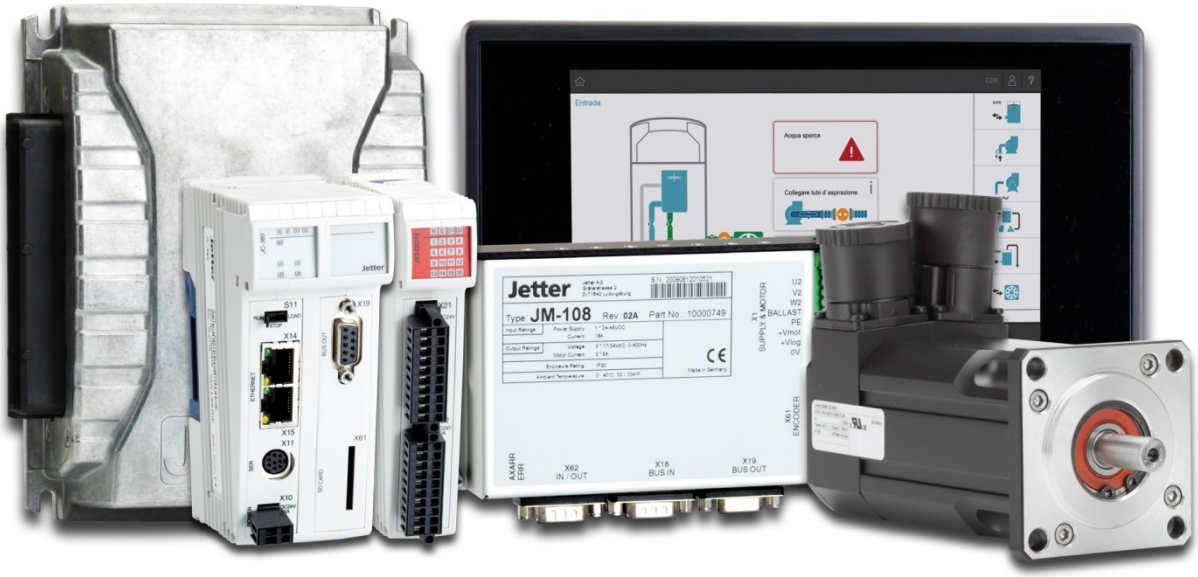
Jetter automation



Motion Control - Using the Cam Disc in a Technology Group

Application Note 056

60886070_01

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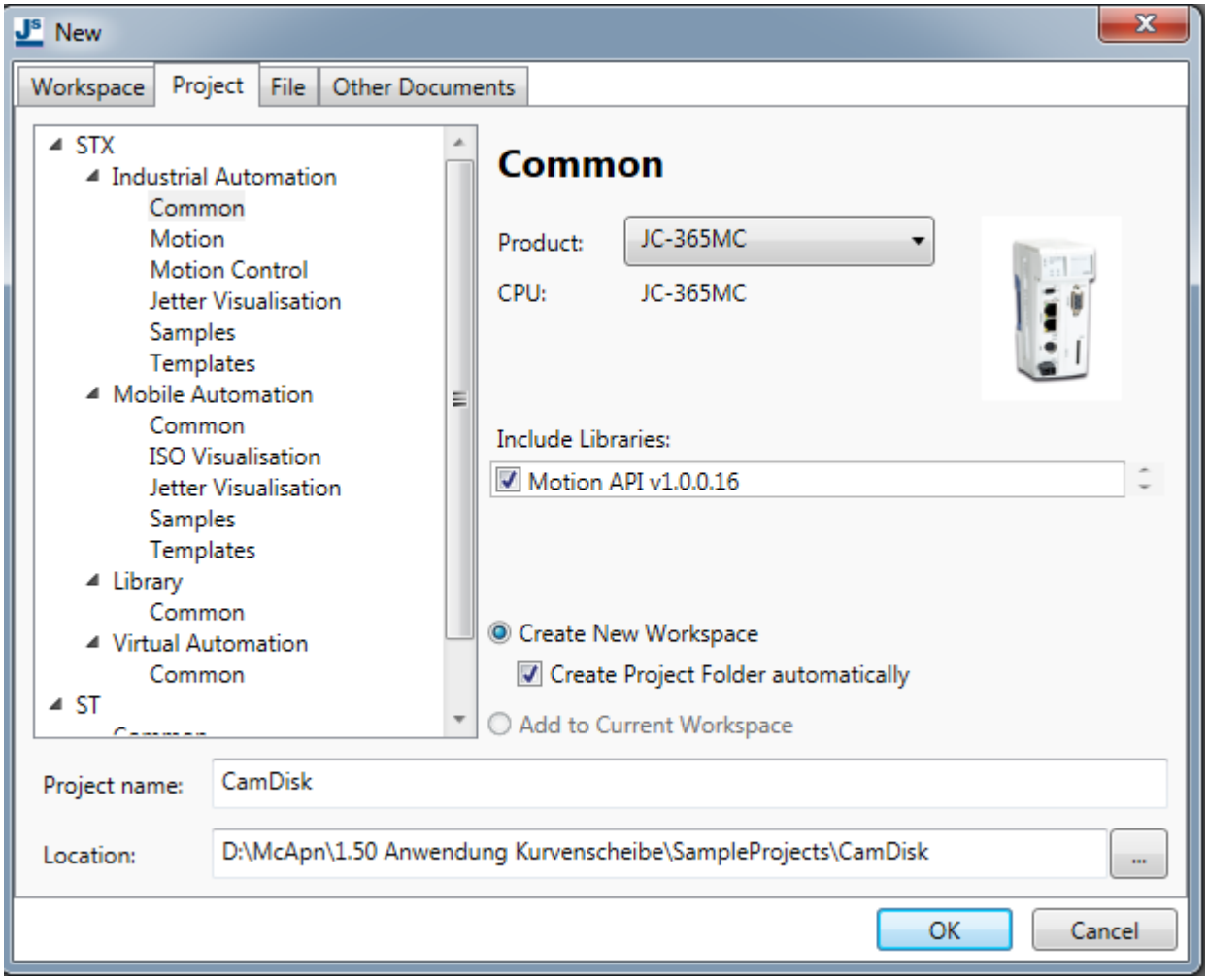
1 Introduction

1.1 Prerequisites

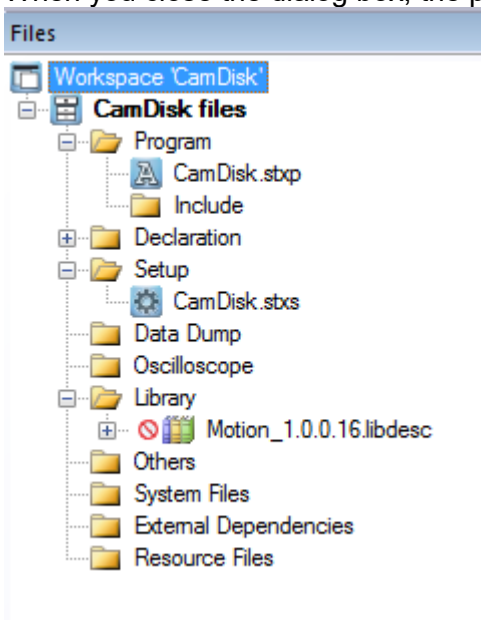
- The following versions are used for the code and project examples as well as for screen-shots - unless otherwise specified:
  - JetSym 5.6.0
  - Motion API 1.0.0.16
  - JC-365MC-OS 1.32.0.0
- Application Notes with further information about Motion Control:
  - Application Note 049 – Technology Group
  - Application Note 050 – Electrical Gearbox
  - Application Note 052 – Cam Definition

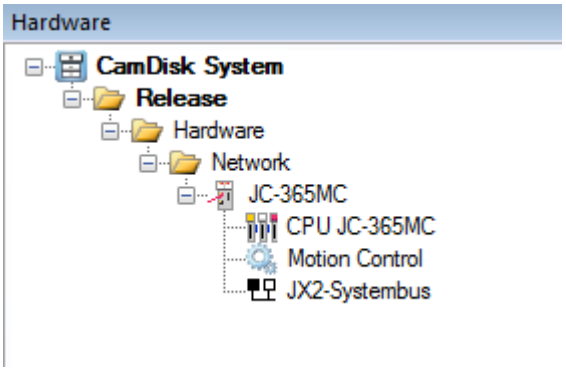
2 Creating a Cam Coupling in the Technology Group

Create a new project using the JetSym menu: File -> New.
In the dialog, make the following settings: Controller, Motion API, project name and path.

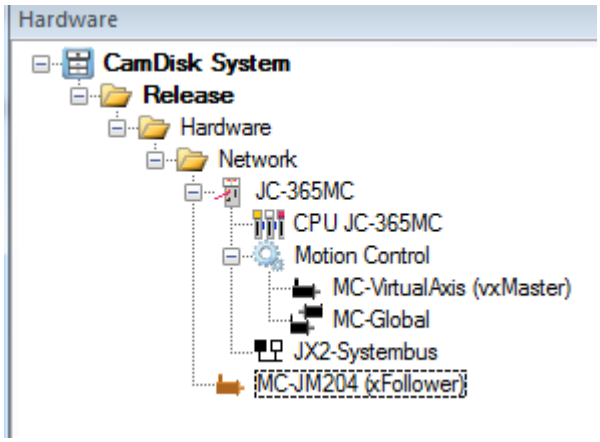


When you close the dialog box, the project and hardware tree are created accordingly:

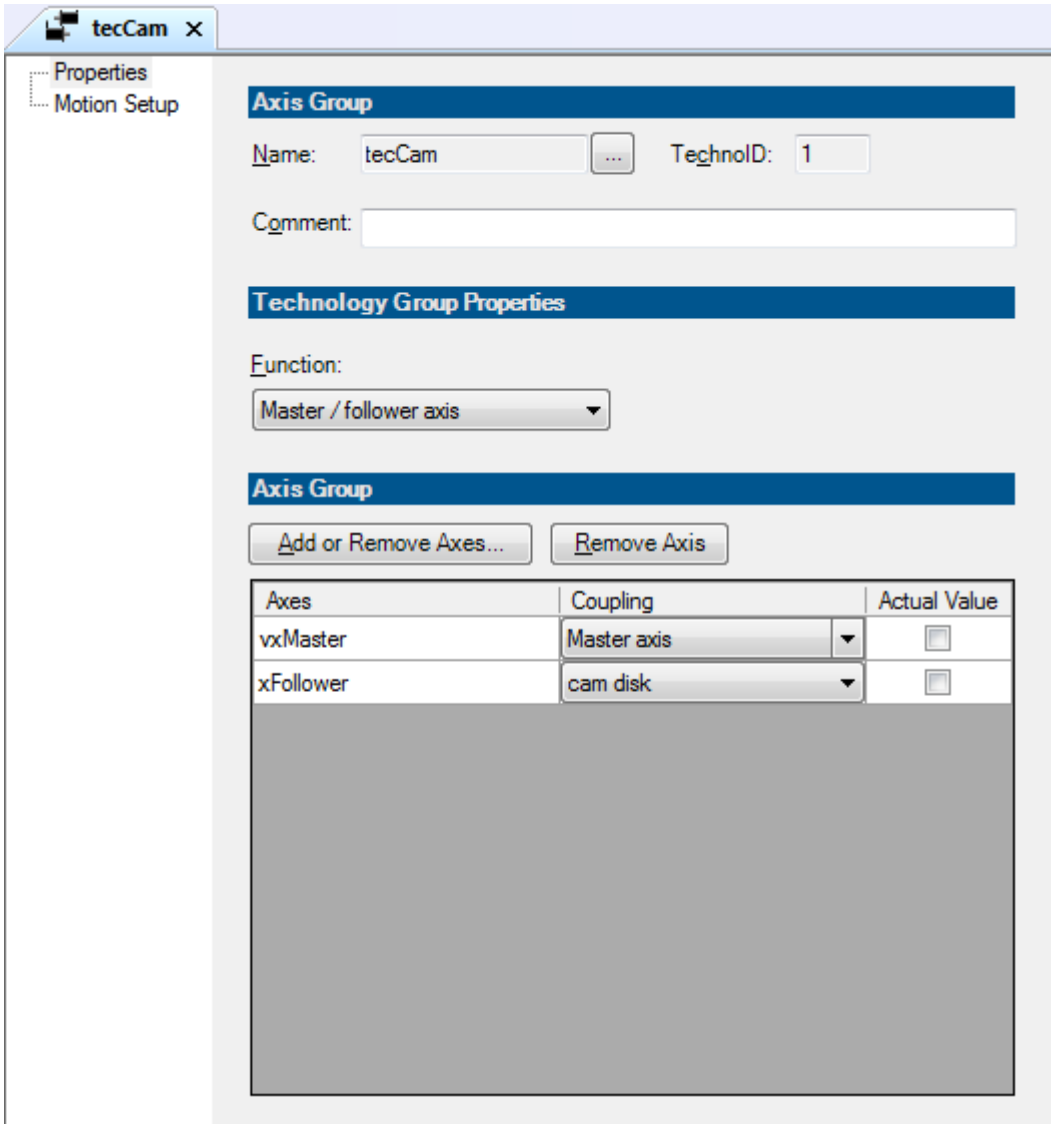




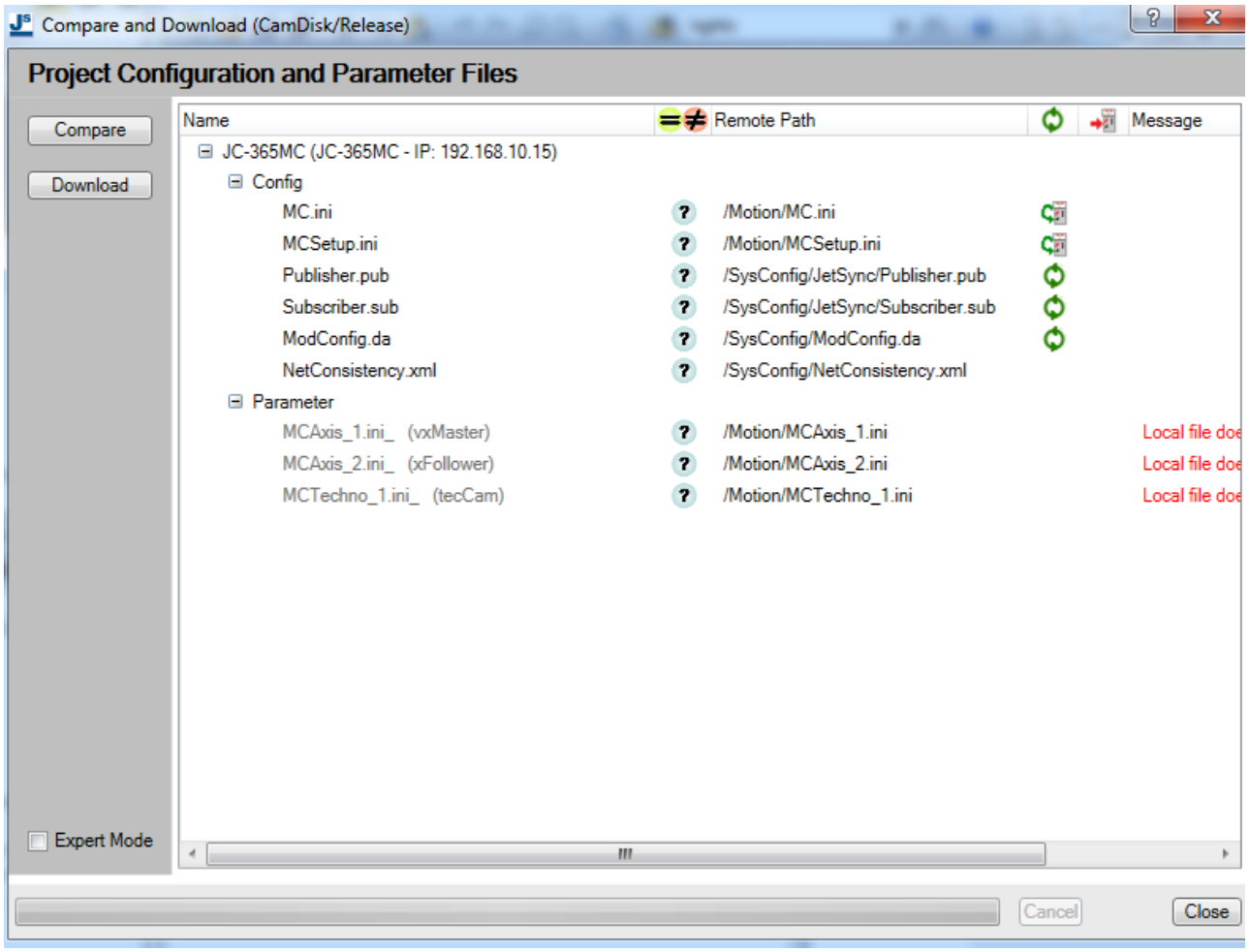
Then, add the required axes.



Now, add the technology group and configure it.



Finally, transfer this configuration to the controller via "Compare and Download" and reboot it.

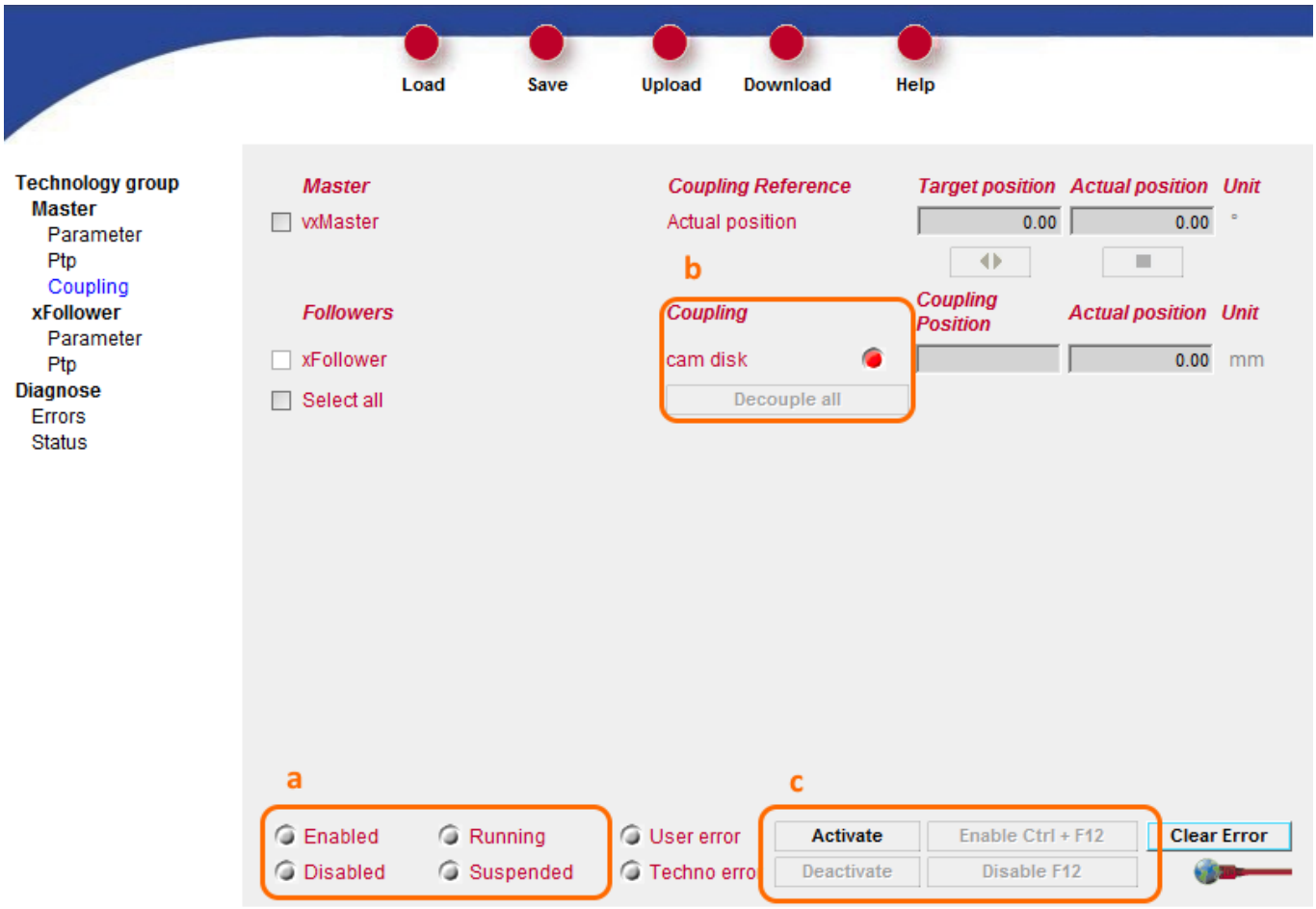


After the controller has been restarted, the configuration is ready for use.

3 Operating the Cam Disc via Motion Setup

3.1 Activating/deactivating the group

Motion Setup of the technology group:
vxMaster: Master axis
xFollower: Follower axis

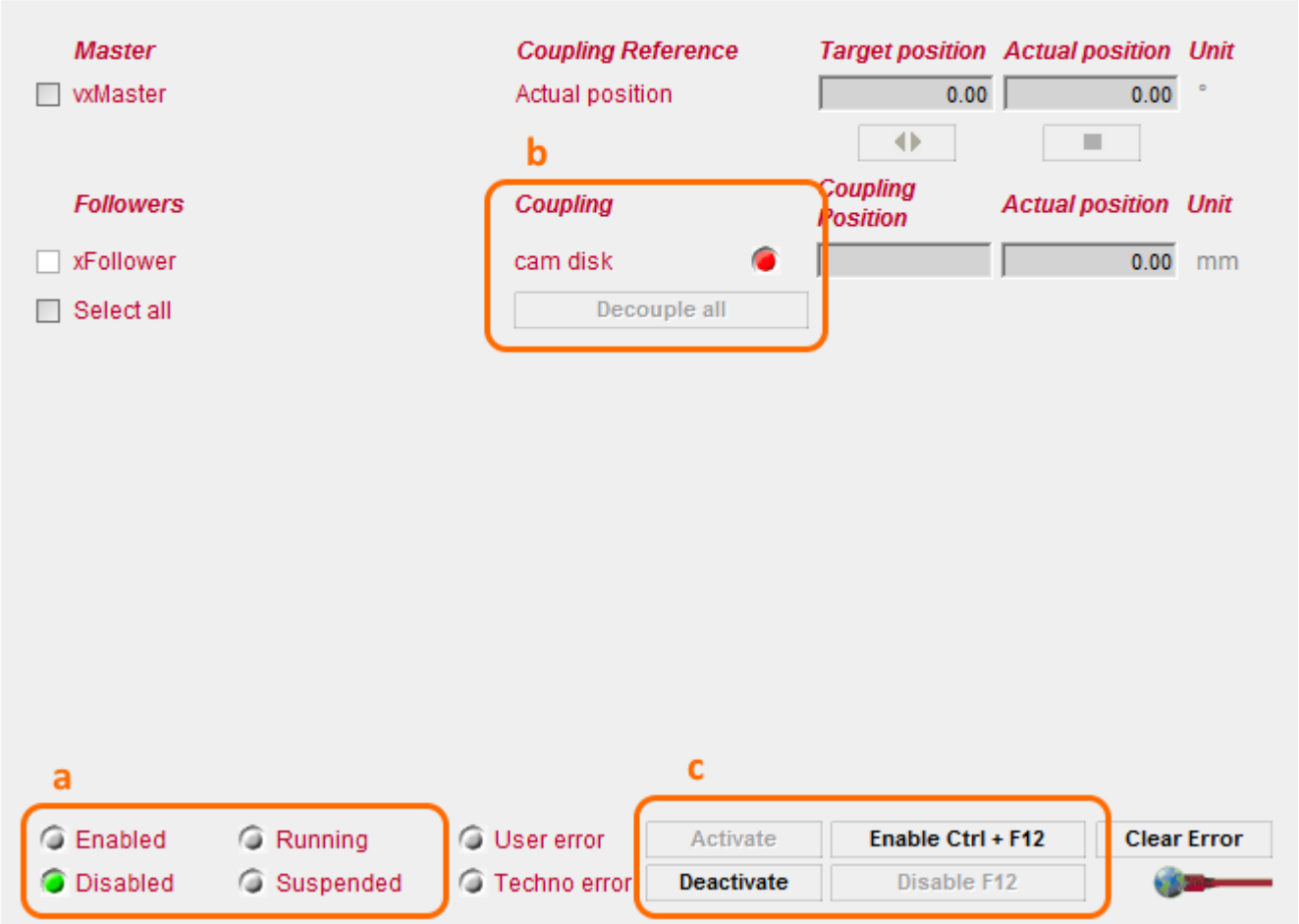


State after controller restart!

a) Displays the operating status of the group. The group is "inactive". Therefore, the status indicators are grayed out.
b) The coupling status of the follower axis is displayed here. Member axes coupling states can be seen here as red (uncoupled) and green (coupled).
c) The only possible state change from "inactive" is "Activate". Since the group is inactive, you can only click on the “Activate” button.

3.1.1 Activating

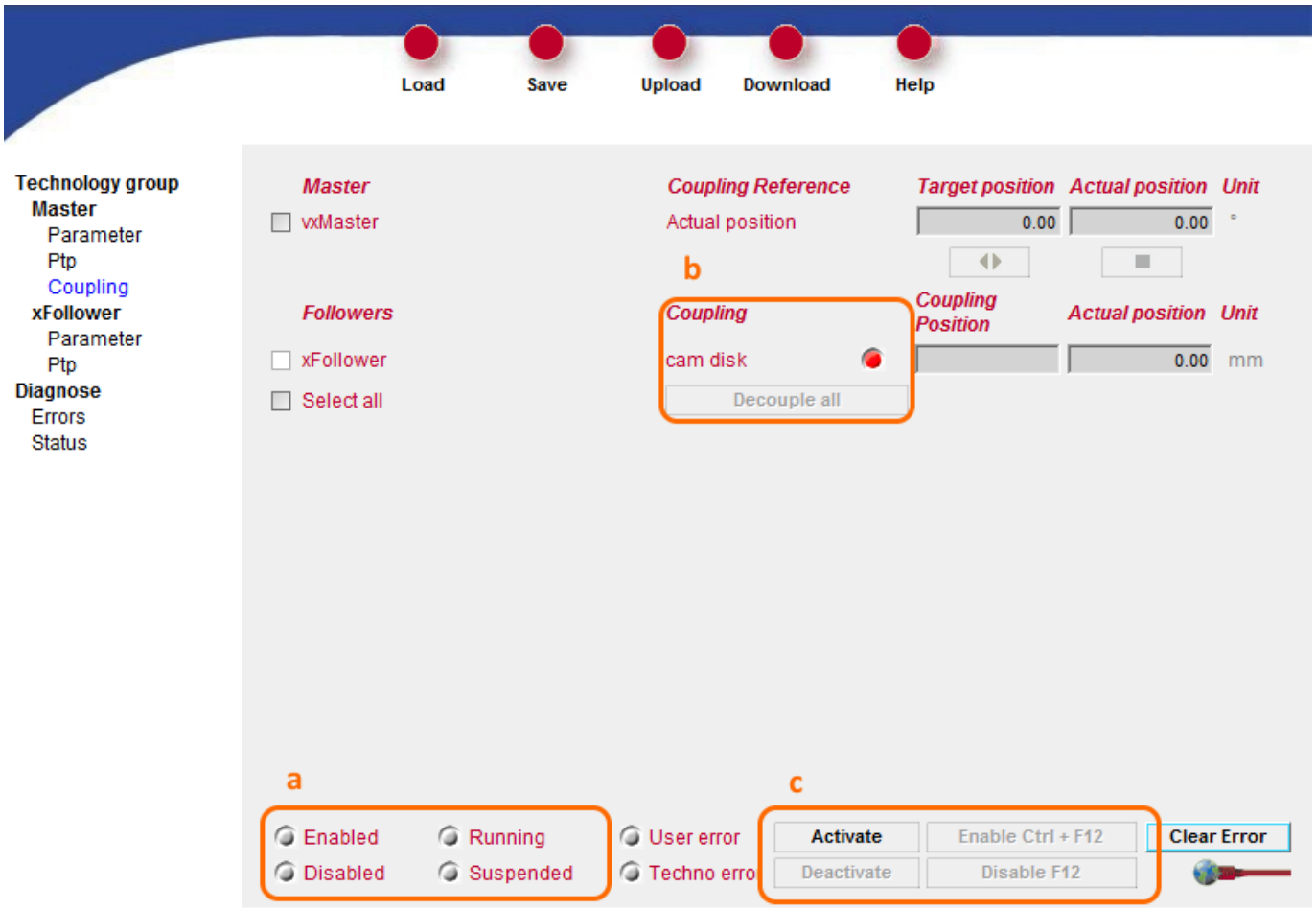
Click the "Activate" button to activate the group.



a) By clicking the "Activate" button, the group adopts the axes' previous state, in this case, "Disabled" as indicated in the status display.
b) The default coupling setting for a follower axis of the type "cam disc" is "decoupled" (red) after activating the group.
c) Due to the state of the group after its activation, the allowed controls are unlocked while the others are locked (grayed out). It is now possible to "Deactivate" or "Enable" the group.

3.1.2 Deactivating

To deactivate the group, click the "Deactivate" button.

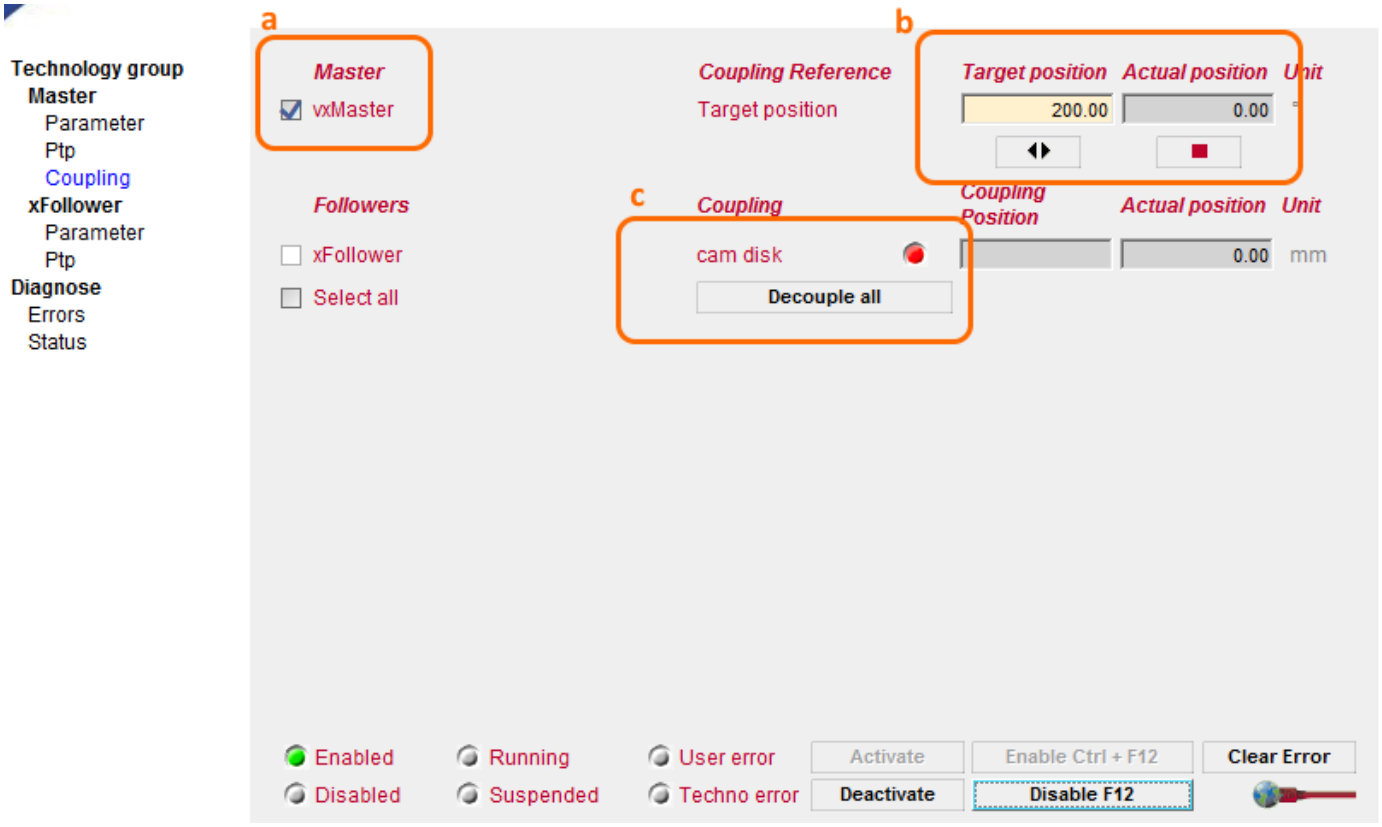


a) Displays the operating status of the group. The group is "Deactivated". Therefore, the status indicators are grayed out.
b) The coupling status of the follower axis is displayed here. With respect to the inactive group, the follower axis is not coupled (red).
c) The only possible state change from "inactive" is "Activate", so only this button is unlocked.

3.1.3 Moving the master axis

For testing, the axis can be moved on the "Coupling" page. Purpose of this page, is not only to monitor the movement of the coupled follower axis by positioning the master axis, but also to move all axes to a position from which they can start moving together in a coupled motion.

At least one cam must be defined for a cam disc follower axis. The cam disc must then be activated. Since this is not supported by the Motion Setup, coupling or synchronous operation can only be tested if cam definition and activation has been performed by the application.



a) By setting the check mark for the master axis, the edit box and the associated controls are enabled.
b) Now, a target position can be specified here, e.g. 200°. The positioning is started by clicking on  . A positioning process can be stopped by clicking  . The position change of master and follower axes can be monitored in the "Actual position" display.
c) With "Decouple all" all follower axes are decoupled so that they no longer follow the movement of the master axis.

3.1.4 Moving the follower axis

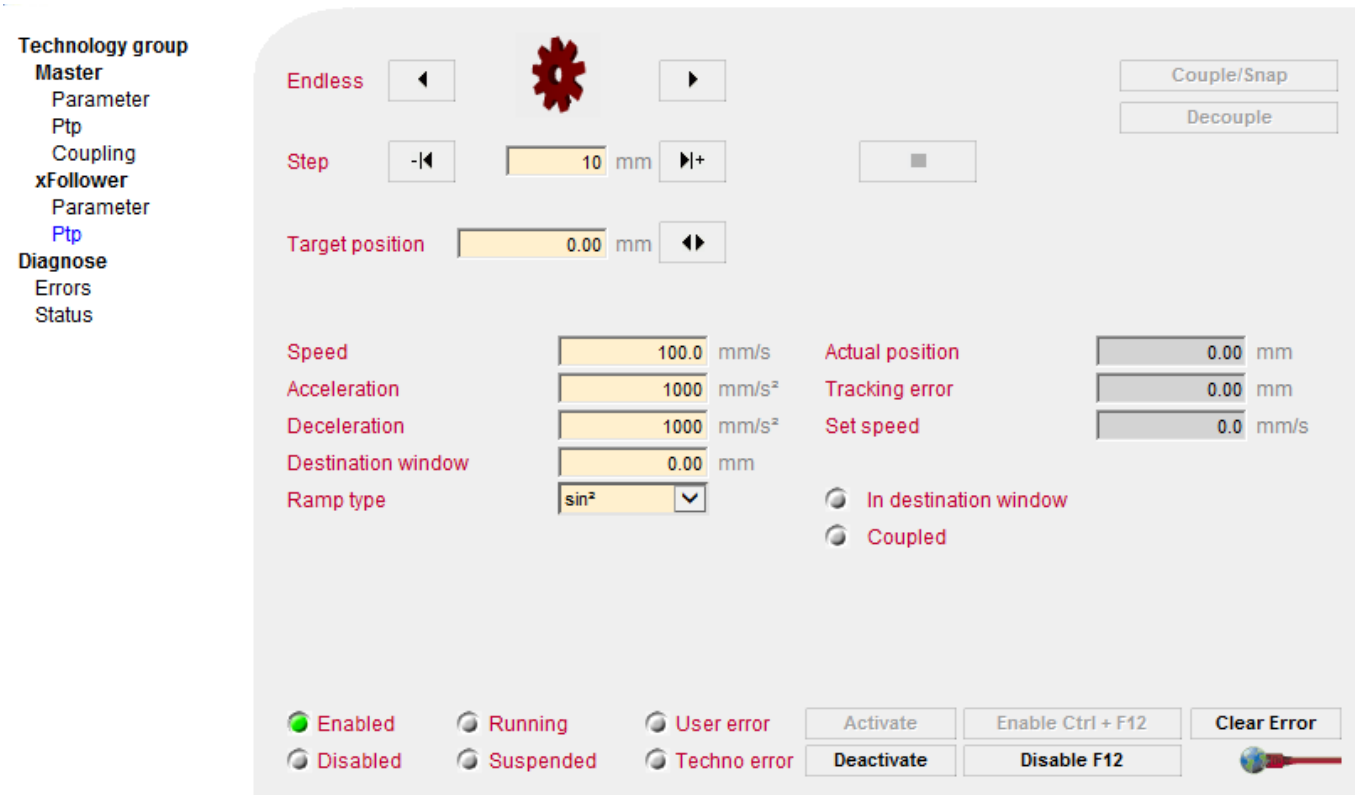
The follower axis of the coupling type "cam disc" cannot be moved on this Motion Setup page.

3.2 Setting the Filter

The filter coefficient in the active group can be set via the Parameter page of the axes involved. The value range of the filter is 0.0 ... 100.0. A 5th degree polynomial filter is used, whose effect is determined by the filter coefficient. The settings for master and follower axes are made in the same way.

Further information on the use of the filter can be found in Application Note 049 "Technology Group", chapter "Actual Value Coupling + Filter"

3.3 Positioning the member axis



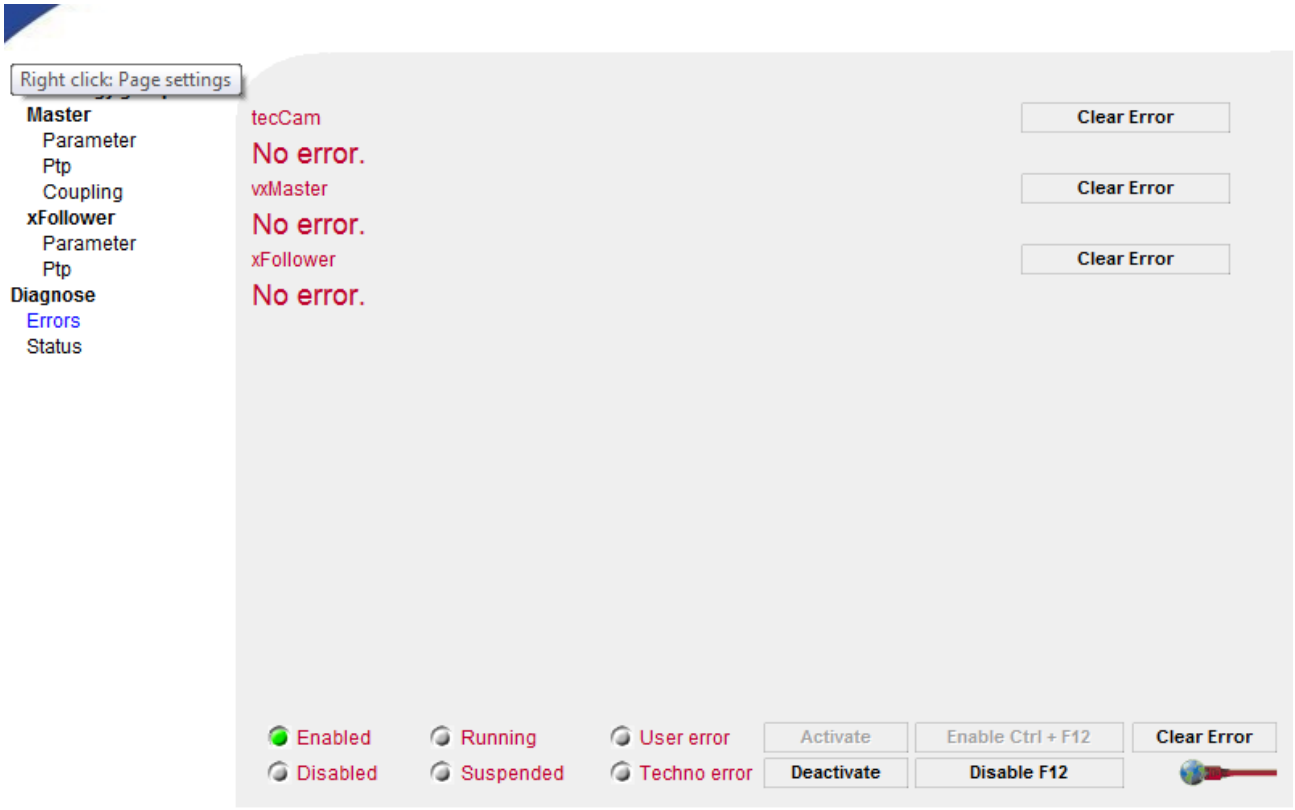
Similar to "Point-to-Point" commissioning pages for individual axes, individual positioning jobs can be carried out on the "PtP" pages for commissioning a group. To do this, you can set the appropriate parameters for the following positioning methods: Endless, Step, and Target Positioning.
The coupling status is also displayed.

INFO

If a coupled electrical gearbox follower axis is positioned, the follower axis gets decoupled. There is no automatic recoupling as on the "Coupling" page!

3.4 Diagnostic functions

3.4.1 Errors

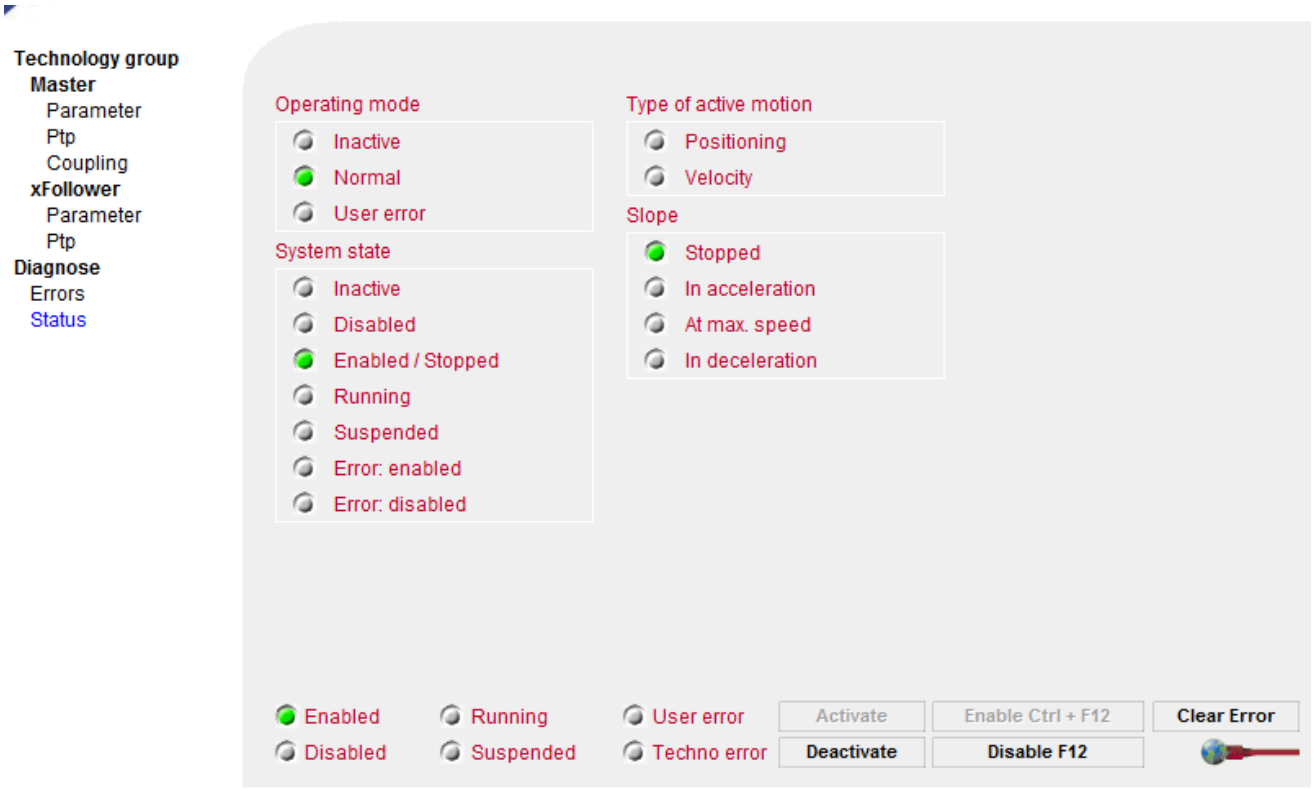


The "Errors" page shows a summary of the currently active alarms of the group and its member axes. Each axis can be individually cleared using its respective "Clear Error" button. The "Clear Error" button on the bottom control bar lets you clear all errors related to the group.

INFO

If the error of a group is cleared, the errors of its member axes are also cleared!

3.4.2 Status



The "Status" page shows an overview of the status of the group axes.

INFO

In the active group, the ramp status (Slope) of the group is identical to that of the master axis. In the active group, the ramp status of the axis object of the master axis remains at "Stopped". The slope status of the follower axis is queried via the respective axis object of the follower axis.

4 Using the Cam Coupling in the Application Program

3 steps are essential for a follower axis to be able to traverse a cam:

1. The cam disc must be defined.
2. The cam disc must be activated.
3. The follower axis must be coupled.

These 3 steps must be performed in this order. But the timing is not decisive.

Example:

```
tecCam.Coupling.Cam.Create(xFollower, 1, 1);
tecCam.Coupling.Cam.DefineSegment(xFollower, 1, 1, MCTechnoCamSegmentTypes.AutoPoly1st);
tecCam.Coupling.Cam.Activate(xFollower, 1);
tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate);
```

or

- at the beginning of the program:

```
tecCam.Coupling.Cam.Create(xFollower, 1, 5);
tecCam.Coupling.Cam.DefineSegment(xFollower, 1, 1, MCTechnoCamSegmentTypes.AutoPoly1st);
...
tecCam.Coupling.Cam.Create(xFollower, 2, 5);
tecCam.Coupling.Cam.DefineSegment(xFollower, 2, 1, MCTechnoCamSegmentTypes.AutoPoly1st);
...
```

- during the process:

```
tecCam.Coupling.Cam.Activate(xFollower, 1);
```

- when starting the automatic mode:

```
tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate);
```

INFO

The decisive factors are:

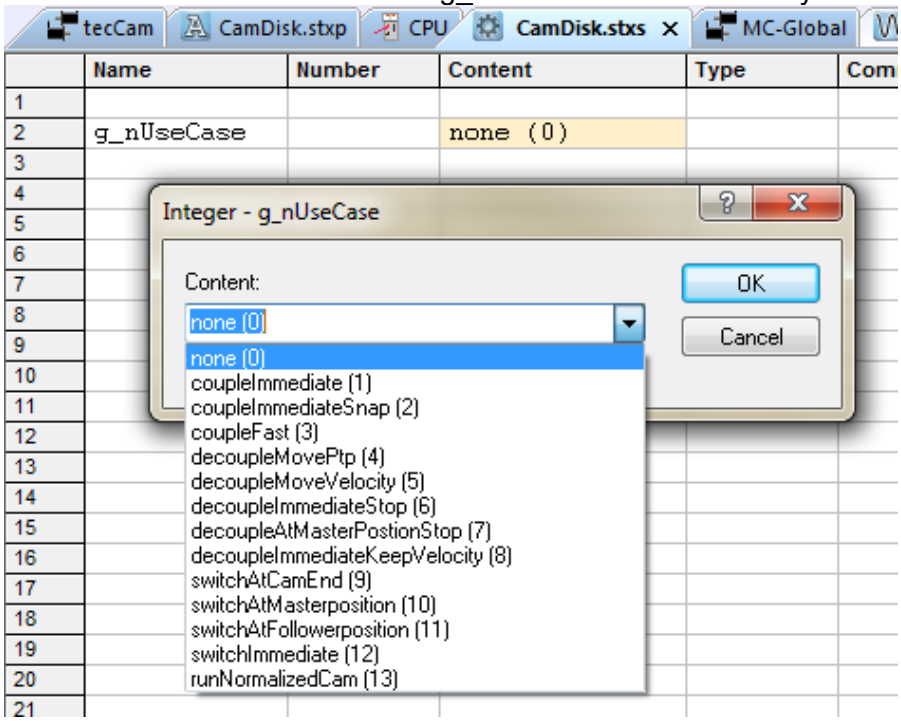
- Only a previously defined cam disc can be activated.
- Coupling is possible only if a cam disc is activated.

4.1 Defining a Cam Disc

See Application Note 052 - Cam Disc Definition.

Explanatory notes on the examples

The "CamDisk" sample project is available for this application note.
All examples are divided into separate functions.
This project uses only virtual and simulation axes. Apart from a Motion Control controller, no other external hardware is required.
To start, set the correct controller and its IP address in the project. Use "Compare and Download" to transfer the required *.ini files to the controller.
After a controller restart, compile the application and download it to the controller.
No remanent registers are used, so there is no need for a DA download for default values.
Once the program is started, you can try out the respective example using the setup "CamDisk.stxs" and the variable "g_nUseCase" and record it yourself in an oscilloscope.



The "CamDisk.zsxof" oscilloscope corresponds to the recordings shown here in the Application Note.

4.2 Activating the Cam Disc

The following function activates a cam disc:

```
<Techno>.Coupling.Cam.Activate(Axis, CamId, MasterOffset, FollowerOffset, MasterFactor, FollowerFac-
tor, StartMode, Position)
```

Parameters	Data type	Description
Axis	pointer to MCAxis	Follower axis for which a cam is to be activated
CamId	Int	Index of the cam disc to be activated
MasterOffset	double	Displacement of the cam disc in the direction of the master axis
FollowerOffset	double	Displacement of the cam disc in the direction of the follower axis
MasterFactor	double	Scaling of the cam disc in the direction of the master axis
FollowerFactor	double	Scaling of the cam disc in the direction of the follower axis
StartMode	<MCTechnoCamStartModes>	Activation method
Position	double	Master/follower axis position, depending on StartMode

Activation method <MCTechnoCamStart-Modes>		Description
Immediate	Immediately	The cam disc is activated immediately
AtCamEnd	At the end of the cam disc	At the end of the current cam disc, the new cam disc is activated
AtMasterPosition	At the master axis position	The cam is activated if the master axis exceeds the value specified as "position" parameter.
AtFollowerPosition	At the follower axis position	The cam is activated if the follower axis exceeds the value specified as "position" parameter.

4.3 Coupling to a Cam Disc

INFO

In contrast to an electrical gearbox, a cam follower axis is not coupled when the group is activated.

By using the coupling function <Techno>.Coupling.Couple(), the following 4 coupling modes are available, as in the case of the electrical gearbox:

1. Fast: "*MCTechnoCoupleModes.Fast*"
2. Waiting: "*MCTechnoCoupleModes.Wait*"
3. Immediately: "*MCTechnoCoupleModes.Immediate*"
4. Snapping-in immediately: "*MCTechnoCoupleModes.ImmediateSnap*"

These functions are applied in the same way as for the electrical gearbox.

- Please refer to the Application Note 050 *"Electrical gearbox* " chapter *"Using the electrical gearbox in the application program - Coupling*"

Observe the sequence for coupling the cam disc:

- Create the cam disc using "*Create*".
- Define the cam disc using "*DefineSegment*".
- Activating the cam disc using "*Activate*".

Coupling is possible only if a cam disc is activated.
The following command can be used to query whether the follower axis is coupling:

```
<Axis>.State.Techno.IsCoupling
```

The following command can be used to query whether the follower axis is coupled:

```
<Axis>.State.Techno.IsCoupled
```

4.3.1 Examples

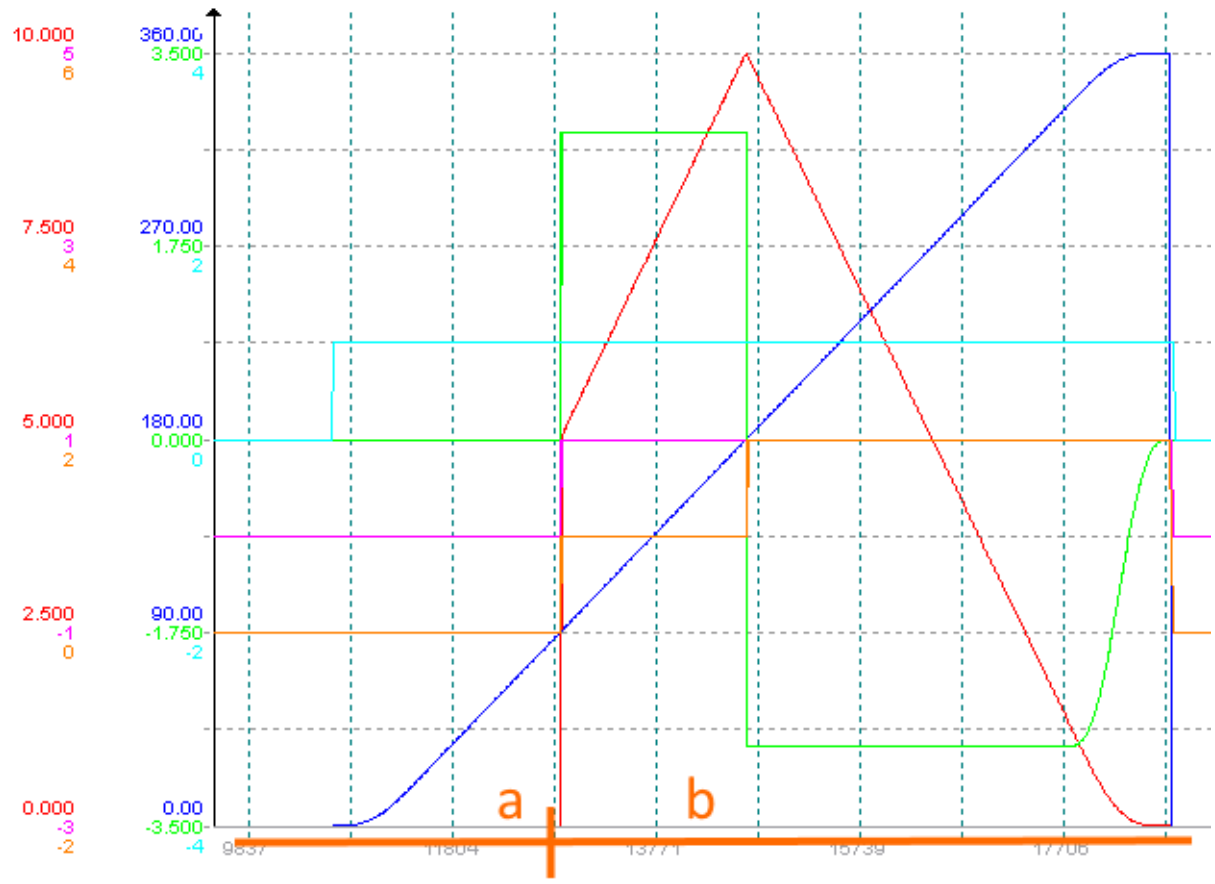
In the following examples, a cam disc is defined in which the follower axis follows linearly to 10 mm at 180° master axis, and returns linearly to the starting point up to 360°.
Oscilloscope legend:
Blue: Setpoint position of the master axis
Red: Setpoint position of the follower axis
Green: Setpoint velocity of the follower axis
Pink: Coupling status of the follower axis
Light blue: Number of the current cam profile
Orange: Number of the current cam segment

4.3.1.1 Coupling Immediately

g_nUseCase	coupleImmediate(1)

In this example, the follower axis with active cam disc 1 is coupled in "*MCTechnoCouple-Modes.immediate*" mode as soon as the master axis position of 90° is reached. According to the cam definition and activation parameters, the follower axis has a synchronous position of 5 mm. In this coupling mode, the axis jumps directly to the synchronous position.

```
function cCamDiskSample.coupleImmediate()

        createTriangleCam();

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual, 360.0, 50.0, 100.0, 100.0, 1.0);
        when vxMaster.Position.Setpoint > 90.0 continue;

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate, 0.0, Directions.Positive, 0.0);

        when tecCam.Mechanism.Slope.IsStopped continue;

end_function;
```



Phase a:

- Cam disc with ID "1" is defined and activated. The follower axis now uses this cam disc, so that the active number of the current cam segment is equal to "1".
- The master axis starts its positioning.
- Since the follower axis is neither positioned nor coupled, it rests at the current position.

Phase b:

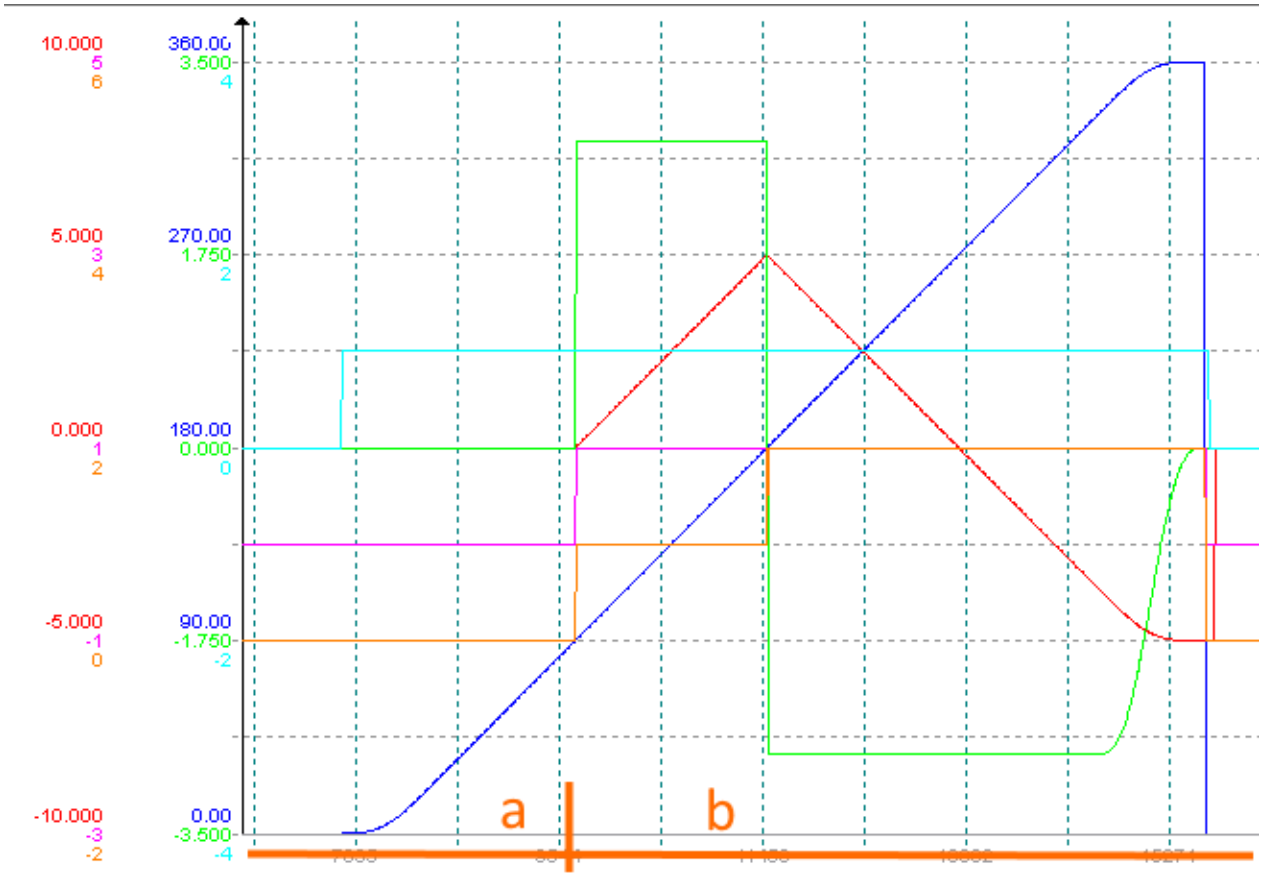
- The coupling command with coupling mode *"Immediate*" is executed.
- The follower axis jumps to the synchronous point and follows the cam disc.
- The velocity of the follower axis also jumps to the synchronous velocity without acceleration ramp.
- In the further course, the master axis finishes its positioning and the follower axis follows according to the cam disc. The deceleration of the master axis consequently also reduces the speed of the follower axis until it comes to a standstill.

4.3.1.2 Coupling in Immediate Snap Mode

g_nUseCase	coupleImmediateSnap (2)

In this example, the follower axis with active cam disc 1 is coupled in "*MCTechnoCoupleModes.immediateSnap*" mode as soon as the master axis position of 90° is reached. Although according to the cam disc definition and activation parameters the synchronous position would be 5 mm, the cam disc now starts directly at the current set position of the follower axis. This automatically generates an offset of the follower axis.

```
function cCamDiskSample.coupleImmediateSnap()

        createTriangleCam();

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual, 360.0, 50.0, 100.0, 100.0, 1.0);
        when vxMaster.Position.Setpoint > 90.0 continue;

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.ImmediateSnap, 0.0, Directions.Positive, 0.0);

        when tecCam.Mechanism.Slope.IsStopped continue;

end_function;
```



Phase a:

- Cam disc with ID "1" is defined and activated. The follower axis now uses this cam disc, so that the active number of the current cam segment is equal to "1".
- The master axis starts its positioning.
- Since the follower axis is neither positioned nor coupled, it rests at the current position.

Phase b:

- The coupling command with coupling mode *"ImmediateSnap*" is executed.

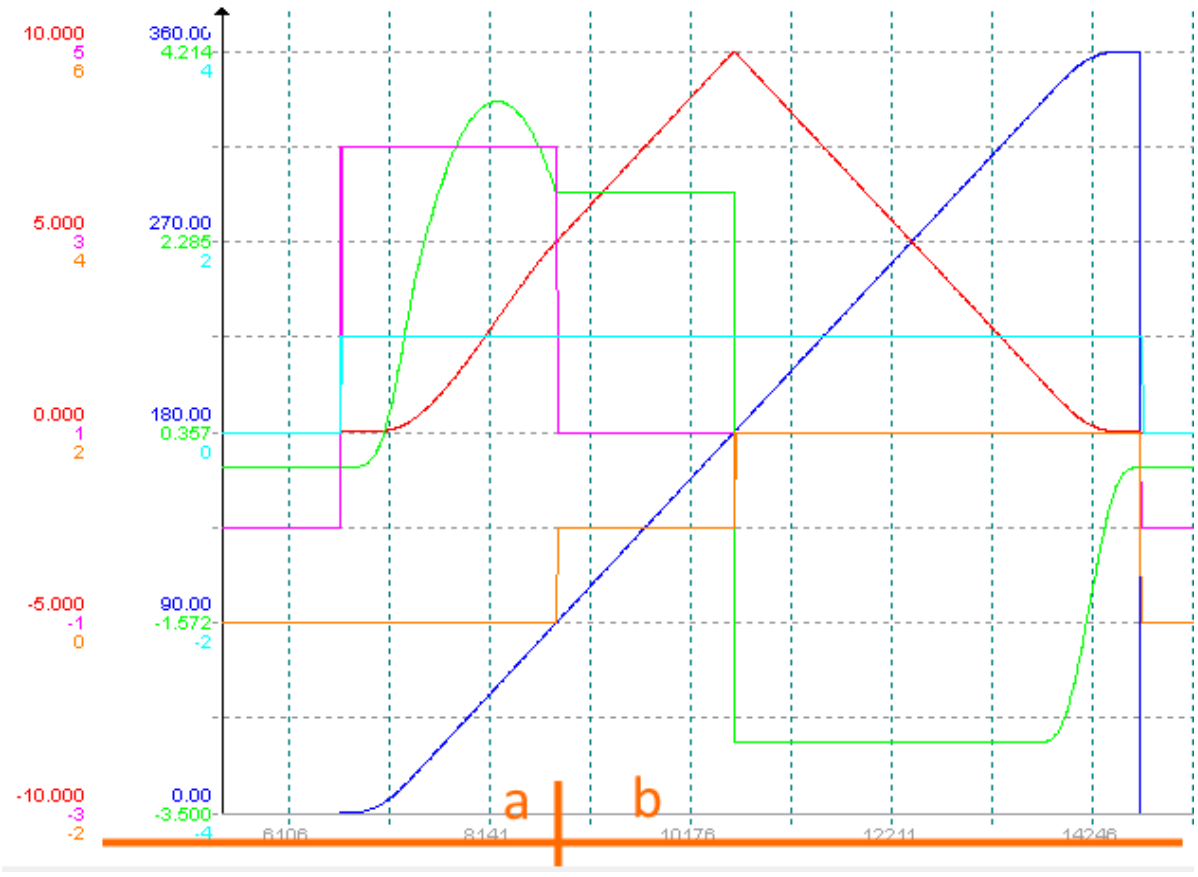
- The actual synchronous point within the cam disc is shifted to the current set position of the follower axis. This means that the follower axis does not jump to the synchronous position. The cam disc now moves with an offset.
- However, the speed of the follower axis jumps to the synchronous speed without acceleration ramp!
- In the further course, the master axis finishes its positioning and the follower axis follows according to the cam disc. The deceleration of the master axis consequently also reduces the speed of the follower axis until it comes to a standstill. In contrast to the example "CoupleImmediate", the follower axis stops according to the offset that occurred during coupling.

4.3.1.3 Coupling in Fast Mode

g_nUseCase	coupleFast (3)

In this example, the follower axis with active cam disc 1 is coupled in *"MCTechnoCoupleModes.Fast*" mode. Here, a coupling-in polynomial is applied so that the follower axis not only reaches the synchronous position at the coupling point, but also with the velocity defined by the cam disc.

```
function cCamDiskSample.coupleFast()

        createTriangleCam();

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Fast, 90.0, Directions.Positive, 0.0);

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual, 360.0, 50.0, 100.0, 100.0, 1.0);
        when tecCam.Mechanism.Slope.IsStopped continue;

end_function;
```



Phase a:

- Cam disc with ID "1" is defined and activated. The follower axis now uses this cam disc, so that the active number of the current cam segment is equal to "1".
- The master axis starts its positioning.
- The coupling command with coupling mode *"Fast*" is executed.
- The coupling status changes to "IsCoupling".
- The follower axis accelerates according to a coupling polynomial, so that it has arrived at the coupling point at synchronous position and synchronous velocity.

Phase b:

- The coupling status changes to "IsCoupled".
- Setpoint position and velocity of the follower axis do not jump.
- In the further course, the master axis finishes its positioning and the follower axis follows according to the cam disc. The deceleration of the master axis consequently also reduces the speed of the follower axis until it comes to a standstill. In contrast to the example "ImmediateSnap", the follower axis stops according to the offset that occurred during coupling.

4.4 Decoupling from a cam disc

As with the electrical gearbox, a cam follower axis is decoupled as follows:

- By starting a positioning motion:
  <Techno>.MovePtp.Start(…)
  <Techno>.MoveVelocity.Start(…)
- By using the "Decouple" command:
  <Techno>.Coupling.Decouple(…)
  By using the following decoupling modes:
  - Immediate_Stop
  - AtMasterPosition_Stop
  - Immediate_KeepVelocity

The following command can be used to query whether the follower axis is decoupling:
<Axis>.State.Techno.IsDecoupling
The following command can be used to query whether the follower axis is decoupled:
<Axis>.State.Techno.IsDecoupled

4.4.1 Samples

In the following examples, a cam disc is defined in which the follower axis follows linearly to 10 mm at 180° master axis, and returns linearly to the starting point up to 360°.

- Cam disc with ID "1" is defined and activated. The follower axis now uses this cam disc, so that the active number of the current cam segment is equal to "1".
- The coupling takes place immediately at the beginning.
- The coupling status changes to "IsCoupled".
- The master axis starts its positioning.

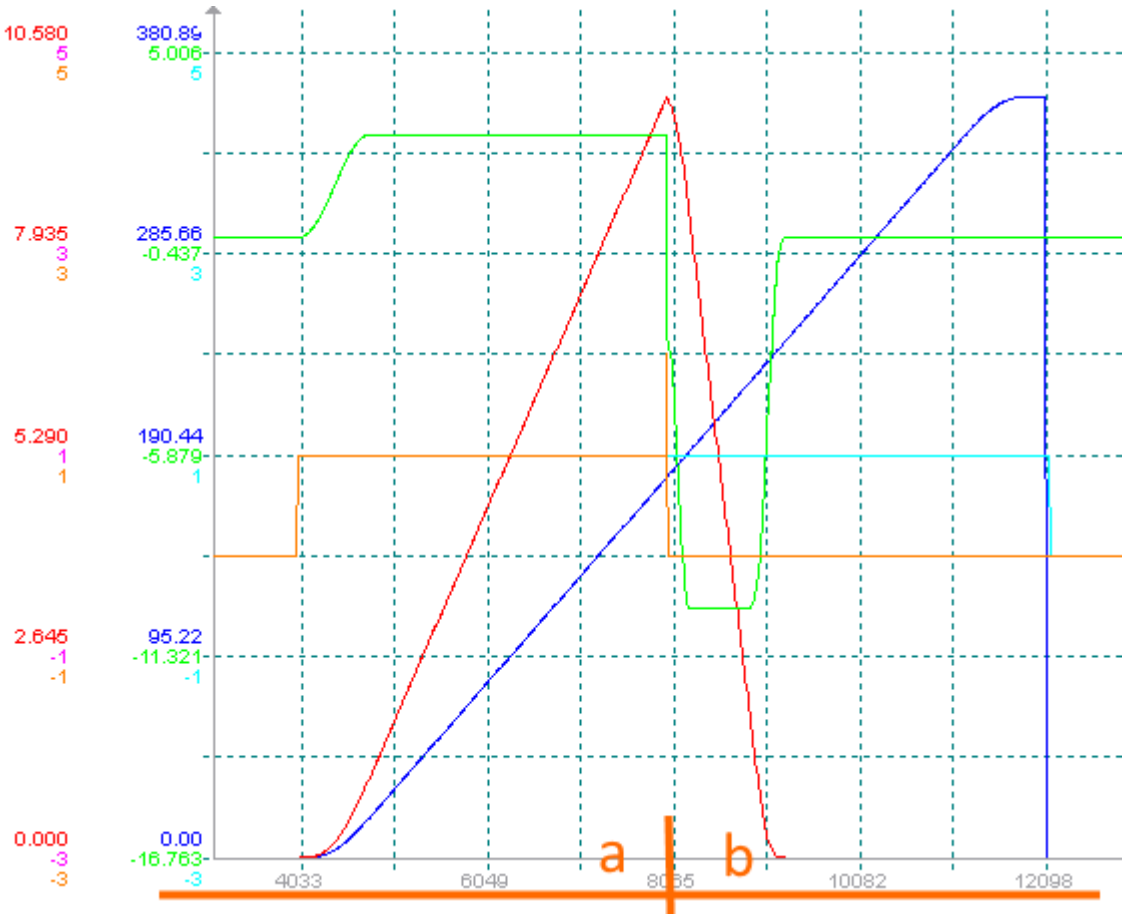
Oscilloscope legend:
Blue: Setpoint position of the master axis
Red: Setpoint position of the follower axis
Green: Setpoint velocity of the follower axis
Pink: Coupling status of the follower axis
Light blue: Number of the current cam profile
Orange: Number of the current cam segment

4.4.1.1 Decoupling with positioning using MovePtp

g_nUseCase	decoupleMovePtp (4)

In this example, the follower axis with active cam disc 1 is coupled. After the master axis has started to move, the follower axis is positioned endlessly using MovePtp. This causes the follower axis to be decoupled and it accelerates or decelerates to the target velocity.
After a short waiting time, the follower axis is positioned to the starting point.

```
function cCamDiskSample.decoupleMovePtp()

        createTriangleCam();

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate, 0.0, Directions.Positive, 0.0);
        when xFollower.State.Techno.IsCoupled continue;

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual, 360.0, 50.0, 100.0, 100.0, 1.0);
        delay(t#4000ms);

        tecCam.MovePtp.Start(xFollower, MCTechnoPositioningModes.AbsNormal, 0.0, 10.0, 50, 50, 1.0);

        when tecCam.Mechanism.Slope.IsStopped continue;
        when xFollower.Mechanism.Slope.IsStopped continue;

end_function;
```



Phase a:

- See general description.
- Until the end of phase a, the follower axis follows according to the cam disc.

Phase b:

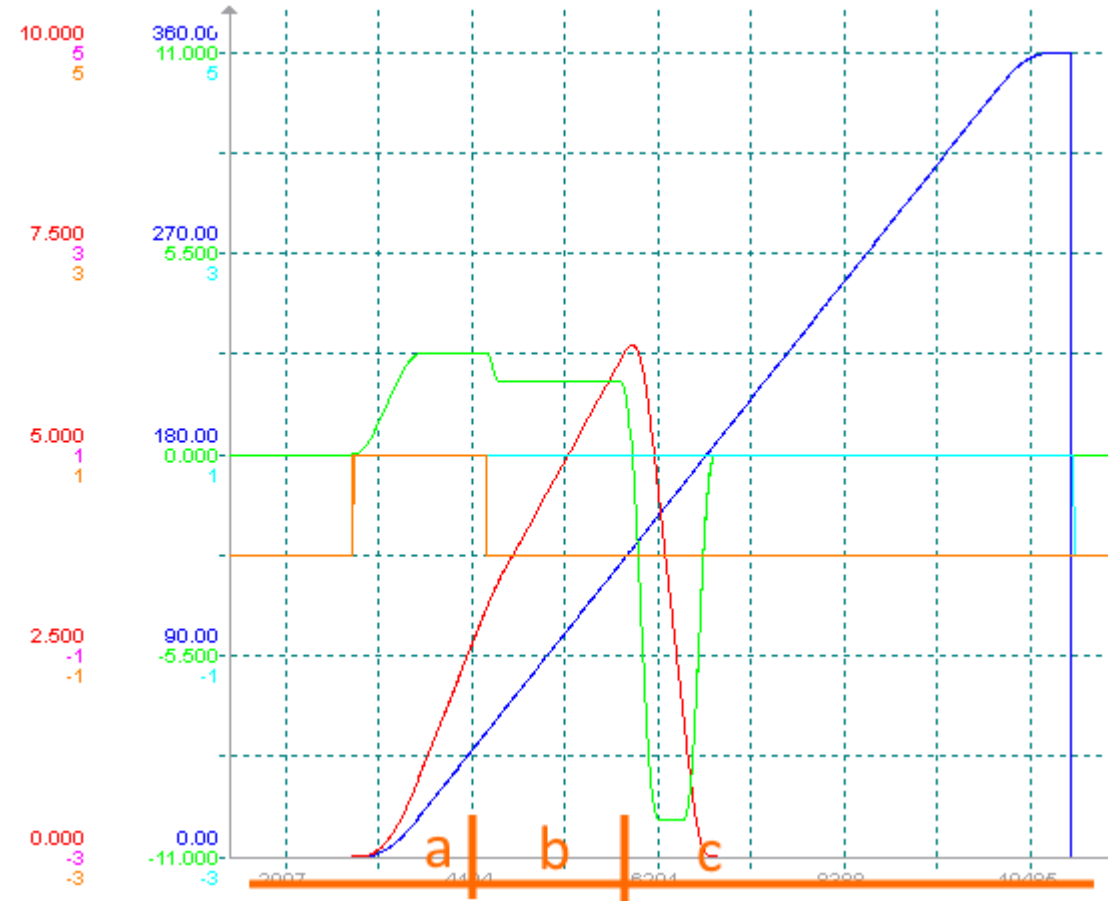
- It starts positioning to the starting position.
- The coupling status changes to "IsDecoupled".

4.4.1.2 Decoupling with endless positioning using MoveVelocity

g_nUseCase	decoupleMoveVelocity (5)

In this example, the follower axis with active cam disc 1 is coupled. After the master axis has started to move, the follower axis is positioned endlessly using MoveVelocity. This causes the follower axis to be decoupled and it accelerates or decelerates to the target velocity.
After a short waiting time, the follower axis is positioned to the starting point.

```
function cCamDiskSample.decoupleMoveVelocity()

        createTriangleCam();

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate, 0.0, Directions.Positive, 0.0);
        when xFollower.State.Techno.IsCoupled continue;

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual, 360.0, 50.0, 100.0, 100.0, 1.0);
        delay(t#1500ms);

        tecCam.MoveVelocity.Start(xFollower, Directions.Positive, 2.0, 10.0, 10.0);
        delay(t#1500ms);
        tecCam.MovePtp.Start(xFollower, MCTechnoPositioningModes.AbsNormal, 0.0, 10.0, 50.0, 50.0, 1.0);

        when tecCam.Mechanism.Slope.IsStopped continue;
        when xFollower.Mechanism.Slope.IsStopped continue;

end_function;
```



Phase a:

- See general description.
- Until the end of phase a, the follower axis follows according to the cam disc.

Phase b:

- An endless positioning is started. The follower axis accelerates/decelerates to the specified velocity.
- The coupling status changes to "IsDecoupled".

Phase c:

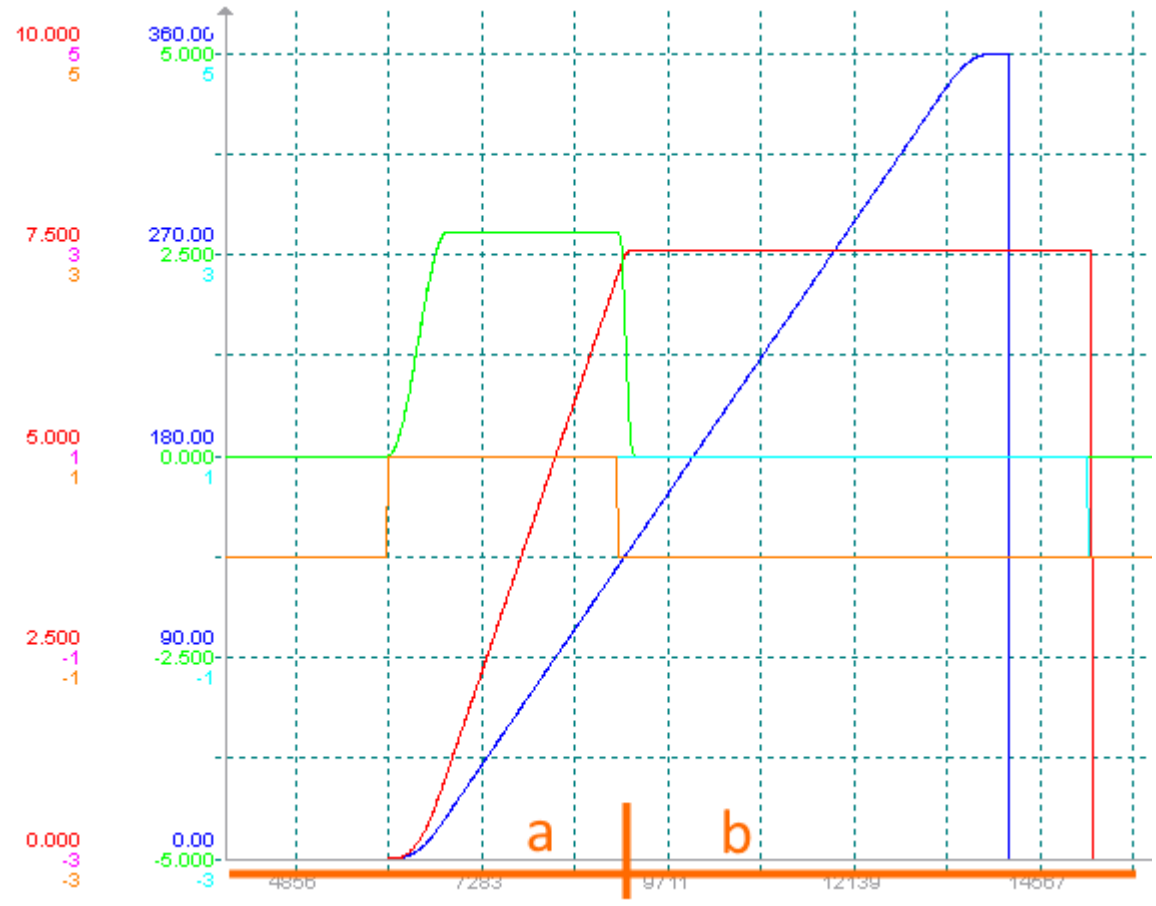
- It starts positioning to the starting position.
- Since the follower axis is already decoupled, this positioning has no effect on the coupling status.

4.4.1.3 Decoupling using the "Immediate_Stop" decoupling command

g_nUseCase	decoupleImmediateStop (6)

In this example, the follower axis with active cam disc 1 is coupled. After the master axis moves off and the follower axis follows according to the cam disc, in "AtMasterPosition_Stop" mode the follower axis is decoupled at the master axis position 270°. At this position, the follower axis decouples and stops with the specified deceleration.

```
function cCamDiskSample.decoupleImmediateStop()

        createTriangleCam();

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate, 0.0, Directions.Positive, 0.0);
        when xFollower.State.Techno.IsCoupled continue;

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual, 360.0, 50.0, 100.0, 100.0, 1.0);
        delay(t#3000ms);

        tecCam.Coupling.Decouple(xFollower, MCTechnoDecoupleModes.Immediate_Stop, 0.0, 25.0);

        when xFollower.State.Techno.IsDecoupled continue;
        when tecCam.Mechanism.Slope.IsStopped continue;
        when xFollower.Mechanism.Slope.IsStopped continue;
        delay(t#1000ms);

end_function;
```



Phase a:

- See general description.
- Until the end of phase a, the follower axis follows according to the cam disc.

Phase b:

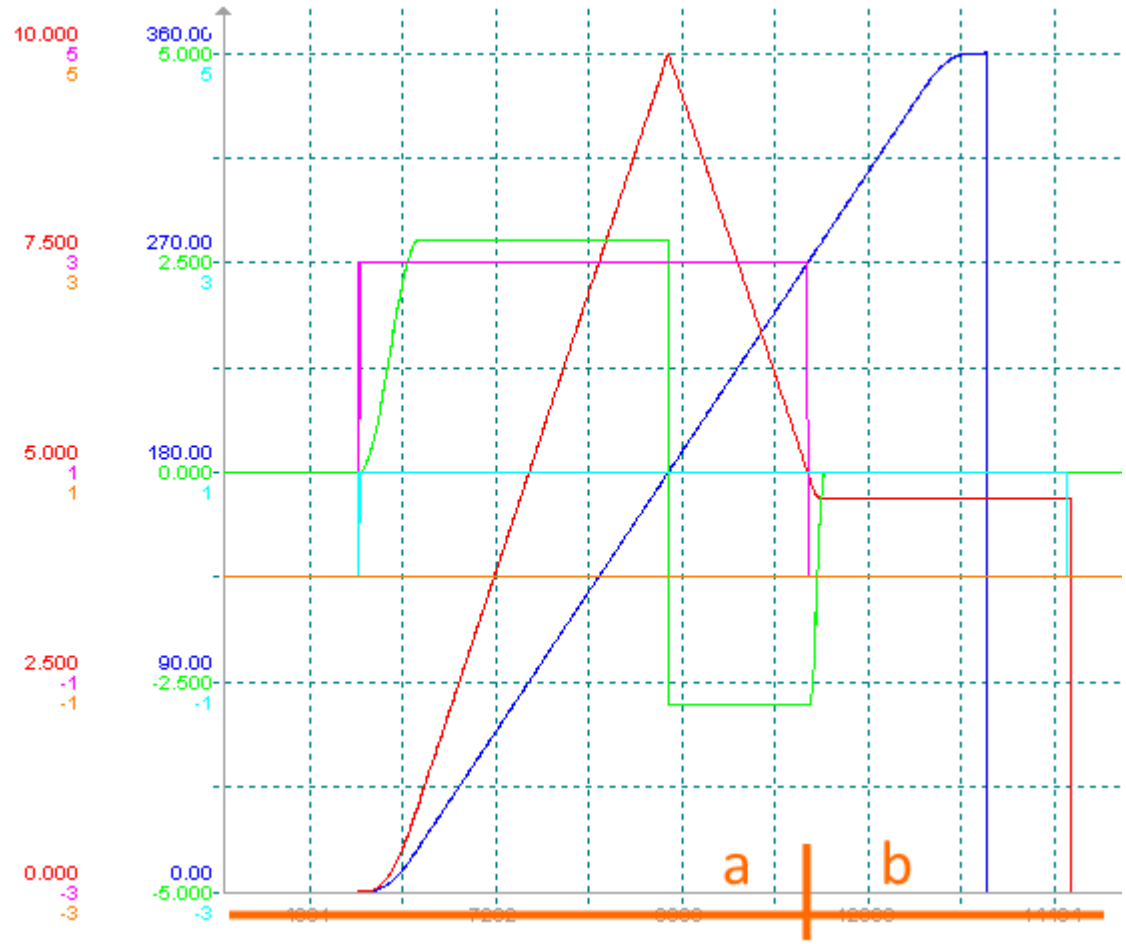
- As a result of the decoupling command the follower axis is decoupled in "Immediate_Stop" mode.
- The coupling status changes to "IsDecoupled".
- The follower axis stops with the specified deceleration.

4.4.1.4 Decoupling at master axis position and stopping using the "Immediate_Stop" decoupling command

g_nUseCase	decoupleAtMasterPostionStop (7)

In this example, the follower axis with active cam disc 1 is coupled. After the master axis moves off and the follower axis follows according to the cam disc, in "AtMasterPosition_Stop" mode the follower axis is decoupled at the master axis position 270°. At this position, the follower axis decouples and stops with the specified deceleration.

```
function cCamDiskSample.decoupleAtMasterPostionStop()

        createTriangleCam();

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate, 0.0, Directions.Positive, 0.0);
        when xFollower.State.Techno.IsCoupled continue;

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual, 360.0, 50.0, 100.0, 100.0, 1.0);


        tecCam.Coupling.Decouple(xFollower, MCTechnoDecoupleModes.AtMasterPosition_Stop, 270.0, 25.0);

        when xFollower.State.Techno.IsDecoupled continue;
        when tecCam.Mechanism.Slope.IsStopped continue;
        when xFollower.Mechanism.Slope.IsStopped continue;
        delay(t#1000ms);

end_function;
```



Phase a:

- See general description.
- Until the end of phase a, the follower axis follows according to the cam disc.
- The decoupling command is given directly at the beginning of the movement in the mode "AtMasterPosition_Stop". The follower axis is decoupled at master axis position 270°.
- The coupling status is now "decoupling".

Phase b:

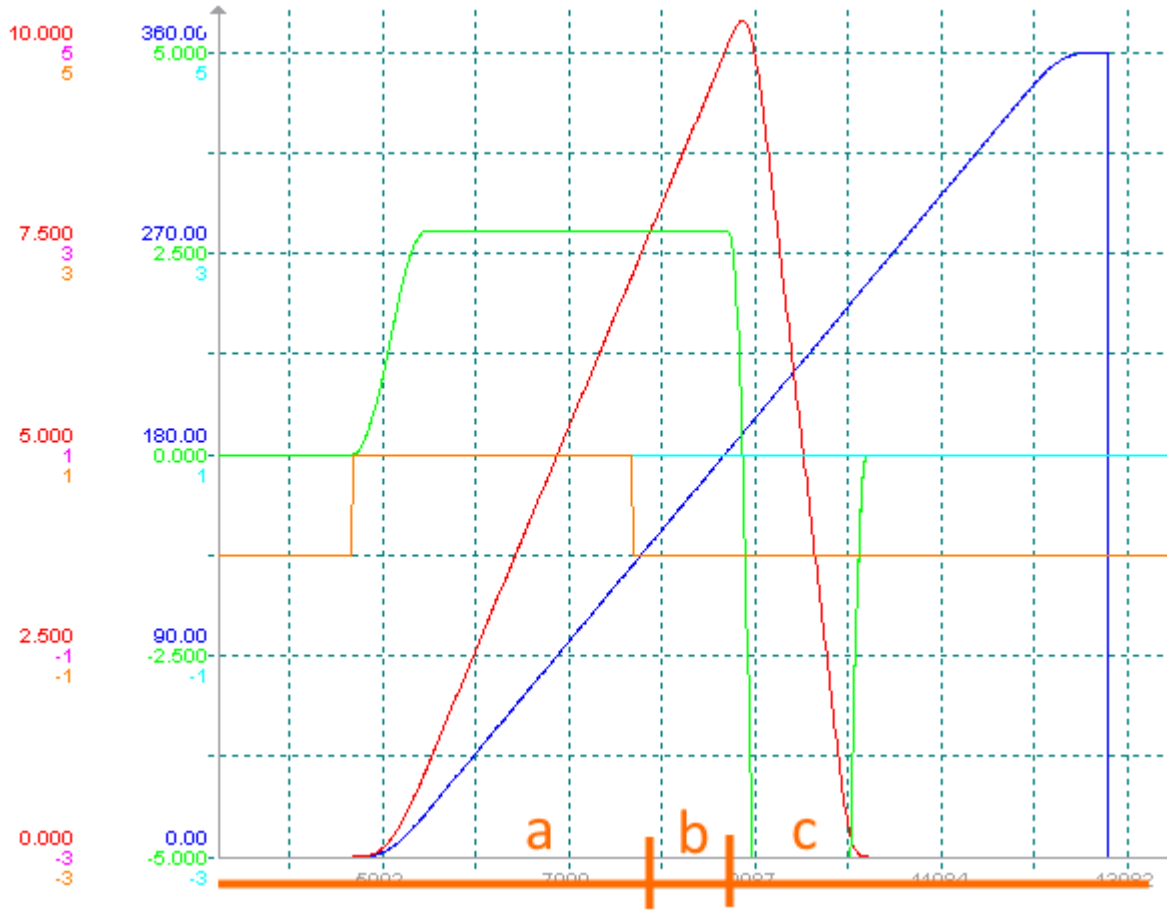
- The master axis position specified in the decoupling command has been reached.
- The coupling status changes to "IsDecoupled".
- The follower axis stops with the specified deceleration.

4.4.1.5 Decoupling using the "Immediate_KeepVelocity" decoupling command

g_nUseCase	decoupleImmediateKeepVelocity (8)

In this example, the follower axis with active cam disc 1 is coupled. After the master axis has moved for some time and the follower axis is following the cam disc accordingly, the system is decoupled in the "Immediate_KeepVelocity" mode. The follower axis now continues to move at the last active speed for a short time until it returns to its starting point with a +positioning.

```
function cCamDiskSample.decoupleImmediateKeepVelocity()

        createTriangleCam();

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate, 0.0, Directions.Positive, 0.0);
        when xFollower.State.Techno.IsCoupled continue;

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual, 360.0, 50.0, 100.0, 100.0, 1.0);
        delay(t#3000ms);

        tecCam.Coupling.Decouple(xFollower, MCTechnoDecoupleModes.Immediate_KeepVelocity, 0.0, 25.0);

        when xFollower.State.Techno.IsDecoupled continue;
        delay(t#1000ms);
        tecCam.MovePtp.Start(xFollower, MCTechnoPositioningModes.AbsNormal, 0.0, 10.0, 50.0, 50.0, 1.0);


        when tecCam.Mechanism.Slope.IsStopped continue;
        when xFollower.Mechanism.Slope.IsStopped continue;
        delay(t#1000ms);

end_function;
```



Phase a:

- See general description.
- Until the end of phase a, the follower axis follows according to the cam disc.

Phase b:

- As a result of the decoupling command the follower axis is decoupled in "Immediate_KeepVelocity" mode.
- The coupling status changes to "IsDecoupled".
- The follower axis continues to move at the last velocity used.

Phase c:

- It starts positioning to the starting position.
- Since the follower axis is already decoupled, this positioning has no effect on the coupling status.

4.5 Switching between cam discs

To switch from one cam disc to another just activate a previously defined cam disc. The new cam becomes active depending on the selected "MCTechnoCamStartModes" activation mode.

INFO

When switching to another cam disc, pay attention to the transition process. No transition polynomial is used. If the positions do not match at the time of the transition, the follower axis jumps to the target position of the new cam disc.

For a smooth movement, position, velocity, acceleration, jerk should be identical at the time of transition.
The easiest time to switch is at a point in time,
- when the follower axis is at standstill
- at the end of a cam disc with known boundary parameters.

4.5.1 Buffering of activations

The activation of a cam disc is not buffered and processed in sequence. It is always the last activation that counts.
If, for example, a command is issued for activating at the master axis position 200°, the MC kernel now waits until this position is reached.

```
tecCam.Coupling.Cam.Activate(xFollower, 1, 0.0, 0.0, 1.0, 1.0, MCTechnoCamStart-
Modes.AtMasterPosition, 200.0);
```

However, if a command is issued for activation at the master axis position 300°, e.g. at the master axis position 180°, the MC kernel now executes this command.

```
tecCam.Coupling.Cam.Activate(xFollower, 1, 0.0, 0.0, 1.0, 1.0, MCTechnoCamStart-
Modes.AtMasterPosition, 300.0);
```

Switching between cams discs at 200° will not take place.
However, if it is absolutely necessary to switch cams at 200°, this must be explicitly taken into account in the program, e.g. by querying the active cam index or by querying whether the master axis position has been exceeded, etc..
When a pending cam activation is replaced by a new activation, a message is output in the Setup->MC-GlobalStatus->Status logger.

4.5.2 Examples

In the following examples, two cam discs are defined.
With cam disc 1, the follower axis travels linearly from (0°, 0 mm) to (180°, 10 mm) and then returns to the starting point (360°, 0 mm).
Cam disc 2 is identical to cam disc 1 except for the segment type. Here, the segment type is "Autopoly3". In the supporting points the 1st derivative is 0.

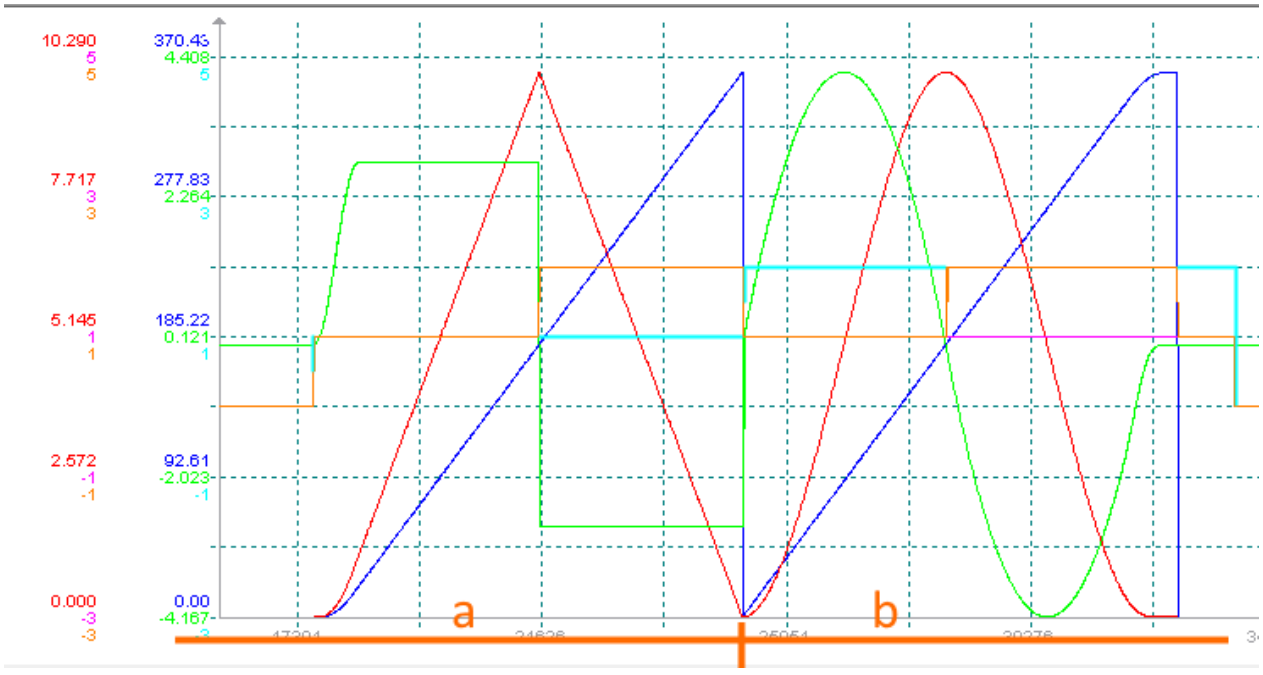
- Cam disc with ID "1" is defined and activated. The follower axis now uses this cam disc, so that the active number of the current cam segment is equal to "1".
- Cam disc 2 with the ID "2" is defined.
- The coupling takes place immediately at the beginning.
- The coupling status changes to "IsCoupled".
- The master axis starts its positioning.

4.5.2.1 Switching at the end of a cam disc

g_nUseCase	switchAtCamEnd (9)

In this example, the follower axis is coupled in. After the master axis starts moving, a new cam is activated in such a way that it starts at the end of the current cam disc.

```
function cCamDiskSample.switchAtCamEnd()

        createTriangleCam();
        createPoly3Cam();

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate, 0.0, Directions.Positive, 0.0);
        when xFollower.State.Techno.IsCoupled continue;

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual, 720.0, 50.0, 100.0, 100.0, 1.0);
        tecCam.Coupling.Cam.Activate(xFollower, 2, 0.0, 0.0, 1.0, 1.0, MCTechnoCamStartModes.AtCamEnd);

        when tecCam.Mechanism.Slope.IsStopped continue;
        delay(t#1000ms);

end_function;
```



Phase a:

- See the general description of the examples for switching between cam discs.
- The master axis is positioned so that it passes through two modulo ranges.
- The follower axis follows the master axis according to cam disc 1.
- During this, cam disc 2 is activated which is to take effect at the end of the current cam disc.

Phase b:

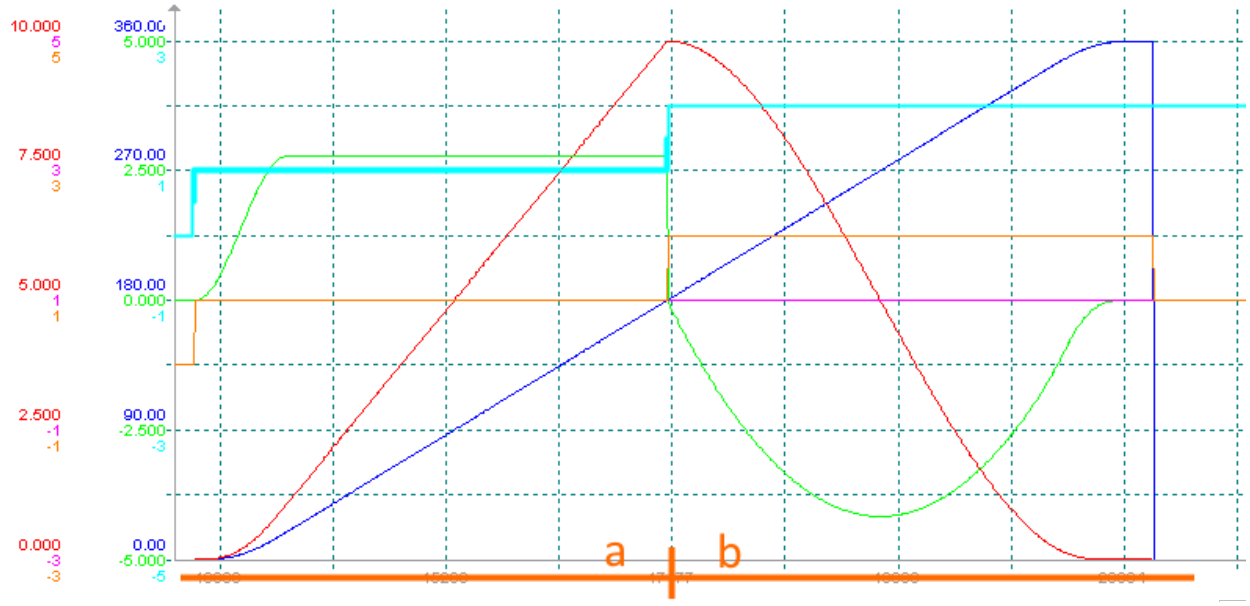
- Cam disc 1 ends at 360° of the master axis.
- Therefore, switching between the cam disc takes place at the modulo wrap.
- From now on, cam disc 2 is active.
- The number of the current cam profile switches from 1 to 2.

4.5.2.2 Switching to a specified master axis position

g_nUseCase	switchAtMasterposition (10)

In this example, the follower axis is coupled in. After the master axis starts moving, a new cam is activated in such a way that it starts at master axis position 180°.

```
function cCamDiskSample.switchAtMasterposition()

        createTriangleCam();
        createPoly3Cam();

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate, 0.0, Directions.Positive, 0.0);
        when xFollower.State.Techno.IsCoupled continue;

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual, 360.0, 50.0, 100.0, 100.0, 1.0);
        tecCam.Coupling.Cam.Activate(xFollower, 2, 0.0, 0.0, 1.0, 1.0,
                MCTechnoCamStartModes.AtMasterPosition, 180.0);
        when tecCam.Mechanism.Slope.IsStopped continue;
        delay(t#1000ms);

end_function;
```



Phase a:

- See the general description of the examples for switching between cam discs.
- The master axis is positioned so that it passes through one modulo range.
- The follower axis follows the master axis according to cam disc 1.
- During this process, cam disc 2 is activated in such a way that it becomes effective at the master axis position 180°.

Phase b:

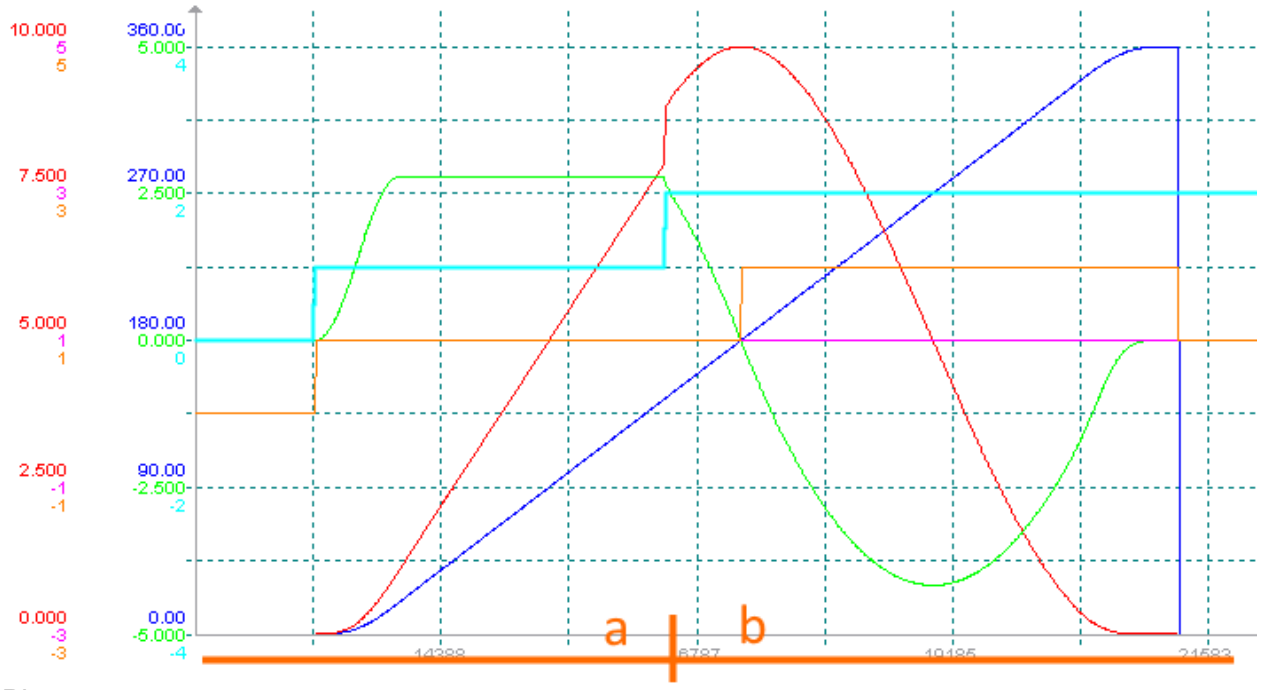
- Cam disk 2 becomes active at the master axis position 180°.
- The number of the current cam profile switches from 1 to 2.
- Whereas in phase 1 a linear progression could be seen, it is now polynomial.

4.5.2.3 Switching to a specified follower axis position

g_nUseCase	switchAtFollowerposition (11)

In this example, the follower axis is coupled in. After the master axis starts moving, a new cam is activated in such a way that it starts when the follower axis position 8 mm is reached.

```
function cCamDiskSample.switchAtFollowerposition()

        createTriangleCam();
        createPoly3Cam();

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate, 0.0, Directions.Positive, 0.0);
        when xFollower.State.Techno.IsCoupled continue;

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelTarget, 360.0, 50.0, 100.0, 100.0, 1.0);
        when tecCam.State.IsRunning continue;
        tecCam.Coupling.Cam.Activate(xFollower, 2, 0.0, 0.0, 1.0, 1.0,
                MCTechnoCamStartModes.AtFollowerPosition, 8.0);
        when tecCam.Mechanism.Slope.IsStopped continue;
        delay(t#1000ms);


end_function;
```



Phase a:

- See the general description of the examples for switching between cam discs.
- The master axis is positioned so that it passes through one modulo range.
- The follower axis follows the master axis according to cam disc 1.
- During this, cam 2 is activated so that it becomes effective when the follower axis position 8 mm is exceeded.

Phase b:

- The cam switches at follower axis position 8 mm.
- The number of the current cam profile switches from 1 to 2.
- Whereas in phase 1 a linear progression could be seen, it is now polynomial.

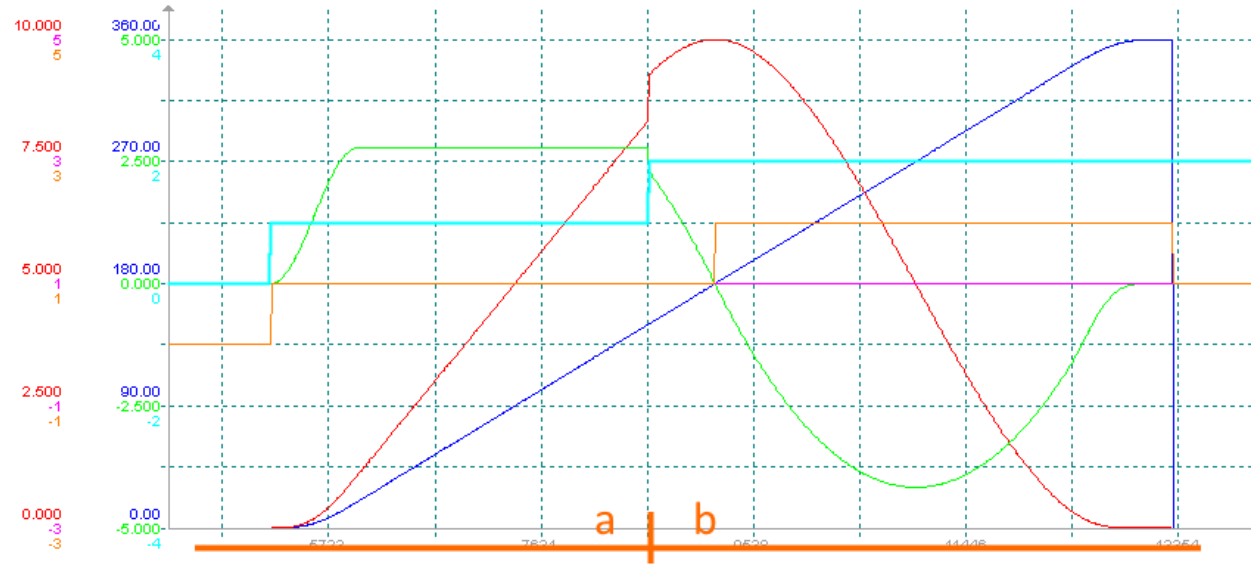
- Since, according to cam disc 2, the follower axis is at a different position than in cam disc 1, the follwer axis jumps to the new valid nominal position.
  A superimposed transition movement does not take place.

4.5.2.4 Switching immediately

g_nUseCase	switchImmediate (12)

In this example, the follower axis is coupled in. After the master axis reaches the position 150°, the cam disc 2 is started immediately.

```
function cCamDiskSample.switchImmediate()

        createTriangleCam();
        createPoly3Cam();

        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate, 0.0, Directions.Positive, 0.0);
        when xFollower.State.Techno.IsCoupled continue;

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual, 360.0, 50.0, 100.0, 100.0, 1.0);

        when vxMaster.Position.Setpoint > 150.0 continue;

        tecCam.Coupling.Cam.Activate(xFollower, 2, 0.0, 0.0, 1.0, 1.0, MCTechnoCamStartModes.Immediate);

        when tecCam.Mechanism.Slope.IsStopped continue;
        delay(t#1000ms);

end_function;
```



Phase a:

- See the general description of the examples for switching between cam discs.
- The master axis is positioned so that it passes through one modulo range.
- The follower axis follows the master axis according to cam disc 1.

Phase b:

- The cam switches at the master axis position 150° (any position in the application program).
- The number of the current cam profile switches from 1 to 2.
- Whereas in phase 1 a linear progression could be seen, it is now polynomial.

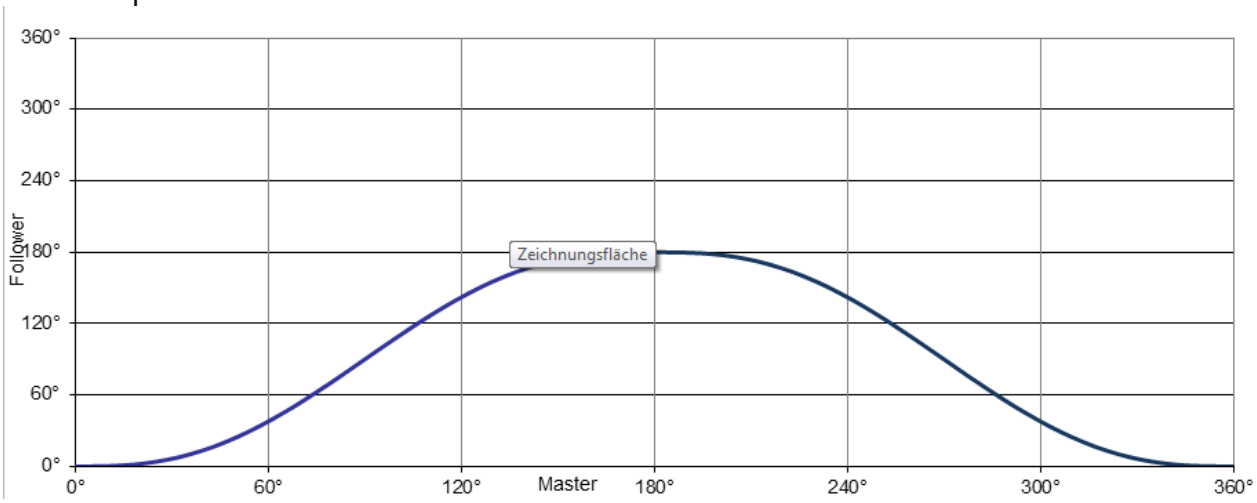
- Since, according to cam disc 2, the follower axis is at a different position than in cam disc 1, the follower axis jumps to the new valid nominal position.
  A superimposed transition movement does not take place.

4.6 Open/closed cam discs

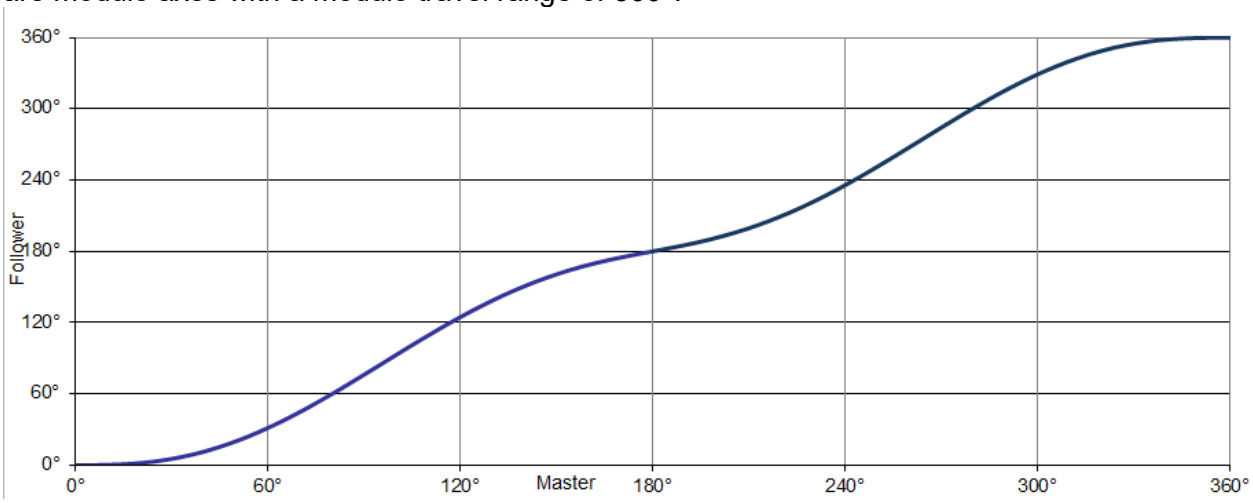
4.6.1 Closed cam disc

- The cam disc extends over the travel range of the master axis.
- The boundary parameters at the start and end of the cam are identical.
- The follower axis position at the beginning and end are identical.
  - Modulo follower axes are also closed cam discs if the difference between start and end positions is n times the modulo range.
    - Example: Modulo range 360°, starting position 0°, end position 720°.
    - Scaling with the follower axis factor can create an open cam disc from this cam!

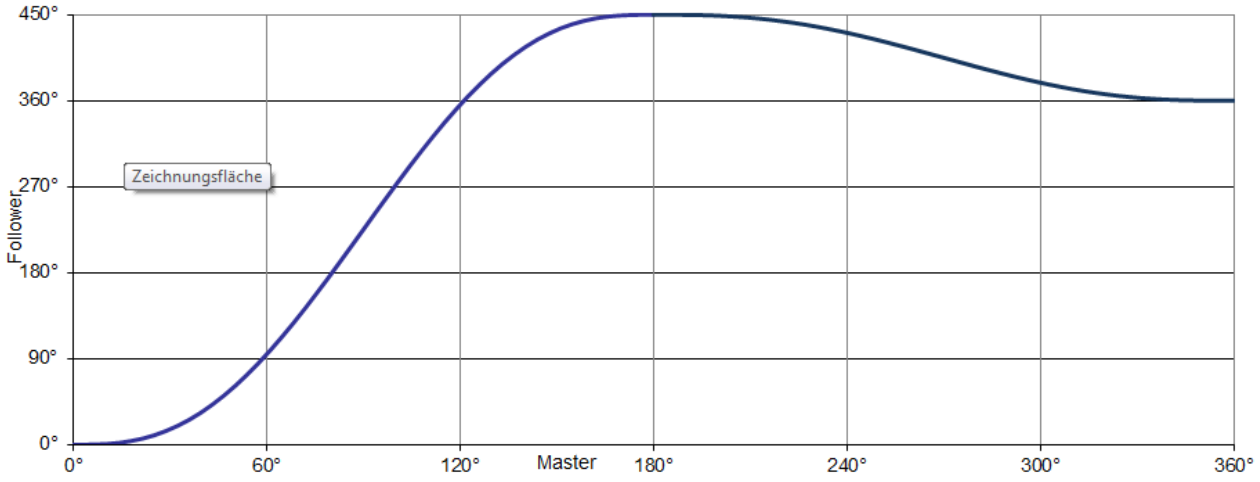
Example of a closed cam disc: Master axis range 360°. Start and end points of the follower axis at the same position.



Example of a closed cam: Travel range of master and follower axis 360°. Master and follower axes are modulo axes with a modulo travel range of 360°.



Example of a closed cam disc: Travel range of master and follower axis 360°. Master and follower axes are modulo axes with a modulo travel range of 360°. Even if the follower axis range is exceeded within the cam disc, the cam ends at the travel limit of the follower axis.



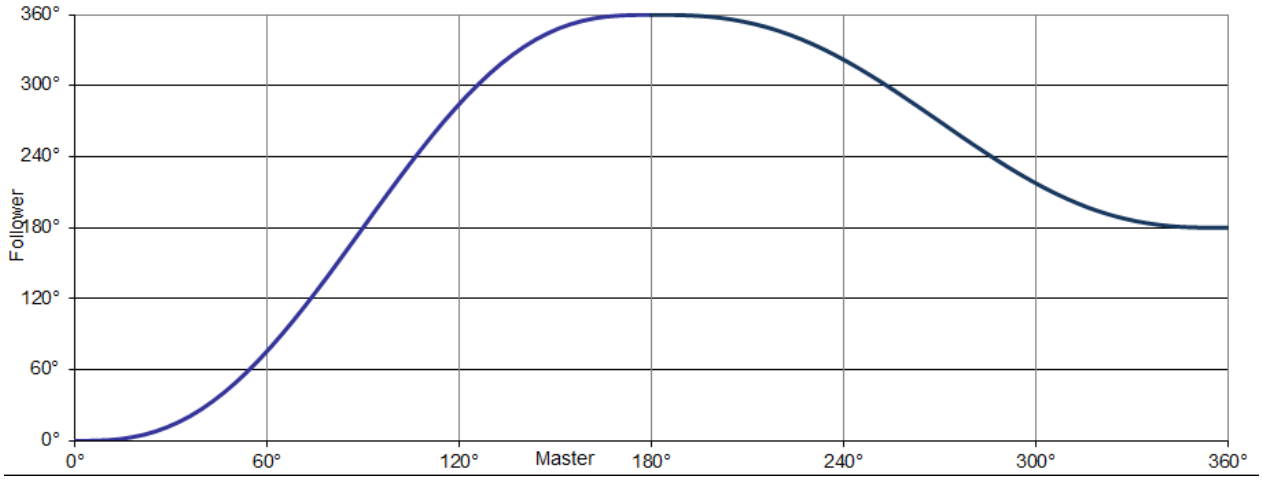
4.6.2 Open cam disc

- Start and end positions of the follower axis are different.
  - If the follower axis is also a modulo axis, scaling with the following axis factor can create a closed cam disc from an open one!

INFO

With open cams, special attention must be paid to the coupling time when coupling for the first time:
If the master axis is only slightly in front of the actual start position, then the MC kernel assumes that the master axis has passed through the modulo range. This results in a position difference here. This position difference becomes effective immediately and can lead to jumps of the follower axis.

Example of an open cam disc: Master axis range 360°, start and end points of the cam are different. The next time the cam is traversed, it will start at 180° in this example.



4.7 Partially defined cam discs

Partially defined cam discs are cams that are not defined over the full master axis range. For such cams we recommend to use the " User-defined master axis range (MCTechnoCam-Options.UserCamRange)" option.

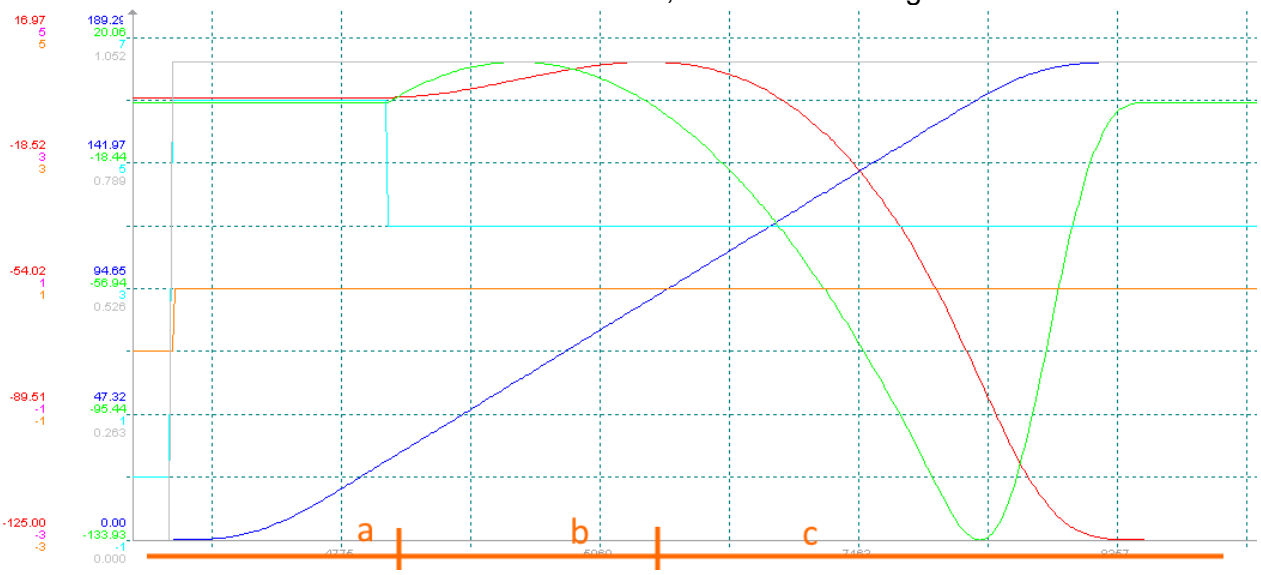
4.7.1 Example 1

g_nUseCase	runPartCam1 (14)

The follower axis is to travel along a special cam disc in the range from 30° to 90°. Consequently, the cam disc is defined only in this area.

```
function cCamDiskSample.createPartCam1()

        tecCam.Coupling.Cam.Create(xFollower, 4, 1);
        tecCam.Coupling.Cam.DefineSegment(xFollower, 4, 1, MCTechnoCamSegmentTypes.AutoPoly3rd,
                30.0,
                MCTechnoCamOptions.NoOption,
                0.0,
                0.0,
                60.0,
                10.0
        );

end_function;
```

Since no user-defined master axis range is specified here, for the MC the cam disc starts at 30°, but goes back to 30° over the full master axis range of 360°. In the master axis range from 30° to 90°, the follower axis also moves from 0 to 10 mm as required. However, if the cam disc remains active while the master axis moves further than 90°, then an increasing movement results.



Phase a:

- Up to master axis position 30°, the follower axis does not move, since only a standstill is defined in the active cam disc.

Phase b:

- The partially defined cam disc is activated. The axis moves as defined in the cam disc. The follower axis starts at 0 mm and moves up to 10 mm at master axis position 90°.

Phase c:

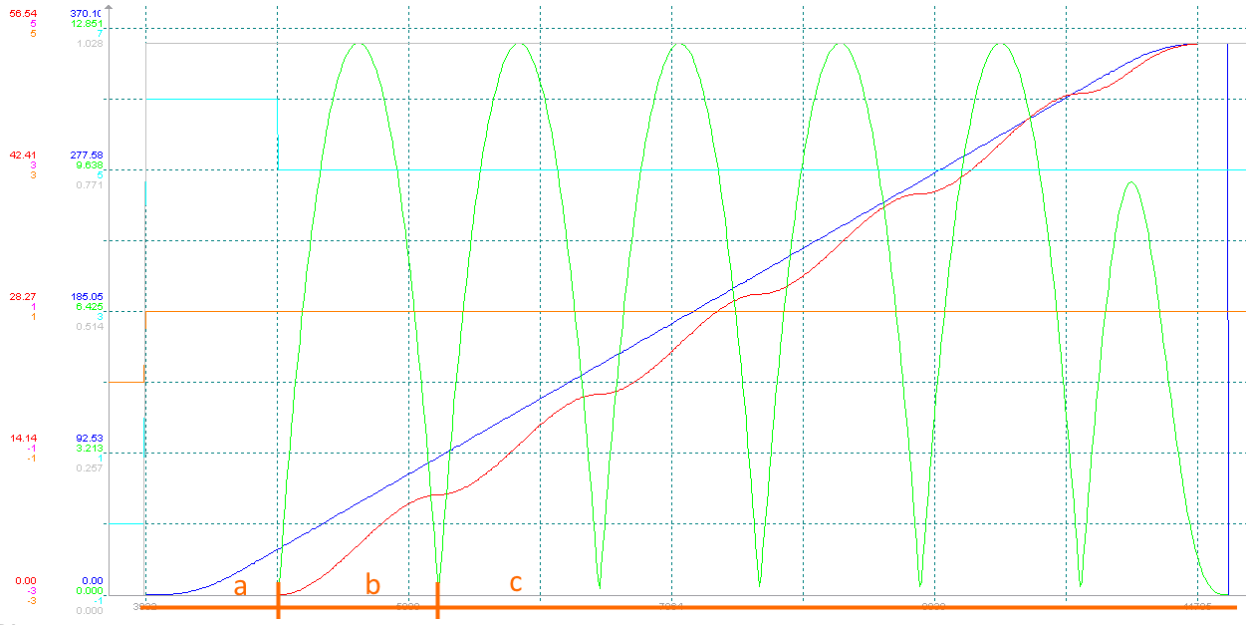
- The partially defined cam disc is still active.
- In this example, the follower axis now moves faster and faster in the negative direction.
- If the master axis would not stop in time, the follower axis would travel to the traversing limit and stop with an error.
- With real axes, however, a drive error with overspeed or following error would most likely occur first!

4.7.2 Example 2

g_nUseCase	runPartCam2 (15)

The follower axis is to travel along a special cam disc in the range from 30° to 90°. Consequently, the cam disc is defined only in this area. In contrast to example 1, a user-defined master axis range is used.

```
function cCamDiskSample.createPartCam2()

        tecCam.Coupling.Cam.Create(xFollower, 5, 1);
        tecCam.Coupling.Cam.DefineSegment(xFollower, 5, 1, MCTechnoCamSegmentTypes.AutoPoly3rd,
                30.0,
                MCTechnoCamOptions.UserCamRange,
                0.0,
                0.0,
                60.0,
                10.0,,,,,,,
                60.0
        );

end_function;
```



Phase a:

- Up to master axis position 30°, the follower axis does not move, since only a standstill is defined in the active cam disc.

Phase b:

- The partially defined cam disc is activated. The axis moves as defined in the cam disc. The follower axis starts at 0 mm and moves up to 10 mm at master axis position 90°.

Phase c:

- The partially defined cam disc is still active.
- The user-defined master axis range now causes the active cam disc to be repeatedly appended.

4.8 Normalized cam discs

Normalized cam discs are those where the follower axis is normalized to "1" in the cam disc definition. Usually, these travel across the complete travel range of the master axis on the master axis side. But depending on the application, they can also be normalized to "1", for example.
If it is planned to use a scaling factor not equal to 1.0 on the master axis side, in defining the cam disc the first segment must be defined with the option "MCTechnoCam-Options.UserDefinedMasterCamRange" and the desired master axis range must be specified.

```
function cCamDiskSample.createNormalizedCam ()

	tecCam.Coupling.Cam.Create(xFollower, 3, 2);
	tecCam.Coupling.Cam.DefineSegment(xFollower, 3, 1, MCTechnoCamSegmentTypes.AutoPoly3rd,
		0.0,
		MCTechnoCamOptions.UserDefinedMasterCamRange,
		0.0,
		0.0,
		180.0,
		1.0,
		,,,,,,
		360.0		// User-defined cam range
	);
	tecCam.Coupling.Cam.DefineSegment(xFollower, 3, 2, MCTechnoCamSegmentTypes.AutoPoly3rd,
		180.0,
		MCTechnoCamOptions.NoOption,
		-180.0,
		1.0,
		180.0,
		-1.0
	);
end_function;
```

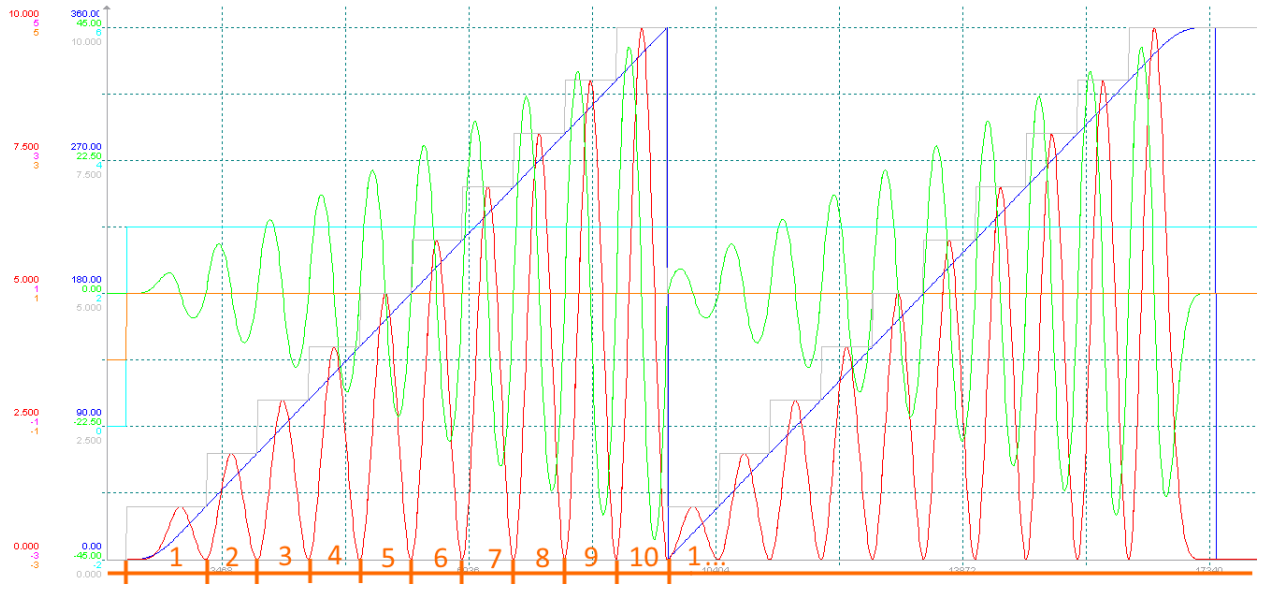
Example

g_nUseCase	runNormalizedCam (13)

In the following example, the above cam disc is defined and traversed ten times within a travel range of the master axis.

- Since a travel range of the master axis of 360° is used when the cam disc is defined, the master axis factor is set to 0.1 at activation.
- The follower axis factor is increased by 1 step by step, so that the follower axis has a stroke of 1 mm in the first pass and 10 mm in the 10th pass.
- For correct processing, the corresponding master axis offset must also be set to the respective starting point.
- The "MCTechnoCamStartModes.AtCamEnd" option starts a cam disc at the end of the current cam, but it does not append it. Therefore, care must be taken to ensure correct transfer of the master axis offset.
- To detect that a cam disc switch or a new follower axis factor is valid, the factor must be queried. The progression condition must be adapted to the requirements of the respective application.

```
function cCamDiskSample.runNormalizedCam()

var
        dFollowerFactor: double;
        dMasterOffset:   double;
end_var;

        createNormalizedCam();

        dFollowerFactor := 1.0;
        tecCam.Coupling.Cam.Activate(
                xFollower, 3,
                0.0, 0.0, 0.1, dFollowerFactor,
                MCTechnoCamStartModes.Immediate
        );
        tecCam.Coupling.Couple(xFollower, MCTechnoCoupleModes.Immediate, 0.0, Directions.Positive, 0.0);
        when xFollower.State.Techno.IsCoupled continue;

        tecCam.MovePtp.Start(vxMaster, MCTechnoPositioningModes.RelActual,720.0, 50.0, 100.0, 100.0, 1.0);
        when tecCam.State.IsRunning continue;

        repeat
                when xFollower.State.Techno.Cam.FollowerFactor == dFollowerFactor then
                        dFollowerFactor += 1.0;
                        if dFollowerFactor > 10.0 then
                                dFollowerFactor := 1.0;
                        end_if;
                        dMasterOffset := (dFollowerFactor - 1.0) * 36.0;
                        tecCam.Coupling.Cam.Activate(
                                xFollower, 3,
                                dMasterOffset, 0.0, 0.1, dFollowerFactor,
                                MCTechnoCamStartModes.AtCamEnd
                        );
                else_when tecCam.Mechanism.Slope.IsStopped then
                end_when;
        until tecCam.Mechanism.Slope.IsStopped
        end_repeat;

        when tecCam.Mechanism.Slope.IsStopped continue;
        delay(t#1000ms);

end_function;
```



Phase 1 ... 10:

- The follower axis moves along the cam disc with increasing amplitude.
- The number of the current cam profile does not change and remains at 3.
- With each pass, the active follower axis factor changes by 1 from 1 to 10.

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