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Power Sources for RFIC Power Amplifier Testing

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THE RFIC power amplifier (RFICPA) is a critical element of most wireless devices. Therefore, each production unit must undergo thorough functional testing that requires both DC and RF measurements. In addition, performance must be tested in a way that accurately simulates portable (battery) operation. For example, the DC power supply used to source voltage to the amplifier bias pins must be capable of providing fast transient response similar to the expected operation with a battery. Furthermore, the DC supply should provide sufficient measurement resolution to read idle and power down current thresholds accurately. During product development, additional power source features are required for testing the wireless device that incorporates the RFICPA. (See sidebar.)

The quantity of RFICPAs manufactured each year is staggering. Cellular handset shipments last year totaled more than 400 million units, and with new generation phones requiring two or three RFICPAs, the annual production volume of power amplifiers will soon approach one billion. Because of these high volumes, it's imperative that manufacturers minimize production test time. This calls for a special purpose DC power source that satisfies the unique requirements of RFICPA functional testing.

Foremost of these power source requirements is wide bandwidth for "burst" communication protocols, such as TDMA and GSM. Load currents can jump virtually instantaneously from milliamp standby levels to full power transmission levels of 1-2A. The power supply must respond to these sudden changes with minimal transient voltage droop and recovery time. In many cases, manufacturers add capacitors to minimize these voltage droops. However, these capacitors also act as a current source, corrupting any attempt at measuring pulsed current power consumption. Using a fast transient power supply that minimizes voltage droop eliminates the need for these capacitors. In addition, a power supply that rapidly changes voltage on command will save precious test time.

To complicate things further, multiple voltage setpoints are needed for RFICPA testing to simulate different voltage stress

Keithley Model 2306-VS

conditions, such as when cellular phones are placed under charger conditions. Similarly, DC stress voltages are sometimes used to check quickly for die bond quality.

The power source should also function as a read-back power supply to measure voltage, fixed currents, and pulse load currents accurately. This eliminates the need for a separate instrument to measure power consumption. In addition to standby and transmission mode currents, the power supply should have sufficient resolution to monitor sleep mode currents. In today's battery operated products, a measurement resolution as low as 100nA is often required .

Avoiding the GPIB Bottleneck

The power source features just described are essential, but other production test issues, especially execution times, must be considered when selecting equipment. Measurement speed and test throughput depend to a great extent on how different elements of the test system are integrated and controlled. In automated test systems, using a PC for total control of all instruments may result in substantial and unpredictable latencies associated with Windows® and its communications features. Nevertheless, delay times and GPIB bottlenecks can be overcome by a power source that essentially runs itself.

The most important feature for minimizing GPIB usage and increasing throughput is the ability to pre-program power source test sequences. Today's RFICPA production tests are so complex, and the need for speed so great, that GPIB communications overhead is intolerable. Hence, the power source must be able to run from a stored test sequence that requires minimal PC intervention.

Power sources with this feature can be pre-configured and tests initiated with external trigger commands. For example, the user can pre-program voltage setpoint levels within power supply memory and simply use

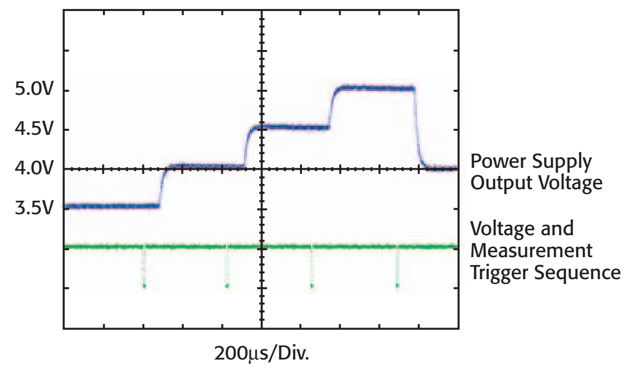

Figure 1. DC Voltage sourcing for RFICPA testing will include multiple voltage level changes simulating different battery conditions. For high throughput, the power source should quickly change voltage levels and provide automatic, trigger-synched current measurements after each voltage step.

the external trigger to have the power supply step through each setpoint. The result is a significant speed improvement, up to four times faster than GPIB control methods. Additionally, the ability to take automatic current measurements after each voltage transition can produce similar time savings. (See voltage sequence in ***Figure 1***.) The current readings can be stored in the power supply's buffer memory until requested by the PC test program.

External, hard-wired triggering allows tight control over signal capture timing for better measurement and load condition coordination. As a result, device manufacturers can achieve greater confidence in compliance testing results and provide more accurate specifications. The power source's trigger output can indicate event completion, which helps minimize delay times between trigger-in sequences. Combining the external trigger input with built-in test sequencing creates an extremely fast voltage supply and measurement instrument that minimizes the need for computer and GPIB interaction. The only GPIB activity is in downloading the test programs beforehand and uploading the buffered results to the PC afterwards, neither of which interferes with actual testing execution. KEITHLEY

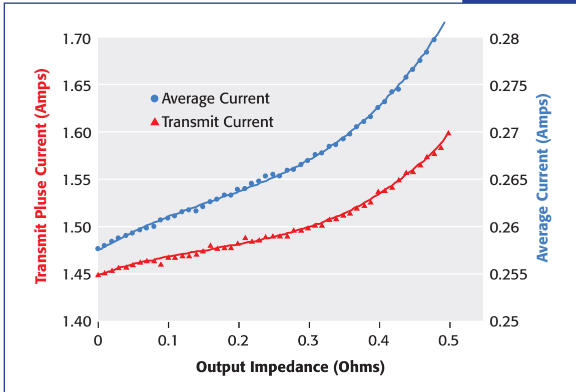

Figure 2. Transmit and average current consumption of a typical power amplifier used in a GSM handset during transmission with a power source simulating a battery with a nominal output voltage of 3.60V, and output impedance ranging from 0.00 to 0.51Ω.

Simulating Battery Impedance in R&D Testing

During wireless product development, a broader set of tests is required. The RFICPA tests described in the body of this article are typically part of the regimen, but it's also necessary to verify overall product performance under extreme operating conditions. One example is testing the power amplifier under conditions that occur near the end of the battery's useful charge.

The internal resistance of a battery varies according to a variety of factors, such as but not limited to chemistry, mechanical construction, number of charge/discharge cycles, temperature, and discharge state. To simulate this characteristic, a power source must have a programmable output resistance that can be varied for each battery type, and over the appropriate range of discharge conditions. Conventional power supplies can't adequately simulate these characteristics.

To simulate power consumption characteristics of an RF power amplifier, the transmit and average currents should be plotted over a variety of battery output impedance states (***Figure 2***). Since the average current consumption is strongly affected by the increase in the transmit current level, it shows a similar dependence on the output impedance of the simulated battery. Using this technique and additional measurement equipment, effects of the voltage drop can be investigated.

About the Author

Jerry Janesch is a product development engineer with the Telecommunications Unit of Keithley Instruments in Cleveland. His product involvement includes RF/Microwave switching and Fast Transient Power Supplies for testing wireless devices. He has a BSEE from Cleveland State University and an MBA from John Carroll University.

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