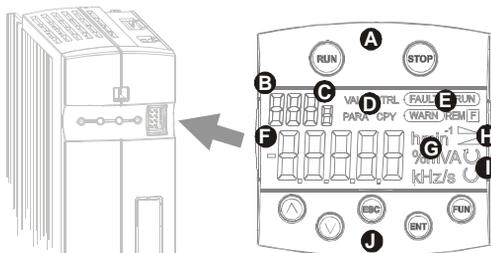


6 Operating unit KP500

The parameterization, parameter display and control of the frequency inverter can be done via the optional operating unit KP500.

The operating unit is not absolutely necessary for the operation of the frequency inverter and can added on if necessary.



Keys

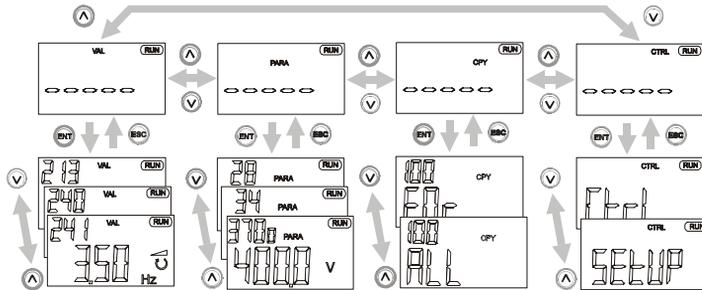
A	RUN	Start of the drive mechanism and change to the CTRL menu. Pressing the RUN key branches to the motor potentiometer function.
	STOP	Change to the CTRL menu and stop of the drive mechanism. Acknowledge fault.
J	▲ ▼	Navigation in the menu structure and selection of parameters. Enlarge or reduce parameter values.
	ENT	Call parameters or change within the menu structure. Confirmation of the selection function or the parameter.
	ESC	Quitting parameters or return within the menu structure. cancellation of the function or reset of the parameter value.
	FUN	Switch-over of the key function and access to special functions.

Display

E	Three-digit 7-segment display to show the parameter number	
C	Single-digit 7-segment display for the active data set, direction of rotation etc.	
D	Display of the selected menu branch:	
	VAL	Display actual values
	PARA	Parameter selection and editing of the parameter values
	CTRL	Selection of functions which can be used via the operating unit: SETUP Guided commissioning Ctrl Motorpoti and jog function
	CPY	Copy function of the parameters via the operating unit: ALL All the parameter values are copied FOR Memory in the operating unit is formatted or deleted
E	Status and operating messages:	
	WARN	Warning about a critical operating behavior
	FAULT	Fault switch-off with the matching message
	RUN	Flashing signalizes readiness for operation Lighting signalizes operation and release of the power part
	REM	Active remote control via interface connection
	F	Function switch-over with the FUN key
F	Five-digit 7-segment display for parameter value and sign	
G	Phys. unit for the parameter value displayed	
H	Active acceleration or deceleration ramp	
I	Current direction of rotation of the drive mechanism	

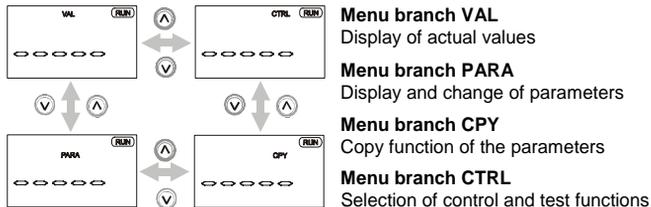
6.1 Menu structure

The menu structure is arranged via the operating unit according to the graphic overview. The PC program structures the functions and parameters functionally on various levels. The complete information is stored in the software and enables flexible use of the options for parameterization and control of the frequency inverters.



6.2 Main menu (MENU)

The various parameters and information of the frequency inverters can be displayed with the help of the operating unit. The menu structure thematically groups the various functions and parameters in four menu branches. Within the menu structure, you change to the main menu by pressing the ESC key for a long time or pressing it repeatedly.



You select the required menu branch with the arrow keys. The selected menu branch is shown flashing on the display.

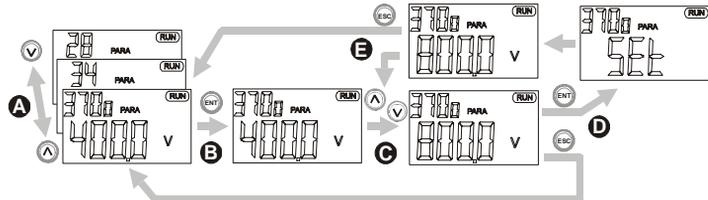
Select the menu branch by pressing the ENT key. The display changes to the first parameter of the first function in the selected menu branch.

Pressing the ESC key leads back to the main menu of the operating unit.

Keys	
▲ + ▼	Navigation in the menu structure and selection of a menu branch
ENT	Transition into the selected menu branch
ESC	Quitting the menu branch and return to the main menu.

6.4 Parameter menu (PARA)

The parameters inquired within the guided commissioning have been selected from known applications and can be supplemented as required by further settings in the PARA menu branch. The operating instructions document the parameters and the basic functions of the software connected with the actual value in question.



A With the help of the arrow keys, select the required number from the parameters displayed in numerical order. Actual value parameters capable of a data set switch are displayed in the current data set with the matching data set number. The seven-segment display shows data set 0 if the actual values in the four data sets are identical.

Keys	
▲ + ▼	Change to the last parameter altered
FUN , ▲	Display of last parameters (highest number)
FUN , ▼	Display of first parameters (lowest number)

B By pressing the ENT key, you select the actual value that is displayed with the current parameter value, unit and active data set. Settings in data set 0 change the parameter values in the four data sets.

C The arrow keys enable adaptation of the parameter value. The value can be changed or an operating mode selected as a function of the parameter. Pressing the arrow keys for a long time increases the value of the change. The change speed is reduced to a tenth of the value difference previously reached after an interruption. If the parameter starts to flash, the increment has been returned to the starting value.

Keys	
▲ + ▼	Parameter is set to the factory setting
FUN , ▲	Parameter is set to the highest setting
FUN , ▼	Parameter is set to the smallest setting
FUN , ENT	Change of the data set with adjustable parameters

D The parameter value is stored by pressing the ENT key. For a short time, the message SEt with the parameter number and the data set is displayed. If you would like to quit the parameter without an alteration, press the ESC key.

Messages	
Err1: EEPrO	Parameter has not been stored
Err2: StOP	Parameter can only be read in operation
Err3: Error	Other kind of error

E After the parameter has been stored, you can change the value again or change to the parameter selection by pressing the ESC key.

6.5 Copy menu (CPY)

The copy function of the operating unit enables a copying of parameter values from the frequency inverter into a non-volatile memory (upload) in the operating unit and storing the values back (download) into a frequency inverter.

The parameterization of recurring applications is facilitated by the copy function. The function archives all the parameters, regardless of the access control and the value range. The memory space available in the operating unit for four files is dynamically scaled to match the scope of the data.

6.5.1 Reading the stored information

If the CPY menu branch is called, information about the data stored in the operating unit must be read out. This process takes a few seconds. For this duration, **init** and a progress display are shown. After the initialization, the function can be selected in the copy menu.

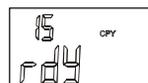
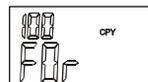


If the existing memory information in the operating unit is not valid, the initialization is stopped with an error message.



In this case, the memory in the operating unit must be formatted. Please take the following steps:

1. Confirm the fault message with the ENT key.
2. With the help of the arrow keys, select the Format function of the memory **FOR** and confirm the selection with the ENT key.
3. For the duration of the formatting, the display shows the sign **FCOPY** and a progress display.
4. The process if complete after a few seconds. The display shows **rdY**. Confirm the display with the ENT key.
5. Now, you can continue with the selection of the copy function.

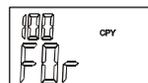


6.5.2 Menu structure

The copy menu CPY is structured in two principal part functions. With the help of the arrow keys, a selection can be made between the memory functionality and deletion of the stored data. The source and the target are to be selected for the process. The three-digit seven-segment display gives information about the free memory space in the non-volatile memory of the operating unit.

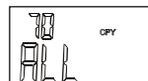
Function – FOR

The FOR function provides the functionality for formatting and deleting the memory in the operating unit. This can be necessary in the first use of a new operating unit.



Function – ALL

All the read and write-capable parameter values are transferred. For a normal copying process, confirm this selection with the ENT key and continue with the selection of the source.



6.5.3 Selection of the source

The ALL part function in the CPY menu branch is to be parameterized specific to the application. With the help of the arrow keys, select the origin of the data for the copy process from the sources available (upload). The seven-segment display shows the free memory space in the operating unit.

Display	Description
Src. 0	The data of the four data sets of the frequency inverter are copied
Src. 1	The data from data set 1 are copied
Src. 2	The data from data set 2 are copied
Src. 3	The data from data set 3 are copied
Src. 4	The data from data set 4 are copied
Src. E	An empty data set for deletion of a file in the operating unit
Src. F1	File 1 is transferred from the memory
Src. F2	File 2 is transferred from the memory
Src. F3	File 3 is transferred from the memory
Src. F4	File 4 is transferred from the memory

6.5.4 Selection of the target

The target for the copy process is likewise to be parameterized specific to the application. The data source is transferred to the selected target (download). The targets available correspond to the logical allocation of the data source selected.

Display	Description
dSt. 0	The four data sets of the frequency inverter are overwritten
dSt. 1	The data are copied into data set 1
dSt. 2	The data are copied into data set 2
dSt. 3	The data are copied into data set 3
dSt. 4	The data are copied into data set 4
dSt. F1	The data are transferred into file 1
dSt. F2	The data are transferred into file 2
dSt. F3	The data are transferred into file 3
dSt. F4	The data are transferred into file 4

6.5.5 Copy process

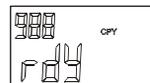


Warning: Transmission of the parameter setting to the frequency inverter demands examination of the individual parameter values. The value range and the parameter setting can differ according to the power range of the frequency inverter. Transmission of parameter values outside the value range leads to an error message.

The display shows **COPY** during the copy process and, as a process display, the number of the parameter currently being copied. Parameters that have no importance for the selected configuration are also copied.



The copy process is complete after about 100 seconds and the display shows **rdY**.



By pressing the ENT key, you change the display to the copy menu and with the help of the ESC key to the selection of the target.

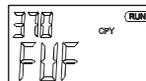
If the ESC key is pressed during the copy process, the copy process is stopped and the data transmitted incomplete. The display shows **Abc** and the number of the last parameter which was copied.



The ENT key leads back to the selection in the copy menu and the ESC key to the selection of the target.

6.5.6 Error messages

The copy function archives all the parameters regardless of the access control and the value range. Some of the parameters are only write-capable if the frequency inverter is not in operation. The controller release (S1IND) may not be activated during the copy process and leads to a stoppage of the data transmission. The display shows **FUF** and the number of the last parameter which was copied. If the controller release is deactivated again, the interrupted copy process is continued.



The data transmission from the selected source to the target is continuously monitored by the copy function. If an error occurs, the copy process is stopped and the message **Err** is displayed with an error key.



Error messages		
Key		Meaning
0	1	Writing error in the memory of the operating unit; repeat the copy function or format the memory in the case of a multiple error.
	2	Reading error in the memory of the operating unit; repeat the copy function or format the memory in the case of a multiple error.
	3	The memory size of the operating unit has been established wrongly; if this error occurs repeatedly, replace the operating unit.
	4	Insufficient memory space, the data are incomplete; delete the incomplete file and data no longer required from the operating unit.
	5	The communication has been disturbed or interrupted; repeat the copy function, delete the incomplete file if necessary.
1	0	Invalid identification of a file in the operating unit; delete faulty file and format memory if necessary.
	2	The memory space of the selected target file is occupied; delete file or use different target file in the operating unit.
	3	The source file to be read in the operating unit is empty; only select files containing sensible data as a source.
	4	Faulty file in the operating unit; delete faulty file and format memory if necessary.
2	0	The memory in the operating unit is not formatted; implement the part function for formatting in the copy menu.
3	0	Reading error of a parameter from the frequency inverter; check connection and repeat reading process.
	1	Writing error of a parameter from the frequency inverter; check connection and repeat reading process.
	2	Unknown parameter type; delete faulty file and format memory if necessary.
4	0	The communication has been disturbed or interrupted; repeat the copy function, delete the incomplete file if necessary.

6.6 Control menu (CTRL)

The control of the frequency inverters can be done with the help of the operating unit. In the CTRL menu branch, various functions facilitating a commissioning and enabling control via the operating unit can be selected.

The control of the frequency inverters via an optional communication module can be parameterized with the help of the parameter *Local/Remote* 412. With the help of the parameter, the possibilities of control that can be available can be selected or limited. The control menu is only partly available as a function of the operating mode selected.

Operating mode	Function
0 - Control via contacts	The Start and Stop command as well as the statement of the direction of rotation are via digital signals.
1 - Control via State machine	The Start and Stop command as well as the statement of the direction of rotation are via the DRIVCOM State machine of the communication interface.
2 - Control via remote contacts	The Start and Stop command as well as the statement of the direction of rotation are via logic signals by the communication protocol.
3 - Cont. Keypad, Dir. rot. contacts	The Start and Stop command comes from the operating unit and the statement of the direction of rotation via digital signals.
4 - Cont. KP or Cont., Dir. rot. Cont.	The Start and Stop command comes from the operating unit or via digital signals. The statement of the direction of rotation only with the help of the digital signals.
13 - Control. Keypad, Dir. rot. Keypad	The Start and Stop command as well as the statement of the direction of rotation are via the operating unit.
14 - St. KP + contact, Dir. rot. Keypad	The Start and Stop command comes from the operating unit or via digital signals. The statement of the direction of rotation only with the help of the operating unit.
20 - Control contacts, only clockwise	The Start and Stop command is via digital signals. The statement of the direction of rotation is fixed, only clockwise.
23 - Control Keypad, only clockwise	The Start and Stop command is via the operating unit. The statement of the direction of rotation is fixed, only clockwise.
24 - Control. contacts + KP, only clockwise	The Start and Stop command comes from the operating unit or via digital signals. The statement of the direction of rotation is fixed, only clockwise.
30 to 34	Operating mode 20 to 24, direction of rotation only anticlockwise.
43 - Control KP, Dir. rot. contact + KP	The Start and Stop command is via the operating unit. The statement of the direction of rotation comes from the operating unit or via digital signals.
44 - Control contact + KP, Dir. rot. contact + KP	The Start and Stop command and the statement of the direction of rotation come from the operating unit or via digital signals.



Warning: Control of the drive mechanism via the operating unit demands the release of the power component via the digital input controller release S1IND. To avoid serious physical injuries or considerable damage to property, only qualified persons may work on the devices. Qualified means people who are acquainted with the erection, assembly, commissioning and operation and have corresponding qualifications for their activity. The documentation is to be read carefully beforehand and the safety instructions are to be obeyed.

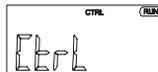
6.7 Control motor via the operating unit

The operating unit enables control of the connected motor in accordance with the selected operating mode of the parameter *Local/Remote* **412**.



Warning: Control of the drive mechanism via the operating unit demands the release of the power component via the digital input controller release S1IND. To avoid serious physical injuries or considerable damage to property, only qualified persons may work on the devices. Qualified means people who are acquainted with the erection, assembly, commissioning and operation and have corresponding qualifications for their activity. The documentation is to be read carefully beforehand and the safety instructions are to be obeyed.

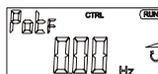
The CTRL menu branch can be reached via the navigation within the menu structure. The Ctrl function contains sub-functions which can be displayed according to the operating point of the frequency inverter.



Pressing the RUN key leads to a direct change from anywhere within the menu structure to the motorpoti function **Pot** or the internal reference value **int**.

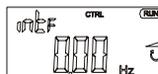
Motorpoti function **Pot**

With the help of the arrow keys, the output frequency of the frequency inverter can be set from the *minimum frequency* **418** to the *maximum frequency* **419**. The acceleration corresponds to the factory setting (2 Hz/s) for the parameter *Ramp Keypad-Motorpoti* **473**. The parameters *Acceleration (clockwise)* **420** and *Deceleration (clockwise)* **421** are taken into account with lower acceleration values.



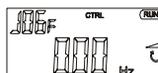
Internal reference value **int**

The drive mechanism is in operation and the current actual value is being displayed. By pressing the arrow keys, you change into the motorpoti function **Pot**, with the current value of the frequency being taken over.



JOG frequency **JOG**

By pressing the FUN key, you change from the internal reference value **int** or the motorpoti function **Pot** to the *JOG frequency* **489**. The frequency can be set with the help of the arrow keys. If the FUN key is released, the drive mechanism stops and the display changes to the output function **Pot** or **int**. The last frequency value is stored in the parameter *JOG frequency* **489**.



Key functions

ENT	Adjustment of the direction of rotation independent of the control signal on the terminals clockwise S2IND or anticlockwise S3IND.
ESC	Quit function and change back into the menu structure.
FUN	Pressing the key changes to the JOG frequency and drive mechanism starts. Releasing the key changes to the sub-function and stops the drive mechanism.
RUN	Start drive mechanism; alternative to control signal S2IND or S3IND
STOP	Stop drive mechanism; alternative to control signal S2IND or S3IND

Attention: The ENT key results in a **change of direction of rotation** independent of the signal on the terminals clockwise S2IND or anticlockwise S3IND. If the *minimum frequency* **418** has been set to 0.00 Hz, there is a **change of direction of rotation** of the motor with a change of sign of the reference frequency value.

7 Commissioning of the frequency inverter

7.1 Switching mains voltage on

After the installation work has been completed, all the control and power connections should be checked again before the mains voltage is switched on. If all the electrical connections are correct, please make sure that the release of the frequency inverter has been switched off (control output S1IND open). After the mains voltage has been switched on, the frequency inverter carries out a self-test and the relay output (X10) reports "Fault".

The frequency inverter concludes the self-test after a few seconds, the relay reacts and reports "No fault".

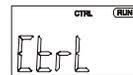
In the state on delivery and after adjustment of the factory setting, the guided commissioning is automatically called. The operating unit shows the menu point "SEtUP" from the CTRL menu branch.

7.2 Set-up with the operating unit

The guided commissioning of the frequency inverter finds all the parameter settings relevant for the desired application. The selection of the available parameters has been derived from the known standard applications of drive technique. This facilitates the selection of the important parameters. After a successful completion of the SETUP routine, the actual value *Actual frequency* 241 from the VAL menu branch is displayed in the operating unit. After this, the user should check whether further parameters are relevant for the application.

Attention: The guided commissioning contains the function for parameter identification. With a measurement, the parameters are determined and set accordingly. Before the start of the measurement, the motor should not yet have been operated, as a part of the machine data depends upon the operating temperature.

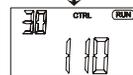
The guided commissioning appears automatically in the state upon delivery. Following a successful commissioning, you can select the CTRL sub-menu in the main menu and call the function once more.



By pressing the ENT key, you change to the CTRL sub-menu. In this sub-menu, you use the arrow keys to select the menu point "SEtUP" and confirm it with the ENT key.



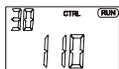
As a function of the selected *Control level* 28 the configurations available are automatically displayed to you. The operating instructions document the configurations described in the following chapter. With the help of the arrow keys, select the number of the required configuration and confirm the input with the ENT key.



If the configuration has been altered, the hardware and software functionality are configured. After the initialization, please confirm the selected configuration once more and continue the guided commissioning.

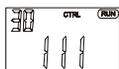
7.2.1 Configuration

The *Configuration 30* determines the occupancy and basic function of the control inputs and outputs and the software functions. The software of the frequency inverter provides a number of configurations for selection. The configurations essentially differ in the way in which the drive mechanism is controlled. The analog and digital inputs are to be combined within the configuration and supplemented by optional communication protocols. The operating instructions describe the following configurations and matching parameters on the **third Control level 28**.



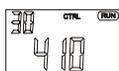
Configuration 110, sensor-less control

Configuration 110 contains the functions for variable-speed controls of a 3-phase machine in a large number of standard applications. The motor speed is set according to the V/f characteristic in accordance with the ratio of voltage and frequency.



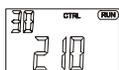
Configuration 111, sensor-less control with technology controller

Configuration 111 extends the sensor-less control by software functions that facilitate customer-specific adaptation in various applications. The technology controller, the volume flow control and the V-belt monitoring are to be used relative to the application.



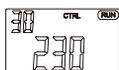
Configuration 410, sensor-less field-oriented control

Configuration 410 contains the functions for sensor-less, field-oriented control of a 3-phase machine. The current motor speed is determined from the present currents and voltages in combination with the machine parameters. Parallel switching of 3-phase motors is only restrictedly possible in this configuration.



Configuration 210, field-oriented control

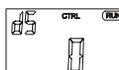
Configuration 210 contains the functions for speed-controlled, field-oriented control of a 3-phase machine with speed sensor feedback. The separate control of torque and flux-forming current enables high drive dynamism with a high moment of load. The necessary speed sensor feedback leads to a precise speed and torque behavior.



Configuration 230, field-oriented control with torque control

Configuration 230 extends configuration 210 by functions for torque-dependent field-oriented control. The reference torque is represented as a percentage and transmitted to a corresponding operating behavior of the application. The switch-over between variable-speed control and torque-dependent control is done via a digital control input.

7.2.2 Data set

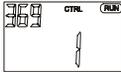


The parameter *Data set* enables a selection between four data sets for storing parameter settings.

In data set 0, data sets 1 to 4 are stored with the same parameter values. The standard application of the frequency inverter, without use of the data set switch-over, uses data set 1.

Setting	
Parameter dS	Function
0	All data sets (DS0)
1	Data set 1 (DS1)
2	Data set 2 (DS2)
3	Data set 3 (DS3)
4	Data set 4 (DS4)

7.2.3 Motor type



The properties of the control functions and methods to be set vary with the motor connected. The parameter *Motor type* 369 provides a selection of motor variants with the matching table values. The check of the rated values input and the guided commissioning take the parameterized motor type into account. The selection of motor types varies according to the applications of the various control functions and methods. The operating instructions describe the functionality and the operating behavior for the 3-phase motor.

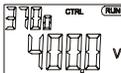
Operation mode	Function
0 - Unknown	The motor is not one of the standard types
1 - Asynchronous	Three-phase asynchronous motor, squirrel cage
2 - Synchronous	Three-phase synchronous motor
3 - Reluctance	Three-phase reluctance motor
10 - Transformer	Transformer with three primary windings



Note: The setting of the motor type leads to differing results in the inquiry and pre-setting of the relevant parameters. A faulty input can lead to damage to the drive mechanism.

After this, you enter the machine data appearing in a tabular order, which are described in the following chapters. Confirm the input of the parameters and the selection by pressing the ENT key. Navigate between the parameters and change the necessary value with the help of the cursors. After input of the machine data, the calculation or examination of the parameters is automatically started. The display briefly changes to CALC, in order to continue the guided commissioning with the parameter identification if the check of the machine data is successful.

7.2.4 Machine data



The machine data to be input in the following sequence of the guided commissioning can be seen on the rating plate or the data sheet of the motor. The factory settings of the machine parameters are relative to the reference data of the frequency inverter and to the applicable four-poled three-phase motor. The machine data necessary for the control functions and methods are calculated in the course of the commissioning from the settings that have been checked for plausibility. The rated values for the three-phase motor stated by the factory are to be checked by the user.

No.	Parameter	Setting		
	Description	Min.	Max.	Fact. sett.
370	Rated voltage	$0.17 \cdot U_{FIN}$	$2 \cdot U_{FIN}$	U_{FIN}
371	Rated current	$0.01 \cdot I_{FIN}$	$10 \cdot I_{FIN}$	I_{FIN}
372	Rated speed	96 min^{-1}	$60,000 \text{ min}^{-1}$	n_N
374	Rated cosine Phi	0.01	1.00	$\cos(\varphi)_N$
375	Rated frequency	10.00 Hz	1000.00 Hz	50.00
376	Rated mechanical power	$0.01 \cdot P_{FIN}$	$10 \cdot P_{FIN}$	P_{FIN}

Attention: The guided commissioning takes the increase of the rated speed with constant torque into account by switching over the motor winding from star to delta connection. The rated data are to be parameterized according to the rating plate of the motor for the switching of the motor winding. The increased rated current of the connected three-phase motor is to be taken into account.

7.2.5 Speed sensor data

Configurations 210 and 230 of the field-oriented control demand the connection of an incremental speed sensor. The track signals of the speed sensor are to be connected to digital inputs S5IND (track A) and S4IND (track B).

The *Operation mode speed sensor 1 490* defines the form of measurement.

Operation mode	Function
0 - off	Speed measurement is not active; the digital inputs are available for further functions.
1 - Single Evaluation	Two-channel speed sensor with recognition of direction of rotation via track signals A and B; one signal edge is evaluated per division mark.
4 - Quadruple Evaluation	Two-channel speed sensor with recognition of direction of rotation via track signals A and B; four signal edges are evaluated per division mark.
11 - Single Evaluation unsigned	One-channel speed sensor via track signal A. The actual speed value is positive. One signal edge is evaluated per division mark. The digital input S4IND is available for further functions.
12 - Double Evaluation unsigned	One-channel speed sensor via track signal A. The actual speed value is positive. Two signal edges are evaluated per division mark. The digital input S4IND is available for further functions.
101 - Single Evaluation inverted	Like operation mode 1. The actual speed value is inverted. (Alternative to exchanging the track signals)
104 - Quadruple Evaluation inverted	Like operation mode 4. The actual speed value is inverted. (Alternative to exchanging the track signals)
111 - Single Evaluation negative	Like operation mode 11. The actual speed value is negative.
112 - Double Evaluation negative	Like operation mode 12. The actual speed value is negative.

The number of increments of the speed sensor is to be parameterized via the parameter *Division marks, speed sensor 1 491*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
491	Division marks, speed sensor 1	1	8192	1024

7.2.6 Plausibility check



Checking the machine data should only be omitted by an expert user. The configurations contain complex control systems that are essentially dependent on the correct input of the machine parameters. The warning and error reports shown in the test sequence must therefore be obeyed. If a critical condition is recognized in the sequence of the guided commissioning, it is displayed on the operating unit. A warning or error message matching the deviation from the expected parameter value is displayed.

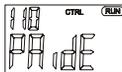
The warning message can be acknowledged with the ENT key and the guided commissioning is continued. A correction of the input parameter values can be done by a subsequent pressing of the ESC key.

Warning messages	
Code	Measures / Remedy
SA000	No warning message exists. This message can be read out via an optional communication card.
SA001	The <i>Rated voltage 370</i> is outside the inverter nominal voltage range. The maximum reference voltage is stated on the rating plate of the frequency inverter.
SA002	The <i>Rated current 371</i> , the <i>Rated power 376</i> and the <i>Rated voltage 370</i> are to be checked. The calculated efficiency is in the threshold area for a three-phased motor.
SA003	The <i>Rated cosine phi 374</i> is outside the standard range (0.6 to 0.95).
SA004	The <i>Rated speed 372</i> and the <i>Rated frequency 375</i> are to be checked. The slip is in the threshold area for a three-phase motor.

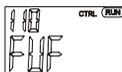
If an error message appears, the parameterized rated data are to be checked and input again. The guided commissioning is repeated until error-free input of the rated values. Premature ending of the guided commissioning with the help of the ESC key should only be done by expert users, as a part of the rated data is not correct.

Error messages	
Code	Measures / Remedy
SF000	No error message exists
SF001	The input <i>Rated current 371</i> is too low.
SF002	The <i>Rated current 371</i> is too high relative to the <i>Rated power 376</i> and the <i>Rated voltage 370</i> .
SF003	The <i>Rated cosine phi 374</i> is faulty (larger than 1 or smaller than 0.3).
SF004	The slip frequency calculated from the reference values is negative. The <i>Rated speed 372</i> and the <i>Rated frequency 375</i> are to be checked.
SF005	The input <i>Rated speed 372</i> and the <i>Rated frequency 375</i> are to be checked as the calculated slip frequency is too large.
SF006	The overall output of the drive mechanism calculated from the reference data is lower than the rated power input.
SF007	The set configuration is not supported by the guided commissioning.

7.2.7 Parameter identification



As a supplement to the parameterized rated data, the selected configuration demands knowledge of further machine data not stated on the rating plate of the three-phase machine. As a supplement to the manufacturer's data sheet or as an alternative, the guided commissioning can measure the necessary machine data. The variables measured with the drive mechanism at a standstill are input directly or following a calculation for the parameter. The sequence and the duration of the parameter identification varies according to the machine connection and the device output. The PAidE display is to be confirmed by pressing the ENT key. The load connected is measured in the following sequence of the parameter identification with the displayed signals.



After checking the input machine data, the guided commissioning changes to the functions of the parameter identification. The security functions of the frequency inverter prevent the release of the power component without switching on digital input S1IND. If a signal has been applied at the start of the guided commissioning, the FUF message is not displayed.



Warning: The parameter identification of the frequency inverter demands the release of the power component. To avoid serious physical injury or considerable damage to property, only qualified people may work on the devices. Qualified means people who are acquainted with erection, assembly, commissioning and operation of frequency inverters or who have qualifications corresponding to their activity. The necessary documentation must therefore be read carefully and the safety information obeyed.



The final message rEAdY is to be confirmed with the ENT key. Cancellation by pressing the ESC key or withholding the release S1IND leads to an incomplete take-over of values.

7.2.8 Application data

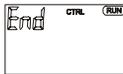
The varied drive applications with the parameter settings resulting from them demand the check of further parameters. The parameters inquired within the guided commissioning have been selected from known applications and are to be supplemented by further settings in the PARA menu branch after completion of the commissioning.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
420	Acceleration (clockwise)	0.00 Hz/s	999.99 Hz/s	5.00 Hz/s
421	Deceleration (clockwise)	0.00 Hz/s	999.99 Hz/s	5.00 Hz/s

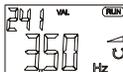
Attention: The deceleration of the drive mechanism is monitored in the parameter setting *Voltage controller operation mode* **670** from the factory settings. The deceleration ramp can be extended with an increase in the DC link voltage in generator operation or in the braking process.

The multifunctional input MF11 is to be parameterized in *Operation mode 452* according to the reference value signal. Operation mode 3 should only be selected by expert users who would like to use a drive mechanism control via *Fixed frequency 1 480* and *Fixed frequency 2 481*.

Operation mode	Function
1 - Voltage input	Voltage signal (MF11A), 0V to 10V
2 - Current input	Current signal (MF11A), 0mA to 20mA
3 - Digital input	Digital signal (MF11D), 0V to 24V



The operating unit shows the message End, which you confirm with the ENT key. The guided commissioning of the frequency inverter is ended with a reset and the initialization of the frequency inverter. Relay output X10 reports a fault in the initialization.



Following the faulty initialization of the frequency inverter, the parameter *Actual frequency 241* defined in the factory settings is displayed. If there is a signal on digital input 1 and on digital input 2 or digital input 3, the drive mechanism is accelerated to the set *Minimum frequency 418* (factory setting: 3.50 Hz)

The guided commissioning facilitates selection of the important parameters for you and finds further rated data of the motor. If the settings of the parameters have been done via the optional operating software or in the PARA menu branch of the operating unit, the display of the selected actual value is to be activated manually. When the frequency inverter is switched on, the set-up function appears, which you quit with the ESC key. Change to the VAL menu branch and select the required actual value that is to be displayed in future. By pressing the ENT key, the value of the parameter is displayed and selected as the actual value in a new start by repeated pressing of the ENT key.

7.3 Check direction of rotation

The interconnection of reference value and actual direction of rotation of the drive mechanism is to be checked. A check should be done as follows. State a reference value of about 10% and briefly switch on the release of the frequency inverter (control inputs FUF (S1IND) and STR (S2IND) for clockwise or FUF (S1IND) and STL (S3IND) for anticlockwise). In the acceleration of the drive mechanism, check whether the motor shaft turns in the right direction. In addition to a check of the drive mechanism, corresponding actual values and operating messages can be read out with the help of the operating unit. If for example, a wrong direction of rotation is established, two motor phases, e.g. U and V, are to be exchanged on the terminals of the frequency inverter. The mains side connection of the frequency inverter has no effects on the direction of rotation of the drive mechanism.

Within the field-oriented control with incremental speed sensor, the actual value is compared with the nominal value via the *Speed Sensor monitoring 760*. The faulty registered direction of rotation demands not only a check of the motor connection, but also a check of the digital inputs S5IND (track A) and S4IND (track B).

Note: The commissioning of the frequency inverter has been completed and can now be supplemented by further settings in the PARA menu. The set parameters have been selected in such a way that they are sufficient for a commissioning in most cases of application. The checking of the further settings relevant for the application is to be done on the basis of the operating instructions.

7.4 Set-up via the communication interface

The parameterization and commissioning of the frequency inverter via one of the optional communication interfaces contains the functions of the plausibility check and the parameter identification. Before starting, the documentation is to be read carefully and the safety information to be obeyed, as the relevant parameter settings are to be parameterized independently by the expert user. The parameter selection within the guided commissioning contains the underlying parameters of known standard applications of the configuration in question and can be used as a guideline. The parameter *SETUP Select* **796** defines the function that is directly implemented. The operation modes share the steps automatically following one another in the course of the guided commissioning.

Operation mode	Function
0 - Clear Status	The auto set-up does not implement a function
1 - Continue	The warning message is acknowledged and the auto set-up continued.
2 - Abort	The auto set-up is stopped and a RESET of the frequency inverter implemented.
10 - Complete Setup, DS0	The auto set-up is implemented in data set 0 and the parameter values are stored identically in all four data sets.
11 - Complete Setup, DS1	The parameter values of the auto set-up are stored in data set 1.
12 - Complete Setup, DS2	The parameter values of the auto set-up are stored in data set 2.
13 - Complete Setup, DS3	The parameter values of the auto set-up are stored in data set 3.
14 - Complete Setup, DS4	The parameter values of the auto set-up are stored in data set 4.
20 - Plaus.-Check Machine Data, DS0	The auto set-up checks the rated motor parameters in the four data sets.
21 - Plaus.-Check Machine Data, DS1	The rated motor parameters are checked for plausibility in data set 1.
22 - Plaus.-Check Machine Data, DS2	The rated motor parameters are checked for plausibility in data set 2.
23 - Plaus.-Check Machine Data, DS3	The rated motor parameters are checked for plausibility in data set 3.
24 - Plaus.-Check Machine Data, DS4	The rated motor parameters are checked for plausibility in data set 4.
30 - Calculation and Para-Ident., DS0	The auto set-up determines extended motor data via the parameter identification, calculates dependent parameters and stores the parameter values identically in all four data sets.
31 - Calculation and Para-Ident., DS1	Extended motor data are measured, dependent parameters calculated and the parameter values stored in data set 1
32 - Calculation and Para-Ident., DS2	Extended motor data are measured, dependent parameters calculated and the parameter values stored in data set 2
33 - Calculation and Para-Ident., DS3	Extended motor data are measured, dependent parameters calculated and the parameter values stored in data set 3
34 - Calculation and Para-Ident., DS4	Extended motor data are measured, dependent parameters calculated and the parameter values stored in data set 4

The monitoring and checking of the individual steps in the course of the auto set-up can be done via the parameter *SETUP Status 797*. The setup via the communication interface continuously updates the status parameter, which can be read out via the interface.

Status	Meaning
0 - Ok	Auto set-up has been carried out.
1 - PC Phase 1	The plausibility check of the motor data is active.
2 - PC Phase 2	The calculation of dependent parameters is active.
3 - FUF	The parameter identification demands the controller release at digital input S1IND.
4 - Parameter Identification	The rated motor values are being checked by the parameter identification.
10 - Setup already active	Setup via the operating unit is being carried out.
11 - SF0001 Rated Current Too Low	The registered <i>Rated current 371</i> is too low.
12 - SF0002 Rated Current Too High	The <i>Rated current 371</i> is too high relative to the <i>Rated output 376</i> and the <i>Rated voltage 370</i> .
13 - SF0003 Rated Cos-Phi	The <i>Rated Cos phi 374</i> is faulty (larger than 1 or smaller than 0.3).
14 - SF0004 Negative Slip Frequency	The slip frequency calculated from the rated values is negative. The <i>Rated speed 372</i> and the <i>Rated frequency 375</i> are to be checked.
15 - SF0005 Slip Frequency Too High	The input <i>Rated speed 372</i> and the <i>Rated frequency 375</i> are to be checked as the calculated slip frequency is too large.
16 - SF0006 Power Balance	The overall output of the drive mechanism calculated from the rated values is lower than the input rated power.
17 - SF0007 Unsupported Configuration	The set configuration is not supported by the auto set-up.
21 - SA0001 Rated Voltage	The <i>Rated voltage 370</i> is outside the reference voltage range of the inverter. The maximum reference voltage is stated on the rating plate of the frequency inverter.
22 - SA0002 Efficiency	The <i>Rated current 371</i> , the <i>Rated output 376</i> and the <i>Rated voltage 370</i> are to be checked. The calculated efficient is in the threshold area for a three-phase motor.
23 - SA0003 Rated Cos-Phi	The <i>Rated Cos phi 374</i> is outside the standard area (0.6 to 0.95).
24 - SA0004 Slip Frequency	The <i>Rated speed 372</i> and the <i>Rated frequency 375</i> are to be checked. The slip is in the threshold area for a three-phase motor.
30 - No Release	The parameter identification demands the controller release on digital input S1IND
31 - Error	An error has occurred in the course of the auto set-up
32 - Warning Phase Asymmetry	The parameter identification has established an unbalance in the measurements in the three motor phases.

8 Inverter data

The series ACT frequency inverters are suited for a wide range of applications. The modular hardware and software structure enables customer-specific adaptation. The available hardware functionality of the frequency inverter is displayed and can be modified by setting the software parameters specific to the application.

8.1 Serial number

The *Serial number 0* is entered when the frequency inverter is manufactured. Information on the type of device and the production data with an 8-digit number are displayed. In addition, the serial number is printed on the rating plate.

Serial number 0 : **ACT 400 – 003 ; 02102013**
 Rating plate: **Type: ACT 400 – 003 ; Serial No.: 02102013**

8.2 Optional modules

Modular extension of the hardware is possible via the plug-in sections. The *Optional modules 1* recognized by the frequency inverter are displayed with the matching abbreviations after initialization.

CM-232 ; EM-SYS

8.3 Inverter software version

The firmware stored in the frequency inverter defines an available parameter and function structure of the software. The *Inverter software version 12* is displayed. In addition to the version, the 6-digit software key is printed on the rating plate of the frequency inverter.

Inverter software version 12 : **4.0.2**
 Rating plate: **Version: 4.0.2 ; Software: 140001**

8.4 Set password

As a protection against unauthorized access, the parameter *Set password 27* can be set in such a way that this password is inquired when a parameter is changed. A change of parameter is only possible if the password is entered correctly. If the *Set password 27* parameter is set with the value zero, there is no password inquiry in access to the parameters. The previous password is deleted.

Parameter		Setting		
No.	Description	Min.	Max.	Fact sett.
27	Set password	0	999	0

8.5 Control level

The *Control level 28* defines the scope of the functions to be parameterized. The operating instructions describe the parameters on the third control level, which should only be set by qualified users. Before starting work, please read the documentation and comply with the safety instructions. For the purposes of the instructions, a "qualified person" means a person acquainted with the erection, assembly, commissioning and operation of the frequency inverters and in possession of a qualification matching the work.

Parameter		Setting		
No.	Description	Min.	Max.	Fact sett.
28	Control level	1	3	1

8.6 User name

The *User name* **29** can be entered via the optional operating software VPlus. The display of the plant or machine designation is only possible in a limited way via the operating unit.

32 alphanumeric characters

8.7 Configuration

The *Configuration* **30** determines the occupancy and basic function of the control inputs and outputs and the software functions. The software of the frequency inverters offers a number of configurations for selection. The configurations essentially differ in the way in which the drive mechanism is controlled. The analog and digital inputs are to be combined within the configuration and supplemented by optional communication protocols. The operating instructions describe the following configurations and matching parameters on the **third Control level 28**.

Configuration 110, sensor-less control

Configuration 110 contains the functions for variable-speed controls of a 3-phase machine in a large number of standard applications. The motor speed is set according to the *V/f* characteristic in accordance with the ratio of voltage and frequency.

Configuration 111, sensor-less control with technology controller

Configuration 111 extends the sensor-less control by software functions that facilitate customer-specific adaptation in various applications. The technology controller, the volume flow control and the V-belt monitoring are to be used relative to the application.

Configuration 410, sensor-less field-oriented control

Configuration 410 contains the functions for sensor-less, field-oriented control of a 3-phase machine. The current motor speed is determined from the present currents and voltages in combination with the machine parameters. Parallel switching of 3-phase motors is only restrictedly possible in this configuration.

Configuration 210, field-oriented control

Configuration 210 contains the functions for speed-controlled, field-oriented control of a 3-phase machine with speed sensor feedback. The separate control of torque and flux-forming current enables a high drive dynamism with a high moment of load. The necessary speed sensor feedback leads to a precise speed and torque behavior.

Configuration 230, field-oriented control with torque control

Configuration 230 extends configuration 210 by functions for torque-dependent field-oriented control. The reference torque is represented as a percentage and transmitted to a corresponding operating behavior of the application. The switch-over between variable-speed control and torque-dependent control is done via a digital control input.

8.8 Language

The parameters are stored in the frequency inverter in various languages. The parameter description is displayed, for example by the PC program VPlus, in the selected *Language* **33**.

Operation mode	Function
1 - Deutsch	Parameter description in the German language
2 - English	Parameter description in the English language
3 - Italiano	Parameter description in the Italian language

8.9 Programming

The parameter *Program 34* permits acknowledgment of a fault message and resetting of the factory setting. The display of the operating unit shows the message "dEFLt" or "rESEt", and the light diodes additionally signalize the status of the frequency inverter.

Setting	Function
123	The current error report can be acknowledged via digital input S1IND and the software parameter. The display of the operating unit shows the message "rESEt".
4444	The setting of the parameters within the selected configuration is overwritten with the factory settings. The display of the operating unit shows the message "dEFLt".

9 Machine data

The input of the machine data is the foundation for the functionality of the control functions and methods. In the course of the guided commissioning, the necessary parameters are inquired according to the selected *Configuration 30*.

9.1 Rated motor parameters

The rated parameters of the three-phase asynchronous machine are to be parameterized according to the rating plate or the data sheet of the motor. The factory settings of the machine parameters are relative to the reference data of the frequency inverter and the matching four-poled 3-phase machine. The machine data necessary for the control functions and methods are calculated in the course of the commissioning from the settings, which have been checked for plausibility.

The factory settings of the rated parameters are to be checked by the user.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
370	Rated voltage	$0.17 \cdot U_{FIN}$	$2 \cdot U_{FIN}$	U_{FIN}
371	Rated current	$0.01 \cdot I_{FIN}$	$10 \cdot I_{FIN}$	I_{FIN}
372	Rated speed	96 min^{-1}	60.000 min^{-1}	n_N
373	No. of pole pairs	1	24	2
374	Rated cosine (φ)	0.01	1.00	$\cos(\varphi)_N$
375	Rated frequency	10.00 Hz	1000.00 Hz	50.00
376	Rated mechanical power	$0.01 \cdot P_{FIN}$	$10 \cdot P_{FIN}$	P_{FIN}

The increase of the rated speed at constant torque can be implemented in 3-speed machines if the motor winding can be changed over from star to delta circuit. The change-over leads to a modification of the dependent rated values by a square root of three.

The admissible rated voltage and rated speed must be observed!

9.2 Further motor parameters

The selected control functions and methods demand determination of further data which cannot be read off the rating plate of the 3-phase machine, in particular with field-oriented controlling, for the precise calculation of the machine model. In the course of the guided commissioning, the parameter identification has been done to measure the further motor parameters.

9.2.1 Stator resistance

The resistance of the stator winding has been measured in the course of the guided commissioning. The parameter is parameterized as a phase value and is a factor of 3 smaller than the winding resistance in the delta circuit.

In the factory, the alternative stator resistance of a standard motor has been input to match the reference output of the frequency inverter.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
377	Stator resistance	0 m Ω	65535 m Ω	R_{SN}

The stator resistance can be optimized in the open circuit of the machine. At the stationary operating point, the torque-forming current *Isq 216* or the selected *Active current 214* should be zero. The adjustment should be done at a winding temperature also reached in normal operation of the motor, as the stator resistance is temperature-dependent.

9.2.2 Leakage coefficient

The leakage coefficient of the machine defines the ratio of the leakage inductivity to the main inductivity. The torque and flux-forming current components are thus coupled via the leakage coefficient. Optimization of the leakage coefficient within the field-oriented control systems demands movement to various operating points of the drive mechanism. The flux-forming current *Isd 215* should be independent of the load moment to a large extent, unlike the torque-forming current *Isq 216*. The flux-forming current component behaves inversely proportional to the leakage coefficient. If the leakage coefficient is increased, the torque-forming current increases and the flux-forming component drops. The adjustment should result in a relatively constant actual current value *Isd 215*, matching the set *Rated magnetizing current 716*, regardless of the load on the drive mechanism.

The sensor-less controlling uses the parameter *Leakage coefficient 378* for optimization of the synchronization to one drive.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
378	Leakage coefficient	1.0 %	20.0 %	7.0 %

9.2.3 Magnetizing current

The *Rated magnetizing current 716* is a measure of the flux in the motor and thus of the voltage set on the machine in an open circuit, regardless of the speed. The guided commissioning determines this value at about 30% of the *Rated current 371*. This current is comparable with the field current of an externally excited direct current machine.

As optimization for the sensor-less field-oriented controls, the machine must be operated in an open circuit at a rotary frequency below the *Rated frequency 375*. The precision of the optimization rises with the set *Switching frequency 400* and the open circuit of the drive to be implemented. The flux-forming actual current value *Isd 215* to be read off should roughly match the set *Rated magnetizing current 716*.

The field-oriented control with speed sensor feedback uses the parameterized *Rated magnetizing current 716* for the flux in the motor.

The dependence of the magnetizing on the frequency and voltage at the operating point in question is taken into account by a magnetizing characteristic. The characteristic is calculated via three points, in particular in the field weakening area above the rated frequency. The parameter identification has determined the magnetizing characteristic and set the parameters *Magnetizing current 50% 713*, *Magnetizing current 80% 713* and *Magnetizing current 110% 713*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
713	Magnetizing current 50%	1.00 %	50.00 %	31.00 %
714	Magnetizing current 80%	1.00 %	80.00 %	65.00 %
715	Magnetizing current 110%	110.00 %	197.00 %	145.00 %
716	Rated magnetizing current	$0.01 \cdot I_{FIN}$	$0 \cdot I_{FIN}$	$0.3 \cdot I_{FIN}$

9.2.4 Rated slip correction factor

The rotor time constant results from the inductivity of the rotor circuit and the rotor resistance. Due to the temperature-dependence of the rotor resistance and the saturation effects of the iron, the rotor time constant is also dependent on temperature and current. The load behavior and thus the rated slip are a function of the rotor time constant. The guided commissioning has determined the machine data in the parameter identification and set the parameter *Rated slip correction factor 718* accordingly. For the fine adjustment or a control of the rotor time constant, the following mode of procedure can be used: the machine is loaded at half the *Rated frequency 375*. Then, about half the *Rated voltage 370* must result with a deviation of max. 5 %. If this is not the case, the corresponding correction factor must be modified. The larger the correction factor is set, the stronger the drop in the voltage upon load. The value of the rotor time constant calculated by the software can be read out via the actual value *Current rotor time constant 227*. The adjustment should be done at a winding temperature also reached in normal operation of the motor.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
718	Rated slip correction factor	0.01 %	300.00 %	100.00 %

9.3 Speed sensor 1

The frequency inverters are to be adapted according to the requirements in the application. Some of the available *Configurations 30* demand continuous measurement of the actual speed value for the control functions and methods. The necessary connection of an incremental speed sensor is done on the digital control terminals S5IND (track A) and S4IND (track B) of the frequency inverter.

9.3.1 Operation mode speed sensor 1

Operation mode speed sensor 1 490 is to be selected according to the connected incremental speed sensor. A unipolar speed sensor is to be connected to the standard control terminals.

Operation mode	Speed sensor 1 490
0 - off	Speed measurement is not active; the digital inputs are available for further functions.
1 - Single Evaluation	Two-channel speed sensor with recognition of direction of rotation via track signals A and B; one signal edge is evaluated per mark.
4 - Quadruple Evaluation	Two-channel speed sensor with recognition of direction of rotation via track signals A and B; four signal edges are evaluated per mark.
11 - Single Evaluation unsigned	One-channel speed sensor via track signal A. The actual speed value is positive. One signal edge is evaluated per mark. The digital input S4IND is available for further functions.
12 - Double Evaluation unsigned	One-channel speed sensor via track signal A. The actual speed value is positive. Two signal edges are evaluated per mark. The digital input S4IND is available for further functions.
101 - Single Evaluation inverted	As operation mode 1. The actual speed value is inverted. (Alternative to exchanging the track signals)
104 - Quadruple Evaluation inverted	As operation mode 4. The actual speed value is inverted. (Alternative to exchanging the track signals)
111 - Single Evaluation negative	As operation mode 11. The actual speed value is negative.
112 - Double Evaluation negative	As operation mode 12. actual speed value is negative.

9.3.2 Division marks speed sensor 1

The number of increments of the connected speed sensor is to be parameterized via the parameter *Division marks speed sensor 1* **491**. The division marks of the speed sensor are to be selected according to the speed range of the application. The maximum number of division marks S_{max} is defined by the frequency limit of $f_{max} = 150\text{ kHz}$ of the digital inputs S5IND (track A) and S4IND (track B).

$$S_{max} = 150000\text{Hz} \cdot \frac{60\text{s} / \text{min}}{n_{max}} \quad n_{max} = \text{Max. speed of the motor in RPM}$$

In order to guarantee a good true running of the drive, a sensor signal must be evaluated at least every 2 ms (signal frequency $f = 500\text{ Hz}$). From this demand, the minimum number of division marks S_{min} of the incremental speed sensor can be calculated for the required minimum speed n_{min} .

$$S_{min} = 500\text{Hz} \cdot \frac{60\text{s} / \text{min}}{A \cdot n_{min}} \quad n_{min} = \text{Min. speed of the motor in RPM}$$

A = Evaluation (1,2,4)

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
491	Division marks, speed sensor 1	1	8192	1024

10 System data

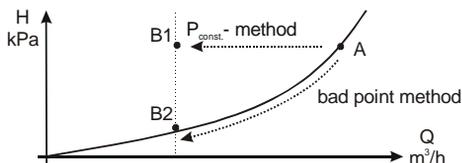
The various control functions and methods according to the selected *Configuration* **30** are supplemented by control and special functions. A calculation of process values from the electrical control values to monitor the application specific to the application in question is helpful.

10.1 Volume flow and pressure

The parameterization of the factors *Nominal volumetric flow* **397** and *Nominal pressure* **398** is necessary if the matching actual values *Volumetric flow* **285** and *Pressure* **286** are used to monitor the drive mechanism. The conversion of the electrical control value is done by the bad point method. In the bad point method, the working point is displaced by modification of the speed on the characteristic.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
397	Nominal volumetric flow	1 m ³ /h	99999 m ³ /h	10 m ³ /h
398	Nominal pressure	0.1 kPa	999.9 kPa	100.0 kPa

Pipe network or channel characteristic:



Point A in the figure describes the rating point of a pump. The transition into part-load operation can be done with constant pressure (modification of conveying flow, pressure remains constant) or by the bad point method (modification of pressure and conveying flow). Both methods can be realized with the integrated technology controller. The actual values displayed are calculated by the bad point method independently of the operation mode of the technology controller selected.

11 Operational behavior

The operational behavior of the frequency inverter is to be parameterized relative to the application. In particular, the starting and stopping behavior is to be configured freely according to the selected *Configuration 30*. In addition, functions such as the auto-start, synchronization and positioning facilitate integration into the application.

11.1 Starting behavior

The start of the 3-phase machine is to be parameterized in accordance with the control functions and methods. The field-oriented control systems are based on a complex controller structure and only demand definition of the maximum *Flux-formation time 780* and *Current during flux-formation 781* limit values, unlike sensor-less controlling, which is supplemented by the selected *Operation mode 620* of the starting behavior.

11.1.1 Starting behavior of sensor-less controlling

The parameter *Operation mode starting behavior 620* is available in the configuration 110 and the configuration 111. Depending on the operation mode selected, the machine is firstly magnetized or a starting current is impressed. The loss of voltage on the stator resistance, which reduces the torque in the lower frequency range, can be compensated by the IxR compensation.

Operation mode	Starting behavior
0 - off	At the start, the voltage set with the parameter <i>Starting voltage 600</i> is output with an output frequency of 0 Hz. After this, the output voltage and the output frequency are altered according to the control functions and methods. The break-away torque or the current at the start is determined by the starting voltage set. The starting behavior must possibly be optimized with the parameter <i>Starting voltage 600</i> .
1 - Magnetisation	In this operation mode, the <i>Current during flux-formation 781</i> for magnetization is impressed into the motor after release. The output frequency is kept to the value of zero Hz for the <i>Maximum flux-formation time 780</i> . After this time has expired, there is continuation with the set V/f characteristic. (see operation mode 0)
2 - Magnetisation + Current Impr.	Operation mode 2 contains operation mode 1. After the expiry of the <i>Maximum flux-formation time 780</i> , the output frequency is increased according to the set acceleration. If the output frequency reaches the value set with the parameter <i>Limit frequency 624</i> , the <i>Starting current 623</i> is withdrawn. There is a smooth transition to 1.4 times the limit frequency to the set V/f characteristic. The output current is dependent on the load from this operating point on.
3 - Magnetisation + IxR-Comp.	Operation mode 3 contains operation mode 1 of the start function. If the output frequency reaches the value set with parameter <i>Limit frequency 624</i> , the increase of the output voltage by the IxR compensation becomes effective. The V/f characteristic is displaced by the share of voltage dependent on the stator resistance.

Operation mode	Starting behavior (continuation)
Magnet. + 4 - Curr.Imp. + IxR-Comp.	In this operation mode, the current set with the parameter <i>Current during flux-formation 781</i> is impressed into the motor for magnetization after release. The output frequency is kept to the value of zero Hz for the <i>Maximum flux-formation time 780</i> . After expiry of the time, the output frequency is increased according to the set acceleration. If the output frequency reaches the value set with the parameter <i>Limit frequency 624</i> , the <i>Starting current 623</i> is withdrawn. There is a smooth transition to the <i>V/f</i> characteristic and an output current dependent on the load is set. At the same time, the increase of the output voltage by the IxR compensation becomes effective from this output frequency onwards. The <i>V/f</i> characteristic is displaced by the share of voltage dependent on the stator resistance.
Magn. + 12 - Curr.Imp. w. Ramp Stop	Operation mode 12 contains an additional function to guarantee a starting behavior under difficult conditions. The magnetization and starting current impress are done according to operation mode 2. The ramp stop takes the current consumption of the motor at the operating point in question into account and controls the frequency and voltage alteration by stopping the ramp. The <i>Controller status 275</i> reports the contact of the controller with the message "RSTP".
Magn. + 14 - Current Imp. w RS. + IxR-Comp.	In this operation mode, the functions of operation mode 12 are extended by the compensation of the loss of voltage on the stator resistance. If the output frequency reaches the value set with the parameter <i>Limit frequency 624</i> , the increase of the output voltage by the IxR compensation becomes effective. The <i>V/f</i> characteristic is displaced by the share of voltage dependent on the stator resistance.

Unlike the field-oriented control systems, sensor-less controls are extended by a current controller for the starting behavior. The compensated proportional regulator controls the current impress of the parameterized *Starting current 623*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. set.
621	Amplification	0.01	10.00	1.00
622	Integral time	1 ms	30000 ms	50 ms

11.1.1.1 Starting current

The configurations 110, 111 and 410 for sensor-less control of a 3-phase machine use the starting current impress in operation modes 2, 4, 12 and 14. The *Starting current 623* guarantees, in particular for high start torque, sufficient torque to reach *Limit frequency 624*.

Applications in which high current is permanently needed at a low speed are to be implemented with forced-ventilated motors for thermal reasons.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. set.
623	Starting current	0.0 A	$0 \cdot I_{FIN}$	I_{FIN}

11.1.1.2 Limit frequency

The *Starting current 624* is impressed in configurations 110, 111 and 410 for sensorless control of a 3-phase machine until the *Limit frequency 624* is reached. Permanent operating points below the limit frequency are only admissible if forced-ventilated motors are used. Above the limit frequency, there is the transition to the control functions and methods of the selected *configuration 30*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
624	Limit frequency	0.00 Hz	100.00 Hz	2.60 Hz

11.1.2 Flux-formation

Field-oriented control in the configurations 210, 230 and the configuration 410 are based on separate regulation of the flux-forming and torque-forming current components. At the start of the machine, there is firstly excitation or impressing of a current. With the parameter *Current during flux formation 781* the magnetization current I_{sd} is set, with the parameter *Maximum flux-formation time 780* setting the maximum time for the current impress.

The current impress is done until the reference value of the rated magnetizing current is reached or the *Maximum flux-formation time 780* has been exceeded.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
780	Maximum flux-formation time	1 ms	10000 ms	1000 ms
781	Current during flux formation	$0.1 \cdot I_{FIN}$	$0 \cdot I_{FIN}$	I_{FIN}

11.2 Stopping behavior

The stop function of the 3-phase machine is to be defined in stopping behavior via *Operation mode 630* and is activated via the digital logic signals *Start clockwise 68* and *Start anticlockwise 69*. The following operation modes can be selected by combination of the logic signals that are assigned to the digital inputs as follows in the factory setting.

Stopping behavior									
		Start clockwise = 0 and Start anticlockwise = 0							
		Stopping behavior 0	Stopping behavior 1	Stopping behavior 2	Stopping behavior 3	Stopping behavior 4	Stopping behavior 5	Stopping behavior 6	Stopping behavior 7
Start clockwise = 1 and Start anticlockwise = 1	Stopping behavior 0	0	1	2	3	4	5	6	7
	Stopping behavior 1	10	11	12	13	14	15	16	17
	Stopping behavior 2	20	21	22	23	24	25	26	27
	Stopping behavior 3	30	31	32	33	34	35	36	37
	Stopping behavior 4	40	41	42	43	44	45	46	47
	Stopping behavior 5	50	51	52	53	54	55	56	57
	Stopping behavior 6	60	61	62	63	64	65	66	67
	Stopping behavior 7	70	71	72	73	74	75	76	77

Operation mode **630** of the stopping behavior is to be parameterized according to the matrix. The selection of the operation modes can vary according to the control functions and methods and the control inputs available.

Stopping behavior	
Stopping behavior 0 Free stopping	The converter is inhibited immediately. The drive mechanism is free of voltage immediately and stops freely.
Stopping behavior 1 Stop + Switch off	The drive mechanism is taken to a standstill with the set deceleration. When standstill has been reached, the converter is inhibited after a holding time. The holding time can be set with the parameter <i>Holding time 638</i> . Depending on the setting of the parameter <i>Starting function 620</i> , there is impressing for the duration of the holding time of the starting current, or the starting voltage is applied.
Stopping behavior 2 Stop + Hold	The drive mechanism is taken to a standstill with the set deceleration and remains permanently supplied with current. Depending on the setting of the parameter <i>Starting function 620</i> there is impressing from the standstill of the <i>Starting current 623</i> , or the starting voltage is applied.
Stopping behavior 3 Stop + brake	The drive mechanism is taken to a standstill with the set deceleration. From the standstill, the DC set with the parameter <i>Braking current 631</i> is impressed for the <i>Braking time 632</i> . Stopping behaviors 3, 6 and 7 are only available in the configurations for sensor-less control.
Stopping behavior 4 Emergency stop + switch off	The drive mechanism is guided to a standstill with the emergency stop deceleration. When a standstill has been reached, the converter is inhibited after a holding time. The holding time can be set with the parameter <i>Holding time 638</i> . Depending on the setting of the parameter <i>Starting function 620</i> the starting current is impressed or the starting voltage applied from standstill.
Stopping behavior 5 Emergency stop + Hold	The drive mechanism is taken to a standstill with the emergency stop deceleration and remains permanently supplied with current. Depending on the setting of the parameter <i>Starting function 620</i> , the <i>Starting current 623</i> is impressed or the starting voltage applied from standstill.
Stopping behavior 6 Emergency stop + Brake	The drive mechanism is guided until a standstill with the set emergency stop deceleration. From standstill, the DC set for the <i>Braking time 632</i> with the parameter <i>Braking current 631</i> is impressed. Stopping behaviors 3, 6 and 7 are only available in the configurations for sensor-less control.
Stopping behavior 7 Direct current brake	Direct current braking is activated immediately. The direct current set with the parameter <i>Braking current 631</i> is impressed for the die <i>Braking time 632</i> . Stopping behaviors 3, 6 and 7 are only available in the configurations for sensor-less control.

11.2.1 Switch-off threshold

The *Switch-off threshold stop function 637* defines the frequency from which a standstill of the drive mechanism is recognized. The percentage parameter value is relative to the set *Maximum frequency 419*.

The switch-off threshold is to be parameterized according to the load behavior of the drive mechanism and the device output, as the drive mechanism must be controlled to a speed below the switch-off threshold.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
637	Switch-off threshold stop function	0.0 %	100.0 %	1.0 %

11.2.2 Holding time

The *Holding time stop function 638* is considered in stopping behavior 1, 3, 4 and stopping behavior 6. Controlling to speed zero leads to a heating of the motor and should only be done for a short period in internally ventilated motors.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
638	Holding time stop function	0.0 s	200.0 s	1.0 s

11.3 Direct current brake

Stopping behaviors 3, 6, 7 and the search run function contain the direct current brake. Depending on the setting of the stop function, a direct current is impressed into the motor either directly or in standstill after the demagnetization time. The impression of the *Braking current 631* leads to a heating of the motor and should only be done for a short period in internally ventilated motors.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
631	Braking current	0.00 A	$\sqrt{2} \cdot I_{FIN}$	$\sqrt{2} \cdot I_{FIN}$

The setting of the parameter *Braking time 632* defines the stopping behavior controlled by time. The contact-controlled operation mode of the direct current brake is to be activated by the value zero for the *Braking time 632*.

Time controlled:

The direct current brake is activated with the controller release and the Start clockwise and Start anticlockwise signals. The current set by the parameter *Braking current 631* flows until the time set by the parameter *Braking time 632* has expired or a control signal logically becomes 0.

Contact-controlled:

If the parameter *Braking time 632* is set to the value 0.0 s, the direct current brake is only controlled by the Start clockwise and Start anticlockwise signals. The time monitoring and limit by the *Braking time 632* are deactivated.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
632	Braking time	0.0 s	200.0 s	10.0 s

To avoid current surges, which can possibly lead to a fault switch-off of the frequency inverter, a direct current may only be impressed into the motor after the latter has been demagnetized. As the demagnetization time depends on the motor used, it can be set with the parameter *Demagnetizing time* **633**.

The demagnetization time should be parameterized in the range of three times the rotor time constant.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
633	Demagnetization time	0.1 s	30.0 s	5.0 s

The selected configuration is extended by a current controller to control the direct current brake. The compensated proportional regulator controls the current impression of the parameterized *Braking current* **631**.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
634	Amplification	0.00	10.00	1.00
635	Integral time	0 ms	1000 ms	50 ms

11.4 Auto-start

The Auto-start function is suitable for applications that permit a start at mains voltage by their function. By activation of the auto-start function with the parameter *Auto-start* **651** the frequency inverter accelerates the drive mechanism after application of the mains voltage. The controller release control signal and the start command are necessary according to the regulations.

The motor is accelerated when switched on according to the parameterization and the reference value signal.

Operation mode	Function
0 - Off	The drive mechanism is accelerated if the controller release and the start command are switched after application of the mains voltage.
1 - Switched on	By application of the mains voltage, the drive mechanism is accelerated by the frequency inverter.



Danger: At the point, we expressly refer to VDE provision 0100 part 227 and provision 0113, in particular Sections 5.4, protection against independent restarting after a power failure and resumption of voltage, and Section 5.5, undervoltage protection.

A risk to man, machines and production goods is to be ruled out if one of these cases occurs.

Further, particular national directives and those applicable for the case of application in question are to be obeyed.

11.5 Search run

The synchronization to a rotating drive mechanism is necessary in applications which drive the motor by their behavior or if the drive mechanism is still rotating after a fault switch-off. With the help of *Operation mode search run* **645** there is synchronization to the current motor speed without an "Overcurrent" fault message. After this, the motor is guided to the reference speed with the set acceleration.

The synchronization function determines the current rotary frequency of the drive mechanism via a search run in operation modes 1 to 5.

The synchronization in operation modes 10 to 15 is accelerated by short test impulses. Rotary frequencies of up to 250 Hz are determined within 100 ms to 300 ms. For higher frequencies, a wrong frequency is determined and the synchronization fails. The search run cannot determine whether an attempt at synchronization has failed in the operation modes "Quick synchronization".

Operation mode	Function
0 - off	The synchronization to a rotating drive mechanism is deactivated.
1 - Search Dir. acc. to Preset Val.	The search direction is stated by the sign in front of the reference value. If a positive reference value (clockwise rotating field) is stated, the search is in a positive direction (clockwise rotating field), with a negative reference value, the search is in a negative direction (anticlockwise rotating field).
2 - First Clockw., Then Anticl., DCB	The first attempt is to synchronize to the drive mechanism in a positive direction (clockwise rotating field). If this attempt fails, the attempt is to synchronize to the drive mechanism in a negative direction (anticlockwise rotating field).
3 - First Anticl., Then Clockw., DCB	The first attempt is to synchronize to the drive mechanism in a negative direction (anticlockwise field of rotation). If this attempt fails, the attempt is to synchronize to the drive mechanism in a positive direction (clockwise rotating field).
4 - Clockwise Only, DC-Brake	Synchronization to the drive mechanism is only done in a positive direction (clockwise rotating field).
5 - Anti-clockwise Only, DC-Brake	Synchronization to the drive mechanism is only done in a negative direction (anticlockwise rotating field).
10 - Quick Synchronisation	An attempt is made to synchronize to the drive mechanism in a positive direction (clockwise rotating field) and negative (anticlockwise rotating field).
11 - Quick Synch. acc. to Preset Value	The search direction is determined by the sign in front of the reference value. If a positive reference value (clockwise rotating field) is stated, the search direction is in a positive direction (clockwise rotating field), with a negative reference value, the search is in a negative direction (anticlockwise rotating field).
14 - Quick Sync., Clockwise Only	Synchronization to the drive mechanism is only done in a positive direction (clockwise rotating field).
15 - Quick Sync., Anti-clockwise Only	Synchronization to the drive mechanism is only done in a negative direction (anticlockwise rotating field).

The operation modes 1, 4 and 5 state a direction of rotation for the search run and avoid a deviating direction. The search run can accelerate drive mechanisms by checking the rotary frequency if the mechanism possesses a low moment of inertia or a small load moment.

In operation modes 10 to 15, determination of a wrong direction of rotation cannot be ruled out in quick synchronization. For example, a frequency not equal to zero can be determined although the drive mechanism is stationary. If there is no overcurrent, the drive mechanism is accelerated accordingly. The statement of a direction of rotation takes place in operation modes 11, 14 and 15.

Synchronization changes the parameterized starting behavior of the selected configuration. To start with, the start command activates the search run in order to determine the rotary frequency of the drive mechanism. In operation modes 1 to 5, the *Current / Rated motor current* **647** is used as a percentage of the *Rated current* **371** for synchronization.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
647	Current / rated motor current	1.00 %	100.00 %	70.00 %

The sensor-less control is extended for the search run by a compensated proportional regulator, which regulates the parameterized *Current / Rated motor current* **647**.

If the *Operation mode Synchronization* **645** parameter has been set to operation mode 1 to 5 (search run), there is firstly a wait for the *Demagnetization time* **633** before the search run is started.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
648	Amplification	0.00	10.00	1.00
649	Integral time	0 ms	1000 ms	20 ms

If synchronization to the drive mechanism is not possible, the *Braking current* **631** is impressed into the motor in operation modes 1 to 5 for the duration of the *Braking time after search run* **646**. The impress of the direct current set in the parameters of the direct current brake leads to a heating of the motor and should only be done for a short period in internally ventilated motors.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
646	Brake time after search run	0.0 s	200.0 s	10.0 s

11.6 Positioning

Controlled positioning uses a digital reference signal for speed-independent positioning of the drive mechanism. The feedback of the current position relates to the revolutions of the motors relative to the time of the reference signal. The precision of the positioning for the application to be realized is dependent on the current *Actual frequency* **241**, the *deceleration (clockwise)* **421**, the *No. of pole pairs* **373**, the selected *Positioning distance* **460** and the parameterized control functions and methods.

The parameter *Positioning* **458** activates the function "Positioning from reference point" in operation mode 1.

Operation mode	Function
0 - Off	Positioning has been switched off.
1 - Pos. from reference point	Positioning from reference point, the reference point is registered via a <i>Signal source</i> 459

The digital signal for registration of the reference point and the logical assignment are to be chosen from a selection of *signal sources* **459**. The assignment of the digital inputs S2IND, S3IND and S6IND with further functions is to be checked according to the selected *Configuration* **030**.

Operation mode	Function
2 - S2IND, falling edge	The positioning starts with the logical signal change from 1 (HIGH) to 0 (LOW) at the reference point.
3 - S3IND, falling edge	
6 - S6IND, falling edge	
1x - SxIND, rising edge	The positioning starts with the logical signal change from 0 (LOW) to 1 (HIGH)
2x - SxIND, rising/falling edge	The positioning begins with the logical signal change

The distance between the reference point and the required position is to be stated in revolutions. The calculation of the distance covered is done with the selected *Positioning distance 460* according to the application.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
460	Positioning distance	0.000 U	1000000.000 U	0.000 U

The actual value parameter *Revolutions 470* facilitates the setting and optimization of the function. The revolutions of the motor displayed should correspond to the *Positioning distance 460* at the required position.

The registration of the reference position via a digital signal can be influenced by a variable dead time in reading in and processing the control command. The signal running time is compensated by a positive value for the *Signal correction 461*. The setting of a negative signal correction decelerates the processing of the digital signal.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
461	Signal correction	-327.68 ms	+327.67 ms	0.00 ms

The influences on the positioning dependent on the operating point are to be corrected empirically via the *Load correction 462* parameter. If the required position is not reached, the deceleration duration is increased by a positive value for the load correction. The distance between the reference point and the required position is lengthened. Negative values accelerate the braking process and shorten the distance of positioning. The limit of the negative signal correction results from the application and the *Positioning distance 460*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
462	Load correction	-32768	+32767	0

The behavior of the positioning after the required position of the drive mechanism has been reached can be defined via the *Activity after positioning 463* parameter.

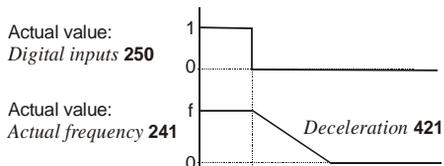
Operation mode	Function
0 - End positioning	The drive mechanism is stopped with the stopping behavior of the <i>Operation mode stop function 630</i> .
1 - Waiting for positioning signal	The drive mechanism is held until the next signal edge; with a new edge of the position signal, there is acceleration in the previous direction of rotation.
2 - Reversal by new edge	The drive mechanism is held until the next signal edge; with a new edge of the position signal, there is acceleration in the opposite direction of rotation.
3 - Positioning ; off	The drive mechanism is stopped and the power part of the inverter switched off.
4 - Start by time control	The drive mechanism is held for the <i>Time to wait 464</i> ; after the waiting time, there is acceleration in the previous direction of rotation.
5 - Reversal by time control	The drive mechanism is held for the <i>Time to wait 464</i> ; after the waiting time, there is acceleration in the opposite direction of rotation.

The position reached can be maintained for the *Waiting time 464* before the drive mechanism is accelerated according to operation mode 4 or 5.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. Set.
464	Waiting time	0 ms	3600000 ms	0 ms

Examples of positioning from reference point as a function of the parameter settings selected in the works.

Positioning 458 = 1



- The reference point is registered according to the *Signal sources 459* parameter in operation mode 2–S2IND, neg. edge by a signal on digital input 2.
- The *Positioning distance 460* with the parameter value 0.000 U defines a direct stoppage of the drive mechanism according to the defined *Operation mode stop function 630*
- The *Signal correction 461* of the signal running time from the measurement point to the frequency inverter is not used by the 0 ms.
- The *Load correction 462* can compensate a faulty positioning by the load behavior. Ex works, the compensation with the value 0 is deactivated.
- The *Action after positioning 463* is defined by operation mode 0–End of positioning.
- The *Waiting time 464* is not considered by the *Activity after positioning 463* parameter in the above setting.
- The actual value *Rotations 470* enables a direct comparison with the required *Positioning distance 460*.

12 Error and warning behavior

Operation of the frequency inverter and the connected load is continuously monitored. The monitoring functions are to be parameterized with the matching limit values specific to the application. If the limits have been set below the switch-off limit of the frequency inverter, the fault switch-off can be prevented by suitable measures in the event of a warning message.

The warning message is displayed with the LED's and can be read out with the operating unit via the parameter *Warnings* **269** or issued via one of the digital control outputs.

12.1 Overload Ixt

The admissible load behavior depends on various technical data of the frequency inverters and the ambient conditions.

The selected *Switching frequency* **400** determines the reference current and the available overload for one second and for sixty seconds. The *Warning limit short-term Ixt* **405** and *Warning limit long-term Ixt* **406** are to be parameterized accordingly.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
405	Warning limit short-term Ixt	6 %	100 %	80 %
406	Warning limit long-term Ixt	6 %	100 %	80 %

12.2 Temperature

The ambient conditions and the current operating point lead to a heating of the application. In order to avoid a fault switch-off of the frequency inverter, the *Warning limit Tc* **407** for the heat sink temperature limit and the *Warning limit Ti* **408** as a temperature limit in the inside are to be parameterized. The temperature value calculated from the type-independent limit value less the warning limit set is to be determined from the application data.

The switch-off limit of the frequency inverter is at 60°C – 70°C inside temperature and 80°C – 90°C heat sink temperature.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
407	Warning limit Tc	-25 °C	0 °C	-5 °C
408	Warning limit Ti	-25 °C	0 °C	-5 °C

12.3 Controller status

The selected control functions and methods and the matching monitoring functions prevent a switch-off of the frequency inverter. The intervention of the function amends the operating behavior of the application and can be displayed by the status messages with the parameter *Controller status* **275**. The limit values and incidents leading to intervention by the controller in question are described in the chapters in question. The behavior in intervention of a controller is configured with the parameter *Controller status message* **409**.

Operation mode	Function
0 - No Message	Controllers influencing the operating behavior are displayed in the <i>Controller status</i> 275 parameter.
1 – Warning Status	The limitation by a controller is displayed as a warning by the operating unit.
4 – Warning Status and LED	The limitation by a controller is displayed as a warning by the operating unit and the LED's.

12.4 IDC compensation limit

A DC voltage component can occur in the output current at the output of the frequency inverter due to unbalances. This DC voltage component can be compensated by the frequency inverter. The maximum output voltage of the compensation is set with the parameter *IDC compensation limit* **415**. If a higher voltage than the set limit is needed for the compensation of a DC voltage component, the error "F1301 IDC COMPENSATION" is triggered.

If this fault occurs, there should be a check whether the load is possibly defective. The voltage limit may possibly have to be increased.

If the parameter *IDC compensation limit* **415** is reduced to zero, the DC compensation is deactivated.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
415	IDC compensation limit	0.0 V	1.5 V	0.0 V

12.5 Frequency switch-off limit

The maximum allowed output frequency of the frequency inverter is to be set with the parameter *Frequency switch-off limit* **417**. If this frequency limit is exceeded by the *Stator frequency* **210** or *Actual frequency* **241**, the frequency inverter switches off with fault message "F1100".

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
417	Frequency switch-off limit	0.00 Hz	999.99 Hz	999.99 Hz

12.6 Motor temperature

The configuration of the control terminals contains the monitoring of the motor temperature. The monitoring function can be parameterized specific to the application via the parameter *Motor-PTC operation mode* **570**. The integration into the application is improved by an operating mode with a switch-off with a delay.

Operation mode	Function
0 - off	Monitoring of the motor temperature
1 - Warning only	The critical operating point is displayed by the operating unit and the parameter <i>Warnings</i> 269 .
2 - Error Switch-Off	The fault switch-off is displayed by message F0400. The fault switch-off can be acknowledged via the operating unit or the digital input.
3 - Err. Switch-Off 1 min delayed	The fault switch-off according to operation mode 2 is delayed by one minute.
4 - Err. Switch-Off 5 min delayed	The fault switch-off according to operation mode 2 is delayed by five minutes.
5 - Err. Switch-Off 10 min delayed	The fault switch-off according to operation mode 2 is delayed by ten minutes.

12.7 Phase failure

If a failure of one of the three phases both on the motor and also on the mains side is not noticed, it can lead to damage on the frequency inverter, the motor and on the mechanical drive components. The behavior in a phase failure can be set with the parameter *Phase supervision* **576**.

Operation mode		Function
10 - Mains: Error Switch-Off		The fault switch-off in a phase failure takes place after one minute with fault F0703. Within the delay, the warning message A0100 is displayed.
11 - Mains & Motor: Error Switch-Off		The phase monitoring switches the frequency inverter off after one minute with the fault message F0403 for a motor phase failure and F0703 for a mains phase failure.
20 - Mains: Shutdown		In a mains phase failure, the drive mechanism is shutdown with the fault F0703 after one minute
21 - Mains & Motor: Shutdown		In a mains phase failure, the function shuts the drive mechanism down directly, in a mains phase failure after one minute.

12.8 Automatic error acknowledgment

The automatic error acknowledgment enables acknowledgment of the faults Overcurrent F0500, Overcurrent F0507 and Overvoltage F0700 without interference of a superior control or the user. If one of the aforementioned errors occurs, the frequency inverter switches the power semi-conductors off and waits for the time stated with the parameter *Restart delay* **579**. If the error must be acknowledged, the speed of the machine is determined with the quick catching function and synchronized to the rotating machine. The automatic error acknowledgment makes use of the quick catching operation mode regardless of the setting of the parameter *Search run operation mode* **645**. The information of the search run function must be observed. With the parameter *Allowed no. of auto-acknowl.* **578**, the number of errors which can be acknowledged within ten minutes is set. The aforementioned faults have a separate counter, by which repeat acknowledgment above the allowed number within 10 minutes leads to a direct switch-off of the frequency inverter.

No.	Parameter Description	Setting		
		Min.	Max.	Fact. sett.
578	Allowed number of auto-acknowl.	0	20	5
579	Restart delay	0 ms	1000 ms	20 ms

13 Reference values

The ACT series frequency inverters are to be configured specific to the application and enable customer-specific adaptation of the module hardware and software structure.

13.1 Frequency limits

The speed setting range and thus the output frequency of the frequency inverter is defined by the parameters *Minimum frequency 418* and *Maximum frequency 419*. The control functions and methods in question use the two limit values for scaling and calculating the frequency.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
418	Minimum frequency	0.00 Hz	999.99 Hz	3.50 Hz
419	Maximum frequency	0.00 Hz	999.99 Hz	50.00 Hz

The torque-forming current component and thus the slip frequency of the 3-phase machine is a function of the required torque. The field-oriented control system also contains the parameter *Slip frequency 719* to limit the torque in the calculation of the machine model. The rated slip calculated from the rated motor parameters is limited in accordance with the percentage parameterized *Slip frequency 719*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
719	Slip frequency	0 %	10000 %	250 %

13.2 Percentage value limits

The setting range of the percentages is defined by the parameters *Minimum reference percentage 518* and *Maximum reference percentage 519*. The control functions and methods in question use the two limit values for scaling and calculating the frequency.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
518	Minimum reference percentage	0.00 %	300.00 %	0.00 %
519	Maximum reference percentage	0.00 %	300.00 %	100.00 %

13.3 Frequency reference value channel

The varied functions for the statement of the reference frequency are connected by the frequency reference value channel in the speed-controlled configurations. The *Reference frequency source 475* determines the additive assignment of the available reference value sources as a function of the hardware installed.

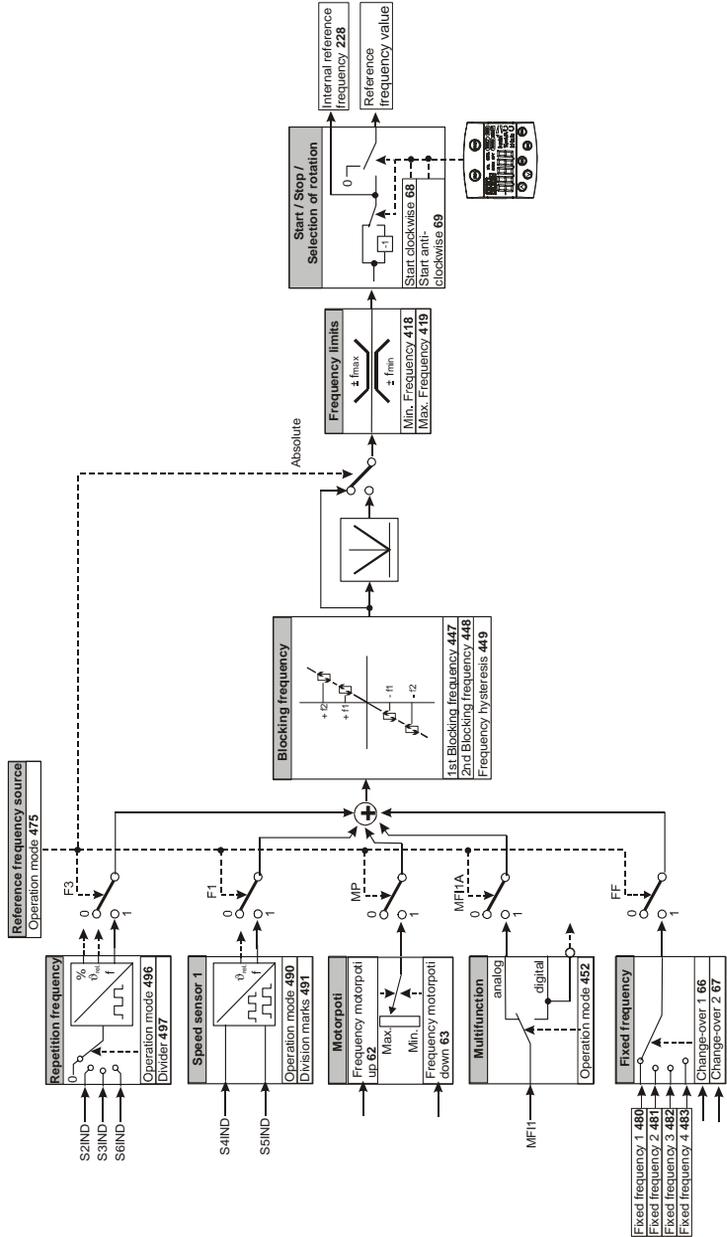
Operation mode	Function
1 - Abs. Analog Value MF1A	Reference value source is the multifunctional input 1 in <i>Operation mode 452</i> - Analog signal.
10 - Abs. Val. Fixed Frequency (FF)	The fixed frequency according to the <i>Fixed frequency change-over 1 66</i> and the current data set
11 - Abs. Value MF1A + FF	Combination of the operation modes 10 and 1
20 - Abs. Val. Motorpoti (MP)	Reference is the function <i>Frequency Motorpoti Up 62</i> and <i>Frequency Motorpoti Down 63</i>
21 - Abs. Value MF1A + MP	Combination of the operation modes 20 and 1
30 - Abs.Val. Speed Sensor 1 (F1)	The frequency signals in the <i>Operation mode Speed Sensor 1 490</i> are evaluated as reference.
31 - Abs. Value MF1A + F1	Combination of the operation modes 30 and 1
32 - Abs. Val. Rep. Freq. Inp. (F3)	The frequency signal on the digital input according to <i>Operation mode repetition frequency 496</i>
33 - Abs. Value MF1A + F3	Combination of the operation modes 32 and 1
90 - Abs. Value MF1A + FF + MP + F3	Combination of the operation modes 1, 10, 20 and 32
91 - Abs. Value MF1A+FF+MP+F1+F3	Combination of the operation modes 1, 10, 20, 30 and 32
101 to 191	Operation modes with sign (+/-)

13.3.1 Circuit diagram

The following table describes the software switches shown in the circuit diagram as a function of the selected *Frequency reference value source 475*.

Operation mode	Switch position on circuit diagram					Sign
	MF1A	FF	MP	F1	F3	
1	1					Abs. value
10		1				Abs. value
11	1	1				Abs. value
20			1			Abs. value
21	1		1			Abs. value
30				1		Abs. value
31	1			1		Abs. value
32					1	Abs. value
33	1				1	Abs. value
90	1	1	1		1	Abs. value
91	1	1	1	1	1	Abs. value
101	1					+/-
110		1				+/-
111	1	1				+/-
120			1			+/-
121	1		1			+/-
130				1		+/-
131	1			1		+/-
132					1	+/-
133	1				1	+/-
190	1	1	1		1	+/-
191	1	1	1	1	1	+/-

Circuit diagram of frequency reference value channel



13.4 Reference percentage channel

The reference percentage channel combines various signal sources for statement of the reference values. The percentage scaling facilitates integration into the application, taking various process values into account.

The *reference percentage source* **476** determines the additive assignment of the available reference value sources as a function of the hardware installed.

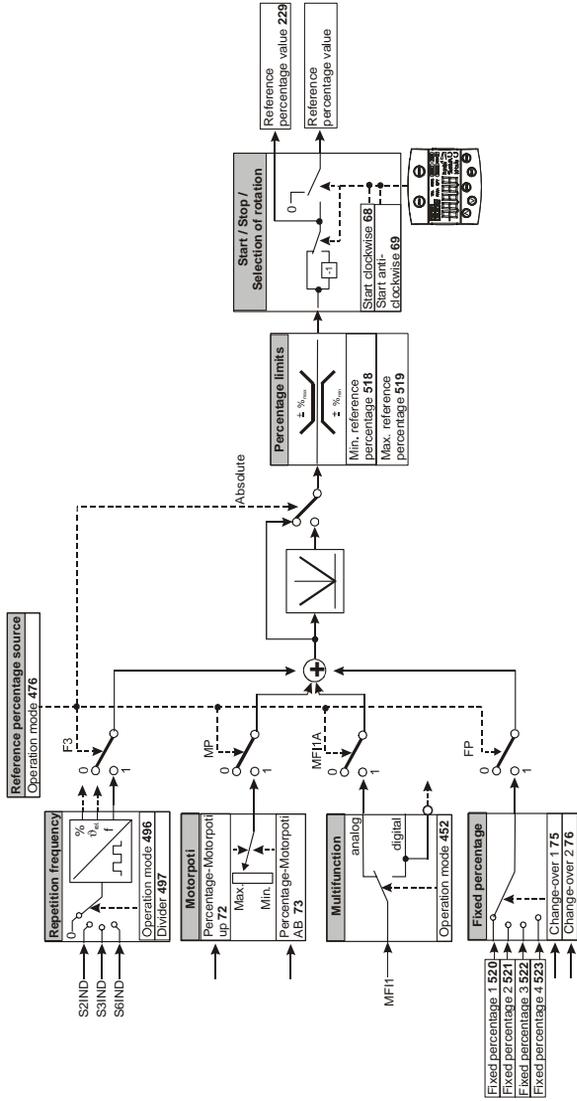
Operation mode	Function
1 - Abs. Analog Value MF1A	Reference value source is the multifunctional input 1 in <i>Operation mode</i> 452 - analog signal.
10 - Abs. Fix. Perc. Val. (FP)	The percentage according to <i>Fixed percent change-over 1</i> 75 , <i>Fixed percent change-over 2</i> 76 and the current data set
11 - Abs. Value MF1A + FP	Combination of operation modes 10 and 1
20 - Abs. Val. Motorpoti (MP)	Reference value source is the function <i>Percent Motorpoti Up</i> 72 and <i>Percent Motorpoti Down</i> 73
21 - Abs. Value MF1A + MP	Combination of the operation modes 20 and 1
32 - Abs. Val. Rep. Freq. Input (F3)	The frequency signal on the digital input according to <i>Operation mode repetition frequency</i> 496
101 to 132	Operation modes with sign (+/-)

13.4.1 Circuit diagram

The following table describes the software switches shown in the circuit diagram as a function of the selected *Reference percentage source* **476**.

Operation mode	Switch position on circuit diagram					Sign
	MF1A	FP	MP	F3		
1	1					Abs. value
10		1				Abs. value
11	1	1				Abs. value
20			1			Abs. value
21	1		1			Abs. value
32				1		Abs. value
101	1					+/-
110		1				+/-
111	1	1				+/-
120			1			+/-
121	1		1			+/-
132				1		+/-

Circuit diagram of percent reference value channel



13.5 Fixed reference values

The fixed reference values are to be parameterized as fixed frequencies or fixed percentages according to the configuration and function.

The signs of the fixed reference values determine the direction of rotation. A positive sign means a clockwise rotation, a negative sign means anticlockwise rotation. The direction can only be changed via the sign if the *Operation mode reference frequency source 475* or *Operation mode reference percentage source 476* is parameterized to an operation mode with sign (+/-). The direction of rotation can also be stated with the digital signal sources assigned to the parameters *Start clockwise 68* and *Start anticlockwise 69*.

The fixed reference values are to be parameterized in four data sets and are assigned to further sources via the reference value channel. The use of the functions *Data set change-over 1 70* and *Data set change-over 2 71* thus enable the setting of 16 fixed reference values.

13.5.1 Fixed frequencies

The four fixed frequencies define reference values which are selected via the *Fixed frequency change-over 1 66* and *Fixed frequency change-over 2 67*. The *Operation mode reference frequency source 475* defines the addition of the various sources in the reference frequency channel.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
480	Fixed frequency 1	-999.99 Hz	999.99 Hz	0.00 Hz
481	Fixed frequency 2	-999.99 Hz	999.99 Hz	10.00 Hz
482	Fixed frequency 3	-999.99 Hz	999.99 Hz	25.00 Hz
483	Fixed frequency 4	-999.99 Hz	999.99 Hz	50.00 Hz

13.5.2 JOG frequency

The JOG function is a part of the functions to control the drive mechanism via the operating unit. With the help of the arrow keys, the JOG frequency can be amended within the function. The drive mechanism starts and the machine turns at the set *JOG frequency 489*. If the JOG frequency has been amended with the help of the arrow keys, this value is stored.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
489	JOG frequency	-999.99 Hz	999.99 Hz	5.00 Hz

13.5.3 Fixed percentages

The four percentage values define reference values which are selected via the *Fixed percent change-over 1 75* and *Fixed percent change-over 2 76*. The *Operation mode reference percentage source 476* defines the addition of the various sources in the reference percentage channel.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
480	Fixed percentage 1	-300.00 %	300.00 %	0.00 %
481	Fixed percentage 2	-300.00 %	300.00 %	20.00 %
482	Fixed percentage 3	-300.00 %	300.00 %	50.00 %
483	Fixed percentage 4	-300.00 %	300.00 %	100.00 %

13.6 Frequency ramps

The ramps determine how quickly the frequency value is altered with an amendment of the reference value or after a start, stop or brake command. The maximum admissible ramp gradient is to be selected according to the application and the current consumption of the motor.

If the settings of the frequency ramps are identical for both directions of rotation, the parameterization via the parameters *Acceleration (clockwise)* **420** and *Deceleration (clockwise)* **421** is sufficient. The values of the frequency ramps are taken over for the *Acceleration anticlockwise* **422** and *Deceleration anticlockwise* **423** if these have been parameterized to the factory setting of -0.01 Hz/s.

The parameter value of 0.00 Hz/s for the acceleration blocks the corresponding direction of rotation.

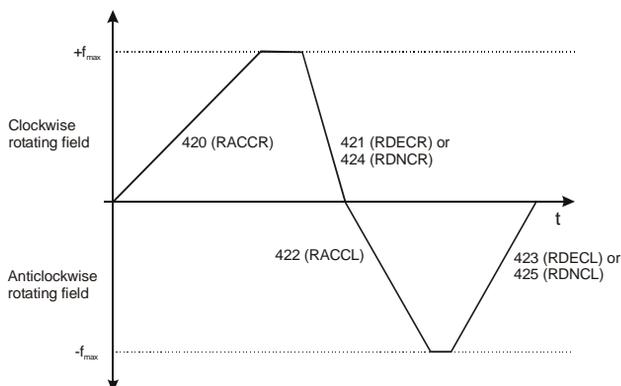
Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
420	Acceleration (clockwise)	0.00 Hz/s	999.99 Hz/s	5.00 Hz/s
421	Deceleration (clockwise)	0.01 Hz/s	999.99 Hz/s	5.00 Hz/s
422	Acceleration anticlockwise	- 0.01 Hz/s	999.99 Hz/s	- 0.01 Hz/s
423	Deceleration anticlockwise	- 0.01 Hz/s	999.99 Hz/s	- 0.01 Hz/s

The ramps for the *Emergency stop clockwise* **424** and *Emergency stop anticlockwise* **425** of the drive mechanism to be activated via *Operation mode stopping behavior* **630** must be selected according to the application. The non-linear (S-shaped) course of the ramps is not active in an emergency stop of the drive mechanism.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
424	Emergency stop clockwise	0.01 Hz/s	999.99 Hz/s	5.00 Hz/s
425	Emergency stop anticlockwise	0.01 Hz/s	999.99 Hz/s	5.00 Hz/s

The parameter *Maximum leading* **426** limits the difference between the output of the ramp and the current actual value of the drive mechanism. The set maximum deviation is a dead time for the control system which should be kept as low as possible.

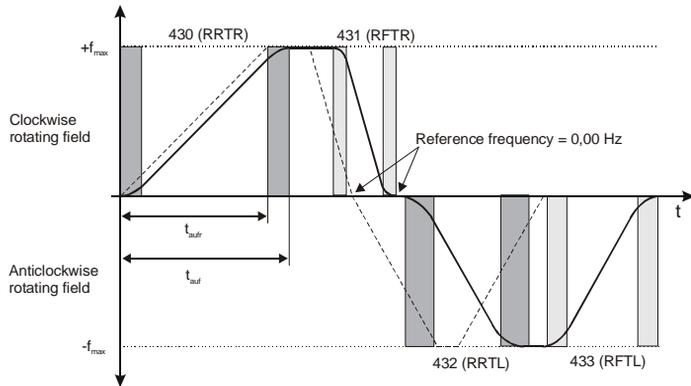
Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
426	Maximum leading	0.01 Hz/s	999.99 Hz/s	5.00 Hz/s



The load occurring in a linear acceleration of the drive is reduced by the modification speeds (S curve) to be set. The non-linear course of the frequency is defined as a ramp and states the time range in which the frequency is to be guided to the set ramp. The values set with the parameters 420 to 423 remain regardless of the selected ramp times.

Setting the ramp time with the value 0 ms deactivates the function S curve and enables the use of the linear ramps. The data set change-over of the parameters within an acceleration phase of the drive mechanism demands the defined take-over of the values. The control calculates the values necessary to reach the reference value from the ratio of the acceleration to the ramp time and uses it until the completion of the acceleration phase. With this method, exceeding the reference values is avoided and the data set change-over between extremely deviating values becomes possible.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
430	Ramp rise time clockwise	0 ms	65000 ms	0 ms
431	Ramp fall time clockwise	0 ms	65000 ms	0 ms
432	Ramp rise time anticlockwise	0 ms	65000 ms	0 ms
433	Ramp fall time anticlockwise	0 ms	65000 ms	0 ms



Example: Calculation of the acceleration time in clockwise rotation with an acceleration from 20 Hz to 50 Hz (f_{max}) and an acceleration ramp **420** of 2 Hz/s. The ramp time **430** is set at 100 ms.

$$t_{aufr} = \frac{\Delta f}{RACCR} \quad t_{aufr} = \text{Acceleration time clockwise rotation}$$

$$t_{aufr} = \frac{50\text{Hz} - 20\text{Hz}}{2\text{Hz/s}} = 15\text{s} \quad \Delta f = \text{Frequency modification acceleration ramp}$$

$$t_{auf} = t_{aufr} + RRTR \quad RACCR = \text{Acceleration clockwise}$$

$$t_{auf} = 15\text{s} + 100\text{ms} = 15,1\text{s} \quad RRTR = \text{Ramp rise time clockwise}$$

13.7 Percentage value ramps

The percentage value ramps scale the percentage reference value modification for the input function in question. The acceleration and deceleration of the drive mechanism are parameterized via the frequency ramps.

The behavior *Gradient percentage ramp 477* corresponds to a function that takes the time behavior of the drive system into account. Setting the parameter to 0%/s deactivates this function and leads to a direct reference value modification for the following function.

The value set in the factory is a function of the *Configuration 30*.

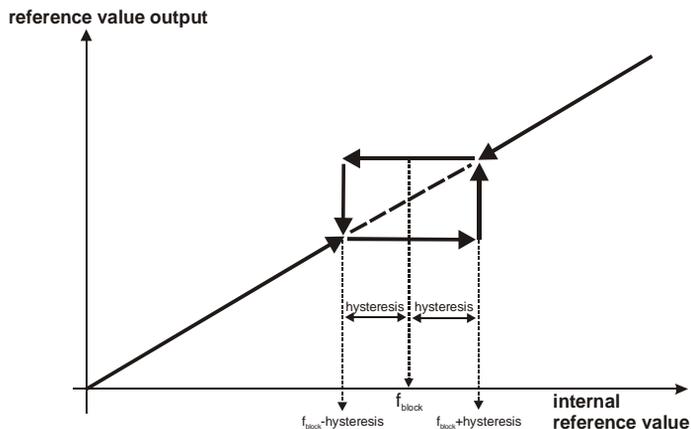
Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
477	Gradient percentage ramp	0 %/s	60000 %/s	x %/s

13.8 Block frequencies

In certain applications, it is necessary to fade out reference frequencies, by which resonance points of the system as stationary operating points are avoided. The parameters *1st block frequency 447* and *2nd block frequency 448* with the parameter *Frequency hysteresis 449* define two resonance points.

A block frequency is active if the parameter values of the block frequency and the frequency hysteresis are not equal to 0.00 Hz.

The area faded out as a stationary working point by the hysteresis is passed through as quickly as possible according to the ramp set. If a limitation of the output frequency comes about as a result of the selected setting of the control parameters, for example by the current limit being reached, the hysteresis is passed through with a delay. The behavior of the reference value can be determined from its direction of movement according to the following diagram.



13.9 Motor potentiometer

The digital control inputs are to be used in addition to the operating unit for the motor potentiometer function. The assignment of the reference value specification via the motor potentiometer is to be parameterized via the parameter *Reference frequency source 475* or *Reference percentage source 476*.

In accordance with the active reference value channel, a digital signal is assigned to the function via the parameters. The assignment is done via the software parameters stated.

Activation		
Motorpoti up	Motorpoti down	Function
0	0	Output signal is not modified
1	0	Output value rises with set ramp
0	1	Output value drops with set ramp
1	1	Output value is reset to initial value

0 = Contact open 1 = Contact closed

The *Operation mode 474* of the motor potentiometer function defines the behavior of the function at various operating points of the frequency inverter. The limitation of the reference values is done via the limit values *Minimum frequency 418*, *Maximum frequency 419* or *Minimum percentage 518*, *Maximum percentage 519*.

Operation mode	Function
0 - Not Latching	In the operation mode motor potentiometer non-storing the drive mechanism goes to the set minimum reference value at each start.
1 - Latching	In the operation mode with storing the motor goes to the reference value selected before the switch-off at the start. The reference value is also stored when the device is switched off.
2 - Taking Over	The operation mode Motorpoti taking over is to be used for the data set change-over of the reference value channel. The current reference value is used in the change to the motorpoti function.
3 - Taking Over and Latching	This operation mode combines the behavior in operation mode 1 and 2

The operating unit contains the motor potentiometer functionality via the various keys. The modification of the reference value is limited by the parameter *Ramp Keypad-Motorpoti 473*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
473	Ramp Keypad-Motorpoti	0.00 Hz/s	999.99 Hz/s	2.00 Hz/s

13.10 Repetition frequency input

The use of a frequency signal completes the various possibilities of the reference value specification. The signal on one of the available digital inputs is evaluated according to the selected *Operation mode 496*.

Operation mode		Function
0 -	off	The repetition frequency is zero.
21 -	S2IND Single Evaluation pos.	One edge of the frequency signal on terminal X210A.4 is evaluated with a positive sign.
22 -	S2IND Double Evaluation pos.	Both edges of the frequency signal on terminal X210A.4 are evaluated with a positive sign.
31 -	S3IND Single Evaluation pos.	One edge of the frequency signal on terminal X210A.5 is evaluated with a positive sign.
32 -	S3IND Double Evaluation pos.	Both edges of the frequency signal on terminal X210A.5 are evaluated with a positive sign.
61 -	S6IND Single Evaluation pos.	One edge of the frequency signal on terminal X210B.1 is evaluated with a positive sign.
62 -	S6IND Double Evaluation pos.	Both edges of the frequency signal on terminal X210B.1 are evaluated with a positive sign.
121 to 162		Operation modes 21 to 62 with evaluation of the frequency signal, but with a negative sign.

The signal frequency at the selected repetition frequency input can be scaled via the parameter *Divider 497*. The parameter value is comparable with the division marks of a speed sensor per rotation of the drive mechanism. The frequency limit of the parameterized digital input is to be taken into account for the frequency of the input signal.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
497	Divider	1	8192	1024

Note: The various possibilities of reference value specification within the different functions enables the use of the repetition frequency input as a percentage value. The signal frequency of 100 Hz on the repetition frequency input corresponds to 100 %, or 1 Hz corresponds to 1 %. The parameter *Divider 497* is to be used in a way comparable with the speed sensor simulation.

14 Control inputs and outputs

The modular structure of the frequency inverters enables a wide range of applications on the basis of the available hardware and software functionality. The control inputs and outputs described below are to be used via connection terminals X210A and X210B and to be freely connected with software modules via the described parameters.

14.1 Multifunctional input MF11

Multifunctional input MF11 can optionally be configured as a voltage input, current input or as a digital input. Depending on the selected *Operation mode Multifunctional input 452* a connection with various functions of the software is possible. The operation modes not used are connected with the signal value zero (LOW).

Operation mode	Function
1 - Voltage input	Voltage signal (MF11A), 0V to 10V
2 - Current input	Current signal (MF11A), 0mA to 20mA
3 - Digital input	Digital signal (MF11D), 0V to 24V

14.1.1 Analog input MF11A

The multifunctional input MF11 is configured in the factory for an analog reference value source with a voltage signal of 0V to 10V.

The operation mode analog current signal from 0mA to 20mA is to be parameterized alternatively. The current signal is continuously monitored and the fault message "F1407" displayed if the maximum value is exceeded.

14.1.1.1 Characteristic

The mapping of the analog input signals onto a reference frequency or percentage value is possible for various requirements. The parameterization is to be done via two points of the linear characteristic of the reference value channel.

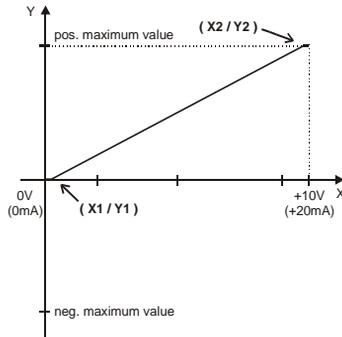
Characteristic point 1 with the coordinates X1 and Y1 and characteristic point 2 with the coordinates X2 and Y2 are to be set in the four data records.

No.	Parameter	Setting		
		Min.	Max.	Fact. sett.
454	Characteristic point X1	0.00 %	100.00 %	2.00 %
455	Characteristic point Y1	-100.00 %	100.00 %	0.00 %
456	Characteristic point X2	0.00 %	100.00 %	98.00 %
457	Characteristic point Y2	-100.00 %	100.00 %	100.00 %

The coordinates of the characteristic points refer as a percentage to the analog signal with 10V or 20mA and the parameter *Maximum frequency 519* or parameter *Maximum percentage 519*. The change of direction of rotation can be done via the digital inputs or by selection of the characteristic points.

Attention: The monitoring of the analog input signal via the parameter *Error/Warning behavior 453* demands the examination of the parameter *Characteristic point X1 454*.

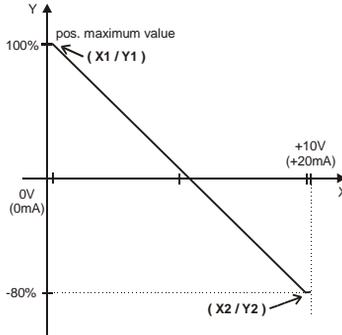
The following characteristic has been set in the factory and is to be adapted to the application by the parameters mentioned.



Characteristic point 1:
 $X1 = 2.00\% \cdot 10V = 0.20V$
 $Y1 = 0.00\% \cdot 50.00Hz = 0.00Hz$

Characteristic point 2:
 $X2 = 98.00\% \cdot 10V = 9.80V$
 $Y2 = 100.00\% \cdot 50.00Hz = 50.00Hz$

The freely configurable characteristic enables not only the setting of a tolerance and the ends but also the definition of two directions of rotation. The following example shows the inverse reference value specification with additional change of the direction of rotation often use in a pressure control.



Characteristic point 1:
 $X1 = 2.00\% \cdot 10V = 0.20V$
 $Y1 = 100.00\% \cdot 50.00Hz = 50.00Hz$

Characteristic point 2:
 $X2 = 98.00\% \cdot 10V = 9.80V$
 $Y2 = -80.00\% \cdot 50.00Hz = -40.00Hz$

The change of direction of rotation is done in this example at an analog input signal of 5.5V.

The definition of the analog input characteristic can be calculated via the two-point form of the linear equation. The speed Y of the drive mechanism is controlled according to the analog control signal X.

$$Y = \frac{Y2 - Y1}{X2 - X1} \cdot (X - X1) + Y1$$

14.1.1.2 Scaling

The analog input signal is mapped onto the freely configurable characteristic. The maximum admissible range of the drive mechanism is to be set according to the selected configuration via the frequency limits or the percentage limits. In the parameterization of a bipolar characteristic, the minimum and maximum limit are taken over for both directions of rotation. The percentage values of the characteristic points are relative to the limits selected.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
418	Minimum frequency	0.00 Hz	999.99 Hz	3.50 Hz
419	Maximum frequency	0.00 Hz	999.99 Hz	50.00 Hz

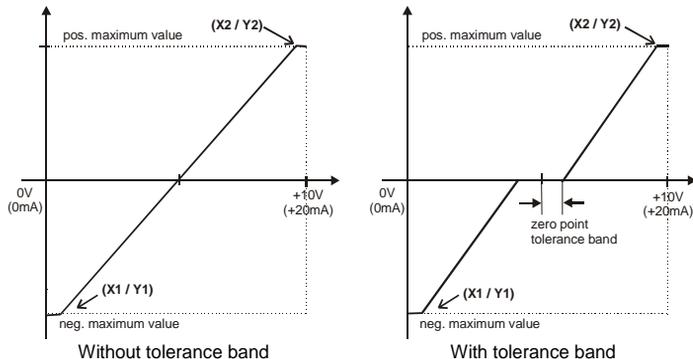
The controller uses the maximum value of the output frequency, which is calculated from the *Maximum frequency* 419 and the compensated slip of the drive mechanism. The frequency limits define the speed range of the drive mechanism and the percentage limits supplement the scaling of the analog input characteristic according to the configured function.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
518	Minimum percentage	0.00 %	300.00 %	0.00 %
519	Maximum percentage	0.00 %	300.00 %	100.00 %

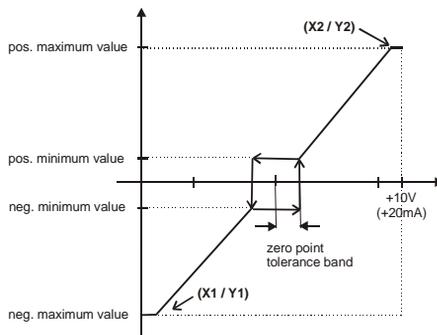
14.1.1.3 Tolerance band and hysteresis

The analog input characteristic with change of sign of the reference value can be adapted to the application by the parameter *Tolerance band* 450. The tolerance band to be defined extends the zero passage of the speed relative to the analog control signal. The percentage parameter value is relative to the maximum current or voltage signal.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
450	Tolerance band	0.00 %	25.00 %	2.00 %



The *Minimum frequency 418* or the *Minimum percentage 518* set in the factory extend the parameterized tolerance band to the hysteresis



Tolerance band with set maximum frequency

For example, the output value coming from the input signals is kept at the positive minimum value until the input signal becomes smaller than the value for the tolerance band in a negative direction. Only then is there further procedure on the characteristic set.

14.1.1.4 Error and warning behavior

The monitoring of the analog input signal necessary according to the application is to be configured via the parameter *Error and warning behavior 453*.

Operation mode	Function
0 - Off	The input signal is not monitored.
1 - Warning < 1V/2mA	If the input signal is smaller than 1V or 2mA there is a warning message.
2 - Shutdown < 1V/2mA	If the input signal is smaller than 1V or 2mA there is a warning message, the drive is decelerated according to stopping behavior 2.
3 - Error-Switch-Off < 1V/2mA	If the input signal is smaller than 1V or 2mA there is a warning and fault message.

The monitoring of the analog input signals is active independent of the release of the frequency inverter according to the selected operation mode.

In operation mode **2**, the drive is decelerated independent of the stopping behavior according to stopping behavior 2 (shutdown and hold). If the set holding time has expired, there is a fault message. The further starting of the drive is possible by switching the start signal on and off.

The operation mode **3** defines the free stopping of the drive, independent of the stopping behavior, which has been stipulated with the parameter *Stop function 630 (DISEL)*.

Attention: The monitoring of the analog input signals via the parameter *Error/warning behavior 453* demands examination of the parameter *Characteristic point X1 454*.

14.2 Multifunctional output MFO1

The multifunctional output MFO1 can optionally be configured as a digital output, analog output or as an output of the repetition frequency. According to the selected *Operation mode Multifunctional output 550*, a connection with various functions of the software is possible. The operation modes not used are deactivated internally.

Operation mode	Function
0 - Off	Output has the logic signal LOW
1 - Digital	Digital output, 0 to 24 V
2 - Analog	Analog output, 0 to 24 V
3 - Repetition frequency	Repetition frequency output, 0 to 24 V, $f_{\max} = 150$ kHz

14.2.1 Analog output MFO1A

The multifunctional output MFO1 has been configured in the factory for the output of a pulse width modulated output signal with a maximum voltage of 24V. The actual values to be selected via the parameter *Analog operation MFO1 553* are a function of the configuration selected.

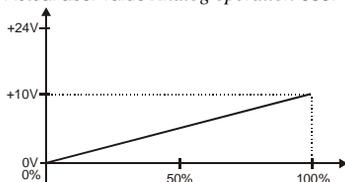
Operation mode	Function
0 - Off	Analog operation MFO1 switched off
1 - Abs. Fs	Abs. value of the stator frequency, 0.00Hz to <i>Maximum frequency 419</i>
2 - Abs. Fs betw. fmin/fmax	Abs. value of the stator frequency, <i>Minimum frequency 418</i> to <i>Maximum frequency 419</i>
3 - Abs. Speed Sensor 1	Abs. value of the speed sensor signal 1, 0.00 Hz to <i>Maximum frequency 419</i>
4 - Abs. Speed Sensor 2	Abs. value of the speed sensor signal 2, 0.00 Hz to <i>Maximum frequency 419</i>
7 - Abs. Actual Frequency	Abs. value of the actual frequency, 0.00 Hz to <i>Maximum frequency 419</i>
20 - Abs. Iactive	Abs. value of the present active current I_{active} , 0.0 A to FU reference current
21 - Abs. Isd	Abs. value of the flux-forming current component, 0.0 A to FU reference current
22 - Abs. Isq	Abs. value of the torque-forming current component, 0.0 A to FU reference current
30 - Abs. Pactive	Abs. value of the present active power P_{active} , 0.0 kW to <i>Rated mech. power 376</i>
31 - Abs. M	Abs. value of the calculated torque M, 0.0 Nm to rated moment
32 - Abs. Inside Temperature	Abs. value of the measured inside temperature, 0 °C to 100 °C
33 - Abs. Heat Sink Temperature	Abs. value of the measured heat sink temperature, 0 °C to 100 °C
40 - Abs. Analog Input MF1A	Abs. signal value on analog input 1, 0.0 V to 10.0 V
50 - Abs. I	Abs. current value of the measured output currents, 0.0 A to FU reference current
51 - DC-Link Voltage	DC link voltage U_d , 0.0 V to 1000.0 V
52 - V	Output voltage U, 0.0 V to 1000.0 V
53 - Volume Flow	Abs. value of calculated volumetric flow 0.0 m ³ /h to <i>Nominal volumetric flow 397</i>
54 - Pressure	Abs. value of calculated pressure 0.0 kPa to <i>Reference pressure 398</i>
101 to 133	Operation modes in analog operation with signs

14.2.1.1 Output characteristic

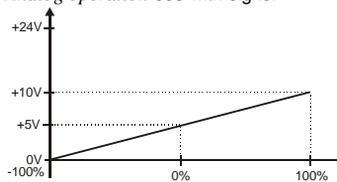
The mapping of the analog output signals to the parameterized *Operation mode Analog operation MFO1 553* is possible for further applications via the parameter *Voltage 100% 551* and *Voltage 0% 552*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
551	Voltage 100%	0.0 V	24.0 V	10.0 V
553	Voltage 0%	0.0 V	24.0 V	0.0 V

Actual abs. value *Analog operation 553*:



Analog operation 553 with signs:



With the parameters *Voltage 100% 551* and *Voltage 0% 552* the voltage range at 100% and 0% respectively of the value to be output is set. If the output value exceeds the reference value, the output voltage exceeds the value of the parameter *Voltage 100% 551* up to the maximum value of 24V.

14.2.2 Frequency output MFO1F

The multifunctional output MFO1 is to be used as a frequency output as a function of the selected *Operation mode Multifunctional output 550*. The 24V output signal is assigned to the abs. value of the speed or frequency via the parameter *Repetition frequency output MFO1 555*.

Operation mode	Function
0 - Off	Repetition frequency operation MFO1 switched off
1 - Actual frequency	Abs. value of the <i>Actual frequency 241</i>
2 - Stator frequency	Abs. value of the <i>Stator frequency 210</i>
3 - Freq. speed sensor 1	Abs. value of the <i>Freq. speed sensor 1 217</i>
4 - Freq. speed sensor 2	Abs. value of the <i>Freq. speed sensor 2 217</i>
5 - Repetition freq. input	Abs. value of the <i>Repetition freq. input 252</i>

14.2.2.1 Scaling

The mapping of the parameterized *Operation mode repetition freq. operation MFO1 555* corresponds to the mapping of an incremental sensor. The parameter *Division marks 556* is to be parameterized, taking the frequency to be output into account.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
556	Division marks	30	8192	1024

The frequency limit of $f_{\max}=150\text{kHz}$ may not be exceeded in the calculation of the parameter *Division marks 556*.

$$S_{\max} = \frac{150000\text{Hz}}{\text{abs. frequency value}}$$

14.3 Digital outputs

The *Operation mode Digital output 1* **530** and the relay output with the parameter *Operation mode Digital output 3* **532** connect the digital outputs with various functions. The selection of functions depends on the parameterized configuration. The use of the multifunctional output MFO1 as a digital output demands parameterization of the *Operation mode MFO1* **550** and connection via the parameter *Digital operation MFO1* **554**.

Operation mode	Function
0 - off	Digital output is switched off
1 - Ready or Standby Signal	Frequency inverter is initialized and on stand-by or in operation
2 - Run Signal	Signal controller approval and a start command exist, output frequency available
3 - Error Signal	Message is displayed via the parameter <i>Current error</i> 259 or <i>Warnings</i> 269
4 - Setting Frequency	The <i>Stator frequency</i> 210 is larger than the parameterized <i>Setting frequency</i> 510
5 - Reference Frequency reached	The <i>Actual frequency</i> 241 of the drive has reached the <i>Internal reference frequency</i> 228
6 - Reference Percentage reached	The <i>Actual percentage</i> 230 has reached the <i>Reference percentage</i> 229
7 - Ixt-Warning	The <i>Warning limit short-term Ixt</i> 405 or <i>Warning limit long-term Ixt</i> 406 has been reached
8 - Warning Heat Sink Temperature	Max. heat sink temperature T_C of 80 °C less the <i>Warning limit T_C</i> 407 reached
9 - Warning Inside Temperature	Max. inside temperature T_i of 65 °C less the <i>Warning limit T_i</i> 408 reached
10 - Warning Motor Temperature	Warning behavior according to parameterized <i>Operation mode Motor PTC</i> 570 at max. motor temperature T_{PTC}
11 - Warning, General	The message is displayed via the parameter <i>Warnings</i> 269
12 - Warning Overtemperature	The selected limit values <i>Warning limit T_C</i> 407 , <i>Warning limit T_i</i> 408 or the maximum motor temperature have been exceeded
13 - Mains Failure	Failure of the mains voltage and power regulation active according to <i>Operation mode Voltage Controller</i> 670
14 - Warning Motor Protect. Switch	Parameterized <i>Operation mode Motor protective switch</i> 571 has triggered
15 - Warning Current Limitation	A controller or the <i>intelligent current limits</i> 573 limit the output current
16 - Controller Current Limit. Long Term Ixt	The overload reserve for 60 s has been used and the output current in being limited
17 - Controller Current Limit. Short Term Ixt	The overload reserve for 1 s has been used and the output current in being limited
18 - Controller Current Limit. T_C	Max. heat sink temperature T_C reached, <i>intelligent current limits</i> 573 active
19 - Controller Current Limit. M-PTC	Max. motor temperature T_{PTC} reached, <i>intelligent current limits</i> 573 active
20 - Comparator 1	The comparison according to the selected <i>Operation mode Comparator 1</i> 540 is true
21 - Comparator 2	The comparison according to the selected <i>Operation mode Comparator 2</i> 543 is true
22 - Warning V-Belt	Warning of the <i>V-belt monitoring</i> 581

Continuation of the operation modes for the digital outputs.

Operation mode	Function
23 - Timer 1	The selected <i>Operation mode Timer 1 790</i> generates an output signal of the function
24 - Timer 2	The selected <i>Operation mode Timer 2 793</i> generates an output signal of the function
25 - Warning Mask	Message of the configured <i>Warning mask 536</i>
30 - Flux-Forming finished	Magnetic field has been impressed
41 - Brake release	Activation of a brake unit dependent on <i>Starting behavior 620</i> , <i>Stopping behavior 630</i> or the configured brake control
43 - Separating Contactor	The <i>Switch-on temperature 39</i> has been reached
50 - External fan	<i>Warning limit 597</i> of the index control exceeded
51 - Synchronization Fault	Index signals of master and slave faulty
100 to 151	Operation modes inverted (LOW active)

14.3.1 Setting frequency

If **operation mode 4** is selected, the output in question becomes active if the *Stator frequency 210* has exceeded the value set under the parameter *Setting frequency 510*.

The output in question is switched over again as soon as the *Stator frequency 210 (FS)* falls below the set value.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
510	Setting frequency	0.00 Hz	999.99 Hz	3.00 Hz

14.3.2 Reference value reached

In **operation mode 5 or 6** a message is generated via the output in question when the actual frequency or percentage has reached the reference value.

The maximum deviation can be stated as a percentage of the adjustable range (Max - Min) via the parameter *Max. control deviation 549*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
549	Max. control deviation	0.01 %	20.00 %	5.00 %

14.3.3 Flux formation ended

If **operation mode 30** is selected, the output in question becomes active when the flux formation is ended. The time for the flux formation results from the operating state of the machine and the set parameters for the magnetizing of the machine. The magnetizing is to be defined via the starting behavior and is influenced by the amount of the set starting current.

14.3.4 Mechanical brake release

The Open brake function in **operation mode 41** enables the activation of a corresponding unit via the digital control output. The function uses both the control commands via the contact inputs and the set starting and stopping behavior to control the digital output.

According to the configured starting behavior, the output is switched on when the magnetizing of the motor is finished. According to the setting selected, the brake is loosened and the drive mechanism accelerated.

The behavior in the stoppage of the drive depends on the configuration of the parameter *Stop function* **630**. If the stopping behavior has been selected with the function Hold, the drive mechanism is controlled to zero speed and the digital output not switched off. In the further operation modes of the stop function, the control of the brake is possible. At the start of a free stoppage of the drive, the digital output is switched off.

The behavior in the stoppage behavior with shutdown is comparable. The drive is decelerated and supplied with current for the set holding time. Within the set holding time, the control output is switched off and thus the brake activated.

14.3.5 Current limitation

Operation modes 15 to 19 connect the digital outputs and the relay output with the functions of the intelligent current limits. The reduction of power by the set value in percent of the rated current is dependent upon the selected operation mode. Accordingly, the incident can be output for intervention of the current limitation with the operation modes of the digital outputs. If the function of the intelligent current limits is deactivated within the sensor-less control, **operation modes 16 to 19** are switched off in the same way.

14.3.6 Comparator

With the help of software functions Comparator 1 and 2, various comparisons of actual values with percentage-adjustable fixed values can be done.

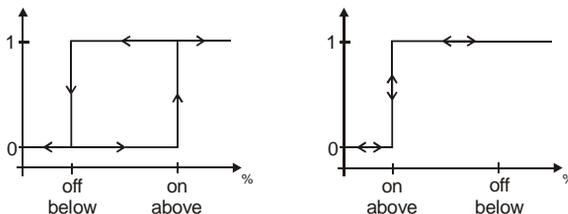
The actual values to be compared can be selected with the parameters *Comparator 1* **540** and *Comparator 2* **543** according to the following table.

Operation mode	Function
0 - off	Comparator is switched off
1 - Absolute Current	Output current > <i>Rated current</i> 371
2 - Abs. Active Current	<i>Active current</i> 214 > <i>Rated current</i> 371
3 - Abs. Stator Frequency	<i>Stator frequency</i> 210 > <i>Maximum frequency</i> 419
4 - Abs. Actual Speed	<i>Encoder 1 speed</i> 218 > maximum calculated speed
5 - Abs. Actual Repetition Freq.	<i>Repetition frequency input</i> 252 > <i>Maximum frequency</i> 419
6 - Winding Temp., Temp. Follow-Up	<i>Winding temperature</i> 226 > temperature 100 °C
7 - Abs. Actual Frequency	<i>Actual frequency</i> 241 > <i>Maximum frequency</i> 419
100 to 107	Operation modes with signs (+/-)

The switch-on and switch-off thresholds for compactors 1 and 2 are set by the parameters *Comparator on above* **541, 544** and *Comparator off below* **542, 545**. The percentage limits are stated to the reference values in question.

No.	Parameter Description	Setting		
		Min.	Max.	Fact. sett.
541	Comparator 1 on above	- 300.00 %	300.00 %	100.00 %
542	Comparator 1 off below	- 300.00 %	300.00 %	50.00 %
544	Comparator 2 on above	- 300.00 %	300.00 %	100.00 %
545	Comparator 2 off below	- 300.00 %	300.00 %	50.00 %

The setting of the percentage limits of the compactors enables the following logical connections. The comparison with signs is possible in the corresponding operation modes of the compactors.



14.3.7 Warning mask

The logic signals of various monitoring and control functions can be set in the configurable *Warning mask* **536**. According to the application, any number of warnings and controller status reports can be combined and enable internal or external control with a joint output signal.

Operation mode	Function
0 - No Change	The configured warning mask is not modified
1 - Activate everything	The warnings and controller status reports stated are connected in the warning mask
2 - Activate all Warnings	The warnings reports stated are connected in the warning mask
3 - Activate all Controller States	The controller status reports stated are connected in the warning mask
10 - Warning Ixt	The frequency inverter is overloaded
11 - Warning Short Term Ixt	Overload reserve for 1 s less the <i>Warning limit short-term Ixt</i> 405 has been reached.
12 - Warning Long Term Ixt	Overload reserve for 60 s less the <i>Warning limit long-term Ixt</i> 406 has been reached.
13 - Warning Heat Sink Temperature	Max. heat sink temperature T_K of 80 °C less the <i>Warning limit Tc</i> 407 reached
14 - Warning Inside Temperature	Max. inside temperature T_I of 65 °C less the <i>Warning limit Ti</i> 408 reached
15 - Warning Limit	The controller stated in <i>Controller status</i> 355 is limiting the reference value
16 - Warning Init	The frequency inverter is being initialized
17 - Warning Motor Temperature	Warning behavior according to parameterized <i>Operation mode MotorPTC</i> 570 at max. motor temperature T_{PTC}
18 - Warning Mains Failure	The <i>Phase monitoring</i> 576 reports a phase failure
19 - Warning Motor Protective Switch	Parameterized <i>Motor protective switch</i> 571 has triggered

Continuation of the operation modes for the warning mask:

Operation mode	Function
20 - Warning Fmax	The <i>Maximum frequency 419</i> has been exceeded. The frequency limitation is active
21 - Warning Analog Input MF11A	The input signal is smaller than 1V / 2mA according to the operation mode <i>Error/warning behavior 453</i>
22 - Warning Analog input MF12A	The input signal is smaller than 1V / 2mA according to the <i>Error/warning behavior</i>
23 - Warning System Bus	A slave on the system bus reports a fault; warning is only relevant with the EM-SYS option
24 - Warning Udc	The DC link voltage has reached the minimum value dependent on the type
25 - Warning V-Belt	The <i>V-belt monitoring 581</i> reports open circuit of the application
30 - Controller Udc Dynamic Operation	Controller is active according to the <i>Operation mode Voltage controller 670</i>
31 - Controller Shutdown	The output frequency in power failure is below the <i>Shutdown threshold 675</i>
32 - Controller Mains Failure	Failure of the mains voltage and power regulation active according to <i>Operation mode Voltage Controller 670</i>
33 - Controller Udc Limitation	The DC link voltage has exceeded the <i>Reference DC link limitation 680</i>
34 - Controller Voltage Pre-Control	The <i>dyn. voltage pre-control 605</i> accelerates the control system
35 - Controller I abs.	The output current is being limited
36 - Controller Torque Limitation	The output power or the torque are being limited on the speed controller
37 - Controller Torque Control	Switch-over of field-oriented control between speed and torque-controlled
38 - Ramp Stop	The <i>Operation mode 620</i> selected in starting behavior limits the output current
39 - Contr. Intel. Curr. Lim. LT-Ixt	Overload limit of the long-term Ixt (60s) reached, intelligent current limits active
40 - Contr. Intel. Curr. Lim. ST-Ixt	Overload limit of the short-term Ixt (1s) reached, intelligent current limits active
41 - Contr. Intel. Curr. Lim. Tc	Max. heat sink temperature T_C reached, <i>intelligent current limits 573</i> active
42 - Contr. Intel. Curr. Lim. M-PTC	Max. motor temperature T_{PTC} reached, <i>intelligent current limits 573</i> active
43 - Controller Freq. Limitation	The nominal frequency has reached the <i>Maximum frequency 419</i> . The frequency limitation is active
101 to 143	Removal or deactivation of the operation mode within the warning mask

The selected warning mask can be read out via the *Actual warning mask 537*. The above operation modes, which you set in the configurable *Warning mask 536* are coded in the *Actual warning mask 537*. The code results from hexadecimal addition of the individual operation modes and the matching abbreviation.

Warning code			Operation mode 536	
A	FFFF	FFFF	-	1 - Activate everything
A	0000	FFFF	-	2 - Activate all Warnings
A	FFFF	0000	-	3 - Activate all Controller States
A	0000	0001	Ixt	10 - Warning Ixt
A	0000	0002	IxtSt	11 - Warning Short Term Ixt
A	0000	0004	IxtLt	12 - Warning Long Term Ixt
A	0000	0008	Tc	13 - Warning Heat Sink Temperature
A	0000	0010	Ti	14 - Warning Inside Temperature
A	0000	0020	Lim	15 - Warning Limit
A	0000	0040	INIT	16 - Warning Init
A	0000	0080	PTC	17 - Warning Motor Temperature
A	0000	0100	Mains	18 - Warning Mains Failure
A	0000	0200	PMS	19 - Warning Motor Protective Switch
A	0000	0400	Flim	20 - Warning Fmax
A	0000	0800	A1	21 - Warning Analog Input MF11A
A	0000	1000	A2	22 - Warning Analog Input MF12A
A	0000	2000	SYS	23 - Warning System bus
A	0000	4000	UDC	24 - Warning Udc
A	0000	8000	BELT	25 - Warning V-Belt
A	0001	0000	UDdyn	30 - Controller Udc Dynamic Operation
A	0002	0000	UDstop	31 - Controller Shutdown
A	0004	0000	UDctr	32 - Controller Mains Failure
A	0008	0000	UDlim	33 - Controller Udc Limitation
A	0010	0000	Boost	34 - Controller Voltage Pre-Control
A	0020	0000	Ilim	35 - Controller I abs.
A	0040	0000	Tlim	36 - Controller Torque Limitation
A	0080	0000	Tctr	37 - Controller Torque Control
A	0100	0000	Rstp	38 - Ramp Stop
A	0200	0000	IxtLtlim	39 - Contr. Intel. Curr. Lim. LT-Ixt
A	0400	0000	IxtStlim	40 - Contr. Intel. Curr. Lim. ST-Ixt
A	0800	0000	Tclim	41 - Contr. Intel. Curr. Lim. Tc
A	1000	0000	PTClim	42 - Contr. Intel. Curr. Lim. M-PTC
A	2000	0000	Flim	43 - Controller Freq. Limitation

14.4 Digital inputs

The assignment of the control signals to the available software functions can be adapted to the application in question. As a function of the selected *Configuration 30* the factory assignment or the selection of the operation mode differs. In addition to the available digital control inputs, further internal logic signals are available as sources. The individual software functions are assigned to the various signal sources by parameter-capable inputs. This enables a flexible and varied use of the digital control signals.

Operation mode	Function
6 - TRUE	Signal input is switched on
7 - FALSE	Signal input is switched off
13 - Technology Controller Start	Start command of the function Technology controller in configuration 111
61 - Error Signal Output	The monitoring functions report an operational fault
70 - S1IND	Digital signal on contact input 1 (X210A.3); firmly connected with the controller release
71 - S2IND	Signal to digital input 2 (X210A.4)
72 - S3IND	Signal to digital input 3 (X210A.5)
73 - S4IND	Signal to digital input 4 (X210A.6)
74 - S5IND	Signal to digital input 5 (X210A.7)
75 - S6IND	Signal to digital input 6 (X210B.1)
76 - MF1D	Signal to multifunctional input 1 (X210A.3) in <i>Operation mode 452 = 3</i> - digital input
157 - Warning mask	The defined <i>Warning mask 536</i> reports a critical operating point
158 - Timer 1	Output signal of the time function according to the input connection <i>Timer 1 83</i>
159 - Timer 2	Output signal of the time function according to the input connection <i>Timer 2 84</i>
163 - Reference frequency reached	Signal when the <i>Actual frequency 241</i> has reached the reference frequency
164 - Setting frequency	Signal when the <i>Setting frequency 510</i> is smaller than or equal to the <i>Actual frequency 241</i>
165 - Warning Ixt	The monitoring functions report an overload of the frequency inverter
166 - Warning heat sink temperature	Max. heat sink temperature T_C of 80 °C less the <i>Warning limit T_C 407</i> reached
167 - Warning inside temperature	Max. inside temperature T_i of 65 °C less the <i>Warning limit T_i 408</i> reached
168 - Warning motor temperature	Warning behavior according to parameterised <i>Operation mode Motor PTC 570</i> at max. motor temperature T_{PTC}
169 - General warning	Signal when <i>Warnings 269</i> are displayed with a critical operating point
170 - Warning Overtemperature	The selected limit values <i>Warning limit T_k 407</i> , <i>Warning limit T_i 408</i> or the maximum motor temperature have been exceeded
171 - Output Comparator 1	The comparison according to the selected <i>Operation mode Comparator 1 540</i> is true
172 - Negated output Comparator 1	Die operation mode 171 with inverted logic (LOW active)
173 - Output Comparator 2	The comparison according to the selected <i>Operation mode Comparator 2 543</i> is true
174 - Negated output Comparator 2	Die operation mode 173 with inverted logic (LOW active)

Continuation of the operation modes for the digital control signals:

Operation mode	Function
175 - Digital message 1	Signal corresponding to the parameterized <i>Operation mode Digital output 1</i> 530
176 - Digital message 2	Signal corresponding to the parameterized <i>Digital operation MF01</i> 554
177 - Digital message 3	Signal corresponding to the parameterized <i>Operation mode Digital output 2</i> 532
178 - Reference percentage reached	Signal when the <i>Actual percentage</i> 230 has reached the reference percentage
180 - Warning motor protective switch	Parameterized <i>Operation mode motor protective switch</i> 571 has triggered
270 to 276	Operation modes 70 to 76 of the digital inputs inverted (LOW active)
691 - Index Contr.: Warn. phase error	Parameterized <i>Warning limit</i> 597 within the configuration index controlling exceeded
692 - Index Contr.: Warning period	Index signals from master and slave in the corresponding configuration faulty
700 - RxPDO1 Boolean1	Signal in optional extension with the extension module EM-SYS
701 - RxPDO1 Boolean2	Signal in optional extension with the extension module EM-SYS
702 - RxPDO1 Boolean3	Signal in optional extension with the extension module EM-SYS
703 - RxPDO1 Boolean4	Signal in optional extension with the extension module EM-SYS
710 to 713	Operation modes 700 to 703 for RxPDO2 with the extension module EM-SYS
720 to 723	Operation modes 700 to 703 for RxPDO3 with the extension module EM-SYS
730 - Sysbus Emergency	Signal in optional extension with the extension module EM-SYS

14.4.1 Start command

The parameters *Start clockwise* **68** and *Start anticlockwise* **69** are to be connected with the available digital control inputs or the internal logic signals. The drive is only accelerated according to the control functions and methods after a start command. The logic functions are used for the specification of the direction of rotation, but also for use of the parameterized operation modes *Starting behavior* **620** and *Stopping behavior* **630**.

14.4.2 Error acknowledgment

The frequency inverters contain various monitoring functions that can be adapted via the error and warning behavior. Switching the frequency inverter off at the various operating points should be avoided by an application-related parameterization. If there is a fault switch-off, this report can be given via the parameter *Program* **34** or the logic signal connected with the parameter *Error acknowledgment* **103**.

14.4.3 Timer

The time functions are to be parameterized via the parameters *Operation mode Timer 1* **790** and *Operation mode Timer 2* **793**. The sources of the logic signals are selected with the parameters *Timer 1* **83** and *Timer 2* **84** and processed according to the configured timer functions.

14.4.4 Motor-PTC

The monitoring of the motor temperature is a part of the error and warning behavior which is to be freely configured. The parameter *Motor-PTC* **204** connects the digital input signal with the defined *Operation mode Motor-PTC* **570**. The temperature monitoring via a digital input checks the input signal for the threshold value. Accordingly, a thermo-contact or an additional circuit is to be used if a temperature-dependent resistor is used.

14.4.5 n/T control change-over

The field-oriented control systems contain the functions for speed or torque-dependent control of the drive mechanism. The change-over can be done in ongoing operation, as an additional functionality monitors the transition between the two control systems. The torque controller or the speed controller is active, depending on the *n/M control change-over* **164**.

14.4.6 Data set change-over

If the function permits, the various software parameters are to be stored in four different data sets. This enables the use of various parameter values as a function of the current operation point of the frequency inverter. The change-over between the four data sets is done via the logic signals assigned with the parameters *Data set change-over 1* **70** and *Data set change-over 2* **71**.

The actual value parameter *active data set* **249** shows the selected data set.

Activation		
Data set change-over 1	Data set change-over 2	Function / active data set
0	0	Data set 1 (DS1)
1	0	Data set 2 (DS2)
1	1	Data set 3 (DS3)
0	1	Data set 4 (DS4)

0 = contact open 1 = contact closed

14.4.7 Fixed value change-over

As a function of the selected configuration, the reference values are specified via the assignment of the *Reference frequency source* **475** or *Reference percentage source* **476**. Accordingly, there can be a change between the fixed values by connection of the logic signals with the parameters *Fixed frequency change-over 1* **66**, *Fixed frequency change-over 2* **67** or the parameters *Fixed percent change-over 1* **75**, *Fixed percent change-over 2* **76**.

Activation		
Fixed value change-over 1	Fixed value change-over 2	Function / active fixed value
0	0	Fixed value 1 (FF1 / FP1)
1	0	Fixed value 2 (FF2 / FP2)
1	1	Fixed value 3 (FF3 / FP3)
0	1	Fixed value 4 (FF4 / FP4)

0 = contact open 1 = contact closed

14.4.8 Motor potentiometer

The parameters *Reference frequency source* **475**, and *Reference percentage source* **476** contain operation modes with motor potentiometer. The *Operation mode* **474** defines the behavior of the motor potentiometer function and the parameters *Frequency Motorpoti Up* **62**, *Frequency Motorpoti Down* **63** or *Percent Motorpoti Up* **72**, *Percent Motorpoti Down* **73** the connection with the available logic signals.

Activation		
Motorpoti Up	Motorpoti Down	Function
0	0	Output signal does not change
1	0	Output value rises with set ramp
0	1	Output value drops with set ramp
1	1	Output value is reset to initial value

0 = contact open 1 = contact closed

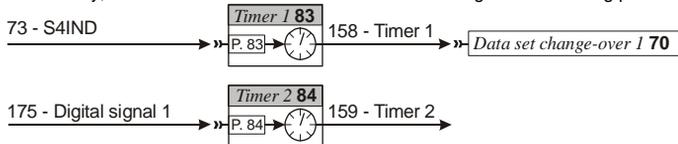
14.5 Timer function

The timer function is to be connected with various functions for the control of the course of time of digital signals.

The parameters *Operation mode Timer 1 790* and *Operation mode Timer 2 793* define the evaluation of the digital input signals and the unit of time of the time function.

Operation mode	Function
0 - off	Signal output is switched off
1 - Normal, rising edge, sec.	Positive signal edge starts timer (trigger), time 1 delays the output signal, time 2 defines the signal period
2 - Retrigger, rising Edge, sec.	Positive signal edge starts timer (trigger), next positive signal edge within time 1 starts the delay in time again (Retrigger), time 2 defines the signal period
3 - AND-connect., rising edge, sec.	Positive signal edge starts timer (trigger), no input signal within time 1 starts the delay in time again (Retrigger), no input signal within time 2 ends the signal period
11 to 13	Negative signal edge starts timer
101 to 113	Operation mode with the unit of time in minutes
201 to 213	Operation mode with the unit of time in seconds

In the factory, the functions have been connected according to the following picture:



The sources of the digital signals are selected with the parameters *Timer 1 83* and *Timer 2 84*. Timer 1 is connected with contact input 4 and Timer 2 with the logic signal digital message 1.

The output signal is assigned to the input function by corresponding parameters. In the factory, *Data set change-over 1 070* is connected with Timer 1 and *Digital output 1 530* with Timer 2.

14.5.1 Timer – Time constant

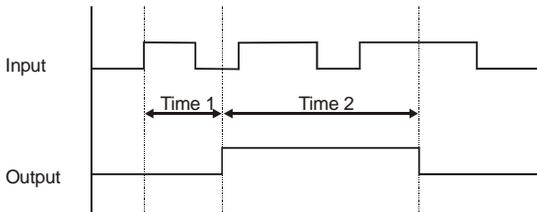
The logical series of input and output signals is to be set separately for both timer functions with the time constants. The parameter values set in the factory lead to a direct connection of input and output signal without a delay in time.

No.	Parameter Description	Setting		
		Min.	Max.	Fact. sett.
791	Time 1 Timer 1, signal delay	0.00 s/m/h	650.00 s/m/h	0.00 s/m/h
792	Time 2 Timer 1, signal duration	0.00 s/m/h	650.00 s/m/h	0.00 s/m/h
793	Time 1 Timer 2, signal delay	0.00 s/m/h	650.00 s/m/h	0.00 s/m/h
794	Time 2 Timer 2, signal duration	0.00 s/m/h	650.00 s/m/h	0.00 s/m/h

Examples of the timer function depending on the selected operation mode and the input signal:

Normal, positive edge

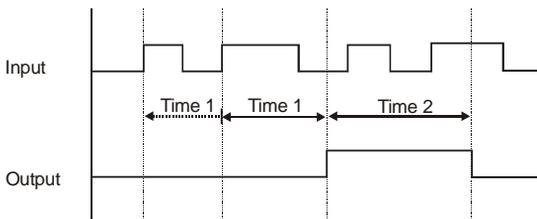
Parameter *Operation mode* *Timer* = 1



With the positive signal edge at the output, time 1 runs. After the expiry of the delay, the output signal is switched for signal duration time 2.

Retrigger, positive edge

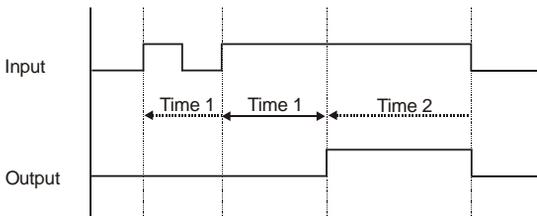
Parameter *Operation mode* *Timer* = 2



With the positive signal edge at the output, time 1 runs. If a positive signal edge is recognized within the delay, time 1 starts again. After the expiry of the delay, the output signal is switched for the signal duration time 2.

AND connection, positive edge

Parameter *Operation mode* *Timer* = 3



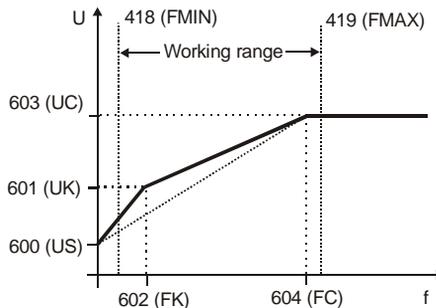
With the positive signal edge at the output, time 1 runs. If a positive signal edge is recognized within the delay, time 1 starts again. After the expiry of the delay, the output signal is switched for the signal duration time 2. Within the signal duration time 2, the output is switched off with the input signal.

15 V/f - characteristic

Sensor-less control in configurations 110 and 111 is based on the proportional change of output voltage to output frequency according to the configured characteristic.

With the setting of the V/f-characteristic, the voltage of the connected 3-phase motor is controlled according to the frequency. The torque to be applied by the motor at the operating point in question demands the control of the output voltage proportional to the frequency. With a constant ratio of the output voltage to the output frequency of the frequency inverter, the magnetization is constant in the reference range of the 3-phase motor. The rating point of the motor or end point of the V/f-characteristic is set via the guided commissioning with the parameter *Cut-off voltage* **603** and the parameter *Cut-off frequency* **604**.

The lower frequency range, where an increased voltage is necessary for the start of the drive, is critical. The voltage at output frequency = zero is set with the parameter *Starting voltage* **600**. An increase in voltage deviating from the linear course of the V/f-characteristic can be defined by the parameters *Voltage rise* **601** and *Rise frequency* **602**. The percentage parameter value is calculated from the linear V/f-characteristic. With the parameters *Minimum frequency* **418** and *Maximum frequency* **419** the working range of the machine or the V/f-characteristic is stipulated.



No.	Parameter	Setting		
		Min.	Max.	Fact. sett.
600	Starting voltage	0.0 V	100.0 V	5.0 V
601	Voltage rise	-100 %	200 %	10 %
602	Rise frequency	0 %	100 %	20 %
603	Cut-off voltage	60.0 V	560.0 V	400.0 V
604	Cut-off frequency	0.00 Hz	999.99 Hz	50.00 Hz

Note: The guided commissioning takes the parameterized rated motor values and reference data of the frequency inverter into account in the pre-setting of the V/f-characteristic. The rise of the rated speed with a constant torque can be implemented with 3-phase machines in the motor winding can be switched over from star to delta. If the data for the delta connection has been entered on the rating plate of the three-phase motor, the cut-off frequency is automatically increased by the square root of three.

The factory setting of the *Cut-off voltage* **603 (UC)** and *Cut-off frequency* **604 (FC)** is derived from the motor data *Rated voltage* **370 (MUR)** and *Rated frequency* **375 (MFR)**. With the parameterized *Starting voltage* **600 (US)**, the linear equation of the V/f-characteristic results.

$$U = \left(\frac{UC - US}{FC - 0} \right) \cdot f + US = \left(\frac{400.0V - 5.0V}{50.00Hz - 0.00Hz} \right) \cdot f + 5.0V$$

The *Rise frequency* **602 (FK)** is input as a percentage of the *Cut-off frequency* **604 (FC)** and is f=10Hz in the factory settings. The output voltage is calculated as U=92.4V for the factory setting of the *Voltage rise* **601 (UK)**.

$$U = \left[\left(\frac{UC - US}{FC - 0} \right) \cdot (FK \cdot FC) + US \right] \cdot (1 + UK) = \left[\left(\frac{400V - 5V}{50Hz - 0Hz} \right) \cdot (0.2 \cdot 50Hz) + 5V \right] \cdot 1.1 = \underline{\underline{92.4V}}$$

15.1 Dynamic voltage pre-control

The *dyn. voltage pre-control* **605** accelerates the control behavior of the *Current limit controller* **610** and *Voltage controller* **670**. The output voltage value resulting from the V/f characteristic is amended by addition of the calculated voltage pre-control.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
605	Dyn. voltage pre-control	0 %	200 %	100 %

16 Control functions

The frequency inverters provide a selection of established control functions and methods in various *Configurations 30*. The selected control structure can be freely parameterized and optimized for the application by further functions.

16.1 Intelligent current limits

The current limits to be set according to the application avoid inadmissible encumbrance of the connected load and prevent the fault switch-off of the frequency inverter. The function extends the current controller available in the control system. The overload reserve of the frequency inverter can be made optimal use of with the help of the intelligent current limits, in particular in applications with dynamic load alternations. The criterion to be selected via the parameter *Operation mode 573* defines the threshold to the activation of the intelligent current limit. The parameterized rated motor current or the reference current of the frequency inverter is synchronized as the limit value of the intelligent current limits.

Operation mode	Function
0 - Off	The function is switched off
1 - lxt	Limitation to the overload of the frequency inverter (lxt)
10 - T _c	Limitation to the maximum heat sink temperature (T _c)
11 - lxt + T _c	Operation mode 1 and 10 (lxt + T _c)
20 - PTC	Limitation to the motor temperature (T _{PTC})
21 - PTC + lxt	Operation mode 20 and 1 (T _{PTC} + lxt)
30 - T _c + PTC	Operation mode 10 and 20 (T _c + T _{PTC})
31 - T _c + PTC + lxt	Operation mode 10, 20 and 1 (T _c + T _{PTC} + lxt)

The threshold value selected via the parameter *Operation mode 573* is monitored by the intelligent current limits. In the operation modes with motor and heat sink temperature monitoring, the reduction of power selected with the parameter *Power limit 574* is done when the threshold value has been reached. This is achieved by reduction of the output current and the speed in motor operation. The load behavior of the connected machine must be a function of the speed for a sensible use of the intelligent current limits. The entirety of the power reduction as a result of an increased motor or heat sink temperature contains not only the duration of the cooling off, but also the additionally defined *Limitation time 575*.

The definition of the power limit should be selected as small as possible in order to give the drive mechanism sufficient time to cool off. The reference value is the reference output of the frequency inverter or the set rated power of the motor.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
574	Power limit	40.00 %	95.00 %	80.00 %
575	Limitation time	5 min	300 min	15 min

In the operation modes with overload reserve (lxt) there is a reduction of the output current when the threshold value is exceeded, with a distinction made between long and short-term overload reserve. After the short-term overload (1s) has been made use of, the output current is reduced to the long-term overload current matching the present switching frequency. After the long-term overload current has been made use of (60s), there is a reduction to the reference current, which is also dependent on the switching frequency. If the output current has already been reduced as the long-term overload has been made use of, the short-term overload is no longer available even if it has not been made use of beforehand. The defined overload reserve (lxt) of the frequency inverter is again available after a power reduction lasting 10 minutes.

16.2 Voltage controller

The voltage controller contains the functions necessary for the monitoring of the DC link voltage.

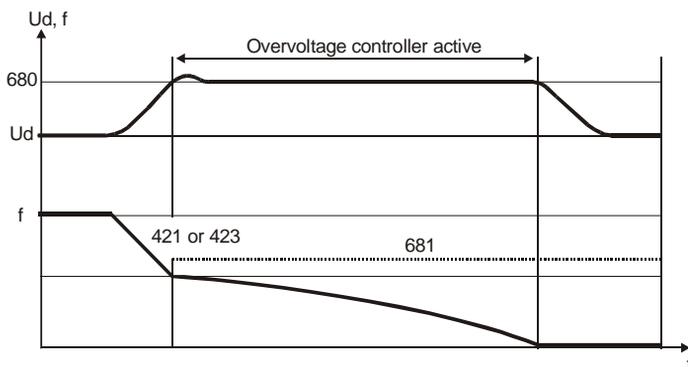
- The DC link voltage which rises in generator operation or in the braking process of the 3-phase machine is controlled to the set limit value by the voltage controller.
- The power failure regulation uses the rotation energy of the drive mechanism to bridge short-term power failures.

The voltage controller is set with the parameter *Operation mode* **670** in accordance with the application.

Operation mode	Function
0 - off	The function is switched off
1 - Udc-Limitation active	Overvoltage controller switched on
2 - Mains Support active	Power failure regulation switched on
3 - Udc-Limit. & Mains Supp. active	Overvoltage controller and power failure regulation switched on

Operation mode overvoltage control,

Parameter *Operation mode voltage controller* **670 (UDSEL) = 1**

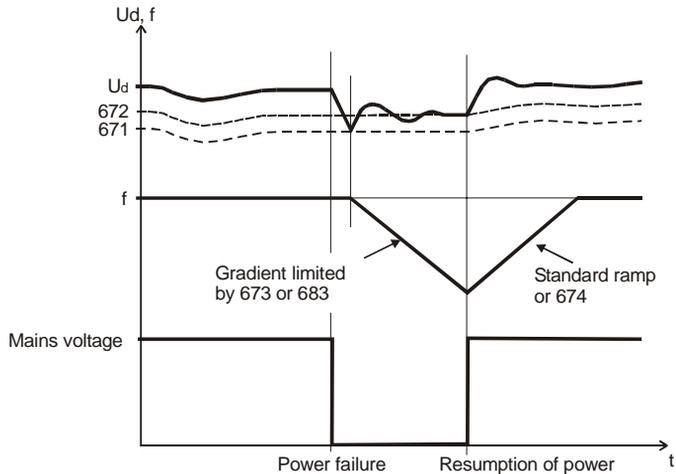


The overvoltage controller prevents a switch-off of the frequency inverter in generator operation. The reduction of the drive speed by a ramp gradient selected via the parameter *Deceleration Clockwise* **421** or *Deceleration Anticlockwise* **423** can lead to an overvoltage in the DC link. If the voltage exceeds the value set by the parameter *Reference DC link limitation* **680**, the deceleration is reduced in such a way that the DC link voltage is regulated to the set value. If the DC link voltage cannot be regulated to the set reference value by the reduction of the deceleration, the deceleration is stopped and the output frequency raised. The output frequency is calculated by addition of the parameter *Max. frequency rise* **681** to the frequency at the operating point of the controller intervention.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
680	Reference DC link limitation	$U_{dmin}+25V$	$U_{dmax}-25V$	U_d
681	Max. frequency rise	0.00 Hz	999.99 Hz	10.00 Hz

Operation mode power failure regulation.

Parameter *Operation mode voltage controller 670 (UDSEL) = 2*



With the power failure regulation, short-term power failures can be bridged. A power failure is recognized if the DC link voltage has fallen below the set value of the parameter *Mains failure threshold 671*. If a power failure is recognized, the controller tries to regulate the DC link voltage to the value set with the parameter *Reference mains support value 672*. For this, the output frequency is continuously reduced and the motor with its rotating masses put into generator operation. The reduction of the output frequency is done according to the configuration with a maximum of the current set by the parameter *Gen. ref. current limit 683* or the ramp *Mains support deceleration 673*.

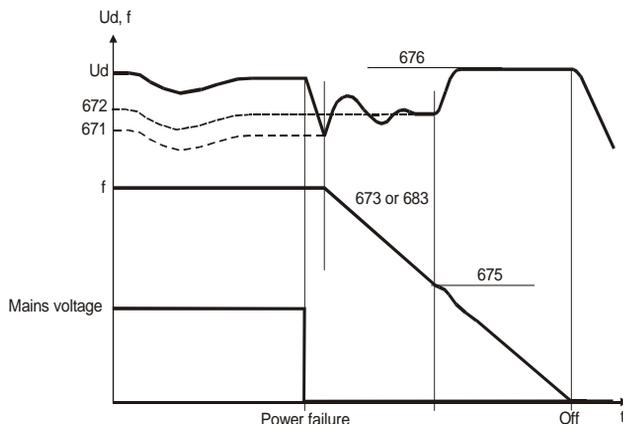
The threshold values of the voltage controller are calculated starting with the current DC link voltage with the parameters *Mains failure threshold 671* and *Reference mains support value 672*.

If the mains voltage resumes before a switch-off is done by the detection of mains undervoltage, the drive mechanism is accelerated to its reference frequency at the set acceleration or according to the parameter *Acceleration on mains resumption 674*.

No.	Parameter Description	Setting		
		Min.	Max.	Fact. sett.
671	Mains failure threshold	-200.0 V	-50.0 V	-100.0 V
672	Reference mains support value	-200.0 V	-10.0 V	-40.0 V

Note: The frequency inverter reacts to the signals on the control inputs with the power failure regulation switched on just like in normal operation. Connection with externally supplied control signals is only possible with no-break supply. As an alternative, supply through the frequency inverter is to be used.

Continuation on the Operation mode power failure regulation



The DC link voltage available in a power failure is provided by the motor. The output frequency is continuously reduced and the motor with its rotating masses put into generator operation. The reduction of the output frequency is done at the maximum with the current set by the parameter *Gen. ref. current limit* **683** or the ramp *Mains support deceleration* **673** until the frequency limit *Shutdown threshold* **675**. If the energy of the system is not sufficient to bridge the mains failure, the deceleration is done with a maximum ramp gradient from the *Shutdown threshold* **675**. The time until the standstill of the motor results from the generator energy of the system, which results in an increase of the DC link voltage. The DC link voltage set with the parameter *Reference shutdown value* **676** is used by the voltage controller as a control value and kept constant. The voltage rise enables optimization of the braking behavior and the time until the standstill. The behavior of the controller is comparable with stopping behavior 2 (Shutdown + Stop), as the voltage controller brings the drive mechanism to a standstill with the maximum deceleration ramp and supplies it with the remaining DC link voltage.

If the mains voltage resumes after the shutdown of the drive mechanism but before the undervoltage switch-off has been reached, the frequency inverter reports a fault. The operating unit displays the fault message "F0702".

If the mains failure without shutdown (*Shutdown threshold* **675** = 0 Hz) takes so long that the frequency has been reduced to 0 Hz, the drive mechanism is accelerated to the reference frequency upon resumption of the mains.

If the mains failure with or without shutdown takes so long that the frequency inverter shuts off completely (LED's = OFF), the frequency inverter will be in the "Standby" state when the mains resume. If the release is switched again, the drive mechanism starts. If the drive is to start automatically with the release permanently switched on after a mains resumption, the *Autostart* **651** must be switched on.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
675	Shutdown threshold	0.00 Hz	999.99 Hz	0.00 Hz
676	Reference shutdown value	Ud _{min}	Ud _{max}	Ud

The voltage controller uses the limit values of the DC link voltage to control. The frequency alteration necessary for this is parameterized by the generator reference current value or the ramp. The *Gen. ref. current limit* **683** or the ramp *Mains support deceleration* **673** defines the maximum deceleration of the drive necessary in order to reach the voltage value *Reference mains support value* **672**. The *Acceleration on mains resumption* **674** replaces the set values of the ramp parameters *Acceleration (clockwise)* **420** or *Acceleration anticlockwise* **422** if the value set in the factory is altered. The voltage control in a mains failure changes from the frequency limit *Shutdown threshold* **675** from *Reference mains support value* **672** to the *Reference shutdown value* **676**.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
683	Gen. ref. current limit	0.0 A	0- I_{FIN}	I_{FIN}
673	Mains support deceleration	0.01 Hz/s	9999.99 Hz/s	50.00 Hz/s
674	Acceleration on mains resumption	0.00 Hz/s	9999.99 Hz/s	0.00 Hz/s

The proportional and integrating parts of the voltage controller are to be set via the parameter *Amplification* **677** and parameter *Integral time* **678**. The control functions are to be deactivated by the parameter value zero. It is a P and an I controller in the settings in question.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
677	Amplification	0.00	30.00	1.00
678	Integral time	0 ms	10000 ms	8 ms

16.3 Functions of sensor-less control

The configurations of the sensor-less control contain the additional functions described below, which supplement the behavior according to the parameterized V/f characteristic.

16.3.1 Slip compensation

The load-dependent difference between reference speed and actual speed of the 3-phase motor is the slip. The dependency can be compensated by the current measurement in the output phases of the frequency inverter. The *Slip compensation* **660** enables a speed control without feedback. The stator frequency and speed are corrected as a function of the load.

Operation mode	Function
0 - Off	The slip compensation has been switched off
1 - On	The load-dependent slip speed is compensated

The control behavior of the slip compensation can only be optimized via the parameters in specific applications. The parameter *Amplification* **661** determines the correction of the speed and the effect of the slip compensation proportional to the change of load. The *Max. slip ramp* **662** defines the max. frequency alteration per second in order to avoid an overload in a load alternation.

The parameter *Minimum frequency* **663** stipulates the frequency from which the slip compensation becomes active.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
661	Amplification	0.0 %	300.0 %	100.0 %
662	max. slip ramp	0.01 Hz/s	650.00 Hz/s	5.00 Hz/s
663	Minimum frequency	0.01 Hz	999.99 Hz	0.01 Hz

16.3.2 Current limit value controller

With a load-dependent speed control, the current limit value controller avoids the inadmissible loading of the drive system. This is extended by the intelligent current limits described in the previous chapter. The current limit value controller reduces the load on the drive, for example, in acceleration by stopping the acceleration ramp. The switch-off of the frequency inverter which happens when the acceleration ramps have been set at an excessive gradient is thus prevented. The current limit value controller is switched on and off with the parameter *Operation mode current limit value controller* **610**.

Operation mode	Function
0 - Off	The current limit value controller functions and the intelligent current limits have been deactivated
1 - On	The current limit value controller is active

Behavior in motor operation:

If the current set with the parameter *Current limit* **613** is exceeded, the switched-on current limit value controller will reduce the output frequency until the current limit is not exceeded. The output frequency is reduced as a maximum to the frequency set by the parameter *Frequency limit* **614**. If the *Current limit* **613** is fallen short of, the output frequency is raised back to the reference value.

Behavior in generator operation:

If the current set with the parameter *Current limit* **613** is exceeded, the switched-on current limit value controller will raise the output frequency until the current limit is not exceeded. The output frequency is raised as a maximum to the set *Maximum frequency* **419**. If the *Current limit* **613** is fallen short of, the output frequency is dropped back to the required reference value.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
613	Current limit	0.0 A	0·I _{FIN}	0·I _{FIN}
614	Frequency limit	0.00 Hz	999.99 Hz	0.00 Hz

The control behavior of the current limit value controller can be set via the proportional component, the parameter *Amplification* **611**, and the integrating component, the parameter *Integral time* **612**. If an optimization of the controller parameters is necessary in exceptional cases, a setting should be done by a jump alteration of the parameter *Current limit* **613**.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
611	Amplification	0.01	30.00	1.00
612	Integral time	1 ms	10000 ms	24 ms

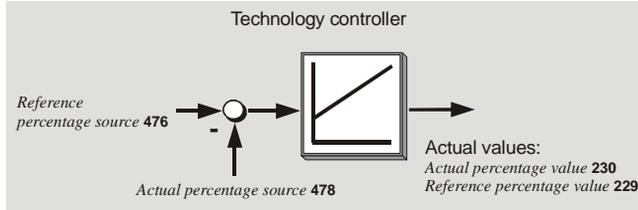
Note: The dynamism of the current limit value controller and the voltage controller is influenced by the setting of the parameter *Dyn. voltage pre-control* **605**.

16.3.3 Technology controller

The technology controller, the behavior of which matches a PI controller, is available as an additional function in configuration 111. The connection of reference and actual value of the application with the functions of the frequency inverter enables process control without further components. In this way, applications such as pressure, volume flow or speed control can be implemented simply.

The configuration of the reference percentage source and the assignment of the actual percentage source are to be obeyed.

Structural image:



For the reference value, the technology controller also demands the assignment of an analog application value with the parameter *Actual percentage source 478*. The difference between reference and actual value is used by the technology controller to control the drive system. The measured actual value is mapped via a measurement converter onto the input signal of the reference percentage source.

Operation mode	Function
1 - Analog input MF1A	The analog signal on the multifunctional input 1 in <i>Operation mode 452 - analog operation</i>
32 - Rep. frequency input (F3)	The frequency signal on the digital input according to the selected <i>Operation mode 496</i>

The function selected via the parameter *Operation mode technology controller 440* defines the behavior of the technology controller.

Operation mode	Function
0 - off	The technology controller is switched off, the reference value specification is done via the reference percentage channel
1 - Standard	For pressure and volume flow control with linear operating behavior and actual value monitoring
2 - Liquid level 1	Contents level control at defined motor speed with lack of actual value
3 - Liquid level 2	Contents level control with defined behavior with lack of actual value or high control deviation
4 - Speed controller	Speed control with analog feedback of the actual speed
5 - Indirect volume flow control	Pressure or volume flow control with square rooted actual value

Attention: The factory assignment of the parameter *Start clockwise 68* with the logic signal of the technology controller is to be observed. The technology controller becomes active with the controller release on digital input S1IND.

Operation mode Standard**Parameter Operation mode technology controller 440 = 1**

This operation mode is suited for example to a pressure or volumetric flow control with linear operation behavior. If the actual value is missing (below 0.5 %), the output frequency is guided to the frequency set with the parameter *Minimum frequency 418* by the set parameter *Deceleration 421*.

With this function, an acceleration period of the drive with a missing actual value is prevented. If the actual value resumes, the controller automatically carries on working.

With the help of the parameter *Hysteresis 443*, an overshoot of the technology controller can be prevented by limiting its output value with regard to the stator frequency. That is to say the output value of the controller cannot become larger or smaller than the current actual value plus the limit values of the set hysteresis.

Operation mode liquid level 1**Parameter Operation mode technology controller 440 = 2**

This operation mode is suited for example to a contents level control. If the actual value is missing (below 0.5 %), the output frequency is guided to the frequency set with the parameter *Fixed frequency 441*. The *Fixed frequency 441* is to be parameterized larger than or equal to the set *Minimum frequency 418*, otherwise the frequency is limited to **418**.

With this function, the drive mechanism can be guided to an adjustable frequency with a missing actual value. The frequency can be in the control range *Minimum frequency 418* and *Maximum frequency 419 (FMAX)*.

If the actual value resumes, the controller automatically carries on working.

Operation mode liquid level 2**Parameter Operation mode technology controller 440 = 3**

This operation mode is suited for example to a contents level control. If the actual value is missing (below 0.5 %), the output frequency is guided to the *Fixed frequency 441* as in contents level 1. If the control deviation becomes zero or negative, the output frequency is guided to the set *Minimum frequency 418* with the set *Deceleration 421*.

With this function, an acceleration period of the drive with a missing actual value is prevented. With a negative or zero control deviation and with a set *Minimum frequency 418* of 0 Hz, the drive is guided to a standstill. The power component is switched off, i.e. the motor is not supplied with current, until the actual value returns or the control deviation exceeds the **positive Hysteresis 443**.

Operation mode speed controller**Parameter Operation mode technology controller 440 = 4**

This operation mode is suited for example for speed controls with an analog actual value transmitter (e.g. analog speedometer). If the actual value is missing (below 0.5 %) the output frequency is guided to the set *Maximum frequency 419* with the set *Acceleration clockwise 420*. If the actual value resumes, the controller automatically carries on working.

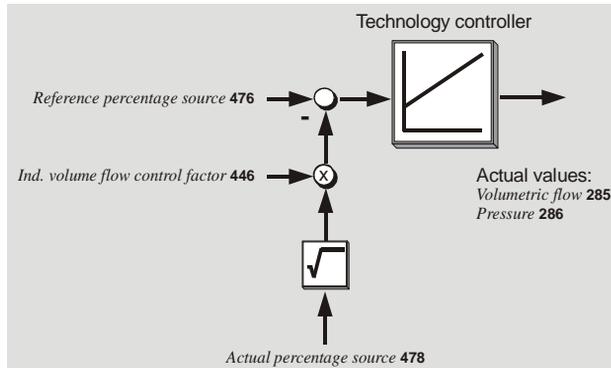
Operation mode indirect volume flow control

Parameter Operation mode technology controller 440 = 5

The pressure or volume flow control in operation mode 1 is extended in its functionality with this operation mode. The actual value square rooted in operation mode 5 of the technology controller enables direct measurement of the active pressure in the system via the intake nozzle of the ventilator. The active pressure has a square proportion to the volume flow and thus forms the control value for the volume flow control. The calculation corresponds to the "Law of Proportionality" which is generally valid for centrifugal machines.

Adaptation to the application in question and measurement are done via the *Ind. volume flow control factor 446*. The actual values are calculated from the system data to be parameterized, reference pressure and volume flow, according to the bad point method.

Structural image:



The behavior of the technology controller matches a PI controller. The proportional component is optimized with the parameter *Amplification 444* and the integral component with the parameter *Integral time 445*. The sign of the amplification determines the direction of control, i.e. with a rising actual value and pos. sign of the amplification, the output frequency is reduced (e.g. in pressure control). With a rising actual value and neg. sign of the amplification, the output frequency is raised (e.g. in temperature control, refrigerating machines, condensers).

The parameter *max. P component 442* limits the frequency alteration on the controller output. This prevents an oscillation of the system if the acceleration ramps have been selected large.

The *Hysteresis 443* limits the deviation of the output value of the technology controller to the current stator frequency of the motor in the standard and contents level 2 operation modes.

No.	Parameter Description	Setting		
		Min.	Max.	Fact. sett.
441	Fixed frequency	-999.99 Hz	+999.99 Hz	0.00 Hz
442	Max. P component	0.01 Hz	999.99 Hz	50.00 Hz
443	Hysteresis	0.01 %	100.00 %	10.00 %
444	Amplification	-15.00	+15.00	1.00
445	Integral time	0 ms	32767 ms	200 ms
446	Ind. volume flow control factor	0.10	2.00	1.00

Note: The parameterization of the technology controller in the individual data sets enables adaptation to various operating points of the application with the data record change-over via control contacts.

16.4 Functions of the field-oriented control

The field-oriented control systems are based on a cascade control and calculation of a complex machine model. In the course of the guided commissioning, a map of the connected machine is produced by the parameter identification and transferred to various parameters. Some of these parameters are visible and can be optimized for various operating points.

16.4.1 Current controller

The inner control loop of the field-oriented control comprises two current controllers. The field-oriented control thus impresses the motor current into the machine via two components to be controlled.

This is done by:

- controlling the flux-forming current value I_{sd}
- controlling the torque-forming current value I_{sq}

By separate regulation of these two values, a decoupling of the system equivalent to an externally excited direct current machine is achieved.

The set-up of the two current controllers is identical and enables joint setting of amplification as well as the integral time for both controllers. For this, the parameters *Amplification 700* and *Integral time 701* are available. The integration and proportional component of the current controllers is to be set by the parameter value zero.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
700	Amplification	0.00	2.00	0.13
701	Integral time	0.00 ms	10.00 ms	10.00 ms

The guided commissioning has selected the parameters of the current controller in such a way that they can be used without alteration in most cases of application.

If, in exceptional cases, an optimization of the behavior of the current controllers is to be done, the reference value jump during the flux-formation phase can be used for this. The reference value of the flux-forming current components leaps to the value *Current during flux-formation 781* with suitable parameterization and then changes controlled to the magnetizing current after the expiry of the *Maximum flux-formation time 780*. The operating point necessary for the adjustment demands the setting of parameter *Minimum Frequency 418* with the frequency value 0.00 Hz, as the drive is accelerated after magnetizing. The measurement of the jump reply, which is defined by the ratio of the currents mentioned, should be done in the motor supply line with the help of a measuring current transformer of a sufficient bandwidth.

Note: The issue of the internally calculated actual value for the flux-forming current component via the analog output cannot be used for this measurement as the time resolution of the measurement is not sufficient.

To set the parameters of the PI controller, the *Amplification 700* is firstly enlarged until the actual value manifests a distinct overshoot during the control process. Now, the amplification is reduced to about a half again and then the *Integral time 701* synchronized until actual value manifests a slight overshoot during the control process.

The setting of the current controllers should not be selected too dynamically in order to ensure a sufficient reserve range. The control tends to increased oscillations if the reverse range is reduced.

Setting	
Switching frequency	Scanning frequency
4 kHz	4 kHz
8 kHz	8 kHz
12 kHz	8 kHz
16 kHz	8 kHz

The dimensioning of the current controller parameters by calculation of the time constant is to be done for a switching frequency of 2 kHz. For other switching frequencies, the values are adapted internally, with the result that the setting can remain unaltered for all switching frequencies. The dynamic properties of the current controller improve with an increase in the switching and scanning frequency. The fixed interval of time for the modulation results in the following scanning frequencies of the current controller via the parameter *Switching frequency* **400**.

16.4.2 Torque controller

The torque-controlled configurations often demand limitation of the speed in the operating points without load moment. The controller increases the speed in order to reach the reference torque until the *Frequency upper limit* **767** or the *Frequency lower limit* **768** is reached. From the limit value, there is control to the maximum speed, corresponding to the behavior of the speed controller. Thus, the controller is limited to the *Maximum frequency* **419**.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
767	Frequency upper limit	-999.99 Hz	999.99 Hz	999.99 Hz
768	Frequency lower limit	-999.99 Hz	999.99 Hz	999.99 Hz

16.4.2.1 Limit value sources

The limitation of the frequency can be done not only with fixed values, but can also be connected with an analog input value. The analog value is limited via the parameters *Minimum reference percentage* **518**, *Maximum reference percentage* **519**, but does not take the *Gradient percentage ramp* **477** of the reference percentage value channel into account.

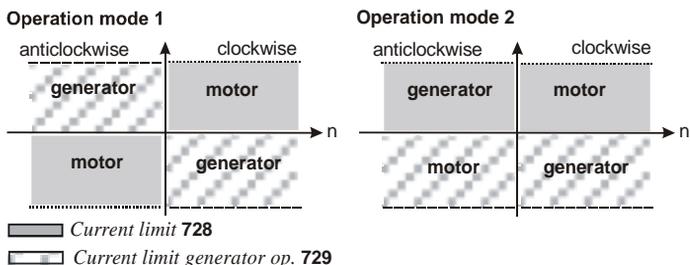
The allocation is done for the torque controller with the help of the parameters *Frequency upper limit source* **769** and *Frequency lower limit source* **770**.

Operation mode	Function
101 - Analog input MF11A	The source is the multifunctional input 1 in an analog <i>Operation mode</i> 452
110 - Fixed limit	The selected parameter values are taken into account to limit the speed controller
201 - Inv. analog input MF11A	Inverted operation mode 101
210 - Inv. fixed limit	Inverted operation mode 110

16.4.3 Speed controller

The control of the torque-forming current components is done in the outer control loop by the speed controller. Specific to the application, the speed controller can be used in various operation modes, which are to be selected via the parameter *Op. mode speed controller 720*. The setting of the operation mode defines the use of the limits to be parameterized relative to the direction of rotation and the direction of the torque as a function of the configuration selected.

Operation mode	Function
0 - Speed Controller Off	The controller is deactivated or the torque-forming component equal to zero.
1 - Limits for Motor/Generator Op.	The limitation of the speed controller assigns the upper limit to the motor operation of the drive. Independent of the direction of rotation, the same limit is used. This applies accordingly for generator operation with the lower limit.
2 - Limits for pos./neg. Torque	The assignment of the limit is done by the sign of the value to be limited. Independent of the motor or generator operating points of the drive mechanism, the positive limitation is done by the upper limit. The lower limit is regarded as a negative limitation.



The properties of the speed controller are to be adapted for adjustment and optimization of the controller. The amplification and integral time of the speed controller are to be set via the parameters *Amplification 1 721*, *Integral time 1 722* and for the second speed range via the parameters *Amplification 2 723*, *Integral time 2 724*. The distinction between the speed ranges is done by the value selected with the parameter *Speed control switch-over limit 738*. The parameters *Amplification 1 721* and *Integral time 1 722* are taken into account with the parameter *Speed control switch-over limit. 738* selected in the factory. If the parameter limit value is parameterized larger than 0.00 Hz, the parameters *Amplification 1 721*, *Integral time 1 722* are active below the limit and the parameters *Amplification 2 723*, *Integral time 2 724* above the limit.

The parameterized amplification at the current operating point can additionally be assessed via the parameter *Backlash damping 748* as a function of the control deviation. In particular the small signal behavior in applications with a gearbox can be improved by a value greater than zero percent.

No.	Parameter Description	Setting		
		Min.	Max.	Fact. sett.
721	Amplification 1	0.00	200.00	10.00
722	Integral time 1	0 ms	60000 ms	125 ms
723	Amplification 2	0.00	200.00	5.00
724	Integral time 2	0 ms	60000 ms	250 ms
738	Speed control switch-over limit	0.00 Hz	999.99 Hz	0.00 Hz
748	Backlash damping	0 %	300 %	100 %

The factory setting is relative to the set machine data for the amplification and integral time. This enables a first function test in a large number of applications. The distinction of the parameters for the current frequency range is done by the software according to the selected limit value.

The optimization of the speed controller can be done with the help of a reference value leap. The amount of the leap is defined by the set ramp or limitation. The optimization of the PI controller should be done with the maximum admissible reference value modification. First, the amplification is enlarged until the actual value manifests a distinct overshoot during the control process. This can be observed with a strong oscillation of the speed and by the running noises. In the next step, the amplification is reduced somewhat (1/2 to 3/4 etc.), in order to then reduce the integral time (larger I component) until the actual value only manifests a slight overshoot in the control process.

In the second step, if necessary, the setting of the speed controller in dynamic processes, i.e. in acceleration and deceleration, is controlled. The frequency at which a change-over of the controller parameters takes place can be set via the parameter *Speed control switch-over limit* **738**.

16.4.3.1 Limitation speed controller

The output signal of the speed controller is the torque-forming current component I_{sq} . The output and the I component of the speed controller are limited via the parameters *Current limit* **728**, *Current limit generator. operation* **729**, *Torque limit* **730**, *Torque limit generator operation* **731** or *Power limit* **739**, *Power limit generator operation* **740**. The limits of the proportional component are set via parameter *P component torque upper limit* **732** and parameter *P component torque lower limit* **733**.

- The output value of the controller is limited by an upper and a lower current limit, parameter *Current limit* **728** and parameter *Current limit generator op.* **729**. The limit values are input in Ampere. The current limits of the controller are to be connected with the fixed limits and also the analog input values. The assignment is done via the parameters *Isq limit source motor operation* **734** and *Isq limit source generator operation* **735**.
- The output value of the controller is limited by an upper and a lower torque limit, parameter *Torque limit* **730** and parameter *Torque limit generator op.* **731**. The limit values are input as a percentage of the rated motor torque. The assignment of fixed values or analog limit values is done via the parameters *Torque limit source, motor op.* **736** and *Torque limit source, generator op.* **737**.
- The output value of the P component is limited with parameter *P comp. torque upper limit* **732** and *P comp. torque lower limit* **733**. The limit values are input as torque limits as a percentage of the rated motor torque.
- The power output by the motor is proportional to the product of speed and torque. This output power can be limited at the controller output with an *Upper power limit* **739** and *Lower power limit* **740**. The power limits are input in Kilowatt.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
728	Current limit	0.0 A	0·I _{FIN}	0·I _{FIN}
729	Current limit generator. operation	0.1 A	0·I _{FIN}	0·I _{FIN}
730	Torque limit	0.00 %	650.00 %	650.00 %
731	Torque limit generator operation	0.00 %	650.00 %	650.00 %
732	P comp. torque upper limit	0.00 %	650.00 %	100.00 %
733	P comp. torque lower limit	0.00 %	650.00 %	100.00 %
739	Power limit	0.00 kW	2·0·P _{FIN}	2·0·P _{FIN}
740	Power limit generator operation	0.00 kW	2·0·P _{FIN}	2·0·P _{FIN}

16.4.3.2 Limit value sources

As an alternative to limiting the output values by a fixed value, connection to an analog input value is also possible. The analog value is limited via the parameters *Minimum Reference Percentage 518*, *Maximum Reference Percentage 519*, but does not take the *Gradient Percentage Ramp 477* of the reference percentage channel into account.

The assignment is done with the help of the parameters *Isq limit source motor operation 734* and *Isq limit source generator operation 735* for the torque-forming current component Isq.

In the same form, the sources for the torque limits are to be stated via the parameters *Torque limit source, motor op. 736* and *Torque limit source, generator op. 737*.

Operation mode	Function
101 - Analog input MF11A	The source is the multifunctional input 1 in an analog <i>Operation mode 452</i>
105 - Rep. frequency input (F3)	The frequency signal on the repetition frequency input corresponding to <i>Operation mode 496</i>
110 - Fixed limit	The selected parameter values for the limiting of the speed controller are taken into account

Note: The limit values and assignments with various limit value sources are data record change-over capable in the configurations. The use of the data record change-over demands examination of the parameters in question.

16.4.4 Acceleration pre-control

The acceleration pre-control is active in the speed-controlled configurations and is activated via the parameter *Operation mode acceleration pre-control 725*.

Operation mode	Function
0 - Off	The control system is not influenced
1 - Switched on	The acceleration pre-control is active according to the limit values

The acceleration pre-control controlled parallel to the speed controller reduces the reaction time of the drive system to a change of reference values. The minimum acceleration time defines the modification speed of the reference speed value from which a torque necessary for acceleration of the drive mechanism is pre-controlled. The acceleration of the mass is a function of the *Mechanical time constant 727* of the system. The value calculated from the rise of the reference value and the multiplication factor of the torque required is added to the output signal of the speed controller.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
726	Minimum acceleration	0.1 Hz/s	6500.0 Hz/s	1.0 Hz/s
727	Mech. time constant	1 ms	60000 ms	10 ms

For optimal setting, the acceleration pre-control is switched on and the mechanical time constant set to the minimum value. The output value of the speed controller is compared with the minimum acceleration time during the acceleration processes. The frequency ramp is to be set to the largest value occurring in operation at which the output value of the speed controller is not yet limited. Now, the value of the *Minimum acceleration time 726* is set to half the set acceleration ramp so that the acceleration pre-control is certain to be active. The acceleration pre-control is not raised by increasing the *Mechanical time constant 727* until the output value corresponds to the time modification of the drive mechanism during the acceleration processes.

16.4.5 Field controller

Control of the flux-forming current component is done in the outer control loop by the field controller. The guided commissioning optimizes the parameters of the field controller by measuring the time constant and magnetizing curve of the connected 3-phase machine. The parameters of the field controller have been selected in such a way that they can be used without alteration in most cases of application. The proportional and the integrating part of the field controller are to be set via the parameters *Amplification 741* and *Integral time 742*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
717	Flux nominal value	0.01 %	300.00 %	100.00 %
741	Amplification	0.0	100.0	2.0
742	Integral time	0.0 ms	1000.0 ms	200.0 ms

Optimization of the controller parameters of the field parameter should be done in the basic speed range. The frequency to be set should be slightly in front of the limit of the modulation controller selected with the parameter *Reference modulation 750* with the result that the latter is not active. The *Reference flux 717* is only to be optimized in exceptional cases. The set percentage modifies the flux-forming current component in the ratio to the torque-forming current component. Correction of the rated magnetizing current with the help of the reference flux thus modifies the torque of the drive mechanism. If the parameter *Reference flux 717* is decreased in a jump (change-over from 100% to 50%), the value I_{sd} can be oscillographed. The course of the signal of the flux-forming current I_{sd} should reach the stationary value after a vibration without oscillating. The integral time of the field controller should be selected according to the half rotor time constant calculated by the software. The actual value to be read out via the parameter *Act. rotor time constant 227* divided by two is to be used in the first approach for the parameter *Integral time field controller 742*. If a quick transition into field weakening is necessary for the application, the integral time should be reduced. The amplification is to be selected relatively large for a good dynamism of the controller. Attention should be paid to the fact that an increased overshoot is necessary for a good control behavior in controlling of a load with low-pass behavior, for example a 3-phase machine.

16.4.5.1 Limitation of field controller

The output signal of the field controller, the integrating and proportional component are limited via the parameter *Ref. Isd upper limit 743* and parameter *Ref. Isd lower limit 744*. The guided commissioning has set the parameter *Ref. Isd upper limit 743* according to the parameter *Rated current 371*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
743	Ref. Isd upper limit	$0.1 \cdot I_{FIN}$	$0 \cdot I_{FIN}$	I_{FIN}
744	Ref. Isd lower limit	$- I_{FIN}$	I_{FIN}	0.0

The limits of the field controller define not only the maximum current occurring, but also the dynamic properties of the controller. The upper and lower limits restrict the modification speed of the machine flux and the torque resulting from it. In particular the speed area above the nominal frequency is to be observed for the modification of the flux-forming component. The upper limit is to be estimated from the product of the set magnetizing current and the correction factor *Reference flux 717*, although the limit may not exceed the overload current of the drive mechanism.

16.4.6 Modulation controller

The modulation controller, which is designed as an I regulator, automatically adapts the output value of the frequency inverter to the machine behavior in the basic speed area and in the field weakening area. If the modulation exceeds the value set with parameter *Reference modulation 750*, the field-forming current component and thus the flux in the machine are reduced.

In order to make the best possible use of the voltage available, the value selected via the parameter *Operation mode modulation controller 753* is put into proportion to the DC link voltage. That means that with a high mains voltage there is also a high output voltage available, the drive mechanism only reaches the field weakening area later and produces a higher torque.

Operation mode	Function
0 - Usq-Control	The modulation is calculated from the ratio of torque-forming voltage component U_{sq} to the DC link voltage
1 - V-Absolute Value Control	The modulation is calculated from the ratio of amount of voltage to the DC link voltage

The integrating part of the modulation controller is to be set via the parameter *Integral time modulation controller 752*.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
750	Reference modulation	3.00 %	105.00 %	102.00 %
752	Integral time modulation controller	0.0 ms	1000.0 ms	10.0 ms

The percentage setting of the *Reference modulation 750* is basically a function of the leakage inductivity of the machine. The default has been selected in such a way that in most cases the remaining deviation of 5% is sufficient as a reserve range for the current controller. For the optimization of the controller parameters, the drive is accelerated with a flat ramp into the area of field weakening, with the result that the modulation controller is in contact. The limit is set via the parameter *Reference modulation 750*. Then, the control loop can be excited with a jump function by modifying the reference modulation (change-over between 95% and 50%). With the help of an oscillographed measurement of the flux-forming current component on the analog output of the frequency inverter, the controlling process of the modulation controller can be assessed. The course of the signal of the flux-forming current i_{sd} should reach the stationary value after a vibration without oscillating. An oscillating of the course of the current is to be damped by increasing the integral time. The parameter *Integral time 752* should roughly correspond to the actual value *Act. rotor time constant 227*.

16.4.6.1 Limitation modulation controller

The output signal of the modulation controller is the internal reference flux. The controller output and the integrating part are limited via the parameter *Reference Imr lower limit 755* or the product of *Rated magnetizing current 716* with *Reference flux 717*. The magnetizing current parameter forming the upper limit is to be set to the rated value of the machine. For the lower limit, select a value that also builds up an adequate flux in the machine in the field weakening area. The limitation of the control deviation on the output of the modulation controller prevents a possible oscillation of the control loop in load strokes. The parameter *Control deviation limitation 756* is stated as an absolute value and acts as both a positive and also a negative limit value.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
755	Reference Imr lower limit	$0.01 \cdot I_{FIN}$	$0 \cdot I_{FIN}$	$0.01 \cdot I_{FIN}$
756	Control deviation limitation	0.00 %	100.00 %	10.00 %

17 Special functions

The various configurations of the software enable a wide range of applications of the frequency inverters thanks to freely configurable functions of the control functions and methods in question. Integration into the application is facilitated by further functions provided an application-specific functionality.

17.1 Pulse width modulation

The motor noises can be reduced by changing over the parameter *Switching frequency* **400**. A reduction of the switching frequency should be up to a maximum ration of 1:10 to the frequency of the output signal for a sine-shaped output signal. The maximum possible switching frequency depends on the drive output and the ambient conditions. The necessary technical data can be seen from the matching table and the diagrams of the type of device.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
400	Switching frequency	2 kHz	16 kHz	4 kHz

The losses of heat rise proportionally to the load point of the frequency inverter and the switching frequency. The automatic reduction adapts the switching frequency to the current operating state of the frequency inverter in order to provide the output performance necessary for the drive task with the greatest possible dynamics and low noise encumbrance.

The switching frequency is adapted between the limits which can be set with the parameters *Switching frequency* **400** and *Minimum switching frequency* **401**. If the *Minimum switching frequency* **401** is larger than or equal to the *Switching frequency* **400**, the automatic reduction is deactivated.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
401	Minimum switching frequency	2 kHz	16 kHz	4 kHz

The change of the switching frequency is a function of the heat sink temperature switch-off limit and the output current.

The temperature limit to be exceeded so that the switching frequency is reduced can be set with the parameter *Reduction limit heat sink temp.* **580**. If the heat sink temperature falls below the threshold set with the parameter *Reduction limit heat sink temp. Tc* **580** by 5°C, the switching frequency is increased again step by step.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
580	Reduction limit heat sink temp.	-25 °C	0 °C	-4 °C

Note: The limit for the switching frequency reduction is influenced by the *Intelligent current limits* **573** as a function of the operating mode selected and the output current. If they have been switched off or provide the full overload current, the switching frequency is reduced when the output current exceeds the limit of 87.5% of the long-term overload current (60s). The switching frequency is increased if the output current drops below the reference current of the next highest switching frequency.

17.2 Heat sink fan

The switch-on temperature of the heat sink fan can be set with the parameter *Switch-on temperature* **39**. If the heat sink temperature exceeds the set temperature value in the stand-by state of the frequency inverter (green LED flashes), the device fan is switched on. If the heat sink temperature falls below the set temperature value by 5°C, the device fan is switched off after a delay period of one minute. If the warning **TC** or the warning **TI** is given, the device fan is switched on. The function is additionally to be connected with the digital control outputs in order to control an external fan.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
39	Switch-on temperature	0 °C	75°C	0 °C

17.3 Bus controller

The frequency inverters are to be extended with various options for data communication and to be integrated into an automation and control system. Parameterization and commissioning can be done via the optional communication card, the operating unit or the interface adapter. The serial communication protocols are set to a transmission rate of 9600 Baud. The parameter *Local/Remote* **412** defines the operating behavior and a change between the control via contacts or the operating unit and the interface.

Operation mode	Function
0 - Control via Contacts	The Start and Stop command as well as the statement of the direction of rotation are via digital signals.
1 - Control via Statemachine	The Start and Stop command as well as the statement of the direction of rotation are via the DRIVECOM State machine of the communication interface.
2 - Control via Remote-Contacts	The Start and Stop command as well as the statement of the direction of rotation are via logic signals by the communication protocol.
3 - Ctrl. KP, direction Contacts	The Start and Stop command comes from the operating unit and the statement of the direction of rotation via digital signals.
4 - Ctrl. KP+Cont., direction Cont.	The Start and Stop command comes from the operating unit or via digital signals. The statement of the direction of rotation only with the help of the digital signals.
13 - Control via KP, direction KP	The Start and Stop command as well as the statement of the direction of rotation are via the operating unit.
14 - Control KP+Cont., direction KP	The Start and Stop command comes from the operating unit or via digital signals. The statement of the direction of rotation only with the help of the operating unit.
20 - Control Contacts, Clockw.	The Start and Stop command is via digital signals. The statement of the direction of rotation is fixed, only clockwise.
23 - Control Keypad, Clockw.	The Start and Stop command is via the operating unit. The statement of the direction of rotation is fixed, only clockwise.
24 - Control Cont. + KP, Clockw.	The Start and Stop command comes from the operating unit or via digital signals. The statement of the direction of rotation is fixed, only clockwise.
30 to 34	Operation mode 20 to 24, direction of rotation only anticlockwise
43 - Ctrl. KP, Dir. Cont. + KP	The Start and Stop command is via the operating unit. The statement of the direction of rotation comes from the operating unit or via digital signals.
44 - Ctrl. Cont.+KP, Dir. Cont.+KP	The Start and Stop command and the statement of the direction of rotation come from the operating unit or via digital signals.

17.4 Brake Chopper

The frequency inverters are fitted with a brake chopper transistor in the factory. The connection of the external brake resistor is done on terminals Rb1 and Rb2. The parameter *Trigger threshold 506* defines the switch-on threshold of the brake chopper. The generator output of the drive mechanism, which leads to the rise in the DC link voltage, is converted into heat by the external brake resistor from the trigger threshold. The temperature monitoring of the resistor is to be integrated into the safety chain according to the matching operating instructions.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
506	Trigger threshold	$U_{dmin}+25V$	1000.0 V	U_{dBC}

The parameter *Trigger threshold 506* is to be set in such a way that it is between the maximum DC link voltage which the mains can generate and the maximum admissible DC link voltage of the frequency inverter.

$$U_{Mains} \cdot 1.1 \cdot \sqrt{2} < U_{dBC} < U_{dmax}$$

If the parameter *Trigger threshold 506* is set larger than the maximum admissible DC link voltage, the brake chopper cannot become active, the brake chopper is switched off.

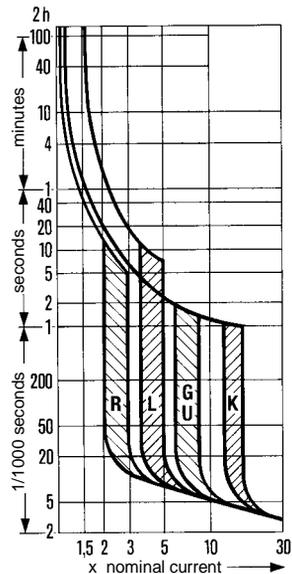
17.5 Motor protective switch

Motor protective switches are used to protect a motor and its supply line against overheating by overload. Depending on the amount of the overload, they act as a protection against short circuits with their quick triggering and, at the same time, as an overload protection with their slow shut-off.

In the trade, conventional motor protective switches are available for various applications with differing trigger characteristics (L, G/U, R and K), as shown in the diagram alongside. As frequency inverters are used to feed motors in the majority of cases, these being classified as operating equipment with very high starting currents, the K characteristic has been exclusively realized in this function.

Unlike the way of working of a conventional motor protective switch, which releases the operating equipment to be protected immediately the trigger threshold is reached, this function provides the possibility of issuing a warning report instead of an immediate cut-off.

The reference current of the motor protective switch refers to the rated motor current stated with the parameter *Rated current 371* of the data set in question. The reference values of the frequency inverter are to be taken into account accordingly in the dimensioning of the application.



The function of the motor protective switch is data set switch-over capable. In this way, various motors can be run on one frequency inverter. Thus, each motor can have its own motor protective switch.

For the case of operation of a motor being operated on a frequency inverter for which some setting values, e.g. minimum and maximum frequency, have been changed via the data set switch-over, only one motor protective switch may exist. This functionality can be differentiated by selecting the parameter *Operation mode motor protective switch 571* for operation of single motors or operation of multiple motors.

Operation mode		Function
0 - Off	K-Char., Mul.Motor Op., Err.Sw.Off	The function is deactivated In each of the four data sets, the rated values are monitored. The overload of the drive mechanism is avoided by the fault switch-off "F0401".
2 -	K-Char., Sing.Motor, Err.Sw.-Off	The rated values in the first data set are used independently of the active data set. The overload of the drive mechanism is avoided by the fault switch-off "F0401".
11 -	K-Char., Multi-Motor Op., Warning	In each of the four data sets, the rated values are monitored. The overload of the drive mechanism is signaled by a warning message "A0200".
22 -	K-Char., Single-Motor, Warning	The rated values in the first data set are used independently of the active data set. The overload of the drive mechanism is signaled by a warning message "A0200".

Multiple motor operation

Parameter *Operation mode motor protective switch 571 = 1 or 11*

In multiple motor operation, it is presupposed that one motor matching each data set is used. For this, one motor and one motor protective switch are assigned to each data set. In this operation mode, the rated values of the active data set are monitored. The current output current of the frequency inverter is only taken into account in the motor protective switch activated by the data set. In the motor protective switches of the other sets, zero current is expected, with the result that the thermal decay functions are taken into account. In combination with the data set change-over, the function of the motor protective switches is like motors connected alternately to the mains with their own circuit breakers.

Single motor operation

Parameter *Operation mode motor protective switch 571 = 2 or 22*

In single motor operation, only one motor protective switch, which monitors the output current of the frequency inverter, is active. In a data set change-over, merely the switch-off limits derived from the rated machine parameters are changed over. Accumulated thermal values are used after the change-over as well. In the data set change-over, please ensure that the machine data are stated identically for all data sets. In combination with the data set change-over, the function of the motor protective switches is like motors connected alternately to the mains with a joint circuit breaker.

Motor protection, in particular self-ventilation motors, is improved via the *Frequency limit 572* which can be set as a percentage of the rated frequency. The measured output current in operating points outside the frequency limit is assessed by a factor of 2 higher in the calculation of the trigger characteristic.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
572	Frequency limit	0 %	300 %	0 %

17.6 Functions of the sensor-less control

The configurations of the sensor-less control contain the special functions described below, which supplement the behavior in accordance with the parameterized V/f characteristic and control functions.

17.6.1 V-belt monitoring

Continuous monitoring of the load behavior and thus of the connection between the 3-phase machine and the load is the task of the V-belt monitoring. The parameter *Operation mode* **581** defines the function behavior if the active current falls short of the set *Trigger limit lactive* **582** for a period greater than the parameterized *Delay time* **583**.

Operation mode	Function
0 - off	The function is deactivated
1 - Warning	If the active current falls short of the threshold value, the warning "A8000" is displayed.
2 - Error	The drive mechanism without a load is switched off with the fault message "F0402"

The error and warning messages can be read out with the help of the digital outputs or notified via a superior control. The *Trigger limit lactive* **582** is to be parameterized as a percentage of the *Rated current* **371** for the application and the possible operating points.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
582	Trigger limit lactive	0.1%	100.0 %	10.0 %
583	Delay time	0.1 s	600.0 s	10.0 s

17.7 Functions of the field-oriented control

The field-oriented control systems are based on a cascade control and the calculation of a complex machine model. The various control functions can be supplemented by special functions specific to the application.

17.7.1 Motor chopper

The field-oriented control systems contain the function for adapted implementation of the generator energy into heat in the connected three-phase machine. This enables the realization of dynamic speed changes with minimum system costs. The torque and speed behavior of the drive system is not influenced by the parameterized braking behavior. The parameter *Trigger threshold* **507** of the DC link voltage defines the switch-on threshold of the motor chopper function.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
507	Trigger threshold	$U_{dmin}+25V$	1000.0	U_{dMC}

The parameter *Trigger threshold* **507** is to be set in such a way that it is between the maximum DC link voltage which the mains can generate and the maximum admissible DC link voltage of the frequency inverter.

$$U_{Mains} \cdot 1.1 \cdot \sqrt{2} < U_{dMC} < U_{dmax}$$

If the parameter *Trigger threshold* **507** is set larger than the maximum admissible DC link voltage, the motor chopper cannot become active, the motor chopper is switched off.

17.7.2 Temperature adjustment

The field-oriented control systems are based on the most precise calculation of the machine model possible. The rotor time constant is an important machine variable for the calculation. The value to be read out via the parameter *Current rotor time constant* **227** is calculated from the inductivity of the rotor circuit and the rotor resistance. The dependence of the rotor time constant on the motor temperature can be taken into account in particularly high demands on precision via a suitable measurement. Various processes and actual value sources for temperature registration can be selected via the parameter *Operation mode temperature adjustment* **465**.

Operation mode	Function
0 - Off	The function is deactivated.
1 - Temp. meas. on MFI1	Temperature synchronization (0 to 200°C => 0/2 to 10V), actual temperature value on multifunctional input 1
2 - Temp. meas. on MFI2	Temperature synchronization (0 to 200°C => 0/2 to 10V), actual temperature value on multifunctional input 2
3 - Temp. meas. on MFI3	Temperature synchronization (0 to 200°C => 0/2 to 10V), actual temperature value on multifunctional input 3
11 to 13	Operation modes 1 to 3 with the VECTRON temperature synchronization extension (-26.0 to 207.8°C => 0 to 10V)

The operation modes 1,2 and 3 demand an external temperature measurement that evaluates the temperature sensor (PT100) and maps the temperature range from 0 to 200°C onto an analog voltage or current signal.

The optional VECTRON temperature measurement card is supplied via the control terminals of the frequency inverters. The card maps the temperature range from -26.0 to 207.8°C onto an analog voltage or current signal. The resistance area of the PTC temperature sensor used is 90 to 180Ω for the aforementioned temperature range.

The material used for the rotor winding of the motor is taken into account via the parameter *Temperature coefficient* **466**. This value defines the change of the rotor resistance as a function of the temperature for a certain material of the rotor winding. Typical temperature coefficients are 39%/100°C for copper and 36%/100°C for aluminum at a temperature of 20°C.

The temperature characteristic within the software is calculated via the aforementioned temperature coefficient and the parameter *Temperature adjustment* **467**. The adjustment temperature enables an additional optimization of the rotor time constant alongside the parameter *Rated slip correction factor* **718**.

Parameter		Setting		
No.	Description	Min.	Max.	Fact. sett.
466	Temperature coefficient	0.00%/100°C	300.00%/100°C	39.00%/100°C
467	Adjustment temperature	-50°C	300°C	100°C

The synchronization of the rotor time constant as a function of the winding temperature can be adjusted. The factory settings of the values should normally be sufficiently precise for neither an adjustment of the rotor time constants via the parameter *Rated slip correction factor* **718** nor an adjustment of the temperature synchronization via the parameter *Temperature coefficient* **466** to be necessary. In adjustment, please remember that the rotor time constant is calculated by the guided commissioning via the machine data. The *Adjustment temperature* **467** is to be set to the temperature at which the optimization of the extended machine data has been done. The temperature is to be read out via the actual value parameter *Winding temperature* **226** and can be used in the optimization for the parameter.

17.7.3 Speed sensor monitoring

Failures of the speed sensor lead to a faulty behavior of the drive mechanism, as the measured speed forms the foundation for the control system. From the factory setting, the speed sensor monitoring continuously monitors the speed sensor signal, the track signal and the division marks. If a faulty signal is recognized with the frequency inverter released for longer than the timeout, there is a fault switch-off. If the parameter *Speed sensor monitoring 760* is set to zero, the monitoring function is deactivated.

Operation mode	Function
0 - Off	The function is deactivated
2 - Fault	A fault message is displayed according to the timeouts set.

The speed sensor monitoring is to be parameterized in the part functions according to the application. The monitoring function becomes active with the release of the frequency inverter and the start command. The timeout defines a monitoring duration in which the condition for the fault switch-off must be fulfilled without interruption. If one of the timeouts is set to zero, this monitoring function is deactivated.

No.	Parameter Description	Setting		
		Min.	Max.	Fact. sett.
761	Timeout: Signal fault	0 ms	65000 ms	1000 ms
762	Timeout: Track fault	0 ms	65000 ms	1000 ms
763	Timeout: Rotation direction fault	0 ms	65000 ms	1000 ms

Timeout: Signal fault

The actual speed measured is compared with the output value of the speed controller. If the actual speed value is exactly zero for the time selected with the parameter *Timeout: Signal fault 761*, although a reference value is available, the fault is displayed with the message "F1430".

Timeout: Track fault

The actual speed measurement monitors the sequence in time of the signals in the quadruple evaluation of the speed sensor operation mode. If the speed sensor signal is faulty for the time selected with the parameter *Timeout: Channel fault 762*, the fault is displayed with the message "F1431".

Timeout: Rotation direction fault

The actual speed measured is compared with the reference speed. If the sign between reference value and actual value differs for the time selected with the parameter *Timeout: Direction fault 763*, the fault is displayed with the message "F1432". The monitoring function is reset when the drive mechanism has moved in the reference value direction by a quarter of a revolution.

18 Actual values

The various control functions and methods contain electrical control variables and various calculated actual values of the machine or system. The varied actual values can be read out for the operational and error diagnosis via a communication interface or in the VAL menu branch of the operating unit.

18.1 Actual values of the frequency inverter

The modular hardware of the frequency inverter enables application-specific adaptation. Further actual value parameters can be displayed as a function of the selection configuration and the installed expansion cards.

Actual values of the frequency inverter		
No.	Description	Function
222	DC link voltage	Direct voltage in the DC link
223	Voltage ratio	Output voltage of the frequency inverter relative to the mains voltage ($100\% = U_{FIN}$)
228	Reference frequency internal	Sum of the <i>Frequency reference value sources 475</i> as a reference value from the frequency reference value channel
229	Reference percentage value	Sum of the <i>Reference percentage sources 476</i> as a reference value from the reference percentage channel
230	Actual percentage value	Actual value signal on the <i>Actual percentage source 478</i>
244	Working hours counter	Operating hours in which the power part of the inverter is active
245	Operating hours counter	Operating hours of the frequency inverter in which supply voltage is available
249	Active data set	The data set actively in use according to <i>Data set change-over 1 70</i> and <i>Data set change-over 2 71</i>
250	Status digital inputs	Decimally coded status of the six digital inputs and of multifunctional input 1 in <i>Operation mode 452</i> - digital input
251	Analog input MF1A	Input signal on multifunctional input 1 in the <i>Operation mode 452</i> - analog input
252	Repetition frequency input	Signal on repetition frequency input according to <i>Operation mode 496</i>
254	Digital outputs	Decimally coded status of the two digital outputs and of the multifunctional output 1 in <i>Operation mode 550</i> - digital
255	Heat sink temperature	Measured heat sink temperature
256	Inside temperature	Measured inside temperature
257	Analog output MFO1A	Output signal on multifunctional output 1 in <i>Operation mode 550</i> – analog
259	Current error	Error message with error code and abbreviation
269	Warnings	Warning message with error code and abbreviation
275	Controller status	The reference value signal is being limited by the controller coded in the controller status

Note: The actual values can be read out and monitored in the VAL menu branch of the operating unit. The parameter *Operation level 28* in the PARA menu branch defines the selection of the actual value parameters to be selected.

18.2 Actual values of the machine

The frequency inverter controls the behavior of the machine in the various operating points. As a function of the configuration selected and the expansion cards installed, control variables and further actual value parameters of the machine can be displayed.

Actual values of the machine		
No.	Description	Function
210	Stator frequency	The output frequency (motor frequency) of the frequency inverter
211	Effective current	Calculated effective output current (motor current) of the frequency inverter
212	Output voltage	Calculated R.m.s. value of the phase-to-phase voltage (motor voltage) of the frequency inverter
213	Active power	Active power calculated from the voltage, the current and the control variables
214	Active current	Active current calculated from the rated motor parameters, the control variables and the current
215	Isd	Current component of the field-oriented control forming the magnetic flux
216	Isq	Current component of the field-oriented control forming the torque
217	Speed sensor 1 frequency	Calculated from the data on speed sensor 1, the <i>No. of pole pairs 373</i> and the speed sensor signal
218	Speed sensor 1 speed	Calculation from speed sensor 1 frequency
221	Slip frequency	Difference from the synchronous frequency calculated from the rated motor parameters, the control variables and the current
224	Torque	Torque at the current output frequency calculated from the voltage, the current and the control variables
225	Rotor flux	Current magnetic flux relative to the rated motor parameters
226	Winding temperature	Measured temperature of the motor winding according to <i>Temperature adjustment operation mode 465</i>
227	Act. rotor time constant	Time constant calculated for the operating point of the machine from the rated motor parameters, the rated and control variables
235	Flux-forming voltage	Voltage component of the field-oriented control forming the magnetic flux
236	Torque-forming voltage	Voltage component of the field-oriented control forming the torque
238	Flux value	Magnetic flux calculated according to the rated values and the operating point of the motor
239	Reactive current	Reactive current calculated from the rated motor parameters, the control variables and the current
240	Actual speed	Measured or calculated speed of the drive mechanism
241	Actual frequency	Measured or calculated frequency of the drive mechanism

Note: The actual values can be read out and monitored in the VAL menu branch of the operating unit. The parameter *Operation level 28* in the PARA menu branch defines the selection of the actual value parameters to be selected.

18.3 Actual value memory

The assessment and maintenance of the frequency inverter in the application is facilitated by the storage of various actual values. The actual value memory guarantees monitoring of the individual variables for a definable period. The parameters of the actual value memory can be read out via a communication interface and displayed via the operating unit. In addition, the operating unit provides monitoring of the peak and mean values in the VAL menu branch.

Actual value memory		
No.	Description	Function
231	Peak value, long term Ixt	Utilization of the device-dependent overload of 60 seconds
232	Peak value, short term Ixt	Utilization of the device-dependent overload of 1 second
287	Peak value, DC link voltage	The maximum DC link voltage measured
288	Mean value, DC link voltage	The mean DC link voltage calculated in the period of observation
289	Peak value, heat sink temp.	The highest measured heat sink temperature of the frequency inverter
290	Mean value, heat sink temp.	The mean heat sink temperature calculated in the period of observation
291	Peak value, inside temp.	The maximum measured inside temperature in the frequency inverter
292	Mean value, inside temp.	The mean inside temperature calculated in the period of observation
293	Peak value, labs.	The highest abs. current calculated from the measured motor phases
294	Mean value, labs.	The mean abs. current calculated in the period of observation
295	Peak value, active power pos.	The largest calculated active power in motor operation
296	Peak value, active power neg.	Maximum generator active power calculated from the voltage, the current and the control variables
297	Mean value, active power	The mean active power calculated in the period of observation
301	Energy positive	The calculated energy to the motor in motor operation
302	Energy negative	The calculated energy from the motor in generator operation

Note: The actual values can be read out and monitored in the VAL menu branch of the operating unit. The parameter *Operation level 28* in the PARA menu branch defines the selection of the actual value parameters to be selected.

The *Reset memory 237* parameter to be selected in the PARA menu branch of the operating unit enables purposeful resetting of the individual mean and peak values. The peak value and the mean value with the values stored in the period are overwritten with the parameter value zero.

Operation mode	Function
0 - No Reset	Values of the actual value memory are unaltered
1 - Peak value long term lxt	Reset <i>Peak value long-term lxt 231</i>
2 - Peak value short term lxt	Reset <i>Peak value short-term lxt 232</i>
3 - Peak value Udc	Reset <i>Peak value DC link voltage 287</i>
4 - Average value Udc	Delete <i>Mean value DC link voltage 288</i>
5 - Peak value Tc	Reset <i>Peak value heat link temp. 289</i>
6 - Average value Tc	Delete <i>Mean value heat link temp. 290</i>
7 - Peak value Ti	Reset <i>Peak value inside temp. 291</i>
8 - Average value Ti	Delete <i>Mean value inside temp. 292</i>
9 - Peak value labs.	Reset <i>Peak value labs. 293</i>
10 - Average value labs.	Delete <i>Mean value labs. 294</i>
11 - Peak value Pactive pos.	Reset <i>Peak value active power pos. 295</i>
12 - Peak value Pactive neg.	Reset <i>Peak value active power neg. 296</i>
13 - Average value Pactive	Delete <i>Mean value active power 297</i>
16 - Energy, positive	Reset parameter <i>Energy positive 301</i>
17 - Energy, negative	Reset parameter <i>Energy negative 302</i>
100 - All peak values	Reset all stored peak values
101 - All average values	Delete mean values and stored values
102 - All values	Delete the entire actual value memory

18.4 Actual values of the system

The calculation of the actual values of the system is based on the parameterized system data. Specific to the application, the parameters are calculated from the factors, electrical variables and the controls. The correct display of the actual values is a function of the data of the system to be parameterized.

18.4.1 Volume flow and pressure

The parameterization of the factors *Nominal volumetric flow 397* and *Nominal pressure 398* is necessary if the matching actual values *Volumetric flow 285* and *Pressure 286* are used for monitoring the drive mechanism. The conversion of the electrical control variable is done according to the bad point method, in which the working point is displaced by an amendment of the speed on the characteristic.

Actual value memory		
No.	Description	Function
285	Volume flow	Calculated volume flow with the unit m ³ /h
286	Pressure	Pressure calculated according to the characteristic with the unit kPa

19 Error protocol

The various control functions and methods and the hardware of the frequency inverter contain functions that continuously monitor the application. The operational and error diagnosis is facilitated by the information stored in the error protocol.

19.1 Error list

The last 16 fault messages are stored in chronological order and the *No. of errors* **362** shows the number of errors which have occurred since initial commissioning of the frequency inverter. In the VAL menu branch of the operating unit, the error code FXXXX is displayed, and the number of operation hours (h), operation minutes (m) and the fault message can additionally be read off via the PC program. The current operating hours can be read off via the *Operation hours counter* **245**. The fault report can be acknowledged via the keys of the operating unit and according to the assignment *Error acknowledgment* **103**.

Error list		
No.	Description	Function
310	Last error	hhhhh:mm ; FXXXX fault message
311	Last error but one	hhhhh:mm ; FXXXX fault message
312 to 325		error 3 to error 16
362	No. of errors	number of errors occurring after the initial commissioning of the fault message

The error/warning behavior of the fault message can be parameterized in a number of ways. The automatic error acknowledgment enables acknowledgment of the overcurrent F0500, overcurrent F0507 and overvoltage F0700 errors without intervention of a superior control or the user. The *No. of self acknowledged errors* **363** shows the sum total of the automatic error acknowledgments.

Error list		
No.	Description	Function
363	No. of self acknowledged errors	Sum total of the automatic error acknowledgment with synchronization

19.1.1 Fault messages

The error code stored following a fault comprises the error group FXX and the following code number XX.

Fault messages		
Code		Meaning
F00	00	No fault has come about

Overload		
F01	02	Frequency inverter overloaded (60 s), check load behavior
	03	Short-term overload (1 s), check motor and application parameters

Heat sink		
F02	00	Heat sink temperature too high, check cooling and ventilator
	01	Temperature sensor defective or ambient temperature too low

Inside		
F03	00	Inside temperature too high, check cooling and ventilator
	01	Inside temperature too low, check electrical cabinet heating

Continuation of the fault messages:

Motor connection		
Code		Meaning
F04	00	High motor temperature or sensor defective, check connection S6IND
	01	The motor protective switch has reacted, check drive
	02	The V-belt monitoring reports no load on the drive
	03	Phase failure, check motor and wiring

Output current		
F05	00	Overloaded, check load situation and ramps
	03	Short circuit or earth fault, check motor and wiring
	04	Overloaded, check load situation and current value limit controller
	05	Asymmetric motor current, check current and wiring
	06	Motor phase current too high, check motor and wiring
	07	Message from phase monitoring, check motor and wiring

DC link voltage		
F07	00	DC link voltage too high, check deceleration ramps and connected brake resistor
	01	DC link voltage too small, check mains voltage
	02	Power failure, check mains voltage and circuit
	03	Phase failure, check mains fuses and circuit
	04	Reference DC link limitation 680 too small, check mains voltage
	05	Brake chopper <i>Trigger threshold</i> 506 too small, check mains voltage
06	Motor chopper <i>Trigger threshold</i> 507 too small, check mains voltage	

Electronics voltage		
F08	01	Electronics voltage 24 V too low, check control terminal
	04	Electronics voltage too high, check wiring of control terminals

Output frequency		
F11	00	Output frequency too high, check control signals and settings
	01	Max. frequency achieved by control, check deceleration ramps and connected brake resistor

Motor connection		
F13	00	Earth fault on output, check motor and wiring
	10	Minimum current monitoring, check motor and wiring

Control connection		
F14	01	Reference value on multifunctional input 1 faulty, check signal
	07	Overcurrent on multifunctional input 1, check signal
	30	Speed sensor signal defective, check connections S4IND and S5IND
	31	One track of the speed sensor signal is missing, check connections
	32	Direction of rotation of speed sensor wrong, check connections

Optional components		
F0B	13	The communication module has been fitted to plug-in section B without disconnection of the mains voltage, switch mains voltage off.

Alongside the fault messages stated, there are further fault messages, however they are only used for internal purposes and are not listed here. If you receive fault messages which are not listed here, please contact us by phone.

19.2 Error environment

The parameters of the error environment help troubleshooting both in the settings of the frequency inverter and also in the complete application. The error environment documents the operational behavior of the frequency inverter at the time of the last four faults.

Error environment		
No.	Description	Function
330	DC link voltage	Direct voltage in the DC link
331	Output voltage	Calculated output voltage (motor voltage) of the frequency inverter
332	Stator frequency	The output voltage (motor voltage) of the frequency inverter
333	Frequency speed sensor 1	Calculated from the data on speed sensor 1, the <i>No. of pole pairs 373</i> and the sensor signal
335	Phase current Ia	Measured current in motor phase U
336	Phase current Ib	Measured current in motor phase V
337	Phase current Ic	Measured current in motor phase W
338	R.m.s. current	Calculated effective output current (motor current) of the frequency inverter
339	Isd / reactive current	Current component forming the magnetic flux or the calculated reactive current
340	Isq / active current	Current component forming the torque or the calculated active current
341	Rotor magnetizing current	Magnetizing current relative to the rated motor parameters and the operating point
342	Torque	Torque calculated from the voltage, the current and the control variables
343	Analog inputs MF1A	Input signal on multifunctional input 1 in <i>Operation mode 452</i> - analog input
346	Analog output MFO1A	Output signal on multifunctional input 1 in <i>Operation mode 550</i> – analog
349	Repetition frequency output	Signal on repetition frequency output according to <i>Operation mode 555</i>
350	Status digital inputs	Decimally coded status of the six digital inputs and of multifunctional input 1 in <i>Operation mode 452</i> - digital input
351	Status digital outputs	Decimally coded status of the two digital outputs and of multifunctional output 1 in <i>Operation mode 550</i> - digital
352	Time since release	The time of the error in hours (h), minutes (m) and seconds (s) after the release signal: hhhh:mm:ss . ^{sec} / ₁₀ ^{sec} / ₁₀₀ ^{sec} / ₁₀₀₀
353	Heat sink temperature	Measured heat sink temperature
354	Inside temperature	Measured inside temperature
355	Controller status	The reference value signal is being limited by the controller coded in the controller status
356	Warning status	The warning messages coded in warning status
357	Int. value 1	Software service parameter
358	Int. value 2	Software service parameter
359	Long value 1	Software service parameter
360	Long value 2	Software service parameter

The *Checksum 361* parameter shows whether the storage of the error environment was free of errors (OK) or incomplete (NOK).

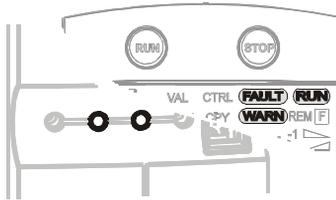
Error environment		
No.	Description	Function
361	Checksum	Check protocol of the error environment

20 Operational and error diagnosis

The operation of the frequency inverter and the connected load is continuously monitored. Various functions document the operational behavior and facilitate the operational and error diagnosis.

20.1 Status display

The green and red light-emitting diodes give information about the operating point of the frequency inverter. If the operating unit has been attached, the status reports are additionally displayed by the display elements RUN, WARN and FAULT.



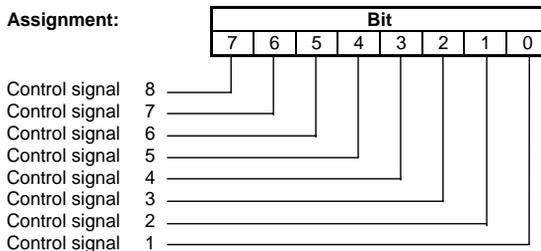
Status display			
green LED	red LED	Display	Description
off	off	-	No supply voltage
on	on	-	Initialization and self-test
flashes	off	RUN flashes	Ready for operation, no output signal
on	off	RUN	Operational message
on	flashes	RUN + WARN	Operational message, current <i>warning 269</i>
flashes	flashes	RUN + WARN	Ready for operation, current <i>warning 269</i>
off	flashes	FAULT flashes	<i>Error message 310</i> of the frequency inverter
off	on	FAULT	<i>Error message 310</i> , acknowledge error

20.2 Status of the digital signals

The status display of the digital input and output signals enables checking of the various control signals and assignment to the software functions in question, in particular in commissioning.

Coding of the status of the digital signals

Assignment:



The display is a decimal value, which states the status of the digital signals in bits after conversion into a binary value.

Example: The display is the decimal value 33. After conversion into the binary system, the bit combination **00100001** results. Thus, the following contact inputs or outputs are operated:

- Control signal in digital input or output 1
- Control signal in digital input or output 6

20.3 Controller status

The controller status can be used to establish which of the control functions are in contact. If a number of controllers are in contact at the time, a controller code composed of the sum total of the individual codes is displayed. The display of the controller status by the operating unit and the light-emitting diodes can be parameterized via the *Controller status message 409*.

Coding of the controller status

CXXXX	ABCDE
Controller code	Controller abbreviation

Code	Controller status
C 00 00 -	No controller active
C 00 01 UDdyn	Controller is in the rise phase according to the <i>Voltage Controller operation mode 670</i>
C 00 02 UDstop	The output frequency in a power failure is below the <i>Shutdown threshold 675</i>
C 00 04 UDctr	Failure of the mains voltage and power support active according to <i>Voltage Controller operation mode 670</i>
C 00 08 UDlim	The DC link voltage has exceeded the <i>Reference DC link limitation 680</i>
C 00 10 Boost	The <i>Dyn. voltage pre-control 605</i> accelerates the control behavior
C 00 20 Ilim	The output current is limited by the current limit value controller or the speed controller
C 00 40 Tlim	The output power or the torque is limited on the speed controller
C 00 80 Tctr	Change-over of the field-oriented control between speed and torque control
C 01 00 Rstp	The <i>Operation mode 620</i> selected in the starting behavior limits the output current
C 02 00 IxtLtLim	Overload limit of the long term Ixt (60s) reached, intelligent current limits active
C 04 00 IxtStLim	Overload limit of the short term Ixt (1s) reached, intelligent current limits active
C 08 00 Tclim	Max. heat sink temperature T_C reached, <i>Intelligent current limits 573</i> active
C 10 00 PTclim	Max. motor temperature T_{PTC} reached, <i>Intelligent current limits 573</i> active
C 20 00 Flim	The reference frequency has reached the <i>Maximum frequency 419</i> . The frequency limit is active

Example: The display is the controller status

C0024 UDctr Ilim

The controller status results from the hexadecimal sum of the controller codes (0004+0020 = 0024). Simultaneously, the power failure regulation and also the current limitation of the speed controller are in contact.

20.4 Warning status

The current warning is displayed by a message in the warning status and can be used for an early message of a critical operational condition. The combination of various warnings can be set in the configurable *Warning mask 536*. If a warning exists, it is displayed by the flashing red LED and the WARN display field of the operating unit. If there are a number of warnings, the warning status is displayed as the sum of the individual warning codes.

Coding of the warning status

AXXXX Warning code	ABCDE Abbreviation for the warning
-----------------------------------	---

Code	Warning status
A 00 00 -	No warning message available.
A 00 01 lxt	Frequency inverter overloaded (A0002 or A0004)
A 00 02 lxtSt	Overload for 60s relative to the nominal output of the frequency inverter
A 00 04 lxtLt	Short term overload for 1s relative to the nominal output of the frequency inverter
A 00 08 Tc	Max. heat sink temperature T_C of 80 °C less the <i>Warning limit Tc 407</i> reached
A 00 10 Ti	Max. inside temperature T_i of 65 °C less the <i>Warning limit Ti 408</i> reached
A 00 20 Lim	The controller stated in <i>Controller status 275</i> limits the nominal value
A 00 40 INIT	Frequency inverter is being initialized
A 00 80 PTC	Warning behavior according to parameterized <i>Motor PTC operation mode 570</i> at max. motor temperature T_{PTC}
A 01 00 Mains	The <i>Phase monitoring 576</i> reports a phase failure
A 02 00 PMS	Parameterized <i>Motor protective switch 571</i> has triggered
A 04 00 Flim	The <i>Maximum frequency 419</i> has been exceeded. The frequency limitation is active
A 08 00 A1	The input signal MFI1A is less than 1V / 2 mA in accordance with the <i>Error/warning behavior 453</i> mode of operation
A 10 00 A2	The input signal is less than 1V / 2mA in accordance with the error/warning behavior
A 20 00 SYS	A slave on the system bus reports a fault; warning is only relevant with the EM-SYS option
A 40 00 UDC	The DC link voltage has reached the type-dependent minimum value
A 80 00 BELT	The <i>V-belt monitoring 581</i> reports no load of the application

Example: The display is the warning status

A008D lxt lxtLt Tc PTC

The warning status results from the hexadecimal sum of the warning codes (0001+0004+0008+0080 = 008D).

The short-term overload (1s), warning limit heat sink temperature and warning limit motor temperature warnings exist.

21 Parameter list

The parameter list is structured according to the menu branches of the operating unit. For better clarity, the parameters have been marked with pictograms:

-  The parameter is available in the four data sets
-  The parameter value is set by the SET-UP routine
-  This parameter cannot be written in the operation of the frequency inverter.

21.1 Actual value menu (VAL)

Actual values of the machine				
No.	Description	Unit	Display range	Chapter
210	Stator frequency	Hz	0.00 to 999.99	18.2
211	R.m.s current	A	0.0 to I_{max}	18.2
212	Output voltage	V	0.0 to U_{FIN}	18.2
213	Active power	kW	0.0 to P_{max}	18.2
214	Active current	A	0.0 to I_{max}	18.2
215	Isd	A	0.0 to I_{max}	18.2
216	Isq	A	0.0 to I_{max}	18.2
217	Encoder 1 frequency	Hz	0.00 to 999.99	9.3
218	Encoder 1 speed	1/min	0 to 60000	9.3
221	Slip frequency	Hz	0.0 to 999.99	18.2
Actual values of the frequency inverter				
222	DC link voltage	V	0.0 to $U_{dmax-25}$	18.1
223	Modulation	%	0 to 100	18.1
Actual values of the machine				
224	Torque	Nm	± 9999.9	18.2
225	Rotor flux	%	0 to 100	18.2
226	Winding temperature	deg.C	0 to 999	17.7.2
227	Act. rotor time constant	ms	0 to τ_{max}	18.2
Actual values of the frequency inverter				
228	Internal reference frequency	Hz	0.00 to f_{max}	18.1
229	Reference percentage value	%	± 300.00	18.1
230	Actual percentage value	%	± 300.00	18.1
Actual value memory				
231	Peak value long-term lxt	%	0.00 to 100.00	18.3
232	Peak value short-term lxt	%	0.00 to 100.00	18.3
Actual values of the machine				
235	Flux-forming voltage	V	0.0 to U_{FIN}	18.2
236	Torque-forming voltage	V	0.0 to U_{FIN}	18.2
238	Flux value	%	0.0 to 100.0	18.2
239	Reactive current	A	0.0 to I_{max}	18.2
240	Actual speed	1/min	0 to 60000	18.2
241	Actual frequency	Hz	0.0 to 999.99	18.2
Actual values of the frequency inverter				
244	Working hours counter	h	99999	18.1
245	Operation hours counter	h	99999	18.1
249	Active data set	-	1 to 4	14.4.6
250	Digital inputs	-	00 to 255	20.2
251	Analog input MFI1A	%	± 100.00	14.1.1
252	Repetition frequency input	Hz	0.00 to 999.99	13.10
254	Digital outputs	-	00 to 255	20.2
255	Heat sink temperature	deg.C	0 to T_{Cmax}	18.1
256	Inside temperature	deg.C	0 to T_{Imax}	18.1
257	Analog output MFO1A	V	0.0 to 24.0	14.2.1

Actual values of the frequency inverter					
No.	Description	Unit	Display range	Chapter	
259	Current error	-	FXXXX	18.1	
269	Warnings	-	AXXXX	18.1	
275	Controller status	-	CXXXX	18.1	
Actual values of the system					
285	Volumetric flow	m ³ /h	0 to 99999	18.4.1	
286	Pressure	kPa	0.0 to 999.9	18.4.1	
Actual value memory					
287	Peak value Vdc	V	0.0 to U _{dmax}	18.3	
288	Average value Vdc	V	0.0 to U _{dmax}	18.3	
289	Peak value heat sink temp.	deg.C	0 to T _{Cmax}	18.3	
290	Average value heat sink temp.	deg.C	0 to T _{Cmax}	18.3	
291	Peak value inside temp.	deg.C	0 to T _{imax}	18.3	
292	Average value inside temp.	deg.C	0 to T _{imax}	18.3	
293	Peak value labs.	A	0.0 to o-I _{FIN}	18.3	
294	Average value labs	A	0.0 to o-I _{FIN}	18.3	
295	Peak value active power pos.	kW	0.0 to o-P _{FIN}	18.3	
296	Peak value active power neg.	kW	0.0 to o-P _{FIN}	18.3	
297	Average value active power	kW	0.0 to o-P _{FIN}	18.3	
301	Energy positive	kWh	0 to 99999	18.3	
302	Energy negative	kWh	0 to 99999	18.3	
Error list					
310	Last error	h:m; F	00000:00; FXXXX	19.1	
311	Last error but one	h:m; F	00000:00; FXXXX	19.1	
312	Error 3	h:m; F	00000:00; FXXXX	19.1	
313	Error 4	h:m; F	00000:00; FXXXX	19.1	
314	Error 5	h:m; F	00000:00; FXXXX	19.1	
315	Error 6	h:m; F	00000:00; FXXXX	19.1	
316	Error 7	h:m; F	00000:00; FXXXX	19.1	
317	Error 8	h:m; F	00000:00; FXXXX	19.1	
318	Error 9	h:m; F	00000:00; FXXXX	19.1	
319	Error 10	h:m; F	00000:00; FXXXX	19.1	
320	Error 11	h:m; F	00000:00; FXXXX	19.1	
321	Error 12	h:m; F	00000:00; FXXXX	19.1	
322	Error 13	h:m; F	00000:00; FXXXX	19.1	
323	Error 14	h:m; F	00000:00; FXXXX	19.1	
324	Error 15	h:m; F	00000:00; FXXXX	19.1	
325	Error 16	h:m; F	00000:00; FXXXX	19.1	
Error environment					
	330	DC link voltage	V	0.0 to U _{dmax}	19.2
	331	Output voltage	V	0.0 to U _{FIN}	19.2
	332	Stator frequency	Hz	0.00 to 999.99	19.2
	333	Encoder 1 frequency	Hz	0.00 to 999.99	19.2
	335	Phase current Ia	A	0.0 to I _{max}	19.2
	336	Phase current Ib	A	0.0 to I _{max}	19.2
	337	Phase current Ic	A	0.0 to I _{max}	19.2
	338	R.m.s current	A	0.0 to I _{max}	19.2
	339	Isd / reactive current	A	0.0 to I _{max}	19.2
	340	Isq / active current	A	0.0 to I _{max}	19.2
	341	Rotor magnetizing current	A	0.0 to I _{max}	19.2
	342	Torque	Nm	± 9999.9	19.2
	343	Analog input MF1A	%	± 100.00	19.2
	346	Analog output MFO1A	V	0.0 to 24.0	19.2
	349	Repetition frequency output	Hz	0.00 to 999.99	19.2
	350	Status of digital inputs	-	00 to 255	20.2
	351	Status of digital outputs	-	00 to 255	20.2
	352	Time since release	h:m:s.ms	00000:00:00.000	19.2
	353	Heat sink temperature	deg.C	0 to T _{Cmax}	19.2
	354	Inside temperature	deg.C	0 to T _{imax}	19.2

Error environment				
No.	Description	Unit	Display range	Chapter
355	Controller status	-	C0000 to CFFFF	20.3
356	Warning status	-	A0000 to AFFFF	20.4
357	Int. value 1	-	± 32768	19.2
358	Int. value 2	-	± 32768	19.2
359	Long value 1	-	± 2147483647	19.2
360	Long value 2	-	± 2147483647	19.2
361	Checksum	-	OK / NOK	19.2
Error list				
362	No. of errors	-	0 to 32767	19.1
363	No. of self acknowledged errors	-	0 to 32767	19.1
Positioning				
470	Rotations	U	0.000 to 1·10 ⁶	11.6
Digital outputs				
537	Actual warning mask	-	AXXXXXXXXX	14.3.7
Self-configuration				
797	SETUP Status	-	OK / NOK	7.4

21.2 Parameter menu (PARA)

Inverter data				
No.	Description	Unit	Setting range	Chapter
0	Serial number	-	Characters	8.1
1	Optional modules	-	Characters	8.2
12	FU software version	-	Characters	8.3
27	Set password	-	0 to 999	8.4
28	Control level	-	1 to 3	8.5
29	User name	-	32 characters	8.6
30	Configuration	-	Selection	8.7
33	Language	-	Selection	8.8
34	Program	-	0 to 9999	8.9
Fan				
39	Switch-on temperature	deg.C	0 to 60	17.2
Digital inputs				
62	Frequency Motorpoti Up	-	Selection	14.4.8
63	Frequency Motorpoti down	-	Selection	14.4.8
66	Fixed frequency change-over 1	-	Selection	14.4.7
67	Fixed frequency change-over 2	-	Selection	14.4.7
68	Start clockwise	-	Selection	14.4.1
69	Start anticlockwise	-	Selection	14.4.1
70	Data set change-over 1	-	Selection	14.4.6
71	Data set change-over 2	-	Selection	14.4.6
72	Percent Motorpoti Up	-	Selection	14.4.8
73	Percent Motorpoti Down	-	Selection	14.4.8
75	Fixed percent change-over 1	-	Selection	14.4.7
76	Fixed percent change-over 2	-	Selection	14.4.7
83	Timer 1	-	Selection	14.4.3
84	Timer 2	-	Selection	14.4.3
103	Error acknowledgment	-	Selection	14.4.2
164	n-/M control change-over	-	Selection	14.4.5
204	Motor-PTC	-	Selection	14.4.4
Actual value memory				
237	Reset memory	-	Selection	18.3
Controlled commissioning				
369	Motor type	-	Selection	7.2.3

Rate motor parameters				
No.	Description	Unit	Setting range	Chapter
370	Rated voltage	V	0.17·U _{FIN} to 2·U _{FIN}	9.1
371	Rated current	A	0.01·I _{FIN} to 10·I _{FIN}	9.1
372	Rated speed	U/min	96 to 60000	9.1
373	No. of pole pairs	-	1 to 24	9.1
374	Rated cosine Phi	-	0.01 to 1.00	9.1
375	Rated frequency	Hz	10.00 to 1000.00	9.1
376	Rated mech. power	kW	0.1·P _{FIN} to 10·P _{FIN}	9.1
Further motor parameters				
377	Stator resistance	mOhm	0 to 65535	9.2
378	Leakage coeff.	%	1.0 to 20.0	9.2
System data				
397	Nominal volumetric flow	m ³ /h	1 to 99999	10.1
398	Nominal pressure	kPa	0.1 to 999.9	10.1
Pulse width modulation				
400	Switching frequency	-	Selection	17.1
401	Min. switching frequency	-	Selection	17.1
Error/warning behavior				
405	Warning limit, short-term Ixt	%	6 to 100	12.1
406	Warning limit long-term Ixt	%	6 to 100	12.1
407	Warning limit Tc	deg.C	-25 to 0	12.2
408	Warning limit Ti	deg.C	-25 to 0	12.2
409	Controller status message	-	Selection	12.3
Bus controller				
412	Local/Remote	-	Selection	17.3
Error/warning behavior				
415	IDC compensation limit	V	0.0 to 1.5	12.4
417	Frequency switch-off limit	Hz	0.00 to 999.99	12.5
Limit frequencies				
418	Minimum frequency	Hz	0.00 to 999.99	13.1
419	Maximum frequency	Hz	0.00 to 999.99	13.1
Frequency ramps				
420	Acceleration (clockwise)	Hz/s	0.01 to 999.99	13.6
421	Deceleration (clockwise)	Hz/s	0.01 to 999.99	13.6
422	Acceleration anticlockwise	Hz/s	-0.01 to 999.99	13.6
423	Deceleration anticlockwise	Hz/s	-0.01 to 999.99	13.6
424	Emergency stop clockwise	Hz/s	0.01 to 999.99	13.6
425	Emergency stop anticlockwise	Hz/s	0.01 to 999.99	13.6
426	Maximum leading	Hz	0.01 to 999.99	13.6
430	Ramp rise time clockwise	ms	0 to 65000	13.6
431	Ramp fall time clockwise	ms	0 to 65000	13.6
432	Ramp rise time anticlockwise	ms	0 to 65000	13.6
433	Ramp rise time anticlockwise	ms	0 to 65000	13.6
Technology controller				
440	Operation mode	-	Selection	16.3.3
441	Fixed frequency	Hz	-999.99 to 999.99	16.3.3
442	max. P component	Hz	0.01 to 999.99	16.3.3
443	Hysteresis	%	0.01 to 100.00	16.3.3
444	Amplification	-	-15.00 to 15.00	16.3.3
445	Integral time	ms	0 to 32767	16.3.3
446	Ind. volume flow control factor	-	0.10 to 2.00	16.3.3
Blocking frequencies				
447	1 st blocking frequency	Hz	0.00 to 999.99	13.8
448	2 nd blocking frequency	Hz	0.00 to 999.99	13.8
449	Frequency hysteresis	Hz	0.00 to 100.00	13.8

Multifunctional input 1				
No.	Description	Unit	Setting range	Chapter
450	Tolerance band	%	0.00 to 25.00	14.1.1.3
452	Operation mode	-	Selection	14.1
453	Error/warning behavior	-	Selection	14.1.1.4
454	Point X1	%	0.00 to 100.00	14.1.1.1
455	Point Y1	%	-100.00 to 100.00	14.1.1.1
456	Point X2	%	0.00 to 100.00	14.1.1.1
457	Point Y2	%	-100.00 to 100.00	14.1.1.1
Positioning				
458	Operation mode	-	Selection	11.6
459	Signal source	-	Selection	11.6
460	Positioning distance	U	0.000 to 1 10 ⁶	11.6
461	Signal correction	ms	-327.68 to 327.67	11.6
462	Load correction	-	-327.68 to 327.67	11.6
463	Activity after positioning	-	Selection	11.6
464	Time to wait	ms	0 to 3.6 10 ⁶	11.6
Temperature adjustment				
465	Operation mode	-	Selection	17.7.2
466	Temperature coefficient	%/100	0.00 to 300.00	17.7.2
467	Adjusting temperature	deg.C	-50.0 to 300.0	17.7.2
Motorpoti				
473	Ramp Keypad Motorpoti	Hz/s	0.01 to 999.99	13.9
474	Operation mode	-	Selection	13.9
Frequency reference value channel				
475	Reference frequency source	-	Selection	13.3
Frequency percentage value channel				
476	Reference percentage source	-	Selection	13.4
Percentage ramp				
477	Gradient percentage ramp	%/s	0 to 60000	13.7
Technology controller				
478	Actual percentage source	-	Selection	16.3.3
Fixed frequencies				
480	Fixed frequency 1	Hz	-999.99 to 999.99	13.5.1
481	Fixed frequency 2	Hz	-999.99 to 999.99	13.5.1
482	Fixed frequency 3	Hz	-999.99 to 999.99	13.5.1
483	Fixed frequency 4	Hz	-999.99 to 999.99	13.5.1
489	JOG frequency	Hz	-999.99 to 999.99	13.5.2
Speed sensor 1				
490	Operation mode	-	Selection	9.3.1
491	Division marks	-	1 to 8192	9.3.2
Repetition frequency input				
496	Operation mode	-	Selection	13.10
497	Divider	-	1 to 8192	13.10
Brake chopper				
506	Trigger threshold	V	U _{dmin} +25 to 1000.0	17.4
Motor chopper				
507	Trigger threshold	V	U _{dmin} +25 to 1000.0	17.7.1
Digital outputs				
510	Setting frequency	Hz	0.00 to 999.99	14.3.1
Percentage value limits				
518	Minimum reference percentage	%	0.00 to 300.00	13.2
519	Maximum reference percentage	%	0.00 to 300.00	13.2
Fixed percentages				
520	Fixed percentage 1	%	-300.00 to 300.00	13.5.3
521	Fixed percentage 2	%	-300.00 to 300.00	13.5.3
522	Fixed percentage 3	%	-300.00 to 300.00	13.5.3
523	Fixed percentage 4	%	-300.00 to 300.00	13.5.3

Digital outputs				
No.	Description	Unit	Setting range	Chapter
530	Operation mode digital output 1	-	Selection	14.3
532	Operation mode digital output 3	-	Selection	14.3
536	Create warning mask	-	Selection	14.3.7
540	Operation mode comparator 1	-	Selection	14.3.6
541	Comparator On above	%	-300.00 to 300.00	14.3.6
542	Comparator Off below	%	-300.00 to 300.00	14.3.6
543	Operation mode comparator 2	-	Selection	14.3.6
544	Comparator On above	%	-300.00 to 300.00	14.3.6
545	Comparator Off below	%	-300.00 to 300.00	14.3.6
549	max. control deviation	%	0.01 to 20.00	14.3.6
Multifunctional output 1				
550	Operation mode	-	Selection	14.2
551	Voltage 100%	V	0.0 to 24.0	14.2.1.1
552	Voltage 0%	V	0.0 to 24.0	14.2.1.1
553	Analog operation	-	Selection	14.2.1
554	Digital operation	-	Selection	14.3
555	Repetition frequency operation	-	Selection	14.2.2
⊗ 556	Division marks	-	30 to 8192	14.2.2.1
Error/warning behavior				
570	Operation mode Motor-PTC	-	Selection	12.6
Motor protective switch				
☒ 571	Operation mode	-	Selection	17.5
☒ 572	Frequency limit	%	0 to 300	17.5
Intelligent current limits				
☒ 573	Operation mode	-	Selection	16.1
☒ 574	Power Limit	%	40.00 to 95.00	16.1
☒ 575	Limitation time	min	5 to 300	16.1
Error/warning behavior				
☒ 576	Phase supervision	-	Selection	12.7
578	Allowed no. of auto-acknowl.	-	0 to 20	12.7
579	Restart delay	ms	0 to 1000	12.7
Pulse width modulation				
580	Reduction limit heat sink temp.	deg.C	-25 to 0	17.1
V-belt monitoring				
☒ 581	Operation mode	-	Selection	17.6.1
☒ 582	Trigger limit lactive	%	0.1 to 100.0	17.6.1
☒ 583	Delay time	s	0.1 to 600.0	17.6.1
V/f characteristic				
☑ ☒ 600	Starting voltage	V	0.0 to 100.0	15
☑ ☒ 601	Voltage rise	%	-100 to 200	15
☑ ☒ 602	Rise frequency	%	0 to 100	15
☑ ☒ 603	Cut-off voltage	V	60.0 to 560.0	15
☑ ☒ 604	Cut-off frequency	Hz	0.00 to 999.99	15
☒ 605	Dyn. voltage pre-control	%	0 to 200	15.1
Current limit value controller				
☒ 610	Operation mode	-	Selection	16.3.2
☒ 611	Amplification	-	0.01 to 30.00	16.3.2
☒ 612	Integral time	ms	1 10000	16.3.2
☒ 613	Current limit	A	0.0 to 0·I _{FIN}	16.3.2
☑ ☒ 614	Frequency limit	Hz	0.00 to 999.99	16.3.2
Starting behavior				
☒ 620	Operation mode	-	Selection	11.1.1
☒ 621	Amplification	-	0.01 to 10.00	11.1.1
☒ 622	Integral time	ms	1 to 30000	11.1.1
☑ ☒ 623	Starting current	A	0.0 to 0·I _{FIN}	11.1.1.1
☑ ☒ 624	Frequency limit	Hz	0.00 to 100.00	11.1.1.2

Stopping behavior				
No.	Description	Unit	Setting range	Chapter
<input type="checkbox"/>	630 Operation mode	-	Selection	11.2
Direct current brake				
<input checked="" type="checkbox"/>	<input type="checkbox"/> 631 Braking current	A	0.00 to $\sqrt{2} \cdot I_{FIN}$	11.3
<input type="checkbox"/>	632 Braking time	s	0.0 to 200.0	11.3
<input type="checkbox"/>	633 Demagnetizing time	s	0.1 to 30.0	11.3
<input type="checkbox"/>	634 Amplification	-	0.00 to 10.00	11.3
<input type="checkbox"/>	635 Integral time	ms	0 to 1000	11.3
Stopping behavior				
<input type="checkbox"/>	637 Switch-off threshold	%	0.0 to 100.0	11.2.1
<input type="checkbox"/>	638 Holding time	s	0.0 to 200.0	11.2.2
Search run				
<input type="checkbox"/>	645 Operation mode	-	Selection	11.5
<input type="checkbox"/>	646 Brak. time after search run	s	0.0 to 200.0	11.5
<input type="checkbox"/>	647 Current / rated motor current	%	1.00 to 100.00	11.5
<input type="checkbox"/>	648 Amplification	-	0.00 to 10.00	11.5
<input type="checkbox"/>	649 Integral time	ms	0 to 1000	11.5
Auto-start				
<input type="checkbox"/>	651 Operation mode	-	Selection	11.4
Slip compensation				
<input type="checkbox"/>	660 Operation mode	-	Selection	16.3.1
<input type="checkbox"/>	661 Amplification	%	0.0 to 300.0	16.3.1
<input type="checkbox"/>	662 max. slip ramp	Hz/s	0.01 to 650.00	16.3.1
<input type="checkbox"/>	663 Minimum frequency	Hz	0.01 to 999.99	16.3.1
Voltage controller				
<input type="checkbox"/>	670 Operation mode	-	Selection	16.2
<input type="checkbox"/>	671 Mains failure threshold	V	-200.0 to -50.0	16.2
<input type="checkbox"/>	672 Reference mains support value	V	-200.0 to -10.0	16.2
<input type="checkbox"/>	673 Mains support deceleration	Hz/s	0.01 to 9999.99	16.2
<input type="checkbox"/>	674 Acceleration on mains resumption	Hz/s	0.00 to 9999.99	16.2
<input type="checkbox"/>	675 Shutdown threshold	Hz	0.00 to 999.99	16.2
<input type="checkbox"/>	676 Reference shutdown value	V	$U_{dmin}+25$ to $U_{dmax}-25$	16.2
<input type="checkbox"/>	677 Amplification	-	0.00 to 30.00	16.2
<input type="checkbox"/>	678 Integral time	ms	0 to 10000	16.2
<input type="checkbox"/>	680 Reference DC link limitation	V	$U_{dmin}+25$ to $U_{dmax}-25$	16.2
<input type="checkbox"/>	681 max. frequency rise	Hz	0.00 to 999.99	16.2
<input type="checkbox"/>	683 Gen. ref. current limit	A	0.0 to $0 \cdot I_{FIN}$	16.2
Current controller				
<input checked="" type="checkbox"/>	<input type="checkbox"/> 700 Amplification	-	0.00 to 2.00	16.4.1
<input checked="" type="checkbox"/>	<input type="checkbox"/> 701 Integral time	ms	0.00 to 10.00	16.4.1
Further motor parameters				
<input checked="" type="checkbox"/>	<input type="checkbox"/> 713 Magnetizing current 50% flux	%	1 to 50	9.2.3
<input checked="" type="checkbox"/>	<input type="checkbox"/> 714 Magnetizing current 80% flux	%	1 to 80	9.2.3
<input checked="" type="checkbox"/>	<input type="checkbox"/> 715 Magnetizing current 110% flux	%	110 to 197	9.2.3
<input checked="" type="checkbox"/>	<input type="checkbox"/> 716 Rated magnetizing current	A	$0.01 \cdot I_{FIN}$ to $0 \cdot I_{FIN}$	9.2.3
Field controller				
<input checked="" type="checkbox"/>	<input type="checkbox"/> 717 Reference flux	%	0.01 to 300.00	16.4.5
Further motor parameters				
<input checked="" type="checkbox"/>	<input type="checkbox"/> 718 Rated slip correction factor	%	0.01 to 300.00	9.2.4
Limit frequencies				
<input type="checkbox"/>	719 Slip frequency	%	0 to 10000	13.1
Speed controller				
<input type="checkbox"/>	720 Operation mode	-	Selection	16.4.3
<input type="checkbox"/>	721 Amplification 1	-	0.00 to 200.00	16.4.3
<input type="checkbox"/>	722 Integral time 1	ms	0 to 60000	16.4.3
<input type="checkbox"/>	723 Amplification 2	-	0.00 to 200.00	16.4.3
<input type="checkbox"/>	724 Integral time 2	ms	0 to 60000	16.4.3

Acceleration pre-control					
No.	Description	Unit	Setting range	Chapter	
	725 Operation mode	-	Selection	16.4.4	
	726 Minimum acceleration	Hz/s	0.1 to $0 \cdot I_{FIN}$	16.4.4	
	727 Mech. time constant	ms	1 to 60000	16.4.4	
Speed controller					
	728 Current limit	A	0.0 to $0 \cdot I_{FIN}$	16.4.3.1	
	729 Current limit generator operation	A	-0.1 to $0 \cdot I_{FIN}$	16.4.3.1	
	730 Torque limit	%	0.00 to 650.00	16.4.3.1	
	731 Torque limit generator operation	%	0.00 to 650.00	16.4.3.1	
	732 P comp. torque upper limit	%	0.00 to 650.00	16.4.3.1	
	733 P comp. torque lower limit	%	0.00 to 650.00	16.4.3.1	
	734 Isq limit source motor operation	-	Selection	16.4.3.2	
	735 Isq limit source gen. operation	-	Selection	16.4.3.2	
	736 Torque limit source motor operation	-	Selection	16.4.3.2	
	737 Torque limit source gen. operation	-	Selection	16.4.3.2	
<input checked="" type="checkbox"/>		738 Speed control switch-over limit	Hz	0.00 to 999.99	16.4.3
	739 Power limit	kW	0.00 to $2 \cdot 0 \cdot P_{FIN}$	16.4.3.1	
	740 Power limit generator operation	kW	0.00 to $2 \cdot 0 \cdot P_{FIN}$	16.4.3.1	
Field controller					
	741 Amplification	-	0.0 to 100.0	16.4.5	
<input checked="" type="checkbox"/>		742 Integral time	ms	0.0 to 100.0	16.4.5
<input checked="" type="checkbox"/>		743 Ref. Isd upper limit	A	$0.1 \cdot I_{FIN}$ to $0 \cdot I_{FIN}$	16.4.5.1
<input checked="" type="checkbox"/>		744 Ref. Isd lower limit	A	$-I_{FIN}$ to I_{FIN}	16.4.5.1
Speed controller					
	748 Backlash damping	%	0 to 300	16.4.3	
Modulation controller					
	750 Reference modulator	%	3.00 to 105.00	16.4.6	
	752 Integral time	ms	0.0 to 1000.00	16.4.6	
	753 Operation mode	-	Selection	16.4.6	
	755 Reference lmr lower limit	A	$0.01 \cdot I_{FIN}$ to $0 \cdot I_{FIN}$	16.4.6.1	
	756 Control deviation limitation	%	0.00 to 100.00	16.4.6.1	
Speed sensor monitoring					
	760 Operation mode	-	Selection	17.7.3	
	761 Timeout: signal fault	ms	0 to 65000	17.7.3	
	762 Timeout: channel fault	ms	0 to 65000	17.7.3	
	763 Timeout: direction fault	ms	0 to 65000	17.7.3	
Torque controller					
	767 Frequency upper limit	Hz	-999.99 to 999.99	16.4.2	
	768 Frequency lower limit	Hz	-999.99 to 999.99	16.4.2	
	769 Frequency upper limit source	-	Selection	16.4.2.1	
	770 Frequency lower limit source	-	Selection	16.4.2.1	
Starting behavior					
<input checked="" type="checkbox"/>		780 Max. flux formation time	ms	1 to 10000	11.1.2
	781 Current during flux formation	A	$0.1 \cdot I_{FIN}$ to $0 \cdot I_{FIN}$	11.1.2	
Timer					
	790 Operation mode Timer 1	-	Selection	14.5	
	791 Time 1 Timer 1	s/m/h	0 to 650.00	14.5.1	
	792 Time 2 Timer 1	s/m/h	0 to 650.00	14.5.1	
	793 Operation mode Timer 2	-	Selection	14.5	
	794 Time 1 Timer 2	s/m/h	0 to 650.00	14.5.1	
	795 Time 2 Timer 2	s/m/h	0 to 650.00	14.5.1	
Auto set-up					
	796 SETUP Select	-	Selection	7.4	

SEDE CENTRALE - HEADQUARTERS

BONFIGLIOLI RIDUTTORI S.p.A.
Via Giovanni XXIII, 7/A
40012 Lippo di Calderara di Reno - Bologna (ITALY)
Tel. (+39) 051 6473111
Fax (+39) 051 6473126
www.bonfiglioli.com
bonfiglioli@bonfiglioli.com

SALES DEPARTMENT

INDUSTRIAL TRANSMISSION & AUTOMATION DRIVES
BONFIGLIOLI RIDUTTORI S.p.A.
Via Giovanni XXIII, 7/A
40012 Lippo di Calderara di Reno - Bologna (ITALY)
Tel. (+39) 051 6473111 - Fax (+39) 051 6473126
bonfiglioli@bonfiglioli.com

SALES DEPARTMENT

MOBILE EQUIPMENT DRIVES
BONFIGLIOLI RIDUTTORI S.p.A.
Via Enrico Mattei, 12 - Z.I. Villa Selva - 47100 Forlì (ITALY)
Tel. (+39) 0543 789111
Fax (+39) 0543 789242 - 0543 789245
trasmital@bonfiglioli.com

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Tel. 0036 1 2061 477 - Fax 0036 1 2061 486
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FRANCE
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14 Rue Eugène Potier 19
Zone Industrielle de Moimont II - 95670 Marly la Ville
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USA
BONFIGLIOLI USA INC
1000 Worldwide Boulevard - Hebron, KY 41048
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www.bonfiglioliusa.com
industrialsales@bonfiglioliusa.com - mobilesales@bonfiglioliusa.com

GERMANY
BONFIGLIOLI GETRIEBE GmbH
Hamburger Straße 18 - 41540 Dormagen
Tel. (+49) 2133 50260 - Fax (+49) 2133 502610
www.bonfiglioli.de - bonfiglioli.getriebe@bonfiglioli.de

POLAND 
POLPACK Sp. z o.o. - Ul. Chrobrego 135/137 - 87100 Toruń
Tel. 0048.56.6559236 - 6559236 - Fax 0048.56.6559238
www.polpack.com.pl - polpack@polpack.com.pl

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