Program for Creating RTC®5 Correction Files

correXion®5

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Contents

1 Introduction

This user manual describes SCANLAB's correXion®5 software and its usage in creating RTC®5 correction files.

Read this user manual in its entirety before attempting to install or use correXion®5.

If you have questions regarding this manual's contents, then contact SCANLAB.

1.1 Scope of Delivery

The software package with the correXion®5 program is normally supplied on CD. All required files reside in one directory:

- correXion5.exe (version 1.11)
- RTC5Base.dll (version 1.0.0.13 or higher)
- MSVCRT.dll
- MFC71.dll
- MSVCR71.dll
- MSVCP71.dll

1.2 Manufacturer

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1.3 System Requirements

Hardware

Full usage of the correXion®5 program requires that the scan system be controlled by an RTC®5 board installed in an IBM-compatible PC. The RTC® board and its driver must be correctly installed (see RTC®5 manual). The RTC®5 board must be properly connected to the scan system.

Note

If you won't be using the section "Marking Test Points via the “Marking Grid” Dialog" (see page 9), then a connection to the RTC®5 board will not be created. Its installation is then not required.

Operating System

correXion®5 is a dialog-based Win32 application usable with the following Microsoft operating systems:

- MS WINDOWS 9x
- MS WINDOWS ME
- MS WINDOWS XP
- MS WINDOWS 2000
- MS WINDOWS Vista

2 correXion®5 Software – Overview

2.1 Image Field Correction

SCANLAB's scan systems implement image field correction with the help of correction files containing all information required for scanning within a plane (or within a working volume in the case of 3D correction files). When calculating control values, the RTC®PC interface board takes the correction file's contents into account to compensate the image field distortion inherent in two-mirror systems (including optics).

RTC®correction files are binary files with the file extension ".ct5" (i.e. correction table 5)(1). 2D correction files consist of two adjoining tables. A 3D correction file appends supplemental information after these two tables. Each of the two tables contains correct digital control values to be output by the RTC®board to one of the scan system's galvanometer scanners (table 1 for galvanometer scanner 2, table 2 for galvanometer scanner 1) for predefined points within the image field. These predefined points represent a 257·257 array of a quadratic grid superimposed over the image field (on the (z=0) plane for 3D correction files).

The output values for an arbitrary point within the image field are calculated by interpolation of the corrected values of neighboring grid points.

By default, SCANLAB's correction files are calculated from general system data (e.g. mirror geometry, calibration factor, objective specifications). Individual system properties and alignment errors aren't taken into account.

SCANLAB has therefore introduced the correXion®5 program for applications requiring very precise image field correction via correction files exactly tuned to properties of the customer's specific system. It generates RTC®5 correction files from test points actually measured by the user.

2.2 General Procedure

With correXion®5, new tuned correction files can be created as follows:

(1) Install the correXion®5 software (see chapter 3).

(2) Mark test points within the image field of your 2D or 3D scan system using its supplied correction file. You can use the "Marking Grid" dialog of the correXion®5 program for this (see chapter 4).

(3) Measure the coordinates of the marked test points. If you need very high precision, then use a measurement microscope.

(4) Use an editor or correXion®5 to create an ASCII-readable data file with the desired correction parameters and enter into it the measured coordinates (i.e. data) (e.g. via a spreadsheet program) (see chapter 5).

(5) Launch correXion®5 in dialog mode (see chapter 6) or silent mode (see chapter 7). Based on your data file and the original RTC®correction file (used for marking the test points), correXion®5 will then calculate a new RTC® correction file tuned to your specific system. Dialog mode allows you to analyze the results of a calculation and, if necessary, set improved calculation parameters for easily creating further correction files with even more precise customization.

Caution!

SCANLAB assumes no liability for damage resulting from invalid measurements or incorrectly entered measurement points.

(6) For documentation purposes, you can generate a log file that lists the applied calculation parameters and measurement data as well as results of the calculation (see chapter 8).

(1) RTC® correction files in ctb-format are not compatible with the RTC®5 board and can't be used with correXion®5. The same applies to data files created for the old version of the correXion program for customizing ctb-files.

2.3 Program Modes

The correXion®5 program can be operated in dialog mode via a graphical user interface (GUI) or in silent (background) mode.

Dialog Mode

correXion®5 will launch as a data dialog when you double-click "correXion5.exe" or an appropriately created desktop symbol. The program's GUI is a dialog box with Windows-typical control elements (see figure 5 on page 23). This box provides input fields, checkboxes and buttons allowing you to make all adjustments required for calculating new correction files.

Two additional dialog boxes let you mark test points and view calculation results. Dialog mode helps you create the required data file (described on page 17).

If errors occur, they will be directly displayed (in pop-up windows).

Test-point marking in dialog mode is described in chapter 4.2 on page 9. How to create new correction files is described in chapter 6 on page 23.

Silent Mode

correXion®5 can also be started via the command line (e.g. via "Start\Run\..." with the data file ([Drive:][Path]<Name>[.<Ext>]) as parameter. It then executes fully in the background (i.e. silently). For this, the data file must contain all (previously created) information needed to generate the new correction file (the data file is described on page 17).

Any occurring errors are appended to a log file ([Drive:][Path]<Name>[.<Ext>].log, see page 33).

Information on creating new correction files in silent mode can be found in chapter 4 on page 31.

2.4 The correXion®5 Process

The correXion®5 program executes a fit function on the test points contained in the data file (more precisely: for a selectable number of image-field grid points, up to a maximum of $511 \cdot 511 = 261.121$) and calculates values for a new correction table.

With the typically-supplied original correction file, the fit function uses the marked and subsequently measured values (x and y coordinates in [mm]) as well as the control values (adjusted for the specified calibration factor) of the test points entered in the data file. The desired order and smoothing of the fit is user-specifiable.

Users can specify the vertical and horizontal positions of a rectangular grid – also permitted here are sections of the image field. Another possibility is the swapping of coordinate axes.

The correXion®5 program reads or writes complete RTC®5 correction files (2D or 3D) only, though only the 2D section (z=0 plane) is altered. The original correction file's 3D section is incorporated without changes into the new correction file. The program may adjust the header information when appropriate.

3 Installing correXion®5

- Insert the software CD into the optical drive of the PC in which your RTC®5 board is installed.
- With Windows Explorer, open the CD's directory containing all the software package's files.
- Copy all of this directory's files to any desired directory on your PC.

Caution!

After installation, all of the software package's files must reside in the same directory.

4 Performing Test Measurements

To determine the data points (coordinates) that were entered in the data file, you need to mark test points onto the image field and precisely measure them.

Caution!

The following procedures are only appropriate for creating new 3D correction files if the designated working distance and the calibration factor don't change when switching from the old to the new correction file.

SCANLAB's correXion®5 program provides a "Marking Grid" dialog for marking the test points. It lets you make all necessary adjustments and start the procedure (see chapter 4.2 on page 9).

You can also mark test points without using correXion®5 (see chapter 4.1 on page 9).

When marking, observe the following:

- To mark the test points, use an appropriate correction file (typically supplied with your scan system). For calculations, correXion®5 also allows using the RTC®5 software packet's 1:1 correction file when marking the test points – though 1:1 correction files aren't recommended.
- With correXion®5, digital control values for the test points (in [Bit]) cannot be randomly specified: the test points must lie on a rectangular grid and the number of test points along a grid side must be an uneven value between 3 and 511. Furthermore, the average value must be 0. Hence, the number of grid lines on both sides of the midpoint must be identical.
  [GRIDNUMBERS] = <Xn><Yn> (see page 18) will result in $(2 \cdot Xn + 1)$ resp. $(2 \cdot Yn + 1)$ point rows and a total of $(2 \cdot Xn + 1) \cdot (2 \cdot Yn + 1)$ data points to mark.
- The control values should, as much as possible (see below), cover the maximum area (–524288 ... +524287). You can also select sections at any time. But table areas outside a section won't get corrected (other than a transition phase). Non-markable points can in fact be omitted. In the data file, these points must be entered by extrapolating measured values.

Caution!

- Ensure that the scan system's maximum scan angle will not be exceeded and that the scan system will not incur damage from possible vignetting of the laser beam.
- The "Marking Grid" dialog marks points at the edge of the test grid section too. If this is not possible due to vignetting or hitting the galvanometer scanners' limits, then the "Marking Grid" dialog shouldn't be used for this purpose (also see note on page 15).

- Before marking points, allow a 30-60 minute warm-up phase in which the galvanometer scanners are in motion and the typical working temperature is reached. Only then can the test points' target positions be reliably achieved.

4.1 Marking Test Points without the “Marking Grid” Dialog

To mark the test points, proceed as follows:

- Let your scan system run until its typical working temperature is reached.
- Suitably set dynamics-related parameters so that the test points’ target positions will be reliably reached.
- Mark the supplied test points via your scan system.
- If you are using a 3D correction file, then mark the test points in the (z = 0) plane.
- Mark at least 9 and not more than 261,121 (511·511) test points.

The measuring of marked test points is described in chapter 4.3 on page 16.

4.2 Marking Test Points via the “Marking Grid” Dialog

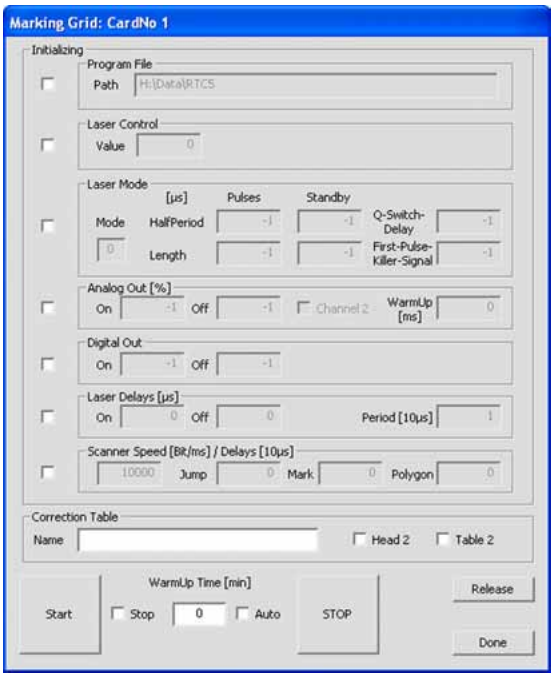
The “Marking Grid” dialog can be accessed after correXion®5 is started. Access of this dialog requires that the file RTC5DLL.dll reside in the current working directory (or in a directory specified in the “path” environment variable).

Note

You can change the current working directory via the {Load} and {Save} buttons in “Data File” and “Correction File” groups (see "Dialog Box" on page 23).

To access the “Marking Grid” dialog box, proceed as follows:

- To launch correXion®5, double-click on “correXion5.exe” or an appropriately created desktop symbol (see figure 5 on page 23).
- If necessary, change the current working directory when loading the input correction file – e.g. via the {Load} button in the “Correction File” group (see page 26).
- In the “CardNo” editable field in the “Mark” group, enter the number of the RTC® board installed in the control PC that you’ll use for marking.
  Optional: confirm your entry with <Enter> or <Return>.
- Click the {Mark Grid} button.
  The “Marking Grid” dialog will now open and the RTC® board number (“CardNo #”) will be displayed in the title bar (see figure 1).
  If the board is not responsive (e.g. because it’s BUSY or servicing another application), then the dialog box will not open. Instead, a popup window will appear with a corresponding error message.



1

“Marking Grid” dialog box

Checkboxes, editable fields and buttons are provided as control elements. They have the following functions:

“Initializing” Group

> **Note**
>
> Users have the following possibilities:
>
> – Initialize the board yourself and let the galvanometers warm up
> – Or use the settings in the “Marking Grid” dialog box

You can activate or deactivate initializations and their parameters in the “Initializing” group either individually or as a complete group. A further selection possibility for some groups is to specify “–1” for individual parameters. These initializations will then not be performed. Then, the individual parameters will only be editable if you’ve activated the corresponding group.

You can use a period or comma as the decimal separator for floating point numbers (entries in [µs], [ms], [%], [Bit/ms], but not [10 µs]).

If an initialization is performed in the initialization sequence, then its corresponding checkbox will be greyed out. For subsequent starts, most of these initializations (see below) won’t be performed again – provided they weren’t expressly activated between two clicks of the {Start} button (see below).

> **Note**
>
> Detailed descriptions of the RTC®5 functions mentioned here can be found in the RTC®5 user manual.

“Program File” Group

By default, the “Path” editable field displays the most recent working directory passed on from the main dialog (correXion5 dialog box), but can be edited at any time. The path entry corresponds to the working directory even if you completely delete the editable field’s contents. Otherwise, the path entry will be treated as relative to the working directory as long as it does not itself describe a complete path.

Invalid directories are indicated via a pop-up warning window with the typical error code for `load_program_file`.

If the checkbox is enabled, then
`n_load_program_file(cardNo, <Path>)`
will be executed.

“Laser Control” Group

If the checkbox is enabled, then
`set_laser_control(<Value>)`
will be executed.

“Laser Mode” Group

If the checkbox is enabled, then
`set_laser_mode(<Mode>)`
will execute.

The commands
`set_laser_pulses(<LaserHalfPeriod>*64, <LaserLength>*64)`,
`set_standby(<StandbyHalfPeriod>*64, <StandbyLength>*64)`,
`set_qswitch_delay(<QSwitchDelay>*64)` and
`set_firstpulse_killer(<FirstPulseKiller>*64)`
will be executed if all corresponding editable fields of a command have values greater than or equal to zero (≥0).

“Analog Out [%]” Group

If the checkbox was enabled and the “On” editable field contains a value greater than or equal to zero (≥0), then
`write_da_x_list(Channel, <AnalogOn>*40.95)`
and
`long_delay(<AnalogWarmUp>*100)`
will execute before the marking and
`write_da_x_list(Channel, <AnalogOff>*40.95)`
afterward.

If the “Channel 2” checkbox is enabled, then output will proceed on channel 2 (`Channel=2`) instead of channel 1 (`Channel=1`).

The value in the “WarmUp” editable field should be entered in [ms].

“Digital Out” Group

If the checkbox was enabled and the “On” editable field contains a value greater than or equal to zero (≥0), then
`write_8bit_port_list(<DigitalOn>)`
will execute before the marking and
`write_8bit_port_list(<DigitalOff>)`
afterward.

“Laser Delays [µs]” Group

If the checkbox was enabled and the “On” and “Off” editable fields contain values greater than or equal to zero (≥0), then
`set_laser_delays(<LaserOnDelay>*2, <LaserOffDelay>*2)`
will execute. Negative LaserOn delays can’t be used here.

The LaserOn time (in [10 *µ*s]) displayed in the “Period” editable field will be read when loading command lists even if the “Laser Delays” checkbox isn’t enabled. The LaserOn time can only be altered if you at least temporarily enable the “Laser Delays” checkbox.

“Scanner Speed [Bit/ms] / Delays [10 µs]” Group

If the checkbox was enabled, then the commands
`set_jump_speed(<Speed>)`
and
`set_scanner_delays(<JumpDelay>, <MarkDelay>, <PolygonDelay>)`
will execute, provided that all editable fields related to a command have values greater than or equal to zero (≥0).

“Correction Table” Group

The “**Name**” editable field displays the name of the correction file (automatically passed on from the main dialog (“Correction File” group, “Out” editable field). The field corresponds to the most recent read or saved correction file, but can also be edited afterward.

The “Name” editable field can contain path information. If it isn’t itself absolute, then it will be interpreted as relative to the current working directory (regardless of whether a different entry was applied for “Path” (“Program File” group, see above)). Then, Name will be <Name>[.ct5] or NULL if <Name> has been completely deleted. In this case, a 1:1 correction file will be internally generated. If an error occurs, then a pop-up window will display the return value of `load_correction_file`.

If the “**Table 2**” checkbox is enabled, then Table 2 will be loaded (`Table=2`), otherwise Table 1 will be loaded (`Table=1`).

If the “**Head 2**” checkbox is enabled, then `HeadB=Table` and `HeadA=0`, otherwise `HeadA=Table` and `HeadB=0`.

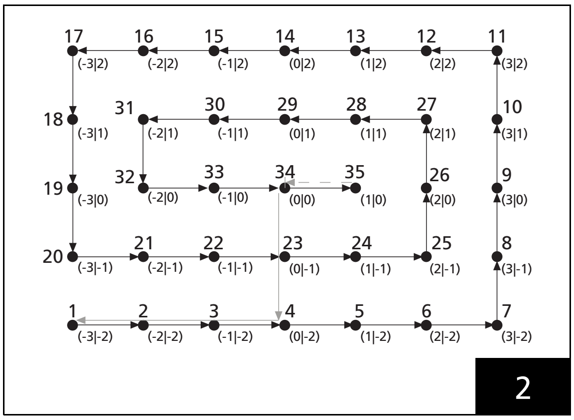
The directives
`load_correction_file(Name, Table, 3)`
and
`select_cor_table(HeadA, HeadB)`
will **always** be executed! If the 3D option hasn’t been activated, then “3” will be automatically changed to “2”. This is not treated as an error.

“WarmUp Timer/Start/Stop” Group

Enter your desired warmup time (in [min]) for the galvanometers in the “**WarmUp Time**” editable field. Upon starting, a timer will count the specified time in 3-second intervals. Time entries should be floating-point numbers:

- If the value is greater than zero (> 0.0), then warmup can be initiated via the {Start} button (see below).
- If the value is equal to or less than zero (≤ 0.0), then pressing the {Start} button will immediately initiate the actual marking (provided that the {Start} button is enabled).

If you want test-point marking to start automatically immediately after galvanometer warmup, then enable the “**Auto**” checkbox via a check mark. Marking commences with test points in the lower left corner of the longer side and proceeds spirally from the exterior to the interior (as illustrated by points 1 - 35 in figure 2). Thus, jumps will be no larger than the largest raster distance and the edges will be traversed in a “crawling” manner.



Marking sequence of the “Mark Grid” function

After marking of the final test point, the midpoint (0|0) will be navigated again. The “Marking Grid” dialog box will then automatically close as if the {Done} button has been clicked.

You can also enable the "Auto" checkbox during or after the warmup phase. As long as the WarmUp timer is still active, marking will start afterward. But if you temporarily stopped the WarmUp timer via the "Stop" checkbox (see below), then subsequent enabling of "Auto" won't have an effect. Likewise, subsequent disabling of "Auto" won't have an effect if test point marking has already begun.

To start the galvanometer warmup phase and initialization (see above), click the {**Start**} button (also see "{Start} Button" below). As soon as the button is clicked, it will be disabled (to prevent (invalid) starts as long as the warmup phase is in progress). A timer counts down the time entered in the "WarmUp Time" editable field (see above) in 3-second intervals (the remaining warmup time is displayed).

If "WarmUp Time" is less than or equal to zero (≤ 0.0), then marking of test points can be started by clicking the {Start} button again (marking sequence, see below). The timer will be stopped and "WarmUp Time" set to "0". If the "Auto" checkbox is enabled, then you don't need to click the {Start} button again – marking will start automatically.

The {Start} button will be available again

- at the end of the warmup phase – provided that the "Auto" checkbox wasn't enabled
- when you click the {STOP} button (see below)
- or via WarmUp-Time = 0 after clicking "Stop"

The {Start} button remains deactivated as long as the {Release/Acquire} button's label (see below) displays 'Acquire' (see ""Release/Acquire" Button" on page 15).

If you want to stop an already started "WarmUp Time" timer (that is currently counting down the time), then enable the "**Stop**" checkbox. The timer will be stopped, but not the galvanometers' warmup movements.

If you want the timer to resume counting, then disable the "Stop" checkbox. The time in the "WarmUp Time" editable field will resume counting down – provided that the {Start} button is deactivated (warmup phase is active) and the {STOP} button is activated (board is owned by the dialog) and "0" wasn't entered meanwhile in the "WarmUp-Time" editable field.

If you want to completely shut off the timer, then click the {**STOP**} button. The timer will be immediately stopped, the "WarmUp-Time" set to "0" and the galvanometers' movements halted. In some circumstances, the {Start} and {Done} buttons (see below) will be reactivated.

The {STOP} button remains deactivated as long as the {Release/Acquire} button's label (see below) displays 'Acquire' (no access rights).

{Start} Button

The {Start} button begins initialization, which results in the following:

Note

The "Marking Grid" dialog box shows already completed (e.g. in the warmup phase) initializations as greyed out and will not reexecute them when {Start} is reclicked (e.g. for actual marking or a second warmup phase). For further details, see ""Initializing" Group" on page 10 and the user manual for the RTC®5 board.

The following characters have the following meaning:

- (√) only when activated and not greyed out
- (O) always
- (+) only if parameter ≥ 0

(√) n_load_program_file(CardNo, <Path>)

(O) load_correction_file(Name, Table, 3)

(O) select_cor_table(HeadA, HeadB)

(O) Determining the configuration (of list memory):

get_config_list() // query the current configuration
set_start_list_pos(2, 0) // input pointer to beginning of list 2
List1Memory = get_input_pointer() // list memory 1
List2Memory = get_list_space() // list memory 2
If List1Memory = 0 // no list memory 2
    List1Memory = List2Memory; List2Memory = 0

(for {Done}: restore with set_config_list(List1Memory, List2Memory))

New list memory configuration:

List1Space = GridLengthX·GridLengthY·2+GridNumberX+GridNumberY
    +abs(GridNumberX–GridNumberY) // see Points group
List2Space = List1Memory+List2Memory–List1Space

(If List2Space < 10, then a popup window is displayed (“Memory too low”). Continue by confirming with {Yes}, terminate with {No}. You should appropriately reduce the number of points or the size of the protected list area.)

set_config_list(List1Space, List2Space) // new list memory configuration

(O) Load list 1 for marking the points:

set_start_list_pos(1, 0)

for (xi = 0, yi = 0; yi > –GridNumberY; yi--)
    jump_abs(x_{xi}, y_{yi})
for (yi = 1–GridNumberY, xi = 0; xi > –GridNumberX–1; xi--)
    jump_abs(x_{xi}, y_{yi})
for (i = 0; i< TotalNumber; i++)
    jump_abs(x_{xi}, y_{yi})
    laser_on_list(<Period>)
// ni=xi, if GridNumberX > GridNumberY, else yi

for (ni = abs(GridNumberX – GridNumberY); ni > 0; ni--)
    jump_abs(x_0, y_{ni}) or jump_abs(x_{ni}, y_0)

list_nop() // not set_end_of_list()

If “WarmUp Time”> 0 (see above), then {Start} begins the warmup phase:

(O) disable_laser() // laser permanently off
(O) set_start_list_pos(2, 0) // beginning of list 2

(√) Scanner parameters

set_jump_speed(<Speed>)
set_scanner_delays(<JumpDelay>, <MarkDelay>, <PolygonDelay>)

(O) jump_abs(0, 0) // to midpoint
(O) set_end_of_list() // end of list 2
(O) execute_list_pos(2, 0) // start list 2
(O) auto_change_pos(0) // start list 1 when list 2 is finished

(The list_nop() command is in the last memory position of list 1. Therefore even if the dialog box has released the board, the spiral sequence will run continuously (warmup phase) until a stop_execution() is explicitly called, either via {STOP}, or by subsequently activating “Auto”, or via a stop from outside the dialog.)

If “WarmUp Time” ≤ 0, then {Start} begins the marking:

(√) LaserControl

set_laser_control(<Value>)

√) Laser-Mode

(O) set_laser_mode(<Mode>)
(+) set_laser_pulses(<LaserHalfPeriod>*64, <LaserLength>*64)
(+) set_standby(<StandbyHalfPeriod>*64, <StandbyLength>*64)
(+) set_qswitch_delay(<QSwitchDelay>*64)
(+) set_firstpulse_killer(<FirstPulseKiller>*64)

(O) enable_laser() // laser active

(O) set_start_list_pos(2, 0) // beginning of list 2

(√) Scanner p parameters

set_jump_speed(<Speed>)
set_scanner_delays(<JumpDelay>, <MarkDelay>, <PolygonDelay>)

(O) jump_abs(0, 0) // to midpoint

(√) Laser-Delays

(+) set_laser_delays(<LaserOnDelay>*2, <LaserOffDelay>*2)

(√) DigitalOut (8Bit-Port) executes even if greyed out

(+) write_8bit_port_list(<DigitalOn>)

(√) AnalogOut executes even if greyed out

(+) write_da_x_list(Channel, <AnalogOn>*40.95)
(+) long_delay(<AnalogWarmUp>*100)

(O) set_end_of_list() // end list 2

(O) set_start_list_pos(1, List1Space – 1) // position of list_nop()
(O) set_end_of_list() // end list 1
(During marking, the spiral sequence will therefore execute only once.)

(O) execute_list_pos(2, 0) // start list 2
(O) auto_change_pos(0) // start list 1 when list 2 is finished

Wait until list 1 has ended, then:

(√) DigitalOut (8Bit-Port) executes even if greyed out

(+) write_8bit_port(<DigitalOff>)

(√) AnalogOut executes even if greyed out

(+) write_da_x(Channel, <AnalogOff>*40.95)

Note

SkyWriting, wobbel and fly should be deactivated, but the dialog box doesn’t explicitly provide for this.
AutoLaserControl shouldn’t be set for speed dependence, but can be set for edge-damping correction (PositionControl) (not possible in conjunction with (√) n_load_program_file).

"Release/Acquire" Button

At any time, you can use the {Release/Acquire} button to release your selected RTC board (CardNo, see above) for another application or to reacquire it. Here, the "Marking Grid" dialog box won't close and your settings therefore won't be lost. This functionality offers you the possibility to perform other actions between warmup time and the actual marking of test points.

Each time you click the button, the label alternates between "Release" and "Acquire":

- If you click the {Release} button, the RTC board will be released for other applications and the button label will change to "Acquire". The {Start} and {STOP} buttons (see ""WarmUp Timer/Start/Stop" Group" on page 11) will be deactivated and no further actions executed in the "Marking Grid" dialog box. In some circumstances, the {Done} button will also be deactivated (see below).
- If you click the {Acquire} button, the "Marking Grid" dialog box will attempt to acquire ownership of the RTC board. If successful, the button label will change to "Release". The {STOP} button will be reactivated, but the {Start} button reactivated only if the board isn't BUSY (e.g. no warmup phase or not marking). Therefore, actions can be performed again. If the {Done} button was deactivated, then it too will be reactivated.

"Done" Button

To exit the "Marking Grid" dialog box, you need to click the {Done} button. Before the dialog box closes, the previously existing list memory configuration will be restored. For this, the RTC board must still be owned by the "Marking Grid" dialog box, hence the {Release/Acquire} button (see above) displays "Release". The RTC board will then be available again for other possible applications.

As long as a list is being processed (started by clicking the {Start} button or from outside the dialog box), the {Done} button will remain deactivated. By clicking the {STOP} button, you can reactivate the {Done} button at any time.

Caution!

The {Done} button will be activated even if the RTC board was released by clicking the {Release} button.
SCANLAB recommends that you not close the "Marking Grid" dialog box if the {Release/Acquire} button displays "Acquire", because in this situation, the original configuration can't be automatically restored!

Marking the Test Points

To mark the test points, proceed as follows:

- Activate the desired control box and edit the desired editable fields. Here, you should suitably set dynamics-related parameters so that the test points' target positions can be reliably reached.
- If necessary, click the {Acquire} button.
  The button must display {Release} in order for marking to begin.
- Start the marking process (possibly including the warmup phase and initialization) by clicking the {Start} button.

In chapter 4.3 on page 16 you can find a description of how to measure the marked points.

Note

If vignetting or reaching the galvanometers' excursion limits makes complete marking of all edge points impossible, then the "Marking-Grid" dialog box can't be used for this purpose. Then you must execute the warmup phase and marking on your own without the "Marking-Grid" dialog box (see figure 1 on page 9). Here, you could simply omit the non-markable points. In the input data file, you should then enter these points by extrapolating from measured values.

4.3 Measuring Test Points

Note

- For the RTC®5 board, the following convention has been chosen as the standard for describing the coordinate axes of the real image field:
  - The Y axis points in the opposite direction of the entering laser beam.
  - The Z axis points in the opposite direction of the exiting laser beam.
  - The direction of the X axis is determined by the coordinate system's right-handedness (galvanometer scanner 1 deflects the beam in the Y direction, galvanometer scanner 2 in the X direction).
- If you chose a non-standard convention (see above) for measuring the test points, then the (x|y) coordinates will be with respect to your chosen coordinate system when the correction file is used.
- If you require very high precision, then SCANLAB recommends using a measuring microscope.

Caution!

You should assign the value 0.0 0.0 to the midpoint.
Anyway, deviations from this value will be subtracted (after the fit result) from all data points as an offset.

To measure the test points, proceed as follows:

- Decide which coordinate system you wish to use (standard or your own).
- Select your desired image-field midpoint as the zero point (0|0) of the measurement coordinate system (see figure 2 on page 11).
- Assign to the midpoint the measurement value 0.0 0.0.
- Measure the (x|y) coordinates (in [mm]) of the marked test points.
  If necessary, use a measurement microscope for this purpose.
- Note down the measured coordinates/data.

Note

If you want to maintain the "Caption" data file (with the calculation parameters) separately from the pure data-point section, then SCANLAB recommends entering the data directly in a separate file (e.g. via a spreadsheet program). (For related information, see "Notes" on page 19.)

5 Data Files

You can create data files either with a normal text editor or via the dialog-mode box's {Create} button (see ""Data File" Group" on page 25). With the {Save} button the data file can be saved. Data files must be ASCII-readable and contain the following entries:

- The identifiers and values for the calculation parameters (e.g. calibration factor, fit order and the names of the input and output correction files).
- The data points (measured coordinates of the marked test points), along with the positions of the grid lines.

If the new correction file is to be calculated in dialog mode, then all calculation parameters can also be subsequently supplied or modified there and hence don't need to be specified in the data file. Calculation parameters and data point information can thus be maintained in separate files and will be incorporated together at a later time (see "Notes" on page 19).

In contrast, if the correction file is to be calculated in silent mode, then some of the parameters must be specified in the data file or else the correction file can't be calculated (see below). Here, the calculation parameters and data point information must be listed together in a data file prior to calculation of the correction file.

Note

When creating the data file, you can save much effort by letting dialog mode generate a default file with the desired number of data points and initialization values (see ""Data File" Group" on page 25). Then you only need to enter the desired parameter values and measurement data.

An example data file created in dialog mode is shown on page 22.

Caution!

Old correction software data files for customizing RTC®4 ctb files can't be used by correXion®5.

5.1 File Format and Structure

The data file can be saved under any name and extension (<Name>[.<Ext>]) compatible with normal Windows filenaming conventions. The data file can be opened for reading and writing from any directory.

Each individual parameter requires its own line. The data file uses parameter identifiers as keywords to identify the corresponding entries. These "captions" must reside at the start of each corresponding line (maximum length up to the start of a comment (see below): 80 characters).

Captions are enclosed by square brackets ([ ]), followed by an equal sign (=). Whitespaces(2) are not allowed before or within the brackets, but are allowed before or after the equal sign. Any unrequired captions will be ignored and therefore can be omitted.

In calculating the new correction file, correXion®5 uses parameter values to the right of each equal sign. For character strings, everything beginning with the first non-whitespace character following the equal sign and ending with the last non-whitespace character (or the first semicolon in the same line) is regarded as belonging together. This allows a file name to contain spaces.

All characters after the optional semicolon are interpreted as comments.

The data points are likewise listed in their own lines, but without captions. They are the only individual entries without captions. The reading of data points or numbers within a line terminates upon the first encountered non-numerical character. Thus, captions after or between data points are ignored during reading.

Captions and data points within a data file can be arbitrarily ordered. Thus, both can be interspersed.

(2) Whitespace characters: space <SPACE>, tab <TAB>, carriage return<CR> and line feed<LF>.

5.2 Parameters/Captions

Regarding the descriptions of individual parameters below, please note the following:

- Do not enter the angle brackets (< >) into the data file.
- Either a period or a comma can be used as the decimal separator.
- Default values are displayed when the dialog box opens. In silent mode, if no valid entry is found for a particular caption, then its default value will be used.

[INPUT] = <character string>

For [INPUT], the name of the input correction file must be supplied. The extension ".ct5" will be automatically appended, but path information will be ignored.

The [INPUT] parameter is required so that the original correction file's header information, and possibly 3D section, can be passed on. Otherwise, a 1-to-1 correction file without this information will be started.

In silent mode, this entry is absolutely required. In dialog mode, the input correction file can be specified later.

Default: ; empty character string or only whitespaces.

[OUTPUT] = <character string>

For [OUTPUT], the name of the output correction file must be supplied. The extension ".ct5" will be automatically appended, but path information will be ignored.

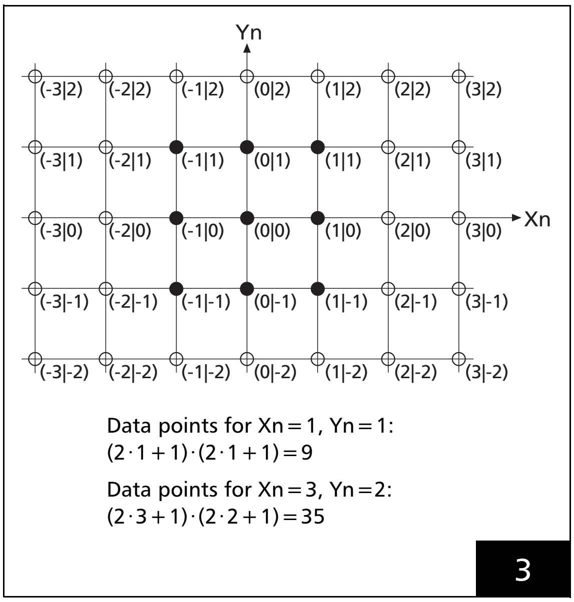
The name of the output correction file shouldn't be identical with the name of the input correction file. Otherwise, loss of data will occur (the 2D correction would be overwritten). This entry will, however, not be checked.

In silent mode, this entry is absolutely required. In dialog mode, the output correction file can be specified later.

Default: ; empty character string or only whitespaces.

[GRIDNUMBERS] = <integerX> <integerY>

The [GRIDNUMBERS] parameter determines the number of data points (to be entered in the data file). For the X and Y directions, positive integers (n) ranging from 1 to 255 can be specified. <IntegerX> determines the number Xn points per line, and <IntegerY> the number Yn points per column. The values Xn and Yn correspond to a rectangular (possibly square) raster with side lengths of (2·Xn+1) and (2·Yn+1) data points and a total of (2·Xn+1)·(2·Yn+1) data points (see the example in figure 3). The data point (0|0) is always at the center of the XY raster.



Number of data points – example

In addition to the number of data points, you also need to provide the same data file with the actual sampling point values for both directions (see [GRIDVALUES_X and Y]). If they are missing, then [GRIDNUMBERS] will be ignored.

For RTC®5 correction files the maximum resolution will be attained with [GRIDNUMBERS] = 128 128 (66,049 data points), for RTC®4 correction files with [GRIDNUMBERS] = 32 32 (4,225 data points).

In silent mode, grid numbers greater than zero (> 0) must be supplied, or else the correction file can't be created. In dialog mode, this value can be specified later.

Default: 1 1; number of data points: 9.

Notes

- [GRIDNUMBER] = 0 n or n 0 (i.e. at least one of the two values is zero) is invalid in silent mode. Such a case would result in termination.
- When dialog mode reads data files containing the entry [GRIDNUMBERS] = 0 n, n 0 or 0 0, then all parameter entries (except the [GRIDNUMBER] entry) will be taken on, but not the data file's data point information. This allows parameter information to be maintained in a file (or multiple files) separately from the data point information. The data point information can be specified in its own file, easily editable via a spreadsheet program etc. When you subsequently use dialog mode for calculating the correction file or for creating a complete data file (for silent mode), then this information will be incorporated with the parameter information (also see ""Data File" Group" on page 25).
  However, the data will only be read if reading of the associated [GRIDVALUES_X and Y] from the same file was successful.
- When you place data point information in a separate file, it should always correspond to the [GRIDNUMBERS] values (> 0) in terms of the number of entered data points (incl. caption). This helps prevent subsequent usage errors. The values will then be taken on during loading of the file in dialog mode (see ""Data File" Group" on page 25).

[GRIDVALUES_X] = <floating-point> ... <floating-point>

The parameter [GRIDVALUES_X] determines the sampling points on a line (positions of the vertical grid lines) in [mm]. The caption [GRIDVALUES_X] can be followed by one or more floating point values separated from another only by whitespaces.

Xn <floating-point> values must be less than 0.0 and Xn greater than 0.0. By necessity, a line's sampling midpoint has the floating-point value 0.0 [mm], which is automatically assigned to it. Entering of the value 0.0 isn't necessary; if entered, it will be ignored.

If you have more values (2·Xn, see [GRIDNUMBERS]) than will fit on a maximum-80-character text line, then you can distribute them across multiple text lines that must all contain the caption [GRIDVALUES_X]. Reading will terminate after (2·Xn) values if the end of file wasn't already encountered.

If (2·Xn) values cannot be successfully read, then the entries will be ignored; likewise for duplicate values. Values are 'duplicates' if they are nearer to each other than a thousandth (1/1,000) of the total image field width (and aren't precisely 0.0).

[GRIDVALUES_Y] = <floating-point> ... <floating-point>

The parameter [GRIDVALUES_Y] is similar to the parameter [GRIDVALUES_X] (see above), but specifies the number of sampling points of a column (positions of the horizontal grid lines) in [mm].

[CALIBRATION] = <integer>

The optional parameter [CALIBRATION] (in [bit/mm]) only needs to be supplied if a calibration factor is desired that differs from that of the input correction file ([Field 1] in the header) or if the input correction file specifies zero for it.

Note

If compatibility with the RTC®4 board is needed, then an <integer> that is a multiple of 16 is required. The parameter [RTC4] can be used to force this compatibility (see below).

Default: 1 or "calibration factor from the input correction file" (see figure 4 on page 22).

[RTC4] = <integer>

In order to automatically calculate a correction file with an RTC®4-compatible calibration factor, a special compatibility mode needs to be activated. The optional parameter [RTC4] serves this purpose:

- [RTC4] = 0:
  Compatibility mode is deactivated
- [RTC4] = n; where n > 0):
  RTC®4 compatibility mode is activated. The calibration factor will be rounded up to a multiple of 16.

Default: 0; compatibility mode deactivated.

[FITORDER] = <integer>

The optional parameter [FITORDER] determines the degree of the two-dimensional interpolation polynomial. Numbers from 1 to 10 switch on the polynomial fit and specify the degree. Numbers greater than 10 will be clipped to 10. If [FITORDER] = 0, then the polynomial fit will be switched off.

Default: 0; polynomial fit switched off.

Also see below note on [SMOOTHING].

[SMOOTHING] = <floating-point>

The optional parameter [SMOOTHING] determines the strength of smoothing by the spline interpolation. For numbers s (where s ≥ 0), the spline fit will be switched on. The larger the number, the stronger the smoothing by the spline fit, up to essentially full straightening (for the points of a line).

- [SMOOTHING] = 0.0 corresponds to an ordinary spline.
- [SMOOTHING] = s (where s < 0) switches off the spline fit.

Because an appropriate value for s depends on the number of data points and variance of the measurement points, it cannot be estimated in advance. It is especially recommended in connection with [AUTO_FIT] (see below).

Default: –1.0; spline fit switched off.

Note

- If the polynomial fit is switched on ([FITORDER] = n; where n > 0), then the spline fit (see below) will be switched off ([SMOOTHING] = –1.0).
- If both the polynomial fit and the spline fit are switched off ([FITORDER] = 0 and [SMOOTHING] = s; where s < 0), then a piecewise (bi)linear correction will be performed.

[AUTO_FIT] = <integer>

If a polynomial fit (with [FITORDER]) or a spline fit (with [SMOOTHING]) is activated, then the optional parameter [AUTO_FIT] causes their parameters to be automatically adjusted ([FITORDER] minimal, [SMOOTHING] maximal) so that the maximum deviation between the measured and calculated test points won't exceed a fixed tolerance ([TOLERANCE], see below). If [TOLERANCE] = 0.0, then [FITORDER] will be set to 10 and [SMOOTHING] to 0.0.

- [AUTO_FIT] = 0:
  Effect is deactivated.
- [AUTO_FIT] = n; with n > 0:
  Effect is activated – thus the parameters will be automatically adjusted.

Default: 0; the parameters will not be automatically adjusted.

[TOLERANCE] = <floating-point>

If [AUTO_FIT] (see above) = n (where n > 0), then the optional parameter [TOLERANCE] determines how large the maximal allowed deviation (in [mm]) of the calculated interpolation values from the measured test points may be.

Default: 0.1; size of the maximal deviation = 0.1 mm.

5.3 Data Points

The data point information also needs to be entered into the data file (for [GRIDNUMBERS] = Xn Yn, these data values will then be for $(2\cdot Xn+1)\cdot(2\cdot Yn+1)$ data points in rectangle grid.

As with the parameters, the data points each occupy a line, but without captions. The data points can be listed in any order.

Data points are entered using the following format (but don't place the angle brackets (< >) into the data files): <integer> <integer> <floating-point> <floating-point>

For clarity, **<integer> <integer>** indicates position-number pairs (Xi|Yi) in the coordinate system of the regular quadratic raster in which the test points are situated (see figure 3 on page 18 and "Example Data File" on page 22) instead of the actual coordinates (which, importantly, are calibration-dependent).

At least the following position-number pairs must be found in each data file
(even if [GRIDNUMBERS] = 1 1):

–Xn	–Yn	bottom left corner,
0	–Yn	midpoint of the bottom side,
Xn	–Yn	bottom right corner,
–Xn	0	midpoint of the left side,
0	0	midpoint,
Xn	0	midpoint of the right side,
–Xn	Yn	top left corner,
0	Yn	midpoint of the top side,
Xn	Yn	top right corner.

If $n > 1$, then position-number pairs are also required for corresponding intermediate points.

<floating-point> <floating-point> indicates the actually measured (in mm) point positions/coordinates (X mm and Y mm as floating-point numbers, see figure 4 on page 22) corresponding to a position-number pair. Either a period or a comma can be used as the decimal separator.

Notes

- The midpoint should be assigned a measured value of 0.0 0.0. Otherwise, any deviation will be subtracted as an offset from all data points (after interpolation).
- The number of entered data points $(2\cdot Xn+1)\cdot(2\cdot Yn+1)$ must correspond to the entry [GRIDNUMBERS] = Xn Yn. Otherwise, the correction file might be incorrect or not generated at all.

Order

Every four consecutive numbers are regarded as a point-measurement pair and must reside on a line (each line can contain a maximum of one data point, i.e. a point measurement pair). At least one whitespace is required before, between and after each number.

For tidier formatting, multiple whitespaces can also be used as separators, but not commas, semicolons or other characters.

All characters starting with the first non-numerical character, or after two proper whole or floating-point numbers, are regarded as comments.

If two whole or floating-point numbers can't be identified in the line, then the line will be ignored. This can lead to an error (for a too small amount of data) unless it was intended as a to-be-ignored caption line.

Tables generated via the {Create} button (see "“Data File” Group" on page 25) list the data points line-wise from bottom left to top right (see figure 4 on page 22).

Example Data File

The following is a data file created via the {Save} button directly after starting in dialog mode (see "“Data File” Group" on page 25). It therefore contains initialized values.

```
[INPUT]        = ; input table file name
[OUTPUT]       = ; output table file name
[CALIBRATION] = 1; calibration in bits/mm
[RTC4]         = 0; RTC4-compatibility mode
[FITORDER]     = 0; degree of overall polynomial fit
[SMOOTHING]    = -1; smoothing parameter for overall spline fit
[AUTO_FIT]     = 0; adjust parameters for fitting
[TOLERANCE]    = 0.1; tolerance value

[Limit(Bits)] = 524288; control value limits
[Limit(mm)]    = 524288; field size limits
[OffsetX]      = 0; offset X
[OffsetY]      = 0; offset Y
[Deviation]    = 0; max. deviation

[GRIDNUMBERS]  = 1  1; grid X, grid Y; points: 3 per line, 3 per column, total 9

[GRIDVALUES_X] = -524288.000000  0.000000  524288.000000  0.000000

[GRIDVALUES_Y] = -524288.000000  0.000000  524288.000000  0.000000

    Xn     Yn         X mm           Y mm

    -1     -1    -524288.000000 -524288.000000
     0     -1          0.000000 -524288.000000
     1     -1     524288.000000 -524288.000000
    -1      0    -524288.000000       0.000000
     0      0          0.000000       0.000000
     1      0     524288.000000       0.000000
    -1      1    -524288.000000  524288.000000
     0      1          0.000000  524288.000000
     1      1     524288.000000  524288.000000
```

4

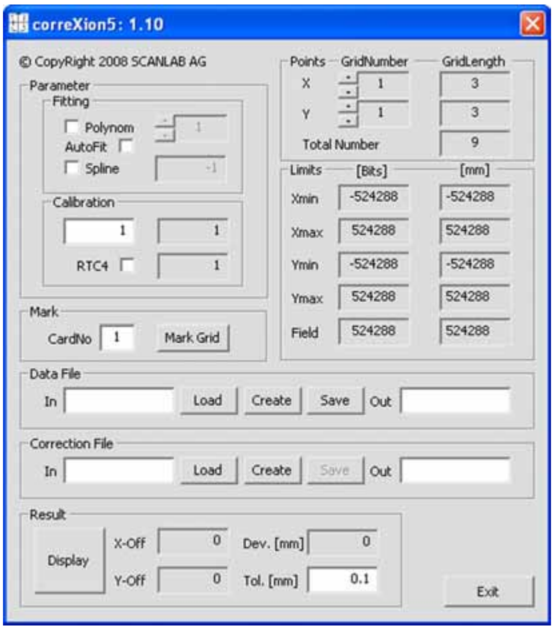
Data file with initialized values – example

6 Create New Correction File in Dialog Mode

6.1 Dialog Box

Launch the correXion®5 program in typical Windows manner for dialog mode:

- Double-click "correXion5.exe" or an appropriately created desktop symbol.
  The dialog box (see figure 5) appears. The box's title bar displays the program's current version.



5

GUI mode – "correXion5" dialog box

Checkboxes, editable fields and buttons are available as control elements. Synchronized to an extent with the data file's corresponding parameters, these control elements have the following functions:

> **Note**
>
> You can confirm direct entries with <Enter> or <Return>.
> This won't cause the dialog box or the program to terminate.

"Parameter" Group

"Fitting" Group

The "**Polynom**" and "**Spline**" checkboxes activate/deactivate the polynomial and spline fits respectively. These fit functions are synchronized with [FITORDER] and [SMOOTHING] in the data file (see page 20). The functions are activated if their corresponding checkboxes are enabled. You can only activate one of the two functions, but both functions can be simultaneously deactivated.

When one of the functions is activated, you can edit its editable field:

- The "Polynom" editable field is only indirectly editable – via the two {▲} and {▼} buttons. Values range between 1 and 10 (integer numbers).
- The "Spline" editable field lets you directly enter a floating-point number greater than or equal to zero (≥0). Negative numbers will be replaced by –1.0 and cause the spline fit to be deactivated.

> **Note**
>
> If neither the "Polynom" nor the "Spline" checkboxes are enabled, then a piecewise linear interpolation will be automatically selected (similarly to CFMP for the RTC®4).

The "**AutoFit**" checkbox enables automatic adjustment of either the polynomial or spline fit parameters. For this, one of the two functions needs to be active (i.e. the corresponding checkbox enabled). The "AutoFit" function is synchronized with [AUTO_FIT] in the data file (see page 20). The tolerance value for AutoFit (the calculated interpolation values' maximum deviation from the measured values) can be specified in the "Tol. [mm]" editable field within the "Result" group (see page 26 and the parameter [TOLERANCE] in the data file on page 20).

"Calibration" Group

If necessary, directly enter the calibration factor (as an integer number) into the left-side editable field. This function is synchronized with [CALIBRATION] in the data file (see page 19).

The "**RTC4**" checkbox lets you specify that "Calibration" (see above) is a multiple of 16. The function is synchronized with [RTC4] in the data file (see page 20). The editable field 'Bits' (see "Limits" Group) will likewise show the Bit value as an RTC®4 value.

If you've activated the function (i.e. enabled the checkbox), then the calibration factor will be rounded up to a multiple of 16.

The upper right-side non-editable field displays the calibration factor actually used.

The lower right-side non-editable field always shows the RTC®4 calibration factor (this is 16 times smaller than the RTC®5 calibration factor).

"Points" Group

The {▲} and {▼} buttons let you adjust the number of data points. This function is synchronized with [GRIDNUMBER] in the data file (see page 18). Each click of {▲} or {▼} changes the editable field's displayed contents:

- The editable fields in the column "**GridNumber**" show the n value of the line (Xn, editable field "X") and the n value of the column (Yn, editable field "Y") for [GRIDNUMBERS]. The range of allowable values n is from 1 to 255.
- The editable fields in the column "**GridLength**" show the number of data points per line (editable field "X") and per column (editable field "Y") of the grid mesh ((2·Xn + 1) or (2·Yn + 1)): "3, 5, 7, ... , 511".
- The editable field "**Total Number**" shows the total number of data points in the grid ((2·Xn+1)·(2·Yn+1)): "9, 15, 25, 35, 49, ... , 261,121".

The {Create} ("Correction File" group, see page 26), {Display} ("Result" group, see below) and {Mark Grid} ("Mark" group, see below) buttons will be deactivated if the displayed number of data points (number of lines, number of columns or total number) doesn't correspond with the current internally-stored number. To reactivate the buttons, input the correct number of data points from a data file via the {Load} ("Data File" group, see page 25) button (in this case, an entry for [GRIDNUMBERS] in the data file is absolutely required) or generate a default data set (measured points = target values) via {Create} ("Data File" group, see below).

"Limits" Group

The 5 non-editable fields in the column "**Bits**" ("Xmin, Xmax, Ymin, Ymax and Field") show the control values that reach the boundaries in [mm] (see below) – with RTC®4 compatibility if you activated the "RTC4" function (see below). Larger values won't get clipped, but aren't actually reachable.

The 5 non-editable fields in the column "**mm**" show the boundaries in [mm].
Here, the fields "Xmin, Xmax, Ymin and Ymax" show the largest sampling-point values entered in the data file (see page 19, [GRID_VALUES_X and Y]).
The field "Field" shows the maximum achievable image field size in [±mm] for the current calibration factor.

"Mark" Group

The "**CardNo**" editable field lets you specify the number of the RTC®5 boards in your PC that should be controlled for marking. The range of values depends on the number of available RTC®5 boards (1 ... CardsFound).

If required, you can make the "**Mark Grid**" button available via use of the {Load} or {Create} buttons ("Data File" group, see below). The button will be deactivated if you subsequently set "GridNumber X" and/or "GridNumber Y" (see "Points" group) to a different value.

You can open the "Marking Grid" dialog box (see figure 1 on page 9) via the "Mark Grid" button – provided that the board specified via "CardNo" is accessible and not "BUSY". Otherwise, a pop-up window will appear with an error message.

“Data File” Group

The “**In**” editable field (synchronized with the {Load} button, see below) shows the name of the input data file – with a freely-selectable filename extension, but without path information. Either you can enter the name directly or else the name of the data file loaded via {Load} will be shown.

The {**Load**} button is synchronized with the “In” editable field. When the button is clicked, a Windows-typical Explorer window will open for loading an input data file from a freely-selectable directory:

- the data file specified in the “In” editable field
- or a different freely-selectable data file – the “In” editable field will then be appropriately updated.

If the data file specifies a valid correction file, then it will automatically load if the user clicks the {Load} button.

When required, you can use the {Load} button to reactivate the {Create} (“Correction File” group, see page 26), {Display} (“Result” group, see page 26) and {Mark Grid} (“Mark” group, see page 24) buttons.

Note

During loading of a data file, its specified calculation parameters and data point information are taken on. The acquired calculation parameters are displayed in corresponding editable fields and checkboxes (previously made entries/settings will be overwritten).

Special case:
If dialog mode reads a data file with the entry [GRIDNUMBERS] = 0 n, n 0 or 0 0, then only its parameter entries (except the [GRIDNUMBERS] entry), will be taken on. None of the data file’s data point information will be taken on. This allows calculation parameters and data point information to be read in from multiple data files and subsequently, if necessary, written to a new (e.g. log) file (via {Save}, see below).

Via the {**Create**} button, you can generate a default data set (standard data points) in accordance with the settings in “Points” and “Calibration” (“Parameter” group, see page 23). **In the process, previously loaded or generated data point information will be lost**. The button reactivates {Mark Grid}, {Create} (“Correction File” group) and {Display}.

The {**Save**} button is synchronized with the “Out” editable field (see below). When the button is clicked, a Windows-typical Explorer window will open for saving (as a log file in any directory) the current parameter settings and most recently loaded data point information, as well as the most recently generated default data set:

- using the name specified in the “Out” editable field
- or using a new name – the “Out” editable field will then be appropriately updated

You can use the “**Out**” editable field (synchronized with the {Save} button) to enter the name of the current data file (with extension, but without path information).

Note

Directly after the correction file is calculated (via {Create} in the “Correction File” group, see below), you can use the {Save} button to store the data file as a log file that also contains all calculation results (see page 34).

“Correction File” Group

The “**In**” editable field – synchronized with the {Load} button (see below) and with [INPUT] in the data file (see page 18) – shows the name of the (to-be-manipulated) input correction file. Either you can enter the name without path or extension (“.ct5” will be automatically appended as the extension) or the name of the input correction file loaded with {Load} will be displayed.

The {**Load**} button is synchronized with the “In” editable field. By clicking the button, you can open a Windows-typical Explorer window for loading an input correction file:

- the correction file specified in the “In” editable field
- or a new freely-selectable correction file

After the file is loaded, the “In” and “Out’” editable fields will be updated (whereby the output correction file becomes a duplicate of the input correction file). The corresponding values in the editable fields of the “Calibration” field (see page 24) will also be updated. Loading a new input correction file causes the {Save} button (see below) to be deactivated.

The {**Create**} button (synchronized with the “Calibration” and “Limits” groups, see page 24) lets you start the calculation of a new output correction file. The calculation is based on the tables of the current input correction file and the settings in the dialog box. Where applicable, the {Save} button will be reactivated.

If you enabled the “Polynom” checkbox (“Fitting” group, see page 23), then [FITORDER] will automatically be sufficiently reduced in accordance with “Total Number” (“Points”, see page 24) so that [FITORDER+1] · [FITORDER+2] / 2 < “Total Number” (otherwise there would be too few data points or too many parameters).

If non-recoverable errors occur during the calculation, then an appropriate pop-up window will appear. No output correction file will be generated, but the fit results will be displayed in the dialog box (“Default” or “Curve”, see page 27). If a polynomial fit is unobtainable due to numerical deficiencies (rounding error), then [FITORDER] will be considered to be zero.

The adjusted (via “Spline” or “Polynom”) correction must be numerically inverted before it can be combined with the input correction file. This requires fulfillment of certain monotonicity conditions to prevent the occurrence of inversion errors. ([SMOOTHING] = 0.0 always leads to [Deviation] = 0.0, but might have an (objectionably) wave-like progression). If necessary, check the result in the display dialog (see page 27).

The {**Save**} button is synchronized with the “Out” (see below) editable field. Click the button to open a Windows-typical Explorer window for saving the new output correction file:

- using the name that was updated via {Load}
- or using a new name – the “Out” editable field will then be appropriately updated

During saving, items such as the header information will be adjusted with respect to the input correction file and the calibration. With each saved alteration, the version number (field 10 of the header) will be incremented.

The “**Out**” editable field (synchronized with the {Save} button and with [OUTPUT] in the data file, see page 18) lets you enter a name for the new (altered) output correction file. Provide a name without an extension or path – the extension “.ct5” will be automatically appended.

Caution!

Actions performed via the {Save} and {Load} buttons in the “Data File” and “Correction File’” groups might change the current working directory.

“Result” Group

The {**Display**} button opens a display dialog that presents the calculated results (for a detailed description, see "Display Dialog Box" below).

Note

The display dialog box can also be opened prior to calculating the correction file (via {Create} in the “Correction File” group, see page 26) and the calculation started subsequently. But then, not all parameters will remain available for changing.

The "**Offset X**" and "**Offset Y**" fields show the calculation-resultant zero point offsets in the X and Y directions in [Bits]. Both fields are non-editable.

> **Note**
>
> You can use the command `set_offset(OffsetX, OffsetY)` to compensate the RTC®5 board's zero point offset.

After calculations, the "**Dev. [mm]**" field shows the adjusted interpolation values' maximum deviation to the measured points in [mm]. The field is non-editable.

The "**Tol. [mm]**" editable field shows the tolerance value for automatic adjustment ("AutoFit" checkbox in the "Fitting" group, see page 23) in [mm]. This editable field is synchronized with the display dialog's "Tol" editable field (see ""Create" Group" on page 28). Either a period or a comma can be used as the decimal separator when entering the floating-point tolerance value.

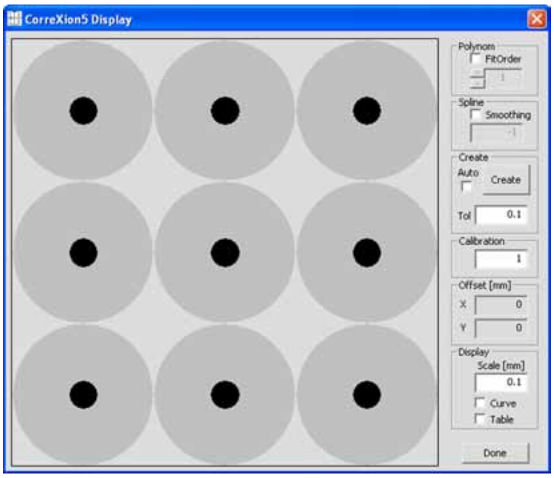
{Exit} Button

Use the {Exit} button to end the correXion®5 program.

Alternatively, you can use the close symbol {×} in the title bar or the keyboard's <Esc> key.

6.2 Display Dialog Box

Before or after calculating the new correction file, you can click the {**Display**} button (see figure 5 on page 23) to open a "Display" dialog box that presents the results (see figure 6). Moreover, this box's control elements for new calculations often eliminate the need to jump back to the "correction5" main dialog box.



6

GUI mode – "Display" default dialog box

The "Display" dialog box and its control elements (some of which are synchronized with the "correction5" dialog box, see figure 5 on page 23) offer the following functions:

> **Note**
>
> You can confirm direct entries with <Enter> or <Return>.
> This won't cause the dialog box to terminate.

"Polynom" Group

The "**FitOrder**" checkbox and editable field are synchronized with the "Fitting" group within the "Parameter" group (described on page 23).

"Spline" Group

The "**Smoothing**" checkbox and editable field are synchronized with the "Fitting" group within the "Parameter" group (described on page 23).

Either a period or a comma can be used as the decimal separator when entering the floating-point smoothing value.

"Create" Group

The checkbox "**Auto**" is synchronized with the "AutoFit" checkbox in the "Fitting" group (described on page 23).

The {**Create**} button is synchronized with the similarly-named button in the "Correction File" group (described on page 26).

When you start a new calculation via {Create}, the new results will be immediately presented in the "Display" dialog box.

The "**Tol**" editable field is synchronized with the "Tol. [mm]" editable field in the "Result" group (see page 26).

"Calibration" Group

The editable field is synchronized with the "Calibration" group in the Display Dialog Box (see page 24). The RTC4 settings there will be automatically taken into account.

"Offset" Group

The non-editable "**X**" and "**Y**' fields show the zero point offset in the X and Y direction in [mm] (in contrast, the "correXion5" dialog box shows it in [Bits], see figure 5 on page 23).

"Display" Group

The meanings and labeling of this editable field are display-mode dependent. The value ranges can never be negative!

For convenient analysis of the results, please change editable-field contents as follows:

- Enter a floating-point value in the editable field. You can use either a period or a comma as the decimal separator.
- Confirm your entry via the keyboard's <Enter> or <Return> key.
  The presentation of results (see below) will be automatically updated.
- If you wish to alter the value again – and haven't clicked another of the dialog box's control elements in the meantime – then simply press your keyboard's <Tab> key.
  The text in the editable field will be automatically selected so that you can directly overwrite it.
- If you subsequently wish to close the dialog box – and the cursor is still in the editable field – then press your keyboard's <Tab> key.
  The {Done} button (see page 15) then automatically receives the focus and you can press your keyboard's <Enter> or <Return> key to close the "Display" dialog box.

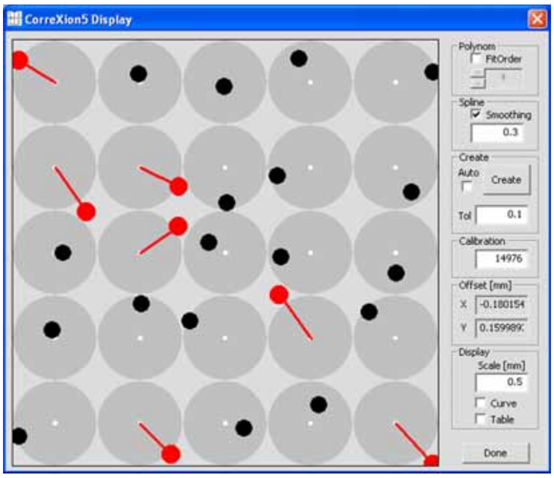
The calculated results can be presented in three different ways:

- Targets Dialog Box (see below)
- Curve Dialog Box (see page 29)
- Table Dialog Box (see page 30)

You can select these via the "Curve" and "Table" checkboxes.

Targets Dialog Box

If you've enabled neither the "Curve" nor the "Table" checkbox– this is the **default** – then all data points will be displayed as targets in the results presentation (see Figure 7 on page 29).



7

GUI mode– “Display” targets dialog box

- The **grey disks** depict the measured data points’ “targets”: the centers (white dots) depict the measured data points (on a regular grid) and the grey disks indicate the scale range (for the respective data point) determined in the “Scale [mm]” editable field in [mm].
- The **black circles** with one-fifth the radius of the grey disks indicate the calculation’s deviation from the measured data points, provided that the **deviation lies within the scale range** (smaller than the value entered in “Scale [mm]”). In an ideal case, they will cover the white points.
- The **red circles** with one-fifth the radius of the grey disks and a red line connecting to the corresponding midpoint depict the calculation’s deviation from the measured data points, provided that the **deviation lies outside the scale range** (equal or greater than the value entered in “Scale [mm]”).

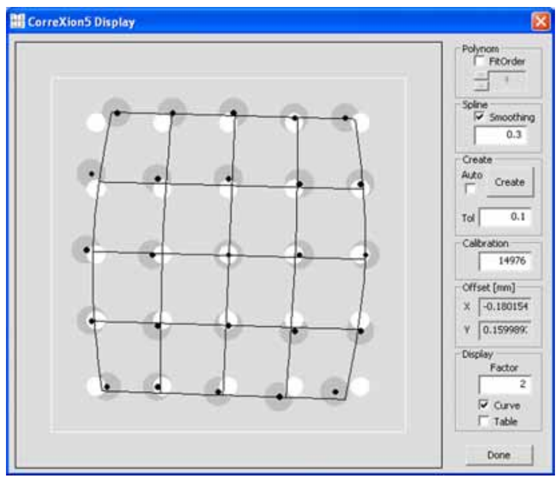
Note

The dimensions of the grey disks and the black and red circles depend on their number only and will not change if the scale value is altered in the “Scale [mm]” editable field.

Even for many data points and with the resolution limitations of a monitor, this presentation method lets you clearly see whether calculated data points lie outside the set scale range. Moreover, you can virtually “measure” the deviation of a data point and the maximum deviation of all data points (see the above guidance on changing the scaling).

Curve Dialog Box

If the “**Curve**” checkbox is enabled, then the interpolated path between the measured points will be shown to scale in [mm] (see figure 8). Deviations from set values (sampling points, white points) will be depicted via a spread of “Factor” (labeling of the editable field within the “Display” group changes to “Factor”). Additionally, a white square shows the resulting (maximum) field size.



8

GUI mode – “Display” curve dialog box

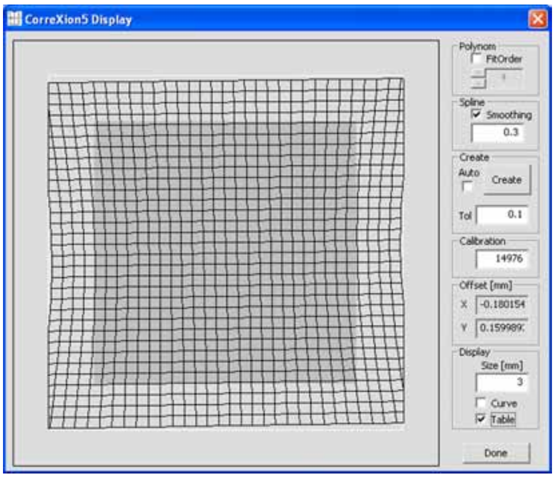
The measured points are signified via small target disks with black centerpoints. The size for target disks can be specified in [mm]: First enable the “Table” checkbox - the display then changes to “Size [mm]”. Now re-enable the ‘Curve’ checkbox.

Please Note: The curves show the interpolated measurement values, but not their correction that is the inverse of this depiction. Likewise not shown is the influence of the input correction table.

Table Dialog Box

If the “**Table**” checkbox is enabled, then the resulting table – as linked to the input correction table – will be shown (see figure 9). Additionally, a white square will indicate the maximum control values, provided it is not obscured by other image elements. The grey shading depicts the area encompassed by the sampling points.

Labeling of the editable field within the “Display” group automatically changes to “Size [mm]”, but it has no meaning in the context of this depiction.



9

GUI mode– “Display” table dialog box

{Done} Button

The {Done} button closes the “Display” dialog box and returns you to the main dialog box.

Settings for the polynomial fit, spline fit and most recently performed calculation are passed on to the main dialog box. The value entered in the “Display” group will be ignored and the value in the “Tol” editable field is transferred to the “Tol. [mm]” editable field (“Result” group, see page 26). Eventual calibration changes will likewise be taken over.

Alternatively, you can exit the dialog box via the title bar’s close symbol **{×}** or your keyboard’s <Esc> key.

6.3 Create New Correction File

Before a new correction file can be created, you need to have performed the following steps:

- Install the correXion®5 software (see chapter 3 on page 7).
- Mark and measure the test points (see chapter 4 on page 8).
- Create a data file
  - via the correXion®5 dialog box (see "“Data File” Group" on page 25)
  - or manually in a freely selectable file of your own (conventions, see "Data Files" on page 17).

To create a new correction file, proceed as follows:

Note

Higher-order polynomials are generally not well-conditioned. Rounding errors from a limited number of digits can result in macroscopic errors leading to completely false interpolations. Polynomial degrees also have wave-like tendencies and can't reliably correct small residual errors even after multiple repetitions. In such cases, a spline interpolation or piecewise linear interpolation is preferable.

Note

You can confirm direct entries with <Enter> or <Return>.
This won't cause the dialog box or the program to terminate.

- Double-click “correXion5.exe” or an appropriately created desktop symbol.
  The “correXion®5” dialog box appears (see figure 5 on page 23).
- Load the created data file by clicking the “Data File” group's {Load} button (see page 25).
  After the input data file loads correctly, its name will be displayed in the “In” editable field and the appropriate parameter settings will be passed on to the corresponding editable fields.
- If the data file doesn't specify an input correction file, then load the correction file you used for the test measurements by clicking the “Correction File” group's {Load} button (see page 26).
  After the to-be-manipulated correction file has loaded, its name will be displayed in the “In” editable field.
- Set any parameters that weren't contained in the data file (described in chapter 6.1 on page 23).
- Start the calculation of a new correction file by clicking the {Create} button.
  During calculation, the mouse cursor will have an hour-glass shape.
- To view and possibly modify the calculated results, click the “Result” group's {Display} button.
  The “Display” dialog box appears (see figure 6 on page 27).
- View the results and – if desired – perform a new calculation (described in "Display Dialog Box" on page 27).
- When you are satisfied with the calculated results, then click the {Done} button.
  The “Display” dialog box will close and you'll be returned to the “correXion®5” dialog box.
- Save the (most recent) newly calculated correction file by clicking the “Correction File” group's {Save} button.
  During saving, some header information (related to the input correction file and calibration factor) will be adjusted.
- Save the output data file by clicking the “Data File” group's {Save} button.
  An output data file will be generated that protocols all settings (including any automatic adjustments) and results (it serves as a log file for dialog mode, see chapter 8 on page 33).

Caution!

Between calculating and saving the correction file, make sure not to change any settings.

- Exit the correXion®5 program by clicking the {Exit} button.
  (Alternatively, you can click the title bar's close symbol {×} or press your keyboard's <Esc> key.)

7 Create New Correction File in Silent Mode

Note

Because silent mode directly performs the calculation without a dialog box, your data file must contain all desired parameter settings for the specific parameters, as well as all measurement points and data points (see chapter 5 on page 17). Otherwise, a new correction file can't be generated.

You need to have performed the following steps before a new correction file can be calculated:

- Install the correXion®5 software (see chapter 3 on page 7).
- Mark and measure the test points (see chapter 4 on page 8).
- Create a complete data file
  - via the correXion®5 dialog box (see "“Data File” Group" on page 25)
  - or manually in a freely selectable file (conventions are described in "Data Files" on page 17).
- Before starting the program, copy the original RTC® correction file used to mark the test points into the same directory as the data file. Otherwise, a correction file won't be generated.

To generate a new correction file in silent mode, proceed as follows:

- Launch correXion®5 via Windows (“Start/Run”) or from an application and provide the data file name as the command line parameter:

```
correXion5.exe [name of the generated data file]
```

After the data file loads, various tests will be performed sequentially. The first encountered failure of a test will result in immediate termination of the program. These tests include:

- Is an input correction file [INPUT] specified?
- Is an output correction file [OUTPUT] specified?
- Has the input correction file successfully loaded?
- Is a calibration factor [CALIBRATION] greater than zero specified?
  - Here, [CALIBRATION] overwrites the calibration from the input correction file.
  - If [RTC4] is greater than zero, then the calibration factor will be rounded up to a multiple of 16.
- Are larger-than-zero [GRIDNUMBERS] specified?
- Have a sufficient number of data points been read in?
- Has the corrected correction table been successfully calculated?
  If neither [FITORDER] nor [SMOOTHING] were supplied, then a piecewise (bi)linear interpolation will be performed. But no output correction file will be calculated if a non-recoverable error occurs when [FITORDER] >0.
- Has the output correction file been successfully saved?

If the data file contains all required entries and no errors occurred during calculation, then a new calculation file and a text file (log file, see page 33) will be generated. Both files will be saved in the same directory as the data file.

8 Log Files

Note

Log file entries are appended in the already-existing log file of the same name and begin with the current date and time. Thus, previous log information won't be overwritten and is readily identifiable.

8.1 Log File as Results Protocol

After calculating a new correction file, silent mode automatically generates and saves a log file (see chapter 4 on page 31) protocolling all settings, automatic adjustments, results (see figure 10 on page 35) and errors. In dialog mode, such log files can be manually created via the “Data File” group's {Save} button (see chapter 6.3 on page 31).

8.2 Log Files in Silent Mode

The log file is automatically assigned the name **[Drive:][Path]<Name[.Ext]>.log**, whereby [Drive:][Path]<Name[.Ext]> is identical to [Name of the generated data file].

- If correXion®5 is started in silent mode (see chapter 7 on page 32) and can open the data file ([Drive:][Path]<Name[.Ext]>), then it attempts to generate a log file ([Drive:][Path]<Name[.Ext]>.log).
  If unsuccessful (e.g. the directory is write-protected), then it attempts to create a default log file named “correXion5.log” in the current working directory.
  If this, too, is unsuccessful, then the calculation will be performed without a log file. Directly prior to the program's termination, a corresponding message will be displayed in a pop-up window. But the generated correction file should be treated with caution, because no information about errors or results (e.g. offset) is available.
- If the program is started in silent mode (see chapter 7 on page 32) and the specified data file ([Drive:][Path]<Name[.Ext]>) can't be opened, then a default log file named “correXion5.log” will be generated and saved in the current working directory. It will contain the date, time and specified working directory as well as a file-opening-failure remark.
- If correXion®5 is started in silent mode but can't open the specified data file ([Drive:][Path]<Name[.Ext]>) and an attempt to generate a default log file named “correXion5.log” was also unsuccessful, then a corresponding message will appear in a pop-up window. Press this window's {OK} button to exit the program.

8.3 Calculation Results

Additionally to the parameter values and data point information used for calculating the correction file, the log file also lists a number of calculation results as detailed below. Log files can also be used as input data files. The captioned (similarly to parameters) calculation results will be ignored in both silent and dialog modes.

[OffsetX] = <integer>

This value indicates the offset (in [Bit]) of the correction file's zero point with respect to that of interpolation in the X direction.

[OffsetY] = <integer>

This value indicates the offset (in [Bit]) of the correction file's zero point with respect to that of interpolation in the Y direction.

Note

The RTC®5 command `set_offset(OffsetX, OffsetY)` lets you compensate the RTC®5 board's zero point offset.

[Limit(Bits)] = <integer>

This value indicates the maximum control values (Plus (+) and Minus (–) in [Bit]) that won't result in clipping.
Note: The maximum value "524288" should be interpreted as "–524288" and "+524287" (or, if the RTC®4 compatibility mode has been activated, the maximum value "32768" should be interpreted as "–32768" and "+32767").

[Limit(mm)] = <floating-point>

This value indicates the largest image field (in [mm]) that can be achieved with the supplied calibration.

[Deviation] = <floating-point>

This value indicates the maximum deviation between the calculated and measured test points (in [mm]).

8.4 Example Log File

```
[INPUT]       = <Input-Name>; input table file name
[OUTPUT]      = <Output-Name>; output table file name
[CALIBRATION] = 14976; calibration in bits/mm
[RTC4]        = 0; RTC4-compatibility mode
[FITORDER]    = 0; degree of overall polynomial fit
[SMOOTHING]   = 0.3; smoothing parameter for overall spline fit
[AUTO_FIT]    = 0; adjust parameters for fitting
[TOLERANCE]   = 0.1; tolerance value

[Limit(Bits)] = 524288; control value limits
[Limit(mm)]   = 35.0085; field size limits
[OffsetX]     = -2666; offset X
[OffsetY]     = 2367; offset Y
[Deviation]   = 0.659463; max. deviation

[GRIDNUMBERS] = 2 2; grid X, grid Y; points: 5 per line, 5 per column, total 25

[GRIDVALUES_X] =  -26.000000  -13.000000    0.000000   13.000000
[GRIDVALUES_X] =   26.000000    0.000000    0.000000    0.000000

[GRIDVALUES_Y] =  -26.000000  -13.000000    0.000000   13.000000
[GRIDVALUES_Y] =   26.000000    0.000000    0.000000    0.000000

    Xn      Yn         X mm           Y mm

    -2      -2      -25.000000     -26.000000
    -1      -2      -13.500000     -26.000000
     0      -2       -1.000000     -26.500000
     1      -2       11.500000     -27.000000
     2      -2       23.500000     -26.500000
    -2      -1      -26.500000     -13.000000
    -1      -1      -13.500000     -13.500000
     0      -1        0.000000     -13.500000
     1      -1       13.000000     -14.000000
     2      -1       26.000000     -14.000000
    -2       0      -27.000000       0.500000
    -1       0      -14.000000       0.000000
     0       0        0.000000       0.000000
     1       0       13.500000       0.000000
     2       0       26.500000       0.000000
    -2       1      -26.500000      14.500000
    -1       1      -13.500000      14.000000
     0       1        0.000000      14.000000
     1       1       13.500000      13.500000
     2       1       26.000000      13.500000
    -2       2      -24.000000      27.000000
    -1       2      -12.000000      27.000000
     0       2        0.500000      27.000000
     1       2       13.000000      26.500000
     2       2       24.500000      26.500000
```

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Log file as results protocol (via "Data File" group's {Save}button) – Example

Revision History

This list ignores spelling/grammar corrections, syntax reformulations or additions (such as new cross-references) that don't affect the technical meaning. The supplied page numbers refer to this document.

Changes from revision 1.1 to revision 1.2

Page	Name of section / command	Change
4	"Scope of Delivery"	new version number of correXion®5 software
6	"The correXion®5 Process"	larger maximum number of specifiable grid points
9	"Marking Test Points without the "Marking Grid" Dialog"	larger maximum number of allowable test points
11	""WarmUp Timer/Start/Stop" Group"	change to test-point marking mode; figure 2, "Marking sequence" exchanged
12	"{Start} Button"	changed sequence for initializing (marking of test points)
18–20	"Parameters/Captions"	[GRIDNUMBERS] modified; [GRIDVALUES_X] and [GRIDVALUES_Y] inserted; [GRIDSPACING], [RESTRICTED] and [AUTO] deleted; figure 3, "Number of data points" exchanged
21	"Data Points"	Properties of <integer> and <floating-point> modified
22	"Example Data File"	several captions (see above) modified, inserted and deleted
23–27	"Dialog Box"	Properties of specific window elements revised; figure 5, "Dialog box" exchanged
27–30	"Display Dialog Box"	Properties of specific window elements revised; figure 6 – figure 9 exchanged
32	"Create New Correction File in Silent Mode"	Calibration factor properties changed via elimination of [RESTRICTED] and [AUTO]; Use of piecewise (bi)linear interpolation if neither [FITORDER] nor [SMOOTHING] are supplied
35	"Example Log File"	several captions (see above) modified, inserted and deleted; data points modified

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