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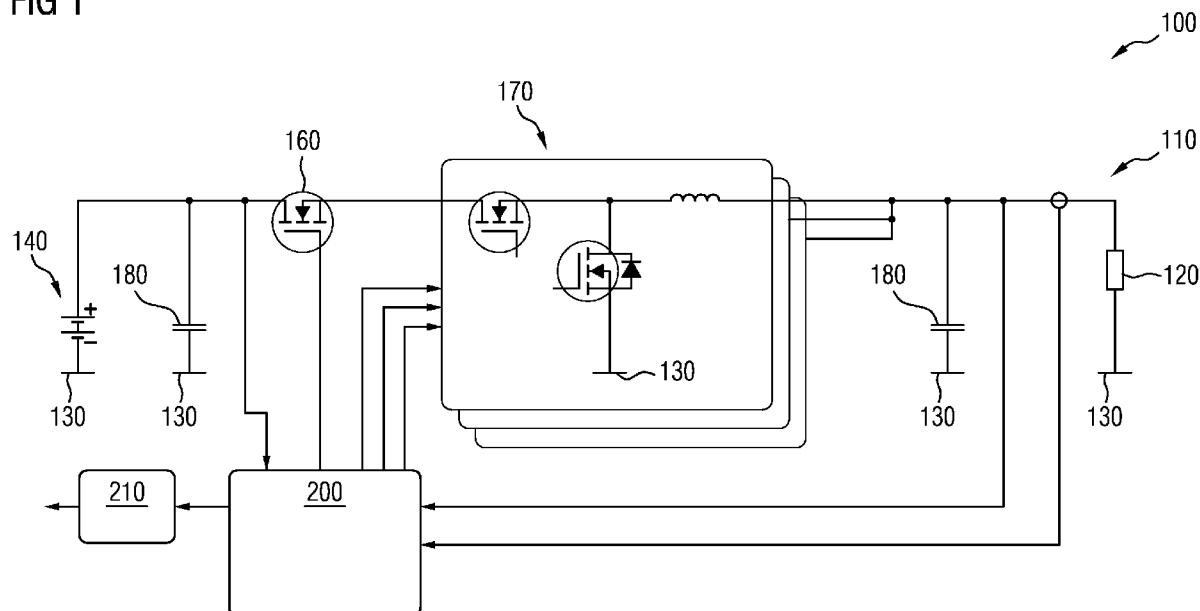
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FIG 1



(57) Abstract: The invention relates to an exhaust gas aftertreatment system (100) for treating exhaust gas from an internal combustion engine, wherein the exhaust gas after treatment system (100) comprises: - an exhaust gas catalyst (110) comprising an exhaust gas catalysis portion and a heating element (120), wherein the heating element (120) is configured to heat the exhaust gas catalysis portion, - a voltage source (140) which supplies the heating element (120) with electric power for heating the heating element (120), - a DC to DC converter (170) which is configured to control the electric power supply from the voltage source (140) to the heating element (120), and - a control unit (200) which is configured to control the DC to DC converter (170) based on the required electric power to heat the exhaust gas catalysis portion.

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Description

Exhaust gas aftertreatment system and method for controlling an exhaust gas aftertreatment system of an internal combustion engine

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The invention relates to an exhaust gas aftertreatment system for treating exhaust gas from an internal combustion engine and to a method for controlling an exhaust gas aftertreatment system of an internal combustion engine.

- 10 Exhaust gas aftertreatment systems are in particular used in vehicles with an internal combustion engine to treat its exhaust gas to reduce emissions out of the exhaust gas of the internal combustion engine. The exhaust gas aftertreatment system comprises therefore components like an exhaust gas catalyst. The exhaust gas catalyst treats by means of a chemical oxidation or reduction the emissions in
15 the exhaust gas. The exhaust gas catalyst comprises therefore an exhaust gas catalysis portion through which the exhaust gas flows and in which the chemical oxidation or reduction happens.

- The required working temperature for the exhaust gas catalysis portion lies
20 conventionally in an area above 200°C. To reach this temperature, the exhaust gas catalyst uses conventionally heat of the exhaust gas itself. This means that the first time after an internal combustion engine cold start the exhaust gas catalyst is not operating at the required temperature level. If the exhaust gas catalyst is not operating at the required temperature level, the emissions of the internal
25 combustion engines are not reduced as required. Especially the initial emissions after a cold start of the internal combustion engine are aggravated by the fact that modern internal combustion engines have higher combustion efficiency which lead to lower exhaust gas temperatures. Lower exhaust gas temperature means a longer time for the exhaust gas catalyst to reach the operational temperature and therefore
30 this leads to higher emissions.

For hybrid vehicles this is also a problem, because due to their nature, the internal combustion engine has an intermitted operation, which might not be sufficing to rise

the temperature of the exhaust gas catalyst to its operating temperature even during the operation of the hybrid vehicle.

To cope with such issues exhaust gas catalysts are used which comprise a heating
5 element. The heating element is configured to heat up the exhaust gas catalysis
portion of the exhaust gas catalyst during operation of the internal combustion
engine. The heating element is conventionally supplied with electric power from a
voltage source. The required electric power to heat the heating element could be
between 2 kW and 10 kW. Because of the high electric power requirements of the
10 heating element most of the needed electric power is conventionally provided from
an alternator or from a starter generator of the vehicle.

The control of the electric power supply is conventionally realized by an on/off
control switch. In case the heating element is connected by means of the on/off
15 switch to an electric power supply grid, it is difficult to handle sudden power
consumption on the grid due to the high electric power requirements of the heating
element. When the heating element is suddenly disconnected from the electric
power supply grid by means of the on/off switch, transient pulses might appear on
the electric power supply grid.

20

In the case of sudden connection of the heating element to the electric power supply
grid and in the case of sudden disconnection of the heating element from the power
supply grid the whole grid could be destabilized, or high energy pulses could appear
on the grid which may possibly harm or destroy control units or other parts of the
25 electric grid.

US 2010/212 981 A1 discloses a system and a control module for controlling an
electrically heated catalyst including a remote start module generating a remote
start signal, a catalyst control module controlling the electrically heated catalyst
30 based on the remote start signal and an engine control module starting the engine
after preheating and/or when required by the vehicle to honor a request as defined.

JP 2009-18 9921 A discloses a current flow control system for use in a catalyst device heated by current flow which equipped with a catalyst device heated by current flow comprising a catalyst support that heats a supported catalyst by its temperature rise caused by its current flow characterized of changing the current flow resistance in accordance with its temperature change, first and second temperature sensors disposed on the catalyst support and a controller that controls the current flow of the catalyst support from the information coming from the first and second temperature sensors.

10 US 5,261,230 A discloses a device for controlling a heating of a catalyst arranged in the exhaust passage of an engine.

It is an object of the present disclosure to provide an exhaust gas aftertreatment system and a method for controlling the exhaust gas aftertreatment system with which a reliable and safely operation of the exhaust gas aftertreatment system can be realized.

This object is achieved by an exhaust gas aftertreatment system with the feature according to independent claim 1 and by a method to control an exhaust gas aftertreatment system with the features of the independent claim 6. Dependent claims indicate advantageous embodiments and developments.

According to the present disclosure an exhaust gas aftertreatment system for treating exhaust gas from an internal combustion engine comprises:

- 25 - an exhaust gas catalyst comprising an exhaust gas catalysis portion and a heating element, wherein the heating element is configured to heat the exhaust gas catalysis portion,
- a voltage source which supplies the heating element with electric power for heating the heating element,
- 30 - a DC to DC converter which is configured to control the electric power supply from the voltage source to the heating element, and

- a control unit which is configured to control the DC to DC converter based on the required electric power to heat the exhaust gas catalysis portion.

5 The exhaust gas catalyst comprises the exhaust gas catalysis portion and the heating element. In the exhaust gas catalysis portion the catalysis takes place to reduce the emissions in the exhaust gas. The heating element is configured to heat the exhaust gas catalysis portion. According to one embodiment the heating element is configured to heat the exhaust gas catalysis portion selectively during
10 operation of the exhaust gas aftertreatment system. The heating element is according to one embodiment arranged upstream of the exhaust gas catalysis portion with respect to an exhaust gas flow direction through the internal combustion engine. According to another embodiment it is also conceivable that the heating element is in the exhaust gas flow direction arranged downstream of the exhaust
15 gas catalysis portion. According to another embodiment the exhaust gas catalyst comprises two heating elements, wherein one of the two is arranged in exhaust gas flow direction upstream of the exhaust gas catalysis portion and the other one of the two is arranged in exhaust gas flow direction downstream of the exhaust gas catalysis portion. The heating element is supplied with electric power by the voltage
20 source. The voltage source is for example a battery or a rechargeable battery. The exhaust gas catalysis portion is only then heated up to a predetermined temperature by means of the heating element if the exhaust gas catalysis portion has a temperature which is below a threshold temperature which is required for a sufficient exhaust gas aftertreatment. This is for example the case immediately after a cold
25 start of the internal combustion engine. Accordingly, the exhaust gas catalysis portion does not have to be heated during the whole time of operation of the internal combustion engine by means of the heating element.

The heating element comprises according to one embodiment a honeycomb
30 structure or a matrix structure. Electric current flows according to this embodiment from the voltage source through the honeycomb structure or the matrix structure. The honeycomb structure or the matrix structure work as an ohmic resistance. Because of this the honeycomb structure or the matrix structure get heated and

supply the exhaust gas catalysis portion with heat. The temperature of the heating element is therefore directly depending on the electric power supplied by the voltage source.

- 5 The DC to DC converter is an electronic circuit or electromechanical device that converts a source of direct current from one voltage level to another, it is therefore possible to control the supply of consumers with electric power with the DC to DC converter. The DC to DC converter has the advantage that it is possible to safely connect or disconnect electric consumers which require high electric power without
- 10 harming the power supply grid. The DC to DC converter can thus be used to connect or disconnect the heating element with the voltage source and with the DC to DC converter the output voltage supplied to the heating element can be controlled safely. The DC to DC converter has a high efficiency level compared to a conventional on/off switch and can therefore reduce undesired heat production.
- 15 With the DC to DC converter it is possible to control the electric power supply from the voltage source to the heating element safely and reliable. The power consumption of the heating element when the DC to DC converter closes the circuit so that electric power flows from the voltage source to the heating element can be controlled safely and reliable without transient pulses on the electric grid. With the
- 20 DC to DC converter which controls the electric power supply from the voltage source to the heating element the electric grid of the exhaust gas aftertreatment system is not so easily destabilized even if the power supply from the voltage source to the heating element is constantly switching between on or off. The DC to DC converter handles such sudden connections or disconnections without harming the electric
- 25 grid of the exhaust gas aftertreatment system.

The control unit is configured to control the DC to DC converter based on the required electric power to heat the exhaust gas catalysis portion. In other words, if the heating element has to heat up the exhaust gas catalysis portion the control unit

30 controls the DC to DC converter to supply electric power from the voltage source to the heating element to heat the exhaust gas catalysis portion. In addition, the control unit is also configured to control the DC to DC converter to disconnect the voltage

source from the heating element so that no electric power flows from the voltage source to the heating element.

5 The control unit controls according to the present disclosure via the DC to DC converter the power supply from the voltage source to the heating element to control the temperature of the exhaust gas catalysis portion. With the control unit in combination with the DC to DC converter it is possible to control the power supply from the voltage source to the heating element in such a manner that the electric grid of the exhaust gas aftertreatment system is not harmed during connection or
10 disconnection of the heating element to the voltage source. This makes the whole exhaust gas aftertreatment system reliable and robust.

According to one embodiment the DC to DC converter is a buck converter. A buck converter is a DC to DC converter which steps down voltage (via stepping up
15 current) from its input to its output. With the buck converter it is advantageously possible to control the electric power supply from the voltage source to the heating element in such a manner that the electric grid of the exhaust gas aftertreatment system is not overloaded if the heating element is connected by the buck converter to the voltage source or if the heating element is disconnected by means of the buck
20 converter from the voltage source. In addition, energy pulses which may appear on the grid when the heating element is disconnected or connected to the voltage source can be reduced by means of the buck converter. The buck converter makes the whole exhaust gas aftertreatment system more reliable and robust.

25 In one embodiment the DC to DC converter is a multi-phase buck converter. A multi-phase buck converter is a DC to DC converter which comprises multiple groups wherein each group comprises a switch with a corresponding inductance wherein the groups are connected in parallel which respect to each other. With such a converter it is possible to enhance the power and to regulate a stepless current
30 flow. With the multi-phase buck converter, it is possible to control the power supply from the voltage source to the heating element in such a manner that the electric grid and in particular the whole exhaust gas aftertreatment system are not harmed during connecting or disconnecting of the heating element from/to the voltage

source. The multi-phase buck converter can be adjusted on the power requirements of the heating element so that especially during the on or off switching of the power supply from the voltage source to the heating element the electric grid does not face transient energy pulses. With the multi-phase buck converter, the power supply from the voltage source to the heating element can be realized in a very reliable and robust manner.

In one embodiment the DC to DC converter is configured to control the electric power supply from the voltage source to the heating element during ramp-up and/or ramp-down process of the electric power supply from the voltage source to the heating element. In addition, the exhaust gas aftertreatment system comprises a main switching element which is configured to control the electric power supply from the voltage source to the heating element after the ramp-up process and/or before the ramp-down process. The control unit is according to this embodiment configured to control the DC to DC converter and the main switching element based on the required electric power to heat the exhaust gas catalysis portion. The ramp-up process is the process or the phase during which the electric power supply to the heating element from the voltage source is enhanced from zero load to the required load. The ramp-down process is the process or the phase during which the electric power supply from the voltage source to the heating element is reduced from the required load to zero load. According to this embodiment the DC to DC converter is used to control electric power from the voltage source to the heating element during the ramp-up and/or during the ramp-down process. This means that the DC to DC converter is controlled by the control unit to enhance the electric power supplied from the voltage source to the heating element from zero load to the required load and that the DC to DC converter is controlled by the control unit to reduce the electric power supplied from the voltage source to the heating element from the required load to zero.

The main switching element is configured to control the electric power supply from the voltage source to the heating element after the ramp-up process and/or before the ramp-down process. This means that the main switching element is controlled by the control unit to control the electric power supply from the voltage source to the

heating element after the ramp-up process and/or before the ramp-down process. According to one embodiment the main switching element is connected in parallel with respect to the DC to DC converter. If for example the control unit controls the exhaust gas aftertreatment system to supply the heating element with electric power from the voltage source the control unit controls during the ramp-up process the DC to DC converter to supply the heating element with electric power from the voltage source and the control unit controls after the ramp-up process the main switching element to control the electric power supply from the voltage source to the heating element.

According to one embodiment the main switching element is activated once the required electric power during the ramp-up process has reached 90% of its required load. Using the DC to DC converter during ramp-up and/or ramp-down process of the electric power supply from the voltage source to the heating element the electric power supply can be precisely controlled. This assures the stability of the electric grid of the exhaust gas aftertreatment system. Using the main switching element to control the electric power supply from the voltage source to the heating element after the ramp-up process and/or before the ramp-down process increases the efficiency of the overall circuit. With a configuration according to this embodiment the whole exhaust gas aftertreatment system and in particular the circuit / grid are very reliable and robust even if the heating element is connected or disconnected from the voltage source.

According to one embodiment the voltage source supplies the exhaust gas aftertreatment system with an electric voltage of at least 36 Volt, preferably with an electric voltage of 48 Volt. It is conceivable that hybrid vehicles are powered by an internal combustion engine and by an electrical engine. The electrical engine is supplied with electrical energy by a voltage source. It is conceivable that the voltage source which supplies the electric engine to drive the hybrid vehicle is also used to supply the heating element of the exhaust gas catalyst with electric power. If this is the case the number of voltage sources in such a vehicle can be reduced which reduces the overall costs of the vehicle. The voltage source which is configured to supply the electric engines to drive the vehicle conventionally supply them with an

electric voltage of at least 36 Volt, preferably with an electric voltage of 48 Volt. Therefore, it is advantageously if the exhaust gas aftertreatment system is configured to handle the electric voltage of at least 36 Volt, preferably the electric voltage of 48 Volt. This helps to reduce the number of different parts and therefore to
5 reduce the costs.

According to the present disclosure a method for controlling an exhaust gas aftertreatment system of an internal combustion engine is disclosed, wherein the exhaust gas aftertreatment system comprises an exhaust gas catalyst comprising
10 an exhaust gas catalysis portion and a heating element, and wherein the exhaust gas aftertreatment system comprises a voltage source, wherein the voltage source supplies the heating element with electric power for heating the heating element, a DC to DC converter and a main switching element are provided, wherein the DC to DC converter and the main switching element are configured to control the electric
15 power supply from the voltage source to the heating element, wherein the method comprises the following steps:

- Providing a signal, wherein the signal determines if the exhaust gas catalysis portion is to be heated by the heating element or not;
- Controlling the DC to DC converter to control a ramp-up process of an
20 electric power supply from the voltage source to the heating element based on the signal;
- Controlling the main switching element to control the electric power supply from the voltage source to the heating element after the ramp-up process and/or before a ramp-down process based on the
25 signal;
- Controlling the DC to DC converter to control the ramp-down process of the electric power supply from the voltage source to the heating element based on the signal.

30 If for example a sensor or a sensor arrangement in the exhaust gas aftertreatment system detects that the temperature of the exhaust gas catalysis portion is below a predetermined threshold value, for example after a cold start, a control unit, which is configured to detect, for example by means of the sensor arrangement, that the

temperature of the exhaust gas catalysis portion is below the predetermined threshold, the control unit can provide the signal according to which the heating element is to be heated. After that the DC to DC converter is controlled to enhance the electric power to the heating element from the voltage source. If the electric power has reached a predetermined level, for example 90% of the defined electric load, the main switching element is controlled to supply the electric power from the voltage source to the heating element. If, for example, the same sensor arrangement detects that the temperature of the exhaust gas catalysis portion is above the predetermined threshold, then the main switching element and the DC to DC converter are controlled to reduce the electric power supplied from the voltage source to the heating element from the predetermined load to for example 50% of the maximum load, for example 20% of the maximum load or to zero load. The maximum load is the maximum electric load which can be handled by the heating element.

The DC to DC converter is also used during this ramp-down process. With the method according to the disclosure it is possible to control the electric power supply from the voltage source to the heating element during the ramp-up and the ramp-down process precisely and in addition to ensure the stability of the grid. Therefore, the method to control the exhaust gas aftertreatment system is very reliable and robust.

According to another embodiment a device for controlling an exhaust gas aftertreatment system of an internal combustion engine comprises a control unit which is configured to control the pre-described method.

According to another embodiment a computer program product comprises instructions which, when the program is executed by a computer, causes the computer to carry out steps of the pre-described method.

The device for controlling an exhaust gas aftertreatment system is for example an engine control unit. It is also conceivable that the device is part of the engine control unit or that the device is an additional control unit which is arranged in the vehicle

with the internal combustion engine. It is conceivable that the computer program product is executed in the engine control unit. It is also conceivable that the computer program product is executed by the additional control unit which is arranged in the vehicle with the internal combustion engine.

5

Further advantageous embodiments of the present disclosure will become apparent from the detailed description of exemplary embodiments in connection with the figures. In the figures:

10 Fig. 1 shows a schematic circuit of the exhaust gas aftertreatment system according to a first exemplary embodiment,

Fig. 2 shows a first diagram of a duty cycle of the circuit according to the first exemplary embodiment,

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Fig. 3 shows a schematic view of a circuit of an exhaust gas aftertreatment system according to the second exemplary embodiment,

20 Fig. 4 shows a second diagram of a duty cycle of the circuit according to the second exemplary embodiment,

Fig. 5 shows a third diagram of a duty cycle of the circuit of the second exemplary embodiment.

25 Fig. 1 shows first in a schematic manner a circuit of an exhaust gas aftertreatment system 100. The exhaust gas aftertreatment system 100 comprises an exhaust gas catalyst 110 wherein the exhaust gas catalyst 110 comprises a heating element 120 and an exhaust gas catalysis portion. The heating element 120 is configured to heat the exhaust gas catalysis portion. The exhaust gas aftertreatment system 100
30 comprises further a voltage source 140. The voltage source 140 is configured to supply the heating element 120 with electric power. According to this embodiment the exhaust gas aftertreatment system 100 comprises further a redundancy

switching element 160. According to this embodiment the redundancy switching element 160 is arranged to provide an additional shut-off path.

The exhaust gas aftertreatment system 100 comprises further an DC to DC converter 170. The DC to DC converter 170 is configured to control the electric power supply from the voltage source 140 to the heating element 120. The exhaust gas aftertreatment system 100 comprises according to this embodiment further capacitors 180. The capacitors 180 are arranged to smooth out ripple current and smooth DC voltage variations.

The exhaust gas aftertreatment system 100 comprises in addition a control unit 200 and a communication unit 210. The control unit 200 is configured to control the DC to DC converter 170 based on the required electric power to heat the exhaust gas catalysis portion of the exhaust gas catalyst 110. The communication unit 210 is configured to communicate with other parts of a vehicle if the exhaust gas aftertreatment system is arranged in the vehicle. The DC to DC converter 170 according to this exemplary embodiment is a three phase buck converter. The three phases of the DC to CD converter 170 are controlled by the control unit 200. This is schematically illustrated in Figure 1 by means of three arrows which go from the control unit 200 to the DC to DC converter 170. The DC to DC converter 170 is used during the ramp-up process of the electric power supply from the voltage source 140 to the heating element 120, during the steady state power supply from the voltage source 140 to the heating element 120 and during the ramp-down process of the electric power supply from the voltage source 140 to the heating element 120. According to this embodiment the whole power supply is controlled by the DC to DC converter. According to this embodiment the voltage source 140, the capacitors 180, the DC to DC converter and the heating element 120 are connected to an engine ground 130.

A duty cycle of the above described embodiment can be seen in fig. 2. Fig. 2 shows schematically as first diagram 300 which shows the current 330 flowing from the voltage source 140 to the heating element 120 over time 310. During a first time period the current flow from the voltage source 140 to the heating element 120 is

zero until the ramp-up process is initiated. To initiate the power supply the control unit 200 controls the DC to DC converter 170 accordingly. This can be seen in the first diagram 300 wherein during a first time period a current course 332 from the voltage source 140 to the heating element 120 increases over time 310 from zero
5 current to the required current. When the ramp-up process is completed, the current 330 flows from the voltage source 140 to the heating element 120 in a steady state mode or phase. This can be seen in the first diagram 300 wherein the current course 332 remains constant over time 310 during a second time period. During a third time period after the second time period the electric power supply from the voltage
10 source 140 to the heating element 120 is reduced to zero. This can be seen in the first diagram 300 in the current course 332, wherein the current 330 supplied from the voltage source 140 to the heating element 120 is reduced to zero. This third time period is the ramp-down process. The whole duty cycle is controlled by the control unit 200 by means of the DC to DC converter 170.

15 Figure 3 shows in schematic manner a second exemplary embodiment of a circuit of an exhaust gas aftertreatment system 100. The second exemplary embodiment differs from the first exemplary embodiment in that the exhaust gas aftertreatment 100 comprises in addition a main switching element 190. The main switching
20 element 190 is configured to control the electric power supply from the voltage source 140 to the heating element 120 after the ramp-up process and/or before the ramp-down process, in particularly during the steady state power supply from the voltage source 140 to the heating element 120. The control unit 200 of the second exemplary embodiment of the exhaust gas aftertreatment system 100 is therefore in
25 addition also configured to control the main switching element 190.

Fig. 4 shows in a second diagram 301 the current flow over the DC to DC converter 170 of the second exemplary embodiment of the exhaust gas aftertreatment system 100 during a duty cycle.

30 Fig. 5 shows in a third diagram 302 the current flow over the main switching element 190 of the second exemplary embodiment of the exhaust gas aftertreatment system 100 during a duty cycle.

As it can be seen in the figures 4 and 5 the DC to DC converter 170 is used during the ramp-up process to increase the power supply from the voltage source 140 to the heating element 120 and during the ramp-down process of the energy supply from the voltage source 140 to the heating element 120. As it can be seen in fig. 5 the main switching element is used to control the power supply from the voltage source 140 to the main switching element 120 after the ramp-up process and before the ramp-down process, therefore during the steady state of the power supply.

- 10 The control unit 200 of the second exemplary embodiment of the exhaust gas aftertreatment system 100 is configured to control the power supply from the voltage source 140 to the heating element 120 during the ramp-up process via the DC to DC converter 170 and to switch from the DC to DC converter 170 to the main switching element 190 after the ramp-up process or after a predefined part of the ramp-up process, for example 90% or 75 % of the ramp-up process. The control unit 200 is additionally configured to control the electric power supply from the voltage source 140 to the heating element 120 via the main switching element 190. The control unit 200 is in addition configured to change the electric power supply from the main switching element 190 to the DC to DC converter 170 during the ramp-down process. So that the ramp-down process the electric power supply from the voltage source 140 to the heating element 120 is controlled by the DC to DC converter 170.

Patent claims

1. An exhaust gas aftertreatment system (100) for treating exhaust gas from an internal combustion engine, wherein the exhaust gas aftertreatment system (100) comprises:

- an exhaust gas catalyst (110) comprising an exhaust gas catalysis portion and a heating element (120), wherein the heating element (120) is configured to heat the exhaust gas catalysis portion,

- a voltage source (140) which supplies the heating element (120) with electric power for heating the heating element (120),

- a DC to DC converter (170) which is configured to control the electric power supply from the voltage source (140) to the heating element (120), and

- a control unit (200) which is configured to control the DC to DC converter (170) based on the required electric power to heat the exhaust gas catalysis portion.

2. The exhaust gas aftertreatment system (100) according to claim 1, wherein the DC to DC converter (170) is a buck converter.

3. The exhaust gas aftertreatment system (100) according to claim 2, wherein the DC to DC converter (170) is a multi-phase buck converter.

4. The exhaust gas aftertreatment system (100) according to any one of the preceding claims, wherein the DC to DC converter (170) is configured to control the electric power supply from the voltage source (140) to the heating element (120) during ramp-up and/or ramp-down process of the electric power supply from the voltage source (140) to the heating element (120), and

wherein the exhaust gas aftertreatment system (100) comprises a main switching element (190) which is configured to control the electric power supply from the

voltage source (140) to the heating element (120) after the ramp-up process and/or before the ramp-down process, and

wherein the control unit (200) is configured to control the DC to DC converter (170)

and the main switching element (190) based on the required electric power to heat the exhaust gas catalysis portion.

5 5. The exhaust gas aftertreatment system (100) according to any one of the preceding claims, wherein the voltage source (140) supplies the exhaust gas aftertreatment system (100) with an electric voltage of at least 36 Volt, preferably with an electric voltage of 48 Volt.

10 6. A Method for controlling an exhaust gas aftertreatment system (100) of an internal combustion engine, wherein the exhaust gas aftertreatment system (100) comprises an exhaust gas catalyst (110) comprising an exhaust gas catalysis portion and a heating element (120), and wherein the exhaust gas aftertreatment system (100) comprises a voltage source (140), wherein the voltage source (140) supplies the heating element (120) with electric power for heating the heating
15 element (120), a DC to DC converter (170) and a main switching element (190), wherein the DC to DC converter (170) and a main switching element (190) are configured to control the electric power supply from the voltage source (140) to the heating element (120), wherein the method comprises the following steps:

- 20 - Providing a signal, wherein the signal determines if the exhaust gas catalysis portion is to be heated by the heating element (120) or not;
- Controlling the DC to DC converter (170) to control a ramp-up process of an electric power supply from the voltage source (140) to the heating element (120) based on the signal;
- 25 - Controlling the main switching element (190) to control the electric power supply from the voltage source (140) to the heating element (120) after the ramp-up process and/or before a ramp-down process based on the signal;
- Controlling the DC to DC converter (170) to control the ramp-down process of the electric power supply from the voltage source (140) to the heating element (120) based on the signal.

30 7. The method according to claim 6, wherein the DC to DC converter (170) is a buck converter.

8. The method according to claim 7, wherein the DC to DC converter (170) is a multi-phase buck converter.

5 9. A device for controlling an exhaust gas aftertreatment system (100) of an internal combustion engine, wherein the device comprises a control unit (200), which is configured to control a method according to any one of the claims 6, 7 or 8.

10 10. A computer program product comprising instructions which, when the program is executed by a computer, cause the computer to carry out the steps of the method according to any one of the claims 6, 7 or 8.

FIG 1

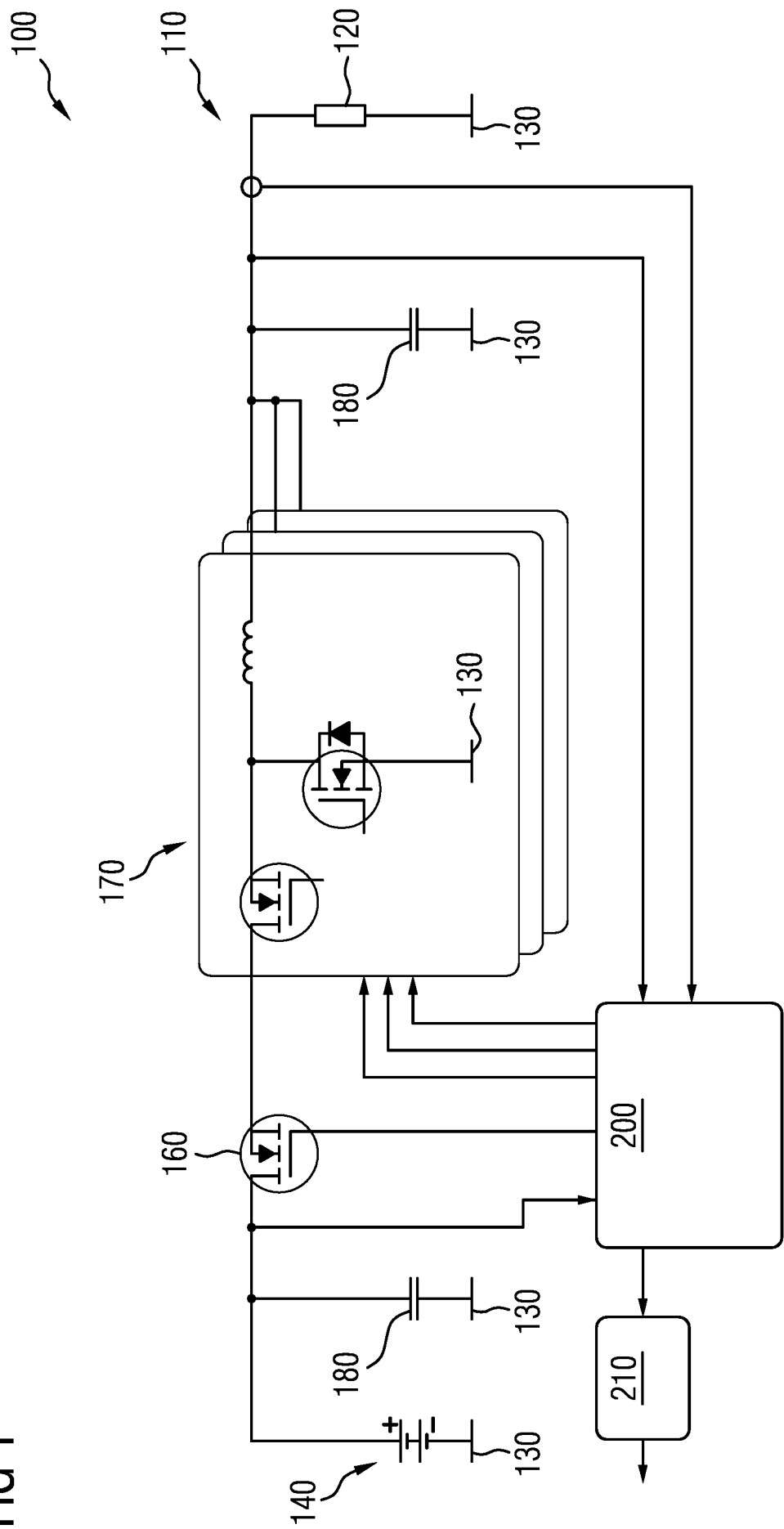


FIG 2

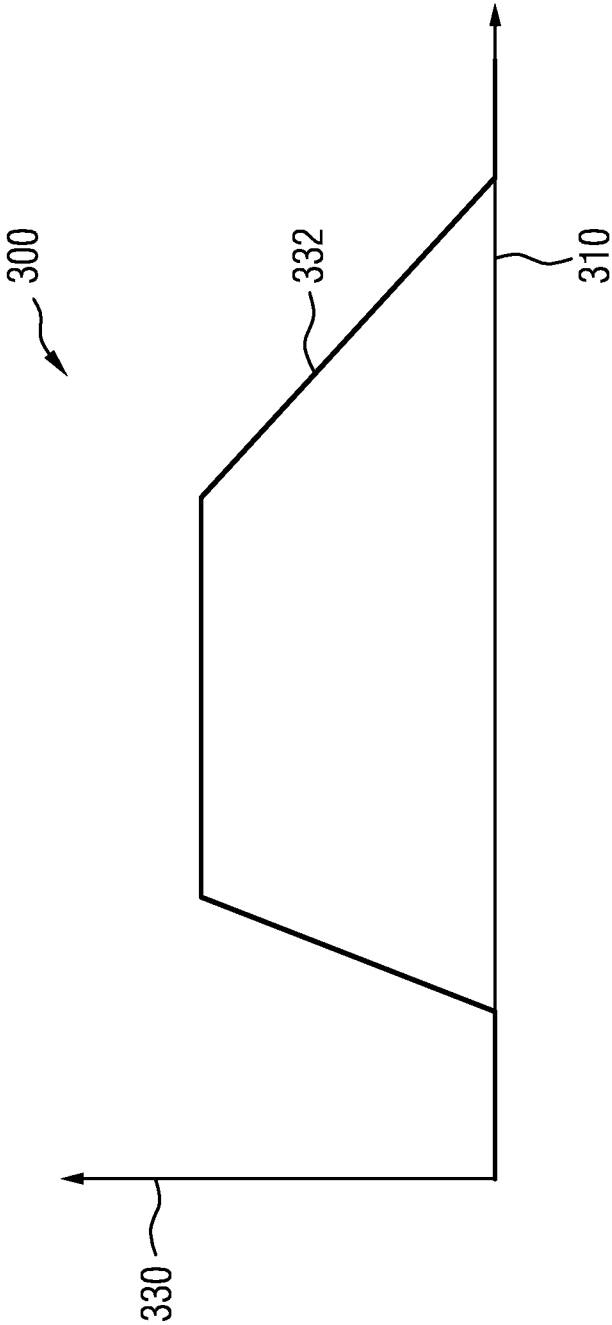


FIG 3

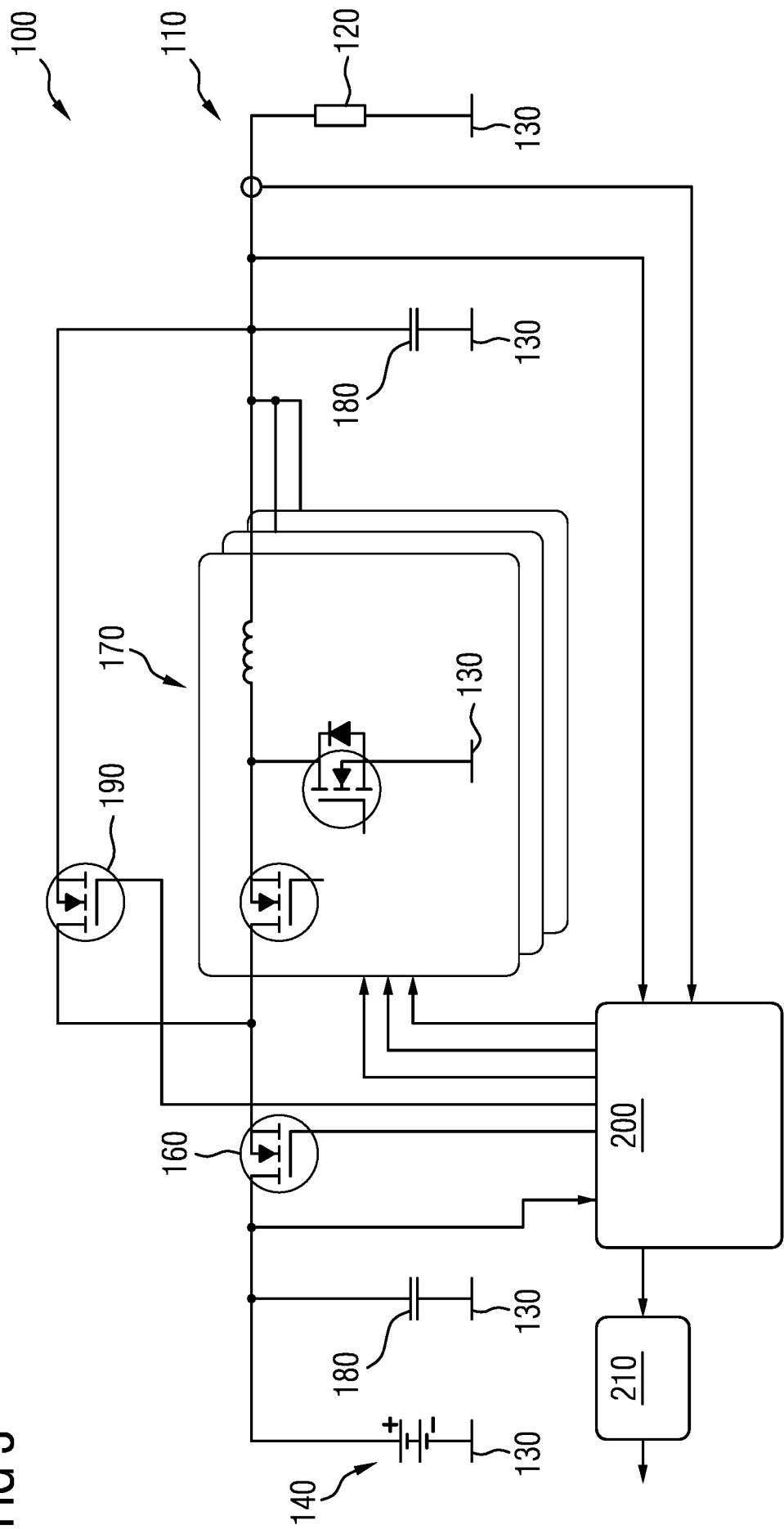


FIG 4

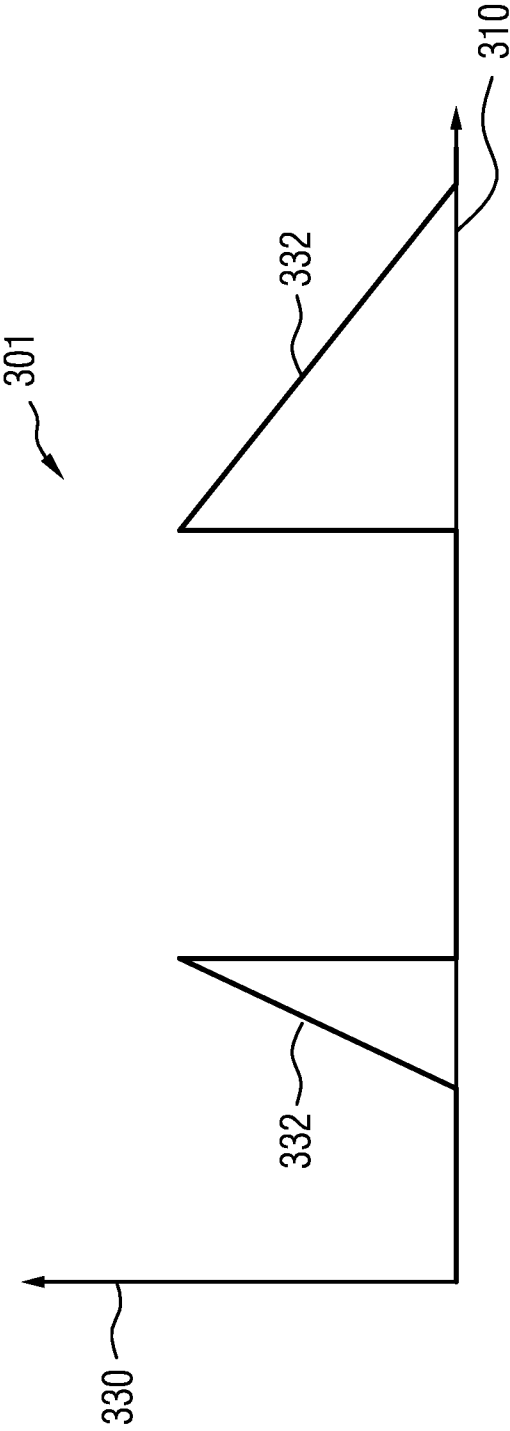
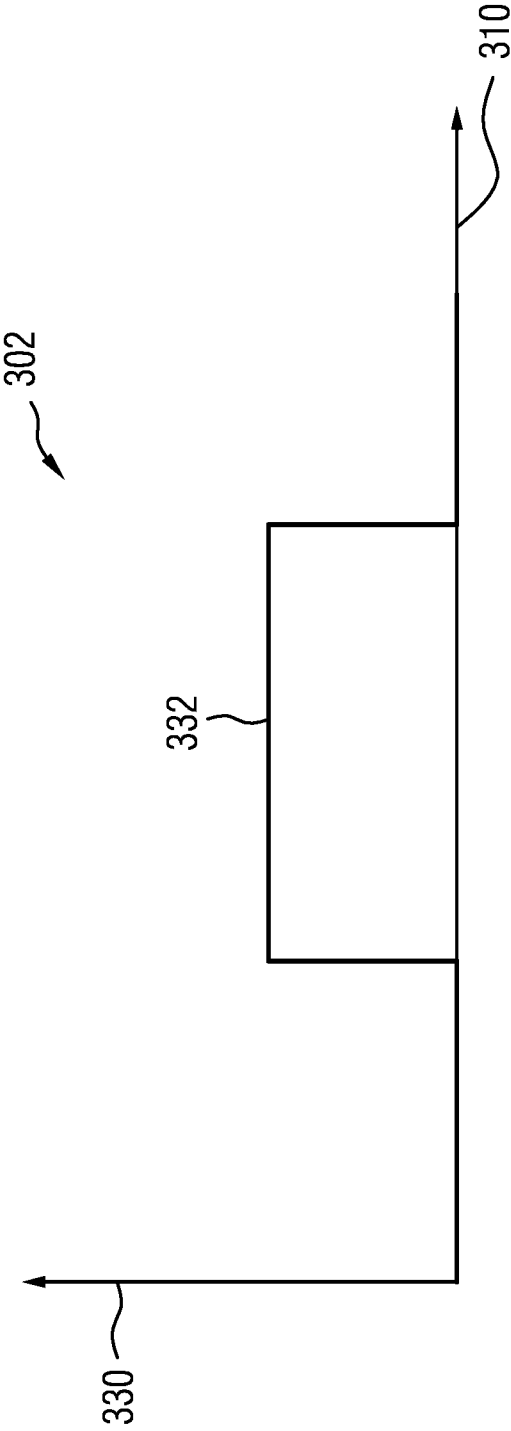


FIG 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/066704

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01N3/20 F01N9/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 645 745 A (HARTWICK LARRY R [US] ET AL) 8 July 1997 (1997-07-08) claims 1-18; figure 1 -----	1-10
X	US 2012/303200 A1 (ANG WANLENG [JP]) 29 November 2012 (2012-11-29) paragraph [0066]; claim 1; figures 1-2 -----	1
A	DE 10 2016 224711 A1 (CONTINENTAL AUTOMOTIVE GMBH [DE]) 14 June 2018 (2018-06-14) claim 1; figure 1 -----	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

17 August 2020

Date of mailing of the international search report

02/09/2020

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Seifert, Marco

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2020/066704

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