USER'S MANUAL

NX FREQUENCY CONVERTERS

BEAM PUMP APPLICATION

ASFIFF13

INDEX

Vacon Beam Pump Application

1. Introduction

Select the Beam Pump Application in menu M6 on page *S6.2*.

The purpose of the Beam Pump Application is to keep a constant stroke time (SPM) by adjusting the internal frequency reference. The control principle is to give a proper current limit for normal operation so that during motoring cycle the motor's actual speed is less than reference but during generating the motor speed is allowed go higher than reference, keeping the average SPM constant. With balanced load, the application uses two different references for downstroke and upstroke.

2. Commissioning

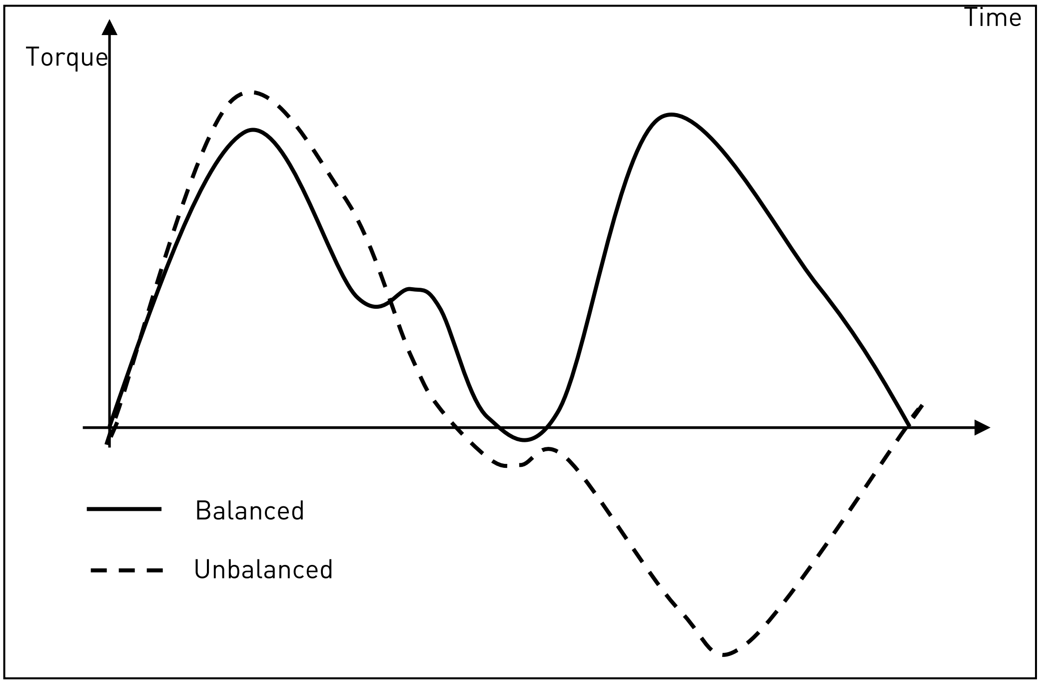


Figure 1. Beam Pump typical torque demand.

2.1 Commissioning unbalanced load

1. Set motor name plate values
   - Motor nominal current must be set before the operation current limits.

2. Set proper values for START operation
   - *Start Time* par. 2.1.18.2 Default 10.0 s
   - *Starting Current Limit* par. 2.1.18.3 Default 110% * I_n
   - Starting acceleration time (*Acceleration time 2*) P2.4.3 Default 10.0 s

3. Set proper value for *Normal Current Limit* (P2.1.18.1)
   - Speed drops during motoring operation but it will reach the reference before the generating cycle. If the speed drops to boost limit in normal operation you should increase the current limit.
   - If the motor load increases there is no need for higher current limit because the control principle is to increase the speed on generating side and use the pump's own inertia to overcome higher load.

4. Set proper values for boost
   - *Boost ON Limit* par. 2.1.18.4 Default 15.00 Hz
   - *Boost OFF Limit* par. 2.1.18.5 Default 20.00 Hz
   - *Boost Current Limit* par. 2.1.18.6 Default 120% * In

   Boost ON Limit should be near the minimum frequency, which is reached during normal operation.

5. Set Control Mode: *SPM Control* (P2.1.19.1).

6. Set *SPM Regulator Maximum Step*. (P2.1.19.3) The parameter defines the frequency step which can be made to compensate load changes. A higher value shortens the response time, but may cause hunting on control.

7. Set *SPM regulator Gain*. (P2.1.19.2) Defines the gain of control. If the parameter is set to 100% SPM error is corrected completely within *SPM Regulator Maximum Step*. It is typical that on start situation the adjustment is hunting. If hunting continues over 3-4 minutes you should decrease the adjustment gain.

2.2 Commissioning balanced load

The commissioning of a balanced load is done in the same way as of an unbalanced load except for the normal current limit. You have to select control method for balanced load.

1. Use higher normal current limit (P2.1.18.1) than in the unbalanced mode. In the balanced mode, there is no clear generating side in torque.
2. Select proper control method at *Balanced mode* P2.1.20.1.

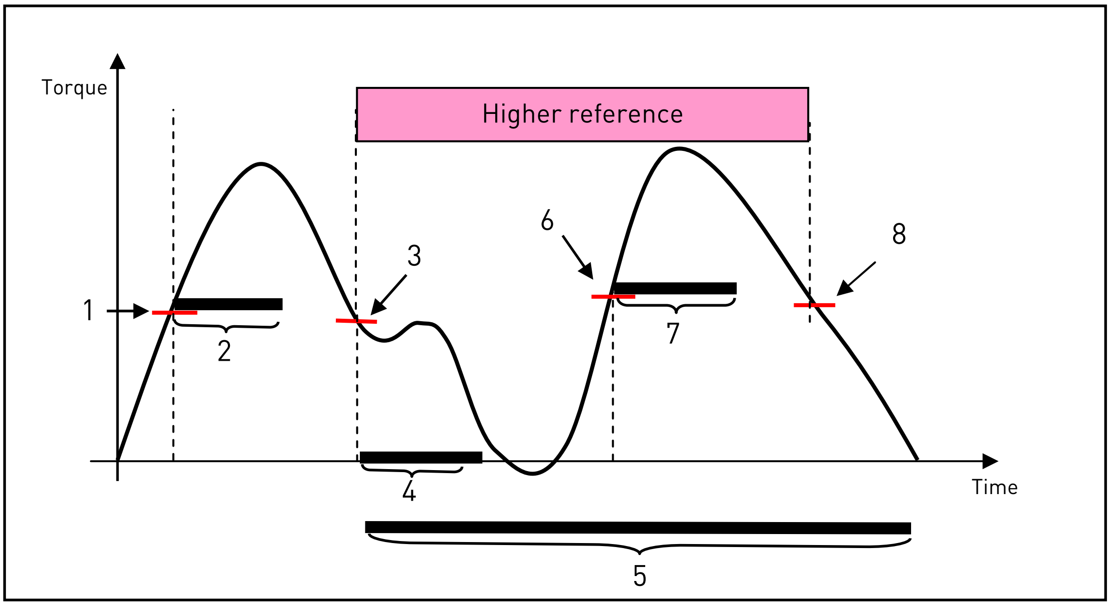
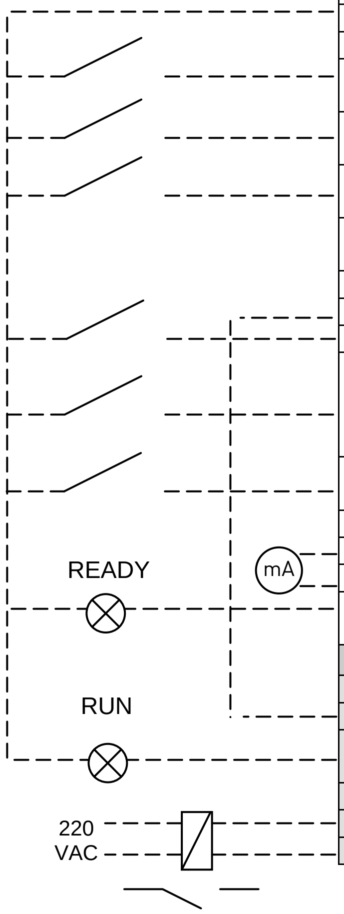


Figure 2. Typical torque demand of a beam pump.

1. P2.1.21.1 *First Counter Start*. This parameter is defined as percentage of torque. When torque is above this limit higher reference allow time counter is calculating.
2. P2.1.21.2 *Higher Reference Allow Time*. Time how long torque most be higher than P2.1.21.1 so that higher reference is permitted.
3. P2.1.21.3 *First Torque Middle Point*. Torque point where High reference is activated. When high reference allow time is full and motor torque goes below this parameter higher reference is activated.
4. P2.1.21.4 *Minimum Time at Higher Reference*. Minimum time until low reference is permitted after high reference activaton.
5. P2.1.21.5 *Minimum High Reference Cycle Time*. Minimum time until high reference can be activated again.

6. P2.1.21.6 *Second Counter Start*. This parameter is defined as percentage of torque. When torque is above this limit lower reference allow time counter is calculating.
7. P2.1.21.7 *Lower Reference Allow Time*. Time how long torque most be higher than P2.1.21.6 so that lower reference is permitted.
8. P2.1.21.8 *Second Torque Middle Point*. Torque point where low reference is activated. When low reference allow time is full and motor torque goes below this parameter lower reference is activated.

3. Control I/O



NXOPTA1					
Terminal		Signal	Description		
1	$+10V_{ref}$	Reference output	Voltage for potentiometer, etc.		
2	AI1+	Analogue input, voltage range 0—10V DC	Voltage input frequency reference		
3	AI1-	I/O Ground	Ground for reference and controls		
4	AI2+	Analogue input, current range 0—20mA	Current input frequency reference		
5	AI2-				
6	+24V	Control voltage output	Voltage for switches, etc. max 0.1 A		
7	GND	I/O ground	Ground for reference and controls		
8	DIN1	Start forward (programmable)	Contact closed = start forward		
9	DIN2	Start reverse (programmable)	Contact closed = start reverse		
10	DIN3	External fault input (programmable)	Contact open = no fault Contact closed = fault		
11	CMA	Common for DIN 1—DIN 3	Connect to GND or +24V		
12	+24V	Control voltage output	Voltage for switches (see #6)		
13	GND	I/O ground	Ground for reference and controls		
14	DIN4	Multi-step speed select 1	DIN4	DIN5	Frequency ref.
15	DIN5	Multi-step speed select 2 (Multi-step input can be use for synchronizing)	Open Closed Open Closed	Open Open Closed Closed	$Ref.U_{in}$ Multi-step ref.1 Multi-step ref.2 $Ref.I_{in}$
16	DIN6	Fault reset	Contact open = no action Contact closed = fault reset		
17	CMB	Common for DIN4—DIN6	Connect to GND or +24V		
18	AO1+	Output frequency	Programmable		
19	AO1-	Analogue output	Range 0—20 mA/R_L, max. 500Ω		
20	DO1	Digital output READY	Programmable Open collector, I≤50mA, U≤48 VDC		
NXOPTA2					
21	RO1	Relay output 1 RUN	Programmable		
22	RO1				
23	RO1				
24	RO2	Relay output 2 FAULT	Programmable		
25	RO2				
26	RO2				

Table 1. Beam Pump application default I/O configuration.

4. Beam Pump Application – Parameter lists

On the next pages you will find the lists of parameters within the respective parameter groups. The parameter descriptions are given on pages 20 to 55.

Column explanations:

Code = Location indication on the keypad; Shows the operator the present parameter number
Parameter = Name of parameter
Min = Minimum value of parameter
Max = Maximum value of parameter
Unit = Unit of parameter value; Given if available
Default = Value preset by factory
Cust = Customer's own setting
ID = ID number of the parameter (used with PC tools)
(cyan) = On parameter code: Parameter value can only be changed after the frequency converter has been stopped.
(grey) = In parameter row: Use TTF method to program these parameters

4.1 Monitoring values (Control keypad: menu M1)

The monitoring values are the actual values of parameters and signals as well as statuses and measurements. Monitoring values cannot be edited. See the product's User's Manual for more information.

Code	Parameter	Unit	ID	Description
V1.1	Output frequency	Hz	1	Output frequency to motor
V1.2	Frequency reference	Hz	25	Frequency reference to motor control
V1.3	Motor speed	rpm	2	Motor speed in rpm
V1.4	Motor current	A	3	
V1.5	Motor torque	%	4	
V1.6	Motor power	%	5	Motor shaft power
V1.7	Motor voltage	V	6	
V1.8	DC link voltage	V	7	
V1.9	Unit temperature	°C	8	Heatsink temperature
V1.10	Motor Temperature	%	9	
V1.11	Voltage input	V	13	AI1
V1.12	Current input	mA	14	AI2
V1.13	DIN1, DIN2, DIN3		15	Digital input statuses
V1.14	DIN4, DIN5, DIN6		16	Digital input statuses
V1.15	DO1, RO1, RO2		17	Digital and relay output statuses
V1.16	Analogue I_{out}	mA	26	AO1
V1.17	Controlled reference	Hz	1508	Reference with adjustment
V1.18	Balanced reference	Hz	1509	Balanced load reference
V1.19	Controlled Balanced reference	Hz	1509	Balanced load reference with adjustment
V1.20	Total Correction	Hz	1502	Made correction
V1.21	Feedback frequency	Hz	1524	
V1.22	Average Freq Error	Hz	1505	Correction to be made
V1.23	Current limit	A	1600	Currently used current limit
V1.24	Status Word		1523	
V1.26.1	1st Area		1601	
V1.26.2	2nd Area		1602	
V1.26.3	1st Time		1561	

V1.26.4	2nd Time		1565	
V1.26.5	Simulated balanced reference	Hz	1702	
P1.26.6	Simulated control mode		1564	0=Not in use 1=Torque 2=1 DIN operation 3=2 DIN operation 4=Time operation
V1.26.7	Power monitoring filter time	S	1504	
V1.26.8	SPM reference	SPM	1500	
V1.26.9	SPM Out	SPM	1501	SPM From Output frequency
V1.26.10	SPM from time	SPM	1506	Actual SPM, calculated from cycle time
P1.26.11	SPM Filter time	S	1525	Filtering time for SPM Out
P1.26.12	No of Cycles		1526	How meny cycle until timer is reset
V1.26.13	N Cycle time	S	1527	

Table 2. Monitoring values

V1.17 Controlled reference

Frequency reference which contains the SPM controller adjustment.

V1.18 Balanced reference

Balanced control mode reference without SPM control.

V1.19 Controlled balanced reference

Balanced control mode reference with SPM control.

V1.20 Total Correction

Correction in frequency made to achieve the reference value.

V1.21 Torque feedback reference

Shows the correction added to final reference if in use.

V1.22 Average Frequency Error

Corrections which will be made within gain and step limits.

V1.23 Actual current limit

Shows the presently used current limit.

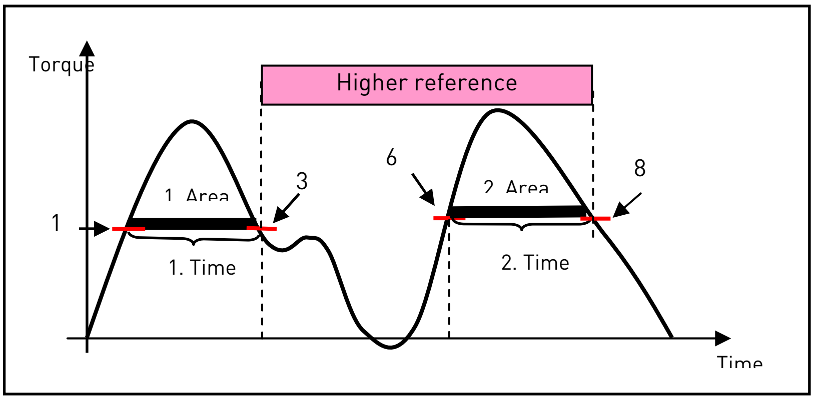


Figure 3. Beam Pump monitoring values explanation

V1.26.5 Simulated balanced reference

This value simulates the balanced mode reference. The simulated mode can be selected with parameter P1.29.6 on monitoring window.

V1.26.6 Simulated control mode

With this parameter you can select the simulated control mode. The reference is shown on monitoring page V1.29.5.

V1.26.7 Power monitoring filter time

Filtering time for monitored power V1.6. Filtering time helps to determine the power consumption

V1.26.8 SPM reference

Shows reference as SPM if P2.1.22 has been defined correctly.

V1.26.9 SPM output

Shows output frequency as SPM if P2.1.22 has been defined correctly.

V1.26.10 SPM from time

Shows actual SPM when the torque synchronization parameters (G2.1.21) have been set correctly. This value is used for controlling the internal frequency reference when the adjust type (P2.1.19.4) is Time control = 2.

V1.26.11 SPM filtering time

Filtering time for SPM output. Helps to determine the average SPM if P2.1.22 has been defined correctly.

V1.26.12 Number of cycles

This parameter defines the number of cycles calculated to time shown at V1.26.13.

V1.26.13 n Cycle time

Time which is passed to complete cycles defined with parameter V1.26.12.

4.2 Basic parameters (Control keypad: Menu M2 → G2.1)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.1.1	Minimum frequency	0.00	320.00	Hz	0		101	
P2.1.2	Maximum frequency	0.00	320.00	Hz	50.00		102	
P2.1.3	Acceleration time 1	0,1	3000,0	s	3,0		103	
P2.1.4	Deceleration time 1	0,1	3000,0	s	3,0		104	
P2.1.5	Nominal voltage of the motor	180	690	V	NX2: 230V NX5: 400V NX6: 690V		110	
P2.1.6	Nominal frequency of the motor	30,00	320,00	Hz	50,00		111	Check the rating plate of the motor
P2.1.7	Nominal speed of the motor	300	20 000	rpm	1440		112	The default applies for a 4-pole motor and a nominal size frequency converter.
P2.1.8	Nominal current of the motor	0,4 x I_H	2 x I_H	A	I_H		113	Check the rating plate of the motor.
2.1.9	Motor cosφ	0,30	1,00		0,85		120	Check the rating plate of the motor
2.1.10	I/O reference	0	3		0		117	0=AI1 1=AI2 2=Keypad 3=Fieldbus
2.1.11	Keypad control reference	0	3		2		121	0=AI1 1=AI2 2=Keypad 3=Fieldbus
2.1.12	Fieldbus control reference	0	3		3		122	0=AI1 1=AI2 2=Keypad 3=Fieldbus
2.1.13	Preset speed 1	0,00	Par. 2.1.2	Hz	10.00		105	Speeds preset by operator
2.1.14	Preset speed 2	0,00	Par. 2.1.2	Hz	50.00		106	Speeds preset by operator
P2.1.15	Feed back maximum torque	0.0	320.00	%	100.00		1528	
P2.1.16	Feed back minimum frequency	0.00	320.00	Hz	0.00		1529	
P2.1.17	Feed back maximum frequency	0.00	320.00	Hz	0.00		1546	
P2.1.22	SPM at nominal frequency	0.00	320.00	SPM	10.00		1510	

Table 3. Basic parameters G2.1

4.2.1 *Current limits (Control keypad: Menu M2 → G2.1.18)*

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.1.18.1	Normal current limit	0,1xI_n	2,5xI_n	A	0,7xI_n		1513	
P2.1.18.2	Start time	0,0	60.0	s	10,0		1514	
P2.1.18.3	Start current limit	0,1xI_n	2,5xI_n	A	1,1xI_n		1515	
P2.1.18.4	Boost ON limit	0.00	Par. 2.1.16.5	Hz	15.00		1516	
P2.1.18.5	Boost OFF limit	Par. 2.1.16.4	100.00	Hz	20.00		1517	
P2.1.18.6	Boost current limit	0,1xI_n	2,5xI_n	A	0,8xI_n		1518	

Table 4. Current limits parameters G2.1.18

4.2.2 *SPM regulating (Control keypad: Menu M2 → G2.1.19)*

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.1.19.1	Control Mode	0	1		1		1519	0=No Regulating 1=SPM Regulating
P2.1.19.2	SPM Regulator Gain	0.0	200.0	%	70.0		1520	Regulator gain
P2.1.19.3	SPM Regulator Max Step	0.00	50.00	Hz	3.00		1521	Maximum adjustment in a 30 second
P2.1.19.4	Adjust Type	0	2		1		1522	0=Sliding average 1=Reset average 2=Time control

Table 5. SPM regulating parameters G2.1.16

4.2.3 *Balanced mode (Control keypad: Menu M2 → G2.1.20)*

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.1.20.1	Balanced mode	0	4		0		1540	0=Unbalanced 1=Torque 2=1 DIN operation 3=2 DIN operation 4=Time operation
P2.1.20.2	Up/Down stroke difference	0	100.00	Hz	15.00		1545	
P2.1.20.3	Time at higher reference	0.00	327.67	s	4.00		1544	

Table 6. Balanced mode parameters G2.1.16

4.2.4 *Torque synchronizing (Control keypad: Menu M2 → G2.1.21)*

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.1.21.1	1st Counter start torque point	0.0	300.0	%	30.0		1533	
P2.1.21.2	Higher reference allow time	0.000	32.000	s	0.700		1534	
P2.1.21.3	1st torque middle point	0.0	300.0	%	30.0		1531	
P2.1.21.4	Minimum time at higher reference	0.000	32.000	s	1.000		1535	
P2.1.21.5	Minimum higher reference cycle time	0.000	32.000	s	3.000		1536	
P2.1.21.6	2nd counter start torque point	0.0	300.0	%	30.0		1537	
P2.1.21.7	Lower reference allow time	0.000	32.000	s	0.700		1538	
P2.1.21.8	2nd torque middle point	0.0	300.0	%	30.0		1539	
P2.1.21.9	Toggle torque cycle	0	1		1		1541	0=Toggle 1=Normal
P2.1.21.10	Actual torque filtering time	0.00	320.00	s	0.20		1530	
P2.1.21.11	Use unfiltered torque	0	1		1		1570	0=Unfiltered 1=Filtered

Table 7. SPM regulating parameters G2.1.21

4.3 Input signals (Control keypad: Menu M2 → G2.2)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.2.1	Start/Stop logic	0	6		0		300	DIN1 / DIN2 0 Start fwd / Start rvs 1 Start/Stop / Rvs/Fwd 2 Start/Stop / Runenable 3 Start pulse / Stop pulse 4 Fwd* / Rvs* 5 Start*/Stop / Rvs/Fwd 6 Start*/Stop / Runenable
P2.2.2	DIN3 function	0	8		1		301	0=Not used 1=Ext. fault, closing cont. 2=Ext. fault, opening cont. 3=Run enable 4=Acc./Dec. time select. 5=Force cp. to IO 6=Force cp. to keypad 7=Force cp. to fieldbus 8=Rvs (if par. 2.2.1=3)
P2.2.3	Current reference offset	0	1		1		302	0=No offset 1=4—20 mA
P2.2.4	Reference scaling minimum value	0,00	par. 2.2.5	Hz	0,00		303	Selects the frequency that corresponds to the min. reference signal 0,00 = No scaling
P2.2.5	Reference scaling maximum value	0,00	320,00	Hz	0,00		304	Selects the frequency that corresponds to the min. reference signal 0,00 = No scaling
P2.2.6	Reference inversion	0	1		0		305	0 = Not inverted 1 = Inverted
P2.2.7	Reference filter time	0,00	10,00	s	0,10		306	0 = No filtering
P2.2.8	Digital input for preset speed 1	0			A.4		1550	TTF programming method used.
P2.2.9	Digital input for preset speed 2	0			A.5		1551	TTF programming method used.
P2.2.10	Digital input for low reference	0			0.1		1542	TTF programming method used.
P2.2.11	Digital input for higher reference	0			0.1		1543	TTF programming method used.

Table 8. Input signals, G2.2

4.4 Output signals (Control keypad: Menu M2 → G2.3)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.3.1	Analogue output function	0	8		1		307	0=Not used 1=Output freq. (0—f_{max}) 2=Freq. reference (0—f_{max}) 3=Motor speed (0—Motor nominal speed) 4=Output current (0-I_{nMotor}) 5=Motor torque (0—T_{nMotor}) 6=Motor power (0—P_{nMotor}) 7=Motor voltage (0-U_{nMotor}) 8=DC-link volt (0—1000V)
P2.3.2	An.output filter time	0,00	10,00	s	1,00		308	
P2.3.3	Analogue output inversion	0	1		0		309	0=Not inverted 1=Inverted
P2.3.4	Analogue output minimum	0	1		0		310	0=0 mA 1=4 mA
P2.3.5	An. output scale	10	1000	%	100		311	
P2.3.6	Digital output 1 function	0	14		1		312	0=Not used 1=Ready 2=Run 3=Fault 4=Fault inverted 5=FC overheat warning 6=Ext. fault or warning 7=Ref. fault or warning 8=Warning 9=Reversed 10=Preset speed 11=At speed 12=Mot. regulator active 13=OP freq. limit superv. 14=Control place: IO
P2.3.7	Relay output 1 function	0	14		2		313	As parameter 2.3.6
P2.3.8	Relay output 2 function	0	14		3		314	As parameter 2.3.6
P2.3.9	Output frequency limit 1 supervision	0	2		0		315	0=No limit 1=Low limit supervision 2=High limit supervision
P2.3.10	Output frequency limit 1; Supervised value	0,00	320,00	Hz	0,00		316	
P2.3.11	Analogue output 2 signal selection	0			0.1		471	TTF programming method used. See PFC application.
P2.3.12	An.output 2 function	0	8		4		472	As parameter 2.3.1
P2.3.13	Analogue output 2 filter time	0,00	10,00	s	1,00		473	
P2.3.14	Analogue output 2 inversion	0	1		0		474	0=Not inverted 1=Inverted
P2.3.15	Analogue output 2 minimum	0	1		0		475	0=0 mA 1=4 mA
P2.3.16	Analogue output 2 scaling	10	1000	%	1000		476	

Table 9. Output signals, G2.3

4.5 Drive control parameters (Control keypad: Menu M2 → G2.4)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.4.1	Ramp 1 shape	0,0	10,0	s	0,0		500	0=Linear >0=S-curve ramp time
P2.4.2	Ramp 2 shape	0,0	10,0	s	0,0		501	0=Linear >0=S-curve ramp time
P2.4.3	Acceleration time 2	0,1	3000,0	s	10,0		502	
P2.4.4	Deceleration time 2	0,1	3000,0	s	10,0		503	
P2.4.5	Brake chopper	0	3		0		504	0=Disabled 1=Used when running 2=External brake chopper 3=Used when stopped/running
P2.4.6	Start function	0	1		0		505	0=Ramp 1=Flying start
P2.4.7	Stop function	0	3		0		506	0=Coasting 1=Ramp 2=Ramp+Run enable coast 3=Coast+Run enable ramp
P2.4.8	DC braking current	0,4 x I_H	2 x I_H	A	I_H		507	
P2.4.9	DC braking time at stop	0,00	600,00	s	0,00		508	0=DC brake is off at stop
P2.4.10	Frequency to start DC braking during ramp stop	0,10	10,00	Hz	0,00		515	
P2.4.11	DC braking time at start	0,00	600,00	s	0,00		516	0=DC brake is off at start
P2.4.12	Flux brake	0	1		0		520	0=Off 1=On
P2.4.13	Flux braking current	0,4 x I_H	2 x I_H	A	I_H		519	

Table 10. Drive control parameters, G2.4

4.6 Prohibit frequency parameters (Control keypad: Menu M2 → G2.5)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.5.1	Prohibit frequency range 1 low limit	0,00	par. 2.5.2	Hz	0,00		509	
P2.5.2	Prohibit frequency range 1 high limit	0,00	320,00	Hz	0,0		510	
P2.5.3	Prohibit acc./dec. ramp	0,1	10,0		1,0		518	

Table 11. Prohibit frequency parameters, G2.5

4.7 Motor control parameters (Control keypad: Menu M2 → G2.6)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.6.1	Motor control mode	0	1		0		600	0=Frequency control 1=Speed control
P2.6.2	U/f optimisation	0	1		0		109	0=Not used 1=Automatic torque boost
P2.6.3	U/f ratio selection	0	3		0		108	0=Linear 1=Squared 2=Programmable 3=Linear with flux optim.
P2.6.4	Field weakening point	30,00	320,00	Hz	50,00		602	
P2.6.5	Voltage at field weakening point	10,00	200,00	%	100,00		603	n% x U_{nmot} Parameter max. value = par. 2.6.7
P2.6.6	U/f curve midpoint frequency	0,00	par. P2.6.4	Hz	50,00		604	
P2.6.7	U/f curve midpoint voltage	0,00	100,00	%	100,00		605	n% x U_{nmot}
P2.6.8	Output voltage at zero frequency	0,00	40,00	%	0,00		606	n% x U_{nmot}
P2.6.9	Switching frequency	1,0	Varies	kHz	Varies		601	See Table 20 for exact values
P2.6.10	Overvoltage controller	0	1		2		607	0=Disabled 1=Active, but no Ramping 2=Ramping
P2.6.11	Undervoltage controller	0	1		1		608	0=Not used 1=Used

Table 12. Motor control parameters, G2.6

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4.8 Protections (Control keypad: Menu M2 → G2.7)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.7.1	Response to reference fault	0	5		0		700	0=No response 1=Warning 2=Warning+Old Freq. 3=Wrng+PresetFreq 2.7.2 4=Fault,stop acc. to 2.4.7 5=Fault,stop by coasting
P2.7.2	Reference fault frequency	0,00	Par. 2.1.2	Hz	0,00		728	
P2.7.3	Response to external fault	0	3		2		701	0=No response 1=Warning 2=Fault,stop acc. to 2.4.7 3=Fault,stop by coasting
P2.7.4	Input phase supervision	0	3		0		730	
P2.7.5	Response to undervoltage fault	1	3		2		727	
P2.7.6	Output phase supervision	0	3		2		702	
P2.7.7	Earth fault protection	0	3		2		703	
P2.7.8	Thermal protection of the motor	0	3		2		704	
P2.7.9	Motor ambient temperature factor	–100,0	100,0	%	0,0		705	
P2.7.10	Motor cooling factor at zero speed	0,0	150,0	%	40,0		706	
P2.7.11	Motor thermal time constant	1	200	min	10		707	
P2.7.12	Motor duty cycle	0	100	%	100		708	
P2.7.13	Stall protection	0	3		0		709	0=No response 1=Warning 2=Fault,stop acc. to 2.4.7 3=Fault,stop by coasting
P2.7.14	Stall current	0,1	I_{nMotor} x 2	A	I_L		710	
P2.7.15	Stall time limit	1,00	120,00	s	15,00		711	
P2.7.16	Stall frequency limit	1,0	Par. 2.1.2	Hz	25,0		712	
P2.7.17	Underload protection	0	3		0		713	0=No response 1=Warning 2=Fault,stop acc. to 2.4.7 3=Fault,stop by coasting
P2.7.18	Underload curve at nominal frequency	10	150	%	50		714	
P2.7.19	Underload curve at zero frequency	5,0	150,0	%	10,0		715	
P2.7.20	Underload protection time limit	2	600	s	20		716	
P2.7.21	Response to thermistor fault	0	3		0		732	0=No response 1=Warning 2=Fault,stop acc. to 2.4.7 3=Fault,stop by coasting
P2.7.22	Response to fieldbus fault	0	3		0		733	See P2.7.21
P2.7.23	Response to slot fault	0	3		0		734	See P2.7.21

Table 13. Protections, G2.7

4.9 Autorestart parameters (Control keypad: Menu M2 → G2.8)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.8.1	Wait time	0,10	10,00	s	0,50		717	
P2.8.2	Trial time	0,00	60,00	s	30,00		718	
P2.8.3	Start function	0	2		0		719	0=Ramp 1=Flying start 2=According to par. 2.4.6
P2.8.4	Number of tries after undervoltage trip	0	10		0		720	
P2.8.5	Number of tries after overvoltage trip	0	10		0		721	
P2.8.6	Number of tries after overcurrent trip	0	3		0		722	
P2.8.7	Number of tries after reference trip	0	10		0		723	
P2.8.8	Number of tries after motor temperature fault trip	0	10		0		726	
P2.8.9	Number of tries after external fault trip	0	10		0		725	

Table 14. Autorestart G2.8

4.10 Closed Loop parameters (NXP) (Control keypad: M2 → G2.9)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.9.1	Magnetizing current	0,00	100,00	A	0,00		612	
P2.9.2	Speed control P gain	0	1000		30		613	
P2.9.3	Speed control I time	0,0	500,0	ms	30,0		614	
P2.9.4	Load drooping	0,00	100,00	%	0,00		620	
P2.9.5	Acceleration compensation	0,00	300,00	s	0,00		626	
P2.9.6	Slip adjust	0	500	%	100		619	
P2.9.9	0-speed time at start	0	32000	ms	100		615	
P2.9.10	0-speed time at stop	0	32000	ms	100		616	
P2.9.11	Start-up torque	0	1		0		621	0=Not used 1=Torque memory
P2.9.12	Start-up torque FWD	–300,0	300,0	s	0,0		633	
P2.9.13	Start-up torque REV	–300,0	300,0	s	0,0		634	
P2.9.15	Encoder filter time	0	1000	ms	0		618	
P2.9.17	Current control P gain	0,00	100,00	%	40,00		617	

4.11 Advanced Open Loop parameters (NXP) (Control keypad: M2 → G2.10)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.10.1	Zero speed current	0,0	250,0	%	120,0		625	
P2.10.2	Minimum current	0,0	100,0	%	80,0		622	
P2.10.3	Flux reference	0,0	100,0	%	80,0		623	
P2.10.4	Frequency limit	0,0	100,0	%	20,0		635	

Table 15. Closed Loop parameters, G2.9

4.12 CanBus parameter (Control keypad: M2 → G2.11)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.11.1	CanBus node nr	0	255		0		800	

Table 16. CanBus parameter

4.13 Keypad control (Control keypad: Menu M3)

The parameters for the selection of control place and direction on the keypad are listed below. See the Keypad control menu in the product's User's Manual.

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P3.1	Control place	1	3		1		125	0=I/O terminal 1=Keypad 2=Fieldbus
R3.2	Keypad reference	Par. 2.1.1	Par. 2.1.2	Hz				
P3.3	Direction (on keypad)	0	1		0		123	0 = Forward 1 = Reverse
R3.4	Stop button	0	1		1		114	0=Limited function of Stop button 1=Stop button always enabled

Table 17. Keypad control parameters, M3

4.14 System menu (Control keypad: M6)

For parameters and functions related to the general use of the frequency converter, such as application and language selection, customised parameter sets or information about the hardware and software, see the product's User's Manual.

4.15 Expander boards (Control keypad: Menu M7)

The M7 menu shows the expander and option boards attached to the control board and board-related information. For more information, see the product's User's Manual.

5. Description of parameters

5.1 Basic parameters

2.1.1 Minimum frequency

Defines the frequency limits of the frequency converter.
The maximum value for parameters 2.1.1 and 2.1.2 is 320 Hz. The software will automatically check the values of parameters 2.1.13, 2.1.14, 2.3.10 and 2.7.2.

2.1.2 Maximum frequency

Defines limit for output frequency, this limit could be reached when motor is generating side and drive tries to compensate DC-link voltage rising. If limit is reached and motor is still accelerating due the pump mass of inertia over voltage trip may occur, if this happens set maximum frequency higher.

2.1.3, 2.1.4 Acceleration time 1, deceleration time 1

These limits correspond to the time required for the output frequency to accelerate from the zero frequency to the set maximum frequency (par. 2.1.2).

2.1.5 Nominal voltage of the motor

Find this value U_n on the rating plate of the motor. This parameter sets the voltage at the field weakening point (parameter 2.6.5) to 100% x U_{nmotor}.

2.1.6 Nominal frequency of the motor

Find this value f_n on the rating plate of the motor. This parameter sets the field weakening point (parameter 2.6.4) to the same value.

2.1.7 Nominal speed of the motor

Find this value n_n on the rating plate of the motor.

2.1.8 Nominal current of the motor

Find this value I_n on the rating plate of the motor.

2.1.9 Motor cos phi

Find this value "cos phi" on the rating plate of the motor.

2.1.10 I/O frequency reference selection

Defines which frequency reference source is selected when controlled from the I/O control place. Default value is 0.

0 = Analogue voltage reference from terminals 2—3, e.g. potentiometer
1 = Analogue current reference from terminals 4—5, e.g. transducer
2 = Keypad reference from the Reference Page (Group M3)
3 =Reference from the fieldbus

2.1.11 *Keypad frequency reference selection*

Defines which frequency reference source is selected when controlled from the keypad. Default value is 2.

0 = Analogue voltage reference from terminals 2—3, e.g. potentiometer
1 = Analogue current reference from terminals 4—5, e.g. transducer
2 = Keypad reference from the Reference Page (Group M3)
3 = Reference from the Fieldbus

2.1.12 *Fieldbus frequency reference selection*

Defines which frequency reference source is selected when controlled from the fieldbus. Default value is 3.

0 = Analogue voltage reference from terminals 2—3, e.g. potentiometer
1 = Analogue current reference from terminals 4—5, e.g. transducer
2 = Keypad reference from the Reference Page (Group M3)
3 = Reference from the Fieldbus

2.1.13 *Preset speed 1*
2.1.14 *Preset speed 2*

Parameter values are automatically limited between the minimum and maximum frequencies (par. 2.1.1, 2.1.2).

Feedback torque

Feedback torque is used for lower output frequencies when the load is high. This option reduces energy need from network and can save energy.

2.1.15 *Feedback maximum torque*

This parameter defines the torque value when minimum feedback frequency is added to final frequency reference.

2.1.16 *Feedback minimum frequency*

This frequency is added to final frequency reference when torque is in feedback maximum torque.

2.1.17 *Feedback maximum frequency*

This frequency is added to final frequency when torque is zero.

Current limits

2.1.18.1 *Normal current limit*

Motor current limit while motor is working within normal limits.

2.1.18.2 *Start Time*

When start command is given this time defines how long *Acceleration Time 2* (P2.4.3), *Deceleration Time 2* (P2.4.3) and *Starting Current Limit* (P2.12.6) are active.

2.1.18.3 Starting Current Limit

Starting time current limit.

2.1.18.4 Boost ON Limit

When the output frequency goes below this limit the *Boosting Current Limit* will activate.

2.1.18.5 Boost OFF Limit

When the *Boost Current Limit* is active and the output frequency exceeds this limit the *Normal Current Limit* will be activated again.

2.1.18.6 Boost Current Limit

Current limit for boosting.

Regulator

2.1.19.1 Control Mode

0 = No Control
  No adjustment is made to keep the constant stroke time, all other functions are operational.
1 = SPM Control
  Output frequency is adjusted to keep the constant stroke time.

2.1.19.2 SPM Regulator Gain

A percent value of *Average Frequency Error* (V1.22), which is made every 30 seconds.

2.1.19.3 SPM Regulator Maximum Step

Limit for adjustment, which is made every 30 seconds.

2.1.19.4 Adjusting Type

0 = Error is calculated as moving average
1 = Average error calculator is reset after every adjustment
2 = Time control

To use the time control you must define SPM at nominal frequency.

Balanced mode

2.1.20.1 Balanced mode

Select proper control mode for balanced load.

0= Not in use
1=Torque
  Reference setpoints are determined totally on the basis of torque. See Figure 4.
2= 1 DIN operation
  Higher reference is set through digital input, but is deactivated at second torque point.
3= 2 DIN operation
  Both higher reference and lower reference are activated from digital inputs.
4= Time operation
  Higher reference is activated at first torque point and will be active for a certain time defined by P2.1.21.5.

2.1.20.2 Up/Down stroke difference

Defines up- and downstroke speed difference in hertz.

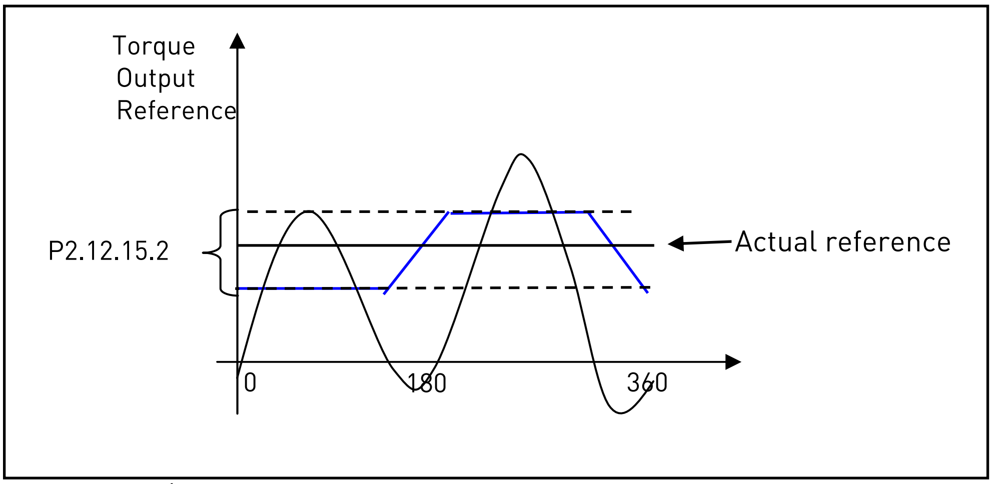

Figure 4. Up/Down stroke difference

2.1.20.3 Time at higher reference

When selected balanced control mode is 4 (Time operation), with this parameter you can define for how long the higher reference remains active.

Torque synchronize

See Commissioning balanced load, chapter 2.2.

2.1.21.1 First Counter Start

This parameter is defined as percentage of torque. When the torque is above this limit the *Higher Reference Allow Time* counter is calculating.

2.1.21.2 Higher reference allow time

Defines the time for how long the torque must be higher than P2.1.21.1 so that higher reference is permitted.

2.1.21.3 First torque middle point

The torque point where High Reference is activated. When high reference allow time is full and the motor torque goes below the value of this parameter the higher reference is activated.

2.1.21.4 Minimum time at higher reference

The minimum time until low reference is permitted after high reference activation.

2.1.21.5 Minimum high reference cycle time

Minimum time until high reference can be activated again.

2.1.21.6 Second counter start

This parameter is defined as percentage of torque. When the torque is above this limit the lower reference allow time counter is calculating.

2.1.21.7 Lower reference allow time

The time for how long the torque must be higher than P2.1.21.6 before the lower reference is permitted.

2.1.21.8 Second torque middle point

The torque point where the low reference is activated. When the low reference allow time is full and the motor torque goes below the value of this parameter the lower reference is activated.

2.1.21.9 Toggle torque cycle

If higher reference is activated during upstroke, it is possible with this parameter to move the higher reference activation to downstroke.

2.1.21.10 Torque filtering time

The filtering time for torque which is used for synchronization. This parameter also defines the filtering time for monitored torque.

2.1.21.11 Use unfiltered torque

With this parameter it is possible to use the unfiltered torque as input for the application level filter.

2.1.22 SPM At Motor Nominal frequency

Defines how many strokes the pump makes in one minute while the motor is driven at its nominal speed. *Time control* (par. 2.1.19.4 = 2) must be used or values are monitored as SPM.

5.2 INPUT SIGNALS

2.2.1 Start/Stop logic selection

0 DIN1: closed contact = start forward
DIN2: closed contact = start reverse

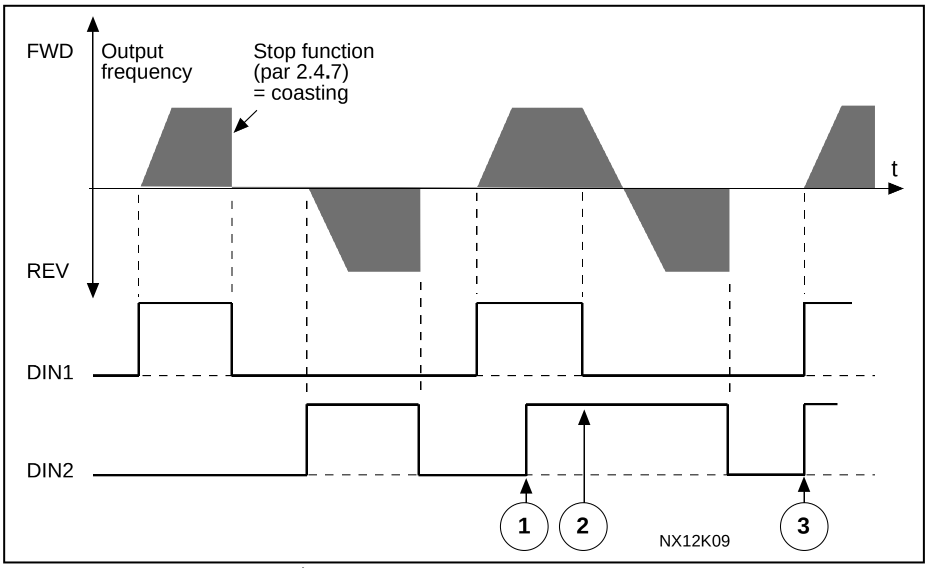

Figure 5. Start forward/Start reverse

① The first selected direction has the highest priority.

② When the DIN1 contact opens the direction of rotation starts the change.

③ If Start forward (DIN1) and Start reverse (DIN2) signals are active simultaneously the Start forward signal (DIN1) has priority.

1 DIN1: closed contact = start open contact = stop
DIN2: closed contact = reverse open contact = forward
See Figure 6 below.

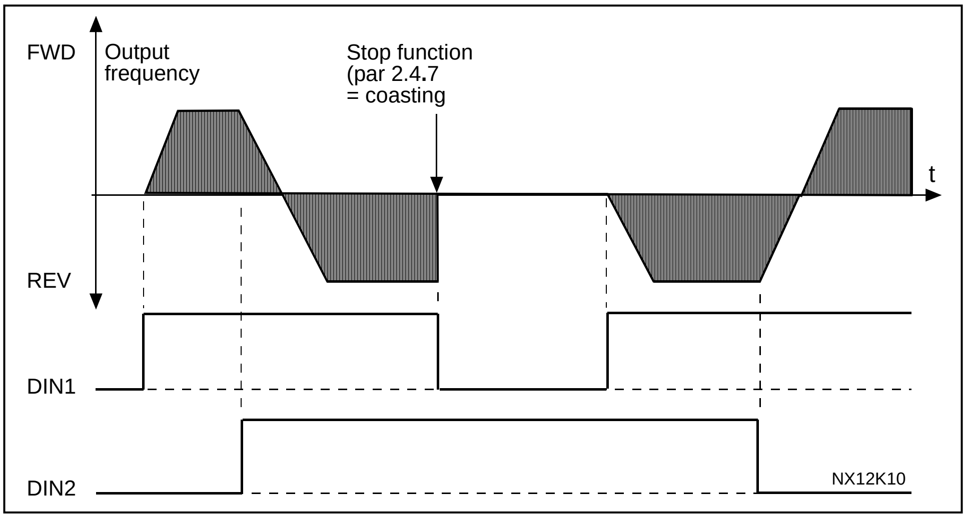

Figure 6. Start, Stop, Reverse

2 DIN1: closed contact = start open contact = stop
DIN2: closed contact = start enabled open contact = start disabled and drive stopped if running

3 3-wire connection (pulse control):
DIN1: closed contact = start pulse
DIN2: open contact = stop pulse
(DIN3 can be programmed for reverse command)
See Figure 7.

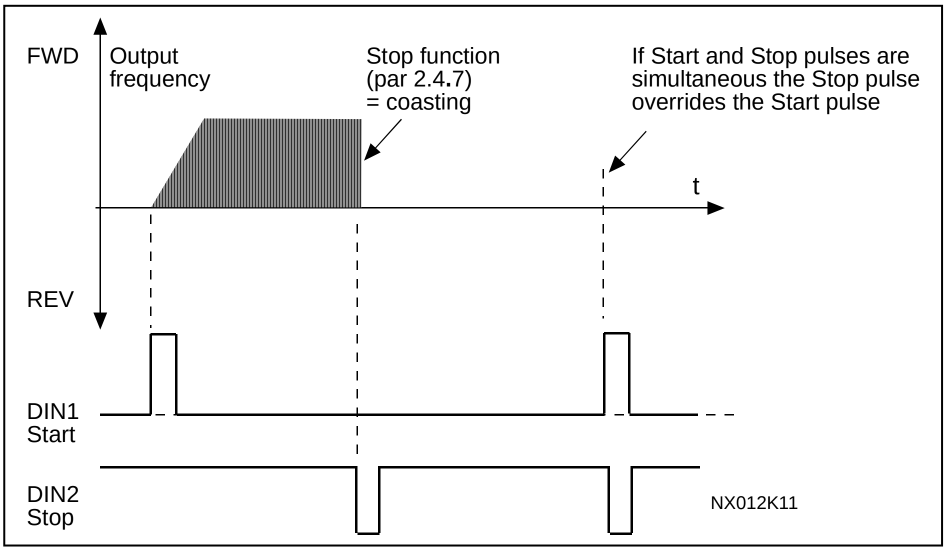

Figure 7. Start pulse/ Stop pulse.

The selections 4 to 6 shall be used to exclude the possibility of an unintentional start when, for example, power is connected, re-connected after a power failure, after a fault reset, after the drive is stopped by Run Enable (Run Enable = False) or when the control place is changed. The Start/Stop contact must be opened before the motor can be started.

4 DIN1: closed contact = start forward (Rising edge required to start)
DIN2: closed contact = start reverse (Rising edge required to start)

5 DIN1: closed contact = start (Rising edge required to start)
open contact = stop
DIN2: closed contact = reverse
open contact = forward

6 DIN1: closed contact = start (Rising edge required to start)
open contact = stop
DIN2: closed contact = start enabled
open contact = start disabled and drive stopped if running

2.2.2 DIN3 function

1 External fault, closing contact = Fault is shown and motor is stopped when the input is active.
2 External fault, opening contact = Fault is shown and motor is stopped when the input is not active.
3 Run enable, contact open = Motor start disabled and the motor is stopped
contact closed = Motor start enabled
4 Acc./Dec time select. contact open = Acceleration/deceleration time 1 selected
contact closed = Acceleration/deceleration time 2 selected

5 Closing contact: Force control place to I/O terminal
6 Closing contact: Force control place to keypad
7 Closing contact: Force control place to fieldbus

When the control place is forced to change the values of Start/Stop, Direction and Reference valid in the respective control place are used (reference according to parameters 2.1.11, 2.1.12 and 2.1.13).
Note: The value of parameter 3.1 Keypad Control Place does not change.
When DIN3 opens the control place is selected according to parameter 3.1.

8 Reverse contact open = Forward
contact closed = Reverse

Can be used for reversing if parameter 2.2.1 has value 3

2.2.3 Reference offset for current input

0 No offset: 0—20mA
1 Offset 4 mA ("living zero"), provides supervision of zero level signal. The response to reference fault can be programmed with parameter 2.7.1.

2.2.4
2.2.5 Reference scaling, minimum value/maximum value

Setting value limits: $0 \leq$ par. 2.2.4 $\leq$ par. 2.2.5 $\leq$ par. 2.1.2. If parameter 2.2.5 = 0 scaling is set off. The minimum and maximum frequencies are used for scaling.

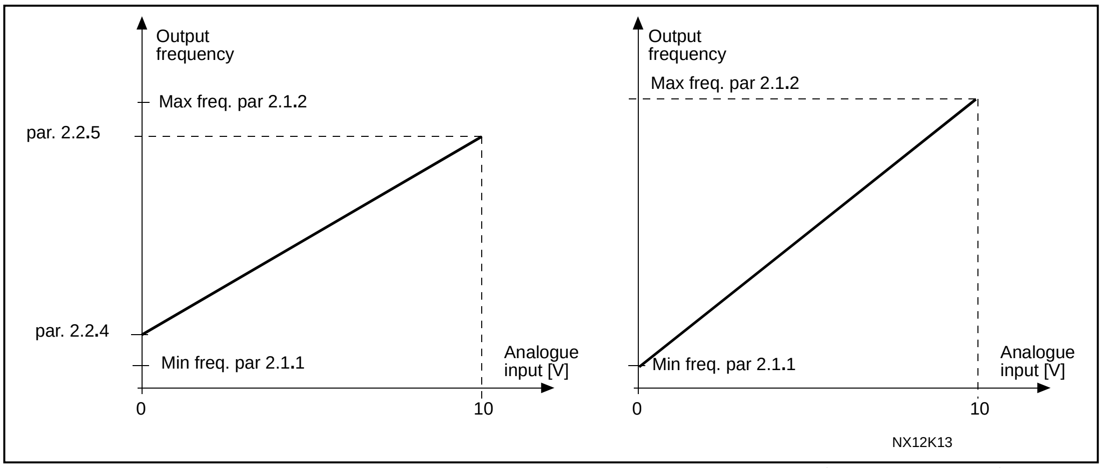

*Figure 8. **Left**: Reference scaling; **Right**: No scaling used (par. 2.2.5 = 0).*

2.2.6 Reference inversion

Inverts reference signal:
Max. ref. signal = Min. set freq.
Min. ref. signal = Max. set freq.

0 No inversion
1 Reference inverted

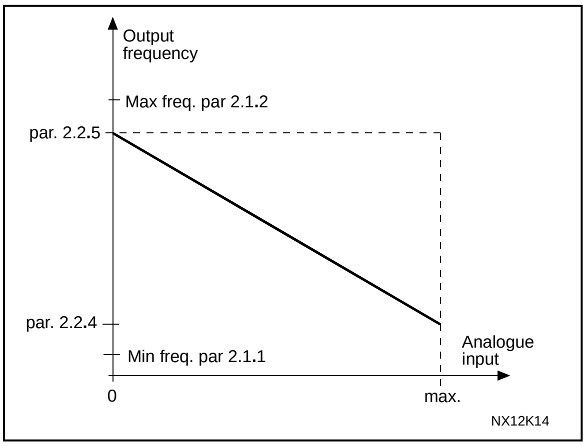

Figure 9. Reference invert.

2.2.7 Reference filter time

Filters out disturbances from the incoming analogue U_{in} signal. Long filtering time makes regulation response slower.

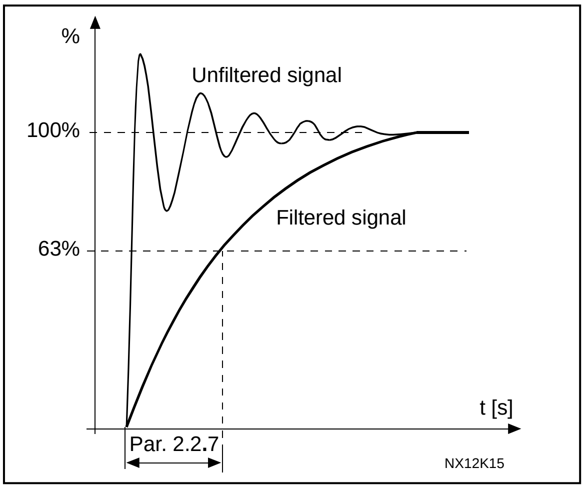

Figure 10. Reference filtering

2.2.8 Digital input for Preset Speed 1
2.2.9 Digital input for Preset Speed 2

Default values are as in Standard Application, set these to 0.1 if you are using DIB4 and/or DIB5 for synchronizing cycle.

2.2.10 Digital input for low reference
2.2.11 Digital input for higher reference

With these parameter you can define inputs for low and high reference command if used for synchronization.

5.3 OUTPUT SIGNALS

2.3.1 Analogue output function

This parameter selects the desired function for the analogue output signal.
See Table 9. Output signals, G2.3 on page 14 for the parameter values.

2.3.2 Analogue output filter time

Defines the filtering time of the analogue output signal.

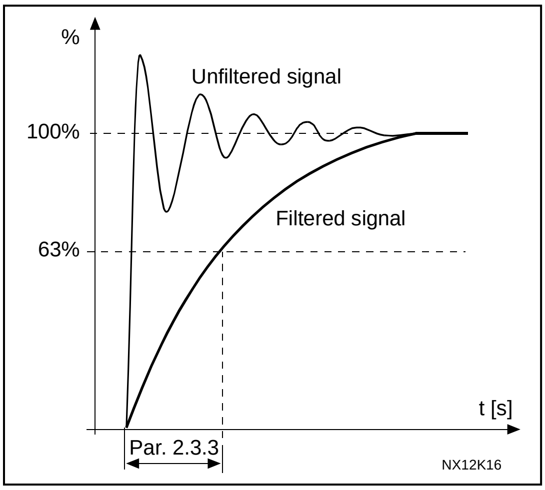

Figure 11. Analogue output filtering

2.3.3 Analogue output invert

Inverts the analogue output signal:
Maximum output signal = Minimum set value
Minimum output signal = Maximum set value

See parameter 2.3.5 below.

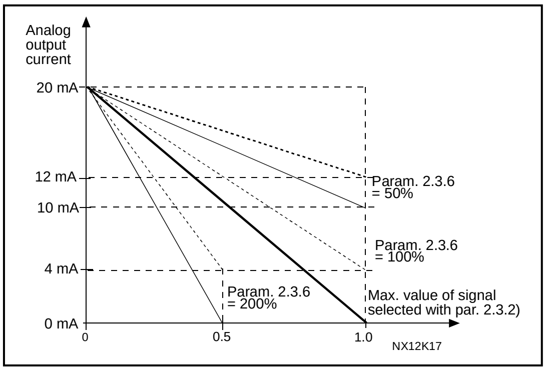

Figure 12. Analogue output invert

2.3.4 Analogue output minimum

Defines the signal minimum to either 0 mA or 4 mA (living zero). Note the difference in analogue output scaling in parameter 2.3.5 (Figure 13).

0 Set minimum value to 0 mA
1 Set minimum value to 4 mA

2.3.5 *Analogue output scale*

Scaling factor for analogue output.

Signal	Max. value of the signal
Output frequency	Max frequency (par. 2.1.2)
Freq. Reference	Max frequency (par. 2.1.2)
Motor speed	Motor nom. speed $1xn_{mMotor}$
Motor current	Motor nom. current $1xI_{nMotor}$
Motor torque	Motor nom. torque $1xT_{nMotor}$
Motor power	Motor nom. power $1xP_{nMotor}$
Motor voltage	100% x U_{nmotor}
DC-link voltage	1000 V

Table 18. Analogue output scaling

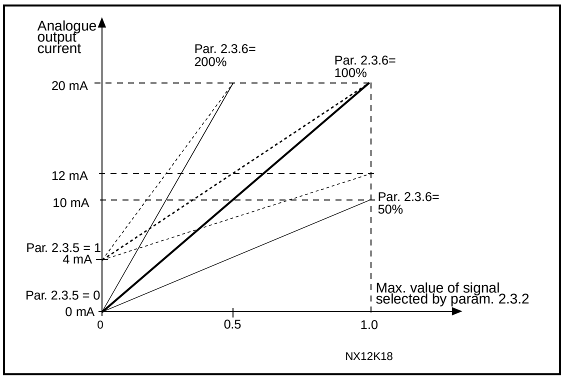

Figure 13. Analogue output scaling

2.3.6 *Digital output function*
2.3.7 *Relay output 1 function*
2.3.8 *Relay output 2 function*

Setting value	Signal content
0 = Not used	Out of operation
	<u>Digital output DO1 sinks the current and programmable relay (RO1, RO2) is activated when:</u>
1 = Ready	The frequency converter is ready to operate
2 = Run	The frequency converter operates (motor is running)
3 = Fault	A fault trip has occurred
4 = Fault inverted	A fault trip <u>not</u> occurred
5 = Vacon overheat warning	The heat-sink temperature exceeds +70°C
6 = External fault or warning	Fault or warning depending on par. 2.7.3
7 = Reference fault or warning	Fault or warning depending on par. 2.7.1 - if analogue reference is 4—20 mA and signal is <4mA
8 = Warning	Always if a warning exists
9 = Reversed	The reverse command has been selected
10 = Preset speed	The preset speed has been selected with digital input
11 = At speed	The output frequency has reached the set reference
12 = Motor regulator activated	Overvoltage or overcurrent regulator was activated
13 = Output frequency supervision	The output frequency goes outside the set supervision low limit/high limit (see parameters 2.3.9 and 2.3.10 below)
14 = Control from I/O terminals	I/O control mode selected (in menu M3)
15 = ThermistFlt/Wrn	
16 = FB Digital Input 1	
17 = Boosting	Drive is using Boosting current limit

Table 19. Output signals via DO1 and output relays RO1 and RO2.

2.3.9 Output frequency limit supervision function

0 No supervision
1 Low limit supervision
2 High limit supervision

If the output frequency goes under/over the set limit (P 2.3.10) this function generates a warning message via the digital output DO1 and via the relay output RO1 or RO2 depending on the settings of parameters 2.3.7—2.3.9.

2.3.10 Output frequency limit supervision value

Selects the frequency value supervised by parameter 2.3.10.

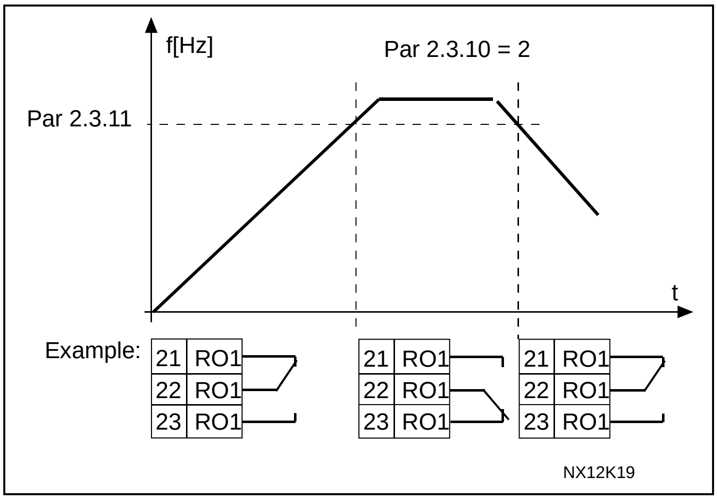

Figure 14. Output frequency supervision

2.3.11 Analogue output 2 signal selection

Connect the AO2 signal to the analogue output of your choice with this parameter. For more information, see Pump and fan control application manual, Chapter 2.

2.3.12 Analogue output 2 function
2.3.13 Analogue output 2 filter time
2.3.14 Analogue output 2 inversion
2.3.15 Analogue output 2 minimum
2.3.16 Analogue output 2 scaling

For more information on these five parameters, see the corresponding parameters for the analogue output 1 on pages 30 and 31.

5.4 DRIVE CONTROL

2.4.1 Acceleration/Deceleration ramp 1 shape
2.4.2 Acceleration/Deceleration ramp 2 shape

The start and end of acceleration and deceleration ramps can be smoothed with these parameters. Setting value 0 gives a linear ramp shape which causes acceleration and deceleration to act immediately to the changes in the reference signal.
Setting value 0.1…10 seconds for this parameter produces an S-shaped acceleration/deceleration. The acceleration time is determined with parameters 2.1.3/2.1.4 (2.4.3/2.4.4).

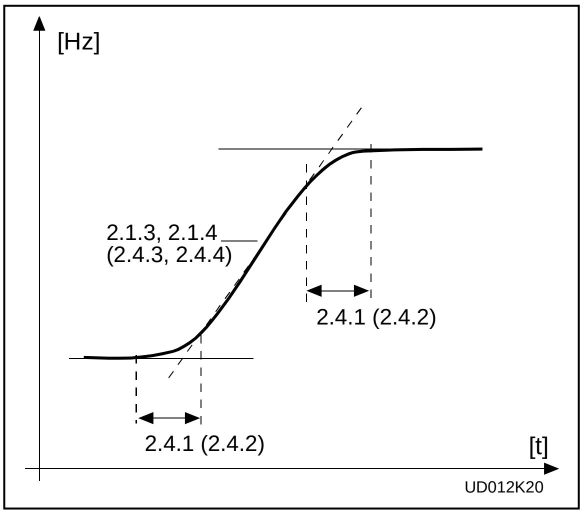

Figure 15. Acceleration/Deceleration (S-shaped)

2.4.3 Acceleration time 2
2.4.4 Deceleration time 2

These parameters define Acceleration times, when start time is active.

These values correspond to the time required for the output frequency to accelerate from the zero frequency to the set maximum frequency (par. 2.1.2). These parameters give the possibility to set two different acceleration/deceleration time sets for one application. The active set can be selected with the programmable signal DIN3 (par. 2.2.2).

2.4.5 Brake chopper

0 = No brake chopper used
1 = Brake chopper in use and tested when running. Can be tested also in READY state
2 = External brake chopper (no testing)
3 = Used and tested in READY state and when running
4 = Used when running (no testing)

When the frequency converter is decelerating the motor, the inertia of the motor and the load are fed into an external brake resistor. This enables the frequency converter to decelerate the load with a torque equal to that of acceleration (provided that the correct brake resistor has been selected). See separate Brake resistor installation manual.

2.4.6 *Start function*

Ramp:

0 The frequency converter starts from 0 Hz and accelerates to the set reference frequency within the set acceleration time. (Load inertia or starting friction may cause prolonged acceleration times).

Flying start:

1 The frequency converter is able to start into a running motor by applying a small torque to motor and searching for the frequency corresponding to the speed the motor is running at. Searching starts from the maximum frequency towards the actual frequency until the correct value is detected. Thereafter, the output frequency will be increased/decreased to the set reference value according to the set acceleration/deceleration parameters.

Use this mode if the motor is coasting when the start command is given. With the flying start it is possible to ride through short mains voltage interruptions.

2.4.7 *Stop function*

Coasting:

0 The motor coasts to a halt without any control from the frequency converter, after the Stop command.

Ramp:

1 After the Stop command, the speed of the motor is decelerated according to the set deceleration parameters.
If the regenerated energy is high it may be necessary to use an external braking resistor for faster deceleration.

Normal stop: Ramp/ Run Enable stop: coasting

2 After the Stop command, the speed of the motor is decelerated according to the set deceleration parameters. However, when Run Enable is selected (e.g. DIN3), the motor coasts to a halt without any control from the frequency converter.

Normal stop: Coasting/ Run Enable stop: ramping

3 The motor coasts to a halt without any control from the frequency converter. However, when Run Enable signal is selected (e.g. DIN3), the speed of the motor is decelerated according to the set deceleration parameters. If the regenerated energy is high it may be necessary to use an external braking resistor for faster deceleration.

2.4.8 *DC-braking current*

Defines the current injected into the motor during DC-braking.

2.4.9 *DC-braking time at stop*

Determines if braking is ON or OFF and the braking time of the DC-brake when the motor is stopping. The function of the DC-brake depends on the stop function, parameter 2.4.7.

0 DC-brake is not used
>0 DC-brake is in use and its function depends on the Stop function, (param. 2.4.7). The DC-braking time is determined with this parameter

<u>Par. 2.4.7 = 0; Stop function = Coasting:</u>

After the stop command, the motor coasts to a stop without control of the frequency converter.

With DC-injection, the motor can be electrically stopped in the shortest possible time, without using an optional external braking resistor.

The braking time is scaled according to the frequency when the DC-braking starts. If the frequency is ≥ the nominal frequency of the motor, the set value of parameter 2.4.9 determines the braking time. When the frequency is ≤10% of the nominal, the braking time is 10% of the set value of parameter 2.4.9.

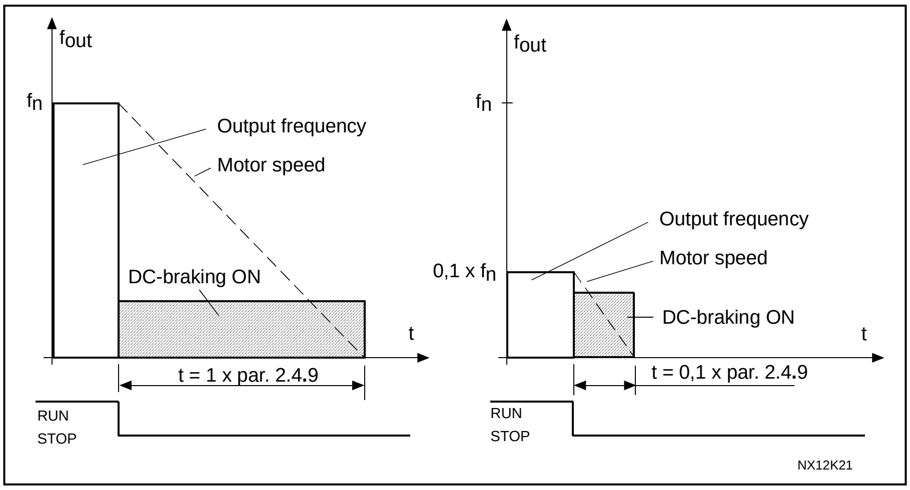

Figure 2- 1. DC-braking time when Stop mode = Coasting.

Par. 2.4.7 = 1; Stop function = Ramp:

After the Stop command, the speed of the motor is reduced according to the set deceleration parameters, as fast as possible, to the speed defined with parameter 2.4.10, where the DC-braking starts.

The braking time is defined with parameter 2.4.9. If high inertia exists, it is recommended to use an external braking resistor for faster deceleration. See Figure 16.

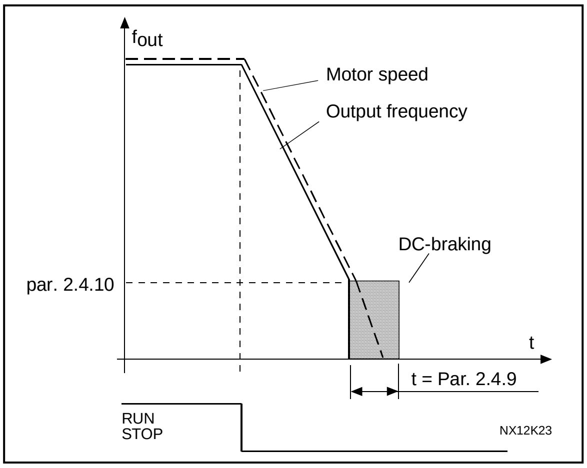

Figure 16. DC-braking time when Stop mode = Ramp

2.4.10 DC-braking frequency at stop

The output frequency at which the DC-braking is applied. See Figure 16.

2.4.11 DC-braking time at start

DC-brake is activated when the start command is given. This parameter defines the time before the brake is released. After the brake is released, the output frequency increases according to the set start function by parameter 2.4.6.

2.4.12 Flux brake

The flux braking can be set ON or OFF.

0 = Flux braking OFF
1 = Flux braking ON

2.4.13 Flux braking current

Defines the flux braking current value. This value can be set between $0.4*I_H$ and the Current limit.

5.5 PROHIBIT FREQUENCIES

2.5.1 Prohibit frequency area; Low limit
2.5.2 Prohibit frequency area; High limit

In some systems it may be necessary to avoid certain frequencies because of mechanical resonance problems. With these parameters it is possible to set limits for the "skip frequency" region. See Figure 17.

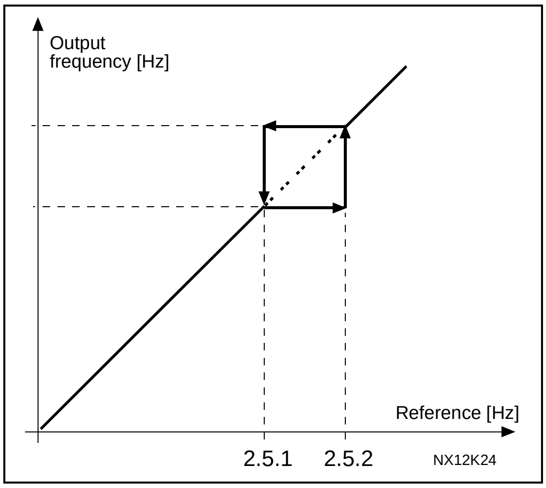

Figure 17. Prohibit frequency area setting.

2.5.3 Acc/dec ramp speed scaling ratio between prohibit frequency limits

Defines the acceleration/deceleration time when the output frequency is between the selected prohibit frequency range limits (parameters 2.5.1 and 2.5.2). The ramping speed (selected acceleration/ deceleration time 1 or 2) is multiplied with this factor. E.g. value 0.1 makes the acceleration time 10 times shorter than outside the prohibit frequency range limits.

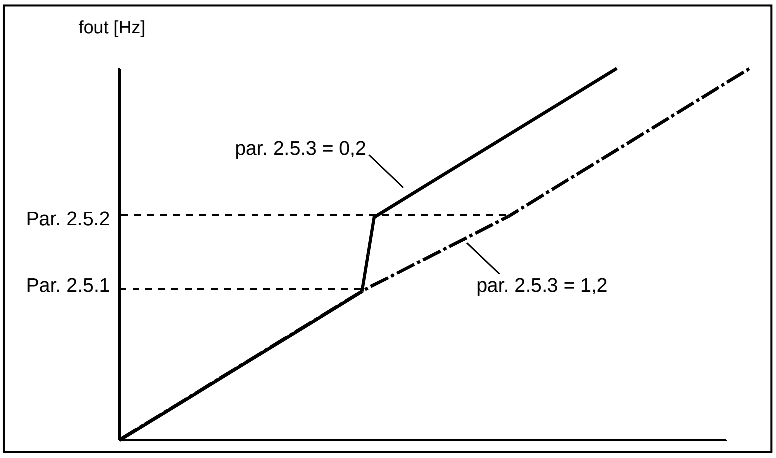

Figure 18. Ramp speed scaling between prohibit frequencies

5.6 MOTOR CONTROL

2.6.1 Motor control mode

NXS:

0	Frequency control:	The I/O terminal and keypad references are frequency references and the frequency converter controls the output frequency (output frequency resolution = 0.01 Hz)
1	Speed control:	The I/O terminal and keypad references are speed references and the frequency converter controls the motor speed compensating the motor slip (accuracy ± 0,5%).
2	Torque control	In torque control mode, the references are used to control the motor torque.

Additionally for NXP:

3	Speed crtl (closed loop)	The I/O terminal and keypad references are speed references and the frequency converter controls the motor speed very accurately comparing the actual speed received from the tachometer to the speed reference (accuracy ±0.01%).
4	Torque crtl (closed loop)	The I/O terminal and keypad references are torque references and the frequency converter controls the motor torque.
5	Frequency control (advanced open loop)	Frequency control with better performance at lower speeds.
6	Speed control (advanced open loop)	Speed control with better performance at lower speeds.

2.6.2 U/f optimisation

Automatic torque boost	The voltage to the motor changes automatically which makes the motor produce sufficient torque to start and run at low frequencies. The voltage increase depends on the motor type and power. Automatic torque boost can be used in applications where starting torque due to starting friction is high, e.g. in conveyors.

EXAMPLE:

What changes are required to start with load from 0 Hz?

- First set the motor nominal values (Parameter group 2.1).
- Motor Control Mode = 0 (Frequency control) and 1 (Speed control)

Option 1: Activate the Automatic torque boost (par. 2.6.2).

Option 2: Programmable U/f curve
To get torque you need to set the zero point voltage and midpoint voltage/frequency (in parameter group 2.6) so that the motor takes enough current at low frequencies.
First set par. 2.6.3 to *Programmable U/F-curve* (value 2). Increase zero point voltage (P2.6.8) to get enough current at zero speed. Set then the midpoint voltage (P2.6.7) to 1.4142*P2.6.8 and midpoint frequency (P2.6.6) to value P2.6.7/100%*P2.1.7.

NOTE! *In high torque - low speed applications - it is likely that the motor will overheat. If the motor has to run a prolonged time under these conditions, special attention must be paid to cooling the motor. Use external cooling for the motor if the temperature tends to rise too high.*

2.6.3 U/f ratio selection

Linear: 0 — The voltage of the motor changes linearly with the frequency in the constant flux area from 0 Hz to the field weakening point where the nominal voltage is supplied to the motor. Linear U/f ratio should be used in constant torque applications. **This default setting should be used if there is no special need for another setting.**

Squared: 1 — The voltage of the motor changes following a squared curve form with the frequency in the area from 0 Hz to the field weakening point where the nominal voltage is also supplied to the motor. The motor runs under magnetised below the field weakening point and produces less torque and electromechanical noise. Squared U/f ratio can be used in applications where torque demand of the load is proportional to the square of the speed, e.g in centrifugal fans and pumps.

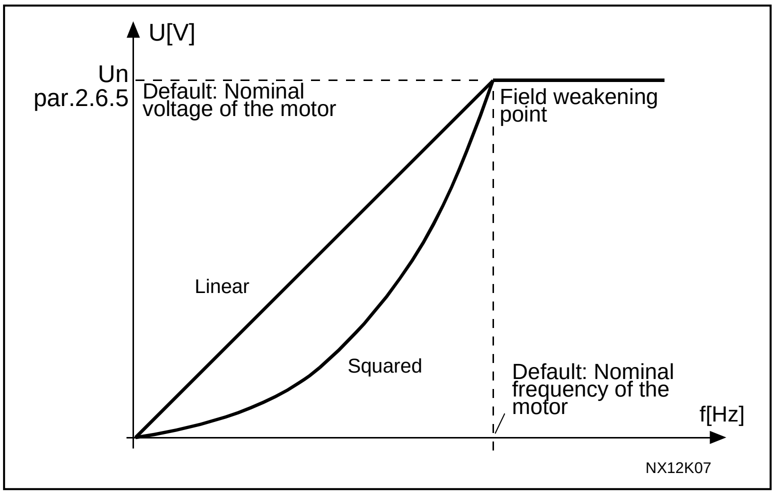

Figure 19. Linear and squared change of motor voltage

Programmable U/f curve: 2 — The U/f curve can be programmed with three different points. Programmable U/f curve can be used if the other settings do not satisfy the needs of the application.

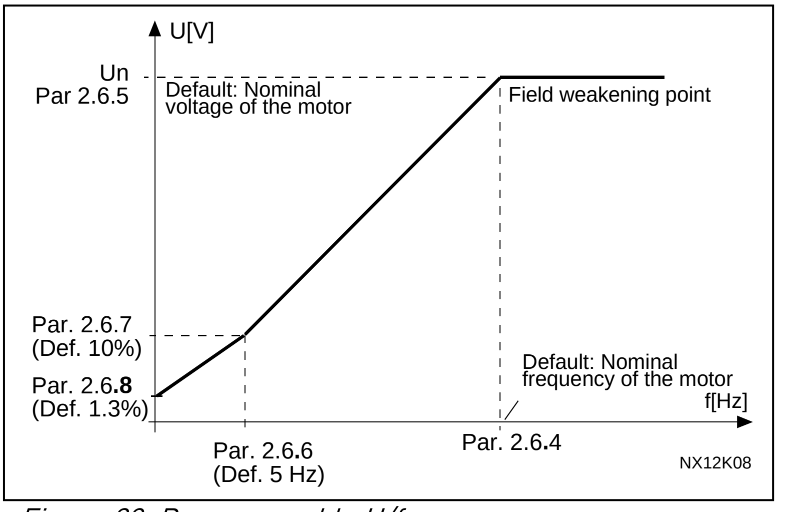

Figure 20. Programmable U/f curve

Linear with flux optimisation:

3 The frequency converter starts to search for the minimum motor current in order to save energy, lower the disturbance level and the noise. This function can be used in applications with constant motor load, such as fans, pumps etc.

2.6.4 Field weakening point

The field weakening point is the output frequency at which the output voltage reaches the set (par. 2.6.5) maximum value.

2.6.5 Voltage at field weakening point

Above the frequency at the field weakening point, the output voltage remains at the set maximum value. Below the frequency at the field weakening point, the output voltage depends on the setting of the U/f curve parameters. See parameters 2.6.2, 2.6.3, 2.6.6 and 2.6.7.

When the parameters 2.1.6 and 2.1.7 (nominal voltage and nominal frequency of the motor) are set, the parameters 2.6.4 and 2.6.5 are automatically given the corresponding values. If you need different values for the field weakening point and the maximum output voltage, change these parameters **after** setting the parameters 2.1.6 and 2.1.7.

2.6.6 U/f curve, middle point frequency

If the programmable U/f curve has been selected with the parameter 2.6.3 this parameter defines the middle point frequency of the curve. See Figure 20.

2.6.7 U/f curve, middle point voltage

If the programmable U/f curve has been selected with the parameter 2.6.3 this parameter defines the middle point voltage of the curve. See Figure 20.

2.6.8 Output voltage at zero frequency

If the programmable U/f curve has been selected with the parameter 2.6.3 this parameter defines the zero frequency voltage of the curve. See Figure 20.

2.6.9 Switching frequency

Motor noise can be minimised using a high switching frequency. Increasing the switching frequency reduces the capacity of the frequency converter unit.
The range of this parameter depends on the size of the frequency converter:

Type	Min. [kHz]	Max. [kHz]	Default [kHz]
0003—0061 NX_5 0003—0061 NX_2	1.0	16,0	10.0
0072—0520 NX_5	1.0	10.0	3.6
0041—0062 NX_6 0144—0208 NX_6	1.0	6.0	1.5

Table 20. Size-dependent switching frequencies

2.6.10 Overvoltage controller

These parameters allow the under-/overvoltage controllers to be switched out of operation. This may be useful, for example, if the mains supply voltage varies more than –15% to +10% and the application will not tolerate this over-/undervoltage. In this case, the regulator controls the output frequency taking the supply fluctuations into account.

0 Controller switched off
1 Controller switched on (no ramping) = Minor adjustments of OP frequency are made
2 Controller switched on (with ramping) = Controller adjusts OP freq. up to max.freq.

2.6.11 Undervoltage controller

See par. 2.6.10

Note: Over-/undervoltage trips may occur when controllers are switched out of operation.

0 Controller switched off
1 Controller switched on

5.7 PROTECTIONS

2.7.1 Response to 4 mA reference fault

0 = No response
1 = Warning
2 = Warning, the frequency from 10 seconds back is set as reference
3 = Warning, the Preset Frequency (Par. 2.7.2) is set as reference
4 = Fault, stop mode after fault according to parameter 2.4.7
5 = Fault, stop mode after fault always by coasting

A warning or a fault action and message is generated if the 4…20 mA reference signal is used and the signal falls below 3.5 mA for 5 seconds or below 0.5 mA for 0.5 seconds. The information can also be programmed into digital output DO1 or relay outputs RO1 and RO2.

2.7.2 4 mA reference fault frequency

If the value of parameter 2.7.1 is set to 3 and the 4 mA fault occurs then the frequency reference to the motor is the value of this parameter.

2.7.3 Response to external fault

0 = No response
1 = Warning
2 = Fault, stop mode after fault according to parameter 2.4.7
3 = Fault, stop mode after fault always by coasting

A warning or a fault action and message is generated from the external fault signal in the programmable digital inputs DIN3. The information can also be programmed into digital output DO1 and into relay outputs RO1 and RO2.

2.7.4 Input phase supervision

0 = No response
1 = Warning
2 = Fault, stop mode after fault according to parameter 2.4.7
3 = Fault, stop mode after fault always by coasting

The input phase supervision ensures that the input phases of the frequency converter have an approximately equal current.

2.7.5 Response to undervoltage fault

1 = Warning
2 = Fault, stop mode after fault according to parameter 2.4.7
3 = Fault, stop mode after fault always by coasting

For the undervoltage limits see the product's User's Manual.

2.7.6 Output phase supervision

0 = No response
1 = Warning
2 = Fault, stop mode after fault according to parameter 2.4.7
3 = Fault, stop mode after fault always by coasting

Output phase supervision of the motor ensures that the motor phases have an approximately equal current.

2.7.7 Earth fault protection

0 = No response
1 = Warning
2 = Fault, stop mode after fault according to parameter 2.4.7
3 = Fault, stop mode after fault always by coasting

Earth fault protection ensures that the sum of the motor phase currents is zero. The overcurrent protection is always working and protects the frequency converter from earth faults with high currents.

Parameters 2.7.8—2.7.12, Motor thermal protection: General

The motor thermal protection is to protect the motor from overheating. The Vacon drive is capable of supplying higher than nominal current to the motor. If the load requires this high current there is a risk that the motor will be thermally overloaded. This is the case especially at low frequencies. At low frequencies the cooling effect of the motor is reduced as well as its capacity. If the motor is equipped with an external fan the load reduction at low speeds is small.

The motor thermal protection is based on a calculated model and it uses the output current of the drive to determine the load on the motor.

The motor thermal protection can be adjusted with parameters. The thermal current I_T specifies the load current above which the motor is overloaded. This current limit is a function of the output frequency.

The thermal stage of the motor can be monitored on the control keypad display. See the product's User's Manual.

CAUTION! *The calculated model does not protect the motor if the airflow to the motor is reduced by blocked air intake grill.*

2.7.8 Motor thermal protection

0 = No response
1 = Warning
2 = Fault, stop mode after fault according to parameter 2.4.7
3 = Fault, stop mode after fault always by coasting

If tripping is selected the drive will stop and activate the fault stage.
Deactivating the protection, i.e. setting parameter to 0, will reset the thermal stage of the motor to 0%.

2.7.9 *Motor thermal protection: Motor ambient temperature factor*

The factor can be set between -100.0%—100.0%.

2.7.10 *Motor cooling factor at zero speed*

The factor can be set between 0—150.0% x I_{nMotor}. This parameter sets the value for thermal current at zero frequency. See Figure 21.

The default value is set assuming that there is no external fan cooling the motor. If an external fan is used this parameter can be set to 90% (or even higher).

Note: The value is set as a percentage of the motor name plate data, parameter 2.1.9 (Nominal current of motor), not the drive's nominal output current. The motor's nominal current is the current that the motor can withstand in direct on-line use without being overheated.

If you change the parameter Nominal current of motor, this parameter is automatically restored to the default value. Setting this parameter does not affect the maximum output current of the drive which is determined by parameter 2.1.5 alone.

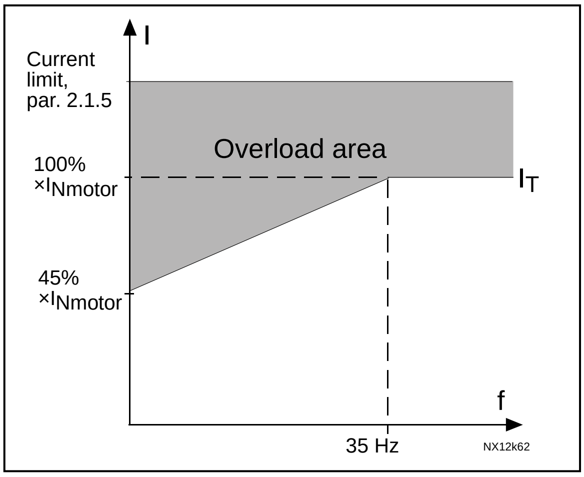

Figure 21. Motor thermal current I_T curve

2.7.11 *Motor thermal protection: Time constant*

This time can be set between 1 and 200 minutes.

This is the thermal time constant of the motor. The bigger the motor, the bigger the time constant. The time constant is the time within which the calculated thermal stage has reached 63% of its final value.

The motor thermal time is specific to the motor design and it varies between different motor manufacturers.

If the motor's t6–time (t6 is the time in seconds the motor can safely operate at six times the rated current) is known (given by the motor manufacturer) the time constant parameter can be set basing on it. As a rule of thumb, the motor thermal time constant in minutes equals to 2xt6. If the drive is in stop stage the time constant is internally increased to three times the set parameter value. The cooling in the stop stage is based on convection and the time constant is increased. See also Figure 22.

2.7.12 Motor thermal protection: Motor duty cycle

Defines how much of the nominal motor load is applied.
The value can be set to 0%...100%.

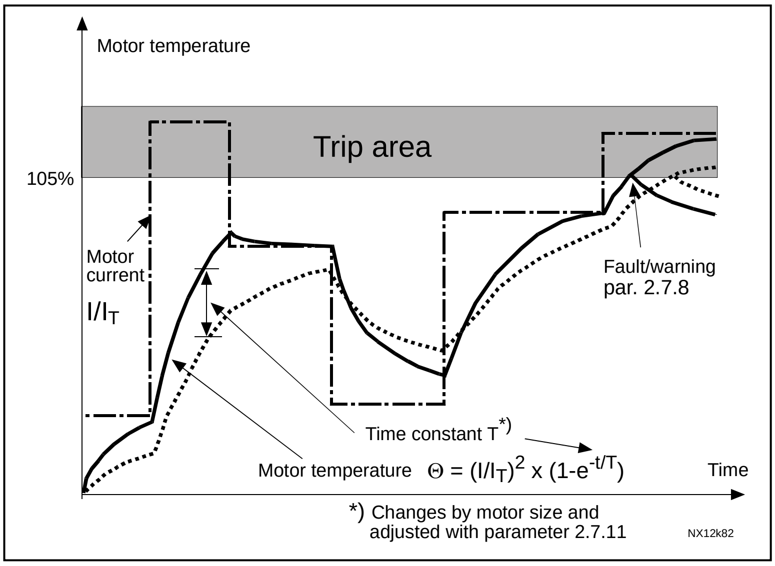

Figure 22. Motor temperature calculation

Parameters 2.7.13—2.7.16, Stall protection:

General

The motor stall protection protects the motor from short time overload situations such as one caused by a stalled shaft. The reaction time of the stall protection can be set shorter than that of motor thermal protection. The stall state is defined with two parameters, 2.7.14 (Stall current) and 2.7.16 (Stall frequency). If the current is higher than the set limit and output frequency is lower than the set limit, the stall state is true. There is actually no real indication of the shaft rotation. Stall protection is a type of overcurrent protection.

2.7.13 Stall protection

0 = No response
1 = Warning
2 = Fault, stop mode after fault according to parameter 2.4.7
3 = Fault, stop mode after fault always by coasting

Setting the parameter to 0 will deactivate the protection and reset the stall time counter.

2.7.14 Stall current limit

The current can be set to 0.0...I_{nMotor}*2. For a stall stage to occur, the current must have exceeded this limit. See Figure 23. The software does not allow entering a greater value than I_{nMotor}*2. If the parameter 2.1.9 Nominal current of motor is changed, this parameter is automatically restored to the default value (I_L).

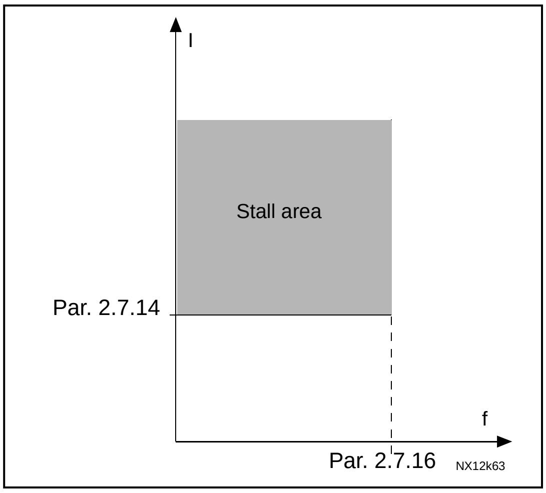

Figure 23. Stall characteristics settings

2.7.15 Stall time

This time can be set between 1.0 and 120.0s.
This is the maximum time allowed for a stall stage. The stall time is counted by an internal up/down counter. If the stall time counter value goes above this limit the protection will cause a trip (see parameter 2.7.13).

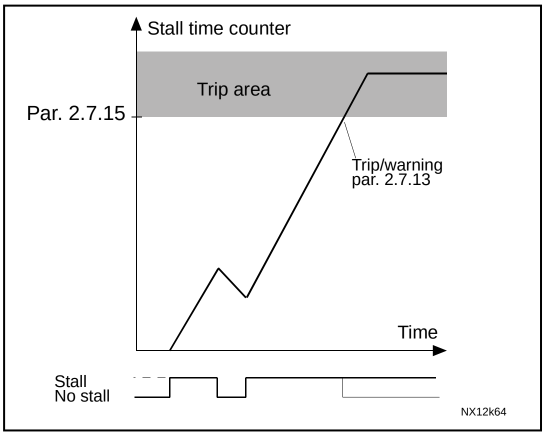

Figure 24. Stall time count

2.7.16 Maximum stall frequency

The frequency can be set between 1-f_{max} (par. 2.1.2). For a stall state to occur, the output frequency must have remained below this limit.

Parameters 2.7.17—2.7.20, Underload protection:

General

The purpose of the motor underload protection is to ensure that there is load on the motor when the drive is running. If the motor loses its load there might be a problem in the process, e.g. a broken belt or a dry pump.
Motor underload protection can be adjusted by setting the underload curve with parameters 2.7.18 (Field weakening area load) and 2.7.19 (Zero frequency load), see below. The underload curve is a squared curve set between the zero frequency and the field weakening point. The protection is not active below 5Hz (the underload time counter is stopped).

The torque values for setting the underload curve are set in percentage which refers to the nominal torque of the motor. The motor's name plate data, parameter motor nominal current and the drive's nominal current I_H are used to find the scaling ratio for the internal torque value. If other than nominal motor is used with the drive, the accuracy of the torque calculation decreases.

2.7.17 Underload protection

0 = No response
1 = Warning
2 = Fault, stop mode after fault according to parameter 2.4.7
3 = Fault, stop mode after fault always by coasting

If tripping is set active the drive will stop and activate the fault stage.
Deactivating the protection by setting the parameter to 0 will reset the underload time counter to zero.

2.7.18 Underload protection, field weakening area load

The torque limit can be set between 10.0—150.0 % x T_{nMotor}.
This parameter gives the value for the minimum torque allowed when the output frequency is above the field weakening point. See Figure 25.

If you change the parameter 2.1.9 (Motor nominal current) this parameter is automatically restored to the default value.

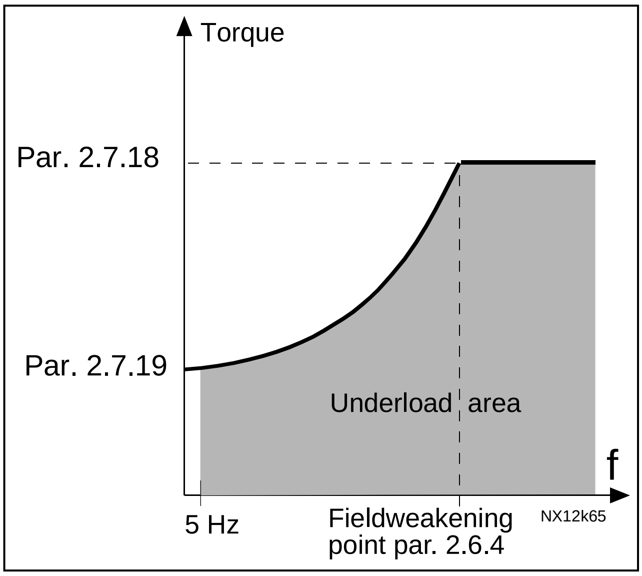

Figure 25. Setting of minimum load

2.7.19 Underload protection, zero frequency load

The torque limit can be set between 5.0—150.0 % x TnMotor.
This parameter gives value for the minimum torque allowed with zero frequency. See Figure 25.

If you change the value of parameter 2.1.9 (Motor nominal current) this parameter is automatically restored to the default value.

2.7.20 Underload time

This time can be set between 2.0 and 600.0 s.
This is the maximum time allowed for an underload state to exist. An internal up/down counter counts the accumulated underload time. If the underload counter value goes above this limit the protection will cause a trip according to parameter 2.7.17). If the drive is stopped the underload counter is reset to zero. See Figure 26.

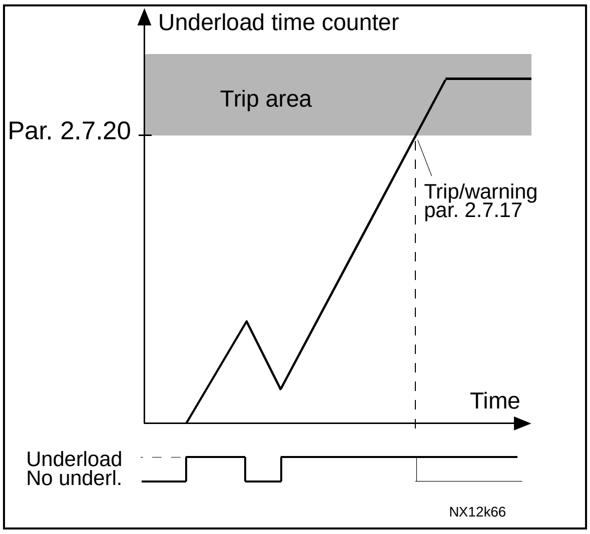

Figure 26. Underload time counter function

2.7.21 Response to thermistor fault

0 = No response
1 = Warning
2 = Fault, stop mode after fault according to parameter 2.4.7
3 = Fault, stop mode after fault always by coasting

Setting the parameter to 0 will deactivate the protection.

2.7.22 Response to fieldbus fault

Set here the response mode for the fieldbus fault if a fieldbus board is used. For more information, see the respective Fieldbus Board Manual.

See parameter 2.7.21.

2.7.23 Response to slot fault

Set here the response mode for a board slot fault due to missing or broken board.

See parameter 2.7.21.

5.8 AUTORESTART PARAMETERS

2.8.1 Automatic restart: Wait time

Defines the time before the frequency converter tries to automatically restart the motor after the fault has disappeared.

2.8.2 Automatic restart: Trial time

The Automatic restart function restarts the frequency converter when the faults selected with parameters 2.8.4 to 2.8.9 have disappeared and the waiting time has elapsed.

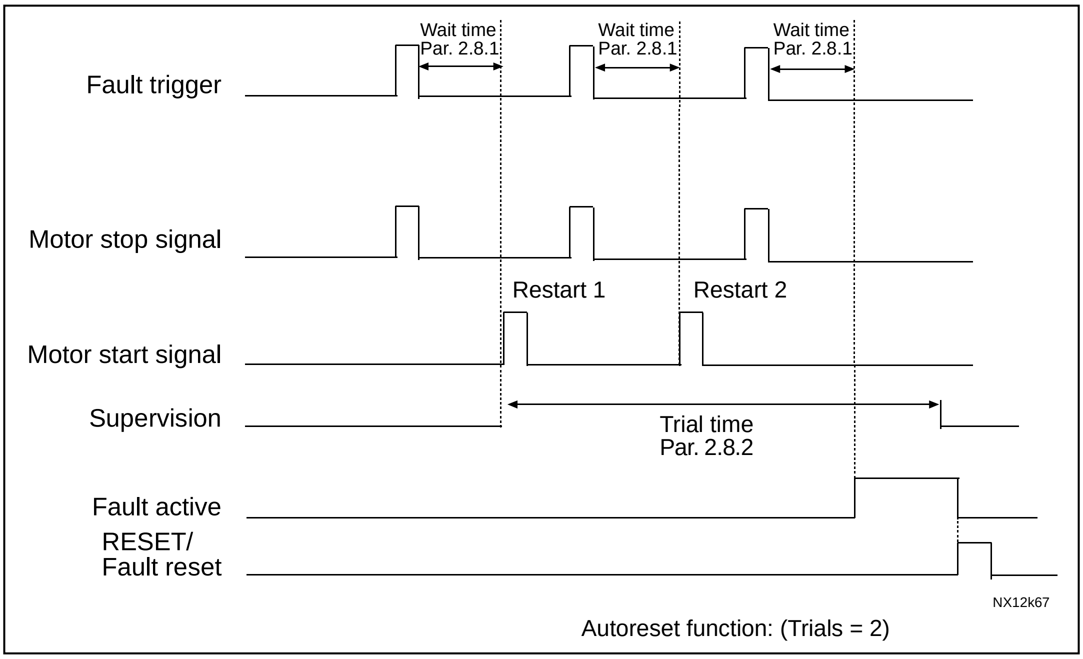

Figure 27. Example of Automatic restart with two restarts.

Parameters 2.8.4 to 2.8.9 determine the maximum number of automatic restarts during the trial time set by parameter 2.8.2. The time count starts from the first autorestart. If the number of faults occurring during the trial time exceeds the values of parameters 2.8.4 to 2.8.9, the fault state becomes active. Otherwise the fault is cleared after the trial time has elapsed and the next fault starts the trial time count again.

If a single fault remains during the trial time, a fault state is true.

2.8.3 Automatic restart, start function

The Start function for Automatic restart is selected with this parameter. The parameter defines the start mode:

0 = Start with ramp
1 = Flying start
2 = Start according to par. 2.4.6

2.8.4 *Automatic restart: Number of tries after undervoltage fault trip*

This parameter determines how many automatic restarts can be made during the trial time set by parameter 2.8.2 after an undervoltage trip.

0 = No automatic restart after undervoltage fault trip
>0 = Number of automatic restarts after undervoltage fault. The fault is reset and the drive is started automatically after the DC-link voltage has returned to the normal level.

2.8.5 *Automatic restart: Number of tries after overvoltage trip*

This parameter determines how many automatic restarts can be made during the trial time set by parameter 2.8.2 after an overvoltage trip.

0 = No automatic restart after overvoltage fault trip
>0 = Number of automatic restarts after overvoltage fault. The fault is reset and the drive is started automatically after the DC-link voltage has returned to the normal level.

2.8.6 *Automatic restart: Number of tries after overcurrent trip*

(NOTE! IGBT temp Fault also included)
This parameter determines how many automatic restarts can be made during the trial time set by parameter 2.8.2.

0 = No automatic restart after overcurrent fault trip
>0 = Number of automatic restarts after overcurrent trip, saturation trip and IGBT temperature faults.

2.8.7 *Automatic restart: Number of tries after reference trip*

This parameter determines how many automatic restarts can be made during the trial time set by parameter 2.8.2.

0 = No automatic restart after reference fault trip
>0 = Number of automatic restarts after the analogue current signal (4…20 mA) has returned to the normal level (≥4 mA)

2.8.8 *Automatic restart: Number of tries after motor temperature fault trip*

This parameter determines how many automatic restarts can be made during the trial time set by parameter 2.8.2.

0 = No automatic restart after Motor temperature fault trip
>0 = Number of automatic restarts after the motor temperature has returned to its normal level.

2.8.9 *Automatic restart: Number of tries after external fault trip*

This parameter determines how many automatic restarts can be made during the trial time set by parameter 2.8.2.

0	=	No automatic restart after External fault trip
>0	=	Number of automatic restarts after External fault trip

5.9 CLOSED LOOP PARAMETERS

Select the Closed loop control mode by setting value 3 or 4 for parameter 2.6.1.
Closed loop control mode (see page 38) is used when enhanced performance near zero speed and better static speed accuracy with higher speeds are needed. Closed loop control mode is based on "rotor flux oriented current vector control". With this controlling principle, the phase currents are divided into a torque producing current portion and a magnetizing current portion. Thus, the squirrel cage induction machine can be controlled in a fashion of a separately excited DC motor.

Note: These parameters can be used with Vacon NXP drive only.

2.9.1 Magnetizing current

Set here the motor magnetizing current (no-load current).

2.9.2 Speed control P gain

Sets the gain for the speed controller in % per Hz.

2.9.3 Speed control I time

Sets the integral time constant for the speed controller. Increasing the I-time increases stability but lengthens the speed response time.

2.9.4 Load drooping

The drooping function enables speed drop as a function of load. This parameter sets that amount corresponding to the nominal torque of the motor.

2.9.5 Acceleration compensation

Sets the inertia compensation to improve speed response during acceleration and deceleration. The time is defined as acceleration time to nominal speed with nominal torque. This parameter is active also in advanced open loop mode.

2.9.6 Slip adjust

The motor name plate speed is used to calculate the nominal slip. This value is used to adjust the voltage of motor when loaded. The name plate speed is sometimes a little inaccurate and this parameter can therefore be used to trim the slip. Reducing the slip adjust value increases the motor voltage when the motor is loaded.

2.9.9 Zero speed time at start

After giving the start command the drive will remain at zero speed for the time defined by this parameter. The ramp will be released to follow the set frequency/speed reference after this time has elapsed from the instant where the command is given.

2.9.10 Zero speed time at stop

The drive will remain at zero speed with controllers active for the time defined by this parameter after reaching the zero speed when a stop command is given. This parameter has no effect if the selected stop function (par. 2.4.7) is *Coasting*.

2.9.11 Startup torque

Choose here the startup torque.
Torque Memory is used in crane applications. Startup Torque FWD/REV can be used in other applications to help the speed controller.
0 = Not Used
1 = TorqMemory
2 = Torque Ref
3 = Torq.Fwd/Rev

2.9.12 Start-up torque, forward

Sets the start-up torque for forward direction if selected with par. 2.9.11.

2.9.13 Start-up torque, reverse

Sets the start-up torque for reverse direction if selected with par. 2.9.11.

2.9.15 Encoder filter time

Sets the filter time constant for speed measurement.
The parameter can be used to eliminate encoder signal noise. Too high a filter time reduces speed control stability.

2.9.17 Current control P gain

Sets the gain for the current controller. This controller is active only in closed loop and advanced open loop modes. The controller generates the voltage vector reference to the modulator.

5.10 ADVANCED OPEN LOOP PARAMETERS

Select the Advanced Open Loop control mode by setting value 5 or 6 for parameter 2.6.1.
The Advanced Open Loop control mode finds similar implementations as the Closed Loop control mode above. However, the control accuracy of the Closed Loop control mode is higher than that of the Advanced Open Loop control mode.

2.10.1 Zero speed current

At very low frequencies, this parameter defines the constant current reference to the motor.

2.10.2 Minimum current

Minimum current to the motor in the current control frequency region. Larger value gives more torque, but increases losses.

2.10.3 Flux reference

Reference for flux below the frequency limit. Larger value gives more torque, but increases losses.

2.10.4 Frequency limit

Corner frequency for transition to standard U/f control. The value is given in % of motor nominal frequency.

5.11 CAN BUS PARAMETER

2.11.1 CanBus node number

Write here the Can bus node ID which is needed by the application to contact the drive.

5.12 KEYPAD CONTROL PARAMETERS

3.1 Control Place

The active control place can be changed with this parameter. For more information, see the product's User's Manual.

The output frequency can be copied as the keypad reference by pushing the *Stop button* for 3 seconds when you are on any of the pages of menu *M3*. In the same way, pushing the *Start button* for 3 seconds selects the control keypad as the active control place and copies the Run status information (Run/Stop, direction and reference).

3.2 Keypad Reference

The SPM reference can be adjusted from the keypad with this parameter. For more information, see the product's User's manual.

3.3 Keypad Direction

0 Forward: The rotation of the motor is forward, when the keypad is the active control place.

1 Reverse: The rotation of the motor is reversed, when the keypad is the active control place.

For more information, see the product's User's Manual.

3.4 Stop button activated

If you wish to make the Stop button a "hotspot" which always stops the drive regardless of the selected control place, give this parameter the value 1.

See also parameter 3.1.

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