APPLICATION NOTE

Faster Spectrum Measurements for X-Series Signal Analyzers

Improving measurement speed is key to reducing test time in automated environments

KEYSIGHT

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Introduction to the Speed Topic

Recent improvements in Keysight's X-Series Signal Analyzer software and hardware have led to increased speeds when making spectrum and demodulation measurements. This application note explains the theory behind these improvements and provides performance comparisons, use cases, and tips to get improved measurement speeds from your analyzer.

Best Practices for Achieving Fastest Measurement Speed Throughput

It is good to be mindful of simple techniques to reduce the time that measurements take. If you can save 10 milliseconds for a measurement and make that same measurement a thousand times, then you can save 10 seconds in total. Below are some practical time-tested techniques for saving time.

Turn off display (for automated testing)

In an automated environment, it is not often necessary for the display on the instrument to be updated. However, sometimes automated programs will grab screen images for report purposes, where leaving the instrument display on is necessary. Otherwise, turning off the instrument display saves time, especially for complex displays for measurements like for modulation analysis for 5G NR and Wireless LAN. Turning off the display saves more time for CXA and EXA analyzers that use the lower cost CPUs as opposed to the higher performance CPUs used in MXA, PXA, and UXA. The SCPI command to turn off the display is "DISP:ENAB OFF". To turn on the display, use "DISP:ENAB ON".

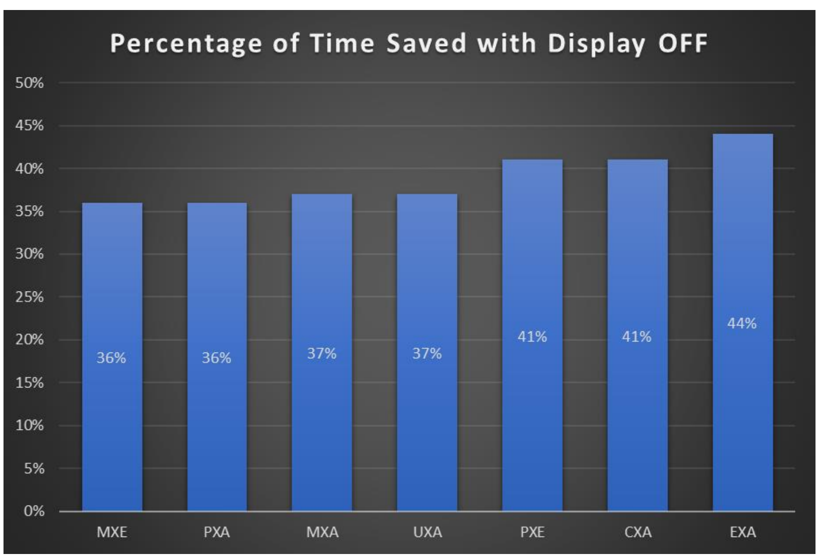

Figure 1. This graph shows the percentage of time saved on an example set of measurements while the display is OFF compared to it being ON. Time-savings will vary depending on use case.

Put the analyzer in single sweep

When the analyzer first boots into the Spectrum Analyzer mode, or when you press the green preset button, or when you send the remote SCPI command “SYST:PRES”, the analyzer is by default in continuous sweep. However, when remotely controlling the analyzer, precious time can be wasted by the analyzer finishing up a sweep or measurement prior to making the intended measurement. You can use the “:ABORT” command to cease the previous measurement. At the beginning of a test sequence, send the command, “INIT:CONT OFF” to put the analyzer in single sweep. Sending the “*RST” command (instead of the “SYST:PRES” command) will also put the analyzer in single sweep after doing a mode preset. After you have set up the measurement you want, initiate the measurement by sending a “READ:<measurement>?” query, “INIT:IMM;*WAI”, “INIT:IMM;*OPC?, or other appropriate command.

Minimize number of transactions

Each transaction (instruction sent to the instrument) takes time to accomplish. The instruction needs to be sent and then interpreted and applied. Minimizing transactions will decrease time used. This can be accomplished by writing multiple SCPI commands on the same line instead of writing them on separate lines that may require reinitialization. We demonstrated this in the previous section by mentioning that you can combine the “INIT:IMM” and “*WAI” commands as one transaction, “INIT:IMM;*WAI”. You can also combine other commands such as “INIT:CONT:OFF;:ABORT”. You can even combine multiple queries together and read back the results all at once. For example, you can have the analyzer perform a channel power measurement and an EVM measurement and then read back the results from both queries at once by sending “READ:CHP?;:READ:EVM?”. The analyzer’s measurements within a specific measurement application are set up such that they can be configured individually. So, you can send all of the setup parameters for the Channel Power measurement such as “SENSE:CHP:FREQ:SPAN 1 MHz”, and you can setup all of the parameters for the Adjacent Channel Power measurement such as “SENSE:ACP:FREQ:SPAN 1E9”. Once you setup the measurements you will be making, then simply make each measurement “READ:<measurement>?” Whenever you need to change a parameter (such as frequency), then just set that parameter without resending the setup for other parameters that you have already set. For the power user, you can even save a transaction by adding in the optional frequency parameter for the READ query: “READ:<measurement>? {<frequency>}”.

Importantly, do not add in extra “*RST” reset commands. This wastes time for the instrument to both perform the mode reset and for the measurement being setup again. When switching modes and then switch back to the mode you were in previously, it is not necessary to set up the various measurements again, since the analyzer will retain the settings for that mode.

A common habit with SCPI command users is to write their automation test sequence and get it working and then stop. Go back over your test sequence and look for patterns and ways to do the various test sequences more efficiently. Most likely you can speed up the way a test sequence is done. For example, if you are making measurements at three different frequencies, instead of making a CCDF measurement at the three frequencies and then making an EVM measurement at the three frequencies, save time by measuring CCDF and EVM at the first frequency before making a CCDF and EVM measurement at the second frequency. Any time you change the frequency of the analyzer, it takes time to tune the Local Oscillator of the analyzer.

Avoid extra “*WAI”s and “*OPC?”s and sleeps

Many customers add in extra “*WAI” commands and extra “*OPC?” queries. Most SCPI commands for X-Series Analyzers are blocking commands, which means that if you send any subsequent commands, the response is held off until the previous command returns its results. Adding in extra “*WAI”s and “*OPC?” queries doesn’t do anything except take extra time. There are some commands that aren’t blocking commands, such as the “INIT:IMM” command. This comes in handy to be able to send the “:ABORT” command if you need to stop a long sweep from completing. The only time you need to add in a “*WAI” or “*OPC?” is directly after an “INIT:IMM” command. Resist the urge to add in wait statements or sleep statements in your code. A couple of places you see people add in wait/sleep statements is after an “INIT:IMM” or after a command that takes a relatively long time to complete such as “CAL:ALL?”. For the “INIT:IMM” you can use the “*OPC?” query and read back the result when the sweep is complete. For “CAL:ALL?”, you can increase your timeout to allow plenty of time for the alignment to complete. Alternatively, instead send “CAL:ALL;OPC” and then serial poll the Status Byte Register. Also, consider using “CAL:EXPIRED?” instead of “CAL:ALL?”. This saves time by having only the expired alignments run instead of running all alignments.

Reduce number of attenuator cycles

Each time a mechanical switch (such as the mechanical attenuators changes position), the analyzer must wait about 20 milliseconds for the switch to settle. The mechanical attenuators are quite helpful for adjusting the input power seen by the first mixer. Adding in attenuation can reduce internally generated second and third order products or can get the analyzers first mixer or final IF out of an overload condition.

In many situations it is possible to make good measurements without the need to make fine adjustments to the amount of attenuation chosen. Here are some examples:

- If measuring over more than one power level, it may be possible to use a single attenuation setting instead of multiple attenuation settings, especially if the measured power is well above the noise floor.
- Enable the use of the Full Bypass path when using the “Optimize EVM” functionality in the 5G NR and Wireless LAN for Modulation Analysis measurements.
- Avoid using the “CAL:ALL?” command to unnecessarily run all alignments. Instead, run all alignments at the start of a long test sequence, then set alignments to Partial using the SPCI command “CAL:AUTO PART”. With this, only those alignments that take less than a second or so will run automatically. Periodically, when it is convenient between test sequences, you can query to determine if alignments are needed by using the “STAT:QUES:CAL:COND?” query. Then use “CAL:EXPIRED?” to run just the expired alignments.

Consider using HiSLIP

The HiSLIP communication protocol has been available in the X-Series Analyzers since the A.15 software release. It is faster than its predecessor VXI 11.3. It is simple to change your previous VISA addresses from VXI 11.3 format to HiSLIP format by replacing the sub-address from "inst0" to "hislip0". For example, you would change "TCPIP0::localhost::inst0::INSTR" to "TCPIP0::localhost::hislip0::INSTR".

HiSLIP creates two TCP connections to the same server port (referred to as the synchronous channel and asynchronous channel). HiSLIP sends packetized messages between the client and server on both channels. The synchronous channel carries normal bi-directional ASCII command traffic (such as SCPI) and synchronous GPIB-like meta-messages (such as END and trigger). The asynchronous operation allows for multiple queries to be sent by the client without having to wait for each to complete before the next one is sent. VXI-11, on the other hand, is single-threaded, regardless of which connections they come from. This was intentional to mimic the behavior of the GPIB bus where only one command/query can be active at a time (this was part of the hardware definition of the GPIB bus).

VXI-11 has a single session regardless of how many connections are made. Each HiSLIP connection is a separate session. Therefore, be mindful that the status register is not shared between HiSLIP connections, and it is the user's responsibility not to send differing commands at the same time through multiple HiSLIP connections.

Whenever using a LAN communication to an instrument, it is often best to use a closed network to avoid other traffic on the network from slowing down communications. If controlling an instrument over a network that is open to outside traffic, then it is preferrable to used wired LAN instead of wireless LAN.

The IQ Analyzer mode allows for transferring huge amounts of data (gigabytes of IQ captured data) over LAN using "FETCH:FCAP?". The newer X-Series Analyzer CPU options PCA and PCB and later have an additional 10 Gbit LAN port that, when used with a PC with 10 Gbit LAN, will allow for faster offloading of the data.

Avoid storing and recalling state files

Resist the urge to setup a measurement and then store a state file and recall that state file whenever you want to make the same measurement. The three reasons are:

- Reading from a drive takes time, and it is always faster to use SCPI commands to set up the measurement.
- Even though X-Series Analyzers are good at maintaining backwards compatibility for state files, there is not a guarantee that a state file stored with one version of software will work with another version.
- Not all analyzers have the same options, so there is an ambiguity when restoring a state file on an analyzer that doesn't have the same option set.

The SCPI Recorder feature can be used for newer versions of X-Series software running on Windows 10 operating system or higher. This makes it easy to find the appropriate SCPI commands that correspond to front panel buttons.

Use "binblock" binary data transfer when available

Whenever trace data, IQ data, or large amounts of data are transferred from the instrument, binary block (binblock) data format should be used as opposed to ASCII data. Binary data is more efficient than ASCII data. When binblock data format is turned on, only those commands that support it will use it. Queries with small amounts of data such as reading back a marker value will still return ASCII data.

To turn on binblock data form, use the command ":FORM:DATA REAL,64" or ":FORM:DATA REAL,32" depending on the precision required for the results.

The binblock data format was created when there were a lot more UNIX computers that used big-endian format for binary data. Therefore, you may need to change the bit order to little-endian (like what Intel PCs use) by sending the command "FORM:BORD SWAP".

Use Fast Capture data transfer in the IQ Analyzer

The IQ Analyzer Waveform measurement is the primary measurement to get IQ data out of the analyzer into other programs such as MATLAB. There are four ways to get IQ data out of the analyzer:

- Directly save the IQ data from the front panel of the instrument as a .csv, .mat, .sdf, .bin, etc.
- Use 89600 VSA software to get the IQ data and store it to file.
- Use the "READ:WAV0?" SCPI command to get up to 32 mega samples (Msamples) of IQ data. When you use the "READ:WAV0?" command, the display of the analyzer is also updated to display the waveform data from the measurement.
- Use Fast Capture (the fastest way without using VSA software). This allows for data captures up to the full capture depth of the digitizer, up to >= 1 giga sample (Gsample) of data. It also allows you to choose the block size for how much data is transferred at a time. With a fast capture the display is not updated when a capture is initiated. You must specify a block size with the command "FCAP:BLOC <block size>". A measurement is started using the "INIT:FCAP" command. The blocks of IQ data are queried using the "FETCH:FCAP?" command.

Be smarter when it comes to averaging

There are basically three types of averaging in the Spectrum Analyzer application in X-Series Signal Analyzers. Understanding how best to accomplish averaging can speed up your measurements.

Perhaps the most powerful averaging tool is the Average detector. Since the year 2000, Keysight Signal Analyzers have used all-Digital IFs. With the advent of the Digital IF came the ability to choose how to represent the trace data including the ability to choose variable trace points, increased choices for detector types, and the ability to display multiple detectors for multiple traces at the same time. Each trace point bucket contains multiple ADC samples. The digital IF samples at a raw sample rate of 30 Msample/s or higher (15 Msample/s for IQ pair or higher). If for example you have a 1 ms sweep time with 1001 trace points, then each trace point bucket represents 1 µs of time, which is 1 ms / (sweep points -1). During that 1 µs of time, there are at least 66 sample points. If you choose the peak detector, then only the maximum sample point is displayed for that trace point. If you choose the sample detector, then only the middle sample point is displayed. If you turn on trace averaging and average 66 traces using sample detector, you will average over the same number of samples for that trace point as you would if you did one average and used the Average detector! You may ask yourself, “why do we still have the sample detector?” The answer is that the sample detector was historically used in analog spectrum analyzers since the 1970s when measuring noise-like signals, and that it was necessary back then to use trace averaging to reduce the noisy-ness of the trace results. Nevertheless, we live in the 21st century, so whenever measuring noise or noise-like signals (such as modern OFDM signals), then make sure to use the Average detector.

Another way to be smarter about averaging is to increase the sweep time instead of increasing the trace averages. If you double the sweep time when using the Average detector, you get the same amount of averaging power as doubling the number of trace averages. This saves time because you avoid the dead time between sweeps when taking multiple sweeps. The sweep time reported by the analyzer is the time represented by the trace results and does not include the additional processing time and time it takes the analyzer to get set up to take a sweep.

Although this is a little off topic when discussing speed, it is important to let you in on an important detail about video averaging for the X-Series Analyzer. Video averaging is yet another way to average the trace data. It is essentially a low pass filter performed on the trace data and has been around since the beginning of spectrum analyzers. It is useful when measuring CW signals. However, in X-Series Analyzers when using Average detection with Power (RMS) trace averaging, the analyzer automatically corrects for the under-response of the trace data. So, the net effect of reducing video bandwidth for those conditions is the same as simply increasing the sweep time.

Newer CPU Options Provide Faster Throughput

The capability to upgrade CPU has been built into the X-Series Signal Analyzers since their inception in 2006 with the MXA N9020A. As newer CPU options have been launched, there have been improvements in processor speed, number of processor cores, RAM memory, and connectivity. The latest revisions of CPU, for example, support Thunderbolt connectivity via USB Type-C connectors and new 10 Gbit LAN connectivity. Thus, one way to speed up measurement throughout is to upgrade to a new CPU revision.

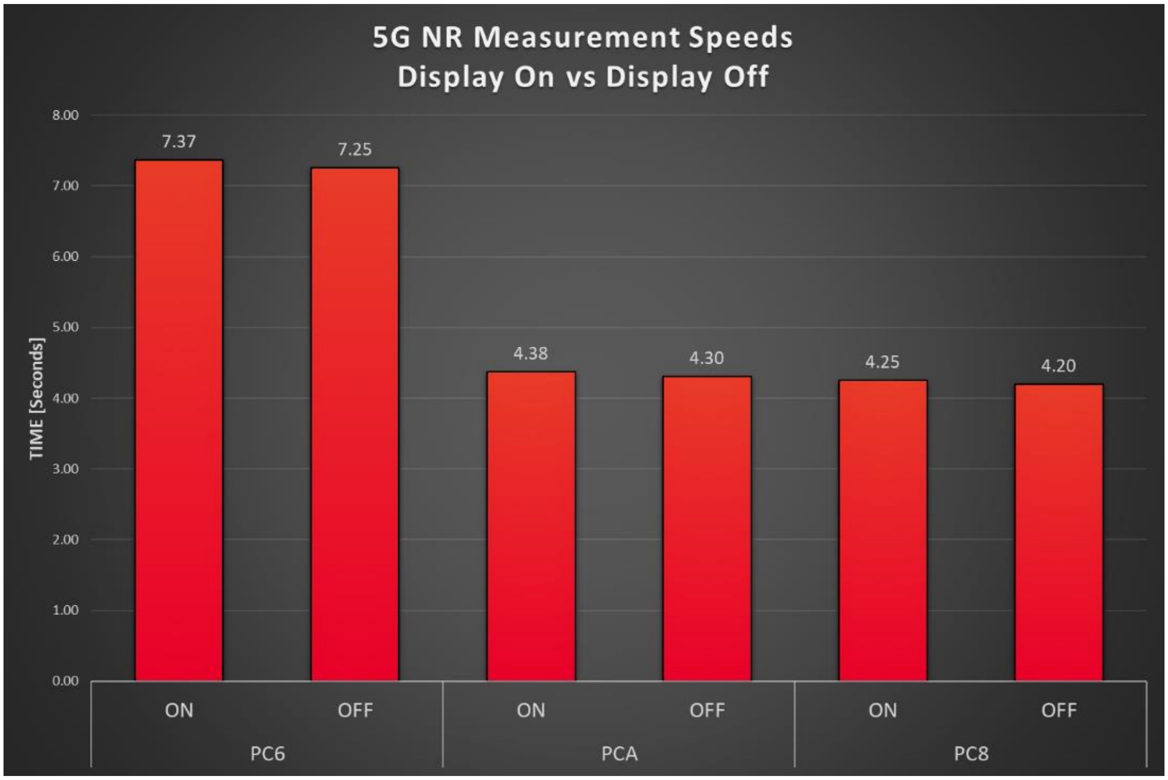

Figure 2. The graph above shows the speed for demodulating a 5G NR FR2 400 MHz wide Test Model 3 signal on an N9030B. The PC8 and PCA CPU options are faster than the PC6 / PC6S CPU option.

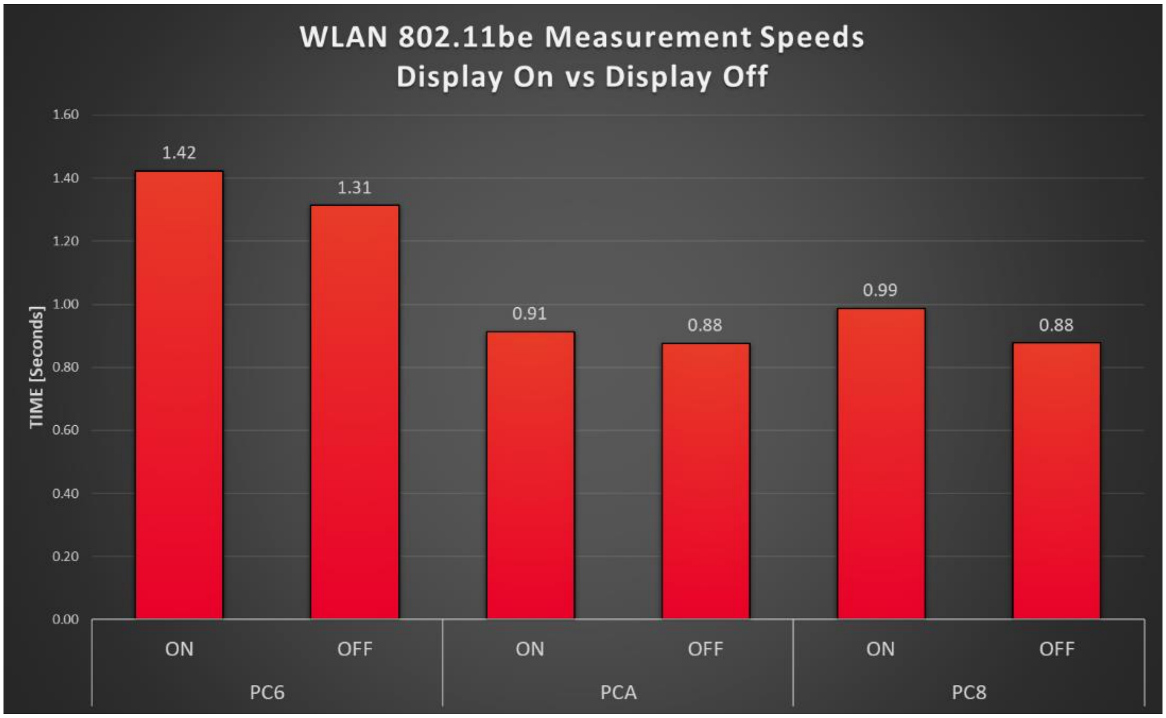

Figure 3. The graph above shows the speed for demodulating a WLAN 802.11be signal on an N9030B. The PC8 and PCA CPU options are faster than the PC6 CPU option.

The newer 10 Gbit/s LAN on PCA and PCB CPUs can be used with a 10 Gbit/s switch and controlling PC with 10 Gbit/s LAN to achieve faster performance for offloading Fast Capture IQ data from the IQ Analyzer application.

Sweep Speed Improvements

The ability of a signal analyzer to sweep quickly while maintaining accuracy is crucial when making measurements on a production line. Many sweep speed improvements were introduced starting with A.26 software revision. Therefore, for any X-Series Signal Analyzers still running Windows XP and Windows 7, it is recommended to upgrade to Windows 10 or later to be able to take advantage of the sweep speed improvements.

The default Sweep Type Rules for X-Series Analyzers is Best Dynamic Range. This setting can be changed to Best Speed to realize even faster sweep speeds. There are some tradeoffs with the Best Speed setting. In some case there can be approximately 1 to 2 dB less dynamic range for small signals close to big signals (< 1 MHz away). Also, the Best Speed setting can show more residuals. The Best Speed setting will switch into FFT mode at a larger resolution bandwidth setting (RBW) as you reduce the RBW.

Anatomy of a sweep

A Sweep generally consist of two phases:

- Pre/post sweep where the instrument is set up to the correct state. This can be considered a fixed overhead; although, with newer software versions newer techniques can be employed to reduce this overhead time.
- Sweeping of the LO where the sweep time equations dictate how long complete the sweep.

If the analyzer sweeps across any band breaks, then there will be multiple setups and multiple sub-sweeps. Additionally, when using techniques such as Software Preselection, then additional sweeps are performed in the background using additional intermediate frequencies (IFs).

As RBWs get smaller, there is a point where it is more efficient to use stepped FFTs where the analyzer doesn’t have to follow the sweep equation rules and is mostly limited by how fast the analyzer can perform the FFTs.

Fast Sweep

Fast Sweep is sometimes also called chirp sweep and was first introduced in X-Series software revision A.13 as Option FS1 for narrower resolution bandwidths down to 5.1 kHz. Fast sweep was subsequently extended in A.18 software revision to work for RBWs from 4.7 kHz down to approximately 510 Hz as Option FS2. The 4.7 kHz RBW is somewhat a magical RBW in that it provides faster sweep speeds and more sensitivity than the wider RBWs that proceed it. In the fast sweep plots, you will notice the prominence of the 4.7 kHz RBW when comparing RBW to sweep speed. Fast Sweep 1 (FS1) improves sweep speed up to 50 times compared to the normal sweep speed, and Fast Sweep 2 (FS2) improves sweep speed up to 8 times compared to FS1.

Sweep Time is traditionally determined by the following relationship:

$$\boldsymbol{Sweep\ Time} = \frac{\boldsymbol{k(Span)}}{\boldsymbol{RBW^2}}$$

Normally, the value of ***k*** is between 2 and 3 for the synchronously tuned, near gaussian filters used in signal analyzers. Exceeding this value (without having Fast Sweep) results in over-sweeping, which produces errors in frequency and amplitude, and causes bandwidth spreading. This is due to the RBW filter not having enough time to charge up as the analyzer sweeps across the band. However, through chirp-IF processing with the Digital RBW filter, Fast Sweep effectively increases ***k*** to ~30 for FS1 and ~200 for FS2. The errors that would normally be incurred by sweeping too fast can be corrected for.

FS1 and FS2 increase the IF pre-filter BW to allow for faster sweeps. This wider analog prefiltering can lead to the digital IF seeing a larger instantaneous combined power level for wider bandwidth signals. For example, high level multi-tone signals, such as comb generators at 0 dB, can overload the ADC due to the digitizer seeing more individual tones at one time that would otherwise be filtered out by the analog IF prefiltering. This effect can be mitigated by reducing the sweep speed slightly which will result in a reduction of the analog IF pre-filter bandwidth. Thus, the best application for Fast Sweep is in measurement of low-level spurs and impulses.

FS2 is implemented through a digital filter designed inside the FPGA on the 40 MHz digitizer. Unfortunately for X-Series Analyzers that also have the Time Domain Scan (TDS) feature used in the EMC application, there is not enough space in the FPGA on the 40 MHz digitizer to have both TDS and FS2 loaded in the FPGA at the same time. The user must choose which feature to install on the FPGA at startup. Instruments that have Option TDS loaded will still benefit from the FS1 sweep speed improvements, though.

Please note that Fast Sweep is only active when VBW >= RBW. This is because video bandwidth filtering is incompatible with Fast Sweep. Consequently, since there is not a way to directly turn on Fast Sweep (other than by removing the license), then one way to visually see the improvement in sweep speed from the effect of Fast Sweep is to decrease VBW to be slightly less than RBW (10% less, for example) so that you can see the increase in sweep speed while not having the Fast Sweep capability.

Starting in A.26 software revision, sweep speed improvements were implemented for RBWs in the range covered by Fast Sweep (Option FS1 and FS2), for wide RBWs, and for narrow RBWs that use FFT sweeps. As shown in the plots below you will see the sweep speed improvements between A.18.24 software revision and A.35.08 software revision. For these plots, the default Sweep Type Rules of best Dynamic Range was chosen. In Figure 6 where there is a jump up in sweep time versus RBW, this is where those swept RBWs that have more dynamic range than the FFT RBWs but are slower than the FFT RBWs. To stay in the faster FFT RBWs longer, change the Sweep Type Rules to Best Speed. Also, for those plots where Fast Sweep RBWs are faster than FFT RBWs you will notice the prominence of the dip in sweep time at the 4.7 kHz RBW for option FS2.

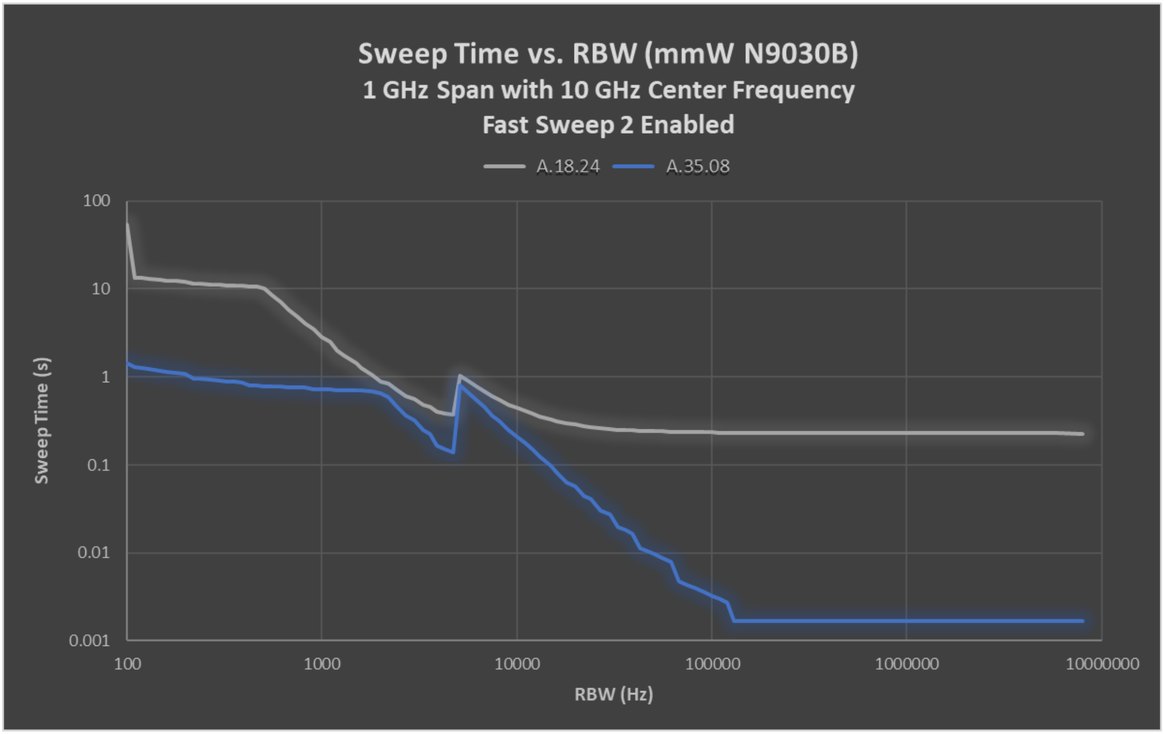

Figure 4. Comparison in sweep speed improvements between A.18 and A.35 software with Fast Sweep 2 enabled. Notice the improvement in FFT RBWs from about 2 kHz and below. Notice the improvement in sweep speeds for FS2 bandwidths from about 2 kHz to 4.7 KHz. Notice the “sweet spot RBW” of 4.7 kHz. Notice the sweep speed improvements for FS1 bandwidths from 5.1 kHz to just below 1 MHz RBW. Lastly, notice the improvement for the widest RBWs from 1 MHz and larger.

To be able to see the sweep speed improvements for Fast Sweep, it is helpful to compare what the sweep speed vs. RBW of the analyzer is with and without Fast Sweep. To do this, we simply remove the Fast Sweep FS1 and FS2 licenses from License Manager. These licenses can easily be added back.

With the speed up in FFT RBWs in software versions A.26 and later, there are some spans and center frequencies where FFTs are now faster than FS2 RBWs and even some FS1 RBWs.

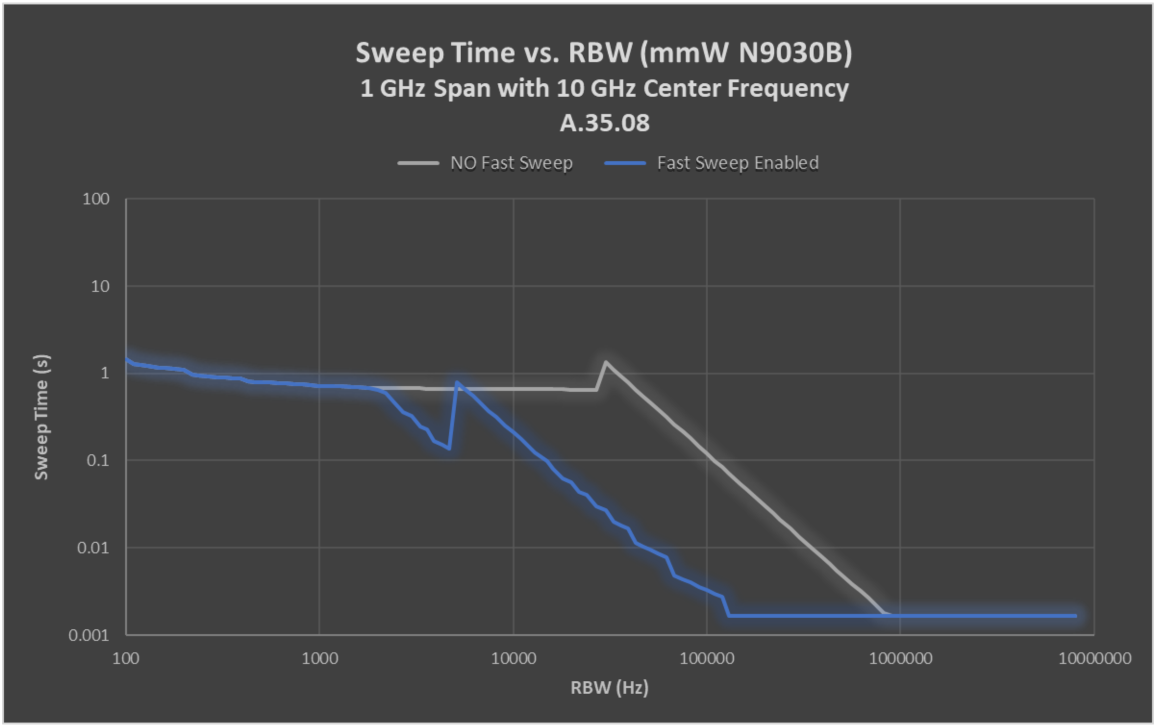

Figure 5. Comparison in sweep speed between FS1 and FS2 enabled and not enabled. Notice how we no longer have the FS2 "sweet spot RBW" of 4.7 kHz. RBWs from 5.1 kHz to just under 1 MHz are slower without the Fast Sweep options.

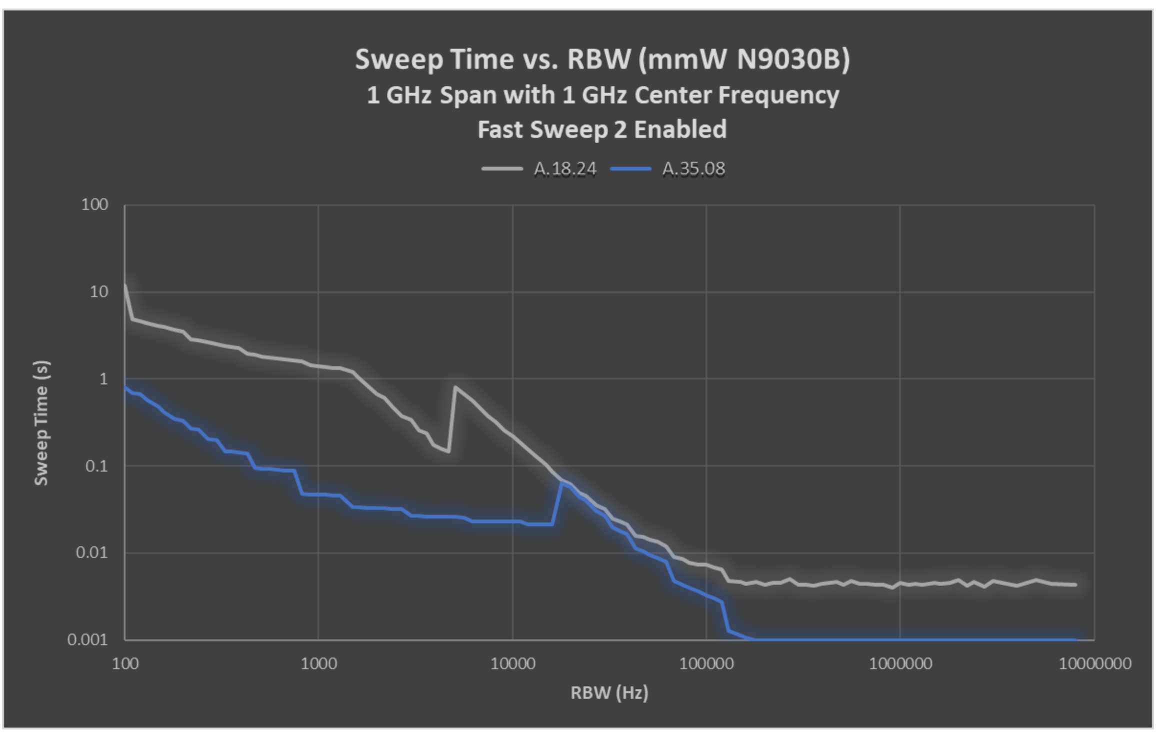

Figure 6. Comparison in sweep times vs RBW between A.18 and A.35 software at a span of 1 GHz and center frequency of 1 GHz. FFT RBWs are now faster than 4.7 kHz FS2 RBW.

Wider swept FFT bandwidths

The ability to choose wider FFT bandwidths in Spectrum Analyzer mode up to the maximum digitizer bandwidth can be a powerful tool to speed up measurements. You must be mindful of a few things:

- When using the preselected path, the YIG Tuned Filter (YTF) is limited in bandwidth from about 30 to 70 MHz, depending on center frequency. So, you will need to choose an FFT bandwidth that is narrower than the YTF filter bandwidth, or when using wider FFT bandwidths you will need to change the μW path to bypass (option MPB).
- The analyzer's best spurious response performance is when using traditional swept sweeps.

Faster EVM "Bathtub Curve" Measurements

The concept of Error Vector Magnitude (EVM) was introduced with the 89400 Vector Signal Analyzer in 1992. The 89400 VSA evolved into the modern day Keysight 89600 VSA software, and the concept of EVM is now ubiquitous. As customers build more eco-friendly devices that consume less electric power and have more advanced amplifier bias techniques, it is necessary to verify EVM over a range of power levels. We often refer the concept of measuring EVM versus power as a "bathtub curve", since measured EVM is typically the lowest over the mid-range power levels and degrades at the lower and higher power levels.

Techniques such as using predistortion can extend out the higher power end of the bathtub curve for a device under test (DUT). Signal Analyzers have no problems accurately measuring EVM at higher power (up to the maximum power handling capability of the analyzer), because you can usually add in more mechanical or electronic attenuation such that the optimal power is being seen by the analyzer's input mixer. The ability of signal analyzers to measure the low end of the bathtub curve is enhanced by using low noise amplifiers (LNAs) and by reducing noise contribution in the signal path with options such as Full Bypass (FBP), and by adding in software or physical filters to reduce broadband noise outside of the measurement bandwidth.

Keysight X-Series Signal Analyzers have a feature called "Optimize EVM" in the 5G NR and WLAN measurement applications to automatically adjust the attenuation, IF gain, and signal path to be able to achieve the lowest EVM floor of the analyzer. For the normal functionality of Optimize EVM, the analyzer measures the signal power for the given measurement setup and directly sets up the analyzer's hardware based on a lookup table. For software versions A.32 and later, there has been an improvement in speed for how quickly a typical bathtub curve can be measured over the power range of the DUT.

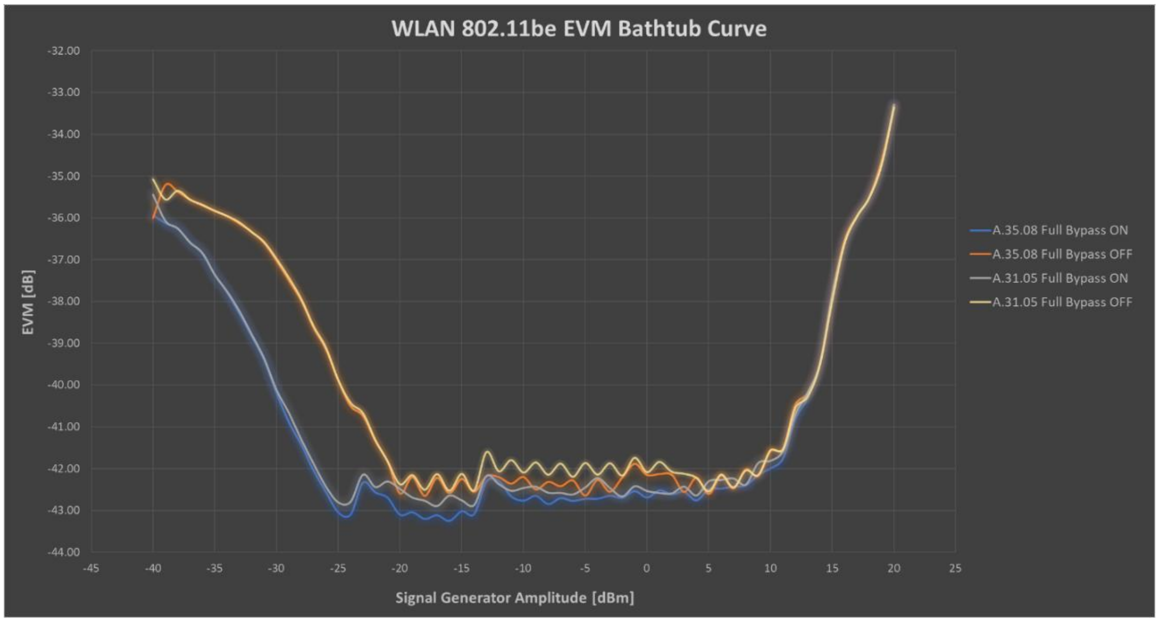

Figure 7. Example bathtub curve plot comparing results between A.31 and A.35 software versions with an N9030B measuring WLAN 802.11be. Notice that the EVM floor is improved and that the ability to measure at lower power levels is improved when the full bypass path is enabled in the Amplitude menu.

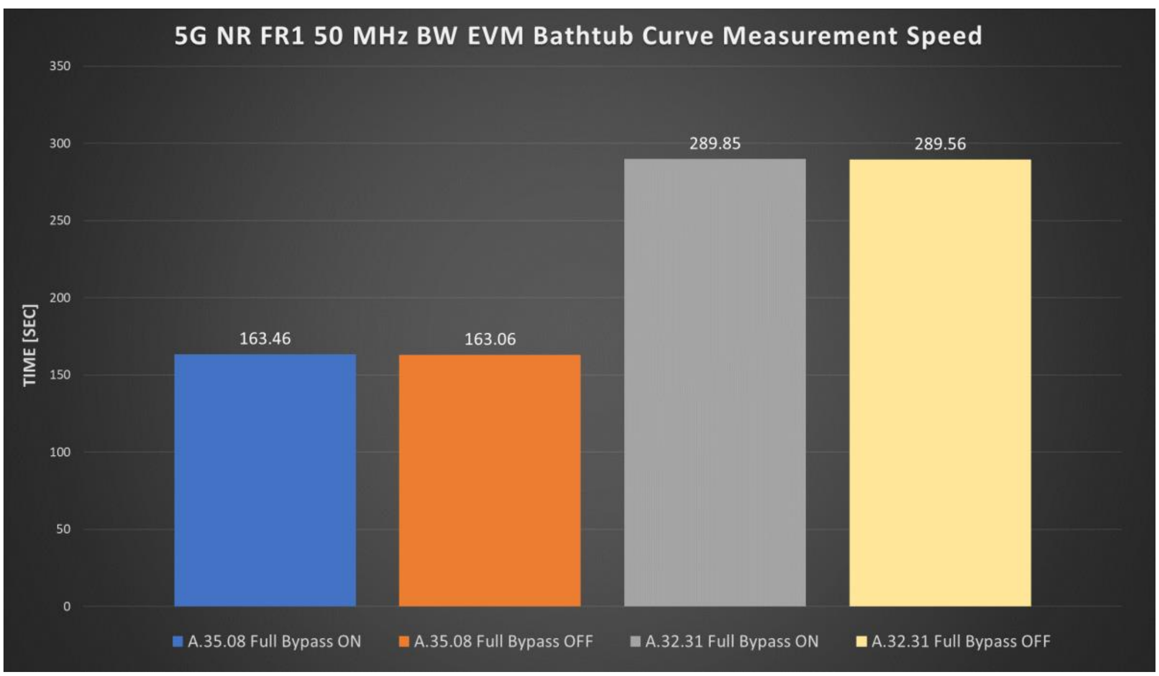

Figure 8. A.35 software is faster compared to A.32 software for the example bathtub curve test sequence for 5G NR measurements.

Fast Power Measurements

Fast Power measurements in X-Series Signal Analyzers are often unknown to customers; however, many customers can benefit. The Fast Power Option enables hardware accelerated FFT spectrum measurements up to 2 GHz bandwidth. Fast Power measurements can generally be performed as quickly as 10 ms per acquisition. Keysight's own Compact Antenna Test Range (CATR) systems use Fast Power measurements when rapidly creating three-dimensional field strength plots for DUTs. Fast Power measurements are ideally suited for making both channel power and adjacent channel power measurements over bandwidths up to the maximum digitizer bandwidth of the analyzer.

The first way to interface with the Fast Power engine in X-Series Analyzers is to use the:CALC:FPOW SPCI interface. You can create numerous Fast Power definitions that specify parameters such as mechanical attenuator state, center frequency, bandwidth, and acquisition time. Then, a Fast Power measurement can be made using the "CALC:FPOW:POW[n]?" command. The Fast Power interface is simple and efficient without a display, and spectrum measurements are made using the embedded FFT engine on the associated digitizer instead of being performed in the traditional software layer.

The second way to use Fast Power is in the Power Suite measurement in the Signal Analyzer Application and other applications such as the 5G NR app for the Adjacent Channel Power Measurement. Choose the Meas Method setting of Fast Power. This will allow the embedded FPGA FFT engine on the associated digitizer to be used. It is possible to see ACP measurements performed six times faster using the Fast Power engine compared to the default Integration BW setting.

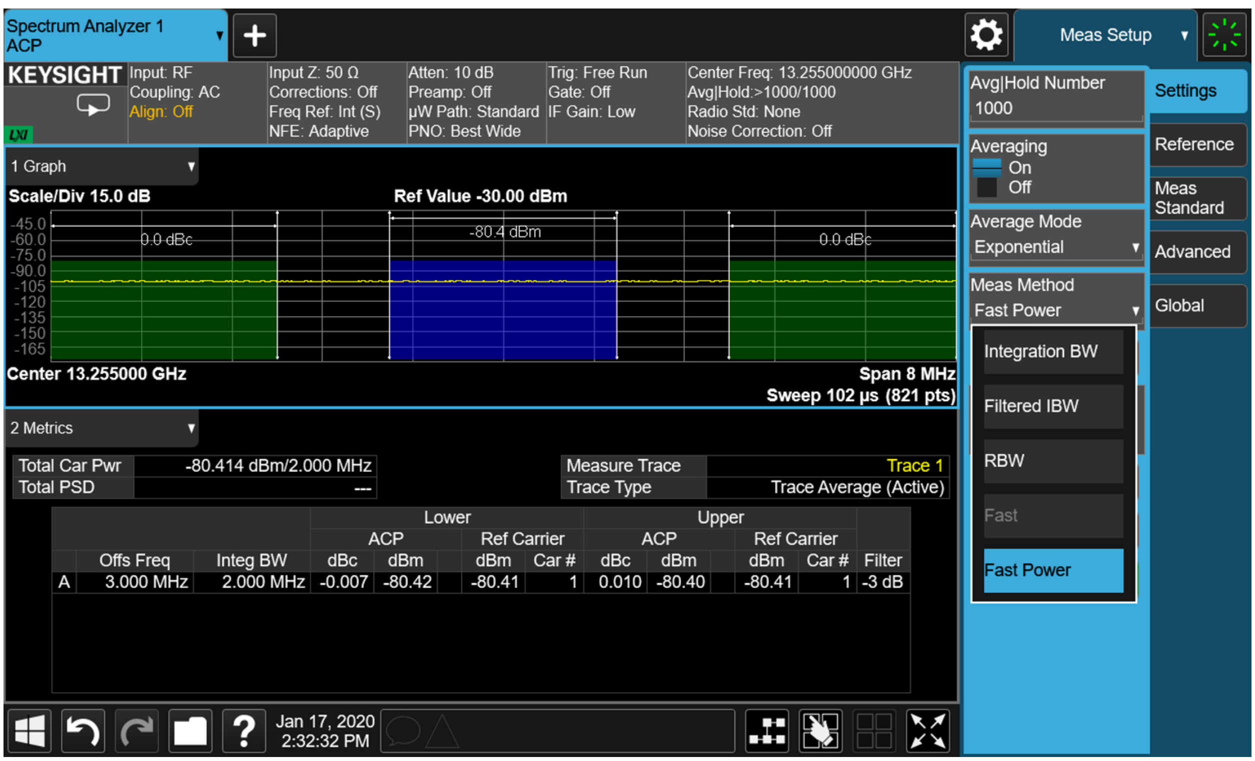

Figure 9. Demonstration of Fast Power Measurement Method in the ACP measurement.

There is a key limitation to be mindful of when making Fast Power measurements. Whereas the newer wideband digitizers for N9032B and N9042B have RMS power averaging for Fast Power measurements, the wideband digitizers for N9020B, N9021B, N9030B, N9040B, and N9041B only have voltage averaging. For all X-Series, RMS power averaging is available on the 40 MHz digitizer (Option B40).

RTSA Software Preselection for N9041B and N9042B above 50 GHz

Although Software Preselection in X-Series Analyzers doesn't allow RTSA to make faster measurements in the conventional way that we think of speed applying to trace update rate, it does allow for the more rapid visualization of low rate sweeping, wideband signals such as what automotive radar uses with FMCW (LFM) signals in the 76 to 81 GHz band. When viewed on a conventional signal analyzer, there is a low probability of instantaneous tuning of the signal analyzer and unit under test (UUT). To obtain a trace that represents the maximum amplitude of the signal versus frequency, this traditionally requires setting the analyzer's trace to max hold and letting the trace fill out over time. Using RTSA with software preselection allows the wideband radar signal to be traced out in a faction of the time (on the order of a minute instead of an hour in the case of automotive radar). Software preselection works well for signal bandwidths up to about twice the highest IF frequency used. Therefore, for the N9041B when measuring above 50 GHz, software preselection works when measuring signals up to approximately 10 GHz in bandwidth. The RTSA application can stitch together bandwidths up to the maximum bandwidth of the digitizer. When not using software preselection with RTSA, images will erroneously be seen.

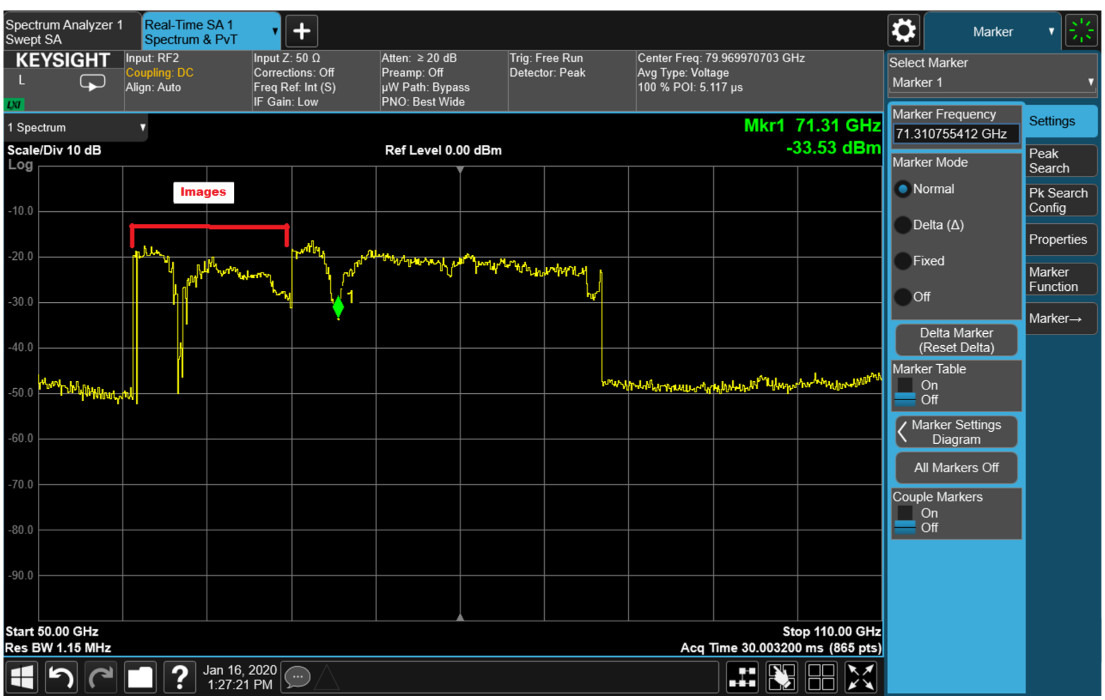

Figure 10. The above image is an RTSA trace using an N9041B for an automotive radar device. Software preselection is turned off resulting in an image being seen below the lowest frequency for the DUT. A dip in the measured trace is seen at the marker frequency, but this is not caused by the N9041B.

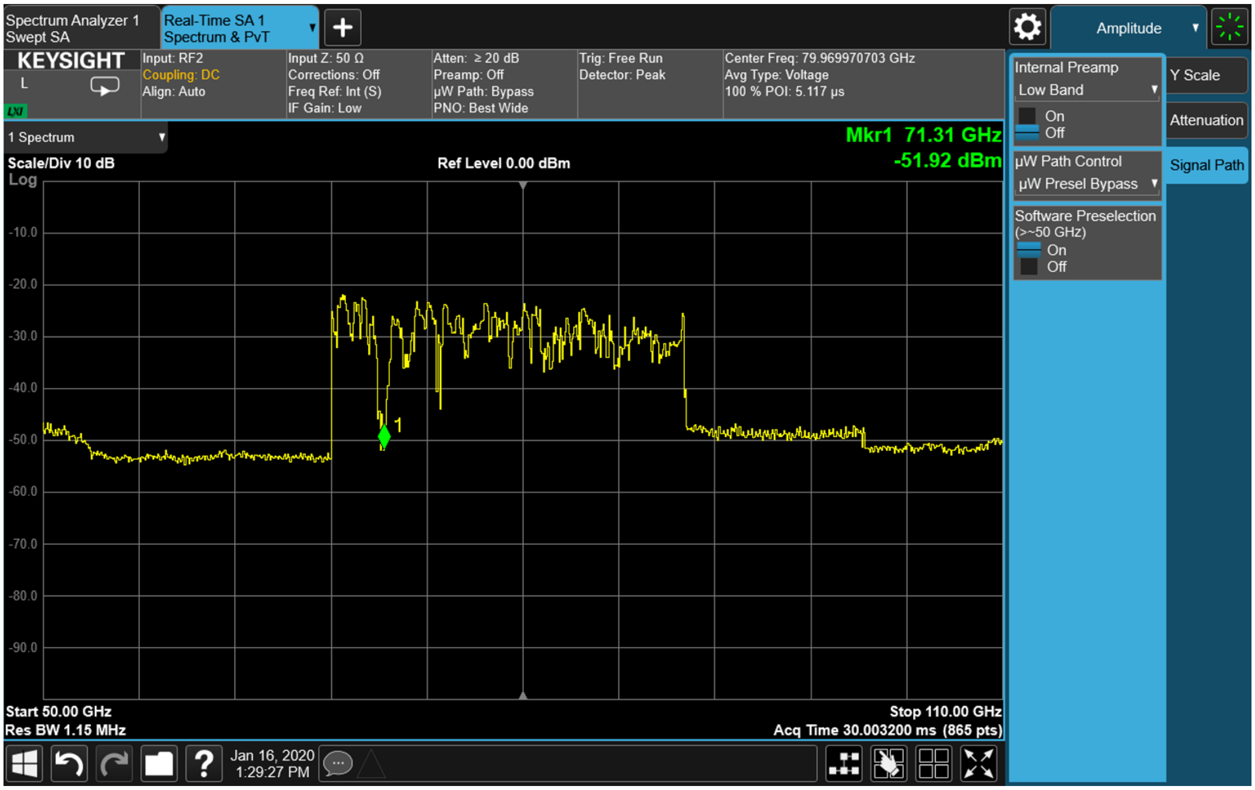

Figure 11. The above image shows an RTSA trace with an N9041B of an automotive radar device. Software preselection is turned on, and so the lower frequency image is suppressed. The suck out seen previously at 71.31 GHz is still present and is a characteristic of the DUT.

RTSA Density Trace Yields Faster Visualization

Since we are on the topic of RTSA, it would be good to make a note about speed concerning RTSA. Anytime you can process lots of data rapidly and display that data in a meaningful way, you save time. We made mention of how powerful the Average detector can be to make use of all the digitizer samples within a trace point bucket. The RTSA Density plot is even more powerful to perform continuous gap-free FFTs and not only display amplitude versus frequency but to add a third dimension that represents density of the occurrence of signals. This is as amazing as how the forensic detectives combine a moving image of a car leaving a bank robbery to produce an enhanced still image which shows the car's license plate. Just as in that case, the net effect is to make sense of all the data available.

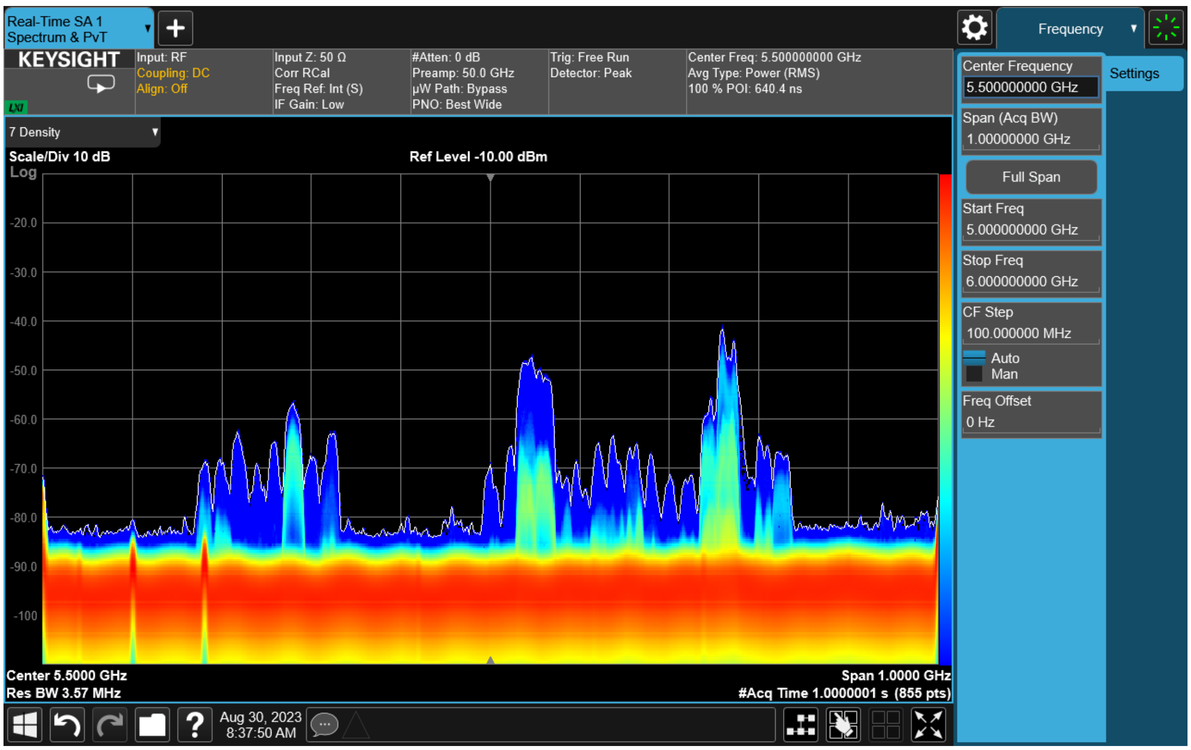

Figure 12. N9042B RTSA Density trace at 5.5 GHz center frequency and 1 GHz span.

Saving Time on Instrument Alignments

Automatic instrument alignments are wonderful to ensure that X-Series Signal Analyzers are meeting specifications; however, they can be intrusive and run when it is not convenient, especially when using an instrument in an automated environment. X-Series Analyzers provide the ability to change how often alignments run and which alignment(s) will run. The automated alignments for X-Series Analyzers run based on temperature and temperature change. In A.17 software revision, the auto alignment setting of Light was introduced. The Light alignment schedule increases the temperature threshold by which alignments run by a factor of three. So, an alignment that would normally run every 1 degree C change in temperature would instead run every 3 degrees change in temperature. When using light alignments, the amplitude accuracy of the instrument is nominally degraded by about one to two tenths of a dB. Allowing the alignments to run less frequently saves time.

Another time saving technique was introduced in A.11 software revision allowing users to only run the expired alignments via the “CAL:EXPIRED?” command. Running all alignments via the “CAL:ALL?” command takes a lot longer to complete. The recommendation instead is to set the alignments to the Partial alignment setting via the “CAL:AUTO:PART” command so that just those alignment that take less than one second can automatically run while the longer alignments are held off. When it is convenient between test sequences, you can query to see if any alignments are needed by querying the status register using the “STAT:QUES:CAL:COND?” command. If alignments are needed, then just the expired ones can be run. Note: to be able to query the Condition register, you must first enable bit 14 (value of 16384, Align Now Needed bit) using the “STAT:QUES:CAL:ENAB 16384” command.

When an instrument is set to partial alignments, you can also set the alerts notifying when alignments need to run to the Light alignment schedule instead of the Normal alignment schedule. To do this, use the SCPI command, “CAL:AUTO:ALER LIGHT”. For more information on auto alignments and the alignment alert schedule, refer to the help text available from the System -> Alignments menu.

Bypassing the Preselector for Faster Tuning

Signal analyzers are uniquely designed for measuring over wide power levels from 30 dBm down to near the kTB noise floor. The YTF preselector allows for excellent image rejection to make it possible to measuring low level spurious signals. Nevertheless, often signal analyzers are used to measure power levels of higher-level signals in the power range of what power meters are also used. When measuring higher level signals, sometimes the ability to suppress images is not needed. In this case, the YTF preselector can be bypassed using option MPB. When the YTF preselector is bypassed, the analyzer can tune faster between the signal in the high band (> 3.6 GHz). Without the YTF preselector in the signal path in the analyzer, the amplitude accuracy is also improved in the high band.

Changing Software Preselection Settings

Software Preselection was first introduced in N9041B for frequencies above 50 GHz. Subsequently, Software Preselection was added to N9042B for frequencies above 50 GHz when using V3050A. For the N9041B the default Software Preselection Bandwidth setting under the Amplitude -> Signal Path menu is Normal. For this setting the analyzer takes three to four background acquisition (sweeps) to produce one resultant trace. The trace update rate can be improved by selecting a Software Preselection Bandwidth setting of Narrow. This will result in only two background acquisitions, but the image rejection bandwidth is narrowed from approximately 3 GHz to 2 GHz. Note: when measuring pulsed or noise-like signals, or for sweeps where the bucket width is much larger than the RBW, then it is recommended to change the Software Preselection Type to Advanced and change the Trace Type to Max Hold. This will, however, slow the trace update rate.

When making measurements above 50 GHz with N9042B and V3050A, software preselection is defaulted on. The V3050A has a filter bank consisting of five overlapping filters that covers 50 to 90 GHz with image rejection to 88 GHz while providing a 2 GHz buffer zone. Software preselection improves image rejection over this range of frequencies. If the image rejection between 50 and 88 GHz with the built-in bank of filters is sufficient for a customer’s needs, then swept measurements can be made twice as fast by turning off software preselection.

Segmented Capture

Segmented capture is useful when analyzing repetitive or pulsed signals. Only the portion of the burst or pulse signal of interest needs to be captured for each pulse while the other time periods can be excluded from the capture. This saves time by being able to capture a much longer sequence of pulses while not filling up the capture buffer with periods of time that are not useful for the analysis. Segmented capture is currently available in the X-Series Pulse application and in 86900 VSA software when measuring pulsed signals. The segmented capture can either have a fixed length or variable length that uses a gated acquisition to control the start and stop of each segment.

Selecting which Applications Preload on Bootup

Reducing the number of applications that are preloaded at bootup can help speed up the boot time of an X-Series Signal Analyzer. If the user switches to an application that was not preloaded at bootup, then the application will be loaded at that time. The ability to choose which applications are preloaded has always existed in X-Series Analyzers via the Configure Applications shortcut on the Windows desktop. A new feature, called “Preload / Unload Modes”, was added in A.34 software revision under the System menu. It allows measurements applications to be unloaded to free up memory space. This is especially helpful for instruments with smaller RAM for CPU versions prior to PC8.

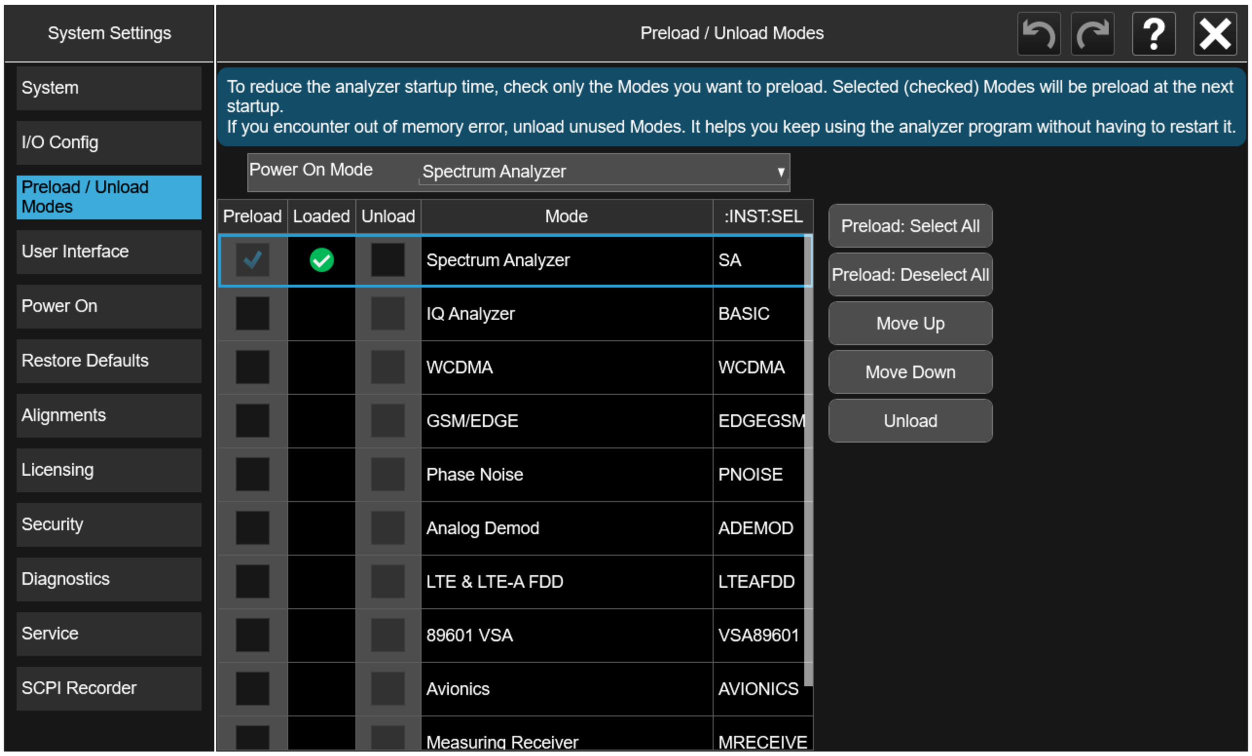

Figure 13. Demonstration of new Preload / Unload Modes menu in A.34 X-Series software revision.

Power Suite Measurements Save Setup Time

Sometimes it is easy to overlook the Power Suite measurements (N90EMPSMB) and their usefulness for making measurements common to spectrum analysis. These measurements include Channel Power, Occupied Bandwidth, ACP, Power Stat CCDF, Burst Power, Spurious Emissions, SEM, TOI, Harmonics, List Sweep, and Phase and Amplitude vs Time (PAvT). The Power Suite has developed over two decades and has gone through speed optimization during that time. A lot of time can be saved using the predefined Power Suite measurements rather than simply using the base spectrum analyzer functionality.

List Sweep

The List Sweep measurement (part of Power Suite) was developed with speed in mind as a remote-only measurement. It allows you to set up a list of frequencies to quickly make measurements over in succession using a trigger signal. Parameters such as RBW, attenuation, detector, and preselector state are set up for the list of frequencies. Only those parameters explicitly allowed for List Sweep can be set, this means other Spectrum Analysis parameters don't affect List Sweep measurements.

Other Ways to Make Faster Measurements

Any time you can reduce the amount of data transferred or can take advantage of hardware acceleration; you can make measurements faster. The Fast Power option is the best for fast power measurements; however, there are some other techniques to take note of. The "CALC:DATA<n>:COMPress?" command can be useful for returning the power in a series of bursts measured in the IQ Analyzer mode. This command is used to compress or decimate a long trace to extract and return only the desired data. A typical example would be to acquire N frames of GSM data and return the mean power of the first burst in each frame. The command can also be used to identify the best curve fit for the data. It can also be used to return the standard deviation of a data point values for a specified region or return the arithmetic mean phase for every specified region and frequency offset.

Yet another way to make power measurements quickly in the X-Series Analyzers is to successively read the Power versus Time trace data from the RTSA application.

Accelerated Time Domain Scan (TDS) for PXE

Customers engaged in making EMC / EMI measurements can greatly benefit from the speed improvements provided by the Accelerated Time Domain Scan (TDS) feature in the PXE N9048B (Option N9048WT1B or N9048WT2B), compared to older EMC analyzers. EMI receiver mode test speeds with Accelerated Time Domain Scans are faster compared to the Standard Time Domain Scan (Option N9048TDSB) in the frequency range of 30 MHz to 3.2 GHz.

Accelerated TDS uses a wider IF prefilter (350 MHz) to route the input signal through wideband filters instead of the narrowband filter bands (59 MHz with standard TDS). Additionally, Accelerated TDS increases the real time scan bandwidth to 350 MHz, allowing for scans up 1000 MHz (CISPR band C/D) in only 3 steps. This increase in bandwidth allows for near-gapless, continuous spectrum monitoring and improves peak and quasi-peak detection speeds by a factor of 4 to 6 when compared to standard TDS.

Prior to Keysight X-Series firmware version A.27, Accelerated TDS could be used for EMI compliance testing for signals with pulse repetition frequency (PRF) ≥ 20 Hz. With A.27 and later X-Series firmware, Accelerated TDS is reclassified to be used for **CISPR compliant testing for PRF down to 10 Hz**.

For further details about the speed improvements offered by Accelerated TDS, refer to the application note tiled Boost EMC Test Throughput with Accelerated Time Domain Scans.

Conclusion

Most all of us have heard the saying, “time is money.” When setting up test processes using signal analyzers, often the primary goal of the test engineer is to get the test process working. Nevertheless, it is our hope that this application note has given some valuable information to help you be mindful of things to be aware of to save precious time when making measurements with an X-Series Signal Analyzer.

Resources

1. Understanding and Applying Probability of Intercept in Real-Time Spectrum Analysis
   https://www.keysight.com/us/en/assets/7018-04381/application-notes/5991-4317.pdf

2. Fast Power Measurements for X-Series Signal Analyzers
   https://www.keysight.com/us/en/assets/3120-1459/application-notes/Fast-Power-Measurements-for-X-Series-Signal-Analyzers.pdf

3. Optimizing Fast Power ACLR Measurements with the N9042B and N9032B X-Series Signal Analyzers
   https://www.keysight.com/us/en/assets/3122-1317/application-notes/Optimizing-Fast-Power-ACLR-Measurements-with-N9042B-N9032B-X-Series-Signal-Analyzers.pdf

4. Understanding and Applying Probability of Intercept in Real-Time Spectrum Analysis
   https://www.keysight.com/us/en/assets/7018-04381/application-notes/5991-4317.pdf

5. Fast Power Measurements for X-Series Signal Analyzers
https://www.keysight.com/us/en/assets/3120-1459/application-notes/Fast-Power-Measurements-for-X-Series-Signal-Analyzers.pdf
6. Optimizing Fast Power ACLR Measurements with the N9042B and N9032B X-Series Signal Analyzers
https://www.keysight.com/us/en/assets/3122-1317/application-notes/Optimizing-Fast-Power-ACLR-Measurements-with-N9042B-N9032B-X-Series-Signal-Analyzers.pdf
7. 8 Errors Common to Spectrum Analysis
https://www.keysight.com/us/en/assets/3122-1990/application-notes/8-Errors-Common-to-Spectrum-Analysis.pdf
8. Getting the Most Out of Your X-Series Signal Analyzer
https://www.keysight.com/us/en/assets/3121-1318/application-notes/Getting-the-Most-Out-of-Your-X-Series-Signal-Analyzer.pdf
9. Making Fast and Accurate Power Measurements with Absolute Confidence
https://www.keysight.com/us/en/assets/7018-06123/application-notes/5992-2906.pdf
10. Time-Gated Spectral Analysis with X-Series Signal Analyzers
https://www.keysight.com/us/en/assets/3121-1446/application-notes/Time-Gated-Spectral-Analysis-with-X-Series-Signal-Analyzers.pdf
11. Spectrum and Signal Analyzer Measurements and Noise
https://www.keysight.com/us/en/assets/7018-06765/application-notes/5966-4008.pdf
12. Spectrum Analysis Basics
https://www.keysight.com/us/en/assets/7018-06714/application-notes/5952-0292.pdf
13. Using Noise Floor Extensions in an X-Series Signal Analyzer
https://www.keysight.com/us/en/assets/7018-02450/application-notes/5990-5340.pdf
14. Measuring the Characteristics of Pulsed Radar Signals
https://www.keysight.com/us/en/assets/7018-05222/application-notes/5992-1521.pdf
15. How to Make D-band Noise Figure Measurements with Signal Analyzers
https://www.keysight.com/us/en/assets/3122-1579/application-notes/How-to-Make-D-band-Noise-Figure-Measurement-with-Signal-Analyzer.pdf
16. Full Bypass Path for X-Series Signal Analyzers
https://www.keysight.com/us/en/assets/3120-1504/application-notes/Full-Bypass-Path-for-X-Series-Signal-Analyzers.pdf