Southwest Research Institute

Founded in 1947 as an independent, nonprofit research and development organization, Southwest Research Institute provides significant research, engineering, and testing resources for industry, business, and government. With 11 technical divisions and state-of-the-art laboratories, the Institute uses a multidisciplinary, integrated approach to solving complex problems in science and applied technology. Subject to the client's wishes, programs are kept confidential. As part of a long-held tradition, patent rights arising from sponsored research at the Institute are often assigned to the client. SwRI generally retains the rights to Institute-funded advancements.

Cover inset photo: *Laboratory demonstration of nonlinear compensation.*

An increasing number of radio frequency (RF) applications implement advanced system features and reduce system cost by combining multiple single-carrier applications into a single transmitter that broadcasts a multicarrier signal. Combining several carrier signals within the transmitter power amplifier creates large variations in the instantaneous output power, a condition described as high peak-to-average ratio (PAR).

The multichannel amplifier may exhibit nonlinear behavior as a result of the high PAR. Simulations have demonstrated that digital predistortion (DPD) of the input signal can improve multicarrier, high-power amplifier linearity.

Engineers at Southwest Research Institute (SwRI) are developing advanced algorithms and demonstration systems for digital predistortion. SwRI capabilities range from consulting to assistance in subsystem development and testing to full system design, prototyping, and validation.

Benefits

Digital predistortion offers the following benefits for multicarrier RF applications:

- Improves RF amplifier linearity
- Improves RF amplifier efficiency
- Supports higher RF amplifier output power
- Reduces adjacent and alternate channel interference

Applications

Digital predistortion is applicable to the following types of RF systems:

- Multicarrier RF cellular base station transmitters
- Satellite Earth stations and orbital vehicles
- Multichannel digital television broadcasts
- Multichannel cable television and video-on-demand applications
- Precision RF test equipment

Program Components

The SwRI digital predistortion program consists of four main components:

- Nonlinear compensation
- Memory effects compensation
- Linear compensation
- Crest factor reduction

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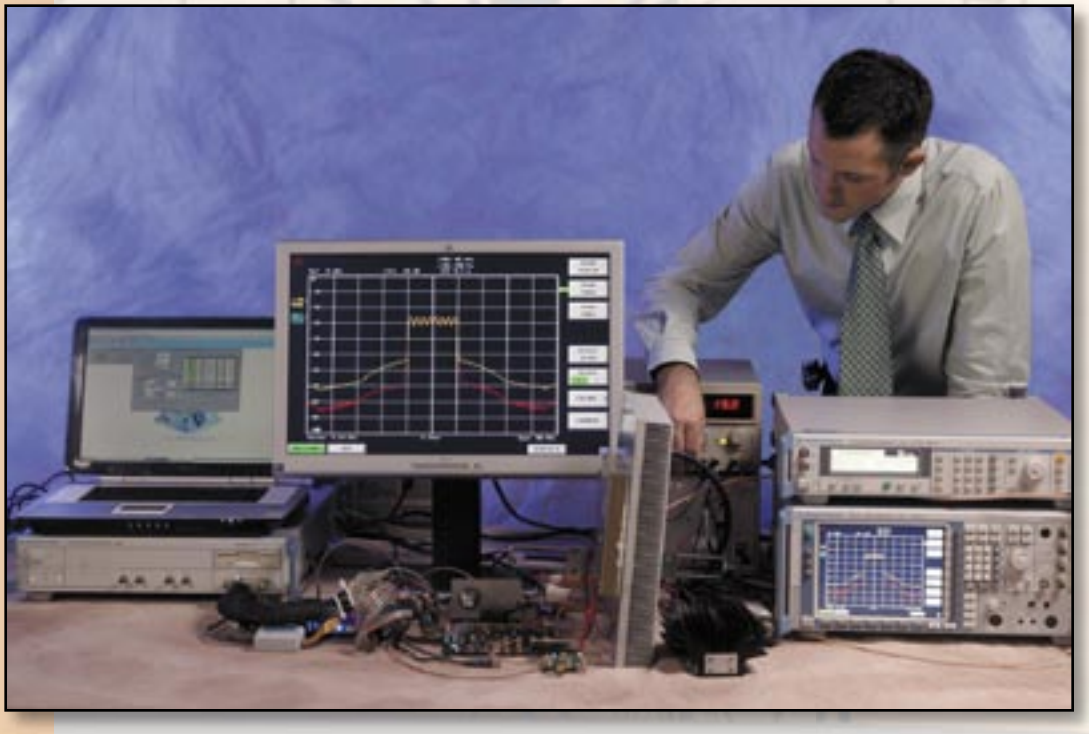
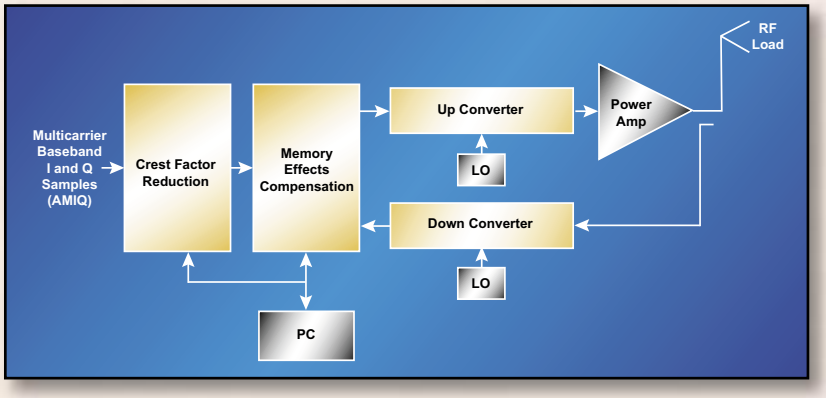
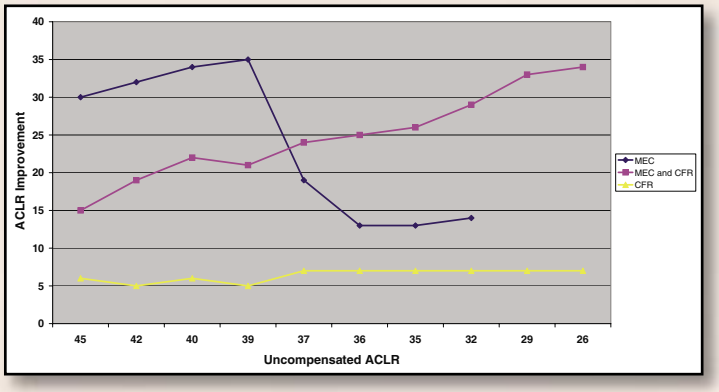


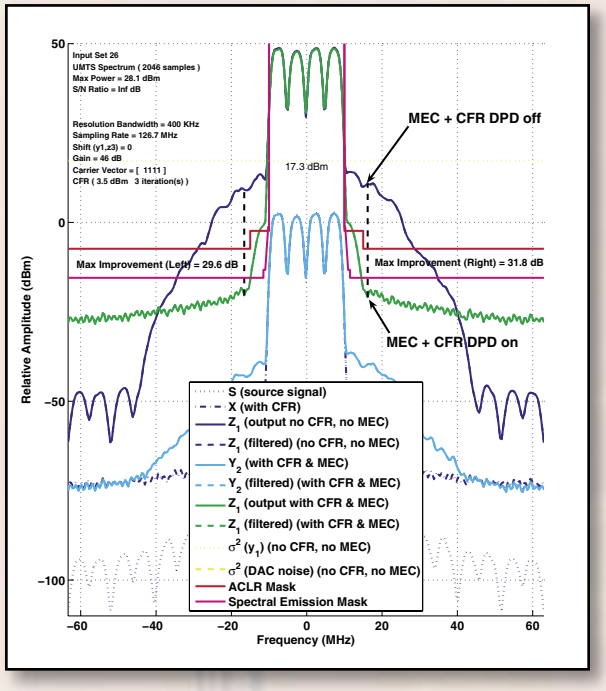
SwRI engineers develop a digital predistortion hardware-in-the-loop demonstration system.



SwRI engineers developed this advanced digital predistortion system architecture.



Digital predistortion simulated performance comparisons show adjacent channel leakage power ratio improvement.



This digital predistortion simulation system example shows the effects of power amplifier nonlinearities on the transmitted spectrum and the potential spectral benefits of digital predistortion.

Nonlinear Compensation

Nonlinear compensation is a method of digital predistortion in which each sample of the base-band input signal is adjusted for magnitude and phase distortion based on the instantaneous power level of that sample. The amount of distortion is estimated with a feedback system, and the compensation is usually implemented in a Field Programmable Gate Array (FPGA) for speed.

Memory Effects Compensation

Memory effects compensation builds on nonlinear compensation by taking into account several input signal samples at a time for improved performance. A significant amount of the nonlinear distortion in a typical amplifier is a function of the particular input signal level. However, in many high-power amplifiers, much of the nonlinearity is based on recent signal levels.

Linear Compensation

SwRI has developed feedback system algorithms for automatically calibrating the output signals for up-conversion even with broadband signals, where the image and local oscillator leakage are completely covered in the frequency domain by the main signal. Although these spurious signals may not be large enough in power relative to the main signal to cause problems in receivers, they become a problem in feedback-based nonlinear and memory effects compensation systems.

Crest Factor Reduction

SwRI has developed crest factor reduction algorithms that reduce the peak-to-average power ratio of multicarrier signals while minimally impacting the integrity of the signals. A number of methods can be used depending on system latency and loss requirements.

Software-Defined Radio

Digital predistortion is one of several enabling technologies for software-defined radio (SDR). SwRI engineers are conducting internal research and externally funded development projects in smart antennas, software architectures, and model-based design tools. Smart antennas can be used to control the directionality, band of operation, or other antenna parameters based on the current communication needs and operating environment. Software architectural trade-offs are critical for maximizing the benefits of SDR technology in the context of real-world system resources. The model-based design tools allow system engineers to make objective trade-offs and shorten system development time.

The software-defined radio demonstration system allows engineers to make objective tradeoffs.

Southwest Research Institute is an independent, nonprofit, applied engineering and physical sciences research and development organization using multidisciplinary approaches to problem solving. The Institute's main facility, located in San Antonio, Texas, occupies more than 1,200 acres and provides nearly two million square feet of laboratories, test facilities, workshops, and offices for more than 3,000 employees who perform contract work for industry and government clients.

Benefiting government, industry and the public through innovative science and technology

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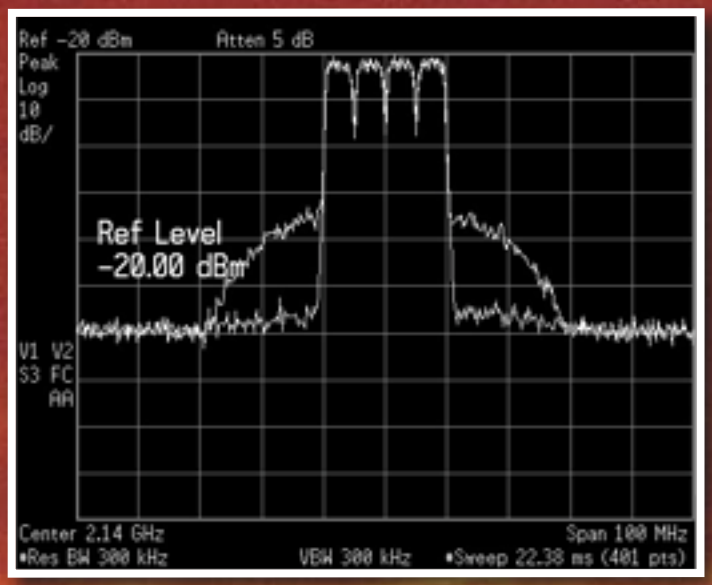
Digital Predistortion Technology

for RF High-Power Amplifiers



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