

Method for supporting a carrier vehicle

The present invention relates to a method for supporting a carrier vehicle, parked on a piece of ground, for a lifting device with a support system according to the preamble of claim 1, a computer program product for executing such a method, a controller for a support system for carrying out such a method, and a vehicle with such a controller.

10 It is known in the state of the art that carrier vehicles are supported on a piece of ground with support systems, for example for increasing the stability of the carrier vehicle, or in order to orient the carrier vehicle relative to a predefined or predefinable spatial direction and/or spatial plane. The supporting is normally effected via supporting legs which are adjustable in terms of their longitudinal extent and which can be supported on the piece of ground and can influence the inclination of the carrier vehicle by alteration of the longitudinal extent. An inclination of the carrier vehicle and/or of the lifting device relative to a predefined or predefinable spatial direction and/or spatial plane can be detected with an inclination sensor.

25 Devices in the form of hydraulically operable support systems for leveling a carrier vehicle are known in the state of the art, in which the operation of the individual supporting legs is effected manually and iteratively until a predefined leveling of the carrier vehicle is achieved (usually between 0° and 3° with respect to the horizontal).

30 Devices and methods which make an at least partially automatically controlled leveling of a carrier vehicle possible are further known in the state of the art.

A leveling system with extendable supporting legs with hydraulic cylinders is known from the document US 5,580,095 A. Operation times for the supporting legs, for the duration of which an activation of the supporting legs can be effected, can be
5 calculated starting from a measured inclination about a transverse axis and about a longitudinal axis of a carrier vehicle.

A leveling mechanism with support cylinders which can be
10 selectively supplied with hydraulic fluid is known from the document DE 40 33761 C1. For leveling a body to be leveled, the support cylinders can be extended synchronously or successively with metered quantities of hydraulic fluid.

15 The object of the invention is to specify a method for leveling a carrier vehicle that is improved compared with the state of the art.

The object is achieved by a method according to claim 1, a
20 computer program product for executing such a method, and a controller which is formed for carrying out such a method.

Advantageous embodiments are defined in the dependent claims.

25 The method serves for supporting a carrier vehicle with a support system on a piece of ground. Through a support system, for example, an increase in the stability of the carrier vehicle can be achieved and the carrier vehicle can be oriented relative to a predefined or predefinable spatial direction and/or spatial
30 plane.

A predefined or predefinable spatial plane can be, for example, a horizontal plane. A possible orientation which can be achieved after minimization of the inclination of the carrier vehicle

and/or the lifting device can be, for example, between 0° and 3° with respect to the horizontal.

5 The supporting is normally effected via supporting legs which are adjustable in terms of their longitudinal extent and which can be supported on the piece of ground and can influence the inclination of the carrier vehicle and/or the lifting device by alteration of the longitudinal extent.

10 There can be an inclination of the carrier vehicle and/or the lifting device due to parking on an inclined piece of ground. An inclination can also be caused by a payload of the carrier vehicle or a loading of a lifting device arranged on the carrier vehicle.

15 The support system can be connected to the vehicle frame. If the carrier vehicle has a lifting device, the support system can be connected to the lifting device.

20 The support system can have two or more supporting legs. The supporting legs can be arranged in different positions relative to the carrier vehicle or the lifting device.

In particular, the support system can have four supporting legs, 25 which can be part of a so-called H support (H-shaped arrangement of the supporting legs) or an X support (X-shaped arrangement, also called star support).

The support system can have a controller for actuating drives 30 of the supporting legs using control commands. For example, the supporting legs can have drives in the form of hydraulic cylinders for retracting and/or extending the supporting legs, and the controller can actuate magnetically operable control valves of the hydraulic cylinders using control pulses. A

corresponding activation of electric drives is not to be ruled out.

5 It is not to be ruled out that the support system has horizontally adjustable supporting arms, on which the supporting legs are arranged. It is also not to be ruled out that the controller is formed for actuating drives of the supporting arms using control commands.

10 The support system can have at least one inclination sensor for detecting an inclination of the carrier vehicle and/or of the lifting device relative to at least one predefined or predefinable spatial direction and/or spatial plane.

15 For example, the inclination of the carrier vehicle and/or of the lifting device relative to two spatial directions can be detected.

20 In particular, inclinations relative to two spatial directions which span a horizontal plane can be detected.

For example, an inclination about a transverse axis and/or about a longitudinal axis of a carrier vehicle, for example with reference to a frame of the carrier vehicle, can be detected.

25 The detected inclination can be with reference, for example, to a horizontal orientation of the carrier vehicle.

30 For example, an inclination of a lifting device arranged on a carrier vehicle, in particular a crane column of a lifting device, relative to at least one spatial direction in a horizontal and/or vertical plane can be detected.

A detected inclination can be, for example, an angle of a substantially vertically running swivel axis of a crane column

of a lifting device relative to a horizontal plane, spatial plane or spatial direction. For the orientation, an at least approximately right angle of the swivel axis of the crane column relative to the horizontal can be sought.

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In the method, in a calculation method step a sequence of control commands for the sequential and time-limited activation of individual drives of the supporting legs of the support system can be calculated on the basis of a currently detected
10 inclination of the carrier vehicle and/or of the lifting device.

The calculation of the control commands can be effected with the aim of orienting the carrier vehicle relative to a predefined or predefinable spatial direction and/or spatial plane. In the
15 case of such an orientation or leveling a spatial direction and/or spatial plane can be predefined or predefinable, and a part of the carrier vehicle or of a lifting device arranged on a carrier vehicle can be oriented relative to this spatial direction and/or spatial plane by executing the calculated
20 control commands.

The calculation of the control commands can be effected such that a reduction of the inclination is achievable to a certain degree through the execution of the control commands.

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It is not to be ruled out that an orientation relative to two different spatial directions can be effected when the method is carried out.

30 With a currently detected inclination of the carrier vehicle and/or of the lifting device, a deviation relative to the predefined or predefinable spatial direction and/or spatial plane can be determined, and corresponding control commands for reducing the deviation can be calculated.

By currently detected inclination of the carrier vehicle and/or of the lifting device can be meant the inclination of the carrier vehicle and/or of the lifting device prevailing immediately
5 before or while the calculation method step is carried out.

In a leveling method step, in principle, an activation of the drives of the supporting legs of the support system can be effected for reducing the inclination of the carrier vehicle
10 and/or of the lifting device. During execution of a leveling method step the inclination of the carrier vehicle and/or of the lifting device can be at least partially reduced.

During activation of the drives of the supporting legs of the support system using the sequence of control commands a
15 sequential and time-limited activation of individual drives of the supporting legs of the support system can be effected using control pulses.

20 Individual drives of the supporting legs can be actuated substantially separately from each other in terms of time in an order or sequence.

The activation of the drives can be effected using control pulses
25 which are output sequentially by the controller and time-limited.

An activation of a drive of a supporting leg can, in principle, be effected for the time duration of a control pulse.

30 In the method, a repetition of the calculation method step and of the leveling method step can be effected in a loop for minimizing the inclination of the carrier vehicle and/or of the lifting device.

The inclination of the carrier vehicle and/or of the lifting device relative to at least one predefined or predefinable spatial direction and/or spatial plane can be effected in each pass through the loop, during which a repetition of the calculation method step and of the leveling method step is effected, a partial reduction of the inclination relative to at least one predefined or predefinable spatial direction and/or spatial plane.

- 10 An inclination of the carrier vehicle and/or of the lifting device and a corresponding deviation from the desired orientation can be detected in each pass through the loop.

- 15 If the inclination of the carrier vehicle and/or of the lifting device is only partially reduced during an execution of an individual leveling method step, a further sequence of control commands for the sequential and time-limited activation of individual drives of the supporting legs of the support system can be calculated in at least one further calculation method step on the basis of an inclination of the carrier vehicle and/or of the lifting device detected after the preceding leveling method step has been carried out.

- 25 Subsequently, in at least one further leveling method step an activation of the drives of the supporting legs of the support system can be effected using the further sequence of control commands for minimizing the inclination of the carrier vehicle and/or of the lifting device relative to at least one predefined or predefinable spatial direction and/or spatial plane.

- 30 This repetition loop can be passed through until the detected inclination of the carrier vehicle and/or of the lifting device reaches or falls below a predefined or predefinable threshold value. The threshold value can be with reference to the

inclination of the carrier vehicle and/or of the lifting device relative to at least one predefined or predefinable spatial direction and/or spatial plane.

- 5 Through the method, instead of a clocked activation, thus a temporally dimensioned, continuous and possibly simultaneous activation, of the supporting legs, an orientation of a carrier vehicle, parked on a piece of ground, for a lifting device with a support system can be broken down into a sequential sequence
10 of a plurality of control pulses with, in each case, limited time duration.

Through the activation of the drives using control pulses which are sequentially output by the controller and time-limited, an
15 inclination of the carrier vehicle and/or of the lifting device can be incrementally reduced.

In a calculation method step a sequence of control commands for the sequential and time-limited activation of individual drives
20 of the supporting legs of the support system for the partial reduction of the inclination of a carrier vehicle and/or of the lifting device can generally be calculated. A partial reduction of the inclination can be a part of the total desired or required reduction of the inclination for orienting the carrier vehicle
25 and/or the lifting device.

In a leveling method step a partial reduction of the inclination of a carrier vehicle and/or of the lifting device can generally be effected. A partial reduction of the inclination can be a
30 part of the total desired or required reduction of the inclination for orienting the carrier vehicle and/or the lifting device.

A repetition of the calculation method step and of the leveling method step can be effected in a loop for minimizing the inclination of the carrier vehicle and/or of the lifting device, wherein during each repetition of the loop a sequence of control
5 commands for the partial reduction of the inclination of a carrier vehicle and/or of a lifting device can be calculated and the sequence of control commands for the partial reduction of the inclination of a carrier vehicle and/or of the lifting device can be implemented. This can be effected incrementally until the
10 detected inclination of the carrier vehicle and/or of the lifting device reaches or falls below a predefined or predefinable threshold value, thus in total the desired or required reduction of the inclination for orienting the carrier vehicle and/or the lifting device is achieved.

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In an advantageous embodiment of the method, for example after the carrier vehicle has been parked on the piece of ground, an activation of the drives of the supporting legs of the support system can be effected in a floor-contact method step using
20 control commands, through which the supporting legs are brought into contact with the piece of ground. The control commands can be calculated as a sequence of control commands for the sequential and time-limited activation of individual drives of the supporting legs of the support system on the basis of a
25 currently detected inclination of the carrier vehicle and/or of the lifting device.

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In an advantageous embodiment of the method, after minimization of the inclination of the carrier vehicle and/or of the lifting device has been effected, a continuous detection of an inclination of the carrier vehicle and/or of the lifting device relative to at least one predefined or predefinable spatial direction and/or spatial plane can be effected in a monitoring method step.

If, for example after supporting and orientation of the carrier vehicle, a lifting device arranged thereon is used during working operation, or for example a payload of the carrier vehicle is altered, undesired changes in the inclination of the carrier vehicle and/or of the lifting device can occur due to the loads occurring and/or alterations in the piece of ground used for the supporting. These can be recognized and determined through a continuous detection of the inclination.

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When the detected inclination reaches or exceeds a predefined or predefinable deviation, a repetition of the execution of at least one calculation method step and of at least one leveling method step can be effected. The deviation can be with reference to the threshold value used for the orientation.

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Such a repetition can be effected autonomously by the controller or after corresponding confirmation, or by targeted selection by a user.

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Analogously to the minimization of the inclination of the carrier vehicle and/or of the lifting device, a repetition of the calculation method step and of the leveling method step can be effected in a loop until the detected inclination of the carrier vehicle and/or of the lifting device again reaches or falls below a predefined or predefinable threshold value.

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In an advantageous embodiment of the method, in a calculation method step, which follows a leveling method step carried out beforehand, a change in the inclination due to the preceding leveling method step can be detected. It can be determined whether a corresponding reduction of the inclination was achieved with effected execution of the control commands. It can be deduced from this whether the actuated supporting legs have

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been in floor contact. It is not to be ruled out that a torsional and bending stiffness and/or a twisting of the carrier vehicle can be determined thereby.

- 5 In an advantageous embodiment of the method, the time-limited activation of the individual drives of the supporting legs of the support system using the sequence of control commands can be effected using control pulses with variable pulse duration. Different parameters of the support system can be taken into
10 account with a variable pulse duration.

The pulse duration of the control pulses can advantageously be 0.05 seconds to 3.50 seconds. The pulse duration of the control pulses can preferably be 0.25 seconds to 1.5 seconds. It is
15 conceivable that the pulse duration of the control pulses is 0.25 to 0.50.

A variation of the pulse duration - and where applicable of a duration of an overlap of successive control pulses - can in
20 principle be effected depending on:

- parameters of the drives of the supporting legs, such as for instance the lifting rate, the piston diameter or the pumping power and/or
- parameters of the geometry of the supporting legs, such as
25 for instance the prevailing or possible longitudinal extent, or a length of extension arms with supporting legs of the support system and/or
- parameters of the position of the supporting legs and/or
- the number of supporting legs and/or
- 30 - the currently measured inclination of the carrier vehicle and/or of the lifting device, and/or
- the currently predefined pulse duration, for example calculated in a preceding calculation method step, and/or

- the number and/or position of axles of the carrier vehicle and/or
 - the position of a lifting device arranged on the carrier vehicle and/or
- 5 - a torsional and bending stiffness and/or a twisting of the carrier vehicle
- the predefined or predefinable spatial direction and/or spatial plane.
- 10 In an advantageous embodiment of the method, the activation of the drives of the individual supporting legs of the support system using the sequence of control commands can be effected in an activation sequence in a predefinable or predefined order. Particular supporting legs of the support system can preferably
- 15 be actuated.

A preferred activation can be effected, for example, in order to keep a center of gravity of the carrier vehicle as low as possible or in order to take torsional and bending stiffnesses

20 of the carrier vehicle into account.

A preferred activation can comprise a selection or weighting of individual or several supporting legs.

25 In an advantageous embodiment of the method, the longitudinal extent of the supporting legs can be made larger and/or smaller during an activation of the drives of the supporting legs of the support system in a leveling method step. The support system can thereby not only lift the carrier vehicle away from the piece

30 of ground, but also lower it toward the piece of ground.

In an advantageous embodiment of the method, the activation of the individual drives of the supporting legs of the support system using the sequence of control commands can be effected

using control pulses with a time-limited, predefined or predefinable overlap between successive control pulses. Control pulses succeeding one another in the sequence of control commands can be simultaneously output by the controller in sections.

An overlap of control pulses can be calculated in a calculation method step.

Thus, for example, the activation of a drive of one supporting leg for the duration of a control pulse can be started by output by the controller, and the activation of the drive of the next supporting leg according to the calculated sequence can already be started before the ongoing control pulse has ended.

The time-limited, predefined or predefinable duration of the overlap determines the duration of an activation, which is simultaneous in sections, of drives of supporting legs.

A substantially smooth orientation of a carrier vehicle can be effected through an overlap between successive control pulses. Vibrations occurring due to abrupt switching on and off of drives of supporting legs can be lessened.

Within the overlap between successive control pulses a simultaneous activation of at most two drives can advantageously be effected.

The duration of the overlap between successive control pulses output by the controller can generally be between 0.01 seconds and 0.5 seconds. The duration of the overlap can preferably be between 0.01 seconds and 0.1 seconds.

Protection is also sought for a computer program product comprising commands which, when executed by a computing unit, prompt the latter to execute a method as described previously from a storage unit which is in or can be brought into data connection with the computing unit.

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Commands of the computer program product can be recorded, for example, in at least one storage unit of a controller and can be executed by at least one computing unit of a controller.

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Protection is also sought for a controller for a support system which is formed for carrying out a method as described previously.

The controller can, in principle, have at least one computing unit and at least one storage unit. The computing unit can be in or be able to be brought into data connection with the storage unit.

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In a calculation operating mode a sequence of control commands for the sequential and time-limited activation of individual drives of the supporting legs of the support system can be calculable by the controller on the basis of a currently detected inclination of the carrier vehicle and/or of the lifting device.

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The calculation can be effected, for example, by a computing unit of the controller, and calculated control commands can be stored in a storage unit of the controller.

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In an activation operating mode of the controller the drives of the supporting legs of the support system can be actuatable using the sequence of control commands for reducing the inclination of the carrier vehicle and/or of the lifting device relative to at least one predefined or predefinable spatial direction and/or spatial plane, wherein, using the sequence of

control commands, a sequential and time-limited activation of individual drives of the supporting legs of the support system is effected using control pulses.

- 5 Control commands stored in a storage unit of the controller can be output by the controller in accordance with the sequence.

In a loop operating mode of the controller, for minimizing the inclination of the carrier vehicle and/or of the lifting device,
10 the calculation of the sequence of control commands and the activation of the drives of the supporting legs of the support system using the sequence of control commands can be able to be carried out repeatedly in a loop until the detected inclination of the carrier vehicle and/or of the lifting device reaches or
15 falls below a predefined or predefinable threshold value.

In each pass through the loop a calculation can be effected by a computing unit of the controller, calculated control commands can be stored in a storage unit of the controller, and control
20 commands stored in a storage unit of the controller can be output by the controller in accordance with the sequence.

Protection is also sought for a vehicle, in particular a carrier vehicle with a lifting device, with a support system as described
25 previously and a controller as described previously for the support system. The lifting device can generally be formed as a crane, in particular as an articulated arm crane.

Embodiment examples of the invention are discussed with
30 reference to the figures. There are shown in:

Fig. 1, schematically, the procedure of an embodiment of the method,

- Fig. 2, schematically, the procedure of a further embodiment of the method,
- Fig. 3 a side view of an embodiment of a carrier vehicle parked on an inclined piece of ground,
- 5 Fig. 4 a side view of an embodiment of a leveled carrier vehicle parked on an inclined piece of ground,
- Fig. 5 a top view of an embodiment of a carrier vehicle,
- Fig. 6 a schematic representation top view of an embodiment of a carrier vehicle
- 10 Fig. 7 a schematic representation of a lifting device with an embodiment of a support system
- Fig. 8 a perspective view of an embodiment of a carrier vehicle,
- Figs. 9a to 9e a schematic representation of a leveling, and
- 15 Figs. 10a and 10b, in each case, a schematic representation of two successive control pulses.

With reference to the embodiments, shown in the above figures, of a carrier vehicle 8 with a support system 7, Figure 1

20 illustrates an embodiment of a method for supporting a carrier vehicle 8, parked on a piece of ground 10, for a lifting device 9 with a support system 7. The support system 7 comprises, as represented,

- supporting legs 1, 2, 3, 4 vertically adjustable in terms
- 25 of their longitudinal extent for supporting on the piece of ground 10, and
- a controller 5 for actuating drives of the supporting legs 1, 2, 3, 4 using control commands, and
- at least one inclination sensor 6 for detecting an
- 30 inclination α of the carrier vehicle 8 and/or of the lifting device 9 relative to at least one predefined or predefinable spatial direction and/or spatial plane.

In a calculation method step i, a sequence of control commands for the sequential and time-limited activation of individual drives of the supporting legs 1, 2, 3, 4 of the support system 7 can be calculated on the basis of a currently detected
5 inclination α of the carrier vehicle 8 and/or of the lifting device 9.

In a leveling method step ii following that, an activation of the drives of the supporting legs 1, 2, 3, 4 of the support
10 system 7 can be effected using the sequence of control commands for reducing the inclination α of the carrier vehicle 8 and/or of the lifting device 9 relative to at least one predefined or predefinable spatial direction and/or spatial plane, wherein, using the sequence of control commands, a sequential and time-
15 limited activation of individual drives of the supporting legs 1, 2, 3, 4 of the support system 7 can be effected using control pulses s1, s2 (see Figures 10a and 10b).

For minimizing the inclination α of the carrier vehicle 8 and/or
20 of the lifting device 9, a repetition of the calculation method step i and of the leveling method step ii can be effected in a loop iii until the detected inclination α of the carrier vehicle 8 and/or of the lifting device 9 reaches or falls below a predefined or predefinable threshold value.

25 As in a particularly preferred embodiment of the method, as is shown schematically in Figure 2, after minimization of the inclination α of the carrier vehicle 8 and/or of the lifting device 9 (steps i to iii) has been effected, a continuous
30 detection of an inclination α of the carrier vehicle 8 and/or of the lifting device 9 relative to at least one predefined or predefinable spatial direction and/or spatial plane can be effected in a monitoring method step iv.

When the detected inclination α reaches or exceeds a predefined or predefinable threshold value, a repetition of the execution of at least one calculation method step i and of at least one leveling method step ii can be effected.

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For minimizing the inclination α of the carrier vehicle 8 and/or of the lifting device 9 occurring, a repetition of the calculation method step i and of the leveling method step ii can be effected again in a loop iii until the detected inclination

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α of the carrier vehicle 8 and/or of the lifting device 9 again reaches or falls below a predefined or predefinable threshold value.

Generally, in the loop iii, in a calculation method step I, which can follow a leveling method step ii carried out beforehand, a detection of the change in the inclination α due to the preceding leveling method step ii can be effected. Effects of the activation carried out can thereby be assessed.

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Figure 3 shows a side view of an embodiment of a carrier vehicle 8 parked on an inclined piece of ground 10 (inclination angle in the representation is approximately 5°) with a lifting device 9 in the form of an articulated arm crane arranged thereon. The piece of ground 10 is inclined by an angle with respect to the horizontal H. In this unsupported state the carrier vehicle 8 parked on the inclined piece of ground 10 is inclined with respect to the horizontal H substantially about a transverse axis y of the carrier vehicle 8 (see Figure 6) by the inclination α , in this embodiment measured relative to the vehicle frame.

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An inclination of the carrier vehicle 8 about a longitudinal axis x can analogously be there, but is not shown in this example embodiment.

In this embodiment, the carrier vehicle 8 has a support system with four supporting legs 1, 2, 3, 4 (partially concealed, cf. also Figure 5), an inclination sensor 6 and a controller 5, arranged on the carrier vehicle in this embodiment, for
 5 actuating drives of the supporting legs 1, 2, 3, 4 using control commands.

Figure 4 shows a side view of the embodiment shown in Figure 3 of a carrier vehicle 8 parked on an inclined piece of ground 10.
 10 The parked carrier vehicle has been oriented relative to the horizontal H and thus leveled after supporting has been effected via the supporting legs 1, 2, 3, 4 on the piece of ground 10 by carrying out the method. The inclination α with respect to the horizontal H is substantially 0° in the representation.

15 It can be seen that at least one wheel of the carrier vehicle 8 has remained on the piece of ground 10, thus the carrier vehicle 8 has not been completely lifted by the supporting legs 1, 2, 3, 4. Unlike what is represented, a complete lifting of the
 20 carrier vehicle 8 can also be effected.

Unlike what is represented, the inclination can also be with reference to the angle of a substantially vertically running swivel axis 15 of a crane column of the lifting device 9 relative
 25 to the horizontal H or to a vertical plane. For this, Figure 4 shows an alternative or additional arrangement of the inclination sensor 6. For the orientation, an at least approximately right angle of the swivel axis 15 of the crane column relative to the horizontal can be sought.

30 Generally, an orientation relative to a predefined or predefinable spatial direction and/or spatial plane can be possible.

Figure 5 shows a top view of an embodiment as shown previously of a carrier vehicle 8. As represented, the support system 7 has horizontally adjustable supporting arms 11, 12, 13, 14, on which the supporting legs 1, 2, 3, 4 are arranged. The controller 5
 5 can be formed for actuating drives of the supporting arms 11, 12, 13, 14 using control commands.

Figure 6, which shows a schematic representation of a top view of an embodiment of a carrier vehicle 8 with a front axle 18 and
 10 a rear axle 19 analogous to the preceding embodiments, illustrates the longitudinal axis x and the transverse axis y of the carrier vehicle 8. The inclination sensor 6 can, as represented, lie at the origin of the coordinate system spanned by the longitudinal axis x and the transverse axis y and situated
 15 on the swivel axis 15 of the crane column of the lifting device 9.

An orientation about the longitudinal axis x can be effected through the relationship of the longitudinal extents of the
 20 supporting legs 1 and 2 (cf. Figure 9). An orientation about the transverse axis y can be effected through the constant component, thus the respective absolute value of the longitudinal extents.

A variation of the pulse duration t1, t2 of the control pulses
 25 s1, s2, using which the controller 5 (cf. Figure 7) can actuate the drives of the supporting legs 1, 2, 3, 4, and possibly of an overlap d can be effected depending on:

- parameters of the drives of the supporting legs 1, 2, 3, 4 and/or
- 30 - parameters of the geometry of the supporting legs 1, 2, 3, 4, for instance the distance thereof from the swivel axis 15 of the crane column of the lifting device 8 and/or
- parameters of the position of the supporting legs (1, 2, 3, 4), for instance the arrangement thereof on the vehicle

frame relative to a lifting device 8, in particular relative to a swivel axis 15 of a crane column of the lifting device 8, and/or

- the number of supporting legs 1, 2, 3, 4 and/or
- 5 - the currently measured inclination α of the carrier vehicle 8 and/or of the lifting device 9 and/or
- the currently predefined pulse duration t_1 , t_2 and/or
- the position of axles 18, 19 of the carrier vehicle 8 and/or
- the position of a lifting device 9 arranged on the carrier
- 10 vehicle 8 and/or
- a torsional and bending stiffness and/or a twisting of the carrier vehicle 8 and/or
- the predefined or predefinable spatial direction and/or spatial plane.

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Figure 7 shows a schematic representation of a lifting device 9 with an embodiment of a support system 7. The support system 7 comprises, as represented,

- two supporting legs 1, 2, vertically adjustable in terms
- 20 of their longitudinal extent, for supporting on a piece of ground 10, and
- a controller 5 for actuating drives of the supporting legs 1, 2 using control commands, and
- at least one inclination sensor 6 for detecting an
- 25 inclination α of the lifting device 9 relative to at least one predefined or predefinable spatial direction and/or spatial plane.

Unlike what is represented, the support system 7 can have

30 additional supporting legs and several inclination sensors 6, for instance such as those in Figures 3 to 6.

Besides the inclination sensor 6, the controller 5 can generally also be able to be supplied with measured values relating to operating parameters of the supporting legs 1, 2.

- 5 The controller 5 can, in principle, have at least one computing unit 16 and at least one storage unit 17. The computing unit 16 can be able to be brought into data connection with the storage unit 17.
- 10 In a calculation operating mode a sequence of control commands in the form of control pulses for the sequential and time-limited activation of individual drives of the supporting legs 1, 2 of the support system 7 can be calculable by the controller 5 on the basis of a currently detected inclination α of the lifting
- 15 device 9.

The calculation can be effected, for example, by a computing unit 16 of the controller 5, and calculated control commands can be stored in a storage unit 17 of the controller 5.

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- In an activation operating mode of the controller 5 the drives of the supporting legs 1, 2 of the support system 7 can be actuatable using the sequence of control commands for reducing the inclination α of the lifting device 9 relative to at least
- 25 one predefined or predefinable spatial direction and/or spatial plane, wherein, using the sequence of control commands, a sequential and time-limited activation of individual drives of the supporting legs 1, 2 of the support system 7 can be effected using control pulses.

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Control commands stored in a storage unit 17 of the controller 5 can be output by the controller 5 in accordance with the sequence.

In a loop operating mode of the controller 5, for minimizing the inclination α of the lifting device 9, the calculation of the sequence of control commands and the activation of the drives of the supporting legs 1, 2 of the support system 7 using the sequence of control commands can be carried out repeatedly in a loop until the detected inclination α of the lifting device 9 reaches or falls below a predefined or predefinable threshold value.

In each pass through the loop a calculation can be effected by a computing unit 16 of the controller 5, calculated control commands can be stored in a storage unit 17 of the controller 5, and control commands stored in a storage unit 17 of the controller 5 can be output by the controller 5 in accordance with the sequence.

The longitudinal extent of the supporting legs 1, 2 can generally be made larger and/or smaller during an activation of the drives of the supporting legs 1, 2 of the support system 7.

Figure 8 shows a support device 7 analogous to the embodiment of Figure 7 and arranged on a carrier vehicle 8 with lifting device 9.

An orientation, using a support system 7 (cf. Figure 3 or Figure 7), relative to a spatial direction H (horizontal) predefined by way of example is shown schematically in Figures 9a to 9d. The support system can be connected to a carrier vehicle, not represented in this figure, and/or a lifting device (swivel axis 15).

The orientation represented in Figures 9a to 9e can correspond, with reference to Figure 6, to a leveling about a longitudinal axis x and also to a leveling about a transverse axis y.

The support system 7 has two supporting legs 1, 2 arranged on length-adjustable supporting arms 11, 12. The supporting legs 1, 2 are length-adjustable in terms of their longitudinal extent.

5 The supporting legs 1, 2 used for the orientation in this sequence of figures have, as represented, different (settable) longitudinal extents x_{11} , x_{12} , x_{13} , x_{14} , x_{21} , x_{22} .

10 It is not to be ruled out that, unlike what is represented, the support system 7 has several supporting legs (for example four) and that several of these supporting legs are also used for the orientation, in particular relative to a spatial plane. However, for presentation reasons, the procedure is restricted to two supporting legs.

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Figure 9a shows a support system 7 supported on an inclined piece of ground 10, wherein the supporting legs 1, 2 have been brought into contact with the piece of ground. The direction of view can correspond to a view along a longitudinal axis of a carrier vehicle. The supporting legs 1, 2 in each case have a first longitudinal extent x_{11} , x_{21} . The inclination meter 6
20 outputs an inclination angle α of 7° measured with respect to the horizontal H.

25 Through the activation of the drives of the supporting legs 1 using control pulses s_1 , s_2 which are sequentially output by the controller 5 and time-limited (see Figures 10a and 10b), an inclination α of a carrier vehicle and/or of a lifting device can be incrementally reduced.

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In a calculation method step i (see Figure 1), starting from the respectively measured inclination α , a sequence of control commands for the sequential and time-limited activation of individual drives of the supporting legs 1, 2 of the support

system 7 for the partial reduction of the inclination α can be calculated. A partial reduction of the inclination, such as is represented by way of example from one figure of Figures 9a to 9e to another, can be a part of the total desired or required reduction of the inclination α for orienting the carrier vehicle or the lifting device.

A partial reduction of the inclination α can generally be effected in a leveling method step ii (see Figure 1). A partial reduction of the inclination α can be a part of the total desired or required reduction of the inclination for orienting the carrier vehicle or the lifting device.

In Figure 9b the supporting leg 1 has a second, larger longitudinal extent x_{12} after activation by the controller 5 using a control pulse s_1 . The inclination meter 6 outputs an inclination angle α of 5° measured with respect to the horizontal H , thus the inclination α has been partially reduced.

This can correspond, for example, to a first pass through the calculation method step i and the leveling method step ii.

A repetition of the calculation method step i and of the leveling method step ii can be effected in loops iii (see Figure 1), wherein in each case control commands - and thus control pulses and possibly overlaps - for the supporting legs 1, 2 can be calculated and activations of their drives can be effected using control pulses.

In Figure 9c the supporting leg 2 has a second, larger longitudinal extent x_{22} after a pass through the loop iii and activation effected in the process by the controller 5 using a control pulse s_2 . The inclination meter 6 again outputs an inclination angle α of 7° measured with respect to the horizontal

H. Although the inclination α has been made larger again relative to the shown spatial direction H, with reference to Figure 6 an orientation about the longitudinal axis x can also be effected by changing the longitudinal extents of the supporting legs 1 and 2. Through the constant component, thus the respective absolute value of the longitudinal extents of the supporting legs 1, 2, an orientation about the transverse axis y can be effected. With reference to a horizontal spatial plane, the inclination relative to a spatial direction situated therein (for example seen orthogonal to the spatial direction H) can thus have been reduced again.

In further passes through the loop iii (see Figure 1), in each case, a further repetition of the calculation method step i and of the leveling method step ii can be effected for minimizing the inclination α , wherein, during each repetition of the loop iii, a sequence of control commands and corresponding control pulses, and possibly overlaps of control pulses, for the partial reduction of the inclination α can be calculated and the sequence of control commands for the partial reduction of the inclination α can be implemented.

In Figure 9d the longitudinal extent x13 of the supporting leg 1 has been made incrementally larger in a further pass through the loop iii.

In Figure 9e the longitudinal extent x14 of the supporting leg 1 has been further made incrementally larger a further pass through the loop iii.

The sequence of Figures 9c to 9e represents, for example, three such repetitions of the loop iii, during which the longitudinal extent of the supporting legs 1, 2 is altered stepwise. The reduction of the inclination α is effected incrementally until

the detected inclination α reaches or falls below a predefined or predefinable threshold value, which in the case shown is predefined by way of example as 2° with respect to the spatial direction H. It is not to be ruled out that an orientation
5 relative to two different spatial directions can be effected when the method is carried out. Unlike what is represented, it is possible for a time-limited simultaneous sequential activation of the drives of the supporting legs 1, 2 (and possibly further supporting legs) to be effected for a
10 predefined or predefinable duration.

Figures 10a and 10b in each case show a schematic representation of two successive control pulses s1, s2 with pulse duration t1, t2, wherein the sequential control pulses s1, s2 in Figure 10b
15 have a temporal overlap d.

Through an activation, as illustrated for example in Figures 9a, 9b and 9c, of the drives of the supporting legs 1 using control pulses s1, s2 which are sequentially output by the controller 5
20 and time-limited, an inclination α of a carrier vehicle 8 and/or of a lifting device can be incrementally changed.

In Figure 9b the supporting leg 1 has larger longitudinal extent x12 compared with the representation in Figure 9a after
25 activation by the controller 5 using a first control pulse s1 with pulse duration t1. In Figure 9c the supporting leg 2 has a larger longitudinal extent x22 compared with the representation in Figure 9b after activation by the controller 5 using a second control pulse s2 with pulse duration t2. The activation can be
30 effected, for example, using control pulses s1, s2 according to Figure 10a.

Control pulses s_1 , s_2 succeeding one another in the sequence of control commands can also be simultaneously output by the controller in sections, thus for the duration of an overlap d .

- 5 Thus, for example, according to Figure 10b, the activation of a drive for example of the supporting leg 1 for the pulse duration t_1 of the control pulse s_1 can be started first. Before the ongoing control pulse s_1 ends, the activation of the drive of the next supporting leg 2 can already be started with the output
10 of the control pulse s_2 sequentially following according to the calculated sequence.

- The time-limited, predefined or predefinable duration of the overlap d can determine the duration of an activation,
15 simultaneous in sections, of drives of supporting legs 1, 2.

List of reference numbers:

	1	supporting leg		
	2	supporting leg		
5	3	supporting leg		
	4	supporting leg		
	5	controller		
	6	inclination sensor		
	7	support system		
10	8	carrier vehicle		
	9	lifting device		
	10	piece of ground		
	11	supporting arm		
	12	supporting arm		
15	13	supporting arm		
	14	supporting arm		
	15	crane column swivel axis		
	16	computing unit		
	17	storage unit		
20	18	carrier vehicle front axle		
	19	carrier vehicle rear axle		
	α	inclination		
	i	calculation method step		
	ii	leveling method step		
25	iii	repetition loop		
	iv	monitoring method step		
	H	horizontal		
	x	longitudinal axis		
	y	transverse axis		
30	x11, x12, x13, x14, x21, x22	supporting legs	longitudinal	
		extent		
	s1, s2	control pulse		
	t1, t2	pulse duration		
	d	overlap		

Claims

1. Method for supporting a carrier vehicle (8), parked on a piece
5 of ground (10), for a lifting device (9) with a support system
(7), wherein the support system (7) has at least
- supporting legs (1, 2, 3, 4), vertically adjustable in
terms of their longitudinal extent, for supporting on
the piece of ground (10), and
 - 10 - a controller (5) for actuating drives of the supporting
legs (1, 2, 3, 4) using control commands, and
 - at least one inclination sensor (6) for detecting an
inclination (α) of the carrier vehicle (8) and/or of the
lifting device (9) relative to at least one predefined
 - 15 or predefinable spatial direction and/or spatial plane,
characterized in that
 - in a calculation method step (i) a sequence of control
commands for the sequential and time-limited activation of
individual drives of the supporting legs (1, 2, 3, 4) of
 - 20 the support system (7) is calculated on the basis of a
currently detected inclination (α) of the carrier vehicle
(8) and/or of the lifting device (9)
 - in a leveling method step (ii) an activation of the drives
of the supporting legs (1, 2, 3, 4) of the support system
 - 25 (7) using the sequence of control commands is effected for
reducing the inclination (α) of the carrier vehicle (8)
and/or of the lifting device (9) relative to at least one
predefined or predefinable spatial direction and/or spatial
plane, wherein, using the sequence of control commands, a
 - 30 sequential and time-limited activation of individual drives
of the supporting legs (1, 2, 3, 4) of the support system
(7) is effected using control pulses (s1, s2)

- 5 – for minimizing the inclination (α) of the carrier vehicle (8) and/or of the lifting device (9), a repetition of the calculation method step (i) and of the leveling method step (ii) is effected in a loop (iii) until the detected inclination (α) of the carrier vehicle (8) and/or of the lifting device (9) reaches or falls below a predefined or predefinable threshold value.
- 10 2. Method according to claim 1, wherein, after minimization of the inclination (α) of the carrier vehicle (8) and/or of the lifting device (9) has been effected, a continuous detection of an inclination (α) of the carrier vehicle (8) and/or of the lifting device (9) relative to at least one predefined or predefinable spatial direction and/or spatial plane is

15 effected in a monitoring method step (iv).
- 20 3. Method according to the preceding claim, wherein, when the detected inclination (α) reaches or exceeds a predefined or predefinable deviation, a repetition of the execution of at least one calculation method step (i) and of at least one leveling method step (ii) is effected.
- 25 4. Method according to the preceding claim, wherein, in the loop (iii), in a calculation method step (i), which follows a leveling method step (ii) carried out beforehand, a detection of the change in the inclination (α) due to the preceding leveling method step (ii) is effected.
- 30 5. Method according to one of the preceding claims, wherein the time-limited activation of the individual drives of the supporting legs (1, 2, 3, 4) of the support system (7) using the sequence of control commands is effected using control pulses (s1, s2) with variable pulse duration.

6. Method according to the preceding claim, wherein the pulse duration (t_1 , t_2) of the control pulses (s_1 , s_2) is 0.05 seconds to 3.50 seconds, preferably 0.25 seconds to 1.5 seconds.

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7. Method according to one of the two preceding claims, wherein a variation of the pulse duration (t_1 , t_2) - and where applicable a temporal overlap (d) between successive control pulses (s_1 , s_2) - is effected depending on:

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- parameters of the drives of the supporting legs (1, 2, 3, 4) and/or

- parameters of the geometry of the supporting legs (1, 2, 3, 4) and/or

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- parameters of the position of the supporting legs (1, 2, 3, 4) and/or

- the number of supporting legs (1, 2, 3, 4) and/or

- the currently measured inclination (α) of the carrier vehicle (8) and/or of the lifting device (9), and/or

- the currently predefined pulse duration (t_1 , t_2) and/or

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- the position of axles (18, 19) of the carrier vehicle (8) and/or

- the position of a lifting device (9) arranged on the carrier vehicle (8) and/or

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- a torsional and bending stiffness and/or a twisting of the carrier vehicle (8) and/or

- the predefined or predefinable spatial direction and/or spatial plane.

8. Method according to one of the preceding claims, wherein the activation of the drives of the individual supporting legs (1, 2, 3, 4) of the support system (7) using the sequence of control commands is effected in an activation sequence in a predefinable or predefined order.

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9. Method according to one of the preceding claims, wherein the longitudinal extent of the supporting legs (1, 2, 3, 4) is made larger and/or smaller during an activation of the drives of the supporting legs (1, 2, 3, 4) of the support system (7) in a leveling method step (ii).
10. Method according to one of the preceding claims, wherein the activation of the individual drives of the supporting legs (1, 2, 3, 4) of the support system (7) using the sequence of control commands is effected using control pulses (s1, s2) with a time-limited, predefined or predefinable overlap (d) between successive control pulses (s1, s2).
11. Method according to the preceding claim, wherein a simultaneous activation of at most two drives is effected within the overlap (d) between successive control pulses (s1, s2).
12. Method according to one of the two preceding claims, wherein the duration of the overlap (d) between successive control pulses (s1, s2) is between 0.01 seconds and 0.5 seconds, preferably between 0.01 seconds and 0.1 seconds.
13. Computer program product comprising commands which, when executed by a computing unit, prompt the latter to execute a method according to one of claims 1 to 12 from a storage unit which is in or can be brought into data connection with the computing unit.
14. Controller (5) for a support system (7) which is formed for carrying out a method according to at least one of claims 1 to 12, wherein by the controller (5)

- in a calculation operating mode a sequence of control commands for the sequential and time-limited activation of individual drives of the supporting legs (1, 2, 3, 4) of the support system (7) is calculable on the basis of a currently detected inclination (α) of the carrier vehicle (8) and/or of the lifting device (9), and
- in an activation operating mode the drives of the supporting legs (1, 2, 3, 4) of the support system are actuatable using the sequence of control commands for reducing the inclination (α) of the carrier vehicle (8) and/or of the lifting device (9) relative to at least one predefined or predefinable spatial direction and/or spatial plane, wherein, using the sequence of control commands, a sequential and time-limited activation of individual drives of the supporting legs (1, 2, 3, 4) of the support system (7) is effected using control pulses, and
- in a loop operating mode, for minimizing the inclination (α) of the carrier vehicle (8) and/or of the lifting device (9), the calculation of the sequence of control commands and the activation of the drives of the supporting legs (1, 2, 3, 4) of the support system (7) using the sequence of control commands can be carried out repeatedly in a loop until the detected inclination (α) of the carrier vehicle (8) and/or of the lifting device (9) reaches or falls below a predefined or predefinable threshold value.

15. Vehicle, in particular carrier vehicle (8) with a lifting device (9), with a support system (7) according to one of claims 1 to 12 and a controller (5) according to claim 14.