ES4550.1 Loadbox Emulation Board
User's Guide

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Contents

1 Introduction

This section contains information about the basic features and applications of the ES4550.1 Loadbox Emulation Board.

Before the initial operation of the ES4550.1 Loadbox Emulation Board please observe the following safety instructions:

Warning

Please do not touch any contacts and plugs on the printed circuit board during operation !
When operating the ES4550.1 Loadbox Emulation Board with the Piezo piggyback PB4550PCR **together with a Piezo-ECU, high and dangerous voltages - up to 200V - can be present** *on circuits and contacts of the printed circuit boards on both - the ES4550 Carrier Board and the Piezo piggyback PB4550PCR! This may cause*
- dangerous current flowing through the body, when getting in direct contact;
- irritation of nerves and muscles and
- danger for persons with "cardiac pacemaker", because of magnetic fields
The dangerous voltage is also present in case the ES4550 with Piezo piggyback PB4550PCR itself is switched-off, but the Piezo ECU is connected and operating.

Make sure, the ES4550 Boards with the Piezo piggyback PB4550PCR are protected against touching the boards during operation of the system.
All front planes are mounted, no open slot present!

Do not touch the contacts of the ECU plug at the ES4550 Board immediately after unplugging the connection to the ECU*, because the dangerous voltages are present at the plug for up to 5 seconds.*

Shut down and switch off the system before removing any front planes or exchanging any boards.

It is not allowed for persons with cardiac pacemaker to stay close *to the LABCAR system, when the system is operated with Piezo systems (ES4550 +PB4550PCR) and Piezo ECUs, because the high voltages with varying loads causing magnetic fields, which can disturb the function of a cardiac pacemaker.*

The ES4550.1 Loadbox Emulation Board has to be signed with the symbol for dangerous voltage. The whole laboratory system has to be signed with a safety labeling "Prohibition for persons with cardiac pacemaker" in case the system is operated with Piezo systems.

1.1   Features

The ES4550.1 Loadbox Emulation Board has the following features:

- flexible and configurable simulation of injector loads
- emulation of all standard load types: gasoline direct injection (GDI), common rail and piezo actuators
- simple connection of customized original loads
- measuring of current and voltage of up to 12 ECU channels
- flexible internal grouping of loads as groups or banks
- battery nodes of the backplane fuse-protected
- fuse control with LED display
- temperature monitoring and automatic emergency shutdown
- LEDs and speaker to display the load status
- optional processor module for system control (ES4060)
- lowpass filter (5 kHz) which can be deactivated for measuring signals (only with processor module)

Fig. 1-1 on page 8 shows the front panel of the ES4550.1 Loadbox Emulation Board with

- connectors for the ECU ("ECU") and external loads ("ext. LOAD"),
- two potentiometers for setting the reference voltage ("Threshold upper", "Threshold lower") (see section 4.5 on page 72),
- a speaker for acoustic display and the switch for the speaker (see section 4.3 on page 71) and
- a field of LEDs for visualizing the configuration or the status of the ES4550.1 (see section 4.2 on page 70).

1.2 Applications

The ES4550.1 Loadbox Emulation Board is used to simulate loads (e.g. fuel injection systems). This enables LABCAR to simulate, for example, the operating characteristics of actuators of standard engines. The ES4550.1 Loadbox Emulation Board makes it possible to simulate a real engine with precise electrical responses and with the features resulting from the grouping of the loads.

The different load types are realized by implementing a piggyback concept in which different piggybacks are mounted on a universal board depending on the load type to be simulated. It is also possible to simulate other load types, e.g. for driving dynamics applications, using project-specific piggybacks.

The following load types can be simulated in the injection system sector:

- common rail
- gasoline direct injection (GDI)
- piezo actuators
- original loads used by the customer
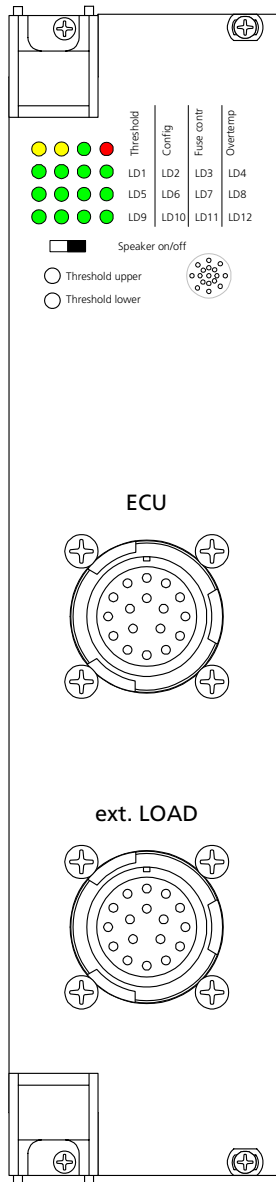
Fig. 1-1   Front Panel of the ES4550.1 Loadbox Emulation Board

2 Hardware Features

The ES4550.1 has a flexible design and can therefore be used for lots of different kinds of load emulations. The load emulations themselves are on specific piggybacks which can be screwed to the main board. The ES4550.1 is thus a board which is perfectly designed for project-specific applications.

The main board connects the load emulations on the piggybacks with the front-facing connectors. There are various configuration possibilities thanks to a bridge area which can be used by the user to arrange loads and battery voltages as required (see the section "Load Modules" on page 10 and the chapter "Load Modules - Types and Configuration" on page 35).

Voltage and current measuring signals generated by the piggybacks are also conditioned on the main board and routed to reserved backplane channels (see the section "Measuring Signals" on page 19).

The measuring signals are visualized via the LEDs on the front panel and conditioned acoustically so that any irregularities of periodic signals can easily be detected (see the section "Optical and Acoustic Evaluation of the Measuring Signals" on page 23).

The ES4550.1 can also be equipped with an ES4060.1 processor module if required which provides further options during measuring signal conditioning and enables automatic querying of the configuration and ES4550.1 status (see the section "Processor Module" on page 28).

The temperature of the piggybacks is monitored by the main board (see the section "Overtemperature Protection" on page 31).

Fuses protect the battery voltages against overcurrent on the main board (see the section "Fuses" on page 32).

2.1 Load Modules

This section contains general information on the mechanical and electrical features of the load modules. Please refer to the chapter "Load Modules - Types and Configuration" on page 35 for a description of the types available, assembly and configuration.

Different piggybacks are available for the ES4550.1 for load types which are required frequently. Load emulations can also be set up on normal prototyping boards. The PB4550OL.1 piggyback is designed to measure the voltage and current signals of loads; the loads are not on the ES4550.1 but are contacted via the front-facing connector "EXT. LOAD". This makes it possible, for example, to connect original loads.

There can be up to three loads on any one load piggyback as high-current and measuring-signal connectors are available in that number. Every piggyback also has an output for temperature monitoring and a 12-bit ID. Fig. 2-1 shows a piggyback with two loads.
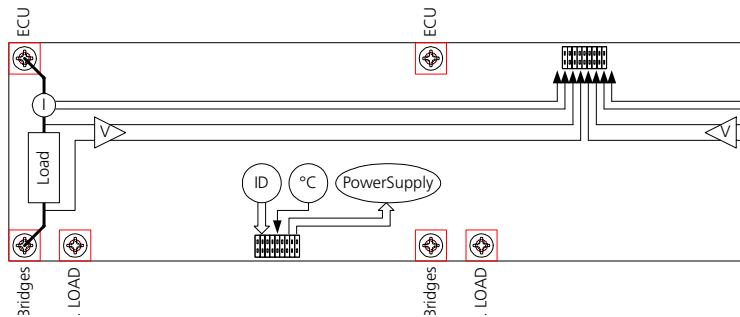
Fig. 2-1   Structure of the Piggybacks

2.1.1 Mechanical Structure of Load Piggybacks

Two different types of piggyback are supported by the ES4550.1. Fig. 2-2 and Fig. 2-3 show the dimensions and the positions of the connectors of these two types.
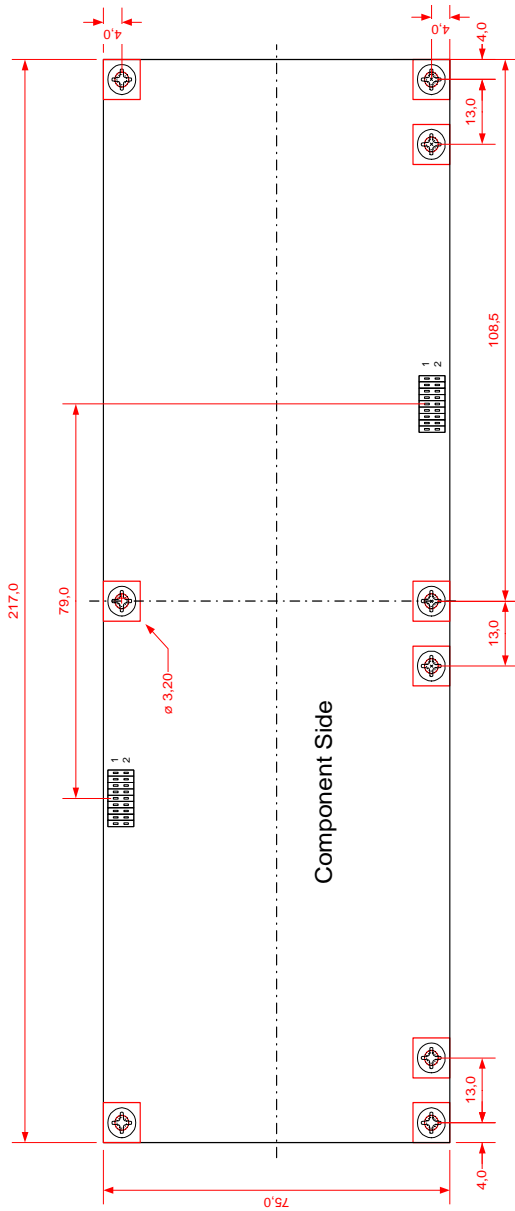
Fig. 2-2   Dimensions of a Large Piggyback

Fig. 2-3   Dimensions of a Small Piggyback

2.1.2 Piggyback Connectors

The piggybacks are attached to the ES4550.1 using spacing bolts. The component sides of the ES4550.1 and the piggybacks face each other. The maximum nine spacing bolts also form the electrical 20 A connection to the piggybacks. The measuring signals are routed to the ES4550.1 via two flat band cables (CON1 and CON2 in Fig. 2-4).
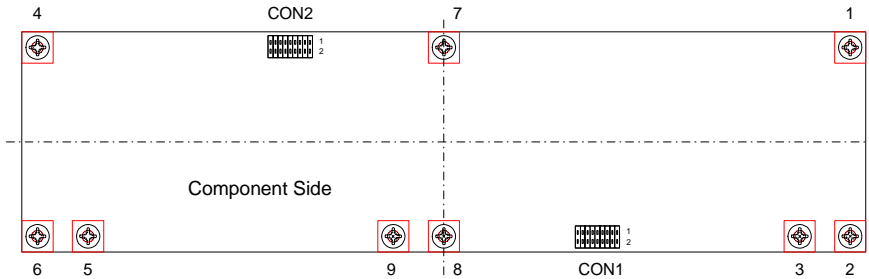
Fig. 2-4   Connectors and Bolts

High-Current Spacing Bolts

The load piggybacks are connected to the ES4550.1 using brass spacing bolts for high currents to 20 A. The spacing bolts have a dual purpose of both establishing the connection and attaching the piggybacks to the ES4550.1.

Bolt	Name	Meaning
1	ECU 1	ECU connector, first load
2	EXT. LOAD 1	EXT. LOAD connector, first load
3	JP 1	Bridge area connector, first load
4	ECU 2	ECU connector, second load
5	EXT. LOAD 2	EXT. LOAD connector, second load
6	JP 2	Bridge area connector, second load
7	ECU 3	ECU connector, third load
8	EXT. LOAD 3	EXT. LOAD connector, third load
9	JP 3	Bridge area connector, third load

Tab. 2-1   High-Current Spacing Bolts

Low-Current Connectors

The low-current signals are routed to the main board of the ES4550.1 via ribbon cable. Every load module requires two 26-pin flat band cable connections.

Part	Manufacturer	Order Number
Flat band cable	Samtec	FFSD-13-D-04-01-N
Board connector	Samtec	FTSH-113-01-F-DV-K

Tab. 2-2　　Low-Current Connectors

CON1 Connector

Pin	Name	Meaning
1	U_P0	Voltage load 0, negative output
2	U_N0	Voltage load 0, positive output
3	I_P0	Current load 0, negative output
4	I_N0	Current load 0, positive output
5	U_P1	Voltage load 1, negative output
6	U_N1	Voltage load 1, positive output
7	I_P1	Current load 1, negative output
8	I_N1	Current load 1, positive output
9	U_P2	Voltage load 2, negative output
10	U_N2	Voltage load 2, positive output
11	I_P2	Current load 2, negative output
12	I_N2	Current load 2, positive output
13 .. 26	NC	Not assigned

Tab. 2-3　　CON1 Connector

CON2 Connector

Pin	Name	Meaning
1, 3, 5	+5V	Supply voltage +5 V
2, 4, 6	+15V	Supply voltage +15 V
7	NC	Not assigned
8	T	Temperature signal
9	ID0	ID bit 0
10	ID1	ID bit 1
11	ID2	ID bit 2
12	ID3	ID bit 3
13	ID4	ID bit 4
14	ID5	ID bit 5
15	ID6	ID bit 6
16	ID7	ID bit 7
17	ID8	ID bit 8
18	ID9	ID bit 9
19	ID10	ID bit 10
20	ID11	ID bit 11
21, 23, 25	-15V	Supply voltage -15 V
22, 24, 26	GND	Ground

Tab. 2-4   CON2 Connector

2.1.3 Measuring Signals of the Piggybacks

The ES4550.1 supports three differential voltage and three differential current measuring signals as well as a temperature signal for every piggyback.

Current Measuring

The current measurement input of the ES4550.1 is differential which makes it possible to correct offset voltages of current measurement, which can occur, for example, with current converters. The measuring signal can be amplified using the piggyback's output resistor.
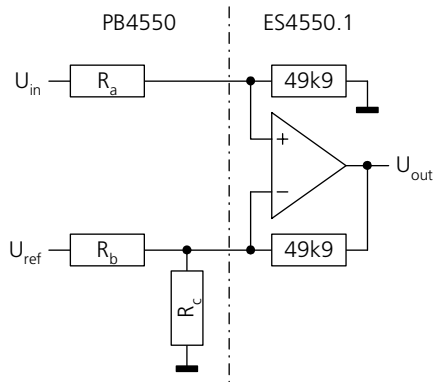
Fig. 2-5   Current Measuring Signals

The following have to be taken into consideration in terms of current, voltage and temperature measuring when developing customer-specific piggybacks:

The input and output voltages have to be determined before the resistors can be dimensioned. The amplification and resistance values can then be calculated.

Abbreviations	Meaning
Uin	Input voltage, wanted signal
UinO	Input voltage, offset
Uref	Reference voltage
Uout	Output voltage, wanted signal
UoutO	Output voltage, offset
A	Amplification
T	Voltage divider ratio

Tab. 2-5   Current Measuring Signal

The resistance values are calculated from the formulae listed in Tab. 2-6. If T is 1, R_C is superfluous.

Calculation of the Resistance Values
A = Uout / Uin
T = (UinO - UoutO / A) / Uref
Ra = 49.9 kΩ / A
Rb = Ra / T
Rc = Ra / (1 - T)

Tab. 2-6   Current Measuring Signal

Voltage Measuring

Differential inputs are available to measure voltage via the loads.

Variable	Value
Common mode voltage	-200 V .. +200 V
Differential mode voltage	-10 V .. +10 V
Input resistance of the ES4550.1	380 kΩ

Tab. 2-7   Voltage Measuring Signal

Temperature Measuring

An LM35 manufactured by National Semiconductor is used to measure temperature. This component returns a voltage proportional to the temperature.

Technical Data	
Voltage	10 mV / °C
Temperature range	0 °C .. +100 °C
Input resistance of the ES4550.1	10 kΩ

Tab. 2-8   Temperature Measuring

2.1.4   Supply Voltages and Identification of the Piggybacks

Supply Voltages

The ES4550.1 makes three supply voltages and ground available to the piggybacks so that measuring signals can be matched on the piggyback.

Supply Voltage	Current Rating
+5 V	50 mA
+15 V	20 mA
-15 V	20 mA
Ground	

Tab. 2-9   Supply Voltages

Identification

Every piggyback has 12 connectors which make it possible to identify the piggyback. This identification number can be read when an ES4060.1 processor module is assembled. The ID number cannot be read if there is no processor module.

Electrical State	Meaning
Open	0
Connection to +5 V	1

Tab. 2-10   Identification

2.2   Measuring Signals

The ES4550.1 supports the measuring of voltages across and currents through the loads. Currents and voltages are measured on load piggybacks. These are described in chapter 3 on page 35.

2.2.1   Areas of the Backplane Channels

28 channels are reserved for voltage measuring signals and 28 for current measuring signals on the ES4500.1 backplane. This is sufficient to support the measuring signals of two ES4550.1.

The backplane area to be accessed by the board has to be configured on the ES4550.1 using the multiple jumpers JP8001 and JP8002. The configuration of the jumpers is shown on the front panel by the yellow "Config" LED. The default state is the configuration to the lower area.

The configuration can be read by software when the optional ES4060.1 processor module is assembled.

Fig. 2-6 shows the configuration of JP8001 and JP8002 to the lower area of backplane channels (default setting) on the left. The configuration to the upper area of the backplane channels is shown on the right.
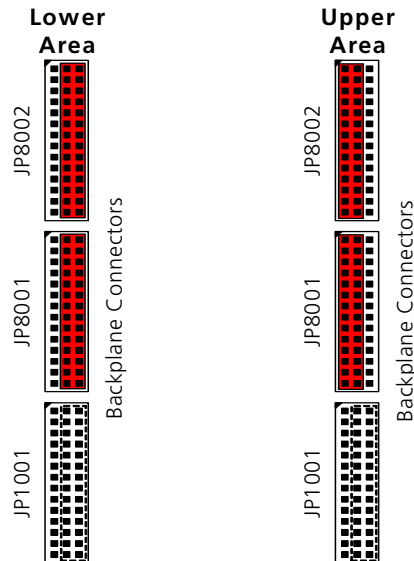
Fig. 2-6   Configuration of the Jumpers for the Measure Channels

Tab. 2-11 shows which backplane channels the measuring signals of the individual loads are routed to in the configuration to the lower or upper area.

Load	Current, Lower Area	Voltage, Lower Area	Current, Upper Area	Voltage, Upper Area
1	107	254	121	268
2	108	255	122	269
3	109	256	123	270
4	110	257	124	271
5	111	258	125	272
6	112	259	126	273
7	113	260	127	274
8	114	261	128	275
9	115	262	129	276
10	116	263	130	277
11	117	264	131	278
12	118	265	132	279

Tab. 2-11   Assignment of the Loads to the Measure Channels

The assignment of load numbers to the front-facing pins differs depending on whether the piggyback is large or small. For more details, please refer to the configuration tables Tab. 3-18 on page 55, Tab. 3-21 on page 57, Tab. 3-24 on page 60, and Tab. 3-27 on page 63.

2.2.2   Load Voltages

The voltage via the load is measured differentially. The attenuation of the signal takes place on the piggyback so that the piggyback types can be matched with various voltage ranges. The signals is routed to the backplane via a multiplexer, an output protective circuit and the configuration of the channel areas.

After the multiplexer, the signals are routed to comparators, whose output signal is used for optical and acoustic evaluation.

A filter with a 5 kHz cutoff frequency can also be connected using the optional ES4060.1 processor module.
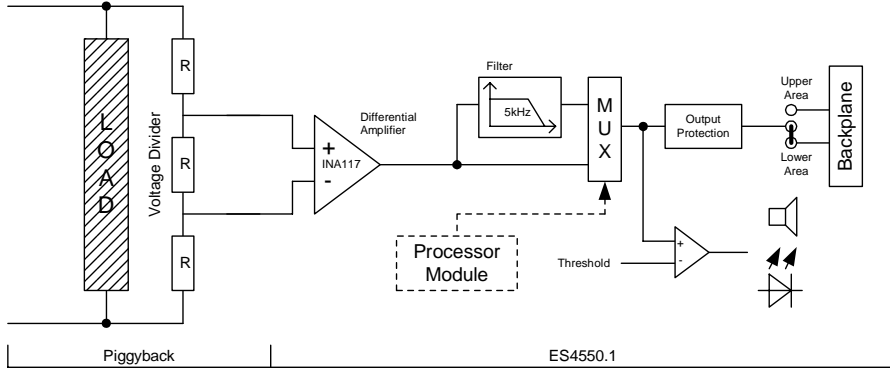
Fig. 2-7   Voltage Measuring

2.2.3   Load Currents

The measure input for ES4550.1 currents is differential. This means the offset voltage of the current converter offset can be adapted on the piggyback using a reference voltage. The amplification is set using the output resistor of the piggyback and can thus be set on the piggyback. The signal is routed to the backplane via a multiplexer, an output protective circuit and the configuration of the channel areas.

After the multiplexer, the signals are routed to comparators, whose output signal is used for optical and acoustic evaluation.

Offset compensation can be executed and a filter with a 5kHz cutoff frequency can also be connected using the optional ES4060.1 processor module.
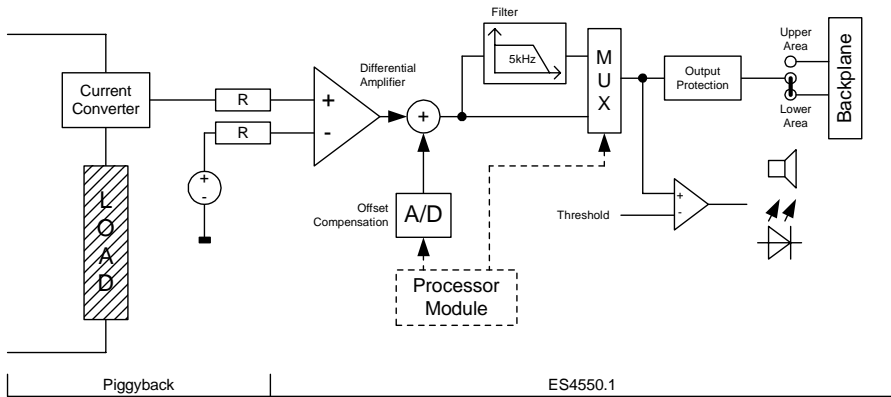
Fig. 2-8   Current Measuring

2.2.4   Output Protection

The output protection protects the measure outputs against short-circuits and overcurrent. The output current should always flow towards ground.

Variable	Value
Current	10 mA
Output voltage	-10 V .. +10 V
Dielectric strength	-60 V .. + 60 V

Tab. 2-12   Output Protection of the Measuring Signals

2.3 Optical and Acoustic Evaluation of the Measuring Signals

To detect irregularities in periodic signals as simply as possible, the measuring signals can be displayed optically and acoustically via the green LEDs "LD1" to "LD12" on the front panel. The LEDs "LD1" to "LD12" are assigned to loads 1 to 12. As soon as the current or alternatively the voltage of a load exceeds the settable thresholds, the relevant LED lights up. An impulse is transmitted to the speaker as soon as one of the LEDs lights up for acoustic evaluation.

2.3.1 Reference Voltages

There are two reference voltages on the ES4550.1: these are used as thresholds for the optical and acoustic evaluation. The two voltages are the upper ("Threshold upper") and lower ("Threshold lower") threshold of a comparator with hysteresis. As soon as a measure voltage exceeds the upper threshold, the relevant LED lights up on the front panel and does not go out until the voltage is below the level of the lower reference voltage.

The reference voltages are set with the two trimmer potentiometers in the top half of the front panel. The reference voltages can be set to values between -10 V and +10 V. The voltages refer to the voltage level of the measuring signals as they are measured on the backplane channels after the signal adaptation of the ES4550.1 .

If the upper reference voltage is set to a smaller value than the lower one, the yellow "Threshold" LED and the LEDs "LD1" to "LD12" light up.

The reference voltages can be set via the software with the optional ES4060.1 processor module.
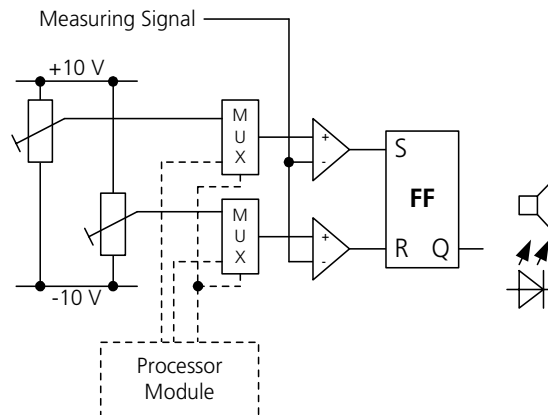
Fig. 2-9   Measuring Signal Processing

2.3.2 DIP Switch

The DIP switch specifies whether optical and acoustic evaluation refer to the voltage or current measuring signal.

The SW1001 DIP switch is at the bottom of the main board on the front. Fig. 2-10 shows the switch.
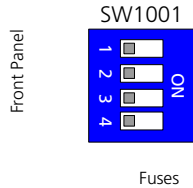
Fig. 2-10 SW1001 DIP Switch

Tab. 2-13 lists details of the individual switches.

Switch no.	Meaning	OFF	ON
1	Optical and acoustic evaluation	Current	Voltage
2	Not assigned	Not assigned	Not assigned
3	Not assigned	Not assigned	Not assigned
4	Not assigned	Not assigned	Not assigned

Tab. 2-13 Meaning of the DIP Switches

This setting can also be made via the software when the optional ES4060.1 processor module is used.

2.3.3 Front Panel Switch

The switch on the front panel is used to deactivate acoustic evaluation of the measuring signals when it is not required.

2.4 Control Signals to the Backplane

The ES4550.1 serves backplane signals which are required for controlling the ES4500.

These are:

- reset input (channel 19)
- reset output (channel 19) using the optional processor module
- system emergency shutdown input (channel 29)
- system emergency shutdown output (channel 29)
- battery voltage A emergency shutdown output (channel 45)
- battery voltage B emergency shutdown output (channel 52)

Reset Input (Channel 19)

The reset signal is low-active. The input has a pull-up resistance against +5 V. The input is protected against voltages on channel 19 between -60 V and +60 V.

The reset input can be deactivated with a CAN command using the optional ES4060.1 processor module. The ES4550.1 can then still initiate a reset of the component rack but cannot be reset itself. Once the supply voltage has been applied, the reset input is active.

Reset Output (Channel 19)

The reset output can only be addressed using the optional ES4060 processor module.

The reset can be initiated by the ES4550.1 with a CAN command. In this case, the ES4550.1 ensures that the reset signal is pending long enough even if the board itself is reset.

Once the supply voltage has been applied, the reset input is inactive.

The reset signal is low-active. The output is an open collector output which can drive -10 mA against ground (channel 1). The output is protected against voltages on channel 19 between -60 V and +60 V.

System Emergency Shutdown Input (Channel 29)

An active "system emergency shutdown" has the following effects on the ES4550.1:

- the "battery voltage A emergency shutdown" is active for the duration of the active "system emergency shutdown"

- the "battery voltage B emergency shutdown" is active for the duration of the active "system emergency shutdown"

The system emergency shutdown signal is low-active. The input has a pull-up resistance against +5 V. The input is protected against voltages on channel 29 between -60 V and +60 V.

System Emergency Shutdown Output (Channel 29)

A "system emergency shutdown" is activated when the following states of the ES4550.1 occur:

- the temperature on one of the load piggybacks exceeds the admissible limit
- when the optional ES4060.1 processor module is used, the system emergency shutdown can be activated via a CAN command

Once the supply voltage has been applied, the system emergency shutdown output is inactive.

The "system emergency shutdown" signal is low-active. The output is an open collector output which can drive -10 mA against ground. The output is protected against voltages on channel 29 between -60 V and +60 V.

A "system emergency shutdown" can be triggered by the ES4550.1 using a CAN command when the optional ES4060.1 processor module is used.

Battery Voltage A Emergency Shutdown Output (Channel 45)

A "battery voltage A emergency shutdown" is activated when the following states of the ES4550.1 occur:

- the temperature on one of the load piggybacks exceeds the admissible limit
- the "system emergency shutdown" is active
- when the optional ES4060.1 processor module is used, the "battery voltage A emergency shutdown" can be activated via a CAN command

Once the supply voltage has been applied, the "battery voltage A emergency shutdown" output is inactive if the emergency shutdown condition is not fulfilled.

The channel 45 output is an open collector output galvanically isolated from ground (channel 1) which in an active state switches channel 45 against stabilizer A ground (channel 50). The channel 45 open collector output is voltage-proof to +25 V against channel 50. The output can tolerate currents to -10 mA, but is not protected against an overcurrent.

The "battery voltage A emergency shutdown" output can be triggered by the ES4550.1 using a CAN command when the optional ES4060.1 processor module is used.

Battery Voltage B Emergency Shutdown Output (Channel 52)

A "battery voltage B emergency shutdown" is activated when the following states of the ES4550.1 occur:

- the JP1001 jumper is configured in such a way that the second battery voltage, +UBatt_B, is not used
- the temperature on one of the load piggybacks exceeds the admissible limit
- the "system emergency shutdown" is active
- when the optional ES4060.1 processor module is used, the "battery voltage B emergency shutdown" can be activated via a CAN command

Once the supply voltage has been applied, the "battery voltage B emergency shutdown" output is inactive if the emergency shutdown condition is not fulfilled.

The channel 52 output is an open collector output galvanically isolated from ground (channel 1) which in an active state switches channel 52 against stabilizer B ground (channel 57). The channel 52 open collector output is voltage-proof to +25 V against channel 57. The output can tolerate currents to -10 mA, but is not protected against an overcurrent.

The "battery voltage B emergency shutdown" output can be triggered by the ES4550.1 using a CAN command when the optional ES4060.1 processor module is used.

2.5 Processor Module

The ES4550.1 can also be equipped with an ES4060.1 processor module. The processor module makes it possible to configure the measuring signals and query the status of the ES4550.1.

- configuration of the measuring signals for current and voltage
- offset compensation of the measuring signals for current
- configuration of optical and acoustic evaluation
- addressing and querying the backplane ECU signals
- querying the fuse status
- querying the configuration of the backplane range of measuring signals
- querying the temperature on the piggybacks
- querying the configuration of battery voltage B
- querying the IDs of the piggybacks
- querying the ES4550.1 hardware version

Piggyback ID

Each load piggyback has a 12-bit ID. This ID is used to determine exactly how many and what kind of piggybacks are on the ES4550.1. The ID 0x000 denotes an unused slot.

Flash Memory for Configuration Data

The ES4550.1 has a flash memory for configuration data which can be queried using the processor module.

The following data is stored in the memory:

- hardware version
- PLD versions
- configuration data for the offset compensation

Slot ID and ES4500 ID

The slot ID and the ES4500 ID are acquired by the processor module. This determines the slot position in the load box which in turn determines the board's CAN-ID.

The following steps have to be executed when assembling the ES4060.1 processor module.

---

note

Some components of the ES4060.1 processor module and the ES4550.1 Load-box Emulation Board may be damaged or destroyed by electrostatic discharges. Please keep the ES4060.1 processor module in its storage package until it is installed.
The ES4060.1 processor module should only be taken from its package, configured and installed at a working place that is protected against static discharge by qualified technical personnel.

- Take the processor module out of its packaging and insert it into the correct slot of the ES4550.1.

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note

When slotting the processor module onto the two slot connectors, please observe the correct orientation of the module. The programming connector and the reset switch on the bottom of the module must face the front panel. If the alignment is not correct, the module cannot be attached correctly and the connectors may be damaged.

- Screw the processor module tight with four M2.5 x 6 screws.
- Update the firmware of the processor module.

2.6   Configuring the Second Battery Voltage +UBatt_B

Channels 313 to 319 can either be used singly as 3 A channels or the seven channels are combined and used as a second battery voltage, +UBatt_B. The default setting is to use them as a second battery voltage, +UBatt_B.

> **note**
>
> *The configuration of channels 313 to 319 **must** be identical on all boards of a component rack. The boards must either all be configured for using the second battery voltage (+UBatt_B) or all for use as individual channels. A mixed configuration is **not** admissible.*
> *A mixed configuration can lead to the ECU, boards and component rack being damaged.*

The second battery voltage (+UBatt_B) is configured via the multiple jumper JP1001.

If the pins of the middle row of multiple jumpers are connected with the row not facing the backplane connector, the board is configured for using the second battery voltage, +UBatt_B. If they are connected with the row facing the backplane connector, channels 313 to 319 can be used as separate 3 A channels. The following figure shows JP1001 with the default jumper configuration (second battery voltage) on the left, and, on the right, when configured for using as separate channels.

+UBatt_B   **Separate Channels**
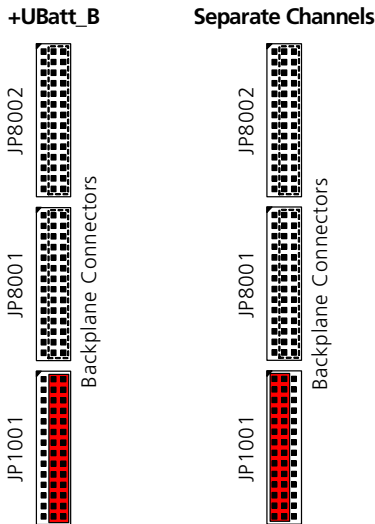
Fig. 2-11   JP1001

2.7   Overtemperature Protection

Each piggyback has a temperature sensor whose measuring signal is evaluated by the ES4550.1. If the temperature on one of the module exceeds 65 °C, the emergency shutdown line (channel 29) and the stabilizer emergency shutdown lines (channel 45 and channel 52) are activated to power off the battery voltages and stop the board overheating.

The optional ES4060.1 processor module can be used to query the temperature of the piggybacks and to lower the temperature threshold at which an emergency shutdown is caused.

2.8   Fuses

The battery voltages and battery nodes are protected with fuses. The fuses are monitored electronically. Intact fuses are indicated on the front panel by the green "FUSE" LED (please refer to the section "LED Displays" on page 70).

The status of the fuse can be queried using the optional ES4060.1 processor module.

Fuse	Name	Value
+UBatt_A	Positive battery voltage A	20 A
+UBatt_B	Positive battery voltage B	20 A
-UBatt	Negative battery voltage	30 A
BN0	Battery node 0	5 A
BN1	Battery node 1	5 A
BN2	Battery node 2	5 A
BN3	Battery node 3	5 A
BN4	Battery node 4	5 A
BN5	Battery node 5	5 A
BN6	Battery node 6	5 A
BN7	Battery node 7	5 A

Tab. 2-14   Fuses

Tab. 2-15 lists the types of fuse used.

Value	Manufacturer	Order Number
30 A / 80 V	Pudenz	166.7000.530
20 A / 80 V	Pudenz	166.7000.520
5 A	Littlefuse	454 005

Tab. 2-15   Types of Fuse

Fig. 2-12 shows the position of the fuses on the main board.
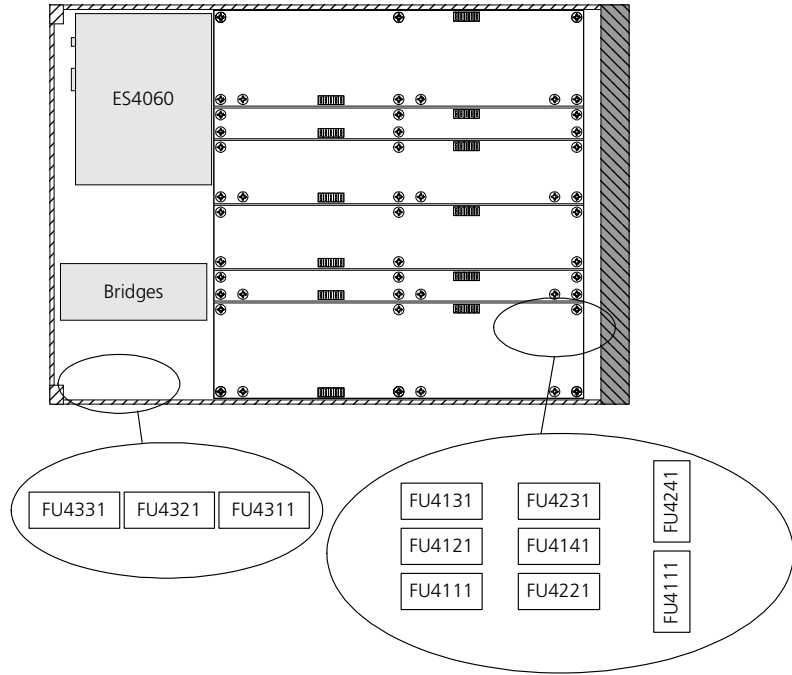
Fig. 2-12   Position of the Fuses on the Main Board

> **note**
>
> *The 5 A fuses of the battery nodes can only be changed when the piggyback in slot 3 is not assembled.*

3 Load Modules - Types and Configuration

The general mechanical and electrical features of the load modules have already been described in section 2.1 on page 10. This chapter contains information on the different types of load module, their assembly and configuration.

3.1 PB4550 Piggybacks

ETAS has a selection of prefabricated piggybacks for frequently required loads. These are the following piggybacks, each of which is described in this section:

- "PB4550OL.1 - Load Piggyback for Original Loads" on page 35
- "PB4550CR.1 - Load Piggyback for Common Rail" on page 39
- "PB4550GDI.1 - Load Piggyback for Gasoline Direct Injection" on page 40
- "PB4550PCR.1 - Load Piggyback for Piezo Injectors" on page 41

3.1.1 PB4550OL.1 - Load Piggyback for Original Loads

The PB4550OL.1 does not actually have any loads itself but makes it possible to measure currents and voltages from original loads which are connected to the front-facing connector "EXT. LOAD". Original valves, for example, can be connected via this connector without the user having to do without measuring possibilities.

Fig. 3-1 External Loads with PB4550OL.1

Three signals can be measured with each PB4550OL.1. A maximum of 12 signals can be measured with the ES4550.1.

Fig. 3-2 Equivalent Circuit: PB4550OL.1

±25 A, ±6 A or ±2 A can be specified as the measuring range for each signal on the PB4550OL.1. This takes place via bridges and jumpers. Tab. 3-1 lists which jumpers have to be open or closed for each measuring range.
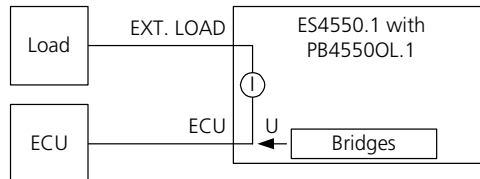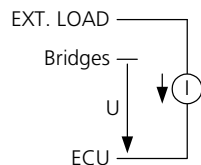
The top row shows the names of the jumpers.

From the second row down, the rows deal with a specific current range which is listed in the first column. Columns 2 to 9 show whether the jumpers whose names are listed at the top of each column have to be closed (X) or open (-). The last column refers to jumpers JP69, JP79 and JP89. The jumpers either have to be configured between pins 1 and 2 ("1 - 2") or pins 2 and 3 ("2 - 3").

Fig. 3-3 shows the arrangement of the jumpers on the PB4550OL.1.

Current Range	JP61, JP71, JP81	JP62, JP72, JP82	JP63, JP73, JP83	JP64, JP74, JP84	JP65, JP75, JP85	JP66, JP76, JP86	JP67, JP77, JP87	JP68, JP78, JP88	Jumper JP69, JP79, JP89
±25 A	X	-	-	X	-	-	-	-	1 - 2
±6 A	-	X	X	X	X	X	-	-	2 - 3
±2 A	-	-	-	X	-	-	X	X	2 - 3

Tab. 3-1   Configuration: PB4550OL.1

A voltage divider can be equipped with three resistors per measuring signal for voltage measuring. This makes it possible to adapt the voltage range individually. The resistors are through-hole resistors (0.5 W).

The input and output voltages have to be determined to dimension the resistors. The amplification and resistance values can then be calculated. The input resistance of the voltage measuring inputs of the ES4550.1 is 380 kΩ. The Ra resistor should be approx. 10 kΩ.

Abbreviations	Meaning
Uin	Input voltage
Uout	Output voltage
A	Amplification, A < 1
Ra	R61, R63, R71, R73, R81 and R83 resistor
Rb	R62, R72 and R82 resistor

Tab. 3-2   Voltage Measuring Signal

The resistance values are calculated using the formulae in Tab. 3-3.

Calculation of the Resistance Values

A = Uout / Uin

Rb = 2 * Ra * A / (1 - A)

Tab. 3-3   Voltage Measuring Signal

The arrangement of the jumpers for the configuration of the current measuring range and the position of the resistors for voltage measuring is shown in Fig. 3-3.
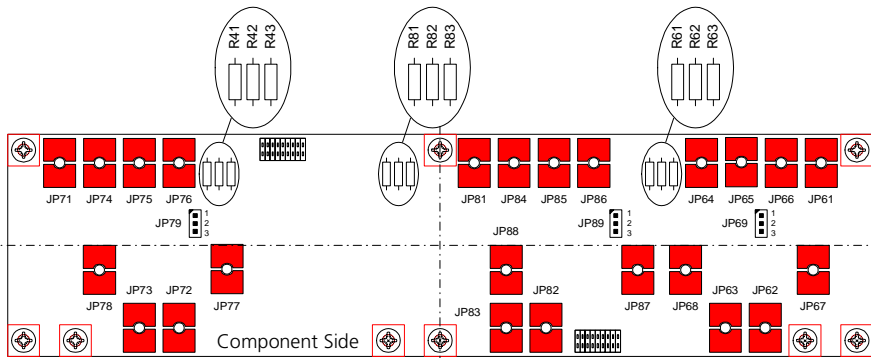
Fig. 3-3   Arrangement of the Jumpers on the PB4550OL.1

Technical Data on the PB4550OL.1

Variable	Value
Number of loads	3
Maximum current	25 A, 6 A, 2 A
Voltage	-
Current measuring signal: input range	-25 A .. +25 A -6 A .. +6 A -2 A .. +2 A
Current measuring signal: amplification	0.16 V / A 0.67 V / A 2 V / A
Current measuring signal: output range	+1 V .. +9 V
Voltage measuring signal: input range	Can be assembled according to the project
Voltage measuring signal: amplification	Can be assembled according to the project
Voltage measuring signal: output range	Can be assembled according to the project
ID	0x001
Format	Small (217 mm x 56 mm)
Height	50 mm

Tab. 3-4   Technical Data on the PB4550OL.1

3.1.2 PB4550CR.1 - Load Piggyback for Common Rail

The PB4550CR.1 piggyback simulates two common rail valves.

Fig. 3-4 Equivalent Circuit: PB4550CR.1

Technical Data on the PB4550CR.1

Variable	Value
Number of loads	2
Maximum current	8 A
Voltage	12 V
Current measuring signal: input range	-8 A .. +8 A
Current measuring signal: amplification	0.5 V / A
Current measuring signal: output range	+1 V .. +9 V
Voltage measuring signal: input range	-16 V .. +16 V
Voltage measuring signal: amplification	0.25 V / V
Voltage measuring signal: output range	-4 V .. +4 V
ID	0x002
Format	Small (217 mm x 56mm)
Height	50 mm

Tab. 3-5 Technical Data on the PB4550CR.1

3.1.3   PB4550GDI.1 - Load Piggyback for Gasoline Direct Injection

The PB4550GDI.1 piggyback simulates two valves for GDI.
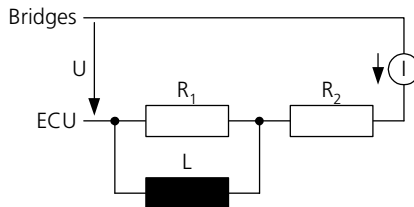
Fig. 3-5   Equivalent Circuit: PB4550GDI.1

Technical Data on the PB4550GDI.1

Variable	Value
Number of loads	2
Maximum current	6 A
Voltage	12 V
Current measuring signal: input range	-2 A .. +2 A
Current measuring signal: amplification	2 V / A
Current measuring signal: output range	+1 V .. +9 V
Voltage measuring signal: input range	-16 V .. + 16 V
Voltage measuring signal: amplification	0.25 V / V
Voltage measuring signal: output range	-4 V .. +4 V
ID	0x003
Format	Large (217 mm x 75 mm)
Height	57 mm

Tab. 3-6   Technical Data on the PB4550GDI.1

3.1.4   PB4550PCR.1 - Load Piggyback for Piezo Injectors

The PB4550PCR.1 piggyback simulates two piezo valves for common rail.

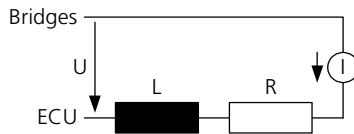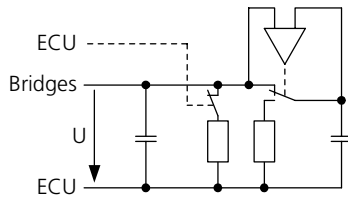**Fig. 3-6**   Equivalent Circuit: PB4550PCR.1

Technical Data on the PB4550PCR.1

Variable	Value
Number of loads	2
Voltage	< 175 V
Voltage measuring signal: input range	-175 V .. +175 V
Voltage measuring signal: amplification	0.057 V / V
Voltage measuring signal: output range	-10 V .. +10 V
ID	0x004
Format	Small (217 mm x 56 mm)
Height	50 mm

Tab. 3-7   Technical Data on the PB4550PCR.1

3.2   Assembly and Dismantlement

The following steps have to be executed to assemble a PB4550 piggyback.

note

Some components of the piggybacks and the ES4550.1 may be damaged or destroyed by electrostatic discharges. Please keep the piggybacks in their storage package until they are installed.
The piggybacks should only be taken from their package, configured and installed at a working place that is protected against static discharge by qualified technical personnel.

- Insert the two flat band cables into the relevant connectors on the ES4550.1.

  Make sure you use the connectors which are positioned exactly under the relevant piggyback connector. The connectors are coded so that polarity inversion is not possible. The flat band cables run straight from the piggyback to the main board without any twists. If the flat band cables cannot be inserted straight, the alignment of the piggyback could well be incorrect.

- Screw all metal spacing bolts on the piggyback tight (on the bottom of the main board).

  The spacing bolts have to be assembled with brass M3 x 8 screws using plain brass washers and tooth lock washers.

3.3 Configuring the Loads

Up to twelve loads can be used with the ES4550.1 depending on the size of the piggybacks.

To ensure more flexibility in the configuration of dummy loads, the ES4550.1 supports two different formats of piggyback which can each be equipped with up to three loads. The main board can accommodate three large piggybacks or four small ones.

The format of the piggybacks can be made to depend on the size of the required components (e.g. coils). More dummy loads with compact components can be used on the ES4550.1 than dummy loads with large components.

3.3.1 Piggyback Connections

The piggybacks are screwed to the main board using brass spacing bolts. These spacing bolts both physically attach the piggybacks and are responsible for the electrical high-current connection of the piggybacks (maximum of 20 A). The measuring signals are routed from the piggybacks to the main board using flat band cable with connectors. To make it possible to use both types of piggyback, there are two sets of flat band cable connectors and fastening holes for

the screws of the spacing bolts on the main board: one set for the large format
(Fig. 3-7) and one for the small format (Fig. 3-8) whereby some connectors and
fastening holes can also be used for both formats.
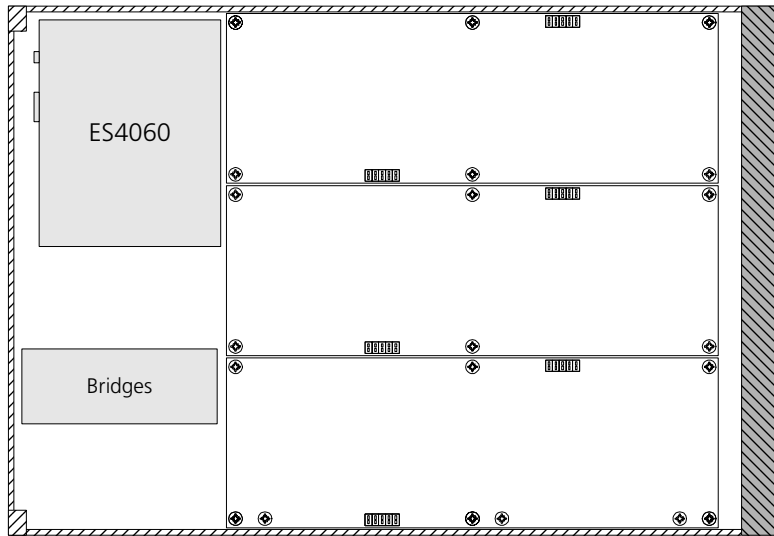
Fig. 3-7   Three Large Piggybacks
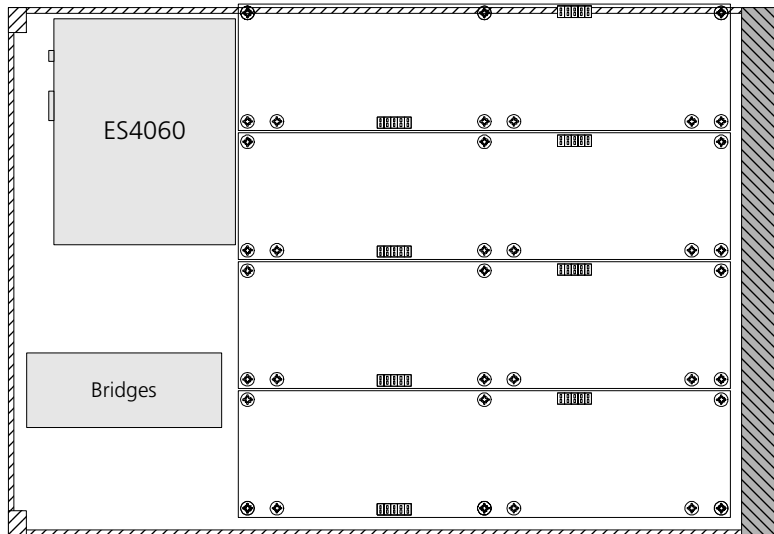
Fig. 3-8   Four Small Piggybacks

The slots for both small and large piggybacks are connected in parallel. Fig. 3-9 shows the assignment of the loads to the slots.
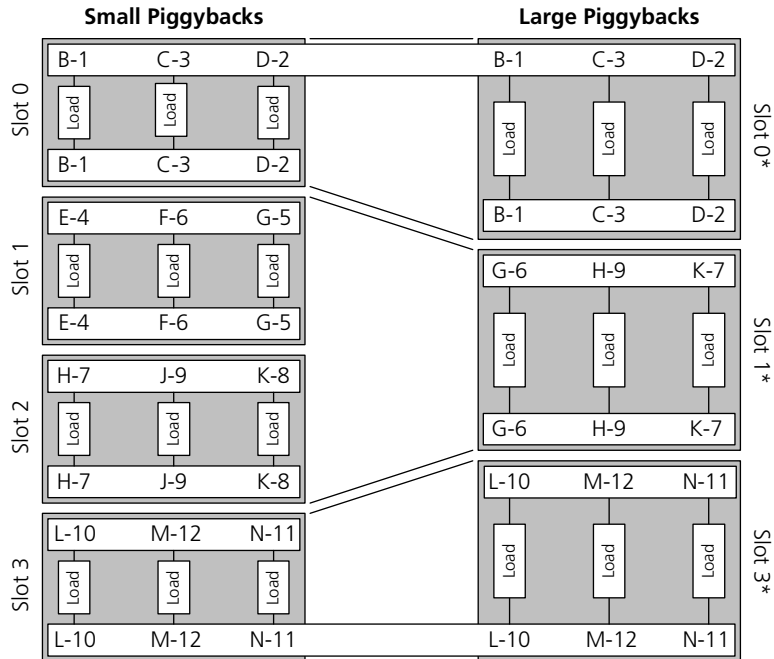
Fig. 3-9   Assignment of the Loads to the Slots

3.3.2   Flexible Load Configuration

Flexible load configuration is possible on the ES4550.1 due to a field with bridges.

Bridges

The 20 A load signals of the ES4550.1 are configured using bridges. A bridge is a drill hole with two copper plates on the top and bottom of the circuit board (see Fig. 3-10, on the left). To close the jumper, a plain brass washer is pressed against the two copper plates on the top and bottom resulting in an electrical

connection (see Fig. 3-10, on the right). The plain washers are held in position by an M3 screw with a nut and lock washer which is threaded through the drill hole.
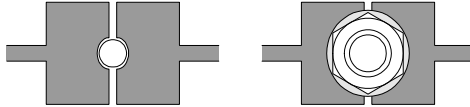
Fig. 3-10   Bridges

Configuration of the Loads

Very often several loads are combined to form what is referred to as a bank. With injection valves it is often the case that each valve has one ECU pin against -UBatt with a low-side switch to control the valve whereas several valves only have one common pin (star point) to +UBatt.
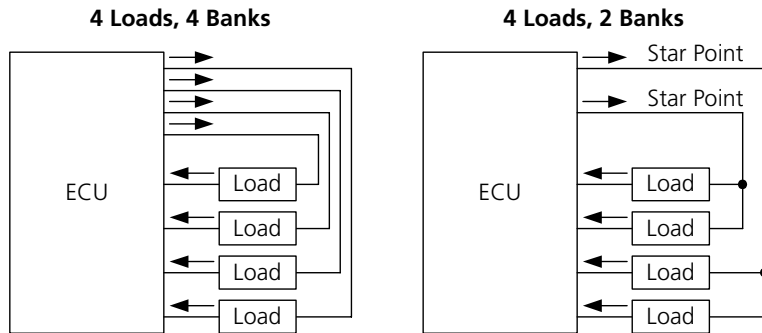
Fig. 3-11   Grouping of Loads to Form Banks

Fig. 3-12 on page 47 shows the load circuit and the configuration possibilities made possible by bridges. For the purposes of clarity, however, the various configurations are listed in tables which are explained in more detail in the section "Tables for Configuration" on page 49.
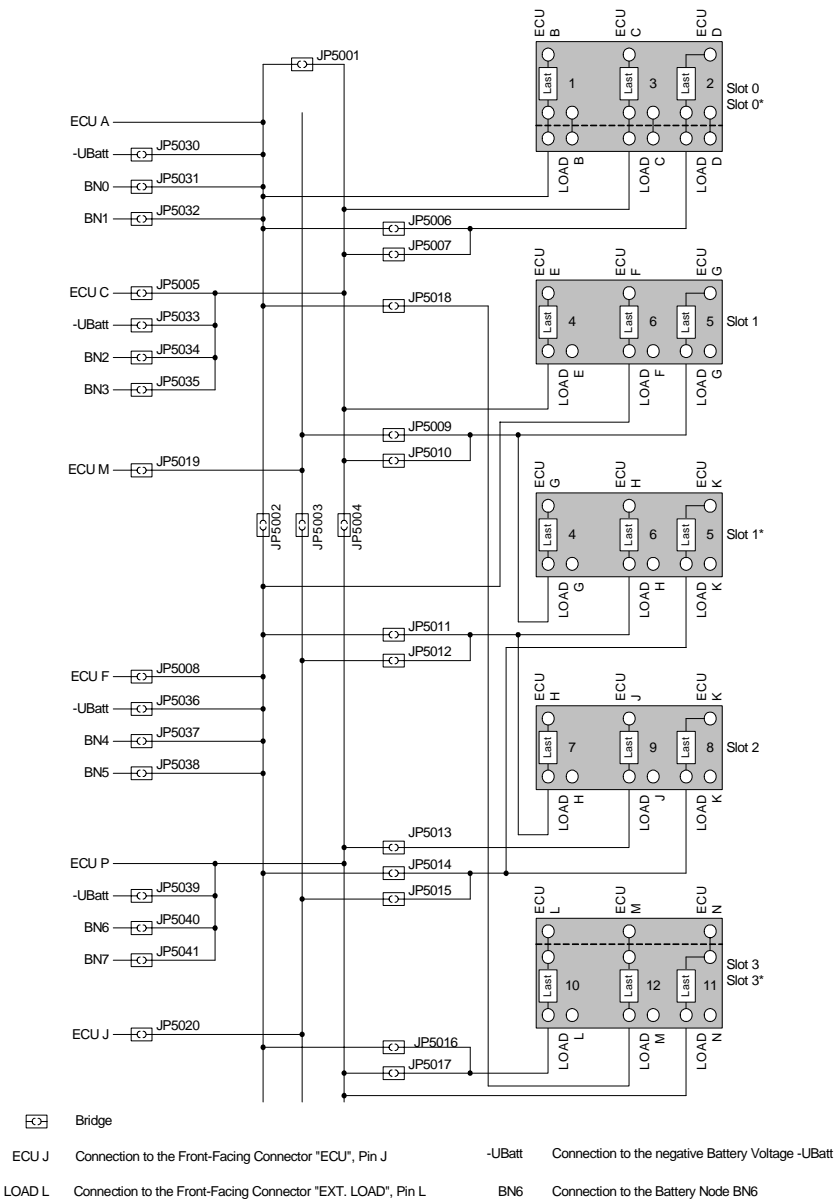
Fig. 3-12   Load Grouping using Bridges

The star points of the individual banks can be configured using bridges to -UBatt or the battery nodes BN0 to BN7. It is not, however, possible to select all voltages for each star point; only a few voltages are available in each case. For details of which voltages are possible for which star points, refer to the "-UBatt and Battery Node Configuration" tables. Tab. 3-8 lists the assignment of the voltages to the bridges.

Voltage	Star Point	Jumper	Current Rating
-UBatt	A	JP5030	Total: 30 A
-UBatt	C	JP5033	Total: 30 A
-UBatt	F	JP5036	Total: 30 A
-UBatt	P	JP5039	Total: 30 A
BN0	A, C, F, P	JP5031	5 A
BN1	A, C, F, P	JP5032	5 A
BN2	A, C, F, P	JP5034	5 A
BN3	A, C, F, P	JP5035	5 A
BN4	A, C, F, P	JP5037	5 A
BN5	A, C, F, P	JP5038	5 A
BN6	A, C, F, P	JP5040	5 A
BN7	A, C, F, P	JP5041	5 A

Tab. 3-8   Bridges for -UBatt and Battery Nodes

Fig. 3-13 shows the arrangement of the bridges on the main board.
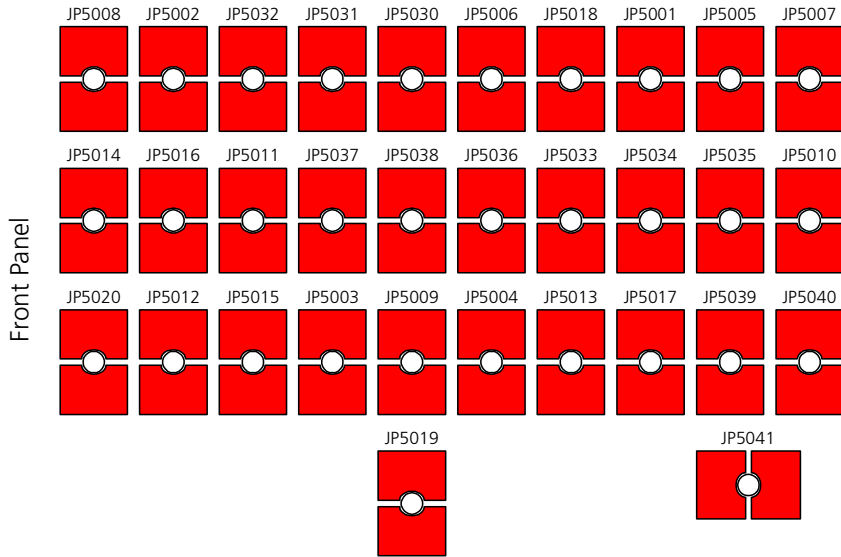
Fig. 3-13   Arrangement of the Bridges on the Main Board

3.3.3   Tables for Configuration

This section explains how to get the information needed for configuring the ES4550.1 using tables.

The tables are listed in subsections according to the format of the piggybacks and the number of loads on the piggyback.

Format	Loads	Section
Large	2	"Large Piggybacks with Two Loads Each" on page 55
Large	3	"Large Piggybacks with Three Loads Each" on page 57
Small	2	"Small Piggybacks with Two Loads Each" on page 60
Small	3	"Small Piggybacks with Three Loads Each" on page 63

Tab. 3-9   Subsections on Configuration

Example: As an example, we want to take a look at a four-cylinder engine with gasoline direct injection and two banks.

A piggyback for gasoline direct injection, PB4550GDI, is large and has two loads per module. This means the tables in section 3.3.4 on page 55 have to be used.

The ES4550.1 supports a maximum of 12 loads depending on the format of the load piggybacks. The 12 loads are numbered from 1 to 12. Due to the flexible configuration of the loads and the different designs of the piggybacks, the numbers in the different configurations are frequently incomplete and not consecutive.

The "Configuration" Tables

The "Configuration" tables list which numbers the available loads have for the different configurations and how the loads can be combined to form banks.

The top row of Tab. 3-11 shows the numbers of the loads from the third field onwards.

From the second row down, the rows are assigned to the different configurations whereby the first column contains the number of loads and the second column the number of banks.

From the third column, the front-facing connector pin is specified in each case; this is used as the star point of a bank. If you move up the relevant column, the top field contains the number of a load which is assigned to this star point. If the same pin is listed several times from the third column (row of the required configuration), the relevant loads belong to the same bank. The table contains other characters in addition to letters the meaning of which is explained in Tab. 3-10.

Character	Meaning
A, C, F, J, M, P	Star point (front-facing connector pin)
/	Load is not used in this configuration
-	Load is not assembled

Tab. 3-10   Definition of Characters

The second (lower) part of the "Configuration" tables contains the allocation of the load numbers to the front-facing connector pins (second-last row) and to the piggyback slots (last row). Slots marked with a "*" are large slots; slots without a "*" are small ones.

Example: Tab. 3-18 on page 55 is used in the case of a four-cylinder engine with two banks (e.g. gasoline direct injector). The second row (in the excerpt, fifth row in the original table) contains the specification "4" loads (first column) and "2" banks (second column). This is the line relevant for us.

Number of		Load Number					
Loads	Banks	1	2	7	6	10	11
4	2	A	A	-	-	P	P

Tab. 3-11   Excerpt from Tab. 3-18, Upper Part

The third column contains the letter "A". The load number in the top field of this column is "1". This means that the ECU connector pin "A" is the star point of a bank to which load "1" is assigned.

The fourth column also contains the letter "A". The load number in the top field of this column is "2". This means that load "2" is also assigned to the star point pin "A".

"-" is contained in the fifth and sixth columns. Load numbers "7" and "6" are listed in the top field of these columns. "-" means that these loads are not assembled.

In the seventh and eighth column, pin "P" is listed as start point. In the top line of these columns, you can find the relevant loads "10" and "11".

Now the relevant ECU connector pin for the loads can be determined in the lower part of the table.

Load Number	1	2	7	6	10	11
Pin of front panel connector	B	D	K	G	L	N
Module slot	0*	0*	1*	1*	3*	3*

Tab. 3-12   Excerpt from Tab. 3-18, Lower Part

To do this, you find the required load number in the top row and then move down the relevant column to the second last line. "B" is specified for our load "1". The connector pin "B" is thus the connector for load "1". For loads "2", "10" and "11", the relevant connectors are the pins "D", "L" and "N".

The lower part of the table also lists in which piggyback slot the relevant load is to be found. To find the relevant information, look for the required load number in the top row and move down the relevant column to the bottom row. "0*" is specified for our load "1". Load "1" is thus in slot "0*". The character "*" specifies that this is a large piggyback. Load "3" is also in slot "0*", whereas loads "10" and "12" are in slot "3*".

In this configuration, the two loads "7" and "6" are not needed and are thus both marked with "-" in the upper part of Tab. 3-18 on page 55. Both loads are in slot "1*". As neither of these loads is required, slot "1*" does not need to be equipped with a piggyback for this configuration.

This means that the table shows that our first bank with its star point is connected to the ECU connector pin "A" and contains loads "1" and "2" with the pins "B" and "D". The second bank is connected to "P" and contains loads "10" and "11" with pins "L" and "N". It is sufficient to equip only two piggybacks as slot "1*" can remain free.

The "Bridges" Tables

The "Bridges" tables describe which bridges are required for the configuration of the loads and banks.

The numbers of the bridges are listed in the top row from the third field onwards.

From the second row, the rows are dedicated to the different configurations whereby the first column lists the number of loads and the second the number of banks. From the third column, there is a list stating whether the bridge specified in the top field of the relevant column has to be open or closed. "-" means that the bridge has to be open. If a letter is specified, the bridge has to be closed. The letters specify the star point of the bank for which this bridge is intended. This is helpful if you want to understand how the bridges in Fig. 3-12 work.

Character	Meaning
A, C, F, J, M, P	Bridge closed
-	Bridge open

Tab. 3-13 Definition of Characters

Example: Tab. 3-19 on page 56 is used for our example. The second row (in the excerpt, seventh row in the original table) specifies "4" loads (first column) and "2" banks (second column). This is the relevant line for us.

Loads	Banks	JP5001	JP5002	JP5003	JP5004	JP5005	JP5006	JP5007	JP5008	JP5009	JP5010	JP5011	JP5012	JP5013	JP5014	JP5015	JP5016	JP5017	JP5018	JP5019	JP5020
4	2	-	A	-	P	-	A	-	-	-	-	-	-	-	-	-	-	P	-	-	-

Tab. 3-14 Excerpt from Tab. 3-19

The third column contains a "-". This means that the JP5001 bridge, whose number is specified in the top field of this column, has to remain open.

The fourth column contains an "A". A letter means that the JP5002 bridge, whose number is specified in the top field of this column, has to be closed.

In our example, the bridges JP5002, JP5004, JP5006 and JP5017 have to be closed whereas all other bridges have to remain open.

The "-UBatt and Battery Node Configuration" Tables

The star points of the jumpers can be connected with the negative battery voltage -UBatt or with the battery nodes BN0 to BN7 via bridges. It is, however, not possible to select all voltages for all star points. The "-UBatt and battery node configuration" tables show which connections are possible.

From the third field onwards, the front-facing connector pins of the start points are listed in the top row (see Tab. 3-16 on page 54).

From the second row, the rows refer specifically to the different configurations whereby the first column contains the number of loads and the second column the number of banks. As of the third column there is a list of which voltages can be applied to the star point. The star point is listed in the top row. Apart from voltages, the table also contains other characters the meaning of which is described in Tab. 3-15.

Character	Meaning
-UBatt, BN0	Connection to these voltages possible
/	No connection to voltages possible
-	The star point is not used

Tab. 3-15   Definition of Characters used in the "-UBatt and Battery Node Configuration" Tables

The position of the bridges on the main board is shown in Fig. 3-13 on page 49.

Example: Tab. 3-20 is used for our example. The second row (in the excerpt, seventh row in the original table) specifies "4" loads (first column) and "2" banks (second column). This is the relevant line for us.

Loads	Banks	A	C	J	M	F	P
4	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7

Tab. 3-16 Excerpt from Tab. 3-20

"-UBatt, BN0, BN1, BN4, BN5" are listed in the third column. This means that star point "A", which is specified in the top field of this column, can be connected with the voltages -UBatt, BN0, BN1, BN4 and BN5.

"-" is specified in the fourth, fifth, sixth and seventh columns. This means that star points "C", "J", "M" and "F" cannot be used for this configuration.

The last column lists "-UBatt, BN2, BN3, BN6, BN6". This means that star point "P" can be connected with the voltages -UBatt, BN2, BN3, BN6 and BN7.

The assignment of the bridges, which are needed for the connections between the star points and the voltages, are listed in Tab. 3-8 on page 48. The current rating of the voltages is also listed.

note

Never connect two of the battery or battery node voltages with each other. The bridges in Tab. 3-8, which are not explicitly needed for a connection, must be open.

The position of the bridges on the main board is shown in Fig. 3-13 on page 49.

Example: Let's assume that bank "A" has to be connected with the battery node BN0 and bank "P" with the battery node BN7.

Voltage	Star Point	Jumper	Current Rating
BN0	A, C, F, P	JP5031	5A
BN7	A, C, F, P	JP5041	5A

Tab. 3-17 Excerpt from Tab. 3-8

The row whose first column contains the voltage "BN0" and second the star point has to be found. In our example, this is the second row (in the excerpt, fifth row in the original table). The third column contains the name of the bridge "JP5031". This bridge has to be closed. The current rating is specified in the last column as 5 A.

The third row (in the excerpt, twelfth row in the original table) lists the voltage as "BN7" and the star point as "P". It also specifies that the bridge "JP5041" has to be closed. The current rating is 5 A.

The remaining bridges in this table (JP5030 and JP5032 to JP5040) must be open!

3.3.4 Large Piggybacks with Two Loads Each

A maximum of six loads is available with large piggybacks with two loads each.

Number of		Load Number						
Loads	Banks	1	2	7	6	10	11
6	1	A	A	A	A	A	A
6	2	A	A	A	P	P	P
6	3	A	A	J	J	P	P
6	6	A	C	J	M	F	P
4	1	A	A	-	-	A	A
4	2	A	A	-	-	P	P
4	4	A	C	-	-	F	P

Pin of front panel connector to star point of a bank

Load Number	1	2	7	6	10	11
Pin of front panel connector	B	D	K	G	L	N
Module slot	0*	0*	1*	1*	3*	3*

Tab. 3-18   Configuration: Large Format, Two Loads

Loads	Banks	JP5001	JP5002	JP5003	JP5004	JP5005	JP5006	JP5007	JP5008	JP5009	JP5010	JP5011	JP5012	JP5013	JP5014	JP5015	JP5016	JP5017	JP5018	JP5019	JP5020
6	1	A	A	-	A	-	A	-	-	-	A	-	-	-	A	-	-	A	-	-	-
6	2	-	A	-	P	-	A	-	-	-	P	-	-	-	A	-	-	P	-	-	-
6	3	-	A	J	P	-	A	-	-	J	-	-	-	-	-	J	-	P	-	-	J
6	6	-	-	-	-	C	-	C	F	M	-	-	-	-	-	J	F	-	-	M	J
4	1	A	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	A	-	-	-
4	2	-	A	-	P	-	A	-	-	-	-	-	-	-	-	-	-	P	-	-	-
4	4	-	-	-	-	C	-	C	F	-	-	-	-	-	-	-	F	-	-	-	-

Tab. 3-19   Bridges: Large Format, Two Loads

Loads	Banks	A	C	J	M	F	P
6	1	-UBatt, BN0 .. BN7	-	-	-	-	-
6	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7
6	3	-UBatt, BN0, BN1, BN4, BN5	-	/	-	-	-UBatt, BN2, BN3, BN6, BN7
6	6	-UBatt, BN0, BN1	-UBatt, BN2, BN3	/	/	-UBatt, BN4, BN5	-UBatt, BN6, BN7
4	1	-UBatt, BN0 .. BN7	-	-	-	-	-
4	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7
4	4	-UBatt, BN0, BN1	-UBatt, BN2, BN3	-	-	-UBatt, BN4, BN5	-UBatt, BN6, BN7

Tab. 3-20   -UBatt and Battery Nodes: Large Format, Two Loads

3.3.5 Large Piggybacks with Three Loads Each

A maximum of nine loads is available with large piggybacks with three loads each.

Number of		Load Number								
Loads	Banks	12	1	7	9	2	6	10	11	3
8	1	A	A	A	A	A	A	A	A	/
8	2	A	A	A	A	P	P	P	P	/
8	4	A	A	F	F	C	C	P	P	/
6	1	A	-	A	A	-	A	A	A	-
6	2	A	-	A	A	-	P	P	P	-
6	3	A	-	A	M	-	M	P	P	-
6	6	/	A	J	/	C	M	F	P	/
4	1	/	A	-	-	A	-	A	A	/
4	2	/	A	-	-	A	-	P	P	/
4	4	/	A	-	-	C	-	F	P	/

Pin of front panel connector to star point of a bank

Load Number	12	1	7	9	2	6	10	11	3
Pin of front panel connector	M	B	K	H	D	G	L	N	C
Module slot	3*	0*	1*	1*	0*	1*	3*	3*	0*

Tab. 3-21   Configuration: Large Format, Three Loads

Loads	Banks	JP5001	JP5002	JP5003	JP5004	JP5005	JP5006	JP5007	JP5008	JP5009	JP5010	JP5011	JP5012	JP5013	JP5014	JP5015	JP5016	JP5017	JP5018	JP5019	JP5020
8	1	A	A	-	A	-	-	A	-	-	A	A	-	-	A	-	-	A	A	-	-
8	2	-	A	-	P	-	-	P	-	-	P	A	-	-	A	-	-	P	A	-	-
8	4	-	-	-	-	C	-	C	F	-	C	F	-	-	F	-	-	P	A	-	-
6	1	A	A	-	A	-	-	-	-	-	-	A	A	-	-	A	-	-	A	A	-
6	2	-	A	-	P	-	-	-	-	-	-	P	A	-	-	A	-	-	P	A	-
6	3	-	A	M	P	-	-	-	-	M	-	-	M	-	A	-	-	P	A	M	-
6	6	-	-	-	-	C	-	C	F	M	-	-	-	-	-	-	J	F	-	M	J
4	1	A	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-
4	2	-	A	-	P	-	A	-	-	-	-	-	-	-	-	-	-	-	P	-	-	-
4	4	-	-	-	-	C	-	C	F	-	-	-	-	-	-	-	-	F	-	-	-

Tab. 3-22   Bridges: Large Format, Three Loads

Loads	Banks	A	C	J	M	F	P
8	1	-UBatt, BN0 .. BN7	-	-	-	-	-
8	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7
8	4	-UBatt, BN0, BN1	-UBatt, BN2, BN3	-	-	-UBatt, BN4, BN5	-UBatt, BN6, BN7
6	1	-UBatt, BN0 .. BN7	-	-	-	-	-
6	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7
6	3	-UBatt, BN0, BN1, BN4, BN5	-	-	/	-	-UBatt, BN2, BN3, BN6, BN7
6	6	-UBatt, BN0, BN1	-UBatt, BN2, BN3	/	/	-UBatt, BN4, BN5	-UBatt, BN6, BN7
4	1	-UBatt, BN0 .. BN7	-	-	-	-	-
4	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7
4	4	-UBatt, BN0, BN1	-UBatt, BN2, BN3	-	-	-UBatt, BN4, BN5	-UBatt, BN6, BN7

Tab. 3-23 -UBatt and Battery Nodes: Large Format, Three Loads

3.3.6 Small Piggybacks with Two Loads Each

A maximum of eight loads is available with small piggybacks with two loads each.

When using a PB4550CR.1 (common rail piggyback), it may be necessary to create a prototyping piggyback with two resistors to set the rail pressure. This piggyback is referred to as a "rail pressure piggyback" in this documentation. The special feature of this configuration is that two different types of piggyback are integrated in the ES4550.1 at the same time.

Number of		Load Number							
Loads	Banks	1	2	7	8	5	4	10	11
8	1	A	A	A	A	A	A	A	A
8	2	A	A	A	A	P	P	P	P
8	4	A	A	F	F	C	C	P	P
6	1	A	A	A	A	-	-	A	A
6 *	2 *	A **	A **	J	J	J	P	P	P
6 *	3 *	A **	A **	F	F	C	C	P	P
6	6	A	/	J	/	M	C	F	P
4	1	A	A	-	-	-	-	A	A
4	2	A	A	-	-	-	-	P	P
4	4	A	C	-	-	-	-	F	P

(Right margin note: Pin of front panel connector to star point of a bank)

* also with additional rail pressure bank
** rail pressure piggyback

Load Number	1	2	7	8	5	4	10	11
Pin of front panel connector	B	D	H	K	G	E	L	N
Module slot	0	0	2	2	1	1	3	3

Tab. 3-24   Configuration: Small Format, Two Loads

Loads	Banks	JP5001	JP5002	JP5003	JP5004	JP5005	JP5006	JP5007	JP5008	JP5009	JP5010	JP5011	JP5012	JP5013	JP5014	JP5015	JP5016	JP5017	JP5018	JP5019	JP5020
8	1	A	A	-	A	-	A	-	-	-	A	A	-	-	A	-	-	A	-	-	-
8	2	-	A	-	P	-	A	-	-	-	P	A	-	-	A	-	-	P	-	-	-
8	4	-	-	-	-	-	C	A	-	F	-	C	F	-	-	F	-	-	P	-	-
6	1	A	A	-	A	-	A	-	-	-	-	A	-	-	A	-	-	A	-	-	-
6 *	2 *	-	A	J	P	-	A	-	-	J	-	-	J	-	-	J	-	P	-	-	J
6	3	-	-	-	-	-	C	A	-	F	-	C	F	-	-	F	-	-	P	-	-
6	6	-	-	-	-	-	C	-	-	F	M	-	-	J	-	-	-	F	-	M	J
4	1	A	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	A	-	-	-
4	2	-	A	-	P	-	A	-	-	-	-	-	-	-	-	-	-	P	-	-	-
4	4	-	-	-	-	-	C	-	C	F	-	-	-	-	-	-	-	F	-	-	-

* also with additional rail pressure bank

Tab. 3-25 Bridges: Small Format, Two Loads

Loads	Banks	A	C	J	M	F	P
8	1	-UBatt, BN0 .. BN7	-	-	-	-	-
8	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7
8	4	-UBatt, BN0, BN1	-UBatt, BN2, BN3	-	-	-UBatt, BN4, BN5	-UBatt, BN6, BN7
6	1	-UBatt, BN0 .. BN7	-	-	-	-	-
6 *	2 *	-UBatt, BN0, BN1, BN4, BN5 **	-	/	-	-	-UBatt, BN2, BN3, BN6, BN7
6 *	3 *	-UBatt, BN0, BN1 **	-UBatt, BN2, BN3	-	-	-UBatt, BN4, BN5	-UBatt, BN6, BN7

Loads	Banks	A	C	J	M	F	P
6	6	-UBatt, BN0, BN1	-UBatt, BN2, BN3	/	/	-UBatt, BN4, BN5	-UBatt, BN6, BN7
4	1	-UBatt, BN0 .. BN7	-	-	-	-	-
4	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7
4	4	-UBatt, BN0, BN1	-UBatt, BN2, BN3	-	-	-UBatt, BN4, BN5	-UBatt, BN6, BN7

* also with additional rail pressure bank

** rail pressure piggyback

Tab. 3-26   -UBatt and Battery Nodes: Small Format, Two Loads

3.3.7   Small Piggybacks with Three Loads Each

A maximum of twelve loads is available with small piggybacks with three loads each.

Number of		Load Number											
Loads	Banks	12	1	2	6	7	8	3	5	4	9	10	11
12	1	A	A	A	A	A	A	A	A	A	A	A	A
12	2	A	A	A	A	A	A	P	P	P	P	P	P
8	1	A	-	-	A	A	A	-	A	A	/	A	A
8	2	A	-	-	A	A	A	-	P	P	/	P	P
8	4	A	-	-	A	J	J	-	C	C	/	P	P
6	1	-	-	-	A	A	A	-	A	A	A	-	-
6	2	-	-	-	A	A	A	-	P	P	P	-	-
6	3	-	-	-	A	A	M	-	M	P	P	-	-
6	6	/	A	/	/	F	J	/	M	C	/	/	P
4	1	/	A	A	-	-	-	/	-	-	-	A	A
4	2	/	A	A	-	-	-	/	-	-	-	P	P
4	4	/	A	C	-	-	-	/	-	-	-	F	P

Load Number	12	1	2	6	7	8	3	5	4	9	10	11
Pin of front panel connector	M	B	D	F	H	K	C	G	E	J	L	N
Module slot	3	0	0	1	2	2	0	1	1	2	3	3

Pin of front panel connector to star point of a bank

Tab. 3-27   Configuration: Small Format, Three Loads

Loads	Banks	JP5001	JP5002	JP5003	JP5004	JP5005	JP5006	JP5007	JP5008	JP5009	JP5010	JP5011	JP5012	JP5013	JP5014	JP5015	JP5016	JP5017	JP5018	JP5019	JP5020
12	1	A	A	-	A	-	A	-	-	-	A	A	-	A	A	-	-	A	A	-	-
12	2	-	A	-	P	-	A	-	-	-	P	A	-	P	A	-	-	P	A	-	-
8	1	A	A	-	A	-	-	-	-	-	-	A	A	-	-	A	-	-	A	A	-
8	2	-	A	-	P	-	-	-	-	-	-	P	A	-	-	A	-	-	P	A	-
8	4	-	A	-	-	C	-	-	-	-	C	-	J	-	-	J	-	P	A	-	J
6	1	A	A	-	A	-	-	-	-	-	-	A	A	-	A	A	-	-	-	-	-
6	2	-	A	-	P	-	-	-	-	-	-	P	A	-	P	A	-	-	-	-	-
6	3	-	A	M	P	-	-	-	-	M	-	A	-	P	-	M	-	-	-	M	-
6	6	-	-	-	-	C	-	-	F	M	-	F	-	-	-	J	-	-	-	M	J
4	1	A	A	-	A	-	A	-	-	-	-	-	-	-	-	-	-	A	-	-	-
4	2	-	A	-	P	-	A	-	-	-	-	-	-	-	-	-	-	P	-	-	-
4	4	-	-	-	-	C	-	C	F	-	-	-	-	-	-	-	-	F	-	-	-

Tab. 3-28   Bridges: Small Format, Three Loads

Loads	Banks	A	C	J	M	F	P
12	1	-UBatt, BN0 .. BN7	-	-	-	-	-
12	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7
8	1	-UBatt, BN0 .. BN7	-	-	-	-	-
8	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7
8	4	-UBatt, BN0, BN1, BN4, BN5	-UBatt, BN2, BN3	/	-	-	-UBatt, BN6, BN7
6	1	-UBatt, BN0 .. BN7	-	-	-	-	-
6	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7
6	3	-UBatt, BN0, BN1, BN4, BN5	-	-	/	-	-UBatt, BN2, BN3, BN6, BN7
6	6	-UBatt, BN0, BN1	-UBatt, BN2, BN3	/	/	-UBatt, BN4, BN5	-UBatt, BN6, BN7
4	1	-UBatt, BN0 .. BN7	-	-	-	-	-
4	2	-UBatt, BN0, BN1, BN4, BN5	-	-	-	-	-UBatt, BN2, BN3, BN6, BN7
4	4	-UBatt, BN0, BN1	-UBatt, BN2, BN3	-	-	-UBatt, BN4, BN5	-UBatt, BN6, BN7

Tab. 3-29   -UBatt and Battery Nodes: Small Format, Three Loads

4 Pin Assignment and Display Elements

This chapter describes the pin assignment and display elements of the ES4550.1 Loadbox Emulation Board.

4.1 Pin Assignment

This section describes the pin assignment of the "ECU" and "LOAD" connectors on the front panel of the ES4550.1 Loadbox Emulation Board.

4.1.1 "ECU" Connector

This connector is used for the input of signals from the ECU to the loads. It is a male "ITT Cannon CA20COM-E20-29P-B" connector with a contact rating of 22 A.

To avoid the user coming into contact with voltages from the ECU which can, at times, be very high, the mating connector (from the direction of the ECU) is female - the socket type is „ITT Cannon CA06COM-E20-29S-B-44".
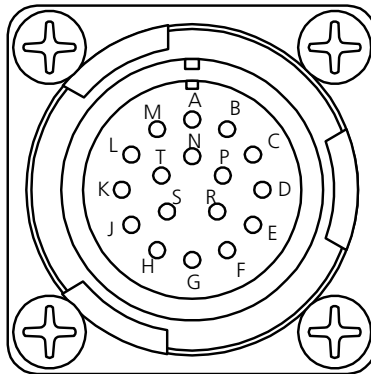
Fig. 4-1   "ECU" Connector (Male)

Pin	Signal	Meaning	Nominal Current
A	ECU_A	ECU channel A	20 A
B	ECU_B	ECU channel B	20 A
C	ECU_C	ECU channel C	20 A
D	ECU_D	ECU channel D	20 A
E	ECU_E	ECU channel E	20 A
F	ECU_F	ECU channel F	20 A
G	ECU_G	ECU channel G	20 A
H	ECU_H	ECU channel H	20 A
J	ECU_J	ECU channel J	20 A
K	ECU_K	ECU channel K	20 A
L	ECU_L	ECU channel L	20 A
M	ECU_M	ECU channel M	20 A
N	ECU_N	ECU channel N	20 A
P	ECU_P	ECU channel P	20 A
R	NC	Open	-
S	NC	Open	-
T	NC	Open	-

Tab. 4-1   "ECU" Pin Assignment

4.1.2 "LOAD" Connector

This connector is used to connect external original loads. This is a female "ITT Cannon CA20COM-E20-29S-B" connector with a contact rating of 22 A - as male counterpart use type „ITT Cannon CA06COM-E20-29P-B-44".
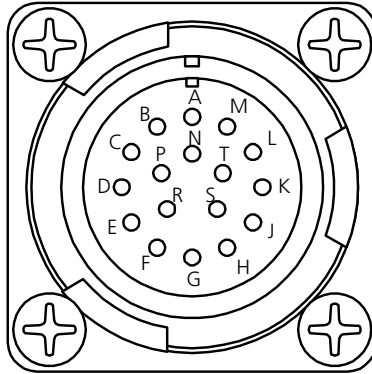
Fig. 4-2 "LOAD" Connector (Female)

Pin	Signal	Meaning	Nominal Current
A	LOAD_A	Load channel A	20 A
B	LOAD_B	Load channel B	20 A
C	LOAD_C	Load channel C	20 A
D	LOAD_D	Load channel D	20 A
E	LOAD_E	Load channel E	20 A
F	LOAD_F	Load channel F	20 A
G	LOAD_G	Load channel G	20 A
H	LOAD_H	Load channel H	20 A
J	LOAD_J	Load channel J	20 A
K	LOAD_K	Load channel K	20 A
L	LOAD_L	Load channel L	20 A
M	LOAD_M	Load channel M	20 A
N	LOAD_N	Load channel N	20 A
P	LOAD_P	Load channel P	20 A

Pin	Signal	Meaning	Nominal Current
R	+UBat_A	Battery voltage A	20 A
S	-UBat	Battery ground	20 A
T	+UBat_B	Battery voltage B	20 A

Tab. 4-2   "LOAD" Pin Assignment

4.2   LED Displays

There are sixteen LEDs on the front panel. The top row indicates the status of the configuration or the ES4550.1. The bottom three rows of LEDs provide visual information on the voltage or current measuring signals. The significance of the LEDs is described in Tab. 4-3.

Labeling	Name	Color	LED On	LED Off
Threshold	Threshold	Yellow	lower > upper	lower < upper
Config	Configuration	Yellow	Configuration to channels [107..120] and [254..267]	Configuration to channels [121..134] and [268..281]
Fuse	Fuse Control	Green	Fuses OK	Fuse defective
Overtemp	Overtemperature Control	Red	Overtemperature	No overtemperature
LD1	Load 1	Green	Visualization	Visualization
LD2	Load 2	Green	Visualization	Visualization
LD3	Load 3	Green	Visualization	Visualization
LD4	Load 4	Green	Visualization	Visualization
LD5	Load 5	Green	Visualization	Visualization
LD6	Load 6	Green	Visualization	Visualization
LD7	Load 7	Green	Visualization	Visualization
LD8	Load 8	Green	Visualization	Visualization
LD9	Load 9	Green	Visualization	Visualization
LD10	Load 10	Green	Visualization	Visualization
LD11	Load 11	Green	Visualization	Visualization
LD12	Load 12	Green	Visualization	Visualization

Tab. 4-3   LED Displays on the Front Panel

The LEDs work regardless of whether an optional ES4060.1 processor module is assembled on the ES4550.1 or not.

"*Threshold*" *LED*

The "Theshold" display indicates whether the references for the voltage and current comparators have inadmissible values. As soon as the "upper" reference is lower than the "lower" reference, this LED lights up. At the same time, LEDs LD1 .. LD12 light up and the visualization of the measuring signals is no longer valid.

"*Configuration*" *LED*

The "Configuration" LED indicates whether the board's measuring signals are configured as the lower (channel 107..120 and 254 .. 267) or upper range (channel 121..134 and 268..281) of the backplane measure channels. When the lower range is configured, the LED lights up; when the upper range is configured, the LED does not light up. If the configuration is not clear, the LED flashes.

"*Fuse*" *LED*

The "Fuse" LED lights up when all fuses are intact. If one of the fuses fuses, the LED goes out.

"*Overtemp*" *LED*

The "Overtemp" LED lights up as soon as an inadmissibly high temperature is detected on one of the load piggybacks. The LED is normally off.

"*LDNN*" *LEDs*

The LEDs "LD1" .. "LD12" visualize the voltage or current measuring signals. As soon as the measuring signal exceeds the "upper" reference, the relevant LED lights up - if the measuring signal goes below the "lower" reference, it goes out again.

4.3 Speaker

The speaker makes acoustic control of the voltage or current measuring signals possible. This means that the drop out of periodic signals, such as the control of injection valves, is easy to detect acoustically. The outputs of the voltage or current measuring signal comparators are compiled via an OR circuit and then transmitted to the speaker.

4.4 Switch

If the acoustic signal is not required, the speaker can be switched off using the "Speaker on/off" switch.

4.5 Threshold Potentiometer

The references for the voltage and current measuring signal comparators can be set using the two potentiometers "Threshold upper" and "Threshold lower". The setting range is -10 V .. +10 V. This corresponds to the output voltage range of the measuring signals on the backplane.

5   Technical Data

Piggybacks	GDI, Common Rail, piezo, original load integration
Current rating "ECU" connector	20 A
Current rating "Ext. Load" connector	20 A
Voltage rating "ECU" connector	+250 V
Voltage rating "Ext. Load" connector	+250 V
Transmission bandwidth RS485	57.6 kbps
Transmission bandwidth CAN	500 kbps
Insert depth	340 mm
Height	233 mm
Front panel width	12 HP
Front panel height	6 U
Ambient temperature during operation	+5 °C .. +35 °C

6　Description of the Firmware Commands

This chapter describes the board-specific firmware commands for the ES4550.1 Loadbox Emulation Board.

6.1　Overview

The following table is an overview of the special firmware commands of the ES4550.1 Loadbox Emulation Board described in this chapter.

The command ID of the CAN command is specified hexadecimally. A tick in the "RV" column shows that this command has return values.

Command	ID	RV	Page
Set_LED	x0101		page 76
Get_LED	x0102	√	page 79
Get_SW	x0122	√	page 84
Get_Comp	x0123	√	page 85
Get_PBCfg	x0124	√	page 89
Get_Fuse	x0125	√	page 90
Set_Speaker	x0130		page 92
Set_BPCntrl	x0140		page 93
Get_BPCntrl	x0141	√	page 94
Set_Meas	x0150		page 95
Get_Meas	x0151	√	page 96
Set_Threshold	x0152		page 97
Set_Tmp	x0153		page 98
Get_Threshold	x0154	√	page 99
Get_Tmp	x0155	√	page 100
Get_BatCfg	x01A0	√	page 101
Set_Cal	x0A00		page 102
Cal_Flash	x0A02		page 103
Set_Cal_Date	x0A10		page 104
Get_Cal_Date	x0A11	√	page 105

6.2 ES4550.1 Commands

This section contains a description of the ES4550.1-specific CAN commands. These commands are executed by LabCar Pin Control as CAN macros.

```
Set_LED
```

Command ID: 0101 (hex) / 257 (dec)

Description: `Set_LED` is used to configure the LEDs.

Parameters:

DPRAM Address	Content
130[1..0]	Sets the "Threshold" LED 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically
130[3..2]	Sets the "Config" LED 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically
130[5..4]	Sets the "Fuse" LED 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically
130[7..6]	Sets the "Over Temperature" LED 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically
131[1..0]	Sets the "LD1" LED (slot 0 / load 0) 0: LED off 1: LED on 2, 3: LED flashing
131[3..2]	Sets the "LD2" LED (slot 0 / load 1) 0: LED off 1: LED on 2, 3: LED flashing

DPRAM Address	Content
131[5..4]	Sets the "LD3" LED (slot 0 / load 2) 0: LED off 1: LED on 2, 3: LED flashing
131[7..6]	Sets the "LD4" LED (slot 1 / load 0) 0: LED off 1: LED on 2, 3: LED flashing
132[1..0]	Sets the "LD5" LED (slot 1 / load 1) 0: LED off 1: LED on 2, 3: LED flashing
132[3..2]	Sets the "LD6" LED (slot 1 / load 2) 0: LED off 1: LED on 2, 3: LED flashing
132[5..4]	Sets the "LD7" LED (slot 2 / load 0) 0: LED off 1: LED on 2, 3: LED flashing
132[7..6]	Sets the "LD8" LED (slot 2 / load 1) 0: LED off 1: LED on 2, 3: LED flashing
133[1..0]	Sets the "LD9" LED (slot 2 / load 2) 0: LED off 1: LED on 2, 3: LED flashing
133[3..2]	Sets the "LD10" LED (slot 3 / load 0) 0: LED off 1: LED on 2, 3: LED flashing

DPRAM Address	Content
133[5..4]	Sets the "LD11" LED (slot 3 / load 1) 0: LED off 1: LED on 2, 3: LED flashing
133[7..6]	Sets the "LD12" LED (slot 3 / load 2) 0: LED off 1: LED on 2, 3: LED flashing
134[1..0]	Configures LEDs "LD1" .. "LD12" 0: LEDs are controlled by programming 1: LEDs are controlled automatically by the current comparators 2: LEDs are controlled automatically by the voltage comparators 3: LEDs are controlled automatically in accordance with DIP switch 0

Return values: None

```
Get_LED
```

Command ID: 0102 (hex) / 258 (dec)

Description: `Get_LED` is used to query the current status of the LEDs.

Parameters: None

Return values:

DPRAM Address	Content
130[0]	Control of the "Threshold" LED 0: automatic 1: programmed
130[2..3]	Status of the "Threshold" LED 0: LED off 1: LED on 2: LED flashing
130[4]	Control of the "Config" LED 0: automatic 1: programmed
130[6..5]	Status of the "Config" LED 0: LED off 1: LED on 2: LED flashing
131[0]	Control of the "Fuse" LED 0: automatic 1: programmed
131[2..1]	Status of the "Fuse" LED 0: LED off 1: LED on 2: LED flashing
131[4]	Control of the "Overtemp" LED 0: automatic 1: programmed
131[6..5]	Status of the "Overtemp" LED 0: LED off 1: LED on 2: LED flashing
132[0]	Control of the "LD1" LED (slot 0 / load 0) 0: automatic 1: programmed

DPRAM Address	Content
132[3..1]	Status of the "LD1"LED (slot 0 / load 0) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)
132[4]	Control of the "LD2" LED (slot 0 / load 1) 0: automatic 1: programmed
132[7..5]	Status of the "LD2" LED (slot 0 / load 1) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)
133[0]	Control of the "LD3" LED (slot 0 / load 2) 0: automatic 1: programmed
133[3..1]	Status of the "LD3" LED (slot 0 / load 2) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)
133[4]	Control of the "LD4" LED (slot 1 / load 0) 0: automatic 1: programmed
133[7..5]	Status of the "LD4" LED (slot 1 / load 0) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)

DPRAM Address	Content
134[0]	Control of the "LD5" LED (slot 1 / load 1) 0: automatic 1: programmed
134[3..1]	Status of the "LD5" LED (slot 1 / load 1) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)
134[4]	Control of the "LD6" LED (slot 1 / load 2) 0: automatic 1: programmed
134[7..5]	Status of the "LD6" LED (slot 1 / load 2) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)
135[0]	Control of the "LD7" LED (slot 2 / load 0) 0: automatic 1: programmed
135[3..1]	Status of the "LD7" LED (slot 2 / load 0) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)
135[4]	Control of the "LD8" LED (slot 2 / load 1) 0: automatic 1: programmed

DPRAM Address	Content
135[7..5]	Status of the "LD8" LED (slot 2 / load 1) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)
136[0]	Control of the "LD9" LED (slot 2 / load 2) 0: automatic 1: programmed
136[3..1]	Status of the "LD9" LED (slot 2 / load 2) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)
136[4]	Control of the "LD10" LED (slot 3 / load 0) 0: automatic 1: programmed
136[7..5]	Status of the "LD10" LED (slot 3 / load 0) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)
137[0]	Control of the "LD11" LED (slot 3 / load 1) 0: automatic 1: programmed

DPRAM Address	Content
137[3..1]	Status of the "LD11" LED (slot 3 / load 1) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)
137[4]	Control of the "LD12" LED (slot 3 / load 2) 0: automatic 1: programmed
137[7..5]	Status of the "LD12" LED (slot 3 / load 2) 0: LED off 1: LED on 2: LED flashing 3: LED is controlled automatically by the current comparator (no indication of the current LED status) 4: LED is controlled automatically by the voltage comparator (no indication of the current LED status)

```
Get_SW
```

Command ID: 0122 (hex) / 290 (dec)

Description: `Get_SW` is used to query the status of the DIP switches.

Parameters: None

Return values:

DPRAM Address	Content
130[0]	Status of DIP switch 0 0: DIP switch off 1: DIP switch on
130[1]	Status of DIP switch 1 0: DIP switch off 1: DIP switch on
130[2]	Status of DIP switch 2 0: DIP switch off 1: DIP switch on
130[3]	Status of DIP switch 3 0: DIP switch off 1: DIP switch on

```
Get_Comp
```

Command ID: 0123 (hex) / 291 (dec)

Description: `Get_Comp` is used to query the status of the voltage and current comparators.

Parameters: None

Return values:

DPRAM Address	Content
130[1..0]	Voltage 1 (slot 0 / load 0) 0: U1 < "lower" reference 1: "lower" reference < U1 < "upper" reference 2: inadmissible status 3: "upper" reference < U1
130[3..2]	Current 1 (slot 0 / load 0) 0: I1 < "lower" reference 1: "lower" reference < I1 < "upper" reference 2: inadmissible status 3: "upper" reference < I1
130[5..4]	Voltage 2 (slot 0 / load 1) 0: U2 < "lower" reference 1: "lower" reference < U2 < "upper" reference 2: inadmissible status 3: "upper" reference < U2
130[7..6]	Current 2 (slot 0 / load 1) 0: I2 < "lower" reference 1: "lower" reference < I2 < "upper" reference 2: inadmissible status 3: "upper" reference < I2
131[1..0]	Voltage 3 (slot 0 / load 2) 0: U3 < "lower" reference 1: "lower" reference < U3 < "upper" reference 2: inadmissible status 3: "upper" reference < U3
131[3..2]	Current 3 (slot 0 / load 2) 0: I3 < "lower" reference 1: "lower" reference < I3 < "upper" reference 2: inadmissible status 3: "upper" reference < I3

DPRAM Address	Content
131[5..4]	Voltage 4 (slot 1 / load 0) 0: U4 < "lower" reference 1: "lower" reference < U4 < "upper" reference 2: inadmissible status 3: "upper" reference < U4
131[7..6]	Current 4 (slot 1 / load 0) 0: I4 < "lower" reference 1: "lower" reference < I4 < "upper" reference 2: inadmissible status 3: "upper" reference < I4
132[1..0]	Voltage 5 (slot 1 / load 1) 0: U5 < "lower" reference 1: "lower" reference < U5 < "upper" reference 2: inadmissible status 3: "upper" reference < U5
132[3..2]	Current 5 (slot 1 / load 1) 0: I5 < "lower" reference 1: "lower" reference < I5 < "upper" reference 2: inadmissible status 3: "upper" reference < I5
132[5..4]	Voltage 6 (slot 1 / load 2) 0: U6 < "lower" reference 1: "lower" reference < U6 < "upper" reference 2: inadmissible status 3: "upper" reference < U6
132[7..6]	Current 6 (slot 1 / load 2) 0: I6 < "lower" reference 1: "lower" reference < I6 < "upper" reference 2: inadmissible status 3: "upper" reference < I6
133[1..0]	Voltage 7 (slot 2 / load 0) 0: U7 < "lower" reference 1: "lower" reference < U7 < "upper" reference 2: inadmissible status 3: "upper" reference < U7
133[3..2]	Current 7 (slot 2 / load 0) 0: I7 < "lower" reference 1: "lower" reference < I7 < "upper" reference 2: inadmissible status 3: "upper" reference < I7

DPRAM Address	Content
133[5..4]	Voltage 8 (slot 2 / load 1) 0: U8 < "lower" reference 1: "lower" reference < U8 < "upper" reference 2: inadmissible status 3: "upper" reference < U8
133[7..6]	Current 8 (slot 2 / load 1) 0: I8 < "lower" reference 1: "lower" reference < I8 < "upper" reference 2: inadmissible status 3: "upper" reference < I8
134[1..0]	Voltage 9 (slot 2 / load 2) 0: U9 < "lower" reference 1: "lower" reference < U9 < "upper" reference 2: inadmissible status 3: "upper" reference < U9
134[3..2]	Current 9 (slot 2 / load 2) 0: I10 < "lower" reference 1: "lower" reference < I9 < "upper" reference 2: inadmissible status 3: "upper" reference < I9
134[5..4]	Voltage 10 (slot 3 / load 0) 0: U10 < "lower" reference 1: "lower" reference < U10 < "upper" reference 2: inadmissible status 3: "upper" reference < U10
134[7..6]	Current 10 (slot 3 / load 0) 0: I10 < "lower" reference 1: "lower" reference < I10 < "upper" reference 2: inadmissible status 3: "upper" reference < I10
135[1..0]	Voltage 11 (slot 3 / load 1) 0: U11 < "lower" reference 1: "lower" reference < U11 < "upper" reference 2: inadmissible status 3: "upper" reference < U11
135[3..2]	Current 11 (slot 3 / load 1) 0: I11 < "lower" reference 1: "lower" reference < I11 < "upper" reference 2: inadmissible status 3: "upper" reference < I11

DPRAM Address	Content
135[5..4]	Voltage 12 (slot 3 / load 2) 0: U12 < "lower" reference 1: "lower" reference < U12 < "upper" reference 2: inadmissible status 3: "upper" reference < U12
135[7..6]	Current 12 (slot 3 / load 2) 0: I12 < "lower" reference 1: "lower" reference < I12 < "upper" reference 2: inadmissible status 3: "upper" reference < I12
136[0]	Comparison of references 0: "lower" reference < "upper" reference 1: "lower" reference > "upper" reference

`Get_PBCfg`

Command ID: 0124 (hex) / 292 (dec)

Description: `Get_PBCfg` is used to query the identification number of the load piggybacks.

Parameters: None

Return values:

DPRAM Address	Content
130[2..0] + 131[7..0]	Identification number of the piggyback module in slot 0
132[2..0] + 133[7..0]	Identification number of the piggyback module in slot 1
134[2..0] + 135[7..0]	Identification number of the piggyback module in slot 2
136[2..0] + 137[7..0]	Identification number of the piggyback module in slot 3

```
Get_Fuse
```

Command ID: 0125 (hex) / 293 (dec)

Description: `Get_Fuse` is used to query the status of the fuses.

Parameters: None

Return values:

DPRAM Address	Content
130[0]	Status of the "BN0" fuse (channel 333) 0: fuse intact 1: fuse defective
130[1]	Status of the "BN1" fuse (channel 332) 0: fuse intact 1: fuse defective
130[2]	Status of the "BN2" fuse (channel 331) 0: fuse intact 1: fuse defective
130[3]	Status of the "BN3" fuse (channel 330) 0: fuse intact 1: fuse defective
130[4]	Status of the "BN4" fuse (channel 338) 0: fuse intact 1: fuse defective
130[5]	Status of the "BN5" fuse (channel 337) 0: fuse intact 1: fuse defective
130[6]	Status of the "BN6" fuse (channel 326) 0: fuse intact 1: fuse defective
130[7]	Status of the "BN7" fuse (channel 327) 0: fuse intact 1: fuse defective

DPRAM Address	Content
131[0]	Status of the "-UBatt" fuse 0: fuse intact 1: fuse defective
131[1]	Status of the "+UBatt_A" fuse 0: fuse intact 1: fuse defective
131[2]	Status of the "+UBatt_B" fuse 0: fuse intact 1: fuse defective

```
Set_Speaker
```

Command ID: 0130 (hex) / 304 (dec)

Description: `Set_Speaker` is used to configure the control of the speaker.

Parameters:

DPRAM Address	Content
130[1..0]	Status of the speaker 0: speaker off 1: speaker on 2: speaker in accordance with the switch on the front panel
130[5..4]	Control of the speaker 0: a click 1: sustained signal 100 Hz 2: sustained signal 50 Hz 3: speaker is controlled automatically

Return values: None

```
Set_BPCntrl
```

Command ID: 0140 (hex) / 320 (dec)

Description: `Set_BPCntrl` is used to configure the backplane control signals.

Parameters:

DPRAM Address	Content
130[0]	System emergency shutdown (channel 29) 0: inactive 1: active
130[1]	Battery voltage A emergency shutdown (channel 45) 0: inactive 1: active
130[2]	Battery voltage B emergency shutdown (channel 52) 0: inactive 1: active
1303]	Reset output (channel 19) 0: inactive 1: active
130[4]	Configuration of the reset input (channel 19) 0: resets the processor module 1: does not reset the processor module

Return values: None

```
Get_BPCntrl
```

Command ID: 0141 (hex) / 321 (dec)

Description: `Get_BPCntrl` is used to query the current setting of the backplane control signals.

Parameters: None

Return values:

DPRAM Address	Content
130[0]	System emergency shutdown (channel 29, output) 0: inactive 1: active
130[1]	Battery voltage A emergency shutdown (channel 45, output) 0: inactive 1: active
130[2]	Battery voltage B emergency shutdown (channel 52, output) 0: inactive 1: active
130[3]	Reset output (channel 19) 0: inactive 1: active
130[4]	Configuration of the reset input (channel 19) 0: resets processor module 1: does not reset the processor module
131[0]	System emergency shutdown (channel 29, input) 0: inactive 1: active

```
Set_Meas
```

Command ID: 0150 (hex) / 336 (dec)

Description: `Set_Meas` is used to configure the settings for the signal adaptation of the measuring signals.

Parameters:

DPRAM Address	Content
130[0]	Configuration of the voltage measurement 0: no filter 1: filter 5 kHz
130[1]	Configuration of the current measurement 0: no filter 1: filter 5 kHz
130[2]	Configuration of the offset calibration of the current measurement 0: no offset calibration 1: offset calibration active

Return values: None

```
Get_Meas
```

Command ID: 0151 (hex) / 337 (dec)

Description: `Get_Meas` is used to query the current settings of the signal matching of the measuring signals.

Parameters: None

Return values:

DPRAM Address	Content
130[0]	Status of the voltage measurement 0: no filter 1: filter 5 kHz
130[1]	Status of the current measurement 0: no filter 1: filter 5 kHz
130[2]	Status of the offset calibration of the current measurement 0: no offset calibration 1: offset calibration active
130[5..4]	Backplane area of the measure channels 0: [107..120] and [254..267] 1: [121..134] and [268..281] 2: incorrect jumper configuration (see section 2.2.1 on page 19)

`Set_Threshold`

Command ID: 0152 (hex) / 338 (dec)

Description: `Set_Threshold` is used to configure the references for the voltage and current comparators.

Parameters:

DPRAM Address	Content
130[0]	Reference source 0: potentiometer on the front panel 1: programmed
131[1..0] + 132[7..0]	Value of the "lower" reference
133[1..0] + 134[7..0]	Value of the "higher" reference

Return values: None

```
Set_Tmp
```

Command ID: 0153 (hex) / 339 (dec)

Description: Set_Tmp is used to configure the maximum admissible temperatures on the load piggybacks. The values are specified in °C; the value range is 0 .. 65.

Parameters:

DPRAM Address	Content
130[6..0]	Maximum admissible temperature on piggyback module 0 (0 °C .. 65 °C)
131[6..0]	Maximum admissible temperature on piggyback module 1 (0 °C .. 65 °C)
132[6..0]	Maximum admissible temperature on piggyback module 2 (0 °C .. 65 °C)
133[6..0]	Maximum admissible temperature on piggyback module 3 (0 °C .. 65 °C)

Return values: None

`Get_Threshold`

Command ID: 0154 (hex) / 340 (dec)

Description: `Get_Threshold` is used to query the reference settings for the voltage and current comparators.

Parameters: None

Return values:

DPRAM Address	Content
130[0]	Source of the references 0: potentiometer on the front panel 1: programmed
131[1..0] + 132[7..0]	Status of the "lower" reference
133[1..0] + 134[7..0]	Status of the "higher" reference

```
Get_Tmp
```

Command ID: 0155 (hex) / 341 (dec)

Description: `Get_Tmp` is used to query the overtemperature protection status and the current temperatures on the load piggybacks. The values are specified in °C.

Parameters: None

Return values:

DPRAM Address	Content
130[6..0]	Temperature on load piggyback 0 (0 °C .. 100 °C)
130[7]	Status of the overtemperature protection of piggyback 0 0: no overtemperature 1: overtemperature
131[6..0]	Temperature on load piggyback 1 (0 °C .. 100 °C)
131[7]	Status of the overtemperature protection of piggyback 1 0: no overtemperature 1: overtemperature
132[6..0]	Temperature on load piggyback 2 (0 °C .. 100 °C)
132[7]	Status of the overtemperature protection of piggyback 2 0: no overtemperature 1: overtemperature
133[6..0]	Temperature on load piggyback 3 (0 °C .. 100 °C)
133[7]	Status of the overtemperature protection of piggyback 3 0: no overtemperature 1: overtemperature

```
Get_UBatCfg
```

Command ID: 01A0 (hex) / 416 (dec)

Description: `Get_UBatCfg` is used to query the settings of the second battery voltage +UBatt_B.

Parameters: None

Return values:

DPRAM Address	Content
130[0]	Configuration of +UBatt_B 0: +UBatt_B 1: channels 313 to 319 as separate 3 A channels

```
Set_Cal
```

Command ID: 0A00 (hex) / 2560 (dec)

Description: Set_Cal saves one value for the offset compensation of a current measuring signal.

Parameters:

DPRAM Address	Content
130[7..4]	Number of the measuring signal 12 .. 1
130[1..0] + 131[7..0]	Value for offset compensation

Return values: None

```
Cal_Flash
```

Command ID: 0A02 (hex) / 2562 (dec)

Description: `Cal_Flash` is used to control the flash memory operations.

The flash memory operation "Load" loads calibration values from the flash memory into the values list which is used to set the offset compensation. The "Load" command is executed automatically during initialization of the ES4550 (after power-on or when the board has been reset). If the board has never been calibrated, default values are used during initialization until the board is calibrated for the first time.

The values in the value list can be modified using "Set_Cal". The values currently in the value list for the offset compensation can be written to the flash memory with the flash memory operation "Save". They are then used again automatically when the board is next powered on.

The flash memory operation "Reset to Nominal Values" assigns the value list the default values before the first calibration.

Parameters:

DPRAM Address	Content
130[1..0]	Flash memory operations 0: Load 1: Save 2: Reset to Nominal Values

Return values: None

Set_Cal_Date

Command ID: 0A10 (hex) / 2576 (dec)

Description: Set_Cal_Data is used to write the date and name of the person who executed the last calibration into the serial flash memory. The data is stored in ASCII.

Parameters:

DPRAM Address	Content
130[7..0]	Date: tens column of the day
131[7..0]	Date: units column of the day
132[7..0]	Date: tens column of the month
133[7..0]	Date: units column of the month
134[7..0]	Date: thousands column of the year
135[7..0]	Date: hundreds column of the year
136[7..0]	Date: tens column of the year
137[7..0]	Date: units column of the year
138[7..0]	Person executing the test: 1st letter
139[7..0]	Person executing the test: 2nd letter
140[7..0]	Person executing the test: 3rd letter
141[7..0]	Person executing the test: 4th letter
142[7..0]	Person executing the test: 5th letter
143[7..0]	Person executing the test: 6th letter
144[7..0]	Person executing the test: 7th letter
145[7..0]	Person executing the test: 8th letter
146[7..0]	Person executing the test: 9th letter
147[7..0]	Person executing the test: 10th letter
148[7..0]	Person executing the test: 11th letter
149[7..0]	Person executing the test: 12th letter
150[7..0]	Person executing the test: 13th letter
151[7..0]	Person executing the test: 14th letter
152[7..0]	Person executing the test: 15th letter
153[7..0]	Person executing the test: 16th letter

Return values: None

```
Get_Cal_Date
```

Command ID: 0A11 (hex) / 2577 (dec)

Description: `Get_Cal_Date` is used to read the date and name of the person who last calibrated the board. The data is stored in ASCII.

Parameters: None

Return values:

DPRAM Address	Content
130[7..0]	Date: tens column of the day
131[7..0]	Date: units column of the day
132[7..0]	Date: tens column of the month
133[7..0]	Date: units column of the month
134[7..0]	Date: thousands column of the year
135[7..0]	Date: hundreds column of the year
136[7..0]	Date: tens column of the year
137[7..0]	Date: units column of the year
138[7..0]	Person executing the test: 1st letter
139[7..0]	Person executing the test: 2nd letter
140[7..0]	Person executing the test: 3rd letter
141[7..0]	Person executing the test: 4th letter
142[7..0]	Person executing the test: 5th letter
143[7..0]	Person executing the test: 6th letter
144[7..0]	Person executing the test: 7th letter
145[7..0]	Person executing the test: 8th letter
146[7..0]	Person executing the test: 9th letter
147[7..0]	Person executing the test: 10th letter
148[7..0]	Person executing the test: 11th letter
149[7..0]	Person executing the test: 12th letter
150[7..0]	Person executing the test: 13th letter
151[7..0]	Person executing the test: 14th letter
152[7..0]	Person executing the test: 15th letter
153[7..0]	Person executing the test: 16th letter

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Index