TTControl
HYDAC INTERNATIONAL

Fusion

User Manual

Product versions 00.05, 00.06, 00.07 and 00.08

Original Instructions

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Revision History

Date	Author	Version	Comment
2023-07-19	TTC	0.1.0	• Initial version
2023-11-16	TTC	0.1.1	• Added information about product version 0.06 • Corrected values and diagrams throughout the document • Added missing content throughout the document
2024-02-13	TTC	0.2.0	• Added several chapters to the document • Corrected values and diagrams throughout the document • Added missing content throughout the document

2024-05-13	TTC	0.3.0	• Added information about CAN FD
			• Added information about product versions 0.07 and 00.08
			• Clarified information about T15 usage
			• Corrected low-voltage mode values
			• Updated functional descriptions
			  • 1000/100BASE-T1
			  • CPUs
			  • A^2B audio bus
			• Corrected values and diagrams throughout the document
			  • Hardware corner frequency (digital inputs)
			  • Supply pin (BAT+)
			  • Input voltage measurement tolerance (digital inputs)
			  • Nominal input voltage range (RTC)
			  • Non-destructive working voltage range (RTC)

2024-09-09	TTC	0.3.1	• Added ”Conformities” chapter • Corrected LIN voltage value • Amended text regarding safety-critical usage
2024-09-17	TTC	1.0.0	• Final released version

1 Introduction

1.1 General

This document provides detailed information about the Fusion, including applicable safety standards and guidelines, instructions for safe operation, connectors and parts, I/O features, and other hardware-related topics.

This User Manual is intended for qualified technicians and system integrators.

1.2 Further documentation

This User Manual is one of many user documents for the Fusion. Please see your release package for additional user documentation.

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2 Product overview

The information in this User Manual refers to a prototype version of the Fusion (product versions 00.05, 00.06, 00.07 and 00.08). The information contained in this document is subject to change.

2.1 General description

The Fusion is a multi-purpose computing platform with a high-performance multicore processor, able to drive multiple remote displays and offering rich 1000BASE-T1, 100BASE-T1, 100BASE-TX connectivity. The separation of the computing unit from the display functions allows for freedom in the deployment of application windows, and flexibility in the number of displays and their position in the operator cabin.

2.2 Block diagram

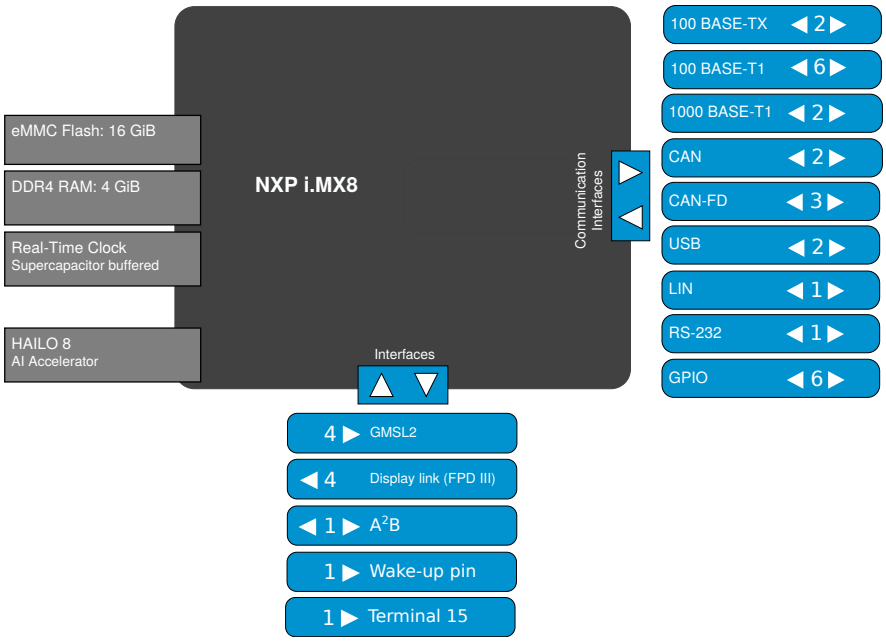

Figure 1: *Block diagram for the Fusion*

2.3 Physical specifications

- Dimensions: 200 x 244 x 39.2 mm
- Weight: 1957 g
- Operating temperature: -40 to +70 °C
- Storage temperature: -40 to +85 °C
- IP rating: IP67, IP6K9K for product version 00.07 and 00.08
- IP rating: IP20 for product version 00.05 and 00.06

Additional physical specifications, including thermal requirements, can be found in the Mounting Requirements Document (MRD) [2].

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2.4 System components

Components	Fusion
CPU	Multicore i.MX 8® Series SoC
DDR4 RAM	4 GiB
eMMC Flash	16 GiB
Real-Time Clock (super-capacitor buffered)	1
Non-volatile memory	32 KiB EEPROM
Temperature sensors	2
Power LED	1
Status LED	3
Service pin	2
Terminal 15	yes
Wake-up	yes
RTC	yes
Load dump protection	yes
ISOBUS compatibility	yes

Table 1: *Fusion system components*

2.5 Interfaces

Interface	Fusion 300	Fusion 422	Fusion 622	Fusion 844	Fusion 844 AI
CAN 2.0B	2	2	2	2	2
CAN FD	3	3	3	3	3
USB 2.0	2	2	2	2	2
100BASE-T1	2	2	4	6	6
100BASE-TX	0	0	2	2	2
1000BASE-T1	1	2	2	2	2
RS-232	1	1	1	1	1
LIN	1	1	1	1	1
GMSL2 camera	0	2	2	4	4
Display link (FPD III)	0	2	2	4	4
Digital input	4	4	4	4	4
High-side output	2	2	2	2	2
A^2B audio bus	No	Yes	Yes	Yes	Yes

Table 2: *Fusion interfaces*

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3 Internal structure

This section gives an overview of the internal structure of the Fusion.

3.1 CPU

The i.MX 8® application processors from NXP are a multicore platform based on the Arm® Cortex® architecture.

Feature	i.MX 8®QuadPlus	i.MX 8®QuadMax
Variant	Fusion 300, 422	Fusion 622, 844, 844 AI
Arm core	1 x Cortex-A72	2 x Cortex-A72
Arm core	4 x Cortex-A53	4 x Cortex-A53
Arm core	2 x Cortex-M4F	2 x Cortex-M4F
GPU	2 x GC7000Lite/XSVX	2 x GC7000XSVX

Table 3: *Fusion i.MX 8® processors – characteristics*

3.2 AI accelerator

The Fusion 844 AI variant includes a Hailo-8 AI processor, featuring up to 26 tera-operations per second (TOPS). With an architecture that takes advantage of the core properties of neural networks, the neural chip allows the Fusion to run deep-learning applications at full scale. The AI accelerator is connected to the CPU via PCIe interface.

3.3 Non-volatile memory

The Fusion contains two different non-volatile memory components:

Main storage eMMC

The memory has a capacity of 16GiB and complies with the eMMC standard V5.1 or newer. While programming the device, the voltages on Terminal 15 and BAT+ inputs must stay within the nominal input voltage range.

User EEPROM

Parameter	Note	Value	Unit
Memory available for user data		32	KiB
Data retention	1	≥ 50	years
Erase/write cycles per byte	1	≥ $1.2*10^6$	cycles

Table 4: *User EEPROM – characteristics*

Note 1 at 70 °C.

3.4 Thermal management and sensors

Temperature sensors

To allow monitoring of the internal temperature, the Fusion is equipped with two temperature sensors. One measures the ambient air temperature within the housing (PCB sensor). The other sensor is integrated in the CPU to measure the core temperature (on-die sensor).

Symbol	Parameter	Note	Min	Max	Unit
T_{op}	Operating temperature measurement range	1	-40	+125	°C
$T_{PCB, acy}$	PCB sensor temperature accuracy at -55 °C to 125 °C		-3	+3	K
$T_{on\text{-}die, acy}$	On-die sensor accuracy		-7	+7	K

Table 5: *Fusion characteristics*

Note 1 Valid for both sensors.

Thermal management

The Fusion is equipped with a standard thermal protection, implemented by Linux. The System on a Chip (SoC) temperature is monitored via the on-die sensor, and the device is protected from overheating by:

- reducing the ARM core clock frequency when SoC temperature reaches 115 °C
- system shut down when the SoC temperature reaches 120 °C

The user is responsible for monitoring the device temperature, and ensuring that the device does not overheat. See MRD [2] for further information.

3.5 Status LEDs

The Fusion has 4 blue LEDs:

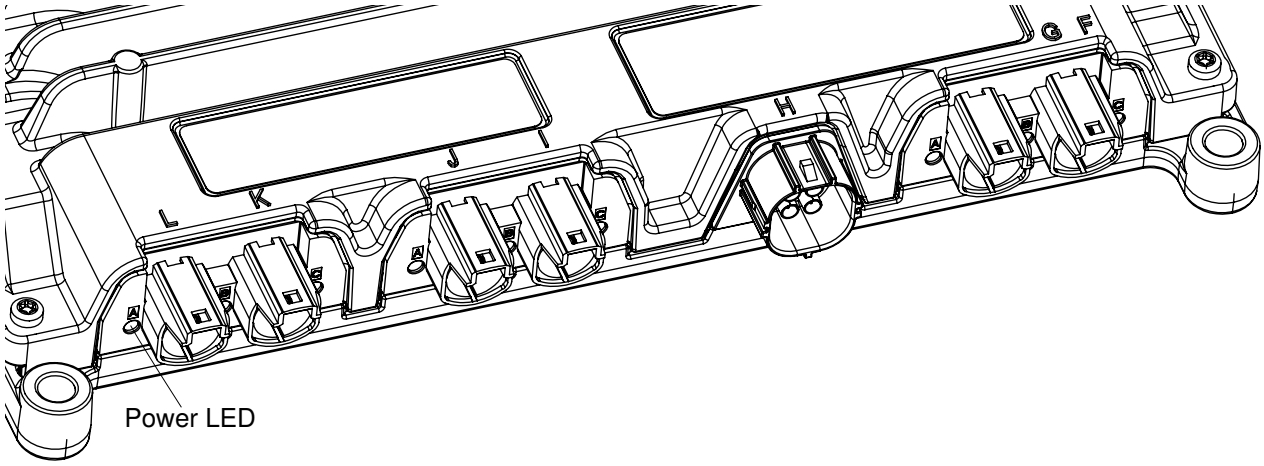

Figure 2: *Power LED placement on the Fusion*

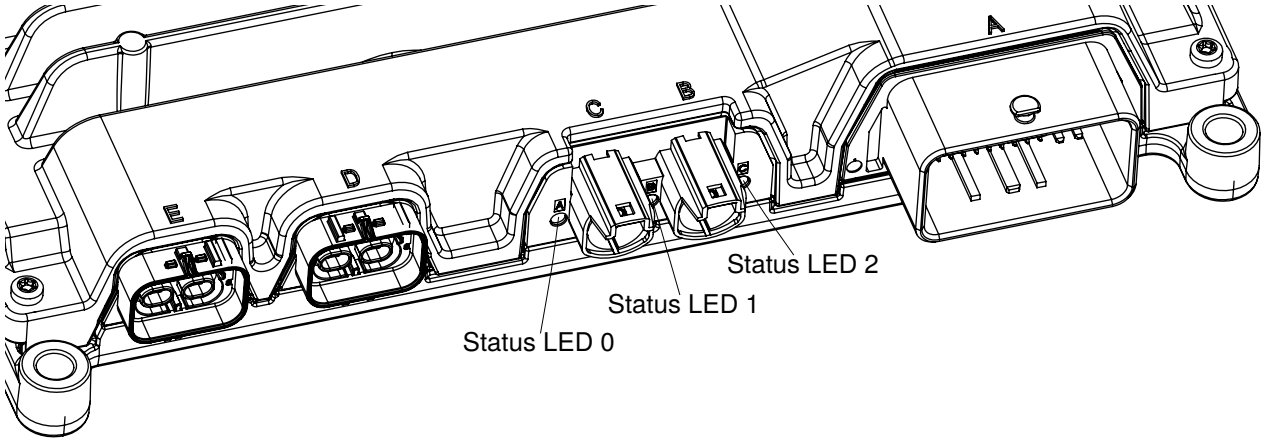

Figure 3: *Status LEDs placement on the Fusion*

- Power LED:
  - Permanently on if the Fusion is powered (BAT+ & BAT- connected), Terminal 15 is high and the Fusion is not in Suspend Mode. For further information, see Power modes.
  - Not controllable by application software.
- Status LED 0:
  - Controllable and dimmable by application software.
  - The control circuit of this LED includes an ultra-low power pulse generator, allowing the LED to flash even in Off Mode while still meeting the low Off Mode power requirements. For further information, see Power modes.
- Status LED 1:
  - Controllable by application software.
- Status LED 2:
  - Controllable by application software.

3.6 Power modes

The Fusion has five power modes:

- In *Disconnected Mode*, BAT+ is disconnected from the power supply. Only the Real-Time Clock is powered (until the RTC energy buffer is drained).
- In *Power-off Mode*, BAT+ is connected to the power supply, but the RAM content is lost. Only the Real-Time Clock is running and gets charged, the rest of the device is off.
- In *Power-on Mode*, BAT+ is connected to the power supply and the device is fully operational.
- In *Suspend Mode*, BAT+ is connected to the power supply and the RAM content is preserved, but the device is mostly inactive.
- In *Low voltage mode*, the Fusion shuts off supply voltages for the following external peripherals:
  - GMSL2 cameras
  - A^2B audio bus peripherals
  - USB devices

The mode transitions can be triggered as follows:

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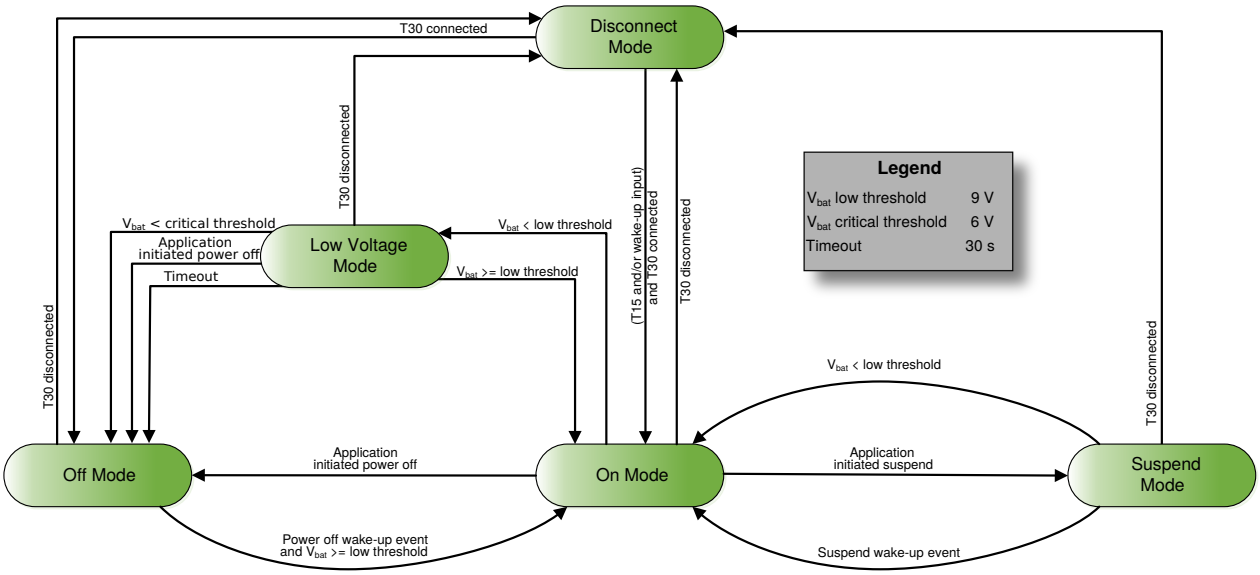

Figure 4: *Power modes*

Power mode transition	Note	Trigger
Disconnected → Power-off		BAT+ connected to power supply
Disconnected → Power-on		Connected to power supply: • BAT+ and Terminal 15 • BAT+ and Wake-up input • BAT+, Terminal 15, and Wake-up input
Power-off → Disconnect		BAT+ disconnected from power supply
Power-off → Power-on	1	Wake-up event: • rising edge on Terminal 15 signal • rising edge on Wake-up signal • reception of wake-up pattern on a wake-up enabled CAN interface • reception of wake-up pattern on a wake-up enabled 100BASE-T1 interface • reception of wake-up pattern on a wake-up enabled 1000BASE-T1 interface • Real-Time Clock with configured alarm-time and date
Power-on → Disconnect	2	BAT+ disconnected from power supply
Power-on → Power-off		On application request
Power-on → Suspend		On application request
Power-on → Low voltage		Battery voltage falls below the nominal supply voltage range
Suspend → Disconnect	2	BAT+ disconnected from power supply

Suspend → Power-on		Battery voltage falls below the nominal supply voltage OR Wake-up event: • rising edge on Terminal 15 signal • rising edge on Wake-up signal • reception of wake-up pattern on a wake-up enabled CAN interface • reception of wake-up pattern on a wake-up enabled 100BASE-T1 interface • reception of wake-up pattern on a wake-up enabled 1000BASE-T1 interface • Real-Time Clock with configured alarm-time and date
Low voltage → Disconnect		BAT+ disconnected from power supply
Low voltage → Power-off	3	On application request or supply voltage is out of specification
Low voltage → Power-on		Battery voltage is within the nominal supply voltage range

Table 6: *Power mode transitions*

Note 1 Ensure that the device remains disconnected for a minimum of one second when switching the device off and on again (corresponds to power mode transition: *Power-off* → *Disconnect* → *Power-on*).

Note 2 Performing this mode transition is *not* recommended as all unsaved data will be lost, and all operations running will be terminated in an uncontrolled manner. Users are advised to power-off by setting Terminal 15 to low, and waiting until the application performs a controlled shut down of the device.

Note 3 This mode transition is done autonomously after 30 s to avoid damaging the hardware as a result of input voltage being out of specification.

4 Specification of inputs and outputs

All values given in the tables below are valid for the ambient operating temperature range: -40 to +70 °C, unless stated otherwise.

4.1 Available connectors

For an overview of the available interfaces on each of the Fusion variants, see section 2.5.

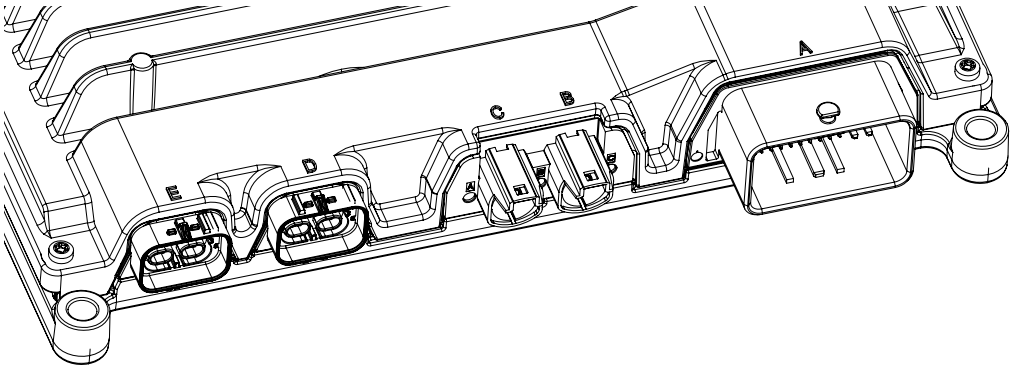

Figure 5: *Connector interfaces E-A on the Fusion*

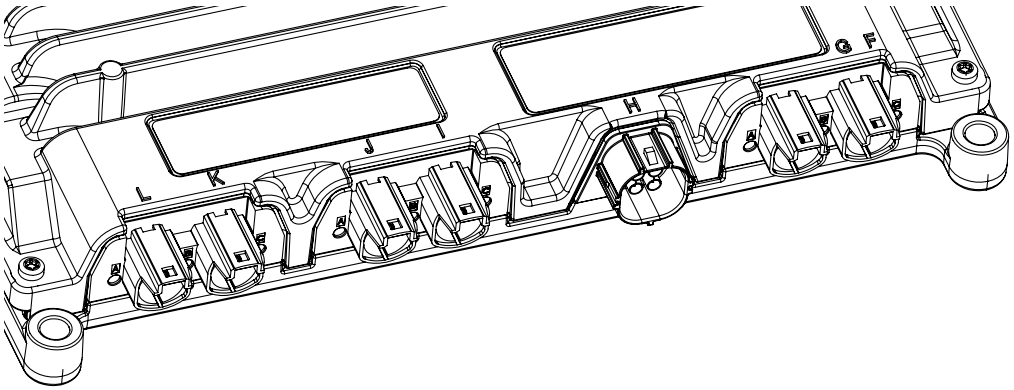

Figure 6: *Connector interfaces L-F on the Fusion*

Connector	Type	Coding	Description
A	Tyco 48 pin CMC header	Black	Main connector
B, C	Rosenberger HSD D4K14A-1D5A5-A	White transparent	USB 2.0
D	Rosenberger E6K14D-1CAZ5-B	Pure white	100/1000BASE-T1
E	Rosenberger E6K14D-1CAZ5-A	White transparent	100BASE-T1
F, G	Rosenberger HSD D4K14A-1D5A5-A	White transparent	100BASE-TX
H	Rosenberger AMK148-102Z5-Z	Water blue	GMSL2 Cameras
I, J, K, L	Rosenberger HSD D4K14A-1D5A5-A	White transparent	Remote displays

Table 7: *Connector interfaces*

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Product version 00.05

Connector	Fusion 300	Fusion 422	Fusion 622	Fusion 844	Fusion 844 AI
A	✓	✓	✓	✓	✓
B	✓	✓	✓	✓	✓
C	✓	✓	✓	✓	✓
D	✓	✓	✓	✓	✓
E			✓	✓	✓
F			✓	✓	✓
G			✓	✓	✓
H		✓	✓	✓	✓
I		✓		✓	✓
J				✓	✓
K		✓	✓	✓	✓
L			✓	✓	✓

Table 8: *Available connectors – product version 00.05*

Product version 00.06, 00.07 and 00.08

Connector	Fusion 300	Fusion 422	Fusion 622	Fusion 844	Fusion 844 AI
A	✓	✓	✓	✓	✓
B	✓	✓	✓	✓	✓
C	✓	✓	✓	✓	✓
D	✓	✓	✓	✓	✓
E			✓	✓	✓
F			✓	✓	✓
G			✓	✓	✓
H		✓	✓	✓	✓
I		✓		✓	✓
J		✓	✓	✓	✓
K				✓	✓
L			✓	✓	✓

Table 9: *Available connectors – product version 00.06, 00.07 and 00.08*

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4.2 Main connector (A)

Mates with: Molex 64320-1311

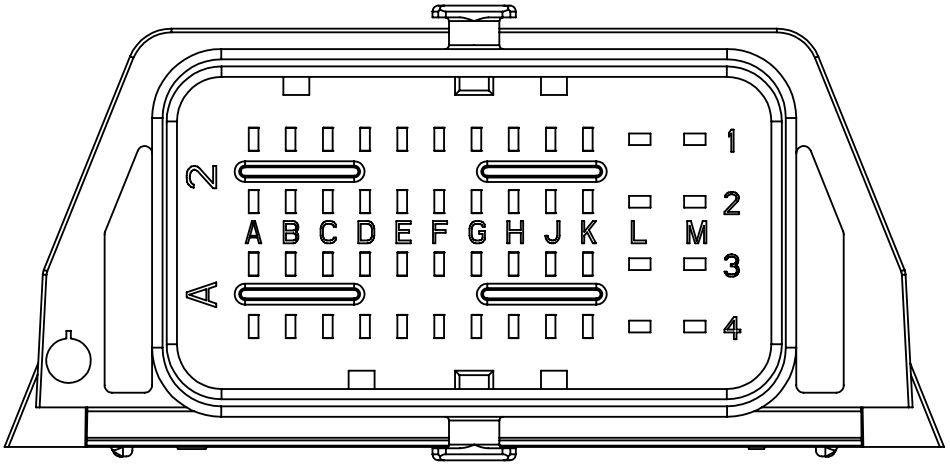

Figure 7: *Main connector (A) pinout*

	1	2	3	4
M	BAT+	BAT+	BAT+	BAT-
L	Digital output 1	Digital output 0	BAT-	BAT-
K	Service 0	Service 1	Terminal 15	Wake-up
J	CAN 2 Termination	RS-232 RX	LIN	RTC BAT
H	CAN 2 High	RS-232 TX	LIN GND	RTC GND
G	CAN 2 Low	RS-232 GND	Digital input 0	Digital input 1
F	CAN 1 Termination	CAN 4 Termination	Digital input GND	Digital input GND
E	CAN 1 High	CAN 4 High	Digital input 2	Digital input 3
D	CAN 1 Low	CAN 4 Low	N/A	N/A
C	CAN 0 Termination	CAN 3 Termination	N/A	A2B+
B	CAN 0 High	CAN 3 High	N/A	A2B-
A	CAN 0 Low	CAN 3 Low	N/A	N/A

Table 10: *Main connector (A) pin group*

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4.3 Positive power supply (BAT+)

To prevent overload under all device load and temperature conditions, always connect all BAT+ and BAT- pins to the vehicle's power supply.

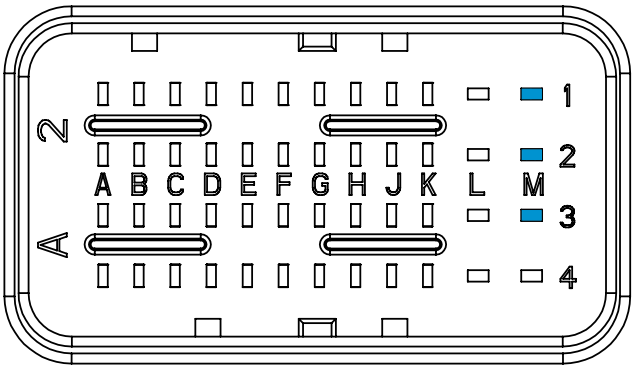

Figure 8: *BAT+ pinout*

Connector	Pin no.	Function
A	M1	Battery power supply input (BAT+)
A	M2	Battery power supply input (BAT+)
A	M3	Battery power supply input (BAT+)

Table 11: *BAT+ pin group*

Functional description

Nominal supply voltage for full operation is 9 to 32 V, including both voltage ranges for 12 V and 24 V battery systems.

While programming the device, the voltages on Terminal 15 and BAT+ inputs must remain within the nominal input voltage range.

Low voltage mode

Below 9 V, the following peripherals will be switched off:

- GMSL2 cameras
- A^2B audio bus peripherals
- USB devices

The CPU is powered and operational down to 6 V power supply (as defined in ISO 16750 part 2 for 12 V systems) for up to 30 s. During this period, the voltage must be raised to 9 V again, or the device will be switched off.

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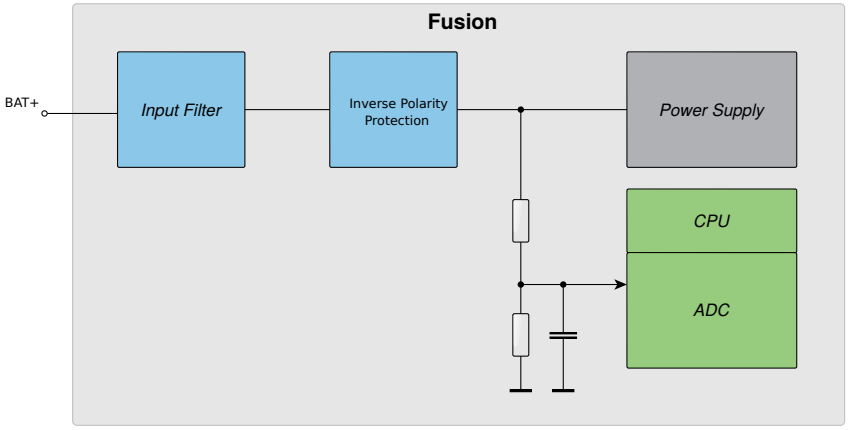

Figure 9: *Fusion supply pin*

Maximum ratings

Symbol	Parameter	Note	Min	Max	Unit
$V_{BAT+\ max}$	Permanent non-destructive supply voltage		-33	33	V
$V_{BAT+\ lim}$	Peak non-destructive supply clamping voltage	1	-40	40	V
$I_{BAT+\ lim}$	Peak non-destructive supply clamping current	1	-10	+100	A
$I_{BAT+\ max}$	Permanent input current at V_{BAT+} = 9 V, 25 °C	2		9.3	A
T_d	Load dump protection according to ISO 16750-2, Pulse 4, test 4.6.4 (superimposed 202 V, R_i = 2 Ω)	1		350	ms

Table 12: *BAT+ – maximum ratings*

Note 1 The control unit is protected by an active load dump protection circuit

Note 2 With external loads.

Characteristics

Symbol	Parameter	Note	Min	Max	Unit
CBAT+	Capacitance load at input			1000	µF
V_{BAT+}	Supply voltage for full operation	1	9	32	V
T_{rise}	Supply voltage rise time	2		3	s

Table 13: *BAT+ – characteristics*

Note 1 For details on power modes and related voltage limits if the supply voltage is below the full operation voltage range, please refer to section 3.6.

Note 2 The time it takes for V_{BAT+} to get higher than 9 V

4.4 Negative power supply (BAT-)

To prevent overload under all device load and temperature conditions, always connect all BAT+ and BAT- pins to the vehicle's power supply.

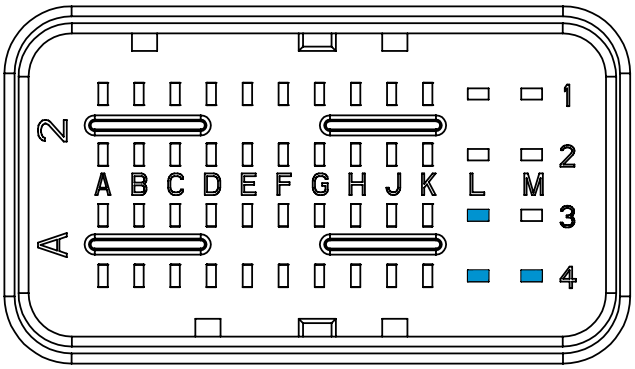

Figure 10: *BAT- pinout*

Connector	Pin no.	Function
A	L3	Battery power supply input (BAT-)
A	L4	Battery power supply input (BAT-)
A	M4	Battery power supply input (BAT-)

Table 14: *BAT- pin group*

Functional description

Pins for negative power supply. The housing of the Fusion is capacitively connected to BAT-.

GND loss detection

The Fusion is equipped with a GND loss detection to protect the device itself and loads connected to the high-side outputs from being damaged by fault currents.

The Fusion housing is not connected to BAT- internally, but must be mounted in a way that it is electrically bonded to the vehicle chassis (vehicle GND). The housing voltage is permanently monitored in comparison to the BAT- voltage. As long as the Fusion is properly connected to BAT-, these two voltages are the same. In case the BAT- connection is lost, these two voltages may differ which could result in high currents at the high-side outputs. Consequently, as soon as the offset between these two voltages is more than +/- 3V, the Fusion internal power supply is switched off within 50ms. The remaining current distributed over connected loads is less than 1 mA in total.

To ensure stable operation and prevent the GND loss detection from being triggered, ensure the following requirements are met:

- Use all three BAT- pins in parallel with dedicated wires to a central grounding point
- Ensure adequate strain relief for all wires

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- Electrically connect the housing of the Fusion to GND. Mount the device directly to the chassis, which is supposed to be connected to BAT- at a central point of the vehicle. Use adequate mounting equipment to puncture the anodic layer of the aluminum housing. If the mounting base is not connected to BAT-, the housing must be connected to BAT- at a mounting point of the device using a ring cable lug and a wire width of at least 0.5 mm^2. Ensure that no currents that could cause a voltage drop (e.g., due to earth loops in the common path) flow through this connection.

Maximum ratings

Symbol	Parameter	Note	Min	Max	Unit
$I_{BAT\text{-}max}$	Permanent supply current at V_{BAT-} = 9 V, 25 °C	1		7.3	A
R_{DC}	DC resistance	2, 3	500	550	kΩ
C_{AC}	AC impedance	2, 3	88	132	nF
$U_{DC/AC}$	Max DC/AC peak voltage level	2, 3	-28	+28	V
U_{max}	Max transient level EN61000-4-5 (1.2 µs/50 µs, 12R generator resistance)	2, 3	-0.5	+0.5	kV

Table 15: *BAT- – maximum ratings*

Note 1 With external loads.

Note 2 Electrical separation of housing to GND.

Note 3 BAT- to housing.

4.5 Ignition on switch input (Terminal 15)

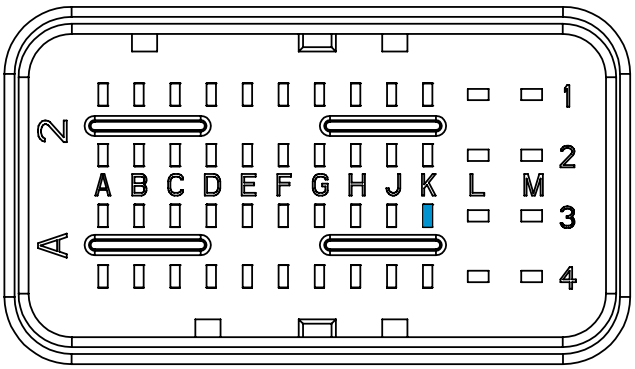

Figure 11: *Terminal 15 pinout*

Connector	Pin no.	Function
A	K3	Terminal 15

Table 16: *Terminal 15 – pin group*

Functional description

Terminal 15 switches the power supply of the Fusion.

When switched to positive supply, this input gives the command to power up the Fusion, regardless of the Wake-up pin status. When switched off, the Fusion activates its keep-alive functionality[1] (if keep-alive functionality is enabled by software) and the device is switched off by the user application software.

While programming the device, the voltages on Terminal 15 and BAT+ inputs must remain within the nominal input voltage range.

Power-on/off sequence

Prior to software release 0.5.0.0, Terminal 15 was defined as level-triggered functionality. Starting with software release 0.5.0.0, the initial connection to BAT+ is level-triggered; however, the device powers on with the rising edge of Terminal 15 thereafter.

Once the device has started, the application software is responsible for saving all data to flash memory before it powers down the device. This is necessary to ensure data integrity.

1. The keep-alive functionality is activated by default.

Maximum ratings

Symbol	Parameter	Min	Max	Unit
V_{in}	Permanent (DC) input voltage	-33	33	V
V_{in}	Transient peak input voltage 500 ms	-50	50	V
V_{in}	Transient peak input voltage 1 ms	-200	200	V

Table 17: *Terminal 15 – maximum ratings*

Characteristics

Symbol	Parameter	Min	Max	Unit
R_{GND}	Pin input resistance to GND	7	11	kΩ
C_{in}	Pin input capacitance	8	12	nF
V_{IL}	Input voltage for low level	-33	3	V
V_{IH}	Input voltage for high level	8.66	33	V
τ_{in}	Input low-pass filter	0.1	0.3	ms

Table 18: *Terminal 15 – characteristics*

4.6 Wake-up

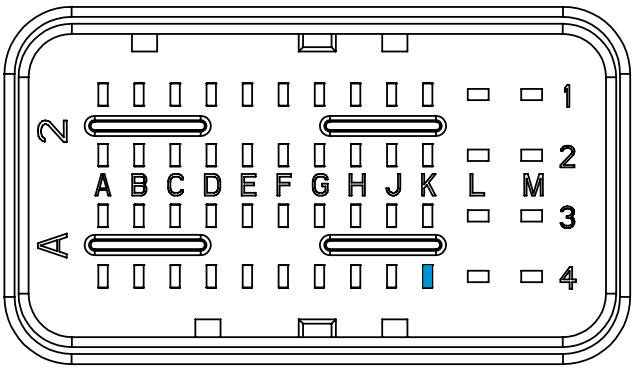

Figure 12: *Wake-up pinout*

Connector	Pin no.	Function
A	K4	Wake-up

Table 19: *Wake-up – pin group*

Functional description

This is a pin to wake up the Fusion from power-off and suspend mode. The application software needs to enable this pin as a wake-up source. When switched to positive supply (rising edge triggered), this input triggers the power-on sequence regardless of the Terminal 15 pin status. Once the power-on sequence is initiated, switching the wake-up pin has no effect.

The application software can command the Fusion to switch off even if the wake-up pin is high.

Characteristics

Symbol	Parameter	Note	Min	Max	Unit
R_{GND}	Pin input resistance to GND		106.7	113.3	kΩ
C_{in}	Pin input capacitance		8	12	nF
V_{il}	Input voltage for low level			2.2	V
V_{ih}	Input voltage for high level		3.6	32	V
τ_{in}	Input filter		59.3	60.7	µs

Table 20: *Wake-up – characteristics*

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4.7 Service Enable

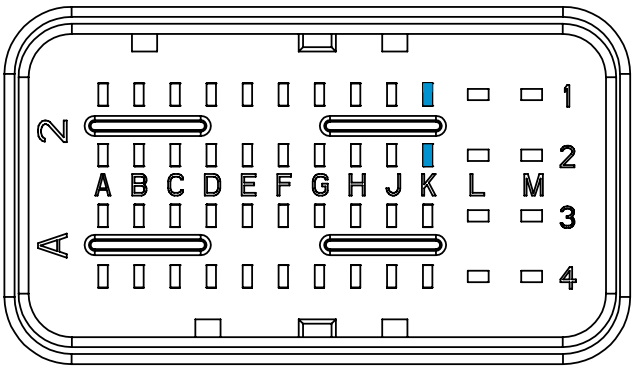

Figure 13: *Service Enable pinout*

Connector	Pin no.	Function
A	K1	Service 0
A	K2	Service 1

Table 21: *Service Enable – pin group*

Functional description

Service Enable is used for debugging and servicing functionalities.

There are two Service Enable input pins on the main connector. Each pin is a tri-mode input – it can be connected to GND, V_{bat} (any voltage > 9V), or not connected at all.

If Service 0 is connected to GND during power up, the CPU boots into ROM bootloader mode. In ROM bootloader mode, the flash memory of the CPU can be programmed via USB. The user application will not be started in this configuration, and the device is otherwise inactive.

All other combinations of Service Enable pins Service 0 and Service 1 are software defined.

Maximum ratings

Symbol	Parameter	Min	Max	Unit
$V_{in\ max}$	Permanent (DC) input voltage	-1	33	V

Table 22: *Service Enable – maximum ratings*

Characteristics

Symbol	Parameter	Min	Max	Unit
C_{in}	Pin input capacitance	8	12	nF
V_{IL}	Input voltage for low level	-1	2	V
V_{IH}	Input voltage for high level	9	32	V
V_{NC}	Input voltage if not connected (typical value)		3.3	V

Table 23: *Service Enable – characteristics*

4.8 Real-Time Clock

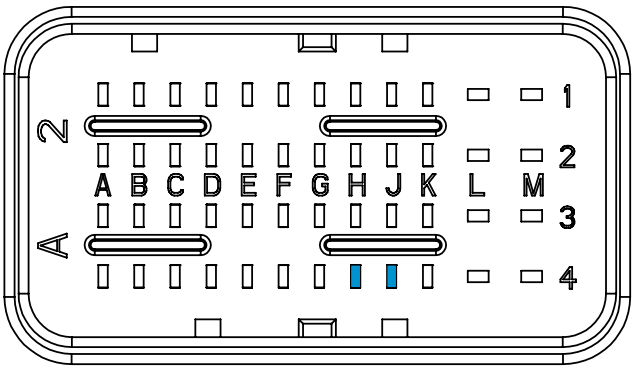

Figure 14: *Real-Time Clock pinout*

Connector	Pin no.	Function
A	J4	RTC BAT
A	H4	RTC GND

Table 24: *Real-Time Clock – pin group*

Functional description

The Fusion includes a Real-Time Clock (RTC) with a backup power system. There are two possible sources for the backup power system. The source is selected based on the external wiring of the RTC BAT and RTC GND pins.

The Fusion is equipped with an internal super-capacitor which provides approximately 14 days of backup time (when fully charged). To select the internal super-capacitor as the backup power source, connect RTC BAT to RTC GND.

To maintain RTC data for longer periods of time, the RTC can be powered by an external battery. To do so, connect the positive terminal of the battery to RTC BAT and the negative terminal to RTC GND. It is advised to use a single 3 V primary (non-rechargeable) lithium cell, or two 1.5 V alkaline cells connected in series for this purpose.

The voltage of the battery is monitored, and a low voltage alarm is triggered at 2.5 V. Once this voltage level is reached, we recommend replacing the external battery while BAT+ is connected, as the backup time without BAT+ connected is only around 30s, which might be insufficient to replace the external battery without losing RTC data.

When the device is connected to the vehicle's battery via the main connector's BAT+ pin, the RTC is supplied and the super-capacitor is charged by the vehicle's battery, regardless of whether the device is operational or not. The super-capacitor is fully charged after 2 hours.

It is not advised to leave the RTC pins unconnected, as this leads to an increased internal current draw of the RTC, and reduces the retention time provided by the super-capacitor.

Symbol	Parameter	Note	Max	Unit
Δ t/day	Time variation per day at +25 °C		± 1.5	s/day
RTC_{res}	RTC resolution		1	s
T_{pr}	RTC power reserve	1	14	days

Table 25: *Real-Time Clock – functional characteristics*

Note 1 If the super-capacitor has been charged for at least 2 hours with V_{BAT+} > 9 V.

The RTC BAT pin may be used as RTC supply input only.

Characteristics

Symbol	Parameter	Note	Min	Max	Unit
C_{in}	Pin input capacitance		8	12	nF
I_{in}	Steady state input current (after 1 min, 3.6 V)			10	µA
I_{in}	Steady state input current (after 1 min, 16 V)			260	µA
I_{in}	Steady state input current (after 1 min, 32 V)			600	µA
V_{nom}	Nominal input voltage range		2.5	5.5	V
V_{max}	Non-destructive working voltage range	1	1.8	32	V

Table 26: *Real-Time Clock – pin characteristics*

Note 1 -40 to +70 °C.

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4.9 Digital input

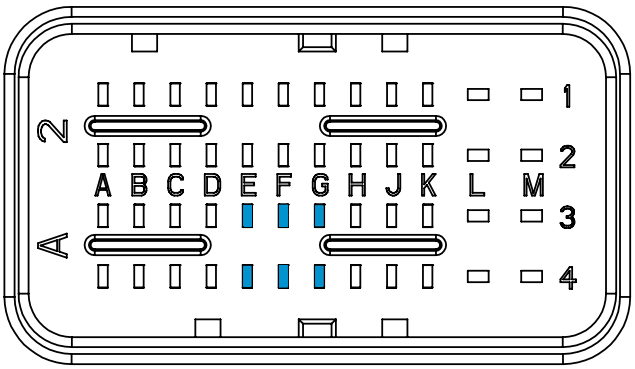

Figure 15: *Digital input pinout*

Connector	Pin no.	Function
A	G3	Digital input 0
A	G4	Digital input 1
A	E3	Digital input 2
A	E4	Digital input 3
A	F3	Digital input GND
A	F4	Digital input GND

Table 27: *Digital input – pin group*

Functional description

The Fusion has four digital inputs. The thresholds for low and high states, as well as the settings of the pull-up/down resistors, can be configured by the application software. In addition, the inputs are protected against transient voltages.

The pull resistors can be set to:

- do not use pull-up/pull-down resistor.
- use pull-up resistor to V_{pu}.
- use pull-down resistor to GND.

The voltages at the digital inputs are measured via an ADC, and are reported to the application software. Four threshold values can be configured, and the correlating state is reported to the application for each input channel.

If the digital inputs are not used, the GND pins can be used as additional GND pins for other interfaces.

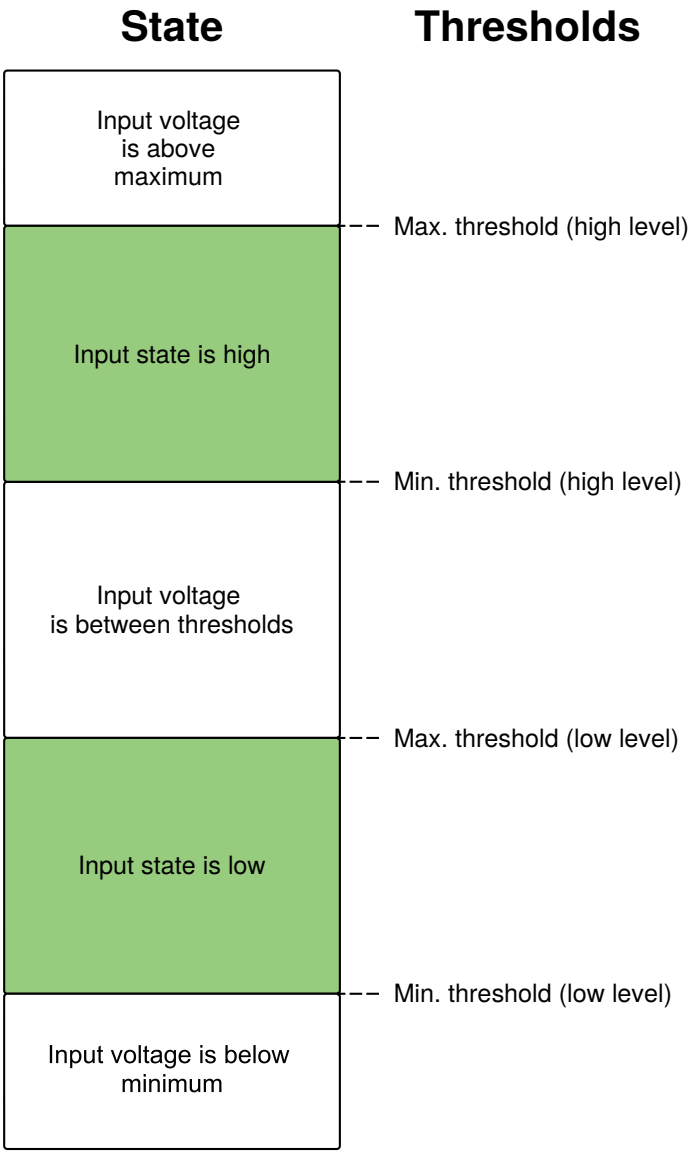

Figure 16: *Digital input – switching threshold voltage*

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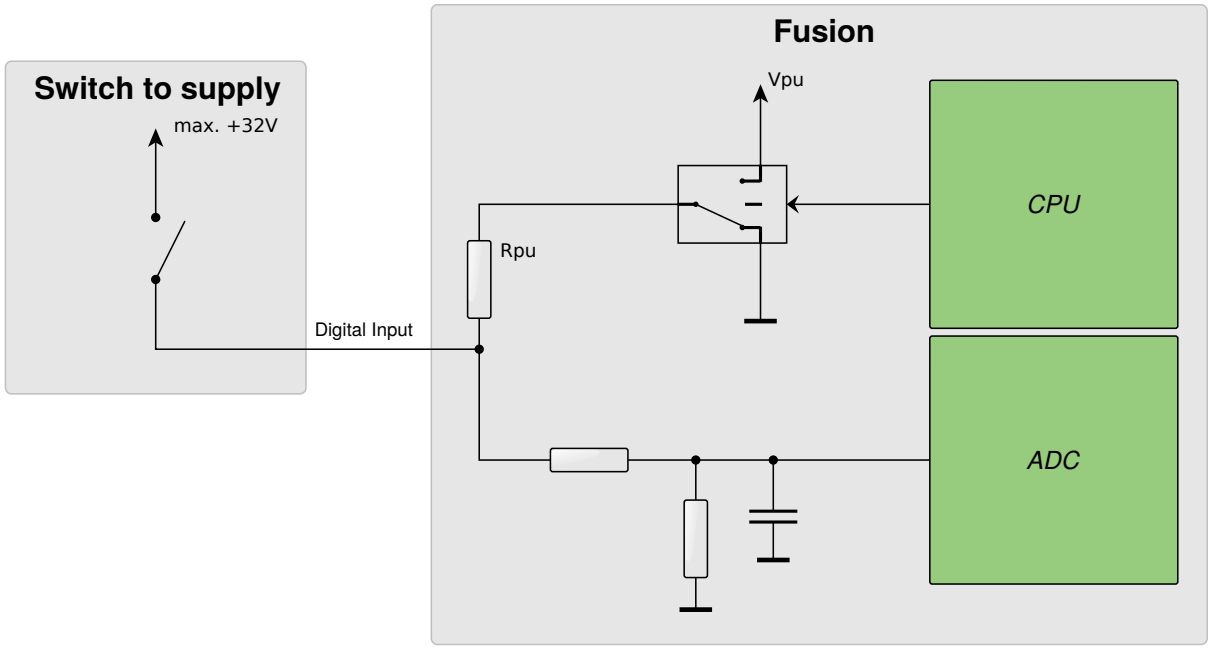

Figure 17: *Digital input for switch connected to (battery) supply voltage*

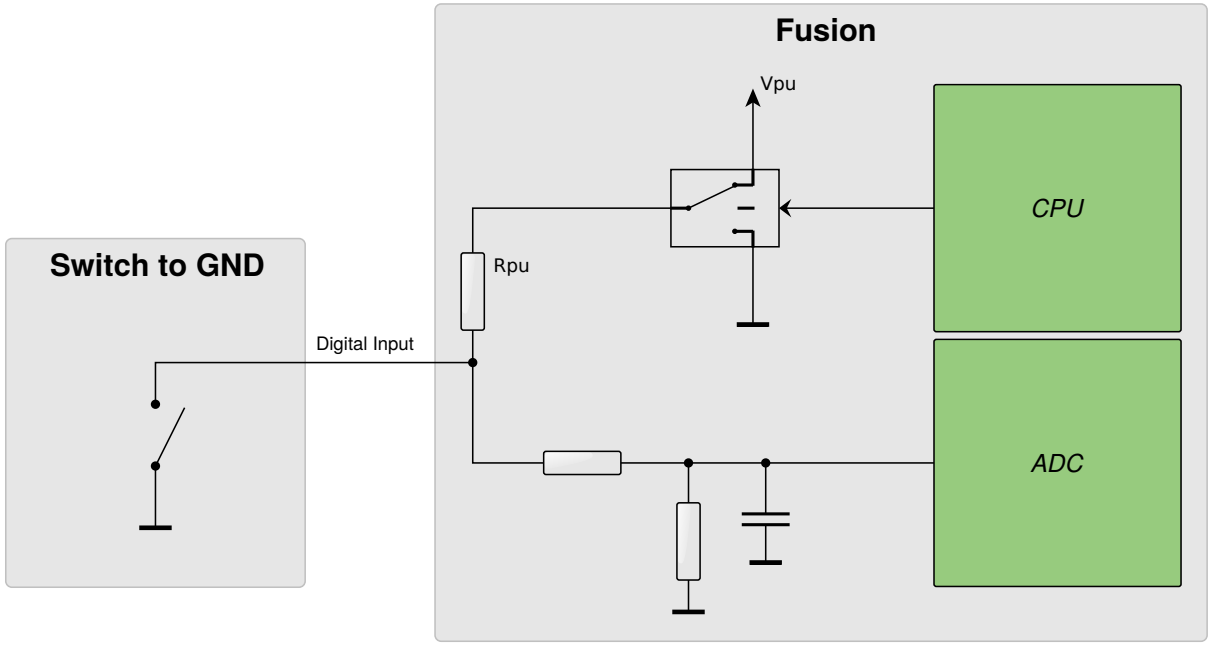

Figure 18: *Digital input for switch connected to GND*

Characteristics

Symbol	Parameter	Note	Min	Max	Unit
V_{in}	Input voltage range	1	0	32	V
R_{pu}	Pull-up/down resistor		9.5	10.5	kΩ
V_{pu}	Pull-up voltage	2	4.4	4.7	V
V_{tol}	Input voltage measurement tolerance		-6.3	5.2	%
f_c	Hardware corner frequency		61	113	Hz

Table 28: *Digital input – characteristics*

Note 1 The input voltage may go up to 32 V, but must never exceed the battery supply voltage.

Note 2 This is the input voltage with the pull-up resistor activated, and the digital input disconnected.

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4.10 High-side digital output

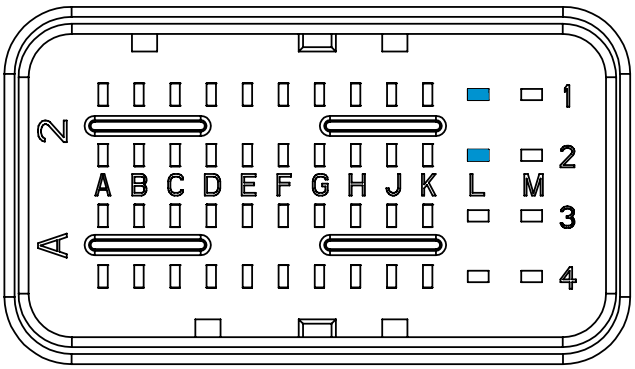

Figure 19: *High-side digital output pinout*

Connector	Pin no.	Function
A	L2	Digital output 0
A	L1	Digital output 1

Table 29: *High-side digital output – pin group*

Functional description

The Fusion has 2 high-side digital outputs with freewheeling diodes for inductive and resistive loads with low-side connection. Suitable loads are lamps, valves, relays, etc. Pull-up/pull-down resistors can be configured via software. In addition, the outputs are protected against electrical surges and short-circuits.

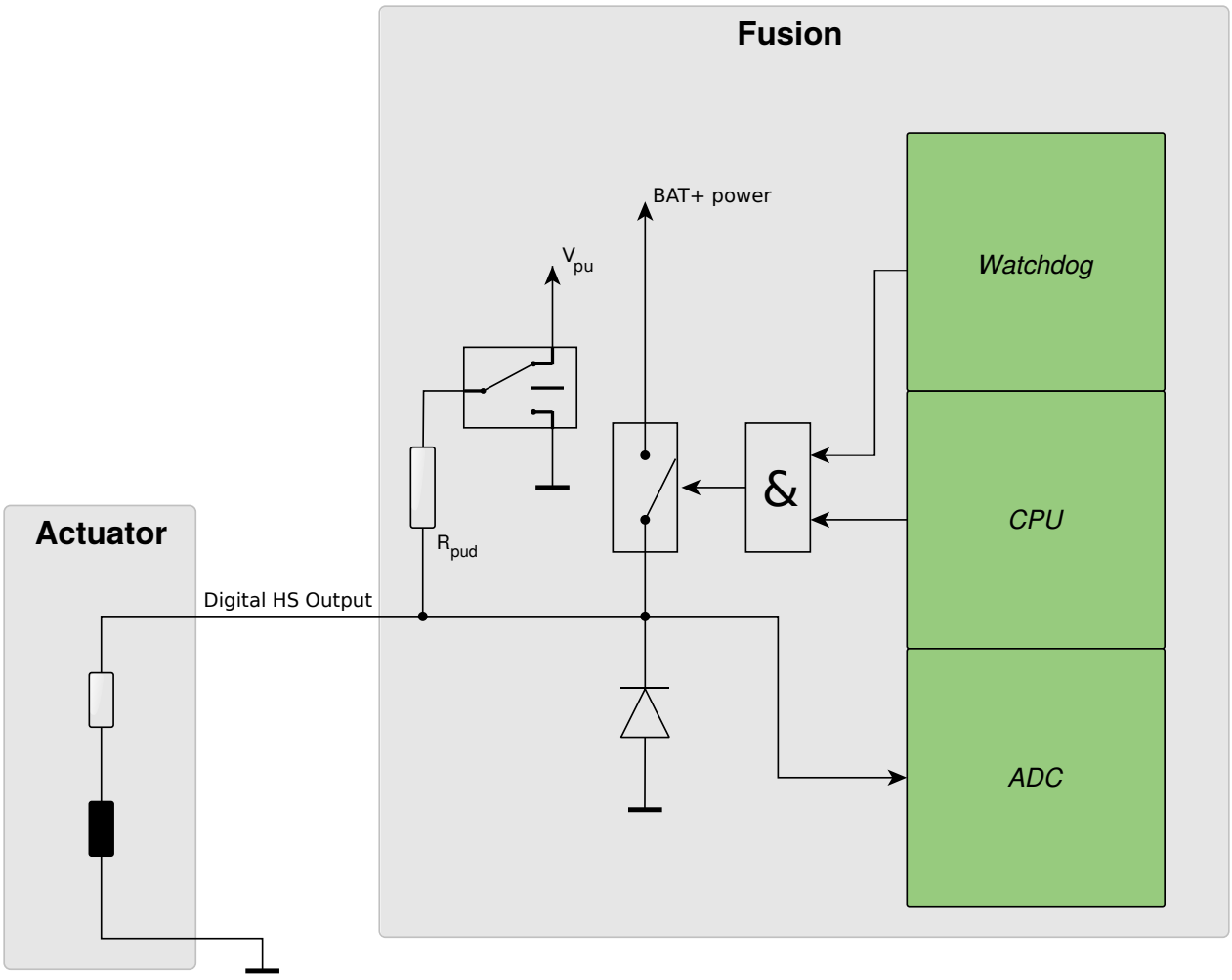

Figure 20: *Digital high-side power stage*

Diagnostic functions

The diagnostic functions allow the detection of overloads, external short-circuits to positive or negative power supply (BAT+/BAT-), and the detection of load loss.

Output	Status signal			
signal	Normal	Open load	Short to BAT-	Short to BAT+
on	✓	✗	✓	✗
off	✓	✓	✗	✓

Table 30: *Digital output – diagnostic functions*

✓ Detected

✗ Not detected

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Characteristics

Symbol	Parameter	Note	Min	Max	Unit
R_{pu}	Pull-up/pull-down resistor		9.5	10.5	kΩ
V_{pu}	Pull-up voltage	1	4.4	4.7	V
I_{load}	Nominal load current			1	A
I_{max}	Maximum load current			1.33	A
I_{peak}	Peak load current	2		2	A
V_{drop}	Voltage drop			0.5	V
L_{max}	Inductive load			200	µH

Table 31: *Digital output – characteristics*

Note 1 This is the input voltage with pull-up setting.

Note 2 Peak current for maximum 180 ms. Exceeding this value will trigger overload protection and switch off the power stage.

Maximum ratings

Symbol	Parameter	Min	Max	Unit
V_{ex}	External voltage on output pin	-0.3	[BAT+] + 0.3	V
L_{out}	Maximum conductivity of the connected load		200	µH
F_{out}	Switching frequency	0	10	Hz

Table 32: *Digital output – maximum ratings*

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4.11 A²B audio interface

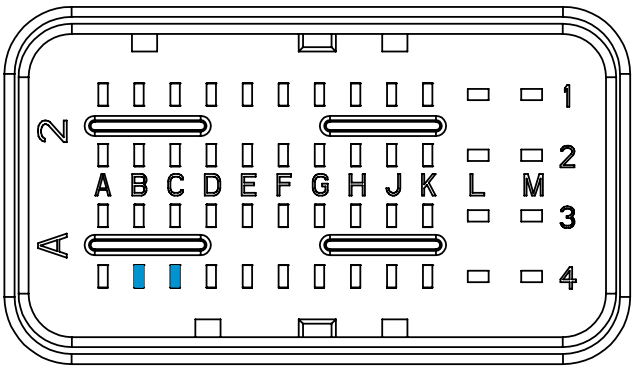

Figure 21: *A²B audio bus pinout*

Connector	Pin no.	Function
A	C4	A2B+
A	B4	A2B-

Table 33: *A²B audio bus – pin group*

Functional description

The Automotive Audio Bus (A²B) provides a multichannel I²S/TDM link over distances of up to 15 m between nodes. It embeds bidirectional synchronous pulse-code modulation (PCM) data (for example, digital audio), clock, and synchronization signals onto a single differential wire pair.

A²B supports a direct point to point connection and allows multiple, daisy-chained nodes at different locations to contribute and/or consume time division multiplexed (TDM) channel content.

Maximum ratings

Parameter	Note	Min	Max	Unit
Maximum cable length	1, 2		40	m
Maximum untwist cable length at connectors (at each end)			30	mm
Maximum number of nodes	3		11	
Maximum number of interconnects	4		4	
Maximum number of audio slots	5		64	
Audio sampling frequency		44.1	48	kHz
Network speed			49.2	Mbit/s
Total bus capacitance			70	pF

Table 34: *A²B audio bus – maximum ratings*

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Note 1 15 m between nodes.

Note 2 Maximum cable length depends on the allowable voltage drop between Fusion and bus-powered nodes, influenced by the nodes' current consumption, minimum input voltage, and total cable resistance.

Note 3 1 master node (Fusion) and 10 slave nodes.

Note 4 Applicable to all nodes.

Note 5 Up to 32 upstream and 32 downstream slots, depending on the system design.

Remote power feeding (RPF)

Parameter	Min	Max	Unit
Master's RPF enabled-state voltage	8.7	9.3	V
Master's RPF enabled-state circuit current sourcing	300		mA
Master's RPF enabled-state circuit current limiting		700	mA
Master's RPF enabled-state circuits output impedance		2.6	Ω
Master's RPF disabled-state open load detection voltage		4.5	V
Master's RPF disabled-state open load detection current		0.5	mA

Table 35: *Remote power feeding – characteristics*

4.12 RS-232 interface

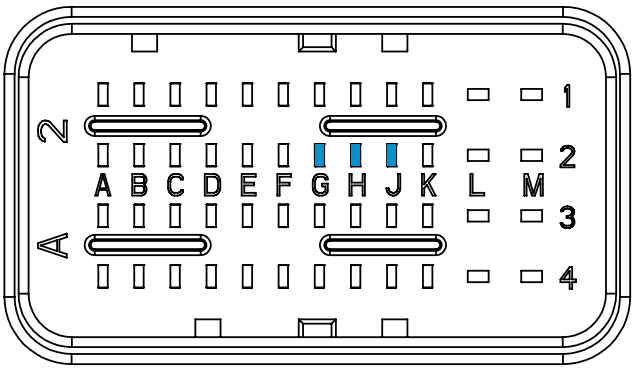

Figure 22: *RS-232 pinout*

Connector	Pin no.	Function
A	H2	RS-232 TX – serial interface output
A	J2	RS-232 RX – serial interface input
A	G2	RS-232 GND – serial interface ground signal

Table 36: *RS-232 – pin group*

Functional description

The RS-232 interface is a RS-232 compatible asynchronous full duplex serial interface. No handshake lines (like RTS or CTS) are provided.

A proper ground connection is necessary for the RS-232 operation. It is recommended to use the RS-232 GND pin for this purpose. When connecting an external device (for example, a PC with RS-232 interface) make sure that the maximum voltage ratings are not violated.

If the RS-232 interface is not used, the GND pin can be used as an additional GND pin for other interfaces (e.g., for digital inputs).

Maximum ratings

Symbol	Parameter	Min	Max	Unit
V_{RS-232_TxD}, V_{RS-232_RxD}	Bus voltage under overload conditions	-15	33	V

Table 37: *RS-232 – maximum ratings*

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Characteristics

Symbol	Parameter	Min	Max	Unit
C_{out}	Pin output capacitance	100	200	pF
V_{IL}	Input voltage for low level	-15	+0.8	V
V_{IH}	Input voltage for high level	+2.7	+15	V
R_{pd}	Input resistor (to GND)	5	9	kΩ
V_{OL}	Output voltage for low level	-9	-5	V
V_{OH}	Output voltage for high level	+5	+9	V
S_{Tr}	Data rate		115.2	kBd

Table 38: *RS-232 – characteristics*

4.13 CAN interfaces

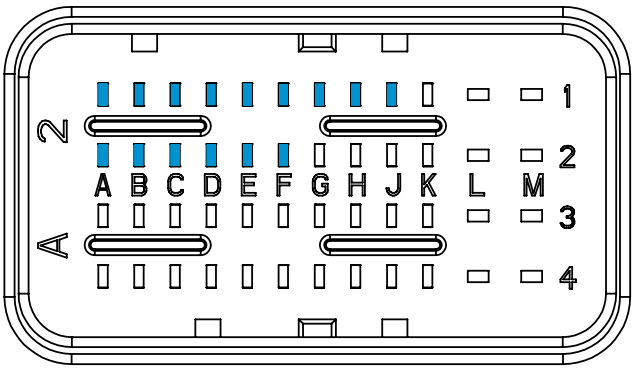

Figure 23: *CAN pinout*

Connector	Pin no.	Function
A	A1	CAN 0 Low
A	B1	CAN 0 High
A	C1	CAN 0 Termination
A	D1	CAN 1 Low
A	E1	CAN 1 High
A	F1	CAN 1 Termination
A	G1	CAN 2 Low
A	H1	CAN 2 High
A	J1	CAN 2 Termination
A	A2	CAN 3 Low
A	B2	CAN 3 High
A	C2	CAN 3 Termination
A	D2	CAN 4 Low
A	E2	CAN 4 High
A	F2	CAN 4 Termination

Table 39: *CAN interface – pin group*

Functional description

CAN utilizes a bidirectional twisted pair bus for high-speed serial data transfer, supporting speeds of up to 1 Mbit/s. However, CAN Flexible Data (FD) offers increased speed capabilities of up to 5 Mbit/s. Please refer to Table 40 to identify interfaces that support standard CAN and those that support CAN FD.

The bus must be terminated with 120 Ω at each end to prevent wave reflection. If the Fusion is connected at the end of a CAN bus, it is necessary to use internal termination resistors. To activate the internal termination resistor, connect the high line with the termination pin of the respective interface.

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The CAN interfaces are ISO 11898-2/-5 [1] compliant, except for the input resistances. The input resistances are lower due to an RF termination, which drastically improves EMC immunity and are used, required and proven for their performance in the automotive industry for many years. The differential internal resistance (R_{diff}) is given in Table 42.

Functionality	CAN 0	CAN 1	CAN 2	CAN 3	CAN 4
Speed	FD	FD	FD	Std	Std
Wake-up capable	yes	yes	no	no	no
ISOBUS capable	no	no	no	no	yes

Table 40: *CAN – available functionalities per port*

A common ground (chassis) or a proper ground connection is necessary for CAN operation. When connecting an external device (for example, a PC with CAN interface for downloading software), make sure that the maximum voltage ratings are not violated when connecting to or disconnecting from the CAN bus.

Maximum ratings

Symbol	Parameter	Min	Max	Unit
V_{CAN_CN}	Bus voltage under overload conditions (short circuit to supply voltages)	-58	58	V

Table 41: *CAN interface – maximum ratings*

Characteristics

Symbol	Parameter	Note	Min	Max	Unit
C_{out}	Pin output capacitance			100	pF
$V_{in\text{-}CMM}$	Input common mode range	1	-12	12	V
$V_{in\text{-}dif}$	Differential input threshold voltage		0.5	0.9	V
	($V_{CAN\_CNH} - V_{CAN\_CNL}$)				
$V_{out\text{-}dif}$	Differential output voltage dominant state		1.5	3.0	V
	($V_{CAN\_CNH} - V_{CAN\_CNL}$)				
$V_{out\text{-}dif}$	Differential output voltage recessive state		-0.1	+0.1	V
	($V_{CAN\_CNH} - V_{CAN\_CNL}$)				
V_{CAN_CNL}, V_{CAN_CNH}	Common mode idle voltage (recessive state)		2	3	V
I_{CAN_CNL}	Output current limit		-40	-100	mA
I_{CAN_CNH}	Output current limit		40	100	mA
S_{Tr}	Bit rate	2,3	25	1000	kbit/s
S_{Tr}	Bit rate (CAN FD)		25	5000	kbit/s

R_{diff}	Differential internal resistance		3.7	3.9	kΩ
R_{diff}	Differential internal resistance	4	27	29	kΩ

Table 42: *CAN interface – characteristics*

Note 1 Due to possible high currents in the wiring harness the individual ground potential of control units may differ up to several volts. This difference will also appear between a transmitting and receiving control unit as common mode voltage and does not influence the differential bus signal if the common mode voltage is within the common mode limits.

Note 2 The arbitration process will allow 1 Mbit/s operation only in small networks and reduced wire length. For example, a so-called *private CAN*, a short point-to-point connection (less than 10 m) between only two nodes can be operated at 1 Mbit/s.

Note 3 For typical network size and topology (network with stub wires) and more than two nodes, the practical limit is 500 kbit/s.

Note 4 ISOBUS CAN variant.

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4.14 LIN interface

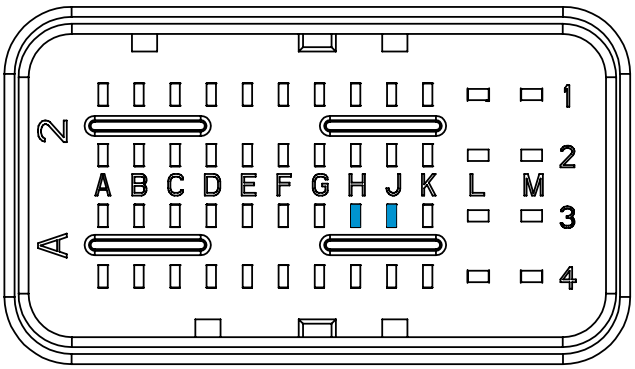

Figure 24: *LIN pinout*

Connector	Pin no.	Function
A	J3	LIN
A	H3	LIN GND

Table 43: *LIN – pin group*

Functional description

LIN is a bidirectional half duplex serial bus for up to 10 nodes.

If the LIN interface is not used, the GND pin can be used as an additional GND pin for other interfaces (e.g., for digital inputs).

A common ground (chassis) or a proper ground connection is necessary for LIN operation. If you connect to an external device (e.g., to a PC with a LIN interface), make sure not to violate the maximum voltage ratings when connecting to the LIN connection.

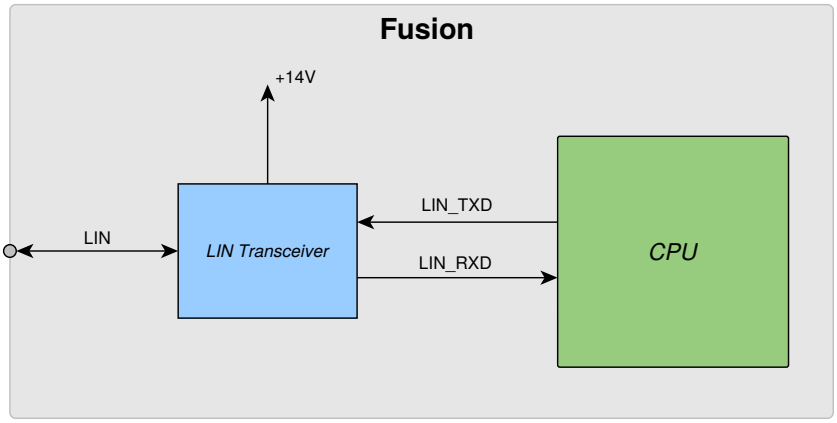

Figure 25: *LIN interface*

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Maximum ratings

Symbol	Parameter	Min	Max	Unit
V_{LIN}	Bus voltage under overload conditions	-1	33	V

Table 44: *LIN – maximum ratings*

Characteristics

Symbol	Parameter	Note	Min	Max	Unit
C_{out}	Pin output capacitance		200	400	pF
V_{BUSdom}	Receiver dominant state			0.4 · V_{Bat_LIN}	V
V_{BUSrec}	Receiver recessive state		0.6 · V_{Bat_LIN}	-	V
V_{OL}	Output low voltage		2		V
V_{Bat_LIN}	LIN supply voltage	1	13	15	V
R_{pu}	Pull-up resistor		0.95	1.05	kΩ
S_{Tr}	Baud rate			20	kBd

Table 45: *LIN – characteristics*

Note 1 For battery voltages higher than 13.5 V

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4.15 USB 2.0 interfaces

Product versions 00.05 and 00.06 use the HSD connector coding A for USB 2.0 interfaces. Product versions 00.07 and 00.08 of the Fusion use coding F, as will all future versions.

Mates with:

Product version 00.05 and 00.06: Rosenberger D4K14A-1D5A5-A

Product version 00.07 and 00.08: Rosenberger D4K14A-1D5A5-F

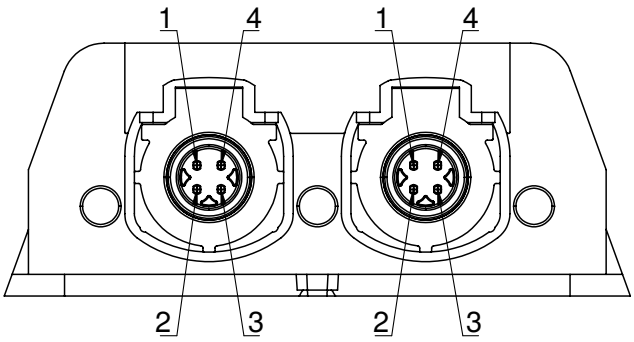

Figure 26: *USB 2.0 connectors (C & B) pinout*

Pin	Connector C	Connector B
1	USB 0 D+	USB 1 D+
2	USB 0 VBUS	USB 1 VBUS
3	USB 0 D-	USB 1 D-
4	USB 0 GND	USB 1 GND
Shield	SHIELD	SHIELD

Table 46: *USB connectors (C & B) pin group*

Functional description

The USB interfaces are compliant with the USB 2.0 standard.

The power supply of the USB ports is directly connected to the Fusion's internal GND (which is connected to BAT- input). In order to prevent any GND loops as well as to maximize EMC performance, any USB device connected to the Fusion must not be connected to chassis or vehicle GND on the USB device side.

In case of a self-powered USB device, the implementer must ensure that there is no GND offset between the Fusion and the connected USB device (e.g., by connecting a dedicated GND wire between the USB device supply input to the Fusion BAT- pin).

In case of permanently connected USB devices, the connection shall be established and removed while no power is applied to the Fusion.

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Be sure to use an appropriate shielded cable for the USB connection. For the USB data lines, a twisted pair connection must be used. In a noisy environment the data line pair should be shielded separately. In this case, connect the cable shielding to USB shield.

If the USB interface is used to connect a removable device, provide a connector compliant with the USB standard. This ensures that the pins of the USB interface are connected in the correct order (first shield, then ground (GND), then V_{bus}, then the data lines), thus preventing the interface from getting damaged.

For power supply below 9 V, see Low voltage mode.

The USB interfaces are not protected against any short circuits other than short to GND.

Maximum ratings

Symbol	Parameter	Note	Min	Max	Unit
L_{max}	Maximum cable length	1, 2		5	m
V_{usb}	Maximum voltage on V_{bus}, D+ and D-		-0.5	5.5	V
I_{max}	Maximum current on V_{bus} (USB0)			1.32	A
I_{max}	Maximum current on V_{bus} (USB1)			0.5	A
$V_{in\text{-}CMM}$	Input common mode range DC or AC-peak with line frequency (max 60 Hz)	3	-0.05	0.5	V
$V_{in\text{-}CMM}$	Input common mode range DC or AC-peak with line frequency (max 60 Hz)	4	0.8	2.5	V
C_{max}	Maximum load capacitance			<150	µF

Table 47: *USB 2.0 – maximum ratings*

Note 1 The maximum cable length depends on the type of cable used, the number of connectors between the devices, the environment where the cable is installed, as well as the used USB transmission speed mode. As a rule of thumb, each connector pair decreases the maximum cable length by 0.5 meters if a USB conform connector is used. If an arbitrary connector is used, the length penalty will be higher.

Note 2 A USB high speed (HS) connection is more sensitive than a USB full speed (FS) or low speed (LS) connection. Hence, the maximum possible cable length also depends on the kind of peripheral connected to the USB interface.

Note 3 For high speed USB.

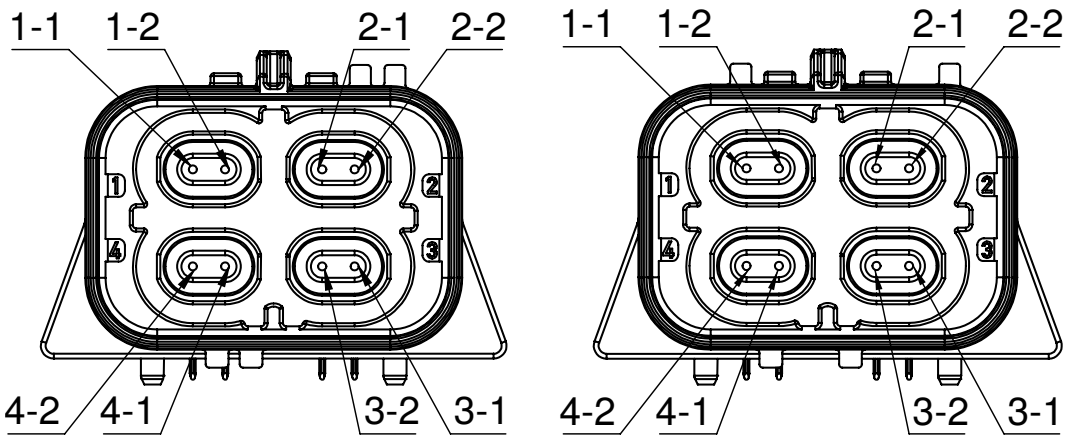
Note 4 For low speed USB and full speed USB.

4.16 100BASE-T1/1000BASE-T1 interfaces

Pinout

Mates with:

Rosenberger E6K14D-1CAZ5-A Rosenberger E6K14D-1CAZ5-B



(a) *Connector E* **(b)** *Connector D*

Figure 27: *100BASE-T1 and 1000BASE-T1 connectors (E & D) – pinout*

Fusion product version 00.05

Pin	Connector E (Coding A)	Connector D (Coding B)
1-1	100BASE-T1 4 TRD+	100BASE-T1 1 TRD+
1-2	100BASE-T1 4 TRD-	100BASE-T1 1 TRD-
2-1	100BASE-T1 3 TRD+	100BASE-T1 0 TRD+
2-2	100BASE-T1 3 TRD-	100BASE-T1 0 TRD-
3-1	100BASE-T1 2 TRD+	1000BASE-T1 0 TRD+
3-2	100BASE-T1 2 TRD-	1000BASE-T1 0 TRD-
4-1	100BASE-T1 5 TRD+	1000BASE-T1 1 TRD+
4-2	100BASE-T1 5 TRD-	1000BASE-T1 1 TRD-
Shield	SHIELD	SHIELD

Table 48: *100BASE-T1 & 1000BASE-T1 connectors (E & D) pin group (Fusion 00.05)*

Fusion product version 00.06, 00.07 and 00.08

Pin	Connector E (Coding A)	Connector D (Coding B)
1-1	100BASE-T1 4 TRD+	100BASE-T1 1 TRD+
1-2	100BASE-T1 4 TRD-	100BASE-T1 1 TRD-
2-1	100BASE-T1 3 TRD+	100BASE-T1 0 TRD+
2-2	100BASE-T1 3 TRD-	100BASE-T1 0 TRD-
3-1	100BASE-T1 2 TRD+	1000BASE-T1 1 TRD+
3-2	100BASE-T1 2 TRD-	1000BASE-T1 1 TRD-
4-1	100BASE-T1 5 TRD+	1000BASE-T1 0 TRD+
4-2	100BASE-T1 5 TRD-	1000BASE-T1 0 TRD-
Shield	SHIELD	SHIELD

Table 49: *100BASE-T1 & 1000BASE-T1 connectors (E & D) pin group (Fusion 00.06, 00.07 and 00.08)*

Functional description

100BASE-T1 and 1000BASE-T1 are standardized Ethernet interfaces (IEEE 802.3) aimed at increased throughput and reduced costs in vehicle networks. They operate using full-duplex communications over a single pair of twisted wires with an effective rate of 100 Mbit/s for 100BASE-T1 and 1 Gbit/s for 1000BASE-T1 in each direction simultaneously.

Maximum ratings

Symbol	Parameter	Min	Max	Unit
V_{T1}	Bus voltage under overload conditions (i.e., short circuit to supply voltages)	- 32	32	V

Table 50: *100BASE-T1 – maximum ratings*

Characteristics

Symbol	Parameter	Min	Max	Unit
$V_{in\text{-}CMM}$	Input common mode range	- 32	32	V
$V_{out\text{-}dif}$	Differential output voltage	-1	1	V
V_{T1_P}, V_{T1_M}	Common mode idle voltage	-0.1	0.1	V
S_{Tr}	Bit rate (100BASE-T1)		100	Mbit/s
S_{Tr}	Bit rate (1000BASE-T1)		1000	Mbit/s
$R_{in\_AC\_dif}$	Input resistance AC	90	110	Ω
$R_{in\_DC\_dif}$	Input resistance DC	1.8	2.2	kΩ

Table 51: *100BASE-T1/1000BASE-T1 – characteristics*

4.17 100BASE-TX interfaces

Mates with: Rosenberger HSD D4K14A-1D5A5-A

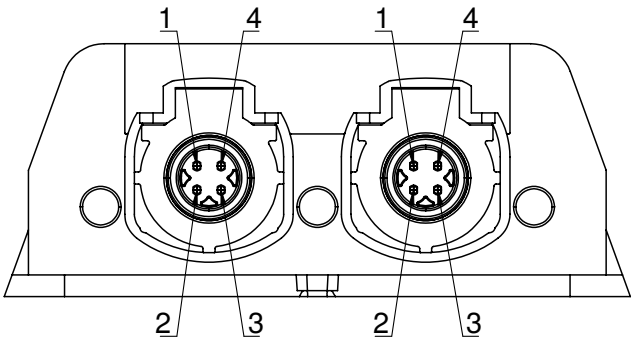


Figure 28: *100BASE-TX connectors (G & F) pinout*

Connector	Pin no./Shield	Function
F	1	Ethernet TX 1+
F	2	Ethernet RX 1-
F	3	Ethernet TX 1-
F	4	Ethernet RX 1+
G	1	Ethernet TX 0+
G	2	Ethernet RX 0-
G	3	Ethernet TX 0-
G	4	Ethernet RX 0+
Shield	SHIELD	SHIELD

Table 52: *100BASE-TX – pin group*

Functional description

The 10/100 Mbit full-duplex Ethernet port is compliant with IEEE 802.3.

Use cabling that is compliant with the Ethernet standard; at least Ethernet CAT5 cable for 100 Mbit/s, and Ethernet CAT3 cable for 10 Mbit/s transmission speed. In a noisy environment it is recommended to use shielded cables. In this case, the connector's shield must be connected to the shield of the Ethernet cable.

Maximum ratings

Symbol	Parameter	Min	Max	Unit
$V_{in\text{-}CMM}$	Input common mode range DC or AC-peak with line frequency (max 60 Hz)		1500	V

Table 53: *100BASE-TX – maximum ratings*

4.18 GMSL2 camera interfaces

Mates with: Rosenberger AMK148-102Z5-Z or AMK148-1M4Z5-Z

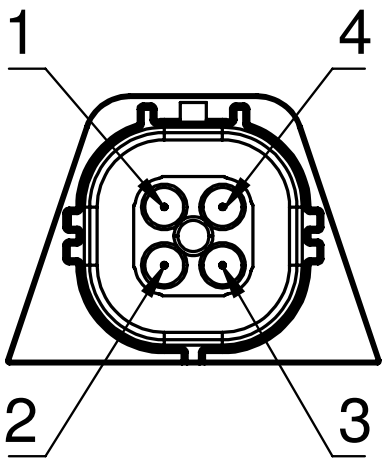


Figure 29: *Camera interface connector (H) pinout*

Connector	Pin no.	Function
H	1	Camera 0 Data/Supply
H	2	Camera 1 Data/Supply
H	3	Camera 2 Data/Supply
H	4	Camera 3 Data/Supply
H	Shield	GND

Table 54: *Analog video input – pin group*

Functional description

GMSL2 is a high-speed serial interface for transmitting digital video data in automotive applications. It supports up to 10 Gb/s data rates and can transport power, control data and video simultaneously over a single cable.

The Fusion has up to four GMSL2 interfaces and is capable of supplying and operating 4 cameras simultaneously.

The Fusion provides power to the external cameras. To avoid ground loops or excessive current flow in the event of a ground loss, used cameras should not form an electrical connection with the vehicle's chassis.

Since the camera supply uses a shielded cable, the output is not made short to battery proof. Always use the correct cabling specified for each camera to avoid voltage loss.

The Fusion does not support GMSL1 cameras.

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Characteristics

Symbol	Parameter	Note	Min	Max	Unit
V_{cam}	Output voltage	1	0	0	V
V_{cam}	Output voltage	2	V_{BAT+} -1.7	0.9*V_{BAT+}	V
V_{cam}	Output voltage	3	11.7	12.5	V
I_{out}	Output current per camera			300	mA

Table 55: *Camera supply – characteristics*

Note 1 V_{BAT+} < 9 V (for power supply below 9 V, see Low voltage mode).

Note 2 9.5 V ≤ V_{BAT+} ≤ 10.5 V

Note 3 V_{BAT+} > 10.5 V

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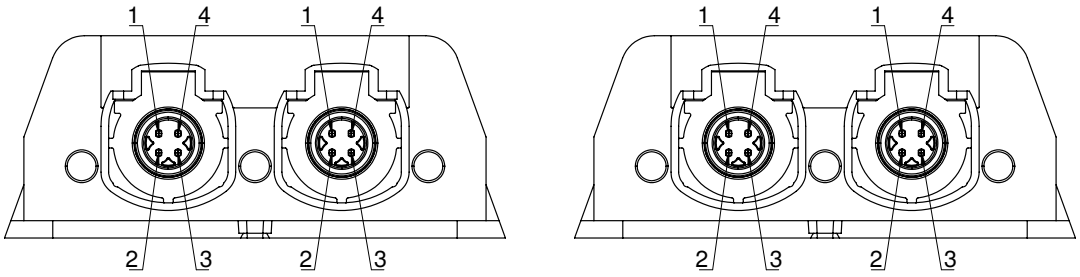
4.19 Remote display interfaces

Product versions 00.05 and 00.06 use the HSD connector coding A for remote display interfaces. Product versions 00.07 and 00.08 of the Fusion use coding C, as will all future versions.

Mates with:

Product version 00.05 and 00.06: Rosenberger HSD D4K14A-1D5A5-A

Product version 00.07 and 00.08: Rosenberger HSD D4K14A-1D5A5-C



(a) *Connectors L & K* **(b)** *Connectors J & I*

Figure 30: *Remote display connectors (L, K, J & I) pinout*

Fusion product version 00.05

Pin	Connector L	Connector K	Connector J	Connector I
1	Display 0 D0+	Display 2 D0+	Display 1 D0+	Display 3 D0+
2	Display 0 D1-	Reserved[3]	Display 1 D1-	Reserved[3]
3	Display 0 D0-	Display 2 D0-	Display 1 D0-	Display 3 D0-
4	Display 0 D1+	Reserved[3]	Display 1 D1+	Reserved[3]
Shield	SHIELD	SHIELD	SHIELD	SHIELD

Table 56: *Remote display connectors (L, K, J & I) pin group (Fusion 00.05)*

Fusion product version 00.06, 00.07 and 00.08

Pin	Connector L	Connector K	Connector J	Connector I
1	Display 0 D0+	Display 1 D0+	Display 2 D0+	Display 3 D0+
2	Display 0 D1-	Display 1 D1-	Reserved[3]	Reserved[3]
3	Display 0 D0-	Display 1 D0-	Display 2 D0-	Display 3 D0-
4	Display 0 D1+	Display 1 D1+	Reserved[3]	Reserved[3]
Shield	SHIELD	SHIELD	SHIELD	SHIELD

Table 57: *Remote display connectors (L, K, J & I) pin group (Fusion 00.06, 00.07 and 00.08)*

3. Do not connect, reserved for future use.

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Functional description

The Fusion has up to 4 remote display ports using FPD-Link 3 technology. FPD-Link 3 is a high-speed interface designed to transmit high-definition video signals between different components in automotive systems. It utilizes a single cable to carry both video data and control signals.

Further information about FPD-Link 3 channel specification is available from Texas Instruments.

5 Connectors and cable specifications

This section lists recommended plug housings for *mating* connectors, cables, receptacle contacts, cavity plugs, and blind plugs.

For detailed specifications, please contact the supplier or refer to the supplier's website.

5.1 Main connector (A)

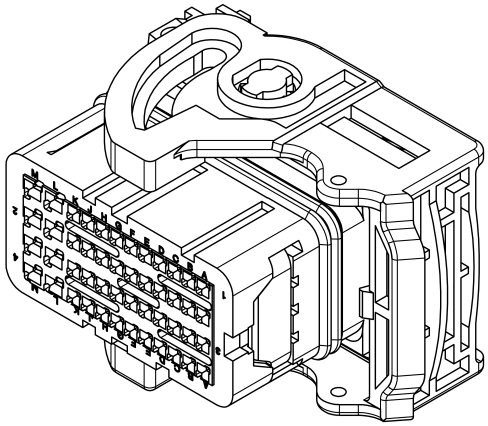

Figure 31: *Main connector*

Housings

TTControl recommends the following housing components for mating connector A:

Connector	Description	Part no.	Supplier
A	0.635 mm, 1.50 mm, CMC receptacle, 48 circuits, right wire output, black coding, mat sealed	64320-3311	Molex
A	CMC wire cap for 48 circuits and 28 circuits, CMC receptacle, mat sealed	64320-1301	Molex

Table 58: *Recommended plug housings for mating connectors*

Crimping contacts

TTControl recommends the following crimping contacts for mating connector A:

Connector	Description	Part no.	Supplier
A	1.50 mm CMC CP female terminal, tin plated, for tab dimensions 1.5 mm x 0.8 mm, wire size 0.5 mm^2 - 1.0 mm^2	64323-1029	Molex
A	1.50 mm CMC CP female terminal, tin plated, for tab dimensions 1.5 mm x 0.8 mm, wire size > 1.0 mm^2 - 2.0 mm^2	64323-1039	Molex
A	0.635 mm CMC CP female terminal, tin plated, for square 0.635 mm x 0.635 mm, wire size 0.5 mm^2	64322-1039	Molex
A	0.635 mm CMC CP female terminal, tin plated, for square 0.635 mm x 0.635 mm, wire size 0.75 mm^2	64322-1029	Molex

Table 59: *Recommended crimping contacts for mating connector A*

Blind cavity plugs

TTControl recommends the following blind cavity plugs for mating connector A, used to plug unused terminals in the connector to ensure tightness.

Connector	Description	Part no.	Supplier
A	0.60 mm blind cavity plug (White)	064325-1010	Molex
A	1.50 mm blind cavity plug (Orange)	064325-1023	Molex

Table 60: *Recommended blind cavity plugs for mating connector A*

Tools

TTControl recommends the following tools for mating connector A:

Connector	Description	Part no.	Supplier
A	Power pin extraction tool	63813-2300	Molex
A	Power pin hand crimp tool wire size 0.5 mm^2 - 1.0 mm^2	63811-8900	Molex
A	Power pin hand crimp tool wire size 1.0 mm^2 - 2.0 mm^2	63811-9000	Molex
A	I/O pin extraction tool	63811-2400	Molex
A	I/O pin hand crimp tool wire size 0.35 mm^2	63811-9100	Molex
A	I/O pin hand crimp tool wire size 0.5 mm^2 - 0.75 mm^2	63811-9200	Molex

Table 61: *Recommended tools for mating connector A*

Cables

TTControl recommends the following cables for mating connector A:

Connector	Description	Function	Recommendation
A	2.0 mm^2	BAT+Power BAT+ BAT-	Automotive standard
A	Twisted stranded wire pair, FLRY 2x0.5 mm^2	CAN High/Low	Automotive standard
A	0.5 mm^2	CAN Termination RTC LIN	Automotive standard
A	Leoni Dacar 545	A^2B	Automotive standard
A	0.75 mm^2	all other functions	Automotive standard

Table 62: *Recommended cables for mating connectors*

5.2 H-MTD connectors (D and E)

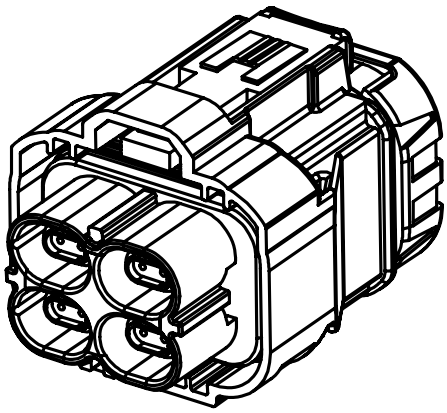

Figure 32: *H-MTD connector*

Connector	Description	Part no.	Supplier
D	Connector housing	E6K14D-1CAZ5-B	Rosenberger
E	Connector housing	E6K14D-1CAZ5-A	Rosenberger
D, E	Pin	E6K10A-1CAZ5	Rosenberger
D, E	Blind cavity plug	E6Z064-001/57	Rosenberger

Table 63: *H-MTD connector – connector parts*

The recommended cables for the H-MTD connectors are:

Cable name	Impedance
G&G 2Speed 251	100 Ω
LEONI Dacar 647-4	100 Ω

Table 64: *H-MTD connectors – recommended shielded cables*

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5.3 HFM connector (H)

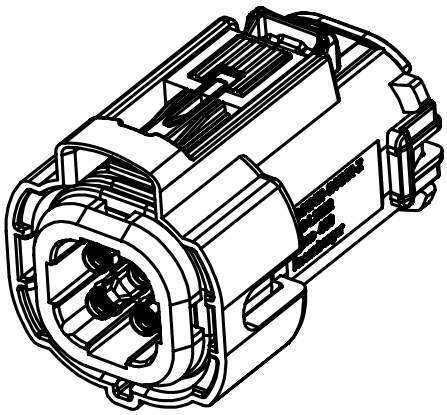

Figure 33: *HFM connector*

Connector	Description	Part no.	Supplier
H	Connector housing	AMK148-102Z5-Z	Rosenberger
H	Pin	AMK12A-102Z5	Rosenberger
H	Blind cavity plug	E6Z064-001/57	Rosenberger

Table 65: *HFM connector – connector parts*

Cable name	Impedance
LEONI Dacar 140, LEONI Dacar 462	50 Ω
1.5 DS-QEHB, 1.5 DS QFB	50 Ω
CoSpeed5044	50 Ω
CoSpeed5031, LEONI Dacar 302	50 Ω

Table 66: *HFM connectors – recommended cables*

5.4 HSD connectors (B, C, F, G, I, J, K, L)

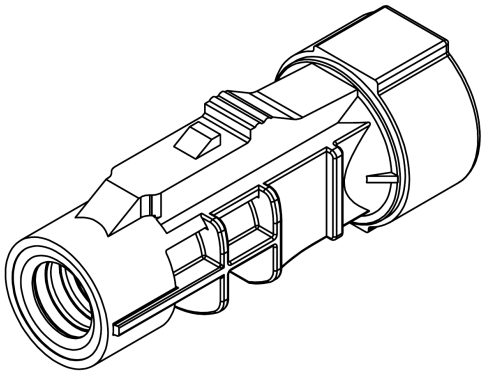

Figure 34: *HSD connector*

Connector	Description	Prod. version	Part no.	Supplier
B, C	Connector housing	00.05/00.06	D4K14A-1D5A5-A	Rosenberger
B, C	Connector housing	00.07/00.08 & future versions	D4K14A-1D5A5-F	Rosenberger
I, J, K, L	Connector housing	00.05/00.06	D4K14A-1D5A5-A	Rosenberger
I, J, K, L	Connector housing	00.07/00.08 & future versions	D4K14A-1D5A5-C	Rosenberger
F, G	Connector housing	All	D4K14A-1D5A5-A	Rosenberger
B, C, F, G, I, J, K, L	Blind cavity plug	All	D4Z023-002-Z	Rosenberger

Table 67: *HSD connector – connector parts*

Cable name	Impedance
LEONI Dacar 535, 535-2, 636, 636-2	100 Ω

Table 68: *HSD connectors – recommended cables*

6 Instructions for safe operation

6.1 General

- Carefully read, understand, and follow the instructions and specifications listed in this document before operating the device. Failure to comply with these instructions or operation of the device outside the intended field of operation may result in serious damage to machinery and may affect the safety of users. TTControl cannot be held liable for any personal injury or property damage resulting from improper installation or use of the device, non-compliance with the instructions in this document, or non-compliance with the intended field of operation. Non-compliance will result in the exclusion of any liability and warranty.
- Different regulations and standards may apply to the off-highway machinery, depending on the use and field of operation. Ensure that the Fusion fulfills all requirements and standards for the intended use and field of operation.
- Always operate the product within the electrical and environmental specifications and follow the handling and mounting instructions provided by TTControl. Usage of the product outside the specifications may be hazardous to persons or property.
- Only skilled and trained personnel are allowed to operate this device.
- The device must be stored, handled, and installed carefully.
- The surface of the device can reach high temperatures. Ensure that there is enough heat dissipation on the back side of the device. Avoid touching the metal parts of the housing.
- The device must be mounted and operated using the type of connectors specified in this document.
- The label on the housing contains important information. The label must not be destroyed or made unreadable.
- The device hardware does not require maintenance activities.
- Check regularly if updated versions of this document or additions to it are available.

6.2 Intended use

The Fusion is a robust, programmable electronic control unit that provides communication, remote display, and camera interfaces. It also includes general-purpose IOs for sensor/actuator management, allowing it to carry out safety-related applications in mobile machinery for construction, agricultural, forestry, and municipal purposes.

Typical use cases:

- Instrument panel replacement
- Display of camera images
- Control unit
- Human-Machine Interface:
  - for working functions
  - for machine functions
  - for operator assistance systems
  - for office functions
  - as connectivity interface
- Display as ISOBUS Virtual Terminal

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6.3 Improper use

Do not mount or use the Fusion if it appears visibly damaged.

- Opening and/or modifying the device is not permissible. Failure to comply may result in serious damage to machinery and may affect the safety of users, or reduce the lifetime or operability of the device. Opening the device will result in the exclusion of any liability and warranty claims.
- Operation of the device in an environment that violates the specified range is not permissible.
- Use in explosive areas is not permissible.
- Any use of the product other than as described in section 6.2 is considered to be improper.
- TTControl is not liable for damages resulting from improper use.

The non-safety certified Fusion device must not be used for safety-critical tasks!

6.4 Checks to be done before commissioning the device

- Check the supply voltage before connecting the device.
- Check that the device connector and the cable harness are free of defects.
- Check the correct dimensioning of the wires in the cable harness.
- Always disconnect the power supply before conducting any maintenance or repair work to the machine where the device is mounted (for example, welding or maintenance of the battery system).
- Choose a mounting location for the device so that the operating temperature of the device does not exceed the maximum allowed operating temperature.
- A protective fuse must be installed between the vehicle's battery and the power supply input (BAT+) of the device.

6.5 Disposal

Disposal of the device must be performed in accordance with prevailing national environmental regulations.

6.6 Electromagnetic compatibility (EMC)

In order to fulfill EMC requirements, the housing shall be electrically bonded to the vehicle chassis, battery GND or PE (industrial application).

6.7 Thermal management

Be aware that the device needs sufficient cooling to work properly (including during development on the lab workbench).

Be aware that, depending on the applied cooling solution, the device may get hot during operation.

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7 Compliance

Fusion conforms to the following:

- CE marking
- ECE type approval (E mark)
- FCC (Federal Communications Commission) certification

7.1 Regulatory information

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

NOTE Changes or modifications made to this equipment not expressly approved by TTControl may void the FCC authorization to operate this equipment.

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Glossary

Entry	Description
AC	Alternating Current
ARM	Advanced RISC Machine
CAN	Controller Area Network
CPU	Central Processing Unit
DC	Direct Current
DSP	Digital Signal Processor
EEPROM	Electrically Erasable Programmable Read-Only Memory
GND	(Signal) ground
HSD	High Speed Data
LED	Light-emitting Diode
LIN	Local Interconnect Network
MRD	Mounting Requirements Document
PCB	Printed Circuit Board
RAM	Random Access Memory
RTC	Real-Time Clock
RX	Reception
SDE	Software Developement Environment
STR	Summary Test Report
SW	Software
SoC	System on a Chip
T15	Terminal 15
TX	Transmission
USB	Universal Serial Bus
eMMC	embedded MultiMediaCard

References

[1] ISO. ISO 11898:2003, *Road vehicles – Controller area network (CAN)*. International Standard, International Organization for Standardization (ISO), 2008.

[2] TTControl GmbH. Fusion Mounting Requirements Document. D-VI4-M-02-001.

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Fusion User Manual

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