By JACK BROWNE, Contributing Editor

Design Kits Create Lessons for Success

By building key components into design kits and application platforms, suppliers give circuit and system designers head starts in getting the most value and performance for their applications.

Design kits and design platforms are "starting points" offered by electronic companies to help users better understand how to incorporate one or more components or devices in their own applications. The kits may be as simple as a selection of RF filters or as complex as a subsystem with multiple evaluation boards and supporting software. Users range from students pursuing an early look at the industry they hope to join, to veteran design engineers faced with adding modern technologies to their own system designs.

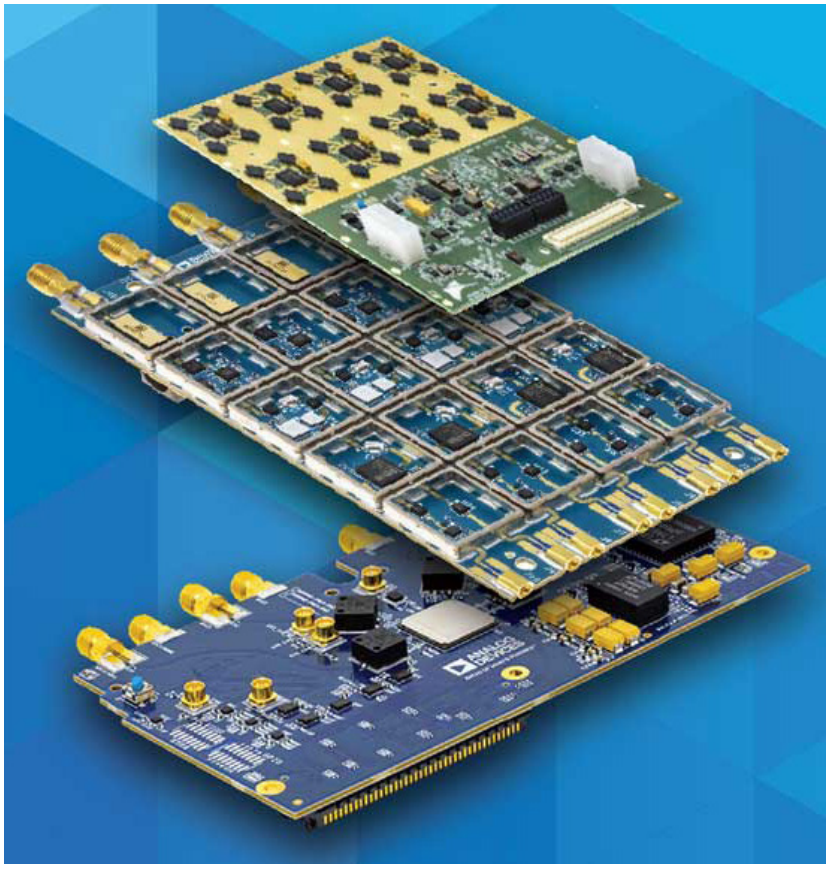
Design kits are widely available for essential passive components to the most complex integrated circuits (ICs). What follows is a sampling of those kits and their contents that may help designers working at circuit through system levels. It's never too late to learn!

Engineering college students typically build a strong background from reading textbooks and technical papers. They also can gain practical experience through experimentation with a pair of low-cost analog design kits offered by Analog Devices and Digilent.

Experience Through Experimenting

The Analog Discovery Design Kit and Analog Explorer Design Kit are single-board circuits with USB ports for connection to a PC to create a portable classroom. With a PC and Digilent's waveform software, they show how one may generate and analyze various waveforms. Students have access to downloadable teaching materials and online support; the kits come with an ac-dc converter to power each board.

For system-level architects with a bit more experience, especially those learning to apply phased-array active antenna beamforming to this modern electronic world, there



1. Analog Devices' X-Band Phased Array Platform features high-speed mixed-signal ICs assembled on three PCBs and works with a fourth controller PCB for extensive phased-array beamforming experimentation.

are lessons to be learned from Analog Devices' much more sophisticated X-Band Phased Array Platform.

The platform leverages the company's high-performance RF analog-to-digital converters (ADCs) and digital-to-analog converters (DACs) to assemble three printed circuit boards (PCBs) into part of a learning platform that's a complete system *(Fig. 1)*. The X-band platform consists of an AD9081 FMLA-EBZ multiplexer front-end (MxFE) evaluation board, an ADAR1000EVAL TZ X/Ku-band analog beamforming prototyping board, and an ADXUDIAEBZ quad-channel X-to-C-band frequency up/down converter.

Each board holds numerous lessons and ICs. The AD9081 board, for example, is based on a highly integrated IC that packs a system's worth of components into a 15- × 15-mm, 324-ball BGA package. Individual function blocks within the IC include four DAC cores with 16-bit resolution and 12-Gsample/s maximum sample rate, and four ADC cores with 12-bit resolution and 4-Gsample/s maximum sampling rate.

The IC and its evaluation board are well-suited for signals with wide instantaneous bandwidths (as wide as 2,000 MHz per channel) and support single-, dual-, and quad-band operation. It provides eight transmit and eight receive lanes supporting JESD204 data standards-based operation up to 24.75 Gb/s. The board includes a clock multiplier and high-speed digital-signal-processing (DSP) capability.

The ADAR1000EVAL prototyping board is based on the ADAR1000 four-channel phased-array X/Ku-band beamforming IC. The IC uses half-duplex operation for transmit and receive modes. Input signals through the four receive channels merge at a common RF input/output (I/O) port while RF signals for transmission are split and passed through four channels.

The IC operates from 8 to 16 GHz with 360-degree phase adjustment range and 2.8-degree phase resolution. It controls signal amplitude with a 31-dB gain adjustment range and 0.5-dB gain resolution. Housed in a 7- × 7-mm LGA package, the IC integrates four power detectors and enough memory for 121 phase positions. The PCB provides power and control circuitry to take full advantage of the ADAR1000.

The X-band designer's platform works with a model ZCU102 Evaluation Board from Xilinx, which contains a field-programmable gate array (FPGA). The educational platform comes with reference software, though it also requires MATLAB system-level software from MathWorks. When linked by coaxial cables, the boards form a scalable 32-element, hybrid beamforming phased-array radar for training, or a starting point for integration of phased-array technology into radars, 5G cellular wireless networks, electronic-warfare (EW) systems, and satellite-communications (satcom) systems.

For higher-frequency use at mmWave frequencies, Anokiwave offers Innovator's Kits that convey lessons on the company's innovative phased-array beamforming ICs. The model AWMF-0129 Active Antenna Innovator's Kit is based on one of Anokiwave's earliest ICs, the 26.5- to 29.5-GHz single-polarization, quad-core model AWMF-0108. Each Gen-1 beamforming IC supports four transmit/receive radiating elements with 5-bit phase and 5-bit gain control, using a half-duplex approach for a single antenna to receive and transmit.

The kit assembles at least 16 of the ICs into a low-profile, single-polarization, 64-element PCB antenna; its SMT layout is a lesson in power efficiency and short transmission lines at mmWave frequencies. Even with only 12-W dc power consumption, the active antenna is capable of reasonable mmWave transmit power (+50 dBmi) and gigabit-per-second wireless data rates.

The same mmWave frequency range, 26.5 to 29.5 GHz, also is available as a dual-polarized antenna design kit with downconversion to intermediate frequencies (IFs) in the AWA-0213-PAK kit *(Fig. 2)*. It's based on the company's newer, Gen 3 beamforming and IF up/downconversion ICs and provides an easy-to-apply piece when experimenting with a 5G new radio (NR) system design at the lower mmWave frequencies (n257 and n261 bands).

For higher mmWave frequency coverage, Anokiwave offers the AWA-0219-PAK design kit with frequency range of 37.0 to 40.0 GHz (for the n260 band) and full downconversion to a lower IF range. This dual-polarized phased-array antenna design kit also is based on the Gen 3 ICs.

2. Anokiwave's Innovator's kits, as shown here, surround beamforming ICs with the required hardware for frequency downconversion from 26.5 to 29.5 GHz to a lower intermediate-frequency (IF) range.

Component Classrooms

Seasoned RF designers can often learn a great deal simply by substitution, by trying various parts in a circuit. For the most essential building blocks of RF circuits, long-time chip capacitor maker American Technical Ceramics, an AVX Group Co., offers a lineup of multilayer ceramic capacitor designer kits containing a set of components with different values. The kits can be specified as lead or lead-free (RoHS-compliant) versions.

Designer Kit DK0002 contains 16 Porcelain Superchip capacitors with values from 10 to 8.2 pF. Components from 1.0 to 3.3 pF feature consistency within ±0.10 pF, while capacitors with values 3.9 to 8.2 pF have consistency within ±0.25 pF of the rated value. Having the assortment allows experimenters to try different values on their boards and circuits to learn the results.

Skyworks Solutions offers several design kits for its Si5121x family of clock oscillators, including the Si51211-EVB evaluation kit. It includes a Model Si514 on-board programmable oscillator to generate the input clock frequency signals.

Skyworks' ClockBuilderPro software programs the clock, which contains the frequency plan for the source. The clock runs on a PC with Microsoft Windows 7 or newer operating system (OS). The software guides users through customized clock generation and provides a step-by-step process for entering reference clock parameters specific to a user's design goals. It provides feedback on optimizing performance as well, such as phase jitter and power consumption.

One of the largest suppliers of RF components, Mini-Circuits, also is one of the most diversified suppliers of design kits, offering more than 200 kits to introduce high-frequency engineers to its parts. Long associated with frequency mixers, Mini-Circuit's K1-MCA+ Frequency Mixers Designer's Kit contains five each of six triple-balanced models (30 total) and covers an overall range of RF and local-oscillator (LO) frequencies from 0.5 to 5.0 GHz. Circuit designers can experiment by dropping these tiny (0.25 × 0.30 × 0.19 in.) mixers with different RF/LO frequencies onto a PCB—they all share an intermediate-frequency (IF) range of 10 to 1500 MHz to simplify testing. Evaluation boards are available for most the designer kits.

Mini-Circuits' Wideband Amplifiers Designer's Kit includes an assortment of compact K1-ERA+ amplifiers, with 10 each of three models (30 total) covering an overall frequency range of dc to 8 GHz (usable to 10 GHz). The small-signal, 50-Ω amplifiers deliver as much as +13-dBm output power from drop-in, plastic packages.

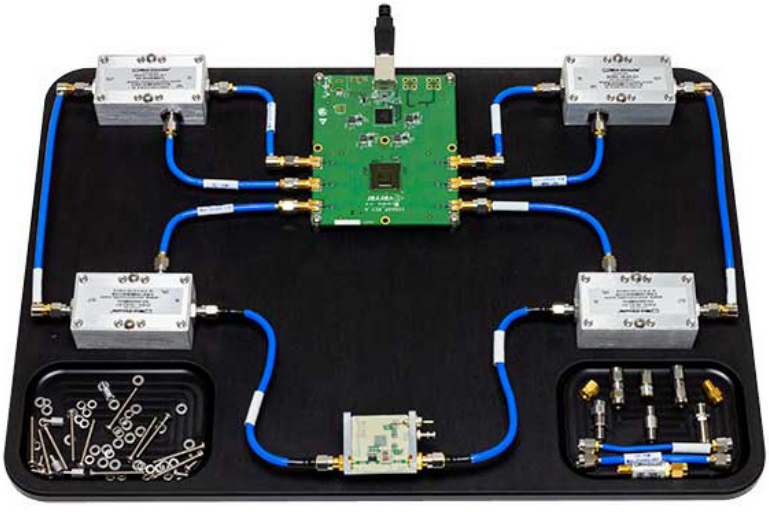
On the passive side, the K1-DBTC+ Directional Couplers Designer's Kit contains five each of five surface-mount-technology (SMT) couplers (25 total) covering 5 MHz to 2 GHz with coupling values from 9 to 20 dB. The leadless couplers are built onto low-temperature-cofired-ceramic (LTCC) bases and measure just 0.150 × 0.150 × 0.150 in.

Mini-Circuits even has a kit to help evaluate its components—the model UVNA-63 microwave transceiver kit *(Fig. 3)*. With it, one may assemble different systems and subsystems, including a two-port vector network analyzer (VNA) operating from 100 MHz to 6 GHz under the control of a PC with USB connections. This kit was developed in partnership with Tel Aviv-based educational professionals Vayyar.

Several years ago, Mini-Circuits began teaming with Vayyar on the IMAGEVK-74 development kit for four-dimensional (4D) mmWave sensing and imaging as a function of time. The mmWave kit, which operates over radar bands from 3 to 81 GHz, is based on Vayyar's wideband mmWave transceiver IC that contains as many as 72 transceiver circuits, an integrated microcontroller, and DSP. The kit is an excellent starting point for applications in automotive, aerospace/military, medical, and security systems.

Students learning about filters at mmWave frequencies can experiment with design kits from Knowles Precision Devices. Featuring temperature-stable capacitors based on Dielectric Laboratories Inc. (DLI) technology, these kits offer an assortment of values for mmWave filters, including bandpass filters with passbands at 26 GHz and higher. The kits are available from RFMW.

Experimenters translating between RF and mmWave frequency ranges may benefit from a pair of reference de-



3. A microwave transceiver kit developed by Mini-Circuits includes a first lesson on how to assemble its components into a two-port VNA with frequency range of 100 MHz to 6 GHz.

sign kits from X-Microwave, a Quantic Co. They leverage mmWave frequency-converter ICs from Analog Devices for upconversion to, and downconversion from, 24 to 44 GHz.

The XM-RDK-201/ADMV1013 frequency-upconversion kit *(Fig. 4)* and the XM-RDK-202/ADMV1014 frequency-downconversion kit come on PCBs with supporting components, including additional ICs from Analog Devices, and amplifiers, filters, and reference oscillators required for the frequency translation process. Both boards are programmed by the X-MWcontroller microcontroller for quick and simple operation.

Intrinsix, a CEVA Co., offers a series of Jump Start Kits for RF/mmWave semiconductor design, including kits for voltage-controlled oscillators (VCOs) and phase-locked loops (PLLs). These may be combined to perform computer modeling of phase noise and RMS jitter. Additional Jump Start Kits include phase and time delays, transmit/receive (T/R) switches, low-noise amplifiers (LNAs), power amplifiers, and mixer/multipliers.

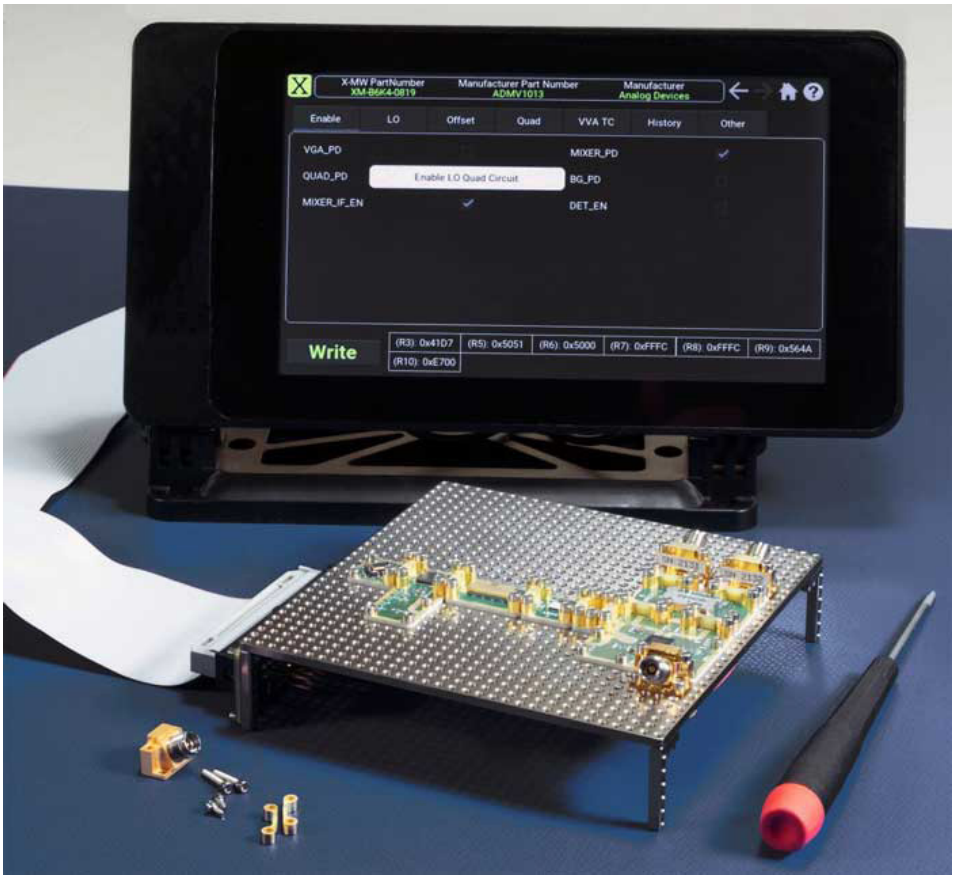
Semiconductor Studies

Semiconductor suppliers can speed the acceptance of their devices when they offer them as part of design kits, such as the DWM3001CDK Ultra-Wideband (UWB) Module Development Kit from Qorvo, based on the company's DW3110 UWB transceiver. The IC serves two-way ranging (TWR) and time difference of arrival (TDoA) applications at 6.5 and 8.0 GHz. The kit includes an evaluation board with a port for a planar UWB antenna and two micro-USB ports to simplify testing and system development. Batteries power the board while the user evaluates USB link integration approaches.

The CSR101x Bluetooth Low Energy (LE) Starter Development Kit from Qualcomm is based on the company's CSR101x family of system-on-chip (SoC) devices for the simplified development of Bluetooth Low Energy (BLE) products. The SoCs integrate controller, host, and application circuitry within a single small package, reducing the need for external components and shortening interconnection times on product PCBs with reduced power consumption.

Among the available variations of the SoC family are smaller packages for portable and wearable applications and high-I/O-count configurations for densely configured product designs with high functionality. BLE applications include fitness devices, heart-rate monitors, and smart lighting products. The kits feature software support, too.

Texas Instruments also offers a variety of design starter



4. The XM-RDK-201/ADMV1013 frequency-upconversion kit from X-Microwave provides components needed for upconversion of RF signals to the range of 24 to 44 GHz.

kits for Bluetooth LE and other wireless protocols, including at 2.4 GHz and below 1 GHz.

NXP Semiconductors, which has developed software modeling kits with major computer-aided-engineering (CAE) simulation professionals, also maintains a wide range of kits based on development boards for its processors, power ICs, sensors, and motor-control devices.

One NXP design kit features its model 88W8801 single-band SoC transceiver for high-throughput Wi-Fi applications. The SoC radio contains a medium access controller, memory, and supporting circuitry within a 48-pin QFN package; the kit serves to speed and simplify voice, video, and multimedia applications. Host interfaces include USB 2.0 and SDIO 2.0 to connect the Wi-Fi radio to the host processor.

In a unique design arrangement for engineers learning how to apply FPGAs, such as those from Xilinx, Xylon developed kits based on its applications experience and intellectual property (IP), such as its logiADAK Automotive Driver Assistance kits. They integrate Xylon's logicBRICKS library of IP with the Xilinx Zynq-7000 SoC and Zynq UltraScale+ MPSoC development platforms for advanced driver-assistance system (ADAS) applications. They help realize ADAS solutions with the Xilinx devices by interfacing with multiple sensors, processing data from the sensors, and executing required communications.

The small sampling of RF design kits presented here are available at distinct levels. Many kits also are offered by simulation software companies as collections of models based on different circuit-board materials, semiconductor devices, and even semiconductor processes. Software provides a low-cost means of trying different circuit approaches in a virtual way, experimenting with differences in such parameters as dielectric constant (Dk), transmission-line type, and conductor thicknesses.

As circuits and devices head into the mmWave range, even minute design differences can mean major differences in performance and design kits, whether based on hardware or software. And they can provide lessons worth learning.