AC Main Spindle Drives with Controlled Asynchronous Motors and Frameless Spindle Motors

Applications Manual

DOK-DIA01 MAIN+2AD+1M-ANW1-EN-P
# Overview of Sections

## About this Documentation

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About this documentation

**Titel**
AC Main Spindle Drives with Controlled Asynchronous Motors and Frameless Spindle Motors

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**This documentation is used:**
- Assists in the commission of AC main spindle drives used in module systems with KDA/TDA or complete systems with RAC.
- Explains how to operate the controllers.
- Clarifies the technical background specific to the applications and the technical conversion of the main spindle drive functions. Complex functions are graphically illustrated where necessary.
- Explains the diagnostics of the main spindle drives and can be used as a reference when clearing faults.

This documentation:
- Offers safety guidelines on how to handle Indramat drives.
- Summarizes drive parameters and functional interfaces.
- Can be used as a reference when setting the parameters of the drive at the time of delivery and to agree with the machine (parameter protocols).

**Change procedures**

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Dept ENA (MR, FS)
AC main spindle drives with controlled asynchronous motor or frameless spindle motors

Applications description
- AC main spindle drive commissioning
- operating the controller
- the functions of the controller
- diagnostics and fault clearance
- summary of parameters and interfaces
About this document

... asynchronous motor or frameless spindle motor"

AC spindle drive with 1MB controlled frameless spindle motor
Selection data
- summary of the AC main drive system
- power ratings
- technical functions of the AC main spindle drive
- selection protocols and order lists
- product availability

AC main spindle drives with 2AD controlled asynchronous motor and changeover 2K planetary gearboxes
Selection data
- summary of the AC main drive system
- power ratings
- order guidelines

Frameless spindle motor
Project Planning
- machine construction plans
- integrating into the cooling system
- electrical and coolant connections
- delivery

Mounting guidelines
- delivery, handling, transport
- mounting
- cooling guidelines

Supplementary documentation
- high-resolution main spindle position encoder
- incremental encoder output IGS
- high-resolution encoder branching HGV

Main Spindle Drive Applications
(commissioning, operating, diagnosing)

Select (details, ordering)

Project Planning (construction, mounting, installing the machine)

Bausatzspindel-motor 1MB 375
Bausatzspindel-motor 1MB 310
Bausatzspindel-motor 1MB 240
Bausatzspindel-motor 1MB 200
Frameless spindle motor 1MB 160
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1. Commissioning INDRAMAT AC Main Spindle Drives

1.1 Summary of Main Spindle Drive Systems

Figure 2: Main spindle drives with KDA or TDA (modular drive system)
1. Commissioning INDRAMAT AC Main Spindle Drives

Figure 3: Main spindle drive with RAC 2.2 controller
For RAC 4.1:

The same arrangement applies here as with an RAC 2.2 (Figure 3). The motor blower does not receive its power from the RAC 4.1, however. It must be directly connected to the three-phase mains!

The name of the programming module is AS 8./..
1. Commissioning INDRAMAT AC Main Spindle Drives

1.2 Safety Guidelines

1.2.1 Notes on Protecting Personnel

The following problems can occur when operating a drive or a drive package for the first time:

- wiring fault
- fault in NC program
- for operational reasons, monitors are not working

These can cause increased risk of accidents and can lead to

- personal injuries,
- damage to drives and
- machines.

The drive may only be operated as prescribed in the relevant documentation!

**Danger from moving axes**

There is danger from moving axes due to

- unintentional starting due to malfunctions and faults and
- operation in the speed or position control circuit.

Precautionary measures for personnel:

- Personnel must not remain in the area of the machine in which movements can take place.
- The drives must be stopped and secured against unintentional starting when personnel are working in the hazardous area.

Precautionary measures against unintentional starting:

- Disconnect the power contactor (EMERGENCY STOP).
- Switch the master switch off during prolonged breaks in operation.

**Danger from contact with electrical parts**

Dangerous voltages on equipment terminals:

- mains voltage L1, L2 and L3
- DC bus voltage L+, L-
- motor voltage A1, A2 and A3

⚠️ **Open master switches and secure against reconnection prior to working on electrical equipment. The drives must be securely locked because voltage appears on the motor cables when the motors rotate!**
1.2.2 Guidelines on Protecting Equipment

- Allow approximately five minutes for DC bus to discharge. Check that voltage is below 50V before commencing work. If in doubt, use short-circuit!
- The transparent cover or front panel must be screwed on to prevent accidental contact during operation.
- Current-operated e.l.c.b systems cannot be used with INDRAMAT equipment. In the case of indirect contact, the mains contactor should be replaced by other means, e.g., overcurrent protective devices.

Indramat electronic drive components are fitted with comprehensive protection circuits and are protected against overload as far as is technically feasible.

- Connect to the inputs of the unit only those voltages which conform to the specified data.
- Outputs must not be connected to separate voltage sources.
- Mains, DC bus and motor cables must not be connected to or brought into contact with low-voltage ±15V and +24V rails. They must be adequately insulated from each other.

Indramat drive components are subjected during routine testing to high-voltage tests which conform to VDE 0160 standards.

If a high-voltage or separate-source voltage withstand test is carried out on the electrical equipment of the machine, then all the connections of the unit must be disconnected or withdrawn to avoid damaging the electronic components in the units (permissible as per VDE 0113).

Electrostatic charges damage electronic components. The human body, which can come into contact with components and printed circuit boards, must be discharged by earthing:

- the human body by touching a conductive, earthed object
- the soldering iron when soldering
- parts and tools must be placed on a conductive substrate

Components at risk, such as programming modules, should only be stored or dispatched in conductive packaging.

1.2.3 Guidelines on Protecting the Machine

If, during commissioning, the position control loop of the NC controller is run and the drive is run in the speed control loop, then there exists the risk of damage to the machine because of the limited travel of linear axes.

To prevent machine damage:

- the drive enable signal and speed command value should only be applied by skilled personnel and
- the emergency stop facility should be provided by limit switches or EMERGENCY-STOP (E-stop) buttons.
1. Commissioning INDRAMAT AC Main Spindle Drives

1.3 The Equipment Required

The following equipment is needed for commissioning:

- DC and AC multimeter
- command value box (analogue command value)
- 37-pin subminiature connector
- 9-pin subminiature connector
- 10-pin plug terminal block (RAC only)

Figure 5: Circuit for operating the drive with the above equipment (command value box and subminiature connectors)
1. Commissioning INDRAMAT AC Main Spindle Drives

1.4 Main Spindle Drives with KDA or TDA

1.4.1 Mains Supply Requirements

Each time prior to switching on, check that the mains supply meets the requirements of the supply module being used (see supply module documentation).

1.4.2 Checks with the Equipment Switched Off

The installed drive components must be designed for the existing input voltages. The input voltages shown on the rating plate should be checked against the type code (see respective drive and supply module documentation).

The details on the AS programming module must match the ratings of the installed drive components, otherwise there is a risk of damage.

Check the wiring for short-circuits, breaks, incorrect connections, conductor cross sections and identify these against the Indramat connection diagram.

- Earthing arrangements:
  The earthing arrangements should be made exactly as per the respective connection diagrams. These should also include the relevant protective measures for the machine. Each motor must be earthed at its associated drive module.

  Drive modules should be separately earthed at the power supply module. The earthing point of the supply module is the central reference earth point for all drive components. This should be connected to the mains earth. The above earth connections provide an operational earth with a protective function.

  When installing the modules in the control cabinet, ensure that the housing makes a good electrical connection with the control cabinet. Otherwise faults could occur.

- Twisting the load conductors:
  The motor connections from the main drive module should be either twisted or a four-core cable (3 x phase, 1 x earth) should be used.

- Connections to auxiliary modules:
  The power connections to the additional capacitance module or to further additional storage capacitors should be twisted and kept as short as possible.

- Power connections to the main drive modules:
  Normally, the units are alongside each other and the connection is made via two busbars. If this is not possible, then the power connection must be made with two twisted 16 mm² conductors not more than one meter in length.

The cross sections of conductors must be such that the permissible current densities stipulated by the relevant specifications (VDE 0100 and VDE 0113) are not exceeded at the maximum ambient temperatures and the corresponding continuous motor and transformer currents.
### 1. Commissioning INDRAMAT AC Main Spindle Drives

<table>
<thead>
<tr>
<th>Checking the terminals and connectors</th>
<th>Check that the conductors are securely attached to the terminals, otherwise there exists the risk of damage. The subminiature connectors must be screwed up!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus connecting cable</td>
<td>The control voltage and monitor connections are made via a bus cable the black core of which must be underneath.</td>
</tr>
<tr>
<td>End connector for bus connecting cable</td>
<td>Ensure that the line monitor end connector supplies with the power supply module is fitted to the drive module farthest from the power supply module.</td>
</tr>
<tr>
<td>Shielding</td>
<td>The shielding of the command value cable and motor feedback cable, the spindle transmitter cable and temperature sensor leads must be connected at the main drive module.</td>
</tr>
<tr>
<td>Power transformer connection</td>
<td>Where a power transformer is required for the supply module, make sure that the primary and secondary sides of the transformer are not interchanged. Excessively high supply voltage can damage the drive.</td>
</tr>
</tbody>
</table>

#### 1.4.3 Checks with the Signal Conditioning Powered Up

First, with the drive package switched off, disconnect the speed command from the controller (X4) and remove the connections to the control inputs and signal outputs (X2). Connect the command value box to interface X4 and connect the control inputs X2 as shown in Figure 4 of section 1.3.

Control voltage must be available at the power supply module before the following checks can be carried out. The voltage for the signal conditioning circuits is then available in the drive modules. The mains contactor K1 must be switched off.

<table>
<thead>
<tr>
<th>Check LED and LCD display status signals</th>
<th>At the supply module:</th>
<th>Color:</th>
<th>Status:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>bleeder overload</td>
<td>red</td>
<td>off</td>
</tr>
<tr>
<td></td>
<td>power on</td>
<td>green</td>
<td>off</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>At the main drive module KDA or TDA:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• FAULT</td>
</tr>
<tr>
<td>• READY</td>
</tr>
<tr>
<td>• NO POWER must appear in the LCD display.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Blower operation</th>
<th>Check the blower and the electrical connections in the main drive modules and the main drive motors.</th>
</tr>
</thead>
</table>

| Power stage on/off sequence | The correct switching sequence is obtained when the "ready" contacts of the supply and main drive modules are installed as per the Indramat connection diagrams. The power can only then be applied when the Bb1 contact in the supply module is closed. Any series resistors are short-circuited only if the Bb contact of the main drive modules closes or +24V is present at the READY output. |
To ensure that the main drive can be braked when the mains is disconnected, fit no DC bus short-circuit resistor.

Set mode switch to right. Pressing the "up" arrow key brings the motor speed N into the display (see Section 2, "Operating the Controllers"). Positive speed must be indicated on the display when the motor shaft is rotated clockwise by hand (motor shaft viewed from front).

Press the "up" arrow until speed command C appears.
- Positive voltage at connector X4/1 with respect to X4/2 shows a positive command in the display.
- For C-axis operation, apply positive command to connector X4/5 with respect to X4/6. Activate command value input via EXT POS input and parameter PQ-FUNCT (P/Q/R/S 16). A positive command again appears in the display (see Section 3.8, "C-axis Operation").

The null of the command value input is set at the factory with the inputs short-circuited and may be adjusted for command value input X4/1 and X4/2 with potentiometer P1 above connector X4, and command value input X4/5 and X4/6 with potentiometer P2 below X4.

Condition: separate spindle feedback must be connected to the optional interface on the second encoder input (X5). Press the "up" arrow key until spindle speed S appears in the display. Positive speed must appear in the display when the incremental encoder shaft is rotated clockwise by hand.

Press the "up" arrow key until motor temperature T appears.
- Display with cold motor: "T<40°C".
- A flashing display means that the motor temperature sensors are incorrectly connected or the motor temperature is less than 0°C.
- The drive switches off after ten minutes if the motor temperature sensors are faulty. "NO TEMP" appears. "TEMP WARN" goes to 0 thirty seconds before this.

1.4.4 Checks after the Power Infeed has been Connected

Set controller enabling switch on command value box to OFF and set speed command value to 0 volts.

Now, connect the power supply to the drive package.
- The green "power on" LED on the supply module must light up.
- "NO RF" (no controller enabling signal) must appear in the KDA module display.
- The green LED "READY" on the KDA must light up.

Press the "up" arrow key until the DC bus voltage (UD) appears. A voltage of between 255 and 345 V must be indicated.
1. Commissioning INDRAMAT AC Main Spindle Drives

1.4.5 Initial Start-Up

Switch on the controller enabling signal on the command value box. Apply a small command value. The speed of the drive must follow the command value input.

![Warning]

In the event of a fault, the drive can "chatter" uncontrollably. Disconnect the controller enabling signal immediately. If the motor rotates in an uncoordinated way, check that the phasing of the motor power connections is correct. If the motor rotates at low speeds only, without following the command value, then check the feedback connections!

Checking the speed/command value ratio

The drive must reach the speed specified in parameter MAX RPM (A01) when the command value voltage programmed in parameter CMD VOLT (A02) is applied.
1. Commissioning INDRAMAT AC Main Spindle Drives

1.5 Main Spindle Drives with RAC Controllers

1.5.1 Mains Requirements

For RAC 2.2 and RAC 4.1

Before switching on each time, check that the following mains requirements are met:

- For 380V type: (type code field „AC supply voltage“=380)
  3 x 400V +6% -15%  50 to 60 Hz
- For 460V type: (type code field „AC supply voltage“ = 460)
  3 x 400V ±15%, 50 Hz or 3 x 460V ±10%, 60 Hz
- mains-related earth

For RAC 3.1

3 x 380V…460V ±10%  50 to 60 Hz
- mains-related earth

A transformer is not needed if the mains supply meets these conditions.

Other mains supplies

In the case of three-phase supplies with mains-related earth, conductor but with phase-phase voltages other than those stated above, an autotransformer must be used for voltage matching.

With three-phase supplies without mains-related conductor but with phase-phase voltages meeting the above requirements, no isolating transformer is necessary if the mains meets special conditions and the RAC is protected by overvoltage protection devices (see "Electrical Connections").

With three-phase supplies without mains-related earth conductor and different mains voltages, a three-phase isolating transformer, with a secondary voltage as stated above and a short-circuit voltage not exceeding 4%, must be used. The neutral point of the secondary must be connected to the system earth (see "Electrical Connections").

1.5.2 Checks with the Equipment Switched-Off

Checking the installed drive components

Compare the data on the equipment rating plates with the existing supply voltage.

The details on the AS programming module must match the ratings of the installed drive components, otherwise there is the risk of damage.

If a KDA 34.2 is to be operated with an RAC 2.2, then the KDA must be designed for a supply voltage of 500 V (type code field “DC supply voltage” = 500).

Condition of wiring

Check the wiring for short-circuits, breaks, incorrect connections, conductor cross sections and compare with the Indramat connection diagram.

- Earthing arrangements:
  The earthing arrangements should be made as per the respective Indramat connection diagrams. These should also include the relevant protective measures for the machine. The earth connection provides an operational earth with a protective function.
When installing the RAC into the control cabinet, ensure that the housing makes a good electrical connection with the cabinet. Faults could otherwise occur.

- Twisting the load conductors:
  The motor connections from the RAC should either be twisted or a four-core cable (3 x phase, 1 x earth) should be used.

- Connections to other KDA modules (RAC 2.2 only):
  The power connections to additional KDA main drive modules should be twisted and kept as short as possible.

The cross sections of conductors must be such that the permissible current densities stipulated by the relevant specifications (VDE 0100 and VDE 0113) are not exceeded at the maximum ambient temperatures and the corresponding continuous motor and transformer currents.

Check that the conductors are securely attached to the terminals, otherwise there is the risk of damage. The subminiature connector must be screwed up!

The control voltage and monitor connections are made via a bus cable the black core of which is underneath. An end connector is not required.

The shields of the command cable and motor feedback cable, the spindle transmitter cable and temperature sensor leads must be connected at the RAC.

Where a power transformer is required, ensure that the primary and secondary sides of the transformer are not interchanged. Excessively high supply voltage can damage the drive package!

1.5.3 Checks with Mains Supply Connected/Power Circuits Disconnected

First, with the RAC switched off, disconnect the speed command from the controller (X4) and remove the connections to the control inputs and signal outputs (X2). Connect the command value box to interface X4 and connect up the control inputs X2 as shown in Figure 14 of section 1.3.

RAC 2.2: set master switch to ON
RAC 3.1: apply 220 V control voltage to terminal X14

Check the following messages on the control panel:
- both the READY and FAULT LEDs remain off
- NO POWER appears in the display

Check operation of blower on the controller and the main drive motor.

A transformer is only required for the motor blower supply if the RAC 3.1 or RAC 4.1 is connected to three-phase mains supplies with rated voltages exceeding 3 x 420 V, 50 Hz. There are terminals for the motor blower on the RAC 2.2.
The motor blower is protected internally when mounted in the RAC 2.2 by means of the Q1 circuit breaker.

The Q1 circuit breaker must be set as follows for axial blowers on 2AD motors:
- RAC 2.2 with 2AD 132/2AD 160 – 0.63 A
- RAC 2.2 with 2AD 180 – 1.00 A

The value actually set depends on the respective supply module of the RAC 2.2. Blowlers of separate motors must be directly connected to three-phase mains via a separate circuit breaker!

Pressing the "up" arrow key brings the motor speed N into the display. Positive speed must be indicated on the display when the motor shaft is rotated clockwise by hand (motor shaft viewed from front).

Press the "up" arrow until speed command value C appears.

- Positive voltage at connector X4/1 with respect to X4/2 shows a positive command value in the display.
- For C-axis operation, apply positive command to connector X4/5 with respect to X4/6. Activate command value input via EXT POS input and parameter PQ-FUNCT (PQRS 16). A positive command value again appears in the display (see section 3.8, "C-axis Operation").

The null of the command value input is set at the factory with the inputs short-circuited and may be adjusted for command value input X4/1 and X4/2 with potentiometer P1 to the left of connector X4, and command value input X4/5 and X4/6 with potentiometer P2 to the right of X4.

Condition: separate spindle feedback must be connected to the optional interface for the second encoder input (X5).

Press the "up" arrow key until spindle speed S appears on the display.

A positive speed must appear in the display when the incremental encoder shaft is rotated clockwise by hand.

Press the "up" arrow key until motor temperature T appears.

- Indication with cold motor: "T<40°C"
- A flashing display means that the motor temperature sensors are incorrectly connected or the motor temperature is less than 0°C.
- The drive switches off after ten minutes if the motor temperature sensors are faulty. "NO TEMP" appears. "TEMP WARN" goes to zero 30 seconds before this.
1.5.4 Connecting the Power Infeed

Set controller enabling switch on command value box to OFF and set speed command value to 0 volts.

The power is applied by shunting the ON and OFF contacts on terminals strip X15. Do this by using a ten-pin terminal block with two switches, i.e., a N/O contact between terminals 1 and 2, and an N/C between 3 and 4. Attach the terminal to X15.

The power must not be disconnected with the N/C contact when the motor is rotating as the motor could coast uncontrollably. Switch the control input E-stop (X2/23) to 0. Fit N/C contact between X2/18 and X2/23 (see Figure 4, section 1.3). The motor is then braked to a standstill before the main contactor is disengaged!

Controlling the messages
Check the messages on the control panel:
- the green READY LED must come on and
- the message NO RF (no controller enabling signal) appears on the display.

Checking the DC bus voltage
Press the "up" arrow key until the DC bus voltage (UD) appears. A voltage of between 480 and 550 V must be indicated.

1.5.5 Initial Start-Up

Switch on controller enabling signal on command value box. Apply a small command value. The speed of the drive must follow the command value input.

With a fault, the drive can "chatter" uncontrollably. Disconnect the controller enabling signal immediately. If the motor rotates in an uncoordinated way, check that the phasing of the motor power connections is correct. If the motor rotates at low speed only without following the command value, check the feedback connections.

Checking the speed / command value ratio
The drive must reach the speed specified in parameter MAX RPM (A01) when the command value voltage programmed in parameter CMD VOLT (A02) is applied.
2. Operating the Controllers

Indramat main spindle drives make a wide range of functions available for numerous applications. The drives can be easily matched to specified applications.

The controllers are operated via the control panel, provided that the controllers are supplied with control voltage, i.e., commissioning must have already been carried out to a large extent.

2.1 The Control Panel

The control panel is located on the front panel of the controller. It is used for drive and fault diagnoses, checking and setting parameters. The green LED indicates the drive is OK, the red LED comes on with a fault.

![Control panel with legends](image)

**Figure 6: Control panel with legends**

**Operating mode**

The mode switches enable the main spindle drive to be changed from the operating mode to the parameter mode.

The main spindle drive is ready for power input or power output. The mode switch is set to the right.

**Parameter mode**

Power output from the main spindle drive is inhibited. Parameters can be checked and changed. The mode switch is set to the left.
2. Operating the Controllers

2.2 Main Spindle Drive in Operating Mode

The main spindle drive is ready for power input or output.

Choice of operating mode:

The mode selection switch must be set to the right. Control voltage must be present.

Message in Display at Power Up:

If the unit is only supplied with control voltage, NO POWER is displayed. Both LEDs are off. If the unit is ready for power output, NO RF is displayed. The green LED comes on.

<table>
<thead>
<tr>
<th>Display</th>
<th>Operating mode switch</th>
<th>key pad</th>
<th>internal state variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO POWER or NO RF</td>
<td></td>
<td></td>
<td>output state</td>
</tr>
<tr>
<td>N =</td>
<td></td>
<td></td>
<td>motor speed</td>
</tr>
<tr>
<td>C =</td>
<td></td>
<td></td>
<td>torque command value</td>
</tr>
<tr>
<td>S =</td>
<td></td>
<td></td>
<td>spindle feedback speed</td>
</tr>
<tr>
<td>M =</td>
<td></td>
<td></td>
<td>torque load (torque command value)</td>
</tr>
<tr>
<td>POS =</td>
<td></td>
<td></td>
<td>spindle or motor position</td>
</tr>
<tr>
<td>UD=</td>
<td></td>
<td></td>
<td>voltage in DC bus (ZK)</td>
</tr>
<tr>
<td>ID=</td>
<td></td>
<td></td>
<td>current in DC bus (ZK)</td>
</tr>
<tr>
<td>PD=</td>
<td></td>
<td></td>
<td>power in DC bus (ZK)</td>
</tr>
<tr>
<td>T =</td>
<td></td>
<td></td>
<td>motor winding temperature</td>
</tr>
<tr>
<td>P . . . . . .</td>
<td></td>
<td></td>
<td>signal states of control inputs</td>
</tr>
</tbody>
</table>

Figure 7: Internal state variables of the drive
2. Operating the Controllers

2.2.1 Displaying the Internal State Variables of the Drive

In operating mode, all the internal state variables of the drive that are important for drive diagnostics can be called up into the display. This is done by pressing the “up” and “down” arrow keys. The “down” key enables the sequence shown in Figure 6 to be displayed in reverse order. Both keys have a continuous function.

Note: Pressing the red central key (accept key) moves the display back from the current position to the initial state. The signal states of the control inputs are also displayed.

2.2.2 Outputting the Drive Internal State Variables for Analogue Output N

Analogue output N (X23/21) is designed as a universal output. It outputs voltage between -10 and +10 volts. The internal state variables of the drive which are displayed can be switched to the analogue output N as a voltage by pressing the LEFT arrow key. This is possible when the control voltage is applied and allows the variations in the state variables to be recorded with just one measuring set-up, e.g., via an oscilloscope, when the drive is operating.

Note on Figure 8
All the state variables of the drive can be called up into the display when the assignment of the analogue output N is unchanged. The contents of the previous display can be restored or scrolled backwards by pressing the DOWN key.

Pressing the red ACCEPT key resets the display to the initial state. The assignment of analogue N output remains unchanged.
2. Operating the Controllers

<table>
<thead>
<tr>
<th>Display</th>
<th>Oper. mode switch =</th>
<th>Analogue output N (X2/21)</th>
<th>Definition</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO POWER</td>
<td>N=NCMD</td>
<td>Output status</td>
<td>Motor speed</td>
<td>± 10 V = ± MAX RPM</td>
</tr>
<tr>
<td>NO RF</td>
<td></td>
<td></td>
<td>The last or the last set weighting of the N output is maintained.</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td></td>
<td>Motor speed, high-resolution</td>
<td>± 10 V = ± 50 1/min over the entire speed range</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Motor speed</td>
<td>± 10 V = MAX RPM (value in parameter A01)</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>Speed command value</td>
<td>± 10 V = MAX RPM (value in parameter A01)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Internal speed command value (after ramp)</td>
<td>± 10 V = MAX RPM (value in parameter A01)</td>
</tr>
<tr>
<td>S</td>
<td></td>
<td>Spindle encoder speed</td>
<td>± 10 V = ± 10 000 1/min</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td></td>
<td>Torque command value, no delay</td>
<td>± 10 V = drive-dependent torque command value</td>
<td></td>
</tr>
<tr>
<td>POS</td>
<td></td>
<td>Spindle position (motor position) in deg.</td>
<td>± 10 V = ± 180 °</td>
<td></td>
</tr>
<tr>
<td>UD</td>
<td></td>
<td>Spindle position (motor position) in deg. (high-resolution)</td>
<td>- 10 V ..... + 10 V = 0.044 °</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Voltage in DC bus (ZK)</td>
<td>+ 10 V = ± 1000 V in the DC bus (ZK)</td>
</tr>
<tr>
<td>ID</td>
<td></td>
<td></td>
<td>Current in DC bus (ZK)</td>
<td>± 10 V = rated current of the control unit</td>
</tr>
<tr>
<td>PD</td>
<td></td>
<td></td>
<td>Power in DC bus (ZK)</td>
<td>± 10 V = ± 100 kW with RAC 2.2 ± 50 kW with KDA 3 and RAC 3</td>
</tr>
<tr>
<td>T</td>
<td></td>
<td></td>
<td>Motor winding temperature</td>
<td>0...± 10 V = 0...± 150° C</td>
</tr>
<tr>
<td>P</td>
<td></td>
<td></td>
<td></td>
<td>The last selected weighting of the N output is maintained.</td>
</tr>
</tbody>
</table>

Figure 9: Switching the analogue output N of the internal state variables of the drive
2.3 The Main Spindle Drive in Parameter Mode

The main spindle drive is not ready for either power input or output. The parameters can be tested, read and changed. They are stored in an EEPROM on the AS programming module.

The mode selection switch must be set to the left. Control voltage must be present.

If parameter mode is selected when the motor is rotating, the drive brakes to a standstill and remains without torque!

Message in display:
(P01...) appears when the parameter mode is selected for the first time after the control voltage is applied. Otherwise, the parameter displayed is the one which was current when the operating mode was reselected.

2.3.1 Parameter Value Quick-Check

The parameter values of a programming module are stored with a parameter checksum. This is an advantage in that the many parameter values can be characterized by a number.

The correspondence between the current parameter values of the main spindle drive of a machine and the values in the parameter record in the machine file can be checked by comparing the checksums.

In standard production machines, the parameter checksum provides a rapid check indicating that the programming modules in use contain the correct parameter values.

The parameter checksum does not contain the value of the OFFSET parameter (A07) since this can differ, even in identical machines.

Figure 10: Parameter checksum display
2. Operating the Controllers

2.3.2 Reading the Parameters

The parameter values can be called up into the display in the parameter mode. They are subdivided into six parameter records:

- **Parameter Record A (general parameters)**
- **Parameter Record M (motor parameters)**

Parameter records A and M are permanently active, so is one of the four selectable parameter records P, Q, R or S.

**Reading a parameter record**

The parameter number, value and name can be displayed via the keyboard.

**Changing to another parameter record**

The other parameter records have to be displayed in order to read all the parameters. After changing to one of the other parameter records, the system for reading the parameter records as described is repeated.

![Parameter protocol diagram](image)

*Figure 11: The six parameter records of Indramat main spindle drives*

*Figure 12: Reading a parameter record, e.g., parameter record P*
2. Operating the Controllers

**Recording the parameter values**

A parameter form for listing parameters is in section 5. This allows the values as supplied, and those modified by the user, to be recorded.

The permissible ranges of parameter values are also shown in the form.

<table>
<thead>
<tr>
<th>Display</th>
<th>Operating mode switch</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>P06...</td>
<td>key</td>
<td>output state (any) display of a P parameter</td>
</tr>
<tr>
<td>P06</td>
<td>pad</td>
<td>ready to leave P parameters</td>
</tr>
<tr>
<td>Q06</td>
<td></td>
<td>change in Q parameters</td>
</tr>
<tr>
<td>Q06</td>
<td></td>
<td>number activating for scrolling</td>
</tr>
<tr>
<td>R06</td>
<td></td>
<td>change in R parameters</td>
</tr>
<tr>
<td>.</td>
<td></td>
<td>and so on</td>
</tr>
</tbody>
</table>

![Display Definition](image)

**2.3.3 Changing the Parameters**

The user parameters (A, P, Q, R and S) are given default values at the factory. Parameter values may need to be changed to match the drive to a special application.

The drive-specific motor parameters (m) have been optimized at the factory. They may only be modified by trained personnel, as otherwise the drive can be damaged. Exceptions are the M03 T-filter and M15 MOTFUNCT parameters (see section 5, parameter overview or list).

The parameter values are protected against unintentional modification by a code.
2. Operating the Controllers

When a parameter gets a new value it must be transferred into the memory of the programming module by pressing the red key ("accept key").

![Diagram of Display Definition]

**Figure 14: Changing the values in parameter records A, P, Q, R and S**

**Note:**
The controller accepts the new value into memory if the LEFT key is pressed after the parameter value has been changed. The parameter number flashes and the old value is displayed.

![Diagram of Display Definition]

**Figure 15: Changing the parameters in parameter record M**
There is a risk of damage from modified motor parameter values. To start up the drive again with the new parameters, the mode switch must be moved to the right. The message "RF-AGAIN" appears in the display. The RF control input must be switched from 0 to +24 volts.

Possible fault messages

Possible fault message: UNACCEPT
Cause: Invalid parameter combination
Remedy: Move operating mode switch to left and press the red key. The incorrect parameter is displayed. Enter a valid value.

Possible fault message: FEEDBACK
Cause: Type of motor feedback and value in M02 do not coincide.
Remedy: Move mode switch to left. Enter correct value (see 5.3).

2.3.4 Displaying the Software Version

Apart from the drive parameters, the AS programming module also holds the operating software. The name of the installed software can be called up on the display. The software version should be noted on the parameter form. It can be important when dealing with questions about applications.

2.3.5 Duplicating the Parameters

The parameter values of a programming module (master) can be copied to another (slave) for the same controller. This produces another programming module with the same parameter contents.

This enables

- parameter values to be protected (back-up copy) and
- programming modules to be rapidly provided with the necessary parameters for mass-produced machines.

Prerequisite:

Parameter duplication adapter PDA 1
2. Operating the Controllers

Procedure:
• Switch off main drive. Control voltage must not be present.
• Unplug programming module AS and replace with PDA 1.
• Plug the master programming module into the „MASTER“ connector.
• Plug the slave programming module into the „SLAVE“ connector.
• Move the operating mode switch to the left.
• Switch on the control voltage. The display now shows the checksum of the master module and a rotating pointer, i.e., transfer running (up to 30 seconds). If the mode switch is not set to the left-hand position, the prompt “SWITCH” appears and the transfer commences when the switch is moved to the left. At the end of the transfer, the display reads “SWITCH->”.
• The mode switch must now be set to the right so that the contents of the slave EEPROM cannot be destroyed during any subsequent power down. If the switch is in the right-hand position, the checksum of the slave EEPROM appears along with the request to switch off the control voltage, e.g., "4B13 OFF".
• Switch off the control voltage and remove the slave module.
• If no further duplicates are to be made, replace the PDA 1 with the master programming module.

Do not remove the programming module when power is on. The slave module is erased if no master module is plugged in.

During duplication, only the contents of the master EEPROM are transferred to the slave EEPROM. The system software is ignored. The checksums of the master and slave EEPROMs are not compared.

Possible fault message: EEPROM
Cause: EEPROM of slave module cannot be programmed.
Remedy: Switch the unit off and use a new slave module.

Possible fault message: PARALOST
Cause: Programming module has no parameters. Values are not loaded or parameters in software of master and slave modules do not agree.
Remedy: Move mode switch to left and press the red key. This loads the general parameters with which the drive can be put into service. If the message "BASISPART" appears in the display, the loading cycle is complete. Pressing the red key once again puts the drive into the parameter mode. The basic parameters are not optimized for the drive and they should be replaced by optimized values (AS/..).

2.3.6 Loading Operating Parameters via Serial Interface

Prerequisite: Serial interface on controller. (Type code field "additional interfaces": S), device for data input such as PC, magnetic tape, perforated tape or other control unit.

Purpose: Rapid input of parameters for mass production machines. Parameters can be printed out. For details on data transfer process see section 3.22, "Serial Interface".
3. Controller Functions

3.1 Drive "Ready" State

The main spindle drive is "ready" when the following conditions are met:

- All controller signal voltages must be present.
- The control inputs and signal outputs (terminal strip X2) must be supplied with ±24 V and 0 V. The supply voltage should be provided via the external controller, but the internal +24V can also be used.
- The motor and controller temperatures are within permissible range:
  - motor winding \(0 < J < 155^\circ C\)
  - controller heatsink \(0 < J < J_{\text{maxperm}}\)
- The mode switch must be to the right.
- There must be no fault message in the display.
- The DC bus voltage must be present.
- For an RAC the "E-Stop" control input must be at 1.
- For KDA3/TDA 1 the "AS" (starting lockout) control input must be at 1.

The "ready" state of the drive can be evaluated via the "READY" signal output and the "Bb" potential-free contact.

Figure 17: Control inputs and signal output, "Bb" potential-free contact

"Ready" display If the drive is "ready", it can start operating with the available functions. The green "READY" LED comes on. If there is a fault in the drive, the green "READY" LED is off, the red "FAULT" LED comes on and the fault message flashes in the display.
3. Controller Functions

3.2 Speed Command Value

**Performance features**
The speed command value can be communicated to the control devices from the controller via an analogue voltage or digitally via a bit pattern.

**Feature:** very broad speed range from minimum speed of 0.0005 rpm to maximum speed.

In addition, Indramat main spindle drives offer a far more powerful type of command value input via the "SERCOS interface" option (see section 3.2.1).

The speed command value is read at 1.2 ms intervals.

3.2.1 Analogue Speed Command Value (option)

The drive with interface for analogue speed command value is designed for multiple applications:
- as a main spindle drive
- as a positioning drive with various gear ratios
- as a C-axis drive for lathes

The differential input provides a large degree of decoupling between NC controller and control unit. Command value voltage matching is easily carried out. Excessive N command value produces only specified maximum speed.

One of the two available command value inputs is always active.

Suitable command value weighting is required for positioning, depending on the gear reduction ratio. C-axis operation requires high resolution for the speed command value.

Command value weighting for various speeds and C-axis operation is obtainable via parameter records (PQRS).

**Function conversion**
The control unit must be fitted with the analogue command value interface (type code field "speed command value = A").

**Note:**
For noise immunity reasons (earth loops), connect screen of command value cable to controller only!

Avoid running command value line and power cable in parallel!
3. Controller Functions

### Parameter Designation & Function

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 01</td>
<td>MAX RPM</td>
<td>maximum motor speed</td>
<td>1.....24000 (1/min)</td>
</tr>
<tr>
<td>A 02</td>
<td>CMD VOLT</td>
<td>analogue voltage value</td>
<td>6.0.....10.0 (V)</td>
</tr>
<tr>
<td>P Q R S 15</td>
<td>P-MAXRPM</td>
<td>motor speed for additional input weightings</td>
<td>1.....24000 (1/min)</td>
</tr>
<tr>
<td>P Q R S 16</td>
<td>PQ-FUNCT</td>
<td>switching analogue inputs with switching of input weighting</td>
<td>&lt;1 &gt;</td>
</tr>
<tr>
<td>A 05</td>
<td>FUNCT 1</td>
<td>analogue speed command value below MIN RPM is invalid!</td>
<td>&lt;2 &gt;</td>
</tr>
<tr>
<td>A 03</td>
<td>MIN RPM</td>
<td>speed limit</td>
<td>1.....999 (1/min)</td>
</tr>
<tr>
<td>A 06</td>
<td>FUNCT 2</td>
<td>with EXTPOS = 1 is at analogue output N: 10V = P-MAXRPM</td>
<td>&lt;128 &gt;</td>
</tr>
</tbody>
</table>

### Figure 18: Inputs for analogue speed command value and control inputs

---

**Table:**

<table>
<thead>
<tr>
<th>control inputs</th>
<th>active parameter record</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAR 1</td>
<td>P</td>
</tr>
<tr>
<td>PAR 2</td>
<td>Q</td>
</tr>
<tr>
<td>0 0</td>
<td>P</td>
</tr>
<tr>
<td>1 0</td>
<td>Q</td>
</tr>
<tr>
<td>0 1</td>
<td>R</td>
</tr>
<tr>
<td>1 1</td>
<td>S</td>
</tr>
</tbody>
</table>

**Legend:**

- 1 = +24V
- 0 = 0V
- = signal step
- = any control state

---

**Figure 19: Parameter for analogue speed command value**

---

Drehzahlsollwert

Para-Sollwert-Analog
Input weighting

**Note:** Command value weighting is CMDVOLT/MAXRPM, if control input EXTPOS is at 0.

If control input EXTPOS is at 1, then the weighting is CMDVOLT/P-MAXRPM. P-MAXRPM is part of the selected parameter record (P, Q, R or S). The voltage at the analogue output N can be output with parameter FUNCT2 with reference to P-MAXRPM.

Input switching

Changing to the second differential input is effected with the EXTPOS control unit. In this case, the value in parameter PQ-FUNCT must be increased by <1> and EXTPOS must be at 1.

Maximum/minimum speed command value

If the value of parameter CMDVOLT is less than 10 V, 10% of MAXRPM can be obtained by suitable voltage input. To prevent drift if the speed command value zero is affected by noise, a command value less than the value in the parameter MINRPM can be arranged to be invalid.

Speed limiting

RPM is limited to 112% of MAXRPM in the event of a fault!

Possible error messages in the display

- ADW2
- NO INPUT
3. Controller Functions

3.2.2 Digital Speed Command Value (option)

The "digital speed command value" enables a task to be matched to the specific plant requirements.

The speed command value can be transferred directly from the PLC controller, binary or floating-point coded, depending on the required speed resolution. The parallel signals are interrogated by the control unit every 1.2 ms.

In plants with severe interference, and in the case of long lines, digital parallel transmission ensures high speed command value accuracy.

Speed command value resolution:
- binary coded 1 rpm
- floating-command coded to 0.0005 rpm

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 06</td>
<td>FUNCT 2</td>
<td>dig. speed comm. value, binary coded</td>
<td>&lt; 0 &gt;</td>
</tr>
<tr>
<td>A 01</td>
<td>MAXRPM</td>
<td>maximum speed of the motor</td>
<td>1...24000 (1/min)</td>
</tr>
<tr>
<td>A 05</td>
<td>FUNCT 1</td>
<td>weighting change of the digital speed command value with respect to parameter value of A 01: $N_{\text{comm}} = \frac{A 01}{16383} \cdot N_{\text{comm digital}}$</td>
<td>&lt; 1024 &gt;</td>
</tr>
</tbody>
</table>

PARAMETER PROTOCOL!

Figure 20: Parameters for a digital speed command value

Function conversion

The control unit must be fitted with the digital command value interface (type code field "speed command value = D").

Speed limits

The maximum speed of the motor MAX RPM is not exceeded, even with excessively high speed command values!
3. Controller Functions

Binary Coding

Figure 21: Inputs for digital speed command values, weighting for binary coding and control inputs

**Speed command value validity**

- If the "DATA VALID" input is at 1, then the bit pattern is read continuously and is passed to the processor.
- If the "DATA VALID" input is at 0, then the bit pattern last read and passed to the processor is the effective speed command value.
Floating-Point Coding

If the "DATA VALID" input is always at 1, the bit pattern is read continuously and is passed to the processor.

If the "DATA VALID" input goes to 0, then the bit pattern last read and passed to the processor is the effective speed command value.

Possible error message in display

NO INPUT

Legend:
- = signal step
= any control state
3. Controller Functions

3.3 Main Spindle Speed Signals

The main spindle speed determines the time point of the feed enabling signal, gear change and clamping of the holding brake.

The requirements are met if signal output \( N_{\text{act}} = N_{\text{comm}} \), \( N < N_{\text{min}} \) and the selectable torque disconnect is below \( N_{\text{min}} \). The signal operating thresholds can be set as required.

### Function conversion

**Table:**

<table>
<thead>
<tr>
<th>Signal outputs</th>
<th>Display messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>( N = \text{CMD} )</td>
<td>( N &lt; \text{MIN} )</td>
</tr>
<tr>
<td>1</td>
<td>0 or 1</td>
</tr>
<tr>
<td>( N * \text{NCMD} )</td>
<td>0</td>
</tr>
<tr>
<td>0 or 1</td>
<td>1</td>
</tr>
<tr>
<td>( N &lt; \text{NMIN} )</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

**Legend:**
- \( ^1 = +24\text{V} \)
- \( ^0 = 0\text{V} \)
- \( ^\Delta = \text{signal step} \)
- \( ^3 = \text{any control state} \)

**Figure 24:** Control inputs, signal outputs, displays for main spindle speed

**Note:**

The display message \( N * \text{NCMD} \) means \( N_{\text{act}} \neq N_{\text{comm}} \). This appears when the speed is above the minimum speed, but has not yet reached the command value speed.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A03</td>
<td>MIN RPM</td>
<td>if speed command value and motor speed are under MIN RPM, then signal output ( N &lt; \text{MIN} ) goes to 1</td>
<td>1.....999 ( 1 / min )</td>
</tr>
<tr>
<td>A04</td>
<td>MAX DEV</td>
<td>maximum deviation of speed from command value within which signal output ( N = \text{CMD} ) goes to 1</td>
<td>1.....999 ( 1 / min )</td>
</tr>
<tr>
<td>A05</td>
<td>FUNCT 1</td>
<td>signal output ( N = \text{CMD} ) also signals without RF enabling signal (control input RF = 0)</td>
<td>(&lt; 256 &gt;)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>change of input value of ( \text{MAX DEV} ); ( 1 = 0.1% ) of current Ncommand</td>
<td>(&lt; 512 &gt;)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>torque off if speed is less than value in MINRPM</td>
<td>(&lt; 4 &gt;)</td>
</tr>
<tr>
<td>PQR S 16</td>
<td>PQ-FUNCT</td>
<td>independent of speed command value, signal output ( N &lt; \text{MIN} ) goes to 1 if motor speed less than MIN RPM (A 03)</td>
<td>(&lt; 512 &gt;)</td>
</tr>
</tbody>
</table>

**Figure 25:** Parameter for main spindle speed signals

**Note:** When the values of parameter \( \text{MAX DEV} \) (A 04) are input as per cents of the speed command value, then the smallest deviation is limited to 10 rpm.
3. Controller Functions

**Motor standstill**
Furthermore, when the drive is stopped with the controller enable signal switched off (RF control input=0), the controller can check standstill via the signal output "N=CMD" (speed command value must be 0!).

**Torque disconnect**
Torque disconnection is compatible via function parameters if the motor speed is less than the value in parameter MINRPM. This is useful if the motor has to be locked in the stopped position after controller braking, but the controller enabling signal does not have to be disconnected.

![The signal „N < MIN“ does not meet personnel protection needs in the working area of the main spindle!](image)

### 3.4 Speed Command Value Ramps

In many cases in main spindle drives it suffices to apply the speed command value via simple control devices (PLC and the like). Sudden changes in the speed command value can be converted in the control unit to ramp-type characteristics.

Three different selectable, successive ramp slopes are available in the controller. They can be used, for example, for breakaway damping and limiting the acceleration for belt couplings. In the constant-power range, the torque is reduced via the speed. In this case, the regulation can be maintained in the active area by means of the third ramp (constant speed increase).

Different ramp slopes can be entered for a maximum of four speed reduction stages.

![Figure 26: Control inputs affecting the speed command value ramps](image)

**Ramps**
The specified ramps are active when the controller enabling signal (RF) and the speed command value enable signal (RUN) are switched on and off!
### 3. Controller Functions

#### Controller Functions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P01</td>
<td>RAMP 1</td>
<td>ramp 1 switched off</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>gradient of ramp 1</td>
<td>1...999 (\text{rad} / \text{s}^2)</td>
</tr>
<tr>
<td>P02</td>
<td>RPM 1</td>
<td>end speed of ramp 1</td>
<td>1...24000 (1 / \text{min})</td>
</tr>
<tr>
<td>P03</td>
<td>RAMP 2</td>
<td>ramp 2 switched off</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>gradient of ramp 2</td>
<td>1...999 (\text{rad} / \text{s}^2)</td>
</tr>
<tr>
<td>P04</td>
<td>RPM 2</td>
<td>end speed of ramp 2</td>
<td>1...24000 (1 / \text{min})</td>
</tr>
<tr>
<td>P05</td>
<td>RAMP 3</td>
<td>ramp 3 switched off</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>gradient of ramp 3</td>
<td>1...999 (\text{rad} / \text{s}^2)</td>
</tr>
<tr>
<td>A06</td>
<td>FUNCT 2</td>
<td>the ramp set is also active</td>
<td>&lt; 32 &gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- switching EXT POS and power failure (all controllers)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- switching of E-STOP (RAC only)</td>
<td></td>
</tr>
</tbody>
</table>

If the ramps are to remain active during a change of weighting (EXT POS), during an E-stop and mains off, this must be specified via function parameters.

**Note:**
All three ramps must be set when the ramp function is used. Slopes must be entered in \(\text{rad/s}^2\) (see Figure 27 for conversion).
3. Controller Functions

Example 1:
\[ \Delta N = 5000 \text{ rpm in } \Delta t = 2 \text{s} \]
\[ RAMP = \frac{250}{2^2} \text{ rad/s}^2 \]

Example 2:
\[ \Delta N = 9000 \text{ rpm in } \Delta t = 1 \text{s} \]
\[ RAMP = \frac{940}{2^2} \text{ rad/s}^2 \]

Instructions for using the conversion graph

- Determine your desired end speed \( \Delta N \) in rpm and the necessary time period \( \Delta t \) in seconds (s).
- Mark the point corresponding to the combined values of \( \Delta N \) and \( \Delta t \) on the graph.
- Draw a straight line through the marked point and the origin of the graph.
- Read the slope of your desired ramp in rad/s\(^2\) at the intersection of the straight line and the RAMP axis and enter the respective RAMP parameter (see example).

Conversion formula (alternative to conversion graph)

\[ RAMP = \frac{\pi}{30} \frac{\Delta N}{\Delta t} \text{ min/s} \quad (\Delta N \text{ in rpm and } \Delta t \text{ in s}) \]
3. Controller Functions

Function sequence graph

3.5 Command Value Smoothing

When controlling the main spindle drive along a ramp via the NC controller or when operating in positioning mode, staircase changes in command values by the NC controller cause sudden torque changes. The speed command value can be smoothed to dampen these.

Adjustable smoothing time constants provide matching to different NC clock times and mechanical conditions for the various speed reduction stages!

Note: The speed command value smoothing is inoperative when the input weighting (EXTPOS=1) is changed. However, it can be made operative via parameters when EXTPOS=1.
3. Controller Functions

### Table: Parameters for smoothing speed command value

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRO P01</td>
<td>RAMP 1</td>
<td>Value for smoothing time constant</td>
<td>0 to 11</td>
</tr>
<tr>
<td>SRO P02</td>
<td>RPM 1</td>
<td>no function, but defined value 0 is needed!</td>
<td>0</td>
</tr>
<tr>
<td>SRO P03</td>
<td>RAMP 2</td>
<td>&quot; &quot; &quot; &quot; &quot; &quot;</td>
<td>0</td>
</tr>
<tr>
<td>SRO P04</td>
<td>RPM 2</td>
<td>&quot; &quot; &quot; &quot; &quot; &quot;</td>
<td>0</td>
</tr>
<tr>
<td>SRO P05</td>
<td>RAMP 3</td>
<td>&quot; &quot; &quot; &quot; &quot; &quot;</td>
<td>0</td>
</tr>
<tr>
<td>A06</td>
<td>FUNCT 2</td>
<td>the smoothing set is also active with: control input EXT POS = 1</td>
<td>&lt; 32 &gt;</td>
</tr>
</tbody>
</table>

**Note:** Smoothing is achieved via a digital filter. The smoothing time constant is calculated as follows:

\[
T_g = 0.5 \times 2^{\text{RAMP1}} \text{ ms}
\]

In the same parameter record the speed command value smoothing excludes the speed ramp function.

Speed command value smoothing is possible for both analogue and digital command values.
3.6 Spindle Positioning

Three standard spindle positions can be set for the drive via the controller for simple and rapid tool change on milling centers.

If more than three positions are required, for example,

- for aligning the tool to the workpiece contour on milling machines,
- indexing the workpiece on lathes, or,
- positioning workpieces for balance holes on balancing machines,

then 3600 optional selectable spindle positions are available.

**Positioning accuracy**

The position command values can be accurately set to 0.1 angular degrees and are corrected to a maximum of 1/1000th of an angular degree.

Three modes of mechanical coupling between motor and spindle make different types of positioning possible.

<table>
<thead>
<tr>
<th>types of mechanical coupling</th>
<th>positioning process</th>
<th>Spindle positioning with the use of...</th>
</tr>
</thead>
<tbody>
<tr>
<td>rigid gears, i = 1 : 1</td>
<td>X</td>
<td>... motor feedback</td>
</tr>
<tr>
<td>changeover gears, i = any</td>
<td>X</td>
<td>... motor feedback + spindle homing switch</td>
</tr>
<tr>
<td>gears with slip, i = any</td>
<td>X</td>
<td>... spindle feedback</td>
</tr>
</tbody>
</table>

see sections 3.6.1 and 3.6.2
see sections 3.6.1 and 3.6.3
see sections 3.6.1 and 3.6.4

*Figure 32: Mechanical coupling and positioning methods*
The three spindle positioning methods:

**Figure 33: Spindle positioning via motor feedback with solid gearing, \( i = 1 \)**

**Figure 34: Spindle positioning via motor feedback with spindle reference switch and change speed gear**

**Figure 35: Spindle positioning via spindle feedback with gearing subject to slip**
3. Controller Functions

3.6.1 Basic Data for Spindle Positioning

Function conversion:

a) Standard version - three spindle positions
   - Inhibit the speed command value at the control unit by removing the RUN control signal from the PLC.
   - Binary selection of one of the three spindle positions via control signals POS1 and POS2 from the PLC.

---

### Table: Control Inputs and Signal Outputs for Spindle Positioning (Standard Unit)

<table>
<thead>
<tr>
<th>Control Inputs</th>
<th>Selected Spindle Position</th>
<th>Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>POS 1</td>
<td>POS 2</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>no position</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>position 1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>position 2</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>position 3</td>
</tr>
</tbody>
</table>

All spindle positions relate to parameter A07 (OFFSET)

Legend:
- 1 = +24V
- 0 = 0V
- ^ = signal step
- ^ = any control state
- 1 = "position reached"

- (tolerance window P-WINDOW)

---

Note:
If "no position" has been selected, the drive brakes to a standstill and remains under speed control without drift. The display then shows NO RUN.

The drive switches back to speed control when the speed command value is enabled (RUN = 1).
3. Controller Functions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A07</td>
<td>OFFSET</td>
<td>angular offset of the zero pulse and the spindle reference point</td>
<td>0.....360.0 (*)</td>
</tr>
<tr>
<td>A08</td>
<td>POS 1</td>
<td>spindle position 1</td>
<td>0.....360.0 (*)</td>
</tr>
<tr>
<td>A09</td>
<td>POS 2</td>
<td>spindle position 2</td>
<td>0.....360.0 (*)</td>
</tr>
<tr>
<td>A10</td>
<td>POS 3</td>
<td>spindle position 3</td>
<td>0.....360.0 (*)</td>
</tr>
<tr>
<td>A06</td>
<td>FUNCT 2</td>
<td>positioning direction (valid in all switching parameter records PQRS) - shortest path: &lt; 0 &gt; - relevant qualifying sign of speed command value: &lt; 16 &gt;</td>
<td></td>
</tr>
<tr>
<td>SRO P16</td>
<td>PQ-FUNCT</td>
<td>positioning direction valid only in the presently active PQRS parameter record; A06 may not be &lt;16&gt;! - shortest path: &lt; 0 &gt; (A06 ≠ &lt; 16 &gt; !) - relevant qualifying sign of speed command value: &lt; 128 &gt; (A06 ≠ &lt; 16 &gt;)</td>
<td></td>
</tr>
<tr>
<td>SRO P17</td>
<td>POS GAIN</td>
<td>gain factor in position control loop 16.6 = Kv = 1</td>
<td>0.....99.9 (1/s)</td>
</tr>
<tr>
<td>SRO P18</td>
<td>POS RPM</td>
<td>positioning speed (limited to 30*POSGAIN)</td>
<td>0.....9999 (1/min)</td>
</tr>
<tr>
<td>SRO P21</td>
<td>P-WINDOW</td>
<td>tolerance window within which the message &quot;INPOS&quot; is issued</td>
<td>0.01.....99.99 (*)</td>
</tr>
<tr>
<td>SRO P12</td>
<td>GEAR IN</td>
<td>gear ratio i = ( \frac{N_1}{N_2} )</td>
<td>N_1 1.....999</td>
</tr>
<tr>
<td>SRO P13</td>
<td>GEAR OUT</td>
<td></td>
<td>N_2 1.....999</td>
</tr>
</tbody>
</table>

Figure 37: Parameters for spindle positioning (standard)

Note:
The parameter values refer to the spindle.

The spindle position values refer to the OFFSET values (for details on OFFSET, see positioning procedure).

Direction of positioning

The direction of positioning can be specified in the FUNCT 2 parameter (A06) for the shortest path or according to the sign of the applied speed command value. This arrangement is then valid in each of the selectable parameter records P, Q, R and S.

Changing the direction of positioning

If the positioning direction has to be specified for each of the selectable parameter records via PQ FUNCT (PQRS 16), then A06 must not contain the value <16>!
3. Controller Functions

**3600 spindle positions**

Precondition is that the interface for digital position input must be fitted to control unit (type code field "additional interface" = D).

Note:
The applied speed command value must also be inhibited when entering digital position command values (RUN control input must be 0).

The bit pattern at the digital interface is switched through to the control unit by means of the DATA VALID input. If the bit pattern changes while the DATA VALID input is at 1, the drive moves immediately up to the new position.

The three parameter-specific positions have priority over the digital position input. The control inputs POS1 and POS2 must therefore be set to 0!

### Entering position command value

**Note:**
The applied speed command value must also be inhibited when entering digital position command values (RUN control input must be 0).

The bit pattern at the digital interface is switched through to the control unit by means of the DATA VALID input. If the bit pattern changes while the DATA VALID input is at 1, the drive moves immediately up to the new position.

### Priority of the position command value

The three parameter-specific positions have priority over the digital position input. The control inputs POS1 and POS2 must therefore be set to 0!
### 3. Controller Functions

#### Note:

The parameter values refer to the spindle. The digital spindle position command values refer to the OFFSET parameter (for details on OFFSET see positioning procedure).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A07</td>
<td>OFFSET</td>
<td>angular offset of the zero pulse and spindle reference point</td>
<td>0.....360.0 (°)</td>
</tr>
<tr>
<td>P17</td>
<td>POS GAIN</td>
<td>gain factor in position control loop 16.6 ( \times ) Kv = 1</td>
<td>0.....99.9 (1/s)</td>
</tr>
<tr>
<td>P18</td>
<td>POS RPM</td>
<td>positioning speed (limited to 30°/POS GAIN)</td>
<td>0.....9999 (1/min)</td>
</tr>
<tr>
<td>P21</td>
<td>P-WINDOW</td>
<td>tolerance window within which the message &quot;INPOS&quot; is issued</td>
<td>0.01.....99.99 (°)</td>
</tr>
<tr>
<td>P12</td>
<td>GEAR IN</td>
<td>gear ratio ( \frac{N_1}{N_2} )</td>
<td>( N_1 ) 1.....999</td>
</tr>
<tr>
<td>P13</td>
<td>GEAR OUT</td>
<td>( \frac{N_1}{N_2} )</td>
<td>( N_2 ) 1.....999</td>
</tr>
</tbody>
</table>

Figure 39: Parameter for spindle positions (3600 positions)
3. Controller Functions

3.6.2 Spindle Positioning via Motor Feedback

Positioning accuracy  The positioning accuracy of motor feedback type 1 is 0.1 angular degrees and 0.001 angular degrees for motor feedback type 3 (see type code field "Motor Feedback" of motor in use).
3. Controller Functions

3.6.3 Spindle Positioning via Motor Feedback with Spindle Reference Switch

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P16</td>
<td>PQ-FUNCT</td>
<td>rotational direction of motor and spindle</td>
<td>- same: &lt; 0 &gt;, - opposite: &lt; 2 &gt;</td>
</tr>
<tr>
<td>P-MAXRPM</td>
<td>Here: spindle speed for searching the reference switch signal</td>
<td>1.....24000 1/min</td>
<td></td>
</tr>
</tbody>
</table>

Note: invalid value: < 65 > !

The sign of the reference switch search speed (P MAXRPM) corresponds to the sign of the speed command value that applies when positioning is initiated (control input RUN 1->0). If the speed command value at the time has to be switched to zero by the controller, then positive or negative speed can be set for locating the reference switch signal.

- The reference switch signal from the spindle must be connected to the EXT POS control input.
- The angle \( a_{\text{min}} \) is the minimum \( \geq \)° of the spindle reference switch. The maximum reference point detection error is given by the angle \( a_{\text{min}} \) and the hysteresis of the spindle reference switch.

The affect of the hysteresis can be eliminated, if the reference switch signal is always searched for in the same direction. In this case, the speed command value must always have the same sign when positioning is initiated.

- \( a_{\text{min}} \) depends on the search speed of the reference point on the spindle. Search speed is the value of parameter P-MAXRPM.

Reference switch search direction

Information about the spindle reference switch
3. Controller Functions

Note:
The reference switch can, e.g., be an inductive proximity switch such as one of the Balluf BES 516 series.

A shielded cable must be used to connect the spindle reference switch. Connect shield to X2/17. Do not run in parallel with power cables!

Since the INPOS message can only be obtained by indirect comparison of command value and actual position, the spindle position should be monitored by a second proximity switch, since the machine can be damaged by position errors!

Figure 43: Reference switch connections and dwell angle

$$\alpha_{\text{min}} = \text{P-MAXRPM} \times 550 \times 10^{-6} \times 6 \times \frac{\text{min}}{\text{s}}$$
3. Controller Functions

Figure 44: Operating sequence for spindle positioning via motor feedback with reference switch (e.g., direction of rotation as per sign of applied speed command value)

Rising edge of reference switch

The OFFSET parameter refers to the rising edge of the reference switch pulse for clockwise rotation and the trailing edge for counterclockwise rotation of the spindle. The same edge of the reference switch pulse is evaluated for either.

Positioning accuracy

The value of the OFFSET parameter is the angle between the reference point for spindle positioning and the edge of the reference switch pulse.

The positioning accuracy for motor feedback type 1 (see "motor feedback" type code of motor in use) is 0.1/i angular degrees, and 0.001/i angular degrees for motor feedback type 3.

Possible fault message

HOMING remains on the display.
3.6.4 Spindle Positioning via Spindle Feedback

A precondition is that the control unit is fitted with the interface for the second encoder input (type code field "second encoder input" = P).

The incremental encoder fitted to the spindle must be compatible with ROD 420/426 (5V supply voltage).

The Indramat high-resolution encoder used for spindle feedback can only be evaluated at high resolution in conjunction with the incremental encoder output or "Sercos" interface (type code "additional interface"=1).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P16</td>
<td>PQ-FUNCT</td>
<td>rotational direction of motor and spindle</td>
<td>- same: &lt; 0 &gt;, - opposite: &lt; 2 &gt;</td>
</tr>
<tr>
<td>A05</td>
<td>FUNCT 1</td>
<td>positioning not via spindle feedback,</td>
<td>lines, if an incremental encoder is</td>
</tr>
<tr>
<td>A11</td>
<td>ENCODER 2</td>
<td>but via motor feedback</td>
<td>used as spindle feedback</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Parameter protocol !

Figure 45: Additional parameters to 3.6.1 for spindle positioning via spindle feedback

Positioning accuracy

When an incremental encoder is used, the spindle positioning accuracy depends on the number of lines used.

If an Indramat high-resolution encoder is used and the control unit is modified as above, the spindle positioning accuracy is 1/1000th of an angular degree. (For further information on Indramat high-resolution main spindle position encoders, refer to document number 9.552.247.4.)
3. Controller Functions

**Note:**
The value of the OFFSET parameter is the angle between the spindle positioning reference point and the spindle feedback zero pulse.
3. Controller Functions

3.7 Speed Controller Functions

When changing the speed or changing the operating mode of the drive from the main spindle to the C-axis servo function, different mechanical systems make different demands on the speed controller.

**Torque build-up**

Four different parameter records, which can be called up via control inputs, are available. Specified speed control parameters are in each of these parameter records for the appropriate mechanical coupling or operating mode.

**Ramp function**

Because of the wide speed range, the main spindle drive operates in the constant torque or constant power range regardless of speed. This also requires the speed controller to be changed over according to the speed.

![Control inputs for selecting the switchable parameter records](image)

**Note:**

The motor is sufficiently magnetized and can provide the full torque only 200 ms after the controller enabling signal (RF = 1). The command value is inhibited during this interval.

If the controller enabling signal (RF) switches to 0 while the drive is turning, then the drive will brake at a set ramp until it reaches the zero velocity and only then becomes torque-free. If neither a ramp nor torque reduction are set, then the drive will brake at maximum torque!
3. Controller Functions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P07</td>
<td>P-GAIN 1</td>
<td>P-gain of the speed controller below switching speed</td>
<td>0.....20.00</td>
</tr>
<tr>
<td>P08</td>
<td>I-GAIN 1</td>
<td>I-gain of the speed controller below switching speed</td>
<td>0.....20.00</td>
</tr>
<tr>
<td>P09</td>
<td>GAIN RPM</td>
<td>switching speed from P-I-Gain1 to P-I-Gain2</td>
<td>0.....9999 (1/min)</td>
</tr>
<tr>
<td>P10</td>
<td>P-GAIN 2</td>
<td>P-gain of the speed controller above switching speed</td>
<td>0.....9.99</td>
</tr>
<tr>
<td>P11</td>
<td>I-GAIN 2</td>
<td>I-gain of the speed controller above switching speed</td>
<td>0.....9.999</td>
</tr>
<tr>
<td>A03</td>
<td>MIN RPM</td>
<td>speed limit</td>
<td>1.....999 (1/min)</td>
</tr>
<tr>
<td>A05</td>
<td>FUNCT 1</td>
<td>general switch off of I-gain of the speed controller at N command below MINRPM</td>
<td>&lt; 16 &gt;</td>
</tr>
<tr>
<td>P16</td>
<td>PQ FUNCT</td>
<td>parameter-dependent switch off of I-gain of the speed controller at N command below MINRPM</td>
<td>&lt; 4 &gt;</td>
</tr>
<tr>
<td>M03</td>
<td>T-FILTER</td>
<td>time constant value of the tachometer filter</td>
<td>0.....3</td>
</tr>
</tbody>
</table>

**Figure 48: Parameter for speed controller functions**

- **Speed dependent changeovers**: Changeover from P-I-GAIN 1 into P-I-GAIN 2 is automatic if the speed of the motor is below the value of GAIN RPM.

  The drive automatically switches to P-GAIN 2 and I-GAIN 2 at the speed in parameter I-U-RPM (M09), even if GAIN RPM was set higher!

- **Braking without overshoot**: For braking without overshoot, for a speed command value of less than MINRPM, the drive can be switched to pure P-control. This is always achieved with the FUNCT 1 parameter (A parameter), but only with the PQ FUNCT parameter (PQRS parameter) in the respective, active parameter record.

  The drive can also be run with true P or I control (value 0 is set for the other respective parameter).
Further information about the speed controller and tachometer filter.

Follow-up time $T_N$ of the speed controller: $T_N = 7 \text{ms} \times \frac{\text{P-GAIN}}{\text{I-GAIN}}$

P-GAIN data: approx. $80 \text{ 1/min} \wedge \frac{\text{P-GAIN}}{\text{I-GAIN}}$ = maximum torque command value

Time constant $T_{GN}$ of tacho filter:

<table>
<thead>
<tr>
<th>T-FILTER</th>
<th>$T_{GN}$/ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$= 0$</td>
</tr>
<tr>
<td>1</td>
<td>$= 1.1$</td>
</tr>
<tr>
<td>2</td>
<td>$= 1.7$</td>
</tr>
<tr>
<td>3</td>
<td>$= 2.7$</td>
</tr>
</tbody>
</table>

Figure 49: Data of the speed controller and tachometer filter

Note:
The values given are guide values only. They vary by about 10% depending on the drive.

3.8 C-Axis Function

At low lathe speeds, the main spindle is used as a servo axis. Contours can be cut on the workpiece through interpolation with the X-axis.

Requirements

The performance of the C-axis largely depends on the stiffness of the coupling between the motor and the spindle. Maximum stiffness is obtained with the 1MB frameless spindle motor.
3. Controller Functions

In comparison to pure main spindle speed control, the drive requires the following for C-axis applications.

- higher rotational stiffness,
- finer resolution of command value input voltage and
- a second command value input, depending on the type of controller.

The following functions are available:

- changeover to a parameter record that is specially optimized to high rotational speed stiffness,
- changeover to fine resolution command value voltage and
- changeover to second command value input with function parameters.

Prerequisites:

- high-resolution motor feedback (on 2AD motor - type code field "motor feedback" = 3, 1MB motor with Indramat high-resolution encoder)
- direct measuring system on spindle (with incremental encoder or Indramat high-resolution encoder)

Note:

When the Indramat high-resolution encoder is used, the additional "incremental encoder output" interface is required on the control unit. This provides the NC controller with incremental encoder-compatible signals with adjustable number of encoder lines.
Conversion of functions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A01</td>
<td>MAXRPM</td>
<td>maximum motor speed</td>
<td>1.......24000 (1/min)</td>
</tr>
<tr>
<td>A02</td>
<td>CMD VOLT</td>
<td>analogue voltage value</td>
<td>6.0.....10.0 (V)</td>
</tr>
<tr>
<td>P15</td>
<td>P-MAXRPM</td>
<td>motor speed for additional input weighting (low speeds)</td>
<td>1.......24000 (1/min)</td>
</tr>
<tr>
<td>P16</td>
<td>PQ-FUNCT</td>
<td>analogue input switching with input switching</td>
<td>&lt; 1 &gt;</td>
</tr>
<tr>
<td>A11</td>
<td>ENCODER 2</td>
<td>only with option &quot;incremental encoder output&quot;:</td>
<td>&lt; 3 &gt;</td>
</tr>
</tbody>
</table>

- high-resolution INDRAMAT encoder: 128 mm Ø
- high-resolution INDRAMAT encoder: 256 mm Ø

Note:
If the EXT POS control input is set to 0, then the weighting CMDVOLT = MAXRPM applies (for high speeds).

If the EXTPOS control input is set to 1, then the weighting CMDVOLT = P-MAXRPM applies (for lower speeds).

Weighting conversion speed command value
Changeover to the second differential input (parameter PQ FUNCT) can be obtained with the weighting changeover (EXT POS = 1).
3.9 Power and Torque Limits

Torque and power limiting protects the workpiece, tool and machine from damage in some cases.

Indramat main spindle drives provide a choice between:

- limiting peak torque without limiting peak power of the drive or
- limiting peak torque and peak power of the drive at the same time.

Figure 54: Example showing the torque limited to 80% of the peak value without limiting the peak power

Figure 55: Example of torque and power limited to 80% of peak value
3. Controller Functions

Limiting with parameter or analogue voltage

In the simplest case, the amount of limiting is stored as a per cent in the switchable parameter records. One value is possible per parameter record.

If several limiting values are required within the parameter records, then the limiting value can also be input as a voltage of the analogue input.

In both cases, limiting is activated via the MD-RED control input. To avoid speed dips, the drive monitors the utilization. If the utilization has reached 90% of the current possible maximum value, then the "90% LOAD" output switches from 1 to 0!

![Figure 55: Control and analogue inputs, signal output for peak value limiting](image)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A05</td>
<td>FUNCT 1</td>
<td>torque and power limits if control input MD-RED is at 1</td>
<td>&lt; 0 &gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>only torque limit with control input MD-RED at 1</td>
<td>&lt; 1 &gt;</td>
</tr>
<tr>
<td>S R C P6</td>
<td>MD-RED</td>
<td>per cent value of peak torque</td>
<td>1...99 ( % )</td>
</tr>
<tr>
<td>S R C P16</td>
<td>PQ-FUNCT</td>
<td>torque limit via voltage at analogue input X4 (E3/E4): ±10V = 100% = peak torque</td>
<td>&lt; 32 &gt;</td>
</tr>
</tbody>
</table>

![Figure 56: Parameter for peak value limiting](image)

Changeover capability of the limiting mode and values

As the "MD-RED" and "PQ-FUNCT" parameters occur several times, both types of limiting can be used via relevant parameters or by switching parameter records, without interrupting the operation of the drive.
3.10 Drive Utilization Output

There is a risk of damage to tools, workpieces or the machine if cutting power is fully utilized.

To prevent damage, the main spindle drive controller has three simple ways for displaying and signalling the utilization:

- analogue output for visual display on a measuring instrument (analogue output M, see 3.1.0.1)
- 90% LOAD signal output (see 3.9)
- LOAD LIMIT signal output with adjustable signal threshold (see 3.10.2)

3.10.1 Analogue output for drive utilization (analogue output M)

A simple visual indication of the drive utilization can be set up at analogue output M with a voltage value of between 0 and +10V.

The voltage value at analogue output M (0 to 10 V) corresponds to

a) either the percentage torque utilization of the drive,
b) a torque utilization related to the machining,
c) a power level related to the machining and
d) a torque value.

- Basic state of the analogue output M (for default parameter values).

The voltage value refers to the speed-dependent, available maximum torque (100% value). This shows how near the utilization approaches the 100% value.

![Figure 58: Display of percentage torque utilization](image-url)
3. Controller Functions

B) Torque utilization related to the machining

- The voltage value relates to the value in parameter LOAD LIM (PQRS 19).
- LOAD LIM (PQRS 19) must be arranged via function parameter FUNCT2 (A06) = < 1 > as a % value.
- The value in parameter PQ-FUNCT (PQRS 16) must contain < 16 >!

The analogue output M now indicates how near the drive approaches a set percentage torque utilization threshold. Four machining-dependent thresholds can be set by the fourfold LOAD LIM parameters.

C) Power level related to the machining

- The voltage value relates to the value in parameter LOAD LIM (PQRS 19).
- LOAD LIM (PQRS 19) is arranged as the power value in the basic state (default parameter value FUNCT 2 (A06) = < 0 >).
- The value in parameter PQ-FUNCT (PQRS 16) must contain < 16 >!

The analogue output M now indicates how near the drive approaches a set power threshold. Four machining-dependent thresholds can be set by the fourfold LOAD LIM parameters.
3. Controller Functions

D) Torque value

- The voltage value relates to the value in parameter LOAD LIM (PQRS 19).
- The value in function parameter FUNCT2 (A06) must contain < 512 >!
- Parameter PQ-FUNCT (PQRS 16) has no significance in this case!

The analogue output M now indicates how near the load approaches a machining-dependent torque limit. Four machining-dependent torque thresholds can be set by the fourfold LOAD LIM parameters.

The torque value indicated is calculated from the DC bus power and the present motor speed.

![Torque value display](image1)

Figure 61: Torque value display

General data on the functions of the analogue output M

![Control inputs and analogue output M](image2)

Figure 62: Control inputs and analogue output M
### 3. Controller Functions

> **Figure 63: Parameter for analogue output M**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRO P16</td>
<td>PQ-FUNCT</td>
<td>M output indicates load in per cent +10V = 100%</td>
<td>&lt; 0 &gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M output indicates voltage +10V as relates to value in LOAD LIM, (kW or %) as specified in A06</td>
<td>&lt; 16 &gt;</td>
</tr>
<tr>
<td>SRO P19</td>
<td>LOAD LIM</td>
<td>torque or power output threshold, depends on A06</td>
<td>0....99 (% or kW)</td>
</tr>
<tr>
<td>A06</td>
<td>FUNCT2</td>
<td>Parameter LOAD LIM is output-related, value in kW</td>
<td>&lt; 0 &gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parameter LOAD LIM is torque-related, value in %</td>
<td>&lt; 1 &gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M output indicates torque, +10V = 10 * (number in LOAD LIM) * Nm</td>
<td>&lt; 512 &gt;</td>
</tr>
</tbody>
</table>

**Note:**

Analogue output M is designed to monitor static drive utilization. The voltage that it delivers is smoothed to suppress high-frequency variations in drive utilization. This produces a clearer display.

When the torque value is output at analogue output M, the percent drive utilization that is otherwise output at this point appears at analogue N.

If parameter LOAD LIMIT (PQRS 19) is used as a torque threshold, power threshold or as a weighting factor for torque output, then the LOAD LIMIT signal output is also active for this value.
3.10.2 Signal output with adjustable threshold for drive utilization (LOAD LIMIT)

The signal threshold for drive utilization is fully adjustable. It is included in each of the switchable parameter records PQRS and can be arranged as torque utilization or power signal threshold.

If the drive utilization reaches the signal threshold of the active parameter record, then the LOAD LIMIT signal output is active.

```
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRO P19</td>
<td>LOAD LIM</td>
<td>signal limit for output load</td>
<td>1 to 99 (% or kW)</td>
</tr>
<tr>
<td>A06</td>
<td>FUNCT 2</td>
<td>signal limit is power-related, value in LOAD LIM is kW</td>
<td>&lt; 0 &gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>signal limit is torque-related, the value in LOAD LIM is a % of peak torque</td>
<td>&lt; 1 &gt;</td>
</tr>
</tbody>
</table>
```

Figure 64: Control inputs and signal output for adjustable signal threshold

Figure 65: Parameter for adjustable signal threshold
3. Controller Functions

3.11 Temperature Pre-Warning

Due to the overload capacity of the main drives, load cycles can be used which need more than the continuous power from the drive for short periods. Choice of correct drive size ensures that the temperature of motor and controller is always in the permissible temperature range. If, though, the cooling system of motor or controller is not operating correctly (dirt, etc.), there is a risk of damage to the drive from overheating.

INDRAMAT main spindle drives are protected against overheating:

- If the motor or controller temperature approaches the limit of the temperature range, this is signalled to the controller via the TEMPWARN alarm output. If the alarm is caused by the motor temperature, the message MOTWARN appears in the display. KKWARN appears if it is caused by the controller.
- The drive is switched off automatically if the load is not removed and the temperature continues to rise.

<table>
<thead>
<tr>
<th>X2 control inputs</th>
<th>X2 signal output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 23 E-STOP (RAC only)</td>
<td>9 TEMP WARN</td>
</tr>
<tr>
<td>1 24 RF</td>
<td></td>
</tr>
<tr>
<td>1 25 RUN</td>
<td></td>
</tr>
<tr>
<td>1 26 POS 1</td>
<td></td>
</tr>
<tr>
<td>1 27 POS 2</td>
<td></td>
</tr>
<tr>
<td>0 28 MD-RED</td>
<td></td>
</tr>
<tr>
<td>0 29 OSCILATE</td>
<td></td>
</tr>
<tr>
<td>0 30 PAR 1</td>
<td></td>
</tr>
<tr>
<td>0 31 PAR 2</td>
<td></td>
</tr>
<tr>
<td>0 32 LIMIT 1</td>
<td></td>
</tr>
<tr>
<td>0 33 LIMIT 2</td>
<td></td>
</tr>
<tr>
<td>0 34 LIMIT 4</td>
<td></td>
</tr>
<tr>
<td>0 35 SPEED 1</td>
<td></td>
</tr>
<tr>
<td>0 36 SPEED 2</td>
<td></td>
</tr>
<tr>
<td>0 37 EXT POS</td>
<td></td>
</tr>
<tr>
<td>1 3 AS KDA/TDA only</td>
<td></td>
</tr>
</tbody>
</table>

Table: permissible temperature range and signal thresholds

| Motor: | 0° < ϑ < 155°C | 145°C |
| Control: | 0° < ϑ < ϑ_{maxperm} | ϑ_{maxperm} |

Legend:

- 1 = +24V
- 0 = 0V
- 2 = signal step
- 3 = any control state

Figure 66: Control inputs and signal output for temperature pre-warning

Heatsink pre-warning

If KKWARN appears in the display, the drive switches off after 30 seconds and KKTEMP appears in the display.

Drive torque is immediately limited to 50% when KKWARN appears!

Motor temperature pre-warning

If MOTWARN (winding temperature 145°C) appears and the temperature continues to rise, the drive switches off at a windings temperature of 155°C and MOTTEMP then appears in the display.

Wire break monitoring

With no temperature sensor connected, the TEMPWARN output is also active after ten minutes with at least 10% loading. NO TEMP appears in the display and the drive switches off.

Possible error messages in the display

- NO TEMP
- MOT WARN
- KK WARN
- MOT TEMP
- KK TEMP
3.12 Maximum Spindle Speed

In machine tools, various tools or chucking devices with different permissible maximum speeds, can be used on the main spindle.

INDRAMAT main spindle drives enable the spindle speed to be monitored and limited to seven different, freely-selectable maximum speeds.

Function conversion

Table:

<table>
<thead>
<tr>
<th>control input</th>
<th>maximum spindle speed</th>
<th>stored in parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIMIT 1</td>
<td>LIMIT 1</td>
<td>A12</td>
</tr>
<tr>
<td>LIMIT 2</td>
<td>LIMIT 2</td>
<td>A13</td>
</tr>
<tr>
<td>LIMIT 3</td>
<td>LIMIT 3</td>
<td>A14</td>
</tr>
<tr>
<td>LIMIT 4</td>
<td>LIMIT 4</td>
<td>A15</td>
</tr>
<tr>
<td>LIMIT 5</td>
<td>LIMIT 5</td>
<td>A16</td>
</tr>
<tr>
<td>LIMIT 6</td>
<td>LIMIT 6</td>
<td>A17</td>
</tr>
<tr>
<td>LIMIT 7</td>
<td>LIMIT 7</td>
<td>A18</td>
</tr>
</tbody>
</table>

Legend:

1 \(\to\) +24V \(\uparrow\) signal step \(\uparrow\) any control state

Value range or value

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A12</td>
<td>LIMIT 1</td>
<td>spindle maximum speed 1</td>
<td>1…..24000 (1/min)</td>
</tr>
<tr>
<td>A13</td>
<td>LIMIT 2</td>
<td>spindle maximum speed 2</td>
<td>1…..24000 (1/min)</td>
</tr>
<tr>
<td>A14</td>
<td>LIMIT 3</td>
<td>spindle maximum speed 3</td>
<td>1…..24000 (1/min)</td>
</tr>
<tr>
<td>A15</td>
<td>LIMIT 4</td>
<td>spindle maximum speed 4</td>
<td>1…..24000 (1/min)</td>
</tr>
<tr>
<td>A16</td>
<td>LIMIT 5</td>
<td>spindle maximum speed 5</td>
<td>1…..24000 (1/min)</td>
</tr>
<tr>
<td>A17</td>
<td>LIMIT 6</td>
<td>spindle maximum speed 6</td>
<td>1…..24000 (1/min)</td>
</tr>
<tr>
<td>A18</td>
<td>LIMIT 7</td>
<td>spindle maximum speed 7</td>
<td>1…..24000 (1/min)</td>
</tr>
<tr>
<td>SRC P12</td>
<td>GEAR IN</td>
<td>gear ratio i = (\frac{N_1}{N_2})</td>
<td>(N_1) 1…..999</td>
</tr>
<tr>
<td>SRC P13</td>
<td>GEAR OUT</td>
<td></td>
<td>(N_2) 1…..999</td>
</tr>
</tbody>
</table>

Figure 67: Control inputs and signal output for maximum spindle speed

Figure 69: Parameter for maximum spindle speed
3. Controller Functions

**Acknowledging maximum speeds**

The spindle speed is limited to the amount (±) of the selected maximum speed, and, on reaching the limit speed, is also acknowledged via the LIMIT signal output.

**Condition for “\(N_{\text{actual}} = N_{\text{command}}\)”**

The controller calculates the limit speed of the motor associated with the limit speed of the spindle with the reduction ratio (GEAR IN/GEAR OUT). If the speed command value is excessively high, the message \(N_{\text{actual}} = N_{\text{command}}\) (signal output N=CMD) does not appear.

### 3.13 Spindle Monitor

The spindle monitor detects any defective or dangerous condition when the machine is first started, if this is due to a malfunction in the mechanical transmission components.

The controller monitors breaks in the mechanical connection between the spindle and the spindle feedback. The controller also detects the absence of signals from the spindle feedback but when the motor is running.

Spindle monitoring requires a spindle feedback unit connected to the controller.

**Legend:**

1 = +24V
0 = 0V
= signal step
= any control state

**Figure 69: Control inputs and signal output for spindle monitor**

**Note:**

For very slow spindle speeds (spindle coasting), the spindle monitor still signals the OK status.

Faults on the spindle encoder line can be detected as increments and the OK status is signalled despite the fact that the spindle is stationary (check function precisely during commissioning).
3. Controller Functions

3.14 Switchable Parameter Records

The switchable parameter records enable the drive to automatically and rapidly match the various tasks of a flexible machine tool while the drive is in operating mode by

• matching to different speeds,
• providing functions for various operating processes,
• operating with position control loop parameters for spindle positioning,
• and with automatic speed change in a two-speed gearbox.

Indramat main spindle drives have six parameter records. Of these, two (the A and M parameters) are always active. In addition, one of the four switchable parameter records (P, Q, R or S) is always active.

![Parameter Record A (general parameters)](image1)

Parameter Record M (motor parameters)

![Parameter protocol](image2)

**Parameter protocol**

![Parameter protocol](image3)

**Table:**

<table>
<thead>
<tr>
<th>control inputs</th>
<th>active parameter records</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAR 1</td>
<td>PAR 2</td>
</tr>
</tbody>
</table>
| 0              | 0                        | P
| 1              | 0                        | Q
| 0              | 1                        | R
| 1              | 1                        | S

**Legend:**

1 \(\wedge\) +24V
0 \(\wedge\) 0V
\(\wedge\) signal step
\(\wedge\) any control state

![Function conversion](image4)

**Figure 70:** The six parameters records for Indramat spindle drives

**Figure 71:** Control inputs for switching the parameter records
### Parameter name

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Parameter record P</th>
<th>Parameter record Q</th>
<th>Parameter record R</th>
<th>Parameter record S</th>
<th>Function</th>
<th>Value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAMP 1</td>
<td>P01</td>
<td>O01</td>
<td>R01</td>
<td>S01</td>
<td>3 speed command value ramps or command value smoothing</td>
<td>0...999 (rad/s²)</td>
</tr>
<tr>
<td>RPM 1</td>
<td>P02</td>
<td>O02</td>
<td>R02</td>
<td>S02</td>
<td>3 speed command value ramps or command value smoothing</td>
<td>0...24000 (1/min)</td>
</tr>
<tr>
<td>RAMP 2</td>
<td>P03</td>
<td>O03</td>
<td>R03</td>
<td>S03</td>
<td>3 speed command value ramps or command value smoothing</td>
<td>0...999 (rad/s²)</td>
</tr>
<tr>
<td>RPM 2</td>
<td>P04</td>
<td>O04</td>
<td>R04</td>
<td>S04</td>
<td>3 speed command value ramps or command value smoothing</td>
<td>0...24000 (1/min)</td>
</tr>
<tr>
<td>RAMP 3</td>
<td>P05</td>
<td></td>
<td></td>
<td></td>
<td>3 speed command value ramps or command value smoothing</td>
<td>0...999 (rad/s²)</td>
</tr>
<tr>
<td>MD-RED</td>
<td>P06</td>
<td></td>
<td></td>
<td></td>
<td>torque limit in %</td>
<td>0...99</td>
</tr>
<tr>
<td>P-GAIN 1</td>
<td>P07</td>
<td></td>
<td></td>
<td></td>
<td>speed controller interconnect 1</td>
<td>0...19.99</td>
</tr>
<tr>
<td>I-GAIN 1</td>
<td>P08</td>
<td></td>
<td></td>
<td></td>
<td>speed controller interconnect 2</td>
<td>0...9.99</td>
</tr>
<tr>
<td>GAIN-RPM</td>
<td>P09</td>
<td></td>
<td></td>
<td></td>
<td>changeover speed from P-I-GAIN 1 to 2</td>
<td>0...99999 (1/min)</td>
</tr>
<tr>
<td>P-GAIN 2</td>
<td>P10</td>
<td></td>
<td></td>
<td></td>
<td>speed controller interconnect 2</td>
<td>0...9.99</td>
</tr>
<tr>
<td>I-GAIN 2</td>
<td>P11</td>
<td></td>
<td></td>
<td></td>
<td>speed controller interconnect 2</td>
<td>0...9.999</td>
</tr>
<tr>
<td>GEAR IN</td>
<td>P12</td>
<td></td>
<td></td>
<td></td>
<td>gear ratio ( N_i ) ( N_o )</td>
<td>1...999</td>
</tr>
<tr>
<td>GEAR OUT</td>
<td>P13</td>
<td></td>
<td></td>
<td></td>
<td>allocation of switchable gear stages</td>
<td>0...2</td>
</tr>
<tr>
<td>G-CHANGE</td>
<td>P14</td>
<td></td>
<td></td>
<td></td>
<td>allocation of switchable gear stages</td>
<td>0...2</td>
</tr>
<tr>
<td>P-MAX RPM</td>
<td>P15</td>
<td></td>
<td></td>
<td></td>
<td>add. weighting of command value voltage</td>
<td>1...24000 (1/min)</td>
</tr>
<tr>
<td>PQ-FUNCT</td>
<td>P16</td>
<td></td>
<td></td>
<td></td>
<td>parameter record functions</td>
<td>0...9999</td>
</tr>
<tr>
<td>POS GAIN</td>
<td>P17</td>
<td></td>
<td></td>
<td></td>
<td>gain factor of the position control loop</td>
<td>0...999.9 (1/s)</td>
</tr>
<tr>
<td>POS RPM</td>
<td>P18</td>
<td></td>
<td></td>
<td></td>
<td>positioning speed</td>
<td>1...99999 (1/min)</td>
</tr>
<tr>
<td>LOAD LIM</td>
<td>P19</td>
<td></td>
<td></td>
<td></td>
<td>output signal threshold</td>
<td>1...9.99 (%.kW)</td>
</tr>
<tr>
<td>ALPHA</td>
<td>P20</td>
<td></td>
<td></td>
<td></td>
<td>tolerance window for positioning</td>
<td>0...9.99</td>
</tr>
<tr>
<td>P-WINDOW</td>
<td>P21</td>
<td>O21</td>
<td>R21</td>
<td>S21</td>
<td>tolerance window for positioning</td>
<td>0...9.99</td>
</tr>
</tbody>
</table>

- only with incremental encoder output option IGS, type code field "additional interface" = I

<table>
<thead>
<tr>
<th>Parameter name</th>
<th>Parameter record P</th>
<th>Parameter record Q</th>
<th>Parameter record R</th>
<th>Parameter record S</th>
<th>Function</th>
<th>Value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGS REF</td>
<td>P22</td>
<td>O22</td>
<td>R22</td>
<td>S22</td>
<td>reference switch offset</td>
<td>0...359.9 (∠°)</td>
</tr>
<tr>
<td>IGS OPEN</td>
<td>P23</td>
<td>O23</td>
<td>R23</td>
<td>S23</td>
<td>acceptance angle of the reference switch</td>
<td>0...359.9 (∠°)</td>
</tr>
<tr>
<td>IGS LINES</td>
<td>P24</td>
<td>O24</td>
<td>R24</td>
<td>S24</td>
<td>resolution of the simul. encoder</td>
<td>1...16383</td>
</tr>
<tr>
<td>IGS FUNCT</td>
<td>P25</td>
<td>O25</td>
<td>R25</td>
<td>S25</td>
<td>functions with IGS</td>
<td>0...9999</td>
</tr>
</tbody>
</table>

* Only see section "incremental encoder output"

**Switchable function parameters**

When the drive is operating the parameter record functions PQ-FUNCT, the following is possible:

- changeover of analogue differential inputs (X4)
- indication of possible reversed direction of rotation of motor and spindle feedback or motor and spindle after a gear change
- changeover to stop drive without overshoot
- changeover of speed and torque controlled operations
- changeover of voltage at analogue output M from torque loading to LOAD LIM related voltage output
- changeover from torque limiting by parameter value to limiting by voltage at analogue differential input (X4)
- changeover to spindle positioning via spindle reference switch

---

*Para Übersicht*
3.15 Gear Change

Various gear reduction stages are used, according to the spindle speed, to obtain a wide speed range with constant power at the spindle. This requires automatic gear changes in modern machine tools.

For two reduction stages, the controller handles the automatic changeover; for more than two stages, the changeover is supported by the controller by speed oscillation (hunting).

3.15.1 Automatic Gear Change via the Controller

Prerequisites:

- two auxiliary d.c. contactors (see Figure 75)
- two-stage gearbox with gear-change motor
- acknowledgement feedback for gear stages

Gear change is initiated by a change to a parameter record that is assigned to a stage that is not engaged.

![Figure 73: Control inputs and signal outputs for gear-change via the controller](image-url)

Note:

The assignment of gear stages to parameter records P and Q is given as an example only. Any combination of parameter records P, Q, R and S is possible.
3. Controller Functions

### Parameter Functions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P14</td>
<td>G-CHANGE</td>
<td>allocation of parameter record to a gear stage</td>
<td>- none &lt; 0 &gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- stage 1 &lt; 1 &gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- stage 2 &lt; 2 &gt;</td>
</tr>
<tr>
<td>A20</td>
<td>OSCI RPM</td>
<td>oscillation speed for gear changeover</td>
<td>1 to 200 (1/min)</td>
</tr>
</tbody>
</table>

**Note:**

Gear stages 1 and 2 must each be assigned at least once to a parameter record by parameter values 1 and 2 in the G-CHANGE parameters.

When changing from a parameter record with assigned gear stage to a parameter record that is not assigned to any gear stage, the previous gear stage remains coupled.

**Gear stage dependent drive optimization**

The switchable parameter records enable the drive to be optimized according to the gear stages (see section 3.14).
3. Controller Functions

The gear change must be completed within ten seconds. If the gear stage to be engaged is not acknowledged via the corresponding control input SPEED 1 or SPEED 2, then the controller display shows GEARBOX and switches the drive and actuating motor off.

The indexing mechanism is displaced against the direction of engagement by the gear-change motor every two seconds for 200 ms so that the tooth-to-tooth points on the gear wheels can be released again. This can happen up to a maximum of five times during the ten-second interval.

During the gear-change process, the motor shaft hunts at the OSCI RPM speed and at a frequency of approximately 2.5 Hz. The message OSCILLATE appears in the display.

Possible error messages on the display

GEAR BOX

Functional sequence

The gear change must be completed within ten seconds. If the gear stage to be engaged is not acknowledged via the corresponding control input SPEED 1 or SPEED 2, then the controller display shows GEARBOX and switches the drive and actuating motor off.

The indexing mechanism is displaced against the direction of engagement by the gear-change motor every two seconds for 200 ms so that the tooth-to-tooth points on the gear wheels can be released again. This can happen up to a maximum of five times during the ten-second interval.

During the gear-change process, the motor shaft hunts at the OSCI RPM speed and at a frequency of approximately 2.5 Hz. The message OSCILLATE appears in the display.

Figure 75: Sequence of operations - gear change via the controller

Possible error messages on the display

GEAR BOX

Functional sequence

The gear change must be completed within ten seconds. If the gear stage to be engaged is not acknowledged via the corresponding control input SPEED 1 or SPEED 2, then the controller display shows GEARBOX and switches the drive and actuating motor off.

The indexing mechanism is displaced against the direction of engagement by the gear-change motor every two seconds for 200 ms so that the tooth-to-tooth points on the gear wheels can be released again. This can happen up to a maximum of five times during the ten-second interval.

During the gear-change process, the motor shaft hunts at the OSCI RPM speed and at a frequency of approximately 2.5 Hz. The message OSCILLATE appears in the display.
3. Controller Functions

Figure 76: Connection diagram for gear change

- Controller Functions
  - Anschlußplan-Getriebe
  - S1 acknowledges gear stage I
  - S2 acknowledges gear stage II
  - Optional blocking brake 24V DC - 2A
  - ZF-indexing mech.

**SPEED CHANGE 2**
- S2 acknowledges gear stage II

**SPEED CHANGE 1**
- S1 acknowledges gear stage I

**SPEED 2**
- K1

**SPEED 1**
- K2

Control unit

- +24 V<sub>ext</sub>
- 24 V<sub>DC</sub>
- 0 V

Load:
- f<sub>max</sub> = 7A (starting torque)
- f<sub>cont</sub> = 2A

Do not tap off 24 V DC for gear change motor from the control unit.

Indexing mechanism

- K1
- K2

- Optional blocking brake 24V DC - 2A
- ZF-indexing mech.

Figure 76: Connection diagram for gear change
3. Controller Functions

3.15.2 Gear Change via an External Controller

The controller supports the gear change by the NC by:

- signalling the gear change "ready" stage \( (N < N_{min}) \)
- and oscillating the speed of the motor shaft.

The four parameter records enable the drive to be optimized according to the reduction stage.

**Table:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P14</td>
<td>G-CHANGE</td>
<td>assignment of gear stage</td>
<td>- none</td>
</tr>
<tr>
<td>A20</td>
<td>OSCI RPM</td>
<td>oscillation speed for gear changeover</td>
<td>1 to 200 (1/min)</td>
</tr>
<tr>
<td>A03</td>
<td>MIN RPM</td>
<td>speed to initiate gear changeover via external control</td>
<td>1 to 999 (1/min)</td>
</tr>
</tbody>
</table>

**Legend:**

- 1 \( \swarrow \) +24V  
- 0 \( \swarrow \) 0V  
- \( \swarrow \) signal step  
- \( \swarrow \) any control state

**Figure 77:** Control inputs for gear change via external controller

**Figure 78:** Parameter for gear change via external controller
3. Controller Functions

**Sequence of operations**

The controller initiates the gear change by taking the OSCILLATE control input to 1. The drive then brakes at the set ramp and changes to oscillating speed at 2.5 Hz. The OSCILLATE message appears in the display. The oscillating speed is the value in parameter OSCI RPM.

The control unit tells the controller via the N<MIN signal output at what time point the speed of the motor permits a gear change. The signal output N<MIN gives a steady 1 if the value of the parameter MIN RPM is greater than that input by OSCI RPM.

Oscillation is asymmetrical, i.e., the motor shaft continues to turn during oscillation and can overcome tooth-tooth positions during engagement.

If the OSCILLATE control input is switched back to 0 after the gear change, the drive returns to the command value speed.

*Figure 79: Sequence of operations - gear change via external controller with constant speed command value*
3.16 Two-Motor Changeover

It is conceivable in some installations that two drive tasks have to be performed at two different sites. If the two tasks never occur at the same time, then they can be performed with two motors connected to one control unit. The motors are selected by the controller.

Prerequisites:
- two motors of identical type
- a control unit with two encoder inputs (type code field "second encoder inputs"=P)
- two auxiliary d.c. contactors and two motor contactors (see Figure 83)

Function conversion
Motor changeover is initiated by changing one of the parameter records that is assigned to the other motor.

![Figure 80: Schematic of two-motor changeover arrangement](image)

Function tables for control inputs and signal outputs

<table>
<thead>
<tr>
<th>control inputs</th>
<th>assignment example</th>
<th>assignment in para. G-CHANGE (PQRS 14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAR 1 PAR 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 0 P</td>
<td>Motor 1</td>
<td>P14</td>
</tr>
<tr>
<td>1 0 Q</td>
<td>Motor 2</td>
<td>Q14</td>
</tr>
<tr>
<td>0 1 R</td>
<td>Motor 1</td>
<td>R14</td>
</tr>
<tr>
<td>1 1 S</td>
<td>Motor 2</td>
<td>S14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>control inputs</th>
<th>acknowledged by motor contactor</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPEED 1 SPEED 2</td>
<td></td>
</tr>
<tr>
<td>0 1</td>
<td>Motor 2 engaged</td>
</tr>
<tr>
<td>1 0</td>
<td>Motor 1 enganged</td>
</tr>
<tr>
<td>0/1 0/1</td>
<td>fault message MOTOR 1/2 (display)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>signal outputs</th>
<th>actuated gear-change motor</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPEED 1 SPEED 2</td>
<td></td>
</tr>
<tr>
<td>0 1</td>
<td>motor contactor 2 engaged</td>
</tr>
<tr>
<td>1 0</td>
<td>motor contactor 1 engaged</td>
</tr>
<tr>
<td>0/1 0/1</td>
<td>fault</td>
</tr>
</tbody>
</table>

Legend: $1^\circ$ +24V $2^\circ$ signal step $0^\circ$ any output state $0^\circ$ 0V

![Figure 81: Control inputs and signal outputs for two-motor changeover](image)
3. Controller Functions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>P14</td>
<td>G-CHANGE</td>
<td>assignment to motor</td>
<td>- motor 1: &lt; 1 &gt;, motor 2: &lt; 2 &gt;</td>
</tr>
<tr>
<td>A06</td>
<td>FUNCT 2</td>
<td>additional encoder input is used as input for the motor feedback of motor 2</td>
<td>&lt; 4 &gt;</td>
</tr>
</tbody>
</table>

**Figure 82: Parameters for two-motor changeover**

**Note:** The values 1 or 2 must always be assigned to the G-CHANGE parameters in the four switchable parameter records. 0 is not allowed!

No spindle position can be performed via the spindle position encoder during two-motor changeover as the second encoder input is used for motor feedback from the second motor.

**Functional sequence**

**Figure 83: Functional sequence of two-motor changeover**

**Note:**
Motor changeover must be completed within two seconds, otherwise "Motor 1/2" fault message appears and drive is switched off.

The auxiliary contactors must also change the temperature sensors of the motors, otherwise the active motor is not monitored.

**Possible error messages in the display**
- Motor 1/2
- NO TEMP
- FEEDBACK
3. Controller Functions

Figure 84: Connection diagram for two-motor changeover

- With KDA/TDA: X8
  - With RAC: X14
- With KDA/TDA: X12
  - With RAC: X16

Motor feedback 1
Motor feedback 2

Speed 1 35
Speed 2 36
Speed change 1 11
Speed change 2 12

X2

2 x 3TJ50

X14 (RAC 2 only)

Mains connection for K1 and K2
For all other control units

24V ext
0V ext
3.17 Master-Slave Operation
Two drives can be combined as master/slave to increase drive power. Here, the master receives the speed command value from the NC; the slave, the torque command value from the master. Master-slave operation is used in a stiff mechanical connection for transmitting power to a common drive shaft.

If the mechanical link between the slave and master drive is broken, the speed of the slave drive goes to maximum speed.

![Diagram of master-slave drive](image)

**Master drive data**
With regard to hardware and software, the control units for the master-slave drive are identical and are defined as master and slave via parameters.

![Control inputs and signal outputs for master drive](image)
3. Controller Functions

### Parameter protocol

#### Para-Master

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A05</td>
<td>FUNCT 1</td>
<td>Analogue output N continuously outputs the torque command value, cannot be changed!</td>
<td>&lt; 64 &gt;</td>
</tr>
</tbody>
</table>

#### Para-Slave

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A06</td>
<td>FUNCT 2</td>
<td>The voltage at analogue input E1/E2 (X4) is interpreted as torque command value - cannot be switched</td>
<td>&lt; 8 &gt;</td>
</tr>
<tr>
<td>SRC P16</td>
<td>PQ-FUNCT</td>
<td>The voltage at analogue input E1/E2 (X4) is interpreted as torque command value - parameter-dependent switching</td>
<td>&lt; 8 &gt;</td>
</tr>
</tbody>
</table>

---

**Slave drive data**

The slave drive must be fitted with an analogue command value interface (type code field "speed command value" = A).

---

Figure 87: Parameters for master drive

Figure 88: Control inputs and signal outputs for slave drive

Figure 89: Slave drive parameters
3. Controller Functions

**Switching torque-speed control**
If a main spindle drive is programmed for torque input, the message SLAVE appears in the display.

**Matching slave to master**
The drive can be switched from torque to speed input with the PQ FUNCT whilst the machine tool is operating.

**Polarity of the torque command value**
The correct polarity (direction of rotation) must be observed when applying the torque command value to the slave. Connecting 0 VM of the master and E2 of the slave gives the same direction of rotation. If the master and slave act in opposition (M indication shows 100% for both), then the torque command value must be reversed.

![Diagram]

**Figure 90: Data for matching the slave, parameters for slave**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A02</td>
<td>CMD VOLT</td>
<td>matching the input value of the slave to the torque command value of the master</td>
<td>value input as per above formula (V)</td>
</tr>
<tr>
<td>M05</td>
<td>FLUX</td>
<td>magnetizing current of the master motor</td>
<td>use value as read in formula (A)</td>
</tr>
<tr>
<td>M06</td>
<td>CURRENT</td>
<td>maximum value of the motor current of the master motor</td>
<td>use value as read in formula (A)</td>
</tr>
</tbody>
</table>

**Formula:**
\[
A02 = \sqrt{M06^2 - M05^2} \times 10V
\]

**Note:**
The motor parameter values (M parameters) for the master and slave must be identical.
3. Controller Functions

Figure 91: Connection diagram for master-slave drive with RAC

Figure 92: Connection diagram for master-slave drive with KDA/TDA
3.18 EMERGENCY-STOP circuit (RAC)

The EMERGENCY-STOP circuit is built into the RAC control unit. It requires no additional circuitry for the power-down logic.

In addition, energy released during braking is fed back into the mains.

For the E-stop circuit, there are two distinct methods for stopping the drive and switching off the power.

The speed command value is set to zero internally after the E-stop control inputs goes from 1 to 0. This can be effected immediately or via the speed command value ramps (selected via function parameters).

Power-down occurs when the motor shaft is stationary but no later than five seconds after the internal N command value is set to 0. If the command value is set to zero immediately, the drive brakes at maximum torque, just like when the drive follows steeply-set ramps.

The motor coasts if the power is disconnected before the motor stops.

The OFF contact must be opened after the controller has stopped the drive. This disconnects the power.

**The E-stop system must be selected and tested according to the installation in use.**

**Note:**
The message E-STOP appears in the display when the E-stop control input is at 0!
3. Controller Functions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A06</td>
<td>FUNCT 2</td>
<td>Ramp active with E-Stop also</td>
<td>&lt; 32 &gt;</td>
</tr>
</tbody>
</table>

Figure 94: Parameters to activate speed command value ramps with E-Stop due to mains failure

### 3.19 Performance during mains failure (RAC)

To prevent the main spindle from coasting during a mains failure, the RAC control unit can also brake the asynchronous drive. This is done either at maximum or at approximately 1/5th of the maximum braking torque with so-called direct-current braking.

**DC braking**

The energy regenerated during braking is converted into heat in the rotor of the motor. The braking time is approximately five times longer than that of controlled braking at maximum braking torque, but is adequate for many main spindle applications.

The permissible amount of braking energy depends on the size of the motor. Braking the load moment of inertia of the rotor from \( N_{\text{max}} \) increases the rotor temperature by about 2K (°C). Additional moments of inertia increase the temperature-rise linearly.

When the motor is at operating temperature, the temperature-rise should not be more than 20K. This otherwise affects bearing service life. When idling, the thermal recovery time is about 30 minutes.

DC braking is included in the standard control unit and is activated in the standard parameter record.

**Braking at maximum torque (RAC 2 and 3 only)**

The energy regenerated in the RAC during braking is converted into heat via a load resistor (additional bleeder). Due to short deceleration distances and times, this type of braking is advantageous in servo applications. The deceleration time is the same as in regenerative braking. The permissible amount of energy depends on the controller:

- RAC 3.1 120 kWs
- RAC 2.2 240 kWs

Maximum-torque braking is only possible in the RAC 2.2 and 3.1 with the "additional bleeder" option (type code field = Z1)!

An additional bleeder cannot be integrated into the RAC 4.1!
3. Controller Functions

### Parameter Protocol

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>M15</td>
<td>MOT-FUNCT</td>
<td>no braking with power failure</td>
<td>&lt; 0 &gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>braking with power failure by &quot; DC bus dynamic braking &quot;</td>
<td>&lt; 16 &gt;</td>
</tr>
</tbody>
</table>

Note:
Braking is not possible with the set ramp or via the NC controller during d.c. braking!

### Parameter Protocol

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A06</td>
<td>FUNCT 2</td>
<td>additional bleeder monitor (RAC 2.2 only) - not working</td>
<td>&lt; 0 &gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- active</td>
</tr>
<tr>
<td>S R O P16</td>
<td>PQ-FUNCT</td>
<td>motor brakes with mains failure</td>
<td>&lt; 0 &gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>the NC controller must brake the motor with power failure</td>
<td>&lt; 256 &gt;</td>
</tr>
</tbody>
</table>

Note on bleeder monitor:
So that the bleeder has time to cool down, braking operations with the additional bleeder must not be repeated in rapid succession. A cooling time of ten to 15 minutes is necessary after braking at maximum permissible energy. In addition, no large amounts of braking energy must be allowed to occur!

If bleeder overheating is detected during braking, the RAC automatically changes over to d.c. braking, if this is activated!
3. Controller Functions

Bleeder monitor features of the RAC 2.2
Activated bleeder monitoring prevents a device with overheated bleeder from being switched on again. The display then shows „BLEEDER“. Activated bleeder monitoring also signals „BLEEDER“, if the RAC 2.2 has been inadvertently installed with a bleeder!

Bleeder monitor features of the RAC 3.1
Bleeder monitoring is always operative when a bleeder is fitted. A missing bleeder is therefore not diagnosed!

During a mains failure, in both control units RAC 2.2 and 3.1 (with additional bleeder option), the decision to brake the drive immediately or whether the internal ramp or the NC controller specifies the speed command value for deceleration, can be made with the PQ FUNCT value in the switchable parameter records. The tool and workpiece can thus be separated without damage during NC braking.

Possible error message in display

BLEEDER

3.20 Performance during mains failure and E-stop (KDA, TDA)
Apart from the main drive with KDA or TDA, servo drives can also be connected in the modular drive system to the same power supply module.

Modular drive system requirements:
• Stopping the servo drives has priority over stopping the main drive.
• The total power regenerated by the drives during braking must not exceed the regenerated power of the supply unit, otherwise the voltage in the DC bus circuit rises to inadmissible levels.
• If the DC bus voltage, as a result of the power that is regenerated when the drives are braking, reaches the permissible limit value, then the KDA/TDA interrupts the braking of the main spindle drives. If the voltage drops, then the main spindle drives return to braking mode.

The command value is switched to zero either abruptly or with the use of ramps, depending upon the parameter FUNCT2 (A06).

If the control unit must separate tool and workpiece by switching the command value to zero, then an NCB jumper must be installed on the supply module (KDV, TVD or KVR, etc). All drives connected to the supply module must, in this case, be braked by the control unit via the speed command value!
3.21 Starting lockout in KDA/TDA

For safety reasons, the main spindle should be stopped when setting-up machine tools. INDRAMAT main spindle drives are thus fitted with a starting lockout.

- The modular system's main drive remains selectively and reliably shut down.
- Disconnection is safe, even if the electronics malfunction, since the opto-couplers are switched off and the power bridge is inhibited.
- Even with defective power transistors, no rotating field can be generated with an active starting lockout.

**Note:**
If the AS control input is at 0, the display shows DISABLED and the starting lockout is activated.

If the AS control input goes from 0 to 1, the controller enabling signal must be applied once again (RF control input goes from 0 to 1) in order to start the drive.

![Figure 97: Control inputs for starting lockout in KDA; internal circuit of controller](image)

If the starting lockout is active, the READY signal output goes to 0. The Bb potential-free contact remains closed so that the other control units of the drive package are not shut down.

**Safety note:** Remove connector plug from terminal strip X2 to ensure that the AS input is set to 0. The starting lockout (AS) does not meet personnel safety requirements in the vicinity of the main spindle!
3. Controller Functions

3.22 Serial Interface (option) – in preparation

3.23 SERCOS interface (option) - in preparation

3.24 Incremental Encoder Output (option) –
see Section 9
4. Diagnostics and Fault Clearance

The control unit shows main spindle drive operating states and faults in the display. Requirements are that the drive is in operating mode (mode switch to the right).

4.1 Operating Status Diagnostics

The green „READY“ LED comes on. The operating states appear in the display.

**DISABLED (KDA only)**

The drive is free of torque, the power output stage is inhibited. The AS (X2/3) control input is at 1.

Note: see Section 3.20

**E-STOP (RAC only)**

The drive is free of torque when at standstill. The E-STOP (X2/23) control input is not at 1.

Note: see Section 3.18

**HOMING**

The drive searches for the spindle reference signal at the speed set in parameter P-MAXRPM, or looks for the spindle feedback or motor feedback zero pulse at the speed set in parameter POS RPM (PQRS 18).

Note: see Section 3.6

**IN POS**

The spindle or rotor position has reached the position command value within tolerance. The tolerance is the value of parameter P-WINDOW (PQRS 21).

Note: see Section 3.6

**NO POWER**

The DC bus voltage in the control unit is less than 400 V (KDA/TDA).

Note: see Sections 3.1

**NO RF**

Controller enabling signal not input. The RF control input (X2/24) is not at 1.

Note: see Section 3.7

**NO RUN**

The applied speed command value is switched off internally. The drive is controlled to zero speed without drift. The RUN control input (X2/25) is at 0.

Note: see Section 3.6.1

**N = NCMD**

The speed of the motor has reached the speed command value within the tolerance (value in parameter MAX DEV (A04)) parameter.

Note: see Section 3.3

**N * NCMD**

The speed of the motor deviates from the command value speed by more than the specified tolerance. The tolerance is the value of parameter MAX DEV (A04).
Note: The message appears in the acceleration and braking mode if the speed command value is changed abruptly. It can also appear when the drive is purely P-controlled under load!

Note: see Section 3.3

**N<MIN**

The speed of the motor is less than the value set in parameter MIN RPM (A03).

Note: see Section 3.3

**OSCILATE**

The motor speed oscillates at the value set in the OSCI RPM (A20) parameter to support the gear change. The OSCILATE (X2/29) control input is at 1.

Note: see Section 3.15.2

**POS ORDER**

The drive has received a position command via POS1 (X2/26) and POS2 (X2/27) control inputs or the digital position input (optional) and approaches the command value position.

Note: see Section 3.6

**SLAVE**

Cause:
The drive is parametrized as the slave drive. It now operates in the torque control mode.

Note: see Section 3.17
4.2 Fault Diagnostics

The red „FAULT“ LED comes on. The fault messages appear in the display. The fault messages must be cancelled with the red accept key after the fault has been remedied (reset).

**ADW2**

Cause:
Plug connector X7 on the CDR board in the control unit has been fitted with an ADW2 analogue speed command value interface.

Remedy:
Switch off the control unit. Replace ADW2 with ADW3. Contact Indramat customer service!

**BLEEDER**

Cause:
- Bleeder monitor has tripped due to overheating.
- The bleeder in the control unit is faulty or no bleeder has been fitted.

Remedy:
- Check whether the bleeder resistor in the upper part of the control unit is faulty (visual inspection). If the bleeder is OK, then allow for the cooling-down period (approximately 15 minutes).
- If the control unit is not fitted with the "additional bleeder" option, <256> is incorrectly contained in the value of FUNCT2 (A06).

**BS (KDA only)**

Cause:
The limiting current in the control unit set on the electronic cut-out has been exceeded.

Remedy:
Check the motor cable for a short-circuit or earth fault. Check the motor for shorted windings or earth fault.

**DACFAULT**

Cause:
Error on the CDR board.

Remedy:
Switch control unit off. Replace CDR board. Contact Indramat customer service!

**DC-FAULT**

Cause:
The DC bus circuit is not charging up properly when the power contactor is energized.

Remedy:
- Check supply cable is securely connected to mains terminal.
- Remove possible short-circuit in the DC bus circuit (L+,L-) (KDA/TDA and RAC2 only).
- Otherwise, contact Indramat customer service!

**EARTH CON**

Cause:
Earth fault in motor cable or DC bus circuit.

Remedy:
Switch off control unit. Check motor cable (cabinet cable entry gland?) and replace if necessary. Check motor. With KDA, check the DC bus wiring.
4. Diagnostics and Fault Clearance

**EEPROM**

Cause:
No EEPROM (IC3) in the programming module, or the existing EEPROM is faulty.

Remedy:
Switch control unit off. Insert EEPROM into programming module, or replace faulty EEPROM. Contact Indramat customer service!

**FEEDBACK**

Cause:
- Wrong value in FEEDBACK (M03) parameter. This type of motor feedback requires a different parameter value.
- Faulty or wrong feedback cable.

Remedy:
- Set parameter value in M03 which suits the type of motor feedback.
- Repair or replace feedback cable.

Note: see Section 5.3

**GEAR BOX**

Cause:
The gear box cannot be engaged or the reduction stage acknowledgment signal is faulty.

Remedy:
Switch the control unit off. Examine contactor wiring and acknowledgement contacts. Check correct operation of change gear.

Note: see Section 3.15.1

**HOMING (does not go off after spindle rotates)**

Cause:
- No spindle reference signal at EXT POS control input (X2/37).
- No spindle or motor feedback zero pulse.

Remedy:
- Check correct connections and closing angle of spindle reference switch!
- Check feedback leads!

Note: see Section 3.6

**KK TEMP**

Cause:
The heatsink of the control unit has overheated. The TEMPWARN signal (X2/9) was ignored. The control unit has shut down.

Remedy:
Check the control unit fan and airways. Check ambient temperature. Check link between TEMPWARN signal output (X2/9) and controller. Reset required.

Note: see Section 3.11
**KK WARN**

Cause:
The heatsink of the control unit has reached the cut-off temperature. The TEMP WARN signal output (X2/9) has switched from 1 to 0.

Remedy:
With KK WARN, the drive must be perceptibly unloaded because a further rise in temperature at the heatsink means the drive switches off after 30 seconds!

Note: see Section 3.11

**MOT TEMP**

Cause:
The temperature of the motor windings has reached 155°C. The TEMPWARN signal was ignored. The control unit has switched off.

Remedy:
Check motor fan, airways, load cycle and interconnections between the TEMPWARN signal output and the controller. Reset required.

Note: see Section 3.11

**MOT WARN**

Cause:
The motor has reached a temperature of 145°C. The TEMP WARN signal output (X2/9) has switched from 1 to 0.

Remedy:
Check motor fan, airways and load cycle. Cancel the fault message with the red accept key!

Note: see Section 3.11

**MOTOR 1/2**

Cause:
No motor contactor changeover acknowledgement.

Remedy:
Check the wiring for agreement with the connection diagram.

Note: see Section 3.16

**NO INPUT**

Cause:
No command value interface card is inserted, or the one fitted is not recognized.

Remedy:
Switch off the control unit. Check command value interface. Replace if necessary. Contact Indramat customer service!

**NO MAINS**

(RAC 3 only)

Cause:
No voltage at mains terminals L1,L2,L3 or voltage too low.

Remedy:
Check mains supply conditions!

**NO RAC 2.2**

(RAC 2.1 only)

Cause:
Software and equipment do not match.

Remedy:
Use correct programming module (AS4/...).
4. Diagnostics and Fault Clearance

**NO TEMP**

Cause:
- Broken connection between motor temperature sensor and control unit, or faulty temperature sensor (signal appears approximately ten minutes after fault occurs).

Remedy:
- Check temperature sensor connections.
- If sensor is faulty, contact Indramat customer service!

Note: see Section 3.11

**NO 8 MHz or NO 12 MHz**

Cause:
Software in programming module does not match control unit.

Remedy:
Use a programming module which matches the control unit. Contact Indramat customer service.

**NO 8V**

Cause:
The control unit's 8V supply is faulty.

Remedy:
Contact Indramat customer service.

**NO 15V**

Cause:
The ±15V supply of the control unit is faulty.

Remedy:
- Check bus connecting cable (in KDA)
- Contact INDRAMAT customer service (with RAC)

**NO 24V**

Cause:
The ±24V supply of the control unit is faulty.

Remedy:
- Check bus connecting cable (in KDA)
- Contact INDRAMAT customer service (with RAC)

**NO 24 VEX**

Cause:
No external voltage for the control inputs and signal outputs (X2/1 and 19), incorrect polarity or outside the tolerance range.

Remedy:
- Check connections and voltage of external +24V supply. The voltage level must be between 18V and 36V. If the external +24V is OK, the fault message is cancelled automatically.
- If the external +24V is absent, the control unit's internal +24V/0V supply can also be used (link +24Vint/OVint to +24Vext/OVext on X2!).

Note: see Section 3.1

**OVER VOLT (RAC only)**

Cause:
The mains voltage exceeds the rated device voltage by more than 15%. The power contactor in the unit cannot be engaged.

Remedy:
Check mains conditions. If necessary, use transformer to match mains voltage.
4. Diagnostics and Fault Clearance

**PARA LOST**
Cause:
Programming module has no parameter values. The values were either not loaded or erased.
Remedy:
Slide mode switch to left and press red button. This loads the general base parameters for running the drive. The load operation is completed when the message "BASISPAR" appears in the display. Pressing the red button again puts the drive into parameter mode. The base parameters are not the optimum ones for the drive and should be replaced (AS ../..). (Refer to parameter list supplied with the programming module.)

**PHASE (RAC only)**
Cause:
No mains supply clockwise field, or one of the three phases is missing (phase failure in RAC 3 only).
Remedy:
Check mains conditions.

**POS ERROR**
Cause:
Contouring error monitor has tripped during spindle positioning with spindle reference switch. Drive cannot follow the position input.
Remedy:
- Check whether spindle is jammed, sluggish or coupling is faulty.
- Check whether drive's torque reduction is active. Switch off torque reduction (set MD-RED (X2/28) to 0)!
- Reduce the positioning rate (POSRPM).

**RAC or KDA TYPE**
Cause:
The value set in CURRENT parameter (M06) exceeds the rated current of the control unit.
Remedy:
Set the value in accordance with the parameter list supplied with the programming module!

**RAM FAULT (RAC only)**
Cause:
Fault while checking RAM in control unit.
Remedy:
Switch off control unit. Replace CDR board. Contact Indramat.

**RF AGAIN**
Cause:
The drive is waiting for a new controller enabling signal in order to run again.
Remedy:
The RF control input (X2/24) must be switched from O to 1 again.

**RSK FAULT (RAC 3 only)**
Cause:
The RSK board is inoperative.
Remedy:
Switch off control unit. If fault is indicated after switching on again, contact Indramat.
RSKCURNT (RAC 3 only)  Cause:  Overcurrent during regenerative feedback.
Remedy:  Check if infeed voltage is below minimum.

S-CIRCUIT  Cause:  Short-circuit in motor cable.
Remedy:  Switch off control unit. Check motor cable (control cabinet cable gland?) and replace, if necessary. Check motor.

SPINDLE  Cause:  No speed information from spindle position encoder.
Remedy:  • Check coupling between spindle and drive.
• Check electrical connections between spindle feedback and control unit!
Note see Section 3.13

X12 ADW  Cause:  Connector strip X12 on CDR board has been fitted with an ADW2 analogue interface.
Remedy:  Switch off control unit. Replace ADW2 board with correct interface board. Contact Indramat.

2X SIM  Cause:  The control unit is fitted with two serial interfaces. Only one serial interface is permitted.
Remedy:  Compare interface configuration indicated by type code and the interface in the control unit. Incorrect interface must be replaced. Contact Indramat.
### 5. Overview of Parameters

#### 5.1 General Parameters (A Parameters)

The general parameters are always active when the drive is in operation. Changes can only be made to parameter values in the parameter mode. When the parameter mode is selected, the drive brakes to the set ramps and is then free of torque.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>See sec.</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A01</td>
<td>MAX RPM</td>
<td>maximum motor speed</td>
<td>3.2</td>
<td>1.....24000 (1/min)</td>
</tr>
<tr>
<td>A02</td>
<td>CMD VOLT</td>
<td>analogue voltage for MAX RPM</td>
<td>3.2</td>
<td>6.....10 ( V )</td>
</tr>
<tr>
<td>A03</td>
<td>MIN RPM</td>
<td>if speed command and motor speed are below MIN RPM then signal output &quot;N &lt; MIN&quot; goes to 1</td>
<td>3.3</td>
<td>1.....999 (1/min)</td>
</tr>
<tr>
<td>A04</td>
<td>MAX DEF</td>
<td>maximum speed deviation from command value within signal output &quot;N = CMD&quot; goes to 1</td>
<td>3.3</td>
<td>1.....999 (1/min)</td>
</tr>
<tr>
<td>A05</td>
<td>FUNCT 1</td>
<td>see function table for A05</td>
<td>sum</td>
<td>0.....9999 (Σ&lt;&gt; )</td>
</tr>
<tr>
<td>A06</td>
<td>FUNCT 2</td>
<td>see function table for A06</td>
<td>sum</td>
<td>0.....9999 (Σ&lt;&gt; )</td>
</tr>
<tr>
<td>A07</td>
<td>OFFSET</td>
<td>phase offset of the zero impulse</td>
<td>3.6.1</td>
<td>0.....360.0° ( deg.)</td>
</tr>
<tr>
<td>A08</td>
<td>POS 1</td>
<td>spindle position 1</td>
<td>3.6.1</td>
<td>0.....360.0° ( deg.)</td>
</tr>
<tr>
<td>A09</td>
<td>POS 2</td>
<td>spindle position 2</td>
<td>3.6.1</td>
<td>0.....360.0° ( deg.)</td>
</tr>
<tr>
<td>A10</td>
<td>POS 3</td>
<td>spindle position 3</td>
<td>3.6.1</td>
<td>0.....360.0° ( deg.)</td>
</tr>
<tr>
<td>A11</td>
<td>ENCODER</td>
<td>resolution of the spindle position encoder or i.d. of Indramat encoder</td>
<td>3.6.4</td>
<td>128,256,512,1024,2048,4096,8192, 3 or 4</td>
</tr>
<tr>
<td>A12</td>
<td>LIMIT 1</td>
<td>maximum spindle speed 1</td>
<td>3.12</td>
<td>1.....24000 (1/min)</td>
</tr>
<tr>
<td>A13</td>
<td>LIMIT 2</td>
<td>maximum spindle speed 2</td>
<td>3.12</td>
<td>1.....24000 (1/min)</td>
</tr>
<tr>
<td>A14</td>
<td>LIMIT 3</td>
<td>maximum spindle speed 3</td>
<td>3.12</td>
<td>1.....24000 (1/min)</td>
</tr>
<tr>
<td>A15</td>
<td>LIMIT 4</td>
<td>maximum spindle speed 4</td>
<td>3.12</td>
<td>1.....24000 (1/min)</td>
</tr>
<tr>
<td>A16</td>
<td>LIMIT 5</td>
<td>maximum spindle speed 5</td>
<td>3.12</td>
<td>1.....24000 (1/min)</td>
</tr>
<tr>
<td>A17</td>
<td>LIMIT 6</td>
<td>maximum spindle speed 6</td>
<td>3.12</td>
<td>1.....24000 (1/min)</td>
</tr>
<tr>
<td>A18</td>
<td>LIMIT 7</td>
<td>maximum spindle speed 7</td>
<td>3.12</td>
<td>1.....24000 (1/min)</td>
</tr>
<tr>
<td>A19</td>
<td>BAUDRATE</td>
<td>transmission rate for serial interface</td>
<td>3.23</td>
<td>50,75,110,150,300,600,1200,2400,4800,9600,19200</td>
</tr>
<tr>
<td>A20</td>
<td>OSCI RPM</td>
<td>oscillating speed for gear switches</td>
<td>3.15</td>
<td>1.....200 (1/min)</td>
</tr>
</tbody>
</table>

**Note:**
The totals of the summands (Σ<> ) assigned to the functions should be entered as parameter values of the function parameters FUNCT1 (A05) and FUNCT2 (A06) (see functions table). An additions list is added to the parameter list for recording the necessary summands.
5. Overview of Parameters

<table>
<thead>
<tr>
<th>Function</th>
<th>Relevant summand</th>
<th>Function</th>
<th>See section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Torque limit if control input MD-RED is on 1</td>
<td>&lt; 1 &gt;</td>
<td>Torque and power limit if control output MD-RED is on 1</td>
<td>3.9</td>
</tr>
<tr>
<td>Analogue speed command value below value in parameter MIN RPM (A03) is</td>
<td>&lt; 2 &gt;</td>
<td>Analogue speed command value is always 1</td>
<td>3.3</td>
</tr>
<tr>
<td>invalid (drift prevention)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Torque off if speed less than value in parameter MIN RPM (A03)</td>
<td>&lt; 4 &gt;</td>
<td>No speed-dependent torque switch off</td>
<td>3.3</td>
</tr>
<tr>
<td>An existing second encoder input being ignored (type code field</td>
<td>&lt; 8 &gt;</td>
<td>Positioning on spindle if 2nd encoder input present, otherwise on</td>
<td>3.6.4</td>
</tr>
<tr>
<td>&quot;2nd encoder input&quot; = P)</td>
<td></td>
<td>motor shaft</td>
<td></td>
</tr>
<tr>
<td>Braking of the motor without overshoot (speed command dependent switch</td>
<td>&lt; 16 &gt;</td>
<td>Drive overshoots during braking as I amplification of the N control</td>
<td>3.7</td>
</tr>
<tr>
<td>off of I-amplification of the N-control unit)</td>
<td></td>
<td>unit is always active</td>
<td></td>
</tr>
<tr>
<td>After powering up, power P = U * I is switched to analogue output N</td>
<td>&lt; 32 &gt;</td>
<td>After power up, speed N is switched to analogue output N (basic state)</td>
<td>2.2.2</td>
</tr>
<tr>
<td>Master drive, analogue output N constantly issues speed command value</td>
<td>&lt; 64 &gt;</td>
<td>Analogue output N can be switched via user interface (see 2.2.2)</td>
<td>3.17</td>
</tr>
<tr>
<td>After switching on, the motor temperature T is switched to analogue output N</td>
<td>&lt; 128 &gt;</td>
<td>After power up, speed N is switched to analogue output N (basic state)</td>
<td>2.2.2</td>
</tr>
<tr>
<td>Signal output N = CMD remains active even without RF signal (control</td>
<td>&lt; 256 &gt;</td>
<td>Signal output N = CMD is only active with drive running</td>
<td>3.3</td>
</tr>
<tr>
<td>input RF = 0 )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change in definition of parameter MAX DEV (A04), speed deviation</td>
<td>&lt; 512 &gt;</td>
<td>The value of parameter MAX DEV means (1 / min)</td>
<td>3.3</td>
</tr>
<tr>
<td>equals MAX DEV * 0.1% of current speed command value</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N&lt;sub&gt;comm&lt;/sub&gt; = [ \frac{A01}{16383} ] * N&lt;sub&gt;comm digital&lt;/sub&gt;</td>
<td>&lt; 1024 &gt;</td>
<td>No change in value of the digital speed command value</td>
<td>3.2.2</td>
</tr>
</tbody>
</table>

Figure 99: Function table for parameter FUNCT1 (A05)
5. Overview of Parameters

<table>
<thead>
<tr>
<th>Function</th>
<th>Relevant summand</th>
<th>Function</th>
<th>See section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value in parameter LOAD LIM ( PQRS 19 ) means torque in % of peak torque</td>
<td>&lt; 1 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>value in parameter LOAD LIM ( PQRS 19 ) means power in kW</td>
</tr>
<tr>
<td>Type code field &quot;speed command value&quot; = D floating decimal point of the speed command value</td>
<td>&lt; 2 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>Type code field &quot;speed command value&quot; = D binary coded speed command value</td>
</tr>
<tr>
<td>Type code field &quot;speed command value&quot; = A and &quot;add. interface&quot; = D Analogue speed comm. value in parameter record P, Q Binary speed command value in parameter record R, S</td>
<td>&lt; 4 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>Type code field &quot;2nd enc. input&quot; = P 2nd encoder input is input for spindle feedback</td>
</tr>
<tr>
<td>Slave mode: 2nd encoder input is used as motor feedback of motor 2</td>
<td>&lt; 8 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>analogue input E1/E2 at terminal strip X4 supports speed default</td>
</tr>
<tr>
<td>Spindle positioning with speed POS RPM ( PQRS 19 ), rotational direction as per qualifying sign of the presently applied speed command value</td>
<td>&lt; 16 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>spindle positioning with speed POS RPM ( PQRS 19 ), using shortest path</td>
</tr>
<tr>
<td>with control input EXT POS = 1, control input E-STOP = 1 → 0 and power failure: command value ramp or smoothing active!</td>
<td>&lt; 32 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>with control input EXT POS = 1 control input E-STOP 1 → 0 and mains failure: command value ramp or smoothing inactive!</td>
</tr>
<tr>
<td>with RAC 3 only: compensation of mains undervoltage active</td>
<td>&lt; 64 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>with RAC 3 only: compensation of mains undervoltage inactive</td>
</tr>
<tr>
<td>with control input EXT POS = 1: at analogue input N equals 10V = speed MAXRPM ( PQRS15 )</td>
<td>&lt; 128 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>10V = speed MAXRPM ( A01 )</td>
</tr>
<tr>
<td>with RAC 2.2 only: bleeder monitoring active</td>
<td>&lt; 256 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>with RAC 2.2 only: bleeder monitoring not operating</td>
</tr>
<tr>
<td>switching analogue input M: output of the approximate drive torque and switching of analogue output N: torque command value is output</td>
<td>&lt; 512 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>no switching of analogue outputs M and N via function parameter ( A06 )</td>
</tr>
</tbody>
</table>

Figure 100: Function table for parameter FUNCT2 (A06)
5.2 Switchable parameter records (P,Q,R,S parameters)

These records can be selected when the drive is running. Use control inputs PAR1 and 2. Change parameter values only in parameter mode. When the parameter mode is selected, the drive brakes to set ramp and is then torque free. Refer to section 3.14 for explanations of the switchable parameter records.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>See section</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PQRS S01</td>
<td>RAMP 1</td>
<td>increase in speed command value ramp 1</td>
<td>3.4 ; 3.5</td>
<td>0.....999 ( rad/s^2 )</td>
</tr>
<tr>
<td>PQRS S02</td>
<td>RPM 1</td>
<td>end speed of ramp 1</td>
<td>3.4 ; 3.5</td>
<td>0.....24000 (1/min)</td>
</tr>
<tr>
<td>PQRS S03</td>
<td>RAMP 2</td>
<td>increase in speed command value ramp 2</td>
<td>3.4 ; 3.5</td>
<td>0.....999 ( rad/s^2 )</td>
</tr>
<tr>
<td>PQRS S04</td>
<td>RPM 2</td>
<td>end speed of ramp 2</td>
<td>3.4 ; 3.5</td>
<td>0.....24000 (1/min)</td>
</tr>
<tr>
<td>PQRS S05</td>
<td>RAMP 3</td>
<td>increase in speed command value ramp 3</td>
<td>3.4 ; 3.5</td>
<td>0.....999 ( rad/s^2 )</td>
</tr>
<tr>
<td>PQRS S06</td>
<td>MD-RED</td>
<td>torque limit</td>
<td>3.9</td>
<td>1.....99 (1/min)</td>
</tr>
<tr>
<td>PQRS S07</td>
<td>P-GAIN 1</td>
<td>P-gain 1 of the speed controller</td>
<td>3.7</td>
<td>0.....20.0</td>
</tr>
<tr>
<td>PQRS S08</td>
<td>I-GAIN 1</td>
<td>I-gain 1 of the speed controller</td>
<td>3.7</td>
<td>0.....20.0</td>
</tr>
<tr>
<td>PQRS S09</td>
<td>GAIN RPM</td>
<td>changeover speed P-I-GAIN 1 to P-I-GAIN 2</td>
<td>3.7</td>
<td>0.....99999 (1/min)</td>
</tr>
<tr>
<td>PQRS S10</td>
<td>P-GAIN 2</td>
<td>P-gain 2 of the speed controller</td>
<td>3.7</td>
<td>0.....9.99</td>
</tr>
<tr>
<td>PQRS S11</td>
<td>I-GAIN 2</td>
<td>I-gain 2 of the speed controller</td>
<td>3.7</td>
<td>1.....9999</td>
</tr>
<tr>
<td>PQRS S12</td>
<td>GEAR IN</td>
<td>gear ratio i = ( \frac{N_1}{N_2} )</td>
<td>3.6 ; 3.12</td>
<td>1.....9999</td>
</tr>
<tr>
<td>PQRS S13</td>
<td>GEAR OUT</td>
<td>( \frac{N_1}{N_2} )</td>
<td>1.....9999</td>
<td></td>
</tr>
<tr>
<td>PQRS S14</td>
<td>G-CHANGE</td>
<td>allocation of the gear stage or motor</td>
<td>3.15 ; 3.16</td>
<td>0,1,2</td>
</tr>
<tr>
<td>PQRS S15</td>
<td>P-MAX RPM</td>
<td>motor speed for additional weighting of the analogue speed command value voltage</td>
<td>3.2</td>
<td>1.....24000 (1/min)</td>
</tr>
<tr>
<td>PQRS S16</td>
<td>POQ-FUNCT</td>
<td>see function table of PQRS 16</td>
<td>( \Sigma &lt; &gt; )</td>
<td></td>
</tr>
<tr>
<td>PQRS S17</td>
<td>POS GAIN</td>
<td>gain factor in position control loop</td>
<td>3.6</td>
<td>0.....99.9 ( 1/s )</td>
</tr>
<tr>
<td>PQRS S18</td>
<td>POS RPM</td>
<td>positioning speed (limited to 30*POSGAIN)</td>
<td>3.6</td>
<td>1.....99999 (1/min)</td>
</tr>
<tr>
<td>PQRS S19</td>
<td>LOAD LIM</td>
<td>signal limit for drive output</td>
<td>3.10</td>
<td>1.....99 ( % or kW )</td>
</tr>
<tr>
<td>PQRS S20</td>
<td>ALPHA</td>
<td>corrective factor of the phase offset</td>
<td>0.....9.99</td>
<td></td>
</tr>
<tr>
<td>PQRS S21</td>
<td>P-WINDOW</td>
<td>tolerance window within which the message &quot;INPOS&quot; is output</td>
<td>3.6</td>
<td>0.01.....99.99 ( ( \epsilon ) )</td>
</tr>
</tbody>
</table>

Note: Enter the totals of the summands (\( _{<}> \)) assigned to the functions as the parameter value of the function parameter PQ FUNCT PQRS 16 (see function tables). An additions list is added to the parameter list for recording the summands. ALPHA parameter (PQRS 20) is used to correct the phase angle between the motor current and the motor voltage in the constant torque range. In the RAC, the value is permanently set to 1.0.
### 5. Overview of parameters

#### Function table for parameter PQ-FUNCT (PQRS 16)

<table>
<thead>
<tr>
<th>Function</th>
<th>Relevant summand</th>
<th>Function</th>
<th>See section</th>
</tr>
</thead>
<tbody>
<tr>
<td>If control input EXT POS = 1: analogue N command value via E3/E4 (X4)</td>
<td>&lt; 1 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>If control input EXT POS = 1: analogue N command value via E1/E2 (X4)</td>
</tr>
<tr>
<td>Rotational direction of motor shaft and spindle or spindle feedback is counterclockwise</td>
<td>&lt; 2 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>Rotational direction of motor shaft and spindle or spindle feedback is the same</td>
</tr>
<tr>
<td>Drive stops without overshoot by switching off l-amplification of the speed controller with Ncomm&lt;MINRPM (A03)</td>
<td>&lt; 4 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>l-amplification of the speed controller is always active!</td>
</tr>
<tr>
<td>Slave mode: Voltage at analogue input E1/E2 (X4) is interpreted as torque command value</td>
<td>&lt; 8 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>Speed control mode: analogue input E1/E2 (X4) supports speed default</td>
</tr>
<tr>
<td>Switching to analogue input M: 10 V = value of LOAD LIM ( % or kW )</td>
<td>&lt; 16 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>Analogue output M cannot be switched</td>
</tr>
<tr>
<td>Torque limitation via voltage at analogue input E3/E4 (X4) : 10V = 100% Mcomm</td>
<td>&lt; 32 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>No torque limitation exceeding voltage level</td>
</tr>
<tr>
<td>Spindle positioning with homing switch on the spindle</td>
<td>&lt; 64 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>Spindle positioning without homing switch on spindle</td>
</tr>
<tr>
<td>Spindle positioning counter specification in A06: if A06 = &lt;16&gt; affect of A06 = &lt;0&gt; if A06 = &lt;0&gt; affect of A06 = &lt;16&gt;</td>
<td>&lt; 128 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>Spindle positioning as specified in A06 (A06 = &lt;16&gt; or &lt;0&gt;)</td>
</tr>
<tr>
<td>Only with RAC 2.2 and RAC 3.1 with optional additional bleeder: with power failure, braking via the NC controller</td>
<td>&lt; 256 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>Only with RAC 2.2 and RAC 3.1 with optional additional bleeder: braking during power failure</td>
</tr>
<tr>
<td>Regardless of speed command value, signal output &quot;N &lt; MIN&quot; goes to 1, if motor speed is less than MIN RPM (A03)</td>
<td>&lt; 512 &gt;</td>
<td>&lt; 0 &gt;</td>
<td>If speed command value and motor speed are below MIN RPM then signal output &quot;N &lt; MIN&quot; goes to 1</td>
</tr>
</tbody>
</table>

![Additions list!](Fix: TablePQ)
5.3 Motor Parameters (M Parameters)

The motor parameter values are set at the factory and guarantee the characteristics that are specified for the drive (motor controller programming module).

The M parameter values may only be changed by trained personnel. The drive could otherwise be damaged. An exception is the MOTFUNCT parameter in drives with RAC.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>See section</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>M01</td>
<td>POLES</td>
<td>pole number of the motor</td>
<td>2,4,6,8</td>
<td></td>
</tr>
<tr>
<td>M02</td>
<td>FEEDBACK</td>
<td>feedback type</td>
<td>1.....4</td>
<td></td>
</tr>
<tr>
<td>M03</td>
<td>T-FILTER</td>
<td>tachometer filter</td>
<td>3.7</td>
<td></td>
</tr>
<tr>
<td>M04</td>
<td>SLIP-LIM</td>
<td>slip limit is multiple of SIGN SLIP</td>
<td>1.0.....7.9</td>
<td></td>
</tr>
<tr>
<td>M05</td>
<td>FLUX</td>
<td>magnetizing current (peak value in A)</td>
<td>1.....I_{type} (A)</td>
<td></td>
</tr>
<tr>
<td>M06</td>
<td>CURRENT</td>
<td>maximum motor current (peak value in A)</td>
<td>1.....I_{type} (A)</td>
<td></td>
</tr>
<tr>
<td>M07</td>
<td>SIGNSLIP</td>
<td>characteristic slip of the drive</td>
<td>0.....300 (1/min)</td>
<td></td>
</tr>
<tr>
<td>M08</td>
<td>SIGN RPM</td>
<td>speed for increasing slip</td>
<td>100.....9999 (1/min)</td>
<td></td>
</tr>
<tr>
<td>M09</td>
<td>I-U RPM</td>
<td>speed for switching to voltage control</td>
<td>100.....9999 (1/min)</td>
<td></td>
</tr>
<tr>
<td>M10</td>
<td>SIGN VOLT</td>
<td>idle voltage of drive at 1500 rpm</td>
<td>0.....999 (V)</td>
<td></td>
</tr>
<tr>
<td>M11</td>
<td>BETA</td>
<td>corrective factor to adjust phase angle in field control range</td>
<td>0.....9.99</td>
<td></td>
</tr>
<tr>
<td>M12</td>
<td>PHI</td>
<td>corrective angle for transition to field control range</td>
<td>0.....45 (degrees)</td>
<td></td>
</tr>
<tr>
<td>M13</td>
<td>VOLT FACT</td>
<td>factor for load-dependent increase in voltage</td>
<td>0.....1.0</td>
<td></td>
</tr>
<tr>
<td>M14</td>
<td>SLIP FACT</td>
<td>factor for increase in slip in field control range</td>
<td>0.....1.0</td>
<td></td>
</tr>
<tr>
<td>M15</td>
<td>MOT FUNCT</td>
<td>see function table for M15</td>
<td>Σ &lt; &gt;</td>
<td></td>
</tr>
<tr>
<td>M16</td>
<td>PHI FACT</td>
<td>factor for transition to basic speed range in field control range</td>
<td>0.....9.99</td>
<td></td>
</tr>
</tbody>
</table>

Parameter protocol! Para Motor

Figure 103: Overview of motor parameter (M)
5. Overview of Parameters

<table>
<thead>
<tr>
<th>Function</th>
<th>Relevant summand</th>
<th>Function</th>
<th>See section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter VOLT FACT (M13) is effective</td>
<td>(&lt; 1 &gt;) &lt; 0 &gt;</td>
<td>Parameter VOLT FACT (M13) is not effective (standard voltage rise is active)</td>
<td></td>
</tr>
<tr>
<td>Parameter SLIP FACT (M14) is effective</td>
<td>(&lt; 2 &gt;) &lt; 0 &gt;</td>
<td>Parameter SLIP FACT (M14) is not effective (standard slip rise is active)</td>
<td></td>
</tr>
<tr>
<td>Voltage amplitude in DA converter is being limited to 7V in the field control range</td>
<td>(&lt; 4 &gt;) &lt; 0 &gt;</td>
<td>amplitude of voltage at DA converter is not being limited</td>
<td></td>
</tr>
<tr>
<td>Voltage amplitude in DA converter is being limited in the field control range: idle: 7V acceleration: 7V + ΔU deceleration: 7V + ΔU/2</td>
<td>(&lt; 8 &gt;) &lt; 0 &gt;</td>
<td>amplitude of voltage at DA converter is not being limited</td>
<td></td>
</tr>
<tr>
<td>as with &lt; 8 &gt; but: braking: 7V + ΔU</td>
<td>(&lt; 12 &gt;) &lt; 0 &gt;</td>
<td>amplitude of voltage at DA converter is not being limited</td>
<td></td>
</tr>
<tr>
<td>with RAC 2.2 and RAC 3.1 only d.c. dynamic braking with power failure</td>
<td>&lt; 16 &gt; &lt; 0 &gt;</td>
<td>no d.c. braking with mains failure</td>
<td>3.19</td>
</tr>
<tr>
<td>with RAC 2.2 - 250: cycle time 565 μs with KDA/TDA: twice the back-up output of the voltage</td>
<td>&lt; 32 &gt; &lt; 0 &gt;</td>
<td>with RAC 2.2 - 250: cycle time 600 μs</td>
<td></td>
</tr>
<tr>
<td>With water-cooled motors: greater increase in slip</td>
<td>(&lt; 64 &gt;) &lt; 0 &gt;</td>
<td>normal slip increase</td>
<td></td>
</tr>
</tbody>
</table>

Note:
The user should only change the existing value in the MOTFUNCT parameter by the summand <16>. Please consult Indramat before changing the sum (Σ<>).

Possible error message: FEEDBACK

Cause:
- Wrong value in FEEDBACK parameter (M02). The existing motor feedback type requires a different parameter value.
- Faulty or incorrect feedback cable.
5. Overview of Parameters

Remedy:
- Set a parameter value in M02 that corresponds to the feedback type of the motor.
- Repair or replace feedback cable.

Note:
In 2AD motors, the feedback type can be read directly from the type designation of the motor (see type code field "motor feedback").

In the case of 1MB motors (spindle motors), the feedback type cannot be obtained from the type designation as the motor feedback is fitted separately on the spindle. Only three and four can be parameter values.

### Values for the FEEDBACK parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Designation</th>
<th>Function</th>
<th>Value range or value</th>
</tr>
</thead>
<tbody>
<tr>
<td>M02</td>
<td>FEEDBACK</td>
<td>Typ 1 - incremental encoder with a resolution of 1024</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Typ 3 - high-resolution INDRAMAT encoder with 256 teeth, 125 mm dia.</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Typ 4 - high-resolution INDRAMAT encoder with 512 teeth, 256 mm dia.</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Typ 2 - incremental encoder with a resolution of 4096</td>
<td>2</td>
</tr>
</tbody>
</table>

*Parameter protocol*

Interchanging feedback types 3 and 4 can damage the drive!

### 5.4 Parameter Protocol and Additions List

Both the parameter values and the drive data can easily be compiled and fixed with the use of the parameter protocol.

The values at time of delivery (parameter list is enclosed with the AS programming module!) can be recorded together with the user-specific values matched to the machine. The permissible value range is set in the parameter protocol.

The parameter protocol is supplemented to the functional parameters A05, A06 and PQRS 16 with the use of an additions list. This list can be used to set the summands (<summand>), with comment, needed for the functions. The sum is then transferred to the parameter protocol.
### 5. Overview of Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX RPM E01</td>
<td>1...24000</td>
<td>(tr/min)</td>
<td>1...24000</td>
<td>(tr/min)</td>
</tr>
<tr>
<td>MAX RPM E02</td>
<td>0...10</td>
<td>(tr/min)</td>
<td>1...24000</td>
<td>(tr/min)</td>
</tr>
<tr>
<td>MAX RPM E03</td>
<td>1...999</td>
<td>(tr/min)</td>
<td>1...24000</td>
<td>(tr/min)</td>
</tr>
<tr>
<td>MAX DEF E04</td>
<td>1...999</td>
<td>(tr/min)</td>
<td>1...24000</td>
<td>(tr/min)</td>
</tr>
<tr>
<td>FUNCT 1 E05</td>
<td>sum value 0...9999</td>
<td>(≥ &gt;)</td>
<td>LIMIT 6</td>
<td>LIMIT 6</td>
</tr>
<tr>
<td>FUNCT 2 E06</td>
<td>sum value 0...9999</td>
<td>(≥ &gt;)</td>
<td>LIMIT 7</td>
<td>LIMIT 7</td>
</tr>
<tr>
<td>OFFSET E07</td>
<td>0...350.9</td>
<td>(Ω)</td>
<td>LIMIT 1</td>
<td>LIMIT 1</td>
</tr>
<tr>
<td>POS 1 E08</td>
<td>0...350.9</td>
<td>(°)</td>
<td>LIMIT 2</td>
<td>LIMIT 2</td>
</tr>
<tr>
<td>POS 2 E09</td>
<td>0...350.9</td>
<td>(°)</td>
<td>LIMIT 3</td>
<td>LIMIT 3</td>
</tr>
<tr>
<td>POS 3 E10</td>
<td>0...350.9</td>
<td>(°)</td>
<td>LIMIT 4</td>
<td>LIMIT 4</td>
</tr>
<tr>
<td>ENCODER E11</td>
<td>1...24000</td>
<td>(tr/min)</td>
<td>LIMIT 5</td>
<td>LIMIT 5</td>
</tr>
</tbody>
</table>

**P Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAMP 1 E12</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 6</td>
<td>LIMIT 6</td>
</tr>
<tr>
<td>RPM 1 E13</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 7</td>
<td>LIMIT 7</td>
</tr>
<tr>
<td>RPM 2 E14</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 8</td>
<td>LIMIT 8</td>
</tr>
<tr>
<td>RPM 3 E15</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 9</td>
<td>LIMIT 9</td>
</tr>
<tr>
<td>MD-REF E16</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 10</td>
<td>LIMIT 10</td>
</tr>
</tbody>
</table>

**Q Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAIN RPM E17</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 11</td>
<td>LIMIT 11</td>
</tr>
<tr>
<td>I-GAIN 1 E18</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 12</td>
<td>LIMIT 12</td>
</tr>
<tr>
<td>I-GAIN 2 E19</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 13</td>
<td>LIMIT 13</td>
</tr>
<tr>
<td>GEAR IN E20</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 14</td>
<td>LIMIT 14</td>
</tr>
<tr>
<td>G-CHANGE E21</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 15</td>
<td>LIMIT 15</td>
</tr>
<tr>
<td>P-MAX RPM E22</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 16</td>
<td>LIMIT 16</td>
</tr>
<tr>
<td>T-_FILTER E23</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 17</td>
<td>LIMIT 17</td>
</tr>
<tr>
<td>POS GAIN E24</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 18</td>
<td>LIMIT 18</td>
</tr>
<tr>
<td>POS RPM E25</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 19</td>
<td>LIMIT 19</td>
</tr>
<tr>
<td>LOAD LAM E26</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 20</td>
<td>LIMIT 20</td>
</tr>
<tr>
<td>ALPHA E27</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 21</td>
<td>LIMIT 21</td>
</tr>
<tr>
<td>P-WINDOW E28</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 22</td>
<td>LIMIT 22</td>
</tr>
<tr>
<td>IGS REF E29</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 23</td>
<td>LIMIT 23</td>
</tr>
<tr>
<td>IGS OPEN E30</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 24</td>
<td>LIMIT 24</td>
</tr>
<tr>
<td>IGS LINES E31</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 25</td>
<td>LIMIT 25</td>
</tr>
<tr>
<td>IGS FUNC E32</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 26</td>
<td>LIMIT 26</td>
</tr>
<tr>
<td>KV-SYNC E33</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 27</td>
<td>LIMIT 27</td>
</tr>
<tr>
<td>S-WINDOW E34</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 28</td>
<td>LIMIT 28</td>
</tr>
<tr>
<td>SMOOTH E35</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 29</td>
<td>LIMIT 29</td>
</tr>
</tbody>
</table>

**R Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIMIT 1 E36</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 30</td>
<td>LIMIT 30</td>
</tr>
</tbody>
</table>

**S Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIMIT 1 E36</td>
<td>0...45</td>
<td>(rad/s)</td>
<td>LIMIT 30</td>
<td>LIMIT 30</td>
</tr>
</tbody>
</table>

**M Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Value</th>
<th>Value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>POLES E37</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 31</td>
<td>LIMIT 31</td>
</tr>
<tr>
<td>FEEDBACK E38</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 32</td>
<td>LIMIT 32</td>
</tr>
<tr>
<td>T-FILTER E39</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 33</td>
<td>LIMIT 33</td>
</tr>
<tr>
<td>SLIP-LM E40</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 34</td>
<td>LIMIT 34</td>
</tr>
<tr>
<td>FLUX E41</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 35</td>
<td>LIMIT 35</td>
</tr>
<tr>
<td>CURRENT E42</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 36</td>
<td>LIMIT 36</td>
</tr>
<tr>
<td>SIGNUP E43</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 37</td>
<td>LIMIT 37</td>
</tr>
<tr>
<td>SIGN RPM E44</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 38</td>
<td>LIMIT 38</td>
</tr>
<tr>
<td>I/U RPM E45</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 39</td>
<td>LIMIT 39</td>
</tr>
<tr>
<td>SIGN VOLT E46</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 40</td>
<td>LIMIT 40</td>
</tr>
<tr>
<td>BETA E47</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 41</td>
<td>LIMIT 41</td>
</tr>
<tr>
<td>PHI E48</td>
<td>2...4</td>
<td>(rad/s)</td>
<td>LIMIT 42</td>
<td>LIMIT 42</td>
</tr>
</tbody>
</table>

**Parameter Blatt 2**
### ADDITIONS LIST for the FUNCT Parameters for the Parameter Protocol

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>PQ-FUNCT :P16</td>
<td>&lt; &gt;</td>
<td>value input by manufacturer&lt;br&gt;possibly &lt; 16 &gt; for DC bus dynamic braking</td>
</tr>
<tr>
<td>PQ-FUNCT :Q16</td>
<td>&lt; &gt;</td>
<td></td>
</tr>
<tr>
<td>PQ-FUNCT :R16</td>
<td>&lt; &gt;</td>
<td></td>
</tr>
<tr>
<td>PQ-FUNCT :S16</td>
<td>&lt; &gt;</td>
<td></td>
</tr>
<tr>
<td>SYNCMODE :P26</td>
<td>&lt; &gt;</td>
<td></td>
</tr>
<tr>
<td>SYNCMODE :Q26</td>
<td>&lt; &gt;</td>
<td></td>
</tr>
<tr>
<td>SYNCMODE :R26</td>
<td>&lt; &gt;</td>
<td></td>
</tr>
<tr>
<td>SYNCMODE :S26</td>
<td>&lt; &gt;</td>
<td></td>
</tr>
</tbody>
</table>

**Motor:**

**Controller:**

**Prog. module:**

**Software:**

**Checksum:**

**Date:**
6. Interfaces for the NC Controller and Feedback

6.1 Controller Inputs, Signal and Analogue Outputs, Bb Contact

---

### 6. Interfaces for the NC Controller and Feedback

#### 6.1 Controller Inputs, Signal and Analogue Outputs, Bb Contact

**Figure 106: Function overview of controller inputs, signal and analogue outputs**

<table>
<thead>
<tr>
<th>POS 1</th>
<th>POS 2</th>
<th>selected spindle position</th>
<th>parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>no position</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>position 1</td>
<td>A08</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>position 2</td>
<td>A09</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>position 3</td>
<td>A10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>control inputs</th>
<th>PAR 1</th>
<th>PAR 2</th>
<th>active parameter record</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>P</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Q</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>R</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>S</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>control inputs</th>
<th>control inputs</th>
<th>max. spindle speed</th>
<th>stored in parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIMIT 1</td>
<td>0</td>
<td>0</td>
<td>none</td>
</tr>
<tr>
<td>LIMIT 2</td>
<td>1</td>
<td>0</td>
<td>LIMIT 1</td>
</tr>
<tr>
<td>LIMIT 3</td>
<td>0</td>
<td>1</td>
<td>LIMIT 2</td>
</tr>
<tr>
<td>LIMIT 4</td>
<td>1</td>
<td>0</td>
<td>LIMIT 3</td>
</tr>
<tr>
<td>LIMIT 5</td>
<td>0</td>
<td>1</td>
<td>LIMIT 4</td>
</tr>
<tr>
<td>LIMIT 6</td>
<td>1</td>
<td>0</td>
<td>LIMIT 5</td>
</tr>
<tr>
<td>LIMIT 7</td>
<td>1</td>
<td>1</td>
<td>LIMIT 6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>control inputs</th>
<th>control inputs</th>
<th>acknowledged, from gearbox (motor)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPEED 1</td>
<td>0</td>
<td>gear st. 2 (motor 2) in gear-tooth eng.</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>gear st. 1 (motor 1) in gear-tooth eng.</td>
</tr>
<tr>
<td>0.1</td>
<td>0.1</td>
<td>error message GEAR BOX (display)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>signal outputs</th>
<th>speed change</th>
<th>Affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPEED 1</td>
<td>0</td>
<td>gear stage 2 engaged or motor 2 is switched on</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>gear stage 1 engaged or motor 1 is switched on</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>X2 Control inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>X2 Control inputs</th>
<th>X2 Control inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>E-STOP (RAC only)</td>
</tr>
<tr>
<td>1</td>
<td>RF</td>
</tr>
<tr>
<td>0</td>
<td>RUN</td>
</tr>
<tr>
<td>1</td>
<td>POS 1</td>
</tr>
<tr>
<td>0</td>
<td>POS 2</td>
</tr>
<tr>
<td>1</td>
<td>MD-RED</td>
</tr>
<tr>
<td>0</td>
<td>OSCILATE</td>
</tr>
<tr>
<td>1</td>
<td>PAR 1</td>
</tr>
<tr>
<td>0</td>
<td>PAR 2</td>
</tr>
<tr>
<td>1</td>
<td>LIMIT 1</td>
</tr>
<tr>
<td>0</td>
<td>LIMIT 2</td>
</tr>
<tr>
<td>1</td>
<td>LIMIT 3</td>
</tr>
<tr>
<td>0</td>
<td>LIMIT 4</td>
</tr>
<tr>
<td>1</td>
<td>LIMIT 5</td>
</tr>
<tr>
<td>0</td>
<td>LIMIT 6</td>
</tr>
<tr>
<td>1</td>
<td>LIMIT 7</td>
</tr>
<tr>
<td>0</td>
<td>MUX</td>
</tr>
<tr>
<td>1</td>
<td>MAX</td>
</tr>
<tr>
<td>0</td>
<td>MPH</td>
</tr>
<tr>
<td>1</td>
<td>SPD</td>
</tr>
<tr>
<td>0</td>
<td>EXT</td>
</tr>
<tr>
<td>1</td>
<td>POS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signal outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 = drive ready</td>
</tr>
<tr>
<td>1 = N_{out} = N_{cmd}</td>
</tr>
<tr>
<td>1 = N_{out} &lt; N_{min}</td>
</tr>
<tr>
<td>1 = position reached</td>
</tr>
<tr>
<td>1 = drive has 90% of load</td>
</tr>
<tr>
<td>1 = temperature pre-warning</td>
</tr>
<tr>
<td>1 = speed limit exceeded</td>
</tr>
<tr>
<td>1 = gearbox control</td>
</tr>
<tr>
<td>1 = motor changeover</td>
</tr>
<tr>
<td>1 = output signal threshold reached</td>
</tr>
<tr>
<td>1 = enable signal for SLAVE drive</td>
</tr>
<tr>
<td>1 = spindle not turning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analogue outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 = OVM</td>
</tr>
<tr>
<td>21 = N</td>
</tr>
<tr>
<td>20 = M</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supply voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 V internal</td>
</tr>
<tr>
<td>+ 24 V from controller</td>
</tr>
<tr>
<td>0 V from controller</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>X15 with RAC X11 with KDA/TDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 / 1</td>
</tr>
<tr>
<td>6 / 2</td>
</tr>
</tbody>
</table>

---
6. Interfaces for the NC controller and feedback

The inputs and outputs are electrically isolated. If no +24V/0V are available from the controller to supply the outputs, link terminals 18 and 19 and terminals 1 and 2.
6. Interfaces for the NC controller and feedback

6.2 Analogue Speed Command Value •10V (option)

Analogue inputs E1/E2 are configured as differential inputs. Potentiometers P2 and P2 compensate drive when 0 V is applied to the respective analogue input. They are located to the right and left of plug terminal strip X4.

Identification in the "speed command value" type code field is: A
6. Interfaces for the NC controller and feedback

6.3 Digital Speed Command Value (option)

The inputs are electrically isolated. If no +24V/0 V are available from the controller to drive the inputs, link terminals 18 and 21.

Terminal 19 is then 1 (high) and terminal 18 is 0 (low). The controller must then generate the bit pattern for the position command value via potential-free contacts.

If the internal \(\pm 15V\) is used, the total loading must not exceed 150 mA. A digital position input above \(\pm 15V\) is also not possible!
6. Interfaces for the NC controller and feedback

6.4 SERCOS Interface (option)

Identification in "speed command value" type code field: L
6. Interfaces for the NC controller and feedback

6.5 Digital Position Command Value (option)

![Diagram](image)

The inputs are electrically isolated. If no +24 V/0V are available from the controller to drive the inputs, link terminals 18 and 21.

Terminal 19 is then 1 (high) and terminal 18 is 0 (low). The controller must then generate the bit pattern for the position command value via potential-free contacts.

Identification in "additional interfaces" type code field: D

If the internal ±15 V is used, the total loading must not exceed 150 mA. A digital position input above ±15 V is also not possible!
6.6 Incremental Encoder Output (option)

The control unit supplies incremental encoder-compatible signals to the controller for displacement measurement. For this option, the motor must be fitted with high-resolution feedback (feedback type 3 or 4).

The outputs are electrically isolated. The controller must provide the +5V supply.

Identification in "additional interfaces" type code field: I
6.7 Serial Interface (option)

The serial interface is not potential-free but can be correctly run from any input device (PC or something similar) with an RS 232 C interface.

Identification in "additional interfaces" type code field: S
6. Interfaces for the NC controller and feedback

6.8 Motor Feedback Connection

Plug terminal strip X3 has pins for the high-resolution motor feedback (type 3) as well as for pins for the incremental encoder motor feedback (type 1).
6.9 Additional Encoder Input (option)

The control unit supplies the associated spindle feedback with +5V. The inputs AA, BB and OO are differential inputs.

Plug terminal strip X5 has pins for the Indramat high-resolution spindle feedback as well as for pins for incremental encoders used as spindle feedback (compatible with ROD 420 or ROD 426).

**Only one of the quoted feedback types can be connected!**

Identification in "second encoder input" type code field: P
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8. Abbreviations, Agreements, Type Codes

**RAC**  Main spindle drive controllers with 2AD and 1MB asynchronous motors with regenerative capabilities (see type codes for RAC)

**KDA**  Modular main spindle drive controller for 2AD and 1MB asynchronous motors in cold-running technology (see type codes for KDA)

**TDA**  Modular main spindle drive controller for 2AD and 1MB asynchronous motors (see type codes for TDA)

**AS.**  Programming modules for RAC, KDA and TDA drive controllers (see type codes for AS)

**2AD**  Asynchronous motor, with separate-source blower

**1MB**  Frameless spindle motor, water-cooled

**Bb**  Drive controller "ready" contact

**Bb1**  "Ready" contact on supply module

**E1/E2**  First analogue input of the main spindle controller

**E3/E4**  Second analogue input of the main spindle controller

**L+/L-**  DC bus voltage terminals (DC output)

**J**  Temperature

**rpm**  Speed in rpm

**IGS**  Incremental encoder output interface

**Master**  Master drive (speed-controlled)

**Slave**  Slave drive (speed-controlled)

**L1, L2, L3**  Mains terminals for the RAC controller

**A1, A2, A3**  Motor terminals for the controller

0  low = 0 V

1  high = +24 V

[ ] [ ]  Signal step change

[ ] [ ]  Signal state (any)

**RSK**  Board in RAC, controls mains regeneration

**CDR**  Board in controller, entails micro-processor control unit
8. Abbreviations, Agreements, Type Codes

**ADW**  Interface for analogue speed command value

**PDS**  Interface for digital speed command value

**PDA**  Parameter duplicating adapter

< >  Summand, a part of the total value for the function parameters
### Abbreviations, Agreements, Type Codes

#### Type code fields:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Device abbreviation:</td>
<td>KDA</td>
</tr>
<tr>
<td>2. Series:</td>
<td>3</td>
</tr>
<tr>
<td>3. Version:</td>
<td>2</td>
</tr>
<tr>
<td>4. Rated current:</td>
<td>50 A 050, 100 A 100, 150 A 150</td>
</tr>
<tr>
<td>5. DC supply voltage:</td>
<td>DC 300V: 3</td>
</tr>
<tr>
<td>7. Second encoder input:</td>
<td>without second encoder input O, Second encoder input for spindle feedback or add. motor feedback P, Second encoder input and synchronous input (if AS 35 and speed command value = A) Y</td>
</tr>
<tr>
<td>9. AC supply voltage for mounted blower:</td>
<td>AC 115 V/50…60 Hz U, AC 220 V/50…60 Hz W</td>
</tr>
<tr>
<td>10. Type of cooling:</td>
<td>with mounted blower 1</td>
</tr>
</tbody>
</table>

#### Example:

<table>
<thead>
<tr>
<th>Type code fields</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device abbreviation:</td>
<td>KDA</td>
</tr>
<tr>
<td>Series:</td>
<td>3</td>
</tr>
<tr>
<td>Version:</td>
<td>2</td>
</tr>
<tr>
<td>Rated current:</td>
<td>50 A 050, 100 A 100, 150 A 150</td>
</tr>
<tr>
<td>DC supply voltage:</td>
<td>DC 300V: 3</td>
</tr>
<tr>
<td>Speed command value:</td>
<td>analogue (+/- 10 V) A, digital (16 bit parallel) D, SERCOS interface L</td>
</tr>
<tr>
<td>Second encoder input:</td>
<td>without second encoder input O, Second encoder input for spindle feedback or add. motor feedback P, Second encoder input and synchronous input (if AS 35 and speed command value = A) Y</td>
</tr>
<tr>
<td>Additional interfaces:</td>
<td>without additional interfaces O, Position command value, digital (16 bit parallel) D, Serial interface (RS 232 C) S, Incremental encoder output I</td>
</tr>
<tr>
<td>AC supply voltage for mounted blower:</td>
<td>AC 115 V/50…60 Hz U, AC 220 V/50…60 Hz W</td>
</tr>
<tr>
<td>Type of cooling:</td>
<td>with mounted blower 1</td>
</tr>
</tbody>
</table>

**Figure 116: Type codes for KDA 3**
### Type code fields:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Device abbreviation:</td>
<td>TDA</td>
</tr>
<tr>
<td>2. Series:</td>
<td>1</td>
</tr>
<tr>
<td>3. Version:</td>
<td>1</td>
</tr>
<tr>
<td>4. Rated current:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50 A</td>
</tr>
<tr>
<td></td>
<td>100 A</td>
</tr>
<tr>
<td>5. DC supply voltage:</td>
<td>DC 300V:</td>
</tr>
<tr>
<td>6. Speed command value:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>analogue (+/- 10 V)</td>
</tr>
<tr>
<td></td>
<td>digital (16 bit parallel)</td>
</tr>
<tr>
<td></td>
<td>SERCOS interface</td>
</tr>
<tr>
<td>7. Second encoder input:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>without second encoder input</td>
</tr>
<tr>
<td></td>
<td>Second encoder input for spindle feedback or add. motor feedback</td>
</tr>
<tr>
<td></td>
<td>Second encoder input and synchronous input (if AS 75 and speed command value = A)</td>
</tr>
<tr>
<td>8. Additional interfaces:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>without additional interfaces</td>
</tr>
<tr>
<td></td>
<td>Position command value, digital (16 bit parallel)</td>
</tr>
<tr>
<td></td>
<td>Serial interface (RS 232 C)</td>
</tr>
<tr>
<td></td>
<td>Incremental encoder output</td>
</tr>
</tbody>
</table>

**Example:** TDA 1.1 - 100 - 3 - A00

---

*Figure 117: Type codes for TDA 1*
## 8. Abbreviations, Agreements, Type Codes

### Type code fields:

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Device abbreviation:</td>
<td>RAC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Series:</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Version:</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Rated current:</td>
<td></td>
<td>150 A</td>
<td>200 A</td>
<td>250 A</td>
</tr>
<tr>
<td>5. AC supply voltage:</td>
<td></td>
<td>3 x AC 400V/50 Hz, 3 x AC 460V/60 Hz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Speed command value:</td>
<td></td>
<td>digital (16 bit parallel)</td>
<td>SERCOS interface</td>
<td></td>
</tr>
<tr>
<td>7. Second encoder input:</td>
<td></td>
<td>without second encoder input</td>
<td>Second encoder input for spindle feedback or add. motor feedback</td>
<td></td>
</tr>
<tr>
<td>8. Additional interfaces:</td>
<td></td>
<td>without additional interfaces</td>
<td>Position command value, digital (16 bit parallel)</td>
<td>Serial interface (RS 232 C)</td>
</tr>
<tr>
<td>9. Additional bleeder</td>
<td></td>
<td>without additional bleeder</td>
<td>Additional bleeder (for braking with mains failure)</td>
<td></td>
</tr>
<tr>
<td>10. Type of cooling:</td>
<td></td>
<td>internal blower</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Example:**

```plaintext
RAC 2.2 - 200 - 460 - A00 - W1
```

---

**Figure 118: Type codes for RAC 2**
8. Abbreviations, Agreements, Type Codes

### Type code fields:

<table>
<thead>
<tr>
<th>Field</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Device abbreviation:</td>
<td>RAC</td>
</tr>
<tr>
<td>2. Series:</td>
<td>3</td>
</tr>
<tr>
<td>3. Version:</td>
<td>1</td>
</tr>
<tr>
<td>4. Rated current:</td>
<td>100 A 100</td>
</tr>
<tr>
<td></td>
<td>150 A 150</td>
</tr>
<tr>
<td>5. AC supply voltage for power electronics:</td>
<td>3 x 380V…460V; 50…60 Hz 460</td>
</tr>
<tr>
<td>6. Speed command value:</td>
<td>analogue (+/- 10 V) A</td>
</tr>
<tr>
<td></td>
<td>digital (16 bit parallel) D</td>
</tr>
<tr>
<td></td>
<td>SERCOS interface L</td>
</tr>
<tr>
<td>7. Second encoder input:</td>
<td>without Second encoder input O</td>
</tr>
<tr>
<td></td>
<td>Second encoder input for spindle feedback or add. motor feedback P</td>
</tr>
<tr>
<td></td>
<td>Second encoder input and synchronous input (if AS 65 and speed command value = A) Y</td>
</tr>
<tr>
<td>8. Additional interfaces:</td>
<td>without additional interfaces O</td>
</tr>
<tr>
<td></td>
<td>Position command value, digital (16 bit parallel) D</td>
</tr>
<tr>
<td></td>
<td>Serial interface (RS 232 C) S</td>
</tr>
<tr>
<td></td>
<td>Incremental encoder output I</td>
</tr>
<tr>
<td>9. Additional bleeder:</td>
<td>without additional bleeder W</td>
</tr>
<tr>
<td></td>
<td>Additional bleeder (for braking with mains failure) Z</td>
</tr>
<tr>
<td>10. Type of cooling:</td>
<td>internal blower 1</td>
</tr>
<tr>
<td>11. AC supply voltage for control electronics:</td>
<td>AC 220 V/ 50…60 Hz 220</td>
</tr>
</tbody>
</table>

*Figure 119: Type codes for RAC 3*
8. Abbreviations, Agreements, Type Codes

Type code fields:

1. Device abbreviation: RAC
2. Series: 4
3. Version: 1
4. Rated current:
   - 300 A 300
   - 400 A 400
5. AC supply voltage:
   - 3 x AC 400V/50Hz, 3 x AC 460V/60Hz 460
6. Speed command value:
   - analogue (+/- 10 V) A
   - digital (16 bit parallel) D
   - SERCOS interface L
7. Second encoder input:
   - without Second encoder input O
   - Second encoder input for spindle feedback or add. motor feedback P
   - Second encoder input and synchronous input (Speed command value = A) Y
8. Additional interfaces:
   - without additional interfaces O
   - Position command value, digital (16 bit parallel) D
   - Serial interface (RS 232 C) S
   - Incremental encoder output I
9. Additional bleeder:
   - without additional bleeder W
10. Type of cooling:
    - internal blower 1

Example: RAC 4.1 - 400 - 460 - A00 - W1

Figure 120: Type codes for RAC 4
### 8. Abbreviations, Agreements, Type Codes

#### Type code fields:

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Device abbreviation:</td>
<td>AS</td>
<td></td>
</tr>
<tr>
<td>2. Differentiation by controller</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KDA 3.2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>RAC 2.2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>RAC 3.1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>TDA 1.1</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>RAC 4.1</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>3. Software i.d.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard main spindle drive controller</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>(all combinations not listed below)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Servo drive (always with incremental enc. output)</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Main spindle drive with incremental enc. output</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Main spindle drive with SERCOS interface</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Main spindle drive with add. functions</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>4. Differentiation by motor feedback</td>
<td></td>
<td>0 and 1</td>
</tr>
<tr>
<td>High-resolution motor feedback</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. I.D. no. motor-controller-combination</td>
<td></td>
<td>e.g., 04</td>
</tr>
<tr>
<td>Fixed and documented by INDRAMAT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Customer specification</td>
<td></td>
<td>000</td>
</tr>
</tbody>
</table>

**Example:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS 53</td>
<td></td>
</tr>
<tr>
<td>/ 004</td>
<td></td>
</tr>
<tr>
<td>- 001</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 121: Type codes for AS*
9. Supplementary documentation

Selection (details, order)

Project planning (construction, mounting, installing the machine)

Controller

Project planning
KDA 3.2, doc. no. 209-0042-4110-00
TDA 1.1 - in preparation
RAC 2.2, doc. no. 9.558.084.4-01
RAC 3.1, doc. no. 9.558.085.4-01
RAC 4.1 - in preparation

Electrical connections

Project planning
- in preparation

Asynchronous motor

Project planning
2AD 100, doc. no. 9.567.009.4-01
2AD 101, doc. no. 9.567.018.4-00
2AD 132, doc. no. 9.567.010.4-01
2AD 160, doc. no. 9.567.011.4-01
2AD 180, doc. no. 9.567.012.4-01
2AD 200 - in preparation
2AD 225 - in preparation

Main spindle drive applications
(commissioning, using, diagnosing)

AC main spindle drives with controlled asynchronous motor or frameless spindle motor

Applications
doc. no. 209-0041-4109-00

Figure 122: Supplementary documentation
9. Supplementary documentation

AC main spindle drive with controlled frameless spindle motor 1MB
Selection data
doc. no. 9.567.012.4-00

AC main spindle drive with 2AD controlled asynchronous motor and 2K changeover planetary gearbox
Selection data
doc. no. 9.567.022.4-00

Frameless spindle motor
Project planning
1MB 160, doc. no. 9.576.014.4-00
1MB 200, doc. no. 9.576.016.4-00
1MB 240/241, doc. no. 9.576.015.4-00
1MB 310/312, doc. no. 9.576.008.4-00
1MB 375, doc. no. 9.576.007.4-00

Mounting guidelines
Stator, doc. no. 9.600.063.4-00
Rotor, doc. no. 9.600.062.4-00

Supplementary documentation
- High-resolution main spindle position encoder
  Applications
doc. no. 9.552.247.4-02
- Mounting guidelines
doc. no. 9.600.060.4-01
- Incremental enc. output IGS
doc. no. 9.568.015.4-02
- High-resolution encoder junction HGV
doc. no. 9.568.010.4-00

Main spindle drive applications
(commissioning, using, diagnosing)

Project planning
(construction, mounting, installing the machine)