Overview (continued)

Brakes

The brakes with order code **F01** (**F02** brake for increased frequency of operation for SIMOTICS GP motors on request) are designed to be spring-operated brakes. When the brake is ordered, the supply voltage must be specified. For an explanation of the supply voltage, see the descriptions of each brake model in "Modular technology".

For the design of the braking time, run-on revolutions, braking energy per braking procedure as well as the lifetime of the brake linings, see "Configuration of motors with brakes" on page 1/92.

When a brake is mounted, the length of the motor increases by Δl. For explanations of the additional dimension and weights, see "Mounting technology" and "Dimensions and weights" from page 1/106.

*The brake can be retrofitted by authorized partners. The motor must be prepared for this. When the motor is ordered, the option "Prepared for mountings, center hole only" order code **G40** must be specified (see "Mechanical version and degrees of protection" on page 1/79).*

Ambient temperature

- –40°C to +45°C (with nominal excitation) for SFB-SH brake
- –40°C to +75°C (with double excitation) for SFB-SH brake
- –20 to +40 °C holding/operating brake (standard 2LM8)
- up to +60 °C only as holding brake
- –20 to +60 °C holding/operating brake only for KFB and FDX brake

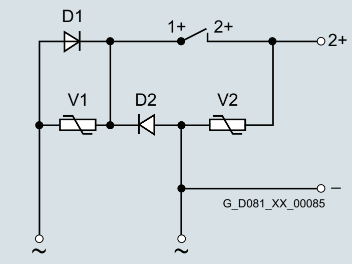
Definition of duty type

- Operating brake:
  The motor shaft can be braked from full operating speed down to zero speed of the motor. All the kinetic energy produced by the drive train is converted to heat by friction during braking. Braking energy is produced at $n > 0$ rpm. The maximum permissible switching frequency must be taken into account. When this brake is used, installation of a separately driven fan is recommended in order to ensure adequate cooling when the motor is at a standstill. The operating brake is also capable of functioning as a holding brake.
- Holding brake:
  The purpose of braking or "holding" the motor shaft is merely to suppress unintended rotation caused by externally applied torque forces, e.g. when a load is suspended from a crane rope drum. The holding brake is primarily deployed when the motor is at a standstill ($n = 0$ rpm) by holding the motor shaft or is close to $n = 0$ rpm and coasting down to a standstill. As a result, no additional braking energy or braking heat is transferred to the motor.

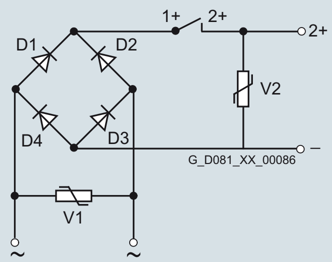
Note:
A holding brake must not be used as an operating brake as it could then cause danger to life and damage to property.

Bridge rectifier / half-wave rectifier

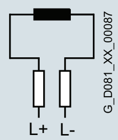
Brakes are connected through a standard bridge or half-wave rectifier or directly to the 2LM8/SFB-SH brake. See the circuit diagrams below.



Half-wave rectifier 400 V AC



Bridge rectifier 230 V AC



Brake connection for 24 V DC

Overview (continued)

2LM8 spring-operated disk brake

Motor series

This brake is the standard brake for 1LE1/1FP1 motors in frame sizes 63 to 225 (except for 1LE1 with order code **F90** version "Forced-air cooled motors without external fan and fan cover").

Other characteristics of the 2ML8 brake

The 2LM8 brake has IP55 degree of protection.

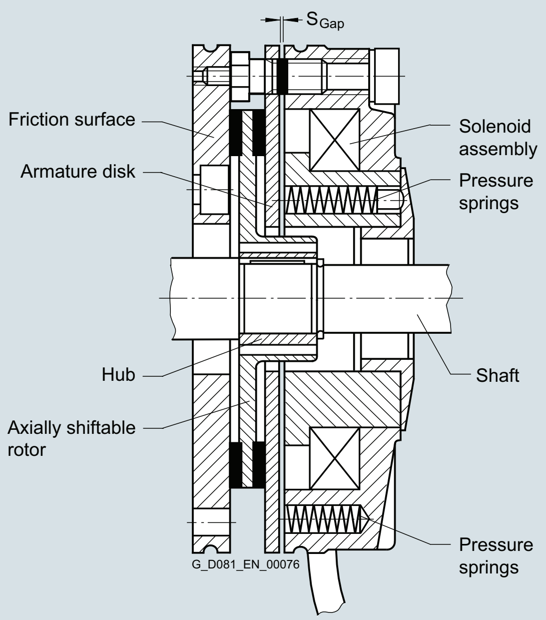
Please inquire if motors with brakes are to be operated below the freezing point or in conjunction with very humid environments (e.g. close to the sea) with long standstill times. Please also inquire if motors with brakes are to be used for low-speed converter operation.

Design and mode of operation

The brake takes the form of a single-disk brake with two friction surfaces.

The braking torque is generated by friction when pressure is applied by one or more pressure springs in the de-energized state.
The brake is released electromagnetically.

When the motor brakes, the rotor which can be axially shifted on the hub or the shaft is pressed via the armature disk against the friction surface by means of the springs. In the braked state, there is a gap S_{Gap} between the armature disk and the solenoid component. To release the brake, the solenoid is energized with DC voltage. The resulting magnetic force pulls the armature disk against the spring force on to the solenoid component. The spring force is then no longer applied to the rotor, which can rotate freely.



Design of the 2LM8 spring-operated disk brake

Rating plate

The following brake data is specified on the motor rating plate:
- Brake type
- Supply voltage
- Frequency
- Current
- Temperature class
- Braking torque

Voltage and frequency

The solenoids and the brake rectifier are designed for connection to the following voltages or can be supplied for the following voltages:
- Brake supply voltage 24 V DC
  Order code **F10**
- Brake supply voltage 230 V AC
  Order code **F11**
- Brake supply voltage 400 V AC
  (directly at the terminal strip)
  Order code **F12**

When 60 Hz is used, the voltage for the brake must not be increased!

Order codes **F10**, **F11**, and **F12** must only be used in conjunction with order code **F01**.

Lifetime of the brake lining

The braking energy L_N until readjustment of the brake depends on various factors. The main influencing factors include the masses to be braked, the operating speed, the switching frequency, and therefore the temperature at the frictional surfaces. This means it is not possible to specify a value for the friction energy until readjustment that is valid for all operating conditions.

When used as an operating brake, the specific frictional surface wear (wear volume for the frictional work) is approximately 0.05 to 2 cm^3/kWh.

Overview (continued)

Operating values for spring-operated brakes with standard excitation														Service capability of the brake	
For motor frame size	Brake type	Rated braking torque at 100 rpm	Rated braking torque at 100 rpm in % at the following speeds			Supply voltage	Current/ power input [1]		Brake application time t_2 [2]	Brake release time	Brake moment of inertia	Noise level L_p with rated air gap	Lifetime L of the brake lining	Air gap adjustment required after braking energy L_N
			1500 rpm	3000 rpm	Max. speed									
		Nm	%	%	%	V	A	W	ms	ms	kgm²	dB (A)	Nm · 10⁶	Nm · 10⁶
63	**2LM8 005-1NA10**	5	87	80	65	AC 230	0.1	20	25	56	0.000013	77	105	16
	2LM8 005-1NA60					AC 400	0.11							
	2LM8 005-1NA80					DC 24	0.83							
71	**2LM8 005-2NA10**	5	87	80	65	AC 230	0.1	20	25	56	0.000013	77	105	16
	2LM8 005-2NA60					AC 400	0.11							
	2LM8 005-2NA80					DC 24	0.83							
80	**2LM8 010-3NA10**	10	85	78	65	AC 230	0.12	25	26	70	0.000045	75	270	29
	2LM8 010-3NA60					AC 400	0.14							
	2LM8 010-3NA80					DC 24	1.04							
90	**2LM8 020-4NA10**	20	83	76	66	AC 230	0.15	32	37	90	0.00016	75	740	79
	2LM8 020-4NA60					AC 400	0.17							
	2LM8 020-4NA80					DC 24	1.25							
100	**2LM8 040-5NA10**	40	81	74	66	AC 230	0.2	40	43	140	0.00036	80	1350	115
	2LM8 040-5NA60					AC 400	0.22							
	2LM8 040-5NA80					DC 24	1.67							
112	**2LM8 060-6NA10**	60	80	73	65	AC 230	0.25	53	60	210	0.00063	77	1600	215
	2LM8 060-6NA60					AC 400	0.28							
	2LM8 060-6NA80					DC 24	2.1							
132	**2LM8 100-7NA10**	100	79	72	65	AC 230	0.27	55	50	270	0.0015	77	2450	325
	2LM8 100-7NA60					AC 400	0.31							
	2LM8 100-7NA80					DC 24	2.3							
160	**2LM8 260-8NA10**	260	75	68	65	AC 230	0.5	100	165	340	0.0073	79	7300	935
	2LM8 260-8NA60					AC 400	0.47							
	2LM8 260-8NA80					DC 24	4.2							
180	**2LM8 315-0NA10**	315	75	68	65	AC 230	0.5	100	152	410	0.0073	79	5500	470
	2LM8 315-0NA60					AC 400	0.56							
	2LM8 315-0NA80					DC 24	4.2							
200, 225	**2LM8 400-0NA10**	400	73	68	65	AC 230	0.55	110	230	390	0.0200	93	9450	1260
	2LM8 400-0NA60					AC 400	0.61							
	2LM8 400-0NA80					DC 24	4.6							

[1] For 400 V AC and for 24 V DC, the power can deviate by up to +10 % as a function of the selected supply voltage.

[2] The specified switching times are valid for switching on the DC side with a rated release travel and with the coil already warm. They are average values, which may vary depending on factors such as the rectifier type and the release travel. The brake application time for switching on the AC side, for example, is approximately 6 times longer than for switching on the DC side.

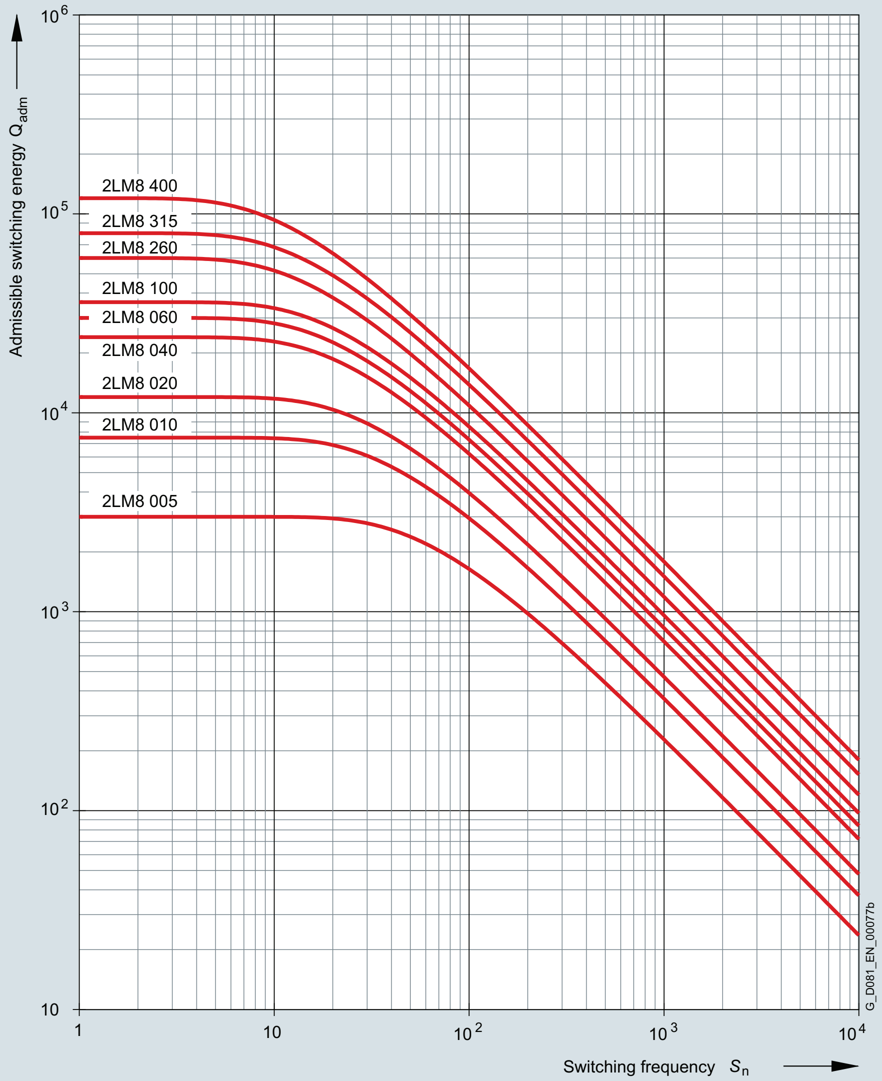
Modular technology

Overview (continued)

Maximum admissible speeds

The maximum admissible speeds from which emergency stops can be made are listed in the next table. These speeds should be considered as guide values and must be checked for the specific operating conditions.

The maximum admissible friction energy depends on the switching frequency and is shown for the individual brakes in the following diagram. Increased wear can be expected when the brakes are used for emergency stops.



For motor frame size	Brake type	Maximum admissible speeds: Max. adm. operating rpm if max. operating energy utilized	Max. adm. no-load rpm with emergency stop function: for horizontal mounting position	Max. adm. no-load rpm with emergency stop function: for vertical mounting position	Changing the braking torque: Reduction per notch	Changing the braking torque: Dimension "O_1"	Changing the braking torque: Min. braking torque	Readjusting the air gap: Rated air gap $S_{Gap\ rated}$	Readjusting the air gap: Maximum air gap $S_{Gap\ max.}$	Readjusting the air gap: Minimum rotor thickness $h_{min.}$
		rpm	rpm	rpm	Nm	mm	Nm	mm	mm	mm
63	**2LM8 005-1NA . .**	3000	6000	6000	0.17	7	3.7	0.2	0.4	4.5
71	**2LM8 005-2NA . .**	3000	6000	6000	0.17	7	3.7	0.2	0.4	4.5
80	**2LM8 010-3NA . .**	3000	6000	6000	0.35	8.0	7.0	0.2	0.45	5.5
90	**2LM8 020-4NA . .**	3000	6000	6000	0.76	7.5	18.2	0.2	0.55	7.5
100	**2LM8 040-5NA . .**	3000	6000	6000	1.29	12.5	21.3	0.3	0.65	8.0
112	**2LM8 060-6NA . .**	3000	6000	6000	1.66	11.0	32.8	0.3	0.75	7.5
132	**2LM8 100-7NA . .**	3000	5300	5000	1.55	13.0	61.1	0.3	0.75	8.0
160	**2LM8 260-8NA . .**	1500	4400	3200	5.6	17.0	157.5	0.4	1.2	12.0
180	**2LM8 315-0NA . .**	1500	4400	3200	5.6	17.0	178.4	0.4	1.0	12.0
200, 225	**2LM8 400-0NA . .**	1500	3000	3000	6.15	21.0	248.7	0.5	1.5	15.5

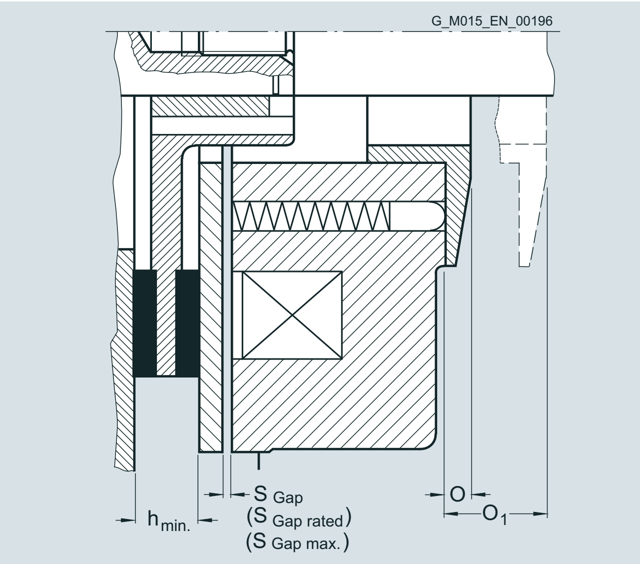
Overview (continued)

Changing the braking torque

The brake is supplied with the braking torque already set. For 2LM8 brakes, the torque can be reduced to the dimension O_1 by unscrewing the adjusting ring with a hook wrench. The braking torque changes by the values shown in the above table for each notch of the adjusting ring.

Readjusting the air gap

Under normal operating conditions, the brake is practically maintenance-free. The air gap S_{Gap} must only be checked at regular intervals if the application requires an extremely large amount of frictional energy and readjusted to the rated air gap $S_{Gap\ rated}$ at the latest when the maximum air gap $S_{Gap\ max}$ is reached.



Connection

Labeled terminals are provided in the main terminal box of the motor to connect the brake.

The AC voltage for the brake excitation winding is connected to the two free terminals of the rectifier block (~).

The brake can be released when the motor is at a standstill by separately exciting the solenoid. In this case, an AC voltage must be connected at the rectifier block terminals. The brake remains released as long as this voltage is present.

The rectifiers are protected against overvoltages by varistors in the input and output circuits.

For 24 V DC brakes, the brake terminals are directly connected to the DC voltage source.

For this purpose, see the circuit diagrams on page 1/81.

Fast brake application

If the brake is disconnected from the line supply, the brake is applied.
The application time for the brake disk is delayed as a result of the inductance of the solenoid (shutdown on the AC side). This results in a considerable delay before the brake is mechanically applied. In order to achieve short brake application times, the circuit must be interrupted on the DC side. To realize this, the wire jumpers, located between contacts 1+ and 2+ at the rectifier, are removed and replaced by the contacts of an external switch.
For this purpose, see the circuit diagrams on page 1/81.

Mechanical manual brake release with lever

The brakes can be supplied with a mechanical manual release with lever.
Order code **F50**

The dimensions of the brake lever depend on the motor frame size and can be read from the dimensional drawing generator for motors in the DT Configurator tool for low-voltage motors.

Modular technology

Overview (continued)

KFB spring-operated brake

KFB spring-operated brake

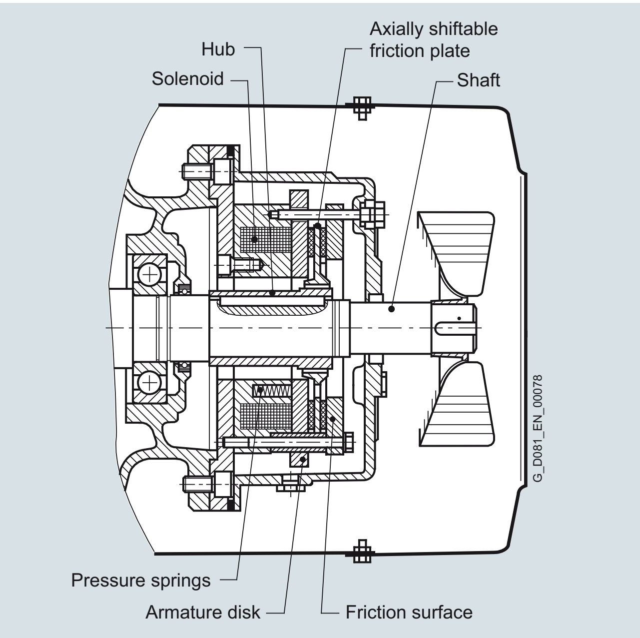
The KFB solenoid double-disk spring-operated brake is a safety brake that brakes the motor if the supply is disconnected (power failure, emergency stop). The KFB brake with degree of protection IP67 is mainly used for electric motors for traversing, cross-traversing and lifting gear in cranes as well as for special industrial applications.

Motor series

This brake is the standard brake for 1LE1 motors in frame sizes 250 to 315. For frame sizes 180 to 225, apart from the standard brake 2LM8, KFB brakes can also be supplied. Special brake selections are available on request.

Design and mode of operation

When the brake current is switched on, an electromagnetic field develops which overcomes the spring force of the brake. The corresponding modules, including the motor shaft, can rotate freely. The brake is released. If the brake current is switched off or if there is a power failure, the electromagnetic field of the brake disappears. The mechanical braking energy is transferred to the motor shaft. The motor is braked.



Design of KFB spring-operated brakes

Other characteristics of the KFB brake

- High degree of protection IP67.
- Corrosion-resistant in seawater and in the tropics.
- The brake is a dynamic brake, not simply a holding brake. For this reason there is less wear, especially in the case of emergency stops (commissioning).
- High wear reserves – repeated stepless air gap readjustment is possible. This results in extremely long operating times and low service and operating costs.
- The function and wear can be monitored with microswitches and proximity switches. Microswitch On/Off is standard for 1LE motors, frame size 250 to 315. Microswitch On/Off is not standard for 1LE motors, frame size up to 225. Anti-condensation heating is possible as an option.
- Fully functional brake for housing acceptance test. Visual inspection of brake is possible during operation.
- The brake (air gap) can be adjusted in the factory, for example, and mounted on the drive motor without further adjustments.
- The wear parts can be replaced without great outlay. After the housing has been opened (three screws), it is easy to replace the friction plate. It is not necessary to disassemble the entire brake.

Voltage and frequency

The solenoids and the brake rectifier can be connected to the following voltages:
1 AC 50 Hz 230 V ±10 %

When 60 Hz is used, the voltage for the brake must not be increased!

The brake can also be supplied for other voltages:

- Brake supply voltage: 24 V DC
  Order code **F10**
- Brake supply voltage: 230 V AC
  Order code **F11**
- Brake supply voltage: 400 V AC
  (directly at the terminal strip)
  Order code **F12**

Order codes **F10** and **F12** may only be used in conjunction with order code **F01**.

Fast brake application

Not available for the KFB brake.

Mechanical manual brake release with lever

The brake can be released manually with screws as standard. Mechanical manual release with a lever can be ordered with order code **F50**.

The dimensions of the brake lever depend on the motor frame size and can be read from the dimensional drawing generator for motors in the DT Configurator tool for low-voltage motors. Up-to-date data are available from the brake manufacturer.

Overview (continued)

Connection

Labeled terminals are provided in the main terminal box of the motor to connect the brake.
KFB brakes are connected through a standard bridge or half-wave rectifier.

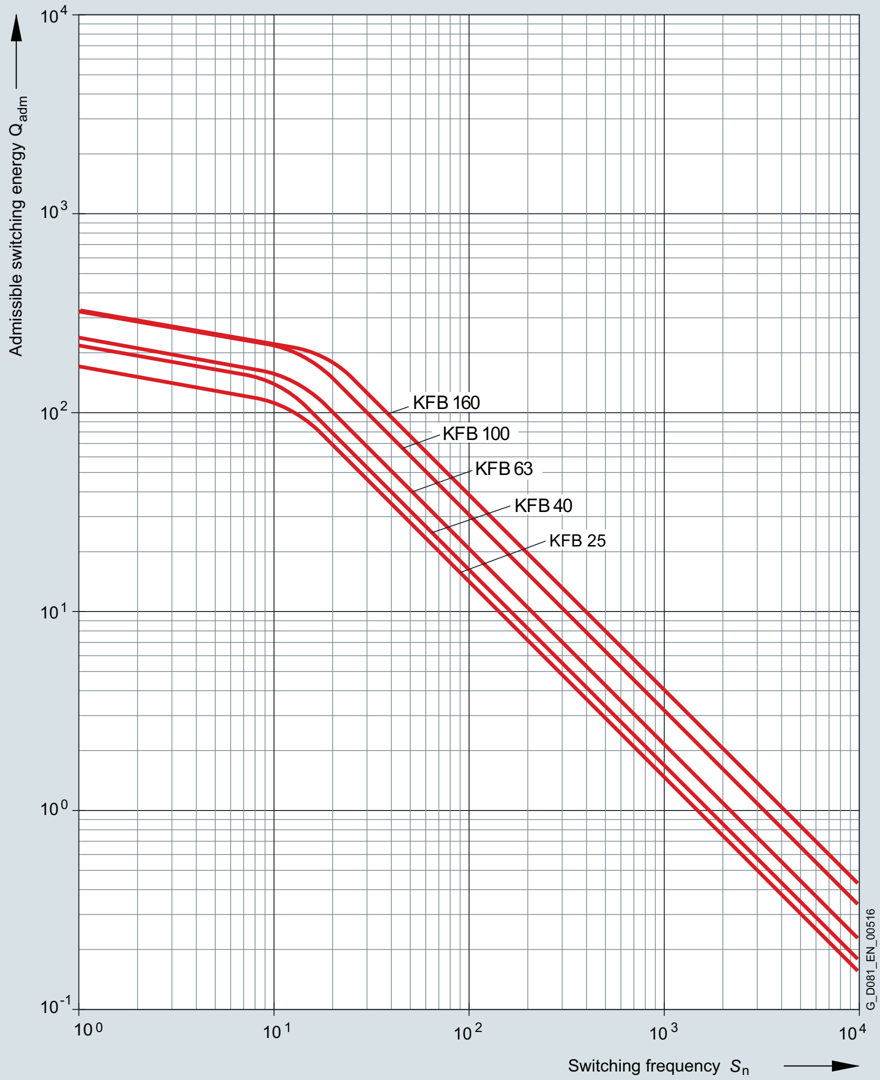
A special circuit is not required. Optimal switching times are achieved without the need to use special circuits.

For this purpose, see the circuit diagrams on page 1/81.

Maximum admissible speeds

The maximum admissible speeds from which emergency stops can be made are listed in the next table. These speeds should be considered as guide values and must be checked for the specific operating conditions.

The maximum admissible friction energy depends on the switching frequency and is shown for the individual brakes in the following diagram. Increased wear can be expected when the brakes are used for emergency stops.



Modular technology

Overview (continued)

Overview of brake selection for 1LE1 motors			For motor frame sizes					
			180 [1]	200 [1]	225 [1]	250 [2]	280 [2]	315 [2]
No. of poles			2 to 8	2 to 8	2 to 8	2 to 8	4 to 8	4 to 8
Flanged end shield NDE brake installation			A300	A350	A350	A400	A450	A550
Max. diameter of 2nd shaft extension			48_{k6}	55_{m6}	55_{m6}	60_{m6}	65_{m6}	70_{m6}
Brake type			**KFB 25**	**KFB 40**	**KFB 40**	**KFB 63**	**KFB 100**	**KFB 160**
Braking torque		Nm	225	360	360	567	900	1440
Nominal dynamic braking torque according to VDE 0580		Nm/rpm	250/127	400/117	400/117	630/92	1000/78	1600/69
Dynamic braking torque [3]	at 750 rpm	Nm	207	332	332	504	780	1248
	at 1000 rpm	Nm	200	316	316	491	760	1200
	at 1500 rpm	Nm	192	304	304	466	720	1136
	at 3000 rpm	Nm	175	276	276	378	580	880
	at n_{max}	Nm	137	220	220	346	500	800
Maximum speed n_{max} – IM B3/V1		rpm	6000	5500	5500	4700	4000	3600
Power at 110 V DC		W	158	196	196	220	307	344
Power at 230 V AC		W	160	188	188	206	316	340
Current at 110 V DC		A	1.44	1.78	1.78	2	2.79	3.13
Current at 230 V AC (207 V DC coil voltage)		A	0.77	0.91	0.91	1	1.53	1.64
Current at 400 V AC (180 V DC coil voltage)		A	0.8	1.18	1.18	1.25	1.8	2.1
Current at 24 V DC		A	5.21	6.92	6.92	8.17	12.2	12.8
Weight, approx.		kg	42	55	55	74	106	168
Application time t_1		ms	70	80	80	112	126	183
Release time t_2		ms	240	250	250	342	375	500
Brake moment of inertia		kgm^2	0.0048	0.0068	0.0068	0.0175	0.036	0.05
Lifetime L of the brake lining		$Nm \cdot 10^6$	3600	3110	3110	4615	7375	10945
Air gap adjustment L_N required after braking energy		$Nm \cdot 10^6$	810	935	935	1185	2330	3485

[1] The standard brake for frame sizes 180 to 225 is the 2LM8 brake. KFB brake on request.

[2] The standard brake for frame sizes 250 to 315 is the KFB brake.

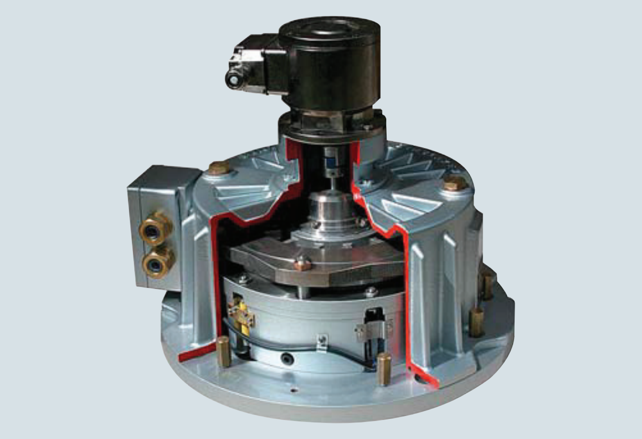
[3] The dynamic braking torque also depends on the load data; temperatures in excess of the maximum admissible lining surface temperatures must be avoided.

Overview (continued)

SFB-SH solenoid double-disk spring-operated brake

Motor series

This brake is the standard brake for 1LE5 motors in frame sizes 315 to 355.
Special brake selections are available on request.



SFB-SH solenoid double-disk spring-operated brake

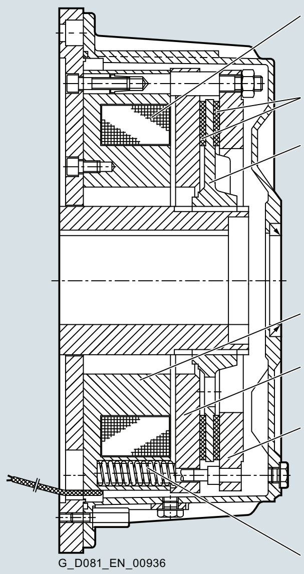
SFB-SH solenoid double-disk spring-operated brakes are safety brakes that are mechanically operated on a power failure. This ensures that the brake still works during a power failure. These brakes are designed for dry running, must only ever be operated in a safe state, and only installed, commissioned, operated, and maintained by specially trained installation personnel. The brakes of the SFB-SH type series have an increased braking torque due to use of a different friction material and are used for emergency stops as a dynamically loaded brake with a safety margin.

Other characteristics of the SFB-SH brake

- High degree of protection IP67.
- Corrosion-resistant in seawater and in the tropics.
- High wear margins – simple air-gap adjustment. This results in extremely long operating times and low service and operating costs.
- The function and wear can be monitored with microswitches and proximity switches. Microswitch On/Off is standard for 1LE5 motors. Anti-condensation heating is possible as an option.
- Fully functional brake for housing acceptance test. Visual inspection of brake is possible during operation.
- The brake (air gap) can be adjusted in the factory, for example, and mounted on the drive motor without further adjustments.
- The wear parts can be replaced without great effort. After the housing has been opened (three acorn nuts), it is easy to replace the friction plate. It is not necessary to disassemble the entire brake.

Design and mode of operation

When the brake current is switched on, an electromagnetic field develops which overcomes the spring force of the brake. The corresponding modules, including the motor shaft, can rotate freely. The brake is released. If the brake current is switched off or if there is a power failure, the electromagnetic field of the brake disappears. The mechanical braking energy is transferred to the motor shaft. The motor is braked.



Design of the SFB-SH solenoid double-disk spring-operated brake

Voltage and frequency

The solenoids and the brake rectifier can be connected to the following voltages:
1 AC 50 Hz 230 V ±10 %

When 60 Hz is used, the voltage for the brake must not be increased!

The brake can also be supplied for other voltages:

- Brake supply voltage: 24 V DC
  Order code **F10**
- Brake supply voltage: 230 V AC
  Order code **F11**
- Brake supply voltage: 400 V AC
  (directly at the terminal strip)
  Order code **F12**

Order codes **F10** and **F12** may only be used in conjunction with order code **F01**.

Modular technology

Overview (continued)

Connection

Labeled terminals are provided in the main terminal box of the motor to connect the brake.

The AC voltage for the brake excitation winding is connected to the two free terminals of the rectifier block (~). The rectifier is located in the main terminal box and must be connected in the customer's switchboard.

The brake can be released when the motor is at a standstill by separately exciting the solenoid. In this case, an AC voltage must be connected at the rectifier block terminals. The brake remains released as long as this voltage is present.

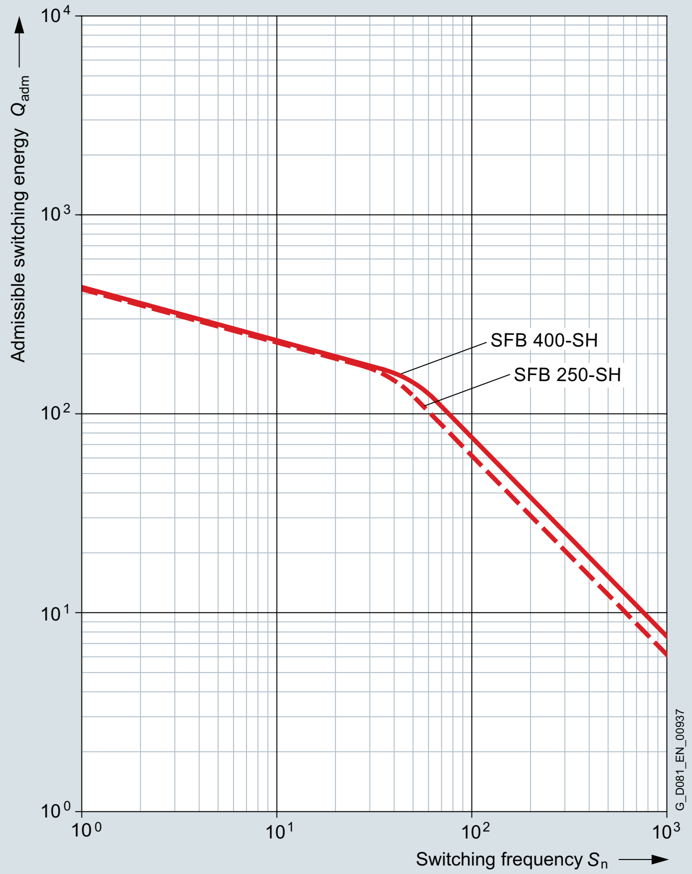
For 24 V DC brakes, the brake terminals are directly connected to the DC voltage source.

For this purpose, see the circuit diagrams on page 1/81.

Maximum admissible speeds

The maximum admissible speeds from which emergency stops can be made are listed in the next table. These speeds should be considered as guide values and must be checked for the specific operating conditions.

The maximum admissible friction energy depends on the switching frequency and is shown for the individual brakes in the following diagram. Increased wear can be expected when the brakes are used for emergency stops.



Overview (continued)

Overview of brake selection for 1LE5 motors			For motor frame sizes	
			315	355
No. of poles			4 to 8	4 to 8
Flanged end shield NDE brake installation			FF500 (A550) [1]	FF600 (A660) [2]
Max. diameter of 2nd shaft extension			75_{m6}	90_{m6}
Brake type			**SFB 250-SH**	**SFB 400-SH**
Braking torque		Nm	2970	4680
Nominal dynamic braking torque according to VDE 0580		Nm/rpm	3300/54	5200/47
Dynamic braking torque [3]	at 750 rpm	Nm	2400	2100 [4]
	at 1000 rpm	Nm	2200	2300 [4]
	at 1500 rpm	Nm	1850	2100 [4]
	at n_{max}	Nm	1580	2100 [4]
Maximum speed n_{max} – IM B3/V1		rpm	2800	2500
Power at 110 V DC		W	495	553
Power at 230 V AC (207 V DC coil voltage)		W	511	–
Current at 110 V DC		A	4.5	5.03
Current at 230 V AC (207 V DC coil voltage)		A	2.47	–
Current at 400 V AC (180 V DC coil voltage)		A	2.98	3.36
Current at 24 V DC		A	19.93	–
Weight, approx.		kg	306	357
Application time t_1		ms	640	700
Release time t_2		ms	690	1100
Brake moment of inertia		kgm^2	0.14	0.325
Minimum air gap		mm	0.4	0.4
Maximum air gap		mm	2.5	2.5

[1] External dimension increases to 560 mm.
[2] External dimension decreases to 640 mm.
[3] The dynamic braking torque also depends on the load data, temperatures in excess of the maximum admissible lining surface temperatures must be avoided.
[4] Value is guaranteed by the brake manufacturer. In practice, a higher braking torque can be expected. Restrictions are determined at the test station of the brake manufacturer. Information: www.pintschbubenzer.de

Overview (continued)

Configuration of motors with brakes

Braking time

The time it takes the motor to come to a standstill comprises two components:
a.) The application time of the brake t_2
b.) The braking time t_{Br}

$$t_{Br} = \frac{J \cdot n_{rated}}{9.55 \cdot (T_B \pm T_L)}$$

t_{Br} Braking time in s
J Total moment of inertia in kgm^2
n_{rated} Rated speed of the motor with brake in rpm
T_B Rated braking torque in Nm
T_L Average load torque in Nm (If T_L supports the braking operation, T_L is positive)

Braking energy per braking operation Q_{adm}

The braking energy per braking operation in Nm comprises the energy of the moments of inertia to be braked Q_{Kin} and the energy Q, which must be applied in order to brake against a load torque:

$Q_{adm} = Q_{Kin} + Q$

a.) The energy of the moments of inertia in Nm

$$Q_{Kin} = \frac{J \cdot n_{rated}^2}{182.4}$$

n_{rated} Rated speed before braking in rpm
J Total moment of inertia in kgm^2. The mass moment of inertia J specified in the formula corresponds to the total moment of inertia of all braked masses referred to the motor/brake speed.

b.) Braking energy on emergency trip

The braking energy for occasional emergency trips must be checked to ensure that it does not cause the brake to overheat. Please refer to table "Technical specifications of brakes" for admissible values. The braking energy produced for traversing gear can be calculated approximately with the following equation:

$$Q = \frac{J_{tot} \cdot n^2_{Br}}{182.4 \cdot 10^3} \cdot \frac{T_{Br}}{T_{Br} \pm T_L}$$

Q Energy capability/braking energy in kJ
T_{Br} Braking torque in Nm
T_L Total of all load torques in Nm referred to the brake (motor) shaft
n_{Br} Speed of brake (motor) shaft in rpm
J_{tot} Total moment of inertia to be braked in kgm^2 reduced to the brake (motor) shaft
T_L is positive if it supports braking (e.g. hoisting a load)
T_L is negative if it counteracts braking (e.g. lowering a load)

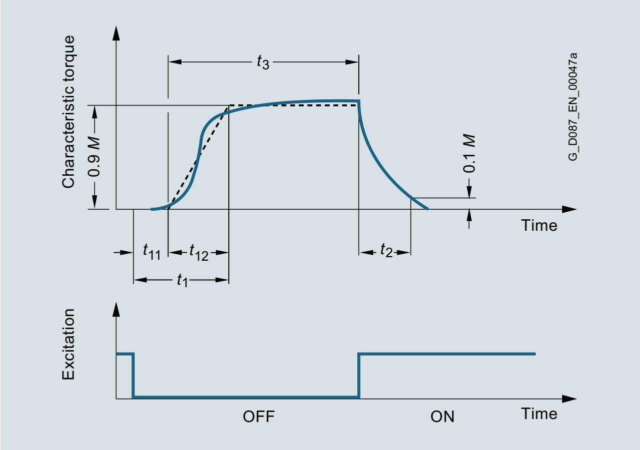
The total moment of inertia J_{tot} is the sum of the individual moments of inertia of the system components to be braked, reduced to the brake (motor) shaft, and the moments of inertia of the linear-motion masses. The equivalent mass inertia J_{Eqv} of a linear-motion mass m with velocity v, referred to the brake (motor) speed n_{Br}, is calculated as follows:

$$J_{Eqv} = 91.2 \cdot m \cdot \left(\frac{v}{n_{Br}}\right)^2$$

m Mass of the linear-motion load in kg
v Velocity of the linear-motion load in m/s
n_{Br} Speed of brake (motor) shaft in rpm

The velocity and/or speed to be entered here must equal the maximum values in normal operation. An increase in velocity resulting from wind forces may also need to be taken into account.

Definition of switching times (VDI 2241)



Brake switching times

Switching times:
t_1 Brake application time
t_2 Disconnection time
t_3 Slip time
t_{11} Response delay
t_{12} Rise time

Run-on revolutions U

The number of run-on revolutions U of the motor with brake can be calculated as follows:

$$U = \frac{n_{rated}}{60}\left(t_1 + \frac{t_{Br}}{2}\right)$$

t_1 Brake application time in ms

Lifetime of the brake lining L and readjustment of the air gap

The brake lining wears due to friction which increases the air gap and the release time for the brake at standard excitation.

In order to calculate the lifetime of the brake lining in terms of operations S_{max}, the lifetime of the brake lining L in Nm must be divided by the braking energy Q_{adm}:

$$S_{max} = \frac{L}{Q_{adm}}$$

The interval between adjustments N can be calculated in terms of operations by dividing the braking energy L_N that the brake can output until it is necessary to readjust the working air gap by Q_{adm}:

$$N = \frac{L_N}{Q_{adm}}$$

Overview (continued)

FDX spring-operated brake

Motor series

This brake is provided for 1LE1 motors in frame sizes 225 to 315.

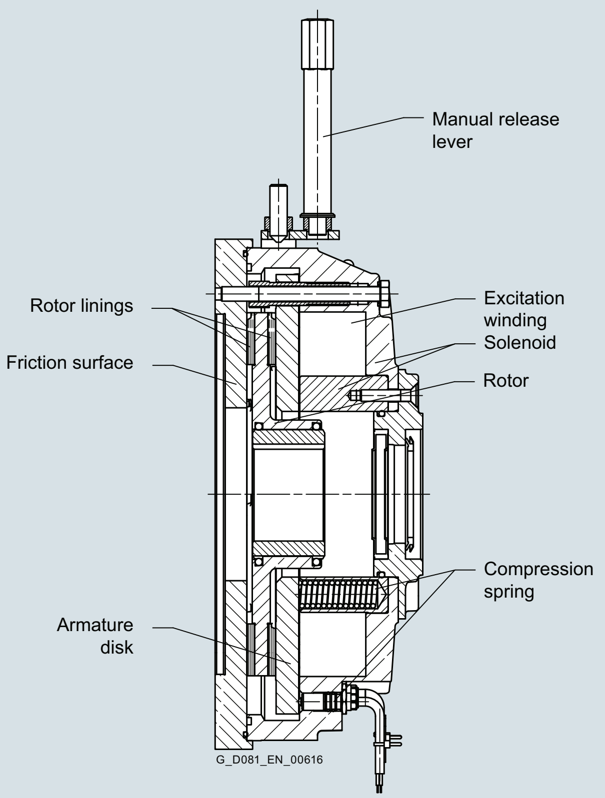
Mode of operation of FDX spring-operated brake (holding brake/operating brake)

The FDX solenoid spring-operated brakes (order code **F04**), with IP67 degree of protection, are quiescent current brakes, meaning that the braking torque is produced by spring force and increased by magnetic force in normal operation.

During the braking operation, the built-in compression springs apply pressure to the rotor that interlocks radially with the machine shaft using the axially moving armature disk. In turn, this applies pressure to the opposing side against the friction surface (→ motor label). The braking torque is produced from the linings of the rotor and the armature disk/friction surface being in contact.

During the brake release process, a magnetic force is produced by applying a direct current via the excitation winding in the solenoid. The armature disk is thereby pulled from the solenoid and the rotor is released.

During the manual brake release process (only available for the brake version with manual brake release), the armature disk is pressed mechanically against the solenoid by operating the manual release lever. The brake can therefore still be released in the event of a power failure, for example.



Voltage and frequency

The solenoids and the brake rectifier are designed for connection to the following voltages or can be supplied for the following voltages:

- Brake supply voltage 230 V AC
  Order code **F11**
- Brake supply voltage 400 V AC
  Order code **F12**

When 60 Hz is used, the voltage for the brake must not be increased!

Order codes **F11** and **F12** may only be used in conjunction with order code **F04**.

Connection

Labeled terminals are provided in the main terminal box of the motor to connect the brake.

The AC voltage for the brake excitation winding is connected to the two free terminals of the rectifier block (~).

The brake can be released when the motor is at a standstill by separately exciting the solenoid. In this case, an AC voltage must be connected at the rectifier block terminals. The brake remains released as long as this voltage is present.

The rectifiers are protected against overvoltages by varistors in the input and output circuits. The function and wear can be monitored with microswitches and proximity switches. Microswitch On/Off is standard for 1LE1 motors. Anti-condensation heating is possible as an option.

Mechanical manual brake release with lever

The brake can be supplied with a mechanical manual release with lever.
Order code **F50**

The dimensions of the brake lever depend on the motor frame size and can be read from the dimensional drawing generator for motors in the DT Configurator tool for low-voltage motors.

Lifetime

The amount of frictional energy that can be transferred before the rotor must be replaced depends on various factors:

- Mass to be decelerated
- Switching frequency
- Speed
- Resulting temperature on the friction surfaces

As a result, only guide values can be specified for the frictional energy to be transferred until rotor replacement.

Overview (continued)

Abbreviations and definitions used (with their units):

T_{LR} = Motor starting torque (Nm)

T_b = Braking torque (Nm)

T_{breq} = Required braking torque (Nm)

$T_{b, rated}$ = Rated torque of the spring-operated brake (Nm)

T_L = Load torque (Nm)

T_{tot} = Total torque (Nm)

F = Force (N)

r = Lever arm (m)

n = Speed (rpm)

K = Safety factor $K \geq 2$

P = Power (kW)

t = Overall braking time (ms)

t_{st} = Startup time (s)

t_B = Braking time (s)

t_2 = Disconnection time (ms)

t_1 = Application time (ms)

t_{11} = Response delay (ms)

P_R = Frictional power (J/s)

W_R = Friction energy (J)

S = Switching cycles (brake operations) per second (Hz)

J_E = Internal moment of inertia (kgm^2)

J_{add} = Additional moment of inertia (kgm^2)

$J_{2.3..}$ = Moment of inertia (kgm^2)

J_{tot} = Total moment of inertia (kgm^2)

n_1 = Motor speed (rpm)

$n_{2.3..}$ = Speeds (rpm)

Multiple moments of inertia with different speeds are converted into a moment of inertia relative to the motor shaft:

$$J_{add} = \frac{J_2 \cdot n_2^2 + J_3 \cdot n_3^2 \cdots}{n_1^2} \quad (\text{kgm}^2)$$

Torque

A spring-operated brake is designed mainly in accordance with the required braking torque T_{breq}. If the moment of inertia, speed, and admissible braking time of the machine are known, the braking torque of the spring-operated brake can be calculated. If the masses that are to be decelerated by the spring-operated brake are running at a different speed from the shaft decelerated by the spring-operated brake, the moment of inertia of these masses (J_{add}) must be calculated relative to this shaft (see above). In addition, the moment of inertia of the rotor-hub system (J_E) must be taken into account.

Load torque (static loading)

Torque which is present when the system is at a standstill and must be held by the brake. The loading force is converted into the load torque via the relevant lever arm

$T_L = F \cdot r$ (Nm)

Braking torque (dynamic loading)

A purely dynamic load is present when flywheels, rollers, etc., are to be delayed and the static load torque is negligibly small.

The required braking torque is calculated as follows:

$$T_b = 1.046 \cdot 10^2 \cdot J_{tot} \cdot \frac{n}{t - t_1} \ (\text{Nm})$$

$T_{breq} = T_b \cdot K \leq T_{b, rated}$ (Nm)

Dynamic and static loading

Most applications involve dynamic loading as well as static load torque:

$$T_{breq} = (T_b \pm T_L) \cdot K \ (\text{Nm})$$

$$T_{breq} = (1.046 \cdot 10^2 \cdot J_{tot} \cdot \frac{n}{t - t_1} \pm T_L) \cdot K \ (\text{Nm})$$

$$T_{breq} \leq T_{b, rated} \ (\text{Nm})$$

Sign for T_L:

$+ T_L$ = Load torque is applying force (in the direction of motion)

$- T_L$ = Load torque is applying a decelerating force (opposite to the direction of motion)

If both cases occur, the specific configuration is always adapted to the larger torque.

Approximate determination of T_{breq}

If the moment of inertia is not known and if the input power has been defined, the required braking torque is determined as follows:

$$T_{breq} = 9.55 \cdot 10^3 \cdot \frac{P}{n} \cdot K \leq T_{b, rated} \ (\text{Nm})$$

$K \geq 2$

Braking time

General

$$t = 1.046 \cdot 10^2 \cdot J_{tot} \cdot \frac{n}{T_{b, rated} \pm T_L} + t_1 \ (\text{ms})$$

Sign for T_L:

$- T_L$ = Load torque is applying force (in the direction of motion)

$+ T_L$ = Load torque is applying a decelerating force (opposite to the direction of motion)

Calculation of the starting and braking time for motors

Startup time for motors with brakes

$$t_{st} = J_{tot} \cdot \frac{n_1}{9.55 \cdot (T_{LR} \pm T_L)} + \frac{t_2}{1000} \ (\text{s})$$

$J_{tot} = J_E + J_{add}$ (kgm^2)

Sign for T_L:

$+ T_L$ = Load torque is applying force (in the direction of motion)

$- T_L$ = Load torque is applying a decelerating force (opposite to the direction of motion)

Overview (continued)

Braking time for motors with brakes

$$t_B = J_{tot} \cdot \frac{n_1}{9.55 \cdot (T_{b,\ rated} \pm T_L)} + \frac{t_1}{1000} \quad (s)$$

Sign for T_L:

– T_L = Load torque is applying force (in the direction of motion)

+ T_L = Load torque is applying a decelerating force (opposite to the direction of motion)

Thermal load

When braking, friction energy is applied during the slip phase, which releases thermal energy.

Friction energy per braking operation

$$W_R = J_{tot} \cdot n^2 \cdot \frac{T_{b,\ rated}}{182.5 \cdot (T_{b,\ rated} \pm T_L)} \quad (J)$$

Sign for T_L:

– T_L = Load torque is applying force (in the direction of motion)

+ T_L = Load torque is applying a decelerating force (opposite to the direction of motion)

The friction energy per braking operation must be no greater than the admissible value W_{Rmax}

$W_R \leq W_{Rmax}$ (J)

Frictional power

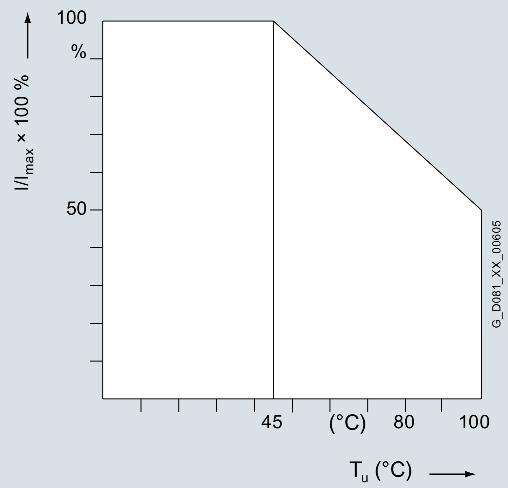
$P_R = W_R \cdot S$ (J/s)

The friction energy must be no greater than the admissible value P_{Rmax}

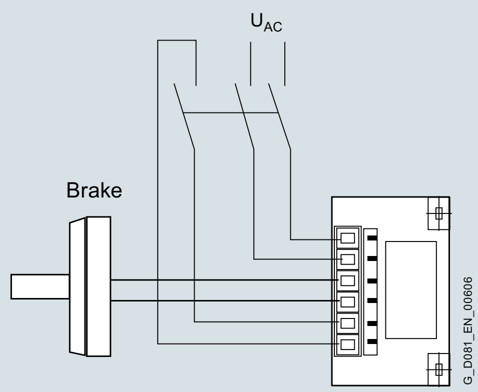
$P_R \leq P_{Rmax}$ (J/s)

Connection

Load rating of the rectifier diodes as a function of the ambient temperature:



Block diagram:



The high-speed rectifier performs the following functions:

- The coil is first supplied with a voltage $U_2 = 0.9 \times U_1$: Over-excitation of the brake
- After excitation time t_1 the voltage is reduced to $U_3 = 0.45 \times U_1$: Non-release voltage of the brake

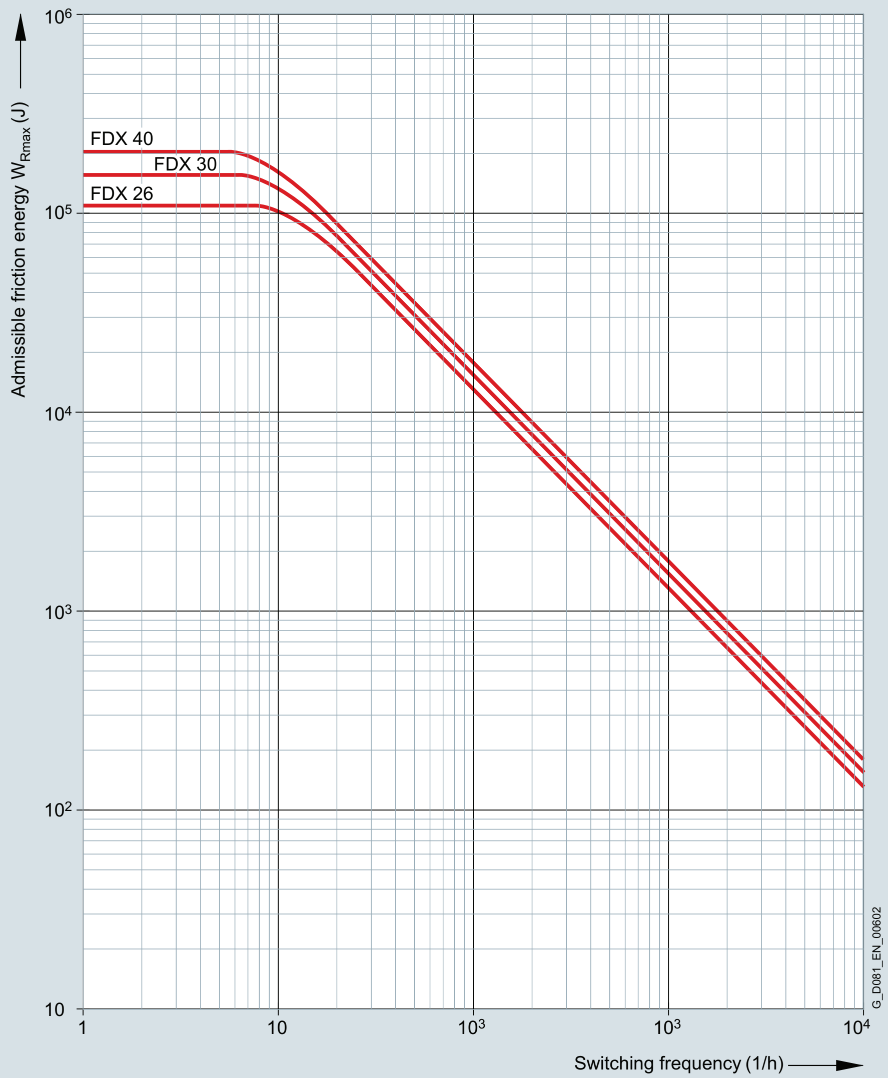
Designation	Supply voltage (V AC)	Output voltage (V DC)		Ambient temperature
Article No.:	U_1 at 50/60 Hz	U_2	U_3	°C
PMG 480	215 … 500	$0.9 \times U_1$	$0.45 \times U_1$	–15 … +80

Overview (continued)

Maximum admissible speeds

The maximum admissible speeds from which emergency stops can be made are listed in the next table. These speeds should be considered as guide values and must be checked for the specific operating conditions.

The maximum admissible friction energy depends on the switching frequency and is shown for the individual brakes in the following diagram. Increased wear can be expected when the brakes are used for emergency stops.



Overview (continued)

Overview of brake selection for 1LE1 motors (option F04)			**For motor frame sizes**			
			225	250	280	315
No. of poles			2 to 8	2 to 8	2 to 8	2 to 8
Flange bearing plate for brake mounting on the NDE side			A350	A400	A450	A535
Max. diameter for the second shaft extensions			55m6	48m6	65m6	48m6
Brake type			**FDX 30**	**FDX 30**	**FDX 40**	**FDX 40**
Static braking torque		Nm	450	567	900	1440[1]
Dynamic rated braking torque acc. to DIN VDE 0580		Nm/rpm	500/88	630/88	1000/65	1600[1]/65
	at 750 rpm	Nm	480	600	800	1200[1]
	at 1000 rpm	Nm	460	580	740	1150[1]
	at 1500 rpm	Nm	460	580	740	1150[1]
	at 3000 rpm	Nm	380	480	600	860[1]
Admissible speed n_{max}		rpm	3000[2]/6000[3]	3000[2]/6000[3]	3000[2]/6000[3]	3000[2]/6000[3]
Power at 180 V DC		W	880/220	880/220	1080/270	1080/270
Power at 103 V DC		W	560/140	560/140	560/140	560/140
Rated current at 230 V AC (103 V DC coil voltage)		A	2.72/1.36	2.72/1.36	2.72/1.36	2.72/1.36
Rated current at 400 V AC (180 V DC coil voltage)		A	2.44/1.22	2.44/1.22	3/1.5	3/1.5
Weight, approx.		kg	45	45	80	80
Closing time t_1 (switching on the DC side)		ms	60	60	160	160
Release time t_2 (switching on the DC side)		ms	140	140	320	320
Brake moment of inertia		kgm^2	0.0195	0.0195	0.0445	0.0445
Lifetime L of brake lining		$Nm \cdot 10^6$	3700	3700	4900	4900

1) Limit: ON time S3 -50 %
2) Operating brake
3) Holding brake