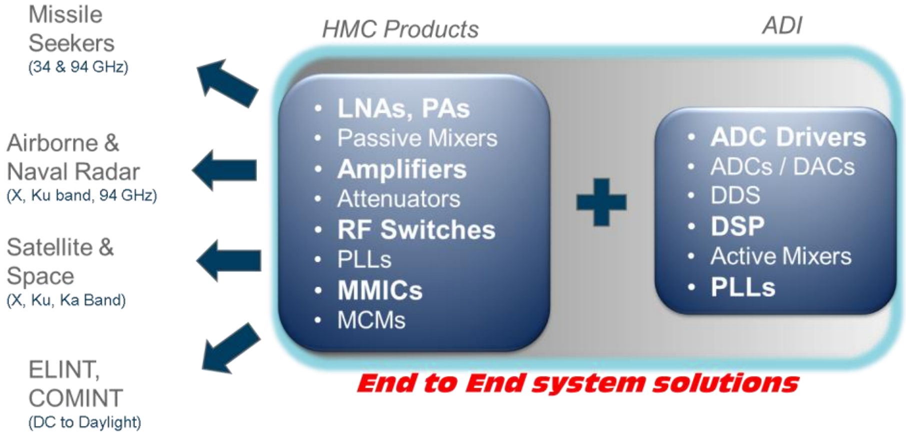
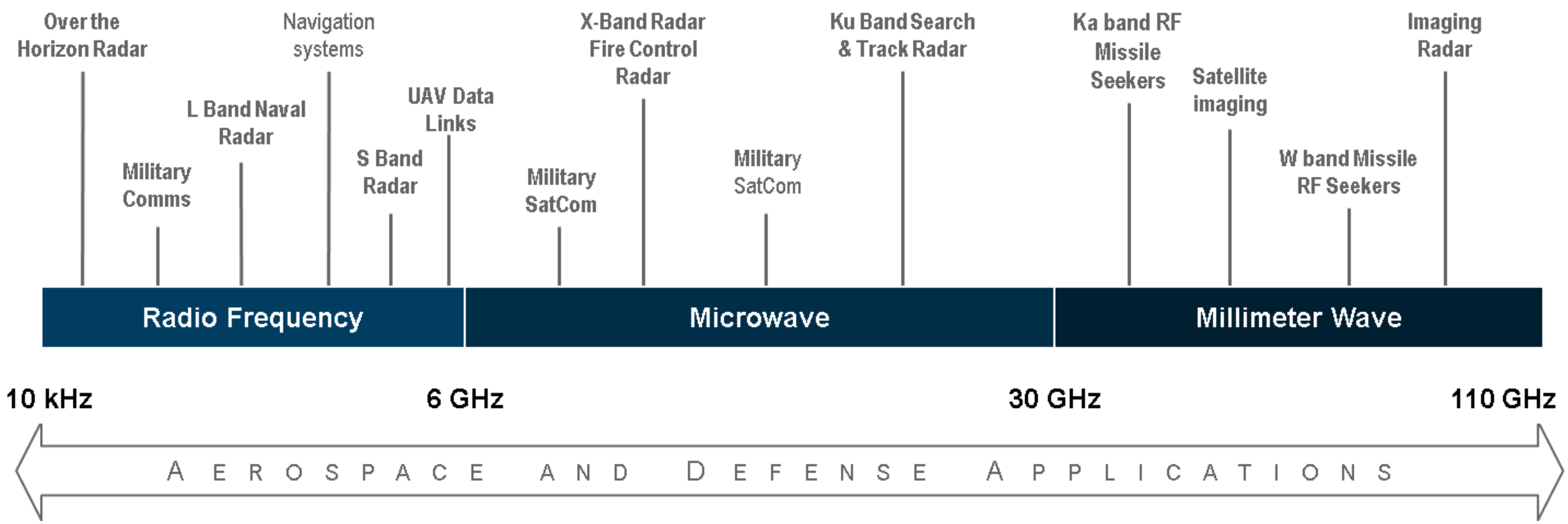
Aerospace and Defense Spectrum Usage

Complete Solutions for the Entire Spectrum





Device Technology Reducing SWaP in ISR

Increased Silicon Integation
- SiGe & CMOS developments support mutli-function integration -> RF Chain integration
- Digital & analog Functions
- RF Transceivers

Reduced Process Geometries
- 65 nm CMOS
- Reduces Power
- Enables increased Digital Integration

Reduced SWaP

Wider BW devices
- Reduces component count to cover same surveillance BW
- 2-18GHz mixers provide single solution for ELINT
- 50 MHz to 14 GHz PLL+VCO solutions

Digital Signal Processing
- Relaxes analog needs & increases integration
    - DPD, QEC correction, Digital Accelerator cores

Novel Architectures
- Reduces component count & increases sensitivity
    - CTSD converters for SIGINT

ADI ISR Solutions

High Performance Building Blocks

High Speed Converters
- High linearity CMOS GSPS converters for maximum sensitivity
- Best in Class IF Converters for SigInt

RF Transceivers
- RF to bits integrated solutions
- Lowest SWaP solutions

RF / uWave
- Wideband GaAs & SiGe devices reduce component count
- Mixers, PLLs, VCOs,

GaN PAs
- Wideband Efficient PA & LNA solutions

Leading Edge Technology to Support Customer Developed Solution

ISR Reference Solutions

Std Example / Prototyping Platforms
- FMC Mixed signal solutions combined with FPGA eval cards

Custom Designs
- Customized reference designs for specific applications. RF to bits & DF examples

ADI technology and System Knowledge to Reduce Time to Market

Integrated Modules & Sub-Assemblies

Solid State HPAs
- Advanced Power Combining
- Up to 32 kW X-Band Solutions

RF / uWave Tuners
- Highly integrated customized form factor solutions
- Best in class Synthesizers
- L to Ka Solutions

Digital Transceivers
- Mixed Signal & FPGA based solutions
- Low Latency Signal Processing

Integrated Solutions to Support COTs / customized COTs development

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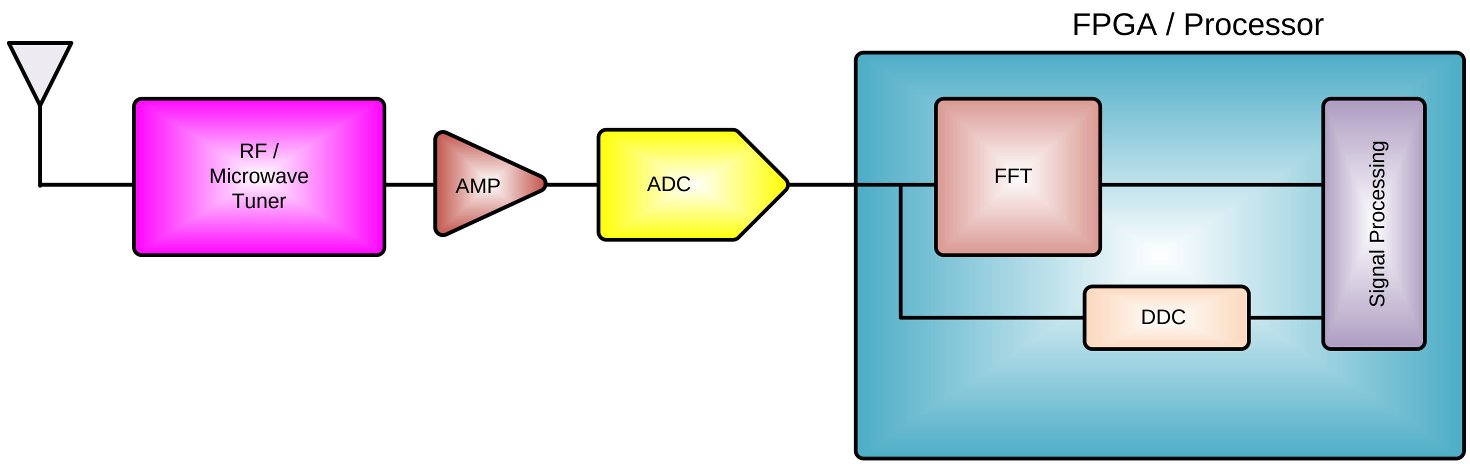
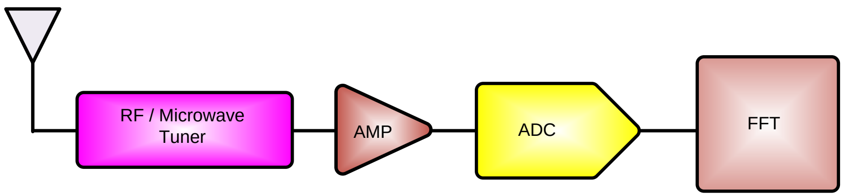
Basic Electronic Surveillance Architecture



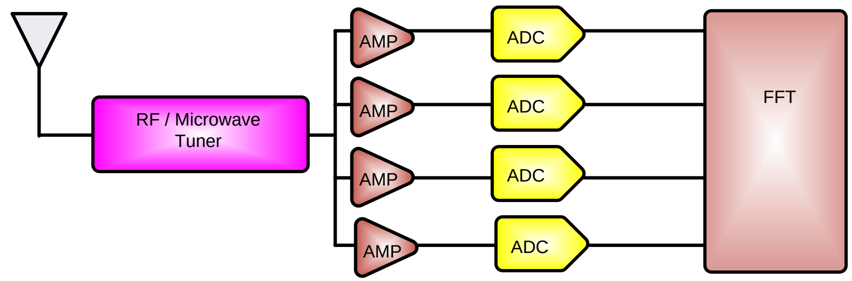
- Classical Surveillance Systems
  - RF / Microwave Tuner
  - Digitizer, the ADC with associated amplifier & buffer
  - Fast Fourier Transform and Digital Signal Processing
- Continuous trend to digitize closer to the Antenna
- EA Systems require RF DACs and Analog Upconverters

ISR System Architectures

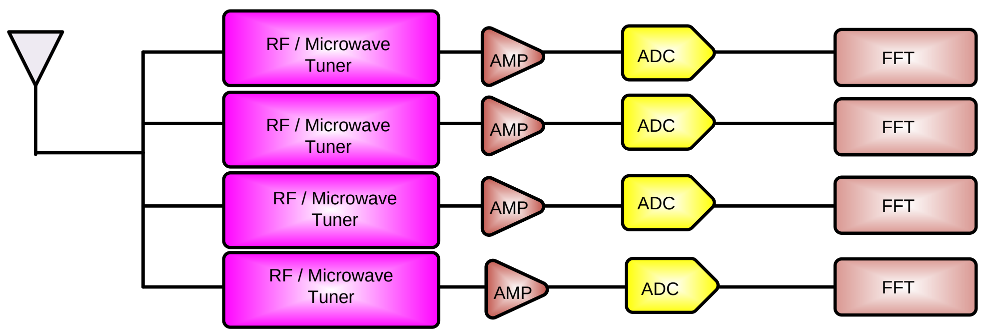
Trading Off Performance, Size & Cost



A) Single RF Tuner & Digitizer per Antenna



B) Single RF Tuner with Interleaved ADCs (interleaving of 4 shown)

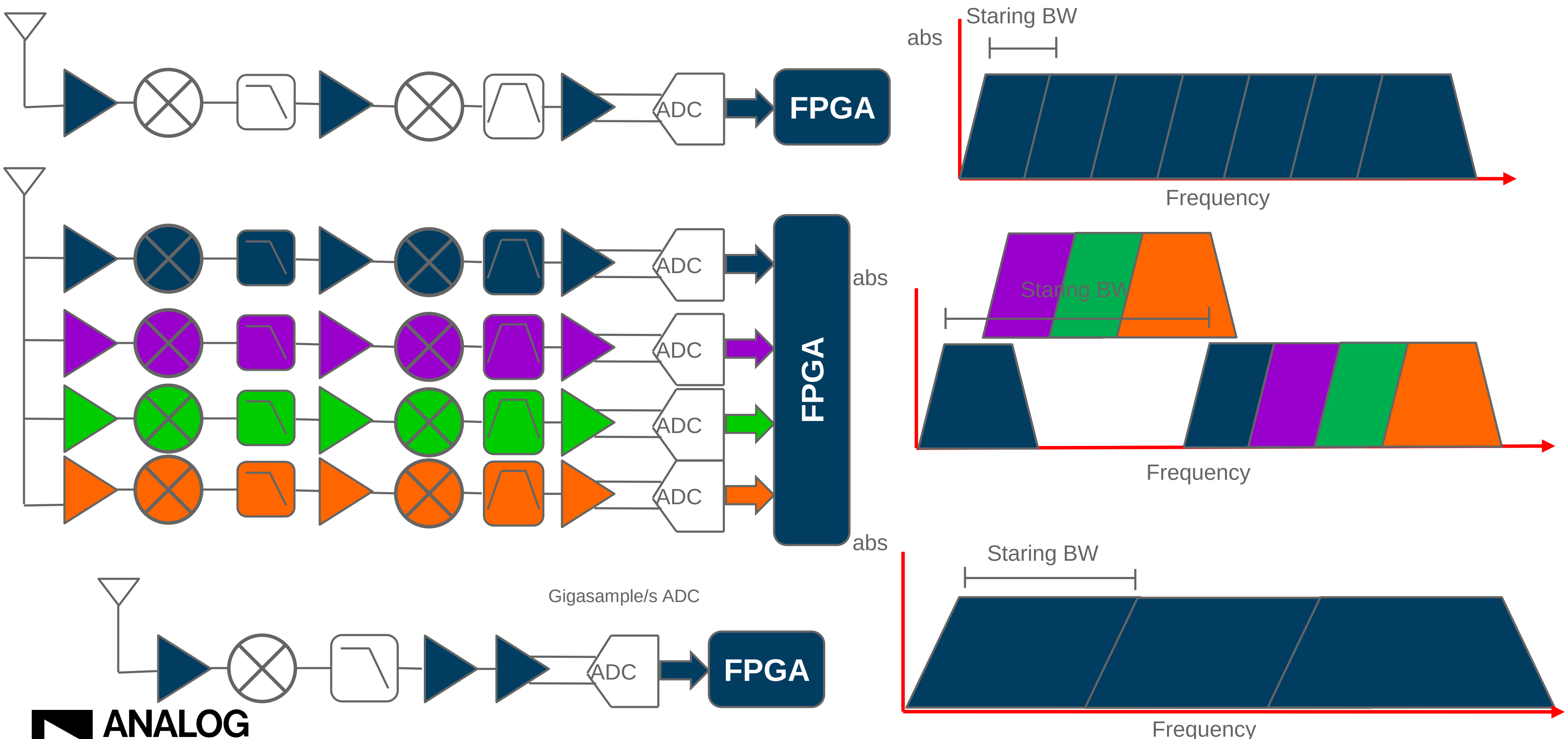


C) Antenna Feed partitioned between multiple sets of RF tuners and Digitizers

- More ADCs & tuners minimizes blocking effects & maximizes system sensitivity but at the expense of cost!

What is Instantaneous / Staring BW?

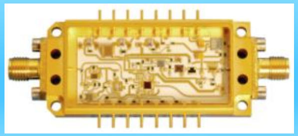
- Instantaneous BW is the BW that is observable by the system at any instant in time
  - Determined by the Nyquist band of the converter and the filtering of the RF Tuner
  - BW can be increased by using multiple channels with overlapping frequency bands
  - BW can also be increased by using higher speed ADC
- The faster you can survey the EM spectrum the more than can be seen and identified – consider agile signals!

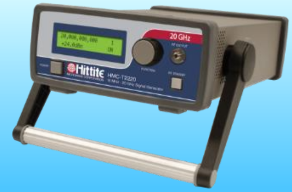


Example Module and Subsystems

Frequency Synthesizers

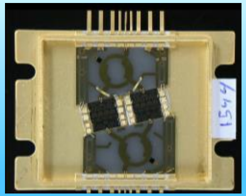
- Extremely low phase noise
- Fast hopping speed
- Direct and VCO-based architectures
- Commercial, Military and Space

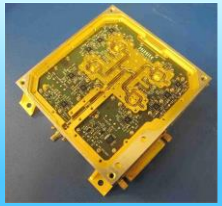




Wideband Power Amplifiers

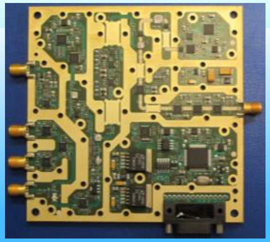
- GaAs and GaN based
- 10MHz-40GHz applications
- Pulsed and CW power
- 10W to 32kW power levels
- Integrated power supplies, monitoring, and protection





RF Frequency Converters

- DC-110 GHz capabilities
- Full RF to bits and back MMIC portfolio
- Low noise/ wide dynamic range



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RF Tuners & Analog Downconverters

2-18 GHZ EXAMPLES

Antenna Interface Converter Circuitry - Introduction

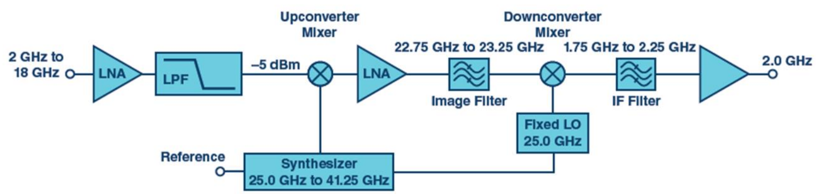
System Challenges

- Increased Spectral Density
- Intentional & Unintentional Blocking
- Reduced SWaP+C
- Increased Sensitivity

Receiver Design Goals

- Increased Dynamic Range
- Wider Instantaneous Bandwidth

Optimum Receiver Architecture



RF Converter topology
- Upconvert to low mmWave IF
- Filter
- Downconvert to Lower IF

Up-Down Converter topology Benefits
- Reduces filter banks
- Potentially only single Band Pass Filter Required
- Significantly reduces Size & Cost
- New Microwave Devices Provide Off the Shelf Solutions
- Flexible Frequency Planning
- Lowest Spurious Performance

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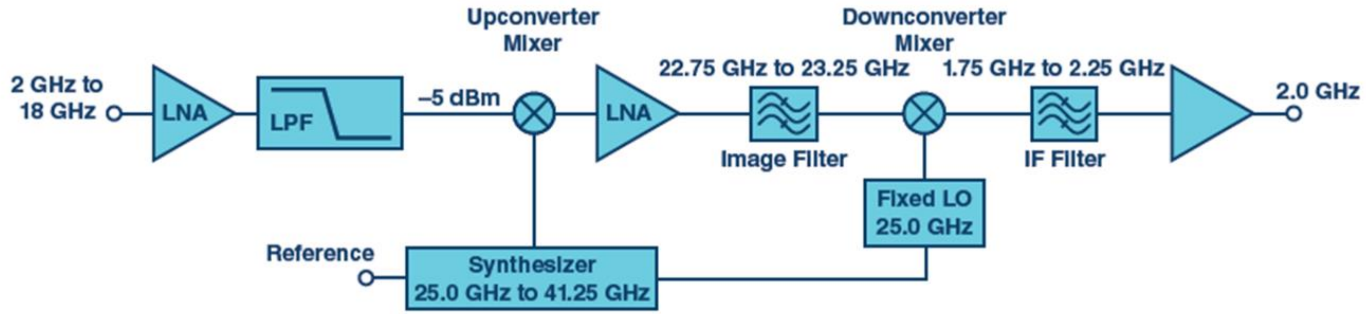
Minimum Filtering Converter Architecture with Spur Analysis

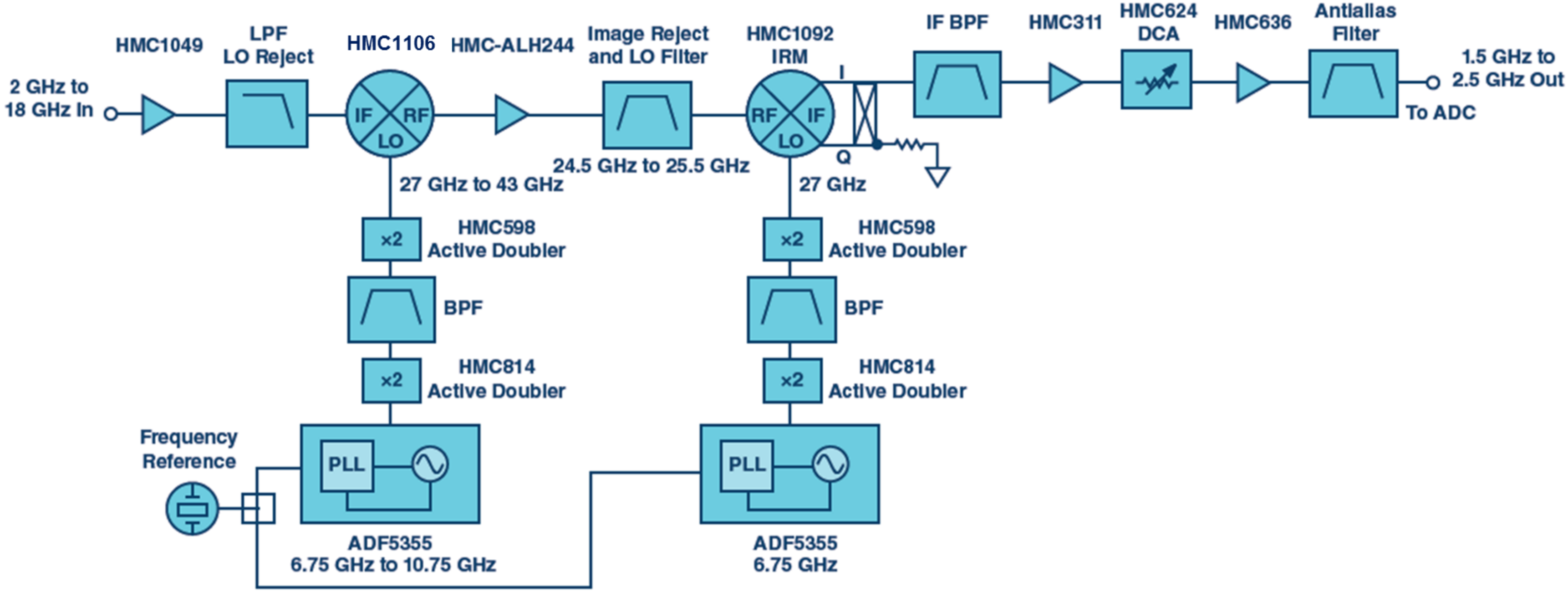


mxRF	nxLO	dBc	Ent-LO(GHz)	Ex-LO(GHz)	Ent-RF(GHz)	Ex-RF(GHz)	Ent-IF(GHz)	Ex-IF(GHz)
-1	1	0.02	25.00	41.25	22.00	24.00	2.00	18.00
2	0	**-59.34**	25.00	41.25	22.00	24.00	11.00	12.00
-2	1	**-56.58**	26.00	41.25	22.00	24.00	2.00	9.63
-2	2	**-59.34**	25.00	30.00	22.00	24.00	13.00	18.00
3	-1	**-67.91**	25.00	32.00	22.00	24.00	15.67	18.00
-3	1	**-67.91**	28.00	41.25	22.00	24.00	2.00	6.42
-3	2	**-79.08**	25.00	39.00	22.00	24.00	8.67	18.00
-3	3	**-58.37**	25.00	26.00	22.00	24.00	17.00	18.00

Minimum Filtering Topology Advantages

- Single bandpass filter does all the image filtering.
- All RxnL spurs are above band, allows excellent performance to be achieved with almost no filtering.
- Bulky bandpass filter reduction elimination allows dramatic reductions in size and weight.
- Architecture is applicable to the multichannel and/or interleaved receiver schemes previously described.
- Higher dynamic range performance can be achieved by including simple preselectors in front of this tuner.

Minimal Filtering Example Using ADI Parts



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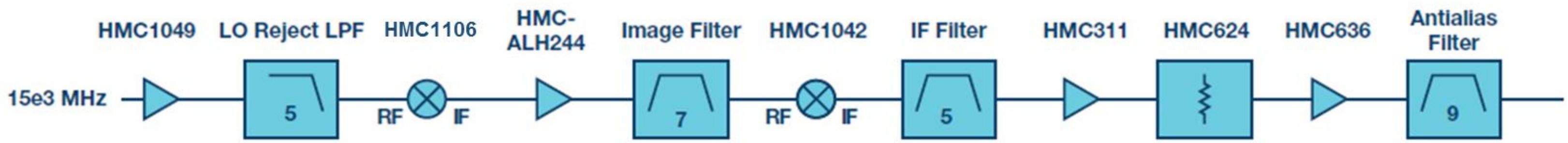
Predicted Chain Performance



	HMC1049	LO Reject LPF	HMC1106	HMC-ALH244	Image Filter	HMC1042	IF Filter	HMC311	HMC624	HMC636	Antialias Filter	Total
		Chebyshev Fc: 20e3 Gain: –1.01 Rip: 0.01	RF: 15e3 LO: 40e3 IF: 25e3 NF: 8.00 Gain: –8.00		Chebyshev Fo: 25000 BW: 1000 Gain: –5 Rip: 0.01	RF: 25e3 LO: 27e3 IF: 2e3 NF: 11 Gain: –11	Chebyshev Fo: 2000 BW: 3000 Gain: –1 Rip: 0.01				Chebyshev Fo: 2000 BW: 1000 Gain: –2 Rip: 0.01	
NF (dB)	2.50			3.00				4.50	6.00	2.00		7.28
Gain (dB)	14.00			12.00				15.00	–6.00	13.00		19.99
OIP3 (dBm)	24.00			24.00				28.00	49.00	38.00		21.13

Input Pwr (dBm)	–20.00	System Temp (K)	290.00	IM Offset (MHz)	0.025
OIP2 (dBm)	33.11	OIP3 (dBm)	21.13	Output P1dB (dBm)	14.10
IIP2 (dBm)	13.12	IIP3 (dBm)	1.14	Input P1dB (dBm)	–4.90
OIM2 (dBm)	–33.13	OIM3 (dBm)	–42.29	Compressed (dB)	0.00
ORR2 (dB)	33.12	ORR3 (dB)	42.28	Gain, Actual (dB)	19.99
IRR2 (dB)	16.56	IRR3 (dB)	14.09	Inp Backoff (dBm)	0.00
SFDR2 (dB)	49.91	SFDR3 (dB)	58.55	Gain, Linear (dB)	19.99

Typical Predicted RT Performance			
Gain	NF (dB)	OIP3 (dBm)	OP1dB (dBm)
20 dB	7.5 dB	21 dBm	14 dBm

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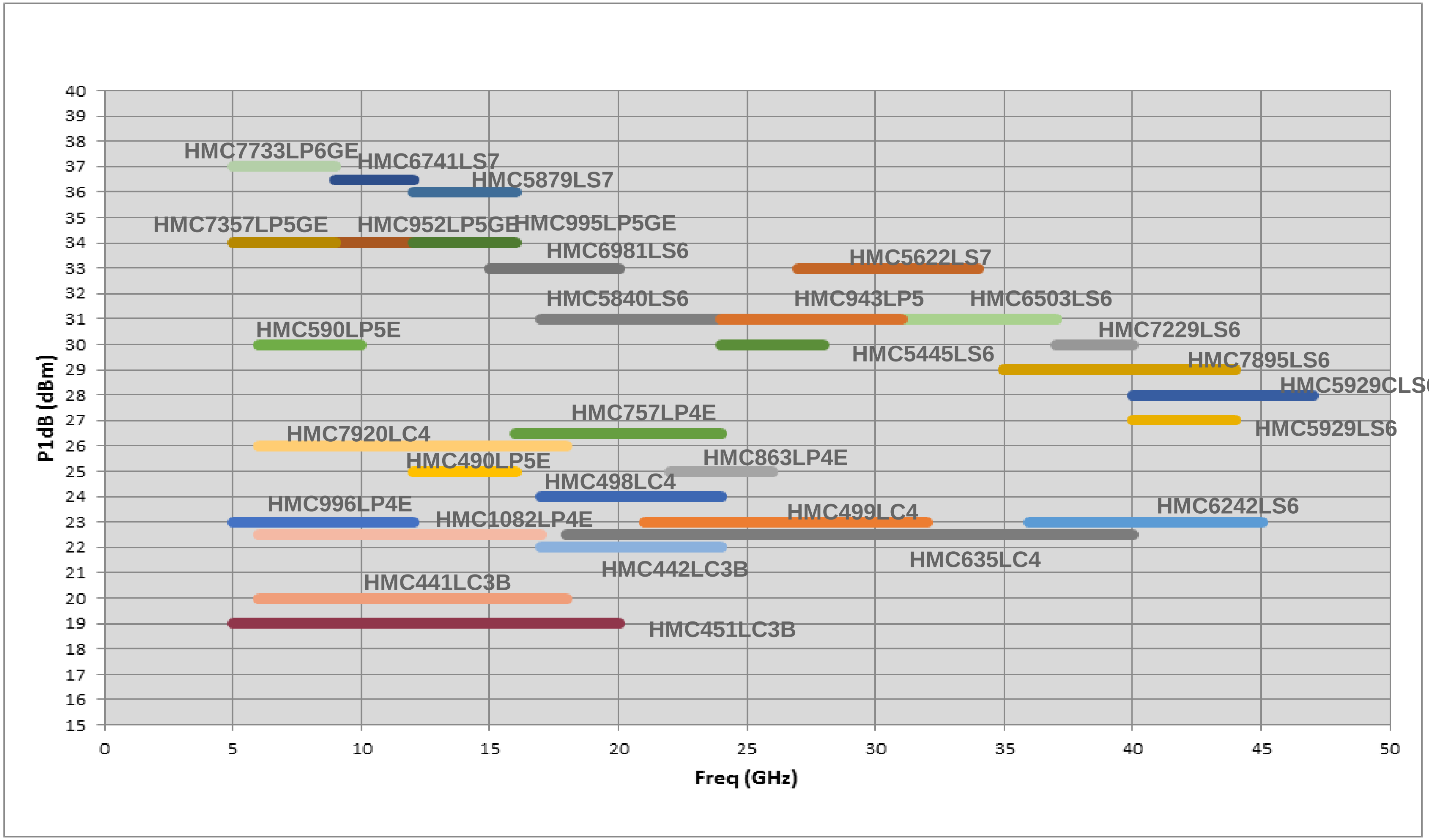
RF Converter Summary Points

- Excellent block conversion performance to complement ADIhigh performance ADCs is achievable using very simple techniques.
- Consideration to the actual signal environment and system needs is important in order to provide the best compromise between cost, complexity, and performance.
- Many parameters associated with broadband converters such as tuning speed, step size, phase coherence, phase noise, etc., are a function of the synthesizer architecture and are beyond the scope of this paper. **Please contact us to discuss your specific requirements as we have solutions for most system operational requirements.**
  - There is a strong tradeoff space between LO complexity and cost that is related to system performance needs. Careful analysis of requirements is always advised to avoid over specifying.
- We have shown the simplest synthesizer implementation in the example which would be appropriate for most surveillance missions that do not require high speed tuning. We can provide many other synthesizer solutions that will work with the basic conversion architecture.
- Coherent Upconversion is also possible with this architecture by simply reversing the direction of the signal chain path and making other slight modifications to the block diagram.

ADI Power Amplifiers

COMPLEMENT TO UPCONVERTER SIGNAL CHAINS

ADI Driver / Power Driver & Power Amplifiers for Defense Applications



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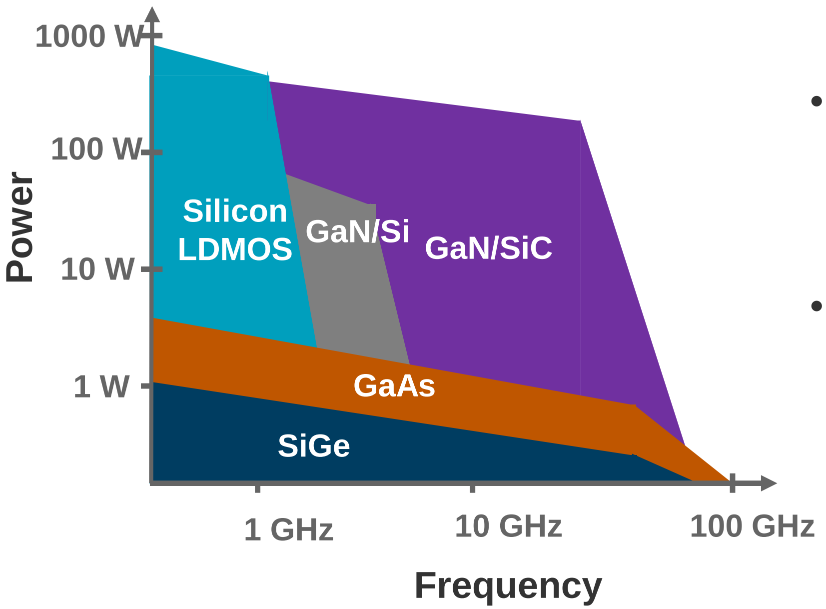
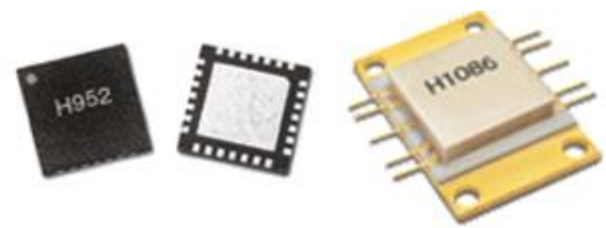
High Power Amplifiers & GaN

GaN



- Critical Next Generation EW Technology
  - Systems Migrating from Silicon & GaAs to GaN
  - Increased Power Efficiency
- ADI technology supports GaN Power Amplifier devices up to 25W and from L to Ku band



Solid State

- ► High power amplifiers for TWT replacements
  - ▪ Upto 8 kW Solid-state Broadband Power Amplifiers
  - ▪ X-band (8-11 GHz)
  - ▪ Compact & Efficient

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Example HPA : HMC8114 6 to 18 GHz 100 W GaN

► OVERVIEW

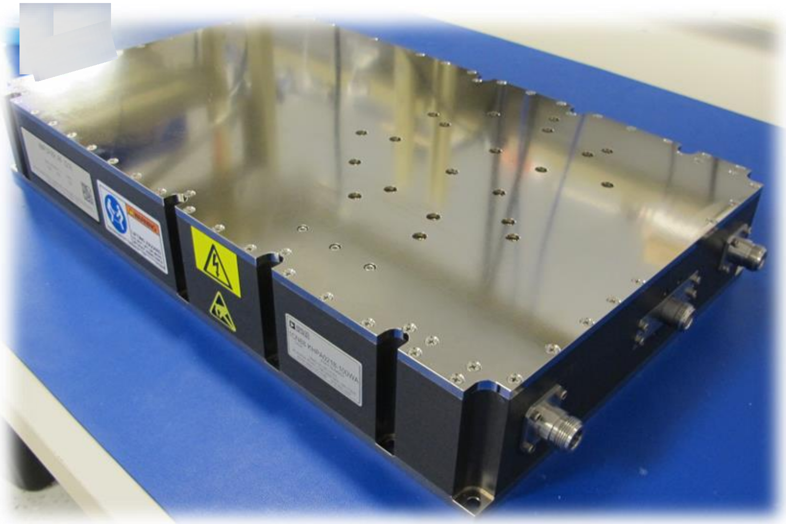
- Broadband GaN HPA
- Utilizes ADI GaN MMICs
- Same foot print as ADI 2 to 18 GHz, 100 W HPA
- Available as rack mounted housing
- Built in Chelmsford MA

► TECHNICAL

- Adjustable small signal gain
- Forward and reflected RF power sample ports
- PA enable function
- +48 V_{DC} prime power input
- -20°C to 64°C operating temperature

► SPECIFICATIONS

- 6 to 18 GHz
- 51.5 dBm typical saturated output power
- 68 dB typical small signal gain



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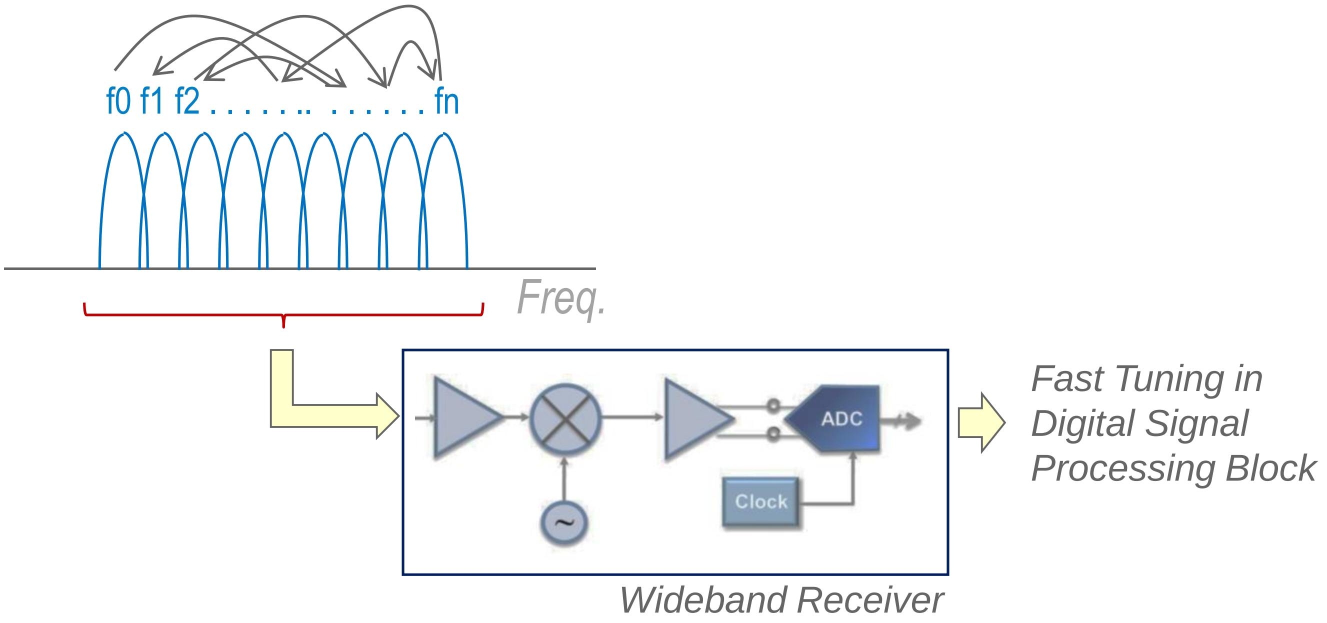
Digitizing the Spectrum

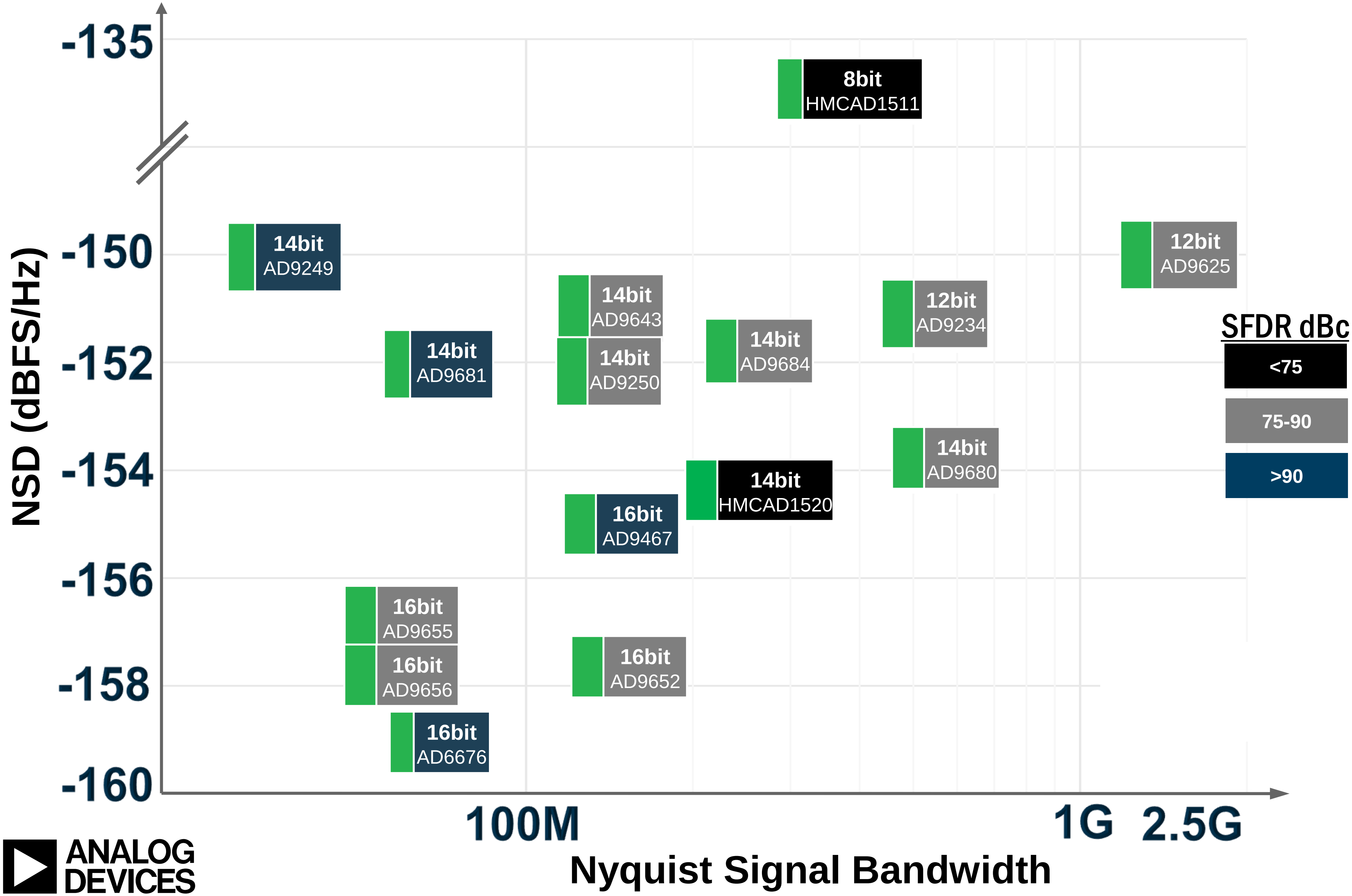
Electronic Surveillance Needs for Wideband Digitizers

- Because of the need to intercept radar systems that are agile frequencies across a wideband, an ECM must have **wideband** frequency measurement capacity.
- It also needs either a very fast-tuning narrowband receiver to sweep the hopping range, or a very **wideband receiver** that can cover the entire hopping range.



Critical Component: The Wideband ADC

ADC PERFORMANCE DRIVEN & FLEXIBLE SIGNAL PROCESSING



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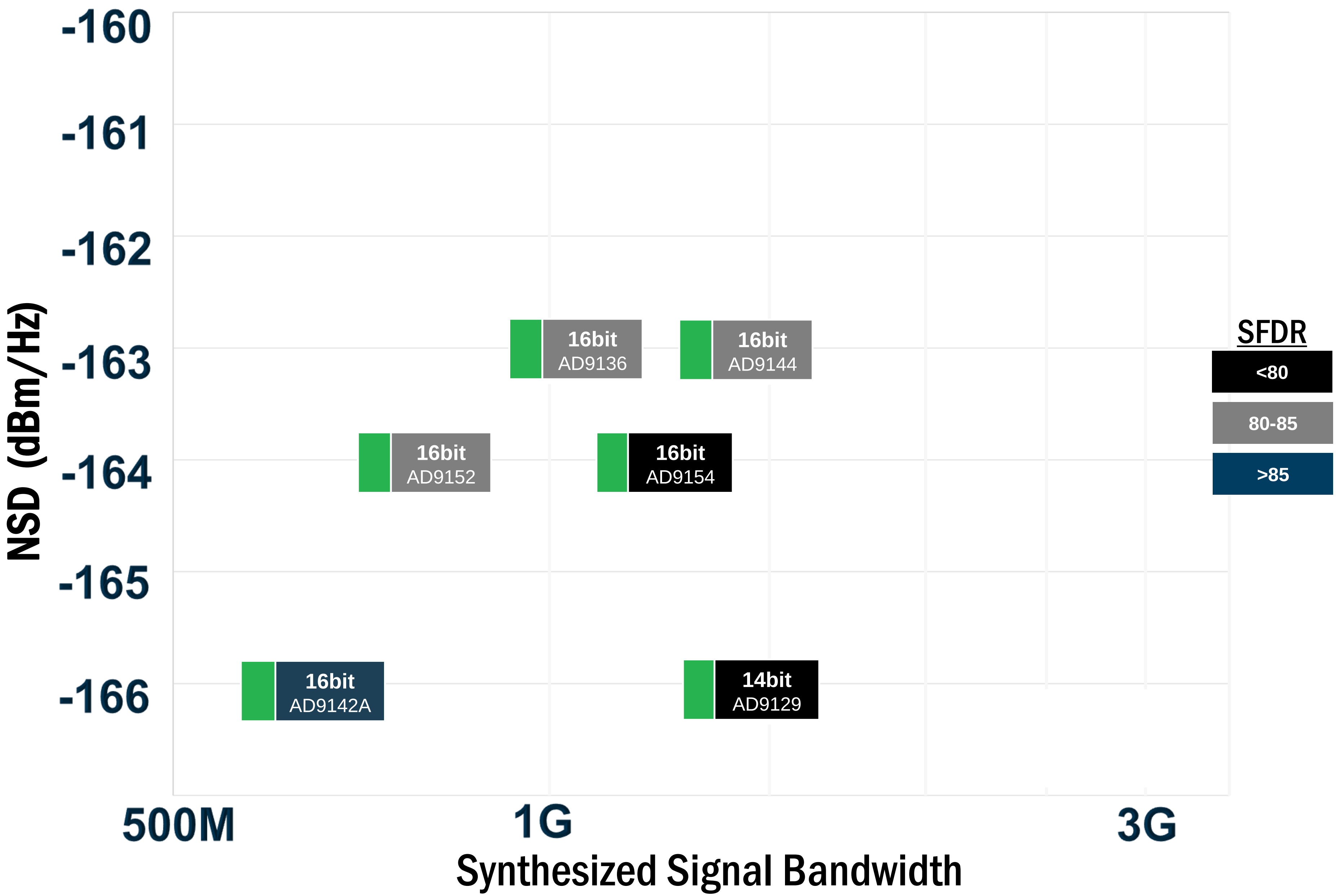
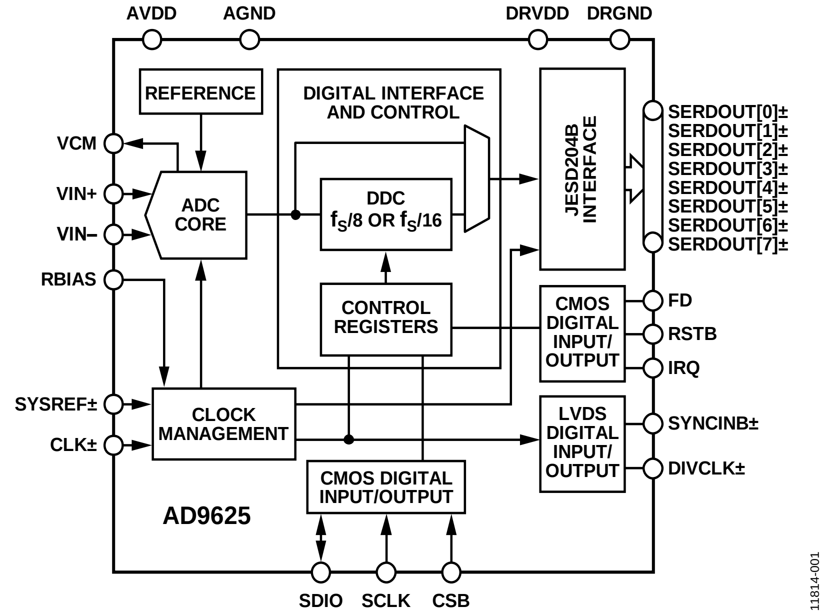
DAC PERFORMANCE DRIVEN & FLEXIBLE SIGNAL PROCESSING



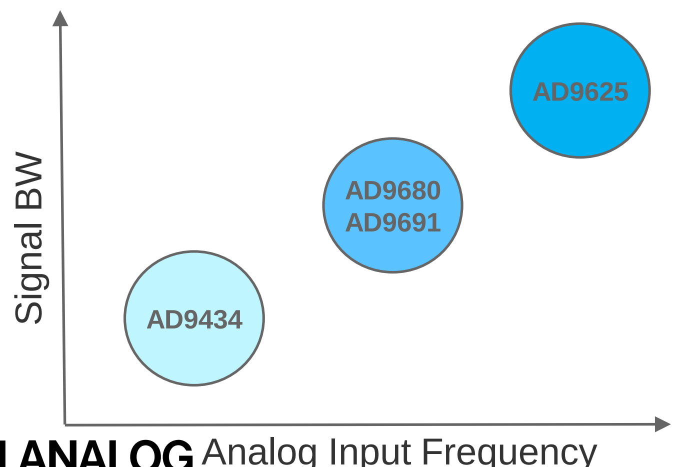
AD9625: 12b 2.5/2.6GSPS JESD204B ADC

Value Proposition

- Acquisition of wideband signals (1.25GHz) at high analog input frequencies (up to 2.5GHz)
- High dynamic range and superior noise performance with wideband and flexible frequency planning
- Integrated digital down converters enabling center frequency placement, decimation and out of band filtering



Product Positioning



Key Benefits

- Direct RF sampling
- JESD204B outputs for ease of routing and low pin-count
- Superior SFDR (-77dBC) at 1.8GHz
- Amplitude detection for efficient AGC implementation
- Internal Digital Down Conversion for lower output data
- Wideband signal acquisition for array applications

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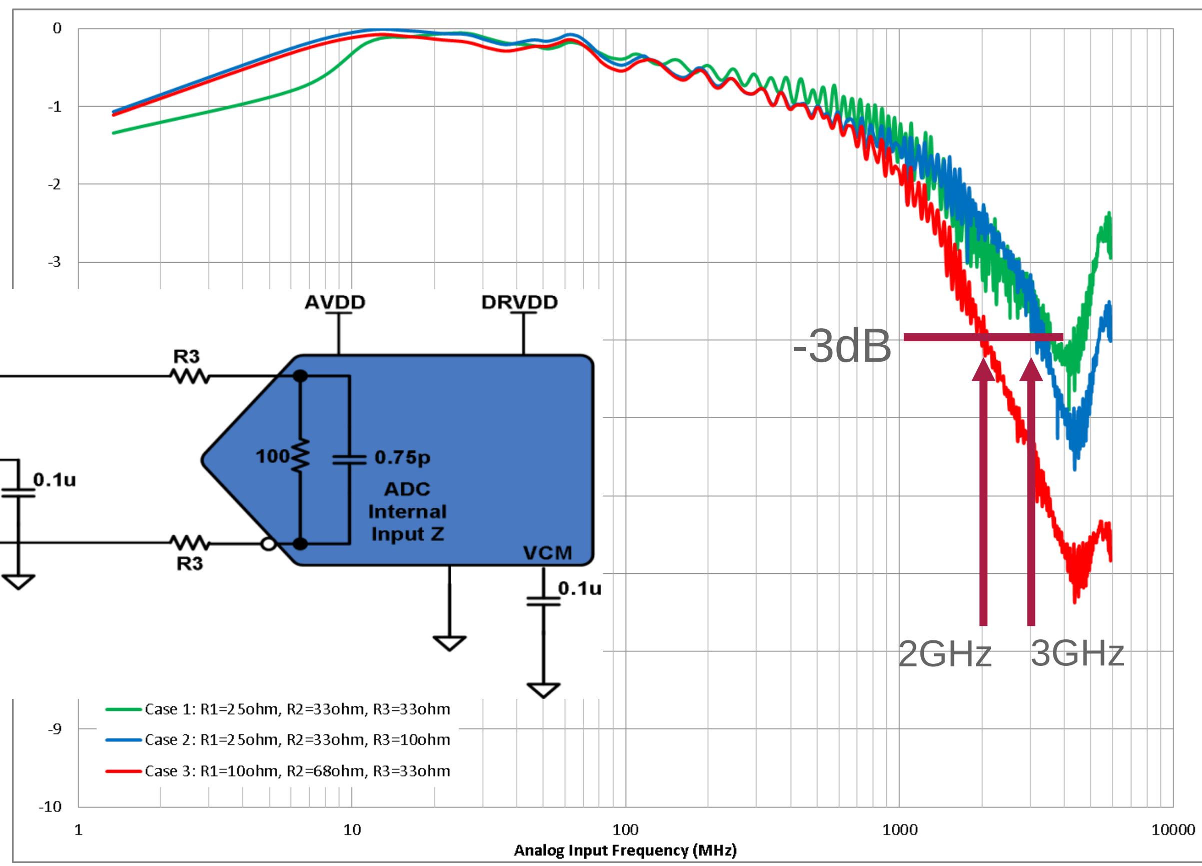
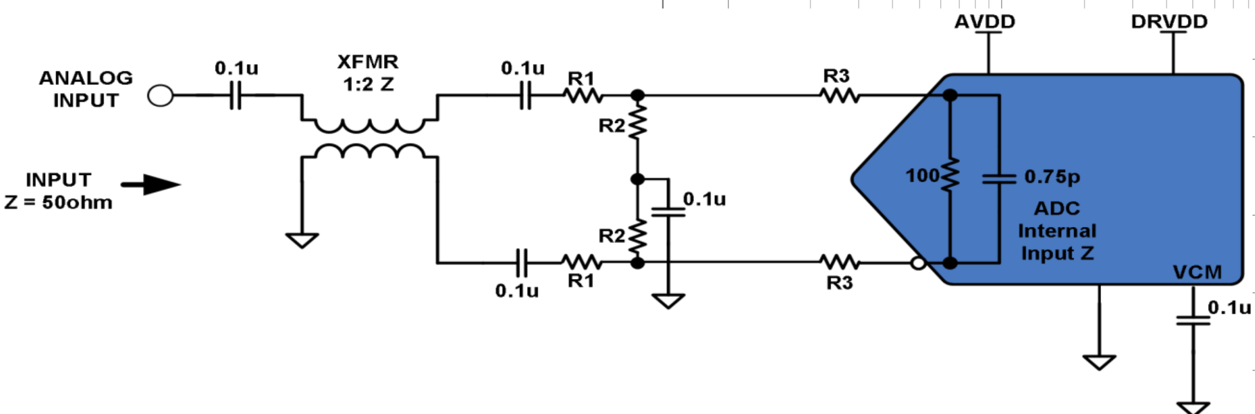
Wideband Solutions for the AD9625

Enabling maximum Bandwidth

Performance Specs	Case 1 – R1=25Ω, R2=33Ω, R3=33Ω	Case 2 – R1=25 Ω, R2=33 Ω, R3=10 Ω	Case 3 – R1=10 Ω, R2=68 Ω, R3=33Ω
Bandwidth (-3dB)	3169 MHz	3169 MHz	1996 MHz
Pass-Band Flatness (2GHz Ripple)	2.34 dB	2.01 dB	3.07 dB
SNRFS @ 1000 MHz	58.3 dBFS	58.0 dBFS	58.2 dBFS
SFDR @ 1000 MHz	74.5 dBc	74.0 dBc	77.5 dBc
H2/H3 @ 1000 MHz	-74.5 dBc/-83.1 dBc	-77.0 dBc/-74.0 dBc	-77.5 dBc/-85.6 dBc
Input Impedance @ 500MHz	46 Ohms	45.5 Ohms	44.4 Ohms
Input Drive @ 500 MHz	+15.0 dBm	+12.6dBm	+10.7dBm





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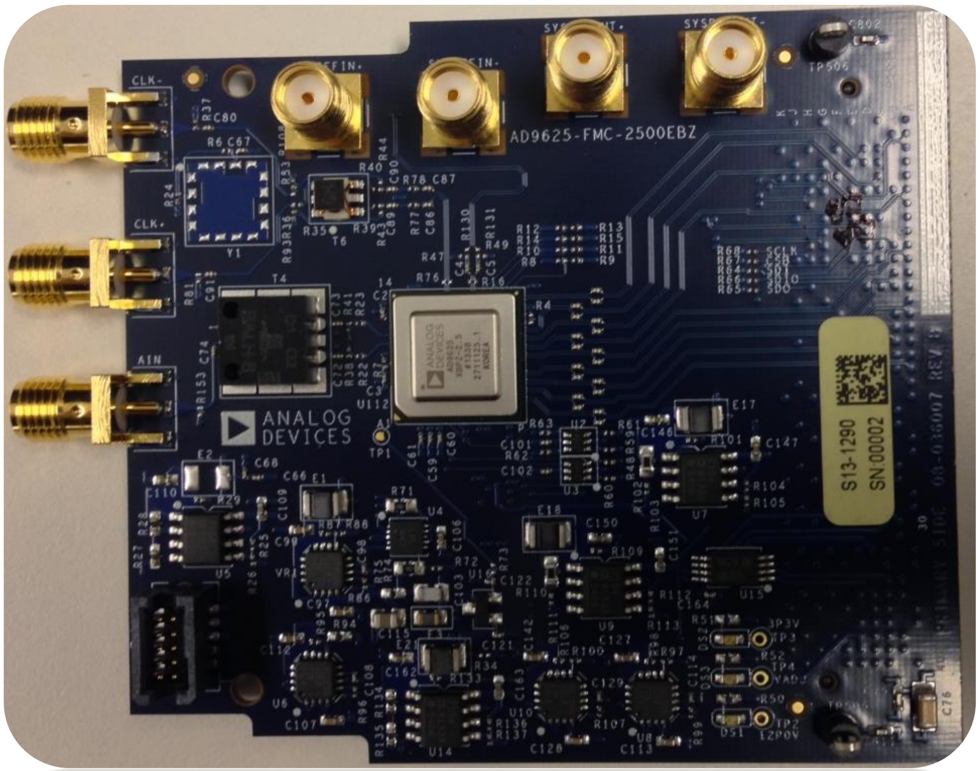
AD-FMCADC2-EBZ: Single AD9625 ADC, 12b, 2.5GSPS, w/ WB Balun Frontend



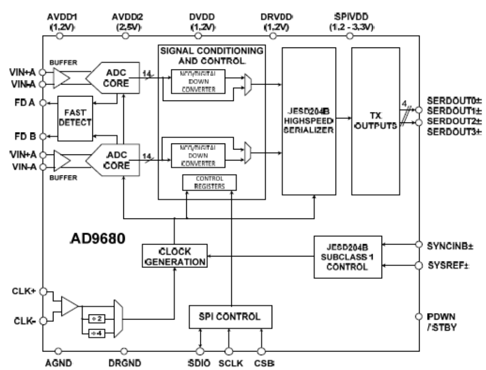
AD-FMCADC2-EBZ:

- Highest in class performance and sampling rate
- +70dB SFDR / 58dBFS SNR 12bit, 2500MSPS ADC
- on-board power supply, clock oscillator
- Synchronization support

Validated Multi-board Synchronization

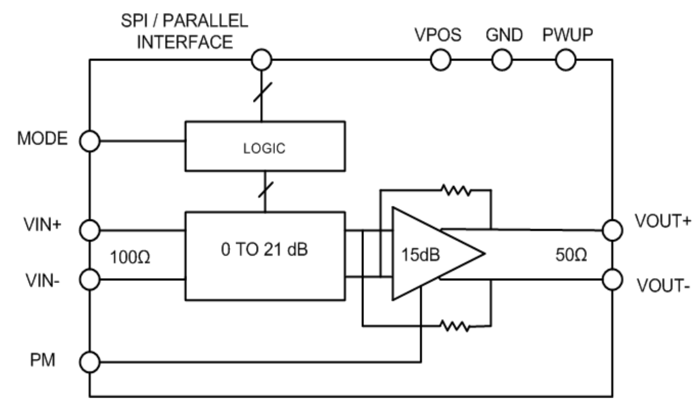
GSPS ADCs and Active Drivers Examples

AD9680
Dual 14-bit 1250MSPS ADC



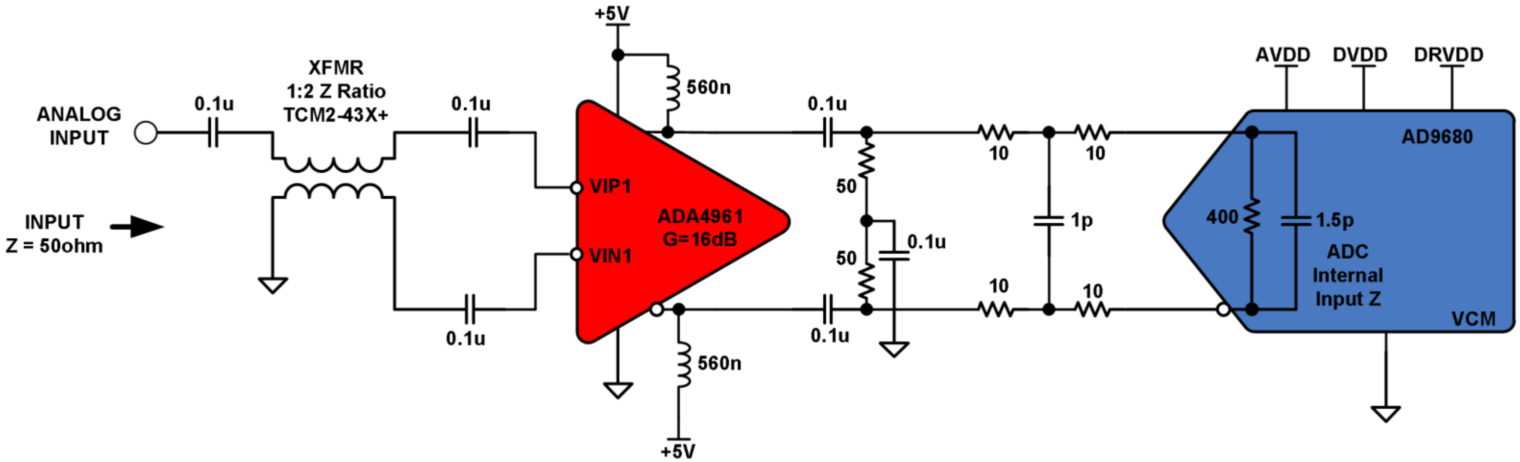
- JESD204B (subclass 1) serial digital outputs, 4 lanes
- 1.65W total power per channel at 1GSPS
- Noise Density = -154dBFs/Hz
- SFDR = 81 dBc at 340MHz Fin (1Gsps)
- SFDR = 78 dBc at 1000MHz Fin (1Gsps)
- ENOB = 10.9 bits
- +/-0.5 LSB DNL, +/-1.0 LSB INL
- 2GHz analog input bandwidth

ADA4961
DVGA for Driving GSPS ADCs

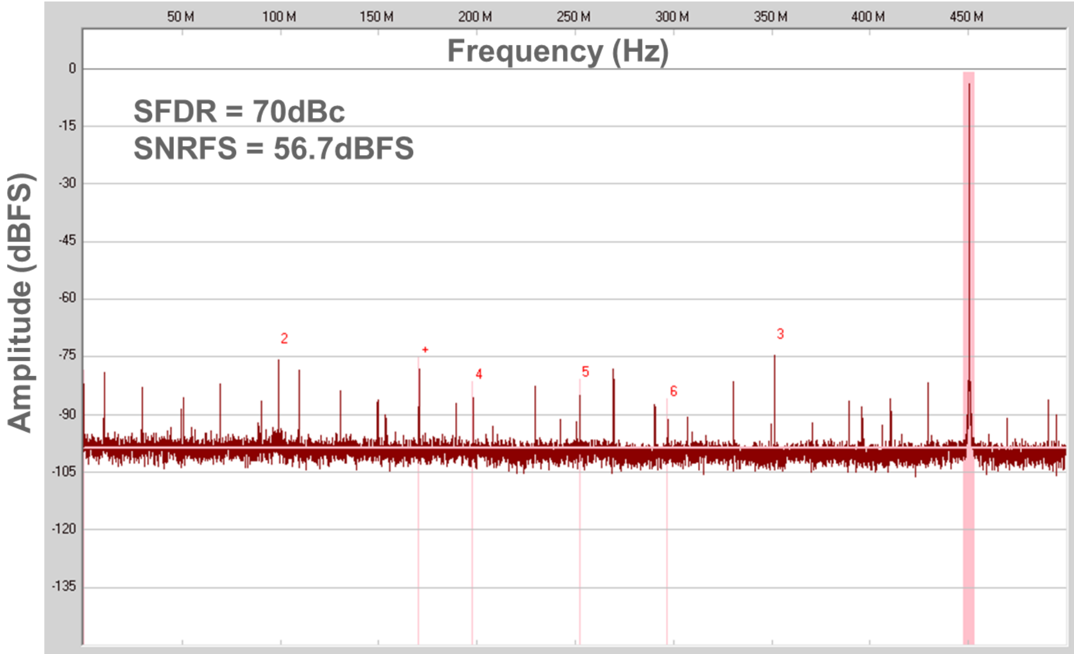


- Voltage gain range: −6 dB to +15 dB
- Power gain range: -3 dB to + 18 dB
- 5.8 dB noise figure at maximum gain
- RTO noise 7 nV/√Hz
- IMD3: -100 dB at 1 GHz (max gain)
- OIP3: 50 dBm at 1 GHz (max gain)
- −3 dB bandwidth of 25 MHz to 2.5 GHz
- Single 3.3 V to 5 V supply operation
- 150 mA supply current

Driving the AD9680 for Maximum BW & Performance



- *AD9680/9234 -1000MSPS Dual ADC, 14/12 bit Res, with JESD204B*
- *ADA4961 VGA / ADC Driver, MaxGain Applied*



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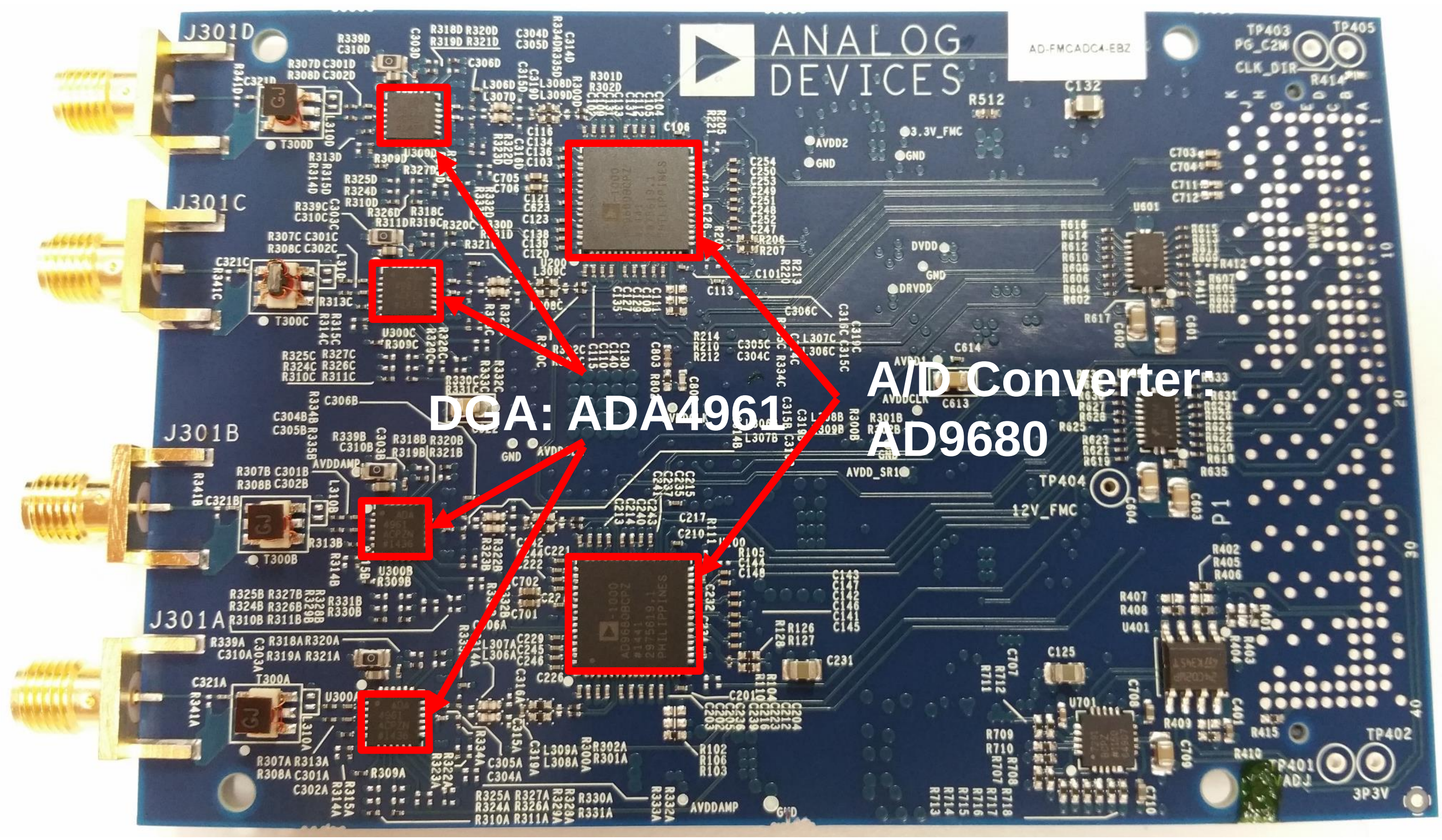
AD-FMCADC4-EBZ: Top Side View



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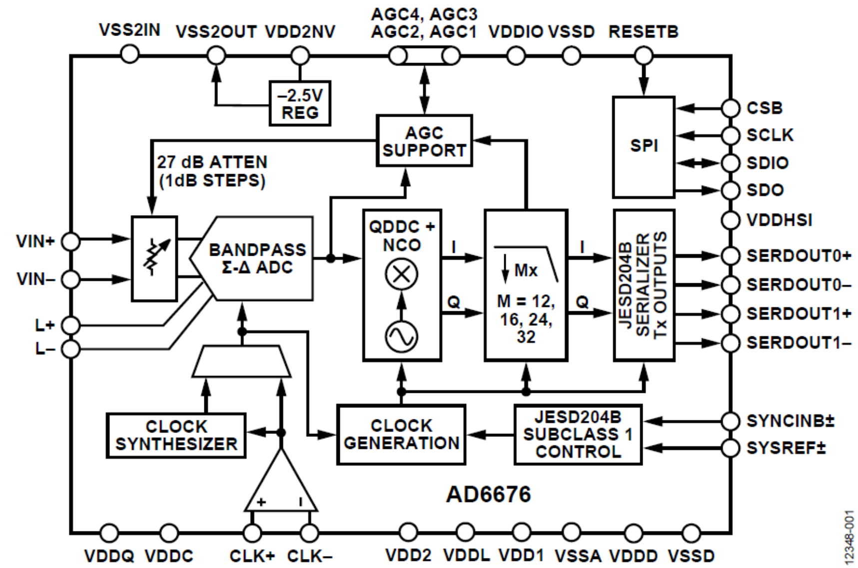
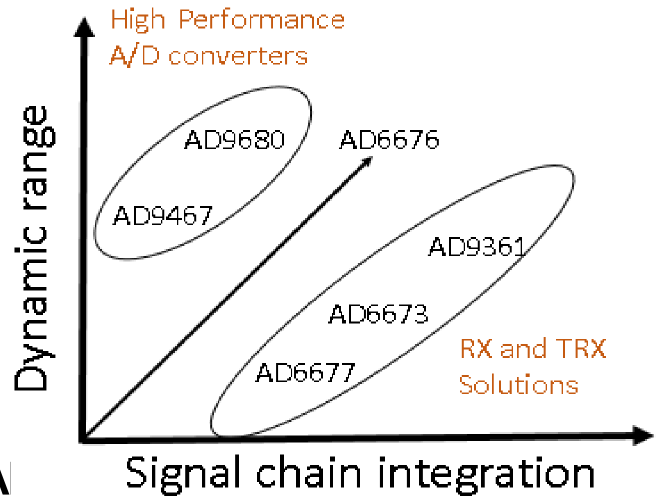
AD6676: Wideband IF Receiver Subsystem

Key Value Proposition

- Enables industry's highest dynamic range superheterodyne receiver designs
- Up to 70% reduction in PCB area because of the simple interface sufficient between the AD6676 and the upfront RF to IF mixer
- Significantly simplifies the IF planning of receiver designs, thanks to an on chip high performance 16-bit band-pass ΣΔ A/D converter that supports a very wide tunable IF



Product Positioning



Key Benefits

- Large AGC free Dynamic range (DR)
  - Allows a receiver to set a high AGC threshold which leads to reduced AGC switching activity, improving the radio performance
  - Reduces the requirement for higher order analog RF/IF filtering for out of band blockers
- A very wide programmable bandwidth (BW) of 20-160MHz
  - Allows receiver designs to tradeoff BW for DR
  - Allows switching between different IF/BW configurations within 1μs to observe a wide/narrow BW at different IF frequencies.
- Alias rejection greater than 50dB
  - An easy to drive resistive input and inherent alias rejection removes the need for SAW filter, DGA and IF gain blocks.

A DEVICES

AHEAD OF WHAT'S POSSIBLE™

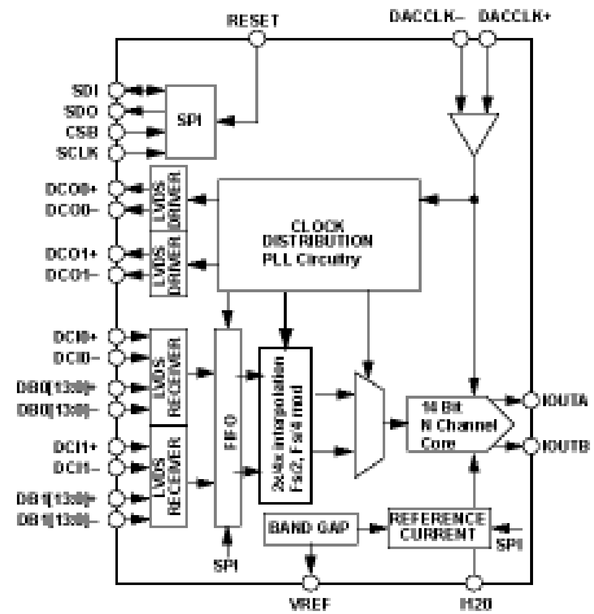
AD9129, AD9119
TxDAC+® with MixMode™ Direct RF Synthesis

Key Features

- 14b/11b, 5.6 GSPS DAC update rate to support Direct RF synthesis
- 2x DDR interpolator
- Dual port source synchronous LVDS input
- MixMode™ allows 2nd & 3rd Nyquist Band Direct RF
- Current sinking DAC architecture
- Programmable full-scale output current
- Compatible interface to AD9739

ANALOG DEVICES
AHEAD OF WHAT'S POSSIBLE™

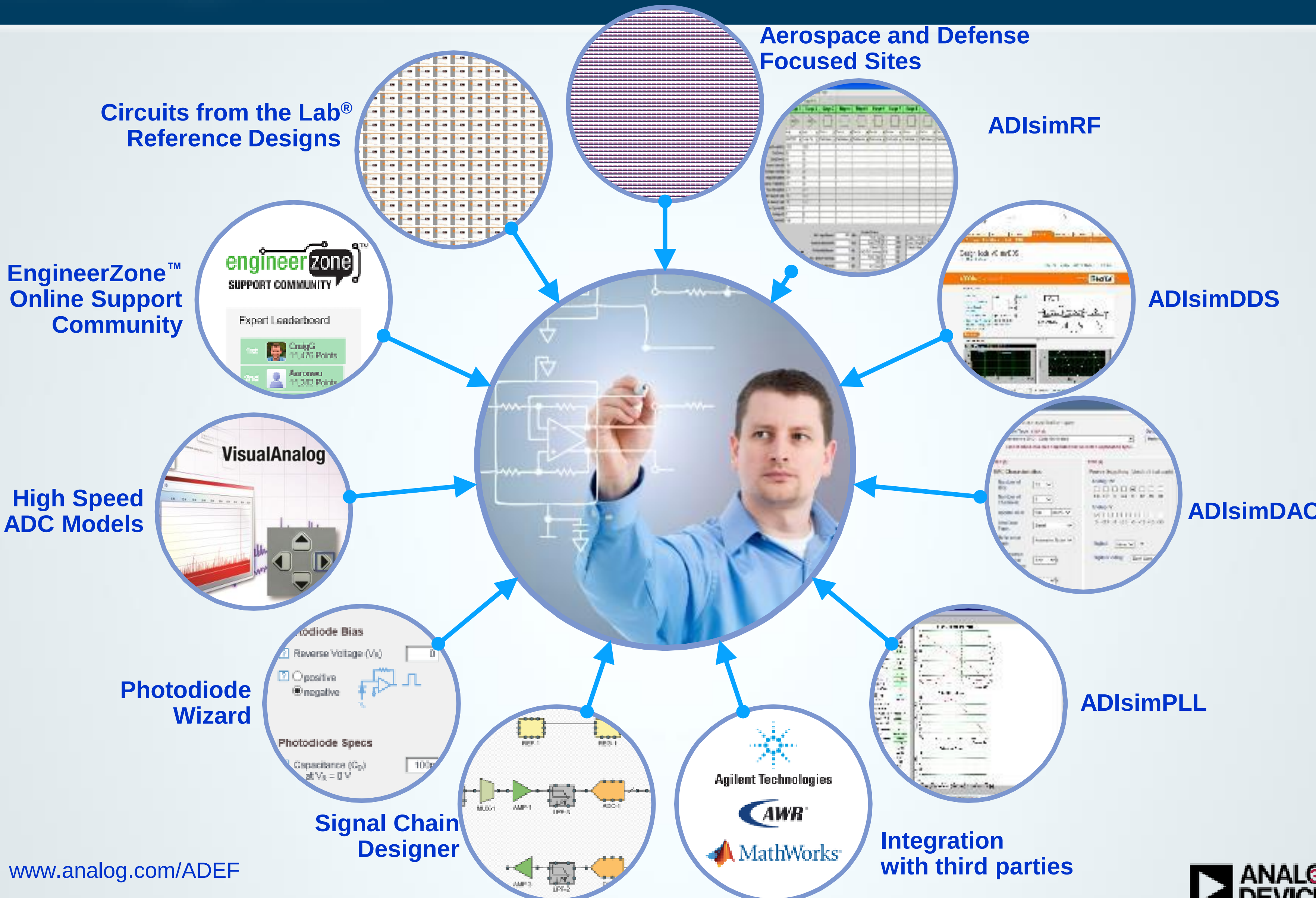
Key Benefits
Wide Bandwidth, On-Chip Interpolation & Coarse Modulation, Direct RF Synthesis



Temp	Package
-40°C to +85°C	160 ball 12x12mm Pb-Free CSP_BGA

Released

ADI Design Tools



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