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.

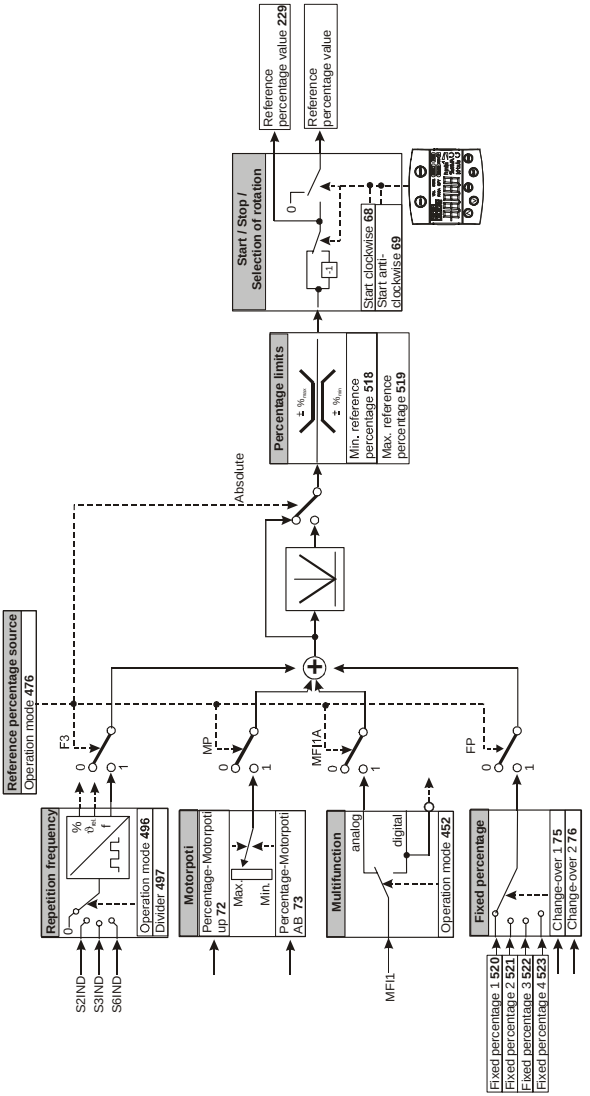
Operation mode	Function
1 - Abs. Analog Value MFI1A	Reference value source is the multifunctional input 1 in *Operation mode* **452** - analog signal.
10 - Abs. Fix. Perc. Val. (FP)	The percentage according to *Fixed percent change-over 1* **75**, *Fixed percent change-over 2* **76** and the current data set
11 - Abs. Value MFI1A + FP	Combination of operation modes 10 and 1
20 - Abs. Val. Motorpoti (MP)	Reference value source is the function *Percent Motorpoti Up* **72** and *Percent Motorpoti Down* **73**
21 - Abs. Value MFI1A + 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 *Operation mode repetition frequency* **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**.

Switch position on circuit diagram					
Operation mode	**MFI1A**	**FP**	**MP**	**F3**	**Sign**
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.

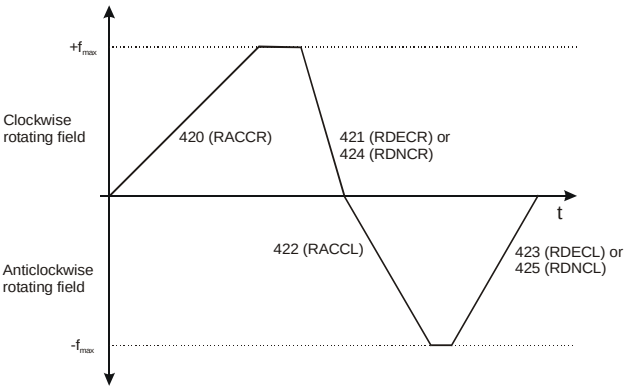
Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
420	Acceleration (clockwise)	0.00 Hz/s	999.99 Hz/s	5.00 Hz/s
421	Deceleration (clockwise)	0.01 Hz/s	999.99 Hz/s	5.00 Hz/s
422	Acceleration anticlockwise	- 0.01 Hz/s	999.99 Hz/s	- 0.01 Hz/s
423	Deceleration anticlockwise	- 0.01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

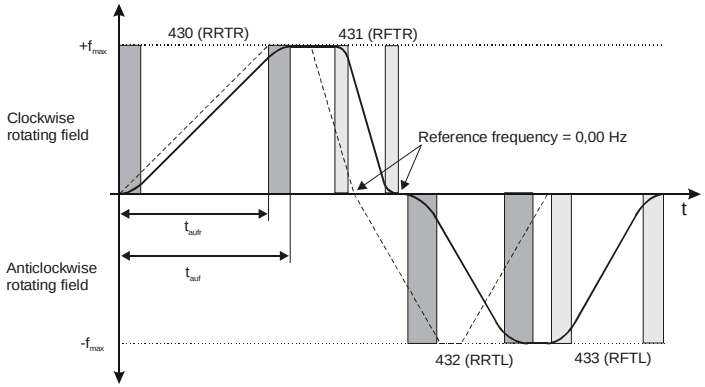
The parameter *Maximum leading* **426** limits the difference between the output of the ramp and the current actual value of the drive mechanism. The set maximum deviation is a dead time for the control system which should be kept as low as possible.

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 (fmax) and an acceleration ramp **420** of 2 Hz/s. The ramp time **430** is set at 100 ms.

$$t_{aufr} = \frac{\Delta f}{RACCR}$$

$$t_{aufr} = \frac{50Hz - 20Hz}{2Hz/s} = 15s$$

$$t_{auf} = t_{aufr} + RRTR$$

$$t_{auf} = 15s + 100ms = 15,1s$$

t_{aufr} = Acceleration time clockwise rotation

Δf = Frequency modification acceleration ramp

RACCR = Acceleration clockwise

RRTR = Ramp rise time clockwise

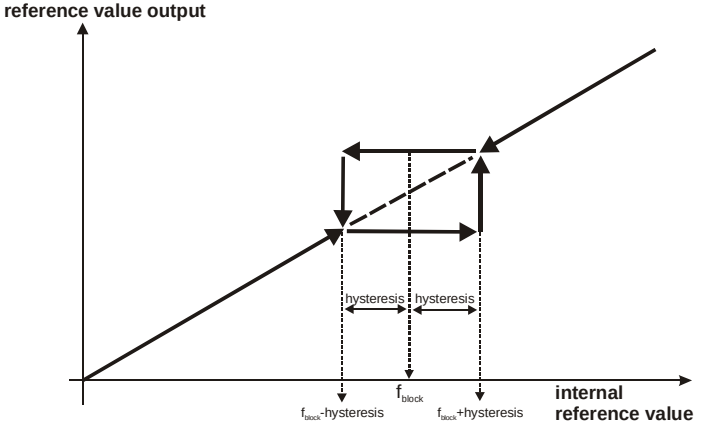
13.7 Percentage value ramps

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 MFI1

Multifunctional input MFI1 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 (MFI1A), 0V to 10V
2 - Current input	Current signal (MFI1A), 0mA to 20mA
3 - Digital input	Digital signal (MFI1D), 0V to 24V

14.1.1 Analog input MFI1A

The multifunctional input MFI1 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

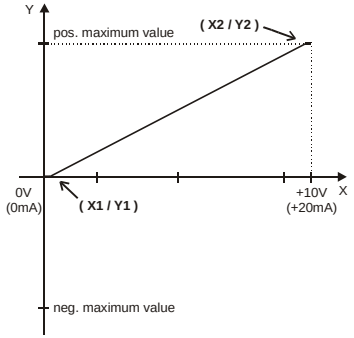
The mapping of the analog input signals onto a reference frequency or percentage value is possible for various requirements. The parameterization is to be done via two points of the linear characteristic of the reference value channel.
Characteristic point 1 with the coordinates X1 and Y1 and characteristic point 2 with the coordinates X2 and Y2 are to be set in the four data records.

Parameter		Setting		
No.	**Description**	**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* **419** 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 is the factory and is to be adapted to the application by the parameters mentioned.



Characteristic point 1:

$X1 = 2.00\% \cdot 10V = 0.20V$

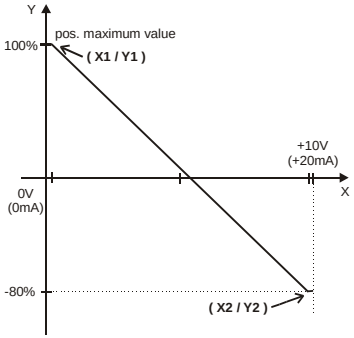
$Y1 = 0.00\% \cdot 50.00Hz = 0.00Hz$

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

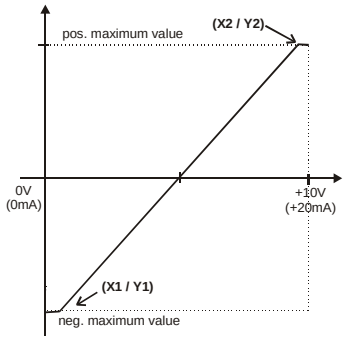
The controller uses the maximum value of the output frequency, which is calculated from the *Maximum frequency* **419** and the compensated slip of the drive mechanism. The frequency limits define the speed range of the drive mechanism and the percentage limits supplement the scaling of the analog input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

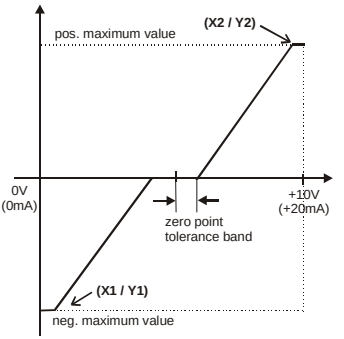
14.1.1.3 Tolerance band and hysteresis

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 %

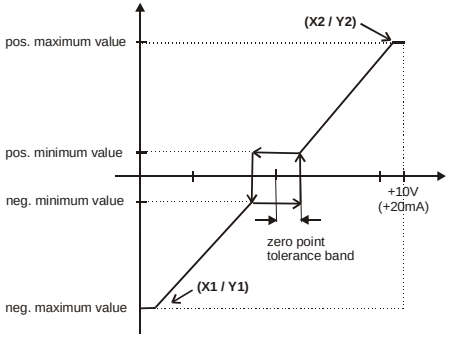


Without tolerance band



With tolerance band

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.

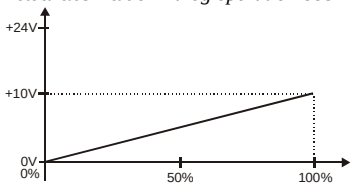
Operation mode	Function
0 - Off	Analog operation MFO1 switched off
1 - Abs. Fs	Abs. value of the stator frequency, 0.00Hz to *Maximum frequency* **419**
2 - Abs. Fs betw. fmin/fmax	Abs. value of the stator frequency, *Minimum frequency* **418** to *Maximum frequency* **419**
3 - Abs. Speed Sensor 1	Abs. value of the speed sensor signal 1, 0.00 Hz to *Maximum frequency* **419**
4 - Abs. Speed Sensor 2	Abs. value of the speed sensor signal 2, 0.00 Hz to *Maximum frequency* **419**
7 - Abs. Actual Frequency	Abs. value of the actual frequency, 0.00 Hz to *Maximum frequency* **419**
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 *Rated mech. power* **376**
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 MFI1A	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 *Nominal volumetric flow* **397**
54 - Pressure	Abs. value of calculated pressure 0.0 kPa to *Reference pressure* **398**
101 to 133	Operation modes in analog operation with signs

14.2.1.1 Output characteristic

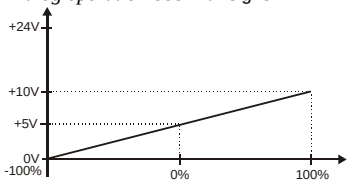
The mapping of the analog output signals to the parameterized *Operation mode Analog operation MFO1* **553** is possible for further applications via the parameter *Voltage 100%* **551** and *Voltage 0%* **552**.

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 *Actual frequency* **241**
2 - Stator frequency	Abs. value of the *Stator frequency* **210**
3 - Freq. speed sensor 1	Abs. value of the *Freq. speed sensor 1* **217**
4 - Freq. speed sensor 2	Abs. value of the *Freq. speed sensor 2* **217**
5 - Repetition freq. input	Abs. value of the *Repetition freq. input* **252**

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}=150kHz 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 *Current error* **259** or *Warnings* **269**
4 - Setting Frequency	The *Stator frequency* **210** is larger than the parameterized *Setting frequency* **510**
5 - Reference Frequency reached	The *Actual frequency* **241** of the drive has reached the *Internal reference frequency* **228**
6 - Reference Percentage reached	The *Actual percentage* **230** has reached the *Reference percentage* **229**
7 - Ixt-Warning	The *Warning limit short-term Ixt* **405** or *Warning limit long-term Ixt* **406** has been reached
8 - Warning Heat Sink Temperature	Max. heat sink temperature T_C of 80 °C less the *Warning limit* Tc **407** reached
9 - Warning Inside Temperature	Max. inside temperature T_i of 65 °C less the *Warning limit* Ti **408** reached
10 - Warning Motor Temperature	Warning behavior according to parameterized *Operation mode MotorPTC* **570** at max. motor temperature T_{PTC}
11 - Warning, General	The message is displayed via the parameter *Warnings* **269**
12 - Warning Overtemperature	The selected limit values *Warning limit Tc* **407**, *Warning limit Ti* **408** or the maximum motor temperature have been exceeded
13 - Mains Failure	Failure of the mains voltage and power regulation active according to *Operation mode Voltage Controller* **670**
14 - Warning Motor Protect. Switch	Parameterized *Operation mode Motor protective switch* **571** has triggered
15 - Warning Current Limitation	A controller or the *intelligent current limits* **573** limit the output current
16 - Conroller Current Limit. Long Term Ixt	The overload reserve for 60 s has been used and the output current in being limited
17 - Conroller 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. Tc	Max. heat sink temperature T_C reached, *intelligent current limits* **573** active
19 - Controller Current Limit. M-PTC	Max. motor temperature T_{PTC} reached, *intelligent current limits* **573** active
20 - Comparator 1	The comparison according to the selected *Operation mode Comparator 1* **540** is true
21 - Comparator 2	The comparison according to the selected *Operation mode Comparator 2* **543** is true
22 - Warning V-Belt	Warning of the *V-belt monitoring* **581**

Continuation of the operation modes for the digital outputs.

Operation mode	Function
23 - Timer 1	The selected *Operation mode Timer 1* **790** generates an output signal of the function
24 - Timer 2	The selected *Operation mode Timer 2* **793** generates an output signal of the function
25 - Warning Mask	Message of the configured *Warning mask* **536**
30 - Flux-Forming finished	Magnetic field has been impressed
41 - Brake release	Activation of a brake unit dependent on *Starting behavior* **620**, *Stopping behavior* **630** or the configured brake control
43 - Separating Contactor	The *Switch-on temperature* **39** has been reached
50 - External fan	*Warning limit* **597** 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

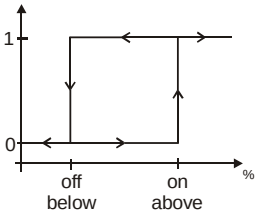
With the help of software functions Comparator 1 and 2, various comparisons of actual values with percentage-adjustable fixed values can be done.
The actual values to be compared can be selected with the parameters *Comparator 1* **540** and *Comparator 2* **543** according to the following table.

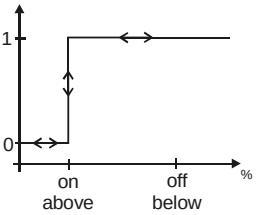
Operation mode	Function
0 - off	Comparator is switched off
1 - Absolute Current	Output current > *Rated current* **371**
2 - Abs. Active Current	*Active current* **214** > *Rated current* **371**
3 - Abs. Stator Frequency	*Stator frequency* **210** > *Maximum frequency* **419**
4 - Abs. Actual Speed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

Parameter		Setting		
No.	**Description**	**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 *Warning limit short-term Ixt* **405** has been reached.
12 - Warning Long Term Ixt	Overload reserve for 60 s less the *Warning limit long-term Ixt* **406** has been reached.
13 - Warning Heat Sink Temperature	Max. heat sink temperature T_K of 80 °C less the *Warning limit* Tc **407** reached
14 - Warning Inside Temperature	Max. inside temperature T_i of 65 °C less the *Warning limit* Ti **408** reached
15 - Warning Limit	The controller stated in *Controller status* **355** is limiting the reference value
16 - Warning Init	The frequency inverter is being initialized
17 - Warning Motor Temperature	Warning behavior according to parameterized *Operation mode MotorPTC* **570** at max. motor temperature T_{PTC}
18 - Warning Mains Failure	The *Phase monitoring* **576** reports a phase failure
19 - Warning Motor Protective Switch	Parameterized *Motor protective switch* **571** has triggered

Continuation of the operation modes for the warning mask:

Operation mode	Function
20 - Warning Fmax	The *Maximum frequency* **419** has been exceeded. The frequency limitation is active
21 - Warning Analog Input MFI1A	The input signal is smaller than 1V / 2mA according to the operation mode *Error/warning behavior* **453**
22 - Warning Analog input MFI2A	The input signal is smaller than 1V / 2mA according to the Error/warning behavior
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 *V-belt monitoring* **581** reports open circuit of the application
30 - Controller Udc Dynamic Operation	Controller is active according to the *Operation mode Voltage controller* **670**
31 - Controller Shutdown	The output frequency in power failure is below the *Shutdown threshold* **675**
32 - Controller Mains Failure	Failure of the mains voltage and power regulation active according to *Operation mode Voltage Controller* **670**
33 - Controller Udc Limitation	The DC link voltage has exceeded the *Reference DC link limitation* **680**
34 - Controller Voltage Pre-Control	The *dyn. voltage pre-control* **605** 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 *Operation mode* **620** 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, *intelligent current limits* **573** active
42 - Contr. Intel. Curr. Lim. M-PTC	Max. motor temperature T_{PTC} reached, *intelligent current limits* **573** active
43 - Controller Freq. Limitation	The nominal frequency has reached the *Maximum frequency* **419**. 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 MFI1A
A	0000	1000	A2	22 - Warning Analog Input MFI2A
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 - MFI1D	Signal to multifunctional input 1 (X210A.3) in *Operation mode* **452** = 3 - digital input
157 - Warning mask	The defined *Warning mask* **536** reports a critical operating point
158 - Timer 1	Output signal of the time function according to the input connection *Timer 1* **83**
159 - Timer 2	Output signal of the time function according to the input connection *Timer 2* **84**
163 - Reference frequency reached	Signal when the *Actual frequency* **241** has reached the reference frequency
164 - Setting frequency	Signal when the *Setting frequency* **510** is smaller than or equal to the *Actual frequency* **241**
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 Warning limit Tc **407** reached
167 - Warning inside temperature	Max. inside temperature T_i of 65 °C less the *Warning limit* Ti **408** reached
168 - Warning motor temperature	Warning behavior according to parameterised *Operation mode MotorPTC* **570** at max. motor temperature T_{PTC}
169 - General warning	Signal when *Warnings* **269** are displayed with a critical operating point
170 - Warning Overtemperature	The selected limit values *Warning limit Tk* **407**, *Warning limit Ti* **408** or the maximum motor temperature have been exceeded
171 - Output Comparator 1	The comparison according to the selected *Operation mode Comparator 1* **540** 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 *Operation mode Comparator* 2 **543** 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 *Operation mode Digital output 1* **530**
176 - Digital message 2	Signal corresponding to the parameterized *Digital operation MFO1* **554**
177 - Digital message 3	Signal corresponding to the parameterized *Operation mode Digital output 2* **532**
178 - Reference percentage reached	Signal when the *Actual percentage* **230** has reached the reference percentage
180 - Warning motor protective switch	Parameterized *Operation mode motor protective switch* **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 *Warning limit* **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

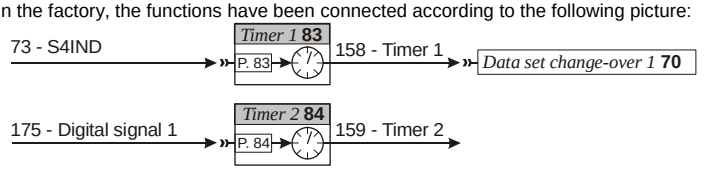
0 = contact open 1 = contact closed

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

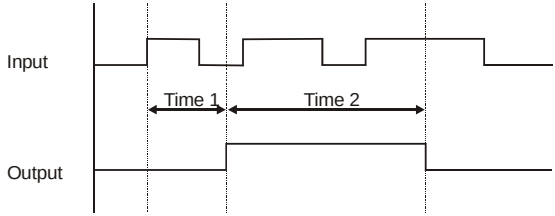
The logical series of input and output signals is to be set separately for both timer functions with the time constants. The parameter values set in the factory lead to a direct connection of input and output signal without a delay in time.

Parameter		Setting		
No.	**Description**	**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

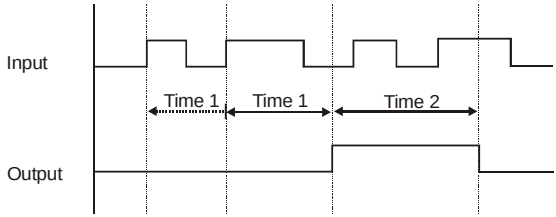
Parameter *Operation mode Timer* **= 1**



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

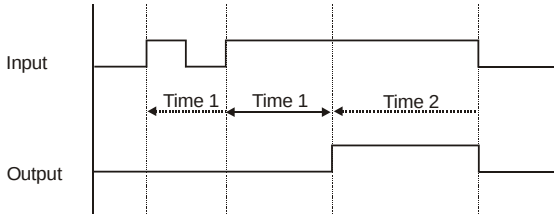
Parameter *Operation mode Timer* **= 2**



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

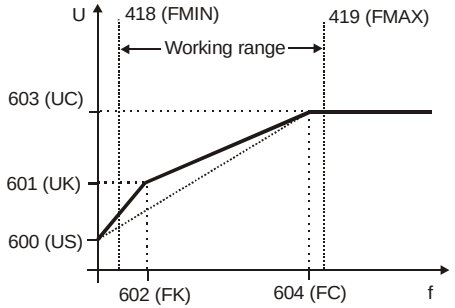
Parameter *Operation mode Timer* **= 3**



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.



Parameter		Setting		
No.	**Description**	**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 - Ixt	Limitation to the overload of the frequency inverter (Ixt)
10 - Tc	Limitation to the maximum heat sink temperature (T_C)
11 - Ixt + Tc	Operation mode 1 and 10 (Ixt + T_C)
20 - PTC	Limitation to the motor temperature (T_{PTC})
21 - PTC + Ixt	Operation mode 20 and 1 (T_{PTC} + Ixt)
30 - Tc + PTC	Operation mode 10 and 20 (T_C + T_{PTC})
31 - Tc + PTC + Ixt	Operation mode 10, 20 and 1 (T_C + T_{PTC} + Ixt)

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 (Ixt) 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 (Ixt) of the frequency inverter is again available after a power reduction lasting 10 minutes.

16.2 Voltage controller

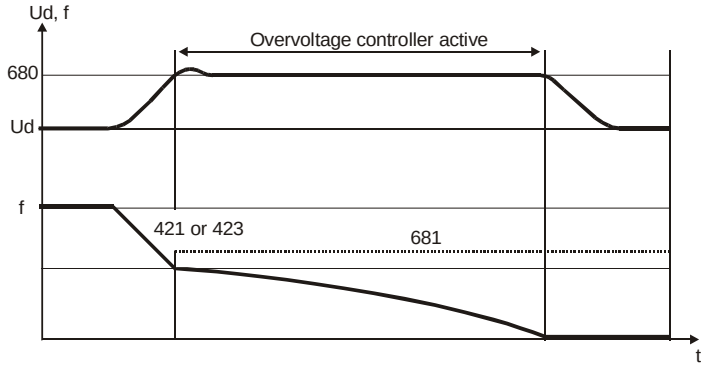
The voltage controller contains the functions necessary for the monitoring of the DC link voltage.

- 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

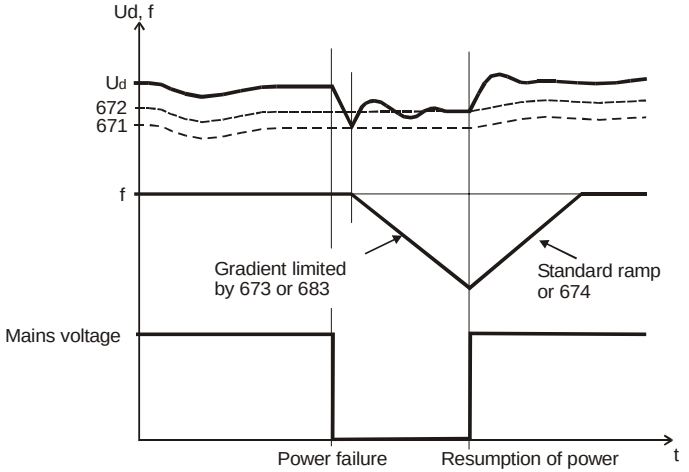
Operation mode overvoltage control,
Parameter *Operation mode voltage controller* **670 (UDSEL) = 1**



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**

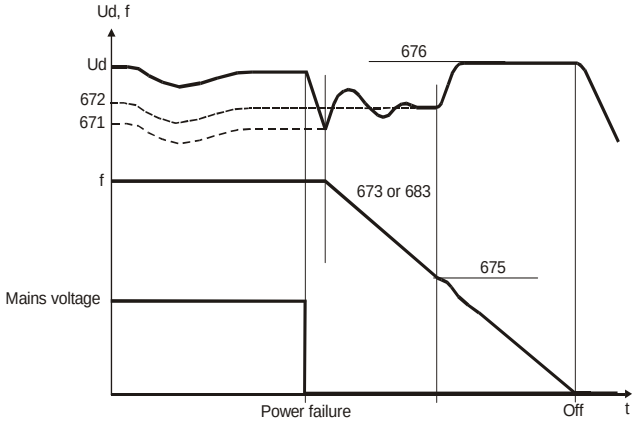


With the power failure regulation, short-term power failures can be bridged. A power failure is recognized if the DC link voltage has fallen below the set value of the parameter *Mains failure threshold* **671**. If a power failure is recognized, the controller tries to regulate the DC link voltage to 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**.

Parameter		Setting		
No.	**Description**	**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	$o \cdot I_{FIN}$	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	$o \cdot I_{FIN}$	$o \cdot I_{FIN}$
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**.

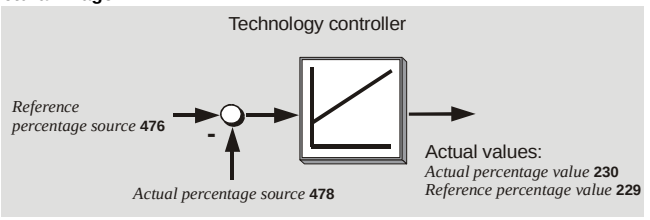
Parameter		Setting		
No.	**Description**	**Min.**	**Max.**	**Fact. sett.**
611	Amplification	0.01	30.00	1.00
612	Integral time	1 ms	10000 ms	24 ms

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 MFI1A	The analog signal on the multifunctional input 1 in *Operation mode* **452** - analog operation
32 - Rep. frequency input (F3)	The frequency signal on the digital input according to the selected *Operation mode* **496**

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.

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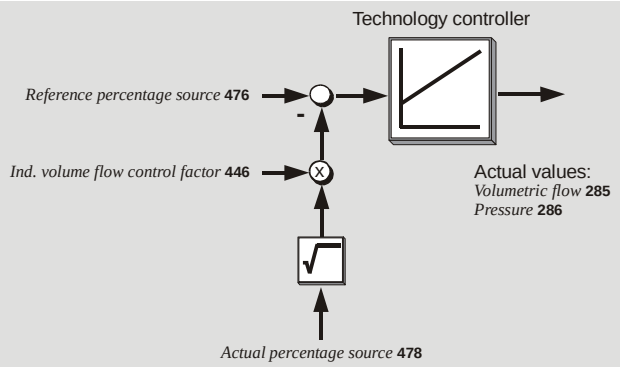


The behavior of the technology controller matches a PI controller. The proportional component is optimized with the parameter *Amplification* **444** and the integral component with the parameter *Integral time* **445**. The sign of the amplification determines the direction of control, i.e. with a rising 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.

Parameter		Setting		
No.	**Description**	**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

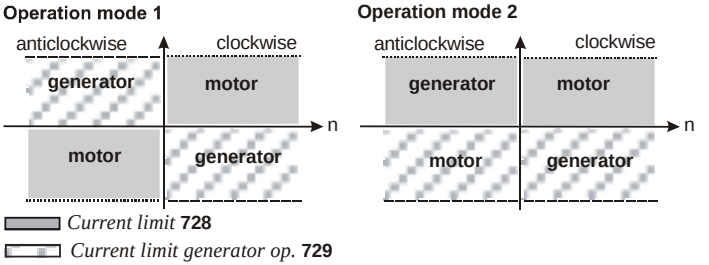
The limitation of the frequency can be done not only with fixed values, but can also be connected with an analog input value. The analog value is limited via the parameters *Minimum reference percentage* **518**, *Maximum reference percentage* **519**, but does not take the *Gradient percentage ramp* **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 MFI1A	The source is the multifunctional input 1 in an analog *Operation mode* **452**
110 - Fixed limit	The selected parameter values are taken into account to limit the speed controller
201 - Inv. analog input MFI1A	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.

Parameter		Setting		
No.	**Description**	**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 to3/4 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 Isq. 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	$o \cdot I_{FIN}$	$o \cdot I_{FIN}$
729	Current limit generator. operation	0.1 A	$o \cdot I_{FIN}$	$o \cdot I_{FIN}$
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	$2 \cdot o \cdot P_{FIN}$	$2 \cdot o \cdot P_{FIN}$
740	Power limit generator operation	0.00 kW	$2 \cdot o \cdot P_{FIN}$	$2 \cdot o \cdot P_{FIN}$

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 MFI1A	The source is the multifunctional input 1 in an analog *Operation mode* **452**
105 - Rep. frequency input (F3)	The frequency signal on the repetition frequency input corresponding to *Operation mode* **496**
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	$0.1 \cdot I_{FIN}$	$o \cdot I_{FIN}$	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 made 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.

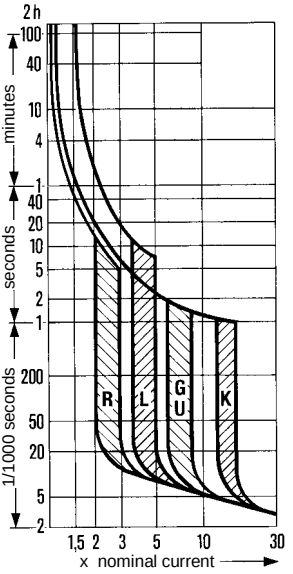
$$U_{Mains} \cdot 1.1 \cdot \sqrt{2} < Ud_{BC} < Ud_{max}$$

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	The function is deactivated
1 - K-Char., Mul.Motor Op., Err.Sw.Off	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 signalized 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 signalized 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 Iactive* **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 Iactive* **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 Iactive	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.

$$U_{Mains} \cdot 1.1 \cdot \sqrt{2} < Ud_{MC} < Ud_{max}$$

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.

Parameter		Setting		
No.	**Description**	**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 *Frequency reference value sources* **475** as a reference value from the frequency reference value channel
229	Reference percentage value	Sum of the *Reference percentage sources* **476** as a reference value from the reference percentage channel
230	Actual percentage value	Actual value signal on the *Actual percentage source* **478**
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 *Data set change-over 1* **70** and *Data set change-over 2* **71**
250	Status digital inputs	Decimally coded status of the six digital inputs and of multifunctional input 1 in *Operation mode* **452** - digital input
251	Analog input MFI1A	Input signal on multifunctional input 1 in the *Operation mode* **452** - analog input
252	Repetition frequency input	Signal on repetition frequency input according to *Operation mode* **496**
254	Digital outputs	Decimally coded status of the two digital outputs and of the multifunctional output 1 in *Operation mode* **550** - 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 *Operation mode* **550** – 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 *No. of pole pairs* **373** 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 *Temperature adjustment operation mode* **465**
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, Iabs.	The highest abs. current calculated from the measured motor phases
294	Mean value, Iabs.	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 Ixt	Reset *Peak value long-term Ixt* **231**
2 - Peak value short term Ixt	Reset *Peak value short-term IxT* **232**
3 - Peak value Udc	Reset *Peak value DC link voltage.* **287**
4 - Average value Udc	Delete *Mean value DC link voltage* **288**
5 - Peak value Tc	Reset *Peak value heat link temp.* **289**
6 - Average value Tc	Delete *Mean value heat link temp.* **290**
7 - Peak value Ti	Reset *Peak value inside temp.* **291**
8 - Average value Ti	Delete *Mean value inside temp.* **292**
9 - Peak value Iabs.	Reset *Peak value Iabs*, **293**
10 - Average value Iabs.	Delete *Mean value Iabs.* **294**
11 - Peak value Pactive pos.	Reset *Peak value active power pos.* **295**
12 - Peak value Pactive neg.	Reset *Peak value active power neg.* **296**
13 - Average value Pactive	Delete *Mean value active power* **297**
16 - Energy, positive	Reset parameter *Energy positive* **301**
17 - Energy, negative	Reset parameter *Energy negative* **302**
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 *Trigger threshold* **506** too small, check mains voltage
	06	Motor chopper *Trigger threshold* **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 *No. of pole pairs* **373** 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 MFI1A	Input signal on multifunctional input 1 in *Operation mode* **452** - analog input
346	Analog output MFO1A	Output signal on multifunctional input 1 in *Operation mode* **550** – analog
349	Repetition frequency output	Signal on repetition frequency output according to *Operation mode* **555**
350	Status digital inputs	Decimally coded status of the six digital inputs and of multifunctional input 1 in *Operation mode* **452** - digital input
351	Status digital outputs	Decimally coded status of the two digital outputs and of multifunctional output 1 in *Operation mode* **550** - digital
352	Time since release	The time of the error in hours (h), minutes (m) and seconds (s) after the release signal: hhhhh: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).

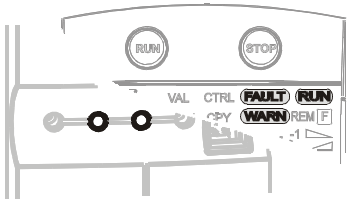
Error environment		
No.	**Description**	**Function**
361	Checksum	Check protocol of the error environment

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

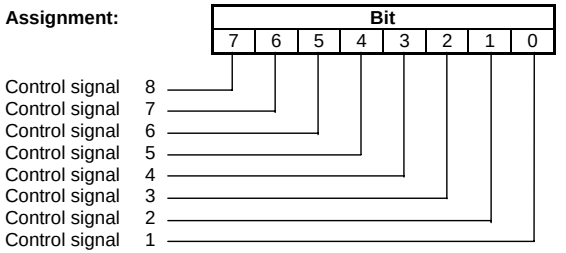
green LED	red LED	Display	Description
off	off	-	No supply voltage
on	on	-	Initialization and self-test
flashes	off	RUN flashes	Ready for operation, no output signal
on	off	RUN	Operational message
on	flashes	RUN + WARN	Operational message, current *warning* **269**
flashes	flashes	RUN + WARN	Ready for operation, current *warning* **269**
off	flashes	FAULT flashes	*Error message* **310** of the frequency inverter
off	on	FAULT	*Error message* **310,** 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 **OOIOOOOI** 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 | Controller code

ABCDE | Controller abbreviation

Code				Controller status
C	00	00	-	No controller active
C	00	01	UDdyn	Controller is in the rise phase according to the *Voltage Controller operation mode* **670**
C	00	02	UDstop	The output frequency in a power failure is below the *Shutdown threshold* **675**
C	00	04	UDctr	Failure of the mains voltage and power support active according to *Voltage Controller operation mode* **670**
C	00	08	UDlim	The DC link voltage has exceeded the *Reference DC link limitation* **680**
C	00	10	Boost	The *Dyn. voltage pre-control* **605** 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 *Operation mode* **620** 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, *Intelligent current limits* **573** active
C	10	00	PTClim	Max. motor temperature T_{PTC} reached, *Intelligent current limits* **573** active
C	20	00	Flim	The reference frequency has reached the *Maximum frequency* **419**. 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 Ixt	Frequency inverter overloaded (A0002 or A0004)
A 00 02 IxtSt	Overload for 60s relative to the nominal output of the frequency inverter
A 00 04 IxtLt	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 *Warning limit Tc* **407** reached
A 00 10 Ti	Max. inside temperature T_i of 65 °C less the *Warning limit* Ti **408** reached
A 00 20 Lim	The controller stated in *Controller status* **275** limits the nominal value
A 00 40 INIT	Frequency inverter is being initialized
A 00 80 PTC	Warning behavior according to parameterized *Motor PTC operation mode* **570** at max. motor temperature T_{PTC}
A 01 00 Mains	The *Phase monitoring* **576** reports a phase failure
A 02 00 PMS	Parameterized *Motor protective switch* **571** has triggered
A 04 00 Flim	The *Maximum frequency* **419** 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 *Error/warning behavior* **453** 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 *V-belt monitoring* **581** reports no load of the application

Example: The display is the warning status

A008D Ixt IxtLt 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)

No.	Description	Unit	Display range	Chapter
	Actual values of the machine			
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 Ixt	%	0.00 to 100.00	18.3
232	Peak value short-term Ixt	%	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

No.	Description	Unit	Display range	Chapter
	Actual values of the frequency inverter			
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	m3/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 Iabs.	A	0.0 to o·I_{FIN}	18.3
294	Average value Iabs	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 MFI1A	%	± 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

	No.	Description	Unit	Display range	Chapter
		Error environment			
🖹	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 $1 \cdot 10^6$	11.6
		Digital outputs			
	537	Actual warning mask	-	AXXXXXXXX	14.3.7
		Self-configuration			
	797	SETUP Status	-	OK / NOK	7.4

21.2 Parameter menu (PARA)

	No.	Description	Unit	Setting range	Chapter
		Inverter data			
	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

		No.	Description	Unit	Setting range	Chapter
			Rate motor parameters			
		370	Rated voltage	V	$0.17 \cdot U_{FIN}$ to $2 \cdot U_{FIN}$	9.1
		371	Rated current	A	$0.01 \cdot I_{FIN}$ to $10 \cdot o \cdot I_{FIN}$	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	$0.1 \cdot P_{FIN}$ to $10 \cdot P_{FIN}$	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	m3/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

	No.	Description	Unit	Setting range	Chapter
		Multifunctional input 1			
	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

		No.	Description	Unit	Setting range	Chapter
			Digital outputs			
		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 Iactive	%	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 o·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 o·I_{FIN}	11.1.1.1
☑	🗐	624	Frequency limit	Hz	0.00 to 100.00	11.1.1.2

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

		No.	Description	Unit	Setting range	Chapter
			Acceleration pre-control			
		725	Operation mode	-	Selection	16.4.4
		726	Minimum acceleration	Hz/s	0.1 to 6500.0	16.4.4
		727	Mech. time constant	ms	1 to 60000	16.4.4
			Speed controller			
		728	Current limit	A	0.0 to $o \cdot I_{FIN}$	16.4.3.1
		729	Current limit generator operation	A	-0.1 to $o \cdot I_{FIN}$	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
☑		738	Speed control switch-over limit	Hz	0.00 to 999.99	16.4.3
		739	Power limit	kW	0.00 to $2 \cdot o \cdot P_{FIN}$	16.4.3.1
		740	Power limit generator operation	kW	0.00 to $2 \cdot o \cdot P_{FIN}$	16.4.3.1
			Field controller			
		741	Amplification	-	0.0 to 100.0	16.4.5
☑		742	Integral time	ms	0.0 to 100.0	16.4.5
☑		743	Ref. Isd upper limit	A	$0.1 \cdot I_{FIN}$ to $o \cdot I_{FIN}$	16.4.5.1
☑		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 Imr lower limit	A	$0.01 \cdot I_{FIN}$ to $o \cdot I_{FIN}$	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			
		780	Max. flux formation time	ms	1 to 10000	11.1.2
☑		781	Current during flux formation	A	$0.1 \cdot I_{FIN}$ to $o \cdot I_{FIN}$	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

* UNDER PREPARATION

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SEDE CENTRALE - *HEADQUARTERS*

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