

Test Report Trailers with more than three Axles



Assessment according to ECE-Regulation No. 13, Annex 20, paragraph 7.4

Test Report No.: **EB159_SUPPL.1E**

EB⁺

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1 Introduction

1.1 The current scope of the Annex 19 and 20 procedures with respect to anti-lock braking is limited to trailers with a maximum of three axles. As a result, up to now, trailers with more than 3 axles could not make use of this procedure and therefore had to be approved by practical tests.

Taking into account that

- the approval costs are significantly high due to the relatively low volume of these trailers which are often special, and
- as a matter of principle, trailers with more than 3 axles tend to be more stable due to the number of axles on the ground

the brake experts group in Geneva (GRRF) developed a special procedure which allows the Annex 19 ABS test report to be utilized provided the conditions as laid down in ECE-R13, Annex 20, paragraph 7.4 are fulfilled. These requirements are introduced into ECE-Regulation No. 13 by Supplement 7 to the 11 series of amendments which will enter into force on 28.10.2011.

For the system EB⁺ extensive tests have been carried out for trailers up to three axles. These tests are covered by the current test reports EB159.2E and EB128.9E. For the sake of simplicity the Manufacturer's Trailer ABS Information Document of the Trailer EBS **BPW ECO Tronic** is abbreviated in this report to "**ID_GS0443**" and Trailer **EB⁺** system is abbreviated in this report to "**ID_GS0441**".

This test report is only valid when used in conjunction with test reports EB159.2E (ID_GS0443) and EB128.9E (ID_GS0441).

2 Identification

- 2.1 Manufacturer:** **Haldex Brake Products Ltd**
Redditch, Worcestershire B98 9HA
United Kingdom
- 2.2 System name/model:** **EB⁺**

2.3 System variants:

2.3.1 EB⁺ Gen 1:

This is a modular EBS package consisting of one or two modulators and a **removable** ECU with the following possibilities:

- 1M system with integrated single modulator (ABS category B system, category O₃ trailers)
- 2M system with integrated twin modulator
- 2M system with integrated single modulator plus slave modulator
- 3M system with integrated twin modulator plus slave modulator

2.3.2 EB⁺ Gen 2:

This is an integrated EBS package consisting of a **non-removable** ECU with the following two possibilities:

- 2M system with integrated twin modulator
- 3M system with integrated twin modulator plus Gen 1 1M slave modulator

2.3.3 BPW ECO Tronic:

This is an integrated EBS package consisting of a **non-removable** ECU with the two possibilities according to paragraph 2.3.2.

This variant is identical to the variant EB⁺ Gen 2 (see TÜV NORD Report EB159.2E) as far as ECE Regulation 13 is concerned.

BPW is the manufacturer's authorised representative for this variant only.

3 System and installation

3.1 Configurations:

4S/3M (independent side by side and select low control) utilising 2S/2M (independent side by side control) and 2S/1M (select low control)

3.2 Range of application:

The assessment of this report covers the "Installation Options" as illustrated in **Annex 1**

3.2.1 ABS Configuration:

The 4S/3M configuration (combinations of 2S/1M and 2S/2M configuration) as defined in paragraph 3.1 above ensure that the minimum number of directly controlled wheels installed on the trailer, irrespective of type, is four (as prescribed by paragraph 7.4.1, Annex 20, ECE-R13).

3.2.2 Application:

Semi-trailer and full trailers with more than 3 axles

The axles are grouped in such a way that each modulator controls brakes on no more than three axles and each axle group installations/configurations are covered by the ABS performance tests documented in TÜV NORD test reports EB159.2E and EB128.9E.

3.3 Identification of approved components

3.3.1 Scope:

The scope of this report is limited to the components identified in test reports EB159.2E (ID_GS0443) and EB128.9E (ID_GS0441) as follows:

3.3.1.1 Wheel speed sensors:

See paragraph 2.1.3.1 of ID_x

3.3.1.2 Controller (ECU):

See paragraph 2.1.3.2 of ID_x

3.3.1.3 Modulators:

See paragraph 2.1.3.3 of ID_x

4 ABS Performance

4.1 Utilisation of adhesion:

For the trailers referenced in Annex 1, the minimum utilisation of adhesion specified within paragraph 6.2 of Annex 13 (75%) is deemed to be achieved when following conditions are fulfilled (see paragraph 7.4.2, Annex 20, ECE R13):

- The relationship of the number of wheels directly or indirectly controlled by one or more pressure modulators and the location of the directly controlled wheels within the axle group (see also paragraph 3.1 above) shall correspond to those defined within Appendix 1 of ID_GS0443 and ID_GS0441.*
- The corresponding ABS performance tests are reported in TÜV NORD test reports EB159.2E and EB128.9E.*

* It is noted that when two ABS configurations are combined into one system the control logic for each configurations is unchanged but the vehicle reference speed is calculated from four wheels instead of two which ensures an even more reliable determination of the vehicle reference speed (especially in case of single wheel speed sensor failures).

- 4.2 Energy consumption:** The number of equivalent static brake applications is regarded as not dependent on the number of axles controlled but a function of the trailer and brake type. Therefore, the number of equivalent static brake applications defined within paragraph 2.5 of the test reports EB159.2E and EB128.9E may be used in conjunction with the verification procedure of paragraph 7.3 of Annex 20 to ECE Regulation 13. Alternatively the test procedure specified within paragraph 6.1 of Annex 13 may be used; see also paragraph 7.4.3, Annex 20, ECE R13.
- 4.3 Low speed performance:** Additional verification is not required (paragraph 7.4.4, Annex 20, ECE R13)
This performance (at speeds of 40 km/h; see paragraph 6.3.1 of Annex 13) is seen as a function of the anti-lock braking system which is not dependent on the number of axles on the trailer. Thus, the positive assessment of paragraph 3.3.4 of test reports EB159.2E and EB128.9E does also cover the range of trailers as defined in paragraph 3.2 above.
- 4.4 High speed performance:** Additional verification is not required (paragraph 7.4.5, Annex 20, ECE R13)
This performance (at speeds of 80 km/h; see paragraph 6.3.1 of Annex 13) is seen as a function of the anti-lock braking system which is not dependent on the number of axles on the trailer. Thus, the positive assessment of paragraph 3.3.5 of test reports EB159.2E and EB128.9E does also cover the range of trailers as defined in paragraph 3.2 above.
- 4.5 Split-friction test /
Category A performance:** The split friction requirements specified within paragraph 6.3.2. of Annex 13 to ECE-R13 are deemed to be fulfilled when the number of wheels which are subject to independent left/right control is equal to or greater than the number of wheels controlled using "select low" axle control (paragraph 7.4.6, Annex 20, ECE R13).
“Independent control” here means that the wheels on each side are controlled by different brake pressures according to the available tyre/road adhesion.

The test trailers with the 2S/1M anti-lock system configuration which test results are reported in Appendix 4-1 to TÜV NORD test report EB128.9E have not been tested to the split- μ requirements of paragraph 6.3.2 of Annex 13 due to its select low control (SL) and therefore do not fulfil the Category 'A' requirements.

Based on a simplified worst case assumption that the "low" and "high" wheels during a split-friction test are controlled with the same minimum efficiency of 75 % the following table "Split-friction Performance" shows for the various vehicle configurations the theoretical achievable braking rates for the 75 % efficiency assumption.

Used abbreviations:

STx x-axle semi-trailer

FTx x-axle full trailer

Note: In the case of full trailers the calculation assumed a load transfer of plus 15% for the front wheels and minus 15% for the rear wheels which can only be regarded as a very simplified assumption since the load transfer is dependent on the achieved deceleration during the μ -split test.

xL x number of wheels running on low adhesion surface **or** wheels SL controlled

xH x number of wheels running on high adhesion surface (except wheels SL controlled)

r ratio of the friction coefficients of low and high adhesion surfaces ($r = k_H / k_L$)

Z_{min1} minimum required braking rate zRALS according to formula
$$z_{RALS} \geq \frac{0.75}{\epsilon_H} \cdot \frac{4z_{RALL} + z_{RALH}}{5}$$

Z_{min2} minimum required braking rate zRALS according to formula
$$z_{RALS} > \frac{z_{RALL}}{\epsilon_H}$$

Z_{75%} calculated braking rate performance based on an assumed efficiency of $\epsilon = 75\%$

It should be noted that for r values from 2 to 2,331 requirement z_{min2} is more stringent than requirement z_{min1} . Therefore, for these ratios r the relevant Z_{RALS} requirement is Z_{min2} .

Note: The borderline case at ratio 2,67 has to be disregarded due to the requirement of paragraph 2.2 of Appendix 3 of Annex 13: “If $\epsilon_H > 0.95$, use $\epsilon_H = 0.95$ ”

Table “Split-friction Performance”			
Trailer	r	Z75% / Z _{min2}	Z75% / Z _{min1}
Semi-Trailer			
S_1L3I_L	2,00	1,03	-
S_1L3I_R	2,33	1,12	1,18
S_3I1L_L	3,00	-	1,25
S_3I1L_R	6,00	-	1,44
ST4_5L_3H			
S_2L2I_L	2,00	1,00	-
S_2L2I_R	2,33	1,08	1,14
S_2I2L_L	3,00	-	1,19
S_2I2L_R	6,00	-	1,33
ST4_6L_2H			
S_2L3I_L	2,00	0,98	-
S_3I2L_L	2,33	1,05	1,11
S_2L3I_R	3,00	-	1,14
S_3I2L_R	6,00	-	1,25
ST5_7L_3H			

Table "Split-friction Performance"			
Trailer	r	Z75% / Z _{min2}	Z75% / Z _{min1}
Full Trailer			
F_2L2I_L	2,00	0,91	-
	2,33	0,96	1,01
F_2L2I_R	3,00	-	1,02
	FT4_6L_2H	6,00	1,03
F_2L3I_L	2,00	0,98	-
	2,33	1,05	1,11
F_2L3I_R	3,00	-	1,14
	FT5_7L_3H	6,00	1,25

4.6 Surface transitions performance:

Additional verification is not required (paragraph 7.4.7, Annex 20, ECE R13)

See also requirements of paragraphs 5.4.1.5.1 (high to low) and 5.4.1.5.2 (low to high) of Annex 19.

This performance is seen as a function of the anti-lock braking system which is not dependent on the number of axles on the trailer. Thus, the positive assessments of paragraphs 3.3.6.1 and 3.3.6.2 of test reports EB159.2E and EB128.9E do also cover the range of trailers as defined in paragraph 3.2 above.

5 Limitations of installation

5.1 This report is only applicable when all installation limitations specified within test reports EB159.2E (**ID_GS0443**) and EB128.9E (**ID_GS0441**) are observed; in particular these include:

- Only products identified and referenced in ID_GS0443 or ID_GS0441 may be installed, in particular:
- Only the sensors, controllers and modulators described in ID_GS0443 or ID_GS0441, paragraph 2.1.3.1.1 and Appendix 7 may be installed.
- Tyre to exciter relationship – see ID_GS0443 or ID_GS0441, paragraph 2.1.2.3

- Tyre size tolerance - see ID_GS0443 or ID_GS0441, paragraph 2.1.2.4
- Suspension type - see ID_GS0443 or ID_GS0441, Appendix 4
- Full trailer wheel base – minimum wheel base is 3210 mm
- Brake type – air operated drum or disc brakes
- Tube sizes and length: see ID_GS0443 or ID_GS0441, Appendix 2 (maximum length of 5.0 m)
- Delivery volume which each pressure modulator may control – see ID_GS0443 or ID_GS0441, paragraph 2.1.3.3.2.1

5.2 Lifting axles:

See limitations in the associated installation schematics of [Appendix 1](#).

Paragraph 3.2 of Annex 13 to ECE-R13 requires that all wheels must be either directly or indirectly controlled. Thus, an axle with directly controlled wheels may only be lifted if axles which are indirectly controlled from this directly controlled axle are lifted in parallel (paragraph 7.4.8.4, Annex 20, ECE R13).

5.3 Steering axles:

This report does not cover an assessment of the reaction of any steering systems to the anti-lock braking control of the EB⁺ system.

For approved installation options with respect to sensor / modulator locations and recommendations by the manufacturer for the use of steering axles see ID_GS0443 and ID_GS0441, paragraph 2.1.2.2 and Appendix 1 of this report.

6 Attachments

6.1 Annex 1 “Installation Options”

7 Conclusions

- 7.1 Testing according to the Annex 19 of ECE Regulation 13 is limited to trailers with up to 3 axles. This range of trailers is covered by TÜV NORD test reports EB159.2E and EB128.9E.
- 7.2 This report gives a positive technical assessment for trailers with four and five axles according to the procedure as laid down in ECE R13, Annex 20, paragraph 7.4. The specific ABS performance requirements of ECE-Regulation No. 13 introduced by Supplement 7 to the 11 series of amendments (which will enter into force on 28.10.2011) are fulfilled for the Trailer EBS system covered by this report.

Essen, 19th August 2011

TDB/Gaupp

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TÜV NORD Mobilität GmbH & Co. KG
Institute for Vehicle Technology and
Mobility (IFM)

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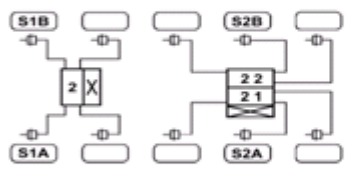
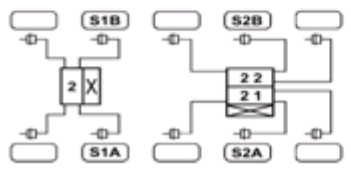
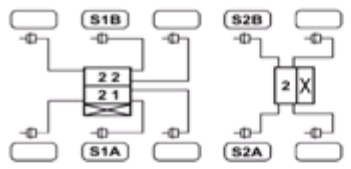
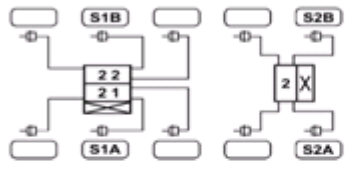
Technical Service for Braking Systems

A handwritten signature in blue ink, appearing to read "W. Gaupp". The signature is written in a cursive, flowing style.

Dipl.-Ing. Winfried Gaupp

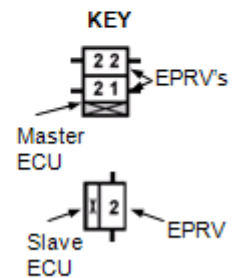
Annex 1: Installation Options

EB+ Gen 1 & EB+ Gen 2 Installation Options Semi trailers

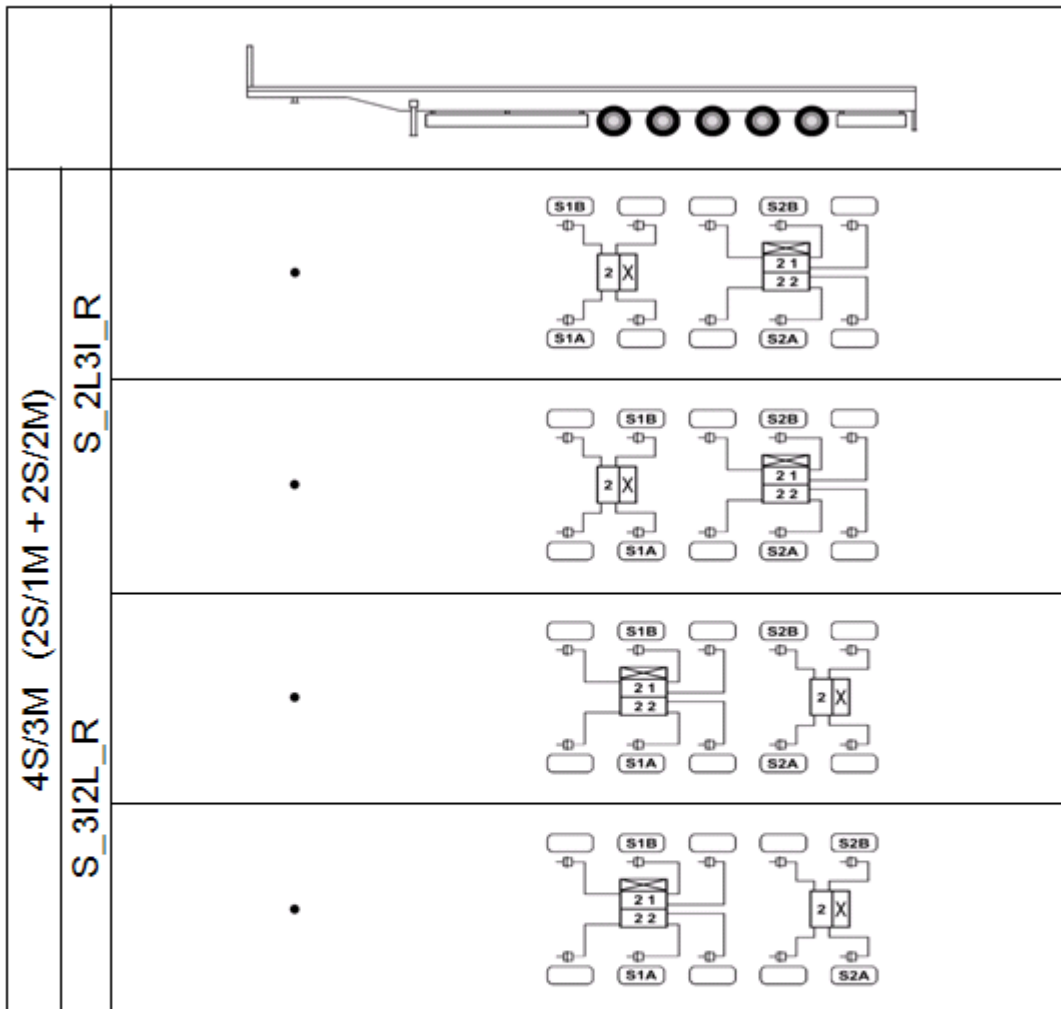
	
4S/3M (2S/1M + 2S/2M)	S_2L3I_L 
	
	S_3I2L_L 
	

Applicable notes

- N1 – Master ECU is mounted to EPRV's 21/22. All sensors must be connected to this Master ECU.
- N2 – Directly controlled wheels connected pneumatically to EPRV's 21/22 cannot be lifted.
- N3 – Slave ECU is mounted to EPRV 2 and is controlled by Master ECU. Slave ECU/EPRV 2 is shown facing rear but can also be installed facing forward, left or right, as EPRV 2 is always select low control.
- N4 – Sensed wheels connected pneumatically to EPRV 2 can be lifted but corresponding in directly controlled wheels must be lifted in parallel.
- N5 – Any axle without directly controlled wheels may be lifted.
- N6 – Any axle may be a steered axle.



EB+ Gen 1 & EB+ Gen 2 Installation Options Semi trailers



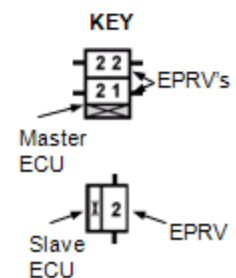
4S/3M (2S/1M + 2S/2M)

S_2L3I_R


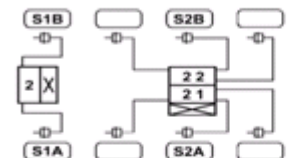


S_3I2L_R

Applicable notes

- N1 – Master ECU is mounted to EPRV's 21/22. All sensors must be connected to this Master ECU.
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- N4 – Sensed wheels connected pneumatically to EPRV 2 can be lifted but corresponding indirectly controlled wheels must be lifted in parallel.
- N5 – Any axle without directly controlled wheels may be lifted.
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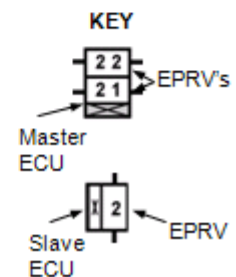


EB+ Gen 1 & EB+ Gen 2 Installation Options Semi trailers

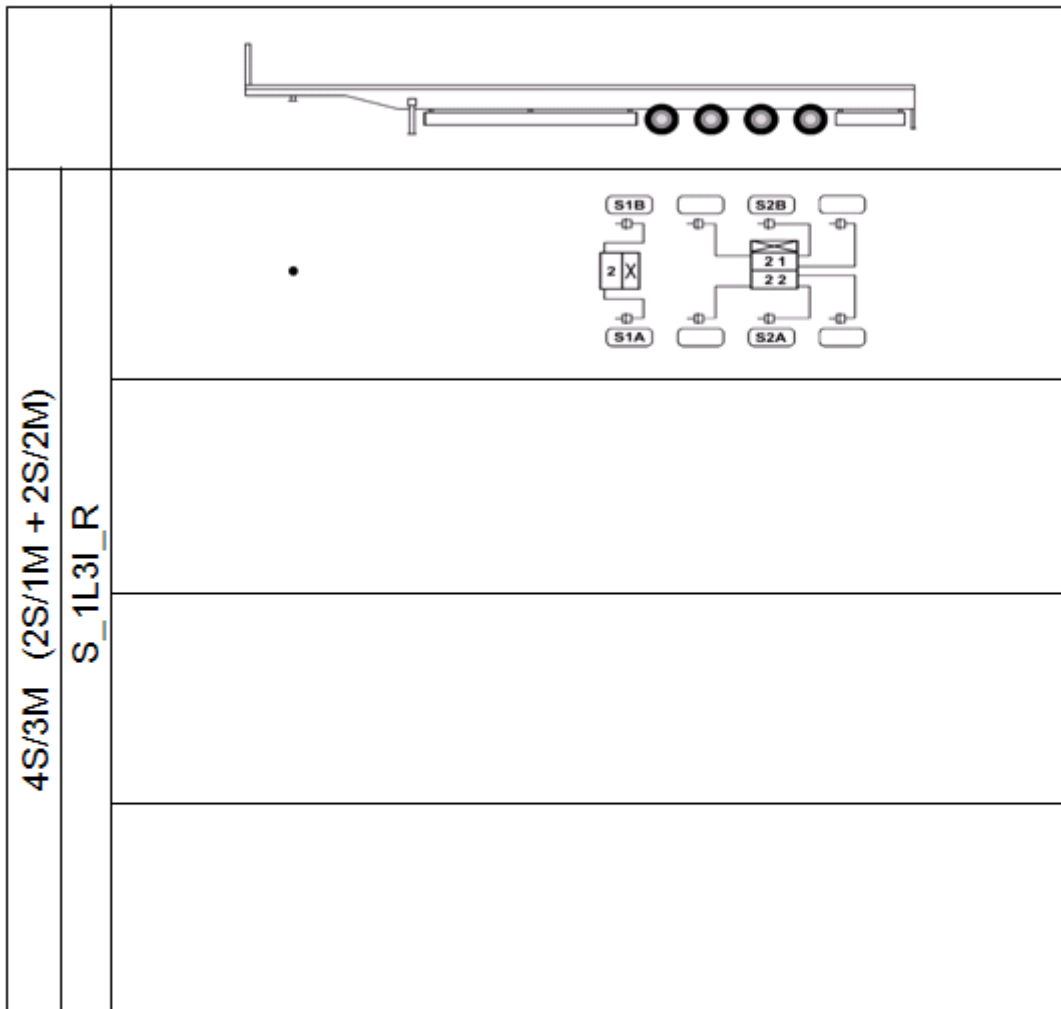
	
	
4S/3M (2S/1M + 2S/2M) S_1L3J_L	
	

Applicable notes

- N1– Master ECU is mounted to EPRV's 21/22. All sensors must be connected to this Master ECU.
- N2– Directly controlled wheels connected pneumatically to EPRV's 21/22 cannot be lifted.
- N3– Slave ECU is mounted to EPRV 2 and is controlled by Master ECU. Slave ECU/EPRV 2 is shown facing rear but can also be installed facing forward, left or right, as EPRV 2 is always select low control.
- N4– Sensed wheels connected pneumatically to EPRV 2 can be lifted but corresponding indirectly controlled wheels must be lifted in parallel.
- N5– Any axle without directly controlled wheels may be lifted.
- N6– Any axle may be a steered axle.

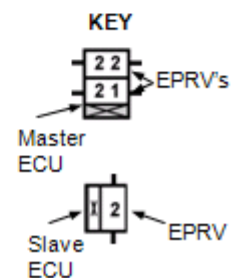


EB+ Gen 1 & EB+ Gen 2 Installation Options Semi trailers


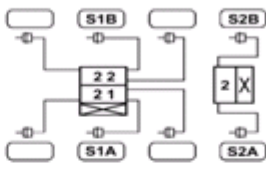
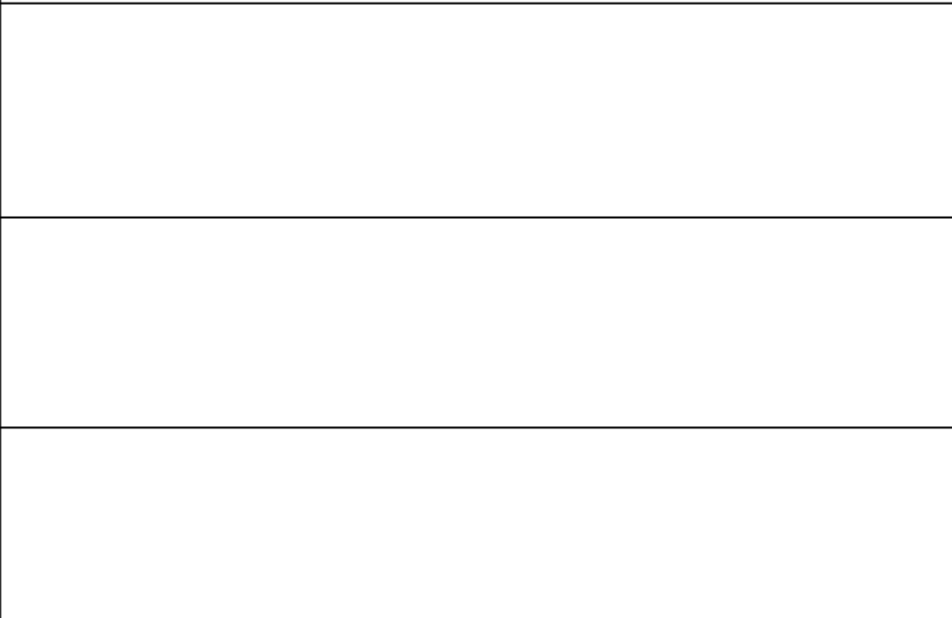


Applicable notes

- N1 – Master ECU is mounted to EPRV's 21/22. All sensors must be connected to this Master ECU.
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- N4 – Sensed wheels connected pneumatically to EPRV 2 can be lifted but corresponding indirectly controlled wheels must be lifted in parallel.
- N5 – Any axle without directly controlled wheels may be lifted.
- N6 – Any axle may be a steered axle.

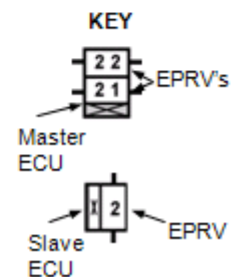


EB+ Gen 1 & EB+ Gen 2 Installation Options Semi trailers


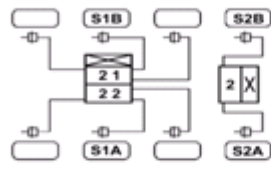



	
	
4S/3M (2S/1M + 2S/2M) S_311L_L	

Applicable notes

- N1 – Master ECU is mounted to EPRV's 21/22. All sensors must be connected to this Master ECU.
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- N3 – Slave ECU is mounted to EPRV 2 and is controlled by Master ECU. Slave ECU/EPRV 2 is shown facing rear but can also be installed facing forward, left or right, as EPRV 2 is always select low control.
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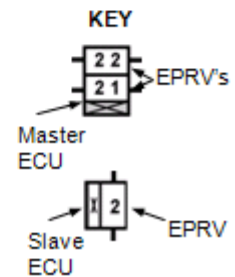


EB+ Gen 1 & EB+ Gen 2 Installation Options Semi trailers


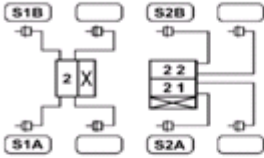
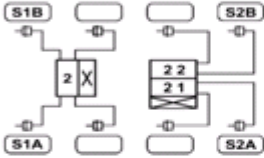
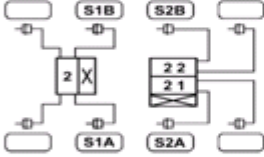
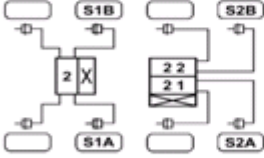
	
	
4S/3M (2S/1M + 2S/2M) S_3I1L_R	
	
	

Applicable notes

- N1 – Master ECU is mounted to EPRV's 21/22. All sensors must be connected to this Master ECU.
- N2 – Directly controlled wheels connected pneumatically to EPRV's 21/22 cannot be lifted.
- N3 – Slave ECU is mounted to EPRV 2 and is controlled by Master ECU. Slave ECU/EPRV 2 is shown facing rear but can also be installed facing forward, left or right, as EPRV 2 is always select low control.
- N4 – Sensed wheels connected pneumatically to EPRV 2 can be lifted but corresponding indirectly controlled wheels must be lifted in parallel.
- N5 – Any axle without directly controlled wheels may be lifted.
- N6 – Any axle may be a steered axle.

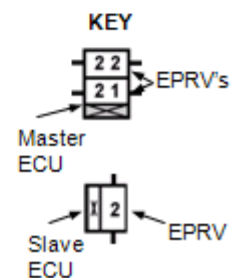


EB+ Gen 1 & EB+ Gen 2 Installation Options Semi trailers

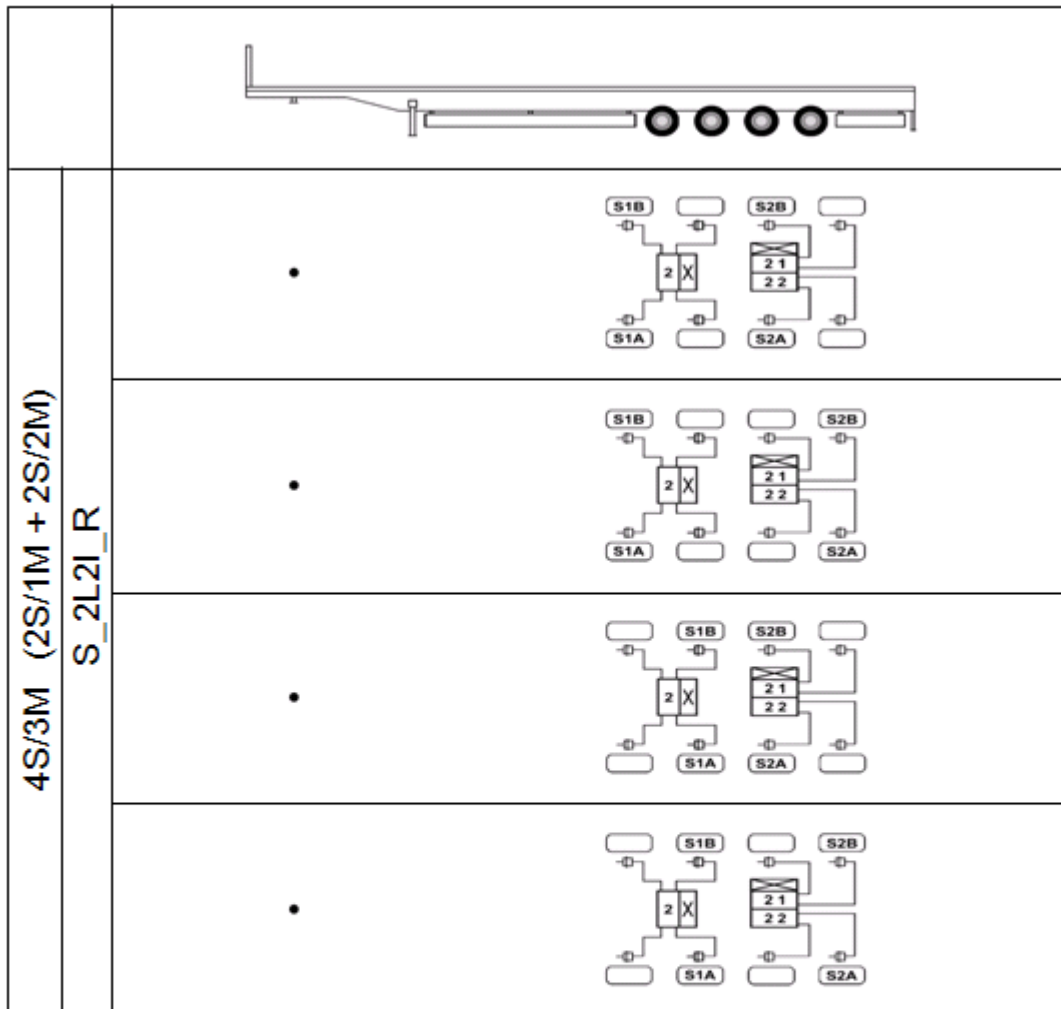
	
4S/3M (2S/1M + 2S/2M) S_2L2I_L	
	
	
	

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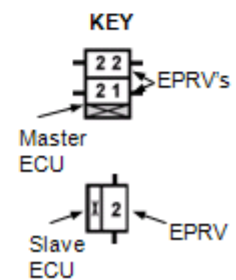


EB+ Gen 1 & EB+ Gen 2 Installation Options Semi trailers

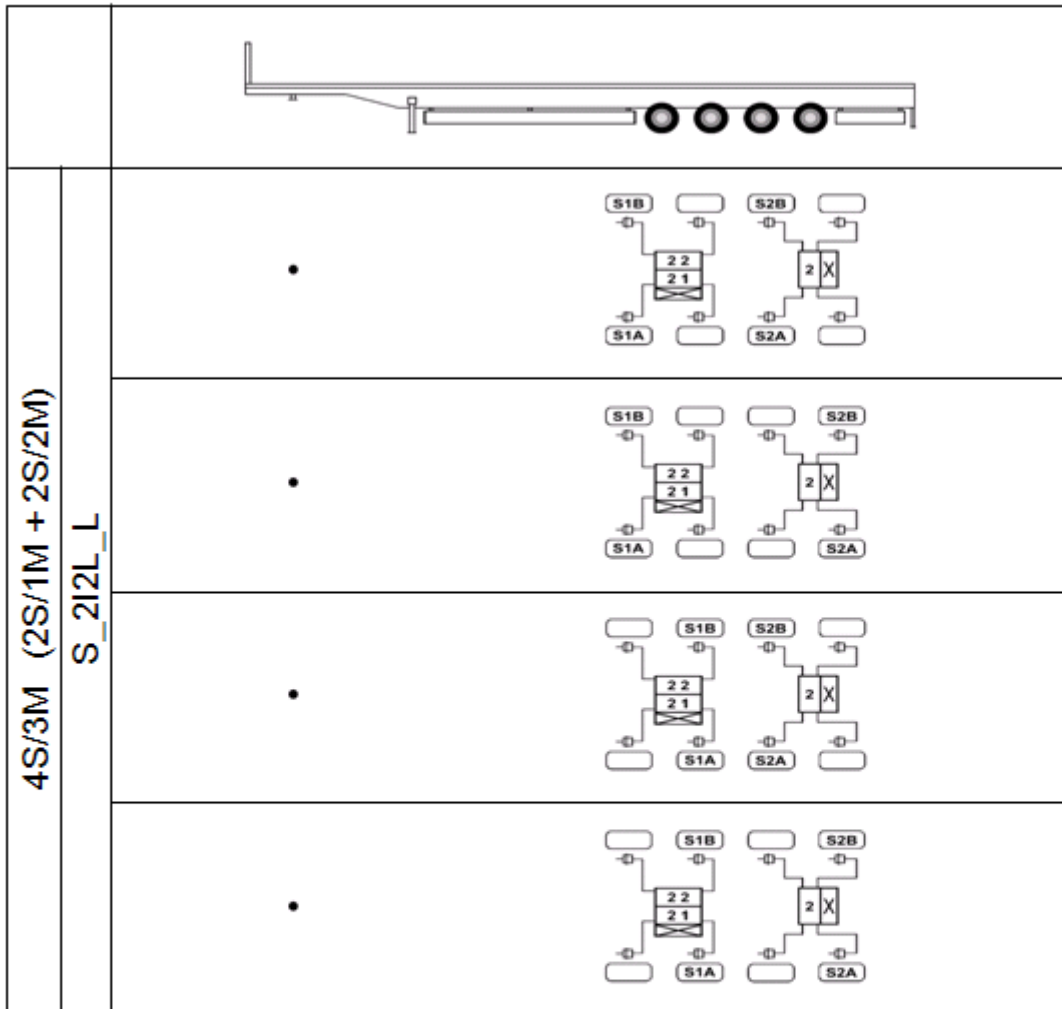


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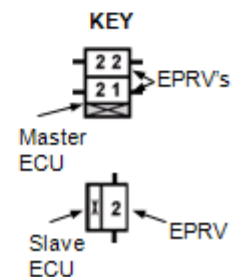


EB+ Gen 1 & EB+ Gen 2 Installation Options Semi trailers


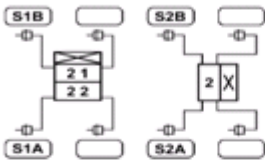
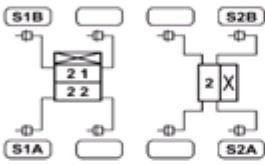
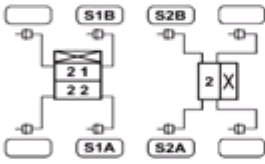
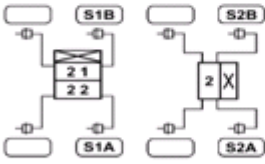


Applicable notes

- N1- Master ECU is mounted to EPRV's 21/22. All sensors must be connected to this Master ECU.
- N2- Directly controlled wheels connected pneumatically to EPRV's 21/22 cannot be lifted.
- N3- Slave ECU is mounted to EPRV 2 and is controlled by Master ECU. Slave ECU/EPRV 2 is shown facing rear but can also be installed facing forward, left or right, as EPRV 2 is always select low control.
- N4- Sensed wheels connected pneumatically to EPRV 2 can be lifted but corresponding indirectly controlled wheels must be lifted in parallel.
- N5- Any axle without directly controlled wheels may be lifted.
- N6- Any axle may be a steered axle.

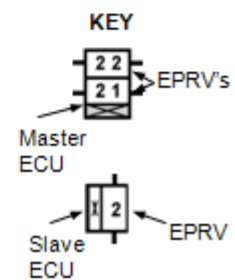


EB+ Gen 1 & EB+ Gen 2 Installation Options Semi trailers

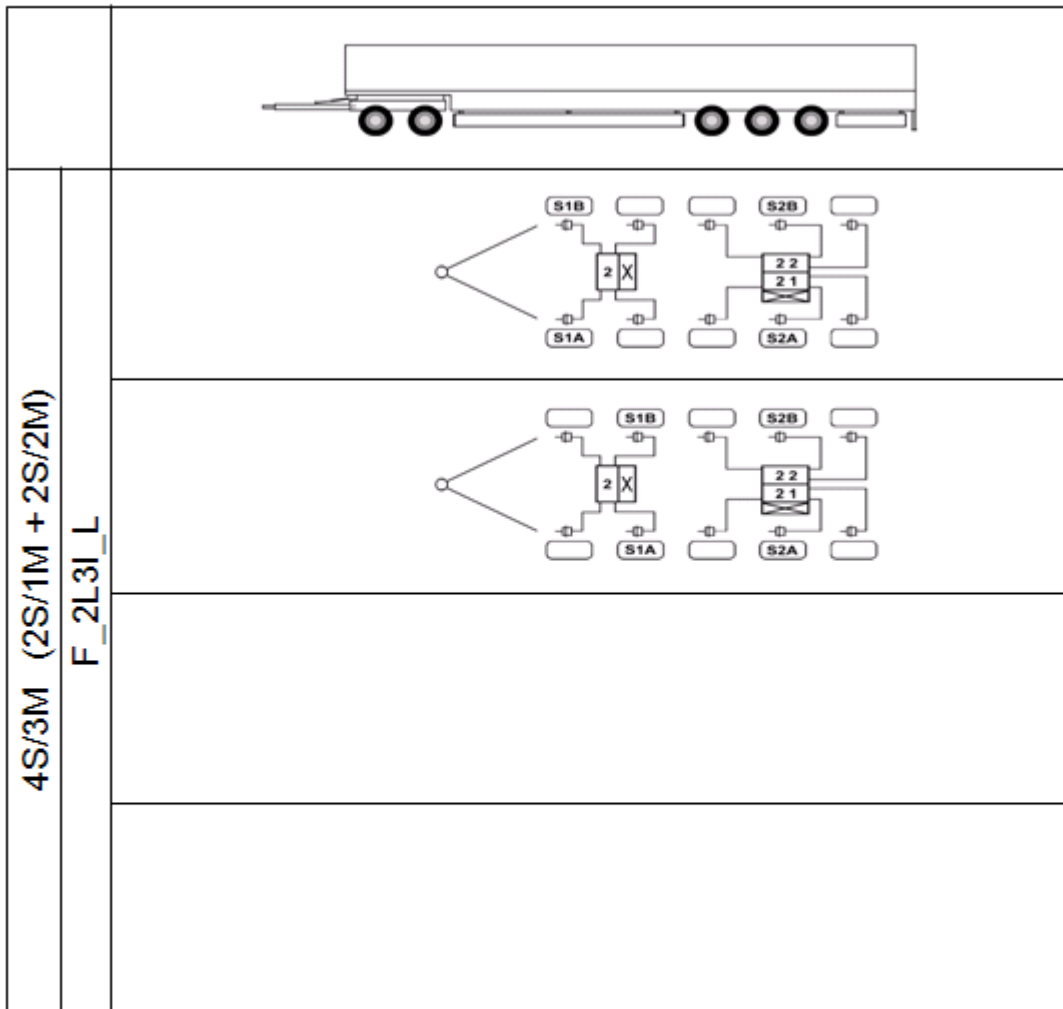
	
4S/3M (2S/1M + 2S/2M) S_2I2L_R	
	
	
	

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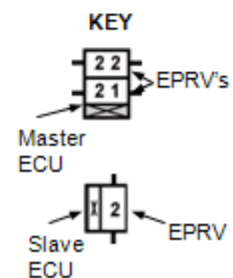


EB+ Gen 1 & EB+ Gen 2 Installation Options Full trailers



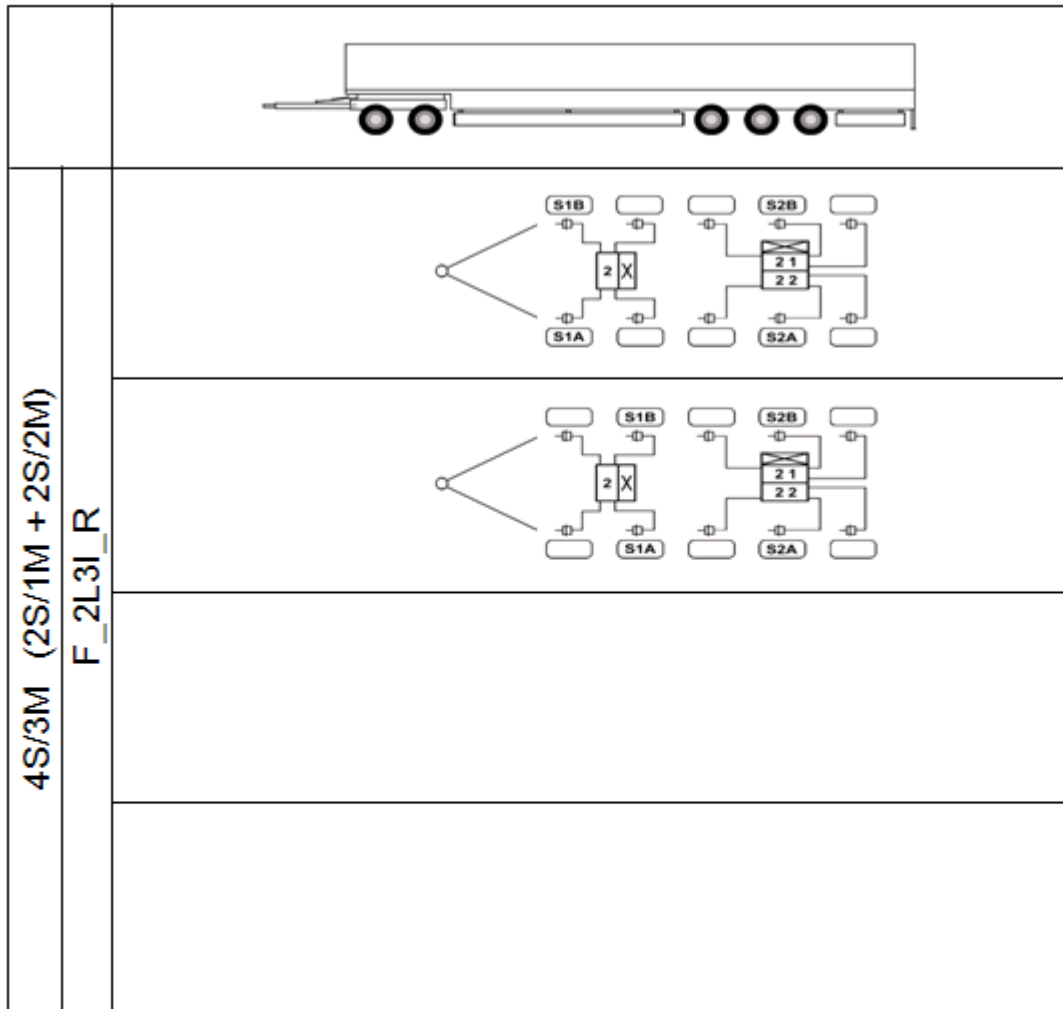
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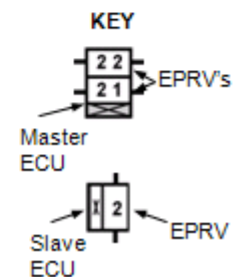
EB+ Gen 1 & EB+ Gen 2 Installation Options

Full trailers



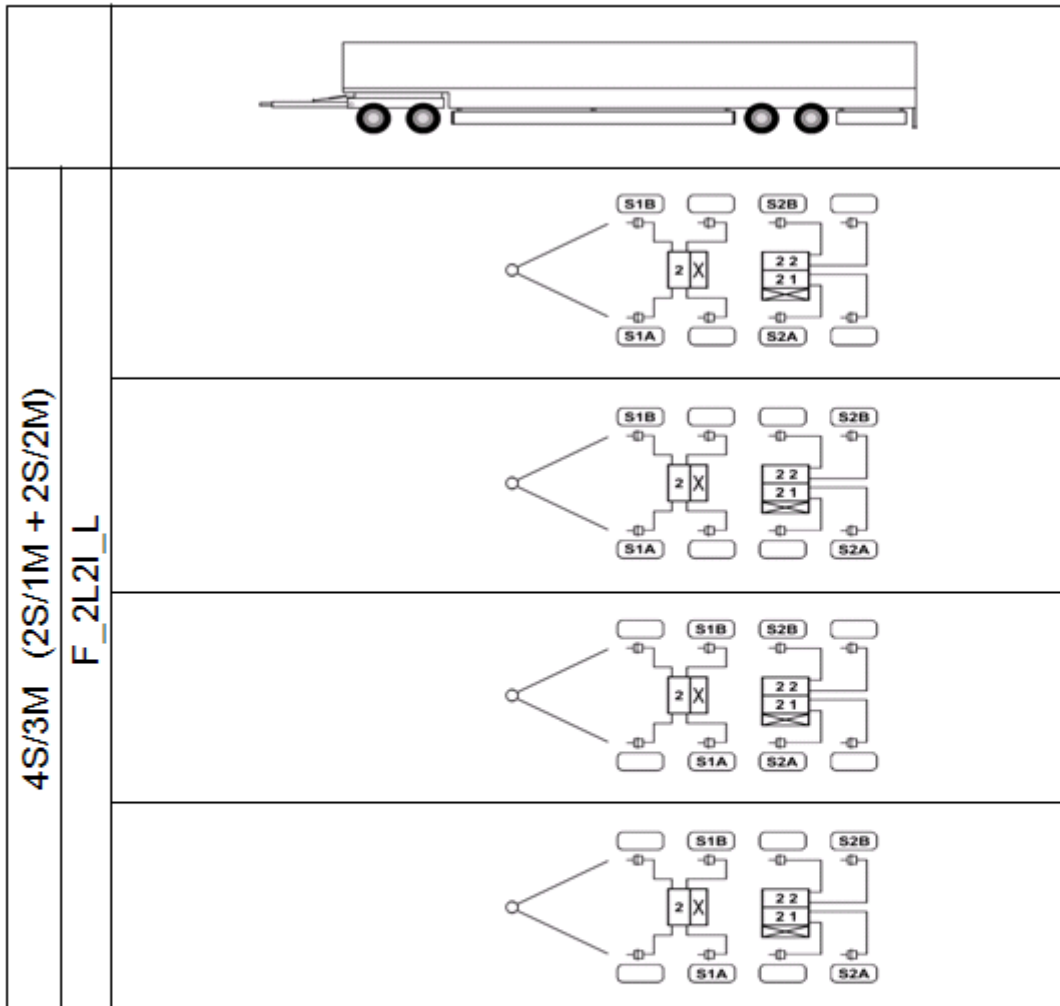
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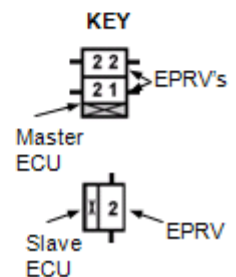
EB+ Gen 1 & EB+ Gen 2 Installation Options

Full trailers

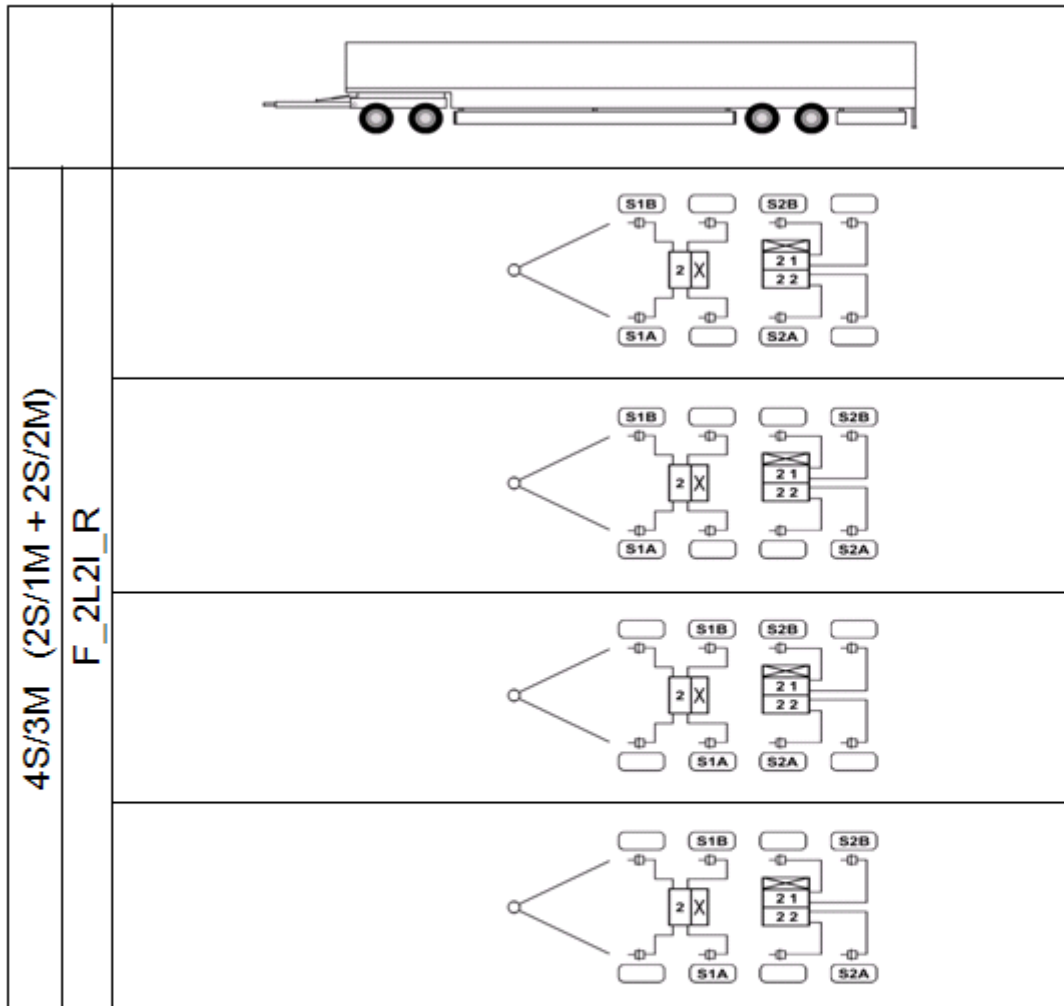


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EB+ Gen 1 & EB+ Gen 2 Installation Options Full trailers



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