

ESX.iot

ESX I/O modules

KEY FEATURES

- Control specially designed for use in harsh mobile applications
- Flexible I/O module configurable via CANopen
- Suitable for safety-related applications up to PL b according to EN ISO 13849-1:2015
- Pin-compliant to ESX.iox

TECHNICAL DATA

- 1 CAN interface, CAN FD ready, wake-up, HW compliant to ISOBUS ISO 11783-3
- Variants with 16, 20, 24 or 28 inputs
SENT interface available for 2 input types (upcoming feature)
- Variants with 13, 9, 5 or 0 outputs
up to 8 half bridges supporting PVG valves
- 1 sensor supply 5 V ... 12 V, max. 250 mA
- 6-axis accelerometer & gyroscope (optional),
Bluetooth LE v5.1 with internal antenna (optional),
LIN Spec 2.2A (optional)

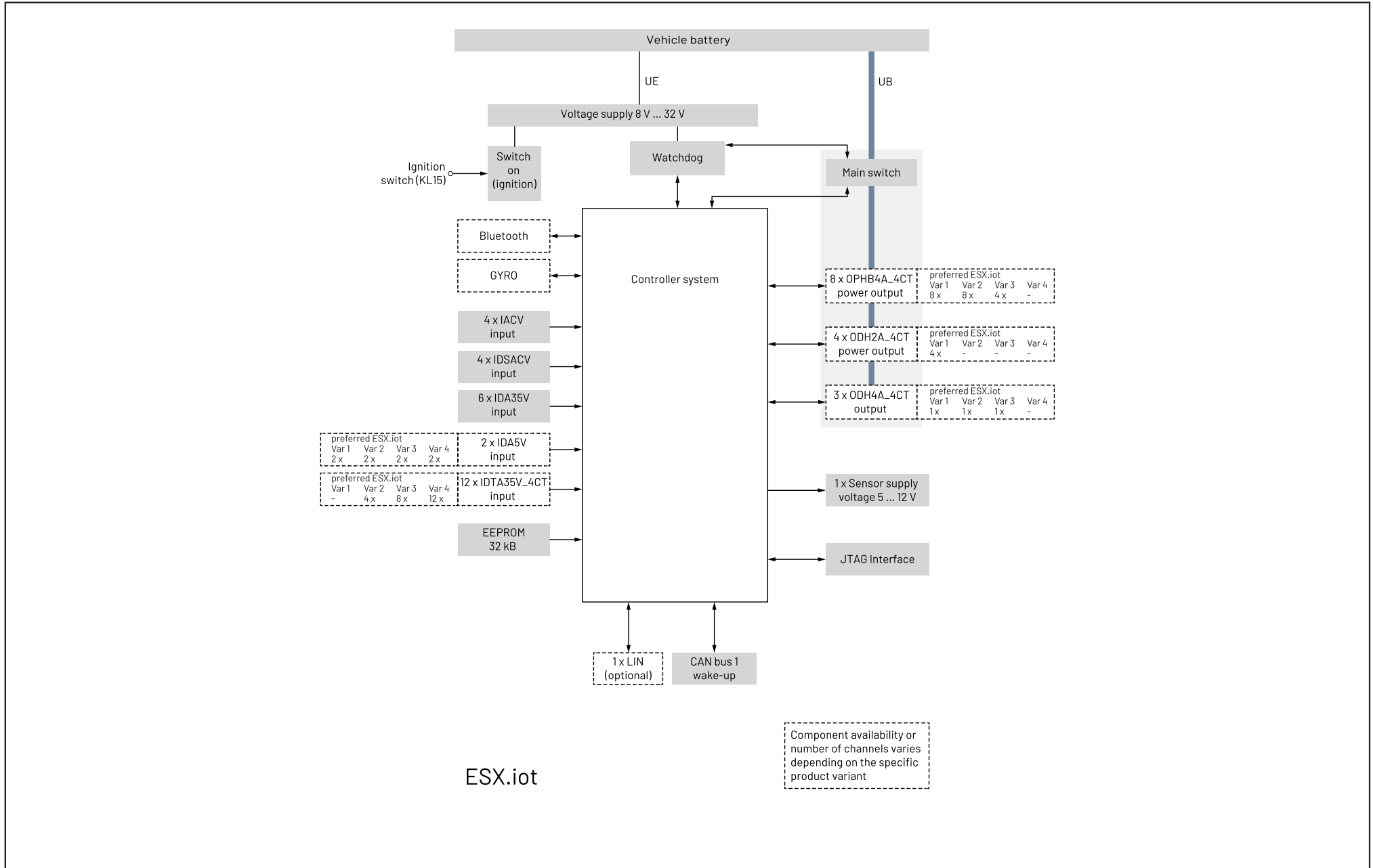
ACCESSORIES

- Starter kit
- Mating Plug
- Integrated into STW's openSYDE software platform

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BLOCK DIAGRAM



VARIANTS

Variant features of the ESX.iot The variants listed here are STW standard variants. Further variants available on request. A complete overview of the possible assignment of each individual pin can be found in the PIN ASSIGNMENT.

preferred ESX.iot	Var 1	Var 2	Var 3	Var 4
CAN bus	1 CAN with wake-up	1 CAN with wake-up	1 CAN with wake-up	1 CAN with wake-up
CAN1 Termination	Optional	Optional	Optional	Optional
X_IN_IDA35V	6	6	6	6
X_IN_IACV	4	4	4	4
X_IN_IDSACV	4	4	4	4
X_IN_IDA5V	2	2	2	2
X_IN_IDTA35V_4CT	—	4	8	12
X_OUT_OPHB4A_4CT (with current measurement) ¹⁰⁾	4/8	4/8	4	—
X_OUT_OPHB4A_4CT_NCM (without current measurement) ¹⁰⁾	4/0	4/0	—	—
X_OUT_ODH2A_4CT ¹⁰⁾	4	—	—	—
X_OUT_ODH4A_4CT	1	1	1	—
X_UEXT_ADJ_5V_12V	1	1	1	1
EEPROM	32 kByte	32 kByte	32 kByte	32 kByte
Gyro	Optional	Optional	Optional	Optional
Bluetooth	Optional	Optional	Optional	Optional
LIN	Optional	Optional	Optional	Optional

¹⁰⁾ Outputs can be initialized as IDTA35V_4CT inputs. This invokes risks an restrictions due to possible reverse supply of other outputs over the freewheeling diode inside the switch.



TECHNICAL DATA

Communication Interfaces

Type	Maximal available counts	Configuration
CAN	1	CAN 2.0 B, high-speed and low-speed, baud rate from 100 kbit/s to 1 Mbit/s CAN FD ready, ISOBUS ISO 11783-3, wake-up - functionality
LIN	1	LIN Spec. 2.2A (upcoming feature) Either 2x IDA5V or LIN is selectable, as both share the same pins.

TECHNICAL DATA

Inputs

Type	Maximal available counts	Possible configuration	Measurement	Feature
Digital analog input IDSACV	4	Analog voltage range (programmable)	0 ... 35 V 0 ... 12 V 0 ... 5 V	Voltage measurement accuracy <ul style="list-style-type: none"> • $\pm 2\%$ ± 200 mV (35 V measuring range) • $\pm 2\%$ ± 100 mV (12 V measuring range) • $\pm 2\%$ ± 60 mV (5 V measuring range)
		Analog current	0 ... 24 mA	Current measurement accuracy $\pm 2\%$ ± 0.20 mA
		Programmable pull-up resistor	1 k Ω to GND 1.1 k Ω to +8.5 V 10 k Ω to +5 V	
		NAMUR sensor	NAMUR sensor compatible	
		Digital (voltage mode)	Active high Active low	
		Frequency	0.6 Hz ... 20 kHz	<ul style="list-style-type: none"> • Frequency measurement bandwidth 120 kHz $\pm 40\%$ (signal 10 V_{pp} and 5 V offset) • Frequency measurement accuracy $\pm 0.4\%$ • Frequency measurement resolution $(f_{\text{signal}})^2 / 10$ MHz
		SENT (upcoming feature)	SENT interface provided (requires 5 V analog measuring range)	

TECHNICAL DATA

Inputs

Type	Maximal available counts	Possible configuration	Measurement	Feature
Multifunctional input IDA35V	6	Analog voltage	0 ... 35 V	<ul style="list-style-type: none"> Voltage measurement bandwidth 115 Hz \pm30% Voltage measurement accuracy \pm2% \pm300 mV
		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	
		Edge Evaluation	Events, reacts on falling or rising edge of the signal	
		Frequency	0.6 Hz ... 20 kHz	<ul style="list-style-type: none"> Frequency measurement bandwidth 120 kHz \pm40% (input signal with 10 V_{pp} and 5 V DC offset) Frequency measurement accuracy \pm0.4%
Analog input IACV	4	Analog voltage	0 ... 12 V	<ul style="list-style-type: none"> Voltage measurement accuracy \pm2.3% \pm100 mV Voltage measurement impedance 24 kΩ \pm10% related to AGND
		Analog current	0 ... 25 mA	<ul style="list-style-type: none"> Current measurement accuracy \pm2% \pm0.20 mA Current measurement impedance 140 Ω \pm10% related to AGND, includes \approx 0.7 V for the polarity protection diode
		Digital (voltage mode)	Active-high/active-low	

TECHNICAL DATA

Inputs

Type	Maximal available counts	Possible configuration	Measurement	Feature
Multifunctional input IDA5V	2	Analog voltage	0 ... 5 V (suitable for example for PT1000 and KTY)	<ul style="list-style-type: none"> Voltage measurement bandwidth 125 Hz \pm30% Voltage measurement accuracy \pm2% \pm35 mV
		Programmable pull-up resistor	6.8 k Ω to +5 V	
		Digital	Active-high/active-low	
		Edge Evaluation	Events, reacts on falling or rising edge of the signal	
		Frequency	0.6 Hz ... 20 kHz	<ul style="list-style-type: none"> Frequency measurement bandwidth 200 kHz \pm40% Frequency measurement accuracy \pm0.4%
		SENT (upcoming feature)	SENT interface	
Digital analog voltage input IDTA35V_4CT	12	Analog voltage	0 ... 35 V	<ul style="list-style-type: none"> Voltage measurement bandwidth 132 Hz \pm20% Voltage measurement accuracy \pm3% \pm150 mV
		Adjustable threshold	1.5 V to 9.0 V	
		Fixed pull-up resistor	36 k Ω to +13.5 V	
		Effective pull-down resistor	\approx 30 k Ω to GND	
		Frequency	0.6 Hz ... 20 kHz	<ul style="list-style-type: none"> Frequency measurement bandwidth 100 kHz \pm40% Frequency measurement accuracy \pm0.4% at 20 kHz

TECHNICAL DATA

Outputs

Type	Maximal available counts	Possible configuration	Range	Characteristics	Feature
Digital output ODH2A_4CT	4	Digital	-	ON/OFF	<ul style="list-style-type: none"> • high side switch • optimized for digital operation mode (ON/OFF) • current feedback, measurement accuracy is $\pm 5\%$ (gain) ± 150 mA (offset) • output voltage feedback, voltage measurement with $\pm 3\%$ (gain) ± 120 mV (offset)
Digital output ODH4A_4CT	3	Digital	-	ON/OFF	<ul style="list-style-type: none"> • high side switch • optimized for digital operation mode (ON/OFF) • current feedback, measurement accuracy is $\pm 5\%$ (gain) ± 300 mA (offset) • output voltage feedback, voltage measurement with $\pm 3\%$ (gain) ± 120 mV (offset)
Digital/PWM half bridge output OPHB4A_4CT	4	PWM	0 ... 4 A	0 ... 100 % duty cycle resolution < 0.1 % PWM frequency 5 ... 20000 Hz	<ul style="list-style-type: none"> • push-pull output • current measurement $\pm 2\%$ ± 60 mA • supports current control mode • digital feedback • output voltage feedback, accuracy is 3% ± 120 mV • automated shutdown on overcurrent • automated shutdown on overtemperature • two half-bridge outputs might be combined as full-bridge • control of PVG valves possible

TECHNICAL DATA

Outputs

Type	Maximal available counts	Possible configuration	Range	Characteristics	Feature
Digital/PWM half bridge output OPHB4A_4CT, NCM (no current measurement)	4	PWM	0 ... 4 A	0 ... 100 % duty cycle resolution < 0.1 % PWM frequency 5 ... 20000 Hz	<ul style="list-style-type: none"> • push-pull output • digital feedback • output voltage feedback, accuracy is 3 % ±120 mV • automated shutdown on overcurrent • automated shutdown on overtemperature • two half-bridge outputs might be combined as full-bridge • control of PVG valves possible <p>Optional with current measurement:</p> <ul style="list-style-type: none"> • current measurement ±2 % ±60 mA • supports current control mode
Main Switch	1		8 ... 32 V DC	ON/OFF	<ul style="list-style-type: none"> • powers all digital and PWM outputs • Current up to 15 A
Sensor supply voltage 5 ... 12 V	1	Voltage	5 ... 12 V	Accuracy voltage output is ±0.9% ±50 mV This is valid under the following conditions: <ul style="list-style-type: none"> • capacitive load ≤470 µF • settling time 100 ms 	<ul style="list-style-type: none"> • maximal output current $I_{MAX} = 250$ mA • programmable output needs derating for output voltages $U_{EXT} < 10$ V: $I_{MAX} = 0.875 / (13.5 - U_{EXT})$ A • accuracy voltage feedback: ±0.9% ±50 mV

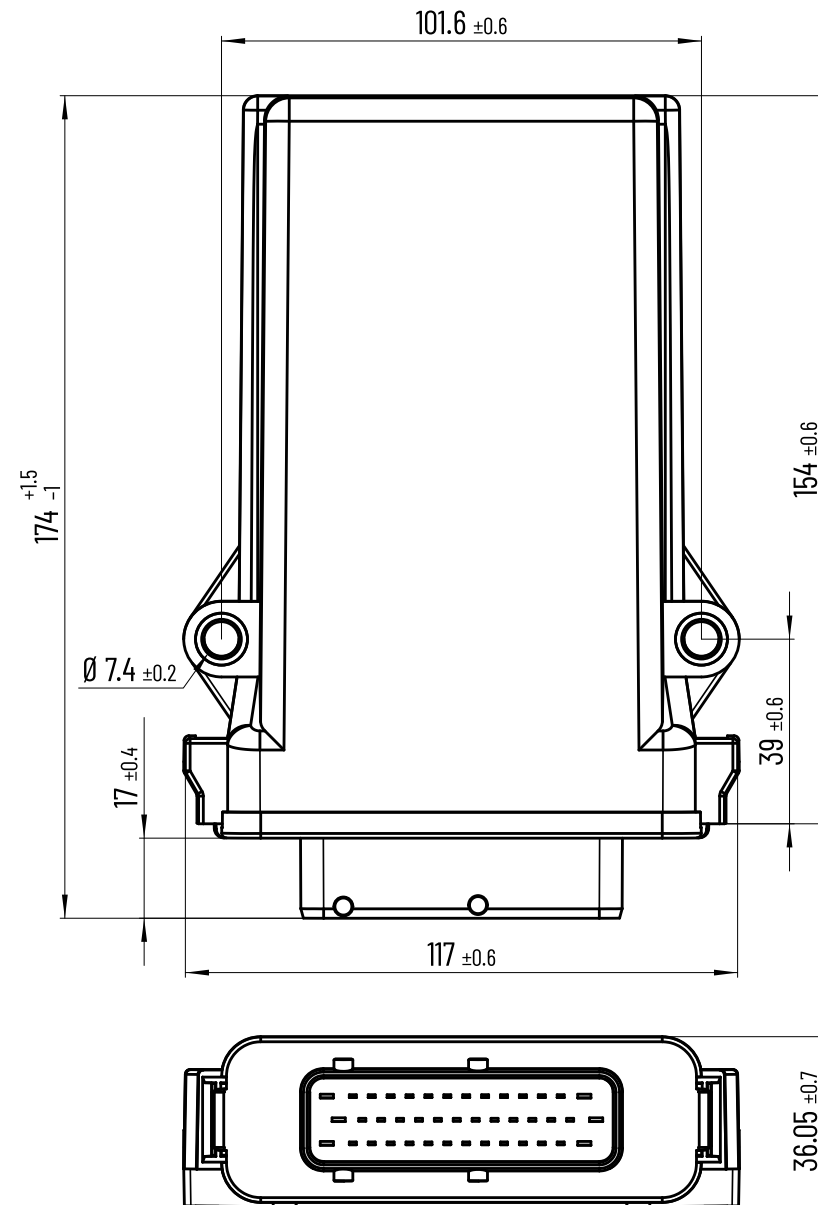
TECHNICAL DATA

Mechanical Data

Component	Description	Value
Connector	Automotive type vehicle connector (compatible to TE part number 1-0967281-1)	42 pin, 3 row, cable suited plug
IP protection class	-	IP6Kx, IPx6, IPx7
Weight	-	≈ 0.32 kg
Dimensions (L x W x H)	-	174 x 117 x 36 mm
Operating temperature (T_{min} / T_{max})	Internal PCB temperature (to be checked/ensured by application)	-40 °C ... +85 °C

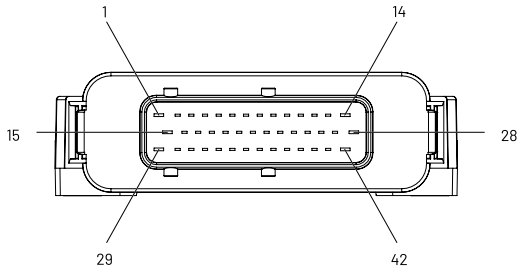
Power Supply

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		
	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)		≈ 250 mA at +UE = 8 V ≈ 100 mA at +UE = 32 V



PIN ASSIGNMENT

Pin Assignment



Pin	Type	Variant 1	Variant 2	Variant 3	Variant 4
X1.01	GND	—	—	—	—
X1.02	Input Output	X_OUT_ODH2A_1 X_IN_IDTA35V_1	X_IN_IDTA35V_1	X_IN_IDTA35V_1	X_IN_IDTA35V_1
X1.03	Input Output	X_OUT_ODH2A_2 X_IN_IDTA35V_2	X_IN_IDTA35V_2	X_IN_IDTA35V_2	X_IN_IDTA35V_2
X1.04	Input Output	X_OUT_ODH2A_3 X_IN_IDTA35V_3	X_IN_IDTA35V_3	X_IN_IDTA35V_3	X_IN_IDTA35V_3
X1.05	Input Output	X_OUT_ODH2A_4 X_IN_IDTA35V_4	X_IN_IDTA35V_4	X_IN_IDTA35V_4	X_IN_IDTA35V_4
X1.06	Input Output	X_OUT_OPHB4A_1 X_IN_IDTA35V_5	X_OUT_OPHB4A_1 X_IN_IDTA35V_5	X_OUT_OPHB4A_1 X_IN_IDTA35V_5	X_IN_IDTA35V_5
X1.07	Input Output	X_OUT_OPHB4A_2 X_IN_IDTA35V_6	X_OUT_OPHB4A_2 X_IN_IDTA35V_6	X_OUT_OPHB4A_2 X_IN_IDTA35V_6	X_IN_IDTA35V_6
X1.08	Input Output	X_OUT_OPHB4A_3 X_IN_IDTA35V_7	X_OUT_OPHB4A_3 X_IN_IDTA35V_7	X_OUT_OPHB4A_3 X_IN_IDTA35V_7	X_IN_IDTA35V_7
X1.09	Input Output	X_OUT_OPHB4A_4 X_IN_IDTA35V_8	X_OUT_OPHB4A_4 X_IN_IDTA35V_8	X_OUT_OPHB4A_4 X_IN_IDTA35V_8	X_IN_IDTA35V_8
X1.10	Input Output	X_OUT_OPHB4A_5(NCM)* X_IN_IDTA35V_9	X_OUT_OPHB4A_5(NCM)* X_IN_IDTA35V_9	X_IN_IDTA35V_9	X_IN_IDTA35V_9

PIN ASSIGNMENT

Pin Assignment

Pin	Type	Variant 1	Variant 2	Variant 3	Variant 4
X1.11	Input Output	X_OUT_OPHB4A_6 (NCM)* X_IN_IDTA35V_10	X_OUT_OPHB4A_6 (NCM)* X_IN_IDTA35V_10	X_IN_IDTA35V_10	X_IN_IDTA35V_10
X1.12	Input Output	X_OUT_OPHB4A_7 (NCM)* X_IN_IDTA35V_11	X_OUT_OPHB4A_7 (NCM)* X_IN_IDTA35V_11	X_IN_IDTA35V_11	X_IN_IDTA35V_11
X1.13	Input Output	X_OUT_OPHB4A_8 (NCM)* X_IN_IDTA35V_12	X_OUT_OPHB4A_8 (NCM)* X_IN_IDTA35V_12	X_IN_IDTA35V_12	X_IN_IDTA35V_12
X1.14	UB	—	—	—	—
X1.15	AGND	—	—	—	—
X1.16	KL15	—	—	—	—
X1.17	CAN bus 1 low	CAN1_L	CAN1_L	CAN1_L	CAN1_L
X1.18	Input	X_IN_IDA5V_1	X_IN_IDA5V_1	X_IN_IDA5V_1	X_IN_IDA5V_1
X1.19	Output Uext	X_OUT_ODH4A_4CT_1	X_OUT_ODH4A_4CT_1	X_OUT_ODH4A_4CT_1	X_UEXT_ADJ_5V_12V_1
X1.20	Input	X_IN_IDA35V_1	X_IN_IDA35V_1	X_IN_IDA35V_1	X_IN_IDA35V_1
X1.21	Input	X_IN_IDA35V_2	X_IN_IDA35V_2	X_IN_IDA35V_2	X_IN_IDA35V_2
X1.22	IMID2/Input	X_IN_IDA35V_3	X_IN_IDA35V_3	X_IN_IDA35V_3	X_IN_IDA35V_3
X1.23	CAN bus 1 high	CAN1_H	CAN1_H	CAN1_H	CAN1_H
X1.24	Input	X_IN_IACV_1	X_IN_IACV_1	X_IN_IACV_1	X_IN_IACV_1
X1.25	Input	X_IN_IACV_2	X_IN_IACV_2	X_IN_IACV_2	X_IN_IACV_2
X1.26	Input	X_IN_IDSACV_1	X_IN_IDSACV_1	X_IN_IDSACV_1	X_IN_IDSACV_1
X1.27	Input	X_IN_IDSACV_2	X_IN_IDSACV_2	X_IN_IDSACV_2	X_IN_IDSACV_2
X1.28	UB	—	—	—	—
X1.29	GND	—	—	—	—

PIN ASSIGNMENT




Pin Assignment

Pin	Type	Variant 1	Variant 2	Variant 3	Variant 4
X1.30	UE	—	—	—	—
X1.31	CAN bus 1 high	CAN1_H	CAN1_H	CAN1_H	CAN1_H
X1.32	Uext	X_UEXT_ADJ_5V_12V_1	X_UEXT_ADJ_5V_12V_1	X_UEXT_ADJ_5V_12V_1	X_UEXT_ADJ_5V_12V_1
X1.33	Input	X_IN_IDA5V_2	X_IN_IDA5V_2	X_IN_IDA5V_2	X_IN_IDA5V_2
X1.34	Input	X_IN_IDA35V_4	X_IN_IDA35V_4	X_IN_IDA35V_4	X_IN_IDA35V_4
X1.35	Input	X_IN_IDA35V_5	X_IN_IDA35V_5	X_IN_IDA35V_5	X_IN_IDA35V_5
X1.36	IMID1/Input	X_IN_IDA35V_6	X_IN_IDA35V_6	X_IN_IDA35V_6	X_IN_IDA35V_6
X1.37	CAN bus 1 low	CAN1_L	CAN1_L	CAN1_L	CAN1_L
X1.38	Input	X_IN_IACV_3	X_IN_IACV_3	X_IN_IACV_3	X_IN_IACV_3
X1.39	Input	X_IN_IACV_4	X_IN_IACV_4	X_IN_IACV_4	X_IN_IACV_4
X1.40	Input	X_IN_IDSACV_3	X_IN_IDSACV_3	X_IN_IDSACV_3	X_IN_IDSACV_3
X1.41	Input	X_IN_IDSACV_4	X_IN_IDSACV_4	X_IN_IDSACV_4	X_IN_IDSACV_4
X1.42	UB	—	—	—	—

* NCM = No current measurement:
The output type OPHB4A, provided for this variant of the ESX.iot has no current feedback signal.

QUALIFICATION

Compliance information (tests and final approval in progress)

Standard	Description	Parameter
ISO/IEC 17050-1	 Conformity	
UK marking		
ISO 11783-2:2019	CAN ISOBUS conformity	AEF conformance test Only hardware functionality tested.
KBA (Kraftfahrt-Bundesamt)	 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

DETAILED QUALIFICATION

CE - EN IEC 61000-6-2:2019

Standard	Test	Parameter
EN IEC 61000-6-2:2019 Immunity for industrial environments	Electrostatic discharge immunity test - direct discharges DIN EN 61000-4-2	330 Ω / 150 pF, Contact discharge ± 4 kV Air discharge ±2 kV, ±4 kV, ±8 kV
	Electrostatic discharge immunity test - indirect discharges (HCP, VCP) DIN EN 61000-4-2	330 Ω / 150 pF, Contact discharge ± 4 kV
	Radiated, radio-frequency, electromagnetic field immunity test DIN EN 61000-4-3	80 MHz to 1000 MHz -> 10 V/m; 1.4 GHz to 6.0 GHz -> 3 V/m; horizontal and vertical
	Burst - supply lines (Electrical fast transient / burst immunity test) DIN EN 61000-4-4	± 1 kV, 5/50 ns tr/th, repetition frequency 100kHz
	Burst - data lines (Electrical fast transient / burst immunity test) DIN EN 61000-4-4	± 1 kV, 5/50 ns tr/th, repetition frequency 100kHz
	Surge - supply lines (immunity test) DIN EN 61000-4-5	asymmetrical coupling: ± 0,5 kV symmetrical coupling: ± 0,5 kV Test on supply lines performed as informative on basis that cable length does not exceed 30m.
	Surge - data lines (immunity test) DIN EN 61000-4-5	asymmetrical coupling: ± 0,5 kV, ± 1 kV Test on LIN is not required on basis that cable length does not exceed 30m.

CE - EN IEC 61000-6-2:2019

Standard	Test	Parameter
	Conducted immunity - supply lines (Immunity to conducted disturbances, induced by radio-frequency fields) DIN EN 61000-4-6	150 kHz to 80 MHz, 10 V
	Conducted immunity - data lines (Immunity to conducted disturbances, induced by radio-frequency fields) DIN EN 61000-4-6	150 kHz to 80 MHz, 10 V
	Immunity to magnetic fields DIN EN 61000-4-8	50 Hz / 60 Hz, 30 A/m
	EN 61000-6-4:2007 + A1:2011	Emission standard for industrial environments

DETAILED QUALIFICATION

Automotive EMC tests - E1 (ECE R10)

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 12 V System, Level 3 ISO 7637-2:2004	Pulse 1 - 75 V, 5000 pulses t1 = 0,5 s to 5 s Pulse 2a 37 V, 5000 pulses t1 = 0,2 s to 5 s

Automotive EMC tests - E1 (ECE R10)

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 -6 V 1 pulse
	Electrical transient conduction along supply lines 24 V 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

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 Testduration for each voltage level: 60 min.
	Overvoltage - Systems with 12 V / 24 V nominal voltage - 12 V System	18 V for 60 min. at 20 °C below Tmax
	Overvoltage - Systems with 12 V / 24 V nominal voltage - 24 V System	36 V for 60 min. at 20 °C below Tmax
	Superimposed alternating voltage - 12 V System	Usmax = 16 V (for $U_N = 12 V$) Sweep duration: 120 seconds Number of sweeps: 5 Severity 4: Upp = 2 V @ Unom 12 V
	Superimposed alternating voltage - 24 V System	Usmax = 32 V (for $U_N = 24 V$) Sweep duration: 120 seconds Number of sweeps: 5 Severity 3: Upp = 10 V @ Unom 24 V
	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 - 24 V System	Drop to 9 V for ≤ 100 ms
	Discontinuities in supply voltage - Reset behavior voltage drop	Decrease supply voltage from Usmin in 5 % steps

Electrical safety

Standard	Test	Parameter
	Discontinuities in supply voltage - Starting profile 12 V code C	Voltage cranking; Level 3
	Discontinuities in supply voltage - Starting profile 24 V code E	Voltage cranking; Level 2
	Discontinuities in supply voltage- Load Dump (Pulse B) - 12 V System	Test with centralized load dump suppression 5 pulses Us = 101 V, Us* = 35 V, Ri = 4 Ohm, td = 400 ms
	Discontinuities in supply voltage- Load Dump (Pulse B) - 24 V System	Test with centralized load dump suppression 5 pulses Us = 202 V, Us* = 70 V, Ri = 8 Ohm, td = 350 ms
	Reversed voltage - Case 2 - 12 V System	Unom. = 12 V -> Case 2 - Test Voltage = - 14 V reversed polarity Duration: 60 s
	Reversed voltage - Case 2 - 24 V System	Unom. = 24 V -> Case 2 - Test Voltage = 28 V reversed polarity Duration: 60 s
	Ground reference and supply offset - 12 V System	± 1 V offset; only required if two or more power supplies exist; Low-Side-Sensor must be connected to ground point at ECU connector Case 1: offset between UB and UE, if no internal connection exists

DETAILED QUALIFICATION

Electrical safety

Standard	Test	Parameter
	Ground reference and supply offset - 24 V System	± 1 V offset; only required if two or more power supplies exist; Low-Side-Sensor must be connected to ground point at ECU connector Case 1: offset between UB and UE, if no internal connection exists
	Open circuit tests - Single line interruption - 12 V System	Interruption of each single Output for (10 ± 1) s.
	Open circuit tests - Single line interruption - 24 V System	Interruption of each single Output for (10 ± 1) s.
	Open circuit tests - Multiple line interruption - 12 V System	Disconnect the DUT for (10 ± 1) s.
	Open circuit tests - Multiple line interruption - 24 V System	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

Earth-moving and building construction machinery (EMC tests) - ISO 13766-1

Standard	Test	Parameter
DIN EN ISO 13766-1:2019	Radiated Emission - Broadband CISPR25:2008	30 ... 75 MHz: 64 ... 54 dBµV QP 75 ... 400 MHz: 54 ... 65 dBµV QP 400 ... 1000 MHz: 65 dBµV QP 120 kHz, 1m
	Radiated Emission - Narrowband CISPR25:2008	30 ... 75 MHz: 54 ... 44 dBµV PK 75 ... 400 MHz: 44 ... 55 dBµV PK 400 ... 1000 MHz: 55 dBµV PK 120 kHz, 1m
	Immunity of ESAs to electromagnetic radiation 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, 48 mA (substitution, 150 mm, 450 mm, 750 mm) Antenne, ALSE (hor/ver) 200 MHz ... 800 MHz, 24 V/m, AM 800 MHz ... 2000 MHz, 24 V/m, PM
	ESD - Component immunity test method Powered-up test - direct discharges ISO 10605:2008	2000 Ω / 330 pF, 2000 Ω / 150 pF, contact: ± 2 kV, ± 4 kV, ± 6 kV air: ± 2 kV, ± 4 kV, ± 8 kV
	ESD - Component immunity test method Powered-up test - indirect discharges ISO 10605:2008	2000 Ω / 330 pF, 2000 Ω / 150 pF, contact: ± 2 kV, ± 4 kV, ± 6 kV air: ± 2 kV, ± 4 kV, ± 8 kV

DETAILED QUALIFICATION

Earth-moving and building construction machinery (EMC tests) – ISO 13766-1

Standard	Test	Parameter
	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 – 12 V System, Level 3 ISO 7637-2:2011	Pulse 1, -112 V, 500 pulses t1 ≥ 0,5s
		Pulse 2a +55 V, 500 pulses t1 = 0,2 s to 5 s
		Pulse 2b +10 V, 10 pulses td = 0,2 s to 2 s
		Pulse 3a, -165 V, 1 h
		Pulse 3b, +112 V, 1 h
	Electrical transient conduction along supply lines – 24 V System, Level 3 ISO 7637-2:2011	Pulse 1 -450 V, 500 pulses t1 ≥ 0,5s
		Pulse 2a +55 V, 500 pulses t1 = 0,2s to 5s
		Pulse 2b +20 V, 10 pulses td = 0,2s to 2s

Earth-moving and building construction machinery (EMC tests) – ISO 13766-1

Standard	Test	Parameter
		Pulse 3a, -220 V, 1h
		Pulse 3b, +220 V, 1h
	Discontinuities in supply voltage – Starting profile 12 V code C ISO 16750-2:2012	Voltage Cranking: Level 4 Note: DUT performs powers down at 6 V, hence only Level 3 is achieved.
	Discontinuities in supply voltage – Starting profile 24 V code E ISO 16750-2:2012	Voltage Cranking: Level 2
	Discontinuities in supply voltage – Load Dump (Pulse B) – 12 V System ISO 16750-2:2012	with centralized load dump suppression 5 Pulses Us = 101 V, Us* = 35 V, Ri = 4 Ohm, td = 400 ms
	Discontinuities in supply voltage – Load Dump (Pulse B) – 24 V System ISO 16750-2:2012	with centralized load dump suppression 5 Pulses Us = 202 V, Us* = 58 V, Ri = 8 Ohm, td = 350 ms

DETAILED QUALIFICATION

Environmental qualification

Standard	Test	Parameter
ISO 16750-3:2012	Resonance search	10 Hz - 2000 Hz, 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 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

Environmental qualification

Standard	Test	Parameter
	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. 100 cycles, Tmin to Tmax Dwell time: 60 min.
	Salt spray test - Corrosion test	acc to IEC60068-2-52, Test Kb Severity 4
	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;

DETAILED QUALIFICATION

Environmental qualification

Standard	Test	Parameter
	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) Test duration: 21 days
	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 - IP Protection ISO 20653:2013-02	Dust Test - IP6kX Water Test - IPX6k Water Test - IPX7 Water Test - IPX9k
ISO 16750-5:2010	Chemical resistance - Code D	Exposure time 22 h, RT Agents - Protective lacquer, Cold cleaning agent, Cavity

Environmental qualification

Standard	Test	Parameter
		protection, Ammonia containing cleaner Exposure time 2 h, RT Agents - Windscreen washer fluid, Wheel cleaner, Vehicle washing chemicals, Glass cleaner, Runway de-icer Exposure time 10 min, RT Agent - Denatured alcohol Exposure time 22h, +65 °C Agents - Protective lacquer remover, Ad-Blue/Urea

DETAILED QUALIFICATION

Agricultural and forestry machines (EMC tests) - ISO 14982

Standard	Test	Parameter
DIN EN ISO 14982:2009	Radiated Emission - Broadband CISPR16 / CISPR12	30 ... 75 MHz: 64 ... 54 dB μ V QP 75 ... 400 MHz: 54 ... 65 dB μ V QP 400 ... 1000 MHz: 65 dB μ V QP 120kHz, 1m
	Radiated Emission - Narrowband CISPR16 / CISPR12	30 ... 75 MHz: 54 ... 44 dB μ V PK 75 ... 400 MHz: 44 ... 55 dB μ V PK 400 ... 1000 MHz: 55 dB μ V PK 120kHz, 1m
	Immunity of ESAs to electromagnetic radiation ALSE: ISO 11452-2:2004 BCI: ISO 11452-4:2011 (Stripline and TEM alternative test methods)	General 20 MHz ... 1000 MHz 20 MHz ... 1000 MHz: AM BCI: 20 MHz ... 400 MHz, 48 mA (substitution, 150 mm, 450 mm, 750 mm) Antenne, ALSE (hor/ver) 200 MHz ... 1000 MHz, 24 V/m, AM
	ESD - Component immunity test method (Powered-up test) - direct discharges	330 Ω / 330 pF, 330 Ω / 150 pF, Level I: contact: ± 2 kV, ± 4 kV Level I: air: ± 2 kV, ± 4 kV
	ESD - Component immunity test method (Powered-up test) - indirect discharges	330 Ω / 330 pF, 330 Ω / 150 pF, Level I: contact: ± 2 kV, ± 4 kV Level I: air: ± 2 kV, ± 4 kV
	Conducted transient emission from ESAs on 12 V supply lines ISO 7637-2:2004	pos: +75 V neg: -100 V

Agricultural and forestry machines (EMC tests) - ISO 14982

Standard	Test	Parameter
	Conducted transient emission from ESAs on 24 V supply lines ISO 7637-2:2004	pos: +150 V neg: -450 V
	Electrical transient conduction along supply lines 12 V System ISO 7637-2:2004	Pulse 1 - 25 V, 5000 pulses t1 = 0,5s to 5s
		Pulse 2a 25 V, 5000 pulses t1 = 0,2s to 5s
		Pulse 3a -25 V, 1 hr
		Pulse 3b 25 V, 1 hr
		Pulse 4 Us = -4 V Ua = -2,5 V to -6 V 1 pulse
		Pulse 5a Us = 26,5 V, Ri = 4 Ohm, td = 400 ms, 1 pulse
	Electrical transient conduction along supply lines 24 V System, Level 3 ISO 7637-2:2004	Pulse 1 - 50 V, 5000 pulses t1 = 0,5s to 5s
		Pulse 2a 25 V, 5000 pulses t1 = 0,2s to 2s
		Pulse 3a -35 V, 1 hr

DETAILED QUALIFICATION

Agricultural and forestry machines (EMC tests) - ISO 14982

Standard	Test	Parameter
		Pulse 3b +35 V, 1 hr
		Pulse 4 U _s = -5 V U _a = -5 V to -12 V 1 pulse
		Pulse 5a U _s = 70 V, R _i = 8 Ohm, t _d = 350 ms, 1 pulse

STW company standard (EMC tests)

Standard	Test	Parameter
STW Company Standard	Radiated emission Cispr25:2016	0,15 MHz ... 2500 MHz CISPR Class 3
	Conducted emission CISPR25:2016	Power lines (Voltage method) - CISPR Class 3 data lines (current probe method) - CISPR Class 2 150 kHz to 108 MHz
	Immunity of ESAs to electromagnetic radiation General: ISO 11452-1:2015 ALSE: ISO 11452-2:2019 BCI: ISO 11452-4:2020	General 1 MHz ... 3200 MHz 1 MHz ... 3200 MHz: CW 1 MHz ... 800 MHz: AM 800 MHz ... 3200 MHz: PM BCI: 1 MHz ... 400 MHz, Level IV (200 mA) (substitution (150 mm, 450 mm, 750 mm) or closed loop (900 mm) method allowed) Antenne, ALSE: 200 MHz ... 800 MHz, Level V (200 V/m), CW, AM 800 MHz ... 3200 MHz, Level V (200 V/m), CW, PM
	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

DETAILED QUALIFICATION

STW company standard (EMC tests)

Standard	Test	Parameter
	Electrical transient conduction along supply lines - 12 V System, Level 4 ISO 7637-2: 2011	Pulse 1 -150 V, 500 pulses $t_1 \geq 0,5s$
		Pulse 2a +112 V, 500 pulses $t_1 = 0,2s$ to 5s
		Pulse 2b +10 V, 10 pulses $t_d = 0,2s$ to 2s
		Pulse 3a -220 V, 1h
	Electrical transient conduction along supply lines - 24 V System, Level 4 ISO 7637-2: 2011	Pulse 1 -600 V, 500 pulses $t_1 \geq 0,5s$
		Pulse 2a +112 V, 500 pulses $t_1 = 0,2s$ to 5s
		Pulse 2b +20 V, 10 pulses $t_d = 0,2s$ to 2s
		Pulse 3a -300 V, 1h
	Faults on data lines; 12 V system, Level 4	Slow +: ICC, +6 V, 5 min, $t_1 = 0,2s$ to 5s

STW company standard (EMC tests)

Standard	Test	Parameter
		Slow -: ICC, -6 V, 5 min, $t_1 = 0,2s$ to 5s Pulse 3a: CCC, -110 V, 10 min Pulse 3b: CCC, +75 V, 10 min
	Faults on data lines; 24 V system, Level 4	Slow +: ICC, +10 V, 5 min, $t_1 = 0,2s$ to 5s Slow -: ICC, -10 V, 5 min, $t_1 = 0,2s$ to 5s Pulse 3a: CCC, -150 V, 10 min Pulse 3b: CCC, +150 V, 10 min
	ESD - Component immunity test method (Powered-up test) - direct discharges	330 Ω / 330 pF, 330 Ω / 150 pF, contact: ± 2 kV, ± 4 kV ± 8 kV air: ± 8 kV, ± 15 kV, ± 25 kV
	ESD - Component immunity test method (Powered-up test) - indirect discharges	330 Ω / 330 pF, 330 Ω / 150 pF, contact: ± 2 kV, ± 4 kV ± 8 kV
	ESD - Packaging and handling (Unpowered test)	2000 Ohm / 150 pF contact: ± 2 kV, ± 4 kV ± 8 kV air: ± 4 kV, ± 8 kV, ± 15 kV

DETAILED QUALIFICATION

STW company standard (electrical loads)

Standard	Test	Parameter
STW Company Standard	Overvoltage / Undervoltage / Switch-on hysteresis	<p>1st: Decrease supply voltage from U_{min} in steps of 0.1 V until all outputs turned off. The determined voltage is called switch-off voltage. Increase supply voltage in steps of 0.1 V. The voltage where the device is running again in normal operating mode is the determined switch-on voltage. The difference between switch-off voltage and switch-on voltage is the hysteresis. Operate the device below U_{min}. Duration: 5 minutes.</p> <p>2nd: Overvoltage: Operate the device with maximum 3 % above U_{max} (32,96 V). Duration: 5 minutes</p>
	Short circuit strength of signal and communication lines	<p>Case 1: Short circuit test of each type of Input and Output (CIN, VIN, DIN, FIN, PWM, DOUT ...) against GND and UB at U_{max} and U_{min} for a duration of 1 minute.</p> <p>Case 2: Short circuit test of PWM outputs and digital outputs to low resistance loads against GND for a duration of 1 minute. Resistance loads - 0,1 Ω ($\pm 0,05$), 0,5 Ω ($\pm 0,2$), 1,0 Ω ($\pm 0,2$) and 1,5 Ω</p>

STW company standard (electrical loads)

Standard	Test	Parameter
		<p>($\pm 0,2$)</p> <p>Case 1 test scenario is covered under Standard ISO16750-2</p>
	Start test	<p>Supply lines are disconnected, GND is connected. Then connect one input and if available one low-side output to UB Duration: 5 Min.</p>
	Load test	<p>48 hrs. at T_{min}: 12 hrs. OM 2.1 - from the 13th hour OM 3.2 at U_{min} & I_{max}.</p> <p>48 hrs. at T_{max}: OM 3.2 at U_{max} and I_{max} Duration: 4 days</p>
	Life-time (Operation)	<p>Test Temperature: +95 °C Test Duration: 920 hrs. O.M. 3.2 with Loaded Condition Test temperature is set to 10 °C more than maximum operational temperature (T_{max}) to reduce the test duration.</p>
	Slow decrease and increase of supply voltage	<p>Decrease supply voltage from U_{max} to 0 V and increase it from 0 V to U_{max}. Applying a change rate of (0.5 \pm 0.1)V per minute</p>

DETAILED QUALIFICATION

STW company standard (environmental qualification)

Standard	Test	Parameter
STW Company Standard	Vibration (sinusoidal) DIN EN 60068-2-6:2008	10 ... 2000 Hz: 5g 1 oct/min, 3 axis, 10 cycles, bidirectional
	Bump DIN EN 60068-2-27:2010	Acceleration: 30 g Time: 6 ms half-sine, 500 Shocks/direction