Annex acc. to FCC Title 47 CFR Part 15
relating to
AMBER wireless GmbH
AMB9626

Annex no. 5
User Manual
Functional Description

Title 47 - Telecommunication
Part 15 - Radio Frequency Devices
Subpart C – Intentional Radiators
ANSI C63.4-2014
ANSI C63.10-2013

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Manual AMB9626

Release 1.5

SW-V1.1.0

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Abbreviations and abstract

ACK	Acknowledgement	Acknowledgement pattern confirming the reception of the transmitted data package
CS	Checksum	Checksum of the respective hex array
DC	Duty cycle	Relative frequency reservation period
LPM	Low power mode	Operation mode for efficient power consumption, suited for battery powered devices
RF	Radio frequency	Describes everything relating to the wireless transmission or reception
PL	Payload	The real, non-redundant information in a frame/packet
US	User settings	Any relation to a specific entry in the user settings is marked in a special font and can be found in the respective chapter
UART	Universal Asynchronous Receiver Transmitter	This function allows the Host to communicate with the module over a specified interface.
DC	Duty cycle	Transmission time in relation of one hour e.g. 1% means, channel is occupied for 36 seconds per hour, 0.1% means 3.6 seconds per hour.
[HEX] 0xhh	Hexadecimal	All numbers beginning with 0x are stated as hexadecimal numbers. All other numbers are decimal.

1 Summary

The AMB9626 module was designed as a radio sub module for wireless communication between devices such as control systems, remote controls, sensors etc. It offers several addressing modes and relieves the host system of radio-specific tasks such as

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

A device AMB9665 (USB-dongle with SMA antenna connector) is also available. The AMB9626-EV is suitable for evaluation purposes.

They can be deployed wherever the wireless exchange of small data packets (up to 120 bytes) between two or more parties is required.

A serial interface (UART) whose data rate and format can be adjusted flexibly is available for communicating with the host system.

The AMB9626 is compatible to the AMB8626 footprint.

The concept of parameters that define behaviour on UART and radio introduces two types of parameters one called RuntimeSettings that are volatile and will be reinitialized with each reset of the module. One called user settings that are no-volatile which are used to initialize the RuntimeSettings on reset. So for frequent parameter changes the RuntimeSettings shall be used whereas for static settings the user settings shall be used. Later chapters will show how the parameters can be accessed by the host.

The 915 MHz band is restricted in the EU and the modules must therefore not be used where the EU regulatories are applicable.

In those countries the frequency range may be allocated to other applications e.g. to cell phones (GSM, GSM-R).

Please consult your local administration if the 902 to 928 MHz band is free to use for you before buying this product.

2 Electrical parameters

For a full overview see AMB9626 datasheet.

2.1 Input voltage

Description	min	typ	max	unit
Supply voltage	2.0	2.5	3.6	V

2.2 Power consumption

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

3 Dimensions and weight

Dimensions	17 x 27 mm
Weight	3 g

4 Pinout

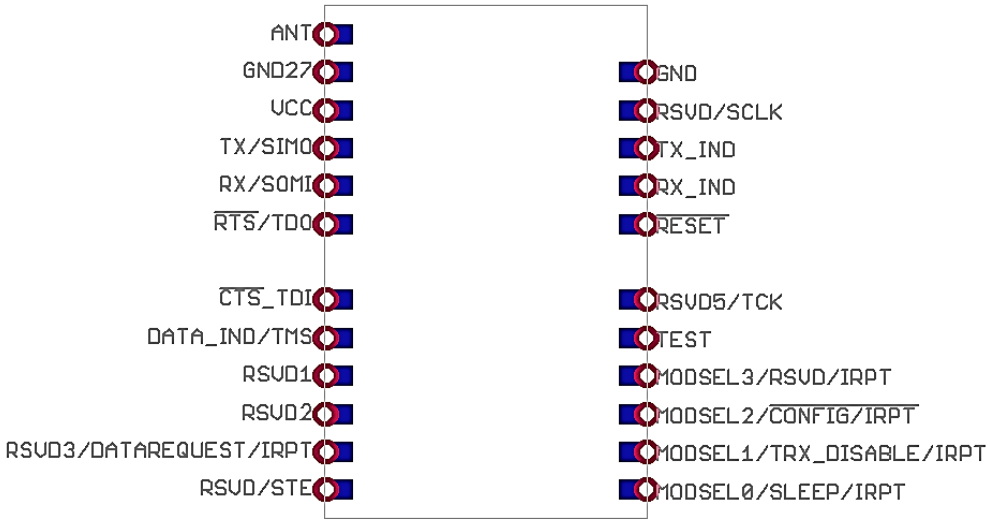


Figure 1 Pinout

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

Designation	I/O	Description
/DATA_REQUEST	Input	Prompts the wireless transmission, falling edge. As long as no new data is received via UART or wireless transmission, the buffer content remains valid and can be resent by means of a new signal. If the function of this pin is enabled (see chapter 9.3.18), this pin has an internal pull-up resistor. **If the pin function is disabled and the pin is not needed, connect it to the GND.** **Without function in the command mode.**
/RTS	Output	Ready to send, active low. Signalizes a busy UART buffer. When Set, no more bytes will be accepted over UART.
/CTS	Input	Clear To Send, active low. Can be used to signalize to the AMB9626 that the connected host's buffer is busy.
/DATA_INDICATE	Output	Packet received, active low. Goes low as soon as a valid packet with correct address is received via radio and remains low as long as the output via UART continues. Can be used to prepare a "sleeping" host system for the output of data. The delay between the falling edge and the start of transmission via UART can be configured with `UART_DIDelay`.
TX_INDICATE / RX_INDICATE	Output	Shows radio activity, active high.
RESERVED		Reserved for currently not implemented functions e.g. SPI. **Do not connect**.
TEST	JTAG	For JTAG / SPY-Bi-Wire. **Do not connect**.

Table 1 Pinout

5 Start-up and minimal configuration

5.1 Minimal configuration

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

If the module has to be connected to a PC, an adaptor (TTL to RS-232 or TTL to USB) has to be used. The AMB9626-EV is suited for this.

In the default configuration all module inputs (TRX_DISABLE and /CONFIG) are activated and must be connected as shown in Table 1. If the function of the /DATA_REQUEST pin is enabled (see chapter 9.3.18), this pin has an internal pull-up resistor.

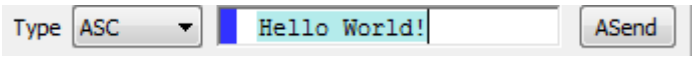
If TRX_DISABLE is used by the host it must be set to GND during start-up / after reset till the module's start-up is completed. The module will wait for this pin to go to GND level before finishing its start-up procedure. The module's UART or function pins (such as /CONFIG) will not be available until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

5.2 Sending & Receiving: "Hello World"

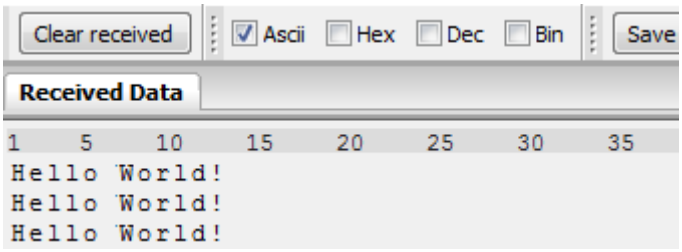
Connect your pair of modules, EV-boards or USB-sticks with the PC as explained in chapter 5.1. Please make sure you have a minimum distance of 3 meters between the two modules or devices to avoid over modulation. The module's firmware is very sensitive to over modulation due to the active channel detection algorithm that is used due to the need for frequency hopping. When short distances are needed, you could reduce the `PAPower` to a minimum.

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

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



This data will be received by the second module and shows up as received data in the second hterm instance. You may send any string of size 1 to 120 characters from one module to the other.



You just used the so called “transparent mode” of the modules to send your data. The address mode that was used is “0”. Thus all radio frames are broadcasts that can be received by anyone listening with an AMB9626 in default settings. The frame you send was generated using the timeout method.

Due to the frequency hopping that is needed for 915 MHz FCC compliance, the amount of data that can be send and received per time is limited. A minimum delay of 100ms between 2 frames shall be implemented.

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

5.3 Adopting parameters to fit your application

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

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

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

5.4 Deployment of several modules, use of addresses

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

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

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

In command mode, the command CMD_DATAEX_REQ, that has the destination address as an own parameter, can be used to send your data to the specified address. A broadcast message

can still be achieved when using 0xFF (255) for both destination address LSB and destination net ID.

6 Host Connection: Serial interface

6.1 UART

6.1.1 Supported data rates and data formats

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

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

The default baud rate of the AMB9626 is 9600 baud.

The output of characters on the serial interface takes place with secondary priority. For this reason, short interruptions may occur *between* the output of individual characters.

The following data formats are supported:

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

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

7 Modes

7.1 Operating modes

The AMB9626 can be used in the following operating modes:

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

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

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

7.1.1 Switching from transparent to command mode

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

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

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

7.1.2 Switching from command to transparent mode

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

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

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

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

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

7.1.3 Transparent mode

In this mode, data is received via the serial interface and initially buffered. As soon as a specific condition is met, the RF telegram is generated with a preamble, checksum, and address information (optional). The condition of your choice can be determined by the user setting `UART_PktMode`.

To initiate a RF transmission several options are available (see Table 2).

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

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

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

Table 2 Communication in transparent mode

The `UART_PktMode` parameter (see 9.3.1) can be used to determine which of the listed combinations is to be used.

7.1.3.1 /RTS signal, busy processor

The /RTS pin signalizes a busy UART buffer which means, when /RTS is set, no more UART bytes will be accepted nor processed.

The /RTS pin is set when any of the events in the prior chapter has occurred and a data packet is processed.

To avoid loss of data bytes by the UART it is absolutely essential to use the /RTS pin for the flow control and consider it byte by byte.

If the /RTS pin is ignored it could lead to malfunctions of the module.

7.1.4 Command mode

This operating mode primarily serves the module configuration. The module AMB9626 acts as a slave and can be fully controlled by an external host using the predefined command interface described in chapter 8.

It can also be used for wireless transmission of payload data providing a feedback dependent on the transmission success.

8 The command interface

8.1 Overview

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

Start signal	Command	No. of data	Data	Checksum

Table 3 Telegram format in the command mode

Start signal: 0x02 (1 byte)

Command: One of the predefined commands (1 byte)

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

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

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

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

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

On each command follows a response from the AMB9626 to the host.

8.2 Data transfer & reception in the command mode

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

8.2.1 CMD_DATA_REQ

This command serves the simple data transfer in the command mode. Transmission takes place on the configured channel to the previously parameterised destination address.

This command is especially suitable for transmission for a point-to-point connection. The number of payload data bytes is limited to 120.

Format:

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

Response:

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

Status:

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

0x01: no ACK received

8.2.2 CMD_DATAEX_REQ

This command serves data transfer in a network with several parties. The destination address to be used (depending on the parameterised addressing mode, see also chapter 9.3.8) is specified along with the command. The number of payload data bytes is limited to 120.

The inserted destination network and destination address are loaded into the volatile runtime settings und thus kept until the system is reset or they are changed by the user.

Format in addressing mode 0:

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

Format in addressing mode 1:

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

Format in addressing mode 2:

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

Response:

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

Status:

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

0x01: no ACK received, if requested

0x02: invalid channel selected

8.2.3 CMD_DATAEX_IND

This telegram indicates the reception of data bytes and represents the counterpart to the commands `CMD_DATA_REQ` and `CMD_DATAEX_REQ`. Apart from the RX field strength (RSSI value), this telegram also includes the sender's address (number of address bytes is depending on the parameterised addressing mode, see also chapter 9.3.8).

Format in addressing mode 0:

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

Format in addressing mode 1:

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

Format in addressing mode 2:

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

8.3 Requesting parameters and actions

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

8.3.1 CMD_FWRELEASE_REQ

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

Format:

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

Response:

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

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

8.3.2 CMD_SERIALNO_REQ

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

Format:

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

Response:

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

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

8.3.3 CMD_RESET_REQ

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

Format:

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

Response:

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

Status:

0x00: success

8.3.4 CMD_RSSI_REQ

This command returns the RX level of the last received radio frame start indicator “SYNC” (so even for frames with bit errors in the payload the rssi value is updated) determined by the transceiver IC in the form of a signed two's complement.

Format:

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

Response:

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

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

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

Example:

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

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

8.3.5 CMD_ERRORFLAGS_REQ

This command returns internal error states.

Format:

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

Response:

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

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

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

8.4 Modification of volatile parameters

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

8.4.1 CMD_SET_MODE_REQ

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

The following operating modes are defined:

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

Format:

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

Enter transparent mode:

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

Response:

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

Enter transparent mode response:

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

Enter command mode response:

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

8.4.2 CMD_SET_PAPOWER_REQ

This command is used to set the RF TX-power (output power). Unlike the user settings parameter `PHY_PAPower`, this is a volatile runtime parameter, but it is handled in the same way. Thus see section 9.3.14 for more information.

The entered power value is entered as a complement on two. The valid range is from -10 to +14 dBm

Format:

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

Example (setting the power to +14 dBm):

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

Response:

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

Return for above example:

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

8.4.3 CMD_SET_DESTNETID_REQ

This command serves to configure the destination network ID in addressing mode 2. Unlike the user settings 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	Channel	CS
0x02	**0x47**	**0x01**	**1 Byte**	**1 Byte**

Status:

0x00: success

8.4.4 CMD_SET_DESTADDR_REQ

This command serves to configure the destination address in addressing modes 1 and 2.

Unlike the user settings parameter `MAC_DefaultDestAddrLSB`, this is a volatile runtime parameter.

Format:

Mode 1 + 2:

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

Return:

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

Status:

0x00: success

8.5 Modification of non-volatile parameters

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

8.5.1 CMD_SET_REQ

This command enables direct manipulation of the parameters in the module's non-volatile user settings. The respective parameters are accessed by means of the memory positions described in chapter 9.2.

You can modify individual or multiple consecutive parameters in the memory at the same time. The sum of memory position and forwarded data has to be less than the total size of the user settings (however a max. of 128 bytes). Otherwise the package is discarded in the module.

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

Parameters with the size of 2 or more bytes have to be transferred with the LSB first unless stated otherwise.

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

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

To save the parameters in the flash memory of the module, the particular memory segment must first be flushed entirely and then restored from RAM.

If a reset occurs during this procedure (e.g. due to supply voltage fluctuations), the entire memory area may be irreversibly destroyed.

Recommendation: First verify the configuration of the module with `CMD_GET_REQ`; and only write if required.

Format:

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

Response:

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

Status:

0x00: Request successfully received and processed

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

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

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

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

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

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

Parameter:

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

To set the UART baud rate on 19200 Baud would result in the following data content:

19200 => Parameter = 0x00 0x00 0x4B 0x00

`UART_Baudrate_LSB` = 0x00
`UART_Baudrate_LSB`+1 = 0x4B
`UART_Baudrate_LSB`+2 = 0x00
`UART_Baudrate_MSB` = 0x00

8.5.2 CMD_GET_REQ

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

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

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

Format:

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

Example (query of all parameters):

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

Response:

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

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

8.5.3 CMD_FACTORY_RESET_REQ

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

Format:

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

Response:

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

Status:

0x00: Request successfully received and processed

0x01: Request not successful

9 User settings

9.1 Difference between volatile and non-volatile settings

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

9.2 List of user settings

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

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

Designation	Summary	Permissible values	Default value	Memory position	Number of bytes
`UART_PktMode` Packetizing mode	Selects the packet generation method	0 or 1	0	5	1
`UART_PktSize` Packet size	Number of characters for transmission start with set packet size	1 - 120	120	7	1
`UART_RTSLimit` /RTS limit	Number of received characters after which /RTS responds	1 - 120	100	8	1
`UART_ETXChar` ETX character	End-of-text character used to mark data packets; reception of this character triggers wireless transmission	0 - 255	10	9	1
`UART_Timeout` Timeout	Timeout after the last character before the data received via UART are transmitted via wireless transmission [ms]	2 – 65535	5	12	2
`UART_DIDelay` Data Indication Delay	Delay between signal by Pin /DATA_INDICATION and beginning of output by UART [ms]	0 – 65535	0	14	2
`MAC_NumRetrys` Retries	Number of wireless retries, 0: retrys disabled	0 – 255	0	20	1

Designation	Summary	Permissible values	Default value	Memory position	Number of bytes
MAC_AddrMode Addressing mode	Wireless Addressing mode	0/1/2	0	21	1
MAC_DefaultDestNetID Dest. net ID	Default destination network ID	0 – 255	0	24	1
MAC_DefaultDestAddrLSB Dest. device address	Default destination address (LSB)	0 – 255	0	25	1
MAC_DefaultSourceNetID Local net ID	Own network ID	0 – 254	0	28	1
MAC_DefaultSourceAddrLSB Local device address	Own address (LSB)	0 – 255	0	29	1
MAC_ACKTimeout ACK timeout	Waiting time for wireless acknowledgement [ms]	5 – 65535	8	32	2
PHY_PAPower Output power	Output power [dBm]; value range depends on RF configuration Format: two's complement	-11 – 15	15	41	1
PHY_LongPreambleTimeout Long preamble timeout	Length of the preamble used for channel hopping [ms]	5 – 65535	50	44	2
PHY_RSSIThreshold	RSSI value [dB] over noise level that determines the threshold for active channel detection	6 – 40	10	46	1
OpMode	Operating mode, transparent or command mode	0, 16	0	60	1
CfgFlags Configuration flags (hex.)	Flags for setting various properties; see chapter 9.3.18	0 – 65535	512	72	2
UART_Baudrate	Symbol rate of the UART	1200-19200	9600	80	4
UART_Databits	Number of data bits	7,8	8	84	1
UART_Parity	Parity	0,1,2	0	85	1
UART_Stoppbits	Stop bits	1,2	1	86	1
RF_ConfigIndex	Index for predefined radio settings	0	0	92	1

Table 4 Overview of non-volatile user-settings

9.3 Details to UserSetting parameters for advanced settings

9.3.1 UART_PktMode

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

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

Not used in command mode.

9.3.2 UART_PktSize

Maximum number of bytes after which the wireless transmission of the data received via UART starts. Used in packet mode 0 as well as in packet mode 1. Maximum is 120 due to buffer size.

Not used in command mode.

9.3.3 UART_RTSLimit

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

Not used in command mode.

9.3.4 UART_ETXChar

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

Not used in the command mode.

9.3.5 UART_Timeout

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

Not used in the command mode.

9.3.6 UART_DIDelay

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

9.3.7 MAC_NumRetrys

Determines the maximum number of wireless transmission retries. If this parameter is set to a value other than 0, the receiver module will automatically be prompted to send a wireless

acknowledgement (“ACK”). Please note that sending acknowledgements additionally increases the traffic.

Retrys shall only be used if MAC_AddrMode != 0.

The addresses used in the radio frames are not allowed to be broadcast addresses and there must not exist a pair of network clients with the same address.

Addressing does not influence the radio channel or its utilisation – this means that addressing is a method for shared medium access but it does not provide any methods for collision prevention.

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

9.3.8 MAC_AddrMode

Addressing mode selection. The following modes have been implemented:

1. No addressing (mode 0): Each module receives the transmitted RF telegram and delivers the received data to the host system via UART. No address information is transmitted in the radio telegram.
2. 1-byte address (mode 1): The receiving module only delivers the data to the host system via UART if the destination address configured at the sender (`MAC_DestAddrLSB`) corresponds to the source address (`MAC_SourceAddrLSB`) or the destination address 255 (broadcast) was specified. Both the destination address and the source address are transmitted in the wireless telegram (total = 2 bytes).
3. 2-bytes address (mode 2): The receiving module only delivers the data to the host system via UART if both the destination network ID and the destination address correspond to the source addresses (`MAC_SourceNetID` and `MAC_SourceAddrLSB`) or the destination address 255 (broadcast) was specified. A total of 4 bytes of address information are transmitted in the wireless telegram.

Caution: In addressing mode 0, the use of wireless acknowledgement may cause problems if several wireless modules are addressed simultaneously. In this case, all modules will simultaneously acknowledge the receipt of the package. Thus, the wireless acknowledgement cannot be received by the sending module due to the collision, and the maximum number of retries will be sent.
Avoid using `MAC_NumRetrys` other than 0 with addressing mode 0.

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

9.3.9 MAC_DefaultDestNetID

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

9.3.10 MAC_DefaultDestAddrLSB

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

9.3.11 MAC_DefaultSourceNetID

Source network ID to be used in addressing mode 2.

9.3.12 MAC_DefaultSourceAddrLSB

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

9.3.13 MAC_ACKTimeout

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

RF_ConfigIndex	ACK timeout recommended
0	8 ms

For optimal data transmission quality, all communicating modules have to have the same ACK timeout value.

9.3.14 PHY_PAPower, Transmit Power

Parameter for the RF output power of the module. The maximum permissible output depends on the used RF configurations. The maximum supported output power value with this chip set is +15 dBm. The minimum supported value is -11 dBm.

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

The user settings `PHY_PAPower` is entered as a complement on two.

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

When using high power values like +15dBm, a minimum distance of 3 meters is required between the modules to ensure a good transmission quality and to avoid over modulation.

9.3.15 PHY_LongPreambleTimeout

This value specifies the length of the preamble send in advance to the payload data packet. This preamble is used to detect the right channel for data transmission.

RF_ConfigIndex	Preamble timeout recommended
0	50 ms

For optimal data transmission quality, all communicating modules have to have the same preamble timeout value.

9.3.16 PHY_RSSIThreshold

This value determines the threshold that is used to detect an active channel. The threshold is calculated as `PHY_RSSIThreshold` dB over the current noise level of the respective channel.

The minimum applicable value is 6 dB the default is 10 dB.

To make the firmware more robust against false channel detections, the value of `PHY_RSSIThreshold` has to be increased. In this case, the operating range decreases since all signals lower than the current noise level plus `PHY_RSSIThreshold` are classified as noise and hence ignored.

9.3.17 OpMode, Operation Mode

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

9.3.18 CfgFlags, Configuration Flags

16-bit field in which the use of individual pins or signals can be disabled. Table 5 represents a description of the respective flags.
To use multiple settings, add the bit numbers and choose the result as value for `CfgFlags`.

By default, CfgFlags is 0x0200. (= LEDs enabled)

Bit no.	Description
0 (0x0001)	Setting this bit disables the ***/CONFIG*** pin. Thus the unit can no longer be switched to the transparent or command mode via this pin.
1 (0x0002)	Setting this bit disables the ***/DATA_REQUEST*** pin.
2 (0x0004)	Reserved
3 (0x0008)	Setting this bit, disables handling of the status of the ***TRX_DISABLE*** pin. Hence, the module can no longer be set to the various power-saving modes via this pin.
4 (0x0010)	Setting this bit, enables a different behaviour of the ***TRX_DISABLE*** pin. If this bit is set and the ***TRX_DISABLE*** pin is set, then additionally to the RF-chip, the UART is also powered down. Furthermore the µC is powered down to LPM3 and the ***ICONFIG*** pin is disabled. A wakeup is only possible through **TRX_DISABLE** pin or reset. With this options selected '1' the lowest current consumption can be achieved (even with 19200 Baud as UART symbol rate). The needed wakeup time after releasing the ***TRX_DISABLE*** pin is < 1ms, since the channel calibration values and noise levels have been retained.
5 (0x0020)	Any character will be accepted as valid ***checksum*** in the command mode if this bit is set.
6 (0x0040)	Setting this bit '1', disables the internal pulldown of the pin ***TRX_DISABLE***.
7 (0x0080)	"Sniffer-Mode" The address will not be resolved if this bit is set. The particular module can be used as packet sniffer to monitor a wireless link. No ACKs are sent.
8 (0x0100)	Setting this bit enables the /CTS flow control pin.
9 (0x0200)	Setting this bit enables the outputs for RF activity, (e.g. for LEDs).
10 to 15	Reserved

Table 5 Configuration flags

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

9.3.19 UART_Baudrate

A 32 bit field, that contains the symbol rate for the communication interface. Symbol rates up to 19200 baud are supported. Default symbol rate is 9600 baud. Please note that for baud rates higher than 9600 baud the Sleep state has a reasonable higher energy consumption.

9.3.20 UART_Databits

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

9.3.21 UART_Parity

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

9.3.22 UART_Stoppbits

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

9.3.23 RF_ConfigIndex, Radio Configuration

An 8 bit field that addresses the applied RF configuration.

RF_ConfigIndex	Data rate (gross) [kcps]	Modulation
0	38.4	2-GFSK

10 Device addressing and wireless monitoring

To connect several modules to networks or to send data to specific devices, the AMB9626 supports the so called address mode. The corresponding user setting parameter `MAC_AddrMode` determines whether all modules in range, or all modules in a network or a single module with a fixed address is supposed to receive a certain message.

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

11 Channel hopping for the 915MHz frequency band

The 915MHz frequency band is splitted into the channels of Table 6, where the band limit channels 200 and 252 are not to be used for any RF activity. They are chosen with equal distances of 500 kHz so that the neighbour channels should not disturb each other at the default rf data rate (38400 baud).

Channel	Frequency	Channel	Frequency	Channel	Frequency
200	902	218	911	236	920
201	902,5	219	911,5	237	920,5
202	903	220	912	238	921
203	903,5	221	912,5	239	921,5
204	904	222	913	240	922
205	904,5	223	913,5	241	922,5
206	905	224	914	242	923
207	905,5	225	914,5	243	923,5
208	906	**226**	**915**	244	924
209	906,5	227	915,5	245	924,5
210	907	228	916	246	925
211	907,5	229	916,5	247	925,5
212	908	230	917	248	926
213	908,5	231	917,5	249	926,5
214	909	232	918	250	927
215	909,5	233	918,5	251	927,5
216	910	234	919	252	928
217	910,5	235	919,5		

Table 6 Overview of the 51 active channels according to FCC.

To operate in this band the radio-norm FCC $15.247 prescribes to use all channels equally for data transmission. Thus the AMB9626 implements the so called “asynchronous channel hopping technique” [3] using a new channel for each packet send. Figure 2 illustrates exemplary the underlying idea for a frequency band consisting of 10 channels.

Thereby the device in RX mode jumps quickly through the channels to listen for some RF activity. If an active channel was detected, the receiving device listens to the data packet that will follow afterwards. To find out whether a channel is active or not, the noise level of each channel is determined permanently. A channel is classified as active if its signal power is at least `PHY_RSSIThreshold` dB above the current noise level of the channel. Otherwise the measured value is used to update the corresponding noise level.

On the TX side, the transmitting device first sends a long preamble to signalize RF activity on the chosen channel. This preamble has to be sufficiently long, that the receiver can detect the chosen channel (see the user setting `PHY_LongPreambleTimeout`). After this preamble was sent, the transmission of the data packet follows. For each transmission (preamble plus payload data) a new channel is chosen.

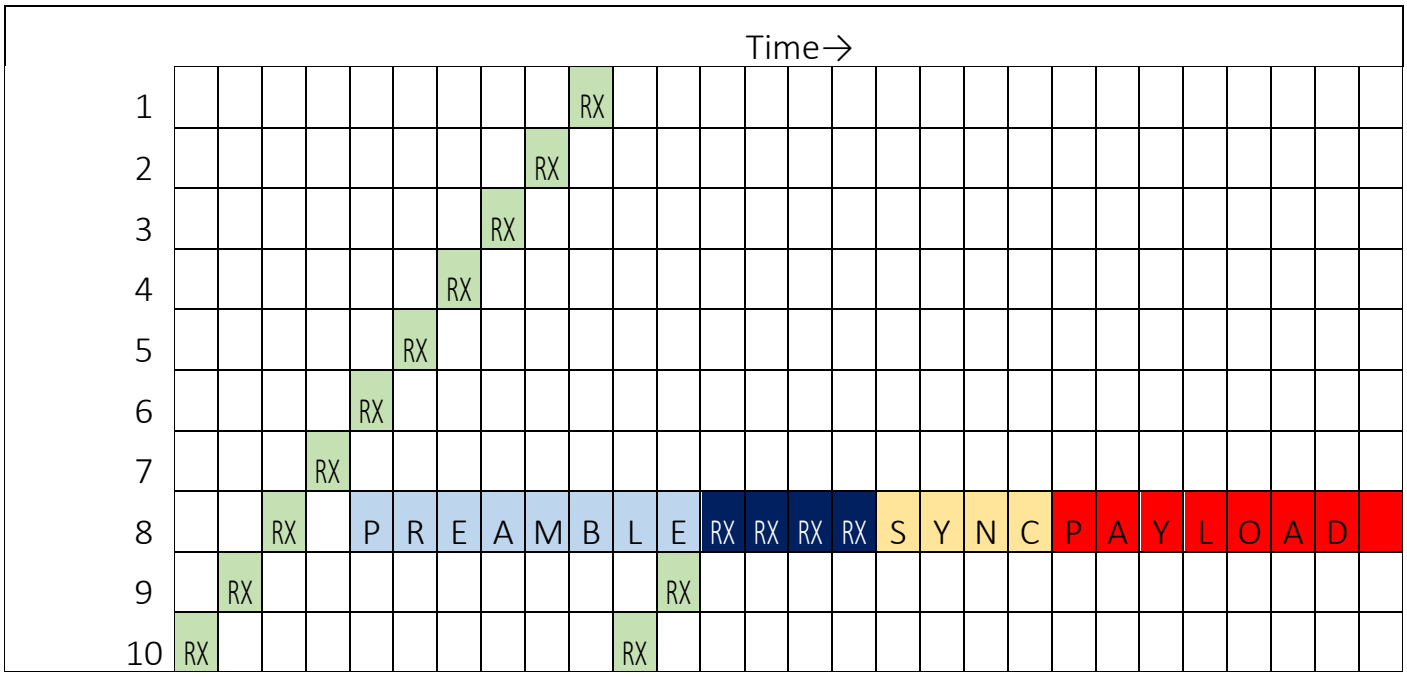


Figure 2 Channel hopping for a 10 channel system

12 Battery powered operation

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

12.1 Active mode

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

12.2 Stand-by mode

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

The CfgFlag Bit 4 can modify this behaviour (see chapter 9.3.18).

13 Timing parameters

13.1 Reset behaviour

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

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

13.1.1 Power-on reset

After switching the supply voltage and releasing the /RESET pin (if wired), the time until the module is ready for operation can last up to 1 s. During this time, the processor clock-rate will be calibrated, which takes anyway between 2 and 20 ms depending on the supply voltage and temperature.

Furthermore all channels are precalibrated to allow fast channel switching and the noise level of all channels is determined to detect the active channels without fault.

13.1.2 Reset via /RESET pin

To force a module restart by means of the /RESET pin, it must first be drawn to low for at least 10 ms. After the pin is released, /RTS will switch to high after 100 µs at the latest and the start-up procedure begins.

Recommended procedure: After the /RESET pin is released, wait for additional 100 µs after the /RTS pin is low to be sure that the system is ready.

13.1.3 Reset as result of a serious error condition

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

13.2 Latencies when leaving the LPM

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

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

13.3 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).

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 immediately after the packet reception.

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

14 Firmware update

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

14.1 Update using UART interface

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

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

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

14.2 Update using JTAG or Spy-Bi-Wire

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

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

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

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

15 Firmware history

Version 1.0.0

- First product release.

Version 1.1.0

- Improved channel detection methode for frequency hopping

16 Hardware integration

16.1 Footprint

The unit of the distances is mm.

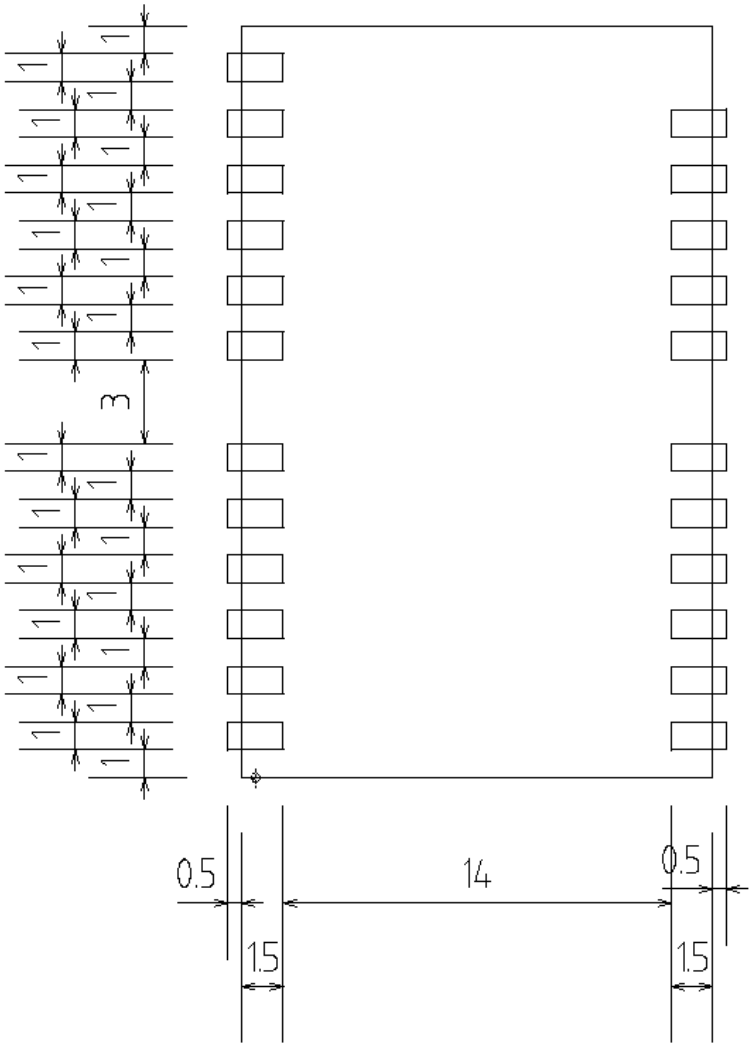


Figure 3 Footprint AMB9626

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

17 Design in guide

17.1 Advice for schematic and layout

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

The following general advice should be taken into consideration:

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

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

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

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

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

We highly recommend to have pads/connectors for realizing at least one of the 3 possible firmware update connections on any customer PCB.

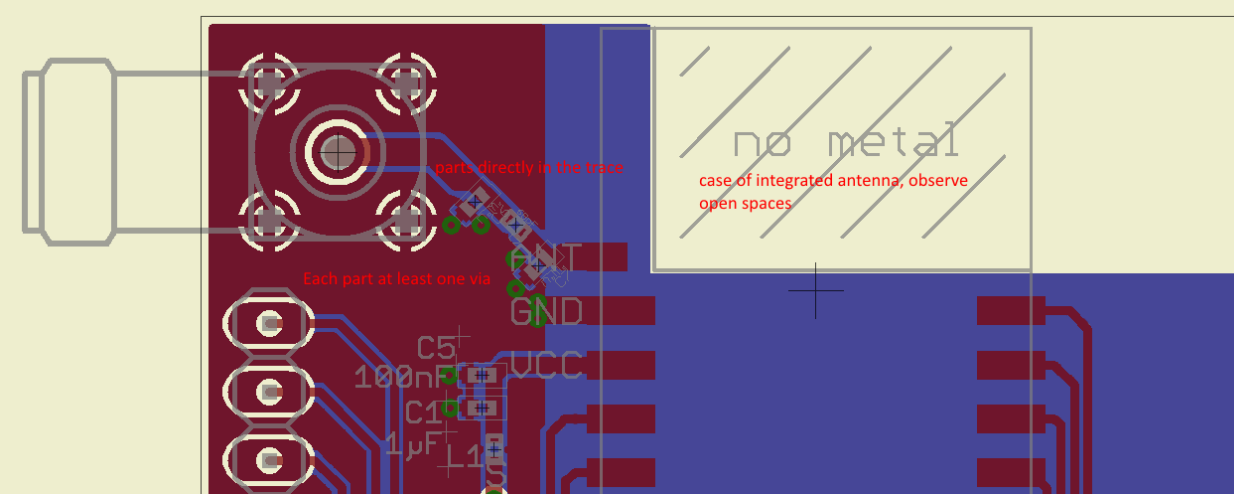


Figure 4 Layout

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

Dimensioning of the 50 Ohm microstrip

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

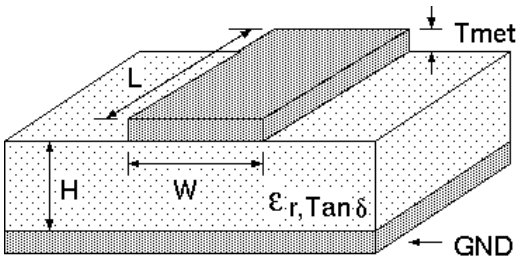


Figure 5 Dimensioning the antenna feed line as micro strip

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.

17.2 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 λ/10 (3.5 cm @ 868 MHz, 1.2 cm @ 2.44 GHz, 17,8 cm@169MHz) 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.

17.2.1 λ/4 radiator

An effective antenna is a λ/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 or a 44.4 cm wire for 169 MHz. 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 λ/4 radiator has approximately 40 Ohm input impedance, therefore matching is not required.

17.2.2 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.

17.2.3 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 Manufacturing information

- The assembly contains moisture sensitive devices of the MSL classification 3. **Caution**: 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).

The next figure shows an example of a soldering curve that had been used for a 31 cm^2 carrier board for single-side assembly.

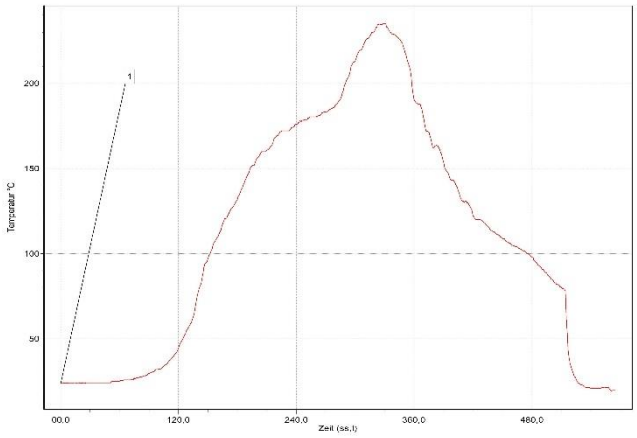


Figure 6 Example of a temperature profile
Caution: Must be adjusted to the characteristics of the carrier board!

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

Caution! ESD sensitive device.

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

Caution! This assembly contains moisture sensitive components.

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

MSL 3

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

19 References

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

[2] „AMB9626 Datasheet", AMBER wireless GmbH

[3] „Application Report: Asynchronous Channel Hopping System for FCC 15.247 Compliance", Texas Instruments

20 Regulatory compliance information

20.1 Important notice

The use of RF frequencies is limited by national regulations. The AMB9626 has been designed to comply with the FCC and IC.

The AMB9626 can be operated without notification and free of charge in the area of USA and Canada.

Conformity assessment of the final product

The AMB9626 is a subassembly. It is designed to be embedded into other products (products incorporating the AMB9626 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 FCC and IC.

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.

20.2 FCC Compliance statement AMB9626

FCC ID: R7TAMB9626

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.

Antenna Requirements

Caution: The module uses a unique coupling. The use of a permanently attached antenna with an antenna gain below 6 dBi or of an antenna that uses a unique coupling is required.

20.3 IC Compliance statement AMB9626

Certification Number: 5136A- AMB9626

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.

20.4 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 6dBi.
- A label must be affixed to the outside of the host product with the following statements:

This device contains FCCID: R7TAMB9625

This equipment contains equipment certified under ICID: 5136A-AMB9625

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: R7TAMB9625

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 Important information

21.1 Exclusion of liability

AMBER wireless GmbH presumes that the information in this document is correct at the time of publication. However, AMBER wireless GmbH reserves the right to modify technical specifications or functions of its products or discontinue the production of these products or the support of one of these products without any written announcement or notification to customers. The customer must make sure that the information used is valid. AMBER wireless GmbH does not assume any liability for the use of its products. Amber wireless GmbH does not grant licenses for its patent rights or for any other of its intellectual property rights or third-party rights. Customers bear responsibility for compliance of systems or units in which AMBER wireless products are integrated with applicable legal regulations.

21.2 Trademarks

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

21.3 Usage restriction

AMBER wireless products are not approved for use in life-supporting or life-sustaining systems or units or other systems whose malfunction could result in serious bodily injury to the user. Moreover, AMBER wireless products are not approved for use as key components of any life-supporting or life-sustaining system or unit whose malfunction could result in the failure of the life-supporting system or unit or could affect its safety or effectiveness. AMBER wireless customers who use these products in such applications or sell them for such usage act at their own risk and must relieve AMBER wireless GmbH from all damages that may result from the sale for unsuitable purposes or unsuitable usage.

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

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