Manual AMB8626 & AMB8665

Release 3.8

SW-V3.4.0

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Abbreviations and abstract

ACK	Acknowledgement	Acknowlegdement pattern confirming the reception of the transmitted data package
CS	Checksum	
DC	Duty cycle	Relative frequency reservation period
LPM	Low power mode	Operation mode for efficient power consumption.
RF	Radio frequency	Describes everything relating to the wireless transmission
Payload		The real, non-redundant information in a frame/packet
User settings		Any relation to a specific entry in the user settings is marked in a special font and can be found in the respective chapter
UART		Universal Asynchronous Receiver Transmitter, allows to communicate with the module of a specific interface.
Duty cycle		Transmission time in relation of one hour 1% means, channel is occupied for 36 seconds per hour.
Hexadecimal	[HEX] 0xhh	All numbers beginning with 0x are stated as hexadecimal numbers. All other numbers are decimal.

1 Summary

The AMB8626 module was designed as a radio sub module for wireless communication between devices such as control systems, remote controls, sensors etc. It offers several addressing modes and relieves the host system of radio-specific tasks such as

- checksum calculation,
- address resolution, and
- repetition of unacknowledged telegrams.

It can be deployed wherever the wireless exchange of small data packets (up to 128 bytes) between two or more parties is required.

A serial interface (UART) whose data rate and format can be adjusted flexibly is available for communicating with the host system. A variant with SPI functionality can be implemented upon request (separate firmware).

The AMB8626 is not fully pin-compatible with the AMB8425/26. The pin functionality with Amber software is identically, but the programming-interface is located on different pins.

However a compatibility between RF-profiles with the same index does exist (firmware version 2.x.x).

Details can be found in the the AMB8426 to AMB8626 Migration Guide (AMB8626_MG_EN).

The following chapters give a short description of settings, which can be configured in the non-volatile user settings, detailed description in chapter 8.

2 Electrical parameters

2.1 Input voltage

Description	min	typ	max	unit
Supply voltage	2.0	2.5	3.6	V

2.2 Power consumption

Description	typ	unit
TX current consumption	53	mA
RX current consumption	30	mA
Low Power	3	µA

3 Dimensions and weight

Dimensions	17 x 27 mm
Weight	3 g

4 Pinout

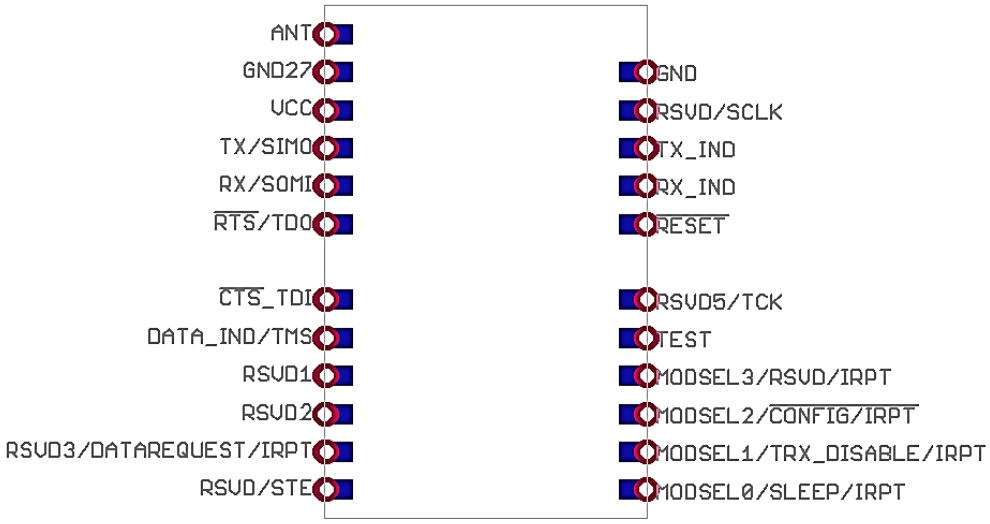


Figure 1 Pinout

Designation	I/O	Description
ANT	I/O	Antenna connection
VCC	Supply	Supply voltage
GND, GND27	Supply	Ground
TX	Output	UART(Transmission)
RX	Input	UART (Reception)
/RESET	Input	Active low. Internally network to VCC. **Do not connect if not needed.**
/CONFIG	Input	Switch the module to command mode, falling edge. **Connect to GND if not needed.**
SLEEP	Input	Reserved. **Connect to GND**
TRX_DISABLE	Input	Switches the RF (RX) part off, high level, as long as no data is to be sent. **The pin level must be set to GND during boot up**. The boot up finished when /RTS is low. **Connect to GND if not needed.**

Designation	I/O	Description
/DATA_REQUEST	Input	Prompts the wireless transmission, falling edge. As long as no new data is received via UART or wireless transmission, the buffer content remains valid and can be resent by means of a new signal. If the function of this pin is enabled (see 9.2.20), this pin has an internal pull-up resistor. **If the pin function is disabled and the pin is not needed, connect it to the GND.** **Without function in the command mode.**
/RTS	Output	Ready to send, active low. Signalizes a busy UART buffer. When Set, no more bytes will be accepted over UART.
/CTS	Input	Clear To Send, active low. Can be used to signalize to the AMB8626 that the connected host's buffer is busy.
/DATA_INDICATE	Output	Packet received, active low. Goes low as soon as a valid packet with correct address is received via radio and remains low as long as the output via UART continues. Can be used to prepare a "sleeping" host system for the output of data. The delay between the falling edge and the start of transmission via UART can be configured with `UART_DIDelay`.
TX_INDICATE / RX_INDICATE	Output	Shows radio activity, active high.
RESERVED		Reserved for currently not implemented functions e.g. SPI. **Do not connect**.
TEST	JTAG	For JTAG / SPY-Bi-Wire. **Do not connect**.

Table 1 Pinout

5 Start-up and minimal configuration

5.1 Minimal configuration

In the factory state, the modules are immediately ready for operation; the following pins are required in the minimal configuration: VCC, GND, UTXD, and URXD.

If the module has to be connected to a PC, an adaptor (TTL to RS-232 or TTL to USB) has to be used. The AMB8626-EV is suited for this.

In the default configuration all module inputs (TRX_DISABLE and /CONFIG) are activated and must be connected as shown in Table 1. If the function of the /DATA_REQUEST pin is enabled (see chapter 9.2.20), this pin has an internal pull-up resistor.

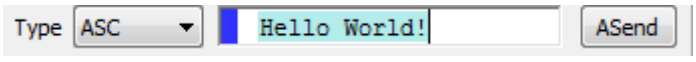
If TRX_DISABLE is used by the host it must be set to GND during start-up / after reset till the module's start-up is completed. The module will wait for this pin to go to GND level before finishing its start-up procedure. The module's UART or function pins (such as /CONFIG) will not be available until the start-up is finished.

5.2 Sending & Receiving: "Hello World"

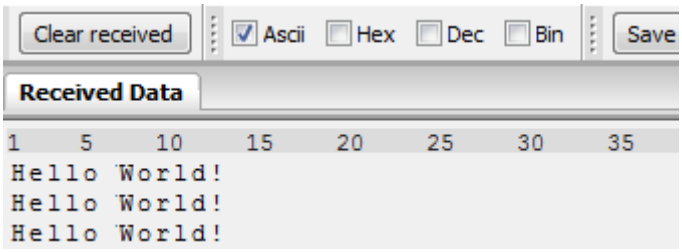
Connect your pair of modules, EV-boards or USB-sticks with the PC as explained in chapter 5.1. Please make sure you have a minimum distance of 3 meters between the two modules or devices to avoid over modulation. When short distances are needed, you could reduce the `PAPower` to a minimum.

When the connection to the PC is done, please use a terminal tool of your choice. For convenience we assume you selected the tool "hterm". Select the two corresponding COM ports and open them with a configuration of 9600 Baud, 8 Data bits, 1 Stop bit and Parity set to None.

Enter the string "Hello World" into the input line of hterm and use the "ASend" button followed by pushing the "start" button to send the data once.



This data will be received by the second module and shows up as received data in the second hterm instance. You may send any string of size 1 to 128 characters from one module to the other.



You just used the so called “transparent mode” of the modules to send your data. The address mode that was used is “0”. Thus all radio frames are broadcasts that can be received by anyone listening with an AMB8626 in default settings. The frame you send was generated using the timeout method.

Besides the transparent mode, that is suited for transparent data transmission, the so called “command mode” allows both, the module configuration and the data transmission, using a predefined command interface (see chapter 8).

5.3 Adopting parameters to fit your application

The non-volatile parameters (see chapter 9) can only be changed in the command mode by using the CMD_SET_REQ command. This command will need the following parameters:

- memory position of the parameter
- the new value that shall be applied to this parameter

Furthermore, there are volatile settings that can be accessed by explicit commands for each parameter. All available commands are introduced in chapter 8.

5.4 Deployment of several modules, use of addresses

Settings like the module address can only be modified in the command mode. Thus we recommend to permanently operate in command mode by setting the user settings parameter `OpMode` to the value of 0x10 (16).

To use non-broadcast transmissions you need to adopt the following non-volatile settings:

- MAC_AddrMode (mode 1 or 2 should be used depending on the number of addresses you need)
- MAC_DefaultSourceAddrLSB as the local address for each device of your network, each member of the network will need an unique address. A value of 255 is invalid.
- MAC_DefaultSourceNetID, as the local network address for each device of your network, each member of the network will need an unique address. A value of 255 is invalid.

In command mode, the command CMD_DATAEX_REQ, that has the destination address as an own parameter, can be used to send your data to the specified address. A broadcast message can still be achieved when using 0xFF (255) for both destination address LSB and destination net ID.

6 Host connection: Serial interface

6.1 UART

6.1.1 Supported data rates and data formats

The data rate is adjusted through a configuration structure. The structure allows the configuration of the `UART_Baudrate`, `UART_Databits`, `UART_Parity` and `UART_Stoppbits`.

Since the UART speed is derived from a digitally calibrated oscillator, this may result in variations of up to ± 2 %.

The default baud rate of the AMB8626 is 9600 baud.

The output of characters on the serial interface takes place with secondary priority. For this reason, short interruptions may occur *between* the output of individual characters (e.g. in the event of an interrupt).

The following data formats are supported:

- 7 or 8 bits
- None, even, or odd parity
- 1 or 2 stop bits

The default data format is 8 data bits, no parity and 1 stop bit ("8n1").

6.2 SPI interface

As an alternative to the UART interface a version with SPI interface can be implemented upon requested (separate firmware).

7 Modes

7.1 Operating modes

The AMB8626/AMB8665 can be used in the following operating modes:

1. Transparent mode (transparent data transmission)
2. Command mode (module configuration and data transmission using the predefined command interface)

The operating mode after power-up can be configured by means of the `OpMode` parameter. By default, the module operates in transparent mode.

Starting in the command mode, the module responds with a `CMD_SET_MODE_CNF` telegram.

7.1.1 Switching from transparent to command mode

The command mode can be entered by applying a falling edge on the /CONFIG pin. The detection of the falling edge on the /CONFIG pin can be disabled using the user setting `CfgFlags`.

The successful switchover is acknowledged by a `CMD_SET_MODE_CNF` (0x02 *0x44* 0x01 0x10 0x57) telegram indicating command mode.

The switchover can only occur when no data is being received by wireless transmission or UART interface (approximately 100 µs after /RTS goes low and indicates readiness).

7.1.2 Switching from command to transparent mode

The transparent mode can be entered by applying a falling edge on the /CONFIG pin or by using the command `CMD_SET_MODE_REQ` . The detection of the falling edge on the /CONFIG pin can be disabled using the user setting `CfgFlags`.

The successful switchover is acknowledged by a `CMD_SET_MODE_CNF` (0x02 *0x44* 0x01 0x00 0x47) telegram indicating transparent mode.

The switchover can only occur when no data is being received by wireless transmission or UART interface (approximately 100 µs after /RTS goes low and indicates readiness).

Recommendation: Automatic switching to a specific mode can be realized by applying falling edges on the /CONFIG pin as long as the needed `CMD_SET_MODE_CNF` is returned:

- 0x02 *0x44* 0x01 0x10 0x57 telegram indicating command mode
- 0x02 *0x44* 0x01 0x00 0x47 telegram indicating transparent mode

7.1.3 Transparent mode

In this mode, data is received via the serial interface and initially buffered. As soon as a specific condition is met, the RF telegram is generated with a preamble, checksum, and address information (optional).

To initiate an RF transmission, several options are available, listed in Table 2.

Start Condition	Description:	Dependent usersettings
Timeout	Transmission starts if no new character is detected within a configurable time period after receiving a character via UART. The timeout is reset every time a new character is received.	`UART_Timeout` `UART_PktMode`
End-Of-Text-Character	Transmission begins when the preconfigured character is transmitted via UART.	`UART_PktMode` `UART_ETXChar`

Fixed Packet Size	Transmission starts when the preconfigured number of bytes is reached in the RX buffer of the UART.	`UART_PktSize`
		`UART_RTSLimit`
		`UART_PktMode`

/Data Request Pin	The transmission starts as soon as a falling edge is detected on the /DATA_REQUEST pin.	`CfgFlags`

Table 2 Communication in transparent mode

The `UART_PktMode` parameter (see 9.2.1) can be used to determine which of the listed combinations is to be used.

7.1.3.1 /RTS signal, busy processor

/RTS signalizes a busy UART buffer which means, when /RTS is set, no more UART bytes will be accepted nor processed.
/RTS is set when any of the events in the prior chapter has occurred.

7.1.4 Command mode

This operating mode primarily serves module configuration. The module AMB8626 acts as a slave and can be fully controlled by an external host using the commands of the command interface (see chapter 10).
It can also be used for wireless transmission of payload data providing a feedback dependent on the transmission success.

8 The command interface

8.1 Overview

In the command mode, communication with the module occurs in form of predefined commands. These commands must be sent in telegrams according to the format described in Table 3.

Start signal	Command	No. of data	Data	Checksum

Table 3 Telegram format in the command mode

Start signal: 0x02 (1 byte)

Command: One of the predefined commands according to chapter 10 (1 byte)

No. of data: Specifies the number of data in the following field of variable length and is limited to 128 in order to prevent buffer overflow (1 byte). With appropriate commandos values > 128 can occur.

Data: Variable number of data or parameters (maximum 128 byte, payload plus 6 byte parameter, LSB first)

Checksum: Byte wise XOR combination of the preceding fields including the start signal, i.e. 0x02 ^ command ^ no. of data ^ data byte 0 ... (1 byte)

Using a specific command, data can also be sent via RF, i.e. the module can be operated entirely in the command mode. Only in this way quick channel changes, can be realized.

If no new signal is received for `UART_Timeout` milliseconds after receiving the STX signal, the unit will wait for a new start signal.

On each command follows a response from the AMB8626 to the host.

8.2 Data transfer & reception in the command mode

This group of commands includes the commands that are used to either request a radio telegram to be send or indicates a received frame.

8.2.1 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.
This command is especially suitable for transmission for a point-to-point connection. The number of payload data bytes is limited to 128.

Format:

Start signal	Command	Payload length	Payload	CS
0x02	**0x00**	**1 Byte**	**Payload length**	**1 Byte**

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	**0x40**	**0x01**	**1 Byte**	**1 Byte**

Status:

0x00: ACK received or not requested (`MAC_NumRetrys` is 0 or `MAC_AddrMode` is 0)

0x01: no ACK received

8.2.2 CMD_DATAEX_REQ

This command serves data transfer in a network with several parties. Both the channel to use and the destination address (depending on the parameterised addressing mode) are specified along with the command. The number of payload data bytes is limited to 128. The entered channel, destination network and destination address are loaded into the volatile runtime settings und thus kept until the system is reset.

Format in addressing mode 0:

Start signal	Command	Payload length + 1	Channel	Payload	CS
0x02	**0x01**	**1 Byte**	**1 Byte**	**Payload length**	**1 Byte**

Format in addressing mode 1:

Start signal	Command	Payload length + 2	Channel	Destination address	Payload	CS
0x02	**0x01**	**1 Byte**	**1 Byte**	**1 Byte**	**Payload length**	**1 Byte**

Format in addressing mode 2:

Start signal	Command	Payload length + 3	Channel	Destination network ID	Destination address	Payload	CS
0x02	**0x01**	**1 Byte**	**1 Byte**	**1 Byte**	**1 Byte**	**Payload length**	**1 Byte**

Response:

Start signal	CMD_DATA_REQ | 0x40	Length	Status	CS
0x02	**0x40**	**0x01**	**1 Byte**	**1 Byte**

Status:

0x00: ACK received or not requested (`MAC_NumRetrys` is 0 or `MAC_AddrMode` is 0)

0x01: no ACK received

0x02: invalid channel selected

8.2.3 CMD_DATAEX_IND

This telegram indicates the reception of data bytes and represents the counterpart to the commands `CMD_DATA_REQ` and `CMD_DATAEX_REQ`. Apart from the RX field strength (RSSI value), this telegram also specifies the sender address (depending on the parameterised addressing mode).

Format in addressing mode 0:

Start signal	Command	Payload length + 1	Payload	Field strength	CS
0x02	**0x81**	**1 Byte**	**Payload length**	**1 Byte**	**1 Byte**

Format in addressing mode 1:

Start signal	Command	Payload length + 2	Sender address	Payload	Field strength	CS
0x02	**0x81**	**1 Byte**	**1 Byte**	**Payload length**	**1 Byte**	**1 Byte**

Format in addressing mode 2:

Start signal	Command	Payload length + 3	Sender network ID	Sender address	Payload	Field strength	CS
0x02	**0x81**	**1 Byte**	**1 Byte**	**1 Byte**	**Payload length**	**1 Byte**	**1 Byte**

8.2.4 CMD_DATARETRY_REQ

This command resends the transmission of the data submitted earlier on with `CMD_DATA_REQ` or `CMD_DATAEX_REQ`. Thus, the data does not need to be transmitted again via UART.

The buffered data is lost as soon as new data is sent via UART or data is received via wireless transmission.

Format:

Start signal	Command	0x00	CS
0x02	**0x02**	**0x00**	**1 Byte**

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	**0x42**	**0x01**	**1 Byte**	**1 Byte**

Status:

0x00: ACK received, only possible if `MAC_NumRetrys` is not 0; or none is requested

0x01: no ACK received

0x03: no data available (e.g., overwritten by wireless data reception)

8.2.5 CMD_REPEAT_IND

This command indicates that the module has repeated a data packet when acting in repeater mode. The source address and NetID is the address of the first sender of the RF packet, the destination address and NetID is the address of the device that is supposed to receive the RF packet.

Format in addressing mode 0:

Start signal	Command	Length	Status	Addressing mode	CS
0x02	**0x80**	**0x02**	**1 Byte**	**0x00**	**1 Byte**

Format in addressing mode 1:

Start signal	Command	Length	Status	Addressing mode	Destination address	Source address	CS
0x02	**0x80**	**0x04**	**1 Byte**	**0x01**	**1 Byte**	**1 Byte**	**1 Byte**

Format in addressing mode 2:

Start signal	Comm and	Length	Status	Address. mode	Dest. NetID	Dest. address	Source NetID	Source address	CS
0x02	**0x80**	**0x06**	**1 Byte**	**0x02**	**1 Byte**	**1 Byte**	**1 Byte**	**1 Byte**	**1 Byte**

Status:

0x00: OK

0x01: Failed

8.3 Requesting parameters and actions

This group includes all commands that will return read-only parameters or request actions in the module.

8.3.1 CMD_FWRELEASE_REQ

This command is used to request the firmware version of the module.

Format:

Start signal	Command	Length	CS
0x02	**0x0C**	**0x00**	**0x0E**

Response:

Start signal	Command | 0x40	Length	Firmware Version	CS
0x02	**0x4C**	**0x03**	**Length**	**1 Byte**

The main version number is returned first, followed by the secondary version number and the revision number.

8.3.2 CMD_SERIALNO_REQ

This command can be used to query the individual serial number of the module.

Format:

Start signal	Command	Length	CS
0x02	**0x0B**	**0x00**	**0x09**

Response:

Start signal	Command | 0x40	Length	Serial Number	CS
0x02	**0x4B**	**0x04**	**Length**	**1 Byte**

For the serial number, the most significant byte (MSB), which identifies the product (product ID), is returned first.

8.3.3 CMD_RESET_REQ

This command triggers a software reset of the module. The reset is performed after the acknowledgement is transmitted.

Format:

Start signal	Command	0x00	CS
0x02	**0x05**	**0x00**	**0x07**

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	**0x45**	**0x01**	**1 Byte**	**1 Byte**

Status:

0x00: success

8.3.4 CMD_RSSI_REQ

This command returns the RX level of the last received packet determined by the transceiver IC in the form of a signed two's complement.

Format:

Start signal	Command	Length	CS
0x02	**0x0D**	**0x00**	**0x0F**

Response:

Start signal	Command | 0x40	Length	RX level	CS
0x02	**0x4D**	**0x01**	**1 Byte**	**1 Byte**

The value obtained in this way delivers the RX level $RSSI_{dBm}$ in dBm as follows:

Conversion of the hexadecimal value to a decimal $RSSI_{dec}$

Example:

$$0xBD_{hex} = 10111101_{bin} ->$$
$$-128 + 0*64 + 1*32 + 1*16 + 1*8 + 1*4 + 0*2 + 1*1 = -67dBm$$

The relation between the calculated value and the physical RX level in dBm is not linear across the entire operating range but can be estimated as linear in the range from -110 to -30 dBm.

8.3.5 CMD_ERRORFLAGS_REQ

This command returns internal error states.

Format:

Start signal	Command	Length	CS
0x02	**0x0E**	**0x00**	**0x0C**

Response:

Start signal	Command | 0x40	Length	Error Flags MSB	Error Flags LSB	CS
0x02	**0x4E**	**0x02**	**1 Byte**	**1 Byte**	**1 Byte**

The value of "0" returned by the error flag implies that no error has occurred. The value is reset either after a query or by a reset.

The meaning of the error flags is not described in detail in this context.

8.4 Modification of volatile parameters

This group contains all functions that will modify runtime settings while the module is running. These settings are all volatile and will be reset to defaults on a reset of the module.

8.4.1 CMD_SET_MODE_REQ

This command is used to toggle the operating mode, e.g. to exit the command mode. The new operating mode is loaded into the volatile runtime settings. This and all other commands can be used in command mode only.

The following operating modes are defined:

- Transparent mode: 0x00
- Command mode: 0x10

Format:

Start signal	Command	Length	Desired operating mode	CS
0x02	**0x04**	**0x01**	**0x00**	**0x07**

Enter transparent mode:

0x02 ***0x04*** 0x01 0x00 0x07

Response:

Start signal	Command | 0x40	Length	Newly configured operating mode	CS
0x02	**0x44**	**0x01**	**1 Byte**	**1 Byte**

Enter transparent mode response:

0x02 ***0x44*** 0x01 0x00 0x47

Enter command mode response:

0x02 ***0x44*** 0x01 0x10 0x57

8.4.2 CMD_SET_PAPOWER_REQ

This command is used to set the RF TX-power. Unlike the user settings parameter `PHY_PAPower`, this is a volatile runtime parameter, but it is handled in the same way. Thus see section 9.2.16 for more information.

The entered power value is entered as a complement on two.

Format:

Start signal	Command	Length	Power	CS
0x02	**0x11**	**0x01**	**1 Byte**	**1 Byte**

Example (setting the power to 14 dBm):

0x02 ***0x11*** 0x01 0x0E 0x1C

Response:

Start signal	Command | 0x40	Length	Power	CS
0x02	**0x51**	**0x01**	**1 Byte**	**1 Byte**

Return for above example:

0x02 ***0x51*** 0x01 0x0E 0x5C

8.4.3 CMD_SET_CHANNEL_REQ

This command is used to select the radio channel. Unlike the user settings parameter `PHY_DefaultChannel`, this is a volatile runtime parameter.

Format:

Start signal	Command	Length	Channel	CS
0x02	**0x06**	**0x01**	**1 Byte**	**1 Byte**

Example (selection of channel 108):

0x02 ***0x06*** 0x01 0x6C 0x69

Response:

Start signal	Command | 0x40	Length	Channel	CS
0x02	**0x46**	**0x01**	**1 Byte**	**1 Byte**

Return for above example:

0x02 ***0x46*** 0x01 0x6C 0x29

8.4.4 CMD_SET_DESTNETID_REQ

This command serves to configure the destination network ID in addressing mode 2. Unlike the user settings parameter `MAC_DestNetID`, this is a volatile runtime parameter.

Format:

Start signal	Command	Length	Destination network ID	CS
0x02	**0x07**	**0x01**	**1 Byte**	**1 Byte**

Return:

Start signal	Command | 0x40	Length	Status	CS
0x02	**0x47**	**0x01**	**1 Byte**	**1 Byte**

Status:

0x00: success

8.4.5 CMD_SET_DESTADDR_REQ

This command serves to configure the destination address in addressing modes 1 and 2. Unlike the user settings parameter `MAC_DestAddrLSB` and `MAC_DefaultDestAddrMSB`, this is a volatile runtime parameter.

Format:

Mode 1 + 2:

Start signal	Command	Length	Destination address	CS
0x02	**0x08**	**0x01**	**1 Byte**	**1 Byte**

Return:

Start signal	Command | 0x40	Length	Status	CS
0x02	**0x48**	**0x01**	**1 Byte**	**1 Byte**

Status:

0x00: success

8.5 Modification of non-volatile parameters

The non-volatile parameters are also called user settings and are stored in a special flash location.

8.5.1 CMD_SET_REQ

This command enables direct manipulation of the parameters in the module's non-volatile user settings. The respective parameters are accessed by means of the memory positions described in chapter 8**.**

You can modify individual or multiple consecutive parameters in the memory at the same time. The sum of memory position and forwarded data has to be less than the total size of the user settings (however a max. of 128 Bytes). Otherwise the package is not acknowledged.

The module always makes a local copy of the user settings, then the new values are copied into the respective memory area and finally the complete user settings are rewritten.

Parameters of 2 or more bytes have to be transferred with the LSB first.

The changed parameters only take effect after a restart of the module.
This can be done by a `CMD_RESET_REQ`.

Caution: The validity of the specified parameters is not verified. Incorrect values can result in device malfunction!

To save the parameters in the flash memory of the module, the particular memory segment must first be flushed entirely and then restored from RAM.
If a reset occurs during this procedure (e.g. due to supply voltage fluctuations), **the entire memory area may be destroyed**.
In this case, the module may no longer be operable, which means that the firmware must be re-installed via "ACC V3", in which user settings can also be configured and verified.
Recommendation: First verify the configuration of the module with `CMD_GET_REQ`; and only write if required.

Format:

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	**0x09**	**1 Byte**	**1 Byte**	**1 Byte**	**Length**	**1 Byte**

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	**0x49**	**0x01**	**1 Byte**	**1 Byte**

Status:

0x00: Request successfully received and processed

0x01: invalid memory position (write access to unauthorised area > 127 / 0xFF)

0x02: invalid number of bytes to be written (write access to unauthorised area > 0xFF)

Example 1: Setting the number of wireless retries to 5 (parameter `MAC_NumRetrys`, memory position 20):

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	**0x09**	**0x03**	**0x14**	**0x01**	**0x05**	**0x18**

Example 2: Setting the UART baud rate (memory position 80-83):

Start signal	Command	Length + 2	Memory Position	Length	Parameter	CS
0x02	**0x09**	**0x06**	**0x50**	**0x04**	**Parameter**	**1 Byte**

Parameter:
< `UART_Baudrate_LSB` > < `UART_Baudrate_LSB` +1 > < `UART_Baudrate_LSB` +2 >
< `UART_Baudrate_MSB` >

To set the UART baud rate on 115200 baud would result in the following data content:

115200 => Parameter = 0x00 0x01 0xC2 0x00
`UART_Baudrate_LSB` = 0x00
`UART_Baudrate_LSB`+1 = 0xC2
`UART_Baudrate_LSB`+2 = 0x01
`UART_Baudrate_MSB` = 0x00

8.5.2 CMD_GET_REQ

This command can be used to query individual or multiple user settings parameters. The requested number of bytes from the specified memory position are returned.

You can query individual or multiple consecutive parameters in the memory at the same time. The sum of the memory position and requested data must not be more than the total size of the user-settings (however a max. of 128 Bytes). Otherwise no data will be returned.

Parameters of 2 or more bytes will be transmitted LSB first.

Format:

Start signal	Command	Length	Memory Position	Amount of Bytes	CS
0x02	**0x0A**	**0x02**	**1 Byte**	**1 Byte**	**1 Byte**

Example (query of all parameters):

0x02 ***0x0A*** 0x02 0x00 0x80 0x8A

Response:

Start signal	Command | 0x40	Length + 2	Memory Position	Number of Bytes	Parameter	CS
0x02	**0x4A**	**1 Byte**	**1 Byte**	**1 Byte**	**Number of Bytes**	**1 Byte**

Read access to the memory area outside the user settings is blocked.

8.5.3 CMD_FACTORY_RESET_REQ

This command restores the default user settings of the module. If this was successful, a software reset of the module is executed additionally. The reset is performed after the acknowledgement is transmitted.

Format:

Start signal	Command	Length	CS
0x02	**0x12**	**0x00**	**0x10**

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	**0x52**	**0x01**	**1 Byte**	**1 Byte**

Status:

0x00: Request successfully received and processed

0x01: Request not successful

9 User settings

9.1 Difference between volatile and non-volatile settings

The so called user settings are stored permanently into the internal flash of the module. At start-up, these user settings are loaded into volatile settings, so called runtime settings. The validation of these runtime settings is lost after the module is powered off, or restarted (the process starts over again).

9.2 List of user settings

The non-volatile user settings listed in the following table can be modified by means of specific commands in the configuration mode (`CMD_SET_REQ`) of the module or by using the Windows software "ACC V3". These parameters are stored permanently in the module's flash memory. All settings are described on the following pages. After changing those parameters, a reset will be necessary to make use of the new settings.

The validity of the specified parameters is not verified. Incorrect values can result in device malfunction!

Designation	Summary	Permissible values	Default value	Memory position	Number of bytes
`UART_PktMode` Packetizing mode	Selects the packet generation method	0 or 1	0	5	1
`UART_PktSize` Packet size	Number of characters for transmission start with set packet size	1 - 128	128	7	1
`UART_RTSLimit` /RTS limit	Number of received characters after which /RTS responds	1 - 128	112	8	1
`UART_ETXChar` ETX character	End-of-text character used to mark data packets; reception of this character triggers wireless transmission	0 - 255	10	9	1
`UART_Timeout` Timeout	Timeout after the last character before the data received via UART are transmitted via wireless transmission [ms]	2 – 65535	5	12	2
`UART_DIDelay` Data Indication Delay	Delay between signal by Pin /DATA_INDICATION and beginning of output by UART [ms]	0 – 65535	0	14	2
`MAC_NumRetrys` Retries	Number of wireless retries	0 – 255	0	20	1
`MAC_AddrMode` Addressing mode	Addressing mode to use	0/1/2	0	21	1

Designation	Summary	Permissible values	Default value	Memory position	Number of bytes
MAC_NumRetrysCCA Retries	Number of wireless retries for the CCA	0 – 255	5	22	1
MAC_CCARetryDelay Retries	Delay for the retry of the CCA	5 – 255	20	23	1
MAC_DefaultDestNetID Dest. net ID	Default destination network ID	0 – 255	0	24	1
MAC_DefaultDestAddrLSB Dest. device address	Default destination address (LSB)	0 – 255	0	25	1
MAC_DefaultDestAddrMSB Dest. device address	Default destination address (MSB)	0 – 255	0	26	1
MAC_DefaultSourceNetID Local net ID	Own network ID	0 – 254	0	28	1
MAC_DefaultSourceAddrLSB Local device address	Own address (LSB)	0 – 255	0	29	1
MAC_DefaultSourceAddrMSB Local device address	Own address (MSB)	0 – 255	0	30	1
MAC_ACKTimeout ACK timeout	Waiting time for wireless acknowledgement [ms]	5 – 65535	10	32	2
PHY_PAPower PA power	Output power [dBm]; value range depends on RF configuration complement on two	-11 …15	14	41	1
PHY_DefaultChannel Default channel	Utilised wireless channel after reset; value range depends on RF configuration	100 - 140	106 (868,3 MHz)	42	1
PHY_CCAThr CCA threshold	Threshold used for CCA complement on two	0-102	22	43	1
OpMode Mode	Operating mode	0, 16	0	60	1
CfgFlags Configuration flags (hex.)	Flags for setting various properties; see 9.2.20	0 – 65535	512	72	2
RpFlags Repeater configuration flags (hex.)	Flags to set the repeater options, see 12	0 – 65535	0	74	2
RP_NumSlots	Number of (time) slots for packet repetition, see 12	0 – 255	32	76	1
UART_Baudrate	Symbol rate of the UART (4 bytes!)	1200-115200	9600	80	4
UART_Databits	Number of data bits	7,8	8	84	1
UART_Parity	Parity	0,1,2	0	85	1

Designation	Summary	Permissible values	Default value	Memory position	Number of bytes
UART_Stoppbits	Stop bits	1,2	1	86	1
RF_ConfigIndex	Configuration index	0-2	0	92	1
RF_CCADisabled	Clear channel assessment	0,1	1	93	1
RF_CCACheckTime LSB (Index 95) und MSB(Index 96)	Observation time [ms]	0-60000	5	94	2

Table 4 Overview of Non-Volatile user-settings

Compared to the AMB8425/AMB8426, the following user settings are no longer implemented:

- UART_CTL0, UART_CTL1
- UART_MCTL, UART_BR0, UART_BR1
- PHY_FIFOPrecharge, PHY_CCARSSILevel
- MSP_RSELx
- WOR_Prescaler, WOR_Countdown, WOR_RXOnTime
- Synch1, Synch0

9.2.1 UART_PktMode

Selects the packet mode used for generating packets for **the transparent operating mode**. In command mode the packet end is defined by the length information in the packet header.
Two modes have been implemented:

- Mode 0:
  Transmission starts when the timeout defined with UART_Timeout has been reached or the packet has reached size UART_PktSize .
- Mode 1:
  Transmission starts when the character defined with UART_ETXChar has been detected or the packet has reached size UART_PktSize .The UART_ETXChar will be sent too.

Not used in command mode.

9.2.2 UART_PktSize

Maximum number of bytes after which the wireless transmission of the data received via UART starts. Used in packet mode 0 as well as in packet mode 1. Maximum is 128 due to buffer size.

Not used in command mode.

9.2.3 UART_RTSLimit

Number of bytes after which the host system is prompted to interrupt the data transfer over /RTS. This is necessary, because depending on the host system, an immediate response to the /RTS signal may not take place (UART FIFO).

Not used in command mode.

9.2.4 UART_ETXChar

End-of-text character that triggers the transmission of the data received via UART. Only used in packet mode 1. During the wireless transmission, the ETX character is treated like a normal character.

Not used in the command mode.

9.2.5 UART_Timeout

The timeout defines the delay in milliseconds in transparent mode after the last character has been received by the UART before the wireless transmission starts. Only used in packet mode 0. The value should be chosen appropriate to the UART data rate.

9.2.6 UART_DIDelay

This parameter determines the delay in milliseconds between the indication of incoming RF data by the /DATA_INDICATION pin and the output of the data on UART.
This delay can be used to alert a sleeping host system to prepare for the reception of data.

9.2.7 MAC_NumRetrys

Determines the maximum number of wireless transmission retries. If this parameter is set to a value other than 0, the receiver module will automatically be prompted to send a wireless acknowledgement (“ACK”). Please note that sending acknowledgements additionally increases the traffic.

According to *ESTI EN 301 391*, the value for `MAC_NumRetrys` should be 5 at most.

9.2.8 MAC_AddrMode

Addressing mode selection. The following modes have been implemented:

1. No addressing (mode 0): Each module receives the transmitted RF telegram and delivers the received data to the host system via UART. No address information is transmitted in the radio telegram.
2. 1-byte address (mode 1): The receiving module only delivers the data to the host system via UART if the destination address configured at the sender (`MAC_DestAddrLSB`) corresponds to the source address (`MAC_SourceAddrLSB)` or the destination address 255 (broadcast) was specified. Both the destination address and the source address are transmitted in the wireless telegram (total = 2 bytes).

3. 2-bytes address (mode 2): The receiving module only delivers the data to the host system via UART if both the destination network ID and the destination address correspond to the source addresses (`MAC_SourceNetID` and `MAC_SourceAddrLSB`) or the destination address 255 (broadcast) was specified. A total of 4 bytes of address information are transmitted in the wireless telegram.

Caution: In addressing mode 0, the use of wireless acknowledgement may cause problems if several wireless modules are addressed simultaneously. Therefore no ACK is requested when using addressing mode 0.

The receiver and transmitter modules must operate in the same addressing mode! Otherwise the receiver cannot decrypt the data packet sent and thus the packet is discarded!

9.2.9 MAC_NumRetrysCCA

Determines the maximum number of retries, the module is checking for a clear channel before wireless transmission (CCA).

9.2.10 MAC_CCARetryDelay

Determines the delay the module waits for wireless transmission after a busy channel was detected.

9.2.11 MAC_DefaultDestNetID

Destination network address which is used in addressing mode 2. Can be modified with the command CMD_SET_DESTNETID_REQ at runtime (volatile). If the special broadcast ID and the broadcast address are set to 255, the packets will be received by all network participants.

9.2.12 MAC_DefaultDestAddrLSB

Least significant byte of the destination address which is used in addressing modes 1 and 2. Can be modified with the command CMD_SET_DESTADDRESS_REQ at runtime (volatile). If the special broadcast address 255 is used (in the case of addressing mode 2, broadcast ID is also 255), the packets will be received by all network participants.

9.2.13 MAC_DefaultSourceNetID

Source network ID to be used in addressing mode 2.

9.2.14 MAC_DefaultSourceAddrLSB

Source device address to be used in addressing modes 1 and 2.

9.2.15 MAC_ACKTimeout

Time to wait for a RF acknowledgement before a RF retry is triggered.

RF data rate	ACK timeout recommended
2.4 kbps	45 ms
38.4 kbps	8 ms
100.0 kbps	5 ms

Table 5 Recommended timeouts

9.2.16 PHY_PAPower

Parameter for the RF output power of the module. The maximum permissible output depends on the used RF configurations.
The default value is 14 dBm corresponding to the default channel 106 (868.3 MHz) in the frequency band “g1”, with permissible output power of up to 14dBm. The maximum possible output power with this chip set is 15 dBm.

The RF chip only supports discrete values. Mapping to the next possible `PHY_PAPower` value is done by the module. The next smaller `PHY_PAPower` value is always chosen when the transferred value is not possible. The step distance equals 1 dB.

The usersettings `PHY_PAPower` is entered as a complement on two.

Caution: The statutory regulations for the maximum power output have to be adhered to.

9.2.17 PHY_DefaultChannel

Determines the wireless channel of the module to be used after a reset. Default channel is 106 with 868.3 MHz

$$Channel = \frac{Frequency_{tar} - 863.0MHz}{0.05MHz}$$

Check Table 10 for more information.

9.2.18 PHY_CCAThr

This parameters sets the threshold at which a signal is considered as such. The calculation for the user settings is as follow:

$$Threshold = PHY\_CCAThr - 102dBm$$

9.2.19 OpMode

Choose between operating modes. Can be selected between mode 0 (transparent data transfer) and mode 16 (command mode).

9.2.20 CfgFlags

16-bit field in which the use of individual pins or signals can be disabled. Table 6 represents a description of the respective flags.
To use multiple settings, add the bit numbers and choose the result as value for `CfgFlags`.

By default, CfgFlags for modules are 0x0200 (Led's enabled). For the USB-Sticks the default CfgFlags are 0x021F (Led's enabled, Config, Data_Request & TRX_Disable pins disabled).

Bit no.	Description
0 (0x0001)	Setting this bit disables the ***/CONFIG*** pin. Thus the unit can no longer be switched to the command mode via this pin.
1 (0x0002)	Setting this bit disables the ***/DATA_REQUEST*** pin.
2 (0x0004)	Reserved
3 (0x0008)	Setting this bit, disables handling of the status of the ***TRX_DISABLE*** pin. Hence, the module can no longer be set to the various power-saving modes via this pin.
4 (0x0010)	Setting this bit, enables a different behaviour of the ***TRX_DISABLE*** pin. If this bit is set and the ***TRX_DISABLE*** pin is set, then additionally to the RF-chip, the UART is powered down. In this case, furthermore the chip is powered down to LPM3 and the ***CONFIG*** pin is disabled. The needed weakup time after releasing the ***TRX_DISABLE*** pin is < 1ms.
5 (0x0020)	Any character will be accepted as valid ***checksum*** in the command mode if this bit is set.
6 (0x0040)	Setting this bit, disables the pulldown of the pin ***TRX_DISABLE***.
7 (0x0080)	The address will not be resolved if this bit is set. The particular module can be used as packet sniffer to monitor a wireless link. No ACK is sent.
8 (0x0100)	Setting this bit enables the /CTS flow control pin.
9 (0x0200)	Setting this bit enables the outputs for RF activity, (e.g. for LEDs).
10 to 15	Reserved

Table 6 Configuration flags

Warning: If both bit 0 and bit 2 are set, the module can no longer be set to the command mode.

This parameter set consisting of two bytes has to be transferred LSB first. That means, first the byte with bits 0 ... 7, then the byte with bits 8 ... 15.

9.2.21 RpFlags

16-bit field contains the settings of the repeater functionality. Table 6 represents a description of the respective flags.
To use multiple settings, add the bit numbers and choose the result as value for `RpFlags`.

On `RF_ConfigIndex = 1` the RpFlags must be keept at the default value of 0x0000.

By default, RpFlags is 0x0000.

Bit no.	Description
0 (0x0001)	Setting this bit enables the repeater function, see 12
1 to 15	Reserved

Table 7 Repeater configuration flags

9.2.22 RP_NumSlots

An 8 bit field that contains the number of time slots to be used for the packet repetition.

When using several repeater devices in a single network, repeated data packets can collide in the frequency channel, when all repeater devices send the received packet at the same time. To avoid this, the frequency channel is divided in `RP_NumSlots` time slots, where each repeater chooses a certain slot by random.

The smallest number of time slots that is needed, depends on the network structure and the number of the repeaters used. When there are `NumRP` repeater devices in the range of a sending device, the propability that two repeated packets collide can be calculated by:

$$1 - \frac{RP\_NumSlots!}{RP\_NumSlots^{NumRP}(RP\_NumSlots - NumRP)!}$$

Common values are:

NumRP	RP_NumSlots	Collision propability
2	32	3.1%
3	32	9.2%
4	32	17.7%
5	64	14.8%
6	64	21.5%
7	128	15.4%

Table 8 Common settings of RP_NumSlots

In the example network shown in Figure 7, there are only two repeater that can conflict each other. Repeater 2 and 3 are forwarding the packet received from Sender 1 “at the same time”. Thus NumRP equals 2 and RP_NumSlots equal 32 is sufficient.

The time delay used by the repeater device can determined as the time needed to send one packet (see 9.2.27) times a random number between 1 and RP_NumSlots .

Example:

In RF_ConfigIndex 0 the maximum send time for one packet is about 40ms. If we now use 32 RP_NumSlots , the packet is forwarded latest after 32×40ms=1280ms.

9.2.23 UART_Baudrate

A 32 bit field, that contains the symbol rate for the communication interface. Symbol rates up to 115200 baud are supported. Default symbol rate is 9600 baud. Please note that for baud rates higher than 9600 baud the LPM has a higher energy consumption.

9.2.24 UART_Databits

An 8 bit field that contains the number of data bits on the communication interface. Supported values are 7 and 8.

9.2.25 UART_Parity

An 8 bit field that contains the parity for the communication interface. Values of 0 (no parity), 1 (even parity) and 2 (odd parity) are supported.

9.2.26 UART_Stoppbits

An 8 bit field that contains the number of stop bits for the communication interface. Supported are 1 and 2 stop bits.

9.2.27 RF_ConfigIndex

An 8 bit field that addresses the applied RF configuration.

`RF_ConfigIndex = 1` is a low datarate but high sensitivity configuration (=higher range due to higher link budget). The tradeoff happens between datarate and rf range. Packets in this setting can easily have a tx or rx duration of serveral 100ms.

We do not recommend to use the full 128 byte payload with this ConfigIndex. Using a maximum of 32 byte payload per packet is recommended.

The Repeater Mode must not be used when the ConfigIndex “1” is used.

`RF_ConfigIndex`	Data rate (gross) [kcps]	Freq. range [kHz]	Modulation	Max packet time for repeater mode [ms]
0	38.4	20	GFSK	40
1	2.4	5	GFSK	500
2	100	47	GFSK	20

Table 9 RF profiles

9.2.28 RF_CCADisabled

An 8 bit field that disables the channel access via clear channel assessment.
The default value is 1 that means CCA disabled.

9.2.29 RF_CCACheckTime

A 16 bit field that contains the time in milliseconds for which the channel with activated CCA has to be observed and identified as free before channel access can take place.

It contains `RF_CCACheckTimeLSB` and `RF_CCACheckTimeMSB`.

Def. value = 25 ms, i.e. `RF_CCACheckTimeLSB` = 0x19 and `RF_CCACheckTimeMSB` = 0x00.

If CCA is used to implement LBT, to be not effected by the duty cycle requirements, the parameters have to be chosen in accordance with EN 300 220, and for systems with sporadic bursts of small data packets in accordance with EN 301 391.

10 Device addressing and wireless monitoring

To connect several modules to networks or to send data to specific devices, the AMB8626/AMB8665 supports the so called address mode. The corresponding user setting parameter `MAC_AddrMode` determines whether all modules in range, or all modules in a network or a single module with a fixed address is supposed to receive a certain message.

The address resolution can be disabled ("packet sniffer") with bit 7 in the `CfgFlags`. A module configured in this way will receive all data packets and forward them to the serial interface, regardless of the addressing mode. In sniffer mode, the module does not send any acknowledgement.

11 Radio parameters

The RF parameters are configured with the `RF_ConfigIndex` as well as with `PHY_DefaultChannel` and `PHY_PAPOWER`.

Further the volatile runtime parameter `MAC_RuntimeChannel` can also be changed with the corresponding command during the runtime. This leads to the adoption of this parameters with the next packet transmit or receive. The parameters `PHY_PAPOWER` and `MAC_RuntimePtx` are numbers in complement of two.

Caution: The Parameters must be chosen with prudence to reach good functionality and compliance with EN 300 220.

The AMB8626 is pre-certified, which means measured at 50 Ohm on the AMB8626-EV-Board all requirements are met. However decisive for the end product is the real radiated power. This depends on the selected antenna, the wiring to the antenna, the quality of the power supply, possible disturbances etc., and should therefore be tested.

An important aspect to comply with the radio-norm is to meet the requirements of the duty cycle. The duty cycle marks the transmission time of the device in relation of one hour – a duty cycle of 1% means that the channel is occupied for a maximum of 36 seconds per hour. The customer is responsible for the compliance, there are no interception mechanisms.

The frequency channels of the module can be selected from a 50 kHz raster. Not all channels are suitable and permissible, depending on the selected band width, output power and antenna. To visualise this effect the following two figures display two overlapping signals. The extreme overlap as in Figure 2 results in strong interference between modules in close proximity.

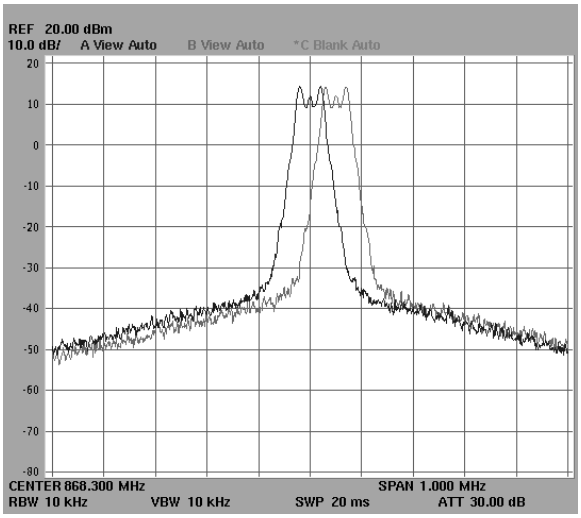


Figure 2 Spectrum of two signals with 38.4 kBaud data rate and 20 kHz deviation with a frequency separation of 50 kHz.

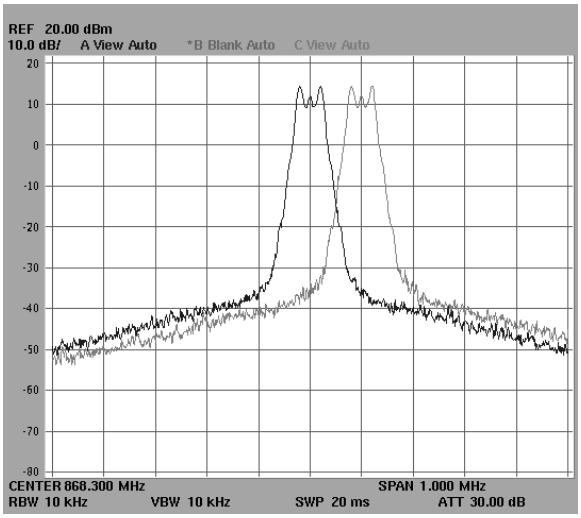


Figure 3 Spectrum of two signals with 38.4 kBaud data rate and 20 kHz deviation with a frequency separation of 100 kHz.

To meet the radio norm not all channels of the bandwidth are permissible depending of the data rate and output power (and antenna). To visualize this effect, two signals near the edge of the band are displayed in Figure 4 and Figure 5. Caution, the figures display only a part of the necessary considerations for the bandwidth and are only meant for demonstration.

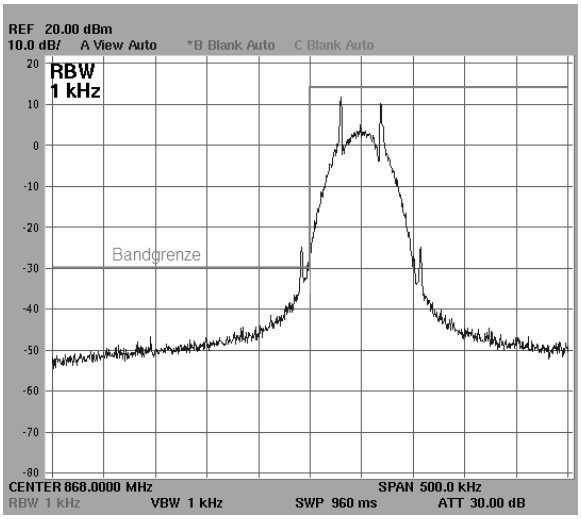


Figure 4 Violation of limit at the band edge of a 38.4 kBaud data rate and 20 kHz deviation signal on channel 101.

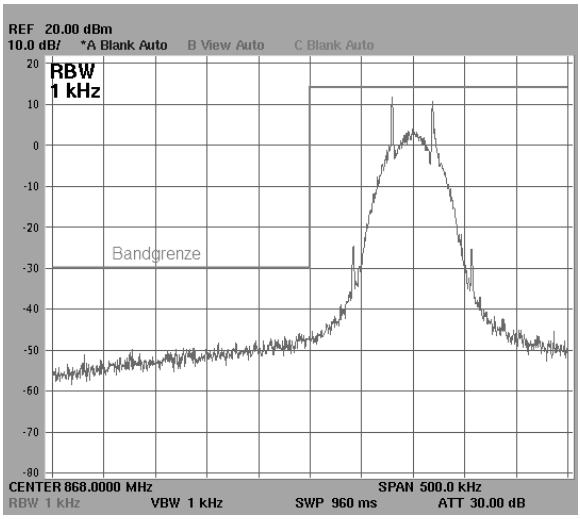


Figure 5 Compliance of limit at the band edge of a 38.4 kBaud data rate and 20 kHz deviation signal on channel 102.

The default configuration consists of a data rate of 38.4 kcps (`RF_ConfigIndex` = 0), a frequency of 868.3 MHz (`PHY_DefaultChannel` = 106) and an output power of 14 dBm (`PHY_PAPOWER` = 14).

Channel occupancy and requirements in the 868 MHz frequency band

Caution: The following represented allowable channels are valid for 50 Ohm wired systems.

The real allowable channels may vary from these, because the real effective radiated power is the determining criteria. A generally valid declaration is not possible, because it depends on the chosen antenna and the environmental conditions.

For the channel occupancy this may be an advantage – if the whole wired wave is not converted into a free space wave, it is possible, that more channels meet the requirements.

11.1 Channel assignment

Band	Sub Band	Channel	Frequency MHz	2.4 kBaud (index 1)	38.4 kBaud (index 0)	100 kBaud (index 2)
g 863 MHz - 870 MHz output power ≤ 14 dBm channel separation ≤ 100 kHz duty cycle ≤ 0,1% or LBT + AFA	g1 868 MHz – 868.6 MHz output power ≤14 dBm no requirements for the channel separation duty cycle ≤ 1% or LBT + AFA	100	868.00	g		
		101	868.05	g1 + g	g	g
		102	868.10	g1 + g	g1 + g	g
		103	868.15	g1 + g	g1 + g	g
		104	868.20	g1 + g	g1 + g	g
		105	868.25	g1 + g	g1 + g	g1 + g
		106	**868.30**	g1 + g	**g1 + g**	**g1 + g**
		107	868.35	g1 + g	g1 + g	g1 + g
		108	868.40	g1 + g	g1 + g	g
		109	868.45	g1 + g	g1 + g	g
		110	868.50	g1 + g	g1 + g	g
		111	868.55	g1 + g	g	g
		112	868.60	g		
		113	868.65	g	g	g
	g2 868.7 MHz – 869.2 MHz output power ≤ 14 dBm no requirements for the channel separation duty cycle ≤ 0,1% or LBT + AFA	114	868.70	g		
		115	868.75	g2 + g	g	g
		116	868.80	g2 + g	g2 + g	g
		117	868.85	g2 + g	g2 + g	g
		118	868.90	g2 + g	g2 + g	g
		119	868.95	g2 + g	g2 + g	g2 + g
		120	869.00	g2 + g	g2 + g	g
		121	869.05	g2 + g	g2 + g	g
		122	869.10	g2 + g	g2 + g	g
		123	869.15	g2 + g	g	g
		124	869.20	g		
		125	869.25	g	g	g
		126	869.30	g	g	g
		127	869.35	g	g	g
	g3 869.4 MHz – 869.65 MHz output power ≤ 27 dBm channel separation ≤ 25 kHz or one wideband channel for high speed data transmission duty cycle ≤ 10% or LBT + AFA	128	869.40	g		
		129	869.45	g3 + g	g	g
		130	869.50	g3 + g	g3 + g	g
		131	869.55	g3 + g	g3 + g	g
		132	869.60	g3 + g	g	g
		133	869.65	g		
	g4 869.7 MHz - 867 MHz output power ≤ 7 dBm no requirements for the channel separation and the duty cycle	134	869.70	g		
		135	869.75	g4 + g	g	g
		136	869.80	g4 + g	g4 + g	-
		137	869.85	g4 + g	g4 + g	-
		138	869.90	g4 + g	g4 + g	-
		139	869.95	g4 + g	-	-
		140	870.00	Band limit		

Table 10 Overview of the channels with remark relating to compliance with 50 Ohm wired.

12 Using the repeater functionality

The AMB8626/AMB8665 module can be run as a repeater to artificially extend the range of sending devices in an existing network. This feature is available in all firmwares equal or newer than version 3.4.0.

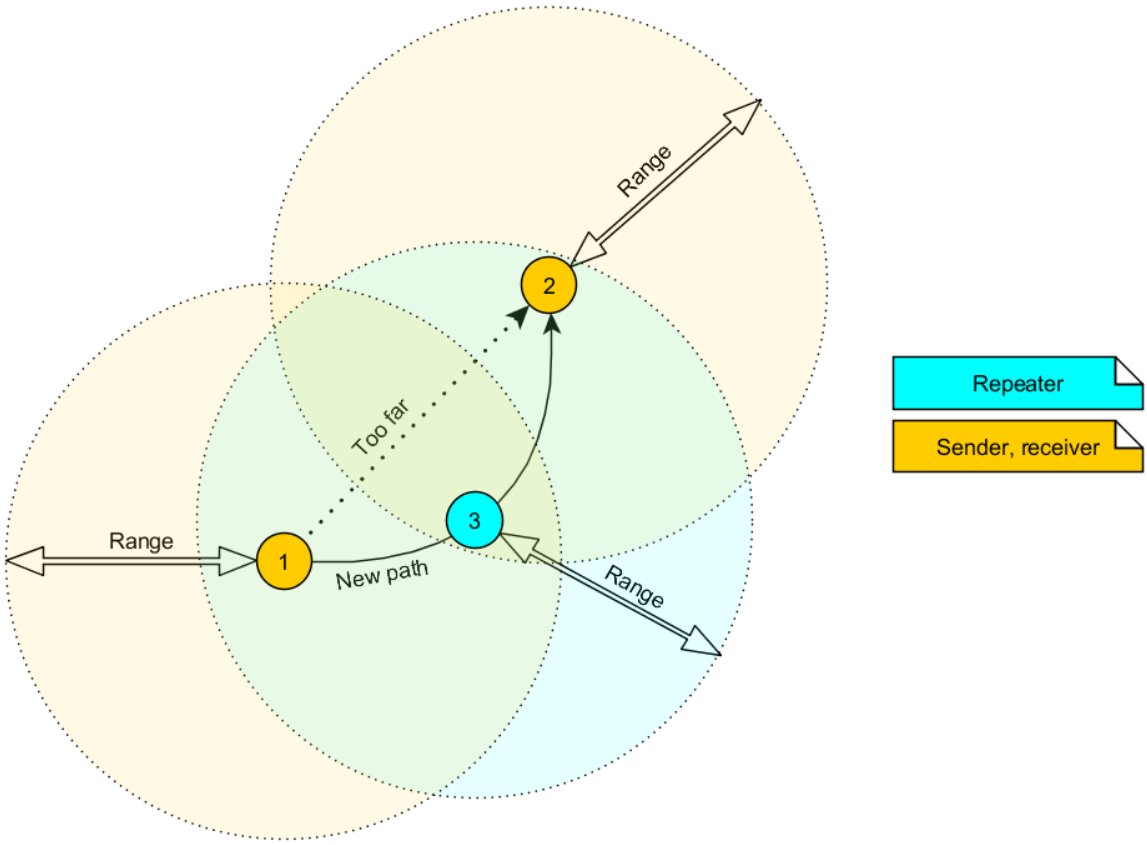


Figure 6 Range extention using repeaters

If the module is configured as repeater it can be simply added to existing wireless networks consisting of AMB8626/AMB8665 modules. With this, the network uses the so called “flooding technique” to deliver data packets from their source to their destination device.

The repeater module itself simply listens to the configured channel and forwards all received packets, whose destination address does not coincide with the repeater’s source address or which are send broadcast. Thereby a random delay (see `RP_NumSlots`) is used to avoid RF packet collision. To reduce traffic on the frequency channel, each repeater device checks before repetition, if the channel is free and whether it has already sent this packet before or not. Thus every repeater sends each packet only once.

In a network with `NumRP` repeater devices, each data packet is repeated `NumRP` times. Therefore each packet that is send from node A to node B forces a traffic of `NumRP+1` data packets in total on the frequency channel.

Besides of this, a AMB8626/AMB8665 that is configured as repeater supports also the functions of a standard module. Thus it can receive data and can initiate the data transmission to other modules.

12.1.1 Setup of the network and repeater device

The repeater mode can be enabled with setting bit 1 in the `RpFlags`.

As ACKs are not supported by the Repeater-Mode all network members must make sure that the UserSettings value of `MAC_NumRetrys` is set to 0.

The Repeater mode will automatically select OpMode 16 (Command mode). The transparent mode is not supported when repeater mode is selected.

If the AMB8626/AMB8665 device is configured as repeater, the following notes have to be considered:

Requirements on the network:

- The repeater devices have to be line-powered (no batterie), since due to packet repetition it demands more energy.
- Depending on the data rate, each repeater should repeat a maximum of 2-5 packets per second to give a good chance that the repeater is not busy with repeating when already a new packet arrives for repetition. Otherwise, packets can get lost. Please setup your network such that this requirement is fulfilled. More packets per second will result in more packet loss as the collision propability is increased.
- If the network consists of several layers of repeaters, each layer delays the packet transmission additionally.
- To setup the network all participants have to use the same `RF_ConfigIndex`, `PHY_DefaultChannel` and `MAC_AddrMode`.

Information for the repeater device:

- Clear Channel Assessment (CCA) is enabled, thus the user setting `RF_CCADisabled` is ignored. CCA is necessary to fullfil the corresponding duty cycle.
- The repeater module operates in command mode.
- Acknowlegdements (ACK) of successfully received packets are blocked. If an ACK is requested by the sending module, the request is ignored. Furthermore, the repeater does not request any ACK, when repeating a packet.
- The “packet sniffer” mode cannot run at the same time as the module is in repeater mode. Thus the bit 7 in the `CfgFlags` is ignored.
- Each time a packet has been repeated a `CMD_REPEAT_IND` is printed over UART. Depending on the address mode the address of the involved devices is placed in the `CMD_REPEAT_IND` telegram. With this the original sender of the rf packet and the device, that is supposed to receive the packet, can be identified.

Information for the sending and receiving devices:

- The senders should send less frequently to avoid packet collision on the frequency channel and to not exceed the duty cycle.
- The repeater devices do not support the AMB8626/AMB8665 feature of ACKs for the successful reception of the packets. Thus the sender will never receive ACKs if requested. To ensure that transmitted packets are successfully received by the destination device, the network administrator has to integrate his own acknowledging

feature in the customer's application. To be sure that the sender does not request ACKs the user setting `MAC_NumRetrys` must be set to 0.

- Every repeater sends each packet only once. But receivers can receive each packet several times (sent by different repeaters), if there are packets of different content in the network temporally close to each other. Thus, on the side of the receiving device, a mechanism can be implemented that filters double packets.

12.1.2 Example network

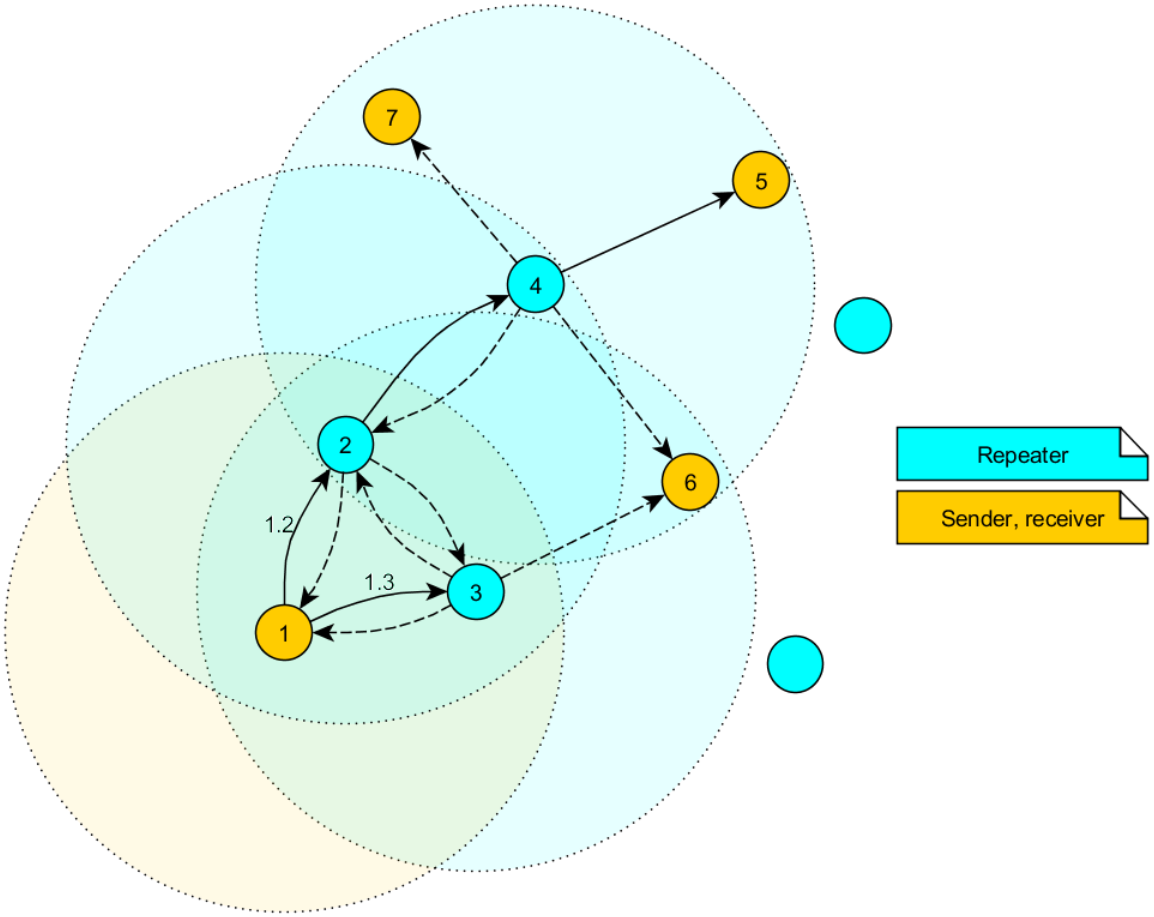


Figure 7 Example network

In the example network shown above, the goal is to send a packet from device 1 to 5. Without the repeater devices, this would be impossible. The steps are as follows:

A. Sender 1 sends a packet.
    a. Repeater 2 and 3 receive and accept it at the same time.
B. Device 2 and 3 delay the packet.
    a. Repeater 3 sends the packet.
        i. Sender 1 and 6 do not accept it, since their addresses are wrong (unequal 5).
        ii. Repeater 2 does not accept it, since it has been already received before (1.2).

   b. Repeater 2 sends the packet.
      i. Repeaters 3 does not accept it, since it has been already received before (1.3).
      ii. Sender 1 does not accept it, since its address is wrong (unequal 5).
      iii. Repeater 4 receives and accepts the packet.
C. Repeater 4 delays and sends the packet.
   a. Sender 6 and 7 do not accept it, since their addresses are wrong (unequal 5).
   b. Repeater 2 does not accept it, since it has been already received before (1.2).
   c. Receiver 5 accepts it and its successfully delivered (address equals 5)

Please note that the packet forwarded by repeater 2 and 3 would collide in the frequency channel, if they wouldn't be randomly delayed (see `RP_NumSlots` in 9.2.22).

12.1.3 Application in parallel networks

As described above, a repeater device forwards all packets that are received before. If a network needs to have a bigger throughput of data, a parallel network can be set up, that relaxes the stress of the primal network. To do so, all sending, receiving and repeater devices of the parallel network are configured to use a new channel, such that the primal network is not affected at all by the traffic of the parallel network.

13 Battery powered operation

The TRX_DISABLE pin can set the module to one of two different modes of operation.

13.1 Active mode

When TRX_DISABLE is low, the module is permanently ready to receive and forward data via UART or wireless transmission. The module will switch to one of the internal LPM after having processed any pending data transmission, i.e. /RTS must be low.

13.2 Stand-by mode

When TRX_DISABLE is high, the operation of the module's transceiver is disabled. Wireless reception is not possible, but transmission of data is possible. The module will switch to one of the internal LPM as long as no data will be transmitted. A UART data rate of more than 9600 baud will result in a higher current consumption.

The CfgFlag Bit 4 can modify this behaviour (see chapter 9.2.20).

14 Timing parameters

14.1 Reset behaviour

Following a reset, a low on the /RTS pin signals that the module is ready for operation.

This level is however only valid, after the delay required for the internal initialisation of the processor (a few µs).

14.1.1 Power-on reset

After switching the supply voltage and releasing the /RESET pin (if wired), the time until the module is ready for operation can last up to 1 s.

14.1.2 Reset via /RESET pin

To force a module restart by means of the /RESET pin, it must first be drawn to low for at least 10 ms.

After the pin is released, /RTS will switch to high after 100 µs at the latest. Since the start-up time for the clock quartz does not apply in this case, the time until the module is ready for operation is reduced to a couple of ms. During this time, the processor clock-rate will be calibrated, which takes anyway between 2 and 20 ms depending on the supply voltage and temperature.

Recommended procedure: After the /RESET pin is released, wait for 2 ms for the low level on the /RTS pin. Subsequently, additional 100 µs are required until the system is ready.

14.1.3 Reset as result of a serious error condition

If the module runs in a serious error condition, a software reset is executed. In this case, the module starts up automatically and can be used again. The volatile runtime settings are reset to default, see chapter 8.

14.2 Latencies when leaving the LPM

The module enters a LPM as soon as no data-transmission request is received via serial and RF interface.

If the device returns from such a mode, all internal settings like the channel calibration values and noise levels have been retained, such that the module is ready after a few µs. Also here a low signal at the /RTS indicates that the module is ready for operation.

14.3 Latencies during data transfer / packet generation

The data transfer is always buffered, i.e. data received via UART is buffered in the module until a specific event occurs. Subsequently, the UART reception is interrupted (flow control with /RTS signal), and the payload data is passed to the internal memory of the wireless transceiver (FIFO).

By using several UART buffers the time during which the UART is not receiving can be minimized.

The channel access method adds additional latency. This can be configured in the user settings.

The wireless transmission starts as soon as the first data is available in the transceiver memory. During the continuous wireless transmission the remaining payload data is transmitted byte by byte.

On the receiver side, the FIFO is read as soon as an incoming packet is detected.

If the module detects a packet that requires an ACK, the ACK is sent directly after the packet reception. The channel access method is always deactivated for ACKs.

In combination with a suitable packet generation method, this procedure enables the minimisation of the latencies resulting from buffering.

According to ETSI EN 301 391 (access protocol for small data packets on one shared radio channel) the time for one packet (including the respective acknowledge) should not exceed 100 ms. For slow data rates the packet size has to be reduced respectively.

15 Firmware update

We highly recommend to have pads/connectors for realizing these (external) uart connection on any customer PCB.

15.1 Update using UART interface

As long as a firmware is running on the module the module can be updated with the PC utility "AMBER Config Center" (ACC V3) via the serial interface.

If the module is not directly connected to a PC, the UART should be made accessible, e.g. by means of suitable connectors. Only the UTDX, URXD and GND signals are needed for this connection. An adapter is required for a PC connection (e.g. the FTDI TTL-323R-3V3 uart to usb converter).

The /RESET signal shall be connectable to GND for performing a reset of the module (e.g. using a push-button which pulls to GND when pressed)

15.2 Update using JTAG or Spy-Bi-Wire

Using one of this two interface options allows performing a fail-safe firmware update even in case of a broken firmware or malconfiguration.

The user needs hardware and software tools to be able to perform this procedure. In detail those are:

- Flash adapter for MSP430 µC's (e.g. from TI, Elprotronic or Olimex), caution: not every adapter supports both described connection methods. Recommended adapter: "Elprotronic Flash Pro 430"
- In case of SPY-Bi-Wire a dedicated connector with some passive parts is needed (see the documentation of the flash adapter you use) this connector may vary from µC to µC
- In general /Reset, GND and VCC are needed for such connections
- JTAG is supported through the module's pads 6(J.0), 7(J.1), 8(J.2), 18(J.3)
- SPY-Bi-wire is supported through pad 17 (TEST pin of the µC)

The manual of the EV-Board gives an example of a JTAG connection with a 2*7 Pin connector for the MSP430F2xxx and MSP430F5xxx Platforms.

16 Firmware history

Version 2.0

- First product release. The version number is related to the AMB8426 because of the compatibility of the RF

Version 2.3

- Addition and optimization of 100kcps for RF transmission

Version 2.4

- Added possibility to enable/disable LPM when UART baud rate higher than 9600 baud (`MISC_EnableMaxPowerSavings`)

Version 3.0

- Removed the user setting `MISC_EnableMaxPowerSavings`, LPM now is self-controlled
- Removed break signal detection functionality
- Added user setting `TRX_DISABLE_PULLDOWN_DISABLE` to disable the `PULLDOWN_TRX_DISABLE`
- Added command `CMD_SET_PAPOWER_REQ` to update the RF TX-power during operation
- The module restarts if a serious error condition appeared
- Added the command `CMD_FACTORY_RESET_REQ` to restore the default user settings
- Added improved user settings and functionality for the CCA.

Version 3.1

- Moved user setting `TRX_DISABLE_PULLDOWN_DISABLE` to CfgFlags (0x0040)
- Added new CfgFlag to force a different behaviour of the `TRX_DISABLE` pin (0x0010)

Version 3.2

- Introduced the functionality to drive the module as repeater

Version 3.3.9

- Improved repeater functions. Module supports standard operations (e.g. inititiate data transmission) also in repeater mode.

17 Hardware integration

17.1 Footprint

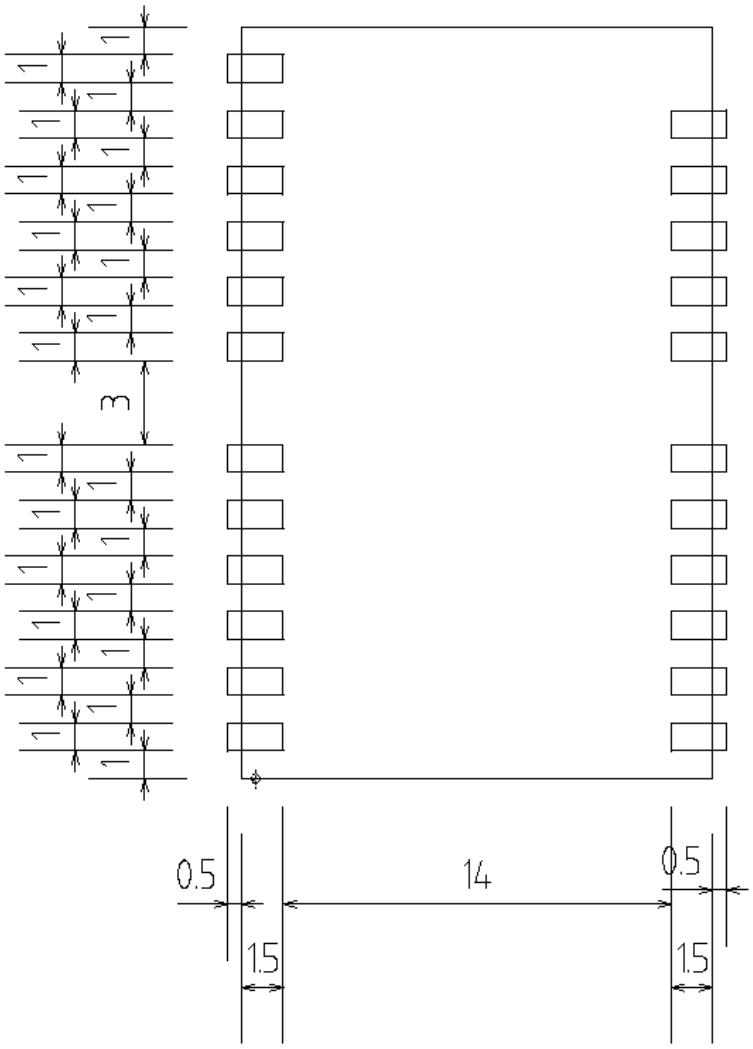


Figure 8 Footprint AMB8626 (also applicable for AMB8426), [mm]

To avoid the risk of short circuits between VCC and GND, a minimum clearance of at least 14 mm between the opposing pad rows has to be maintained!

18 Design in guide

18.1 Advice for schematic and layout

For users with less RF experience it is advisable to closely copy the relating evaluation board with respect to schematic and layout, as it is a proven design. The layout should be conducted with particular care, because even small deficiencies could affect the radio performance and its range or even the conformity.

The following general advice should be taken into consideration:

- A clean power supply is strongly recommended. Interference, especially oscillation can severely restrain range and conformity.
- Variations in voltage level should be avoided.
- LDOs, properly designed in, usually deliver a proper regulated voltage.
- Blocking capacitors and a ferrite bead in the power supply line can be included to filter and smoothen the supply voltage when necessary.

No fixed values can be recommended, as these depend on the circumstances of the application (main power source, interferences etc.).

Frequently switching the module on and off, especially with a slowly changing voltage level of the power supply, can lead to erratic behavior, in rare cases even as far as damaging the module or the firmware. The use of an external reset IC can solve this matter.

- Elements for ESD protection should be placed on all Pins that are accessible from the outside and should be placed close to the accessible area. For example, the RF-Pin is accessible when using an external antenna and should be protected.
- ESD protection for the antenna connection must be chosen such as to have a minimum effect on the RF signal. For example, a protection diode with low capacitance such as the LXES15AAA1-100 or a 68 nH air-core coil connecting the RF-line to ground give good results.
- Placeholders for optional antenna matching or additional filtering are recommended.

Again, no fixed values can be recommended, as they depend on the influencing circumstances of the application (antenna, interferences etc.).

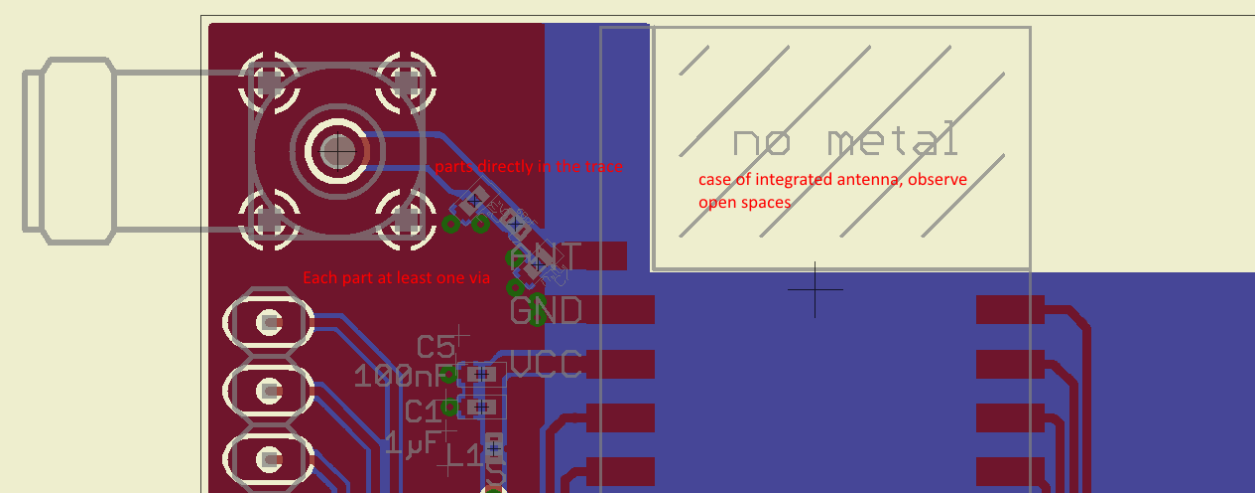


Figure 9: Layout

- To avoid the risk of short circuits and interference there should be no routing underneath the module on the top layer of the baseboard.
- On the second layer, a ground plane is recommended, to provide good grounding and shielding to any following layers and application environment.
- In case of integrated antennas it is required to have areas free from ground. This area should be copied from the evaluation board.
- The area with the integrated antenna must overlap with the carrier board and should not protrude, as it is matched to sitting directly on top of a 1.5 mm thick PCB.
- Modules with integrated antennas should be placed with the antenna at the edge of the main board. It should not be placed in the middle of the main board or far away from the edge. This is to avoid tracks beside the antenna.
- Filter and blocking capacitors should be placed directly in the tracks without stubs, to achieve the best effect.
- Antenna matching elements should be placed close to the antenna / connector, blocking capacitors close to the module.
- Ground connections for the module and the capacitors should be kept as short as possible and with at least one separate through hole connection to the ground layer.
- ESD protection elements should be placed as close as possible to the exposed areas.

18.2 Dimensioning of the 50 Ohm microstrip

The antenna track has to be designed as a 50 Ohm feed line.

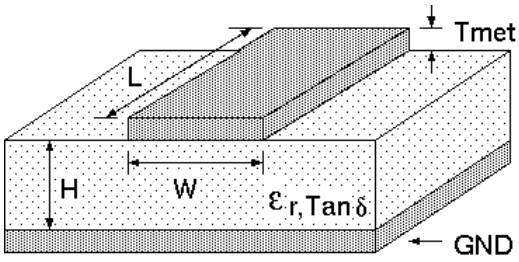


Figure 10 Dimensioning the antenna feed line as micro strip

The width W for a micro strip can be calculated using the following equation:

$$W = 1.25 \cdot \left(\frac{5.98 \cdot H}{e^{\frac{50 \cdot \sqrt{\varepsilon_r + 1.41}}{87}}} - T_{met} \right)$$

Equation 1 Parameters of the antenna feeding line

Example: a FR4 material with ε_r = 4.3, a height H = 1000 µm and a copper thickness of T_{met}= 18 µm will lead to a trace width of W ~ 1.9 mm. To ease the calculation of the Microstrip line (or e.g. a coplanar) many calculators can be found in the internet.

- As rule of thumb a distance of about 3 x W should be observed between the micro strip and other traces / ground.
- The Microstrip refers to ground, therefore there has to be the ground plane underneath the trace.
- Keep the feeding line as short as possible.

18.3 Antenna solutions

There exist several kinds of antennas, which are optimized for different needs. Chip antennas are optimized for minimal size requirements but at the expense of range, PCB antennas are optimized for minimal costs, and are generally a compromise between size and range. Both usually fit inside a housing. Range optimization in general is at the expense of space. Antennas that are bigger in size, so that they would probably not fit in a small housing, are usually equipped with a RF connector. A benefit of this connector may be to use it to lead the RF signal through a metal plate (e.g. metal housing, cabinet).

As a rule of thumb a minimum distance of Lambda/10 (3.5 cm @ 868 MHz, 1.2 cm @ 2.44 GHz) from the antenna to any other metal should be kept. Metal placed further away will not directly influence the behavior of the antenna, but will anyway produce shadowing.

Keep the antenna away from large metal objects as far as possible to avoid electromagnetic field blocking.

In the following chapters, some special types of antenna are described.

18.3.1 Lambda/4 radiator

An effective antenna is a Lambda/4 radiator. The simplest realization is an 8.6 cm long piece of wire for 868 MHz, respectively a 3.1 cm long piece of wire for 2.44 GHz. This radiator needs a ground plane at its feeding point. Ideally, it is placed vertically in the middle of the ground plane. As this is often not possible because of space requirements, a suitable compromise is to bend the wire away from the PCB respective to the ground plane. The Lambda/4 radiator has approximately 40 Ohm input impedance, therefore matching is not required.

18.3.2 Chip antenna

There are many chip antennas from various manufacturers. The benefit of a chip antenna is obviously the minimal space required and reasonable costs. However, this is often at the expense of range. For the chip antennas, reference designs should be followed as closely as possible, because only in this constellation can the stated performance be achieved.

18.3.3 PCB antenna

PCB antenna designs can be very different. The special attention can be on the miniaturization or on the performance. The benefits of the PCB antenna are their small / not existing (if PCB space is available) costs, however the evaluation of a PCB antenna holds more risk of failure than the use of a finished antenna. Most PCB antenna designs are a compromise of range and space between chip antennas and connector antennas.

19 Manufacturing information

- The assembly contains moisture sensitive devices of the MSL classification 3. Only the dry packed Tape & Reel devices are suitable for the immediate processing in a reflow process.
- Further information concerning the handling of moisture sensitive devices, (e.g. drying) can be obtained from the IPC/ JEDEC J-STD-033.
- Recommendations for the temperature profile for the soldering furnace cannot be made, as it depends on the substrate board, the number and characteristics of the components, and the soldering paste used (consult your EMS).

Figure 11 shows a soldering curve that had been used for a 31 cm^2 carrier board for single-side assembly.

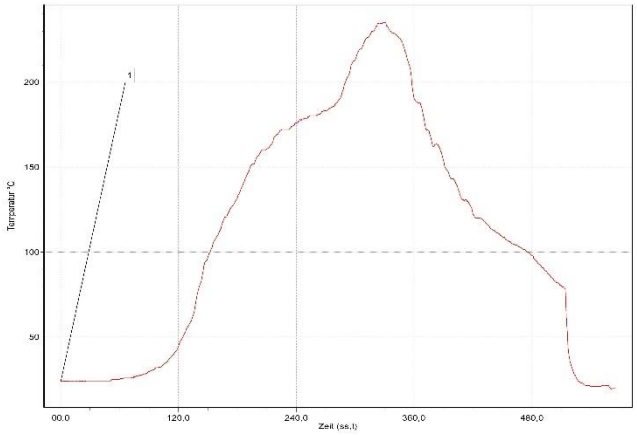


Figure 11 Example of a temperature profile –

Caution: Must be adjusted to the characteristics of the carrier board!

To ensure the mechanical stability of the modules it is recommended to solder all the pads of the module to the base board, even if they are not used for the application.

Caution! ESD sensitive device.

Precaution should be taken when handling the device in order to prevent permanent damage.

Caution! This assembly contains moisture sensitive components.

Precaution should be taken when processing the device according to IPC/JEDEC J-STD-033.

MSL 3

Since the module itself is not fused the voltage supply shall be coming from a limited power source according to clause 2.5 of EN 60950-1.

20 References

[1] „CC1125 Single-Chip Low Cost Low Power RF-Transceiver”, Texas Instruments

[2] „AMB8626 Datasheet”, AMBER wireless GmbH

21 Regulatory compliance information

21.1 Important notice

The use of RF frequencies is limited by national regulations. The AMB8626 has been designed to comply with the R&TTE directive 1999/5/EC of the European Union (EU).

The AMB8626 can be operated without notification and free of charge in the area of the European Union. However, according to the R&TTE directive, restrictions (e.g. in terms of duty cycle or maximum allowed RF power) may apply.

Conformity assessment of the final product

The AMB8626 is a subassembly. It is designed to be embedded into other products (products incorporating the AMB8626 are henceforward referred to as "final products").

It is the responsibility of the manufacturer of the final product to ensure that the final product is in compliance with the essential requirements of the European Union's Radio & Telecommunications Terminal Equipment (R&TTE) directive.

The conformity assessment of the subassembly AMB8626 carried out by AMBER wireless GmbH does not replace the required conformity assessment of the final product in accordance to the R&TTE directive!

Exemption clause

Relevant regulation requirements are subject to change. AMBER wireless GmbH does not guarantee the accuracy of the before mentioned information. Directives, technical standards, procedural descriptions and the like may be interpreted differently by the national authorities. Equally, the national laws and restrictions may vary with the country. In case of doubt or uncertainty, we recommend that you consult with the authorities or official certification organizations of the relevant countries. AMBER wireless GmbH is exempt from any responsibilities or liabilities related to regulatory compliance.

21.2 Declaration of conformity

DECLARATION OF CONFORMITY
Directive 1999/5/EG (R&TTE)

The manufacturer: AMBER wireless GmbH
Albin-Köbis-Straße 18
51147 Köln
Tel. +49-2203-699195-0

Declares on its sole responsibility, that the following product:

Type-designation: **AMB8626**

Intended purpose: 868MHz transceiver module
Transfer of digital messages

Satisfies all the technical regulations applicable to the product within the scope of council directives 2006/95/EC, 2004/108/EC and 99/5/EC if used for its intended purpose and complies the following norms, standards or documents:

EN 300 220-1 V2.4.1 (2012-05)
EN 300 220-2 V2.4.1 (2012-05)
EN 301 489-1 V1.9.2 (2012-10)
EN 301 489-3 V1.4.1 (2002-08)
EN 60950-1 : 2006 + A11 : 2009 + A1 : 2010
EN 62479 : 2010

Trier, 16th of October 2013
Place and date of issue

Manufacturer/Authorized representative
Gudrun Eckhardt

AMBER WIRELESS

CE

DECLARATION OF CONFORMITY
Directive 1999/5/EG (R&TTE)

The manufacturer: AMBER wireless GmbH
Rudi-Schillings-Straße 31
54296 Trier
+49 651 99355 0

Declares on its sole responsibility, that the following product:

Type-designation: **AMB8665**[1]

Intended purpose: 868MHz transceiver module
Transfer of wM-Bus telegrams for metering systems

Satisfies all the technical regulations applicable to the product within the scope of council directive 99/5/EC if used for its intended purpose and complies the following norms, standards or documents:

EN 300 220-1 V2.4.1 (2012-05)
EN 300 220-2 V2.4.1 (2012-05)
EN 301 489-1 V1.9.2 (2012-10)
EN 301 489-3 V1.6.1 (2002-08)
EN 60950-1 : 2006 + A11 : 2009 + A1 : 2010 + A12 : 2011 + A2 : 2013
EN 62479 : 2010

Trier, 9th of September 2016
Place and date of issue

G. Eckhardt
Manufacturer/Authorized representative
Gudrun Eckhardt

[1] Every product starting with the stated number, as it is identical hardware

22 Important information

22.1 Exclusion of liability

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All other trademarks, registered trademarks, and product names are the exclusive property of the respective owners.

22.3 Usage restriction

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By using AMBER wireless products, the user agrees to these terms and conditions.

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