## Revision history

<table>
<thead>
<tr>
<th>Manual version</th>
<th>Driver version</th>
<th>HW version</th>
<th>Notes</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>1.0.0 - 1.2.0</td>
<td>2.1</td>
<td>• Initial version</td>
<td>January 2018</td>
</tr>
</tbody>
</table>
| 1.6            | 1.6.3, 2.0.0   | 2.1        | • New corporate design and structure  
• Description of the driver version 2.0.0 | November 2018 |
| 1.7            | 1.6.3, 2.0.0   | 3.0        | • Description of the new hardware version 3.0  
• Added chapter Hardware history | February 2019 |
| 1.8            | 1.6.3, 2.0.0   | 3.0        | • Added chapter Regulatory compliance information | February 2019 |
| 1.9            | 1.6.3, 2.0.0   | 3.0        | • Package content image updated. | March 2019 |
| 2.0            | 3.0.0          | 3.0        | • Renamed product names in driver  
• Moved other drivers to Wireless Connectivity SDK  
• Moved description of other drivers on Wireless Connectivity SDK manual | April 2019 |
| 2.1            | 3.1.0          | 3.0        | • Added the requirements for operation with Raspberry Pi 4  
• Updated wiringPi install instructions | September 2019 |

* For hardware history see chapter Hardware history
## Abbreviations and abstract

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACK</td>
<td>Acknowledgement</td>
<td>Acknowledgement pattern confirming the reception of the transmitted data packet.</td>
</tr>
<tr>
<td>CS</td>
<td>Checksum</td>
<td></td>
</tr>
<tr>
<td>DC</td>
<td>Duty cycle</td>
<td>Transmission time in relation of one hour. 1% means, channel is occupied for 36 seconds per hour.</td>
</tr>
<tr>
<td>FSE</td>
<td>Field Sales Engineer</td>
<td>Support and sales contact person responsible for limited sales area</td>
</tr>
<tr>
<td>0xhh [HEX]</td>
<td>Hexadecimal</td>
<td>All numbers beginning with 0x are stated as hexadecimal numbers. All other numbers are decimal.</td>
</tr>
<tr>
<td>HIGH</td>
<td>High signal level</td>
<td></td>
</tr>
<tr>
<td>LOW</td>
<td>Low signal level</td>
<td></td>
</tr>
<tr>
<td>LSB</td>
<td>Least significant bit</td>
<td></td>
</tr>
<tr>
<td>MSB</td>
<td>Most significant bit</td>
<td></td>
</tr>
<tr>
<td>PL</td>
<td>Payload</td>
<td>The real, non-redundant information in a frame/packet.</td>
</tr>
<tr>
<td>RF</td>
<td>Radio frequency</td>
<td>Describes everything relating to the wireless transmission.</td>
</tr>
<tr>
<td>UART</td>
<td>Universal Asynchronous Receiver Transmitter</td>
<td>Universal Asynchronous Receiver Transmitter allows communicating with the module of a specific interface.</td>
</tr>
<tr>
<td>US</td>
<td>UserSettings</td>
<td>Any relation to a specific entry in the UserSettings is marked in a special font and can be found in the respective chapter.</td>
</tr>
<tr>
<td>VCC</td>
<td>Supply voltage</td>
<td></td>
</tr>
</tbody>
</table>
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AMBER PI reference manual version 2.1 © September 2019
www.we-online.com/wireless-connectivity
1 Summary & introduction

The AMBER PI is an expansion board for the Raspberry Pi that equips the Raspberry Pi with the sub GHz RF interface provided by Würth Elektronik eiSos. The included sensor boards as well as the delivered RF-stick, that run as remote station for radio transmissions, allow to develop various creative applications on top of the Raspberry Pi.

Besides the hardware of the AMBER PI, Würth Elektronik eiSos provides a driver in C-code that includes the functions for the integrated RF-module as well as the connected sensors to enable an easy and quick custom application development.
Würth Elektronik eiSos delivers a box that contains the AMBER PI, the sensor boards and an empty SPI prototype board. The included radio-stick can be used as remote station to communicate with the AMBER PI via radio.

To complete this development kit, the user has to add its Raspberry Pi and the corresponding power supply to the placeholders that are provided in the box.

With this and the corresponding AMBER PI driver, that can be downloaded from the AMBER PI web page [1], the kit is ready to bring numerous remarkable custom ideas to life.
3 Raspberry Pi compatibility

The AMBER PI uses a 40 pin connector to be mounted on top of the Raspberry Pi. The AMBER PI as well as this manual have been created using the Raspberry Pi 3B as base providing sufficient computing power for a convenient application development. But nevertheless, also other types of Raspberry Pi may be compatible.

Compatible Raspberry Pi versions:

- Raspberry Pi 4B (1, 2 and 4GB)
  - Requires: Raspbian Buster or newer
  - Requires: Wiring Pi version 2.52 or newer (manual steps are required till this version is in the official repositories. See instructions at: wiringpi.com).

- Raspberry Pi 3B (recommended)

- Raspberry Pi Zero W
  - When using Raspbian with GUI most of the computing power is used for the GUI

- Others
  - To be tested
4 Quickstart guide: Taking into operation

To take the AMBER PI into operation the AMBER PI driver has to be installed. To do so the following chapter contains the complete description how to setup the Raspberry Pi as well as the AMBER PI driver. This description has been created using a Raspberry Pi 3B.

Please perform the following steps:

4.1 Install the Raspbian OS on the Raspberry Pi

1. First of all the Raspberry Pi has to be installed and configured.
   a) Download the latest Raspbian with GUI from

   b) Install the Raspbian OS by writing its image on your SD-card. In Windows the
      Win32DiskImager tool can be used, as described here

2. After installing the image on the SD card, insert it into the Raspberry Pi’s SD card slot, connect your monitor, mouse and keyboard. Now the Raspberry Pi is ready to boot up. Please start it by powering it up.

3. After booting the Raspberry, switch off the Bluetooth interface by clicking on the Bluetooth button on the right upper corner of the screen (see figure 3).

4. Then turn on the WiFi for connecting to the internet by clicking on the WiFi button on the right upper corner of the screen and selecting the WiFi of your choice.
5. After connecting to the internet make sure your Raspberry Pi is up to date with the latest versions of Raspbian OS. To update the system open a terminal by clicking on the terminal symbol in the left upper corner (see figure 4).

Figure 4: Terminal button

6. Then upgrade the Raspbian OS by typing in terminal:

```
sudo apt-get update
sudo apt-get upgrade
```

4.1.1 Configuring the peripherals

1. Next, the peripherals have to be enabled. To do so open the menu by clicking on the Raspberry symbol on the left upper corner of the screen and open the Preferences → Raspberry Pi Configuration window (see figure 5). Enable the SPI, I2C and SERIAL interface. The SPI and I2C are used for the sensors, the SERIAL interface (UART) drives the integrated RF-module.
2. After enabling the interfaces a dialog should appear asking for a reboot to apply the changes. If no dialog appears reboot by clicking on the Raspberry symbol on the left upper corner of the screen and select **Shutdown**.

The Raspbian OS claims the serial interface for console output. We need to disable this feature to use the serial interface for the communication with our integrated RF-module.

3. Now, after enabling the serial interface, the Raspbian OS claims it for console output. To disable this feature, please remove the string "console = serial0,115200" from the file `/boot/cmdline.txt` and save it. Root privilege is needed to change the file. To open the file accordingly type in terminal:

```
sudo leafpad /boot/cmdline.txt
```

4. Please check whether the serial interface is still enabled by opening the file `/boot/config.txt` and check whether the string "enable_uart=1" is still included. If not, please add it and save the file. Root privilege is needed to change the file. To open the file accordingly type in terminal:

```
sudo leafpad /boot/config.txt
```

5. Please reboot as before and check whether the files `/boot/cmdline.txt` and `/boot/config.txt` are still as described in the previous two points. If not, adapt the two files again as described before and reboot. Otherwise the UART-interface to the module is not active and thus the module communication fails.
4.2 Install the wiringPi library

The wiringPi library is used to easily access the peripherals of the Raspberry Pi.

1. First check if wiringPi is already installed. In a terminal type:

   `gpio -v`

   If you get a version number, then you have it installed already. Make sure that in case of Raspberry Pi 4 the version of wiringPi is at least 2.52 (instructions follow in the next step).
   In this case continue with the next chapter 4.3.

2. If it is not installed, install wiringPi by

   `sudo apt-get install wiringpi`

   Note: For Raspberry Pi 4B, currently a manual update is required as shown in this instruction: `wiringpi.com 2.52 manual install`.

3. The result of `gpio -v` should now be the version number of the installed wiringPi version.

4. Double check that

   `cd /usr/lib/`
   `ls -l *wiring*`

   is showing that `libwiringPi.so` is found at this location.

4.3 Install the AMBER PI driver

The AMBER PI driver was developed in the codeblocks development environment.

1. Thus first download and install the software codeblocks. Therefore open a terminal and type:

   `sudo apt-get install codeblocks`

2. Now download the AMBER PI driver as zip file from (www.we-online.com/amber-pi) to the location `~/Downloads`

3. The file is going to be extracted to the folder `~/Projects`. If the folder does not exist create it by typing in terminal:

   `mkdir ~/Projects`

4. Now extract the AMBER PI project to `~/Projects` by typing in terminal:

   `unzip ~/Downloads/AMBER_PI.zip -d ~/Projects`

5. Then start the project via codeblocks by typing in terminal

   `sudo codeblocks ~/Projects/AMBER_PI/AMBER_PI.workspace &`
It’s important to start the project with root permissions (sudo...). Otherwise the access to the peripherals is blocked and thus the Raspbian OS freezes.

6. Now include the wiringPi libraries into codeblocks by opening the global linker settings in Settings → Compiler → Linker Settings and adding the library /usr/lib/libwiring-Pi.so to the Link libraries field (see figure 6).

7. Additionally add -pthread in the Other linker options field. Close the linker settings again.

All necessary libraries are also linked in the projects linker settings to not run into trouble in case they have not been linked in the global linker settings.

8. Then press Build → Rebuild to build the project (see figure 7).
If it builds without errors the Raspberry Pi, WiringPi and AMBER PI driver setup succeeded. Warnings can be ignored as they just provide further information.
In case of compilation errors, see also chapter FAQ – Frequently asked questions.

### 4.4 Setup the AMBER PI hardware

Set the jumpers according to the default configuration (see Table 1).

1. Now attach the sensors to the predefined connectors.
   a) The motion sensor LIS2DW12 to the SPI1 connector.
   b) The pressure sensor LPS22HB to one of the I2C connectors.
   c) The humidity and temperature sensor HTS221 to the remaining I2C connector.

2. Now the AMBER PI is ready for operation. Turn the Raspberry Pi off, connect the AMBER PI and start the Raspberry Pi again.

3. After reboot, open the project again via codeblocks by

```
sudo codeblocks ~/Projects/AMBER_PI/AMBER_PI.workspace &
```

### 4.5 Run the AMBER PI

1. Please press **Build → Run** to run the application on the Raspberry Pi (see figure 8).
If the module communication fails, most probably the Raspberry Pi claims the serial interface for its console output. Please repeat the instructions in chapter 4.1.1 to fix this issue.

2. The default application starts and configures the Tarvos-III module as well as the connected sensors, reads their measurement values (temperature, humidity, motion, pressure) once per second and transmits the data via the Tarvos-III. Each time the Tarvos-III transmits data the red TX LED on the AMBER PI is flashing.

3. To receive the transmitted data the delivered RF-dongle can be used. Thus please connect the RF stick to the USB port of a Microsoft Windows machine and open the resulting COM port using a terminal program of your choice (e.g. hterm) with its default UART settings (115200Baud, Data 8, Stop 1, Parity None, see figure 10). For better readability of the received data the "new line after ... ms" can be set to 100ms.

The Tarvos-III Plug is compatible to the Tarvos-III.
If your computer does not recognize the connected RF-stick as COM port, please install the latest driver from [http://www.ftdichip.com/Drivers/VCP.htm](http://www.ftdichip.com/Drivers/VCP.htm) first.

The Tarvos-III Plug uses the so called command mode. Thus when receiving data via radio a CMD_DATA_IND message including the received radio data is transmitted on the UART.

![Example_AMBERPi](image)

**Figure 9: Default application**

![Figure 10: Receiving the transmitted data using the Tarvos-III Plug radio stick and the terminal program HTerm](image)
The **CMD_DATA_IND** frame is of the following form, and contains besides the received payload, also the RSSI value.

<table>
<thead>
<tr>
<th>Start signal</th>
<th>Command</th>
<th>Length</th>
<th>Payload</th>
<th>RSSI</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x02</td>
<td>0x81</td>
<td>1 Byte</td>
<td>x Byte</td>
<td>1 Byte</td>
<td>1 Byte</td>
</tr>
</tbody>
</table>

Figure 11: Received **CMD_DATA_IND** in hex with length field of 0x6C, RSSI of 0xA8 and CS of 0x0E.

### 4.6 Advanced: Bidirectional transmission

To demonstrate also the receiving capabilities of the Tarvos-III the test function **RX_test()**, that simply starts the Tarvos-III driver and stays in a while-loop, can be used.

1. Please enable this function in the MainThread of the driver (see figure 12), build and run the program again.

```c
PI_THREAD (MainThread)
{
  /* apply a higher priority to this thread to be prioritized w.r.t. the main function */
  pinMode(PIND1, PRI0_MAIN_THREAD);
  // initialize wiringPi 
  if (wiringPiSetup () == -1)
  {
    fprintf (stdout, "Unable to start wiringPi: %s\n", strerror (errno));
  }
  else
  {
    /* wiring PI started successfully */
    int wiring_version_major;
    int wiring_version_minor;
    wiringPiVersion(&wiring_version_major, &wiring_version_minor);
    fprintf (stdout, "WiringPi library version %d.%d\n", wiring_version_major, wiring_version_minor);

    #if 0
    Application();
    #elif RX_test();
    #else
    RX0826_test_function();
    #endif
    AbortMainLoop = true;
    return 0;
  }
}
```

Figure 12: Enabling the RX_test() function in the driver application
2. Then, on your windows machine, you have to use a CMD_DATA_REQ command to transmit data with the Tarvos-III Plug. The format of the CMD_DATA_REQ is as follows:

<table>
<thead>
<tr>
<th>Start signal</th>
<th>Command</th>
<th>Length</th>
<th>Payload</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x02</td>
<td>0x00</td>
<td>1 Byte</td>
<td>Length Byte</td>
<td>1 Byte</td>
</tr>
</tbody>
</table>

Thus, to transmit a string like "Hey, I'm the AMB8865", the command looks like shown in figure 13. In this example the length field is 0x14 (20) and the checksum is 0x79.

Figure 13: Transmitting an arbitrary string using the Tarvos-III Plug radio stick

3. The Tarvos-III on the AMBER PI will receive the data transmitted and gives it to the driver (see figure 14).
Figure 14: Receiving the transmitted data
5 The AMBER PI driver

The AMBER PI driver contains drivers of the delivered sensors, of the integrated Tarvos-III RF-module as well as of additional Würth Elektronik eiSos products.

Figure 15: AMBER PI driver

5.1 Tarvos-III - Würth Elektronik eiSos 868MHz radio module

The Tarvos-III is one of the compact and low-cost radio data transmission module for wireless half-duplex communication provided by Würth Elektronik eiSos. For full information we refer to the Tarvos-III manual [2] and Tarvos-III datasheet [3].

The Tarvos-III acts as a slave and can be fully controlled by the Raspberry Pi. The configuration as well as the operation of the module can be managed by predefined commands that are sent as telegrams over the UART interface. The AMBER PI driver implements this command interface to provide a simple API to the user. A short description of the command interface can be found in chapter 5.1.1.

Besides the routines to set the module into low power mode, reset it or transmit and receive data, several functions are provided to readout and adapt the module’s configuration parameters.
To run the Tarvos-III driver the function `TarvosIII_Init()` has to be called first. Its input arguments are:

- the connected pin numbers (reset, wake up, boot) of the Raspberry Pi
- the data baudrate to setup the serial connection to the integrated RF-module
- the callback function that returns the data that has been received by the module via RF
- the address mode that defines number of available addresses and thus the structure of the `CMD_DATAEX_CMD` command

Please note that when adapting the baudrate or address mode of the module, the driver has to be restarted (deinit and init again). The default UART baudrate is 115200 Baud and the default address mode is mode 0. Please check the Tarvos-III manual [2] for all default values.

Please be cautious when frequently updating the non-volatile user settings. These settings are stored in the module’s flash and thus can be updated only a limited number of times before hardware failure.

### 5.1.1 The Tarvos-III command interface

The commands of the command interface can be divided into 3 groups:

- **Requests:** The host requests the module to trigger any action, e.g. in case of the request `CMD_RESET_REQ` the host asks the Tarvos-III to perform a reset.

- **Confirmations:** On each request the module answers with a confirm message to give a feedback on the requested operation status. In case of a `CMD_RESET_REQ`, the module answers with a `CMD_RESET_CNF` to tell the host whether the reset will be performed or not.

- **Indications and Responses:** The module indicates spontaneously when a special event occurred. The `CMD_DATAEX_IND` indicates for example that data was received via RF.

Thus for example, when calling the function `TarvosIII_Reset()`, the driver sends the `CMD_RESET_REQ` message and waits for the corresponding `CMD_RESET_CNF` message that is send back from the module to confirm that the reset request was received and will be executed.

Second example: When the driver spontaneously receives a `CMD_DATAEX_IND` message that contains data received by the module via RF, the driver gives the received RF packet data to its registered callback function to inform the user about the received RF data.

The commands itself have to following format:
Example 1: CMD_RESET_REQ
This command triggers a software reset of the module. The reset is performed after the acknowledgement is transmitted. All volatile settings are initialized with their defaults.

The CMD_RESET_REQ has the command number 0x05 with length field 0x00. Thus the payload field is empty.

Format:

<table>
<thead>
<tr>
<th>Start signal</th>
<th>Command</th>
<th>Length</th>
<th>Payload</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x02</td>
<td>0x05</td>
<td>0x00</td>
<td></td>
<td>0x07</td>
</tr>
</tbody>
</table>

Example 2: CMD_DATA_REQ
This command serves the simple data transfer in the command mode. Transmission takes place on the configured channel to the previously parameterised destination address. The CMD_DATA_REQ has the command number 0x00. The length field is the number of bytes we’d like to transmit via RF.

Format:

<table>
<thead>
<tr>
<th>Start signal</th>
<th>Command</th>
<th>Length</th>
<th>Payload</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x02</td>
<td>0x00</td>
<td>1 Byte</td>
<td></td>
<td>1 Byte</td>
</tr>
</tbody>
</table>

Sending "Hello World!" means

<table>
<thead>
<tr>
<th>Start signal</th>
<th>Command</th>
<th>Length</th>
<th>Payload</th>
<th>CS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x02</td>
<td>0x00</td>
<td>0x0C</td>
<td>0x48 0x65 0x6C 0x57 0x6F 0x72 0x6C 0x64 0x21</td>
<td>0x0F</td>
</tr>
</tbody>
</table>

where we send 12 bytes (0x0C), which are "Hello World!" (0x48 0x65 0x6C 0x57 0x6F 0x72 0x6C 0x64 0x21). The resulting checksum is 0x0F.

5.2 HTS221 - Digital sensor for relative humidity and temperature
The HTS221 is an ultra-compact sensor for relative humidity and temperature. It includes a sensing element and a mixed signal ASIC to provide the measurement information through digital serial interfaces.
The AMBER PI driver contains the main functions to configure and run the HTS221. For the description of the driver functions we refer to the documentation that is provided in the source code. For the description of this sensor, we refer to its datasheet [4].

When connecting the HTS221 sensor board please align it following the white "triangle marking" located on top.

![Figure 16: HTS221 sensor board](image)

5.3 LPS22HB - MEMS nano pressure sensor

The LPS22HB is an ultra-compact piezoresistive absolute pressure sensor which functions as a digital output barometer. The device comprises a sensing element and an IC interface which communicates through I2C or SPI from the sensing element to the application. The AMBER PI driver contains the main functions to configure and run the LPS22HB. For the description of the driver functions we refer to the documentation that is provided in the source code. For the description of this sensor, we refer to its datasheet [5].

When connecting the LPS22HB sensor board please align it following the white "triangle marking" located on top.
5.4 LIS2DW12 - MEMS digital output motion sensor

The LIS2DW12 is an ultra-low-power high-performance three-axis linear accelerometer belonging to the "femto" family which leverages on the robust and mature manufacturing processes already used for the production of micromachined accelerometers.

The LIS2DW12 has user-selectable full scales of $\pm 2g/\pm 4g/\pm 8g/\pm 16g$ and is capable of measuring accelerations with output data rates from 1.6 Hz to 1600 Hz.

The AMBER PI driver contains the main functions to configure and run the LIS2DW12. For the description of the driver functions we refer to the documentation that is provided in the source code. For the description of this sensor, we refer to its datasheet [6].

Please connect the LIS2DW12 sensor board on P9 (SPI1) connector.

When connecting the LIS2DW12 sensor board please align it following the white "triangle marking" located on top.
5.5 PROTO SPI - Mini breadboard for SPI customized connections

The PROTO SPI is a mini breadboard with onboard all the typical 4-wires SPI signals plus the power signals +3.3V and GND.

Please refer to the schematics chapter for detailed signal connections.

When connecting the PROTO SPI board please align it following the white "triangle marking" located on top.
6 FAQ - Frequently asked questions

6.1 Is my Raspberry Pi compatible to the AMBER PI?
Please refer to the chapter 3 to check your compatibility.

6.2 I get the following compilation errors, what can I do?

- Undefined reference to pullUpDnControl, pinMode, digitalWrite,...

Solution: Probably the wiringPi was not linked correctly. Please refer to figure 6.

- Undefined reference to symbol pthread_create,...

Solution: Probably the pthread library was not linked correctly. Please refer to figure 6.

6.3 After installation of the AMBER PI driver, I get a "NOK" when calling the TarvosIII_Init-function. What can I do?

Probably the configuration of the serial interface (UART) did not work properly. To use the AMBER PI, the serial interface has to be enabled. By default, the Raspberry Pi uses the enabled serial interface for console output. To make the serial interface available for the AMBER PI communication, the console output has to be disabled. Please follow the instructions in chapter 4.1.1 to solve this issue.

6.4 When starting codeblocks, there are many warnings in the console. Is this a problem?

Warning: Mismatch between the program and library build versions detected. The library used 3.0 (wchar_t,compiler with C++ ABI 1010,wx containers,compatible with 2.8), and your program used 3.0 (wchar_t,compiler with C++ ABI 1009,wx containers,compatible with 2.8)
No it is not, since a compatible version of codeblocks has been installed. If it is still a problem the newest version of codeblocks has to be compiled and installed as described in: http://wiki.codeblocks.org/index.php/Installing_Code::Blocks_from_source_on_Linux

6.5 How can I get the AMBER PI driver?

Please check the download section of the AMBER PI website
www.we-online.com/amber-pi

6.6 Is there also a driver for other radio modules of Würth Elektronik eiSos?

Yes, in version 2.1.0 of the driver the support of other Würth Elektronik eiSos products has been moved to the Wireless Connectivity SDK. It is available on our website
www.we-online.com
7 AMBER-PI development board

Please connect the sensor boards as indicated by the "triangle markings" on the top side for the correct alignment.
Figure 21: Bottom view

Figure 22: Sensor boards alignment
7.1 Tarvos-III long range radio module

For detailed information of the Tarvos-III radio module, please refer to the Tarvos-III manual [2].

Please note that we do not guarantee the proper operation of the radio profile 3 (0.625 kbps long range mode) of the Tarvos-III over the full temperature range. This only holds for Tarvos-III of hardware version 2.2 or older and serial number 116.002000 or smaller.

7.2 Jumper settings

![Jumper settings diagram]

Figure 23: Jumper settings
<table>
<thead>
<tr>
<th>Jumper designator</th>
<th>Function</th>
<th>Default location</th>
</tr>
</thead>
<tbody>
<tr>
<td>JP1-2</td>
<td>UART Connect the Raspberry Pi UART pins to the Tarvos-III UART pins. Set = Connected, Not set = Not connected</td>
<td>Set</td>
</tr>
<tr>
<td>JP3</td>
<td>Module power supply Supply module with power. Set = module is powered, Not set = module is not powered</td>
<td>Set</td>
</tr>
<tr>
<td>JP4-7</td>
<td>Sensor power supply Supply sensors with power. Set = Sensor is powered, Not set = Sensor is not powered</td>
<td>Set</td>
</tr>
<tr>
<td>JP8</td>
<td>Boot Connect the Tarvos-III Boot pin. Left = Connected to GND (Normal operation), Middle = Boot pin is handled by the Raspberry Pi, Right = Connected to high (Bootloader starts after reset)</td>
<td>Left</td>
</tr>
<tr>
<td>JP10-13, JP20</td>
<td>SPI Connect Raspberry Pi SPI pins or Tarvos-III SPI pins to the SPI sensors. Right = Raspberry Pi SPI pins are connected to the SPI sensors, Left = Tarvos-III SPI pins are connected to the SPI sensors</td>
<td>Right</td>
</tr>
<tr>
<td>JP14-15</td>
<td>I2C Connect Raspberry Pi I2C pins or Tarvos-III I2C pins to the I2C sensors. Right = Raspberry Pi I2C pins are connected to the I2C sensors, Left = Tarvos-III I2C pins are connected to the I2C sensors</td>
<td>Right</td>
</tr>
<tr>
<td>JP16</td>
<td>Power source Power source for the AMBER PI. Left = Battery is used as power source, Right = Raspberry Pi is used as power source</td>
<td>Right</td>
</tr>
<tr>
<td>JP17</td>
<td>Power LED source Supply the power. Right = PWM of Raspberry Pi is used, Left = Constant 3.3V signal is used</td>
<td>Right</td>
</tr>
<tr>
<td>JP18-19</td>
<td>I2C Pull up Set: Pull-up resistors are connected, Not set = Pull-up resistors are not connected</td>
<td>Set</td>
</tr>
<tr>
<td>LPS22HB-JP1</td>
<td>LPS22HB SA0/SD0 Switch the address of this sensor</td>
<td>Right</td>
</tr>
</tbody>
</table>

Table 1: Jumper documentation

### 7.3 Power supply

There are two possibilities to supply the evaluation board and the module with voltage.
Figure 24: Power supply schematic

The different power sources are connected with diodes (approx. dropout 0.2V) for protection reasons. The power source is simply chosen mounting the JP16 jumper in the wanted position. For convenience two 2x1 contactable headers provide +3.3V and GND potentials.

7.3.1 Battery source

The development board has the possibility to be powered on by a standard 3V CR2032 coin battery (e.g. standalone application). Battery has to be inserted in the battery holder named H1 located in the bottom side of the pcb.

Please respect the polarity when inserting the battery as indicated on the H1 battery holder serigraphy.

7.3.2 Raspberry Pi source

In this case the development board is powered on using the +3.3V lines coming from the Raspberry Pi through the P1 connector.

7.4 Current measurement

The development board provides the opportunity to measure the current consumption of each stage, especially useful when designing a dedicated application in which current budget is a key parameter.
Please consider the overall current consumption when designing a final application.
When using battery as power source, please refer to CR2032 coin battery datasheet.
When using Raspberry Pi as power source, please refer to its datasheet.

7.4.1 Tarvos-III current measurement

For Tarvos-III current measurement please follow these steps:

1. Remove the jumper on JP3
2. Connect a current meter in series on JP3 (refer to the schematics pages for reference)

For normal operation please set again the jumper on JP3 in default position.

7.4.2 Sensor current measurement

For sensor current measurement please follow these steps:

1. Remove the relative jumpers related to the sensors under analysis (JP4, JP5, JP6 or JP7)
2. Connect a current meter in series on relative JP position (refer to the schematics pages for reference)

For normal operation please set again the jumpers on default positions.

7.5 Interfaces

7.5.1 Extended connector P1

![Extended connector P1 from Raspberry Pi board](image)

Figure 25: Extended connector P1 from Raspberry Pi board
The connector P1 extends the power and GPIO signals coming from the Raspberry Pi board on the AMBER PI board. This allows the user the possibility to contact the shared pins on it once the two boards are mounted together.

7.5.2 SMA connector P2

The development board gives the user the possibility to use an external antenna (when using a module with RF pad) through the P2 SMA connector.

![Diagram of SMA connector P2](image)

Figure 26: SMA connector P2 for external antenna connection

7.5.3 Headers P4, P5, P6

All pins of the RF module, except for the RF-pin, are available on 2.54 mm pitch headers P4, P5, P6 (not mounted).
7.5.4 SPI connectors P8, P9

On the development board the connectors P8 and P9 share the SPI signals plus the +3.3 and GND power signals. Depending on how the SPI jumpers are set (please refer to chapter 7.1), there is the possibility to drive the P8 connector directly with the SPI signals coming from RF module (e.g. dedicated programmed firmware on it). In default SPI jumper settings, both P8 and P9 are driven directly from Raspberry Pi SPI signals as shown in the schematics.

Please be sure that the jumpers are set on JP4 and JP5 in order to provide power to P8 and P9 connectors.
7.5.5 I2C connectors P10, P11

On the development board the connectors P10 and P11 share the I2C signals plus the +3.3 and GND power signals. Depending on how the I2C jumpers are set (please refer to chapter 7.1), there is the possibility to drive the P10 and P11 connectors directly with the I2C signals coming from RF module (e.g. dedicated programmed firmware on it). In default I2C jumper settings, both P10 and P11 are driven directly from Raspberry Pi I2C signals as shown in the schematics.

Please be sure that the jumpers are set on JP6 and JP7 in order to provide power to P10 and P11 connectors.
7.5.6 **BOOT**

Based on the jumper position on JP8 (please refer to chapter 7.1), the *BOOT* pin of the module can be set in three different status:

1. Fixed to 1 logic level through a pull-up resistor
2. Fixed to 0 logic level through a pull-down resistor
3. Connected and driven by Raspberry Pi

![BOOT pin connections](image)

Figure 29: BOOT pin connections

7.5.7 **RESET**

The RESET signal can be provided to the module in two ways:

1. Driven directly from Raspberry Pi board by the driver
2. Using the S1 pushbutton

7.5.8 **LEDs**

Three different kind of leds are located on the development board in order to show the respective status:

- RX led D3 (GREEN) flashes when the module receives packets
- TX led D2 (RED) flashes when the module transmits packets
• POWER SUPPLY leds D4-D8 (BLUE) flashing when the development board is powered on. Based on the jumper position on JP17, these leds can be constantly turned on or driven by the PWM of the Raspberry Pi board (please refer to chapter 7.1).
7.6 Schematics

Figure 33: Schematic page 1 of 2
Figure 34: Schematic page 2 of 2
<table>
<thead>
<tr>
<th>Designator</th>
<th>Value</th>
<th>Voltage</th>
<th>Tolerance</th>
<th>Description</th>
<th>Manufacturer</th>
<th>Manufacturer part number</th>
<th>Quantity</th>
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</thead>
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<tr>
<td>AMBB826-1</td>
<td>2.2-3.8V</td>
<td></td>
<td></td>
<td>Tarvos-III 868 MHz module with RF on pad</td>
<td>Wurth Electronics Inc.</td>
<td>Tarvos-III-1</td>
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<td>C1, C3, C6, C8</td>
<td>1uF</td>
<td>6.3V</td>
<td>±20%</td>
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<td>Murata Electronics North America</td>
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<td>Diode LED</td>
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<td>D4, D5, D6, D7, D8</td>
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<td>Kingbright</td>
<td>APT1608LVBC/D</td>
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<td>D9, D10</td>
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<td></td>
<td>Schottky Diode</td>
<td>Toshiba Semiconductor and Storage</td>
<td>CUS10S30,H3F</td>
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<td>H1</td>
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<td></td>
<td>Coin Battery Holder</td>
<td>Keystone Electronics</td>
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<tr>
<td>J5, J6, J7, J8</td>
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<td></td>
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<td>EPT</td>
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<td>P2</td>
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<td></td>
<td></td>
<td>SMA RF Coaxial PCB Connector, Thru-Hole, Vertical Mount Plug, 50 Ohm Impedance</td>
<td>Samtec Inc.</td>
<td>SMA-J-P-H-ST-TH1</td>
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<td>P4, P5</td>
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<td>Sullins Connector Solutions</td>
<td>PRPC011SAAN-RC</td>
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<td>P10, P11</td>
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<td></td>
<td></td>
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<tr>
<td>R1, R2, R3</td>
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<td></td>
<td>±5%</td>
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<td>TE Connectivity Passive Product</td>
<td>CRG0402J1K0</td>
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<td></td>
<td>±5%</td>
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<td>Yageo</td>
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<td>R6</td>
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<td>Yageo</td>
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<td>±5%</td>
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<td>Jumper</td>
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<td>SWITCH TACTILE SPST-NO</td>
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<td>430471025826</td>
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</tr>
</tbody>
</table>

**Table 2: Bill of material**
8 Hardware history

Version 2.1 "Production"

- First production release.
- Amber PI packet contains the radio stick AMB8665 (Tarvos-II Plug).

Version 3.0 "Production"

- Sensor connectors have been updated. 4-pin I2C sensor interface was replaced by a 6-pin sensor interface.
- PCB color changed to red.
- In delivery state, the radio stick AMB8665 (Tarvos-II Plug) was replaced by the AMB8865 (Tarvos-III Plug).
  - The Tarvos-III Plug supports all radio profiles of the Tarvos-III radio module, which is mounted on the Amber PI. Thus radio profile 3 (long range mode) can be used in this package version.
  - Unlike Tarvos-II Plug, the Tarvos-III Plug uses a command interface on the UART. Thus the communication protocol on the COM port of the radio dongle has been modified. Applications using the Tarvos-II Plug from Amber PI version 2.1 need to be updated to the new communication interface of the Tarvos-III Plug. To do so, the Tarvos-III Plug driver, which is part of the Wireless Connectivity SDK has been used as a basis.
9 References


10 Regulatory compliance information

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The responsibility for the applicability and use of the Würth Elektronik eiSos wireless connectivity product with the incorporated Firmware in a particular customer design is always solely within the authority of the customer. Due to this fact, it is up to you to evaluate and investigate, where appropriate, and to decide whether the device with the specific product characteristics described in the product specification is valid and suitable for your respective application or not.

You are responsible for using the Würth Elektronik eiSos wireless connectivity product with the incorporated Firmware in compliance with all applicable product liability and product safety laws. You acknowledge to minimize the risk of loss and harm to individuals and bear the risk for failure leading to personal injury or death due to your usage of the product.

Würth Elektronik eiSos’ products with the incorporated Firmware are not authorized for use in safety-critical applications, or where a failure of the product is reasonably expected to cause severe personal injury or death. Moreover, Würth Elektronik eiSos’ products with the incorporated Firmware are neither designed nor intended for use in areas such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network etc. You shall inform Würth Elektronik eiSos about the intent of such usage before
design-in stage. In certain customer applications requiring a very high level of safety and in which the malfunction or failure of an electronic component could endanger human life or health, you must ensure to have all necessary expertise in the safety and regulatory ramifications of your applications. You acknowledge and agree that you are solely responsible for all legal, regulatory and safety-related requirements concerning your products and any use of Würth Elektronik eiSos’ products with the incorporated Firmware in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by Würth Elektronik eiSos. YOU SHALL INDEMNIFY WÜRTH ELEKTRONIK EISOS AGAINST ANY DAMAGES ARISING OUT OF THE USE OF WÜRTH ELEKTRONIK EISOS’ PRODUCTS WITH THE INCORPORATED Firmware IN SUCH SAFETY-CRITICAL APPLICATIONS.

13.3 Ownership

The incorporated Firmware created by Würth Elektronik eiSos is and will remain the exclusive property of Würth Elektronik eiSos.

13.4 Firmware update(s)

You have the opportunity to request the current and actual Firmware for a bought wireless connectivity Product within the time of warranty. However, Würth Elektronik eiSos has no obligation to update a modules firmware in their production facilities, but can offer this as a service on request. The upload of firmware updates falls within your responsibility, e.g. via ACC or another software for firmware updates. Firmware updates will not be communicated automatically. It is within your responsibility to check the current version of a firmware in the latest version of the product manual on our website. The revision table in the product manual provides all necessary information about firmware updates. There is no right to be provided with binary files, so called “Firmware images”, those could be flashed through JTAG, SWD, Spi-Bi-Wire, SPI or similar interfaces.

13.5 Disclaimer of warranty

THE Firmware IS PROVIDED "AS IS". YOU ACKNOWLEDGE THAT WÜRTH ELEKTRONIK EISOS MAKES NO REPRESENTATIONS AND WARRANTIES OF ANY KIND RELATED TO, BUT NOT LIMITED TO THE NON-INFRINGEMENT OF THIRD PARTIES’ INTELLECTUAL PROPERTY RIGHTS OR THE MERCHANTABILITY OR FITNESS FOR YOUR INTENDED PURPOSE OR USAGE. WÜRTH ELEKTRONIK EISOS DOES NOT WARRANT OR REPRESENT THAT ANY LICENSE, EITHER EXPRESS OR IMPLIED, IS GRANTED UNDER ANY PATENT RIGHT, COPYRIGHT, MASK WORK RIGHT, OR OTHER INTELLECTUAL PROPERTY RIGHT RELATING TO ANY COMBINATION, MACHINE, OR PROCESS IN WHICH THE WÜRTH ELEKTRONIK EISOS’ PRODUCT WITH THE INCORPORATED Firmware IS USED. INFORMATION PUBLISHED BY WÜRTH ELEKTRONIK EISOS REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE A LICENSE FROM WÜRTH ELEKTRONIK EISOS TO USE SUCH PRODUCTS OR SERVICES OR A WARRANTY OR ENDORSEMENT THEREOF.
13.6 Limitation of liability
Any liability not expressly provided by Würth Elektronik eiSos shall be disclaimed. You agree to hold us harmless from any third-party claims related to your usage of the Würth Elektronik eiSos' products with the incorporated Firmware, software and source code. Würth Elektronik eiSos disclaims any liability for any alteration, development created by you or your customers as well as for any combination with other products.

13.7 Applicable law and jurisdiction
Applicable law to this license terms shall be the laws of the Federal Republic of Germany. Any dispute, claim or controversy arising out of or relating to this license terms shall be resolved and finally settled by the court competent for the location of Würth Elektronik eiSos' registered office.

13.8 Severability clause
If a provision of this license terms is or becomes invalid, unenforceable or null and void, this shall not affect the remaining provisions of the terms. The parties shall replace any such provisions with new valid provisions that most closely approximate the purpose of the terms.

13.9 Miscellaneous
Würth Elektronik eiSos reserves the right at any time to change this terms at its own discretion. It is your responsibility to check at Würth Elektronik eiSos homepage for any updates. Your continued usage of the products will be deemed as the acceptance of the change. We recommend you to be updated about the status of new firmware and software, which is available on our website or in our data sheet and manual, and to implement new software in your device where appropriate. By ordering a wireless connectivity product, you accept this license terms in all terms.
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