LAN Industrial HAT

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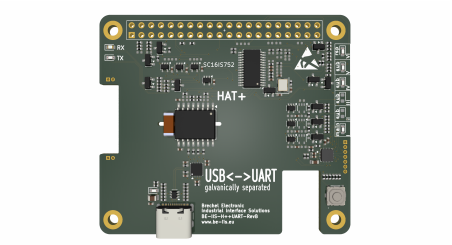

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The UART available on the RSP 40-pin header enables direct serial communication and provides a reliable debug interface if other communication interfaces fail.

This HAT provides a UART-to-USB connection. Galvanic seperation between the UART and USB sections ensures electrical robustness and protects the system against ground potential differences and noise coupling.

Key Features

- FT234X USB-to-UART bridge
- Integrated ESD protection
- Galvanic isolation
- TX/RX activity LEDs
- Pi UART support (Instance VI)
- I^2C-UART support (Instances I, IV, V)
- Stackable HAT++ design
- RSP HAT+ compliant (2024)
- Stackable HAT (BE-IIS-HAT++)
- Configurable addressing and IRQ routing
- RoHS compliant
- Quality component suppliers

Product Description

The UART Industrial HAT is a Raspberry Pi HAT+ compliant interface board providing a reliable UART interface for debugging and service access when other communication paths are unavailable, or to add additional USB-to-UART interfaces to the system.
It integrates an SC16IS752 dual UART controller and an isolated UART interface, providing galvanic isolation between the host system and the external interface. In fallback scenarios, the native Raspberry Pi UART can be used as an alternative interface.

Applications

- UART debugging and service interfaces
- Sevelopment and prototyping
- Education and training environments
- Protocol gateway and converter design
- Industrial communication evaluation and testing

Contents

1 Introduction

The BE-IIS HAT++ UART Industrial HAT is a Raspberry Pi HAT+ compliant interface board providing reliable UART connectivity via USB for debugging, service, and system integration in industrial and laboratory environments.

The board integrates an SC16IS752 [1] dual UART controller and an FT234X [2] USB-to-UART bridge, enabling flexible expansion of serial interfaces while maintaining compatibility with standard operating system drivers.

Galvanic seperation is implemented between the host system and the external interface, ensuring robust operation and protection against ground potential differences.

The HAT can be used to extend a Raspberry Pi system with additional UART interfaces or as a dedicated fallback interface when primary communication channels are unavailable. In such scenarios, the native Raspberry Pi UART remains accessible as an alternative debug interface.

The HAT is designed for evaluation, rapid prototyping, system integration, and educational use.

As part of the BE-IIS HAT++ ecosystem, the board supports stacking and can be combined with additional modules to extend system functionality, including communication interfaces and power supply solutions.

The HAT is fully compliant with the Raspberry Pi HAT+ specification and supports advanced HAT++ features such as multi-board stacking and automatic system configuration.

2 Hardware Configuration

The hardware architecture is designed for robustness, flexibility, and seamless integration into industrial and embedded environments.

2.1 Main Features

The BE-IIS HAT++ UART Industrial HAT is a Raspberry Pi HAT+ compliant interface board that extends Raspberry Pi platforms with additional UART interfaces via USB, enabling flexible serial communication for debugging, service, and system integration.

It enables standard Raspberry Pi systems (e.g. Raspberry Pi Zero or Raspberry Pi 3/4/5, excluding Compute Module variants) to operate with multiple independent UART channels.

Communication between the Raspberry Pi and the UART interfaces is realized via an SC16IS752 I^2C-connected UART bridge [1] in combination with an FT234X USB-to-UART interface [2], ensuring compatibility with standard operating system drivers and seamless integration.

Galvanic separation between the host system and the external interface improves robustness against ground potential differences and enhances overall system reliability.

2.2 Main Features

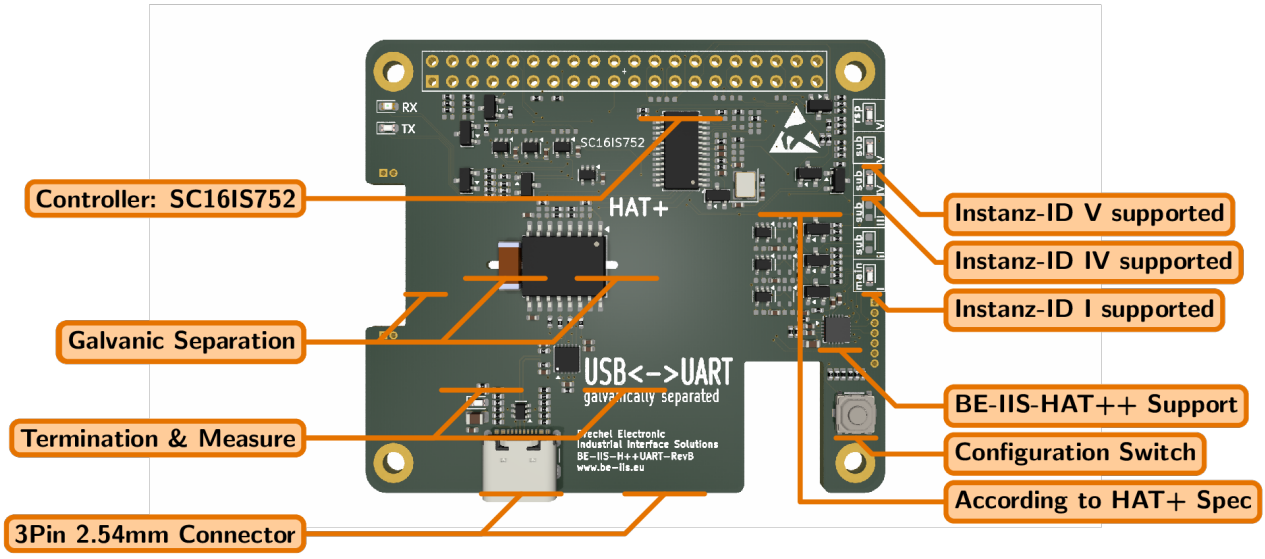

Figure 1: BE-IIS-H++UART top view with annotations

Device

- Supplier: FTDI
- Part: FT234XD
- Oscillator: 3.072MHz

UART Interface

- Pi UART Interface (14/15)
- Additional USB-to-UART interface (ttyUSB)

Separation

- Galvanically separated Interface
- Digital isolator (ISO734x, TI)

Signal Levels

- UART (TTL-level)
- USB-powered interface
- No user configuration required

LEDs

- RX LED
- TX LED

2.3 Block Diagram

The block diagram shown in Figure 2 is simplified. It illustrates the power domains, separation barriers, main functional blocks, and principal signal paths.

The interrupt signal routing is not shown.

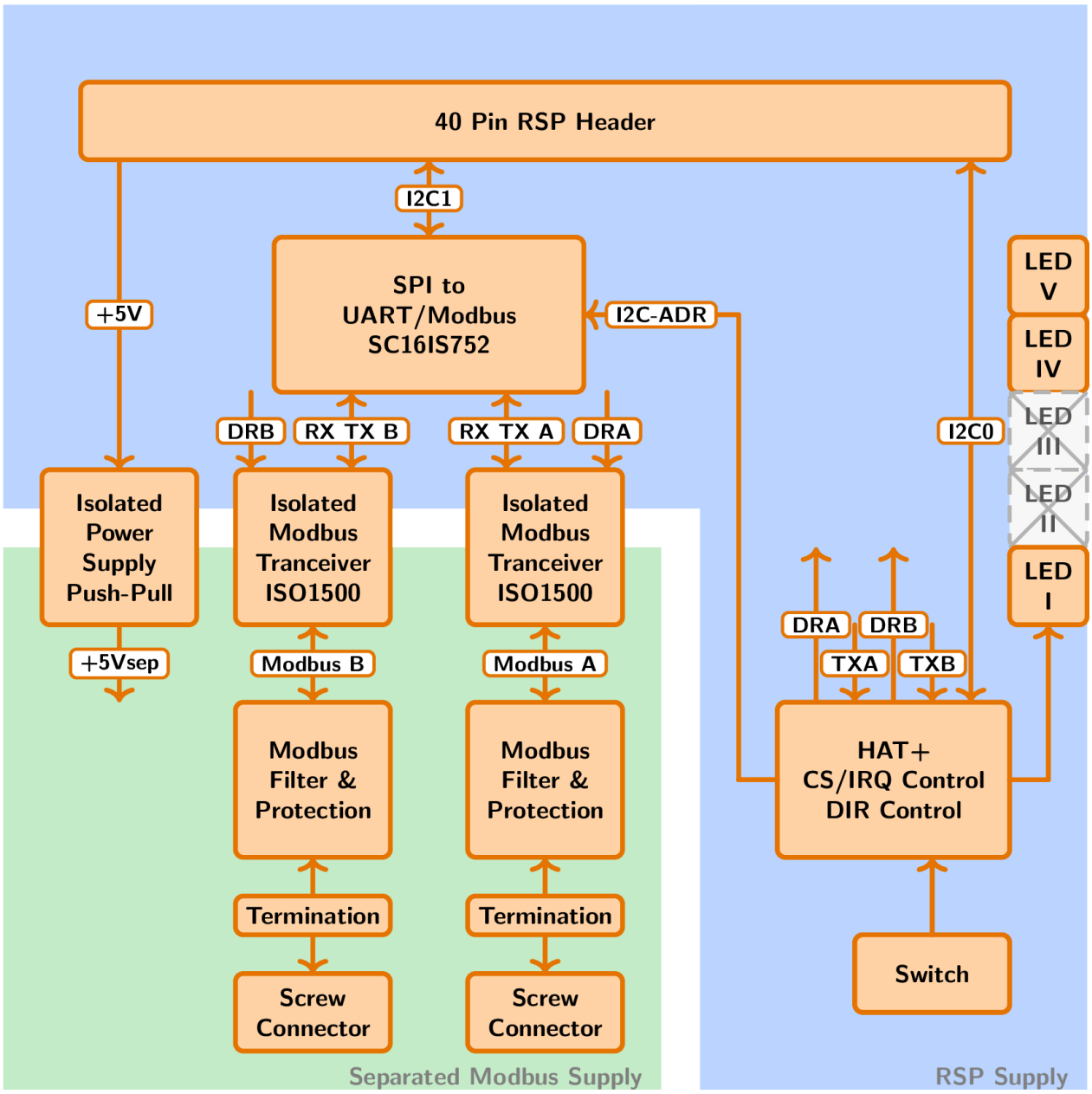

Figure 2: Simplified block diagram

2.4 HAT Configuration

The BE-IIS-HAT++ system is fully compliant with the Raspberry Pi HAT+ specification [7].

The HAT automatically provides its device tree overlay via the onboard EEPROM. As a result, no manual configuration through the bootloader or user-space tools is required. The device tree overlay defines the software configuration of the HAT hardware.

In addition, the BE-IIS-HAT++ system extends the standard HAT+ functionality by supporting multiple hardware configurations on a single HAT.

Up to three predefined configurations can be stored and selected. Each configuration is referred to as an **instance mode**. An instance mode defines the assignment and usage of interfaces such as SPI, I^2C, GPIO, and interrupt lines.

This enables:

- Operation of multiple identical HATs within one system
- Combination of several BE-IIS-HAT++ modules
- Flexible interface mapping without manual reconfiguration

2.5 Instance Modes and System Constraints

Instance Mode I corresponds to the primary Raspberry Pi HAT+ configuration. A HAT operating in this mode enables the I^2C pull-ups and participates in the HAT+ EEPROM detection mechanism.

For proper system operation, exactly one HAT must be configured in Instance Mode I.

In stacked configurations:

- One HAT must operate in Instance Mode I
- Additional HATs must use alternative instance modes
- No two HATs may use the same instance mode simultaneously

The BE-IIS-HAT++ system supports stacking of up to five HATs, depending on the selected instance modes and system configuration.

This HAT supports Instance-Mode I, IV and V

2.6 Interfaces

The board interfaces with the host system via the I²C bus (I²C1) [6] and a dedicated interrupt (IRQ) signal.

The I²C bus is used for communication between the Raspberry Pi (I²C master) and the onboard interface controller (I²C slave). An interrupt line is used for event-driven communication.

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2.7 Galvanic Separation

Galvanic separation is implemented between the USB-powered interface domain and the Raspberry Pi logic domain.

The separation barrier decouples the USB interface from the host-side circuitry, improving robustness against ground potential differences, reducing EMI coupling, and preventing ground-loop currents that could otherwise lead to communication errors or hardware damage.

Separation of the UART RX and TX signal paths is realized using a quad-channel digital isolator (ISO734x, Texas Instruments) [3]. No direct galvanic connection exists between the two domains.

The required isolation performance depends on the specific application and corresponding safety requirements. If such requirements are defined, application-specific evaluation, testing, and certification may be supported. Upon request, variants with validated isolation performance, including testing, labeling and certification, can be provided.

In the default configuration, the board provides functional separation only.

2.8 Connectors

The board features a USB Type-C connector for power supply and data communication.

The USB-C interface provides the connection to the host system and is used for the USB-to-UART communication channel. It ensures reliable mechanical stability and reversible plug orientation [5].

Although a USB Type-C connector is used, the electrical interface operates as a USB 2.0 device [4]. No USB 3.x functionality is supported.

The connector does not require external configuration for standard operation.

2.9 Signal Polarity and Wiring Orientation

The USB Type-C connector is fully reversible and can be inserted in either orientation without affecting functionality [5].

3 Software and System Configuration

The BE-IIS-HAT++ system provides a unified platform for fast system integration.

- Predefined drivers and kernel modules
- Support for prebuilt modules and custom kernel builds
- Ready-to-use build and configuration scripts
- Centralized software repository [TODO]
- Typical setup time below a few minutes

After installation, the system can be used without further software modification.

4 Electrical Characteristics

4.1 Supply Voltage

Parameter	Min	Typ	Max
3.3 V Input [V]	3.0	3.3	3.6
5 V Input (Pi) [V]	–	5.0	–
5 V Input (USB-C) [V]	4.75	5.0	5.25

Table 1: Voltage supply

Note: The board does not draw power from the Raspberry Pi 5 V rail. The logic domain is supplied by the 3.3 V rail of the Raspberry Pi header, while the USB/PHY domain is powered independently via the USB-C [5] input.

4.2 Current Consumption

Parameter	Typ	Unit
Current @ 3.3 V (Raspberry Pi)	15	mA
Current @ 5 V (Raspberry Pi)	0	mA
Current @ 5 V (USB-C)	14	mA

Table 2: Current consumption

Note: The board does not draw power from the Raspberry Pi 5 V rail. The logic domain is supplied by the 3.3 V rail of the Raspberry Pi header, while the USB/PHY domain is powered independently via the USB-C [5] input.

5 Environmental Conditions

5.1 Conditions

Condition	Min	Max
Operating Temperature [°C]	-40	+85
Storage Temperature [°C]	-40	+105
Relative humidity [%]	5	95

Table 3: Operating conditions

5.2 Usage

Condition	Parameter
Usage	indoor
Pollution degree	2
Operating altitude	up to 2000 m

Table 4: Operating usage

5.3 EMC and Environmental Compliance (Preliminary)

The standard version of the board is provided without formal EMC or safety certification.

The hardware design is developed with consideration of commonly applied IEC standards, including:

- **ESD immunity:** IEC 61000-4-2
- **Electrical fast transient (EFT/Burst):** IEC 61000-4-4
- **Surge immunity:** IEC 61000-4-5
- **Conducted RF immunity:** IEC 61000-4-6
- **Radiated RF immunity:** IEC 61000-4-3
- **EMC immunity (industrial):** IEC 61000-6-2
- **EMC emission (industrial):** IEC 61000-6-4
- **Safety / isolation reference:** IEC 62368-1

These standards are not verified for the standard product variant.

Compliance with specific standards, test levels, or safety requirements is not guaranteed unless explicitly specified.

If defined EMC or isolation requirements are provided, application-specific validation, testing, and certification can be supported. Upon request, product variants with validated performance, including labeling, certification, and test reports (e.g. Hi-Pot testing), can be delivered.

6 Delivery

The product is delivered as a partially assembled kit intended for final user assembly. Mechanical accessories and connector components required for standard evaluation and stacked operation are included.

Order Code	BE-IIS-HPP-UART-REV.B
Condition	Assembly kit
Status	Partially assembled
Included Items	1× HAT 1× 2×20 pin stackable header
REACH & RoHS	Compliant with EU Directive 2011/65/EU and REACH Regulation (EC) No 1907/2006

Table 5: Delivery condition and included parts

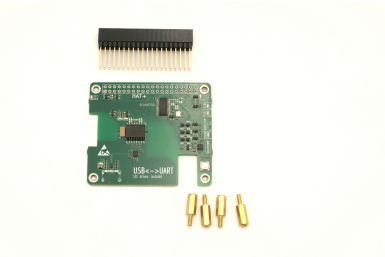


Figure 3: Delivery condition

7 Mechanical

7.1 Board Format

- Form factor: Raspberry Pi HAT+
- Mechanical dimensions: Raspberry Pi HAT compatible [7]
- Mounting hole pattern: Raspberry Pi HAT compatible [7]
- Stackszize: 15mm

7.2 Connectors and Assembly Height

- Host connector: 40-pin Raspberry Pi header
- Field connector: J6000, updated connector option
- Assembly height: [TODO]

7.3 Board Views

Figure 4: Mechanical overview

8 Assembly

This product is delivered as a kit and requires basic soldering and mechanical assembly.

8.1 2x20-Pin Main Connector

The 2x20-pin connector provides the interface to the Raspberry Pi. For proper HAT functionality, the connector must be assembled carefully.

A stackable 2x20-pin header is included in the delivery and is recommended for most applications, especially when using the BE-IIS HAT++ stacking system.

- Mount the header on the top side of the PCB (component side)
- The socket side faces down towards the Raspberry Pi

Alternatively, a standard (non-stackable) pin header may be used if stacking is not required.

Soldering instructions:

- Use a suitable soldering iron with adequate temperature control
- Ensure good ventilation and avoid inhaling solder fumes
- Heat both the pad and the pin simultaneously, then apply solder
- Solder each pin individually and ensure proper wetting
- Avoid excessive solder to prevent large solder cones, which may affect stacking capability

Proper alignment of the connector is important to ensure mechanical compatibility with the Raspberry Pi and other HATs.

8.2 Spacer

To ensure mechanical stability and correct stacking height, spacers must be installed.

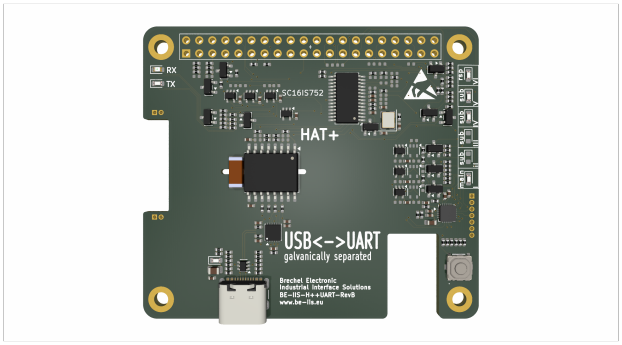
- Recommended spacer height: 15 mm
- Fix the PCB using appropriate screws and spacers
- Ensure stable mechanical mounting to avoid stress on the connector

The spacers define the stacking distance and provide mechanical fixation of the HAT.

8.3 Board Overview

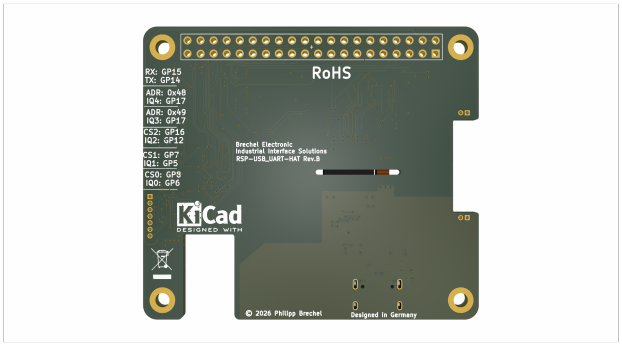
9 References

1. NXP SC16IS752 Datasheet
2. FTDI FT234XD Datasheet
3. Texas Instruments ISO734x Datasheet
4. USB 2.0 Specification
5. USB Type-C Cable and Connector Specification
6. NXP I²C-bus Specification and User Manual
7. Raspberry Pi HAT+ Specification
8. BE-IIS Installer (Software and Setup Tools)



Top view

Front view



Bottom view

Side view

Figure 5: BE-IIS-HAT++UART – mechanical overview