



Rheinmetall Defence Electronics GmbH, Bremen

## DESCRIPTION

### Scalable Cargo Loading System, particularly for an Aircraft

#### Technical Field

The invention in the present case concerns a scalable cargo loading system, particularly for an aircraft.

#### Actual State of the Art

For the loading of a cargo unit, e.g. a container or a pallet, into transport means and for the shunting inside the transport means, cargo loading systems with prime movers are deployed for instance in form of so-called power-drive-units (PDU). Furthermore, such systems have covering-over sensors, approaching switches and interlocks for immobilisation of the cargo units. A covering-over sensor detects, whether the associated prime mover is covered by the cargo unit, while an approaching switch controls the interlock status. The cargo loading system is monitored by a central controlling device, in which, for instance, navigating commands are entered by a joystick or other means.

According to the actual state of the art it is common practice, to connect individual components of the cargo loading system, like prime movers and sensors, with serial interfaces to the central controlling device. This is unfavorable, because the central controlling device must comprise and manage likewise many IO-ports. If all these ports are used, an expansion of the cargo loading system later on is only possible through the replacement of the central controlling device.

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Another option is connecting all components of the cargo loading system with a data bus to the central controlling device. But this is unfavorable, because even the simplest components like approaching switches must have a bus-interface, which may be more complex in the realisation than the component to-be-connected.

### Outline of the Invention

Hence, the objective of the invention in the present case is providing a cargo loading system, which is easily scalable, inexpensive and easy to maintain. Another objective of the invention in the present case is to describe a method for the operation of such scalable cargo loading system.

This objective is solved by a scalable cargo loading system according to patent claim 1 and by a method for the operation of such scalable cargo loading system according to patent claim 5. Favorable design types are illustrated in the relevant patent claims.

A scalable cargo loading system according to invention has prime movers, covering-over sensors, interlocks, approaching switches and a central controlling device, whereby the load platform is divided in sectors, a local controlling device is allocated to each sector, the prime movers, covering-over sensors and approaching switches of a sector are connected to IO-ports of the local controlling device and the local controlling devices are connected with a bus system to the central controlling device. During the operation of such scalable cargo loading system, the local controlling devices send the status of the prime movers, covering-over sensors and approaching switches with the bus system.

The advantage of the partitioning of the load platform into sectors is, that a local controlling device assigned to a sector, which is also called sector control box (SCB), must have only a limited number of IO-ports. If a large load platform shall be equipped with a cargo loading system, it will be realised by the use of the

relevant quantity of SCBs. Because the SCBs are connected with a bus system to the central controlling device (CCB: Compartment Control Box), the number of potential sectors is only limited by the quantity, how many SCBs can be addressed through the bus system.

Because each SCB is sending through the bus system the sector status, thus information about which prime movers and approaching switches exist in the relevant sector and about the status of covering-over sensors and approaching switches, each SCB captures an image and the status of the entire cargo loading system. For this purpose, the local controlling devices have means for the storage of all sectors' states.

One design type of the invention includes a CAN-bus system (CAN: Controller Area Network), being an established and reliable bus system. Preferably, the sector status is sent in a standardised status-object of the CAN-bus. The sector status is coded in the user data of the status-object, while the address of the SCB is captured from the message's header and hence the associated sector is identified.

Preferably, a local controlling device sends the sector status during the start-up of the cargo loading system and/or while changing the sector status. In this way, an initialisation is done during the start-up of the cargo loading system, after which each SCB knows the image and status of the cargo loading system. An update of these data is only necessary, if the components' status changes in a sector.

One design type of the invention includes floor conveyors as prime movers, in particular roller conveyors. Such prime movers are known as PDUs (Power Drive Unit) for cargo loading systems.

In order to reduce the wear-out and the energy requirement of the prime movers, it is common practice with cargo loading systems, to activate only those prime movers, thus to start operation, which are covered by the cargo unit. In one design type of the invention, a prime mover not covered by a cargo unit is

activated, if it is arranged (viewed in the transport direction) behind a prime mover covered by a cargo unit. This means, that a prime mover, being involved in transportation afterwards, is activated anticipatory. By doing so it is prevented, that the cargo unit is jerkily forced during the activation of the prime mover.

After a cargo unit has arrived at its final position on the load platform, an interlock is erected and thus the cargo unit is immobilised. In doing so, approaching switches serve for detecting, whether an interlock is erected. In one design type of the invention, a prime mover, looking into the cargo deck and located behind an erected interlock, is not activated. By doing so it is prevented, that the prime mover underneath a fixed cargo unit are activated and wear out intensively.

The invention is explained in more detail by an exemplary version.

### Brief Description of the Drawing

It is illustrated in

- Figure 1      the physical arrangement of the cargo loading system and  
Figure 2      the logical structure of the cargo loading system.

### Implementation Methods of the Invention

Figure 1 shows an airplane's cargo deck CD in vertical section. This comprises of a ball mat area BM and a load platform, which is divided into three sectors S1, S2 and S3. In each sector, six prime movers and six approaching switches are arranged, whereby each approaching switch functions for the status monitoring of an interlock not depicted in the figure. The altogether 18 prime movers L1 to L9 and R1 to R9 and 18 approaching switches PL1 to PL9 and PR1 to PR9 are divided into two rows each, which are, viewed from the ball mat BM towards the cargo deck CD, named as right-hand and left-hand row.

In each row are prime movers, which are in the present example PDUs, and the approaching switches are numbered consecutively. Thus, in sector S1 are the PDUs L1, L2, L3, R1, R2 and R3 and the approaching switches PL1, PL2, PL3, PR1, PR2 and PR3. Moreover, a local controlling device is allocated to each sector. The controlling device SCB1 is allocated to sector S1, the controlling device SCB2 is allocated to sector S2 and the controlling device SCB3 to sector S3. In addition, the cargo loading system has covering-over sensors, which are not depicted in the figures, and which detect, whether a PDU is covered-over by a cargo unit. For clarity purposes, not every PDU and not every approaching switch has a reference sign in figure 1.

In addition, the cargo loading system has a central controlling device CCB. This is connected with at least one operation panel (not depicted), with which the operating staff enters controlling data into the CCB. For instance, this may happen with a joystick (not depicted).

If a cargo unit is moved into the cargo deck CD, hence conveyed from the right to the left in figure 1, sector S3 is behind sector S2 and sector S1 is in front of sector S2, as viewed in the transport direction; however, if the cargo unit is removed from the cargo deck CD, then sector S1 is behind sector S2, as viewed in the transport direction. Nevertheless, the viewing direction into the cargo deck CD originates always from a viewpoint in ball mat area BM and consequently is independent from the transport direction of the cargo unit.

Figure 2 shows a section of the logical structure of the cargo loading system according to invention. Hereby, the three local controlling devices SCB1, SCB2 and SCB3 as well as the central controlling device CCB are linked to each other with a CAN-bus. In addition, a typical connection of the prime mover and approaching switches to the local controlling device SCB2 of sector S2 is shown. The PDUs L4, L5, L6, R4, R5 and R6 and the approaching switches PL4, PL5, PL6, PR4, PR5 and PR6 are each connected with dedicated lines to the IO-ports

of the SCB2. The other prime movers and approaching switches are connected to the other local controlling devices in the same way.

In the present example, the local controlling devices SCB1, SCB2 and SCB3 are designed, that they can manage in total up to 16 PDUs and likewise 16 covering-over sensors and up to 32 approaching switches.

At first, it is assumed, that no cargo unit has reached its final position in the cargo deck CD yet. A first cargo unit is located in the ball mat area BM and shall be brought to its final position. With the joystick connected to the CCB a forward-signal is given, which is transformed by the CCB and sent out by the CAN-bus. The PDUs L1 and R1 are located in the ball mat area BM, that is why a cargo unit brought into the cargo deck covers both prime movers. This is detected by the associated covering-over sensors and communicated to the local controlling device SCB1. The SCB1 receives also the moving signal by the CAN-bus and activates the PDUs L1 and R1 in such a way that they convey the cargo unit into the cargo deck CD. From the forward-signal by the CAN-bus and the covering-over of the PDUs L1 and R1, the SCB1 realises that the cargo unit soon will reach the PDUs L2 and R2. These are activated although they are not yet covered by the cargo unit. The covering-over of the PDUs L1 and R1 is communicated to the other local controlling devices by the CAN-bus. Hence, each local controlling device knows from the signal of the covering-over sensors the actual position of the cargo unit and the general status of the cargo loading system. The message sent by the local controlling device via the CAN-bus includes also information about the existing PDUs and the existing approaching switches and their status.

In the further process of the cargo unit's transport into the cargo deck CD, the PDUs L3 and R3 are activated and subsequently covered-over by the cargo unit. This covering-over is communicated by the SCB1 via the CAN-bus.

From the forward-moving-signal of the CCB, the information that the PDUs L3 and R3 are located at the sector boundary, and the covering-over of the PDUs L3 and R3, the SCB2 detects that the PDUs L4 and R4 take part in the transportation process as the next, which fall into the sector S2 controlled by the SCB2. Thus, the SCB2 activates the PDUs L4 and R4. The transportation process of the cargo unit continues into the cargo deck CD, until the cargo unit has reached its final position.

In the present example, the cargo unit covers-over in its final position the PDUs L8, L9, R8 and R9. By erecting the interlocks, which are controlled by the approaching switches PL8 and PR8, the cargo unit is secured in its position. The approaching switches PL8 and PR8 report the erecting of the associated interlocks to the SCB3. The SCB3 sends a corresponding message via the CAN-bus to the other local controlling devices. If a second cargo unit is brought into the cargo deck CD, it will be moved within the cargo deck CD analogously to the first cargo unit. If the second cargo unit was moved within the cargo deck CD so far, that it covers-over the PDUs L7 and R7, then the SCB3 would activate the PDUs L8 and R8. Because the interlocks associated to the approaching switches PL8 and PR8 are erected, an activation of the PDUs L8 and R8 remains undone, which are arranged behind the erected interlocks viewed in the transport direction.

Although the aforementioned explanations refer exclusively to the transport of cargo unit into the cargo deck CD, they are also applicable analogously for the reverse transport direction. In this case, the CCB sends an aft-signal via the CAN-bus, and the local controlling devices identify from that and from the image and status of the cargo loading system the PDUs to be activated. In this case as well, the PDUs (viewed in the transport direction and directly arranged behind the PDUs covered-over by the cargo unit) are anticipatory activated. Likewise, PDUs (arranged behind an erected interlock as viewed into the cargo deck CD) are not activated.

In a modified version of the design example, the cargo loading system is designed for cargo units with two different standardised sizes. Thus, it is necessary, to mount interlocks for fixing of the cargo units at several positions depending on the various sizes. Specifically, two interlocks and hence two approaching switches are arranged ahead of each PDU. As a result, various loading scenarios can be realised.

In the firmware of each local controlling device, the potential positions of the PDUs and interlocks/ approaching switches within a sector are stored. Thus, in the information, which of these positions is occupied, the complete structure of the sector is shown. Only information for each sector must be communicated via the CAN-bus, which PDUs exist, which PDUs are covered-over, which approaching switches exist and which approaching switches are activated. Because this information is in each case binary, preferably the sector status is coded in a bit pattern. Because the status object standardised for the CAN-bus provides eight byte user data, the existing PDUs, the existing approaching switches, the covered-over PDUs and the activated approaching switches are coded in two byte each. The result is that within a status object the sector status of in total 16 PDUs and 16 approaching switches can be communicated.

Preferably, the CAN-bus addresses of the local controlling devices follow a pattern known to the local controlling devices, for instance by the allocation of serial addresses. Hence, each local controlling device might be able to define from the address of another local controlling device the position of the sector controlled by this other local controlling device inside the cargo deck CD.

In the design example shown in Figure 1, three PDUs and three approaching switches per row are arranged in each sector. The four byte, in which the existing PDUs and approaching switches are coded, hence read conformably 00000111. From this bit pattern for the existing PDUs in each row, the SCB2 detects for instance, that the PDU L4 of sector S2 follows on the PDU L3 of sector S1, and

the PDU R4 of sector S2 follows on the PDU R3 of sector S1.

Afore it was already described, that in a modified version of the design example two interlocks and thus two approaching switches are installed in front of each PDU. Which of either interlocks is erected for the fixing of the cargo unit, depends on the size of the cargo unit. However, at most either interlock can be erected in each case. Therefore, the output signals of both approaching switches in front of each PDU may undergo a disjunction in the local controlling device, whereby the result of this disjunction is coded into the message of the sector status. Therefore, the number of bits available in the status object is sufficient for the modification with double number of interlocks.

Following the design example, a status might be considered, where the first cargo unit is locked in its final position and the second cargo unit is not yet brought into the cargo deck CD. The PDUs L8, L9, R8 and R9 are covered-over and the approaching switches PL8 and PR8 send a signal to the SCB3, that the associated interlocks are erected. Besides the aforementioned bit pattern 00000111 for the four byte of the existing PDUs and approaching switches, in each case the bit pattern 00000110 arises for both bytes of the covered-over PDUs as well as the bit pattern 00000010 for the status bytes of the approaching switches.

If a cargo unit has reached its final position, preferably the PDUs covered-over by it are operated in the hold-mode despite the locking of the cargo unit, until another cargo unit has reached its final position and the local approaching switches indicate its locking. By that it is ensured, that cargo units are secured against shifting throughout and thus the operational safety of staff is enhanced.

Preferably, the moving signal sent from the CCB via the CAN-bus is cyclical repeated. By that it is ensured, that activated PDUs are switched off, even if the

associated local controlling device has not received a stop signal. The result is that for instance at a malfunction of the CAN-bus active PDUs are switched off instantly or put into the hold mode.

The aforementioned design example is purely exemplary and insofar not limited. Particularly, the size, the quantity and arrangement of the sectors may vary, whereby in principle the sectors do not have to be of the same size. Thus, it is for instance possible to leave positions for prime movers vacant, which is represented by zeros in the relevant bit pattern. If according to the cargo loading system in Figure 1 there is for instance the option, to allocate another PDU between the PDUs R1 and R2 or R2 and R3 respectively, but these positions are vacant, this would yield to the bit pattern 00010101 for the occupied PDU-positions of the right row. Also the arrangement of the prime movers and approaching switches within a sector may be modified, without leaving the idea of the invention.

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Rheinmetall Defence Electronics GmbH, Bremen

## PATENT CLAIMS

1.

Scalable cargo loading system, particularly for an aircraft, with prime movers (L1-L9, R1-R9), covering-over sensors, interlocks, approaching switches (PL1-PL9, PR1-PR9) and a local controlling device (CCB), **characterised**, that the load platform is divided in sectors (S1, S2, S3), a local controlling device (SCB1, SCB2, SCB3) is allocated to each sector, the prime movers, covering-over sensors and approaching switches of a sector are connected to IO-ports of the local controlling device and the local controlling devices are connected with a bus system (CAN-BUS) to the central controlling device.

2.

Cargo loading system according to claim 1, **characterised**, that the local controlling devices (SCB1, SCB2, SCB3) have means for storage of states of all sectors (S1, S2, S3).

3.

Cargo loading system according to claim 1 or 2, **characterised**, that the prime movers (L1-L9, R1-R9) are floor conveyors, in particular roller conveyors.

4.

Cargo loading system according to one of claims 1 to 3, **characterised**, that the bus-system is a CAN-bus.

5.

A method for the operation of a scalable cargo loading system according to one of claims 1 to 4, **characterised**, that the local controlling devices (SCB1, SCB2, SCB3) send the status of the prime movers (L1-L9, R1-R9), covering-over sensors and approaching switches (PL1-PL9, PR1-PR9) via the bus-system (CAN-bus).

6.

A method according to claim 5, **characterised**, that a local controlling device (SCB1, SCB2, SCB3) sends the sector status during the start-up of the cargo loading system and/or while changing the sector status.

7.

A method according to one of claims 5 or 6, **characterised**, that the sector status is sent in a standardised status object of the CAN-bus.

8.

A method according to one of claims 5 to 7, **characterised**, that a prime mover (L1-L9, R1-R9) not covered-over by a cargo unit is activated, if it is arranged (viewed in the transport direction) behind a prime mover covered by a cargo unit.

9.

A method according to one of claims 5 to 8, **characterised**, that (as viewed into the cargo deck) a prime mover (L1-L9, R1-R9) located behind an erected interlock is not activated.