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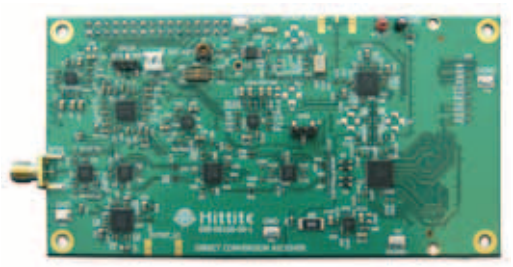

High Performance Programmable Direct Conversion Receiver Platform

For many years, the wireless industry has been seeking a generic RF receiver that could adapt its frequency of operation and bandwidth to the desired signal, digitize the signal at high resolution and then demodulate the signal in software. The coexistence of various cellular (2G, 3G and 4G) and microwave point-to-point standards and bands of operation around the globe have created a real and pressing need for a flexible, multi-carrier, multi-standard, modular radio design that can be configured on the fly. To date, the so-called Software Defined Radio has been an elusive target due to the practical performance limitations of RF hardware.

Hittite Microwave has integrated a number of its discrete components onto a single direct conversion receiver (DCR) demonstration evaluation board. Hittite's DCR platform design features unparalleled receiver flexibility with no sacrifice in the high performance of its discrete parts (see ***Table 1***). The DCR can be configured to operate with input frequencies from 700 to 3000 MHz, with fully field programmable I and Q baseband bandwidths anywhere from 3.5 to 50 MHz, or equivalently 7

TABLE I

TYPICAL PERFORMANCE OF HITTITE'S DCR PLATFORM

Parameter	*Typical Performance*
Operating Frequency Range	700 to 3000 MHz
Analog-to-Digital Converters	14-bit @ 105 MSPS 12-bit @ 320 MSPS
Programmable Bandwidth	3.5 to 50 MHz Baseband 7 to 100 MHz at the Antenna
Receiver Bandwidth Accuracy	±2.5% of the Programmed Bandwidth
Gain Control Range	0 to 90 dB
Input IP2	>+60 dBm
Receiver Image Rejection	>90 dB

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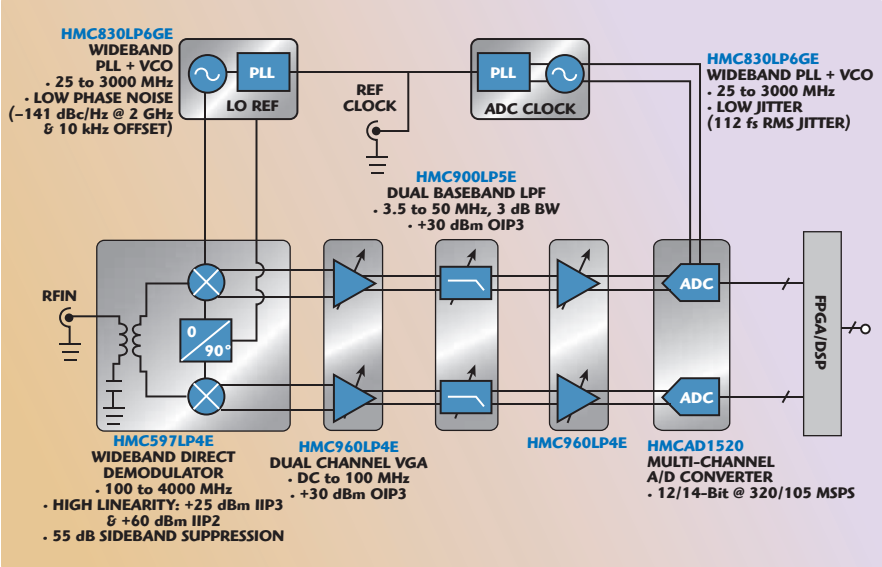


▲ *Fig. 1 Hittite DCR block diagram.*

to 100 MHz receiver RF bandwidths that are captured and digitized by Hittite's high resolution data converters.

The DCR features programmable analog filtering bandwidth accurate to ±2.5 percent, and up to 90 dB of baseband gain. Distributed adaptable gain provides optimal application-specific noise figure, blocker, and linearity performance – all software configurable.

Field configurable frequency of operation, bandwidth and gain make Hittite's DCR evaluation platform design an ideal subsystem receiver module for multi-carrier, multi-standard cellular base stations, microwave point-to-point radio, adaptive IF strips, wireless LAN, test equipment and software-defined radio applications. Programmable bandwidth and complete cellular frequency band coverage enable the DCR to be paired with a low noise amplifier, such as the HMC374E and an RF bandpass filter, to form a complete cellular receive chain with a low noise figure. All of this is available with bandwidth, gain distribution and frequency of operation software configurable to comply with the cellular standards of today, and hardware ready to adapt to the standards of tomorrow.

The Hittite DCR platform presents an ideal IF receiver subsystem in a microwave radio. Wideband frequency of operation enables configurable microwave IF frequencies. Field programmable bandwidth enables operators to deploy the same platform while only adjusting the receiver bandwidth depending on the particular microwave standard and data rate requirements. The microwave radio bandwidth, IF frequency and gain distribution can be dynamically adjusted with software to optimize radio performance in the presence of new or existing blocker signals, thereby eliminating the need for a site visit and drastically reducing the cost of ownership.

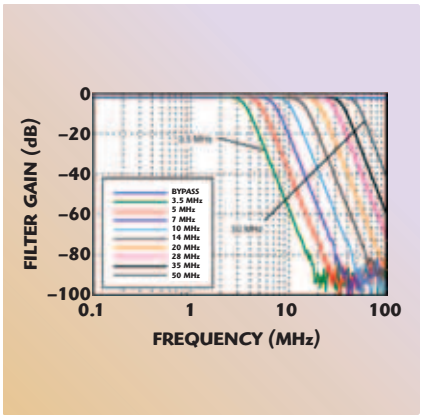
Being fully software field programmable, Hittite's DCR enables suppliers to offer a single hardware receiver platform across various standards, jurisdictions, and bands of operation and either pre-configuring or field configuring the receiver to suit each individual deployment. This capability significantly reduces cost and complexity of manufacturing, deploying and supporting standard and region-specific equipment. OEMs no longer need to source, design and manufacture multiple parts for each region or standard. Hittite's DCR enables the user to focus on one design that is configurable for all standards and jurisdictions that can be software field configured optimally for each application.

Hittite's DCR achieves flexibility by utilizing a homodyne receiver architecture with exceptionally high IP2 performance (> +60 dBm), which results in minimum baseband DC offset. Hittite's DCR block diagram is shown in ***Figure 1***. It includes a built-in receiver calibration algorithm that is capable of over 90 dB if receiver image rejection is after digital filtering. The calibration algorithm operates on the incoming data signal and does not require any receiver down time. Excellent IP2 performance and digitally calibrated receiver amplitude and gain mismatch enable Hittite's DCR to overcome the traditional challenges of direct conversion receiver architectures while reaping all of the benefits. The benefits include lower sampling rate requirement of the analog-to-digital converters (ADC), therefore, increasing ADC SNR, and, most importantly, removing the need for application and band-specific image rejection filtering.

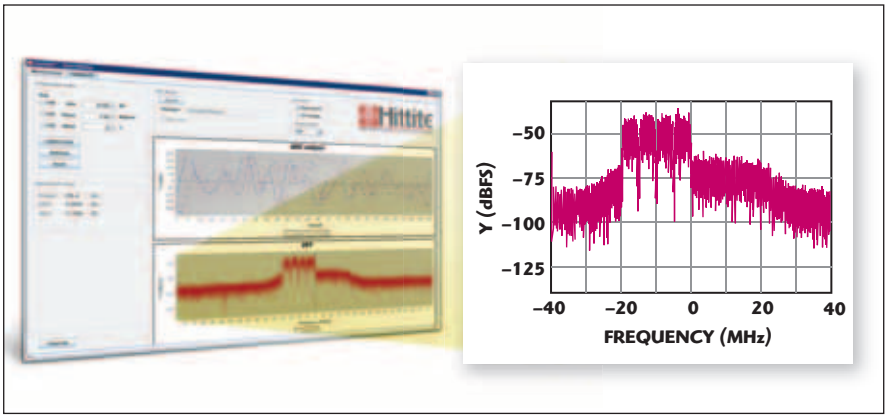
The HMC830LP6GE wideband PLL with integrated VCO is used as the local oscillator (LO) for the wideband RF demodulator (I and Q mixer) HMC597LP4E. A second HMC830LP6GE also provides an ultra-low jitter clock for the HMCAD1520 dual-channel ADC. The wide bandwidth PLL and demodulator enable operation over a wide range of input frequencies (700 to 3000 MHz) while maintaining the industry-leading phase noise performance, resulting in minimal receiver contribution to received signal EVM and ACPR. Exceptionally low jitter specification of the HMC830LP6GE (112 fs rms in integer mode) ensures minimum ADC aperture error and maximum SNR performance. The very low noise floor (<–170 dBc/Hz) further maximizes ADC SNR performance.

The integrated HMC900LP5E programmable sixth order Butterworth lowpass filter (LPF) allows the bandwidth of the DCR to be programmed anywhere from 3.5 to 50 MHz baseband (7 to 100 MHz RF) with ±2.5 MHz accuracy (see ***Figure 2***). The filter includes programmable 0 or 10 dB gain settings and has an output IP2 greater than +60 dBm throughout the passband, ensuring little contribution to ADC DC offsets. The high performance HMCAD1520 data converters minimize the need for gain in the receiver and also reduce the effects of DC offsets.

Two integrated HMC960LP4E dual-programmable variable gain amplifiers (VGA) provide the DCR with a total of 80 dB (40 dB each) of precisely



▲ *Fig. 2 DCR field programmable filter bandwidth.*



▲ *Fig. 3 Hittite's DCR receiving a multi-carrier W-CDMA signal.*

distributed programmable gain. Exceptional VGA Output IP2 of > +75 dBm throughout the band also ensures minimal VGA contribution to DC offset at the ADC. The VGA's low noise figure (NF) of 6 dBm, combined with large available gain, ensures little contribution from follow-on components to the overall noise figure of the receiver.

The integrated HMCAD1520 12/14 bit ADC with 70 dB SNR relative to full scale and 77 dBc SFDR excluding interleaving spurs (60 dBc including interleaving spurs) ensure excellent received signal SNR. Integrated programmable digital gain of the HMCAD1520 allows calibration of internal ADC gain errors. Often overlooked, ultra-low noise power supply regulation and isolation are critical to the success of a high performance DCR. The DCR includes three ultra low noise regulators: two HMC860LP3Es, one HMC976LP3E, and one HMC6048LP5E. These regulators supply full current while maintaining low noise densities, typically at the 3 nV/√Hz level.

An integrated HMC1031MS8E jitter cleaner PLL improves the quality of the reference signal, and provides reference clock flexibility and cost savings. The jitter cleaner allows the radio to lock to a standard low cost, low frequency crystal, while generating a locked internal reference at 1×, 3× or 5× frequency multiplication. The higher frequency reference generated by the HMC1031MS8E contributes to market-leading phase noise performance of the integrated HMC830LP6GE PLLs and, therefore, better SNR performance of the entire DCR, while saving the cost of a higher frequency crystal oscillator.

The DCR evaluation development kit includes a full software suite that enables complete control and configuration of all parts of the DCR (see ***Figure 3***). This flexibility enables system designers to observe and understand the effects and implications of any parameter on their overall system performance. In fact, the DCR can be connected via coaxial cable to a wide variety of Hittite evaluation boards, including high performance LNAs, or microwave demodulators such as the HMC977LP4E, to form a complete cellular or microwave radio receiver evaluation board. This capability allows designers to test and fine tune their system design under real-world conditions.

Hittite's DCR has addressed the classical challenges of direct conversion architectures. First, the DCR is composed of individual components with exceptionally high output IP2 performance, resulting in minimal second order distortion products and DC offsets. Second, the DCR utilizes a digital receiver calibration algorithm that does not require any receiver down time, and achieves over 90 dB of image rejection after digital filtering. The combination of market-leading components and a robust fully configurable design, makes the Hittite DCR evaluation platform an ideal starting point from which to design a modular, highly configurable, multi-standard multi-carrier receiver module.

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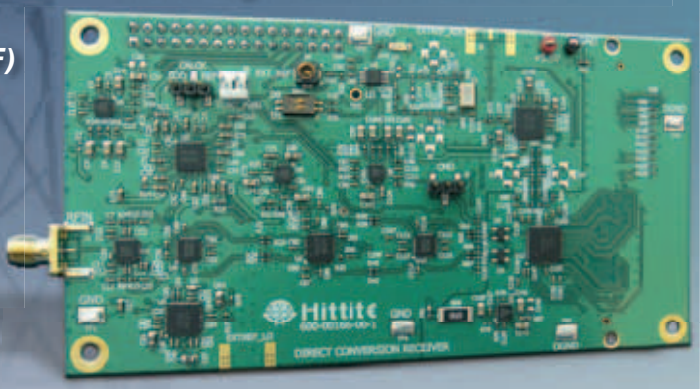
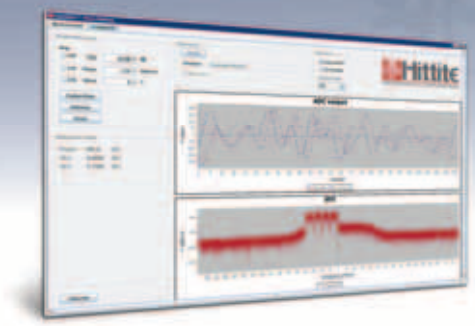
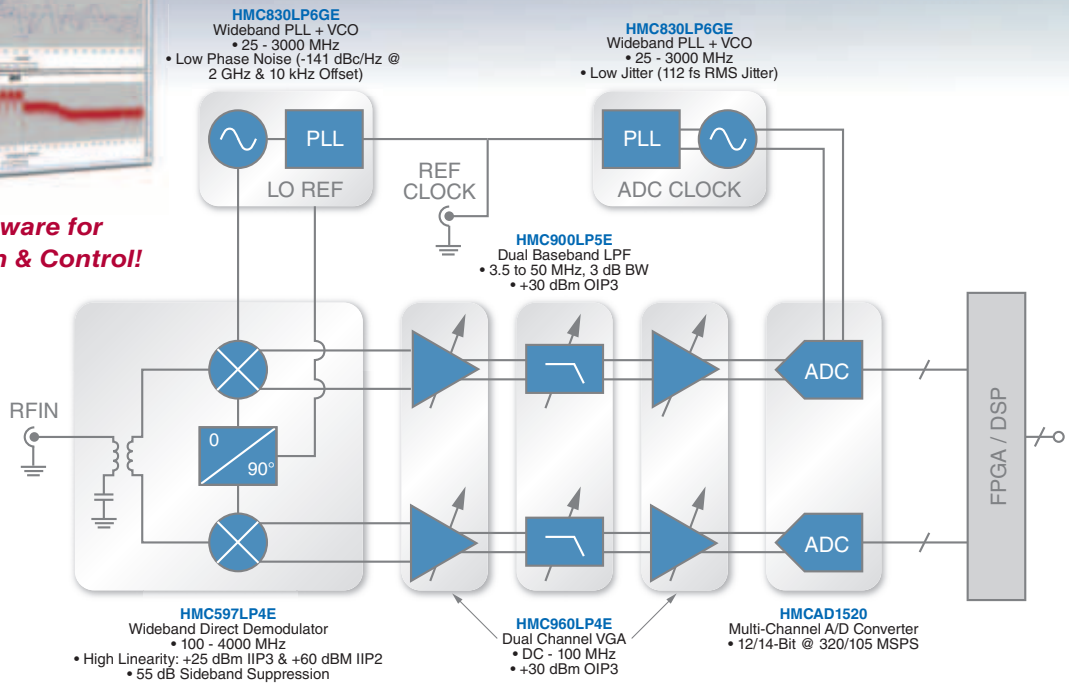




DCR Evaluation Software for Complete Configuration & Control!



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