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Optimizing Power Supplies for the AD9129

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INTRODUCTION

The AD9129 evaluation board features filtering on the power supplies to guarantee optimal performance of the digital-to-analog converter (DAC). This application note explores the effects of removing most of the filtering components. All ferrite beads on the board were removed, as well as the majority of the capacitors on the power supplies. Phase noise, noise spectral density (NSD), spurious-free dynamic range (SFDR), intermodulation distortion (IMD), and adjacent channel leakage ratio (ACLR) performance were then all measured to demonstrate the effect of removing the filtering components. The measurement results showed that the ferrite beads improved close-in phase noise at 20 Hz offset by approximately 5 dB, as well as single-tone IMD by up to 5 dB. Most of the capacitors proved to be redundant; these are shown as Xs in Figure 1. The decoupling capacitors, C1 and C2, encircled in Figure 1, improved the ACLR for 6 MHz carriers by 5 dB. The capacitor arrays, CN1 and C25, also encircled in Figure 1, improved the ACLR for 6 MHz carriers by approximately 6 dB and the NSD by approximately 1 dB.

Removing all of the capacitors crossed out with an X in Figure 1 did not affect the performance of the DAC.

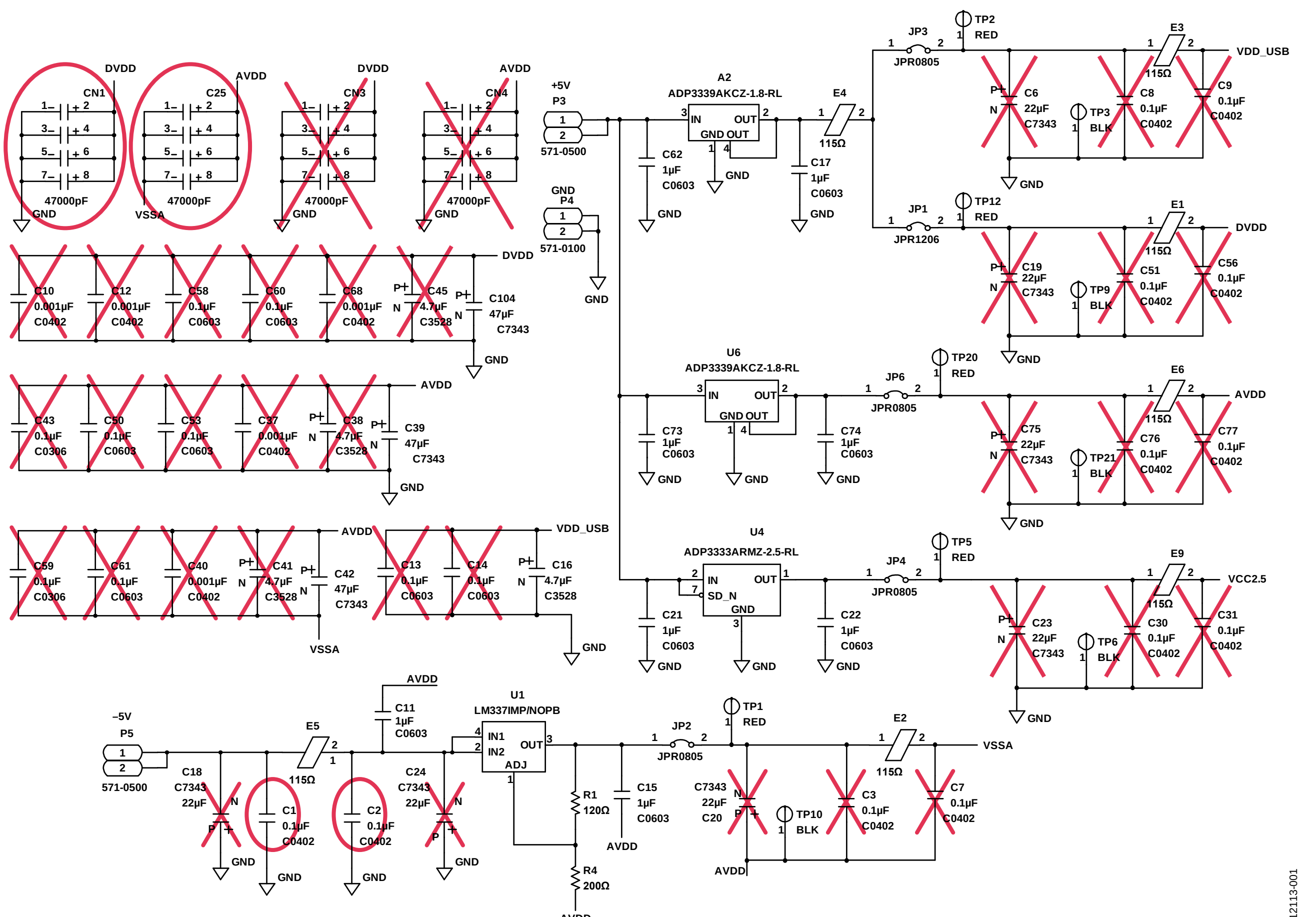

Figure 1. Capacitors Removed from the Power Supplies

Removal of Ferrite Beads

The E1 to E6 and E9 ferrite beads were all replaced with shorts. Because the E7 and E11 ferrite beads are parallel to the E8 and E10 ferrite beads, the E7 and E11 ferrite beads were deemed unnecessary and were removed. The E8 and E10 ferrite beads were left in place to ensure that the AVDD and the DVDD domains power up simultaneously. Inductors can be used in place of ferrite beads; however, one or the other is needed to give a dc short, while providing radio frequency (RF) isolation. Because AVDD and DVDD are at the same voltage, the same low dropout (LDO) regulator can power them; however, separate filtering networks and power planes are needed to ensure that the digital noise does not couple back onto the DAC output.

Replacing the ferrite beads with shorts degraded the close-in phase noise performance slightly, as shown in Figure 2. This measurement was taken with a maximum full-scale current of 33 mA and no digital backoff. The phase noise was measured across multiple clock frequencies, at a low output frequency of 51 MHz, and a high output frequency of 991 MHz. The phase noise degraded by approximately 5 dB within 20 Hz of the 991 MHz signal when the ferrite beads were removed. Otherwise, performance with and without the ferrite beads was similar.

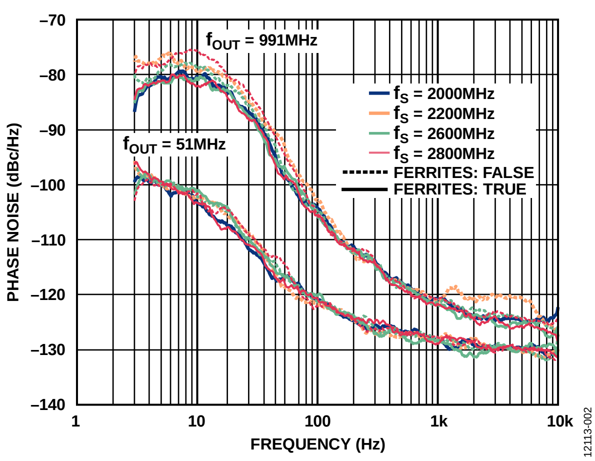

Figure 2. Phase Noise With and Without Ferrite Beads

Replacing the ferrite beads with shorts degraded single-tone IMD by up to 5 dB. The IMD is shown at two different clock rates, with and without the ferrite beads, in Figure 3. This measurement was taken with a full-scale current of 28 mA and no digital backoff.

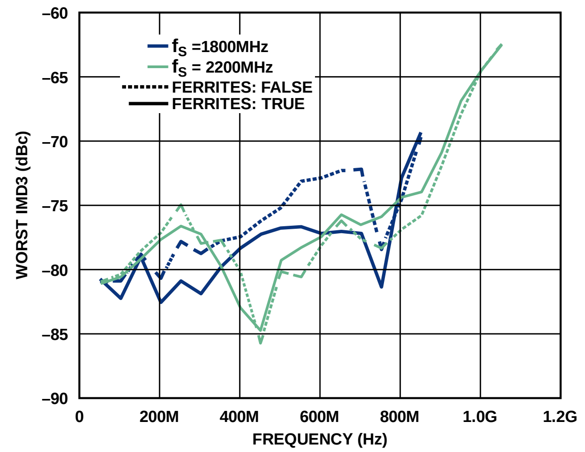

Figure 3. IMD With and Without Ferrite Beads

Removal of C1 and C2

The removal of C1 and C2 degraded the ACLR performance with 6 MHz carriers by about 5 dB, as shown in Figure 4. The ACLR performance was measured with an eight carrier, 256 quadrature amplitude modulation (QAM) signal, full-scale current of 33 mA, no digital backoff, FIR40, and a clock rate of 2.3 GHz. The performance of the 5.25 MHz bandwidth channel on both sides of the eight carriers is plotted in Figure 4 and Figure 5.

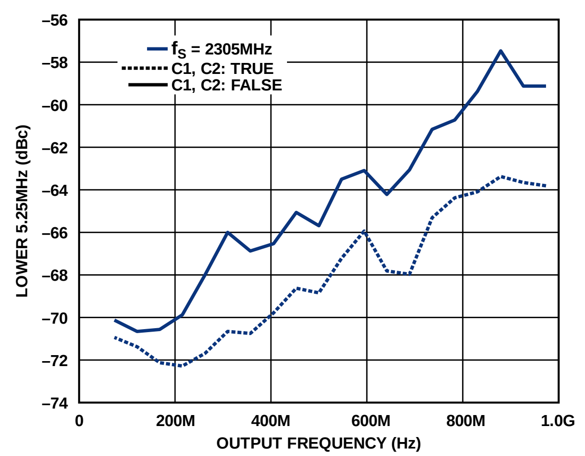

Figure 4. ACLR Without C1 and C2, Lower 5.25 MHz

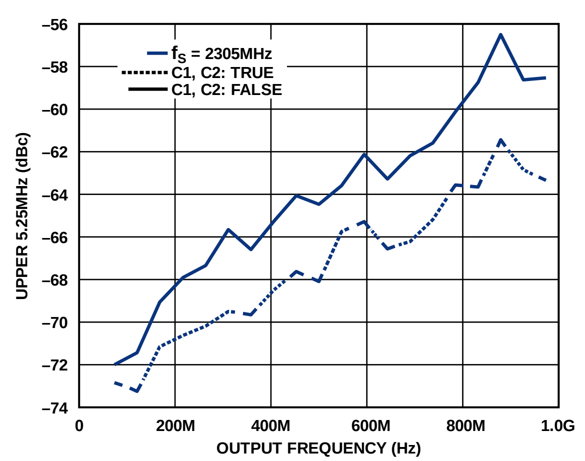

Figure 5. ACLR Without C1 and C2, Upper 5.25 MHz Channel

Removal of Capacitor Arrays

Removing capacitor arrays, CN1 and C25, degraded the NSD performance by about 1 dB, except at lower output frequencies, as shown in Figure 6. The NSD was tested with a band-pass filter centered at 70 MHz. Figure 6 shows the performance at a full-scale current of 28 mA, no digital backoff, and a clock rate of both 2200 MHz and 2800 MHz. The performance was also verified to be similar at other clock rates.

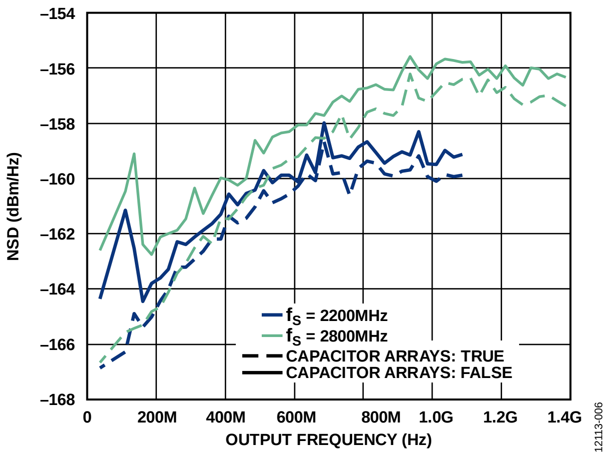

Figure 6. NSD Without Capacitor Arrays

The removal of the capacitor arrays degraded the ACLR performance with 6 MHz, 256 QAM carriers by about 6 dB, as shown in Figure 7 and Figure 8. The ACLR performance was measured with an eight carrier, 256 QAM signal, full-scale current of 33 mA, no digital backoff, FIR40, and a clock rate of 2.3 GHz. The performance of the 5.25 MHz bandwidth channel on both sides of the eight carriers is plotted in Figure 7 and Figure 8.

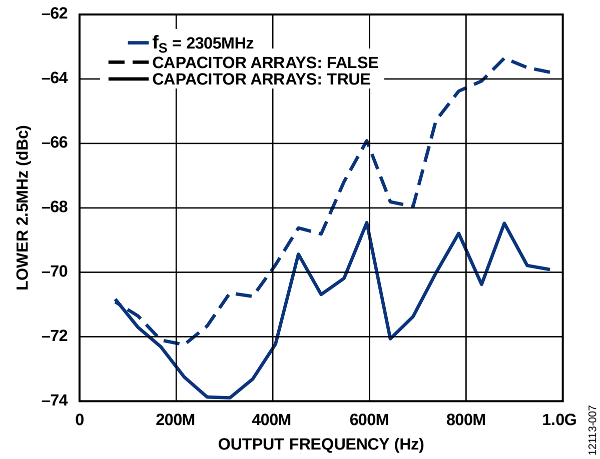

Figure 7. ACLR Without Capacitor Arrays, Lower 5.25 MHz Channel

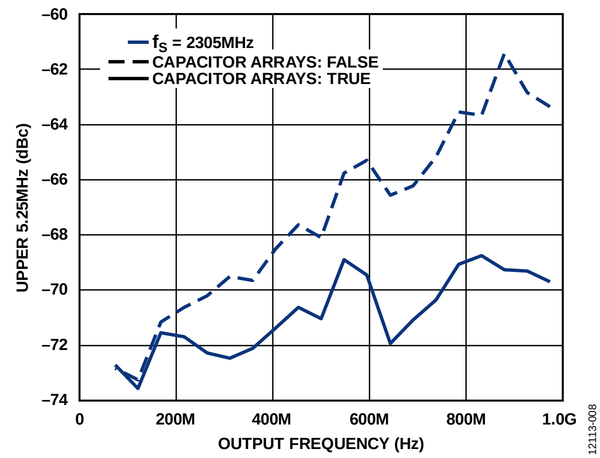

Figure 8. ACLR Without Capacitor Arrays, Upper 5.25 MHz Channel

Conclusion

Removing the ferrite beads degraded the phase noise by about 5 dB, and the IMD by about 5 dB. Most of the decoupling capacitors on the AD9129 evaluation board did not demonstrate any noticeable contribution to performance and, therefore, it was concluded that they were not needed. Removing the decoupling capacitors on the negative supply, C1 and C2, degraded the ACLR by about 5 dB. Removing the capacitor arrays, CN1 and C25, degraded the NSD by about 1 dB, and the ACLR by about 6 dB.

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