



**NX FREQUENCY CONVERTERS**

**SHAFT SYNCHRONIZATION  
APPLICATION APF1FF11**

**USER'S MANUAL**

## ABOUT THE SHAFT SYNCHRONIZATION APPLICATION MANUAL

Congratulations for choosing the Smooth Control provided by Vacon NX Frequency Converters!

This manual is available in both paper and electronic editions. We recommend you to use the electronic version if possible. If you have the **electronic version** at your disposal you will be able to benefit from the following features:

The manual contains several links and cross-references to other locations in the manual which makes it easier for the reader to move around, to check and find things faster.

The manual also contains hyperlinks to web pages. To visit these web pages through the links you must have an internet browser installed on your computer.

## VACON SHAFT SYNCHRONIZATION APPLICATION MANUAL

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## SHAFT SYNCHRONIZATION APPLICATION

(Software APFIF11 V1.13 or higher)

Select the Shaft Synchronization Application in menu **M6** on page *S6.2*.

### 1. INTRODUCTION

The Shaft Synchronization Application provides Position synchronization control of a follower drive to a master position signal, with the ability to control the synchronization ratio online via fieldbus, parameter or by digital trim +/- input. The drive requires feedback from an encoder or resolver. The master position signal comes from an incremental encoder or a single phase pulse generator and is read using the OPT-A7 board if the follower drive employs an induction motor or the OPT-BC board if the motor is of a PM synchronous type.

The application offers general purpose functionality support also for independent speed or torque control when the shaft synchronization mode is not enabled.

Specific application features:

- Synchronization commands: enable sync. mode, engage/release, freeze and reference speed are all controlled from digital inputs or fieldbus control register
- Ratio range -4 to +4 in steps of 1/65536 can be controlled by parameter or fieldbus in RUN mode
- Programmable trim inputs +/- and trim ratio change parameter for temporary ratio change from digital inputs
- Programmable ratio change ramp
- Programmable engage/ release ramp
- Digital or relay outputs for "Ratio change" and "Synchronization engaged"
- Supported fieldbuses: Profibus, CanOpen, Modbus, Modbus TCP
- Synchronization regulator cycle time is 5 ms
- Phasing from standstill or during running (offset of follower position)
- Mechanical brake control

Other general purpose features:

- Induction motor identification
- PM motor rotor angle identification
- All digital and analogue inputs and outputs are freely programmable
- Analogue input signal range selection, with automatic adjustment
- Supervision of two frequency thresholds
- Supervision of torque limit
- Supervision of reference limit
- Second ramp and S-shape ramp programming
- Programmable start/stop and reverse logic
- DC-braking at start and stop
- Programmable U/f curve and switching frequency
- Fully programmable motor thermal and stall protection
- Input and output phase supervision
- Joystick with programmable hysteresis

**NOTE:** The Shaft Synchronization application creates a rigid electrical coupling between master and follower(s) axis. The application is not suitable if there is a rigid mechanical coupling between master and follower(s).

## 1.1 Requirements

- NXP frequency converter with control board type VB00561 (“nxp2” type) or newer.
- NXP00002V155 system software package (NXP00002V160 for the support of single phase master pulse reference).
- Double encoder board OPTA7 for induction motor with HTL incremental encoder for closed loop control. The second encoder channel is used for master pulse reference.
- Resolver board OPTBC for permanent synchronous motor with resolver feedback for closed loop control. The second encoder channel is used for master pulse reference.
- Application license key is needed for shaft synchronization functions (based on power unit serial number)  
However there is a 2 week trial time without charge. It is always possible to run the drive in multi-purpose mode without the license key.

## 1.2 Trial Time period

Trial time is very useful for test and evaluation. If FC has to be replaced during a weekend there is 2 weeks trial time for free and during that time a new license can be ordered from Vacon. After loading the application it will be possible to run in Shaft synchronization mode without license key for 2 weeks (336 h)

### STEPS IN TRIAL PERIOD

1. A warning **F72** with the text “**Trial time**” will appear on the display (until <24 hours left) at every run request *rising edge* in shaft synchronization mode.
2. When only 24 hours is left of trial time the warning **F73 “<24 hours left”** is triggered and remains on all the time when FC is in run in shaft synchronization mode.
3. When trial time has expired and the drive will trip with F72 Error: “**TrialTimeOver**”  
**NOTE: Drive will trip in run mode!**
4. A monitoring value V1.23 on the keypad shows **Trial time left (h)**. The trial time starts from 336 h and counts down to 0.

**NOTE:** The trial time counter is counting when the shaft synchronization is enabled by digital input or from fieldbus.

2. CONTROL I/O

		OPT-A1		
Terminal	Signal	Description		
1	+10V <sub>ref</sub>	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	Shaft Synchronization Enable (programmable)	Contact closed = Enabled	
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	Synch. Mode BIT0 (programmable)	Contact closed = Engage Synchronization	
15	DIN5	Synch. Mode BIT1 (programmable)	Contact closed = Freeze follower speed	
16	DIN6	Free (programmable)	Programmable	
17	CMB	Common for DIN4–DIN6	Connect to GND or +24V	
18	AOA1+	Output frequency	Programmable	
19	AOA1-	Analogue output	Range 0–20 mA/R <sub>L</sub> , max. 500Ω	
20	DOA1	Digital output READY	Programmable Open collector, I <sub>L</sub> ≤50mA, U <sub>S</sub> ≤48 VDC	
		OPT-A2		
21	R01	Relay output 1 RUN	Programmable	
22	R01			
23	R01			
24	R02	Relay output 2 FAULT	Programmable	
25	R02			
26	R02			

Table 1. Shaft Synchronization application default I/O configuration and connection example.

**Note:** See jumper selections below. More information in the product's User's Manual.

**Jumper block X3: CMA and CMB grounding**

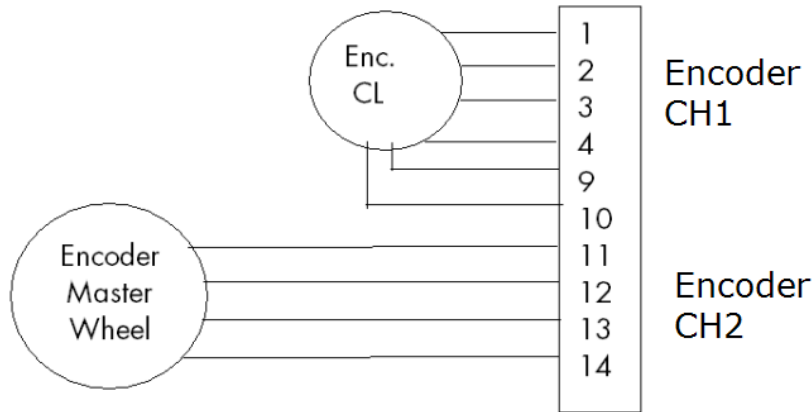
- CMB connected to GND  
CMA connected to GND
- CMB isolated from GND  
CMA isolated from GND
- CMB and CMA internally connected together, isolated from GND

= Factory default

### 3. CONNECTION OF SIGNALS BETWEEN MASTER AND FOLLOWER DRIVE (OPT-A7)

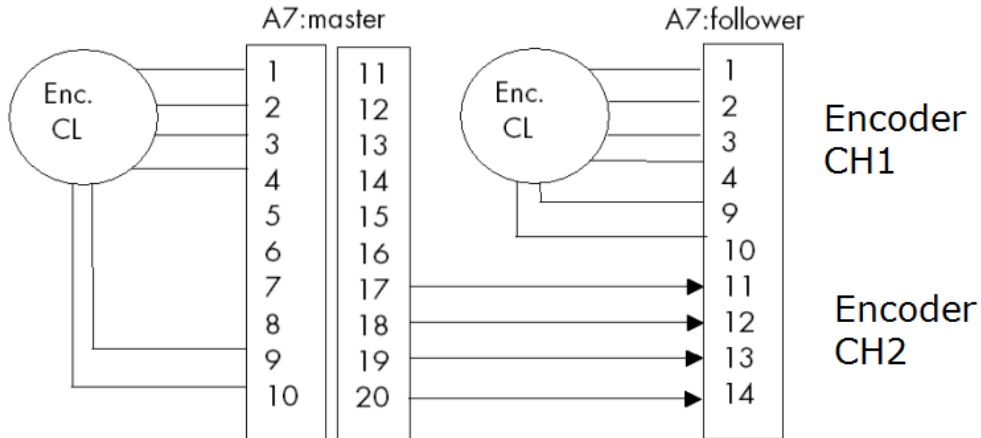
When the master is a passive wheel with encoder

- Encoder CH2 inputs 11-14 are used for master pulses and is compared with pulses coming to follower drive 1,2,3,4



When the master drive is an NXP drive

- The repeater outputs 17-20 on OPT-A7 from master drive are connected to the CH2 inputs 11-14 on OPT-A7 on the follower drive (max distance approx. 300m)

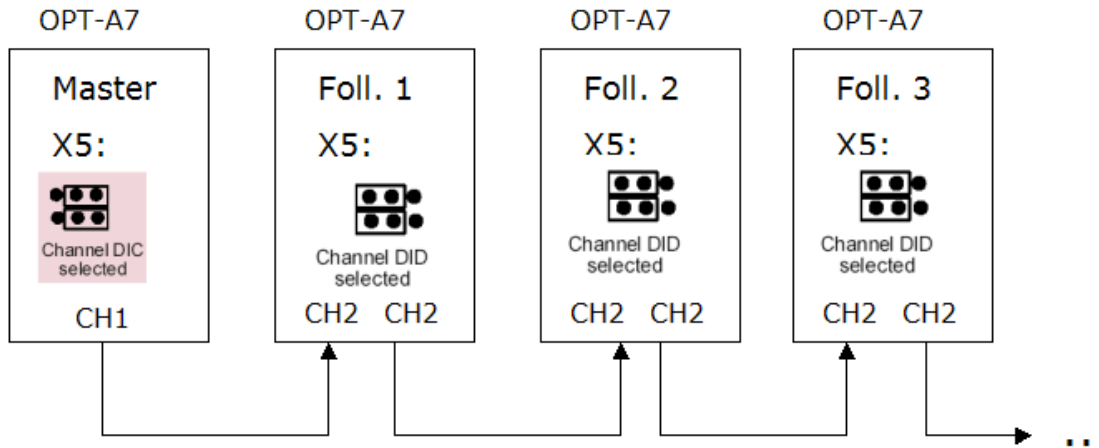


**NOTE:** To eliminate the risk of electrical noise, use only double shielded twisted pair cable for connections.



#### 4. JUMPER SETTING ON THE OPT-A7 BOARD

The X5 jumper selects which channel is sent to the repeater outputs (connections 17-20). On the Master drive OPT-A7 the channel 1 (DIC) has to be sent to repeater outputs. If there are more than one follower normally channel 2 (DID) is to be sent from follower(s) to follower(s). Then all drives will follow master drive. See the Option board manual UD00741 for more information.



Master drive can have any software application. Follower is regulating based on incoming encoder channel 2 pulses.

**COMMISSIONING NOTE:**

Always check in option board menu (M7) that master pulses are coming to encoder channel 2 on the follower OPT-A7 board (or OPT-BC if resolver board is used).

Pulses per revolution for follower channel 2 (P7.3.1.4 Enc 2 Pulse/rev for OPT-A7) should normally be set equals to Master encoder pulses/rev.

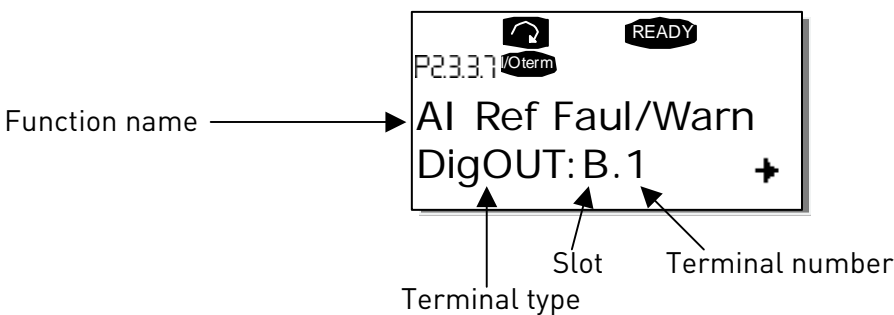
## 5. "TERMINAL TO FUNCTION" (TTF) PROGRAMMING PRINCIPLE

The programming principle of the input and output signals in the **Multipurpose Control Application** as well as in the **Pump and Fan Control Application** (and partly in the other applications) is different compared to the conventional method used in other Vacon NX applications.

In the conventional programming method, *Function to Terminal Programming Method (FTT)*, you have a fixed input or output that you define a certain function for. This application, however, use the *Terminal to Function Programming method (TTF)* in which the programming process is carried out the other way round: Functions appear as parameters which the operator defines a certain input/output for. See *Warning* on page 11.

### 5.1 Defining an input/output for a certain function on keypad

Connecting a certain input or output with a certain function (parameter) is done by giving the parameter an appropriate value. The value is formed of the *Board slot* on the Vacon NX control board (see the product's User's Manual) and the *respective signal number*, see below.

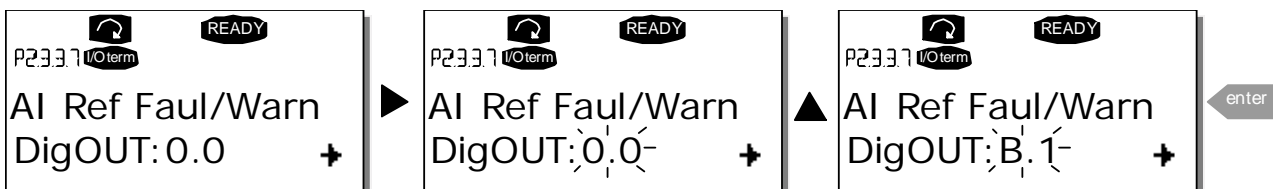


**Example:** You want to connect the digital output function *Reference fault/warning* (parameter 2.3.3.7) to the digital output DO1 on the basic board OPT-A1 (see the product's User's Manual).

First find the parameter 2.3.3.7 on the keypad. Press the *Menu button right* once to enter the edit mode. On the *value line*, you will see the terminal type on the left (DigIN, DigOUT, An.IN, An.OUT) and on the right, the present input/output the function is connected to (B.3, A.2 etc.), or if not connected, a value (0.#).

When the value is blinking, hold down the *Browser button up or down* to find the desired board slot and signal number. The program will scroll the board slots starting from 0 and proceeding from A to E and the I/O selection from 1 to 10.

Once you have set the desired value, press the *Enter button* once to confirm the change.



### 5.2 Defining a terminal for a certain function with NCDrive programming tool

If you use the NCDrive Programming Tool for parametrizing you will have to establish the connection between the function and input/output in the same way as with the control panel. Just pick the address code from the drop-down menu in the *Value* column (see the Figure below).

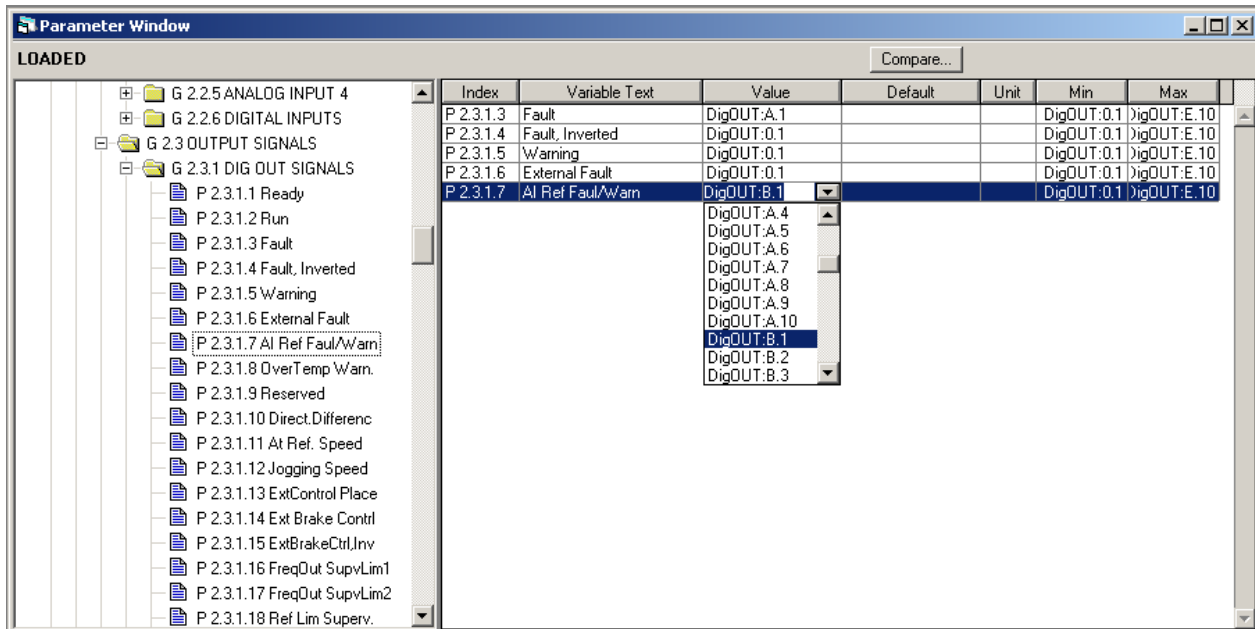



Figure 1. Screenshot of NCDrive programming tool; Entering the address code

 <b>WARNING</b>	<p>Be <b>ABSOLUTELY</b> sure not to connect two functions to one and same <u>output</u> in order to avoid function overruns and to ensure flawless operation.</p>
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**Note:** The *inputs*, unlike the *outputs*, cannot be changed in RUN state.

### 5.3 Defining unused inputs/outputs



All unused inputs and outputs must be given the board slot value **0** and the value **1** also for the terminal number. The value **0.1** is also the default value for most of the functions. However, if you want to use the **values of a digital input signal** for e.g. testing purposes only, you can set the board slot value to **0** and the terminal number to any number between 2...10 to place the input to a TRUE state. In other words, the value 1 corresponds to 'open contact' and values 2 to 10 to 'closed contact'.

In case of analogue inputs, giving the value **1** for the terminal number corresponds to 0% signal level, value **2** corresponds to 20%, value **3** to 30% and so on. Giving value **10** for the terminal number corresponds to 100% signal level.

## 6. SHAFT SYNCHRONIZATION 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 32 to 85.

### Column explanations:

Code	=	Location indication on the keypad; Shows the operator the present param. 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
	=	On parameter code: Parameter value can only be changed after the FC has been stopped.
	=	Apply the Terminal to Function method (TTF) to these parameters (see chapter 3)

### 6.1 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	In % of Motor nominal torque
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	Calculated motor temperature
V1.11	Analogue input 1	V/mA	13	AI1
V1.12	Analogue input 2	V/mA	14	AI2
V1.13	DIN1, DIN2, DIN3		15	Digital input statuses
V1.14	DIN4, DIN5, DIN6		16	Digital input statuses
V1.15	Analog lout	MA	26	AOA1
V1.16	Torque reference	%	18	
V1.17	Actual ratio*2 <sup>16</sup>		1700	Actual synch. ratio
V1.18	Position error	u	1701	Psotion error in user unit
V1.19	Encoder 1 Freq	Hz	1124	Shaft Frequency filtered
V1.20	Encoder 2 Freq	Hz	53	Master encoder frequency
V1.21	Pole pair number		58	Calculated pole pair number based on given motor data
V1.22	ID Run Status		49	Status of ID run made
V1.23	Trial time left	h	67	Hours left of trial time
V1.24	Accum Space Error	u	1803	Displays accumulated position error when follower not running in synch. mode.
G1.25	Multimonitoring items			Displays three selectable monitoring values

Table 2. Monitoring values

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

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.1.1	Max frequency	Par. 2.1.1	320,00	Hz	50,00		102	<b>NOTE:</b> If $f_{max}$ > than the motor synchronous speed, check suitability for motor and drive system
P2.1.2	Acceleration time 1	0,1	3000,0	s	1,0		103	
P2.1.3	Deceleration time 1	0,1	3000,0	s	1,0		104	
P2.1.4	Current limit	$0,4 \times I_H$	$2 \times I_H$	A	$I_L$		107	
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	$0,4 \times I_H$	$2 \times I_H$	A	$I_H$		113	Check the rating plate of the motor.
P2.1.9	Motor cosφ	0,30	1,00		0,85		120	Check the rating plate of the motor
P2.1.10	I/O Reference	0	14		0		117	0=A11 1=A12 2=A11+A12 3=A11-A12 4=A12-A11 5=A11xAl2 6=A11 Joystick 7=A12 Joystick 8=Keypad 9=Fieldbus 10=Motor potentiometer 11=A11, A12 minimum 12=A11, A12 maximum 13=Max frequency 14=A11/A12 selection
P2.1.11	Keypad control reference	0	9		8		121	0=A11 1=A12 2=A11+A12 3=A11-A12 4=A12-A11 5=A11xAl2 6=A11 Joystick 7=A12 Joystick 8=Keypad 9=Fieldbus
P2.1.12	Fieldbus control reference	0	9		9		122	See par. 2.1.12
P2.1.13	Jogging speed reference	0,00	Par. 2.1.2	Hz	5,00		124	
P2.1.14	Preset speed 1	0,00	Par. 2.1.2	Hz	10,00		105	Multi-step speed 1
P2.1.15	Preset speed 2	0,00	Par. 2.1.2	Hz	15,00		106	Multi-step speed 2
P2.1.16	Preset speed 3	0,00	Par. 2.1.2	Hz	20,00		126	Multi-step speed 3
P2.1.17	Preset speed 4	0,00	Par. 2.1.2	Hz	25,00		127	Multi-step speed 4
P2.1.18	Preset speed 5	0,00	Par. 2.1.2	Hz	30,00		128	Multi-step speed 5
P2.1.19	Preset speed 6	0,00	Par. 2.1.2	Hz	40,00		129	Multi-step speed 6
P2.1.20	Preset speed 7	0,00	Par. 2.1.2	Hz	50,00		130	Multi-step speed 7

Table 3. Basic parameters G2.1

## 6.3 Input signals

### 6.3.1 Basic settings (Control keypad: Menu M2 → G2.2.1)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.2.1.1	Start/Stop logic selection	0	7		0		300	Start signal 1 (Default: DIN1)
								Start signal 2 (Default: DIN2)
								0 Start forw.
								1 Start/Stop
								2 Start/Stop
								3 Start pulse
								4 Start
								5 Fwd pulse
6 Start pulse								
7 Start pulse								
								Start signal 2 (Default: DIN2)
								Start rev. Reverse Run enable Stop pulse Mot.pot.UP Rev pulse Enabl pulse
P2.2.1.2	Motor potentiometer ramp time	0,1	2000,0	Hz/s	10,0		331	
P2.2.1.3	Motor potentiometer frequency reference memory reset	0	2		1		367	0=No reset 1=Reset if stopped or powered down 2=Reset if powered down

Table 4. Input signals: basic settings, G2.2.1

### 6.3.2 Analogue input 1 (Control keypad: Menu M2 → G2.2.2)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.2.2.1	AI1 signal selection	0			A.1		377	
P2.2.2.2	AI1 filter time	0,00	10,00	s	0,10		324	0=No filtering
P2.2.2.3	AI1 signal range	0	3		0		320	0=0...100%* 1=20...100%* 2= -10V...+10V* 3= Custom range*
P2.2.2.4	AI1 custom minimum setting	-100,00	100,00	%	0,00		321	
P2.2.2.5	AI1 custom maximum setting	-100,00	100,00	%	100,00		322	
P2.2.2.6	AI1 reference scaling, minimum value	0,00	320,00	Hz	0,00		303	Selects the frequency that corresponds to the min. reference signal
P2.2.2.7	AI1 reference scaling, maximum value	0,00	320,00	Hz	0,00		304	Selects the frequency that corresponds to the max. reference signal
P2.2.2.8	AI1 joystick hysteresis	0,00	20,00	%	0,00		384	
P2.2.2.9	AI1 joystick offset	-50,00	50,00	%	0,00		165	

Table 5. Analogue input 1 parameters, G2.2.2

\*Remember to place jumpers of block X2 accordingly. See NX User's Manual, chapter 6.2.2.2

### 6.3.3 Analogue input 2 (Control keypad: Menu M2 → G2.2.3)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.2.3.1	AI2 signal selection	0			A.2		388	
P2.2.3.2	AI2 filter time	0,00	10,00	s	0,10		329	0=No filtering
P2.2.3.3	AI2 signal range	0	3		1		325	0=0...100%* 1=20...100%* 2= -10V...+10V* 3= Custom range*
P2.2.3.4	AI2 custom minimum setting	-100,00	100,00	%	0,00		326	
P2.2.3.5	AI2 custom maximum setting	-100,00	100,00	%	100,00		327	
P2.2.3.6	AI2 reference scaling, minimum value	0,00	320,00	Hz	0,00		393	Selects the frequency that corresponds to the min. reference signal
P2.2.3.7	AI2 reference scaling, maximum value	0,00	320,00	Hz	0,00		394	Selects the frequency that corresponds to the max. reference signal
P2.2.3.8	AI2 joystick hysteresis	0,00	20,00	%	0,00		395	
P2.2.3.9	AI2 joystick offset	-50,00	50,00	%	0,00		166	

Table 6. Analogue input 2 parameters, G2.2.3

### 6.3.4 Free analogue input, signal selection (Keypad: Menu M2 → G2.2.4)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.2.4.1	Scaling of current limit	0	3		0		399	0=Not used 1=AI1 2=AI2 3=Fieldbus
P2.2.4.2	Torque limit	0	3		0		485	See par. 2.2.4.1

Table 7. Free analogue input signal selection, G2.2.6



### 6.3.5 Digital inputs (Control keypad: Menu M2 → G2.2.5)

Code	Parameter	Min	Default	Cust	ID	Note
P2.2.5.1	Start signal 1	0	A.1		403	
P2.2.5.2	Start signal 2	0	A.2		404	
P2.2.5.3	Run enable	0	0.2		407	Motor start enabled (cc)
P2.2.5.4	Reverse	0	0.1		412	Direction forward (oc) Direction reverse (cc)
P2.2.5.5	Preset speed 1	0	0.1		419	
P2.2.5.6	Preset speed 2	0	0.1		420	
P2.2.5.7	Preset speed 3	0	0.1		421	
P2.2.5.8	Motor potentiometer reference DOWN	0	0.1		417	Mot.pot. reference decreases (cc)
P2.2.5.9	Motor potentiometer reference UP	0	0.1		418	Mot.pot. reference increases (cc)
P2.2.5.10	Fault reset	0	0.1		414	All faults reset (cc)
P2.2.5.11	External fault (close)	0	0.1		405	Ext. fault displayed (cc)
P2.2.5.12	External fault (open)	0	0.2		406	Ext. fault displayed (oc)
P2.2.5.13	Acc/Dec time selection	0	0.1		408	Acc/Dec time 1 (oc) Acc/Dec time 2 (cc)
P2.2.5.14	Acc/Dec prohibit	0	0.1		415	Acc/Dec prohibited (cc)
P2.2.5.15	DC braking	0	0.1		416	DC braking active (cc)
P2.2.5.16	Jogging speed	0	0.1		413	Jogging speed selected for frequency reference (cc)
P2.2.5.17	AI1/AI2 selection	0	0.1		422	
P2.2.5.18	Motor control mode 1/2	0	0.1		164	Closed cont.=Mode 2 is used Open cont.=Mode 1 is used See par 2.6.1, 2.6.12
<b>SHAFT SYNCHRONIZATION SPECIFIC PARAMETERS</b>						
P2.2.5.19	Synch. enable	0	A.3		1710	Enable shaft synchronization control mode (software license required) Disabled = multi-purpose control mode
P2.2.5.20	Synch. ModeBit0	0	A.4		1711	Engage synchronization input
P2.2.5.21	Synch. ModeBit1	0	A.5		1712	Reference speed/Freeze follower speed request input
P2.2.5.22	Synch. trim +	0	0.1		1713	Trim input for increasing of ratio in run mode
P2.2.5.23	Synch. trim -	0	0.1		1714	Trim input for decreasing of ratio in run mode
P2.2.5.24	Brake Opened Ack	0	0.1		1602	Hardware feedback from mechanical brake.

Table 8. Digital input signals, G2.2.4

cc = closing contact  
oc = opening contact

## 6.4 Output signals

### 6.4.1 Delayed digital output 1 (Keypad: Menu M2 → G2.3.1)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.3.1.1	Digital output 1 signal selection	0			0.1		486	
P2.3.1.2	Digital output 1 function	0	26		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=Reverse 10=Jogging spd selected 11=At speed 12=Mot. regulator active 13=Freq. limit 1 superv. 14=Freq. limit 2 superv. 15=Torque limit superv. 16=Ref. limit supervision 17=External brake control 18=I/O control place act. 19=FC temp. limit superv. 20=Reference inverted 21=Ext. brake control inverted 22=Therm. fault or warn. 23=On/Off control 24=Fieldbus input data 1 25=Fieldbus input data 2 26=Fieldbus input data 3
P2.3.1.3	Digital output 1 on delay	0,00	320,00	s	0,00		487	0,00 = delay not in use
P2.3.1.4	Digital output 1 off delay	0,00	320,00	s	0,00		488	0,00 = delay not in use

Table 9. Delayed digital output 1 parameters, G2.3.1

### 6.4.2 Delayed digital output 2 (Keypad: Menu M2 → G2.3.2)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.3.2.1	Digital output 2 signal selection	0			0.1		489	
P2.3.2.2	Digital output 2 function	0	26		0		490	See par. 2.3.1.2
P2.3.2.3	Digital output 2 on delay	0,00	320,00	s	0,00		491	0,00 = delay not in use
P2.3.2.4	Digital output 2 off delay	0,00	320,00	s	0,00		492	0,00 = delay not in use

Table 10. Delayed digital output 2 parameters, G2.3.2

**6.4.3 Digital output signals (Control keypad: Menu M2 → G2.3.3)**

Code	Parameter	Min	Default	Cust	ID	Note
P2.3.3.1	Ready	0	A.1		432	
P2.3.3.2	Run	0	B.1		433	
P2.3.3.3	Fault	0	B.2		434	
P2.3.3.4	Inverted fault	0	0.1		435	
P2.3.3.5	Warning	0	0.1		436	
P2.3.3.6	External fault	0	0.1		437	
P2.3.3.7	Reference fault/warning	0	0.1		438	
P2.3.3.8	Overtemperature warning	0	0.1		439	
P2.3.3.9	Reverse	0	0.1		440	
P2.3.3.10	Unrequested direction	0	0.1		441	
P2.3.3.11	At speed	0	0.1		442	
P2.3.3.12	Jogging speed	0	0.1		443	
P2.3.3.13	External control place	0	0.1		444	
P2.3.3.14	External brake control	0	0.1		445	See explanations on page 53.
P2.3.3.15	External brake control, inverted	0	0.1		446	
P2.3.3.16	Output frequency limit 1 supervision	0	0.1		447	
P2.3.3.17	Output frequency limit 2 supervision	0	0.1		448	
P2.3.3.18	Reference limit supervision	0	0.1		449	
P2.3.3.19	Temperature limit supervision	0	0.1		450	
P2.3.3.20	Torque limit supervision	0	0.1		451	
P2.3.3.21	Motor thermal protection	0	0.1		452	
P2.3.3.22	Motor regulator activation	0	0.1		454	
P2.3.3.23	Fieldbus input data 1	0	0.1		455	
P2.3.3.24	Fieldbus input data 2	0	0.1		456	
P2.3.3.25	Fieldbus input data 3	0	0.1		457	
P2.3.3.26	Fieldbus input data 4	0	0.1		169	
P2.3.3.27	Fieldbus input data 5	0	0.1		170	
P2.3.3.28	SynchronEngaged	0	0.1		1720	
P2.3.3.29	Ratio changing	0	0.1		1721	
P2.3.3.30	External Brake Opened	0	0.1		1722	Indication for mechanical brake fully open

Table 11. Digital output signals, G2.3.3



**Be ABSOLUTELY sure not to connect two functions to one and same output in order to avoid function overruns and to ensure flawless operation.**

**6.4.4 Limit settings (Control keypad: Menu M2 → G2.3.4)**

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.3.4.1	Output frequency limit 1 supervision	0	3		0		315	0=No limit 1=Low limit supervision 2=High limit supervision 3=Brake-on control
P2.3.4.2	Output frequency limit 1; Supervised value	0,00	Par. 2.1.2	Hz	0,00		316	
P2.3.4.3	Output frequency limit 2 supervision	0	4		0		346	0=No limit 1=Low limit supervision 2=High limit supervision 3=Brake-off control 4=Brake on/off-control
P2.3.4.4	Output frequency limit 2; Supervised value	0,00	Par. 2.1.2	Hz	0,00		347	
P2.3.4.5	Torque limit supervision	0	3		0		348	0=Not used 1=Low limit supervision 2=High limit supervision 3=Brake-off control
P2.3.4.6	Torque limit supervision value	-1000,0	1000,0	%	100,0		349	
P2.3.4.7	Reference limit supervision	0	2		0		350	0=Not used 1=Low limit 2=High limit
P2.3.4.8	Reference limit supervision value	0,00	Par. 2.1.2	Hz	0,00		351	
P2.3.4.9	FC temperature supervision	0	2		0		354	0=Not used 1=Low limit 2=High limit
P2.3.4.10	FC temperature supervised value	-10	75	°C	0		355	

Table 12. Limit settings, G2.3.4

**6.4.5 Analogue output 1 (Control keypad: Menu M2 → G2.3.5)**

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.3.5.1	Analogue output 1 signal selection	0			A.1		464	
P2.3.5.2	Analogue output 1 function	0	14		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=Motor 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) 9=AI1 10=AI2 11=Output freq. ( $f_{min}$ - $f_{max}$ ) 12=Motor torque (-2...+2x $T_{Nmot}$ ) 13=Motor power (-2...+2x $T_{Nmot}$ ) 14=PT100 temperature
P2.3.5.3	Analogue output 1 filter time	0,00	10,00	s	1,00		308	0=No filtering
P2.3.5.4	Analogue output 1 inversion	0	1		0		309	0=Not inverted 1=Inverted
P2.3.5.5	Analogue output 1 minimum	0	1		0		310	0=0 mA 1=4 mA
P2.3.5.6	Analogue output 1 scale	10	1000	%	100		311	
P2.3.5.7	Analogue output 1 offset	-100,00	100,00	%	0,00		375	

Table 13. Analogue output 1 parameters, G2.3.5

**6.4.6 Analogue output 2 (Control keypad: Menu M2 → G2.3.6)**

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.3.6.1	Analogue output 2 signal selection	0			0.1		471	
P2.3.6.2	Analogue output 2 function	0	14		4		472	See par. 2.3.5.2
P2.3.6.3	Analogue output 2 filter time	0,00	10,00	s	1,00		473	0=No filtering
P2.3.6.4	Analogue output 2 inversion	0	1		0		474	0=Not inverted 1=Inverted
P2.3.6.5	Analogue output 2 minimum	0	1		0		475	0=0 mA 1=4 mA
P2.3.6.6	Analogue output 2 scale	10	1000	%	100		476	
P2.3.6.7	Analogue output 2 offset	-100,00	100,00	%	0,00		477	

Table 14. Analogue output 2 parameters, G2.3.6

**6.4.7 Analogue output 3 (Control keypad: Menu M2 → G2.3.7)**

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.3.7.1	Analogue output 3 signal selection	0			0.1		478	
P2.3.7.2	Analogue output 3 function	0	14		5		479	See par. 2.3.5.2
P2.3.7.3	Analogue output 3 filter time	0,00	10,00	s	1,00		480	0=No filtering
P2.3.7.4	Analogue output 3 inversion	0	1		0		481	0=Not inverted 1=Inverted
P2.3.7.5	Analogue output 3 minimum	0	1		0		482	0=0 mA 1=4 mA
P2.3.7.6	Analogue output 3 scale	10	1000	%	100		483	
P2.3.7.7	Analogue output 3 offset	-100,00	100,00	%	0,00		484	

Table 15. Analogue output 3 parameters, G2.3.7

**6.4.8 Mechanical Brake (Control keypad: Menu M2 → G2.3.8)**

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.3.8.1	Mechanical brake used	0	1		0		1550	0 = Not used 1 = Mechanical brake used
P2.3.8.2	Current limit open	0	P2.1.8	A	0,00		1551	Current limit for brake open enable
P2.3.8.3	Freq Limit open, OL	0	P2.1.6	Hz	1,00		1535	Frequency limit for brake open in open loop
P2.3.8.4	Freq Limit open, CL	0	P2.1.6	Hz	0,00		1553	Frequency limit for brake open in closed loop
P2.3.8.5	Brake open delay	0	10,00	s	0,00		1554	Delay time for brake open
P2.3.8.6	Brake reaction time	0	10,00	s	0,10		1544	Physical reaction time
P2.3.8.7	Close Frequency limit	0	P2.1.6		1,00		1539	Frequency limit for closing the brake
P2.3.8.8	Brake close delay	0	10,00	s	0,00		1541	Closing delay after close frequency limit is reached.

Table 16. Analogue output 3 parameters, G2.3.7

## 6.5 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	4		0		504	0=Disabled 1=Used when running 2=External brake chopper 3=Used when stopped/running 4=Used when running (no testing)
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	$0,4 \times I_H$	$2 \times I_H$	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	1,50		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	$0,4 \times I_H$	$2 \times I_H$	A	$I_H$		519	

Table 17. Drive control parameters, G2.4

## 6.6 Motor control parameters (Control keypad: Menu M2 → G2.5)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.5.1	Motor control mode	0	6		0		600	0=Frequency control 1=Speed control 2=Torque control 3=Closed loop speed ctrl 4=Closed loop torque ctrl 5=Adv. open loop freq. control 6=Advanced open loop speed control
P2.5.2	U/f optimisation	0	1		0		109	0=Not used 1=Automatic torque boost
P2.5.3	U/f ratio selection	0	3		0		108	0=Linear 1=Squared 2=Programmable 3=Linear with flux optim.
P2.5.4	Field weakening point	8,00	320,00	Hz	50,00		602	
P2.5.5	Voltage at field weakening point	10,00	200,00	%	100,00		603	$n\% \times U_{nmot}$
P2.5.6	U/f curve midpoint frequency	0,00	par. P2.6.4	Hz	50,00		604	
P2.5.7	U/f curve midpoint voltage	0,00	100,00	%	100,00		605	$n\% \times U_{nmot}$ Parameter max. value = par. 2.6.5
P2.5.8	Output voltage at zero frequency	0,00	40,00	%	0,00		606	$n\% \times U_{nmot}$
P2.5.9	Switching frequency	1,0	Varies	kHz	Varies		601	See Table 35 for exact values
P2.5.10	Overvoltage controller	0	2		1		607	0=Not used 1=Used (no ramping) 2=Used (ramping)
P2.5.11	Undervoltage controller	0	1		1		608	0=Not used 1=Used
P2.5.12	Motor control mode 2	0	2/6		2		521	See par. 2.6.1
P2.5.13	Speed controller P gain (open loop)	0	32767		3000		637	
P2.5.14	Speed controller I gain (open loop)	0	32767		300		638	
P2.5.15	Load drooping	0,00	100,00	%	0,00		620	
P2.5.16	Identification	0	5		0		631	0=No Action 1=ID No Run 2=ID With Run 3=Enc. ID Run 4=No Action 5=ID Run failed
P2.5.17	RsVoltageDrop	0	30000		0		662	Measured Rs voltage drop
<b>Closed Loop parameter group 2.5.18</b>								
P2.5.18.1	Magnetizing current	0,00	100,00	A	0,00		612	
P2.5.18.2	Speed control P gain	0	1000		30		613	
P2.5.18.3	Speed control I time	0,0	500,0	ms	30,0		614	
P2.5.18.5	Acceleration compensation	0,00	300,00	s	0,00		626	
P2.5.18.6	Slip adjust	0	500	%	100		619	
P2.5.18.7	Magnetizing current at start	MotCurr Min	MotCurr Max	A	0,00		627	



P2.5.18.8	Magnetizing time at start	0,000	60,000	s	0,0		628	
P2.5.18.9	0-speed time at start	0	32000	ms	100		615	
P2.5.18.10	0-speed time at stop	0	32000	ms	100		616	
P2.5.18.11	Start-up torque	0	3		0		621	0=Not used 1=Torque memory 2=Torque reference 3=Start-up torque fwd/rev
P2.5.18.12	Start-up torque FWD	-300,0	300,0	s	0,0		633	
P2.5.18.13	Start-up torque REV	-300,0	300,0	s	0,0		634	
P2.5.18.14	Encoder filter time	0	100,0	ms	0		618	
P2.5.18.15	Current control P gain	0,00	100,00	%	40,00		617	
P2.5.18.16	KpF1 spd threshld	P2.5.18.17	P2.1.2	Hz	2,00		1555	Frequency threshold for transition to normal speed regulator gain
P2.5.18.17	KpF0 spd threshld	0,00	P2.5.18.16	Hz	1,00		1556	Frequency threshold for transition to low speed regulator gain
P2.5.18.18	%Kp spd reg @ F0	0	100	%	50		1557	Speed regulator gain at low speed, as a percentage of normal gain (P2.5.18.2)
P2.5.18.19	Stop State Flux	0,0	150,0	%	100,0		1401	Stop state magnetization current in % of nominal magnetizing current
P2.5.18.20	Flux Off Delay	-1	32000	s	0		1402	Maximum time for stop state magnetization

Table 18. Motor control parameters, G2.5

### 6.6.1 PMSM settings (Control keypad: Menu M2 → G2.5.19)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	note
P2.5.19.1	Motor type	0	1		0		650	0=Asynchronous motor 1=PMS Motor
P2.5.19.2	FluxCurrent Kp	0	32000		500		651	Gain for flux current control
P2.5.19.3	FluxCurrent Ti	0	1000	ms	50		652	Integral time for flux control
P2.5.19.4	PMSMShaft Position	0	65535		0		649	Low word of encoder angle corresponding to the shaft 0 position
P2.5.19.5	EnableRsIdentific	0	1		1		654	Enable Rs identification during DC brake at start
P2.5.19.6	ModIndexLimit	0	200		100		655	Modulation index limit at field weakening point

Table 19. Parameters for permanent magnet synchronous motor, G2.5.19

## 6.7 Protections (Control keypad: Menu M2 → G2.6)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.6.1	Response to 4mA reference fault	0	5		0		700	0=No response 1=Warning 2=Warning+Prev. Freq. 3=Wrng+PresetFreq 2.7.2 4=Fault,stop acc. to 2.4.7 5=Fault,stop by coasting
P2.6.2	4mA reference fault frequency	0,00	Par. 2.1.2	Hz	0,00		728	
P2.6.3	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
P2.6.4	Input phase supervision	0	3		0		730	0=No response 1=Warning 2=Fault,stop acc. to 2.4.7 3=Fault,stop by coasting
P2.6.5	Response to undervoltage fault	0	1		0		727	0=Fault stored in history 1=Fault not stored
P2.6.6	Output phase supervision	0	3		2		702	0=No response 1=Warning 2=Fault,stop acc. to 2.4.7 3=Fault,stop by coasting
P2.6.7	Earth fault protection	0	3		2		703	
P2.6.8	Thermal protection of the motor	0	3		2		704	
P2.6.9	Motor ambient temperature factor	-100,0	100,0	%	0,0		705	
P2.6.10	Motor cooling factor at zero speed	0,0	150,0	%	40,0		706	
P2.6.11	Motor thermal time constant	1	200	min	45		707	
P2.6.12	Motor duty cycle	0	100	%	100		708	
P2.6.13	Stall protection	0	3		0		709	0=No response 1=Warning 2=Fault,stop acc. to 2.4.7 3=Fault,stop by coasting
P2.6.14	Stall current	0,1	$I_{nMotor} \times 2$	A	$I_L$		710	
P2.6.15	Stall time limit	1,00	120,00	s	15,00		711	
P2.6.16	Stall frequency limit	1,0	Par. 2.1.2	Hz	25,0		712	
P2.6.17	Response to thermistor fault	0	3		2		732	0=No response 1=Warning 2=Fault,stop acc. to 2.4.7 3=Fault,stop by coasting
P2.6.18	Response to fieldbus fault	0	3		2		733	See P2.6.17
P2.6.19	Response to slot fault	0	3		2		734	See P2.6.17

SHAFT SYNCHRONIZATION SPECIFIC PARAMETERS								
P2.6.20	Response to position error	0	3		2		1730	See P2.6.17
P2.6.21	Position error threshold	0	2147483647	u	3932160		1731	Threshold for position error during synchronization
P2.6.22	Power unit temperature sensor supervision	0	1		0		1732	0=Read 1=Ignore
P2.6.23	Encoder supervision	0	1		0		1733	0=Enabled 1=Disabled
P2.6.24	Lock Response	0	3		2		1734	See P2.6.17
P2.6.25	Lock Freq Diff	0,00	Par. 2.1.2	Hz	2,00		1735	Allowed difference between output frequency and the encoder feedback frequency
P2.6.26	Lock fault delay	0,00	10,00	s	0,50		1736	If freq. difference is higher than ID1735 in this time the lock fault is triggered
P2.6.27	Disable stop lock	0	1		0		1086	Only for Vacon personnel. Possibility to change parameters in run state when this parameter is set to 1.

Table 20. Protections, G2.6

## 6.8 Fieldbus parameters (Control Keypad: Menu M2 →G2.7)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.7.1	Fieldbus data out 1 selection	0	10000		0		852	Choose monitoring data with parameter ID
P2.7.2	Fieldbus data out 2 selection	0	10000		0		853	Choose monitoring data with parameter ID
P2.7.3	Fieldbus data out 3 selection	0	10000		1703		854	Choose monitoring data with parameter ID
P2.7.4	Fieldbus data out 4 selection	0	10000		4		855	Choose monitoring data with parameter ID
P2.7.5	Fieldbus data out 5 selection	0	10000		5		856	Choose monitoring data with parameter ID
P2.7.6	Fieldbus data out 6 selection	0	10000		6		857	Choose monitoring data with parameter ID
P2.7.7	Fieldbus data out 7 selection	0	10000		7		858	Choose monitoring data with parameter ID
P2.7.8	Fieldbus data out 8 selection	0	10000		37		859	Choose monitoring data with parameter ID
<b>SHAFT SYNCHRONIZATION SPECIFIC PARAMETERS</b> (See separate description)								
P2.7.9	Fieldbus data out 1_2 selection	0	10000		1702		1740	Choose 32-bit monitoring data with parameter ID. See separate description.
P2.7.10	Synch. ratio register selection	0	7		0		1741	Selection of PD in channels for ratio register. <b>Occupies 2 PD in channels !</b>
P2.7.11	Synch. control register selection	0	8		1		1742	Selection of PD in channel for synchronization control register. See table 39.
P2.7.12	Torque reference selection	0	8		6		1680	Select PD in channel for Torque reference
P2.7.13	Free signal selection	0	8		7		1681	Select PD in channel for Free Signal. Can be used for Torque or Current limit. See G2.2.4.

Table 21. Fieldbus parameters

**6.9 Torque control parameters (Control Keypad: Menu M2 →G2.8)**

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.8.1	Torque limit	0,0	400,0	%	400,0		609	
P2.8.2	Torque limit control P-gain	0,0	32000		3000		610	Used only in Open Loop control mode
P2.8.3	Torque limit control I-gain	0,0	32000		200		611	
P2.8.4	Torque reference selection	0	8		0		641	0=Not used 1=A11 2=A12 3=A13 4=A14 5=A11 joystick 6=A12 joystick 7=Torque reference from keypad, R3.5 8=Fieldbus
P2.8.5	Torque reference max.	-300,0	300,0	%	100		642	
P2.8.6	Torque reference min.	-300,0	300,0	%	0,0		643	
P2.8.7	Torque speed limit	0	2		1		644	0=Max. frequency 1=Selected freq.reference 2=Preset speed 7
P2.8.8	Minimum frequency for open loop torque control	0,00	par.2.1.1	Hz	3,00		636	
P2.8.9	Torque controller P gain	0	32000		150		639	
P2.8.10	Torque controller I gain	0	32000		10		640	

Table 22. Torque control parameters, G2.8

## 6.10 Shaft synchronization parameters (Control keypad: Menu M2 → G2.9)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
<b>MASTER settings group 2.9.1 (See separate section)</b>								
P2.9.1.1	Master distance	1	32767	u	360		1750	Master distance in user units, Integer part
P2.9.1.2	Master distance fractional	0	65535	u	0		1751	Master distance in user units, fractional part
P2.9.1.3	Master turns	1	32767		1		1752	Master turns, Integer part corresponding to P2.9.1.1 and 2.9.1.2
P2.9.1.4	Master turns fractional	0	65535		0		1753	Master turns, fractional part corresponding to P2.9.1.1 and 2.9.1.2
P2.9.1.5	Master speed filter TI	0,000	32,767		0,100		1754	Time constant [s] of the 1st order low-pass filter on master speed measurement
<b>FOLLOWER settings group 2.9.2</b>								
P2.9.2.1	Follower distance	1	32767	u	360		1757	Follower distance in user units, integer part
P2.9.2.2	Follower distance Fractional	0	65535	u	0		1758	Follower distance in user units, fractional part
P2.9.2.3	Follower turns	1	32767		1		1759	Follower turns, Integer part corresponding to P2.9.1.1 and 2.9.1.2
P2.9.2.4	Follower turns fractional	0	65535		0		1760	Follower turns, fractional part corresponding to P2.9.2.1 and 2.9.2.2
P2.9.2.5	Follower speed filter TI	0,000	32,767		0,010		1761	Time constant [s] of the 1st order low-pass filter on follower speed measurement
P2.9.2.6	PID control gain	0	2147483647		30		1762	Proportional gain for synchroniz. regulator
P2.9.2.7	PID control I gain		2147483647		1		1763	Integral gain for synchronization regulator
P2.9.2.8	Synchronization acceleration	1	32767	u/s <sup>2</sup>	3600		1764	Acceleration for engage synchronization and deceleration for the release synchronization commands
P2.9.2.9	Electrical Gear ratio	-262144	262144		65536		1765	Adjust register for changing of the ratio in run mode
P2.9.2.10	Ratio ramp time	0,000	2147483,647	ms	10,000		1766	Ramp time in ms for ratio change according tp P2.9.2.9
P2.9.2.11	Trim ratio change	0,1	200,0	%	10,0		1767	Setting of how much digital trim inputs affects the ratio.
<b>PHASING settings group 2.9.3</b>								
P2.9.3.1	Distance	-32000	32000	U	1		1805	Distance in user unit for phasing command.
P2.9.3.2	Sel PosPhasing	0.1	E.10		0.1		1716	Input selection by TTF for positive phasing
P2.9.3.3	Sel NegPhasing	0.1	E.10		0.1		1717	Input selection by TTF for negative phasing

Table 23. Parameters for Shaft Synchronization, G2.9

### 6.11 License key (Control keypad: Menu M2 → G2.10)

Code	Parameter	Min	Max	Unit	Default	Cust	ID	Note
P2.10.1	License key	0	65535		0		1694	Software enable code related to the serial number of power unit
V2.10.2	Power unit serial number key	0	65535		0		1515	Serial number key of the power unit. Value for monitoring only.

Table 24. License key parameters

### 6.12 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	1=I/O terminal 2=Keypad 3=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
P3.4	Stop button	0	1				114	0=Limited function of Stop button 1=Stop button always enabled
R3.5	Torque reference	0,0	100,0	%	0,0			

Table 25. Keypad control parameters, M3

#### 6.12.1 System menu (Control keypad: Menu 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.

#### 6.12.2 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.

## 7. DESCRIPTION OF PARAMETERS

On the following pages you will find the parameter descriptions arranged according to the individual ID number of the parameter. A shaded parameter ID number (e.g. **418 Motor potentiometer UP**) indicates that the *TTF programming method* shall be applied to this parameter (see chapter 5 on page 10).

Some parameter names are followed by a number code indicating the "All in One" applications in which the parameter is included. If **no code** is shown the parameter is available in **all applications**. See below. The parameter numbers under which the parameter appears in different applications are also given.

### 102 *Maximum frequency* (2.1.1)

Defines the frequency limits of the frequency converter.

The maximum value for these parameters is 320 Hz.

The software will automatically check the values of parameters ID105, ID106, ID315 and ID728.

### 103 *Acceleration time 1* (2.1.2)

### 104 *Deceleration time 1* (2.1.3)

These limits correspond to the time required for the output frequency to accelerate from the zero frequency to the set maximum frequency (par. ID102).

See also parameter ID1764.

### 105 *Preset speed 1* (2.1.14)

### 106 *Preset speed 2* (2.1.15)

Parameter values are automatically limited between the minimum and maximum frequencies (par. ID101, ID102).

Note the use of TTF-programming method in the Multi-purpose Control Application. See parameters ID419, ID420 and ID421.

Speed	Multi-step speed sel. 1 (DIN4)	Multi-step speed sel. 2 (DIN5)
Basic speed	0	0
ID105	1	0
ID106	0	1

Table 26. Preset speed

### 107 *Current limit* (2.1.4)

This parameter determines the maximum motor current from the frequency converter. The parameter value range differs from size to size.

### 108 *U/f ration selection* (2.5.3)

Linear: 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 ration should be used in constant torque applications. **This default setting should be used if there is no special need for another setting.**



- Squared: 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 undermagnetised below the field weakening point and produces less torque and electro-mechanical 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.

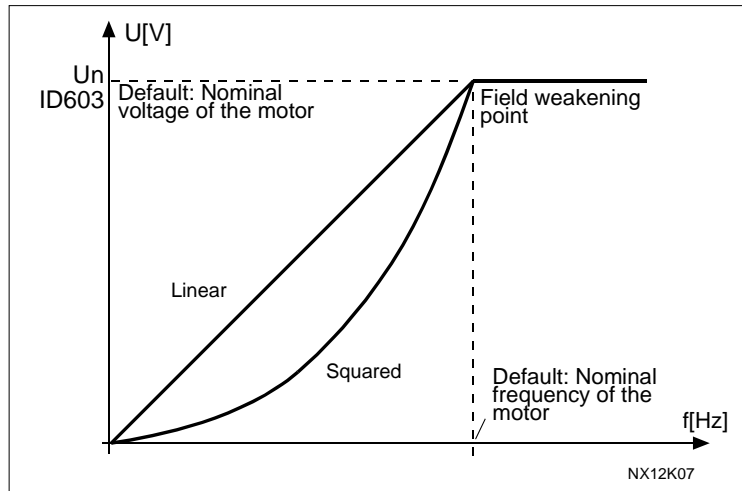


Figure 2. Linear and squared change of motor voltage

- 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.

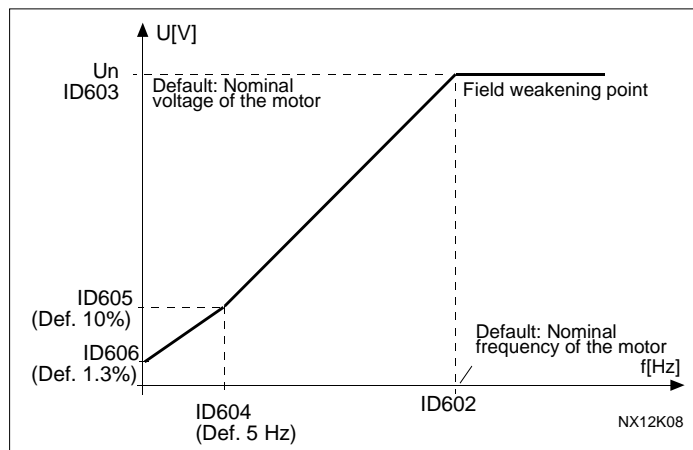


Figure 3. Programmable U/f curve

- 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.

- 109**      ***U/f optimisation***      (2.5.2)
- 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).

Option 1: Activate the Automatic torque boost.

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. ID108 to *Programmable U/f curve* (value 2). Increase zero point voltage (ID606) to get enough current at zero speed. Set then the midpoint voltage (ID605) to  $1.4142 \cdot \text{ID606}$  and midpoint frequency (ID604) to value  $\text{ID606}/100\% \cdot \text{ID111}$ .

*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.*

- 110**      ***Nominal voltage of the motor***      (2.1.5)
- Find this value  $U_n$  on the rating plate of the motor. This parameter sets the voltage at the field weakening point (ID603) to  $100\% \cdot U_{n\text{Motor}}$ .
- 111**      ***Nominal frequency of the motor***      (2.1.6)
- Find this value  $f_n$  on the rating plate of the motor. This parameter sets the field weakening point (ID602) to the same value.
- 112**      ***Nominal speed of the motor***      (2.1.7)
- Find this value  $n_n$  on the rating plate of the motor.
- 113**      ***Nominal current of the motor***      (2.1.8)
- Find this value  $I_n$  on the rating plate of the motor.

**117**      ***I/O frequency reference selection***      (2.1.10)

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

Applic.	6
Sel.	
0	Analogue volt. ref. Terminals 2-3
1	Analogue curr.ref. Terminals 4-5
2	AI1+AI2
3	AI1-AI2
4	AI2-AI1
5	AI1*AI2
6	AI1 joystick
7	AI2 joystick
8	Keypad reference (Menu M3)
9	Fieldbus reference
10	Potentiometer reference; controlled with DIN5 (TRUE=increase) and DIN6 (TRUE=decrease)
11	AI1 or AI2, whichever is lower
12	AI1 or AI2, whichever is greater
13	Max. frequency (recommended in torque control only)
14	AI1/AI2 selection

Table 27. Selections for parameter ID117

**120**      ***Motor cos phi***      (2.1.9)

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

**121**      ***Keypad frequency reference selection***      (2.1.11)

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

Applic.	6
Sel.	
0	Analogue volt.ref. Terminals 2-3
1	Analogue curr.ref. Terminals 4-5
2	AI1+AI2
3	AI1-AI2
4	AI2-AI1
5	AI1*AI2
6	AI1 joystick
7	AI2 joystick
8	Keypad reference (Menu M3)
9	Fieldbus reference*

Table 28. Selections for parameter ID121

\*FBSpeedReference

**122**      *Fieldbus frequency reference selection*      (2.1.12)

Defines which frequency reference source is selected when controlled from the fieldbus. For selections in different applications, see ID121.

**124**      *Jogging speed reference*      (2.1.13)

Defines the jogging speed selected with the DIN3 digital input which can be programmed for Jogging speed. See parameter ID301.

Parameter value is automatically limited between minimum and maximum frequency (ID's 101 and 102).

**126**      *Preset speed 3*      (2.1.16)**127**      *Preset speed 4*      (2.1.17)**128**      *Preset speed 5*      (2.1.18)**129**      *Preset speed 6*      (2.1.19)**130**      *Preset speed 7*      (2.1.20)

Parameter values define the Multi-step speeds selected with the DIN3, DIN4, DIN5 and DIN6 digital inputs. See also parameter ID's 105 and 106.

Parameter value is automatically limited between minimum and maximum frequency (ID's 101 and 102).

Speed	Multi-step speed sel. 1 (DIN4)	Multi-step speed sel. 2 (DIN5)	Multi-step speed sel. 3 (DIN6)	Multi-step speed sel. 4 (DIN3)
Basic speed	0	0	0	0
P2.1.16 (3)	1	1	0	0
P2.1.17 (4)	0	0	1	0
P2.1.18 (5)	1	0	1	0
P2.1.19 (6)	0	1	1	0
P2.1.20 (7)	1	1	1	0

Table 29. Preset speeds 3 to 7

**141**      *AI3 signal selection*      (2.2.4.1)

Connect the AI3 signal to the analogue input of your choice with this parameter. For more information, see Chapter 5, on page 10.

**142**      *AI3 signal filter time*      (2.2.4.2)

When this parameter is given a value greater than 0 the function that filters out disturbances from the incoming analogue signal is activated. Long filtering time makes the regulation response slower. See parameter ID324.

**143**      ***AI3 signal range***      (2.2.4.3)

With this parameter you can select the AI3 signal range.

Applic. Sel.	6
0	0...100%
1	20...100%
2	-10...+10V
3	Customised

Table 30. Selections for parameter ID143

**144**      ***AI3 custom setting minimum***      (2.2.4.4)**145**      ***AI3 custom setting maximum***      (2.2.4.5)

Set the custom minimum and maximum levels for the AI3 signal within 0...100%.

**151**      ***AI3 signal inversion***      (2.2.4.6)

0 = No inversion

1 = Signal inverted

**152**      ***AI4 signal selection***      (2.2.5.1)

See ID141.

**153**      ***AI4 filter time***      (2.2.5.2)

See ID142.

**154**      ***AI4 signal range***      (2.2.5.3)

See ID 143.

**155**      ***AI4 custom setting minimum***      (2.2.5.4)**156**      ***AI4 custom setting maximum***      (2.2.5.5)

See ID's 144 and 145.

**162**      ***AI4 signal inversion***      (2.2.4.4, 2.2.5.6)

See ID 151.

**164**      ***Motor control mode 1/2***      (2.2.5.18)

Contact is open = Motor control mode 1 is selected

Contact is closed = Motor control mode 2 is selected

See parameter ID's 600 and 521.

**165**      ***AI1 joystick offset***      (2.2.2.9)

Define the frequency zero point as follows: With this parameter on display, place the potentiometer at the assumed zero point and press *Enter* on the keypad. **Note:** This will not, however, change the reference scaling.

Press *Reset* button to change the parameter value back to 0,00%.

**166**      ***AI2 joystick offset***      (2.2.3.9)

See par. ID165.

169 *Fieldbus input data 4 (FBFixedControlWord, bit 6)* (2.3.3.26)

170 *Fieldbus input data 5 (FBFixedControlWord, bit 7)* (2.3.3.27)

The data from the fieldbus (FBFixedControlWord) can be led to frequency converter digital outputs.

300 *Start/Stop logic selection* (2.2.1.1)

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

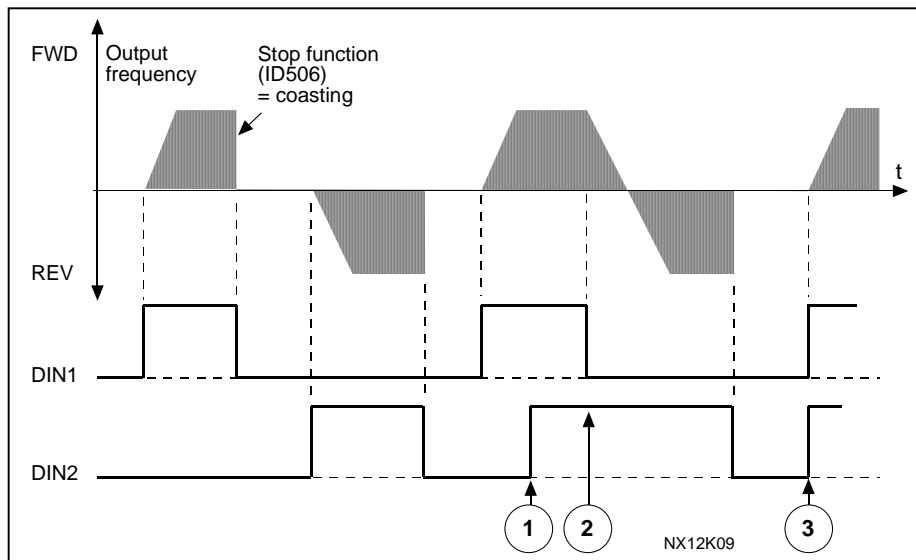


Figure 4. Start forward/Start reverse

- 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 below.

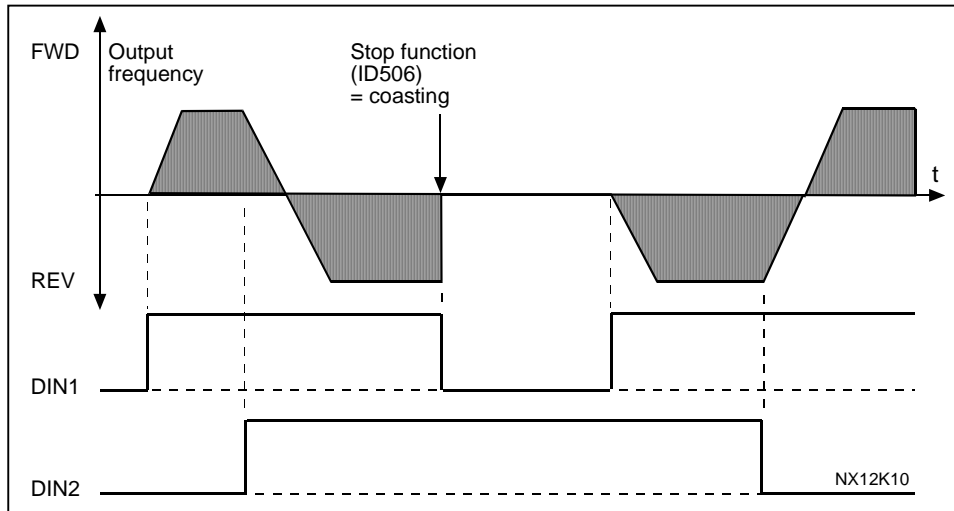


Figure 5. Start, Stop, Reverse

- 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 6.

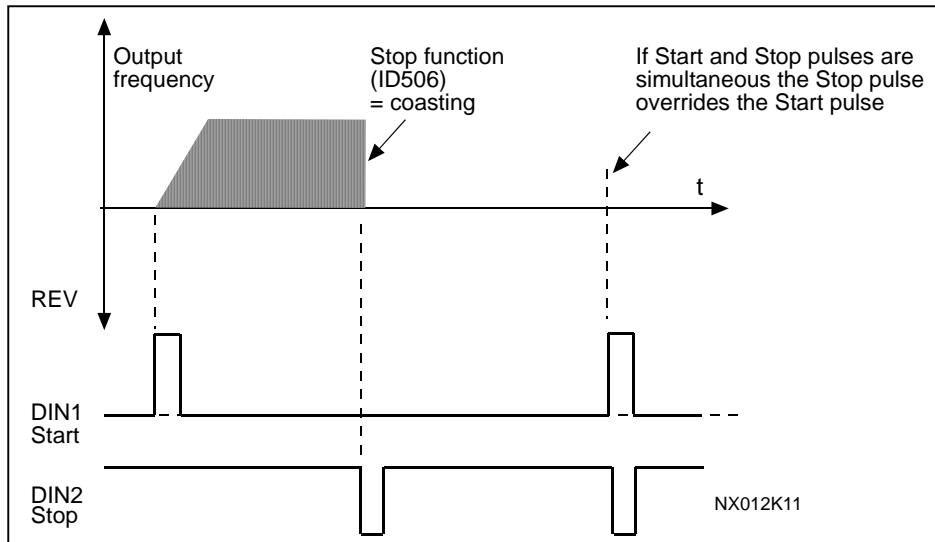


Figure 6. Start pulse/ Stop pulse.

The selections including the text **'Rising edge required to start'** 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  
 DIN2: closed contact = reference increases (motor potentiometer reference; this parameter is automatically set to 4 if par. ID117 is set to 3 or 4).
- 5 DIN1: closed contact = start forward (**Rising edge required to start**)  
 DIN2: closed contact = start reverse (**Rising edge required to start**)
- 6 DIN1: closed contact = start (**Rising edge required to start**)  
 open contact = stop  
 DIN2: closed contact = reverse  
 open contact = forward
- 7 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

303 *Reference scaling, minimum value* (2.2.2.6)

304 *Reference scaling, maximum value* (2.2.2.7)

Setting value limits:  $0 \leq \text{par. ID303} \leq \text{par. ID304} \leq \text{par. ID102}$ . If parameter ID303 = 0 scaling is set off. The minimum and maximum frequencies are used for scaling.

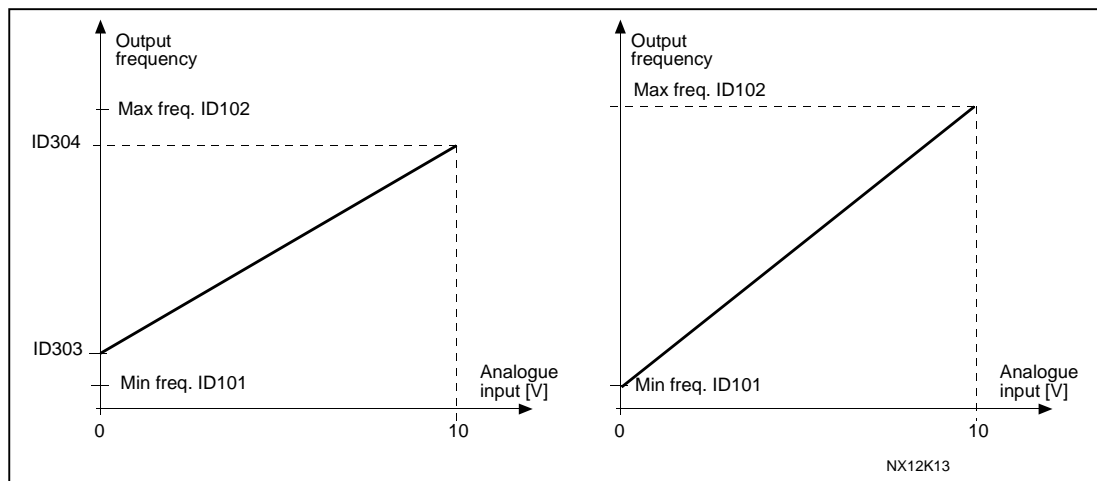


Figure 7. **Left:** Reference scaling; **Right:** No scaling used (par. ID303 = 0).

307 *Analogue output function* (2.3.5.2)

This parameter selects the desired function for the analogue output signal. See page 21 for the parameter values available in the application.



### 308 *Analogue output filter time* (2.3.5.3)

Defines the filtering time of the analogue output signal.  
Setting this parameter value 0 will deactivate filtering.

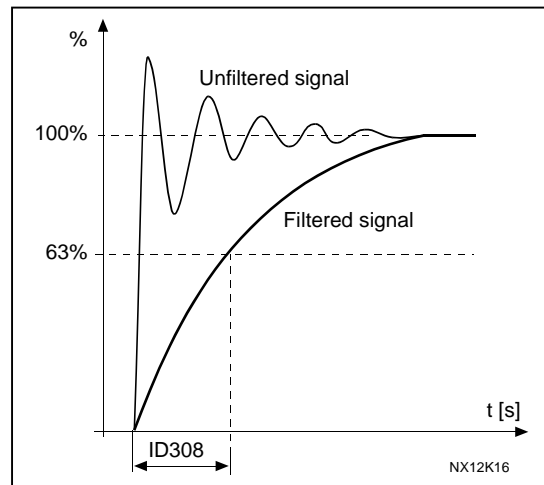


Figure 8. Analogue output filtering

### 309 *Analogue output inversion* (2.3.5.4)

Inverts the analogue output signal:

Maximum output signal = Minimum set value  
Minimum output signal = Maximum set value

See parameter ID311 below.

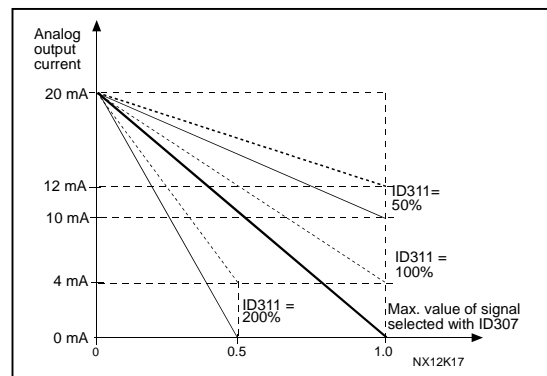


Figure 9. Analogue output invert

### 310 *Analogue output minimum* (2.3.5.5)

Defines the signal minimum to either 0 mA or 4 mA (living zero). Note the difference in analogue output scaling in parameter ID311 (Figure 8-15).

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

311 *Analogue output scale* (2.3.5.6)

Scaling factor for analogue output.

Signal	Max. value of the signal
Output frequency	Max frequency (par.ID102)
Freq. Reference	Max frequency (par.ID102)
Motor speed	Motor nom. speed $1 \times n_{nMotor}$
Output current	Motor nom. current $1 \times I_{nMotor}$
Motor torque	Motor nom. torque $1 \times T_{nMotor}$
Motor power	Motor nom. power $1 \times P_{nMotor}$
Motor voltage	$100\% \times U_{nMotor}$
DC-link voltage	1000 V

Table 31. Analogue output scaling

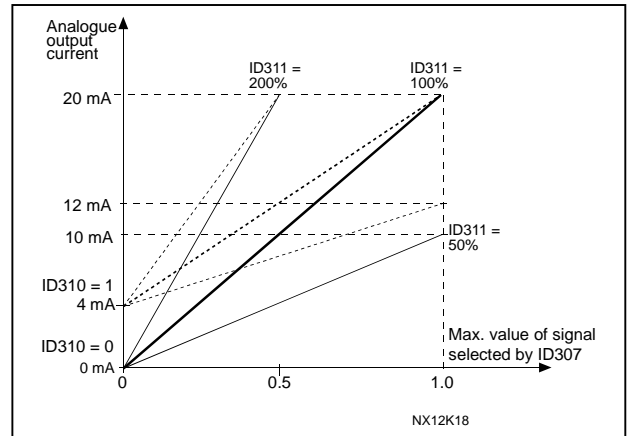


Figure 10. Analogue output scaling

312 *Digital output function* (2.3.1.2)

Setting value	Signal content
0 = Not used	Out of operation
	<u>Digital output DO1 sinks the current and programmable relay (R01, R02) 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. ID701
7 = Reference fault or warning	Fault or warning depending on par. ID700 - 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 1 (Applications 2)	The preset speed has been selected with digital input
10 = Jogging speed (Applications 3456)	The jogging 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 limit supervision	The output frequency goes outside the set supervision low limit/high limit (see parameter ID's 315 and 316 below)
14 = Control from I/O terminals (Appl. 2)	I/O control mode selected (in menu M3)
14 = Output freq.limit 2 supervision (Applications 3456)	The output frequency goes outside the set supervision low limit/high limit (see parameter ID's 346 and 347 below)
15 = Thermistor fault or warning (Appl.2)	The thermistor input of option board indicates overtemperature. Fault or warning depending on par ID732.
15 = Torque limit supervision (Appl.3456)	The motor torque goes beyond the set supervision low limit/high limit (par. ID348 and ID349).
16 = Fieldbus input data (Application 2)	Fieldbus input data (FBFixedControlWord) to DO/RO.
16 = Reference limit supervision	Active reference goes beyond the set supervision low limit/high limit (par. ID350 and ID351)
17 = External brake control (Appl. 3456)	External brake ON/OFF control with programmable delay (par. ID352 and ID353)

18 = Control from I/O terminals (Appl. 3456)	External control mode (Menu <b>M3</b> ; ID125)
19 = Frequency converter temperature limit supervision (Appl. 3456)	Frequency converter heatsink temperature goes beyond the set supervision limits (par. ID354 and ID355).
20 = Unrequested rot. direction (Appl. 345) 20 = Reference inverted (Appl. 6)	Rotation direction is different from the requested one.
21 = External brake control inverted (Appl. 3456)	External brake ON/OFF control (par. ID352 and ID353); Output active when brake control is OFF
22 = Thermistor fault or warning (Appl.3456)	The thermistor input of option board indicates overtemperature. Fault or warning depending on parameter ID732.
23 = Fieldbus input data (Application 5) 23 = On/Off control (Application 6)	Fieldbus input data (FBFixedControlWord) to DO/RO. Selects the analogue input to be monitored. See par. ID356, ID357, ID358 and ID463.
24 = Fieldbus input data 1 (Application 6)	Fieldbus data (FBFixedControlWord) to DO/RO
25 = Fieldbus input data 2 (Application 6)	Fieldbus data (FBFixedControlWord) to DO/RO
26 = Fieldbus input data 3 (Application 6)	Fieldbus data (FBFixedControlWord) to DO/RO

Table 32. Output signals via D01

**315**      *Output frequency limit supervision function*      (2.3.4.1)

- 0 No supervision
- 1 Low limit supervision
- 2 High limit supervision
- 3 Brake-on control (See chapter **Error! Reference source not found.** on page **Error! Bookmark not defined.**)

If the output frequency goes under/over the set limit (ID316) this function generates a warning message via the digital output D01 or via the relay output RO1 or RO2 depending on the settings of parameters ID312...ID314.

**316**      *Output frequency limit supervision value*      (2.3.4.2)

Selects the frequency value supervised by parameter ID315. See Figure 11.

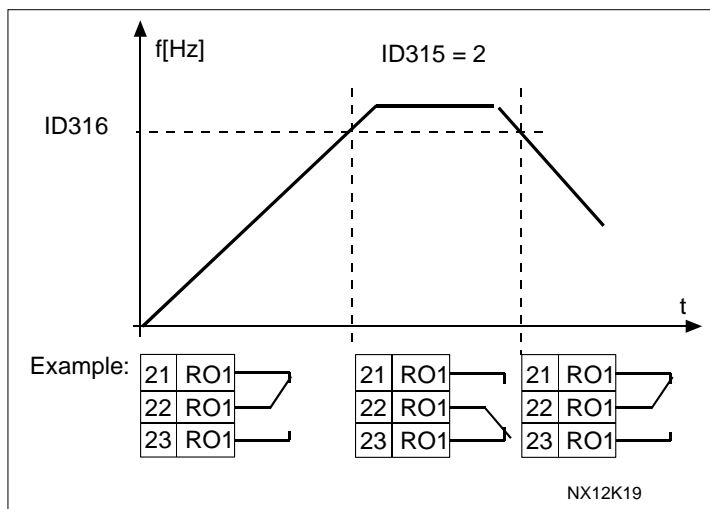


Figure 11. Output frequency supervision

**320** *A11 signal range* (2.2.2.3)

Applic.	ASFIFF06
Sel.	
0	0...100%
1	20...100%
2	-10...+10V
3	Customised

Table 33. Selections for parameter ID320

For selection 'Customised', see parameters ID321 and ID322.

**321** *A11 custom setting minimum* (2.2.2.4)

**322** *A11 custom setting maximum* (2.2.2.5)

These parameters set the analogue input signal for any input signal span within 0—100%.

**324** *A11 signal filter time* (2.2.2.2)

When this parameter is given a value greater than 0 the function that filters out disturbances from the incoming analogue signal is activated.

Long filtering time makes the regulation response slower. See Figure 12.

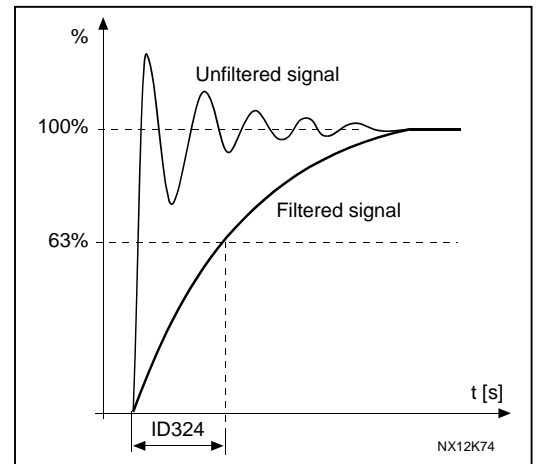


Figure 12. A11 signal filtering

**325** *Analogue input A12 signal range* (2.2.3.3)

Selection	Value
0	0...100%
1	20...100%
2	-10...+10V
3	Customised

Table 34. Selections for parameter ID325

- 326 *Analogue input AI2 custom setting min.* (2.2.3.4)  
 327 *Analogue input AI2 custom setting max.* (2.2.3.5)

These parameters set AI2 for any input signal span within 0...100%.

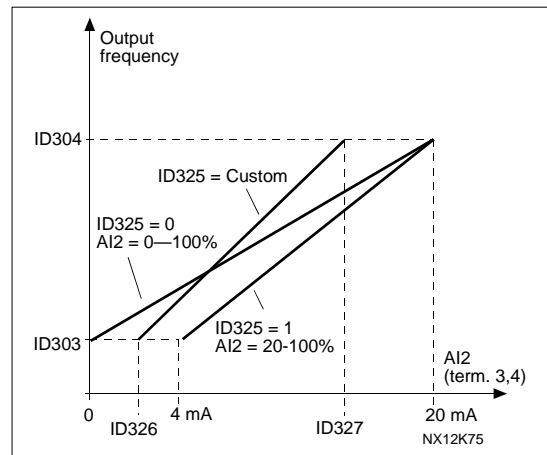


Figure 13. Analogue input AI2 scaling.

- 329 *Analogue input AI2 ( $I_{in}$ ) filter time* (2.2.3.2)

See ID324.

- 331 *Motor potentiometer ramp time* (2.2.1.2)

Defines the speed of change of the motor potentiometer value.

- 346 *Output freq. limit 2 supervision function* (2.3.4.3)

- 0 No supervision
- 1 Low limit supervision
- 2 High limit supervision
- 3 Brake-on control (Application 6 only, see chapter **Error! Reference source not found.** on page **Error! Bookmark not defined.**)
- 4 Brake-on/off control (Application 6 only, see chapter **Error! Reference source not found.** on page **Error! Bookmark not defined.**)

If the output frequency goes under/over the set limit (ID347) this function generates a warning message via the digital output DO1 and via the relay output RO1 or RO2 depending

- 1) on the settings of parameters ID312 to ID314 (applications 3,4,5) or
- 2) depending on to which output the supervision signals (par. ID447 and ID448) are connected (applications 6 and 7).

- 347 *Output frequency limit 2 supervision value* (2.3.4.4)

Selects the frequency value supervised by parameter ID346. See Figure 11.

- 348**      *Torque limit, supervision function*                      (2.3.4.5)
- 0 = No supervision  
 1 = Low limit supervision  
 2 = High limit supervision  
 3 = Brake-off control (See chapter **Error! Reference source not found.** on page **Error! Bookmark not defined.**)
- If the calculated torque value falls below or exceeds the set limit (ID349) this function generates a warning message via the digital output DO1 or via a relay output R01 or R02 depending on to which output the supervision signal (par. ID451) is connected.
- 349**      *Torque limit, supervision value*                              (2.3.4.6)
- Set here the torque value to be supervised by parameter ID348.
- 350**      *Reference limit, supervision function*                      (2.3.4.7)
- 0 = No supervision  
 1 = Low limit supervision  
 2 = High limit supervision
- If the reference value falls below or exceeds the set limit (ID351), this function generates a warning message via the digital output DO1 or via a relay output R01 or R02 depending on to which output the supervision signal (par. ID449) is connected
- The supervised reference is the current active reference. It can be place A or B reference depending on DIN6 input, or panel reference if the panel is the active control place.
- 351**      *Reference limit, supervision value*                              (2.3.4.8)
- The frequency value to be supervised with the parameter ID350.
- 354**      *Frequency converter temperature limit supervision*                      (2.3.4.11)
- 0 = No supervision  
 1 = Low limit supervision  
 2 = High limit supervision
- If the temperature of the frequency converter unit falls below or exceeds the set limit (ID355), this function generates a warning message via the digital output DO1 or via a relay output R01 or R02 depending on to which output the supervision signal (par. ID450) is connected.
- 355**      *Frequency converter temperature limit value*                      (2.3.4.12)
- This temperature value is supervised by parameter ID354.

**356**      *On/Off control signal*      (2.3.4.13)

With this parameter you can select the analogue input to be monitored.

- 0 = Not used
- 1 = AI1
- 2 = AI2
- 3 = AI3
- 4 = AI4

**357**      *On/Off control low limit*      (2.3.4.14)**358**      *On/Off control high limit*      (2.3.4.15)

These parameters set the low and high limits of the signal selected with par. ID356. See Figure 14.

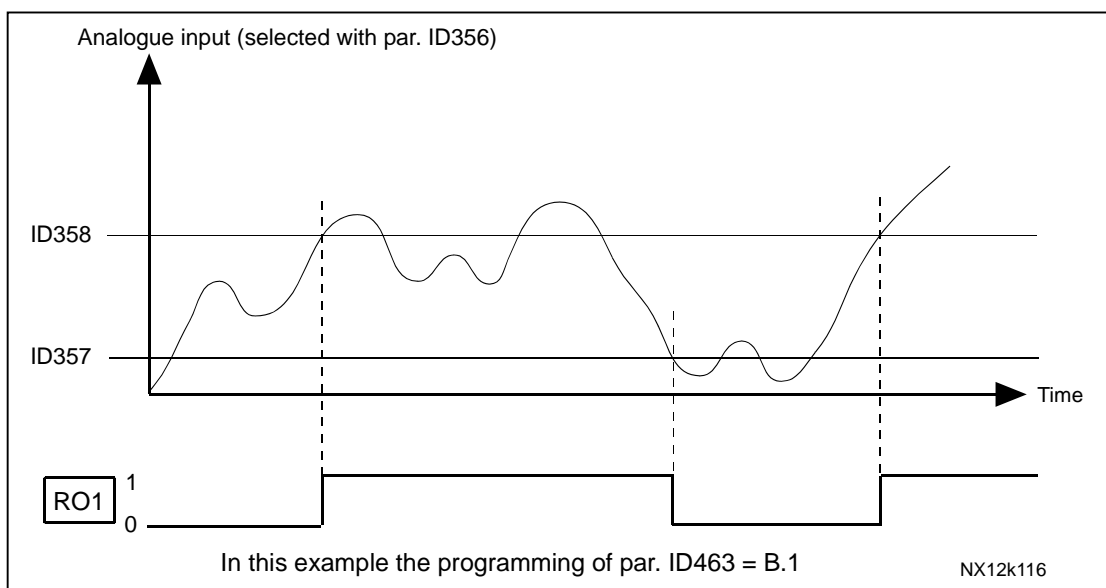


Figure 14. An example of On/Off-control

**367**      *Motor potentiometer memory reset (Frequency reference) 3*      (2.2.1.3)

- 0 No reset
- 1 Memory reset in stop and powerdown
- 2 Memory reset in powerdown

**375**      *Analogue output offset*      (2.3.5.7)

Add -100.0 to 100.0% to the analogue output.

**377**      *All signal selection*      (2.2.2.1)

Connect the AI1 signal to the analogue input of your choice with this parameter. For more information about the TTF programming method, see chapter 5 on page 10.

384 *All joystick hysteresis* (2.2.2.8)

This parameter defines the joystick hysteresis between 0 and 20 %.  
 When the joystick or potentiometer control is turned from reverse to forward, the output frequency falls linearly to the selected minimum frequency (joystick/potentiometer in middle position) and stays there until the joystick/potentiometer is turned towards the forward command. It depends on the amount of joystick hysteresis defined with this parameter, how much the joystick/potentiometer must be turned to start the increase of the frequency towards the selected maximum frequency.  
 If the value of this parameter is 0, the frequency starts to increase linearly immediately when the joystick/potentiometer is turned towards the forward command from the middle position. When the control is changed from forward to reverse, the frequency follows the same pattern the other way round. See Figure 15.

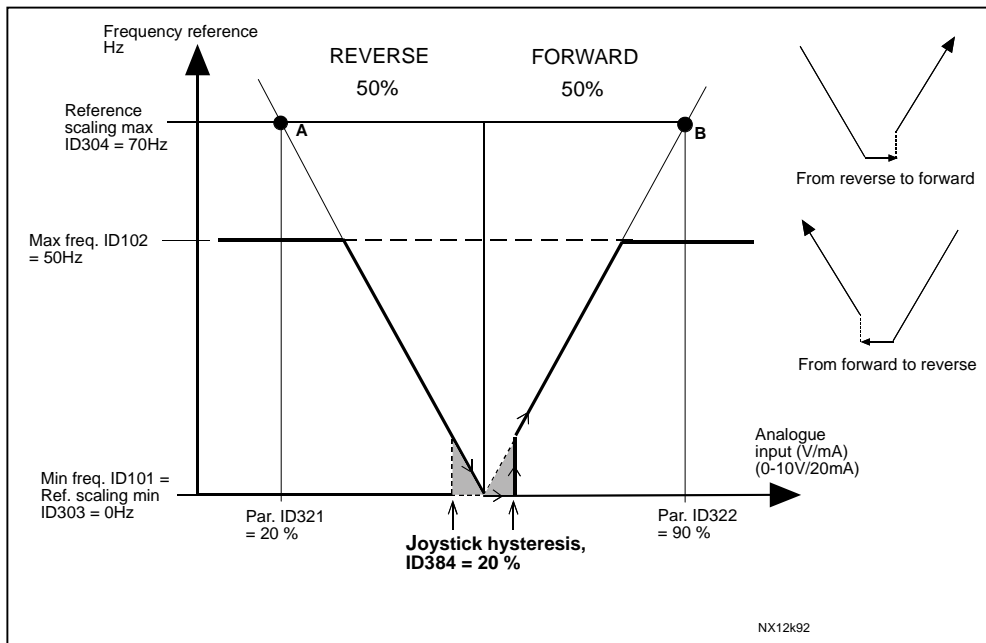


Figure 15. An example of joystick hysteresis. In this example, the value of par. ID385 (Sleep limit) = 0



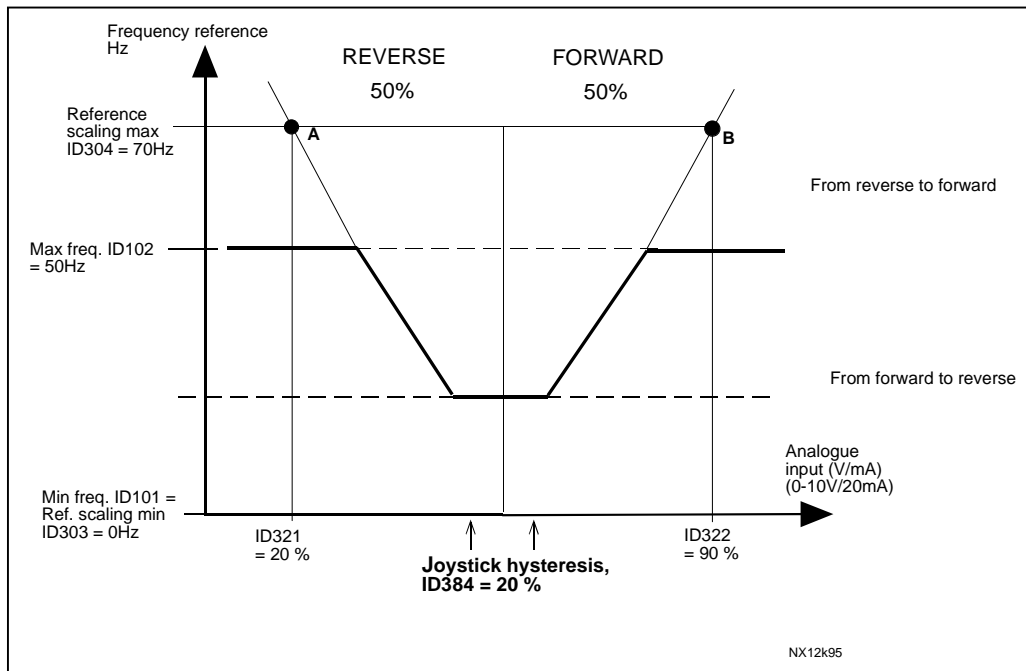


Figure 16. Joystick hysteresis with minimum frequency at 35Hz

**388** *AI2 signal selection* (2.2.3.1)

Connect the AI2 signal to the analogue input of your choice with this parameter. For more information about the TTF programming method, see chapter 5 on page 10.

**393** *AI2 reference scaling, minimum value* (2.2.3.6)

**394** *AI2 reference scaling, maximum value* (2.2.3.7)

See ID's 303 and 304.

**395** *AI2 joystick hysteresis* (2.2.3.8)

See ID384.

**399** *Scaling of current limit* (2.2.4.1)

0 = Not used

1 = AI1

2 = AI2

3 = Fieldbus

This signal will adjust the maximum motor current between 0 and max. limit set with parameter ID107.

- 403**      *Start signal 1*      (2.2.5.1)  
Signal selection 1 for the start/stop logic.  
Default programming A.1.
- 404**      *Start signal 2*      (2.2.5.2)  
Signal selection 2 for the start/stop logic.  
Default programming A.2.
- 405**      *External fault (close)*      (2.2.5.11)  
Contact closed:    Fault is displayed and motor stopped.
- 406**      *External fault (open)*      (2.2.5.12)  
Contact open:      Fault is displayed and motor stopped.
- 407**      *Run enable*      (2.2.5.3)  
Contact open:      Start of motor disabled  
Contact closed:    Start of motor enabled
- 408**      *Acceleration/Deceleration time selection*      (2.2.5.13)  
Contact open:      Acceleration/Deceleration time 1 selected  
Contact closed:    Acceleration/Deceleration time 2 selected  
  
Set Acceleration/Deceleration times with parameters ID103 and ID104.
- 409**      *Control from I/O terminal*      (2.2.7.18)  
Contact closed:    Force control place to I/O terminal
- 410**      *Control from keypad*      (2.2.7.19)  
Contact closed:    Force control place to keypad
- 411**      *Control from fieldbus*      (2.2.7.20)  
Contact closed:    Force control place to fieldbus
- NOTE:** When the control place is forced to change the values of Start/Stop, Direction and Reference valid in the respective control place are used. The value of parameter ID125 (Keypad Control Place) does not change. When the input opens the control place is selected according to keypad control parameter ID125.
- 412**      *Reverse*      (2.2.5.4)  
Contact open:      Direction forward  
Contact closed:    Direction reverse
- 413**      *Jogging speed*      (2.2.5.16)  
Contact closed:    Jogging speed selected for frequency reference  
See parameter ID124.  
Default programming: A.4.

**414**      *Fault reset*      (2.2.5.10)

Contact closed: All faults are reset.

**415**      *Acceleration/Deceleration prohibited*      (2.2.5.14)

Contact closed: No acceleration or deceleration possible until the contact is opened.

**416**      *DC-braking*      (2.2.5.15)

Contact closed: In STOP mode, the DC braking operates until the contact is opened.

- 417**      *Motor potentiometer DOWN*                      (2.2.5.8)  
Contact closed: Motor potentiometer reference DECREASES until the contact is opened.
- 418**      *Motor potentiometer UP*                              (2.2.5.9)  
Contact closed: Motor potentiometer reference INCREASES until the contact is opened.
- 419**      *Preset speed 1*    (2.2.5.5)  
**420**      *Preset speed 2*    (2.2.5.6)  
**421**      *Preset speed 3*    (2.2.5.7)  
Parameter values are automatically limited between the minimum and maximum frequencies (parameters ID101 and ID102).
- 422**      *AI1/AI2 selection*    (2.2.5.17)  
With this parameter you can select either AI1 or AI2 signal for frequency reference.
- 432**      *Ready*    (2.3.3.1)  
The frequency converter is ready to operate.
- 433**      *Run*    (2.3.3.2)  
The frequency converter operates (the motor is running).
- 434**      *Fault*    (2.3.3.3)  
A fault trip has occurred.  
Default programming: A.1.
- 435**      *Inverted fault*    (2.3.3.4)  
No fault trip has occurred.
- 436**      *Warning*    (2.3.3.5)  
General warning signal.
- 437**      *External fault or warning*                                (2.3.3.6)  
Fault or warning depending on par. ID701.
- 438**      *Reference fault or warning*                                (2.3.3.7)  
Fault or warning depending on parameter ID700.
- 439**      *Overtemperature warning*                                (2.3.3.8)  
The heatsink temperature exceeds +70°C.
- 440**      *Reverse*    (2.3.3.9)  
The Reverse command has been selected.

- 441**      *Unrequested direction*      (2.3.3.10)  
Motor rotation direction is different from the requested one.
- 442**      *At speed*      (2.3.3.11)  
The output frequency has reached the set reference.
- 443**      *Jogging speed*      (2.3.3.12)  
Jogging speed selected.
- 444**      *External control place*      (2.3.3.13)  
Control from I/O terminal selected (Menu **M3**; par. ID125).
- 445**      *External brake control*      (2.3.3.14)  
External brake ON/OFF control with programmable delay. Used in applications where the mechanical brake is released when the brake coil is not energized.
- 446**      *External brake control, inverted*      (2.3.3.15)  
External brake ON/OFF control; Output active when brake control is OFF. Used in applications where the mechanical brake is in duty when voltage is not applied to the brake coil.
- 447**      *Output frequency limit 1 supervision*      (2.3.3.16)  
The output frequency goes outside the set supervision low limit/high limit (see parameters ID315 and ID316)
- 448**      *Output frequency limit 2 supervision*      (2.3.3.17)  
The output frequency goes outside the set supervision low limit/high limit (see parameters ID346 and ID347)
- 449**      *Reference limit supervision*      (2.3.3.18)  
Active reference goes beyond the set supervision low limit/high limit (see parameters ID350 and ID351).
- 450**      *Temperature limit supervision*      (2.3.3.19)  
Frequency converter heatsink temperature goes beyond the set supervision limits (see parameters ID354 and ID355).
- 451**      *Torque limit supervision*      (2.3.3.20)  
The motor torque goes beyond the set supervision limits (see parameters ID348 and ID349).
- 452**      *Motor thermal protection*      (2.3.3.21)  
Motor thermistor initiates a overtemperature signal which can be led to a digital output.
- NOTE: This parameter will not work unless you have Vacon OPT-A3 or OPT-B2 (thermistor relay board) connected.

- 454**      *Motor regulator activation*      (2.3.3.22)  
 Overvoltage or overcurrent regulator has been activated.
- 455**      *Fieldbus input data 1 (FBFixedControlWord, bit 3)*      (2.3.3.23)  
**456**      *Fieldbus input data 2 (FBFixedControlWord, bit 4)*      (2.3.3.24)  
**457**      *Fieldbus input data 3 (FBFixedControlWord, bit 5)*      (2.3.3.25)
- The data from the fieldbus (FBFixedControlWord) can be led to frequency converter digital outputs.
- 463**      *Analogue input supervision limit*      (2.3.3.)  
 The selected analogue input signal goes beyond the set supervision limits (see parameters ID372, ID373 and ID374).
- 464**      *Analogue output 1 signal selection*      (2.3.5.1)  
 Connect the A01 signal to the analogue output of your choice with this parameter. For more information about the TTF programming method, see chapter 5 on page 10.
- 471**      *Analogue output 2 signal selection*      (2.3.6.1)  
 Connect the A02 signal to the analogue output of your choice with this parameter. For more information about the TTF programming method, see chapter 5 on page 10.
- 472**      *Analogue output 2 function*      (2.3.6.2)  
**473**      *Analogue output 2 filter time*      (2.3.6.3)  
**474**      *Analogue output 2 inversion*      (2.3.6.4)  
**475**      *Analogue output 2 minimum*      (2.3.6.5)  
**476**      *Analogue output 2 scaling*      (2.3.6.6)
- For more information on these five parameters, see the corresponding parameters for the analogue output 1 on pages 40 to 42.
- 477**      *Analogue output 2 offset*      (2.3.6.7)  
 Add -100.0 to 100.0% to the analogue output.
- 478**      *Analogue output 3, signal selection*      (2.3.7.1)  
 See ID464.
- 479**      *Analogue output 3, function*      (2.3.7.2)  
 See ID307.
- 480**      *Analogue output 3, filter time*      (2.3.7.3)  
 See ID308.
- 481**      *Analogue output 3 inversion*      (2.3.7.4)  
 See ID309.

**482**      *Analogue output 3 minimum*      (2.3.7.5)

See ID310.

**483**      *Analogue output 3 scaling*      (2.3.7.6)

See ID311.

**484**      *Analogue output 3 offset*      (2.3.7.7)

See ID375.

**485**      *Torque limit*      (2.2.4.2)

See par. ID399 for the selections.

**486**      *Digital output 1 signal selection*      (2.3.1.1)

Connect the delayed DO1 signal to the digital output of your choice with this parameter. For more information about the TTF programming method, see chapter 5 on page 10.

**487**      *Digital output 1 on-delay*      (2.3.1.3)

**488**      *Digital output 1 off-delay*      (2.3.1.4)

With these parameters you can set on- and off-delays to digital outputs.

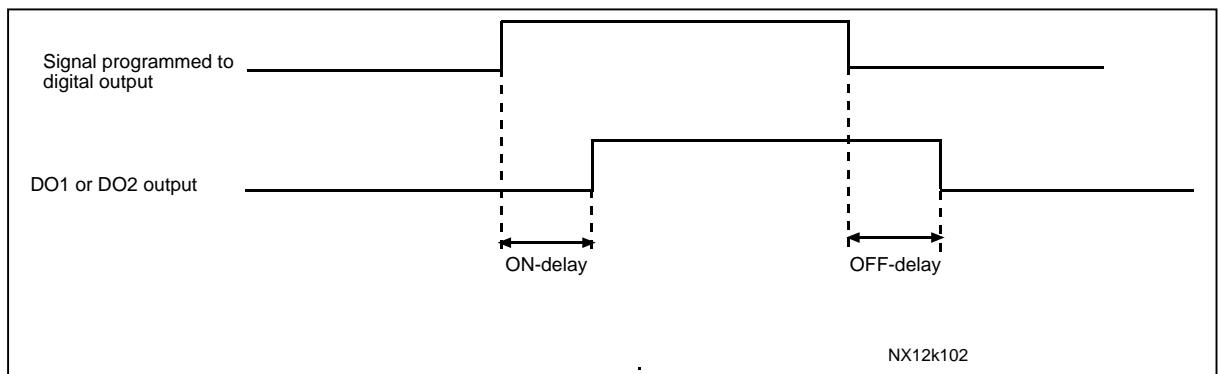


Figure 17. Digital outputs 1 and 2, on- and off-delays

**489**      *Digital output 2 signal selection*      (2.3.2.1)

See ID486.

**490**      *Digital output 2 function*      (2.3.2.2)

See ID312.

**491**      *Digital output 2 on-delay*      (2.3.2.3)

See ID487.

**492**      *Digital output 2 off-delay*      (2.3.2.4)

See ID488.

- 500 *Acceleration/Deceleration ramp 1 shape* (2.4.1)  
 501 *Acceleration/Deceleration ramp 2 shape* (2.4.2)

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 ID103/ID104 (ID502/ID503).

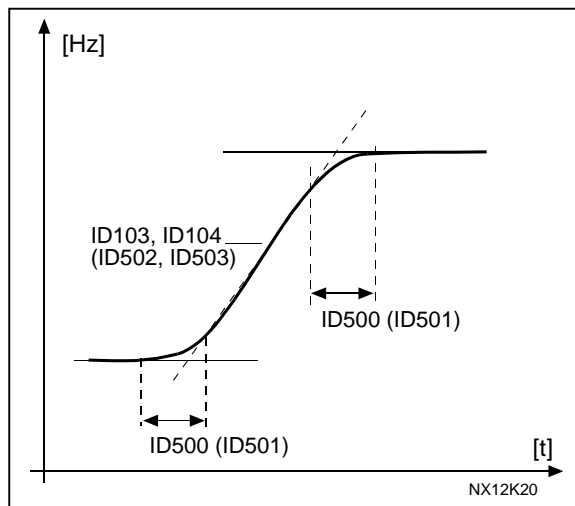


Figure 18. Acceleration/Deceleration (S-shaped)

- 502 *Acceleration time 2* (2.4.3)  
 503 *Deceleration time 2* (2.4.4)

These values correspond to the time required for the output frequency to accelerate from the zero frequency to the set maximum frequency (par. ID102). 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. ID301). See also parameter ID1764.

- 504 *Brake chopper* (2.4.5)

- 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.



**505**      **Start function**                      (2.4.6)

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.

**506**      **Stop function**                              (2.4.7)

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, 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, 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.

**507**      **DC-braking current**                      (2.4.8)

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

508 *DC-braking time at stop*

(2.4.9)

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 ID506.

- 0 DC-brake is not used
- >0 DC-brake is in use and its function depends on the Stop function, (param. ID506). The DC-braking time is determined with this parameter.

**Par. ID506 = 0; Stop function = Coasting:**

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  $\geq$  the nominal frequency of the motor, the set value of parameter ID508 determines the braking time. When the frequency is  $\leq 10\%$  of the nominal, the braking time is 10% of the set value of parameter ID508.

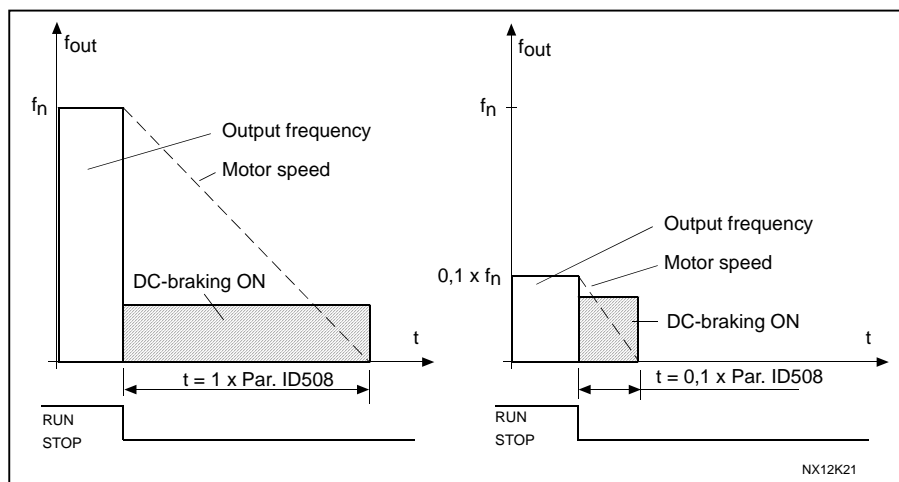


Figure 19. DC-braking time when Stop mode = Coasting.

**Par. ID506 = 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 ID515, where the DC-braking starts.

The braking time is defined with parameter ID508. If high inertia exists, it is recommended to use an external braking resistor for faster deceleration. See Figure 20.

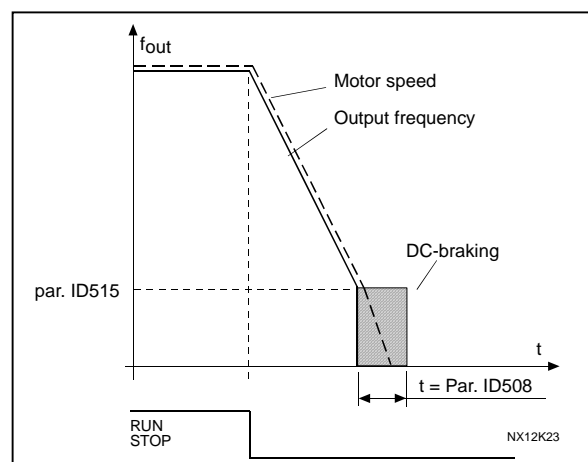


Figure 20. DC-braking time when Stop mode = Ramp

509	<i>Prohibit frequency area 1; Low limit</i>	(2.5.1)
510	<i>Prohibit frequency area 1; High limit</i>	(2.5.2)
511	<i>Prohibit frequency area 2; Low limit</i>	(2.5.3)
512	<i>Prohibit frequency area 2; High limit</i>	(2.5.4)
513	<i>Prohibit frequency area 3; Low limit</i>	(2.5.5)
514	<i>Prohibit frequency area 3; High limit</i>	(2.5.6)

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 21.

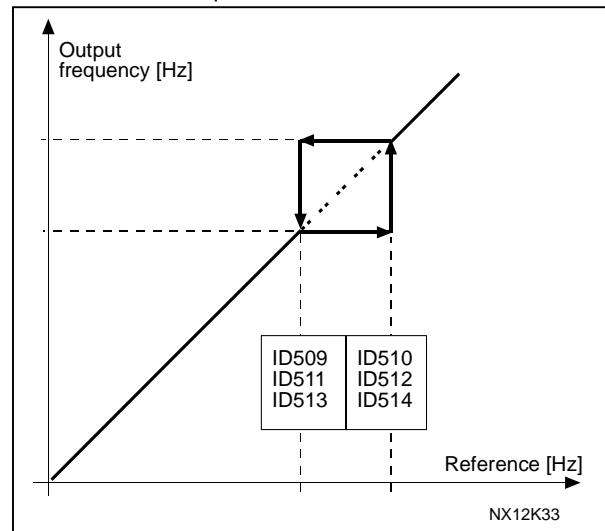


Figure 21. Example of prohibit frequency area setting.

515	<i>DC-braking frequency at stop</i>	(2.4.10)
-----	-------------------------------------	----------

The output frequency at which the DC-braking is applied. See Figure 21.

516	<i>DC-braking time at start</i>	(2.4.11)
-----	---------------------------------	----------

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 ID505.

518	<i>Acceleration/deceleration ramp speed scaling ratio between prohibit frequency limits</i>	(2.5.3, 2.5.7)
-----	---	----------------

Defines the acceleration/deceleration time when the output frequency is between the selected prohibit frequency range limits (parameters ID509 and ID510). 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.

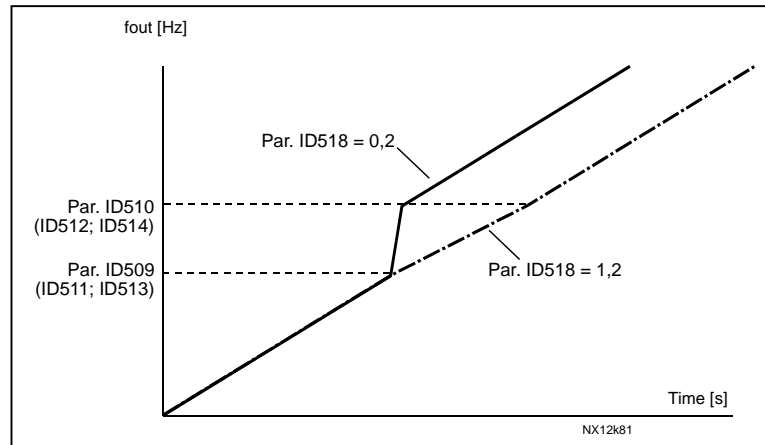


Figure 22. Ramp speed scaling between prohibit frequencies

**519**      **Flux braking current**      (2.4.13)

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

**520**      **Flux brake**      (2.4.12)

Instead of DC braking, flux braking is a useful way to raise the braking capacity in cases where additional brake resistors are not needed. When braking is needed, the frequency is reduced and the flux in the motor is increased, which in turn increases the motor's capability to brake. Unlike DC braking, the motor speed remains controlled during braking.

The flux braking can be set ON or OFF.

0 = Flux braking OFF  
1 = Flux braking ON

**Note:** Flux braking converts the energy into heat at the motor, and should be used intermittently to avoid motor damage.

**521**      **Motor control mode 2**      (2.5.12)

With this parameter you can set another motor control mode. Which mode is used is determined with parameter ID164. For the selections, see parameter ID600.

**600 Motor control mode** (2.5.1)**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  $\pm 0,5\%$ ).
- 2 Torque control In torque control mode, the references are used to control the motor torque.
- 3 Speed ctrl (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  $\pm 0.01\%$ ).
- 4 Torque ctrl (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.

**601 Switching frequency** (2.5.9)

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 35. Size-dependent switching frequencies

**602 Field weakening point** (2.5.4)

The field weakening point is the output frequency at which the output voltage reaches the set (ID603) maximum value.

- 603**      *Voltage at field weakening point*      (2.5.5)  
 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 ID109, ID108, ID604 and ID605.  
 When the parameters ID110 and ID111 (nominal voltage and nominal frequency of the motor) are set, the parameters ID602 and ID603 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 ID110 and ID111.
- 604**      *U/f curve, middle point frequency*      (2.5.6)  
 If the programmable U/f curve has been selected with parameter ID108 this parameter defines the middle point frequency of the curve. See Figure 3.
- 605**      *U/f curve, middle point voltage*      (2.5.7)  
 If the programmable U/f curve has been selected with the parameter ID108 this parameter defines the middle point voltage of the curve. See Figure 3.
- 606**      *Output voltage at zero frequency*      (2.5.8)  
 If the programmable U/f curve has been selected with the parameter ID108 this parameter defines the zero frequency voltage of the curve. NOTE: If the value of parameter ID108 is changed this parameter is set to zero. See Figure 3.
- 607**      *Overvoltage controller*      (2.5.10)  
 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.
- 608**      *Undervoltage controller*      (2.5.11)  
 See par. ID607.  
**Note:** Over-/undervoltage trips may occur when controllers are switched out of operation.  
 0 Controller switched off  
 1 Controller switched on
- 609**      *Torque limit*      (2.8.1)  
 With this parameter you can set the torque limit control between 0.0 – 400.0 %.
- 610**      *Torque limit control P-gain*      (2.8.2)  
 This parameter defines the gain of the torque limit controller. It is used in Open Loop control mode only.

- 611**      ***Torque limit control I-gain***      (2.8.3)  
This parameter determines the I-gain of the torque limit controller. It is used in Open Loop control mode only.
- 612**      ***CL: Magnetizing current***      (2.5.18.1)  
Set here the motor magnetizing current (no-load current). See chapter 9.1.
- 613**      ***CL: Speed control P gain***      (2.5.18.2)  
Sets the gain for the speed controller in % per Hz. See chapter 9.1.
- 614**      ***CL: Speed control I time***      (2.5.18.3)  
Sets the integral time constant for the speed controller. Increasing the I-time increases stability but lengthens the speed response time. See chapter 9.1.
- 615**      ***CL: Zero speed time at start***      (2.5.18.9)  
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. See chapter 9.1.
- 616**      ***CL: Zero speed time at stop***      (2.5.18.10)  
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 (ID506) is *Coasting*. See chapter 9.1.
- 617**      ***CL: Current control P gain***      (2.5.18.15)  
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. See chapter 9.1.
- 618**      ***CL: Encoder filter time***      (2.5.18.14)  
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. See chapter 9.1.
- 619**      ***CL: Slip adjust***      (2.5.18.6)  
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. See chapter 9.1.
- 620**      ***Load drooping***      (2.5.15)  
The drooping function enables speed drop as a function of load. This parameter sets that amount corresponding to the nominal torque of the motor.

- 621**      *CL: Startup torque*      (2.6.18.11)
- 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. See chapter 9.1.  
0 = Not Used  
1 = TorqMemory  
2 = Torque Ref  
3 = Torq.Fwd/Rev
- 626**      *CL: Acceleration compensation*      (2.6.18.5)
- 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.
- 627**      *CL: Magnetizing current at start*      (2.6.18.7)
- 628**      *CL: Magnetizing time at start*      (2.6.18.8)
- Set here the rise time of magnetizing current.
- 631**      *Identification*      (2.5.16)
- Identification Run is a part of tuning the motor and the drive specific parameters. It is a tool for commissioning and service of the drive with the aim to find as good parameter values as possible for most drives. The automatic motor identification calculates or measures the motor parameters that are needed for optimum motor and speed control.
- 0 = No action  
No identification requested.
- 1 = Identification without motor run  
The drive is run without speed to identify the motor parameters. The motor is supplied with current and voltage but with zero frequency.
- 2 = Identification with motor run  
The drive is run with speed to identify the motor parameters.  
**Note:** It is recommended to do the this identification test with no load on the motor for best results.
- The basic motor name plate data has to be set correctly before performing the identification run:
- ID110*    *Nominal voltage of the motor (par. 2.1.6)*
  - ID111*    *Nominal frequency of the motor (par. 2.1.7)*
  - ID112*    *Nominal speed of the motor (par. 2.1.8)*
  - ID113*    *Nominal current of the motor (par. 2.1.9)*
  - ID120*    *Motor cos phi (par. 2.1.10)*
- When in closed loop and with an encoder installed, also the parameter for pulses / revolutions (in Menu M7) has to be set.



The automatic identification is activated by setting this parameter to the appropriate value followed by a start command in the requested direction. The start command to the drive has to be given within 20 s. If no start command is given within 20 s the identification run is cancelled and the parameter will be reset to its default setting. The identification run can be stopped any time with normal stop command and the parameter is reset to its default setting. In case identification run detects fault or other problems, the identification run is completed if possible. After the identification is finished, the application checks the status of the identification and generates fault/ warning if any. During Identification Run, the brake control is disabled (see chapter **Error! Reference source not found.**).

3 = Encoder identification run

For PMS motor drive will make angle identification run when absolute encoder is in use.

4 = No Action

5 = Identification failed

- 633**      *CL: Start-up torque, forward*      (2.5.18.12)  
Sets the start-up torque for forward direction if selected with par. ID621.
- 634**      *CL: Start-up torque, reverse*      (2.5.18.13)  
Sets the start-up torque for reverse direction if selected with par. ID621.
- 636**      *Minimum frequency for Open Loop torque control*      (2.8.8)  
Defines the frequency limit below which the frequency converter operates in *frequency control mode*.  
Because of the nominal slip of the motor, the internal torque calculation is inaccurate at low speeds where is it recommended to use the frequency control mode.
- 637**      *Speed controller P gain, Open Loop*      (2.5.13)  
Defines the P gain for the speed controlled in Open Loop control mode.
- 638**      *Speed controller I gain, Open Loop*      (2.5.14)  
Defines the I gain for the speed controlled in Open Loop control mode.
- 639**      *Torque controller P gain*      (2.8.9)  
Defines the P gain of the torque controller.
- 640**      *Torque controller I gain*      (2.8.10)  
Defines the I gain of the torque controller.

- 641**      *Torque reference selection*      (2.8.4)  
 Defines the source for torque reference.  
 0 Not used  
 1 Analogue input 1  
 2 Analogue input 2  
 3 Analogue input 3  
 4 Analogue input 4  
 5 Analogue input 1 (joystick)  
 6 Analogue input 2 (joystick)  
 7 From keypad, parameter R3.5  
 8 Fieldbus
- 642**      *Torque reference scaling, maximum value*      (2.8.5)  
**643**      *Torque reference scaling, minimum value*      (2.8.6)  
 Scale the custom minimum and maximum levels for analogue inputs within -300,0...300,0%.
- 644**      *Torque speed limit*      (2.8.7)  
 With this parameter the maximum frequency for the torque control can be selected.  
 0 Maximum frequency, par. ID102  
 1 Selected frequency reference  
 2 Preset speed 7, par. ID130
- 649**      *PMS motor shaft position*      (2.5.19.4)  
 Identified shaft position. Updated when making encoder identification.
- 650**      *Motor type*      (2.5.19.1)  
 Selection of motor type, drive must be in stop state to edit.  
 0 Asynchronous induction motor  
 1 Permanent magnet synchronous motor (“AC brushless”) control
- 651**      *Flux current Kp*      (2.5.19.2)  
 Defines the gain for the flux current controller when a PMS motor is used.
- 652**      *Flux current Ti*      (2.5.19.3)  
 Defines the integration time for the flux current controller when a PMS motor is used.
- 654**      *Enable Rs identification*      (2.5.19.5)  
 With this parameter its possible to disable Rs identification during DC brake start.
- 655**      *Modulator index limit*      (2.5.19.6)  
 Defines used voltage ration in field weakening area with PMS motors
- 662**      *Rs voltage drop*      (2.5.17)  
 Measured Voltage drop at stator resistanse between two phases with nom current of motor.

- 700**      *Response to the 4mA reference fault*      (2.6.1)
- 0 = No response  
1 = Warning  
2 = Warning, the frequency from 10 seconds back is set as reference  
3 = Warning, the Preset Frequency (Par. ID728) is set as reference  
4 = Fault, stop mode after fault according to ID506  
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.
- 701**      *Response to external fault*      (2.6.3)
- 0 = No response  
1 = Warning  
2 = Fault, stop mode after fault according to ID506  
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.
- 702**      *Output phase supervision*      (2.6.6)
- 0 = No response  
1 = Warning  
2 = Fault, stop mode after fault according to ID506  
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.
- 703**      *Earth fault protection*      (2.6.7)
- 0 = No response  
1 = Warning  
2 = Fault, stop mode after fault according to ID506  
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.
- 704**      *Motor thermal protection*      (2.6.8)
- 0 = No response  
1 = Warning  
2 = Fault, stop mode after fault according to ID506  
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%. See chapter 9.2.

**705**      *Motor thermal protection: Motor ambient temp. factor*      (2.6.9)

The factor can be set between -100.0%—100.0%. See chapter 9.2.

**706**      *Motor thermal protection: Motor cooling factor at zero speed*      (2.6.10)

The current can be set between 0—150.0%  $\times I_{nMotor}$ . This parameter sets the value for thermal current at zero frequency. See Figure 23.

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, par. ID113 (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 ID107 alone. See chapter 9.2.

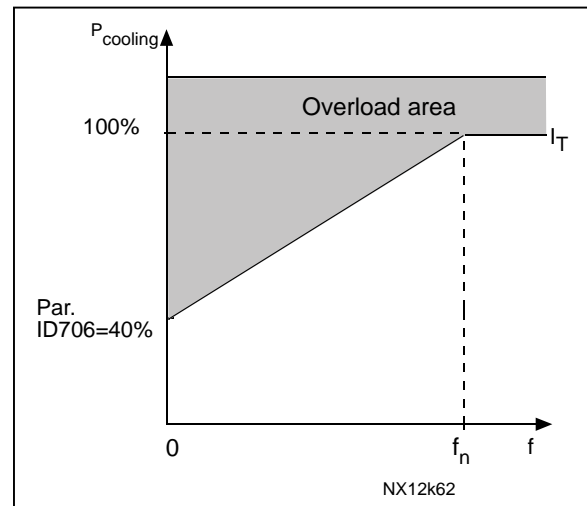


Figure 23. Motor thermal current  $I_T$  curve

**707**      *Motor thermal protection: Time constant*      (2.6.11)

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  $t_6$ -time ( $t_6$  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  $2 \times t_6$ . 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 24.

**708 Motor thermal protection: Motor duty cycle** (2.6.12)

Defines how much of the nominal motor load is applied. The value can be set to 0%...100%. See chapter 9.2.

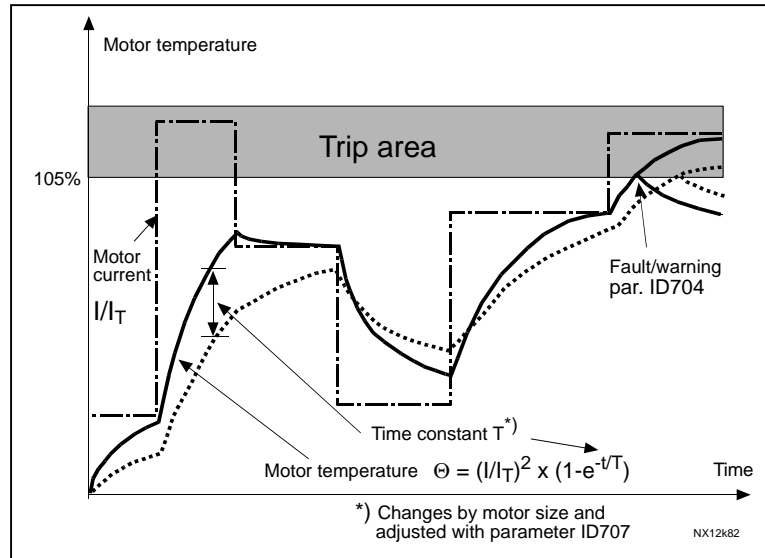


Figure 24. Motor temperature calculation

**709 Stall protection** (2.6.13)

- 0 = No response
- 1 = Warning
- 2 = Fault, stop mode after fault according to ID506
- 3 = Fault, stop mode after fault always by coasting

Setting the parameter to **0** will deactivate the protection and reset the stall time counter. See chapter 9.3.

**710 Stall current limit** (2.6.14)

The current can be set to  $0.1 \dots I_{nMotor} * 2$ . For a stall stage to occur, the current must have exceeded this limit. See Figure 25. The software does not allow entering a greater value than  $I_{nMotor} * 2$ . If parameter ID113 *Nominal current of motor* is changed, this parameter is automatically restored to the default value ( $I_L$ ). See chapter 9.3.

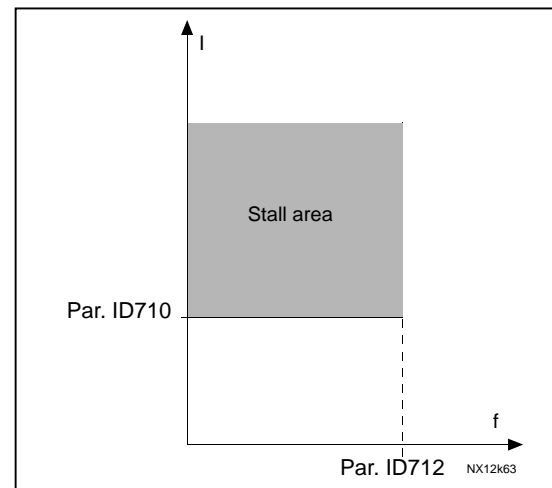


Figure 25. Stall characteristics settings

**711 Stall time** (2.6.15)

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 ID709). See chapter 9.3.

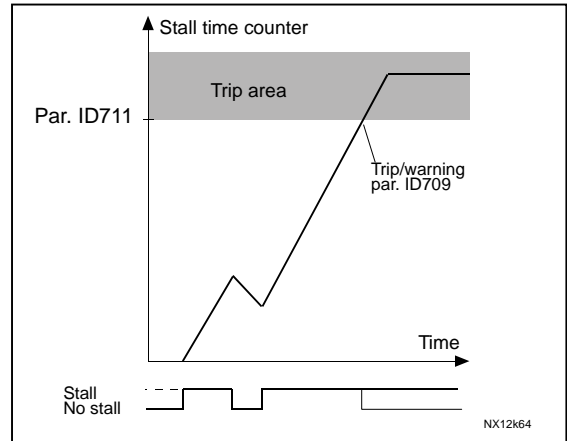


Figure 26. Stall time count

**712 Stall frequency limit** (2.6.16)

The frequency can be set between  $1-f_{max}$  (ID102).  
 For a stall state to occur, the output frequency must have remained below this limit. See chapter 9.3.

**717 Automatic restart: Wait time** (2.8.1)

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

**718 Automatic restart: Trial time** (2.8.2)

The Automatic restart function restarts the frequency converter when the faults selected with parameters ID720 to ID725 have disappeared and the waiting time has elapsed.

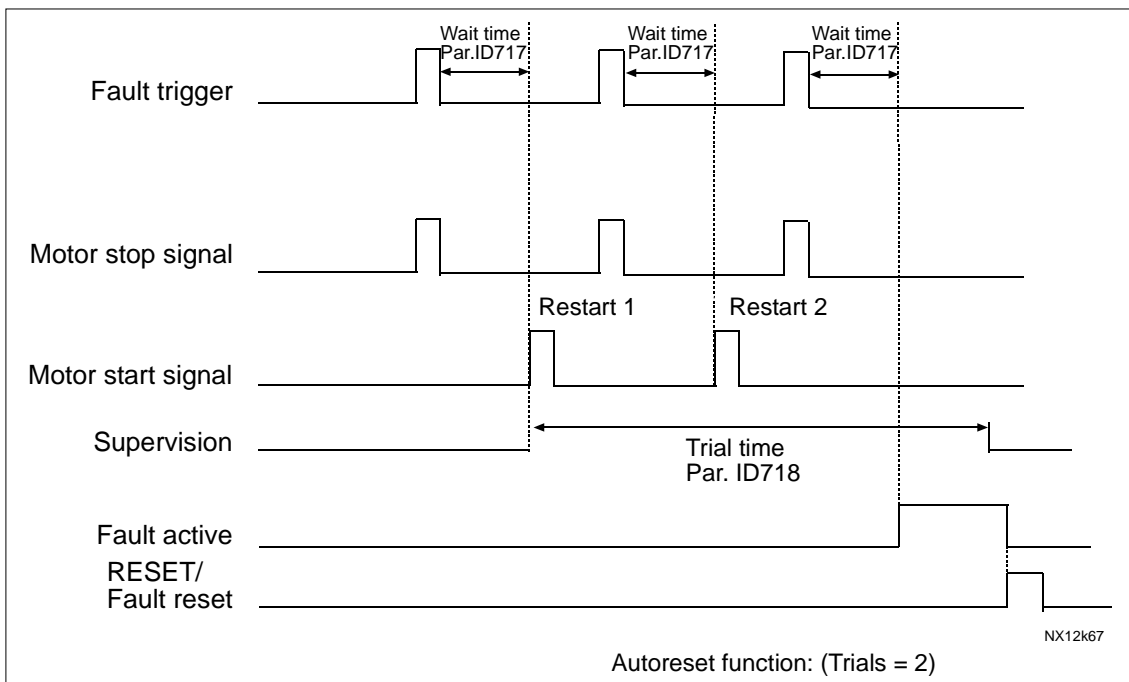


Figure 27. Example of Automatic restarts with two restarts

Parameters ID720 to ID725 determine the maximum number of automatic restarts during the trial time set by parameter ID718. The time count starts from the first autorestart. If the number of faults occurring during the trial time exceeds the values of parameters ID720 to ID725 the fault state becomes active. Otherwise the fault is cleared after the trial time has elapsed and the next fault start the trial time count again.

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

**719**      ***Automatic restart: Start function***      (2.8.3)

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 ID505

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

This parameter determines how many automatic restarts can be made during the trial time set by parameter ID718 after an undervoltage trip.

- 0 = No automatic restart
- >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.

**721**      ***Automatic restart: Number of tries after overvoltage trip***      (2.8.5)

This parameter determines how many automatic restarts can be made during the trial time set by parameter ID718 after an overvoltage trip.

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

**722**      ***Automatic restart: Number of tries after overcurrent trip***      (2.8.6)

(NOTE! IGBT temp fault also included)

This parameter determines how many automatic restarts can be made during the trial time set by ID718.

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

**723**      ***Automatic restart: Number of tries after reference trip***      (2.8.7)

This parameter determines how many automatic restarts can be made during the trial time set by ID718.

- 0 = No automatic restart after reference fault trip
- >0 = Number of automatic restarts after the analogue current signal (4...20mA) has returned to the normal level ( $\geq 4$ mA)

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

This parameter determines how many automatics restarts can be made during the trial time set by ID718.

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

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

This parameter determines how many automatics restarts can be made during the trial time set by ID718.

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

**727 Response to undervoltage fault** (2.6.5)

- 0 = Fault stored in fault history
- 1 = Fault not stored in fault history

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

**728 4mA reference fault: preset frequency reference** (2.6.2)

If the value of parameter ID700 is set to 3 and the 4mA fault occurs then the frequency reference to the motor is the value of this parameter.

**730 Input phase supervision** (2.6.4)

- 0 = No response
- 1 = Warning
- 2 = Fault, stop mode after fault according to ID506
- 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.

**731 Automatic restart** 1 (2.20)

The Automatic restart is taken into use with this parameter.

- 0 = Disabled
- 1 = Enabled

The function resets the following faults (max. three times) (see Vacon NX User's Manual, Chapter 9):

- Overcurrent (F1)
- Overvoltage (F2)
- Undervoltage (F9)
- Frequency converter overtemperature (F14)
- Motor overtemperature (F16)
- Reference fault (F50)



- 732**      *Response to thermistor fault*                      (2.6.17)
- 0 = No response  
 1 = Warning  
 2 = Fault, stop mode after fault according to ID506  
 3 = Fault, stop mode after fault always by coasting
- Setting the parameter to 0 will deactivate the protection.
- 733**      *Response to fieldbus fault*                      (2.6.18)
- 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 ID732.
- 734**      *Response to slot fault*                      (2.6.19)
- Set here the response mode for a board slot fault due to missing or broken board.
- See parameter ID732.
- 738**      *Automatic restart: Number of tries after underload fault trip*      (2.8.10)
- This parameter determines how many automatic restarts can be made during the trial time set by parameter ID718.
- 0        = No automatic restart after Underload fault trip  
 >0      = Number of automatic restarts after Underload fault trip
- 739**      *Number of PT100 inputs in use*                      (2.7.24)
- If you have a PT100 input board installed in your frequency converter you can choose here the number of PT100 inputs in use. See also the Vacon I/O boards manual.  
**Note:** If the selected value is greater than the actual number of used PT100 inputs, the display will read 200°C. If the input is short-circuited the displayed value is -30°C.
- 740**      *Response to PT100 fault*                      (2.7.25)
- 0 = No response  
 1 = Warning  
 2 = Fault, stop mode after fault according to ID506  
 3 = Fault, stop mode after fault always by coasting
- 741**      *PT100 warning limit*                      (2.7.26)
- Set here the limit at which the PT100 warning will be activated.
- 742**      *PT100 fault limit*                      (2.7.27)
- Set here the limit at which the PT100 fault (F56) will be activated.

**850**      *Fieldbus reference minimum scaling*      (2.9.1)

**851**      *Fieldbus reference maximum scaling*      (2.9.2)

Use these two parameters to scale the fieldbus reference signal.

Setting value limits:  $0 \leq \text{par. ID850} \leq \text{par. ID851} \leq \text{ID102}$ . If par. ID851 = 0 custom scaling is not used and the minimum and maximum frequencies are used for scaling.

The scaling takes place as presented in Figure 7. See also chapter 9.4.

**Note:** Using this custom scaling function also affects the scaling of the actual value.

**852 to  
859**

*Fieldbus data out selections 1 to 8*      (2.7.1 to 2.7.9)

Using these parameters, you can monitor any monitoring or parameter value from the fieldbus. Enter the ID number of the item you wish to monitor for the value of these parameters. See additional description for Shaft synchronization ID1740.

**852**      *Fieldbus data out selection 1*      (2.7.1)

Selector for output variable to be mapped to process data 1 output channel. Selection is made assigning the ID value of the variable among those listed in table 4. Only variables allocating 1 channel can be selected.

**Note:** To avoid channel allocation conflict, when using ID852 and ID853, parameter ID1740 for dual channel transfer must be set to 0.

**853**      *Fieldbus data out selection 2*      (2.7.2)

Selector for output variable to be mapped to process data 2 output channel. Selection method same as with ID852.

**Note:** to avoid channel allocation conflict, when using ID852 and ID853, parameter ID1740 for dual channel transfer must be set to 0.

**854**      *Fieldbus data out selection 3*      (2.7.3)

Selector for output variable to be mapped to process data 3 output channel. Selection method same as with ID852.

**855**      *Fieldbus data out selection 4*      (2.7.4)

Selector for output variable to be mapped to process data 4 output channel. Selection method same as with ID852.

**856**      *Fieldbus data out selection 5*      (2.7.5)

Selector for output variable to be mapped to process data 5 output channel. Selection method same as with ID852.

**857**      *Fieldbus data out selection 6*      (2.7.6)

Selector for output variable to be mapped to process data 6 output channel. Selection method same as with ID852.

**858**      *Fieldbus data out selection 7*      (2.7.7)

Selector for output variable to be mapped to process data 7 output channel. Selection method same as with ID852.

859 *Fieldbus data out selection 8* (2.7.8)

Selector for output variable to be mapped to process data 8 output channel. Selection method same as with ID852.

Some typical values:

1	Output frequency	15	Digital inputs 1,2,3 statuses
2	Motor speed	16	Digital inputs 4,5,6 statuses
3	Motor current	17	Digital and relay output statuses
4	Motor torque	25	Frequency reference
5	Motor power	26	Analogue output current
6	Motor voltage	27	AI3
7	DC link voltage	28	AI4
8	Unit temperature	31	A01 (expander board)
9	Motor temperature	32	A02 (expander board)
13	AI1	37	Active fault 1
14	AI2	45	Motor current (drive independent) given with one decimal point

Table 36.

Application-specific variables			
# of required channels to allocate	ID	Variable	Resolution
2	1702	High resolution position error	65536 counts = 1 engineering unit [u]
1	1703	Shaft synchronization status register	
2	1700	Actual electric gear ratio	1 count = $1/2^{16}$ 65536 counts = unity ratio
1	1701	Position error	1 engineering unit [u]
1	45	Motor current, fixed resolution	0.1 A
High dynamics diagnostic variables			
# of required channels to allocate	ID	Variable	Resolution
1	37	Last active fault code	
1	1113	Unfiltered motor current	Size dependent, same as monitor variable
1	1125	Unfiltered motor torque	0.1% of motor nominal torque
1	44	Unfiltered dc voltage	1 V
1	43	Motor control status word	
Monitor variables			
1	1	Output frequency	0.01 Hz
1	25	Frequency reference	0.01 Hz
1	2	Motor speed	1 rpm
1	3	Filtered motor current	Size dependent
1	4	Filtered motor torque	0.1% of motor nominal torque

1	5	Motor power	0.1% of motor nominal power
1	6	Motor voltage	0.1 V
1	7	DC link voltage	1 V
1	8	Unit temperature	1 °C
1	9	Motor temperature	1 % of nominal overtemperature
1	13	Analogue input 1	1 count = 1/10000 of range, conversion resolution 10 bit
1	14	Analogue input 2	1 count = 1/10000 of range, conversion resolution 10 bit
1	15	$DIN1*2^0 + DIN2*2^1 + DIN3*2^2$	
1	16	$DIN4*2^0 + DIN5*2^1 + DIN6*2^2$	
1	26	Analog out	2000 count at full scale
1	18	Torque reference	0.1 %

Table 37. Output variables for use with process data outputs

#### 1401 **Stop State Flux** (P2.5.18.19)

The amount of flux as a percentage of the motor nominal flux maintained in the motor after the drive is stopped. The flux is maintained for the time set by parameter ID1402. This parameter can be used in closed loop motor control mode only.

#### 1402 **Flux Off Delay** (P2.5.18.20)

The flux defined by parameter ID1401 is maintained in the motor for the set time after the drive is stopped.

- 0 No flux after the motor is stopped.
- >0 The flux off delay in seconds.
- <0 The flux is maintained in the motor after stop until the next Run request is given to the drive.

**NOTE:** Using of stop state flux is useful when there is a large motor which has a relative long magnetizing time and the motor is started frequently (inching). Then the motor is already magnetized and ready to run.

**1515**      *Power unit serial number key*      (V2.10.2)

Monitoring value for power unit serial number key

This application software (the shaft synchronization mode) is protected by an individual license key tied to the power unit serial number of the drive on which it is installed.

The unit will work in the multi-purpose mode only, until the right license key has been set by parameter P2.10.1. (Possible to run in Shaft Synchronization mode 2 weeks without license key during Trial Time)

Please request the appropriate key of your Vacon representative according to your license agreement. The data you shall specify to obtain your key are

- the frequency converter serial number and, in case the unit is restarted after replacing power unit or power card
- the value of this parameter *PowerUnitSerNoKey* that you can read after ID1694 in the same submenu.

Enter the key in P2.10.1 and the unit will then be ready for use in shaft synchronization mode. After setting the right key, P2.10.1 will automatically lock to prevent accidental corruption of the value. When downloading a set of parameters using the NCDrive PC tool, a write error on this parameter may occur. This is normal and will not affect the operation of the downloaded parameter set.

*Parameters for mechanical brake control*

- 1535**      *Freq Limit brake open, OL*                      (2.3.8.3)  
 Frequency limit for brake open in open loop control.  
 Frequency reference is also limited to this value until brake is opened
- 1539**      *Close Freq Limit*                                      (2.3.8.7)  
 Frequency limit for brake close enable.  
 Brake close delay ID1541 starts to count when stop command is given and the frequency is ramped down to this limit.
- 1541**      *Brake close delay*                                      (2.3.8.8)  
 Delay time for brake close after close frequency limit given by ID1539 is reached. This parameter is normally set to 0,00 s.
- 1544**      *Brake reaction time*                                      (2.3.8.6)  
 Set the physical reaction time for the mechanical brake by this parameter.  
 Waits this time before the reference is released after brake is commanded to open.
- NOTE:** This parameter has no influence if an digital input is programmed for brake open acknowledgement. See P2.2.5.24.
- 1550**      *Mechanical brake used*                                      (2.3.8.1)  
 Set this parameter to 1 when there is a mechanical brake in the system.  
 Then the frequency reference will be limited to ID1535/ID1553 until brake is opened.
- 1551**      *Current limit open*                                      (2.3.8.2)  
 Motor current has to exceed this limit to enable brake open.
- 1553**      *Freq Limit open, CL*                                      (2.3.8.4)  
 Frequency limit for brake open in closed loop control.  
 Frequency reference is also limited to this value until brake is opened  
 This parameter is normally set to 0.
- 1554**      *Brake open delay*                                      (2.3.8.5)  
 Delay time for brake open after open conditions are fulfilled (current and frequency limits)  
 In closed loop the internal variable Rotor flux ready is also required for brake open.  
 The mechanical brake is commanded to open after this delay time has expired.

**1555** *KpF1 speed threshold* (2.5.18.16)

Frequency threshold for transition to normal speed regulator gain, see Figure 28.

**1556** *KpF0 speed threshold* (2.5.18.17)

Frequency threshold for transition to low speed regulator gain, see Figure 28.

**1557** *%Kp speed regulator @ F0* (2.5.18.18)

Speed regulator gain at low speed, as a percentage of normal gain (P2.5.17.2 Speed control Kp, ID 613). See figure 1. A reduced gain at low speed/standstill avoids vibration when using incremental encoders or resolvers. Resulting gain should be lower than 20 when frequency is lower than a value that depends on encoder pulses/rev. Some recommended figures are given in Table 38.

Encoder pulses/rev	Motor poles	Critical speed	Recommended value KpF0	Recommended value KpF1
256 or resolver with 10 bit conversion	4	60 rpm	2 Hz	4 Hz
1024 or resolver with 12 bit conversion	4	15 rpm	0.5 Hz	1 Hz
1024	2	15 rpm	0.25 Hz	0.5 Hz
4096	4	4 rpm	0.13 Hz	0.25 Hz

Table 38. Recommended gain scheduling parameters for example data cases

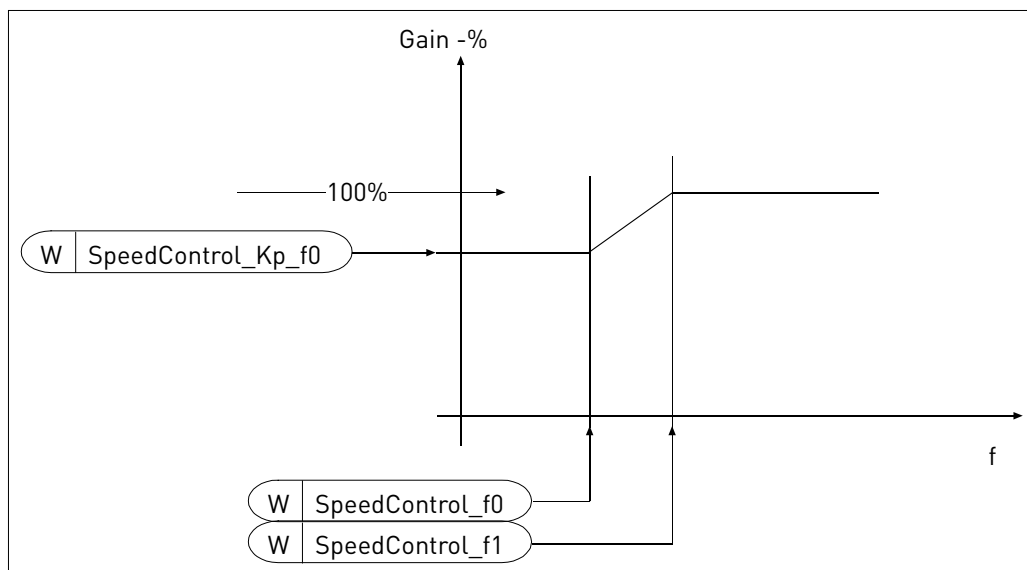


Figure 28. Scheduling of speed regulator gain at low speed

**1602** *Brake Opened Acknowledgement* (2.2.5.24)

By using this input the frequency reference is released when this input goes high. The brake mechanical delay given by P2.3.8.6 is used for releasing of reference if this input is not used.

**1680** *Torque reference selection* (2.7.12)

Selector that maps the Torque reference to one process data input channel. Values the same as in ID1742.

- 1681**      *Free signal selection*      (2.7.13)  
 Selector that maps “Free analog input” to one process data input channel. Use of “Free analogue input” is determined by parameters ID399 and ID485. Values the same as in ID1742.
- 1694**      *License key*      (2.10.1)  
 Correct license key is needed to enable the shaft synchronization mode when the two weeks free Trial Time has expired.  
 It is only possible to run multi-purpose functions without a correct license key after trial time is over.  
**NOTE:** If wrong license has been set 3 times or more the drive has to be power cycled.
- 1710**      *Shaft synchronization enable*      (2.2.5.19)  
 Digital input selection format  
 Selects the source of signal for Shaft synchronization mode general enable.  
 Set to value “DigIn:0.2” if shaft synchronization mode must be permanently enabled.  
 In disable mode the multi-purpose commands are in use.  
  
 If fieldbus control is used the Shaft synchronization is enabled from the fieldbus control word (selected by P2.7.11). See table 39.
- 1711**      *SyncModeBit0*      (2.2.5.20)  
 Selector of digital input for Bit 0 of Synchronization mode command. See Table 39.
- 1712**      *SyncModeBit1*      (2.2.5.21)  
 Selector of digital input for bit 1 of Synchronization Mode command. See Table 39.
- | Sync Mode bit 1 | Sync Mode bit 0 | Action  |
|-----------------|-----------------|---|
| 0               | 0               | Release synchronization   |
| 0               | 1               | Engage synchronization  |
| 1               | 0               | Use reference speed given from selected reference place.                              |
| 1               | 1               | Freeze follower speed. Only possible when synchronization is engaged to master speed. |
- Table 39. Synchronization mode command bits*
- 1713**      *Synchronization trim +*      (2.2.5.22)  
 Selector of digital input for Trim + command.  
 The ratio is temporarily changed by the trim ratio change in % specified by parameter P2.9.2.11. The follower speed will increase.
- 1714**      *Synchronization trim -*      (2.2.5.23)  
 Selector of digital input for trim - command.  
 The ratio is temporarily changed by the trim ratio change in % specified by parameter P2.9.2.11. The follower speed will decrease.



- 1716**     *Sel PosPhasing*
- Selection of digital input for positive phasing command. In fieldbus control bit 3 in the fieldbus control word selected by P2.7.11 (default Process data in1) is used for a positive phasing command. The phasing distance is set by P2.9.3.1 in user units (u).
- 1717**     *Sel NegPhasing*
- Selection of digital input for negative phasing command. Same as ID 1716 but in negative direction. In fieldbus control bit 4 in the fieldbus control word selected by P2.7.11 (default Process data in1) is used for a negative phasing command.
- 1720**     *Synchronization engaged*     (2.3.3.28)
- Selector of digital or relay output for the “Synchronization engaged” signal. This supervision signal indicates that the follower drive has achieved space synchronization to the master reference (See Diagram 3).
- 1721**     *Ratio changing*     (2.3.3.29)
- Selector of digital or relay output for the “Ratio changing” signal. This supervision signal indicates that the ratio of the follower drive synchronization to the master speed is changing. This occurs after a new ratio value has been set (either from parameter or fieldbus) and the control is still ramping the ratio to the new value.
- 1722**     *External brake opened*     (2.3.3.30)
- Selection of digital output for indication that mechanical brake is fully open. This output can be connected to other drive (Master) for releasing of the reference when follower drive is ready to run.
- 1730**     *Position error F R*     (2.6.20)
- Response to position error fault  
 0= No action  
 1= Warning  
 2= Fault, stop mode based on P2.4.7 Stop function  
 3= Fault, coast
- 1731**     *Position error threshold*     (2.6.21)
- Position threshold for position error fault supervision  
 65536 counts = 1 engineering space unit [u].  
 Default value is 3932160 = 60 [u]. Range is 0 thru  $2^{31}-1$ .  
 The actual position of the follower drive is monitored with a symmetrical error band of +/- P2.6.21 around the reference position.
- 1732**     *Power unit temperature sensor supervision*
- The temperature supervision of the power unit can be disabled by setting this parameter to 1.

- 1733**     *Encoder supervision*                      (2.6.23)  
Encoder fault software mode supervision  
0= Enabled  
1= Disabled  
Encoder fault supervision is based on hardware detection of missing individual signals plus a software supervision that can detect if a cable is disconnected. Software supervision may cause nuisance trips if the drive runs against the current limit at standstill. For the special cases when this action is required, the software supervision functionality can be disabled.
- 1734**     *Lock response*                              (2.6.24)  
Response to the lock error fault. **Only used in closed loop control.**  
0= No action  
1= Warning  
2= Fault, stop mode based on P2.4.7 Stop function  
3= Fault, coast
- 1735**     *Lock frequency difference*                (2.6.25)  
Allowed maximum difference between output frequency and the encoder feedback frequency. The lock fault delay time given by ID1736 starts to count if the frequency difference exceeds this parameter value.
- 1736**     *Lock Fault Delay*                              (2.6.26)  
If freq. difference is higher than ID1735 in this time the lock fault is triggered.
- 1740**     *FB Data Out 1 and 2 Sel*                      (2.7.9)  
Selector for output variable to be mapped to process data 1 and 2 output channels. Data transfer of the two words is guaranteed coherent in time. Selection is made assigning the ID value of the variable among those listed in Table 37. Only variables allocating 2 channels can be selected.  
**Note:** To avoid channel allocation conflict, when using dual channel transfer of a 32 bit variable, the parameters ID852 and ID853 must be set to 0.
- 1741**     *Synchronization ratio register selection*                (2.7.10)  
Selector that maps Ratio reference to two process data input channels. Data transfer of the two words is guaranteed coherent in time.  
Used for changing of the electrical gear ratio between Master/Follower. It is possible to change the ratio during run in order to fine adjust the ratio.  
0 PD0 low + PD1 high; low part on PD0, high part on PD1  
1 PD1 low + PD2 high; low part on PD1, high part on PD2  
2 PD2 low + PD3 high; low part on PD2, high part on PD3  
3 PD3 low + PD4 high; low part on PD3, high part on PD4  
4 PD4 low + PD5 high; low part on PD4, high part on PD5  
5 PD5 low + PD6 high; low part on PD5, high part on PD6  
6 PD6 low + PD7 high; low part on PD6, high part on PD7  
7 PD7 low + PD8 high; low part on PD7, high part on PD8

- 1742**      *Shaft synchronization control register selection*      (2.7.11)  
 Selector that maps shaft synchronization control register to one process data input channel. See table 39.  
 Values:  
 0 PD0  
 1 PD1  
 2 PD2  
 3 PD3  
 4 PD4  
 5 PD5  
 6 PD6  
 7 PD7  
 8 PD8
- 1750**      *Master distance*      (2.9.1.1)  
 Number of engineering units [u] corresponding to the number of motor shaft turns specified by ID1752 and ID1753 for the master drive. Integer part.
- 1751**      *MDistFract \* 2<sup>16</sup>*      (2.9.1.2)  
 Number of engineering units [u] corresponding to the number of motor shaft turns specified by ID1752 and ID1753 for the master drive. Fractional part x 2<sup>16</sup>.
- 1752**      *Master turns*      (2.9.1.3)  
 Number of motor shaft turns corresponding to the distance specified in engineering units [u] by ID1750 and ID1751 for the master drive. Integer part.
- 1753**      *MTurnsFract \* 2<sup>16</sup>*      (2.9.1.4)  
 Number of motor shaft turns corresponding to the distance specified in engineering units [u] by ID1750 and ID1751 for the master drive. Fractional part x 2<sup>16</sup>.
- 1754**      *Master speed filter Tl*      (2.9.1.5)  
 Time constant [s] of the 1st order low-pass filter on master speed measurement.
- 1757**      *Follower distance*      (2.9.2.1)  
 Number of engineering units [u] corresponding to the number of motor shaft turns specified by ID1759 and ID1760 for the follower drive. Integer part.
- 1758**      *Follower DistFrac \* 2<sup>16</sup>*      (2.9.2.2)  
 Number of engineering units [u] corresponding to the number of motor shaft turns specified by ID1759 and ID1760 for the follower drive. Fractional part x 2<sup>16</sup>.
- 1759**      *Follower turns*      (2.9.2.3)  
 Number of motor shaft turns corresponding to the distance specified in engineering units [u] by ID1757 and ID1758 for the follower drive. Integer part.
- 1760**      *Follower TurnsFrac \* 2<sup>16</sup>*      (2.9.2.4)

- Number of motor shaft turns corresponding to the distance specified in engineering units [u] by ID1757 and ID1758 for the follower drive. Fractional part  $\times 2^{16}$ .
- 1761**     *Follower speed filter Tl*                      (2.9.2.5)  
Time constant [s] of the 1st order low-pass filter on follower speed measurement.
- 1762**     *PID control gain*                              (2.9.2.6)  
Synchronization regulator proportional gain. The unity gain causes a speed correction of 1 u/s with a unity position error (1 u). Too high gain leads to oscillation.
- 1763**     *PID controller I gain*                      (2.9.2.7)  
Synchronization regulator integral gain. The unity gain causes a speed correction increment of 200 u/s per second with a unity position error (1 u). Integral action is limited to +/- 10000 u/s of speed correction.
- 1764**     *Synchronization acceleration* (2.9.2.8)  
Acceleration for the *Engage synchronization* command and deceleration for the *Release synchronization* command [u/s<sup>2</sup>].
- NOTE:** *Synchronization release* command causes the drive to decelerate to standstill under position control using the synchronization ramp par. ID1764. However, the synchronization mode is disabled when Stop is requested or during a Fault response. Therefore synchronization ramp (ID1764) is not used in these cases. The ramp time used will be either par. ID104 *Deceleration time 1* or ID503 *Deceleration time 2* (whichever is selected). ID104 (or ID503) should therefore be appropriately tuned for use as the emergency ramp.
- 1765**     *GearRatio \* 2<sup>16</sup>*                              (2.9.2.9)  
Electrical gear ratio of the follower speed and position reference to the master actual speed and position. Useful for gear ratio change during run.  
  
1 count =  $1/2^{16}$  ratio, that is the number 65536 represents unity ratio.  
The range is from -262144 to + 262144 corresponding to a ratio of -4 to +4.
- 1766**     *Ratio ramp time*                              (2.9.2.10)  
Ramp time in milliseconds for the variation of the ratio.  
A change of ratio from 0 to +4 (242144 counts) takes a time equal to this parameter.
- 1767**     *Trim ratio change*                              (2.9.2.11)  
Parameter for how much the trim + input ID1713 or trim - input ID1714 affects the ratio. The setting range is 0-200%.  
This function works only when running in synchronization mode. The ratio change uses the ratio ramp time of par. ID1766. The new ratio target is  $ID1765 + ID1767 * ID1765 / 100$  when the trim + input is on and  $ID1765 - ID1767 * ID1765 / 100$  when the trim - input is high.
- 1805**     *Distance for phasing*  
Set the distance in user units for phasing command. In fieldbus is used it is possible to write phasing distance to this parameter by using the parameter ID number.

## 7.1 Keypad control parameters

Unlike the parameters listed above, these parameters are located in the **M3** menu of the control keypad. The reference parameters do not have an ID number.

### 114 *Stop button activated* (3.4, 3.6)

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 ID125.

### 125 *Control Place* (3.1)

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

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).

### 123 *Keypad Direction* (3.3)

- 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.

### R3.2 *Keypad Reference* (3.2)

The frequency reference can be adjusted from the keypad with this parameter.

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

### R3.5 *Torque reference* 6 (3.5)

Define here the torque reference within 0.0...100.0%.

## 7.2 Application specific variables in the monitor menu and fieldbus interface

- 1700**     *Monitoring value: ActualRatio \* 2<sup>16</sup>*     (V1.17)  
 Actual value of ratio after the ramp. 65536 counts = unity ratio.
- 1701**     *Monitoring value: Position error*     (V1.18)  
 Actual value of position error = Master position x actual ratio – Follower position.  
 1 count = 1 engineering distance unit. Positive error means follower lagging compared to the master when running in the forward direction.
- 1702**     *Fieldbus high resolution position error*  
 Actual value of position error = Master position x actual ratio – Follower position.  
 65536 counts = 1 engineering space unit.
- 1703**     *Fieldbus synchronization status register*  
 The map of the status register is shown in Table 41.
- 1803**     *Accum SpaceError*  
 Shows the accumulated Position Error in user units between Master and Follower. This value will grow if Follower drive trips and the master continue to run before it is stopped. (Normally Fault output from follower should stop the master drive when there is a fault in follower)
- NOTE:** This value is resetted when synchronization is enabled again (B0).  
 Value is useful for correction of position error between master and follower when fieldbus control is used. In that case this value can be transferred to parameter P2.9.3.1 (ID 1805) to correct the error.  
 In that case, be sure to store the Accum Space Error value in controller before enabling Synchronization again.

### 8. SHAFT SYNCHRONIZATION OPERATION

Figures 36 to 39 show the operation of the Shaft synchronization control.

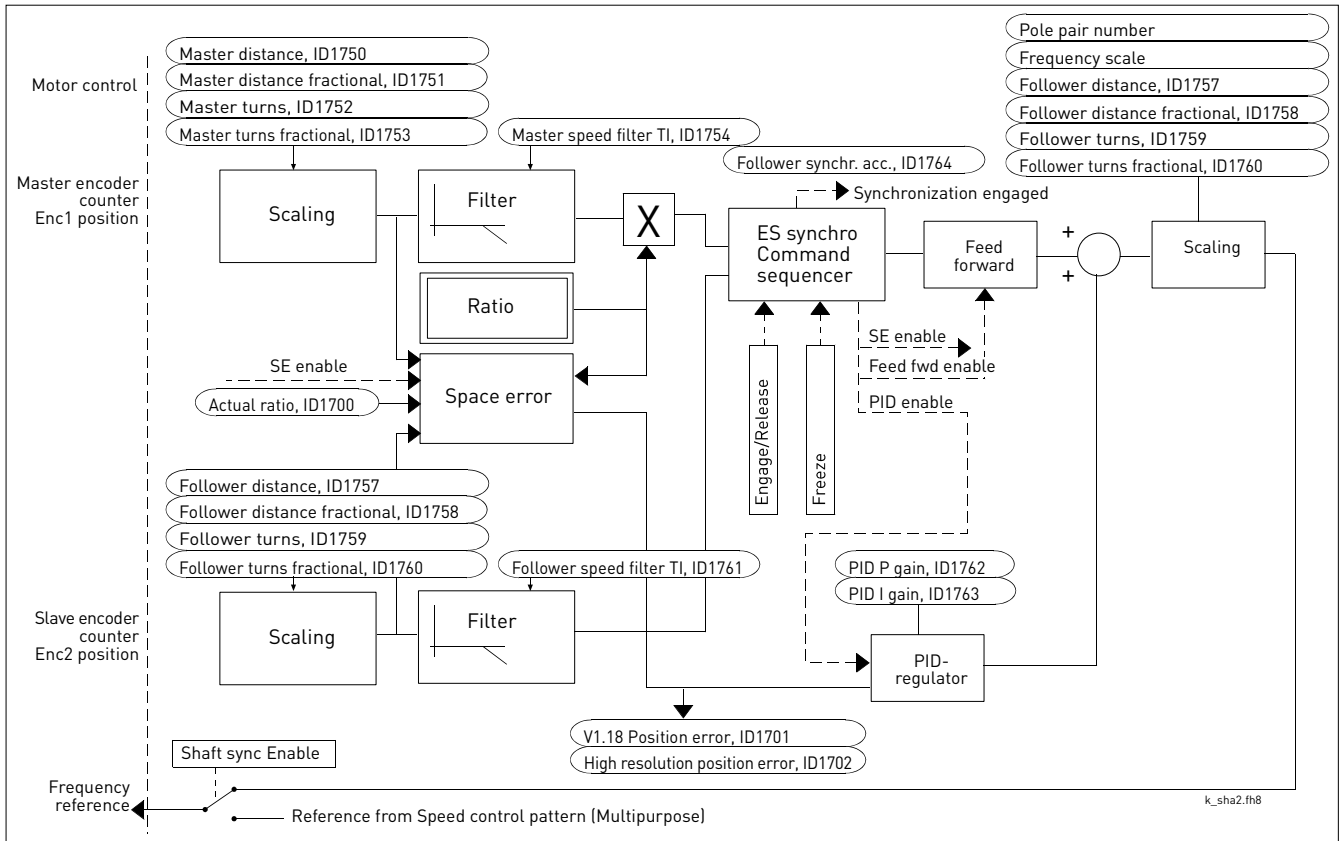


Figure 29. Shaft synchronization application, block diagram

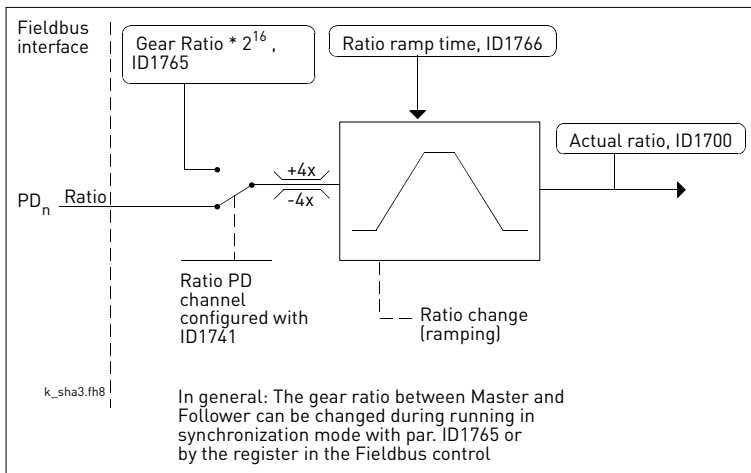


Figure 30. Ratio control (in Run mode)

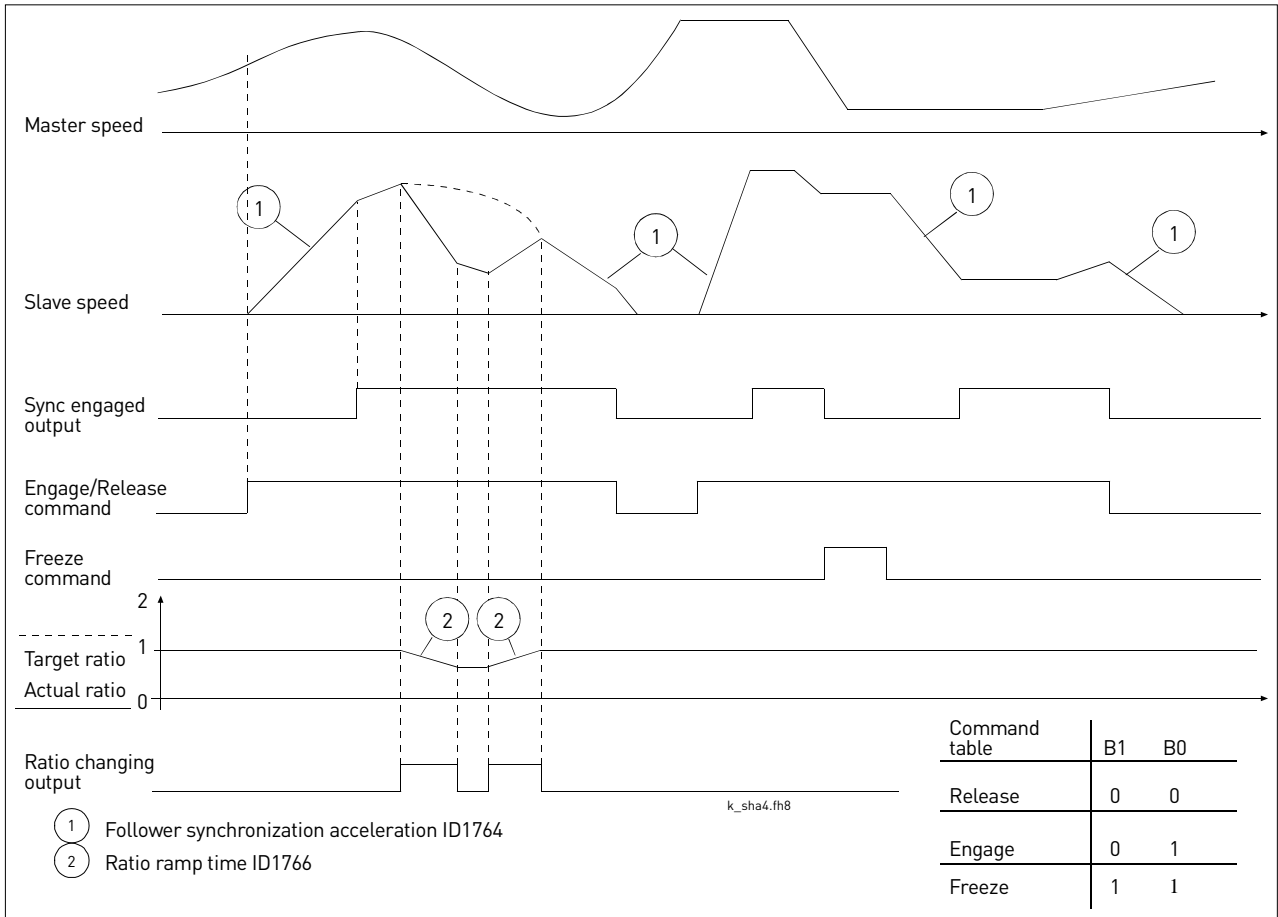


Figure 31. Shaft synchronization application; command, speed and output timing

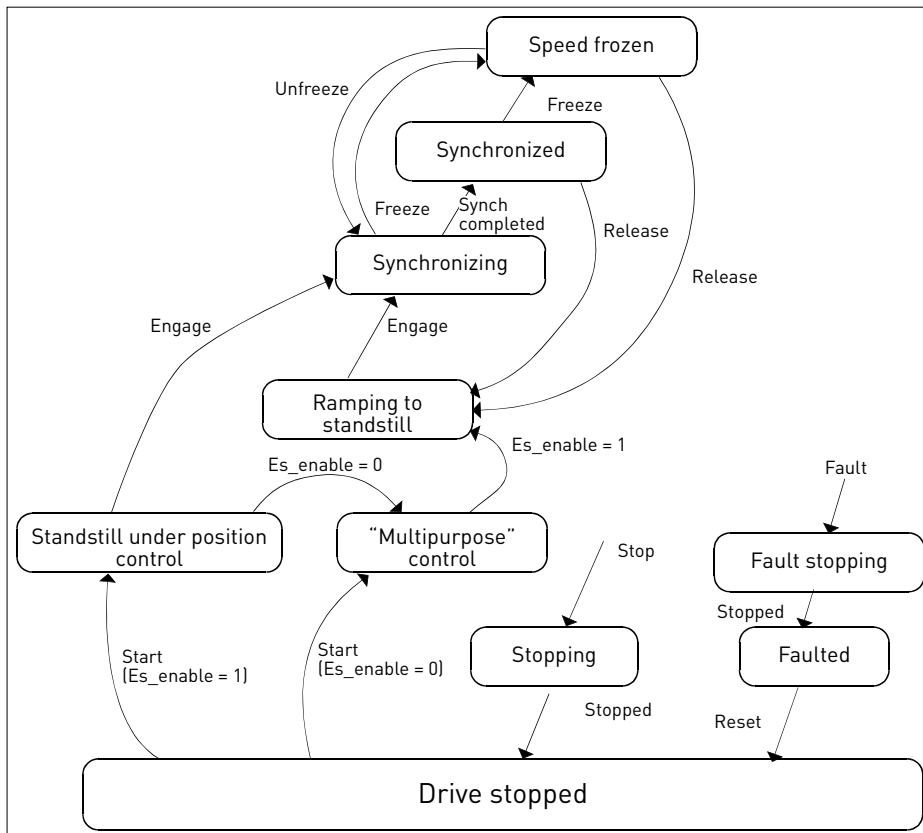


Figure 32. Shaft synchronization, state diagram



Engineering distance unit is defined by the user.

The Kinematic ratio is to be set up for the master (P2.9.1.1 ... P2.9.1.4) and the follower drive (P2.9.2.1 ... P2.9.2.4). **This describes the physical relationship between the master and follower drive.**

### Synchronization Commands:

Can be performed by digital inputs (see P2.2.5.20, P2.2.5.21) or from fieldbus interface (see table 39) Shaft synchronization mode has to be enabled to accept these commands.

**Note:** When Shaft synchronization is disabled the normal Multi-purpose speed control is active.

Sync Mode bit 1	Sync Mode bit 0	Action
0	0	Release synchronization
0	1	Engage synchronization
1	0	Use reference speed given from selected reference place.
1	1	Freeze follower speed. Only possible when synchronization is engaged to master speed.

### Phasing Commands:

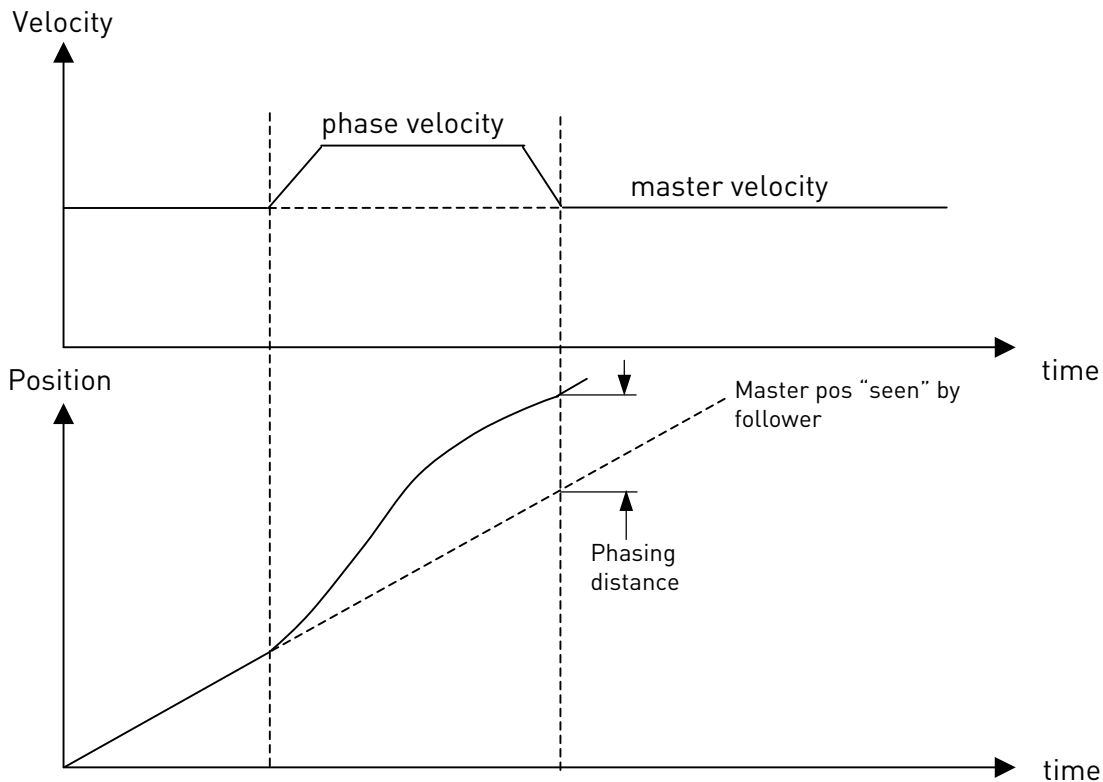
Shaft synchronization mode has to be enabled and Sync mode B0=1 to accept these commands.

The phasing command is for exact position adjustment in user units of follower. It can be executed when follower is in standstill or when running synchronized. The control bit B0 has to be on to accept phasing commands.

The maximum frequency is the speed limit during phasing.

Acceleration/Deceleration during phasing command is same as for engage/release synchronization

See P2.9.2.8 Sync Acceleration.



### Change of gear ratio during run:

The ratio of the follower to the master speed and position can be dynamically changed by a ramped, high resolution ratio control. Ratio can be changed by P2.9.2.9 from keypad.

If fieldbus control is used better use the 2 process datas selected by P2.7.10.

See Figure 36.

In I/O control the ratio can be changed by P2.9.2.11 dynamically with the trim +/- inputs connected to digital inputs selected by P2.2.5.22 and P2.2.5.23.

Then the ratio is temporarily changed when the trim input is active.

Function is useful for changing of the gear ratio during running. See Figure 36.

### Output signal for diagnostics:

Digital or relay outputs include a flag to signal changing value of the ratio and a flag to signal that space synchronization has been achieved.

The Ratio changing output is set whenever a change in the ratio is requested and it remains on until the ramp has reached the required value.

The Synchronization engaged output is set at the end of execution of the Engage synchronization command, after the follower has been brought to master speed x ratio and space control loop is activated. The Synchronization engaged output is cleared whenever a Release synchronization command is issued or whenever a Freeze command is issued.

The Synchronization engaged output is also cleared whenever a Drive stop is requested or a fault occurs.

## 8.1 Shaft Synchronization fieldbus interface

Control register mapping is shown in Table 40. (Process data for control selected by P2.7.11)

Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
Enable Synch	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Negative Phasing	Positive Phasing	Enable Sync sequencer (always set this bit to 1)	Sync mode bit 1 (Ramp to reference speed)	Sync mode bit 0 (Engage /release synchronization)

Table 40. Shaft synchronization control register

The map of the status register is shown in Table 41. Status register contains additional detailed information on the internal operation of the synchronization sequencer that is reserved for future use on the fieldbus interface. The status bits significant for the existing control interface are highlighted in bold characters.

Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
Shaft synch. enabled	Feed forward enabled	Position error enabled	Position loop active	Ratio changing	PID regulator enabled	PID Integral action enabled	PID derivative action enabled
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved	Reserved	Reserved	Reserved	Speed frozen	Synchronization reached	Releasing synchronization	Engaging synchronization

Table 41. Shaft synchronization status register

## 9. APPENDICES

In this chapter you will find additional information on special parameter groups. Such groups are:

- *Closed Loop parameters (Chapter 9.1)*
- *Parameters of Motor thermal protection (Chapter 9.2)*
- *Parameters of Stall protection (Chapter 9.3)*
- *Fieldbus control parameters (Chapter 9.4)*

### 9.1 Closed loop parameters (ID's 612 to 621)

Select the Closed loop control mode by setting value **3** or **4** for parameter ID600.

Closed loop control mode (see page 61) 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.

#### EXAMPLE:

Motor Control Mode = 3 (Closed loop speed control)

This is the usual operation mode when fast response times, high accuracy or controlled run at zero frequencies are needed. Encoder board should be connected to slot C of the control unit. Set the encoder P/R-parameter (P7.3.1.1). Run in open loop and check the encoder speed and direction (V7.3.2.2). Change the direction parameter (P7.3.1.2) or switch the phases of motor cables if necessary. Do not run if encoder speed is wrong. Program the no-load current to parameter ID612 and set parameter ID619 (Slip Adjust) to get the voltage slightly above the linear U/f-curve with the motor frequency at about 66% of the nominal motor frequency. The Motor Nominal Speed parameter (ID112) is critical. The Current Limit parameter (ID107) controls the available torque linearly in relative to motor nominal current.

#### 9.1.1 Note on use of permanent magnet motors ("AC brushless" motors)

Parameter *Magnetizing current* (par. ID612) is not relevant to CL control of these motors. Suggested values for other CL motor control parameters:

- ID613 *Speed control Kp*: much lower value, 10 to 20, for low inertia loads.
- ID617 *Current control Kp* = 20 for typical V/f values (eg. 400V/150Hz), values proportional to full load V/f ratio.

## 9.2 Parameters of motor thermal protection (ID's 704 to 708):

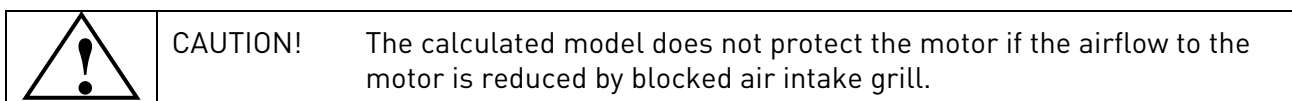
### General

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.



## 9.3 Parameters of stall protection (ID's 709 to 712):

### 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, ID710 (Stall current) and ID712 (Stall frequency limit). 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.

## 9.4 Fieldbus control parameters (ID's 850 to 859)

The Fieldbus control parameters are used when the frequency or the speed reference comes from the fieldbus (Modbus, Profibus, DeviceNet etc.). With the Fieldbus Data Out Selection 1...8 you can monitor values from the fieldbus.

## 10. SHAFT SYNCHRONIZATION APPLICATION SPECIFIC FAULT CODES

The Shaft Synchronization Application includes warnings and faults in addition to those described in the product's User's Manual. The fault codes, their causes and correcting actions are presented in the NX All-in-one manual (W=warning, F= fault).

Code	Fault/Warning	Type	Stored in history fault	Possible causes	Correcting actions
61	Position error	Program mable	Yes	The position error is over the specified threshold	Tune the drive harder to be able to follow the master or change the position error threshold
62	Shaft Locked	Program mable	Yes	The mechanical brake is not open or encoder fault	Check mechanical brake control. Check encoder and wirings.
72	Trial Time	Warning	No	The trial time is in use. Correct software license key is missing.	If the license is available set up the correct license key in parameter P2.10.1
72	Trial Time over	Fault	Yes	The 2 weeks trial time has expired	Set up the correct license key in parameter P2.10.1
73	<24 h left	Warning	No	Less than 24 hours left of trial time	If the license is available set up the correct license key in parameter P2.10.1 <b>Note that the drive will trip also in run mode when trial time has expired!</b>

## 11. COMMISSIONING OF SHAFT SYNCHRONIZATION APPLICATION

Perform following steps during commissioning

1. Set correct Motor data by basic parameters P2.1.5-P2.1.9
2. Set parameters for kinematic gear ratio with parameters P2.9.1.1-P2.9.1.4 and P2.9.2.1-P2.9.2.4
3. Run automatic motor identification by RUN (2) if it is possible to disconnect the load. See parameter P2.5.16. Go to step 5. If not possible do step 4.
4. Set magnetizing current P2.5.18.1 manually if it was not possible to perform step 2. (if magnetizing current is set to 0 the magnetizing current is estimated by system software based on given motor data)
5. Make test run in Open loop to check the encoder direction in Expander board menu. Swap encoder channels A/B if encoder speed feedback is opposite than output frequency.
6. Change parameter P2.5.1 to 3 for Closed loop speed control. (Shaft synchronization works only in closed loop speed control)
7. Check that pulses are coming to encoder channel 2 in follower (Expander board menu)
8. Set P2.1.1. Max frequency high enough to have a margin for regulation. If command speed from master is higher than the maximum frequency allows the follower drive to run there will be a mathematic overflow in synch. regulator.
9. Set drive in run and enable synchronization and set Synch. mode B0 = 1
10. Run Master with very slow speed and check that follower is following
11. If rotation direction of follower is wrong. Swap encoder channels A/B on encoder board for CH2.
12. Set parameters for mechanical brake in G2.3.8 If mechanical brake is used. Also program a digital output ID445/ID446 for controlling the brake and eventual input, ID1602 for hardware acknowledgement.

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