APPLICATION NOTE

Optimizing the VST to Achieve the Best EVM Margin for Wi-Fi 7 Test

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Introduction

Wi-Fi 7 Challenges

The IEEE definition for Wi-Fi 7, known as 802.11be or extreme high throughput (EHT), promises to gain higher throughput and efficiencies that build on its predecessor, 802.11ax. Along with additional flexibility for multiuser packets and increased bandwidth options comes inherent challenges for optimizing test equipment and achieving an accurate EVM measurement for RFICs. Allowed configurations include 320 MHz channels—double the previous maximum bandwidth of 11ax—and the resulting format of the preamble to support multiuser resource units has naturally increased the peak to average power ratio (PAPR) of the waveforms. As with 11ax, there are also dense constellations up to 4096-QAM that require a greater degree of modulation accuracy in the transmit and receive functions of a chip or measurement device.

In the case of increased bandwidth, the signal has twice the noise in spectrum across the channel which leads to a theoretical degradation of 3 dB of EVM performance. This is true for the modulation/demodulation accuracy of the device under test (DUT) as well as the EVM noise floor, or residual EVM floor, of the measurement instrument itself. As always, it is crucial that the measurement device is by some degree more performant than the DUT such that the measurement is not impacted by contributions of the instrument. This is normally referred to as the EVM noise floor margin which typically is sufficient within 4 dB or better. Some engineering teams may require a margin of 10 dB or greater where possible, but this is largely a subjective preference. As the technology and chips become more performant, it is important to evaluate the measurement equipment in loopback (RF output directly cabled to RF input) to ensure that the EVM noise floor margin is acceptable.

There are of course other capabilities defined by Wi-Fi 7, such as trigger-based PPDU, but an exhaustive explanation of all Wi-Fi 7 features goes beyond the scope of this application note. The focus of this discussion will be strictly on achieving the best EVM floor of the measurement device for evaluating Modulation Accuracy (ModAcc) of the DUT TX (transmit) tests as well as RX sensitivity tests where the generator optimizations for lower PAPR to be discussed are applicable.

IEEE-Compliant Testing

The IEEE standard draft document for 11be defines a common or standardized way in which test engineers can quantify the DUT performance for modulation accuracy tests. This serves as a way to ensure that when performance data is evaluated of a particular component to be integrated, it can be relied on with a common set of test methodologies and lead to fair comparison.

There also exist some additional test methodologies that are not IEEE compliant but can serve as useful diagnostic tools, such as channel smoothing. These are optional features that engineers may choose to apply, but it is helpful to be aware of these when comparing instruments or data sets for correlation.

Further, test engineers may desire to measure EVM when operating under dynamic conditions to simulate and fairly represent the DUT EVM performance when it is powered "just in time" for a packet. The test is conducted by enabling the DUT in conjunction with the beginning of a packet. This is more representative of how the component, such as a power amplifier, will perform in a real-world scenario, as devices are designed to be more energy efficient. End devices commonly use this technique to extend battery life. When EVM is measured in this way, it is referred to as dynamic EVM (dEVM). Though this app note does not intend to go into dEVM approaches, all the optimizations discussed still apply and will translate to a more accurate measurement in either case.

Guide to This App Note

This application note is created with the assumption that the reader is familiar with WLAN PHY-layer testing and is based on the use of a vector signal transceiver (VST) for stimulation and measurement of an RF front-end device. All of the optimizations discussed are demonstrated as a loopback test on the VST such that the EVM floor can be ideal and evaluated, but these would still apply in the case a DUT was inline for testing. It is also assumed that the reader understands how EVM is calculated by the WLAN standard; all EVM mentioned hereafter will comply with that standard.

A Quick Introduction to the PXIe-5842

The instrument used as an example for this note is the third-generation VST from NI, or the PXIe-5842. The PXIe-5842 is paired with a PXIe-5655 which is a dedicated low-phase noise two-channel local oscillator (LO). This serves as the default "onboard" LO source for the VSG and VSA paths of the VST. As there are two independent LOs available, the generator and receiver can each independently tune while achieving best-in-class phase noise performance.

A large advantage of this system topology is that sharing the LO between the generator and analyzer—which will be discussed as one approach to reduce phase noise for EVM—is not necessary and would mean each could be tuned to a unique center frequency. Additionally, for devices such as transceivers (TRx) in which one port of the DUT would interface with baseband frequencies (BB) and the other port is converted to intermediate or radio frequencies (IF/RF), the low-phase noise LO will provide the best EVM floor where an LO could not be shared.

As components become more performant and the standard increases the challenge of overcoming noise and distortion with dense constellations and wider bandwidths, so must the instrument become increasingly capable. The PXIe-5842 has improved dynamic range which translates to better inherent EVM performance, as well as a full frequency coverage of all three WLAN bands (2.4G, 5G, and 6G) in a single instrument.

Learn more about the PXIe-5842 and other PXI VSTs

Factors That Degrade EVM

As with any instrument, there are ways to optimize settings so that the best possible performance can be achieved. This requires a knowledge of instrument settings that impact EVM as well as properties of the WLAN 11be waveform itself, which will be discussed shortly. First, a review of the factors that lead to poor EVM is helpful.

Following each explanation of factors that degrade EVM, steps that can be taken to improve will be demonstrated. Each example is shown on a PXIe-5842 using an 11be 320 MHz MCS 13 (4096 QAM) waveform at 5.5 GHz. By checking each of these elements, you can achieve the optimal EVM floor of the VST and thus have the best possible EVM floor margin to give high confidence of the DUT measurement results.

Noise

In any RF channel or system, whether over-the-air (OTA) or conductive (copper cabling), there is the presence of noise in an even Gaussian distribution across the entire spectrum. This is commonly referred to as the noise floor; with any RF signal it is possible to measure the signal power as ratio compared to the noise floor power. We refer to this as the signal-to-noise ratio (SNR), and it is typically expressed in decibels (dB).

The ability to detect a WLAN signal and correctly demodulate the transmitted symbols greatly depends on the degree of SNR during transmission. The channel, whether in the air or conducted, suppresses this ratio to the point that symbols may be incorrectly interpreted in the demodulation process. When creating a plot of EVM versus output power of the DUT or VSG, we typically see it result in what is known as a “bathtub curve” given its general shape (Figure 1).

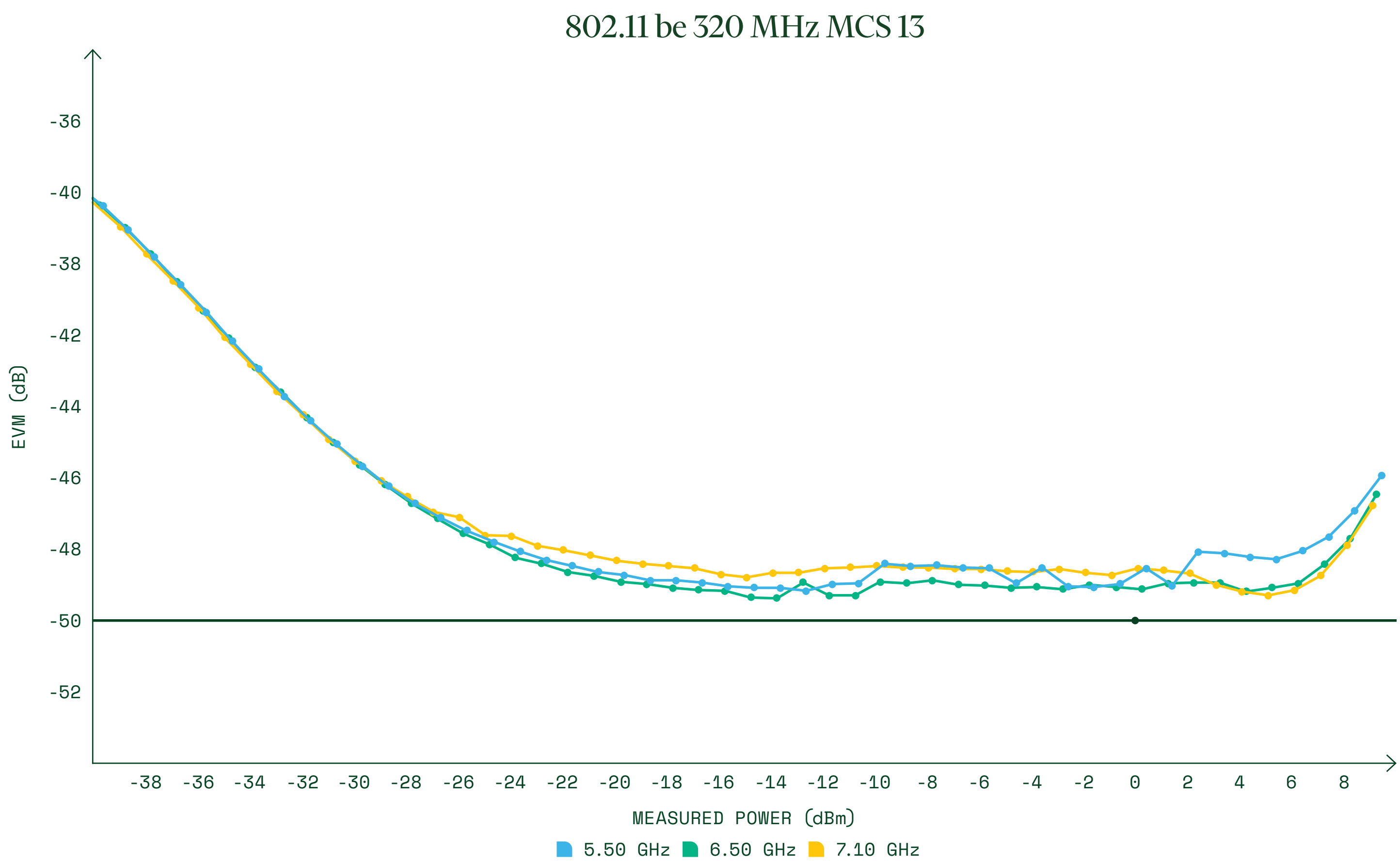

FIGURE 01

11be 320M MCS13 Waveform EVM Across Power in Loopback on PXIe-5842

As you will notice in Figure 1, the left side of the curve starts at a certain EVM level that improves as the output power increases. This is a direct result of the SNR improving and less noise affecting each symbol. For this reason, we say the left side is “noise dominated.”

Additionally, any attenuation that is added to the path will reduce the SNR in the signal chain along the way, so care should be taken to use only where necessary (such as impedance matching). In the case of testing a PA where the signal and noise are equally boosted, attenuation can be added at the output to test higher output powers than the VSA is able to handle.

Reducing Noise (Improving SNR)

In the aim of mitigating EVM degradation when it comes to noise contributions, the focus should be increasing the SNR of the signal where possible. The PAPR for the signal being generated plays a part in this and will be discussed in a moment—but let us assume that is already ideal or as good as we can make it.

The next place we can think of for improvement is in our signal chain to and from the DUT. A small amount of attenuation (approximately 3 dB) is typically inserted in front of the DUT input as a means to get a better impedance match for the 50 Ω system. If too much attenuation is introduced at this stage, it will have the effect of lowering the signal power while bringing it closer to the noise floor, thereby reducing the SNR further. When a PA amplifies the input signal, both signal and noise power are amplified equally so the SNR is maintained, but any additional attenuation inserted after the DUT output will decrease the SNR as well. It may be necessary to add as much as 20 dB attenuation on the output in order to measure output powers that exceed the limits of the VSA front end, but it comes at a tradeoff.

One way to think of this when planning the test system signal chain is to consider the VST loopback bathtub curve's ideal "bottom" range. At the point which EVM is best and continues until nonlinear effects begin to degrade it again is considered the dynamic range of the EVM floor of the instrument, seen in Figure 2:

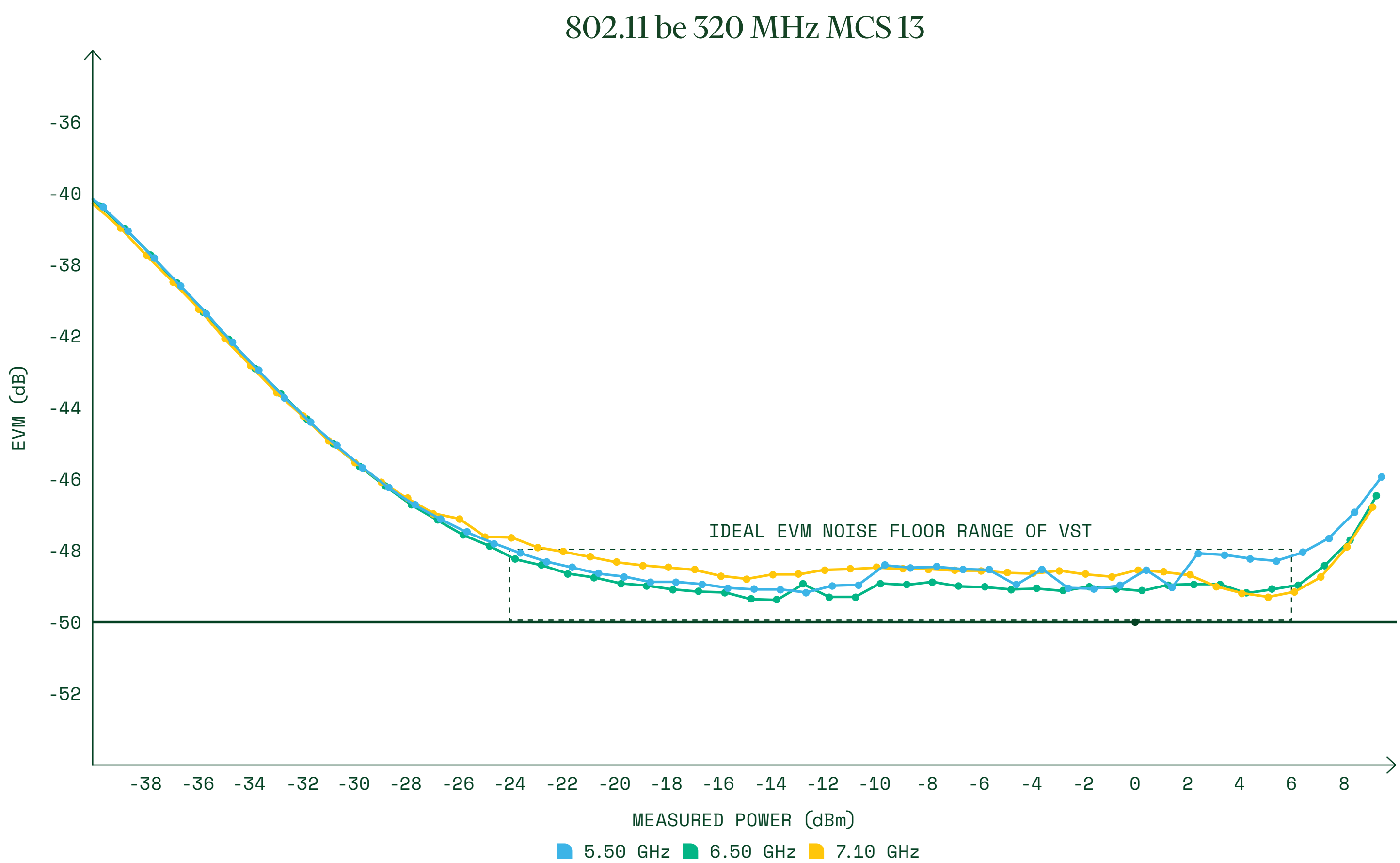

FIGURE 02

Ideal Operating Power Range of VST for Best EVM Noise Floor

This is extrapolated to a higher range of power when boosted by a PA. So for instance, if the VST has an ideal EVM floor ranging from −22 dBm to +5 dBm as shown in Figure 2, this will translate to an ideal test range of −2 dBm to +25 dBm output power of a PA with 20 dB of gain. As the output power would exceed the VSA limits, a 10 dB attenuator could be introduced to the output so that in actuality the output power seen at the VSA input is +15 dBm, but the PA is still outputting at +25 dBm and can be characterized. The main point here is that if too much attenuation is applied, it will begin to decrease your SNR seen at the ADC and move away from the sweet spot—or ideal EVM floor—of the instrument as a result.

With these RF signal chain effects considered and optimized, the next thing to ensure is that the optimal reference level of the VSA is set. One way to achieve this is by using a reference level “servo” which is a standard feature of RFmx WLAN to iteratively lower the reference level to the point of “best EVM” while not crossing into the domain of an ADC overload warning. As seen in Figure 3, the reference level is set to the peak power of the signal where the average power of the waveform is −10 dBm and the PAPR is approximately 14 dB, which would mean the reference level is initially set to +4 dBm.

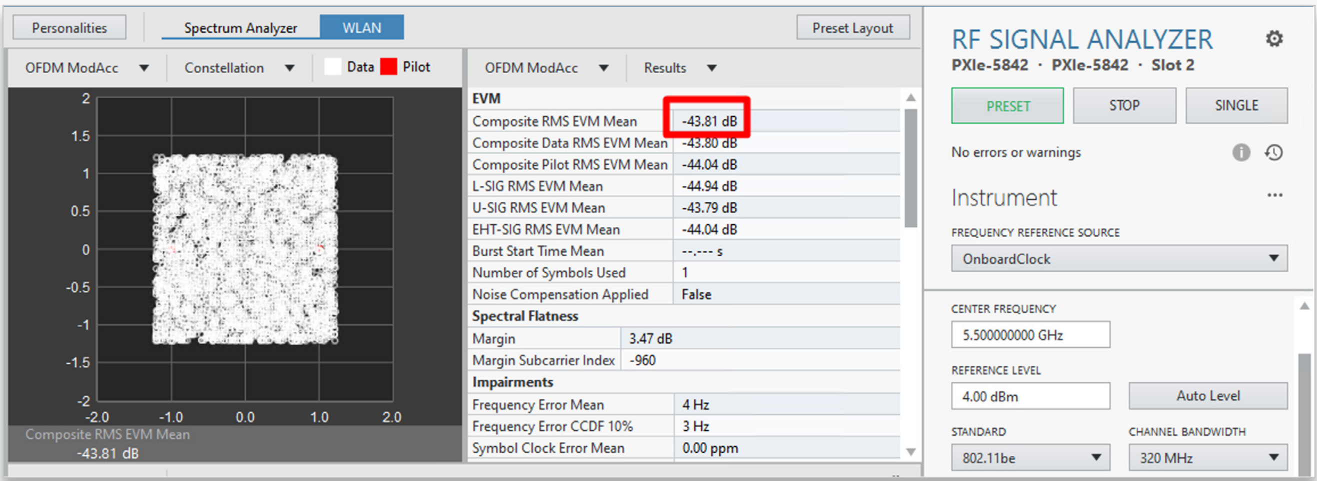

FIGURE 03

11be 320M MCS13 Waveform with Typical Reference Level Set Achieving −43.81 dB EVM in Loopback at a Center Frequency of 5.5 GHz and an Average Power = −10 dBm

Now, notice what happens when we reduce the reference level to the point just before the ADC overload warning in Figure 4:

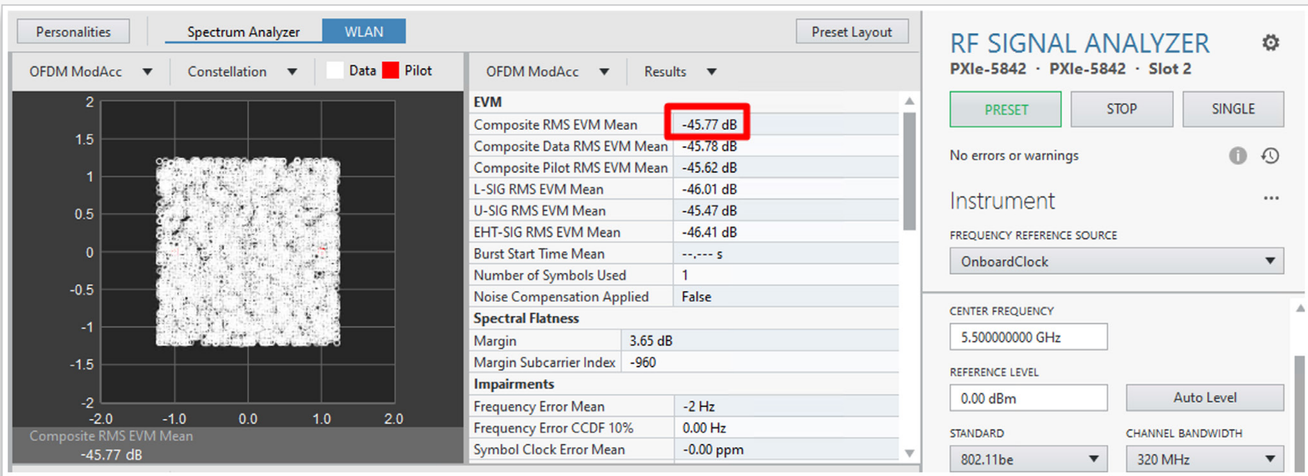

FIGURE 04

11be 320M MCS13 Waveform with Optimized Reference Level Set to Achieve –45.77 dB EVM in Loopback at a Center Frequency of 5.5 GHz and an Average Power = –10 dBm

This optimization can decrease EVM by as much as 2 to 3 dB alone. It is possible to ignore the ADC overload warning to a point as it is only distorting preamble sections, but it would be difficult to know when clipping of the data portion begins which would invalidate the results. In practice, if the reference level reaches the point of clipping the data EVM, the number will degrade sharply as a result and can be observed during experimentation.

Non-Linear Effects (Distortion)

As the left side (low power) of a bathtub curve is dominated by effects of noise, nonlinear distortion has a dominative effect on the right side of the curve. Any nonlinear device in the signal chain introduces distortions as a result of intermodulation and harmonics. Additionally, PAs create nonlinear behaviors due to compression that results in degraded EVM quality. As seen in Figure 1, at a certain point of output power, the EVM generally degrades as the power level increases. It is also important to recognize that the VSG introduces these effects as the generated signal passes through a power amplification stage. Ultimately, the more linear a device is or the more it is operated within its linear range, the less impact on the resulting error vectors.

Reducing Non-Linear Effects on VST Measurement

As mentioned before, operating the instrument within the “dynamic range” of the ideal EVM noise floor is the best way to avoid introducing nonlinear effects of the generator VSG on the DUT EVM measurement. The bathtub curve shown in Figure 2 is produced in loopback, so this translates to the ideal power input (Pin) of the DUT for testing.

IQ Impairments

With vector signals that utilize in-phase and quadrature (IQ) signals, the discrete I and Q signal paths on both the generator and analyzer side can degrade EVM. These IQ “imbalances” are also possibly introduced by a DUT where the baseband modem is included. Shown in Figure 5 is an example of an ideal constellation, virtually free of impairments.

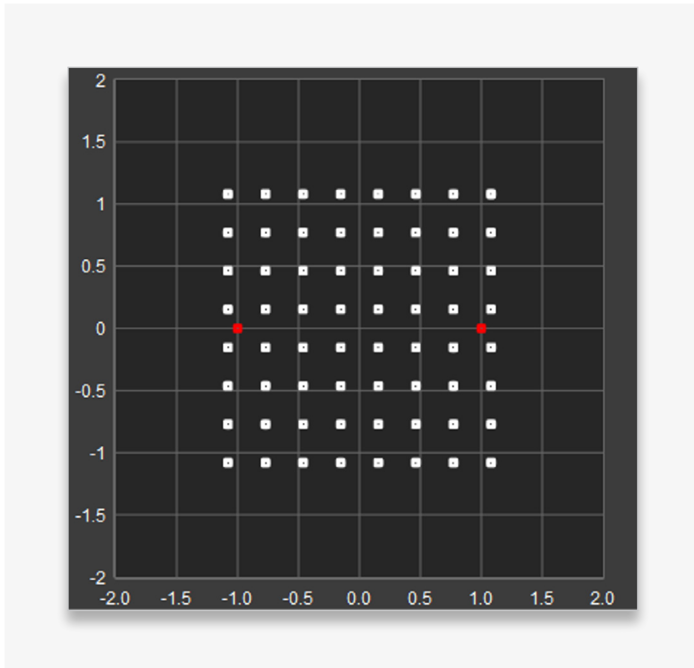

FIGURE 05

Close to Ideal Received 64-QAM WLAN Constellation (11be 80 MHz MCS 7)

Typically, these imbalances manifest as skews, rotations, and other deformations of the transmitted or received symbol constellation (see Figure 6). If the gain is slightly different in I and Q signal paths, it can create an imbalanced power range in the I and Q plane of the constellation, known as IQ gain imbalance. If the I and Q signals are not separated by a precisely 90° phase difference, it can lead to what is known as IQ quadrature error, which can appear as a rotation in the constellation. Finally, it may be possible that I and Q are misaligned in time because of signal path delays, which would also lead to constellation distortions. This is known as IQ timing skew and would similarly appear as quadrature error and gain imbalances between the I and Q coordinate planes.

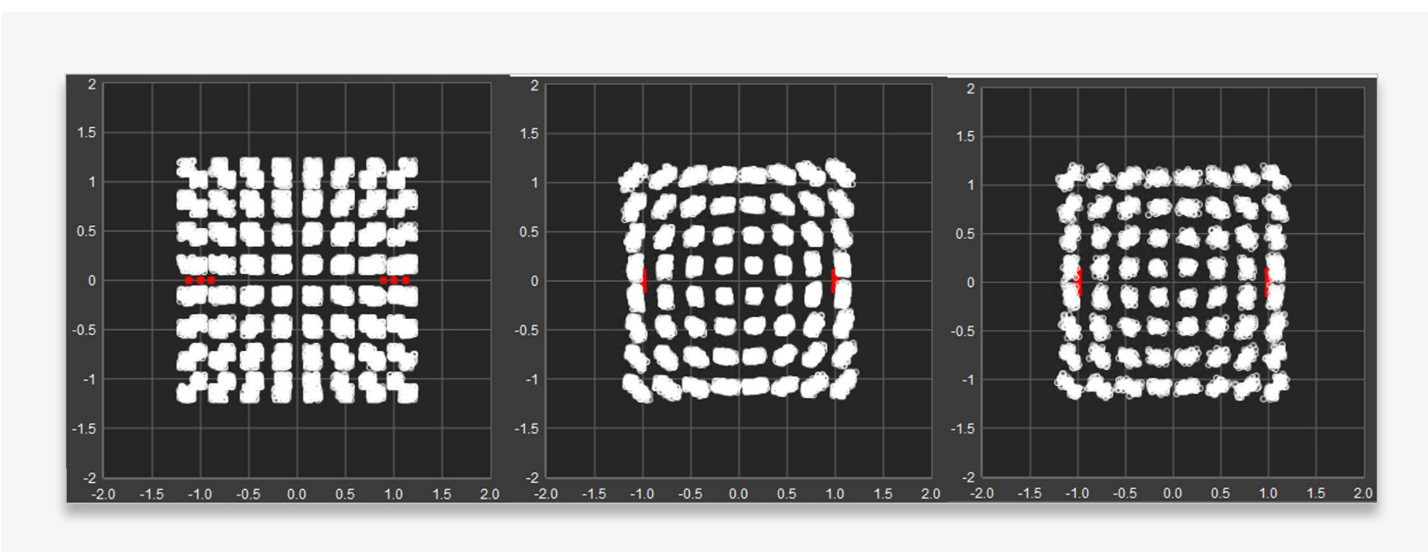

FIGURE 06

Shown Left to Right: IQ Gain Imbalance (1 dB), IQ Quadrature Error (5 degrees), and IQ Timing Skew

Correcting IQ Impairments

It is possible to estimate and compensate for these IQ impairments by using the RFmx WLAN API. These impairments do not typically come from the VST, but in some cases where the DUT may introduce them because of the evaluation board, these elements can be corrected to show EVM of the DUT in an ideal configuration.

Read more about IQ impairments

Phase Noise of the LO

When a baseband signal is introduced to an RF mixer for up or down conversion, the performance of the LO that is used is critical to EVM performance. An LO is simply a single tone generator and is never perfectly steady. In the time domain of a signal we see the imperfections of the tone as jitter, where a signal peak sometimes comes early or late in time from a common reference point. In the frequency domain this translates to an imperfect frequency and results in what we call phase noise. This effect will contribute to symbol accuracy relative to its intended target along with effects of noise, distortion, and IQ impairments. It is important to select an LO source that has as low phase noise as possible to improve this effect, as well as mitigation techniques discussed in a moment.

LO Configurations to Improve Phase Noise Contribution to EVM

As for improving phase noise of the LO and its impacts to EVM, the PXIe-5842 is already in a good state using its dedicated low-phase noise LOs from the PXIe-5655. But what if a higher quality LO is not available? For a two-port device such as a PA in which the center frequency is the same at input and output, it is possible to share the same LO signal between VSG and VSA. In effect, this means that in every instance the phase noise pushes a generated symbol off target in some vector direction, the analyzer is measuring it by the same vector offset—meaning that phase noise is not playing a part in the EVM degradation. It can be observed that the bathtub curve for a VST in loopback with a shared LO is essentially the same level of performance as using low-phase noise LOs independently on each side. The benefit of the PXIe-5842 is that you have the option to share LOs if desired (sometimes this is still beneficial for phase coherency between multiple channels, or MIMO), but is not necessary to achieve a great EVM floor.

By either sharing LOs or using high quality LOs to drive each mixer, the EVM floor will typically improve by 2 to 3 dB, as well.

High PAPR

As mentioned in the introduction, 802.11be introduces many features for flexibility to serve multiple users simultaneously through what is known a multi-RU aggregation where an “RU” is a single resource unit as defined by the IEEE draft. The preamble contains details for scheduling packet transmissions of each user and their respective channel allocations. This has been true since OFDMA techniques were introduced in previous standards, but what has been added to 11be is a more dynamic way to aggregate RUs to serve a single user.

Without taking time to fully discuss these features, what is important for this note is that the format of the preamble can be more variable in power level relative to the data portion of the packet. When comparing PAPRs of 11ax waveforms and earlier, this typically did not exceed beyond 10 or 11 dB. The current draft of 11be waveforms can be anywhere from 11 to as much as 16 dB in PAPR, which has an impact on the SNR. Therefore, the range at which an analyzer can measure close to the power of the data portion of the WLAN packet where EVM is calculated.

Shown in Figure 7 is a comparison in power versus time of an antiquated 11ax 320 MHz signal that was only used as an early proxy for 11be along with the actual 11be 320 MHz signal as defined by subsequent updates to the 11be draft. This gives a good perspective of how much of a difference the PAPR makes when considering how low the VSA reference level can be set to get to the peak power of the data portion.

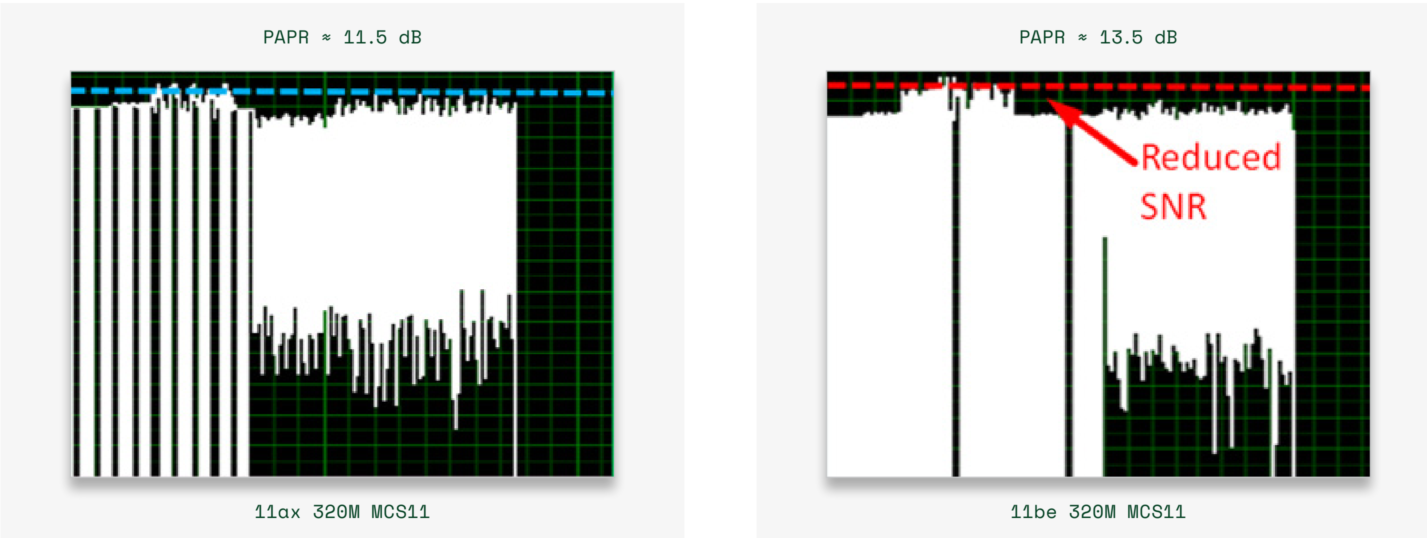

FIGURE 07

Comparison of 11ax 320M Proxy to 11be 320M to Show Increased PAPR

Each dotted line in the figure represents a potential reference level set to get as close to the peak power of the data portion (lower power section that follows the higher power preamble). When the reference level is lowered to this point, some of the peak samples of the preamble can be ignored, as they do not create significant ADC overload. It follows that the higher the peak power of the preamble relative to the data portion, the higher this limit becomes before ADC overload and thus a poorer SNR for EVM measurement. There are techniques to lower the PAPR that will be discussed that can help mitigate this challenge.

Improving PAPR by Manipulating Standard Parameters

As mentioned in the introduction, 11be waveforms can produce much higher PAPRs than previous WLAN standards, creating an issue for both the PA designer and the test engineer where EVM degradation is concerned. The higher PAPR means that while a PA is operating in the linear region, assuming techniques like digital predistortion are not being utilized to extend linearization, the higher peak samples will be more likely to create nonlinear distortions. For an instrument like the VST, this translates to a higher threshold for the analyzer's reference level, thus farther away from the data portion of the WLAN packet where EVM is being measured.

Figure 8 shows a standard 11be 320 MHz MCS 13 (4096-QAM) waveform and the calculated PAPR of almost 14 dB:

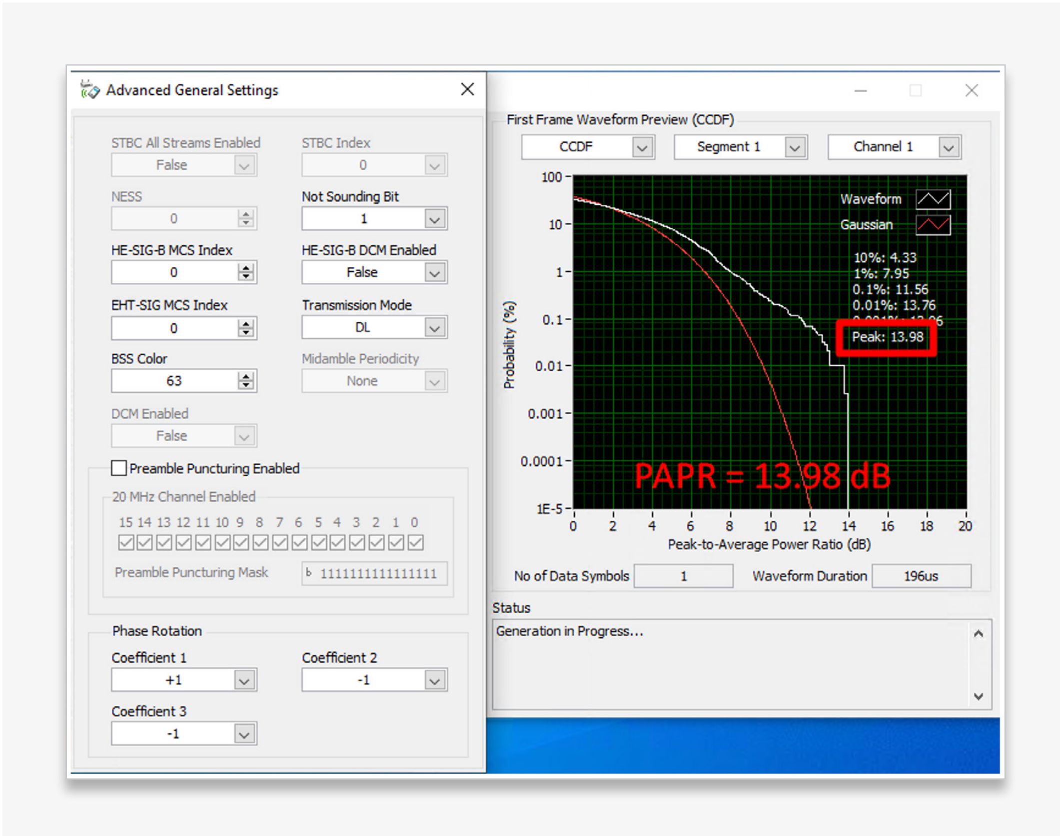

FIGURE 08

11be 320 MHz MCS23 Waveform (1 Symbol)

The resulting EVM floor that can be achieved on the PXIe-5842 in this case is around −45.44 dB EVM (where reference level optimization and the low-phase noise LOs are utilized) as seen in Figure 9:

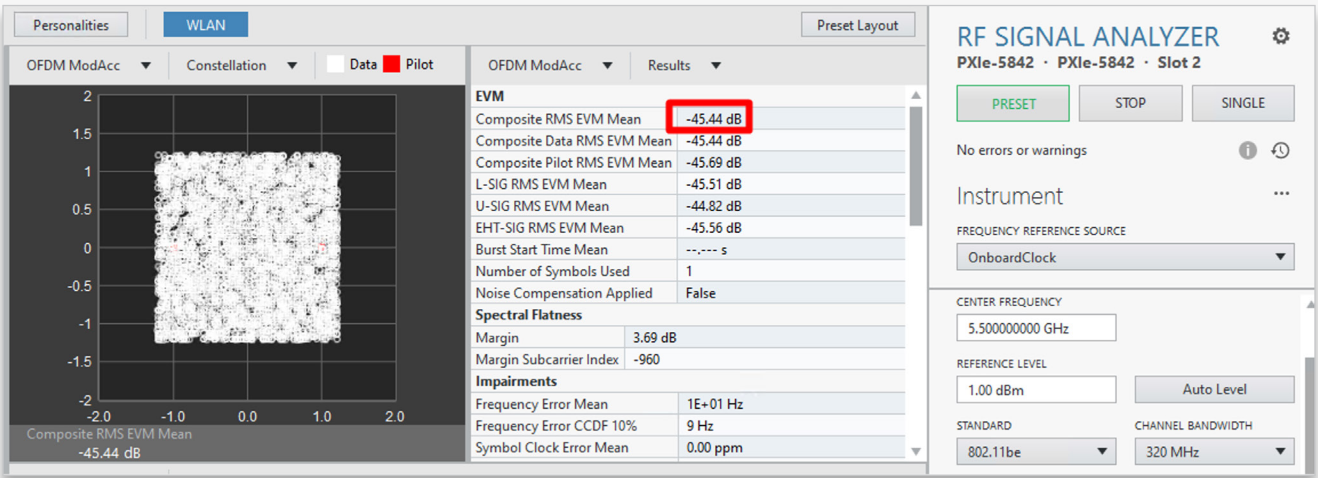

FIGURE 09

PXIe-5842 in Loopback Measuring 11be 320 MHz MCS13 with −45.44 dB EVM

The PAPR can be improved through techniques such as crest factor reduction (CFR) or digital pre-distortion (DPD), but in either case there is not a standardized way to reduce PAPR that would be within the IEEE measurement specifications.

Alternatively, there are a few properties of the header that can be manipulated to create a more favorable PAPR, and specifically for the bandwidth of 320 MHz, IEEE has allowed a concept called phase rotation for precisely this challenge. Phase rotation is a technique by which the phases of each preamble symbol are manipulated to reduce the sample peaks and then can be undone at the demodulator (receiver).

OPTIMIZING THE VST TO ACHIEVE THE BEST EVM MARGIN FOR WI-FI 7 TEST

Leveraging phase rotation along with other standard fields can yield the following improvements:

1. Setting all phase rotation coefficients to –1:

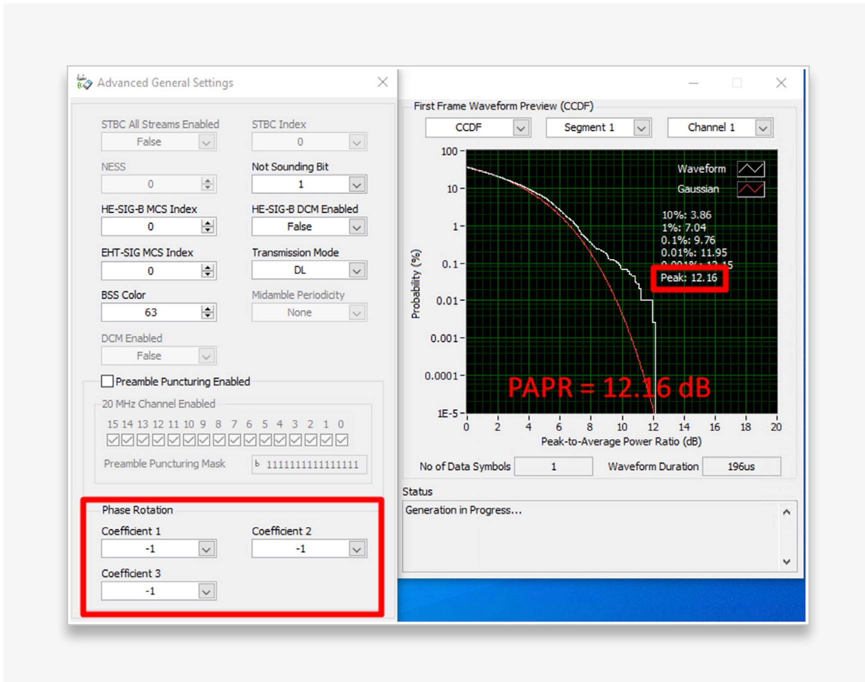

FIGURE 10

Setting Phase Rotation Coefficients to –1 under Advanced Settings for 11be 320 MHz Results in PAPR of 12.16 dB

2. Setting the EHT-SIG MCS Index to 2 (this is a signal field that supports multiple modulation types in 11be) and experimenting with a BSS Color setting that further improves the PAPR (in this case BSS Color = 58).

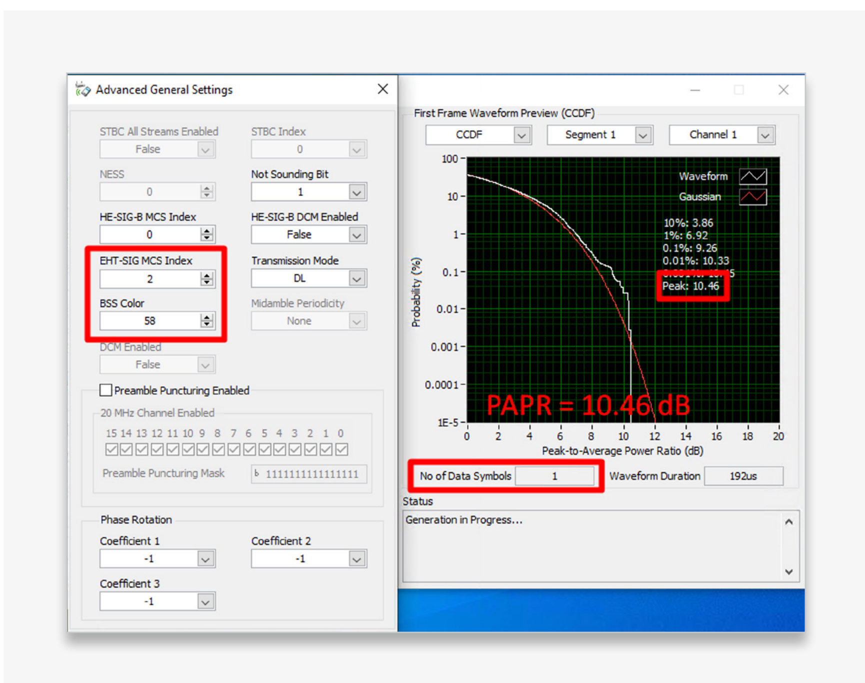

FIGURE 11

Setting EHT-SIG MCS Index to 2 and BSS Color to 58 Results in PAPR of 10.46 dB

OPTIMIZING THE VST TO ACHIEVE THE BEST EVM MARGIN FOR WI-FI 7 TEST

Now with a PAPR of 10.46 dB, the analyzer's reference level can be lowered even closer to the peak samples of the data portion of the packet and results in −49 dB EVM for the EVM noise floor using 11be 320 MHz (see Figure 12).

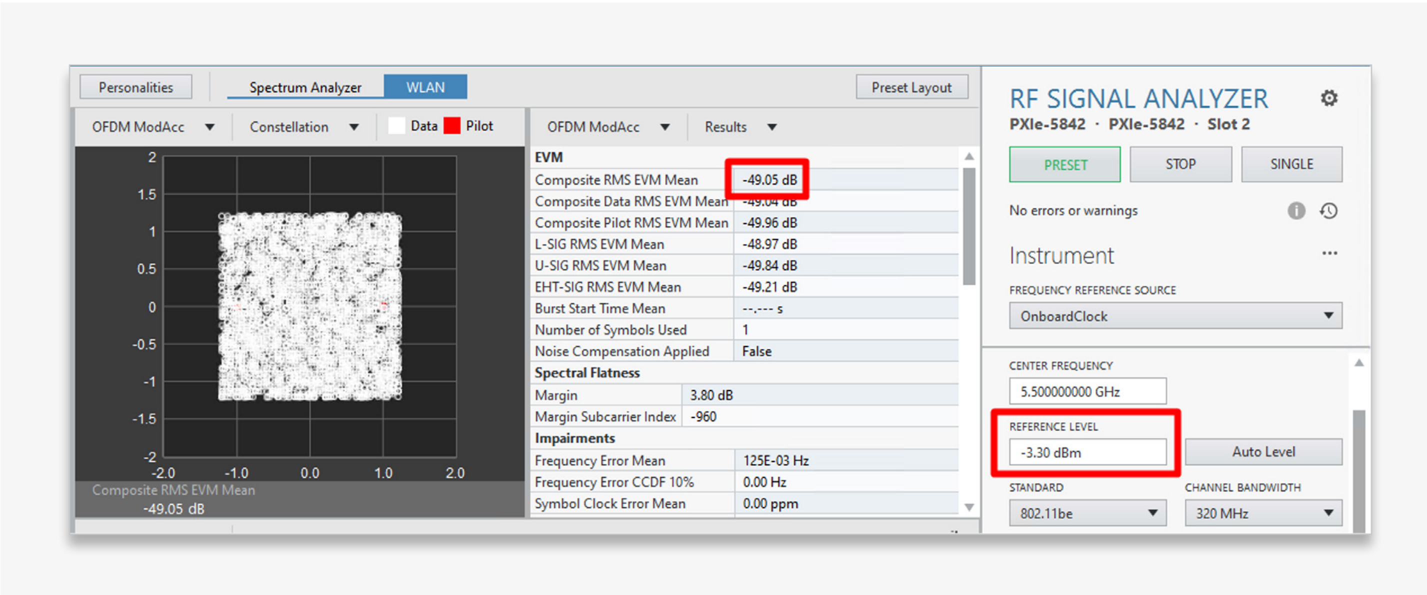

FIGURE 12

EVM Floor of the VST Improved to −49.05 dB EVM

There is, however, one issue with either testing or evaluating the VST in this way—the PAPR was achieved with only one WLAN symbol (as observed in Figure 11). Where it is possible to find this kind of optimization on a single symbol, it is less likely as the number of symbols increases. The IEEE draft for 11ax requires the modulation accuracy test to be conducted over a minimum of 16 symbols, and in the case of 11be it has been updated to a minimum of 32 symbols.

For this reason, it would be more appropriate to test a DUT or evaluate the EVM floor performance of an instrument using the correct number of symbols. To make the point, the same PAPR-reducing techniques are still being applied, but now the packet is extended to 32 symbols in length, as shown in Figure 13:

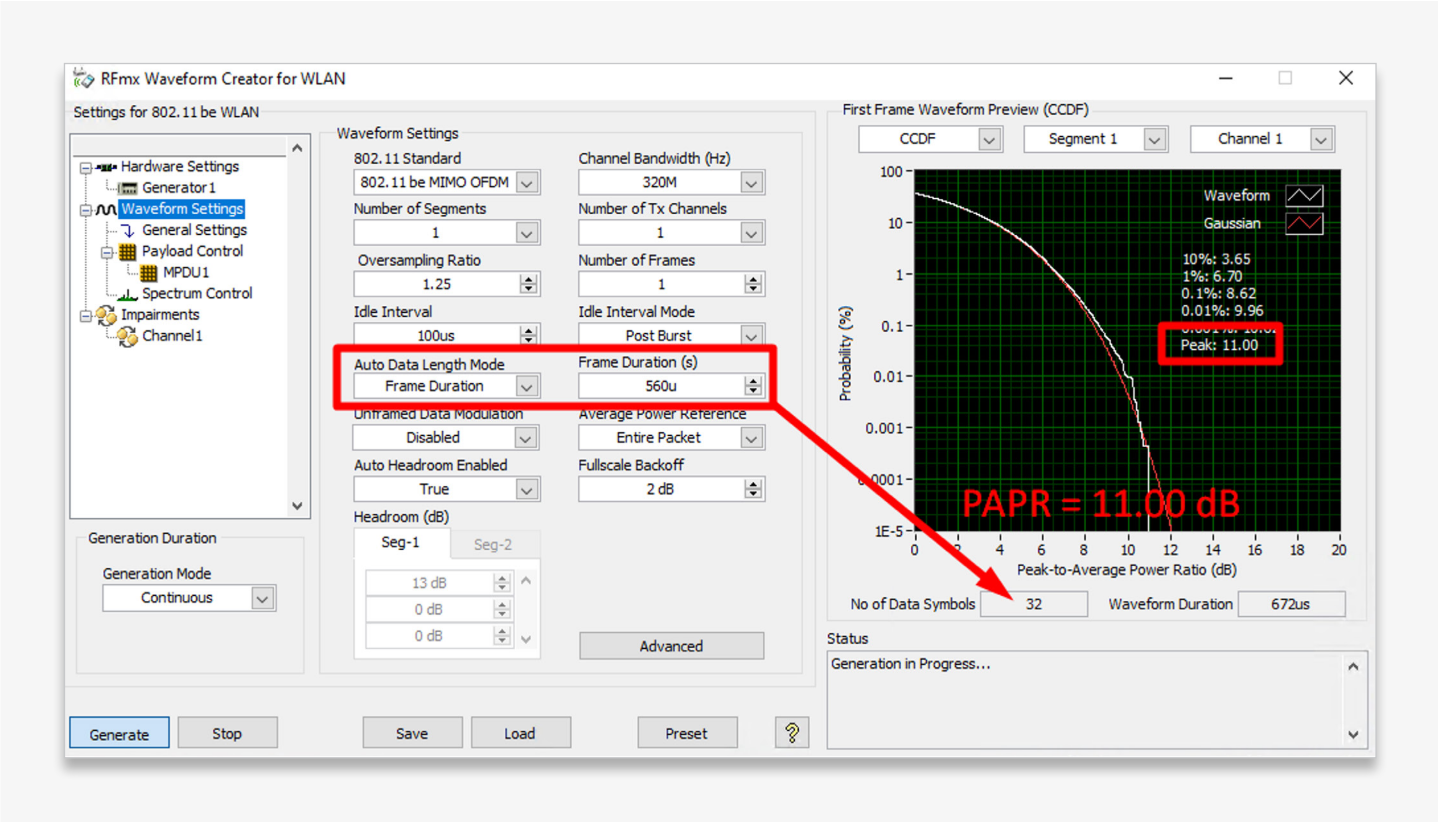

FIGURE 13

Increasing Frame Duration to 560 us to Achieve 32 Symbols Resulting in PAPR = 11.00 dB

It follows that this increase in PAPR of approximately 0.6 dB translates to an EVM floor on the PXIe-5842 of slightly higher performance than before of −48.24 dB EVM (compare Figure 14 with Figure 12).

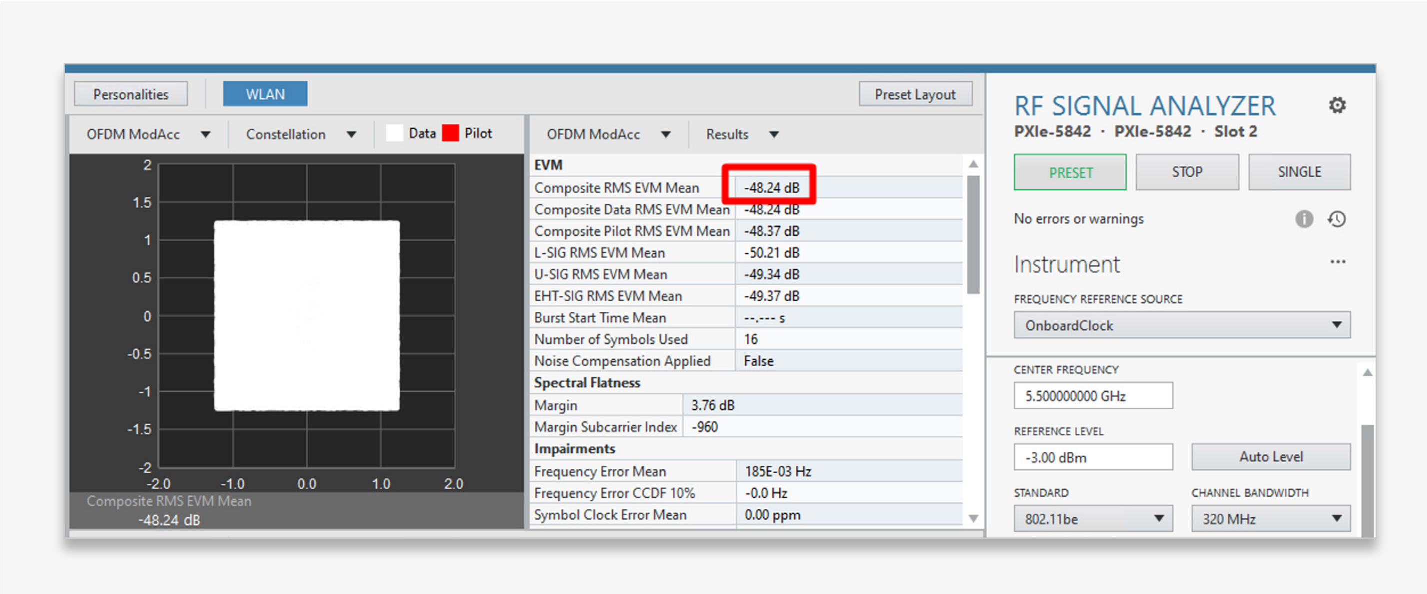

FIGURE 14

EVM Floor on PXIe-5842 of −48.24 dB for 11be 320 MHz MCS 13 When Increasing to 32 Symbols and Raising the PAPR

Extending EVM Noise Floor with Cross Correlation

When a greater EVM floor margin is required while maintaining IEEE compliance, there is still a way to reduce the VSA contributions to EVM even further by expanding the measurement setup to two VSAs. Shown in Figure 15, NI has patented a measurement technique that utilizes an external splitter to measure the output of either the generator (loopback) or the VSG + DUT on two distinct analyzer paths.

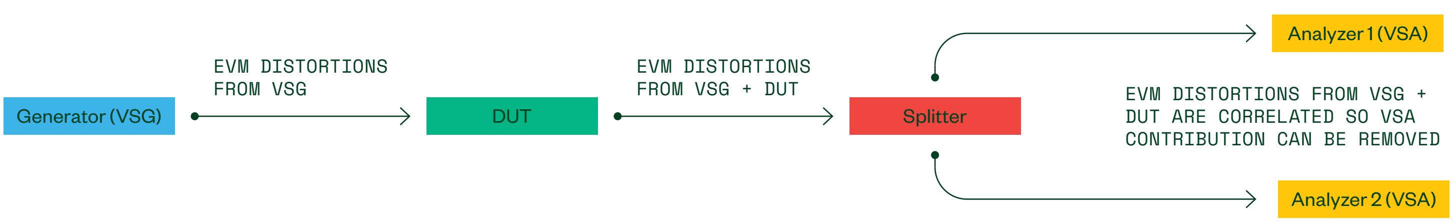

FIGURE 15

Diagram to Show Setup for Cross-Correlated EVM Measurements Using NI Cross Correlation

This means that when vectors are received by each VSA or cross-correlated, the uncorrelated contributions are what is different between each VSA, thereby reducing the VSA contribution only in the final result. This is not to be confused with vector averaging (explained in a later section), where a single VSA uses multiple acquisitions and averages out the uncorrelated noise between each iteration—reducing everything in the signal path, including the VSA.

Read the Cross-Correlation for EVM App Note

Noise Compensation

Another technique commonly made available for the vector signal analyzer involves measuring the noise floor across the WLAN channel of interest such that the noise contributions of the VSA can be removed from the final measurement results. While not explicitly defined as a standard way to measure by IEEE, this technique can provide increased confidence that the EVM measured on a DUT is indeed accurate and not affected by the instrument EVM floor. This may become increasingly useful when the margin between the expected DUT EVM performance is small compared to the EVM floor of the instrument.

Additional details of NI noise compensation

Additional Diagnostic Techniques for Measurement (Non-IEEE Compliant)

Reference + Data Estimation

In a standard demodulation process for WLAN, the pilot tones that are distributed throughout the channel are meant for channel estimation as the noise/distortion will vary by frequency. As can be seen in Figure 16 as one example, this 11be 20 MHz waveform has a symmetrical distribution of known pilot tones around the center frequency of the channel in which an estimation of distortion—and subsequently correction—can be applied to the closest data subcarrier tones. These pilot tones are distributed according to the IEEE draft and are dependent on how the resource unit (RU) sizes are selected.

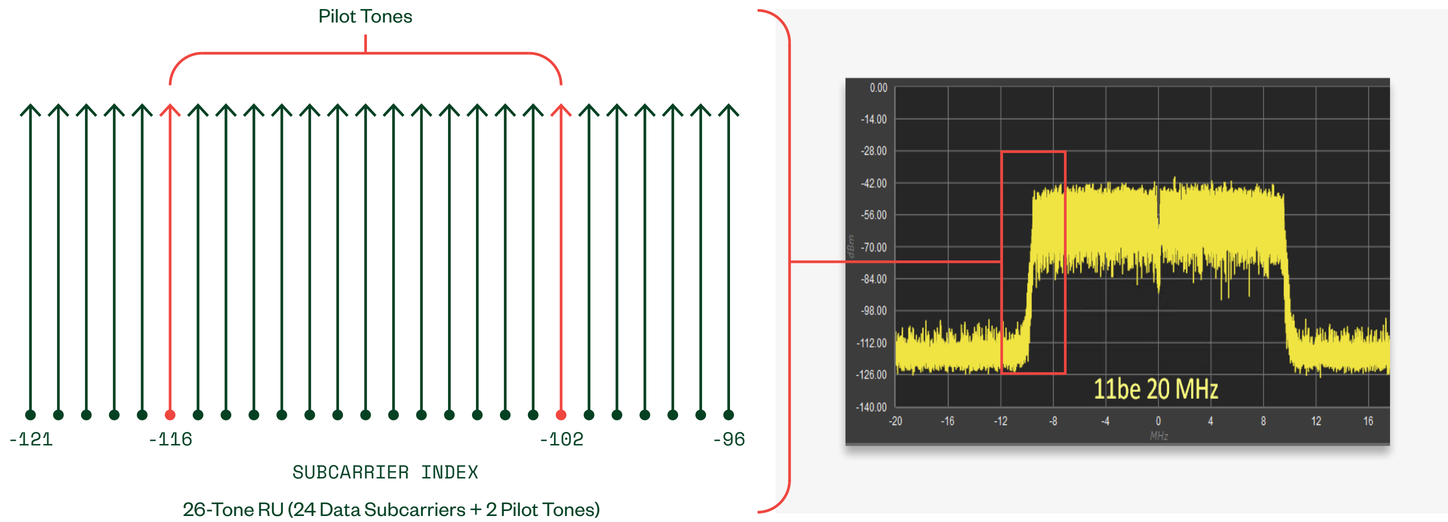

FIGURE 16

26-Tone Resource Unit (RU) Zoomed in to Show Data Subcarrier vs. Pilot Tone Distribution

This is the standard expectation for a receiver channel estimation operation per IEEE, but there are other channel estimation methods available to the test engineer that can allow for increased performance. This serves as a confidence test for the standard measurement results, or may simulate an end device performance where these techniques are integrated. The key thing to understand is that we must start from a standard baseline approach so that comparing the performance data is based on the same set of variables.

Seen in Figure 17, the 11be 320 MHz signal that was optimized before is shown with an EVM floor of −48.24 dB EVM using the standard IEEE reference channel estimation type (Figure 18). This is using only the pilot tones in the preamble for channel estimation and correction of the data subcarriers.

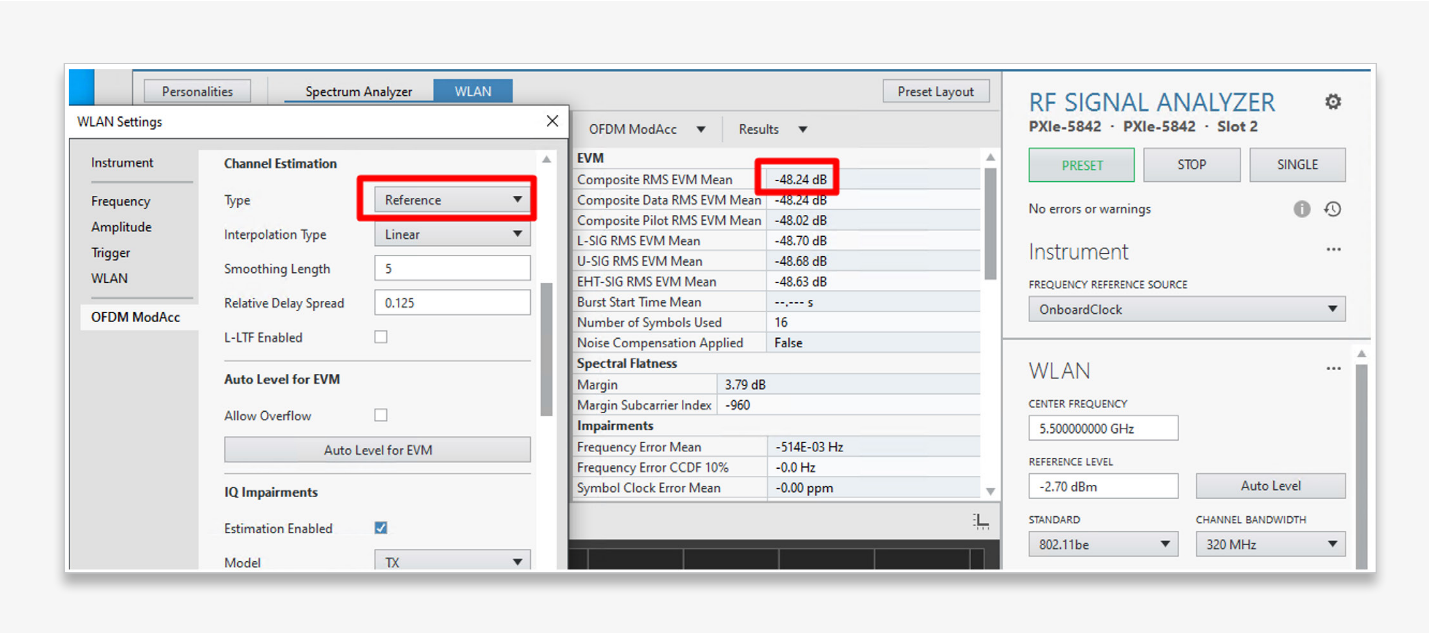

FIGURE 17

Resulting EVM Floor for 11be 320 MHz Signal Using Standard Reference Channel Estimation

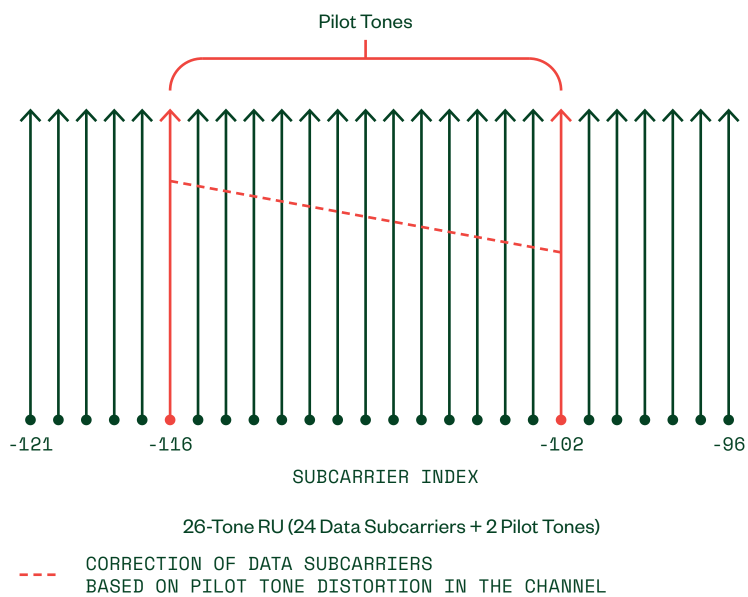

FIGURE 18

Pilot Tones in a 26-Tone RU Applying the IEEE Standard Linear Estimation to Correct the Data Subcarriers

If the data subcarriers are used for the channel estimation as well, this can increase the accuracy of the channel correction because now it is being estimated with a "finer-tooth comb" in spectrum.

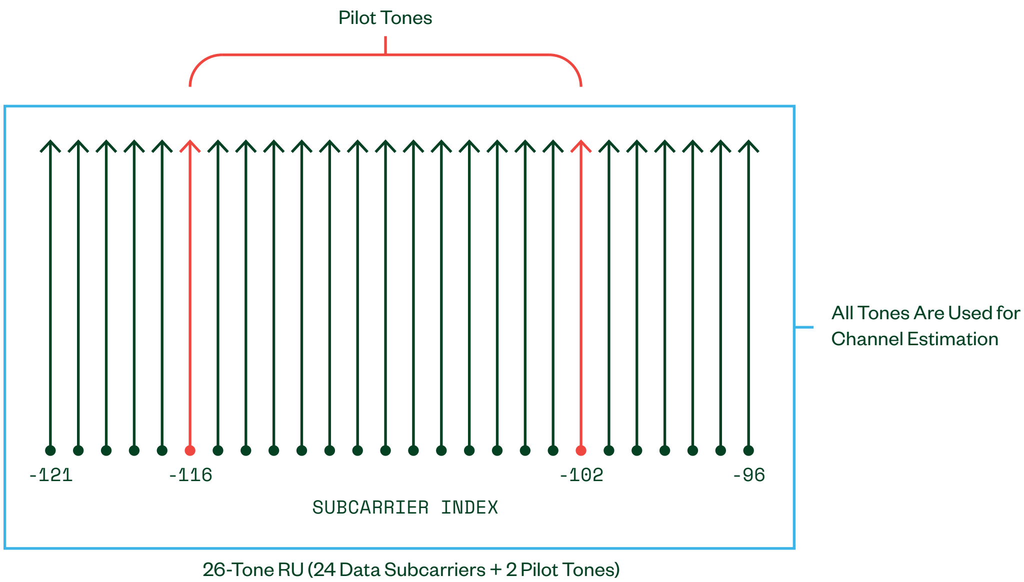

FIGURE 19

Pilot Tones and Data Subcarriers in a 26-tone RU Used to Estimate the Distortion across the Channel (Non-IEEE Compliant)

Seen in Figure 20, the additional estimation from each data subcarrier (where Channel Estimation Type = "Reference and Data") improves the EVM floor to −51.53 dB.

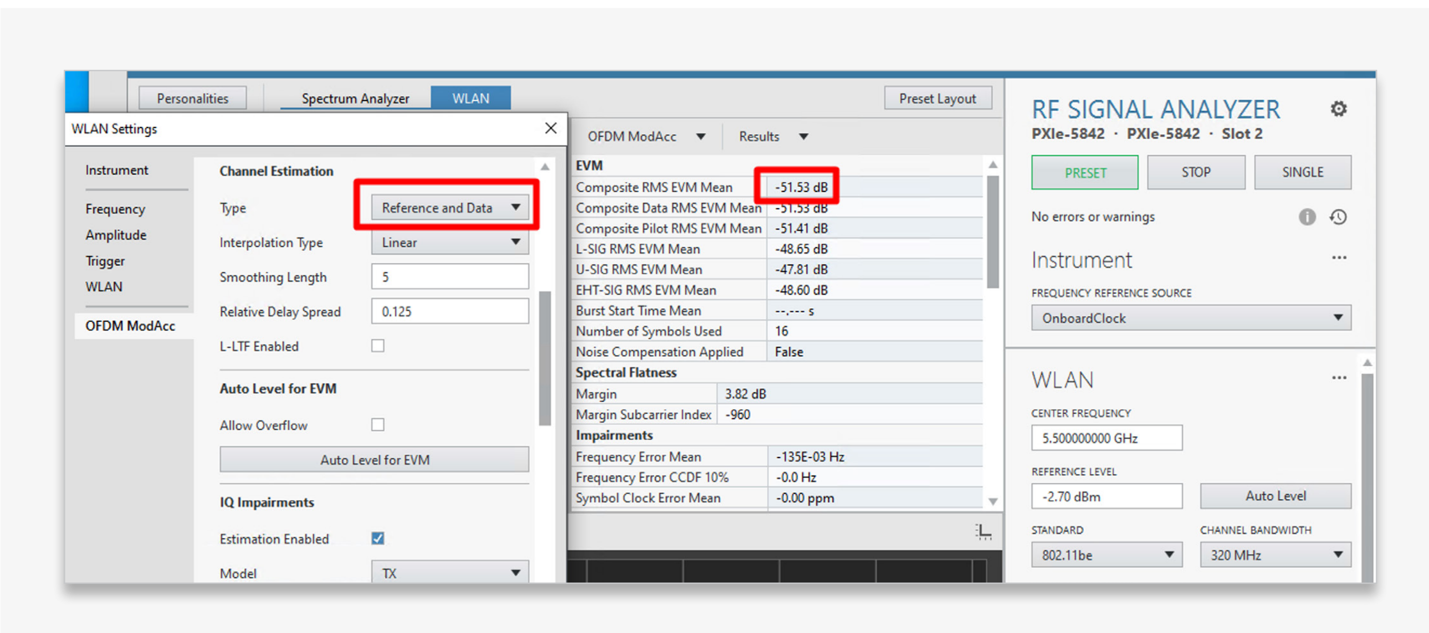

FIGURE 20

Resulting EVM Floor for 11be 320 MHz Signal Using "Reference and Data" Channel Estimation

Channel Smoothing

Taking a step back from the full estimation of each subcarrier tone in the channel, there is also an approach that still utilizes only the pilot tones but creates a more statistical adjustment than the standard linear estimation. This is known as channel smoothing (Figure 21).

OPTIMIZING THE VST TO ACHIEVE THE BEST EVM MARGIN FOR WI-FI 7 TEST

There are multiple interpolation filters that can be applied to create a better estimation of the distortion in the data subcarriers that are in between the known pilot tones. The most commonly used are triangular and Wiener interpolations. In Figure 22, it can be observed that applying a Wiener filter to the channel estimation (i.e., turning a type of "channel smoothing" on) will improve the EVM floor in this case to −50.45 dB EVM.

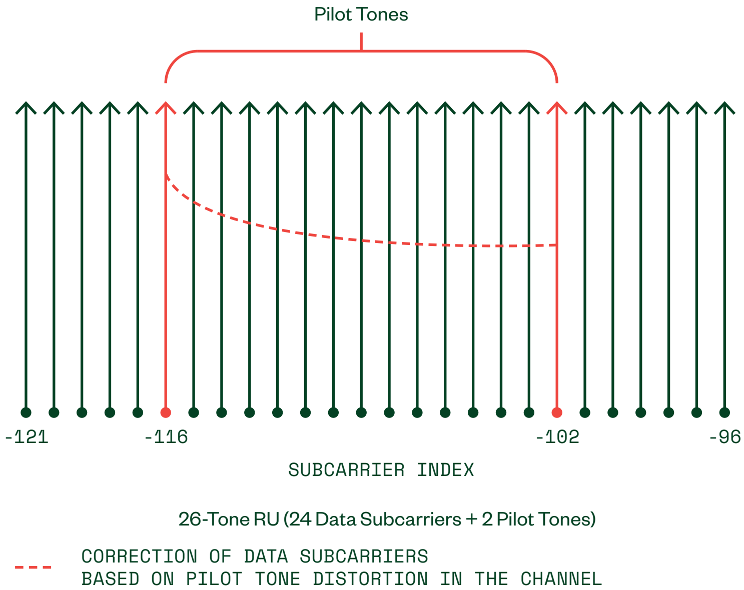

FIGURE 21

Pilot Tones in a 26-tone RU Used to Estimate the Distortion across the Channel with a Channel Smoothing Filter Applied (Non-IEEE Compliant)

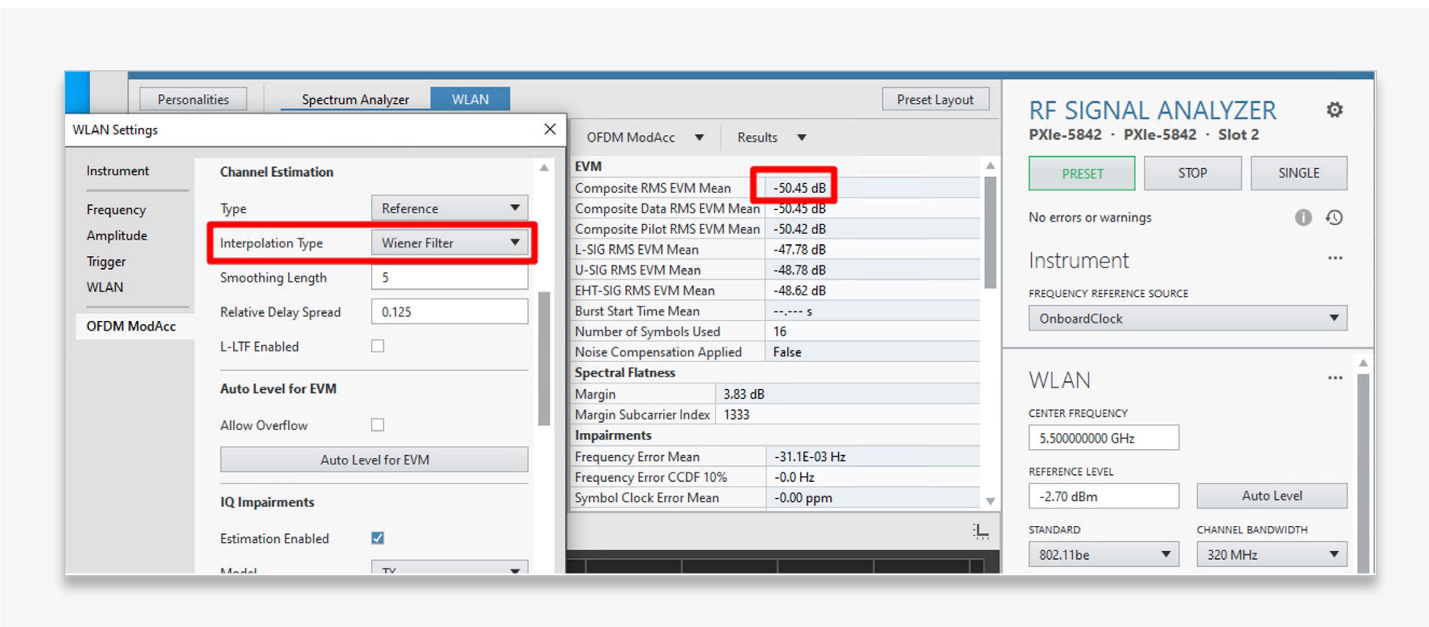

FIGURE 22

Resulting EVM Floor for 11be 320 MHz Signal Using Wiener Channel Smoothing

Vector Averaging

Unlike cross correlation described before, vector averaging is a technique by which only a single VSA channel is used and multiple acquisitions are averaged to reduce all uncorrelated noise contributions in a signal path. Where cross-correlation using two VSA channels to reduce the uncorrelated noise between them reveals only the generator (VSG) and DUT contributions, vector averaging would reduce uncorrelated noise from one iteration to the next. This means that all EVM contributions, not just the VSA, would be reduced by each iteration until the point that even the true DUT EVM would be obscured.

Additional information on vector averaging

Conclusion

In summary, many optimizations have been discussed, both IEEE compliant and some that are useful for diagnostics only. In order to ensure that your evaluation of the EVM noise floor of an instrument such as a Vector Signal Transceiver will adequately provide a good margin for DUT measurement, it is advised to do the following:

- Use test waveforms that are compliant with the standard but are as low as possible in PAPR.
- Share local oscillators from the VSG to the VSA to eliminate phase noise contributions for a PA test. In the case of transceivers, a low-phase noise LO should be used to drive the IF/RF port of the DUT.
- Characterize and plan the signal path before and after the DUT to ensure the best tradeoff is made between impedance matching or higher power output of the DUT while maintain good SNR through the signal chain.
- Optimize the reference level of the signal analyzer to get as close to the peak samples of the data portion of the WLAN packet before overloading the ADC (due to the preamble).
- When the EVM floor margin is too close to the expected DUT EVM performance, consider the following in order:
  - Check DUT EVM against a measurement where noise compensation is applied to see that the numbers correlate. If they do not, then the VST contribution is potentially masking the true results.
  - Consider extending the EVM noise floor by utilizing the NI Cross-Correlation solution.
  - Consider upgrading to the latest released PXIe-5842 for best-in-class EVM performance.

Learn more about Wi-Fi 7 and wireless connectivity test