One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106, U.S.A. • Tel: 781.329.4700 • Fax: 781.461.3113 • www.analog.com

Determining if a Spur is Related to the DDS/DAC or to Some Other Source (For Example, Switching Supplies)

by David Brandon

INTRODUCTION

A direct digital synthesizer (DDS) is known for its ability to produce a frequency-agile tone with excellent residual phase noise. In addition, most users are well aware of the spurious artifacts in the DDS output spectrum, such as phase truncation spurs and spurs associated with the phase-to-amplitude conversion process. These spurs are a consequence of the finite phase and amplitude resolution in a practical DDS design.

Other sources of spurs are related to the integrated DAC—the sampled output of the DAC produces image frequencies of the fundamental and associated harmonics. Furthermore, nonideal switching properties associated with the DAC can result in increased power levels for low order harmonics. One last source of spurs is mixing products produced between the fundamental and any internal submultiple clock (for example, the SYNC_CLK provided by select Analog Devices, Inc. direct digital synthesizers) of the system clock frequency.

All the identified sources of the previously mentioned spurious artifacts are predictable in frequency offset relative to the fundamental signal at the DDS/DAC output. This application note aids users in determining the root source of spurs in the spectrum of their DDS output signal. It is easy to determine if a spur is related to the DDS/DAC by changing the DDS frequency tuning word. This is because all the spurious artifacts previously mentioned move in frequency offset to the fundamental by a change in the tuning word.

For example, a fundamental of 24 MHz has a third harmonic at 72 MHz. If the DDS system clock is 100 MHz, then the product of the third harmonic and system clock has a harmonic fold back product (100 MHz to 72 MHz) at 28 MHz, which is only 4 MHz offset from the fundamental. If the fundamental is increased 10 KHz to 24.010 MHz, the new fold back product would be 3.97MHz away from the fundamental, which is predictable in advance.

If the frequency offset of the spur relative to the fundamental remains unchanged regardless of the frequency tuning word, then the DDS/DAC is not the source of the spur. Conversely, if the frequency offset of the spur relative to the fundamental varies with a change in the DDS tuning word, then the DDS/DAC is most likely the source of the spur. Discovery of the spur's source is facilitated by ensuring that the frequency tuning word change includes changes in both the truncated and untruncated parts of the frequency tuning word. The truncated part typically ranges from 14 bits to 19 bits (MSBs) of the tuning word.

Spurs that do not change in frequency offset relative to the fundamental (carrier) when the DDS frequency tuning word is changed usually fall into one of two categories: either the spur is somehow being coupled onto the DDS power supply or the spur is a component on the reference clock source driving the DDS.

Note, if the DDS's internal reference clock multiplier (PLL) is enabled, the DDS output also has fixed sideband spurs relative to the fundamental at a frequency offset equal to the reference clock frequency.

REFERENCE CLOCK SOURCE SPURS

Figure 1 displays the 500 MHz reference clock to the DDS with 10% AM modulation by a 100 KHz tone. The reference clock source is a Rohde and Schwartz SMA signal generator with modulation capability. The gray trace in Figure 1 is the reference clock without modulation. Figure 2 displays the same 100 KHz tone transferring onto the DDS/DAC output at the exact same frequency offset regardless of the tuning word frequency. The frequency tuning words in Figure 2 show four different DDS carriers superimposed onto each other. Notice that the frequency offset of the spur on the reference clock remains fixed in frequency offset to all four of the carrier changes; however, the amplitude of the spur follows a 20 log(x) change where x is the ratio of reference clock frequency to the frequency of the DDS carrier.

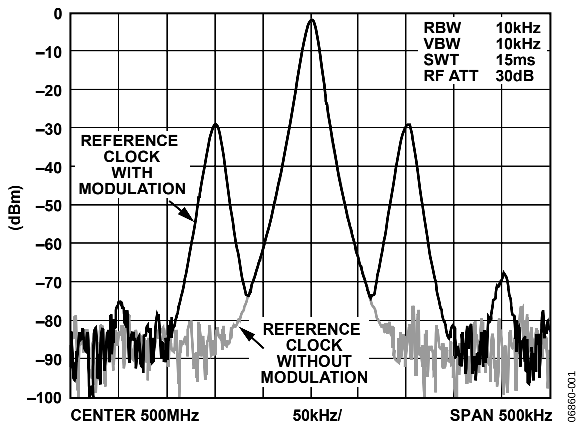

Figure 1. Display of the 500 MHz Reference Clock to the DDS with AM Modulation (10%) by a 100 kHz Tone (Blue Trace)

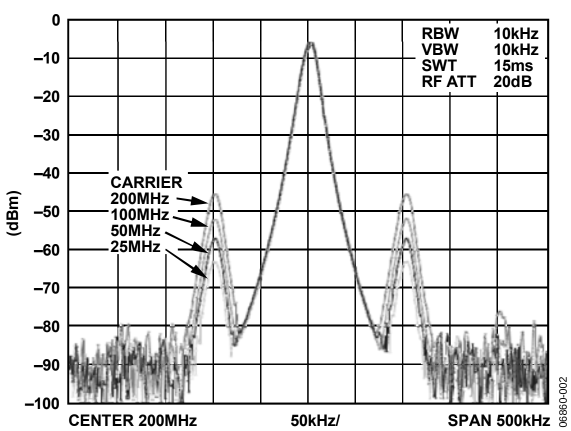

Figure 2. Four DDS Output Carriers Displaying the Effect of a 100 kHz Spur that is AM Modulating the Reference Clock (500 MHz) of the DDS

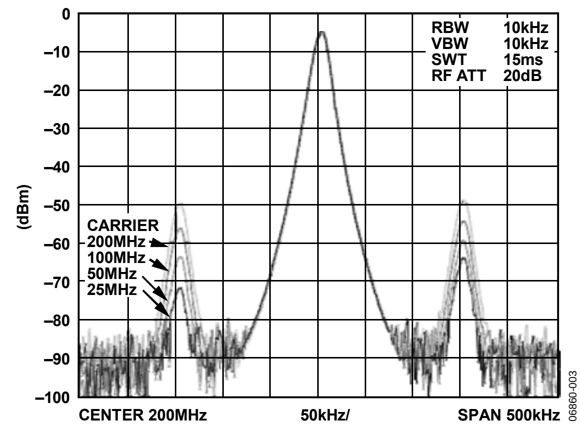

Figure 3. Four DDS Output Carriers Displaying the Effect of a 150 kHz Spur that is AM Modulating the Power Supply of the DDS

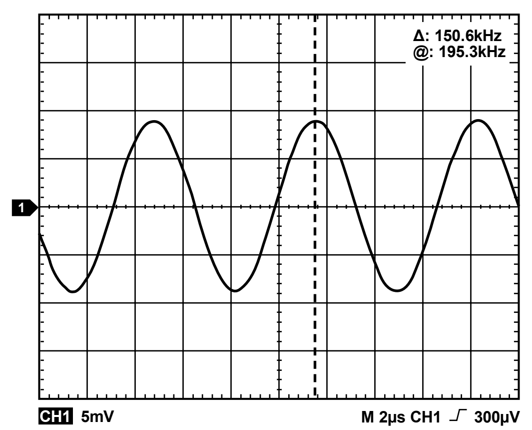

Figure 4. 150 kHz Tone (16 mV p-p) Applied onto the DDS Power Supply via a Function Generator

SWITCHING POWER SUPPLY SPURS

Figure 3 and Figure 4 demonstrate how spurs (for example, switching supplies) on the DDS power supply relate to the DDS output. Notice they also keep the same fixed frequency offset relative to the same carrier changes as previously noted. Figure 4 is the actual time domain picture of the DDS power supply having a 150 kHz modulated tone applied to the DDS power supply to simulate a power supply switching spur.

Spurs on the DDS reference clock or power supplies (typically AVDD) impact the DDS output to some degree. The outcome is fixed sidebands around the carrier as the carrier is changed. Therefore, the reference clock source and DDS power supplies should be checked for spurs when fixed spurs are observed at the DAC/DDS output per tuning word changes.

AN06860-0-7/07(0)