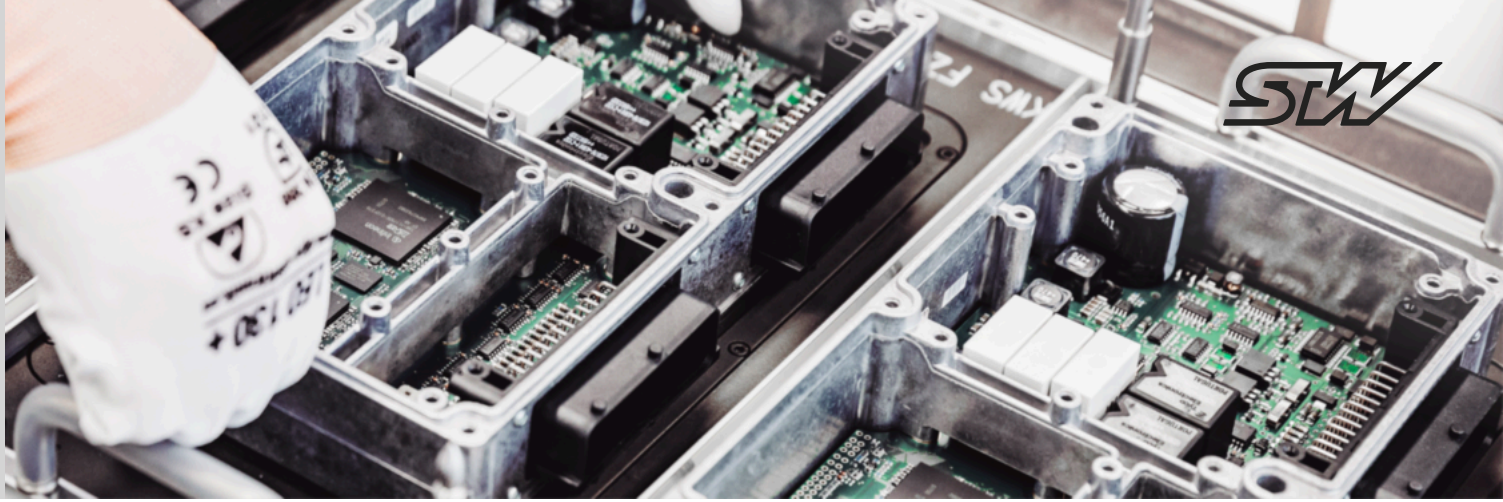


ESX.iom

ESX Control units

KEY FEATURES

- Control specially designed for use in harsh mobile applications
- Suitable for safety-related applications up to SIL2 according to IEC 61508:2010 or PLd according to EN ISO 13849-1:2015
- Flexible I/O module for programming via CANopen. Other protocols (CANopen safety, ESX CAN efficient safety (ECeS), J1939) on request

TECHNICAL DATA

- Aurix TC299 multicore 32 bit, 300 MHz
- 1 CAN interface
- 32 inputs
- 29 outputs

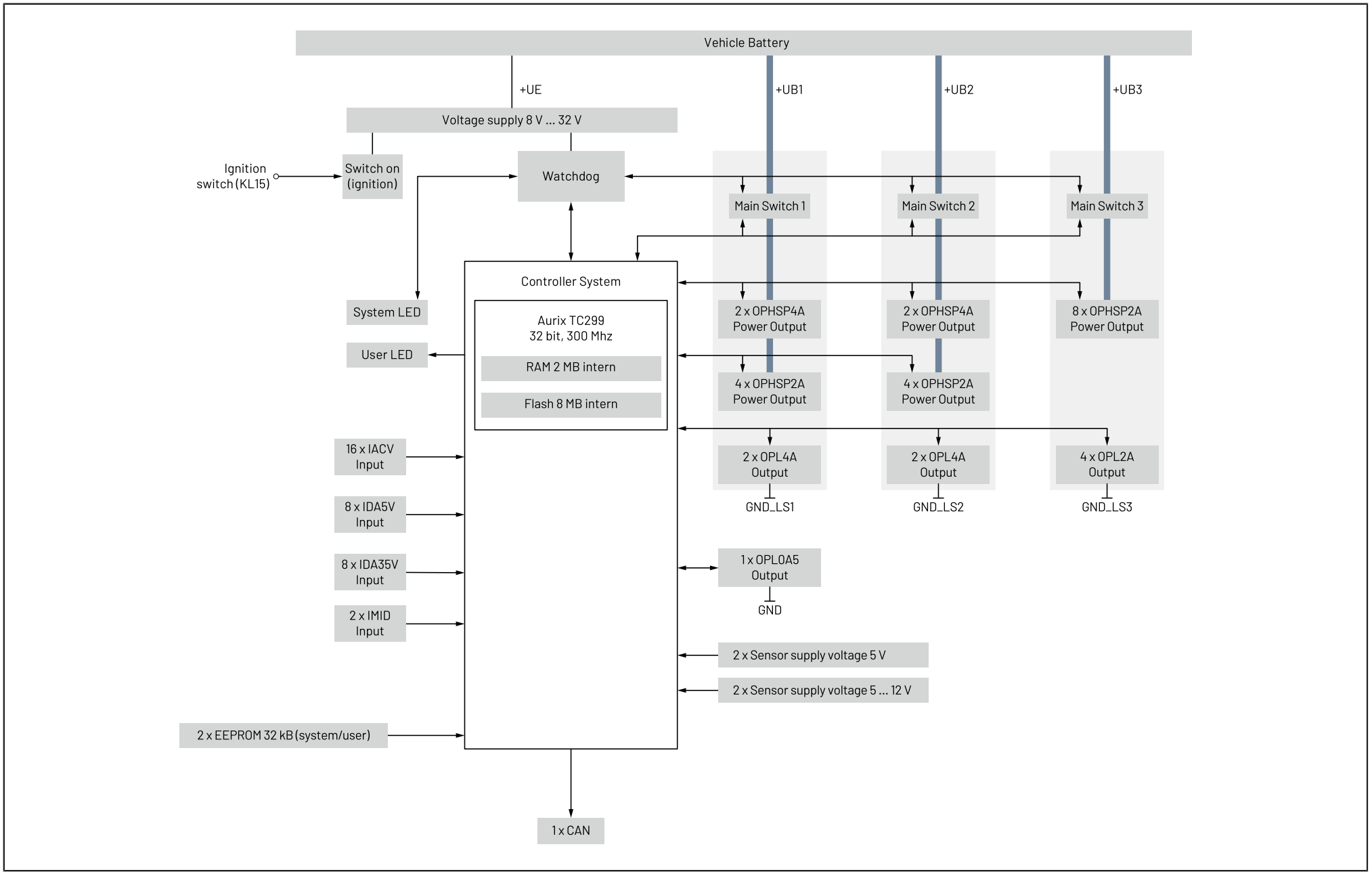
ACCESSORIES

- Mating plug
- Integrated into STW's openSYDE software platform

Sensor-Technik Wiedemann GmbH

Am Bärenwald 6
87600 Kaufbeuren
Germany
+49 8341 9505-0
info.stw@wiedemann-group.com
www.stw-mm.com

BLOCK DIAGRAM



TECHNICAL DATA

Processor and memory

Type	Properties	Description
Aurix TC299	32 bit, multicore processor, 300 MHz	• External system supervisor with programmable watchdog • 12 bit A/D converter for analog signal processing
RAM	2 MB	On-chip RAM This memory mainly serves as system memory for BIOS stack and data, but also includes a heap for the customer application.
Flash	8 MB	7.75 MB available for customer application
EEPROM	32 kB	1 x Available for customer application. 1 x Available for system. Typical endurance according to manufacturer: • 1,000,000 erase/program cycles @ 25°C • 300,000 erase/program cycles @ 85°C • Data retention > 20 years

Communication interfaces

Type	Max. quantity	Configuration
CAN	1	CAN 2.0 B, high-speed and low-speed, baud rate from 40 kbit/s to 1 Mbit/s

TECHNICAL DATA

Inputs

Type	Max. quantity	Possible configuration	Measurement
Multifunctional input IDA35V	8	Analog voltage	0 ... 35 V
		Programmable pull-up resistor	1.1 kΩ to +8.5 V
		Programmable pull-down resistor	1 kΩ to GND
		NAMUR sensor	NAMUR sensor compatible
		Digital	Active high Active low
		Event driven	Events, reacts on falling or rising edge of the signal
		Frequency	0.6 Hz ... 20 kHz
		Incremental encoder interface	Change of position or angular change
Analog input IACV	16	Analog voltage	0 ... 12 V
		Analog current	0 ... 24 mA
		Digital (voltage mode)	Active high
		Event driven	Events, reacts on falling or rising edge of the signal

TECHNICAL DATA

Inputs

Type	Max. quantity	Possible configuration	Measurement
Multifunctional input IDA5V	8	Analog voltage	0 ... 5 V
		Programmable pull-up resistor	6.8 kΩ to +5 V
		Digital	Active low
		Event driven	Events, reacts on falling or rising edge of the signal
		Frequency	0.6 Hz ... 20 kHz
		SENT	SENT interface
Identification input IMID	2	Externally connected resistors	Open, short to GND and up to 6 different resistor values

TECHNICAL DATA

Outputs

Type	Max. quantity	Possible configuration	Range	Characteristics	Feature
Digital/PWM high side output OPHSP2A	16	Digital	ON/OFF		• high side switch • precise current measurement, accuracy is 2 % • supports current control mode • digital feedback, open load detection in OFF state • automated shutdown on overcurrent > 7.5 A ±20 % • combine several outputs for parallel operation
		PWM	0 ... 2.5 A	0 ... 100 % duty cycle resolution < 0.1 % PWM frequency 20 ... 500 Hz	
Digital/PWM high side output OPHSP4A	4	Digital	ON/OFF		• high side switch • precise current measurement, accuracy is 2 % • supports current control mode • digital feedback, open load detection in OFF state • automated shutdown on overcurrent > 7.5 A ±20 % • combine several outputs for parallel operation
		PWM	0 ... 4 A	0 ... 100 % duty cycle resolution < 0.1 % PWM frequency 20 ... 500 Hz	
Digital/PWM low side output OPL4A	4	Digital PWM	0 ... 4 A	0 ... 100 % duty cycle resolution < 0.1 % PWM frequency 20 ... 500 Hz	
Digital/PWM low side output OPL2A	4	Digital PWM	0 ... 2 A	0 ... 100 % duty cycle resolution < 0.1 % PWM frequency 20 ... 500 Hz	
Digital low side output OPL0A5	1	PWM	0 ... 0.5 A		
Main Switch	3		8 ... 32 V DC	ON/OFF	• switches the four output groups • high-side switch • Current up to 12 A

TECHNICAL DATA

Outputs

Type	Max. quantity	Possible configuration	Range	Characteristics	Feature
Sensor supply voltage 5 V	2		5 V	ON/OFF	Maximal output current 250 mA
Sensor supply voltage 5 ... 12 V	2		5 ... 12 V	Confgurable	100 ... 250 mA

Mechanical Data

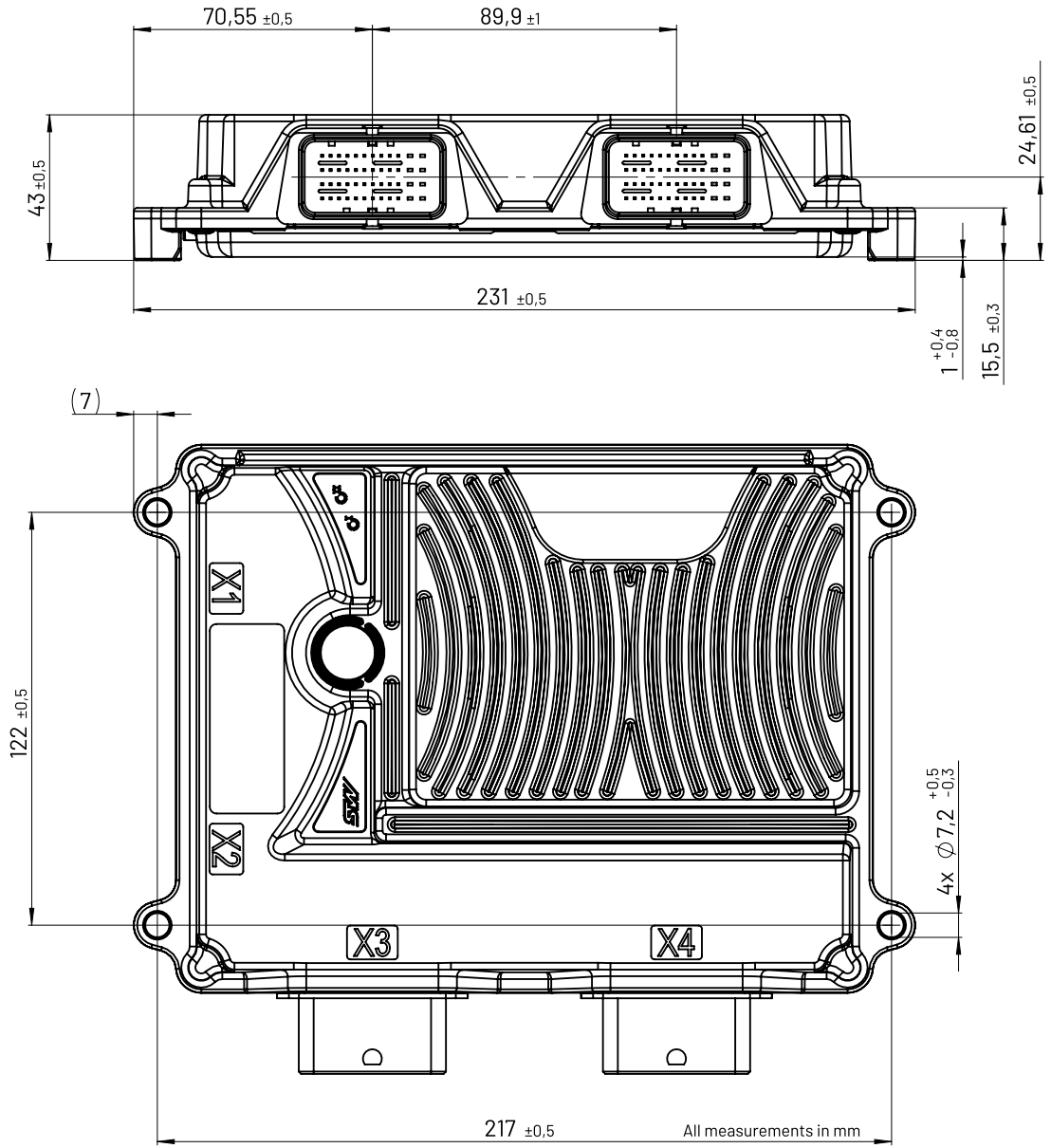
Component	Description	Value
Connectors		2 x Molex CMC 48 pin
Indicators	2 x LED, dual color (red/green or mixed colors)	1 for the state of the system 1 freely programmable
Housing	Die-cast aluminum	GORE-TEX™-breathing filter for pressure equalization
Weight		About 0.580 kg (1.28 lbs)
Degree of protection		IP6k7 and IP6k9k
Dimensions		231 mm x 162 mm x 43 mm
Operating temperature, housing temperature		-40 ... +85 °C (-40 ... +185 °F)
Operating altitude		-400 ... +4000 m

TECHNICAL DATA

Power Supply

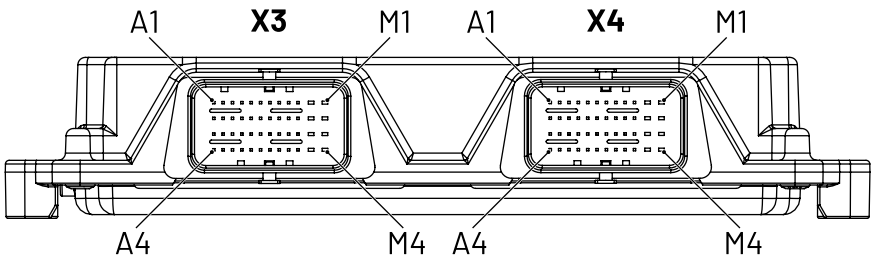
Component	Description	Range	
		Minimum Value	**Maximum Value**
DC voltage supply	Voltage at +UE ECU supply and +UB power supply	8 V DC	32 V DC
Current consumption	Power supply +UB fully loaded, short-term		60 A, short-term
Standby	Sum of input currents at +UE and +UB (U_{KL15} = 0 V, ignition off)		< 1 mA
ECU active	+UE supply current ($U_{KL15} > U_{KL15HIGH}$, without external load)		

TECHNICAL DRAWING



PIN ASSIGNMENT

Pin Assignment 48 Pin Connector X3 (black):



Pin Assignment 48 Pin Connector X3 (black):

Pin	Signal Name	Description
X3A1	CAN1_H	CAN bus 1 high
X3A2	CAN1_L	CAN bus 1 low
X3A3	-	Not connected
X3A4	-	Not connected
X3B1	-	Not connected
X3B2	-	Not connected
X3B3	-	Not connected
X3B4	-	Not connected
X3C1	-	Not connected
X3C2	-	Not connected
X3C3	UEXT5V_1	Sensor supply 5V
X3C4	AGND	Analog ground, used for sensor supply
X3D1	IACV_1	Analog input IACV_01
X3D2	IACV_2	Analog input IACV_02
X3D3	IACV_3	Analog input IACV_03
X3D4	IACV_4	Analog input IACV_04
X3E1	IDA5V_1	Multi function input IDA5V_01
X3E2	IDA5V_2	Multi function input IDA5V_02
X3E3	IMID_1	Ident input IMID_1
X3E4	AGND	Analog ground, used for sensor supply

PIN ASSIGNMENT

Pin Assignment 48 Pin Connector X3 (black):

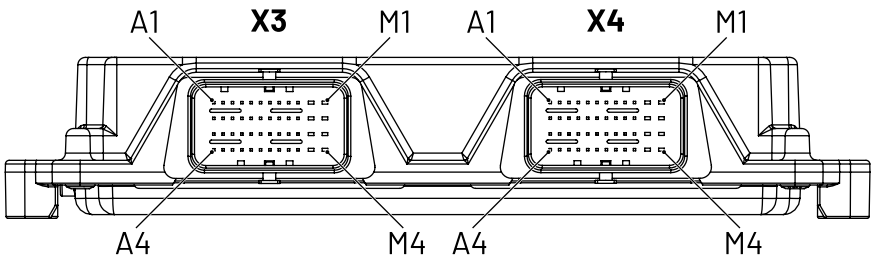
Pin	Signal Name	Description
X3F1	IDA35V_1	Multi function input IDA35V_01
X3F2	IDA35V_2	Multi function input IDA35V_02
X3F3	UEXT5-12V_1	Sensor supply 5-12V
X3F4	AGND	Analog ground, used for sensor supply
X3G1	IDA5V_5	Multi function input IDA5V_05
X3G2	IDA5V_6	Multi function input IDA5V_06
X3G3	IMID_2	Ident input IMID_2
X3G4	AGND	Analog ground, used for sensor supply
X3H1	IACV_5	Analog input IACV_05
X3H2	IACV_6	Analog input IACV_06
X3H3	IACV_7	Analog input IACV_07
X3H4	IACV_8	Analog input IACV_08
X3J1	IDA35V_3	Multi function input IDA35V_03
X3J2	IDA35V_4	Multi function input IDA35V_04
X3J3	KL15	Ingnition (KL15)
X3J4	OPL0A5	Digital/PWM output OPL0A5
X3K1	OPHSP2A_1	Digital/PWM output OP2A_01
X3K2	OPHSP2A_2	Digital/PWM output OP2A_02
X3K3	OPHSP2A_3	Digital/PWM output OP2A_03
X3K4	OPHSP2A_4	Digital/PWM output OP2A_04

Pin Assignment 48 Pin Connector X3 (black):

Pin	Signal Name	Description
X3L1	UB_1	UB_1: Power supply pin for hardware drivers of the outputs
X3L2	OPL4A_1	Digital/PWM output OPL4A_01
X3L3	OPHSP4A_1	Digital/PWM output OP4A_01
X3L4	UE	UE: Power supply electronic
X3M1	GND_LS1	Ground pin for hardware drivers of the low side outputs OPL4A_1 and OPL4A_2
X3M2	OPL4A_2	Digital/PWM output OPL4A_02
X3M3	OPHSP4A_2	Digital/PWM output OP4A_02
X3M4	GND	Ground of the controller

PIN ASSIGNMENT

Pin Assignment 48 Pin Connector X4 (grey):



Pin Assignment 48 Pin Connector X4 (grey):

Pin	Signal Name	Description
X4A1	-	Not connected
X4A2	-	Not connected
X4A3	-	Not connected
X4A4	-	Not connected
X4B1	IACV_11	Analog input IACV_11
X4B2	IACV_12	Analog input IACV_12
X4B3	UEXT5V_2	Sensor supply 5V
X4B4	AGND	Analog ground, used for sensor supply
X4C1	IDA35V_5	Multi function input IDA35V_05
X4C2	IDA35V_6	Multi function input IDA35V_06
X4C3	IDA5V_3	Multi function input IDA5V_03
X4C4	IDA5V_4	Multi function input IDA5V_04
X4D1	IACV_9	Analog input IACV_09
X4D2	IACV_10	Analog input IACV_10
X4D3	UEXT5-12V_2	Sensor supply 5-12V
X4D4	AGND	Analog ground, used for sensor supply
X4E1	IDA35V_7	Multi function input IDA35V_07
X4E2	IDA35V_8	Multi function input IDA35V_08
X4E3	IDA5V_7	Multi function input IDA5V_07
X4E4	IDA5V_8	Multi function input IDA5V_08

PIN ASSIGNMENT

Pin Assignment 48 Pin Connector X4 (grey):

Pin	Signal Name	Description
X4F1	IACV_13	Analog input IACV_13
X4F2	IACV_14	Analog input IACV_14
X4F3	IACV_15	Analog input IACV_15
X4F4	IACV_16	Analog input IACV_16
X4G1	OPHSP2A_9	Digital/PWM output OP2A_9
X4G2	OPHSP2A_10	Digital/PWM output OP2A_10
X4G3	OPHSP2A_11	Digital/PWM output OP2A_11
X4G4	OPHSP2A_12	Digital/PWM output OP2A_12
X4H1	OPHSP2A_13	Digital/PWM output OP2A_13
X4H2	OPHSP2A_14	Digital/PWM output OP2A_14
X4H3	OPHSP2A_15	Digital/PWM output OP2A_15
X4H4	OPHSP2A_16	Digital/PWM output OP2A_16
X4J1	OPHSP2A_5	Digital/PWM output OP2A_05
X4J2	OPHSP2A_6	Digital/PWM output OP2A_06
X4J3	OPHSP2A_7	Digital/PWM output OP2A_07
X4J4	OPHSP2A_8	Digital/PWM output OP2A_08
X4K1	OPL2A_1	Digital/PWM output OPL2A_01
X4K2	OPL2A_2	Digital/PWM output OPL2A_02
X4K3	OPL2A_3	Digital/PWM output OPL2A_03
X4K4	OPL2A_4	Digital/PWM output OPL2A_04

Pin Assignment 48 Pin Connector X4 (grey):

Pin	Signal Name	Description
X4L1	GND_LS2	Ground pin for hardware drivers of the low side outputs OPL4A_3 and OPL4A_4
X4L2	UB_2	UB_2: Power supply pin for hardware drivers of the outputs
X4L3	OPL4A_3	Digital/PWM output OPL4A_03
X4L4	OPHSP4A_3	Digital/PWM output OP4A_03
X4M1	GND_LS3	Ground pin for hardware drivers of the low side outputs OPL2A_1, OPL2A_2, OPL2A_3 and OPL2A_4
X4M2	UB_3	UB_3: Power supply pin for hardware drivers of the outputs
X4M3	OPL4A_4	Digital/PWM output OPL4A_04
X4M4	OPHSP4A_4	Digital/PWM output OP4A_04

QUALIFICATION

Compliance Information

Standard	Description		Parameter
ISO/IEC 17050-1 REGULATION (EC) No 765/2008	CE	Conformity	See Declaration of Conformity
UK marking	UKCA	UK Conformity	See UK Declaration of Conformity
EN ISO 13849-1:2015	Safety of machinery		PL d / Cat. 2
IEC 61508:2010	Functional safety		SIL 2
KBA (Kraftfahrt-Bundesamt)	E1	Certification This approved device can be used on any vehicle type with the following restrictions: All vehicle types with a 12 V respectively 24 V - electrical wiring and battery(-) at the body	According UN ECE Regulation No. 10
2011/65/EU 2015/863/EU	RoHS	Restriction of Hazardous Substances	
2006/42/EC	Machinery directive		

DETAILED QUALIFICATION

CE - EN IEC 61000-6-2:2019 (Test specifications are currently still being processed

Standard	Test	Parameter
EN IEC 61000-6-2:2019	Immunity for industrial environments	-
	DIN EN 61000-4-2 Electrostatic discharge immunity test - direct discharges	330 Ω / 150 pF, Contact discharge ±4 kV Air discharge ±8 kV
	DIN EN 61000-4-2 Electrostatic discharge immunity test - indirect discharges (HCP, VCP)	330 Ω / 150 pF, Contact discharge ±4 kV
	DIN EN 61000-4-3 Radiated, radio-frequency, electromagnetic field immunity test	80 MHz to 1000 MHz ⟶ 10 V/m; 1.4 GHz to 6.0 GHz ⟶ 3 V/m; horizontal and vertical
	DIN EN 61000-4-4 Burst - supply lines (Electrical fast transient / burst immunity test)	±1 kV, 5/50 ns tr/th, repetition frequency 5 kHz or 100 kHz
	DIN EN 61000-4-4 Burst - data lines (Electrical fast transient / burst immunity test)	±1 kV, 5/50 ns tr/th, repetition frequency 5 kHz or 100 kHz
	DIN EN 61000-4-5 Surge - supply lines (immunity test)	asymmetrical: ±1 kV symmetrical: ±0,5 kV
	DIN EN 61000-4-5 Surge - data lines (immunity test)	asymmetrical: ±1 kV
	DIN EN 61000-4-6 Conducted immunity - supply lines (Immunity to conducted disturbances, induced by radio-frequency fields)	150 kHz to 80 MHz, 10 V
	DIN EN 61000-4-6 Conducted immunity - data lines	150 kHz to 80 MHz, 10 V

DETAILED QUALIFICATION

CE - EN IEC 61000-6-2:2019 (Test specifications are currently still being processed

Standard	Test	Parameter
	(Immunity to conducted disturbances, induced by radio-frequency fields)	
	DIN EN 61000-4-8 magnetic field	50, 60 Hz, 30 A/m
EN 61000-6-4:2007 + A1:2011	Emission standard for industrial environments	Conducted (CE) 0.15 MHz ... 30 MHz Radiated (RE) 30 MHz ... 1000 MHz (6000 MHz) 10 m

DETAILED QUALIFICATION

Functional Safety - DIN EN 61326-3-1 (Test specifications are currently still being processed)

Standard	Test	Parameter
DIN EN 61326-3-1:2018	Tabelle 2 DIN EN 61000-4-2 - direct discharges Electrostatic discharge immunity test	330 Ω / 150 pF, Contact discharge ±6 kV Air discharge ±8 kV
	Tabelle 2 DIN EN 61000-4-2 - indirect discharges Electrostatic discharge immunity test	330 Ω / 150 pF, Contact discharge ±6 kV
	Tabelle 2 DIN EN 61000-4-3 Radiated, radio-frequency, electromagnetic field immunity test	80 MHz to 1000 MHz, 20 V/m; 1,4 GHz to 2 GHz, 10 V/m 2,0 GHz to 2,7 GHz ⟶ 3 V/m; horizontal, vertical
	Tabelle 2 DIN EN 61000-4-8 magnetic field	30 A/m (No higher test levels will be applied)
	Tabelle 4 DIN EN 61000-4-4 Burst - supply lines (Electrical fast transient / burst immunity test)	±3 kV, 5/50 ns tr/th, repetition frequency 5 kHz
	Tabelle 5 DIN EN 61000-4-4 Burst - data lines (Electrical fast transient / burst immunity test)	±2 kV, 5/50 ns tr/th, repetition frequency 5 kHz
	Tabelle 4 DIN EN 61000-4-5 Surge - supply lines (immunity test)	asymmetric: ±2 kV symmetric: ±1 kV
	Tabelle 5 DIN EN 61000-4-5 Surge - data lines (immunity test)	asymmetric: ±2 kV

DETAILED QUALIFICATION

Functional Safety - DIN EN 61326-3-1 (Test specifications are currently still being processed)

Standard	Test	Parameter
	Tabelle 4 DIN EN 61000-4-6 Conducted immunity - supply lines (Immunity to conducted disturbances, induced by radio-frequency fields)	150 kHz to 80 MHz, 10 V
	Tabelle 5 DIN EN 61000-4-6 Conducted immunity - data lines (Immunity to conducted disturbances, induced by radio-frequency fields)	150 kHz to 80 MHz, 10 V
	Tabelle 4 IEC 61000-4-16 Conducted common-mode voltages Supply lines	1 V to 10 V, 20 dB/Decade (1,5 kHz to 15 kHz) 10 V (15 kHz to 150 kHz) 10 V (constant with direct current, $16^2/_3$ Hz, 50 / 60 Hz and 150 / 180 Hz) 100 V short period (1 s, with direct current, $16^2/_3$ Hz and 50 / 60 Hz)
	Tabelle 5 IEC 61000-4-16 Conducted common-mode voltages signal lines	1 V to 10 V, 20 dB/Decade (1,5 kHz to 15 kHz) 10 V (15 kHz to 150 kHz) 10 V (constant with direct current, $16^2/_3$ Hz, 50 / 60 Hz and 150 / 180 Hz) 100 V short period (1 s, with direct current, $16^2/_3$ Hz and 50 / 60 Hz)
	Tabelle 4 IEC 61000-4-29 Votlage dips (Supply lines)	40 % U_T during 10 ms
	Tabelle 4 IEC 61000-4-29 Short interruptions (Supply lines)	0 % U_T during 20 ms

DETAILED QUALIFICATION

E1 - ECE R10(Test specifications are currently still being processed)

Standard	Test	Parameter
UN ECE R10 Add. 9, Rev. 6 Annex 7	Radiated broadband emissions from ESAs CISPR25:2004	30 MHz ... 1000 MHz
UN ECE R10 Add. 9, Rev. 6 Annex 8	Radiated narrowband emissions from ESAs CISPR25:2004	30 MHz ... 1000 MHz
UN ECE R10 Add. 9, Rev. 6 Annex 9	Immunity of ESAs to electromagnetic radiation General: ISO 11452-1:2005 ALSE: ISO 11452-2:2004 BCI: ISO 11452-4:2011 (Stripline and TEM alternative test methods)	General 20 MHz ... 2000 MHz 20 MHz ... 800 MHz: AM 800 MHz ... 2000 MHz: PM BCI: 20 MHz ... 400 MHz, 60 MA (substitution (150 Mm) or closed loop (900 Mm) method allowed) Antenne, ALS E (vert): 200 MHz ... 800 MHz, 30 V/m, AM 800 MHz ... 2000 MHz, 30 V/m, PM
UN ECE R10 Add. 9, Rev. 6 Annex 10	Conducted transient emission from ESAs on 12 V supply lines ISO 7637-2:2004	slow/fast: pos: +75 V neg: -100 V
	Conducted transient emission from ESAs on 24 V supply lines ISO 7637-2:2004	slow/fast: pos: +150 V neg: -450 V
	Electrical transient conduction along supply lines 12V System, Level 3 ISO 7637-2:2004	Pulse 1 - 75V, 5000 pulses t1 = 0,5 s to 5 s
		Pulse 2a 37V, 5000 pulses t1 = 0,2 s to 5 s

DETAILED QUALIFICATION

E1 - ECE R10(Test specifications are currently still being processed)

Standard	Test	Parameter
		Pulse 2b 10 V, 10 pulses td = 0,2 s to 2 s
		Pulse 3a -112 V, 1 hr
		Pulse 3b 75 V, 1 hr
		Pulse 4 Us = -6 V Ua = -2,5 V to -6V 1 pulse
	Electrical transient conduction along supply lines 24V System, Level 3 ISO 7637-2:2004	Pulse 1 -450 V, 5000 pulses t1 = 0,5 s to 5 s
		Pulse 2a 37 V, 5000 pulses t1 = 0,2 s to 2 s
		Pulse 2b 20 V, 10 pulses td = 0,2 s to 2 s
		Pulse 3a -150 V, 1 hr
		Pulse 3b +150 V, 1 hr
		Pulse 4 Us = -12 V Ua = -5 V to -12 V 1 pulse

DETAILED QUALIFICATION

Electrical Safety (Test specifications are currently still being processed)

Standard	Test	Parameter
ISO 16750-2:2012-11	Direct current supply voltage	Operation at Tmax with maximum and minimum voltage Operation at Tmin with maximum and minimum voltage
	Overvoltage - Systems with 12 V / 24 V nominal voltage - 12 V Systems	18 V for 60 min. at 20 °C below Tmax
		24 V for 60 s at room temperature
	Overvoltage - Systems with 12 V / 24 V nominal voltage - 24 V Systems	36 V for 60 min. at 20 °C below Tmax
	Superimposed alternating voltage - 12 V Systems	Usmax = 16 V (for U_N = 12 V) Sweep duration: 120 seconds Number of sweeps: 5 Severity 1, 2, 4
	Superimposed alternating voltage - 24 V Systems	Usmax = 32 V (for U_N = 24 V) Sweep duration: 120 seconds Number of sweeps: 5 Severity 1, 2, 3
	Slow decrease and increase of supply voltage	Decrease supply voltage from Usmin to 0 V and increase it from 0 V to Usmin. Applying a change rate of (0.5 ±0.1) V per minute
	Discontinuities in supply voltage - Momentary drop in supply voltage - 12 V Systems	Drop to 4.5 V for ≤ 100 ms
	Discontinuities in supply voltage - Momentary drop in supply voltage - 24 V Systems	Drop to 9 V for ≤ 100 ms
	Discontinuities in supply voltage - Reset behavior voltage drop	Decrease supply voltage from Usmin in 5 % steps
	Discontinuities in supply voltage - Starting profile 12 V code C	Voltage cranking; Level 1
		Voltage cranking; Level 2

DETAILED QUALIFICATION

Electrical Safety (Test specifications are currently still being processed)

Standard	Test	Parameter
		Voltage cranking; Level 3
		Voltage cranking; Level 4
	Discontinuities in supply voltage - Starting profile 24 V code E	Voltage cranking; Level 1
		Voltage cranking; Level 2
		Voltage cranking; Level 3
	Discontinuities in supply voltage-Load Dump - Pulse B - 12 V System	with centralized load dump suppression 5 Pulses
	Discontinuities in supply voltage-Load Dump - Pulse B - 24 V System	with centralized load dump suppression 5 Pulses
	Reversed voltage - Case 1 - 12 V Systems	Unom. = 12 V → Case 1 - Test Voltage = -4 V reversed polarity Duration: 60 s
	Reversed voltage - Case 2 - 12 V Systems	Unom. = 12 V → Case 2 - Test Voltage = -14 V reversed polarity Duration: 60 s
	Reversed voltage - Case 2 - 24 V Systems	Unom. = 24 V → Case 2 - Test Voltage = 28 V reversed polarity Duration: 60 s
	Ground reference and supply offset - 12 V Systems	±1 V offset; only required if two or more power supplies exist; Low-Side-Sensor must be connected to ground point at ECU connector
	Ground reference and supply offset - 24 V Systems	±1 V offset; only required if two or more power supplies exist; Low-Side-Sensor must be connected to ground point at ECU connector
	Open circuit tests - Single line interruption - 12 V Systems	Interruption of each single Output for (10 ±1) s.
	Open circuit tests - Single line interruption - 24 V Systems	Interruption of each single Output for (10 ±1) s.
	Open circuit tests - Multiple line interruption - 12 V Systems	Disconnect the DUT for (10 ±1) s.

DETAILED QUALIFICATION

Electrical Safety (Test specifications are currently still being processed)

Standard	Test	Parameter
	Open circuit tests - Multiple line interruption - 24 V Systems	Disconnect the DUT for (10 ±1) s.
	Short circuit protection - signal circuits	Connect every In- and Output to maximum supply voltage (Usmax) and Ground for 1 minute various modes necessary
	Short circuit protection - load circuits (supply lines)	to load circuits

Electromagnetic Compatibility (E1)(Test specifications are currently still being processed)

Standard	Test	Parameter
ISO 7637-2: 2011	Conducted transient emission from ESAs on 12 V supply lines, Level 3 ISO 7637-2:2011	slow+: +37 V slow-: -75 V fast+: +75 V fast-: -112 V
	Conducted transient emission from ESAs on 24 V supply lines, Level 3 ISO 7637-2:2011	slow+: +37 V slow-: -150 V fast+: +150 V fast-: -150 V
	Electrical transient conduction along supply lines -24 V System, Level 4	Pulse 1 -600 V, 500 pulses t1 ≥ 0,5 s
		Pulse 2a +112 V, 500 pulses t1 = 0,2 s to 5 s
		Pulse 2b +20 V, 10 pulses td = 0,2 s to 2 s
		Pulse 3a -300 V, 1 h
		Pulse 3b +300 V, 1 h

DETAILED QUALIFICATION

Environmental Qualification

Standard	Test	Parameter
ISO 16750-3:2012	Resonance search	10Hz - 2000Hz, 1g, 0.5 oct/min
	Test VII - Commercial vehicle, sprung masses	Vibration noise with temperature superimposition in case of natural frequencies of DUT upper 30 Hz: random vibration acc IEC60068-2-64 from 10 Hz to 2000 Hz for 32 hrs each axis, Temperature cycle 8h from Tmin to Tmax
	Test VII - Commercial vehicle, sprung masses, Additional profile in the case of DUT natural frequencies < 30 Hz (Test VII)	Random vibration acc IEC60068-2-64 from 10 Hz to 45 Hz for 32 hrs each axis, Temperature cycle 8 h from Tmin to Tmax
	Mechanical Shock - Test for devices on rigid points on the body and on the frame	In acc. IEC 60068-2-27 half-sinusoidal Acceleration 500 m/s^2 Duration 6 ms room temperature 10 shocks per test direction
	Free fall (parts that may withstand falling without damages)	3 devices, 2 falls every device on the opposite side of the housing. Drop height: 1 m to concrete ground or steel plate
ISO 16750-4:2010	Tests at constant temperature: Low temperature - storage	- 40 °C for 24 hrs
	Tests at constant temperature: Low temperature - operation	Tmin for 24 hrs
	Tests at constant temperature: High temperature - storage	85 °C for 48 hrs
	Tests at constant temperature: High temperature - operation	Tmax for 96 hrs
	Temperature step test	20 °C to Tmin to Tmax, 5 °C steps; *Perform functional tests (OM 3.2) when DUT has reached the new temperature with Usmin and Usmax

DETAILED QUALIFICATION

Environmental Qualification

Standard	Test	Parameter
	Temperature cycling test	acc. to IEC 60068-2-14, Test Nb 30 cycles á 480 min , Tmin to Tmax Duration: 10 days *OM 3.2 for phases with electrical operation
	Temperature cycling test - Rapid change of Temperature	acc. to IEC 60068-2-14, Test Na Transfer time ≤ 30 sec.
	Ice water shock test - Splash water test	Heat the DUT at Tmax for the specified holding time t_h, then splash it with ice water (0 °C to +4 °C) for 3 sec.; (t_h = 1 hr or until temp. Stabilization is reached) 100 cycles each 66 Min.
	Salt spray test - Corrosion test	acc to IEC60068-2-52, Test Kb
	Salt spray test - Leakage and function	acc to IEC60068-2-11, Ka; 8h salt spray and 16h without spray, minimum 6 cycles á 24 hrs
	Humid heat cyclic - Test 2: Composite temperature / humidity cyclic test	acc to IEC60068-2-38, -Z/AD 10 cycles, upper temperature +65°C 93% r.H. 5 cycles with frost phase (-10°C); Duration: 11 days *OM 3.2 when the maximum cycle temperature is reached;
	Humid head cyclic - Test 3: Dewing test	In acc. To IEC 60068-2-38, Test Db Upper Temp.: 80°C, 5 cycles
	Damp heat, steady-state test	acc to IEC60068-2-78; +40°C and 85% r.H. OM: 2.1 for 20 days 23 hrs OM: 3.2 for the last hour Duration: 21 days
	Corrosion test with flow of mixed gas	acc to IEC60068-2-60, Test Ke, method 4; (SO2, H2S, NO2, CL2) 10 days (mounting passenger or luggage/load compartment) 21 days (other mounting locations)

DETAILED QUALIFICATION

Environmental Qualification

Standard	Test	Parameter
	Solar radiation	Confirmation of housing- and plug manufacturer about UV and OZON durability or test e.g. ISO 75220 or DIN EN 60068-2-5
	Dust Test	Acc. To ISO 20653 but different dust 50% limestone 50% fly ash (33% < 32 µm, 67% >32 µm but <250 µm) 20 cycles
	Protection against dust and water	ISO 20653
ISO 16750-5:2010	Chemical resistance	Exposure time 24 h, Exposure condition. 20 °C, 85% relative humidity, Gasoline, Methanol, Battery acid, Protective lacquer, Windshield washer fluid, Vehicle washing chemicals, Cold cleaning agent, Cleaning solvent, Denatured alcohol, Runway deicer, Aceton
		Exposure time 24 h Exposure. 125 °C, 85% rel. humidity Diesel fuel, Diesel fuel "Bio", Engine oil, Transmission fluid, Automatic transmission oil, Hydraulic oil, Greases, Silicone oil, Brake fluid, Antifreeze fluid, Urea, Protective lacquer remover, Contact spray
ISO 20653: 2013-02	IP Protection	IP6KX, IPX7, IPX9K IPX9K: This IP protection class only applies to variants that have a housing without M12 connector.
ISO 4892-2:2013-06	Exposure from Xenon-arc lamps	Method A - Testing with filters for global radiation - Cycle no. 1, table 3)
DIN EN 50102:1997-09	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code).	IK7 Impact energy (joules): 2