

Method for controlling a railway vehicle, associated control system and railway vehicle

The present invention relates to a method for controlling a railway vehicle, comprising the following steps: moving the railway vehicle forward, wherein the railway vehicle is driven by a traction system, and receiving, via a railway vehicle control system, a stop command defining an extreme stop position located in front of the railway vehicle.

This method is typically intended to assist in the parking of the railway vehicle in a railway siding. The extreme stop position is thus the position of one end of the siding for the railway vehicle.

Due to civil engineering constraints on the layout of sidings, the size of the siding is sometimes too short to allow automatic vehicle parking without having the railway vehicle come into contact with the end of the vehicle siding at a non-zero collision speed.

When the size of the siding is too short, the only existing choices are then to sacrifice the criterion of safety of the absence of collision with the end of the garage track, or to have manual parking of the vehicle by its driver.

The first choice may not be always acceptable. The second choice runs counter to an approach for automating the driving of railway vehicles, nor does it guarantee that there will be no collision with the end of the railway siding.

The invention therefore aims to reduce the minimum stopping distance required for the railway vehicle in order to prevent it coming into contact with an obstacle or overshooting the end stop position.

For this purpose, the invention relates to a method for controlling a railway vehicle of the aforementioned type which also comprises the following steps: determination of a traction inhibition zone extending behind the extreme stop position, and activation of a traction inhibition module to prevent the traction system driving the railway vehicle forward when the railway vehicle is in the traction inhibition zone.

Furthermore, the method may have one or more of the following features, taken alone or in any technically feasible combination:

- a current speed of the railway vehicle is measured and, during the activation step, the traction inhibition module is activated when the railway vehicle is in the traction inhibition zone and the current speed is below a threshold speed;
- a current speed of the railway vehicle is measured, and the traction inhibition module is deactivated when the current speed is greater than a threshold speed;
- the threshold speed is comprised between 3 km/h and 6 km/h;

- the traction inhibition zone extends from the extreme stop position to a threshold position located behind the extreme stop position, at a threshold distance from the extreme stop position;
- a current speed of the railway vehicle is measured, and the traction inhibition module is deactivated when the current speed is zero;
- a current speed and a current distance of the railway vehicle relative to the extreme stop position are measured, wherein the control system of the railway vehicle comprises an engagement module for an emergency braking system of the railway vehicle, wherein it is programmed to engage the emergency braking when the current distance of the railway vehicle falls below a warning distance associated with the current speed, wherein the engagement module has a first mode of operation when the rail vehicle is outside the traction inhibition zone and/or that the traction inhibition module is deactivated, wherein the warning distance has a first value, and a second operating mode when the railway vehicle is in the traction inhibition zone and the traction inhibition module is activated, wherein the warning distance has a second value lower than the first value;
- the extreme stop position is the position of one end of a railway siding of the railway vehicle.

The invention also relates to a control system of a railway vehicle that is programmed to receive a stop command defining an extreme stop position located in front of the railway vehicle, wherein the control system comprises an electronic computer that is programmed to determine a traction inhibition zone extending behind the extreme stop position, in order to prevent a railway vehicle traction system from driving the railway vehicle forward when the railway vehicle is in the traction inhibition zone.

The invention also relates to a railway vehicle comprising a control system as defined above.

The invention will be better understood upon reading the description which follows, given solely by way of example and with reference to the appended drawings, wherein:

Fig. 1 shows a schematic view of a vehicle according to the invention;

Fig. 2 shows a graph showing examples of changes in the current speed of the railway vehicle as a function of the current position; and

Fig. 3 shows a flowchart of a method according to the invention.

Fig. 1 shows a railway vehicle 10 according to the invention.

The railway vehicle 10 comprises a traction system 12 designed to move the vehicle 10 along a railway track, a braking system 14 of the vehicle 10, and a control system 16 monitoring the operation of the railway vehicle 10. The traction system 12 and the braking system 14 are connected to the control system 16.

The vehicle 10 further comprises wheels (not shown) for traveling on the railway. In the remainder of the description, the terms "front" and "rear" are applied with respect to the direction of circulation of the vehicle 10.

The vehicle 10 has a front end and a rear end.

For example, the vehicle 10 may be a passenger train or an urban transport vehicle such as a subway. Alternatively, it may be any type of guided vehicle traveling on a dedicated infrastructure, such as a monorail.

The traction system 12 is particularly suitable for driving the vehicle 10 forward. For this purpose, the traction system 12 typically comprises one or more motors for moving the vehicle 10 along the railway track and a power module to supply power to the, or each, motor. These elements are well known and are not illustrated or described in more detail here.

The braking system 14 comprises a service brake 18 and an emergency brake 20. The emergency brake 20 is configured to ensure that braking is available in all situations, even in the event of failure of the service brake 18. For this purpose, the emergency brake 20 is designed to meet SIL 4 level certification according to the standards EN 50126, EN 50128, EN 50129.

The control system 16 comprises a system 22 for measuring a current speed of the railway vehicle 10, a system 24 for determining a current position of the vehicle 10 along the railway, a system 26 for receiving external information, an automated driving module 28, an engagement module 30 for an emergency braking system of the railway vehicle 10, and an electronic computer 32.

The systems and modules of the control system 16 are connected to the electronic computer 32.

The measurement system 22 measures a current speed of the railway vehicle 10, and may be, for example, an odometer. The current speed is here defined as the instantaneous speed of the front end of the vehicle 10.

The system 24 for determining the current position is designed to measure the current position of the railway vehicle 10. The current position of the railway vehicle 10 is here defined as the position of the front end of the vehicle 10 along the railway track.

For this purpose, the determination system 24 comprises, for example, an odometric
5 system capable of calculating the displacement of the train as a function of the movement of the wheels relative to a known reference point identified by reading a beacon. Such an odometric system is known *per se* and will not be described in more detail here.

The system 26 for receiving external information is designed to receive information external to the railway vehicle 10. This information is typically transmitted by a railway
10 signaling system outside the vehicle 10 by means of a communications system, for example comprising a radio link of the GSM-R or WiFi or LTE type, or with transponders fixedly placed along the railway and inductively coupled to a corresponding receiver on the vehicle 10.

This information preferably comprises a stop command defining an extreme stop position Pa situated in front of the railway vehicle 10.

15 The external information reception system 26 is thus designed to receive a stop command defining an end stop position Pa (see Fig. 2) located in front of the railway vehicle. This extreme stop position Pa is, for example, the position of one end of a railway track of the railway vehicle 10. In a variant, the extreme stop position Pa is a position from which the rail vehicle 10 is obliged to reverse.

20 The automated driving module 28 is designed to regulate the current speed of the vehicle 10 and to replace a driver.

For example, the automated driving module 28 is an ATO (Automatic Train Operation) type module.

The automated driving module 28 is designed to control the traction system 12 and
25 the braking system 14. Specifically, the automated driving module 28 is programmed to actuate, cut out and/or control the service brake 18 and the traction system 12.

In particular, the automated driving module 28 is designed to determine, as a function of the extreme stop position Pa received, a deceleration profile of the railway vehicle 10 until an effective stop position Pe.

30 An example of a deceleration profile is illustrated in Fig. 2 by the curve C1.

The engagement module 30 is intended to ensure that the railway vehicle 10 does not overshoot the extreme stop position Pa. For this purpose, the engagement module 30 is

typically in the form of a module known under the acronym ATP (Automatic Train Protection) and as defined by the IEEE 1474 standard.

5 The engagement module 30 is programmed to engage the emergency brake 20 of the braking system 14 when, for a given current speed V_d , the current distance of the rail vehicle 10 from the extreme stop position P_a is less than a warning distance D_a with respect to the extreme stop position P_a .

The curve C2 of Fig. 2 is an example of a curve relating to the warning distance D_a regulated by the engagement module 30. The engagement module 30 is programmed to engage the emergency brake 20 in the case where the curve C1 passes over the curve C2.

10 The warning distance D_a depends on the current speed of the vehicle 10. In particular, for a given current speed V_d , the warning distance D_a is calculated from a minimum braking distance D_m . For a given current speed V_d , this minimum distance D_m is the distance below which the emergency brake 20 is unable to brake the vehicle 10 before the extreme stop position P_a .

15 The minimum distance D_m is defined as a function of the configuration of the track, such as the presence of a steep curve or gradient, and the emergency braking capability.

The curve C3 of Fig. 2 is an example of a curve relating to the minimum braking distance D_m . In the case where the curve C1 passes over the curve C3, the emergency brake 20 is not able to stop the vehicle 10 before the extreme stop position P_a . This case must never occur since the emergency brake 20 is triggered on the curve C2.

For a given current speed V_d , the warning distance D_a is greater than the minimum distance D_m . The difference between the warning distance D_a and the minimum distance D_m constitutes a first safety margin M_1 . This first safety margin M_1 is defined in more detail below.

25 For a given speed V_d , the automated driving module 28 is advantageously designed to regulate the deceleration profile so that the current position has a second safety margin M_2 between the current position and a warning position, wherein the warning position is located at the warning distance D_a from the extreme stop position P_a .

30 For a given speed, this second safety margin M_2 corresponds, for example, to the distance traveled by the vehicle 10 at the given speed for two seconds. This second safety margin M_2 is calculated by the automated driving module 28.

The electronic computer 32 comprises a module for determining a traction inhibition zone 34, and a traction inhibition module 36.

These modules 34, 36 are typically implemented in the form of programs stored in a memory 38 of the computer 32 and executable by a processor 42 of the computer 32. As a variant, these modules 34, 36 may be at least partially implemented in the form of programmable logical components, or in the form of dedicated integrated components within the electronic computer 32.

The module 34 for determining a traction inhibition zone is designed to determine a traction inhibition zone ZI (shown in Fig. 2) extending behind the extreme stop position Pa.

The traction inhibition zone ZI extends from the extreme stop position Pa to a threshold position Ps located behind the extreme stop position Pa at a threshold distance Ds from the extreme stop position Pa.

The threshold distance Ds is here independent of the current speed of the vehicle 10. The threshold distance is advantageously between 10 m and 40 m.

The traction inhibition module 36 may be activated and deactivated by the computer 32.

The traction inhibition module 36 is designed to be activated at least when the railway vehicle 10 is in the traction inhibition zone ZI and the current speed is neither zero nor greater than a threshold speed Vs. The railway vehicle 10 is considered to be in the traction inhibition zone ZI when the distance between the front end of the vehicle 10 and the extreme stop position Pa is less than the threshold distance Ds. More particularly, the railway vehicle 10 is considered to be in the traction inhibition zone ZI when the current position is situated between the threshold position Ps and the extreme stop position Pa.

When the traction inhibition module 36 is activated, it is designed to prevent the traction system 12 from driving the railway vehicle 10 forward when the railway vehicle 10 is in the traction inhibition zone ZI.

In the example of Fig. 2, the traction inhibition module 36 is designed to be deactivated when the current speed of the railway vehicle 10 is greater than a threshold speed Vs.

The threshold speed Vs is here independent of the current position of the vehicle 10. The threshold speed Vs is advantageously comprised between 3 km/h and 6 km/h.

The traction inhibition module 36 is also designed to be deactivated when the current speed of the railway vehicle 10 is canceled when the railway vehicle 10 is in the traction inhibition zone ZI.

When the traction inhibition module 36 is deactivated, the traction system 12 of the railway vehicle 10 is allowed to drive the railway vehicle 10 forward, even when the railway vehicle 10 is in the traction inhibition zone ZI.

When the railway vehicle 10 is thus outside the traction inhibition zone ZI and/or
 5 when the traction inhibition module 36 is deactivated, the module 30 for engagement of the emergency braking has a first mode of operation wherein, for a given current speed V_d , the warning distance has a first value D_a .

For a given current speed V_d , the first value of the warning distance D_a is calculated from the minimum distance D_m as a function of an estimated delay required to cut
 10 off traction towards the front of the traction system 12 caused by a traction command sent to the traction system 12 and as a function of an estimated delay for activation of the emergency brake 20.

The safety margin of the first value of the warning distance D_a with respect to the minimum distance D_m is thus calculated in order to be greater than the sum of the distances
 15 traveled as a result of these two delays.

This first mode of operation is illustrated in Fig. 2 by the curve C2.

When the railway vehicle 10 is in the traction inhibition zone ZI and the traction inhibition module 36 is activated, the engagement module 30 has a second mode of operation wherein, for a given current speed V_d , the warning distance has a second value
 20 D_a' .

For a given current speed V_d , the second value of the warning distance D_a' is less than the first value of the warning distance D_a .

In fact, for a given current speed V_d , the second value of the warning distance D_a' is calculated from the minimum distance D_m as a function of the estimated activation delay for
 25 the emergency brake 20 and, advantageously, only as a function of this delay. As the forward traction of the vehicle 10 by the traction system 12 is prevented, the second value of the warning distance D_a' is not calculated as a function of an estimated delay to cut off forward traction of the traction system 12.

The safety margin $M1'$ of the second value of the warning distance D_a' with respect
 30 to the minimum distance D_m thus no longer includes the estimated delay for cutting off forward traction of the traction system 12.

This second mode of operation is illustrated in Fig. 2 by the curve C2'.

The automated driving module 28 is designed to determine a first deceleration profile (curve C1) that is applicable when the traction inhibition module 36 is deactivated, and a second deceleration profile (curve C1') that is applicable when the inhibition module traction 36 is activated and the railway vehicle 10 is in the traction inhibition zone ZI. The second
5 deceleration profile C1' defines an effective stop position Pe' closer to the stop end position Pa than the actual stop position Pe defined by the first deceleration profile C1. This is made possible by the fact that the first safety margin M1' of the warning distance Da' with the minimum distance Dm is reduced when the traction inhibition module 36 is activated and the railway vehicle 10 is in the traction inhibition zone ZI.

10 A method of controlling the railway vehicle 10 according to the invention will now be described with reference to Fig. 3.

The method is applicable here in the case where the railway vehicle 10 is to be parked on a railway siding having an end against which the vehicle 10 must not come into contact.

15 The railway vehicle 10 thus moves forward, driven by the traction system 12.

During this process, the measurement system 22 determines the current speed of the railway vehicle 10, while the system 24 determines the current position of the railway vehicle 10.

20 This current speed and this current position are transmitted to the electronic computer 32.

A railway signaling system outside the vehicle 10 sends a stop command defining the extreme stop position Pa located in front of the railway vehicle 10, wherein this extreme stop position Pa is here the position of the end of the railway siding

25 The system 26 of the railway vehicle control system 10 for receiving external information receives this stop command and transmits it to the electronic computer 32 during a reception step 100.

This step 100 is followed by a step 102 for determining the traction inhibition zone during the course of which the determination module 34 determines a traction inhibition zone ZI extending behind the extreme stop position Pa, to a threshold position Ps.

30 The method then comprises a step 104 for activating the traction inhibition module 36. This step is preferably engaged when it is detected that the current position is ahead of the threshold position Ps, and that the current speed is less than a threshold speed Vs. The

traction inhibition module 36 then prevents the traction system 12 from driving the railway vehicle 10 forward as long as the railway vehicle 10 is in the traction inhibition zone ZI.

Once the traction inhibition module 36 has been engaged, the automated driving module 38 regulates the current speed of the vehicle 10 according to the second deceleration profile C1' during a step 106. The automated driving module 38 actuates and controls the service brake 18 accordingly.

In a variant, the automated driving module 38 presents the second deceleration profile C1' to a driver of the vehicle 10 who himself controls the service brake 18 as a function of the second deceleration profile C1'.

The railway vehicle 10 finally stops at an effective stop position Pe' defined by the second deceleration profile C1' during a stopping step 108.

After the stopping step 108, the method comprises a step 110 for deactivating the traction inhibitor module 36.

By virtue of the invention, the safety margins over the distances are reduced and the railway vehicle 10 may be stopped closer to the extreme stop position Pa without coming into contact with or overshooting this position. The stop may also be performed automatically, without the intervention of a driver.

In comparison with a conventional control system, the control system 16 according to the invention thus allows a reduction of between 3 m and 5 m of the distance between the effective stop position and the extreme stop position.

CLAIMS

1. Method for controlling a railway vehicle (10), comprising the following steps:

- moving the railway vehicle (10) forward, wherein the railway vehicle (10) is driven
5 by a traction system (12), and
 - reception (100), by a control system (16) of the railway vehicle (10), of a stop
command defining an extreme stop position (Pa) located in front of the railway vehicle (10),
characterized in that the method also comprises the following steps:
 - determination (102) of a traction inhibition zone extending behind the extreme stop
10 position (Pa), and
 - activation (104) of a traction inhibition module (36) preventing the traction system
(12) from driving the railway vehicle (10) forward when the railway vehicle (10) is in the
traction inhibition zone.

15 2. Control method according to claim 1, wherein a current speed of the railway
vehicle (10) is measured, and wherein, during the activation step, the traction inhibition
module (36) is activated when the railway vehicle (10) is in the traction inhibition zone and the
current speed is less than a threshold speed.

20 3. Control method according to claim 1 or 2, wherein a current speed of the railway
vehicle (10) is measured, and the traction inhibition module (36) is deactivated when the
current speed is greater than a threshold speed.

25 4. Control method according to claim 2 or 3, wherein the threshold speed is
comprised between 3 km/h and 6 km/h.

30 5. Control method according to any one of the preceding claims, wherein the
traction inhibition zone extends from the extreme stop position (Pa) to a threshold position
(Ps) located behind the extreme stop position (Pa) at a threshold distance from the extreme
stop position (Pa).

6. Control method according to any one of the preceding claims, wherein a current speed of the railway vehicle (10) is measured, and the traction inhibition module (36) is deactivated when the current speed is zero.

5 7. Control method according to any one of the preceding claims, wherein a current speed and a current distance of the railway vehicle (10) relative to the extreme stop position (Pa) are measured,

 and wherein the railway vehicle control system comprises a module (30) for engaging an emergency braking system of the railway vehicle (10) that is programmed to
10 engage emergency braking when the current distance of the railway vehicle (10) becomes less than a warning distance associated with the current speed, wherein the engagement module (30) has a first mode of operation when the railway vehicle (10) is outside the traction inhibition zone and/or the traction inhibition module (36) is deactivated wherein the warning distance has a first value, and a second operating mode when the railway vehicle (10) is in
15 the traction inhibition zone and the traction inhibit module (36) is activated wherein the warning distance has a second value less than the first value.

 8. Control method according to any one of the preceding claims, wherein the extreme stop position (Pa) is the position of an end of a railway siding of the railway vehicle
20 (10).

 9. Control method according to any one of the preceding claims, wherein the control system comprises an automated driving module configured to determine a first deceleration profile that is applicable when the traction inhibition module is deactivated, and a second deceleration profile that is applicable when the inhibition module traction is activated and the
25 railway vehicle is in the traction inhibition zone.

 10. Control system (16) of a railway vehicle (10), programmed to receive a stop command defining an extreme stop position (Pa) located in front of the railway vehicle (10), wherein the control system (16) comprises an electronic computer (32) programmed for:
30 - determining a traction inhibition zone extending behind the extreme stop position (Pa), and

- preventing a traction system (12) of the railway vehicle (10) from driving the railway vehicle (10) forward when the railway vehicle (10) is in the traction inhibition zone.

5 11. Railway vehicle (10) comprising a control system (16) according to claim 10.