Exercise Report

You are asked to give a detailed and precise explanation for every exercise. Solutions without the accurate derivation of results are not acceptable. The measurement results to be processed can be found on the homepage of the Laboratory 2 subject. Select your measurements based on your neptun code. The measurement results have to be copied into this report file for all exercises.

Videos for the measurements can be found in this report.

|  |  |
| --- | --- |
| **Subject of this exercise:** | “A/D and D/A converters” (#7) |
| **Students:** | <me><myself><I> |
| **Course/code:** | <course>, <group> |
| **Date & time:** | 20<YY>. <MM>. <DD>. |
| **Lecturer today:** |  |

Equipment in use, device under test

|  |  |  |
| --- | --- | --- |
| Oscilloscope | Agilent 54622A | MY4< > |
| Signal generator | Agilent 33220A | MY4< > |
| Digital multimeter (6½ digit) | Agilent 33401A | MY4< > |
| Analog Devices MicroConverter Evaluation Board | VIK-II-07 | W/O No.: < >Unit No.: < > |

Exercises

1. DAC - static characteristics

A unipolar DAC of 12 bits and 2.5 V reference voltage is studied in the first exercise. Generally, the nonidealities of the converters (both ADC and DAC) are defined as the deviations of the actual characteristics of the device, compared to the ideal converter width the same bit width. If the converter was ideal, the value of the LSB could be expressed as:

$$LSB=\frac{2.5 V}{2^{12}}=0.6104 mV.$$

Once the LSB is known, the output voltage can be determined for any input code as $U\_{out}\left(D\right)=D⋅LSB$ (where $D$ denotes the converted code, and $U\_{out}$ is the output voltage).

1.1. Determine the offset and gain errors of the DAC, based on the results shown in the table!

<https://web.microsoftstream.com/video/ea896732-5b7f-4b9e-a34b-7f212feea72a>

<https://web.microsoftstream.com/video/aee76f59-25ba-4807-bca9-04402833f019>

What we have done is the following:

This is how we measured/calculated the offset and the LSB values:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Input code* | *Measured Voltage* |  |  | *Calculated Voltage* |
| 0 | 8.9 mV |  | Offset: |  |
| 4095 | 2493 mV |  | LSB: |  |

The above determined LSB is the real quantization step of the converter. From now on, where it is necessary, use this value as the LSB.

1.2. Based on your measurement results, determine the integral non-linearity (INL) of the converter; scale all results with LSB! Use the results of the previous exercise. Determine the INL in every point of the measurement. Compare your results with the datasheet of the device.

<https://web.microsoftstream.com/video/006c6c83-8703-4fc2-aeca-1d8d622cdb0b>

We have used these input codes and yielded these output values:

We have made this MATLAB code to plot the nice figures below:

%MATLAB code

The transfer characteristics (fitted onto some smartly chosen input/output values) and the endpoint-line:

The INL-plot:

See below what we have learnt here:

1.3. Evaluate the differential non-linearity (DNL) of the converter; use LSB again for scaling all results!

<https://web.microsoftstream.com/video/816cb332-8cdf-411a-9c52-ef12432fa9de>

The processed measurement record was the following:

Now we have made this MATLAB code to plot the nice figures below:

%MATLAB code

The DNL-plot:

We have understood here that ... .

2. DAC - dynamic characteristics (glitch)

An ideal DAC monotonically increases its output voltage by exactly 1 LSB when the input code is incremented by one. The behavior of real converters often differ: the output is likely to undershoot, overshoot, or do both. This transient on the output of the controller is known as glitch. Glitch is often related to converter architectures where the digits are processed individually, and the processing time varies slightly among the bits. For example, the input of a 4-bit DAC switches from 0111 to 1000. If the switching time of the LSB is the slowest, while the MSB is the fastest digit, the following transient can be observed on the output: 0111, 1111, 1011, 1001 and finally1000. So if the value of the LSB for this converter was 0.5 V, the following voltages would appear before the steady state is reached: 3.5 V, 7.5 V, 5.5 V, 4.5 V, and 4 V (which is the steady state value of the output).

The glitch is often described with the area of the transient on the output, this is the so-called glitch energy, its unit is [Vs]. Your task is to determine (approximately) the glitch energy based on the provided measurement result. Take the acutal time base and the voltage resolution settings of the oscilloscope into account.

2.2. Measure the glitch area on the “DAC1” output when input code is changing from 0111…1 to 1000…0!

<https://web.microsoftstream.com/video/5aa0732f-4aca-40c2-bda5-a26ee53697c2>

Oscilloscope had these nice figures:

The way we approximated the glitch energy:

This was new for us:

3. Quantization error

In this exercise the provided measurement result shows the original and the quantized signal, and the difference of the two signals: the so-called quantization error. Note that the resolution of the error differs from the resolution of the other two signals! Study the error, and estimate the resolution of the converter used for the second, roughly quantized signal. Use the relation between the bit width and the worst case value of the quantization error.

 Compare the two DAC output for a sine wave. Observe the quantization error (the difference of the two signals) as well!

<https://web.microsoftstream.com/video/872ed4ce-2aa7-4d6c-9ff8-ab5923285d0b>

This is what we can see:

The bit width of the converter is:

The thing we will always remember from doing this is the following:

4. Effect of noncoherent sampling

Coherent sampling means that an integer number of periods are measured from a periodic signal. For example, if the number of samples is $N$, and we want to measure exactly $D$ periods ($D$ is an integer number) with $f\_{s}$ sampling frequency, then the signal frequency can be expressed using the following equation:

$$\frac{D}{N}=\frac{f\_{x}}{f\_{s}}.$$

 Based on your measurement records, determine whether each record was sampled coherently or not! Try to estimate the signal frequency in both cases assuming $N=8192$ samples were measured, and the value of the sampling frequency is $f\_{s}=115200 Hz$.

<https://web.microsoftstream.com/video/6d6951cf-b3c1-42b7-b477-0c940140d586>

Measurement record plots:

The estimated number of periods, and signal frequencies:

And, at last, now we know this:

The End.