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(54) An engine system and method for adjustment in air/fuel ratio control in an engine system

(57) The invention refers to an engine system (1) and a method in an engine system (1) comprising an internal combustion engine with at least one cylinder (2), and air control means (10) and/or fuel injection means (11), the engine system further comprising an exhaust gas treatment device (8), an upstream gas sensor (13), located upstream of the exhaust gas treatment device (8), and a downstream gas sensor (12), located downstream of, or at least partly within, the exhaust gas treatment device (8). The method comprises

- determining (301, 302, 303), during a finite time period (t1-t2), a plurality of values of a control parameter (U12., U12Diff, C12) related to the downstream gas sensor (12),
- determining (307), after the end of the finite time period (t1-t2), at least one value of an adjustment parameter (A 12) at least partly based on at least some of the control parameter values, and
- adjusting (309) the control of the air control means (10) and/or the fuel injection means (11) at least partly based on at least one of the at least one adjustment parameter value.

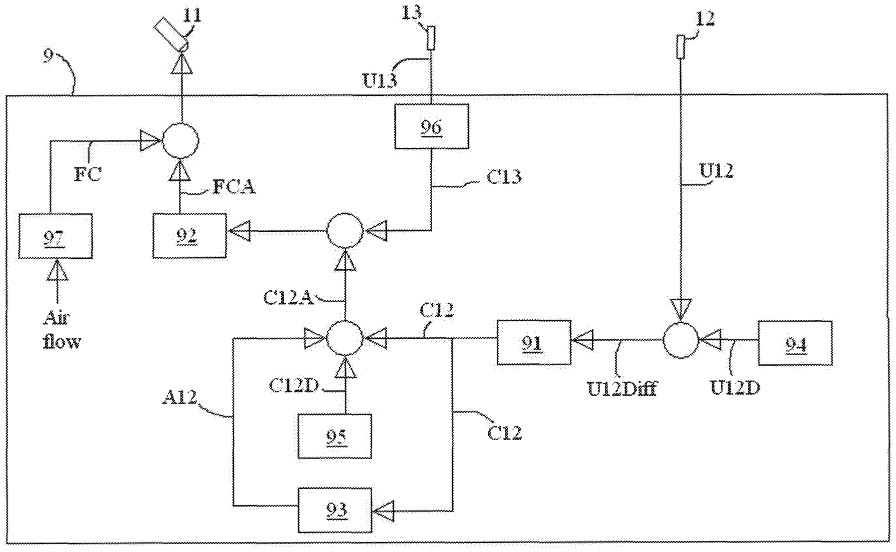


Fig. 2

EP 1 990 525 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to an engine system and a method in an engine system comprising an internal combustion engine with at least one cylinder, and air control means and/or fuel injection means, the engine system further comprising an exhaust gas treatment device, an upstream gas sensor, located upstream of the exhaust gas treatment device, and a downstream gas sensor, located downstream of, or at least partly within, the exhaust gas treatment device.

BACKGROUND

[0002] Modem vehicles are equipped with exhaust gas treatment devices, known as catalytic converters, that convert toxic gases such as hydrocarbons (HC), carbon monoxide (CO) and nitrogen oxides (NOx) into substances such as carbon dioxide (CO2) nitrogen (N2) and water (H2O). Upstream of the catalytic converter, a gas sensor, known as a lambda sensor, is provided. An engine control unit is adapted to determine, based on outputs from the lambda sensor, the oxygen content in the exhaust gases, which is indicative of the lambda value of the air/fuel mixture provided to the engine, which in turn is controlled based partly on the sensor outputs. In practice, sensors of the same type can present slightly different outputs in identical measurement conditions. An erroneous output from the lambda sensor will affect the sensor output and air/fuel mixture control loop negatively. As a result, the requested lambda value of the air/fuel mixture is not reached and the performance of the catalytic converter is seriously degraded.

[0003] It is known to provide, for monitoring the catalytic converter activity, a further lambda sensor downstream or within the catalytic converter. Such an additional sensor makes it possible to provide an accurate fine-adjustment of the air/fuel control.

[0004] US5224345 suggests adjusting the measured values from an upstream lambda sensor with integrated measurement values from a lambda sensor located downstream of the catalytic converter. However, since the downstream lambda sensor measurement values fluctuate, specially if a so called binary sensor is used, also the integrated measurement values will fluctuate, and this will result in a less than optimal accuracy for the adjustment of the upstream lambda sensor measurement values.

SUMMARY OF THE INVENTION

[0005] An object of the invention is to improve the control of the air/fuel ratio in an internal combustion engine.

[0006] A further object of the invention is to decrease variations in emission control qualities between different individual engine systems.

[0007] These objects are reached with a method of the type mentioned initially, comprising

- determining, during a finite time period, a plurality of values of a control parameter related to the downstream gas sensor,
- determining, after the end of the finite time period, at least one value of an adjustment parameter at least partly based on at least some of the control parameter values,
- adjusting the control of the air control means and/or the fuel injection means at least partly based on at least one of the at least one adjustment parameter value.

[0008] Determining the adjustment parameter value(s) after the end of the time period during which the control parameter values are determined, means that the adjustment parameter value(s) can be determined very accurately, since it is based on information gathered for a certain period of time, thus eliminating miscalculations due to instantaneous fluctuations in the outputs from the downstream gas sensor. Thus, as described closer below, the less than optimal accuracy for the adjustment of the upstream lambda sensor measurement values, provided by the known art continuous adjustment of these values with integrated measurement values from the downstream sensor, will be substantially improved.

[0009] The improved accuracy for the adjustment of the upstream lambda sensor measurement values will improve the control of the air/fuel ratio in the engine, and will decrease variations in emission control qualities between different individual engine systems.

[0010] Preferably, the finite time period is at least 10 seconds. This will secure that a enough values of the control parameter are obtained for determining the adjustment parameter in order to allow an accurate adjustment of the exhaust control. More preferably, the finite time period is at least 60 seconds. This will provide a substantial amount of values of the control parameter for determining the adjustment parameter, providing a very accurate adjustment of the lambda control.

[0011] Preferably, at least some of the control parameter values are determined at least partly based on outputs from the downstream gas sensor. Thus, instead of outputs from the downstream gas sensor, the control parameter values can be based on such outputs, e.g. they could be the result of data processing of the outputs. Such processing could for example involve outputs from a further downstream sensor of the engine system. However, as an alternative, the control parameter values could be direct outputs from the downstream gas sensor.

[0012] Preferably, the method comprises storing at least some of the control parameter values, the at least one value of the adjustment parameter being determined at least partly based on at least some of the stored control parameter values. The at least one value of the adjustment parameter could be determined as a mean value of at least some of the control parameter values. However, as an alternative, the adjustment parameter value (s) could be obtained by integrating the control parameter values.

[0013] Preferably, as exemplified below with reference to fig. 5 and 6, the method comprises

- determining during a finite time period, a plurality of values of a control parameter related to the upstream gas sensor,
- determining, after the end of the finite time period, at least one value of a comparison parameter at least partly based on at least some of the values of the control parameter related to the upstream gas sensor,
- comparing the at least one comparison parameter value to the adjustment parameter value, and
- determining, based at least partly on the comparison between the comparison parameter value and the adjustment parameter value, whether to use the adjustment parameter value for adjusting the control of the air control means and/or the fuel injection means.

[0014] Preferably, the method comprises determining the at least one value of the adjustment parameter as a mean value of at least some of the values of the control parameter related to the downstream gas sensor, determining the at least one value of the comparison parameter as a mean value of at least some of the values of the control parameter related to the upstream gas sensor, and determining to not use the adjustment parameter value for adjusting the control of the air control means and/or the fuel injection means if the difference between these mean values is larger than a predetermined deviation threshold value. As also explained below with reference to fig. 5 and 6, since mean values of the control parameter values are used for determining whether to adapt the lambda control of the engine system, the system will not discard the downstream control parameter values due large differences between the control parameter values having relative short duration. Such short duration deviations are not necessarily indicative of a serious malfunction: rather they will be due to temporary parameter fluctuations normally occurring in an exhaust control system.

[0015] The objects are also reached with an engine system according to any of the claims 8-14.

DESCRIPTION OF THE FIGURES

[0016] Below, the invention will be described in detail with reference to the drawings, in which

- fig. 1 shows a schematic view of parts of a vehicle engine system,
- fig. 2 is a block diagram depicting functions in an engine control unit of the vehicle engine system,
- fig. 3 is a flow diagram depicting steps in a method according to a preferred embodiment of the invention, and
- fig. 4a-e are diagrams showing parameter values in the engine control unit in a time domain,
- fig. 5 is a block diagram depicting functions in an engine control unit of the vehicle engine system, according to an alternative embodiment of the invention, and
- fig. 6 is a diagram showing control parameter values in the engine control unit in a time domain.

DETAILED DESCRIPTION

[0017] Fig. 1 shows a schematic view of parts of a vehicle engine system 1 comprising an internal combustion engine. The engine comprises at least one cylinder 2 with a reciprocating piston 3. Communication between the cylinder 2 and an inlet duct 4 is controlled by at least one inlet valve 5, and communication between the cylinder 2 and an exhaust duct 6 is controlled by at least one exhaust valve 7. Downstream of the cylinders 2, an exhaust gas treatment device 8, in this presentation referred to as a first exhaust gas treatment device 8 or a first catalytic converter 8, is provided. Downstream of the first exhaust gas treatment device 8, a second exhaust gas treatment device 82, here also referred to as a second catalytic converter, is provided.

[0018] The engine system 1 also comprises an engine control unit (ECU) 9, which can be provided as one unit or more than one logically interconnected physical units. The ECU 9 is adapted to control air control means 10 comprising a throttle valve 10, and fuel injection means 11 in the inlet duct 4.

[0019] The fuel injection means 11 comprises at least one fuel injector 11 in the inlet duct 4. In this embodiment, where the engine presents more than one cylinder, the fuel injection can be controlled individually for each cylinder, by a fuel injector being provided at a separate portion of the inlet duct 4 communicating with the respective cylinder, (so called port fuel injection). Alternatively, as is known in the art, a fuel injector can be provided in each cylinder 2, (so called direct fuel injection). As a further alternative, one single fuel injector can be provided for more than one cylinder, or all cylinders, for example at an upstream portion of the inlet duct communicating with more than one cylinder, or all cylinders. The fuel injection means 11 communicate with fuel storage means in the form of a fuel tank 20, via a fuel pump 21.

[0020] The ECU 9 is also adapted to receive output signals from a downstream gas sensor 12 located downstream of the first catalytic converter 8, and upstream of the second catalytic converter 82. The ECU 9 is further adapted to receive output signals from an upstream gas sensor 13 located in the exhaust duct 6 between the cylinder 2 and the first catalytic converter 8. The ECU 9 is adapted to determine, based on outputs from the downstream and upstream sensors 12, 13, the oxygen content in the exhaust gases upstream and downstream, respectively, of the first catalytic converter 8. As is known in the art, the oxygen content in the exhaust gases is indicative of the lambda value of the air/fuel mixture provided to the engine.

[0021] The downstream gas sensor can alternatively be located so as to detect gas directly in the first catalytic converter 8. Thereby, preferably the downstream gas sensor is located downstream of an upstream end of the first catalytic converter 8. As a further alternative the downstream gas sensor can be located so as to detect gas directly in the second catalytic converter 82.

[0022] The gas sensors 12, 13 are provided in the form of lambda or oxygen sensors. In this example, the downstream gas sensor 12 is a so called narrowband (binary) oxygen sensor, giving a highly non-linear relationship between the oxygen content of the exhaust gas and the output signal voltage. The upstream gas sensor 13 is a wideband (linear) sensor, giving a more linear relationship between the oxygen content and the output signal voltage.

[0023] In addition, the ECU 9 is also adapted to receive output signals from an air flow sensor 14 located in the inlet duct 4. As an alternative, as is known in the art, the air flow can be computed based on parameters such as the inlet manifold pressure, throttle position, engine speed, inlet temperature, and atmospheric pressure.

[0024] Further, at each cylinder, ignition means 16 comprising a spark plug 16 are provided and controllable individually by the ECU 9. However, the invention is also applicable to internal combustion engines with non-spark ignition, such as diesel engines or HCCI (Homogenous Charge Combustion Ignition) engines.

[0025] Reference is made to fig. 2, 3 and 4a-e.

[0026] The ECU 9 continuously receives 301 outputs U12, in the form of voltage levels, from the downstream gas sensor 12. The outputs V12 the binary downstream gas sensor is exemplified in fig. 4a, which is given for the presentation of the invention according to this embodiment. The output values of a binary lambda sensor are in practice more erratically distributed than in fig. 4. In this embodiment, the engine system is adapted to provide a so called bang-bang control of the air/fuel mixture so as to successively alternate between a rich and a lean mixture. Hence the alternating values shown in fig. 4a. A rich mixture will result in a relative high voltage output U12 from the downstream gas sensor 12, a lean mixture will result in a relative low voltage output U12 from the downstream gas sensor 12.

[0027] The downstream sensor outputs U12 are compared 302 to a desired downstream sensor output U12D, and the differences U12Diff between the desired output U12D and the actual outputs U12 are continuously received by a downstream lambda control unit 91. The desired output U12D is determined by a desired output determination function 94 in dependence on the engine operational condition, and is based at least partly on the engine speed, engine load, air flow, etc. In this example, as depicted in fig. 4b, the difference U12Diff will alternate between a negative and a positive value.

[0028] Based on the differences U12Diff between the desired output U12D and the actual outputs U12, the downstream lambda control unit 91 is adapted to continuously determine 303 values of a downstream control parameter C12. In case one or more received output difference U12Diff corresponds to a lean air/fuel mixture, the downstream control parameter values C12 will be adjusted so as to correspond to a richer air/fuel mixture, and vice versa. The resulting downstream control parameter values C12 are depicted in fig. 4c.

[0029] The downstream control parameter values C12 are compared to a desired control parameter value C12D, preferably corresponding to a lambda value of 1. Based on this comparison, adjusted downstream control parameter values C12A are determined 304. The desired control parameter value C12D is determined by a desired control parameter value determination function 95, preferably based on the engine operating condition. The adjusted downstream control parameter values C12A are depicted in fig. 4d, and it is assumed that the desired control parameter value C12D is set so as to correspond to a lambda value of 1, and the adjusted downstream control parameter values C12A are determined as differences between the downstream control parameter values C12 and the desired control parameter value C12D.

[0030] The ECU 9 continuously receives outputs U13, in the form of voltage levels, from the upstream gas sensor 13. The downstream sensor outputs U13 are continuously received by an upstream lambda control unit 96. The upstream lambda control unit 96 is adapted to continuously determine, based on the actual outputs U13, values of an upstream control parameter C13, in a manner corresponding to the determination of the downstream control parameter values C12 described above.

[0031] The adjusted downstream control parameter values C12A, as well as the upstream control parameter values C13 are received by a lambda regulator 92. The adjusted downstream control parameter values C12A and the upstream control parameter values C13 correspond in this embodiment to desired lambda values, and actual lambda values, respectively. In a preferred embodiment, differences between the adjusted downstream control parameter values C12A and the upstream control parameter values C13 are determined, and based on these continuously determined differences the lambda regulator 92 is adapted to continuously send 305 fuel injection control adjustments FCA. The latter are used to adjust 306 fuel feed forward signals FC, which in turn are determined based on signals from the air flow sensor 14 (fig. 1), by a fuel feed forward determination function 97. The air flow is adjusted by the throttle valve 10 at least partly based on requested torque parameter values Treq. The fuel injection means 11 is controlled by the fuel feed forward signals FC adjusted by the fuel injection control adjustments FCA.

[0032] An adjustment parameter value A12 is determined 307 as follows: The downstream control parameter values C12 are continuously stored accessible to an adjustment unit 93. The adjustment unit 93 is adapted to determine a mean value of at least some of the stored downstream control parameter values C12 stored during a finite time period.

[0033] The finite time period can be a predetermined time period, or based on a predetermined amount of gas flowing through the engine. Alternatively, as in this example, the finite time period during which control parameter values C12 are stored, is based on a predetermined number of switches of the control parameter values C12 from a lean to a rich mixture and vice versa. In fig. 4c the finite time period is indicated as extending from the time t1 to the time t2, and corresponds to a time period during which the control parameter values C12 switches six times between a lean and a rich mixture. In practice, the accuracy of the adjustment parameter value A12 will increase with the number of switches included in the finite time period.

[0034] Since in this theoretical example, the duration of the "rich periods" of the downstream gas sensor outputs U12 are longer than the duration of the "lean periods" thereof, periods during which the downstream control parameter values C12 correspond to a lean mixture are longer than the periods during which the downstream control parameter values C12 correspond to a rich mixture. Therefore the mean value of the downstream control parameter values C12 from the time t1 to the time t2 will correspond to a lean mixture. This is taken as an indication that the upstream gas sensor 13 provides values that are offset resulting in the engine control providing an air/fuel mixture that is too rich.

[0035] The downstream control parameter values C12 are compared to the desired control parameter value C12D, and the adjustment parameter value A12. The adjusted downstream control parameter values C12A are determined 308 based on these comparisons. More particularly, the adjustment parameter value A12 is added to the difference between the downstream control parameter values C12 and the desired control parameter value C12D, and the resulting adjusted downstream control parameter values C12A are depicted in fig. 4e. Thus, the adjustment value A12 will provide 309 signals to provide a leaner control to compensate for the rich control caused by the off-set values from the upstream gas sensor 13.

[0036] Preferably, the adjustment value A12 is reviewed periodically, whereby the steps described above are repeated.

[0037] Determining the adjustment parameter value A12 based on information gathered for a certain period of time, will eliminating miscalculations due to instantaneous fluctuations in the outputs from the downstream gas sensor.

[0038] As an alternative to determining the adjustment parameter A12 by calculating a mean value of the control parameter values C12 stored during the finite time period, the adjustment parameter can be calculated by integrating the control parameter values stored during the finite time period. Thus, referring to fig. 4c, the adjustment parameter A12 can be determined as the integral of the control parameter values C12 from the time t1 to the time t2.

[0039] As a further alternative, the adjustment parameter A12 can be determined by calculating a mean value of the downstream gas sensor outputs U12 (fig. 4a) stored during the finite time period. More specifically, the downstream sensor outputs U12 can be continuously stored accessible to an adjustment unit 93, and a mean value of at least some of the stored downstream sensor outputs U12, stored during the finite time period, can be determined.

[0040] Reference is made to fig. 5 showing a block diagram depicting functions in an engine control unit of the vehicle engine system, according to an alternative embodiment of the invention. A large difference between the downstream control parameter values C12 and the upstream control parameter values C13 may be an indication of a malfunction of the exhaust control system which is more serious than an off-set of the outputs of the upstream gas sensor 13.

[0041] As in the embodiment described above, the adjustment unit 93 is adapted to determine a mean value of the stored downstream control parameter values C12 stored during a finite time period t1-t2 (fig. 4c). An upstream mean value determination function 961 is adapted to determine a value of a comparison parameter A13 as a mean value of the upstream control parameter values C13 received during the finite time period t1-t2. The adjustment unit 93 is adapted to compare the mean value of the downstream control parameter values C12 with the mean value of the upstream control parameter values C13. If the difference between these mean values is larger than a predetermined deviation threshold value, the mean value of the downstream control parameter values C12 will not be used to determine an adjustment parameter A12 for the lambda control. As an alternative, the deviation threshold value can be determined based at least partly on the engine speed and engine load.

[0042] As an example, referring to fig. 6, during a time period Dt, a large difference between the control parameter values C12, C13 occurs, but the duration of the time period Dt is short compared to the finite time period t1-t2. Therefore, the downstream control parameter values C12, (indicated in fig. 6 with a broken curve), may still be used for adaptation of the lambda control. In general, since mean values of the control parameter values C12, C13 are used for determining whether to adapt the lambda control as described above, the system will not discard the downstream control parameter values C12 due large differences between the control parameter values C12, C13 having short durations Dt. Such short duration deviations are not necessarily indicative of a serious malfunction; rather they will be due to temporary parameter fluctuations normally occurring in an exhaust control system.

Claims

1. A method in an engine system (1) comprising an internal combustion engine with at least one cylinder (2), and air control means (10) and/or fuel injection means (11), the engine system further comprising an exhaust gas treatment device (8), an upstream gas sensor (13), located upstream of the exhaust gas treatment device (8), and a downstream gas sensor (12), located downstream of, or at least partly within, the exhaust gas treatment device (8), **characterized in that** it comprises

   - determining (301, 302, 303), during a finite time period (t1-t2), a plurality of values of a control parameter (U12, U12Diff, C12) related to the downstream gas sensor (12),
   - determining (307), after the end of the finite time period (t1-t2), at least one value of an adjustment parameter (A12) at least partly based on at least some of the control parameter values, and
   - adjusting (309) the control of the air control means (10) and/or the fuel injection means (11) at least partly based on at least one of the at least one adjustment parameter value (A12).

2. A method according to claim 1, wherein the finite time period is at least 10 seconds, preferably at least 60 seconds.

3. A method according to any of the preceding claims, wherein at least some of the values of the control parameter (C12) are determined (303) at least partly based on outputs (U12) from the downstream gas sensor (12).

4. A method according to any of the preceding claims, comprising storing at least some of the values of the control parameter (U12, U12Diff, C12), the at least one value of the adjustment parameter (A12) being determined (307) at least partly based on at least some of the stored values of the control parameter (U12, U12Diff, C12).

5. A method according to any of the preceding claims, wherein the at least one value of the adjustment parameter (A12) is determined (307) as a mean value of at least some of the values of the control parameter (U12, U12Diff, C12).

6. A method according to any of the preceding claims, comprising

   - determining during a finite time period (t1-t2), a plurality of values of a control parameter (U13, C13) related to the upstream gas sensor (13),
   - determining, after the end of the finite time period (t1-t2), at least one value of a comparison parameter (A13) at least partly based on at least some of the values of the control parameter (U13, C13) related to the upstream gas sensor (13),
   - comparing the at least one comparison parameter value (A13) to the adjustment parameter value (A12), and
   - determining, based at least partly on the comparison between the comparison parameter value (A13) and the adjustment parameter value (A12), whether to use the adjustment parameter value (A12) for adjusting (309) the control of the air control means (10) and/or the fuel injection means (11).

7. A method according to claim 6, comprising determining (307) the at least one value of the adjustment parameter (A12) as a mean value of at least some of the values of the control parameter (U12, U12Diff, C12) related to the downstream gas sensor (12), determining the at least one value of the comparison parameter (A13) as a mean value of at least some of the values of the control parameter (U13, C13) related to the upstream gas sensor (13), and determining to not use the adjustment parameter value (A12) for adjusting (309) the control of the air control means (10) and/or the fuel injection means (11) if the difference between these mean values (A12, A13) is larger than a predetermined deviation threshold value.

8. An engine system comprising an internal combustion engine with at least one cylinder (2), and air control means (10) and/or fuel injection means (11), the engine system further comprising an exhaust gas treatment device (8), an upstream gas sensor (13), located upstream of the exhaust gas treatment device (8), a downstream gas sensor (12), located downstream of, or at least partly within, the exhaust gas treatment device (8), and an engine control unit (9), **characterized in that** the engine control unit (9) is adapted

   - to determine (301, 302, 303), during a finite time period (t1-t2), a plurality of values of a control parameter (U12, U12Diff, C12) related to the downstream gas sensor (12),
   - to determine (307), after the end of the finite time period (t1-t2), at least one value of an adjustment parameter (A12) at least partly based on at least some of the control parameter values, and
   - to adjust (309) the control of the air control means (10) and/or the fuel injection means (11) at least partly based on at least one of the at least one adjustment parameter value (A12).

9. An engine system according to claim 8, wherein the finite time period is at least 10 seconds, preferably at least 60 seconds.

10. An engine system according to any of the claims 8-9, wherein the engine control unit (9) is adapted to determine (303) at least some of the values of the control parameter (C12) at least partly based on outputs (U12) from the downstream gas sensor (12).

11. An engine system according to any of the claims 8-10, wherein, the engine control unit (9) is adapted to store at least some of the values of the control parameter (U12, U12Diff, C12), and to determine (307) the at least one value of the adjustment parameter (A12) at least partly based on at least some of the stored values of the control parameter (U12, U12Diff, C12).

12. An engine system according to any of the claims 8-11, wherein the engine control unit (9) is adapted to determine (307) the at least one value of the adjustment parameter (A12) as a mean value of at least some of the values of the control parameter (U12, U12Diff, C12).

13. An engine system according to any of the claims 8-12, wherein the engine control unit (9) is adapted

- to determine during a finite time period (t1-t2), a plurality of values of a control parameter (U13, C13) related to the upstream gas sensor (13),
- to determine, after the end of the finite time period (t1-t2), at least one value of a comparison parameter (A13) at least partly based on at least some of the values of the control parameter (U13, C13) related to the upstream gas sensor (13),
- to compare the at least one comparison parameter value (A13) to the adjustment parameter value (A12), and
- to determine, based at least partly on the comparison between the comparison parameter value (A13) and the adjustment parameter value (A12), whether to use the adjustment parameter value (A12) for adjusting (309) the control of the air control means (10) and/or the fuel injection means (11).

14. An engine system according to claim 13, wherein the engine control unit (9) is adapted to determine (307) the at least one value of the adjustment parameter (A12) as a mean value of at least some of the values of the control parameter (U12, U12Diff, C12) related to the downstream gas sensor (12), to determine the at least one value of the comparison parameter (A13) as a mean value of at least some of the values of the control parameter (U13, C13) related to the upstream gas sensor (13), and to determine to not use the adjustment parameter value (A12) for adjusting (309) the control of the air control means (10) and/or the fuel injection means (11) if the difference between these mean values (A12, A13) is larger than a predetermined deviation threshold value.

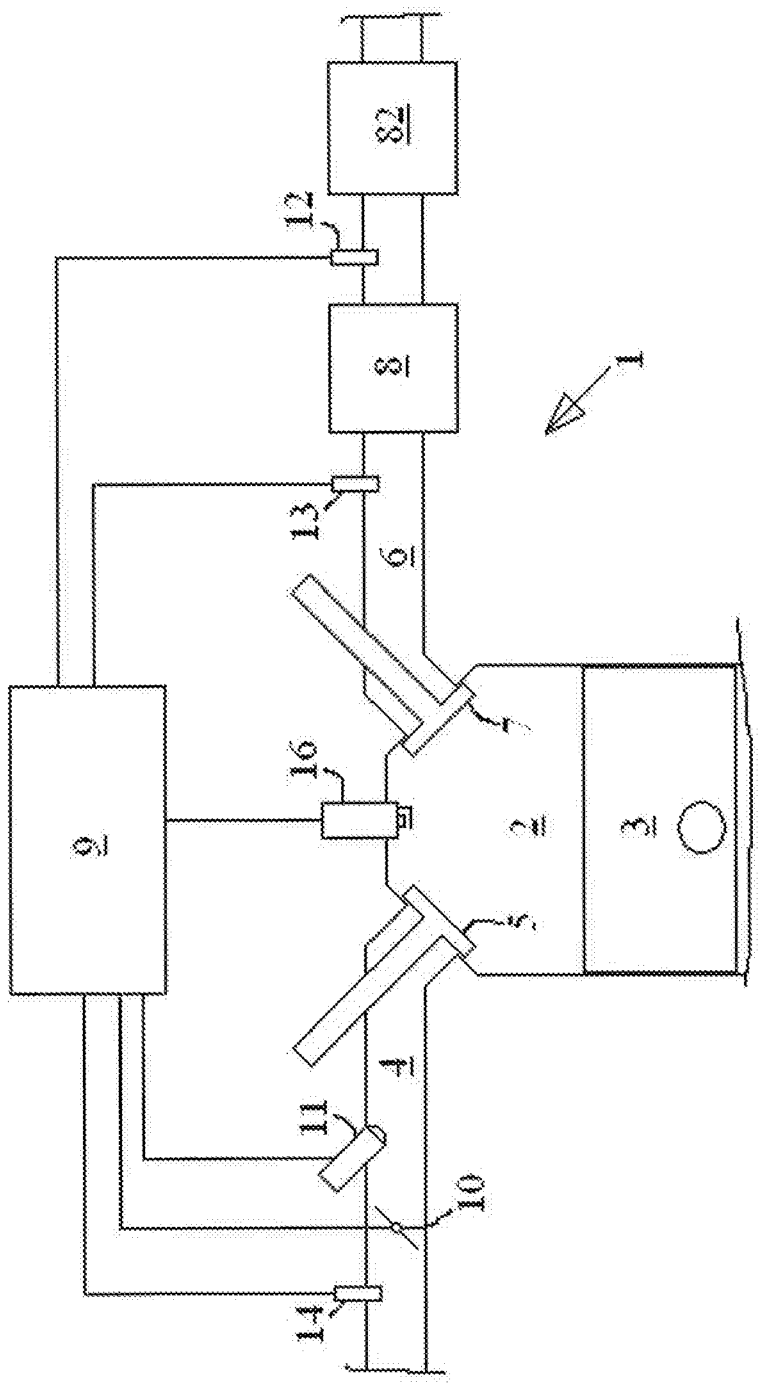


Fig. 1

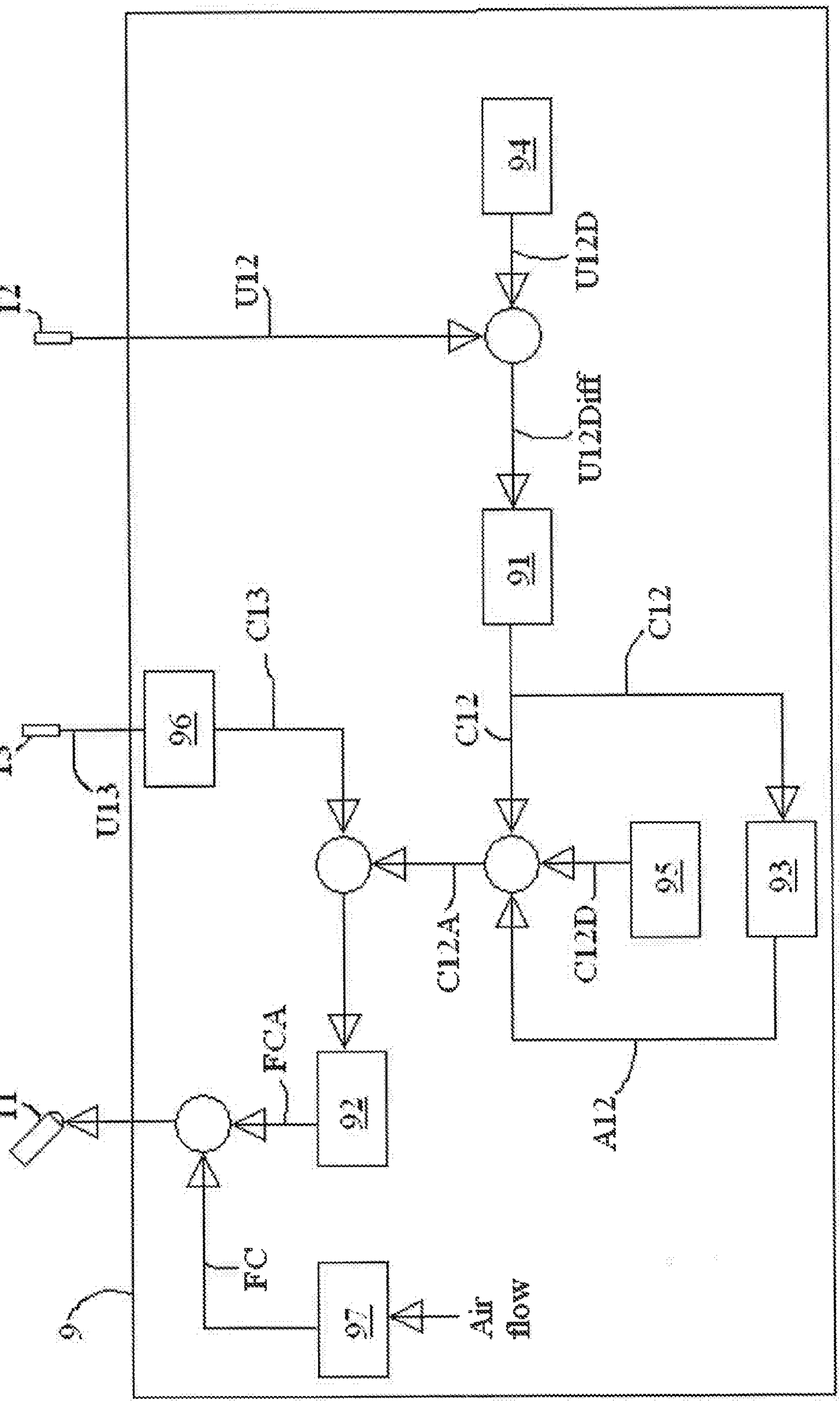

12
U12
94
U12D
U12Diff
91
C12
C12
93
95
C12D
C12A
A12
13
U13
96
C13
92
FCA
11
FC
97
Air
flow
9

Fig. 2

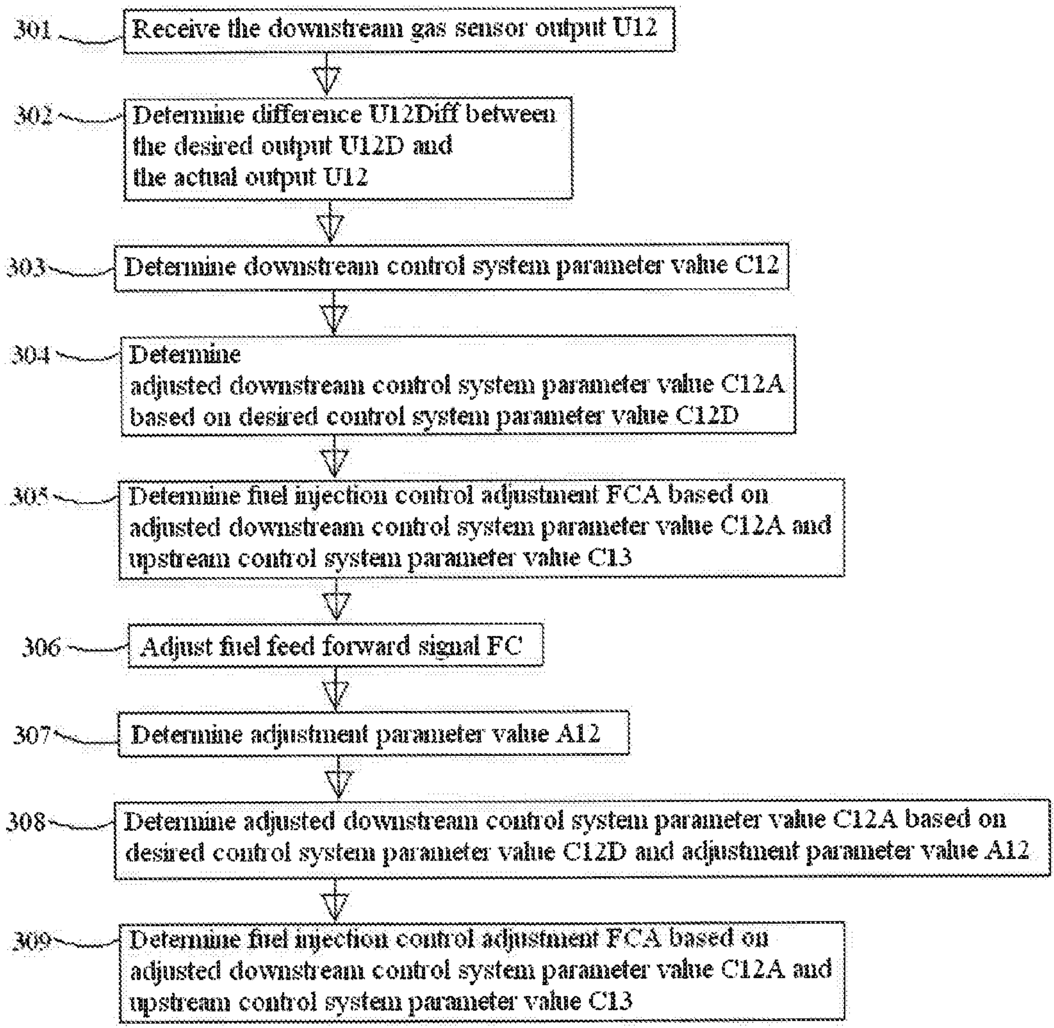

301
Receive the downstream gas sensor output U12
302
Determine difference U12Diff between
the desired output U12D and
the actual output U12
303
Determine downstream control system parameter value C12
304
Determine
adjusted downstream control system parameter value C12A
based on desired control system parameter value C12D
305
Determine fuel injection control adjustment FCA based on
adjusted downstream control system parameter value C12A and
upstream control system parameter value C13
306
Adjust fuel feed forward signal FC
307
Determine adjustment parameter value A12
308
Determine adjusted downstream control system parameter value C12A based on
desired control system parameter value C12D and adjustment parameter value A12
309
Determine fuel injection control adjustment FCA based on
adjusted downstream control system parameter value C12A and
upstream control system parameter value C13

Fig. 3

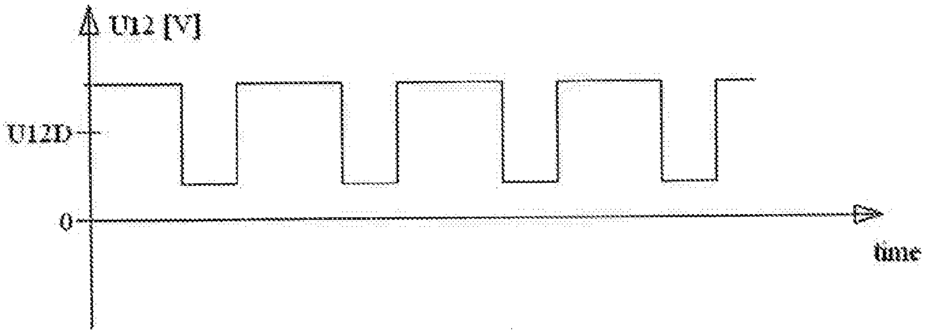


Fig. 4a

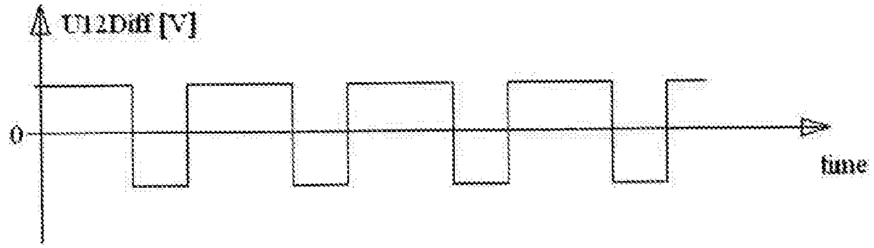


Fig. 4b

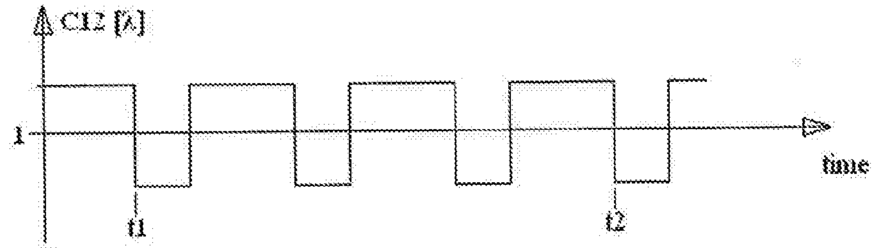


Fig. 4c

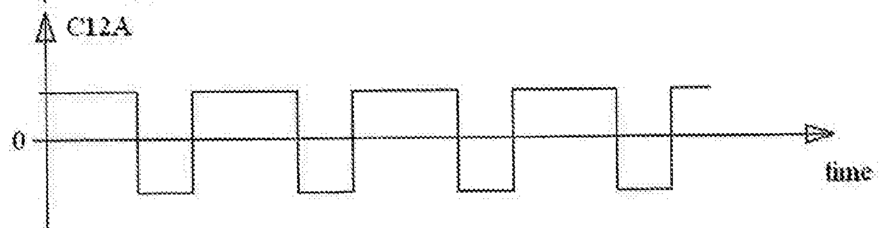


Fig. 4d

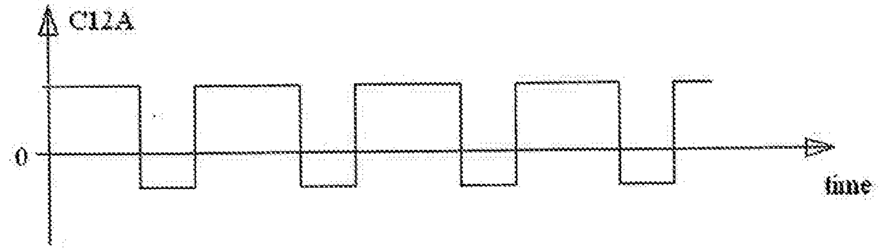
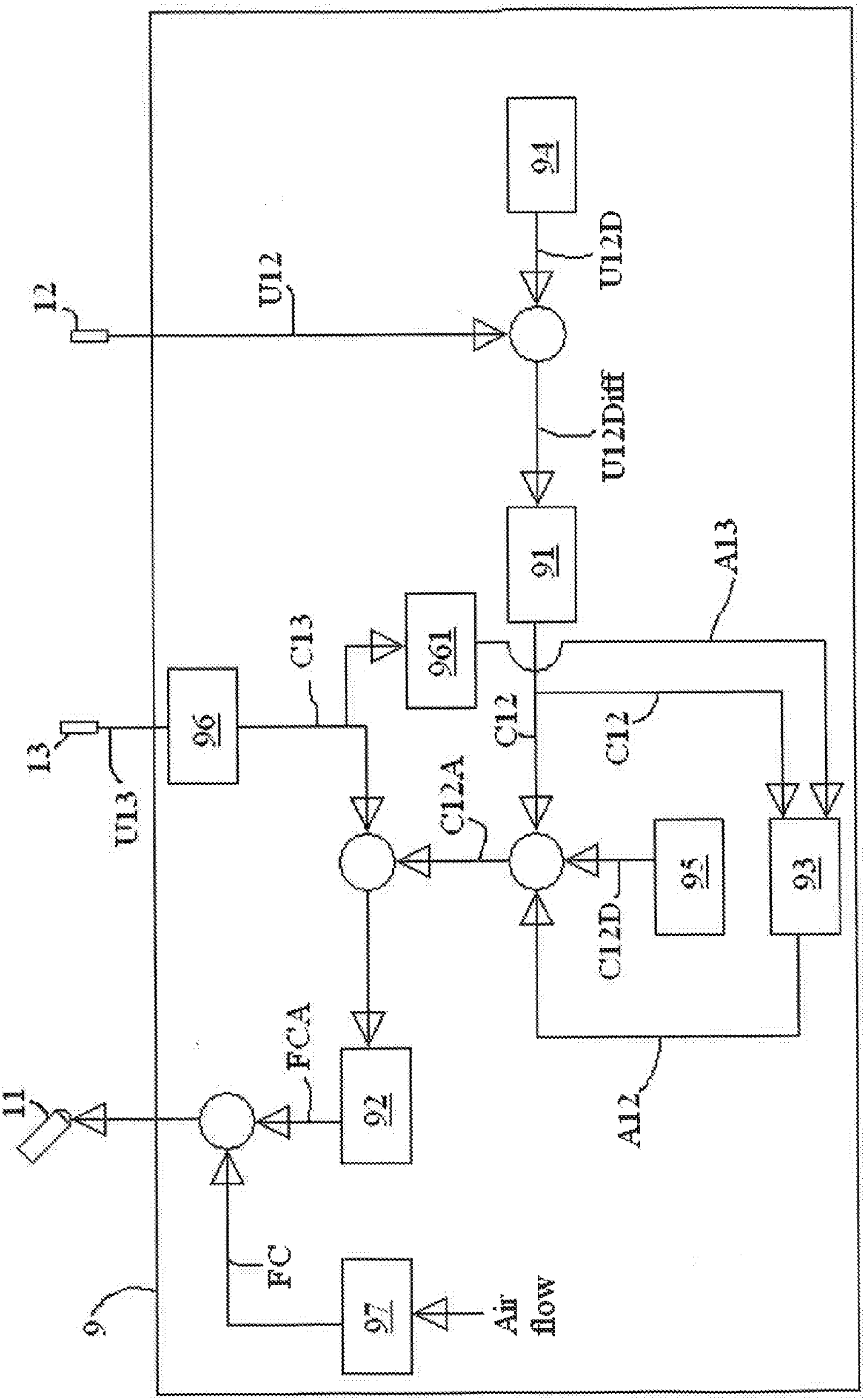


Fig. 4e



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11
12
13
U12
U13
U12D
U12Diff
94
91
961
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93
95
97
C13
C12
C12A
C12D
A12
A13
FCA
FC
Air flow

Fig. 5

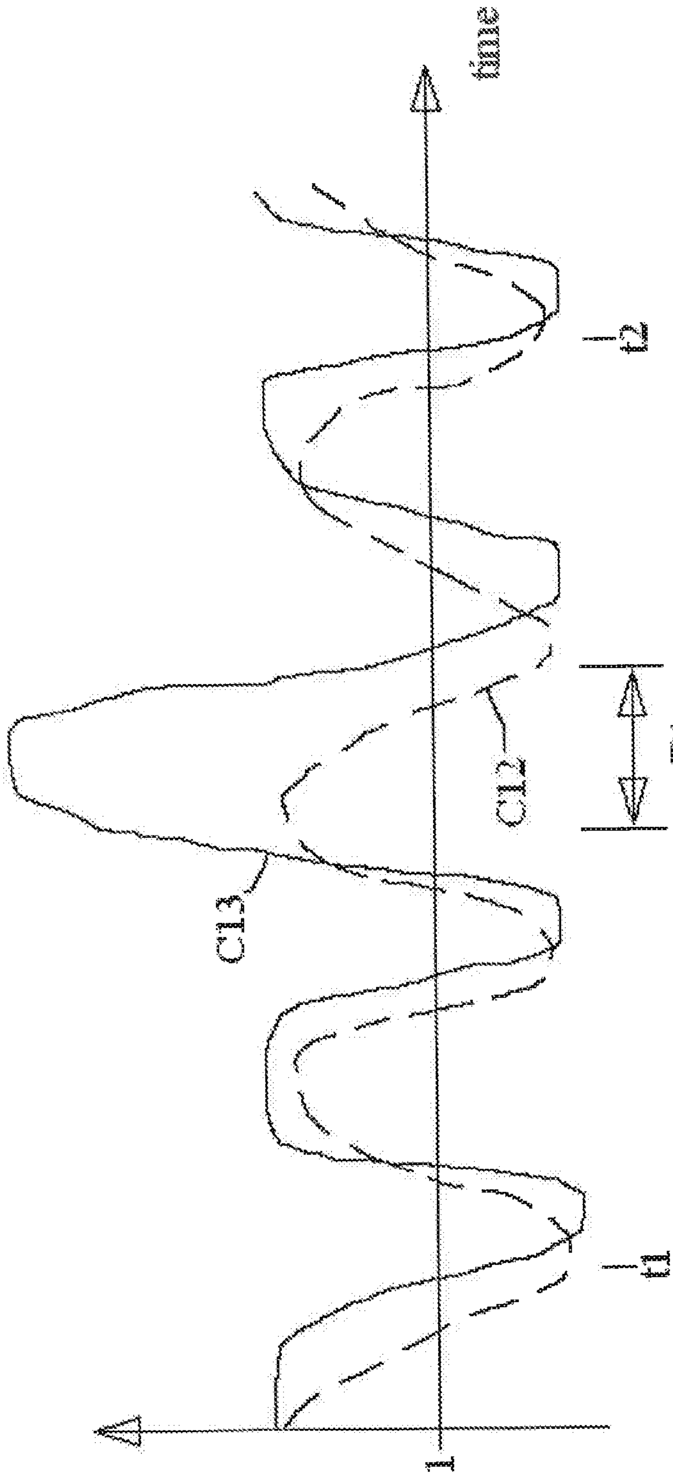

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 07 10 7648

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The present search report has been drawn up for all claims

3

Place of search	Date of completion of the search	Examiner
Munich	30 August 2007	Calabrese, Nunziante

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