

# High power resistors for transportation systems



## Safe, reliable and long-lasting

EMC-compliant  
stainless steel housing,  
bolted and jointed  
Convection cooling  
or forced ventilation  
solutions  
up to 5 megawatt

Customized  
engineering and  
manufacture  
meeting the  
highest demands





## Application

In accordance with the state of the art, rail-bound vehicles are equipped with three-phase motors whose acceleration, speed and braking are controlled by means of power electronics.

When the brakes are operated, the kinetic energy of the vehicle is converted into electric energy, returned to the grid wherever possible and reused. But this requires a grid that is capable of taking on this energy at any time, because otherwise only the grid voltage would rise and the braking effect would be nil. As an alternative, the braking energy can be transformed into heat by using a braking resistor.

Braking resistors are used as auxiliary brakes for energy return to the grid, for relieving the mechanical brake and as an emergency braking resistor.

Electrical braking is wear-free and can be optimally controlled so that abrupt changes in braking deceleration are avoided which would be uncomfortable for the passengers.



## Resistors for transportation systems

The 6GN1 technology applied by GINO so far is based on individual embossed and gilled strip elements which are series-connected by means of spot welding and mounted on support brackets with ceramic insulators. The support brackets are provided with additional insulation. This technology allows for a high power density and is particularly advantageous for fan-cooled resistors.

By acquiring the 3PQ4 technology developed and patented by Siemens, GINO added a further high-performance insulation system to its portfolio. This system in addition affords the extension of the operating range to temperatures of up to 850°C, i.e. up to the maximum thermal strength of the resistor material and the limits set by the geometric structure.

Even if this range is not fully utilized in operation, it provides additional overload protection.



## Resistor material

Our resistor strips are made of the classic resistor materials nickel-chromium and iron-chromium–aluminum. Nickel-chromium alloys are corrosion-proof and high-temperature resistant. The iron content determines the change in resistance under the impact of heat. The higher the iron content, the greater the resistance change will be. Aluminum-chromium-iron alloys can become magnetized and cause considerable noise in clogged resistors.



## Cooling and resistor designs

Because of the large amounts of heat to be dissipated, braking resistors require sufficient cooling air. Depending on the cooling type, braking resistors are available with natural air cooling and with forced ventilation. Natural air cooled braking resistors are typically mounted on the outside of a vehicle so that in some cases the airflow may enhance the cooling effect.

The externally mounted resistors are either located on the rooftop of the vehicle or installed as underfloor resistors.

Roof-mounted resistors are in most cases easier to cool, but sometimes they may cause aerodynamic and optical problems. With underfloor resistors, heat dissipation may be problematic, in particular during standstill after braking.

Braking resistors with forced ventilation are supplied with cooling air by a fan so that they may also be mounted inside the vehicle.

# Resistors

## Underfloor resistors with convection cooling:

for mounting under a subway/ underground train, in **3PQ4 technology**



## Underfloor resistors with forced ventilation:

by high-performance axial-flow fan for mounting under a subway / underground train, in **6GN1 technology**



## Rooftop resistors:

designed for direct mounting on the vehicle roof, in **3PQ4 technology**



## Rooftop resistors with forced ventilation:

designed for mounting on the roof, in **6GN1 technology**



## Braking resistor towers



They are installed in the machine room of a locomotive. Continuous duty in the megawatt range is achievable with this design.

Whenever resistors are to convert high electric power into thermal energy in a confined space, in many cases natural convection is not sufficient. In such cases the active part of the resistor has to be cooled by forced ventilation using an appropriate fan type.

To this end, high-performance axial-flow fans are used which are purpose-manufactured for application in transportation systems. The cooling air flow generated is routed through the resistor packages equally distributed by a diffusor or air guide.

Both the 6GN1 and our 3PQ4 resistor system are suitable for this application, depending on the specific requirements.

## High-performance resistors in mining trucks

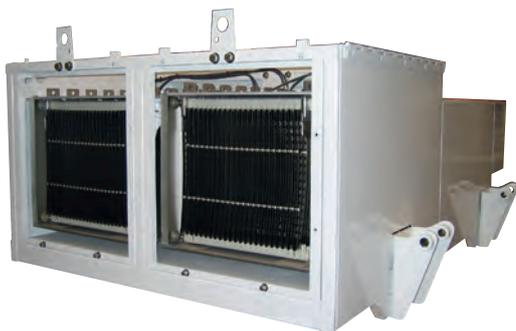


For the largest dump trucks with diesel-electric drive, GINO produces braking resistors based on the patented resistor system 3PQ4.

Such vehicles are used in mining operations worldwide, working under extremely harsh conditions. Fully loaded vehicles may reach a total weight of more than 600 tons. In order to brake such a colossus from a speed of more than 60 km/h down to complete standstill, braking power ratings of over 5 megawatt are required.

For this specific application, GINO uses the proven 3PQ4 technology which is wear-proof and only needs little maintenance, boasting very high performance reserves in the boundary range thanks to the admissible strip temperature of 850°C.

Moreover, in such vehicles motor control resistors are applied which limit the working voltage of the fan motors. In order to be able to tune them optimally to the vehicle characteristics, they are equipped with a series of taps. For this purpose the likewise tried-and-tested 6GN1 technology is deployed.



### Braking resistor box

20 resistor packages divided between 2 air ducts.  
Implemented continuous braking power: 5 megawatt



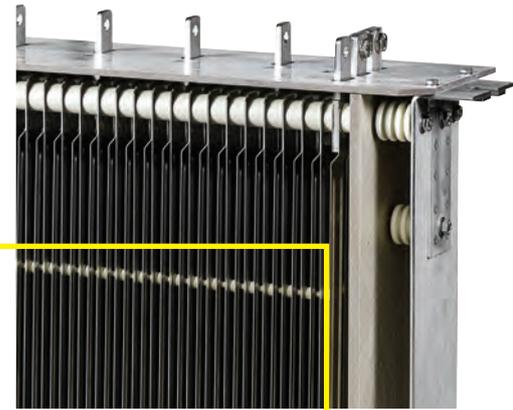
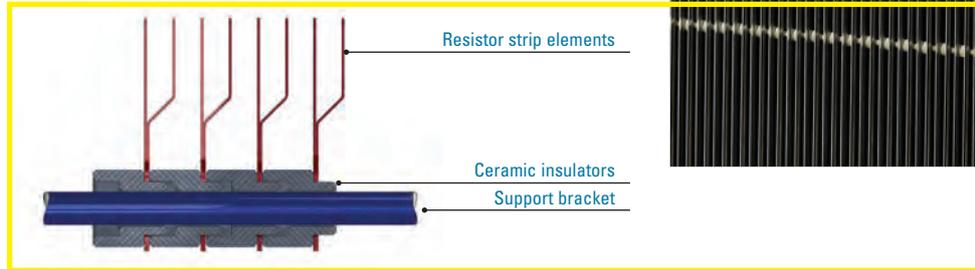
### Motor control resistor

Although relatively high resistance values are required, it is viable to use extremely compact designs with NiCr 6023 as active material.

## 6GN1 Technology:

Embossed and gilled strip elements connected by spot welding are mounted with ceramic insulators on support brackets with additional insulation. Admissible strip temperatures: up to 600 °C.

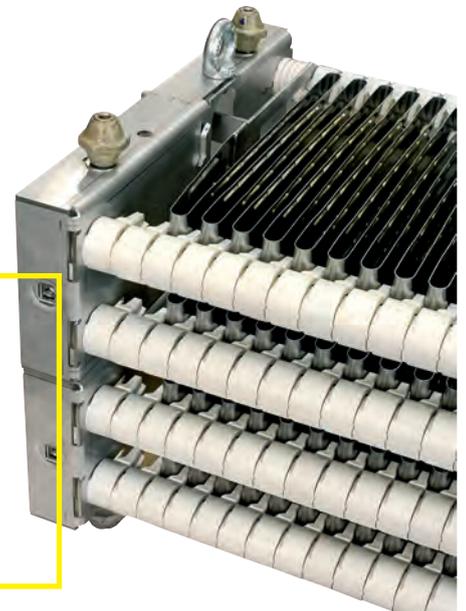
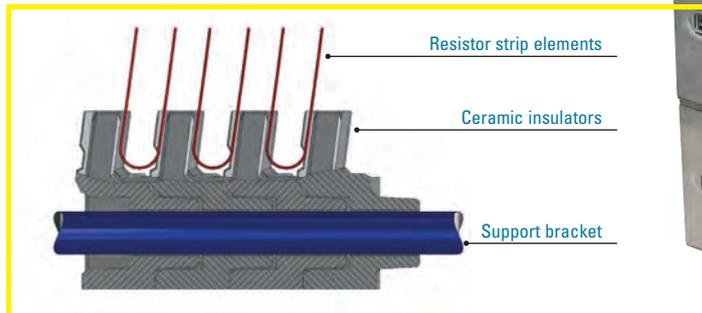
Non-wear and low-maintenance



## 3PQ4 Technology:

Continuously folded strips are installed between ceramic insulators arranged on support brackets. Due to the large air and creepage distances no additional insulation is required in the strip zone. Admissible strip temperatures: up to 850°C.

Non-wear and low-maintenance



The demands made on resistors for transportation systems rise in line with increasing travel speed and safety requirements of the vehicles. Already in the system design phase, vehicle manufacturers must rely on competent partners. The relevant DIN, EN and VDE codes and standards are applied as well as supplementary customer specifications in individual cases.

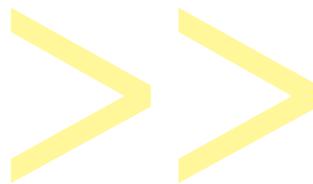
All equipment complies with the EC Low Voltage Directive and bears the CE mark of conformity. Highly qualified project engineers warrant that the design is at all times up to the latest state of the art.

We develop, plan and implement the appropriate individualized solutions based on your specific wishes and requirements.



Brake with us

*Your drives are our challenge!*



**GINO AG**  
**Elektrotechnische Fabrik**  
Friedrich-Woehler-Str. 65  
53117 Bonn  
Germany

Phone: +49 (0) 228 98 98 6-0  
Fax: +49 (0) 228 98 98 6-34