IncOder® Field Calibration User Manual

REV230330

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INTRODUCTION

This user manual explains how to generate and program a calibration table into a Zettlex IncOder.

The manual is split into the following sections:

- Hardware Interface
- Serial Communications Interface
- Syntax of a calibration table
- How to create a calibration table
- Examples

The examples in this manual are based on the part number INC-3**C**-200-**21**1001-SSI1-AC1-5-AN, though is applicable to any valid IncOder part number.

The **C** denotes that the part can be programmed with a calibration table.

The **21** is the resolution of the part, this resolution giving a Full-Scale Range (FSR) of 0 to 2097151.

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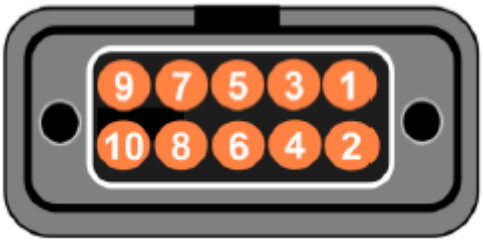
HARDWARE INTERFACE

To perform the calibration on the IncOder, it is necessary to use an RS485 serial port, this is referred to as the Zettlex Communications Protocol port (ZCP port). This section details how to connect to this port and to communicate with it.

RS485 SERIAL COMMUNICATIONS PORT

The interface for the IncOder consists typically of a 10-pin connector (or lead) as shown below. The ZCP Port is accessed on pins 3 and 4.



Connector Pin	Digital Output SSI, SPI and BiSS-C
1	Zero Set
2	Zero Reset
3	ZCP Data A
4	ZCP Data B
5	Data A
6	Clock B
7	Data B
8	Clock A
9	0V
10	VSupply

To use the calibration facility, it is only necessary to use Pins 9 and 10 (for the power supply) and pins 3 and 4.

Pins 3 and 4, (normally marked as reserved), allow a serial communication link to be established with the IncOder using RS485 hardware. RS485 is defined as a differential half-duplex link. Typically, these pins are connected to an RS485 to USB convertor such as USB-RS485-WE-1800-BT.

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The IncOder is powered using an independent power supply (the supply available from the USB adaptor may be used but it should be checked that it can provide the required 100mA for the IncOder). The power supply 0V must be connected to the USB adaptor 0V.

POWER SUPPLY REQUIREMENTS

The IncOder product guide specifies that the IncOder draws < 100mA.

In normal operation the IncOder will be connected to some form reader or master, irrespective of whether this is SSI, SPI, or BiSS-C (using the DATA/CLOCK signals on pins 5 through 8).

For the purposes of performing a calibration, such a reader must not be connected (the SSI/SPI or BiSS-C interface must not be operating). The IncOder position data will be available using the ZCP port used for the calibration. It will be necessary to use such a reader however, as part of a validation procedure, to ensure that after calibration, the performance is as expected.

When the IncOder is connected to such a reader, then the current draw may be as high as 100mA. If it is not connected to a reader, then the current draw will be more typically 50-60mA.

SERIAL COMMUNICATION SETTINGS AND USB PORT ACCESS

The RS485 style USB adaptor will typically appear on a host device, such as a PC, as a COM port. The settings for the COM port should be configured as:

Parameter	Setting
Baud Rate	115200
Parity	None
Data Bits	8
Stop Bits	1

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SERIAL COMMUNICATIONS INTERFACE

Commands are issued to the IncOder using the Hardware interface defined in the previous section.

A propriety protocol is used to send commands and to receive responses. This protocol is referred to as the Zettlex Communication Protocol or ZCP.

The protocol is ASCII based (human-readable) and consists of messages of the form:

```
<ZCP Command>
      <ZCP Response>
```

Each ZCP command consists of a command identifier followed by between 0 and 3 parameters. This takes the form:
`<ZCP Command ID|P1|P2|P3>`

The command and the parameters are separated by the "|" character

Each ZCP response consists of the command identifier that is being responded to, plus 1 or more parameters. The form of the response is the same as the command.

The nature of the parameters will depend on the command and are detailed in the section below.

Typically, the IncOder will respond within less than 5 milliseconds, though some commands may take longer. All responses should be complete within 50mS.

In designing a controller, a timeout of ~100ms would be appropriate.

The following is a list of supported commands, with their responses.

Command	Response	Comments
`<Null>`	`<Null>`	A simple command that causes the IncOder to respond. This can be used to ensure a valid communication link exists.
`<Enable Field Calibration>`	`<Enable Field Calibration|Ok>`	Enables the device to accept Field Calibration commands. An “Ok” response indicates that the command has been accepted.
`<Reset>`	`No response is sent`	Performs a software reset of the IncOder - equivalent to a power cycle.
`<Get Part Number>`	`<Get Part Number|Text String>`	The IncOder responds to this message with a text string indicating the part number of the IncOder.

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Command	Response	Comments
<Get Serial Number>	<Get Serial Number|Text String>	The IncOder responds to this message with a text string indicating the serial number of the IncOder.
<Get date>	<Get Date|Text String>	The IncOder responds to this message with a text string indicating the manufacture date of the IncOder.
<Get Position Data>	<Get Position|position>	The IncOder responds with the current position of the sensor in the range 0 to 2R - 1 (where R is the binary resolution of the device).
<Zero Set>	<Zero Set|Ok>	The current position of the sensor is set as the zero position.
<Zero Reset>	<Zero Reset|Ok>	The zero position of the IncOder is reset to the factory default position.
<Set CW>	<Set CW|Ok>	The direction of the IncOder is set to Clockwise (this is the factory default).
<Set CCW>	<Set CCW|Ok>	The direction of the IncOder is set to Counterclockwise.
<Field Calibration Configuration|Pc1|Pc2|Pc3>	<Field Calibration Configuration|Pr>	This performs a Field Calibration Configuration instruction using parameters P_{c1}, P_{c2} and P_{c3}. P_{c1} defines the specific instruction. The IncOder responds with a parameter P_r depending on the specific instruction. The valid set of Field Calibration Configuration instructions is defined in a later section.

It is possible that error responses may be generated by the IncOder. On such occasions, please refer to Zettlex for advice/support.

The following shows a typical ZCP session (as captured using a terminal emulator package - the text in **blue** are the commands to the IncOder and the text in **red** are the responses from the IncOder).

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```
25/10/2021 13:39:07.952 [TX] - <Null>
25/10/2021 13:39:07.963 [RX] - <Null>

25/10/2021 13:39:11.335 [TX] - <Enable Field Calibration>
25/10/2021 13:39:11.347 [RX] - <Enable Field Calibration|Ok>

25/10/2021 13:39:17.785 [TX] - <Get Part Number>
25/10/2021 13:39:17.800 [RX] - <Get Part Number|INC-3C-75-211002-BIS3-AC1-5-AN>

25/10/2021 13:39:18.881 [TX] - <Get Serial Number>
25/10/2021 13:39:18.892 [RX] - <Get Serial Number|0000146248>

25/10/2021 13:39:20.591 [TX] - <Get Date>
25/10/2021 13:39:20.601 [RX] - <Get Date|25102021>

25/10/2021 13:39:21.718 [TX] - <Get Position Data>
25/10/2021 13:39:21.729 [RX] - <Get Position Data|+1416712>

25/10/2021 13:39:26.281 [TX] - <Reset>
```


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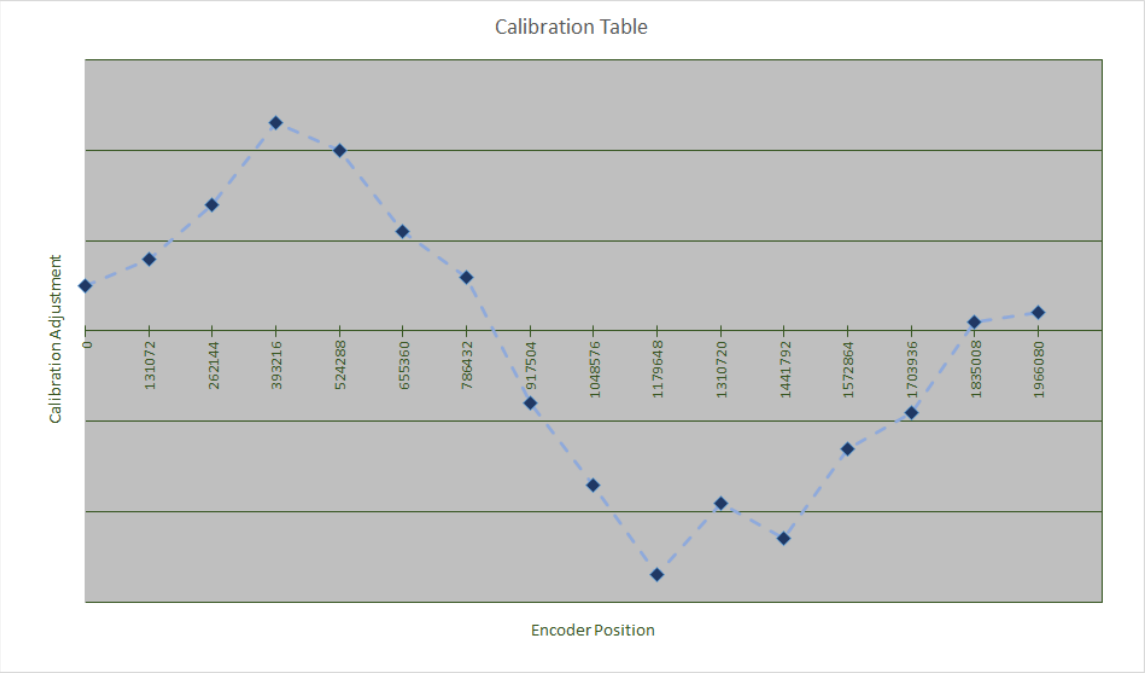
SYNTAX OF A CALIBRATION TABLE

This page defines what a calibration looks like in an IncOder and how to load such a calibration table into an IncOder using the ZCP serial communications interface defined above.

HOW A CALIBRATION TABLE WORKS

The position that is measured by the IncOder will always consist of some deterministic errors or non-linearities. Although testing during manufacture can reduce the overall magnitude of these errors, some will always remain, primarily due to factors associated with installation.

Due to the high repeatability of IncOder, once the device is installed in its final assembly, these errors become deterministic. The errors can then be measured (using an accurate reference), and it is possible to construct a calibration table that can be used to remove these residual non-linearities.



The above example shows a simplified calibration table that illustrates the concept.

Each calibration point in the table (16 in the example) consists of a position and an adjustment value. The position is as measured by the IncOder, and the adjustment value is used by the IncOder to null the non-linearity at that position. These adjustment values are derived from the data collected from IncOder itself and the reference device during the calibration process.

The IncOder uses the data in this table to correct for non-linearities. For positions that lie between points in the calibration table, a simple linear spline estimation is calculated and used.

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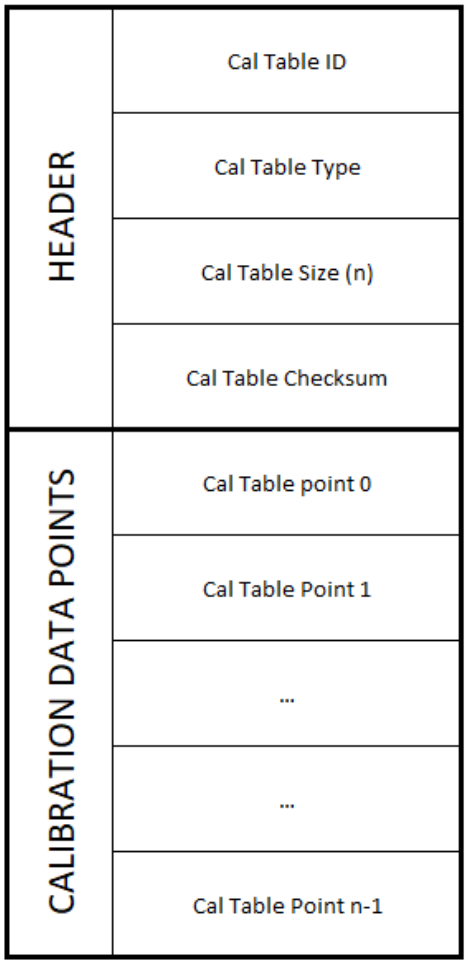
STRUCTURE OF A CALIBRATION TABLE

A calibration table in an IncOder consist of two main parts as shown below:



Upto 7 ASCII chacters that can be used as an identification of the calibration table

An ASCII character that defines the type of Calibration table (0 or 2)

The size of the calibration table (max 6826)

CRC32 checksum. Used by the IncOder at initialisation to verify the integrity of the data stored in the cal table.

Calibration point 0 - Position/Adjustment data pair

Calibration point 1 - Position/Adjustment data pair

Calibration point (n-1) - Position/Adjustment data pair

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CALIBRATION TABLE TYPES

There are two possible calibration table types that can be used.

Calibration Table Type	Description
0	**EMPTY CALIBRATION TABLE** This is an empty Calibration table, so no calibration will take place. This is the Default condition of the device.
2	**REGULAR CALIBRATION TABLE** The number of calibration points should be a power-of-2, and the separation between the points should be equidistant. For example, a 21-bit resolution IncOder with a 1024-point calibration table should position the calibration points at 0, 2048, 4096, …, 2095104. The first point should always be at 0.

For a device with resolution 2^R, (e.g., for part number INC-3C-200-211001-SSI1-AC1-5-AN, where R is 21 and the FSR is 2097152), and the size of the calibration table is 2^S (e.g. for a 1024 point calibration table, S is 10), then the separation in position between each calibration point is given as:

$$D = 2^{(R-S)}$$

and the actual positions for each calibration point will be in the sequence:

0, D, 2*D, 3*D … (Size-1)*D

Each calibration point is represented by a pair of data: the position value and the adjustment value. The Position is stored as a 32-bit unsigned integer and the Adjustment value is stored as a 16-bit signed integer.

The adjustment value range is +/-13 bits.

CALIBRATION TABLE CHECKSUM

On initialisation (at power-on), the integrity of the calibration table data is verified by calculating the checksum and comparing it with the data stored in the Calibration Table Header.

Note: Some C Programming language terminology is used here.

The Checksum used is CRC-32, with polynomial 0x4C11DB7 with an initial value of 0xFFFFFFFF.

The Checksum is calculated by adding each Calibration point in turn, first with calibration point position and second with the adjustment (this 16-bit signed number is first cast to a signed 32-bit number).

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HOW TO LOAD A CALIBRATION TABLE

To load a new calibration table into an IncOder the ZCP interface is used, specifically the <Field Calibration Configuration|P_{c1}|P_{c2}|P_{c3}> command, using the various instructions specified by parameter P_{c1}.

These instructions are:

Instruction Description	P_{C1}	P_{C2}	P_{C3}	Result	Comments
Define New Table (1)	0x04	ID1: 32-bit integer 0xSSTTUUVV where 0xSS = ASCII code for Cal Table Type 0xTTYYVV = first 3 ASCII characters for the user defined ID	ID2: 32-bit integer 0xWWXXYYZZ Which are the last 4 ASCII characters of the user defined ID	The ZCP response will be “Ok”	This starts the calibration table definition process. The use of a user defined ID is optional.
Get ID	0x05	Defines which ID value is returned. Set to 0 to return ID1 Set to 1 to return ID2	Defines format of result. Set to 0 for decimal formatting Set to 1 for hexadecimal formatting	The ZCP response will be the value of ID1 or ID2 as selected by P_{C2}	
Get Max Length	0x07	Not used- set to 0	Not used- set to 0	The ZCP response will be the total number of calibration points that can be stored	Note this is the max length, not the current remaining length
Set Length (2)	0x08	Should be set to 0	The length of the new calibration table.	The ZCP response will either be: “Ok” ”Error2” if this instruction is not expected ”Error3” if the length is out-of-range	If the length is always less than the Max Length and this instruction is issued after Define New Table, then the result should always be “Ok”
Get Length	0x09	Should be set to 0	Not used- set to 0	The ZCP response will be the value of the currently set table length	
Set Checksum (3)	0x0A	Should be set to 0	Expected Checksum: 32-bit Integer	The ZCP response will either be: “Ok” ”Error2” if this instruction is not expected	If this instruction is issued after Define New Table, then the result should always be “Ok”

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Instruction Description	P_{C1}	P_{C2}	P_{C3}	Result	Comments
Get Checksum	0x0B	Should be set to 0	Set to 0 to return the value of the Expected Checksum Set to 1 to return the value of the actual checksum	The ZCP response will be the value of the Expected Checksum or Actual Checksum as selected by P_{C2}	
Set Calibration Point Position (4a)	0x0C	Index: 32-bit Integer where the Least Significant Byte is always 0 and the 3 Most Significant Bytes contain the index value.	Position: 32 Bit Integer. Must be in the range 0 to *Full Scale Range*	The ZCP response will either be: "Ok" "Error2" if this instruction is not expected "Error3" if the Index is out-of-range	If the Index is consistent with the Table Size and device resolution, and this instruction is issued after Define New Table, then the result should always be "Ok"
Get Calibration Point Position	0x0D	Index: 32-bit Integer where the Least Significant Byte is always 0 and the 3 Most Significant Bytes contain the index value.	Not used- set to 0	The ZCP response will be: The Position value as selected by the Table index in P_{C2}. "Error3" if the Index is out-of-range	If the Index is consistent with the Table Size and device resolution, then the result should always be the requested Position value
Set Calibration Point Adjustment Value (4b)	0x0E	Index: 32-bit Integer where the Least Significant Byte is always 0 and the 3 Most Significant Bytes contain the index value.	Adjustment: a value in the range -8192 to +8191 (a signed 13-bit integer).	The ZCP response will either be: "Ok" "Error2" if this instruction is not expected "Error3" if the Index is out-of-range	If the Index is consistent with the Table Size and device resolution, and this instruction is issued after Define New Table, then the result should always be "Ok"
Get Calibration Point Adjustment Value	0x0F	Index: 32-bit Integer where the Least Significant Byte is always 0 and the 3 Most Significant Bytes contain the index value.	Not used- set to 0	The ZCP response will be: The Adjustment Value as selected by the Table index in P_{C2}. "Error3" if the Index is out-of-range	If the Index is consistent with the Table Size and device resolution, then the result should always be the requested Adjustment value
Get Status (6)	0x10	Should be set to 0	Not used- set to 0	Calibration Table Status	The Calibration Status is only updated at initialisation or after the Store Table instruction.
Store Table (5)	0x11	Not used- set to 0	Not used- set to 0	The ZCP response will be "Ok"	This stores the Header information into flash and ends the calibration table definition process.

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The general process to load a calibration table is as follows (see the table above - the Instruction Definitions are annotated with the sequence numbers defined below):

(1) Define the (new) calibration table.
(2) Set the calibration table length.
(3) Set the calibration table checksum.
(4) For each point in the calibration table define (a) the position and (b) the adjustment value.
(5) Store the calibration table to flash.
(6) Confirm the calibration table status to ensure it has been accepted.

STATUS CODES

In response to the Get Status instruction, the IncOder will return a Status Code. This is a 32-bit integer, and the following table defines the status associated with each bit.

A bit set to 0 indicates that the condition is “OK”.

A bit set to 1 indicates that the condition is in an error state.

Bit Position	Description of Error State
0	Overall Summary of Calibration Table Status.
1	Checksum Error (the expected checksum is not the same as the calculated checksum).
2	The calibration table size is too large.
3	The calibration table size is too small.
4	One or more of the adjustment values is too large.
5	One or more of the adjustment values is too small.
6	One or more of the position values is too large (greater than the device resolution).
7	One or more calibration points has not been defined.
8	One or more calibration points are out of order (the calibration points should be ordered by their position - small to large)
9	The Calibration Table type is not valid (should be either ‘0' or '2’)
10	The size of the calibration table is not a power-of-2
11	One or more position values is not the correct value for the given index.
12-31	Reserved

The status of a correctly loaded calibration table (or an Empty Calibration table) will be 0x00000000

The Status code response is always represented as an HEX number (though it is not preceded by “0x”).

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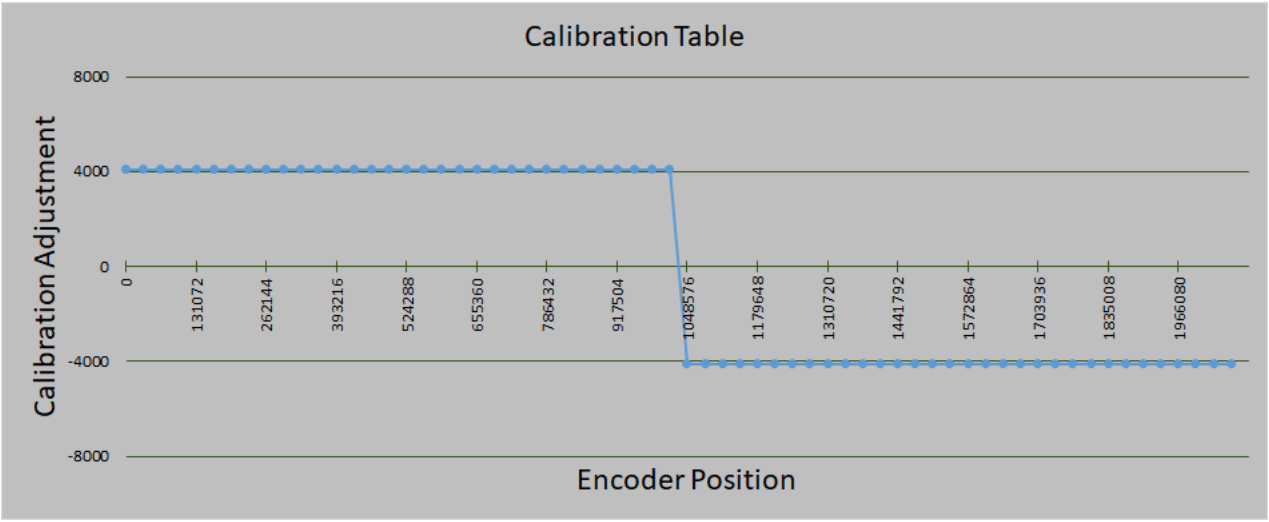
EXAMPLES

On this page, we will describe a real calibration table together with some scripts which could be used to load it into an IncOder. We also include some example code used to generate the checksum.

SIMPLE CALIBRATION TABLE EXAMPLE

The following graph describes the example table.



This is an extremely simplistic calibration table that is designed to easily demonstrate how to create and load a calibration table, and then see it in action.

It has a size of 64 (data points) and assumes the IncOder has a resolution of 21 bits (full scale range of 20971452).

The values for the table (header and 64 calibration points) are:

Header Item	Item Value	Description
ID1	2_Ex	'2' is the Table Type and '_Ex' is the first part of the user ID
ID2	Cal1	'Cal1' is the second part of the user ID
Size	64	
Checksum	743139612	

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The 64 Datapoints are:

Table data point number	Data point Position	Data point value	Table data point number	Data point Position	Data point value	Table data point number	Data point Position	Data point value
Point 0	0	4096	Point 22	720896	4096	Point 44	1441792	-4096
Point 1	32768	4096	Point 23	753664	4096	Point 45	1474560	-4096
Point 2	65536	4096	Point 24	786432	4096	Point 46	1507328	-4096
Point 3	98304	4096	Point 25	819200	4096	Point 47	1540096	-4096
Point 4	131072	4096	Point 26	851968	4096	Point 48	1572864	-4096
Point 5	163840	4096	Point 27	884736	4096	Point 49	1605632	-4096
Point 6	196608	4096	Point 28	917504	4096	Point 50	1638400	-4096
Point 7	229376	4096	Point 29	950272	4096	Point 51	1671168	-4096
Point 8	262144	4096	Point 30	983040	4096	Point 52	1703936	-4096
Point 9	294912	4096	Point 31	1015808	4096	Point 53	1736704	-4096
Point 10	327680	4096	Point 32	1048576	-4096	Point 54	1769472	-4096
Point 11	360448	4096	Point 33	1081344	-4096	Point 55	1802240	-4096
Point 12	393216	4096	Point 34	1114112	-4096	Point 56	1835008	-4096
Point 13	425984	4096	Point 35	1146880	-4096	Point 57	1867776	-4096
Point 14	458752	4096	Point 36	1179648	-4096	Point 58	1900544	-4096
Point 15	491520	4096	Point 37	1212416	-4096	Point 59	1933312	-4096
Point 16	524288	4096	Point 38	1245184	-4096	Point 60	1966080	-4096
Point 17	557056	4096	Point 39	1277952	-4096	Point 61	1998848	-4096
Point 18	589824	4096	Point 40	1310720	-4096	Point 62	2031616	-4096
Point 19	622592	4096	Point 41	1343488	-4096	Point 63	2064384	-4096
Point 20	655360	4096	Point 42	1376256	-4096			
Point 21	688128	4096	Point 43	1409024	-4096			

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A script (which runs in the terminal emulator package, Docklight) and data files have been created and can be used to program this example table into a suitable IncOder (either 18-, 19-, 20- and 21-bit resolution IncOders). Contact Zettlex to obtain of copy of the Docklight Script and the Data files.

The data files will load the calibration table and then after a reset, issue some commands to inspect some of the header information.

The following screen captures show recorded serial communications at the start and end of the sequence of commands to load this table.

Start of sequence

```
26/10/2021 16:15:39.012 [TX] - <Null>
26/10/2021 16:15:39.027 [RX] - <Null>

26/10/2021 16:15:39.040 [TX] - <Enable Field Calibration>
26/10/2021 16:15:39.047 [RX] - <Enable Field Calibration|Ok>

26/10/2021 16:15:39.070 [TX] - <Field Calibration Configuration|0x04|0x32205465|0x73743031>
26/10/2021 16:15:39.091 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:39.104 [TX] - <Field Calibration Configuration|0x08|0|64>
26/10/2021 16:15:39.139 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:39.147 [TX] - <Field Calibration Configuration|0x0C|0|0>
26/10/2021 16:15:39.155 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:39.194 [TX] - <Field Calibration Configuration|0x0E|0|4096>
26/10/2021 16:15:39.204 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:39.227 [TX] - <Field Calibration Configuration|0x0C|256|32768>
26/10/2021 16:15:39.235 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:39.272 [TX] - <Field Calibration Configuration|0x0E|256|4096>
26/10/2021 16:15:39.283 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:39.305 [TX] - <Field Calibration Configuration|0x0C|512|65536>
26/10/2021 16:15:39.314 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:39.322 [TX] - <Field Calibration Configuration|0x0E|512|4096>
26/10/2021 16:15:39.330 [RX] - <Field Calibration Configuration|Ok>
```


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End of sequence

```
26/10/2021 16:15:43.459 [TX] - <Field Calibration Configuration|0x0C|15872|2031616>
26/10/2021 16:15:43.469 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:43.488 [TX] - <Field Calibration Configuration|0x0E|15872|-4096>
26/10/2021 16:15:43.501 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:43.532 [TX] - <Field Calibration Configuration|0x0C|16128|2064384>
26/10/2021 16:15:43.549 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:43.568 [TX] - <Field Calibration Configuration|0x0E|16128|-4096>
26/10/2021 16:15:43.581 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:43.590 [TX] - <Field Calibration Configuration|0x0A|0|743139612>
26/10/2021 16:15:43.605 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:43.627 [TX] - <Field Calibration Configuration|0x11|0|0>
26/10/2021 16:15:43.692 [RX] - <Field Calibration Configuration|Ok>

26/10/2021 16:15:43.708 [TX] - <Field Calibration Configuration|0x10|0|0>
26/10/2021 16:15:43.725 [RX] - <Field Calibration Configuration|0>

26/10/2021 16:15:43.753 [TX] - <Reset>
26/10/2021 16:15:44.260 [TX] - <Null>
26/10/2021 16:15:44.275 [RX] - <Null>

26/10/2021 16:15:44.299 [TX] - <Enable Field Calibration>
26/10/2021 16:15:44.316 [RX] - <Enable Field Calibration|Ok>

26/10/2021 16:15:44.326 [TX] - <Field Calibration Configuration|0x10|0|0>
26/10/2021 16:15:44.337 [RX] - <Field Calibration Configuration|0>

26/10/2021 16:15:44.360 [TX] - <Field Calibration Configuration|0x05|0|1>
26/10/2021 16:15:44.380 [RX] - <Field Calibration Configuration|32205465>

26/10/2021 16:15:44.395 [TX] - <Field Calibration Configuration|0x05|1|1>
26/10/2021 16:15:44.412 [RX] - <Field Calibration Configuration|73743031>

26/10/2021 16:15:44.433 [TX] - <Field Calibration Configuration|0x09|0|0>
26/10/2021 16:15:44.444 [RX] - <Field Calibration Configuration|64>

26/10/2021 16:15:44.459 [TX] - <Field Calibration Configuration|0x0B|0|0>
26/10/2021 16:15:44.476 [RX] - <Field Calibration Configuration|2C4B691C>

26/10/2021 16:15:44.498 [TX] - <Field Calibration Configuration|0x0B|0|1>
26/10/2021 16:15:44.508 [RX] - <Field Calibration Configuration|2C4B691C>
```

The last few ZCP commands indicate:

- The table status of 0
- The two ID values of 0x32205465 and 0x73743031 (the most significant byte is the ASCII code for 2 - so this is a Type 2 table)
- The size of the table (64)
- The expected and calculated checksums 0f 2C4B691C (in Hex)

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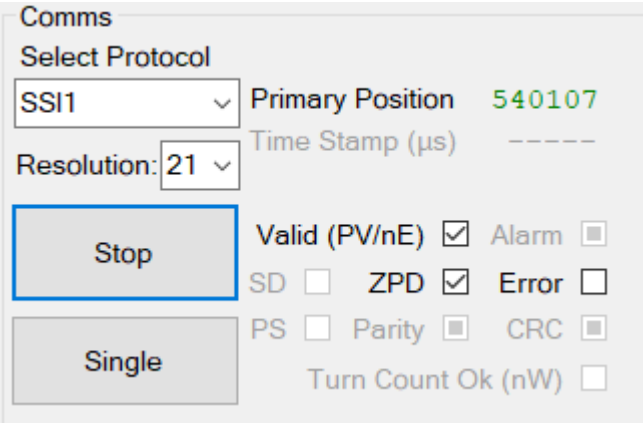
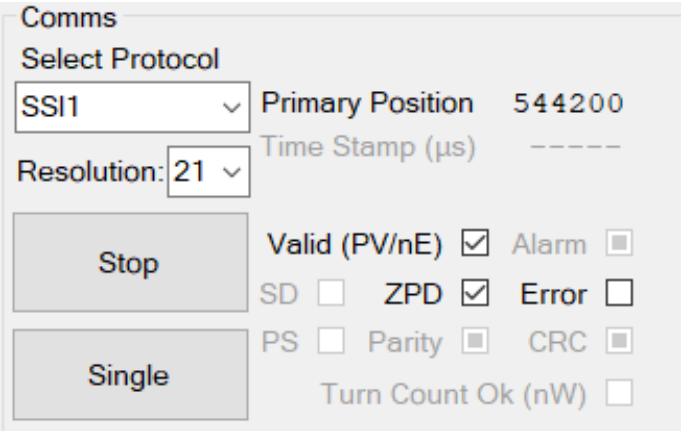
The following diagrams show the positions captured before and after the calibration table was loaded (~90 degrees)





They show that the output has changed by 4093 counts - which (within 1 or 2 counts due to noise) is the adjustment value defined by this simple calibration table.,

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EXAMPLE VISUAL BASIC CODE TO CALCULATE CRC

Shown for a fixed table size of 64 cal positions. The calibration table data is not shown being initialised in this example, it is assumed that is performed elsewhere.

```
Const TableSize = 64
Dim TablePositions(TableSize) ' The table of positions for each calibration
point
Dim TableAdjustments(TableSize) ' The table of adjustments for each
calibration point
Private Function CalculateCalTableCRC()
    Dim TableCRC As UInt32
    ' as Visual Basic doesn't allow a UInt32 to be assigned the value
&HFFFFFFFF (all one's) or -1
    ' use this technique to do the same thing
    TableCRC = 0
    TableCRC -= 1

    For i = 0 To (TableSize - 1)
        TableCRC = CRC32(TableCRC, TablePositions(i))
        TableCRC = CRC32(TableCRC, CUInt(CInt(TableAdjustments(i))))
'perform the cast by first casting int16 to int32 and then to uint32
    Next
    CalculateCalTableCRC = TableCRC
End Function
Private Function CRC32(current_crc As UInt32, new_data As UInt32)
    Dim result As UInt32

    result = current_crc
    result = result Xor new_data
    For i = 0 To 31
        If ((result And &H80000000) = &H80000000) Then
            result = result << 1
            result = result Xor &H4C11DB7
        Else
            result = result << 1
        End If
    Next
    CRC32 = result
End Function
```

It is also possible to use the IncOder to generate the checksum. First define and load a calibration table except for the expected CRC value. Once stored (the status will show an error, which is to be expected), you can read back the calculated checksum. The calibration table can then be loaded again by repeating the first steps but this time using the value previously read back for the expected checksum.

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REVISION HISTORY

Revision	Release Date	Changes
1.1	23 Aug 2022	Power Supply Requirements – During calibration, the SSI/BiSS-C/SPI interface must not be used. Calibration Table Types – Actual positions for each calibration point corrected Tables re-formatted (p.11-p.14) Status code – status code clarification (HEX number) added.

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