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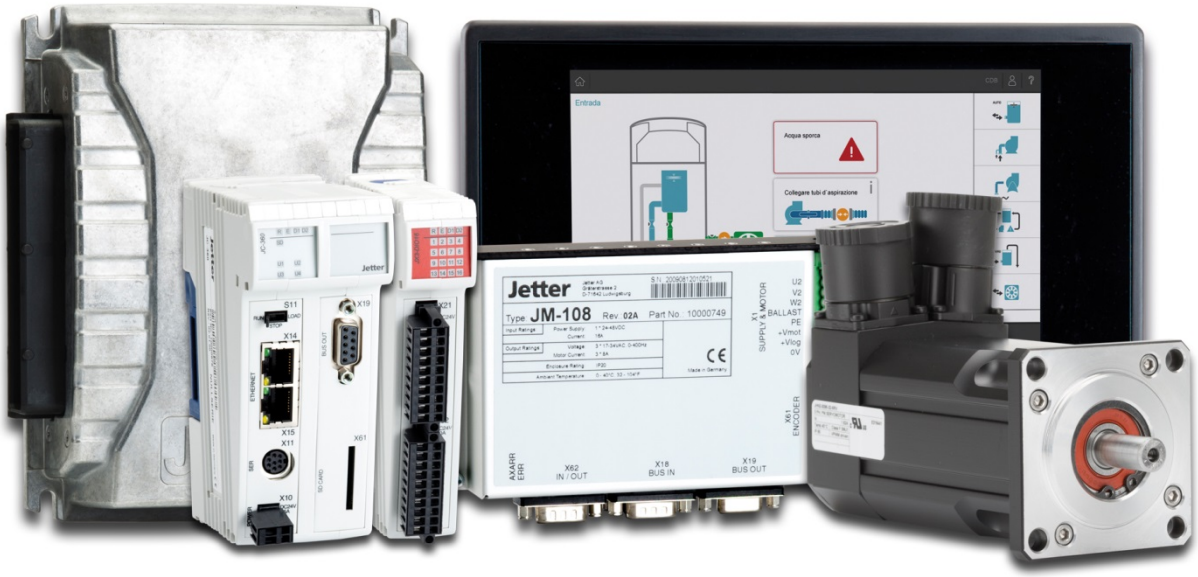

Motion Control - Superimposed Positioning

Application Note 051

608 847 54_00

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Table of Contents

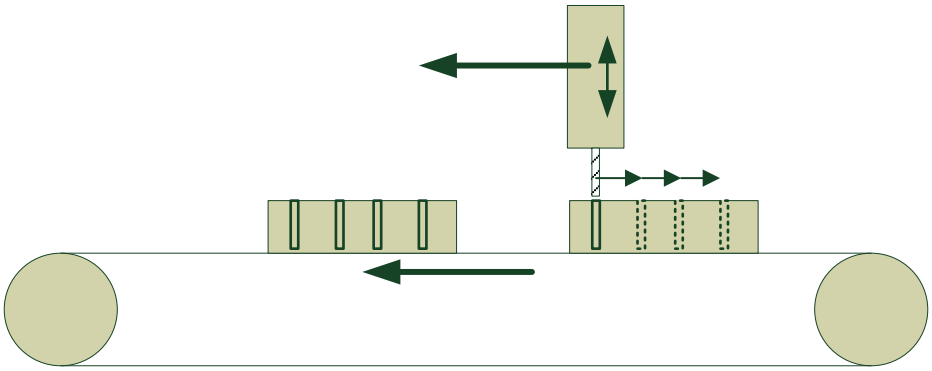
1 Introduction

1.1 Prerequisites

- The following versions were used for the code and project examples as well as screen-shots:
  - JetSym 5.51
  - Motion API 1.0.13 or Motion API 1.0.014_Beta
  - JC365MC-OS 1.30.0.00
- Application Note 049: Motion Control - Technology Group
- Application Note 050: Motion Control - Electrical Gearbox in a Technology Group

2 Superimposed positioning - Introduction

A superimposed positioning is a movement that is performed in addition to the basic movement of an axis. It can only be used in conjunction with an electrical gearbox. If a follower axis is moving synchronized with the master axis, it follows the master axis in a fixed gear ratio. However, if the distance between master and follower axis is to be changed in the coupled state, superimposed positioning is used. This allows the phase position of the follower axis to be adjusted.



In this example, you want to drill 4 holes in a product while the product is being transported on a conveyor belt. For this purpose the drilling machine couples with the workpiece at the position of the first drill hole. After the drilling process has been completed, a superimposed positioning to the next drill hole is carried out. When all machining operations have been completed, the drilling machine decouples by moving to the home position.

This application note describes how superimposed positioning is used. Primarily, it covers the following commands:
<Techno>.MovePtp.StartSuperpose
<Techno>.MovePtp.StartNewTargetPositionSuperPose
<Techno>.MoveVelocity.StartSuperPose
<Techno>.MoveVelocity.ReverseSuperPose
Furthermore, it considers how the motion state of the superimposed positioning is monitored, a superimposed positioning is stopped and the current offset is determined.

INFO

Normal positioning

A motion without superimposed positioning, e.g. "<Techno>.MovePtP.Start", is hereinafter referred to as "normal positioning".

3 Applying superimposed positioning

3.1 Commands

The following commands are available for superimposed positioning:
<Techno>.MovePtp.StartSuperpose
<Techno>.MovePtp.StartNewTargetPositionSuperPose
<Techno>.MoveVelocity.StartSuperPose
<Techno>.MoveVelocity.ReverseSuperPose
As you can already see from "<Techno>", these commands are only available within a technology group.
In the decoupled state, superimposed positioning is exactly the same as normal positioning.
In the coupled state, an additional positioning motion is superimposed on the synchronous motion. The follower axis remains coupled. After completion of a superimposed positioning cycle, the follower axis follows the master axis according to its set gear ratio.
Normal positioning in the coupled state results in immediate decoupling of the follower axis!

Command	Coupling status	Response
Move*.Start	Decoupled	Positioning
Move*.StartSuperpose	Decoupled	Positioning
Move*.Start	Coupled	Immediate decoupling with positioning
Move*.StartSuperpose	Coupled	Superimposed positioning

3.1.1 <Techno>.MovePtp.StartSuperpose

<Techno>.MovePtp.StartSuperpose(axis, positioning mode, target position, velocity, acceleration, deceleration, target window)
Point-to-point positioning with specification of all relevant parameters.

3.1.2 <Techno>.MovePtp.StartNewTargetPositionSuperPose

<Techno>.MovePtp. StartNewTargetPositionSuperPose (axis, positioning mode, target position, target window)
Point-to-point positioning with specification of a few parameters, using the currently valid parameters for velocity, acceleration and deceleration.

3.1.3 <Techno>.MoveVelocity.StartSuperPose

<Techno>. MoveVelocity.StartSuperPose (axis, direction, velocity, acceleration, deceleration)
Endless positioning with specification of the relevant parameters.

3.1.4 <Techno>.MoveVelocity.ReverseSuperPose

<Techno>. MoveVelocity.ReverseSuperPose (axis)
Change of direction (reversing) of an endless positioning in progress. The currently valid parameters for velocity, acceleration and deceleration are used. The change of direction is carried out with the value valid for acceleration.

3.2 Stopping a superimposed positioning

The following command is used to stop a superimposed positioning:
<Techno>.MoveHalt.Start(<follower axis>, halt mode, deceleration);
The same conditions apply here as for normal positioning.
Stop mode:

MCTechnoHaltModes.AtActualPosition: The axis is stopped with the set deceleration and returned to the position at the time when the command was issued.
MCTechnoHaltModes.Normal: The axis is stopped with the set deceleration.

3.3 Monitoring the superimposed positioning

As with normal positioning, the ramp status of the single axis is queried for superimposed positioning. The return values are as follows:
0: Stopped
1: Accelerating
2: At constant speed
3: Decelerating
If a follower axis is coupled or moves synchronized with the master axis, the ramp status of the single axis is "IsStopped".
When starting a positioning, the states change during the individual phases – from acceleration, possibly constant velocity to deceleration.
So, if a superimposed positioning is carried out in addition to the synchronous movement, the end can be queried with <Axis>.Mechanism.Slope.IsStopped.

INFO

Even if a target window is specified during positioning, the target window status is not set in the case of superimposed positioning.

3.4 Calculating the superimposed position

If superimposed positioning is used, the resulting set position for the follower axis results from the sum of the positions of the electrical gearbox and the superimposed positioning.

$$x(t) = x_{EGearbox}(t) + x_{Ptp}(t)$$

The start value of x_{Ptp} is always 0 when coupling.
If a superimposed absolute position is carried out to e.g. 10° and then once more, no movement takes place the second time.

3.5 Determining the current superimposed position

The current value of x_{Ptp} cannot be read out directly from the MCX.
Therefore, the current actual or target positions of the master and follower axes must be read out instead. The difference between the position of the master and follower axis minus the initial difference (offset) at the time of coupling results in the current superimposed position.

$$x_{Ptp}(t) = x(t) - x_{MasterAxis}(t) - x_{Offset}(CouplingTime)$$

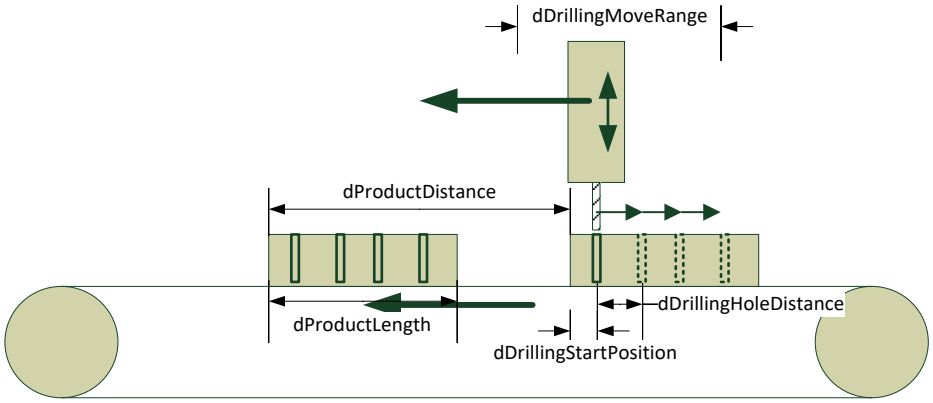
If the gear ratio is not equal to 1 and/or the modulo traversing ranges are different or if several modulo cycles have already been traversed, then the above formula cannot be sufficient.
Alternatively, the superimposed positioning should be considered accordingly.
With superimposed absolute positioning, the target position after positioning is automatically the superimposed position.
For superimposed relative positioning, the distances must be summed up.
For superimposed endless positioning, it is recommended to read out the current target position before the positioning command, to count possible modulo wraps of the follower axis and to read

the current target position of the follower axis again when endless positioning is stopped. The difference between the positions plus the modulo ranges that have been traversed result in the superimposed position.

3.6 Examples:

3.6.1 Workpiece machining

See sample project "*ContinousProductdrilling*".
In this example, holes are to be drilled in a product at a fixed distance while the product is being transported on a conveyor belt. For this purpose the drilling machine couples with the workpiece at the position of the first drill hole. After the drilling process has been completed, a superimposed positioning to the next drill hole is carried out. When all machining operations have been completed, the drilling machine decouples by moving to its home position.
This application is basically a "flying saw" application. However, this usually includes a print mark recognition to detect the position of the product on the belt with the corresponding calculation for synchronization of the tool. To simplify the example, however, the same distance between products is assumed, so that the product is always expected at the same position.
For further simplification, the example does not include monitoring functions and corresponding error responses. In a real application, for example, it should be checked that the travel range of the tool feed is not exceeded/undershot during machining. Assume that the tool feed has a travel range of 500 mm. The first machining operation starts at tool feed position 450 mm and the workpiece is transported at 100 mm/s. Drilling takes 1 sec. Within the machining time, the workpiece and thus the tool feed move 100 mm. Drilling would then be completed at the tool feed position of 550 mm. However, since the end of the travel range is reached at 500 mm, an error would occur here. Similar scenarios are also conceivable for the opposite travel range limit.



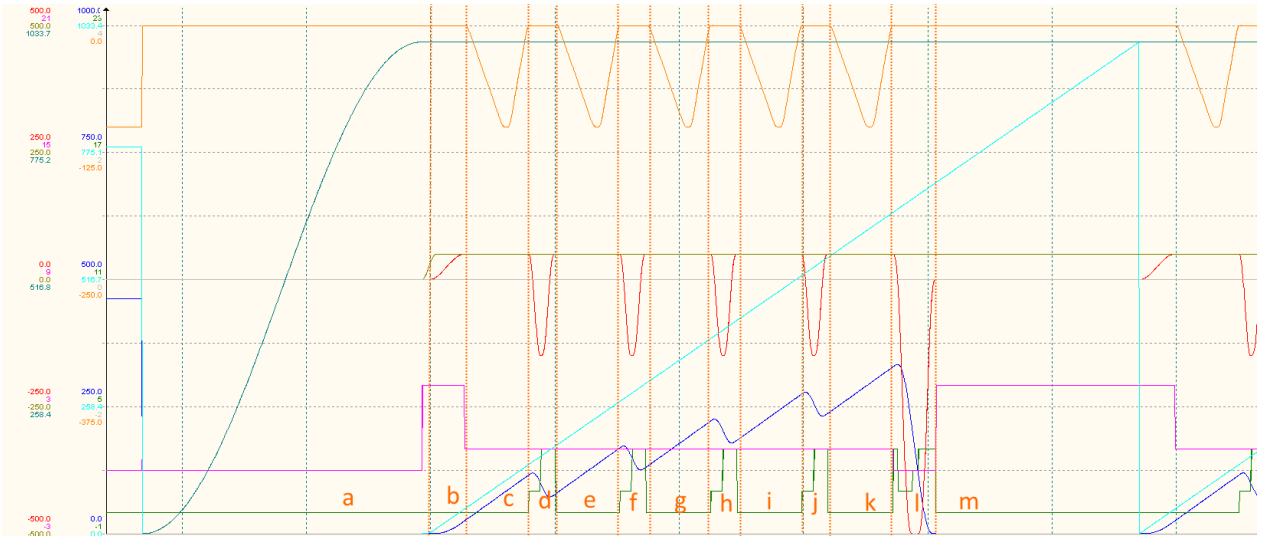
The following parameters are used:

dProductDistance: Fixed product distance
dProductLength: Length of the product
dDrillingMoveRange: Travel range of the drilling machine
dDrillingStartPostition: Position of the first hole
dDrillingHoleDistance: Distance between holes

The hardware configuration consists of the following:

- xConveyor: Linear/modulo - conveyor belt that transports the product
- xDrillingMove: Linear/normal - moves the drilling machine parallel to the conveyor belt
- xDrillingLift: Linear/normal - vertical movement of the drilling machine
- xDriller: Rotary/modulo - rotation of the drilling machine

The "tecDrilling" technology group consists of "xConveyor" as the master axis and "xDrillingMove" as the e-gearbox follower axis, so that the tool can synchronize itself with the conveyor belt and thus with the product.



Legend:
Dark blue: Feed axis - set position (xDrillingMove)
Red: Feed axis - set velocity (xDrillingMove)
Pink: Feed axis - coupling status (xDrillingMove)
Green: Feed axis - ramp status (xDrillingMove)
Light blue: Conveyor belt - set position (xConveyor)
olive: Conveyor belt - set velocity (xConveyor)
Gray: Drilling machine - set velocity (xDriller)
Orange: Set position for vertical movement of the drilling machine (xDrillingLift)

a) The drill starts and accelerates to the target velocity.
   All other axes are at home position. The feed axis is decoupled.
b) As soon as the target velocity of the drilling machine is reached, the conveyor belt starts.
   The feed axis is coupled in "Fast" mode. The coupling status changes to "IsCoupling".
c) The feed axis is coupled and is now located above the first hole to be drilled. Drilling is now started: The xDrillingLift axis is lowered into the workpiece and returns then to its home position.
   During the machining time, the feed axis moves synchronized with the conveyor belt.
d) The drilling cycle is finished. Superimposed positioning moves the drilling machine to the next hole. The oscilloscope shows that the position of the feed axis is getting smaller and that the velocity is also lower than the synchronous speed.
   The ramp status can be used to monitor the superimposed positioning.
e) … k) the steps c) and d) are repeated.
l) All holes have been drilled. The feed axis moves to its home position in normal positioning mode.
   The feed axis is thus directly decoupled.
m) Once the home position has been reached, the feed axis is re-coupled directly so that the coupling status changes to "IsCoupling".
   A new product arrives on the conveyor belt and is machined accordingly.

Project "MoveSuperpose"

In the project "MoveSuperpose" different use cases are shown:

- Use Case 01: Synchronous movement with MovePtp.StartSuperpose and MovePtp.StartNewTargetPositionSuperPose
- Use Case 02: Synchronous movement with MoveVelocity.StartSuperpose, MoveVelocity.ReverseSuperpose and MoveHalt.Start
- Use Case 03: Synchronous movement with MoveVelocity.StartSuperpose and MovePtp.StartSuperpose

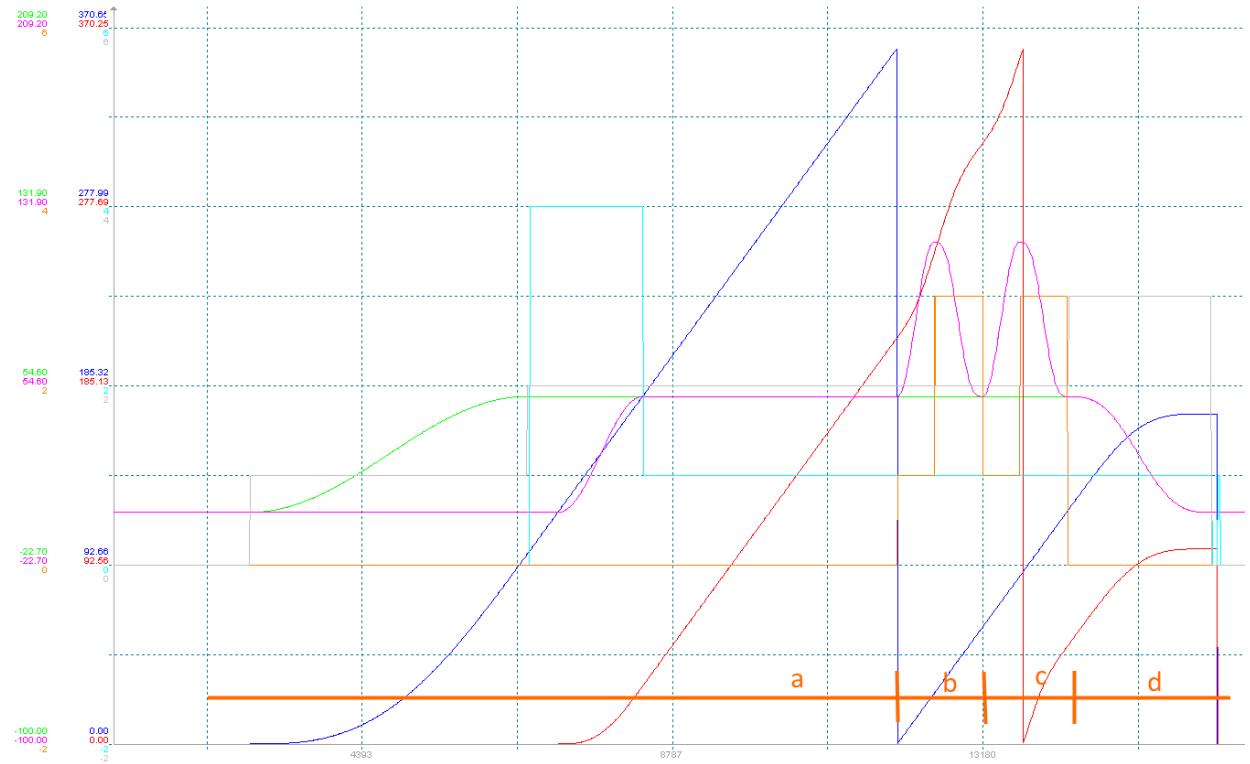
- Use Case 04: Decoupled with MovePtp.Start and MovePtp.StartSuperpose
- Use Case 05: Decoupled with MovePtp.StartSuperpose/MovePtp.Start followed by coupling in "Immediate" mode
- Use Case 06: Decoupled with MovePtp.StartSuperpose/MovePtp.Start followed by coupling in "Fast" mode
- Use Case 07: Coupling in "Fast" mode followed by MovePtp.StartSuperpose/MovePtp.Start
  - Before optimum synchronous point
  - During the coupling movement
- Use Case 08: MovePtp.StartSuperpose and MoveVelocity.StartSuperpose during decoupling
- Use Case 09: Decoupling during MovePtp.StartSuperpose and MoveVelocity.StartSuperpose

3.6.1.1 Use Case 01: Synchronous movement with MovePtp.StartSuperpose and MovePtp.StartNewTargetPositionSuperPose

In this use case it shall be shown how the two commands affect each other when superimposed positioning is started during synchronous movement. You can see how the ramp statuses change. The "StartSuperPose" and "StartNewTargetPositionSuperPose" commands are almost identical in behavior and effect, except that all positioning parameters such as velocity, acceleration and deceleration can be specified with the first command.
For both commands, a target window can also be specified, but this is not evaluated if the follower axis is coupled. (See also Use Case 04; in decoupled state, the commands have the same effect as for non-superimposed positioning, i.e. "MovePtp.Start" and "MovePtp.StartNewTargetPosition")

```
when xvFollower.State.Techno.IsCoupled continue;
when xvMaster.Position.Setpoint < 100.0 continue;
tecGear.MovePtp.StartSuperPose(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0,
200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;
tecGear.MovePtp.StartNewTargetPositionSuperPose(xvFollower, MCTechnoPositioningModes.AbsModuloAuto,
80.0);
when xvFollower.Mechanism.Slope.IsStopped continue;
```

According to the code, a superimposed positioning "StartSuperPose()" is to be started at a certain time. When this is completed – query using "slope.IsStopped", the next superimposed positioning is started. Again, the system waits for the end of the "StartNewTargetPositionSuperPose()" positioning using "Slope.IsStopped".



Legend:

- Set position of the master axis
- Set velocity of the master axis
- Setpoint position of the follower axis
- Set velocity of the follower axis
- Coupling status of the follower axis (0: Decoupled, 1: Coupled, 3: Decoupling, 4: Coupling)
- Ramp status of the follower axis (0: Stopped, 1: Acceleration, 2: Constant velocity, 3: Deceleration)

Phases:

a) The master axis accelerates to target velocity. As soon as the target velocity is reached, the follower axis is coupled. The coupling status changes to "Coupling" followed by "IsCoupled". The follower axis moves synchronized with the master axis and has the same velocity as shown in the oscilloscope.

b) The first superimposed positioning "StartSuperPose()" is started at the modulo limit. The setpoint position no longer increases linearly, but the gradient increases. This can better be seen by the setpoint velocity of the follower axis. It increases briefly, and then decreases again to the synchronous speed.
The ramp status changes from "IsStopped", to "Accelerating" and directly to "Decelerating", because the target velocity is not reached for this positioning. Using other positioning parameters, this can also be recognized.
When the superimposed target position is reached, the ramp status changes to "IsStopped".

c) The second superimposed positioning "StartNewTargetPositionSuperPose()" is started. Since in this example the positioning parameters are the same as in the first positioning cycle, the characteristic is identical. The axis moves further by 40°.

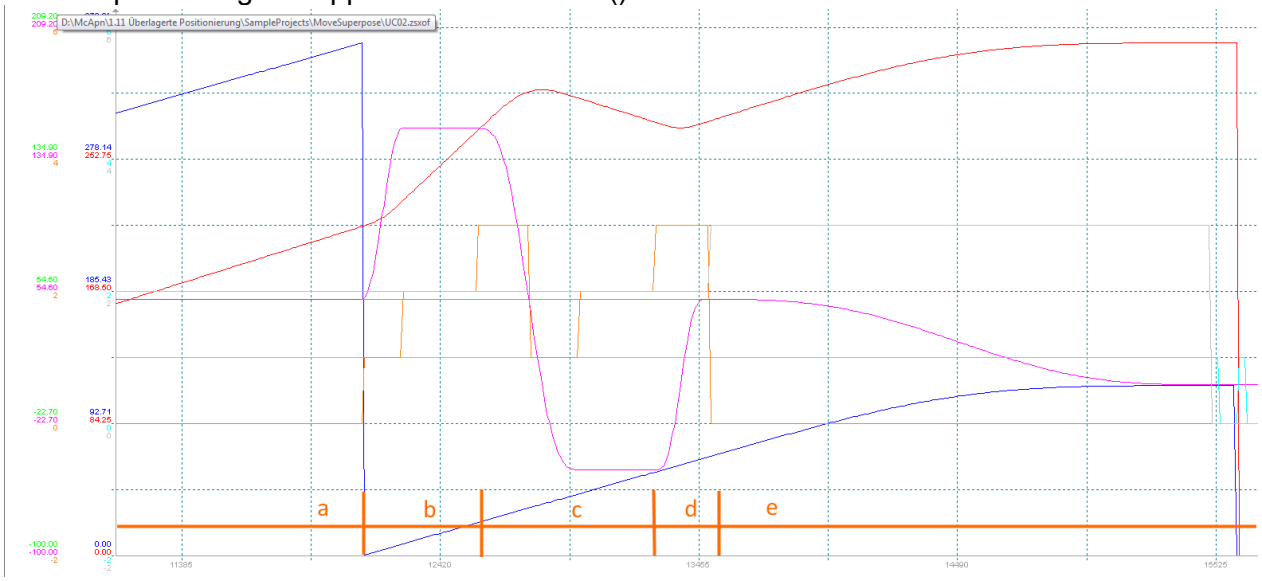
d) The master axis is stopped and the follower axis is decoupled at the end.

3.6.1.2 Use Case 02: Synchronous movement with MoveVelocity.StartSuperpose, MoveVelocity.ReverseSuperpose and MoveHalt.Start

In this use case it shall be shown how the two commands affect each other when a superimposed endless positioning is started during synchronous movement. You can see how the ramp statuses change.
MoveHalt.Start terminates the superimposed endless positioning, so that the follower axis continues to follow the master axis at synchronous velocity.

```
when xvFollower.State.Techno.IsCoupled continue;

when xvMaster.Position.Setpoint < 100.0 continue;
tecGear.MoveVelocity.StartSuperPose(xvFollower, Directions.Positive, 100.0, 1000.0, 1000.0);
when xvFollower.Mechanism.Slope.IsAtConstantSpeed continue;
delay(t#300ms);

tecGear.MoveVelocity.ReverseSuperPose(xvFollower);
when xvFollower.Mechanism.Slope.IsAtConstantSpeed continue;
delay(t#300ms);
tecGear.MoveHalt.Start(xvFollower, MCTechnoHaltModes.Normal);
when xvFollower.Mechanism.Slope.IsStopped continue;
```

At a certain point in time the superimposed endless positioning "MoveVelocity.StartSuperPose()" is started. Then - here 300 ms after reaching the target velocity for better display in the oscilloscope - the superimposed endless positioning is reversed "MoveVelocity.ReverseSuperPose()".
Here too, the system waits 300 ms after reaching the new target velocity. Then the superimposed endless positioning is stopped "MoveHalt.Start()".



Legend (see legend Use Case 01)

Phases:

a) The master axis accelerates to target velocity. As soon as the target velocity is reached, the follower axis is coupled. The coupling status changes to "Coupling" followed by "Is-Coupled". The follower axis moves synchronized with the master axis and has the same velocity as shown in the oscilloscope.
b) The superimposed endless positioning "MoveVelocity.StartSuperPose()" is started at the modulo limit.
The setpoint velocity of the follower axis increases from synchronous velocity to the specified target velocity.
The setpoint position of the follower axis which previously runs parallel to the setpoint posi-

tion of the master axis becomes steeper.
The ramp status changes from "IsStopped", to "Accelerating" and "Constant Velocity".

c) After 300 ms, the currently running superimposed endless positioning is reversed "MoveVelocity.ReverseSuperPose()".
The setpoint velocity of the follower axis is reduced. It is even reduced to such an extent that the direction of rotation of the follower axis is reversed.
From the moment the direction of rotation is reversed, the setpoint position of the follower axis decreases.
The ramp status clearly shows that reversing decelerates first to the superimposed velocity 0 and then accelerates to the new, now negative velocity.

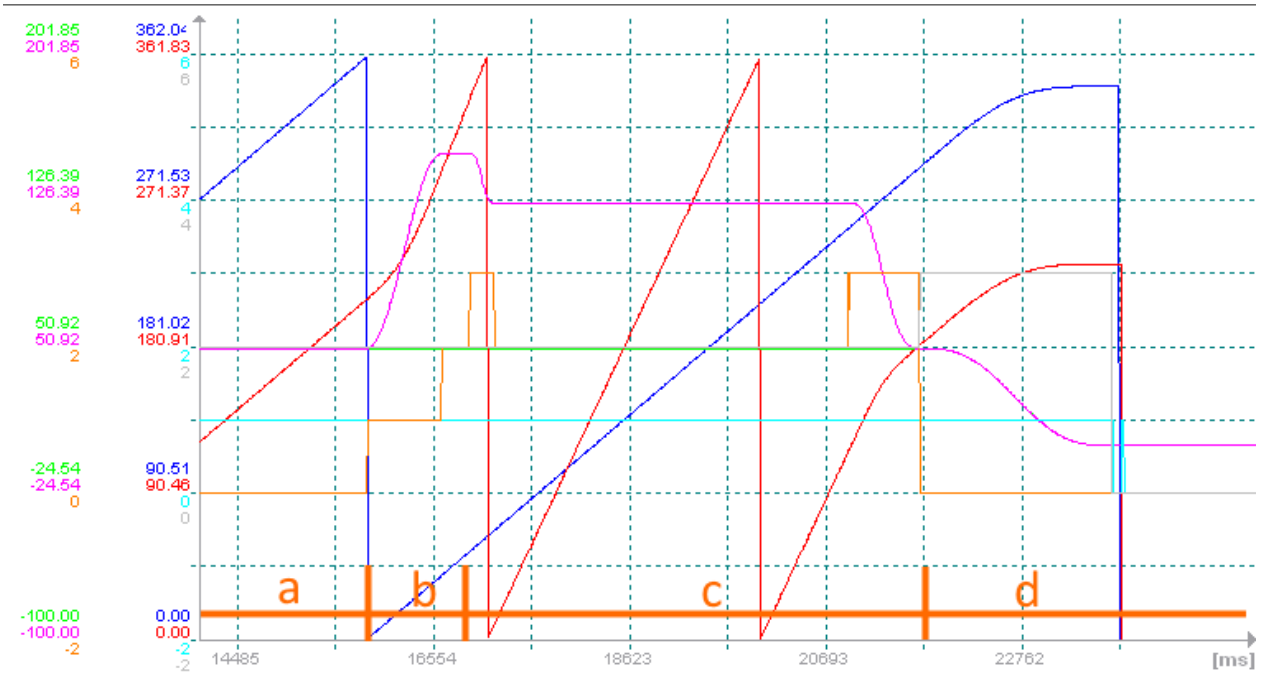
d) After 300 ms the currently running superimposed endless positioning is stopped "MoveHalt.Start()".
The absolute velocity of the superimposed endless positioning decreases which is noticeable here in a velocity increase to synchronous velocity.
The ramp status changes to "Decelerating" and further to "IsStopped". It is now also visible that only the superimposed endless positioning is stopped and not the axis itself.

e) At the end of this use case the master axis is stopped.

3.6.1.3 Use Case 03: Synchronous movement with MoveVelocity.StartSuperPose and MovePtp.StartSuperPose

In this use case, it is to be shown in principle what effects the commands have when a superimposed endless positioning followed by a superimposed positioning is started during synchronous travel. You can see how the ramp statuses change.
MoveHalt.Start terminates the superimposed endless positioning, so that the follower axis continues to follow the master axis at synchronous velocity.

```
when xvFollower.State.Techno.IsCoupled continue;

when xvMaster.Position.Setpoint < 100.0 continue;
tecGear.MoveVelocity.StartSuperPose(xvFollower, Directions.Positive, 100.0, 200.0, 200.0);
when xvFollower.Mechanism.Slope.IsAtConstantSpeed continue;
delay(t#300ms);

tecGear.MovePtp.StartSuperPose(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 75.0,
200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;
```



Legend (see legend Use Case 01)

Phases:

a) The master axis moves at target velocity. The follower axis is coupled and moves synchronously to the master axis. The coupling status is "IsCoupled".
b) The superimposed endless positioning "MoveVelocity.StartSuperPose()" is started at the modulo limit.
   The setpoint velocity of the follower axis increases from the synchronous velocity to the specified target velocity.
   The setpoint position of the follower axis which previously runs parallel to the setpoint position of the master axis becomes steeper.
   The ramp status changes from "IsStopped", to "Accelerating" and "Constant Velocity".
c) After 300 ms at constant velocity, the currently running superimposed endless positioning is interrupted by a superimposed positioning. Due to a lower target velocity, the follower axis

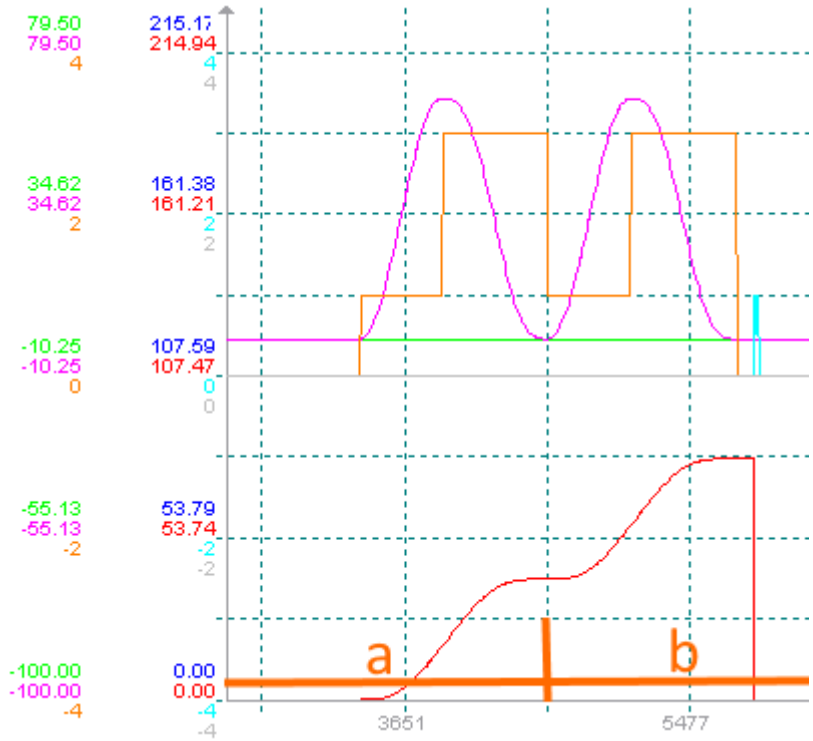
first decelerates to the new velocity.
When the superimposed target position is reached, the ramp status changes to "IsStopped".
The velocity of the follower axis is now again the same as the synchronous velocity.

d) At the end of the use case, the master axis is stopped and the follower axis is decoupled.

3.6.1.4 Use Case 04: Decoupled with MovePtp.Start and MovePtp.StartSuperpose

In this use case it shall be shown that in decoupled state the commands "MovePtp.Start" for normal positioning and "MovePtp.StartSuperpose" for superposed positioning behave identically.
In the decoupled state of the follower axis, the commands "MoveVelocity.Start" and "MoveVelocity.StartSuperpose" are also identical. However, a separate presentation is not provided here.

```
tecGear.MovePtp.StartSuperPose(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0,
200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;

tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 80.0, 100.0, 200.0,
200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;
```



Legend (see legend Use Case 01)

Phases:

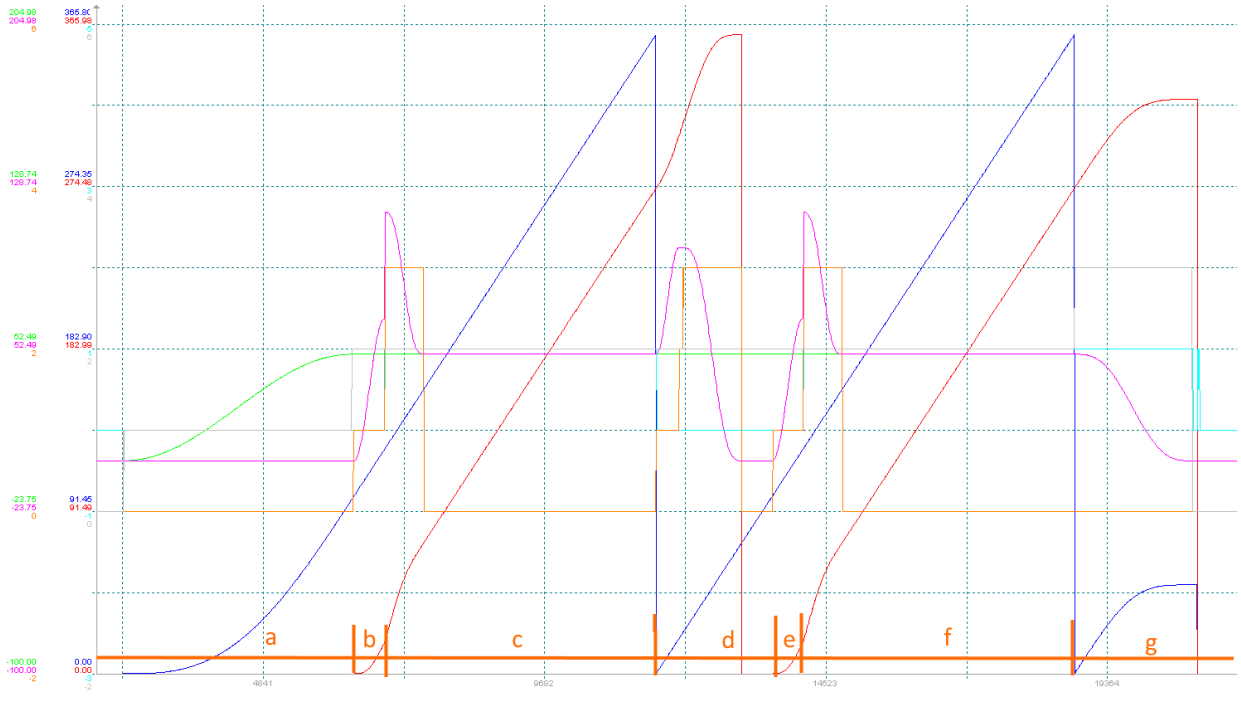
a) The coupling status of the follower axis is "IsDecoupled".
A superimposed positioning to an absolute target position is started.
In this case the ramp status changes from "Accelerating" to "Decelerating".
The follower axis stops at position 40.0.

b) A normal positioning to an absolute target position is started.
In this case the ramp status changes from "Accelerating" to "Decelerating".
The follower axis stops at position 80.0.
The course of both positionings is the same.

3.6.1.5 Use Case 05: Decoupled with MovePtp.StartSuperpose / MovePtp.Start followed by coupling in "Immediate" mode

This application case shows the behavior when during normal or superimposed positioning the follower axis is coupled in "Immediate" mode.
In this case, both positioning modes behave identically.
When coupling in "Immediate" mode, the coupling status changes to "IsCoupled". In both cases, the current positioning process is terminated as a superimposed positioning.
See also Use Case 06, as this behavior differs from the "Fast" coupling mode.

```
when xvMaster.Position.Setpoint > 100.0 continue;

// Beginning the sequence with MovePtp.StartSuperPose
tecGear.MovePtp.StartSuperPose(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0,
200.0, 200.0);
when xvFollower.Mechanism.Slope.IsAtConstantSpeed continue;

tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Immediate);
when xvFollower.State.Techno.IsCoupled continue;

when xvMaster.Position.Setpoint < 100.0 continue;
// Decoupling and return to start position
tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 0.0, 100.0, 200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;

// Repeating sequence with MovePtp.Start
when xvMaster.Position.Setpoint < 100.0 continue;
when xvMaster.Position.Setpoint > 100.0 continue;

tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0, 200.0,
200.0);
when xvFollower.Mechanism.Slope.IsAtConstantSpeed continue;

tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Immediate);
when xvFollower.State.Techno.IsCoupled continue;
```



Legend (see legend Use Case 01)

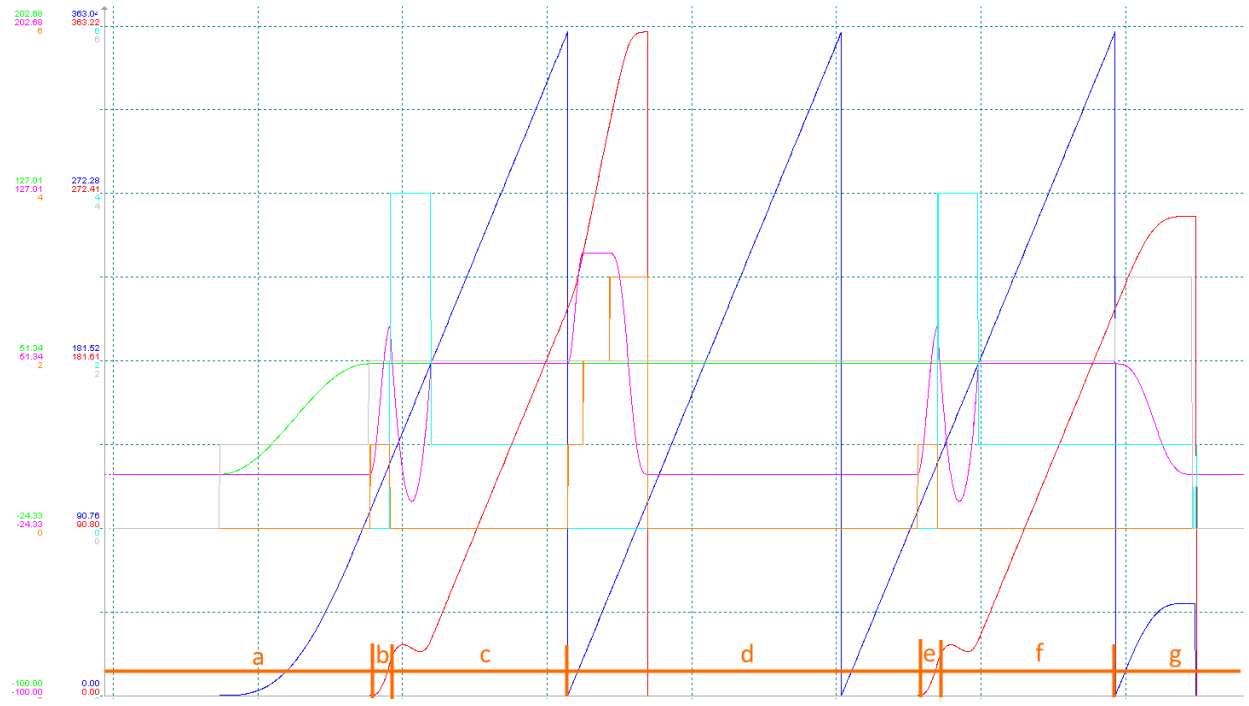
Phases:

a) The master axis accelerates to target velocity. The follower axis is decoupled and stationary.
b) A superimposed positioning to position 40.0 is started.
   The ramp status changes to "Accelerating".
c) When the target velocity of the current positioning is reached, "Immediate" coupling is performed.
   The coupling status changes to "IsCoupled".
   Since the follower axis is "Immediately" coupled to the master axis, no coupling polynomial is calculated, but the follower axis moves "immediately" at synchronous velocity. This results in a jump in velocity. This jump can also be seen in the setpoint velocity of the follower axis.
   Now, the superimposed positioning is terminated which causes the velocity to drop to synchronous velocity.
d) The follower axis is decoupled by normal positioning and moved to the start position.
e) See also b) only with the difference that a normal positioning is now started here.
f) See c).
g) At the end of the use case, the master axis is stopped and the follower axis is decoupled.

3.6.1.6 Use Case 06: Decoupled with MovePtp.StartSuperpose/MovePtp.Start followed by coupling in "Immediate" mode or "Waiting"

This use case shows the behavior when during normal or superimposed positioning the follower axis is coupled in "Fast" mode.
The behavior in "Waiting" mode is similar to "Fast" mode. A separate presentation is not provided here.
In this case, too, both positioning modes behave identically.
In contrast to Use Case 05, the current positioning is now interrupted and synchronized to the master axis using a coupling polynomial corresponding to the synchronous position.

```
// Beginning the sequence with MovePtp.StartSuperPose
tecGear.MovePtp.StartSuperPose(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0,
200.0, 200.0);
when xvFollower.Mechanism.Slope.IsAtConstantSpeed continue;

tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Fast, 180.0, Directions.Positive, 30.0);
when xvFollower.State.Techno.IsCoupled continue;

when xvMaster.Position.Setpoint < 100.0 continue;
// Decoupling and returning to start position
tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 0.0, 100.0, 200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;

// Repeating sequence with MovePtp.Start
when xvMaster.Position.Setpoint < 100.0 continue;
when xvMaster.Position.Setpoint > 100.0 continue;

tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0, 200.0,
200.0);
when xvFollower.Mechanism.Slope.IsAtConstantSpeed continue;

tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Fast, 180.0, Directions.Positive, 30.0);
when xvFollower.State.Techno.IsCoupled continue;
```



Legend (see legend Use Case 01)

Phases:

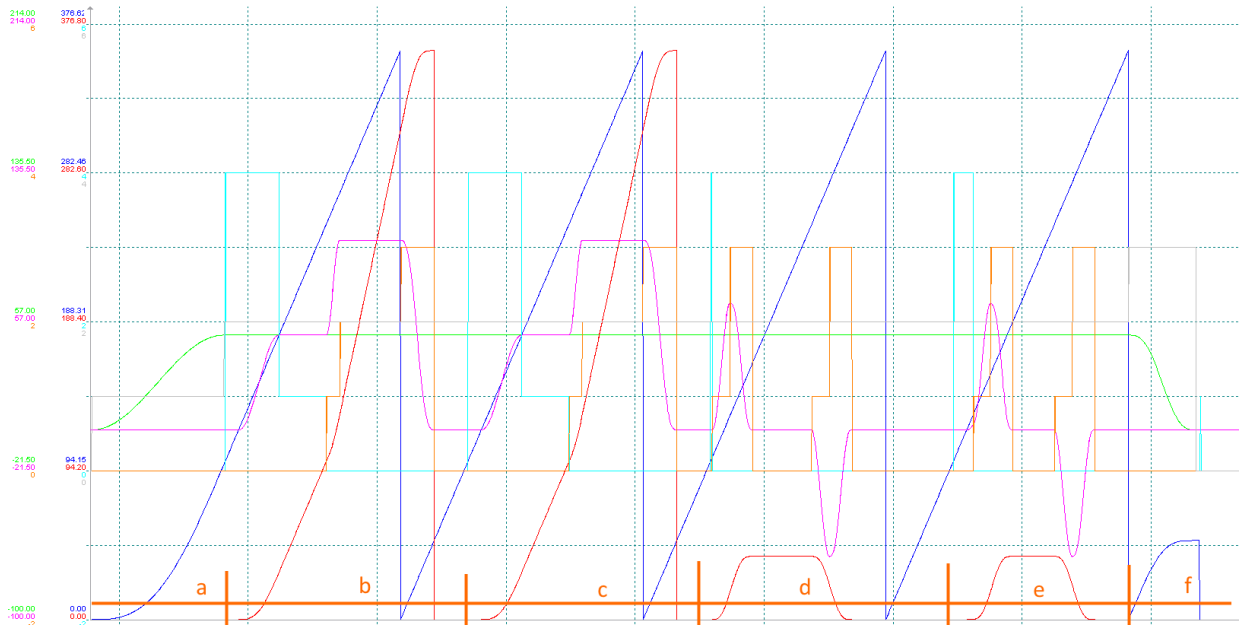
a) The master axis accelerates to target velocity. The follower axis is decoupled and stationary.
b) A superimposed positioning to position 40.0 is started.
   The ramp status changes to "Accelerating".
c) When the target velocity of the current positioning is reached, "Fast" coupling is performed.
   The coupling state changes to „IsCoupling“.
   The setpoint velocity does not jump as in "Immediate" coupling mode, but a coupling polynomial is calculated and the follower axis is synchronized to the synchronous point.
   The current superimposed positioning is terminated directly.
d) The follower axis is decoupled by normal positioning and moved to the start position.
e) See also b) only with the difference that a normal positioning is now started here.
f) See c).
g) At the end of the use case, the master axis is stopped and the follower axis is decoupled.

3.6.1.7 Use Case 07: Coupling in "Fast" mode followed by MovePtp.StartSuperpose/MovePtp.Start

In this use case, positioning and coupling are now performed in the reverse order of Use Case 06. Here you can see how the follower axis reacts while it is in the coupling motion or waiting for the optimum coupling point (OCP) and a superimposed or normal positioning is started.

```
// Beginning sequence with MovePtp.StartSuperPose before OCP
tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Fast, 180.0, Directions.Positive, 30.0);
when xvFollower.State.Techno.IsCoupling continue;
delay(t#10ms);
tecGear.MovePtp.StartSuperPose(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0,
200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;
when xvMaster.Position.Setpoint > 250.0 continue;
// Decoupling and returning to start position
tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 0.0, 100.0, 200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;

// Repeating sequence with MovePtp.StartSuperPose between OCP and SP
when xvMaster.Position.Setpoint < 100.0 continue;
when xvMaster.Position.Setpoint > 100.0 continue;

tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Fast, 180.0, Directions.Positive, 30.0);
when xvFollower.State.Techno.IsCoupling continue;
when xvMaster.Position.Setpoint > 130.0 continue;
tecGear.MovePtp.StartSuperPose(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0,
200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;
when xvMaster.Position.Setpoint > 250.0 continue;
// Decoupling and returning to start position
tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 0.0, 100.0, 200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;

// Repeating sequence with MovePtp.Start before OCP
when xvMaster.Position.Setpoint < 100.0 continue;
when xvMaster.Position.Setpoint > 100.0 continue;

tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Fast, 180.0, Directions.Positive, 30.0);
when xvFollower.State.Techno.IsCoupling continue;
delay(t#50ms);
tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0, 200.0,
200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;
when xvMaster.Position.Setpoint > 250.0 continue;
// Decoupling and returning to start position
tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 0.0, 100.0, 200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;

// Repeating sequence with MovePtp.Start between OCP and SP
when xvMaster.Position.Setpoint < 100.0 continue;
when xvMaster.Position.Setpoint > 100.0 continue;

tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Fast, 180.0, Directions.Positive, 30.0);
when xvFollower.State.Techno.IsCoupling continue;
when xvMaster.Position.Setpoint > 130.0 continue;
```

```
tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0, 200.0,
200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;
when xvMaster.Position.Setpoint > 250.0 continue;
// Decoupling and returning to start position
tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 0.0, 100.0, 200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;
```



Legend (see legend Use Case 01)

Phases:

a) The master axis accelerates to target velocity. The follower axis is decoupled and stationary.

b) Coupling mode is "Fast".
A superimposed positioning is started even before the coupling movement begins.

16:40:52.468	*tecGear / xvFollower*: MotionMoveCouple ( ) - Call ok
16:40:52.483	*tecGear / xvFollower*: Error: 7301 - Level: Message - Starting superimposed positioning: Coupling/uncoupling process is in progress
16:40:52.483	*tecGear / xvFollower*: MotionMoveSuperPosePtp ( ) - Call ok
16:40:55.468	*tecGear / xvFollower*: MotionMovePtp ( ) - Call ok
16:40:59.669	*tecGear / xvFollower*: MotionMoveCouple ( ) - Call ok
16:41:00.268	*tecGear / xvFollower*: Error: 7301 - Level: Message - Starting superimposed positioning: Coupling/uncoupling process is in progress
16:41:00.269	*tecGear / xvFollower*: MotionMoveSuperPosePtp ( ) - Call ok

Superimposed positioning in this phase is rejected and not executed!

c) Coupling mode is "Fast".
After the coupling movement has started, a superimposed positioning is started.
In this case, too, the superimposed positioning is rejected and not executed!

d) Coupling mode is "Fast".
Normal positioning is started before the coupling movement begins.
This cancels the coupling process and starts positioning.
The coupling state changes from "Coupling" to "IsDecoupled".

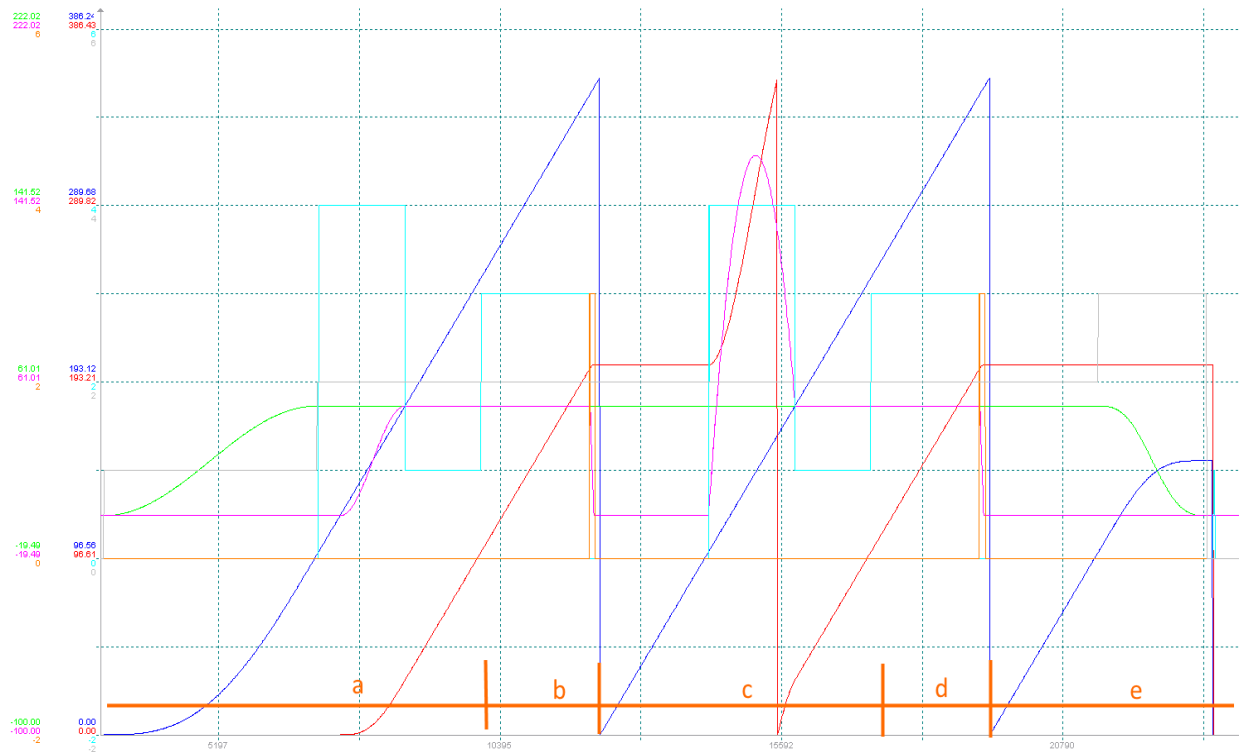
e) Coupling mode is "Fast".
After the coupling movement has started, a normal positioning is started. This cancels the coupling process and starts positioning.
The coupling state changes from "Coupling" to "IsDecoupled".

f) At the end of this use case the master axis is stopped.

3.6.1.8 Use Case 08: MovePtp.StartSuperpose and MoveVelocity.StartSuperpose during decoupling

This use case is to show how the follower axis behaves when superimposed positioning or endless positioning is started during the decoupling process.
It becomes clear that superimposed positioning during decoupling is rejected and not executed.
In this case, the MCX generates error message 7301 to inform the user of this condition.

```
// Beginning sequence with MovePtp
tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Fast, 180.0, Directions.Positive, 30.0);
when xvFollower.State.Techno.IsCoupled continue;

when xvMaster.Position.Setpoint > 250.0 continue;
tecGear.Coupling.Decouple(xvFollower, MCTechnoDecoupleModes.AtMasterPosition Stop, 350.0, 1000.0);
when xvFollower.State.Techno.IsDecoupling continue;

tecGear.MovePtp.StartSuperPose(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0,
200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;

// Repeating sequence with MoveVelocity
when xvMaster.Position.Setpoint < 100.0 continue;
when xvMaster.Position.Setpoint > 100.0 continue;

tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Fast, 180.0, Directions.Positive, 30.0);
when xvFollower.State.Techno.IsCoupled continue;

when xvMaster.Position.Setpoint > 250.0 continue;
tecGear.Coupling.Decouple(xvFollower, MCTechnoDecoupleModes.AtMasterPosition Stop, 350.0, 1000.0);
when xvFollower.State.Techno.IsDecoupling continue;

tecGear.MoveVelocity.StartSuperPose(xvFollower, Directions.Positive, 100.0, 200.0, 200.0);

when xvMaster.Position.Setpoint < 100.0 continue;
when xvMaster.Position.Setpoint > 100.0 continue;
tecGear.MoveHalt.Start(xvFollower, MCTechnoHaltModes.Normal);
when xvFollower.Mechanism.Slope.IsStopped continue;
```



Legend (see legend Use Case 01)

Phases:

a) The master axis accelerates to target velocity. The follower axis is decoupled and stationary.
   Coupling mode is "Fast".

b) After a short synchronous movement, the axis is decoupled in "Stop at master axis position" mode.
   The coupling state changes to "Decoupling".
   A superimposed positioning is started. This positioning is rejected and not executed.

```
16:42:42.717  tecGear / xvFollower: MotionMoveDecouple ( ) - Call ok
16:42:42.721  tecGear / xvFollower: Error: 7301 - Level: Message - Starting superimposed positioning:
              Coupling/uncoupling process is in progress
16:42:42.721  tecGear / xvFollower: MotionMoveSuperPosePtp ( ) - Call ok
16:42:46.917  tecGear / xvFollower: MotionMoveCouple ( ) - Call ok
16:42:49.916  tecGear / xvFollower: MotionMoveDecouple ( ) - Call ok
16:42:49.921  tecGear / xvFollower: Error: 7301 - Level: Message - Starting superimposed positioning:
              Coupling/uncoupling process is in progress
16:42:49.921  tecGear / xvFollower: MotionMoveSuperPoseVelocity ( ) - Call ok
```

   For this reason, the follower axis is decoupled at the master axis position as specified in the decoupling command and stopped with the set deceleration.

c) The follower axis is coupled again in "Fast" mode.

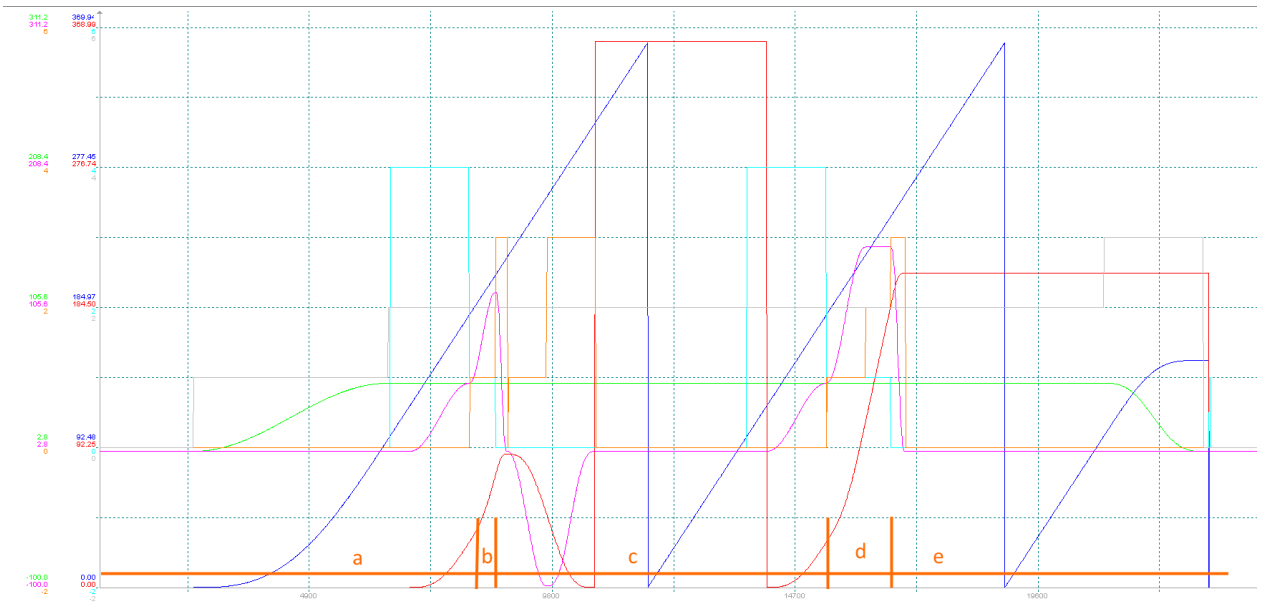
d) After a short synchronous movement, the axis is decoupled in "Stop at master axis position" mode.
   The coupling state changes to "Decoupling".
   A superimposed endless positioning is started. This positioning is rejected and not executed.
   For this reason, the follower axis is decoupled at the master axis position as specified in the decoupling command and stopped with the set deceleration.

e) At the end of this use case the master axis is stopped.

3.6.1.9 Use Case 09: Decoupling during MovePtp.StartSuperpose and MoveVelocity.StartSuperpose

This use case, in contrast to use case 08, is to show how the follower axis behaves when decoupling is performed during a superimposed positioning.
It is to be shown that in this case the superimposed positioning is aborted and the axis is directly decoupled.

```
// Beginning sequence with MovePtp
tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Fast, 180.0, Directions.Positive, 30.0);
when xvFollower.State.Techno.IsCoupled continue;

tecGear.MovePtp.StartSuperPose(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 40.0, 100.0,
200.0, 200.0);
when xvFollower.Mechanism.Slope.IsAtConstantSpeed continue;

tecGear.Coupling.Decouple(xvFollower, MCTechnoDecoupleModes.Immediate_Stop, , 1000.0);
when xvFollower.State.Techno.IsDecoupled and xvFollower.Mechanism.Slope.IsStopped continue;

tecGear.MovePtp.Start(xvFollower, MCTechnoPositioningModes.AbsModuloAuto, 0.0, 100.0, 200.0, 200.0);
when xvFollower.Mechanism.Slope.IsStopped continue;

// Repeating sequence with MoveVelocity
when xvMaster.Position.Setpoint < 100.0 continue;
when xvMaster.Position.Setpoint > 100.0 continue;

tecGear.Coupling.Couple(xvFollower, MCTechnoCoupleModes.Fast, 180.0, Directions.Positive, 30.0);
when xvFollower.State.Techno.IsCoupled continue;
       tecGear.MoveVelocity.StartSuperPose(xvFollower, Directions.Positive, 100.0, 200.0, 200.0);
when xvFollower.Mechanism.Slope.IsAtConstantSpeed continue;
delay(t#500ms);
tecGear.Coupling.Decouple(xvFollower, MCTechnoDecoupleModes.Immediate_Stop, , 1000.0);
when xvFollower.State.Techno.IsDecoupled continue;

when xvMaster.Position.Setpoint < 100.0 continue;
when xvMaster.Position.Setpoint > 100.0 continue;
tecGear.MoveHalt.Start(xvFollower, MCTechnoHaltModes.Normal);
when xvFollower.Mechanism.Slope.IsStopped continue;
```



Legend (see Legend UseCase 01)

Phases:

a) The master axis accelerates to target velocity. The follower axis is decoupled and stationary.
   In the further course the follower axis is coupled.
   The coupling status changes to "IsCoupling". The setpoint velocity of the follower axis increases to synchronous velocity.
b) As soon as the follower axis is coupled, a superimposed positioning starts.
   The ramp status changes to "Accelerating".
c) As soon as the ramp status changes to "Constant Velocity", the follower axis is decoupled in "Immediately with stop" mode.
   The coupling status changes to "IsDecoupled".
   The ramp status changes to "Decelerating" because the follower axis is stopped directly with the set deceleration.
   After stopping, the follower axis is moved back to the home position.
   In the further course the follower axis is coupled in again.
   The coupling status changes to "IsCoupling". The setpoint velocity of the follower axis increases to synchronous velocity.
d) As soon as the follower axis is coupled, a superimposed endless positioning starts.
   The ramp status changes to "Accelerating" and then to "Constant Speed".
e) After a short waiting time, the follower axis is decoupled in "Immediately with stop" mode.
   The coupling status changes to "IsDecoupled".
   The ramp status changes to "Decelerating" because the follower axis is stopped directly with the set deceleration.

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