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Annex acc. to FCC Title 47 CFR Part 15
relating to
Würth Elektronik eiSos GmbH & Co. KG
2609011091001, 2609011191001

Annex no. 5
User Manual
Functional Description

Title 47 - Telecommunication
Part 15 - Radio Frequency Devices
Subpart C – Intentional Radiators
ANSI C63.4-2014
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Manual AMB8826 / AMB9826

Release 2.0

SW-V2.1.0

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Abbreviations and abstract

ACK	Acknowledgement	Acknowledgement pattern confirming the reception of the transmitted data packet
CS	Checksum	
DC	Duty cycle	Relative frequency reservation period
LPM	Low power mode	Operation mode for reduced power consumption.
RF	Radio frequency	Describes everything relating to the wireless transmission
Payload		The real, non-redundant information in a frame/packet
UserSettings		Any relation to a specific entry in the UserSettings is marked in a special font and can be found in the respective chapter
UART		Universal Asynchronous Receiver Transmitter allows communicating 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 Introduction

The AMB8826 / AMB9826 module is a radio sub module for wireless communication between devices such as control systems, remote controls, sensors etc. It offers several radio configurations, address modes and relieves the host system of radio-specific tasks as

- checksum calculation,
- address resolution
- repetition of unacknowledged telegrams (if enabled)

It can be deployed wherever the wireless exchange of data packets (up to 224 bytes user data) 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.

2 Physical parameters

2.1 Dimensions and weight

Dimensions	17 x 27 x 4 mm
Weight	3g

2.2 Electrical parameters

As not otherwise stated measured on AMB8826-EV / AMB9826-EV with T=25°C, VDDS=3V, internal DC-DC converter in use. Radio transmission uses boost mode independent of the chosen output power.

2.2.1 Absolute maximum ratings

Description	min	typ	max	unit
Supply voltage (VDDS)	-0.3		4.1	V
Voltage on any digital pin	-0.3		VDDS + 0.3, max 4.1	V
Input RF level			10	dBm
Output RF level, with boost mode		14		dBm

2.2.2 Recommended operating conditions

Description	min	typ	max	unit
Ambient temperature	-40		85	°C
Supply voltage (VDDS)	2.2[1]		3.8	V
Rising supply voltage slew rate	0		100	mV/µs
Falling supply voltage slew rate	0		20	mV/µs
Falling supply voltage slew rate, with low power flash settings			3	mV/µs

[1] When the whole temperature range is used, a minimum voltage of 2.4V is recommended.

2.2.3 Power consumption

As a DC/DC voltage regulator is integrated, the current consumption is strongly depending on the supplied voltage level.

The Transmit and Receive Currents are depending on the impedance matching, and therefore may vary depending on antenna selection and matching.

The indicated values are the complete current consumption for radio and active MCU. Not to be confused with only radio or only cpu core currents, as sometimes stated by others.

A stable supply indispensable to ensure valid operating conditions for the module.

VDDS = 3.6V, transmit current in boost mode

Description	typ	unit
TX current 10 dBm output power TX current 14 dBm output power	17 26	mA
RX current	8	mA
Low Power (standby) radio off, uart off, rtc running, full RAM retention	1.0	µA
Low Power (shutdown) radio off, uart off, rtc off, no RAM retention	0.2	µA

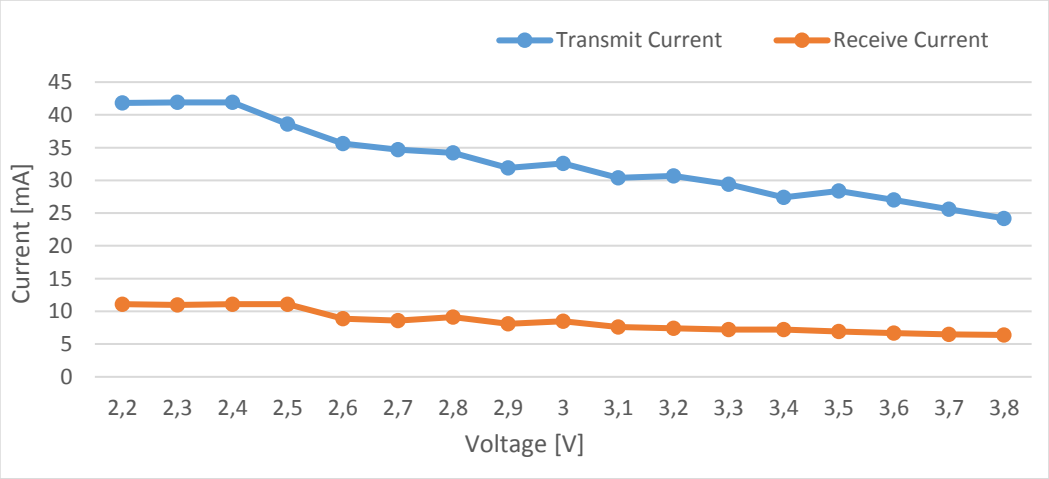


Figure 1: Typical behavior of transmit and receive current in relation to applied supply voltage

3 Pinout

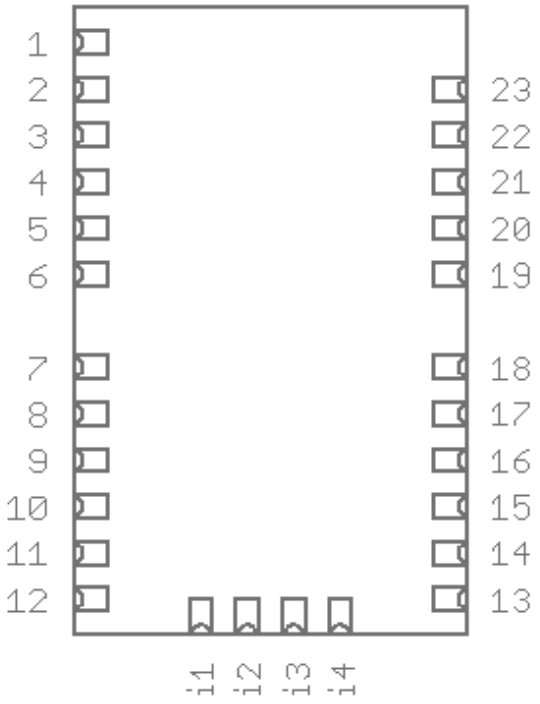


Figure 2 Pinout (Top view)

No	Designation	I/O	Description
1	ANT	I/O	Antenna connection
2, 23	GND	Supply	Ground
3	VCC	Supply	Supply voltage
4	UTXD	Output	UART (Transmission), bootloader TX
5	URXD	Input	UART (Reception), bootloader RX, App: Uses an internal pull-up. Bootloader: Uses an internal pull-up
6	/RTS	Output	Indicates that the module is busy, busy = high level.
7	Reserved (/CTS)	I/O	Reserved for future use. Uses an internal pull-up. Do not connect.
8, 9, 10, 11	Reserved	I/O	Reserved for future use. Uses an internal pull-down. Do not connect.

No	Designation	I/O	Description
12	BOOT	Input	Apply a low-level signal during and shortly after reset to start the application firmware. Apply a high level to enable the CC13x0 bootloader, which is necessary for ACC Connection, configuration and firmware updates. Connect to GND if ACC and firmware update function is not needed (e.g. 1kΩ pull-down).
13	Reserved	I/O	Reserved for future use. Uses an internal pull-down. Do not connect.
14	WAKE-UP	Input	Apply a falling edge to wake-up from shutdown or standby mode. Uses an internal pull-down. Do not connect if not needed.
15, 16, 17, 18	Reserved	I/O	Reserved for future use. Uses an internal pull-down. Do not connect.
19	/RESET	Input	Apply a falling edge to reset the module. Pin has internal Pull-up of 100kΩ. Low level holds module in reset state.
20	RX_IND	Output	Indicates RF data reception, active = high Do not connect if not needed.
21	TX_IND	Output	Indicates RF data transmission, active = high Do not connect if not needed.
22	Reserved	I/O	Reserved for future use. Uses an internal pull-down. Do not connect.
i1	JTAG TMS	Input	Debug interface Do not connect if not needed.
i2	JTAG TCK	Input	Debug interface Do not connect if not needed.
i3	JTAG TDO	Input	Debug interface Do not connect if not needed.
i4	JTAG TDI	Input	Debug interface Do not connect if not needed.

Table 1 Pinout

4 Start-up and minimal configuration

4.1 Minimal configuration

In factory state, the module is immediately ready for operation in command mode. The following pins are required in the minimal configuration:
/RESET, BOOT, VCC, GND, /RTS, UTXD and URXD.

If the module is connected to a PC, a converter (TTL to RS-232 or TTL to USB) is necessary to achieve interface compatibility. The AMB8826-EV / AMB9826-EV already implements such a USB converter to be connected to a PC.

Not interpreting the /RTS line of the module as described in this manual may cause undefined behaviour.

For enabling a quick WAKE-UP (after Standby) the pin “wake-up” has to be connected.

The lines BOOT and WAKE-UP may be connected via external pull-up / down to a fixed level according to their description when not switched by a host.

In case of the WAKE-UP pin the external pull-up has to be selected accordingly in comparison with the internal resistor of typical 13kΩ.

4.2 Power up

Recommended procedure for starting the module into normal operation:

Set and hold the BOOT pin to LOW. After supply voltage is applied to the module, the /RESET pin shall be hold to LOW level for another Δt of at least 1ms after the VCC is stable to ensure a safe start-up. The module will send a `CMD_RESET_IND` message as well as showing a low level of the /RTS line once it is booted into application.

Then the Boot pin may be released or kept at LOW level.

If the module is used on a battery-powered system, using a matching Reset-IC is highly recommended to ensure a correct power up and stable behaviour towards battery getting empty.

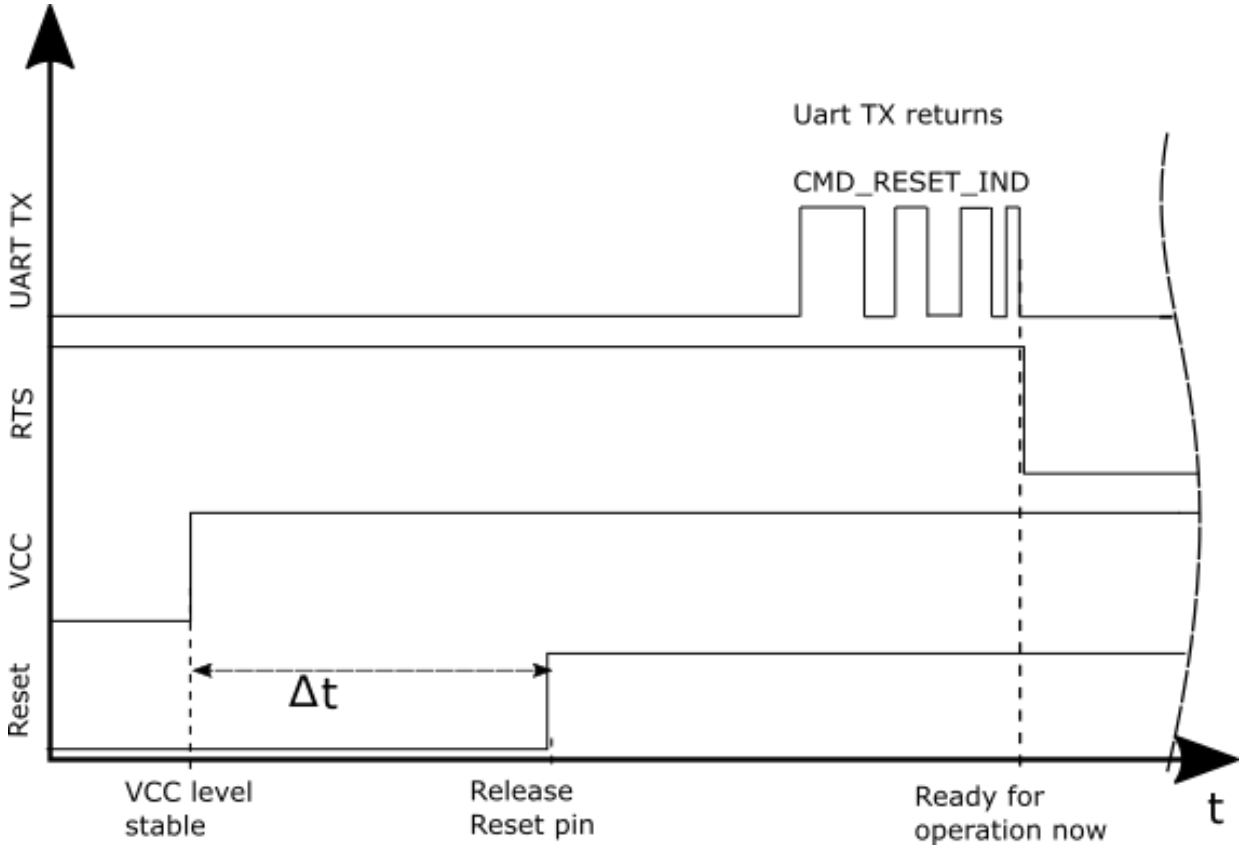


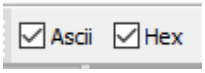
Figure 3 Power up timing

4.3 Sending & receiving: “Hello World”

Connect the two devices (modules, EV-boards or USB dongles) to a PC. A minimum distance of 2 meters between the devices should be kept to avoid over modulation of the receiver.

A terminal program, for example *hterm*, is used to perform the communication via COM ports. The two corresponding COM ports have to be selected and opened with a default configuration of 115200 baud, 8 Data bits, 1 Stop bit and Parity set to none (8n1).

Make sure the received data is shown also as hex by enabling the corresponding checkbox:



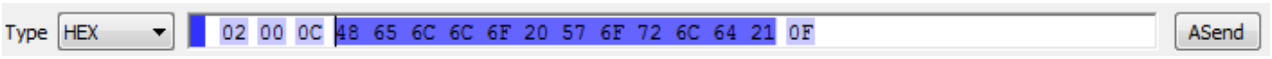
As soon as the module is ready for operation (at start-up or after a reset), the device sends a `CMD_RESET_IND` message (0x02 0x85 0x01 0x10 0x96) on the UART. Eventually the reset button has to be pushed (or `CMD_RESET_REQ` performed) to trigger a reset and see this message.

Next, the command interface can be used to configure the module or to transmit data. The `MAC_DefaultAddressMode` is “0”, which means that all radio frames are broadcasts that can be received by any other radio compatible device in default settings.

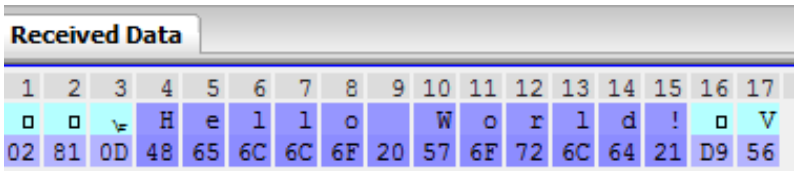
To send the string “Hello World” the corresponding CMD_DATA_REQ has to be inserted into the input line of *hterm*. The “Type” needs to be change from “ASC” to “HEX” before entering the first byte. The command CMD_DATA_REQ has the following structure:

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

In this example the payload 0x48 0x65 0x6C 0x6C 0x6F 0x20 0x57 0x6F 0x72 0x6C 0x64 0x21 (Hello World!) has a length of 12 (0x0C) bytes. The checksum CS is a XOR conjunction of all previous bytes, which is 0x0F in this case.



Using the “ASend” button followed by pushing the “start” button sends the data once. The second module receiving this packet outputs a CMD_DATAEX_IND message containing the transmitted payload data and the corresponding RSSI value.



In the default address mode (MAC_DefaultAddressMode = 0), the format of the CMD_DATAEX_IND is as follows:

Start signal	Command	Length	Payload	RSSI	CS
0x02	**0x81**	**1 Byte**	**(Length - 1) bytes**	**1 byte**	**1 byte**

Thus, the CMD_DATAEX_IND message informs us that we received a packet with payload of 13 (0x0D) bytes.

12 byte of these bytes are the transmitted user payload 0x48 0x65 0x6C 0x6C 0x6F 0x20 0x57 0x6F 0x72 0x6C 0x64 0x21 (Hello World!) and one byte is the RSSI value, here 0xD9 (-39dBm in two’s complement notation).

5 Functional description

The AMB8826/AMB9826 can be configured to operate in several modes at the physical, MAC as well as the network layer. This chapter describes all the available modes of operation.

5.1 Physical layer

At the physical layer, the AMB8826/AMB9826 can be configured to use one of the following radio profiles (see parameter `RADIO_DefaultRfProfile`). Radio profiles 3,4 are optimized to provide long range transmission whereas profiles 5,6 enable higher data rates.

	Radio profile	Data rate (gross) [kcps]	Modulation	Max packet size [bytes]
AMB8826:	**0**	**38.4**	**FSK**	**128**
	2	100	FSK	128
	3 (long range mode)	10 (=0.625 kbps net)	FSK (with FEC)	48
	4 (long range mode)	20 (=2.5 kbps net)	FSK (with FEC)	64
	5	400	GFSK	224
AMB9826:	**6**	**400**	**GFSK**	**224**

Additionally, the frequency channel of operation is configurable to avoid interference between several subnets of radio devices (see parameter `RADIO_DefaultRfChannel`).

The radio parameters need to be chosen for optimal performance based on the required range, data rate, maximum payload size, keeping in mind the compliance with valid regulatory requirements.

A detailed description for configuring these parameters could be found in chapter 8 and chapter 9.

5.2 MAC and network layer

5.2.1 Addressing modes

In order to interconnect several modules and build a network or to send data to specific devices, the AMB8826 / AMB9826 supports addressing at MAC and network levels. Based on the address mode of the module configured using the UserSetting `MAC_DefaultAddressMode`, each device can be configured with an address (1 or 2 byte) and a network id (1 byte) that is defined by the UserSettings `MAC_SourceAddr` and `MAC_SourceNetID` respectively.

Address mode	MAC address size [byte]	Network address size [byte]
0	0	0
1	1	0
2	1	1
3	2	1

Depending on the selected address mode up to 254 network IDs and up to 65534 addresses are supported.

Please note that the RF settings (e.g. RF profile, RF channel, address mode, repeater settings) must be the same for all nodes in the network.

Violation may cause interrupted transmission, or received packets that cannot to be interpreted correctly.

In addition, the timing parameters in case of repeater or enabled ACKs must be the same for all nodes in a network.

The address mode 3 (254 network ids and 65534 addresses) is only supported by the AMB8626 and AMB8826 / AMB9826.

Radio messages of devices that are using the same radio channel may interfere with each other leading to possible collisions and packet loss.

5.2.2 Unicast

A module can use the command `CMD_DATA_REQ` to send data to a pre-defined destination specified by the parameters `MAC_DefaultDestAddr` and `MAC_DefaultDestNetID`. Besides this, the command `CMD_DATAEX_REQ` triggers the data transmission to the address specified in the command (refer section 7.2.1).

5.2.3 Multicast/Broadcast

The destination address or destination network id of 0xFF (255) or 0xFFFF (65535) stands for a broadcast which will trigger any compatible receiver to interpret this frame to forward it to its host.

5.2.4 Acknowledgement and retries

In order to improve reliability in communication, the module can be configured to use radio acknowledgement and retry mechanism. It can be activated using the parameter, `MAC_NumRetrys` (refer section 8.2.6).

5.2.5 Packet sniffer mode

The address resolution can be disabled ("packet sniffer") by enabling the sniffer mode in the UserSetting `CfgFlags`. A module in sniffer mode will accept all data packets (ignoring the target address) and forward them to the serial interface. Furthermore, it does not send any acknowledgement and cannot work as repeater at the same time (see section 8.2.12).

5.2.6 Repeater mode and mesh network

The AMB8826 / AMB9826 module can be run as a repeater to artificially extend the range of sending devices in an existing network. A module configured as repeater, simply re-transmits the received packet after a random back off time. This mode allows options to build a flooding mesh network described in detail in chapter 12.

5.3 System configuration parameters

The parameters that determine the functionality of the module are classified into two categories.

The non-volatile UserSettings (see chapter 8) values that can be modified using the `CMD_SET_REQ` command retain their values after a power reset.

Please note that each `CMD_SET_REQ` will consume one flash erase/write cycle, which are limited due to the hardware (guaranteed are 100k cycles, see TI CC13x0 datasheet).

On the other hand, the volatile settings (called “RuntimeSettings”) can be accessed by explicit commands (see chapter 7.4) and used to quickly (but temporarily) modify specific parameters without using flash cycles. These settings are only valid until a reset is performed and shall be used when frequent updates of settings are necessary.

6 Host connection: Serial interface

6.1 UART

The configuration in factory state of the UART is 115200 baud with data format of 8 data bits, no parity and 1 stop bit ("8n1"). The baud rate of the UART can be configured by means of the UserSetting `UART_Baudrate`. The data format is fixed to 8n1.

The output of characters on the serial interface runs with secondary priority. For this reason, short interruptions may occur between the outputs of individual successive bytes. The host must not implement too strict timeouts between two bytes to be able to receive packets that have interruptions in between. Up to four full byte durations (32 bit) delay between two successive bytes shall be accepted by the host.

For the direction “host to module” the host must respect byte-wise the line /RTS, which will indicate that the next byte of the packet can be received by the module. This direction also accepts a pause of up to four full byte durations (32bit) delay between two successive bytes before discarding received content (without user notification).

7 The command interface

7.1 Overview

The AMB8826 / AMB9826 acts as a slave and can be fully controlled by an external host. 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 of the module.

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 module to perform a reset.
- Confirmations:
  On each request, the module answers with a confirmation 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 has occurred. The `CMD_DATAEX_IND` indicates for example that data was received via radio.

All commands must be sent in telegrams according to the format / structure described below. This command structure matches the structure of AMB8420, AMB8426 and AMB8626 for compatibility reasons.

Start signal	Command	Length	Payload	CS
0x02	**1 Byte**	**1 Byte**	**Length Byte**	**1 Byte**

Start signal: 0x02 (1 byte)

Command: One of the predefined commands (1 byte), the AMB8826 / AMB9826 implements new and modified commands in comparison to other radio compatible modules.

Length: Specifies the number of payload data in the following field.

Payload: Variable number (defined by the length field) of data or parameters.

Checksum: Byte wise XOR combination of all preceding bytes including the start signal, i.e. 0x02 ^ command ^ length ^ payload = CS

All commands of type Request must obey the following rules:

- Only one Request at a time may be active. Wait for Confirmation of the previous command and implement a suiting Timeout (depends on the command or action that was requested, 500ms should cover the worst-case time).
- Indications are spontaneous messages, they may occur in between a command request and its confirmation.
- A high /RTS line signalizes that the module UART is not ready for reception. Thus, any byte(s) sent will be discarded without user notification (“module busy”). If “module busy” occurs while sending a command to the module, it is necessary to resend this entire command again when /RTS shows “module idle” again.

7.2 Data transfer & reception in the command mode

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

7.2.1 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 (taken from the volatile RuntimeSettings). This command is especially suitable for transmission for a point-to-point connection.

The maximum number of payload data bytes depends on the chosen `RADIO_DefaultRfProfile` (see chapter 8.4.2). Most of the RF profiles allow 128Bytes and more.

Format:

Start signal	Command	Length	Payload	CS
0x02	**0x00**	**1 Byte**	**Length Byte**	**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, `MAC_DefaultAddressMode` is 0 or a broadcast address is set as destination address)

0x01: no ACK received within a timeout after using all `MAC_NumRetrys`

0xFF: invalid (payload too long)

7.2.2 CMD_DATAEX_REQ

This command serves data transfer in a network with several parties. Both the RF channel to use and the destination address (depending on the parameterised address mode) are specified along with the command.

The maximum number of payload data bytes depends on the chosen `RADIO_DefaultRfProfile` (see chapter 8.4.2). Most of the RF profiles allow 128Bytes and more.

The entered channel, destination network and destination address are loaded into the volatile RuntimeSettings und thus are kept until the system is reset or these values are modified again.

Please note that the format of this command depends on the configured `MAC_DefaultAddressMode`.

Address mode 0:

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

Address mode 1:

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

Address mode 2:

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

Address mode 3:

Start signal	Command	Length	Channel	Destination network id	Destination address	Payload	CS
0x02	**0x01**	Payload length + 4	**1 Byte**	**1 Byte**	**2 Byte** (LSB first)	**Payload length bytes**	**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, `MAC_DefaultAddressMode` is 0 or destination is a broadcast)

0x01: no ACK received within a timeout after using all `MAC_NumRetrys`

0x02: invalid channel selected

0xFF: invalid (payload too long)

7.2.3 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 given in two's complement notation), this telegram also displays the source address of the sending device (depending on the parameterised address mode).

Please note that the format of this command depends on the configured `MAC_DefaultAddressMode`.

Format in address mode 0:

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

Format in address mode 1:

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

Format in address mode 2:

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

Format in address mode 3:

Start signal	Command	Length	Sender network id	Sender address	Payload	Field strength	CS
0x02	**0x81**	Payload length + 4	**1 Byte**	**2 Byte** (LSB first)	**Payload length bytes**	**1 Byte**	**1 Byte**

7.2.4 CMD_REPEAT_IND

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

Format in address mode 0:

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

Format in address mode 1:

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

Format in address 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**

Format in address mode 3:

Start signal	Comm and	Length	Status	Address. mode	Dest. NetID	Dest. address	Source NetID	Source address	CS
0x02	**0x80**	**0x08**	**1 Byte**	**0x02**	**1 Byte**	**2 Byte** (LSB first)	**1 Byte**	**2 Byte** (LSB first)	**1 Byte**

Status:

0x00: OK

0x01: Failed

7.3 Requesting parameters, actions and events

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

7.3.1 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.

Format:

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

Response:

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

Status:

0x00: Request successfully received and processed

0x01: Request not successful

As soon as the module has restarted a `CMD_RESET_IND` is printed on the UART and the /RTS line will show “module idle”.

7.3.2 CMD_RESET_IND

This message indicates that the module has restarted. After the /RTS line is low and the start-up timeout has passed, the module is ready to receive UART data and radio frames.

Start signal	Command	Length	Mode	CS
0x02	**0x85**	**0x01**	**0x10**	**0x96**

7.3.3 CMD_SHUTDOWN_REQ

This command triggers the shutdown mode of the chip, which is the mode with lowest power consumption. The shutdown is performed after the command confirmation message is transmitted. The UART interface is disabled in shutdown mode.

Format:

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

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	**0x4E**	**0x01**	**1 Byte**	**1 Byte**

Status:

0x00: Request successfully received and processed

0x01: Request not successful

To wake-up from shutdown mode, a falling edge has to be applied to the WAKE-UP pin. In this case, the module restarts such that all volatile settings are lost. As soon as it has restarted a `CMD_RESET_IND` message (0x02 0x85 0x01 0x10 0x96) is printed on the UART.

Please note that in shutdown mode, the wake-up pin has an internal pull-down to ensure the wake-up is not performed accidentally due to a floating pin.

7.3.4 CMD_STANDBY_REQ

This command triggers the standby mode of the chip, a low power mode with RAM retention. The standby mode is entered after the command confirmation message is transmitted. The UART interface is disabled in standby mode.

The latency is smaller than the latency caused by a complete restart of the module as done in the shutdown mode.

Format:

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

Response:

Start signal	Command | 0x40	Length	Status	CS
0x02	**0x4F**	**0x01**	**1 Byte**	**1 Byte**

Status:

0x00: Request successfully received and processed

0x01: Request not successful

To wake-up from standby mode, a falling edge has to be applied to the wake-up pin. Please note that in standby mode, the wake-up pin has an internal pull-down to ensure the wake-up is not performed accidentally due to a floating pin.

When a falling edge is detected, the module wakes up but does not revert to factory settings as the RAM content is retained and all volatile settings are kept. Upon being idle again, a `CMD_STANDBY_IND` message is printed on the UART and the /RTS pin will show a low level.

7.3.5 CMD_STANDBY_IND

This message indicates that the module woke up from standby mode and is ready for operation.

Start signal	Command | 0x80	Length	Status	CS
0x02	**0x8F**	**0x01**	**0x00**	**0x8C**

Status:

0x00: wake-up successful

7.3.6 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. The current RSSI value of the radio IC (“live RSSI value”) cannot be requested by means of this command.

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:

Example: Conversion of the hexadecimal value in two’s complement notation to a decimal $RSSI_{dec}$

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

If the RSSI equals 0x80, there is currently no RSSI value available.

7.4 Modification of volatile parameters

This group contains all functions that will modify RuntimeSettings while the module is running. These settings are volatile and will be reset to their defaults (see UserSettings) on a reset of the module or after a shutdown command.

7.4.1 CMD_SET_PAPOWER_REQ

This command is used to set the RF TX-power. Unlike the UserSettings parameter `RADIO_DefaultRfTXPower`, this is a volatile runtime parameter, but it is handled in the same way. Thus, see section 8.2.3 for more information.

Caution: The parameter must be chosen with prudence to reach good functionality and compliance with valid regulatory requirements as the EN 300 220 in the European Union or the FCC in the United States of America.

The 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	Configured power	CS
0x02	**0x51**	**0x01**	**1 Byte**	**1 Byte**

Return for above example:

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

7.4.2 CMD_SET_CHANNEL_REQ

This command is used to select the radio channel. Unlike the UserSettings parameter `RADIO_DefaultRfChannel`, this is a volatile runtime parameter.

Caution: The parameter must be chosen with prudence to reach good functionality and compliance with valid regulatory requirements as the EN 300 220 in the European Union or the FCC in the United States of America.

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	Configured channel	CS
0x02	**0x46**	**0x01**	**1 Byte**	**1 Byte**

Return for above example:

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

7.4.3 CMD_SET_DESTNETID_REQ

This command serves to configure the destination network id in address mode 2 and 3. Unlike the UserSettings parameter `MAC_DefaultDestNetID`, 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: Request successfully received and processed

0x01: Request not successful

7.4.4 CMD_SET_DESTADDR_REQ

This command serves to configure the destination address in address modes 1, 2 and 3. Unlike the UserSettings parameter `MAC_DefaultDestAddr`, this is a volatile runtime parameter.

Format:

Mode 1 + 2:

Start signal	Command	Length	Destination address	CS
0x02	**0x08**	**0x01 or 0x02**	**1 byte or 2 byte**	**1 byte**

Return:

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

Status:

0x00: Request successfully received and processed

0x01: Request not successful

7.5 Modification of non-volatile parameters

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

7.5.1 CMD_SET_REQ

This command enables direct manipulation of the parameters in the module's non-volatile UserSettings. The respective parameters are accessed by means of the corresponding SettingsIndex that can be found in Table 7.

Parameters with size of two or more bytes have to be transferred with the LSB first unless otherwise specified.

The modified parameters only take effect after a restart of the module. This can be done by a `CMD_RESET_REQ` or using the /RESET pin.

Caution: The validity of the specified parameters is not verified. Incorrect values can result in device malfunction up to a scenario where the firmware of the module needs to be re-flashed to get it operating again!

Any use of `CMD_SET_REQ` will consume one flash erase/write cycle. Flash erase/write cycles are limited through hardware (guaranteed minimum 100k cycles). For

frequently changing parameters use the volatile parameters “RuntimeSettings”, see chapter 7.4.

To store the parameters in the flash memory of the module, the particular memory segment must be buffered into RAM, then to be erased 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 and the module can only be resurrected by means of the JTAG or Bootloader firmware update.
Recommended procedure: First verify the configuration of the module with `CMD_GET_REQ` and only apply a `CMD_SET_REQ` if required. Make sure the VCC is stable and no reset occur during this procedure.

Format:

Start signal	Command	Length	SettingsIndex	Parameter	CS
0x02	**0x09**	**1 Byte**	**1 Byte**	**(Length -1) bytes**	**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: Operation failed due to invalid parameter

7.5.2 CMD_GET_REQ

This command can be used to query the UserSettings parameters. The respective parameters are accessed by means of the corresponding SettingsIndex that can be found in Table 7.

Parameters with size of two or more bytes will be transmitted LSB first unless otherwise noted.

Format:

Start signal	Command	Length	SettingsIndex	CS
0x02	**0x0A**	**0x01**	**1 byte**	**1 byte**

Response:

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	**0x4A**	**1 byte**	**1 byte**	**(Length -1) bytes**	**1 byte**

Status:

0x00: Request successfully received and processed

0x01: Request not successful

7.5.3 CMD_FACTORY_RESET_REQ

This command restores the default UserSettings of the module. If this was successful, a software reset of the module is performed in addition.

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

7.6 Message overview

Start signal	CMD	Message name	Short description	Chapter
Requests				
0x02	0x00	CMD_DATA_REQ	Send data to configured address	7.2.1
0x02	0x01	CMD_DATAEX_REQ	Send data to specific address	7.2.1
0x02	0x05	CMD_RESET_REQ	Reset module	7.3.1
0x02	0x06	CMD_SET_CHANNEL_REQ	Change the RF channel	7.4.2
0x02	0x07	CMD_SET_DESTNETID_REQ	Set the destination network id	7.4.3
0x02	0x08	CMD_SET_DESTADDR_REQ	Set the destination address	7.4.4
0x02	0x09	CMD_SET_REQ	Change the UserSettings	7.5.1
0x02	0x0A	CMD_GET_REQ	Read the UserSettings	7.5.2
0x02	0x0D	CMD_RSSI_REQ	Request RSSI of last packet	7.3.6
0x02	0x0E	CMD_SHUTDOWN_REQ	Go to shutdown mode	7.3.3
0x02	0x0F	CMD_STANDBY_REQ	Go to standby mode	7.3.4
0x02	0x11	CMD_SET_PAPOWER_REQ	Change the RF TX power	7.4.1
0x02	0x12	CMD_FACTORY_RESET_REQ	Perform a factory reset	7.5.3
0x02	0x1F	Reserved	Reserved	n.a.
Confirmations				
0x02	0x40	CMD_DATA_CNF	Data has been sent	7.2.1
0x02	0x45	CMD_RESET_CNF	Reset request received	7.3.1
0x02	0x46	CMD_SET_CHANNEL_CNF	Channel has been updated	7.4.2
0x02	0x47	CMD_SET_DESTNETID_CNF	Destination network id has been updated	7.4.3
0x02	0x48	CMD_SET_DESTADDR_CNF	Destination address has been updated	7.4.4
0x02	0x49	CMD_SET_CNF	UserSettings have been updated	7.5.1
0x02	0x4A	CMD_GET_CNF	Return the requested UserSetting values	7.5.2
0x02	0x4D	CMD_RSSI_CNF	Return the requested RSSI value	7.3.6
0x02	0x4E	CMD_SHUTDOWN_CNF	Shutdown request received	7.3.3
0x02	0x4F	CMD_STANDBY_CNF	Standby request received	7.3.4
0x02	0x51	CMD_SET_PAPOWER_CNF	RF TX power has been updated	7.4.1
0x02	0x52	CMD_FACTORY_RESET_CNF	Factory reset request received	7.5.3
0x02	0x5F	Reserved	Reserved	n.a.
Indications				
0x02	0x80	CMD_REPEAT_IND	Data has been repeater	7.2.4
0x02	0x81	CMD_DATAEX_IND	Data has been received	7.2.3
0x02	0x85	CMD_RESET_IND	Reset has been applied	7.3.2
0x02	0x8F	CMD_STANDBY_IND	Woke up from standby mode	7.3.5

Table 2 Message overview

8 UserSettings – AMB8826 / AMB9826 configuration values

8.1 Difference between volatile and non-volatile settings

The so-called UserSettings are stored permanently into the internal flash of the module. At start-up, these UserSettings are loaded as start values into the volatile settings (“RuntimeSettings”). Some of the RuntimeSettings can be modified by special commands (see chapter 7.4).

These RuntimeSettings are lost and replaced by the UserSettings content when the module is restarted.

See chapters 7.4 and 7.5 for methods to change volatile and/or non-volatile settings.

The non-volatile UserSettings can be modified by means of specific commands in the configuration mode (`CMD_SET_REQ`) of the module. 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 given with a CMD_SET_REQ is not verified. Incorrect values can result in device malfunction and may even result in the need of re-flashing the entire module firmware!

8.2 Modifying the UserSettings

The following chapters will give examples for the modification for many parameters using the commands `CMD_SET_REQ` and `CMD_GET_REQ`.

The PC software ACC (version 3.4.2.5 or newer) can also be used to change non-volatile parameters.

8.2.1 UART_Baudrate: Configure the UART speed

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
0	`UART_Baudrate`	9600 – 921600	115200	read/write	4

The UserSetting `UART_Baudrate` is a 32 bit field that contains the symbol rate for the communication interface. The format for the value is LSB first.

After changing the baud rate using the CMD_SET_REQ the module restarts using the new baud rate. Thus, please do not forget to update the baud rate of the connected host to be able to use the module's UART further on.

8.2.1.1 Example 1

Set the baud rate of the module to 9600Baud (0x00002580) using the CMD_SET_REQ with SettingsIndex 0

Start signal	Command	Length	SettingsIndex	Parameter (4 byte)	CS
0x02	0x09	0x05	0x00	**0x80 0x25 0x00 0x00**	0xAB

Response CMD_SET_CNF: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.1.2 Example 2

Request the baud rate of the module using CMD_GET_REQ with SettingsIndex 0

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x00	0x09

Response CMD_GET_CNF: Successfully read out the baud rate 0x00002580 (9600) baud

Start signal	Command | 0x40	Length	Status	Parameter (4 byte)	CS
0x02	0x4A	0x05	0x00	**0x80 0x25 0x00 0x00**	0xE8

8.2.2 RADIO_DefaultRfProfile: Configure the RF-settings

	SettingsIndex	Designation	Permissible values	Default value	Permissions	Number of bytes
AMB8826:	1	RADIO_DefaultRfProfile	0,2,3,4,5	0	read/write	1
AMB9826:			6	6		

The UserSetting `RADIO_DefaultRfProfile` is an 8 bit field that addresses the applied RF configuration.

Caution: The parameter must be chosen with prudence to reach good functionality and compliance with valid regulatory requirements as the EN 300 220 in the European Union or the FCC in the United States of America.

After modification of the `RADIO_DefaultRfProfile`, please check whether the `RADIO_DefaultRfChannel` has to be updated too. Therefore, please refer to chapter 9.

	`RADIO_DefaultRfProfile`	Data rate (gross) [kcps]	Modulation	Max packet time for repeater mode [ms]	Max packet size [bytes]
AMB8826:	**0**	**38.4**	**FSK**	**40**	**128**
	2	100	FSK	20	128
	3 (long range mode)	10 (=0.625 kbps net)	FSK (with FEC)	1000	48
	4 (long range mode)	20 (=2.5 kbps net)	FSK (with FEC)	300	64
	5	400	GFSK	10	224
AMB9826:	**6**	**400**	**GFSK**	**10**	**224**

Due to the low data rate in radio profiles 3 and 4 the packet size is reduced. The maximum allowed packet duration is 1000ms respective 300ms. The receiver and sender will not accept larger packets.

To achieve the long range in profile 3 a high receiver sensitivity is needed and therefore a high frequency accuracy. For modules with hardware version 2.3 or newer (serial number 116.002001 or bigger), a temperature dependant compensation of the frequency is implemented for this profile to work properly over the whole temperature range of -40°C to 85°C.

The repeater mode (flooding mesh) is currently only supported in profiles 0, 2, 5 and 6.

8.2.2.1 Example 1

Set the RF profile to 0 using the `CMD_SET_REQ` with SettingsIndex 1

Start signal	Command	Length	SettingsIndex	Parameter	CS
0x02	0x09	0x02	0x01	**0x00**	0x08

Response `CMD_SET_CNF`: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.2.2 Example 2

Request the RF profile of the module using `CMD_GET_REQ` with SettingsIndex 1

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x01	0x08

Response `CMD_GET_CNF`: Successfully read out the RF profile as 2.

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	0x4A	0x02	0x00	**0x02**	0x48

8.2.3 RADIO_DefaultRfTXPower: Configure the RF TX-power

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
2	RADIO_DefaultRfTXPower	0 – 14	14	read/write	1

This UserSetting defines the RF output power of the module. The UserSettings parameter RADIO_DefaultRfTXPower is entered as a complement on two.

Caution: The user is responsible for adhering to the statutory regulations for the maximum power output when using this module.

8.2.3.1 Example 1

Set the TX power to 0 using the CMD_SET_REQ with SettingsIndex 2

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

Response CMD_SET_CNF: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.3.2 Example 2

Request the TX power of the module using CMD_GET_REQ with SettingsIndex 2

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x02	0x0B

Response CMD_GET_CNF: Successfully read out the TX power as 0 dBm.

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	0x4A	0x02	0x00	**0x00**	0x48

8.2.4 RADIO_DefaultRfChannel: Configure the RF channel

	Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
AMB8826:	3	RADIO_DefaultRfChannel	100 – 140	106	read/write	1
AMB9826:			201 – 251	226		

This UserSetting determines the wireless channel of the module to be used after a reset. The dependence between channel and frequency is as follows:

$$Channel_{RF} = \frac{Frequency_{RF} - 863.00MHz}{0.05MHz}$$

Check chapter 9 for more information.

Caution: The user is responsible for adhering to the statutory regulations for the frequency use when using this module.

8.2.4.1 Example 1

Set the RF channel to 110 (0x6E) using the CMD_SET_REQ with SettingsIndex 3

Start signal	Command	Length	SettingsIndex	Parameter	CS
0x02	0x09	0x02	0x03	**0x6E**	0x64

Response CMD_SET_CNF: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.4.2 Example 2

Request the RF channel of the module using CMD_GET_REQ with SettingsIndex 3

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x03	0x0A

Response CMD_GET_CNF: Successfully read out the RF channel as 0x6E (110).

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	0x4A	0x02	0x00	**0x6E**	0x24

8.2.5 MAC_DefaultAddressMode: Configure the address mode

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
4	MAC_DefaultAddressMode	0 – 3	0	read/write	1

This setting defines the address mode of the module. 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) of the receiver or
   - if the destination broadcast address 255 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) of the receiver or
   - if the destination broadcast address 255 and/or network broadcast id 255 was specified.

   A total of 4 bytes of address information are transmitted in the wireless telegram.

4. 2-bytes address (mode 3):

   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, MAC_SourceAddrLSB and MAC_SourceAddrMSB) of the receiver or
   - if the destination broadcast address 65535 and network broadcast id 255 was specified.

   A total of 6 bytes of address information are transmitted in the wireless telegram.

Caution: In address mode 0, the use of wireless acknowledgement will cause problems if several wireless modules are addressed simultaneously. Therefore, no ACK is requested when using address mode 0 or when having any broadcast address in the frame (destination net ID and/or destination address). The user shall also not set MAC_NumRetrys ≠ 0 in address mode 0.

The receiver and transmitter modules must always operate in the same address mode! Otherwise, the receiver cannot interpret the received data packet meaning that the packet is discarded!

8.2.5.1 Example 1

Set the address mode to 2 using the CMD_SET_REQ with SettingsIndex 4

Start signal	Command	Length	SettingsIndex	Parameter	CS
0x02	0x09	0x02	0x04	**0x02**	0x0F

Response CMD_SET_CNF: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.5.2 Example 2

Request the address mode of the module using CMD_GET_REQ with SettingsIndex 4

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x04	0x0D

Response CMD_GET_CNF: Successfully read out the address mode as 1.

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	0x4A	0x02	0x00	**0x01**	0x4B

8.2.6 MAC_NumRetrys: Configure the number of retries

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
6	MAC_NumRetrys	0 – 255	0	read/write	1

This UserSetting determines the maximum number of wireless transmission retries. If this parameter is set to a value other than zero, the receiver module will automatically be prompted to send a wireless acknowledgement (“ACK”). Please note that sending acknowledgements additionally increases the traffic and will have influence on the *duty-cycle*, which can be crucial for CE compliance.

If *EN 301 391* is applicable the value for `MAC_NumRetrys` should be 5 at most.

This parameter shall only be enabled (i.e. set to another value than 0) if the parameter address mode selects a value of 1, 2 or 3 and the customer has configured unique addresses for the entire network.

A use of broadcast messages (destination network ID and/or destination address) is not allowed when `MAC_NumRetrys` is set to any value not equal to 0.

8.2.6.1 Example 1

Set the retry number to 1 using the `CMD_SET_REQ` with SettingsIndex 6

Start signal	Command	Length	SettingsIndex	Parameter	CS
0x02	0x09	0x02	0x06	**0x01**	0x0E

Response `CMD_SET_CNF`: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.6.2 Example 2

Request the retry number of the module using `CMD_GET_REQ` with SettingsIndex 6

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x06	0x0F

Response `CMD_GET_CNF`: Successfully read out the retry number as 3.

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	0x4A	0x02	0x00	**0x03**	0x49

8.2.7 MAC_DefaultDestNetID: Configure the destination network id

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
7	MAC_DefaultDestNetID	0 – 255	255	read/write	1

This UserSetting specifies the default destination network ID, which is used in address modes 2 and 3. If the special broadcast id and the broadcast address are set to 255, the packets will be received by all network participants.

Its volatile RuntimeSettings can be modified with the command CMD_SET_DESTNETID_REQ at runtime.

8.2.7.1 Example 1

Set the default destination network id to 1 using the CMD_SET_REQ with SettingsIndex 7

Start signal	Command	Length	SettingsIndex	Parameter	CS
0x02	0x09	0x02	0x07	**0x01**	0x0F

Response CMD_SET_CNF: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.7.2 Example 2

Request the default destination network id of the module using CMD_GET_REQ with SettingsIndex 7

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x07	0x0E

Response CMD_GET_CNF: Successfully read out the default destination network id as 0.

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	0x4A	0x02	0x00	**0x00**	0x4A

8.2.8 MAC_DefaultDestAddr: Configure the destination address

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
8	MAC_DefaultDestAddr	0 – 65535	65535	read/write	1-2

This UserSetting specifiest destination address, which is used in address modes 1, 2 and 3. If a broadcast address (in addressmodes 1 and 2 255 or 65535 in address mode 3) is used, the packets will be received by all network participants or by participants in the same network id.

Its volatile RuntimeSettings can be modified with the command CMD_SET_DESTADDR_REQ at runtime.

8.2.8.1 Example 1

Set the default destination address to 1 using the CMD_SET_REQ with SettingsIndex 8. If only one-byte parameter size is used, the LSB is set to the value of the parameter and the MSB is automatically written to 0xFF.

Start signal	Command	Length	SettingsIndex	Parameter	CS
0x02	0x09	0x02	0x08	**0x01**	0x00

Response CMD_SET_CNF: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.8.2 Example 2

Set the default destination address to 256 (0x0100) using the CMD_SET_REQ with SettingsIndex 8. LSB = 0x00, MSB = 0x01. The MSB of the address is used in address mode 3, only. The 2-byte parameter field has the order LSB first.

Start signal	Command	Length	SettingsIndex	Parameter (2 byte)	CS
0x02	0x09	0x03	0x08	**0x00 0x01**	0x01

Response CMD_SET_CNF: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.8.3 Example 3

Request the default destination address of the module using `CMD_GET_REQ` with SettingsIndex 8.

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x08	0x01

Response `CMD_GET_CNF`: Successfully read out the default destination address as 0 (0x0000). The 2 byte parameter has the order LSB first. The return value of this SettingsIndex is always read as 2 byte parameter.

Start signal	Command | 0x40	Length	Status	Parameter (2 byte)	CS
0x02	0x4A	0x03	0x00	**0x00 0x00**	0x4B

8.2.9 MAC_SourceNetID: Configure the source network id

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
10	`MAC_SourceNetID`	0 – 254	0	read/write	1

This UserSetting specifies the source network id to be used in address modes 2 and 3. Setting the Source Net ID to Broadcast 255 is not allowed.

8.2.9.1 Example 1

Set the source network id to 1 using the `CMD_SET_REQ` with SettingsIndex 10

Start signal	Command	Length	SettingsIndex	Parameter	CS
0x02	0x09	0x02	0x0A	**0x01**	0x02

Response `CMD_SET_CNF`: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.9.2 Example 2

Request the source network id of the module using `CMD_GET_REQ` with SettingsIndex 10

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x0A	0x03

Response `CMD_GET_CNF`: Successfully read out the source network id as 2.

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	0x4A	0x02	0x00	**0x02**	0x48

8.2.10 MAC_SourceAddr: Configure the source address

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
11	`MAC_SourceAddr`	0 – 65534	0	read/write	1-2

This UserSetting specifies the source device address to be used in address modes 1, 2 and 3. The LSB corresponds to the first byte in “parameter” the MSB (if used) to the second byte.

The broadcast address 0xFF or 0xFFFF shall not be used for the source address (LSB, LSB+MSB) and source network id parameter.

8.2.10.1 Example 1

Set the source address to 1 (this will set the LSB to 0x01, the MSB is automatically set to 0xFF) using the `CMD_SET_REQ` with SettingsIndex 11.

Start signal	Command	Length	SettingsIndex	Parameter	CS
0x02	0x09	0x02	0x0B	**0x01**	0x03

Response `CMD_SET_CNF`: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.10.2 Example 2

Set the source address to 256 (LSB =0x00, MSB = 0x01) using the `CMD_SET_REQ` with SettingsIndex 11. The 2 byte parameter is to be used LSB first.

Start signal	Command	Length	SettingsIndex	Parameter (2 byte)	CS
0x02	0x09	0x03	0x0B	**0x00 0x01**	0x02

Response `CMD_SET_CNF`: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.10.3 Example 3

Request the source address of the module using `CMD_GET_REQ` with SettingsIndex 11

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x0B	0x02

Response `CMD_GET_CNF`: Successfully read out the source address as 2 (0x0002). The 2 byte parameter is to be used LSB first.

Start signal	Command | 0x40	Length	Status	Parameter (2 byte)	CS
0x02	0x4A	0x03	0x00	**0x02 0x00**	0x49

8.2.11 OpMode: Read the operating mode of the module

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
14	`OpMode`	16	16	read	1

The OpMode 0x10 (16) is indicating that the module is in Command mode. Currently no other OpMode is available.

8.2.11.1 Example 1

Read `OpMode` parameter value

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x0E	0x07

Response `CMD_GET_CNF`: Successfully read out that the OpMode is Command Mode (0x10).

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	0x4A	0x02	0x00	**0x10**	0x5A

8.2.12 CfgFlags: Configure the configuration flags of the module

This parameter is used for the general module configuration.

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
15	`CfgFlags`	See description	0	read/write	2

Repeater and sniffer mode cannot be enabled at the same time. A module configured as sniffer will not send any ACKs even if requested by the sender.

Bit no.	Description
0	Set this bit to 1 to enable the sniffer mode.
1 - 15	Reserved

Table 3 Configuration flags

8.2.12.1 Example 1

Read `CfgFlags` parameter value

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x0F	0x06

Response `CMD_GET_CNF`: Successfully read out the value of `CfgFlags`. The 2 byte parameter is to be used LSB first.

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	0x4A	0x03	0x00	**0x0000**	0x4B

A parameter value 0x0000 indicates that the sniffer mode is disabled.

8.2.12.2 Example 2

Enable the sniffer mode by setting the `CfgFlags` parameter value to 0x0001 using the `CMD_SET_REQ` with SettingsIndex 15. The 2 byte parameter is to be used LSB first.

Start signal	Command	Length	SettingsIndex	Parameter (2 byte)	CS
0x02	0x09	0x03	0x0F	**0x01 0x00**	0x06

Response `CMD_SET_CNF`: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.13 RpFlags: Configure the repeater flags of the module

This parameter is used for the repeater configuration. See chapter 12 for more information about the repeater mode.

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
16	`RpFlags`	See description	0	read/write	2

Repeater and sniffer mode cannot be enabled at the same time.

The Repeater function shall not be enabled in radio profiles 3 and 4.

Bit no.	Description
0	Set this bit to 1 to enable the repeater mode.
1 - 15	Reserved

Table 4 Repeater configuration flags

8.2.13.1 Example 1

Read `RpFlags` parameter value

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x10	0x19

Response `CMD_GET_CNF`: Successfully read out the value of `RpFlags`. The 2 byte parameter is to be used LSB first.

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	0x4A	0x03	0x00	**0x0000**	0x4B

A parameter value 0x0000 indicates that the repeater mode is disabled. A value of 0x0001 indicates that the repeater mode is enabled.

8.2.13.2 Example 2

Enable the repeater mode by setting the `RpFlags` parameter value to 0x0001 using the `CMD_SET_REQ` with SettingsIndex 16. The 2 byte parameter is to be used LSB first.

Start signal	Command	Length	SettingsIndex	Parameter (2 byte)	CS
0x02	0x09	0x03	0x10	**0x01 0x00**	0x19

Response `CMD_SET_CNF`: Successfully modified the setting.

Start signal	Command | 0x40	Length	Status	CS
0x02	0x49	0x01	0x00	0x4A

8.2.14 RP_NumSlots: Configure the repeater data base

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
17	`RP_NumSlots`	1-255	32	read/write	1

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 may collide on 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. Assume there are NumRP repeater devices in the range of a sending device, then the probability of 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 probability
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 5 Common settings of RP_NumSlots

In the example network shown in Figure 7, there are only two repeaters 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 to have a collision probability of less than 5%.

The time delay used by the repeater device can be determined as the time needed to send one packet (see 8.4.2) times a random number between one and RP_NumSlots.

Example:

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

8.2.14.1 Example 1

Read RP_NumSlots parameter value

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x11	0x18

Response CMD_GET_CNF: Successfully read out the value of RP_NumSlots.

Start signal	Command | 0x40	Length	Status	Parameter	CS
0x02	0x4A	0x02	0x00	**0x00**	0x4A

8.2.15 FactorySettings: Read out the factory settings

SettingsIndex	Designation	Permissible values	Default value	Permissions	Number of bytes
32	`FactorySettings`	-	-	read	8

This parameter defines the serial number of the module.

Byte no.	Description
3 : 0	Serial number: 3 byte ID (LSB first), 1 byte PID
6 : 4	Hardware version: Major , Minor, Patch
7	Frequency correction factor

Table 6 Factory settings

8.2.15.1 Example 1

Request the serial number of the module using `CMD_GET_REQ` with SettingsIndex 32

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x20	0x29

Response `CMD_GET_CNF`: Successfully read out the FactorySettings (8 byte). Checkout Table 6 for byte order of the sub-parameters.

Start signal	Command | 0x40	Length	Status	Parameter (8 byte)	CS
0x02	0x4A	0x09	0x00	**0x01 0x00 0x00** 0x74 **0x00 0x01 0x02** 0x00	0x36

Successfully returned the following factory settings, the order of the multi byte parameters was changed to MSB first to be converted into decimal numbers later:

- Serial number: 0x74.000001 (116.000001) with PID 0x74 (116) and SN 0x000001 (1)
- Hardware version 0x02 01 00 (2.1.0)

- Frequency correction factor of 0x00 (0)

8.2.16 FirmwareVersion: Read out the firmware version

Settings Index	Designation	Permissible values	Default value	Permissions	Number of bytes
33	FirmwareVersion	-	-	read	3

This parameter defines the version of the firmware currently running on the module.

8.2.16.1 Example 1

Request the firmware version of the module using CMD_GET_REQ with SettingsIndex 33

Start signal	Command	Length	SettingsIndex	CS
0x02	0x0A	0x01	0x21	0x28

Response CMD_GET_CNF: Successfully read out the firmware version as 2.0.0. The order inside the field “Parameter” is Patch, Minor, Major.

Start signal	Command | 0x40	Length	Status	Parameter (3 byte)	CS
0x02	0x4A	0x04	0x00	**0x00 0x00 0x02**	0x4E

8.3 Settings overview

Settings Index	Designation	Summary	Permissible values	Default value	Permissions	Number of bytes
0	UART_Baudrate	Baud rate of the UART [baud]	9600 – 921600	115200	read/write	4
1	RADIO_DefaultRfProfile	RF-settings of the module	AMB8826: 0, 2, 3, 4, 5 AMB9826: 6	AMB8826: 0 AMB9826: 6	read/write	1
2	RADIO_DefaultRfTXPower	TX-power of the module [dBm]	0 – 14	14	read/write	1
3	RADIO_DefaultRfChannel	RF-channel of the module	AMB8826: 100 – 140 AMB9826: 201 – 251	AMB8826: 106 AMB9826: 226	read/write	1
4	MAC_DefaultAddressMode	Mode used to device addressing	0 – 3	0	read/write	1
6	MAC_NumRetrys	Number of wireless retries	0 – 255	0	read/write	1
7	MAC_DefaultDestNetID	Default destination address	0 – 255	255	read/write	1
8	MAC_DefaultDestAddr	Default destination network ID	0 – 65535	65535	read/write	1-2
10	MAC_SourceNetID	Own network id	0 – 254	0	read/write	1
11	MAC_SourceAddr	Own address	0 – 65534	0	read/write	1-2

Settings Index	Designation	Summary	Permissible values	Default value	Permissions	Number of bytes
13	reserved	reserved	0	0	read/write	1
14	OpMode	Operation mode	16	16	read	1
15	CfgFlags	Configuration Flags	0 – 65535	0	read/write	2
16	RpFlags	Enable the repeater mode	0 – 65535	0	read/write	2
17	RP_NumSlots	Number of repeater slots in database	0 – 255	32	read/write	1
32	FactorySettings	Serial number and Hardware version of the module	-	-	read	8
33	FirmwareVersion	Firmware version	-	-	read	3

Table 7 Settings overview

9 Radio parameters

9.1 AMB8826

The default radio parameters of AMB8826 are determined by the values of `RADIO_DefaultRfProfile`, `RADIO_DefaultRfChannel` and `RADIO_DefaultRfTXPower` in the user settings. These non-volatile parameters can be modified using `CMD_SET_REQ` as described in chapter 8.To modify their volatile counterparts the commands `CMD_SET_PAPOWER_REQ` and `CMD_SET_CHANNEL_REQ` can be used.

Caution: The parameters must be chosen with prudence not only to ensure optimal functionality, but also in compliance to the appropriate regulatory requirements such as the EN 300 220 in the European Union.

AMB8826 module (both the PCB antenna and the external antenna versions) is pre-certified by mounting it on the AMB8826-EV board. However, conformance of the end-device to this certification depends on the radiated power. Among other factors, the radiated power depends on the selected antenna, the wiring to the antenna and the quality of the power supply. Thus, it is highly recommended that the end-device manufacturer verify the radiated power on the end application.

An important aspect to comply with the radio regulatory is to adhere to the requirements of the duty cycle. The duty cycle is the ratio expressed as a percentage of the cumulative duration of transmission T_{on_cum} within an observation time interval of T_{obs}. DC = (T_{on_cum} / T_{obs})$_{Fobs}$ on an observation bandwidth $F_{obs.}$ Unless otherwise specified, T_{obs} is 1 hour and the observation bandwidth F_{obs} is the operational frequency band.

There are no mechanisms for constraining the duty cycle in the firmware. The customer is fully responsible for the compliance of the duty cycle.

The frequency channels of the module can be selected from a 50 kHz grid. Not all channels are permissible, depending on the selected Profile, output power and antenna (RF profile, RF TX power and RF channel).

Depending on the chosen Profile the Channel Spacing declared in Table 8, chapter 9.1.1 has to be applied.

9.1.1 AMB8826 Channel assignment

Sub Band	Channel	Frequency MHz	Profile 3 ,4	Profile 0	Profile 2	Profile 5
	required channel spacing		50 kHz	100kHz	200kHz	600kHz
Band M 868 MHz – 868.6 MHz output power ≤14 dBm The whole band except for audio & video applications limited to 300 kHz duty cycle ≤ 1% or polite spectrum access	100	868.00	Band limit			
	101	868.05	M	M	-	-
	102	868.10	M	*	M	-
	103	868.15	M	M	*	-
	104	868.20	M	*	*	-
	105	868.25	M	M	*	-
	106	**868.30**	M	*	M	M
	107	868.35	M	M	*	-
	108	868.40	M	*	*	-
	109	868.45	M	M	*	-
	110	868.50	M	*	M	-
	111	868.55	M	M	-	-
	112	868.60	Band limit			
	113	868.65	Out of band			
Band N 868.7 MHz – 869.2 MHz output power ≤ 14 dBm The whole band except for audio & video applications limited to 300 kHz duty cycle ≤ 0,1% or polite spectrum access	114	868.70	Band limit			
	115	868.75	N	N	-	-
	116	868.80	N	*	*	-
	117	868.85	N	N	N	-
	118	868.90	N	*	*	-
	119	868.95	N	N	*	-
	120	869.00	N	*	*	-
	121	869.05	N	N	N	-
	122	869.10	N	*	*	-
	123	869.15	N	N	-	-
	124	869.20	Band limit			
	125	869.25	Out of band			
	126	869.30				
	127	869.35				
Band O / Band P 869.4 MHz – 869.65 MHz output power ≤ 14 dBm / output power ≤ 27 dBm duty cycle ≤ 0,1% or polite spectrum access / duty cycle ≤ 10% or polite spectrum access	128	869.40	Band limit			
	129	869.45	P	P	-	-
	130	869.50	P	*	P	-
	131	869.55	P	P	*	-
	132	869.60	P	*	-	-
	133	869.65	Band limit			
Band Q / Band R 867.9 MHz – 870 MHz output power ≤ 7 dBm / output power ≤ 14 dBm No duty cycle / duty cycle ≤ 1% or polite spectrum access	134	869.70	Band limit			
	135	869.75	Q / R	Q / R	-	-
	136	869.80	Q / R	*	Q / R	-
	137	869.85	Q / R	Q / R	*	-
	138	869.90	Q / R	*	*	-
	139	869.95	Q / R	Q / R	-	-
	140	870.00	Band limit			

Table 8 Channel assignment for AMB8826 according to the radio profiles

"M, N, P, Q, R" means that the channel is allowed corresponding to the appropriate EN 300 220 Operational Frequency Band requirements.

"-" means, that the channel is not allowed.

"*" means, that the channel in general is allowed, but the above mentioned channel spacing must be fulfilled. In general allowed means, that the occupied Channel fits into the appropriate Frequency Band and meets the requirement of Out of Band Emissions and Unwanted Emissions in the Spurious Domain.

9.2 AMB9826

9.2.1 AMB9826 Channel assignment

Band	Channel	Frequency MHz	Profile 6		Channel	Frequency MHz	Profile 6	
			Proposed channel grid 1	Proposed channel grid 2			Proposed channel grid 1	Proposed channel grid 2
902.000 MHz – 928.000 MHz	200	902			227	915.5		
	201	902.5			228	916		
	202	903			229	916.5		
	203	903.5			230	917		
	204	904			231	917.5		
	205	904.5			232	918		
	206	905			233	918.5		
	207	905.5			234	919		
	208	906			235	919.5		
	209	906.5			236	920		
	210	907			237	920.5		
	211	907.5			238	921		
	212	908			239	921.5		
	213	908.5			240	922		
	214	909			241	922.5		
	215	909.5			242	923		
	216	910			243	923.5		
	217	910.5			244	924		
	218	911			245	924.5		
	219	911.5			246	925		
	220	912			247	925.5		
	221	912.5			248	926		
	222	913			249	926.5		
	223	913.5			250	927		
	224	914			251	927.5		
	225	914.5			252	928		
	226	**915**						

Table 9 AMB9826 channel assignment

The AMB9826 meets the FCC §15.247 (a)(2) Systems using digital modulation techniques with minimum 6 dB bandwidth of 500 kHz. For this reason it is recommended to use every second channel.

10 Battery powered operation

For battery-powered operation, the AMB8826 / AMB9826 provides two sleep modes. Each mode can be entered by a specific command and left by applying a falling edge at the wake-up pin.

	Shutdown	Standby
Enter mode	By command CMD_SHUTDOWN_REQ	By command CMD_STANDBY_REQ
Typical current consumption [µA]	0.1	1.6
Wake-up trigger	Falling edge at the wake-up pin	
CPU wake-up time [ms]	see chapter 11.2.	see chapter 11.2.
Wake-up behaviour	The module restarts such that all volatile settings are lost.	RAM is retained and module just continues its operation
Wake-up message	CMD_RESET_IND message (0x02 0x85 0x01 0x10 0x96)	CMD_STANDBY_IND message (0x02 0x8F 0x01 0x00 0x8C)

11 Timing parameters

11.1 Reset behaviour

Following a reset, a CMD_RESET_IND and a stable low level on the /RTS pin signalizes that the module is ready for operation.

During restart the /RTS may be pulled for a short time (<100µs, see Figure 5) to GND level until it is configured by the application on the module.

11.1.1 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 100µs. After the pin is released, the module will reboot, indicate a CMD_RESET_IND. Please note that the selected UART baud rate will introduce a latency for transmitting the 5-byte packet at module start-up.

Recommended procedure: After the /RESET pin is released, wait for up to 2ms + UART transmission time for the CMD_RESET_IND packet (value is to be adopted for the selected UART baud rate) and for the stable low level on the /RTS pin.

11.1.2 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 (this includes sending a CMD_RESET_IND) automatically and can be used again. The volatile RuntimeSettings are reset to default. Therefore, the host needs to detect the start-up indication and implement reconfigure the module's volatile settings.

11.2 Latencies when leaving standby or shutdown

The indication `CMD_RESET_IND` or `CMD_STANDBY_IND` (5 bytes in total) are written before the /RTS pin is pulled back to low level. Therefore, the start-up time is dependent on the UART baud rate.

The time presented here was measured with the UART default setting of 115200 baud, 8n1.

11.2.1 Wake-up latency from standby

The wake-up time is 1.6 ms.

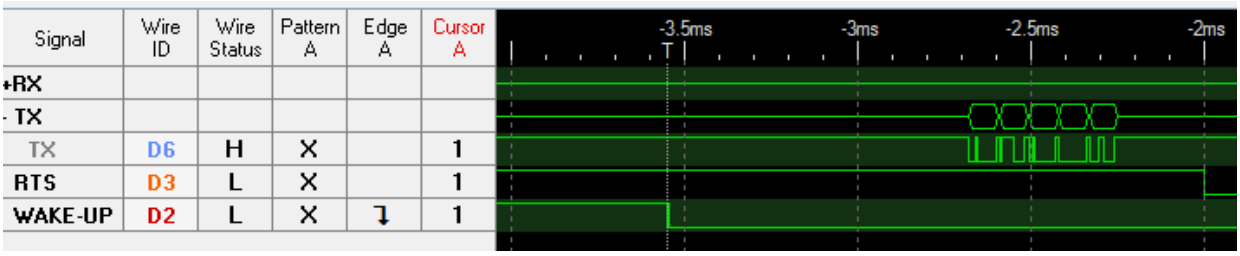


Figure 4 Wake-up from standby

11.2.2 Wake-up latency from shutdown

The wake-up time is 5ms.

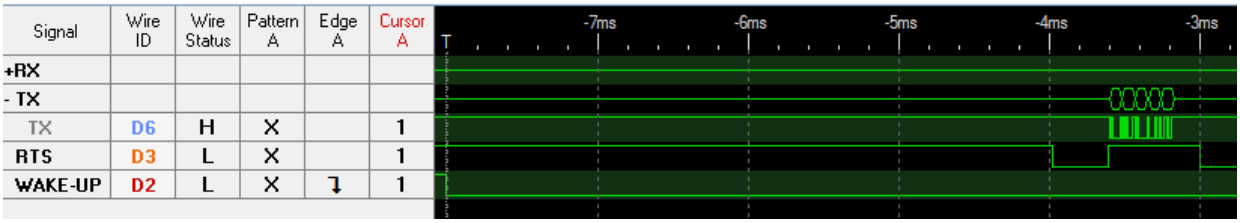


Figure 5 Wake-up from shutdown

11.3 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 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 every packet should not exceed 100ms. For slow data rates the packet size has to be reduced respectively when applying EN 301 391.

12 Flooding mesh: Using the repeater functionality

The AMB8826 / AMB9826 module can be run as a repeater to artificially extend the range of sending devices in an existing network.

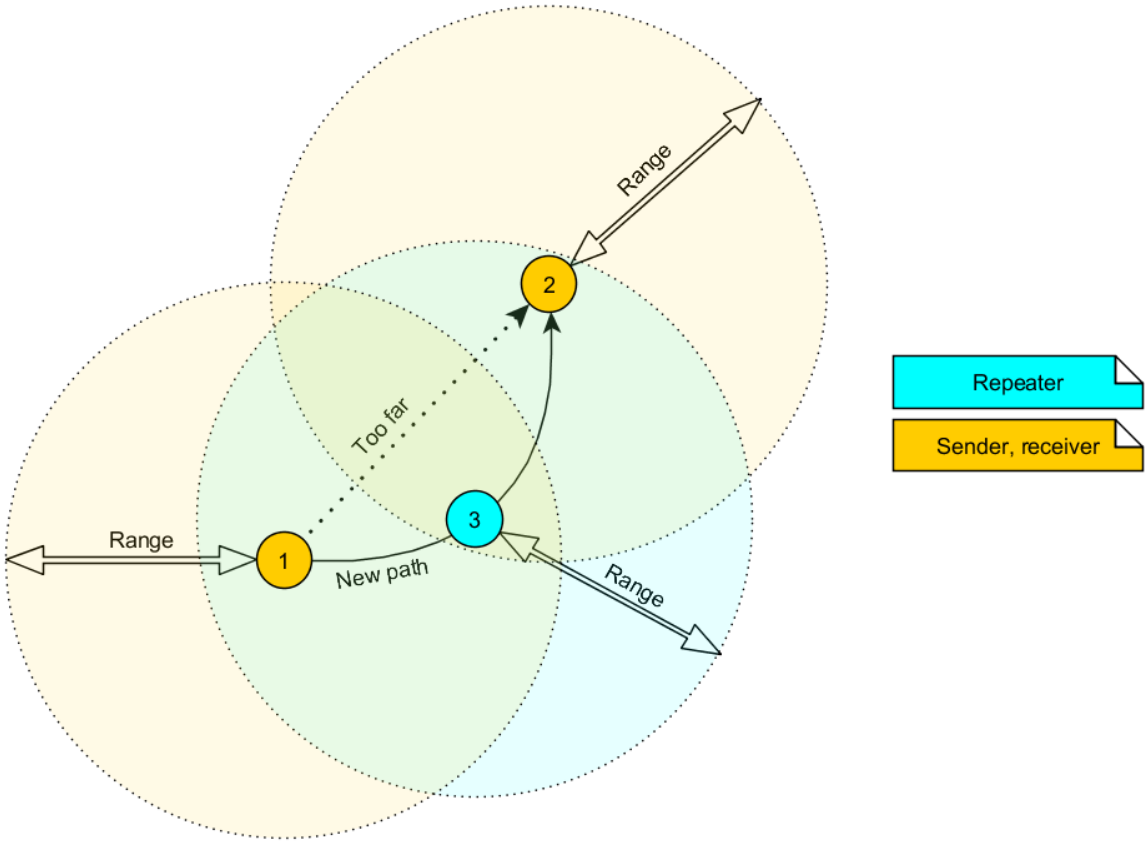


Figure 6 Range extension using several repeaters

If the module is configured as repeater, it can be simply added to existing wireless networks consisting of compatible modules. With this, the newly generated mesh 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 except the ones addressed to itself. Thereby a random delay 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, an AMB8826 / AMB9826 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 0 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.

If the AMB8826 / AMB9826 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 battery), 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 probability 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 `RADIO_DefaultRfProfile`, `RADIO_DefaultRfChannel` and `MAC_DefaultAddressMode`.

Information for the repeater device:

- The repeater module operates in command mode.
- Acknowledgements (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.
- Each time a packet has been repeated a `CMD_REPEAT_IND` is outputted 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 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 UserSetting `MAC_NumRetrys` must be set to 0.
- Every repeater sends each packet only once. However, 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

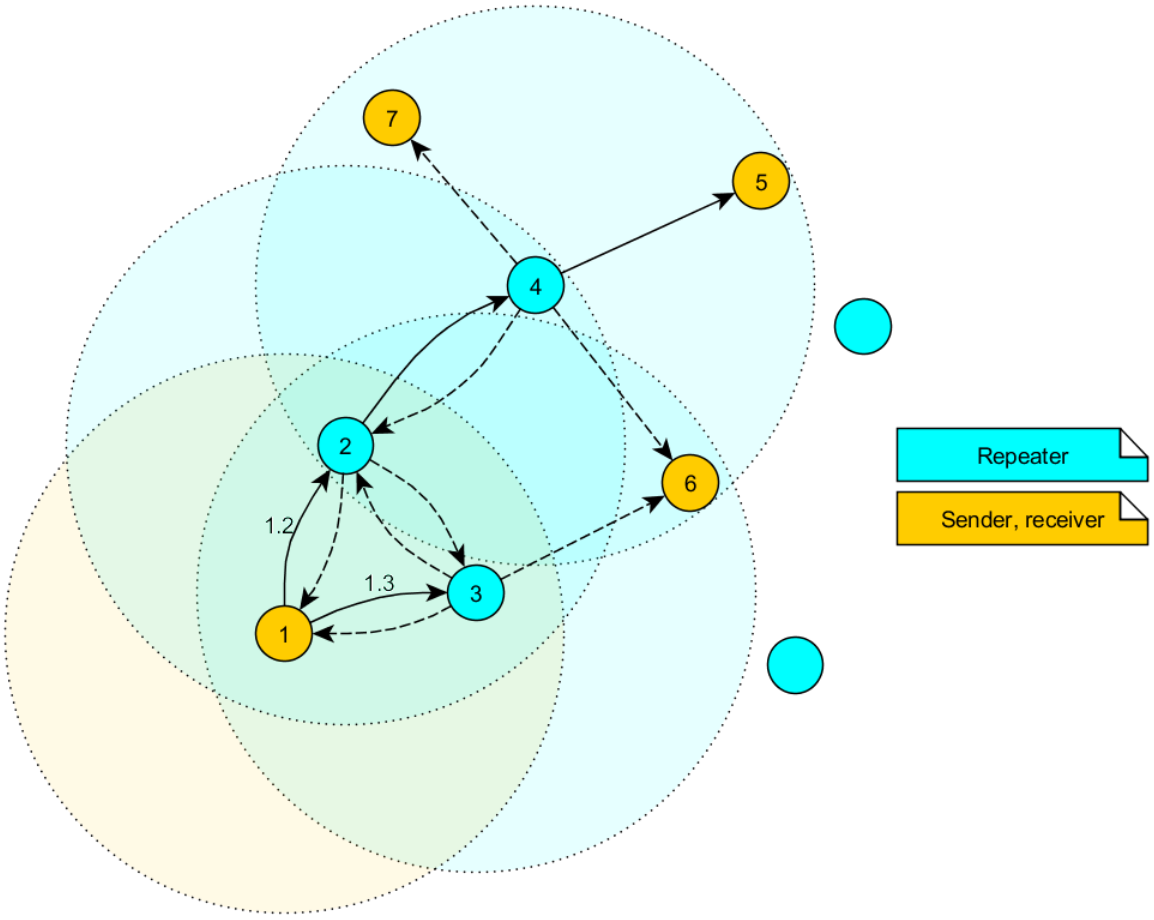


Figure 7 Example network

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)

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 8.4.14).

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 Using the long range mode in AMB8826

The AMB8826 provides several so called “long range modes” that allows to achieve ranges up to 10km. To enable any long range mode, the parameter `RADIO_DefaultRfProfile` must be set to an according value, see chapter 8.4.2 for more information.

To do so the `CMD_SET_REQ` can be used as it is in case of any other parameter. In this particular case, it looks as follows:

Format:

Start signal	Command	Length	SettingsIndex of the `RADIO_DefaultRfProfile`	Parameter value	CS
0x02	**0x09**	**0x02**	**0x01**	**0x03**	**0x0B**

Response in case of success:

Start signal	Command | 0x40	Length	Status	CS
0x02	**0x49**	**0x01**	**0x00**	**0x4A**

14 Firmware update

We highly recommend having the UART or JTAG accessible in any application to have the possibility to perform a firmware update.

Firmware updates can only be performed through this interfaces once a module is implemented into a customer PCB.

14.1 Update using UART0 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, AMB8826 / AMB9826 HW-V >= 2.2 support is added with version 3.4.2.5 whereas support for AMB8826 beta HW-V < 2.2 and firmware 1.x.x was removed) via the serial interface.

Therefore the module must be reset (`CMD_RESET_REQ` or /RESET pin) while holding the BOOT pin on a high level until the bootloader is active.

If the module is not directly connected to a PC, at least 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/converter is required for a PC connection (e.g. the FTDI TTL-323R-3V3 UART to USB converter).

Neither of the lines of the AMB8826 / AMB9826 is 5V compatible. Applying overvoltage to any pin may damage the hardware permanently (see chapter 2.2.1).

The pin BOOT must be connected to a high level (while and short after a reset) in order to start the bootloader. If the BOOT pin is connected to GND the application will start, so for normal operation the level on the BOOT pin must be pulled to GND (directly or using a pull-down with e.g. 1kΩ) to make sure the application is started.

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). The /RESET pin has an internal pull-up of 100 kΩ.

As an alternative, a host may implement the ARM / TI UART Bootloader according to CC1310 technical reference manual chapter 8. This option also needs the pins BOOT and /RESET to be switched to the needed levels and the pins UTXD and URXD for communication with the bootloader.

Never erase the entire chip. Some memory segments (such as CCFG and FactorySettings) must be retained if AMBER firmware shall be flashed onto the µC again.

In the case all flash segments were accidentally erased it is highly recommended to not flash an AMB8826 / AMB9826 firmware again onto the module. Missing, illegal or erased parameters/flash segments may lead to module malfunctions.

14.2 Update using JTAG

Using this interface option allows performing a fail-safe firmware update even in case of a broken firmware or misconfiguration.

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

- Flash adapter for Cortex M µC (supporting TI CC1310)
  Caution: not every adapter supports the used connection methods. Recommended adapters are: “Segger J-Flash” and “TI XDS110v3”
- Flasher software according to the used flasher adapter
- /RESET, GND and VCC are needed for the JTAG connection
- JTAG connection is supported through the module’s Pads i1 to i4

The manual of the EV-Board gives an example of a JTAG connection with a 2*10 pin (2.54mm pitch) connector for the ARM Cortex M Platforms.

Never erase the entire chip. Some memory segments (such as CCFG and FactorySettings) must be retained if AMBER firmware shall be flashed onto the µC again.

Missing, illegal or erased parameters/flash segments may lead to module malfunctions when AMBER firmware is used.

15 AMB8826 compatibility to existing proprietary modules

Under certain conditions and settings, the AMB8826 is radio compatible to AMB8626, AMB8426, AMB8420 and their related USB dongles AMB8665, AMB8465.

To allow interoperability check the following settings:

- AMB8626/AMB8665 firmware must be of version 3.4.5 or later, AMB8426/65 firmware must be 1.2.4 or later
- RF profiles / RF settings:

  RF-profile 0 (38.4 kBaud) and RF-profile 2 (100 kBaud) are compatible to existing modules. The remaining profiles are for AMB8826 usage only.
- Address mode:

  Existing modules only support address mode 0, 1, some may also support address mode 2.
- `MAC_DefaultDestAddr` and `MAC_DefaultNetID` are set to the corresponding Broadcast Addresses (255 and/or 65535), so a CMD_DATA_REQ after a reset in any MAC_DefaultAddressMode will result in a Broadcast frame. The “old” modules have selected 0 as default destination Address and NetID
- User data size:

  Existing modules only support up to 120 bytes user data, some may also support up to 128 bytes payload.
- Timings:

  Some timings of existing modules (ACK timeouts with retries) may need adjustment, see chapter 2.1.
- Pinout:

  The pinout for basic functionality is kept the same as AMB8626 and AMB8426. Thus, UART_RX, UART_TX and RTS, /RESET, GND, VCC and LED’s remain on the same pads. Nevertheless, the AMB8826 requires further pins to operate: those pins are “BOOT” and “WAKE-UP” .
- Operation mode:

  The AMB8826 only supports Command Mode using the same command structure as known from previous products but different commands (e.g. `CMD_SET_REQ` and `CMD_GET_REQ` structures were changed for better usability). The transparent mode is not available on AMB8826.
- UART:

  The AMB8826 uses 115200 baud 8n1 instead of 9600 baud 8n1 as factory default for the UART. Users can change this setting to 9600 Baud using the `CMD_SET_REQ` command.
- Low power mode:

  AMB8826 will enable low power modes on UART commands `CMD_STANDBY_REQ` and `CMD_SHUTDOWN_REQ`. In low power mode, the UART is disabled and a wake-up can be triggered by using the wake-up pin accordingly. The low power modes cannot be enabled by my means of a pin.

15.1 Restrictions

AMB8626/AMB8665:

- To successfully transmit ACKs from an AMB8826 to an AMB8626/AMB8665 the parameter `MAC_AckTimeout` of the AMB8626/AMB8665 must be set to a value of 20ms.

  Furthermore, the firmware of the AMB8626/AMB8665 must be of version 3.4.5 or newer.

  When using an older firmware version for AMB8626/AMB8665 a network consisting of AMB8826 and AMB8626/AMB8665 does not support ACKs and `RADIO_DefaultRfProfile` 2 may lead to reduced transmission quality.

AMB8426/AMB8465, AMB8420:

- To successfully transmit ACKs from an AMB8826 to an AMB8426/AMB8465 the parameter `MAC_AckTimeout` of the AMB8426/AMB8465 must be set to a value of 20ms.

Furthermore, the firmware of the AMB8426/AMB8465 must be of version 1.2.4 or newer.

16 Firmware history

Version 1.x.x

- Status “Engineering” of firmware
- For AMB8826 HW-V <= 2.1 “Engineering” only

Version 2.0.0 Beta

- Status “Engineering” of firmware
- For AMB8826 HW-V = 2.2 “Engineering” only
- Known issues:
    - This is not the final release! Major changes will occur until release.
    - FactorySettings and UserSettings location is not on the final Address, yet
    - An update from firmware version 1.0.0 to version 2.0.0 Beta is not possible due to the HW differences

Version 2.0.0

- For CC1310 Revision B only
- For AMB8826 HW-Version = 2.2 “Engineering” and 2.3 “Release”
- Status “Release” firmware
- New additional radio profiles for AMB8826/65 (4, 5)
- Added temperature dependant frequency compensation for radio profile 3
- Sniffer mode can be enabled using the `CfgFlags`
    - Removed UserSetting `RADIO_SnifferModeEnabled`
- Known issues:
    - TI-RTOS: Additional latencies up to 5ms due to task priorities may occur
    - An update from firmware version 1.0.0 to version 2.0.0 is not possible due to the HW differences
    - Works with reservations on AMB8826 HW-V 2.2. You are advised to not use Profile 3 with AMB8826 HW-V 2.2 and firmware 2.0.0 as the temperature compensation is selected for HW-V 2.3

Version 2.x.x

- Not used pins are pulled to low level.
- Known issues:
    - TI-RTOS: Additional latencies up to 5ms due to task priorities may occur
    - An update from firmware version 1.0.0 to version 2.x.x is not possible due to the HW differences
    - Works with reservations on AMB8826 HW-V 2.2. You are advised to not use radio profile 3 with AMB8826 HW-V 2.2 and firmware 2.0.0 as the temperature compensation is selected for HW-V 2.3

17 Hardware integration

17.1 Footprint and dimensions

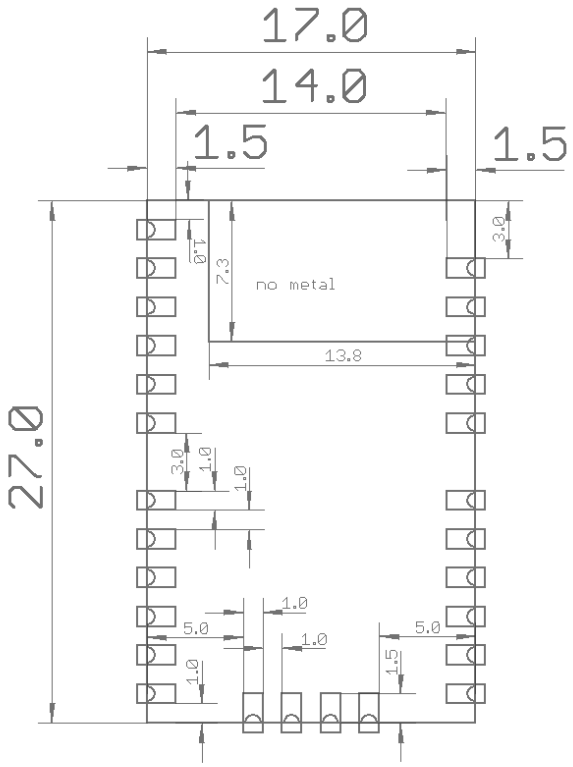


Figure 8: Footprint and dimensions for the AMB8826 / AMB9826, [mm]

The following points have to be considered:

- To avoid the risk of short circuits, a minimum clearance of at least 14 mm between the opposing pad rows has to be maintained! No Routing on the top layer of a carrier PCB (i.e. “under” the module) shall be performed.
- For the AMB8826 / AMB9826 variant with integrated antenna the marked corner area of 7.3 x 13.8 mm has to be kept free from metal, on any layer.
- The four bottom side pads are optionally for the firmware update using JTAG can be left open when JTAG update is not needed in the customer’s application.
- This footprint is also compatible to AMB8626, AMB8426, AMB4426 and AMB3626.

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.
- The antenna path should be kept as short as possible.

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

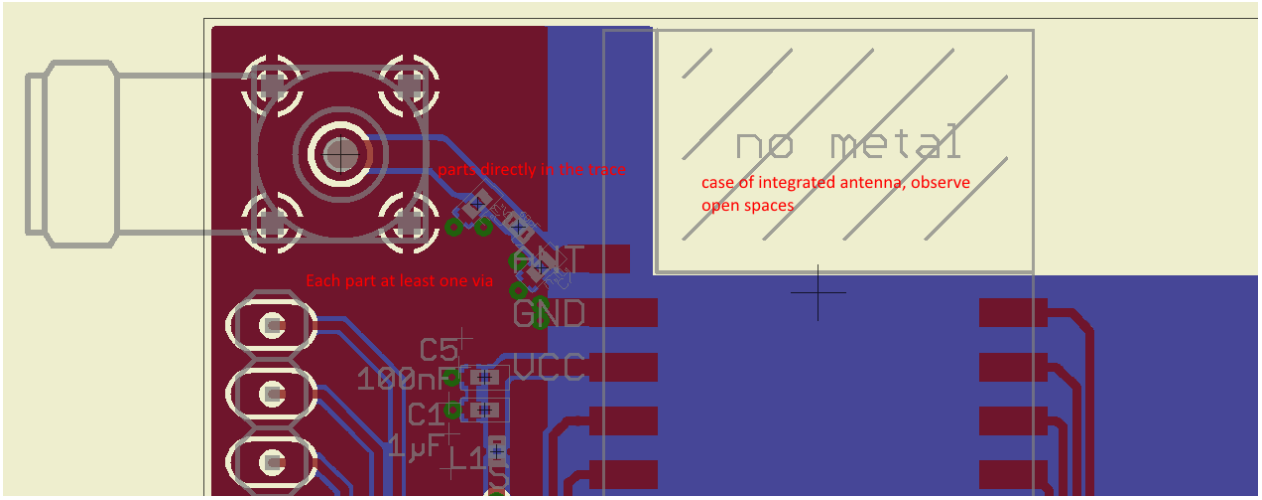


Figure 9: Layout

- 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 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.

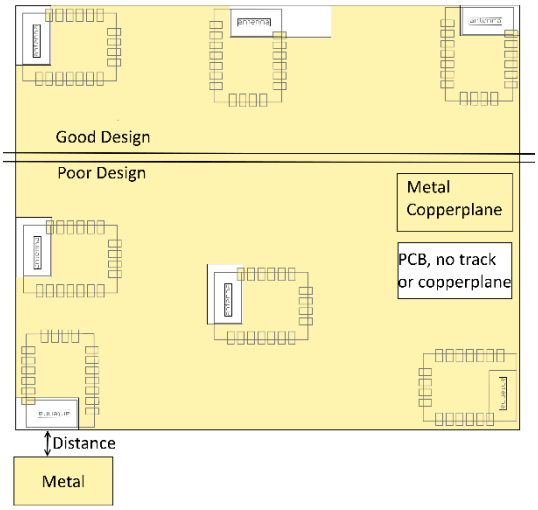


Figure 10 Placement of the module with integrated antenna

18.2 Dimensioning of the 50 Ohm micro strip

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

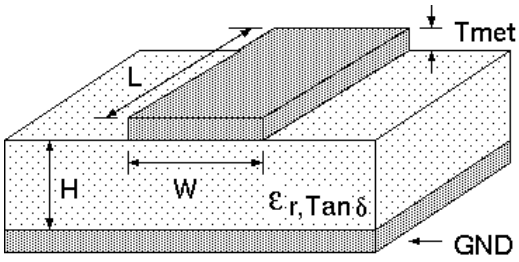


Figure 11 Dimensioning the antenna feed line as micro strip

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 micro strip 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 micro strip 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.

18.3.4 Antennas provided by AMBER

18.3.4.1 AMB1981 – 868 MHz dipole antenna

Ideally suited for applications where no ground plane is available.

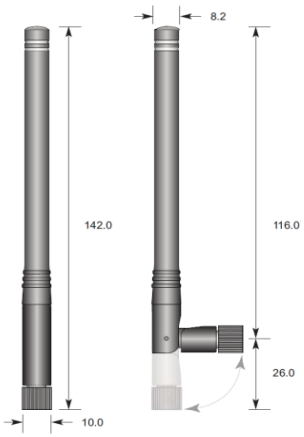


Figure 12 AMB1981:
868 MHz dipole-antenna

The AMB1981 antenna can be also used for 902MHz – 928MHz range.

18.3.4.2 AMB1982 – 868 MHz magnetic base antenna

Well suited for applications where the RF is lead through a metal wall that could serve as ground plane to the antenna.

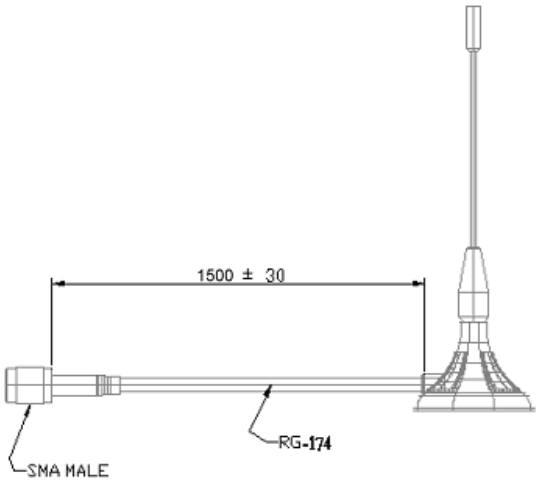


Figure 13 AMB1982: 868 MHz magnet foot antenna with 1.5 m antenna cable

The AMB1982 is a kind of Lambda/4 radiator and therefore needs a ground plane at the feeding point.

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

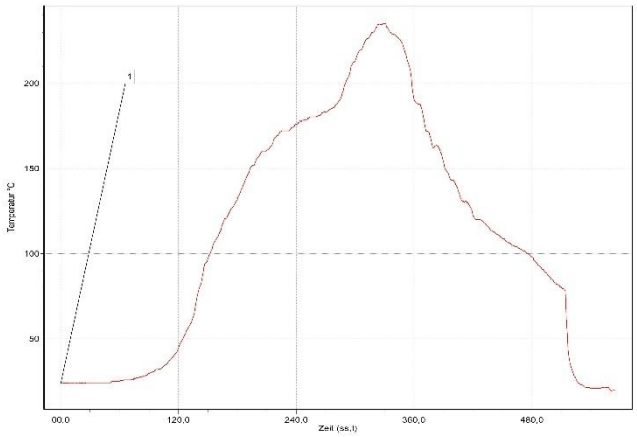


Figure 14 Example of a temperature profile

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 pads of the module to the base board, even if they are not used for the application.

Caution! ESD sensitive device.

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

Caution! This assembly contains moisture sensitive components.

Care 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 fed from a limited power source according to clause 2.5 of EN 60950-1.

20 References

[1] „CC1310 SimpleLink™ Ultralow Power Sub-1-GHz Wireless MCU”, Texas Instruments

[2] “CC13xx, CC26xx SimpleLink Wireless MCU Technical Reference Manual”, Texas Instruments

[3] „CC1310 SimpleLink Wireless MCU Silicon Errata“, Texas Instruments

[4] „AMB8826 Datasheet”, AMBER wireless GmbH

[5] “AMB8926 Datasheet”, AMBER wireless GmbH

21 Regulatory compliance information

21.1 Important notice

The use of RF frequencies is limited by national regulations. The AMB8826 has been designed to comply with the R&TTE directive 1999/5/EC of the European Union (EU).

The AMB8826 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, frequency or maximum allowed RF power) may apply.

Conformity assessment of the final product

The AMB8826 is a subassembly. It is designed to be embedded into other products (products incorporating the AMB8826 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 AMB8826 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.

21.1.1 FCC Compliance statement AMB9826 & AMB9826-1

FCC ID: R7TAMB9826

This device complies with Part 15 of the FCC Rules.

Operation is subject to the following two conditions:

(1) this device may not cause harmful interference, and

(2) this device must accept any interference received, including interference that may cause undesired operation.

(FCC 15.19)

Modifications (FCC 15.21)

Caution: Changes or modifications for this equipment not expressly approved by AMBER wireless may void the FCC authorization to operate this equipment.

21.1.2 IC Compliance statement AMB9826 & AMB9826-1

Certification Number: 5136A- AMB9826

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

21.1.3 FCC and IC Requirements to OEM integrators

This module has been granted modular approval. OEM integrators for host products may use the module in their final products without additional FCC / IC (Industry Canada) certification if they meet the following conditions. Otherwise, additional FCC / IC approvals must be obtained.

The host product with the module installed must be evaluated for simultaneous transmission requirements.

- The users manual for the host product must clearly indicate the operating requirements and conditions that must be observed to ensure compliance with current FCC / IC RF exposure guidelines.
- To comply with FCC / IC regulations limiting both maximum RF output power and human exposure to RF radiation, the maximum antenna gain including cable loss in a mobile-only exposure condition must not exceed 2dBi.
- A label must be affixed to the outside of the host product with the following statements:

This device contains FCCID: R7TAMB9826

This equipment contains equipment certified under ICID: 5136A-AMB9826

The final host / module combination may also need to be evaluated against the FCC Part 15B criteria for unintentional radiators in order to be properly authorized for operation as a Part 15 digital device.

If the final host / module combination is intended for use as a portable device (see classifications below) the host manufacturer is responsible for separate approvals for the SAR requirements from FCC Part 2.1093 and RSS-102.

OEM Requirements:

The OEM must ensure that the following conditions are met.

- End users of products, which contain the module, must not have the ability to alter the firmware that governs the operation of the module. The agency grant is valid only when the module is incorporated into a final product by OEM integrators.
- The end-user must not be provided with instructions to remove, adjust or install the module.
- The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the final product. Attaching a label to a removable portion of the final product, such as a battery cover, is not permitted.

The label must include the following text:

Contains FCC ID: R7TAMB9826

The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to

the following two conditions: (i.) this device may not cause harmful interference and

(ii.) this device must accept any interference received, including interference that may cause undesired operation.

When the device is so small or for such use that it is not practicable to place the statement above on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

The user manual for the end product must also contain the text given above.

- Changes or modifications not expressly approved could void the user's authority to operate the equipment.
- The OEM must ensure that timing requirements according to 47 CFR 15.231(a-c) are met.
- The OEM must sign the OEM Modular Approval Agreement with xxxxx
- The module must be used with only the following approved antenna(s).

21.1.4 AMB9826 & AMB9826-1

The module variants HVIN AMB9826 and AMB9826-1 collected in the PMN AMB9826 are identicall in enclosure, appearance, PCB design and bands/technologies.

The only difference is, that in AMB9826 an integrated Chip Antenna is used and for the AMB9826-1 an external λ/4 Antenna is used.

22 Important information

22.1 Exclusion of liability

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