ETS

Electronic Door Controls
for Motor Buses

General Information,
System Design,
Functional Description and
Circuit Diagrams
Information for Diagnosis and
Workshops

2000 Edition

WABCO
Fahrzeugbremsen

A Division of
WABCO Standard GmbH

Table of Contents

1. Introduction

Due to more stringent safety requirements, buses used in suburban areas both by public transport companies and private operators in Germany have had safety controls fitted since the early 80s to protect their passengers and to reduce the hazard of accidents in the workshop. The two most important criteria which have had to be met since then are:

- ❑ Features protecting persons and objects while doors are opening or closing.
- ❑ Protective features for the prevention of sudden door movements after cylinders have again been pressurized.

Although this demand for the introduction of the two WABCO systems, the pressureless and the pressure-reduced principle, has achieved the desired safety enhancements, it soon turned out that there was still some room for improvement in these systems in terms of reducing the number of components used, and facilitating maintenance.

For this reason, WABCO decided to develop an electronically controlled system which covers the following key requirements:

- **passenger safety**
- **reducing the hazard of accidents in the workshop**
- **easy to handle by workshop staff**
- **reducing system expense**
- **eliminating maintenance and servicing work**

The development on the basis of these improvements is an electronically controlled door operating system known as

*** E T S ***

which has been produced since late 1987.

The key improvements this system achieves are as follows:

- **elimination of limit and drum-type switches**
- **elimination of adjustment work to be by the vehicle manufacturer and bus operators**
- **development of a uniform system acceptable to all bus manufacturers subject to their respective safety policies**
- **permitting the combination with ETS by means of simple pneumatic drive systems which have been known and established for many years**
- **reduction of jamming forces**

2. Regulations for Door Operating Systems (German C.U.R. and Regulations for the Prevention of Accidents)

§35e Subsection 5 German C.U.R. - as amended on 16/11/1984 - governs pneumatically operated doors:

One-man operating systems for passenger doors on buses for more than 16 passengers must allow the opening or closing process to be achieved either automatically or from the driver's seat. Such systems must ensure that when power-operated doors are closed, people cannot get jammed; features which require clamping forces to prevent more than brief jamming being permissible provided they represent no hazard to passengers. If a passenger door which is within the driver's field of vision and directly controlled by him is actuated, it is sufficient to affix lining strips of an adequate width and flexibility on the main closing edges. If the bus has more than two passenger doors, only the two front passenger doors may be designed in such a way that they can be operated from the driver's seat. All other passenger doors, especially in the hinged sections of articulated buses, must be such that they can be actuated automatically. The driver must be able to watch, from his seat, the passengers getting on or off the bus at least in the area of the passenger doors operated by him - e. g. by way of mirrors. The driver must have some indication of whether all doors are closed. Structural measures must ensure that no hazard to persons, either inside or outside the bus, is likely to be caused by doors while they are opening or closing.

§ 35e, Subsection 5 came into force on January 1st, 1986 and applies to all motor buses first put into operation after that date.

For motor buses which were first put into operation prior to January 1st, 1986, Section 35e Subsection 5 valid prior to December 1st, 1984 applies.

The 'Guidelines for Power-Operated Windows, Doors and Gates' (ZH 1/494) published by the German Principal Mutual Indemnity Association for Industry continue to apply. These guidelines essentially cover the following:

1. Anti-jammping feature in opening and closing directions

2. No unintentional door movement after operation of emergency cock

3. No abrupt door movement after the door cylinders have been pressureless

In order to be able to meet the provisions of § 35e Subsection 5, the Guidelines for Power-Operated Doors have been revised. The new version of this Guideline was published in Traffic Gazette on 11/3/1988.

Among other things, this Guideline provides for proper operation of the anti-jamming feature for passenger doors requiring regular inspection as part of general or intermediate inspections. This has applied since 1/1/1990 to all new motor buses being put into operation. For older buses it is recommended that the measuring procedure as defined in Annex 5.1.3 for this purpose be used provided the required information has been obtained from the vehicle manufacturer:

(Subsection "5.1.3") Facilities which are designed to prevent jamming of passengers not just briefly must have instigated a reversal of the closing motion or a neutralization of the closing force at a jamming force of no more than 150 N.

With the amendment of §35e Subsection 5: of the Guideline for Power-Operated Passenger Doors on Motor Buses (amendment of the Annex to No. 5.1.3 of the Guideline) dated May 27, 1991, a new, simplified procedure has been defined for regular checks to ensure reliable operation of anti-jamming features on passenger doors of motor buses. According to this, the jamming forces of power-operated doors on buses only need to be tested with a squeezing force meter of Category 2. In the event of recurring tests, only the peak forces need to be measured.

The ”k” value is obsolete and is no longer stipulated for these vehicles.

As mentioned above, the measuring procedure was introduced on 27/5/1991 in the Annex to Section 5.1.3 and must be used on motor buses which have first been put into operation after 1/7/1990.

For motor buses first registered between 1/1/1986 and 30/6/1990, measuring the peak forces F_S as described in that measuring procedure is recommended for passenger doors as part of maintenance or repair work, the objective being that a value of 200 N in closing and opening directions is adhered to.

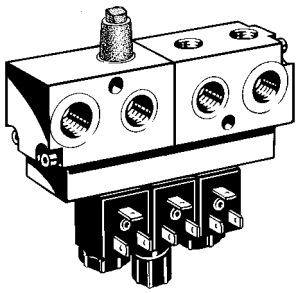
Taking Readings of Force Values:

1. When inspecting a vehicle for the purpose of granting homologation, the peak force, F_S, and the effective force F_E must be measured using Category 1 measuring equipment.

2. In the case of recurring tests on the occasion of main or intermediate inspections as laid down in § 29 or in connection with Annex VIII, inspection personnel must measure the effective force F_E using Category 1 mesuring equipment, or the peak force F_S using Category 2 measuring equipment. For both readings, the peak force F_S may not exceed a value of 200 N in closing direction, or of 250 N in opening direction.

3. When taking readings of doors’ forces for statistical purposes, it is necessary, due to the learning capability of ETS, to perform an unhindered door operation prior to each individual reading being taken to ensure that independent readings are achieved.

3. System Design of ETS

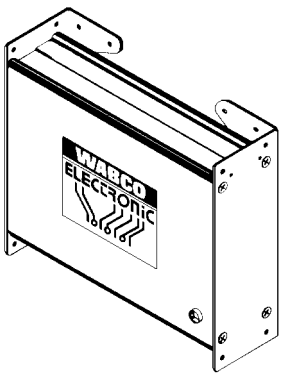


3.1 Pneumatic Control

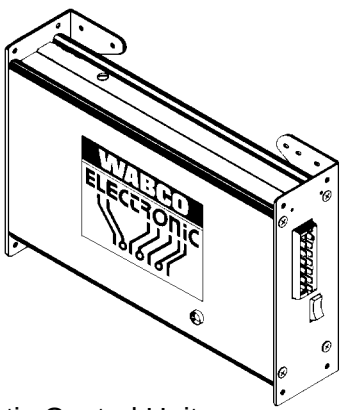
Compared to the pressureless / pressure reduction circuits used previously, the use of ETS considerably reduces the number of components to be installed. They are replaced by a single door operating valve which has two essential features:

- ❑ increasing and decreasing the air pressure in the cylinder chambers
  (4/2 function = normal door function)

- ❑ preventing door slamming after re-pressurizing the cylinders following actuation of the emergency cock. After this process, the door continues to be powerless. The door leaves can be moved manually, thus ensuring that a hazard to passengers is prevented.



ETS - Standard Control Unit



ETS - Automatic Control Unit

3.2 Electronic Control

Electrical control is achieved by control electronics which include a micro-controller. They are available in two basic versions:

1. Control for actuation by the driver only

2. Automatic controls for automatic door actuation

The computer programme in both types of electronic control units (ECU) is basically identical. Adjustment for the different functions is achieved by a special programming procedure. The type of ECU can also be identified by its plug-in connectors:

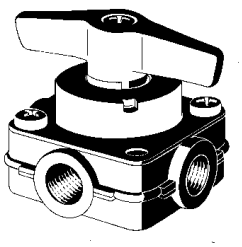
The standard-type ECU has a 25-pole plug-in connector, the automatic version also has that 25-pole plug on one side but also a 15-pole plug-in connection for the automatic functions on the other side, and a manual-automatic change-over switch.

The list below shows the ETS ECUs most commonly used:

Part Number	Type	Drive and Marking	Comments
446 020 006 0	Standard	rotary drive ETS-D	
446 020 007 0	Automatic	rotary drive ETS-D	
446 020 008 0	Automatic	rotary drive ETS-D-CH	special version for Switzerland
446 020 009 0	Standard	linear drive ETS-L	Has been replaced by 446 020 012 0
446 020 010 0	Automatic	linear drive ETS-L	Has been replaced by 446 020 013 0
446 020 011 0	Automatic	linear drive ETS-L-CH	special version for Switzerland
446 020 012 0	Standard	linear drive ETS-L	ECU with ”audible emergency cock”, downward compatibility with 446 020 009 0
446 020 013 0	Automatic	linear drive ETS-L	ECU with ”audible emergency cock”, downward compatibility with 446 020 010 0

Please note:

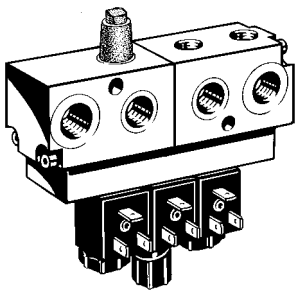
If an ETS ECU No.:
446 020 009/010 0 is to be replaced by an ECU No.: 446 020 012/013 0, remember that the wiring is different (audible emergency cock).



952 003 0 . . 0

3.3 Components

The emergency cock is needed to exhaust the door cylinders in a potentially hazardous situation and when repairs are done, or in the event of a failure of the door operating system. This allows the door leaves to be moved manually. At the same time, this emergency cock actuates the door valve in a way that when the door operating system is pressurized again, the door cylinders are switched to a ”pressureless” state. Variant **952 003 031 0** is an emergency cock which has a switch for actuating a warning facility.

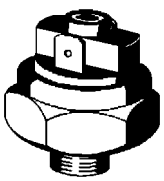


372 060 . . . 0

The **door operating valve** is a recent development and is used for **ETS control**. Its operation is identical to that of the previous door operating valve, 472 017 for normal opening and closing functions of doors. This valve, however, has an additional function, **door powerless control** which becomes effective when a person or an object are being jammed as the door is opening. In closing direction, the usual reversal facility becomes operable via the ETS ECU. The operating voltage of the door operating valve is 24 volts.

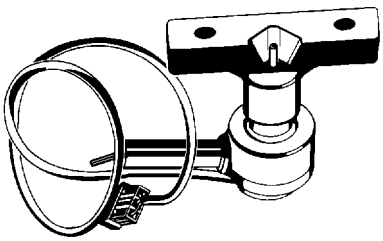
422 808 . . . 0

The purpose of the **door operating cylinder** is to generate the forces necessary for opening and closing a door.



441 014 . . . 0

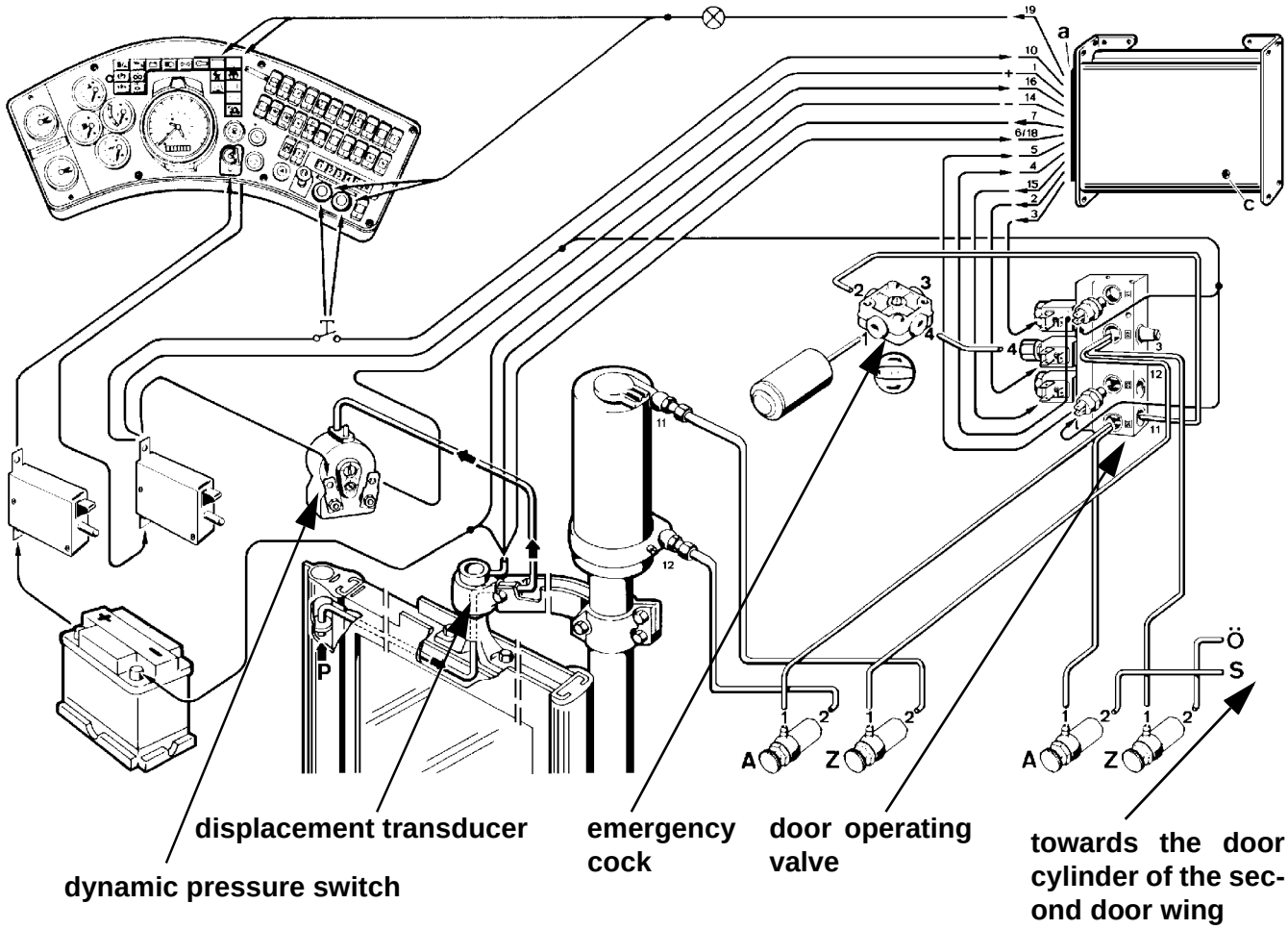
The **pressure switch** is used for switching solenoid valves or tell-tale lamps on and off. Consequently there is one off switch and one on switch. The switching position and pressure settings are dependent on the detail function of the facility to be controlled. The individual pressure switch variants as such are not adjustable.



446 020 4 . . 0

The **displacement transducer** (sensor) is a potentiometer which is displacement-controlled. During the opening process, the voltage rises from approx. **0.9 volts to approx. 14.0 volts**, and falls from approx. **14 volts to approx. 0.9 volts** during the closing process. These voltage variances are passed to the door's ECU and processed. If the door makes contact with an obstacle during the opening or closing process, the ECU is immediately able to detect this and control the door operating valve **372 060** accordingly.

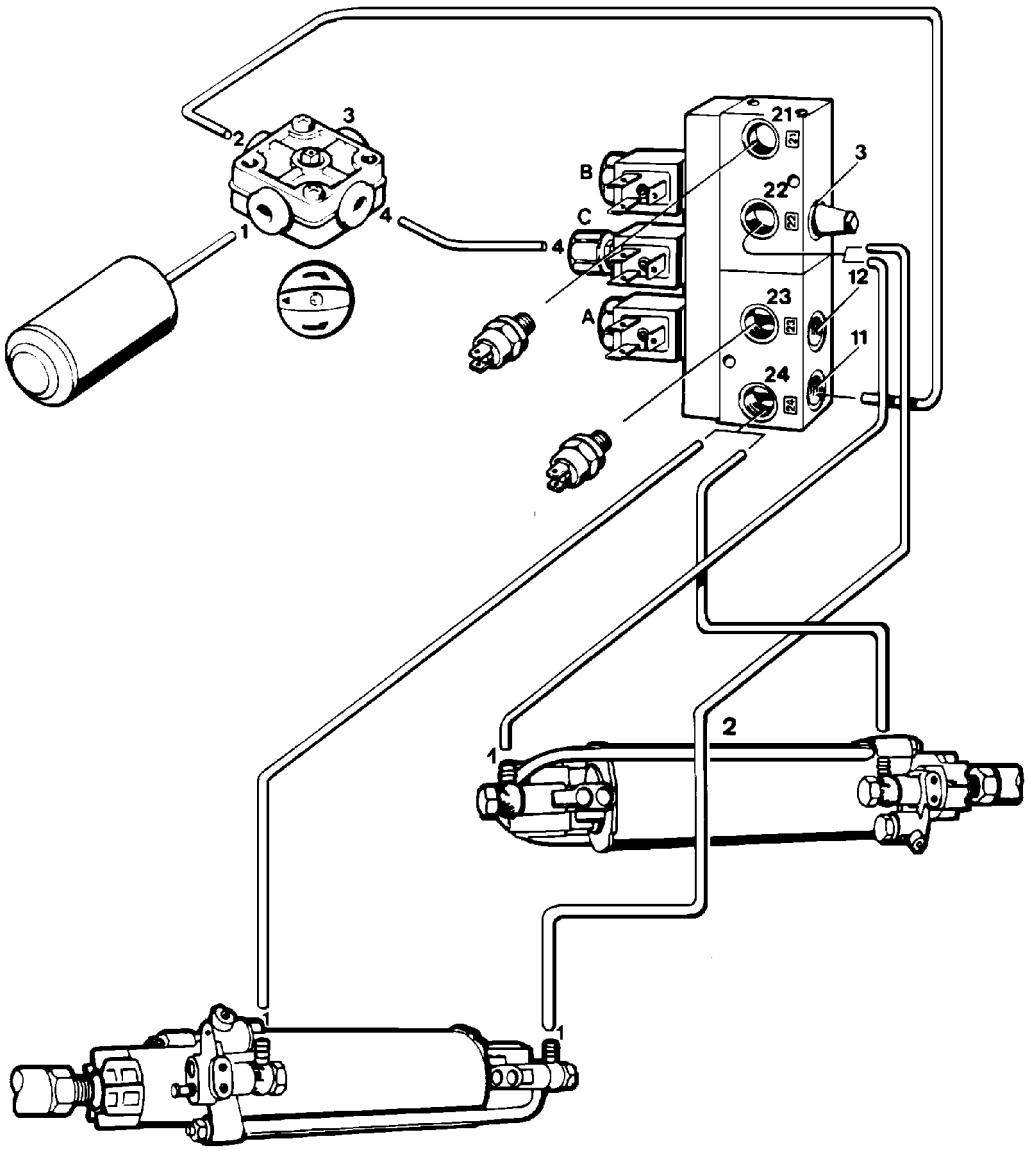
Example of an ETS System with Rotary Drive



The diagram above shows an ETS door operating system and the arrangement of the door components. The system in this example has a rotary drive. i.e. the door operating cylinder is mounted directly on the heel post of the door wing.

In this example, the door not only has a displacement transducer but is also monitored by a dynamic pressure switch which is actuated by a pressure pulse from the sealing rubber of the main closing edge. For this purpose, the ETS ECU is provided with a separate input port.

3.4 ETS Door Operating System with Linear Drive



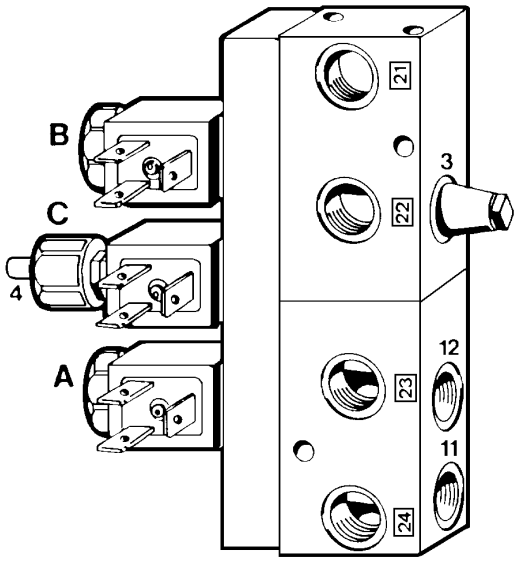
The diagram above shows the pneumatic circuit with a linear cylinder drive. The electrical circuit is identical to that described for the rotary drive on Page 9.

Both types of drive allow the opening and closing speeds to be adjusted by using suitable throttles or panels. The type of adjustment is shown in the vehicle documents provided by the vehicle manufacturer.

4. Functional Description

Description of WABCO's Bus Door Operating System with Reversal Facility and "Powerless Control"

ETS control requires only one door operating valve. In normal operation, the door operating valve acts in a similar way to a 4/2-way valve and is used to alternately pressurize the chambers of the door cylinders. Unlike older systems, the vehicle door - provided it does not encounter an obstacle while opening - becomes "powerless" which means that the door operating valve pressurizes **all** door cylinder chambers simultaneously. This causes the door to stop, a hazard to people (jamming) is prevented and the wings of the door can be moved by hand.



4.1 Opening and Closing Doors

In order to set the door operating valve to "open", the corresponding push-button on the dashboard must be pressed. This causes the ECU (output port PIN 15) to close the electric circuit to solenoid A of the door operating valve; the opening chambers of the door cylinders are pressurized and the doors open.

When the driver presses the push-button on the dashboard again, the door operating valve is switched over to "close" by energizing solenoid B. The closing chambers of the door cylinders are evacuated and the doors close.

4.2 Anti-Jamming Facility Reversal While Door Is Closing

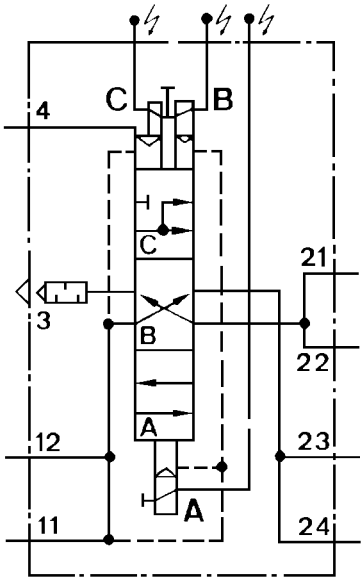
If a person or an object is jammed between the main closing edges of the doors during the closing process, the motion of the doors is impeded. Through the electronic displacement transducers (potentiometers), this impediment is detected and processed by the ECU. The ECU now reverses the door operating valve into its opening direction and the reversal process causes the doors to be opened again. After another control pulse has been received, i.e. when the driver presses the push-button once more, the door cylinders are again pressurized in the closing direction, causing the doors to close.

Anti-Jamming Facility While Door Is Opening

To make sure that the guidelines for automatically actuated doors and doors on buses operated by the driver are complied with, constructional measures must ensure that passengers located in the vicinity of the doors cannot get jammed as the doors open.

To comply with these guidelines, solenoid C of the door operating valve is used in combination with the electronic displacement transducers.

If a person or an object gets jammed between the rear edges of the doors during the opening process, the slowing motion of the doors is detected by the electronic displacement transduc-



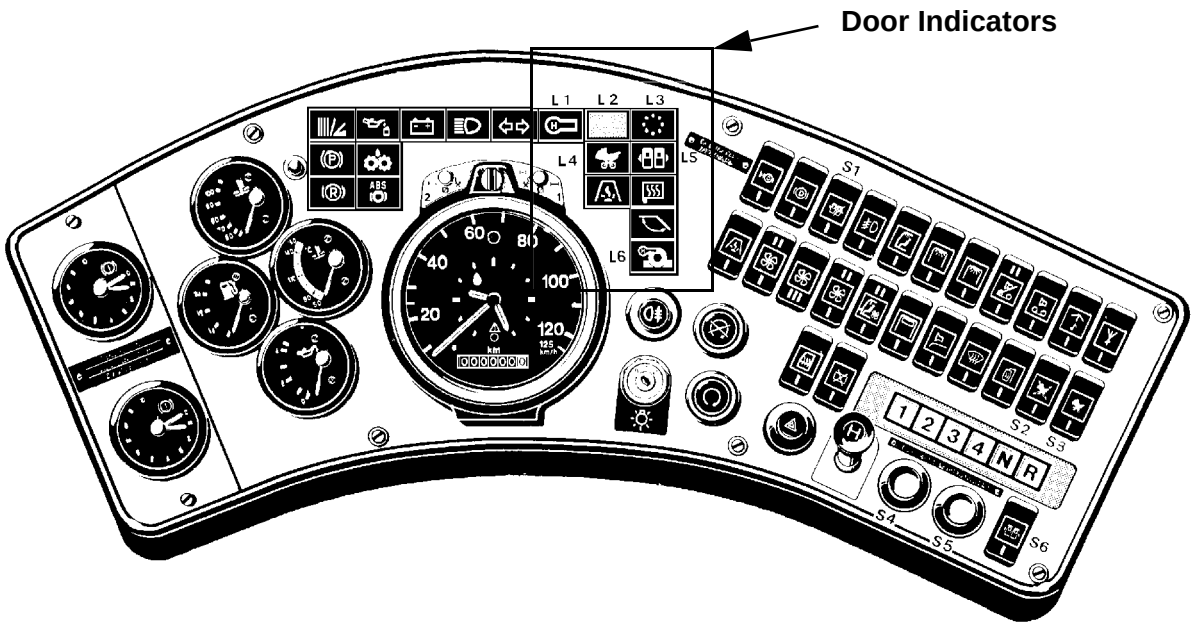
ers, and processed by the ECU. Solenoid C of the door operating valve is energized. The valve actuates and pressurizes both sides of the door cylinders, virtually rendering them ”powerless”. The door leaves stop and can be moved by hand.

It is important to remember that - due to the different surfaces of the door cylinder pistons - the door leaves move deliverately slowly towards the open position. The driver can close the door again at any time by pressing the push-button on the dashboard.

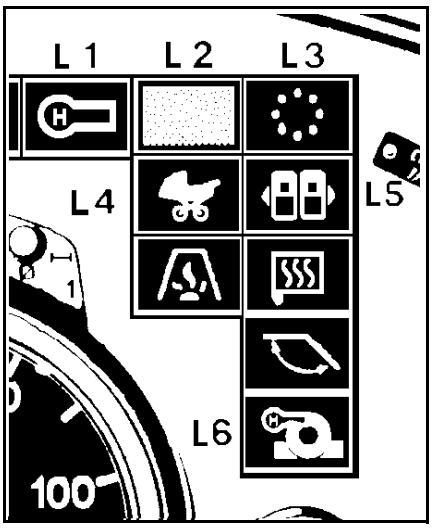
4.3 Emergency Cock Actuation

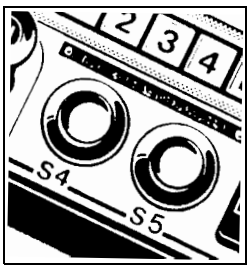
When the emergency cock is actuated, the door operating valve is automatically actuated via Port 4. The emergency cock is used to evacuate the door operating system. The door cylinders are pressureless, and the door cannot be moved or opened manually. If the door is to be operated again it is sufficient to return the emergency cock to its normal position. Via the door operating valve (pneumatically actuated via Port 4), all chambers of the door cylinders are pressurized - similar to ”Anti-Jamming Facility While Door Is Opening”. The push-button can then be pressed to close the door again.

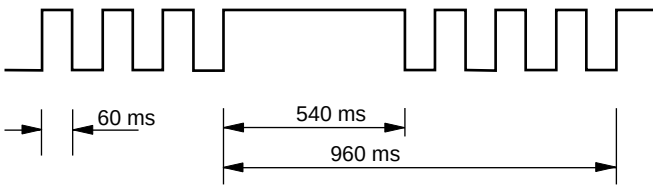
4.4 Telltale and Malfunction Indicators



The illustration on Page 12 shows an example of the typical dashboard of an urban routine bus. Different indicators are used to inform the driver of the ”condition” of the doors via the ETS ECU.







L1: The **request stop** indicator shows the driver that a passenger would like him to stop at the next bus stop. If automatic doors are in place, a door opening pulse is stored which automatically opens the door when released by the driver.

L2(red)/L3(green) provide information on the position of all doors: red = open, green = closed. L2 can also flash to show that there is a malfunction on the 3rd door of the vehicle (automatic door).

L4 shows a ”baby buggy request” made by a passenger. This means that automatic doors prevent automatic closing for approx. 3 seconds after the passenger has passed the monitoring facility. This function is deleted by the driver.

L5 shows if the driver has released the (automatic) door. This causes that door to be opened automatically when the speed falls below a certain threshold (usually 3 k.p.h.) provided the request stop function has been actuated.

L6 indicates to the driver that the bus stop brake has been activated. It is activated automatically when the vehicle is stationary and one door is open. It can also be activated manually by the driver.

S 4 : Driver’s push-button for door 1

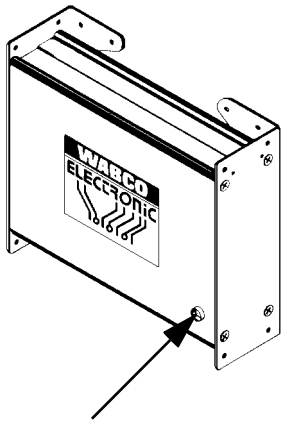
S 5 : Driver’s push-button for door 2

The push-buttons for doors 1 and 2 each have an integrated telltale in the form of an electric filament bulb indicating the door position and any defects.

The following signals are available to the driver:

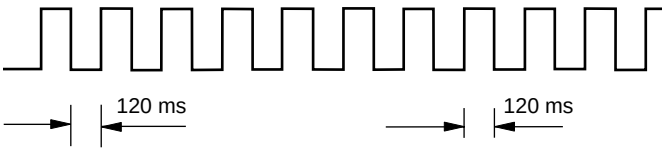
- ❑ red push-button telltale on permanently: door is open
- ❑ push-button telltale not on: door is closed
- ❑ push-button telltale flashing rhythmically: door is pressureless or powerless.

Pressureless Indication via Push-Button Telltale



light-emitting diode

Slow, rhythmical flashing



Rapid, rhythmic flashing
(approx. 4 pulses/second)

Another telltale is found inside the housing of the ETS ECU. This is a light-emitting diode (LED).
When trying to locate an error, this malfunction indicator and/or the telltale in the driver's push-button are used to flash out error codes.

Please note: If errors occur simultaneously on the displacement sensors of the front and rear door wings (e.g. MAXFEL-R/MAXFEL-L), the ETS ECU always shows the malfunction of the rear door wing first. After this defect has been remedied, the error of the front door wing is indicated.

Normal Function

Readiness of the ETS ECU is indicated by the flash code of the telltale at a ratio of
$t_{on} = t_{off} \sim$ 2seconds.

This indication is **not** shown in the driver's push-button for that respective vehicle door.

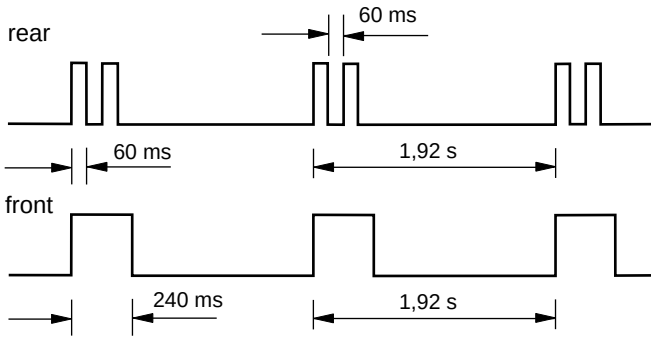
Overload or Short Circuit

This flash code is used to indicate an overload or a short at an ETS output port. It is a rapid flashing signal of the telltale at a ratio of $t_{on} = t_{off}$ = 120 ms (milliseconds).

This indication is **not** shown in the driver's push-button for that respective vehicle door.

Whenever an error or defect of this type occurs, the ETS ECU is out of operation until the defect has been repaired!

Sensor Defect:
Minimum values (Minfel-H/Minfel-V)

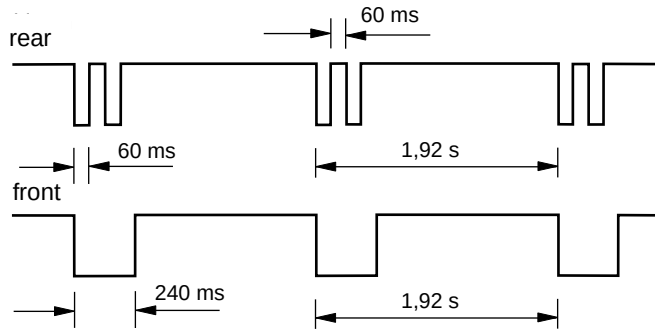


Sensor value U ≤ 0.2 volt
If a voltage at one of the displacement sensor input ports falls below U ≤ 0,2 volt, ETS identifies this as a voltage which is too low. The ETS ECU reacts to this insufficient voltage with arhythmic flashing of the malfunction lamp, this being predominantly switched to "OFF". To indicate a defect at the front door wing, the malfunction indicator is periodically switched on **once**, to indicate a defect at the rear door wing it is switched on briefly **twice**. This is repeated at intervals of approx. 2 seconds.

This is **also** indicated by the lamp in the driver's push-button for the respective vehicle door.

If this type of error occurs, the ETS ECU is out of operation until the defect has been repaired!

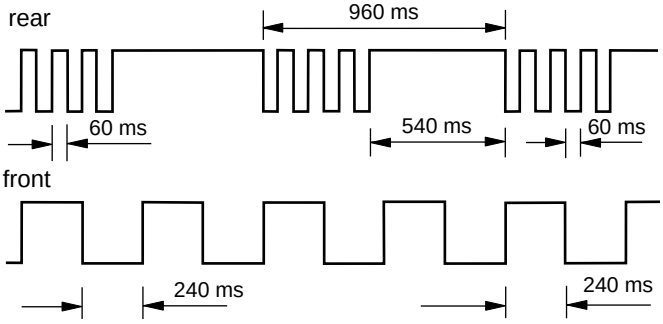
Sensor Error: Maximum values (Maxfel-H/Maxfel-V)



Sensor value U ≥ 14.8 volt
If a voltage at one of the displacement sensor input ports rises above U ≥ 14.8 volt, ETS identifies this as a voltage which is too high. The ETS ECU reacts to this with arhythmic flashing of the malfunction lamp, this being predominantly switched to "ON". To indicate a defect at the front door wing, the malfunction indicator is periodically switched off **once**, to indicate a defect at the rear door wing it is switched off **briefly twice**. This is repeated at intervals of approx. 2 seconds.

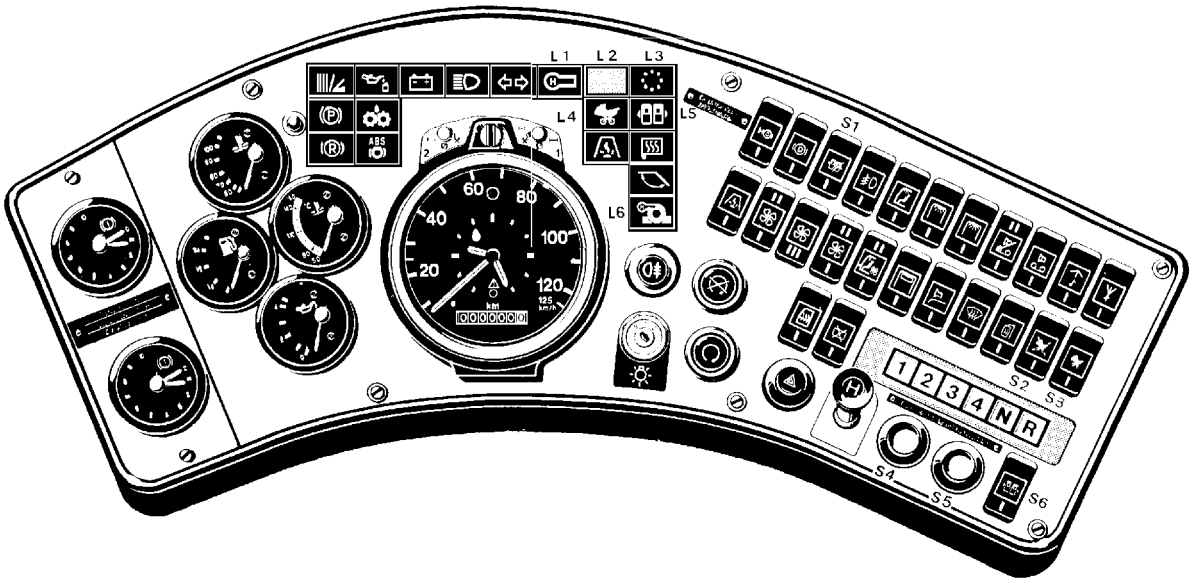
If this type of error occurs, the ETS ECU is out of operation until the defect has been repaired!

Sensor Error: Intermediate values (Felhi/Felvo)



If a minimum door speed as defined in the ETS ECU is not achieved before that door wing reaches its fully closed or open position, the system reverses if the door is being closed or, if the door is being opened, renders the door cylinders powerless. Usually this monitoring function is activated only when a person or object is jammed in the door.
These monitoring functions are, however, also activated if a displacement sensor has been incorrectly adjusted or has a mechanical defect and the voltage does not change before the fully closed or open position is reached.
When this monitoring function responds, this is indicated only by the internal telltale lamp of ETS and **not** by the lamp in the push-button for that vehicle door.

4.5 Switch for Special Functions



Door Wing Lock on Door I
This switch allows the rear wing of door I to be locked provided the door has had a second door operating valve fitted. When that door of the vehicle is closed and a ‘door open’ command is given, only the front wing of door I is opened. The rear wing of that door will remain closed. when that lock is released, the rear wing of the door will also open.

Baby Buggy Request ”Driver”
This push-button is used to set the ”baby buggy function”. The ETS display ”baby buggy request” is activated. When the vehicle has stopped and the door has been released, the automatic closing process for a door opened due to a request by a passenger is discontinued. After this baby buggy function is deleted by the driver, and after the time for keeping the door open has expired, the door of the vehicle will again close automatically.

Please note:
In addition it is possible to extend the function of this push-button in such a way that the door of the vehicle can be opened without a passenger having pushed the request-stop button.

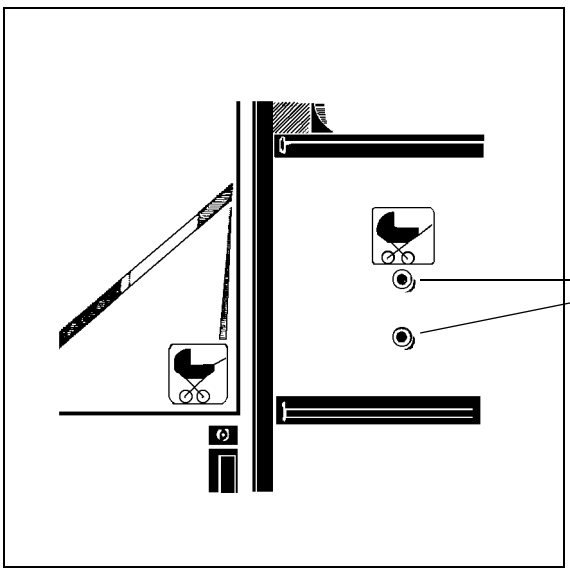
Baby Buggy Request ”Delete”
This push-button is used to delete the release of the baby buggy function in the ETS ECU and the ‘baby buggy release’ display on the dashboard. After the time for keeping the door open has expired, the automatic closing process is initiated.

Driver Switch ”Door Release”
The door release command can be given to the automatic ETS function via a release switch. This allows the vehicle’s doors to be opened automatically if a request stop has been made and the vehicle is stationary.

Please note:
This function can also be executed by means of two **push-buttons** (set and delete push-buttons) (mode bridge required).

Standard Circuit:

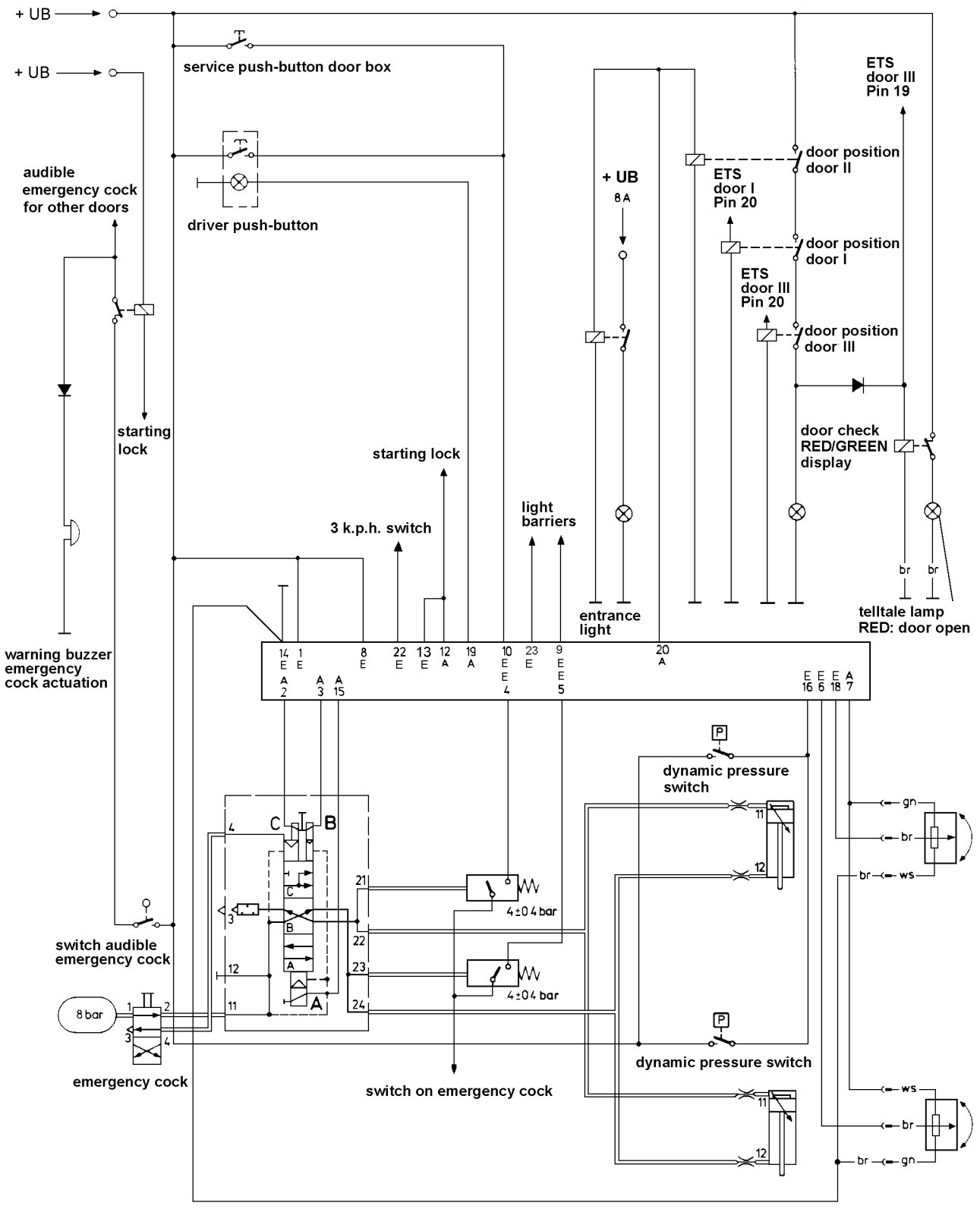
Today’s standard circuit on routine buses provides for only one release switch (S6) and one ”baby buggy delete” push-button (S2). The ”baby buggy request” is exclusively entered by the passenger via strategically placed push-buttons.



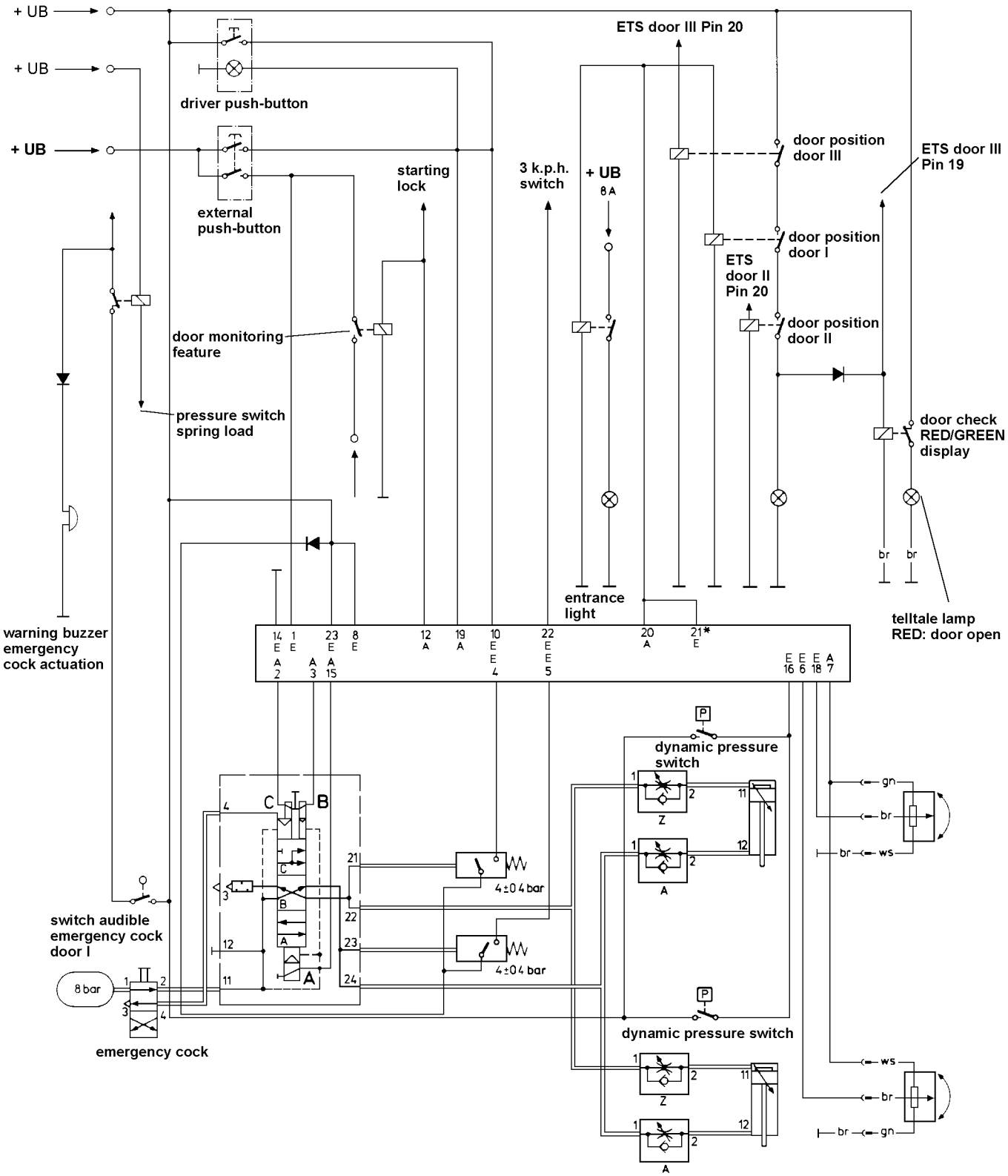
passenger push-button ”baby buggy request”

Circuit Diagrams

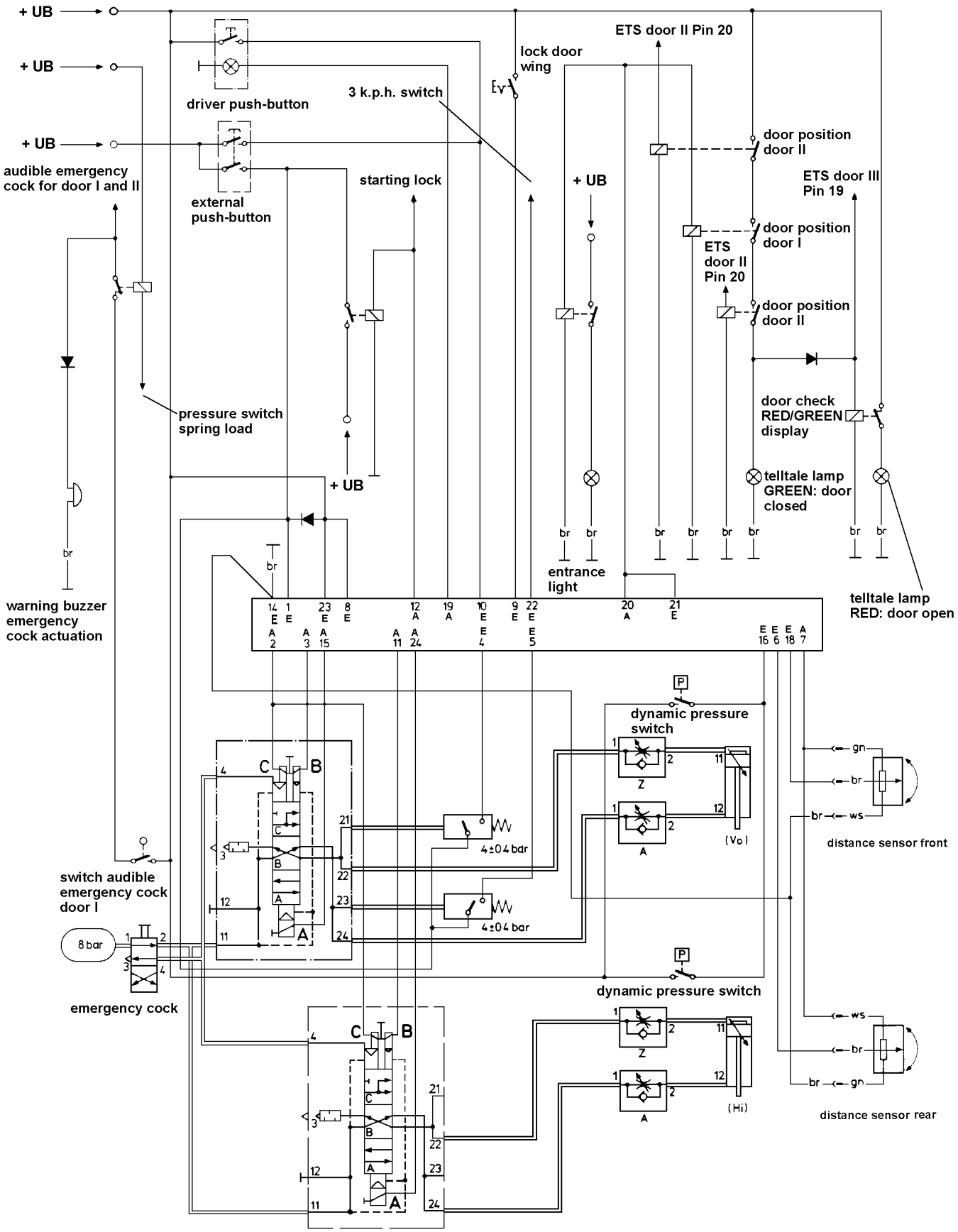
"Standard Version" 2nd door
"closed" door position



1st door without "lock 2nd door wing"
door position "closed"

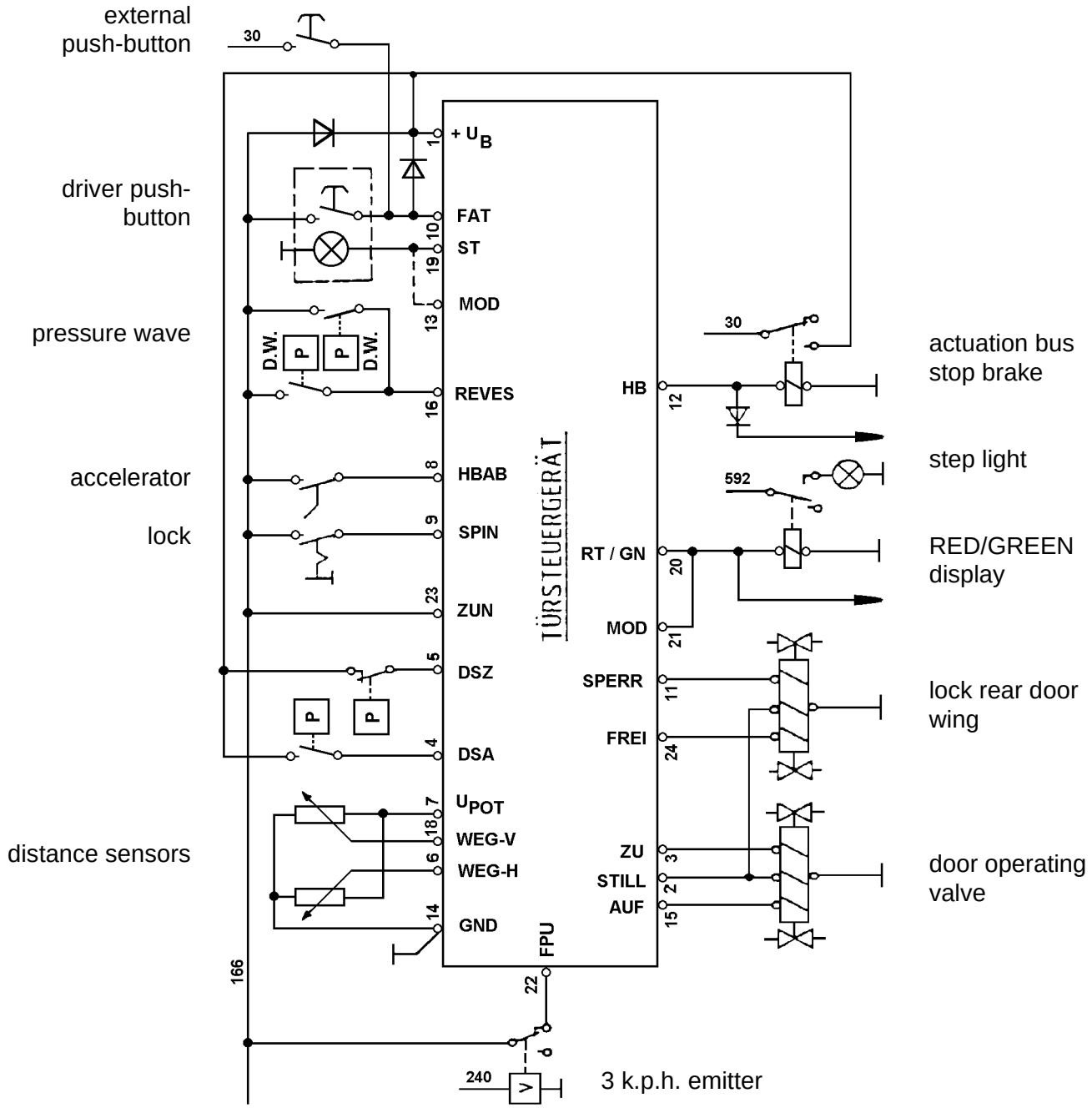


1st door with "lock 2nd door wing"
door position "closed"



WABCO

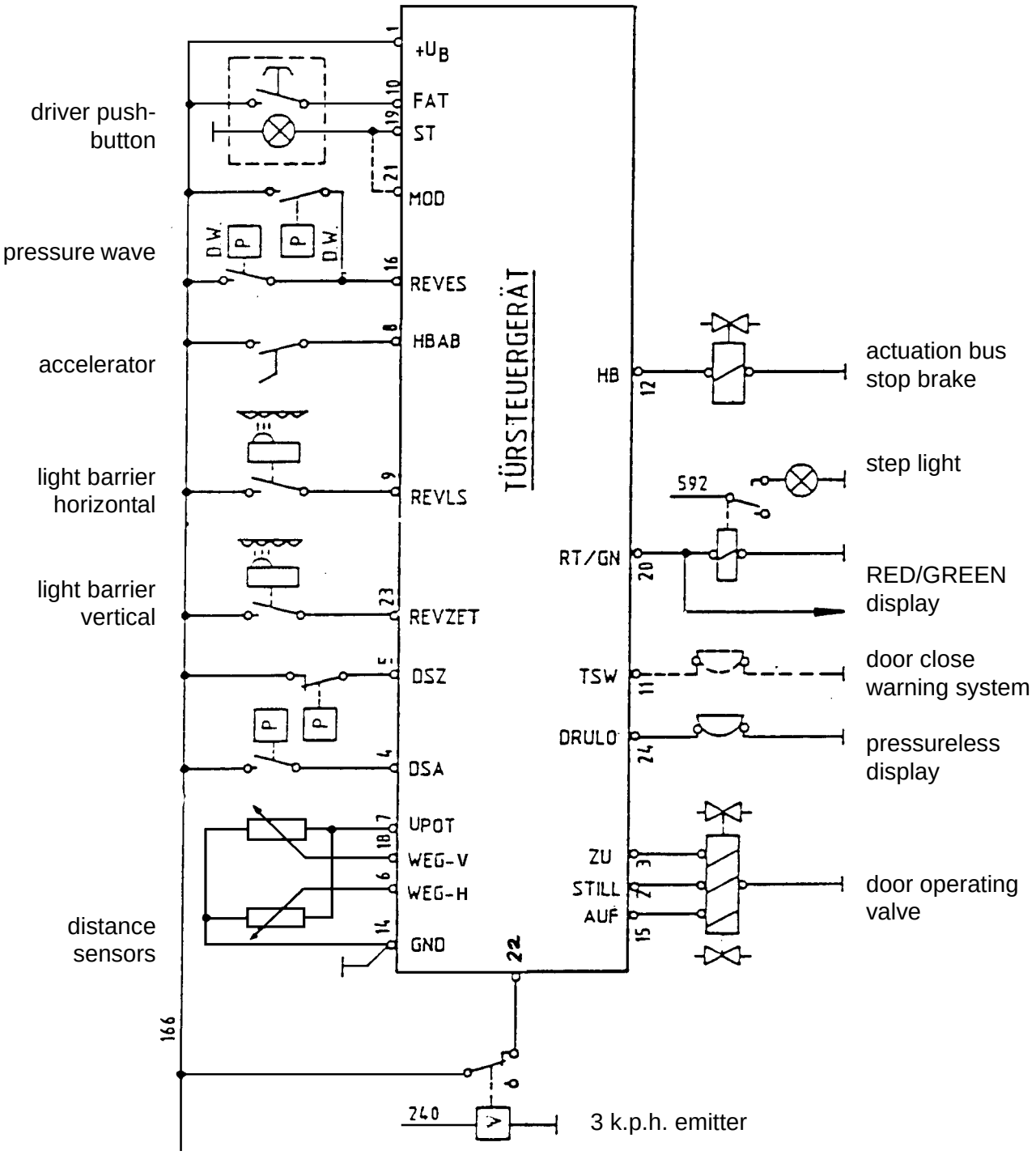
Block Diagram ETS 1st door



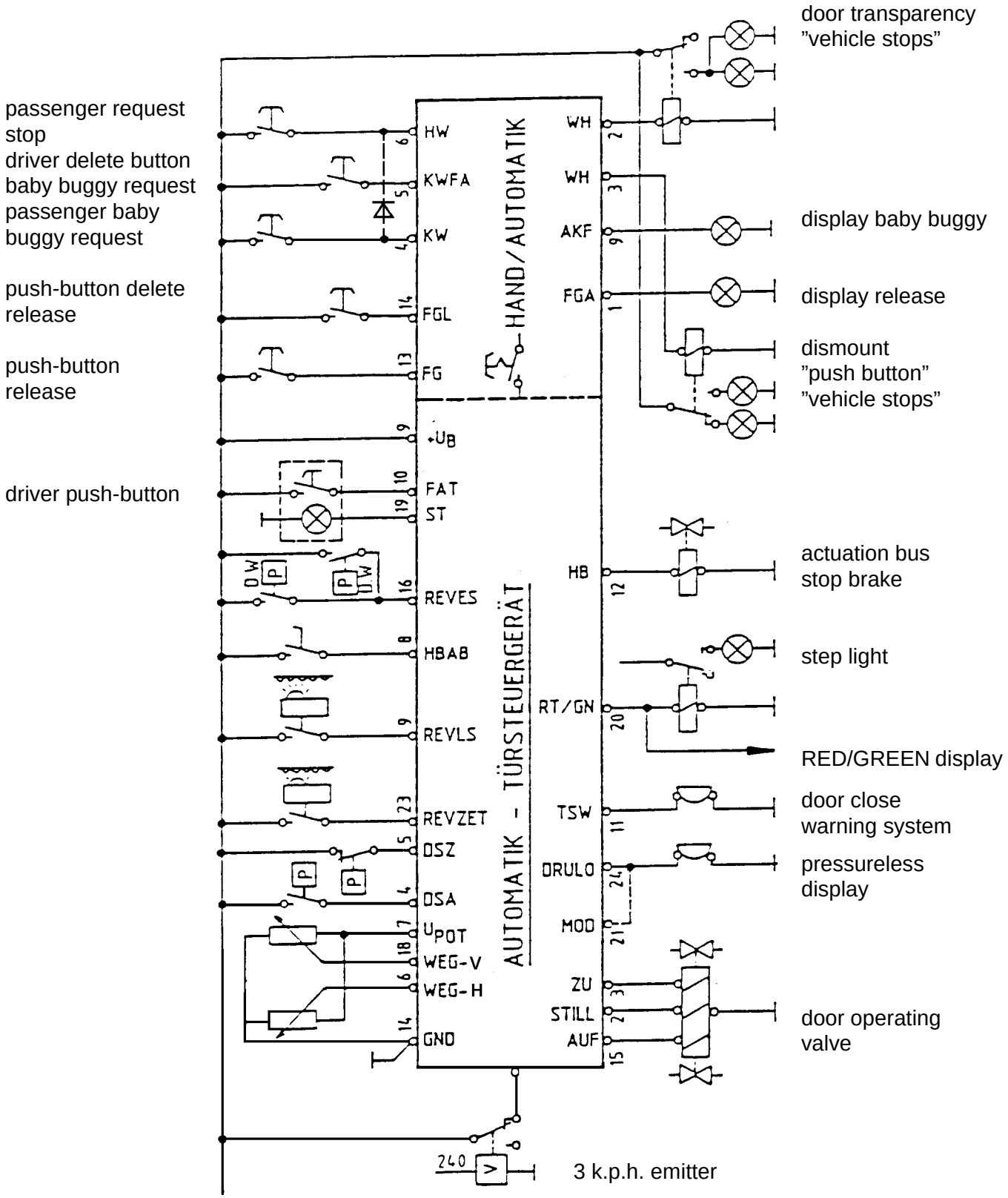
Layout of "1st door" function:
This function is selected via the connection of control unit ports 20 and 21 (RT/GN and MOD.). Inpurt port 9 (SPIN) is connected to a switch.

Layout of "separate door wing actuation" function:
This function is selected via the connection of control unit ports 20, 21 (RT/GN, MOD.) and 19, 13 (ST, MOD.). Input port 9 (SPIN) is connected to a second driver push-button.

Standard ETS Door Control System, 2nd door



Automatic ETS Door Operating System
2nd and 3rd doors



The basic ETS unit is ECU 446 020 012 0 for controlling non-automatic vehicle doors (door 1 and door 2). The electrical connections of this ECU are achieved by means of a 25-pole AMP plug.

This unit is used as a basis for extending ETS to provide automatic door operation. The input and output ports of this automatic function (446 020 013 0) are conducted via a 15-pole AMP plug. Because of the different options for using ETS to control door 1 and door 2 or to automatically control door 3, the input and output ports of the two control units of the 25-pole AMP plug which both control units have in common have had some different functions allocated.

Designation of input ports (25-pole plug):

PIN		control door 1	control door 2	automatic door control
1	+24V	operating voltage + 24 volts		
4	DSA	manometric switch in opening line, e.g. 4bar E		
5	DSZ	manometric switch in closing line, e.g. 4bar E		
6	WEG-H	distance sensor rear door wing (right-hand side)		
18	WEG-V	distance sensor front door wing (left-hand side)		
8	HBAB	accelerator pedal switch		
9	SPIN	lock door wings	reversal input port, e.g. for horizontal light barrier (REVLS)	
10	FAT	driver push-button		
16	REVES	reversal input port, e.g. for dynamic pressure, step etc.		
13	MOD	programming input ports		
21				
25				
22	FPU	3 k.p.h. emitter		
23	ZUN	vehicle ignition	reversal input port, e.g. for vertical light barrier	
14	GND	vehicle ground		

Designation of output ports (25-pole plug):

PIN		control door 1	control door 2	automatic door control
15	AUF	front door wing ‘open’	door wing ‘open’	
3	ZU	front door wing ‘close’	door wing ‘close’	
2	STILL	door valve ‘stationary’		
11	TSW	rear door wing ‘close’	door close warning system	
24	DRULO	rear door wing ‘open’	pressureless display (emergency cock actuation)	
12	HB	bus stop brake		
20	RT/GN	display RED/GREEN		
19	ST	door position display (fault indicator) driver push-button		
7	UPOT	distance sensor voltage		

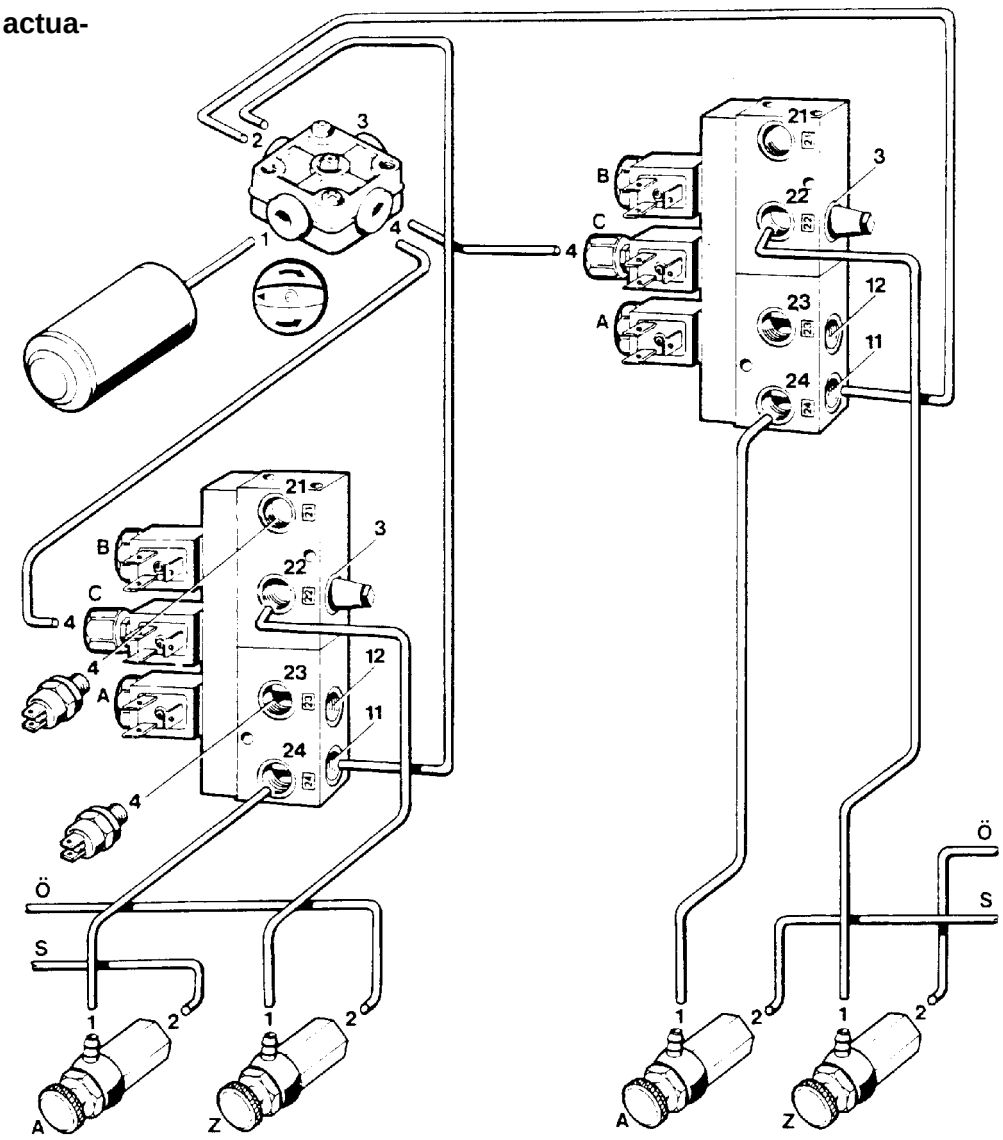
Designation of input ports for automatic door operation (15-pole plug):

PIN		automatic door operation door 3
4	KW	notification of passenger's baby buggy request
5	KWFA	driver's baby buggy function
6	HW	passenger's stop request
12	HAND	external switchover manual/automatic
13	FG	door release
14	FGL	delete door release

Designation of output ports for automatic door operation (15-pole plug):

PIN		automatic door operation door 3
9	AKF	display baby buggy release
1	FGA	display door release
2	WH	display vehicle stops
3		

Special ETS circuit for 1st door with separate door wing actuation:



Diagnosis

6.1 Options for Diagnosis

There are basically three options for checking ETS door operating systems for errors, and for functional testing:

- ❑ testing with the Diagnostic Controller
- ❑ testing with the ETS test equipment case
- ❑ testing with the flash code

In this context it is important to remember that the ETS ECUs installed in the past do not have a built-in **error memory**. Thus an error or defect cannot be read out in the way this is done for ABS systems, for example.

6.2 Testing with the Diagnostic Controller

Information on using WABCO's Diagnostic Controller 446 300 320 0 and ETS Programme Card 446 300 800 0:

Abbreviations and terms used:

ETS	Electronic door control system
ECU	Electronic Control Unit
R-AUF	rear door operating valve 'open'
R-ZU	rear door valve solenoid 'close'

Mode 0:
Automatic closing of the door by pressing the driver's push-button is not possible (reversing input ports are active).

Mode 1:
Standard mode for door 1.

Mode 2:
Door closing warning system is active.

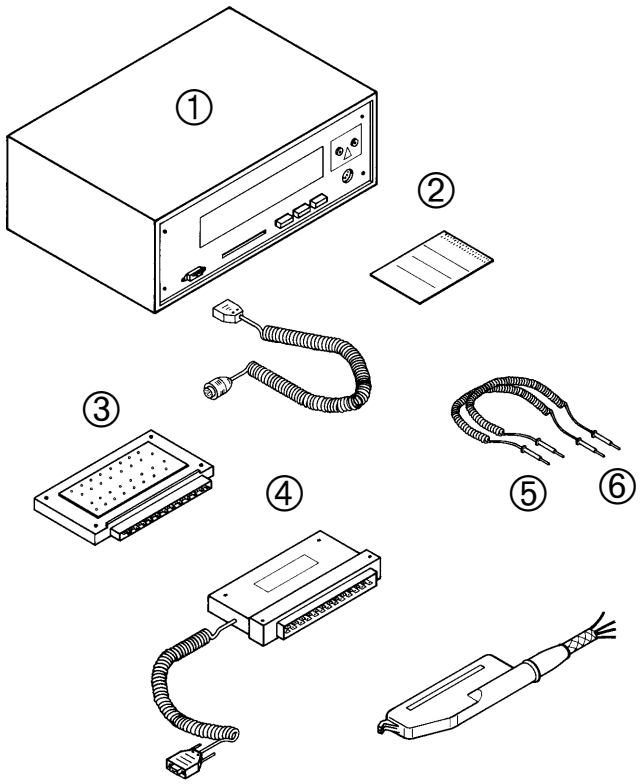
Mode 8:
Door 1 can be controlled by the driver by means of two push-buttons.

Trigger dynamic pressure:
The front edges of the doors have had sensors fitted and generate dynamic pressure when actuated (e.g. compression by hand).

Programming input ports:
Balanced input ports for programming the ECU. On the 25-pole connection these are PINs 13, 21 and 25.

Door Recognition:
Via MODE programming the ECU is aware of which door is being controlled.

Components for Diagnosis:



1...	Diagnostic Controller	446 300 320 0
2...	Programme Card	446 300 800 0
3...	Measuring Adapter ECAS/ETS 25-pole	446 300 311 0
4...	Connecting Adapter 25-pole	446 301 200 0
5...	Multimeter Cable black	894 604 301 2
6...	Multimeter Cable red	894 604 302 2

The Diagnostic Controller Set	446 300 331 0
consisting of Diagnostic Controller	446 300 320 0
and Carrying Case	446 300 022 2

Connecting Procedure

To connect the Diagnostic Controller, the following procedure must be followed:

– Switch off ignition

– Pull 25-pole plug of the ETS ECU

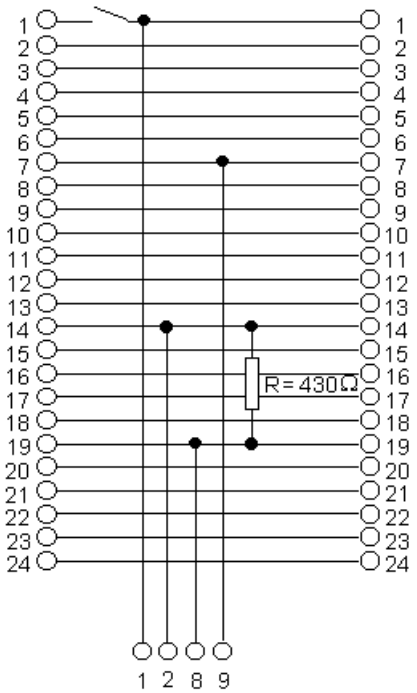
– Push one end of the connecting adapter to the ECU and the other to the vehicle wiring

– Connect the cable of the connecting adapter to the 'Diagnostic Input' socket of the Diagnostic Controller

– Push in the programme card

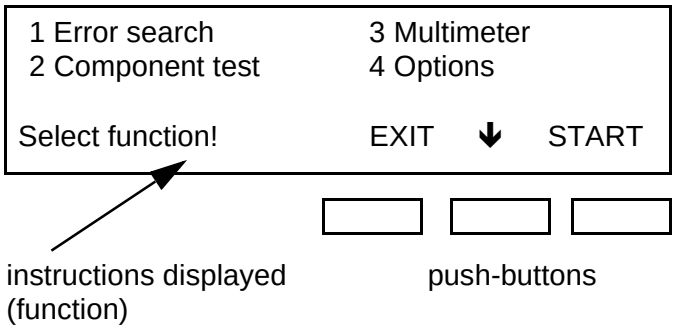
– Switch on ignition

Circuit Diagram Adapter 446 301 200 0 :



Operating the Diagnostic Controller

The Diagnostic Controller is operated from the three push-buttons on its front panel. The function of the individual push-buttons depends on the instructions displayed above each of those push-buttons



push-button	**function**
START	Starting the programme
EXIT	The display returns to the previous menu or programme item.
↓	Selecting a menu item in the main menu. Every time the push-button is pressed, the next menu item is addressed. The menu item selected is flashing.
CONTINUE	The menu item selected previously is activated or triggered.
ABORT	The respective function can be aborted.

Programme Description

Menu selection Electronic Door Control 1.00

- 1 error search
- 2 component test
  - 1 mode door I
  - 2 mode door II
  - 3 mode door II / III
  - 4 displacement sensor test
  - 5 MODE recognition
- 3 multimeter
  - 1 direct voltage
  - 2 alternating voltage
  - 3 resistance
- 4 options
  - 1 help texts
  - 2 version
  - 3 testable ECUs

Error Search

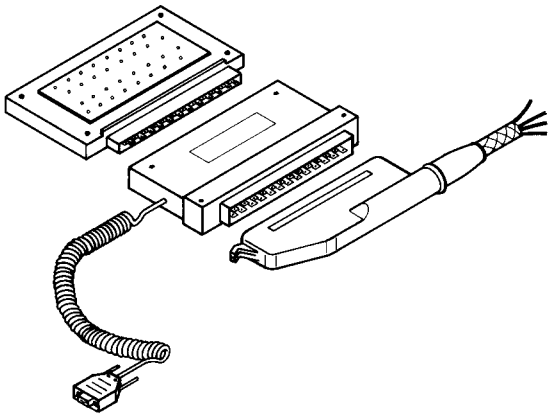
After selecting menu item 1 ”error search”, the flash-code signals transmitted to the driver’s push-button are read out and displayed in plaintext. Any errors produced by a displacement sensor are shown only if the supply pressure is sufficient and the door wing is stationary.
Example: rear sensor reading too great

error from flash code diagnosis: sensor reading >= 14.8 ’rear’ CONTINUE

Component Test

It is important that the component test is done only with the circuit diagram applicable to that vehicle to ensure that the readings are interpreted correctly!

For component testing, Measuring Adapter 446 300 311 0 must be plugged onto Connecting Adapter 446 301 200 0.



1 Mode door I	4 displacement sensor test
2 Mode door I I	5 MODE recognition
3 Mode door II/III	
Select function!	EXIT ↓ CONT.

Select the appropriate menu items and connect the multimeter to the respective PINs for taking the readings for the components. Follow the instructions in the display!

Confusion of the multimeter cables (red or black) causes a negative actual value to be displayed.

Displacement Sensor Test

Static displacement sensor test:
For a static displacement sensor, the question of which type of drive is being used must be answered first. The limit values and the absolute limits of the open door vary, depending to the type of drive.

Linear drive:

ACCEPTABLE: 9.6 volt to 14.5 volt for both door leaves

ACCEPTABLE: 0.5 volt difference between the door leaves

Rotary drive:

ACCEPTABLE: 9.0 volt to 14.5 volt

ACCEPTABLE: 1.2 volt difference between the door leaves.

The Diagnostic Controller then supplies voltage at Ports 7/14, the amount of which depends on the displacement sensor used. This voltage is measured and set to +15 volts by the programme (standardized).

The voltage at Ports 7/14 must be greater than +5 volts, otherwise the test is aborted.

Possible causes for this can be:

– Diagnostic Controller's measuring cable not connected to 7/14

– Diagnostic Controller's measuring cable wrongly connected

– Displacement sensor cable discontinuity

The subsequent readings in the static displacement sensor test then relate to the standardized voltage.

The ports and the limit values for the readings on both door wings are displayed and need to be evaluated by the person doing the testing. The differences between the absolute values for the 'door open' position are evaluated by the programme and displayed if the permissible maximum is exceeded.

Dynamic displacement sensor test:
In the dynamic displacement sensor test, the displacement sensor is tested for discontinuity. The multimeter cables must be connected as instructed by the programme. Starting from a closed door, the door leaf must be pulled open slowly and smoothly.

Any errors which have occurred while the door leaf was being pulled open are subsequently displayed. The measuring time is shown in the display in the form of a dot bar.

If "!" appears in the display, the door leaf is being pulled open too quickly. If "?" appears, a sensor defect has been detected.

Multimeter

1 direct voltage 2 alternating voltage	3 resistance		
select function!	EXIT	↓	CONT.

CAUTION!
The unit is designed only for taking readings within the range applicable to the vehicle (low potential).
With the integrated multimeter function, electrical readings can be taken on the vehicle. For this purpose, it is sufficient to select the desired function for measuring

1 direct voltage
2 alternating voltage
3 resistance.

The measuring range is set automatically by the equipment. It may not be used outside the ranges mentioned!

Range	Display resolution	Accuracy of measuring range. Final value at 20°C	
DC-voltage 2.0 volt 20.0 volt 50.0 volt	 0.1 volt 0.1 volt 0.1 volt	 ± 0.2 % ± 0.2 % ± 0.2 %	 ± 0.0 volt ± 0.1 volt ± 0.1 volt
AV-Voltage 2.0 volt 35.0 volt	 0.01 volt 0.1 volt	 ± 0.6 % ± 0.6 %	 ± 0.02 volt ± 0.4 volt
Resistance 20.0 Ω 200.0 Ω 2.0 kΩ 20.0 kΩ 95.0 kΩ	 0.1 Ω 0.1 Ω 1.0 Ω 10.0 Ω 100.0 Ω	 ± 0.3 % ± 0.2 % ± 0.2 % ± 0.1 % ± 0.2 %	 ± 0.1 Ω ± 0.1 Ω ± 1.0 Ω ± 10.0 Ω ± 100.0 Ω

Options

1 help texts	3 testable ECUs		
2 version			
select function!	EXIT	🡻	CONT.

”Options” comprises the following sub-items:

Help Texts

With this function the operator can obtain additional information on the operation. If this function has been activated, more detailed information about the programme will appear at the appropriate times.

Version

hardware	:	V1 multimeter : V1	
operating system	:	V3.1 of 07/03/1991	
programme	:	V2.00 of 14/10/1994	
checksum	:	5B09 (hex)	CONT.

This function shows the type of Controller and the programme used.

Testable ECUs

The display shows which ETS ECUs can be tested with this programme card.

Overview ETS ECUs 446 020 XXX 0:

P... pneumatic
D... rotary drive
L... linear drive
ENL... extended emergency cock logic

	P/D	P/L	P/L/ENL
door control	006	009	012
automatic door operation*	007	010	013

* Automatic functions cannot be tested.

Malfunctions

no display

Cause	Remedy
- no voltage supply - undervoltage (less than about 7 volts)	- check all plugged connections - check supply voltage

IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII

black "bars"

Cause	Remedy
- program card not inserted	- push program card in as far as the stop (Contacts overhead)

*** Error during self-test ***
EEPROM of Diagnostic Controller faulty

Cause	Remedy
- EEPROM (Diagnostic Controller's) non-volatile memory of DC defective	- Repair Diagnostic Controller

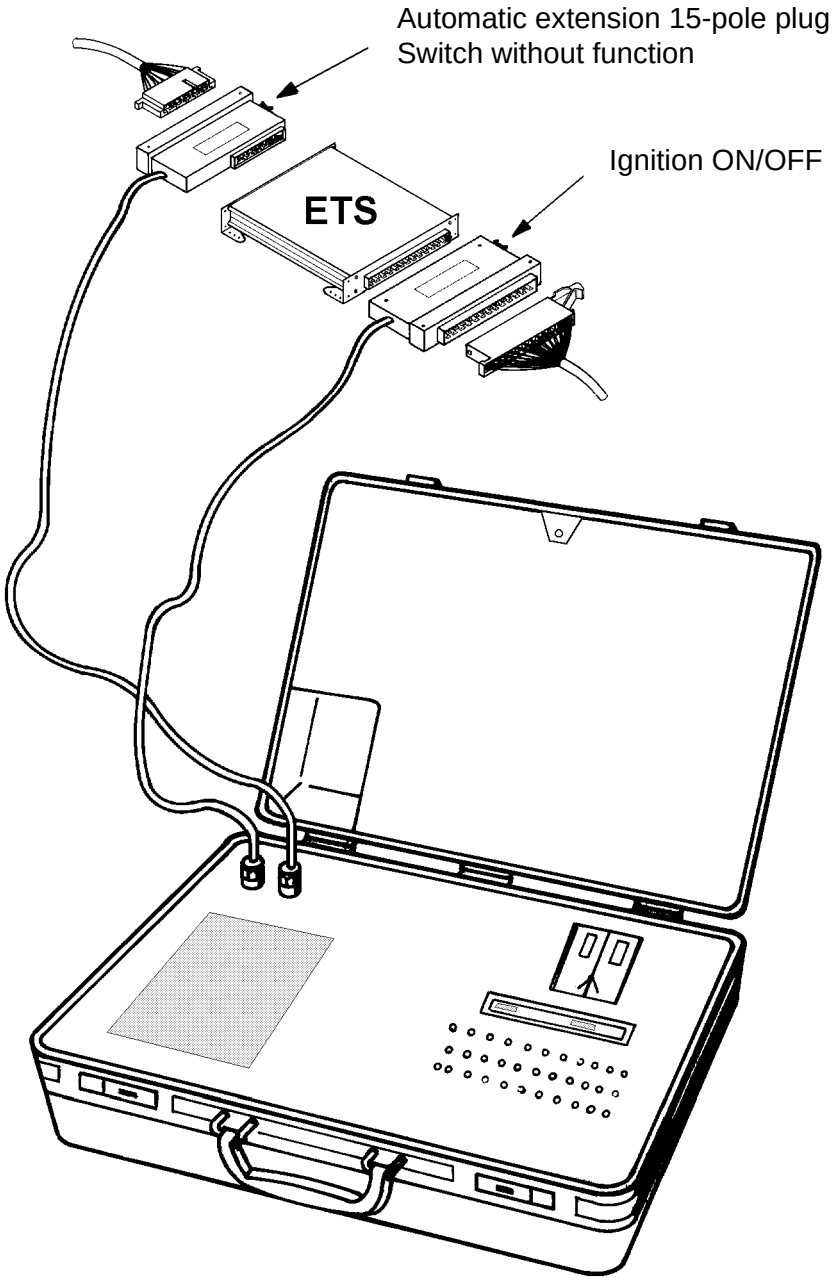
Defective Program Card !

Cause	Remedy
- Defective program card - Wrong program card	- Change program card - push program card in as far as the stop - clean contacts

*** wrong multimeter ***
This equipment cannot be used for
this mode of operation!
CONTINUE

Cause	Remedy
- built-in multimeter defective - wrong multimeter version built in	- have Diagnostic Controller repaired - have Diagnostic Controller updated

6.3 Testing the ETS System With the Test Equipment Case



The ETS test equipment case has the WABCO Part No.: 884 901 555 0.
This test equipment case can be used for testing all WABCO ETS door control systems. Essentially this is a ”box of jacks” allowing all input and output ports of the respective ETS ECU to be measured with a multimeter. Additional light-emitting diodes show the type of door drive used.
The test equipment case is connected between the ETS ECU and the ETS cable harness using flexible cables and adapters.
The condition of the ETS system can be used by referring to corresponding test tables.

ETS PIN Designation	+ UB	STILL	ZU	DSA	DSZ	Weg-R	Upot	HBAB	SPIN	FAT	R-ZU	HB	AUF	REVES	Weg-L	ST	RT/GN	FPU	ZUN	R-AUF
ETS PIN Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**15**	**16**	**18**	**19**	**20**	**22**	**23**	**24**
Functions																				
Door closed under pressure, ignition on	x				x	(V)[1]	x[10]	x[11]	x[2]						(V)[1]		x	x[12]	x[3]	
Door open under pressure, ignition on	x			x		(V)[4]	x	x				x			(V)[4]	x		x	x	
Door is closed via driver's push-button	x		π		x	(V)[17]	x	x		π	π[5]	x[6]			(V)[17]	x[7]	x[7]	x	x	
Additional signals from the external reversing facility while closing				x									π	π[8]						π[5]
Door is openned via driver's push-button	x			x		(V)[17]	x	x		π		x	p		(V)[17]	x		x	x	π[5]
Additional signals during powerless circuit while opening		π		x	x											ππ				
Door is opened via driver's push-button, ignition off	x[13]			x	π	(V)[17]	x			π		x	π		(V)[17]	x	π			π
Door is closed via driver's push-button, ignition off	x[13]		π	π	x	(V)[17]				π	π	x			(V)[17]	x				
Mode Programming	**Mode 0 :** Preventing the reversing facility being copied by means of a bridge in the 25-pole plug from HB (PIN 12) to the mode input port (PIN 25). Required since 1/7/90 as per decree by Federal Ministry of Transport. **Mode 1 :** Identification for door I by way of bridge from RT/GN (PIN 20) to the mode inpurt port (PIN 21).																			

ETS PIN Designation	+ UB	STILL	ZU	DSA	DSZ	Weg-R	Upot	HBAB	SPIN	FAT	R-ZU	HB	AUF	REVES	Weg-L	ST	RT/GN	FPU	ZUN	R-AUF
ETS PIN Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**15**	**16**	**18**	**19**	**20**	**22**	**23**	**24**
Functions																				
Door closed under pressure, ignition on	x				x	(V)[1]	x[10]	x[11]							(V)[1]		x	x[12]		
Door open under pressure, ignition on	x			x		(V)[4]	x	x				x			(V)[4]	x			x	
Door is closed via driver's push-button	x		π		x	(V)[1] [7]	x	x	x[9]	π	π[15]	x			(V)[17]	x[7]	x[7]	x		
Additional signals from the external reversing facility while closing				x					π[9]				π	π[8]					π[9]	
Door is openned via driver's push-button	x			x		(V)[1] [7]	x	x		p		x	π		(V)[17]	x		x		
Additional signals during powerless circuit while opening		π		x	x											ππ				
Mode Programming	**Mode 0 :** Preventing the reversing facility being copied by means of a bridge in the 25-pole plug from HB (PIN 12) to the mode input port (PIN 25). Required since 1/7/90 as per decree by Federal Ministry of Transport. **Mode 2 :** By way of a bridge from ST (PIN 19) to the mode inpurt port (e.g. PIN 13), the driver's push-button the door closing warning system is activated prior to the closing pulse.																			

ETS PIN Designation	+ UB	STILL	ZU	DSA	DSZ	Weg-R	Upot	HBAB	SPIN	FAT	R-ZU	HB	AUF	REVES	Weg-L	ST	RT/GN	FPU	ZUN
ETS PIN Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**15**	**16**	**18**	**19**	**20**	**22**	**23**
Functions																			
Door closed under pressure, ignition on	x				x	(V)[1]	x[10]	x[11]							(V)[1]		x	x[12]	
Door open under pressure, ignition on, no automatic closing, only if baby buggy request applies PIN 4 (KWFA) 15-pole ”ETS automatic plug”	x			x		(V)[4]	x	x				x			(V)[4]	x			x
Door closes automatically after setting of the baby buggy delete button PIN 5 (KWFA) 15-pole ”ETS automatic plug”	x		π		x	(V)[17]	x	x	x[9]		π	x[6]	π		(V)[17]	x[7]	x[7]	x	
Open door via request stop PIN 6 (HW) 15-pole ”ETS automatic plug”	x			x		(V)[17]	x	x				x	π		(V)[17]	x		x	
Door closes automatically after the time for keeping the door open has expired	x				x	(V)[17]	x	x	x[9]		π	x[6]			(V)[17]	x[7]	x[7]	x	

ETS Door II/III (with extended automatic function) ECU Number 446 020 007 0
010 0
013 0

ETS PIN Designation	FGA	WH	WH	KW	KWFA	HW	AKF	FG	FGL
ETS PIN Number	**1**	**2**	**3**	**4**	**5**	**6**	**9**	**13**	**14**
Automatic functions (15-pole plug)									
Door closed under pressure, notification request stop (6)		x	x			π	x	x	x
Release (13), door opens if FPU (PIN 22 = 1 Signal)	x[14]							x	x
After the time for keeping the door open has expired it closes automatically.	TSW (PIN 11, 25-pole plug) is pulsed 3 times prior to closing.								
Door remains closed under pressure, notification baby buggy request KW (4)		x	x	π		π[19]	x		x
Release (13), door opens and remains open.	x						x	x	x
Delete baby buggy request KWFA (5), door closes.					π				x
	TSW (PIN 11, 25-pole plug) is pulsed 3 times prior to closing.								

Legend

(V) = check voltage by means of multimeter
X = LED on
π = pulse (approx. 250 ms)
ππ = driver's push-button is flashing ST (PIN 19)
TSW = door close warning system active TSW (PIN 11) pulses 3 x before solenoid door CLOSE (PIN 3) is actuated

1. Sensor voltage when door closed approx. 1 volt ± 0.3 volt (LED 6 and 18 have not been assigned)

2. At door I if one door wing has been inhibited SPIN (PIN 9) 1 signal

3. At door I if ignition on 1 signal

4. Sensor voltage when door is open 9.65 - 14,5 volt. The voltage depends on the swing angle.

5. If individual wing control, pulse to R-ZU (PIN 11) and R-AUF (PIN 24) if SPIN (PIN 9) carries 0 signal.

6. After door close, HB (PIN 12) turns into 0 signal if HBAB (PIN 8) carries 1 signal.

7. After door close, ST (PIN 19) turns into 0 signal and RT/GN (PIN20) into 1 signal.

8. Pulse or 1 signal to REVES (PIN 16) reverses the door to opening (only effective while closing).

9. Pulse or 1 signal to REVLS (PIN 9) or to REVEZT (PIN 23) reverses the door to opening (only effective while closing). REVLS (PIN 9) can turn into 1 signal again while door is closed (light beam reflected by mirror).

10. Voltage approx. 15 volt (reference voltage)

11. HBAB (PIN 8) receives its power via the accelerator pedal or from ignition on (line 166) and must carry a 1 signal while the door is closed, otherwise HB (PIN 12) does not fall.

12. FPU (PIN 22) is connected to a 3 k.p.h. generator. If connected to stop switch, FPU turns into 0 signal while vehicle is in motion.

13. When the door wings reach their end position, the relay for self-hold is switched off via HB (PIN 12) and the ECU is dead again.

14. Reset to 0 signal is achieved automatically or when FGL (PIN 14) is connected to ignition on (line 166). If FGA (PIN 1, 15-pole plug) is not reset, the door will not close.

15. If ST (PIN 19) is connected to a mode input port, TSW (PIN 11) is pulsed three times after FAT signal.

16. KW (PIN 4) is usually connected to HW (PIN 6) with one diode to prevent KW notification of request stop being notified once again.

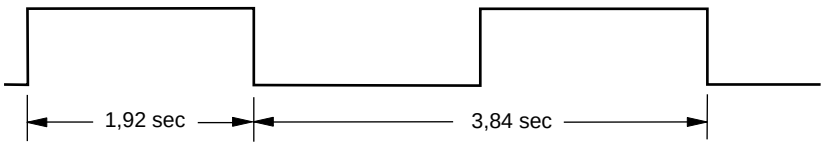
17. Sensor voltage changes depending of the direction of the door.

18. After the time for keeping the door open has expired, output port TSW (PIN 11) is pulsed 3 times (optional for buzzer). Only then will the pulse door operating valve CLOSE (PIN 3) be given.

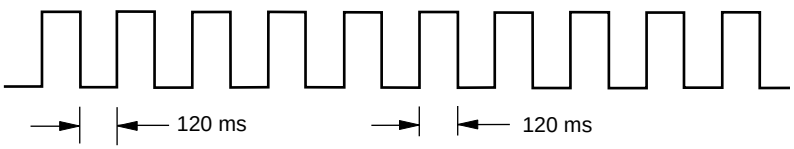
19. For notification of baby buggy request KW (PIN 4), the stop request HW (PIN 6) can also be actuated via a diode to prevent the stop request being notified once again.

6.4 ETS Flash Code

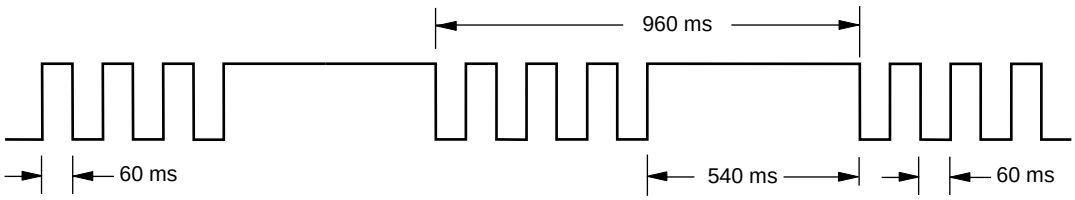
Normal Function
Display via ETS malfunction indicator lamp only



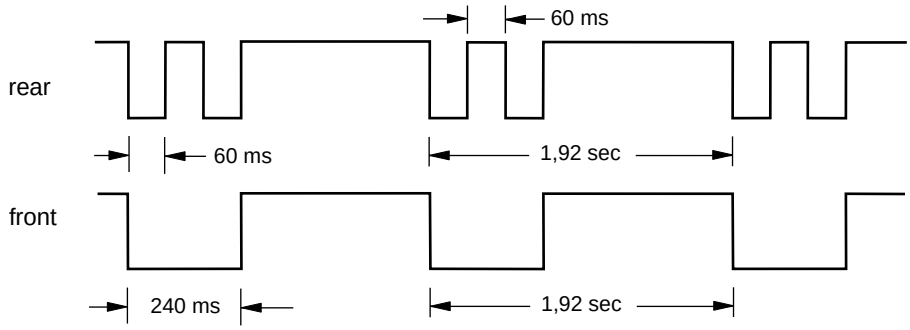
Short Circuit Indication
via ETS malfunction indicator lamp only



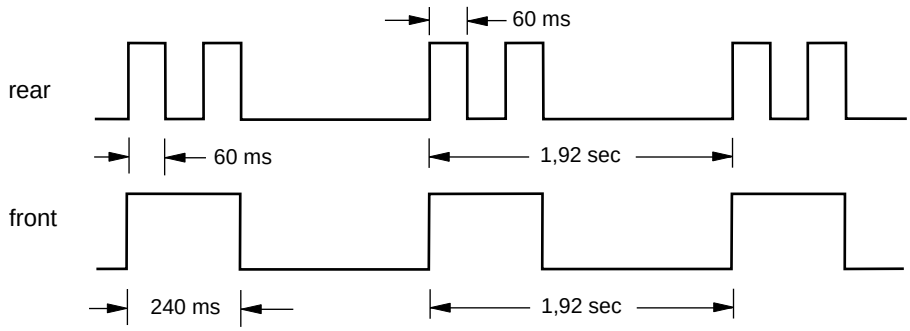
Pressureless Indicator
via driver's push-button only



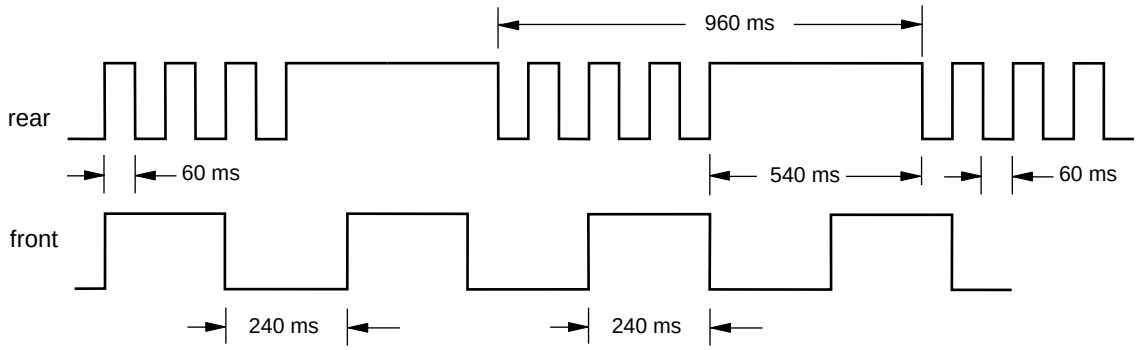
Sensor defect, maximum values (MAXFEL - H/ MAXFEL - V)
display via driver's push-button and ETS malfunction indicator lamp



Sensor defect, minimum values (MINFEL - H/ MINFEL - V)
display via driver's push-button and ETS malfunction indicator lamp



Sensor defect, intermediate values (FELRE/ FELIN)
information via ETS malfunction indicator lamp only

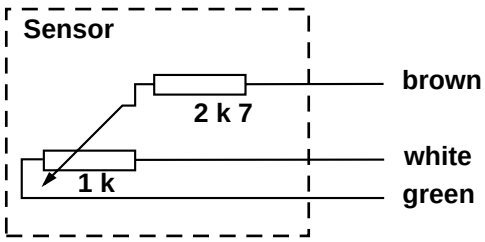


7. Operating Information for the Workshop

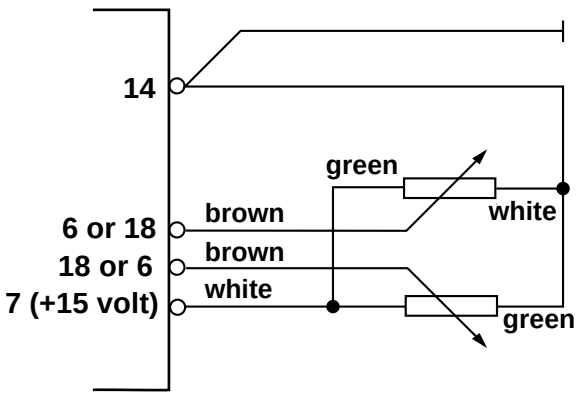
General:

The sensors for ETS are located in the socket joints usually found between the bracket and the door leaf. There is one sensor per door wing. These sensors are special potentiometers integrated in the socket joints. They receive a continuous voltage of 15 volt from the ECU. The respective voltage readings at the sliding member are evaluted by the ECU.

Sensor, internal circuit



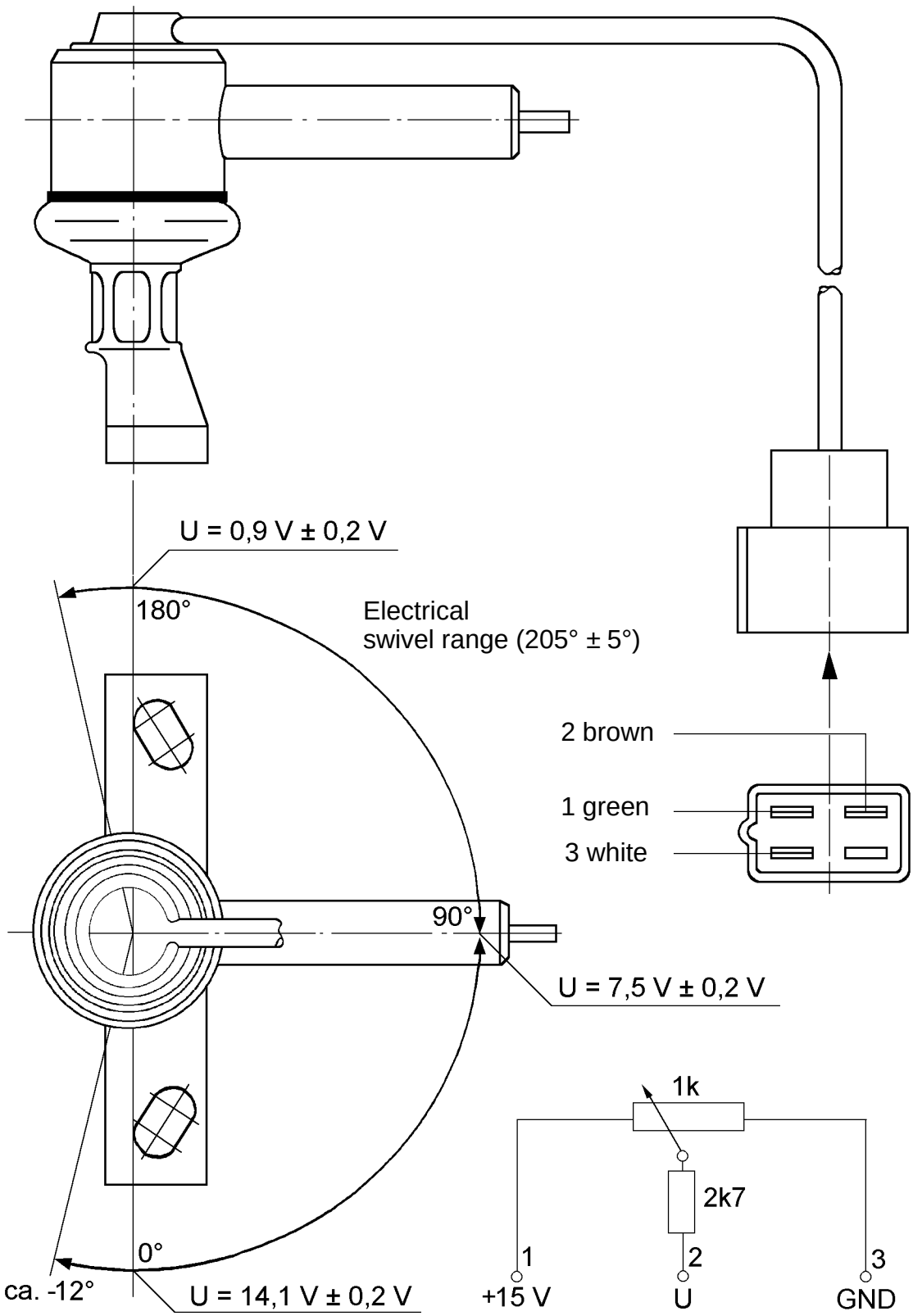
Connection to ECU



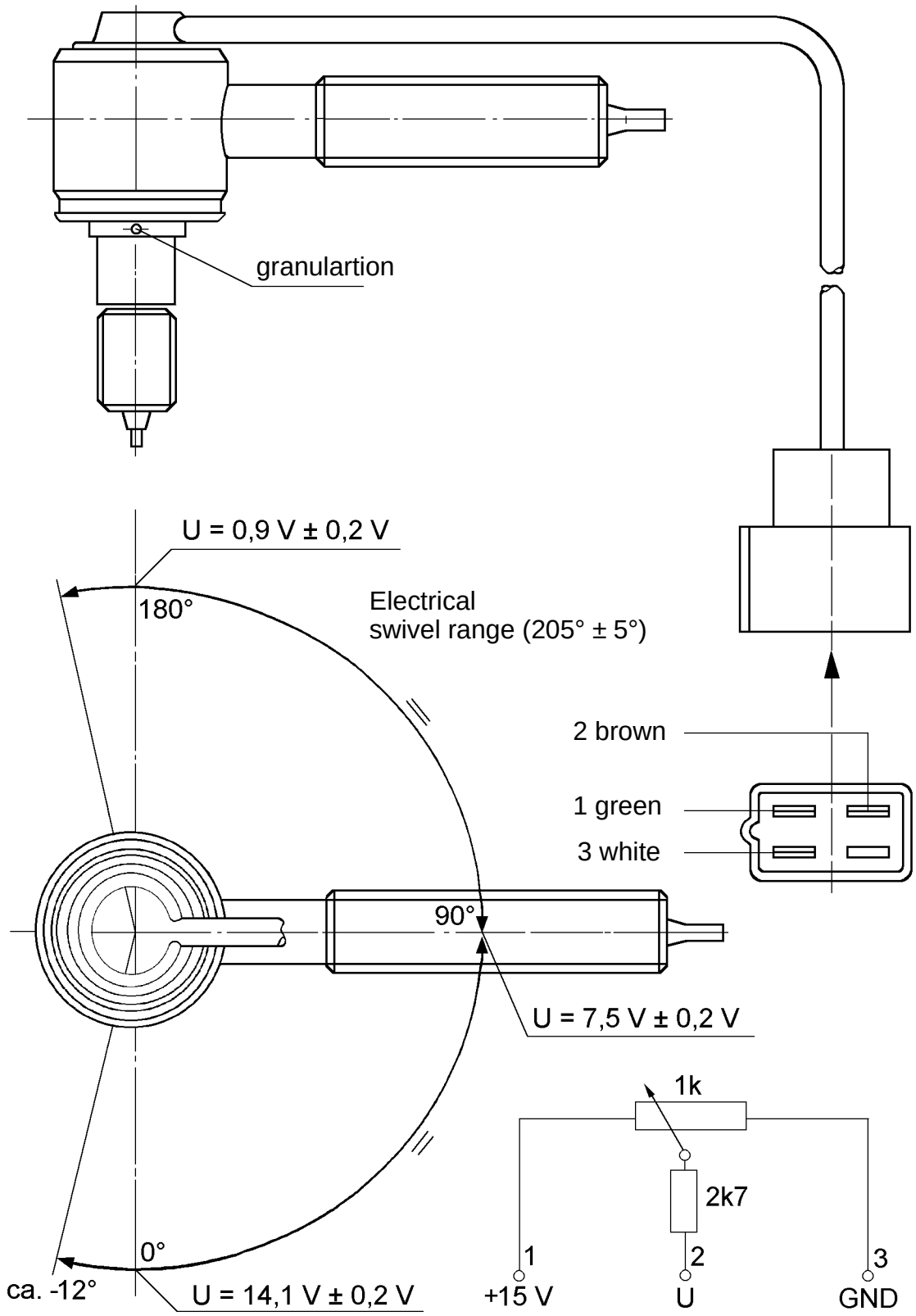
Sensor Adjustment:

1. The sensor to be checked or adjusted has a voltmeter connected as follows:
   - Voltmeter negative to vehicle earth.
   - Voltmeter positive to the brown cable of the sensor or to PIN 6 (front door wing) or PIN 18 (rear door wing) of the 25-pole ECU plug.
2. When the vehicle door is closed by the supply pressure, the voltmeter should now show approx. 1.0 ± 0.3 volt (when ”ignition on”).
3. If this is not the case, the door operating system must be evacuated via the emergency cock, and the door pulled shut manually.
4. The sensors can now, after the nut of the ball pivot has been released, be adjusted by turning the ball pivot until the reference value for the sensor voltage has been reached. Then the nut is tightened again. It is important that the sensor voltage remains within the tolerance band while the nut is being tightened.
5. When the door is being moved towards its open position, the sensor voltage should rise and be at least 9.65 volt when the door is fully open.
6. After both sensors (on doors with two wings) have been adjusted, the emergency cock is moved to its operating condition once again. This causes the door control system to be made ‘powerless’, i.e. the full supply pressure acts on both sides of the door cylinders. As an ‘excess force’ is acting in the opening direction - due to the difference in piston surfaces - a door which moves easily will open slowly.
7. When the driver’s push-button is then actuated, the door must close. The sensor voltages must be measured again while the doors are closed under pressure. The adjustment is then repeated as necessary.

ETS Sensor for Inside Hinged Door



ETS Sensor for Outside Hinged Door



WABCO's Recommendation for Doors with Linear Drive

If the vehicle's doors have a linear drive, WABCO recommends that the speed for opening and closing the doors is adjusted by means of non-adjustable throttles in the pneumatic ports of the door operating cylinders:
The throttles should always have a diameter of 1.3 mm. One exception is the door cylinder of the front wing of a door where a throttle of 1.2 mm should be fitted on the opening side. As this function causes the air being which is evacuated to be throttled, an adjustable throttle with a check valve can also be used.

ETS with Extended Emergency Cock Logic

Because of more stringent requirements, including legislation (Guideline for Section 35e, Subsection 6.3), this function has been integrated in the ETS ECU. These requirements essentially apply to the abuse of the emergency cock on power door systems, because if the emergency cock is wrongfully actuated while the vehicle is in motion, the door cylinders are evacuated, and the door wings could be moved freely. Even external factors such as relative wind etc. could now open the door.

Its technical implementation is described below:

Display of emergency cock actuation on the 2nd and 3rd doors
If the emergency cock is actuated, a buzzer will sound. The buzzer signal is switched off when:

- the emergency cock is returned to its normal position;
- all door wings are closed;
- the closing chambers of the door operating cylinders are fully pressurized.

Unlike previous circuit types, this means that the driver will be made aware of a door which is open or pressureless until it is closed again under pressure.

Actively holding the 2nd and 3rd doors closed after actuation of emergency cock followed by immediate return to its original position
This function becomes active when the emergency cock has been actuated and then immediately returned to its normal position. Another requirement for this is that the door leaves have not moved:
When the emergency cock has been actuated, the ETS ECU actuates the door operating valve by clock pulses on the door-closing solenoid of the ETS door actuating valve for a maximum period of 2 minutes. Immediately after the emergency cock has been returned to its original position, one of these pulses then becomes effective. The door is then again in its closed position while under pressure.

Special Closing Functions

If, after the emergency cock has been actuated, the door leaves are no longer in their closed position, a special closing function closes the door again. As the first door is in the immediate field of vision of the driver, allowing him to keep an eye on it at all times, the buzzer of the emergency cock for that door is not actuated via the ETS ECU but via a switch on the emergency cock, as before.

Deliberately closing a door without automatic function:
While the vehicle is in motion, the driver can also close the door by pushing the appropriate push-button.

Deliberately closing a door with automatic function:
When the vehicle is stationary and the time set for keeping the door open (standard setting approx. 3 seconds), the door closes automatically. All monitoring features are switched on.
If the vehicle is in motion, the door is closed automatically after approx. 1.5 seconds. Only the pressure transducer (sensitive edge) is switched on.

Modifications when Replacing ETS ECUs

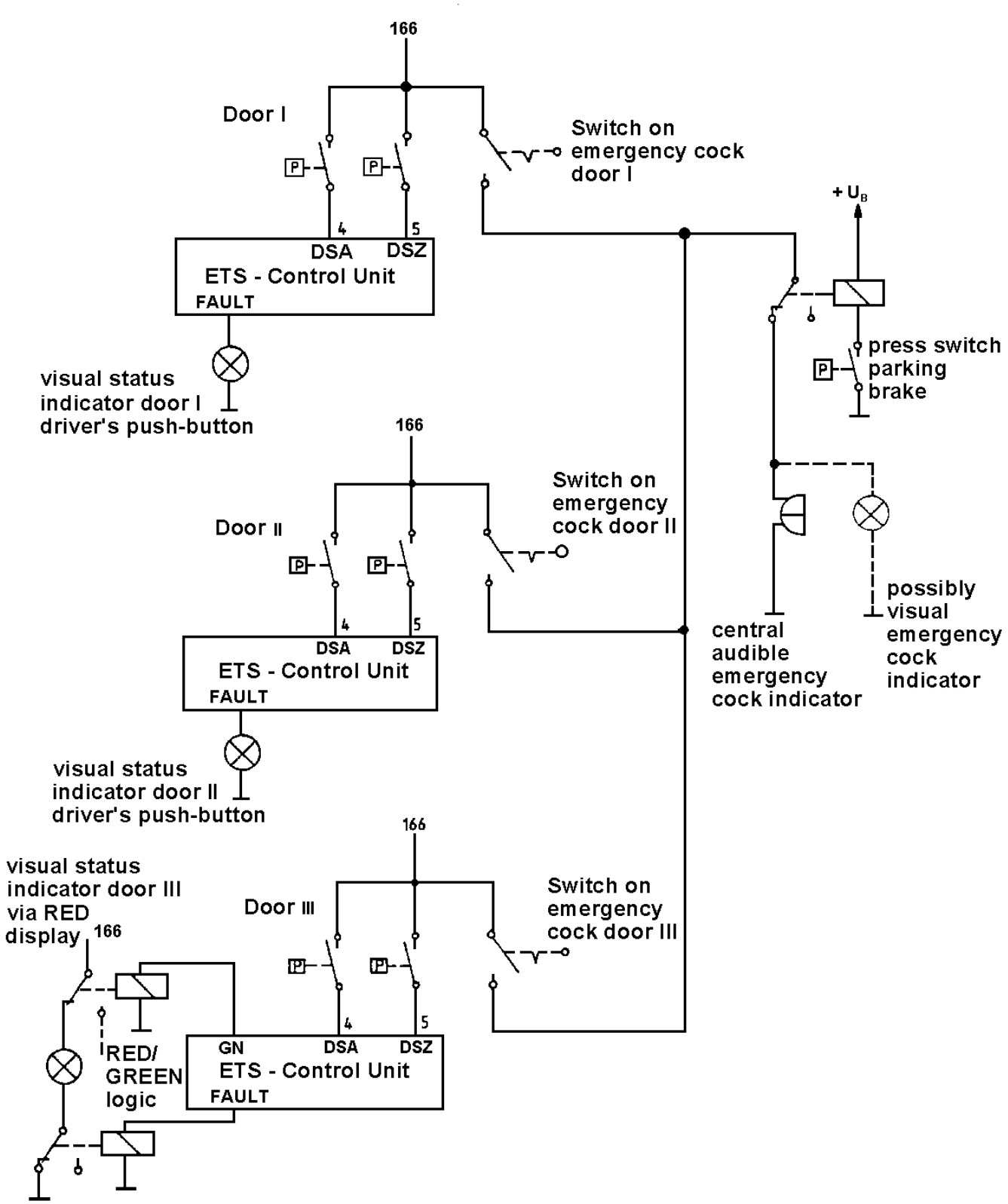
When replacing an ECU 446 020 009/010 0 by an ECU 446 020 012/013 0, the special closing functions continue to be available without any technical modifications being necessary.

However, when replacing ECUs as described above, the extended emergency cock logic must be made operational by making the following technical changes:

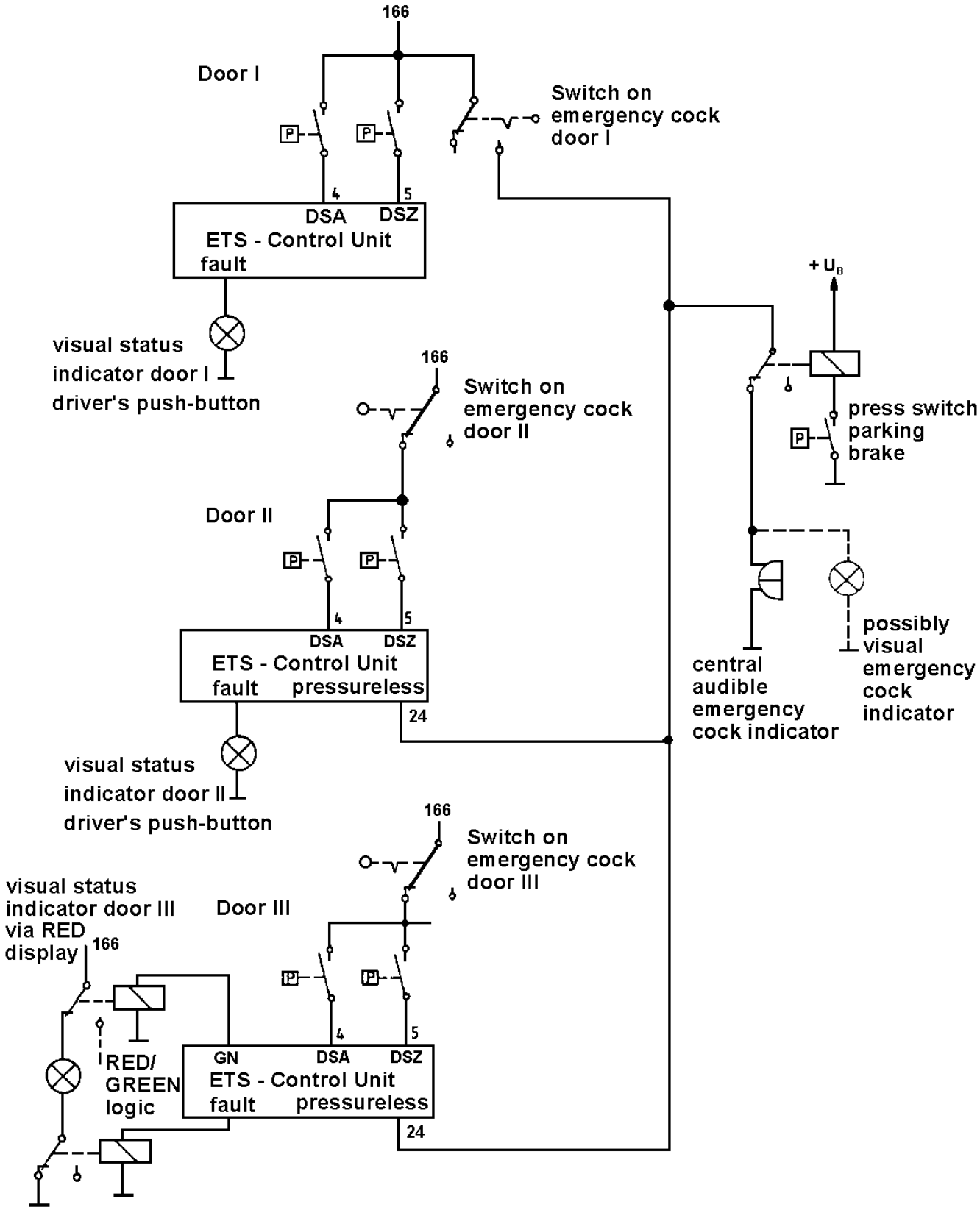
- The buzzer must be connected to PIN 24 of the ETS ECU.
- The power supply for the press switches is provided by a switch attached to the emergency cock. This receives its power supply via terminal 15.

PLEASE NOTE: In the new version, the switch on the emergency cock has an opening function, in the old version it has a closing function. For this reason it needs to be replaced!

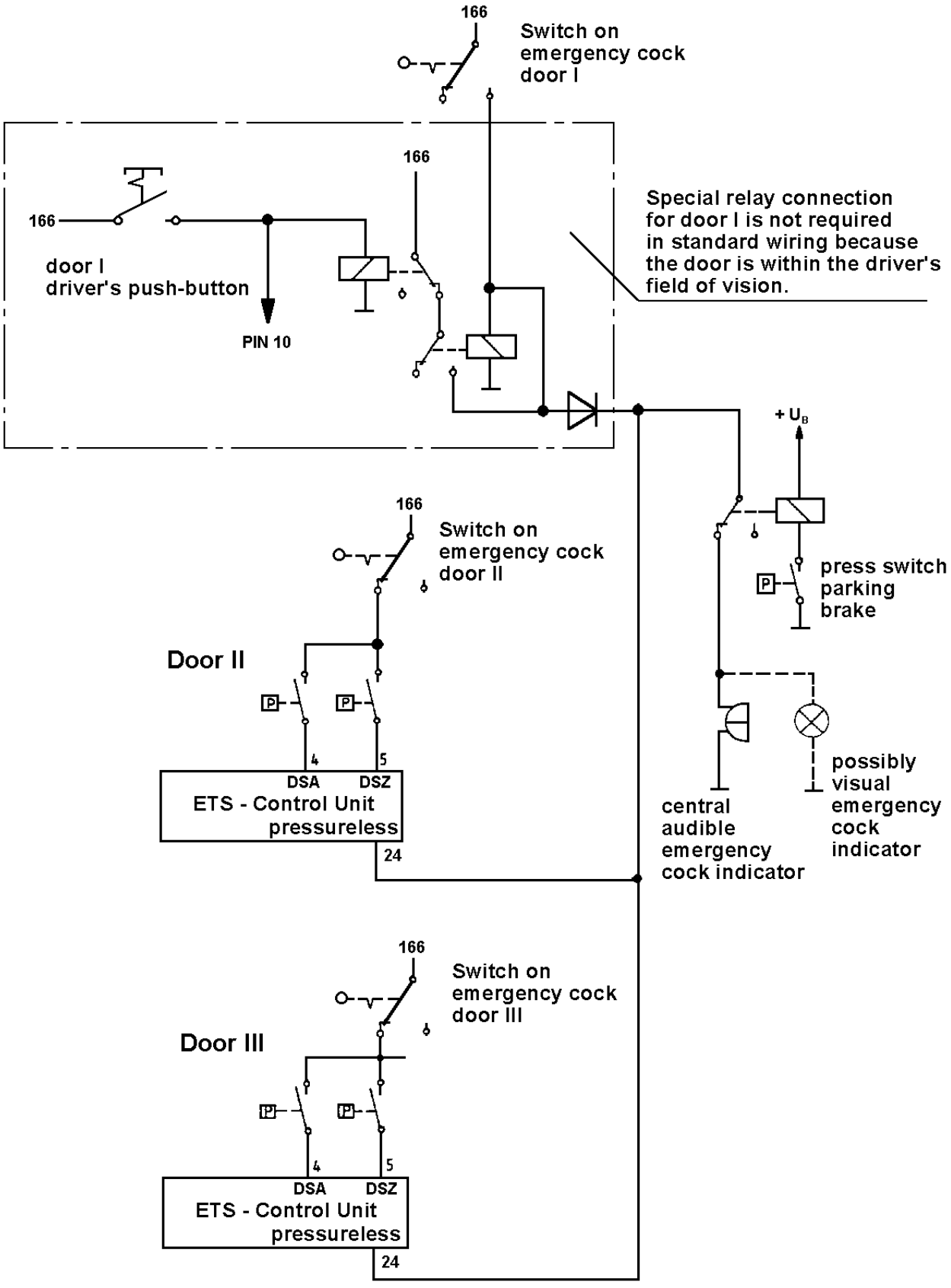
Wiring for Audible Emergency Cock Using ETS ECUs 446 020 009/010 0. (old series)



Wiring for Extended Audible Emergency Cock with ETS ECUs 446 020 012/013 0.



Typical Wiring for Extended Audible Emergency Cock with Additional Connections for Door I



ETS ECUs 446 020 012 0 / 013 0 for Linear Drive, only Door II or III with Extended Emergency Cock Logic