APPLICATION NOTE

RFSA2033 Low Loss VVA

Investigation into AM and phase noise observed at 3dB attenuation

Introduction

This document provides application information for the Qorvo® RFSA2033 low loss voltage variable attenuator. Information is presented to demonstrate the rise in AM and phase noise observed around the 3dB attenuation point. This coincides with a 'knee' in the control voltage vs attenuation response, as shown in plots in the RFSA2033 datasheet. The noise increase is similar for both negative and positive attenuation slopes.

The rise in noise from the RFSA2033 at around 3dB attenuation will be negligible in most applications. This is especially the case at higher frequencies where LO phase noise will be proportionally higher and dominate performance. It may only become noticeable for lower frequency applications like CATV, where extremely high system C/N, MER or EVM performance is required.

This is an issue related to the low loss architecture of the RFSA2033, and is not observed in other VVAs in the Qorvo portfolio such as the RFSA2013 and RFSA2023 which have slightly higher loss.

Referenced Documents

The reference documents below take precedence over the contents of this application note, and should always be consulted for the latest information.

RFSA2033 Data Sheet.

Test Setup

A SMA100A signal generator was used to generate a low phase noise signal. A pad was used on the generator output to prevent any interaction with the RFSA2033, for example as the VVA return loss changes with its attenuation. A standard 50R RFSA2033 evaluation board was tested (RFSA2033PCK-410). The output signal from the RFSA2033 was measured using an E5052B signal source analyzer, making use of both the phase noise and AM noise measurement windows. Measurements were correlated using an FSQ-8 spectrum analyzer.

Normally a more complex set-up is needed to measure the residual phase noise of a passive component, however the set up below was adequate to easily demonstrate the performance of the VVA. A low frequency of 100MHz was selected where the signal generator phase noise is low, helping analysis of the VVA itself.

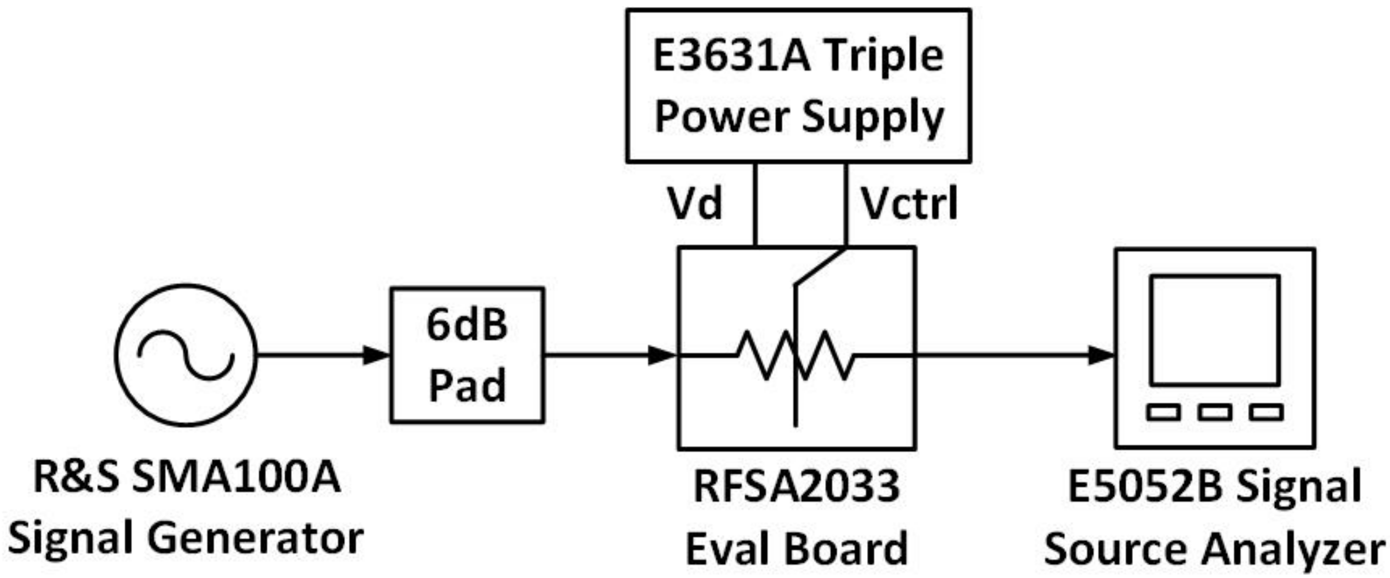
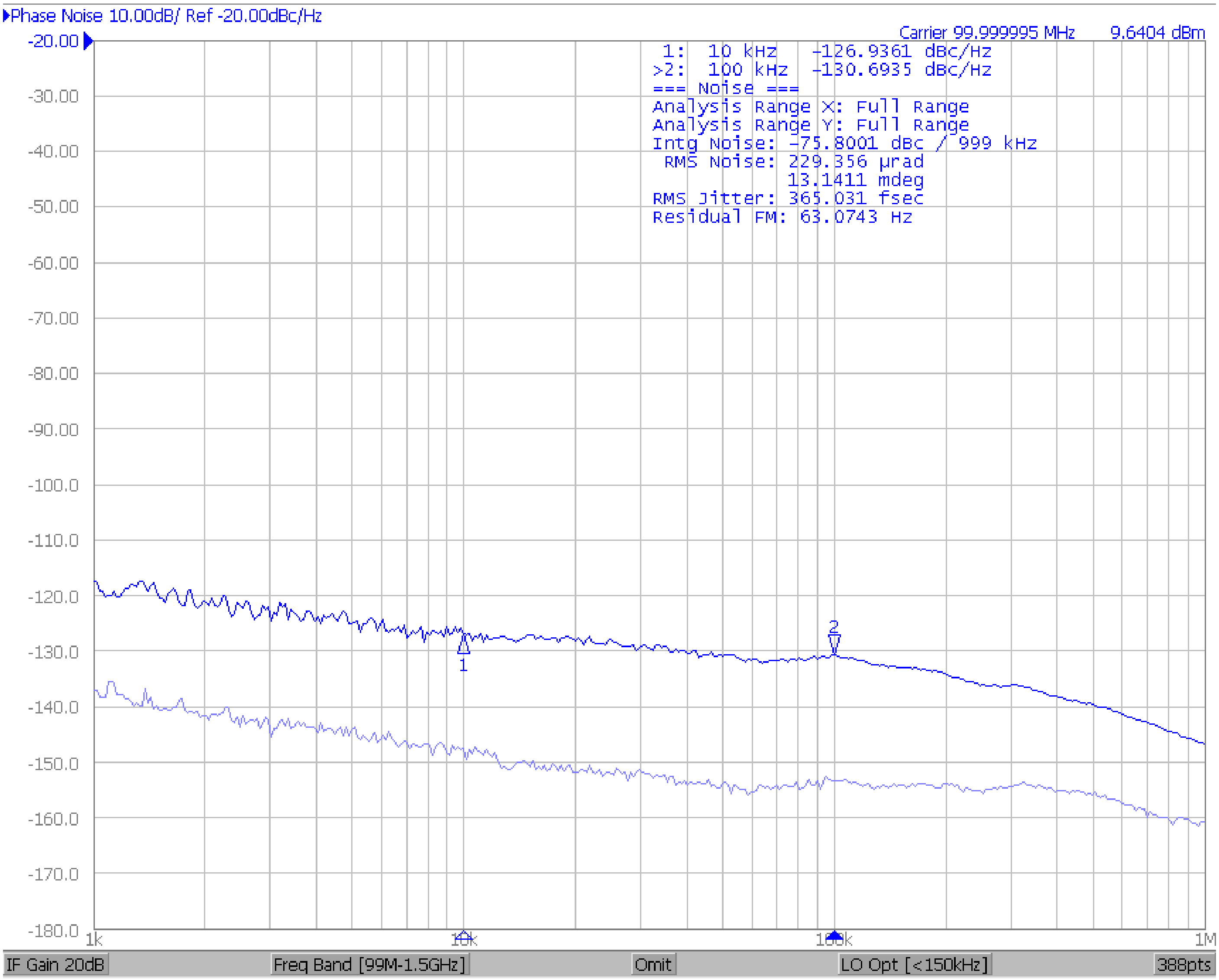


Figure 1. – Test setup for phase and AM noise measurements

Phase Noise Results

Initially the phase noise was measured for negative control slope. Plot 1. below compares the RFSA2033 output at 0dB attenuation (memory trace) to the maximum phase noise observed at 2.5dB attenuation (active trace). The 0dB plot shows negligible increase on the phase noise of the input signal from the SMA100A. At 2.5dB attenuation the phase noise increases slightly with input power, and the highest observed was with Pin of 18dBm giving 16mdegs rms integrated phase noise over 1KHz to 1MHz. This increase in phase noise, whilst easily observable on the E5052B, is very small and will be negligible in a real system.

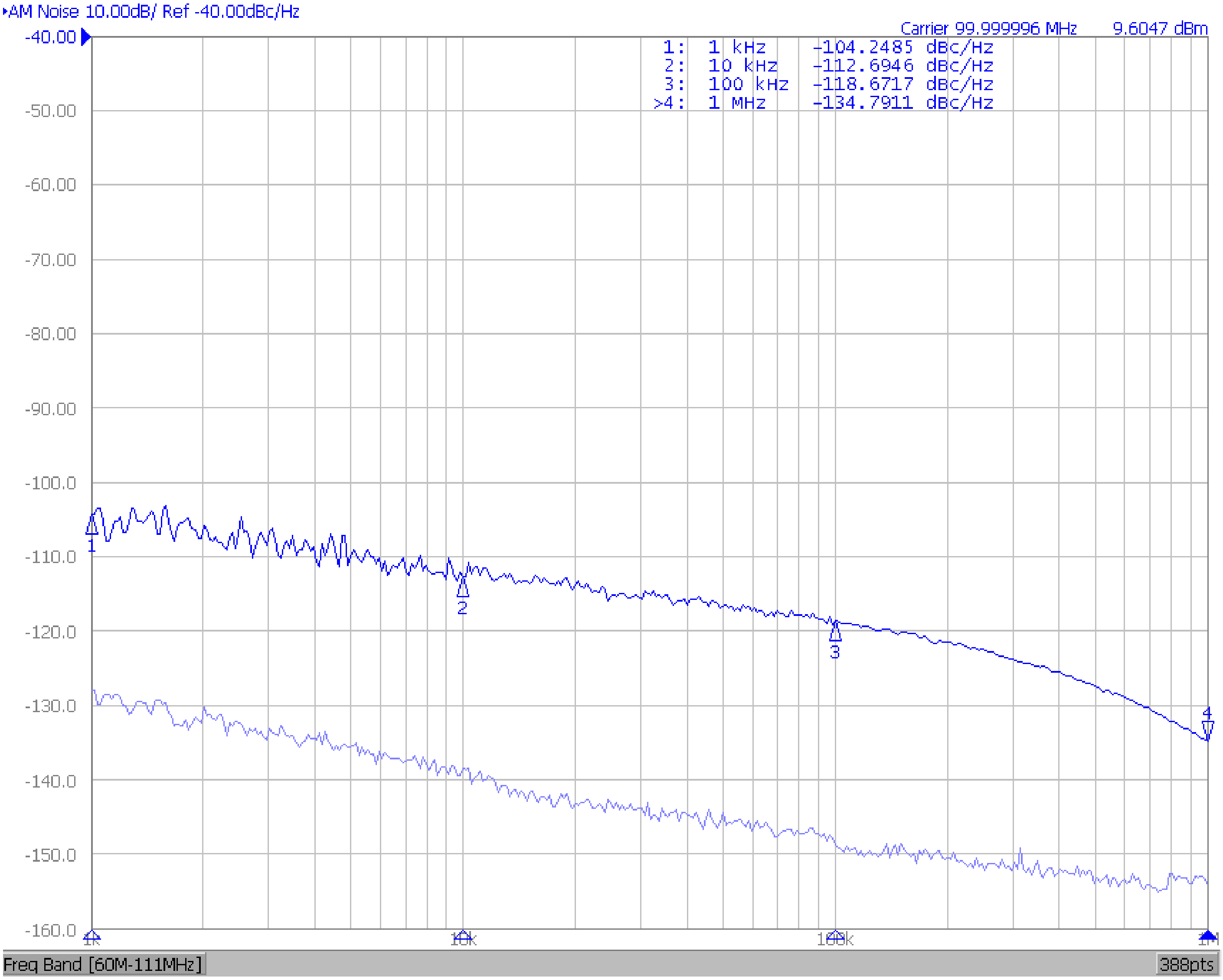


Plot 1. – Phase noise measurement for 100MHz at Pin = 12dBm with negative slope and Vd = 3V

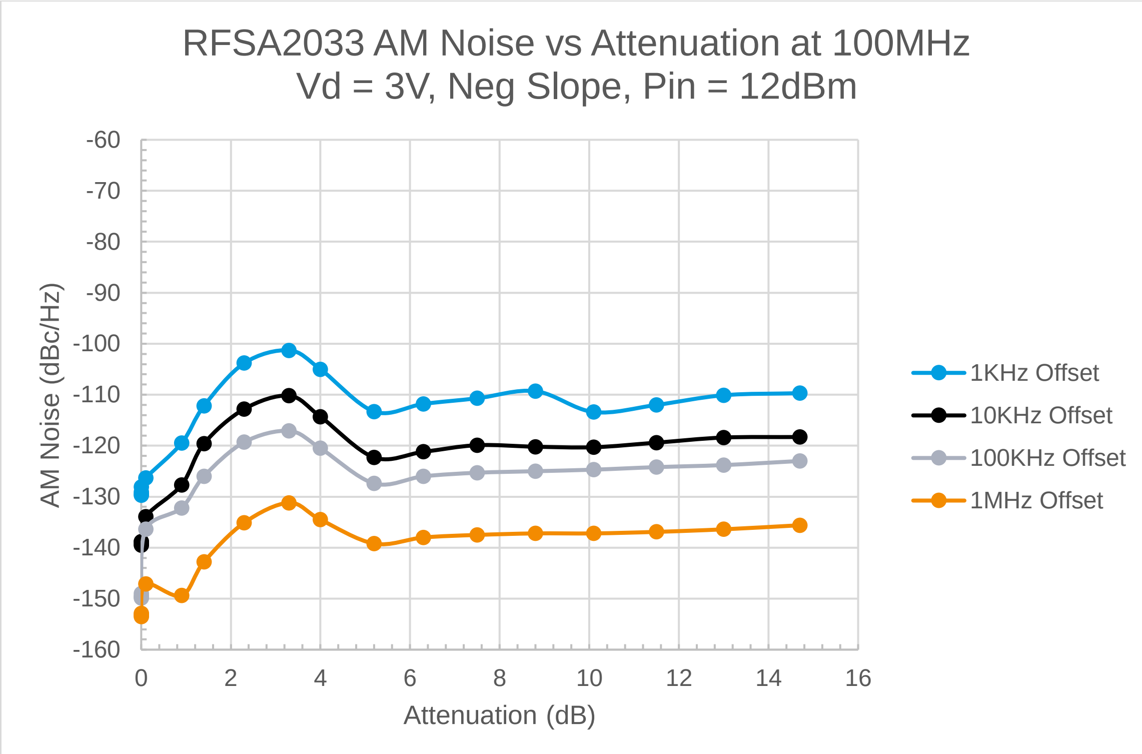
AM Noise Results

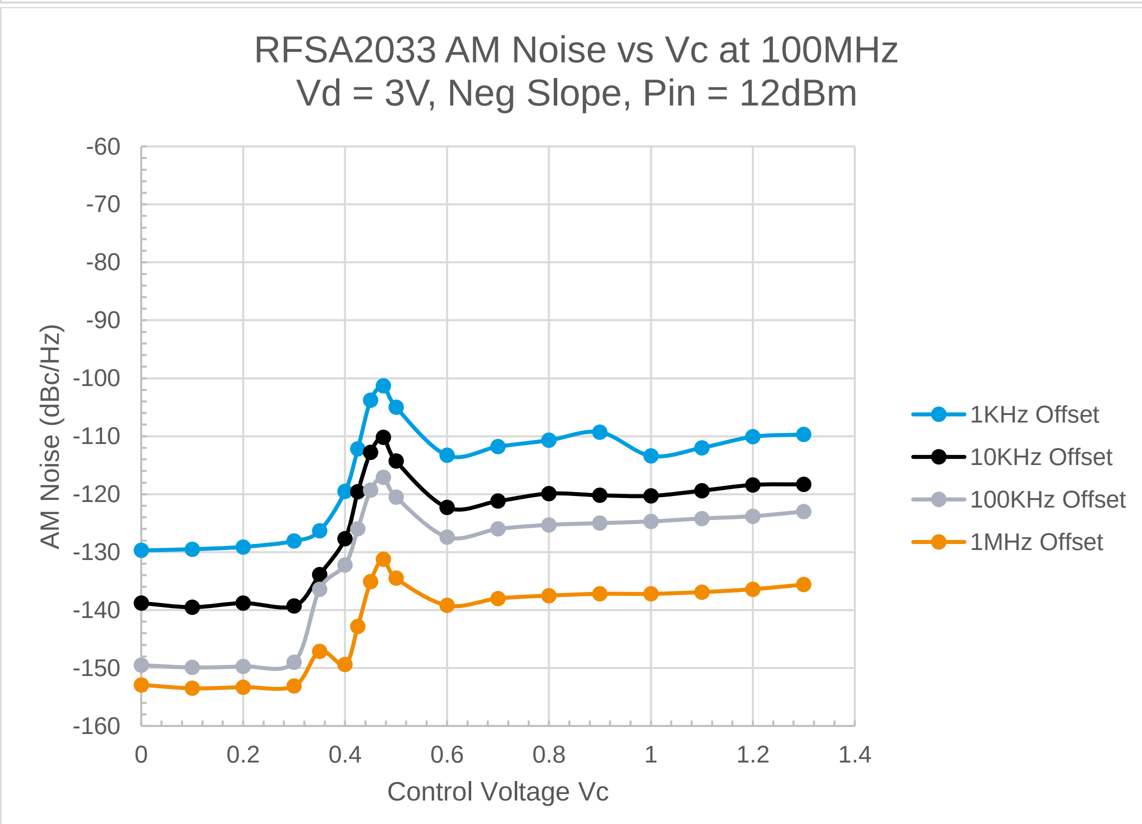
Plot 2. below compares the AM noise at the RFSA2033 output at 0dB attenuation (memory trace) to the maximum AM noise observed at 3dB attenuation (active trace). The 0dB plot shows negligible increase on the noise of the input signal from the SMA100A. At 3dB attenuation the AM noise increases significantly. The AM noise was not affected by input power.

In the following pages further results are included to demonstrate the AM noise versus control voltage, attenuation and frequency for both positive and negative attenuation control slopes.

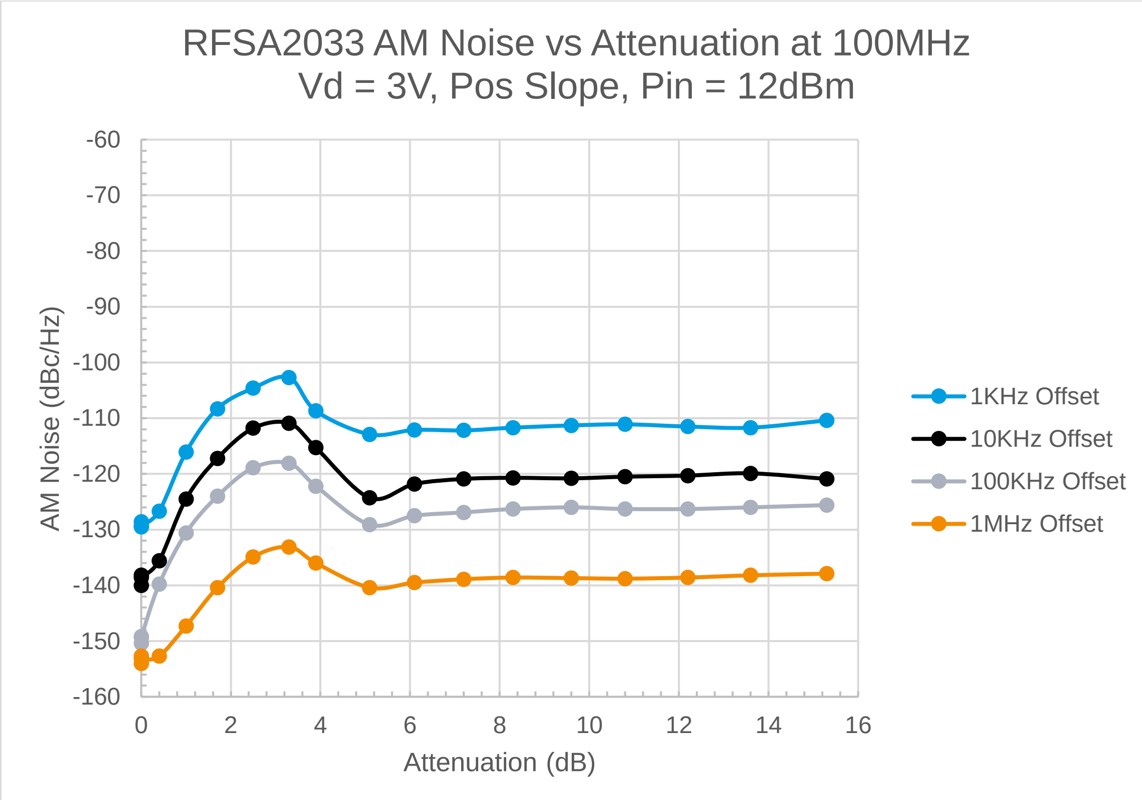


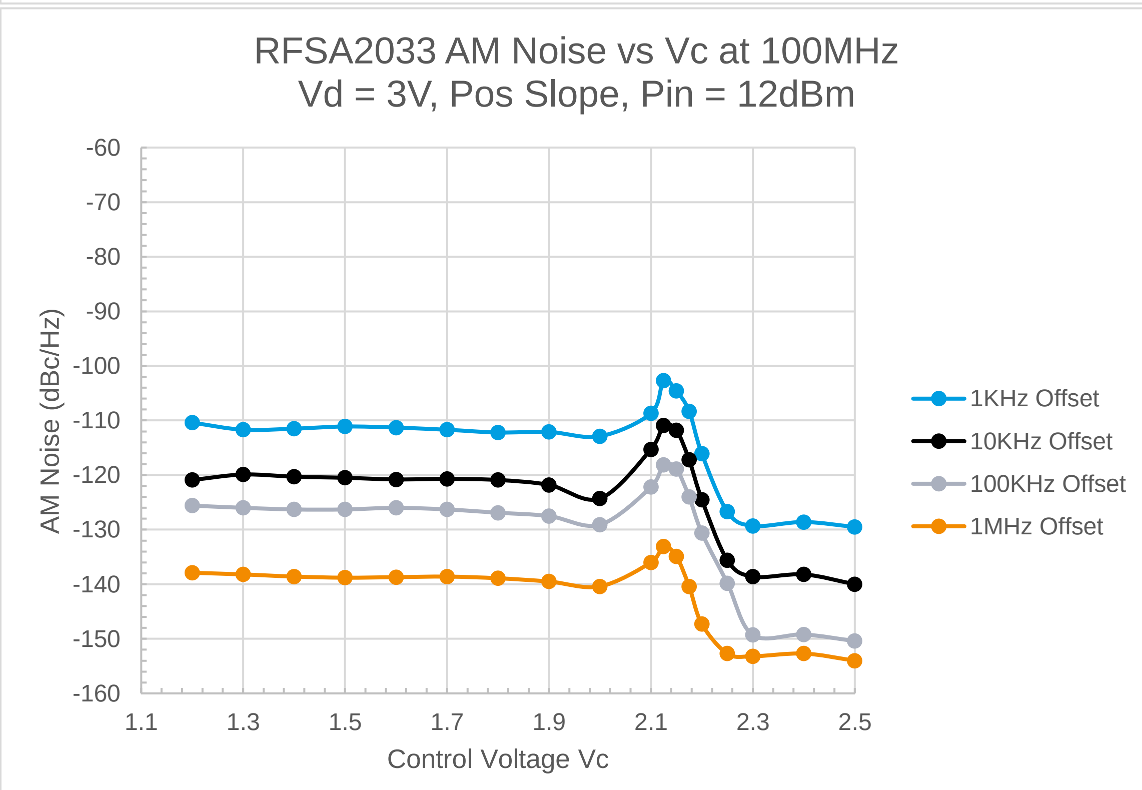
Plot 2. – AM noise measurement for 100MHz at Pin = 12dBm with negative slope and Vd = 3V



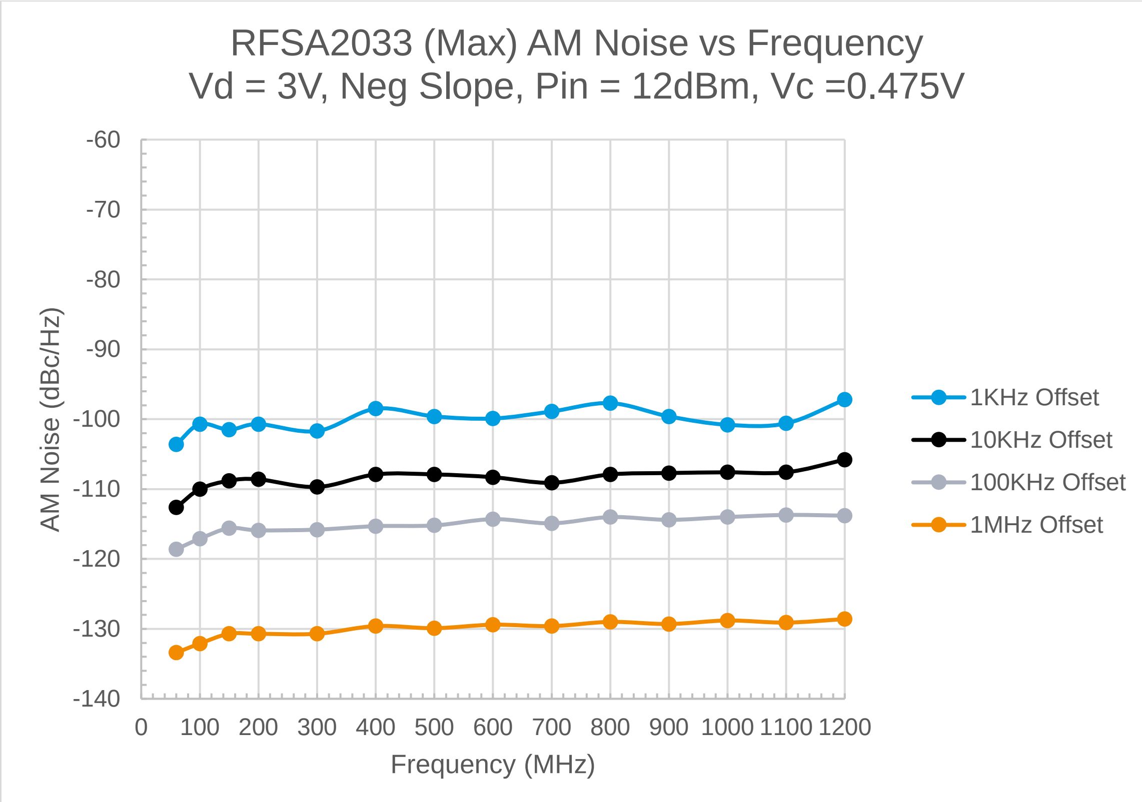


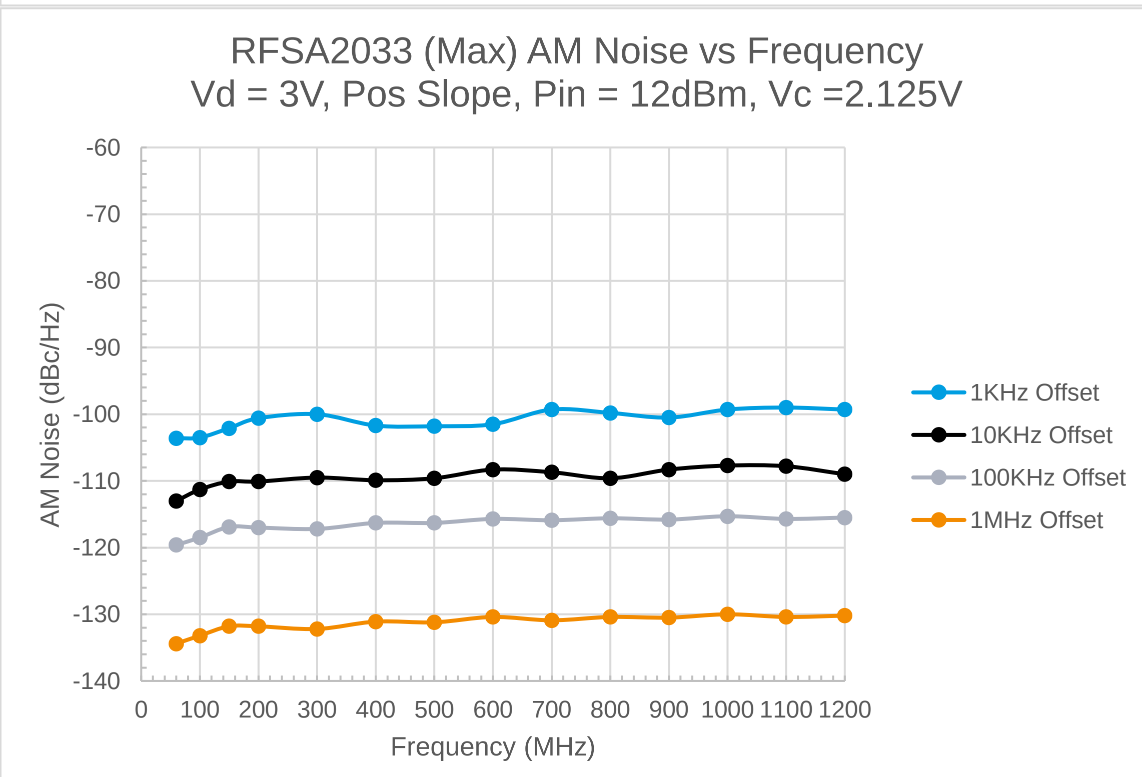
Plot 3 & 4. – AM noise at 100MHz versus attenuation and control voltage for negative slope





Plot 5 & 6. – AM noise at 100MHz versus attenuation and control voltage for positive slope





Plot 7 & 8. – Maximum AM noise versus frequency for negative and positive slopes

Conclusions

The RFSA2033 has been shown to give increased noise in an area around the 3dB attenuation point, coinciding with the 'knee' in the attenuation response. This noise increase has been shown to be:

1. Dominated by AM noise, with phase noise contribution negligible
2. Similar for both positive and negative control slopes
3. Independent of input power and supply voltage
4. Flat across frequency
5. Not affected by modifications to application circuit (supply decoupling or control line filtering)

The RFSA2013 and RFSA2023 VVAs have slightly higher insertion loss, but do not exhibit the same AM noise issue as the RFSA2033 or the 'knee' in the attenuation response. The issue is related to the low loss architecture used for the RFSA2033, that gives typically 1.5dB lower insertion loss.

So how significant is the AM noise from the RFSA2033? Looking at the effect on a system using digital modulation then the AM noise will cause an EVM of approximately 0.3% or -50dB. This is well below the EVM floor of many systems. At higher frequencies (>1GHz) it is likely that the LO phase noise of the system plus other impairments would dominate over this level of AM noise.

The effect of the RFSA2033 AM noise is considered only to be an issue in applications below 1GHz where extremely high system performance levels are required.

Contact Information

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