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Automatic setting of motor control

.Automatic setting of motor control

. General information

For operating motors, it is necessary to collect the motor data in order to derive the values of the motor parameters (resistance values, inductances, ...) and to determine the motor control parameters (flux controller, voltage controller, current controller, ...).

Depending on the manufacturer and type of the motor to be controlled, the values for motor parameters and motor control parameters are made available to the drive controller in different ways.

.Rexroth motors

For Rexroth motors, the values for the motor and motor control parameters are specified, optimized and made available by the manufacturer. The automatic setting of the motor control parameters by the drive firmware is not required and not allowed for Rexroth motors!

.Third-party motors

For motors of other manufacturers (third-party motors), the motor data are usually made available via the motor type plate and a data sheet. The motor and motor control parameters have to be determined on the basis of these data.

.Relevance for the user

.Use case third-party motor

For third-party motors, the drive firmware possesses commands that generate the values for the motor and motor control parameters, depending on the motor data and the functional principle of the third-party motor. This chapter shows how to use these commands and their operating principle.

.Application-related information for project planning

The commands for determining the motor and motor control parameters of third-party motors and for setting motor control can only be used if the required manufacturer-side motor data are known.

For the project planning and commissioning of a third-party motor, the form or from the chapter "Third-party motors at ctrlX DRIVE controllers" has to be available, filled out completely by the motor manufacturer!

.Commissioning

For additional information on the commissioning of third-party motors, please see the following link: Commission 3rd party motors with ctrlX DRIVE

.Basis: Motor type plate

Based on the manual input of the **type plate data**, the controller can determine the parameter values for motor operation via the "Calculate motor data" command. Due to largely consistent type plate data, this is the usual case of asynchronous motors (due to other project planning data, however, the form filled out completely by the motor manufacturer has to be available):

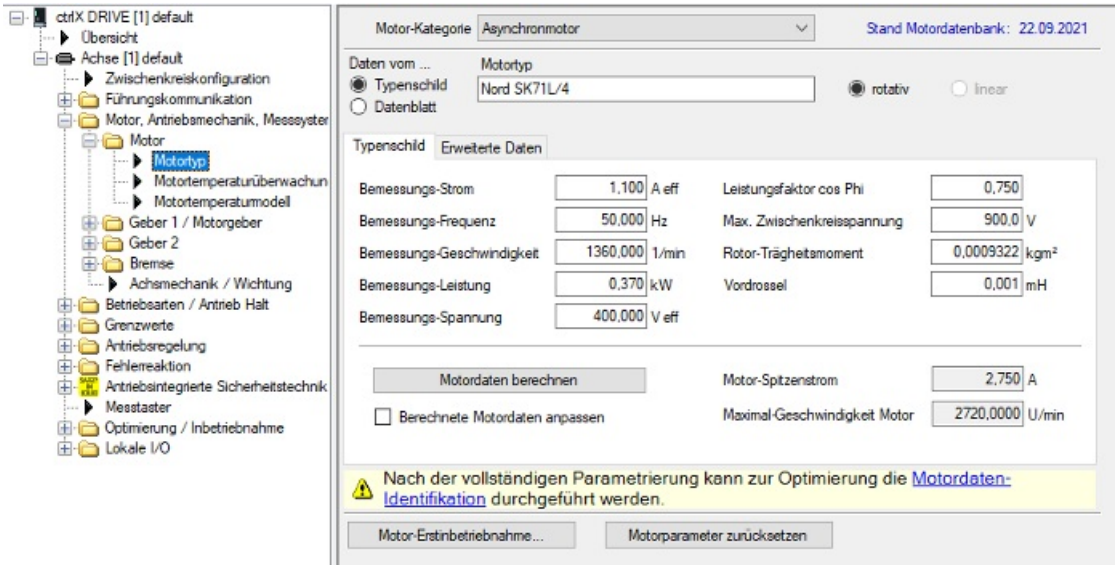

Fig. 302: ctrlX DRIVE Engineering motor type dialog, example of an asynchronous motor

.Based on: Motor data sheet

Based on the manual input of the data from a motor data sheet, or the form for manufacturer-side motor data filled out completely by the manufacturer, the controller can also determine the parameter values for motor operation via the "Calculate motor control parameters" command:

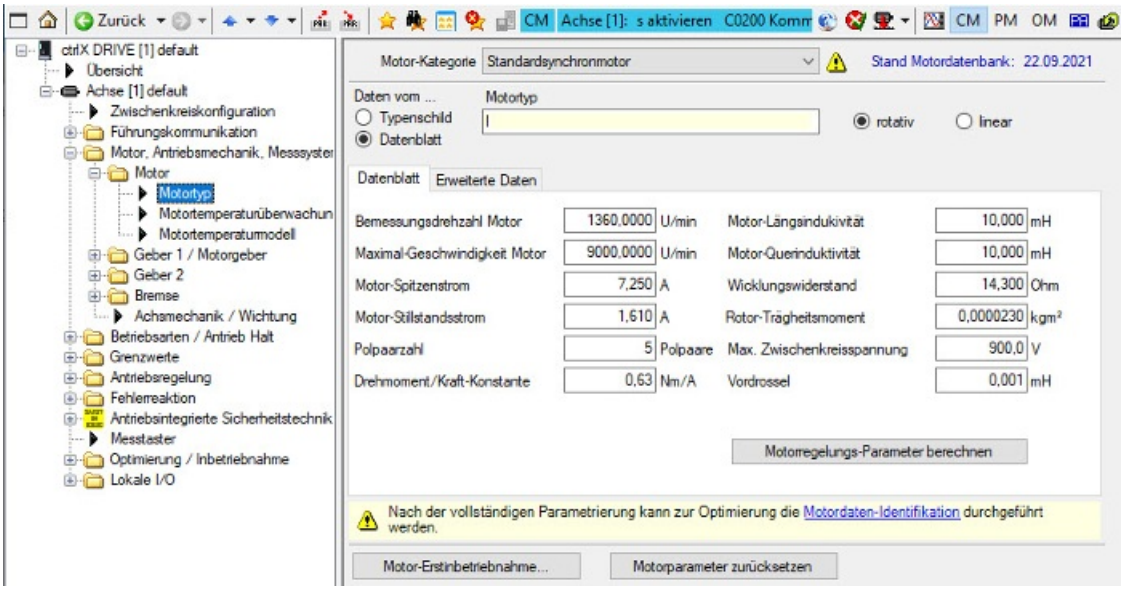

Fig. 303: ctrlX DRIVE Engineering motor type dialog, example of a standard synchronous motor

.Adjustment, optimization

If necessary, the controller should perform an optimizing adjustment to the connected motor:

- If the parameter values for motor operation were determined by "Calculate motor data" based on type plate data.
- If motor operation is not satisfactory after "Calculate motor control parameters" was executed:

The calculated values are automatically adjusted by command start, through the motor data identification method with current, stepwise first without, and then, if necessary, with motor shaft motion:

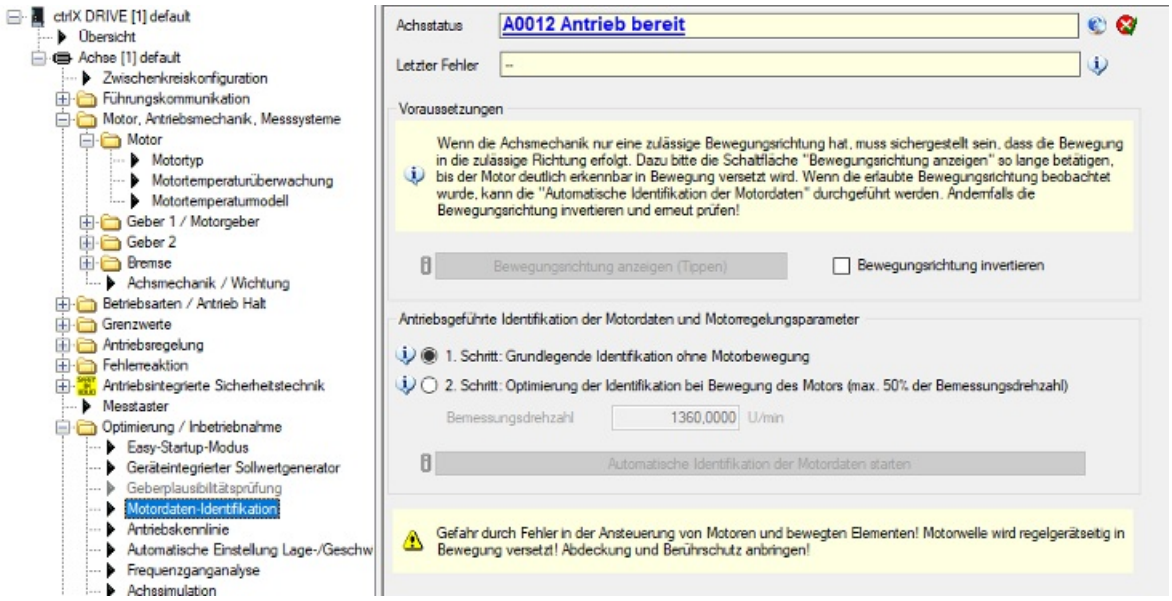

Fig. 304: ctrlX DRIVE Engineering dialog for motor data identification, selecting the drive-controlled identification, step 1

For motor data identification, the drive has to be ready for power output (A0012). The duration of the commands is a matter of minutes, noise may develop in the motor due to the current supplied for test purposes.

- Both identification steps should always be carried out! The "Identification with motion" does not depend on the presence of an evaluated motor encoder. Therefore, identifying the motor data is also possible for sensorless motors.
- To operate the motor in FOC control with encoder, the motor encoder also has to be parameterized and commissioned. The interaction of the motor with the motor encoder and its correct parameterization can be checked in the "Encoder plausibility check" dialog. In addition, during commissioning of synchronous third-party motors, the commutation offset and/or the method for determining the commutation offset have/has to be set.

See also ↘ Position measuring system evaluation and ↘ “Supported motors and motor encoders”.

See also chapter ↘ “Commutation setting” .

.Additional information and details

In particular for motors that are not from the Bosch Rexroth product range (so-called "third-party motors"), the drive firmware provides commands for calculating the motor and motor control parameters in order to support and simplify their commissioning procedure in the best possible way:

- C3200 Command Calculate motor data: Drive-internal calculation of the values for the motor and motor control parameters from the **type plate data** (type plate data of rotary motors).
- "C3600 Command Motor data identification": Drive-internal adjustment of the values for the motor data parameters by supplying current for test purposes to the motor in standstill and, if necessary, also with motor motion. Subsequently, the "C4600 Command Calculate motor control parameters" command is internally executed.
- "C4600 Command Calculate motor control parameters": Drive-internal calculation of the motor control parameters from the motor data available in the controller. These data may have been input based on a motor data sheet or generated by motor data identification (command C3600).

Rexroth motors offer the easiest commissioning:

- For motors **with motor encoder data memory**:
  → Parameters loaded automatically when drive is switched on, see "Default settings in the motor encoder data memory"
- For motors **without motor encoder data memory**:
  - Parameters loaded from the motor database (DriveBase) via the ctrlX DRIVE Engineering commissioning tool
    - or -
  - Individual parameters manually written via the Engineering Port or the master communication interface using a motor parameter list provided by the manufacturer.

The figure below illustrates the options for determining the motor and motor control parameters for third party motors and Rexroth motors without motor encoder data memory:

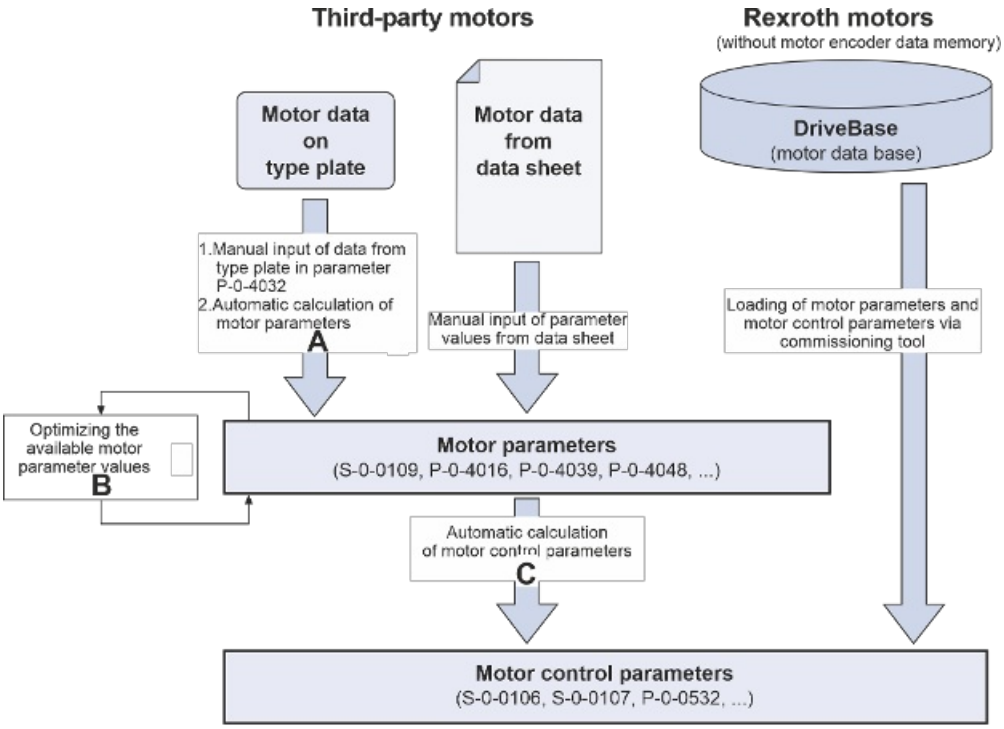

Fig. 305: Overview of options for determining motor and motor control parameters for motors without motor encoder

data memory

In addition to determining the motor and motor control parameters, other data of motor encoder, temperature sensor, motor temperature model, motor holding brake and position and velocity controllers might be required.

The table below contains an overview of the motor parameters for synchronous and asynchronous motors:

. Overview of motor parameters for synchronous and asynchronous motors

Motor parameters	
Synchronous motor	**Asynchronous motor**
P-0-4014, Type of construction of motor	P-0-4014, Type of construction of motor
S-0-0109, Motor peak current	S-0-0109, Motor peak current
S-0-0111, Motor current at standstill	S-0-0111, Motor current at standstill
S-0-0113, Maximum motor velocity	S-0-0113, Maximum motor velocity
S-0-0533, Nominal torque/force of motor	S-0-0533, Nominal torque/force of motor
S-0-0534, Maximum torque/force of motor	S-0-0534, Maximum torque/force of motor
P-0-0018, Number of pole pairs/pole pair distance	P-0-0018, Number of pole pairs/pole pair distance
P-0-0051, Torque/force constant	P-0-0051, Torque/force constant
P-0-0448, Temperature-depend. torque/force coefficient	P-0-0510, Rotor inertia
P-0-0449, Speed-dependent torque/force coefficient	P-0-0530, Slip increase
P-0-0472, Motor saturation current	P-0-0600, Rated slip frequency

Motor parameters	
Synchronous motor	**Asynchronous motor**
P-0-0510, Rotor inertia	P-0-0853, Max. DC bus voltage, motor
P-0-0853, Max. DC bus voltage, motor	P-0-4004, Magnetizing current
P-0-4048, Stator resistance	P-0-4036, Rated motor speed
P-0-4013, Current limit value of demagnetization	P-0-4039, Stator leakage inductance
P-0-4015, Motor voltage constant	P-0-4040, Rotor leakage inductance
P-0-4016, Direct-axis inductance of motor	P-0-4041, Motor magnetizing inductance
P-0-4017, Quadrature-axis inductance of motor	P-0-4042, Characteristic of motor magnetizing inductance
P-0-4002, Charact. of quadrature-axis induct. of motor, inductances	P-0-4043, Rotor time constant
P-0-4003, Charact. of quadrature-axis inductance of motor, currents	P-0-4048, Stator resistance
P-0-4005, Flux-generating current, limit value	
P-0-4036, Rated motor speed	
P-0-3940, Motor torque/force at nominal current when using reluctance	
P-0-3941, Motor torque/force at maximum current when using reluctance	
P-0-3942, Reluctance angle at nominal motor current	

Motor parameters	
Synchronous motor	Asynchronous motor
P-0-3943, Reluctance angle at maximum motor current	

The following tables contain an overview of the motor control parameters for synchronous and asynchronous motors that are used for field-oriented current control with motor encoder, the sensorless, closed-loop vector-controlled and open-loop voltage-controlled, motor operation:

. Overview of motor control parameters for synchronous and asynchronous motors and field-oriented current control (FOC)

Motor control parameters for field-oriented current control (FOC) with motor encoder	
Synchronous motor	Asynchronous motor
P-0-0045, Motor operation configuration	
P-0-0062, Velocity-dependent PWM switching: Switching velocity	
P-0-3945, Motor control configuration	
S-0-0100, Velocity controller proportional gain	
S-0-0101, Velocity controller integral action time	
P-0-0004, Speed controller smoothing time constant	
S-0-0106, Current controller proportional gain 1	
S-0-0107, Current controller integral action time 1	
P-0-0533, Voltage controller proportional gain	
P-0-0534, Voltage controller integral action time	

Motor control parameters for field-oriented current control (FOC) with motor encoder	
Synchronous motor	**Asynchronous motor**
P-0-0535, Motor voltage at no load	
P-0-0536, Maximum motor voltage	
P-0-0516, Commutation speed smoothing time constant	P-0-0528, Flux controller proportional gain
	P-0-0529, Scaling of stall current limit
	P-0-0530, Slip increase
	P-0-0532, Premagnetization factor

. Overview of motor control parameters for synchronous and asynchronous motors for sensorless motor operation (SVC)

Motor control parameters for closed-loop vector-controlled, sensorless motor operation (SVC)	
Synchronous motor	**Asynchronous motor**
P-0-0045, Motor operation configuration	
P-0-3945, Motor control configuration	
S-0-0100, Velocity controller proportional gain	
S-0-0101, Velocity controller integral action time	
P-0-0004, Speed controller smoothing time constant	
S-0-0106, Current controller proportional gain 1	
S-0-0107, Current controller integral action time 1	

Motor control parameters for closed-loop vector-controlled, sensorless motor operation (SVC)	
Synchronous motor	Asynchronous motor
P-0-0592.0.33, SVC: Motor inductance adjustment factor	
P-0-0592.0.34, SVC: EMF adjustment factor SVC: EMF adjustment factor	
P-0-0592.0.43, SVC: Low velocity range, switching vel. adjustment factor	
P-0-0592.0.44, SVC: Load-dependent standstill current increase, gain	
P-0-0592.0.52, SVC: Velocity controller P-gain adjustment factor	
P-0-0592.0.53, SVC: Velocity ctrler integral action time adjustment factor	
P-0-0592.0.54, SVC: Current at standstill	
P-0-0592.0.55, SVC: Low velocity range, maximum frequency slope	
P-0-0592.0.56, SVC: Heavy starting, gain	

. Overview of motor control parameters for open-loop voltage-controlled operation (V/Hz [U/f]), for asynchronous motors only

Motor control parameters for open-loop voltage-controlled, sensorless motor operation (V/Hz [U/f])	
Synchronous motor	Asynchronous motor
	P-0-0568, Voltage boost
	P-0-0569, Maximum stator frequency slope
	P-0-0570, Stall protection controller proportional gain
	P-0-0571, Stall protection controller integral action time

Motor control parameters for open-loop voltage-controlled, sensorless motor operation (V/Hz [U/f])	
Synchronous motor	Asynchronous motor
	P-0-0572, Slip compensation factor
	P-0-0573, IxR boost factor
	P-0-0574, Oscillation damping factor
	P-0-0575, Search mode: Search current factor
	P-0-0576, Search mode: Finding point slip factor
	P-0-0577, Square characteristic curve: Lowering factor
	P-0-0578, Current for deceleration, absolute value
	P-0-0579, Current for deceleration, time period
	P-0-0614, V/Hz (U/f): User-defined characteristics, frequencies
	P-0-0615, V/Hz (U/f): User-defined characteristics, voltages

For rotary motors it is possible via "C3200 Command Calculate motor data" to calculate the values for motor parameters from the type plate data and then the values of the motor control parameters. The use of C3200 first requires manual input of the motor data from the type plate of the motor in "P-0-4032, Motor type plate data".

See ↘ “Commissioning” or description of parameter "P-0-4032, Motor type plate data"

The C3200 command cannot be used for linear motors but for rotary motors only! It can only be activated in the "PM" communication phase!

The figure below illustrates the scope of functions of the C3200 command:

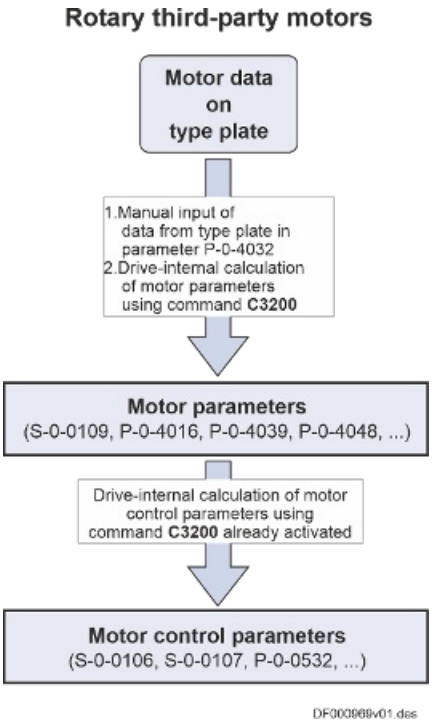

Fig. 306: Procedure and results of "C3200 Command Calculate motor data"

The motor type plate alone does not contain the complete information required for safe operation of the third-party motor!

All required data are part of the form of manufacturer-side motor data which has to be available in completed form! The additional data, however, are not required for executing the C3200 command.

By activating the C3200 (P-0-4033) command, the following parameter values are calculated based on the type plate data of the motor entered in list parameter P-0-4032:

- Motor parameters
  - Motor parameters, general
  - Specific motor parameters for asynchronous motors
  - Specific motor parameters for synchronous motors
- Motor control parameters
  - Motor control parameters for open-loop voltage-controlled operation (V/Hz [U/f]) of sensorless asynchronous motors
  - Motor control parameters for field-oriented current control (FOC) of synchronous and asynchronous motors
  - Motor control parameters for closed-loop vector-controlled operation (SVC) of sensorless synchronous and asynchronous motors

- The inputs in P-0-4032 are irrelevant unless the C3200 command has been started!
- When the C3200 command was processed without error, operational values of the motor and motor control parameters for the connected motor are already available, provided the type plate data were complete and has been input correctly.
- See also chapter "Third-party motors at ctrlX Drive controllers" under "Determining the parameter values" and "Commissioning"!

Using the "C3600 Command Motor data identification", it is possible to identify the motor and motor control parameters in a drive-controlled way using appropriate start values, and to adjust merely calculated values to the specific motor.

The C3600 command can only be activated in the operating mode "Ab", the drive has to be ready for power output!

The figure below illustrates the scope of functions of the C3600 command:

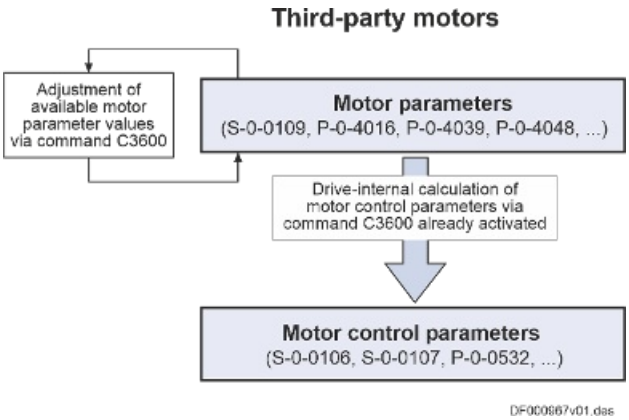

Fig. 307: Procedure and results of "C3600 Command Motor data identification"

To execute the C3600 command, the following requirements must have been fulfilled:

- manual input of type plate data of rotary motors in "P-0-4032, Motor type plate data", and subsequent execution of "C3200 Command Calculate motor data"
  - or -
- manual input of motor data of synchronous or asynchronous motors according to manufacturer's specifications (completed form) into the motor parameters

This provides appropriate start values to start the drive-controlled motor data identification.

In ready-for-power-output state ("Ab"), test signals are transmitted to the motor when executing command C3600. Thereby, the motor parameters are adjusted and optimized for the specific motor, the motor control parameters are recalculated and saved:

- Motor control parameters for open-loop voltage-controlled operation (V/Hz [U/f]) of sensorless asynchronous motors
- Motor control parameters for field-oriented current control (FOC) of synchronous and asynchronous motors
- Motor control parameters for closed-loop vector-controlled operation (SVC) of sensorless synchronous and asynchronous motors
- Velocity control parameters if at least one of the values of "P-0-0510, Rotor inertia" or "P-0-4010, Load inertia" is

unequal to zero:

- Velocity controller proportional gain (S-0-0100)
- Velocity controller integral action time (S-0-0101)

The procedure of the motor data identification command C3600 can be set in "P-0-0601, Configuration motor data identification":

- Motor remains in standstill
- Motor is set in motion (not for linear motors)
  The direction of motion of the motor for command execution can be checked and set in advance:
  - In the dialog of the ctrlX DRIVE Engineering commissioning tool, see ↘ “Commissioning”, using buttons - or -
  - Making a selection in "P-0-0582, Commissioning commands C3600 and C3700 configuration"

  In the case of identification with motion, the rotor inertia is approximately calculated and the value then displayed in "P-0-0510, Rotor inertia" (if the motor has already been connected to the mechanics, the value corresponds to the total inertia).
  If the inertia value is known, the velocity controller parameters S-0-0100 and S-0-0101 are automatically preset to operational start values. The "Automatic control loop setting" command, see ctrlX DRIVE Engineering dialog under "Optimization/commissioning", allows the inertia and velocity controller parameters to be determined more precisely!
  Particularly for synchronous motors and identification with motion, the value of "P-0-0051, Torque/force constant" and of "P-0-4015, Motor voltage constant" is determined.
  Any holding brake which may be present is controlled by the controller in a suitable way during execution of the command.

- When the command C3600 was processed without error, operational values of the motor and motor control parameters for the connected motor are available.
- If the command execution is aborted during the measurement, all motor and motor control parameters remain unchanged.

For synchronous and asynchronous motors, it is possible via C4600 to have the motor control parameters drive-internally calculated, directly from the motor parameters.

The C4600 command can only be activated in the operating mode (OM)! → Communication phase P4 ("bb" or "Ab")

The figure below illustrates the scope of functions of the C4600 command:

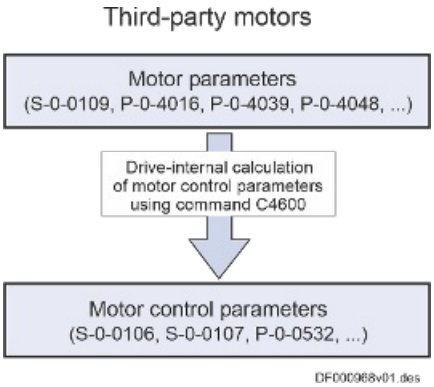

Fig. 308: Procedure and results of "C4600 Command Calculate motor control parameters"

To execute the C4600 command, the following requirements must have been fulfilled:

- **Third-party motors** require manual input of the motor data in the motor data parameters. This is supported by the motor type dialog of the ctrlX DRIVE Engineering tool, see above, under ↘ “Commissioning”.
- The values of the connected third-party motor, provided by the filled-out “Form for manufacturer-side motor data", have to be converted for input in the motor type dialog fields, if necessary.

- The C4600 command has been integrated in the commands "C3200, Command Calculate motor data" and "C3600, Command Motor data identification". Subsequently, it is not necessary any more to start C4600!
- When the command C4600 was processed without error, operational values of the motor and motor control parameters for the connected motor are available.
- If the command execution is aborted during the measurement, all motor and motor control parameters remain unchanged.

.Parameters and diagnostics involved

.Parameters involved

See

- ↘ Further information
- ↘ Further information
- ↘ Further information
- ↘ Overview of motor control parameters for open-loop voltage-controlled operation (V/Hz [U/f]), for asynchronous motors only

- P-0-4033, C3200 Command Calculate motor data
- P-0-0565, C3600 Command Motor data identification
- P-0-0566, C4600 Command Calculate motor control parameters

.Diagnostics involved

C3200 Command Calculate motor data

C3202 Incorrect input for voltage

C3203 Incorrect input for frequency

C3204 Incorrect input for speed

C3205 Incorrect input for power factor

C3206 Incorrect input for power

C3207 Type plate list incomplete

C3208 Error when writing parameters -> P-0-0567

C3600 Command Motor data identification

C3601 Motor not or not correctly connected

C3602 Determined values invalid

C3603 Device current limit too low

C3604 Error when calculating the motor parameters -> P-0-0567

C3605 Motor turning

C3606 Type of construction of motor not allowed

C3607 Motor revolution/motion impeded

C3611 Test velocity not reached

C3612 Command execution impossible

C3613 Error during command execution

C3614 Current ctrler oscillates during measurement w. rotor motion

C3615 Error during initialization of motor control

C3616 Overcurrent in power section

C3617 Overvoltage in power section

C4600 Command Calculate motor control parameters

C4601 Error when writing parameters (->P-0-0567)