Keysight Technologies
Adapt to Evolving Standards and Technology with Instrument Upgrades
Extending frequency range, bandwidth, and options of X-Series signal analyzers
Introduction

Wireless applications are constantly evolving but for most R&D and manufacturing operations the inventory of test equipment is a relatively fixed set of assets. Test solutions must be evaluated and configurations chosen at time of purchase, with limited visibility of future needs. Nonetheless, the one constant of wireless is change, and for signal analyzers there are several approaches for adapting to evolving needs:

- Software updates can add measurement functionality, though these changes do not change fundamental equipment characteristics such as bandwidth, operating frequency range, and sensitivity.
- Existing instruments can be sold or traded as part of the process of purchasing new equipment with the required frequency range, bandwidth, etc. Unfortunately this approach can be expensive in terms of transaction costs and time, and disruptive in terms of inventory tracking when asset and serial numbers change. In addition, instrument changes can create problems with test program software compatibility.
- Modular test equipment can offer the opportunity to change fundamental equipment characteristics. In many cases separate modules are used to implement RF front ends, IF sections, digitizers, and more. New modules can meet new measurement needs, though their acquisition and management may involve similar processes to the purchase and trade of separate instruments as described above.

A well-established alternative to the choices above is to upgrade existing instruments, especially their hardware, using available manufacturer-provided options. In the past, however, most of these options have been limited to smaller hardware assemblies such as preamplifiers to improve sensitivity, frequency references, and external IF or mixer connections.

The hardware and firmware architecture of the Keysight X-Series signal analyzers enables a much wider range of upgrades, including fundamental characteristics such as frequency coverage and analysis bandwidth. These upgrades provide access to the full range of capabilities for each model in the series. With the included calibration and guaranteed specifications, the original purchase decision can be updated to match current measurement needs.
Extending Frequency Range to Microwave and Millimeter Bands

The majority of cellular and wireless data services to date have used bands in the ultra high frequency (UHF) 300 MHz to 3 GHz per International Telecommunication Union (ITU) designation frequency range. These frequencies provide an effective combination of transmission range and payload capacity. However, this frequency band has become increasingly crowded, to the point of saturation in some areas. Compounding this, the demand for wireless data access via cellular and WLAN/ISM services continues to grow rapidly. Improvements in spectral efficiency are a limited solution, and the long-term trend is toward the additional use of microwave and millimeter frequencies.

Measurement of UHF fundamentals can be performed with the base frequency ranges of most RF signal analyzers, though the corresponding measurements of harmonic and spurious performance often require extended analyzer frequency coverage. These distortion and interference measurements and associated regulations are becoming more important due to an increasingly crowded microwave spectrum and the growing potential for interference.

The use of microwave and millimeter frequencies is growing, including some LTE bands at 3-4 GHz and the ISM band at 5.8 GHz. Both the use of higher fundamental frequencies and the increased scrutiny of out-of-band emissions will require signal analysis at frequencies to 10 GHz and beyond.

The base frequency range of all X-Series signal analyzers is 3.6 GHz, implemented with fundamental mixing. Higher frequency coverage is achieved with harmonic mixing. A preselector is added to remove mixing images from the analysis, and a preselector bypass capability can be added for wideband and real-time analysis.

In the X-Series signal analyzers, frequency upgrades are available to change any originally-purchased frequency range to any higher frequency range for that model of signal analyzer. Common frequency upgrades for wireless applications are 8.4, 13.6, and 26.5 GHz. Millimeter frequency coverage is also available as an upgrade, extending coverage as high as 50 GHz with coaxial inputs and internal mixing. External mixing can be added to several analyzer models to extend coverage to 110 GHz using Keysight’s Smart Harmonic Mixers, and to 1.1 THz with third-party mixers.

Frequency upgrades are performed at Keysight service centers and include calibration. Some upgrades will involve a change in the front panel connector and require a minor change in connection to the test system.

Increasing Analysis Bandwidth to Handle New Standards

Traditional swept spectrum analysis does not require wide bandwidths or digitizers, needing only digitizers that can support the widest available resolution bandwidth (RBW). Common measurements of this type include harmonic, intermodulation, and spurious, often grouped under a spectrum emission mask (SEM) specification.

Wide bandwidth IF sections and digitizers may use DSP to improve sweep speed for SEM measurements, but the main requirements for a wide IF section (wide instantaneous bandwidth) are associated with demodulation, adjacent channel power (ACP), and pulse measurements. Wide IF sections are also needed for real-time spectrum analysis (RTSA).
Evolving wireless standards have implemented a rapid and consistent progression in channel bandwidths. While some early data services were provided through channels spaced for voice services at 15 kHz, new generations of mobile standards have progressively implemented wider bandwidths to meet payload requirements. The widest channels in current standards such as LTE and IEEE 802.11ac WLAN are around one to ten thousand times wider than the original voice channels.

In addition, these wide-bandwidth requirements may be further extended by requirements for frequency agility, spread spectrum, and carrier aggregation.

Analyzers that were purchased for narrowband spectrum analysis or earlier wireless standards may benefit greatly from upgrades that increase instantaneous analysis bandwidth.

The instantaneous bandwidth of the signal analyzer also determines its acquisition bandwidth when used with the 89600 VSA software, including bandwidth for time capture operations. Since the VSA software allows center frequency and span to be changed in post-processing after capture, additional bandwidth can enable the analysis of multiple different channels or aggregated channels from a single wide capture.

Several bandwidth upgrades are available for most X-Series signal analyzers, extending to 160 MHz or the maximum bandwidth offered on each instrument (up to 510 MHz on the UXA).

Finding Elusive Signals and Transient Behavior: Adding Real-Time Analysis

The modern spectral environment is crowded and highly dynamic, with signals that may be deliberately or accidentally agile, or whose behavior is unknown. Real-time spectrum analysis (RTSA) is a powerful tool for dealing with the challenges of this environment and characterizing the most elusive signals and behavior.

![Figure 1. The density display of an RTSA measurement uses color to represent how often signals appear at different frequencies and power levels.](image)
Earlier real-time analyzers were implemented as dedicated tools, but the architecture and signal processing in Keysight’s X-Series signal analyzers allow the capability to be added as an option to all PXA and MXA models.

Available real-time bandwidth is determined by the analysis bandwidth as originally installed or upgraded. A minimum analysis bandwidth of 85 MHz is required for RTSA. Signals as brief as 5 ns can be detected, and minimum duration for 100% probability of intercept is as short as 3.57 µs. The following table describes the available real-time bandwidths and minimum signal durations.

<table>
<thead>
<tr>
<th></th>
<th>PXA</th>
<th>MXA</th>
<th>UXA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum real-time</td>
<td>85 or 160 MHz</td>
<td>85, 125, or 160 MHz</td>
<td>255 or 509.5 MHz</td>
</tr>
<tr>
<td>analysis bandwidth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(determined by analysis bandwidth option)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum detectable signal duration with Option RT2</td>
<td>5 ns (Option B1X)</td>
<td>5 ns (Option B1X)</td>
<td>3.33 ns</td>
</tr>
<tr>
<td>(in all display types)</td>
<td>11.42 ns (Option B85)</td>
<td>8 ns (Option B1A)</td>
<td>(Options B5X/B2X)</td>
</tr>
</tbody>
</table>

Precise measurement of transient or agile signals often requires triggering, and the RTSA options include both frequency mask triggering (FMT) and time qualified triggering (TQT). These two trigger types can be used separately or together, allowing both time and frequency criteria to be evaluated in real time to accurately focus analysis on the signal in question. Since triggering happens once the criteria have been met, a negative trigger delay can be used to align analysis with the desired data acquisition window.

Real-time triggering can also be used with the 89600 VSA software as discussed in the Measurement Applications and Vector Signal Analysis Section below to initiate a time capture operation for later post-processing including any or multiple analysis types.

**Adding an Internal Preamplifier to Increase Sensitivity**

Preamplifiers improve effective analyzer sensitivity and can be especially useful at higher frequencies where losses between the DUT and analyzer increase. Smart (USB powered and controlled) external preamplifiers are available for all X-Series signal analyzers.

Internal preamplifiers are available for each frequency range of all X-Series signal analyzers, and can be added as upgrades to match existing or upgraded frequency ranges. If no frequency upgrade is performed, the preamplifier upgrade requires only a license key, and no return to a service center. The preamplifiers are switchable in the signal path, under front panel, or program control.

For both internal and smart external preamplifiers, their gain is automatically accounted for in signal measurements and their effect on amplitude accuracy and sensitivity is included in the analyzer specifications.
Keeping Analyzers Current: Upgrading CPU, I/O Ports, Solid-State Drives, and Operating System

The PC-based X-Series signal analyzers can easily be kept current in terms of processing power, memory, interface connections, and operating systems via a variety on infrastructure upgrades. CPUs and external interfaces (LAN, USB, video) are integrated into a single, removable module, shown in Figure 2.

CPU disks, including solid-state drives, are upgradable and exchangeable as separate assemblies from the CPU. Both CPUs and disks are user-upgradable from the rear panel.

Measurement Applications and Vector Signal Analysis

Standards-based and general-purpose measurement applications can be easily upgraded or added to any X-Series signal analyzer. The measurement speed of some computationally intensive applications such as demodulation may benefit from CPU and memory upgrades.

Figure 3. Both general-purpose and standard-specific measurement applications can be added to X-Series signal analyzers. Applications, such as this LTE example, are updated as standards evolve.
All X-Series signal analyzers are compatible with Keysight’s 89600 VSA software for advanced signal analysis and compatibility with emerging communications standards and design software such as MATLAB and SystemVue.

The VSA software integrates with RTSA to leverage the capabilities of the frequency mask and time qualified triggers. These triggers can be used separately or in combination to initiate any type (or multiple types) of analysis. Triggering can be used with positive or negative trigger delays, and triggering can initiate deep, wideband signal recording. Recordings can be post-processed to perform multiple types of analysis simultaneously. Signal analysis center frequency and frequency span can both be changed during playback (after recording), allowing for separate analysis of multiple signals in the recorded span.

Summary

The complexity and fast evolution of wireless applications demand adaptability in the test equipment used for development and manufacturing. Equipment upgrades, when available, are an effective way to meet these needs as they arise. Upgrades are simpler and less expensive than the purchase of new equipment, and they preserve the productivity and value of test assets.

Extensive upgradability is designed into the Keysight X-Series signal analyzers, providing after-purchase access to the full range of capabilities and performance for each model in the series. The combination of hardware and software upgrades allow earlier test equipment choices to be updated to match the latest measurement needs.

For more information and a full list of upgrades, go to:

www.keysight.com/find/UXA_upgrades
www.keysight.com/find/PXA_upgrades
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