Performing a Precision ADC Evaluation Using a Low Noise DC Source

Featuring the Agilent B2961A/B2962A 6.5 Digit Low Noise Power Source

Application Note

Key Terms

There are three key terms used throughout this application note. In the context of this paper, their definitions are as follows:

- **LSB size**
  The input voltage step size which changes one bit of the ADC's output bits.

- **ADC's input noise**
  The noise level of the ADC which is expressed in the input of the ADC.

- **Reference voltage (Vref)**
  The voltage to set the full-scale input voltage of the ADC. A noise level lower than the LSB size is required.

Introduction

As the operating voltages of analog-to-digital converters (ADCs) continue to decrease, the voltage step associated with the least significant bit (LSB) also decreases. If the voltage step of the LSB becomes smaller than the ADC's equivalent input noise, then a stable and low-noise test signal is essential for precise ADC evaluation. In these situations, a conventional DC power supply cannot be used to evaluate precision ADCs because its noise level is too high compared to the LSB step size. A solution for making these types of measurements is to use a dual-channel low noise power source, such as the Agilent B2961A or B2962A 6.5 digit low noise power source.

This application note outlines the importance of, and the requirements for, low-noise DC signal sources for ADC evaluation, and explains why the Agilent B2961A/62A is the well-suited for this application.

Ultra-Low Noise Filter Performance

The noise density of the B2961A or B2962A when used with the N1294A-021 ultra low noise filter (ULNF) is 1 nVrms/√Hz at 10 kHz. For a 20 MHz bandwidth this corresponds to a noise level of less than 10 μVrms (about 60 μVp-p noise). This is lower than the LSB voltage of most high-speed, 14-bit ADCs, allowing the B2961A/62A and ULNF pair to easily test these devices.[1]

As shown in the Figure 1, the typical range of a conventional precision DC power supply is about 1 μVrms/√Hz. This is more than 100 times larger than the B2961A/62A with the ULNF.

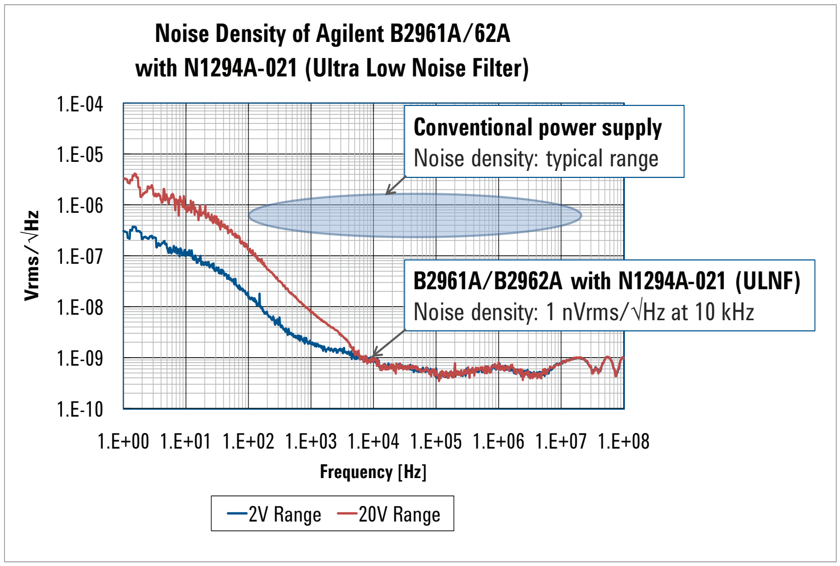

Figure 1. Noise density of the Agilent B2961A/62A with a N1294A-021 (ULNF)

1. LSB = 120 μV for ±1 V input range

Test Configuration Example

The ADC requires low noise performance on the following inputs:

Input B2962A Ch1 with the ULNF connected
Vref B2962A Ch2 with the ULNF or low noise filter (LNF) connected

As noted in Figure 2, the ADC's noise level is highly dependent on the Vref noise. The LNF can be used if the noise filter is included inside the Vref path.

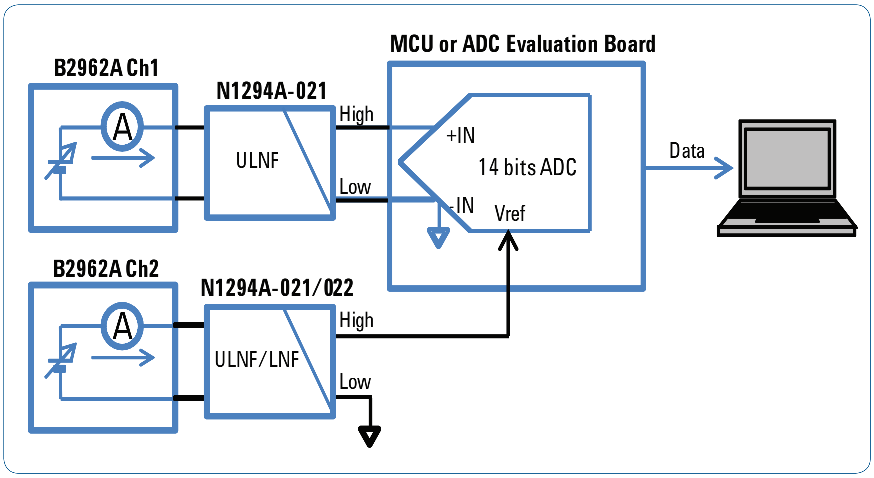

Figure 2. Connection diagram for testing the ADC

Output noise comparison for a 14-bit ADC using three different DC signal sources

The output noise of the ADC was evaluated under the different connections. Each example in this section has three test conditions in common:

DC source voltage: 0 V
ADC Vref: 1.5 V
Sample size: 2048

Test Configuration Example

Example 1. Reference: Input shorted

The reference data shown in Figure 3 was obtained by shorting the input cable of the ADC at the DC source input. Therefore, this data shows the residual noise of the ADC.

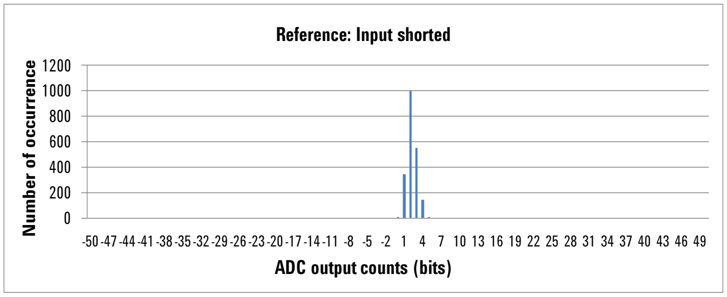

Figure 3. Reference: input shorted

The equivalent input noise of the ADC used in the example is calculated as:

1.5 Vref/2^14bits x 2 x 0.8 (= standard deviation)
= 0.15 mVrms or 150 μVrms

Example 2. B2962A with the ULNF

The DC source in this example is the B2962A with the N1294A-021 ULNF. As shown in Figure 4, the output noise distribution from the ADC is almost the same as the reference data shown in Example 1.

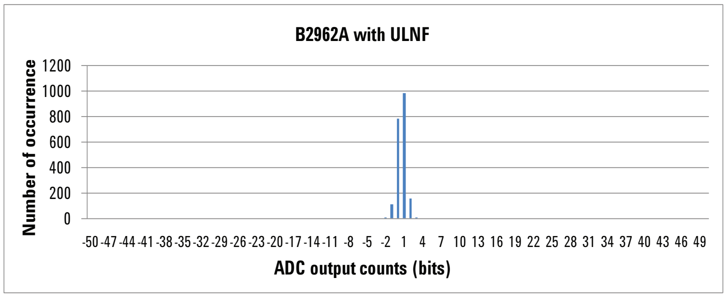

Figure 4. B2962A with ULNF

The noise level of the B2962A with ULNF is less than 10 μVrms (< 20 MHz), which is more than 10 times lower than the noise level of the ADC used in the three examples.

Example 3: Conventional DC source

The DC source in this example is a conventional precision DC source. As shown in Figure 5 the vertical scale is 10 times that of the vertical scale shown in Examples 1 and 2. This was done to show the noise distribution (275 bits p-p in this example) of conventional DC power supplies. As this data shows, the noise distribution from a conventional precision DC source is too large for use in evaluating modern-day precision ADCs.

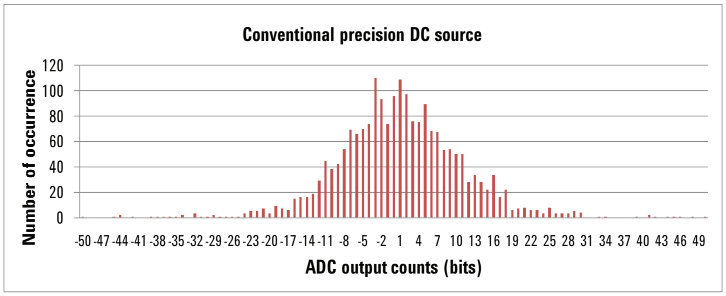

Figure 5. Conventional precision DC source

Comparison Conclusion

Table 1 summarizes the ADC output bit noise distribution for the DC signal sources from the three examples provided.

Table 1. Output noise summary with three signals

	Example 1	Example 2	Example 3
Input source	Reference	B2962A with ULNF	Conventional DC source
Ave. Reading	2.2	0.6	1.1
St. Dev	0.8	0.75	11.5
P-P Noise	6	6	275

As Table 1 shows, a low-noise DC signal source (such as the B2962A with its ULNF) provides much lower noise than conventional precision DC sources/power supplies, which is essential for testing 14 bit ADCs.

The relation of the ADC's total bits, reference voltage, and the LSB size is shown in Figure 6 and shows that the B2962A noise level with ULNF also is effective for testing 16 to 18 bits ADCs.

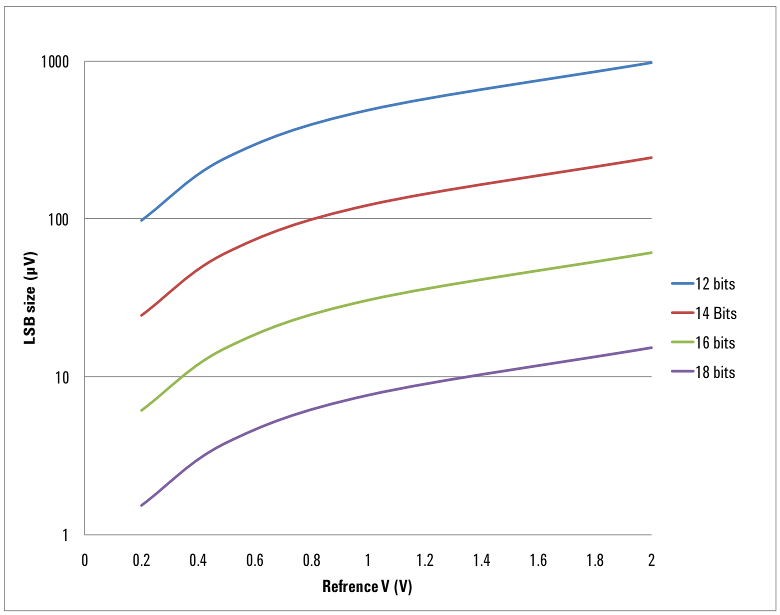

Figure 6. LSB size by ADC bits and reference voltage

Agilent B2961A/B2962A Low Noise Power Source Voltage Key Specification and Characteristics

Product Number	Accessory	Max output (DC)	Source Resolution Digit	Source Resolution Min resolution	Noise[1] 0.1 to 10 Hz	Noise[1] 10 to 20 MHz
B2961A B2962A	---	210 V	6 ½	100 nV	<5 μVpp	3 mVrms
	N1294A-021 (ULNF)	42 V (105 mA)	6 ½	100 nV	<5 μVpp	10 μVrms (1 nVrms/√Hz at 10 kHz)
	N1294A-022 (LNF)	210 V	6 ½	100 nV	<5 μVpp	350 μVrms

1. Supplemental characteristics

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