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

ADE7912/ADE7913 DC Measurement Performance

by Nathan Benamati and Petre Minciunescu

INTRODUCTION

The ADE7912/ADE7913 isolated 3-channel, Σ-Δ ADCs target the polyphase energy metering applications using shunt current sensors. However, because the devices can be used to sense dc signals, this application note presents their dc measurement performance. In energy metering applications, the current channel is used to sense the voltage across shunt current sensors and the voltage channels are used to measure voltages across resistor dividers. From a dc measurement perspective, this separation is not meaningful because every channel can be used to sense dc signals.

The ADE7912/ADE7913 ADCs have a ±31.25 mV input range for signals between the IP and IM pins, and ±500 mV between the V1P and VM pins and between the V2P and VM pins.

This application note describes the performance of the ADE7912/ADE7913 when dc signals are applied at the inputs of the three Σ-Δ ADCs.

RECOMMENDED DC MEASUREMENT PROCEDURE

The ADE7912/ADE7913 data sheet declares an IP, IM channel ADC offset error typical value of −2 mV, and a V1P, VM or V2P, VM channel ADC offset error typical value of −35 mV. This offset affects the accuracy of the dc measurement and must be eliminated. To estimate the dc offset of every channel, follow these steps:

1. Apply 0 V at the ADE7912/ADE7913 between the IP and IM pins, between the V1P and VM pins, and between the V2P and VM pins.
2. Read the ADC output registers IWV, V1WV, and V2WV at least 50 times over 1 second. The period between the readings is not important, although as a good programming practice, the readings should be periodical.
3. Average the readings to obtain the dc offset.

To ensure the stability of the dc measurements, follow these steps:

1. Read the ADC output registers IWV, V1WV, and V2WV at least 50 times over 1 second.
2. Average the readings.
3. Subtract the dc offset to obtain the dc measurement.

TABLE OF CONTENTS

REVISION HISTORY

4/14—Revision 0: Initial Version

ASSESSING THE PERFORMANCE OF DC MEASUREMENTS

For simplicity, the performance was assessed on the ADE7978/ADE7933 evaluation kit. The rms measurements in the ADE7978 were used as a proxy for the ADE7912/ADE7913 dc measurements.

Because the kit contains four ADE7933 devices, four rms measurements were used to assess the performance of each current and voltage channel. The high-pass filters in the current and voltage data paths of the ADE7978 were disabled.

DC signals with variable amplitude were provided from a National Instruments NI_PXI-4461 card between the IP and IM pins, between the V1P and VM pins, and between the V2P and VM pins. The IM and VM pins were connected to ground as the ADE7912/ADE7913 data sheet specifies maximum IM and VM voltage to ground of ±25 mV. One thousand measurements were executed for every signal level and then the standard deviation of the measurements was calculated. Note that one measurement means the average of 50 readings over 1 second.

Figure 1, Figure 2, and Figure 3 present the standard deviation values obtained on every A, B, C, and N data path of the ADE7978.

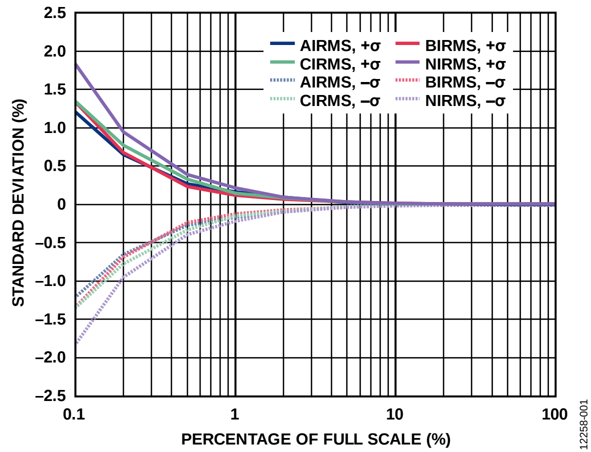

Figure 1. Channel IP, Channel IM DC Measurement Repeatability

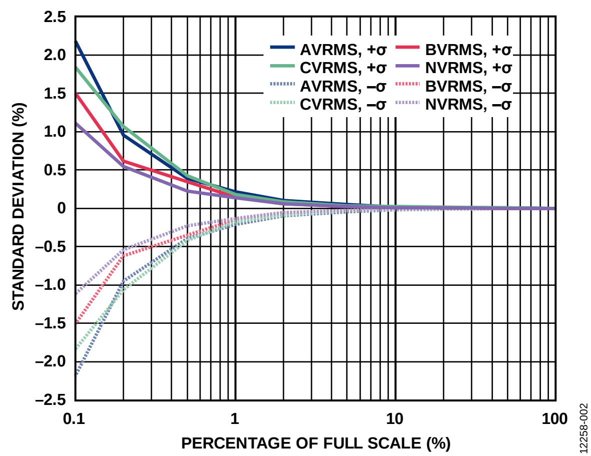

Figure 2. Channel V1P, Channel VM DC Measurement Repeatability

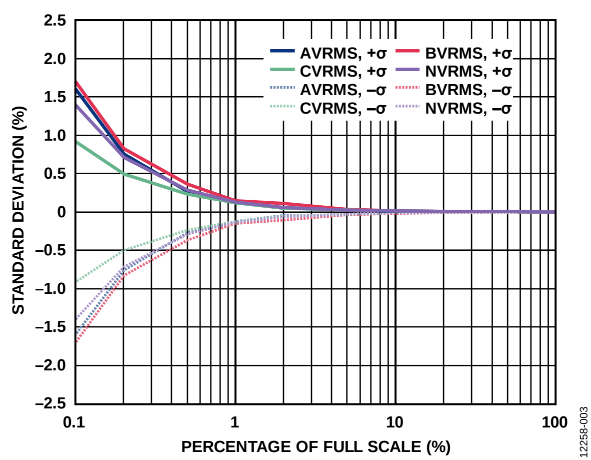

Figure 3. Channel V2P, Channel VM DC Measurement Repeatability

Table 1 presents the standard deviation numbers when the dc signals have certain levels relative to full scale. The performance remains acceptable down to approximately 1% of full scale, when the standard deviation of the dc measurements reaches values around 0.21% for the current and V1 channels, with the V2 channel being a little better at 0.15%.

Table 1. Standard Deviation of DC Measurements at Ambient Temperature T_A = 25°C

	Standard Deviation (%)		
Dynamic Range	I Channel	V1 Channel	V2 Channel
1 to 1	0.008	0.003	0.003
10 to 1	0.02	0.02	0.02
100 to 1	0.22	0.21	0.15
200 to 1	0.40	0.42	0.37
500 to 1	0.94	1.06	0.83
1000 to 1	1.83	2.2	1.7

Based on these results, the specification of the dc measurements at ambient temperature T_A = 25°C is then stated in Table 2.

Table 2. ADE7912/ADE7913 DC Measurement Error Specification

	Measurement Error (%)		
Dynamic Range	I Channel	V1 Channel	V2 Channel
10 to 1	0.02	0.02	0.02
100 to 1	0.25	0.25	0.2
200 to 1	0.5	0.5	0.5
500 to 1	1.2	1.2	1.0
1000 to 1	2.0	2.5	2.0

The ADC offset varies over temperature and power supply; this affects the accuracy of the dc measurements. The ADE7933 temperature measurement was offset compensated at 25°C and a V_{DD} supply of 3.3 V, the nominal value. TheADE7933 temperature range is between −40°C and +85°C and the voltage supply range at the VDD pin is between 2.97 V and 3.63 V.

The ADE7933 devices were set at +85°C and for V_{DD} equal to 2.97 V, 3.3 V, and 3.63 V; dc signals of various amplitudes were measured. Then, the ADE7933 devices were set at −40°C and the measurements over V_{DD} were repeated.

Figure 4, Figure 5, and Figure 6 present the worst errors obtained over these measurements.

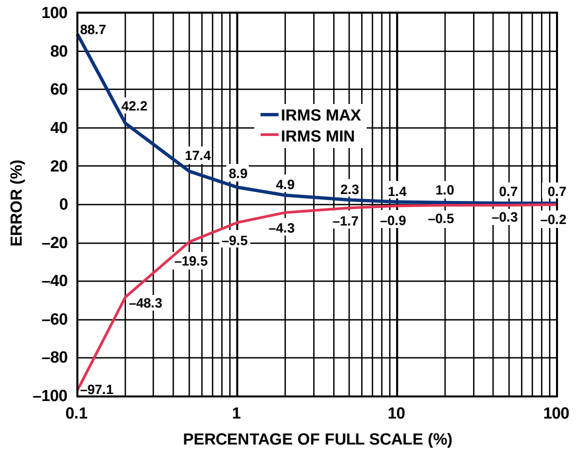

Figure 4. Channel IP, IM Drift Over Temperature

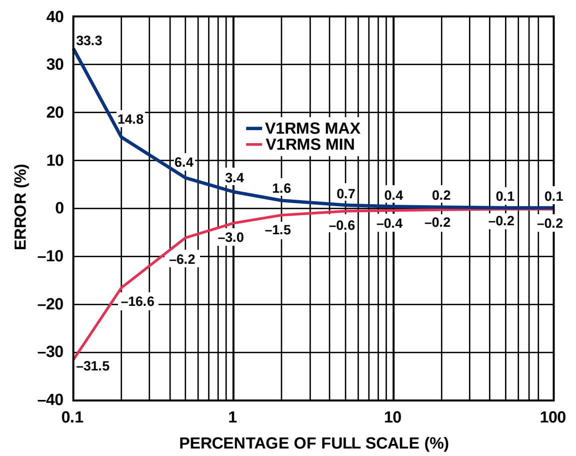

Figure 5. Channel V1P, VM Drift Over Temperature

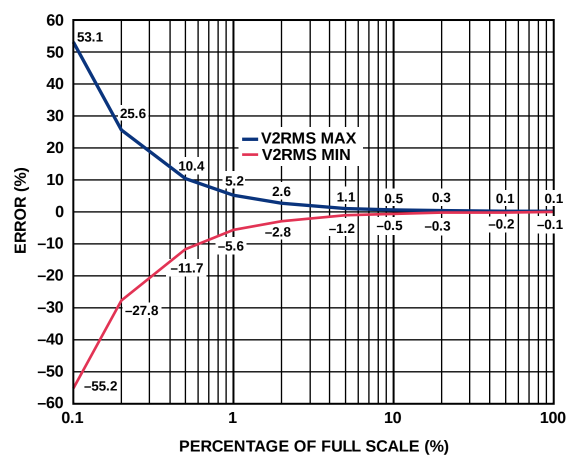

Figure 6. Channel V2P, VM Drift Over Temperature

Table 3. Channel V1 DC Measurement Specifications Over Temperature

Dynamic Range	V1 Channel Measurement Error (%)	Temperature Coefficient (ppm/°C)
10 to 1	0.4	62
100 to 1	3.5	540
200 to 1	6.5	1000
500 to 1	17	2615
1000 to 1	34	5230

Channel V1 has the best performance of all three channels, with a derived specification and temperature coefficient presented in

Table 3. The temperature coefficient was computed as follows for the dynamic range of 100:1:

$$TempCoeff_{V1} = \frac{3.5 \times 10^{-2}}{25-(-40)} = 538.5 \cong 540\, ppm/^{\circ}C$$

The errors over temperature appear mainly because of the dc offset variation. The temperature sensor embedded into the ADE7912/ADE7913 may help in mitigating this temperature variation. The following method estimates the temperature coefficient variation over the temperature range of the meter and uses it to compensate the dc offset:

1. Determine the dc offset, $Offset_r$, at room temperature, t_r, following the procedure indicated in the Recommended DC Measurement Procedure section.
2. Bring the ADE7912/ADE7913 to two temperatures, t_1 and t_2, placed on either side of the room temperature as far away as possible: $t_1 < t_r$ and $t_2 > t_r$.
3. Determine the dc offset at these two temperatures.
4. Calculate the temperature coefficients of the offset between t_1 and t_r and between t_r and t_2. Consider the first coefficient to be a constant below the room temperature and the second to be a constant above room temperature.
5. Use the temperature sensor readings to adjust accordingly the dc measurement.

$$Offset = Offset_r + (t - t_r) \times Temperature\ Coeff$$

$$Result = Register\ value - Offset$$

Note that small nonlinearities can appear when using a Σ-Δ ADC for dc measurements. These nonlinearites typically appear when the effective input dc signal (*input* + *inherent offset*) is near zero. This effect should have little to no impact on the quality of the measurement given the previously stated accuracy.

CONCLUSIONS

For dc measurements, it is recommended to use the V1 channel of the ADE7912/ADE7913. Provide dc signals between ±500 mV. Make an offset calibration at room temperature. The errors of the measurements at room temperature are under 0.25% for a 100:1 dynamic range. Over temperature, the errors are below 3.5% for a 100:1 dynamic range.

To improve the accuracy over temperature, bring the instrument containing the ADE7912/ADE7913 to two temperatures, compute the temperature coefficients, and use the result to adjust the dc measurements.

NOTES

NOTES

I^2C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

AN12258-0-4/14(0)