

Independent Platform Screen Door System

Field of Invention

[001] The present invention relates to an independent screen door system for platforms of a public transit system. In particular, the invention provides a standalone platform screen door control system to allow a train driver to stop a train at a station so that the train doors are sufficiently aligned with the platform screen doors for safe passenger embarkation and disembarkation.

Background

[002] When passenger traffic at passenger transit train platforms increases in volume, there is a need to retrofit existing platforms with screen doors for safety of passengers. It is expensive to upgrade the entire train signaling system when platform screen doors are retrofitted. An alternative to upgrading the train signaling system is to retrofit the screen door system at each platform with sensors that cooperate with a train positioning system. US Patent No. 8,109,214, issued to Knorr-Bremse Rail, describes the use of a first transceiver mounted on a train and a second transceiver mounted on the platform or a screen door. When a train has stopped at the platform, a signal is transmitted from the first transceiver to the second transceiver to open the screen door; after passengers have embarked and disembarked, another signal is transmitted from the first transceiver to the second transceiver to close the screen door. When RFID induction transceivers are used, positioning of train in relation to the screen door is not accurate enough. US Patent No. 7,782,175, issued to K.A. Schmiersal Holding, provides a more accurate solution by measuring the amplitude of an AC signal tapped off from a coil in the transceiver and comparing the amplitude with a threshold value.

[003] The system according to the present invention is directed to another solution for operating platform screen doors which is independent from the existing train signaling system; such a system is easier and cheaper to implement, for example, by implementing the present invention in stages or progressively stations by stations along a route or even at selective stations; such upgrading would minimise service disruptions. Separating the

screen door system from the train signaling system also makes operation of the transit system modular, so that operational faults can be quickly identified and isolated.

[004] It can thus be seen that there exists a need for this new type of platform screen door system and train positioning system which have advantages over the existing prior art.

Summary

[005] The following presents a simplified summary to provide a basic understanding of the present invention. This summary is not an extensive overview of the invention, and is not intended to identify key features of the invention. Rather, it is to present some of the inventive concepts of this invention in a generalised form as a prelude to the detailed description that is to follow.

[006] The present invention seeks to provide a platform screen door (PSD) system at a transit station that is independent from the bigger train signaling system. This PSD system also includes a train positioning system (TPS) and has advantages over known screen door and train positioning systems.

[007] In one embodiment, the present invention provides a PSD system comprising: a PSD control cubicle (PCC); a plurality of door control units (DCUs) linked to the PCC, with each DCU for operating each associated screen door at a platform so that the screen doors keep passengers safe at the platform and away from a trackside; a train positioning system (TPS) and a set of output indicators N1-N2 being linked to the PCC; and a station control unit (SCU) linked to the TPS and in wireless communication with a train control unit (TCU) located on the train, so that: as the train is stopping at the station, the indicators N1-N2 allow the train driver to determine a distance of alignment of the train doors with the associated screen doors for safe passenger embarkation and disembarkation; and the PSD system is being controlled locally at each station and is momentarily dis-connected from the train system.

[008] In another embodiment, the TPS comprises a position sensor (PS) unit. The PS emits three curtain beams (L1-L3), with each curtain beam laying in a plane that is substantially

transverse to the train traveling direction. Corresponding to detection of the curtain beams are the train under-run, target stop and over-run positions; these train positions are visually indicated to the train driver by illuminating indicator lights N1-N3. Preferably, the PS unit emits beams of laser, wavelengths of a predetermined range or ultrasound.

[0009] In another embodiment, the SCU comprises a near-field communication (NFC) transponder linked to a number of NFC tags. Preferably, the number of tags correspond to the number of doors on the train. Preferably, the NFC tags are located on both the right-hand and left-hand sides of each train.

[0010] In another embodiment, the PSD system further comprises a local control panel (LCP) and a set of output indicators PSI. The PSI indicators show the status of locking of both the screen doors and train doors, so that a train driver is allowed to pull in or pull out safely at a station. An additional PSI indicator may be used to show a by-pass mode when the PSD system is turned to manual control.

[0011] In another embodiment, the present invention provides a kit of parts for configuring a PSD system. In yet another embodiment, the present invention provides a method of positioning a train as it pulls in at a platform; the method comprises: detecting an end of a train pulling into a station with a laser position sensor unit (PS) that emits 3 curtain beams; outputting an indicator signal (N1-N3) corresponding to detection by each curtain beam; and narrowing a range of detection of each curtain beam by outputting a wheel sensor (SS) before the associated indicator signal is sent to illuminate an associated lamp, so that train positioning at the platform is made more accurate.

Brief Description of the Drawings

[0012] This invention will be described by way of non-limiting embodiments of the present invention, with reference to the accompanying drawings, in which:

[0013] FIG. 1A illustrates a schematic of an independent platform screen door (PSD) system according to an embodiment of the present invention; FIG. 1B illustrates the use of

multiple sensors for a four-car train, whilst FIG. 1C illustrates locating the sensors at the trackside; and

[0014] FIG. 2 illustrates parts of the station and train control units employed in the system shown in FIG. 1A.

Detailed Description

[0015] One or more specific and alternative embodiments of the present invention will now be described with reference to the attached drawings. It shall be apparent to one skilled in the art, however, that this invention may be practised without such specific details. Some of the details may not be described at length so as not to obscure the invention. For ease of reference, common reference numerals or series of numerals will be used throughout the figures when referring to the same or similar features common to the figures.

[0016] FIG. 1A shows a schematic of a platform screen door (PSD) system 100 configured at a rail transit station 10 according to an embodiment of the present invention. The PSD system 100 is independent from the bigger train signaling system; in other words, the PSD system 100 is locally controlled at the station 10 in conjunction with a train positioning system (TPS) (140). Operationally, the PSD system 100 is controlled by a train driver at each station, that is, control of the train is momentarily localized at the station. The PSD system 100 of the present invention has the advantages that the PSD system can be easily and quickly isolated, for example, during retrofitting, fault finding or maintenance.

[0017] For illustration, the transit station 10 has a trackside 15 and a raised platform 20. Part of the platform is designated for public access and has a plurality of screen doors 30 for controlling passengers embarking on and disembarking from a train 50 that has stopped at the transit station 10. The screen doors 30 are spaced apart and sufficiently aligned with doors of the train 50 for safe embarkation and disembarkation. As shown in FIG. 1, the PSD system 100 includes a PSD Control Cubicle (**PCC**) 110, a plurality of Door Control Units (**DCUs**) 120, 120a, 120b and a Train Positioning System (**TPS**) 140 in communication with the PCC 110. A power distribution panel (PDP) 112 is connected to the PCC 110 for supplying electric power to the PSD system. In one embodiment, the TPS

140 includes two Position Sensors (**PS**) 142, 142a and a Station Control Unit (**SCU**) 160. The SCU 160, in turn, is in wireless communication with a Train Control Unit (**TCU**) 180 located on the train 50. For purposes of description, the direction of travel of the train is indicated by arrow X, and the PS 142 on the left hand side, as seen in FIG. 1A, detects the head of the train. For backup purposes, two PS 142, 142a sensors are provided, with the PS 142a on the right hand side for detecting the end of the train. In any event when direction of the train is reversed, for example during an interrupt, detection of the ends of the train is also reversed. It is possible that one or both of the PS 142, 142a are employed during operation of the PSD system 100.

[0018] The screen doors 30 may extend to a predetermined height above the platform according to a safety code or they may extend to the ceiling in underground stations. For space saving, each screen door is usually configured with two leaves, which are operated with sliding actuators; these actuators (not shown in the figures) are concealed in header boxes above the respective screen doors or in footing boxes at the bases of the screen doors. Each DCU 120, 120a, 120b controls the actuators at the respective screen door and the PCC 110 controls all the DCUs 120, 120a, 120b; in the figures, separate DCUs are only schematically shown as being linked to each other.

[0019] In one embodiment, the PS 142 contains a laser unit, which emits 3 curtain beams L1-L3. Each of the curtain beams L1-L3 fans out at a angle but lays in a plane substantially transverse to the travel direction of the train. For clarity, the plane of the curtain beams may be at an angle to the travel direction of the train; in addition, the plane of the curtain beams may also be inclined, for example, according to a profile of the train at each end. Referring to FIG. 1A, as the train is slowing down at the station, the first curtain beam L1 detects the head of the train and the position of the train is determined as 25 cm prior to a target stop position. At this train under-run position as determined by detection of the first curtain beam L1, the train doors are sufficiently aligned with the associated screen doors 30 for safe embarkation and disembarkation, and the PS 142 sends a signal to the TPS 140 and PCC 110, which then illuminates an indicator light N1; in this manner, the train driver is informed of the under-run position of the train. If the train driver allows the train to inch forward, the second curtain beam L2 would then detect the head of the train and halt the train at the desired target stop position; at the target stop position, the train doors are

ideally aligned with the associated screen doors and a corresponding signal is sent to the TPS 140 and PCC 110, which then illuminates a second indicator light N2.

[0020] If the train overshoots the target stop position and curtain beam L3 detects the head of the train, the train position is determined as 25 cm over-run from the desired target stop position yet the train doors remain sufficiently aligned with the associated screen doors; corresponding to this over-run position, the TPS 140 and PCC 110 illuminate a third indicator light N3.

[0021] In one embodiment, the indicator lights N1-N3 are of the same colour; in another embodiment, the indicator lights N1-N3 are of different colours, or N1 and N3 are of a colour different from that of N2. The indicator light N1-N3 may be illuminated one at a time, or N1-N2 or N2-N3 may be illuminated in pairs; at the over-run position, all the indicator lights N1-N3 may be illuminated at the same time. If only two indicator lights N1 and N2 are provided, the under-run and over-run positions may be indicated by re-illuminating the indicator light N1. When the train is stopped within the distance indicated by N1 and N3, the train doors are still sufficiently aligned with the associated screen doors 30 without compromising on passenger safety. With these indicator lights N1-N3, the train driver is able to determine whether the train is being stopped within the safe stopping distance. In the description, the under-run and over-run of the train stop position is 25 cm; the under-run and over-run distances are usually predetermined by the size of the screen door in relation to the size of the train door; this stopping distance is not so limited and it does not affect the working of the PSD 100 or the TPS 140.

[0022] In the above description, two or three indicator lights N1-N3 are used to indicate to the train driver the halt position of the train. Instead of using discrete light indicators, it is possible to use a linear bar indicator. The bar indicator can be visually continuous, segmented or serial. With the TPS 140, the indicator lights provide feedback to the train driver as the train is slowed down to a halt and the train driver can respond by adjusting the final braking force to bring the train to a halt close to the target stop position. With the TPS 140, stopping the train at the target stop position is enabled and this contributes to operational performance of the rail system. In the above description, the TPS uses laser curtain beams. It is possible to use other types of beam; for example, the beam can be of a

narrow predefined range of wavelengths (visible or invisible), ultrasonic (inaudible) sound and so on.

[0023] In another embodiment, also shown in FIGs. 1A-1C, a set of wheel sensors SS 144 are provided to narrow the stopping distance for turning on the indicator lights N1-N3; in this way, the SS 144 augment the accuracy of the position sensors PS 142, 142a; in another way, the SS 144 provides a backup feature for the PS 142, 142a or TPS 140. As shown in FIG. 1C, the SS 144 are located below the platform 20 and accessed from the trackside 15. The individual SS 144 are spaced apart depending on the size of the train wheels. Preferably, the SS 144 are of the inductive type and have a sensing distance of about 30-40 cm. Although three SS 144 are sufficient for operation, FIG. 1A shows four SS 144.

[0024] In normal operation, the train pulling into a station moves at a fast speed and the PS 142, 142a and SS 144 send rapid pulses to the TPS 140 and PCC 110. The PCC 110 then determines the number of cars that make up the train. The number of cars as determined by the PCC 110 is then checked with the number of detection of near field communication (NFC) tags 184, 184a located on each car, as will be described in a later paragraph.

[0025] In FIG. 1A, a one-car train 50 is shown. FIG. 1B shows a four-car train; in FIG. 1B, four position sensors PS 142 are used, with each corresponding to a car. Two sets of wheel sensors SS 144 are used, one near each end of the train. By providing multiple PS 142 and SS 144, it is possible to predetermine the stop position of the train at the platform that is longer than the train; this allows flexibility in configuring the number of cars of a train.

[0026] Referring back to FIG. 1A, two local control panels (LCP) 190 are linked to the PCC 110. Each LCP 190 is located at each end of the platform 20 and each is connected to two indicator lights PSI. Preferably, one indicator light PSI is green while other is red or amber. When all the screen doors 30 are closed and the screen door status is consistent with status of all the sensors in the DCU 120, 120a, etc., the green PSI indicator light is illuminated and the train driver would understand that the platform is ready for the train to pull in. In a similar manner, when all the train doors are closed and the door status is consistent with status of all the sensors at the train doors, the TCU 180 communicates a signal to the SCU 160 which is relayed to the PCC 110 and LCP 190 for the green PSI indicator light to be

illuminated; when any one of the screen doors or train doors is not fully closed, for example, being obstructed, the red or amber PSI indicator light is illuminated and a corresponding troubleshoot signal is issued by the PCC 110 for control action. In a variation, it is possible for the train driver to switch control of the train to a by-pass or manual mode at the transit station. In the by-pass mode, an additional PSI indicator may be provided; alternatively, in the by-pass mode, the red or amber PSI indicator is made to blink or flash intermittently.

[0027] In FIG. 1A, the SCU 160 and TCU 180 are shown to be in wireless communication. FIG. 2 shows the SCU 160 includes two wireless transceivers 162, 162a and a near-field communication (NFC) transponder linked to NFC antennae 164, 164a at the platform side, whilst the TCU 180 includes two matching wireless transceivers 182, 182a and two matching NFC tags 184, 184a. The wireless transceivers 162, 162a are located on the platform side, with each near each end of the platform whilst the matching wireless transceivers 182, 182a are located near each end of the train. The NFC tags 184, 184a are located on the respective left and right hand side of the train, so that the NFC tags are within communication range of the respective NFC antennae 164, 164a. With multiple cars, the numbers of NFC antennae 164, 164a and NFC tags 184, 184a are provided corresponding to the numbers of cars.

[0028] Now, the wireless communication of the PSD system 100 is described: After the train 50 has stopped at the station 10 and the train doors are aligned with the associated screen doors 30; the NFC antennae 164 or 164a detect the NFC tag 184 or 184a located on a near side of the train 50; at the same time, the PSD system 100 handshakes with the SCU and TCU through wireless communication and operation of the train is passed over to the PSD system 100. Detection of the NFC tag 184, 184a is sent to the TCU 180 to enable the left or right hand side train doors to operate; in response, the TPS 140 sends an unlock signal 146 to the DCU 120 through the PCC 110; at the same time, the SCU 160 communicates to the TCU 180 and enables a door-open signal initiated by the train driver. After the passengers have embarked and disembarked, a door-close signal initiated by the train driver is sent from the TCU 180 to the SCU 160 and PCC 110; in response, the DCUs 120 close the screen doors 30 in coordination with closing of the train doors; once closing of the screen doors is not obstructed and completed, a door lock signal is sent from the

DCUs to the PCC 100, which then relays the lock signal to the SCU 160 and TCU 180; upon receiving of the door lock signal and train door lock signal, the TCU 180 then allows the train driver to pull the train safely out of the station.

[0029] With the present invention, the TPS 140 and SCU 160 allow control of the train at each station 10 to be momentarily localized and independent of the train signaling system. Such a PSD system is easy to retrofit and less costly to implement. In addition, such a PSD system can be implemented in stages or at selective stations. Operationally, this PSD system is modular. As shown in FIG. 2, the PSD system can be commissioned or maintained via a portable terminal equipment (PTE) 200. The PTE 200 can be connected to the programmable logic controller (PLC) in the PCC 110 via a canbus or electronic communication bus, or to the relays in the PCC via the open/close signal lines, for example, through one of the DCUs.

[0030] While specific embodiments have been described and illustrated, it is understood that many changes, modifications, variations and combinations thereof could be made to the present invention without departing from the scope of the invention.

CLAIMS:

1. A train platform screen door (PSD) system being controlled locally at each station, said PSD system comprising:
 - a PSD control cubicle (PCC);
 - a plurality of door control units (DCUs) linked to and controlled by the PCC, with each DCU for operating each associated screen door at a platform so that the screen doors keep passengers safe at the platform and away from a trackside;
 - a train positioning system (TPS) in communication with the PCC, and a set of output indicators being linked to the PCC; wherein the output indicators indicate the position of a train in relation to the screen doors; and
 - a station control unit (SCU) linked to the TPS and in wireless communication with a train control unit (TCU) located on the train;

wherein as the train is stopping at the station, the indicators allow a train driver to determine a distance of alignment of train doors with the associated screen doors and to open the train doors and screen doors for safe passenger embarkation and disembarkation; and

when the screen doors are closed, the PSD system is momentarily dis-connected from a train signaling system.
2. The PSD system according to claim 1, wherein the TPS comprises a position sensor (PS) unit, which emits three curtain beams (L1-L3), with each curtain beam laying in a plane.
3. The PSD system according to claim 2, wherein the plane containing the curtain beams is orientated transverse to the direction of travel of the train.
4. The PSD system according to claim 3, wherein the three curtain beams sequentially detect a head of an approaching train, with the first curtain beam being adjusted to detect the train prior to reaching a target stop position, and the third curtain beam being adjusted to detect an over-run position.

5. The screen door system according to claim 4, wherein the position sensor PS unit outputs a sequence of signals to illuminate a set of indicators (N1-N3) as each curtain beam detection is activated.
6. The PSD system according to claim 5, wherein the set of indicators is visually continuous, segmented or serial.
7. The PSD system according to claim 2, wherein the PS unit emits beams of laser, of a predetermined range of wavelengths or ultrasound.
8. The PSD system according to any one of claims 2-7, wherein the PS unit is further connected to a set of wheel sensors SS.
9. The PSD system according to any one of the preceding claims, wherein the SCU further comprises a wireless transceiver and the TCU further comprises a wireless transceiver matching the SCU wireless transceiver.
10. The PSD system according to claim 9, wherein the TCU wireless transponders are separately disposed near the two ends of the train.
11. The PSD system according to claim 9 or 10, wherein the SCU further comprises a near-field (NFC) transponder linked to a number of NFC tags corresponding to the number of train doors.
12. The PSD system according to claim 11, wherein two sets of NFC tags are separately disposed on the left and right hand side of the train.
13. The PSD system according to any one of the preceding claims, further comprising a local control panel (LCP) and a set of output indicators PSI to show the status of locking of both the screen doors and train doors for a train to pull in or pull out safely at a station.
14. The PSD system according to claim 13, wherein the output indicators PSI includes a by-pass mode indicator.

15. A kit for configuring a train platform screen door (PSD) system comprising:
 - a position sensor (PS) which emits three curtain beams, with each curtain beam laying in a plane and outputs a signal corresponding to detection by each curtain beam;
 - a set of indicators (N1-N2 or N1-N3) operable by the output signals of the PS; and
 - a station control unit (SCU) for connecting to the PS and for wireless communication with a train control unit (TCU).
16. The kit according to claim 15, further comprising:
 - a plurality of door control units (DCUs), with each DCU for operating a platform screen door;
 - a set of wheel sensors (SS); and
 - a local control panel (LCP) and associated status indicators (PSI).
17. The kit according to claim 16, wherein the TCU further comprising:
 - a wireless transceiver matching the SCU; and
 - a plurality of near-field communication (NFC) tags linked to associated NFC antennae and NFC transponder located at the SCU.
18. A train positioning method comprising:
 - detecting an end of a train pulling into a station with a laser position sensor unit (PS) that emits 3 curtain beams;
 - outputting an indicator signal (N1-N3) corresponding to detection by each curtain beam; and
 - narrowing a range of detection of each curtain beam by outputting a wheel sensor (SS) before the associated indicator signal is sent to illuminate an associated lamp, so that train positioning at a platform is made more accurate.