(54) Title: LIFT AXLE CONTROL UNIT FOR A MOTOR VEHICLE

Fig. 2

(57) Abstract: The invention refers to a lift axle control unit (1) for a lift axle suspension system (30) of a vehicle (1000), said lift axle control unit (1) comprising at least: an electronic control unit (4) receiving at least a first electric input signal (SI) and a position indicating signal (S4), at least one supply input port (100) to be connected to a pressure reservoir (2), a first delivery port (220) to be connected to at least one suspension bellows (14) and a second delivery port (250) to be connected to at least one lift bellow (16), a load detection valve (3) being connectable to load variable parts (1010) of said vehicle (1000) and delivering an output pressure signal (p3) in dependence of an axle load of the vehicle (1000), a first relay valve (6) connected to said first delivery port (220) for feeding said suspension bellows (14), a second relay valve (7) connected to said second delivery port (250) for feeding at least one lift bellow (16), a solenoid valve (5) for receiving an electric control signal (S5) from said electronic control unit (4) and for connecting said load detection valve (3) to said first and second relay valve (6, 7) or separating it from said first and second relay valve (6, 7) in dependence of said electric control signal (S5).
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Lift axle control unit for a motor vehicle

Background of the invention

The invention refers to a lift axle control unit to be used in a lift axle suspension system of a commercial vehicle, further to a lift axle suspension system comprising such a lift axle control unit, and a vehicle, in particular a commercial vehicle, comprising such a lift axle suspension system.

A lift axle suspension system of a commercial vehicle comprises in general suspension bellows (like the other axles) for damping and for adjusting the distribution of the axle load between the axles of the vehicle, and additionally one or more lift bellows capable for lifting the axle in order to detach the wheels of the lift axle from ground; further, pneumatic valves for controlling these bellows are provided.

A lift axle suspension system in a commercial vehicle enables the following functions:
- Automatically raising or lowering the lift axle depending on vehicle load condition,
- Override to raise the lift axle when the vehicle is fully loaded for better traction and maneuverability of the vehicle. This override can be initialized manually or by a control unit.

Preferably a damping delay is provided for maintaining the axle position during road undulations. Further it is often preferred to keep the lift axle during an ignition off condition in its lowered position in order to avoid theft of wheels.

Valve assemblies often comprise solenoid valves for receiving electrical signals and relay valves to enlarge the volume flow.
Raising or lowering the axle is achieved through pneumatically actuated valves, which in turn receive appropriate pneumatic and/or electrical signals.

Existing lift axle control valve assemblies can be comprised of essentially a combination of a spool valve, a damping reservoir, a Solenoid valve and a switch, e.g. a double throw pressure switch; the axle control valve assembly works e.g. with an external electrical relay and two external relay valves.

One disadvantage of those prior art lift axle control valves are the high costs of manufacture due to separate cast bodies for the individual valves (lift axle control valve and relay valve) and piping to join them together.

Another disadvantage of the known art is that the separate air exhaust ports of the valves have to be separately protected against water and dust entry.

Another disadvantage of the known art is that the control of an external relay valve connected to the suspension bellow is directly performed without a damping. This results in more air consumption due to frequent exhaust of air from suspension bellow when the vehicle is passing through bump road condition.

A further disadvantage of the known art lift axle control valve can be seen in the fact that load detection is performed through a double throw pressure switch. This results in more inconsistency of pressure sensing and it affects the reliability of the system.

A still further disadvantage of the known art is that a lowering of the lift axle during ignition off condition has to be achieved through an external electrical relay. This affects the reliability of the system.
The WO2012140672A2 discloses a lift axle control valve assembly comprising a stack arrangements of layers including several pneumatic valves to be connected to a reservoir and to lift bellows and suspension bellows.

Disadvantages of this system are still the complexity in its design and the costs of manufacturing.

It is therefore an object of the invention to provide a lift axle control unit, which provides a high reliability at relatively low costs.

Further objects of the invention are to provide a lift axle suspension control system comprising such a lift axle control valve and a vehicle with such a pneumatic system.

Summary of the invention

The lift axle control unit according to the invention is defined in claim 1.

Further a lift axle suspension system comprising this lift axle control unit, air bellows and a lever arrangement and a vehicle comprising this lift axle suspension system are provided.

The present invention enables an integration of the following functions in a modular way:
- Automatically raising or lowering the lift axles depending on vehicle load condition,
- Lifting of the lift axle with preferably manual override function on fully loaded vehicle for better traction and maneuverability,
- Preferably lifting of the lift axle during reverse gear on fully loaded vehicle for better maneuverability,
- Damping delay for maintaining the axle position during road undulations
- Lowering of the lift axle during the vehicle ignition OFF condition irrespective of the vehicle load.

According to a preferred embodiment these elements are integrated in a multi-layer modular construction.

According to a preferred embodiment the function of both lift axle control valve and load detection valve are achieved by a single control unit. So the protection for dust and water entry has to be provided only in single exhaust port of present invention.

According to a preferred embodiment an electrical position sensing system is provided which replaces the pneumatic load detection system in the prior art which requires the complex pressure differential mechanism. In the electrical position sensing system, the vehicle load condition is for example identified by position of a cam in the load detection valve.

The function of the damping reservoir in the prior art is to provide the damping delay for load detection. However, according to a preferred embodiment of the invention the electronic control unit provides the damping delay in reduced size; the damping delay can be realized and adjusted by the electronic control unit which performs a low pass filtering and then outputs the control signal to a solenoid valve.

The electrically actuated pneumatic valve device can in particular comprise only one single solenoid valve, preferably for both relay valves, i.e. the first relay valve of the suspension bellow and the second relay valve of the lift bellow. Thus the hardware costs of solenoid and magnetic equipment are reduced.
The lift axle control valve assembly enables a reduced plumbing on the vehicle. A spool valve and pressure differential valve are preferably not necessary.

The preferred multilayer construction permits flexibility in connecting the air passages between the functional groups of components, said layers being preferably flat bodies with cavities and passages, which results in simplified manufacture and hence reduced costs.

The invention is explained in more detail below by means of preferred embodiments shown in the drawings, wherein

Fig. 1 is an electro-pneumatic diagram of a suspension system according to the prior art;

Fig. 2 is an electro-pneumatic diagram of a suspension system according to an embodiment of the invention;

Fig. 3 is a first sectional view of a lift axle control unit according to an embodiment of the invention in a plane comprising the relay valves,

Fig. 4 is a second sectional view of the lift axle control valve of figure 3 in a plane comprising the control unit and the solenoid valve,

Fig. 5 is a flow chart of the signal processing in an electronic control unit according to an embodiment of the invention.

Description of a preferred embodiment

Referring to figure 1, lift axle control system 101 of the prior art comprises two devices, both shown in dashed lines: a lift axle control valve 102 and a load detection valve 103. Further a pressurized air reservoir 111, suspension bellows 14 and lift bellows 16 are provided. The a lift axle control valve 102 comprises a spool valve 105, a differential pressure valve 106, a first solenoid valve 107 for receiving an ignition signal IG, a second solenoid valve
108 for receiving an electric override signal TA and for enabling a manual override, a relay valve 109, a damping reservoir 110 and a small orifice (throttle) 112.

The delivery pressure 700 of said load detection valve 103 is given as control input 550 to the lift axle control valve 102. The control input 550 is then given to damping reservoir 110 through said small orifice 112. The control pressure from damping reservoir 110 is given to pressure differential valve 106 through first solenoid valve 107 and second solenoid valve 108 for load detection. The damping reservoir 110 and orifice 112 is used to reduce the air consumption by avoiding frequent air exhaust in bump road conditions. The first solenoid valve 107 is getting the signal from dashboard. The second solenoid valve 108 is used for traction assistance to manual override the axle irrespective of load condition.

The pressure differential valve 106 is actuating the spool valve 105 to charge the lift bellow 16 by delivery port 800 or suspension bellow 14 by another delivery port 900. The supply pressure from reservoir 111 is supplied to supply ports 600 for the load detection valve 103 and to port 500 for the lift axle control valve 102. Once the relay valve 109 gets activated through the spool valve 105, then the delivery air of relay valve 109 feeds to suspension bellows 14 connected to delivery port 900. When the second solenoid 108 gets the signal TA from dashboard, it switches from the position shown in Fig. 1 to the other position. This switches the pressure differential valve 106 into its other position and actuates the spool valve 105 to the other, second position. The lift bellow 16 is charged from the supply pressure at 800 from reservoir 111. The supply air at port 500 from auxiliary reservoir 111 is passing through first solenoid valve 107 as shown in Fig 1 and through second solenoid valve 108 as shown in Fig 1 to activate the pressure differential valve 106 and subsequently spool valve 105 as shown position and to charge the suspension bellow 14 through relay valve 109 corresponding to the control
pressure 550 received from load detection valve 103 for achieving the axle in
lowered position during ignition off condition. The lift bellows 16 can be dis-
charged through the common exhaust 130.

5 Figure 2 discloses one embodiment of an inventive lift axle suspension sys-
tem 30 comprising a lift axle control unit 1, suspension bellows 14, lift axle
bellows 16 and a reservoir (pressure tank) 2 containing pressurized air with
supply pressure p2.

10 With respect to figure 2, the proposed lift axle control unit 1 has one supply
port 100, which in fig. 2 is shown twice only for reasons of illustration in this
scheme, further a first delivery port 220 to charge the suspension bellow 14,
a second delivery port 250 to charge the lift bellow 16 and a common ex-
haust 300. Internal first pressure lines 41 are connected to the supply port
100.

An electronic control unit 4 is assembled in the lift axle control unit 1 to con-
trol a solenoid valve 5 to charge either the suspension bellow 14 or lift bellow
16. The electronic control unit receives an ignition input signal S1 from vehi-
cle battery through an ignition key. A ground signal S3 is connected to a ve-
hicle battery. A traction assistance input signal S2 is received from
dashboard switch for manual override function. This traction assistance input
signal S2 may e.g. be output if a reverse gear is used, in order to enable bet-
ter maneuverability.

20 A position sensing system 8 is assembled in the integrated load detection
valve 3 to detect the vehicle load conditions. Output from the position sensing
system 8 is given as load condition sensing signal S4 to the electronic control
unit 4. The electronic control unit 4 actuates the solenoid valve 5 via an elec-
tric control signal S5 depending on the ignition input signal S1, traction assis-
tance input signal S2 and load condition sensing signal S4 to charge or de-
complete the lift bellow 16 and suspension bellow 14.

The solenoid valve 5 comprises a first return spring 501 which forces the so-
lenoid valve 5 into its first, non-actuated position if the electronic control sig-
nal S5 from the electronic control unit 4 is absent or S5 = 0.

The supply pressure in reservoir 2 is connected to the lift axle control unit 1 in single supply port 100. The supply pressure p2 in single supply port 100 is given via the first pressure lines 41 to first relay valve 6 and second relay valve 7 whereupon the first relay valve 6 is connected to the first pressure line 41 via the pressure port 641 and the second relay valve 7 is connected via the pressure port 741. The first pressure lines 41 are also connected to the load detection valve 3 via the pressure port 341 which modulates the pressure and gives a modulated pressure p3, p3 ≤ (smaller or equal to) p2, via a second line 42 to the solenoid valve 5 with respect to vehicle load conditions. The load detection valve 3 and the solenoid valve 5 are thereby connected via the pressure ports 342 and 542. Further the load detection valve 3 com-
prises a self balancing mechanism 301, which limits the supply pressure to a predefined value.

In its non-actuated position (S5=0) as seen in Fig. 2 the solenoid valve 5 is connecting the load detection valve 3 delivery pressure p3 of the second line 42 to a third pressure line 43, which is realized as a control cavity visible in Fig. 4, which acts onto first relay valve 6 and second relay valve 7 in the position as shown in Fig. 2. Thus if the solenoid valve 5 is in its actuated po-
sition (S5 = 1) the second relay valve 7 is not charged with any pressure. In this situation the second relay valve 7 is forced in its non-actuated position by a second return spring 702. The pressure line 43 is connected to the solenoid valve 5 via the pressure port 543 and leads into the first and second relay valves 6, 7 via the pressure ports 643 and 743.
The first relay valve 6 charging the suspension bellow 14 via fourth pressure line 44 through the pressure port 644 and the first delivery port 220 depending on the control pressure from load detection valve 3. Additionally, the first relay valve 6 comprises a self-balancing mechanism 601, which limits the supply pressure to a predefined value. The second relay valve 7 is charging the lift bellows 16 via fifth pressure line 45 through pressure port 745 and second delivery port 250. The pressure in lift bellow 16 is depleted to atmosphere through the second relay valve 7 in the position as shown in Fig. 2 and common exhaust 300 which is connected via pressure port 701.

The electronic control unit 4 actuates the solenoid valve 5 via the electronic control signal S5 when it receives the traction assistance input signal S2 from dashboard or the electrical load condition sensing signal S4 from the position sensing system 8 in the presence of the ignition signal S1. The solenoid valve 5 switches from the shown position in Fig. 2 to its second, actuated position. The pressure in the suspension bellow 14 is depleted to atmosphere through the first delivery port 220, first relay valve 6 and common exhaust 300. The lift bellow 16 charged to supply pressure at port 100 through the second relay valve 7 and delivery port 250.

With respect to Fig. 3, the lift axle control unit 1 comprises a multilayer construction with levels 51, 52, 53, 54, 55 stacked together and fixed by bolts (or screws) 57, whereas also nuts are possible, which do not extend to the section planes of Fig. 3 and 4.

In Fig. 3 the sectional view in a plane of the integration of first relay valve 6 and second relay valve 7 in the is shown. The first layer 51 is the top layer of the single device stack arrangement of lift axle control unit 1; the top layer 51 serves as a lid for closing the valve arrangement.
The second layer 52 serves as an air passage layer and comprises flow passages of pressure lines 41 and 43, said flow passages being designed as cavities 43a, 41a in the second layer 52. In the sectional views of figures 3 and 4 not all air conduits and air passages are visible; in particular, the connections between the cavities 43a, 41a and the first pressure line 41 are not visible. Thus the sectional views may show separated lines 41 and separated lines 43 which are three dimensional lines extending through this device.

The third layer 53 serves as a valve layer and comprises the first relay valve 6 and second relay valve 7 as shown in Fig. 3. The fourth layer 54 comprises the flow passages between the first relay valve 6 and second relay valve 7. The fifth layer 55 supports a cam arrangement 1050 connected to the load dependent lever arrangement 1100 as shown in Fig. 3.

The first relay valve 6 is depleting the suspension bellow 14 shown in Fig. 2 as shown in the construction of the first relay valve 6 in Fig. 3. The lift bellow 16 shown in Fig. 2 is charged to supply pressure by the second relay valve 7 as shown in the construction of Fig. 3.

With respect to Fig. 4, the sectional view of load detection valve 3 discloses an adjustable screw arrangement 1010 in the second layer 52 to define the pressure values at different load conditions. Fig. 4 is showing the construction of third layer 53 with solenoid valve 5 and load detection valve 3. The delivery pressure of load detection valve 3 is supplied via the second pressure line 42 realized as a cavity 42a in the third layer 53 to the solenoid valve 5. The air flow direction is indicated by arrows.

The electronic control unit 4 is assembled in third layer 53 as shown in Fig. 4 to actuate the solenoid valve 5 which is assembled in the third layer 53. The lever arrangement 1100 shown in Fig. 4 is connected to vehicle axle
of vehicle 1000 to detect the vehicle load conditions. The rotation of lever arrangement 1100 is e.g. directly proportional to vehicle load conditions.

The electronic control unit 4 assembled in third layer 53 as shown in Fig. 4, having the control algorithm for damping delay in order to reduce the air consumption by avoiding frequent exhaust in suspension bellow 14 shown in Fig. 2. The input signals S1 of ignition, traction assistance input signal S2 of manual override, and the load signal S4 which are inputted into the electronic control unit 4 as shown in Fig. 2 are monitored for a defined duration in said algorithm for the damping delay to ensure the required action of actuating or deactivating the solenoid valve 5 assembled in layer 53 as shown in Fig. 4.

The electronic control unit 4 preferably executes a logical operation on basis of the input signals S1, S2, S4 and actuates the solenoid valve 5 via an electric control signal S5 to lift the axle in dependence of the statuses of these signals S1, S2, S4. This is shown in the flow chart of Fig. 5, whereupon in a first step F0 the electronic control unit 4 is e.g. initialized. Thereby the electronic control signal S5 can comprise e.g. a Boolean value which defines if the solenoid valve 5 should be actuated, e.g. if S5 = 1, or should be left in its current or a previously stored position, e.g. if S5 = 0.

In a second step F1 the electronic control unit checks if the signals S1, S2, S4 are available. Therefore the electronic control unit 4 periodically monitors these signals S1, S2, S4. If these signals S1, S2, S4 are available their statuses, e.g. ignition "on" or manual override "active", are checked in a further step F2.

In a step F3 the electronic control unit 4 checks the statuses of the signals S1, S2, S4 for a damping delay time t_damp, which may be a predefined time delay set in the electronic control unit 4 to avoid frequent exhaust of the
suspension bellows 14. During this damping delay time $t_{\text{damp}}$ the electronic control unit 4 checks whether the statuses of the signals $S_1$, $S_2$, $S_4$ are changing. If so the changing of the signal is considered as noise or an unwanted change and the signals $S_1$, $S_2$, $S_4$ will maintain at their previous states. If the statuses are not changing during the damping delay time $t_{\text{damp}}$ the signals $S_1$, $S_2$, $S_4$ are stored, e.g. in a memory unit, and are processed further in step F4. After the statuses are checked the damping delay counter is reset to zero.

For further processing the electronic control unit 4 can in particular use the ignition signal $S_1$ as a necessary condition for lifting the lift axle; thus if $S_1 = 1$ may indicate "ignition on", then $S_1=1$ is a necessary condition for $S_5 = 1$, which switches the solenoid valve 5 via a first control input 5a.

Further the electronic control unit 4 can use the traction assistance input signal $S_2$ as a necessary condition for lifting the lift axle; thus if $S_2=1$ may indicate e.g. that a reverse gear is used, then $S_2=1$ is necessary for $S_5=1$ which switches the solenoid valve 5 via the first control input 5a.

Further the electronic control unit 4 compares an axle height position indicated by the load condition sensing signal $S_4$ with a predetermined value $h_{\text{thresh}}$ and decides on basis of this comparison, if the lift axle has to be lifted or not. The result of this comparison is referenced to by "$\text{comp}(S_4)$".

Furthermore, the electronic control unit 4 can perform a low pass filtering (LP) either of this comparison result "$\text{comp}(S_4)$" or on the sensing signal $S_4$ before the comparison is carried out, in order to avoid the above mentioned unnecessary switching in case of e.g. a bumpy road.
The result of this low pass filtering leads to a Boolean value which is referenced to by "LP(comp(S4))" or "comp(LP(S4))" depending on when the low pass filtering is carried out.

This leads to an overall Boolean operation:

\[ S5 = S1 \text{ AND } (S2 \text{ OR } \text{LP}(\text{comp}(S4))), \text{ or } \]
\[ S5 = S1 \text{ AND } (S2 \text{ OR } \text{comp}(\text{LP}(S4))), \]  
(Eq. 1)

whereas the manual override indicated by traction assistance input signal S2=1 is only possible in the state "ignition on", S1=1. If the electric control signal S5 meets the above said equation (Eq.1), meaning S5 = 1, the electronic control unit 4 actuates the solenoid valve 5 to lift the axle by switching the solenoid valve 5 and thus separating the second pressure air line 42 and third pressure air line 43, thereby switching the second relay valve 7 from the position (state) of Fig. 2 into its second position, in which the second control input 7a of the second relay valve 7 is not charged with pressure; in this second position the lift bellow 16 is charged with pressurized air in order to lift the lift axle.

If the signals S1, S2, S4 are not available in step F1 the electronic control unit 4 in a further step F1.1 checks previous signal statuses which may be stored in a memory unit of the electronic control unit 4. If any of the signals, e.g. S4, in memory are active, the electronic control unit 4 considers the current situation. If any of the signals, e.g. S4, becomes 0 the corresponding signal, e.g. S4, is monitored for the predefined damping delay time t_damp in a further step F1.2. If the damping delay time t_damp has elapsed and S4 stays 0, the flag of the signal S4 is disabled and the signal S5 is deactivated (S5=0) in a further step 1.3. If the damping delay time is not elapsed and the signal S4 changes, then it will be considered as an unwanted signal or noise and the electronic control signal S5 is maintained in its previous state.
Thus in the same way as in step F3 the electronic control unit 4 checks the stored statuses of the signals S1, S2, S4 for a predefined amount of time, the damping time $t_{\text{damp}}$, and then further processes these signals S1, S2, S4 in a step F1.4 to actuate the solenoid valve 5 depending on the Boolean operation (Eq. 1) as it is done in step F4.

In a last step F5 the delay counters are reset and the current statuses of the signals S1, S2, S4, S5 are updated.

It will be appreciated that various other embodiments are possible without departing from the scope and ambit of this invention.
List of references (Part of the description)

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<th>Description</th>
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101 lift axle control system
102 lift axle control valve
103 load detection valve
105 spool valve
106 differential pressure valve
107 first solenoid valve
108 second solenoid valve
109 relay valve
110 damping reservoir
111 pressurized air reservoir
112 small orifice (throttle)

130 common exhaust
220 first delivery port
250 second delivery port
300 common exhaust
301 self balancing mechanism of valve 3
342 pressure port of 3
500 port
501 first return spring valve 5
542,543 pressure ports of 5
550 control input
600 supply ports
601 self balancing mechanism of valve 6
641, 643, 644 pressure ports of 6
700 delivery pressure
701, 741, 743, 745 pressure ports of 7
702 second return spring valve 7
800 delivery port
900 delivery port
1000 vehicle
1010 screw arrangement
1050 cam arrangement
1100 lever arrangement

5
comp comparison
h_thresh load detection threshold
IG ignition signal
LP low pass filtering

10
p2 supply pressure
p3 modulated pressure
51 ignition input signal
52 traction assistance input signal
53 ground signal

15
S4 load condition sensing signal
S5 electric control signal
TA electric override signal
t_damp damping delay time
Patent claims

1. Lift axle control unit (1) for a lift axle suspension system (30) of a vehicle (1000), said lift axle control unit (1) comprising at least:

   an electronic control unit (4) receiving at least a first electric input signal (S1) and a position indicating signal (S4),

   at least one supply input port (100) to be connected to a pressure reservoir (2),

   a first delivery port (220) to be connected to at least one suspension bellow (14) and a second delivery port (250) to be connected to at least one lift bellow (16),

   a load detection valve (3) being connectable to load variable parts (1010) of said vehicle (1000) and delivering a pressure output signal (p3) in dependence of an axle load of the vehicle (1000),

   a first relay valve (6) connected to said first delivery port (220) for feeding said suspension bellow (14),

   a second relay valve (7) connected to said second delivery port (250) for feeding at least one lift bellow (16),

   a solenoid valve (5) for receiving an electric control signal (S5) from said electronic control unit (4) and for connecting said load detection valve (3) to said first and second relay valve (6, 7) or separating it from said first and second relay valve (6, 7) in dependence of said electric control signal (S5).

2. Lift axle control unit (1) according to one claim 1, wherein said electronic control unit (4) receives an override input signal (S2), e.g. a traction assistance input signal (S2), for charging the lift bellow (16) independently of said position indicating signal (S4).

3. Lift axle control unit (1) according to one of the preceding claims, wherein said electronic control unit (4) produces said electric control
signal (S5) on basis of a Boolean calculation of said override input signal (S2), said first electric input signal (S1) and a function of said position indicating signal (S4), said function including a comparison with a predetermined value (h_thresh) and/or a low pass filtering.

4. Lift axle control unit (1) according to claim 3, wherein said electric control signal (S5) is calculated by

\[ S5 = S1 \text{ AND } (S2 \text{ OR } LP(\text{comp}(S4))) \text{ or } \]
\[ S5 = S1 \text{ AND } (S2 \text{ OR } \text{comp}(LP(S4))), \]

wherein

5.1 is said first electric input signal

5.2 is said override input signal

LP(\text{comp}(S4)) is a low pass filtered result of said comparison of said position indicating signal (S4) or \text{comp}(LP(S4)) is said comparison after said position indicating signal (S4) has been low pass filtered.

5. Lift axle control unit (1) according to one of the preceding claims, wherein said load detection valve (3) is pneumatically connected to said supply input port (100).

6. Lift axle control unit (1) according to one of the preceding claims, wherein said first and second relay valve (6, 7) are connected in parallel to said solenoid valve (5).

7. Lift axle control unit (1) according to one of the preceding claims, wherein said first and second relay valve (6, 7) are connected to first pressure lines (41) extending from said supply input port (100).

8. Lift axle control unit (1) according to one of the preceding claims, comprising only said a load detection valve (3), said first and second relay valves (6, 7) and said solenoid valve (5) and no further valve
9. Lift axle control unit (1) according to one of the preceding claims, further comprising a position sensor (8) for sensing at least one position of said variable parts (1100) of said vehicle (1000), which depends on an axle position, and for outputting said position signal (S4) to said electronic control unit (4).

10. Lift axle control unit (1) according to claim 9, wherein said position sensor (8) being combined with said load detection valve (3).

11. Lift axle control unit (1) according to one of the preceding claims, wherein said lift axle control unit (1) comprises a multilayer construction of layers (51, 52, 53, 54, 55) connected to each other.

12. Lift axle control unit (1) according to claim 11, wherein said multilayer construction comprises at least a top layer (51) and bottom layer (55) for closing said multilayer construction,
a valve layer (53) comprising said valves (3, 5, 6, 7) and said electronic control unit (4) and an air passage layer (52) comprising air conduits or pressure lines (41, 43) as cavities (41a, 3a).

13. Lift axle control unit (1) according to one of the preceding claims, further comprising one single common exhaust port (300).

14. Lift axle suspension system (30) of a commercial vehicle (1000), comprising:
a lift axle control unit (1) according to one of the preceding claims,
at least one suspension bellow (14) connected to said first delivery port (220) of said lift axle control unit (1),
at least one lift bellow (16) connected to said second delivery port (250) of said lift axle control unit (1), and
a lever arrangement (1100) being influenced by an axle load, which lever arrangement (1100) is connected to or influencing said load detection valve (3).

15. Vehicle (1000) comprising a lift axle suspension system (3) according to claim 14.
Fig. 5

Diagram:

- **F0**
- **F1**
  - no
  - yes
  - **F1.1**
  - **F1.2**
  - **F1.3**
  - **F1.4**
- **F2**
- **F3**
- **F4**
- **F5**
**INTERNATIONAL SEARCH REPORT**

**PCT/IB2014/000598**

### A. CLASSIFICATION OF SUBJECT MATTER

INV. B60G17/052  B60G17/056

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)

B60G

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

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Relevant to claim No.</th>
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* Further documents are listed in the continuation of Box C.  

* See patent family annex.

**Date of the actual completion of the international search**

28 May 2014

**Date of mailing of the international search report**

16/06/2014

**Name and mailing address of the ISA/**

European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016

**Authorized officer**

Sl uimer, Paul

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