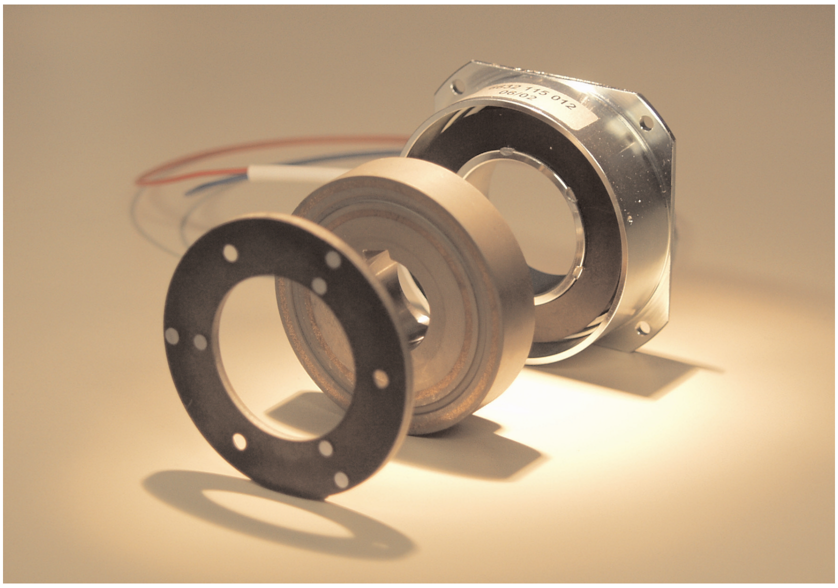
OPERATING INSTRUCTIONS

ZF-SINGLE-DISC



Stationary-field single-disc clutches and brakes

6632 758 101

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Companies entrusted with the repair of ZF units are responsible for their own work safety.
To avoid injury to personnel and damage to products, full compliance with all safety regulations and legal requirements which apply to repair and maintenance work is mandatory.
Before starting work, mechanics must familiarize themselves with these regulations.

Staff required to carry out repairs on ZF products must receive appropriate training in advance. It is the responsibility of each company to ensure that their repair staff are properly trained.

The following safety instructions appear in this operating manual:

NOTE
Note refers to special processes, methods, data etc.

CAUTION
This is used when non-compliant or incorrect operation could damage the product.

⚠ **DANGER !**
This is used when a lack of care could be lead to personal injury or damage to property.

Read this manual carefully before starting installation.

Once installation and electrical connections are in place, the specialists involved in this work must satisfy themselves that the product is functioning correctly.

1 Introduction

Electro-magnetically actuated single-disc clutches and brakes are used in the construction of machines and equipment. Their technical benefits, their simple design and their compact external dimensions make them the ideal choice for use in the automation of mechanical operating processes. They are used, e.g. in textile machines, packaging, printing and paper machines, machine tools and welding machines, office machines etc.

The single-disc clutches and brakes are used for functions such as switching between ratios or changing speed ranges, controlling sequences of motion with positioning or for shutting down machines in the event of a malfunction.

2 Structure and operating method

The clutches and brakes are based on a stationary-field design and require zero-maintenance. One particular benefit is the dual magnetic flux of the armature disk where the dynamic effect of the magnetic field is used twice. High torque levels are therefore achieved with small external dimensions and large clearance bores.

Both friction surfaces are metallic. These clutches are particularly environmentally friendly since they do not feature the organic friction linings usually fitted with single-disc clutches. They are suitable for use in either dry or wet conditions. The clutches and brakes achieve their nominal torque after a short run-in period or after several shifts at differential speed (refer to section 4.1 Operations, General, information). When used in dry conditions, they are insensitive to slight contamination caused by oil and grease. The torque is transferred in a zero-backlash radial manner by a diaphragm spring which is connected to the armature disc at the face end by 3 or 6 points and is secured to the counter piece (input or output gear, flange etc.) by 3 screws.

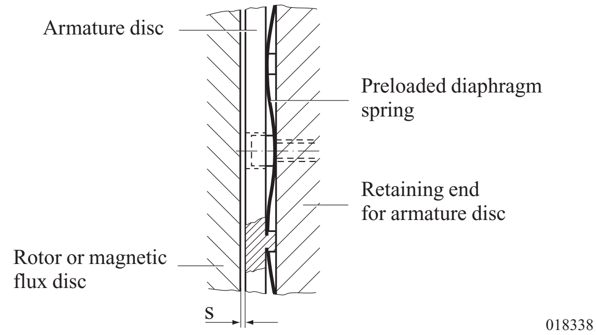


Fig. 1 Armature disc with preloaded diaphragm spring (extreme instance of preload shown)

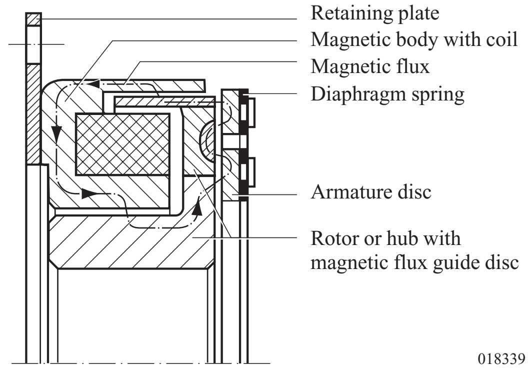


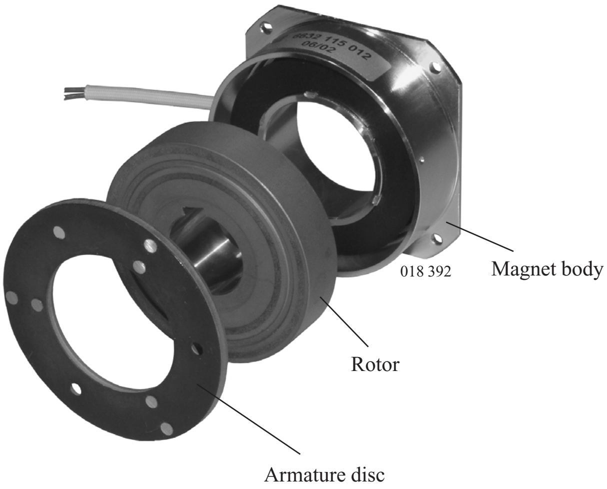
Fig. 2 Magnetic flux in an electromagnetically engaged clutch

The clutches and brakes operate with a direct current of 24 V.

A magnetic field builds up as current flows through the coil causing a pulling force to be exerted on the armature disc. The diaphragm spring allows for the axial movement necessary for the clutch or brake to be engaged. When the unit is disengaged, the armature is released very rapidly and fully causing complete separation of the friction surfaces. This eliminates any possibility of drag torque.

3 Versions

3.1 Single-disc clutch



The clutch consists of the rigid magnetic body with coil, rotor and armature disc.

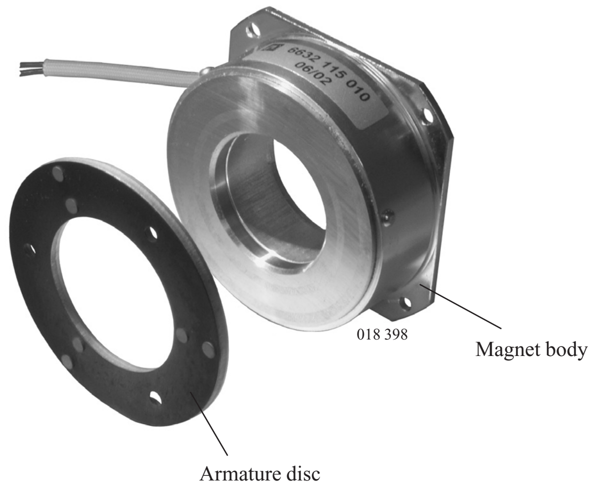
The magnetic body is screwed onto a housing section whereas the rotor is fitted on one of the shafts being engaged by the clutch.

It rotates with the small radial air gap in the immobile magnetic body. The armature disc is secured to the face end of the driven part or part to be driven with 3 screws. The rotor and armature disc are responsible for transmitting torque. It is of no significance whether the rotor or the armature disc drives or is driven in this process. This depends on the design attachment options.
The three machine elements (magnet body, rotor and armature disc) should be centered well in accordance with the tolerances specified under installation/assembly (points 5.2 and 5.3).

3.2 Single-disc brake

The brake consists of the magnet body with coil, in which the brake disc is firmly inserted and serves as a braking surface. As with the clutch, the armature disc is secured to the counter piece with 3 screws.

During braking, the braking torque is supported against the magnet body mounting, e.g. against the housing wall, a motor housing or similar rigid components.



4 Operation

4.1 General

The single-disc clutches and brakes have metal friction surfaces and are equally suitable for use in dry and wet conditions.

NOTE
The nominal torque is only reached after approx. 50 friction rotations in each direction of rotation at low speed (e.g. 100 rpm).

4.2 Operation in dry conditions

When operating in dry conditions, single-disc clutches and brakes have high torque levels and short switching times. The friction surfaces are however subjected to wear during switching. They therefore have a limited service life which depends on switching performance.

If only small volumes of oil or grease reach the friction surfaces when operating in dry conditions, the torque levels are reduced briefly, but usually return to their original values after a few switches with friction work. Without friction work, this self-cleaning does not however take place.

When fitting a new clutch or brake, the oil film applied for anti-corrosion protection must therefore be cleaned off the friction surfaces if the specified dry torques are to be achieved. Torque levels will be reduced by stubborn, severe contamination caused by oil or grease.

4.3 Operation in wet conditions

Single-disc clutches and brakes lubricated with oil or grease have lower torque levels and longer switching times. If lubrication is adequately applied to suit switching performance, the clutches will operate virtually wear-free and require no maintenance. More information about the design for operations in wet conditions are available on request. The remaining torque values for use in wet conditions are approx. 30 % of the specified torque levels.

CAUTION
Only mineral oils with good resistance to ageing and those which act in a neutral manner towards copper and steel in the presence of small volumes of condensate and at high temperatures should be used for operations in wet conditions.

The oils must not have any electrolytic properties because the formation of deposites and oxidation phenomena is encouraged by such properties. This requirement is important to prevent malfunction of the coil caused by electrolyte-forming additives. In instances of doubt, we would recommend obtaining advice from the oil supplier.

5 Installation / assembly

5.1 General

With the clutches, torque is transferred to the shaft via keys as defined in DIN 6885, page 2. When working with small types with bores of up to 8 mm, the shaft-rotor link is established by pinning, gluing or press fit. The rotor must be axially fixed to the shaft.

The magnet body is screwed onto a fixed machine part. With the brakes, the braking torque is supported against the magnet body mounting on this machine section.

The clutches and brakes may be fitted horizontally or vertically. The armature disc may be optionally fitted at either the top or bottom.

5.2 Installation tolerances, permissible center offset

If clutches are used to link two shafts, the center offset specified in the table must not be exceeded. If the specified level of precision cannot be achieved, rotor and armature must be centered on a shaft end and the torque transmitted to the second shaft end using a flexible coupling.

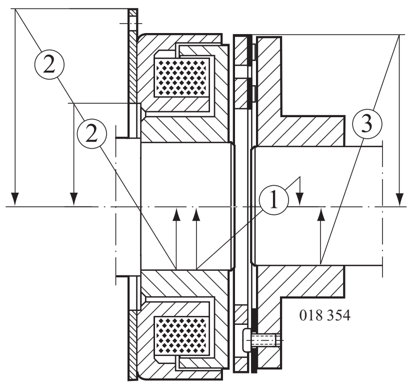
NOTE
A radial air gap must remain between rotor and magnet body because otherwise damage will arise on the other side. The center offset specified for this must therefore NEVER be exceeded.

The D4 and D3 diameters are provided on the magnet body for the centering. It is a good idea to fit the centering on a roller bearing in D3, which means that the axial position of the magnet body in relation to the rotor can be determined at the same time.
The armature disc is only centered using 3 retaining bolts.

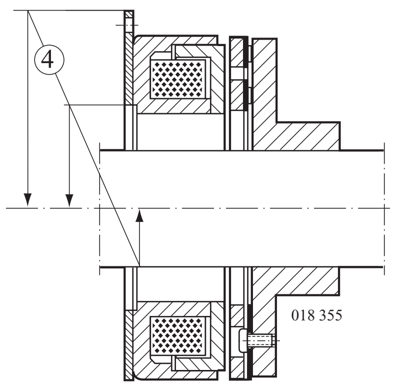
NOTE
The armature disc must not be centered or guided in addition to this. The precondition for this is however that threaded holes are precisely observed in the pitch and pitch circle.

With the brakes, the permissible center offset of the armature disc mounting to the magnet body is kept large enough to ensure that the centering via the magnet body’s retaining bolts is also sufficient.

Permissible center offset



Clutch



Brake

Clutches ZF type	Brakes ZF type	Permissible center offset [mm] to ① rotor axle – axle armature end	② rotor axle – magnet body	③ axle at armature end – external armature diameter	④ axle at armature end – magnet body
electromagnetically engaged single-disc clutches and brakes					
EK-ER 0.5	EB-ER 0.5	0.05	0.10	0.15	0.20
EK-ER 1	EB-ER 1	0.10	0.10	0.15	0.25
EK-ER 2	EB-ER 2	0.10	0.15	0.20	0.30
EK-ER 4	EB-ER 4	0.10	0.15	0.20	0.30
EK-ER 8	EB-ER 8	0.15	0.15	0.20	0.35
EK-ER 16	EB-ER 16	0.15	0.20	0.25	0.40
EK-ER 32	EB-ER 32	0.15	0.20	0.25	0.40
EK-ER 63	–	0.20	0.25	0.30	–
EK-ER 125	–	0.20	0.25	0.30	–

5.3 Installation of armature disc

The armature disc is screwed to 3 points with the connection piece (flange, pulley etc.). Appropriate clearance holes are provided for this purpose in the ring springs as well as recesses for the screw heads. Cylinder head screws as defined in DIN 84 or with Allen screw insert DIN 7984 or DIN 6912 should be used. The screw cannot be secured onto the diaphragm spring; it must therefore be secured by means of cementing, peening or lock nuts.

When fitting the armature disc, the ring spring is pre-loaded in an axial direction. This ensures a rapid opening of the clutch or brake and this prevents the armature disc from rattling or from making contact with the rotor or brake disc.

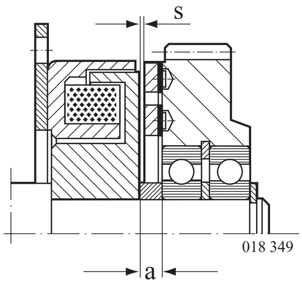
In special instances, sizes 0.5 to 125 can be fitted without preload, e.g. to make use of the greater stroke and therefore to attain long rest periods during use in dry conditions.

With clutches and brakes of sizes 0.5 to 32, the preload results from the height of the rivet heads (dimension k) when fitting the armature disc. Only the threaded bores for mounting are located in the connection piece. With sizes 63 and 125, the preload is achieved by placing 3 brass washers with a thickness of “m” between the armature disc and diaphragm spring with the retaining bolts. The brass washers (m x d_9) for preload are supplied with the clutch or brake.

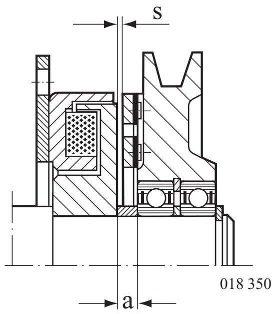
The operating air gap (stroke) “s” can be set during assembly. During installation, the correct size is produced if the connection pieces are produced accurately so that the installation dimensions a or a+k or a+m for the clutches or B or B+k or B+m for the brakes can be observed.

The pulling force of the magnet over a greater operating air gap is limited so that only one particular max. stroke is possible. This depends on the type of installation and should be determined from the tables. The specified minimum operating stroke can be reduced by 50 % if axial movements of the clutch halves can be prevented, e.g. through the use of zero-backlash mountings.

EK-ER 0.5 to EK-ER 16



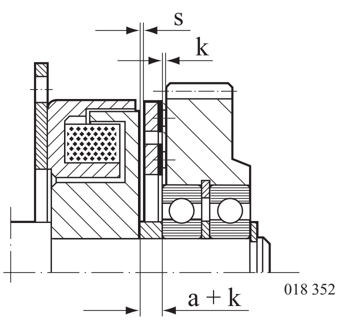
EK-ER 32 to EK-ER 125



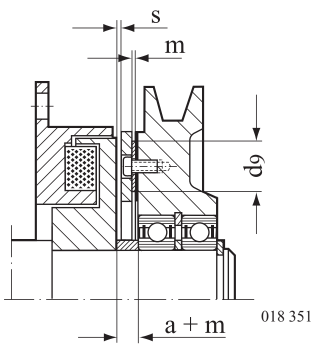
Armature disc without mechanical preload

Clutches ZF type	Brakes ZF type	Without preload Stroke min. s [mm]	Stroke max. s [mm]	a [mm]
Countersinking the rivet heads in the counter piece (should only be used in special instances)				
EK-ER 0.5	EB-ER 0.5	0.3	0.7	3.2
EK-ER 1	EB-ER 1	0.3	0.9	4.1
EK-ER 2	EB-ER 2	0.3	1.1	5
EK-ER 4	EB-ER 4	0.3	1.3	5.9
EK-ER 8	EB-ER 8	0.4	1.5	6.7
EK-ER 16	EB-ER 16	0.4	1.8	8
EK-ER 32	EB-ER 32	0.4	2.2	9.3
EK-ER 63	–	0.5	2.6	12
EK-ER 125	–	0.5	3.0	15

EK-ER 0.5 to EK-ER 32



EK-ER 63 to EK-ER 125



Armature disc with mechanical preload

Clutches ZF type	Brakes ZF type	With preload Stroke min. s [mm]	Stroke max. s [mm]	a + k a + m [mm]	k or m [mm]	d_9 [mm]
Without countersinking the rivet heads in the counter piece						
EK-ER 0.5	EB-ER 0.5	0.3	0.5	3.5	0.3	–
EK-ER 1	EB-ER 1	0.3	0.6	4.5	0.4	–
EK-ER 2	EB-ER 2	0.3	0.7	5.5	0.5	–
EK-ER 4	EB-ER 4	0.3	0.8	6.5	0.6	–
EK-ER 8	EB-ER 8	0.4	1.0	7.5	0.8	–
EK-ER 16	EB-ER 16	0.4	1.2	9	1.0	–
EK-ER 32	EB-ER 32	0.4	1.4	10.5	1.2	–
Countersinking the rivet heads in the counter piece (Preload by placing washers between ring spring and armature disc)						
EK-ER 63	–	0.5	1.7	13.5	1.5	40
EK-ER 125	–	0.5	2.0	17	2.0	50

5.4 Magnetic insulation

In general, no special insulation is needed. It is however a good idea to fit a non-magnetic connection piece or a non-magnetic washer if for example the armature discs of the clutch and brake are fitted on the same connection piece or if the specified maximum stroke is to be used to counteract adverse flux conditions.

6 Electrical connection / power supply

The single-disc clutches and brakes are operated with direct current (DC). The nominal voltage is normally 24 V. The permissible mains fluctuation must not exceed ± 10 %.

The anti-surge elements should always be fitted according to specification (for electrical data, refer to section 11.2).

7 Electrical energizing

7.1 General

The electro-magnetically actuated clutches and brakes have different lengths of activation and deactivation times depending on size and design. The clutches and brakes have been optimized on the basis of years of experience so that the switching times and torque levels correspond to the requirements set in a large application.

The switching times specified in the tables apply with nominal voltage and coils at operating temperature when using the recommended varistors as the anti-surge elements. The switching times may be varied by mechanical and electrical measures.

The usual circuit is shown in Figures 4 and 5.

The clutch or brake coil is routed via a contact or an electronic shift element to nominal voltage. The nominal voltage should be directly present at the coil connection when the clutch (brake) is activated. Voltage drops due to long lines or higher loadings should be taken into consideration. Anti-surge elements must be used to avoid detrimental deactivation voltage levels.

7.2 Anti-surge elements

CAUTION
A peak in voltage occurs when the exciter current is deactivated as a result of the inductivity of the electro-magnetic clutches. This may be in excess of 1000 V.
This may cause damage to the insulation and switching elements.

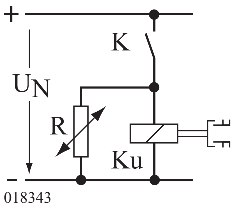
An anti-surge element must therefore be used to reduce this overvoltage to a low level.

The following anti-surge elements may be used:

1. **Varistor** (voltage-dependent resistance)
   Recommended type, e.g. S10 K30.

   This varistor type may be used with all operating voltages up to 30 V. The deactivation voltage peaks are limited to values < 100 V.

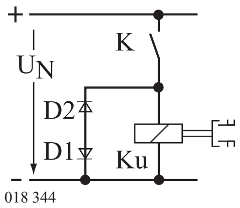
   If excessive excitation causes the voltage level to exceed 30 V, a diode must be switched in line to the varistor and operated in the locking direction.



K switching member as
1. protective contact
2. Thyristor
3. Transistor

R Varistor
Ku Clutch

Fig. 4 Basic circuit of a clutch with varistor



K switching member as
1st protective contact
2. Thyristor
3. Transistor

D1 Diode
D2 Z-diode
Ku Clutch

Fig. 5 Z-diode as an anti-surge element

This circuit is appropriate for all clutches and brakes of this catalogue. If sensitive switching elements or zero-contact switches are used, the deactivation voltage peak of around 90 V may however be too high.

2. Z-diode
One diode must always be switched in line to the Z-diode (see Fig. 5).
The Z-diode is recommended as an anti-surge element, especially for zero-contact switching elements because the inductive voltage only increases slightly above the Z voltage. At Z voltage levels above 60 V, the deactivation period corresponds to the catalogue value and at lower Z voltage levels, it is longer.

This circuit is most especially recommended for applications using sensitive switching contacts and zero-contact switches.

3. Diode
This is predominantly used when switching inductivities with semi-conductors. The diode prevents an increase in voltage during deactivation.

NOTE
It should be noted that when using the diode as an anti-surge element, the deactivation period is lengthened to up to 5 times the period of the catalogue value.

8 Activation and deactivation process

VDE ruling 0580 forms the basis for the definition of switching times and torque levels.

In accordance with this, the deactivation time is the interval between the deactivation of the excitation voltage and the fall in torque from $M_{ü}$ to 10 % of the engageable torque.

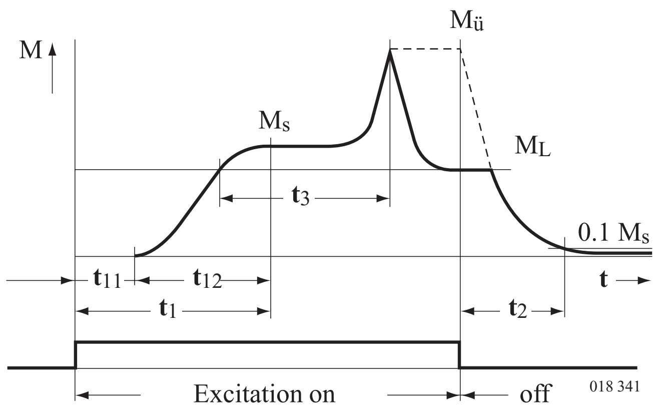
For friction clutches, the engageable torque is considered as the torque acting during slip and this depends on the friction coefficient.

The transmissible torque is the torque level with which the device can be loaded without slip arising.
Residual torque is considered as the maximum stabilization value following deactivation in operating temperature mode.

The diagram on page 23 shows the torque characteristics of an activation and deactivation process. Following the activation delay, t_{11}, the engageable torque level, M_s, occurs during the time, t_{12}. In the example shown, the level of acceleration torque resulting from the difference between Ms and the load torque M_L is so great that after time, t_3, the clutch halves operate synchronously.

At the point of synchronization, the torque level briefly increases to the maximum transmissible torque level, $M_{ü}$, as a result of the standby friction level and then falls to the load torque, M_L. The length of the acceleration process depends on the masses to be accelerated, the difference in speed, the engageable torque level of the clutch and the load torque. With small masses and differences in speed, synchronization can be achieved before time t_{12} elapses.

Diagram for electromagnetically engaged clutches and brakes



t_1	*Activation time (t_{11} + t_{12})*
t_{11}	*Activation delay*
t_{12}	*Increase time*
t_2	*Deactivation time*
t_3	*Clutch run-up time*
M_s	*Engageable torque*
$M_ü$	*Transmissible torque*
M_L	*Load torque*

9 Varying switching times

9.1 Activation time

During activation, the current level increases and the magnetic pulling force therefore also increases by an exponential function. The activation delay, t_{11}, and therefore the entire activation time, t_1, may be reduced if the activation time constant is reduced. Rapid or excessive excitation is appropriate for this.

The following diagram shows the influence of these measures on the current characteristics.

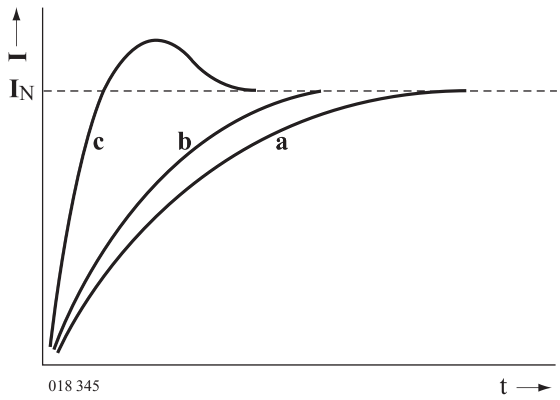


Fig. 6 Time-based current characteristics when activating an electromagnetic clutch with
a normal excitation
b rapid excitation
c excessive excitation by discharging condenser

9.2 Deactivation time

As with activating, the current curve follows an exponential function during deactivation.

Extremely short deactivation times can only be achieved by means of counter excitation.

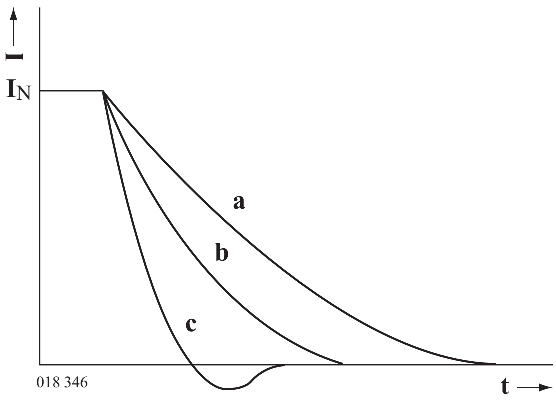
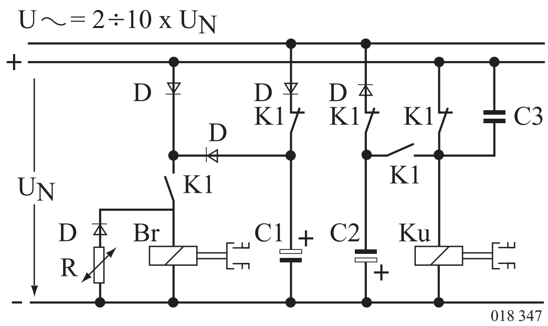


Fig. 7 Time-based current characteristics when activating an electromagnetic clutch. Voltage peak absorbed by
a diode (without resistance)
b varistor
c counter excitation

The deactivation times specified in the selection tables are achieved when using the recommended varistors. Deactivation times are increased if voltage peak is absorbed by a diode. The anti-surge element has the task of damping any peaks in voltage which occur when activating the clutch in order to protect the clutch and shift device from excess overvoltage. The best results to date have been achieved with a varistor. This produces short deactivation times which can only otherwise be achieved without the use of anti-surge elements and at the same time limits peaks in voltage to permissible values.

The varistor is a voltage-dependent form of resistance. It forms great resistance for low levels of voltage and slight resistance for high levels of voltage.



K Shift members as 1. protective contacts,
2. Thyristors,
3. Transistors,
4. Mixture of 1. 2 and 3

Ku clutch
Br brake
C condensers

R Shock absorber as varistor or Z-diode

Fig. 8 Switching example for rapid braking, brake with excess excitation, clutch with counter excitation

If a switch is made from clutch engagement to braking, the brake is subjected to the voltage from C1. A high level of current results in rapid engagement of the brake. Once C1 has discharged, the U_N voltages are responsible for supplies. At the same time, when deactivating, the clutch is subjected to a negative pulse from C2. This causes the clutch to be rapidly opened. For an optimum function, the condensate loading $1/2 \cdot C \cdot U^2$ must be adapted to the clutch size.

10 Maintenance

The clutches and brakes are usually used in applications under dry conditions and when switching at the differential speed are subject to wear which increases the armature stroke.

NOTE
In such instances, the armature stroke should be checked at regular intervals.

This is difficult to do on the worn friction surfaces.
The armature stroke should therefore be checked when the clutch or brake is activated (armature pulled) at the back of the armature disc between the rivet head and locating face.
As soon as the permissible max. operating air gap is reached, this must be adjusted to the correct setting.

The wear reserve provided allows the armature stroke to be reset several times, always to the minimum stroke. This is generally done by sliding back the armature connection piece. The values for the permissible total wear can be found in section 11.1.

NOTE
During repair work, both wear parts (i.e. the armature disc on the clutch and rotor and/or complete brake) must always be replaced.

11 Technical explanations

11.1 Limit values for wear during operation in dry conditions

Order no. Clutches	Brakes	Perm. total wear V_0 [mm]
EK-ER 0.5	EB-ER 0.5	1.6
EK-ER 1	EB-ER 1	1.9
EK-ER 2	EB-ER 2	2.3
EK-ER 4	EB-ER 4	2.7
EK-ER 8	EB-ER 8	3.2
EK-ER 16	EB-ER 16	3.8
EK-ER 32	EB-ER 32	4.5
EK-ER 63	–	5.3
EK-ER 125	–	6.3

11.2 Electrical data of clutches and brakes

ZF type	**Coils-resistance (at 20 °C) R [Ω] ± 7 %**	**Exciter-current (at 20 °C) I [A]**	**Performance - consumption (at 20 °C) P [W]**
Stationery-field electromagnetically engaged single-disc clutches			
EK-ER 0.5	56	0.42	10
EK-ER 1	46	0.51	12.5
EK-ER 2	28	0.85	20
EK-ER 4	23	1	25
EK-ER 8	19	1.3	31
EK-ER 16	14	1.7	42
EK-ER 32	10	2.3	55
EK-ER 63	8.5	2.8	67
EK-ER 125	5.7	4.2	100
Electromagnetically engaged single-disc brakes			
EB-ER 0.5	56	0.42	10
EB-ER 1	46	0.51	12.5
EB-ER 2	28	0.85	20
EB-ER 4	23	1	25
EB-ER 8	19	1.3	31
EB-ER 16	14	1.7	42
EB-ER 32	10	2.3	55