Test Report

No. EB175.0E

Obstacle Detection Device during reversing

according to

ISO TR 12155

Issue 1994-10-01

TÜV NORD Mobilität

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Content

1 Identification

1.1 Manufacturer: **WABCO Fahrzeugsysteme GmbH**
Am Lindener Hafen 21
D - 30453 Hannover

1.1.1 Applicant: see 1.1

1.2 System: **Rear Monitoring System**
(see also note to paragraph **3.1**)

1.2.1 System variants / trade names: **TailGUARDmax (6 sensor system**
see Figure 3 in Annex 4

Note: This report covers only the system variant "**TailGUARDmax**". However, this function is known under the general term **"TailGUARD".** Therefore, the Rear Monitoring System covered by this report is hereinafter referred to as '**TailGUARD'**.

2 Scope

2.1 Vehicle categories: Commercial vehicles (motor vehicles of category N_2 and N_3 and trailers of categories O_3 and O_4 according to framework Directive 2007/46/EC, Annex II or as defined in Annex 7 to the Consolidated Resolution on the Construction of Vehicles (R.E.3).

Note: However, the scope of application in paragraph 1 of ISO standard TR 12155 refers only to solo vehicles.

2.2 Operating Speed: The rear monitoring function is maintained up to a speed of 12 km/h.

The ISO standard TR 12155 assumes that a vehicle is normally reversing at a speed of up to 5 km/h (approximately walking pace). On this assumption the three specific monitoring ranges (paragraph **2.3**) are specified by this standard.

2.3 Monitoring Range:

This is a three-dimensional area (height up to 1.1 m) behind the vehicle which is subdivided into three specific monitoring ranges:

- a pre-warning range
- a main warning range
- a collision range;

see Figure 1 in Annex 2, paragraph 1

3 System Description

3.1 General:

The TailGUARD consists of the following main components:

- Sensors
- ECU (ELEX)
- Visual and acoustic indicator (TRC = Trailer Remote Control)
- and PLC (Power Line Communication)

When the ignition (start) switch is in the 'on' (run) position and the reverse gear is selected, the TailGUARD function is automatically activated. The TailGUARD gives an acoustic and visual indication to the vehicle driver (not an alarm to other personnel in the area) when an obstacle behind the vehicle is detected.

3.2 Monitoring range:

See also paragraph 2.3

The monitoring range for reversing detection devices is defined by the measuring points in **figures 3 to 6** of ISO standard TR 12155:

Figure	Test	Annex 2	Height positions
3	1	paragraph 5.2	
4 / 5	2	paragraph 5.3	< 300 mm 800 mm 1100 mm
3	3	paragraph 5.4	
6	2	-	see Test 2

See also paragraph **2.3** 'Monitoring Range' above.

3.3	**Location of sensors:**	The sensors are arranged so that the monitoring range specified in paragraph **3.2** is covered The following dimensions are programmed by end-of-line" parameterisation (see paragraph **3.6** below and Annex 5, paragraph 4): - Body overhang (distance of sensor with respect to reference plane of vehicle rear side; see Figure **3.2.1**a in Annex 5) - Distance(s) between sensors - Mounting height of sensors
3.4	**Identification:**	The TailGUARD can be identified by its components; see following paragraph **3.5**.
3.5	**Components:**	see also Annex 4, paragraph 2.
3.5.1	**Electronic extension module:**	446 122 070 0
3.5.2	**Ultrasonic sensors:**	446 122 402 0 (2 or 4 - with 15° orientation, fitted on the left and right side of vehicle rear side) 446 122 401 0 (1 or 2 - with 0° orientation fitted in the middle of vehicle rear side)
3.5.3	**Trailer Remote Control:**	446 122 080 0 (see also paragraph **5.2** below and Annex 4, paragraph 2.2
3.6	**End-of-line" Programming:**	See Annex 5, paragraph 4 "Parameter setting / EoL"

4 Software

4.1	**Identification:**	The identification of software version is described in Annex 4, paragraph 2.1.1.

5 Requirement

5.1 Monitoring Range:

The sensors specified in paragraph 3.5.2 are arranged so that the monitoring range defined in paragraph 3.2 is covered.

Note: See also Annex 2, paragraph 5.1 "Overview Test 1 to Test 4" with respect to the tests which were carried out for demonstrating compliance with ISO TR 12155.

5.2 Indicators (TRC):

The TRC mounted in the cab and in the driver's field of vision conveys visual and acoustic signals, (see also Annex 5, paragraph 3.4.

5.2.1 Visual Indicators:

The visual indicators convey analogue messages (see paragraphs 5.3.1 and 5.4)

5.2.2 Acoustic Indicators:

The acoustic indicators convey the messages as described in paragraphs 5.3.2 and 5.4

5.3 Warning

5.3.1 Visual Signal:

The visual warning signals (range indicators) sent by the TRC are:

- **Intermittent yellow**: if there are objects in the pre-warning range (1.8 to 3 m distance)
- **Intermittent red**: if there are objects in the main warning range (0.7 to 1.8 m distance)
- **Continuous red**: if there are objects in the collision range (< 0.7 m distance)

5.3.2 Acoustic Signal:

The acoustic warning signals (range indicators) sent by the TRC are:

- A continuous **sequence** of individual tones with a pulse frequency of **2 Hz**: if there are objects in the pre-warning range (1.8 to 3 m distance)
- A continuous **sequence** of individual tones with a pulse frequency of **4 Hz**: if there are objects in the main warning range (0.7 to 1.8 m distance)
- A continuous **tone**: if there are objects in the collision zone (objects in the collision range: distance < 0.7 m)

Note: The DIN standard 75032:1995 (equivalent German version of ISO TR 12155:1994) allows that the three acoustic warning signals defined above may be so wired that the volume during the current activation process can be reduced manually. However, the wording of the ISO standard is such that this allowance (see 'Note 4' to ISO paragraph 5.3.2.1) is only made to the "continuous tone".

Since both standards are in conflict regarding this requirement, the manufacturer complies with the newer German standard and provides the possibility to reduce the sound volume***** of the three acoustic warning signals defined above. This reduction is automatically cancelled when the ignition (start) switch is switched off.

***** also possible to increase the volume level

5.4 TRC visual and acoustic indication

5.4.1 Initialisation

- Visual: When the ignition is switched on all LEDs of the TRC are illuminated briefly.

- Acoustic: When the ignition is switched on the buzzer sounds briefly.

5.4.2 Activation

- Visual: When the reverse gear is engaged the red and yellow LEDs of the RMS are illuminated briefly.

- Acoustic: When the reverse gear is engaged the buzzer sounds briefly.

5.4.3 Readiness indication

- Visual: If no obstacle is detected the lower (3rd) row of the green LEDs are illuminated.

- Acoustic: **n / a** (no buzzer sound)

5.5 Acoustic signal

5.5.1 Noise level (ISO 7731):

ISO standard TR 12155 (paragraph 4.2.2) requires that the A-weighted sound-pressure level of the danger signal shall not be lower than 65 dB at any position in the signal reception area.

In order to verify this requirement the manufacturer has carried out noise tests (Test Report No. TR-6171-2010-0017 as of 01.09.2010) in a cabin of a truck.

The A-weighted sound-pressure level of the ambient noise in the cabin was measured with the sound level meter while the engine was running at idle speed and at a speed of 1000 rpm.

Test results:

Engine speed (rpm)	**Ambient noise** Sound pressure in the cabin without TRC warning	**Sound pressure in the cabin with TRC warning***
500 (idle)	**54,3 db(A)**	**73,1 db(A)**
1000	**57,1 db(A)**	**74,9 db(A)**

***** See paragraph 5.3.2 above

The TRC exceeds the required sound pressure of 65dbA. The sound pressure difference between the ambient noise and the TRC warning sound is greater than the required difference of 15db(A).

5.6 Faults:

Paragraph 5 of Annex 4 describes the faults and how they are indicated by the TRC.

During the assessment the following failures and their warnings were checked and verified:

- Line interruption of a sensor
- Short cut to ground of LIN bus
- Short cut of power supply of LIN sensors
- Undervoltage (≤ 8 V)*

  * **Note**: The TailGUARD is protected from an **over**voltage (≥ 32 V) by the EBS trailer module

- Soiling and covering of a sensor surface

All simulated faults were recognised and indicated as specified by the manufacturer; see paragraph 5 of Annex 4.

5.6.1 Visual Indication

- System activated: Continuous illumination of the red and yellow signals

- System not activated: Flashing of the red and yellow signals.

5.6.1 Acoustic Indication: Continuous tone with a minimum duration of 3 s and with a tone of a higher frequency than the normal warning tones

5.7 System measuring time: The manufacturer confirms that the measuring time for all 6 sensors of the TailGUARGmax does not take longer than 100 ms before the indication appears which is distinctively faster than the permitted maximum time of 200 ms (paragraph 5.4 of ISO standard TR 12155).

5.8 System activation time: The manufacturer confirms that the activation time of the TailGUARGmax does not take longer than 300 ms before the indication appears which is distinctively faster than the permitted maximum time of 600 ms (paragraph 5.5 of ISO standard TR 12155).

5.9 Resistance to manipulation: The warning device cannot be switched off or its reliable operation easily be altered. Therefore, it is not possible to disable the system by simple means.

5.10 Monitoring of Operational Reliability

is carried out by the following self-testing functions:

5.10.1 Signal generation and echo reception: The transformation of the electrical signal into a waveform (e.g. ultrasonic) is done by the following components: Transducer, Transformer and BURST Transistor (see Figure 4 in paragraph 4 of Annex 4).
The manufacturer confirms, that the transformation of the electrical signal into a waveform (ultrasonic) is indirectly verified by the system by monitoring the post-pulse oscillation of the sensor diaphragm.

5.10.2 Measurement of distance:

Paragraph 5.7.2 of ISO standard TR 12155 stipulates:

"The test equipment shall check whether an echo signal from an object in the main warning range can still be related to this zone of the reversing detection device. This can be achieved, for example with an additional signal on an echo line which simulates the detection of an obstacle at a distance of 1 m. The correct correlation should be checked with the test device. "

In paragraph 4.1 of Annex 4 the manufacturer outlines why this ISO provision is not applicable to the TailGUARDmax with its digital signal processing.

5.10.3 Self-testing device requirements:

With respect to the requirements of ISO TR 12155, paragraph 5.7.3, the manufacturer describes in Annex 4 the safety measures in order to generate safe operation under fault conditions:

- Detection of faults which impede the rear monitoring function (see Annex 4, paragraph 5)
- Warning signals of the detected faults (see Annex 4, paragraph 5)
- Activation of the warning signals each time the reverse gear is engaged (see Annex 4, paragraph 5)
- ROM test (see Annex 4, paragraph 4)
- Watch-dog monitoring (see Annex 4, paragraph 4)

5.10.4 Trailer operation:

When the TailGUARDmax is fitted on a motor vehicle the motor vehicle must be able to recognize when an electrical connection is made between the tractor and the trailer.

For this case the manufacturer provides an additional component (Infomodule, WABCO No. 446 016 002 0) which interrupts the connection between the reverse gear switch and the TailGUARDmax (activation inhibited) when a trailer is coupled and the ignition (start) switch is in the 'on' (run) position.

The required wiring of the 'Infomodule' is shown by **Figure 5** in Annex 5, paragraph 5

5.10.5 Component Testing:

see Annex 3 of this report

6 Limitations

6.1 Scope of Application: see paragraph 2 above

6.2 Trailer Operation: see paragraph 5.10.4 above and Annex 5, paragraph 5

6.3 Operating Instructions: The operating instructions shall be checked with respect to the specification of the manufacturer of the TailGUARDmax before commissioning (see also Annex 5).

7 Test Results

see Annex 2 of this Test Report

8 Date of Test

April 2010

9 Annexes to this Test Report

1: Abbreviations

2: Test Results (monitoring range)

3: Component Testing *

4: Information by the Manufacturer *

5: Manufacturer's Installation Instructions *

***** Information provided by the manufacturer

10 Validity of Test Report

According to paragraph 8.5 of ISO TR 12155 the validity of this Test Report expires three years after the date of this Test Report.

11 Concluding certification

The assessment and tests have been carried out in accordance with ISO TR 12155-1994 . The scope of assessment of this report is limited to this standard.

This assessment applies to the TailGUARGmax system with its non-contact sensors which can be fitted on commercial vehicles.

With respect to the sound volume reduction see note to paragraph 5.3.2.

The obstacle detection device TailGUARD is designed to improve safety during rearward manoeuvring. It is regarded as an additional aid to the vehicle driver when reversing at a low speed of up to around 5 km/h (approximately walking pace). However, this device does not relieve the driver of his special responsibility when reversing (i.e. this is not a reversing alarm for other personnel in the area).

This report may only be published in its entirety unless written permission of the test laboratory referenced below is obtained.

Essen, 2nd November 2010
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TÜV NORD Mobilität GmbH & Co. KG
Institute for Vehicle Technology and Mobility (IFM)
Technical Service for Braking Systems

Accredited according to DIN EN ISO/IEC 17025:
D-PL-11109-01-00 / Designated as Technical Service by Kraftfahrt-Bundesamt: KBA-P 00004-96

W. Gaupp

Dipl.-Ing. Winfried Gaupp

Annex 1: Abbreviations

General	
ASS	ASPÖK SteckSystem
DUT	Device Under Test
EBS	Electronic Braking System
ELEX	Electronic Extension Module (part of the RMS)
EoL	End of line programming
PLC	Power Line Communication
RMS	Rear Monitoring System
TEBS-E	Trailer EBS Version E
TRC	Trailer Remote Control
US	Ultrasonic sensor

Annex 2: Test Results (monitoring range)

1. Monitoring Range

Figure 1 represents the specific three-dimensional area behind the vehicle, which is divided into a pre-warning range, a main warning range and a collision range.

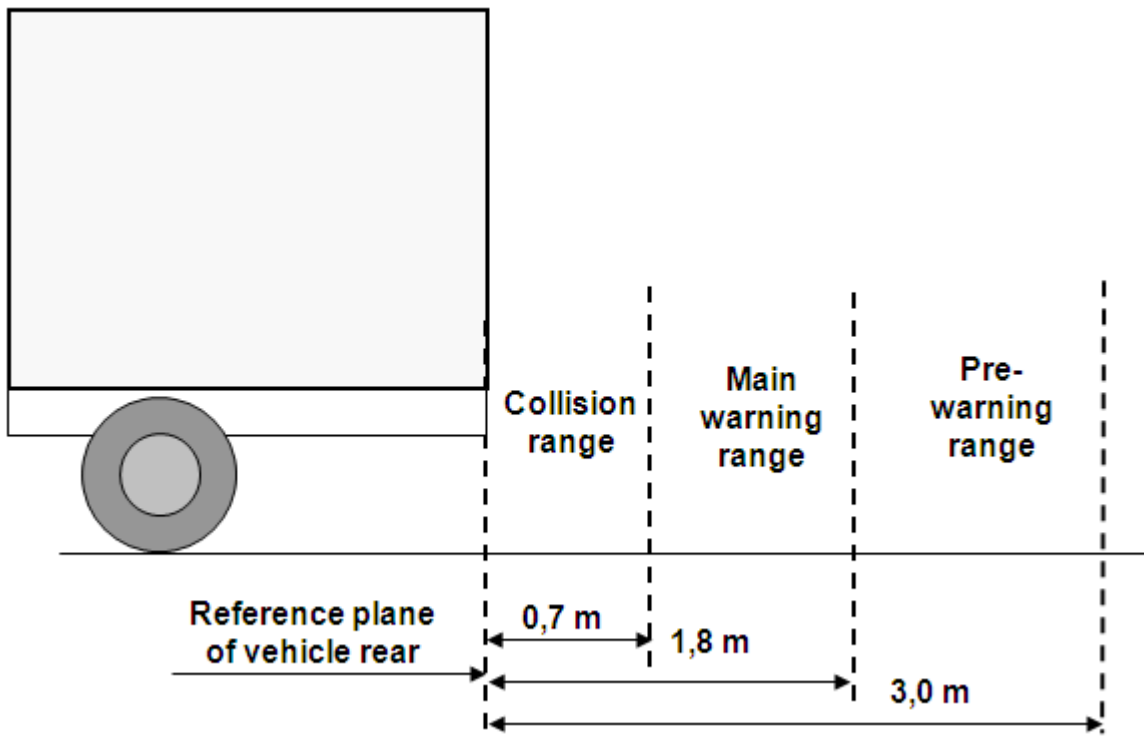


Figure 1: Monitoring range of reversing detection device

2. Location of Sensors

The locations of the sensors of the TailGUARDmax variant are shown in **Figure 3.2.1a** of Annex 5.

3. Test Equipment and Test Objects

3.1 Test Equipment

The used test specimen are listed in following table.

	Serial numbers of test specimen		
	Test A	Test B	Test C
ELEX	0990266088	0990266100	0990266097
Ultrasonic sensors	0010	0008	0002
	0013	0024	0009
	0020	0033	0011
	0022	0028	0013
	0087	0055	0015
	0091	0083	0023
TRC	03	03	03

3.1.1 Software Code

The software code of the TailGUARDmax variant at the time of testing was **"EX010112".**

3.2 Test Objects

As test objects plastics drain tubes for domestic installation were used.

ISO TR 12155 defines two different test object with a specific geometry and surface for testing the monitoring range.

Object H: for the horizontal test: plastics tube, grey, ∅ **75 mm, length 1 000 mm**

Object V: for the vertical test: plastics tube, grey, ∅ **75 mm, length 300 mm**

4. Tests Conditions

4.1 Ambient conditions (except tests described in paragraph 5.6)

Indoors tests were carried out complying with the test condition of ISO standard TR 12155:

- Temperature: ≈ 19 °C
- Wind speed: 0 m/s
- Relative air humidity: ≈ 35 to 40%

5. Test Procedures

ISO standard TR 12155 requires that the prescribed Test 1 to Test 4 are to be carried out positively three times with different test specimen.

In the following tests the three sets of test specimen are defined as "**A**", "**B**" and "**C**".

Whereas Tests 1 to 4 as described in paragraphs 5.2 to 5.5 have been performed on a test vehicle (truck with a vehicle width of 2500 mm), the additional tests under special ambient conditions (low- and high-temperature tests) have been carried out in a climatic chamber (see paragraph 5.6).

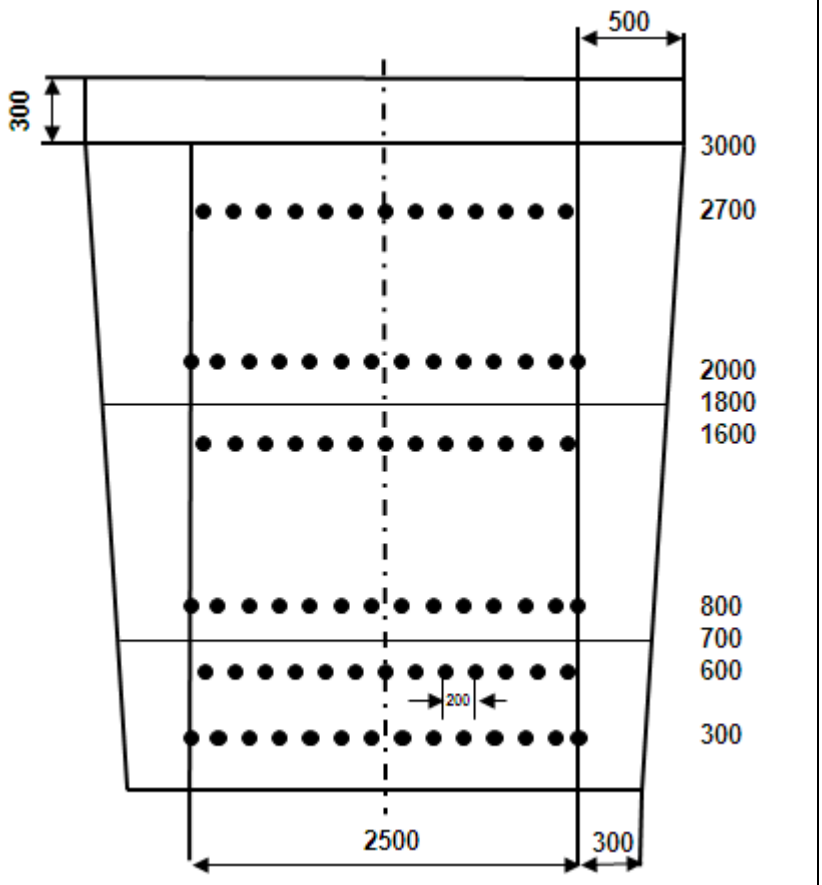
The positioning of the 6 sensors on the truck were as shown in Figure 3.2.1a of Annex 5 (body overhang = 0 mm).

5.1 Overview Test 1 to Test 4

The following table gives an overview of the Tests 1 to 4 which are described in paragraphs 7.3.1 to 7.3.4 of ISO standard TR 12155.

Test Overview	Test 1	Test 2a	Test 2b	Test3	Test 4
	Delimitation of Individual Zones	Height Localization 300 mm 800 mm	Height Localization 0 - 1100 mm	Lateral Localization	Ground Clearance
ISO paragraph	7.3.1	7.3.2	7.3.2	7.3.3	7.3.4
ISO Figure	3	4 / 6	5 / 6	3 (a)	7
Test object	H (1000)	V (300)	H (1000)	H (1000)	V (300)

5.2 Test 1: Delimitation of Individual Zones



● **Grid position of vertically standing test object H**

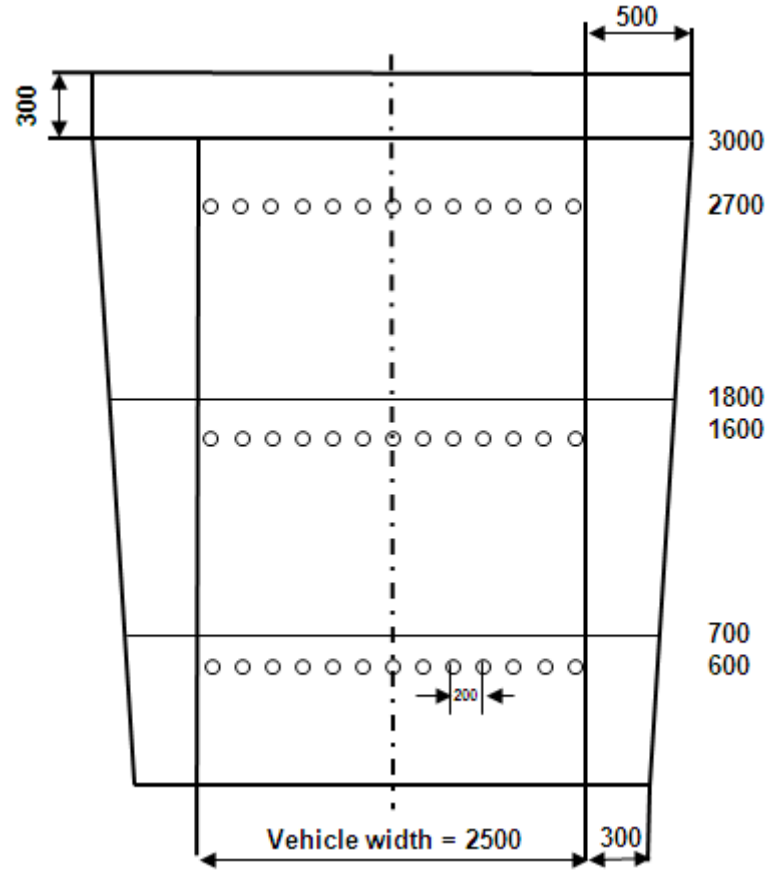
Figure 3 – Test 1 (plan view)

5.2.1 Test Procedure and Test Results

Test object H (see paragraph 3.2) with the longitudinal axis is positioned static in the monitoring range, standing perpendicular on the ground in such a way that its longitudinal axis is in the grid positions shown in **Figure 3**.

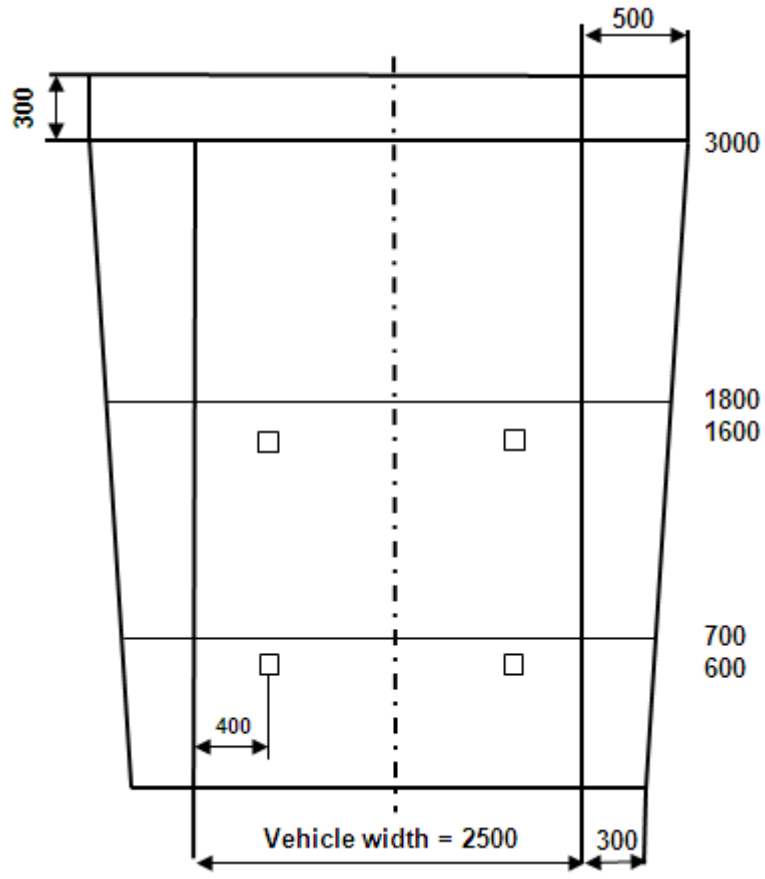
The test object H was detected statically in all grid positions. The respective monitoring ranges were identified correctly by the Trailer Remote Control and indicated accordingly by the visual and acoustic signals (see paragraphs 5.3.1and 5.3.2).

5.3 Test 2: Height Localization



O Grid position of horizontal test object V at 300 mm and 800 planes

Figure 4 – Test 2 (plan view)



☐ **Grid position of horizontal test object V at 1100 mm plane**

Figure 5 – Test 2 (plan view)

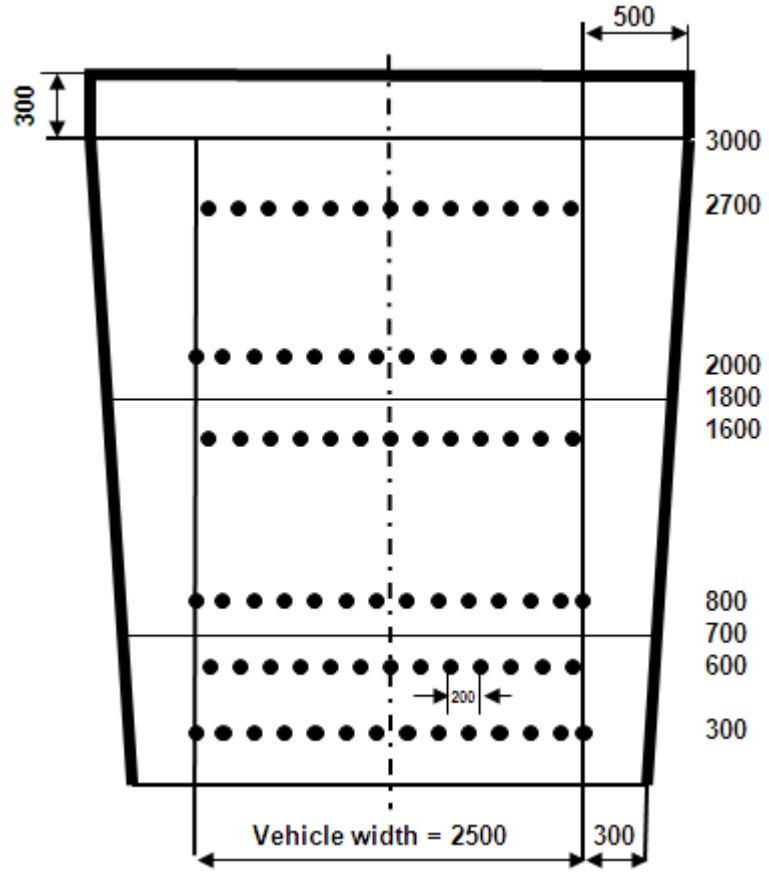
5.3.1 Test Procedure and Test Result

Test object V (see paragraph 3.2) was positioned statically, horizontally in the monitoring range, so that its three-dimensional centre was situated in the prescribed grid positions in **Figure 4** (at 300 and 800 mm heights) and **Figure 5** (at 1100 mm height).

The test object V was detected at all indicated positions of the test planes (300 mm, 800 mm and 1100 mm). However, in some cases, the test object V was only detected after a slightly change in the horizontal alignment (by turning the test object V slightly up to 30 ° horizontally). Since ISO standard TR 12155 does not specify the horizontal position of the test object V, these adjustments are seen in compliance with the standard.

The respective monitoring ranges were identified correctly by the Trailer Remote Control and indicated accordingly by the visual and acoustic signals (see paragraphs 5.3.1and 5.3.2).

5.4 Test 3: Lateral Localization



● **Grid position of vertically standing test object H**

Figure 3a – Test 3 (plan view)

5.4.1 Test Procedure and Test Result

Test object H (see paragraph 3.2), standing vertically on the ground with its longitudinal axis on a line 300 mm to 500 mm away from the limits of the monitoring range, to the left and right sides, and to the rear of the monitoring range in accordance with **Figure 3a**, was moved along this line, which is indicated in the above **Figure 3a** by the broad and bold outside line.

As required, the test object H was not detected either when it was statically or moved on this line. By continuously illuminating the lower (3rd) row of the green LEDs (see in the main report paragraph 5.4.3 "Readiness indication") the Trailer Remote Control showed that no obstacle is detected

5.5 Test 4: Ground Clearance

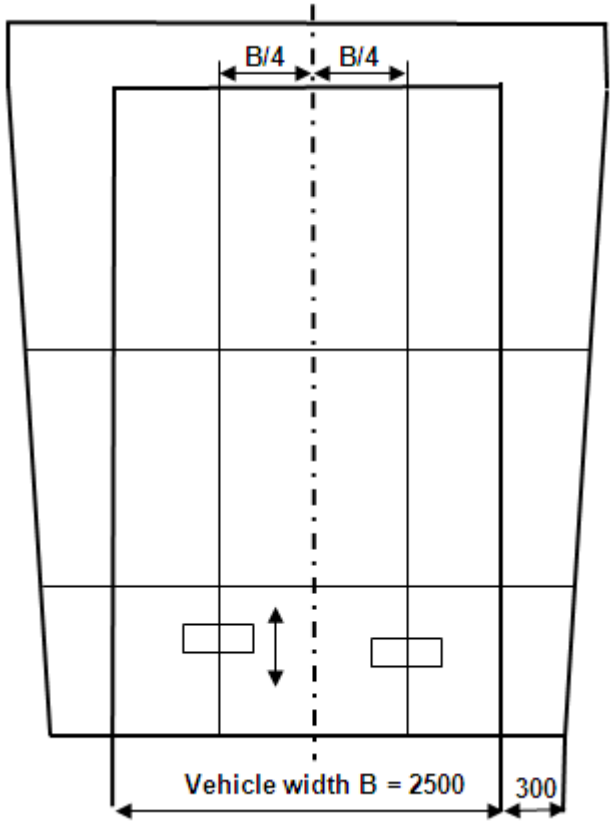


Figure 7 – Test 4 (plan view)

5.5.1 Test Procedure and Test Result

Test object V (see paragraph 3.2), was moved while lying on the ground with its centre axis horizontal, as shown in **Figure 7** through the whole monitoring range along the median axis of the vehicle and parallel axes to the left and right halves of the vehicle. The velocity relative to the vehicle was ≤ 0,5 m/s.

As required, the test object V was not detected in the main warning or collision range either when it was statically or moving on these two lines. The green LEDs of the Trailer Remote Control were continuously illuminated (see also paragraph 5.4.1 above).

5.6 Test under Special Ambient Conditions (Low- and high-temperature tests)

Components designed for installation outside the cab have to be also subjected to low- and high-temperature tests. Since an obstacle position of a distance of 1.6 m could not be realised by the used climatic chamber, the permissible option of alternative tests (see note 9 of ISO standard TR 12155) was chosen.

The following **Figure 5.6** describes the setup for the tests “A”, “B” and “C”

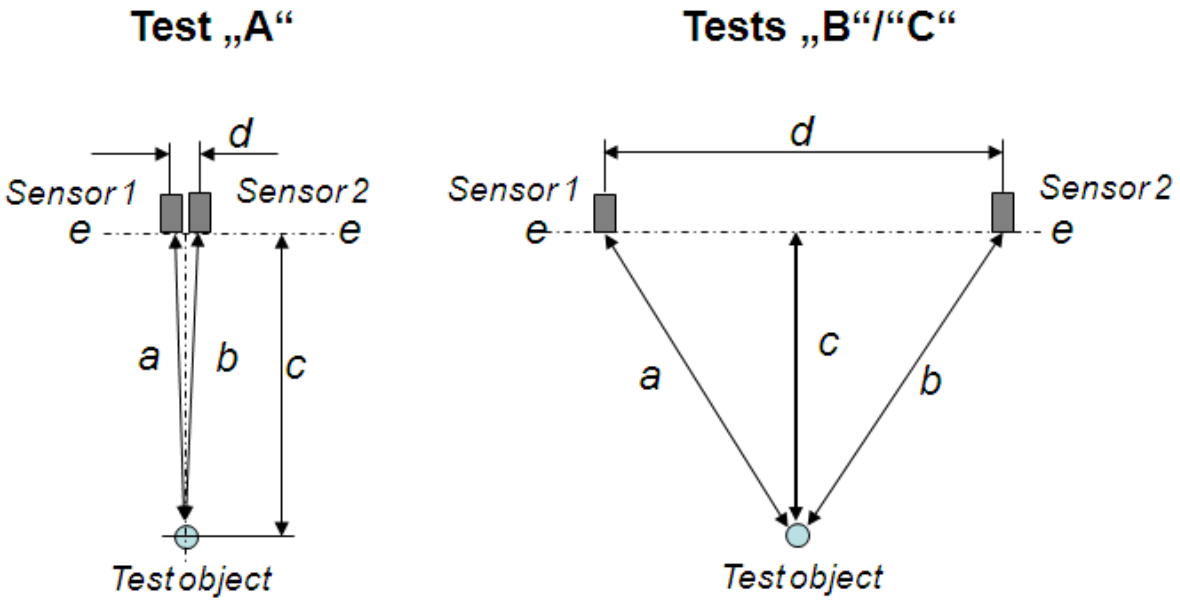


Figure 5.6:Climatic Chamber Test Setup

The following table contains the serial numbers of the used test specimen.

	Serial numbers of test specimen		
	Test A	Test B	Test C
ELEX	0990266088	0990266100	0990266097
Ultrasonic sensors	0010 0013	0008 0024	0002 0009

In a climatic chamber a tube with a diameter of 75 mm was placed at different distances in front of the left and right sensors.

Three tests (A, B and C) were conducted with the test specimen as indicated in the table above at temperatures from –25°C, 25°C and 60°C. The measurements were carried out after a soak period for the hardware of at least 30 minutes.

The results are summarized in the table below.

Meaning of the following expressions which are used in the table below:

"echo length": The echo propagation time was measured and multiplied by the speed of sound (which is dependent on the actual ambient temperature*). This length of the echo signal was calculated for the left and right sensor.

* 316 m/s (–25°C) --- 346,4 m/s (25°C) --- 366,1 m/s (60°C)

"Detection method": Dependent on the position of the obstacle the TailGUARDmax used two different methods of detection:

"Radius": The position of the obstacle is only detected by one sensor. The perpendicular distance "c" to "e" (see Figure 5.6) can thus only be estimated by the system.

"Bearing" The position of the obstacle is detected by both sensors. The perpendicular distance "c" to "e" is calculated by the individual "echo lengths" of each sensor.

Hardware components	Sensor distance [mm]	Actual distance [mm]	Temperature [°C]	Echo length left [mm]	Echo length right [mm]	Calculated distance [mm]	Detection method	TRC display
Test A, B and C	**"d"**	**"c"**		**"a"**	**"b"**	**"c"**		
A	25	**587**	-24,86	1226	1226	533	Radius	Continuous red
			24,95	1210	1210	525		
			60	1215	1215	527		
B	585	**740**	-25,01	1499	1563	744	Bearing	Intermittent red
			24,85	1535	1606	767		
			60,02	1533	1589	767		
C	585	**620**	-25,24	1397	1240	631	Bearing	Continuous red
			25,04	1430	1273	645		
			60,13	1446	1298	652		

5.6.1 Observation

Even under extreme temperature conditions and under much more severe testing conditions (distance of obstacles 80 mm (Test B/C) instead of 400 mm (according to Test1/Figure3) the system was able to detect in which monitoring range (collision range or main warning range) the obstacle was positioned.

Thus, the above described laboratory tests were accepted as alternative tests because these test are regarded as more severe as the ISO standard TR 12155 tests.

5.7 Self-test

5.7.1 Signal generation and echo reception

A reduction in the effectiveness of the sensors was simulated by soiling of the sensor surface with foam and grease and by completely covering the sensor surface.

From a certain degree of soiling the test object H could not anymore be detected at a distance of 2 m symmetrically in front of the sensors and the error messages as described in paragraph 5.6 (of the main report) were given.

5.7.2 Distance measurement (paragraph 7.5.2 of ISO standard TR 12155)

The manufacturer states that the system is equipped with a self monitoring function for the distance measurement and that the system meets the provisions of paragraph 5.7 of ISO standard TR 12155 as to monitoring of the accuracy of distance measurement.

Annex 3: Component Testing

1. General

ISO standard TR 12155 was published in 1994. Thus, the component requirements and tests according to Section 6 of this standard are seen by WABCO as not any more reflecting the state of art. Therefore, paragraph 2 contains a comparison list which itemizes all alternative tests which had been carried out instead of the tests defined by Section 6 of ISO standard TR 12155.

2. Component Tests Comparison: ISO 12155 versus ISO 16750

The following table list all ISO 16750 component tests which had been carried out instead of the less severe ISO 12155 tests.

These tests had been carried out between March 2010 and October 2010.

Before carrying out the tests with regard to mechanical vibration and shock, free fall, salt spray, protection against water and dust, 22 sensors and 13 ECUs were preconditioned by applying climatic and thermal loads to the DUTs.

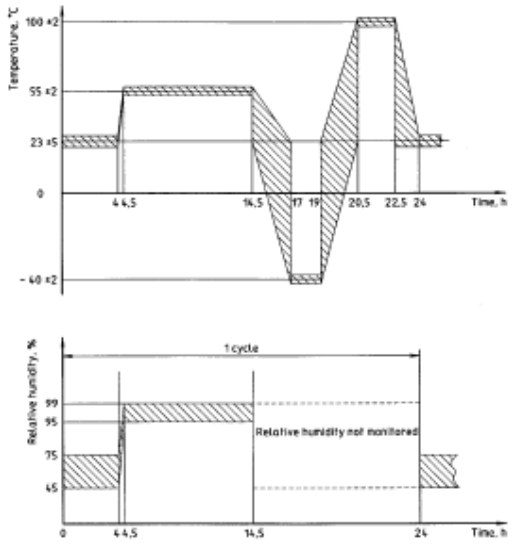
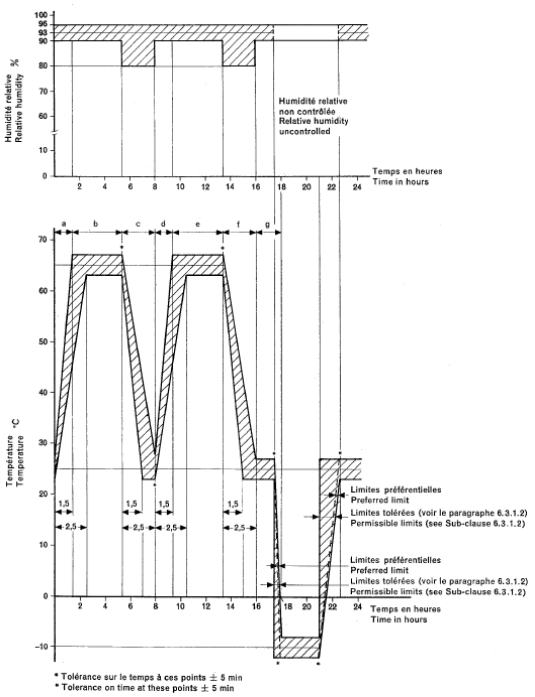
The following table specifies the whole test programme with reference to the specific test reports:

- TR-6171-2010-0026
- TR-6171-2010-0031
- TR-6171-2010-0034
- TR-8703-2010-0038
- TR-8703-2010-0039

All test results of theses test report passed the respective test requirements.

ISO 12155	ISO 16750 (Tests WABCO)
Mechanical Tests	
Mechanical vibration – ISO 12155 - 6.1.1 - frequency: 5Hz to 200Hz - vibration amplitude: ±15mm - acceleration: 49m/s^2 - transition frequency: about 8Hz to 9Hz - number of frequency cycles: 50 - rate of change of frequency: 1 octave/min - duration: 16h for each plane Requirement: After the test, no cracks or changes shall be visible, and the component tested shall be capable of operation.	**ISO 16750-3, Chap. 4.1.2.7, vibration according test specification** WABCO Test Report Nos.: TR-6171-2010-0034-Chap.4.13 TR-8703-2010-0038-page 10 TR-8703-2010-0039-page 08 Random vibration with temperature cycle: Temperature profile (8h/cycle) 1) reduce temperature from 20°C to –40°C in 60min 2) maintain this temperature for 90min 3) increase temperature to 20°C within 60min 4) increase temperature to 80°C (Tmax) within 90min 5) maintain this temperature for 110min 6) reduce temperature to 20°C within 70min **Vibration:** Random vibration: 10-2000Hz with the following profile duration: 32h for each plane
Static loading – ISO 12155 - 6.3 place exterior components between two cylindrical metal plates at least 80mm in diameter und subject them to a vertical load of 50kg acting on the plates. Position the components between the plates such that the load is distributed over as large an area as possible Requirement: After the test, no cracks or changes shall be visible, and the component tested shall be capable of operation.	This test was **not** carried out according to ISO 16750 but to **ISO 12155-6.3 (see column 1)** WABCO Test Report No.: TR-6171-2010-0031
-	**ISO 16750-3, Chap. 4.2.2, shock** WABCO Test Report Nos.: TR-6171-2010-0034-Chap.4.14 TR-8703-2010-0038-page 10 TR-8703-2010-0039-page 08 (Test in addition to ISO 12155) - half-sinusoidal shock with 300 m/s^2 - duration: 6ms - number of shocks: 10 per test direction

ISO 12155	ISO 16750 (Tests WABCO)
-	**ISO 16750-3, Chap. 4.3, free fall** WABCO Test Report Nos.: TR-6171-2010-0034-Chap.4.15 TR-8703-2010-0038-page 14 (Test in addition to ISO 12155) Free fall from 1 m on a concrete ground, 3 specimens (one specimen for each axis of the housing) and 2 falls per specimen (1 fall for each side of the housing) Requirement: Hidden damage is not permitted. Minor damage of the housing is permitted as long as this does not affect the performance of the DUT. Proper performance shall be proven following the test.

ISO 12155	ISO 16750 (Tests WABCO)
Climatic Tests	
Climatic Test – ISO 12155 - 6.2.1 1) temperature equalization: 4h at 23±2°C (ambient temperature) and 45%-75% relative air humidity 2) increase temperature to 55±2°C and relative air humidity to 95-99% within 0,5h 3) maintain this conditions for 10h 4) reduce temperature to -(40±2)°C within 2,5h - no monitoring of humidity necessary 5) maintain this temperature for 2h 6) increase the temperature to 100±2°C within 1,5h 7) maintain this temperature for 2h 8) reduce temperature to ambient temperature within 1,5h duration: 5 cycles, each 24h, no operation  Requirement: After conditioning in the climates specified in 6.2.1, no changes shall be detected and the component shall be capable of operation.	**ISO 16750-4, Chap. 5.6 – humid heat, cyclic – IEC 68-2-38 Z/AD** WABCO Test Report Nos.: TR-6171-2010-0034-Chap.4.4 TR-8703-2010-0038-page 6 24h-temperature-cycle, 10 cycles Tmax 55°C and 95-100% RH Tmin 23°C - perform functional tests, when the maximum cycle temperature is reached 
-	**ISO 16750-4, Chap. 5.7 – damp heat, steady state** WABCO Test Report No.: TR-6171-2010-0034-Chap.4.5 (Test in addition to ISO 12155) The specimen is exposed to a temperature of 40±2°C and 85% relative air humidity for 21 days

ISO 12155	ISO 16750 (Tests WABCO)
-	**ISO 16750-4, Chap. 5.1.1.1 – low temperature storage** WABCO Test Report No.: TR-6171-2010-0034-Chap.4.6 (Test in addition to ISO 12155) The specimen is exposed to a temperature of -40°C for a duration of 24h
-	**ISO 16750-4, Chap. 5.1.1.2 – low temperature operation** WABCO Test Report No.: TR-6171-2010-0034-Chap.4.7 (Test in addition to ISO 12155) The specimen is exposed to a temperature of -40°C for a duration of 24h in operating mode
-	**ISO 16750-4, Chap. 5.1.2.1 – high temperature storage** WABCO Test Report No.: TR-6171-2010-0034-Chap.4.2 (Test in addition to ISO 12155) The specimen is exposed to a temperature of 80°C for a duration of 48h
-	**ISO 16750-4, Chap. 5.1.2.2 – high temperature operation** WABCO Test Report No.: TR-6171-2010-0034-Chap.4.3 (Test in addition to ISO 12155) The specimen is exposed to a temperature of 80°C for a duration of 96h in operating mode
-	**ISO 16750-4, Chap. 5.2.2 – temperature steps** WABCO Test Report No.: TR-6171-2010-0034-Chap.4.8 (Test in addition to ISO 12155) Reduce the temperature in steps of 5°C from 20°C to –40°C and then increase the temperature to 75°C. Wait at each step until the specimen has reached the new temperature and perform functional test (operating mode)
-	**ISO 16750-4, Chap. 5.3.2 – rapid change of temperature** WABCO Test Report No.: TR-6171-2010-0034-Chap.4.10 (Test in addition to ISO 12155) Raise the temperature from –40°C to 65°C within 30s and expose the specimen at this temperature for 30 min / 30 min, 300 cycles

ISO 12155	ISO 16750 (Tests WABCO)
Salt spray – ISO 12155 - 6.4 Subject exterior components to the NSS test procedure in ISO 9227 for a period of 96h. Test the components in the as-installed position. Seal cable ends. Use new, unused components for the tests. ISO 9227: Salt spray at 35±2°C and pH=6,5-7,2 Requirement: After the salt spray test, no corrosion shall be visible on the parts tested in a visual check with the naked eye, corrected if necessary	**ISO 16750-4, Chap. 5.5.2 - IEC 60068-2-11** WABCO Test Report No.: TR-6171-2010-0034-Chap.4.12 6 cycles, each 24h spray the specimen for 8h and operate it during the 4th and 5th hour, then stop spraying and rest for 16h Salt spray at 35±2°C and pH=6,5-7,2
Protection	
IP protection – ISO 12155 - 6.5 Components mounted externally (e.g. sensors) shall conform to IP 59, and other components shall conform to IP 54, as specified in IEC 529	**The specified protection level is IP6K9K.** **IP6K9K is a higher protection level than IP59.** WABCO Test Report No.: TR-6171-2010-0034-Chap.4.16

ISO 12155	ISO 16750 (Tests WABCO)
Electrical Tests	
6.6.1 ISO 12155 **6.6.1 line related interference on supply lines** Apply test pulses 1, 2, 3a, 3b, 4 and 5 in accordance with ISO 7637-2:1990 on supply lines and on all other lines of the reversing detection device which are connected with the supply lines **6.6.1.1 System in non-activated condition** Apply test pulses 1 to 5 and severity level III. After the test, the system shall not be in functional status D or E according to ISO 7637-2:1990 **6.6.1.2 System in activated condition** Apply test pulses 1 to 5 and severity level III. The operating states specified in table 1 shall be observed for the individual test impulses **Table 1** Test pulse / Test severity level / Operating state 1 / III / C 2 / III / A 3a / III / A 3b / III / A 4 / III / B 5 / III / A	**line related interference on supply lines** WABCO Test Report No.: TR-6171-2010-0026 Tests are carried out according to the current version ISO 7637-2:2004. Tests are done only in activated condition, because non-activated condition is not applicable. Tests were carried out with a higher severity level (IV) than severity level III according to ISO 12155. The test with the test pulse 5 (simulation of load dump) is only passed in combination with the TEBS-E.* * The load dump protected is integrated into the ECU of TEBS-E.
6.6.2 Immunity from interference with excited interference on sensor and signal lines Apply test pulses 1, 2, 3a, 3b and severity level III in accordance with ISO 7637-3. Operational state C is acceptable with test pulse 1; A shall be maintained with 2 an 3.	**Immunity from interference with excited interference on sensor and signal lines** WABCO Test Report No.: TR-6171-2010-0026 Tests are carried out according to the current version ISO 7637-2:2004. Tests were carried out with a higher severity level (IV) than severity level III according to ISO 12155
6.6.3 Immunity from high-frequency radiated disturbances During and after one of the test procedures specified in ISO 11451-1 and ISO 11452-1, opening status A shall be maintained during and after exposure to severity level II over the whole frequency range from 10 kHz to 1 GHz	**Electromagnetic compliance (EMV)** was approved by Kraftfahrt-Bundesamt (KBA) according to **ECE-R10** (Approval No. E1-10R-035979) (Tests are carried out with frequencies from 1MHz – 3GHz)

ISO 12155	ISO 16750 (Tests WABCO)
6.6.4 Interference emission Interference suppression level III to DIN-VDE 0879 Part 3 shall be maintained.	**Electromagnetic compliance (EMV)** was approved by Kraftfahrt-Bundesamt (KBA) according to **ECE-R10** (Approval No. E1-10R-035979) (Tests are carried out with frequencies from 1MHz – 3GHz)

Annex 4: Information by the Manufacturer

1. General

1.1 System name/model: Rear Monitoring System

1.2 System variants: TailGUARDmax with 6 Ultrasonic sensors

1.3 Explanation of the basic functions and philosophy of the system

The system does not replace the driver's responsibility to ensure a clear passage when driving backwards. WABCO cannot be held responsible for any accidents encountered when using the system. It is a supporting system. The reverse-warning system does not relieve the driver from his duties while driving. The system performance can be reduced under extreme weather conditions like heavy rain or snow. Also special objects like vertical smooth flat planes when approached under a degree > 10°to the driving direction may not be detected.

The system uses ultrasonic sensors to monitor the area behind the vehicle. The system is automatically activated when shifting into the reverse gear and warns the driver when driving backwards before obstacles behind the vehicle. The system incorporates 6 ultrasonic sensors. The distance to the obstacle is indicated by:

- monitoring of the distance by the TRC (Trailer Remote Control) in the tractor
- the frequency of the buzzer signal in the TRC

and **optionally** in addition by:

- the frequency of the flashing position lamps of the trailer
- the distance (transmitted via ISO 11992-3) accompanied with a symbol (e.g. bar) on the display in the truck

The system operates up to a vehicle speed of 12 km/h.
Precondition for the function is a voltage supply of the trailer via pin 5 or pin 7 of ISO 7638 connector via Trailer EBS–E and a reverse light signal (corresponding to a shifted reverse gear) from the motor vehicle via pin 15 of ISO 12098 connector. In the case of undervoltage the ELEX is switched off by the TEBS-E. By this ECE R13 paragraph 5.2.2.18 is fulfilled.
The system measures the distance to the obstacles which is displayed by the Trailer Remote Control (TRC) in the tractor cabin. In addition, the integrated beeper tones with a changing frequency.

The distance is divided in three warning levels:

Warning:

- Pre-warning range > 1,8 - 3 m distance : flashing and toning 2Hz
- Main warning range: 1,8 m – 0,7 m distance: flashing and toning 4Hz
- Collision range: < 0,7 m: continuous light and continuous tone)

The Warning signals are transmitted to the TRC.

2. Components

2.1 ELEX 446 122 07. 0

The ELEX (ECU) is connected to the TEBS-E modulator and communicates via 5V CAN data bus with the TEBS-E ECU and by the 24V CAN data bus via the ISO 12098 connector with the tractor. The ELEX has two ports for the LIN Interface connection of the ultrasonic sensors.

The In-and Output signals can be connected as follows:

GIO	PIN	Connection	Remark
8	8	Power In from TEBS-E	
9	8	Power-Out Subsystems	
10	8	Battery charging	
11	8	Tail lights	
12	8	ISO 12098-IN: Reverse gear, back-light signal , 24V CAN	
13	4	for other use	
14	4	for other use	
15	4	for other use	
16	4	for other use	
17	4	Ultrasonic sensor LIN	max. 6 LIN sensors in parallel
18	4	Ultrasonic sensor LIN	

2.1.1 Software Identification

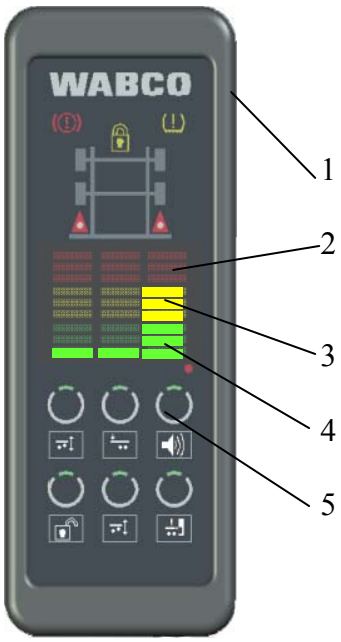
The software version is a running number.

Number at time of assessment: **EX010112**

The software identification can be read-out by using the WABCO PC-diagnostic programme "TEBS-E diagnostic software V2.00" and higher versions. The Software can be identified at the first page when starting the diagnostic programme.

2.2 Trailer Remote Control 446 122 080 0

The Trailer Remote Control is an on-board display for monitoring obstacle detection during reversing. The data is displayed by 3 LED rows. Also a beeper for acoustic signalling is implemented. The TRC is mounted in the driver cabin. The communication with the ELEX ECU is done via PLC.
The TRC is supplied with voltage (8 to 30 V). Only the TRC cable has to be connected to the truck powering system according to WABCO specification. For operations the TRC has six buttons to control trailer functions (e.g. traction help, lift axle control, etc.) and the volume of the beeper. The TRC communicates via PLC (Power Line Communication) with the ELEX. This kind of communication needs no additional cables.



Legend
1 = integrated beeper
2 = red LED
3 = yellow LED
4 = green LED
5 = button for volume control

Figure TRC

The TRC displays the distance to an obstacle by using 3 rows of LED's. Every row is assigned to a position of the obstacle left/middle/right behind the trailer. If the system is active (reverse gear ON) only the first green LED are shining when no obstacle is behind the vehicle in the monitored range. When an obstacle is in the pre-warning area the yellow LEDs are shining depending on the position of the obstacle. When an obstacle is in the main warning range the red LEDs are flashing and in the collision area the red LEDs are permanent ON.

2.3 Ultrasonic Sensor 446 122.40. 0

Ultrasonic sensors with LIN interface for use for rear monitoring. The sensors can be electrically connected parallel up to 6 sensors using the LIN-distributor 894 600 024 0. The sensors are available in two variants.

0°-Orientation: as middle sensor for rear monitoring system
Distance Sensor 0° 446 122 401 0

15°-Orientation: for left and right side sensor s for rear monitoring system
Distance Sensor 15° 446 122 402 0

3. System layout

The following **Figure 3** shows the system architecture for the TailGUARDmax.

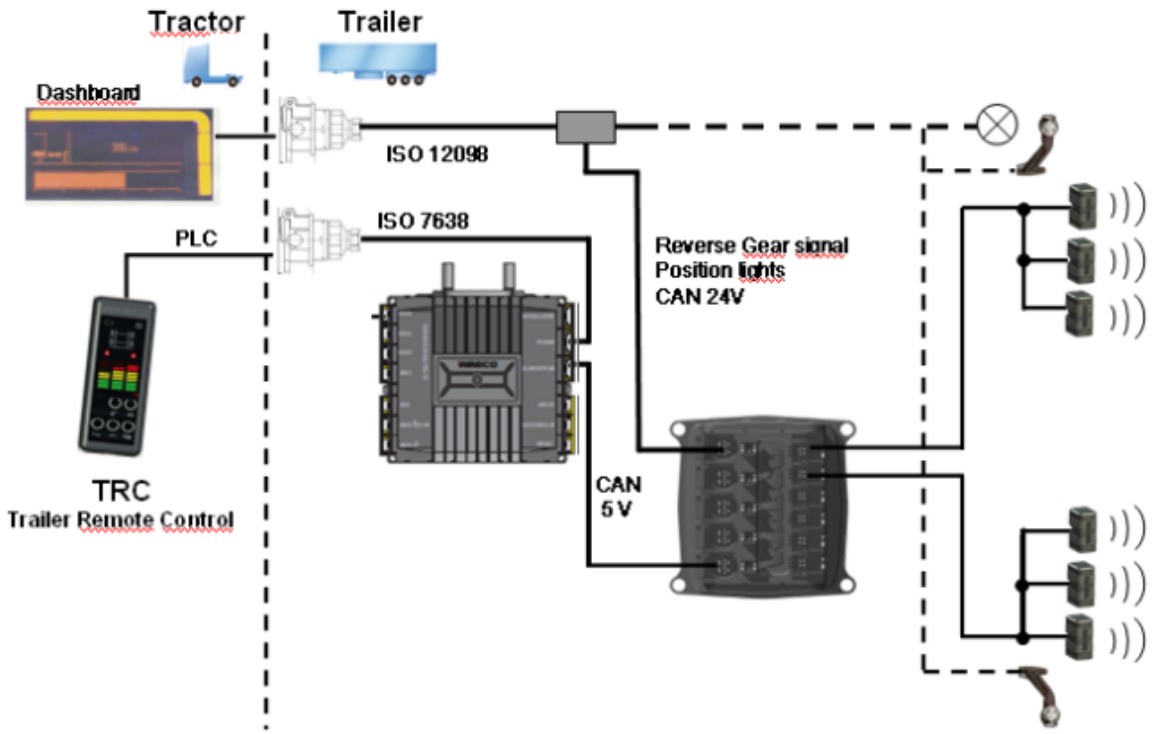


Figure 3 ***System layout***

TailGUARDmax only operates when the ignition power is turned on (Pin 15).

In the case of trailer operation, any additional supply modes are managed through TEBS-E, e.g. battery or stop light supply. Although the ELEX is connected with the ISO 7638 connector via TEBS-E and with ISO 12098 connector, there is no connection of these two grounds or power supplies.

The distance signal of the ELEX is transferred via PLC (power line communication) to the truck and is displayed at the TRC.

4. Monitoring of operational reliability

The transformation of the electrical signal into an ultrasonic signal is done by the following components: Transducer, Transformer and BURST Transistor (see Figure 4: Block diagram of ultrasonic sensor).

The self-testing functions detect any faults which impedes the specific function of the TailGUARDmax system. The test are proceeded continuously. The following self-testing functions are integrated into each ultrasonic sensor.

- PCB temperature and voltage monitoring
- Signal noise analysis
- Memory check
- Signal conditioning path check
- Transducer state monitoring
- ROM test
- Program run check by watch dog monitoring

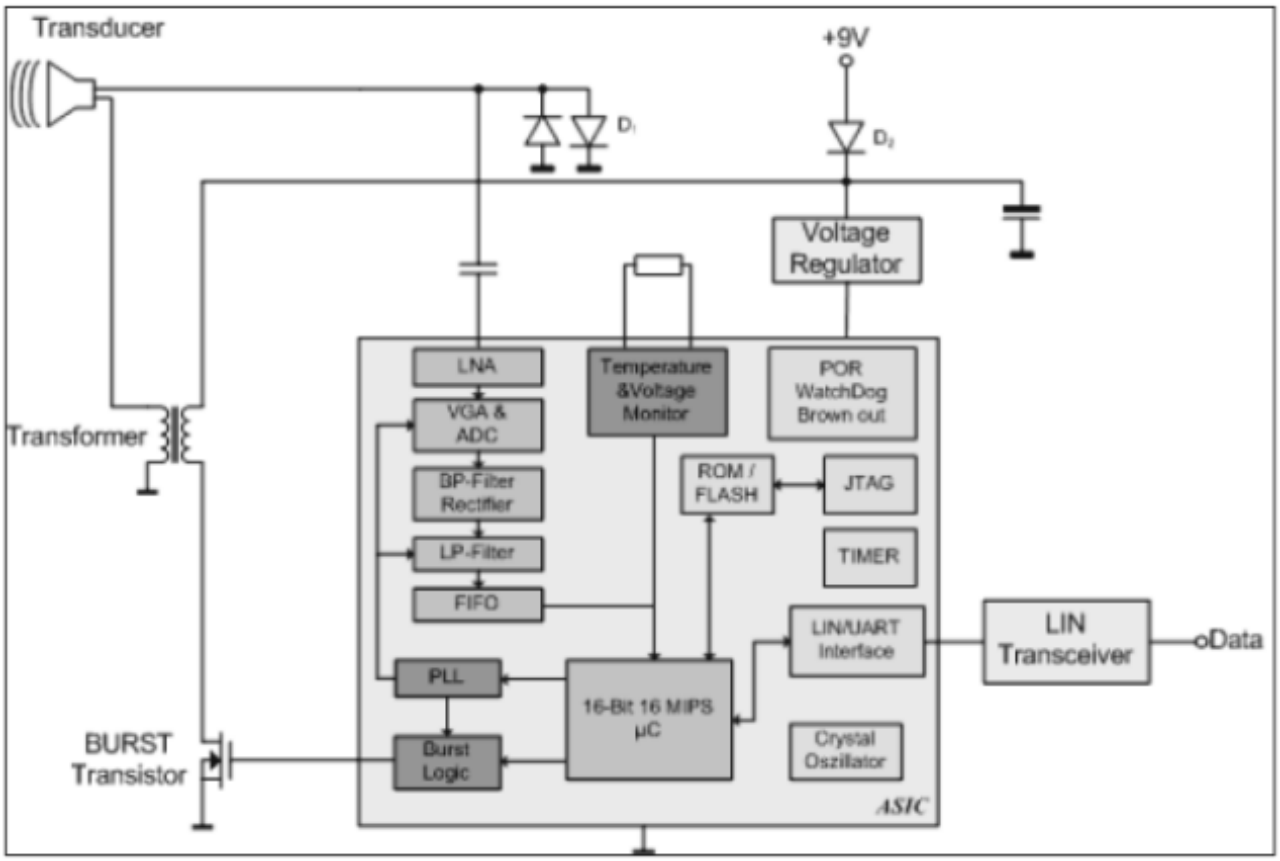


Figure 4: Block diagram

4.1 Monitoring of Distance Measurement

The TailGUARDmax system does not use an additional signal on the echo line to check the distance measurement but by using a digital signal. Thus, an additional (disturbing) signal on the echo line will result in an invalid sensor signal which is detected by a wrong checksum. In this case, an error is indicated by the TRC. A wrong interpretation of the received sensor signal (as in case of a pulse-width modulated signal) is not possible.

5. Monitoring of Faults

The following faults are detected by the System and displayed to the driver by using the TRC

	Failure mode	Warning signals	
		System active (reverse gear engaged) • Continuous illumination of the red and yellow signals • Continuous tone of buzzer in TRC	**System not active** • Flashing of yellow and red LED
	Disconnection of LIN sensor	X	X
	Short cut to ground of LIN bus	X	X
	Short cut of power supply of LIN sensors	X	X
	Undervoltage (≤ 8 V)	X	X
	Soiling and covering of a sensor surface	X	X

Annex 5: Manufacturer's Installation Instructions

1. General

Before using the Rear Monitoring system please read the description and the operation instructions carefully.
The system does not replace the driver's responsibility to ensure a clear passage when driving backwards. WABCO cannot be held responsible for any accidents encountered when using the system. It is a supporting system. The system performance can be reduced under extreme weather conditions like heavy rain or snow. Also objects with a soft surface cannot be detected under all conditions.

2. Range of Applications

2.1 Vehicles categories

Commercial vehicles (motor vehicles of category N2 and N3 and trailers of categories O3 and O4 according to framework Directive 2007/46/EC, Annex II or as defined in Annex 7 to the Consolidated Resolution on the Construction of Vehicles (R.E.3).

2.2 Vehicles width

The system covers a vehicle width from 1,80 m up to 2,50 m.

2.3 Vehicles wheelbase

The vehicle wheelbase has no influence on the function of the system, so there is no restriction regarding wheelbase.

2.4 Vehicles axle loads

The vehicle axle load has no influence on the function of the system, so there is no restriction regarding permissible axle load.

2.5 Vehicles rear

The ultrasonic sensors have to be installed at the vehicle rear on the body or on the run-guard. In the area around the sensor must be a free space specified by a cone with an angle of 15° as shown in **Figure 2.5.**

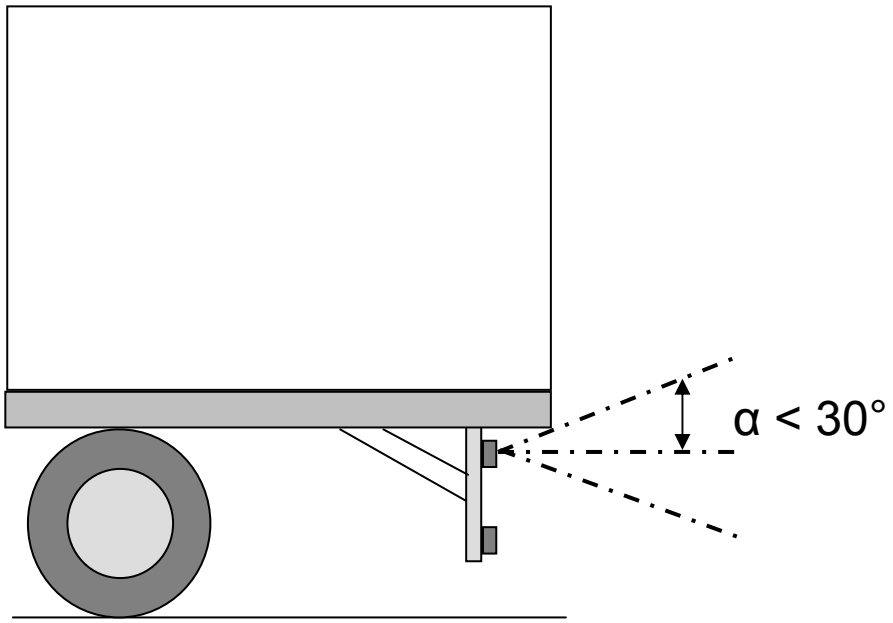


Figure 2.5

2.6 Vehicles tyres

The tyre size or brand has no influence on the function of the system, so there is no restriction regarding permissible tyres.

3. Installation of components

3.1 Installation of ELEX

In the case of trailers, the ELEX has to be installed at a distance of not more than 2 m from the TEBS-E modulator.
The device has to be fixed with 4 screws M8 at the frame or crossbar. The permissible position of the ECU is on edge as followed shown:

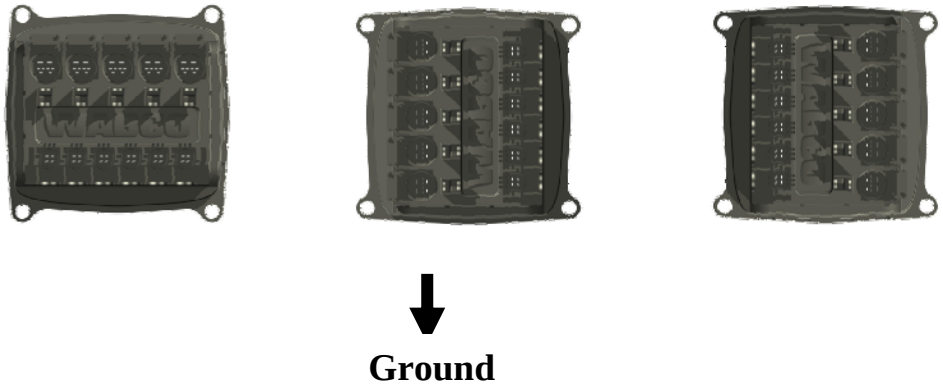


Figure 3.1

The ELEX Power supply cable 449 303 020 0 (2 m) has to be connected to the Subsystem connector at the TEBS-E and with the angled connector at the Power-connector of ELEX

3.2 Installation of Ultrasonic sensors

The Ultrasonic sensor have to be installed at the rear of the trailer. The sensors have to be arranged upright, this means that the WABCO character can be read. At the outside the sensor 446 122 402 0 with 15° orientation has to be used. The sensor surface has to be orientated to the vehicle centreline. In the middle position sensor 446 122 401 0 has to be used.

The sensors can be installed at the buffer-bar or under ride barrier or at a special bracket. The area of the mounting position of the sensor must be at least 10 mm larger at every side of the sensor, so that it is insured, that when using a high pressure cleaner that the back of the sensor with the drain zone gets no direct beam.

The hole pattern for the sensor is described in **Figure 3.2a**

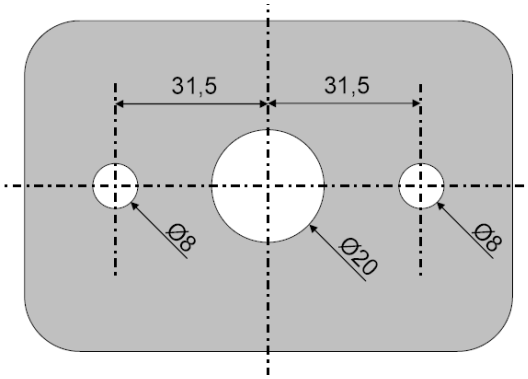


Figure 3.2b

The sensors have to be fixed at a flat surface with two nuts M6 and washers. The If a adjustment of the sensor is necessary (e.g. if the lower row sees obstacles at the ground) the sensor can be adjusted by using two additional nuts at the both bolts.

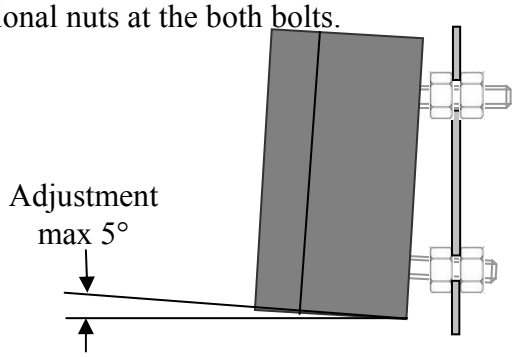


Figure 3.2c

3.2.1 Configuration with 6 sensors according to ISO 12155

For the TailGUARDmax with its 6-sensor systems the sensors have to be arranged as described in the following in **Figure 3.2.1a.**

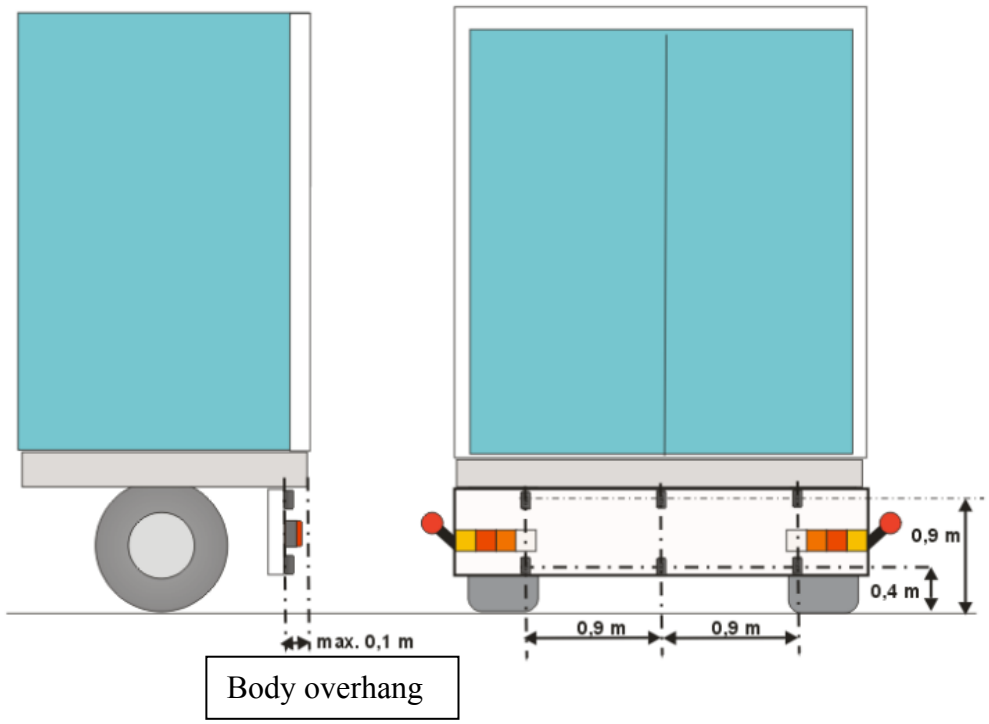


Figure 3.2.1a

The electric wiring of the 6 sensor system is described in **Figure 3.2.1b** .

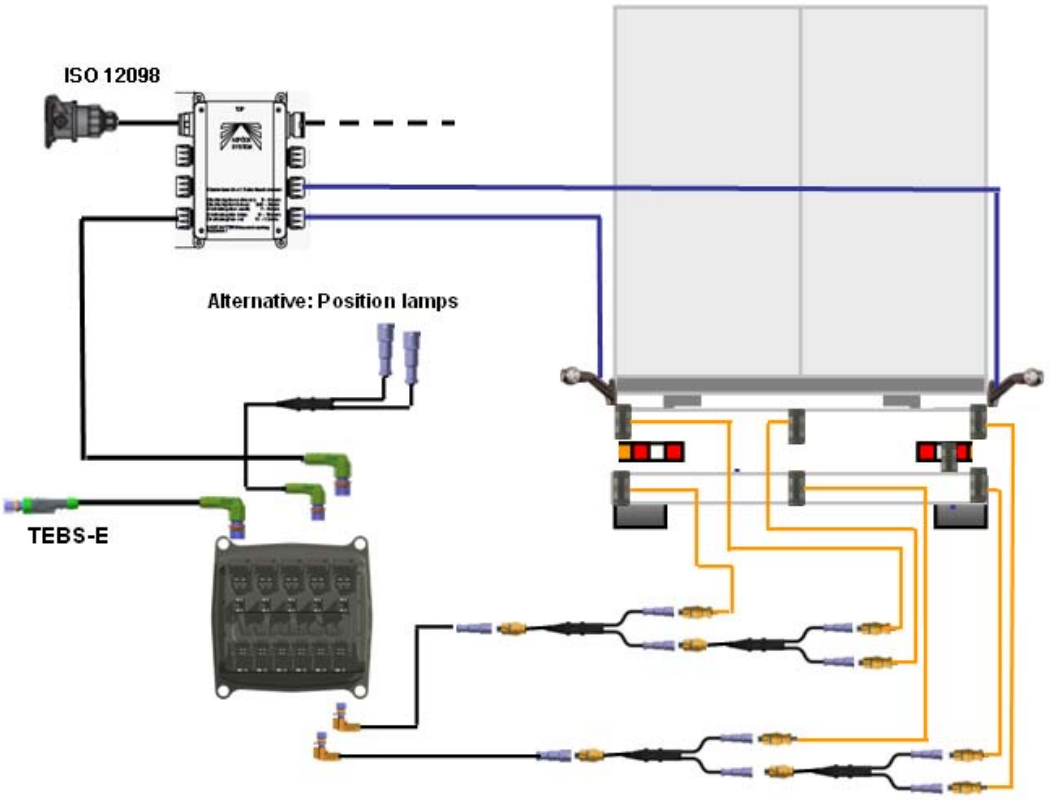


Figure 3.2.1b

The sensors are equipped with a LIN interface to the ELEX and can be connected all parallel by using LIN-adapter cables .

3.3 ISO 12098 Connection

ELEX needs signals from ISO 12098 (lighting) connector.

The following signals have to be connected:

- Reversing light (voltage min. 70% of voltage power supply
- Left / right hand rear position light
- CAN data according to ISO 11992-part 3 and 4 (not necessary when no communication to tractor desired, e.g. no ISO 12098 gateway in truck installed)

To give the ELEX the possibility to control the position lights to indicate the distance to the ramp or obstacle to the driver this lamps have to be connected to the ELEX. There are two possibilities to connect the position lights:

3.3.1 Connection of Position lamps to GIO 12

Example for connection of ELEX to ASPÖK-lighting system with distribution box. The position lamps have to be disconnected from the lighting system and have to be connected directly to the ELEX to give ELEX the possibility to control the position lights.

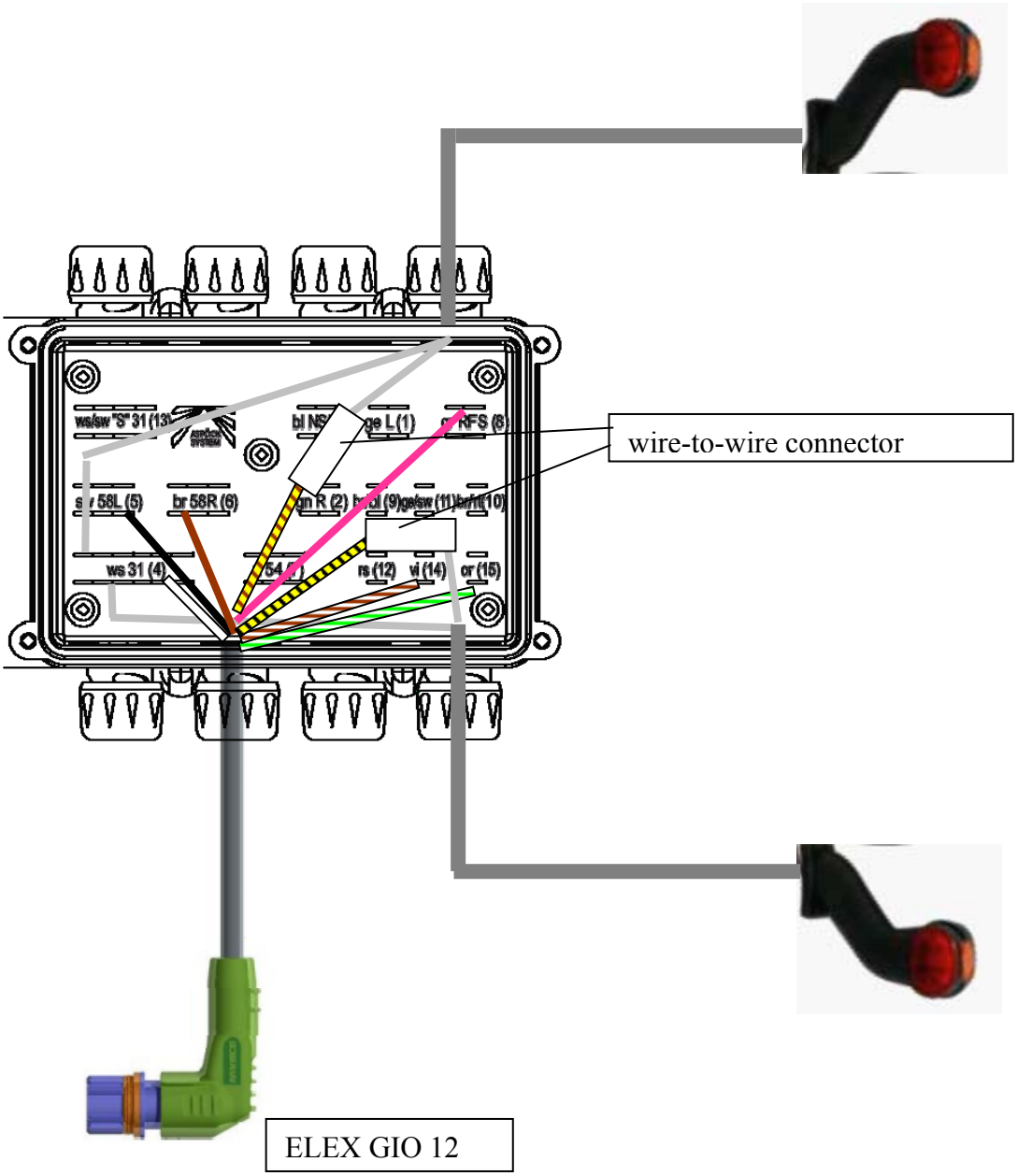


Figure 3.3.1

If no distribution box is installed it is possible to use special boxes from the lighting supplier which can be installed directly into the lighting cable by using the existing connectors.

ASPÖK: with ASS direct connection	76-5123-007
HELLA: with easy-connect	8JE 340 847-001

Assignment of cable colours to pins

Function	ELEX Pin	Cable colors ISO 4141 (HELLA)	Cable colours ASPÖCK	ISO 12098 Pin	Name
Reversing lights	1	pink	grey	8	L
CAN-H	2	White/green	violet	14	
CAN-L	3	white/brown	orange	15	
GND Light	4	white	white	4	31
Backlight left hand - IN	5	black	black	5	58L
Position light left hand	6	yellow/black/			
Position light right hand	7	yellow/brown			
Backlight right hand- IN	8	brown	brown	6	58R

3.4 Installation or Trailer Remote Control (TRC) in the cab

The ELEX ECU communicates with the TRC via Power line communication (PLC).

PLC communication uses the power supply cable from truck to trailer and modulates a carrier frequency on it. Thus, data can be transmitted between trailer and truck without additional cables.

However, when a CAN-Router or CAN-Repeater is installed in the trailer the communication with the TRC does not work due to the reduced signal.

The TRC can be mounted on the A pillar or on the dashboard in the view of the driver.

The TRC is supplied with voltage by a cable (4 m cable with an open end connection). This cable has to be connected to the truck powering system.

The cable is connected to the TRC via a round plug in order to replace the cable or to remove the TRC from its mounting position.

4. Parameter setting / EOL

The system is only working correctly when the parameters are set by using the TEBS-E PC-diagnostic program. The following parameter have to be set for both layers:

- Vehicle width
- Distance between left and right sensor: 180 cm
- Distance between left and middle sensor: 90 cm
- Distance to ground for every layer: 40 and 90 cm
- Installation depth of sensors

5. Deactivation in case of trailer operation

When the TailGUARD System is installed as a stand-alone system (without TEBS-E) in the truck the system has to be switched off when a trailer is coupled.
This can be achieved by using a monitoring module (e.g. Infomodule, see figure 5) for the stop lamp wire to the trailer. When a trailer is connected the Infomodule detects the energised stop lamp wire and switches a relay which interrupts the connection between the reverse switch and the ELEX.

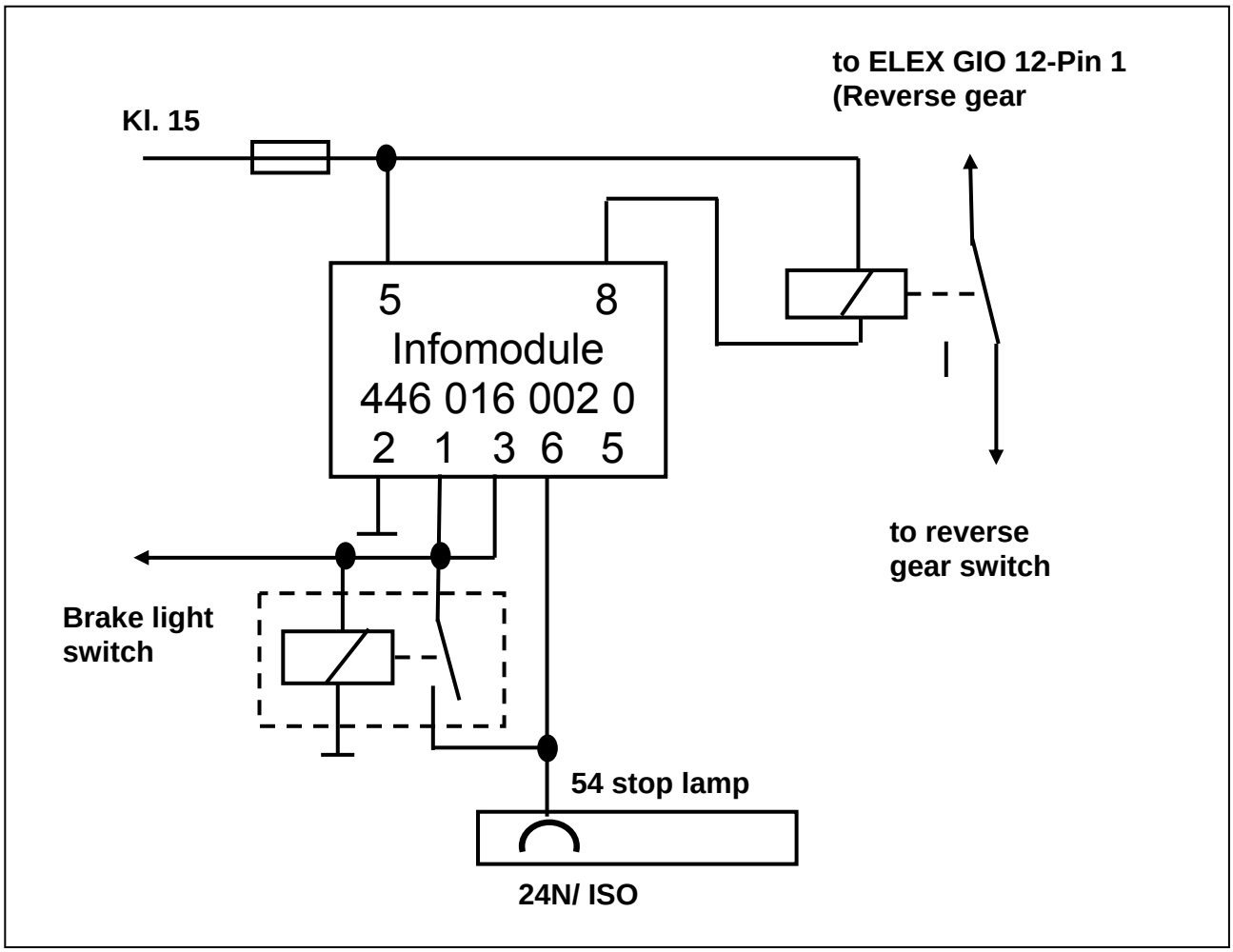

to ELEX GIO 12-Pin 1
(Reverse gear
Kl. 15
5
8
Infomodule
446 016 002 0
2 1 3 6 5
to reverse
gear switch
Brake light
switch
54 stop lamp
24N/ ISO

Figure 5