PXI-Based RF Antenna Testing System

By Timothy R. Brooks, Sierra Peaks Corporation

The Challenge:

Developing a cost-effective, portable system to generate modulated RF transmissions at specific times over a variety of frequencies, power levels, and modulation types.

The Solution:

Providing the ability to generate RF signals with a variety of parameters and transmit them through various signal paths at very precise times using a custom software application and modular instrumentation for flexible signal generation, signal analysis and verification.

Our customer needed a system capable of transmitting a variety of RF signals in a very controlled and flexible environment. We decided to build the solution on the modular PXI platform to minimize cost and size while maximizing performance and flexibility. The solution called for three systems – one portable system for field work, one static system for main testing, and one backup system to fill in for the static system in the case of a malfunction.

The payload waveform, which was designed using a separate custom application, can be modulated using AM, FM, PM, PSK, FSK, MSK, or QAM. We developed scripts to send these waveforms at specific times for specific durations. The script utility lets the user define virtually any form of looping, including iteration or time-based loops, frequency stepping, and power stepping; it also supports multiple payload waveforms. In addition to the payload waveform, a header waveform is transmitted during each step of the script that provides a GPS timestamp and other parameters.

Testing

To begin a test, the user runs a waveform creator to modulate a given signal using AM, FM, PM, PSK, FSK, MSK, or QAM. This software can run on any PC, and the resulting files are transferred to the system.

The system then designs a script in the main application to determine which waveforms will be played, the frequencies to play them at, the power levels to use, and the timing between each step. As an example, a typical script might call for waveform A (modulated using FSK) to be played at frequencies from 10 MHZ to 70 MHZ in increments of 10 MHZ with a 30 millisecond delay between transmissions. Each of these cycles might be transmitted at powers from 100 W to 500 W in 100-watt steps. The entire script might then be repeated for waveform B (modulated as PSK).

The user then runs the script by loading the waveform into a PXI 2.7 GHz RF Vector Signal Generator (VSG) and setting it to trigger from the GPS card. The GPS card is loaded with the appropriate times for each transmission to begin. Using GPS for the timing allows extreme accuracy in transmission start times.

Diagnostics and Other Features

Signal diagnostics are fully integrated into the system, which uses a PXI 2.7 GHz RF Vector Signal Analyzer (VSA) to provide a pseudo-real-time FFT of the transmitted signal, and two PXI RF Analyzers cards to provide forward and reflected power measurements. Diagnostic scripts define a system baseline that measures power and voltage standing wave ratio (VSWR) at various frequencies. A periodic system check is performed and compared to the baseline to ensure that all system components are functioning correctly. Power output is corrected over the entire frequency range via a power calibration mode.

For any given transmission, the software chooses one of 12 antennas based on frequency. RF relays accomplish antenna switching, which is controlled by a PXI digital I/O module. The digital I/O module switches the signal path into a dummy load for baseline and calibration modes.

Using a manual mode screen, the user operates each of the instruments independently to test various aspects of the system in an R&D mode. This feature combines with the signal diagnostics and remote access provided by Windows XP Remote Desktop so the user can operate the system with confidence from hundreds of miles away. With a scheduling utility, the user can schedule given scripts at any time in the future so the system can run unattended. In this way, users can remote in and apply all of the settings necessary for months of unattended testing.

System security and user monitoring are provided in two layers. Standard security measures such as a firewall to the Internet and Windows XP accounts provide the first layer. An access system in the software application requires users to log into the system separately provides the second layer. Three levels of user security provide differing functionality for different users. The system logs out a user after a given period of inactivity, but lets the system continue running scripts.

Because the system is considered mission-critical, backup power and a backup system are included. The system automatically switches between backup power sources, including solar, battery, and generator, with no power interruption. The backup system is an identical PXI system that a user can switch to by simply moving the antenna cables from one rack to the other in case of a problem with the primary system.

The PXI RF Platform

The initial design of this system used GPIB rack-and-stack equipment rather the modular PXI platform. The switch to PXI moved the portable version from a trailer into a box that can be checked as airline baggage. The cost savings (after selling the rack and stack equipment) was enough to pay for a third system in entirety with money left over. Furthermore, with PXI, we could add much more advanced scripting by driving the signal generator from the GPS card – a significant performance benefit.

With the PXI platform and RF instruments we were able to design and implement a system that was not feasible only a few years ago. With the open-standard nature of the PXI bus, we could make additions from multiple vendors to meet needs for features such as GPS time synchronization and simple RF power measurement.

Graphical Programming Flexibility and Power Combined with PXI

A great example of the benefits of Graphical Programming and PXI came during system development, when we needed to verify the signals we were sending. There was no hardware set aside for demodulating and analyzing our signal. Our customer thought that RFSA stood for an RF spectrum

analyzer that we had used to replace an old rack-and-stack spectrum analyzer. We pointed out that RFSA actually referred to a RF signal analyzer, which has capabilities far beyond a spectrum analyzer.

When we used the PXI RFSA to demodulate and decode a signal by writing a simple program using a Modulation Toolkit, our customer was pleasantly surprised – not only was the PXI RFSA much smaller and cheaper than the older unit it replaced, but it was also a much more flexible instrument. By combining the RFSA with Graphical Programming and the Modulation Toolkit, we far exceeded our customer's expectations in the analysis department.

Author Information:

Timothy R. Brooks

Sierra Peaks Corporation

4801 Lincoln Road NE

Albuquerque, NM 87109

United States

Tel: (505) 301-8330

tbrooks@sierra-peaks.com