Manual AMB8636

Version 1.3

SW-V1.0.2

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Table of Contents

Abbreviations

CS	Checksum	
DC	Duty Cycle	Relative frequency allocation
LBT	Listen Before Talk	Collision Avoidance
AFA	Adaptive Frequency Agility	
FIFO	First In First Out	Stack handling treatment
CCA	Clear Channel Assessment	Evaluation of channel access
I/O	Input/output	Pinout description

1 Summary

The AMB8636 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,
- Repetition of unacknowledged telegrams.

It 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.

2 Operating modes

The device can be used in the following operating modes:

1. Transparent, buffered data transfer
2. Command mode

The operating mode after power up can be configured by means of the `OpMode` parameter (See 11.13).

Upon start up in the command mode, the module responds with the respective telegram (see 10.1.4).

By default, the module operates in transparent mode.

2.1 Transparent, buffered data transfer

In this mode, data is received via the serial interface and initially buffered. As soon as a specific condition is met (see 9.2), the RF telegram is generated with a preamble, checksum and address information (optional).

The number of character transmitted in the wireless telegram in addition to the actual payload data depends on the selected addressing method and the data rate, and varies between 12 and 18 byte (packet overhead).

If required, the RF telegram can be acknowledged by the recipient module (see 11.5). If no acknowledgement is received, the telegram will automatically be repeated upon expiry of a timeout (see 11.9). The retries are conducted in the configured quantity (see 11.5)

The buffer size at the UART interface is 120 bytes, i.e. the maximum size of transmitted data packets is 120 bytes (payload). In addition to this 120 bytes payload there are the data of the radio telegram (address, sequence-number, checksum etc.).

As soon as the transmission via radio has started, new data can be received on the serial UART. The /RTS signal, that indicates that the buffer is in use, has to be considered. Because of the limited number of buffer, the data reception on the UART can be deactivated in favour of

the radio transmission for a short time until at least one buffer for the UART reception is available.

In radio receiving mode, the module is able to simultaneously receive radio telegrams and send them on the UART. The /CTS signal of the host can be observed optionally.

2.2 Command mode

This operating mode primarily serves module configuration. It can also be used for wireless transmission of payload data.

2.2.1 Switching to the command mode

The unit switches to the command mode

- when a falling edge is detected on the /CONFIG pin, or
- when a break signal is detected on the UART. A break condition exists if the RX input of the module is kept low for at least 10 more bits after the absence of a stop bit.

Detection of both the falling edge on the /CONFIG pin and of the break signal can be disabled (see 11.13).

The successful switchover is acknowledged by means of a corresponding command (see 10.1.4).

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).

2.2.2 Exiting the command mode

The command mode can be exit by:

1. Sending the corresponding command (see 10.1.4).
2. Detection of another falling edge on the /CONFIG pin.
3. Detection of another break signal by the UART.

Caution: The exiting of the command mode is not confirmed by the corresponding acknowledgement for method 2 and 3 (see 10.1.4).

2.2.3 Communication in the command mode

In command mode, communication with the module occurs in the form of predefined commands. These commands must be sent in telegrams according to the format described in **Table** 1. /RTS is signalising packet reception attendance and should be considered here too.

Start signal	Command	No. of data	Data	Checksum

Table 1 Telegram format in command mode

Start signal:	STX = 0x02 (1 byte)
Command:	One of the predefined commands according to section 9.3 (1 byte)
No. of data:	Specifies the number of data in the following field of variable length and is limited to 120 in order to prevent buffer overflow (1 byte). With appropriate commandos values > 120 can occur.
Data:	Variable number of data or parameters (maximum 128 byte, payload plus 6 byte parameter, LSB first)
Checksum:	XOR (exclusive-OR, „^“)-assignment of the precedent fields, inclusive start sign STX, which means: 0x02 ^ Command ^ No. of Data ^ Databyte0 ... (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 this way quick channel changes, can be realized.

If no new signal is received for `UART_Timeout` milliseconds (see 11.4) after receiving the STX signal, the unit will wait for a new start signal.

3 Addressing modes

The following addressing modes are available:

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_DefaultDestAddr`, see 11.7) corresponds to the source address (`MAC_DefaultSourceAddr`, see 11.8) or the address 255 (broadcast address) was specified as destination address. Both the destination address and the source address are transmitted in the wireless telegram (total = 2 bytes).

The addressing mode to be used can be set with the `MAC_AddrMode` parameter (see 11.6)

The receiver and transmitter modules must be operated in the same addressing mode!

3.1 Monitoring wireless communication

The address resolution can be disabled ("packet sniffer") with bit 7 in the configuration flags (see 11.14). 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 acknowledge.

4 Electrical parameters

T = 25 °C, VDD = 3.3 V, f_c = 869.525 MHz unless otherwise specified.

4.1 Operational range

Description	min	typ	max.	unit
Supply voltage	2		3,6	V
Temperature range	-40		85	°C

4.2 Current consumption

Description	min	typ	max.	unit
TX current consumption at 27 dBm		500		mA
TX current consumption at 20 dBm		235		mA
RX current consumption		48		mA

4.3 Radio parameters

50 Ohm tethered.

Description	min	typ	max.	unit
Output power		27		dBm
Input sensitivity at 50kbps		-113		dBm

5 Dimensions and weight

33.5 x 76 x 14.5 mm

Resp. 33.5 x 64.35 x 5.1 mm without SMA connector

Ca. 14 g

6 Pinout

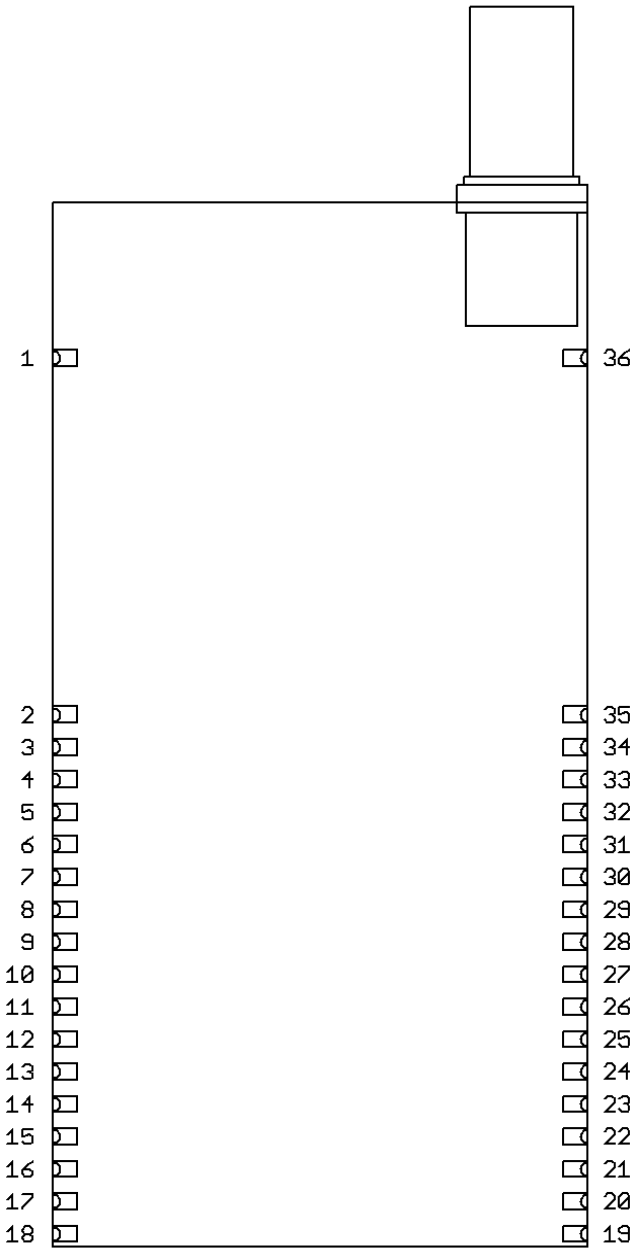

Figure 1 Pinout

Nr.	Designation	I/O	Description
-	HF	I/O	RF-connection, 50 Ohm, antenna connection, SMA-connector.[1]
1, 2, 18, 19, 35, 36	GND	Supply	Ground
33	VCC	Supply	Supply voltage, digital part
34	VCC	Supply	Supply voltage RF part
26	TX	O	UART Output serial interface
27	RX	I	UART Input serial interface
6	/RST	I	Active low. **Do not connect if not needed.**
20	/CONFIG	I	Switch between operational modes at falling edge **Connect to GND if not needed**
11	/RTS	O	Ready To Send, active Low.
8	/CTS	I	Clear To Send, active Low.
9	LED_RX	O	Signalise reception of packet over RF
10	LED_TX	O	Signalise distribution of packet over RF
3 - 5, 31, 32		I / O	Programming interface, internal use**, do not connect.**
7, 12, 13	RESERVED	I / O	No function, **do not connect** Common I/O with A/D-function
14 – 17, 21, 22	RESERVED	I / O	No function, **do not connect** Common I/O with INT-function
23 – 25, 28 – 30	RESERVED	I / O	No function, **do not connect** Common I/O

Table 2 Pinout

7 Serial Interface

The default baud rate of the AMB8636 is 9600bd. The default data format is 8 data bits, no parity and 1 stop bit (8N1).

[1] Alternative with optional U.FL-connector, AMB8636-1

7.1 Supported data rates

The data rate is adjusted through a configuration structure. The structure allows the configuration of the `UART_Baudrate`, `UART_Databits`, `UART_Parity` and `UART_Stoppbits` (See 11.16 to 11.19).

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

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

7.2 Supported data formats

The following data formats are supported:

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

8 Setting the radio parameters (RF)

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

Furthermore, the volatile runtime parameters `MAC_RuntimePtx` and `MAC_RuntimeChannel` can be configured over the respective command during runtime. This leads to the adoption of this parameters with the next packet transmit or receive. The parameters `PHY_PAPOWER` and `MAC_RuntimePtx` are numbers in complement of two.

RF_ConfigIndex	Data rate (gross) [kBaud]	Modulation	Wideband WB/ Narrowband NB
0	2.4	2-GFSK	NB
1	4.8	2-GFSK	WB
2	9.6	2-GFSK	WB
3[2]	19.2	2-GFSK	WB
4[3]	50	2-GFSK	WB
5[4]	2.4	2-GFSK	NB

Table 3 RF parameters

`RF_ConfigIndex` = 0, or 5 is a narrow band modulation with a 12.5 kHz raster.
`RF_ConfigIndex` = 1, 2, 3 or 4 is a wideband modulation with just 1 channel.

Caution: The parameters must be chosen with prudence to reach good functionality and compliance with EN 300 220. The user is in charge of the abidance of the duty cycles.

The AMB8636 is pre-certified, which means measured at 50 Ohm on the AMB8636-EV-Board all requirements are met. However decisive for the end product is the real radiated power. This depends on the selected antenna, the wiring to the antenna, the quality of the power supply, possible disturbances etc., and should therefore be tested.

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

The default configuration is a data rate of 4.8 kbps (`RF_ConfigIndex` = 0), a frequency of 869,5375 MHz (`PHY_DefaultChannel` = 10) and an output power of 27 dBm (`PHY_PAPOWER` = 27).

[2] Not yet implemented in firmware.
[3] Not yet implemented in firmware.
[4] Not yet implemented in firmware.

8.1 Channel assignment and requirements in the 868 MHz frequency band

Attention: The hereafter shown channels were tested at 50 Ohm tethered to satisfy the requirements of the EN 300 220. Other channels are not allowed to be chosen.

Determining for the legitimacy is the finally effective radiated power, that is dependent on the the utilized antenna and the environmental conditions. So the radiated power should be verified.

Band	Channel-Nr.	Frequency [MHz]	2.4 kbps[5] G-FSK	4.8kbps 2-GFSK
g3 869.4 MHz – 869.65 MHz output power ≤ 27 dBm channel raster ≤ 25 kHz or broadband channel for high speed data transfer Duty Cycle ≤ 10% or LBT + AFA	Border	869.4000		
	0	869.4125	ja	ja
	1	869.4250	ja	ja
	2	869.4375	ja	ja
	3	869.4500	ja	ja
	4	869.4625	ja	ja
	5	869.4750	ja	ja
	6	869.4875	**ja**	**ja**
	7	869.5000	ja	ja
	8	869.5125	ja	ja
	9	869.5250	ja	ja
	10	**869.5375**	**ja**	**ja**
	11	869.5500	ja	ja
	12	869.5625	ja	ja
	13	869.5750	ja	ja
	14	869.5875	ja	ja
	15	869.6000	ja	ja
	16	869.6125	ja	ja
	17	869.6250	ja	ja
	18	869.6375	ja	ja
	Border	869.6500		

Table 4 Channel overview, narrow band in 12.5 kHz raster, predefined channel is bolded

[5] Nfot yet implemented in firmware.

Band	Channel-Nr.	Frequency [MHz]	9.6 kbps 2-GFSK	19.2 kbps[6] 2-GFSK	50 kbps[7] 2-GFSK
g3 869.4 MHz – 869.65 MHz output power ≤ 27 dBm channel raster ≤ 25 kHz or broadband channel for high speed data transfer Duty Cycle ≤ 10% or LBT + AFA	Border	869.4000			
	5	869.4750	yes	yes	no
	9	869.5250	yes	yes	yes
	13	869.5750	yes	yes	no
	Border	869.6500			

Table 5 Channel overview, wideband

Attention: In wideband mode the whole stated frequency band may be used as one single channel. (g3 500 mW)

9 Timing-Parameter

9.1 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).

9.1.1 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.

9.1.2 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. Then wait for the low state of the /RTS pin, which should occur by not later than 50 ms. Subsequently additional 100 µs are required until the system is ready.

9.2 Latencies during data transfer / packet generation

The data transfer is generally buffered, which means that data received by the UART are latched in the module until a respective event (see 9.2.1) occurs. The UART reception will then be interrupted (flow control over /RTS signal) and the user data will be forwarded to the internal

[6] Not yet implemented in firmware.
[7] Not yet implemented in firmware.

store of the RF chip (FIFO). With the use of several UART buffer, the time at which the UART is not at reception, will get minimized.

The transmission starts as soon as the first data are in the store of the transceiver. During running transmission, the remaining user data will be loaded and transmitted piece by piece.

At the receiver, the FIFO will be read as soon as an incoming packet is recognized.

As soon as the receiver has received a valid packet, the ACK will be sent right after the reception. The channel assessment is always deactivated for ACKs.

Together with the use of the respective techniques for packet creation, the latencies can be reduced to an absolute minimum.

9.2.1 Transparent operating mode

To minimise the latencies during the packet generation, the following methods are available to control the start of transmission:

1. Transmission starts after **timeout**: Transmission begins if no new character is detected within a configurable time period after receiving a character via UART. The timeout is reset every time a character is received. It can be configured with the `UART_Timeout` parameter (see 11.4).
2. Transmission starts after a fixed **packet size** is reached: Transmission begins when the preconfigured number of bytes (`UART_PktSize`, see 11.2) is reached in the RX buffer of the UART. With the parameter `UART_RSTLimit` a threshold can be set upon which the /RTS pin is set.
3. Transmission starts on detection of an **end-of-text character**: Transmission begins when the preconfigured character is transmitted via UART. The end-of-text character can be configured with the `UART_ETXChar` parameter (11.3).

The `UART_PktMode` parameter (11.1) can be used to determine which of the listed combinations is to be used.

9.2.2 Command mode

In the command mode, the data is buffered as described in 9.2.1. However, the transmission start is defined exclusively by the receipt of the corresponding command (see 10.1, 10.1 or10.1.4) (i.e. on receipt of a valid checksum if activated).

9.3 Active mode

In this mode, the module is permanently ready to receive and forward data via UART or wireless transmission. The module will only switch to one of the other power-saving modes after having processed any pending data transmission, i.e. /RTS must be low.

10 The command interface

The commands already mentioned in 2.2.30 are described in detail below.

The checksum (CS) is a bitwise XOR operation of all previous bytes. See 2.2.3 for more detail.

10.1 Data transfer in the command Mode

10.1.1 CMD_DATA_REQ

This command serves the simple data transfer in the command mode. Transmission takes place on the configured channel (see 10.4) to the previously parameterised destination address (see 10.5).

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

Format (limit 128 payload data bytes):

0x02 ***0x00*** < number of payload data bytes > < payload data bytes > < CS >

Return:

0x02 ***0x40*** 0x01 < status > < CS >

Status:

0x00: ACK received, only possible if `MAC_NumRetrys` is not 0; see 11.5, or none is requested

0x01: no ACK received or requested

10.1.2 CMD_DATAEX_REQ

This command serves data transfer in a network with several parties. Both the channel to use and the destination address (depending on the parameterised addressing mode) are specified along with the command. The number of payload data bytes is limited to 120.

Format in addressing mode 0:

0x02 ***0x01*** < number of payload data bytes + 1 > < channel > < payload > < CS >

Format in addressing mode 1:

0x02 ***0x01*** < number of payload data bytes + 2 > < channel > < destination address > < payload > < CS >

Return:

0x02 ***0x41*** 0x01 < status > < CS >

Status:

0x00: ACK received, only possible if `MAC_NumRetrys` is not 0; see 11.5 or no ACK was requested.

0x01: no ACK received

10.1.3 CMD_DATAEX_IND

This telegram indicates the reception of payload data bytes and represents the counterpart to the commands CMD_DATA_REQ and CMD_DATAEX_REQ. Apart from the RX field strength (RSSI value), this telegram also specifies the sender address (depending on the parameterised addressing mode). The number of payload data bytes is limited to 120

Format in addressing mode 0:

0x02 ***0x81*** < number of payload data bytes + 1 > < payload > < field strength > < CS >

Format in addressing mode 1:

0x02 ***0x81*** < number of payload data bytes + 2 > < sender address > < payload > < field strength > < CS >

Concerning the interpretation of the field strength, see 10.10.

10.1.4 CMD_DATARETRY_REQ

This command re-launches the transmission of the data submitted earlier on with CMD_DATA_REQ or CMD_DATAEX_REQ. Thus, the data does not need to be transmitted again via the serial interface.

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

Format:

0x02 ***0x02*** 0x00 0x00

Return:

0x02 ***0x40*** 0x01 < status > < CS >

Status:

0x00: ACK received, only possible if `MAC_NumRetrys` is not 0; see 11.5 or no ACK requested.

0x01: no ACK received

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

10.2 CMD_SET_MODE_REQ

This command is used to toggle the operating mode, e.g. to exit the command mode.

Format:

0x02 ***0x04*** 0x01 < desired operating mode > < CS >

Example (exit command mode):

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

Return:

0x02 ***0x44*** 0x01 < newly configured operating mode > < CS >

Return for above example:

0x02 0x44 0x01 0x00 0x47

The following operating modes are defined:

- Mode 0 (0x00): transparent data transfer
- Mode 16 (0x10): Command mode

10.3 CMD_RESET_REQ

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

Format:

0x02 ***0x05*** 0x00 0x07

Return:

0x02 ***0x45*** 0x01 < status > < CS >

Status:

0x00: success

10.4 CMD_SET_CHANNEL_REQ

This command is used to select the radio channel. Unlike the non-volatile parameter `PHY_DefaultChannel` (see 11.11), this is a volatile runtime parameter.

Format:

0x02 ***0x06*** 0x01 < 1-byte channel > < CS >

Example (selection of channel 108):

0x02 0x06 0x01 0x6C 0x69

Return:

0x02 ***0x46*** 0x01 < new channel > < CS >

Return for above example:

0x02 0x46 0x01 0x6C 0x29

The number of the newly set channel is returned.

10.5 CMD_SET_DESTADDR_REQ

This command serves to configure the destination network ID in addressing mode 2 and 3. Unlike the non-volatile parameter `MAC_DestNetID` (see 11.7), this is a volatile runtime parameter.

Format:

0x02 ***0x07*** 0x01 < 1-byte destination network ID > < CS >

Return:

0x02 ***0x47*** 0x01 < status > < CS >

Status:

0x00: success

10.6 CMD_SET_REQ

This command enables direct manipulation of the parameters in the module's non-volatile memory. The respective parameters are accessed by means of the memory positions described in **Table 6**.

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

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

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

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

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

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

Format:

0x02 ***0x09*** < number of bytes + 2 > < memory position > < number of bytes > < parameter > < CS >

Return:

0x02 ***0x49*** 0x01 < status > < CS >

Status:

0x00: success

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)

Examples:

1. *Setting the number of wireless retries*
   (parameter `MAC_NumRetrys`, memory position 20 = 0x14):
   0x02 **0x09** 0x03 0x14 0x01 < `MAC_NumRetrys` > < PS >
2. *Setting the UART baud rate (Offset 80-83 = 0x50-0x53):*
   0x02 ***0x09*** 0x06 0x50 0x04 < UART_Baudrate_LSB> < UART_Baudrate_LSB+1>
   < UART_Baudrate_LSB+2> < UART_Baudrate_MSB> < PS >

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

   a. 15200 = 0x00.01.C2.00 ->
      UART_Baudrate_LSB = 0x00
      UART_Baudrate_LSB+1 = 0xC2
      UART_Baudrate_LSB+2 = 0x01
      UART_Baudrate_MSB = 0x00

   b. 9600 = 0x00.00.25.80 - >
      UART_Baudrate_LSB = 0x80
      UART_Baudrate_LSB+1 = 0x25
      UART_Baudrate_LSB+2= 0x00
      UART_Baudrate_MSB = 0x00
3. *Address configuration, set Destination address (`MAC_DefaultDestAddr`, Offset 25)*
   0x02 0x**09** 0x03 0x19 0x01<Dest.Addr> <CS>
4. *Address configuration, set device address*
   (`MAC_DefaultSourceAddr`, Offset 29)
   0x02 0x**09** 0x03 0x1D 0x01 <Src.Addr> <PS>
5. *Packet mode on mode 1 (`UART_PktMode`, Offset 5)*
   0x02 0x09 0x03 0x05 0x01 0x01 0x0D
6. *Set Transmission power to +27 dBm (`PHY_PAPower`, Offset 41)*
   0x02 0x09 0x03 0x29 0x01 0x1B 0x3B

10.7 CMD_GET_REQ

This command can be used to query individual or multiple non-volatile parameters (see 11). 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 not more than 128 bytes. Otherwise no data will be returned.

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

Format:

0x02 ***0x0A*** 0x02 < memory position > < number of bytes > < CS >

Example (query of all parameters):

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

Return:

0x02 ***0x4A*** < number of bytes + 2 > < memory position > < number of bytes > < parameter > < CS >

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

10.8 CMD_SERIALNO_REQ

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

Format:

0x02 ***0x0B*** 0x00 0x09

Return:

0x02 ***0x4B*** 0x04 < 4-byte serial number > < CS >

The most significant byte, which identifies the product (product ID), is returned first.
The product ID of the AMB8636 is 101 = 0x65.

10.9 CMD_FWRELEASE_REQ

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

Format:

0x02 ***0x0C*** 0x00 0x0E

Return:

0x02 ***0x4C*** 0x03 < 3 Byte FW-Version > < CS >

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

10.10 CMD_RSSI_REQ

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

Format:

0x02 ***0x0D*** 0x00 0x0F

Return:

0x02 ***0x4D*** 0x01 < RX level > < CS >

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

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

Example:

$$0xBD_{hex} = 10111101_{bin} ->$$

$$1*-128+0*64+1*32+1*16+1*8+1*4+0*2+1*1=-67dBm$$

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

11 User settings

The non-volatile settings listed in the following table can be modified by means of specific commands in the configuration mode (CMD_SET_REQUEST, see 10.6) of the module or by using the Windows software "ACC V3". These parameters are stored permanently in the module's flash memory.

The validity of the specified parameters is not verified. Incorrect values can result in device malfunction!
The software “ACC V3” does make a limited validation of the settings. Nevertheless, the user is responsible for his own values.

Designation	Description	Permissible Values	Default values	Offset	Byte size
UART_PktMode Packetizing Mode	Selects the packet generation method	0 - 1	0	5	1
UART_PktSize Packet Size	Number of characters for transmission start with set packet size	1 – 120	120	7	1
UART_ETXChar0 ETX Character	End-of-text character 0 used to mark data packets; reception of this character triggers wireless transmission	0 – 255	10	9	1
UART_ETXChar1 ETX Character	End-of-text character 1 used to mark data packets; reception of this character triggers wireless transmission	0 – 255	13	10	1
UART_Timeout Timeout	Timeout after the last character before the data received via UART are transmitted via wireless transmission [ms]	1 – 65535	5	12	2
MAC_NumRetrys Retries	Number of wireless retries	0 – 255	0	20	1
MAC_AddrMode Addressing Mode	Addressing mode to use	0 - 1	0	21	1
MAC_NumRetrysCCA	Number of retries at busy channel, see 11.21	0-255	5	22	1
MAC_CCARetryDelay	Time between retries at busy channel, see 11.21	5-255	20	23	1
MAC_DefaultDestAddr Dest. Device Address	Default destination address (LSB)	0 – 255	0	25	1
MAC_DefaultSourceAddr Local Device Address	Default own address (LSB)	0 – 254	0	29	1
MAC_ACKTimeout ACK Timeout	Waiting time for wireless acknowledgement [ms]	5 – 65535	40	32	2

Designation	Description	Permissible Values	Default values	Offset	Byte size
PHY_PAPower PA Power	Output power [dBm] (complement on two)	2 … 27	27	41	1
PHY_DefaultChannel Default channel	Used wireless channel after reset; value range depends on RF configuration	0 – 18	10	42	1
PHY_CCAThr Empfangsschwelle	Threshold at which input signal is recognized	0 - 134	0[8]	43	1
OpMode	Operating mode	0, 16	0	60	1
CfgFlags Configuration Flags (Hex.)	Flags for setting various properties; see 11.14	0 – 65535	512	72	2
UART_Baudrate	Symbol rate of the UART (4 bytes!)	1200-115200	9600	80	4
UART_Databits	Amount of data bits	7,8	8	84	1
UART_Parity	Parity	0,1,2	0	85	1
UART_Stoppbits	Amount of stop bits	1,2	1	86	1
RF_ConfigIndex	Configuration index	1	0	92	1
RF_CCACheckTimeFix	Fix minimal time in ms the channel must be clear to be recognized as clear, see 11.21	0-255	5	94	1
RF_CCACheckTimeRnd	Additional random time in ms. It is: RF_CCACheckTimeFix + RF_CCACheckTimeRnd = **maximum** time the channel must be clear to be recognized as clear, see 11.21	0-255	10	95	1
RF_LBTRndPrescaler[9]	Prescaler of the random time between to retries, see 11.21	0-255	10	96	1

Table 6 Overview over the non-volatile user settings

[8] since Firmware version 1.0.1, at earlier version default value is 27

[9] since Firmware version 1.0.1

11.1 UART_PktMode

Selects the method used for generating packets for the transparent operating mode

1. Mode 0, “0x00”: at `UART_Timeout` or `UART_PktSize`, default
2. Mode 1, “0x01” at `UART_ETXChar` or `UART_PktSize`

Not applicable in command mode.

11.2 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.

Not used in command mode.

11.3 UART_ETXChar0 & UART_ETXChar1

End-of-text character that triggers the transmission of the data received via UART.
Default is “0x0D0A” which is “CR LF”.

During the wireless transmission, the ETX character is treated like a normal character.

Not used in the command mode.

11.4 UART_Timeout

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

If during this time no more new characters are recognized, after having received the start character STX in the command mode, the characters received thus far are discarded and the module waits for a new start character.

11.5 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”).

The value for `MAC_NumRetrys` should according to ESTI EN 301 391 (Norm about the access-control for small data packets on one shared radio channel) be no larger than 5.

Example: At `MAC_NumRetrys` = 3, the packet will be sent up to 4 times (1 normal try and 3 retries).

The automatic repetitions will be executed after a time of 300ms after the last telegram has been sent. The acknowledgement in command mode will be expended on UART right after the reception of the respective ACK or after the transmission of all retries.

11.6 MAC_AddrMode

Addressing mode to be used. The following modes have been implemented:

1. Mode 0: no address, default
2. Mode 1: 1-byte address

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.

11.7 MAC_DefaultDestAddr

Destination network address to use in addressing mode 1 after a reset. Can be modified with the command `CMD_SET_DESTADDR_REQ` at runtime (volatile). If the special broadcast ID and the broadcast address are set to 255, the sender will be received by all (Broadcast).

If the broadcast address is detected by the receiver, no ACK will be sent.

11.8 MAC_DefaultSourceAddr

Own used device address in addressing mode 1. The address “255” is reserved as broadcast address and can’t be selected as source address.

11.9 MAC_ACKTimeout

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

RF-data rate	ACK-Timeout recommended
1,2 kbps	ms
2,4 kbps	ms
4,8 kbps	30ms
19,2 kbps	ms
38,4 kbps	ms
76,8 kbps	ms
>= 100 kbps	ms
*Further recommendations to follow.	

Table 7 Recommended Timeouts

11.10 PHY_PAPower

This parameter sets the RF output power to the respective level. The maximum allowed output power in frequency band G3, 869.4MHz – 896.65 MHz is 27dBm. This is also the maximal possible output power for the module. This value can be scaled in steps of 1 dBm. Minimum selectable value is +2 dBm.

11.11 PHY_DefaultChannel

Determines the wireless channel of the module to be used after a reset. Default channel is 10 with 868.5375 MHz

$$Channel = \frac{Frequency_{Should} - 869.4125MHz}{0.0125MHz}$$

11.12 PHY_CCAThr

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

$$Threshold = PHY\_CCAThr - 107dBm$$

The maximum is at 27dBm (maximum possible output power), the minimum at -107dBm.

11.13 OpMode

Operating mode to be used after power-up. Mode 0 (transparent data transfer) and mode 16 (command mode) can be selected.

11.15 CfgFlags

16-bit field in which the use of individual pins or signals can be disabled. **Table 8** presents a description of the respective flags.

Bit no.	Description
0 (0x0001)	If this bit is set, the function of the ***/CONFIG*** pin will be disabled. Subsequently, the unit can no longer be switched to the command mode via this pin.
1 (0x0002)	Reserved
2 (0x0004)	If this bit is set, the detection of the ***break signal*** on the UART interface will be suppressed. Subsequently, the unit can no longer be switched to the Command Mode by means of such a signal.
3 (0x0008)	Reserved
4 (0x0010)	Reserved
5 (0x0020)	If this bit is set, any character will be accepted as valid ***checksum*** in the command mode.
6 (0x0040)	Reserved
7 (0x0080)	If this bit is set, the address will not be resolved. The particular module can be used as packet sniffer to monitor a wireless link. No ACK is sent.
8 (0x0100)	If this bit is set the **/CTS** flow control pin is active.
9 (0x0200)	If this bit is set, the outputs for RF activity are active (e.g. for LEDs).
10(0x0400) bis 15 (0xFF00)	Reserved

Table 8 Configuration flags

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

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

11.16 UART_Baudrate

A 32 bit field, which contains the symbol rate oft he communication interface. Supported are symbol rates up to 115200 baud (see 10.60).

11.17 UART_Databits

An 8 bit field, which contains the amount of data bits for the communication interface. Supported values are 7 and 8. Default value is 8.

11.18 UART_Parity

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

11.19 UART_Stoppbits

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

11.20 RF_ConfigIndex

An 8 bit field, which addresses the applied RF configuration, see **Table 3**.

11.22 CCA – Clear Channel Assessment

Basically, 5 parameters are responsible for the CCA:

- `MAC_NumRetryCCA` at Offset 22,
- `MAC_CCARetryDelay` at Offset 23,
- `RF_CCACheckTimeFix` at Offset 94,
- `RF_CCACheckTimeRnd` at Offset 95,
- `RF_LBTRndPrescaler`[10] at Offset 96.

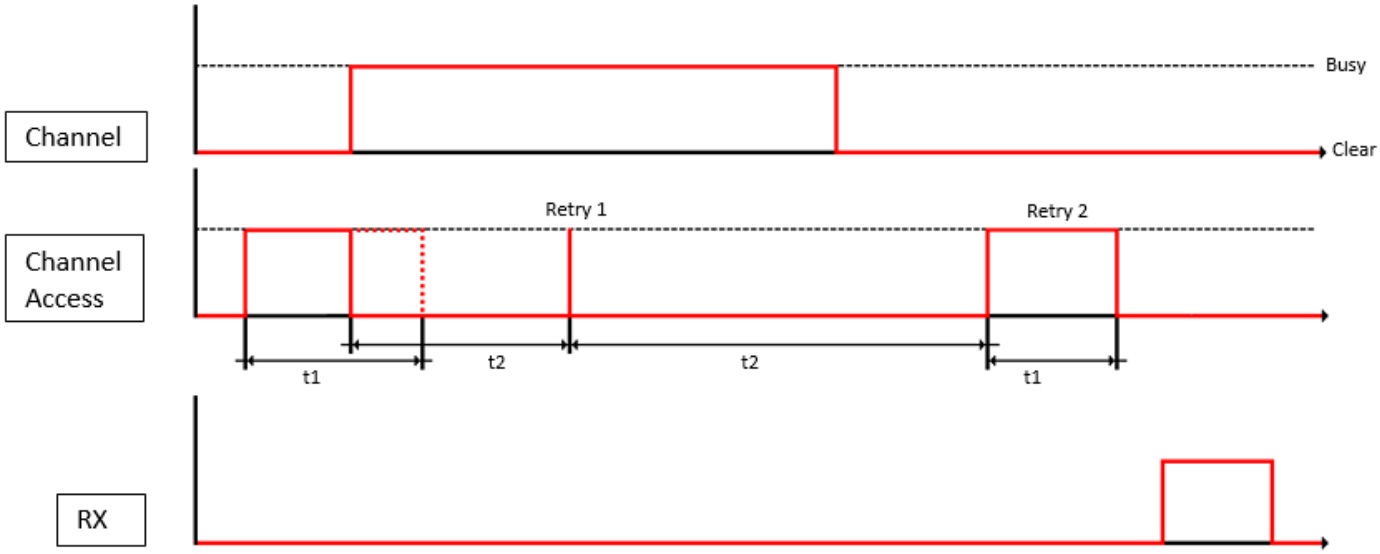

Figure 2 Signal sequence in relation to the CCA parameters

In **Figure 2** (schematic diagram) the following association can be seen:

- The random **time t_1**, at which the channel should not be busy before sending and associated as follow:
  - t_1 = `RF_CCACheckTimeFix` + [0 to `RF_CCACheckTimeRnd`]
  - **This time t_1 changes every channel access try!**
- The random **time t_2** between 2 channel access tries is:

$$t2 = MAC\_CCA\mathrm{Re}tryDelay + \frac{Random\_number}{RF\_LBTRnd\,\mathrm{Pr}escaler}$$

  - if `RF_LBTRndPrescaler` is zero, no random time will be added.
  - **The Random_number itself moves between 0 and 255 every channel access try!**
  - So the random part moves between 0 and 255.
  - The amount of maximum retries is given by `MAC_NumRetryCCA`.

[10] since Firmware version 1.0.1

12 Start up

12.1 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 is to be connected to a PC, an adaptor (TTL to RS-232 or TTL to USB) has to be used. We strongly recommend to use the /RTS pin for flow control purpose.

The AMB8636-EV-board is suited for this.

12.2 Transfer of large amounts of data

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.

12.3 Deployment of several modules, use of adresses, channel switching

In this case, we recommend connecting the /CONFIG pin in order to facilitate the required settings in the command mode. Alternatively, the module can be permanently operated in command mode (non-volatile parameter `OpMode` = 16 = 0x10|hex).

13 Firmware-Update

The firmware of the module can be updated with the PC utility “AMBER Config Center V3” and "AMBER Firmware Xpress” via the serial interface. Therefore an extra boot loader is integrated in the module, which allows access to several areas of the flash store.

Alternatively, the module can be connected and updated via JTAG and Spy-Bi-Wire.

14 Hardware integration

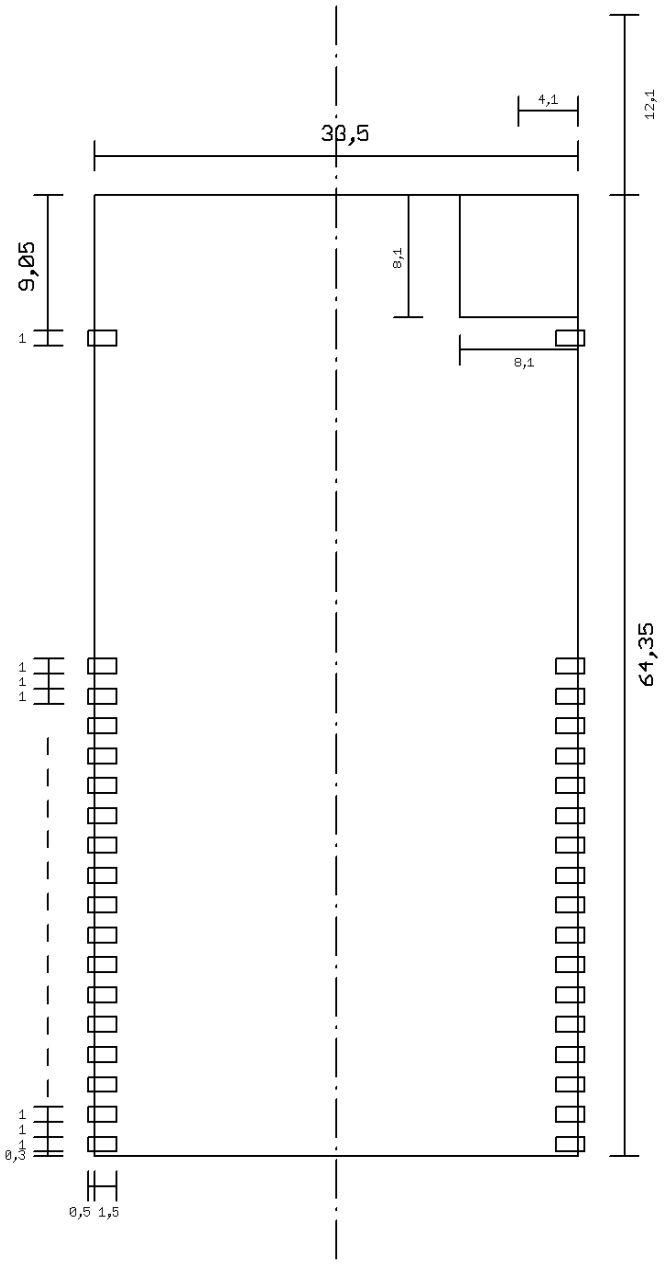

Figure 3 Footprint AMB8636 [mm]

The SMA-connector on the AMB8636 is made in through hole technology. For the at the downside overlapping pins a gap in the motherboard should be planned.

Warning: To avoid the risk of short circuits between VCC and GND, a minimum clearance of at least 30.5 mm between the opposing pad rows has to be maintained!

14.1 Tips for Schematic and Layout

The following tips should be considered for circuit design:

- Blocking capacitor in power supply line (e.g.100 µF Tantal).
- Elements for ESD protection should be destined at all lead through, exposed Pins (e.g. for the antenna connector the ESD protection diode LXES15AAA1-017 or a 68 nH aire-core coil).
- Optional elements for filtering/ matching.

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

The layout must be conducted with particular care, because even small deficiencies in layout can affect the radio performance and its obtained range.

The following should be observed:

- Grounding connection for the module as well as for the capacitors should be kept as short as possible and, when using a ground-layer, should be connected with at least one separate through-hole connection toward it.
- Underneath the radio module the top layer of the carrier pcb should be kept free from tracks and vias due to the fact that the module's bottom side is only covered with solder resist and the vias are not completely covered.
- Tracks on other layers underneath the module should be avoided. If tracks are required, they should be shielded by a ground plane.
- ESD protection elements should be placed as close to the exposed areas as possible.
- Blocking capacitors should be placed as close to the module as possible without any stub.

14.2 Antenna connection

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

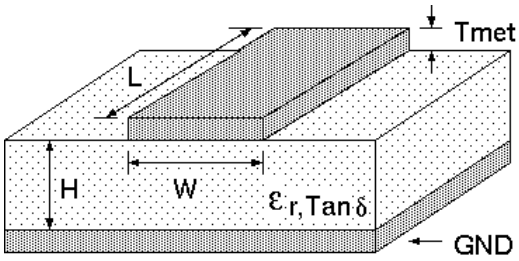

Figure 4 Dimensioning the antenna feed line as micro strip

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.

- Distances between tracks and groundplanes to the microstrip should be observed. For this example a distance of about 2mm should be kept.
- On the next layer underneath the micro strip a ground plane should be placed.
- Keep the feeding line as short as possible.
- The earlier mentioned elements for filtering/ matching are placed directly in the feeding line, one element against ground (**Figure 8** L1) one element in series (**Figure 5** C1) and one element against ground (**Figure 5** L2). Especially for the RF-path it is important to avoid stubs, the elements connecting to ground are placed directly centric in the RF-track. It is also important to use at least one separate via per part to connect to the ground layer.
- First you may assuming, that no filtering/ matching is necessary. The filter can be bridged with a 68 pF capacitor (**Figure 5** C1).

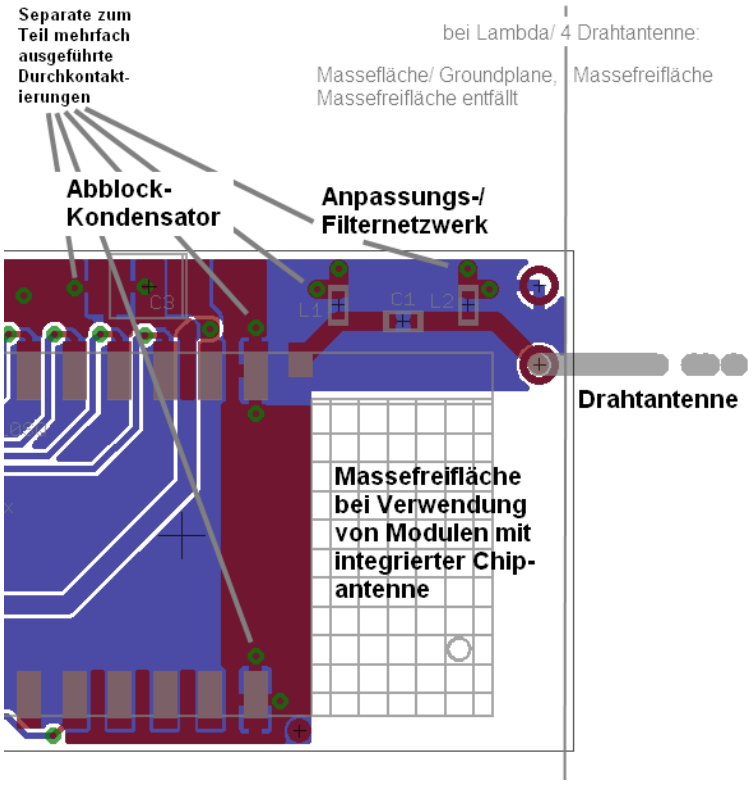

Figure 5 Matching circuit of a λ/4 antenna

A simple but effective antenna solution is an 8.6 cm long piece of wire, a Lambda/4 antenna. This wire should point away from the module and needs a ground plane below the feeding point. The antenna should have a minimum distance of 3.5 cm to any other metal or conductive material.
Any metallic, metalized or conductive material utilized for the system's housing is attenuating or even impenetrable for radio waves. In this case, the antenna has to be placed outside the enclosure. The RF is led through a 50 Ohm track towards an RF connector (e.g. BNC, SMA, GSC or U.FL). This connector could protrude through the enclosure (for example SMA-/BNC right angle connectors, **Figure 6**) or could be led to the outside by a pre-assembled cable (for example GSC to SMA, **Figure 7**).

Figure 6 Housing break through with right angled BNC-connector

Figure 7 GSC-SMA-Adapter

With the AMB1981 dipole-antenna and the AMB1982 monopole-antenna with magnet foot and 1.5m antenna cable AMBER offers ideal solutions for the 868 MHz frequency range (SMA m).

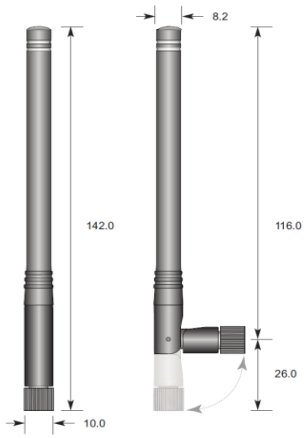

Figure 8 AMB1981:
868 MHz Dipole-Antenna

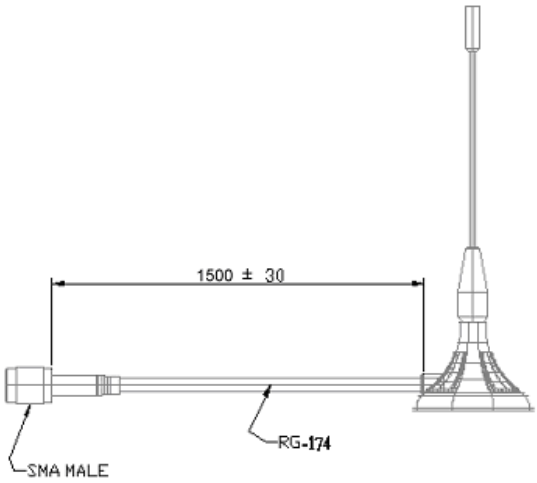

Figure 9 AMB1982: 868 MHz magnet foot antenna with 1.5 m antenna cable

Monopole antennas such as the AMB1982 need a ground plane at the feeding point with a minimum radius of about Lambda/ 4.

15 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 10 shows a soldering curve that had been used for a 31 cm^2 carrier board for single-side assembly.

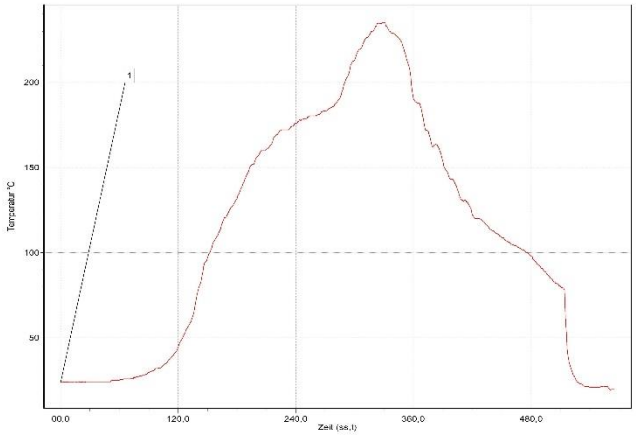

Figure 10 Example of a temperature profile –

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.

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.

16 Firmware

16.1 Firmware history

Version 1.0

- First product release

Version 1.0.2

- Implementation Listen Before Talk (CCA)

17 References

[1] „AMB8636 Datasheet”, AMBER wireless GmbH

18 Regulatory compliance information

18.1 Important notice

The use of RF frequencies is limited by national regulations. The AMB8636 has been designed to comply with the R&TTE directive 1999/5/EC of the European Union (EU).

The AMB8636 can be operated without notification and free of charge in the area of the European Union. However, according to the R&TTE directive, restrictions (e.g. in terms of duty cycle or maximum allowed RF power) may apply.

Conformity assessment of the final product

The AMB8636 is a subassembly. It is designed to be embedded into other products (products incorporating the AMB8636 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 AMB8636 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.

18.2 Declaration of conformity

DECLARATION OF CONFORMITY
Directive 1999/5/EG (R&TTE)
ROHS 2011/65/EU

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

Declares on its sole responsibility, that the following product:

Type-designation: **AMB8636**

Intended purpose: 868MHz transceiver module
Transfer of digital messages

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

EN 300 220-1 V2.4.1
EN 300 220-2 V2.4.1
EN 301 489-1 V1.9.2
EN 301 489-3 V1.6.1
EN 60950-1 : 2006 + A11 : 2009 + A1 : 2010
EN 62311

Furthermore it satisfies the restrictions for the use of certain hazardous substances in electrical and electronic equipment in accordance with Directive 2011/65/EU of the European parliament and of the Council fo 8 June 2011.

Trier, 6th of August 2014
Place and date of issue

Manufacturer/Authorized representative
Gudrun Eckhardt

19 Important Information

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