EG91Hardware Design

LTEModule Series

Rev. EG91_Hardware_Design_V1.3

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About the Document

History

Revision	Date	Author	Description
1.0	2017-03-22	Felix YIN/ Yeoman CHEN/ Jackie WANG	Initial
1.1	2018-01-23	Felix YIN/ Rex WANG	1. Added band B28A. 2. Updated the description of UMTS and GSM features in Table 2. 3. Updated the functional diagram in Figure 1. 4. Updated module operating frequencies in Table 21. 5. Updated current consumption in Table 26. 6. Updated RF output power in Table 27. 7. Updated the conducted RF receiving sensitivity in Table 28. 8. Updated the GPRS multi-slot classes in Table 33. 9. Added thermal consideration in Chapter 5.8 10. Added a GND pad in each of the four corners of the module's footprint in Chapter 6.2. 11. Updated storage information in Chapter 7.1. 12. Added packaging information in Chapter 7.3.
1.2	2018-03-14	Felix YIN/ Rex WANG	1. Added the description of EG91-NA. 2. Updated the functional diagram in Figure 1. 3. Updated pin assignment in Figure 2. 4. Updated GNSS function in Table 1. 5. Updated GNSS Features in Table 2. 6. Updated reference circuit of USB interface in Figure 21. 7. Added description of GNSS receiver in Chapter 4.

			8. Updated pin definition of RF antenna in Table 21. 9. Updated module operating frequencies in Table 22. 10. Added description of GNSS antenna interface in Chapter 5.2. 11. Updated antenna requirements in Table 25. 12. Updated RF output power in Table 32.
1.3	2019-02-03	Ward WANG/ Nathan LIU/ Rex WANG	1. Added new variants EG91-NS, EG91-V, EG91-EC and related contents. 2. Opened pin 24 as ADC0 and added related contents. 3. Updated functional diagram (Figure 1) 4. Updated pin assignment (Figure 2) 5. Updated GNSS features (Table 2) 6. Added USB_BOOT interface information (Chapter 3.18) 7. Updated storage information (Chapter 8.1) 8. Updated module operating frequencies (Table 23) 9. Updatedantenna requirements (Table26) 10. Added current consumption of EG91-NS, EG91-V and EG91-EC (Table 32, 33 and 34) 11. Added conducted RF receiving sensitivityof EG91-NS, EG91-V and EG91-EC (Table 39, 40 and 41)

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1 Introduction

This document defines the EG91module and describes its air interface and hardware interface which are connected with customers' applications.

This document can help customers quickly understand module interface specifications, electrical andmechanical details, as well as other related information of EG91 module. Associated with application note and user guide, customers can use EG91 module to design and set up mobile applications easily.

1.1. Safety Information

The following safety precautions must be observed during all phases of operation, such as usage, service or repair of any cellular terminal or mobile incorporating EG91module. Manufacturers of the cellular terminal should send the following safety information to users and operating personnel, and incorporate these guidelines into all manuals supplied with the product. If not so, Quectel assumes no liability for customers' failure to comply with these precautions.

	Full attention must be given to driving at all times in order to reduce the risk of an accident. Using a mobile while driving (even with a handsfree kit) causes distraction and can lead to an accident. Please comply with laws and regulations restricting the use of wireless devices while driving.
	Switch off the cellular terminal or mobile before boarding an aircraft. The operation of wireless appliances in an aircraft is forbidden to prevent interference with communication systems. If the device offers an Airplane Mode, then it should be enabled prior to boarding an aircraft. Please consult the airline staff for more restrictions on the use of wireless devices on boarding the aircraft.
	Wireless devices may cause interference on sensitive medical equipment, so please be aware of the restrictions on the use of wireless devices when in hospitals,clinics or other healthcare facilities.
	Cellular terminals or mobiles operating over radio signals and cellular network cannot be guaranteed to connect in all possible conditions (for example, with unpaid bills or with an invalid (U)SIM card). When emergent help is needed in such conditions, please remember using emergency call. In order to make or receive a call, the cellular terminal or mobile must be switched on in a service area with adequate cellular signal strength.
	The cellular terminal or mobile contains a transmitter and receiver. When it is ON, it receives and transmits radio frequency signals. RF interference can occur if it is used close to TV set, radio, computer or other electric equipment.
	In locations with potentially explosive atmospheres, obey all posted signs to turn off wireless devices such as your phone or other cellular terminals. Areas with potentially explosive atmospheres include fuelling areas, below decks on boats, fuel or chemical transfer or storage facilities, areas where the air contains chemicals or particles such as grain, dust or metal powders, etc.

1.2. FCC/ISED Regulatory notices

Modification statement

Quectel has not approved any changes or modifications to this device by the user. Any changes or modifications could void the user's authority to operate the equipment.

Quectel *n'approuve aucune modification apportée à l'appareil par l'utilisateur, quelle qu'en soit la nature. Tout changement ou modification peuvent annuler le droit d'utilisation de l'appareil par l'utilisateur.*

Interference statement

This device complies with Part 15 of the FCC Rules and Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

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.

RF exposure

This equipment complies with FCC and ISED radiation exposure limits set forth for an uncontrolled environment. The antenna should be installed and operated with minimum distance of 20 cm between the radiator and your body. Antenna gain must be below:

Antenna Gain

- WCDAM II:≤9.000dBi
- WCDAM V:≤6.000dBi
- WCDAM VIII:≤10.416dBi
- LTE Band2:≤8.500dBi
- LTE Band4:≤5.500dBi
- LTE Band5:≤9.916dBi
- LTE Band12:≤9.234dBi
- LTE Band13:≤9.673dBi
- L TE Band25:≤8.500dBi
- L TE Band25:≤9.837dBi

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

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 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.

Cet appareil est conforme aux limites d'exposition aux rayonnements de l'ISED pour un environnement non contrôlé. L'antenne doit être installé de façon à garder une distance minimale de 20 centimètres entre la source de rayonnements et votre corps. Gain de l'antenne doit être ci-dessous:

Gain de l'antenne

- WCDAM II:≤9.00dBi
- WCDAM V:≤6.00dBi
- WCDAM VIII:≤7.15dBi
- LTE Band2:≤8.50dBi
- LTE Band4:≤5.50dBi
- LTE Band5:≤6.64dBi
- LTE Band12:≤6.15dBi
- LTE Band13:≤6.44dBi
- L TE Band25:≤8.50dBi
- L TE Band25:≤6.63dBi

L'émetteur ne doit pas être colocalisé ni fonctionner conjointement avec à autre antenne ou autre émetteur.

FCC Class B digital device notice

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

• Reorient or relocate the receiving antenna.

• Increase the separation between the equipment and receiver.

• Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

• Consult the dealer or an experienced radio/TV technician for help.

Labelling Requirements for the Host device

The host device shall be properly labelled to identify the modules within the host device. The certification label of the module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labelled to display the FCC ID and ISED of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows:

Contains FCC ID：XMR201903EG91NS

Contains IC: 10224A-20193EG91NS

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 and ISED.

L'appareil hôte doit être étiqueté comme il faut pour permettre l'identification des modules qui s'y trouvent. L'étiquette de certification du module donné doit être posée sur l'appareil hôte à un endroit bien en vue en tout temps. En l'absence d'étiquette, l'appareil hôte doit porter une étiquette donnant le FCC ID et l'ISED du module, précédé des mots « Contient un module d'émission », du mot « Contient » ou d'une formulation similaire exprimant le même sens, comme suit :

Contient FCC ID：XMR201903EG91NS

Contient IC: 10224A-20193EG91NS

Le manuel d'utilisation OEM de l'hôte doit également contenir des instructions claires sur la manière dont les utilisateurs finaux peuvent trouver et / ou accéder au module et à l'ID FCC *et l'ISED*.

CAN ICES-3 (B) / NMB-3 (B)

This Class B digital apparatus complies with Canadian ICES-003.

Cet appareil numérique de classe B est conforme à la norme canadienne ICES-003.

Installation Guidance

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.

To ensure compliance with all non-transmitter functions the host manufacturer is responsible for ensuring compliance with the module(s) installed and fully operational. For example, if a host was previously authorized as an unintentional radiator under the Declaration of Conformity procedure without a transmitter certified module and a module is added, the host manufacturer is responsible for ensuring that the after the module is installed and operational the host continues to be compliant with the Part 15B unintentional radiator requirements.

2 Product Concept

2.1. General Description

EG91module is an embedded 4G wireless communication module with receive diversity. It supportsLTE-FDD/WCDMA/GSM wireless communication, andprovides data connectivity on LTE-FDD,DC-HSDPA, HSPA+, HSDPA, HSUPA, WCDMA,EDGE andGPRSnetworks. It can also provide voice functionality[1)]to meet customers' specific application demands. The following table shows the frequency bands of EG91series module.

Table 1: Frequency Bands of EG91Series Module

Module	LTE Bands (with Rx-diversity)	WCDMA (with Rx-diversity)	GSM	GNSS[2)]
EG91-E	FDD: B1/B3/B7/B8/B20/B28A	B1/B8	900/1800MHz	Not supported
EG91-NA	FDD: B2/B4/B5/B12/B13	B2/B4/B5	Not supported	GPS, GLONASS, BeiDou/Compass,Galileo, QZSS
EG91-NS	FDD: B2/B4/B5/B12/B13/B25/B26	B2/B4/B5	Not supported	GPS, GLONASS, BeiDou/Compass, Galileo, QZSS
EG91-V	FDD: B4/B13	Not supported	Not supported	GPS, GLONASS, BeiDou/Compass, Galileo, QZSS
EG91-EC	FDD: B1/B3/B7/B8/B20/B28	B1/B8	900/1800MHz	GPS, GLONASS, BeiDou/Compass, Galileo, QZSS

NOTES

1. [1)] EG91contains **Telematics**version and **Data-only** version. **Telematics** version supports voice and datafunctions, while **Data-only** version only supports data function.
2. [2)] GNSS function is optional.

With a compact profile of 29.0mm ×25.0mm ×2.3mm, EG91 can meet almost all requirements for M2M applications such as automotive, smart metering, tracking system, security, router, wireless POS, mobile computing device, PDA phone, tablet PC, etc.

EG91 is an SMD type module which can be embedded into applications through its 106 LGA pads.

EG91 is integrated with internet service protocols like TCP, UDP and PPP. Extended AT commands have been developed for customers to use these internet service protocols easily.

2.2. Key Features

The following table describes the detailed features of EG91 module.

Table 2: Key Features of EG91 Module

Feature	Details
Power Supply	Supply voltage: 3.3V~4.3V Typical supply voltage: 3.8V
Transmitting Power	Class 4 (33dBm±2dB) for EGSM900 Class 1 (30dBm±2dB) for DCS1800 Class E2 (27dBm±3dB) for EGSM900 8-PSK Class E2 (26dBm±3dB) for DCS1800 8-PSK Class 3 (24dBm+1/-3dB) for WCDMA bands Class 3 (23dBm±2dB) for LTE-FDD bands
LTE Features	Support up to non-CA Cat 1 FDD Support 1.4MHz~20MHz RF bandwidth Support MIMO in DL direction LTE-FDD: Max 10Mbps (DL), Max 5Mbps (UL)
UMTS Features	Support 3GPP R8 DC-HSDPA, HSPA+, HSDPA, HSUPA and WCDMA Support QPSK, 16-QAM and 64-QAM modulation DC-HSDPA: Max 42Mbps (DL) HSUPA: Max 5.76Mbps (UL) WCDMA: Max 384Kbps (DL), Max 384Kbps (UL)
GSMFeatures	**R99:** CSD: 9.6kbps **GPRS:** Support GPRS multi-slot class 33(33 by default) Coding scheme: CS-1, CS-2, CS-3 and CS-4 Max 107Kbps (DL), Max 85.6Kbps (UL) **EDGE:**

	Support EDGE multi-slot class 33(33 by default) Support GMSK and 8-PSK for different MCS (Modulation and Coding Scheme) Downlink coding schemes: CS 1-4 and MCS 1-9 Uplink coding schemes: CS 1-4 and MCS 1-9 Max 296Kbps (DL)/Max 236.8Kbps (UL)
Internet Protocol Features	SupportTCP/UDP/PPP/FTP/HTTP/NTP/PING/QMI/NITZ/CMUX*/HTTPS*/ SMTP*/MMS*/FTPS*/SMTPS*/SSL*/FILE* protocols Support PAP (Password Authentication Protocol) and CHAP (Challenge Handshake Authentication Protocol) protocols which are usually used for PPP connections
SMS	Text and PDU modes Point-to-point MO and MT SMS cell broadcast SMS storage: ME by default
(U)SIMInterfaces	Support 1.8V and 3.0V (U)SIM cards
Audio Features	Support one digital audio interface: PCM interface GSM: HR/FR/EFR/AMR/AMR-WB WCDMA: AMR/AMR-WB LTE: AMR/AMR-WB Support echo cancellation and noise suppression
PCM Interface	Used for audio function with external codec Support 16-bit linear data format Support long frame synchronization and short frame synchronization Support master and slave mode, but must be the master in long frame synchronization
USB Interface	Compliant with USB 2.0 specification (slave only);the data transfer rate can reach up to 480Mbps Used for AT command communication, data transmission,GNSS NMEA sentences output, software debugging, firmware upgrade and voice over USB* Support USB serial drivers for: Windows 7/8/8.1/10, Windows CE 5.0/6.0/7.0*, Linux 2.6/3.x/4.1~4.14, Android 4.x/5.x/6.x/7.x/8.x, etc.
UART Interface	**Main UART:** Used for AT command communication and data transmission Baud rates reach up to 921600bps, 115200bps by default Support RTS and CTS hardware flow control **Debug UART:** Used for Linux console and log output 115200bps baud rate
Rx-diversity	Support LTE/WCDMA Rx-diversity
GNSS Features	Gen8C Lite of Qualcomm

	Protocol: NMEA 0183
AT Commands	Compliant with 3GPP TS 27.007, 27.005 and Quectel enhanced AT commands
Network Indication	NETLIGHTpin for network activitystatusindication
Antenna Interfaces	Including main antenna interface (ANT_MAIN), Rx-diversity antenna (ANT_DIV) interface and GNSS antenna interface(ANT_GNSS)[1)]
Physical Characteristics	Size: (29.0±0.15)mm × (25.0±0.15)mm × (2.3±0.2)mm Package: LGA Weight: approx. 3.8g
Temperature Range	Operation temperature range: -35°C ~ +75°C [2)] Extended temperature range: -40°C ~ +85°C [3)] Storage temperature range: -40°C ~ +90°C
Firmware Upgrade	USB interface orDFOTA*
RoHS	All hardware components are fully compliant with EU RoHS directive

NOTES

1. [1)]GNSS antenna interface is only supported on EG91-NA/-NS/-V/-EC.
2. [2)] Within operationtemperature range, the module is 3GPP compliant.
3. [3)] Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to normal operationtemperature levels, the module will meet 3GPP specificationsagain.
4. "*" means under development.

2.3. Functional Diagram

The following figure shows a block diagram of EG91 and illustrates the major functional parts.

- Power management
- Baseband
- DDR+NAND flash
- Radio frequency
- Peripheral interfaces

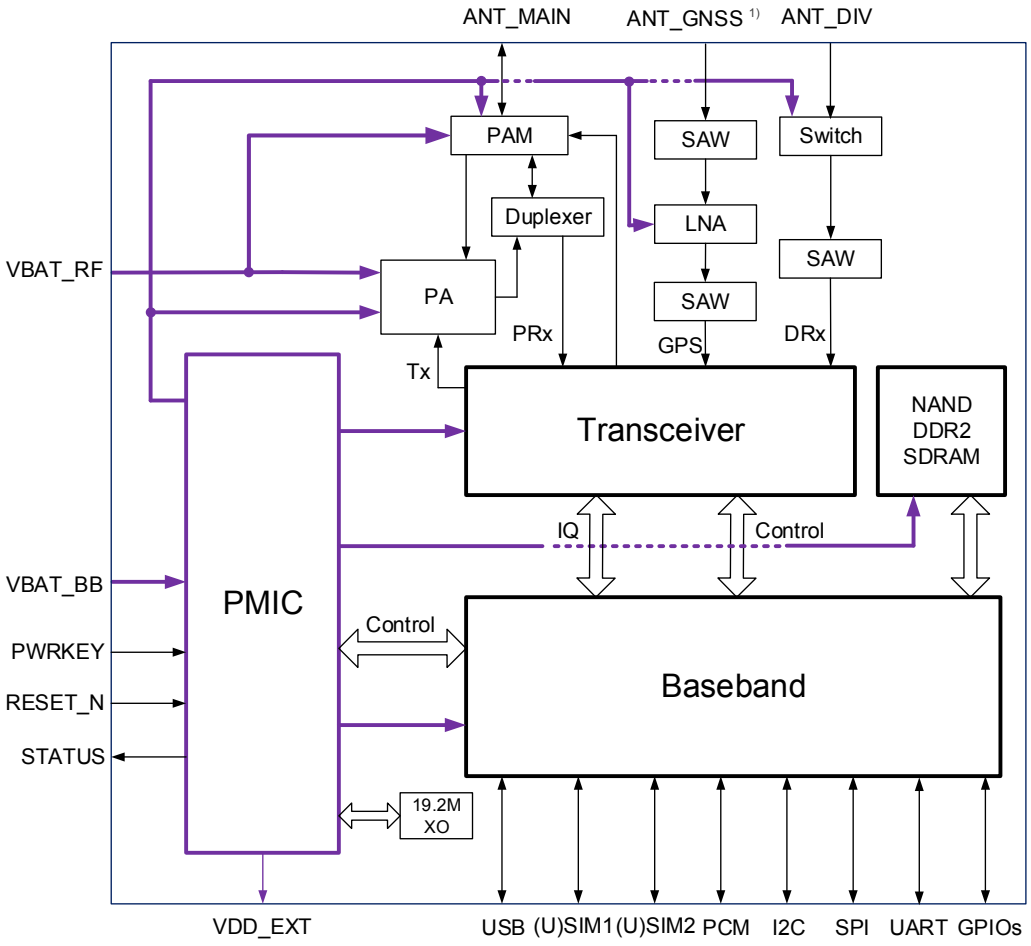


Figure 1: Functional Diagram

NOTE

1) GNSS antenna interface is only supported on EG91-NA/-NS/-V/-EC.

2.4. Evaluation Board

Quectel provides a complete set of evaluation tools to facilitate the use and testing ofEG91 module. The evaluation tool kit includes the evaluation board (UMTS&LTE EVB), USB data cable, earphone, antenna and other peripherals.

3 Application Interfaces

3.1. General Description

EG91is equipped with 62-pin 1.1mm pitch SMT pads plus 44-pin ground/reserved pads that can be connected to customers' cellular application platforms. Sub-interfaces included in these pads are described in detail in the following chapters:

- Power supply
- (U)SIMinterfaces
- USB interface
- UART interfaces
- PCMand I2C interfaces
- SPI interface
- Statusindication
- USB_BOOT interface

3.2. Pin Assignment

The following figure shows the pin assignment of EG91 module.

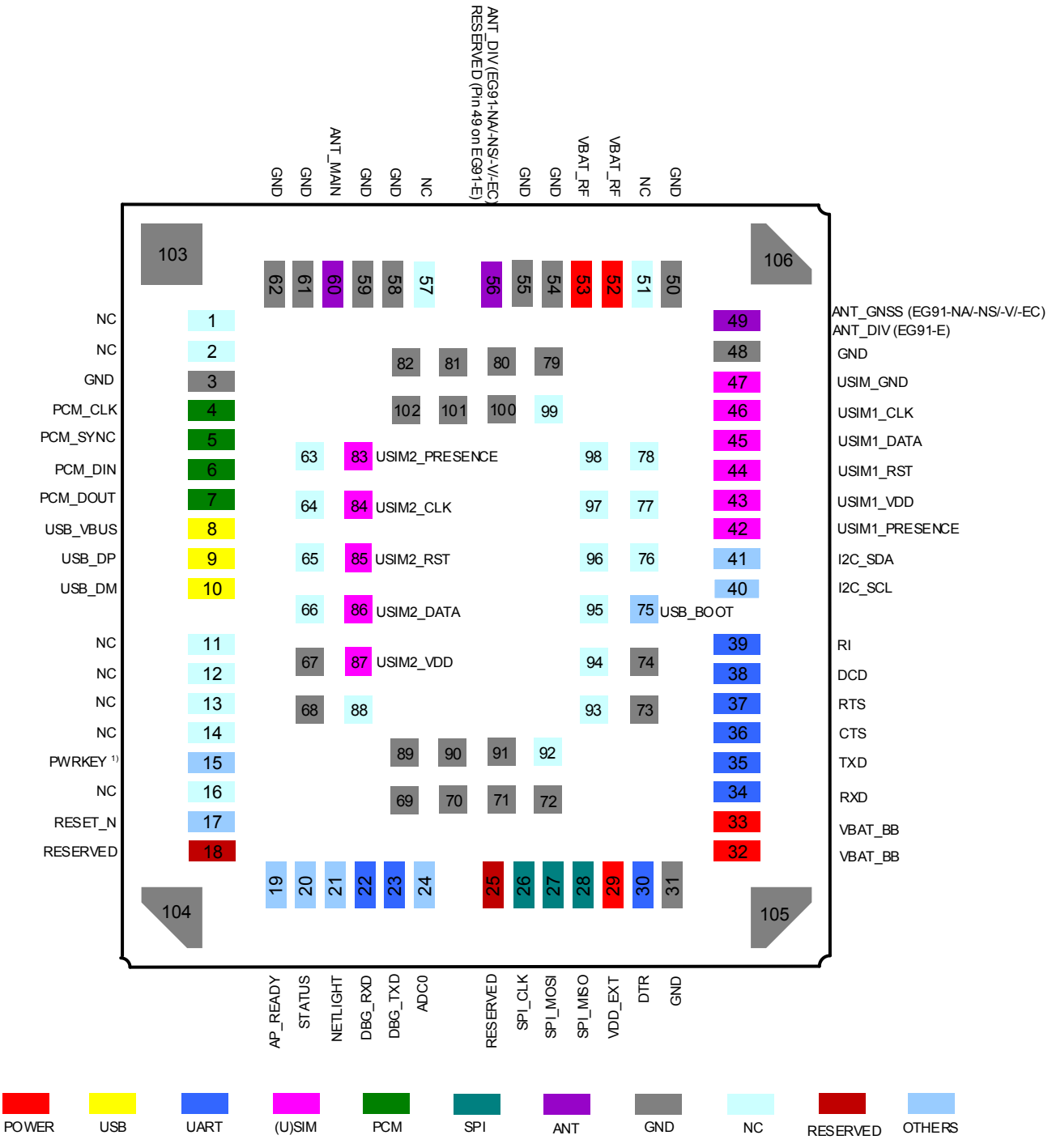


Figure 2:Pin Assignment (Top View)

NOTES

1. [1)]PWRKEY output voltage is 0.8V because of the diode drop in the Qualcomm chipset.
2. Keep all RESERVEDpins and unused pins unconnected.
3. GND pads should be connected to ground in the design.
4. Definition of pin 49 and 56 are different amongEG91-E/-NS/-V/-EC and EG91-NA.For more details, please refer to ***Table 4***.

3.3. Pin Description

The following tables show the pin definition and description of EG91.

Table 3: IO Parameters Definition

Type	Description
AI	Analog input
AO	Analog output
DI	Digital input
DO	Digital output
IO	Bidirectional
OD	Open drain
PI	Power input
PO	Power output

Table 4: Pin Description

Power Supply					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
VBAT_BB	32, 33	PI	Power supply for module's baseband part	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	It must be able to provide sufficient current up to 0.8A.

VBAT_RF	52, 53	PI	Power supply for module's RF part	Vmax=4.3V Vmin=3.3V Vnorm=3.8V	It must be able to provide sufficient current up to 1.8A in a burst transmission.
VDD_EXT	29	PO	Provide 1.8V for external circuit	Vnorm=1.8V $I_O$max=50mA	Power supply for external GPIO's pull up circuits. If unused, keep it open.
GND	3, 31, 48, 50, 54, 55, 58, 59, 61, 62, 67~74, 79~82, 89~91, 100~106		Ground		
Turn-on/off					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PWRKEY	15	DI	Turn on/off the module	V_{IH}max=2.1V V_{IH}min=1.3V V_{IL}max=0.5V	The output voltage is 0.8V because of the diode drop in the Qualcomm chipset.
RESET_N	17	DI	Reset signal of the module	V_{IH}max=2.1V V_{IH}min=1.3V V_{IL}max=0.5V	Pull-up to 1.8V internally. Activelow. If unused,keep it open.
Status Indication					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
STATUS	20	DO	Indicate the module's operating status	V_{OH}min=1.35V V_{OL}max=0.45V	1.8V power domain. If unused, keep it open.
NETLIGHT	21	DO	Indicate the module's network activity status	V_{OH}min=1.35V V_{OL}max=0.45V	1.8V power domain. If unused, keep it open.
USB Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USB_VBUS	8	PI	USB connection detection	Vmax=5.25V Vmin=3.0V Vnorm=5.0V	Typical:5.0V If unused,keep it open.

USB_DP	9	IO	USB differential data bus (+)	Compliant with USB 2.0 standard specification.	Require differential impedance of 90Ω.
USB_DM	10	IO	USB differential data bus (-)	Compliant with USB 2.0 standard specification.	Require differential impedance of 90Ω.
(U)SIM Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
USIM_GND	47		Specified ground for (U)SIM card		Connect to ground of (U)SIM card connector.
USIM1_VDD	43	PO	Power supply for (U)SIMcard	**For 1.8V (U)SIM:** Vmax=1.9V Vmin=1.7V For 3.0V (U)SIM: Vmax=3.05V Vmin=2.7V $I_O$max=50mA	Either 1.8V or 3.0V is supported by the module automatically.
USIM1_DATA	45	IO	Data signal of (U)SIMcard	**For 1.8V (U)SIM:** V_{IL}max=0.6V V_{IH}min=1.2V V_{OL}max=0.45V V_{OH}min=1.35V **For 3.0V (U)SIM:** V_{IL}max=1.0V V_{IH}min=1.95V V_{OL}max=0.45V V_{OH}min=2.55V	
USIM1_CLK	46	DO	Clock signal of (U)SIMcard	**For 1.8V (U)SIM:** V_{OL}max=0.45V V_{OH}min=1.35V **For 3.0V (U)SIM:** V_{OL}max=0.45V V_{OH}min=2.55V	

USIM1_RST	44	DO	Reset signal of (U)SIMcard	**For 1.8V (U)SIM:** V_{OL}max=0.45V V_{OH}min=1.35V **For 3.0V (U)SIM:** V_{OL}max=0.45V V_{OH}min=2.55V	
USIM1_ PRESENCE	42	DI	(U)SIMcard insertion detection	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. If unused, keep it open.
USIM2_VDD	87	PO	Power supply for (U)SIMcard	**For 1.8V (U)SIM:** Vmax=1.9V Vmin=1.7V **For 3.0V (U)SIM:** Vmax=3.05V Vmin=2.7V $I_O$max=50mA	Either 1.8V or 3.0V is supported by the module automatically.
USIM2_DATA	86	IO	Data signal of (U)SIMcard	**For 1.8V (U)SIM:** V_{IL}max=0.6V V_{IH}min=1.2V V_{OL}max=0.45V V_{OH}min=1.35V **For 3.0V (U)SIM:** V_{IL}max=1.0V V_{IH}min=1.95V V_{OL}max=0.45V V_{OH}min=2.55V	
USIM2_CLK	84	DO	Clock signal of (U)SIMcard	**For 1.8V (U)SIM:** V_{OL}max=0.45V V_{OH}min=1.35V **For 3.0V (U)SIM:** V_{OL}max=0.45V V_{OH}min=2.55V	
USIM2_RST	85	DO	Reset signal of (U)SIMcard	**For 1.8V (U)SIM:** V_{OL}max=0.45V V_{OH}min=1.35V **For 3.0V (U)SIM:** V_{OL}max=0.45V	

				V_{OH}min=2.55V	
USIM2_ PRESENCE	83	DI	(U)SIMcard insertion detection	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. If unused, keep it open.
Main UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
RI	39	DO	Ring indicator	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. If unused, keep it open.
DCD	38	DO	Data carrier detection	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. If unused, keep it open.
CTS	36	DO	Clear to send	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. If unused, keep it open.
RTS	37	DI	Request to send	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. If unused, keep it open.
DTR	30	DI	Data terminal ready. Sleep mode control.	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. Pull-up by default. Low level wakes up the module. If unused, keep it open.
TXD	35	DO	Transmit data	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. If unused, keep it open.
RXD	34	DI	Receive data	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. If unused, keep it open.
Debug UART Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
DBG_TXD	23	DO	Transmit data	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. If unused, keep it

					open.
DBG_RXD	22	DI	Receive data	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. If unused, keep it open.
PCM Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
PCM_DIN	6	DI	PCM data input	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. If unused, keep it open.
PCM_ DOUT	7	DO	PCM data output	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. If unused, keep it open.
PCM_SYNC	5	IO	PCM data frame synchronization signal	V_{OL}max=0.45V V_{OH}min=1.35V V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. In master mode, it is an output signal. In slave mode, it is an input signal. If unused, keep it open.
PCM_CLK	4	IO	PCM clock	V_{OL}max=0.45V V_{OH}min=1.35V V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. In master mode, it is an output signal. In slave mode, it is an input signal. If unused, keep it open.
I2C Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
I2C_SCL	40	OD	I2C serial clock. Used for external codec		An external pull-up resistor is required. 1.8V only. If unused, keep it open.
I2C_SDA	41	OD	I2C serial data. Used for external codec		An external pull-up resistor is required. 1.8V only. If unused, keep it open.

ADC Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ADC0	24	AI	General purpose analog to digital converter	Voltage range: 0.3V to VBAT_BB	If unused, keep it open.
SPI Interface					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
SPI_CLK	26	DO	Clock signal of SPI interface	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. If unused, keep it open.
SPI_MOSI	27	DO	Master output slave input of SPI interface	V_{OL}max=0.45V V_{OH}min=1.35V	1.8V power domain. If unused, keep it open.
SPI_MISO	28	DI	Master input slave output of SPI interface	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. If unused, keep it open.
RF Interfaces					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
ANT_GNSS	49 (EG91-NA/-NS/ -V/-EC)	AI	GNSS antenna pad		50Ω impedance. If unused, keep it open. The pin is defined as ANT_DIV on EG91-E.
ANT_DIV	49 (EG91-E) 56 (EG91-NA/-NS/ -V/-EC)	AI	Receive diversity antenna pad		50Ω impedance. If unused, keep it open. The pin is reserved on EG91-E.
ANT_MAIN	60	IO	Main antenna pad		50Ω impedance. If unused, keep it open.
Other Pins					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**

AP_READY	19	DI	Application processor sleep state detection	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. If unused, keep it open.
USB_BOOT	75	DI	Force the module to enter into emergency download mode	V_{IL}min=-0.3V V_{IL}max=0.6V V_{IH}min=1.2V V_{IH}max=2.0V	1.8V power domain. It is recommended to reserve the test points.
RESERVED Pins					
Pin Name	**Pin No.**	**I/O**	**Description**	**DC Characteristics**	**Comment**
NC	1,2, 11~14, 16, 51, 57, 63~66, 76~78, 88, 92~99		NC		Keep these pins unconnected.
RESERVED	18, 25, 49		Reserved		Keep these pins unconnected. Pin 49 is only reserved on EG91-E.

NOTE

Keep all RESERVED pins and unused pins unconnected.

3.4. Operating Modes

The table below briefly summarizes the various operating modes referred in the following chapters.

Table 5: Overview of Operating Modes

Mode	Details	
Normal Operation	Idle	Software is active. The module hasregistered on network, and it is ready to send and receive data.
	Talk/Data	Network connection is ongoing. In this mode, the power consumption is decided by network settingand data transfer rate.
Minimum Functionality	**AT+CFUN** command can set the module to a minimum functionality mode without removing the power supply. In this case, both RF function and (U)SIM card will be invalid.	

Mode	
Airplane Mode	**AT+CFUN** command or W_DISABLE# pin can set the module to enter intoairplane mode. In this case, RF function will be invalid.
Sleep Mode	In this mode, the current consumption of the module will be 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 power management unit shuts down the power supply. Software is not active. The serial interface is not accessible. Operating voltage (connected to VBAT_RF and VBAT_BB) remains applied.

3.5. Power Saving

3.5.1. Sleep Mode

EG91 is able to reduce its current consumption to a minimum value during the sleep mode. The following sub-chaptersdescribe the power saving procedures of EG91 module.

3.5.1.1. UART Application

If the host communicates with the module via UART interface, the following preconditions can let the module enter into sleep mode.

- Execute **AT+QSCLK=1**commandto enable sleep mode.
- Drive DTR to high level.

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

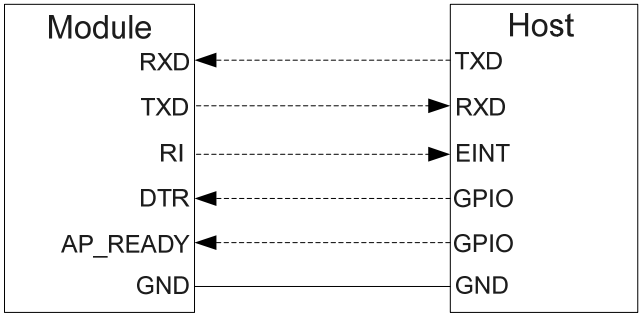


Figure 3: Sleep Mode Application via UART

Driving the host DTR to low level will wake up the module.

- When EG91 has a URC to report, RI signal will wake up the host. Please refer to ***Chapter 3.17***for details about RI behavior.
- AP_READY will detect the sleep state of host (can be configured to high level or low level detection). Please refer to **AT+QCFG="apready"***commandfor details.

NOTE

"*" means under development.

3.5.1.2. USB Application with USB Remote Wakeup Function

If the host supports USB suspend/resume and remote wakeup functions, the following three preconditions must be met to let the module enter into sleep mode.

- Execute **AT+QSCLK=1**commandto enable sleep mode.
- Ensure the DTR is held at high level or keep it open.
- The host's USB bus, which is connected with the module's USB interface, enters into suspend state.

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

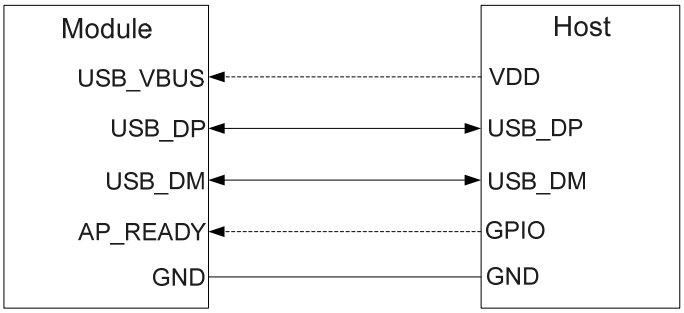


Figure 4: Sleep Mode Application with USB Remote Wakeup

- Sending data to EG91through USB will wake up the module.
- When EG91has a URC to report, the module will send remote wakeup signals via USB busso as to wake up the host.

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

If the host supports USB suspend/resume, but does not support remote wakeup function, the RI signal is needed to wake up the host.

There are threepreconditions to let the module enter into the sleep mode.

- Execute **AT+QSCLK=1**commandto enable sleep mode.
- Ensure the DTR is held at high level or keep it open.
- The host's USB bus, which is connected with the module's USB interface, enters into suspended state.

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

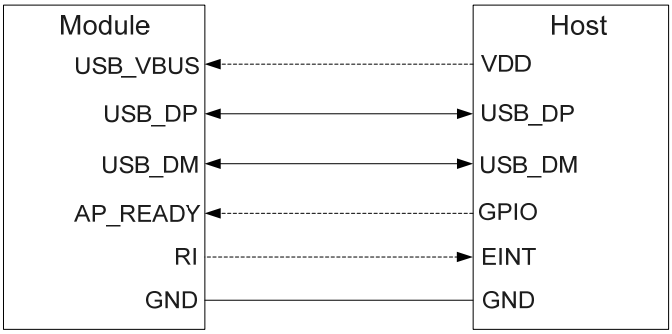


Figure 5: Sleep Mode Application with RI

- Sending data to EG91through USB will wake up the module.
- When EG91has a URC to report, RI signal will wake up the host.

3.5.1.4. USB Application without USB Suspend Function

If the host does not support USB suspend function, USB_VBUS should be disconnected with an externalcontrol circuit to let the module enter into sleep mode.

- Execute **AT+QSCLK=1**commandto enable sleep mode.
- Ensure the DTR is held at high level or keep it open.
- Disconnect USB_VBUS.

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

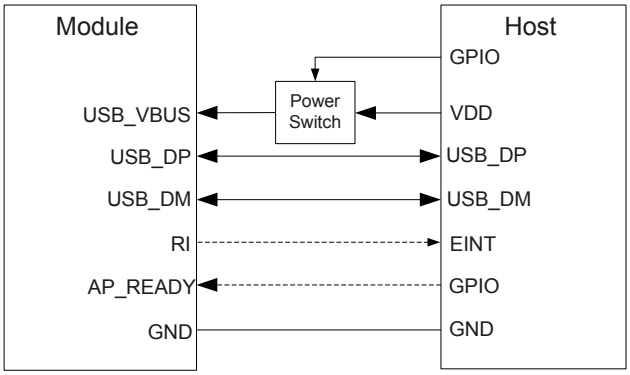


Figure 6: Sleep Mode Application without Suspend Function

Switching onthe power switch tosupply power to USB_VBUS will wake up the module.

NOTE

Please pay attention to the level match shown in dotted line between the module and the host.Please refer to ***document [1]*** for more details about EG91 power management application.

3.5.2. Airplane Mode

When the module enters into airplane mode, the RF function does not work, and all AT commands correlative with RF function will be inaccessible. This mode can be set viathe following ways.

Hardware:

The W_DISABLE# pin is pulled up by default.Driving it to low level will let the module enter into airplane mode.

Software:

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

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

NOTES

1. Airplane mode control via W_DISABLE# is disabled in firmware by default. It can be enabled by **AT+QCFG="airplanecontrol"** command and this command is under development.
2. The execution of **AT+CFUN** command will not affect GNSS function.

3.6. Power Supply

3.6.1. Power Supply Pins

EG91 provides four VBAT pins dedicated to connectwithanexternal power supply. There are two separate voltage domains for VBAT.

- Two VBAT_RF pins for module'sRF part.
- Two VBAT_BB pins for module's baseband part.

The following table shows the details of VBAT pins and ground pins.

Table 6: Pin Definition of VBAT and GND

Pin Name	Pin No.	Description	Min.	Typ.	Max.	Unit
VBAT_RF	52,53	Power supply for module's RF part.	3.3	3.8	4.3	V
VBAT_BB	32,33	Power supply for module's baseband part.	3.3	3.8	4.3	V
GND	3, 31, 48,50, 54, 55,58, 59, 61,62, 67~74, 79~82,89~91, 100~106	Ground	-	0	-	V

3.6.2. Decrease Voltage Drop

The power supply range of the module is from 3.3Vto4.3V. Please make sure thatthe input voltage will never drop below 3.3V. The following figure shows the voltage drop during burst transmission in 2G network.The voltage drop will be less in 3G and 4G networks.

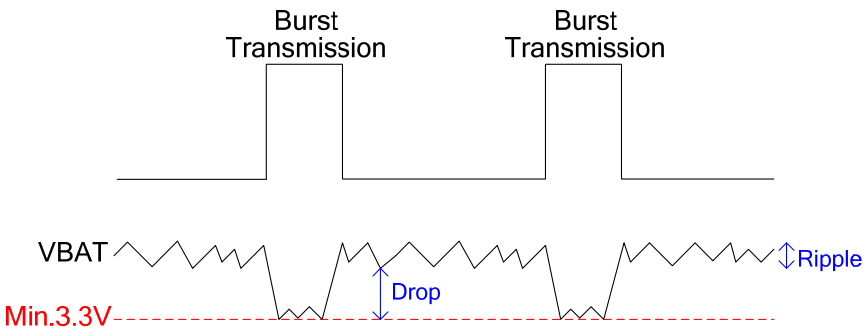


Figure 7: Power Supply Limits during Burst Transmission

To decrease voltage drop, a bypass capacitor of about 100μF with low ESR(ESR=0.7Ω) should be used, and amulti-layer ceramic chip (MLCC) capacitor array should also be reserved due to its ultra-low ESR. It is recommended to usethree ceramic capacitors (100nF, 33pF, 10pF)for composing the MLCC array, and place these capacitors close to VBAT_BB/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 structure. The width of VBAT_BB trace should be no less than 1mm, andthe width of VBAT_RF trace should be no less than 2mm.In principle, the longerthe VBAT trace is, the wider it will be.

In addition, in order to avoid the damage caused by electric surge and ESD, it is suggested that a TVS

diode with low reverse stand-off voltage V_{RWM}, low clamping voltage V_C and high reverse peak pulse current I_{PP} should be used. The following figure shows the star structure of the power supply.

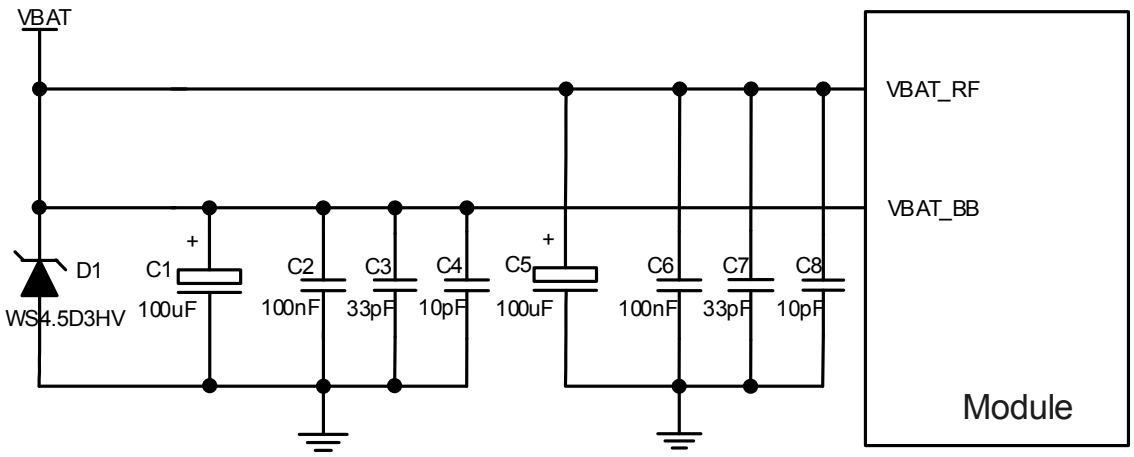


Figure 8: Star Structure of the Power Supply

3.6.3. Reference Design for Power Supply

Power design for the module is very important, asthe performance of the module largely depends on the power source. The power supply should be able to provide sufficient current up to 2A at least. If the voltage drop between the input and output is not too high, it is suggested that an LDO should be usedto supply power for the module. If there is a big voltage difference between the input source and the desired output (VBAT), a buck converter is preferred to be used as the power supply.

The following figure shows a reference design for +5V input power source. The typicaloutput ofthe power supply is about 3.8V and the maximum load current is 3A.

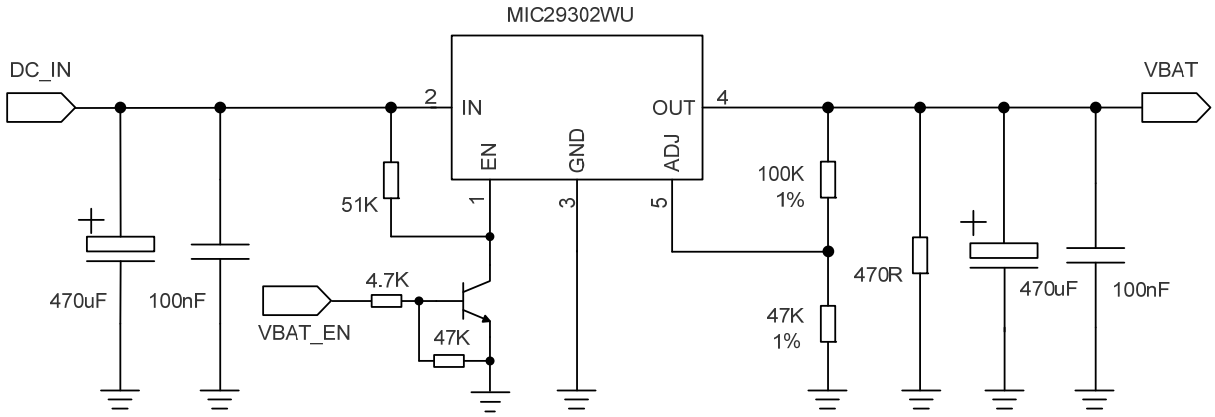


Figure 9: Reference Circuit of Power Supply

3.6.4. Monitor the Power Supply

AT+CBC command can be used to monitor the VBAT_BB voltage value. For more details, please refer to ***document [2]***.

3.7. Power-on/off Scenarios

3.7.1. Turn on Module Using the PWRKEY

The following table shows the pin definitionof PWRKEY.

Table 7: Pin Definition of PWRKEY

Pin Name	Pin No.	Description	DC Characteristics	Comment
PWRKEY	15	Turn on/off the module	V_{IH}max=2.1V V_{IH}min=1.3V V_{IL}max=0.5V	The output voltage is 0.8V because of the diode drop in the Qualcomm chipset.

When EG91 is in powerdown mode, it can be turned on to normal mode by driving the PWRKEY pin to a low level for at least 500ms. It is recommended to use an open drain/collector driver to control the PWRKEY.After STATUS pin outputting a high level, PWRKEY pin can be released. A simple reference circuit is illustrated in the following figure.

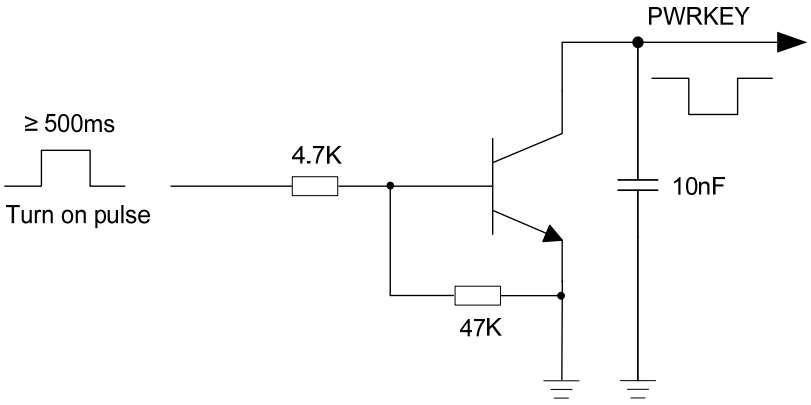


Figure 10: Turn on the Module Using Driving Circuit

Another way to control the PWRKEY is using a button directly. When pressing the key, electrostatic strike may generate from the finger. Therefore, aTVS component is indispensable to be placed nearby the button for ESD protection. A reference circuit is shownin the following figure.

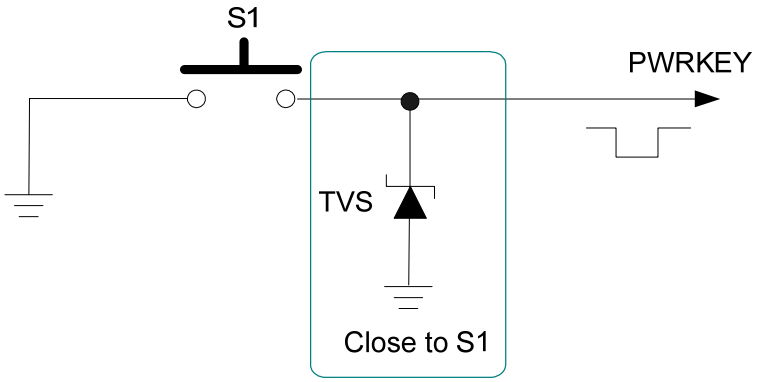


Figure 11: Turn on the Module Using Button

The power-on scenario is illustrated in the following figure.

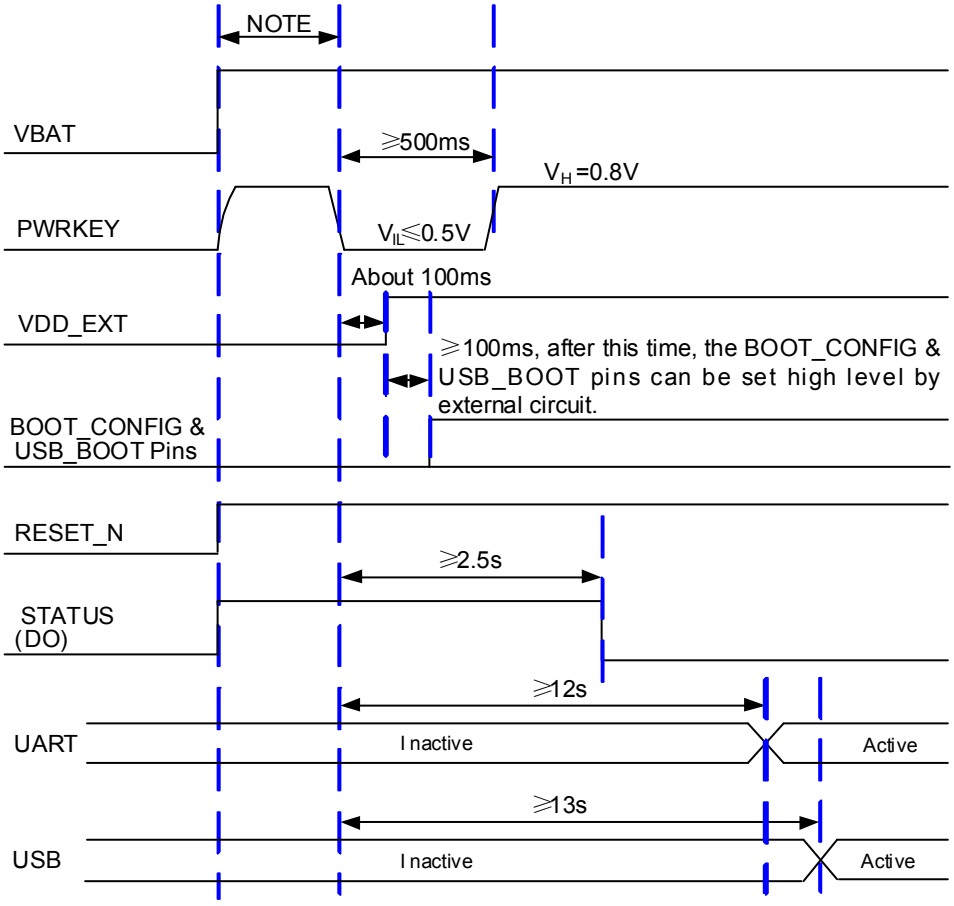


Figure 12: Power-on Scenario

NOTES

1. Please make sure that VBAT is stable before pulling down PWRKEY pin. The time between them is no less than 30ms.
2. PWRKEY can be pulled down directly to GND with a recommended 10K resistor if module needs to be powered on automatically and shutdown is not needed.

3.7.2. Turn off Module

Either of the following methodscan be used to turn off the module:

- Normal power-offprocedure: Turn off the module using the PWRKEY pin.
- Normal power-off procedure: Turn off the module using **AT+QPOWD**command.

3.7.2.1. Turn off Module Using the PWRKEY Pin

Driving the PWRKEY pin to a low level voltage for at least 650ms, the module will execute power-off procedure after the PWRKEY is released. The power-off scenario is illustrated inthe following figure.

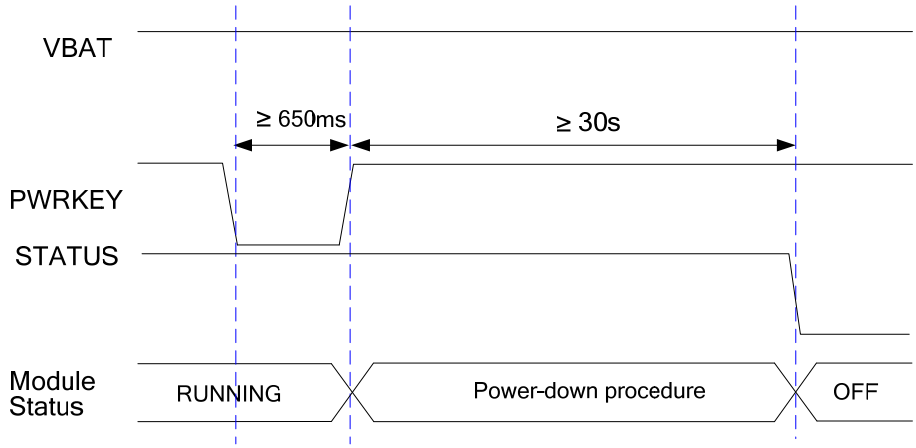


Figure 13: Power-off Scenario

3.7.2.2. Turn off Module Using AT Command

It is also a safe way to use **AT+QPOWD**commandto turn off the module, which is similar to turning off the module via PWRKEY pin.

Please refer to***document [2]*** for details about the **AT+QPOWD**command.

NOTES

1. In order to avoid damaging internal flash, please do not switch off the power supply when the module works normally. Only after the module is shut down by PWRKEY or AT command, the power supply can be cut off.
2. When turning off module with AT command, please keep PWRKEY at high level after the execution of power-off command. Otherwise the module will be turned on again after successful turn-off.

3.8. Reset the Module

The RESET_N pin can be used to reset the module.The module can be reset by driving RESET_N to a low level voltage for 150ms~460ms.

Table 8: Pin Definition of RESET_N

Pin Name	Pin No.	Description	DC Characteristics	Comment
RESET_N	17	Reset the module	V_{IH}max=2.1V V_{IH}min=1.3V V_{IL}max=0.5V	

The recommended circuit is similar to the PWRKEY control circuit. An open drain/collector driver or button can be used to control the RESET_N.

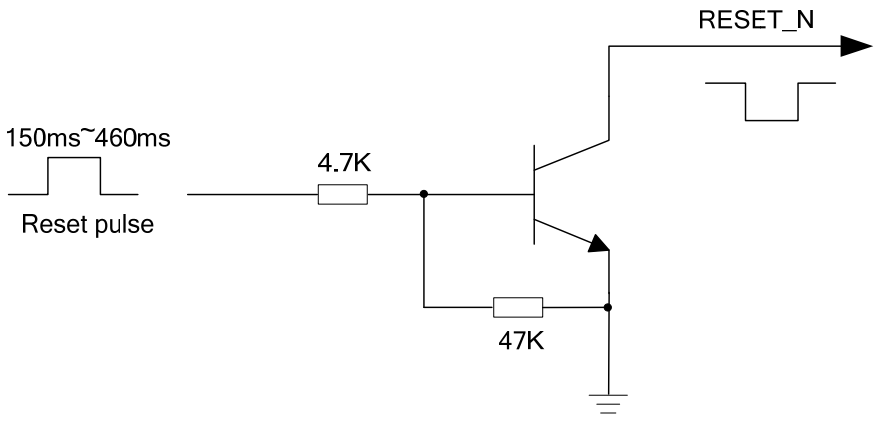


Figure 14: Reference Circuit of RESET_N by Using Driving Circuit

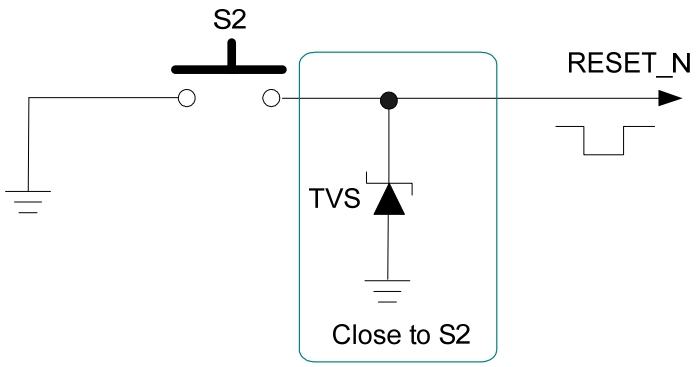


Figure 15: Reference Circuit of RESET_N by Using Button

The reset scenario is illustrated inthe following figure.

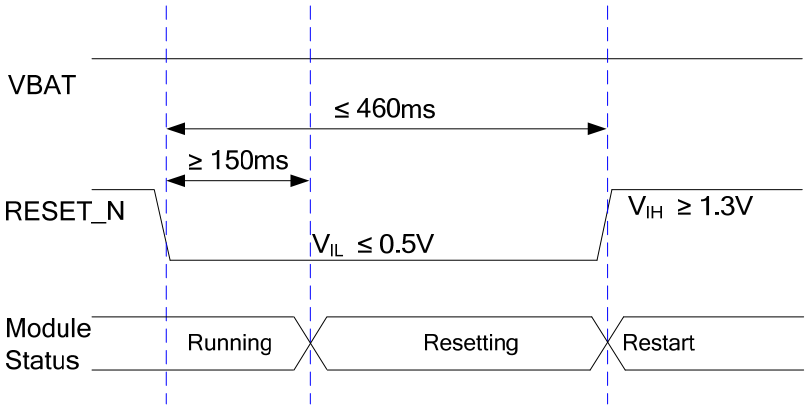


Figure 16: Reset Scenario

NOTES

1. Use RESET_N only when turning off the module by **AT+QPOWD**command and PWRKEY pin failed.
2. Ensure that there is no large capacitance on PWRKEY and RESET_N pins.

3.9. (U)SIM Interfaces

EG91provides two (U)SIMinterfaces, and only one (U)SIMcard can work at a time. The (U)SIM1 and (U)SIM2cards can be switched by **AT+QDSIM*** command. For more details, please refer to ***document [2]***.

The(U)SIM interfacescircuitrymeet ETSI and IMT-2000 requirements. Both 1.8V and 3.0V (U)SIMcards are supported.

Table 9: Pin Definition of (U)SIM Interfaces

Pin Name	Pin No.	I/O	Description	Comment
USIM1_VDD	43	PO	Power supply for (U)SIM1 card	Either 1.8V or 3.0V is supported by the module automatically.
USIM1_DATA	45	IO	Data signal of (U)SIM1 card	
USIM1_CLK	46	DO	Clock signal of (U)SIM1card	
USIM1_RST	44	DO	Reset signal of (U)SIM1 card	
USIM1_ PRESENCE	42	DI	(U)SIM1 card insertion detection	
USIM_GND	47		Specified ground for (U)SIMcard	
USIM2_VDD	87	PO	Power supply for (U)SIM2 card	Either 1.8V or 3.0V is supported by the module automatically.
USIM2_DATA	86	IO	Data signal of (U)SIM2 card	
USIM2_CLK	84	DO	Clock signal of (U)SIM2 card	
USIM2_RST	85	DO	Reset signal of (U)SIM2 card	
USIM2_ PRESENCE	83	DI	(U)SIM2 card insertion detection	

EG91 supports (U)SIMcard hot-plug via USIM_PRESENCE(USIM1_PRESENCE/USIM2_PRESENCE) pin. The functionsupports low level and high level detection, andis disabled by default. Pleaserefer to ***document [2]*** about **AT+QSIMDET**command for details.

The following figure shows a reference design for (U)SIM interface with an8-pin (U)SIMcard connector.

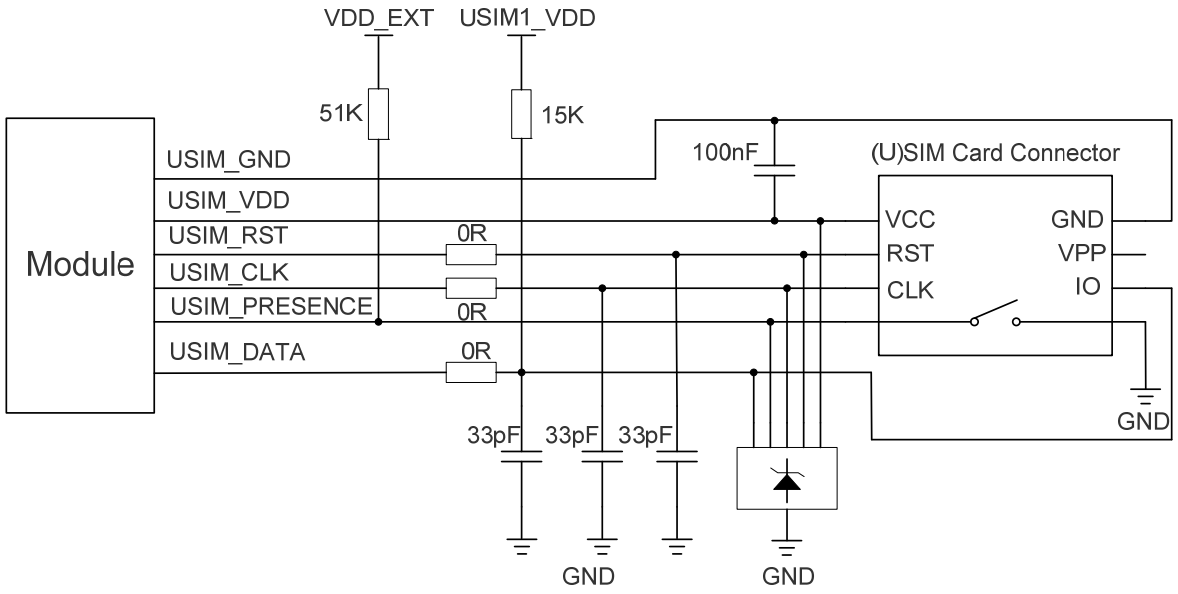


Figure 17: Reference Circuitof (U)SIMInterface with an 8-Pin (U)SIMCard Connector

If (U)SIM card detection function is not needed, please keep USIM_PRESENCE unconnected. Areference circuit of (U)SIM interface with a 6-pin (U)SIMcard connector is illustrated inthe following figure.

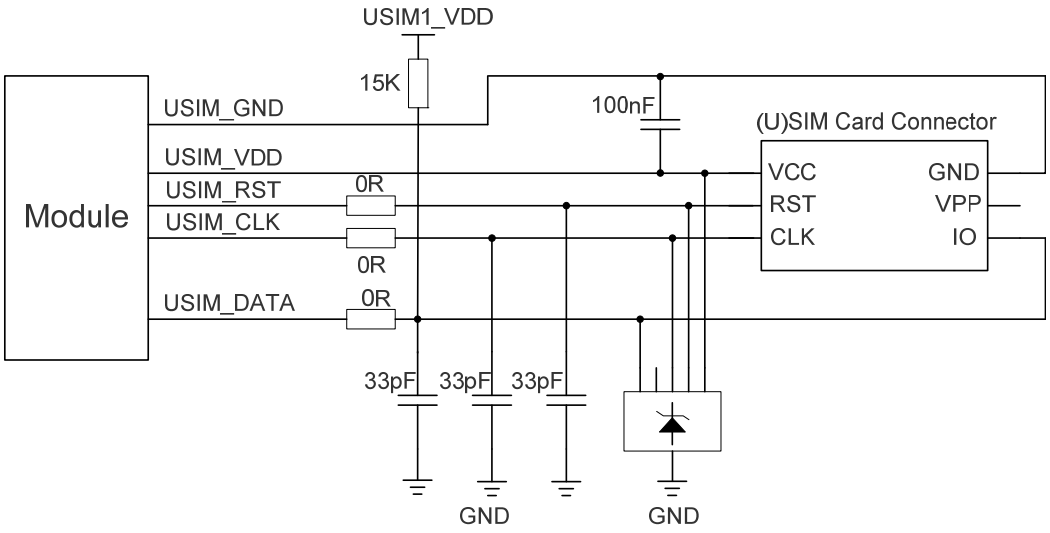


Figure 18: Reference Circuitof (U)SIM Interface with a 6-Pin (U)SIM Card Connector

In order to enhance the reliability and availability of the (U)SIM cardin customers' applications, please follow the criteria below in the (U)SIMcircuit design:

- Keep placementof (U)SIMcard connector to the module as close as possible. Keep the trace length as less than 200mm as possible.
- Keep (U)SIMcard signals away from RF and VBAT traces.

- Assure the ground trace between the module and the (U)SIMcard connector short and wide. Keep the trace width of ground and USIM_VDD no less than 0.5mm to maintain the same electric potential. Make sure the bypass capacitor between USIM_VDD and USIM_GND less than 1uF, and place it as close to (U)SIM card connector as possible.If the ground is complete on customers' PCB, USIM_GND can be connected to PCB ground directly.
- To avoid cross-talk between USIM_DATA and USIM_CLK, keep them away fromeach other and shield them with surrounded ground.
- In order to offer good ESD protection, it is recommended to add a TVSdiode array whose parasitic capacitance should not be more than15pF. The 0Ωresistors should be added in series between the module and the (U)SIMcard to facilitate debugging. The 33pFcapacitors are used for filtering interference of EGSM900.Please note that the (U)SIMperipheral circuit should be close to the (U)SIMcard connector.
- The pull-up resistor on USIM_DATA line can improve anti-jamming capability when long layout trace and sensitive occasion areapplied, and should be placed close to the (U)SIMcard connector.

NOTE

"*" means under development.

3.10. USB Interface

EG91 contains one integrated Universal Serial Bus (USB) interfacewhich complies with the USB 2.0 specification and supports high-speed (480Mbps) and full-speed (12Mbps) modes. The USB interface is used for AT command communication, data transmission, GNSS NMEA sentences output,software debugging, firmware upgrade and voice over USB*. The following table shows the pin definition of USB interface.

Table 10: Pin Definition of USB Interface

Pin Name	Pin No.	I/O	Description	Comment
USB_DP	9	IO	USB differential data bus (+)	Require differential impedance of 90Ω.
USB_DM	10	IO	USB differential data bus (-)	Require differential impedance of 90Ω.
USB_VBUS	8	PI	USB connection detection	Typical:5.0V
GND	3		Ground	

For more details about USB 2.0 specifications, please visit http://www.usb.org/home.

The USB interface is recommended to be reserved for firmware upgrade in customers' design. The following figure shows areference circuit of USB interface.

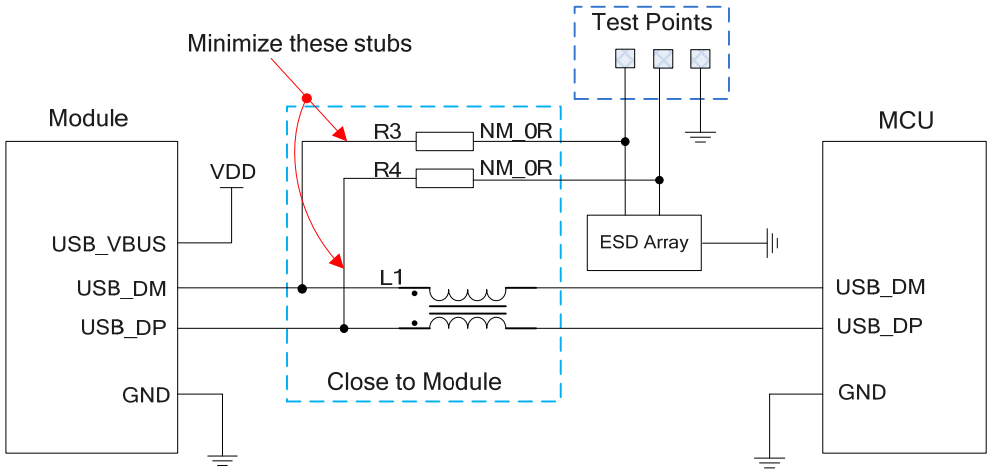


Figure 19: Reference Circuit of USB Interface

A common mode choke L1 is recommended to be added in series between the module and customer'sMCU in order to suppress EMI spurious transmission. Meanwhile, the 0Ω resistors (R3 and R4) should beadded in series between the module and the test points so as to facilitate debugging, and the resistors are
not mounted by default. In order to ensure the integrity of USB data line signal, L1/R3/R4 componentsmust be placed close to the module, and also these resistors should be placed close to each other. Theextra stubs of trace must be as short as possible.

The following principles should be complied with when design the USB interface, so as to meet USB 2.0 specification.

- It is important to route the USB signal traces as differential pairs with total grounding. The impedance of USB differential trace is 90Ω.
- Do not route signal traces under crystals, oscillators, magnetic devices and RF signal traces. It is important to route the USB differential traces in inner-layer with ground shielding onnot only upper and lower layers but also right and left sides.
- Pay attention to the influence of junction capacitance of ESD protection components on USB data lines. Typically, the capacitance value should be less than 2pF.
- Keep the ESD protection components to the USB connector as close as possible.

NOTES

1. EG91 module can only be used as a slave device.
2. "*" means under development.

3.11. UART Interfaces

The module provides two UART interfaces: the main UART interface and thedebug UART interface. The following shows their features.

- The main UART interface supports 9600bps, 19200bps, 38400bps, 57600bps, 115200bps, 230400bps, 460800bps, 921600bps and 3000000bps baud rates, and the default is 115200bps. It supports RTS and CTS hardware flow control, and is used for AT command communication only.
- The debug UART interface supports 115200bpsbaud rate. It is used forLinux console and log output.

The following tables show the pin definition of the two UART interfaces.

Table 11: Pin Definition of Main UART Interfaces

Pin Name	Pin No.	I/O	Description	Comment
RI	39	DO	Ring indicator	
DCD	38	DO	Data carrier detection	
CTS	36	DO	Clear to send	
RTS	37	DI	Request to send	1.8V power domain
DTR	30	DI	Sleep mode control	
TXD	35	DO	Transmit data	
RXD	34	DI	Receive data	

Table 12: Pin Definition of Debug UART Interface

Pin Name	Pin No.	I/O	Description	Comment
DBG_TXD	23	DO	Transmit data	1.8V power domain
DBG_RXD	22	DI	Receive data	1.8V power domain

The logic levels are described in the following table.

Table 13:Logic Levels of Digital I/O

Parameter	Min.	Max.	Unit
V_{IL}	-0.3	0.6	V
V_{IH}	1.2	2.0	V
V_{OL}	0	0.45	V
V_{OH}	1.35	1.8	V

The module provides 1.8V UART interfaces. A level translator should be used if customers' application is equipped with a 3.3V UART interface. A level translator TXS0108EPWR provided by *Texas Instruments* is recommended. The following figure shows areference design.

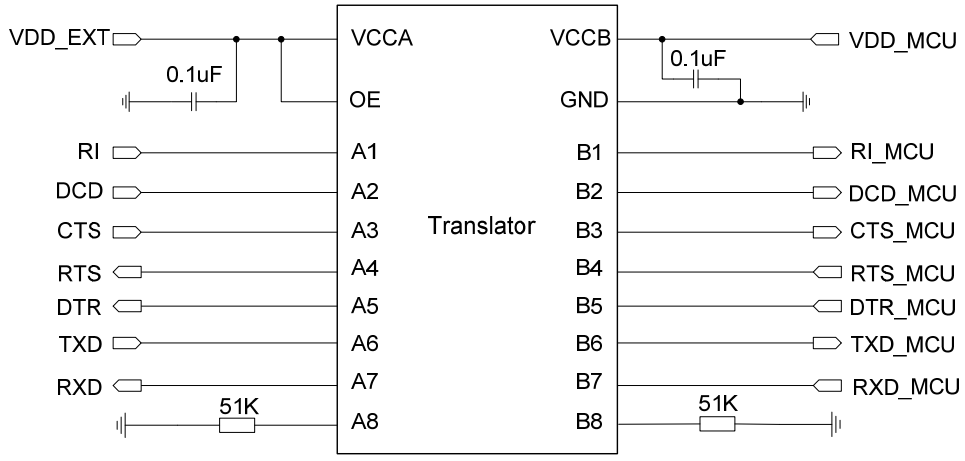


Figure 20: Reference Circuit with Translator Chip

Please visit http://www.ti.com formore information.

Another example with transistor translation circuit is shown as below. Thecircuitdesign of dotted line section can refer to the circuitdesign of solid linesection, in terms of both module input and output circuit design. Please pay attention to the direction of connection.

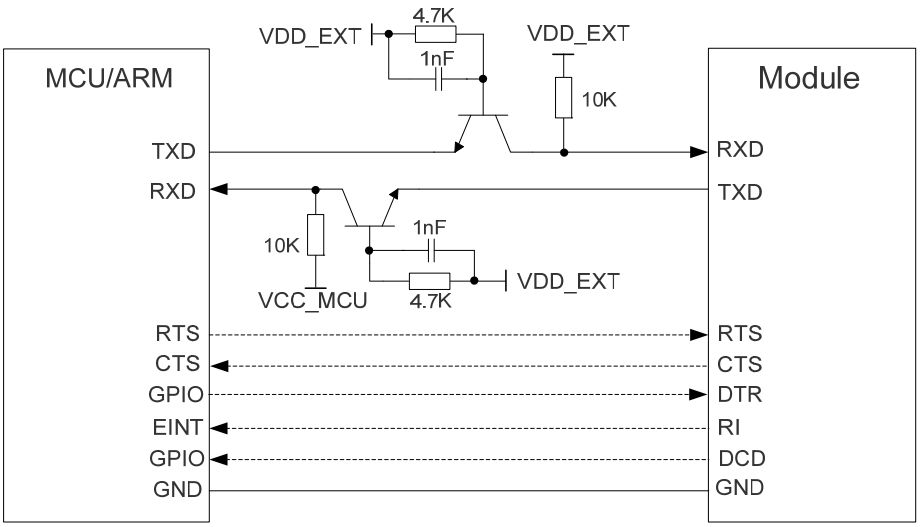


Figure 21: Reference Circuit with Transistor Circuit

NOTE

Transistor circuit solution is not suitable for applications with high baud rates exceeding 460Kbps.

3.12. PCM and I2C Interfaces

EG91 provides one Pulse Code Modulation (PCM) digital interface for audio design, which supports the following modes and one I2C interface:

- Primary mode (short frame synchronization, works as both master and slave)
- Auxiliary mode (long frame synchronization, works as master only)

In primary mode, the data is sampled on the falling edge of the PCM_CLK and transmitted on the rising edge. The PCM_SYNC falling edge represents the MSB. In this mode, the PCM interface supports 256KHz, 512KHz, 1024KHz or 2048KHz PCM_CLK at 8KHz PCM_SYNC, and also supports 4096KHz PCM_CLK at 16KHz PCM_SYNC.

In auxiliary mode, the data is also sampled on the falling edge of the PCM_CLK and transmitted on the rising edge. The PCM_SYNC rising edge represents the MSB. In this mode, the PCM interface operates with a 256KHz, 512KHz, 1024KHz or 2048KHz PCM_CLK and an 8KHz, 50% duty cycle PCM_SYNC.

EG91 supports 16-bit linear data format. The following figures show theprimary mode's timing relationship with 8KHz PCM_SYNC and 2048KHz PCM_CLK, as well asthe auxiliary mode's timing relationship with 8KHz PCM_SYNC and 256KHz PCM_CLK.

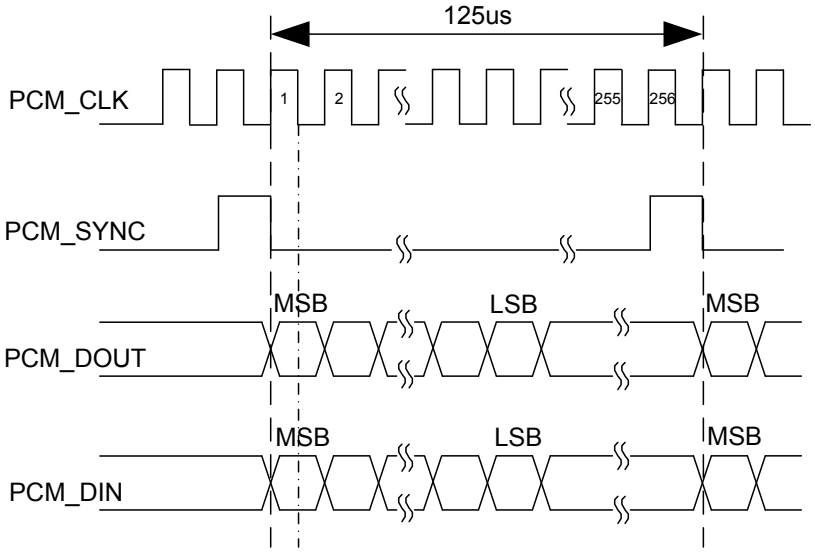


Figure 22: Primary Mode Timing

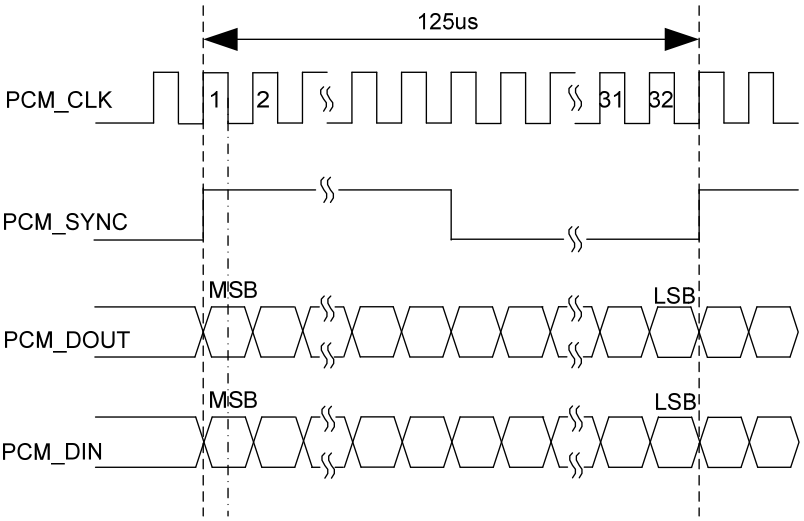


Figure 23: Auxiliary Mode Timing

The following table shows the pin definition of PCM and I2C interfaces which can be applied on audio codec design.

Table 14: Pin Definition of PCM and I2C Interfaces

Pin Name	Pin No.	I/O	Description	Comment
PCM_DIN	6	DI	PCM data input	1.8V power domain
PCM_DOUT	7	DO	PCM data output	1.8V power domain
PCM_SYNC	5	IO	PCM data frame synchronization signal	1.8V power domain
PCM_CLK	4	IO	PCM data bit clock	1.8V power domain
I2C_SCL	40	OD	I2C serial clock	Require an external pull-up to 1.8V
I2C_SDA	41	OD	I2C serial data	Require an external pull-up to 1.8V

Clock and mode can be configured by AT command, and the default configuration is master mode using short frame synchronizationformat with 2048KHzPCM_CLK and 8KHz PCM_SYNC.Please refer to ***document [2]*** about**AT+QDAI**command for details.

The following figure shows areference design of PCM interface with external codec IC.

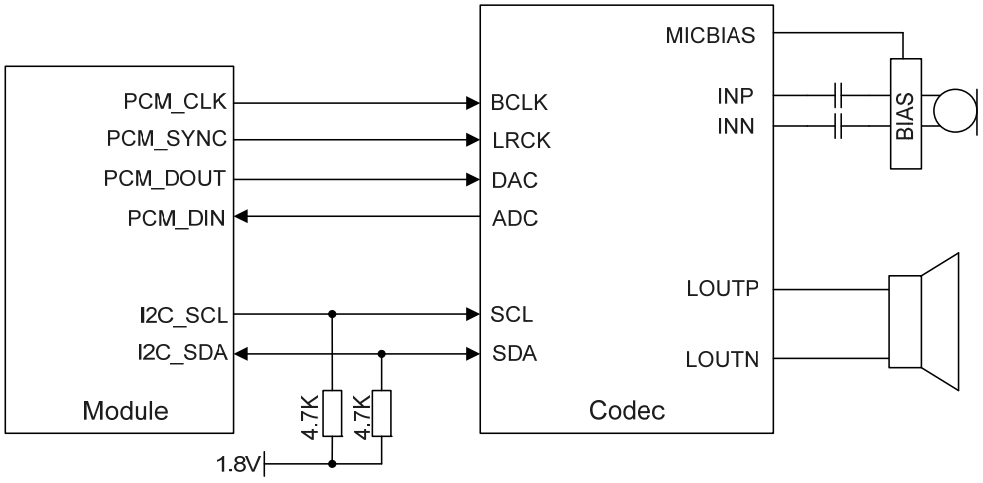


Figure 24: Reference Circuit of PCM Application with Audio Codec

NOTES

1. It is recommended to reserve an RC (R=22Ω, C=22pF) circuit on the PCM lines, especially for PCM_CLK.
2. EG91 works as a master device pertaining to I2C interface.

3.13. SPI Interface

SPI interface of EG91acts asthe master only. It provides a duplex, synchronous and serial communication link with the peripheral devices. It isdedicated to one-to-one connection, withoutchip select.Its operation voltage is 1.8V with clock rates up to 50MHz.

The following table shows the pin definition of SPI interface.

Table 15: Pin Definition of SPI Interface

Pin Name	Pin No.	I/O	Description	Comment
SPI_CLK	26	DO	Clock signal of SPI interface	1.8V power domain
SPI_MOSI	27	DO	Master output slave input of SPI interface	1.8V power domain
SPI_MISO	28	DI	Master input slave output of SPI interface	1.8V power domain

The following figure shows areference design of SPI interface with peripherals.

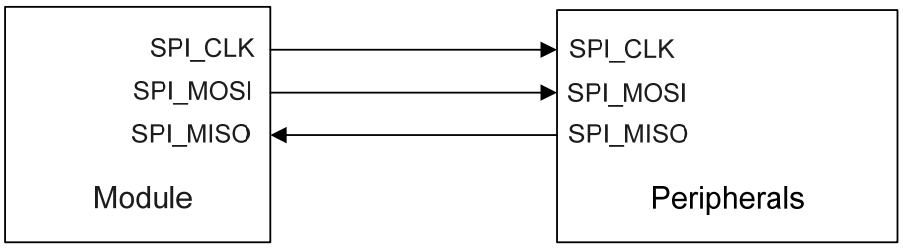


Figure 25: Reference Circuit of SPI Interface with Peripherals

NOTE

The module provides 1.8V SPI interface. A level translator should be used between the module and the host if customer's applicationis equipped with a 3.3V processoror device interface.

3.14. Network Status Indication

The module provides one network indication pin: NETLIGHT. The pin is used to drive a network status indication LED.

The following tables describe the pin definition and logic level changes of NETLIGHT in different network status.

Table 16: Pin Definition of Network StatusIndicator

Pin Name	Pin No.	I/O	Description	Comment
NETLIGHT	21	DO	Indicate the module’snetwork activity status	1.8V power domain

Table 17: Working State of Network Status Indicator

Pin Name	Logic Level Changes	Network Status
NETLIGHT	Flicker slowly (200ms High/1800ms Low)	Network searching
	Flicker slowly (1800ms High/200ms Low)	Idle
	Flicker quickly (125ms High/125ms Low)	Data transfer is ongoing
	Always High	Voice calling

A reference circuit is shown in the following figure.

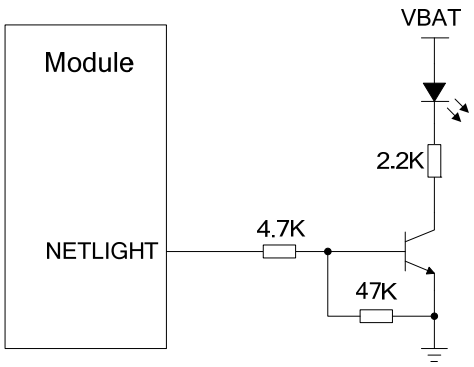


Figure 26: Reference Circuit of Network Status Indicator

3.15. STATUS

The STATUS pin is set as the module’s operation status indicator. It will output high level when the module is powered on. The following table describes the pin definition of STATUS.

Table 18: Pin Definition of STATUS

Pin Name	Pin No.	I/O	Description	Comment
STATUS	20	DO	Indicate the module'soperatingstatus	1.8V power domain. If unused, keep it open.

The following figure showsthe reference circuit of STATUS.

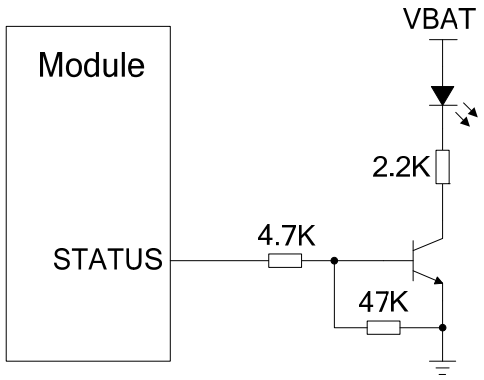


Figure 27: Reference Circuit of STATUS

3.16. ADC Interface

The module provides one analog-to-digital converter (ADC) interface. **AT+QADC=0** command can beused to read the voltage value on ADC0 pin. For more details about the command, please refer to ***document [2]***.

In order to improve the accuracy of ADC voltage values, the traces of ADC should be surrounded by ground.

Table 19: Pin Definition of ADC Interface

Pin Name	Pin No.	I/O	Description	Comment
ADC0	24	AI	Force the module to enter into emergency download mode	If unused, keep this pin open.

The following table describes the characteristics of ADC interface.

Table 20: Characteristics of ADC Interface

Parameter	Min.	Typ.	Max.	Unit
ADC0 Voltage Range	0.3		VBAT_BB	V
ADC Resolution			15	bits

NOTES

1. It is prohibited to supply any voltage to ADC pins when VBAT is removed.
2. It is recommended to use resistor divider circuit for ADC application.

3.17. Behaviors of RI

AT+QCFG="risignaltype","physical"command can be used to configure RI behavior.The default RI behaviors can be changed by **AT+QCFG="urc/ri/ring"** command. Please refer to ***document [2]*** for details.

No matter on which port URC is presented, URC will trigger the behavior ofRI pin.

NOTE

URC can be outputted from UART port, USB AT port and USB modem port through configuration via **AT+QURCCFG** command. The default port is USB AT port.

The default behaviors of the RI are shown as below.

Table 21: Default Behaviors of RI

State	Response
Idle	RI keeps athigh level
URC	RI outputs 120ms low pulse when a new URC returns

3.18. USB_BOOT Interface

EG91provides a USB_BOOT pin. Customerscan pull up USB_BOOT to VDD_EXT before powering on the module, thus the module will enter into emergency download mode when powered on. In this mode, the module supports firmware upgrade over USB interface.

Table 22: Pin Definition of USB_BOOT Interface

Pin Name	Pin No.	I/O	Description	Comment
USB_BOOT	75	DI	Force the module to enter into emergency download mode	1.8V power domain. Active high. It is recommended to reserve test point.

The following figures showthereference circuit of USB_BOOT interface and timing sequence of entering into emergency download mode.

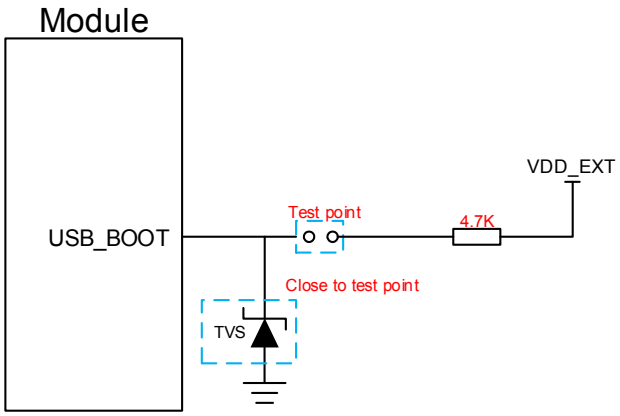


Figure 28: Reference Circuit of USB_BOOT Interface

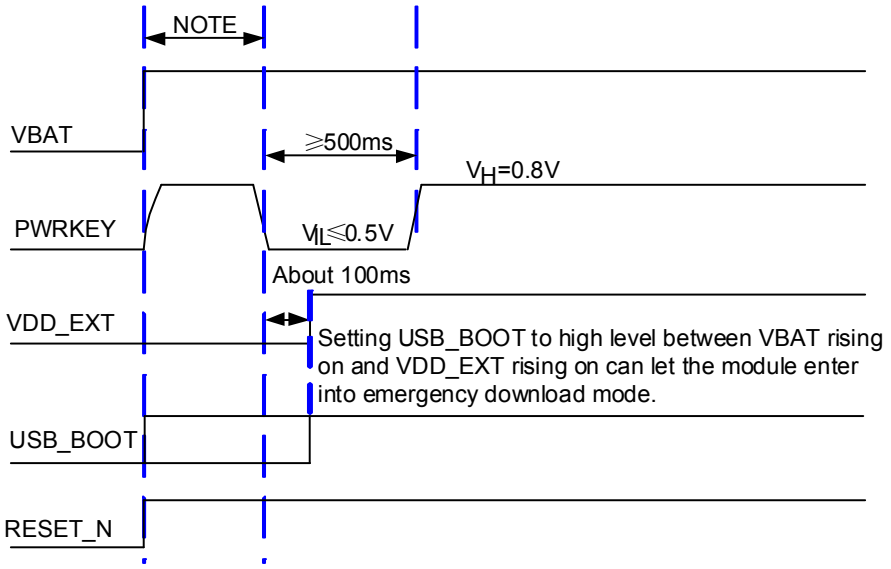


Figure 29: Timing Sequence for Entering into Emergency Download Mode

NOTES

1. Please make sure that VBAT is stable before pulling down PWRKEY pin. The time between them is no less than 30ms.
2. When using MCU to control module to enter into the emergency download mode, follow the above timing sequence. It is not recommended to pull up USB_BOOT to 1.8V before powering up the VBAT. Short the test points as shown in ***Figure 28*** can manually force the module to enter into download mode.

4 GNSS Receiver

4.1. General Description

EG91 includes a fully integrated global navigation satellite system solution that supports Gen8C-Lite of Qualcomm (GPS, GLONASS, BeiDou, Galileo and QZSS).

EG91 supports standard NMEA-0183 protocol, and outputs NMEA sentences at 1Hz data update rate via USB interface by default.

By default, EG91 GNSS engine is switched off. It has to be switched on via AT command. For more details about GNSS engine technology and configurations, please refer to ***document [3]***.

4.2. GNSS Performance

The following table shows GNSS performance of EG91.

Table 23: GNSS Performance

Parameter	Description	Conditions	Typ.	Unit
Sensitivity (GNSS)	Cold start	Autonomous	-146	dBm
	Reacquisition	Autonomous	-157	dBm
	Tracking	Autonomous	-157	dBm
TTFF (GNSS)	Cold start @open sky	Autonomous	34.6	s
		XTRA enabled	11.57	s
	Warm start @open sky	Autonomous	26.09	s
		XTRA enabled	3.7	s

	Hot start @open sky	Autonomous	1.8	s
		XTRA enabled	3.4	s
Accuracy (GNSS)	CEP-50	Autonomous @open sky	<2.5	m

NOTES

1. Tracking sensitivity: the lowest GNSS signal value at the antenna port on which the module can keep on positioning for 3 minutes.
2. Reacquisition sensitivity: the lowest GNSS signal value at the antenna port on which the module can fix position again within 3 minutes after loss of lock.
3. Cold start sensitivity: the lowest GNSS signal value at the antenna port on which the module fixes position within 3 minutes after executing cold start command.

4.3. Layout Guidelines

The following layout guidelines should be taken into account in customers' design.

- Maximize the distance among GNSS antenna, main antenna and Rx-diversity antenna.
- Digital circuits such as (U)SIM card, USB interface, camera module and display connector should be kept away from the antennas.
- Use ground vias around the GNSS trace and sensitive analog signal traces to provide coplanar isolation and protection.
- Keep the characteristic impedance for ANT_GNSS trace as 50Ω.

Please refer to ***Chapter 5*** for GNSS antenna reference design and antenna installation information.

5 Antenna Interfaces

EG91 antenna interfaces include a main antenna interface and anRx-diversity antennainterface which is used toresist the fall of signals caused by high speed movement and multipath effect, and a GNSS antenna interface which is only supported on EG91-NA/-NS/-V/-EC. The impedance of the antenna port is50Ω.

5.1. Main/Rx-diversityAntenna Interfaces

5.1.1. Pin Definition

The pin definitionof main antenna and Rx-diversityantenna interfaces is shown below.

Table 24: Pin Definition of RF Antenna

Pin Name	Pin No.	I/O	Description	Comment
ANT_MAIN	60	IO	Main antenna pad	50Ω impedance
ANT_DIV (EG91-E)	49	AI	Receive diversity antenna pad	50Ω impedance
ANT_DIV (EG91-NA/-NS/-V/-EC)	56	AI	Receive diversity antenna pad	50Ω impedance

5.1.2. Operating Frequency

Table 25: Module Operating Frequencies

3GPP Band	Transmit	Receive	Unit
EGSM900	880~915	925~960	MHz
DCS1800	1710~1785	1805~1880	MHz
WCDMA B1	1920~1980	2110~2170	MHz
WCDMA B2	1850~1910	1930~1990	MHz

WCDMA B4	1710~1755	2110~2155	MHz
WCDMA B5	824~849	869~894	MHz
WCDMA B8	880~915	925~960	MHz
LTE-FDD B1	1920~1980	2110~2170	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 B12	699~716	729~746	MHz
LTE FDD B13	777~787	746~756	MHz
LTE-FDD B20	832~862	791~821	MHz
LTE-FDD B25	1850~1915	1930~1995	MHz
LTE-FDD B26	814~849	859~894	MHz
LTE-FDD B28	703~748	758~803	MHz

5.1.3. Reference Design of RF Antenna Interface

Areference design of ANT_MAIN and ANT_DIVantenna pads is shown as below. Aπ-type matching circuit should be reserved for better RF performance. The capacitors are not mounted by default.

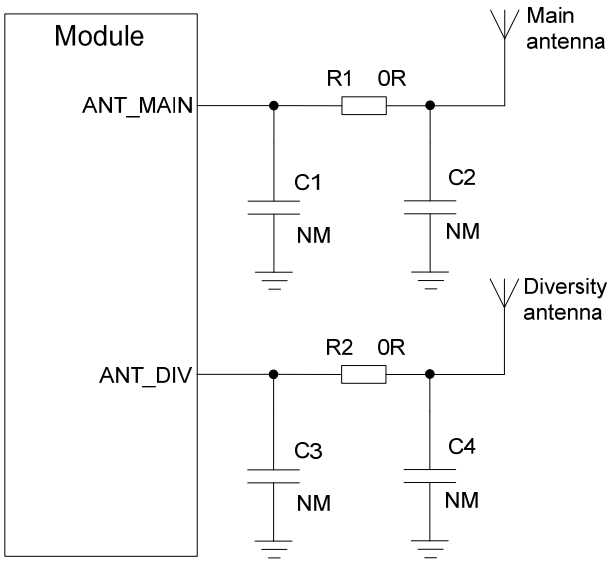


Figure 30: Reference Circuit of RF Antenna Interface

NOTES

1. Keep a proper distance between the main antenna and theRx-diversityantenna to improve the receiving sensitivity.
2. ANT_DIV function is enabledby default.**AT+QCFG="diversity",0**command can be used to disable receive diversity.
3. Place the π-type matching components (R1/C1/C2, R2/C3/C4) as close to the antenna as possible.

5.1.4. Reference Design of RF Layout

For user's PCB, the characteristic impedance of all RF traces should be controlled as 50Ω. The impedance of the RF traces is usually determined by the trace width (W), the materials' dielectric constant, height from the reference ground to the signal layer (H), and the space between the RF trace and the ground (S). Microstrip and coplanar waveguide are typically used in RF layout to control characteristic impedance. The following figures are reference designs of microstrip or coplanar waveguide with different PCB structures.

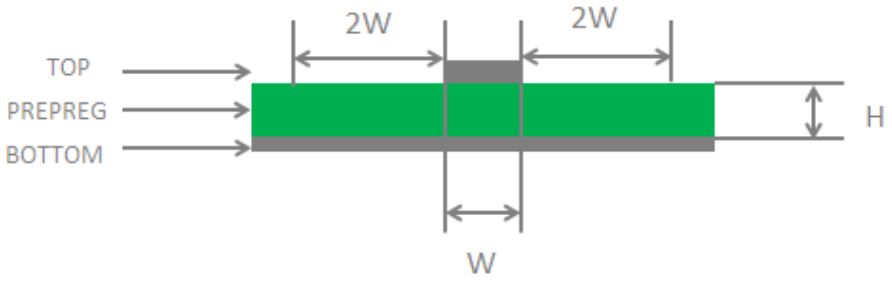


Figure 31: Microstrip Line Design on a 2-layer PCB

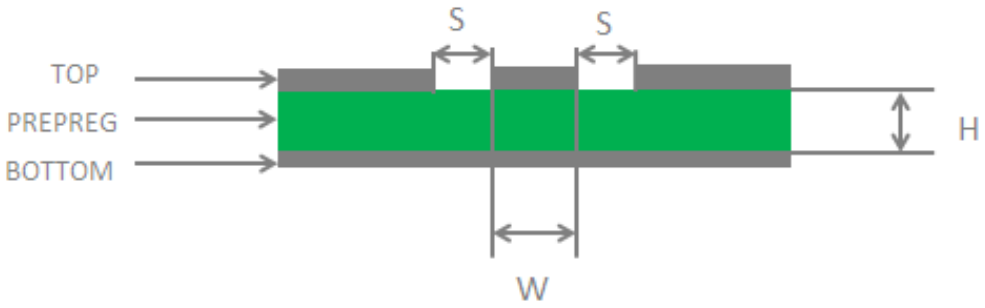


Figure 32: Coplanar Waveguide Design on a 2-layer PCB

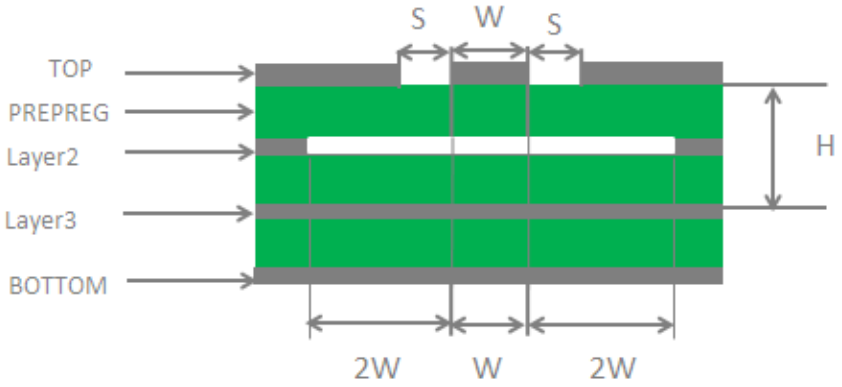


Figure 33: Coplanar Waveguide Design on a 4-layer PCB (Layer 3 as Reference Ground)

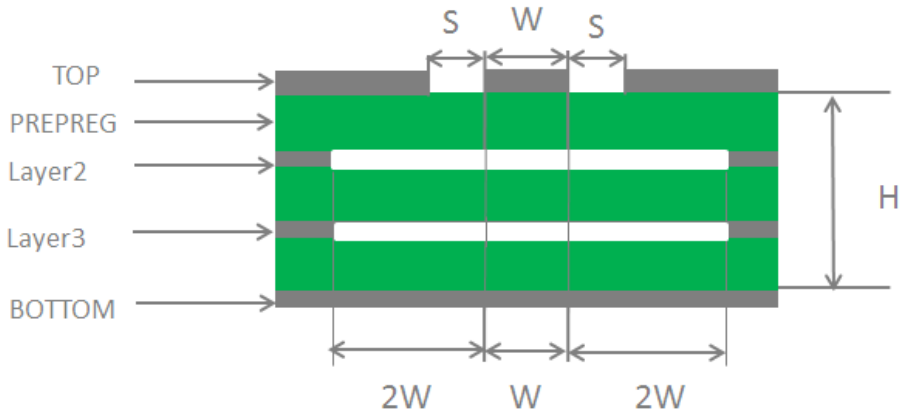


Figure 34: Coplanar Waveguide Design on a 4-layer PCB (Layer 4 as Reference Ground)

In order to ensure RF performance and reliability, the following principles should be complied with in RF layout design:

- Use impedance simulation tool to control the characteristic impedanceof RF tracesas 50Ω.
- The GND pins adjacent to RF pins should not bedesigned as thermal relief pads, and should be fully connected to ground.
- The distance between the RF pinsand the RFconnector should be as short as possible, and all the right angle traces should be changed to curved ones.
- There should be clearance area under the signal pin of the antenna connector or solder joint.
- The reference ground of RF traces should be complete. Meanwhile, adding some ground viasaround RF traces and the reference ground could help to improve RF performance. The distance between the ground vias and RF traces should be no less than two times the width of RF signal traces (2*W).

For more details about RF layout, please refer to ***document [5]***.

5.2. GNSS Antenna Interface

The GNSS antenna interface is only supported on EG91-NA/-NS/-V/-EC. The following tables show pin definition and frequency specification of GNSS antenna interface.

Table 26: Pin Definition of GNSS Antenna Interface

Pin Name	Pin No.	I/O	Description	Comment
ANT_GNSS (EG91-NA/-NS/-V/-EC)	49	AI	GNSS antenna	50Ωimpedance

Table 27: GNSS Frequency

Type	Frequency	Unit
GPS	1575.42±1.023	MHz
GLONASS	1597.5~1605.8	MHz
Galileo	1575.42±2.046	MHz
BeiDou	1561.098±2.046	MHz
QZSS	1575.42	MHz

A reference design of GNSS antenna is shown as below.

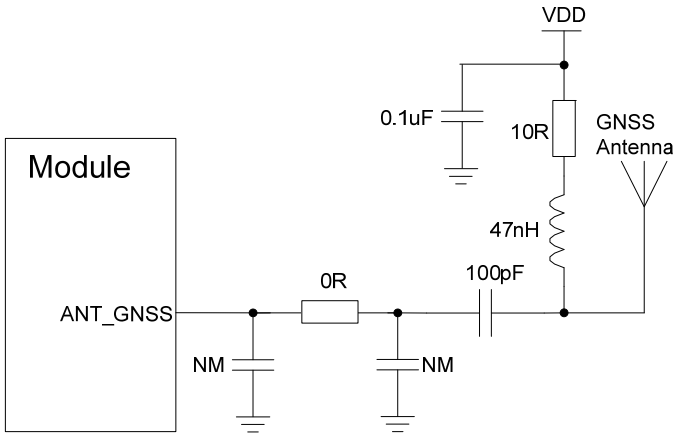


Figure 35: Reference Circuit of GNSS Antenna

NOTES

1. An external LDO can be selected to supply power according to the active antenna requirement.
2. If the module is designed with a passive antenna, then the VDD circuit is not needed.

5.3. Antenna Installation

5.3.1. Antenna Requirement

The following table shows the requirements on main antenna, Rx-diversity antenna and GNSS antenna.

Table 28: Antenna Requirements

Type	Requirements
GNSS[1)]	Frequency range: 1559MHz~1609MHz Polarization: RHCP or linear VSWR: < 2 (Typ.) Passive antenna gain: > 0dBi Active antenna noise figure: < 1.5dB Active antenna gain: > 0dBi Active antenna embedded LNA gain: < 17dB
GSM/WCDMA/LTE	VSWR: ≤ 2 Efficiency: > 30% Max Input Power: 50 W Input Impedance: 50Ω Cable insertion loss: <1dB

	(EGSM900,WCDMA B5/B8, LTE B5/B8/B12/B13/B20/B26/B28) Cable Insertion Loss: <1.5dB (DCS1800, WCDMA B1/B2/B4, LTE B1/B2/B3/B4/B25) Cable insertion loss: <2dB (LTE B7)

NOTE

[1] It is recommended to use a passive GNSS antenna when LTE B13 is supported, as the use of active antenna may generate harmonics which will affect the GNSS performance.

5.3.2. Recommended RF Connector for Antenna Installation

If RF connector is used for antenna connection, it is recommended to use U.FL-R-SMT connector provided by Hirose.

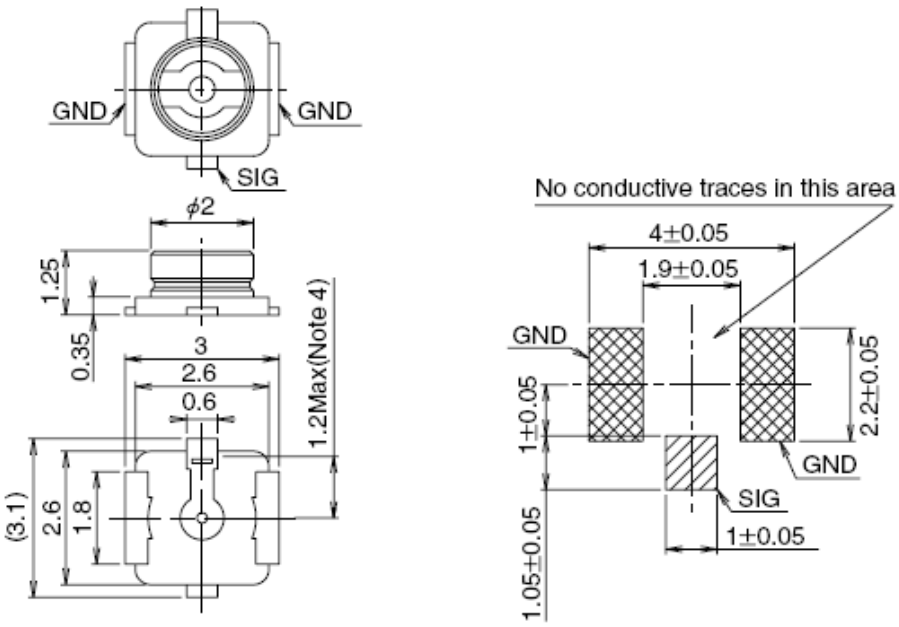


Figure 36: Dimensions of the U.FL-R-SMT Connector (Unit: mm)

U.FL-LP serial connectors listed in the following figure can be used to match the U.FL-R-SMT.

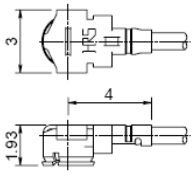
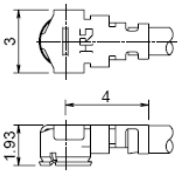
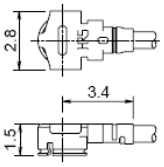
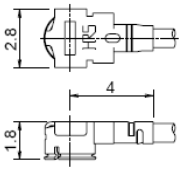
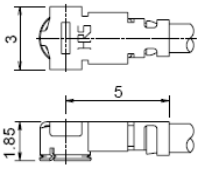
Part No.	U.FL-LP-040	U.FL-LP-066	U.FL-LP(V)-040	U.FL-LP-062	U.FL-LP-088
					
Mated Height	2.5mm Max. (2.4mm Nom.)	2.5mm Max. (2.4mm Nom.)	2.0mm Max. (1.9mm Nom.)	2.4mm Max. (2.3mm Nom.)	2.4mm Max. (2.3mm Nom.)
Applicable cable	Dia. 0.81mm Coaxial cable	Dia. 1.13mm and Dia. 1.32mm Coaxial cable	Dia. 0.81mm Coaxial cable	Dia. 1mm Coaxial cable	Dia. 1.37mm Coaxial cable
Weight (mg)	53.7	59.1	34.8	45.5	71.7

Figure 37:Mechanicals of U.FL-LP Connectors

The following figure describes the space factor of mated connector.

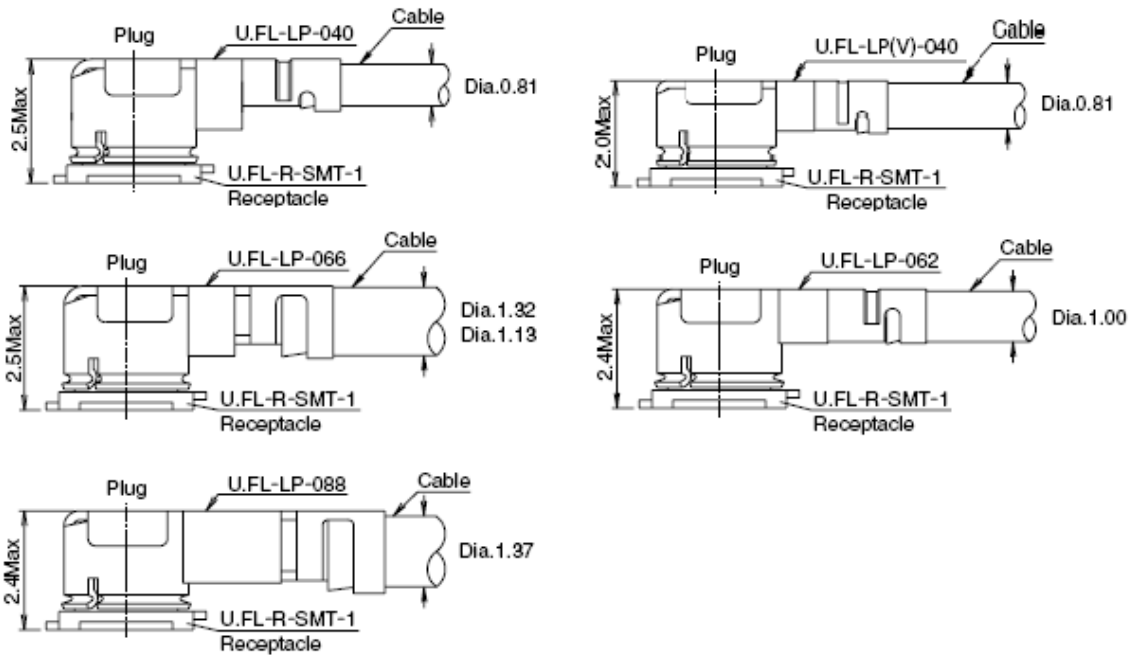


Figure 38:Space Factor of Mated Connector (Unit: mm)

For more details, please visit http://www.hirose.com.

6 Electrical, Reliability and RadioCharacteristics

6.1. 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 29: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
VBAT_RF/VBAT_BB	-0.3	4.7	V
USB_VBUS	-0.3	5.5	V
Peak Current of VBAT_BB	0	0.8	A
Peak Current of VBAT_RF	0	1.8	A
Voltage at Digital Pins	-0.3	2.3	V

6.2. Power Supply Ratings

Table 30: Power Supply Ratings

Parameter	Description	Conditions	Min.	Typ.	Max.	Unit
VBAT	VBAT_BB and VBAT_RF	The actual input voltages must stay between the minimum and maximum values.	3.3	3.8	4.3	V

	Voltage drop during burst transmission	Maximum power control level on EGSM900			400	mV
I_{VBAT}	Peak supply current (during transmissionslot)	Maximum power control level on EGSM900		1.8	2.0	A
USB_VBUS	USB connectiondetection		3.0	5.0	5.25	V

6.3. Operation and Storage Temperatures

The operation and storage temperaturesare listed in the following table.

Table 31: Operation and Storage Temperatures

Parameter	Min.	Typ.	Max.	Unit
Operation Temperature Range[1)]	-35	+25	+75	ºC
ExtendedTemperatureRange[2)]	-40		+85	ºC
Storage Temperature Range	-40		+90	ºC

NOTES

1. [1)] Within operation temperature range, the module is 3GPP compliant.
2. [2)] Within extended temperature range, the module remains the ability to establish and maintain a voice, SMS, data transmission, emergency call, etc. There is no unrecoverable malfunction. There are also no effects on radio spectrum and no harm to radio network. Only one or more parameters like P_{out} might reduce in their value and exceed the specified tolerances. When the temperature returns to the normal operating temperature levels, the module will meet 3GPP specifications again.

6.4. Current Consumption

The values of current consumption are shown below.

Table 32: EG91-E Current Consumption

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	OFF state	Power down	13	uA
	Sleep state	**AT+CFUN=0** (USB disconnected)	1.1	mA
		GSM DRX=2 (USB disconnected)	2.0	mA
		GSM DRX=5 (USB suspended)	1.9	mA
		GSM DRX=9 (USB disconnected)	1.3	mA
		WCDMA PF=64 (USB disconnected)	1.7	mA
		WCDMA PF=64 (USB suspended)	2.1	mA
		WCDMA PF=512 (USB disconnected)	1.1	mA
		LTE-FDD PF=64 (USB disconnected)	2.1	mA
		LTE-FDD PF=64 (USB suspended)	2.6	mA
		LTE-FDD PF=256 (USB disconnected)	1.4	mA
	Idle state	GSM DRX=5 (USB disconnected)	19.0	mA
		GSM DRX=5 (USB connected)	29.0	mA
		WCDMA PF=64 (USB disconnected)	19.0	mA
		WCDMA PF=64 (USB connected)	29.0	mA
		LTE-FDDPF=64 (USB disconnected)	19.0	mA
		LTE-FDDPF=64 (USB connected)	29.0	mA
	GPRS data transfer	EGSM900 4DL/1UL @32.67dBm	260	mA
		EGSM900 3DL/2UL @32.59dBm	463	mA
		EGSM900 2DL/3UL @30.74dBm	552	mA

		EGSM900 1DL/4UL @29.26dBm	619	mA
		DCS1800 4DL/1UL @29.2dBm	165	mA
		DCS1800 3DL/2UL @29.13dBm	267	mA
		DCS1800 2DL/3UL @29.01dBm	406	mA
		DCS1800 1DL/4UL @28.86dBm	467	mA
	EDGE data transfer	EGSM900 4DL/1UL PCL=8 @27.1dBm	163	mA
		EGSM900 3DL/2UL PCL=8 @27.16dBm	274	mA
		EGSM900 2DL/3UL PCL=8 @26.91dBm	383	mA
		EGSM900 1DL/4UL PCL=8 @26.12dBm	463	mA
		DCS1800 4DL/1UL PCL=2 @25.54dBm	136	mA
		DCS1800 3DL/2UL PCL=2 @25.68dBm	220	mA
		DCS1800 2DL/3UL PCL=2 @25.61dBm	306	mA
		DCS1800 1DL/4UL PCL=2 @25.41dBm	396	mA
	WCDMA datatransfer	WCDMA B1 HSDPACH10700 @22.29dBm	507	mA
		WCDMA B1 HSUPA CH10700 @21.79dBm	516	mA
		WCDMA B8 HSDPACH3012 @22.47dBm	489	mA
		WCDMA B8 HSUPA CH3012 @21.98dBm	482	mA
	LTE datatransfer	LTE-FDD B1 CH18300 @22.98dBm	685	mA
		LTE-FDD B3 CH19575 @23.23dBm	698	mA
		LTE-FDD B7 CH21100 @23.46dBm	723	mA
		LTE-FDD B8 CH21625 @23.35dBm	655	mA
		LTE-FDD B20 CH24300 @23.41dBm	723	mA
		LTE-FDD B28A CH27360 @23.16dBm	660	mA
	GSM voice call	EGSM900 PCL=5 @32.5dBm	258	mA
		DCS1800PCL=0 @29.23dBm	159	mA

	WCDMA voice call	WCDMA B1 CH10700 @23.06dBm	555	mA
		WCDMA B8 CH3012 @23.45dBm	535	mA

Table 33: EG91-NA Current Consumption

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	OFF state	Power down	13	uA
	Sleep state	**AT+CFUN=0** (USB disconnected)	1.0	mA
		WCDMA PF=64 (USB disconnected)	2.2	mA
		WCDMA PF=64 (USB suspended)	2.5	mA
		WCDMA PF=512 (USB disconnected)	1.4	mA
		LTE-FDD PF=64 (USB disconnected)	2.6	mA
		LTE-FDD PF=64 (USB suspended)	2.9	mA
		LTE-FDD PF=256 (USB disconnected)	1.7	mA
	Idle state	WCDMA PF=64 (USB disconnected)	14.0	mA
		WCDMA PF=64 (USB connected)	26.0	mA
		LTE-FDDPF=64 (USB disconnected)	15.0	mA
		LTE-FDDPF=64 (USB connected)	26.0	mA
	WCDMA datatransfer	WCDMA B2 HSDPA CH9938@22.45 dBm	569	mA
		WCDMA B2 HSUPACH9938 @21.73 dBm	559	mA
		WCDMA B4 HSDPACH1537@23.05 dBm	572	mA
		WCDMA B4 HSUPACH1537@22.86 dBm	586	mA
		WCDMA B5 HSDPA CH4407@23 dBm	518	mA
		WCDMA B5 HSUPACH4407 @22.88 dBm	514	mA
	LTE datatransfer	LTE-FDD B2 CH1100@23.29 dBm	705	mA
		LTE-FDD B4 CH2175@23.19 dBm	693	mA

		LTE-FDD B5 CH2525@23.39dBm	601	mA
		LTE-FDD B12 CH5060@23.16 dBm	650	mA
		LTE-FDD B13 CH5230 @23.36 dBm	602	mA
	WCDMA voice call	WCDMA B2 CH9938 @23.34 dBm	627	mA
		WCDMA B4 CH1537@23.47 dBm	591	mA
		WCDMA B5 CH4357@23.37 dBm	536	mA

Table 34: EG91-NS Current Consumption

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	OFF state	Power down	8	uA
	Sleep state	**AT+CFUN=0** (USB disconnected)	1.2	mA
		WCDMA PF=64 (USB disconnected)	2	mA
		WCDMA PF=64 (USB suspended)	2.3	mA
		WCDMA PF=512 (USB disconnected)	1.3	mA
		LTE-FDD PF=64 (USB disconnected)	2.5	mA
		LTE-FDD PF=64 (USB suspended)	2.8	mA
		LTE-FDD PF=256 (USB disconnected)	1.6	mA
	Idle state	WCDMA PF=64 (USB disconnected)	19.9	mA
		WCDMA PF=64 (USB connected)	30.1	mA
		LTE-FDDPF=64 (USB disconnected)	21.2	mA
		LTE-FDDPF=64 (USB connected)	30.9	mA
	WCDMA datatransfer	WCDMA B2 HSDPA CH9938@22.4 dBm	527	mA
		WCDMA B2 HSUPACH9938 @22.31 dBm	547	mA
		WCDMA B4 HSDPACH1537@23.01 dBm	575	mA
		WCDMA B4 HSUPACH1537@22.69 dBm	589	mA

		WCDMA B5 HSDPA CH4407@23.05 dBm	553	mA
		WCDMA B5 HSUPACH4407 @22.91 dBm	556	mA
	LTE datatransfer	LTE-FDD B2 CH1100@23.26 dBm	724	mA
		LTE-FDD B4 CH2175@23.52 dBm	693	mA
		LTE-FDD B5 CH2525@23.51dBm	613	mA
		LTE-FDD B12 CH5060@23.39 dBm	634	mA
		LTE-FDD B13 CH5230 @23.54 dBm	576	mA
		LTE-FDD B25CH8590@23.64 dBm	739	mA
		LTE-FDD B26CH8765@23.34 dBm	647	mA
	WCDMA voice call	WCDMA B2 CH9938 @23.39 dBm	571	mA
		WCDMA B4 CH1738@23.27 dBm	593	mA
		WCDMA B5 CH4357@23.35 dBm	554	mA

Table 35: EG91-V Current Consumption

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	OFF state	Power down	9	uA
	Sleep state	**AT+CFUN=0** (USB disconnected)	TBD	mA
		LTE-FDD PF=64 (USB disconnected)	TBD	mA
		LTE-FDD PF=64 (USB suspended)	TBD	mA
		LTE-FDD PF=256 (USB disconnected)	TBD	mA
	Idle state	LTE-FDDPF=64 (USB disconnected)	16.5	mA
		LTE-FDDPF=64 (USB connected)	30.8	mA
	LTEdatatransfer	LTE-FDD B4 CH2175@23.36dBm	715	mA
		LTE-FDD B13 CH5230@23.38dBm	642	mA

Table 36: EG91-EC Current Consumption

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT}	OFF state	Power down	TBD	uA
	Sleep state	**AT+CFUN=0** (USB disconnected)	TBD	mA
		GSM DRX=2 (USB disconnected)	TBD	mA
		GSM DRX=5 (USB suspended)	TBD	mA
		GSM DRX=9 (USB disconnected)	TBD	mA
		WCDMA PF=64 (USB disconnected)	TBD	mA
		WCDMA PF=64 (USB suspended)	TBD	mA
		WCDMA PF=512 (USB disconnected)	TBD	mA
		LTE-FDD PF=64 (USB disconnected)	TBD	mA
		LTE-FDD PF=64 (USB suspended)	TBD	mA
		LTE-FDD PF=256 (USB disconnected)	TBD	mA
	Idle state	GSM DRX=5 (USB disconnected)	TBD	mA
		GSM DRX=5 (USB connected)	TBD	mA
		WCDMA PF=64 (USB disconnected)	TBD	mA
		WCDMA PF=64 (USB connected)	TBD	mA
		LTE-FDDPF=64 (USB disconnected)	TBD	mA
		LTE-FDDPF=64 (USB connected)	TBD	mA
	GPRS data transfer	EGSM900 4DL/1UL @TBDdBm	TBD	mA
		EGSM900 3DL/2UL @TBDdBm	TBD	mA
		EGSM900 2DL/3UL @TBDdBm	TBD	mA
		EGSM900 1DL/4UL @TBDdBm	TBD	mA
		DCS1800 4DL/1UL @TBDdBm	TBD	mA
		DCS1800 3DL/2UL @TBDdBm	TBD	mA

		DCS1800 2DL/3UL @TBDdBm	TBD	mA
		DCS1800 1DL/4UL @TBDdBm	TBD	mA
	EDGE data transfer	EGSM900 4DL/1UL PCL=8 @TBDdBm	TBD	mA
		EGSM900 3DL/2UL PCL=8 @TBDdBm	TBD	mA
		EGSM900 2DL/3UL PCL=8 @TBDdBm	TBD	mA
		EGSM900 1DL/4UL PCL=8 @TBDdBm	TBD	mA
		DCS1800 4DL/1UL PCL=2 @TBDdBm	TBD	mA
		DCS1800 3DL/2UL PCL=2 @TBDdBm	TBD	mA
		DCS1800 2DL/3UL PCL=2 @TBDdBm	TBD	mA
		DCS1800 1DL/4UL PCL=2 @TBDdBm	TBD	mA
	WCDMA datatransfer	WCDMA B1 HSDPA@TBD dBm	TBD	mA
		WCDMA B1 HSUPA @TBD dBm	TBD	mA
		WCDMA B8 HSDPA@TBD dBm	TBD	mA
		WCDMA B8 HSUPA @TBD dBm	TBD	mA
	LTE datatransfer	LTE-FDD B1@TBD dBm	TBD	mA
		LTE-FDD B3@TBD dBm	TBD	mA
		LTE-FDD B7@TBD dBm	TBD	mA
		LTE-FDD B8@TBD dBm	TBD	mA
		LTE-FDD B20@TBD dBm	TBD	mA
		LTE-FDD B28@TBD dBm	TBD	mA
	GSM voice call	EGSM900 PCL=5 @TBDdBm	TBD	mA
		DCS1800PCL=0 @TBDdBm	TBD	mA
	WCDMA voice call	WCDMA B1@TBD dBm	TBD	mA
		WCDMA B8@TBD dBm	TBD	mA

Table 37: GNSS Current Consumption of EG91

Parameter	Description	Conditions	Typ.	Unit
I_{VBAT} (GNSS)	Searching (**AT+CFUN=0**)	Cold start @Passive Antenna	54	mA
		Hot Start @Passive Antenna	54	mA
		Lost state @Passive Antenna	53	mA
	Tracking (**AT+CFUN=0**)	Open Sky @Passive Antenna	32	mA

6.5. RF Output Power

The following table shows the RF output power of EG91 module.

Table 38: RF Output Power

Frequency	Max.	Min.
EGSM900	33dBm±2dB	5dBm±5dB
DCS1800	30dBm±2dB	0dBm±5dB
EGSM900 (8-PSK)	27dBm±3dB	5dBm±5dB
DCS1800(8-PSK)	26dBm±3dB	0dBm±5dB
WCDMA B1/B2/B4/B5/B8	24dBm+1/-3dB	<-49dBm
LTE-FDD B1/B2/B3/B4/B5/B7/ B8/B12/B13/B20/B25/B26/B28A/B28B	23dBm±2dB	<-39dBm

NOTE

In GPRS 4 slots TX mode, the maximum output power is reduced by 3.0dB. Thedesign conforms to the GSM specification as described in ***Chapter 13.16*** of *3GPP TS 51.010-1*.

6.6. RF Receiving Sensitivity

The following tables show the conducted RF receiving sensitivity of EG91 module.

Table 39: EG91-E Conducted RF Receiving Sensitivity

Frequency	Primary	Diversity	SIMO	3GPP
EGSM900	-108.6dBm	NA	NA	-102dBm
DCS1800	-109.4 dBm	NA	NA	-102dbm
WCDMA B1	-109.5dBm	-110dBm	-112.5dBm	-106.7dBm
WCDMA B8	-109.5dBm	-110dBm	-112.5dBm	-103.7dBm
LTE-FDD B1(10M)	-97.5dBm	-98.3dBm	-101.4dBm	-96.3dBm
LTE-FDD B3(10M)	-98.3dBm	-98.5dBm	-101.5dBm	-93.3dBm
LTE-FDD B7(10M)	-96.3dBm	-98.4dBm	-101.3dBm	-94.3dBm
LTE-FDD B8(10M)	-97.1dBm	-99.1dBm	-101.2dBm	-93.3dBm
LTE-FDD B20(10M)	-97dBm	-99dBm	-101.3dBm	-93.3dBm
LTE-FDD B28A(10M)	-98.3dBm	-99dBm	-101.4dBm	-94.8dBm

Table 40: EG91-NA Conducted RF Receiving Sensitivity

Frequency	Primary	Diversity	SIMO	3GPP
WCDMA B2	-110dBm	-111dBm	-112.5dBm	-104.7dBm
WCDMA B4	-110dBm	-111dBm	-112.5dBm	-106.7dBm
WCDMA B5	-111dBm	-111.5dBm	-113dBm	-104.7dBm
LTE-FDD B2 (10M)	-98dBm	-99dBm	-102.2dBm	-94.3dBm
LTE-FDD B4 (10M)	-97.8dBm	-99.5dBm	-102.2dBm	-96.3dBm
LTE-FDD B5 (10M)	-99.6dBm	-100.3dBm	-103dBm	-94.3dBm
LTE-FDD B12 (10M)	-99.5dBm	-100dBm	-102.5dBm	-93.3dBm

LTE-FDD B13 (10M)	-99.2dBm	-100dBm	-102.5dBm	-93.3dBm

Table 41: EG91-NS Conducted RF Receiving Sensitivity

Frequency	Primary	Diversity	SIMO	3GPP
WCDMA B2	-110dBm	-111dBm	-112.5dBm	-104.7dBm
WCDMA B4	-110dBm	-111dBm	-112.5dBm	-106.7dBm
WCDMA B5	-111dBm	-111.5dBm	-113dBm	-104.7dBm
LTE-FDD B2 (10M)	-98dBm	-99dBm	-102.2dBm	-94.3dBm
LTE-FDD B4 (10M)	-97.8dBm	-99.5dBm	-102.2dBm	-96.3dBm
LTE-FDD B5 (10M)	-99.4dBm	-100dBm	-102.7dBm	-94.3dBm
LTE-FDD B12 (10M)	-99.5dBm	-100dBm	-102.5dBm	-93.3dBm
LTE-FDD B13 (10M)	-99.2dBm	-100dBm	-102.5dBm	-93.3dBm
LTE-FDD B25 (10M)	-97.6dBm	-99dBm	-102.2dBm	-92.8dBm
LTE-FDD B26 (10M)	-99.1dBm	-99.9dBm	-102.7dBm	-93.8dBm

Table 42: EG91-V Conducted RF Receiving Sensitivity

Frequency	Primary	Diversity	SIMO	3GPP
LTE-FDD B4 (10M)	-98.2dBm	-99.2dBm	-102.2dBm	-96.3dBm
LTE-FDD B13 (10M)	-99.2dBm	-100dBm	-102.5dBm	-93.3dBm

Table 43: EG91-EC Conducted RF Receiving Sensitivity

Frequency	Primary	Diversity	SIMO	3GPP
EGSM900	TBD	TBD	TBD	-102dBm
DCS1800	TBD	TBD	TBD	-102dbm
WCDMA B1	TBD	TBD	TBD	-106.7dBm

WCDMA B8	TBD	TBD	TBD	-103.7dBm
LTE-FDD B1 (10M)	TBD	TBD	TBD	-96.3dBm
LTE-FDD B3 (10M)	TBD	TBD	TBD	-93.3dBm
LTE-FDD B7 (10M)	TBD	TBD	TBD	-94.3dBm
LTE-FDD B8 (10M)	TBD	TBD	TBD	-93.3dBm
LTE-FDD B20 (10M)	TBD	TBD	TBD	-93.3dBm
LTE-FDD B28 (10M)	TBD	TBD	TBD	-94.8dBm

6.7. Electrostatic Discharge

The module is not protected against electrostatic discharge (ESD) in general. Consequently, it is subject to ESD handling precautions that typically apply to ESD sensitive components. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates the module.

The following table shows the module's electrostatic discharge characteristics.

Table 44: Electrostatic Discharge Characteristics

Test Points	Contact Discharge	Air Discharge	Unit
VBAT, GND	±5	±10	KV
All Antenna Interfaces	±4	±8	KV
Other Interfaces	±0.5	±1	KV

6.8. Thermal Consideration

In order to achieve better performance of the module, it is recommended to comply with the following principles for thermal consideration:

- On customers' PCB design, please keep placement of the module away from heating sources, especially high power components such as ARM processor, audio power amplifier, power supply, etc.

- Do not place components on the opposite side of the PCB area where the module is mounted, in order to facilitate adding of heatsink when necessary.
- Do not apply solder mask on the opposite side of the PCB area where the module is mounted, so as to ensure better heat dissipation performance.
- The reference ground of the area where the module is mounted should be complete, and add ground vias as many as possible for better heat dissipation.
- Make sure the ground pads of the module and PCB are fully connected.
- According to customers' application demands, the heatsink can be mounted on the top of the module, or the opposite side of the PCB area where the module is mounted, or both of them.
- The heatsink should be designed with as many fins as possible to increase heat dissipation area. Meanwhile, a thermal pad with high thermal conductivity should be used between the heatsink and module/PCB.

The following shows two kinds of heatsink designs for reference and customers can choose one or bothof them according to their application structure.

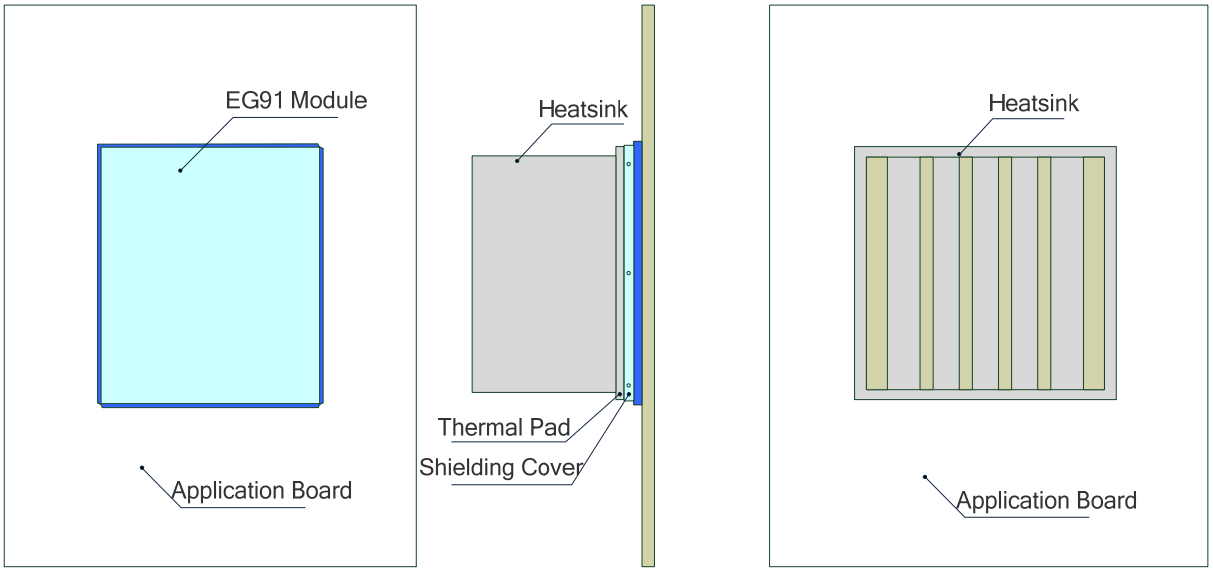


Figure 39: Referenced Heatsink Design (Heatsink at the Top of the Module)

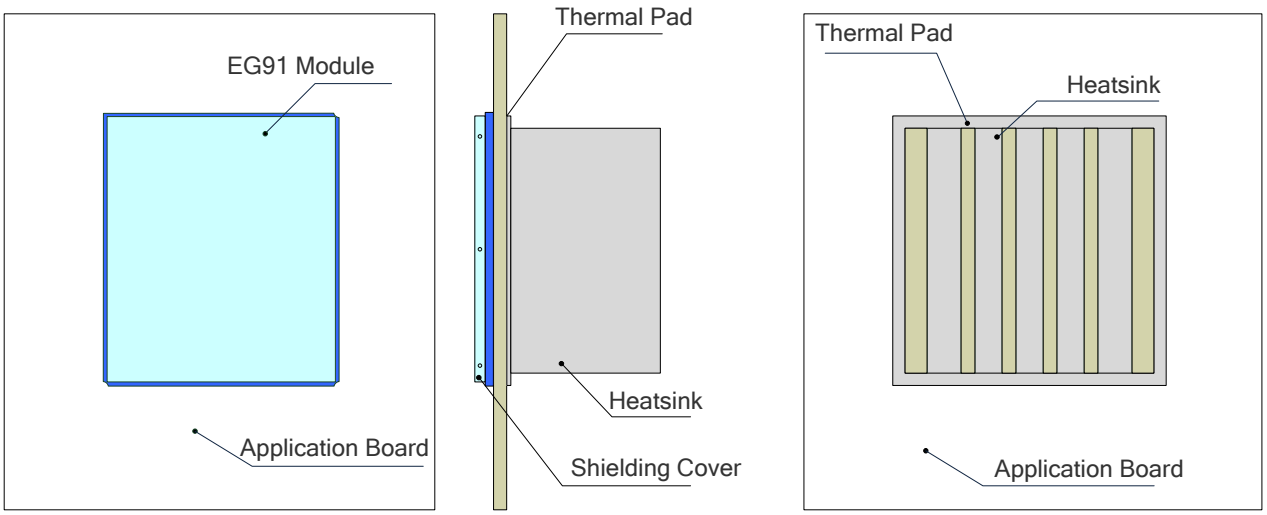


Figure 40: Referenced Heatsink Design (Heatsink at the Backsideof Customers' PCB)

NOTES

1. The module offers the best performance when the internal BB chip stays below 105°C. When the maximum temperature of the BB chip reaches or exceeds 105°C, the module works normal but provides reduced performance (such as RF output power, data rate, etc.). When the maximum BB chip temperature reaches or exceeds 115°C, the module will disconnect from the network, and it will recover to network connected state after the maximum temperature falls below 115°C. Therefore, the thermal design should be maximally optimized to make sure the maximum BB chip temperature always maintains below 105°C. Customers can execute **AT+QTEMP** command and get the maximum BB chip temperature from the first returned value.
2. For more detailed guidelines on thermal design, please refer to ***document [6]***.

7 Mechanical Dimensions

This chapter describes the mechanical dimensions of the module.All dimensions are measured in mm. The tolerances for dimensions without tolerance values are ±0.05mm.

7.1. Mechanical Dimensions of the Module

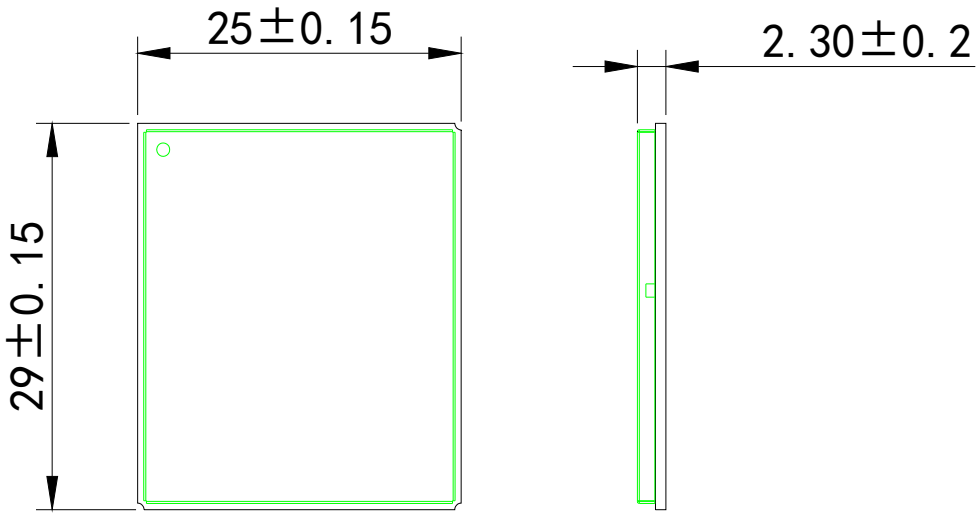


Figure 41: Module Top and Side Dimensions

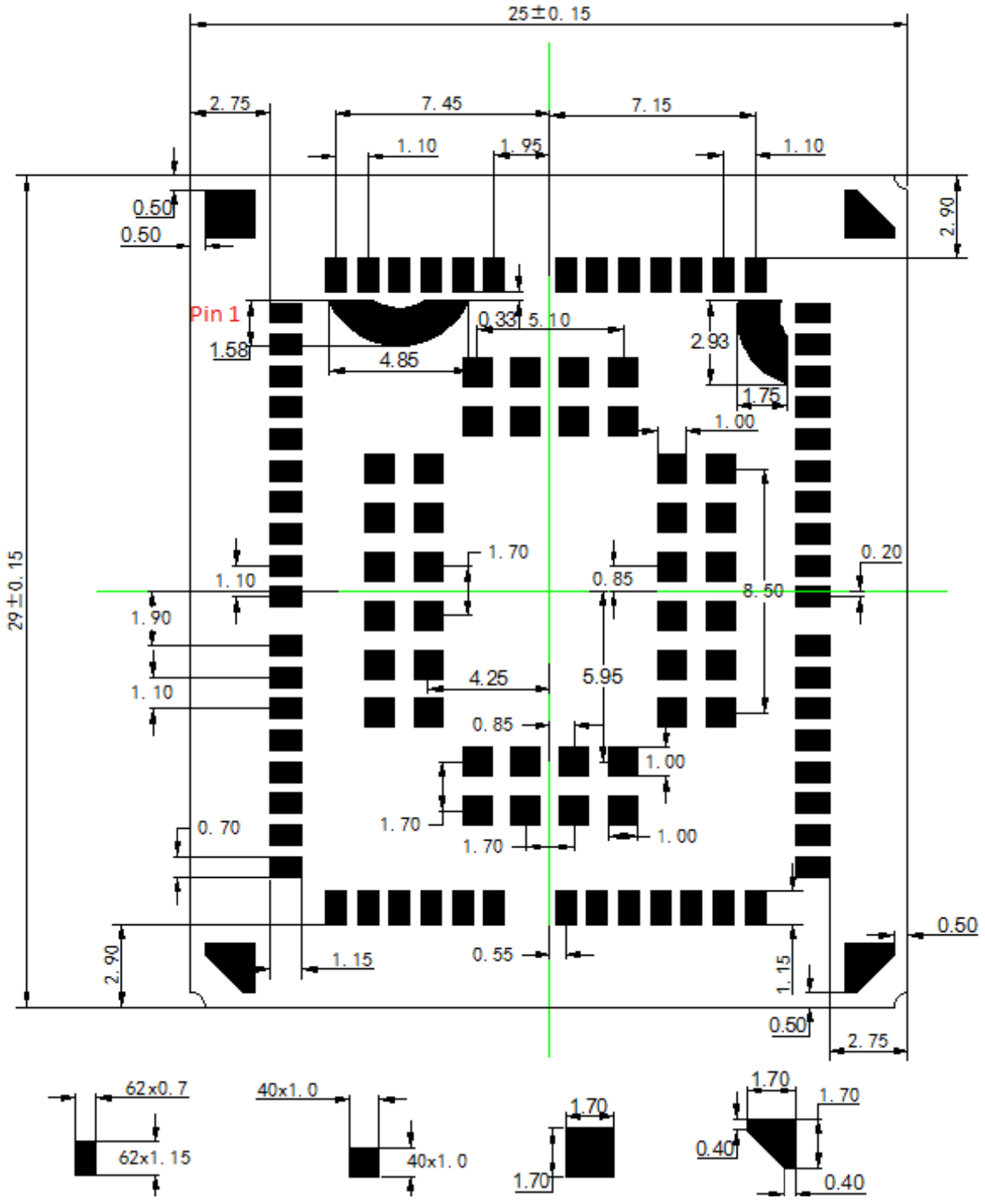


Figure 42: Module Bottom Dimensions (TopView)

7.2. Recommended Footprint

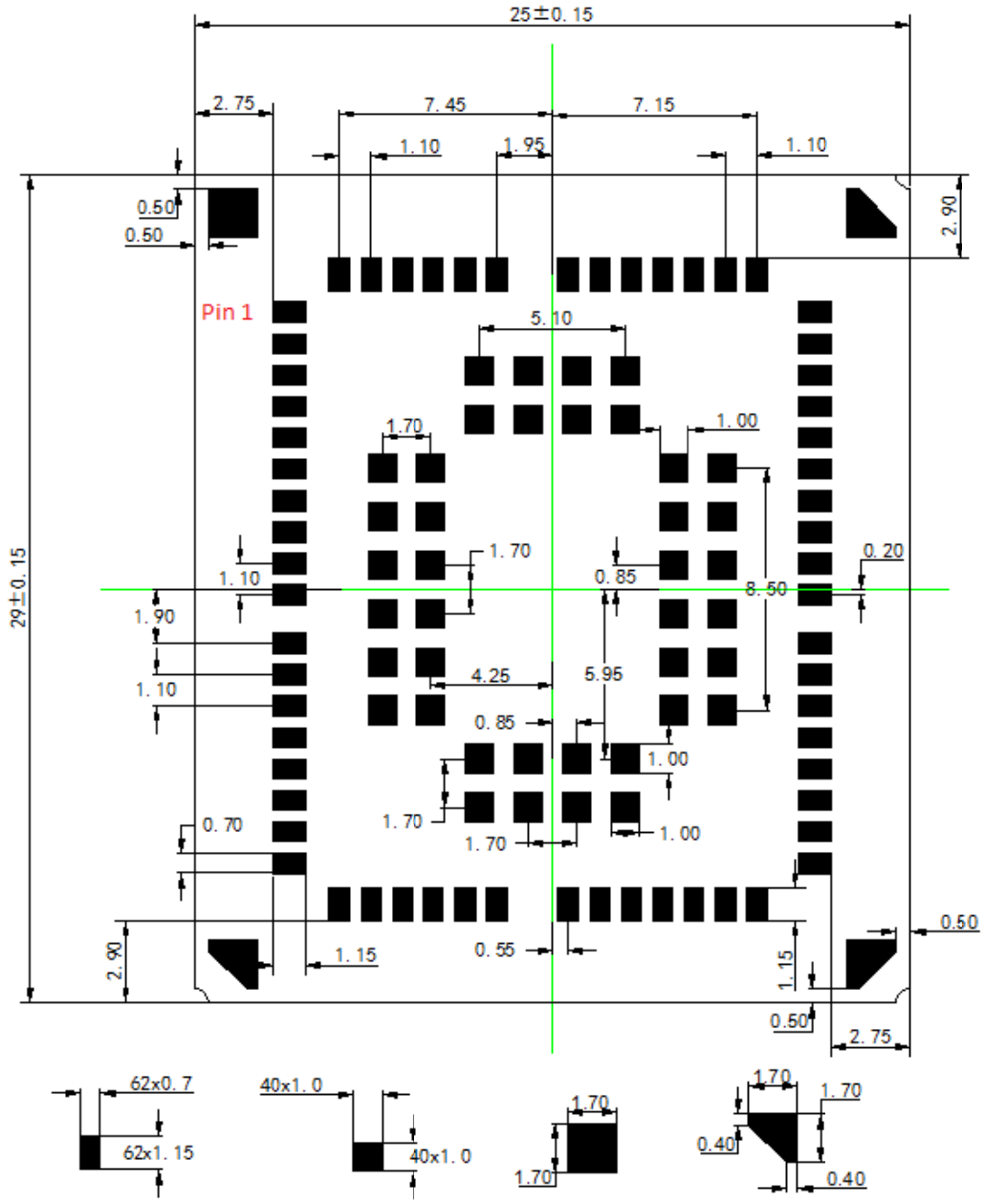


Figure 43: Recommended Footprint (Top View)

NOTE

For easymaintenance of the module, please keep about 3mm between the module and other components in thehost PCB.

7.3. Design Effect Drawings of the Module

Figure 44: Top View of the Module

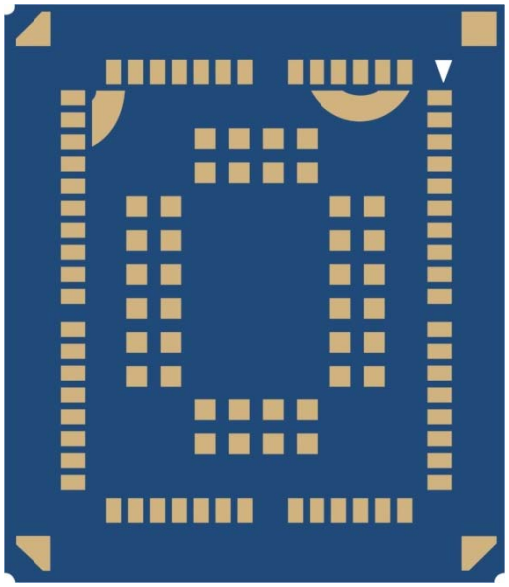


Figure 45: Bottom View of the Module

NOTE

These are design effect drawings of EG91 module. For more accurate pictures, please refer to the module that you get from Quectel.

8 Storage, Manufacturing and Packaging

8.1. Storage

EG91is stored in a vacuum-sealed bag. It is rated at MSL 3, and its storage restrictions are listed below.

1. Shelf life in vacuum-sealed bag: 12 months at <40ºC/90%RH.

2. After the vacuum-sealed bag is opened, devices that will be subjected to reflow soldering or other high temperature processes must be:

   - Mounted within 168 hours at the factory environment of ≤30º C/60%RH.
   - Stored at <10% RH.

3. Devices require bake before mounting, if any circumstances below occurs:

   - When the ambient temperature is 23ºC±5ºC and the humidity indicator card shows the humidity is >10% before opening the vacuum-sealed bag.
   - Device mounting cannot be finished within 168 hours at factory conditions of ⩽30º C/60%RH.

If baking is required, devices may be baked for 8 hours at 120ºC±5ºC.

NOTE

As the plastic package cannot be subjected to high temperature, it should be removed from devices before high temperature (120ºC) baking. If shorter baking time is desired, please refer to *IPC/JEDECJ-STD-033* for baking procedure.

8.2. Manufacturing and Soldering

Push the squeegee to apply the solder paste on the surface of stencil, thus making the paste fill the stencil openings and then penetrate to the PCB. The force on the squeegee should be adjusted properlyso as to produce a clean stencil surface on a single pass. To ensure the module soldering quality, thethickness of stencil for the module is recommended to be 0.15mm~0.18mm. For more details, please refer to***document [4]***.

It is suggested that the peak reflow temperature is 240ºC~245ºC, and the absolute maximum reflow temperature is 245ºC. To avoid damage to the module caused by repeated heating, it is strongly recommended that the module should be mounted after reflow soldering for the other side of PCB has been completed. The recommended reflow soldering thermal profile (lead-free reflow soldering) and related parameters are shown below.

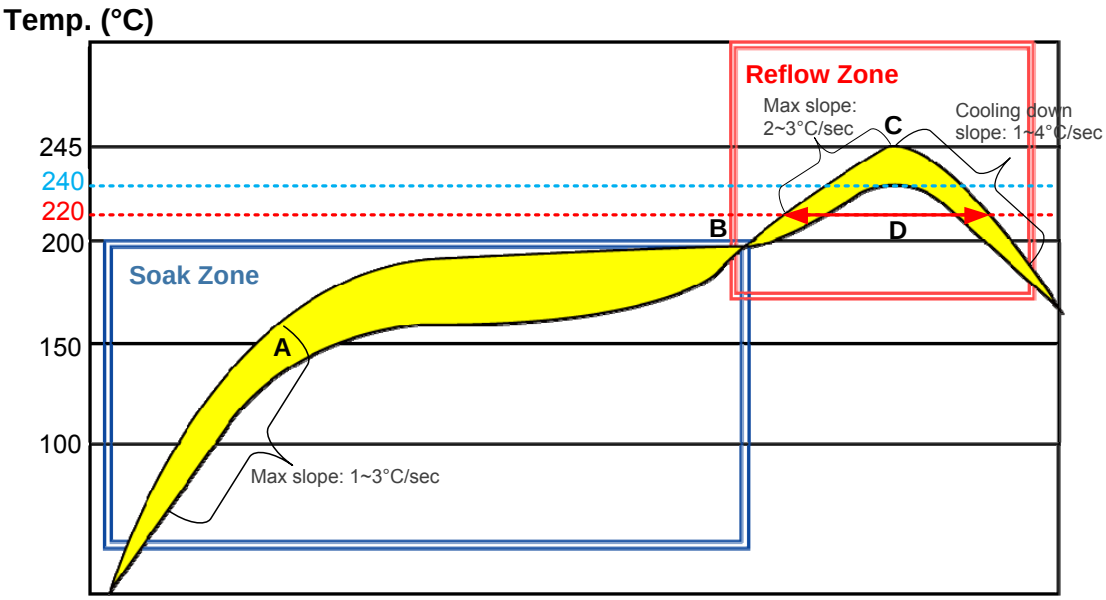


Figure 46: Reflow Soldering Thermal Profile

Table 45: Recommended Thermal Profile Parameters

Factor	Recommendation
Soak Zone	
Max slope	1 to 3°C/sec
Soak time (between A and B: 150°C and 200°C)	60 to 120 sec
Reflow Zone	

Max slope	2 to 3°C/sec
Reflow time (D: over 220°C)	40 to 60 sec
Max temperature	240°C ~ 245°C
Cooling down slope	1 to 4°C/sec
Reflow Cycle	
Max reflow cycle	1

8.3. Packaging

EG91is packaged in a vacuum-sealed bag which is ESD protected. The bag should not be opened until the devices are ready to be soldered onto the application.

The reel is 330mm in diameter and each reel contains 250pcs modules. The following figures show the packaging details, measured in mm.

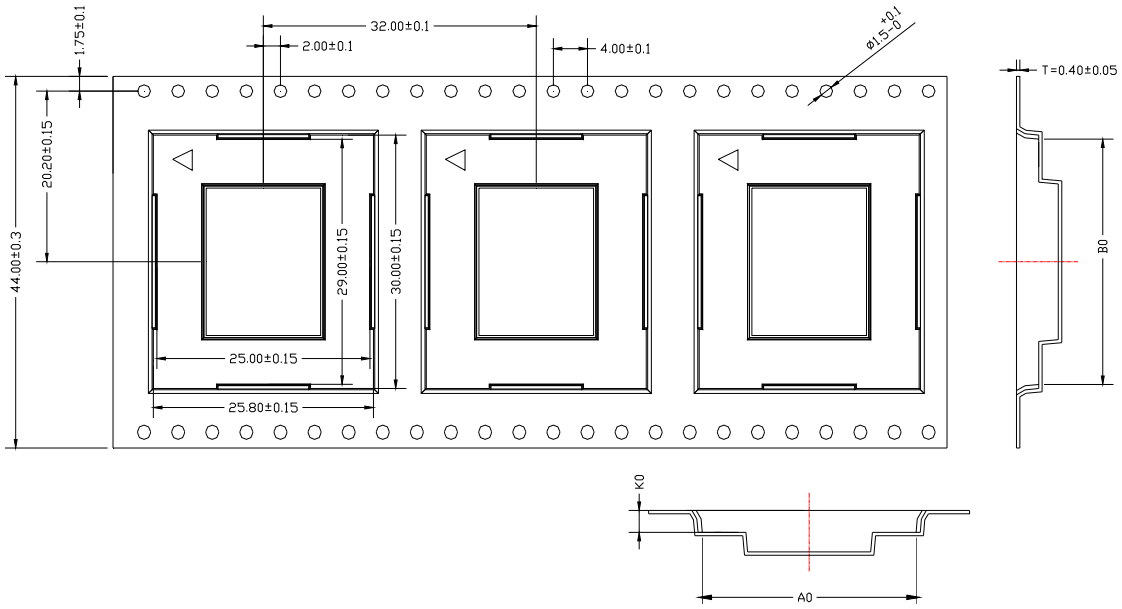


Figure 47: Tape Dimensions

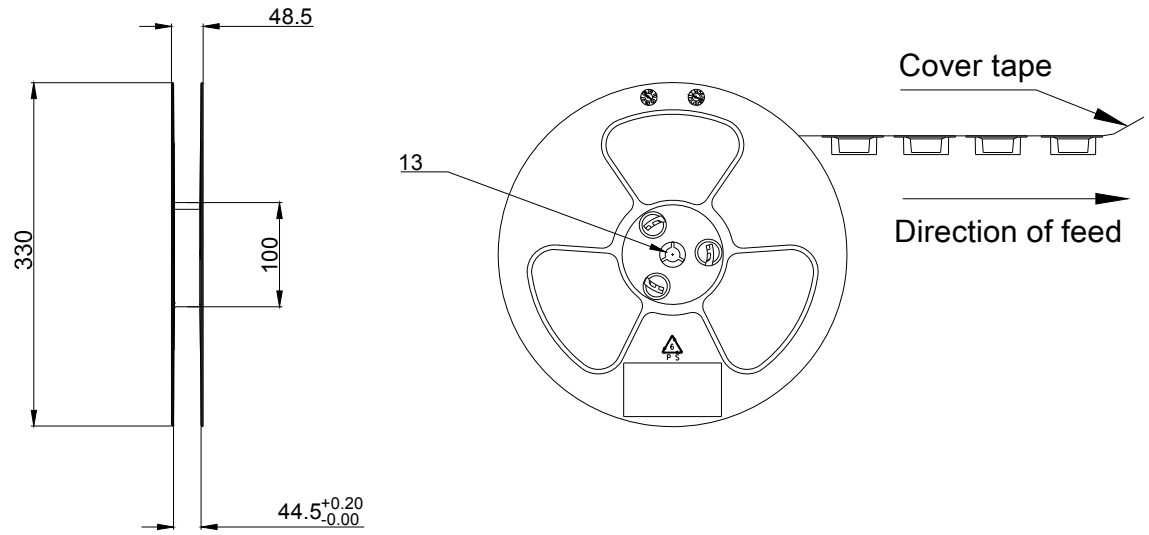


Figure 48: Reel Dimensions

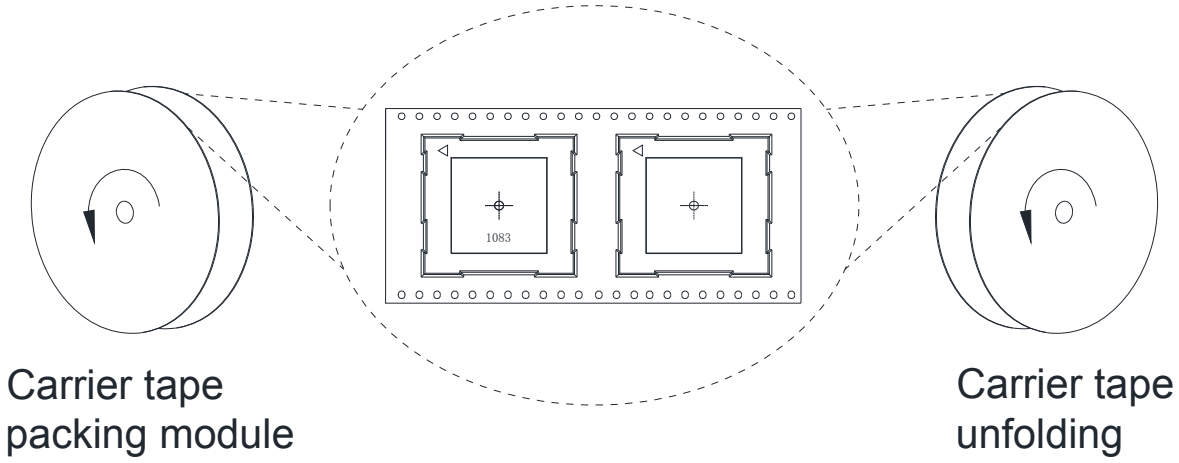


Figure 49: Tape and Reel Directions

9 Appendix A References

Table 46: Related Documents

SN	Document Name	Remark
[1]	Quectel_EC2x&EG9x&EM05_Power_Management_Application_Note	Power Management Application Note for EC25, EC21, EC20 R2.0, EC20 R2.1, EG95, EG91 and EM05
[2]	Quectel_EG9x_AT_Commands_Manual	AT Commands Manual for EG95 and EG91
[3]	Quectel_EC25&EC21_GNSS_AT_Commands_Manual	GNSS AT Commands Manual for EC25 and EC21 modules
[4]	Quectel_Module_Secondary_SMT_User_Guide	Module Secondary SMT User Guide
[5]	Quectel_RF_Layout_Application_Note	RF Layout Application Note
[6]	Quectel_LTE_Module_Thermal_Design_Guide	Thermal design guide for LTE modules including EC25, EC21, EC20 R2.0, EC20 R2.1, EG91, EG95, EG25-G, EP06, EG06, EM06 and AG35.

Table 47: Terms and Abbreviations

Abbreviation	Description
AMR	Adaptive Multi-rate
bps	Bits Per Second
CHAP	Challenge Handshake Authentication Protocol
CS	Coding Scheme
CSD	Circuit Switched Data
CTS	Clear To Send
DC-HSPA+	Dual-carrier High Speed Packet Access

DFOTA	Delta Firmware Upgrade Over-The-Air
DL	Downlink
DTR	Data Terminal Ready
DTX	Discontinuous Transmission
EFR	Enhanced Full Rate
ESD	Electrostatic Discharge
FDD	Frequency Division Duplex
FR	Full Rate
GMSK	Gaussian Minimum Shift Keying
GSM	Global System for Mobile Communications
HR	Half Rate
HSPA	High Speed Packet Access
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
I/O	Input/Output
Inorm	Normal Current
LED	Light Emitting Diode
LNA	Low Noise Amplifier
LTE	Long Term Evolution
MIMO	Multiple Input Multiple Output
MO	Mobile Originated
MS	Mobile Station (GSM engine)
MSL	Moisture Sensitivity Level
MT	Mobile Terminated
PAP	Password Authentication Protocol

PCB	Printed Circuit Board
PDU	Protocol Data Unit
PPP	Point-to-Point Protocol
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RF	Radio Frequency
RHCP	Right Hand Circularly Polarized
Rx	Receive
SMS	Short Message Service
TDD	Time Division Duplexing
TX	Transmitting Direction
UL	Uplink
UMTS	Universal Mobile Telecommunications System
URC	Unsolicited Result Code
(U)SIM	(Universal) Subscriber Identity Module
Vmax	Maximum Voltage Value
Vnorm	Normal Voltage Value
Vmin	Minimum Voltage Value
V_{IH}max	Maximum Input High Level Voltage Value
V_{IH}min	Minimum Input High Level Voltage Value
V_{IL}max	Maximum Input Low Level Voltage Value
V_{IL}min	Minimum Input Low Level Voltage Value
$V_I$max	Absolute Maximum Input Voltage Value
$V_I$min	Absolute Minimum Input Voltage Value
V_{OH}in	Minimum Output High Level Voltage Value

V_{OL}max	Maximum Output Low Level Voltage Value
V_{OL}min	Minimum Output Low Level Voltage Value
VSWR	Voltage Standing Wave Ratio
WCDMA	Wideband Code Division Multiple Access

10 Appendix B GPRS Coding Schemes

Table 48: Description of Different Coding Schemes

Scheme	CS-1	CS-2	CS-3	CS-4
Code Rate	1/2	2/3	3/4	1
USF	3	3	3	3
Pre-coded USF	3	6	6	12
Radio Block excl.USF and BCS	181	268	312	428
BCS	40	16	16	16
Tail	4	4	4	-
Coded Bits	456	588	676	456
Punctured Bits	0	132	220	-
Data Rate Kb/s	9.05	13.4	15.6	21.4

11 Appendix C GPRS Multi-slot Classes

Twenty-nine classes of GPRS multi-slot modes are defined for MS in GPRS specification. Multi-slot classes are product dependent, and determine the maximum achievable data rates in both the uplink and downlink directions. Written as 3+1 or 2+2, the first number indicates the amount of downlink timeslots, while the second number indicates the amount of uplink timeslots. The active slots determine the total number of slots the GPRS device can use simultaneously for both uplink and downlink communications.

The description of different multi-slot classes is shown in the following table.

Table 49: GPRS Multi-slot Classes

Multislot Class	Downlink Slots	Uplink Slots	Active Slots
1	1	1	2
2	2	1	3
3	2	2	3
4	3	1	4
5	2	2	4
6	3	2	4
7	3	3	4
8	4	1	5
9	3	2	5
10	4	2	5
11	4	3	5
12	4	4	5
13	3	3	NA
14	4	4	NA

15	5	5	NA
16	6	6	NA
17	7	7	NA
18	8	8	NA
19	6	2	NA
20	6	3	NA
21	6	4	NA
22	6	4	NA
23	6	6	NA
24	8	2	NA
25	8	3	NA
26	8	4	NA
27	8	4	NA
28	8	6	NA
29	8	8	NA
30	5	1	6
31	5	2	6
32	5	3	6
33	5	4	6

12 Appendix D EDGE Modulation and Coding Schemes

Table 50: EDGE Modulation and Coding Schemes

Coding Scheme	Modulation	Coding Family	1 Timeslot	2 Timeslot	4 Timeslot
CS-1:	GMSK	/	9.05kbps	18.1kbps	36.2kbps
CS-2:	GMSK	/	13.4kbps	26.8kbps	53.6kbps
CS-3:	GMSK	/	15.6kbps	31.2kbps	62.4kbps
CS-4:	GMSK	/	21.4kbps	42.8kbps	85.6kbps
MCS-1	GMSK	C	8.80kbps	17.60kbps	35.20kbps
MCS-2	GMSK	B	11.2kbps	22.4kbps	44.8kbps
MCS-3	GMSK	A	14.8kbps	29.6kbps	59.2kbps
MCS-4	GMSK	C	17.6kbps	35.2kbps	70.4kbps
MCS-5	8-PSK	B	22.4kbps	44.8kbps	89.6kbps
MCS-6	8-PSK	A	29.6kbps	59.2kbps	118.4kbps
MCS-7	8-PSK	B	44.8kbps	89.6kbps	179.2kbps
MCS-8	8-PSK	A	54.4kbps	108.8kbps	217.6kbps
MCS-9	8-PSK	A	59.2kbps	118.4kbps	236.8kbps