



Technical details

Construction
Steel-grid fixed resistor elements
Type series S

Our steel-grid fixed resistor elements (SG) are made from chromium alloyed and heat-resistant steel sheets of alloy X10CrAl13 (material # 1.4724) which are of a high specific resistance value. Both long sides of the SG are perforated with slots in a meander-shaped current path. The ohmic value depends on the width of the straps. They are mechanically reinforced by strips of stainless steel with inlays of mica.

Spectrum

By the use of SG with a big ohmic range of 0,022 Ω to 5,6 Ω and a typical power of 500 W per steel-grid we can reach a wide range of resistance value and power by variation of steel-grid number and ohmic value.

Resistance values/
Production tolerance/
Temperature dependency

Steel-grid fixed resistor elements have a smaller dependence of the resistance value on the steel-grid temperature than cast iron resistors, however a noticeably higher one than wire-wound resistors. The resistance value increases approx. 15% between cold and operating temperature.

The given rated resistance values of each individual SG in the table on page T620 are about 8% higher than the resistance value in cold condition and about 7% below the resistance value at the operating temperature.

The production tolerance is ± 10%.

Energy absorption capacity/
Time constant

The energy absorption capacity varies per SG at a temperature increase of 300 K in dependency of the ohmic value between 50 and 70 kW.

The average thermal time constant is 100 s.

Resistor blocks
Type series FE

If larger power ratings are to be obtained, several SG are assembled by M12-thru bolts and isolating mica tubes to a resistance block. The isolation between 2 neighbouring SG is effected by glazed ceramic rolls, the current conduction by stainless steel rolls. The resistance block is prestressed by cup springs and so held under constant contact pressure. In addition to that individually screwed conductor rolls between two neighbouring SG are possible. A resistor block may consist of identical SG or of different SG with lugs as taps.

Resistors
Type series FK; FGF; FA; FS

In order to facilitate the integration, and/or to provide different degrees of protection, various kinds of enclosures are used. The enclosures are manufactured from hot-galvanized and perforated steel sheet and therefore are well protected against corrosion. Also an extra varnish in RAL 7032 is available with an additional charge as well as enclosures in stainless steel (alloy 1.4301).

Degrees of protection

Correlation of type series and degrees of protection according to EN 60529 and/or DIN VDE 0470 part 1

IP
00

IP
20^①

IP
20

IP
23

Type series	Degree of protection	First characteristic numeral degree of protection against access & solid foreign objects	Second characteristic numeral degree of protection against water
S FE FK..	IP 00	Non-protected – i.e. depending upon integration the user must provide a protection	Non-protected
FGF..	IP 20 ^①		Non-protected
FA..	IP 20	Protected against access to hazardous parts with a finger and against solid foreign objects of 12,5mm Ø and greater.	Non-protected
FS..	IP 23		Protected against spraying water. Water sprayed at an angle up to 60° on either side of the vertical shall have no harmful effects. (for outdoor location)

^① if mounted on an appropriate surface – i.e. mounted on a surface according to degree of protection IP 20 or higher



Protective measures

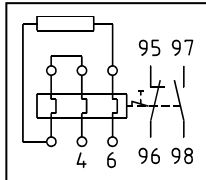


All our power resistors with degree of protection IP 20^① or higher correspond to safety class system I, i.e. we provide connections for protective earth conductors according to EN 61140.

Devices with degree of protection IP 20 or higher correspond to the CE low voltage standardization.

Power resistors being passive electronical or electrical units are not affected by the specific EMC standards. They do not produce any interfering radiations nor are they affected.

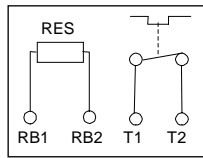
Excess current protection



A protection of the resistors against overloading or excess temperature - as demanded in standards - can be realized with the help of a user thermal overload relay. The set current must correspond to the rated current of the resistor, that is calculated according to continuous duty power and resistance value after Ohm's law (formula: see "terminal details" p. T618E).

With the series FGFT the thermal overload relay is a component of the device with exceeding of the rated current a signal contact is released. There will not be a disconnection of the resistor. Resetting by hand.

Excess temperature protection



Another kind of the excess temperature monitoring, particularly suitable with long-time overloading, is the equipment with a temperature switch. With IP 20 / IP 23 - resistor devices it is wired on terminals, with IP 00 resistors the switch is directly connectable and releases a signal contact when the set temperature is exceeded. There will not be a disconnection of the resistor. See type series FE / FKE / FG / FK / FA / FS.

Contact rating

Contact ratings of the signal contacts of temperature switches and thermal overload relays.

- 2 A / 24 VDC (DC11)
- 2 A / 230 VAC (AC11)

Air und creepage distances

Air and creepage distances are rated after IEC 664 (DIN EN 0110 part 1) for the overvoltage category III and pollution degree 3 for grounded three-phase mains supplies up to 3 x 500 V. Testing voltage 2.5 kV AC.

These data are good for all devices that are connected with mains voltage and derived voltages, like for example the intermediate circuit voltage of frequency converters.

Do not conclude from the calculated relation between the rated power and the maximum producible ohmic value to the rated voltage.

UL-recognition



All important type series do have an UL- recognition both for the American and for the Canadian market. The devices were certified after UL 508 under the number E212934. This recognition is the same as a recognition according to CSA C22.2 No.14. For further information please check the UL-flyer.

(Please ask for it or visit us at www.frizlen.com)



Selection of Type series and dimension

The tables on the following data sheets contain a selection of the available equipment assemblies and/or the appropriate maximum assembly of the respective size of the device. Less steel-grids (SG) are possible.

For all type series, except for S, the following type codes are shown to explain the complete type designations.

Type code 1

FK E U 3 1 3 30 02 - 50 — ohmic value $\pm 10\%$
 — number of terminals or connecting lugs
 — # of steel-grids (e.g.: 30 SG = 15 kW)
 — construction width 1; 2; 3; 4, 5,
 — construction height 1; 2 or 3 tiers
 (with FGF..., FKE., FE. only height 1!)
 — type series 3
 — UL-construction
 — addition like E(Q); FG; FK(Q); FL(Q);
 HD(Q) u. FT - Q stands for temperature-
 switch(TS)
 — type series FK; FE; FG; FA or FS

Type code 2

FS 3 20 09 02 - 22 — ohmic value $\pm 10\%$
 — number of terminals or connecting lugs
 — # of steelgrids (e.g.: 9 SG = 4,5 kW)
 — type series 19; 20; 85; 86; 87; 88
 — type series 3
 — addition like V (only for 85 – 88)
 — type series FA or FS

Type series S represents individual components. You can see their complete type designation in the table on p. T620.



Devices that are built according to UL standard are marked additionally with "U" at the last position in the sequence of letters- see type code 1 and the following example

Selection of devices/ Example given:

- continuous power rating of the resistor: $P = 9,0 \text{ kW}$
- resistance value: $R = 27 \Omega$
- continuous current of the resistor: $I = 18 \text{ A}$
- construction with terminals that are protected against contact
- degree of protection IP 20 (mounting on switch cabinet)
- with temperature switch (TS)
- design according to UL

wanted: resistor

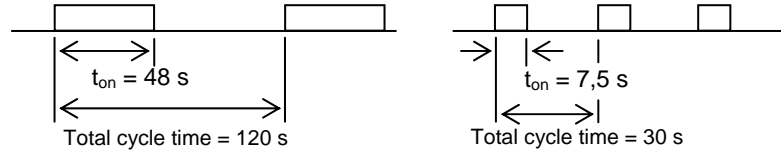
- number of SG = continuous power rating : power per SG = $9,0 \text{ kW} : 0,5 \text{ kW} = 18 \text{ SG}$
- selection of type series from survey on p. T612
- possible type series: FGF...; FA
- with mounting on a switch cabinet – means on a surface of degree of protection IP 20 you can choose the smaller and low priced alternative FGF, compared to type series FA. If the terminals should be in an attached terminal box, type series FGFKQ is adequate, because of the necessary temperature switch (TS)
- with 18 SG you can select within enclosure size construction height 1 and width 2 (max. poss. 24 SG)
- construction according to UL508: add "U" to the type designation,
- type designation would be FGFKQU 3121802 – 27 (with 2 device terminals up to 65 A). Type description see p. T623Eff



Short time dissipation/
Total cycle time/
Duty cycle factor(DCF)

At many applications resistors are not loaded in continuous but in short time operation. In the following you will find indications, how to calculate the allowable short time dissipation with the help of the duty cycle factor (DCF) and the overload factor (OLF). If the DCF factor is not known, it can be calculated as follows:

$$\text{Duty cycle factor(DCF)} = \frac{\text{Switch on time}(t_{on})}{\text{Total cycle time}}$$



$$DCF_1 = \frac{48s}{120s} = 0,4 = 40\%$$

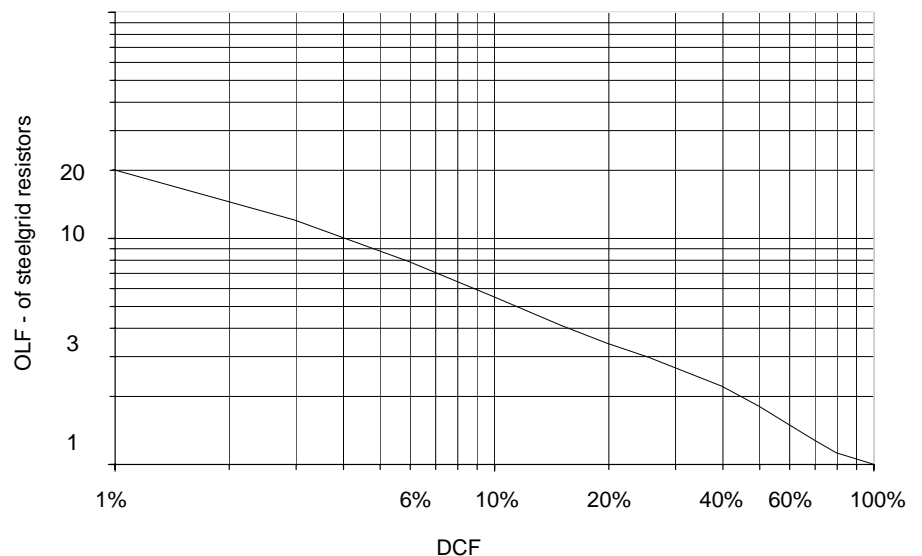
$$DCF_2 = \frac{7,5s}{30s} = 0,25 = 25\%$$

Warning: The total cycle time may be maximum 120 s - shorter total cycle times are possible.
The total cycle times for motors are mostly higher than 120 s

Overload factor(OLF)

By comparison of the known DCF-factor with the following diagram or table you can work out the overload factor (OLF) and/or the continuous and the short time dissipation.

Overload factor (OLF) in dependence of duty cycle factor (DCF)
(Total cycle time = 120s)



DCF	1%	3%	6%	15%	25%	40%	60%	80%	100%
OLF	20	12	7,6	4,0	3,0	2,2	1,5	1,12	1,0

The continuous and the short time dissipation can be calculated as follows:

$$\text{Short time dissipation} = \text{Continuous dissipation} \times \text{OLF}$$

$$\text{Continuous dissipation} = \frac{\text{Short time dissipation}}{\text{Overload factor(OLF)}}$$

Calculation example
given:

wanted:
continuous dissipation

- Resistor with a short time dissipation of 100 kW for 48 s and a total cycle time of 120s
- The duty cycle factor (DCF) would be 48 s : 120 s x 100% = 40%
- Overload factor (OLF) for 40% DCF, according to table it is 2,2
- The continuous dissipation is 100 kW : 2,2 = 45,5 kW;
- You would need a resistor with a continuous dissipation of at least 45,5 kW!



Typical power/ Continuous dissipation/ Ventilation / temperatures

The given typical power values are valid for 100% duty cycle factor (DCF) (continuous dissipation) under the following conditions:

- Temperature rise of 200 K at the surface of the resistor enclosure (degree of protection > IP00)
- Temperature rise of 300 K at the surface of the resistor element (degree of protection IP00)
- Maximum ambient temperature 40°C
- unhindered access of cooling air
- unhindered diverting of warmed up air (keep a minimum separation distance of approx. 200 mm to neighbouring components/walls and of approx. 300 mm to components above/ceiling)
- warning: If the ambient temperature is higher than 40°C, you have to lower the continuous dissipation for 4% per 10 K temperature rise!

Since electrical energy is converted into heat, it is inevitable that the exhaust air will be heated up, as well as the section of enclosure at the air outlet.

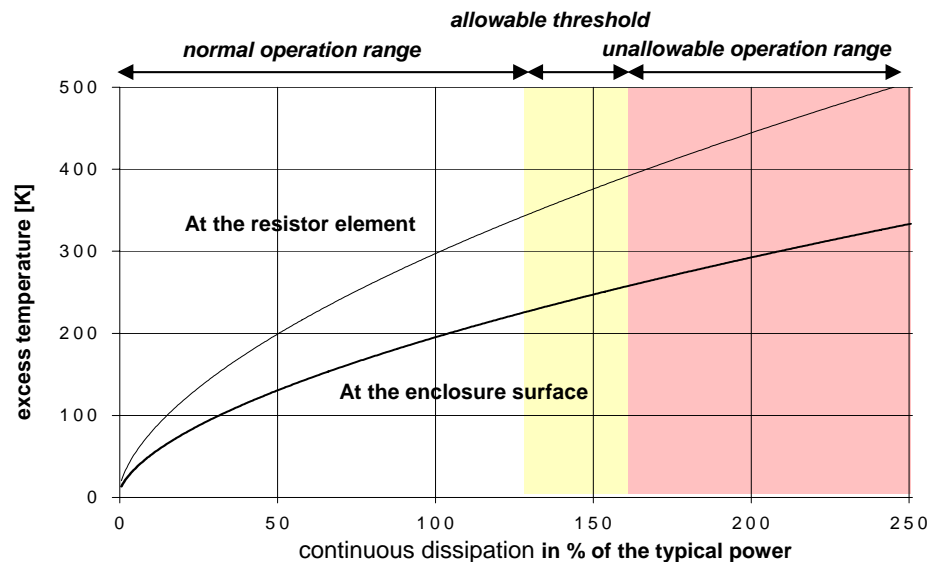
The highest temperature with typical power may be maximum 200°C beyond the ambient temperature. Since the cooling of the devices is accomplished by convection and/or forced ventilation (series FAV/ FSV), the above mentioned aspects have absolutely to be considered.



In a case of insufficient cooling or false mounting the resistor or the surrounding devices could be overheated or ruined.

Depending upon use it can be possible, to increase the continuous dissipation of the resistors, if higher temperatures are accepted. With increase e.g. of 130% of the typical power you will have a rise in temperature of 350K at the surface of the resistor. In other cases of applications the continuous dissipation must be reduced, for example with temperature sensitive devices in the surrounding. The dependence between temperature rise and actual continuous dissipation is shown in the diagram below.

Excess temperature in dependence of continuous dissipation



Normal operation range (up to 130%):

Recommended operation range for maximum product life and failure free operation

Allowable threshold (up to 160%):

Allowable operation range, danger of shorter product life and higher failure probability

Unallowable operation range (more than 160%):

Danger of excessive heat and destruction of resistor and neighbouring components



Terminal details

Rated current and cross section of terminals

type	abbreviation	rated current in A with 100% DCF	rated current in A up to 40% DCF	Maximum cross section
porcelain terminal	PK	16		up to 2,5 mm ²
ceramic flat terminal	FK	35	44	2,5 - 10 mm ²
device terminals out of polyamid (PA)	G 5	30	38	0,5 – 2,5 (4) mm ² AWG 24 - 12
	G 10	60	75	0,5 – 10 (16) mm ² AWG 20 - 6
bolt terminals out of ceramics	BK M6	60	75	cross section depending on lug size with corresponding hole
	BK M8	115	143	
	BK M10	220	287	
	BK M12	400	536	
feed-through terminal out of PA	HDFK4	30	38	up to 4,0 mm ² ; AWG 24 - 12
	HDFK10-HV	65	82	up to 10 mm ² ; AWG 20 - 6
cage clamp terminal out of PA	ST2,5	20	25	up to 2,5 mm ² ; AWG 26 - 12
	ST 4	30	38	up to 4,0 mm ² ; AWG 20 - 10

The rated current is calculated in each case due to the Ohm's law as follows:

$$I = \sqrt{\frac{P}{R}}$$

whereas
P is the power of the resistor and
R is the value of the resistance

Wiring

If terminals are required, the connections are wired by means of flexible, heat resistant, silicone-insulated wire on a terminal strip that is located in the lower and/or front part of the equipment within the area of the entering cooling air. For UL versions wires with UL recognition are used (other wire insulations on request).

With the series FK /FA /FS 3 as well as with F.V 38 there is an undrilled cable entry strip in the lower part. It can be provided by the user with appropriate drillings for cable glands as strain relief.

Mounting

Please mind the mounting indications in the respective series!
You will find these icons in the data sheets:



Allowable: On horizontal surfaces



Allowable: On vertical surfaces terminals at the bottom



Not allowable: On vertical surfaces terminals at the top, left or right



Dimensioning example

Braking resistor

- given:**
- Maximum intermediate circuit voltage 650V : $U_{ZK} = 650\text{ V}$
 - Smallest allowable resistance value:
(from data sheet of frequency converter) $R_{min} = 25\ \Omega$
 - maximum allowable chopper current $I = \frac{U_{ZK}}{R_{min}} = \frac{650\text{V}}{25\Omega} = 26\text{A}$
 - duty cycle factor for braking operation (corresponding to the application),
for a hoist drive e.g. 40 % DCF referring to a total cycle time of 120 s
DCF = 40%
 - degree of protection IP 20 in fixed condition
- wanted:**
- short time dissipation of the resistor with 40%DCF $P = \frac{U^2}{R} = \left(\frac{650\text{V}^2}{25\Omega}\right) = 19,6\text{kW}$
 - continuous dissipation = short time dissipation : overload factor (s. p. T616E)
 - continuous dissipation = 19,6 kW : 2,2 = 8,9 kW
 - number of steel-grids = continuous dissipation : dissipation per SG
 - number of steel-grids = 8,9 kW : 0,5 kW \approx 18 SG
- selection of steel-grids:**
- resistance value of a SG = R_{min} : SG-number = $25\ \Omega : 18 = 1,39\ \Omega$
The ohmic value should not be smaller than R_{min} altogether, since otherwise the allowable chopper current is exceeded! SG selection of p. T620E = 18 pieces
S 23 – 1,5 Ω ; total ohmic value is 27 Ω
- selection of products:**
- With degree of protection IP 20 in fixed condition – series FGFG..
 - With 18 steel-grids – construction size 312 18..
 - with 2 terminals up to 35 A, without temperature switch – type FGFG
 - The type designation would be FGFG 3121802 - 27 (s.p. T623Eff)

Dimensioning example

Load resistor

- given:**
- Rated voltage U of supply unit: $U = 3 \times 230/400\text{ V}$
 - rated dissipation: $P = 15\text{ kW}$
 - star connection, star point in the unit
 - duty cycle factor: DCF = 100%
 - degree of protection IP 23
- wanted:**
- rated current
per phase with star connection: $I_N = \frac{P_N}{\sqrt{3} \times U_N} = \left(\frac{15\text{kW}}{\sqrt{3} \times 400\text{V}}\right) = 21,7\text{A}$
 - nominal value of resistance
per phase with star connection: $R_{wanted} = \frac{U_N}{\sqrt{3} \times I_N} = \left(\frac{400\text{V}}{\sqrt{3} \times 21,7\text{A}}\right) =$
 - value of resistance in cold condition: $R_{cold} = 0,95 \times R_{wanted} = 0,95 \times 10,7\ \Omega =$
If the demanded rated dissipation is to be achieved at operating temperature in the range of the resistance tolerance, it is advisable to consider the value of resistance in cold condition.
 $R_{cold} = 0,95 \times R_{wanted}$
Then you can make your selection of steel grid.
- selection of steel-grids:**
- Selection of steel-grids of p. T620E by the rated current of 21,7 A: S 21 – 1,0 Ω
 - number of SG per phase = value of resist. in cold condition: ohmic value per SG
 - number of SG = 10,2 $\Omega : 1,0 \approx$ 10 SG per phase – 3phases is 30 S 21 – 1
 - value of resistance in cold condition is therefore 3 x 10 Ω
 - resulting rated dissipation: 3 x 10 SG per 0,5 kW = 15 kW
- selection of products:**
- with degree of protection IP 23 – series FS..
 - with 30 steel-grid fixed resistors – size 313 30.. or 322 30..
(size 313.. is lower, size 322.. is narrower)
 - with 3 terminals (star point in the unit) number of terminals ...03
with 4 terminals (star point wired on 1 terminal) number of terminals ...04
 - The type designation would be FS 313 30 03 – 3 x 10,7
(low unit, star point in the unit) (type series FS s. p. T628E)