AMA-02R

Hardware Design Guide

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Contents

1 Introduction

This document defines the AMA-02R series module and describes its air interface and hardware interfaces which are connected with your applications.

This document can help you quickly understand module interface specifications, electrical and mechanical details, as well as other related information of the module. Associated with application notes and user guides, you can use the module to design and set up wireless applications easily.

2 Product Overview

ATEL AMA-02R is a series of LTE Cat 1bis modules optimized specially for M2M and IoT applications. Adopting the 3GPP Rel-9 LTE technology, it delivers maximum data rates up to 10 Mbps downlink and 5 Mbps uplink. Designed in a compact and unified form factor.

Table 1: Brief Introduction

AMA-02R Series	
Packaging	LGA
Pins count	126
Dimensions	(23.6 ±0.2) mm ×(20.0 ±0.2) mm ×(2.4 ±0.2) mm
Weight	Approx. 2.58 g

2.1. Frequency Bands and Functions

Table 2: Frequency Bands

3GPP Band	Transmit	Receive	Unit
GSM850	824-849	869-894	MHz
EGSM900	880-915	925-960	MHz
DCS1800	1710-1785	1805-1880	MHz
PCS1900	1850-1910	1930-1990	MHz
LTE-FDD B2	1850-1910	1930-1990	MHz
LTE-FDD B3	1710-1785	1805-1880	MHz
LTE-FDD B4	1710-1755	2110-2155	MHz
LTE-FDD B5	824-849	869-894	MHz
LTE-FDD B7	2500-2570	2620-2690	MHz
LTE-FDD B8	880-915	925-960	MHz
LTE-FDD B28	703-748	758-803	MHz
LTE-FDD B66	1710-1780	2110-2180	MHz

2.2. Key Features

The following table describes the detailed features of the module.

Features	Details
Power Supply	● Supply voltage: 3.4-4.5 V ● Typical supply voltage: 3.8 V
Transmitting Power	● Class 4 (33 dBm ±2 dB) for GSM850 ● Class 4 (33 dBm ±2 dB) for EGSM900 ● Class 1 (30 dBm ±2 dB) for DCS1800 ● Class 1 (30 dBm ±2 dB) for PCS1900 ● Class E2 (27 dBm ±3 dB) for GSM850 8-PSK ● Class E2 (27 dBm ±3 dB) for EGSM900 8-PSK ● Class E2 (26 dBm ±3 dB) for DCS1800 8-PSK ● Class E2 (26 dBm ±3 dB) for PCS1900 8-PSK ● Class 3 (23 dBm ±2 dB) for LTE-FDD bands
LTE Features	● Supports up to 3GPP Rel-9 non-CA Cat 1 FDD ● Supports 1.4/3/5/10/15/20 MHz RF bandwidth ● LTE-FDD: Max. 10 Mbps (DL), Max. 5 Mbps (UL)
GSM Features	**GPRS:** ● Supports GPRS multi-slot class 12 ● Coding scheme: CS 1-4 ● Max. 85.6 kbps (DL), Max. 85.6 kbps (UL) **EDGE:** ● Supports EDGE multi-slot class 12 ● Supports GMSK and 8-PSK for different MCS ● Downlink coding schemes: MCS 1-9 ● Uplink coding schemes: MCS 1-9 ● Max. 236.8 kbps (DL), Max. 236.8 kbps (UL)
Internet Protocol Features	● Supports TCP/UDP/PPP/FTP/HTTP/NTP/PING/NITZ/CMUX/HTTPS/SMTP/FTPS/SMTPS/SSL/FILE/MQTT protocols ● Supports PAP and CHAP for PPP connections

SMS	● Text and PDU modes ● Point-to-point MO and MT ● SMS cell broadcast ● SMS storage: (U)SIM card and ME, ME by default
Audio Features	● Supports one digital audio interface: PCM interface ● Supports one analog audio input and one analog audio output ● HR/FR/EFR/AMR/AMR-WB ● Supports echo cancellation and noise suppression
USB Interface	● Compliant with USB 2.0 specification (slave mode only), with data transmission rate up to 480 Mbps ● Used for AT command communication, data transmission, software debugging, firmware upgrade and GNSS NMEA message output ● Supports USB serial drivers for: Windows 7/8/8.1/10/11, Linux 2.6–6.5, Android 4.x–13.x, etc.
(U)SIM Interfaces	● Supports (U)SIM card: 1.8/3.0 V ● Supports Dual SIM Single Standby
UART	**Main UART:** ● Used for AT command communication and data transmission ● Baud rate: 115200 bps by default ● Supports RTS and CTS hardware flow control **Auxiliary UART*:** ● Used for communication with peripherals ● Baud rate: 115200 bps ● Supports RTS and CTS hardware flow control **Debug UART:** ● Used for the output of partial logs and GNSS NMEA message ● Baud rate:115200 bps
PCM Interface	● Used for audio function with an external codec ● Short frame mode: module can only be used as master device
I2C Interface	● One I2C interface ● Complies with I2C bus specification version
AT Commands	Compliant with *3GPP TS 27.007, 3GPP TS 27.005*
Network Indication	NET_STATUS to indicate the network connectivity status
Antenna Interfaces	● Main antenna interface (ANT_MAIN) ● 50 Ω impedance

Position Fixing	● Supports Wi-Fi scan and shares the main antenna***
Operating Temperature	● Operating temperature range: -25 °C to +55 °C [2] ● Extended temperature range: -35 °C to +80 °C [3] ● Storage temperature range: -35 °C to +85 °C
Firmware Upgrade	Via USB interface or DFOTA
RoHS	All hardware components are fully compliant with EU RoHS directive

2.3. Functional Diagram

The following figure shows a block diagram of the module and illustrates the major functional parts.

- Power management
- Baseband
- Memory
- Radio frequency
- Peripheral interfaces

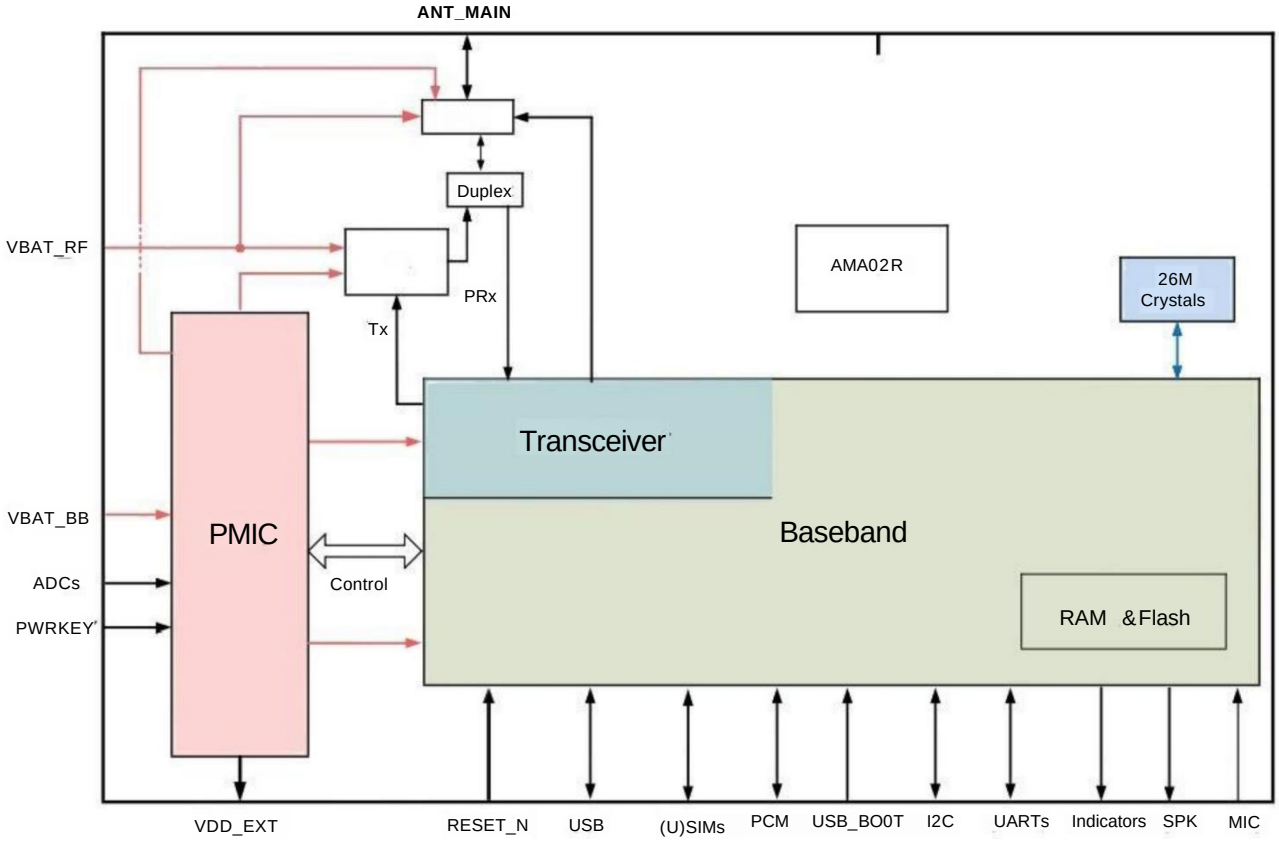


Figure 1:Functional Diagram of AMA-02R Series

3 Application Interfaces

3.1. General Description

The module is equipped with 126 LGA pins that can be connected to cellular application platform. The subsequent chapters will provide detailed descriptions of the following interfaces.

- Power supply
- (U)SIM interfaces
- USB interface
- UART interfaces
- Analog audio interfaces
- PCM and I2C interfaces
- Network status indication
- USB_BOOT interface
- STATUS

3.2. Pin Assignment

The following figure shows the pin assignment of the module.

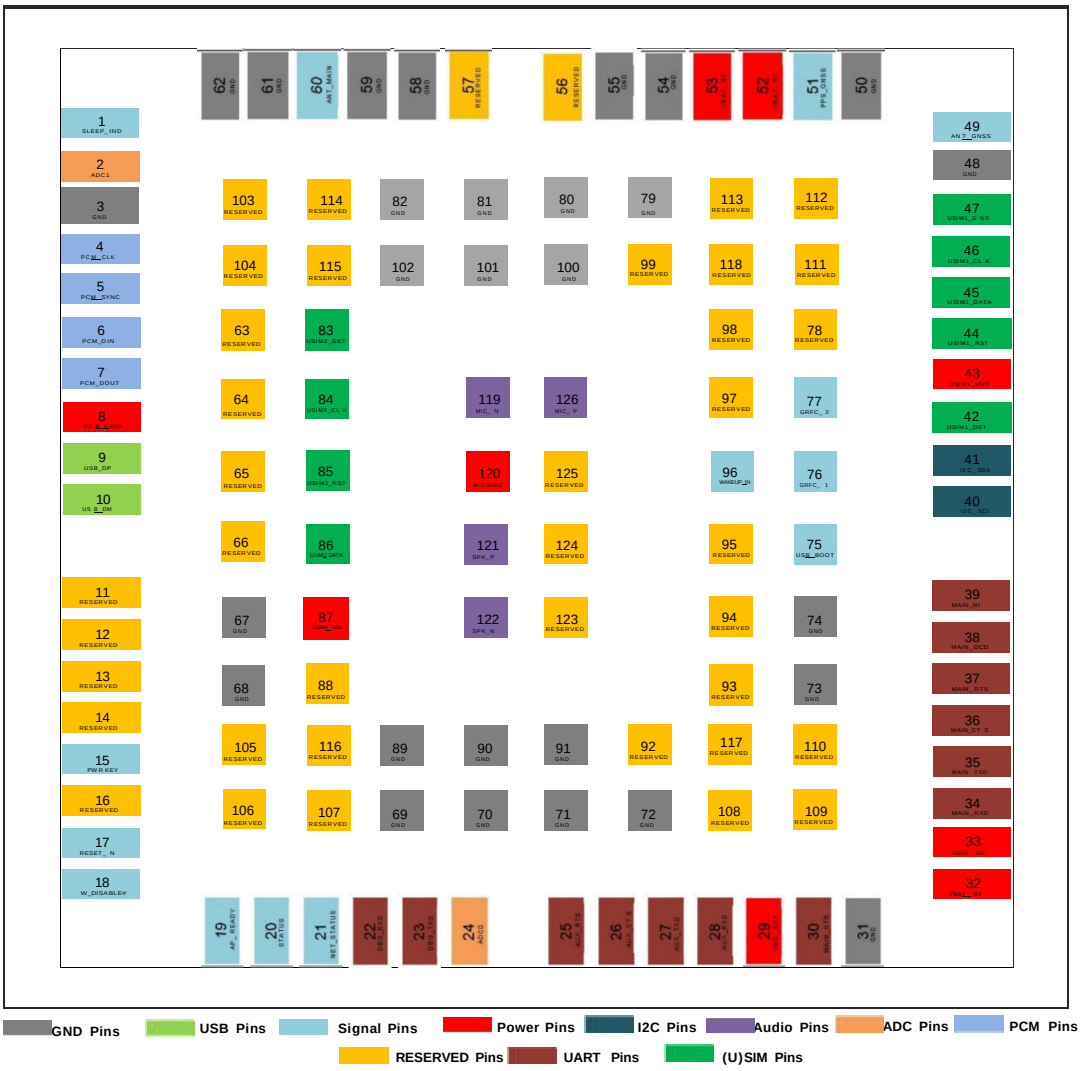


Figure 2: Pin Assignment (Top View)

3.3. Pin Description

The following tables show the pin definition and description of the module.

Table 3: Parameter Definition

Parameter	Description
AI	Analog Input
AIO	Analog Input/Output
AO	Analog Output
DI	Digital Input
DO	Digital Input/Output
DIO	Digital Output
OD	Open Drain
PI	Power Input
PO	Power Output

DC characteristics include power domain and rated current.

Table 4: Pin Description

Power Supply Input					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT_BB	32, 33	PI	Power supply for the module's baseband part	Vmax = 4.5 V Vmin = 3.4 V Vnom = 3.8 V	External power supply must be provided with sufficient current of at least 0.8 A. It is

					recommended to add external TVS diode. A test point is recommended to be reserved.
VBAT_RF	52, 53	PI	Power supply for the module's RF part		External power supply must be provided with sufficient current of at least 2.2 A. It is recommended to add external TVS diode. A test point is recommended to be reserved.
GND	3, 31, 48, 50, 54, 55, 58, 59, 61, 62, 67–74, 79–82, 89–91, 100–102				
Power Supply Output					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VDD_EXT	29	PO	Provide 1.8 V for external circuit	Vnom = 1.8 V $I_O$max = 50 mA	Power supply for external GPIO's pull-up circuits. A test point is recommended to be reserved.
Turn On/Off					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PWRKEY	15	DI	Turn on/off the module	V_{IL}max = 0.5 V Vnom = VBAT	VBAT power domain. A test point is recommended to be reserved.
RESET_N	17	DI	Reset the module	V_{IL}max = 0.5 V Vnom = 1.8 V	Active low. 1.8 V power domain. A test point is recommended to be reserved if unused.
Status Indication					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**

SLEEP_IND	1	DO	Indicate the module's sleep mode	1.8 V	If unused, keep them open.
STATUS	20	DO	Indicate the module's operation status		
NET_STATUS	21	DO	Indicate the module's network activity status		
USB Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USB_VBUS	8	AI	USB connection detect	Vmax = 5.25 V Vmin = 3.0 V Vnom = 5.0 V	A test point must be reserved.
USB_DP	9	AIO	USB differential data (+)		Requires differential impedance of 90 Ω.
USB_DM	10	AIO	USB differential data (-)		USB 2.0 compliant. Test points must be reserved.
(U)SIM Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USIM1_DET	42	DI	(U)SIM1 card hot-plug detect	1.8 V	If unused, keep it open.
USIM1_VDD	43	PO	(U)SIM1 card power supply	$I_O$max = 50 mA 1.8/3.0 V	Either 1.8 V or 3.0 V (U)SIM card is supported and can be identified automatically by the module.
USIM1_RST	44	DO	(U)SIM1 card reset	USIM1_VDD 1.8/3.0 V	
USIM1_DATA	45	DIO	(U)SIM1 card data		
USIM1_CLK	46	DO	(U)SIM1 card clock		
USIM1_GND	47	-	Specified ground for (U)SIM1		Connect to main GND of PCB.
USIM2_DET*	83	DI	(U)SIM2 card hot-plug detect	1.8 V	If unused, keep it open.
USIM2_CLK	84	DO	(U)SIM2 card clock	USIM2_VDD 1.8/3.0 V	
USIM2_RST	85	DO	(U)SIM2 card reset		

USIM2_DATA	86	DIO	(U)SIM2 card data		
USIM2_VDD	87	PO	(U)SIM2 card power supply	I_{O}max = 50 mA 1.8/3.0 V	Either 1.8 V or 3.0 V (U)SIM card is supported and can be identified automatically by the module.
Main UART					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
MAIN_DTR	30	DI	Main UART data terminal ready		If unused, keep them open.
MAIN_RXD	34	DI	Main UART receive		
MAIN_TXD	35	DO	Main UART transmit		
MAIN_CTS	36	DO	Clear to send signal from the module	1.8 V	Connect to MCU's CTS. If unused, keep it open.
MAIN_RTS	37	DI	Request to send signal to the module		Connect to MCU's RTS. If unused, keep it open.
MAIN_DCD	38	DO	Main UART data carrier detect		If unused, keep them open.
MAIN_RI	39	DO	Main UART ring indication		
Auxiliary UART*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
AUX_RTS	25	DI	Request to send signal to the module		Connect to MCU's RTS. If unused, keep it open.
AUX_CTS	26	DO	Clear to send signal from the module	1.8 V	Connect to MCU's CTS. If unused, keep it open.
AUX_TXD	27	DO	Auxiliary UART transmit		If unused, keep them open.

AUX_RXD	28	DI	Auxiliary UART receive		
Debug UART					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
DBG_RXD	22	DI	Debug UART receive	1.8 V	Test points must be reserved.
DBG_TXD	23	DO	Debug UART transmit		
PCM Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PCM_CLK	4	DO	PCM clock	1.8 V	If unused, keep them open.
PCM_SYNC	5	DO	PCM data frame sync		
PCM_DIN	6	DI	PCM data input		
PCM_DOUT	7	DO	PCM data output		
I2C Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
I2C_SCL	40	OD	I2C serial clock	1.8 V	An external 1.8 V pull-up resistor is required. If unused, keep them open.
I2C_SDA	41	OD	I2C serial data		
Analog Audio Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
MICBIAS	120	PO	Bias voltage output for microphone		If unused, keep them open.

MIC_N	119	AI	Microphone analog input (-)		
MIC_P	126	AI	Microphone analog input (+)		
SPK_P	121	AO	Analog audio differential output (+)		The interface can drive 32 Ω earpiece with power rate at 37 mW @ THD = 1 %. It can also be used to drive external power amplifier devices if the output power rate cannot meet the demand. If unused, keep them open.
SPK_N	122	AO	Analog audio differential output (-)		
Antenna Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANT_MAIN	60	AIO	Main antenna interface		50 Ω impedance.
Antenna Tuner Control Interfaces*					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ATC1	76	DO	Generic RF Controller		If unused, keep them open.
ATC2	77	DO			
Other Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
WAKEUP_IN*	96	DI	Wake up the module	1.8 V	If unused, keep them open.
AP_READY	19	DI	Application processor ready		
W_DISABLE#	18	DI	Airplane mode control		Pull-up by default. In low voltage level, module can enter airplane mode.

				If unused, keep it open.
USB_BOOT	75	DI	Force the module into emergency download mode	Active high. A test point is recommended to be reserved.
PPS_GNSS	51	DO	PPS output	Cannot pull it down when GNSS function is active.

Reserved Pins		
Pin Name	**Pin No.**	**Comment**
RESERVED	11-14, 56, 57, 63, 65,66, 88,99, 108-113, 117,118,123-125	Keep them open.

3.4. Operating Modes

Table 5: Overview of Operating Modes

Modes	**Details**	
Full Functionality Mode	Idle	Software is active. The module remains registered on the network, and it is ready to send and receive data.
	Voice/Data	Network connection is ongoing. Power consumption is decided by network setting and data transmission rate.
Minimum Functionality Mode	**AT+CFUN=0** can set the module into a minimum functionality mode without removing the power supply. In this case, both RF function and (U)SIM card will be invalid.	
Airplane Mode	**AT+CFUN=4** or driving W_DISABLE# pin low can set the module to airplane mode. In this case, RF function will be invalid.	
Sleep Mode	Power consumption of the module is reduced to the minimal level. During this mode, the module can still receive paging message, SMS, voice call and TCP/UDP data from the network normally.	

Power Down Mode	In this mode, the module's power supply is cut off by its power management IC. The software is inactive, while the VBAT_RF and VBAT_BB pins are still powered.

3.5. Sleep Mode

With DRX technology, power consumption of the module will be reduced to an ultra-low level.

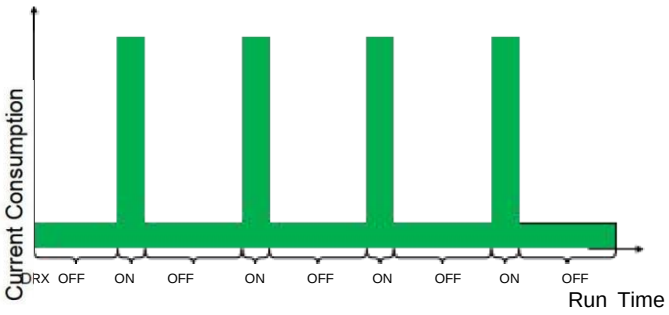


Figure 3: DRX Run Time and Current Consumption in Sleep Mode

3.5.1. UART Application Scenario

If the MCU communicates with module via UART interfaces, the following preconditions should be met at the same time to let the module enter sleep mode.

- Drive MAIN_DTR high or keep it open.

The following figure shows the connection between the module and the MCU.

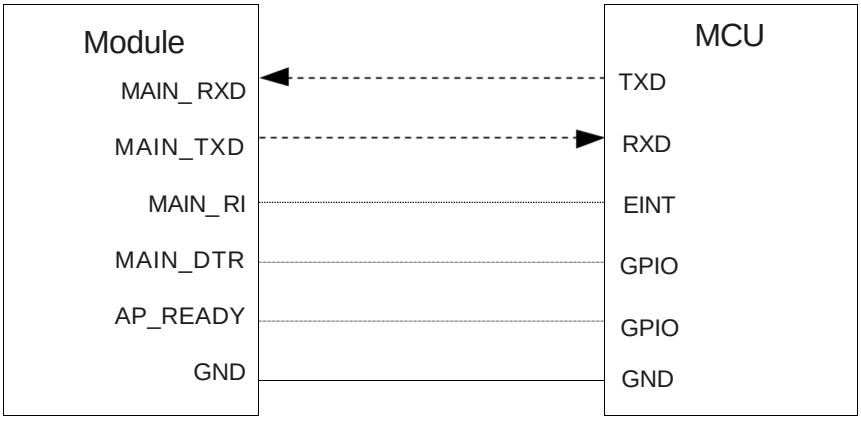


Figure 4: Sleep Mode Application via UART

- Drive MAIN_DTR low by the MCU will wake up the module.
- When the module has a URC to report, the URC will trigger the behavior of MAIN_RI pin.

3.5.2. USB Application Scenario

For the two situations (USB application with USB Suspend/Resume and USB remote wakeup function and USB application with USB Suspend/Resume and RI function) below, three preconditions must be met to set the module into sleep mode:

- Ensure the host's USB bus,which is connected to the module's USB interface, enters Suspend state.

3.5.2.1. USB Application with USB Remote Wakeup Function

If the host supports USB Suspend/Resume and remote wakeup functions. The following figure shows the connection between the module and the host.

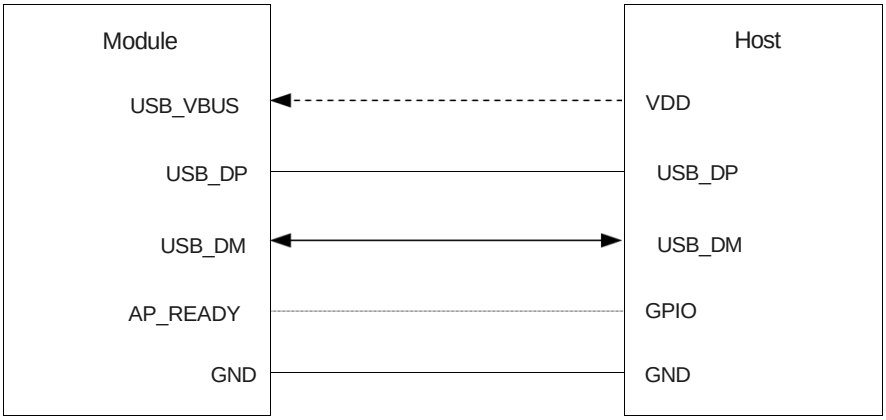


Figure 5: Sleep Mode Application with USB Remote Wakeup Function

- Sending data to the module through USB will wake up the module.
- When the module has a URC to report, the module sends remote wake-up signals to wake up the host via USB bus.

3.5.2.2. USB Application with USB Suspend/Resume and RI Function

If the host supports USB Suspend/Resume, but does not support remote wakeup function, the MAIN_RI signal is needed to wake up the host.

The following figure shows the connection between the module and the host.

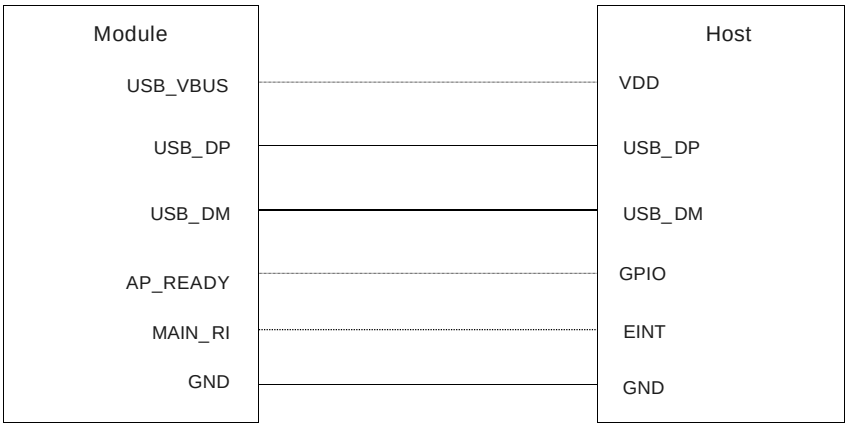


Figure 6: Sleep Mode Application with MAIN_RI

- Sending data to the module through USB will wake up the module.
- When the module has a URC to report, the URC will trigger the behavior of MAIN_RI pin.

3.5.2.3. USB Application without USB Suspend Function

If the host does not support USB Suspend function, disconnect USB_VBUS with an external control circuit to let the module enter sleep mode.

The following three preconditions must be met at the same time to let the module enter sleep mode.

- Ensure the MAIN_DTR is held at high level or keep it open.
- Disconnect the USB_VBUS power supply.

The following figure shows the connection between the module and the host.

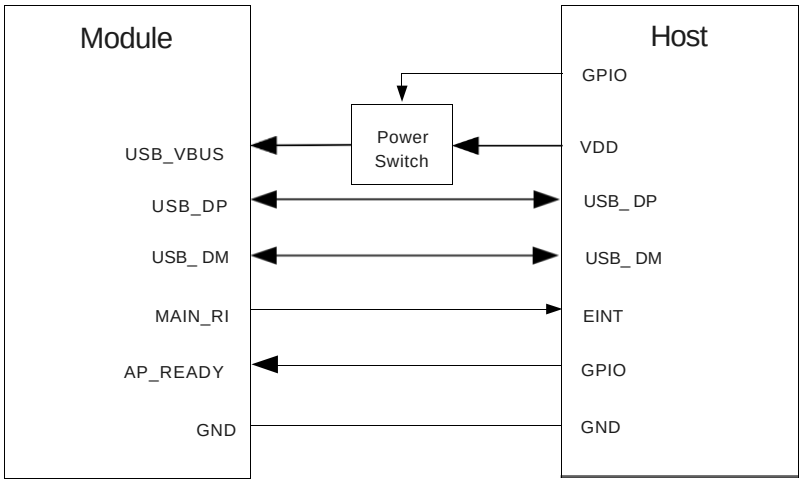


Figure 7: Sleep Mode Application without USB Suspend Function

You can wake up the module by turning on the power switch to supply power to USB_VBUS.

NOTE

1. Pay attention to the level match shown in dotted line between the module and the MCU/host in the circuit diagrams.

3.6. Airplane Mode

When the module enters airplane mode, the RF function does not work and all AT commands related to the RF function are inaccessible. The following ways can be used to let the module enter airplane mode.

Hardware:

The W_DISABLE# pin is pulled up by default. Its control function for airplane mode is disabled by default, Driving the pin low can make the module enter the airplane mode.

Software:

AT+CFUN=<fun> provides the choice of the functionality level through setting **<fun>** into 0, 1 or 4.

- **AT+CFUN=0:** Minimum functionality mode (disable (U)SIM and RF functions).
- **AT+CFUN=1:** Full functionality mode (by default).
- **AT+CFUN=4:** Airplane mode (disable RF function).

3.7. Power Supply

3.7.1. Power Supply Pins

The module provides four VBAT pins dedicated to connecting with the external power supply. There are two separate voltage domains for VBAT.

- Two VBAT_RF pins for module's RF part
- Two VBAT_BB pins for module's baseband part

Table 6: Power Supply and GND Pins

Pin Name	Pin No.	I/O	Description	Comment
VBAT_RF	52, 53	PI	Power supply for the module's RF part	External power supply must be provided with sufficient current of at least 3.0 A.
VBAT_BB	32, 33		Power supply for the module's baseband part	It is recommended to add a TVS diode externally. Test points are recommended to be reserved.
GND	3, 31, 48, 50, 54, 55, 58, 59, 61, 62, 67–74, 79–82, 89–91, 100–102			

3.7.2. Voltage Stability Requirements

The power supply range of the module is from 3.4 V to 4.5 V. Please make sure that the input voltage never drops below 3.4 V. The following figure shows the voltage drop during burst transmission in 2G network. The voltage drop will be less in 4G networks.

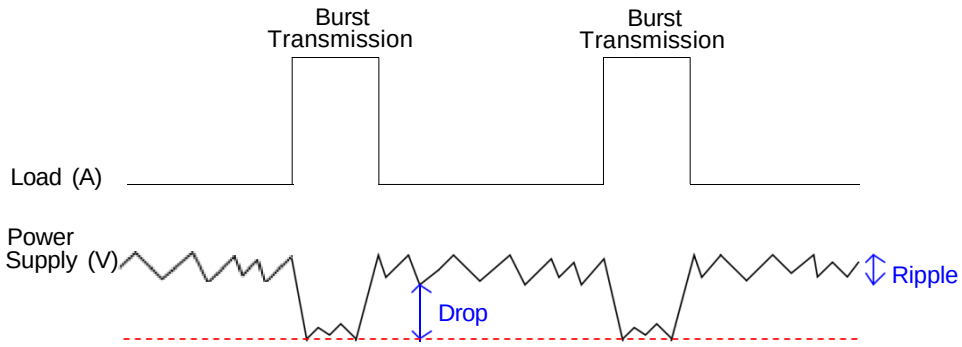


Figure 8: Power Supply Limits during Burst Transmission

To decrease voltage drop, a bypass capacitor of about 100 µF with low ESR (ESR ≤ 0.7 Ω) should be used. It is recommended to reserve three multi-layer ceramic chip (MLCC) capacitors (100 nF, 33 pF and 10 pF) with the best ESD performance, and place these capacitors close to the VBAT_BB and VBAT_RF pins. The main power supply from an external application has to be a single voltage source and can be expanded to two sub paths with star configuration. The width of VBAT_BB trace should be not less than 1 mm; and the width of VBAT_RF trace should be not less than 2 mm. In principle, the longer the VBAT trace is, the wider it will be.

In order to avoid the ripple and surge and ensure the stability of the power supply to the module, add a TVS diode with V_{RWM} = 4.7 V, low-clamp voltage and peak pulse current Ipp at the front end of the power supply.

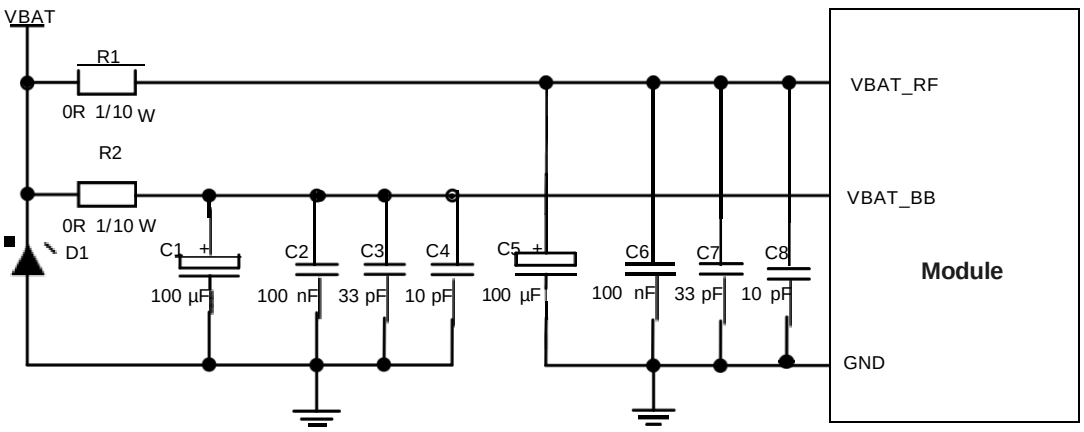
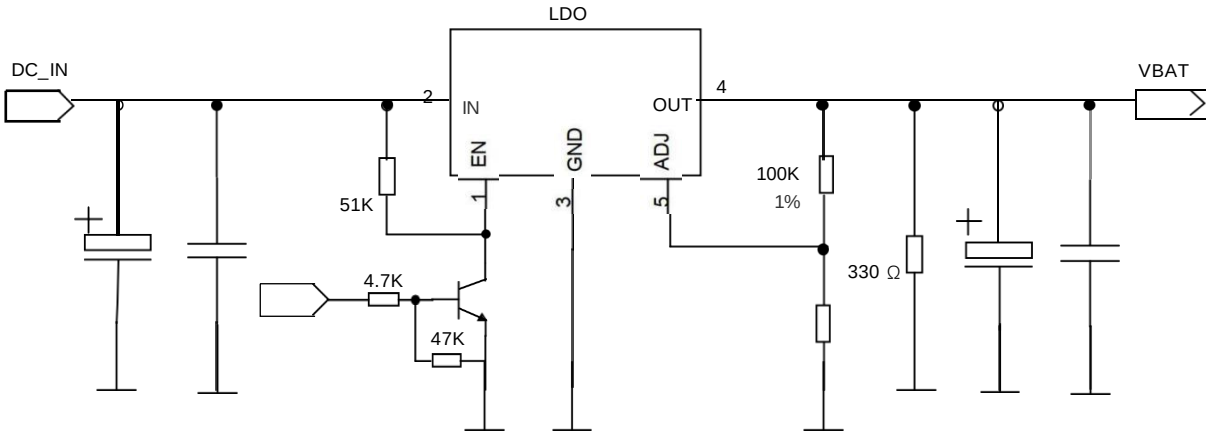


Figure 9: Star Configuration of Power Supply

3.7.3. Reference Design for Power Supply

Power design for the module is very important, as the performance of the module largely depends on the power source. The power supply should be able to provide sufficient current up to 3.0 A to the module. If the voltage drop between the input and output is not too high, it is suggested that an LDO should be used. If there is a big voltage difference between the input source and the desired output (VBAT), a buck converter is preferred to be used.

The following figure shows a reference design for 5 V input power source. The circuit is designed using the LDO of Microchip. The typical output of the power supply is about 3.8 V and the maximum load current is 3.0 A.



4 RF Specifications

Appropriate antenna type and design should be used with matched antenna parameters according to specific application. It is required to perform a comprehensive functional test for the RF design before mass production of terminal products. The entire content of this chapter is provided for illustration only. Analysis, evaluation and determination are still necessary when designing target products.

4.1. Cellular Network

4.1.1. Main Antenna Interface

Table 7: Pin Definition of Main Antenna

ANT_MAIN	60	AIO	Main antenna interface	50 Ω impedance.

4.1.2. Antenna Tuner Control Interfaces*

The module can use ATC interfaces to control external antenna tuner.

Table 8: Pin Definition of GRFC Interfaces

Pin Name	Pin No.	I/O	Description	Comment
ATC1	76	DO	Generic RF Controller	If unused, keep them open.
ATC2	77	DO		

Table 9: AMA-02R Truth Table of GRFC Interface (Unit: MHz)

ATC1 Level	ATC2 Level	Bands
Low	Low	LTE B28
Low	High	LTE B5, GSM850
High	Low	LTE B2/B8/B7, EGSM900,PCS1900
High	High	LTE B3/B4/B66 DCS1800

4.1.3. Transmitting Power

The following tables show the RF output power of the module

Table 10: AMA-02R RF Transmitting Power

Frequency Bands	Max.	Min.
GSM850	33 dBm ±2 dB	5 dBm ±5 dB
EGSM900	33 dBm ±2 dB	5 dBm ±5 dB
DCS1800	30 dBm ±2 dB	0 dBm ±5 dB
PCS1900	30 dBm ±2 dB	0 dBm ±5 dB
GSM850 (8-PSK)	27 dBm ±3 dB	5 dBm ±5 dB
EGSM900 (8-PSK)	27 dBm ±3 dB	5 dBm ±5 dB
DCS1800 (8-PSK)	26 dBm ±3 dB	0 dBm ±5 dB
PCS1900 (8-PSK)	26 dBm ±3 dB	0 dBm ±5 dB
LTE-FDD B2/B3/B4/B5/B7/B8/B28/B66	23 dBm ±2 dB	< -39 dBm

4.1.4. Receiver Sensitivity

The following tables show conducted RF receiver sensitivity of the module.

Table 11: AMA-02R Conducted RF Receiver Sensitivity

Frequency Bands	Receiver Sensitivity (Typ.)			3GPP (SIMO)
	Primary	Diversity	SIMO	
GSM850	-108 dBm	-	-	-102 dBm
EGSM900	-108 dBm	-	-	-102 dBm
DCS1800	-106 dBm	-	-	-102 dBm
PCS1900	-106 dBm	-	-	-102 dBm
LTE-FDD B2 (10 MHz)	-96.4 dBm	-	-	-94.3 dBm
LTE-FDD B3 (10 MHz)	-97.4 dBm	-	-	-93.3 dBm
LTE-FDD B4 (10 MHz)	-98.5 dBm	-	-	-96.3 dBm
LTE-FDD B5 (10 MHz)	-99.8 dBm	-	-	-94.3 dBm
LTE-FDD B7 (10 MHz)	-96.8 dBm	-	-	-94.3 dBm
LTE-FDD B8 (10 MHz)	-99.4 dBm	-	-	-93.3 dBm
LTE-FDD B28 (10 MHz)	-99.6 dBm	-	-	-94.8 dBm
LTE-FDD B66 (10 MHz)	-98.6 dBm	-	-	-96.5 dBm

4.1.5. Reference Design

4.1.5. Reference Design

A reference design of ANT_MAIN antenna is shown as below. A π-type matching circuit should be reserved for better RF performance. The capacitors are not mounted by default.

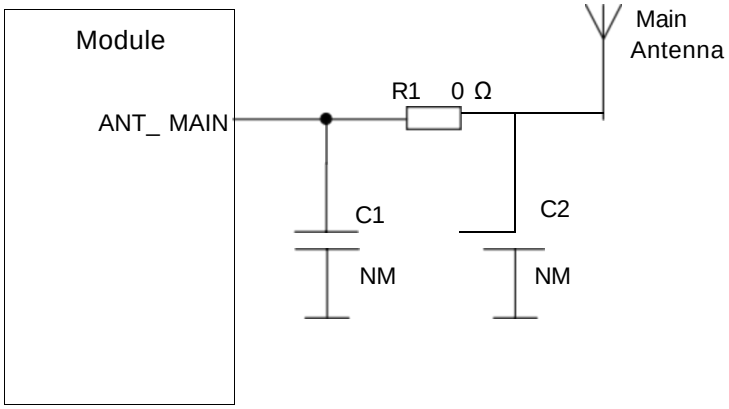


Figure 10: Reference Design for Main Antenna Interface

NOTE

Place the π-type matching components (R1, C1 and C2) as close to the antenna as possible.

5 Electrical Characteristics & Reliability

5.1. Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital and analog pins of the module are listed in the following table.

Table 12: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VBAT_BB/VBAT_RF	-0.3	6.0	V
USB_VBUS	-0.3	5.5	V
Peak Current of VBAT_BB	-	0.8	A
Peak Current of VBAT_RF	-	2.2	A
Voltage at Digital Pins	-0.3	2.3	V

5.2. Power Supply Ratings

Table 13: Power Supply Ratings

Paramete	Description	Conditions	Min.	Typ.	Max.	Unit
VBAT	VBAT_BB and VBAT_RF	The actual input voltages must be kept between the minimum and maximum values.	3.4	3.8	4.5	V
	Voltage drop during burst transmission	Maximum power control level	-	-	400	mV

I_{VBAT}	Peak supply current	Maximum power control level	-	2.0	2.5	A
USB_VBUS	USB connection detect		3.0	5.0	5.25	V

5.4. Digital I/O Characteristics

Table 14: 1.8 V Digital I/O Requirements

Parameter	Description	Min.	Max.	Unit
V_{IH}	Input high voltage	0.7 ×VDDIO	VDDIO + 0.2	V
V_{IL}	Input low voltage	-0.3	0.3 ×VDDIO	V
V_{OH}	Output high voltage	VDDIO - 0.2	-	V
V_{OL}	Output low voltage	-	0.2	V

Table 15: (U)SIM 1.8 V I/O Requirements

Parameter	Description	Min.	Max.	Unit
USIM_VDD	Power supply	1.62	1.98	V
V_{IH}	Input high voltage	0.7 ×USIM_VDD	USIM_VDD	V
V_{IL}	Input low voltage	0	0.2 ×USIM_VDD	V
V_{OH}	Output high voltage	0.7 ×USIM_VDD	USIM_VDD	V
V_{OL}	Output low voltage	0	0.15 ×USIM_VDD	V

Table 16: (U)SIM 3.0 V I/O Requirements

Parameter	Description	Min.	Max.	Unit
USIM_VDD	Power supply	2.7	3.3	V
V_{IH}	Input high voltage	0.7 ×USIM_VDD	USIM_VDD	V
V_{IL}	Input low voltage	0	0.15 ×USIM_VDD	V
V_{OH}	Output high voltage	0.7 ×USIM_VDD	USIM_VDD	V
V_{OL}	Output low voltage	0	0.15 ×USIM_VDD	V

5.5. ESD Protection

Static electricity occurs naturally and it may damage the module. Therefore, applying proper ESD countermeasures and handling methods is imperative. For example, wear anti-static gloves during the development, production, assembly and testing of the module; add ESD protection components to the ESD sensitive interfaces and points in the product design.

The following table shows the module electrostatics discharge characteristics.

Table 17: Electrostatics Discharge Characteristics (Temperature: 25-30 °C, Humidity: 40 ±5 %)

Tested Interfaces	Contact Discharge	Air Discharge	Unit
VBAT, GND	±5	±10	kV
All Antenna Interfaces	±4	±8	kV
Other Interfaces	±0.5	±1	kV

5.6. Operating and Storage Temperatures

Table 18: Operating and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operating Temperature Range [4]	-25	+25	+55	ºC
Extended Operation Range [5]	-35	-	+80	ºC
Storage Temperature Range	-35	-	+85	ºC

[4] Within operating temperature range, the module is 3GPP compliant.

[5] Within extended temperature range, the module remains the ability to establish and maintain functions such as voice, SMS, data transmission and emergency call, without any unrecoverable malfunction. Radio spectrum and radio network are not influenced, while one or more specifications, such as P_{out}, may exceed the specified tolerances of 3GPP. When the temperature returns to the operating temperature range, the module meets 3GPP specifications again.

6 Mechanical Information

This chapter describes the mechanical dimensions of the module. All dimensions are measured in millimeter (mm), and the dimensional tolerances are ±0.2 mm unless otherwise specified.

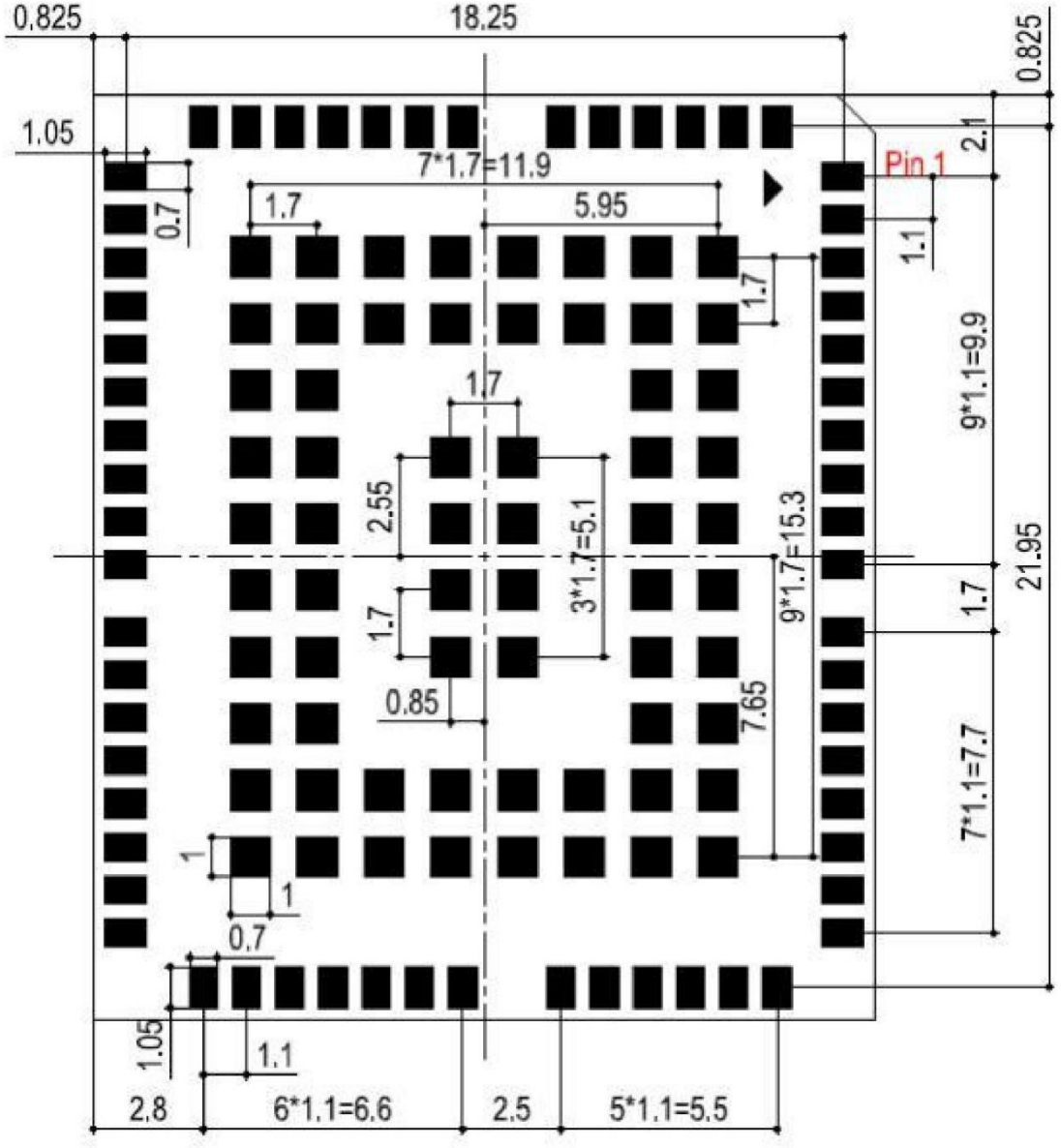


Figure 11: Bottom Dimensions (Bottom View)

FCC Certification Requirements

According to the definition of mobile and fixed device is described in Part 2.1091(b), this device is a mobile device.

And the following conditions must be met:

1. This Modular Approval is limited to OEM installation for mobile and fixed applications only. The antenna installation and operating configurations of this transmitter, including any applicable source-based time-averaging duty factor, antenna gain and cable loss must satisfy MPE categorical Exclusion Requirements of 2.1091.
2. The EUT is a mobile device; maintain at least a 20 cm separation between the EUT and the user's body and must not transmit simultaneously with any other antenna or transmitter.
3.A label with the following statements must be attached to the host end product: This device contains FCC ID: XYO-AMA02R.
4.To comply with FCC regulations limiting both maximum RF output power and human exposure to RF radiation, maximum antenna gain (including cable loss) must not exceed:

- ❒ GSM850/ LTE Band 5: ≤3.53dBi
- ❒ GSM1900/ LTE Band 2: ≤3.65dBi
- ❒ LTE Band 4/66: ≤3.83dBi
- ❒ LTE Band 7: ≤2.37dBi

5. This module must not transmit simultaneously with any other antenna or transmitter
6. The host end product must include a user manual that clearly defines operating requirements and conditions that must be observed to ensure compliance with current FCC RF exposure guidelines.

For portable devices, in addition to the conditions 3 through 6 described above, a separate approval is required to satisfy the SAR requirements of FCC Part 2.1093

If the device is used for other equipment that separate approval is required for all other operating configurations, including portable configurations with respect to 2.1093 and different antenna configurations.

For this device, OEM integrators must be provided with labeling instructions of finished products. Please refer to KDB784748 D01 v07, section 8. Page 6/7 last two paragraphs:

A certified modular has the option to use a permanently affixed label, or an electronic label. For a permanently affixed label, the module must be labeled with an FCC ID - Section 2.926 (see 2.2 Certification (labeling requirements) above). The OEM manual must provide clear instructions explaining to the OEM the labeling requirements, options and OEM user manual instructions that are required (see next paragraph).

For a host using a certified modular with a standard fixed label, if (1) the module's FCC ID is not visible when installed in the host, or (2) if the host is marketed so that end users do not have straightforward commonly used methods for access to remove the module so that the FCC ID of the module is visible; then an additional permanent label referring to the enclosed module:"Contains Transmitter Module FCC ID: FCC ID: XYO-AMA02R." or "Contains FCC ID: FCC ID: XYO-AMA02R." must be used. The host OEM user manual must also contain clear instructions on how end users can find and/or access the module and the FCC ID.

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.

The user's manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. In cases where the manual is provided only in a form other than paper, such as on a computer disk or over the Internet, the information required by this section may be included in the manual in that alternative form, provided the user can reasonably be expected to have the capability to access information in that form.

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.

Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.