Configuration

Performance characteristics SINAMICS S

Characteristics	Servo Control	Vector Control	*V/f* Control	Notes
Typical application	• Drives with highly dynamic motion control • Angular-locked synchronism with isochronous PROFIBUS/PROFINET in conjunction with SIMOTION • For use in machine tools and clocked production machines	• Speed-controlled drives with high speed and torque stability in general mechanical engineering systems • Particularly suitable for asynchronous motors (induction motors)	• Drives with low requirements on dynamic response and accuracy • Multi-motor group drives, e.g. on textile machines with SIEMOSYN motors	Mixed operation of Servo Control and Vector Control is not possible on a single CU320-2. Mixed operation with *V/f* control modes is possible with servo or vector control.
Dynamic response	Very high	High	Low	Highest dynamic response with 1FK7/1FT7 High Dynamic synchronous motors and Servo Control.
Control modes with encoder	Position control/ Speed control/ Torque control	Position control/ Speed control/ Torque control	None	SIMOTION D with Servo Control is standard for coordinated motion control.
Control modes without encoder	Speed control	Speed control/ torque control	All *V/f* control modes	With Servo for asynchronous motors (induction motors) only. With *V/f* control the speed can be kept constant by means of selectable slip compensation.
Asynchronous motor (induction motor)	Yes	Yes	Yes	*V/f* control (textiles) is recommended for SIEMOSYN motors.
Synchronous motor	Yes	No	No	
Torque motor	Yes	Yes	No	
Linear motor	Yes	No	No	
Permissible ratio of motor rated current to rated current of Motor Module	1:1 to 1:4	1.3:1 to 1:4	1:1 to 1:12	Maximum control quality in the case of Servo and Vector Control up to 1:4. Between 1:4 and 1:8 increasing restrictions as regards torque and rotational accuracy. *V/f* Control is recommended for < 1:8.
Maximum number of parallel-connected motors per Motor Module	4	8	Unlimited in theory	Motors connected in parallel must be asynchronous (induction) motors with identical power ratings. With *V/f* control, the motors can have different power ratings.
Setpoint resolution position controller	31 bit + sign	31 bit + sign	–	
Setpoint resolution speed/frequency	31 bit + sign	31 bit + sign	0.001 Hz	
Setpoint resolution torque	31 bit + sign	31 bit + sign	–	
Maximum output frequency				
• For current controller clock cycle/pulse frequency	660 Hz with 125 µs/4 kHz	330 Hz with 250 µs/4 kHz	400 Hz with 250 µs/4 kHz	Note limit voltage (2 kV) and use of VPM Module with synchronous motors. Asynchronous (induction) motors only: When using edge modulation, 600 Hz are possible at 4 kHz, or 300 Hz at 2 kHz and 200 Hz at 1.25 kHz.
• For current controller clock cycle/pulse frequency (chassis frame sizes FX and GX)	330 Hz with 250 µs/2 kHz	160 Hz with 250 µs/2 kHz	200 Hz with 250 µs/2 kHz	
• For current controller clock cycle/pulse frequency (chassis frame sizes HX and JX)	Not permitted	100 Hz with 400 µs/1.25 kHz	100 Hz with 400 µs/1.25 kHz	
Maximum field weakening				
• For asynchronous (induction) motors	5 times	5 times	4 times	With Servo Control combined with encoder and appropriate special motors, field weakening up to 16 times the field-weakening threshold speed is possible.
• For synchronous motors	2 times	2 times	–	These values refer to 1FT7/1FK7 synchronous motors. Note limit voltage (kE factor) with non-Siemens motors.

SINAMICS S120 Control Units

Configuration

Fundamental closed-loop control characteristics of SINAMICS S

- Booksize format, pulse frequency 4 kHz, closed-loop torque control

	Servo Control		Vector Control		Notes
Synchronous motor	**1FK7 with R14DQ** [1]	**1FT7**	Vector Control is not designed as an operating mode for 1FK7/1FT7 synchronous motors.		
Controller cycle	125 µs	125 µs			
Rise time (without delay)	0.7 ms	0.5 ms			At a speed operating range from 50 rpm for resolver.
Characteristic angular frequency -3 dB	650 Hz	900 Hz			In this case, the dynamic response is determined primarily by the encoder system.
Torque ripple	3 % of M_0	0.6 % of M_0			With speed operating range of 20 rpm up to rated speed. A ripple of < 1 % is possible with an absolute encoder ≤ 1 rpm. Not possible with resolver.
Torque accuracy	± 1.5 % of M_0	± 1.5 % of M_0			Measured value averaged over 3 s. With motor identification and friction compensation. In torque operating range up to ± M_0. Speed operating range 1:10 up to rated speed. Notice: External influences such as motor temperature can cause an additional long-time inaccuracy (constancy) of about ± 2.5 %. Approx. ± 1 % less accuracy in field-weakening range.
Asynchronous motor (induction motor)	**1PH7/1PH8 without encoder**	**1PH7/1PH8 with incremental encoder 1024 S/R**	**1PH7/1PH8 without encoder**	**1PH7/1PH8 with incremental encoder 1024 S/R**	
Controller cycle	125 µs	125 µs	250 µs	250 µs	
Total rise time (without delay)	–	0.8 ms	2 ms	1.2 ms	With encoderless operation in speed operating range 1:10, with encoder 50 rpm and above up to rated speed.
Characteristic angular frequency -3 dB	–	600 Hz	250 Hz	400 Hz	With encoderless operation in speed operating range 1:10. The dynamic response is enhanced by an encoder feedback.
Torque ripple	–	1.5 % of M_{rated}	2 % of M_{rated}	2 % of M_{rated}	With encoderless operation in speed operating range 1:20, with encoder 20 rpm and above up to rated speed.
Torque accuracy	–	± 3.5 % of M_{rated}	± 2 % of M_{rated}	± 1.5 % of M_{rated}	Measured value averaged over 3 s. With motor identification and friction compensation, temperature effects compensated by KTY84 and mass model. In torque operating range up to ± M_{rated}. Approx. additional inaccuracy of ± 2.5 % in field-weakening range. Servo: Speed operating range 1:10 referred to rated speed. Vector: Speed operating range 1:50 referred to rated speed.

[1] R14DQ: Resolver 14 bit (resolution 16384, internally 2-pole).

Configuration

- Booksize format, pulse frequency 4 kHz, closed-loop speed control

	Servo Control		Vector Control		Notes
Synchronous motor	**1FK7 with R14DQ** [1]	**1FT7**	Vector Control is not designed as an operating mode for 1FK7/1FT7 synchronous motors.		
Controller cycle	125 µs	125 µs			
Total rise time (without delay)	3.5 ms	2.3 ms			With encoderless operation in speed operating range 1:10, with encoder 50 rpm and above up to rated speed.
Characteristic angular frequency -3 dB	140 Hz	250 Hz			In this case, the dynamic response is determined primarily by the encoder system.
Speed ripple	See note	See note			Determined primarily by the total mass moment of inertia, the torque ripple and especially the mechanical configuration. It is therefore not possible to specify a generally applicable value.
Speed accuracy	≤ 0.001 % of n_{rated}	≤ 0.001 % of n_{rated}			Determined primarily by the resolution of the control deviation and encoder evaluation in the converter. This is implemented on a 32-bit basis for SINAMICS.
Asynchronous motor (induction motor)	**1PH7/1PH8 without encoder**	**1PH7/1PH8 with incremental encoder 1024 S/R**	**1PH7/1PH8 without encoder**	**1PH7/1PH8 with incremental encoder 1024 S/R**	
Controller cycle	125 µs	125 µs	250 µs	250 µs	
Total rise time (without delay)	12 ms	5 ms	20 ms	10 ms	With encoderless operation in speed operating range 1:10, with encoder 50 rpm and above up to rated speed.
Characteristic angular frequency -3 dB	40 Hz	120 Hz	50 Hz	80 Hz	With encoderless operation in speed operating range 1:10. The dynamic response is enhanced by an encoder feedback. Servo with encoder is slightly more favorable than Vector with encoder, as the speed controller cycle with Servo is quicker.
Speed ripple	See note	See note	See note	See note	Determined primarily by the total mass moment of inertia, the torque ripple and especially the mechanical configuration. It is therefore not possible to specify a generally applicable value.
Speed accuracy	0.1 × f_{slip}	≤ 0.001 % of n_{rated}	0.05 × f_{slip}	≤ 0.001 % of n_{rated}	Without encoder: Determined primarily by the accuracy of the calculation model for the torque-producing current and rated slip of the asynchronous motor (induction motor) (see table Typical slip values). With speed operating range 1:50 (vector) or 1:10 (servo) and with activated temperature evaluation.

[1] R14DQ: Resolver 14 bit (resolution 16384, internally 2-pole).

SINAMICS S120 Control Units

Configuration

- Blocksize, booksize compact, booksize and chassis, pulse frequency 4 kHz, position control

	Servo Control		Vector Control		Notes
Synchronous motor	**1FT7**	**1FK7**	Vector Control is not designed as an operating mode for 1FT7/1FK7 synchronous motors.		
Position controller cycle	1 ms	1 ms			
Resolution	4.19×10^6 incr./rev.	16384 incr./rev.			Correspondingly better with multi-pole resolver.
Attainable positioning accuracy	10^5 ... 10^6 incr./rev.	4096 incr./rev.			In practice, the resolution must be higher than the required positioning accuracy by a factor of 4 to 10. These values are approximate nominal values only.
• In relation to the motor shaft, approx.	0.00072 °	0.1 °			
Asynchronous motor (induction motor)	**1PH7/1PH8 with AM22DQ**[1]	**1PH7/1PH8 with incremental encoder 1024 S/R**	**1PH7/1PH8 with AM22DQ**[1]	**1PH7/1PH8 with incremental encoder 1024 S/R**	
Position controller cycle	1 ms	1 ms	2 ms	2 ms	
Resolution	4.19×10^6 incr./rev.	4096 incr./rev.	4.19×10^6 incr./rev.	4096 incr./rev.	
Attainable positioning accuracy	10^5 ... 10^6 incr./rev.	1024 incr./rev.	10^5 ... 10^6 incr./rev.	512 incr./rev.	In practice, the resolution must be higher than the required positioning accuracy by a factor of 4 to 10. These values are approximate nominal values only. Vector is less accurate than servo by a factor of approximately 2.
• In relation to the motor shaft, approx.	0.00072 °	0.35 °	0.00072 °	0.7 °	

[1] AM22DQ: Absolute encoder 22 bit single-turn (resolution 4194304, encoder-internal 2048 S/R) + 12 bit multi-turn (traversing range 4096 revolutions).

Configuration

- Chassis format, pulse frequency 2 kHz, closed-loop torque control

	Servo Control		Vector Control		Notes
Synchronous motor	**1FT7 without encoder**	**1FT7 with AM22DQ**[1]	Vector Control is not designed as an operating mode for 1FT7 synchronous motors.		
Controller cycle	250 µs	250 µs			
Total rise time (without delay)	–	1.2 ms			
Characteristic angular frequency -3 dB	–	400 Hz			In this case, the dynamic response is determined primarily by the encoder system.
Torque ripple	–	1.3 % of M_0			A ripple of < 1 % is possible with an absolute encoder ≤ 1 rpm. Not possible with resolver.
Torque accuracy	–	± 1.5 % of M_0			Measured value averaged over 3 s. With motor identification and friction compensation. In torque operating range up to ± M_0. Speed operating range 1:10 up to rated speed. Notice: External influences such as motor temperature can cause an additional long-time inaccuracy (constancy) of about ± 2.5 %. Approx. ± 1 % less accuracy in field-weakening range.
Asynchronous motor (induction motor)	**1PH7/1PH8 without encoder**	**1PH7/1PH8 with incremental encoder 1024 S/R**	**1PH7/1PH8 without encoder**	**1PH7/1PH8 with incremental encoder 1024 S/R**	
Controller cycle	250 µs	250 µs	250 µs	250 µs	
Total rise time (without delay)	–	1.6 ms	2.5 ms	1.6 ms	With encoderless operation in speed operating range 1:10, with encoder 50 rpm and above up to rated speed.
Characteristic angular frequency -3 dB	–	350 Hz	200 Hz	300 Hz	With encoderless operation in speed operating range 1:10. The dynamic response is enhanced by an encoder feedback.
Torque ripple	–	2 % of M_{rated}	2.5 % of M_{rated}	2 % of M_{rated}	With encoderless operation in speed operating range 1:20, with encoder 20 rpm and above up to rated speed.
Torque accuracy	–	± 3.5 % of M_{rated}	± 2 % of M_{rated}	± 1.5 % of M_{rated}	Measured value averaged over 3 s. With motor identification and friction compensation, temperature effects compensated by KTY84 and mass model. In torque operating range up to ± M_{rated}. Approx. additional inaccuracy of ± 2.5 % in field-weakening range. Servo: Speed operating range 1:10 referred to rated speed. Vector: Speed operating range 1:50 referred to rated speed.

[1] AM22DQ: Absolute encoder 22 bit single-turn (resolution 4194304, encoder-internal 2048 S/R) + 12 bit multi-turn (traversing range 4096 revolutions).

SINAMICS S120 Control Units

Configuration

- Chassis format, pulse frequency 2 kHz, closed-loop speed control

	Servo Control		Vector Control		Notes
Synchronous motor	**1FT7 without encoder**	**1FT7 with AM22DQ**[1]	Vector Control is not designed as an operating mode for 1FT7 synchronous motors.		
Controller cycle	250 µs	250 µs			
Total rise time (without delay)	–	5 ms			With encoderless operation in speed operating range 1:10, with encoder 50 rpm and above up to rated speed.
Characteristic angular frequency -3 dB	–	100 Hz			In this case, the dynamic response is determined primarily by the encoder system.
Speed ripple	–	See note			Determined primarily by the total mass moment of inertia, the torque ripple and especially the mechanical configuration. It is therefore not possible to specify a generally applicable value.
Speed accuracy	–	≤ 0.001 % of n_{rated}			Determined primarily by the resolution of the control deviation and encoder evaluation in the converter. This is implemented on a 32-bit basis for SINAMICS.
Asynchronous motor (induction motor)	**1PH7/1PH8 without encoder**	**1PH7/1PH8 with incremental encoder 1024 S/R**	**1PH7/1PH8 without encoder**	**1PH7/1PH8 with incremental encoder 1024 S/R**	
Controller cycle	250 µs	250 µs	250 µs	250 µs	
Total rise time (without delay)	21 ms	8 ms	20 ms	12 ms	With encoderless operation in speed operating range 1:10, with encoder 50 rpm and above up to rated speed.
Characteristic angular frequency -3 dB	25 Hz	80 Hz	35 Hz	60 Hz	With encoderless operation in speed operating range 1:10. The dynamic response is enhanced by an encoder feedback. Servo with encoder is slightly more favorable than Vector with encoder, as the speed controller cycle with Servo is quicker.
Speed ripple	See note	See note	See note	See note	Determined primarily by the total mass moment of inertia, the torque ripple and especially the mechanical configuration. It is therefore not possible to specify a generally applicable value.
Speed accuracy	0.1 × f_{slip}	≤ 0.001 % of n_{rated}	0.05 × f_{slip}	≤ 0.001 % of n_{rated}	Without encoder: Determined primarily by the accuracy of the calculation model for the torque-producing current and rated slip of the asynchronous motor (induction motor) (see table Typical slip values). With speed operating range 1: 50 (Vector) or 1:10 (Servo) and with active temperature evaluation.

[1] AM22DQ: Absolute encoder 22 bit single-turn (resolution 4194304, encoder-internal 2048 S/R) + 12 bit multi-turn (traversing range 4096 revolutions).

Configuration

Typical slip values for standard asynchronous motors (induction motors)

Motor output	Slip values	Notes
< 1 kW (1.34 HP)	6 % of n_{rated} e.g. motor with 1500 rpm: 90 rpm	The slip values of 1PH asynchronous motors are very similar to those of standard motors
< 10 kW (13.4 HP)	3 % of n_{rated} e.g. motor with 1500 rpm: 45 rpm	
< 30 kW (40.2 HP)	2 % of n_{rated} e.g. motor with 1500 rpm: 30 rpm	
< 100 kW (134 HP)	1 % of n_{rated} e.g. motor with 1500 rpm: 15 rpm	
> 500 kW (671 HP)	0.5 % of n_{rated} e.g. motor with 1500 rpm: 7.5 rpm	

Performance of integrated closed-loop drive control with SIMOTION D4x5/CX32 (closed-loop drive control based on firmware version 2.x)

The degree to which the capacity of the closed-loop drive control with SIMOTION D4x5/CX32 is utilized depends on requirements in terms of number of axes, functional scope and control dynamic response.

When additional software functions (DCC, Safety, etc.) are activated and other components (Terminal Modules, CX32, ...) are employed, fewer axes can be computed by the integrated closed-loop drive control. With the SIZER configuration tool, it is easy to configure the SINAMICS S120 drive family including SIMOTION D. It can also be used to determine the possible number of axes and the resulting load according to performance requirements.

The following table provides a rough overview of computing performance as a function of current controller clock cycle (dynamic response) and number of axes with basic scope of functions (factory setting).

	Dynamic response (current controller clock cycle)	Number of axes	Note
Servo Control	125 µs	6	Including one infeed (Basic Line Module, Smart Line Module, Active Line Module). Number of axes applies only to basic functionality. Without expanded setpoint channel. Note power unit derating where applicable.
	250 µs	6	
Vector Control	250 µs	2	Including one infeed (Basic Line Module, Smart Line Module, Active Line Module). Number of axes applies only to basic functionality. Expanded setpoint channel included as standard. Note power unit derating where applicable.
	500 µs	4	
V/f Control	250 µs	4	Including one infeed (Basic Line Module, Smart Line Module, Active Line Module). Number of axes applies only to basic functionality. Expanded setpoint channel included as standard.
	400 µs	6	
	500 µs	8	
Mixed operation			
Servo Control plus *V/f* Control	125 µs + 250 µs/500 µs	5	Including one infeed (Basic Line Module, Smart Line Module, Active Line Module). Maximum 2 *V/f* axes with 250 µs current controller clock cycle, otherwise divide as required.
Vector Control plus *V/f* Control	250 µs/500 µs	2/4	Including one infeed (Basic Line Module, Smart Line Module, Active Line Module). In mixed operation Vector with *V/f* no difference to pure Vector operation.

SINAMICS S120 Control Units

Configuration

CU320-2: Axis licensing according to performance expansion (firmware version 4.3 and higher)

The CU320-2 is licensed purely according to axis number. The performance expansion is essentially required with four or more servo axes, four or more vector axes and seven or more *V/f* axes, irrespective of computing capacity.

	Dynamic response (current controller clock cycle)	Number of axes without performance expansion	Number of axes with performance expansion	Note
Servo Control	62.5 µs	3	3	3 servo axes are possible with a cycle time of 62.5 µs. The performance expansion is therefore ineffective. The performance expansion is required with 4 or more servo axes irrespective of computing capacity.
	125 µs	3	6	
	250 µs	3	6	
Vector Control	250 µs	3	3	3 servo axes are possible with a cycle time of 250 µs. The performance expansion is therefore ineffective. The performance expansion is required with 4 or more vector axes irrespective of computing capacity.
	500 µs	3	6	
V/f Control	250 µs	6	6	6 *V/f* axes are possible with a cycle time of 250 µs. The performance expansion is therefore ineffective. The performance expansion is required with 7 or more *V/f* axes irrespective of computing capacity.
	500 µs	6	12	
Mixed operation				
Servo Control plus *V/f* Control	125 µs/500 µs	3+0; 2+2; 1+4; 0+6	6+0; 5+2; 4+4; 3+6 2+8; 1+10; 0+12	Two *V/f* axes can be computed instead of a servo or vector axis.
Vector Control plus *V/f* Control	500 µs/500 µs	3+0, 2+2; 1+4; 0+6	6+0; 5+2; 4+4; 3+6 2+8; 1+10; 0+12	

CU320-2: Possible quantity structures, maximum configurations

In addition to the number of axes, the following functions and hardware components also have an influence on the possible quantity structure (maximum configuration) of the CU320-2:

- Extended Safety (SS2, SOS, SSM, SLS)
- EPos
- DCC
- CAN bus
- High-speed Terminal Modules (task = 250 µs)

Some examples of possible quantity structures

Examples with Servo

- 6 servo axes (125 µs) + 2 EPos + 2 extended safety
- 5 servo axes (125 µs) + 5 EPos + 5 extended safety
- 6 servo axes (250 µs) + 6 EPos + 6 extended safety + 100 DCC blocks (task: 2 ms)

Examples with Vector

- 6 vector axes (500 µs) + 50 DCC blocks (task: 2 ms)
- 4 vector axes (500 µs) + 50 DCC blocks (task: 2 ms) + 2 winders (task: 4 ms, DCC-based)

Examples with *V/f*

- 12 *V/f* axes (500 µs) + 50 DCC blocks (task: 2 ms)
- 10 *V/f* axes (500 µs) + 100 DCC blocks (task: 2 ms) + 2 extended safety

The SIZER configuration tool can be used to perform very quick reliability checks on more complex quantity structures.

Configuration

Influencing variables on minimum required pulse frequency of power unit

Basic requirements such as maximum speed or necessary dynamic response of the control have a direct effect in determining the minimum pulse frequency of the power unit. If the minimum pulse frequency exceeds the rated pulse frequency, derating must be implemented accordingly (see chapter SINAMICS S120 drive system).

The following table provides a general overview.

Influencing variables		Minimum pulse frequency	Notes
Servo Control, Vector Control (required max. output frequency/ speed)	100 Hz correspond to: 3000 rpm for Z_p = 2 1500 rpm for Z_p = 4 428 rpm for Z_p = 14 352 rpm for Z_p = 17	1.25 kHz	Z_p is the number of pole pairs of the motor. This equals 2 on 1PH asynchronous motors (induction motors). 1FT7/1FK7 synchronous motors have between 3 and 5 pairs of poles. For torque motors, the numbers of pole pairs are typically 14 and 17. When edge modulation is used (only possible for asynchronous motors), the output frequency is increased by a factor of 2.
	160 Hz correspond to: 4800 rpm for Z_p = 2 2400 rpm for Z_p = 4 685 rpm for Z_p = 14 565 rpm for Z_p = 17	2 kHz	
	200 Hz correspond to: 6000 rpm for Z_p = 2 3000 rpm for Z_p = 4 856 rpm for Z_p = 14 704 rpm for Z_p = 17	2.5 kHz	
	300 Hz correspond to: 9000 rpm for Z_p = 2 4500 rpm for Z_p = 4 1284 rpm for Z_p = 14 1056 rpm for Z_p = 17	4 kHz	
	400 Hz correspond to: 12000 rpm for Z_p = 2 6000 rpm for Z_p = 4	4 kHz	Notice: For Servo Control with 1FT7/1FK7 motors only. Note field weakening requirements and suitable encoder system for higher speeds.
V/f Control (required max. output frequency/ speed)	100 Hz correspond to: 6000 rpm for Z_p = 1 3000 rpm for Z_p = 2	1.25 kHz	*V/f* Control is designed only for asynchronous (induction motors) and SIEMOSYN motors. Z_p is the number of pole pairs of the motor. This is mainly between 1 and 4 on 1LA/1LG standard asynchronous motors (induction motors). SIEMOSYN motors have 1 or 2 pole pairs or, with larger shaft heights, 3 pairs.
	160 Hz correspond to: 9600 rpm for Z_p = 1 4800 rpm for Z_p = 2	2 kHz	
	200 Hz correspond to: 12000 rpm for Z_p = 1 6000 rpm for Z_p = 2	2.5 kHz	
	300 Hz correspond to: 18000 rpm for Z_p = 1 9000 rpm for Z_p = 2	4 kHz	
	400 Hz correspond to: 24000 rpm for Z_p = 1 12000 rpm for Z_p = 2	4 kHz	
Dynamic response requirement (current controller clock cycle)	125 µs 250 µs 400 µs 500 µs	4 kHz 2 kHz 2.5 kHz 1 kHz	Servo Control requires a minimum pulse frequency of 2 kHz.
Sine-wave filters	–	4 kHz	Notice: If sine-wave filters are operated at low pulse frequencies, resonance problems can occur and cause the filters to severely overheat.
Output reactor to motor	Max. frequency: 150 Hz correspond to 4500 rpm for Z_p = 2		The output reactor can be operated at minimum 2 kHz only.