

# ComGage – Test step function SFct023

## “Correction value calculation”



### 1. Introduction

The ComGage special function “Correction value calculation” serves the purpose of calculating axle correction values for CNC machines.

This special function calculates the correction values by means of the collected measurement values of a component and makes these available by the ComGage registers R1 ... R999.

The calculated correction values ( in R1 ... R999 ) are transferred to the CNC machines ( e.g. via Ethernet, Profibus, Profinet or digital I/Os ) by downstream functions.

**Note :** For a better understanding of the function, we recommend to read chapter 5 of this document in advance. It describes in detail how the function works.

### 2. Configuration - Short overview

The function is configured in a setup dialogue ( see chapter 3 ). Chapter 2 provides a short overview of the structure of this setup dialogue.

- In the upper part of the setup dialogue, the characteristics for a joint correction value calculation ( because they are worked by the same axis ) can be selected :

| Correction value calculation  |                             |
|---|-----------------------------|
| Characteristics for correction value calculation                        |                             |
| <input type="checkbox"/> C1 - Bearing 1 - DM - 0° - Level 1             | Factor for weighting 0      |
| <input type="checkbox"/> C2 - Bearing 1 - DM - 0° - Level 2             | Factor for weighting 0      |
| <input type="checkbox"/> C3 - Bearing 1 - DM - 90° - Level 1            | Factor for weighting 0      |
| <input checked="" type="checkbox"/> C4 - Bearing 1 - DM - 90° - Level 2 | Factor for weighting 0.3333 |
| <input checked="" type="checkbox"/> C5 - Bearing 2 - DM - 0° - Level 1  | Factor for weighting 0.3333 |
| <input checked="" type="checkbox"/> C6 - Bearing 2 - DM - 0° - Level 2  | Factor for weighting 0.3333 |

- In the lower part of the setup dialogue, the actual configuration of the correction value calculation takes place.

| Automatic-Mode  |                   | Special correction-Mode |    |
|---|-------------------|-------------------------|----|
| Part buffer ( Number of parts not used for new calculation after transfer of correction value ) | 1                 | 1                       | 1. |
| Mode for correction value calculation   | Fix subgroup      | Fix subgroup            |    |
| Subgroup size / Formula   | 3                 | 1                       |    |
| Correction destination  | (USL+LSL)/2       | (USL+LSL)/2             | 2. |
| Limits for detection, if a correction value must be output                                      |                   |                         |    |
| Upper correction limit  | 0.003 Free input  | 0.003 Free input        |    |
| Lower correction limit  | -0.002 Free input | -0.002 Free input       |    |
| Percent value for correction value  | -100              | -100                    | 3. |
| Offset for correction value   | 0                 | 0                       |    |
| Max. correction value   | 0.005             | 0.05                    |    |
| Min. correction value   | -0.005            | 0                       |    |
| Number of digits behind decimal point   | 3                 | 3                       |    |



The Special correction-Mode ( right column ) is active on machine / test order start. After a sample without a required correction, ComGage changes to the Automatic-Mode ( left column ).

There are three conditions which can cause a change back to the Special correction-Mode :

- The “Register with correction mode” is manually set to 1 ( see chapter 3 ).
- The action code for “activating special correction mode” is set ( see chapter 3 ).
- A bad part has been recognised.

Part 1 of this area ( see red mark ) is used to determine which measured parts are used for the correction value calculation.

In part 2 of this area is determined under which conditions a correction value shall be output. The output is executed, if the correction value is bigger than the correction destination / correction limits.

In part 3 of this area, the parameters for calculation the correction value from the in part 1 selected characteristics are determined.

| Correction value calculation  |  |   |   |
|---|--|---|---|
| Characteristics for correction value calculation  |  | <input type="checkbox"/> C1 - Bearing 1 - DM - 0° - Level 1<br><input type="checkbox"/> C2 - Bearing 1 - DM - 0° - Level 2<br><input type="checkbox"/> C3 - Bearing 1 - DM - 90° - Level 1<br><input checked="" type="checkbox"/> C4 - Bearing 1 - DM - 90° - Level 2<br><input checked="" type="checkbox"/> C5 - Bearing 2 - DM - 0° - Level 1<br><input checked="" type="checkbox"/> C6 - Bearing 2 - DM - 0° - Level 2<br><input type="checkbox"/> C7 - Bearing 2 - DM - 90° - Level 1<br><input type="checkbox"/> C8 - Bearing 2 - DM - 90° - Level 2 | Factor for weighting<br>0<br>Factor for weighting<br>0<br>Factor for weighting<br>0<br>Factor for weighting<br>0.3333<br>Factor for weighting<br>0.3333<br>Factor for weighting<br>0.3333<br>Factor for weighting<br>0<br>Factor for weighting<br>0 |
|   |  | Automatic-Mode  | Special correction-Mode   |
| Part buffer ( Number of parts not used for new calculation after transfer of correction value ) |  | 1   | 1   |
| Mode for correction value calculation   |  | Fix subgroup  | Fix subgroup  |
| Subgroup size / Formula   |  | 3   | 1   |
| Correction destination  |  | (USL +LSL)/2  | (USL +LSL)/2  |
| Limits for detection, if a correction value must be output                                      |  |   |   |
| Upper correction limit  |  | 0.003 Free input  | 0.003 Free input  |
| Lower correction limit  |  | -0.002 Free input   | -0.002 Free input   |
| Percent value for correction value  |  | -100  | -100  |
| Offset for correction value   |  | 0   | 0   |
| Max. correction value   |  | 0.005   | 0.05  |
| Min. correction value   |  | -0.005  | 0   |
| Number of digits behind decimal point   |  | 3   | 3   |
| Output register with State  |  | R1  |   |
| Output register with correction value   |  | R2  |   |
| Register with correction mode   |  | R200  |   |
| Action code number for entry on correction value transfer                                       |  | 0   |   |
| Action code number for activating special correction mode                                       |  | 0   |   |
| <input checked="" type="checkbox"/> Generate Excel-Report                                       |  |   |   |

The part buffer indicates how many components are located between the CNC machine and the measuring system. If a correction value is transferred due to the measurement values of the component currently placed in the measuring system, this correction value has no more effect on the components located between the CNC machine and the measuring system. Hence, these components must not be used for correction value calculation.

### Mode for correction value calculation

3 Modes are available :

a) Fix subgroup :

The number of components defined as subgroup size is measured and the correction value is determined by averaging the measurement values of the subgroup.

b) Sliding subgroup :

The lastly measured component replaces the oldest value in a value buffer with the size of the subgroup size ( shift register / FIFO ).

A correction value is determined by averaging the measurement values in the shift register after each single measurement.

c) Formula :

On input of a formula the correction value is not determined by multiple components ( = subgroup ), but only by the lastly collected measurement value.

In the formula you can allocate numbers and the characteristic's measurement value from file with each other.

Because the correction values are at first generated per characteristic and are then allocated, you can use only the measurement value of a particular characteristic ( symbolised by Cx ) for calculation of a correction value for that characteristic.

In the formulas the following mathematical operators can be used :

| Operator | Function                                  |
|----------|---|
| +        | Addition                                  |
| -        | Subtraction                               |
| *        | Multiplication                            |
| /        | Division                                  |
| ^        | 'x power by y' ( e.g. $2^3 = 2*2*2 = 8$ ) |
| Sin()    | Sine ( unit : degree )                    |
| Cos()    | Cosine ( unit : degree )                  |
| Tan()    | Tangent ( unit : degree )                 |
| asin()   | Arc – Sine ( unit : degree )              |
| acos()   | Arc – Cosine ( unit : degree )            |
| atan()   | Arc – Tangent ( unit : degree )           |
| exp()    | Exponential function ( $2.7182818^x$ )    |
| log()    | Natural logarithm                         |
| Abs()    | Absolute value                            |
| Pi       | Pi ( $\approx 3.14$ )                     |

Example of a formula :  $0.5 * Cx / 3 + 0.23$

**Notice :** In all 3 modes the measurement value minus nominal size is used for calculation of the correction value.

### Correction destination and correction limits

The correction destination is subtracted from the calculated correction value [ = overall correction value of all characteristics ]. If the difference is outside the correction limits, then a correction is necessary and the correction value is output.

The correction destination is calculated by a formula whereupon also a single number may be entered as formula. In the formula you can allocate numbers and specification limits with each other. In the formulas the following parameters can be used :

| Parameter | Function                  |
|-----------|---------------------------|
| USL       | Upper specification limit |
| LSL       | Lower specification limit |
| UCL       | Upper controlling limit   |
| LCL       | Lower controlling limit   |
| UPL       | Upper plausibility limit  |
| LPL       | Lower plausibility limit  |

Since the correction destination refers to the overall correction value of all characteristics, the correction destinations of the individual characteristics are likewise multiplied by the “Factor for weighting” and afterwards added up for calculation of the overall correction destination.

# ComGage – Test step function SFct023

## “Correction value calculation”



In the formulas the following mathematical operators can be used :

| Operator | Function                                  |
|----------|---|
| +        | Addition                                  |
| -        | Subtraction                               |
| *        | Multiplication                            |
| /        | Division                                  |
| ^        | 'x power by y' ( e.g. $2^3 = 2*2*2 = 8$ ) |
| Sin()    | Sine ( unit : degree )                    |
| Cos()    | Cosine ( unit : degree )                  |
| Tan()    | Tangent ( unit : degree )                 |
| asin()   | Arc – Sine ( unit : degree )              |
| acos()   | Arc – Cosine ( unit : degree )            |
| atan()   | Arc – Tangent ( unit : degree )           |
| exp()    | Exponential function ( $2.7182818^x$ )    |
| log()    | Natural logarithm                         |
| Abs()    | Absolute value                            |
| Pi       | Pi (=3.14)                                |

Example of a formula :  $(USL*1+LSL*2)/3$

The following options are available for the correction limits :

- Free Input → The correction limit can be input directly as numerical value
- LSL / USL → Correction limit = specification limit x factor  
The percentage for weighting of the specification limit can be input in the input field.  
Result on an input of 100 : correction limit = specification limit
- LCL / UCL → Correction limit = controlling limit x factor  
The percentage for weighting of the controlling limit can be input in the input field.
- LPL / UPL → Correction limit = plausibility limit x factor  
The percentage for weighting of the plausibility limit can be input in the input field.

Since the correction limits refer to the overall correction value of all characteristics, the specification / correction / plausibility limits of the individual characteristics are likewise multiplied by the “Factor for weighting” and afterwards added up for calculation of the overall specification / correction / plausibility limits ( = USL / LSL / ... ).

**Notice :** In all 3 modes the limits minus nominal size are used for calculation of the correction destination / correction limits.

### Percent value and offset for correction value

The calculated correction value [ = overall correction value of all characteristics minus correction destination ] is multiplied by the percent value ( with an input of 100 it is multiplied by 1 ) and afterwards the input offset value is added up.

### Correction value limits

The calculated correction value [ = overall correction value of all characteristics minus correction destination multiplied by percent value plus offset value ] is limited to the correction value limits. I.e. the correction value can take as maximum the value of the upper correction value limit ( Max. correction value ) or as minimum the value of the lower correction value limit ( Min. correction value ).

### Number of digits behind decimal point

The calculated correction value is rounded to the selected number of digits behind the decimal point.

### Automatic mode and special correction

The special correction mode is started due to one of the 4 following events :

- a) Machine start-up = Start of the test order
- b) Shift register empty ( possible only on selection of **Mode for correction value calculation = Sliding subgroup** )  
The cause of an empty shift register is e.g. a NO-GO component.
- c) Selection of a corresponding action code
- d) Setting of the “Register with correction mode” = 1.

Depending on the current mode, either the one or other set of parameters is used for calculation and evaluation of the correction value.

# ComGage – Test step function SFct023

## “Correction value calculation”



The software automatically switches back to the automatic mode, if a calculated correction value is inside the correction limits. ( I.e. at least one subgroup has to have been filled. )

### Output register with state

The selected register R1...999 contains the result of the correction value calculation :

- 0 = No correction necessary
- 1 = Correction necessary → correction value must be output
- 2 = One of the characteristics is outside the specification limits  
( in automatic mode only; in special correction mode the correction value is commonly calculated. )

The selected register can be evaluated in ComGage formulas.

### Output register with correction value

The selected register R1...999 contains the calculated correction value. The register is transferred to the special function for output of the correction value ( e.g. via Ethernet or digital I/Os ) to the CNC machine.

**( On Output register with state = 2 the Output register with correction value is set to 0.0 to prevent a wrong axle correction. An application-specific reaction to state = 2 has to be manually programmed in the test scheme. )**

### Register with correction mode

The selected register  $R(x+0)$  contains the correction mode :

- $R(x+0) = 0$  : Automatic mode
- $R(x+0) = 1$  : Special correction mode

By setting the register  $R(x+0) = 1$  in the test scheme, the special correction mode is automatically selected on the next call of the function “Correction value calculation”.

It is not possible to switch to automatic mode by setting the register.

ComGage makes available the parameters currently used for calculation of the correction value in the registers shown below. You can display the currently used parameters on the screen by assigning the registers to characteristics.

| Register              | Output value   |
|-----------------------|--|
| $R(x+0)$ , e.g. R200  | Correction mode : 0 = Automatic mode / 1 = Special correction mode                             |
| $R(x+1)$ , e.g. R201  | Part buffer  |
| $R(x+2)$ , e.g. R202  | Mode for correction value calculation :<br>0 = Fix subgroup, 1 = Sliding subgroup, 2 = Formula |
| $R(x+3)$ , e.g. R203  | Subgroup size ( on fix / sliding subgroup )  |
| $R(x+4)$ , e.g. R204  | Correction destination   |
| $R(x+5)$ , e.g. R205  | Upper correction limit   |
| $R(x+6)$ , e.g. R206  | Lower correction limit   |
| $R(x+7)$ , e.g. R207  | Percent value for correction value   |
| $R(x+8)$ , e.g. R208  | Offset value for correction value  |
| $R(x+9)$ , e.g. R209  | Upper correction value limit   |
| $R(x+10)$ , e.g. R210 | Lower correction value limit   |
| $R(x+11)$ , e.g. R211 | Calculated average of the current subgroup   |

### Actioncode number for entry on correction value transfer

The appropriate action code number for correction value transfer is assigned to the last measurement dataset of the selected characteristics ( see page 1 ), if a new correction value must be output.

### Actioncode number for activating special correction mode

If the appropriate action code number is assigned to the last measurement dataset of the activated characteristics, then the correction mode is switched to special correction mode.

The actioncode is saved in the reference information dataset “Event”.



### Generate Excel-Report

The calculation of correction values can be logged into Excel files ( see chapter 6).

An individual Excel file is generated per correction value.

If multiple different correction values are calculated for several axes, then the function can be activated only for the calculation of one of the different correction values.

## 4. Integration in the test scheme

### Task

Correction values are to be calculated for 2 axes.

The results are to be stored in the following registers :

R100 = State register axle 1

R101 = State register axle 2

R200 = Correction value register axle 1

R201 = Correction value register axle 2

### Test scheme

An individual test step is to be created for transferring correction values. It shall contain the following functions :

|   |   |
|---|---|
| Correction value calculation ( axle 1 ) | → Event „Test Step Start“   |
| Correction value calculation ( axle 2 ) | → Event „Test Step Start“   |
| Change to test step S1                  | → Formula „R100=0&R101=0“<br>( No correction necessary )                                    |
| Change to test step Sx                  | → Formula „R100=2 R101=2“<br>( One of the characteristics is outside specification limits ) |
| Change to next test step                | → Formula „R100=1 R101=1“<br>( Correction necessary, correction value must be output )      |

### Deactivating transfer of correction values in the test scheme

You must simply deactivate the call of the test step for correction value calculation in the previous test step. I.e. “Change to next test step” ( = call correction value calculation ) must be altered to “Change to test step S1” for deactivating the correction value calculation.

## 5. Further explanation of the correction value calculation ( program structure for correction value calculation )

1. Evaluation “Automatic mode” or “Special correction mode”.  
The appropriate set of parameters is loaded, depending on the current mode.
2. Use the part buffer to check, if the current component is to be used for correction value calculation or not.  
If not, load “Output register with state”=0 and end.
3. Calculation of correction destination :
  - a) Calculate correction destination per activated characteristic by means of the formula.
  - b) Calculate the overall correction destination by adding up the correction destinations of the individual characteristics multiplied by the “Factor for weighting”.
4. Calculation of correction limits ( if “Free input” was not selected ) :
  - a) Per activated characteristic the particular limit is loaded by means of the selection specification / correction / plausibility limit and is multiplied by the percentage for weighting input in the input field.
  - b) Calculate the overall correction limit by adding up the correction limits of the individual characteristics multiplied by the “Factor for weighting”.



5. Calculation of the correction value per activated characteristic by means of the selected mode :  
Fix subgroup :

- If a measurement value is outside specification limits and “Automatic mode” is activated, then dump subgroup buffer of all characteristics, load “Output register with state”=2 & correction value=0 and end.
- Otherwise load new measurement value ( minus nominal size ) into subgroup buffer.
- If the subgroup buffer is full, then calculate the correction value by averaging the measurement values in the subgroup buffer.
- If the subgroup buffer is not yet full, then load “Output register with state”=0 and end.

Sliding subgroup :

- If a measurement value is outside specification limits and “Automatic mode” is activated, then dump subgroup buffer of all characteristics, load “Output register with state”=2 & correction value=0, **switch to special correction mode** and end.
- Otherwise shift new measurement value ( minus nominal size ) into subgroup buffer ( shift register ).
- If the subgroup buffer is full, then calculate the correction value by averaging the measurement values in the subgroup buffer.
- If the subgroup buffer is not yet full, then load “Output register with state”=0 and end.

Formula :

- If a measurement value is outside specification limits and “Automatic mode” is activated, then load “Output register with state”=2 & correction value=0 and end.
- Otherwise calculate the correction value by using the formula.

6. Calculation of the overall correction value by adding up the correction values of the individual characteristics multiplied by the “Factor for weighting”.
7. Overall correction value = overall correction value – correction destination ( from 3. ).
8. If the overall correction value is inside the correction limits ( from 4. ) :  
  - Load “Output register with state”=0.
  - If “Special correction mode” is activated, then switch back to “Automatic mode” and dump subgroup buffer.
  - End.
9. Overall correction value = overall correction value \* percent value / 100 + offset value.
10. If overall correction value > upper correction value limit,  
then overall correction value = upper correction value limit.
11. If overall correction value < lower correction value limit,  
then overall correction value = lower correction value limit.
12. Round the overall correction value to the selected number of digits behind the decimal point.
13. Assign action code number for correction value transfer to the last measurement dataset of the activated characteristics.
14. Transfer correction value :  
  - Load “Output register with state”=1.
  - Load “Output register with correction value”= overall correction value.
  - End.

# ComGage – Test step function SFct023

## “Correction value calculation”



### 6. Example

The Excel export records the calculation of the correction values in Excel files. With the help of these Excel files, the correction value calculation can be retraced.

Measurement in **Special correction-Mode** ( Sample size = 1 ) : Mea. value = 0.00575

|    | 1  | 2        | 3           |
|----|--|----------|-------------|
| 1  | Special correction-Mode                                      | 0        |             |
| 2  | Correction destination of characteristic C4 (weighting : -1) | 0.005    | (USL+LSL)/2 |
| 3  | Overall correction destination                               | -0.005   |             |
| 4  | Upper correction limit                                       | 0.002    |             |
| 5  | Lower correction limit                                       | -0.002   |             |
| 6  | Sample buffer of characteristic C4                           | 0.00575  |             |
| 7  | Correction value of characteristic C4 (weighting : -1)       | 0.00575  |             |
| 8  | Overall correction value                                     | -0.00575 |             |
| 9  | Correction value - Correction destination                    | -0.00075 |             |
| 10 | Correction value is inside the correction limits             | 0        |             |
| 11 | Output register with state                                   | 0        |             |
| 12 | Output register with correction value                        | 0        |             |

Result :

The correction value is outside the correction limits.

Output register with state : 0 ( no correction required )

Output register with correction value : 0

→ Change to the Automatic-Mode

Measurement in **Automatic-Mode** ( Sample size = 3 ) : Mea. value = 0.01125  
( incomplete sample )

|    | 1  | 2        | 3   |
|----|--|----------|-----|
| 1  | Automatic-Mode   | 0        |     |
| 2  | Correction destination of characteristic C4 (weighting : -1) | 0.01325  | UCL |
| 3  | Overall correction destination                               | -0.01325 |     |
| 4  | Upper correction limit                                       | 0.002    |     |
| 5  | Lower correction limit                                       | -0.002   |     |
| 6  | Sample buffer of characteristic C4                           | 0.01125  |     |
| 7  | Sample buffer of characteristic C4 is not full               | 0        |     |
| 8  | Correction value of characteristic C4 (weighting : -1)       | 0.01325  |     |
| 9  | Output register with state                                   | 0        |     |
| 10 | Output register with correction value                        | 0        |     |

Result :

The sample is still incomplete.

→ no correction value calculation

Measurements in **Automatic-Mode** ( Sample size = 3 ) : Mea. values = 0.01125 / 0.0048 / 0.0036  
( complete sample )

|    | 1  | 2        | 3      | 4      |
|----|--|----------|--------|--------|
| 1  | Automatic-Mode   | 0        |        |        |
| 2  | Correction destination of characteristic C4 (weighting : -1)         | 0.01325  | UCL    |        |
| 3  | Overall correction destination                                       | -0.01325 |        |        |
| 4  | Upper correction limit   | 0.002    |        |        |
| 5  | Lower correction limit   | -0.002   |        |        |
| 6  | Sample buffer of characteristic C4                                   | 0.01125  | 0.0048 | 0.0036 |
| 7  | Correction value of characteristic C4 (weighting : -1)               | 0.00655  |        |        |
| 8  | Overall correction value   | -0.00655 |        |        |
| 9  | Correction value - Correction destination                            | 0.0067   |        |        |
| 10 | (Correction value - Correction destination) x Percent value          | 0.00536  |        |        |
| 11 | (Correction value - Correction destination) x Percent value + Offset | 0.00536  |        |        |
| 12 | Correction value limited to correction limits                        | 0.00536  |        |        |
| 13 | Correction value (rounded)   | 0.005    |        |        |
| 14 | Output register with state   | 1        |        |        |
| 15 | Output register with correction value                                | 0.005    |        |        |

Result :

The correction value is outside the correction limits ( 0.0067 ± 0.002 ).

Output register with state : 1 ( correction required )

Output register with correction value : 0.005

→ Output of the correction value