

Pressure controlled compressors

SINAMICS G120X

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1 Introduction

1.1 Overview

Compressors and blowers compress the air or other gases up to values significantly above atmospheric pressure. The main applications are:

- Generation of compressed air for
  - aeration in wastewater sites
  - pneumatic controls
  - pneumatic transport/conveying of bulk goods (grains, powder, …)
  - pneumatic components of industrial manufacturing devices
  - glass or plastic (PET) forming
  - filling air cylinders for scuba diving or for firefighters
  - medical applications.
- Separation of gases such as in air separation plants.
- Compression of the refrigerant in regenerative cooling systems working on Hampson-Linde principle used in
  - household
  - commercial refrigeration
  - refrigerated counters and vitrines in food retail
  - industrial refrigeration equipment such as cold stores or refrigerated ships
  - air conditioning systems for residential, commercial and industrial purposes.

Increasingly, fixed speed compressors with storage tank have been replaced by variable speed compressors with frequency converters. It allows precise pressure control in a required narrow band. Energy demanding over-compression with fixed speed compressors and storage tank is then avoided as well as high starting currents and torques with frequently repetitive switching on and off.

Figure 1-1 Screw compressor in compressed air industrial applications



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The following description is used to completely set the inverter parameters for the "Pressure controlled compressor" application with up to 4 compressors. It includes a standard control wiring diagram and description of additional functions, which are used for subsequent parameterization.

1.1 Components used

In this application example the following hardware and software components are used:

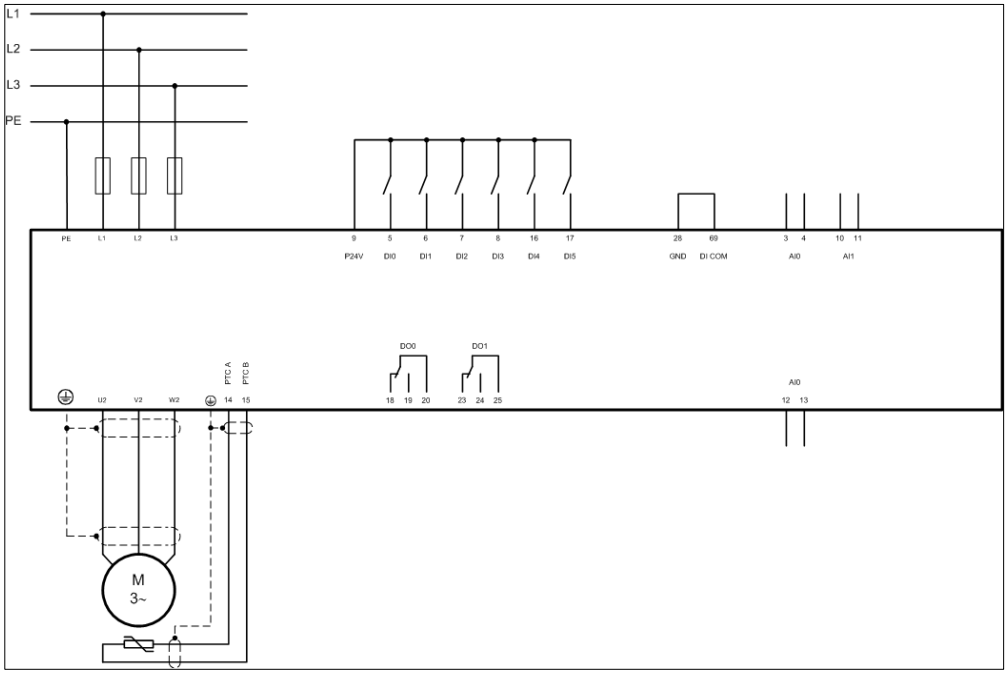
Component	No.	Article number	Note
SINAMICS G120X	1	6SL32x0-xxxxx-xxxx	Firmware V1.01 upwards
IOP-2	1	6SL3255-0AA00-4JA2	Firmware V2.3 upwards

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2 Engineering

2.1 Single compressor wiring diagram

Figure 2-1 Frequency converter wiring diagram



The terminal assignment for the subsequent parameterization is as follows:

DI0 – ON/OFF2
DI5 = Fault acknowledgement

AI1+/- = Connection for the pressure transducer

PTC A/B = Connection for the temperature sensor of the compressor motor

DO0 = Drive signal, fault
DO1 = Drive signal, operation

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2.2 Cascade control wiring diagram

Figure 2-2 Power wiring – converter operated and fixed speed compressors

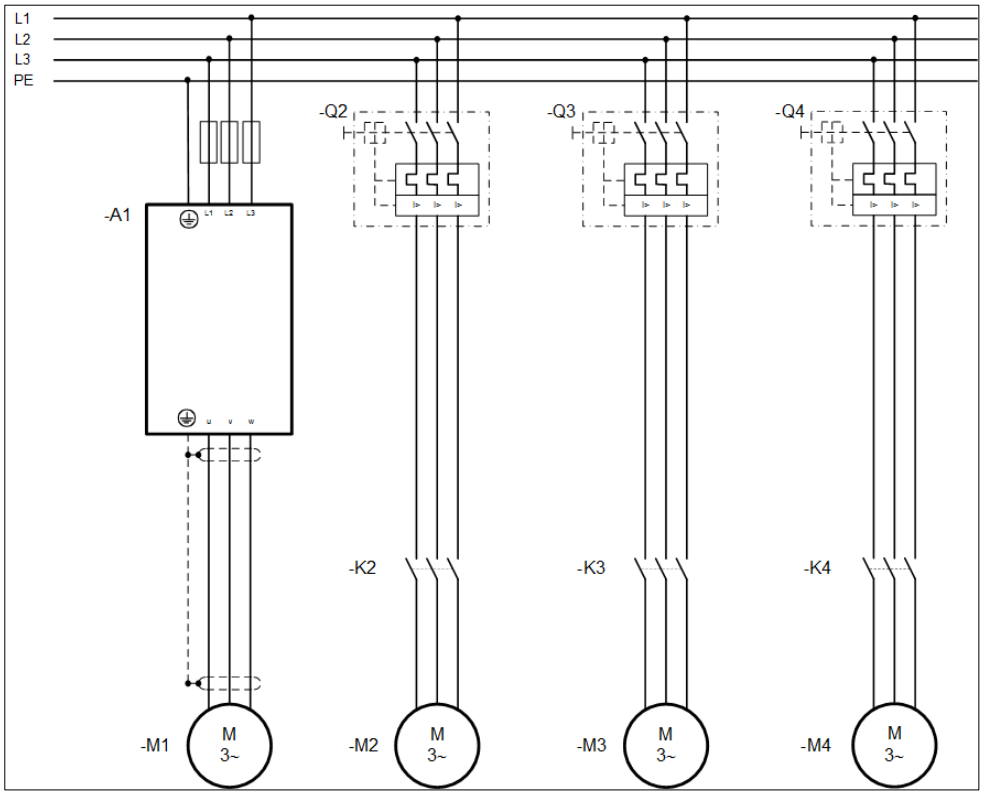
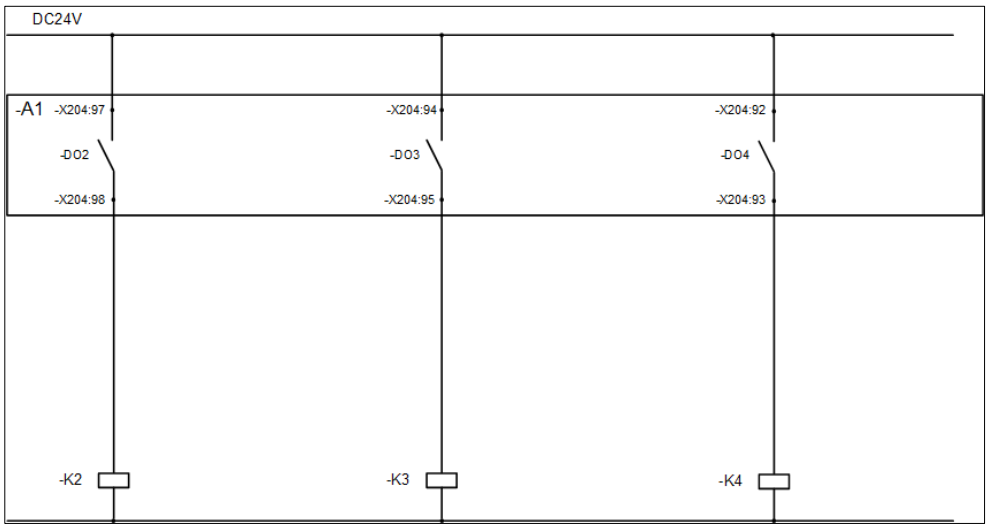


Figure 2-3 Control wiring



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3 Parameterization description

3.1 Preconditions

NOTE This application parameterization requires minimum firmware version V 1.01.

NOTE This application parameterization requires that the basic commissioning of the frequency converter has been carried out. Motor control should be set to the application class standard drive control for standard asynchronous motors or dynamic drive control for synchronous reluctance motors.

NOTE This application parameterization requires that during the basic commissioning of the frequency converter the macro 47 “PID controller with fixed setpoint” is selected.

3.2 Technological units

3.2.1 Technological units in the drive

The setpoint can be entered in technological units, in this application example [bar]. To change the technological units first enter the reference value into p0596 (i.e. enter the maximum pressure of the piping system in [bar]). Then select technological unit [bar] in p0595.

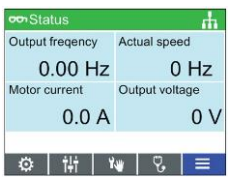
Parameter	Value	Comment
p0010	5	Drive commissioning parameter filter Technological applications/units
p0596	max pressure	Reference quantity, technological units
p0595	3 [bar]	Selecting technological units
p0010	0	Drive commissioning parameter filter Ready

This setting changes the Technological controller units from default [%] to [bar].

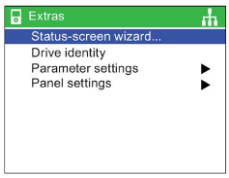
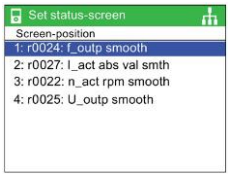
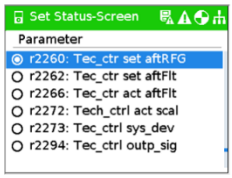
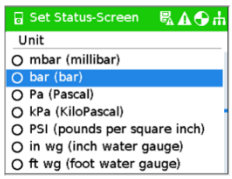
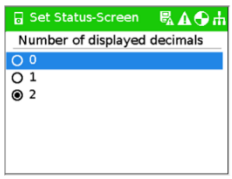
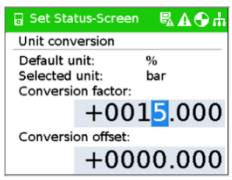
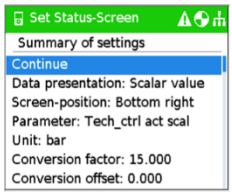
3.2.2 Technological units on the IOP-2

The intelligent operator panel IOP-2 can display simultaneously up to 4 customizable set- and measured values on the Status screen. By default it displays output frequency in Hz, motor current in A, actual speed in Hz and output voltage in V. These can be changed to show other physical values of the converter. Their units can be adapted using known conversion factors and offsets required in the user application.

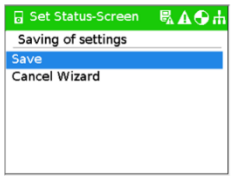
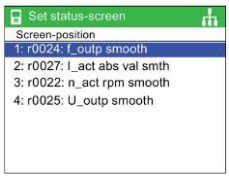
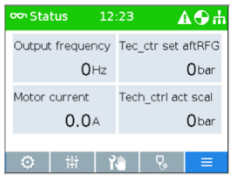
Example of changing displayed technological units on IOP-2 with firmware V2.3:

	Basic setting of the Status screen of the IOP-2 mounted on a SINAMICS G120X.

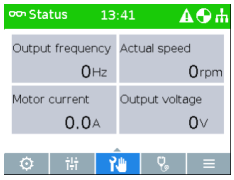
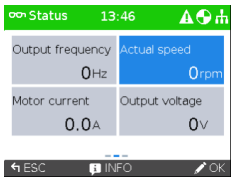
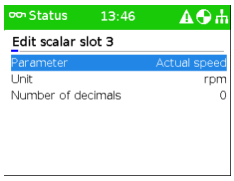
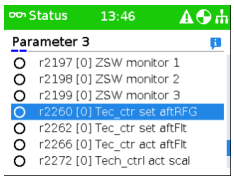
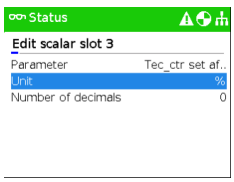
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	Select “Extras”.
	Select “Status screen wizard”.
	Select “Screen position 3” to modify the display for the technological setpoint.
	Select “Parameter r2260” as an example or displaying Technological controller Setpoint value after Ramp Function Generator.
	Select the “Technological unit” (for demonstration purpose technological unit “bar”).
	Select the “Number of displayed decimals”.
	Enter the “Conversion factor” for the displayed technological unit” (for demonstration purpose 15 bar = 100%). Set the “Conversion offset” if there is one. Note that if you already changed Technological units within the drive with parameters p0596, p0595 then the conversion factor usually remains 1 and only selection of the technological unit is necessary.
	At the end, you get a summary of all the settings you have done for the screen position 3.

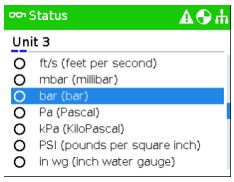
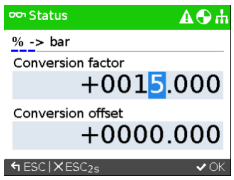
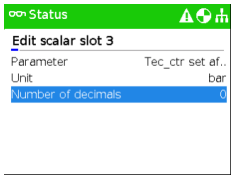
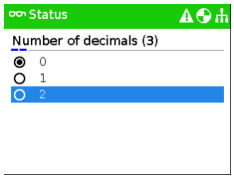
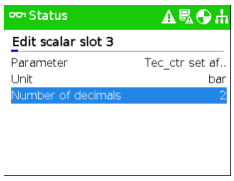
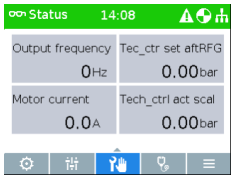
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	Save the settings.
	Continue with screen position 4 to parameterize the technological actual value. Select “Parameter p2272” for the actual value. Select the “Required technological unit”. Select the “Number of displayed decimals”. Select the “Conversion of the technological unit”. Select the “Conversion offset”, if there is one. Save the settings.
	The IOP-2 will display on screen position 1 the output frequency in Hz, on screen position 2 the motor current in A, and on-screen position 3 and 4 the setpoint and the actual value in technological units.

Example of changing technological units on IOP-2 with firmware V2.6 HF1:

	Basic setting of the Status screen of the IOP-2 mounted on a SINAMICS G120X. Status screen can be changed by pressing Up arrow and then using Right/Left arrows.
	Press arrow Up and OK. Then select Actual speed tile.
	Press OK, select “Parameter” and confirm by OK.
	By scrolling find “Parameter r2260” as an example or displaying Technological controller Setpoint value after Ramp Function Generator. Confirm by OK.
	Select “Unit” and press OK.

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	By scrolling find the required “Technological unit” (for demonstration purpose technological unit “bar”).
	Enter the “Conversion factor” for the displayed technological unit” (for demonstration purpose 15 bar = 100%). Set the “Conversion offset” if there is one. Note that if you already changed Technological units within the drive with parameters p0596, p0595 then the conversion factor usually remains 1 and only selection of the technological unit is necessary.
	Press ESC and select ”Number of decimals”. Confirm by OK.
	Select Number of displayed decimals and confirm by OK.
	At the end, you get a summary of all the settings you have done for this tile of Status screen. Press ESC, select the tile below and repeat the identical settings this time for “Parameter p2272” showing Technological controller actual value.
	Once you finished the configuration the new setting is automatically saved.

3.3 Setpoint input

The setpoint is entered in [bar].

Parameter	Value	Comment
p2201	□□□□	Enter the pressure setpoint in [bar]

3.4 Actual value sensor setting

You can select either sensor with a voltage output or a current output. For sensor with the voltage output you can define its maximum output voltage that is then normalized (scaled) to 100% in the PID feedback channel (e.g. sensors with 5V output voltage are generally used). The selection of analog input type is to be done by DIP switch located next to the AI terminals:

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Sensor with voltage output

Parameter	Value	Comment
p0756[1]	0	Voltage input, unipolar (0 … 10V)
p0759[1]	□□□□	Enter the max. sensor voltage

Sensor with current output 0 … 20mA

Parameter	Value	Comment
p0756[1]	2	Current input, unipolar (0 … 20mA)

Sensor with current output 4 … 20mA

Parameter	Value	Comment
p0756[1]	3	Voltage input, unipolar (4 … 20mA)

3.5 Interconnecting the PID controller

The PID controller output is interconnected as a main setpoint, the setpoint for the PID controller is a technology fixed setpoint. The actual value is connected from the analog input AI1. Compressors are only operated with a positive direction of rotation. This is the reason why the PID controller limit is set from 0% to 100%.

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3.6 Tuning of the PID controller

3.6.1 Autotuning

To optimize PID controller parameters (gains) automatically there is a possibility to use Autotuning.

Parameter	Value	Comment
p2350	0	No function
	1	The process variable follows the setpoint after a sudden setpoint change (step function) relatively quickly, however with an overshoot.
	2	Faster controller setting than for p2350 = 1 with larger overshoot of the controlled variable.
	3	Slower controller setting than for p2350 = 1. Overshoot of the controlled variable is, to a large extent, avoided.
	4	Controller setting after completion of the autotuning as for p2350 = 1. Optimize only the P and I action of the PID controller.
p2354	240	PID autotuning monitoring time in s
p2355	5	PID autotuning offset in %

For details see chapter “Autotuning the PID technology controller” in the Operating instructions SINAMICS G120X.

NOTE Autotuning works only if the minimum frequency p1080 is temporarily set to zero.

3.6.2 Manual tuning

In case that Autotuning is not satisfying the tuning of the PID controller can be done manually.

Parameter	Value	Comment
p2280	□□□□	Enter the proportional gain k_p
p2285	□□□□	Enter the integral time T_N
p2274	□□□□	Enter the differentiating time T_D

Details see https://support.industry.siemens.com/cs/ww/en/view/92556266

3.7 Automatic restart

It is possible to select an automatic restart after line supply failure.

Parameter	Value	Comment
p1210	1 4 6 14 16 26	Acknowledge all faults without restarting Restart after line supply failure w/o additional start attempts Restart after fault with additional start attempts Restart after line supply failure following man. acknowledgment Restart after fault following manual acknowledgment Acknowledging all faults and reclosing for an ON command
p1211	1 … 10	Automatic restart start attempts
p1212	0.1 ..1000	Automatic restart delay time start attempts in s

NOTE This value can only be changed if there are no active faults present on the converter. If a fault is still active a new setting is not accepted and a warning message appears.

The parameters must be saved in the non-volatile memory p0971 = 1 in order that the setting becomes effective.

3.8 Cascade control

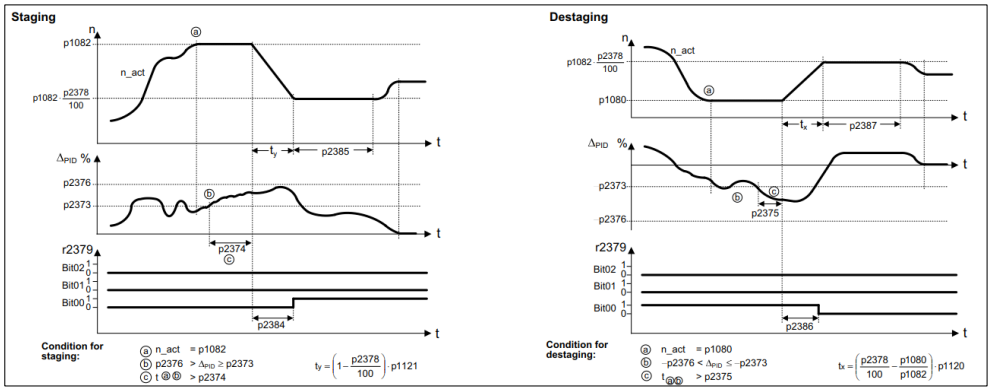
NOTE Cascade control as described in this application description works only in combination with firmware V 1.01 onwards and the I/O extension module.

3.8.1 Functional description

Cascade control allows switching-in up to 3 additional fixed speed (DOL) compressors to meet the pressure demand in the system. You can quicky set the staging function with the selection between 1 to 3 auxiliary motors. All preset parameters values are based on experience and may require post-optimization depending on the specific customer requirements.

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Figure 3-1 Functional description of the cascade control



3.8.2 Basic settings

Parameter	Value	Comment
p2370	1	Enables Motor Staging
p2371	1 2 3 4 5 6 7 8	M1 = 1X M1 = 1X, M2 = 1X M1 = 1X, M2 = 2X M1 = 1X, M2 = 1X, M3 = 1X M1 = 1X, M2 = 1X, M3 = 2X M1 = 1X, M2 = 2X, M3 = 2X M1 = 1X, M2 = 1X, M3 = 3X M1 = 1X, M2 = 2X, M3 = 3X
p2373	20.0	Switch-on threshold, Motor Staging in %
p2374	30.0	Delay time, Motor Staging
p2375	30.0	Delay time, Destaging
p2376	25	Override value, Motor Staging in %
p0732	2379.0	Control motor 2
p0733	2379.1	Control motor 3
p0734	2379.2	Control motor 4

Further adjustment and parameterization of the cascade control is described in the Operating instructions SINAMICS G120X.

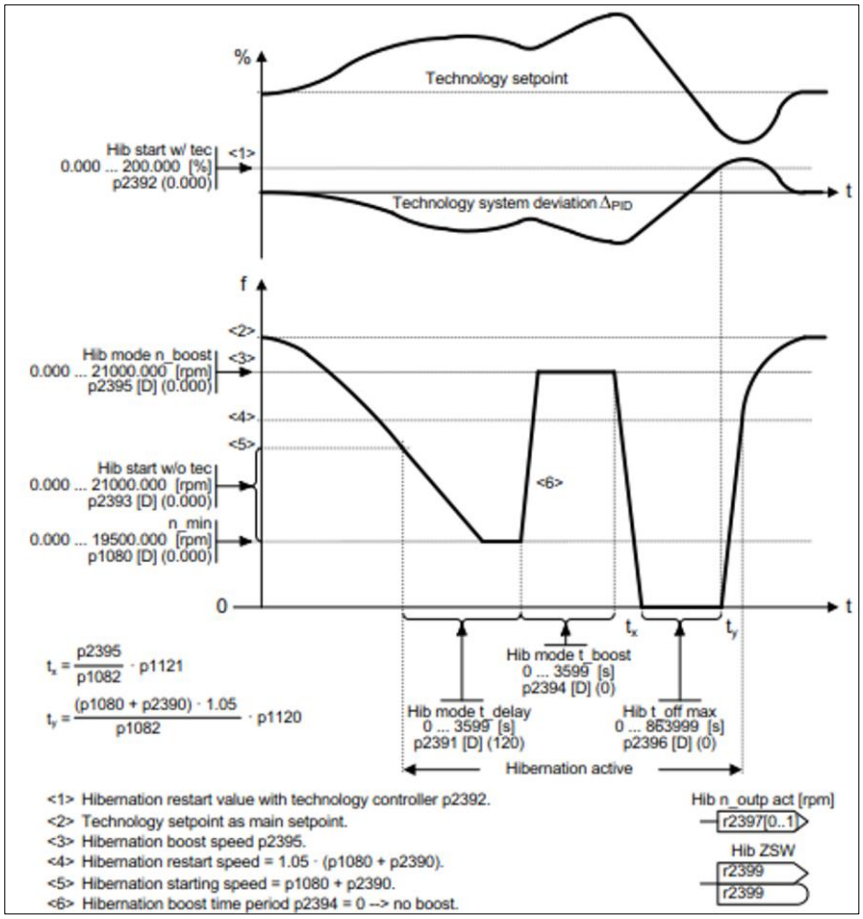
3.9 Hibernation Mode

3.9.1 Functional description

The hibernation mode ensures that the inverter switches itself off if the actual value is greater than the setpoint for a specified time. It means after the drive is running at a minimum speed for a preset time duration. During the off state the PID controller remains active. The hibernation restart value defines the difference between setpoint and actual value at which the compressor is switched-on again. Low setting values in the range of several percent result in a quite narrow switch-in bandwidth; high setting values in the range greater than 10% mean that the pressure drops more before the drive is switched-on again.

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Figure 3-2 Functional principle of the hibernation mode



NOTE

The delay time of the Hibernation Mode must always be longer than the destaging time of the possibly parameterized Motor Staging, otherwise malfunctions can occur.

3.9.2 Basic settings

Parameter	Value	Comment
p2398	1	Hibernation mode activated
p2391	□□□□	Enter the hibernation delay time
p2392	□□□□	Enter the hibernation restart value

Further adjustment and parameterization of the hibernation mode is described in the Operating instructions SINAMICS G120X.

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4 Appendix

4.1 Service and support

Industry Online Support

Do you have any questions or need assistance?

Siemens Industry Online Support offers round the clock access to our entire service and support know-how and portfolio.

The Industry Online Support is the central address for information about our products, solutions and services.

Product information, manuals, downloads, FAQs, application examples and videos – all information is accessible with just a few mouse clicks:

support.industry.siemens.com

Technical Support

The Technical Support of Siemens Industry provides you fast and competent support regarding all technical queries with numerous tailor-made offers – ranging from basic support to individual support contracts.

Please send queries to Technical Support via Web form:

siemens.com/SupportRequest

SITRAIN – Digital Industry Academy

We support you with our globally available training courses for industry with practical experience, innovative learning methods and a concept that's tailored to the customer's specific needs.

For more information on our offered trainings and courses, as well as their locations and dates, refer to our web page:

siemens.com/sitrain

Service offer

Our range of services includes the following:

- Plant data services
- Spare parts services
- Repair services
- On-site and maintenance services
- Retrofitting and modernization services
- Service programs and contracts

You can find detailed information on our range of services in the service catalog web page:

support.industry.siemens.com/cs/sc

Industry Online Support app

You will receive optimum support wherever you are with the "Siemens Industry Online Support" app. The app is available for iOS and Android:

support.industry.siemens.com/cs/ww/en/sc/2067

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4.2 Industry Mall



The Siemens Industry Mall is the platform on which the entire siemens Industry product portfolio is accessible. From the selection of products to the order and the delivery tracking, the Industry Mall enables the complete purchasing processing – directly and independently of time and location:
mall.industry.siemens.com

4.3 Application support

This application example is applicable to SINAMICS G120X converter only.
For further support contact the Competence Center in Prague office:

Siemens, s.r.o.
DI MC GMC CCE 1
Siemensova 1
155 00 Praha, Czech Republic
mailto: gmc.tech.team.infrastructure-drive@siemens.com

4.4 Links and literature

Table 4-1

No.	Topic
\1\	Siemens Industry Online Support https://support.industry.siemens.com
\2\	Link to this entry page of this application example https://support.industry.siemens.com/cs/ww/en/view/109801844
\3\	Link to the Operating instructions G120X https://support.industry.siemens.com/cs/ww/en/view/109781534

4.5 Change documentation

Table 4-2

Version	Date	Modifications
V1.0	08/2021	First version
V1.1	09/2021	Change of support contact address in chapter 4.3

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