

ESX.4cl

ESX Control units

KEY FEATURES

- Control specially designed for use in harsh mobile applications
- Flexible programming in C or IEC61131-3 (logi.CAD)
- Suitable for safety-related applications up to SIL2 according to IEC 61508:2010¹⁾ or PL d according to EN ISO 13849-1:2015¹⁾

TECHNICAL DATA

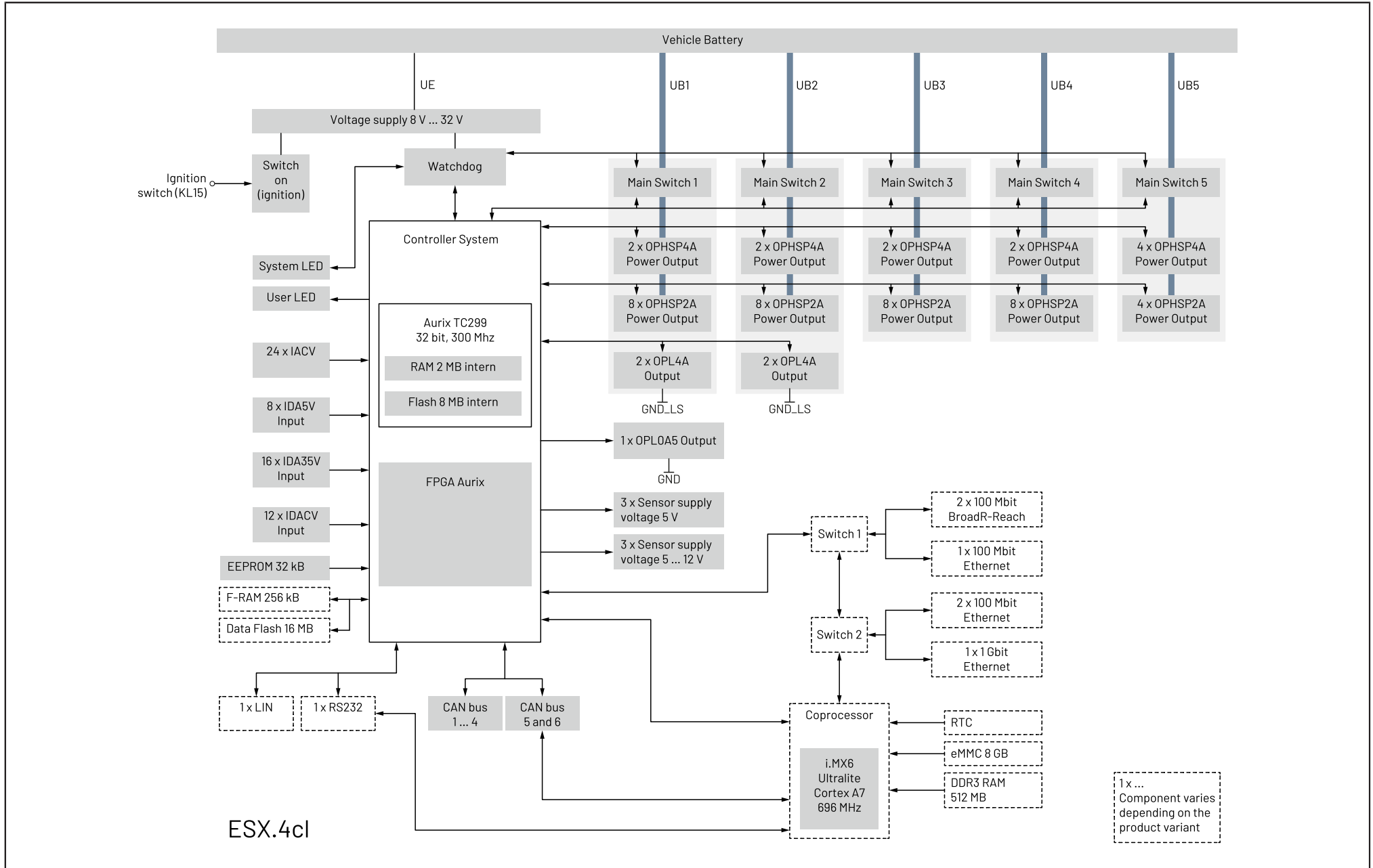
- Aurix TC299 Multicore 32 bit, 300 MHz
- Internal: 2 MB RAM, 8 MB Flash
- External: optional data flash and F-RAM options
- 32 kB EEPROM
- 6 CAN interfaces, 1 RS232 or LIN, optional up to 4 Ethernet interfaces and 2 BroadR Reach
- 60 inputs
- 53 outputs
- 6 sensor supply
- Coprocessor iMX6 with Linux (optional)

ACCESSORIES

- Debug variants of the controller
- Debugger
- Compiler
- Starter kit
- Component Deployment C, logi.CAD
- Mating Plug
- Integrated in STW Software Toolchain openSYDE

¹⁾Scheduled feature

BLOCK DIAGRAM



Variants

Variant features of the ESX.4cl

Options		Variant 3	Variant 4
Processor and Memory	32 bit Infineon Aurix TC299 Multicore CPU, @ 300 MHz	✓	✓
	2 MB internal RAM	✓	✓
	8 MB internal Flash	✓	✓
	32 kB EEPROM	✓	✓
	i.MX6 / RTC	-	✓
Communication Interface	CAN, from 100 kbit/s to 1 Mbit/s	6	6
	100 Mbit Ethernet	3	3
	1 Gbit Ethernet	1	1
	BroadR Reach	2	2
	RS232	1	1
Inputs	Analog Input IACV	24	24
	Multi Functional Input IDA5V	8	8
	Multi Functional Input IDA35V	16	16
	Multi Functional Input IDACV	12	12
Outputs	Digital/PWM High Side Output OPHSP4A	12	12
	Digital/PWM High Side Output OPHSP2A	36	36
	Digital/PWM Low Side Output OPL4A	4	4
	Digital/PWM Low Side Output OPL0A5	1	1

Variant features of the ESX.4cl

Options	Variant 3	Variant 4
Sensor supply voltage 5 V	3	3
Sensor supply voltage 5 ... 12 V	3	3

Available options of the ESX.4cl

Options	
Processor and Memory	256 kB external F-RAM (other memory sizes are available on request) 16 MB external data flash (other memory sizes are available on request)
Communication Interface	LIN in accordance to LIN specification 2.2 A (with equipped i.MX6 the LIN option is not available)

TECHNICAL DATA

Processor and Memory

Type	Properties	Features
Aurix TC299	32 bit, multicore processor, @ 300 MHz	<ul style="list-style-type: none"> External system supervisor with programmable watchdog 12 bit A/D converter for analog signal processing
Flash	8 MB	7.75 MB available for customer application
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.
EEPROM (non volatile memory)	1 x 32 kB	Available for customer application. (temperature refers to the EEPROM specifications) Data Retention: <ul style="list-style-type: none"> 50 years at 125 °C 100 years at 25 °C Typical endurance according to manufacturer: <ul style="list-style-type: none"> 4 million write cycles at 25 °C 1.2 million write cycles at 85 °C
F-RAM (optional)	256 kB Other memory sizes are available on request	External High endurance 100 trillion read/write cycles
Data flash (optional)	16 MB Other memory sizes are available on request	External

Processor and Memory Coprocessor

Type	Properties	Features
i.MX 6UltraLite	32 bit controller @ 696 MHz	Single ARM Cortex®-A7 core
RAM	512 MB DDR3	On-chip ECC
eMMC memory	8 GB	Write Endurance in Total Terabyte Written (TBW): 20TBW Data Retention (Fresh or Early Life Device): 15 years at 55 °C Data Retention (after 3K PE cycles): 20 month at 55 °C

TECHNICAL DATA

Processor and Memory Coprocessor

Type	Properties	Features
EEPROM (non volatile memory)	1 x 64 kB	-
RTC	Accuracy: ± 6 ppm at -40 °C to $+85$ °C	Buffering time for minimum 5 minutes
Temperature measurement	Accuracy: ± 2 °C at -40 °C to 150 °C	Located close to coprocessor and RAM

Communication Interfaces

Type	Maximal available counts	Configuration
CAN	6	CAN 2.0B, baud rate from 100 kbit/s to 1 Mbit/s
Ethernet	4	3 x 100 Mbit/s 100BASE-TX 1 x 1 Gbit/s 1000BASE-TX
BroadR-Reach	2	100 Mbit/s 100BASE-T1
RS232 (optional)	1	Baud rate up to 115 kBit/s
LIN (optional)	1	In accordance to LIN specification 2.2A

Inputs

Type	Maximal available counts	Possible configuration	Measurement
Multifunctional input IDA35V	16	Analog voltage	0 ... 35 V
		Programmable pull-up resistor	1.1 k Ω to +8.5 V
		Programmable pull-down resistor	1 k Ω to GND
		NAMUR sensor	NAMUR sensor compatible
		Digital	Active high Active low
		Frequency	0.6 Hz ... 20 kHz

TECHNICAL DATA

Inputs

Type	Maximal available counts	Possible configuration	Measurement
Analog input IACV	24	Analog voltage	0 ... 12 V
		Analog current	0 ... 24 mA
		Digital (voltage mode)	Active high Active low
Multi functional Input IDACV	12	Analog voltage programmable	0 ... 35 V 0 ... 12 V 0 ... 5 V
		Analog current	0 ... 24 mA
		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 (voltage mode)	Active high Active low
		Frequency	0.6 Hz ... 20 kHz Incremental encoder interface
		Incremental encoder interface	Change of position or angular change
Multifunctional input IDA5V	8	Analog voltage	0 ... 5 V
		Programmable pull-up resistor	6.8 kΩ to +5 V
		Digital	Active high Active low
		Frequency	0.6 Hz ... 20 kHz
		Incremental encoder interface SENT	Change of position or angular change SENT interface IDA5V is not fully compliant with SAE J2716:2016-04.

TECHNICAL DATA

Outputs

Type	Maximal available counts	Possible configuration	Range	Characteristics	Feature
Digital/PWM high side output OPHSP2A	36	PWM	0 ... 2.5 A	0 ... 100 % duty cycle resolution < 0.1 % PWM frequency 20 ... 1000 Hz	<ul style="list-style-type: none"> high side switch precise current measurement, accuracy is $\pm 2.3 \% \pm 70 \text{ mA}$ supports current control mode digital feedback, open load detection in OFF state automated shutdown on overcurrent > 4.6 A $\pm 0.9 \text{ A}$ combine several outputs for parallel operation
		Digital	-	ON/OFF	
Digital/PWM high side output OPHSP4A	12	PWM	0 ... 4 A	0 ... 100 % duty cycle resolution < 0.1 % PWM frequency 20 ... 500 Hz	<ul style="list-style-type: none"> high side switch precise current measurement, accuracy is $\pm 2.3 \% \pm 140 \text{ mA}$ supports current control mode digital feedback, open load detection in OFF state automated shutdown on overcurrent > 7.5 A $\pm 1.5 \text{ A}$ combine several outputs for parallel operation
		Digital	-	ON/OFF	
Digital/PWM low side output OPL4A	4	PWM	0 ... 4 A	0 ... 100 % duty cycle resolution < 0.1 % PWM frequency 20 ... 1000 Hz	<ul style="list-style-type: none"> low side switch precise current measurement, accuracy is $\pm 2.3 \% \pm 120 \text{ mA}$ supports current control mode digital feedback, open load detection in OFF state automated shutdown on overcurrent > 7.5 A $\pm 1.0 \text{ A}$ output voltage feedback, accuracy is $\pm 4.5 \% \pm 200 \text{ mV}$
		Digital	-	ON/OFF	
Digital low side output OPL0A5	1	PWM	0 ... 0.5 A	0 ... 100 % duty cycle resolution < 0.1 % PWM frequency 20 ... 1000 Hz	<ul style="list-style-type: none"> low side switch output voltage feedback, accuracy is $\pm 4 \% \pm 200 \text{ mV}$
		Digital	-	ON/OFF	

TECHNICAL DATA

Outputs

Type	Maximal available counts	Possible configuration	Range	Characteristics	Feature
Main Switch	5		8 ... 32 V DC	ON/OFF	<ul style="list-style-type: none"> high-side switch switches the output groups +UB1 to +UB5 Current up to 12 A
Sensor supply voltage 5 V	3	-	5 V	ON/OFF	Maximal output current 250 mA
Sensor supply voltage 5 ... 12 V	3	Voltage	5 ... 12 V	-	Maximal output current $I_{MAX} = 250 \text{ mA}$ programmable output needs derating for output voltages $U_{EXT} < 10 \text{ V}$: $I_{MAX} = 0.875 / (13.5 - U_{EXT}) \text{ A}$

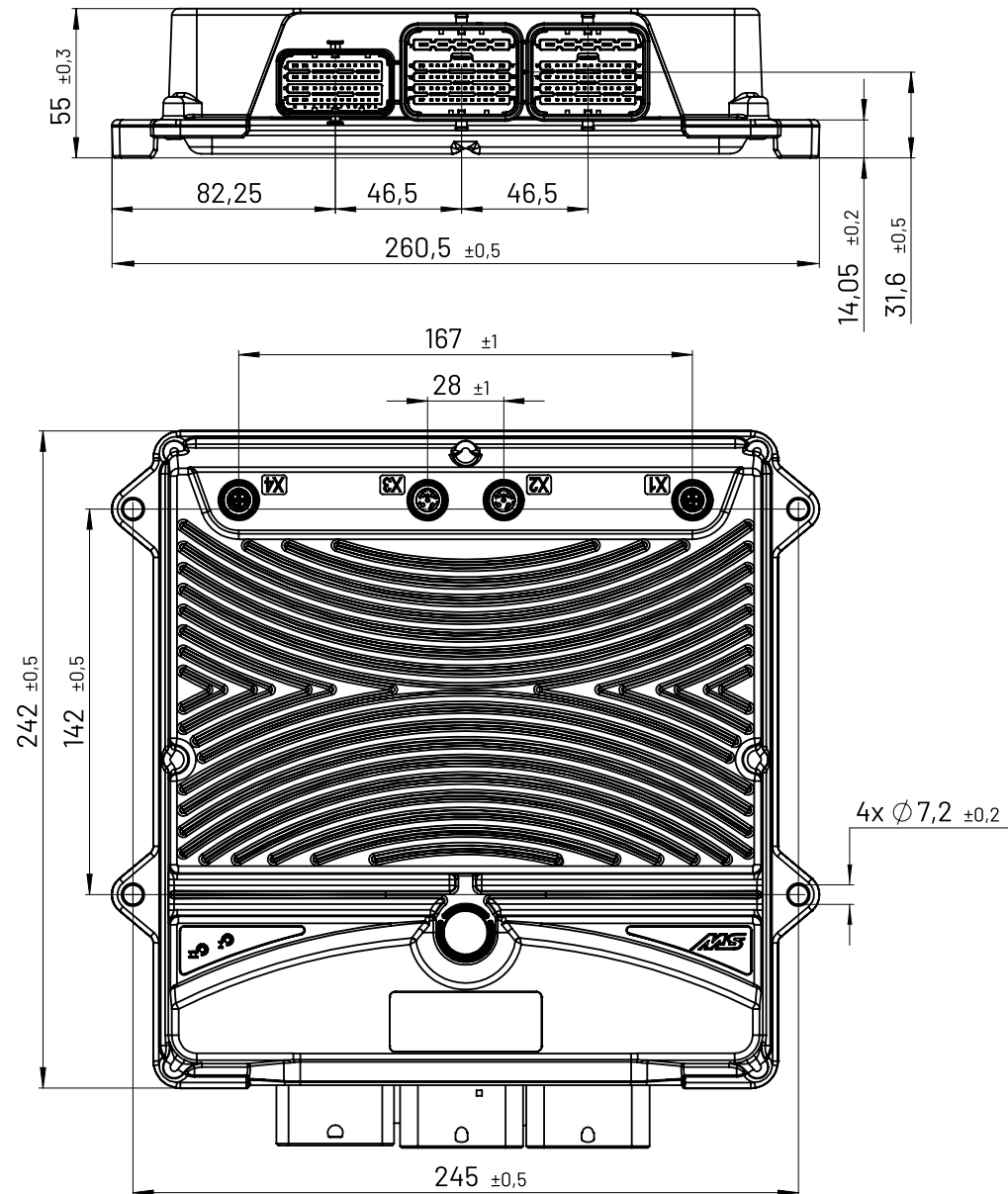
Mechanical Data

Component	Description	Value
Connectors	-	Automotive 154 pins, Molex CMC Ethernet, M12 connector: 100 MBit: 4 pins d-coded 1 GBit: 8 pins x-coded
Indicators	2 LED, dual color (red/green or mixed colors)	System LED and User LED
Housing	Die-cast aluminum	GORE-TEX™-breathing filter for pressure equalization
Degree of Protection	Variant without M12 Ethernet connector	IP6k9k
	Variant with M12 Ethernet connector	IP6k7
Dimensions	-	264 mm x 260 mm x 55 mm
Operating temperature, chassis temperature	-	-40 ... +85 °C (-40 ... +185 °F)
Operating altitude	-	-400 ... +4000 m

TECHNICAL DATA

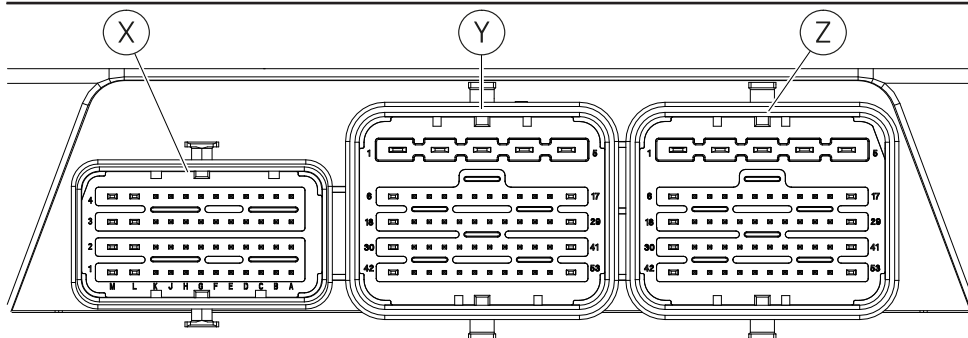
Power Supply

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 +UB1 fully loaded 12 A	-	60 A, short-term
	Power supply +UB2 fully loaded 12 A		
	Power supply +UB3 fully loaded 12 A		
	Power supply +UB4 fully loaded 12 A		
	Power supply +UB5 fully loaded 12 A		
	4 x low side output OPL4A, fully loaded 16 A		
Standby	Sum of input currents at +UE and +UB ($U_{KL15} = 0$ V, ignition off) Without external load		< 1 mA
ECU active	+UE supply current ($U_{KL15} > U_{KL15HIGH}$, no external load)		-
LIN voltage supply	12 V supply voltage for LIN. In a 24 V systems, one of the 5 ... 12 V sensor supplies can be connected to the LIN supply pin.	8 V	16 V



PIN ASSIGNMENT

Pin Assignment Main Connector X1



Pin Assignment Main Connector X1

X		Y		Z	
Pin	Signal name	Pin	Signal name	Pin	Signal name
XD3	IDA5V_2	Y15	IDA35V_13	Z15	IACV_17
XD4	IDA5V_1	Y16	OPHSP2A_33	Z16	KL15
XE1	P2_BRR+	Y17	OPHSP4A_9	Z17	OPL4A_1
XE2	CAN2_L	Y18	OPHSP4A_6	Z18	OPHSP4A_2
XE3	IDA5V_3	Y19	OPHSP2A_26	Z19	OPHSP2A_2
XE4	CAN1_L	Y20	OPHSP2A_28	Z20	OPHSP2A_4
XF1	P2_BRR-	Y21	OPHSP2A_30	Z21	OPHSP2A_6
XF2	CAN2_H	Y22	IDACV_11	Z22	OPHSP2A_8
XF3	IDA5V_4	Y23	IACV_22	Z23	IACV_2
XF4	CAN1_H	Y24	IDA35V_2	Z24	IACV_6
XG1	not connected	Y25	IDA35V_6	Z25	IACV_10
XG2	not connected	Y26	IDA35V_10	Z26	IACV_14
XG3	CAN5_L	Y27	IDA35V_14	Z27	IACV_18
XG4	CAN4_L	Y28	OPHSP2A_34	Z28	IDACV_9
XH1	P1_BRR+	Y29	OPHSP4A_10	Z29	OPL4A_2
XH2	CAN3_L	Y30	OPHSP2A_17	Z30	OPHSP4A_3
XH3	CAN5_H	Y31	OPHSP2A_19	Z31	OPHSP2A_9
XH4	CAN4_H	Y32	OPHSP2A_21	Z32	OPHSP2A_11
XJ1	P1_BRR-	Y33	OPHSP2A_23	Z33	OPHSP2A_13
XJ2	CAN3_H	Y34	OPHSP2A_32	Z34	OPHSP2A_15

X		Y		Z	
Pin	Signal name	Pin	Signal name	Pin	Signal name
XA1	IDACV_8	Y1	OPHSP4A_7	Z1	UB2
XA2	IDACV_7	Y2	UB3	Z2	UB1
XA3	IDACV_6	Y3	UB4	Z3	GND
XA4	IDACV_5	Y4	UB5	Z4	GND_LS
XB1	IDA5V_8	Y5	OPHSP4A_8	Z5	UE
XB2	IDA5V_7	Y6	OPHSP4A_5	Z6	OPHSP4A_1
XB3	IDA5V_6	Y7	OPHSP2A_25	Z7	OPHSP2A_1
XB4	IDA5V_5	Y8	OPHSP2A_27	Z8	OPHSP2A_3
XC1	IDACV_4	Y9	OPHSP2A_29	Z9	OPHSP2A_5
XC2	IDACV_3	Y10	OPHSP2A_31	Z10	OPHSP2A_7
XC3	IDACV_2	Y11	IACV_21	Z11	IACV_1
XC4	IDACV_1	Y12	IDA35V_1	Z12	IACV_5
XD1	not connected	Y13	IDA35V_5	Z13	IACV_9
XD2	not connected	Y14	IDA35V_9	Z14	IACV_13

PIN ASSIGNMENT

Pin Assignment Main Connector X1

X		Y		Z	
Pin	Signal name	Pin	Signal name	Pin	Signal name
XJ3	CAN6_L	Y35	IACV_23	Z35	IACV_3
XJ4	RS232/LIN Rx ¹⁾	Y36	IDA35V_3	Z36	IACV_7
XK1	not connected	Y37	IDA35V_7	Z37	IACV_11
XK2	not connected	Y38	IDA35V_11	Z38	IACV_15
XK3	CAN6_H	Y39	IDA35V_15	Z39	IACV_19
XK4	RS232 Tx/ LIN Sup ¹⁾	Y40	OPHSP2A_35	Z40	OPL0A5
XL1	AGND	Y41	OPHSP4A_11	Z41	OPL4A_3
XL2	UEXT5_3	Y42	OPHSP2A_18	Z42	OPHSP4A_4
XL3	UEXT5_2	Y43	OPHSP2A_20	Z43	OPHSP2A_10
XL4	UEXT5_1	Y44	OPHSP2A_22	Z44	OPHSP2A_12
XM1	AGND	Y45	OPHSP2A_24	Z45	OPHSP2A_14
XM2	UEXT5-12V_3	Y46	IDACV_12	Z46	OPHSP2A_16
XM3	UEXT5-12V_2	Y47	IACV_24	Z47	IACV_4
XM4	UEXT5-12V_1	Y48	IDA35V_4	Z48	IACV_8
		Y49	IDA35V_8	Z49	IACV_12
		Y50	IDA35V_12	Z50	IACV_16
		Y51	IDA35V_16	Z51	IACV_20
		Y52	OPHSP2A_36	Z52	IDACV_10
		Y53	OPHSP4A_12	Z53	OPL4A_4

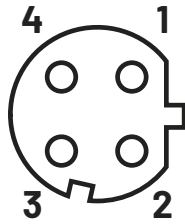
¹⁾ Scheduled feature

PIN ASSIGNMENT

Connectors X2 ... X5:

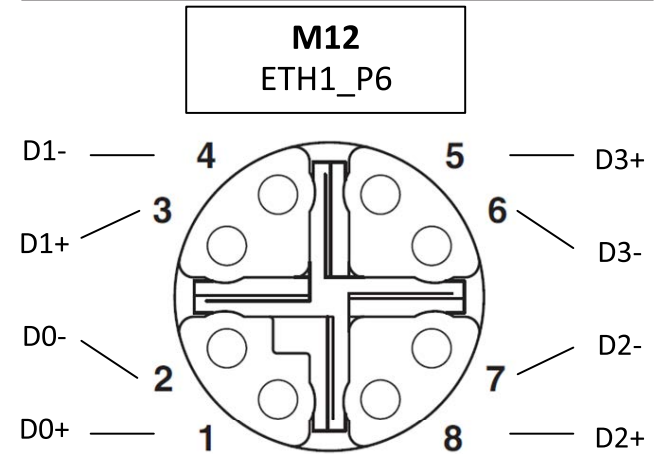


Pin Assignment M12 Connectors X2 ... X4:



Connector	Pin	Description
X2	1	ETH1_P3_TX+
X2	2	ETH1_P3_RX+
X2	3	ETH1_P3_TX-
X2	4	ETH1_P3_RX-
X3	1	ETH1_P4_TX+
X3	2	ETH1_P4_RX+
X3	3	ETH1_P4_TX-
X3	4	ETH1_P4_RX-
X4	1	ETH1_P5_TX+
X4	2	ETH1_P5_RX+
X4	3	ETH1_P5_TX-
X4	4	ETH1_P5_RX-


Pin Assignment M12 Connector X5:



Connector	Pin	Description
X5	1	ETH1_P6_D0+
X5	2	ETH1_P6_D0-
X5	3	ETH1_P6_D1+
X5	4	ETH1_P6_D1-
X5	5	ETH1_P6_D3+
X5	6	ETH1_P6_D3-
X5	7	ETH1_P6_D2-
X5	8	ETH1_P6_D2+

QUALIFICATION

Compliance Information

Standard	Description	Parameter
ISO/IEC 17050-1	 Conformity	See Declaration of Conformity
	RoHS Restriction of Hazardous Substances	

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

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

DETAILED QUALIFICATION

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

Standard	Test	Parameter
	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
	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)

DETAILED QUALIFICATION

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

Standard	Test	Parameter
	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

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

DETAILED QUALIFICATION

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

Standard	Test	Parameter
	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 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

DETAILED QUALIFICATION

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

Standard	Test	Parameter
		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

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
	Overvoltage - Systems with 12 V / 24 V nominal voltage - 24 V Systems	24 V for 60 s at room temperature 36 V for 60 min. at 20 °C below Tmax
	Superimposed alternating voltage - 12 V Systems	Usmax = 16 V (for UN = 12 V) Sweep duration: 120 seconds Number of sweeps: 5 Severity 1, 2, 4
	Superimposed alternating voltage - 24 V Systems	Usmax = 32 V (for UN = 24 V) Sweep duration: 120 seconds Number of sweeps: 5 Severity 1, 2, 3

DETAILED QUALIFICATION

Electrical Safety (Test specifications are currently still being processed)

Standard	Test	Parameter
	Slow decrease and increase of supply voltage	Decrease supply voltage from U_{smin} to 0 V and increase it from 0 V to U_{smin} . 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 U_{smin} in 5 % steps
	Discontinuities in supply voltage - Starting profile 12 V code C	Voltage cranking; Level 1 Voltage cranking; Level 2 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	$U_{nom.} = 12$ V \rightarrow Case 1 - Test Voltage = -4 V reversed polarity Duration: 60 s
	Reversed voltage - Case 2 - 12 V Systems	$U_{nom.} = 12$ V \rightarrow Case 2 - Test Voltage = -14 V reversed polarity Duration: 60 s
	Reversed voltage - Case 2 - 24 V Systems	$U_{nom.} = 24$ V \rightarrow Case 2 - Test Voltage = 28 V reversed polarity Duration: 60 s

DETAILED QUALIFICATION

Electrical Safety (Test specifications are currently still being processed)

Standard	Test	Parameter
	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.
	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

DETAILED QUALIFICATION

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

Standard	Test	Parameter
		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

Environmental Qualification (Test specifications are currently still being processed)

Standard	Test	Parameter
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
ISO 4892-2:2013-06	Exposure from Xenon-arc lamps	Method A - Testing with filters for global radiation - Cycle no. 1, table 3
ISO 16750-3:2012	Resonance search	10 Hz - 2000 Hz, 1 g, 0,5 oct/min
	Test VII - Commercial vehicle, sprung masses	Vibration noise with temperature superimposition in case of natural frequencies of DUT upper 30Hz: 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

DETAILED QUALIFICATION

Environmental Qualification (Test specifications are currently still being processed)

Standard	Test	Parameter
		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
	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 Severity: Severity 4 Cycle duration: 7 days Number of cycles: 2 cycles

DETAILED QUALIFICATION

Environmental Qualification (Test specifications are currently still being processed)

Standard	Test	Parameter
	Salt spray test - Leakage and function	acc. to IEC60068-2-11, Test Ka Cycle duration: 24 hrs (8 hrs salt spray - 16hrs without spray) Number of cycles: 6 cycles
	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 Test cycle: 21 days in pollutant gas atmosphere (SO2, H2S, NO2, Cl2)
	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 Cycle duration: 20 min. Number of cycles: 20 cycles
	Protection against dust and water	ISO 20653
ISO 16750-5	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 de-icer, Aceton Exposure time 24 h Exposure condition 125 °C, 85 % relative humidity Diesel fuel, Diesel fuel "Bio", Engine oil, Transmission fluid, Automatic trans-

DETAILED QUALIFICATION

Environmental Qualification (Test specifications are currently still being processed)

Standard	Test	Parameter
ISO 20653:2013-02	IP Protection	mission oil, Hydraulic oil, Greasees, Silicone oil, Brake fluid, Antifreeze fluid, Urea, Protective lacquer remover, Contact spray IP6k6k, IPx7, IPx9k