# On the calibration of the ELMB ADC

The ADC used in the ELMB CS5523 from Cirrus Logic [1] is a highly integrated device with a resolution of 16 bit. The ADC can be programmed for 6 different input voltage ranges and 8 output rates. This is done via CANopen SDO command to the index 2100 and respectively sub-index 2 and 3, see [2] and [3]. Each time these two sub-index are written to, an internal calibration of the chip a so-called "self-calibration" is done by the CS5523. The result of this operation can give a gain error of up to ± 20 %. As can be seen in Figure 1 the gain of each input voltage range can be different and especially the 5V range often shows large errors. It should be noted that the CS5523 has 4 separate inputs. The CS5523 input 1 is connected to ELMB ch 0 to 3, input 2 to ch 4 to 7, input 3 to ch 8 to 11 and input 4 to ch 12 to 15. Each of the inputs has to be calibrated.

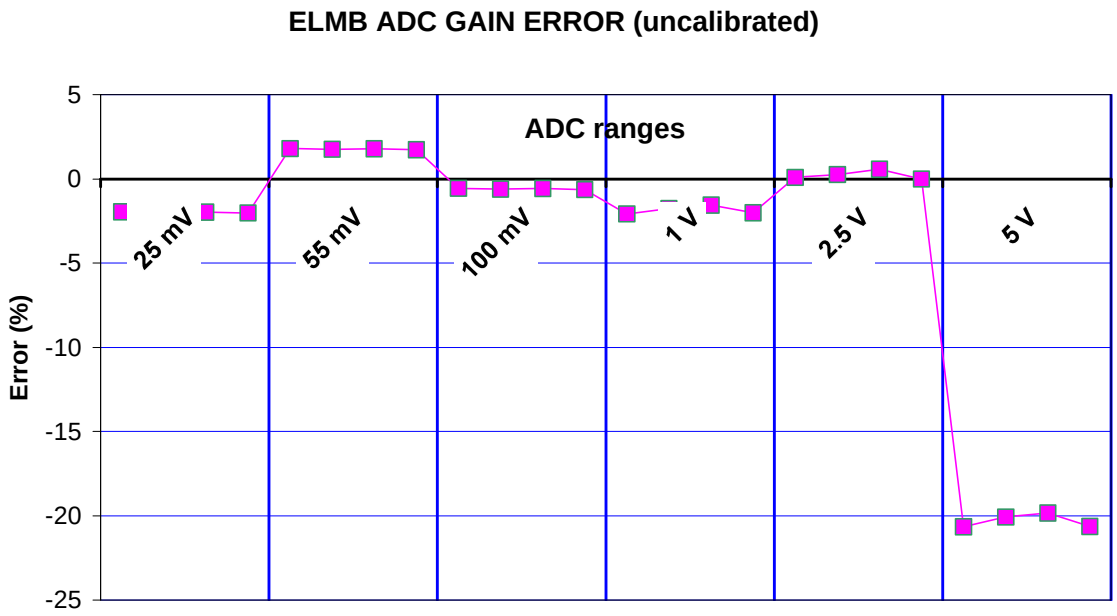


Figure 1 Resulting gain error of the CS5523 after an internal calibration at a word rate of 15 Hz.

## *Calibration of the ELMB ADC*

The calibration can be done by applying known voltages to the inputs of the ELMB. The resulting values of the conversion are used to calculate the gain errors for the respectively inputs. These are then used to multiply the gain obtained at the internal calibration by reading the four gain registers of the ADC via the index 2100 and sub-index 8, 10,12 respectively 14. This is described in the following example for channel 0:

| *ch* | *Digital Voltmeter* | *ELMB* | *Gain Factor* |
|---|---|---|---|
| ***0*** | ***20.4561mV*** | ***54662=20.8522mV*** | ***DVM/ELMB = 0.981004*** |

From the ELMB the index 2100 and subindex 8 is read and gives for example:

***0x3C9A3A = 3971642 decimal***

This value is multiplied with the gain factor and gives in decimal and in hex:

***3896197 decimal = 0x3B7385***

which is written back to the ELMB. Please observe that the gain register is volatile and must be rewritten after each reset and change of ADC setting!

As shown in Figure 2 the resulting gain errors are much decreased. For lower ranges it is better than ±0.01%. In this example voltages around 19 mV was used for all input voltage ranges. This is not optimal for the ranges 1V and above. All voltages were generated from the internal ELMB 2.5V voltage reference (AD680) via resistive divider circuit and measured for each of the inputs with a high accuracy (7 digits) digital multimeter Keithley 2000. The long-term stability of the calibration is terminated mainly by the AD680 and is typically 25 ppm/1000h.

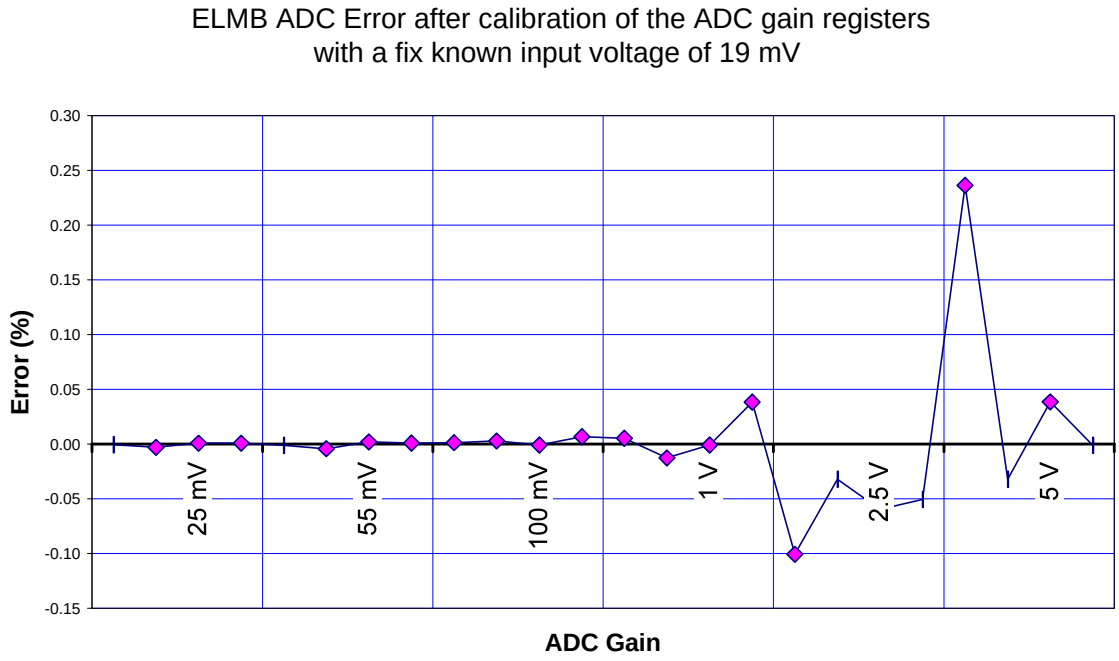


Figure 2 The gain error after an external calibration of the ELMB ADC. The 1V range and above show larger errors because of the low calibration input voltages of ~20 mV.

## *References*

[1] For details see the datasheet of CS5521, CS5522, CS5523, CS5524, CS5528 http://www.cirrus.com

[2] http://www.nikhef.nl/pub/departments/ct/po/html/ELMB/ELMBresources.html

[3] http://www.nikhef.nl/pub/departments/ct/po/html/ELMB/ELMB15.pdf page 18