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(54) **Title:** IMPROVED VEHICLE ELECTRONIC SYSTEM, RELATED VEHICLE AND RELATED METHOD

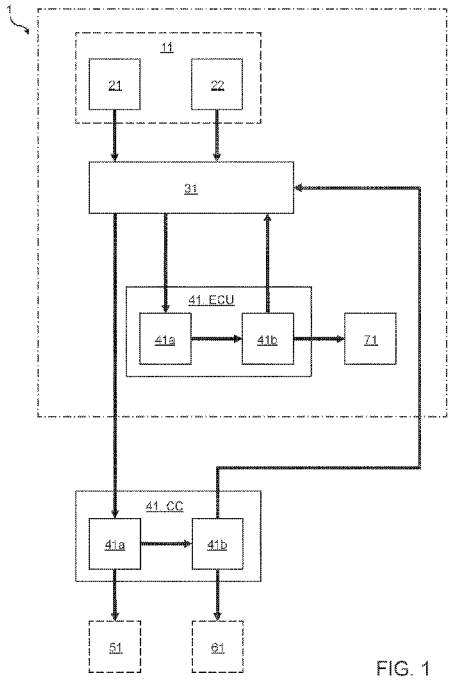

FIG. 1

(57) **Abstract:** Vehicle electronic system for monitoring a dynamics of a vehicle, comprising : a vehicle sensor system (11) comprising one or more pressure sensors (21), each configured to generate and transmit a respective signal indicative of a respective pressure of a respective tyre of the vehicle, and at least one further sensor (22) configured to generate and transmit a respective further signal indicative of another physical quantity associated with the vehicle; a processing unit (31) on board the vehicle configured to receive and process each signal generated and transmitted by the one or more pressure sensors (21) and each signal generated and transmitted by the at least one further sensor (22) so as to generate an output indicative of an aggregation between each signal generated and transmitted by the one or more pressure sensors (21) and each signal generated and transmitted by the at least one further sensor (22); and processing and storage resources (41) configured to: a) receive and process the output indicative of an aggregation between ach

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signal generated and transmitted by the one or more pressure sensors (21) and each signal generated and transmitted by the at least one further sensor (22), received from the processing unit (31) on board the vehicle, so as to generate as output a vibration profile indicative of the dynamics of the vehicle; and b) determine the presence of any anomalies in the vehicle on the basis of a comparison between the generated vibration profile and predefined vibration profiles stored in the same processing and storage resources (41).

"IMPROVED VEHICLE ELECTRONIC SYSTEM, RELATED VEHICLE AND RELATED METHOD"

Cross-Reference to Related Applications

This Patent Application claims priority from Italian Patent Application No. 102023000014814 filed on July 14, 2023, the entire disclosure of which is incorporated herein by reference.

Technical Field

The present invention relates to a vehicle electronic system, in particular for monitoring a dynamics of a vehicle, to a related vehicle and to a related method.

The present invention finds its preferred, although not exclusive, application in a vehicle, for example a truck, comprising the vehicle electronic system. Reference will be made to such application hereinafter by way of example.

Background of the Invention

As is known, a vehicle, for example a truck, comprises a chassis and a plurality of components mounted on, and thus carried by, the chassis of the vehicle.

The vehicle is subjected to numerous accelerations, which cause vibrations in the vehicle, in particular in the chassis and in the components mounted on the chassis. The stresses to which the components are subjected can lead to their deterioration and breakdown. This has negative economic consequences and can also lead to safety problems.

Therefore, the need is felt to monitor the dynamics of the vehicle for detecting any anomalies.

An aim of the present invention is to satisfy the above needs.

Summary of the Invention

The aforementioned aim is achieved by a vehicle electronic system, a vehicle, a software and a method as claimed in the appended claims.

Brief Description of the Drawings

For a better understanding of the present invention, a preferred embodiment is described hereinafter, by way of non-limiting example and with reference to the accompanying Figure 1, which is a block diagram of a vehicle electronic system according to the present invention.

Detailed Description of the Invention

Figure 1 schematically illustrates a vehicle electronic system 1 for monitoring a dynamics of a vehicle, according to the present invention.

Conveniently, in Figure 1 a box with a dash-dot line is present containing the elements of the vehicle electronic system 1 which are on board the vehicle, as described in detail hereinafter.

The vehicle electronic system comprises a vehicle sensor system 11 comprising one or more pressure sensors 21, each configured to generate and transmit a respective signal indicative of a respective pressure of a respective tyre of the vehicle, and at least one further sensor 22 configured to generate and transmit a respective further signal indicative of another physical quantity associated with the vehicle.

In particular, the vehicle sensor system 11 comprises a single pressure sensor 21, associated with a tyre of the vehicle, or a plurality of pressure sensors, each associated with a respective tyre of the vehicle. Each pressure sensor 21 is configured to generate and transmit the respective

signal indicative of the respective pressure of the respective tyre of the vehicle with which such pressure sensor 21 is associated.

Conveniently, each pressure signal, generated and transmitted by the respective pressure sensor 21, represents the evolution of the pressure of the respective tyre of the vehicle with which such pressure sensor 21 is associated. In particular, each pressure signal is a time series, i.e. a series of detections, in time order, of the pressure of the respective tyre of the vehicle. Preferably, such detections are made, by the respective pressure sensor 21, at instants equidistant in time from one another.

Conveniently, each further sensor 22 is configured to generate and transmit the respective further signal indicative of another physical quantity, i.e. a physical quantity other than pressure, associated with the vehicle.

Conveniently, each further signal, generated and transmitted by the respective further sensor 22, represents the evolution of such other physical quantity, other than pressure, associated with the vehicle. In particular, each further signal is a time series, i.e. a series of detections, in time order, of such other physical quantity. Preferably, such detections are made, by the respective further sensor 22, at instants equidistant in time from one another.

Preferably, such other physical quantity associated with the vehicle is selected from the group comprising vehicle speed, torque demand to an engine of the vehicle, rotational speed of the engine of the vehicle, percentage of pressure of a pedal of the vehicle, external temperature of the vehicle. The further sensor 22 is configured to detect such other physical quantity.

Conveniently, the vehicle sensor system 11 comprises a single further sensor 22, or a plurality of further sensors 22 configured to generate and transmit respective signals indicative of a same physical quantity, other than pressure, or of physical quantities different from one another.

For example, the vehicle sensor system 11 comprises two further sensors 22, for example both being temperature sensors or one being a temperature sensor and the other one a vehicle speed sensor. Conveniently, each temperature sensor is configured to detect the temperature in the proximity of a tyre, preferably of a tyre with which a pressure sensor 21 is associated.

The vehicle electronic system 1 further comprises a processing unit 31 on board the vehicle configured to receive and process each signal generated and transmitted by the one or more pressure sensors 21 and each signal generated and transmitted by the at least one further sensor 22 so as to generate an output indicative of an aggregation between each signal generated and transmitted by the one or more pressure sensors 21 and each signal generated and transmitted by the at least one further sensor 22.

In particular, the processing unit 31 is carried by the vehicle and stationary with respect to it. In other words, the processing unit 31 is local.

Conveniently, the processing unit 31 is configured to receive and process all the signals generated and transmitted by all the pressure sensors 21 and by all the further sensors 22, so as to aggregate the signals generated and transmitted by all the pressure sensors 21 with the signals generated and transmitted by all the further sensors 22.

In particular, the processing unit 31 is configured to

synchronise with respect to one another the signals generated and transmitted by all the pressure sensors 21 and the signals generated and transmitted by all the further sensors 22, so that all the signals are temporally consistent with one another.

For example, the output of the processing unit 31 is a time overlap of each pressure signal, generated and transmitted to the processing unit 31 by the respective pressure sensor 21, and of each further signal, generated and transmitted to the processing unit 31 by the respective further sensor 22, wherein all the signals are synchronised with respect to one another. Preferably, such time overlap covers a predetermined time interval, i.e. the output of the processing unit 31 is the synchronous evolution of all the signals in such predetermined time interval.

Conveniently, the processing unit 31 is configured to transmit its output in a continuous or intermittent manner. In the former case the output of the processing unit 31 is transmitted uninterruptedly, in the latter case the output of the processing unit 31 is transmitted at regular intervals, for example every fifteen minutes. Preferably, in the latter case the time distance between two consecutive transmissions coincides with the predetermined time interval of the output of the processing unit 31, for example the output of the processing unit 31 is transmitted every fifteen minutes and is the synchronous evolution of all the signals in the last fifteen minutes.

The vehicle electronic system 1 further comprises processing and storage resources 41 configured to:

a) receive and process the output indicative of an aggregation between each signal generated and transmitted by

the one or more pressure sensors 21 and each signal generated and transmitted by the at least one further sensor 22, received from the processing unit 31 on board the vehicle, so as to generate as output a vibration profile indicative of the dynamics of the vehicle; and

b) determine the presence of any anomalies in the vehicle on the basis of a comparison between the generated vibration profile and predefined vibration profiles stored in the same processing and storage resources 41.

In particular, the processing and storage resources 41 are configured to execute the above steps a) and b), which are schematically illustrated via blocks 41a and 41b, respectively.

Conveniently, in step a), the processing and storage resources 41 are configured to convert the output received from the processing unit 31 on board the vehicle into the vibration profile indicative of the dynamics of the vehicle.

In particular, the vibration profile is indicative of an acceleration to which the vehicle, in particular a chassis of the vehicle, is subjected. Conveniently, the vibration profile is indicative of the acceleration to which a component mounted on, and thus carried by, the chassis of the vehicle is subjected. For example, such component is a radiator of the vehicle.

Conveniently, the vibration profile generated by the processing and storage resources 41 represents the evolution of the acceleration to which the vehicle, and thus a component mounted on the chassis of the vehicle, is subjected in a predetermined time interval. Preferably, such interval coincides with the predetermined time interval of the output of the processing unit 31.

In other words, in step a), the processing and storage resources 41 are configured to pass from each pressure signal of the respective tyre and each signal indicative of another physical quantity associated with the vehicle to the evolution of the acceleration to which the vehicle is subjected.

Conveniently, in step b), the processing and storage resources 41 are configured to compare the vibration profile, generated during step a), with the predefined vibration profiles stored in the same processing and storage resources 41 and to determine, on the basis of the comparison, the presence of any anomalies in the vehicle.

In particular, the predefined vibration profiles are first profiles, with which anomalies in the vehicle are associated, and/or second profiles, with which anomalies in the vehicle are not associated.

For example, in the first profiles the acceleration exceeds a predetermined threshold, possibly for a predetermined number of times and/or a predetermined time interval, whereas this does not occur in the second profiles.

Conveniently, if the vibration profile generated during step a) is sufficiently similar (i.e. similar on the basis of a predetermined criterion) to at least one profile of the first profiles, it can be concluded that anomalies are present in the vehicle. Conveniently, if the vibration profile generated during step a) is sufficiently similar (i.e. similar on the basis of a predetermined criterion) to at least one profile of the second profiles, it can be concluded that anomalies are not present in the vehicle.

Preferably, the processing and storage resources 41 are configured to generate the vibration profile indicative of

the dynamics of the vehicle and/or determine the presence of any anomalies by correlating the signals of the one or more pressure sensors 21 and the at least one further sensor 22.

In particular, in step a) and/or in step b), the processing and storage resources 41 are configured to jointly analyse the signals of the one or more pressure sensors 21 and the at least one further sensor 22. This joint analysis can provide indications on the plausibility of the vibration profile and/or of any anomalies.

For example, if in a time interval numerous pressure jumps are present and the vehicle speed is substantially constant and relatively low, it can be concluded that, in such time interval, the vehicle is travelling on a dirt road. In such a case, it is plausible that the generated vibration profile has numerous oscillations, which can lead to anomalies if the time interval is sufficiently large.

For example, if in a time interval numerous pressure jumps are not present, the vehicle speed is substantially constant and relatively high, and the temperature (detected in the proximity of a tyre with which a pressure sensor 21 is associated) is substantially linearly increasing, it can be concluded that, in such time interval, the vehicle is travelling on a highway and the linear increase in temperature is due to the normal operation of the vehicle. In such a case, it is plausible that the generated vibration profile does not have numerous oscillations, and that anomalies are not present.

Preferably, the processing and storage resources 41 are configured to generate and transmit a feedback signal to the processing unit 31 on board the vehicle indicative of the presence of any anomalies.

In particular, the processing and storage resources 41 are configured to generate and transmit the presence of any anomalies, determined during step b), to the processing unit 31. In other words, the processing and storage resources 41 are configured to inform the processing unit 31, via the feedback signal, of the result of the processing of the processing and storage resources 41.

Preferably, the processing and storage resources 41 comprise a database configured to store the predefined vibration profiles and to update such predefined vibration profiles according to the comparison.

In particular, the processing and storage resources 41 comprise a database configured to store the first profiles, with which anomalies in the vehicle are associated, and/or the second profiles, with which anomalies in the vehicle are not associated. Conveniently, the database is updated with the vibration profiles generated by the processing and storage resources 41, during step a), and the respective any anomalies associated with the vibration profiles, determined during step b) on the basis of the comparison.

Conveniently, the database is updated with further vibration profiles, for example vibration profiles generated by other vehicles which are preferably of the same type as the vehicle in question. Such further vibration profiles can be used, during step b), for the comparison. Preferably, the database is updated remotely, for example via over-the-air (OTA) update.

Conveniently, the processing and storage resources 41 are remote, i.e. not on board the vehicle, and/or on board the vehicle, as described in detail hereinafter. In the former case, the processing and storage resources 41 comprise

IT processing and storage resources, which can be of concentrated type, for example a local server, or of distributed type, for example implementing a cloud computing paradigm.

Preferably, the processing and storage resources 41 are configured to predict, via machine learning methods, the useful life of the components mounted on the chassis of the vehicle, and thus predict the need for a future maintenance before such components breakdown. In other words, the processing and storage resources 41 allow a predictive maintenance of the vehicle, i.e. a type of preventive maintenance wherein a maintenance is planned following the processing of signals, in particular of the vibration profile of the vehicle.

Preferably, the processing and storage resources 41 are configured to implement a cloud computing paradigm and are designed to execute the steps a) and b).

In particular, the processing and storage resources 41 are remote, i.e. are not on board the vehicle. The processing and storage resources 41 comprise IT processing and storage resources CC of distributed type and implementing the cloud computing paradigm.

Conveniently, the processing and storage resources 41 are configured to sequentially execute the steps a) and b). In particular, the IT processing and storage resources CC are configured to execute step a) and subsequently step b).

Preferably, the IT processing and storage resources CC are configured to execute step a) as soon as they receive the output of the processing unit 31.

Preferably, the processing and storage resources 41 are configured to be in communication with a designer 51 of the

vehicle.

In particular, the IT processing and storage resources CC are configured to communicate the vibration profile, generated during step a), to the designer 51 of the vehicle, i.e. who deals with designing the vehicle and/or the premises where the designing of the vehicle is dealt with.

Conveniently, the designer 51 dealt with designing the type of vehicle in question and/or will deal with designing further developments of the type of vehicle in question.

Conveniently, the designer 51 can use the vibration profile of the vehicle for determining the mission profile of the specific vehicle in question and/or for dimensioning the components of the vehicle, in particular the components mounted on, and thus carried by, the chassis of the vehicle.

Preferably, the processing and storage resources 41 are configured to be in communication with a maintainer 61 of the vehicle.

In particular, the IT processing and storage resources CC are configured to communicate the presence of any anomalies, determined during step b), to the maintainer 61 of the vehicle, i.e. who deals with the maintenance of the vehicle and/or the premises where the maintenance of the vehicle is dealt with.

Conveniently, the maintainer 61 will deal with a future maintenance of the specific vehicle in question.

Preferably, the IT processing and storage resources CC are configured to communicate to the maintainer 61 of the vehicle information related to the type of anomaly, for example the component of the vehicle which needs to be repaired or replaced.

Preferably, the processing and storage resources 41

comprise an electronic control unit ECU designed to execute the steps a) and b).

In particular, the processing and storage resources 41 are carried by the vehicle and stationary with respect to it. In other words, the processing and storage resources 41 are local.

Conveniently, the processing and storage resources 41 are configured to sequentially execute the steps a) and b). In particular, the electronic control unit ECU is configured to execute step a) and subsequently step b).

Preferably, the electronic control unit ECU is configured to execute step a) as soon as it receives the output of the processing unit 31.

Preferably, the electronic control unit ECU is configured to be in communication with a vehicle user interface 71 designed to provide an assistance to the driver of the vehicle on the basis of the comparison.

In particular, the vehicle user interface 71 comprises a visual assistance provided to the driver of the vehicle, for example via a light indicator which informs the driver of the vehicle if an anomaly is present in the vehicle, determined during step b), and/or a display which graphically shows the presence of any anomalies in the vehicle, determined during step b).

Conveniently, the vehicle user interface 71 is configured to provide indications to the driver of the vehicle on a future maintenance of the vehicle. For example, the vehicle user interface 71 is configured to indicate to the driver of the vehicle to provide for the maintenance of the vehicle, i.e. take the vehicle to a maintainer of the vehicle. Preferably, the vehicle user interface 71 is

configured to indicate to the driver of the vehicle a maximum distance, for example a maximum number of kilometres, within which to provide for the maintenance of the vehicle, i.e. take the vehicle to the maintainer 61 of the vehicle.

Conveniently, the invention further relates to the vehicle comprising the described vehicle electronic system 1, and to a software loadable and executable on the described vehicle control system designed to cause, when executed, the vehicle control system to become configured to operate as described.

The invention further relates to a method for monitoring a dynamics of a vehicle comprising the described vehicle electronic system 1.

The method comprises the steps of:

- generating and transmitting, by each pressure sensor 21 of the vehicle sensor system 11, a respective signal indicative of a respective pressure of a respective tyre of the vehicle, and generating and transmitting, by the at least one further sensor 22, a respective further signal indicative of another physical quantity associated with the vehicle;

- receiving and processing, by the processing unit 31 on board the vehicle, each signal generated and transmitted by the one or more pressure sensors 21 and each signal generated and transmitted by the at least one further sensor 22 so as to generate an output indicative of an aggregation between each signal generated and transmitted by the one or more pressure sensors 21 and each signal generated and transmitted by the at least one further sensor 22;

- receiving and processing, by the processing and storage resources 41, the output indicative of an aggregation between each signal generated and transmitted by the one or

more pressure sensors 21 and each signal generated and transmitted by the at least one further sensor 22, received from the processing unit 31 on board the vehicle, so as to generate as output a vibration profile indicative of the dynamics of the vehicle; and

- determining, by the processing and storage resources 41, the presence of any anomalies in the vehicle on the basis of a comparison between the generated vibration profile and predefined vibration profiles stored in the same processing and storage resources 41.

In other words, the method comprises the steps of executing, by the processing and storage resources 41, the above steps a) and b).

Conveniently, the steps a) and b) are executed, by the processing and storage resources 41, sequentially.

Preferably, the method comprises the step of generating, by the processing and storage resources 41, the vibration profile indicative of the dynamics of the vehicle and/or of determining, by the processing and storage resources 41, the presence of any anomalies by correlating the signals of the one or more pressure sensors 21 and the at least one further sensor 22.

Preferably, the method comprises the step of generating and transmitting, by the processing and storage resources 41, a feedback signal to the processing unit 31 on board the vehicle indicative of the presence of any anomalies.

The operation of the embodiment of the vehicle electronic system 1 described above is the following.

While the driver of the vehicle drives the vehicle, each pressure sensor 21 generates and transmits, to the processing unit 31, a respective signal indicative of a

respective pressure of a respective tyre of the vehicle, and each further sensor 22 generates and transmits, to the processing unit 31, a respective further signal indicative of another physical quantity associated with the vehicle, for example vehicle speed, torque demand to an engine of the vehicle, rotational speed of the engine of the vehicle, percentage of pressure of a pedal of the vehicle, external temperature of the vehicle. The processing unit 31 on board the vehicle receives and processes each signal generated and transmitted by the one or more pressure sensors 21 and each signal generated and transmitted by the at least one further sensor 22, and generates an output indicative of an aggregation between each signal generated and transmitted by the one or more pressure sensors 21 and each signal generated and transmitted by the at least one further sensor 22. The processing and storage resources 41 receive and process the output indicative of an aggregation between each signal generated and transmitted by the one or more pressure sensors 21 and each signal generated and transmitted by the at least one further sensor 22, received from the processing unit 31 on board the vehicle, so as to generate as output a vibration profile indicative of the dynamics of the vehicle, and determine the presence of any anomalies in the vehicle on the basis of a comparison between the generated vibration profile and predefined vibration profiles stored in the same processing and storage resources 41.

If the processing and storage resources 41 are remote, in particular comprise IT processing and storage resources CC of distributed type and implementing the cloud computing paradigm, then they can communicate the vibration profile to the designer 51 of the vehicle and/or the presence of any

anomalies to the maintainer 61 of the vehicle. The designer 51 can use the vibration profile of the vehicle for determining the mission profile of the specific vehicle in question and/or for dimensioning the components of the vehicle, in particular the components mounted on, and thus carried by, the chassis of the vehicle. The maintainer 61 of the vehicle can use the information related to the type of anomaly for repairing or replacing one or more components of the vehicle.

If the processing and storage resources 41 are local, in particular comprise an electronic control unit ECU, then they can communicate with the vehicle user interface 71 which provides an assistance to the driver of the vehicle on the basis of the comparison. The vehicle user interface 71 can indicate to the driver of the vehicle to provide for the maintenance of the vehicle, preferably indicating a maximum distance, for example a maximum number of kilometres, within which to provide for the maintenance of the vehicle.

In view of the foregoing, the advantages of the vehicle electronic system 1 according to the invention are evident.

In particular, the vehicle electronic system 1 allows to monitor the dynamics of the vehicle and to analyse the stresses to which the components of the vehicle are subjected and which can lead to their deterioration and breakdown. This has positive economic consequences and increases safety.

The vehicle electronic system 1 allows to perform an activity of diagnosis, i.e. an analysis of the vehicle related to the present, and of prognosis, i.e. an analysis of the vehicle related to the future.

Each pressure sensor 21 and each further sensor 22

allows to generate and transmit a respective signal in real time. The processing unit 31 on board the vehicle allows to receive and process such signals in real time and to generate an output indicative of an aggregation between such signals. The processing and storage resources can receive and process the output of the processing unit 31 in real time on board the vehicle, thus being able to generate as output the vibration profile indicative of the dynamics of the vehicle and determine the presence of any anomalies in real time.

The processing and storage resources 41 allow to increase and strengthen the knowledge of the specific vehicle in question and of the type of vehicle in question, updating the database with the generated vibration profiles and the respective any anomalies associated with the vibration profiles.

Furthermore, the processing and storage resources 41 can communicate the vibration profile to the designer 51 of the vehicle and/or the presence of any anomalies to the maintainer 61 of the vehicle, and/or directly inform the driver of the vehicle via the vehicle user interface 71. Therefore, the processing and storage resources 41 allow to determine the mission profile of the specific vehicle in question and/or dimensioning the components of the vehicle, to predict the useful life of the components mounted on the chassis of the vehicle, and thus allow a predictive maintenance of the vehicle.

If the processing and storage resources 41 are remote, in particular comprise IT processing and storage resources CC of distributed type and implementing the cloud computing paradigm, then the generation of the vibration profile indicative of the dynamics of the vehicle and the

determination of any anomalies can exploit a high computing power and a large database, which comprises a high number of vibration profiles, both of the specific vehicle in question and of other vehicles, and which can be updated in real time.

If the processing and storage resources 41 are local, in particular comprise an electronic control unit ECU, then the entire vehicle electronic system 1 is on board the vehicle. Therefore, it is not necessary for the vehicle to be connected, i.e. communicate, with the outside.

If the processing and storage resources 41 are both remote and local, in particular comprise both IT processing and storage resources CC of distributed type and implementing the cloud computing paradigm and an electronic control unit ECU, then the vehicle electronic system 1 is even more precise and robust.

Finally, it is clear that modifications and variations can be made to the vehicle electronic system 1 according to the present invention, which anyway do not depart from the scope of protection defined by the claims.

For example, the further sensor 22 can be of a type different from those described, the processing and storage resources 41 can be remote and comprise IT processing and storage resources of concentrated type, for example a local server.

CLAIMS

1. Vehicle electronic system for monitoring a dynamics of a vehicle, comprising:

- a vehicle sensor system (11) comprising one or more pressure sensors (21), each configured to generate and transmit a respective signal indicative of a respective pressure of a respective tyre of the vehicle, and at least one further sensor (22) configured to generate and transmit a respective further signal indicative of another physical quantity associated with the vehicle;

- a processing unit (31) on board the vehicle configured to receive and process each signal generated and transmitted by the one or more pressure sensors (21) and each signal generated and transmitted by the at least one further sensor (22) so as to generate an output indicative of an aggregation between each signal generated and transmitted by the one or more pressure sensors (21) and each signal generated and transmitted by the at least one further sensor (22); and

- processing and storage resources (41) configured to:

a) receive and process the output indicative of an aggregation between each signal generated and transmitted by the one or more pressure sensors (21) and each signal generated and transmitted by the at least one further sensor (22), received from the processing unit (31) on board the vehicle, so as to generate as output a vibration profile indicative of the dynamics of the vehicle; and

b) determine the presence of any anomalies in the vehicle on the basis of a comparison between the generated vibration profile and predefined vibration profiles stored in the same processing and storage resources (41).

2. System as claimed in claim 1, wherein said other

physical quantity associated with the vehicle is selected from the group comprising vehicle speed, torque demand to an engine of the vehicle, rotational speed of the engine of the vehicle, percentage of pressure of a pedal of the vehicle, external temperature of the vehicle.

3. System as claimed in claim 1 or 2, wherein the processing and storage resources (41) are configured to generate the vibration profile indicative of the dynamics of the vehicle and/or determine the presence of any anomalies by correlating the signals of the one or more pressure sensors (21) and the at least one further sensor (22).

4. System as claimed in any of the preceding claims, wherein the processing and storage resources (41) are configured to generate and transmit a feedback signal to the processing unit (31) on board the vehicle indicative of the presence of any anomalies.

5. System as claimed in any of the preceding claims, wherein the processing and storage resources (41) comprise a database configured to store the predefined vibration profiles and to update said predefined vibration profiles according to the comparison.

6. System as claimed in any of the preceding claims, wherein the processing and storage resources (41) are configured to implement a cloud computing paradigm and are designed to execute the steps a) and b).

7. System as claimed in claim 6, wherein the processing and storage resources (41) are configured to be in communication with a designer (51) of the vehicle.

8. System as claimed in claim 6 or 7, wherein the processing and storage resources (41) are configured to be in communication with a maintainer (61) of the vehicle.

9. System as claimed in any of the preceding claims, wherein the processing and storage resources (41) comprise an electronic control unit (ECU) designed to execute the steps a) and b).

10. System as claimed in claim 9, wherein the electronic control unit (ECU) is configured to be in communication with a vehicle user interface (71) designed to provide assistance to a driver of the vehicle on the basis of the comparison.

11. Vehicle comprising a vehicle electronic system (1) as claimed in any of the preceding claims.

12. Software loadable and executable on a vehicle control system as claimed in any of claims 1 to 10 and designed to cause, when executed, the vehicle control system to become configured to operate as claimed in any of claims 1 to 10.

13. Method for monitoring a dynamics of a vehicle comprising a vehicle electronic system (1) as claimed in any of claims 1 to 10, comprising the steps of:

- generating and transmitting, by each pressure sensor (21) of the vehicle sensor system (11), a respective signal indicative of a respective pressure of a respective tyre of the vehicle, and generating and transmitting, by the at least one further sensor (22), a respective further signal indicative of another physical quantity associated with the vehicle;

- receiving and processing, by the processing unit (31) on board the vehicle, each signal generated and transmitted by the one or more pressure sensors (21) and each signal generated and transmitted by the at least one further sensor (22) so as to generate an output indicative of an aggregation

between each signal generated and transmitted by the one or more pressure sensors (21) and each signal generated and transmitted by the at least one further sensor (22);

- receiving and processing, by the processing and storage resources (41), the output indicative of an aggregation between each signal generated and transmitted by the one or more pressure sensors (21) and each signal generated and transmitted by the at least one further sensor (22), received from the processing unit (31) on board the vehicle, so as to generate as output a vibration profile indicative of the dynamics of the vehicle; and

- determining, by the processing and storage resources (41), the presence of any anomalies in the vehicle on the basis of a comparison between the generated vibration profile and predefined vibration profiles stored in the same processing and storage resources (41).

14. Method as claimed in claim 13, comprising the step of generating, by the processing and storage resources (41), the vibration profile indicative of the dynamics of the vehicle and/or determining, by the processing and storage resources (41), the presence of any anomalies by correlating the signals of the one or more pressure sensors (21) and the at least one further sensor (22).

15. Method as claimed in claim 13 or 14, comprising the step of generating and transmitting, by the processing and storage resources (41), a feedback signal to the processing unit (31) on board the vehicle indicative of the presence of any anomalies.

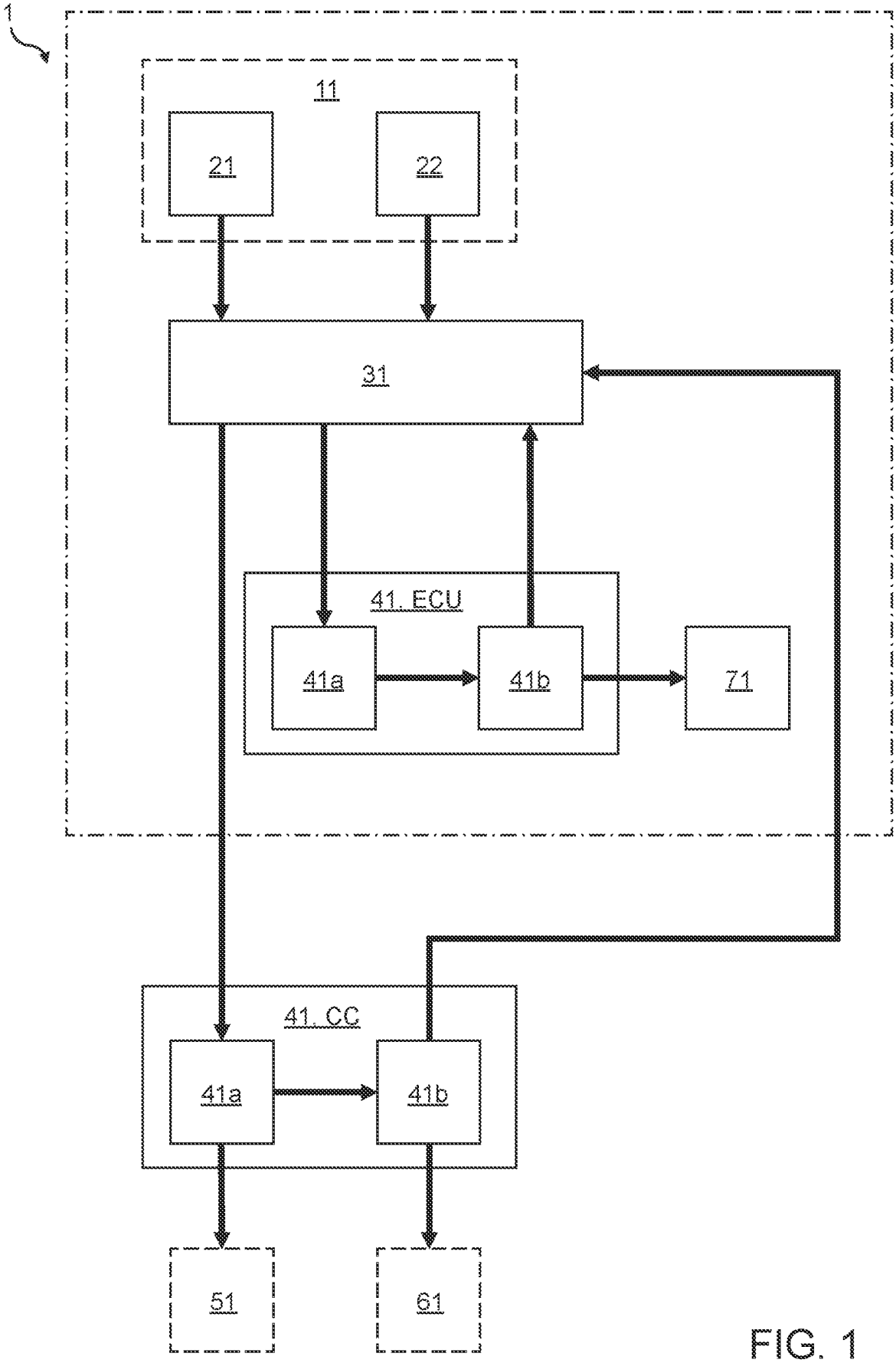

FIG. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2024/056797

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60C23/04 B60W40/10 B60W50/02 B60W50/14
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)
B60W B60C

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 Y A	JP 2005 329907 A (DENSO CORP) 2 December 2005 (2005-12-02) paragraphs [0014] - [0038], [0044] - [0046]	1,4, 9-13,15 1,3-13, 15 2,14

Y	US 2022/414549 A1 (BESSOLO BARBARA [US] ET AL) 29 December 2022 (2022-12-29) paragraphs [0027] - [0057]; figures 3-5 the whole document	1,3-13, 15

A	DE 10 2006 006947 A1 (DAIMLER CHRYSLER AG [DE]) 23 August 2007 (2007-08-23) paragraphs [0007] - [0015] the whole document	2,14

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[x] Further documents are listed in the continuation of Box C. [x] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 September 2024	27/09/2024

Name and mailing address of the ISA/	Authorized officer
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 2 537 723 A2 (BRIDGESTONE CORP [JP]; KEK HIGH ENERGY ACCELERATOR [JP]) 26 December 2012 (2012-12-26) paragraphs [0013] - [0021]; claim 1; figures 3,7	1,12,13
A	US 2022/281467 A1 (YOSHINO FUMIHIRO [JP]) 8 September 2022 (2022-09-08) paragraphs [0037], [0038]	1,12,13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2024/056797

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2005329907 A	02-12-2005	NONE	
US 2022414549 A1	29-12-2022	NONE	
DE 102006006947 A1	23-08-2007	NONE	
EP 2537723 A2	26-12-2012	CN 102837702 A	26-12-2012
		EP 2537723 A2	26-12-2012
		JP 5837341 B2	24-12-2015
		JP 2013006533 A	10-01-2013
		US 2012330493 A1	27-12-2012
US 2022281467 A1	08-09-2022	CN 115092171 A	23-09-2022
		JP 7308236 B2	13-07-2023
		JP 2022134829 A	15-09-2022
		US 2022281467 A1	08-09-2022