ANALOG DEVICES
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Enabling 5G Networks Through High Capacity mmW Wireless Backhaul

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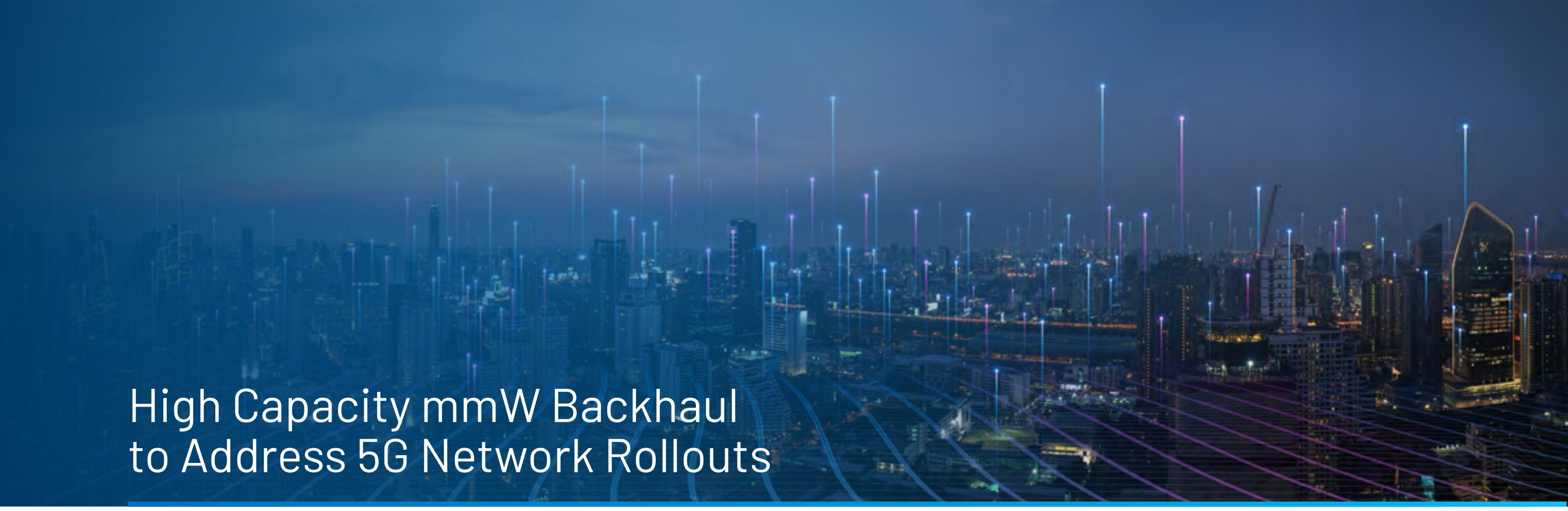


High Capacity mmW Backhaul to Address 5G Network Rollouts

Service providers are upgrading their networks from 4G to 5G and 5G mmW. The drivers are increased data consumption per individual user and the demand for higher speed connectivity. 5G provides an improved user experience and enables new residential and business use cases, but it also requires a higher data capacity backhaul network.

Rollout scenarios for 5G vary from dense urban environments to outlying or rural sites. Fiber optic cable is an attractive means to address high speed backhaul and many densely populated regions have fiber in place. But it is not ubiquitous and a second backhaul technology is required for successful deployment. In dense urban and rural environments, access to fiber for backhaul is not always available due to prohibitive installation costs or challenging topography. Developing and rural regions typically do not have fiber deployed, and they cannot benefit socially and economically from the advantages of 5G.

Fiber optic cable is an excellent solution but the capital cost to deploy is intensive and prohibitive in many situations. Fiber requires significant planning, so specialist contractors across multiple companies must be employed along with agreements between government, city planning, local residential, and special interest groups. The deployment in some locations can take several years and when time to deploy is critical this is unacceptable to the pace of societal demand for increased high speed connectivity.

Enter the wireless world of E-band, an extraordinary technology using 76 GHz/86 GHz portions of the frequency spectrum to deliver a high capacity over-the-air link that is far less capital intensive and extremely agile in site planning and deployment. Microwave backhaul has existed for many years, but E-band has higher capacity available due to wider channel bandwidths in the 76 GHz to 86 GHz spectrum.

Drivers to E-Band Backhaul Deployment in the Coming Years ...

- **High Capacity, Future Proof Technology**

  Delivering 10 Gbps link speed required for 5G mmW RAN backhaul.

- **Easily Add Capacity to Existing Microwave Backhaul Sites (Scalable)**

  Multiband solutions can be deployed, using existing microwave backhaul radios combined with new E-band radios to boost site link capacity for 5G without sacrificing availability.

- **Site Acquisition and Installation Can Be Far Less Intensive than Fiber**

  Fiber and E-band can each address their own use cases and work in tandem to deliver the best 5G experience. E-band is an excellent solution for dense urban areas where fiber to the building is not possible.

- **Where Fiber Optic Cable Doesn't Exist, E-Band Wireless Backhaul Takes Less Time to Deploy**

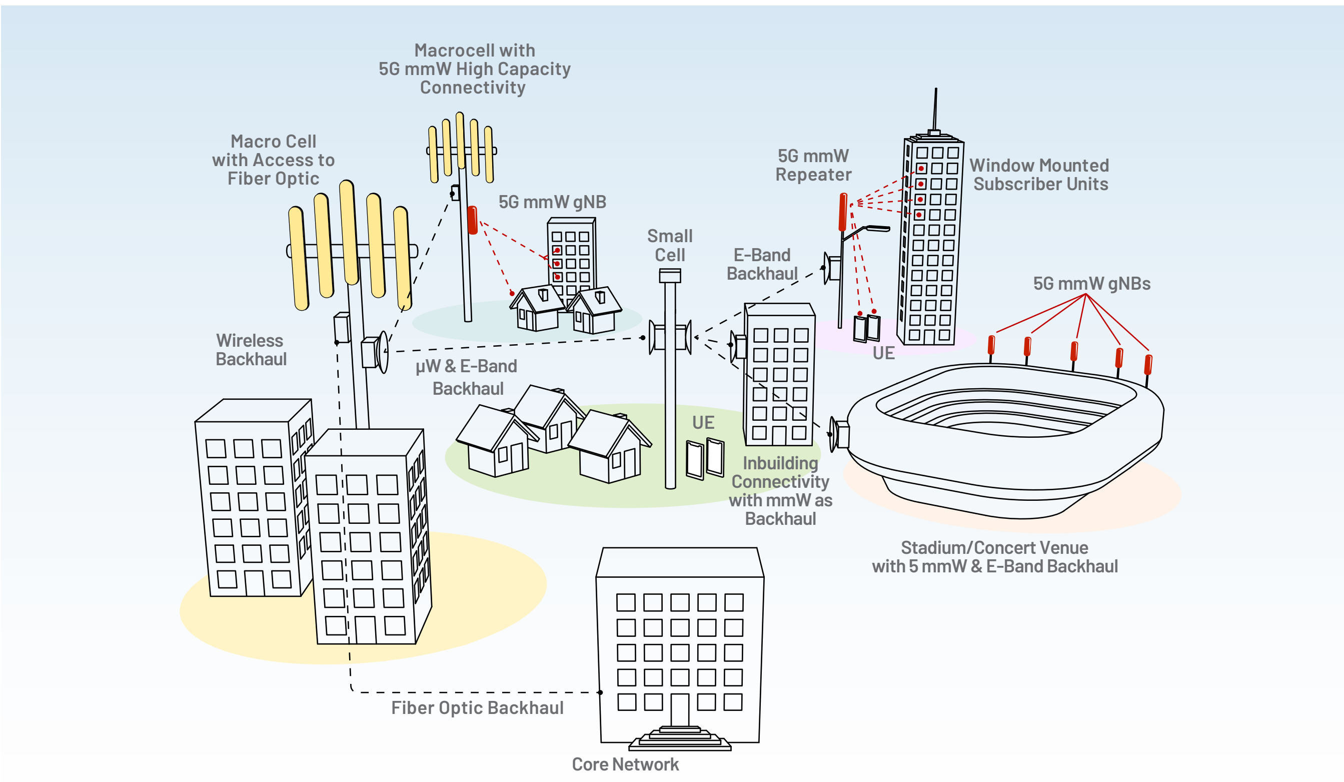
- **Small Physical Form Factor That Can Blend in with the Urban Environment**

- **Widespread Licensing Access to E-Band Spectrum Globally**

- **Less Complex Interference Management**

Analog Devices Understands the Complete Wireless Access Network

ADI continues to develop an ecosystem of solutions, cooperatively, to address the entire wireless network coverage access and backhaul environment. ADI RadioVerse® transceivers and more recently system on chips continue to build an enduring legacy in the world of telecommunications to provide a highly integrated versatile smart system solution for 3GPP radio access. ADI has a complete portfolio ranging from components to system in package (SiP) solutions solving 5G μW and 5G mmW wireless backhaul designs. The components and SiPs cover licensed and unlicensed frequency bands from 76 GHz to 86 GHz. ADI continues to innovate addressing the need for higher capacity backhaul solutions, by introducing a new generation of E-band 76 GHz/86 GHz SiPs to significantly increase wireless backhaul capacity. The family of SiPs have a baseband in/out to a waveguide in/out, including a transmit and receive SiP for each of the 76 GHz and 86 GHz bands. The SiP reduces design complexity and size while simplifying manufacturing with the elimination of die and bonding assembly.



Use Cases for mmW Backhaul

In Building Access

In building connectivity where fiber optic is not available. Instances in a city or metropolitan area where fiber installation costs are prohibitive. Instead, a high capacity E-band link is used to connect to the network.

Enabling Networks

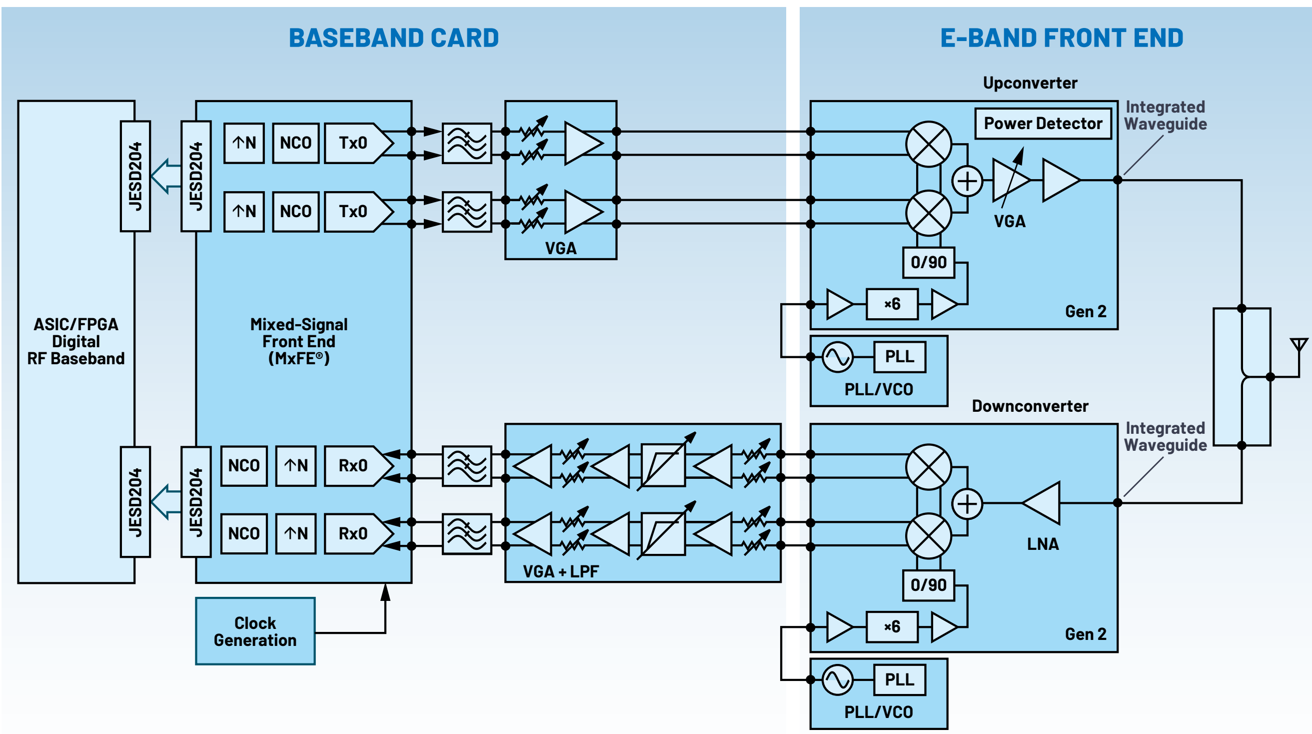
Aggregated data generated at the eNodeB and 5G gNB is transported across these high capacity wireless 76 GHz/86 GHz mmW links to a site that has fiber access to the core network. ADI's solution achieves 10 Gbps bidirectional connectivity using 2.5 GHz of channel BW.

Coexistence

mmW will coexist with fiber to enable the 5G network of the future. mmW backhaul is the solution where fiber is cost prohibitive or not scalable. 76 GHz/86 GHz links create the needed high capacity backhaul with a scalable, small footprint.

Analog Devices Complete E-Band Surface-Mount Packaged Solution

Analog Devices has a rich heritage in µW and mmW Backhaul technology. With the acquisition of Hittite Microwave in 2014, ADI has grown investments in higher frequency wireless communication to enable the next generation of high capacity 76 GHz/86 GHz mmW backhaul. Initially, ADI released its Generation 1 E-band chipset and created a high performance, high capacity solution. ADI developed a Generation 2 chipset that focuses on higher levels of integration, SMT package technology instead of bare die and the integration of a waveguide transition in package. A Generation 3 all new development system in package is in the works that will target even more performance and integration challenges.



Mixed-Signal Front End

- Highly integrated mixed-signal analog front end with 5 GHz bandwidth per transmit and receive channel.
- Hardened on-chip digital signal processing provides system scalability and lower system power.

Baseband VGA

- Integrated RFICs to manage gain control and enable programmable filtering.

Up/Downconverters

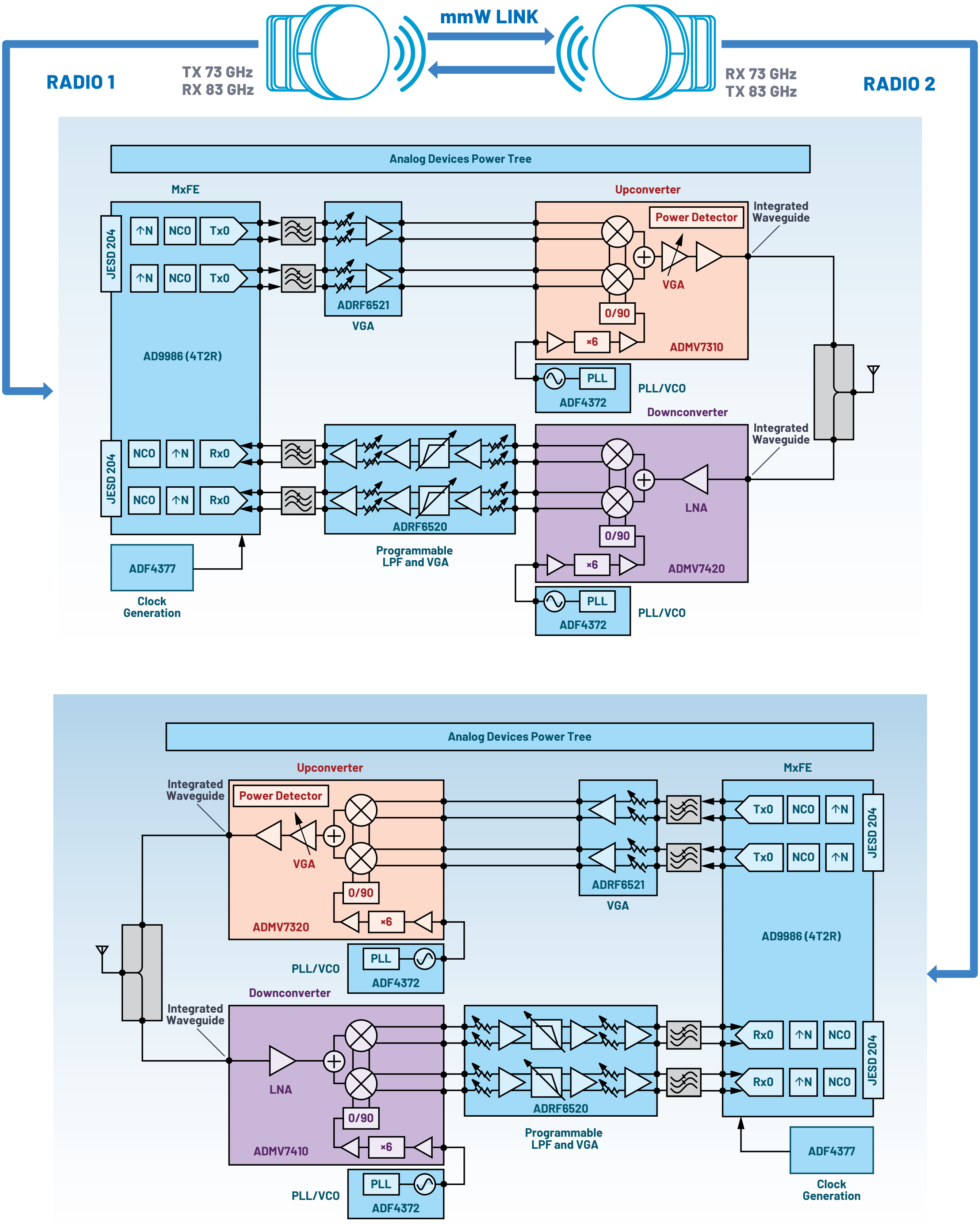
- Generation 2 highly integrated E-band solution integrating PA, VGA, mixer, and LNA to meet market cost and output power demands.
- Integrated LO amp and ×6 LO multiplier.
- High volume enabler using package solutions.
- Integrated waveguide in package to remove design complexity for IC to waveguide transition at mmW frequencies.

PLLVCO

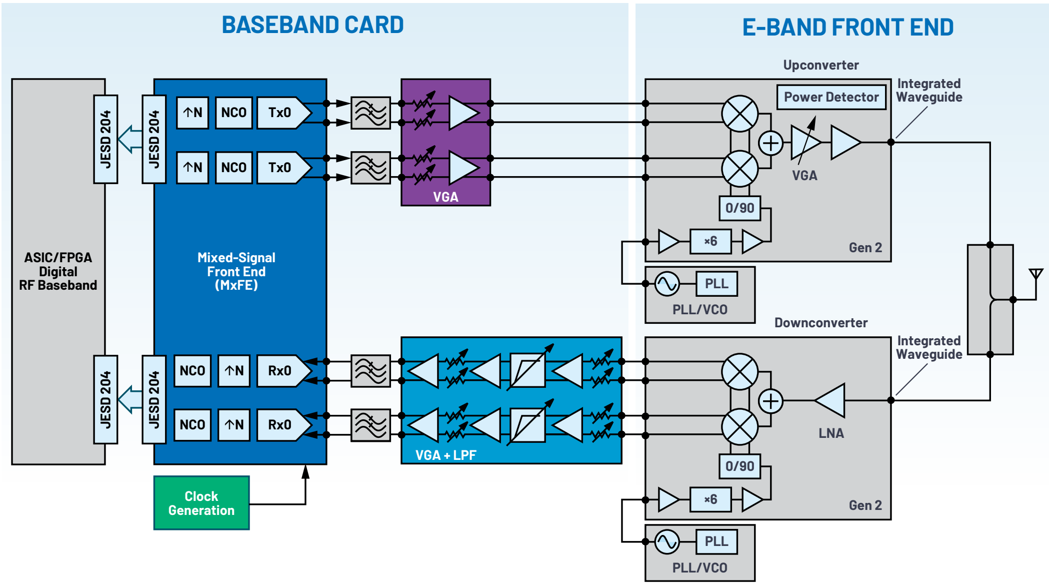
- Lowest in-band phase noise in the industry.
- Outstanding phase drift temperature coefficient.

Analog Devices Complete E-Band Solution Generation 2

Analog Devices solution supports bidirectional 10 Gbps, 2.5 GHz channel BW and up to 1024 QAM.



What Is ADI's E-Band Baseband Platform Solution?



MxFE

- AD9986

Clock Generation

- ADF4377

Prog. VGA Filter

- ADRF6520

VGA

- ADRF6521

MxFE (Mixed-Signal Front End)

Scalable software-defined radio solution with 7.5 GHz bandwidth.

	Description	Device Configuration	DAC/ADC Resolution Bits	DAC/ADC Sample Rate (GSPS)	ADC Analog BW (GHz)	ADC Aperture Jitter (fs rms)	Data Output Interface	Package (mm)	ECCN Code	Ordering Part Number
AD9986	4T2R direct RF transmitter and observation receiver	2 Rx (ADC) 4 Tx (DAC)	16/12	12/6	0 to 8	65	JESD204B JESD204C	15 × 15 BGA_ED	5A991.b	AD9986BBPZ-4D2AC

Clock Generation

Ultralow jitter clock generation products for applications demanding sub-picosecond performance.

	Description	Frequency (GHz)	Open-Loop VCO Phase Noise @ 100 kHz (dBc/Hz)	@ F_{OUT} (GHz)	Divider	VCO Tuning Inductor	Figure of Merit (dBc/Hz)	PFDMAX (MHz)	V_S (V)	I_S (mA)	Package (mm)	ECCN Code	Ordering Part Number
ADF4377	Int-N PLL with VCO	0.8 to 12.8	−108	10	/1 to /8	Internal	−239	500	3.3/5	370/145	7 × 7 LGA	EAR99	ADF4377BCCZ

Programmable VGA Filters

Fully differential low noise, low distortion programmable filters and variable gain amplifiers (VGAs).

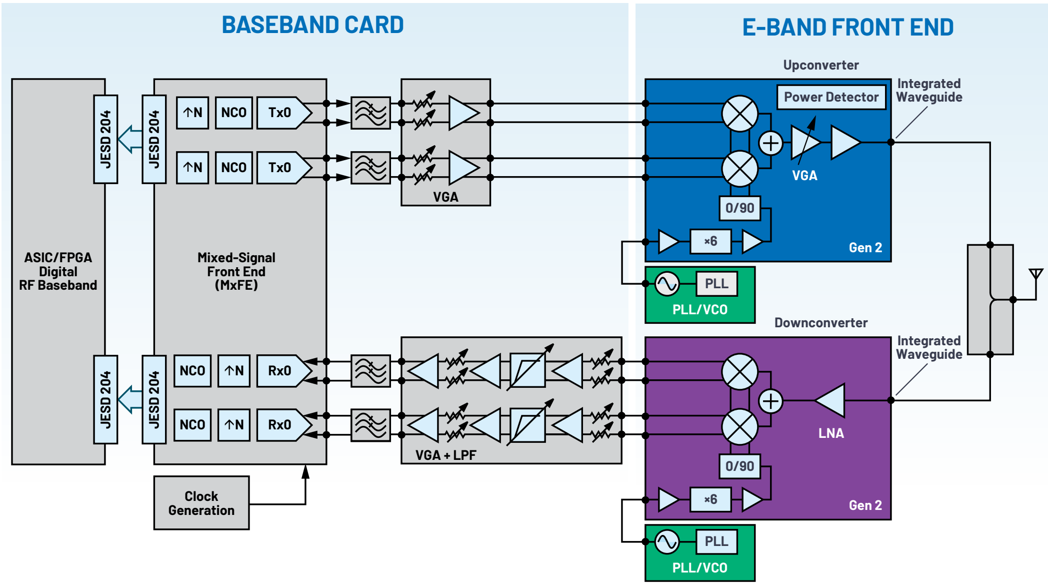
	Description	Bandwidth (MHz)	Gain Range (dB)	Output IP3 (dBm)	Noise Figure (dB)	V_S (V)	I_S (mA)	Package (mm)	ECCN Code	Ordering Part Number
ADRF6520	Dual, with selectable LPF for E-band	LF to 1250	−6 to +54	27 dBV	11	3.3	420	5 × 5 LFCSP	EAR99	ADRF6520ACPZ-R7

VGA

Dual, fully differential, low noise, and low distortion variable gain amplifier (VGA).

	Description	Bandwidth (GHz)	Gain Range (dB)	Output IP3 (dBm)	Noise Figure (dB)	V_S (V)	I_S (mA)	Package (mm)	ECCN Code	Ordering Part Number
ADRF6521	Dual analog VGA	0.01 to 3	−3 to +18	25.9 dBV	10.5	5	200	3 × 3 LFCSP	5A991.b	ADRF6521ACPZ

What Are ADI's E-Band Integrated Front-End mmW ICs?



Upconverter Gen 2 (WG)

- ADMV7310
- ADMV7320

Downconverter Gen 2 (WG)

- ADMV7410
- ADMV7420

PLLVCO

- ADF4372

Upconverter

In-phase quadrature (I/Q) upconverters integrate an I/Q mixer, RF amplifier, 90° hybrid, and an LO buffer in one package.

	Description	RF (GHz)	LO (GHz)	IF (GHz)	Conversion Gain (dB)	IP3 (dBm)	Image/SB Rejection (dBc)	NF (dB)	LO Drive Nominal (dBm)	V_{SUPPLY} (V)	I_{SUPPLY} (mA)	Package (mm)	ECCN Code	Ordering Part Number
ADMV7310	E-band I/Q upconverter SiP	71 to 76	11.8 to 12.7	DC to 2	35	31	20	26	4	—	—	16 × 14 LGA_CAV	EAR99	ADMV7310BCEZ
ADMV7320	E-band I/Q upconverter SiP	81 to 86	13.4 to 14.6	DC to 2	33	31	—	26	4	—	—	16 × 14 LGA_CAV	EAR99	ADMV7320BCEZ

Downconverter

In-phase quadrature (I/Q) downconverters integrate an image reject mixer, a low noise amplifier, a 90° hybrid, and an LO buffer amplifier in one package.

	Description	RF (GHz)	LO (GHz)	IF (GHz)	Conversion Gain (dB)	IP3 (dBm)	Image/SB Rejection (dBc)	NF (dB)	LO Drive Nominal (dBm)	V_{SUPPLY} (V)	I_{SUPPLY} (mA)	Package (mm)	ECCN Code	Ordering Part Number
ADMV7410	E-band I/Q downconverter SiP	71 to 76	11.5 to 13	DC to 2	13	1	30	5	4	4, 2, 1.5	66, 175, 80	11 × 13 LGA_CAV	EAR99	ADMV7410BCEZ
ADMV7420	E-band I/Q downconverter SiP	81 to 86	13.2 to 14.6	DC to 2	10	1	30	5	4	4, 2, 1.5	66, 175, 80	11 × 13 LGA_CAV	EAR99	ADMV7420BCEZ

PLLVCO

Best-in-class performance, phase noise, and integration.

	Description	Frequency (GHz)	Open-Loop VCO Phase Noise (dBc/Hz)		@ F_{OUT} (GHz)	Figure of Merit (dBc/Hz)	PFDMAX Frac-N Mode (MHz)	V_S (V)	I_S (mA)	Package (mm)	ECCN Code	Ordering Part Number
			@ 100 kHz	@ 1 MHz								
ADF4372	Wideband frac-N/int-N PLL and VCO	0.062 to 16.0	−111	−134	8	−234	155	3.3/5	70/110	7 × 7 LGA	EAR99	ADF4372BCCZ

E-Band Bare Die ICs Also Available for Customized Modules

Upconverter

In-phase quadrature (I/Q) upconverters integrate an I/Q mixer, RF amplifier, 90° hybrid, and an LO buffer in one package.

	Description	RF (GHz)	LO (GHz)	IF (GHz)	Conversion Gain (dB)	IP3 (dBm)	Image/SB Rejection (dBc)	NF (dB)	LO Drive Nominal (dBm)	V_{SUPPLY} (V)	I_{SUPPLY} (mA)	Package (mm)	ECCN Code	Ordering Part Number
HMC8118	E-band I/Q upconverter	71 to 76	11.83 to 14.33	0 to 10	−11	—	22	—	2	4, 1.5	175, 80	Die	5A991.b	HMC8118
HMC8119	E-band I/Q upconverter	81 to 86	11.83 to 14.33	0 to 10	−10	—	22	—	2	4, 1.5	175, 80	Die	5A991.b	HMC8119

Downconverter

In-phase quadrature (I/Q) downconverters integrate an image reject mixer, a low noise amplifier, a 90° hybrid, and an LO buffer amplifier in one package.

	Description	RF (GHz)	LO (GHz)	IF (GHz)	Conversion Gain (dB)	IP3 (dBm)	Image/SB Rejection (dBc)	NF (dB)	LO Drive Nominal (dBm)	V_{SUPPLY} (V)	I_{SUPPLY} (mA)	Package (mm)	ECCN Code	Ordering Part Number
HMC7586	E-band I/Q receiver	71 to 76	11.83 to 14.33	0 to 10	12.5	−1 (IIP3)	28	5	2	4, 1.5, 3	175, 80, 50	Die	5A991.b	HMC7586
HMC7587	E-band I/Q receiver	81 to 86	11.83 to 14.33	0 to 10	10	−2 (IIP3)	30	6	2	4, 1.5, 3	175, 80, 50	Die	5A991.b	HMC7587

Power Amplifier

Integrated E-band gallium arsenide (GaAs), pseudomorphic (pHEMT), monolithic microwave integrated circuit (MMIC), power amplifiers with a temperature compensated on-chip power detector.

	Description	Frequency (GHz)	Gain (dB)	Output P1dB (dBm)	Output IP3 (dBm)	Noise Figure (dB)	Match	V_S (V)	I_S (mA)	Package (mm)	ECCN Code	Ordering Part Number
ADMV7710	1 W power amp	71 to 76	24	28	34	–	Internal	4	800	Die	5A991.b	ADMV7710CHIPS
ADMV7810	1 W power amp	81 to 86	20	28	33	–	Internal	4	800	Die	5A991.b	ADMV7810CHIPS

Driver Amplifier/PA

Integrated E-band gallium arsenide (GaAs), pseudomorphic (pHEMT), monolithic microwave integrated circuit (MMIC), driver amplifiers/medium power amplifiers with a temperature compensated on-chip power detector.

	Description	Frequency (GHz)	Gain (dB)	Output P1dB (dBm)	Output IP3 (dBm)	Noise Figure (dB)	Match	V_S (V)	I_S (mA)	Package (mm)	ECCN Code	Ordering Part Number
HMC7543	Power amp	71 to 76	21.5	25	30	–	Internal	4	450	Die	5A991.b	HMC7543
HMC8142	Power amp	81 to 86	21	25	29	–	Internal	4	450	Die	5A991.b	HMC8142

VGA

Integrated E-band, gallium arsenide (GaAs), pseudomorphic (pHEMT), monolithic microwave integrated circuit (MMIC) variable gain amplifier and/or driver amplifier.

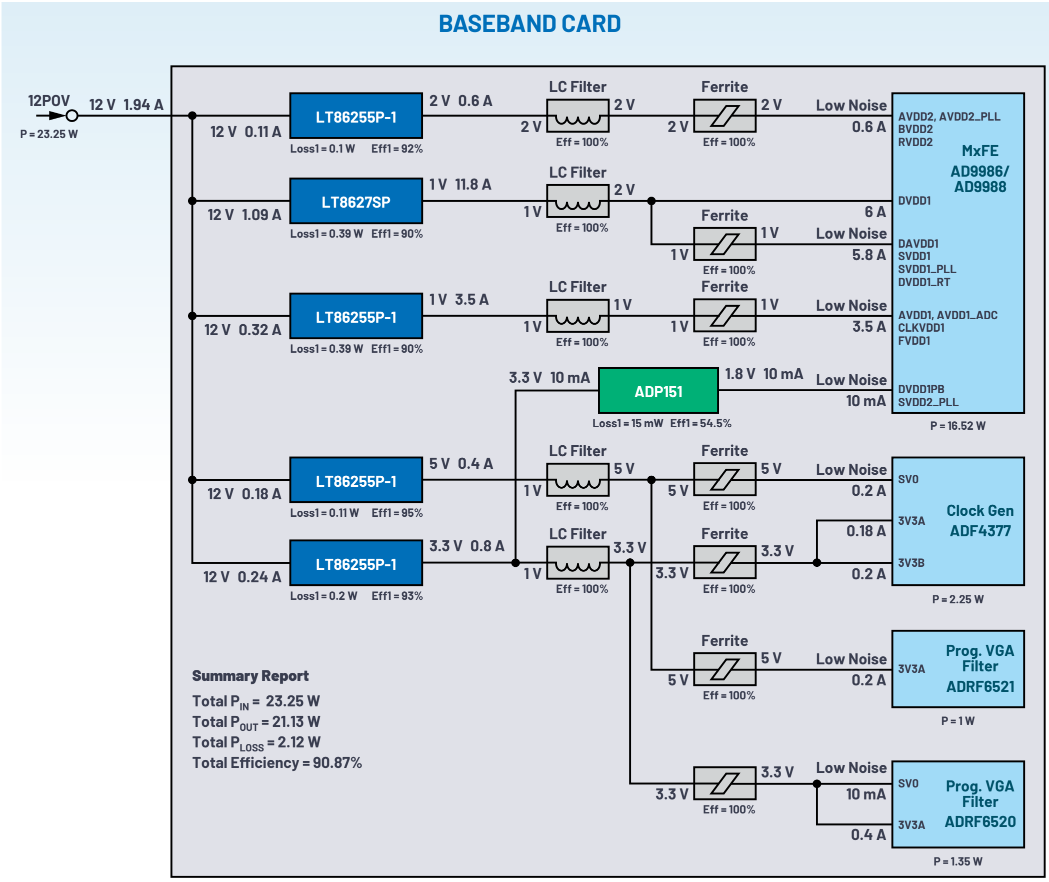
	Description	Bandwidth (GHz)	Gain Range (dB)	Output IP3 (dBm)	Noise Figure (dB)	V_S (V)	I_S (mA)	Package (mm)	ECCN Code	Ordering Part Number
HMC8120	Analog VGA/ driver amp	71 to 76	15	30	–	4	250	Die	5A991.b	HMC8120
HMC8121	Analog VGA/ driver amp	81 to 86	17	27.5	–	4	265	Die	5A991.b	HMC8121

LNA

Integrated E-band gallium arsenide (GaAs), monolithic microwave integrated circuit (MMIC), low noise amplifier (LNA).

	Description	Frequency (GHz)	Max RF Input Power (dBm)	Gain (dB)	Output P1dB (dBm)	Output IP3 (dBm)	Noise Figure (dB)	Device Match	V_S (V)	I_S (mA)	Package (mm)	ECCN Code	Ordering Part Number
HMC8325	LNA	71 to 86	–	21	13	22	3.6	Internal	3	50	Die	3A001.b.2.g	HMC8325

What Is ADI's E-Band Power Tree Solution?



Silent Switcher® Third Generation

- LT8622S
- LT8625S
- LT8625SP
- LT8625SP-1
- LT8627SP

LDO Linear Regulators

- ADP151

Ultralow Noise Silent Switcher Step-Down Converters with High PSRR

ADI's LT862x synchronous step-down regulators feature third-generation Silent Switcher technology, which is uniquely designed to combine an ultralow noise reference with Silent Switcher architecture in order to achieve both high efficiency and excellent wideband noise performance.

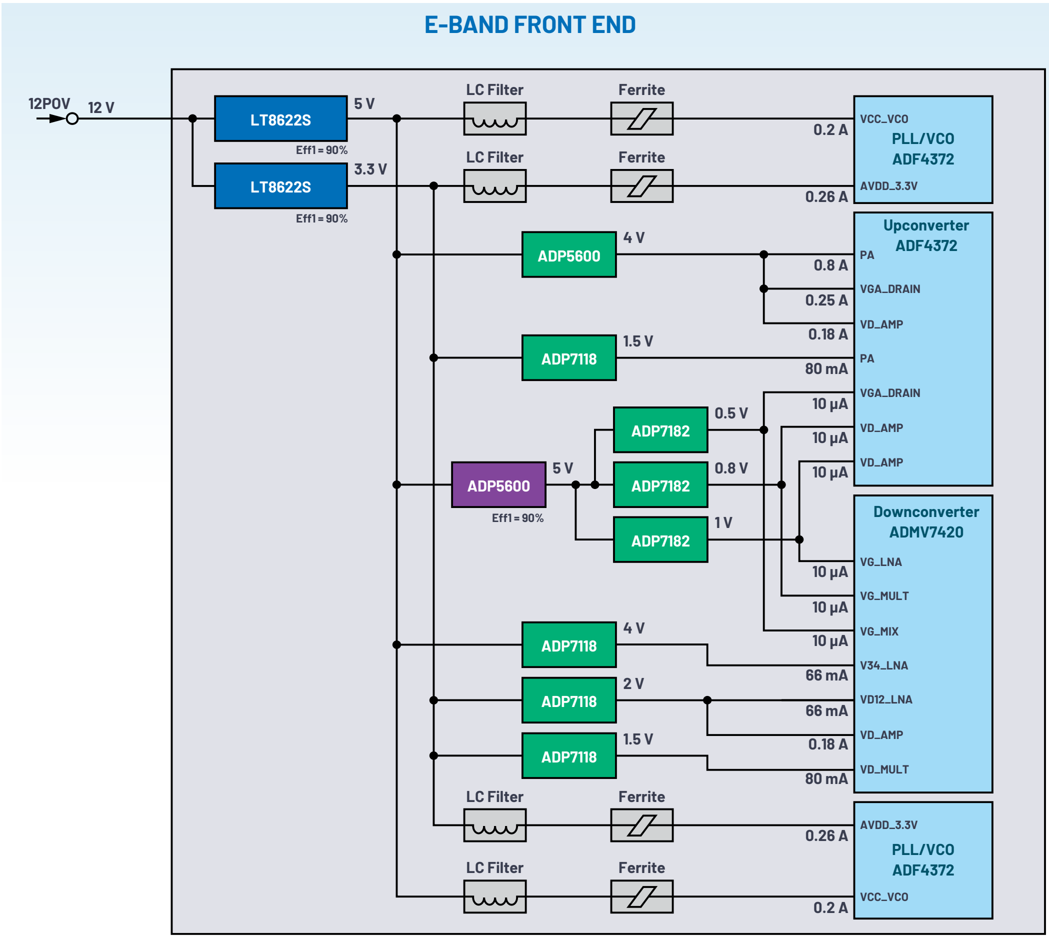
	I_{OUT} (A)	V_{IN} Range (V)	V_{OUT} Min (V)	rms Noise 10 Hz to 100 kHz (µV rms)	Noise Density 10 kHz (nV/√Hz)	Max Temp (°C)	Other Features	Package Options (mm)
LT8622S	2	2.7 to 18	0	4	4	125	Internal $INTV_{CC}$ capacitor, fast transient, polyplase operation	4 × 3 LQFN
LT8625S	8	2.7 to 18	0	4	4	125	Internal $INTV_{CC}$ capacitor, fast transient, polyplase operation	4 × 3 LQFN
LT8625SP	8	2.7 to 18	0	4	4	150	Fast transient, double-side cooling, polyphase	4 × 3 LQFN
LT8625SP-1	8	2.7 to 18	0	4	4	150	Ultralow noise, fast transient, double-side cooling, polyphase. pin-compatible with LT8627SP	4 × 4 LQFN
LT8627SP	16	2.8 to 18	0	4	4	150	Ultralow noise, fast transient, double-side cooling, polyphase	4 × 4 LQFN

Low Dropout Voltage LDO Linear Regulators

Ultralow noise performance without the necessity of a bypass capacitor, ideal for noise sensitive analog and RF applications.

	I_{OUT} (A)	V_{IN} Range	V_{OUT} Range (V)	rms Noise (µV rms)	Dropout Voltage (mV)	Quiescent Current (µA)	Package Options (mm)
ADP151	0.2	2.2 to 5.5	Adj. (1.1 to 3.3), fixed	9	135 @ Io = 200 mA	265 @ Io = 200 mA	2.9 × 2.8 TSOT 2 × 2 LFCSP 0.76 × 0.76 WLCSP

What Is ADI's Baseband Power Tree Solution?



Silent Switcher Third Generation

- LT8622S

LDO Linear Regulators

- ADM7172
- ADP7118
- ADP7182

Inverting Charge Pump

- ADP5600

Ultralow Noise Silent Switcher Step-Down Converters with High PSRR

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	I_{OUT} (A)	V_{IN} Range (V)	V_{OUT} Min (V)	rms Noise 10 Hz to 100 kHz (μV rms)	Noise Density 10 kHz (nV/√Hz)	Max Temp (°C)	Other Features	Package Options (mm)
LT8622S	2	2.7 to 18	0	4	4	125	Internal $INTV_{CC}$ capacitor, fast transient, polyplase operation	4 × 3 LQFN

Low Dropout Voltage LDO Linear Regulators

Ultralow noise performance, ideal for noise sensitive analog and RF applications.

	I_{OUT} (A)	V_{IN} Range (V)	V_{OUT} Range (V)	rms Noise (μV rms)	Dropout Voltage (mV)	Quiescent Current (μA)	Package Options (mm)
ADM7172	2	2.3 to 6.5	1.2 to 5	5	172	700	3 × 3 LFCSP
ADP7118	0.2	2.7 to 20	1.2 to (V_{IN} – VDO)	11	200	50	2 × 2 LFCSP, 2 × 2 SOIC w/EP, 2 × 2 TSOT
ADP7182	-0.2	-2.7 to -28	-1.22 to (-V_{IN} + VDO)	18	-185	-650	2 × 2 LFCSP, 3 × 3 LFCSP, 2.9 × 2.8 TSOT

Inverting Charge Pump

Regulated inverting charge pumps are used to invert an input voltage to a regulated output voltage. By eliminating the inductor, these switched capacitor converters offer alternatives to switching regulator topologies, providing a small solution footprint and a simple design.

	I_{OUT} (A)	V_{IN} Range	V_{OUT} Range (V)	Switching Frequency (MHz)	Feature	Package Options (mm)
ADP5600	-100	2.7 to 16	–0.505 to (-V_{IN} + 0.5)	0.1 to 1, programmable	Integrated power MOSFET	4 × 4 LFCSP

E-Band Chipset Solution

71 GHz to 76 GHz and 81 GHz to 86 GHz

LGA surface-mount packages, delivering highest power. Highly integrated chipset to target cost optimized high volume production.

Multifunction integration, including Waveguide, to reduce chip count and engineering design effort while addressing the full E-band spectrum.

Full signal chain solution to include digital to analog baseband and power attach. Bare die also available for module based solutions.

Learn more at analog.com/eband

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