RF Signal Source Solutions

Application Introduction

RF signal sources are used to create test waveforms at radio frequencies. Some of their common applications are to test if a new radio platform works or if the handsets coming off a production line are performing as they should. RF signal sources can be used to create simple waveforms such as sine waves or complex, modulated waveforms that look like the return echoes from ultrasound or sonar equipment.

System Design Considerations and Major Challenges

With innovations in technology, RF applications now have frequency requirements in the GHz range, and modulation techniques have become more complicated due to both analog and digital approaches. In addition, there are more RF communication standards in the industry.

The first challenge for the RF signal source designers is to implement the various RF test signals in a single system. For example, an RF signal source may need to provide a broad range of outputs, such as FM, FSK, QAM, WCDMA, and LTE signals. The required bandwidth to support these RF test signals now becomes much wider. It is hard to find the components that support the wide bandwidth, good linearity, and low noise performance of these standards. Moreover, designers may need to add different signal paths for different bands.

The second challenge for the RF signal source designer is to control the noise floor of the system. Using more digital signal processing and RF signal processing increases the system's radiated noise. Additional signal paths also add to the noise caused by crosstalk. Therefore, it is more difficult to get clean outputs.

The third challenge for the RF signal source designer is ever-increasing system capability and flexibility. A signal source also needs to support the external clock input and modulation input to meet end users' test purposes, such as synchronization. The system is also required to be compatible with such interfaces as USB, GPIB, Ethernet, and RS-232.

Solutions from ADI

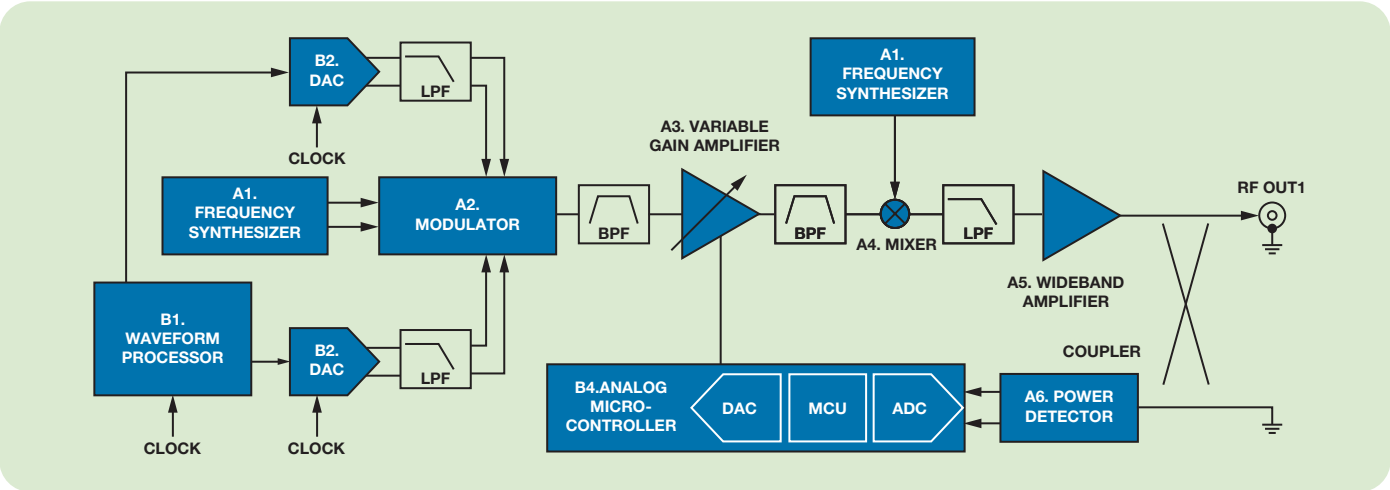
ADI solution value proposition:

- One-stop shopping to provide the broadest product portfolio, from digital to RF components, such as phase lock loops (PLL), mixers, power detectors, ADCs, DACs, amplifiers, and digital signal processors.
- Extensive RF design resources, like easy-to-use simulation tools (ADIsimPLL,™ ADIsimRF,™ ADIsimSRD,™ ADIsimCLK™), the RF forum in ADI's EngineerZone™ web site, and fully-populated evaluation boards.
- ADI's product compatibility supports design migration across multiple platforms, such as the pin compatible high speed ADCs for different sample rates and resolutions.
- On-chip integration optimizes signal chain performance and minimizes board space, BOM cost, and power consumption, such as the power management unit (PMU) integrating the linear regulator, the switching regulator, and supervisory functions.
- Circuits from the Lab™ reference circuits are engineered and tested for quick and easy system integration to help solve today's analog, mixed-signal, and RF design challenges. Web-based design tools optimize performance of custom designs. Some Web-based examples are shown at the end of this document.

System Block Diagram

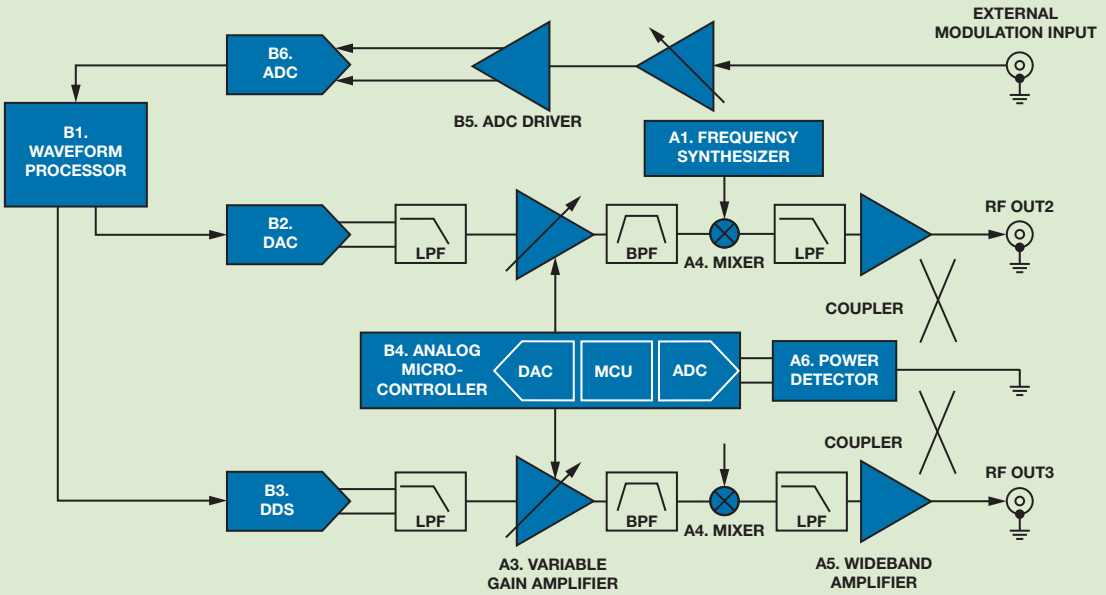
Generally an RF signal source can be divided into the five subsystems shown below:

A. RF signal chains to generate the modulated RF outputs: ADI's RF design focuses on the high performance and low power solutions. The differential architecture minimizes the noise. The low power consumption coupled with the high linearity provides an optimum solution.



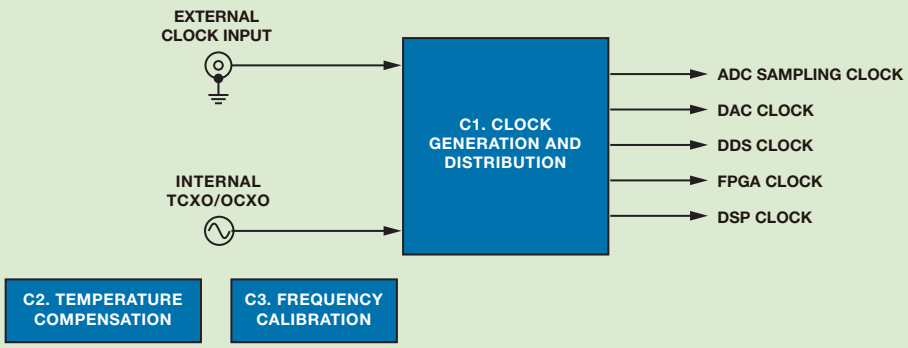
A1. Frequency Synthesizer	A2. Quadrature Modulator	A3. Variable Gain Amplifier	A4. Mixer	A5. Wideband Amplifier	A6. Power Detector
ADF4106/ADF4107/ADF4108 ADF4150/ADF4153/ADF4156/ADF4158 ADF4350/ADF4351	ADL5370/ADL5371/ADL5372/ ADL5373/ADL5374/ADL5375 ADL5385/ADL5386	ADL5240/ADL5243 ADL5201/ADL5202	ADL5801 ADL5350	ADL5541/ADL5542 ADL5530	ADL5501/ADL5502 ADL5513/ADL5519

B. External modulation input to generate the RF outputs via the data converters and processors: ADI's data converter portfolio includes a broad range of innovative ADCs and DACs. ADI also has an expanding portfolio of fixed-point DSPs, floating-point DSPs, and analog microcontrollers for a wide variety of general-purpose and application-specific needs.



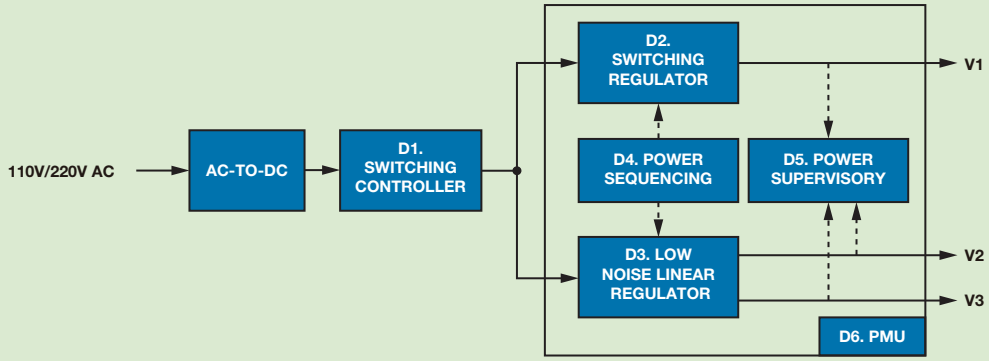
B1. Waveform Processor	B2. DAC	B3. DDS	B4. Analog Microcontroller	B5. ADC Driver	B6. ADC
ADSP-BF51x ADSP-2126x	AD9122/AD9125 AD9780/AD9781/ AD9783	AD9957/AD9959 AD9913	ADuC7023	ADA4927/ADA4930/ ADA4937/ADA4960 ADL5201/ADL5202	AD9255/AD9258 AD9467

C. Clock generation and distribution: ADI offers ultralow jitter clock distribution and clock generation products for sub-picosecond performance. These are ideal for clocking high performance ADCs and DACs (See AN-501 and AN-756 shown in the end of this document). In addition, ADI's accurate temperature sensors and nanoDAC® devices can compensate the oscillators (TCXO/OCXO) well.



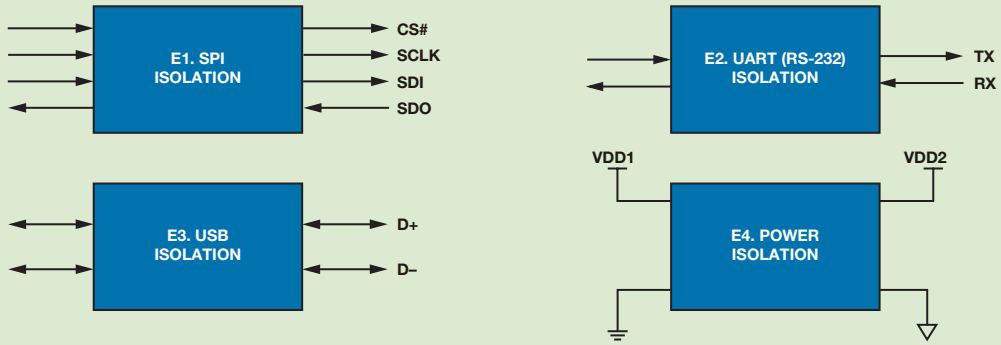
C1. Clock Generation and Distribution	C2. Temperature Compensation	C3. Frequency Calibration DAC
AD9516/AD9517/AD9518 ADCLK846	ADT7320/ADT7420 ADT7310/ADT7410	AD5060/AD5061/AD5062/AD5063 AD5620/AD5640/AD5660

D. Power generation and management: ADI designs power products to complement signal chains where signal integrity requires an efficient power design. The growing portfolio continues ADI's 45-year tradition of reliability, innovation, performance, and value in signal processing ICs.



D1. Switching Controller	D2. Switching Regulator	D3. Low Noise Linear Regulator	D4. Power Sequencing	D5. Power Supervisory	D6. PMU (Power Management Unit)
ADP1870	ADP2114/ADP2116 ADP2323	ADP150 ADP320/ADP322/ADP323	ADM1085/ADM1086/ ADM1087	ADM1191/ADM1192 ADM13305/ADM13307	ADP5034 ADP5040/ADP5041/ ADP5042/ADP5043

E. Data and power isolation: Digital isolators with *i*Coupler® technology enable designers to implement isolation in designs without the cost, size, power, performance, and reliability constraints found with optocouplers.



E1. SPI Isolation	E2. UART (RS-232) Isolation	E3. USB Isolation	E4. Power Isolation
ADuM3471 ADuM1411	ADM3251E ADuM1201	ADuM3160/ADuM4160	ADuM5000/ADuM6000

Note: The signal chains above are representative of signal generator design. The technical requirements of the blocks vary, but the products listed in the table below are representative of ADI's solutions that meet some of those requirements.

Major Product Introduction

Part Number	Description	Key Specifications and Features	Benefit
ADF4108	Frequency synthesizer	Integer-N PLL, 0.5 GHz to 8 GHz RF bandwidth, –219 dBC/Hz normalized phase noise	Programmable charge pump current and pre-scaler values
ADL5375	Quadrature modulator	Noise floor: –160 dBm/Hz @ 900 MHz, carrier feedthrough: –46 dBm @ 900 MHz	Wideband from 400 MHz to 6 GHz
ADL5385	Quadrature modulator	Noise floor: –159 dBm/Hz @ 350 MHz, carrier feedthrough: –46 dBm @ 350 MHz	Wideband from 50 MHz to 2.2 GHz
ADL5240	Digital controlled variable gain amplifier	31.5 dB gain control range with 0.25 dB step accuracy	Both serial and parallel interface, wideband from 100 MHz to 4 GHz
ADL5801	High IP3 active mixer	+27 dBm input IP3, +12.5 dBm input P1dB, +1.5 dB power gain	Wideband RF, LO, and IF ports, single channel up/downconverter
ADL5541/ ADL5542	Wideband amplifier (gain block)	Fixed gain of 15 dB to 20 dB, 50 MHz to 6 GHz	Wideband, input/output internally matched to 50 Ω
ADL5501	TruPwr™ rms power detector	50 MHz to 6 GHz, 30 dB input dynamic range, small SC70 package	True rms detector, waveform and modulation independent

Part Number	Description	Key Specifications and Features	Benefit
ADSP-BF51x	Waveform processor (fixed-point Blackfin DSP)	400 MHz DSP, 116 kB on-chip RAM, on-chip RTC, Ethernet MAC (10/100) with IEEE 1588 supported	400 MHz DSP, IEEE 1588 Ethernet supported
ADSP-2126x	Waveform processor (floating-point SHARC DSP)	150 MHz to 200 MHz float-point DSP, 1 Mbit/2 Mbit on-chip RAM	Low cost floating-point DSP
AD9122	Dual, 16-bit, 1 GSPS DAC	Flexible LVDS interface, integrated 2 × /4 × /8 × interpolator	Gain, dc offset, and phase adjustment for sideband suppression
AD9780/AD9781/ AD9783	Dual, 12-bit/14-bit/16-bit, 500 MSPS LVDS input DAC	Integrate four 10-bit aux DACs for gain and offset adjustment, programmable full-scale output currents from 8.6 mA to 31.7 mA	Pin compatibility makes migration across different platforms easy, integration reduces complexity
AD9957	1 GSPS DDS with quadrature digital upconverter	1 GSPS DDS, 14-bit DAC, 18-bit I/Q data path, reference clock multiplier	Quadrature modulation can generate modulated signals, integration reduces complexity
ADuC7023	Precision analog microcontroller	12-bit ADC/DAC, ARM7TDMI MCU	Small package, low cost
AD9255/AD9258	14-bit, 125 MSPS/105 MSPS/80 MSPS LVDS 1.8 V ADC	SNR: 78 dBFS at 70 MHz and 125 MSPS, 371 mW at 125 MSPS, IF sampling up to 300 MHz	Integer 1-to-8 clock divider, low power consumption, power down mode, CMOS or LVDS output
ADCLK846	Clock fanout buffer	6 LVDS/12 CMOS outputs, 100 fs additive broadband jitter	Selectable LVDS/CMOS outputs, low power operation
ADT7320/ ADT7420	Digital temperature sensor	±0.25°C accuracy from -20°C to 105°C, 16-bit resolution (0.0078°C)	No calibration required, over/undertemperature interrupt
ADP2114	2-channel step-down regulator	Configurable, dual 2 A/single 4 A, light load pulse skip mode to improve efficiency	Synchronous, optimized gate drive slew rate to support noise sensitive analog-to-digital and digital-to-analog converters
ADP5041	Power management unit (PMU)	One 1.2 A buck, two 300 mA LDOs, supervisory, watchdog, manual reset	Integration makes design smaller and BOM cost lower
ADM1191/ ADM1192	I²C power monitor	12-bit ADC for current and voltage readback, power from 3.15 V to 26 V	ALERT output can be used as an interrupt or a basic hot swap
ADuM4160/ ADuM3160	5 kV/2.5 kV USB isolator	Full/low speed, upstream short circuit protection	Bidirectional communication, enhanced ESD per IEC 61000-4-x
ADuM6000/ ADuM5000	5 kV/2.5 kV isolated dc-to-dc converter	Regulated 3.3 V or 5 V output, high temperature operation: 105°C maximum	*iso*Power®, safety and regulatory approvals

Design Resources

Circuits From The Lab™

- *Interfacing the ADL5375 I/Q Modulator to the AD9779A Dual-Channel, 1 GSPS High Speed DAC* (CN0021)—*www.analog.com/CN0021*
- *Interfacing the ADL5371 I/Q Modulator to the AD9779A Dual-Channel, 1 GSPS High Speed DAC* (CN0017)—*www.analog.com/CN0017*
- *Powering a Fractional-N Voltage Controlled Oscillator (VCO) with Low Noise LDO Regulators for Reduced Phase Noise* (CN0147)—*www.analog.com/CN0147*
- *Very Low Jitter Sampling Clocks for High Speed Analog-to-Digital Converters Using the ADF4002 PLL* (CN0003)—*www.analog.com/CN0003*
- *Powering a Fractional-N Voltage Controlled Oscillator (VCO) with Low Noise LDO Regulators for Reduced Phase Noise* (CN0134)—*www.analog.com/CN0134*
- *Broadband Low Error Vector Magnitude (EVM) Direct Conversion Transmitter Using LO Divide-by-2 Modulator* (CN0144)—*www.analog.com/CN0144*
- *Amplitude Control Circuit for AD9834 Waveform Generator (DDS)* (CN0156)—*www.analog.com/CN0156*

Application Notes/Articles

- *Super-Nyquist Operation of the AD9912 Yields a High RF Output Signal* (AN-939)—*www.analog.com/AN-939*
- *Aperture Uncertainty and ADC System Performance* (AN-501)—*www.analog.com/AN-501*
- *Sampled Systems and the Effects of Clock Phase Noise and Jitter* (AN-756)—*www.analog.com/AN-756*
- "Direct Digital Synthesis (DDS) Control Waveforms in Test, Measurement, and Communications." *Analog Dialogue,* Volume 39, August 2005, *www.analog.com/library/analogDialogue/cd/vol39n3.pdf*

Design Tools/Forums

- *ADIsimPLL: www.analog.com/ADIsimPLL*
- *ADIsimRF: Easy-to-use RF Signal Chain Calculator. Cascaded Gain, Noise Figure, IP3 and P1dB as well as Total Power Consumption Are Calculated— www.analog.com/ADIsimRF*
- *DiffAmpCalc : ADI's Differential Amplifier Calculator—www.analog.com/diffampcalc*
- *EngineerZone: Online Technical Support Community—ez.analog.com*

To view additional signal generator resources, tools, and product information, please visit: *instrumentation.analog.com*

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