

LEON-G1 series

quad-band GSM/GPRS data & voice modules

Data Sheet

Abstract

Technical data sheet describing the LEON-G100 quad-band GSM/GPRS data and voice modules.

The LEON-G1 series modules are complete and cost efficient solutions, bringing full feature quad-band GSM/GPRS data and voice transmission technology in a compact form factor.



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This document applies to the following products:

Name	Type number	Firmware version	PCN / IN
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	LEON-G100-07S-01	07.92	UBX-13005361
	LEON-G100-08S-01	07.92	UBX-13005361

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1 Functional description

1.1 Overview

LEON-G1 series modules are cost efficient solutions offering full quad-band GSM / GPRS data and voice functionality in a compact LCC (Leadless Chip Carrier) form factor. Featuring low power consumption and GSM/GPRS class 10 data transmission with voice capability, LEON-G1 series modules combine baseband, RF transceiver, power management unit, and power amplifier in a single, easy-to-integrate solution.

LEON-G1 series modules are fully qualified and certified solutions, reducing cost and enabling short time to market. These modules are ideally suited for M2M and automotive applications such as: Automatic Meter Reading (AMR), Remote Monitoring Automation and Control (RMAC), surveillance and security, eCall, road pricing, asset tracking, fleet management, anti theft systems and Point of Sales (PoS) terminals.

LEON-G1 series modules support full access to u-blox GNSS positioning chips and modules via the GSM modem. GSM and GNSS can be controlled through a single serial port from any host processor. The LEON-G1 compact form factor and SMT pads allow fully automated assembly with standard pick & place and reflow soldering equipment for cost-efficient, high-volume production.

1.2 Product features

Module	Bands	Positioning	Interfaces	Audio	Functions	Grade
	GSM/GPRS quad-band	GNSS receiver GNSS via modem Assist Now Software CellLocate®	UART SPI USB 2.0 DDC for u-blox GNSS GPIO	Analog Audio Digital Audio	Network indication Antenna supervisor Jamming detection Embedded TCP/UDP stack FTP, HTTP, SMTP SSL FW update over-AT (FOAT) FW update over the air (FOTA) eCall / ERA Glonass Battery charging DTMF decoder	Standard Professional Automotive
LEON-G100-06S	•	• • •	1 1 5	2 1	• • • • • •	
LEON-G100-07S	•	• • •	1 1 5	2 1	• • • • • • •	
LEON-G100-08S	•	• • •	1 1 5	2 1	• • • • • • •	

Table 1: LEON-G1 series main features summary

1.3 Block diagram

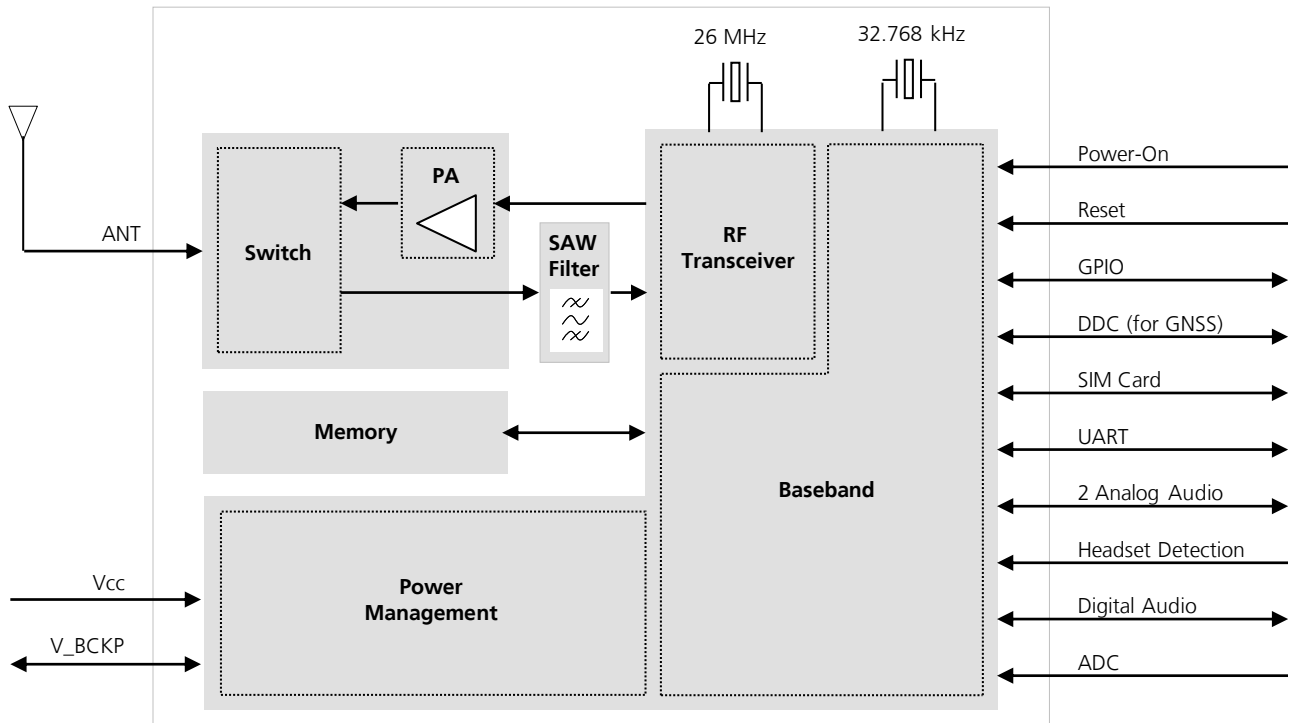


Figure 1: LEON-G100 block diagram

1.4 Product description

Item	LEON-G100
GSM/GPRS Protocol Stack	3GPP Release 99
Mobile Station Class	Class B ¹
GSM/GPRS Bands	GSM 850 MHz E-GSM 900 MHz DCS 1800 MHz PCS 1900 MHz
GSM/GPRS Power Class	Class 4 (33 dBm) for 850/900 Class 1 (30 dBm) for 1800/1900
Packet Switched Data Rate	GPRS multi-slot class 10 ² Coding scheme CS1-CS4 Up to 85.6 kb/s DL ³ Up to 42.8 kb/s UL ³
Circuit Switched Data Rate	Up to 9.6 kb/s DL/UL ³ Transparent mode Non transparent mode
Network Operation Modes	I to III

Table 2: LEON-G1 series GSM/GPRS characteristics summary

Encryption algorithms A5/1 for GSM and GPRS as well as the bearer service fax Group 3 Class 2.0 are supported. With correct configuration via AT commands the module can also function as GPRS multislot class 8 device.

The network will automatically configure the number of timeslots available for usage by the module.

The network automatically configures the channel encoding used by the module, depending on the conditions of the quality of the radio link between cell phone and base station. If the channel is very noisy, the network may use the most robust coding scheme (CS-1) to ensure higher reliability. If the channel provides good conditions, the network can use the least robust but fastest coding scheme (CS-4) to obtain optimum speed.

Direct Link mode is supported for TCP sockets.

Basic features	Supplementary services	Short Message Service (SMS)
Display of Called Number	Call Hold/Resume (HOLD)	Text and PDU mode supported
Indication of Call Progress Signals	Call Waiting (CW)	Mobile-Originating SMS (MO SMS)
Country/PLMN Indication	Call Forwarding (CFU, CFB, CFNRy, CFNRc)	Mobile-Terminating SMS (MT SMS)
Country/PLMN Selection	Call Barring (BAOC, BOIC, BOIC-exHC, BAIC, BIC_Roam)	SMS indication and acknowledgement
International Access Function	Call Deflection (CD)	SMS Cell Broadcast (SMS CB)
Service Indicator	Explicit Call Transfer (ECT)	SMS during circuit-switched calls
Emergency Calls Capabilities	Multi-Party (MTPY)	SMS over CSD
Dual Tone Multi Frequency (DTMF)	Calling Line Identification Presentation (CLIP)	SMS over PSD
Subscription Identity Management	Calling Line Identification Restriction (CLIR)	SMS storage on SIM
Service Provider Indication	Connected Line Identification Presentation (COLP)	SMS storage on module memory
Abbreviated Dialing	Connected Line Identification Restriction (COLR)	Concatenated SMS
Fixed Number Dialing	Unstructured Supplementary Services Data (USSD)	
Barring of Dialed Numbers	Advice of Charge Charging (AoCC, AoCI)	
SIM Application Toolkit	Calling Name Presentation (CNAP)	
ME-SIM lock	Network Identify and Time Zone (NITZ)	

Table 3: LEON-G1 Mobile Station basic features, supplementary services and SMS services summary⁴

¹ Device can be attached to both GPRS and GSM services (i.e. Packet Switch and Circuit Switch mode) using one service at a time.

² GPRS multi-slot class 10 implies a maximum of 4 slots in DL (reception) and 2 slots in UL (transmission) with 5 slots in total.

³ The maximum bit rate of the module depends on the current network settings.

⁴ These functionalities are supported via AT commands (for more details see the u-blox AT Commands Manual [4]).

1.5 AT command support

The module supports AT commands according to 3GPP standards: TS 27.007 [1], 27.005 [2], 27.010 [3], and the u-blox AT command extension.



For the complete list of the supported AT commands and their syntax see the u-blox AT Commands Manual [4].

RIL (Radio Interface Layer) drivers for Windows and Android are available for LEON-G1 series.

1.6 Supported features

Table 4 describes the main features supported by LEON-G1 series modules. For more details, see the LEON-G1 series System Integration Manual [6] and u-blox AT commands manual [4].

Feature	Module	Description
Network Indication	All	GPIO configured to indicate the network status: registered home network, registered roaming, voice or data call enabled, no service. The feature can be enabled through the +UGPIOC AT command.
Antenna Detection	All	Antenna presence detection capability is provided, evaluating the resistance from the ANT pin to GND by means of an internal antenna detection circuit. The antenna detection feature can be enabled through the +UANTR AT command.
Jamming detection	All	Detects "artificial" interference that obscures the operator's carriers providing access to the GSM service and reports the start and stop of such conditions to the application processor (AP). The AP can react appropriately, e.g. by switching off the radio transceiver to reduce power consumption and monitoring the environment at constant periods. The feature can be enabled and configured through the +UCD AT command.
Embedded TCP and UDP stack	All	Embedded TCP/IP and UDP/IP stack for TCP and UDP sockets. Sockets can be configured in Direct Link mode to establish a transparent end-to-end communication with an already connected TCP socket via serial interface.
FTP	All	File Transfer Protocol functionalities are supported via AT commands.
HTTP	All	HTTP protocols are supported. HEAD, GET, POST, DELETE and PUT operations are available. Up to 4 client contexts can be simultaneously used.
SMTP	All	SMTP protocol is implemented. It is possible to specify the common parameters (e.g. server data, authentication method, etc.), send an email to a SMTP server. E-mails can be sent with or without attachment. Attachments are stored in the module local file system.
GNSS via Modem	All	Full access to u-blox positioning chips and modules is available through a dedicated DDC (I ² C) interface. This means that wireless module and positioning chips / modules can be controlled through a single serial port from any host processor. For more details see the GNSS Implementation Application Note [7].
AssistNow Software	All	Embedded AssistNow Online and AssistNow Offline clients to provide full developed to provide better GNSS performance and faster Time-to-First-Fix. The clients can be enabled / disabled with an AT command.
CellLocate [®]	All	Enables the estimation of device position based on the parameters of the mobile network cells visible to the specific device based on the CellLocate [®] database: <ul style="list-style-type: none"> • Normal scan: parameters of the visible home network cells are only sent • Deep scan: parameters of all surrounding cells of all mobile operators are sent CellLocate [®] is implemented using a set of AT commands for CellLocate [®] service configuration and position request.


Feature	Module	Description
Hybrid Positioning	All	The module's current position is provided using a u-blox positioning chip or module or the estimated position from CellLocate [®] , depending on which positioning method provides the best and fastest solution according to the user configuration. Hybrid positioning is implemented through a set of AT commands that allow the configuration and the position request.
Firmware update Over AT commands (FOAT)	All	Firmware module upgrade over UART interface using AT command.
eCall / ERA Glonass	LEON-G100-07S LEON-G100-08S	In-Band modem solution for eCall and ERA-GLONASS emergency call applications over cellular networks is implemented according to the 3GPP TS 26.267 specification [9]. When activated, the in-vehicle eCall / ERA-GLONASS system (IVS) creates an emergency call carrying both voice and data (including vehicle position data) directly to the nearest Public Safety Answering Point (PSAP) to determine whether rescue services should be dispatched to the known position.
DTMF decoder	LEON-G100-07S LEON-G100-08S	During a voice call, the Dual-Tone Multi-Frequency detector analyses the RX speech (coming from the remote party). The detected DTMF symbols can be output via URC. For more details, see the u-blox AT commands manual [4], +UDTMFD AT command.
Smart Temperature Supervisor	All	Constant monitoring of the module board temperature: <ul style="list-style-type: none"> • Warning notification when the temperature approaches an upper or lower predefined threshold • Shutdown notified and forced when the temperature value is outside the specified range (shutdown suspended in case of an emergency call in progress) The feature can be enabled or disabled through the +USTS AT command.  The sensor measures board temperature inside the shields, which can differ from ambient temperature.
Power saving	All	The power saving configuration is by default disabled, but it can be configured using AT command. When power saving is enabled, the module automatically enters the low power idle-mode whenever possible, reducing current consumption. During idle-mode, the module processor core runs with the RTC 32 kHz reference clock, which is generated by the internal 32 kHz oscillator, For more details, see the LEON-G1 series System Integration Manual [6] and u-blox AT commands manual [4], +UPSV AT command.

Table 4: LEON-G1 series' main supported features


u-blox is extremely mindful of user privacy. When a position is sent to the CellLocate[®] server, u-blox is unable to track the SIM used or the specific device.

2 Interfaces

2.1 Power management

2.1.1 Module supply input (VCC)

LEON-G1 series modules must be supplied through the **VCC** pin by a DC power supply. Voltages must be stable: during operation, the current drawn from **VCC** can vary by some order of magnitude, especially due to the surging consumption profile of the GSM system (described in the LEON-G1 series System Integration Manual [6]). It is important that the system power supply circuit is able to support peak power.

2.1.2 RTC supply input/output (V_BCKP)

V_BCKP is the Real Time Clock (RTC) supply. When **VCC** voltage is within the valid operating range, the internal Power Management Unit (PMU) supplies the RTC and the same supply voltage is available on the **V_BCKP** pin. If the **VCC** voltage is under the minimum operating limit (e.g. during not powered mode), the **V_BCKP** pin can externally supply the RTC.

2.2 RF antenna interface

The **ANT** pad has an impedance of 50 Ω and represents the RF antenna interface.

2.3 System functions

2.3.1 Module power-on (PWR_ON)

LEON-G1 series modules can be switched on in one of the following ways:

- Rising edge on the **VCC** pin to a valid voltage for module supply, i.e. applying module supply
- Shorting **PWR_ON** pin to ground: the **PWR_ON** pin requires an external pull-up resistor to set its value to logic high and must not be left floating. Internal circuitry is low level sensitive
- RTC alarm, i.e. pre-programmed scheduled time (see the u-blox AT Commands Manual [4], AT+CALA)

2.3.2 Module power-off

LEON-G1 series modules can be switched off, with proper storage of current parameter settings and network detach, by:

- AT+CPWROFF command

An under-voltage shutdown occurs when the **VCC** supply drops below the extended operating range minimum limit. In this case it is not possible to store the current parameter settings in the module's non-volatile memory and it is not possible to perform the proper network detach.

An over-temperature or an under-temperature shutdown occurs when the temperature measured within the wireless module reaches the dangerous area, if the optional Smart Temperature Supervisor feature is enabled and configured by the dedicated AT command. For more details see the LEON-G1 series System Integration Manual [6] and u-blox AT commands manual [4], +USTS AT command.

2.3.3 Module reset (RESET_N)

LEON-G1 series modules can be reset in one of these ways:

- Low level on the **RESET_N** pin, normally high with internal pull-up. This causes an “external” or “hardware” reset of the module. The current parameter settings are not saved in the module’s non-volatile memory and a proper network detach is not performed
- AT+CFUN command (see the u-blox AT commands manual [4]). This causes an “internal” or “software” reset of the module. The current parameter settings are saved in the module’s non-volatile memory and a proper network detach is performed

RESET_N is pulled low by the module itself when the module is in power-off mode or an internal reset occurs.

2.4 (U)SIM interface

A (U)SIM card interface is provided on the **VSIM**, **SIM_IO**, **SIM_CLK**, **SIM_RST** pins of the LEON-G1 series modules: the high-speed SIM/ME interface is implemented as well as the automatic detection of the required SIM supporting voltage.

Both 1.8 V and 3 V SIM types are supported: activation and deactivation with automatic voltage switch from 1.8 V to 3 V are implemented, according to ISO-IEC 7816-3 specifications. The SIM driver supports the PPS (Protocol and Parameter Selection) procedure for baud-rate selection, according to the values proposed by the connected UICC / SIM card or chip.

2.5 Serial communication

LEON-G1 series modules provide the following serial communication interface, which can be concurrently used for AT command interface and Packet-Switched / Circuit-Switched Data communication:

- One asynchronous serial interface (UART)

When used as an AT command interface, this serial communication interface can be used for firmware upgrade using the AT command +UFWUPD (for more details see the u-blox AT Commands Manual [4]).

Only the following serial communication interface can be used for firmware upgrade using the u-blox EasyFlash tool:

- The UART interface, using the **RxD** and **TxD** lines only (the other UART lines are not needed)

2.5.1 Asynchronous serial interface (UART)

The UART interface is a 9-wire unbalanced asynchronous serial interface provided for all communications with LEON-G1 series modules: AT commands interface, data communication, software upgrades.

UART features are:

- Complete serial port with RS-232 functionality conforming to the ITU-T V.24 Recommendation [5], with CMOS compatible signal levels (0 V for low data bit or ON state and 2.85 V for high data bit or OFF state)
- Data lines (**RxD** as output, **TxD** as input), hardware flow control lines (**CTS** as output, **RTS** as input), modem status and control lines (**DTR** as input, **DSR** as output, **DCD** as output, **RI** as output) are provided
- Hardware flow control (default value), software flow control, or no flow control are supported
- Power saving indication available⁵ on the hardware flow control output (**CTS** line): the line is driven to the OFF state when the module is not prepared to accept data signals

⁵ If enabled

- 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 230400 b/s baud rates are supported for the AT interface; note that 1200 and 230400 b/s are available in conjunction only with autobauding
- Auto baud rate detection (autobauding) is the default configuration
- Frame format can be:
 - 8N2 (8 data bits, no parity, 2 stop bits)
 - 8E1 (8 data bits, even parity, 1 stop bit)
 - 8O1 (8 data bits, odd parity, 1 stop bit)
 - 8N1 (8 data bits, no parity, 1 stop bit)
 - 7E1 (7 data bits, even parity, 1 stop bit)
 - 7O1 (7 data bits, odd parity, 1 stop bit)
- Default frame configuration is 8N1
- Automatic frame recognition is supported: this feature is enabled in conjunction with the auto baud rate detection only

2.5.2 Multiplexer protocol

LEON-G1 series modules have a software layer with MUX functionality, 3GPP TS 27.010 multiplexer protocol [3]. It is a data link protocol (layer 2 of OSI model) which uses HDLC-like framing and operates between the module (DCE) and the application processor (DTE), allowing different simultaneous sessions over the physical link (UART). This allows, for example, an SMS transfer to the DTE when a data connection is in progress.

The following channels are defined:

- Channel 0: control channel
- Channel 1 – 5: AT commands / data connection
- Channel 6: GNSS tunneling

For more details see the Mux Implementation Application Note [8].

2.6 DDC (I²C compatible) interface

LEON-G1 series modules provide an I²C compatible DDC interface on the **SCL** and **SDA** pins exclusively for communication with u-blox GNSS positioning chips / modules.

2.7 Audio

LEON-G1 series modules provide analog and digital audio interfaces:

- Two analog audio inputs:
 - First analog audio input (**MIC_BIAS1**, **MIC_GND1**) can be used for direct connection of the electret condenser microphone of a handset. This audio input is used when the audio uplink path is set as "Handset Microphone" (for more details see the u-blox AT Commands Manual [4], AT+USPM command)
 - Second analog audio input (**MIC_BIAS2**, **MIC_GND2**) can be used for direct connection of the electret condenser microphone of a headset. This audio input is used when the audio uplink path is set as "Headset Microphone" (for more details see the u-blox AT Commands Manual [4], AT+USPM command)
- Two analog audio outputs:
 - First analog audio output (**HS_P**), a single ended low power audio output, can be used to directly connect the receiver (earpiece) of a handset or an headset. This audio output is used when the audio downlink path is "Normal earpiece" or "Mono headset" (for more details see the u-blox AT

Commands Manual [4]; AT+USPM command). These two downlink path profiles use the same physical output but have different sets of audio parameters (for more details see the u-blox AT Commands Manual [4], AT+USGC, +UDBF, +USTN commands)

- Second analog audio output (**SPK_P, SPK_N**), a differential high power audio output, can be used to directly connect a speaker or a loudspeaker used for ring-tones or for speech in hands-free mode. This audio output is used when the audio downlink path is "Loudspeaker" (for more details see the u-blox AT Commands Manual [4], AT+USPM command, <main_downlink> and <alert_sound> parameters)
- Headset detection input (**HS_DET**):
 - The headset detection, if enabled, causes the automatic switch of the uplink audio path to "Headset Microphone" and downlink audio path to "Mono headset". Enabling or disabling of detection can be controlled by the <headset_indication> parameter in AT+USPM command (for more details see the u-blox AT Commands Manual [4])
- I²S digital audio interface (**I2S_TX, I2S_RX, I2S_CLK, I2S_WA**)
 - This audio path is selected when parameters <main_uplink> and <main_downlink> in +USPM command (for more details see the u-blox AT Commands Manual [4]) are respectively "I²S input line" and "I²S output line"



Not all the Input-Output audio path combinations are allowed. Check audio command +USPM in u-blox AT Commands Manual [4] for allowed combinations of audio path and for their switching during different use cases (speech/alert tones).



The default values for audio parameters (for more details see the u-blox AT Commands Manual [4]; +UMGC,+UUBF, +UHFP, +USGC, +UDBF, +USTN AT commands) are tuned for audio device connected as suggested above (i.e. handset microphone connected on first microphone input, headset microphone on second microphone input). For a different use case (i.e. connection of a hands-free microphone) these parameters should be changed on the audio path corresponding to the connection chosen.



For the default values related to the uplink, downlink path and headset detection see the u-blox AT Commands Manual [4].

2.8 ADC input

One Analog to Digital Converter input (**ADC1**) can be configured via u-blox AT commands. The ADC resolution is 11-bit, single ended input range of 0-2.0 V. For more details, see the the u-blox AT Commands Manual [4], +UADC AT command.

2.9 GPIO

LEON-G1 series modules provide some pins which can be configured as general purpose input or output, or to provide special functions via u-blox AT commands (for further details see the LEON-G1 System Integration Manual [6] and to u-blox AT Commands Manual [4], +UGPIOC, +UGPIOR, +UGPIOW, +UGPS, +UGPRF, +USPM).

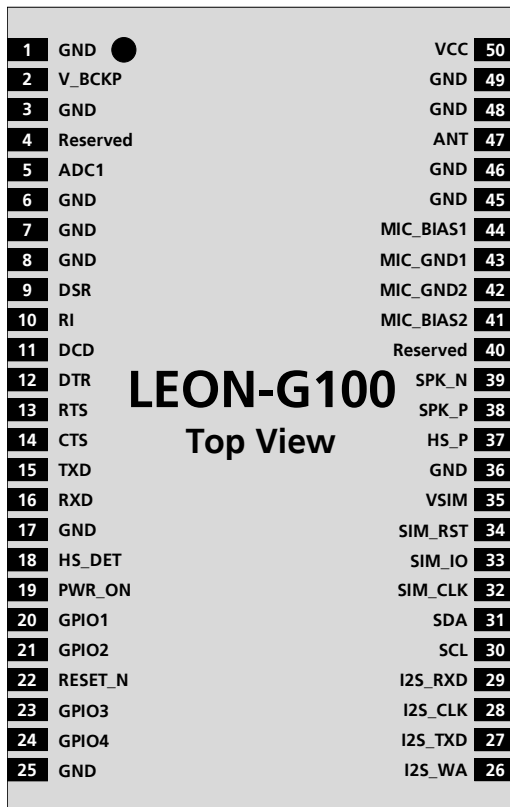
LEON-G1 series modules provide five general purpose input/output pins: **GPIO1**, **GPIO2**, **GPIO3**, **GPIO4** and **HS_DET**, with the available functions described below:

Function	Description	Default GPIO	Configurable GPIOs
GNSS supply enable	Enable/disable the supply of u-blox GNSS receiver connected to wireless module	GPIO2	GPIO1, GPIO2, GPIO3, GPIO4, HS_DET
GNSS data ready	Sense when u-blox GNSS receiver connected to wireless module is ready for sending data by the DDC (I ² C)	GPIO3	GPIO3
GNSS RTC sharing	RTC (Real Time Clock) synchronization signal to u-blox GNSS receiver connected to wireless module	GPIO4	GPIO4
Headset detection	Sense when the headset is connected to wireless module	HS_DET	HS_DET
Network status indication	Network status: registered home network, registered roaming, data transmission, no service	--	GPIO1, GPIO2, GPIO3, GPIO4, HS_DET
General purpose input	Input to sense high or low digital level	--	GPIO1, GPIO2, GPIO3, GPIO4, HS_DET
General purpose output	Output to set the high or the low digital level	--	GPIO1, GPIO2, GPIO3, GPIO4, HS_DET
Pad disabled	Tri-state with an internal active pull-down enabled	GPIO1	GPIO1, GPIO2, GPIO3, GPIO4, HS_DET

Table 5: GPIO custom functions configuration

3 Pin definition

3.1 Pin assignment



Figure

2: LEON-G1 series modules pin assignment

No	Name	Power domain	I/O	Description	Remarks
1	GND		N/A	Ground	All GND pads must be connected to ground.
2	V_BCKP		I/O	Real Time Clock supply	V_BCKP = 2.0 V (typical) generated by the module to supply the Real Time Clock when VCC supply voltage is within valid operating range. See section 4.2.3 for detailed electrical specs.
3	GND		N/A	Ground	All GND pads must be connected to ground.
4	Reserved		N/A	Reserved	Leave unconnected.
5	ADC1	ADC	I	ADC input	Resolution: 11 bits Input operating voltage range: 0 V – 2.0 V See section 4.2.12 for detailed electrical specs.
6	GND		N/A	Ground	All GND pads must be connected to ground.
7	GND		N/A	Ground	All GND pads must be connected to ground.
8	GND		N/A	Ground	All GND pads must be connected to ground.
9	DSR	GDI	O	UART data set ready	Circuit 107 (DSR) in ITU-T V.24. Output driver class B slow. PU/PD class A. Value at reset: T/PU. See section 4.2.9 for detailed electrical specs.

No	Name	Power domain	I/O	Description	Remarks
10	RI	GDI	O	UART ring indicator	Circuit 125 (RI) in ITU-T V.24. Output driver class D. PU/PD class B. Value at reset: T/PD. See section 4.2.9 for detailed electrical specs.
11	DCD	GDI	O	UART data carrier detect	Circuit 109 (DCD) in ITU-T V.24. Output driver class B. PU/PD class B. Value at reset: T/PD. See section 4.2.9 for detailed electrical specs.
12	DTR	GDI	I	UART data terminal ready	Circuit 108/2 (DTR) in ITU-T V.24. Internal active pull-up to 2.85 V enabled. PU/PD class B. Value at reset: T/PD. See section 4.2.9 for detailed electrical specs.
13	RTS	GDI	I	UART ready to send	Circuit 105 (RTS) in ITU-T V.24. Internal active pull-up to 2.85 V enabled. PU/PD class C. Value at reset: T/PU. See section 4.2.9 for detailed electrical specs.
14	CTS	GDI	O	UART clear to send	Circuit 106 (CTS) in ITU-T V.24. Output driver class E. PU/PD class C. Value at reset: T. See section 4.2.9 for detailed electrical specs.
15	TxD	GDI	I	UART transmitted data	Circuit 103 (TxD) in ITU-T V.24. Internal active pull-up to 2.85 V enabled. PU/PD class C. Value at reset: T. See section 4.2.9 for detailed electrical specs.
16	RxD	GDI	O	UART received data	Circuit 104 (RxD) in ITU-T V.24. Output driver class E. PU/PD class C. Value at reset: T. See section 4.2.9 for detailed electrical specs.
17	GND		N/A	Ground	All GND pads must be connected to ground.
18	HS_DET	GDI	I	GPIO	By default, the pin is configured to provide the headset detection function. Internal active pull-up to 2.85 V enabled when the pin is configured for headset detection. Output driver class E. PU/PD class B. Value at reset: T/PD. See section 4.2.9 for detailed electrical specs.
19	PWR_ON	POS	I	Power-on input	The PWR_ON pin has high input impedance: don't leave it floating in noisy environment (an external pull-up resistor is required). See section 4.2.6 for detailed electrical specs.
20	GPIO1	GDI	I/O	GPIO	The pin can be configured to provide the network status indication function. Output driver class C. PU/PD class B. Value at reset: T/PD. See section 4.2.9 for detailed electrical specs.
21	GPIO2	GDI	I/O	GPIO	By default, the pin is configured to provide the GNSS Supply Enable function. Output driver class C. PU/PD class B. Value at reset: T/PD. See section 4.2.9 for detailed electrical specs.
22	RESET_N	ERS	I/O	External reset signal	A series Schottky diode is integrated in the module as protection. An internal 12.6 kΩ pull-up resistor pulls the line to 1.88 V when the module is not in the reset state. An internal open drain FET pulls the line low when an internal reset occurs and when the module is in power down mode. See section 4.2.7 for detailed electrical specs. For more details regarding module reset, see [6].
23	GPIO3	GDI	I/O	GPIO	By default, the pin is configured to provide the GNSS data ready function. Output driver class F. PU/PD class B. Value at reset: T. See section 4.2.9 for detailed electrical specs.

No	Name	Power domain	I/O	Description	Remarks
24	GPIO4	GDI	I/O	GPIO	By default, the pin is configured to provide the GNSS RTC sharing function. Output driver class F. PU/PD class B. Value at reset: T/PD. See section 4.2.9 for detailed electrical specs.
25	GND		N/A	Ground	All GND pads must be connected to ground.
26	I2S_WA	GDI	O	I ² S word alignment	Output driver class D. PU/PD class B. Value at reset: T. See section 4.2.9 for detailed electrical specs.
27	I2S_TXD	GDI	O	I ² S transmit data	Output driver class D. PU/PD class B. Value at reset: T. See section 4.2.9 for detailed electrical specs.
28	I2S_CLK	GDI	O	I ² S clock	Output driver class D. PU/PD class B. Value at reset: T. See section 4.2.9 for detailed electrical specs.
29	I2S_RXD	GDI	I	I ² S receive data	Internal active pull-up to 2.85 V enabled. PU/PD class B. Value at reset: T. See section 4.2.9 for detailed electrical specs.
30	SCL	DDC	O	I ² C bus clock line	Fixed open drain. No internal pull-up. Value at reset: T/OD. See section 4.2.10 for detailed electrical specs.
31	SDA	DDC	I/O	I ² C bus data line	Fixed open drain. No internal pull-up. Value at reset: T/OD. See section 4.2.10 for detailed electrical specs.
32	SIM_CLK	SIM	O	SIM clock	Output driver class E. Value at reset: L. See section 4.2.8 for detailed electrical specs.
33	SIM_IO	SIM	I/O	SIM data	Internal 4.7k pull-up to VSIM. Output driver class E. Value at reset: OD/L. See section 4.2.8 for detailed electrical specs.
34	SIM_RST	SIM	O	SIM reset	Output driver class E. Value at reset: L. See section 4.2.8 for detailed electrical specs.
35	VSIM		O	SIM supply output	VSIM = 1.80 V typical if SIM card = 1.8V type or VSIM = 2.85 V typical if SIM card = 3.0V type See section 4.2.3 for detailed electrical specs.
36	GND		N/A	Ground	All GND pads must be connected to ground.
37	HS_P	AUDIO	O	First speaker output with low power single-ended analog audio	This audio output is used when audio downlink path is "Normal earpiece" or "Mono headset" See section 4.2.11 for detailed electrical specs.
38	SPK_P	AUDIO	O	Second speaker output with high power differential analog audio	This audio output is used when audio downlink path is "Loudspeaker" See section 4.2.11 for detailed electrical specs.
39	SPK_N	AUDIO	O	Second speaker output with power differential analog audio output	This audio output is used when audio downlink path is "Loudspeaker" See section 4.2.11 for detailed electrical specs.
40	Reserved		N/A	Reserved	Leave unconnected.
41	MIC_BIAS2	AUDIO	I	Second microphone analog signal input and bias output	This audio input is used when audio uplink path is set as "Headset Microphone" See section 4.2.11 for detailed electrical specs.
42	MIC_GND2	AUDIO	I	Second microphone analog reference	Local ground of the second microphone See section 4.2.11 for detailed electrical specs.
43	MIC_GND1	AUDIO	I	First microphone analog reference	Local ground of the first microphone See section 4.2.11 for detailed electrical specs.
44	MIC_BIAS1	AUDIO	I	First microphone analog signal input and bias output	This audio input is used when audio uplink path is set as "Handset Microphone" See section 4.2.11 for detailed electrical specs.
45	GND		N/A	Ground	All GND pads must be connected to ground.
46	GND		N/A	Ground	All GND pads must be connected to ground.


No	Name	Power domain	I/O	Description	Remarks
47	ANT		I/O	RF antenna	50 Ω nominal impedance See section 4.2.5 for detailed electrical specs.
48	GND		N/A	Ground	All GND pads must be connected to ground.
49	GND		N/A	Ground	All GND pads must be connected to ground.
50	VCC		I	Module supply input	See section 4.2.3 for detailed electrical specs.

Table 6: Pinout


Pins designated Reserved should not be used. For more information about the pinout see the LEON-G1 series System Integration Manual [6].

Explanation of abbreviations and terms used is reported in Appendix A.


4 Electrical specifications

 **Stressing the device above one or more of the ratings listed in the Absolute maximum rating section may cause permanent damage. These are stress ratings only. Operating the module at these or at any conditions other than those specified in Operating conditions (section 4.2) should be avoided. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability.**

 Operating condition ranges define those limits within which the functionality of the device is guaranteed.


 Where application information is given, it is advisory only and does not form part of the specification.

4.1 Absolute maximum rating

 Limiting values given below are in accordance with the Absolute Maximum Rating System (IEC 134).

Symbol	Description	Condition	Min.	Max.	Unit
VCC	Module supply voltage	Input DC voltage at VCC pin	-0.30	5.5	V
ICC	Module supply current	Input DC current at VCC pin		2.5	A
V_BCKP	RTC supply voltage	Input DC voltage at V_BCKP pin	-0.15	2.50	V
GDI	Generic digital interfaces	Input DC voltage at Generic digital interfaces pins	-0.30	3.60	V
DDC	DDC interface	Input DC voltage at DDC interface pins	-0.30	3.60	V
SIM	SIM interface	Input DC voltage at SIM interface pin	-0.30	3.60	V
ERS	External reset signal	Input DC voltage at External reset signal pin	-0.15	5.50	V
POS	Power-on input	Input DC voltage at Power-on signal pin	-0.15	5.50	V
AUDIO	Audio input pins	Input DC voltage at Audio pins	-0.15	3.00	V
ADC	ADC pins	Input DC voltage at ADC pin	-0.15	3.00	V
V_ANT	Antenna voltage	Input DC voltage at ANT pin	-0.15	3.00	V
P_ANT	Antenna power	Input RF power at ANT pin		-8	dBm
Rho_ANT	Antenna ruggedness	Output RF load mismatch ruggedness at ANT pin		20:1	VSWR
Tstg	Storage temperature		-40	+85	°C

Table 7: Absolute maximum ratings

 **The product is not protected against overvoltage or reversed voltages. If necessary, voltage spikes exceeding the power supply voltage specification, given in table above, must be limited to values within the specified boundaries by using appropriate protection devices.**

4.1.1 Maximum ESD

Parameter	Min.	Typ.	Max.	Unit	Remarks
ESD sensitivity for all pins except ANT pin			1000	V	Human Body Model according to JESD22-A114F
ESD sensitivity for ANT pin			1000	V	Human Body Model according to JESD22-A114F
ESD immunity for ANT pin			4000	V	Contact Discharge according to IEC 61000-4-2
			8000	V	Air Discharge according to IEC 61000-4-2

Table 8: Maximum ESD ratings

 **GSM modules are Electrostatic Sensitive Devices (ESD) and require special precautions when handling. See section 7.4 for ESD handling instructions.**

4.2 Operating conditions

 Unless otherwise specified, all operating condition specifications are at an ambient temperature of 25°C.

 **Operation beyond the operating conditions is not recommended and extended exposure beyond them may affect device reliability.**

4.2.1 Operating temperature range

Symbol	Parameter	Min.	Typ.	Max.	Units	Remarks
T _{opr}	Operating temperature range	-40	+25	+85	°C	
		-30		+85	°C	Normal operating range see section 4.2.1.1
		-40		-30	°C	Extended operating range see section 4.2.1.2

Table 9: Environmental conditions

4.2.1.1 Normal operating temperature range

LEON-G1 series modules are fully functional and meet 3GPP specification across the specified temperature range.

4.2.1.2 Extended operating temperature range

LEON-G1 series modules are fully functional across the specified temperature range. Occasional deviations from the 3GPP specification may occur.

4.2.2 Module thermal resistance

Symbol	Parameter	Min.	Typ.	Max.	Units	Remarks
R _{th, CA}	Case-to-Ambient thermal resistance		14		°C/W	Module mounted on a 130 mm x 110 mm x 1.6 mm FR4 PCB with a high coverage of copper in still air conditions

Table 10: Case-to-Ambient thermal resistance

4.2.3 Supply/power pins

Symbol	Parameter	Min.	Typ.	Max.	Unit
VCC	Module supply normal operating voltage ⁶	3.35	3.8	4.50	V
	Module supply extended operating voltage ⁷	3.00		4.50	V
ICC_PEAK ⁸	Module Supply Peak Current: peak of module current consumption through the VCC pad during a GSM transmit burst, with a matched antenna		1.80	2.00	A
	Module Supply Peak Current: peak of module current consumption through the VCC pad during a GSM transmit burst, with a mismatched antenna			2.50	A
V_BCKP	Real Time Clock Supply input voltage	1.00	2.00	2.25	V
I_BCKP	Real Time Clock Supply average current consumption, at V_BCKP = 2.0 V		2.00		μA

Table 11: Input characteristics of Supply/Power pins

Symbol	Parameter	Min.	Typ.	Max.	Unit
VSIM	SIM Supply	1.75	1.80	1.85	V
		2.76	2.85	2.94	V
V_BCKP	Real Time Clock Supply output voltage	1.86	2.00	2.14	V
I_BCKP	Real Time Clock Supply output current capability			3	mA

Table 12: Output characteristics of Supply/Power pins

⁶ Input voltage at VCC must be above the normal operating range minimum limit to switch-on module. Complete functionality of the module is only guaranteed within the specified range.

⁷ Ensure that input voltage at VCC never drops below the extended operating range minimum limit during module operation. Module switches off when the VCC voltage value drops below the extended operating range minimum limit.

⁸ Use this figure to dimension maximum current capability of power supply.

4.2.4 Power consumption

Status	Current Consumption ⁹
Power Off Mode	< 90 μ A
GSM/GPRS Power Saving (Idle) Mode @ DRX = 5 ¹⁰	< 1.60 mA
GSM/GPRS Power Saving (Idle) Mode @ DRX = 9 ¹¹	< 0.99 mA
GSM Talk (Connected) Mode @ 850 / 900 MHz (P = 32.2 dBm typ.) ¹²	< 300 mA
GSM Talk (Connected) Mode @ 1800 / 1900 MHz (P = 29.2 dBm typ.) ¹²	< 250 mA
GPRS 2 Tx + 3 Rx slots TBF (Connected) Mode @ 850 MHz (P = 30.5 dBm typ.) ¹²	< 410 mA
GPRS 2 Tx + 3 Rx slots TBF (Connected) Mode @ 900 MHz (P = 30.5 dBm typ.) ¹²	< 350 mA
GPRS 2 Tx + 3 Rx slots TBF (Connected) Mode @ 1800 MHz (P = 27.5 dBm typ.) ¹²	< 330 mA
GPRS 2 Tx + 3 Rx slots TBF (Connected) Mode @ 1900 MHz (P = 27.5 dBm typ.) ¹²	< 340 mA

Table 13: Power consumption

4.2.5 RF performance

Parameter		Min.	Max.	Unit	Remarks
Frequency range GSM 850	Uplink	824	849	MHz	Module transmit
	Downlink	869	894	MHz	Module receive
Frequency range E-GSM 900	Uplink	880	915	MHz	Module transmit
	Downlink	925	960	MHz	Module receive
Frequency range DCS 1800	Uplink	1710	1785	MHz	Module transmit
	Downlink	1805	1880	MHz	Module receive
Frequency range PCS 1900	Uplink	1850	1910	MHz	Module transmit
	Downlink	1930	1990	MHz	Module receive

Table 14: Operating RF frequency bands

Parameter	Min.	Typ.	Max.	Unit	Remarks
Receiver input sensitivity GSM 850 / E-GSM 900		-110		dBm	Downlink RF level @ BER Class II < 2.4 % Condition: 50 Ω source
Receiver input sensitivity DCS 1800 / PCS 1900		-109		dBm	Downlink RF level @ BER Class II < 2.4 % Condition: 50 Ω source

Table 15: Receiver sensitivity performance

Parameter	Min.	Typ.	Max.	Unit	Remarks
Maximum output power GSM 850 / E-GSM 900		32.2		dBm	Uplink burst RF power for GSM or GPRS 1-slot TCH at maximum output power control level (PCL 5 or Gamma 3)
			30.5	dBm	Uplink burst RF power for GPRS 2-slot TCH at maximum output power control level (Gamma 3)
Maximum output power DCS 1800 / PCS 1900		29.2		dBm	Uplink burst RF power for GSM or GPRS 1-slot TCH at maximum output power control level (PCL 0 or Gamma 3)
			27.5	dBm	Uplink burst RF power for GPRS 2-slot TCH at maximum output power control level (Gamma 3)

Condition: 50 Ω output load

Table 16: Transmitter maximum output power

⁹ Maximum values for module average current consumption through the VCC pad in the listed status/conditions, at 25°C, with VCC = 3.8 V, with a matched antenna.

¹⁰ Module is registered in the network, with a paging period of 1177 ms (GSM network DRX setting of 5) with 16 neighbour cells.

¹¹ Module is registered in the network, with a paging period of 2118 ms (GSM network DRX setting of 9) with none neighbour cell.

¹² Module transmits at the maximum power level.

4.2.6 PWR_ON pin

Pin Name	Parameter	Min.	Typ.	Max.	Unit	Remarks
PWR_ON	Internal supply for Power-On Input Signal	1.86	2.00	2.14	V	Real Time Clock supply (V_BCKP)
	L-level input	-0.10	0.00	0.86	V	High input impedance (no internal pull-up)
	H-level input	1.60	2.00	4.50	V	High input impedance (no internal pull-up)
	L-level input current		-6		μA	
	PWR_ON low time to switch-on the module	5			ms	

Table 17: PWR_ON pin characteristics

4.2.7 RESET_N pin

Pin Name	Parameter	Min.	Typ.	Max.	Unit	Remarks
RESET_N	Internal supply for External Reset Signal	1.86	2.00	2.14	V	Real Time Clock supply (V_BCKP)
	L-level input	-0.10	0.00	0.15	V	A series Schottky diode is integrated in the module as protection: the module senses a low level when the RESET_N pin is forced low.
	H-level input	1.60	2.00	4.50	V	A series Schottky diode is integrated in the module as protection: the module senses a low level when the RESET_N pin is forced low.
	L-level output		0.00		V	The module has an internal open drain FET which pulls the RESET_N line low when an internal reset occurs and when the module is in power down mode.
	H-level output		1.88		V	The module has an internal pull-up resistor (12.6 kΩ typical) which pulls the level to 1.88 V (typical) when the module is not in the reset state.
	L-level input current			-150		μA
	RESET_N low time to perform a proper reset	50				ms

Table 18: RESET_N pin characteristics

4.2.8 SIM pins

Parameter	Min.	Typ.	Max.	Unit	Remarks
Low-level input		0.00	0.36	V	VSIM = 1.80 V
		0.00	0.57	V	VSIM = 2.85 V
High-level input	1.26	1.80	3.30	V	VSIM = 1.80 V
	2.00	2.85	3.30	V	VSIM = 2.85 V
Low-level output		0.00	0.20	V	VSIM = 1.80 V, Max value at $I_{OL} = +1.0$ mA
		0.00	0.35	V	VSIM = 1.80 V, Max value at $I_{OL} = +1.5$ mA
		0.00	0.20	V	VSIM = 2.85 V, Max value at $I_{OL} = +1.0$ mA
		0.00	0.35	V	VSIM = 2.85 V, Max value at $I_{OL} = +1.5$ mA
High-level output	1.60	1.80		V	VSIM = 1.80 V, Min value at $I_{OH} = -1.0$ mA
	1.45	1.80		V	VSIM = 1.80 V, Min value at $I_{OH} = -1.5$ mA
	2.65	2.85		V	VSIM = 2.85 V, Min value at $I_{OH} = -1.0$ mA
	2.50	2.85		V	VSIM = 2.85 V, Min value at $I_{OH} = -1.5$ mA
Input/Output leakage current			0.7	μ A	$0.2 \text{ V} < V_{IN} < 3.3 \text{ V}$
Internal pull-up resistor on SIM_IO to VSIM		4.7		k Ω	
Clock frequency on SIM_CLK		3.25		MHz	
Pad resistance: Rising edge			130	Ω	1.0-1.5 mA load
Pad resistance: Falling edge			120	Ω	1.0-1.5 mA load

Table 19: SIM pins characteristics

4.2.9 Generic Digital Interfaces pins

Parameter	Min.	Typ.	Max.	Unit	Remarks
Internal supply for GDI domain	2.76	2.85	2.94	V	
Input characteristic: L-level input	-0.20	0.00	0.57	V	
Input characteristic: H-level input	2.00	2.85	3.30	V	
Output characteristics: L-level output		0.00	0.40	V	Max value at $I_{OL} = +10.0$ mA for Driver Class B slow
		0.00	0.80	V	Max value at $I_{OL} = +15.0$ mA for Driver Class B slow
		0.00	0.20	V	Max value at $I_{OL} = +2.5$ mA for Driver Class B
		0.00	0.35	V	Max value at $I_{OL} = +5.0$ mA for Driver Class B
		0.00	0.20	V	Max value at $I_{OL} = +2.0$ mA for Driver Class C
		0.00	0.35	V	Max value at $I_{OL} = +4.0$ mA for Driver Class C
		0.00	0.20	V	Max value at $I_{OL} = +1.0$ mA for Driver Class D
		0.00	0.35	V	Max value at $I_{OL} = +2.0$ mA for Driver Class D
		0.00	0.20	V	Max value at $I_{OL} = +1.0$ mA for Driver Class E and F
		0.00	0.35	V	Max value at $I_{OL} = +1.5$ mA for Driver Class E and F
Output characteristics: H-level output	2.65	2.85		V	Min value at $I_{OH} = -10.0$ mA for Driver Class B slow
	2.50	2.85		V	Min value at $I_{OH} = -15.0$ mA for Driver Class B slow
	2.65	2.85		V	Min value at $I_{OH} = -2.5$ mA for Driver Class B
	2.50	2.85		V	Min value at $I_{OH} = -5.0$ mA for Driver Class B
	2.65	2.85		V	Min value at $I_{OH} = -2.0$ mA for Driver Class C
	2.50	2.85		V	Min value at $I_{OH} = -4.0$ mA for Driver Class C
	2.65	2.85		V	Min value at $I_{OH} = -1.0$ mA for Driver Class D
	2.50	2.85		V	Min value at $I_{OH} = -2.0$ mA for Driver Class D
	2.65	2.85		V	Min value at $I_{OH} = -1.0$ mA for Driver Class E and F
	2.50	2.85		V	Min value at $I_{OH} = -1.5$ mA for Driver Class E and F
Input/Output leakage current			0.7	μ A	0.2 V < V_{IN} < 3.3 V
Pad resistance: Rising edge			50	Ω	2.5-5.0 mA load for Driver Class B slow
			70	Ω	2.5-5.0 mA load for Driver Class B
			70	Ω	2.0-4.0 mA load for Driver Class C
			115	Ω	1.0-2.0 mA load for Driver Class D
			130	Ω	1.0-1.5 mA load for Driver Class E
			180	Ω	1.0-1.5 mA load for Driver Class F
	Pad resistance: Falling edge			50	Ω
			70	Ω	2.5-5.0 mA load for Driver Class B
			70	Ω	2.0-4.0 mA load for Driver Class C
			115	Ω	1.0-2.0 mA load for Driver Class D
			120	Ω	1.0-1.5 mA load for Driver Class E
			180	Ω	1.0-1.5 mA load for Driver Class F
Pull-up input current				-450	μ A
			-100	μ A	PU/PD Class B
			-30	μ A	PU/PD Class C
Pull-down input current			450	μ A	PU/PD Class A
			100	μ A	PU/PD Class B
			30	μ A	PU/PD Class C

Table 20: GDI pins characteristics

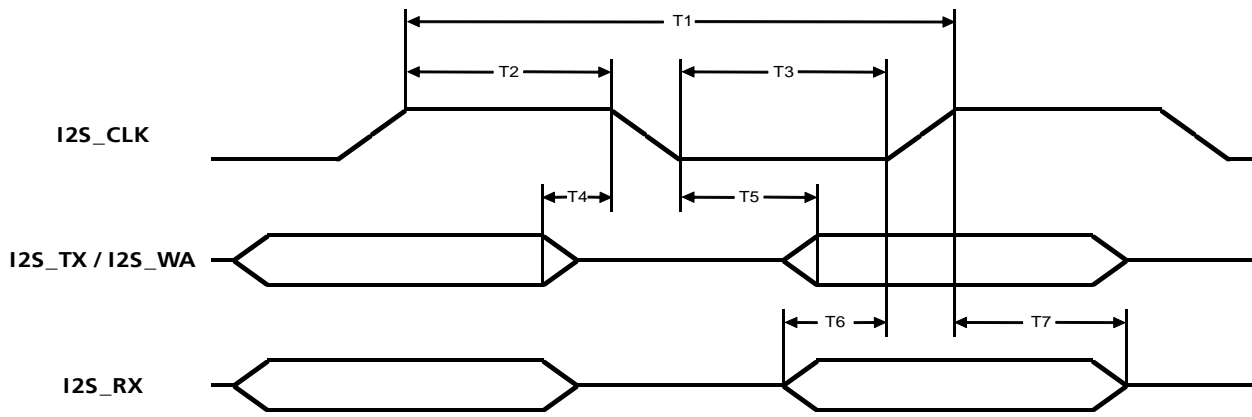


Figure 3: AC characteristics of digital audio interface in normal I2S mode (<I2S_mode> = 2,4,6,8,10,12)

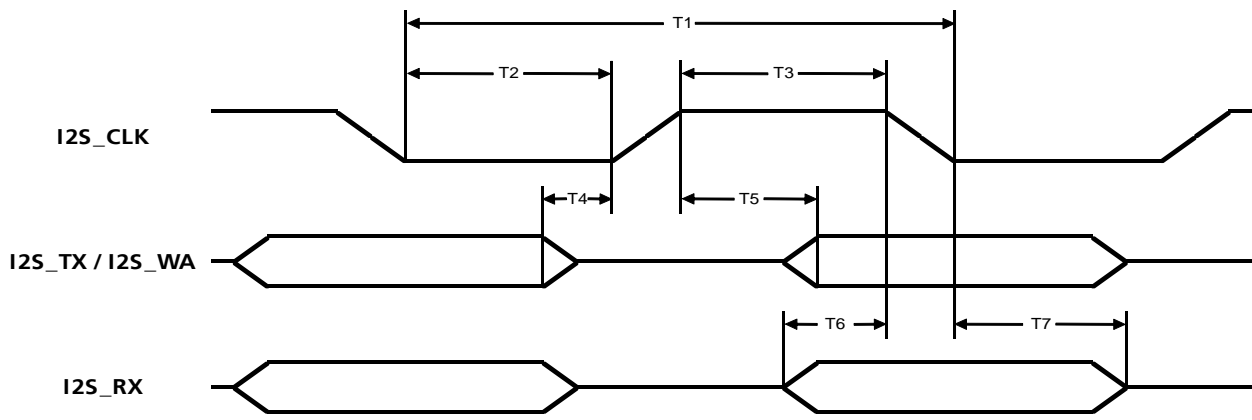


Figure 4: AC characteristics of digital audio interface in normal I2S mode (<I2S_mode> = 3,5,7,9,11,13)

Parameter	Description	Min.	Typ.	Max.	Unit	Remarks
T1	I2S_CLK period		3.906		μs	<I2S_mode> = 2,4,6,8,10,12
			3.906		μs	<I2S_mode> = 3,5,7,9,11,13
1/T1	I2S_CLK frequency		256		kHz	<I2S_mode> = 2,4,6,8,10,12
			256		kHz	<I2S_mode> = 3,5,7,9,11,13
T2	I2S_CLK high time		1.953		μs	<I2S_mode> = 2,4,6,8,10,12
			1.953		μs	<I2S_mode> = 3,5,7,9,11,13
T3	I2S_CLK low time		1.953		μs	<I2S_mode> = 2,4,6,8,10,12
			1.953		μs	<I2S_mode> = 3,5,7,9,11,13
	I2S_WA period		125.0		μs	<I2S_mode> = 2,4,6,8,10,12
			125.0		μs	<I2S_mode> = 3,5,7,9,11,13
			8		kHz	<I2S_mode> = 2,4,6,8,10,12
	I2S_WA frequency		8		kHz	<I2S_mode> = 3,5,7,9,11,13
				24	ns	<I2S_mode> = 2,4,6,8,10,12
T4	I2S_TX invalid before I2S_CLK low end			24	ns	<I2S_mode> = 2,4,6,8,10,12
	I2S_TX invalid before I2S_CLK high end			24	ns	<I2S_mode> = 3,5,7,9,11,13
T5	I2S_TX valid after I2S_CLK high begin			24	ns	<I2S_mode> = 2,4,6,8,10,12
	I2S_TX valid after I2S_CLK low begin			24	ns	<I2S_mode> = 3,5,7,9,11,13
T6	I2S_RX setup time before I2S_CLK high end	27			ns	<I2S_mode> = 2,4,6,8,10,12
	I2S_RX setup time before I2S_CLK low end	27			ns	<I2S_mode> = 3,5,7,9,11,13
T7	I2S_RX hold time after I2S_CLK low begin	0			ns	<I2S_mode> = 2,4,6,8,10,12
	I2S_RX hold time after I2S_CLK high begin	0			ns	<I2S_mode> = 3,5,7,9,11,13

Table 21: AC characteristics of digital audio interface in normal I2S mode (<I2S_mode> = 2,3,4,5,6,7,8,9,10,11,12,13)

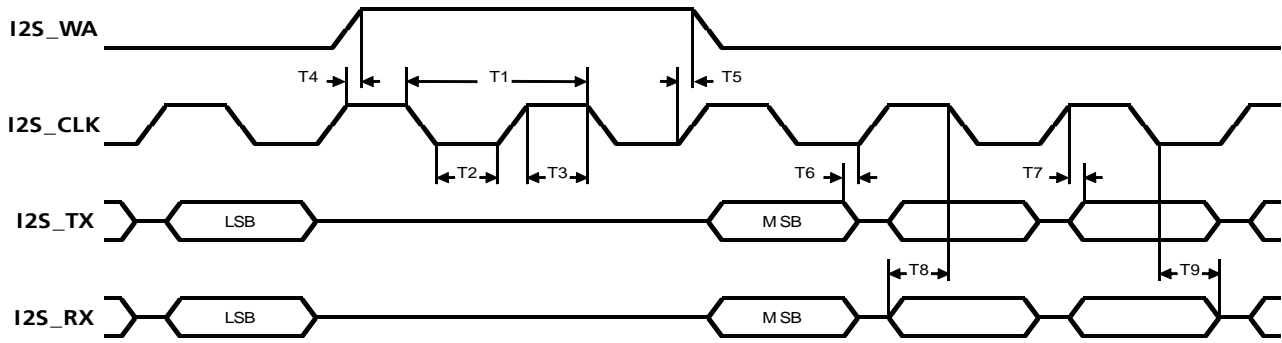


Figure 5: AC characteristics of digital audio interface in PCM mode (<I2S_mode> = 0)

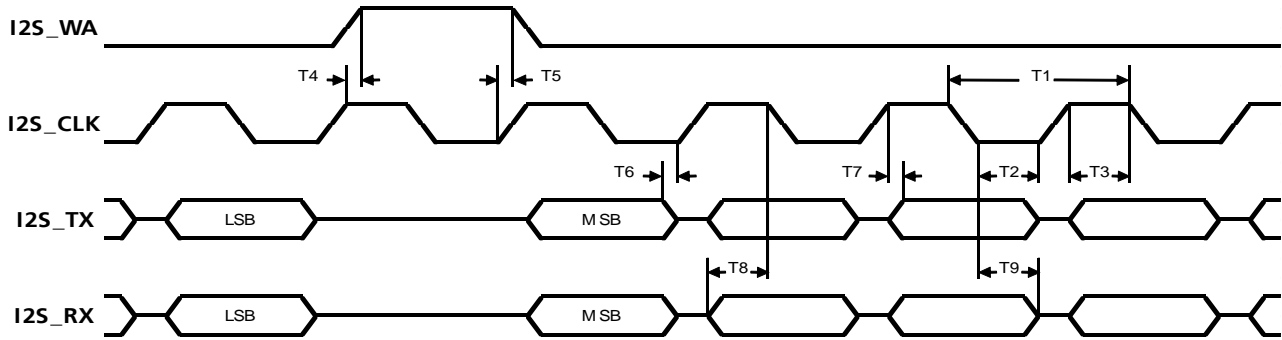


Figure 6: AC characteristics of digital audio interface in PCM mode (<I2S_mode> = 1)

Parameter	Description	Min.	Typ.	Max.	Unit	Remarks
T1	I2S_CLK period		6.944		μs	<I2S_mode> = 0
			7.353		μs	<I2S_mode> = 1
1/T1	I2S_CLK frequency		144		kHz	<I2S_mode> = 0
			136		kHz	<I2S_mode> = 1
T2	I2S_CLK low time		3.472		μs	<I2S_mode> = 0
			3.676		μs	<I2S_mode> = 1
T3	I2S_CLK high time		3.472		μs	<I2S_mode> = 0
			3.676		μs	<I2S_mode> = 1
	I2S_WA period		125.0		μs	<I2S_mode> = 0
			125.0		μs	<I2S_mode> = 1
	I2S_WA frequency		8		kHz	<I2S_mode> = 0
			8		kHz	<I2S_mode> = 1
T4	I2S_CLK high begin to I2S_WA high begin	0		48	ns	<I2S_mode> = 0
		0		48	ns	<I2S_mode> = 1
T5	I2S_CLK low end to I2S_WA high end	0		48	ns	<I2S_mode> = 0
		0		48	ns	<I2S_mode> = 1
T6	I2S_TX invalid before I2S_CLK low end			24	ns	<I2S_mode> = 0
				24	ns	<I2S_mode> = 1
T7	I2S_TX valid after I2S_CLK high begin			24	ns	<I2S_mode> = 0
				24	ns	<I2S_mode> = 1
T8	I2S_RX setup time before I2S_CLK high end	27			ns	<I2S_mode> = 0
		27			ns	<I2S_mode> = 1
T9	I2S_RX hold time after I2S_CLK low begin	0			ns	<I2S_mode> = 0
		0			ns	<I2S_mode> = 1

Table 22: AC characteristics of digital audio interface in PCM mode (<I2S_mode> = 0,1)

4.2.10 DDC (I²C) pins

Parameter	Min.	Typ.	Max.	Unit	Remarks
Internal supply for DDC domain	2.76	2.85	2.94	V	
L-level input	-0.30	0.00	0.86	V	In accordance with I ² C bus specification
H-level input	2.00	2.85	3.30	V	In accordance with I ² C bus specification
Hysteresis	0.14			V	In accordance with I ² C bus specification
L-level output		0.00	0.40	V	Max value at I _{OL} = +3.0 mA
Input/Output leakage current			0.7	μA	0.2 V < V _{IN} < 3.3 V
Clock frequency on SCL		100		kHz	

Table 23: DDC pins characteristics

4.2.11 Audio pins

Pin Name	Parameter	Min.	Typ.	Max.	Unit	Remarks
MIC_BIAS1/2	Microphone supply open circuit voltage output		2.20		V	Open circuit single-ended voltage. Provided by MIC_BIAS1 with MIC_GND1 as reference, or provided by MIC_BIAS2 with MIC_GND2 as reference.
	Microphone supply current			2.0	mA	Provided by MIC_BIAS1 with MIC_GND1 as reference, or provided by MIC_BIAS2 with MIC_GND2 as reference.
	Microphone supply output resistance	2.85	3.00	3.15	kΩ	Series resistance of the microphone voltage supply MIC_BIAS1 or MIC_BIAS2
MIC_GND1/2	Microphone ground		0		V	MIC_GND1 and MIC_GND2 pins are internally connected to GND

Table 24: Microphone supply characteristics

Pin Name	Parameter	Min.	Typ.	Max.	Unit	Remarks
MIC_BIAS1/2	Input level range			1.03	V _{pp}	Full scale single-ended voltage. Signal applied to MIC_BIAS1 with MIC_GND1 as reference, or applied to MIC_BIAS2 with MIC_GND2 as reference.
	Input impedance		1.5		kΩ	At 1 kHz. Impedance between MIC_BIAS1 and MIC_GND1 pins, or between MIC_BIAS2 and MIC_GND2 pins.
	Internal discrete high-pass -3dB cutoff frequency		70		Hz	

If not specified otherwise, all parameters are measured with a bandwidth of 20 Hz,...,20 kHz.

Table 25: Microphone dynamic characteristics

Pin Name	Parameter	Min.	Typ.	Max.	Unit	Remarks ¹³		
HS_P	Maximum single-ended output voltage	1.65	1.85	2.05	Vpp	Full scale single-ended open circuit voltage.		
	Common mode output voltage		1.25		V			
	Internal output resistance		1.7	4	Ω			
	Output load resistance		16		Ω			
	Single-ended output load capacitance			10	nF			
	Signal to noise	70	80		dB		Load = 16 Ω, Gain stage = +0 dB, Input signal = 0 dBFS, Code 0, A-weighted	
	Signal to distortion (THD)		60	70			dB	Load = 16 Ω, Gain stage = +0 dB, Input signal = 0 dBFS
			60	70			dB	Load = 16 Ω, Gain stage = +0 dB, Input signal = -1 dBFS
			60				dB	Load = 16 Ω, Gain stage = +0 dB, Input signal = -6 dBFS
	Power supply rejection	60	66		dB		Gain stage = +0 dB, $U_{VDD}(t) = 2.5 V + 0.15 V \cdot \sin(2\pi \cdot 1 \text{ kHz} \cdot t)$	
	Passband ripple			0.5	dB		$f < 0.45 f_s$	
	Stopband attenuation	50			dB		$f > 0.55 f_s$	
	Absolute gain drift			±2	%		Variation due to change in supply, temperature and life time.	

If not specified otherwise, all parameters are measured with a bandwidth of 20 Hz,...,20 kHz.

Table 26: Low power single-ended audio receive path (HS_P) output characteristics

Pin Name	Parameter	Min.	Typ.	Max.	Unit	Remarks ¹³	
SPK_P/SPK_N	Maximum differential output voltage		6.4		Vpp	Overdrive Gain stage = +9 dB	
	Common mode output voltage		1.6		V		
	Output load resistance		8		Ω		
	Single-ended output load capacitance			10	nF		
	Inductive load			400	μH		Between output pins and GND with series resistance
	Signal to noise	70	80		dB		Load = 16 Ω, Gain stage = +0 dB, Input signal = 0 dBFS, Code 0, A-weighted
	Signal to distortion (THD)	50			dB		Load = 8 Ω, 350 mW
	Power supply rejection	60			dB		1 kHz

If not specified otherwise, all parameters are measured with a bandwidth of 20 Hz,...,20 kHz.

Table 27: High power differential audio receive path (SPK_P, SPK_N) output characteristics

¹³ If not specified otherwise, all parameters are measured with a bandwidth of 20 Hz,...,20 kHz and gain setting $g_s = 0$ dB.

4.2.12 ADC pin

Pin Name	Parameter	Min.	Typ.	Max.	Unit	Remarks
ADC1	Resolution		11		Bits	
	Differential linearity error			±0.5	LSB	
	Integral linearity error			±4	LSB	
	Offset error			±10	LSB	ADC input = 0 V
	Absolute gain drift			±2	%	Variation due to change in supply, temperature and life time.
	Input voltage span	0		2.00	V	
	Throughput rate	0.2	2	4	Hz	
	Input resistance	1.1			MΩ	With respect to GND. If mode OFF is selected.
	Input resistance in measurement mode	387	580	773	kΩ	With respect to GND. Variation due to process tolerances and change in supply, temperature, and life time.
	Internal voltage	0.46	0.48	0.50	V	With respect to GND. Variation due to process tolerances and change in supply, temperature, and life time.
Input leakage current			0.1	μA		

Table 28: ADC pin characteristics

5 Mechanical specifications

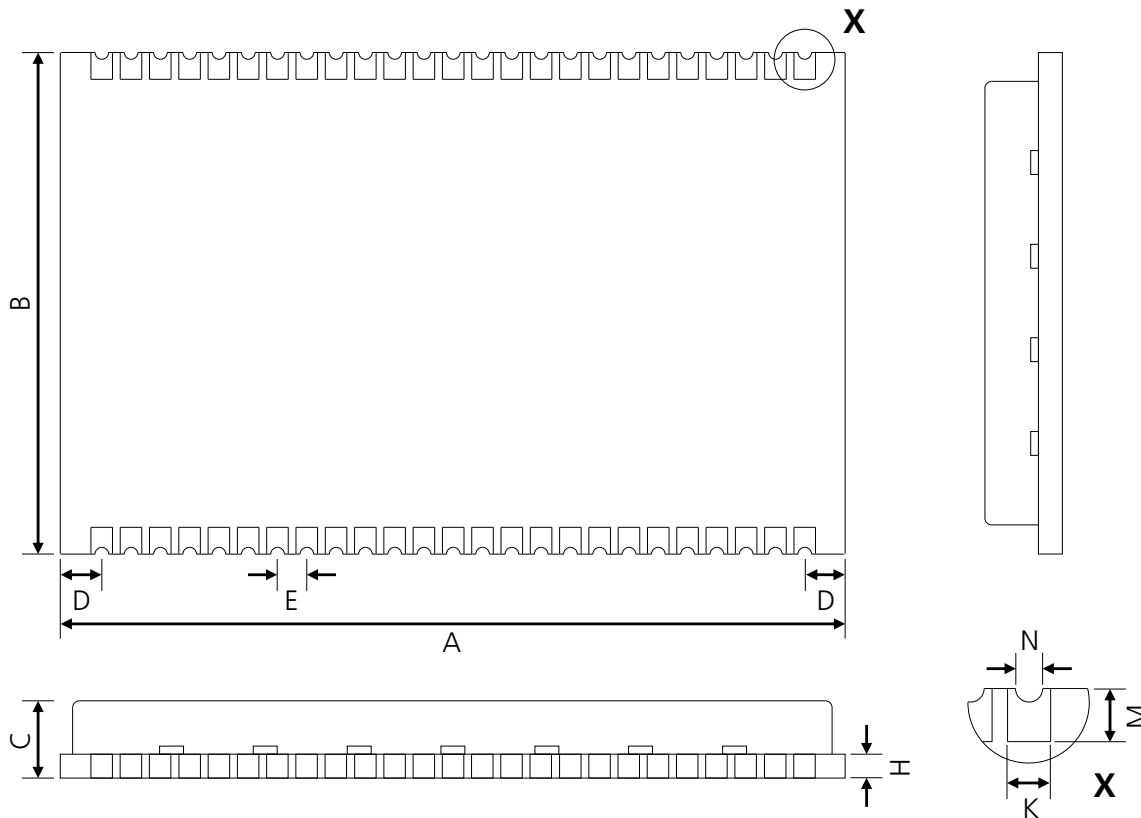


Figure 7: Dimensions (LEON bottom and sides views)

Parameter	Description	Min.		Typ.		Max.	
A	Height (mm)	29.4	[1157.5 mil]	29.5	[1161.4 mil]	30.1	[1185.0 mil]
B	Width (mm)	18.8	[740.2 mil]	18.9	[744.1 mil]	19.0	[748.0 mil]
C	Total Thickness (mm)	2.8	[110.2 mil]	3.0	[118.1 mil]	3.3	[129.9 mil]
D	Edge to Pin Pitch (mm)	1.4	[55.1 mil]	1.55	[61.0 mil]	1.8	[70.9 mil]
E	Pin to Pin Pitch (mm)	1.0	[39.4 mil]	1.1	[43.3 mil]	1.2	[47.2 mil]
H	PCB Thickness (mm)	0.8	[31.5 mil]	0.9	[35.4 mil]	1.0	[39.4 mil]
N	Half-moon Diameter (mm)	0.4	[15.7 mil]	0.5	[19.7 mil]	0.6	[23.6 mil]
M	Pin Height (mm)	0.9	[35.4 mil]	1.0	[39.4 mil]	1.1	[43.3 mil]
K	Pin Width (mm)	0.7	[27.6 mil]	0.8	[31.5 mil]	0.9	[35.4 mil]
Weight	(g)			< 5			

Table 29: Dimensions



For information regarding the paste mask and footprint see the LEON-G1 series System Integration Manual [6].

6 Qualification and approvals

6.1 Reliability tests

Tests for product family qualifications are according to ISO 16750 "Road vehicles - Environmental conditions and testing for electrical and electronic equipment", and appropriate standards (see Table 30).

Test	Reference	Test Conditions
Temperature step test	ISO16750-4 IEC60068-2-1 IEC60068-2-2	Function tests at stable temperature. The temperature must decrease in 5K steps from RT to -40°C followed by increase to +85°C in 5K steps.
Temperature cycling	IEC60068-2-14 Na	-40°C / +125°C, 100 cycles, air to air No function
Damp heat in function	IEC60068-2-3	+85°C / 85%rH VCCmax, 1000 hours, in function
High Temp.Operating Life (Life span) in function	IEC60068-2-2	1000 hrs @ 85°C Ta Toper max, VCCmax
Dry heat no function	IEC60068-2-2	+125°C, 1000 hours, no function
Electrical test at Umin, Unom, Umax	ISO16750-4 IEC60068-2-1 IEC60068-2-2	Function test at Umin, Unom, Umax 1 hour / voltage level Test at -40°C, RT, +85°C, Function tests at stable temperature
Damp heat cyclic	IEC60068-2-30 Db Variation 1	+25°C...+55°C; >90% rH 6 cycles of 24 hrs
Vibration in function	IEC60068-2-6	5-500 Hz; 5g 2.5 hrs/axis at -40°C 2.5 hrs/axis at +85°C 3 hrs/axis at RT Total: 24 hrs, function supervision
Mechanical Shock	IEC60068-2-27 Ea	30 g / 11 ms (halfsine), 3 Shocks/axis, no function
Robustness of terminations of Surface Mounted Devices	IEC60068-2-21 Ue1	1 mm/s +/- 0.5 mm/s D>2 mm 1 Bending cycle Duration on Dmax: 20s +/- 1 s

Table 30: Qualification tests

6.2 Approvals



Products marked with this lead-free symbol on the product label comply with the "Directive 2002/95/EC of the European Parliament and the Council on the Restriction of Use of certain Hazardous Substances in Electrical and Electronic Equipment" (RoHS).

LEON-G1 series GSM/GPRS modules are RoHS compliant.

No natural rubbers, hygroscopic materials, or materials containing asbestos are employed.

Table 31 provides the LEON-G1 series modules' main approvals.

Country	Scope	LEON-G100-06S	LEON-G100-07S	LEON-G100-08S
EU	R&TTE	YES	YES	YES
EU	CE (NB ID: 1909)	YES	YES	YES
US	FCC	FCC ID: XPYLEONG100N	FCC ID: XPYLEONG100N	FCC ID: XPYLEONG100N
US	PTCRB	YES	YES	YES
Independent	GCF – CC plus field trials	NO	YES	YES
Canada	Industry Canada (IC)	IC: 8595A-LEONG100N MODEL: LEONG100N	IC: 8595A-LEONG100N MODEL: LEONG100N	IC: 8595A-LEONG100N MODEL: LEONG100N

Table 31: LEON-G100 certification approvals

For the complete list of countries and network operators approvals, see our website www.u-blox.com.

7 Product handling

7.1 Packaging

LEON-G1 series modules are delivered as hermetically sealed, reeled tapes to enable efficient production, production lot set-up and tear-down. For more information about packaging, see the u-blox Package Information Guide [10].



Figure 8: Reeled LEON-G1 series modules

7.1.1 Reels

LEON-G1 series modules are deliverable in quantities of 250 pieces on a reel. LEON-G1 series modules are delivered using reel Type B as described in the u-blox Package Information Guide [10].

Parameter	Specification
Reel Type	B
Delivery Quantity	250

Table 32: Reel information for LEON-G1 series modules



Quantities of less than 250 pieces are also available. Contact u-blox for more information.

7.1.2 Tapes

Figure 9 shows the position and orientation of LEON-G1 series modules as they are delivered on tape. Figure 10 specifies the tape dimensions.

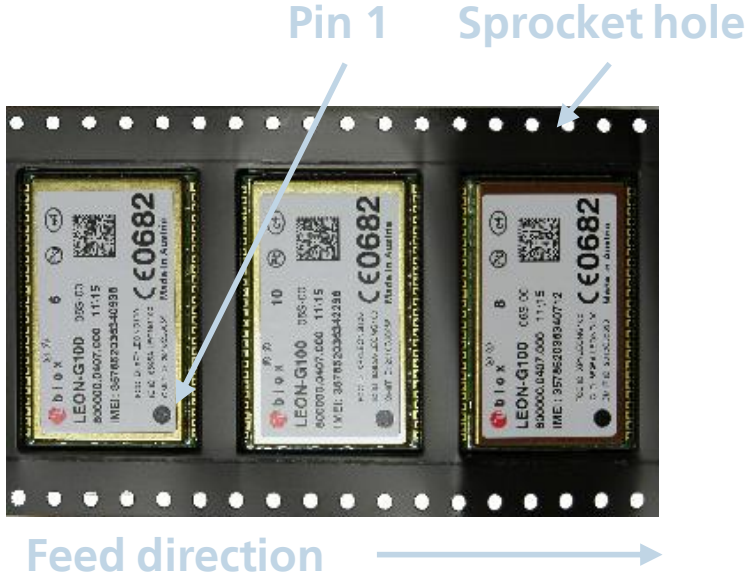


Figure 9: Orientation for LEON-G1 series modules on tape

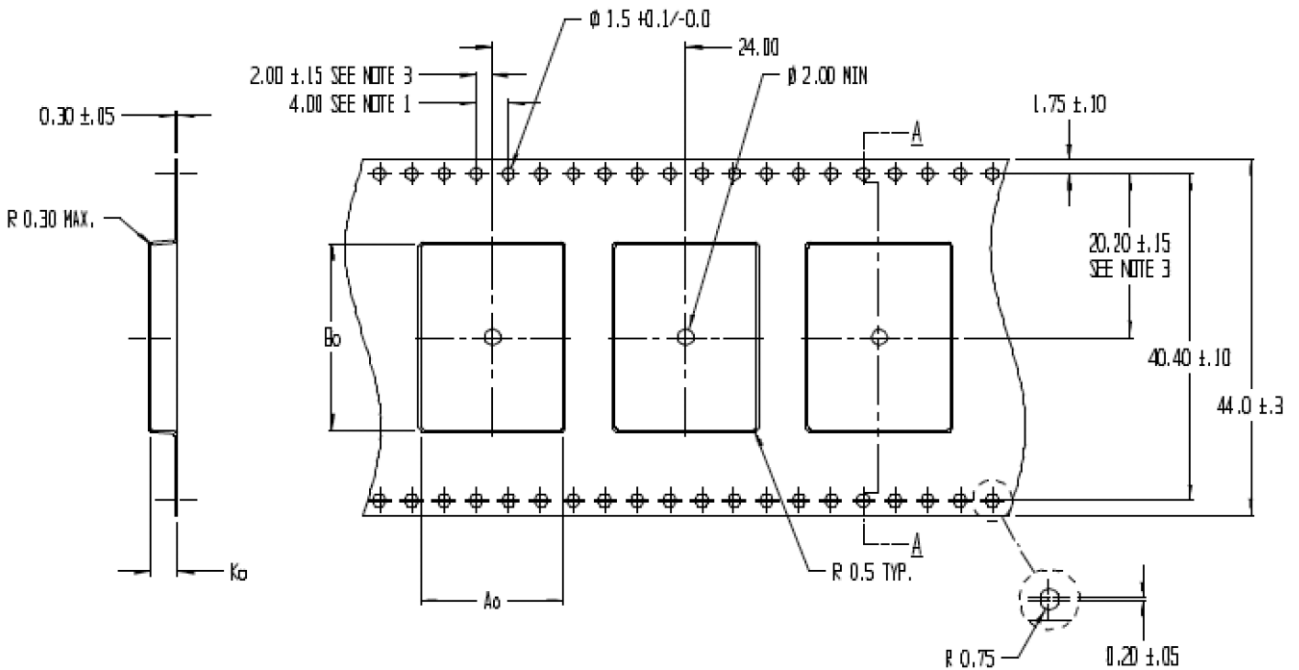






Figure 10: Dimensions for LEON-G1 series modules on tape

Parameter	Value
A_0	19.7
B_0	30.3
K_0	3.2


Table 33: LEON-G1 series tape dimensions (mm)

-  Note 1: 10 sprocket hole pitch cumulative tolerance ± 0.2 .
-  Note 2: the camber is compliant with EIA 481.
-  Note 3: the pocket position relative to sprocket hole is measured as true position of pocket, not pocket hole.
-  Note 4: A_0 and B_0 are calculated on a plane at a distance "R" above the bottom of the pocket.

7.2 Moisture sensitivity levels

 **LEON-G1 series modules are Moisture Sensitive Devices (MSD) in accordance to the IPC/JEDEC specification.**

The Moisture Sensitivity Level (MSL) relates to the packaging and handling precautions required. LEON-G1 series modules are rated at MSL level 4. For more information regarding moisture sensitivity levels, labeling, storage and drying see the u-blox Package Information Guide [10].


-  For MSL standard see IPC/JEDEC J-STD-020 (can be downloaded from www.jedec.org).

7.3 Reflow soldering

Reflow profiles are to be selected according to u-blox recommendations (see LEON-G1 series System Integration Manual [6]).

 **Failure to observe these precautions can result in severe damage to the device!**

7.4 ESD precautions

 **LEON-G1 series modules contain highly sensitive electronic circuitry and are Electrostatic Sensitive Devices (ESD). Handling LEON-G1 series modules without proper ESD protection may destroy or damage them permanently.**

LEON-G1 series modules are Electrostatic Sensitive Devices (ESD) and require special ESD precautions typically applied to ESD sensitive components.

Table 8 reports the maximum ESD ratings of the LEON-G1 series modules.

Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application that incorporates LEON-G1 series modules.

ESD precautions should be implemented on the application board where the module is mounted, as described in the LEON-G1 series System Integration Manual [6].

 **Failure to observe these precautions can result in severe damage to the device!**

8 Default settings

Interface	Settings	Comments
UART interface	AT interface: enabled	AT command interface is by default enabled on the UART physical interface
	AT+IPR=0	Automatic baud rate detection enabled by default
	AT+ICF=0	Automatic frame format recognition enabled by default
	AT&K3	HW flow control enabled
	AT&S1	DSR line sets to ON in connected mode (GPRS data transfer only) and to OFF in command mode
	AT&D1	Upon an ON-to-OFF transition of DTR, the DCE enters online command state and issues an OK result code
	AT&C1	Circuit 109 changes in accordance with the Carrier detect status; ON if the Carrier is detected, OFF otherwise
	MUX protocol: disabled	Multiplexing mode is by default disabled and it can be configured by AT+CMUX command. LEON-G1 series modules define the following virtual channels: <ul style="list-style-type: none"> • Channel 0: control channel • Channel 1 – 5: AT commands / data connection • Channel 6: GNSS tunneling
Power Saving	AT+UPSV=0	Disabled
Network registration	AT+COPS=0	Self network registration

Table 34: Available Protocols

9 Labeling and ordering information

9.1 Product labeling

The LEON-G1 series module labels include important product information as described in this section.

Figure 11 illustrates the label for all LEON-G1 series modules, and includes: u-blox logo, production lot, Pb-free marking, product Type Number, module IMEI number, FCC, IC certification numbers, model, CE marking with the Notified Body number, and production country.

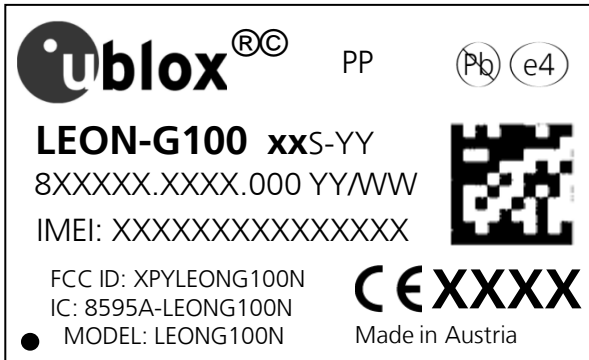


Figure 11: Location of product type number on LEON-G1 series module label



For information about approvals, see the section 6.2.

9.2 Explanation of codes

Three different product code formats are used. The **Product Name** is used in documentation such as this data sheet and identifies all u-blox products, independent of packaging and quality grade. The **Ordering Code** includes options and quality, while the **Type Number** includes the hardware and firmware versions. Table 35 below details these 3 different formats:

Format	Structure
Product Name	LEON-CDVV
Ordering Code	LEON-CDVV-TTQ
Type Number	LEON-CDVV-TTQ-XX

Table 35: Product Code Formats

Table 36 explains the parts of the product code.

Code	Meaning	Example
C	Cellular standard (i.e. G: GSM; E: EDGE; W: WEDGE; H: HSDPA; U: HSUPA, L: LTE; C: CDMA; D: EV-DO)	G: GSM
D	Generation, e.g. chip or function set; range: [0...9]	1
VV	Variant based on the same cellular chip	
TT	Major Product Version	00
Q	Quality grade <ul style="list-style-type: none"> • S = professional / made in Austria • A = automotive / made in Austria • B = standard / made in Brazil 	S
XX	HW version plus GNSS SW (not relevant for certification)	00

Table 36: Part identification code

9.3 Ordering information

Ordering No.	Product
LEON-G100-06S	Quad-band GSM/GPRS Module, 29.5 x 18.9 x 3.0 mm, 250 pcs/reel
LEON-G100-07S	Quad-band GSM/GPRS Module, 29.5 x 18.9 x 3.0 mm, 250 pcs/reel
LEON-G100-08S	Quad-band GSM/GPRS Module, 29.5 x 18.9 x 3.0 mm, 250 pcs/reel

Table 37: Product ordering codes

Appendix

A Glossary

Name	Definition
ADC	Analog to Digital Converter
AT	AT Command Interpreter Software Subsystem, or attention
BER	Bit Error Rate
DCE	Data Communication Equipment
DDC	Display Data Channel (I ² C compatible) Interface
DL	Down-link (Reception)
Driver Class	Output Driver Class: see Table 20 for definition
DRX	Discontinuous Reception
DTE	Data Terminal Equipment
DTMF	Dual-Tone Multi-Frequency
ERS	External Reset Input Signal
GDI	Generic Digital Interfaces (power domain)
GND	Ground
GNSS	Global Navigation Satellite System
GPIO	General Purpose Input Output
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
H	High logic digital level
HBM	Human Body Model
I ² C	Inter-Integrated Circuit Interface
I ² S	Inter-IC Sound Interface
L	Low logic digital level
LGA	Land Grid Array
N/A	Not Applicable
OD	Open Drain
PCN / IN	Product Change Notification / Information Note
PD	Pull-Down
POS	Power-On Input Signal
PU	Pull-Up
PU/PD Class	Pull-Up / Pull-Down Class: see Table 20 for definition
RMC	Reference Measurement Channel
SIM	Subscriber Identity Module
SPI	Serial Peripheral Interface
T	Tristate (Output of the pin set to tri-state, i.e. high impedance state)
T/PD	Tristate with internal active Pull-Down enabled
T/PU	Tristate with internal active Pull-Up enabled
TBD	To Be Defined
UART	Universal Asynchronous Receiver-Transmitter serial interface
UICC	Universal Integrated Circuit Card
UL	Up-link (Transmission)
USB	Universal Serial Bus interface

Table 38: Explanation of abbreviations and terms used

Related documents

- [1] 3GPP TS 27.007 Technical Specification Group Core Network and Terminals; AT command set for User Equipment (UE)
- [2] 3GPP TS 27.005 - Technical Specification Group Terminals; Use of Data Terminal Equipment - Data Circuit terminating Equipment (DTE-DCE) interface for Short Message Services (SMS) and Cell Broadcast Service (CBS)
- [3] 3GPP TS 27.010 - Terminal Equipment to User Equipment (TE-UE) multiplexer protocol (Release 1999)
- [4] u-blox AT Commands Manual, Docu No UBX-13002752
- [5] ITU-T Recommendation V24, 02-2000. List of definitions for interchange circuits between Data Terminal Equipment (DTE) and Data Connection Equipment (DCE)
- [6] LEON-G1 series System Integration Manual, Docu No UBX-13004888
- [7] GNSS Implementation Application Note, Docu No UBX-13001849
- [8] Mux Implementation Application Note Docu No UBX-13001887
- [9] 3GPP TS 26.267 V10.0.0 - Technical Specification Group Services and System Aspects; eCall Data Transfer; In-band modem solution; General description (Release 10)
- [10] u-blox Package Information Guide, Docu No UBX-14001652



For regular updates to u-blox documentation and to receive product change notifications, register on our homepage.

Revision history

Revision	Date	Name	Status / Comments
R01	23-Jan-2014	lpah	Initial release
R02	18-Dec-2014	lpah	Changed status to Production Information

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