TE0950 TRM

Revision v.11

Exported on 2024-01-17

Online version of this document:

https://wiki.trenz-electronic.de/display/PD/TE0950+TRM

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4 Overview

The Trenz Electronic TE0950-02 is a powerful adaptive SoC evaluation board, equipped with an AMD Versal™ AI (Edge) device. Furthermore, the board is equipped with up to 8GB DDR4 SDRAM, 128 MByte SPI Flash and an eMMC for configuration and data storage as well as powerful switching power supplies for all required voltages. Inputs and outputs are provided by robust, flexible and cost-effective high-speed connectors.

Refer to http://trenz.org/te0950-info for the current online version of this manual and other available documentation.

4.1 Key Features

- **SoC**
  - AMD Versal™ AI device [1)]
    - Package: A784
    - Device: VE2002, VE2102, VE2202, VE2302, VM1102 [1)]
    - Speed: -1, -2, -3 [1)]
    - Temperature: I, E [1)]
- **RAM/Storage**
  - DDR4 SDRAM
    - Data width: 64bit
    - Size: def. 8GB, up to 8 GByte possible [1)]
    - Speed: up to 3200Mb/s [2)]
  - 128 MByte SPI Flash (primary boot option)
    - Data width: 8bit
    - size: def. 128MB, up to 512MB possible [1)]
  - MicroSD card (primary boot option)
  - e.MMC (secondary boot option) [1)]
    - Data width: 8bit
    - size: def. 32GB [1)]
  - EEPROM with MAC-address
- **On Board**
  - AMD Artix™ 7 FPGA as configurable Levelshifter/MUX for FMC and other 3.3 V IOs
    - 32 MByte SPI Flash
    - 1 dip switch
    - 2 LEDs
  - USB 2.0 Host/Device/OTG (type Micro A/B connector)
  - USB JTAG + UART Micro-USB B
  - Gigabit Ethernet RJ45
  - Output
    - 2 LEDs (1 x MIO, 1 x PL)
  - Input
    - 1 push button (PL)
    - 2 dip switches (2 x MIO)
    - Reset button
- **Interface**
  - zQSFP
    - 4 GTYP Transceiver
  - 2 x CRUVI HS
    - each optimized for 4 Lane MIPI, one with reduced pinout
  - 2 x CRUVI LS
  - CSI-2 connector

    - optimized for camera, 2 lane MIPI
  - FMC
    - 4 GTYP Transceiver
    - 34 LA diff pairs to Levelshifter/MUX
- **Power**
  - 12 V plug
- **Dimension**
  - 150 mm x 120 mm
- **Notes**
  - [1] depends on assembly version
  - [2] depends on used DDR4
  - [3] productions within 2023 are equipped with engineering samples (AMD Vivado ES licence needed)

4.2 Block Diagram

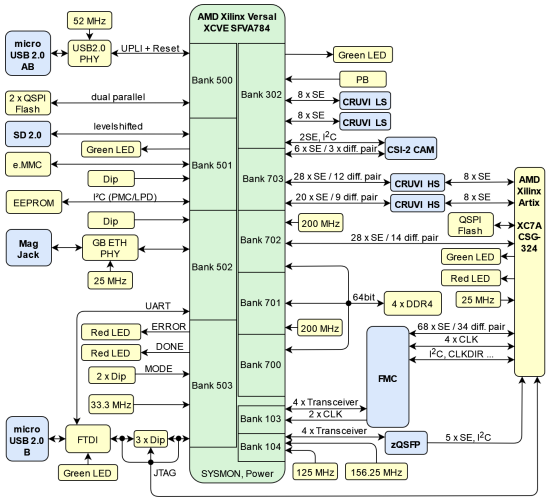

Figure 1: TE0950 block diagram

4.3 Main Components

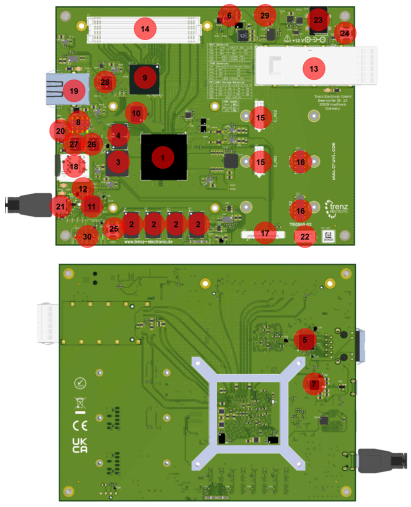

Figure 2: TE0950 main components

1. SoC (Versal) U1
2. DDR4 U8, U9, U10, U11
3. eMMC U25
4. dual QSPI Configuration Flash (Versal) U23, U24
5. ETH Phy U31
6. MAC EEPROM U35
7. USB 2.0 Phy U27
8. Jumper (USB Device/Host/OTG) J5
9. Artix FPGA (Levelshifter/MUX for FMC IOs) U13
10. OSPI Configuration Flash (Artix) U14
11. FTDI JTAG/UART to USB Bridge U15
12. FTDI Configuration EEPROM U17
13. zQSFP U12/J1
14. LPC FMC J3
15. CRUVI HS J10, J11
16. CRUVI LS J12, J13
17. CSI CAM Connector J15
18. SD-CARD Slot J4
19. RJ45 ETH jack J9
20. micro USB A/B Connector J8
21. micro USB B Connector (JTAG/UART) J2
22. 4 Pin FAN Connector J17
23. Power Input Jack J14
24. Reset Push Button S3
25. User Push Button S1
26. Dip Switches (JTAG Selection) S4
27. Dip Switches (Bootmode, User) S2
28. Dip Switches (FMC VADJ Selection, User) S5
29. LEDs (Power) D8, D9, D10
30. LEDs (Status/User) D0, D1, D2, D3 D4, D6, D11

4.4 Initial Delivery State

Storage device name	Content	Notes
DDR4 SDRAM	not programmed	
eMMC	not programmed	
dual Quad SPI Flash (Versal)	not programmed	
MAC EEPROM	not programmed besides factory programmed MAC address	
FTDI EEPROM	FTDI configuration for JTAG/UART with AMD Vivado compatible license	

Storage device name	Content	Notes
Quad SPI Flash (Artix)	Template Design with basic functionality	Design has to be adapted to use case.

Table 1: Initial delivery state of programmable devices on the module

5 Signals, Interfaces and Pins

5.1 Connectors

Connector Type	Designator	Interface	IO CNT	Notes
B2B	J3	FMC	4x MGT Transeiver 34 DIFF / 68 SE 4x CLK, CLKDIR, I^2C, PG	MGTs tested with 15Gbps FMC LA pins from/to Artix. Artix FPGA has to be configured for use case. CLK and management signals connected to Artix.
B2B	J10	CRUVI HS	12 DIFF / 24 SE 4 SE 8 SE	Full pinout, MIPI 4 Lanes optimized (XPIO) (XPIO) connected to Artix @3.3V
B2B	J11	CRUVI HS	9 DIFF / 18 SE 2 SE 8 SE	Reduced pinout, MIPI 4 Lanes optimized (XPIO) (XPIO) connected to Artix @3.3V
B2B	J12	CRUVI LS	8 SE	HD bank 302 @3.3V
B2B	J13	CRUVI LS	8 SE	HD bank 302 @3.3V
CON	J1, U12	zQSFP	4x MGT Transeiver 5 SE, I^2C	MGTs tested with 15Gbps, management signals connected to Artix.
CON	J15	CSI-2 CAM	3 DIFF / 6 SE 4 SE	MIPI 2Lanes (XPIO), (I2C and GPIO) to HD Bank 302 @3.3V
CON	J9	GB ETH	4 DIFF	LPD

Connector Type	Designator	Interface	IO CNT	Notes
CON	J8	micro USB2.0 A/B	1 DIFF	Host/Device/OTG set J5 according for HW configuration
CON	J2	micro USB2.0 B	1 DIFF	JTAG/UART via FTDI
CON	J4	micro SD 2.0	1 DIFF	primary boot option, routed via levelshifter U26
CON	J17	4 pin FAN	2 SE	For SoC FAN with Tacho and PWM signals connected to Artix.

Table 2: Board Connectors

5.2 Test Points

Test Point	Signal	Notes[1)]
TP32	GND	GND
TP29	12V	12V
TP17	5V0	5V
TP16	3V3	3.3V
TP43, TP44	GTYP_AVCC	0.92V
TP46, TP47	GTYP_AVTT	1.2V
TP45	GTYP_AVCC_AUX	1.5V
TP48	A_3V3	3.3V

Test Point	Signal	Notes[1)]
TP19	1V0	1.0V
TP42	3V3_FMC	3.3V
TP40	FMC_VADJ	1.2V, S5A-C: OFF,OFF, OFF 1.8V, S5A-C: ON,OFF, OFF 2.5V, S5A-C: ON,ON, OFF 3.3V, S5A-C: ON,ON, ON
TP18	1V8	1.8V
TP39	V_VCCAUX	1.5V
TP41	C_VADJ	1.2V
TP35	DDR_1V2	1.2V
TP33	DDR_2V5	2.5V
TP36	DDR_VTT	0.6V
TP37	VREFA	0.6V
TP38	V_VCC_SOC	0.8V (low (L) and mid (M) voltage devices) 0.88V (high (H) voltage devices)
TP34	V_VCC_CORE	0.7V (low (L) voltage devices) 0.8V (mid (M) voltage devices) 0.88V (high (H) voltage devices)
TP1	V_VCC_BATT	Input for VCC_BAT supply when R21 removed. Default (R21 assembled) GND.
TP2	V_FUSE	Input for V_FUSE supply when R43 removed. Default (R43 assembled) GND.
TP3	DDR4-TEN_0	pulled-down to GND

Test Point	Signal	Notes[1)]
TP4	DDR4-TEN1	pulled-down to GND
TP5	DDR4-TEN2	pulled-down to GND
TP6	DDR4-TEN3	pulled-down to GND
TP20	PHY_LED2	Function dependent on ETH PHY (U31) configuration.
TP21	I2C_PMC_SCL	@1.8V
TP23	I2C_PMC_SDA	@1.8V
TP22	DCDC_5V0_SCL	@3.3V Levelshifted I2C_PMC_SCL signal
TP24	DCDC_5V0_SDA	@3.3V Levelshifted I2C_PMC_SDA signal
TP25	I2C1_SCL	@1.8V
TP26	I2C1_SDA	@1.8V
TP27	I2C_SYSMON_SCL	@1.8V
TP28	I2C_SYSMON_SDA	@1.8V
TP7	TCK	JTAG TCK (Versal and Artix)
TP12	TMS	JTAG TCK (Versal and Artix)
TP10	V_TDO	JTAG TDO
TP8	FTDI_TDI	JTAG TDI
TP9	A_TDI	JTAG TDI Artix, connected to FTDI_TDI via DIP S4A
TP11	V_TDI	JTAG TDI Versal, connected to FTDI_TDI via DIP S4B

Test Point	Signal	Notes[1)]
TP13	A_TDO	JTAG TDO Versal, connected to VTDI via DIP S4C
TP14	F_UART_TX	@3.3V, from Versal, levelshifted UART1_TX signal, to FTDI
TP15	F_UART_RX	@3.3V, from FTDI, levelshifted UART1_RX signal to Versal
TP31	-	Sense input of reset chip U38, connected to PG_GTYP_AVTT @3.3V via R203
TP30	FAULTn_12V	@12V, Fault signal of input protection U37

Table 3: Test Points Information

6 On-board Peripherals

Chip/Interface	Designator	Connected To	Notes
Versal SoC	U1	-	Engineering Sample
DDR4 SDRAM	U8, U9, U10, U11	Versal XPIO	
dual parallel QSPI	U23, U24	Versal PMC/MIO	primary boot option
GB ETH PHY	U31	Versal MIO	
USB PHY	U27	Versal MIO	USB2.0
Oscillator	U4, U5	Versal XPIO	2x 200Mhz, DDR4 controller, User
Oscillator	U6, U7	Versal GTYP REFCLK	156.25MHz, 125MHz, for QSFP MGTs.
eMMC	U25	Versal PMC/MIO	secondary boot option
EEPROM	U35		for MAC. I2C PS, Address 50H
User Dip 3x	S2C, S2D	Versal MIO	
User LED 2x	D0 D1	Versal MIO Versal HD	both green
Push Button	S1	Versal HD	
Artix FPGA	U13	• Versal XPIO (14 DIFF / 28 SE)	Configurable levelshifter/ MUX for FMC and other 3.3V

Chip/Interface	Designator	Connected To	Notes
		• FMC (J3) LA pins • QSFP (J1, U12) config signals • CRUVI HS (J10, J11) 3.3V signals	periphery configuration signals
QSPI	U14	Artix	configuration Memory for Artix
User LED 2x	D2, D3	Artix	D2 green, D3 red
User Dip	S5D	Artix	

Table 4: On board peripherals

7 Configuration and System Control Signals

Component 'Label'	Signal Name	Direction[1)]	Description
LED D11 (red) 'ERROR'	V_ERROR	OUT	Versal Error → signal 'low' → LED 'ON'
LED D4 (red) 'DONE'	V_DONE	OUT	Versal configuration Done → signal 'high' → LED 'OFF'
Dip switch S2A 'BOOT'	V_MODE1	IN	Select primary boot mode: JTAG QSPI32 SD card (SD1 2.0) OFF ON OFF OFF OFF ON
Dip switch S2B 'BOOT'	V_MODE02	IN	
DIP switch S4A 'JTAG'	FTDI_TDI, A_TDI	IN	Select JTAG: Artix-Versal in chain, Versal only ON, OFF OFF, ON ON, OFF
DIP switch S4B 'JTAG'	FTDI_TDI, V_TDI	IN	
DIP switch S4C 'JTAG'	A_TDO, V_TDI	IN	
LED D6 (red) 'DONE'	A_DONE	OUT	Artix configuration Done → signal 'high' → LED 'OFF'
LED D7 (green) 'UART'	F_UART_LED	OUT	UART activity → signal 'low' → LED 'ON'
Push button S3 'RESET'	MR	IN	On press resets configuration of Versal and Artix by pulling V_POR_B, A_PROG_B signals via reset chip U38 low.
LED D9 (green) '12V'	12V	OUT	'ON' when 12V after power protection available
LED D8 (green) '5V'	5V0	OUT	'ON' when 5V are available

Component 'Label'	Signal Name	Direction[1)]	Description
LED D10 (green) '3.3V_FMC'	3V3_FMC	OUT	'ON' when 3.3V_FMC available
DIP switch S5A 'FMC_VADJ'	FB_FMC_VADJ	IN	Select FMC_VADJ: 1.2V 1.8V 2.5V 3.3V OFF ON ON ON OFF OFF ON ON OFF OFF OFF ON
DIP switch S5B 'FMC_VADJ'	FB_FMC_VADJ	IN	
DIP switch S5C 'FMC_VADJ'	FB_FMC_VADJ	IN	

Table 5: Controller signal.

[1)] Direction:

- IN: Input from the point of view of this board.
- OUT: Output from the point of view of this board.

8 Power and Power-On Sequence

8.1 Power Rails

Power Rail Name/ Schematic Name	Connector + Pin	Direction[1)]	Notes
12V_IN	J14.1	IN	Board Power
5V0	J12.12, J13.12, J10.60, J11.60	OUT	CRUVI LS and HS 5V, shared with onboard 5V supplies and with further switch (U29) for rail USB_VBUS_SUP via jumper (J5) connectable to USB (J8).
3V3	J12.10, J13.10, J3.D32	OUT	QSFP, CRUVI LS 3.3V, CSI-2 CAM, FMC_VAUX, shared with VERSAL VCCO Bank 302 and onboard peripherals.
C_VADJ	J10.36, J11.36	OUT	CRUVI HS IO @1.2V, shared with VERSAL VCCIO XPIO Bank 703.
A_3V3	J10.4, J10.9, J11.4, J11.9	OUT	CRUVI HS 3.3V, shared with ARTIX VCCIO Bank 14 and onboard peripherals.
12V	J3.C35, J3.C37	OUT	FMC, derived from 12V_IN after input protection. Shared with onboard peripherals.
3V3_FMC	J3.C39, J3.D36, J3.D38, J3.D40	OUT	FMC
FMC_VADJ	J3.E39, J3.F40, J3.G39, J3.H40	OUT	FMC 1.2V - 3.3V, Selectable by dip settings.

Table 6: Module power rails.

[1] Direction:

- IN: Input from the point of view of this board.
- OUT: Output from the point of view of this board.

8.2 Recommended Power up Sequencing

Power up sequencing is handled board internally. No further interaction needed. For details See Schematic page 4 Power Diagram.

9 Board to Board Connectors

Following B2B connectors for board extensions are available:

- CRUVI,
  - Please see also CRUVI documentation at CRUVI.com[1].
  - More extensions are available at the Trenz electronic CRUVI[2].
  - CRUVI modules use on bottom side:
    - TMMH-106-04-F-DV-A-M as Low Speed connectors, (12 pins, 6 per row)
    - ST4-30-1.50-L-D as High Speed connectors, (60 pins, 30 per row)

    CRUVI carrier use on top side:
    - CLT-106-02-F-D-A-K as Low Speed connectors , (12 pins, 6 per row)
    - SS4-30-3.50-L-D as High Speed connectors, (60 pins, 30 per row)

9.1 Connector Mating height

Mating height of the high speed connectors is 5mm. The low speed connectors mate correctly within a range from 4.78 mm to 5.29 mm.

9.2 Current Rating

Current rating of High Speed B2B connectors is 1.6A per pin (2 pins powered).
Current rating of Low Speed B2B connectors is 4.1A per pin (2 pins powered).

9.3 Speed Rating

There is no data available for the connectors actual used here. Data available for other stacking heights of same connectors is summarized in the folllowing table:

Connector	Speed ratings
ST4/SS4 single ended (4mm stacking height!)	13.5GHz / 27 Gbps
ST4/SS4 differential (4mm stacking height!)	15.5 GHz / 31 Gbps
TMMH/CLT single ended (4.77mm stacking height!)	5.5GHz / 11 Gbps

Table 7: Connector speed ratings

9.4 Operating Temp Range

All connectors are specified for a temp. range of -55 °C to 125 °C.

- FMC

1 https://cruvi.wordpress.com/
2 https://wiki.trenz-electronic.de/display/PD/CRUVI

- General options are described in the FMC standard. Trenz electronic uses standard height options.
  FMC modules use on bottom side:
  - HPC: ASP-134488-01
  - LPC: ASP-134604-01

  FMC carrier use on top side:
  - HPC: ASP-134486-01
  - LPC: ASP-134603-01

9.5 Connector Mating height

Mating height is 10mm.

9.6 Current Rating

Current rating of High Speed B2B connectors is 1.9A per pin (16 pins powered).

9.7 Speed Rating

Connector	Speed ratings
single ended	18.0 GHz / 36 Gbps
differential (high density)	17.0 GHz / 34 Gbps

Table 8: Connector speed ratings

9.8 Operating Temp Range

All connectors are specified for a temp. range of -55 °C to 125 °C.

10 Technical Specifications

10.1 Absolute Maximum Ratings *)

Power Rail Name/ Schematic Name	Description	Min	Max	Unit
12V_IN	Main power supply	-20	30	V

Table 9: Absolute maximum ratings

*) Stresses beyond those listed under Absolute Maximum Ratings (see page 0) may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Condition (see page 0). Exposure to absolute-maximum rated conditions for extended periods may affect device reliability.

10.2 Recommended Operating Conditions

This TRM is generic for all variants. Temperature range can be differ depending on the assembly version. Voltage range is mostly the same during variants (exceptions are possible, depending on custom request)

Operating temperature range depends also on customer design and cooling solution. Please contact us for options.

- Variants of modules are described here: Article Number Information[3]
- Modules with commercial temperature grade are equipped with components that cover at least the range of 0°C to 75°C
- Modules with extended temperature grade are equipped with components that cover at least the range of 0°C to 85°C
- Modules with industrial temperature grade are equipped with components that cover at least the range of -40°C to 85°C
- The actual operating temperature range will depend on the FPGA / SoC design / usage and cooling and other variables.

Parameter	Min	Max	Units	Reference Document
12V_IN	11.0	13.0	V	-

Table 10: Recommended operating conditions.

10.3 Physical Dimensions

- Module size: 150 mm × 120 mm. Please download the assembly diagram for exact numbers.

PCB thickness: 1.6 mm.

3 https://wiki.trenz-electronic.de/display/PD/Article+Number+Information

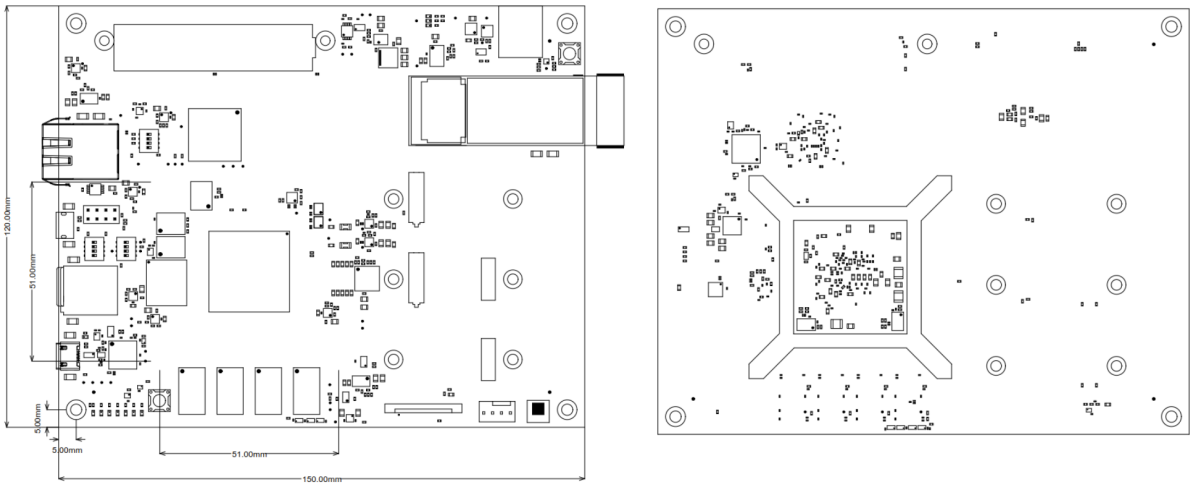

Figure 3: Physical Dimension

11 Currently Offered Variants

Trenz shop TE0950 overview page	
English page[4]	German page[5]

Table 11: Trenz Electronic Shop Overview

4 https://shop.trenz-electronic.de/en/search?sSearch=TE0950
5 https://shop.trenz-electronic.de/de/search?sSearch=TE0950

12 Revision History

12.1 Hardware Revision History

Date	Revision	Changes	Documentation Link
2023-02-09	REV 01	Initial revision	REV01[6]
2023-06-20	REV 02	1. Inverted card detect (pullup-> pulldown) 2. Increased number of capacitors on VTT (C388,C389) 3. Added 1K pullup on FAULTn_12V (R5) 4. Added 4-pin connector J17 for FAN and correspoding circuit. PWM and TACHO connected to ARTIX 5. VERSAL JTAG connection corrected 6. Added CRUVI connector description on silkscreen 7. Changed polarity for CSI2-CAM diff pairs 8. Update from library 9. Changed R266 to 12K and added R281 10. Changed enable 3V3 after 5V0 (R99), Pullup on PG_5V0 connected to 5V0 rail. 11. Replaced C256 (2,2µF) by 2x 1µF 12. Set R131 and R132 to not fitted (2023-08-18)	REV02[7]

Table 12: Hardware Revision History

Hardware revision number can be found on the PCB board together with the module model number separated by the dash.

Figure 4: Board hardware revision number.

6 https://shop.trenz-electronic.de/Download/?path=Trenz_Electronic/Development_Boards/TE0950/REV01
7 https://shop.trenz-electronic.de/Download/?path=Trenz_Electronic/Development_Boards/TE0950/REV02

12.2 Document Change History

Date	Revision	Contributor	Description
2023-09-28	v.11 (see page 6)	Martin Rohrmüller[8]	Typos corrected
09 Aug 2023	v.9 (see page 6)	Martin Rohrmüller[9]	• initial revision

Table 13: Document change history.

8 https://wiki.trenz-electronic.de/display/~m.rohrmueller
9 https://wiki.trenz-electronic.de/display/~m.rohrmueller

13 Disclaimer

13.1 Data Privacy

Please also note our data protection declaration at https://www.trenz-electronic.de/en/Data-protection-Privacy

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13.7 REACH, RoHS and WEEE

REACH

Trenz Electronic is a manufacturer and a distributor of electronic products. It is therefore a so called downstream user in the sense of REACH[10]. The products we supply to you are solely non-chemical products (goods). Moreover and under normal and reasonably foreseeable circumstances of application, the goods supplied to you shall not release any substance. For that, Trenz Electronic is obliged to neither register nor to provide safety data sheet. According to present knowledge and to best of our knowledge, no SVHC (Substances of Very High Concern) on the Candidate List[11] are contained in our products. Furthermore, we will immediately and unsolicited inform our customers in compliance with REACH - Article 33 if any substance present in our goods (above a concentration of 0,1 % weight by weight) will be classified as SVHC by the European Chemicals Agency (ECHA)[12].

RoHS

Trenz Electronic GmbH herewith declares that all its products are developed, manufactured and distributed RoHS compliant.

WEEE

Information for users within the European Union in accordance with Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE).

Users of electrical and electronic equipment in private households are required not to dispose of waste electrical and electronic equipment as unsorted municipal waste and to collect such waste electrical and electronic equipment separately. By the 13 August 2005, Member States shall have ensured that systems are set up allowing final holders and distributors to return waste electrical and electronic equipment at least free of charge. Member States shall ensure the availability and accessibility of the necessary collection facilities. Separate collection is the precondition to ensure specific treatment and recycling of waste electrical and electronic equipment and is necessary to achieve the chosen level of protection of human health and the environment in the European Union. Consumers have to actively contribute to the success of such collection and the return of waste electrical and electronic equipment. Presence of hazardous substances in electrical and electronic equipment results in potential effects on the environment and human health. The symbol consisting of the crossed-out wheeled bin indicates separate collection for waste electrical and electronic equipment.

Trenz Electronic is registered under WEEE-Reg.-Nr. DE97922676.

2019-06-07

10 http://guidance.echa.europa.eu/
11 https://echa.europa.eu/candidate-list-table
12 http://www.echa.europa.eu/