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SINAMICS Drives

SINAMICS S120

Chassis-2 Converter Units

Add-On
D 21.3

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<p>Motion Control Drives D 21.4 SINAMICS S120 and SIMOTICS</p> <p>E86060-K5521-A141-A1-7600</p>		<h2>The Engineering Manual</h2> <p>SINAMICS Low Voltage Engineering Manual</p> <p>Engineering Manual for</p> <ul style="list-style-type: none"> - SINAMICS G130 Drive Converter Chassis Units, - SINAMICS G150 Drive Converter Cabinet Units, - SINAMICS S120 Chassis Format Units, - SINAMICS S120 Cabinet Modules, - SINAMICS S150 Converter Cabinet Units <p>This manual offers users comprehensive support with the configuring of drives and associated system components. The first three chapters are devoted primarily to the fundamental physical principles of variable-speed electric drives and include EMC Installation Guidelines as well as general system descriptions and planning information which relate to all products in the SINAMICS range. The other chapters then discuss in detail questions relating to the dimensioning of drives with converters of specific types as well as the selection of suitable motors.</p> <p>Note: The manual is not available in hard copy form, but only as an electronic file in PDF format.</p>	
<p>SIMOTICS GP, SD, XP, DP D 81.1 Low-Voltage Motors Type series 1FP1, 1LE1, 1MB1 and 1PC1 Frame sizes 71 to 315 Power range 0.09 to 200 kW E86060-K5581-A111-A9-7600</p>			
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SINAMICS S120 Chassis-2 Converter Units

SINAMICS Drives



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SINAMICS S120 Chassis-2 Converter Units
500 kW to 630 kW

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Appendix

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NEW

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Article No.

6SL3070-0AA00-0AG0
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SINAMICS S120 Chassis-2 Converter Units

Air-cooled units

Technical specifications

General technical specifications

Unless clearly specified otherwise, the following technical data are valid for all the following components of the air-cooled SINAMICS S120 Chassis-2 drive system.

Electrical specifications	
Rated voltages	380 ... 480 V 3 AC $\pm 10\%$ (-15 % < 1 min)
Line system configurations	Grounded TN/TT systems or non-grounded IT systems
Line frequency	47 ... 63 Hz
Overvoltage category	III acc. to EN 61800-5-1
Electronics power supply	24 V DC, -15 % +20 % implemented as PELV circuit acc. to EN 61800-5-1 Ground = negative pole grounded via the electronics
Rated short-circuit current Acc. to IEC, in conjunction with the specified fuses or circuit breakers	
• 1.1 ... 447 kW	65 kA
• 448 ... 671 kW	84 kA
• 672 ... 1193 kW	170 kA
• > 1194 kW	200 kA
Rated short-circuit current SCCR (Short Circuit Current Rating) Acc. to UL508C (up to 600 V), in conjunction with the specified fuses or circuit breakers	
• 1.1 ... 447 kW	65 kA
• 448 ... 671 kW	84 kA
• 672 ... 1193 kW	170 kA
• > 1194 kW	200 kA
Control method	Vector/Servo control with and without encoder or V/f control
Fixed speeds	15 fixed speeds plus 1 minimum speed, parameterizable (in the default setting, 3 fixed setpoints plus 1 minimum speed are selectable using terminal block/PROFIBUS/PROFINET)
Skippable speed ranges	4, parameterizable
Setpoint resolution	0.001 rpm digital (14 bits + sign) 12 bits analog
Braking operation	With Active Line Modules and Smart Line Modules, four-quadrant operation as standard (energy recovery). With Basic Line Modules, two-quadrant operation as standard, braking by means of a Motor Module.
Mechanical specifications	
Degree of protection	IP00
Protection class	I acc. to EN 61800-5-1
Touch protection	EN 50274/DGUV regulation 3 when used as intended
Cooling method	Forced air cooling AF acc. to EN 60146

SINAMICS S120 Chassis-2 Converter Units

Air-cooled units

Technical specifications (continued)

Ambient conditions	Storage ¹⁾	Transport ¹⁾	Operation
Ambient temperature	-25 ... +55 °C Class 1K4 acc. to EN 60721-3-1	-25 ... +70 °C Class 2K4 acc. to EN 60721-3-2	<ul style="list-style-type: none"> -10 ... +40 °C at installation altitude ≤ 2000 m above sea level without derating -10 ... +45 °C at installation altitude ≤ 1000 m above sea level without derating > 45 ... +60 °C at installation altitude ≤ 2000 m above sea level, see derating data Control Units, supplementary system components, and Sensor Modules: 0 ... 55 °C (for operation in a control cabinet) DC link components and motor-side components: 0 ... 55 °C
Relative humidity Condensation, splashwater, and ice formation not permitted (EN 60204, Part 1)	<u>5 ... 95 %</u> Class 1K4 acc. to EN 60721-3-1	5 ... 95 % at 40 °C Class 2K3 acc. to EN 60721-3-2	<u>5 ... 95 %</u> Class 3K3 acc. to EN 60721-3-3
Environmental class/ harmful chemical substances	Class 1C2 acc. to EN 60721-3-1	Class 2C2 acc. to EN 60721-3-2	Class 3C2 acc. to EN 60721-3-3
Organic/biological influences	Class 1B1 acc. to EN 60721-3-1	Class 2B1 acc. to EN 60721-3-2	Class 3B1 acc. to EN 60721-3-3
Mechanically active substances	Class 1S1 acc. to EN 60721-3-1	Class 2S1 acc. to EN 60721-3-2	Class 3S1 acc. to EN 60721-3-3
Degree of pollution	2 acc. to EN 61800-5-1		
Installation altitude	Up to 2000 m above sea level without derating > 2000 m above sea level, see derating data		
Mechanical stability	Storage ¹⁾	Transport ¹⁾	Operation
Vibratory load	–	Class 2M2 acc. to EN 60721-3-2	Test values acc. to EN 60068-2-6 test Fc: <ul style="list-style-type: none"> 10 ... 58 Hz with constant deflection 0.075 mm 58 ... 150 Hz with constant acceleration 9.81 m/s² (1 × g)
Shock load	–	Class 2M2 acc. to EN 60721-3-2	Test values acc. to EN 60068-2-27 test Ea: 98 m/s ² (10 × g)/20 ms
Compliance with standards			
Conformances/ certificates of suitability, acc. to	CE (EMC Directive No. 2014/30/EU, Low Voltage Directive No. 2014/35/EU, and Machinery Directive 2006/42/EC for functional safety) RCM, RoHS II cULus (only for devices connected to line supply voltages 380 ... 480 V 3 AC and 500 ... 600 V 3 AC)		
Radio interference suppression	SINAMICS S120 Chassis-2 units are not designed for connection to the public grid (first environment). Radio interference suppression is compliant with the EMC product standard for variable-speed drives EN 61800-3, "second environment" (industrial line supplies). EMC disturbances can occur when connected to the public grid. However, if additional measures are taken (e.g. → line filter), it can also be operated in the "first environment". For additional information, see the SINAMICS Low Voltage Engineering Manual.		

Deviations from the specified class are underlined.

¹⁾ In transport packaging.

SINAMICS S120 Chassis-2 Converter Units

Air-cooled units

Characteristic curves

Derating data for Chassis-2

Air-cooled SINAMICS S120 Chassis-2 units and the associated system components are rated for an ambient temperature of 45 °C and installation altitudes up to 1000 m above sea level.

At ambient temperatures > 45 °C, the output current must be reduced. Ambient temperatures above 60 °C are not permissible.

At installation altitudes > 2000 m above sea level, it must be taken into account that the air pressure, and therefore air density, decreases as the height increases. As a consequence, the cooling efficiency and the insulation capacity of the air also decrease.

Due to the reduced cooling efficiency, it is necessary, on the one hand, to reduce the ambient temperature and on the other hand, to reduce the heat loss in the built-in unit by reducing the output current, whereby ambient temperatures lower than 45 °C may be offset to compensate.

Current derating factors for SINAMICS S120 Chassis-2 units as a function of the ambient/air intake temperature and the installation altitude

Installation altitude above sea level m	Current derating factor (as a percentage of the rated current) for an ambient/air intake temperature of								
	20 °C	25 °C	30 °C	35 °C	40 °C	45 °C	50 °C	55 °C	60 °C
0 ... 1000							83 %	69 %	54 %
1001 ... 1500						98 %	81 %	67 %	52 %
1501 ... 2000			100 %			93 %	78 %	65 %	50 %
2001 ... 2500					96 %				
2501 ... 3000				99 %					
3001 ... 3500									
3501 ... 4000			96 %						
4001 ... 4500		97 %							
4501 ... 5000	98 %								

The following table lists the permissible output currents depending on the installation altitude and ambient temperature. The specified values already include a permitted compensation in respect of installation altitude and ambient temperatures < 40 °C – temperature at the air intake of the built-in unit.

The values apply under the precondition that a cooling air flow through the devices is guaranteed as specified in the technical specifications.

As an additional measure for installation altitudes from 2000 m up to 5000 m, an isolating transformer is required in order to reduce transient overvoltages according to EN 60664-1.

[For additional information, please refer to the SINAMICS Low Voltage Engineering Manual.](#)

Characteristic curves (continued)

Current derating for Motor Modules Chassis-2 as a function of the pulse frequency

To reduce motor noise or to increase output frequency, the pulse frequency can be increased relative to the factory setting (2.5 kHz). When the pulse frequency is increased, the derating factor of the output current must be taken into account. This derating factor must be applied to the currents specified in the technical specifications.

For additional information, please refer to the [SINAMICS Low Voltage Engineering Manual](#).

The following table lists the rated output currents of the SINAMICS S120 Motor Modules with pulse frequency set in the factory as well as the current derating factors (permissible output currents referred to the rated output current) for higher pulse frequencies.

Derating factor of the output current as a function of the pulse frequency for units with a rated pulse frequency of 2.5 kHz

Motor Module	Type rating at 400 V	Output current at 2.5 kHz	Derating factor			
			4 kHz	5 kHz	7.5 kHz	8 kHz
6SL3321-...	kW	A				
380 ... 480 V 3 AC						
1TE41-0AA0	500	975	78 %	67 %	48 %	45 %
1TE41-1AA0	560	1075	78 %	67 %	48 %	45 %
1TE41-2AA0	630	1200	78 %	67 %	48 %	45 %

The following tables list the maximum achievable output frequency as a function of the pulse frequency.

Maximum output frequencies achieved by increasing the pulse frequency in Vector mode

Pulse frequency	Max. achievable output frequency
1.25 kHz	100 Hz
2 kHz	160 Hz
2.5 kHz	200 Hz
4 kHz	300 Hz

Maximum output frequencies achieved by increasing the pulse frequency in Servo mode

Pulse frequency	Max. achievable output frequency
2 kHz	300 Hz
4 kHz	300/550 Hz ¹⁾

¹⁾ Higher frequencies on request. For additional information, see <https://support.industry.siemens.com/cs/document/104020669>

SINAMICS S120 Chassis-2 Converter Units

Air-cooled units

Characteristic curves (continued)

Overload capability

SINAMICS S120 units have an overload reserve, e.g. to handle breakaway torques. If larger surge loads occur, this must be taken into account in the configuration. For drives with overload requirements, the appropriate base-load current must therefore be used as a basis for the required load.

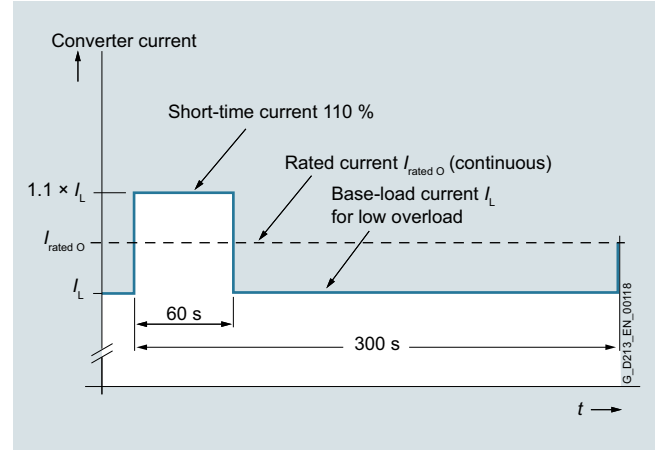
The permissible overload levels are valid under the prerequisite that the drive units are operated with their base-load current before and after the overload condition based on a duty cycle duration of 300 s.

Another precondition is that the Motor Modules are operated at their factory-set pulse frequency at output frequencies > 10 Hz.

For temporary, periodic duty cycles with high variations of load within the duty cycle, the relevant sections of the SINAMICS Low Voltage Engineering Manual must be observed.

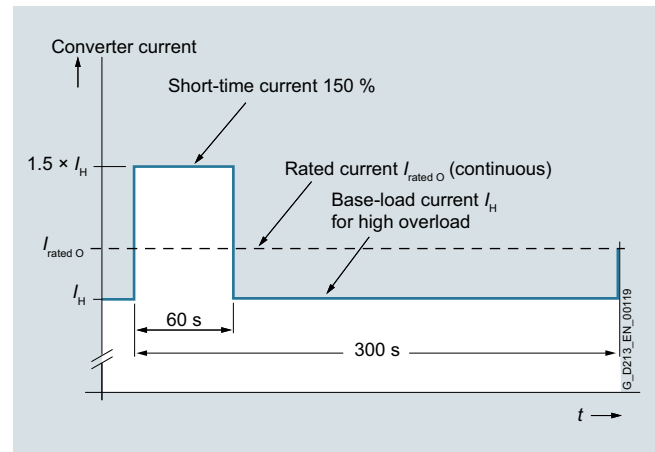
Motor Modules Chassis-2

The base-load current for a low overload I_L is based on a duty cycle of 110 % for 60 s.

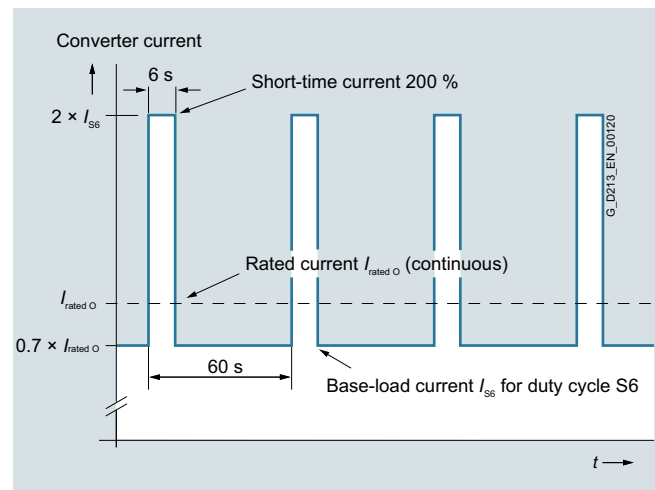


Low overload

The base-load current for a high overload I_H is based on a duty cycle of 150 % for 60 s.



High overload



Duty cycle S6 with previous load with a duty cycle duration of 60 s

SINAMICS S120 Chassis-2 Converter Units

Air-cooled units

Motor Modules

Overview



A Motor Module comprises a self-commutated inverter with IGBTs. It generates a variable voltage with variable frequency from the DC link voltage that feeds the connected motor.

Multiple Motor Modules can be operated on a single DC link. This permits energy to be transferred between the Motor Modules. This means that if one Motor Module operating in generator mode produces energy, the energy can be used by another Motor Module operating in motor mode.

Motor Modules are controlled by a Control Unit that is not included in the scope of supply.

DRIVE-CLiQ cables are required to operate a Motor Module.

Design

The Motor Modules Chassis-2 have the following interfaces as standard:

- 1 motor connection
- 1 connection for the 24 V DC electronics power supply
- 1 DC link connection (DCP, DCN) for connecting to the supply DC link
- 3 DRIVE-CLiQ sockets
- 1 temperature sensor input for KTY84-130, Pt1000, PTC or Pt100
- 1 connection for Safe Brake Adapter
- 1 connection for Safety Integrated
- 2 PE/protective conductor connections

The status of the Motor Modules is indicated via three LEDs.

The scope of supply of the Motor Modules includes:

- PE connection bars
- Mounting brackets for mechanical fastening of the chassis
- Screws for the motor cable connection and PE connection bars
- Connector set for customer connection (control cables)
- Shield connection kit (control cables)
- 1 set of warning labels in 30 languages (BG, CN, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, JP, KR, LT, LV, MT, NL, NO, PL, PT, RO, RU, SE, SI, SK, TR)

Selection and ordering data

Type rating at 400 V kW	Rated output current A	Motor Modules Article No.
Line voltage 380 ... 480 V 3 AC (DC link voltage 510 ... 720 V DC)		
500	975	6SL3321-1TE41-0AA0
560	1075	6SL3321-1TE41-1AA0
630	1200	6SL3321-1TE41-2AA0
Description		Article No.
<i>Accessories for re-ordering</i>		
Dust protection blanking plugs (50 units) For DRIVE-CLiQ port		6SL3066-4CA00-0AA0

For motor-side components, see System components.

SINAMICS S120 Chassis-2 Converter Units

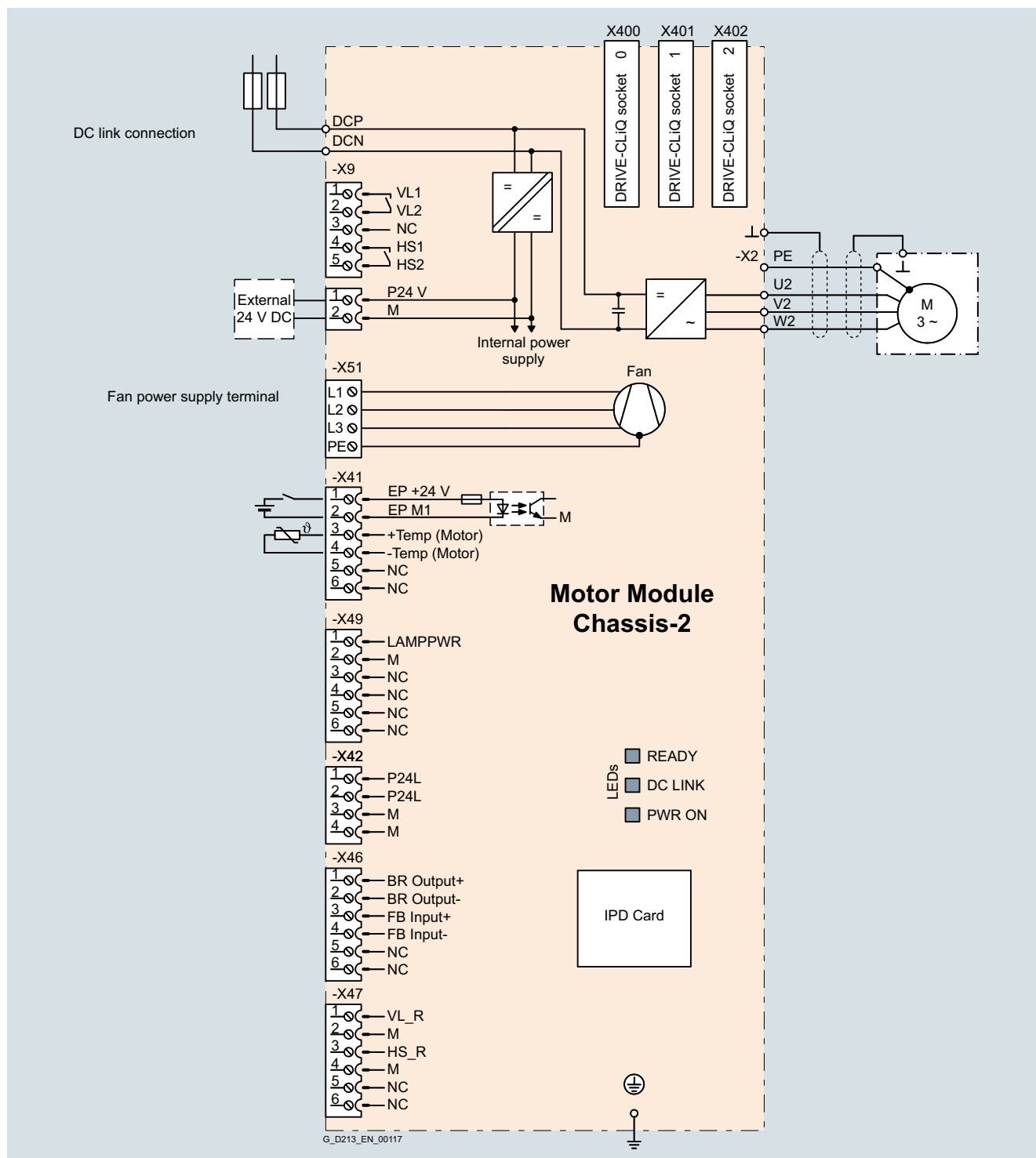
Air-cooled units

Motor Modules

Integration

The Motor Modules communicate with the higher-level control module via DRIVE-CLiQ. This control module can be:

- A CU320-2 Control Unit
- A SIMOTION D Control Unit
- A SINUMERIK 840D sl with NCU 710.3B PN/NCU 720.3B PN/NCU 730.3B PN
- A SINUMERIK NX10.3/NX15.3



Connection example of a Motor Module

Technical specifications

General technical specifications

Electrical specifications	
Efficiency	> 98.5 %
DC link voltage (up to 2000 m above sea level)	510 ... 720 V DC (line connection voltage 380 ... 480 V 3 AC)
Output frequency ¹⁾	
• Control type Servo	0 ... 550 Hz
• Control type Vector	0 ... 550 Hz
• Control mode V/f	0 ... 550 Hz
Safety Integrated	Safety Integrity Level 2 (SIL2) acc. to IEC 61508, Performance Level d (PLd) acc. to EN ISO 13849-1 and Control Category 3 acc. to EN ISO 13849-1

¹⁾ Please note:

- The correlation between the maximum output frequency, pulse frequency and current derating. Higher output frequencies on request. For additional information, see <https://support.industry.siemens.com/cs/document/104020669>
- The correlation between the minimum output frequency and permissible output current (current derating). Information is provided in the SINAMICS Low Voltage Engineering Manual.

SINAMICS S120 Chassis-2 Converter Units

Air-cooled units

Motor Modules

Technical specifications (continued)

Line voltage 380 ... 480 V 3 AC DC link voltage 510 ... 720 V DC		Motor Modules		
		6SL3321-1TE41-0AA0	6SL3321-1TE41-1AA0	6SL3321-1TE41-2AA0
Type rating				
• At I_L (50 Hz 400 V) ¹⁾	kW	500	560	630
• At I_H (50 Hz 400 V) ¹⁾	kW	450	500	560
• At I_L (60 Hz 460 V) ²⁾	hp	750	850	950
• At I_H (60 Hz 460 V) ²⁾	hp	650	750	850
Output current				
• Rated current $I_{rated O}$	A	975	1075	1200
• Base-load current I_L ³⁾	A	910	1000	1145
• Base-load current I_H ⁴⁾	A	800	890	1000
• Maximum current $I_{max O}$	A	1365	1505	1710
DC link current				
• Rated current $I_{rated DC}$	A	1170	1290	1440
Current demand				
• 24 V DC auxiliary power supply	A	1.3	1.3	1.3
• 400 V AC	A	1.8	1.8	1.8
DC link capacitance	μF	25900	25900	25900
Pulse frequency ⁵⁾				
• Rated frequency	kHz	2.5	2.5	2.5
• Pulse frequency, max.				
- Without derating	kHz	2.5	2.5	2.5
- With derating	kHz	8	8	8
Power loss, max. ⁶⁾				
• At 50 Hz 400 V	kW	8.7	9.5	10.4
• At 60 Hz 460 V	kW	9.0	9.8	10.8
Cooling air requirement	m ³ /s	0.64	0.64	0.64
Sound pressure level L_{pA} (1 m) at 50/60 Hz	dB	72.5	72.5	72.5
DC link connection				
DCP, DCN		4 × hole for M12	4 × hole for M12	4 × hole for M12
• Conductor cross-sections, max. (IEC)	mm ²	Busbar	Busbar	Busbar
Motor connection				
U2, V2, W2		6 × M12 screw	6 × M12 screw	6 × M12 screw
• Conductor cross-sections, max. (IEC)	mm ²	6 × 240	6 × 240	6 × 240
Cable length, max. ⁷⁾				
• Shielded	mm	300	300	300
• Unshielded	mm	450	450	450
PE/GND connection				
• Conductor cross-sections, max. (IEC)	mm ²	6 × 240	6 × 240	6 × 240
Degree of protection				
		IP00	IP00	IP00
Dimensions				
• Width	mm	280	280	280
• Height	mm	1430	1430	1430
• Depth	mm	535	535	535
Weight, approx.	kg	162	162	162
Frame size		FS4	FS4	FS4

¹⁾ Rated output of a typical 6-pole standard induction motor based on I_L or I_H for 400 V 3 AC 50 Hz.

²⁾ Rated output of a typical 6-pole standard induction motor based on I_L or I_H for 460 V 3 AC 60 Hz.

³⁾ The base-load current for a low overload I_L is based on a duty cycle of 110 % for 60 s.

⁴⁾ The base-load current for a high overload I_H is based on a duty cycle of 150 % for 60 s.

⁵⁾ Information regarding the correlation between the pulse frequency and maximum output current/output frequency is provided in the [SINAMICS Low Voltage Engineering Manual](#).

⁶⁾ The specified power loss represents the maximum value at 100 % utilization. The value is lower under normal operating conditions.

⁷⁾ Total of all motor cables and DC link. Longer cable lengths for specific configurations are available on request. For additional information, please refer to the [SINAMICS Low Voltage Engineering Manual](#).

SINAMICS S120 Chassis-2 Converter Units

System components

DC link components > DC link fuses

Selection and ordering data

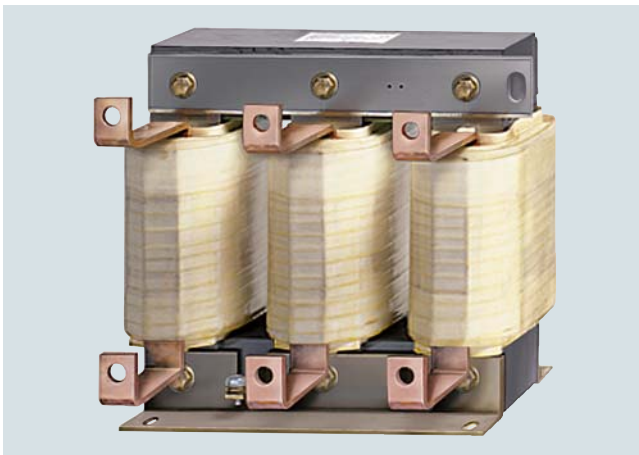
Suitable DC link fuses are assigned depending on the power rating of the Motor Modules. [Additional information about the fuses listed is provided in the Catalogs IC 10 and LV 10.](#)

Assignment of the DC link fuses to the Motor Modules Chassis-2

Type rating at 400 V	Rated DC link current	Suitable for Motor Module Chassis-2	DC link fuse acc. to IEC				DC link fuse acc. to UL ¹⁾			
			Rated current	Quantity/phase	Frame size	Article No.	Rated current	Quantity/phase	Frame size	Article No.
kW	A	6SL3321-...	A				A			
Line voltage 380 ... 480 V 3 AC										
500	1170	1TEA41-0AA0	630	2	2	3NE3336	1400	1	3L	3NB2355-4KK16
560	1290	1TEA41-1AA0	710	2	2	3NE3337-8	1400	1	3L	3NB2355-4KK16
630	1440	1TEA41-2AA0	800	2	2	3NE3338-8	1600	1	3L	3NB2357-4KK16

Motor-side power components > Motor reactors

Overview



Motor reactors reduce the voltage load on the motor windings by reducing the voltage gradients at the motor terminals that occur during converter operation. At the same time, the capacitive charge/discharge currents that place an additional load on the converter output when long motor cables are used, are reduced. For group drives, output reactors should always be used. The maximum permissible output frequency when a motor reactor is used is 150 Hz.

The motor reactor must be installed as close as possible to the Motor Module. Up to two motor reactors can be connected in series.

Motor reactors are approved for use only in conjunction with Vector and V/f control modes.

[For additional notes on the use of motor reactors, please refer to the SINAMICS Low Voltage Engineering Manual.](#)

Selection and ordering data

Suitable for Power Module	Suitable for Motor Module Chassis-2	Type rating at 400 V	Rated output current	Motor reactor
Air-cooled	Air-cooled	kW	A	Article No.
Line voltage 380 ... 480 V 3 AC				
-	6SL3321-1TE41-0AA0	500	975	6SL3000-2AE41-4AA0
-	6SL3321-1TE41-1AA0	560	1075	6SL3000-2AE41-4AA0
-	6SL3321-1TE41-2AA0	630	1200	6SL3000-2AE41-4AA0

¹⁾ To achieve a UL-approved system, it is absolutely essential to use the fuse types specified in the table.

SINAMICS S120 Chassis-2 Converter Units

System components

Motor-side power components > dv/dt filter plus VPL

Selection and ordering data

Suitable for Power Module	Suitable for Motor Module Chassis-2	Type rating at 400 V	Rated output current	dv/dt filter plus VPL
Air-cooled	Air-cooled	kW	A	Article No.
Line voltage 380 ... 480 V 3 AC				
–	6SL3321-1TE41-0AA0	500	975	6SL3000-2DE41-4AA0
–	6SL3321-1TE41-1AA0	560	1075	6SL3000-2DE41-4AA0
–	6SL3321-1TE41-2AA0	630	1200	6SL3000-2DE41-4AA0

Motor-side power components > dv/dt filter compact plus VPL

Selection and ordering data

Suitable for Power Module	Suitable for Motor Module Chassis-2	Type rating at 400 V	Rated output current	dv/dt filter compact plus VPL
Air-cooled	Air-cooled	kW	A	Article No.
Line voltage 380 ... 480 V 3 AC				
–	6SL3321-1TE41-0AA0	500	975	6SL3000-2DE41-4EA0
–	6SL3321-1TE41-1AA0	560	1075	6SL3000-2DE41-4EA0
–	6SL3321-1TE41-2AA0	630	1200	6SL3000-2DE41-4EA0

For additional information on dv/dt filters, please refer to the SINAMICS Low Voltage Engineering Manual.

Appendix

Conversion tables

Rotary inertia (to convert from A to B, multiply by entry in table)

A \ B	lb-in ²	lb-ft ²	lb-in-s ²	lb-ft-s ² slug-ft ²	kg-cm ²	kg-cm-s ²	gm-cm ²	gm-cm-s ²	oz-in ²	oz-in-s ²
lb-in ²	1	6.94×10^{-3}	2.59×10^{-3}	2.15×10^{-4}	2.926	2.98×10^{-3}	2.92×10^3	2.984	16	4.14×10^{-2}
lb-ft ²	144	1	0.3729	3.10×10^{-2}	421.40	0.4297	4.21×10^5	429.71	2304	5.967
lb-in-s ²	386.08	2.681	1	8.33×10^{-2}	1.129×10^3	1.152	1.129×10^6	1.152×10^3	6.177×10^3	16
lb-ft-s ² slug-ft ²	4.63×10^3	32.17	12	1	1.35×10^4	13.825	1.355×10^7	1.38×10^4	7.41×10^4	192
kg-cm ²	0.3417	2.37×10^{-3}	8.85×10^{-4}	7.37×10^{-5}	1	1.019×10^{-3}	1000	1.019	5.46	1.41×10^{-2}
kg-cm-s ²	335.1	2.327	0.8679	7.23×10^{-2}	980.66	1	9.8×10^5	1000	5.36×10^3	13.887
gm-cm ²	3.417×10^{-4}	2.37×10^{-6}	8.85×10^{-7}	7.37×10^{-8}	1×10^{-3}	1.01×10^{-6}	1	1.01×10^{-3}	5.46×10^{-3}	1.41×10^{-5}
gm-cm-s ²	0.335	2.32×10^{-3}	8.67×10^{-4}	7.23×10^{-5}	0.9806	1×10^{-3}	980.6	1	5.36	1.38×10^{-2}
oz-in ²	0.0625	4.34×10^{-4}	1.61×10^{-4}	1.34×10^{-5}	0.182	1.86×10^{-4}	182.9	0.186	1	2.59×10^{-3}
oz-in-s ²	24.13	0.1675	6.25×10^{-2}	5.20×10^{-3}	70.615	7.20×10^{-2}	7.09×10^4	72.0	386.08	1

Torque (to convert from A to B, multiply by entry in table)

A \ B	lb-in	lb-ft	oz-in	N-m	kg-cm	kg-m	gm-cm	dyne-cm
lb-in	1	8.333×10^{-2}	16	0.113	1.152	1.152×10^{-2}	1.152×10^3	1.129×10^6
lb-ft	12	1	192	1.355	13.825	0.138	1.382×10^4	1.355×10^7
oz-in	6.25×10^{-2}	5.208×10^{-3}	1	7.061×10^{-3}	7.200×10^{-2}	7.200×10^{-4}	72.007	7.061×10^4
N-m	8.850	0.737	141.612	1	10.197	0.102	1.019×10^4	1×10^7
kg-cm	0.8679	7.233×10^{-2}	13.877	9.806×10^{-2}	1	10^{-2}	1000	9.806×10^5
kg-m	86.796	7.233	1.388×10^3	9.806	100	1	1×10^5	9.806×10^7
gm-cm	8.679×10^{-4}	7.233×10^{-5}	1.388×10^{-2}	9.806×10^{-5}	1×10^{-3}	1×10^{-5}	1	980.665
dyne-cm	8.850×10^{-7}	7.375×10^{-8}	1.416×10^{-5}	10^{-7}	1.0197×10^{-6}	1.019×10^{-8}	1.019×10^{-3}	1

Length (to convert from A to B, multiply by entry in table)

A \ B	inches	feet	cm	yd	mm	m
inches	1	0.0833	2.54	0.028	25.4	0.0254
feet	12	1	30.48	0.333	304.8	0.3048
cm	0.3937	0.03281	1	1.09×10^{-2}	10	0.01
yd	36	3	91.44	1	914.4	0.914
mm	0.03937	0.00328	0.1	1.09×10^{-3}	1	0.001
m	39.37	3.281	100	1.09	1000	1

Force (to convert from A to B, multiply by entry in table)

A \ B	lb	oz	gm	dyne	N
lb	1	16	453.6	4.448×10^5	4.4482
oz	0.0625	1	28.35	2.780×10^4	0.27801
gm	2.205×10^{-3}	0.03527	1	1.02×10^{-3}	N.A.
dyne	2.248×10^{-6}	3.59×10^{-5}	980.7	1	0.00001
N	0.22481	3.5967	N.A.	100000	1

Power (to convert from A to B, multiply by entry in table)

A \ B	hp	Watts
hp (English)	1	745.7
(lb-in) (deg./s)	2.645×10^{-6}	1.972×10^{-3}
(lb-in) (rpm)	1.587×10^{-5}	1.183×10^{-2}
(lb-ft) (deg./s)	3.173×10^{-5}	2.366×10^{-2}
(lb-ft) (rpm)	1.904×10^{-4}	0.1420
Watts	1.341×10^{-3}	1

Mass (to convert from A to B, multiply by entry in table)

A \ B	lb	oz	gm	kg	slug
lb	1	16	453.6	0.4536	0.0311
oz	6.25×10^{-2}	1	28.35	0.02835	1.93×10^{-3}
gm	2.205×10^{-3}	3.527×10^{-2}	1	10^{-3}	6.852×10^{-5}
kg	2.205	35.27	10^3	1	6.852×10^{-2}
slug	32.17	514.8	1.459×10^4	14.59	1

Rotation (to convert from A to B, multiply by entry in table)

A \ B	rpm	rad/s	degrees/s
rpm	1	0.105	6.0
rad/s	9.55	1	57.30
degrees/s	0.167	1.745×10^{-2}	1

Temperature Conversion

°F	°C	°C	°F
0	-17.8	-10	14
32	0	0	32
50	10	10	50
70	21.1	20	68
90	32.2	30	86
98.4	37	37	98.4
212	100	100	212
subtract 32 and multiply by $\frac{5}{9}$		multiply by $\frac{9}{5}$ and add 32	

Mechanism Efficiencies

Acme-screw with brass nut	~0.35–0.65
Acme-screw with plastic nut	~0.50–0.85
Ball-screw	~0.85–0.95
Chain and sprocket	~0.95–0.98
Preloaded ball-screw	~0.75–0.85
Spur or bevel-gears	~0.90
Timing belts	~0.96–0.98
Worm gears	~0.45–0.85
Helical gear (1 reduction)	~0.92

Friction Coefficients

Materials	μ
Steel on steel (greased)	~0.15
Plastic on steel	~0.15–0.25
Copper on steel	~0.30
Brass on steel	~0.35
Aluminum on steel	~0.45
Steel on steel	~0.58
Mechanism	μ
Ball bushings	<0.001
Linear bearings	<0.001
Dove-tail slides	~0.2++
Gibb ways	~0.5++

Material Densities

Material	lb-in ³	gm-cm ³
Aluminum	0.096	2.66
Brass	0.299	8.30
Bronze	0.295	8.17
Copper	0.322	8.91
Hard wood	0.029	0.80
Soft wood	0.018	0.48
Plastic	0.040	1.11
Glass	0.079–0.090	2.2–2.5
Titanium	0.163	4.51
Paper	0.025–0.043	0.7–1.2
Polyvinyl chloride	0.047–0.050	1.3–1.4
Rubber	0.033–0.036	0.92–0.99
Silicone rubber, without filler	0.043	1.2
Cast iron, gray	0.274	7.6
Steel	0.280	7.75

Wire Gauges¹⁾

Cross-section mm ²	Standard Wire Gauge (SWG)	American Wire Gauge (AWG)
0.2	25	24
0.3	23	22
0.5	21	20
0.75	20	19
1.0	19	18
1.5	17	16
2.5	15	13
4	13	11
6	12	9
10	9	7
16	7	6
25	5	3
35	3	2
50	0	1/0
70	000	2/0
95	00000	3/0
120	0000000	4/0
150	–	6/0
185	–	7/0

¹⁾ The table shows approximate SWG/AWG sizes nearest to standard metric sizes; the cross-sections do not match exactly.

Appendix

Metal surcharges

Explanation of the raw material/metal surcharges¹⁾

Surcharge calculation

To compensate for variations in the price of the raw materials silver, copper, aluminum, lead, gold, dysprosium²⁾ and/or neodym²⁾, surcharges are calculated on a daily basis using the so-called metal factor for products containing these raw materials. A surcharge for the respective raw material is calculated as a supplement to the price of a product if the basic official price of the raw material in question is exceeded.

The surcharges are calculated in accordance with the following criteria:

- Basic official price of the raw material
Basic official price from the day prior to receipt of the order or prior to release order (daily price) for³⁾
 - Silver (sales price, processed)
 - Gold (sales price, processed)
- and for⁴⁾
 - Copper (lower DEL notation + 1 %)
 - Aluminum (aluminum in cables)
 - Lead (lead in cables)
- Metal factor of the products
Certain products are displayed with a metal factor. The metal factor determines the official price (for those raw materials concerned) as of which the metal surcharges are applied and the calculation method used (weight or percentage method). An exact explanation is given below.

Structure of the metal factor

The metal factor consists of several digits; the first digit indicates whether the percentage method of calculation refers to the list price or a possible discounted price (customer net price) (L = list price / N = customer net price).

The remaining digits indicate the method of calculation used for the respective raw material. If no surcharge is added for a raw material, a "-" is used.

1st digit	List or customer net price using the percentage method
2nd digit	for silver (AG)
3rd digit	for copper (CU)
4th digit	for aluminum (AL)
5th digit	for lead (PB)
6th digit	for gold (AU)
7th digit	for dysprosium (Dy) ²⁾
8th digit	for neodym (Nd) ²⁾

Weight method

The weight method uses the basic official price, the daily price and the raw material weight. In order to calculate the surcharge, the basic official price must be subtracted from the daily price. The difference is then multiplied by the raw material weight.

The basic official price can be found in the table below using the number (1 to 9) of the respective digit of the metal factor. The raw material weight can be found in the respective product descriptions.

Percentage method

Use of the percentage method is indicated by the letters A-Z at the respective digit of the metal factor.

The surcharge is increased - dependent on the deviation of the daily price compared with the basic official price - using the percentage method in "steps" and consequently offers surcharges that remain constant within the framework of this "step range". A higher percentage rate is charged for each new step. The respective percentage level can be found in the table below.

Metal factor examples

L E A - - - -	<ul style="list-style-type: none"> Basis for % surcharge: List price Silver Basis 150 €, Step 50 €, 0.5 % Copper Basis 150 €, Step 50 €, 0.1 % No surcharge for aluminum No surcharge for lead No surcharge for gold No surcharge for dysprosium No surcharge for neodym
N - A 6 - - - -	<ul style="list-style-type: none"> Basis for % surcharge: Customer net price No surcharge for silver Copper Basis 150 €, Step 50 €, 0.1 % Aluminum acc. to weight, basic offic. price 225 € No surcharge for lead No surcharge for gold No surcharge for dysprosium No surcharge for neodym
- - 3 - - - -	<ul style="list-style-type: none"> No basis necessary No surcharge for silver Copper acc. to weight, basic official price 150 € No surcharge for aluminum No surcharge for lead No surcharge for gold No surcharge for dysprosium No surcharge for neodym

¹⁾ Refer to the separate explanation on the next page regarding the raw materials dysprosium and neodym (= rare earths).

²⁾ For a different method of calculation, refer to the separate explanation for these raw materials on the next page.

³⁾ Source: Umicore, Hanau (www.metalsmanagement.umicore.com).

⁴⁾ Source: Schutzvereinigung DEL-Notiz e.V. (www.del-notiz.org).

Explanation of the raw material/metal surcharges for dysprosium and neodym (rare earths)

Surcharge calculation

To compensate for variations in the price of the raw materials silver¹⁾, copper¹⁾, aluminum¹⁾, lead¹⁾, gold¹⁾, dysprosium and/or neodym, surcharges are calculated on a daily basis using the so-called metal factor for products containing these raw materials. The surcharge for dysprosium and neodym is calculated as a supplement to the price of a product if the basic official price of the raw material in question is exceeded.

The surcharge is calculated in accordance with the following criteria:

- Basic official price of the raw material²⁾
Three-month basic average price (see below) in the period before the quarter in which the order was received or the release order took place (= average official price) for
- dysprosium (Dy metal, 99 % min. FOB China; USD/kg)
- neodym (Nd metal, 99 % min. FOB China; USD/kg)
- Metal factor of the products
Certain products are displayed with a metal factor. The metal factor indicates (for those raw materials concerned) the basic official price as of which the surcharges for dysprosium and neodym are calculated using the weight method. An exact explanation of the metal factor is given below.

Three-month average price

The prices of rare earths vary according to the foreign currency, and there is no freely accessible stock exchange listing. This makes it more difficult for all parties involved to monitor changes in price. In order to avoid continuous adjustment of the surcharges, but to still ensure fair, transparent pricing, an average price is calculated over a three-month period using the average monthly foreign exchange rate from USD to EUR (source: European Central Bank). Since not all facts are immediately available at the start of each month, a one-month buffer is allowed before the new average price applies.

Examples of calculation of the average official price:

Period for calculation of the average price:	Period during which the order/release order is effected and the average price applies:
Sep 2012 - Nov 2012	Q1 in 2013 (Jan - Mar)
Dec 2012 - Feb 2013	Q2 in 2013 (Apr - Jun)
Mar 2013 - May 2013	Q3 in 2013 (Jul - Sep)
Jun 2013 - Aug 2013	Q4 in 2013 (Oct - Dec)

Structure of the metal factor

The metal factor consists of several digits; the first digit is not relevant to the calculation of dysprosium and neodym.

The remaining digits indicate the method of calculation used for the respective raw material. If no surcharge is added for a raw material, a "-" is used.

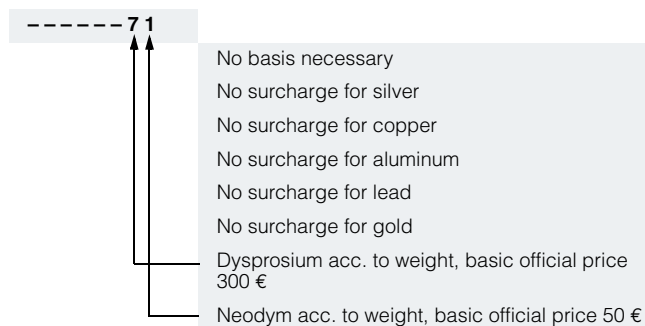
1st digit	List or customer net price using the percentage method
2nd digit	for silver (AG) ¹⁾
3rd digit	for copper (CU) ¹⁾
4th digit	for aluminum (AL) ¹⁾
5th digit	for lead (PB) ¹⁾
6th digit	for gold (AU) ¹⁾
7th digit	for dysprosium (Dy)
8th digit	for neodym (Nd)

Weight method

The weight method uses the basic official price, the average price and the raw material weight. In order to calculate the surcharge, the basic official price must be subtracted from the average price. The difference is then multiplied by the raw material weight.

The basic official price can be found in the table below using the number (1 to 9) of the respective digit of the metal factor. Your Sales contact can inform you of the raw material weight.

Metal factor examples



¹⁾ For a different method of calculation, refer to the separate explanation for these raw materials on the previous page.

²⁾ Source: Asian Metal Ltd (www.asianmetal.com)

Appendix

Metal surcharges

Values of the metal factor

Percentage method	Basic official price in €	Step range in €	% surcharge 1st step	% surcharge 2nd step	% surcharge 3rd step	% surcharge 4th step	% surcharge per additional step	
			Price in €	Price in €	Price in €	Price in €		
			150.01 - 200.00	200.01 - 250.00	250.01 - 300.00	300.01 - 350.00		
A	150	50	0.1	0.2	0.3	0.4	0.1	
B	150	50	0.2	0.4	0.6	0.8	0.2	
C	150	50	0.3	0.6	0.9	1.2	0.3	
D	150	50	0.4	0.8	1.2	1.6	0.4	
E	150	50	0.5	1.0	1.5	2.0	0.5	
F	150	50	0.6	1.2	1.8	2.4	0.6	
G	150	50	1.0	2.0	3.0	4.0	1.0	
H	150	50	1.2	2.4	3.6	4.8	1.2	
I	150	50	1.6	3.2	4.8	6.4	1.6	
J	150	50	1.8	3.6	5.4	7.2	1.8	
			175.01 - 225.00	225.01 - 275.00	275.01 - 325.00	325.01 - 375.00		
O	175	50	0.1	0.2	0.3	0.4	0.1	
P	175	50	0.2	0.4	0.6	0.8	0.2	
R	175	50	0.5	1.0	1.5	2.0	0.5	
			225.01 - 275.00	275.01 - 325.00	325.01 - 375.00	375.01 - 425.00		
S	225	50	0.2	0.4	0.6	0.8	0.2	
U	225	50	1.0	2.0	3.0	4.0	1.0	
V	225	50	1.0	1.5	2.0	3.0	1.0	
W	225	50	1.2	2.5	3.5	4.5	1.0	
			150.01 - 175.00	175.01 - 200.00	200.01 - 225.00	225.01 - 250.00		
Y	150	25	0.3	0.6	0.9	1.2	0.3	
			400.01 - 425.00	425.01 - 450.00	450.01 - 475.00	475.01 - 500.00		
Z	400	25	0.1	0.2	0.3	0.4	0.1	
Price basis (1st digit)								
L	Calculation based on the list price							
N	Calculation based on the customer net price (discounted list price)							
Weight method	Basic official price in €							
1	50	Calculation based on raw material weight						
2	100							
3	150							
4	175							
5	200							
6	225							
7	300							
8	400							
9	555							
Miscellaneous								
-	No metal surcharge							

1. General Provisions

By using this catalog you can acquire hardware and software products described therein from Siemens AG subject to the following Terms and Conditions of Sale and Delivery (hereinafter referred to as "T&C"). Please note that the scope, the quality and the conditions for supplies and services, including software products, by any Siemens entity having a registered office outside Germany, shall be subject exclusively to the General Terms and Conditions of the respective Siemens entity. The following T&C apply exclusively for orders placed with Siemens Aktiengesellschaft, Germany.

1.1 For customers with a seat or registered office in Germany

For customers with a seat or registered office in Germany, the following applies subordinate to the T&C:

- for installation work the "General Conditions for Erection Works – Germany"¹⁾ ("Allgemeine Montagebedingungen – Deutschland" (only available in German at the moment)) and/or
- for Plant Analytics Services the "Standard Terms and Conditions for Plant Analytics Services – for Customer in Germany"¹⁾ ("Allgemeine Geschäftsbedingungen für das Plant Analytics Services – für Kunden in Deutschland" (only available in German at the moment)) and/or
- for stand-alone software products and software products forming a part of a product or project, the "General License Conditions for Software Products for Automation and Drives for Customers with a Seat or registered Office in Germany"¹⁾ and/or
- for other supplies and/or services the "General Conditions for the Supply of Products and Services of the Electrical and Electronics Industry"¹⁾.

In case such supplies and/or services should contain Open Source Software, the conditions of which shall prevail over the "General Conditions for the Supply of Products and Services of the Electrical and Electronics Industry"¹⁾. A notice will be contained in the scope of delivery in which the applicable conditions for Open Source Software are specified. This shall apply mutatis mutandis for notices referring to other third party software components.

1.2 For customers with a seat or registered office outside Germany

For customers with a seat or registered office outside Germany, the following applies subordinate to the T&C:

- for Plant Analytics Services the "Standard Terms and Conditions for Plant Analytics Services"¹⁾ and/or
- for services the "International Terms & Conditions for Services"¹⁾ supplemented by "Software Licensing Conditions"¹⁾ and/or
- for other supplies of hard- and/or software the "International Terms & Conditions for Products"¹⁾ supplemented by "Software Licensing Conditions"¹⁾

1.3 For customers with master or framework agreement

To the extent our supplies and/or services offered are covered by an existing master or framework agreement, the terms and conditions of that agreement shall apply instead of T&C.

2. Prices

The prices are in € (Euro) ex point of delivery, exclusive of packaging.

The sales tax (value added tax) is not included in the prices. It shall be charged separately at the respective rate according to the applicable statutory legal regulations.

Prices are subject to change without prior notice. We will charge the prices valid at the time of delivery.

To compensate for variations in the price of raw materials (e.g. silver, copper, aluminum, lead, gold, dysprosium and neodym), surcharges are calculated on a daily basis using the so-called metal factor for products containing these raw materials. A surcharge for the respective raw material is calculated as a supplement to the price of a product if the basic official price of the raw material in question is exceeded.

The metal factor of a product indicates the basic official price (for those raw materials concerned) as of which the surcharges on the price of the product are applied, and with what method of calculation.

You will find a detailed explanation of the metal factor on the page headed "Metal surcharges".

To calculate the surcharge (except in the cases of dysprosium and neodym), the official price from the day prior to that on which the order was received or the release order was effected is used.

To calculate the surcharge applicable to dysprosium and neodym ("rare earths"), the corresponding three-month basic average price in the quarter prior to that in which the order was received or the release order was effected is used with a one-month buffer (details on the calculation can be found in the explanation of the metal factor).

3. Additional Terms and Conditions

The dimensions are in mm. In Germany, according to the German law on units in measuring technology, data in inches apply only to devices for export.

Illustrations are not binding.

Insofar as there are no remarks on the individual pages of this catalog - especially with regard to data, dimensions and weights given - these are subject to change without prior notice.

¹⁾ The text of the Terms and Conditions of Siemens AG can be downloaded at www.siemens.com/automation/salesmaterial-as/catalog/en/terms_of_trade_en.pdf

Appendix

Conditions of sale and delivery

4. Export regulations

We shall not be obligated to fulfill any agreement if such fulfillment is prevented by any impediments arising out of national or international foreign trade or customs requirements or any embargoes and/or other sanctions.

Export may be subject to license. We shall indicate in the delivery details whether licenses are required under German, European and US export lists.

Our products are controlled by the U.S. Government (when labeled with "ECCN" unequal "N") and authorized for export only to the country of ultimate destination for use by the ultimate consignee or end-user(s) herein identified. They may not be resold, transferred, or otherwise disposed of, to any other country or to any person other than the authorized ultimate consignee or end-user(s), either in their original form or after being incorporated into other items, without first obtaining approval from the U.S. Government or as otherwise authorized by U.S. law and regulations.

The export indications can be viewed in advance in the description of the respective goods on the Industry Mall, our online catalog system. Only the export labels "AL" and "ECCN" indicated on order confirmations, delivery notes and invoices are authoritative.

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If required for the purpose of conducting export control checks, you (upon request by us) shall promptly provide us with all information pertaining to the particular end customer, final disposition and intended use of goods delivered by us respectively works and services provided by us, as well as to any export control restrictions existing in this relation.

The products listed in this catalog may be subject to European/German and/or US export regulations. Any export requiring approval is therefore subject to authorization by the relevant authorities.

Errors excepted and subject to change without prior notice.

Further information can be obtained from our branch offices listed at www.siemens.com/automation-contact

Interactive Catalog on DVD	<i>Catalog</i>	Process Instrumentation and Analytics	<i>Catalog</i>
Products for Automation and Drives	CA 01	<i>Digital: Field Instruments for Process Automation</i>	FI 01
Building Control		<i>Digital: Display Recorders SIREC D</i>	MP 20
GAMMA Building Control	ET G1	<i>Digital: SIPART Controllers and Software</i>	MP 31
Drive Systems		Products for Weighing Technology	WT 10
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