(12) UK Patent (19) GB (11) 2564676 (13) B

(45) Date of B Publication 15.07.2020

(54) Title of the Invention: Method for height determination in air spring suspension systems during time intervals with air turbulences

(51) INT CL: ***B60G 17/015*** (2006.01) ***B60G 17/019*** (2006.01) ***B60G 17/052*** (2006.01) ***F16F 9/05*** (2006.01)

(21) Application No: **1711602.1**

(22) Date of Filing: **19.07.2017**

(43) Date of A Publication **23.01.2019**

(56) Documents Cited:
GB 2177475 A **WO 2007/017022 A1**
US 4798369 A

(58) Field of Search:
As for published application 2564676 A viz:
INT CL **B60G, F16F, G01S**
Other: **WPI; EPODOC**
updated as appropriate

Additional Fields
Other: **WPI, EPODOC**

(72) Inventor(s):
Gheorghe Ispas
Siegfried Reck
Liviu Achim Stoian
Cristian Dorin Zaslo

(73) Proprietor(s):
Continental Automotive Romania SRL
str. Siemens, nr. 1, Timisoara, Timis, 300704, Romania

(74) Agent and/or Address for Service:
Continental Automotive Romania SRL
str. Siemens, nr. 1, Timisoara, Timis, 300704, Romania

GB 2564676 B

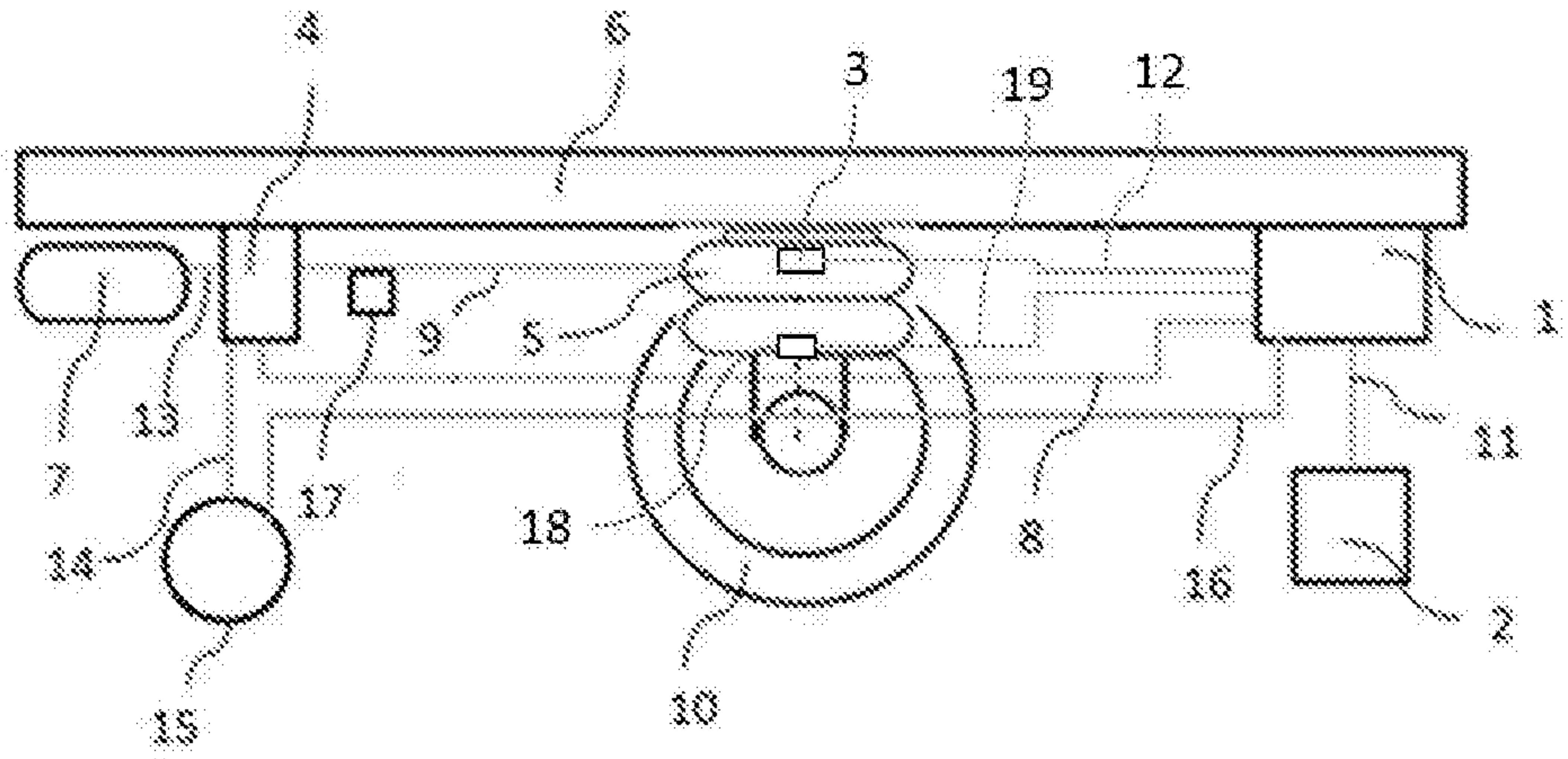
4
6
3
19
12
1
7
13
9
5
17
11
14
18
8
16
2
15
10

Fig.1

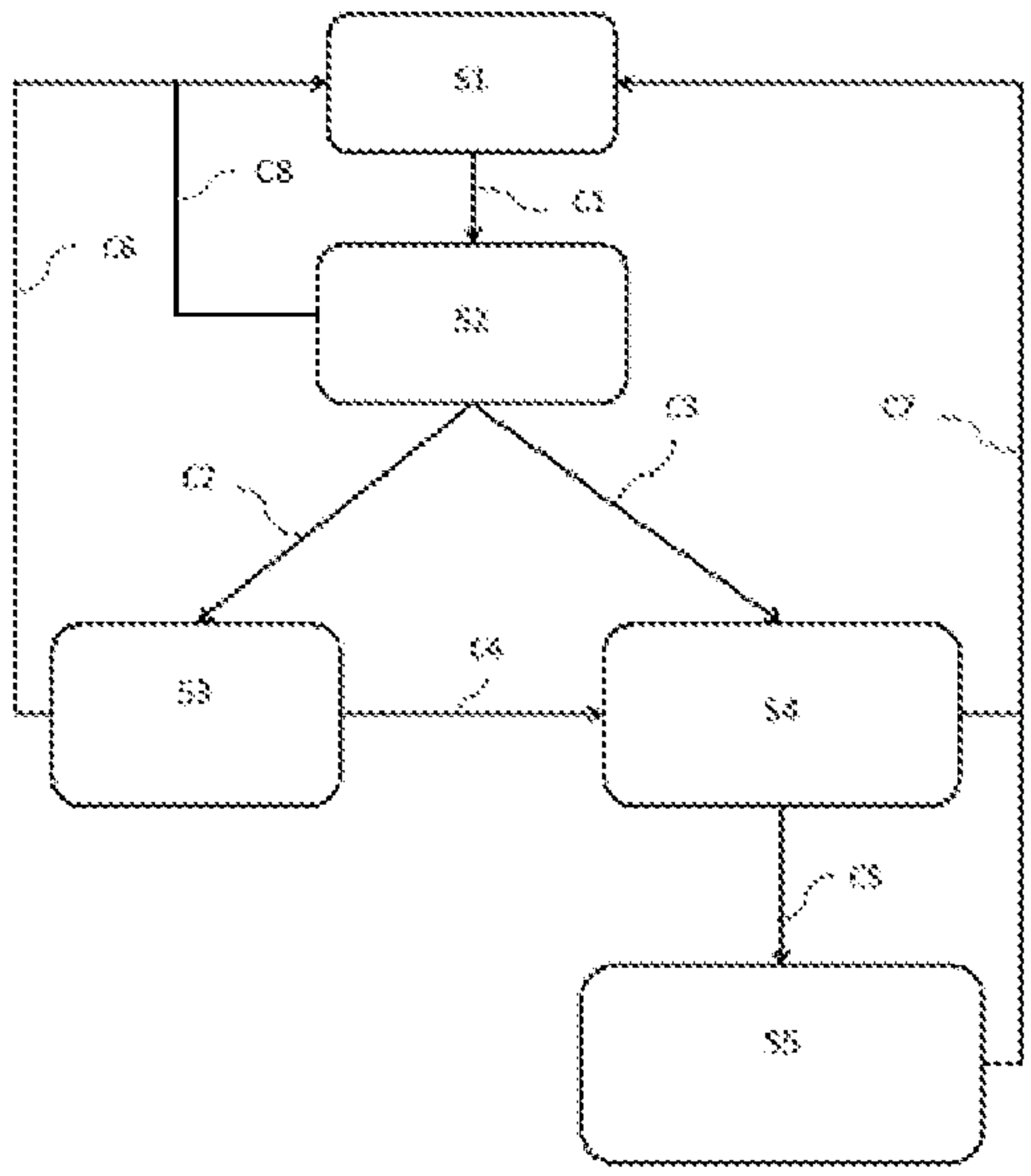
S1
C8
C1
C6
S2
C3
C7
C2
S3
C4
S4
C5
S5

Fig.2

Description

Method for height determination in air spring suspension systems during time intervals with air turbulences

Field of the invention

[0001] The invention relates to a method for height determination in air spring suspension systems for vehicles, systems comprising an air pump or compressor and elastic bellows as air springs. The air pump or compressor of the air spring suspension system pumps the air in the air springs made from rubber or other elastic materials and so the air pressure inflates the air springs and raises the chassis of the vehicle from the axle.

Background of the Invention

[0002] At present, height or distance measurements for air spring leveling systems is carried out using ultrasonic technologies.

[0003] Document WO 2001065139 A1 disclose an air spring, comprising a bellows, fixed on one side to a housing and on the other to an extending piston and enclosing a volume of air, whereby the housing surface facing the air volume of the air spring is pressurized by the air pressure of said air, and the housing side of which may be connected to the chassis of a motor vehicle by means of an intermediate rubber bush. Said housing comprises at least two parts, of which a first part serves as the connection for the air spring with the chassis of a motor vehicle and a second part serves as fixing for the bellows, whereby said rubber bush is annular in form and arranged between the two parts of the housing.

[0004] Document EP 1199196 A2 disclose a motor vehicle air suspension system with an ultrasound arrangement for contactless distance measurement by the pulse / echo method, wherein the air spring essentially comprises a roll bellows, which is closed at its one end with a cover plate as a connection part and the other at its end with a rolling piston as a second connection part, and wherein at one of the two connection parts , an ultrasonic transmitter / receiver and at the other of the two connecting parts, a reflector is arranged, characterized in that the reflector is formed in two stages, wherein the step a as the target reflector and the other stage serves as a reference reflector.

[0005] Document EP 957373 B1 disclose a pulse/echo method for the contactless measurement of the distance between the axle and the chassis of a vehicle with air suspension and for measuring the pressure prevailing in the air spring using an ultrasonic arrangement which is arranged in the air spring, wherein the ultrasonic arrangement contains the following components:

- a transceiver component which is assigned to the chassis of the vehicle,
- a first reference reflector,
- a second reference reflector which is mounted at a different distance from the first reference reflector , and
- a reflector component which is fixed to the axle, wherein ultrasonic pulses are emitted by the transceiver component, and the height of air spring is determined from the relative value of the propagation times of the ultrasonic pulses which have travelled on one of the two reference sections and the measurement section,

characterized in that the method for measuring the pressure prevailing in the air spring is carried out with the following method steps:

- ultrasonic pulses are emitted by the transceiver component,
- the intensity which is reflected back by the first reference reflector is measured,

- the measured intensity of the echo which is reflected back by the first reflector is kept constant using a control unit, for which purpose either the signal power or the gain is correspondingly adjusted,
- the echo amplitude which is reflected back by the second reference reflector is measured with a first device, and
- the internal pressure of the air spring is determined from the measured echo amplitude using an amplitude/pressure characteristic curve and the instantaneous temperature.

[0006] One of the problems associated with the state of the art methods for height or distance measurements for air spring leveling systems with ultrasonic technologies is the fact that this measurement systems for height / distance measurement are quite sensitive to strong air turbulences. The magnitude of these turbulences depends mostly on the pressure difference between the pressure in the air reservoir and the pressure in the air spring and occur when the air spring is inflated. Furthermore, the presence of turbulences translates most of the times into sources of ultrasounds that can corrupt the measurement process so named ghost or echo effects.

[0007] The problem associated with the state of the art mentioned above can be solved by a method for height determination in air spring suspension systems which use ultrasonic technology as means for height determination, the method comprising a dead reckoning algorithm which can estimate the height of an air spring in the context of air turbulences, based on pressure measurements.

[0008]The present invention disclose a method for height determination in air spring suspension systems which includes the steps of:

establishing if the air spring suspension system is in a normal state or is in a state with noises coming from air turbulences produced by the pressure difference between the pressure of the air in the air reservoir and the pressure in the air springs;

determination of the state of the air spring suspension system according to the evaluation of the pressure in the air spring suspension system and comparison of the pressure value with preset thresholds values;

calculation of the height using a formula if the air spring suspension system states meets certain defined conditions;

assignation of a preset value for height if the air spring suspension system states meets specific defined conditions.

[0009]The present invention found a solution for measuring the height in an air spring suspension system when the system is affected by air turbulences. In a first embodiment the invention define a method for height determination when the air spring suspension system is in a normal state and define this state of the system as a state free of air turbulences and more specifically define this state of the air spring suspension system as the state in which zero or a defined limited number (N) of echoes are identified by the ultrasonic emitter-receiver during an operational cycle of the emitter-receiver. The benefits stemming from this first embodiment of the invention relates to a clear definition for a normal state of the air spring suspension system and the way how the height is determined in the conditions of the normal state. In a second embodiment the invention define a method for height determination for the states of the air spring suspension system which are different than the normal state and more specifically the invention defines the states which are different than the normal state and the conditions that make the system reach that states. The benefits stemming from the second embodiment of the invention relates to the clear definition of the different states of the air spring suspension system states which are different than the normal state and more specifically to a clear definition for a state with air turbulences produced by the pressure difference between the pressure of the air in the air reservoir and the pressure in the air springs as the state in which at least one echo is identified by the ultrasonic emitter-receiver during an operational cycle of the emit-ter-receiver. In a third embodiment the invention provide a formula for calculation of the height in the case when the air spring suspension system is in a state with air turbulences. The benefits stemming from the third embodiment of the invention relates to the accuracy with which the height can be calculated. All the benefits mentioned above contribute to a much greater benefits which relates to safety of the passengers of a vehicle during a trip because on the accuracy of the height determination depends the stability of the vehicle.

Brief Description of the Drawings

[0010] The following descriptions using drawings illustrates an air spring suspension system for vehicles and the method for height determination in an air spring suspension system embodying the invention, in which schematically:

Fig.1 shows a basic concept of an air spring suspension system which use ultrasounds for height determination

Fig.2 shows the states of the air spring suspension system and the steps of the method embodying the invention for height determination in an air spring suspension system in case of occurrence of air turbulences

Numbering of the elements in drawings

[0011] In the drawing of Fig.1 the elements of an air spring suspension system which use ultrasounds for height determination are named below and are designated by the following numbers:

Core components

Air pump 15
Air reservoir 7
Air spring 5
Solenoid proportional valve 4

Control units

Electronic control unit 1
Remote control unit 2

Sensors

Ultrasonic emitter 3
Ultrasonic receiver 19
Pressure sensor 17

Electrical wires

First electrical wires 16 for connection of the electronic control unit 1 and air pump 15
Second electrical wires 8 for connection between solenoid valve 4 and electronic control unit 1
Third electrical wires 12 for connection between ultrasonic emitter and electronic control unit 1
Fourth electrical wires 19 for connection between ultrasonic receiver and electronic control unit 1

Fifth electrical wires 11 for connection of the electronic control unit 1 with remote control unit 2

Air pipes

First air pipe 9 between solenoid valve (4) and air spring (5)
Second air pipe 13 between air reservoir (7) and solenoid valve (4)
Third air pipe 14 between air pump (15) and solenoid valve (4)

Vehicle parts
Chassis 6
Wheel 10

[0012] In the drawing of Fig.2 the states of the air spring suspension system and the steps of the method embodying the invention for height determination in an air spring suspension system are named below along with the conditions for transition from a state to the other.

A first system state **S1 – Normal state** is the air spring suspension system state in which samples of pressure Pk and samples of Height Hk are measured in successive moments of time using the pressure sensor and the ultrasonic emitter/receiver

A second system state **S2 – Evaluation state** is the air spring suspension system state in which the value for height Hk is frozen and samples of pressure Pk are measured by the pressure sensor in successive moments of time

A third system state **S3 – Isochoric_1 state** is the air spring suspension system state in which the value for height Hk is frozen, remaining constant, and is set to Hmax and samples of pressure Pk are measured by the pressure sensor in successive moments of time

A fourth system state **S4 – Isobar state** is the air spring suspension system state in which samples of pressure Pk are measured and the height is determined with formula

Hk = Hk-1 +Slope * Delta_T where

Hk is the a sample of height at a certain moment

Hk-1 is the previous sample of height

Slope is the gradient for height change depending on piston movement and pressure

Slope = Function (Piston move, Pressure)

Delta_T is the sampling rate equal with the time duration between the moments when two consecutive pressure samples are measured

A fifth system state **S5 – Isochoric_2 state** is the air spring suspension system state in which the air spring is completely inflated which means the maximum height has been reached, the pressure can grow but not the volume. In state S5 samples of pressure Pk are measured.

A first condition **C1 – condition for transition Noise On** when it is fulfilled the air spring suspension system passes from the Normal state S1 into Evaluation state S2

A second condition **C2 – condition for transition Pk-Pk-1>Th1** when it is fulfilled the air spring suspension system passes from the Evaluation state S2 into Isochoric_1 state S3 where Pk and Pk-1 are pressure samples measured with the pressure sensor 17 in successive moments of time K-1,K while Th1 is a threshold value for the pressure

A third condition **C3 – condition for transition Pk-Pk-1 <Th1** when it is fulfilled the air spring suspension system passes from the

Evaluation state S2 into Isobar state S4 where Pk and Pk-1 are pressure samples measured with the pressure sensor 17 in successive moments of time K-1,K while Th1 is a threshold value for the pressure

A fourth condition **C4 – condition for transition Pk-Pk-1 <Th2** when it is fulfilled the air spring suspension system passes from the Isochoric_1 state S3 into Isobar state S4 where Pk and Pk-1 are pressure samples measured with the pressure sensor 17 in successive moments of time K-1,K while Th2 is a threshold value for the pressure

A fifth condition **C5 – condition for transition Pk-Pk-1>Th3** when it is fulfilled the air spring suspension system passes from the Isobar state S4 into Ischoric_2 state S5 where Pk and Pk-1 are pressure samples measured with the pressure sensor 17 in successive moments of time K-1,K while Th3 is a threshold value for the pressure

A sixth condition **C6 – condition for transition Noise Off** when it is fulfilled the air spring suspension system passes from the Isochoric_1 state S3 into Normal state S1
A seventh condition **C7 – condition for transition Noise Off** when it is fulfilled the air spring suspension system passes from the Isochoric_2 state S5 or Isobar state S4 into Normal state S1
An eight condition **C8 – condition for transition Noise Off** when it is fulfilled the air spring suspension system passes from the Evaluation state S2 into Normal state S1

Detailed Description

[0013] As depicted in Fig.1 an air spring suspension system for a vehicle comprise an air spring 5, made from rubber or other elastic material, inflated by an air pump 15 which pumps the air from the air reservoir 7. The pressure of the air in the air spring is regulated with a solenoid proportional valve 4. The air spring 5 is connected with the solenoid proportional valve 4 by the first air pipe 9. The air reservoir 7 is connected to the solenoid valve 4 by the second air pipe 13 while the air pump 15 is connected with the solenoid valve 4 by the third air pipe 14.

An electronic control unit 1 actuates with electrical signals the air pump 15 and the solenoid proportional valve 4 and this is done through the first electrical wires 16 which connects the electronic control unit 1 with the air pump 15 and the second electrical wires 8 which connects the solenoid valve 4 and the electronic control unit 1. A pressure sensor 17 measure the pressure in the air spring and send the measurements data to the electronic control unit 1. The pressure sensor 17 can be connected by electrical wires to the electronic control unit 1 or can send the data by a wireless communication means. In the system described in the Fig 1 the communication between the pressure sensor 17 and the electronic control unit 1 is done via a wireless communication between the pressure sensor 17 and the electronic control unit 1. When the air spring 5 is inflated the chassis 6 lift and the distance between the chassis 6 and the wheel is getting bigger. The height is determined by using ultrasounds. An ultrasound emitter 3 is placed on the chassis level while an ultrasound receiver is placed on the wheel 10 level. The ultrasound emitter 3 and the ultrasound receiver are connected by electrical wires 12 and 19 or wireless with the electronic control unit 1. The height or distance between chassis and wheel is determined based on the time required for the ultrasound to travel the distance between the ultrasound emitter 3 and ultrasound receiver 18.

[0014]The accuracy of height measurements using ultrasounds depends on the presence or absences of measurements disturbances. These disturbances may appear in case of echoes of the ultrasounds or some named "ghost" effects that can corrupt the measurement process. These echoes or "ghost" effects may appear in case of air turbulences in the air spring. Air turbulences can be produces by the hydraulic components like air pump 15 or solenoid proportional valve 4 or air pipes 9,13,14.

[0015]The present invention disclose a method for height determination in an air spring suspension system during time intervals with air turbulences. First aspect of the invention is represented by determination of the air spring suspension system states. Therefore the method of the invention includes determination and definition of at least five distinct air spring suspension system states:
A first system state S1 - Normal state,
A second system state S2 - Evaluation state,
A third system state S3 - Isochoric_1 state,
A fourth system state S4 - Isobar state,
A fifth system state S5 - Isochoric_2 state .

[0016]The second aspect of the method disclosed by the present invention is formed by the definition for conditions which determine the transition from a system state to another system state therefore at least eight conditions are defined for transition from a system state to the other:
A first condition C1 - condition for transition Noise On,
A second condition C2 - condition for transition Pk-Pk-1>Th1,
A third condition C3 - condition for transition Pk-Pk-1 <Th1,
A fourth condition C4- condition for transition Pk-Pk-1 <Th2,
A fifth condition C5 - condition for transition Pk-Pk-1>Th3,
A sixth condition C6 - condition for transition Noise Off,
A seventh condition C7- condition for transition Noise Off,
An eighth condition C8 - condition for transition Noise Off_Early.

[0017] The third aspect of the invention is composed by the techniques used in each of the air spring suspension system state to determine or identify the height.

For the first system state S1 - Normal state the height is determined using the ultrasonic emitter-receiver.

For the second system state S2 - Evaluation state the height is frozen and set to the last measured value obtained by measurements using the ultrasonic emitter-receiver.

For the third system state S3 - Isochoric_1 state the height is set to Hmax value which is the highest possible value for height.

For the fourth system state S4 - Isobar state the height is determined using the formula Hk = Hk-1 +Slope * Delta_T.

For the fifth system state S5 - Isochoric_2 state the height is to Hmax value which is the highest possible value for height.

[0018] The dynamics of the system and the associated technique to identify or determine the value for the height is described here further.

[0019] In the first system state S1 - Normal state, samples of pressure Pk are measured in successive moments of time k using the pressure sensor and samples of height Hk are measured in successive moments of time k using the ultrasonic emitter/receiver. If the first condition C1 - condition for transition Noise On is fulfilled than the air spring suspension system switches from the first system state S1 - Normal state to the second system state S2 - Evaluation state. The fulfillment of the first condition C1 means the fulfillment of the following conditions: at least one echo is identified by the ultrasonic emitter-receiver during an operational cycle of the emitter-receiver. An operational cycle of the emitter-receiver can last between 0.01ms (milliseconds) and 100ms (milliseconds).

[0020] In the second system state S2 - Evaluation state the value for height Hk is frozen ,remaining constant, and is set to a last measured value obtained by usage of the ultrasonic emitter-receiver and samples of pressure Pk are measured in successive moments of time k by the pressure sensor. If a second condition C2 - condition for transition Pk-Pk-1>Th1is fulfilled than the air spring suspension system switches from the second system state S2 - Evaluation state to the third system state S3 - Isochoric_1 state. The second condition C2-condition for transition Pk-Pk-1>Th1 is fulfilled when the difference between the pressure samples measured in two moments of time K-1 and K is lower than a pressure threshold Th1. If the third condition C3 - condition for transition Pk-Pk-1 <Th1 is fulfilled than the air spring suspension system switches from the third system state S3 - Isochoric_1 state to the fourth system state S4 - Isobar state. The third condition C3 - condition for transition Pk-Pk-1 <Th1 is fulfilled if the difference between the pressure samples measured in two moments of time K-1 and K is bigger than a pressure threshold Th1. If the eighth C8- condition for transition Noise Off is fulfilled than the air spring suspension system switches from the second system state S2 - Evaluation state to the first system state S1 - Normal state. The fulfillment of the eighth C8-condition for transition Noise Off means the fulfillment of the following conditions: zero or a defined limited number N of echoes are identified by the ultrasonic emitter-receiver during an operational cycle of the emitter-receiver. An operational cycle of the emitter-receiver can last between 0.01ms (milliseconds) and 100ms (milliseconds).

[0021] In the third system state S3 - Isochoric_1 state the value for height Hk is frozen, remaining constant, and is set to Hmax which is the biggest value for height and samples of pressure Pk are measured by the pressure sensor in successive moments of time k.

If the fourth condition C4 - condition for transition Pk-Pk-1 <Th2 is fulfilled than the air spring suspension system switches from

the third system state S3 – Isochoric_1 state to the fourth system state S4 – Isobar state. The fourth condition C4 – condition for transition Pk-Pk-1 <Th2 is fulfilled when the difference between the pressure samples measured in two successive moments of time K-1 and K is lower than a pressure threshold Th2. The typical relation between the thresholds Th1 and Th2 is Th2 < Th1 such a way to assure an hysteresis effect and to avoid an unsafe transition into the forth system state S4 – Isobar state.If a sixth condition C6- condition for transition Noise Off is fulfilled than the air spring suspension system switches from the third system state S3 – Isochoric_1 state to the first system state S1 – Normal state. The fulfillment of the sixth condition C6- condition for transition Noise Off means the fulfillment of the following conditions: zero or a defined limited number N of echoes are identified by the ultrasonic emitter-receiver during an operational cycle of the emitter-receiver. An operational cycle of the emitter-receiver can last between 0.01ms (mil-liseconds) and 100ms (milliseconds), but is not limited to this interval.

[0022]In the fourth system state S4 – Isobar state samples of pressure Pk are measured and the height is determined with formula

Hk = Hk-1 +Slope * Delta_T where

Hk is the a sample of height at a certain moment of time k

Hk-1 is the previous sample of height in the moment of time k-1

Slope is the gradient for height change depending on piston movement and pressure

Slope = Function (Piston move, Pressure). Slope is determined using methods like SixSigma or Transfer function or design of experiments

Delta_T is the sampling rate equal with the time duration between the moments when two consecutive pressure samples k-1 and k are measured

If the fifth condition C5 – condition for transition Pk-Pk-1>Th1 is fulfilled than the air spring suspension system switches from the fourth system state S4 – Isobar state to the fifth system state S5 – Isochoric_2 state . The fifth condition C5 – condition for transition Pk-Pk-1 <Th3 is fulfilled if the difference between the pressure samples measured in two moments of time K-1 and K is bigger than a pressure threshold Th3. The typical relation between the thresholds Th1, Th2 and Th3 is Th2 < Th1 < Th3 such a way to assure a hysteresis effect and to avoid an unsafe transition into the fifth system S5 – Isochoric_2 state. The thresholds Th1 and Th3 have close values and can be even equals. If the seventh C7- condition for transition Noise Off is fulfilled than the air spring suspension system switches from the fourth system state S4 – Isobar state to the first system state S1 – Normal state. The fulfillment of the seventh C7- condition for transition Noise Off means the fulfillment of the following conditions: zero or a defined limited number N of echoes are identified by the ultrasonic emitter-receiver during an operational cycle of the emitter-receiver. An operational cycle of the emitter-receiver can last between 0.01ms (milliseconds) and 100ms (milliseconds).

[0023] In the fifth system state S5 – Isochoric_2 state the air spring is completely inflated which means the maximum height Hmax has been reached, therefore the value assigned for height will remain constant while the pressure can grow but not the volume. In state S5 samples of pressure Pk are measured in successive moments of time k. If the seventh C7- condition for transition Noise Off is fulfilled than the air spring suspension system switches from the fifth system state S5 – Isochoric_2 state to the first system state S1 – Normal state. The fulfillment of the seventh C7- condition for transition Noise Off means the fulfillment of the following conditions: zero or a defined limited number N of echoes are identified by the ultrasonic emitter-receiver during an operational cycle of the emitter-receiver. An operational cycle of the emitter-receiver can last between 0.01ms (milliseconds) and 100ms (milliseconds).

Patent claims

1. A method for height determination in air spring suspension systems during time intervals with air turbulences wherein ultrasounds are used for height determination , which includes the steps of :

establishing if the air spring suspension system is in a normal state meaning a state free of air turbulences wherein the measurements with ultrasounds are not disturbed by background noise or is in a state with noises coming from air turbulences produced by the pressure difference between the pressure of the air in the air reservoir and the pressure in the air springs;

determination of the state of the air spring suspension system according to the evaluation of the pressure in the air spring suspension system and comparison of the pressure value with preset thresholds values;

calculation of the height with a formula if the air spring suspension system states fulfill the condition Pk-Pk-1 <Th1 where Pk and Pk-1 are pressure samples measured with the pressure sensor (17) in successive moments of time K-1, K while Th1 is a threshold value for the pressure, wherein the formula used for calculation of the weight is Hk = Hk-1 +Slope * Delta_T where
Hk is the a sample of height at a moment of time k,
Hk-1 is the previous sample of height in the moment of time k-1,
Slope is the gradient for height change depending on piston movement and pressure Slope = Function (Piston move, Pressure),
Delta_T is the sampling rate equal with the time duration between the moments of time when two consecutive pressure samples Pk-1 and Pk are measured;

assignation of a preset value for height if the air spring suspension system states fulfill the following condition: Pk-Pk-1 >Th1 where Pk and Pk-1 are pressure samples measured with the pressure sensor (17) in successive moments of time K-1, K while Th1 is a threshold value for the pressure.

2. A method according to claim 1 wherein the normal state of the air spring suspension system is defined as the state in which zero or a defined limited number (N) of echoes are identified by the ultrasonic emitter-receiver during an operational cycle of the emitter-receiver.

3. A method according to claim 2 wherein the operational cycle of the emitter-receiver can last between 0.01ms (milli-seconds) and 100 ms (milliseconds).

4. A method according to claim 1 wherein a state with noises coming from air turbulences produced by the pressure difference between the pressure of the air in the air reservoir and the pressure in the air springs is defined as the state in which at least one echo is identified by the ultrasonic emitter-receiver during an operational cycle of the emitter-receiver.

5. A method according to claim 1 wherein for the height is assigned a maximum value corresponding to a maximum height value (Hmax) given by the physical limitation of the air spring suspension system.

6. A method for height determination in air spring suspension systems during time intervals with air turbulences wherein ultrasounds are used for height determination, which includes the definition of at least five distinct air spring

suspension system states and wherein the techniques used in the different states of the air spring suspension system in order to identify and determine the height are :

for a first system state (S1 - Normal state) the value of height is determined in different moments of time by measurements done with an ultrasonic emitter-receiver.

for a second system state (S2 - Evaluation state) the value assigned for the height remain constant and is one of the measured value obtained by measurements using an ultrasonic emitter-receiver .

for a third system state (S3 - Isochoric_1 state) the value assigned for height remain constant and is set to a value (Hmax) which is the highest possible value for height given by the physical limitation of the air spring suspension system.

for a fourth system state (S4 - Isobar state) the height is determined using the formula Hk = Hk-1 +Slope * Delta_T where

Hk is the a sample of height at a certain moment of time k

Hk-1 is the previous sample of height in the moment of time k-1

Slope is the gradient for height change depending on piston movement and pressure Slope = Function (Piston move, Pressure).

Delta_T is the sampling rate equal with the time duration between the moments of time when two consecutive pressure samples Pk-1 and Pk are measured

for a fifth system state (S5 - Isochoric_2 state) the value assigned for height remain constant and is set to a value (Hmax) which is the highest possible value for height given by the physical limitation of the air spring suspension system.

7. A method according to claim 6 wherein in each of the system states of the air spring suspension system, samples of

pressure (Pk) are measured in successive moments of time (k) using a pressure sensor.

8. A method according to claim 7 wherein the transition from one system state to another system state occurs when the following conditions are met :

If a first condition (C1 - condition for transition Noise On) is fulfilled than the air spring suspension system switches from a first system state (S1 - Normal state) to a second system state (S2 - Evaluation state). The fulfillment of the first condition (C1) means that at least one echo is identified by the ultrasonic emitter-receiver during an operational cycle of the emit-ter-receiver.

If a second condition (C2 - condition for transition Pk-Pk-1>Th1) is fulfilled than the air spring suspension system switches from a second system state (S2 - Evaluation state) to a third system state (S3 - Isochoric_1 state). The second condition (C2-condition for transition Pk-Pk-1>Th1) is fulfilled when the difference between the pressure samples measured in two moments of time (K-1 and K) is lower than a pressure threshold (Th1).

If a third condition (C3 - condition for transition Pk-Pk-1 <Th1) is fulfilled than the air spring suspension system switches from a third system state (S3 - Isochoric_1 state) to a fourth system state (S4 - Isobar state). The third condition (C3 - condition for transition Pk-Pk-1 <Th1) is fulfilled when the difference between the pressure samples measured in two moments of time (K-1 and K) is bigger than a pressure threshold (Th1).

If a fourth condition (C4 - condition for transition Pk-Pk-1 <Th2) is fulfilled than the air spring suspension system switches from a third system state (S3 - Isochoric_1 state) to a fourth system state (S4 - Isobar state). The fourth condition (C4 - condition for transition Pk-Pk-1 <Th2) is fulfilled when the difference

between the pressure samples measured in two successive moments of time (K-1 and K) is lower than a pressure threshold (Th2).

If a fifth condition (C5 - condition for transition Pk-Pk-1>Th1) is fulfilled than the air spring suspension system switches from a fourth system state (S4 - Isobar state) to a fifth system state (S5 - Isochoric_2 state). The fifth condition (C5 - condition for transition Pk-Pk-1 <Th3) is fulfilled when the difference between the pressure samples measured in two successive moments of time (K-1 and K) is bigger than a pressure threshold (Th3).

If a sixth condition (C6- condition for transition Noise Off) is fulfilled than the air spring suspension system switches from a third system state (S3 - Isochoric_1 state) to a first system state (S1 - Normal state). The fulfillment of the sixth condition (C6- condition for transition Noise Off) means that zero or a defined limited number (N) of echoes are identified by the ultrasonic emitter-receiver during an operational cycle of the emitter-receiver.

If a seventh condition (C7- condition for transition Noise Off) is fulfilled than the air spring suspension system switches from a fourth system state (S4 - Isobar state) to a first system state (S1 - Normal state). The fulfillment of the seventh condition (C7- condition for transition Noise Off) means that zero or a defined limited number (N) of echoes are identified by the ultrasonic emitter-receiver during an operational cycle of the emit-ter-receiver.

If an eighth condition (C8- condition for transition Noise Off) is fulfilled than the air spring suspension system switches from a second system state (S2 - Evaluation state) to a first system state (S1 - Normal state). The fulfillment of the eighth condition (C8- condition for transition Noise Off) means that zero or a defined limited number (N) of echoes are identified by the ultrasonic emitter-receiver during an operational cycle of the emitter-receiver.

9. A method according to claim 8 wherein the operational cycle of the emitter-receiver can last between 0.01ms (milli-seconds) and 100ms (milliseconds).