As satellite systems move to higher frequencies and wider bandwidths, the key challenges are in the characterization of the components and systems needed to meet requirements such as greater data capacity and throughput. Also, given the dramatic increase in the satellite population and the increasingly complex electromagnetic environment, detection of interference signals is emerging as a crucial capability for satellite operators and regulatory agencies. This includes the acquisition and characterization of intermittent or transient signals.

Spectrum analysis is fundamental to the design, verification and manufacturing of satellite components and systems. It’s also an essential tool for interference detection. As satellites evolve, test methodologies are also evolving beyond traditional continuous-wave (CW) tests. With a streamlined multi-touch user interface (UI), wider bandwidth and application software, the Keysight PXA X-Series signal analyzer offers the tools you need to design, test and deliver your next breakthrough in satellite communications.
Applying tools that address the major challenges

In today’s environment, signal analyzers are essential measurement tools in the design, verification and manufacturing of satellite components and systems. They also simplify interference detection. When used with a Keysight X-Series signal analyzer, the 89600 VSA software offers a comprehensive set of tools for demodulation and vector signal analysis. These tools enable you to explore virtually every facet of a signal and optimize your most advanced designs. The optional real-time spectrum analyzer (RTSA) capability available for X-Series signal analyzers ensures greater confidence in interference detection by capturing intermittent or transient signals as short as 3.57 µs.

Today’s newest signal analyzers also offer an enhanced user experience. For example, the touch-enabled user interface (UI) technology widely used in smartphones and tablets has been adapted to the large displays that are increasingly common in signal analyzers. With touch capability, access to rich functionality in measurement, display and analysis no longer requires a deep, complex hardkey/softkey UI. Measurement settings and displays are easily controlled using familiar gestures such as single or double tapping to select a parameter or expand a window; dragging and pinching to zoom and scale a display; and using press-and-hold to access context-sensitive selections. As a result, signal analyzers now provide new levels of interaction that enable intuitive connections between cause and effect during development, debugging and troubleshooting.

Producing multiple simultaneous results in power amplifier testing

In every satellite system, the transmitters and transponders include a power amplifier (PA) that boosts RF signals. To improve power efficiency, the operating power will always be near the saturation point, and this increases the likelihood of distortion. The nonlinear behavior of a PA is commonly tested using AM/AM and AM/PM results, and these highlight the transformation of input amplitude variations into variations in output amplitude and phase.

Traditionally, these measurements have been performed using two-tone testing in a network analyzer. As bandwidths increase, however, this becomes less indicative of PA performance in the real world. Making the measurements using a realistic test signal introduces different challenges. For example, when measuring the nonlinear effects of spectrum regrowth in a PA, the signal analysis bandwidth must typically be three to five times that of the modulated-signal bandwidth. With the availability of 510 MHz analysis bandwidth, the PXA can satisfy satellite test requirements for the characterization of power amplifiers with bandwidths greater than 100 MHz.

Through a simple stimulus/response measurement using the 89600 VSA software (Figure 1), you can simultaneously view AM/AM, AM/PM, gain compression, and delta error vector magnitude (EVM). There is also a polynomial curve fit to the AM/AM, AM/PM and gain compression data, and you can export the coefficients of the polynomial for further processing, such as digital pre-distortion.

Frequently Used Settings Available on Touchscreen

The Keysight Technologies, Inc. X-Series signal analyzers with multi-touch provide a touchscreen UI that includes features such as drop down menus and customizable user menus. Rather than navigating through hardkeys, softkeys and long menus, most of the capabilities can be accessed with the tap of a finger. In addition, many frequently used display settings can be modified in the menu bar, measurement bar and annotation hotspot areas. It’s as easy as tapping the settings tables and diagrams, or you can interact with the selected trace by stretching, pinching, dragging or tapping.
Simplifying group delay measurements on frequency converters

Satellite communication systems depend on the performance of frequency converters. As data rates increase, so do the requirements on frequency response magnitude and phase through each converter. Group delay is another crucial performance factor.

Using the 89600 VSA software, Option BHL, channel-quality measurements, enables you to make group delay measurements using a signal analyzer. This capability uses a multi-tone signal as the stimulus and allows you to calibrate out the effects of the system setup. Displayed measurement results include the frequency response (magnitude and phase) and group delay (Figure 2).
Accurately characterizing noise figure in low-noise amplifiers

In satellite transponders and earth-station receivers, a low-noise amplifier (LNA) is usually the first stage of the system, amplifying weak incoming signals. Because the noise figure of an LNA affects the noise levels in the overall system, accurate noise figure measurements are essential.

The X-Series noise figure measurement application (N9069C) can be quickly accessed through the PXA’s multi-touch UI (Figure 3). This configuration provides one-button operation and includes a built-in uncertainty calculator. When using Keysight smart noise sources with low excess noise ratio (ENR) uncertainty along with external USB-powered preamplifiers, an X-Series signal analyzer can make noise figure measurements with high accuracy. Within the PXA, the foundation of these measurements is the purity and frequency stability provided by the direct digital synthesis local oscillator (DDS-LO) that improves the analyzer’s underlying phase noise performance.

Assessing the modulation accuracy of standard and custom signals

At the system level, the measurement of modulation accuracy is essential to thorough characterization of satellite signals. Key measurement results include EVM, I/Q offset, quadrature error, and gain imbalance. The 89600 VSA software supports all the regular modulation types used in satellite communication: QPSK, QAM, and APSK. In addition, the 89600 VSA can also be used to demodulate custom modulation schemes through creation of your own I/Q maps. For example, you can demodulate a custom 32 APSK signal by defining ring magnitude (for spacing), ring phase, and the number of constellation states for each ring (Figure 4).
Enhancing interference detection with real-time analysis

With the increasingly complex electromagnetic environment in space and on Earth, interference detection is a serious issue for satellite operators and regulatory agencies. Traditional satellite monitoring systems, which are based on swept-frequency technology, work well when detecting interference that will be present on the transponder for a significant amount of time. However, for unintentional interference such as air-to-air radar signals with low duty cycles, the system’s sweep rate will limit its ability to detect such signals.

Real-time spectrum analyzer (RTSA) capability provides gapless analysis at bandwidths up to 510 MHz in the PXA. This lets you see, capture and understand the most elusive signals—known or unknown. In the RTSA mode, the large touchscreen and multi-trace displays make it easier for engineers to create multiple, simultaneous views of complex signals. An example of satellite monitoring is provided in Figure 5 with 12 satellite channels, affected by interference from nearby radar signals (1/10 duty cycle). The interference signals were captured and clearly displayed on the screen.

Figure 4. Digital demodulation in the 89600 VSA software enables detailed analysis of a corrected, custom 32 APSK signal.

Figure 5. RTSA enhances the detection of elusive and intermittent interference signals.
You can also focus on signals of interest using mechanisms such as frequency-mask triggering (FMT) and time-qualified triggering (TQT). When used with the 89600 VSA, it is easy to capture an interference signal, play it back, and perform deep analysis (Figure 6).

![Graph](image-url)

**Figure 6.** Through capture and playback, the 89600 VSA software enables detailed analysis of interference signals.

**Conclusion**

X-Series signal analyzers are the benchmark for accessible performance that puts you closer to the answer by easily linking cause and effect. Across the full spectrum—from CXA to UXA—you’ll find the tools you need to design, test and deliver your next breakthrough.

With measurement options that range from excellent to exceptional, the multi-touch PXA accelerates innovation in satellite components and systems. The available software options include X-Series measurement applications that provide proven, ready-to-use measurements and the 89600 VSA software that enables comprehensive demodulation and vector signal analysis. As satellites become more complex with wider bandwidths and more potential for interference, the PXA can help you link cause and effect and put you closer to the answer.
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