iC-TW2 AN3
Offset Calibration for Magneto-Resistive Sensors

Contents

1. Connecting DUT to PC

Connection of a custom-made sensor PCB ("DUT": equipped with iC-TW2) to an MB3U-I2C adapter requires at least 4 wires:

VDD, SDAT, SCLK, GND

Refer to EVAL TW2_2D evaluation board descriptions and schematics for wiring details.

2. GUI Software

Download and install the Windows PC Software ("GUI") from:

http://www.ichaus.de/TW2_gui
http://www.ichaus.de/TW2_gui_rt

Define your own default setup and store it to file using <File> <Save File>:
default_xy.hex

3. Default Setup

Start GUI and use <Ctrl U> to connect to MB3U-I2C adapter and to DUT via the I2C extension cable. Use <Load File> to display and transfer your *default_xy.hex* to DUT.

NB: For factory calibrated modules use <Read Parameters> first to display the factory setup and backup the factory setup to file.

Group	Name Of Param.	Datum	Function Value	Comments
Sine-To-Digital				
Interpolation	INTER(7:0)	0x08	8	(default)
Index Position	IPOS(7:0)	0x02	3	(not relevant)
Index Width	IWIDTH(7:0)	0x01	1	index generation enabled
Hysteresis	HYST(1:0)	0x03	+/- 5.63°	(default)
Filter	FILTER(1:0)	0x02	Average of 16 samples	input-to-output latency ca. 2.5 µs
Direction	DIR	0x00	off	(default)
Analog				
Gain Coarse	GC(2:0)	0x05	50..25 mV	according to max. 48 mVpk-pk @ 4 Vdc
Gain Fine A	GFA(1:0)	0x00	0 dB	(default)
Gain Fine B	GFB(1:0)	0x00	0 dB	(default)
Offset A	OFSA(5:0)	0x00	0 mV	(default)
Offset B	OFSB(5:0)	0x00	0 mV	(default)
Index Offset	OFSZ(3:0)	0x07	10.5 mV	(not relevant)
Output				
Mode	MODE(1:0)	0x00	AB Quadrature	incremental encoder quadrature signal
Startup	STARTUP(1:0)	0x02	Absolute	A/B/Z phase depends on input angle
Config and Calibration				
Frequency	FREQ(6:0)	0x0A	10	fcore = fsystem / 11 (ca. 1 MHz)
Clock	CLOCK(4:0)	0x00	0	slowest clock (ca. 22 MHz)
Granularity	GRANULAR	0	0	normal operation
Clock Mode	CLKMODE	0	0	default
Clock Divider	CLKDIV	1	1	fsystem = fosc / 2 (ca. 11 MHz)
Clock Delay	CLKDLY	0	0	normal operation
Calib 1	CALIB1(0)	0	0	(default) must be altered for calib 1
Calib 2	CALIB2(0)	0	0	off

Table 1: Example of initial setup

NB: The above given parameter **Gain Coarse** is recommended for magneto-resistive sensor bridge iC-SM2L operated at a supply voltage of ca. 4 V (diff. signal of 8...12 mV/V, offset error of +/- 2 mV/V)

NB: When selecting Gain Coarse attention to the MR sensor's negative-going temperature coefficient must be paid, since the maximum signal amplitude appears at the lowest operating temperature.
Signal clipping may occur at the lowest operating temperature and may not be noted during calibration at room temperature.

NB: The above given parameters **FREQ**, **CLOCK** and **CLKDIV** are suggested to suit the following applications:

6.000 RPM, pole wheel of 32 poles, 32 signal periods per turn, interpolation factor of up to x32, A/B output of 1024 PPR with up to 100 kHz;

3.000 RPM, pole wheel of 64 poles, 64 signal periods per turn, interpolation factor of up to x32, A/B output of 2048 PPR with up to 100 kHz;

3.000 RPM, pole wheel of 128 poles, 128 signal periods per turn, interpolation factor of up to x16, A/B output of 2048 PPR with up to 100 kHz;

Please refer to iC-TW2's data sheet for details on timing parameters when other encoder specifications are required.

4. Initial Operation

The DUT now needs to be opposed to the magnetic target (e.g. tape or pole wheel).
Move either the target or DUT continuously and slow.

Adjusting iC-TW2 can now follow using test mode **Calib 1** and the GUI controls listed under <Analog>.

5. Calibration Methods

Offset Correction

iC-TW2's signal conditioning parameters can be adjusted following different methods. Each method requires periodic input signals (i.e. a movement of the magnet target). In all cases, parameter Gain Coarse must be maintained as initially set.

Method A. Using test mode "Calib 1" and probing the digital test signals by an oscilloscope. Adjustment of parameters Offset A and Offset B to obtain a duty cycle of 50 % at the A, respectively B output.
Adjustment of parameters Gain Fine A and Gain Fine B to center the Z edges exactly in the middle of the A and B edges.

Method B. Using test mode "Calib 1" and probing the digital test signals by an oscilloscope with AC coupled probes. Adjustment of parameters Offset A and Offset B to center both square wave signals around 0 V.

NB: The scope's vertical resolution may be to raw to visualize changes.
Differences in signal amplitudes can not be measured using this method.

Method C. Using test mode "Calib 1" and probing differential outputs A+ versus A- and output B+ versus B- using a DC voltmeter. As with Method B, the voltmeter reads the DC offset introduced by changes of the duty cycle.

NB: A line driver IC outputting the differential signals can amplify the DC offset depending on the driver's supply voltage. Low signal frequencies should be used to avoid measurement errors if different rise and fall times are likely.

Gain Correction

Fine gain adjustment may be omitted for magneto-resistive strong field sensors operated in magnetic saturation. Typically, the sine to cosine differential signal amplitudes match better than 3 % whereas iC-TW2's calibration step width of 0.7 dB represents a change of 8 %.

Phase Correction

iC-TW2 does not feature compensation of sine to cosine phase errors. However, compensation is possible by variation of the air gap between sensor and pole wheel, or tilting the sensor versus the magnetic tape.

6. Offset Calibration (Method A)

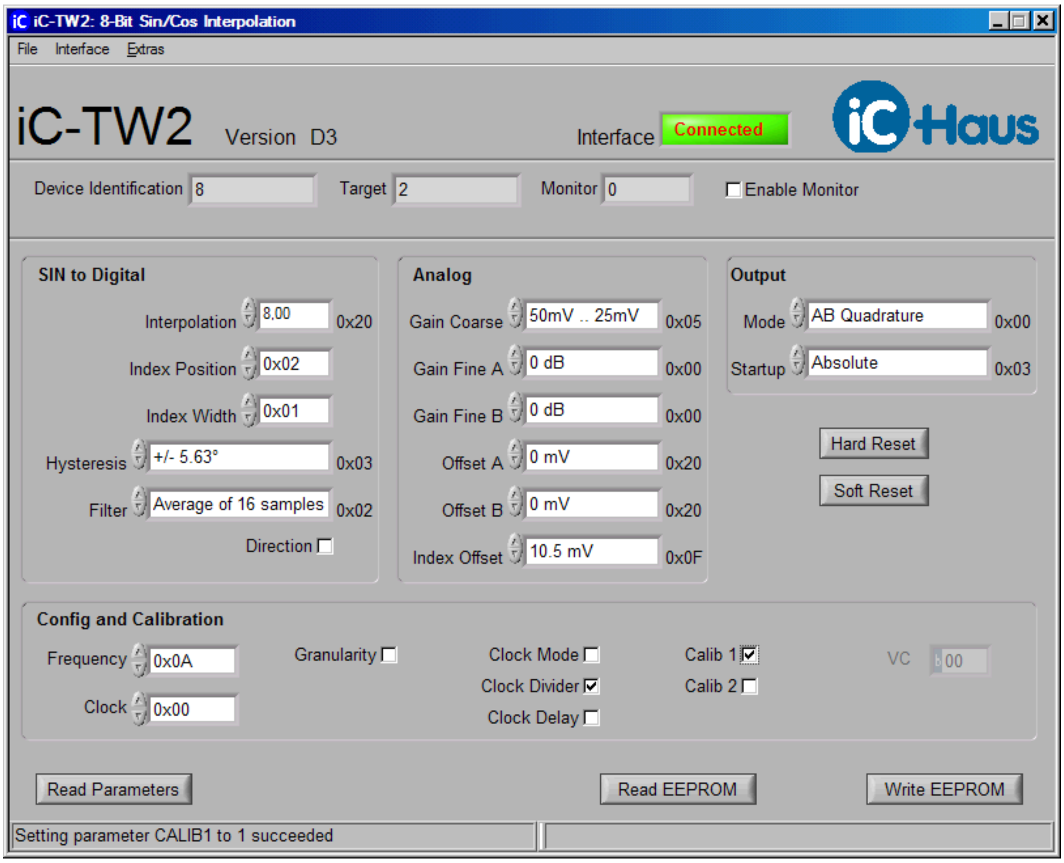

Figure 1: GUI screen shot with default settings and Calib1 enabled.

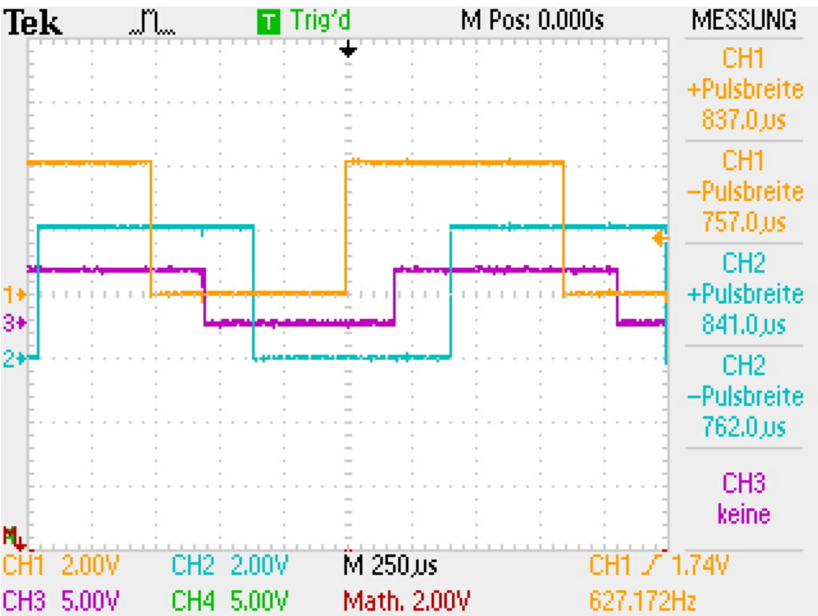

Figure 2: Example of test signals in Calib 1 mode before calibration:
CH1:Output A (duty cycle 52.5 %), CH2: Output B (duty cycle 52.4%), CH3: Output Z.

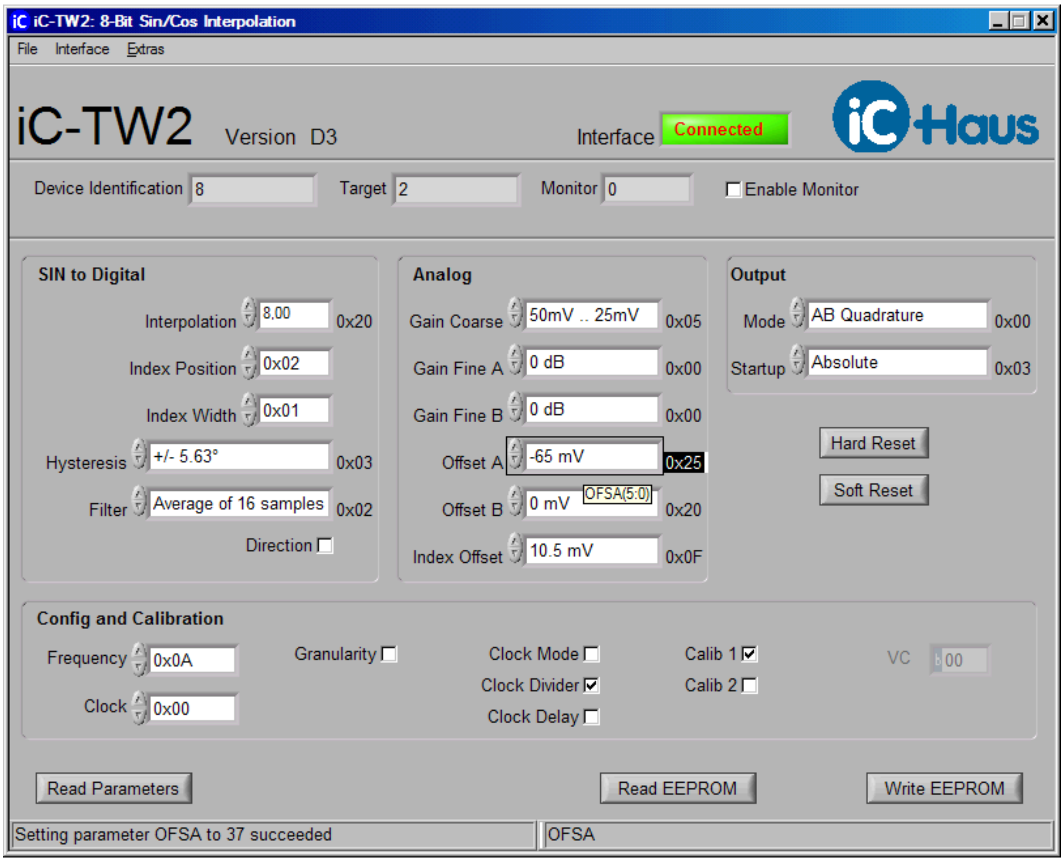

Figure 3: Offset A is adjusted to obtain a duty cycle of ca. 50 % at output A.

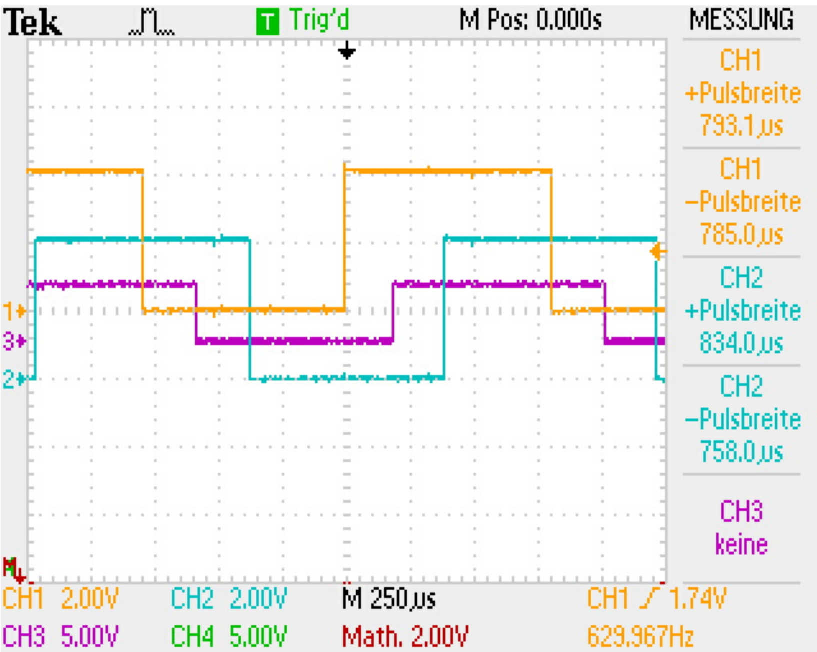

Figure 4: Output A (CH1) calibrated to a duty cycle of ca. 50 %.

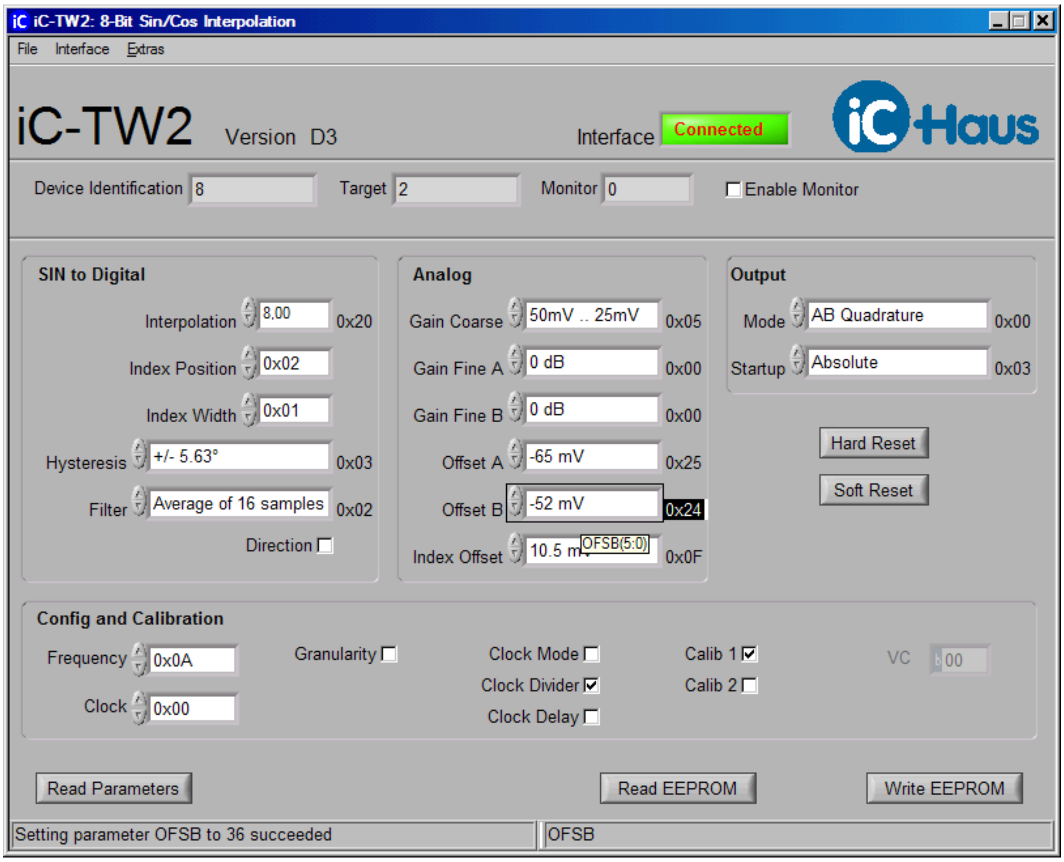

Figure 5: Offset B is adjusted to obtain a duty cycle of ca. 50 % at output B.

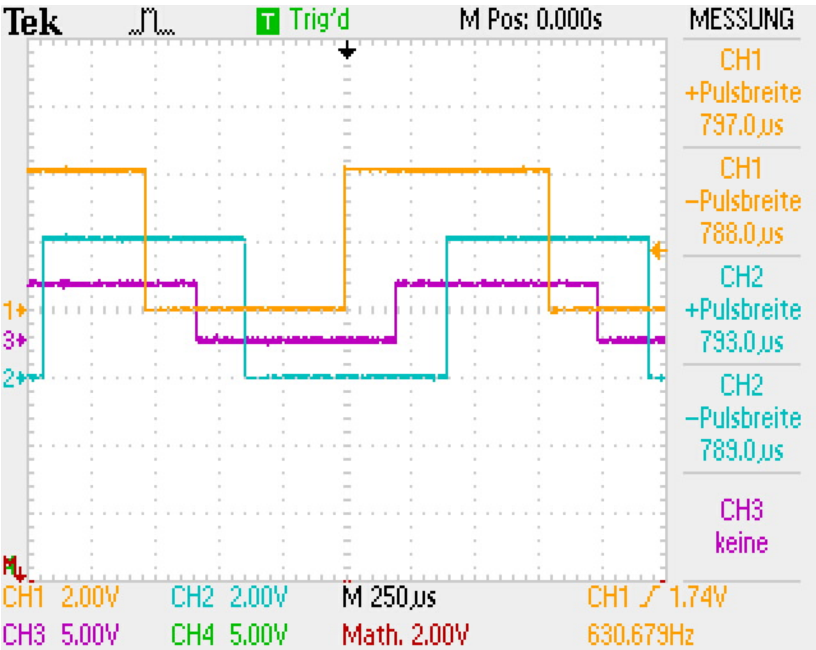

Figure 6: Output B (CH2) calibrated to a duty cycle of ca. 50 %.

7. Offset Calibration (Method B)

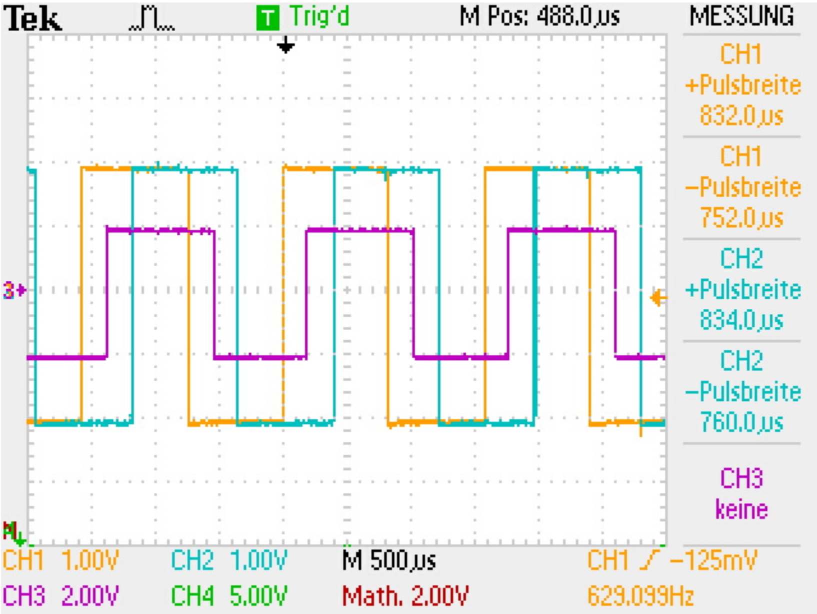

Figure 7: Example of test signals in Calib 1 mode before calibration:

CH1:Output A with ca. -50 mV offset
CH2: Output B with ca. -50 mV offset
(CH3: Output Z – not useful; varies with Offset A and B parameters)

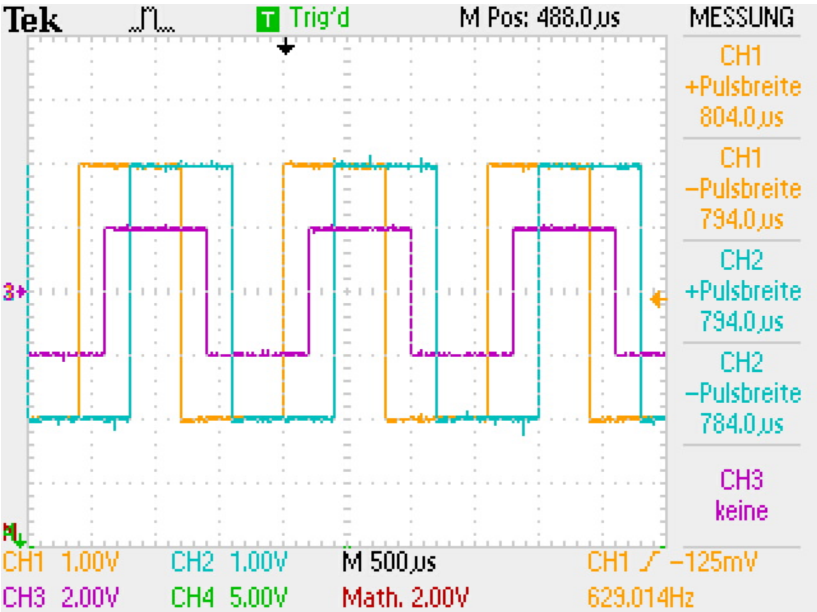

Figure 8: Test signals in Calib 1 mode after calibration.

8. Offset Calibration (Method C)

A DC voltmeter featuring a low pass filter can easily evaluate if a square wave's duty cycle is exactly 50 % or not. Any deviation from 50 % will be indicated either as a positive or negative DC voltage – iC-TW2 parameters Offset A and Offset B are simply adjusted to minimize the reading.

9. Final Configuration

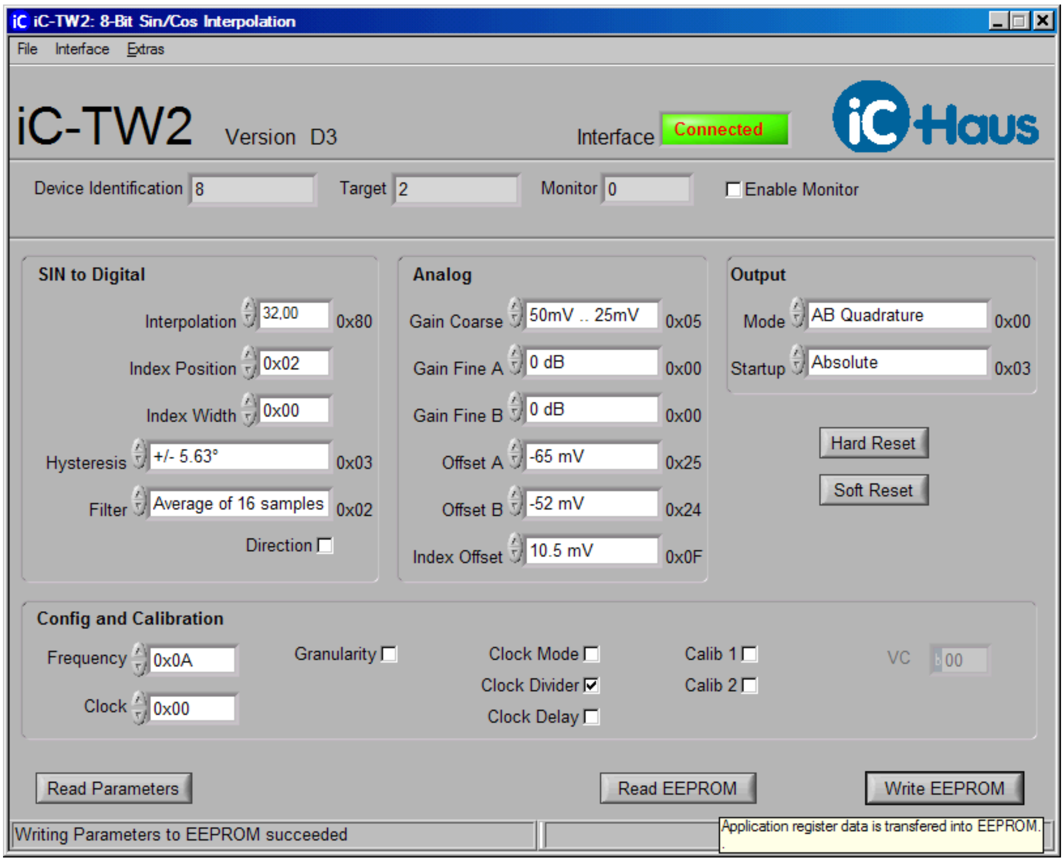

Figure 7: The required operation must be configured finally and saved to iC-TW2's on-chip EEPROM.

Group	Name Of Param.	Datum	Function Value	Comments
Sine-To-Digital				
Interpolation	INTER(7:0)	0x80	32	required interpolation factor
Index Position	IPOS(7:0)	0x02	2	(not relevant)
Index Width	IWIDTH(7:0)	0x00	0	index generation disabled
Hysteresis	HYST(1:0)	0x03	+/- 5.63°	(default)
Filter	FILTER(1:0)	0x02	Average of 16 samples	input-to-output latency ca. 2.5 µs
Direction	DIR	0x00	off	(default)
Analog				
Gain Coarse	GC(2:0)	0x05	50..25 mV	according to max. 48 mVpk-pk @ 4 Vdc
Gain Fine A	GFA(1:0)	0x00	0 dB	(default)
Gain Fine B	GFB(1:0)	0x00	0 dB	(default)
Offset A	OFSA(5:0)	0x...	? mV	calibration data
Offset B	OFSB(5:0)	0x...	? mV	calibration data
Index Offset	OFSZ(3:0)	0x07	10.5 mV	(not relevant)
Output				
Mode	MODE(1:0)	0x00	AB Quadrature	incremental encoder quadrature signal
Startup	STARTUP(1:0)	0x02	Absolute	A/B/Z phase depends on input angle
Config and Calibration				
Frequency	FREQ(6:0)	0x0A	10	fcore = fsystem / 11 (ca. 1 MHz)
Clock	CLOCK(4:0)	0x00	0	slowest clock (ca. 22 MHz)
Granularity	GRANULAR	0	0	normal operation
Clock Mode	CLKMODE	0	0	default
Clock Divider	CLKDIV	1	1	fsystem = fosc / 2 (ca. 11 MHz)
Clock Delay	CLKDLY	0	0	normal operation
Calib 1	CALIB1(0)	0	0	(default) must be altered for calib 1
Calib 2	CALIB2(0)	0	0	off

NB: Index Width 0x00 freezes output Z to low signal.

Revision History

Rev	Notes	Pages affected
A1	Initial version	