

PTC booster heater

General points

On account of the high efficiency of modern, direct injection engines (e.g. TDI), dissipated heat is no longer sufficient for heating up the inside of the vehicle quickly on cold days. PTC booster heaters (Fig. 1), which are installed in the direction of travel in front of the heat exchanger, make it possible to heat up the vehicle interior more quickly. They are made up of several temperature-dependent, electrically controlled resistors. Energy is taken from the vehicle wiring system without delay and dissipated into the inside of the vehicle directly as heat via the blower air flow.

Fig. 1

Design/Function

PTC elements are non-linear ceramic resistors. "PTC" stands for "Positive Temperature Coefficient", i.e. the electrical resistance increases as the temperature of the element increases. This is not absolutely correct, however, since it initially drops as temperature increases. The resistance curve has a negative temperature characteristic in this range. The negative characteristic only changes into a positive one once the minimum resistance has been reached, i.e. as temperature increases, the resistance is first reduced and then increases quickly from about 80 °C, until the PTC heating elements can practically no longer absorb additional current. At this point, the surface temperature is around 150 °C and the temperature of the metal frame around 110 °C if no air is flowing through the PTC heater.
The PTC heater is made up of several heating elements (Fig. 2, Pos. A), an attachment frame, an insulation frame and the relay or electronic power module (Fig. 2, Pos. B). The heating elements comprise PTC ceramic bricks, contact plates, connections and aluminium corrugated fins. The corrugated fins increase the area of the contact plates dissipating heat. To increase heat transfer on the air-side, the corrugated fins have slits, so-called "gills". The improved heat transfer allows the increase in the level of current required to switch on the heater to be significantly reduced compared to booster

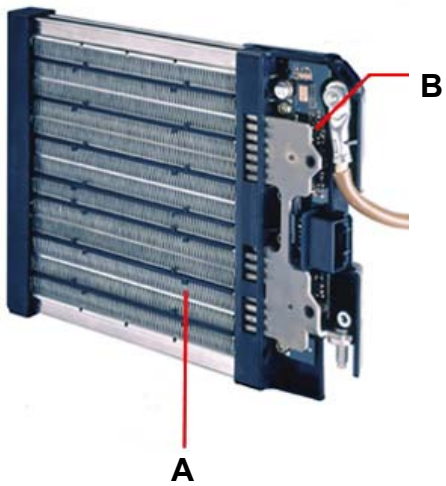
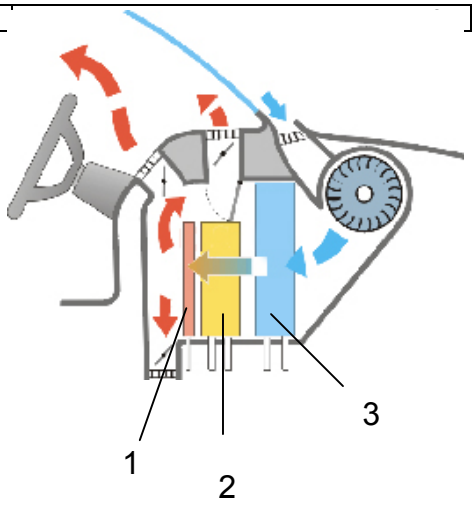


Fig. 2

heaters without "gill" corrugated fins. This means that individual PTC strands can be switched on more often, allowing the heater to be operated at higher power. The production know-how for these "gills" comes from radiator production. The booster heater is located in the heating/air conditioning unit, in the air flow directly after the conventional heat exchanger, which reduces design space requirements to a minimum. At low outdoor temperatures and with the engine cold, only cold air or air heated slightly by the heat exchanger initially flows through the PTC heater. Temperature and resistance of the heating elements are low, but the heating power is high. When the conventional heating reacts, air temperature and resistance increase and the heating power decreases accordingly. A volume flow of approx. 480 kg of air per hour is achieved when air at 25 °C flows through the PTC heater. At this air temperature, the heating network assumes an average temperature of 50 °C.
The nominal resistance of the PTC elements can be chosen individually according to current consumption and power. A low nominal resistance allows a high heating power during operation. The power of PTC heaters is between 1 and 2 kW. At 2 kW the power limit of the 12 V network (150 A at 13 V) has been reached. Higher capacities would be possible with a 42 V vehicle wiring system. The low mass and the fact that the electrically produced heat is dissipated directly to the air flow leads to the PTC heater reacting practically immediately. This high degree of spontaneity is the typical feature of the PTC booster heater. In addition, since the engine reaches operating temperature more quickly as well on account of the additional load caused by the generator, the conventional heating system also reacts more quickly. This additional heating power corresponds to around two thirds of the power of the PTC heater. This heating power can practically be accounted to the PTC heater. The characteristic resistance curve of the PTC elements prevents the PTC heater from overheating. The temperature at the surface of the metal frame is always less than 110 °C. In addition, the power of the PTC heater is reduced at higher blow-out temperatures of the heat exchanger. An electronic power module allows the PTC heater to be regulated in several stages or infinitely so that it can be adapted to the required heating power or the electrical power available.
The PTC heater is triggered either externally by means of a relay or through an integrated control unit with electronic



1 = PTC booster heater
2 = Heat exchanger
3 = Evaporator

power module. In the case of relay triggering, the vehicle manufacturer determines which and how many stages can be switched on. In the case of the control unit integrated in the booster heater, a distinction is made between minimum and high functionality. In the case of minimum functionality, the stages are switched individually. The electronic power module protects the booster heater against excess voltage, short-circuit and inverse polarity. A diagnosis possibility has not be provided for with this control unit. In the case of control stages, up to eight stages are possible. Triggering depends on current balancing and booster heater requirements, i.e. the thermal comfort required. In the case of regulation with high functionality, the electronic power module is triggered infinitely by the LIN or CAN bus on the vehicle side, for example. This means that the current provided by the vehicle wiring system in every situation can always be used optimally for the booster heating. In addition to protection against excess voltage, short-circuit and polarity inversion, the electronic power module with high functionality features excess current protection per stage, protection for the PCB against overheating and voltage monitoring. Regulation with high functionality is diagnosis capable.

Effects of failure

A faulty PTC booster heater can become noticeable as follows:

- Reduced heater power when the engine is cold
- A fault code is stored in the fault memory

The following can be considered as possible causes:

- Electrical triggering or electrical connectors of the PTC booster heater are faulty
- PTC booster heater is faulty (electronic power module, resistors)

Troubleshooting

Test steps towards recognising faults:

- Check fuse
- Read out fault memory

- Read out measured value blocks
- Check electrical triggering (relay)
- Check electrical connections

The vehicle wiring system control unit in many vehicles uses the so-called "load management" feature to regulate the PTC booster heater and switches it off if the vehicle wiring system is overloaded. The load management status can often be recalled using the measured values blocks. If there are complaints about the heating performance, reading out the fault memory and the measured values blocks can provided information about whether or not an excess load on the vehicle wiring system has led to the booster heater being switched off. A faulty booster heater must also be considered as the possible cause of excess load.