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MT-CNC
Main Spindle Synchronization

Applikation Manual

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1 Introduction

On lathes, main spindle synchronization is primarily used for:

- transferring parts
- cutting off parts
- machining shafts
- polygonal turning and
- non-round turning

For the most part, these applications all require the same basic functionality.

2 Typical Applications

2.1 Transferring Parts

Velocity synchronization between the lead (master) spindle and the synchronous spindle is not always adequate for '**transferring parts**' for subsequent reverse machining or for loading or unloading parts. When short parts are transferred and one set of jaws must mesh with the other set without interfering with it, and when parts are not rotationally symmetric, a defined orientation between the lead and synchronous spindles must be established from the beginning and must be maintained during the transfer.

2.2 Cutting Off Parts

'**Cutting off parts**' without leaving a stump is only possible with spindle synchronization. The fact that the lead and synchronous spindles maintain the same angular rotation relative to one another means that the resulting angular synchronization will produce a workpiece that is free of tool marks (in contrast to velocity synchronization).

2.3 Shaft Machining Without Tailstocks

In the case of '**shaft machining**', the synchronous spindle instead of the tailstock holds the turned piece at its free end.

The angular synchronicity between the lead and the synchronous spindles allows turned pieces which might be damaged by internal torsion (long, narrow shafts having recessed areas) to be machined without producing torque differences which might heat the workpiece and drive unnecessarily or might shear off the workpiece at the thinnest point.

When a shaft is held by a second spindle, mutual interactions can result in differences between the positions of the lead and the synchronous spindle in spite of angular synchronicity and following-error free position control—for example, due to spindles which are not correctly aligned, uneven chuck jaws, or asymmetrical parts. In effect, the gripping operation 'locks in' the existing position difference. As a consequence, during subsequent operation in the synchronous mode both spindles work against each other at their maximum torques.

Following the gripping operation, a function used to minimize the existing torsion can be activated by means of an interface signal from the SPS or from the CNC-program by means of an M-function.

2.4 Polygonal Turning

During '**polygonal turning**', one of the spindles holds the workpiece and the other holds the tool. At the beginning of machining, a defined position between both spindles as well as a specific gear ratio is set. The rotating tool then traverses along the workpiece as in normal turning.

Some applications, such as the production of polygons whose position and number of corners differs, require that the position of the lead and synchronous spindles relative to one another as well as their translation ratio be changed during the course of the program.

2.5 Unround Turning

Main spindle synchronization is used twice with '**unround turning**'. In addition to the customary arrangement of the main spindles, a further eccentric oriented spindle is used.

The second and third main spindles act as synchronous spindles by adjusting to the lead spindle command values taking into account the given translation ratio and angular offset.

Certain workpieces, such as those containing spiraled inside and outside grooves, can only be generated by means of a superimposed movement of the synchronous spindle (electronic differential) controlled by the CNC-program. Main spindle synchronization does not offer this functionality.

2.6 Parallel Operation of Spindles

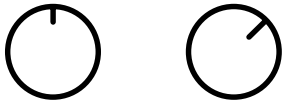
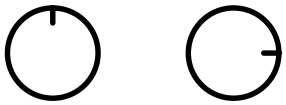
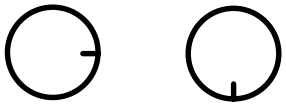
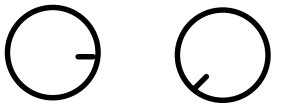
Up to three spindles can be operated in synch within a process on double lathes and double milling machines, as well as on multiple-spindle lathes and multiple-spindle milling machines. One spindle is used as the lead spindle, while the other two spindles are operated as synchronous spindles.

3 Available Functions

3.1 Angular Synchronization — Absolute

The MT-CNC always traverses the lead and synchronous spindles such that they remain in '**absolute angular synchronization**'.

The following example illustrates this in greater detail.

	Angular Position of the Spindles	**Remark**
Prior to Synchronization	Lead Spindle Synchronous Spindle 	Each spindle is located in any given random position.
After synchronization step	Lead Spindle Synchronous Spindle 	The synchronized spindle moves to the specified angular offset position (= 90°) (translation ratio = 1).
After rotation of 90	Lead Spindle Synchronous Spindle 	The synchronized spindle has rotated 90° in synch with the lead spindle.
After an change in the position offset by 45°	Lead Spindle Synchronous Spindle 	The synchronized spindle has rotated 45° relative to the lead spindle.

The advantage of the '**absolute angular synchronization**' mode is that the angular offset between the lead and the synchronous spindles can be set in a carefully defined manner at any point in time. The synchronous spindle receives the position command values for the master spindle after the specified translation ratio and the specified angular and position offsets have been calculated in.

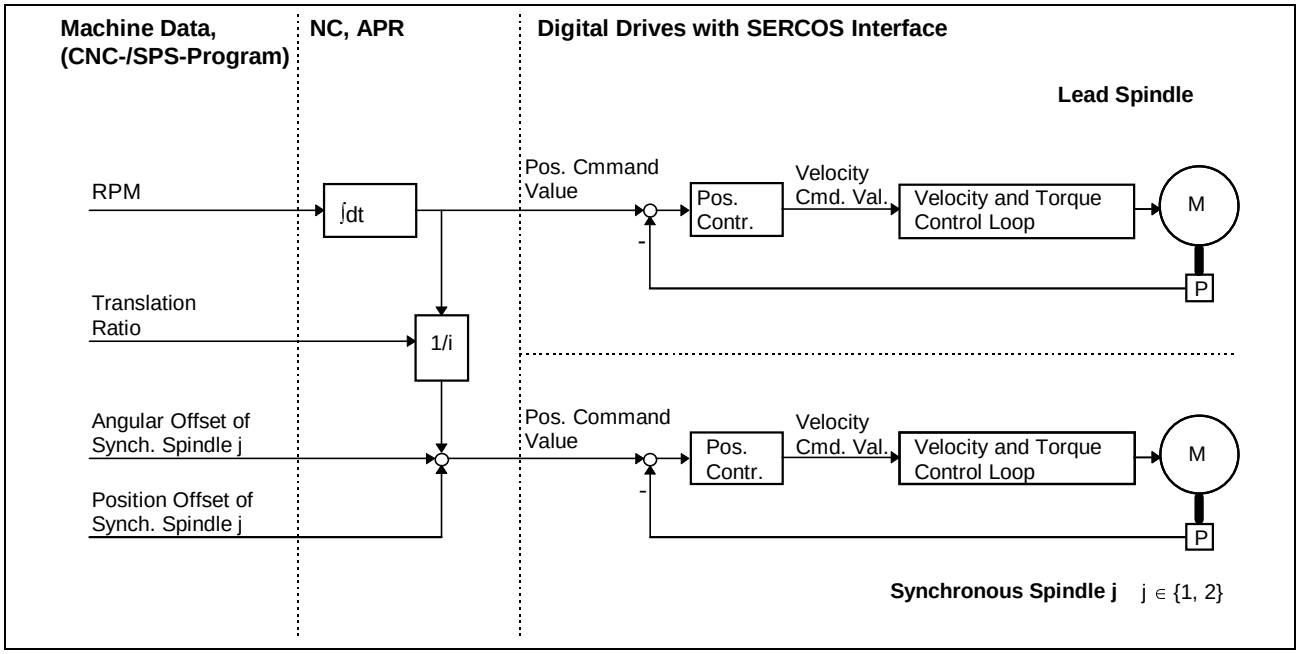


Fig. 3-1: Operation of the angular difference and synchronous position offset.

3.2 Legal Configurations

The following rules describe the configurations which are legal for main spindle synchronization in a process. If one of these rules is violated at the beginning of or during synchronized operation, the CNC interrupts processing and generates an error message.

- One lead spindle and at least one synchronous spindle must be present in each synchronized spindle group.
- Only one lead spindle can be used in main spindle synchronization.
- No more than two synchronous spindles can belong to a synchronization group aside from the lead spindle.
- All spindles participating in main spindle synchronization must belong to a single process.

  ⇒ If a spindle from a different process is to participate in main spindle synchronization, this axis must be switched to the respective process using the FAX and GAX axis transfer commands.
- All spindles used in main spindle synchronization must be connected to and controlled by the same axis process (APRB).
- The lead spindle must have a lower drive number than the synchronous spindles on the SERCOS bus.
- A single spindle cannot simultaneously be both a lead and a synchronous spindle.

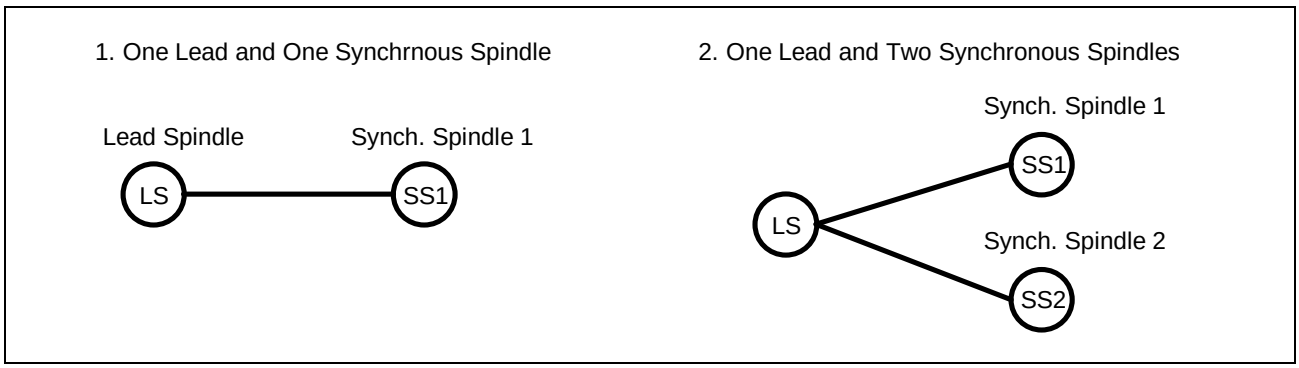


Fig. 3-2: Legal spindle configurations within a process.

3.3 Steps in a Synchronization Process

Activate Main Spindle Synchronization

In CNC-program-controlled mode, '**main spindle synchronization**' is activated from the CNC-program by means of an auxiliary function with acknowledgment. In manual mode, synchronization can be activated by pressing a machine control key or some other PB.

A gateway signal between the SPS and the CNC allows main spindle synchronization to be activated in any operating mode.

The following must be specified from the user interface, the CNC-program, or the SPS program before starting main spindle synchronization:

- The lead spindle to which the synchronous spindle is assigned
- The translation ratio between the lead spindle and the synchronous spindle
- The direction of rotation of the synchronous spindle
- The effective angular offset and position offset between both spindles
- The tolerance limits used to monitor the actual position differences between the lead and the synchronous spindle

Synchronization Procedure

If the spindles are rotating at different speeds (including idle = 0 RPM) when spindle synchronization is activated, the CNC accelerates or decelerates the synchronous spindles at maximum acceleration/ deceleration until it reaches the synchronization speed. As soon as synchronization speed is reached, the CNC switches to position control and rotates the synchronized spindle to the specified position within one revolution over the shortest possible path. If the lead spindle and the synchronous spindle are already stopped, the synchronous spindle simply traverses to its command position taking the already present translation ratio and the specified angular offset and position offset into account.

If functions such as 'Mx03', 'Mx04' (x = ,,1, 2, 3) or 'G95' are active when main spindle synchronization is activated, the CNC continues operation in position control mode for these spindles. The changeover operation does not have any negative effects on the surface of the workpiece.

Deactivate Synchronization

In CNC-program-controlled mode, main spindle synchronization is activated from the CNC-program by means of an auxiliary function with acknowledgment. In manual mode, synchronization can be deactivated by resetting the power-on gateway signal. All spindles involved in the synchronization retain their rotational speeds after synchronization is deactivated. If the spindles must stop after deactivation, this must be programmed by means of 'Mx05' or 'Mx19' (x = ,,1, 2, 3) after synchronization has been deactivated.

When the synchronization is deactivated, the CNC switches the spindles which were involved in the synchronization back to speed (RPM) control if a function which normally runs under speed (RPM) control is active at this time.

3.4 CNC-programming

All of the synchronous spindles which participate in main spindle synchronization may NOT be programmed during synchronized operation. If the user attempts to do this by programming 'Mx03' (x = ,,1, 2, 3) for a synchronous spindle, the CNC interrupts program execution and issues an error message.

Furthermore, the lead and synchronous spindles must not be operated in the 'C-axis' mode and a gear change must not be performed during synchronized operation. Any attempt to do so will cause CNC-program execution to stop, and an appropriate error message will be issued.

3.5 Checks Performed During Main Spindle Synch. Activation

When main spindle synchronization is activated and while it is active, the CNC calculates the maximum synchronized speed of the lead axis taking into account the maximum permissible speeds of all spindles involved in the synchronization as well as the selected translation ratios when a speed limit is programmed for the lead axis. During synchronized operation, the CNC automatically limits the programmed RPMs to the calculated maximum synchronization speed.

In addition, when main spindle synchronization is activated, the CNC calculates the maximum synchronization acceleration of the lead spindle taking into account the maximum accelerations (axis parameter Cxx.084 'Spindle Acceleration, Position Mode') of all spindles involved in the synchronization as well as the selected translation ratios. During main spindle synchronization, the CNC always accelerates and brakes the participating axis at the calculated synchronization acceleration. The CNC ensures that no traverse increments are lost during the acceleration and braking phases.

3.6 Exception Conditions

End of Program and Control Reset

Synchronized operation remains active at the end of the program (BST, RET, JMP, M02 and M30), with 'control reset' or with 'jog in manual mode' (if process parameter Bxx.036 'Manual Axis Jogging Causes Reset' is set to 'yes') if the SPS does not use control signals to deactivate the synchronized spindles which are involved in synchronized operation.

'C-Axis' Main Spindle and Main Spindle with Associated Rotary Axis

The lead and synchronous spindles must already be in spindle mode before the synchronization is activated. If this is not the case, the CNC interrupts CNC-program execution and generates an error message.

A changeover to rotary axis mode is permissible once synchronized mode is no longer active.

instruction: A separate synchronized axis group is required for synchronized axis operation in rotary axis mode (see *Application Manual — 'Follower and Gantry Axes'*).

Reference Spindle

The lead spindle must be the reference spindle during synchronized operation.

The functions:

- thread cutting ‘G33’
- input feedrate in inches or mm per spindle revolution ‘G95’ and
- constant surface speed (CSS) ‘G96’

relate exclusively to the lead spindle in the synchronization mode. For this reason, the lead spindle must be selected as the reference spindle (NC-command SPF) before main spindle synchronization is activated.

Axis Switching

During synchronized operation, the user must **not** switch the spindles which are involved in main spindle synchronization from one process to another. Applying the axis switching commands GAX or FAX to the spindles which are involved in synchronized operation will cause program execution to terminate and an error message to be issued.

Thus, spindles which are part of the synchronized operation and belong to a different primary process must be transferred to the respective process before synchronized mode is activated, and they must not be returned to the primary process until synchronized mode is deactivated.

WARNING

⇒ If spindles which belong to a different primary process are involved in a main spindle synchronization, the synchronization mode must be deactivated prior to the axis enable and thus prior to the end of the CNC-program (BST, RET, JMP, M02, M30), control reset or initial jogging (only if process parameter Bxx.036 ‘Manual Axis Jogging Causes Reset’ is set to ‘yes’).

⇒ At the end of the program (M02 and M30), upon control reset, and upon initial jogging (only if the process parameter ‘Manual Axis Jogging Causes Reset’ is set to ‘yes’), the SPS can deactivate main axis synchronization even before the CNC enables the respective spindles.

Axis Referencing (Homing)

All spindles involved in a main spindle synchronization must already be referenced (homed) before the beginning of main spindle synchronization, since referencing of lead or synchronous spindles is not permissible during main spindle synchronization.

However, if referencing is nevertheless necessary, for example, after turning on a lathe if the lathe was turned off with a part in the chuck during main spindle synchronization, the following steps must be performed (in a homing CNC-program):

1. Deactivate main spindle synchronization (if active).
2. Reference the lead spindle.
   - Disable the synchronous spindle.
   - Reference the lead spindle.
   - Set axis enable for the synchronous spindle.
3. Reference the synchronous spindle.
   - Disable the lead spindle.
   - Reference the synchronous spindle.
   - Set axis enable for the lead spindle.

Spindle Reciprocation, Drifting and Positioning

The spindle movements initiated with the aid of the CNC-command AXD (oscillation, drifting and positioning) are **not** permitted during synchronization mode. The axis processor APR ignores these commands during synchronization. Thus, gear range changes are not permitted during main spindle synchronization. However, if they should be required, for example

when a shaft is clamped into a chuck, the same procedures should be used as for referencing (*see section 'Axis Referencing (Homing)', Side 3-5)*.

Tapping

The spindle which is engaged in tapping, 'G63', 'G64' or 'G65', must not be a lead spindle or a synchronous spindle.

Emergency Stop

Emergency stop in general causes a rapid braking of all drives. Synchronization is not maintained during emergency stop.

If main spindle synchronization must be maintained when the emergency stop button is pressed, the machine manufacturer (OEM) must delay the emergency stop signal for the control, for the drive power supply, as well as for the drives in the SPS until it is possible to deactivate synchronization. The process enable (PxxC.ENABL) can be removed when the Emergency Stop button is pressed. The CNC then brakes the spindles involved in the main spindle synchronization if the control signal 'Spindle Stop' (AxxC.SPSTP) is set for the lead spindle at this point in time.

Not until it has been verified that all axes are stopped can the emergency stop signal be passed on to the NC, the drive power supply or the drives.

Process Operating Mode Selection

The CNC generates an immediate stop upon a change in operating mode. If the control signal 'Spindle stop' (AxxC.SPSTP) is set for the lead spindle, the CNC brakes all spindles involved in the synchronization in a synchronized manner. If this control signal is not set for the lead spindle, the spindles involved in the synchronization continue to operate unaffected by the change in operating mode.

Axis-Specific Status Signals

The CNC updates the axis specific status signals — for example, the signal reporting the motion status of all spindles involved in the main spindle synchronization — as in normal operation.

Axis-Specific Control Signals

The CNC evaluates the axis-specific signals

- AxxC.JGPOS ;Jog positive,
- AxxC.JGNEG ;Jog negative,
- AxxC.M3 ;Spindle on CW,
- AxxC.M4 ;Spindle on CCW,
- AxxC.M5 ;Spindle stop
- AxxC.M19 ;Spindle positioning,
- AxxC.SPSTP ;Spindle stop,
- AxxC.SPHLT ;Spindle stop operating mode,
- AxxC.SPSTE ;Spindle stop at NC-program end,
- AxxC.SPRST ;No Spdl. Stop at Ctrl.Reset,
- AxxC.OVRD ; Override and
- AxxC.MHOLD ;Motion hold

during the course of the synchronized operation for the lead spindle only. The CNC does not consider the signals from the synchronous spindles.

1) Axis enable

The axis enable signal AxxC.ENABL is evaluated by the CNC only in manual operating mode and only for the lead spindle.

2)

The deactivation of drive enable (ready to operate: AxxC.READY) for a synchronous spindle causes the respective spindle to stop moving as

quickly as possible. As processing continues, the CNC generates the message #424 'Inactive @ axis is programmed' and brakes the remaining axes in the process.

The CNC responds in the same way if drive enable is removed from a lead spindle during a move. The CNC then also immediately brakes the synchronous spindles as well as the lead spindle.

3.7 Error Reactions

Errors Which Cause an Error Reaction in the Complete Drive Package

In the case of serious drive errors which do not permit the faulty drive to be stopped in a controlled manner, for example, a motor encoder error or overvoltage condition, the affected drive sends its error signal to the drive power supply and to the control and activates the release of torque control. The drive power supply then shuts off the supply voltage. The CNC shuts off the defective drives as soon as the remaining energy present in the DC circuit permits this.

Errors Which Cause an Error Reaction in a Specific Drive

All non serious drive errors which permit the controlled shut-down of a faulty drive, such as 'Excessive Deviation', permit a fully configurable drive specific error response (*see description of applications for the respective drive unit*).

WARNING

⇒ In order to prevent relatively extensive damage from occurring in the event of an error, a torque-free mode must be selected for all spindles involved in main spindle synchronization as a drive specific error reaction.

3.8 Minimize Torsion

The function 'Minimize Torsion' is provided in the CNC to minimize the torsion which results after a part (shaft) clamp operation. This function can be activated from the SPS by means of the gateway or by means of an auxiliary function with acknowledgement from the CNC-program.

4 Configurable Machine Data

4.1 Structure of Relevant Machine Data

The machine data for the main spindle synchronization occupy a page 50 named ‘Main Spindle Synchronization’.

The following data structure is present in the page for each process:

- 001 Synchron. Synch.spindle 1 ok
- 002 Synchron. Synch.spindle 2 ok
- 003 Lead spindle in Coord.Sys.
- 004 Synch.spdl.1 in Coord.Sys.
- 005 Angle offset Synch.spdl.1
- 006 Position offset Synch.sp.1
- 007 Lead spindle RPM i_LS/SS1
- 008 Synch.spdl.1 RPM i_LS/SS1
- 009 Direction Synch.spdl.1
- 010 Synch.run window Synch.sp1
- 011 Error limit Synch.spdl.1
- 012 Synch.spdl.2 in Coord.Sys.
- 013 Angle offset Synch.spdl.2
- 014 Position offset Synch.sp.2
- 015 Lead spindle RPM i_LS/SS2
- 016 Synch.spdl.2 RPM i_LS/SS2
- 017 Direction Synch.spdl.2
- 018 Synch.run window Synch.sp2
- 019 Error limit Synch.spdl.2

4.2 Modify Machine Data

The individual data elements can be reconfigured from the SPS via the user interface or from the CNC-program provided that the corresponding lead spindle or synchronous spindle is not active. If the user accesses the data for a spindle which is engaged in synchronized operation from the SPS or from the user interface (PC or SOT), an error message will be issued. If the user attempts to do this in the CNC-program, an error message will be issued, and the CNC will stop processing. The data elements ‘005/013 Angle offset Synch.spdl.1/2’ and ‘006/014 Position offset Synch.sp.1/2’ are the only exception. The user can modify them at any time during synchronized operation, either from the SPS, the CNC-program or the user interface.

The data cannot be modified from the user interface, however, if the user does not know the required password.

instruction: If erroneous data are present when a synchronous spindle is activated, for example, master spindle revolutions = 0, the CNC generates an error message and sets the interface signal ‘Error’ (PxxS.ERROR) until the attempt to activate the respective synchronous spindle is withdrawn. If the operator does not correct this problem by the next attempt to activate synchronous spindle, the CNC once again generates an error message upon the next activate attempt, and sets the gateway signal ‘PxxS.ERROR’.

4.3 Description of the Individual Data Elements

Synchron. Synch. spindle 1 ok

Name Synchron. Synch. spindle 1/2 ok

Number 1, 2

Purpose The Page 50 data elements 001/002 ‘synchronized operation of synchronous spindle 1/2 ok’ indicate whether the respective synchronous spindle is activated and whether it will follow the master spindle taking into account the ‘Synch.run window Synch.sp1. 1/2 (010/018)’.

Value Range
0: Synchronized operation of synchronous spindle **NOT** ok
1: Synchronized operation of synchronous spindle ok

Changes The status of Page 50 element 0001/002 ‘Synchron. Synch. spindle 1/2 ok’ is updated exclusively by the NC operating system. All remaining subsystems can only read this data element and not write to it.

Lead Spindle in Coord. Sys.

Name Lead spindle in Coord.Sys.

Number 3

Purpose The axis with the lowest address in the SERCOS loop that is defined in the System Parameters as ‘Main Spindle’ and ‘C-axis capable Main Spindle’ can be declared to be the lead spindle with the aid of this Page 50 element 003.

Value Range 0, 10, 11, 12
0: No lead (master) spindle present
10: Axis meaning: spindle S/S1
11: Axis meaning: spindle S2
12: Axis meaning: spindle S3

Default 0 (no lead (master) spindle present)

Changes The axis meaning of the lead spindle must NOT be written over during synchronous operation.

Evaluation If the axis meaning of the master spindle is set to the value ‘0’ when the synchronization mode is activated, the NC interrupts processing and generates the error message #252 ‘`No lead spindle defined`’.

Synch. Spindle 1/2 in Coord. Sys

Name Synch.spdle 1/2 in Coord.Sys

Number 4, 12

Purpose An axis that has NOT the lowest address in the SERCOS loop and that is defined in the System Parameters as ‘Main Spindle’ and ‘C-axis capable Main Spindle’ can be declared to be the synchronous spindle with the aid of Page 50 element 004 or 012.

Value Range 0, 10, 11, 12
0: No synchronous (slave) spindle 1/2 present
10: Axis meaning: spindle S/S1
11: Axis meaning: spindle S2
12: Axis meaning: spindle S3

Default 0 (no synchronous spindle 1/2 present)

Changes The axis meaning of synchronous spindle 1/2 must NOT be written over during synchronous operation.

Evaluation If the axis meaning of synchronous spindle 1/2 is set to the value ‘0’ when the synchronization mode for synchronous spindle 1/2 is activated, the NC interrupts processing and generates an error message.

Angle Offset Synch. spdl. 1/2

Name Angle offset Synch.spdl.1/2

Number 5, 13

Purpose Page 50 element 005/013 'Angle offset Synch.spdl.1/2' permits the user to set any desired angular offset between the lead (master) spindle and the respective synchronous spindle **during synchronous operation**.

Value Range 0.0000°–359.9999° (For values outside this range, the NC performs a modulo calculation.)

Default 0 (no offset)

Changes 'Angle offset Synch.spdl.1/2' can be written to while the synchronization mode is active. If the user changes the angular offset during the synchronization mode, the NC performs these changes immediately.

Position Offset Synch. sp. 1/2

Name Position offset Synch.sp.1/2

Number 6, 14

Purpose Page 50 element 006/014 'Position offset Synch.sp.1/2' permits the user to set any desired angular offset between the master spindle and the respective synchronous spindle during synchronous operation

Value Range 0.0000°–359.9999° (For values outside this range, the NC performs a modulo calculation.)

Default 0 (no offset)

Changes 'Position offset Synch.sp.1/2' can be written to while the synchronization mode is active. If the user changes the position offset during the synchronization mode, the NC performs these changes immediately. In contrast to other data elements, a separate password entry is NOT required.

instruction: In contrast to other data elements, a separate password entry is not required.

Translation Ratio

Name Translation ratio

$$Translation\ Ratio = \frac{Lead\ Spindle\ Revolutions}{Synchronous\ Spindle\ j\ Revolutions}\ j\varepsilon\{1, 2\}$$

Number 7/8, 15/16

Purpose The synchronous spindle 1 translation ratio is specified using the Machine Data Page 50 and the elements

007 Lead spindle RPM i_LS/SS1
008 Synch.spdl.1 RPM i_LS/SS1

and that of synchronous spindle 2 using the Machine Data Page 50 and the elements

015 Lead spindle RPM i_LS/SS2
016 Synch.spdl.2 RPM i_LS/SS2

in order to avoid rounding errors.

Value Range 1 ... 65536 (for the lead (master) and synchronous spindle rotations)

WARNING

⇒ The translation ratios (i_LS/SS1 and i_LS/SS2) must lie within the range of 0.01 to 100.

Default 0 (for the lead (master) and synchronous spindle rotations)

Direction of rotation of Synchronous spindles 1/2

Name Direction of rotation of Synchronous spindles 1/2

Number 9, 17

Purpose Allows the direction of rotation of synchronous spindle 1 or synchronous spindle 2 to be changed.

Value Range
0: No change in direction
1: Change in direction (to direction opposite the defined direction)

Default 0

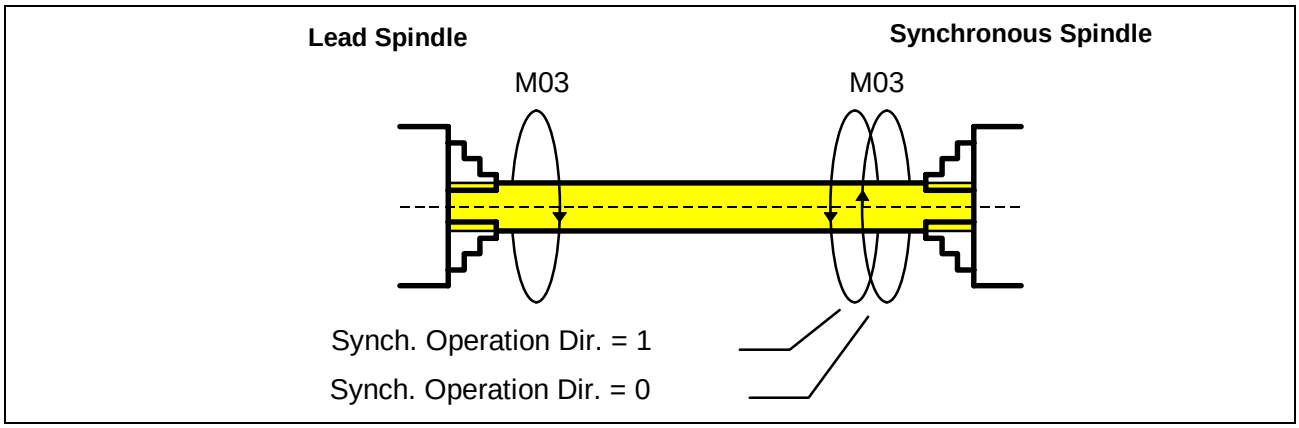


Fig. 4-1: *Synchronized operation direction of rotation.*

Synch. run window Synch. sp1/2

Name Synch.run window Synch.sp1/2

Number 10, 18

Purpose The Page 50 element 010/018 ‘Synch.run window Synch.sp.1/2’ is used to continuously monitor the synchronous operation of synchronous spindles 1/2. The NC monitors the actual-position values of the lead (master) and synchronous spindles taking into account the specified translation ratio. If both actual values diverge sufficiently during operation so that they exceed the synchronous running (operation) window for synchronous spindles 1/2, the NC resets the status of the Gateway axis status signal PxxS.SS1OK / PxxS.SS2OK.

Value Range 0.0000°–359.9999° (For values outside this range, the NC performs a modulo calculation.)

Default 0°

instruction: Exceeding the synchronized run window does not affect the CNC in any way. Any reaction mechanisms and dialog messages which may be needed must be programmed on the SPS.

Error Limit Synch. spdl. 1/2

Name Error limit Synchronous spindles 1/2

Number 11, 19

Purpose Like the synchronous operation window for synchronous spindles 1/2, the 'Error limit Synch.spdl.1/2' is used to continuously monitor the synchronous (running) operation of synchronous spindles 1/2. If both actual values diverge sufficiently during operation so that they exceed the error limit for synchronous spindles 1/2, the NC sets the status of the Gateway axis status signal PxxS.SS1ER / PxxS.SS2ER.

instruction: Exceeding the error limit does not affect the CNC in any way. Any error handling and error messages which may be needed must be programmed on the SPS.

Value Range 0.0000°–359.9999° (For values outside this range, the NC performs a modulo calculation.)

Default 0°

5 Gateway Interface Signals

5.1 Control Signals

Spindle 1/2 Synchr. ON/OFF

Name PxxC.SS1ON (Spindle 1 Synchr.)

PxxC.SS2ON (Spindle 1 Synchr.)

Purpose By setting the control signal 'Spindle 1/2 Synchr. ON', the SPS activates main spindle synchronization for synchronous spindle 1 or 2, and by re-setting this control signal, the CNC cancels synchronization of the respective synchronous spindles.

Meaning

PxxC.SS1ON=1:	Spindle 1 Synchr. ON
PxxC.SS1ON=0:	Spindle 1 Synchr. OFF
PxxC.SS2ON=1:	Spindle 2 Synchr. ON
PxxC.SS2ON=0:	Spindle 2 Synchr. OFF

instruction: When main spindle synchronization is active, the CNC checks the respective configuration (*see section 3.2, side 3-2*). If the CNC detects an error during this check, it generates an error message and stops processing.

WARNING

⇒ If during program operation the SPS independently activates or deactivates main spindle synchronization without an auxiliary function, the CNC does not activate the synchronization until all CNC blocks present in the block preparation buffer are processed to completion.

Spindle 1/2 Minimize Torsion

Name PxxC.SS1MT (Spindle 1 Minimize Torsion)

PxxC.SS2MT (Spindle 2 Minimize Torsion)

Purpose If the SPS sets this signal, the CNC minimizes the torsion between the corresponding synchronous spindle and the lead spindle until this signal is reset.

Meaning

PxxC.SS1MT=1:	Spindle 1 do NOT minimize torsion, ignore it
PxxC.SS1MT=0:	Spindle 1 minimize torsion between lead spindle and synchronous spindle 1
PxxC.SS2MT=1:	Spindle 2 do NOT minimize torsion, ignore it
PxxC.SS2MT=0:	Spindle 2 minimize torsion between lead spindle and synchronous spindle 2

5.2 Status Signals

Spindle 1/2 Synchron OK

Name AxxS.SS1OK (Spindle 1 Synchron OK)

AxxS.SS2OK (Spindle 2 Synchron OK)

Purpose The CNC uses the status signal 'synchronous operation ok' to report whether synchronous spindle 1 or 2 is active and to report that the difference between the lead spindle and synchronized spindle 1 or 2 does not exceed the synchronous operation window.

Meaning

AxxS.SS1OK=0:	Spindle 1 NOT synchronous running or synchronization not active
AxxS.SS1OK=1:	Spindle 1 synchronous running within the defined 'Synch.run window Synch.sp1' (Page 50:010)
AxxS.SS2OK=0:	Spindle 2 NOT synchronous running or synchronization not active
AxxS.SS2OK=1:	Spindle 2 synchronous running within the defifined 'Synch.run window Synch.sp2' (Page 50:018)

instruction: The information '`synchronous operation for synchronous spindle 1 is active`' or '`synchronous operation for synchronous spindle 2 is active`' can be determined for the respective spindle after synchronization has been activated as soon as the CNC outputs the status signal 'Spindle 1/2 Synchron OK.'

Synchr. Spindle 1/2 Error

Name AxxS.SS1ER (Synchr. Spindle 1 Error)

AxxS.SS2ER (Synchr. Spindle 2 Error)

Purpose The CNC uses the 'synchronization error' to report whether the deviation between the lead spindle and synchronous spindle 1 or 2 exceeds the synchronous operation error limit.

Meaning

AxxS.SS1ER=0:	Spindle 1 synchronous running or synchronization not active
AxxS.SS1ER=1:	Spindle 1 synchronization error, outside the defined 'Error limit Synch.spdl.1' (Page 50:011)
AxxS.SS2ER=0:	Spindle 2 synchronous running or synchronization not active
AxxS.SS2ER=1:	Spindle 2 synchronization error, outside the defined 'Error limit Synch.spdl.2' (Page 50:019)

Spindle specific Status Signals

The spindle-specific status signals:

- AxxS.N_CMD N=Ncmd, actual speed = cmd. speed
- AxxS.N_MAX Ncmd>=Nmax, cmd. speed >= max. speed
- AxxS.N_MINN=Nmin, actual speed <= minimum speed
- AxxS.SYNC Synchronous running

are not valid during synchronous operation since the CNC traverses the spindles which are involved in main spindle synchronization in position control.

6 Example: ‘Transferring a Part’

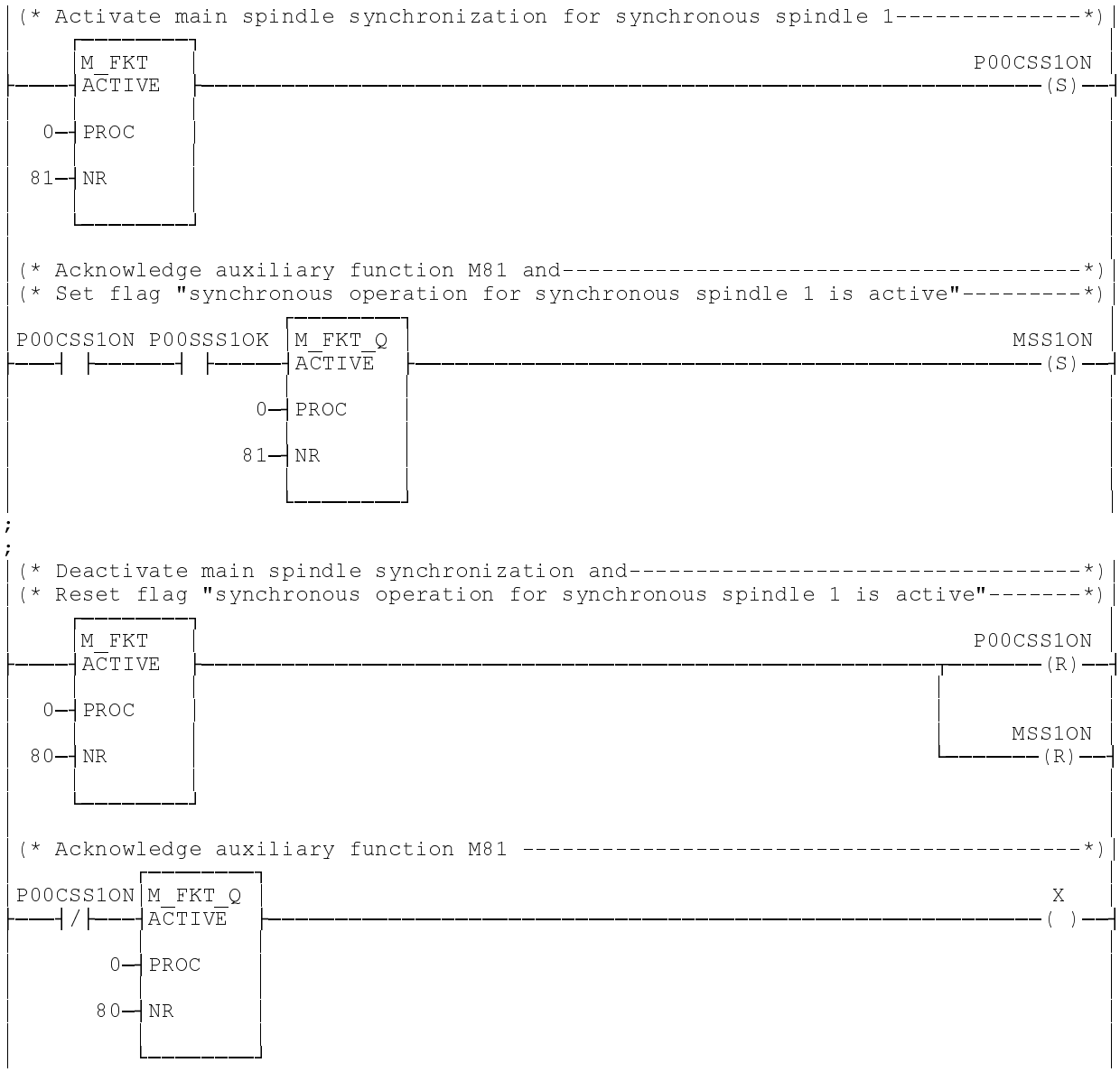
A turned part is to be transferred from spindle 1 (lead spindle) to spindle 2 (synchronous spindle 1) for reverse machining.

6.1 CNC-program

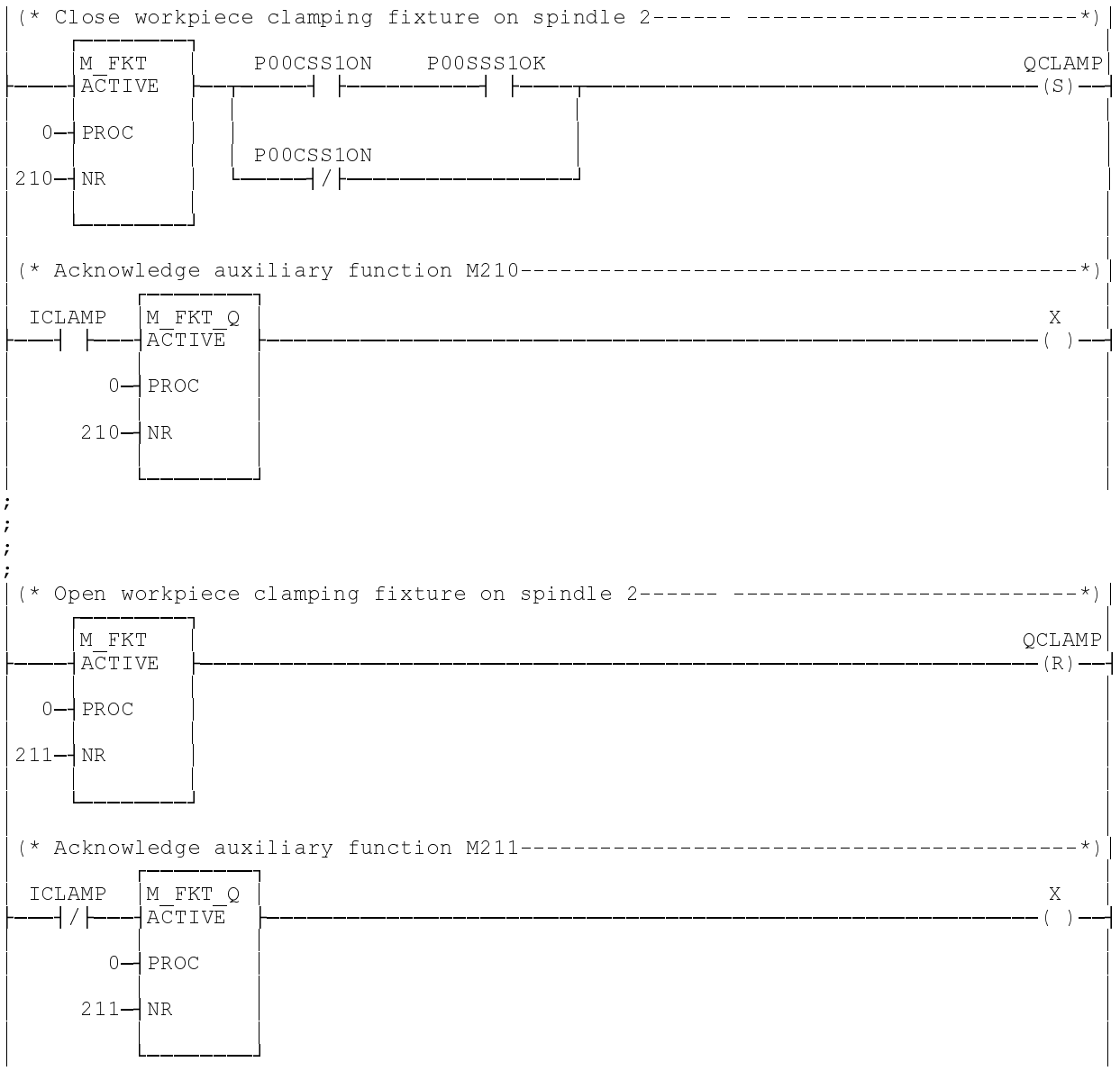
```
          .
          .
          .
N0036   BSR .U_S1S2             ;Transfer the part from spindle 1 to spindle 2
          .
          .
          .
;
;  Transfer the part from spindle 1 to spindle 2
;
N0386   .U_S1S2
          SPF 1                 ;Reference spindle = spindle 1
N0387   M211                    ;Open spindle 2 chuck
N0388   M81                     ;Activate synchronization
N0389   G00 U500                ;Traverse spindle 2 to transfer position
N0390   M210                    ;Close workpiece clamping fixture on spindle
2
N0391   M111                    ;Open workpiece clamping fixture on spindle
1
N0392   G00 U0  M80  RTS        ;Traverse spindle 2 to machining position and

                                deactivate synchronization
```

6.2 SPS Program

In the SPS program M-function ‘M81’ is programmed to activate main spindle synchronization and ‘M80’ is used to deactivate it. The SPS does not acknowledge activation (M81) until the CNC reports that synchronous operation is present using the interface signal ‘P00SSS1OK’.

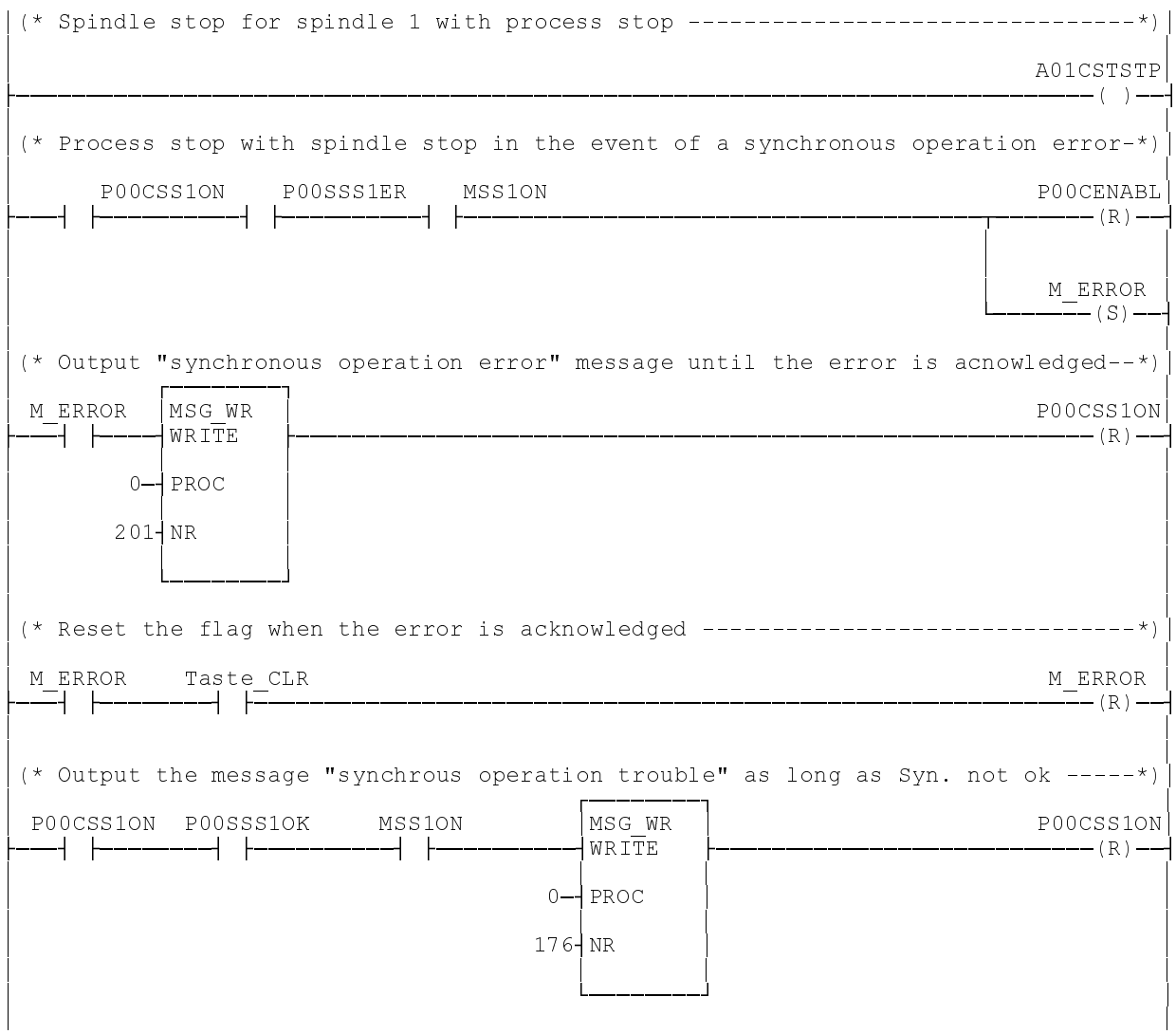


The clamping fixture for spindle 2 (synchronous spindle 1) is closed and opened via the M-functions ‘M210’ and ‘M211’. It is important that during synchronous operation the clamping fixture only be closed when spindle 2 (synchronous spindle 1) is completely in synch with spindle 2 (lead spindle 1) (P00SSS1OK).



The SPS monitors the status signal ‘synchronous operation error (P00SSS1ER) during main spindle synchronization. If a synchronous operation error occurs during main spindle synchronization, the SPS stops all feed axes and the two spindles by removing process enable, and it generates an error message which must be acknowledged by the operator.

In addition, the SPS uses a status message to indicate trouble which leads to the removal of the ‘P00SSS1OK’ signal.


(* Spindle stop for spindle 1 with process stop ----------*)
A01CSTSTP
( )
(* Process stop with spindle stop in the event of a synchronous operation error-*)
P00CSS1ON
P00SSS1ER
MSS1ON
P00CENABL
(R)
M_ERROR
(S)
(* Output "synchronous operation error" message until the error is acnowledged--*)
M_ERROR
MSG_WR
WRITE
0
PROC
201
NR
P00CSS1ON
(R)
(* Reset the flag when the error is acknowledged ----------*)
M_ERROR
Taste_CLR
M_ERROR
(R)
(* Output the message "synchrous operation trouble" as long as Syn. not ok -----*)
P00CSS1ON
P00SSS1OK
MSS1ON
MSG_WR
WRITE
0
PROC
176
NR
P00CSS1ON
(R)

6.3 Machine Data

If main spindle synchronization is only used on the machine to transfer parts, the machine parameters can be preset at startup.

No.	Name	Default	Remark
001	Synchron. Synch.spindle 1 ok	-	
002	Synchron. Synch.spindle 2 ok	-	
003	Lead spindle in Coord.Sys.	10	Spindel 1
004	Synch.spdl.1 in Coord.Sys.	11	Spindle 2
005	Angle offset Synch.spdl.1	180	
006	Position offset Synch.sp.1	0	
007	Lead spindle RPM i_LS/SS1	1	
008	Synch.spdl.1 RPM i_LS/SS1	1	
009	Direction Synch.spdl.1	1	Reverse direction of rotation
010	Synch.run window Synch.sp1	3	
011	Error limit Synch.spdl.1	15	
012	Synch.spdl.2 in Coord.Sys.	0	
013	Angle offset Synch.spdl.2	0	
014	Position offset Synch.sp.2	0	
015	Lead spindle RPM i_LS/SS2	0	
016	Synch.spdl.2 RPM i_LS/SS2	0	
017	Direction Synch.spdl.2	0	
018	Synch.run window Synch.sp2	0	
019	Error limit Synch.spdl.2	0	

The element 5 ‘Angle offset Synch.spdl.1’ is used to match the coordinate systems of the two spindles.

6.4 Explanations

M function ‘M211’ opens the clamping fixture on spindle 2 and ‘M81’ activates spindle synchronization. As soon as the SPS sets the control signal ‘P00CSS10N’, the CNC checks the given spindle configuration using the machine data. If these data match the required data, the synchronous spindle accelerates at its maximum axis acceleration to the required synchronization speed (see figure below).

As soon as the synchronous spindle has reached the synchronization speed it traverses to the transfer position and closes the clamping fixture for spindle 2 (M210). Once the clamping fixture is closed, spindle 1 releases the part (M111), and then spindle 2 traverses to the machining position. The auxiliary function ‘M80’ deactivates main spindle synchronization at the end of the transfer.

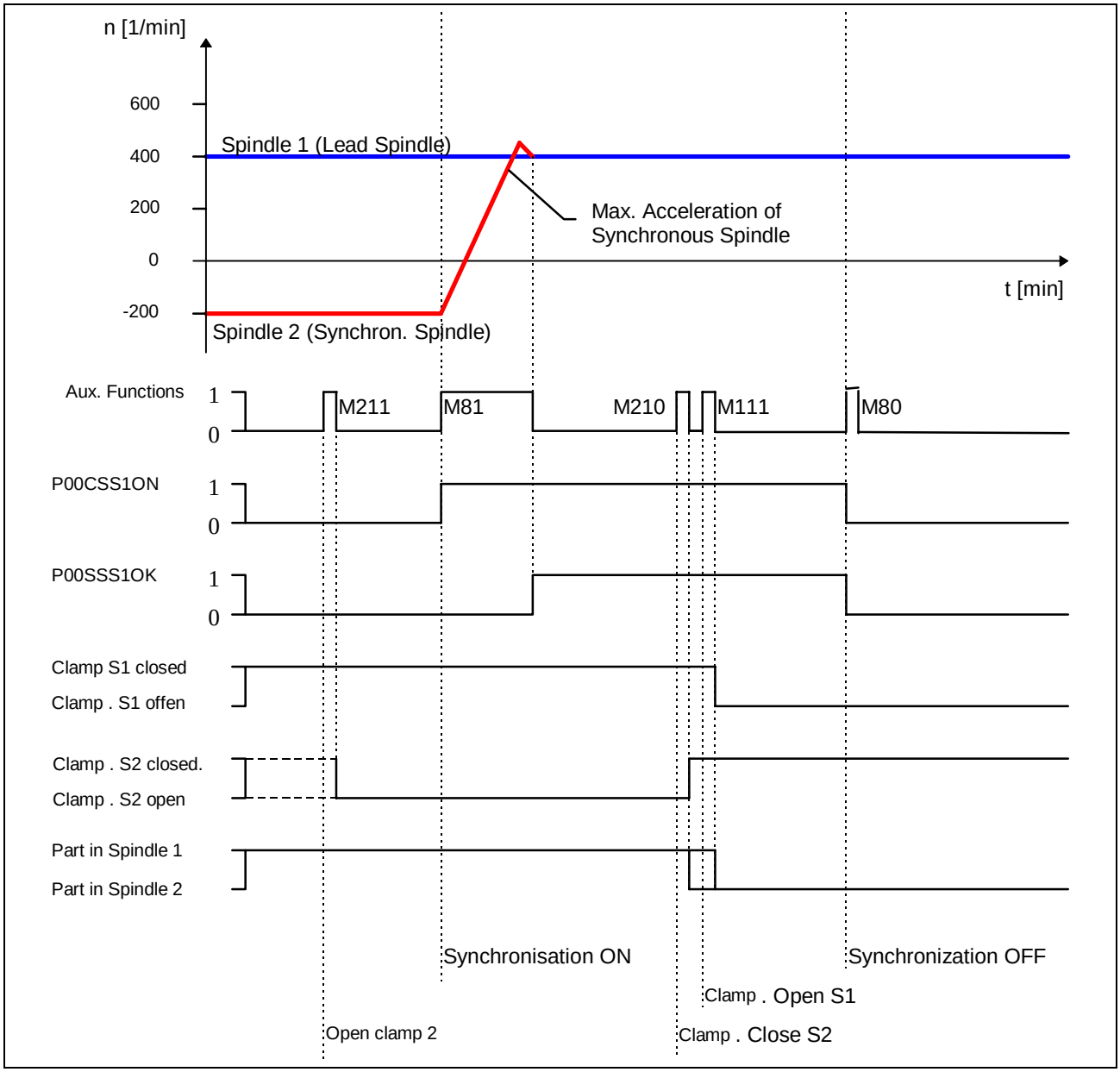


Fig. 6-1: Transferring a part from spindle 1 to spindle 2.

7 Startup Information

- The SERCOS parameter ‘Monitoring Window’ (S-0-0159) must be set to the maximum value.
- It must be noted in conjunction with axis transfer that each axis meaning can only be present once in each process.
- The machine builder my define any desired M- or Q-functions to activate and deactivate main spindle synchronization.
- The active torque or the ‘load’ should be shown in the position display. The ‘load’ of the spindles which are involved in the synchronization must be observed with particular care in the setup phase.

WARNING

⇒ Only digital main drives equipped with the SERCOS interface (beginning software version HASE3V0.5) and digital DDS 2.2 feed drives equipped with main spindle functions and with the SERCOS interface can be used in main spindle synchronization.

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