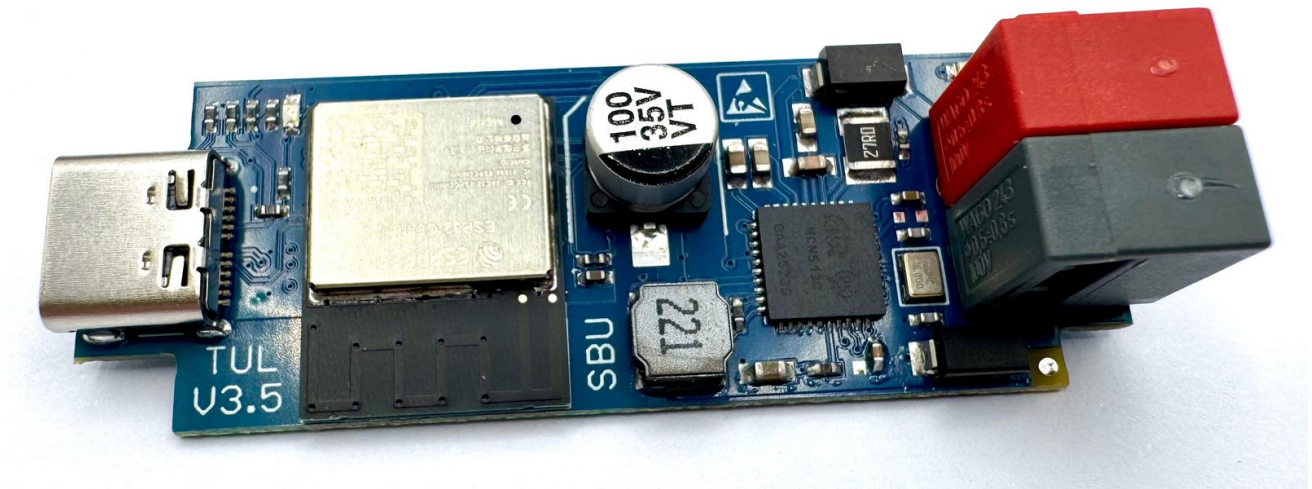


TUL32 — KNX TP interface for USB and Wi-Fi

The TUL32 is a hardware component for DIY use. It connects a KNX TP bus to a computer via USB or to an IP network via Wi-Fi; Ethernet is available through an expansion board. The installed firmware determines what the TUL32 does. The device is shipped without firmware; the customer installs it.

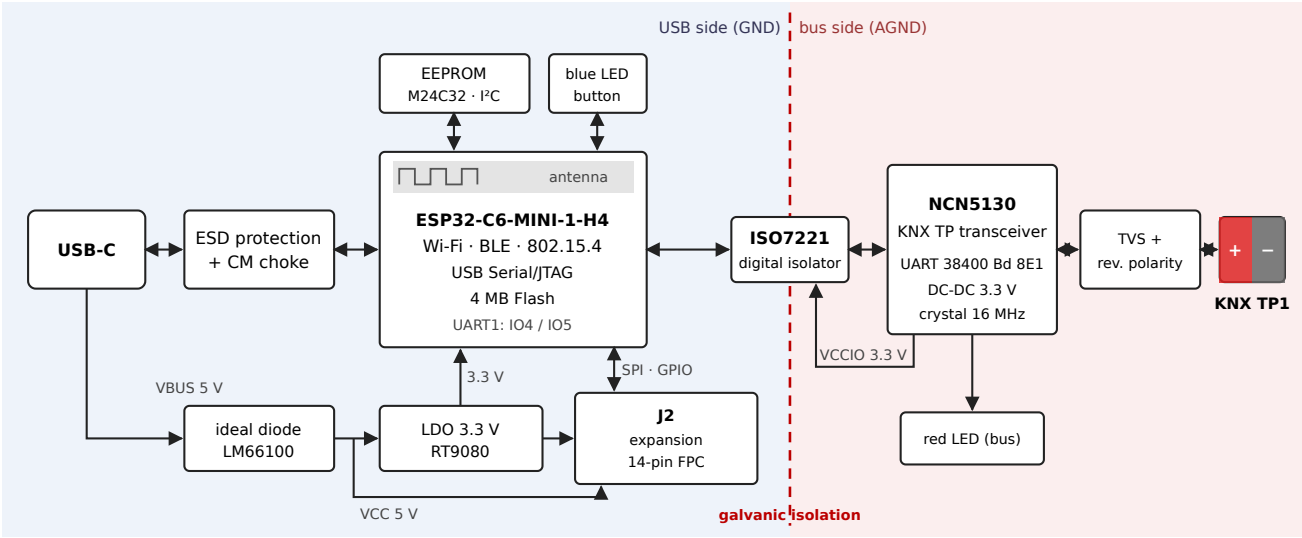


TUL32, hardware revision V3.5, with KNX bus terminal plugged on

Features

- KNX TP1 connection via transceiver onsemi NCN5130, KNX side galvanically isolated from USB (digital isolator, functional isolation)
- Espressif ESP32-C6-MINI-1-H4: IEEE 802.11b/g/n/ax (Wi-Fi 6), 2.4 GHz, Bluetooth LE 5.3, IEEE 802.15.4 (Thread, Zigbee)
- USB-C: power, serial port and firmware installation over one cable
- Expansion connector J2 (SPI, GPIO, power), e.g. for the Ethernet expansion W5500EXT (SPI, connector mirrored: pin $n \leftrightarrow \text{pin } 15-n$)
- EEPROM for configuration data, two LEDs, one push button
- Firmware installation in the web browser, no development tools needed

Block diagram



The dashed line marks the galvanic isolation between the USB side and the KNX bus side.

Technical data

Power supply	
Supply	5 V DC via USB-C (sink, 5.1 kΩ on CC1/CC2); alternatively 5 V via J2 pin 2 (expansion board); back-feed into USB blocked by LM66100
Current consumption (USB)	approx. 46 mA without radio, approx. 90 mA receiving Wi-Fi, up to approx. 400 mA peak when transmitting Wi-Fi (calculated)
Voltage regulator	RT9080-33 (3.3 V)
KNX	
Medium	KNX TP1
Bus voltage	21 ... 32 V DC (SELV)
Current drawn from the bus	typ. 3 mA at 30 V, max. approx. 7 mA (calculated); limited to 30 mA during start-up
Transceiver	onsemi NCN5130
Interface to the processor	UART, 38400 Bd, 8 data bits + even parity
Isolation	KNX side galvanically isolated from USB (digital isolator, functional isolation), TI ISO7221ADR (dual-channel digital isolator); isolation voltage: not specified (functional isolation)
Protection	TVS diode SMAJ43CA (bidirectional); reverse-polarity protection by series diode ES1M
Connection	KNX bus terminal WAGO 243-211 (PUSH WIRE, red/dark grey) on two pins; red = +, dark grey = – (silkscreen “+”/“–”)
USB	
Receptacle	USB Type-C (Molex 105450-0101)
Function	USB device “USB JTAG/serial debug unit” of the ESP32-C6 (serial port + JTAG)

Protection	ESD protection USBLC6-2SC6, common-mode choke DLW21SN900HQ2L
Processor and memory	
Module	Espressif ESP32-C6-MINI-1-H4
Processor	ESP32-C6, 32-bit RISC-V, up to 160 MHz, 512 KB SRAM
Flash	4 MB
EEPROM	M24C32 (32 kbit), I ² C address 0x50, write protect via IO15
Radio	
Wi-Fi	IEEE 802.11b/g/n/ax (Wi-Fi 6), 2.4 GHz; 2400 – 2483.5 MHz; max. 19.81 dBm EIRP
Bluetooth	Bluetooth LE 5.3; 2400 – 2483.5 MHz; max. 18.46 dBm EIRP
IEEE 802.15.4	IEEE 802.15.4 (Thread, Zigbee); 2405 – 2480 MHz; max. 10.40 dBm EIRP
Antenna	PCB antenna in the module
Radio module, certificate	EU-type examination certificate SN23C0148 (rev. A, 2023-09-28) for ESP32-C6-MINI-1, RED Annex III module B, notified body Sporton International (USA) Inc., number 2907
Distance to persons	During radio operation keep a distance of at least 20 cm between the device and persons.
Radio as delivered	As delivered, the TUL32 does not transmit: it is supplied without firmware, and the “USB-serial emulation” firmware does not switch on the radio either. Only firmware installed by the customer can transmit.
Indicators and controls	
Blue LED	blue LED (IO8, active low), controlled by firmware
Red LED	red LED, lit as soon as the bus-side 3.3 V supply from the KNX bus is present
Push button	push button “BOOTLOAD” on the bottom side (IO9); hold while plugging in: download mode for firmware installation
Environment and mechanics	
Operating temperature	0 ... +40 °C
Storage temperature	–20 ... +60 °C
Humidity	5 ... 85 % RH, non-condensing
Place of use	dry indoor locations
Design	bare circuit board, no enclosure; degree of protection IP00 (without enclosure)
Circuit board	4 layers, outline 54.0 × 19.0 mm
Overall dimensions	54.0 × 19.0 × 12 mm (L × W × H, height incl. circuit board and bus terminal WAGO 243-211)
Weight	7 g

Connections

KNX bus terminal

The bus is connected through a KNX bus terminal: red = +, dark grey = – (silkscreen “+”/“–”). With reversed polarity the device does not work but is not damaged (reverse-polarity protection by series diode ES1M). The red LED lights up as soon as bus voltage is present.

USB-C

The TUL32 is powered and accessed through USB-C. The computer sees it as USB device “USB JTAG/serial debug unit” of the ESP32-C6 (serial port + JTAG). The SBU contacts also carry a service UART (ESP32-C6 UART0) on SBU1 (TX) and SBU2 (RX, 499 Ω); ordinary USB 2.0 cables do not connect these contacts.

Expansion connector J2

Hirose FH34SRJ-14S-0.5SH, 14-pin, FPC, 0.5 mm pitch, bottom side. All signals are on the USB side (3.3 V logic, ground GND).

Pin	Signal	ESP32-C6	Use
1	GND	—	ground (USB side)
2	VCC	—	5 V (output when USB-powered / input from expansion)
3	VDD	—	3.3 V (LDO output)
4	IO0	GPIO0	W5500: INT
5	EN	—	reset (active low)
6	IO20	GPIO20	W5500: MISO
7	IO19	GPIO19	W5500: SCLK
8	IO21	GPIO21	W5500: MOSI
9	IO7	GPIO7	free
10	IO6	GPIO6	free
11	BOOT	GPIO9	parallel to push button
12	TXD0	GPIO16	UART0 TX (also USB-C SBU1)
13	RXD0	GPIO17	UART0 RX; W5500: CS
14	GND	—	ground (USB side)

Firmware

The device is shipped without firmware; the customer installs it. It is installed from the web browser (Chrome, Edge or Opera (Web Serial)) at <https://install.busware.de/TUL/>. The following firmware is currently offered for the TUL32:

Firmware	Function
USB-serial emulation	Transparent bridge USB ↔ KNX transceiver, e.g. for knxd
KNX-TP ↔ TCP Bridge (cdc2net)	KNX transceiver reachable over TCP on the network

Firmware	Function
KNX/IP for TUL (ip4knx)	KNXnet/IP gateway (tunnelling, routing) over Wi-Fi or Ethernet (https://install.busware.de/ip4knx/)
MCP for TUL	KNX commissioning through the Model Context Protocol (https://install.busware.de/TUL/mcp/)

Functions and operation are described in the documentation of each firmware.

Notes for integration into other products

- Do not cover the antenna area of the radio module with metal, ground planes or metal enclosure parts; Espressif recommends 15 mm clearance around the antenna inside an enclosure. Follow the module datasheet (Espressif, ESP32-C6-MINI-1).
- The isolation between the USB side and the bus side is functional; no isolation voltage is specified. Do not bridge the isolation gap, including via enclosure, mounting or test equipment.
- J2 is entirely on the USB side. An expansion board may power the TUL32 with 5 V through J2 pin 2; the ideal diode prevents back-feed into the USB port.
- Whoever builds the TUL32 into their own product assesses the conformity of that product themselves.

Ordering information

Type	Article no.	Scope of delivery
TUL32	TUL32-OEM	TUL32 (circuit board TUL V3.5) with KNX bus terminal
Accessory	309.130L, 309.131L	enclosure for self-assembly, available as an option

Disposal

Waste electrical equipment: do not dispose of with household waste. WEEE reg. no. (Germany) DE 54401172.



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Subject to technical change. This datasheet describes the hardware; the functions depend on the installed firmware.