G1: Gantry axes

2

2.1 Brief description

Gantry axes are machine axes that are mechanically and rigidly connected with one another, e.g. axes to move the gantry of gantry milling machines. Because of this mechanical coupling, gantry axes must always be traversed together as gantry grouping.

The axis via which this gantry grouping is explicitly traversed or programmed is called the leading axis. The axes of the gantry grouping, which are automatically and synchronously traversed from the NC, are called synchronous axes.

Traversing the leading axis and synchronous axes that are not in synchronism with one another - e.g. if one of the synchronous axes is blocked - can cause damage to the machine. This is the reason that the synchronism difference between the leading and synchronous axes is continually monitored by the NC. Alarm and alarm limits can be parameterized for the synchronism difference. A message is displayed if the alarm limit is exceeded. The complete gantry grouping is stopped when the alarm limit is exceeded.

2.2 "Gantry axes" function

Application

For gantry milling machines, often various elements - e.g. the gantry or the transverse beams - are moved by several axes operating in parallel that are independent of one another. Each axis comprises a machine axis parameterized in the NC, drive, motor and measuring system. When the gantry traverses, the axes that are mechanically and rigidly coupled with one another must be controlled in absolute synchronism in order to avoid any tension occurring in the mechanical system of the machine.

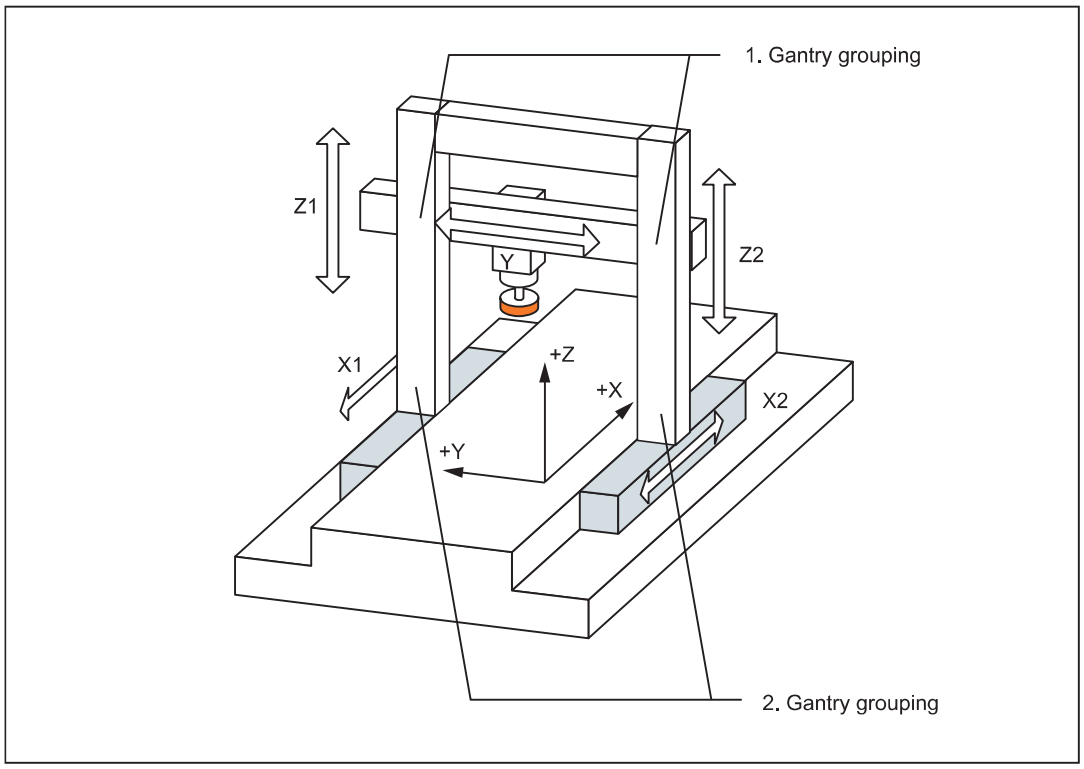


Figure 2-1 Gantry milling machine with 2 parallel axes for gantry and transverse beams

Terms

The following terms are used in this functional description:

Gantry grouping

The axes operating parallel, that together move a mechanical element - and therefore must always traverse in synchronism - together form a gantry grouping. The axes in a gantry grouping must either all be linear axes or all be rotary axes.

Leading axis

The axis of the gantry grouping that is programmed and/or addressed to traverse the mechanical element is known as the leading axis.

Synchronous axis

The axes of the gantry grouping, which are traversed by the NC in synchronism with the leading axis, are known as synchronous axes. From the point of view of the programmer and/or operator, the synchronous axes "do not exist".

Gantry axes

The axes of a gantry grouping, leading axis and synchronous axes are generally called gantry axes.

Synchronism difference

The synchronism difference is the deviation of the axial actual value of the synchronous axis from its ideal position referred to the actual value of the leading axis. The NC continually monitors the synchronism difference. In order to prevent any damage to the machine, the gantry grouping is stopped when a parameterizable limit value is exceeded.

Definition of a gantry grouping

(gantry axis definition)

Machine data:

MD37100 $MA_GANTRY_AXIS_TYPE[<axis>] = <type><number>

is used to define the axes that belong to a gantry grouping. The input is decimal-coded:

- <number> (1st decimal place):
  Number or identifier of the gantry grouping: 1, 2, 3, ... max. number
- <type> (10th decimal place):
  - 0 = Leading axis
  - 1 = Synchronous axis

A maximum of 8 gantry groupings can be defined.

A gantry grouping can have a maximum of 2 synchronous axes.

Boundary conditions

The following boundary conditions apply to a gantry grouping:

- A gantry grouping must not contain a spindle.
- A synchronous axis must not be a concurrent POS axis.
- A synchronous axis must not belong to a transformation.
- A synchronous axis must not be a following axis of another axis coupling.
- A synchronous axis must not be a leading axis of another axis coupling.

Monitoring the synchronism difference

2 limit values can be specified for the synchronism difference.

Gantry warning limit

The gantry warning limit is set using the following machine data:

MD37110 $MA_GANTRY_POS_TOL_WARNING (gantry warning limit)

The "Alarm limit exceeded" message is displayed if the synchronism difference exceeds the gantry warning limit. In addition, the NC/PLC-interface signal is set:

DB31, ... DBX101.3 == 1 (gantry warning limit exceeded)

After the alarm limit has been fallen below, the message and interface signal are automatically reset.

Note

Gantry warning limit

If the "Alarm limit exceeded" message is not to be displayed, then a value of 0 should be entered into MD37110.

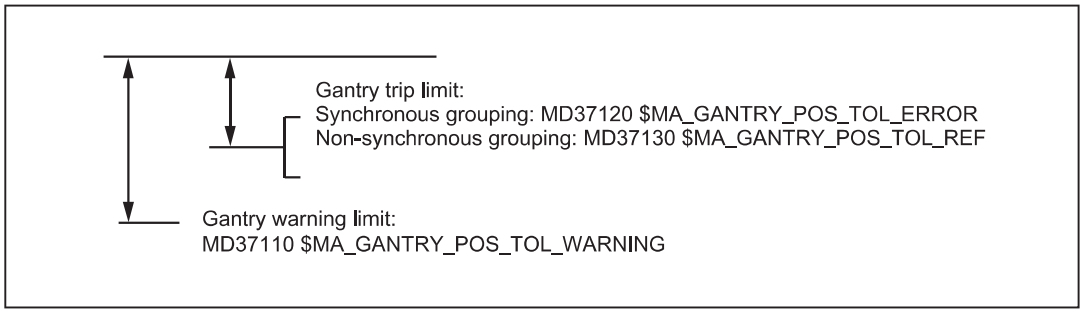
Gantry trip limit

The gantry trip limit is set using the following machine data:

- For the synchronized gantry grouping:
  MD37120 $MA_GANTRY_POS_TOL_ERROR
- For the non-synchronized gantry grouping:
  MD37130 $MA_GANTRY_POS_TOL_REF

Alarm 10653 "Error limit exceeded" is displayed if the synchronism difference exceeds the gantry trip limit. In addition, the NC/PLC-interface signal is set:

DB31, ... DBX101.2 == 1 (gantry trip limit exceeded)



The alarm is also displayed if the gantry grouping is jammed (no controller enable, gantry grouping in the "Hold" state).

Extended monitoring of the synchronism difference

An extended monitoring of the synchronism difference can be activated using the following machine data:

MD37150 $MA_GANTRY_FUNCTION_MASK, Bit 0 = 1

For the extended monitoring, a synchronism difference between the leading and synchronous axis, obtained when tracking or when the gantry grouping is opened, is taken into account.

The extended monitoring becomes active after the NC boots after the first referencing (incremental encoder) or synchronization (absolute encoder).

Exceeding the gantry trip limit

If, when the extended monitoring is active, the trip limit of the synchronism difference is exceeded, Alarm 10653 "Error limit exceeded" is displayed.

In order to be able to reset the alarm, proceed as follows:

1. Deactivating extended monitoring:
   MD37150 $MA_GANTRY_FUNCTION_MASK,Bit0 = 0
2. Deleting the synchronism difference displayed in the machine data:
   MD37135 $GANTRY_ACT_POS_TOL_ERROR = 0
3. Cancel alarm
4. Re-reference or synchronize the axes of the gantry grouping
5. Reactivating extended monitoring:
   MD37150 $MA_GANTRY_FUNCTION_MASK,Bit0 = 1

Referencing and synchronization of gantry axes

In cases where an incremental measuring system is being used for the leading or the synchronous axis, after the NC boots, the measuring systems must be referenced, maintaining the axis coupling.

After every axis in the gantry grouping has approached its reference point, any misalignment that may exist between the axes must be eliminated (gantry synchronization process). Once this has been performed, the NC/PLC interface signal is set:

DB31, ... DBX101.5 == 1 (gantry grouping is synchronized)

For the sequence when referencing or synchronizing gantry axes, see Chapter Referencing and synchronization of gantry axes (Page 158).

Control system dynamics

From the user perspective, a gantry grouping is exclusively traversed via the leading axis. The NC generates the setpoints of the synchronous axes directly from the setpoints of the leading axis in time synchronism and outputs these to them. To minimize the synchronism differences, the dynamic control response settings of all of the axes of a gantry grouping must be identical (see Chapter "Commissioning gantry axes (Page 168)").

Note

Identical control dynamics must be set for all axes of a gantry grouping.

Disturbance characteristic

If faults occur, which cause an axis of the gantry to be stopped, then the complete gantry grouping is always stopped.

Opening the gantry grouping

The axis coupling within a gantry grouping can be opened (dissolved) using the following machine data:

MD37140 $MA_GANTRY_BREAK_UP = 1 (invalidate gantry grouping)

When the setting becomes active, the axes of the gantry grouping can be individually traversed in the JOG, AUTOMATIC and MDI modes.

The monitoring functions of the synchronism difference and/or the alarm and trip limits are not active.

The NC/PLC interface signal "Gantry grouping is synchronized" is reset:

DB31, ... DBX101.5 == 0

⚠ CAUTION

If the gantry axes remain mechanically coupled, there is a risk of damage to the machine when the leading or synchronous axes are traversed in this operating state!

2.3 Referencing and synchronization of gantry axes

2.3.1 Introduction

Misalignment after starting

Immediately after the machine is switched on, the leading and synchronous axes may not be ideally positioned in relation to one another (e.g. misalignment of a gantry). Generally speaking, this misalignment is relatively small so that the gantry axes can still be referenced.

In special cases (e.g. gantry axes were stopped owing to a disturbance, power failure or EMERGENCY STOP), the dimensional offset must be checked for permissible tolerance values and a compensatory motion executed if necessary before the axes are traversed.

To execute this compensatory motion, the gantry grouping must be invalidated by means of the following machine data:

MD37140 $MA_GANTRY_BREAK_UP (invalidate gantry grouping)

Gantry synchronization process

All gantry axes must first be referenced and then synchronized after the control system is switched on. During gantry synchronization, all gantry axes approach **the reference position of the gantry grouping in the decoupled state**. The reference position of the gantry grouping for referencing the gantry axes corresponds to the **reference position of the leading axis:**

MD34100 $MA_REFP_SET_POS (reference point value/destination point for distancecoded system)

Otherwise, the reference position is the **current actual position of the leading axis**.

These operations for referencing and synchronizing the gantry axes are executed automatically in accordance with a special flowchart.

Referencing process

The flowchart for referencing gantry axes using an incremental measuring system is as follows:

Section 1:

Referencing of the leading axis

The axis-specific referencing of the gantry axis will be started by the active machine function REF upon the leading axis' interface signal from the PLC user program:

DB31, ... DBX4.7/4.6 (traversing key plus/minus)

The leading axis approaches the reference point (operational sequence as for reference point approach).

Reference:
Function Manual Basic Functions; Reference Point Approach (R1)

The appropriate synchronous axes traverse in synchronism with the leading axis. Interface signal "Referenced/synchronized" of the leading axis is output to indicate that the reference point has been reached.

Section 2:

Referencing of the synchronous axes

As soon as the leading axis has approached its reference point, the synchronous axis is **automatically** referenced (as for reference point approach).

Reference:
Function Manual Basic Functions; Reference Point Approach (R1)

The dependency between the leading axis and synchronous axis is inverted in the control for this phase so that the leading axis now traverses in synchronism with the synchronous axis. IS "Referenced/synchronized" of the synchronous axis is output to indicate that the reference point has been reached. The gantry axis dependency then reverts to its previous status. If a further synchronous axis is defined in the grouping, then this is also referenced in the way described above.

Section 3:

Gantry synchronization process

Once all axes in the gantry grouping have been referenced, they must be synchronized with the defined reference position. The actual position of each gantry axis is first compared to the defined reference position of the leading axis.

The next step in the operating sequence depends on the difference calculated between the actual values of the leading and synchronous axes:

- difference is **smaller** than the gantry warning limit:

  MD37110 $MA_GANTRY_POS_TOL_WARNING (gantry warning limit)

  The gantry synchronization process is started **automatically**. The message "Synchronization in progress gantry grouping x" is output during this process.

  The message "Synchronization running gantry grouping x" can be suppressed with:

  MD37150 $MA_GANTRY_FUNCTION_MASK Bit 2 = 1

  All gantry axes traverse at a specific position value **in the decoupled state** at the velocity set in the machine data:

  MD34040 $MA_REFP_VELO_SEARCH_MARKER (creep velocity)

  The position value is defined by the leading axis:

  MD34100 $MA_REFP_SET_POS (reference point/destination point for distance-coordinated system)

  The absolute encoders and distanced-coded encoders of the leading axis will be set to the current actual position of the leading axis or to the reference point by the following machine data:

  MD34330 $MA_REFP_STOP_AT_ABS_MARKER (Distancecoded linear measuring system without destination point)

  For this operation, the axes traverse at the same velocity as set for reference point approach:

  MD34070 $MA_REFP_VELO_POS (reference point positioning velocity)

  As soon as all gantry axes have reached their target position (ideal position), IS "Gantry grouping is synchronized" is set to "1" followed by re-activation of the gantry axis coupling. The position actual value of all axes in the gantry grouping must now be identical. The gantry synchronization process is now complete.

- Difference is **higher** than the gantry warning limit for at least one synchronous axis:

  IS "Gantry synchronization read to start" is set to "1" and the message "Wait for synchronization start of gantry grouping x" is output. The gantry synchronization process is not started automatically in this case, but must be started explicitly by the operator or from the PLC user program. The process is initiated by IS "Start gantry synchronization" on the leading axis. The signal is set on the leading axis. The operational sequence is then the same as that described above.

The following flowchart illustrates the referencing and synchronization processes.

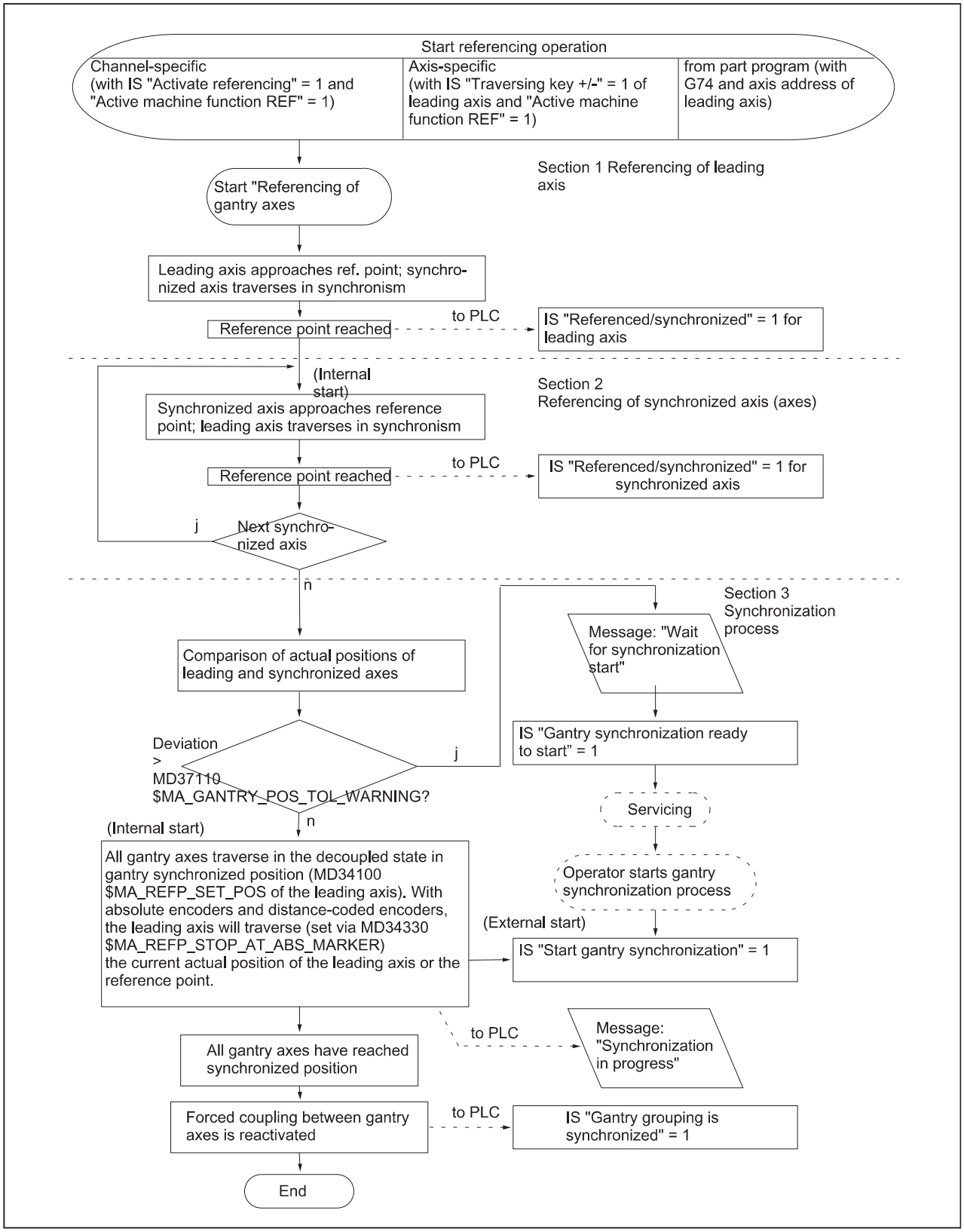


Figure 2-2 Flowchart for referencing and synchronization of gantry axes

Synchronization process

A synchronization process is always required in the following cases:

- after the reference point approach of all axes included in a grouping,
- if the axes become de-synchronized (s below).

Operational sequence failure

If the referencing process described above is interrupted as a result of disturbances or a RESET, proceed as follows:

- **Abort within section 1 or 2:**

  Restart reference point with leading axis (see section 1)

- **Abort in section 3:**

  In cases where the gantry axes have not yet been referenced (IS "Referenced/Synchronized" = 1), the gantry synchronization process can be started again with IS "Synchronize gantry grouping".

Restart gantry synchronization

Synchronization of the gantry axes can be started with IS "Start gantry synchronization" under the following conditions only:

- JOG/REF mode must be active. The following interface signal must be set:

  DB11, DBX5.2 = 1 (active machine function REF)

- DB31, ... DBX 101.5 = 0 (gantry grouping is synchronized)
- All grouping axes operate within the tolerance windows:

  DB31, ... DBX 101.4 = 1(gantry synchronization process ready to start)

- Axes are not referenced in the relevant NC channel

  DB21, ... DBX33.0 = 0 (referencing active)

If the gantry synchronization process is **not started from the referencing process** by means of IS "Start gantry synchronization process", then the reference position is not specified as target position for the synchronous axes:

MD34100 $MA_REFP_SET_POS (reference point value/destination point for distancecoded system)

Instead, **the actual position of the leading axis** is specified as the target position and is approached in the uncoupled state.

Note

For the leading axis, automatic synchronization can be locked using the following NC/PLC interface signal:

DB31, ... DBX29.5 = 1 (no automatic synchronization process)

This always makes sense if no axis enabling signal has yet been issued for the axes. In this case, the synchronization process should also be started explicitly with the NC/PLC interface signal:

DB31, ... DBX29.4 = 1 (start gantry synchronization process)

Loss of synchronization

The gantry grouping becomes desynchronized as a result of:

- "Tracking" the gantry axes
- Loss of the reference position of a gantry axis, e.g. by "Parking" (no measuring system active)
- Re-referencing of gantry axis
- The gantry grouping is opened (dissolved) by:

  MD37140 $MA_GANTRY_BREAK_UP = 0 (invalidate gantry axis grouping)

The corresponding NC/PLC interface signal is reset:

- DB31, ... DBX60.4 or DBX60.5 == 0 (referenced/synchronized 1 or 2 respectively)
- DB31, ... DBX 101.5 == 0 (gantry grouping is synchronized)

If, in operation, gantry grouping synchronization is lost due to a fault, then synchronization can be restarted using the NC/PLC interface signal:

DB31, ... DBX29.4 = 1 (start gantry synchronization process)

Precondition is that the following applies to all axes of the gantry grouping:

DB31, ... DBX60.4 or DBX60.5 == 1 (referenced/synchronized 1 or 2 respectively)

In this case, the synchronizing axes traverse the current actual position of the leading axis in the decoupled state.

If, when the gantry grouping is traversing, the signal "Emergency Stop" (DB10, DBX56.2) is set and again reset, and the gantry axes have drifted apart less than the standstill tolerance of the synchronous axes, then these are automatically resynchronized. Automatic synchronization can be suppressed using the NC/PLC interface signal for the leading axis:

DB31, ... DBX29.5 = 1 (no automatic synchronization process)

Selecting the reference point

To ensure that the shortest possible paths are traversed when the gantry axes are referenced, the reference point values from leading and synchronous axes should be the same in the machine data:

MD34100 $MA_REFP_SET_POS (reference point value/destination point for distancecoded system)

Allowance for deviations in distance between the zero mark and the reference point must be made for specific axes via the machine data:

MD34080 $MA_REFP_MOVE_DIST (reference point distance)

MD34090 $MA_REFP_MOVE_DIST_CORR (reference point offset/absolute offset)

Referencing direction selection

The zero mark search direction of the synchronous axis can be defined via the machine data:

MD37150 $MA_GANTRY_FUNCTION_MASK, Bit 1

Bit	Value	Meaning
1	0	Zero mark search direction of the synchronous axis analog to machine data: MD34010 $MA_REFP_CAM_DIR_IS_MINUS
	1	Zero mark search direction of the synchronous axis the same as the leading axis

During referencing, the reference point value of the leading axis is specified as the target position for all axes in the grouping for the synchronization compensatory motion. This position is then approached without axis coupling. The absolute encoders and distanced-coded encoders of the leading axis will be set to the current actual position of the leading axis or to the reference point by the following machine data:

MD34330 $MA_REFP_STOP_AT_ABS_MARKER (Distancecoded linear measuring system without destination point)

If only one reference cam is used for the leading and synchronous axes, then this must be taken into account in the PLC user program.

2.3.2 Automatic synchronization

Automatic synchronization can take place:

- in referencing mode (see Section "Detailed description", "Introduction")
- in other modes, as described in the following.

If a gantry grouping is switched to follow-up mode, monitoring of the actual values between the leading and synchronized axes is disabled. The grouping is no longer synchronized as a result. Independent of axes positions, the following interface signal will be set to 0 (from leading axis)

DB31, ... DBX101.5 (gantry grouping is synchronous)

If the gantry grouping is switched from follow-up mode to position control mode, axis synchronism is automatically restored provided the actual-value monitor does not detect a difference between the positions of the leading and synchronized axes greater than the setting in the machine data:

MD36030 $MA_STANDSTILL_POS_TOL (standstill tolerance)

In this case, a new setpoint is specified for the synchronized axis (axes) without interpolation. The positional difference detected earlier is then corrected by the position controller. The correction causes only the synchronized axis (axes) to move.

The motional sequence of the synchronized axis (axes) is analogous to the situation in which the grouping switches from the "Hold" state to position control mode. In this case, the position specified by the position controller before the grouping is halted is set again on condition that the zero speed monitor has not activated alarm 25040 (with follow-up as alarm reaction) in the meantime.

The same tolerance window is used for this mode of automatic synchronization as for the zero speed monitoring function:

MD36030 $MA_STANDSTILL_POS_TOL (standstill tolerance)

Parameter rate dependence loads with machine data:

MD36012 $MA_STOP_LIMIT_FACTOR (exact stop coarse/fine and standstill factor)

Note

The following interface signal blocks automatic synchronization in all modes except referencing mode:

DB31, ... DBX29.5 (no automatic synchronization)

Should the automatic synchronization be activated at this point, then the following interface signal must be reset:

DB31, ... DBX29.5 = 0 (no automatic synchronization)

Then switch one of the axes in the gantry grouping from follow-up mode to position-controlled mode. This is achieved with the interface signals:

DB31, ... DBX1.4 = 1 (follow-up mode)

DB31, ... DBX2.1 = 1 (servo enable)

2.3.3 Points to note

2. Position measuring systems per gantry axis

Different types of position measuring systems can be mounted on the gantry axes of a grouping. Furthermore, each gantry axis is capable of processing two position measuring systems, it being possible to switch over from one system to the other at any time:

DB31, ... DBX1.5 (position measuring system 1)

DB31, ... DBX1.6 (position measuring system 2)

The maximum tolerance for position actual value switchover should be set to a lower value than the gantry warning limit:

MD36500 $MA_ENC_CHANGE_TOL (Max. tolerance for position actual value switchover)

The two position measuring systems must, however, have been referenced beforehand. The relevant measuring system must be selected before referencing is initiated. The operational sequence is then the same as that described above.

Channelspecific referencing

Gantry axes can also be referenced by channel with the following interface signal:

DB21, ... DBX1.0 (activate referencing)

The value of the leading axis' machine data are used for the axis sequence for channel-specific referencing:

MD34110 $MA_REFP_CYCLE_NR (Axis sequence for channel-specific referencing)

After the reference point of the leading axis has been reached, the synchronized axes are referenced first as described above.

Referencing from part program with G74

The referencing and synchronization process for gantry axes can also be initiated from the part program by means of command G74. In this case, only the axis name of the leading axis may be programmed. The operational sequence is analogous to that described for axis-specific referencing.

Position measuring system with distancecoded reference marks

In order that return traverses do not have to be made over large distances, it is possible to use a position measuring system with distance-coded reference marks as a sole or second measuring system for gantry axes. In this way the measuring system is referenced after traversal of a short path (e.g. 20 mm). The procedure for referencing the gantry axes is the same as that described for the normal incremental measuring system.

Reference:

/FB1/ Function Manual, Basic Functions, Reference Point Approach (R1)

Absolute encoder

During the course of the synchronization compensatory motion, all axes in the gantry axis grouping traverse to the reference point value of the leading axis defined in the machine data:

MD34100 $MA_REFP_SET_POS (reference point value/destination point for distancecoded system)

The absolute encoders and distanced-coded encoders of the leading axis will be set to the current actual position of the leading axis or to the reference point by the following machine data:

MD34330 $MA_REFP_STOP_AT_ABS_MARKER (Distancecoded linear measuring system without destination point)

Activation of axis compensations

Compensation functions can be activated for both the leading axis and the synchronized axes. Compensation values are applied separately for each individual gantry axis. These values must therefore be defined and entered for the leading axis and the synchronized axes during start-up.

The compensations do not become operative internally in the control until the axis is referenced or the gantry grouping synchronized. The following applies:

Compensation type	Takes effect when	PLC interface signal
Backlash compensation	Axis is referenced	"Referenced/Synchronized"
LEC	Axis is referenced	"Referenced/synchronized"
Sag compensation	Gantry grouping is synchronized	"Gantry grouping is synchronized"
Temperature compensation	Gantry grouping is synchronized	"Gantry grouping is synchronized"

If a movement by the synchronized axis (axes) is caused by an active compensation, a travel command is displayed for the synchronized axis (axes) independently of the leading axis.

Monitoring functions effective

Analogous to normal NC axes, the following monitoring functions do not take effect for gantry axes until the reference point is reached (IS "Referenced/Synchronized"):

- Working area limits
- Software limit switch
- Protection zones

The axial machine data values are used as monitoring limit values for the synchronized axes as well.

Multi-channel block search

The cross-channel block search in Program Test mode (SERUPRO "**Se**arch **R**un by **Pro**gram test") can be used to simulate the traversal of gantry axis groupings.

Note

Further information regarding multi-channel block search SERUPRO can be found under:
References:
/FB1/ Function Manual, Basic Functions; Mode group, Channel, Program Mode (K1), Chapter "Program Test"

2.4 Start-up of gantry axes

General information

Owing to the forced coupling which is normally present between leading and synchronized gantry axes, the gantry axis grouping must be started up as if it were an axis unit. For this reason, the axial machine data for the leading and synchronized axes must always be defined and entered jointly.

If the synchronized axis is being overloaded by the leading axis due to reduced dynamics, this is acknowledged with alarm 10656.

Special points to be noted with regard to starting up gantry axes are described below.

Axis traversing direction

As part of the start-up procedure, a check must be made to ensure that the direction of rotation of the motor corresponds to the desired traversing direction of the axis. Correct by means of axial machine data:

MD32100 $MA_AX_MOTION_DIR (travel direction).

Activation of the axis grouping

MD37100 $MA_GANTRY_AXIS_TYPE (gantry axis definition)

This machine data is determined for the following gantry axis:

- To which gantry grouping (1, 2 or 3) the axis must be assigned,
- Whether it is to act as the leading axis (single-decade MD value only) or as a synchronized axis.

Note

Please make sure that a gantry grouping specified as cross-channel or cross-NCU does not clash with gantry grouping numbers already assigned. In this case the gantry grouping numbers must be clearly assigned cross-channel and cross-NCU. If this is not the case, alarm 10651 is output with reason 40XX. XX is the gantry grouping causing the clash.

For start-up purposes, all axes in a gantry grouping must be declared either as linear axes or as rotary axes:

MD30300 $MA_IS_ROT_AX (rotary axis/spindle)

Table 2- 1 Examples for defining the gantry axis grouping

MD37100 $MA_GANTRY_AXIS_TYPE	Gantry axis	Gantry grouping
0	None	-
1	Leading axis	1
1**1**	Synchronized axis	1
2	Leading axis	2
1**2**	Synchronized axis	2
3	Leading axis	3
1**3**	Synchronized axis	3
...		
8	Leading axis	8
1**8**	Synchronized axis	8

Entering gantry trip limits

For the monitoring of the actual position values of the synchronized axis in relation to the actual position of the leading axis, the limit values for termination, as well as for the leading and synchronized axes, should be entered corresponding to the specifications of the machine manufacturer:

MD37120 $MA_GANTRY_POS_TOL_ERROR (gantry trip limit)

MD37130 $MA_GANTRY_POS_TOL_REF (gantry trip limit for referencing)

Note

The control must then be switched off and then on again because the gantry axis definition and the trip limit values only take effect after power ON.

Response to setpoint changes and disturbances

Since the digital 611D drives respond well to disturbances and setpoint changes, there is no need for a compensatory control between the gantry axes. However, the gantry axes can only operate in exact synchronism if the parameters for the control circuits of the leading and synchronized axes are set to the **same dynamic response value**.

To ensure the best possible synchronism, the leading axis and synchronized axis must be capable of the **same dynamic response to setpoint changes**. The axial control loops (position, speed and current controllers) should each be set to the **optimum** value so that disturbances can be eliminated as quickly and efficiently as possible. The **dynamic response adaptation** function in the setpoint branch is provided to allow differing dynamic responses of axes to be matched without loss of control quality.

The following control parameters must be set to the optimum axial value for both the leading axis and the synchronized axis:

- MD32200 $MA_POSCTRL_GAIN (KV factor)
- MD32620 $MA_FFW_MODE (feedforward control parameter)
- MD32610 $MA_VELO_FFW_WEIGHT (feedforward control factor for acceleration/speed)
- MD32650 $MA_AX_INERTIA (inertia for torque feedforward control)
- MD32800 $MA_EQUIV_CURRCTRL_TIME(Equivalent time constant current control loop for feedforward control)
- MD32810 $MA_EQUIV_SPEEDCTRL_TIME (equivalent time constant speed control loop for feedforward control)

References:

/FB2/ Function Manual, Extended Functions, Compensations (K3)

The following control parameters must be set to the same value for the leading axis and synchronized axis:

- MD33000 $MA_FIPO_TYPE (fine interpolator type)
- MD32400 $MA_AX_JERK_ENABLE (axial jerk limitation)
- MD32410 $MA_AX_JERK_TIME (time constant for the axial jerk filter)
- MD32420 $MA_JOG_AND_POS_JERK_ENABLE (basic position of axial jerk limitation)
- MD32430 $MA_JOG_AND_POS_MAX_JERK (axial jerk)

References:

/FB1/ Function Manual, Basic Functions, Velocities, Setpoint-Actual Value Systems, Closed-Loop Control (G2)

Dynamics matching

The leading axis and the coupled axis must be capable of the same dynamic response to setpoint changes. The same dynamic response means: The following errors are equal in magnitude when the axes are operating at the same speed.

The dynamic response adaptation function in the setpoint branch makes it possible to obtain an excellent match in the response to setpoint changes between axes, which have different dynamic characteristics (control loops). The difference in equivalent time constants between the dynamically "weakest" axis and the other axis in each case must be specified as the dynamic response adaptation time constant.

Example

When the speed feedforward control is active, the dynamic response is primarily determined by the equivalent time constant of the "slowest" speed control loop.

Leading axis:

MD32810 $MA_EQUIV_SPEEDCTRL_TIME [n] = 5ms (equivalent time constant speed control loop for feedforward control)

Following axis:

MD32810 $MA_EQUIV_SPEEDCTRL_TIME [n] = 3ms

- Time constant of dynamic response adaptation for synchronized axis:

  MD32910 $MA_DYN_MATCH_TIME [n] = 5ms - 3ms = 2ms (time constant of dynamic response adaptation)

The dynamic response adaptation must be activated axially with the machine data:

MD32900 $MA_DYN_MATCH_ENABLE (dynamic response adaptation)

Check of dynamic response adaptation:

The following errors of the leading and synchronized axes must be equal in magnitude when the axes are operating at the same speed!

For the purpose of fine tuning, it may be necessary to adjustservo gain factors or feedforward control parameters slightly to achieve an optimum result.

Referencing gantry axes

The positions of the reference points of the leading and synchronized axes must first be set to almost identical values.

To ensure that the synchronization compensatory motion of the gantry axes is not started automatically, the gantry warning limit must be set to 0 at the first start-up before referencing:

MD37100 $MA_GANTRY_POS_TOL (gantry axis definition)

This will prevent a warning message being output during traversing motion.

In cases where an excessively high additional torque is acting on the drives due to misalignment between the leading and synchronized axes, the gantry grouping must be aligned before the axes are traversed. After this, gantry axes referencing must be performed according to the Section "Referencing and synchronizing of gantry axes" and:

References:

/FB1/ Function Manual, Basic Functions, Reference Point Approach (R1)

After the leading and synchronized axes have been referenced, the difference between them must be measured (comparison of position actual value indication in "Service axes" display of "Diagnosis" operating area). This difference must be applied as the reference point offset:

MD34080 $MA_REFP_MOVE_DIST (reference point distance)

MD34090 $MA_REFP_MOVE_DIST_CORR (reference point offset/absolute offset)

The differences in distance between the zero mark and reference point must also be calculated for each gantry axis and adjusted. They are to be customized, via the following machine data, in such a way that the position actual values of the leading and synchronized axes are identical after execution of the compensatory motion:

MD34080 $MA_REFP_MOVE_DIST (reference point distance)

MD34090 $MA_REFP_MOVE_DIST_CORR (reference point offset/absolute offset)

Synchronizing gantry axes

The gantry synchronization process must be activated with IS "Start gantry synchronization" (see Section "Referencing and synchronizing of gantry axes"). Once the axes have been synchronized (IS "Gantry grouping is synchronized" = 1), the dimensional offset between the leading and synchronized axes must be checked to ensure that it equals 0. Corrections may need to be made in the machine data mentioned above.

Input of gantry warning limit

Once the reference point values for the leading and synchronized axes have been optimized so that the gantry axes are perfectly aligned with one another after synchronization, the warning limit values for all axes must be entered in the following machine data:

MD37110 $MA_GANTRY_POS_TOL_WARNING (gantry warning limit)

To do this, the value must be increased incrementally until the value is just below the alarm (limit exceeded) response limit. It is particularly important to check the acceleration phases.

This limit value also determines the position deviation value at which gantry synchronization is automatically started in the control.

Calculating and activating compensations

In cases where the gantry axes require compensation (backlash, sag, temperature or leadscrew error), the compensation values for the leading axis **and** the synchronized axis must be calculated and entered in the appropriate parameters or tables.

References:

/FB2/ Function Manual Extended Functions, Compensations (K3)

Function generator/measuring function

The activation of the function generator and measuring function will be aborted on the synchronized axis with an error message.

When an activation of the synchronized axis is absolutely necessary (e.g. to calibrate the machine), the leading and synchronized axes must be temporarily interchanged.

Note

Generally, the start of the function generator, measuring functions and AM setup triggers the virtual axes to abort upon error recognition.

Special cases

If **individual** axes have to be activated, the gantry groups must be temporarily canceled. As the second axis no longer travels in synchronism with the first axis, the activated axis must not be allowed to traverse beyond the positional tolerance.

If the gantry grouping is canceled, the following points must be noted:

- Always activate the traversing range limits and set them to the lowest possible values (position tolerance)
- Synchronize the gantry grouping first if possible and then execute a POWER-ON-RESET **without** referencing the axes again. This ensures that the traversing range limits always refer to the same position (i.e. that which was valid on power ON).
- Avoid using the step-change function. Position step changes are only permissible if they stay within the permitted tolerance.
- Always use an offset of 0 for the function generator and measuring function in contrast to the recommendations for normal axes.
- Set the amplitudes for function generator and measuring function to such low values that the activated axis traverses a shorter distance than the position tolerance allows. Always activate the traversing range limits as a check (see above).

References:

/FBA/ Description of Functions, Drive Functions, Speed Control Loop (DD2)

Note

As a supplement to the more general description given here of features of start-up and dynamic control response of drives, a complete example of a concrete constellation defined on the basis of its machine data can be found in Chapter "Example".

Start-up support for gantry groupings

The start-up functions of the function generator and measuring are parameterized via the PI service. All parameterized axes commence traversing when the NC Start key on the MCP panel is pressed in JOG mode.

A window is displayed in the "Measuring function and function generator in gantry grouping" operator interface. Two amplitude values, each with an offset and bandwidth, must be entered in this window. The first amplitude value applies to the measuring axis and the second to the other coupled axes.

2.5 PLC interface signals for gantry axes

Special IS for gantry axes

The special NC/PLC interface signals of the coupled gantry axes are taken via the axial NC/PLC interface of the leading or synchronized axes. The table below shows all special gantry NC/PLC interface signals along with their codes and indicates whether the IS is evaluated on the leading axis or the synchronized axis.

NC/PLC interface signal	To axis (PLC → NCK) or from axis (NCK → PLC)	DB31, ... DBX...	Leading axis	Synchronized axis
Start gantry synchronization	PLC → NCK	29.4	X	
No automatic synchronization	PLC → NCK	29.5	X	
Gantry axis	NCK → PLC	101.7	1	1
Gantry leading axis	NCK → PLC	101.6	1	0
Gantry grouping is synchronized	NCK → PLC	101.5	X	
Gantry synchronization ready to start	NCK → PLC	101.4	X	
Gantry warning limit exceeded	NCK → PLC	101.3		X
Gantry trip limit exceeded	NCK → PLC	101.2		X

Effect of axial interface signals on gantry axes

a) Axial interface signals from PLC to axis (PLC → NCK)

The axial interface signals from the PLC to the axis are always referred to all gantry axes in the grouping. In this case, all gantry axes (leading and synchronized axis) have equal priority.

For example, all axes in the gantry groupings will be simultaneously shut down when the following interface signal is set to "0" from the leading axis:

DB31, ... DBX2.1 (servo enable)

The following table shows the effect of individual interface signals (from PLC to axis) on gantry axes:

NC/PLC interface signal	DB31, ... DBX ...	Effect on	
		Leading axis	Synchronized axis
Axis/spindle disable	1.3	On all axes in gantry grouping	No effect
Position measuring system 1/2	1.4 and 1.5	Axial [1]	Axial [1]
Controller enable	2.1	On all axes in gantry grouping [2]	
Delete distance to go (axial)	2.2	Axial	No effect
Clamping in progress	2.3	Axial	Axial
Reference point value 1-4	2.4 - 2.7	Axial	Axial
Feed stop	4.4	On all axes in gantry grouping	
Hardware limit switch plus/minus	12.0 and 12.1	Axial alarm: Brake request on all axes in gantry grouping	
2nd Hardware limit switch plus / minus	12.2 and 12.3	Axial	Axial
Ramp-function generator fast stop (RFGFS)	20.1	On all axes in gantry grouping	
Select drive parameter set	21.0 - 21.2	Axial	Axial
Enable Pulses	21.7	Axial	Axial
DB31, ... DBX1.5 and 1.6 (position measuring system 1/2) The switchover between position measuring systems 1 and 2 applies individually for each gantry axis. However, deactivation of both position measuring systems (known as the parking position) applies as a common signal for all gantry axes. DB31, ... DBX2.1 (servo enable) If the servo enable signal on one gantry axis is canceled, all axes in the gantry grouping are shut down simultaneously. The method by which shutdown is implemented (e.g. with fast stop) is identical for all gantry axes.			

Either the "Follow-up" state (IS of one gantry axis = 1) or the "Stop" state (IS of all gantry axes = 0) is activated for all gantry axes, depending on interface signal:

DB31, ... DBX1.4 (follow-up mode)

b) Axial interface signals from axis to PLC (NCK → PLC)

Each of the axial, axis-to-PLC interface signals for the synchronized axis and the leading axis is always set on an axis-specific basis and output to the PLC.

Example:

DB31, ... DBX60.4 resp. 60.5 (referenced/synchronized 1/2).

Exception:

When the leading axis is traversed, the interface signal will also be set for the synchronizing axis:

DB31, ... DBX64.6 and 64.7 (traverse command plus resp. minus)

2.6 Miscellaneous points regarding gantry axes

Manual travel

It is not possible to traverse a synchronized axis directly by hand in JOG mode. Traverse commands entered via the traversing keys of the synchronized axis are ignored internally in the control. Rotation of the handwheel for the synchronized axis has no effect either.

Handwheel override

An overriding motion by means of the handwheel can only be applied to the leading axis in coupled axis mode. In this case, the synchronized axes traverse in synchronism with the leading axis.

DRF offset

A DRF offset can only be applied to the leading axis. In this case, the synchronized axes traverse in synchronism with the leading axis.

Programming in part program

Only the leading axis of a gantry axis grouping may be programmed in the part program. An alarm is generated while programming a synchronized axis, even when a gantry axis grouping is released (MD37140 $MA_GANTRY_BREAK_UP = 1).

PLC or command axes

Only the leading axis of the gantry grouping can be traversed by the PLC using FC 18 or as a command axis by means of synchronized actions.

Reference:

- Function Manual, Basic Functions, Basic PLC Program (P3)
- Function Manual, Synchronized Actions

PRESET

The PRESET function can only be applied to the leading axis. All axes in the gantry grouping are reevaluated internally in the control when PRESET is activated. The gantry axis then lose their reference and synchronization:

DB31, ... DBX101.5 (gantry grouping is synchronized) = 0

Channel assignment of the gantry axes

Please ensure that for a gantry grouping whose leading axis is known in several channels, its synchronized axes in these channels are also known. If this is not the case, Alarm 10651 is output with reason 60XX (XX is the objectionable gantry grouping).

Axis replacement

All axes in the gantry grouping are released automatically in response to a RELEASE command (leading axis).

A replacement of the leading axis of a closed gantry grouping is only possible, if all axes of the grouping are known in the channel in which they are to be transferred, otherwise alarm 10658 is signaled.

No automatic axis change and no automatic adjustment of the gantry axis conditions are undertaken while trying to reconnect a gantry grouping is released with MD37140 $MA_GANTRY_BREAK_UP = 1. The user is responsible for this. A check of the axis conditions is conducted after the break up and if necessary, a corresponding alarm 10658 is output.

Note

If a gantry grouping is to be closed again, the user must ensure that all axes of the grouping are in a channel with a corresponding axis condition.

Default for RESET

In an active gantry grouping, the following MD parameterization is ignored for the synchronized axes:

MD30450 $MA_IS_CONCURRENT_POS_AX = 1 (Reset default: neutral axis/channel axis)

The state of the leading axis is assumed. The user is informed about the inappropriate configuration with display alarm 4300.

Display data

The position actual value display shows the actual values of both the leading axis and the synchronized axes. The same applies to the service display values in the "Diagnosis" operating area.

Software limit switch

The SW limit switch monitor is processed for the leading axis only. If the leading axis crosses the limit switch, all axes in the gantry grouping are braked to a standstill.

Differences in comparison with the "Coupled motion" function

The main differences between the "gantry axes" and "coupled motion" functions are listed below:

- The axis coupling between the gantry axes must always be active. Separation of the axis coupling via part program is therefore not possible for gantry axes. In contrast, the coupled axis grouping can be separated by means of the part program and the axes then traversed individually.
- In the "Gantry Axes" function, the difference of the actual position values from the leading and synchronized axis is monitored continuously and the traversing motion is shut down if there are impermissible deviations. There is no monitoring for the "Coupled motion" function.
- Gantry axes must remain coupled even during referencing. For this reason, special procedures are applied for the reference point approach of gantry axes. In contrast, coupled-motion axes are referenced as individual axes.
- For the gantry axes to traverse without mechanical offset, the synchronized axes must be set like the leading axes from the control dynamics perspective. In contrast, the "coupled motion" function permits axes with different dynamic control response characteristics to be coupled.

References:
Function Manual, Basic Functions, Reference Point Approach (M3)

2.7 Examples

2.7.1 Creating a gantry grouping

Introduction

The gantry grouping, the referencing of its axes, the orientation of possible offsets and, finally, the synchronization of the axes involved are complicated procedures. The individual steps involved in the process are explained below by an example constellation.

Constellation

Machine axis 1 = gantry leading axis, incremental measuring system

Machine axis 3 = gantry synchronized axis, incremental measuring system

Machine data

The following machine data describe the original values at the beginning of the procedure. Individual settings must be corrected or added later according to the information below.

Gantry machine data

Axis 1

MD37100 $MA_GANTRY_AXIS_TYPE = 1 (gantry axis definition)

MD37110 $MA_GANTRY_POS_TOL_WARNING =0 (gantry warning limit)

MD37120 $MA_GANTRY_POS_TOL_ERROR = e.g. 1 (gantry trip limit)

MD37130 $MA_GANTRY_POS_TOL_REF = e.g. 100 mm (max. misalignment) (gantry trip limit for referencing)

MD37140 $MA_GANTRY_BREAK_UP = 0 (invalidate gantry grouping)

Axis 3

MD37100 $MA_GANTRY_AXIS_TYPE= 11

MD37110 $MA_GANTRY_POS_TOL_WARNING = 0

MD37120 $MA_GANTRY_POS_TOL_ERROR = e.g. 1 mm

MD37130 $MA_GANTRY_POS_TOL_REF = e.g. 100mm (max. misalignment)

MD37140 $MA_GANTRY_BREAK_UP = 0

Reference point machine data (for first encoder each)

Axis 1

MD34000 $MA_REFP_CAM_IS_ACTIVE = TRUE

MD34010 $MA_REFP_CAM_DIR_IS_MINUS = e.g. FALSE

MD34020 $MA_REFP_VELO_SEARCH_CAM =

MD34030 $MA_REFP_MAX_CAM_DIST = corresponds to max. distance traversed

MD34040 $MA_REFP_VELO_SEARCH_MARKER =

MD34050 $MA_REFP_SEARCH_MARKER_REVERSE = e.g. FALSE

MD34060 $MA_REFP_MAX_MARKER_DIST = Difference betw. cam edge and 0 mark

MD34070 $MA_REFP_VELO_POS =

MD34080 $MA_REFP_MOVE_DIST = 0

MD34090 $MA_REFP_MOVE_DIST_CORR = 0

MD34092 $MA_REFP_CAM_SHIFT = 0

MD34100 $MA_REFP_SET_POS = 0

MD34200 $MA_ENC_REFP_MODE = 1

The reference point machine data (for the first encoder) of axis 3 must be specified analogously.

2.7.2 Setting of NCK PLC interface

Introduction

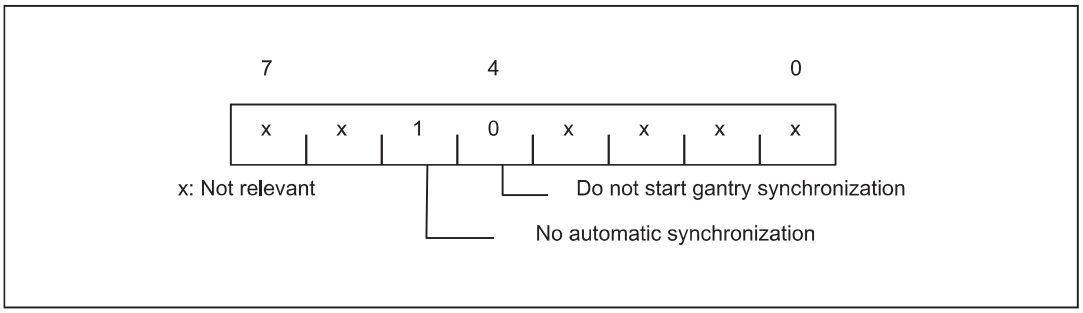
An automatic synchronization process during axis referencing must be disabled initially so as to prevent any damage to grouping axes that are misaligned.

Disabling of automatic synchronization

The PLC user program sets the following for the axis data block of axis 1:

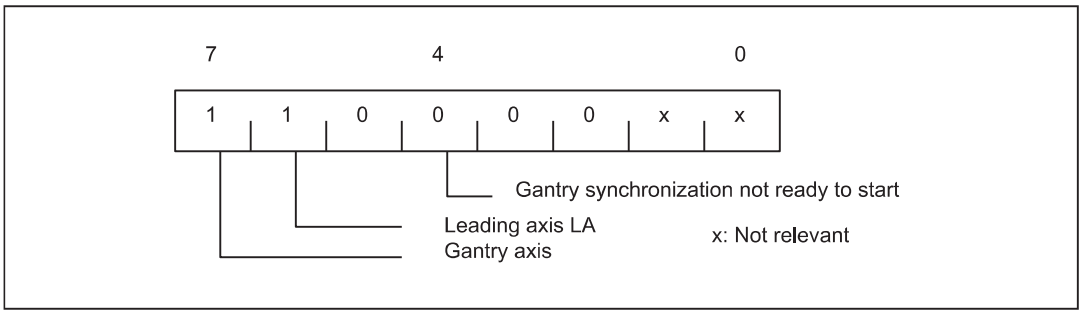
DB31, ... DBX29.4 = 0

DB31, ... DBX29.5 = 1



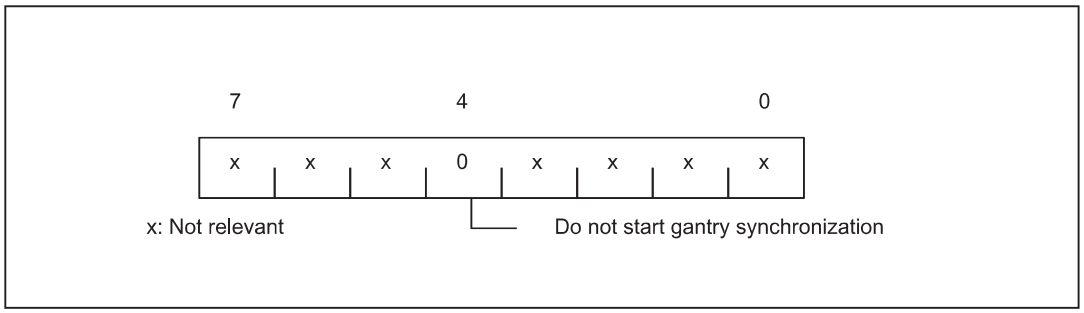
The NCK sets the following as a confirmation in the axis block of axis 1:

DB31, ... DBB101:



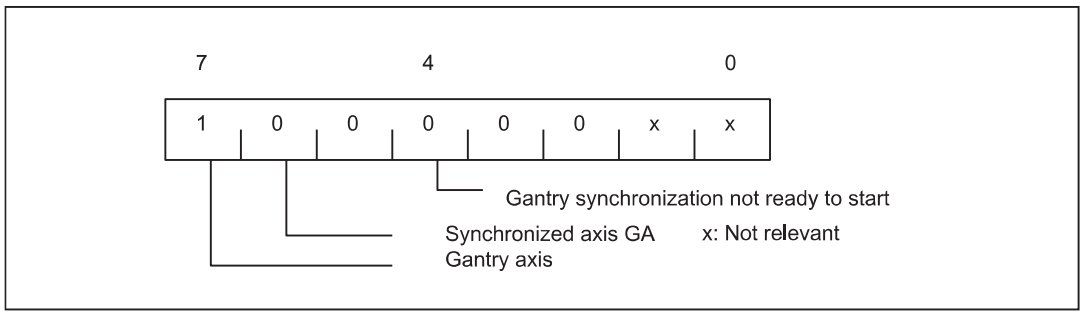
The PLC user program sets the following for the axis data block of axis 3:

DB31, ... DBX29.4 = 0



The NCK sets the following as a confirmation in the axis block of axis 3:

DB31, ... DBB101:



2.7.3 Commencing start-up

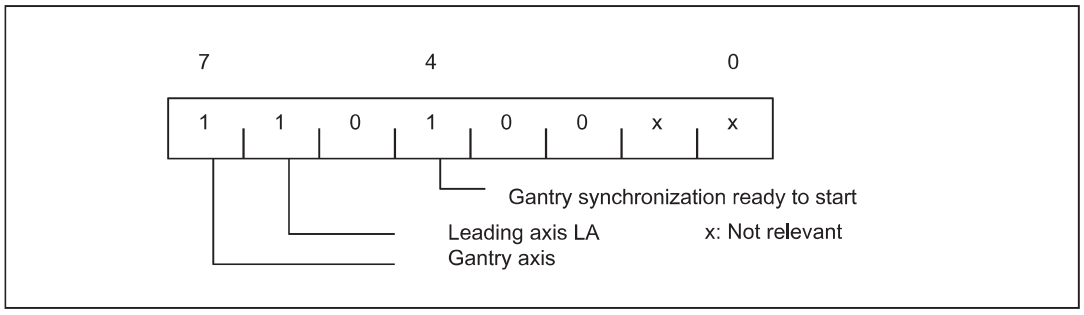
Referencing

The following steps must be taken:

- Select "REF" operating mode
- Start referencing for axis 1 (master axis)
- Wait until message "10654 Channel 1 Waiting for synchronization start" appears.

At this point in time, the NCK has prepared axis 1 for synchronization and registers this to the interface signal:

DB31, ... DBB101 with:



In addition, the following steps must be taken:

- RESET
- Read off values in machine coordinate system:

  e.g.

  X = 0.941

  Y = 0.000

  XF = 0.000

- Enter the X value of master axis 1 with inverted sign in the machine data of slave axis 3:

  MD34090 $MA_REFP_MOVE_DIST_CORR = - 0.941 (reference point offset/absolute offset)

Note

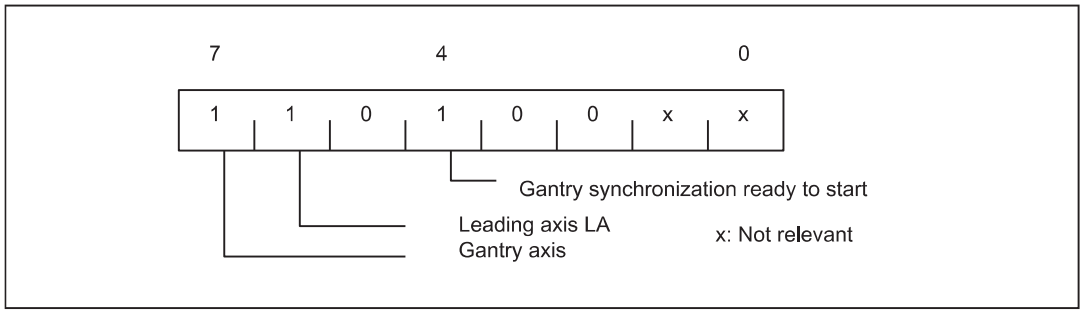
This MD is effective after power ON. To avoid having to perform a power ON now, the value can also be entered in the following machine data:

MD34080 $MA_REFP_MOVE_DIST (reference point distance)

The MD is then valid after a RESET.

- Start referencing again for axis 1 (master axis) with the modified machine data
- Wait until message "10654 Channel 1 Waiting for synchronization start" appears
- At this point in time, the NCK has prepared axis 1 for synchronization and registers this to the interface signal:

  DB31, ... DBB101(gantry)



- Examine actual positions of machine. Case A or B might apply:

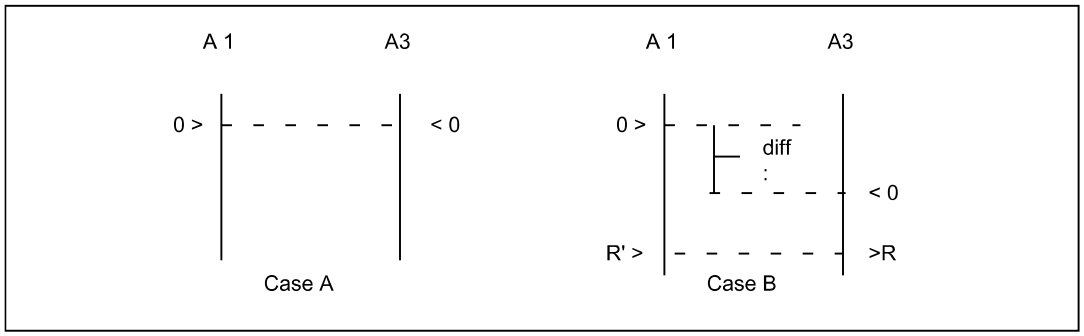


Figure 2-3 Possible results after referencing of axis 1 (master axis)

If Case A applies, the synchronization process can be started immediately. See step "Start synchronization". If Case B applies, the offset "diff" must be calculated and taken into account:

- Measuring of diff
- By using two appropriate, right-angled reference points R' and R" in the machine bed (right in picture), the difference in position in JOG can be traversed. The diff offset can then be read as the difference in the position display. The diff offset must be entered in the machine data of axis 3 (synchronized axis):

  MD34100 $MA_REFP_SET_POS

  Continue with Step 1 (see above).
- Start gantry synchronization. PLC sets:

  DB31, ... DBX29.4 = 1 (start synchronization of gantry)

2.7.4 Setting warning and trip limits

As soon as the gantry grouping is set and synchronized, the following machine data must still be set to correspond:

MD37110 $MA_GANTRY_POS_TOL_WARNING (gantry warning limit)

MD37120 $MA_GANTRY_POS_TOL_ERROR (gantry trip limit)

Proceed as follows

- Set the machine data for all axes with a large value to begin with:

  MD37120 $MA_GANTRY_POS_TOL_ERROR (gantry trip limit)

- Set a very small value in the machine data:

  MD37110 $MA_GANTRY_POS_TOL_WARNING (gantry warning limit)

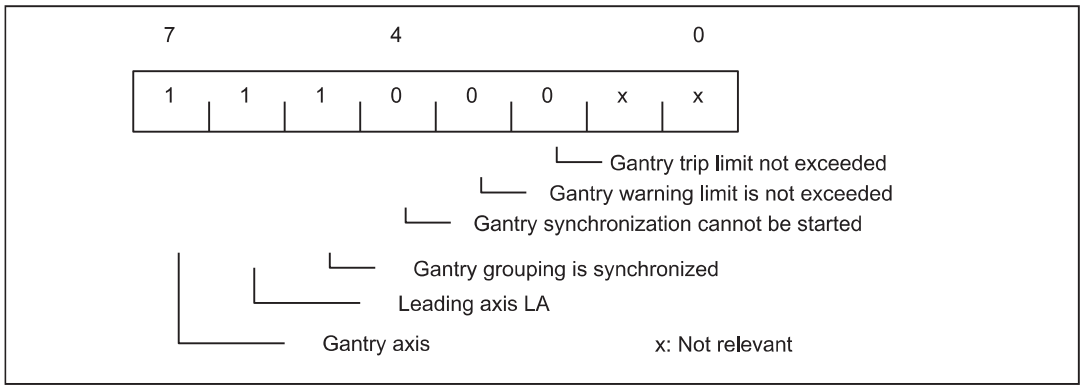
  When you put a heavy, dynamic strain on the axes, always be careful to re-enter the self-canceling alarm "10652 channel %1 axis %2 gantry warning limit exceeded".

- Now increase the following machine data:

  MD37110 $MA_GANTRY_POS_TOL_WARNING (gantry warning limit)

  Do this until the alarm no longer appears. The interface indicates the status specified below. (That must occur in the appropriate window, according to production.)

In case the monitoring still only chimes very sporadically, one can program a centering maker into the PLC user program.



Enter the value calculated for the warning limit + a small safety provision in the following machine data:

MD37120 $MA_GANTRY_POS_TOL_ERROR (gantry trip limit)

Error limit values

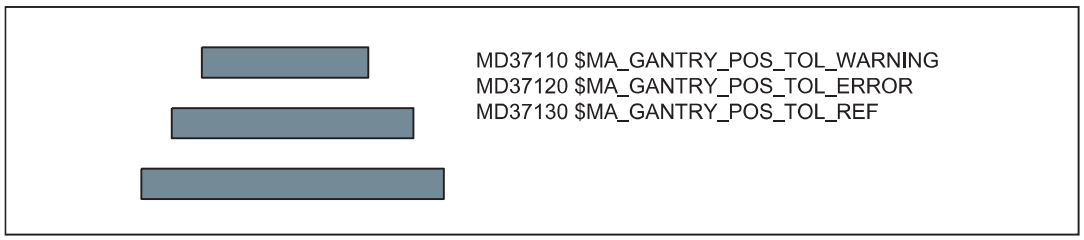
Values are entered in the following machine data:

MD37110 $MA_GANTRY_POS_TOL_WARNING (gantry warning limit)

MD37120 $MA_GANTRY_POS_TOL_ERROR (gantry trip limit)

MD37130 $MA_GANTRY_POS_TOL_REF (gantry trip limit for referencing)

These should have the following scales of magnitude at the end of the customizing process:



Note

The same procedure must be followed when starting up a gantry grouping in which the coupled axes are driven by **linear motors** and associated measuring systems.

The error limits entered into machine data MD37110 and MD37120 are considered as additional tolerance values of the actual-value difference of the master and following axis if the IS "Gantry is synchronous" is not present (e.g. to be resynchronized after canceling alarms without gantry).

2.8 Data lists

2.8.1 Machine data

2.8.1.1 Axis/spindlespecific machine data

Number	Identifier: $MA_	Description
30300	IS_ROT_AX	Rotary axis
32200	POSCTRL_GAIN	K_V factor
32400	AX_JERK_ENABLE	Axial jerk limitation
32410	AX_JERK_TIME	Time constant for axis jerk filter
32420	JOG_AND_POS_JERK_ENABLE	Initial setting for axial jerk limitation
32430	JOG_AND_POS_MAX_JERK	Axial jerk
32610	VELO_FFW_WEIGHT	Feedforward control factor for speed feedforward control
32620	FFW_MODE	Feedforward control mode
32650	AX_INERTIA	Moment of inertia for torque feedforward control
32800	EQUIV_CURRCTRL_TIME	Equivalent time constant, current control loop for feedforward control
32810	EQUIV_SPEEDCTRL_TIME	Equivalent time constant, speed control loop for feedforward control
32900	DYN_MATCH_ENABLE	Dynamic response adaptation
32910	DYN_MATCH_TIME	Time constant for dynamic response adaptation
33000	FIPO_TYPE	Fine interpolator type
34040	REFP_VELO_SEARCH_MARKER	Creep velocity
34070	REFP_VELO_POS	Reference point start velocity
34080	REFP_MOVE_DIST	Reference point approach distance
34090	REFP_MOVE_DIST_CORR	Home position offset
34100	REFP_SET_POS	Reference point value
34110	REFP_CYCLE_NR	Axis sequence for channel-specific referencing
34330	REFP_STOP_AT_ABS_MARKER	Distancecoded linear measuring system without destination point
36012	STOP_LIMIT_FACTOR	Exact stop coarse/fine factor and zero speed
36030	STANDSTILL_POS_TOL	Zero speed tolerance
36500	ENC_CHANGE_TOL	Maximum tolerance for position actual value switchover
37100	GANTRY_AXIS_TYPE	Gantry axis definition
37110	GANTRY_POS_TOL_WARNING	Gantry warning limit
37120	GANTRY_POS_TOL_ERROR	Gantry trip limit
37130	GANTRY_POS_TOL_REF	Gantry trip limit for referencing
37140	GANTRY_BREAK_UP	Invalidate gantry axis grouping

2.8.2 Signals

2.8.2.1 Signals from mode group

DB number	Byte.bit	Description
11, ...	5.2	Active machine function REF

2.8.2.2 Signals from channel

DB number	Byte.bit	Description
21, ...	33.0	Referencing active

2.8.2.3 Signals to axis/spindle

DB number	Byte.bit	Description
31, ...	29.4	Start gantry synchronization
31, ...	29.5	No automatic synchronization

2.8.2.4 Signals from axis/spindle

DB number	Byte.bit	Description
31, ...	60.4, 60.5	Referenced/synchronized 1, referenced/synchronized 2
31, ...	101.2	Gantry trip limit exceeded
31, ...	101.3	Gantry warning limit exceeded
31, ...	101.4	Gantry synchronization ready to start
31, ...	101.5	Gantry grouping is synchronized
31, ...	101.6	Gantry leading axis
31, ...	101.7	Gantry axis