AirPrime HL6528x

Product Technical Specification

SIERRA WIRELESS®

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15.0
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Important Notice

Due to the nature of wireless communications, transmission and reception of data can never be guaranteed. Data may be delayed, corrupted (i.e., have errors) or be totally lost. Although significant delays or losses of data are rare when wireless devices such as the Sierra Wireless modem are used in a normal manner with a well-constructed network, the Sierra Wireless modem should not be used in situations where failure to transmit or receive data could result in damage of any kind to the user or any other party, including but not limited to personal injury, death, or loss of property. Sierra Wireless accepts no responsibility for damages of any kind resulting from delays or errors in data transmitted or received using the Sierra Wireless modem, or for failure of the Sierra Wireless modem to transmit or receive such data.

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Document History

Version	Date	Updates
0.1	April 4th, 2013	Creation
0.2	May 13, 2013	Footprint definition update
0.3	May 24, 2013	Mechanical definition change
0.4	May 31, 2013	Padout definition change Mechanical definition change
0.5	June 7, 2013	Add product label Correct max current Correct padout definition
0.6	June 8, 2013	Add 2G_TX_ON information Add VBATT_PA information
0.7	July 12, 2013	Added: • 4 pad UART0 • UIM1_DET and UIM2_DET signal on default pads • References section • Terms and Abbreviations chapter Corrected Module Tolerance Changed HL6528-G VBATT Max to 4.5V
1.0	July 23, 2013	Major changes to pad definitions: • UART0 removed • Add SPI for SW Traces • Change I²C location • Add TP1, TP2 pads Added customer guidelines including: • Power_on sequence • ESD • Audio design • Radio design
2.0	October 24, 2013	Added: • CF3 pad information • New product variants (HL6528-2.8V and HL6528-G2.8V) • Antenna detection circuitry
		Updated: • Module thickness from 2.55mm to 2.50mm • Pad 57 to support BUZZER output • Section 2 Pad Definition
3.0	January 28, 2014	Added: • Weight in section 1.2 Physical Dimensions • 1.4 Feature Restriction • Table 49 FCC IDs • Table 50 IC IDs
		Updated: • 3.2 Current Consumption • 3.5 UIM Interface • 3.19 GNSS Interface

Version	Date	Updates
4.0	June 06, 2014	Added: • 5.5 Power Supply • 5.9 BUZZER • 5.10 PWM • 5.11 Temperature Monitor • 6 Flash Memory Endurance • 7 Reliability Specification
		Updated: • Electrical characteristics of multiple interfaces • 2 Pad Definition • 3.5 UIM Interface • 3.14 I^2C Interface
		Deleted section 6 X-Ray Exposure
4.1	June 12, 2014	Fixed typos in section 3.14 I^2C Interface
		Updated Table 43 Life Stress Test
4.2	June 19, 2014	Deleted 1.9 ESD
		Added a note in section 7.3.6 Handling Resistance Stress Tests
5.0	July 23, 2014	Updated: • Table 7 Pad Description • Figure 4 UIM1 Implementation Example • Figure 7 8-wire UART Application Example • Figure 8 4-wire UART Application Example
		Added 3.8.3 2-wire Application
6.0	May 07, 2015	Updated: • 2 Pad Definition • Figure 6 Analog Switch Connection Example • Table 35 GNSS Interface Specifications • 3.19.3 GNSS Antenna Recommendations
6.1	May 14, 2015	Updated switch reference number in section 3.5.2.2 UIM2_VCC_CTRL
7.0	July 07, 2015	Updated: • Figure 2 Mechanical Overview • Table 17 Digital I/O Electrical Characteristics • 3.8 Main Serial Link (UART1) • 3.13 PCM
	July 28, 2015	Added: • 3.7 General Purpose Input/Output (GPIO) • Table 9 AC Ripple Noise Level on Power Supply
8.0	October 08, 2015	Updated: • Table 17 Digital I/O Electrical Characteristics • 3.8 Main Serial Link (UART1)
9.0	November 16, 2015	Fixed level shifter recommendation typo in 3.8 Main Serial Link (UART1)
10.0	January 07, 2016	Updated: • 1.4 Feature Restriction • 3.13 PCM
11.0	May 30, 2016	Updated 3.19.3 GNSS Antenna Recommendations
11.1	June 01, 2016	Added 1.10 Conformance with ATEX 94/9/CE Directive
		Updated Table 5 Regulation Compliance
12.0	July 19, 2017	Updated Table 17 Digital I/O Electrical Characteristics

Version	Date	Updates
12.1	July 31, 2017	Updated Table 17 Digital I/O Electrical Characteristics
13.0	January 31, 2018	Added 5.6 Power Cycle
14.0	June 12, 2018	Updated: • 1.9.3 RoHS Directive Compliance • 3.18 RF Interface
15.0	June 05, 2019	Updated 3.15.2 JTAG

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1. Introduction

This document defines the high-level product features and illustrates the interfaces for the AirPrime HL6528x series of embedded modules. This document is intended to cover the hardware aspects of the product series, including electrical and mechanical.

Variants covered in this document are:

- HL6528
- HL6528-G
- HL6528-2.8V
- HL6528-G2.8V

The AirPrime HL6528 and HL6528-G modules are 1.8V IO modules as defined in section 2 Pad Definition. 2.8V IO variants are also available, and defined throughout this document as HL6528-2.8V and HL6528-G2.8V. HL6528x denotes applicability to all four variants.

The AirPrime HL6528x belongs to the AirPrime HL Series from Essential Connectivity Module family. This is an Industrial Grade quad-band GSM/GPRS Embedded Wireless Module, designed for the automotive market and any other market with similar quality and life-time support requirements. The following table enumerates the frequencies supported by the HL6528x module.

Table 1. Supported Frequencies

RF Band	Transmit Band (Tx)	Receive Band (Rx)	Maximum Output Power
GSM 850	824 to 849 MHz	869 to 894 MHz	2 Watts GSM & GPRS
E-GSM 900	880 to 915 MHz	925 to 960 MHz	2 Watts GSM & GPRS
DCS 1800	1710 to 1785 MHz	1805 to 1880 MHz	1-Watt GSM & GPRS
PCS 1900	1850 to 1910 MHz	1930 to 1990 MHz	1-Watt GSM & GPRS

This module supports a large variety of interfaces such as Analog and Digital Audio and Dual UIM Dual Standby to provide customers with the highest level of flexibility in implementing high-end solutions. In addition, both AirPrime HL6528-G and HL6528-G2.8V modules also embed a high-performance GNSS receiver.

1.1. Common Flexible Form Factor (CF^3)

The AirPrime HL6528x module belongs to the Common Flexible Form Factor (CF^3) family of modules. This family consists of a series of WWAN modules that share the same mechanical dimensions (same width and length with varying thicknesses) and footprint. The CF^3 form factor provides a unique solution to a series of problems faced commonly in the WWAN module space as it:

- Accommodates multiple radio technologies (from 2G to LTE advanced) and band groupings
- Supports bit-pipe (Essential Module Series) and value add (Smart Module Series) solutions
- Offers electrical and functional compatibility
- Provides Direct Mount as well Socketability depending on customer needs

1.2. Physical Dimensions

The AirPrime HL6528x modules are compact size, robust, fully shielded modules with:

- Length: 23 mm
- Width: 22 mm
- Thickness: 2.50 mm (including the label)
- Weight: 2.25g

Note: Dimensions specified above are typical values.

1.3. General Features

The table below summarizes the AirPrime HL6528x module features.

Table 2. General Features

Feature	Description
GSM Output Power	• Class 4 (2 W) for GSM 850 and E-GSM 900 • Class 1 (1 W) for DCS 1800 and PCS 1900
GPRS	• Quad-band GSM 850/E-GSM 900/DCS 1800/PCS 1900 • GPRS Multi-slot class 10 • R99 support • PBCCH support • Coding schemes: CS1 to CS4
Audio Interface	• Analog and Digital interfaces • Supports Full Rate (FR), Enhanced Full Rate (EFR), Half Rate (HR) and Adaptive Multi Rate (AMR) • Noise reduction and echo cancellation • DTMF generation
UIM Interface	• Dual UIM Dual Standby support • 1.8V/3.0V support for UIM1 • 3V interface for UIM2 • Supports UIM application tool kit with proactive UIM commands
Application Interface	• Full set of AT commands for GSM/GPRS including GSM 07.07 and 07.05 AT command sets • Comprehensive set of dedicated AT commands for M2M applications
SMS	• SMS class 0,1 and 2 • SMS MT, MO • SMS storage into UIM card or Flash memory • Concatenation of MT SMS
Supplementary Services	• Call Forwarding • Call Barring • Multiparty Service • Call Waiting • Call Hold • USSD • Automatic answer

Feature	Description
RTC	Real Time Clock (RTC) with calendar and alarm
Temperature Sensor	• Temperature monitoring • Alarms

1.4. Feature Restriction

1.4.1. AVMS FOTA

Powering the HL6528x module down during an AVMS FOTA update (or during a local update using `+WDSD`), especially between `+WDSI:14` and the module's reboot, should be avoided.

1.4.2. TTS

The AirPrime HL6528-G and HL6528-G2.8V modules are not compatible with TTS (Text To Speech) feature, which is part of AVL (Automatic Vehicle Location) feature.

1.5. GNSS Features

The table below summarizes the GNSS capabilities of the AirPrime HL6528-G and HL6528-G2.8V modules.

Table 3. GNSS Capabilities

Feature	Description
GPS	L1 band (CDMA 1575.42 MHz)
GLONASS	L1 Band (FDMA 1602MHz)
SBAS	WAAS, EGNOS, MSAS, GAGAN, QZSS
Channels	52
Antenna	Passive or active antenna support
Assistance data	Server-generated Extended Ephemeris

1.6. Architecture

The figure below presents an overview of the AirPrime HL6528x module internal architecture and external interfaces.

Note: Dotted parts are only supported on the AirPrime HL6528-G and HL6528-G2.8V.

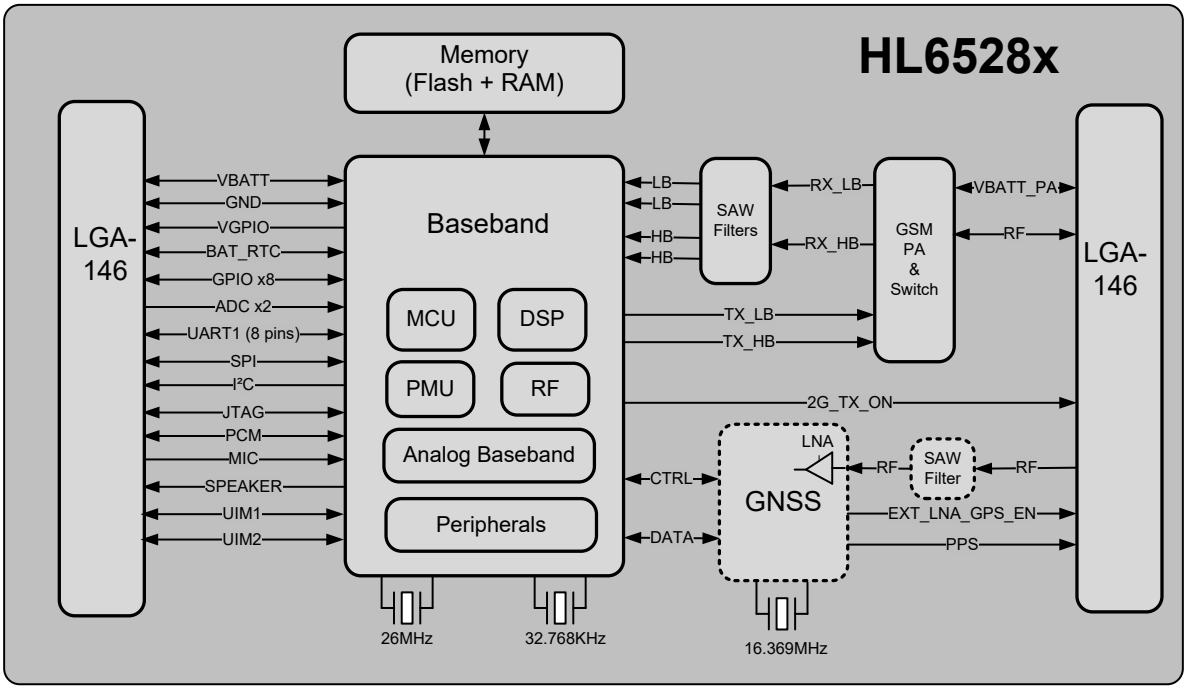


Figure 1. Architecture Overview

1.7. Interfaces

The AirPrime HL6528 and HL6528-2.8V modules provide the following interfaces and peripheral connectivity:

- 1 8-wire UART
- Active Low RESET_IN
- Active Low PWR_ON
- 1 1.8V/3V UIM
- 1 UIM 3V
- 1 Analog Audio Interface (Differential input/output)
- 1 Digital Audio
- 1 I^2C
- 2 ADC
- 1 JTAG Interface
- 8 GPIOs, 5 of which have multiplexes
- 2G TX Burst Indicator
- GSM Antenna

Note: The SPI interface is dedicated to and can only be used for SW traces debug.

In addition to the interfaces above, the AirPrime HL6528-G and HL6528-G2.8V modules also provide the following interfaces and peripheral connectivity:

- GPS Antenna
- External LNA Enable/Disable
- Pulse Per Second

1.8. Connection Interface

The AirPrime HL6528x module is an LGA form factor device. All electrical and mechanical connections are made through the 146 pads Land Grid Array (LGA) on the bottom side PCB.

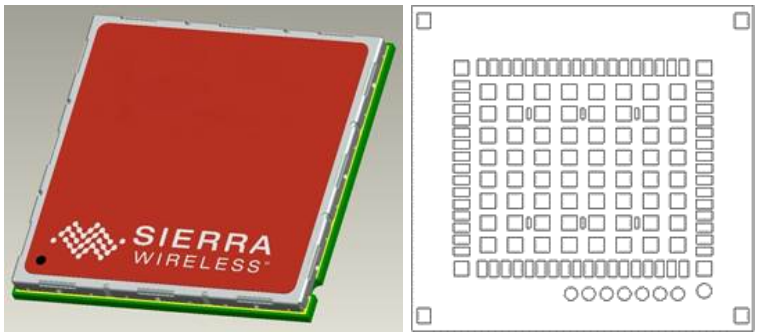


Figure 2. Mechanical Overview

The 146 pads have the following distribution

- 66 inner signal pads, 1x0.5mm, pitch 0.8mm
- 1 reference test point (Ground), 1.0mm diameter
- 7 test point (JTAG), 0.8mm diameter, 1.20mm pitch
- 64 inner ground pads, 1.0x1.0mm, pitch 1.825mm/1.475mm
- 4 inner corner ground pads, 1x1mm
- 4 outer corner ground pads, 1x0.9mm

1.9. Environmental and Certifications

1.9.1. Environmental Specifications

The environmental specification for both operating and storage conditions are defined in the table below.

Table 4. Environmental Specifications

Conditions	Range
Operating Class A	-30°C to +70°C
Operating Class B	-40°C to +85°C
Storage	-40°C to +90°C

Class A is defined as the operating temperature ranges that the device:

- Shall exhibit normal function during and after environmental exposure.
- Shall meet the minimum requirements of 3GPP or appropriate wireless standards.

Class B is defined as the operating temperature ranges that the device:

- Shall remain fully functional during and after environmental exposure
- Shall exhibit the ability to establish a voice, SMS or DATA call (emergency call) at all times even when one or more environmental constraint exceeds the specified tolerance.
- Unless otherwise stated, full performance should return to normal after the excessive constraint(s) have been removed.

1.9.2. Regulatory

The AirPrime HL6528x module is compliant with the following regulations: R&TTE directive, GCF-CC, CE marking, FCC, and PTCRB.

Table 5. Regulation Compliance

Document	Current Version	Title
NAPRD.03	v5.18	Overview of PCS Type certification review board (PTCRB) Mobile Equipment Type Certification and IMEI control
GCF-CC	v3.52.1	GCF Conformance Certification Criteria
TS 51.010-1	V11.3.0 (2014-01)	3rd Generation Partnership Project; Technical Specification Group GSM/EDGE Radio Access Network; Digital cellular telecommunications system (Phase 2+); Mobile Station (MS) conformance specification; Part 1: Conformance specification
EN 301511	V9.0.2 (2003-03)	Global System for Mobile Communications (GSM); Harmonized EN for Mobile Stations in the GSM 900 and GSM 1800 Bands Covering Essential Requirements Under Article 3.2 of the R&TTE Directive (1999/5/EC)
EN 301489-1	V1.9.2 (2011-09)	Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements
EN 301489-3	V1.6.1 (2013-08)	Electromagnetic compatibility and Radio spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) standard for radio equipment and services; Part 3: Specific conditions for Short-Range Devices (SRD) operating on frequencies between 9 KHz and 40 GHz
EN 301489-7	V1.3.1 (2005-11)	Electromagnetic Compatibility and Radio Spectrum Matters (ERM); ElectroMagnetic Compatibility (EMC) Standard for Radio Equipment and Services; Part 7: Specific Conditions for Mobile and Portable Radio and Ancillary Equipment of Digital Cellular Radio Telecommunications Systems (GSM and DCS)
EN 60950-1	NA	IEC 60950-1:2005/A1:2009 EN 60950-1:2006/A11:2009/A1:2010/A12:2011 Information technology equipment – safety- and general requirements
EN 300440-1	v1.6.1 (2012-08)	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short range devices; Radio equipment to be used in the 1 GHz to 40 GHz frequency range; Part 1: Technical characteristics and test methods

Document	Current Version	Title
EN 300440-2	V1.4.1 (2012-08)	Electromagnetic compatibility and Radio spectrum Matters (ERM); Short range devices; Radio equipment to be used in the 1 GHz to 40 GHz frequency range; Part 2: Harmonized EN under article 3.2 of the R&TTE Directive
FCC Part 15B	NA	Subpart B - Radio frequency devices subpart B – Unintentional Radiators
FCC Part 22H	NA	Cellular Radiotelephone Service; Subpart H: Cellular Radiotelephone Service
FCC Part 24E	NA	Personal Communications Service; Subpart E: Broadband PCS
RSS-132	Issue 3:2013	Cellular telephones employing new technologies operating in the 824-849 MHz and 869-894 MHz bands.
RSS-133	Issue 6:2013	2 GHz personal communications services
CCC	NA	China Compulsory Certification

1.9.3. RoHS Directive Compliance

AirPrime HL6528x modules are compliant with RoHS Directive 2011/65/EU, including directive 2015/863 amending annex II, which sets limits for the use of certain restricted hazardous substances. This directive states that electrical and electronic equipment put on the market does not contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), polybrominated diphenyl ethers (PBDE), Bis (2-ethylhexyl) phthalate (DEHP), Butyl benzyl phthalate (BBP), Dibutyl phthalate (DBP) or Diisobutyl phthalate (DIBP) above threshold limits.

1.9.4. Disposing of the Product

This electronic product is subject to the EU Directive 2012/19/EU for Waste Electrical and Electronic Equipment (WEEE). As such, this product must not be disposed of at a municipal waste collection point. Please refer to local regulations for directions on how to dispose of this product in an environmentally friendly manner.

1.10. Conformance with ATEX 94/9/CE Directive

To evaluate the conformity of a product using the AirPrime HL6528x with ATEX 94/9/CE directive, the integrator must take into account the following data from the AirPrime HL6528x.

Table 6. Values for ATEX Conformance

Variant	Sum of all Capacitors	Sum of all Inductors	Biggest Single Capacitor	Biggest Single Inductor
HL6528 (PCA# 1600707)	50 µF	7 µH	10 µF ± 10%	4.7 µH ± 30%
HL6528-G (PCA# 1600661)	60 µF	8 µH	10 µF ± 10%	4.7 µH ± 30%

Variant	Sum of all Capacitors	Sum of all Inductors	Biggest Single Capacitor	Biggest Single Inductor
HL6528-2.8V (PCA# 1600708)	50 µF	7 µH	10 µF ± 10%	4.7 µH ± 30%
HL6528-G2.8V (PCA# 1600709)	60 µF	8 µH	10 µF ± 10%	4.7 µH ± 30%

1.11. References

[1] AirPrime HL Series Customer Process Guidelines
Reference Number: 4114330

[2] AirPrime HL6 and HL8 Series AT Commands Interface Guide
Reference Number: 4114680

[3] AirPrime HL Series Development Kit User Guide
Reference Number: 4114877

2. Pad Definition

AirPrime HL6528x module pads are divided into 3 functional categories.

- **Core functions and associated pads** cover all the mandatory features for M2M connectivity and will be available by default across all CF[3] family of modules. These Core functions are always available and always at the same physical pad locations. A customer platform using only these functions and associated pads is guaranteed to be forward and/or backward compatible with the next generation of CF[3] modules.
- **Extension functions and associated pads** bring additional capabilities to the customer. Whenever an Extension function is available on a module, it is always at the same pad location.
- **Custom functions and associated pads** are specific to a given module, and make an opportunistic use of specific chipset functions and I/Os. Custom features should be used with caution as there is no guarantee that the custom functions available on a given module will be available on other CF[3] modules.

Other pads marked as “not connected” or “reserved” should not be used.

Table 7. Pad Description

Pad #	Signal Name	Function	I/O	Active Low / High	IO Voltage Domain for HL6528 and HL6528-G	IO Voltage Domain for HL6528-2.8V and HL6528-G2.8V	Reset State	Reset Value**	Default State	Default Value	Recommendation for Unused Pads	Type
1	GPIO1 / I2C1_CLK	General purpose input/output / I²C serial clock line	I/O		1.8V	2.8V	I	Pull down	I	Pull down	Left Open	Extension
2	UART1_RI	UART1 Ring indicator	O		1.8V	2.8V	I	Pull up			Left Open	Core
3	UART1_RTS	UART1 Request to send	I	L	1.8V	2.8V	I	Hi-Z			Connect to UART1_CTS	Core
4	UART1_CTS	UART1 Clear to send	O	L	1.8V	2.8V	O	Low			Connect to UART1_RTS	Core
5	UART1_TX	UART1 Transmit data	I		1.8V	2.8V	I	Hi-Z			Mandatory connection	Core
6	UART1_RX	UART1 Receive data	O		1.8V	2.8V	O	Low			Mandatory connection	Core

Pad #	Signal Name	Function	I/O	Active Low / High	IO Voltage Domain for HL6528 and HL6528-G	IO Voltage Domain for HL6528-2.8V and HL6528-G2.8V	Reset State	Reset Value**	Default State	Default Value	Recommendation for Unused Pads	Type
7	UART1_DTR	UART1 Data terminal ready	I	L	1.8V	2.8V	I	Pull down			Connect to UART1_DSR	Core
8	UART1_DCD	UART1 Data carrier detect	O	L	1.8V	2.8V	I	Pull down			Left Open	Core
9	UART1_DSR	UART1 Data set ready	O	L	1.8V	2.8V	I	Pull up			Connect to UART1_DTR	Core
10	GPIO2 / UIM2_VCC_ CTRL	General purpose input/output / UIM2 VCC Control	I/O		1.8V	2.8V	I	Pull up	O	Pull up	Left Open	Core
11	RESET_IN	Input reset signal	I	L	1.8V	2.8V	I	Low			Left Open (Test point recommended)	Core
12	NC	Not Connected										Not Connected
13	NC	Not Connected										Not Connected
14	NC	Not Connected										Not Connected
15	NC	Not Connected										Not Connected
16	NC	Not Connected										Not Connected
17	SPKR_N	Speaker negative output (32Ω impedance)	O		2.8V	2.8V	O	Low			Left Open	Extension
18	SPKR_P	Speaker positive output (32Ω impedance)	O		2.8V	2.8V	O	Low			Left Open	Extension
19	MIC_P	Microphone positive input	I		2.8V	2.8V	I	Pull down			Left Open	Extension
20	MIC_N	Microphone negative input	I		2.8V	2.8V	I	Pull down			Left Open	Extension
21	BAT_RTC	Power supply for RTC backup	I/O		3.0V	3.0V	O	Low			C=10µF	Extension
22	TP2	Internal Sierra Wireless use only	I	L	1.8V	2.8V	I	Hi-Z			Mandatory Left Open	Custom

Pad #	Signal Name	Function	I/O	Active Low / High	IO Voltage Domain for HL6528 and HL6528-G	IO Voltage Domain for HL6528-2.8V and HL6528-G2.8V	Reset State	Reset Value**	Default State	Default Value	Recommendation for Unused Pads	Type
23	NC	Not Connected										Not Connected
24	ADC1	Analog to digital conversion	I		3V	3V	I	Hi-Z			Connected to Ground	Extension
25	ADC0	Analog to digital conversion	I		3V	3V	I	Hi-Z			Connected to Ground	Extension
26	UIM1_VCC	1.8V/3V UIM1 Power supply	O		1.8V/3V	1.8V/3V	O	Low			Mandatory connection	Core
27	UIM1_CLK	1.8V/3V UIM1 Clock	O		1.8V/3V	1.8V/3V	O	Low			Mandatory connection	Core
28	UIM1_DATA	1.8V/3V UIM1 Data	I/O		1.8V/3V	1.8V/3V	I/O	Low			Mandatory connection	Core
29	UIM1_RESET	1.8V/3V UIM1 Reset	O	L	1.8V/3V	1.8V/3V	O	Low			Mandatory connection	Core
30	NC	NC (Reserved for 3G compatibility)										Not Connected
31	NC	NC (Reserved for 3G compatibility)										Not Connected
32	NC	NC (Reserved for 3G compatibility)										Not Connected
33	PCM_OUT	PCM data out	O		2.8V	2.8V	O	Low			Left Open	Extension
34	PCM_IN	PCM data in	I		2.8V	2.8V	I	Hi-Z			Left Open	Extension
35	PCM_SYNC	PCM sync out	I/O		2.8V	2.8V	I/O	Low			Left Open	Extension
36	PCM_CLK	PCM clock	I/O		2.8V	2.8V	I/O	Low			Left Open	Extension
37	GND	Ground	GND		0V	0V					Mandatory connection	Core
38	RF_GPS*	RF GPS Input	I								Mandatory connection	Extension
39	GND	Ground	GND		0V	0V					Mandatory connection	Core
40	GPIO7	General purpose input/output	I/O		1.8V	2.8V	I	Pull down	I	Pull down	Left Open	Core
41	GPIO8	General purpose input/output	I/O		1.8V	2.8V	I	Pull down	I	Pull down	Left Open	Core
42	PPS*	GPS Pulse Per Second	O		1.8V	2.8V		Weak hold			Left Open	Extension

Pad #	Signal Name	Function	I/O	Active Low / High	IO Voltage Domain for HL6528 and HL6528-G	IO Voltage Domain for HL6528-2.8V and HL6528-G2.8V	Reset State	Reset Value**	Default State	Default Value	Recommendation for Unused Pads	Type
43	EXT_LNA_ GPS_EN*	External GPS LNA enable	O	H	1.8V	2.8V		Weak hold			Left Open	Extension
44	SPI1_SRDY	SPI Slave Ready (Debug use only)	I		1.8V	2.8V	I	Pull down			Left Open (Test point mandatory)	Extension
45	VGPIO	GPIO voltage output	O		1.8V	2.8V	O	Low			Left Open	Core
46	GPIO6	General purpose input/output	I/O		1.8V	2.8V	I	Pull down	I	Pull down	Left Open	Core
47	TP1	Test Point 1 0 - JTAG Enable Open - Normal Mode	I	L	1.8V	2.8V	I	Pull up			Mandatory Left Open	Extension
48	GND	Ground	GND		0V	0V					Mandatory connection	Core
49	RF_MAIN	RF GSM Input/output	I/O								Mandatory connection	Core
50	GND	Ground	GND		0V	0V					Mandatory connection	Core
51	SPI1_MRDY	SPI Master Ready (Debug use only)	O		1.8V	2.8V	I	Pull up			Left Open (Test point mandatory)	Extension
52	SPI1_MISO	SPI Master In Slave Out (Debug use only)	I		1.8V	2.8V	I	Pull down			Left Open (Test point mandatory)	Extension
53	SPI1_CLK	SPI Clock (Debug use only)	O		1.8V	2.8V	I	Pull down			Left Open (Test point mandatory)	Extension
54	SPI1_MOSI	SPI Master Out Slave In (Debug use only)	O		1.8V	2.8V	I	Pull down			Left Open (Test point mandatory)	Extension
55	UIM2_VCC	UIM2 Power supply	O		2.8V	2.8V	O	Low			Left Open	Extension
56	UIM2_DATA	UIM2 Data	I/O		2.8V	2.8V	O	Low			Left Open	Extension
57	UIM2_RESET / BUZZER	UIM2 Reset / Buzzer	O		2.8V	2.8V	O	Low			Left Open	Extension
58	UIM2_CLK / PWM	UIM2 Clock / PWM	O		2.8V	2.8V	O	Low			Left Open	Extension
59	PWR_ON	Active Low Power On control signal	I/O	L	3.0V	3.0V	I	Pull up			Mandatory connection	Core
60	2G_TX_ON	2G TX burst indicator	O	H	2.85V	2.85V	O	Low			Left Open	Extension

Pad #	Signal Name	Function	I/O	Active Low / High	IO Voltage Domain for HL6528 and HL6528-G	IO Voltage Domain for HL6528-2.8V and HL6528-G2.8V	Reset State	Reset Value**	Default State	Default Value	Recommendation for Unused Pads	Type
61	VBATT_PA	3.7V Power Amplifier Power supply	I		3.7V	3.7V					Mandatory connection	Core
62	VBATT_PA	3.7V Power Amplifier Power supply	I		3.7V	3.7V					Mandatory connection	Core
63	VBATT	3.7V Power supply	I		3.7V	3.7V					Mandatory connection	Core
64	UIM1_DET / GPIO3	UIM1 Detection / General purpose input/output	I/O	H	1.8V	2.8V	I	Pull up	I	Pull down	Left Open	Core
65	UIM2_DET / GPIO4	UIM2 Detection / General purpose input/output	I/O	H	1.8V	2.8V	I	Pull down	I	Pull down	Left Open	Extension
66	GPIO5 / I2C1_DATA	General purpose input/output / I²C serial data line	I/O		1.8V	2.8V	I	Pull down	I	Pull down	Left Open	Extension
67-70	GND	Ground	GND		0V	0V					Mandatory connection	Core
71-166	*Note: These pads are not available on the AirPrime HL6548x modules.*											
167-234	GND	GND	GND		0V	0V					Mandatory connection	Core
236	JTAG_RESET	JTAG RESET	I	L	1.8V	2.8V	I	Low			Left Open	Extension
237	JTAG_TCK	JTAG Test Clock	I		1.8V	2.8V	O	Low			Left Open	Extension
238	JTAG_TDO	JTAG Test Data Output	O		1.8V	2.8V	I	Low			Left Open	Extension
239	JTAG_TMS	JTAG Test Mode Select	I		1.8V	2.8V	I	Low			Left Open	Extension
240	JTAG_TRST	JTAG Test Reset	I	L	1.8V	2.8V	I	Low			Left Open	Extension
241	JTAG_TDI	JTAG Test Data Input	I		1.8V	2.8V	O	Low			Left Open	Extension
242	JTAG_RTCK	JTAG Returned Test Clock	O		1.8V	2.8V					Left Open	Extension

* This pad is only available on the HL6528-G and H6528-G2.8V.

** Pull-up/pull-down with 100kΩ resistance (±20%).

2.1. Pad Configuration (Top View)

Figure 3. Pad Configuration

3. Detailed Interface Specifications

Note: If not specified, all electrical values are given for VBATT=3.7V and an operating temperature of 25°C.

If needed, the AirPrime HL6528x module can support two different voltages for VBATT and VBATT_PA power inputs. However, using the same power supply for both signals is recommended.

3.1. Power Supply

The AirPrime HL6528x module is supplied through the VBATT signal with the following characteristics.

Table 8. Power Supply

	Minimum	Typical	Maximum
VBATT voltage (V)	3.2[1]	3.7	4.5
VBATT_PA voltage (V) Full Specification	3.0[1]	3.7	4.5
VBATT_PA voltage (V) Extended Range[2]	2.8[2]	3.7	4.5

1 This value must be guaranteed during the burst

2 No guarantee of 3GPP performances over extended range

Table 9. AC Ripple Noise Level on Power Supply

Frequency (kHz)	Maximum AC Ripple Noise Level
< 10kHz	100mVp-p
10kHz ≤ frequency ≤ 200kHz	50mVp-p
> 200kHz	3mVp-p

3.2. Current Consumption

The following table lists the current consumption of the AirPrime HL6528x module at different conditions.

Note: Typical values are defined for VBATT/VBATT_PA at 3.7V and 25°C, for 50Ω impedance at all RF ports. Maximum values are provided for VSWR 3:1 with worst conditions among supported ranges of voltage and temperature.

Table 10. Current Consumption

Parameters		Min.	Typ.	Max.
Off mode (HL6528 and HL6528-2.8V) (µA)		24	37	56
Off mode (HL6528-G and HL6528-G2.8V) (µA)		24	37	56
GSM Sleep mode (average, mA) Single UIM operation	DRX2	1.1	1.3	2.9
	DRX5	0.8	1.0	2.5
	DRX9	0.8	0.9	2.4

Parameters		Min.	Typ.	Max.
GSM Sleep mode (average, mA) Dual UIM operation	DRX2	2.4	3.1	5.3
	DRX5	1.4	1.8	3.7
	DRX9	1.2	1.4	3.0
GSM in communication mode (average, mA)	E-GSM 900 / GSM 850 (PCL=5)	190	220	410
	DCS 1800/ PCS 1900 (PCL=0)	140	160	280
GPRS (2 TX, 3 RX) (average, mA)	E-GSM 900 / GSM 850 (PCL=5)	325	380	700
	DCS 1800/ PCS 1900 (PCL=0)	230	270	450
Peak Current consumption (peak, A)	E-GSM 900 / GSM 850	1.2	1.50	1.8
	DCS 1800/ PCS 1900	0.8	0.90	1.0
GNSS Acquisition[1] (average, mA) GSM registered on network	Max value[3]	37	51	73
	Min value[4]	21	31	44
GNSS Acquisition[1] (average, mA) GSM in Flight mode	Max value[3]	37	51	73
	Min value[4]	21	31	44
GNSS Navigation (1Hz)[1] (average, mA) GSM registered on network	Max value[3]	33	45	65
	Min value[4]	17	25	36
GNSS Navigation (1Hz)[1] (average, mA) GSM in Flight mode	Max value[3]	33	45	65
	Min value[4]	17	25	36
GNSS Hibernate mode[2] (average, mA) GSM registered on network	Max value[3]	16	20	29
	Min value[4]	0.9	1.2	2.9

1 Maximum SVs in view, signal level @-130dBm, high gain configuration

2 Hot start conditions are maintained in Hibernate mode

3 Baseband is running (or no sleep mode allowed) in max value condition. Refer to document [2] AirPrime HL6 and HL8 Series AT Commands Interface Guide for sleep mode description.

4 Baseband is in sleep mode in min value condition. Refer to document [2] AirPrime HL6 and HL8 Series AT Commands Interface Guide for sleep mode description.

Table 11. Current Consumption per Power Supply (VBATT / VBATT_PA)

Parameters			Min.	Typ.	Max.
VBATT_PA	Peak current (A) GPRS communication mode, 2TX	E-GSM 900 / GSM 850 (PCL=5)	1.0	1.3	1.8
		DCS 1800/ PCS 1900 (PCL=0)	0.7	0.8	1.0
	Peak current (A) GSM communication mode, 1TX	E-GSM 900 / GSM 850 (PCL=5)	1.0	1.3	1.8
		DCS 1800/ PCS 1900 (PCL=0)	0.7	0.8	1.0
	Average current (mA) GSM communication mode, 1TX	E-GSM 900 / GSM 850 (PCL=5)	125	150	325
		DCS 1800/ PCS 1900 (PCL=0)	75	90	195

Parameters			Min.	Typ.	Max.
VBATT (HL6528 and HL6528-2.8V)	Peak current (A) GPRS communication mode, 2TX	E-GSM 900 / GSM 850 (PCL=5)	0.25	0.32	0.4
		DCS 1800/ PCS 1900 (PCL=0)	0.2	0.22	0.3
	Peak current (A) GSM communication mode, 1TX	E-GSM 900 / GSM 850 (PCL=5)	0.25	0.32	0.4
		DCS 1800/ PCS 1900 (PCL=0)	0.2	0.22	0.3
	Average current (mA) GSM communication mode, 1TX	E-GSM 900 / GSM 850 (PCL=5)	65	72	85
		DCS 1800/ PCS 1900 (PCL=0)	65	72	85
VBATT (HL6528-G and HL6528-G2.8V)	Peak current (A) GPRS communication mode, 2TX GNSS Navigation mode	E-GSM 900 / GSM 850 (PCL=5)	0.3	0.34	0.4
		DCS 1800/ PCS 1900 (PCL=0)	0.2	0.23	0.3
	Peak current (A) GSM communication mode, 1TX GNSS Navigation mode	E-GSM 900 / GSM 850 (PCL=5)	0.3	0.35	0.4
		DCS 1800/ PCS 1900 (PCL=0)	0.2	0.25	0.3
	Average current (mA) GSM communication mode, 1TX GNSS Navigation mode	E-GSM 900 / GSM 850 (PCL=5)	85	97	120
		DCS 1800/ PCS 1900 (PCL=0)	85	97	120

3.3. VGPIO

The VGPIO output can be used to:

- Pull-up signals such as I/Os
- Supply the digital transistors driving LEDs
- Act as a voltage reference for the ADC interfaces, ADC0 and ADC1

The VGPIO output is available when the AirPrime HL6528x module is switched ON.

Table 12. VGPIO Electrical Characteristics

Parameter	HL6528, HL6528G			HL6528-2.8V, HL6528-G2.8V			Remarks
	Min	Typ	Max	Min	Typ	Max	
Voltage level (V)	1.70	1.80	1.90	2.7	2.80	2.95	Both active mode and sleep mode
Current capability active mode (mA)	-	-	50	-	-	50	
Current capability sleep mode (mA)	-	-	3	-	-	3	32KHz system clock enable
Line regulation (mV/V)	-	-	50	-	-	50	Iout = MAX
Rise Time (ns)	-	-	6	-	-	6	Test load capacitor = 30 pF

3.4. BAT_RTC

The AirPrime HL6528x module provides an input/output to connect a Real Time Clock power supply.

This pad is used as a back-up power supply for the internal Real Time Clock. The RTC is supported when VBATT is available but a back-up power supply is needed to save date and hour when VBATT is switched off.

If VBATT is available, the back-up battery can be charged by the internal 3.0V power supply regulator.

Table 13. BAT_RTC Electrical Characteristics

Parameter	Minimum	Typical	Maximum
Input voltage (V)	2.0	3.0	3.15
Input current consumption (µA)	-	2.5	56
Output voltage (V)	2.82	3.0	3.18
Max charging current (@VBATT=3.6V) (mA)	-	0.6	-

Note: If unused, it is recommended to add a common 10µF capacitor to BAT_RTC.

3.5. UIM Interface

The AirPrime HL6528x module has two physical UIM interfaces – one main UIM interface (UIM1), and a second UIM interface (UIM2) reserved for Dual UIM Dual Standby option.

3.5.1. UIM1 Interface

The UIM1 interface allows control of a 1.8V/3V UIM and is fully compliant with GSM 11.11 recommendations related to UIM functions.

The five signals used by this interface are as follows:

- UIM1_VCC: power supply
- UIM1_CLK: clock
- UIM1_DATA: I/O port
- UIM1_RESET: reset
- UIM1_DET: UIM detection (optional)

Table 14. Electrical Characteristics of UIM1

Parameter	Minimum	Typical	Maximum	Remarks
UIM1 Interface Voltage (V) (VCC, CLK, DATA, RESET)	2.7	3.0	3.15	The appropriate output voltage is auto detected and selected by software.
	1.65	1.80	1.95	
UIM1_VCC Current (mA)	-	-	10	Max output current in sleep mode = 3 mA
UIM1_VCC Line Regulation (mV/V)	-	-	50	At Iout_Max
UIM1_VCC Power-up Setting Time (µs) from power down	-	10	-	

Parameter	Minimum	Typical	Maximum	Remarks
Logic 1 of UIM1_DET (V)	2.4	-	-	VGPIO = 2.8V
	1.4	-	-	VGPIO = 1.8V
Logic 0 of UIM1_DET (V)	-	-	0.4	VGPIO = 2.8V
	-	-	0.4	VGPIO = 1.8V

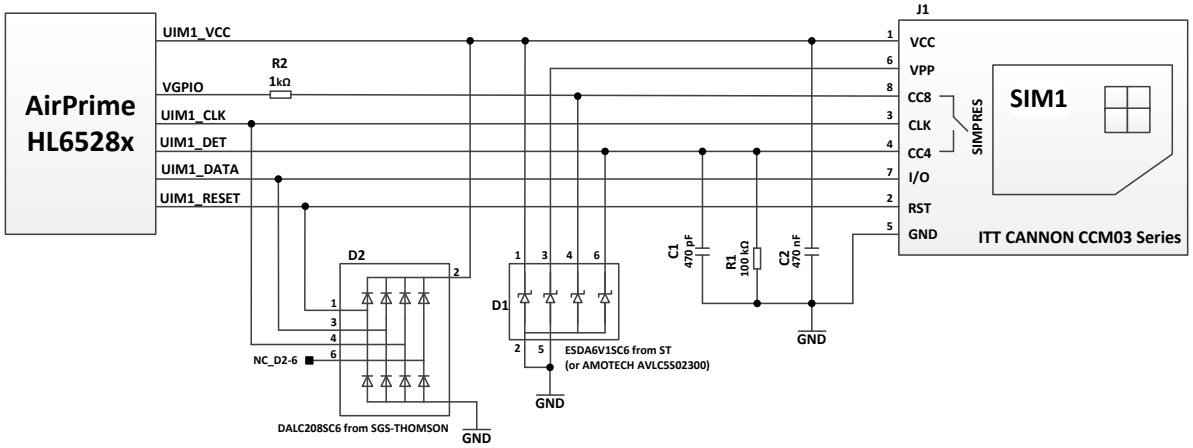


Figure 4. UIM1 Implementation Example

3.5.1.1. UIM1_DET

UIM1_DET is used to detect and notify the application about the insertion and removal of a UIM device in the UIM socket connected to the main UIM interface (UIM1). When a UIM is inserted, the state of UIM1_DET transitions from logic 0 to logic 1. Inversely, when a UIM is removed, the state of UIM1_DET transitions from logic 1 to logic 0.

The GPIO used for UIM1_DET is GPIO3.

3.5.2. UIM2 Interface

The UIM2 interface is optional and only intended to be used with Dual UIM Dual Standby feature.

Note: This is the preferred interface for when MFF2 UIM cards are used.

The six signals used by this interface are as follows:

- UIM2_VCC: power supply
- UIM2_CLK: clock
- UIM2_DATA: I/O port
- UIM2_RESET: reset
- UIM2_DET: HW detection (optional)
- UIM2_VCC_CTRL: control signal for external analog switch (mandatory)

Table 15. Electrical Characteristics of UIM2

Parameter	Minimum	Typical	Maximum	Remarks
UIM2 Interface Voltage (V) (VCC, CLK, DATA, RESET)	2.7	2.85	3.0	
UIM2 Interface Voltage (V) (VCC_CTRL)		1.8 or 2.8		UIM2_VCC_CTRL is on VGPIO power domain
UIM2_VCC Current (mA)	-	-	10	Max output current in sleep mode = 3 mA
Logic 1 of UIM2_DET (V)	2.4	-	-	
Logic 0 of UIM2_DET (V)	-	-	0.4	

Note: The UIM2 interface is fixed at 3V; do not use a direct connection with a 1.8V-only UIM card.

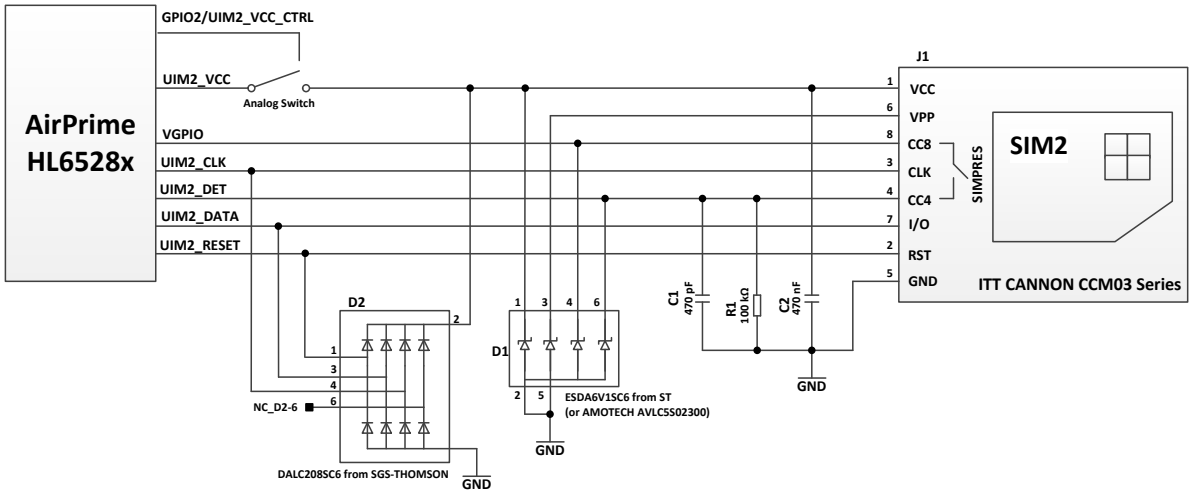


Figure 5. UIM2 Implementation Example

3.5.2.1. UIM2_DET

UIM2_DET is used to detect and notify the application about the insertion and removal of a UIM device in the UIM socket connected to the second UIM interface (UIM2). When a UIM is inserted, the state of UIM2_DET transitions from logic 0 to logic 1. Inversely, when a UIM is removed, the state of UIM2_DET transitions from logic 1 to logic 0.

The GPIO used for UIM2_DET is GPIO4.

3.5.2.2. UIM2_VCC_CTRL

An analog switch must be added on the customer board when using the UIM2 interface. This analog switch is controlled by GPIO2.

Table 16. UIM2_VCC_CTRL Analog Switch Truth Table

GPIO2 (UIM2_VCC_CTRL)	Function
Low	UIM2_VCC connected to UIM2_VCC
High	UIM2_VCC disconnected from UIM2_VCC

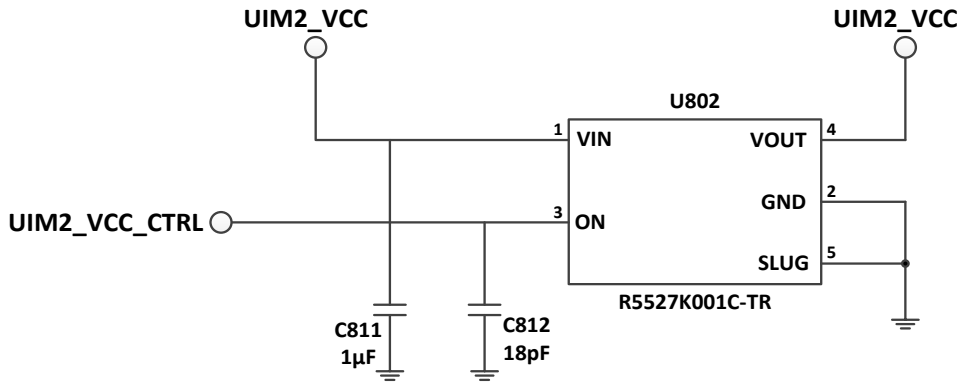


Figure 6. Analog Switch Connection Example

An example of analog switch that can be used is the R5527K001C-TR.

3.6. Electrical Information for Digital I/O

The table below enumerates the electrical characteristics of the following digital interfaces:

- UART
- PCM
- GPIOs
- I²C
- SPI
- JTAG
- RESET

Depending on the AirPrime HL6528x module variant, digital IOs are either 2.8V or 1.8V power domain.

Note: The PCM interface only supports 2.8V even with 1.8V configuration.

Table 17. Digital I/O Electrical Characteristics

Parameter	HL6528, HL6528G		HL6528-2.8V, HL6528-G2.8V		Remarks
	Minimum	Maximum	Minimum	Maximum	
Input Voltage-High (V)	1.4	2.2	2.4	3.2	
Input Voltage-Low (V)	-0.2	0.4	-0.2	0.4	
Output Voltage-High (V)	1.7	1.9	2.7	2.95	
Output Voltage-Low (V)	0	0.1	0	0.1	
For all signals except UART1_TX, UART1_RX, UART1_RTS and UART1_CTS:					
Input Current-High (µA)	-10	10	-10	10	Current consumption
Input Current-Low (µA)	-10	10	-10	10	Current consumption
DC Output Current-High (mA)	0	1.5	0	1.5	

Parameter	HL6528, HL6528G		HL6528-2.8V, HL6528-G2.8V		Remarks
	Minimum	Maximum	Minimum	Maximum	
DC Output Current-Low (mA)	-1.5	0	-1.5	0	
For signals UART1_TX, UART1_RX, UART1_RTS and UART1_CTS:					
Input Current-High (mA)	4		-0.01	0.01	Current consumption
Input Current-Low (mA)		-4	-0.01	0.01	Current consumption
DC Output Current-High (mA)		0.02	0	1.5	
DC Output Current-Low (mA)	-0.02		-1.5	0	

3.7. General Purpose Input/Output (GPIO)

The AirPrime HL6528x provides 8 GPIOs, 5 of which have multiplexes.

Table 18. GPIO Pad Description

Pad #	Signal Name	Multiplex	I/O	Power Supply Domain	
				HL6528, HL6528-G	HL6528-2.8V, HL6528-G2.8V
1	GPIO1	I2C1_CLK1	I/O	1.8V	2.8V
10	GPIO2	UIM2_VCC_CTRL	I/O	1.8V	2.8V
40	GPIO7		I/O	1.8V	2.8V
41	GPIO8		I/O	1.8V	2.8V
46	GPIO6		I/O	1.8V	2.8V
64	GPIO3	UIM1_DET	I/O	1.8V	2.8V
65	GPIO4	UIM2_DET	I/O	1.8V	2.8V
66	GPIO5	I2C1_DATA	I/O	1.8V	2.8V

3.8. Main Serial Link (UART1)

The main serial link (UART1) is used for communication between the AirPrime HL6528x module and a PC or host processor. It consists of a flexible 8-wire serial interface that complies with RS-232 interface.

The supported baud rates of the UART1 are 1200, 2400, 4800, 9600, 19200, 38400, 57600 and 115200 bit/s, with autobauding and up to 1Mbit/s at maximum baud rate.

The signals used by UART1 are as follows:

- TX data (UART1_TX)
- RX data (UART1_RX)
- Request To Send (UART1_RTS)
- Clear To Send (UART1_CTS)
- Data Terminal Ready (UART1_DTR)

- Data Set Ready (UART1_DSR)
- Data Carrier Detect (UART1_DCD)
- Ring Indicator (UART1_RI)

Note: *The capacitive load at UART1_CTS and UART1_RX must be lower than 45pF on the HL6528 and HL6528-G (1.8V configuration).*

A UART transceiver or uni-directional level shifter is needed for connection to the host when the interface level is not compatible with the HL6528x. If an external level shifter is needed, Sierra Wireless recommends using device ST2378E from STMicroelectronics.

Caution: *The HL6528 and HL6528-G have an internal level translator connected to the UART1_TX, UART1_RX, UART1_RTS and UART1_CTS signals before going to the baseband. The impedance loading on these four signals may be different from that of the other UART signals (namely UART1_DTR, UART1_DSR, UART1_DCD and UART1_RI).*

UART1 pad description is summarized below.

Table 19. UART1 Pad Description

Signal Name*	I/O*	Description
UART1_DTR	I (active low)	Prevents the AirPrime HL6528x from entering sleep mode, switches between data mode and command mode, and wakes the module up.
UART1_DCD	O	Signal data connection in progress
UART1_RX	O	Receive data
UART1_RTS	I	Wakes the module up when KSLEEP=1 is used
UART1_TX	I	Transmit data
UART1_CTS	O	AirPrime HL6528x is ready to receive AT commands
UART1_RI	O	Signal incoming calls (voice and data), SMS, etc.
UART1_DSR	O	Signal UART interface is ON

* From module side.

3.8.1. 8-wire Application

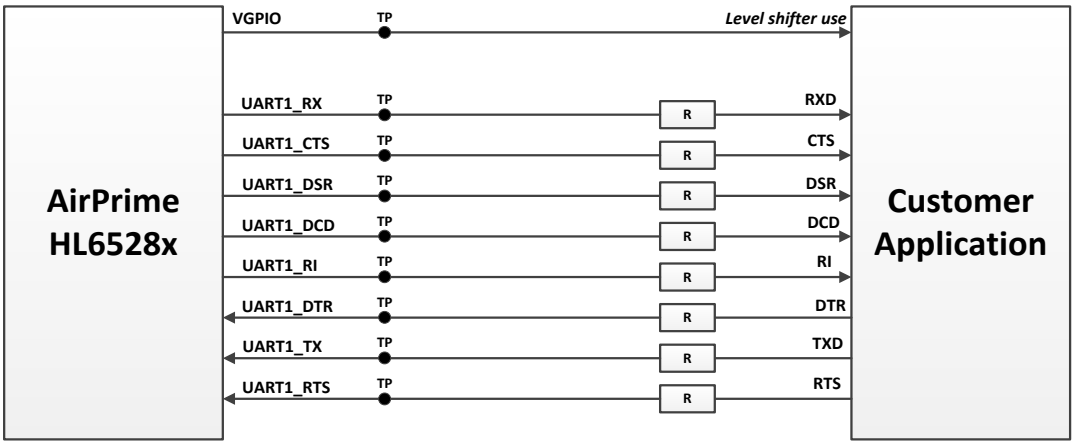


Figure 7. 8-wire UART Application Example

3.8.2. 4-wire Application

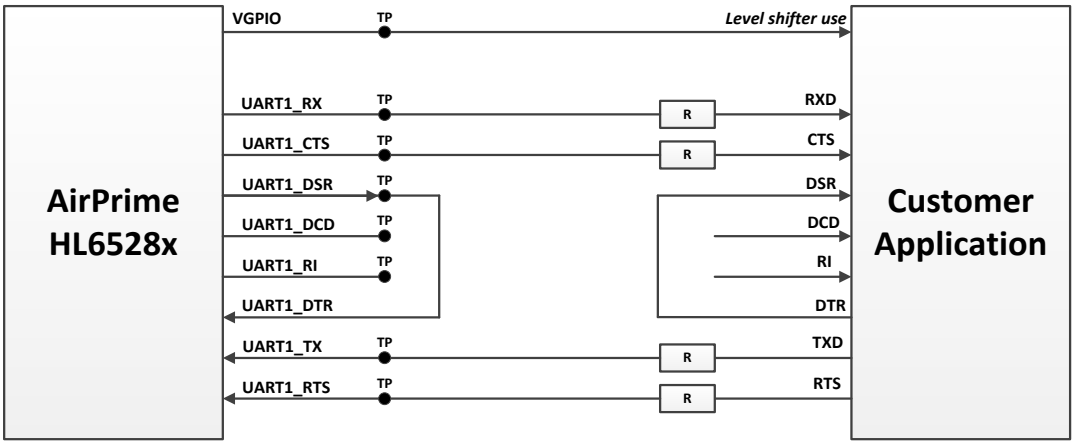


Figure 8. 4-wire UART Application Example

3.8.3. 2-wire Application

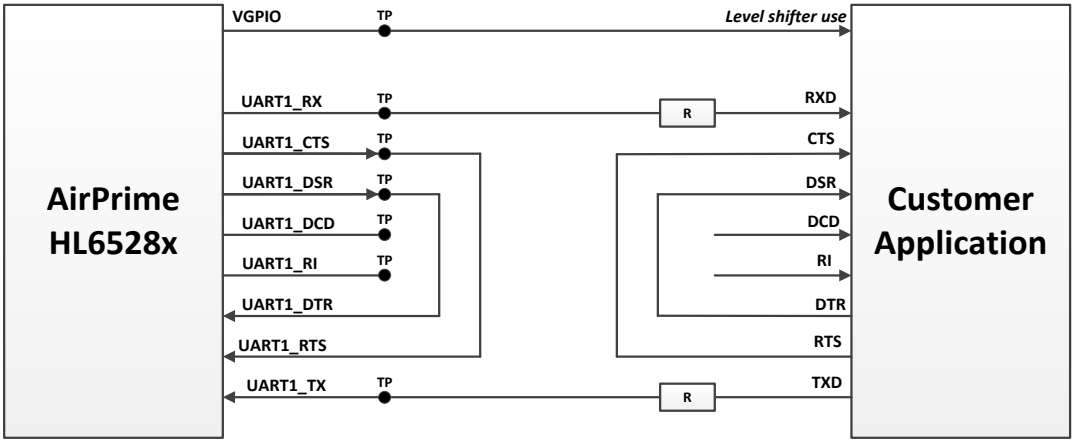


Figure 9. 2-wire UART Application Example

3.9. Power On Signal (PWR_ON)

A low-level signal must be provided to switch the AirPrime HL6528x module ON.

It is internally connected to the permanent 3.0V supply regulator inside the HL6528x via a pull-up resistor. Once VBATT is supplied to the HL6528x module, this 3.0V supply regulator will be enabled and so PWR_ON signal is by default at high level.

The PWR_ON signal's characteristics are listed in the table below.

Table 20. PWR_ON Electrical Characteristics

Parameter	Minimum	Typical	Maximum
Input Voltage-Low (V)	0	-	0.4
Input Voltage-High (V)	2.4	-	3.15
Power-up period (ms) from PWR_ON falling edge	2000	-	-

Note: As PWR_ON is internally pulled up (typically by 100kΩ), a simple open collector or open drain transistor must be used for ignition. For convenience, PWR_ON can be connected to GND to automatically switch the module on when power is supplied.

The PWR_ON signal is bi-directional and it will be internally tied low after the module is ready. It cannot be driven directly by a GPIO signal.

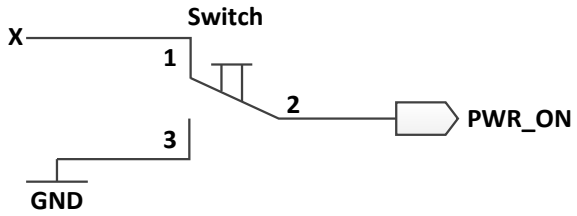


Figure 10. PWR_ON Connection Example with Switch

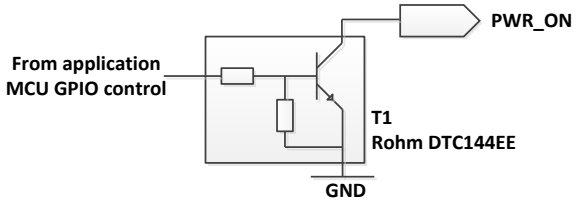


Figure 11. PWR_ON Connection Example with an Open Collector Transistor

VGPIO is an output from the module that can be used to check if the module is active.

- When VGPIO = 0V the module is OFF.
- When VGPIO = 2.8V or 1.8V the module is ON (it can be in Idle, Communication or Sleep mode)

After a few seconds, the UART1_CTS enters active state and the module is ready to receive AT commands.

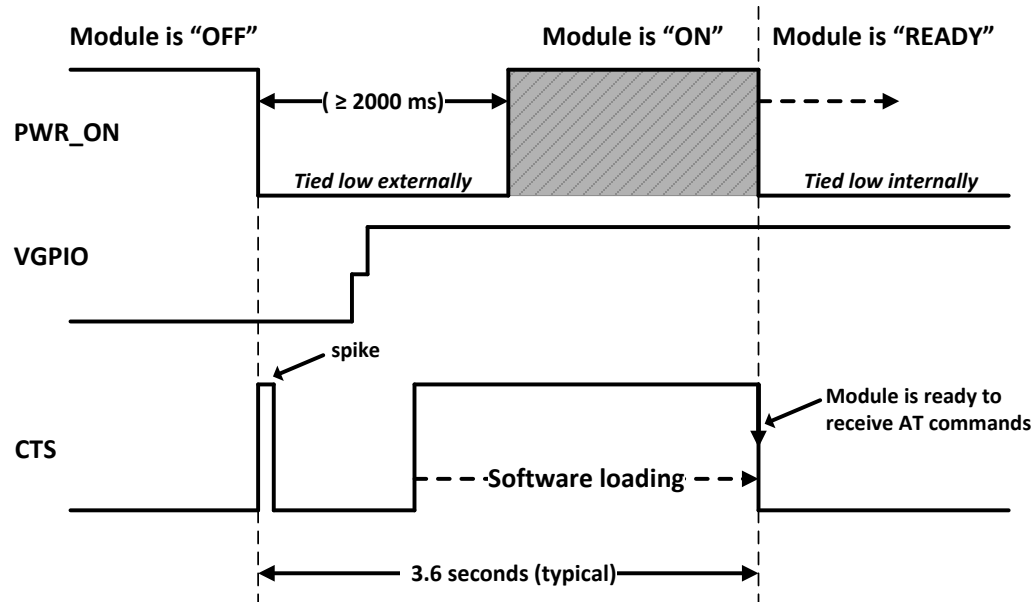


Figure 12. PWR_ON Sequence

*Note: PWR_ON cannot be used to power the module off. The module is powered off with AT command **AT*PSCPOF**, and the PWR_ON signal will be internally pulled up to high level after.*

3.10. Reset Signal (RESET_IN)

To reset the module, the RESET_IN pad must be tied low for at least 10ms. This action will immediately restart the AirPrime HL6528x module. It is therefore useless to perform a new ignition sequence (PWR_ON) afterwards.

As RESET_IN is internally pulled up (typically by 100kΩ), a simple open collector or open drain transistor can be used to control it.

The RESET_IN signal will reset the registers of the CPU and reset the RAM memory as well.

Note: As RESET_IN is referenced to the VGPIO domain (internally pulled up to the module) it is impossible to enable a reset before the module is on or to try to use the RESET_IN as a way to power on the module.

Table 21. RESET_IN Electrical Characteristics

Parameter	HL6528, HL6528G			HL6528-2.8V, HL6528-G2.8V		
	Min	Typ	Max	Min	Typ	Max
Input Voltage-Low (V)	-0.2	-	0.4	-0.2	-	0.4
Input Voltage-High (V)	1.4	-	2.2	2.4	-	3.2
Power up Period (ms) from RESET_IN falling edge	38	-	-	38	-	-

3.11. ADC

Two Analog to Digital Converter input, ADC0 and ADC1 are provided by the AirPrime HL6528x module. These converters are 10-bit resolution ADCs ranging from 0 to 3V.

Typically, the ADCx input can be used to monitor external temperature. This is very useful for monitoring the application temperature and can be used as an indicator to safely power OFF the application in case of overheating (for Li-Ion batteries).

Both ADCs have the characteristics listed in the table below.

Table 22. ADC Electrical Characteristics

Parameter	Minimum	Typical	Maximum	Remarks
ADC Resolution (bits)	-	10	-	
Input Voltage Range (V)	0	-	3	General purpose input
Update rate per channel (KHz)	-	-	200	
Differential Nonlinearity (bits)	-1	-	+3	
Integral Nonlinearity (bits)	-2.5	-	+2.5	LSB
Offset Error (mV)	-	5	-	
Gain Error (mV/LSB)	-	0.02	-	
Input Resistance (kΩ)	120	150	-	
Input Capacitance (pF)	-	-	10	

3.12. Analog Audio Interfaces

The AirPrime HL6528x module supports one differential microphone input and one differential speaker output. It also includes a noise suppression and echo cancellation feature for enhanced voice call quality.

3.12.1. Analog Audio Input

The microphone input can either have a single-ended or a differential connection. However, performance with common mode noise and TDMA noise varies depending on the connection mode and PCB layout.

When connecting a microphone to the AirPrime HL6528x module, ensure to have a very good ground plane, very good filtering as well as shielding to avoid any disturbance on the audio path.

The gain of the microphone input can be tuned using AT commands.

The AirPrime HL6528x module microphone pads already include suitable biasing for an electret microphone. The electret microphone can then be connected directly on the inputs for easy connection.

AC coupling is also already embedded in the HL6528x embedded module.

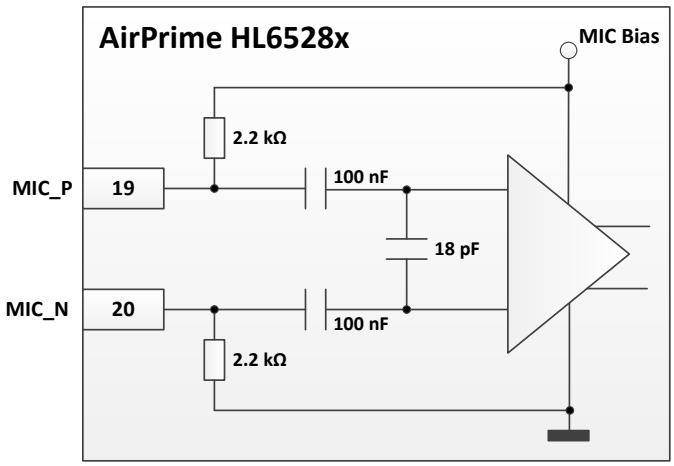


Figure 13. MIC Input Diagram

Table 23. Analog Audio Differential Interface Input

Parameter	Minimum	Typical	Maximum	Test Conditions
MIC_P DC Biasing (V)		2.4		Through internal 2.2kΩ
MIC_N DC Biasing (V)		0		Through internal 2.2kΩ
Maximum input range (Vrms)		0.74		Gain = 0dB
Nominal reference level (mVrms)		16		Gain = + 34dB
Input Micro amplifier gain (dB)	-6		+ 50	

Note: It is recommended to add ESD protection to the microphone when it is exposed to the external environment. The ESD protection should be connected between the audio lines and a good ground, and placed as close to the microphone as possible.

3.12.2. Analog Audio Output

Table 24. Analog Audio Differential Interface Output

Parameter	Min	Typ	Max	Test Conditions
Maximum output range (Vrms)		1.75		Load=32Ω, THD=1%,
Load resistance (Ω)		32		
Output amplifier gain (dB)	-28	-	8	

Note: It is recommended to add ESD protection to the speaker when it is exposed to the external environment. The ESD protection should be connected between the audio lines and a good ground, and placed as close to the speaker as possible.

It's important to select an appropriate speaker. The following table enumerates the recommended speaker characteristics.

Table 25. Recommended Speaker Characteristics

Characteristic	Value
Input power: rated / max	0.1W (Rate)
Audio chain impedance	32Ω ± 10% at 1V 1KHz
Frequency Range	300 Hz ~ 4.0 KHz
Sensitivity (S.P.L)	>105 dB at 1KHz with IEC318 coupler
Distortion	5% max at 1K Hz, nominal input power

3.13. PCM

The Digital Audio Interface (PCM) interface allows connectivity with standard audio peripherals. It can be used, for example, to connect an external audio codec.

The signals used by the Digital Audio Interface are as follows:

- PCM_SYNC: The frame synchronization signal delivers an 8kHz frequency pulse that synchronizes the frame "data in" and the frame "data out" (short frame synchronization only).
- PCM_CLK: The frame bit clock signal controls data transfer with the audio peripheral.
- PCM_OUT: The frame "data out" relies on the selected configuration mode.
- PCM_IN: The frame "data in" relies on the selected configuration mode.

The PCM interface is a high speed full duplex interface that can be used to send and receive digital audio data to external audio ICs. The digital audio interface also features the following:

- PCM master or slave mode
- 8 bits or 16 bits data word length
- MSB or LSB first
- Rising or falling sampling clock edge

*Note: The PCM bit clock rate **must** be set to 1MHz in either master or slave mode in order to accommodate the 8kS/s source/sink mechanism on the DSP side, as well as the 125µs frame length.*

Refer to the following table for the electrical characteristics of the digital audio interface.

Table 26. Digital Audio Interface Electrical Characteristics

Signal	Description	Minimum	Typical	Maximum
Tsync_low + Tsync_high	PCM-SYNC period (µs)		125	
Tsync_low	PCM-SYNC low time (µs)		124	
Tsync_high	PCM-SYNC high time (µs)		1	
TSYNC-CLK	PCM-SYNC to PCM-CLK time (ns)		651	
TCLK-cycle	PCM-CLK period (ns)		1302	
TIN-setup	PCM-IN setup time (ns)	50		
TIN-hold	PCM-IN hold time (ns)	50		
TOUT-delay	PCM-OUT delay time (ns)			20
TSYNC-delay	PCM-SYNC output delay (ns)	-11		9

The following figure shows the PCM timing waveform.

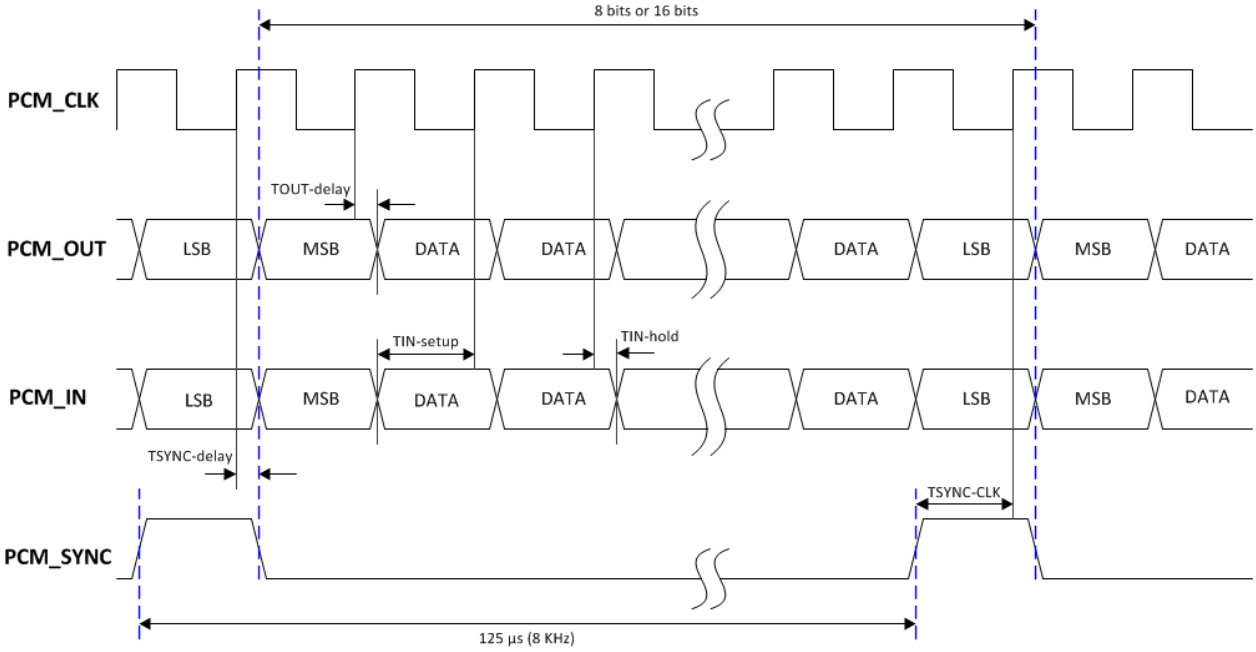


Figure 14. PCM Timing Waveform

3.14. I²C Interface

NMEA frames can be output from the UART or through a dedicated serial port (I²C).

Table 27. I²C Pad Description

Pad #	Name	Function
1	I2C1_CLK	I²C Serial Clock Line
66	I2C1_DATA	I²C Serial Data Line

Note: I²C pads are multiplexed with GPIO features and external pull up resistors (1kΩ for example) are mandatory for I²C pads.

The main characteristics of the I²C interface are as follows:

- Master mode (I2C1_CLK is an output of the AirPrime HL6528x module)
- I²C clock is set at 400KHz

As the HL6528x's I²C interface works in master mode only, devices connected to the I²C bus will be slave devices, and for the HL6528x module to communicate with slave devices, the slave device's 7-bit address should be loaded inside the HL6528x module before activating the GPS NMEA output. For more information on managing slave devices, refer to document [2] AirPrime HL6 and HL8 Series AT Commands Interface Guide

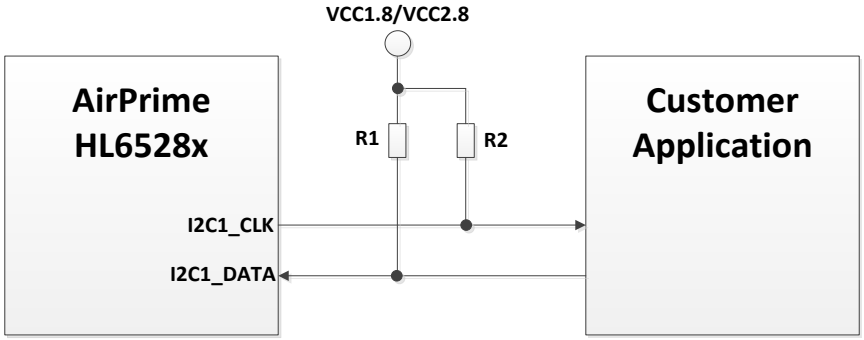


Figure 15. I²C Application Example

3.15. Debug Interfaces

The AirPrime HL6528x module provides two interfaces for a powerful debug system.

3.15.1. SPI Interface (SW Traces)

The AirPrime HL6528x module provides a SW TRACE interface, providing real-time instruction and data trace of the modem core. The SW TRACE interface is accessible through the SPI port.

Table 28. SPI Pad Description

Pad #	Name	Function
44	SPI1_SRDY	SPI Slave Ready
51	SPI1_MRDY	SPI Master Ready
52	SPI1_MISO	SPI Master In Slave Out
53	SPI1_CLK	SPI Clock
54	SPI1_MOSI	SPI Master Out Slave In

Note: Although this interface is not available for customer use, it is strongly recommended that access to this interface be provided through Test Points.

3.15.2. JTAG

Note: This interface is reserved for Sierra Wireless' internal debug use (for customer support).

The JTAG interface provides debug access to the core of the AirPrime HL6528x module. These JTAG signals are accessible through solderable Test Points.

Table 29. JTAG Pad Description

Pad #	Name	Function
47	TP1	Test Point 1
236	JTAG_RESET	JTAG RESET
237	JTAG_TCK	JTAG Test Clock
238	JTAG_TDO	JTAG Test Data Output
239	JTAG_TMS	JTAG Test Mode Select
240	JTAG_TRST	JTAG Test Reset
241	JTAG_TDI	JTAG Test Data Input
242	JTAG_RTCK	JTAG Returned Test Clock

Note: It's recommended to provide access through Test Points to this interface (for failure analysis and debugging). All signals listed in the table above should be outputs on the customer board to allow JTAG debugging.

3.16. PPS (HL6528-G and HL6528-G2.8V only)

The PPS signal is an output pulse related to GPS receiver time.

Table 30. PPS Electrical Characteristics

Parameter		Minimum	Typical	Maximum	Conditions
Voltage Level (V)	HL6528-G	1.70	1.80	1.90	
	HL6528-G2.8V	2.7	2.8	2.95	
Frequency (Hz)			1		
Pulse width (ms)			250		
Synchronization to GPS time (µs)				1	

Note: This output is available only when GNSS is in navigation mode.

3.17. EXT_LNA_GPS_EN (HL6528-G and HL6528-G2.8V only)

EXT_LNA_GPS_EN ON indicates whether the GNSS receiver is active and can be used to enable an external LNA (or active antenna).

Table 31. EXT_LNA_GPS_EN Electrical Characteristics

Parameter		Minimum	Typical	Maximum	Conditions
Output Voltage Level (V)	HL6528-G	1.70	1.80	1.90	
	HL6528-G2.8V	2.7	2.8	2.95	
Output Current (mA)	HL6528-G	0	-	1.5	
	HL6528-G2.8V	0	-	2	

3.18. RF Interface

The GSM RF interface of the AirPrime HL6528x module allows the transmission of RF signals. This interface has a 50Ω nominal impedance.

Contact Sierra Wireless technical support for assistance in integrating the AirPrime HL6528x on applications with embedded antennas.

3.18.1. RF Connection

A short 50Ω (with maximum VSWR 1.1:1, and 0.5dB loss) RF track is recommended to connect to standard RF connectors such as SMA, UFL, etc. for antenna connection.

Table 32. RF Connection

RF Signal	Impedance	VSWR Rx (max)	VSWR Tx (max)
RF_MAIN	50Ω	3:1	3:1

3.18.2. RF Performances

RF performances are compliant with the ETSI recommendation GSM 05.05.

Frequency Band	Typical Sensitivity	Minimum Sensitivity
GSM 850 (dBm)	-109.9	-107
E-GSM 900(dBm)	-109.7	-107
DCS 1800(dBm)	-109.5	-106
PCS 1900 (dBm)	-108.2	-106

Note: Values given above are average values across the frequency band.

3.18.3. TX Burst Indicator (2G_TX_ON)

The AirPrime HL6528x module provides a signal, 2G_TX_ON, for TX burst indication. 2G_TX_ON is a 2.8V signal and its status depends on the module transmitter state.

Refer to the following table for the status of the 2G_TX_ON signal depending on the embedded module's state.

Table 33. Burst Indicator States

Embedded Module State	2G_TX_ON
During TX burst	High
No TX	Low

During TX burst, there is a higher current drain from the VBATT_PA power supply which causes a voltage drop. This voltage drop from VBATT_PA is a good indication of a high current drain situation during TX burst.

The blinking frequency is about 217Hz.

The output logic high duration, $T_{duration}$, depends on the number of TX slots and is computed as follows:

```
T duration = T advance + (0.577ms x number of TX slots) + T delay
```

Table 34. TX Burst Characteristics

Parameter	Minimum	Typical	Maximum
High level output voltage (V)	2.7	2.85	3
Low level output voltage	0		0.1
Tadvance (µs)	30	180	
Tdelay (µs)	0	10	

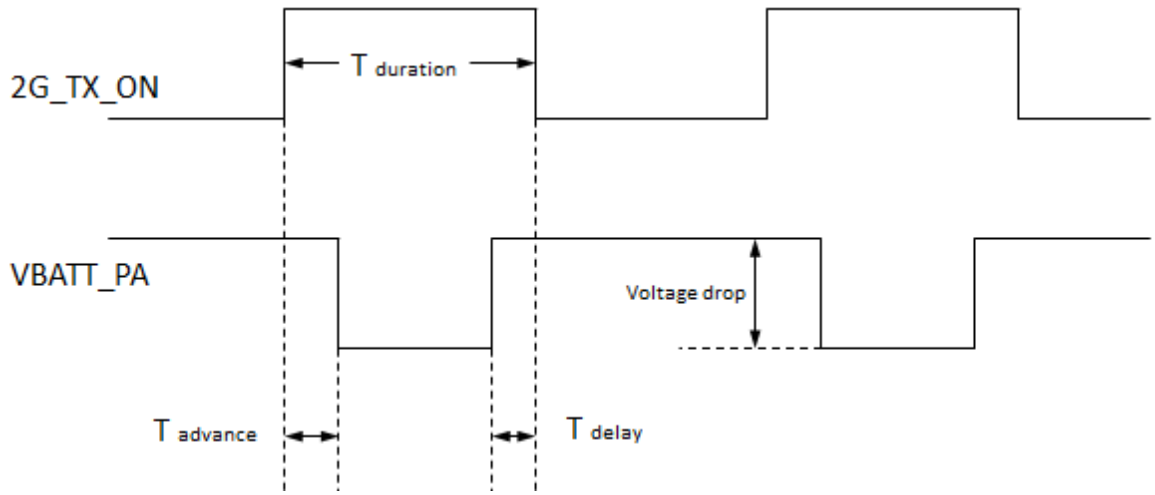


Figure 16. 2G_TX_ON State during TX Burst

3.19. GNSS Interface

The AirPrime HL6528-G and HL6528-G2.8V modules embed an integrated and high-sensitivity Global Navigation Satellite System (GNSS) solution.

Based on SiRFstarV™ from CSR, the AirPrime HL6528-G and HL6528-G2.8V modules combine GPS and GLONASS reception to improve navigation capabilities and position accuracy in obstructed view environments such as urban canyons. GNSS performances are improved by CW jammer and interference mitigation system and automated hardware blanking capabilities.

In addition, it supports Downloaded Extended Ephemeris Assisted-GNSS, for enhanced time to acquire or reacquire a fix.

The operation of GNSS is offloaded to a GNSS standalone solution to guarantee the availability of modem resources for best performance.

The GNSS implementation supports GPS L1 signal (1575.42 ± 20 MHz) and GLONASS L1 FDMA signals for frequency -7 to 6 (1597.5 – 1605.8 MHz), with 50Ω connection on the RF_GPS pad.

3.19.1. GNSS Performances

Table 35. GNSS Interface Specifications

Test	Parameters		Typical Value
Sensitivity	GPS Autonomous Acquisition (dBm); Cold and Warm start conditions		-147
	GPS Autonomous Acquisition (dBm); Hot start conditions		-159
	GPS Navigation (dBm)		-161
	GLONASS Navigation (dBm)		-158
	GNSS Navigation (dBm)		-161
	GPS Tracking (dBm)		-165
	GLONASS Tracking (dBm)		-165
Autonomous Cold Start	Time To First Fix (s)	50%	29.5
		95%	38.6
	2D Position Error (m)	50%	1.1
		95%	5.9
Autonomous Warm Start	Time To First Fix (s)	50%	24.7
		95%	34.8
	2D Position Error (m)	50%	1.6
		95%	4.5
Autonomous Hot Start	Time To First Fix (s)	50%	1.2
		95%	1.9
	2D Position Error (m)	50%	4.2
		95%	9.5
Aiding Warm Start	Time To First Fix (s)	95%	11
	2D Position Error (m)	95% (after 1 day)	10
		95% (after 3 days)	20
		95% (after 6 days)	50

Note: Values in the table above are based on static conditions, RF GNSS level @-130dBm. Cold start does not include internal GNSS firmware download on first GNSS start.

3.19.2. GNSS Antenna Interface

Specifications for the GNSS antenna interface are defined in the table below.

Table 36. GNSS Antenna Specifications

Characteristics		GNSS
Frequency (MHz)	GPS L1	1575.42±20
	GLONASS L1 FDMA	1597.5-1605.8
RF Impedance (Ω)		50
VSWR max		2:1

The minimum isolation between GNSS and GSM antennas should be 20dB.

3.19.3. GNSS Antenna Recommendations

Both passive and active antennas are supported by the AirPrime HL6528-G and HL6528-G2.8V modules.

The table below describes the expected performance function as input signal power.

Table 37. GNSS Antenna Recommendations

GNSS Signal Level Description	Input Signal Power (dBm)	Expected Performances
Absolute maximum	-110	Maximum to input level
Good	>-134	Best performance in TTFF and position accuracy
Acceptable	>-147	Minimum input level to allow initial acquisition without aiding
Poor	<-147	No signal acquisition without aiding
Minimum usable signal	-161	Below this level, no fix with reasonable error
Minimum tracking level	-165	Minimum level to lock the signal for fast recovery when the signal returns to the minimum usable level

For passive antennas, the internal LNA should be set to high gain mode. When configured in high gain mode, the noise figure of the HL6528x's GNSS input is 3 dB.

For active antennas, the configuration of the internal LNA gain is dependent on external RF chain implementation, especially for the external net gain (i.e. gain from the antenna input to the module input including LNA gain minus cable losses).

The internal LNA gain should be set to low gain if the external net gain is higher than 8 dB. When configured in low gain mode, the noise figure of the HL6528x's GNSS input is 7 dB.

The external net gain should never exceed 22 dB.

If the external net gain is lower than 8 dB, it is recommended that the internal LNA gain be set to high gain mode.

These limits have been determined for active antennas with noise figures lower than 3 dB.

4. Mechanical Drawings

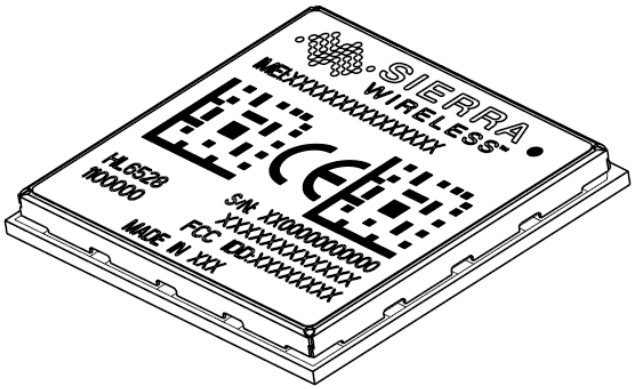


Figure 17. Angular View

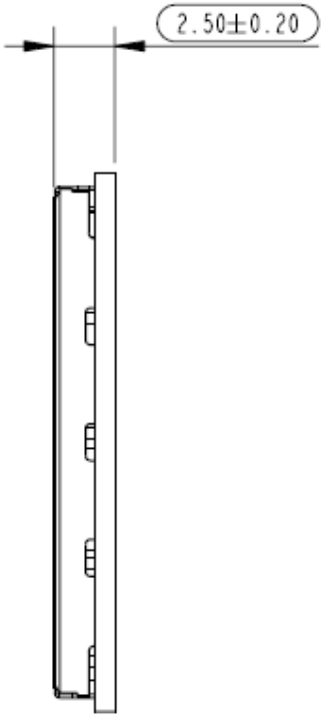


Figure 18. Side View

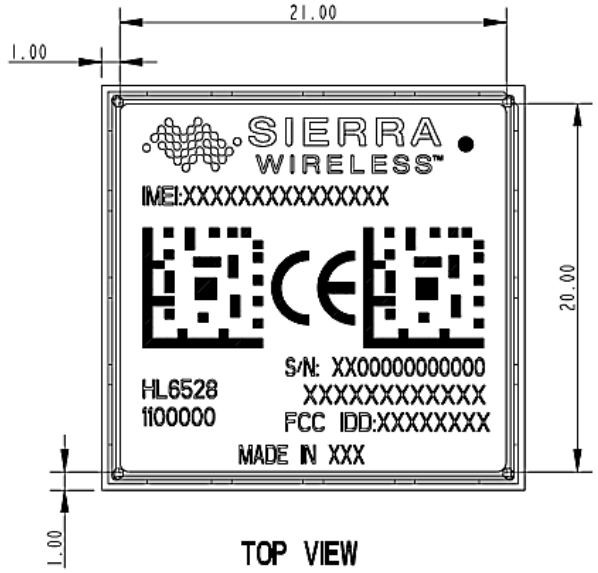


Figure 19. Top View

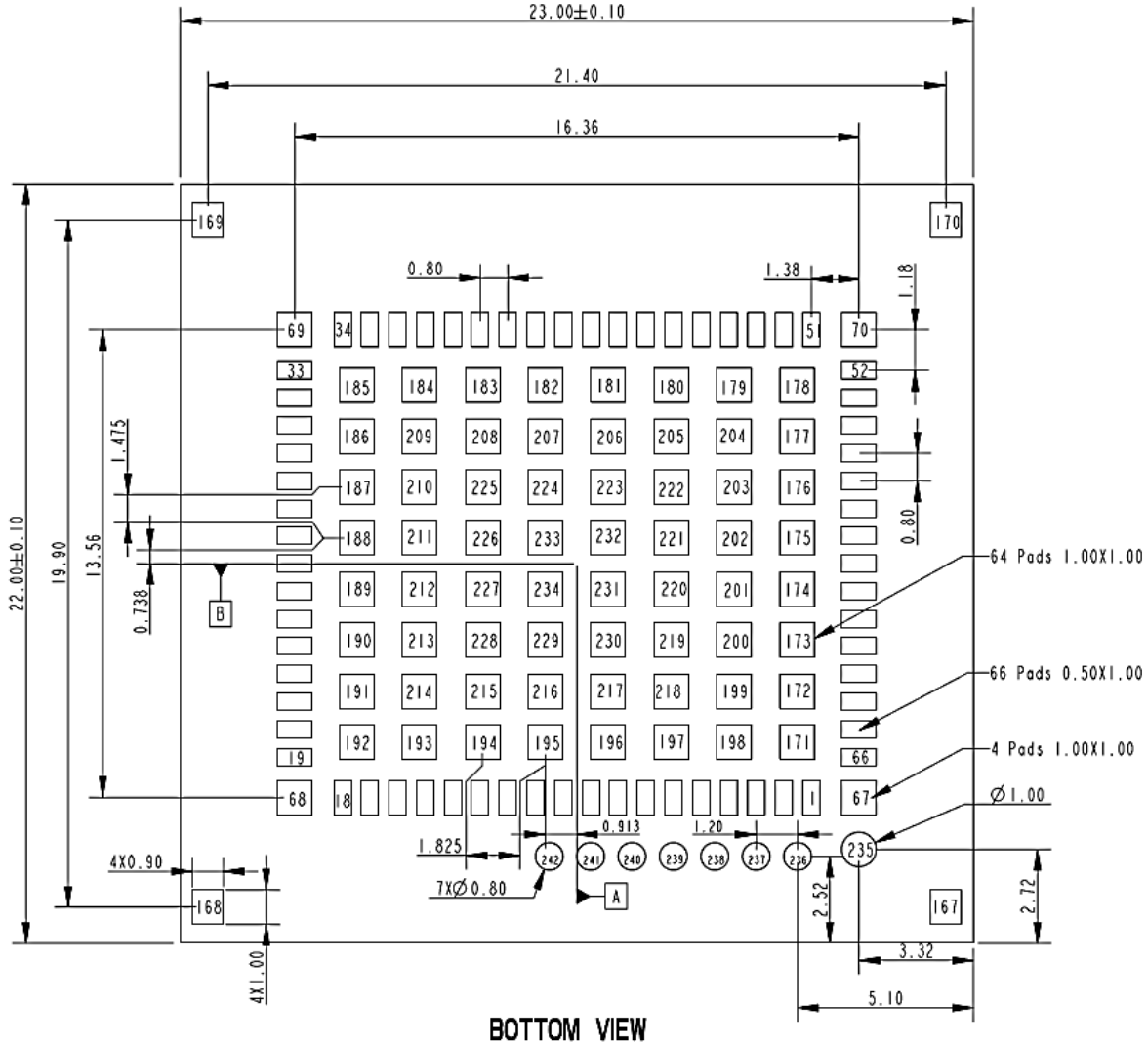


Figure 20. Bottom View with Dimensions

5. Design Guidelines

5.1. Power on Sequence

Apply a low-level logic to the PWR_ON pad (pad 59). When CTS is toggling to low level, the module is ready to receive AT commands.

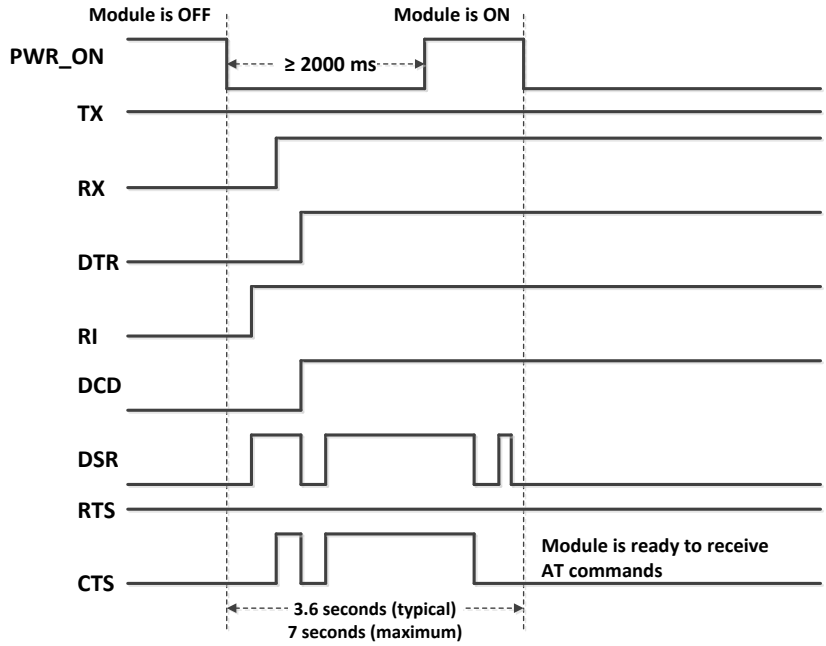


Figure 21. UART Signals during the Power ON Sequence

5.2. Module Switch-Off

AT command **AT*PSCPOF** enables the user to properly switch the AirPrime HL6528x module off.

If required, the module can be switched off by controlling the power supply. This can be used, for example, when the system freezes and no reset line is connected to the AirPrime HL6528x module. In this case, the only way to get control back over the module is to switch off the power line.

VGPIO, PWR_ON and CTS signal behavior during the power off sequence is described in the figure below.

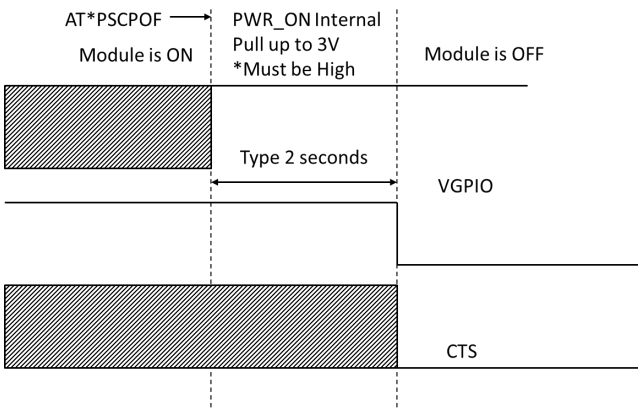


Figure 22. Power OFF Sequence for PWR_ON, VGPIO and CTS

5.3. Sleep Mode Management

AT command **AT+KSLEEP** enables the sleep mode configuration.

AT+KSLEEP=0:

- The AirPrime HL6528x module is active when DTR signal is active (low electrical level).
- When DTR is deactivated (high electrical level), the AirPrime HL6528x module enters sleep mode after a while.
- On DTR activation (low electrical level), the AirPrime HL6528x module wakes up.

AT+KSLEEP=1:

- The AirPrime HL6528x module determines when it enters sleep mode (when no more tasks are running).
- “0x00” character on the serial link wakes the AirPrime HL6528x module up.

AT+KSLEEP=2: The AirPrime HL6528x module never enters sleep mode.

In sleep mode, the module reduces its power consumption and remains waiting for the wake up signals either from the network (i.e. read paging block depending on the DRX value of the network) or the operating system (i.e. timers wake up timers activated) or the host controller (i.e. character on serial link or DTR signal).

5.4. ESD Guidelines for UIM Cards

Decoupling capacitors must be added as close as possible to the UIM card connectors on UIM_CLK, UIM_RST, UIM_VCC and UIM_DATA signals to avoid EMC issues and to pass the UIM card type approval tests, according to the drawings below (this applies to both UIM slots, UIM1 and UIM2).

A typical schematic for hardware UIM detection is provided below.

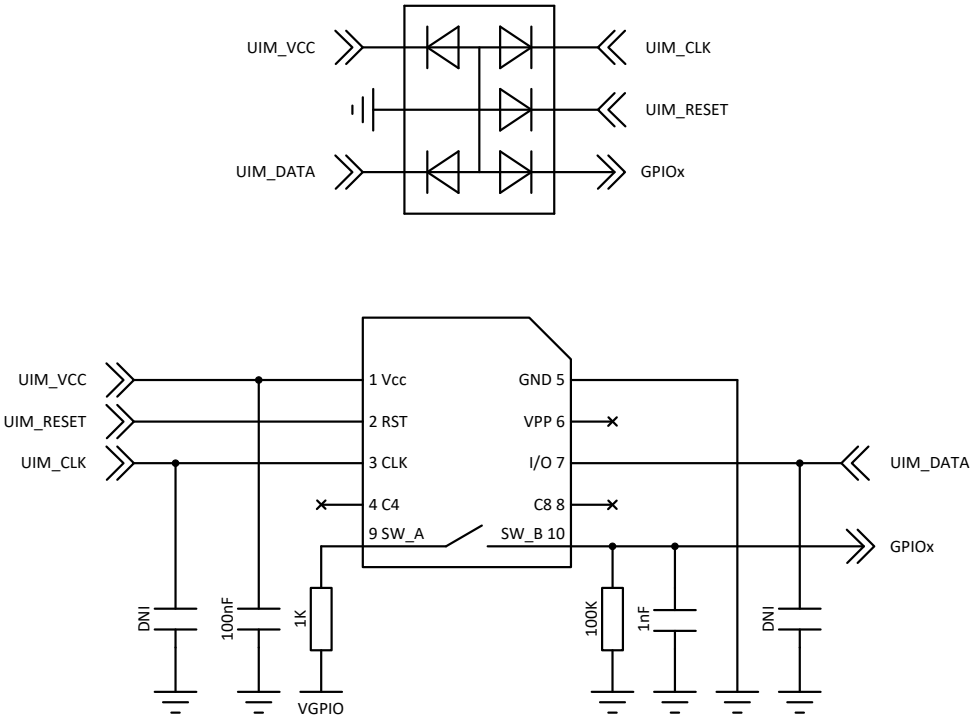


Figure 23. EMC and ESD Components Close to the UIM

5.5. Power Supply

The AirPrime HL6528x module should not be supplied with voltage over 4.5V even temporarily or however briefly.

If the system's main board power supply unit is unstable or if the system's main board is supplied with over 4.5V, even in the case of transient voltage presence on the circuit, the HL6528x's power amplifier and GPS chipset may be severely damaged.

To avoid such issues, add a voltage limiter to the module's power supply lines so that VBATT and VBATT_PA signal pads will never receive a voltage surge over 4.5V. The voltage limiter can be as simple as a Zener diode as shown in the diagram below.

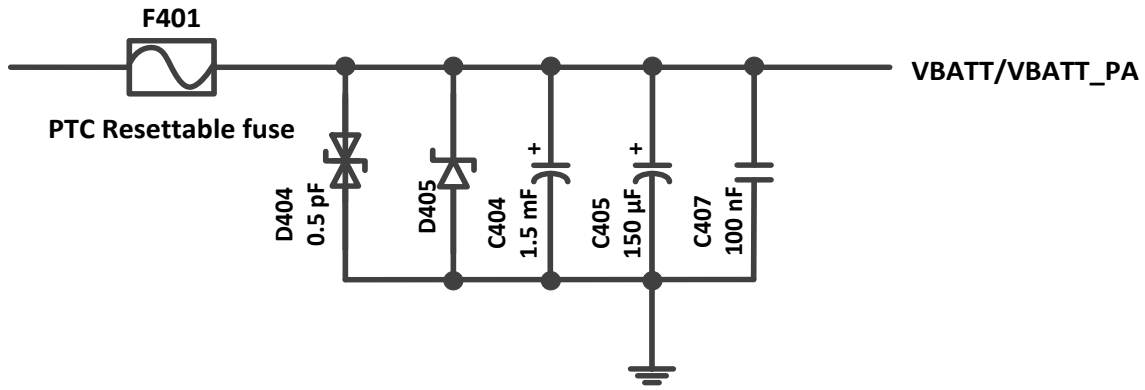


Figure 24. Voltage Limiter Example

5.6. Power Cycle

In addition to Sierra Wireless' reliable recovery mechanisms, it is highly recommended that the ability for a power cycle to reboot the module be included in the design in case the module becomes blocked and stops responding to reset commands.

5.7. Audio Integration

5.7.1. Microphone Audio Design

5.7.1.1. Differential Connection Example

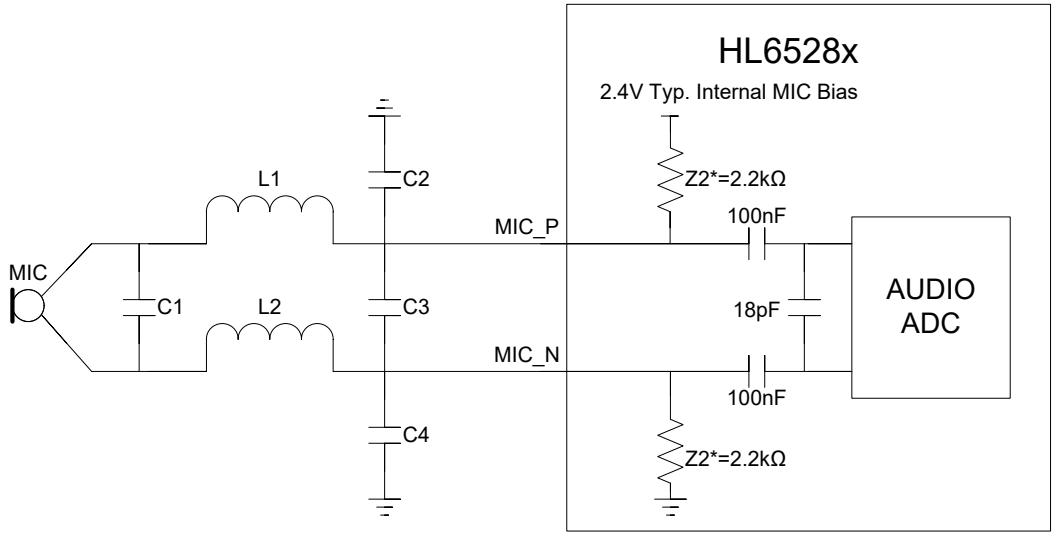


Figure 25. Example of a MIC Input Connection with LC Filter

The LC filter (L1, L2, C2, C3, and C4) is used to reduce EMI perturbation created by TDMA noise, but it is not mandatory. Good quality audio can be achieved without an LC filter depending on the design.

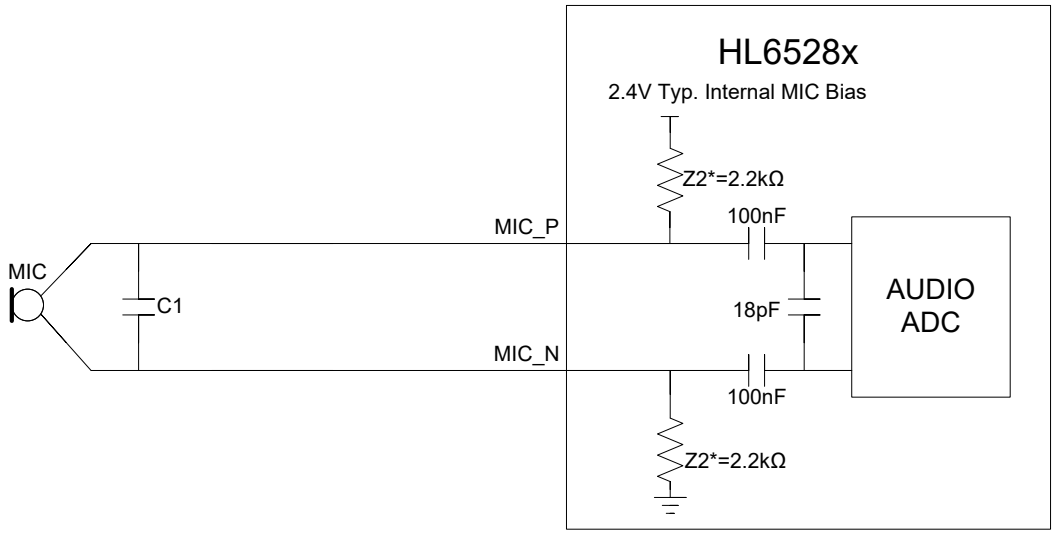


Figure 26. Example of a MIC Input Connection without LC Filter

Capacitor C1 is highly recommended to eliminate TDMA noise. Note that C1 must be close to the microphone.

Refer to the table below for the recommended components to use with a microphone connection.

Table 38. Recommended Components for a Microphone Connection

Component	Description/Details	Notes
C1	12pF to 33pF	Needs to be tuned depending on the design
C2, C3, C4	47pF	Needs to be tuned depending on the design
L1, L2	100nH	Needs to be tuned depending on the design

5.7.1.2. Single-Ended Connection Example

When a single-ended connection is used for MIC, MIC_N is just left open.

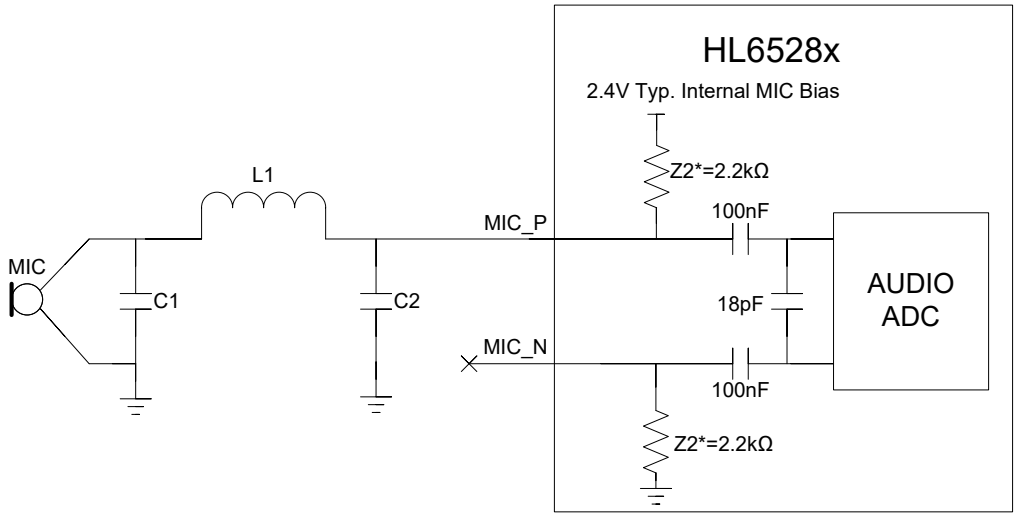


Figure 27. Example of a Single-Ended MIC Input Connection with LC Filter

The internal input impedance value becomes 1100Ω due to the connection of the other end to ground.

The single-ended design is very sensitive to TDMA noise; it is recommended to add L1 and C2 footprint as an LC filter to try to eliminate TDMA noise. Very good grounding on the MIC is required in order to ensure good performance against TDMA. Also, special care on the PCB layout must be taken.

When not used, the filter can be removed by replacing L1 with a 0Ω resistor and by disconnecting C2, as shown in the following figure.

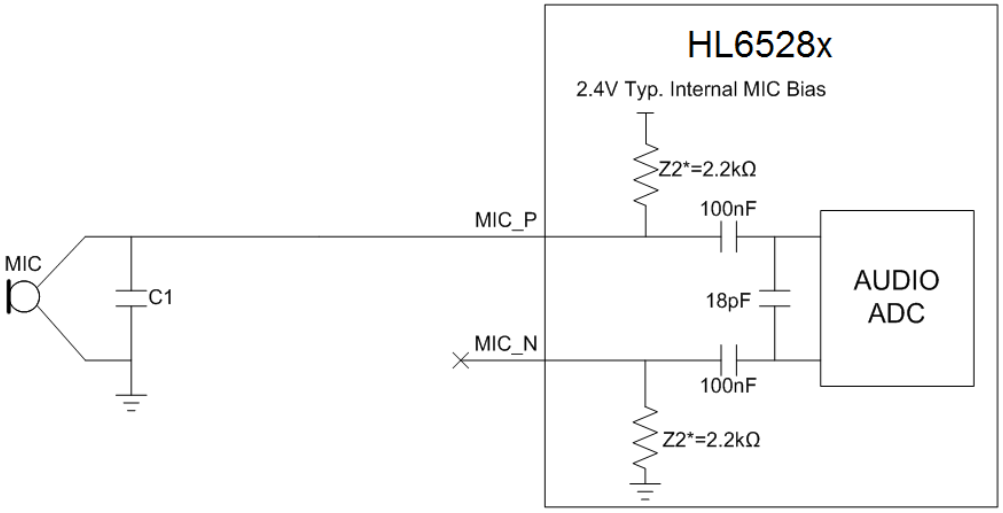


Figure 28. Example of a Single-Ended MIC Input Connection without LC Filter

The capacitor C1 is highly recommended to eliminate TDMA noise, and it must be placed close to the microphone.

Refer to the table below for the recommended components to use with a single-ended microphone connection.

Table 39. Recommended Components for a Single-Ended Microphone Connection

Component	Description/Details	Notes
C1	12pF to 33pF	Needs to be tuned depending on the design
C2	12pF to 33pF	Needs to be tuned depending on the design
L1	100nH	Needs to be tuned depending on the design

5.7.2. Speaker Audio Design

The SPKR interface can be used in a single-ended or a differential connection. However, it is strongly recommended to use a differential connection to reject common mode noise and TDMA noise. Moreover, in single-ended mode, half (1/2) of the power is lost.

When using a single-ended connection, be sure to have a very good ground plane, very good filtering as well as shielding to avoid any disturbance on the audio path.

The following table lists the typical values of both speaker output.

Table 40. Speaker Details

Parameter	Typical Value	Connection
Z (SPKR_P, SPKR_N) (Ω)	32	Differential mode
Z (SPKR_P, SPKR_N) (Ω)	32	Single-ended mode

It is recommended to add ESD protection to the speaker when it is exposed to the external environment. The ESD protection should be connected between the audio lines and a good ground, and placed as close to the speaker as possible.

It is important to select an appropriate speaker and filtering components to avoid TDMA noise.

5.7.2.1. SPKR Differential Connection

Note: Add a 33pF capacitor between the SPKR_P and SPKR_N pads to reduce TDMA noise.

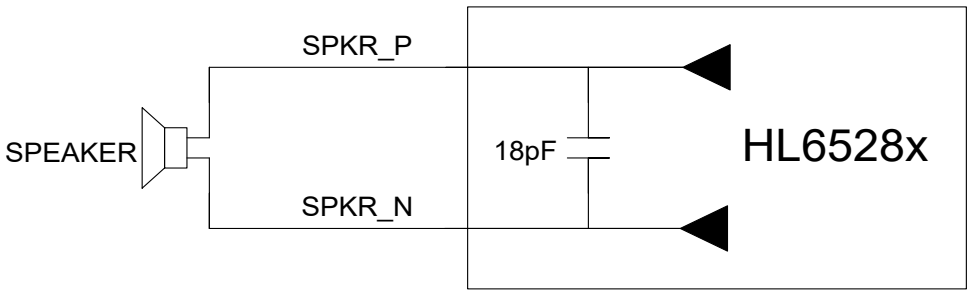


Figure 29. Example of a Differential Connection for SPKR

5.7.2.2. SPKR Single-Ended Connection

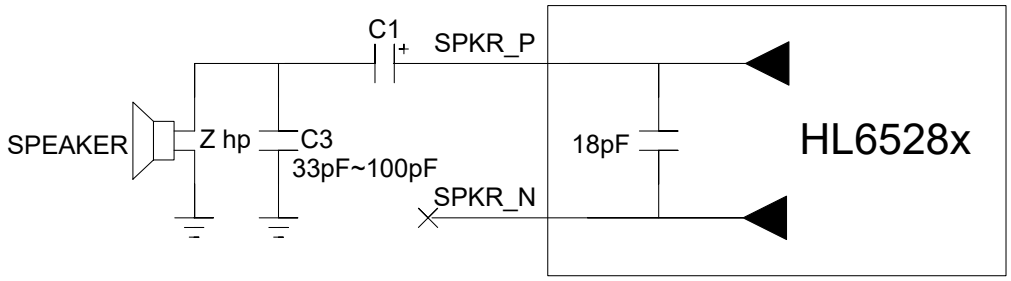


Figure 30. Example of a Single-Ended Speaker Connection (typical implementation)

In a single-ended connection:

- 4.7µF < C1 < 47µF, depending on the speaker characteristics and output power
- the connection between the AirPrime HL6528x module pads and the speaker must be designed to keep the serial impedance lower than 1.5Ω
- SPKR_N can be left open
- output power is lost (-6dB) as compared to a differential connection

5.7.3. Audio Layout Guidelines

To avoid TDMA noise, it is recommended to surround the audio tracks with ground as shown in the following figure.

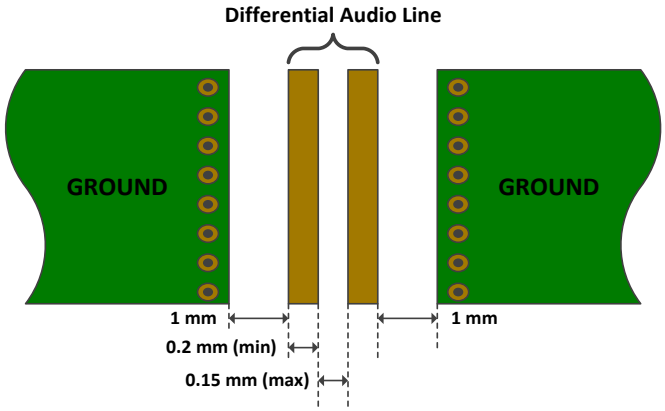


Figure 31. Audio Track Design

For differential connections, refer to the following figure. Note that the differential audio line is always in parallel.

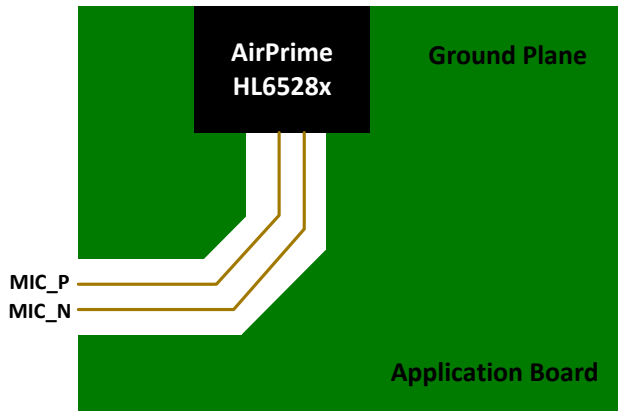


Figure 32. Differential Audio Connection

For single-ended connections, the negative pole of the microphone, MIC_N, should be connected to GND. Refer to the following figure.

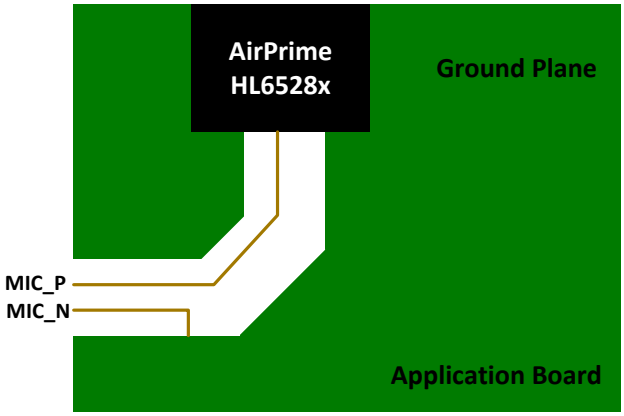


Figure 33. Single-Ended Audio Connection

Caution: *Avoid digital tracks crossing under and over the audio tracks.*

It is highly recommended to have the MIC ground and the LC filter ground to act as an audio analog ground during the PCB layout. This audio ground, together with the MIC_P signal, should act as the differential line pair; and this audio ground should only be connected to the AirPrime HL6528x module ground, as close as possible to the LGA GND pad of the AirPrime HL6528x module. It is the same case for SPKR_P and SPKR_N.

Also, the audio interface is ESD sensitive. ESD protection MUST be added to the interface once it is externally accessible.

To avoid distortion and burst noise, the following guidelines should be followed:

- Audio signals must be symmetric (same components on each path)
- Differential signals must be routed in parallel
- Audio layer must be surrounded by 2 ground layers
- The link from one component to the ground must be as short as possible
- Separate the PCBs for the microphone and the speaker if possible
- Reduce the number of electronic components as much as possible (to avoid loss of quality and greater dispersion)

5.8. Radio Integration

5.8.1. GSM Antenna Integration with Antenna Detection Circuitry

The AirPrime HL6528x module is equipped with external antennas. A 50Ω line matching circuit between the module, the customer's board and the RF antennas is required, for GSM and GPS feed path, as shown in the example below.

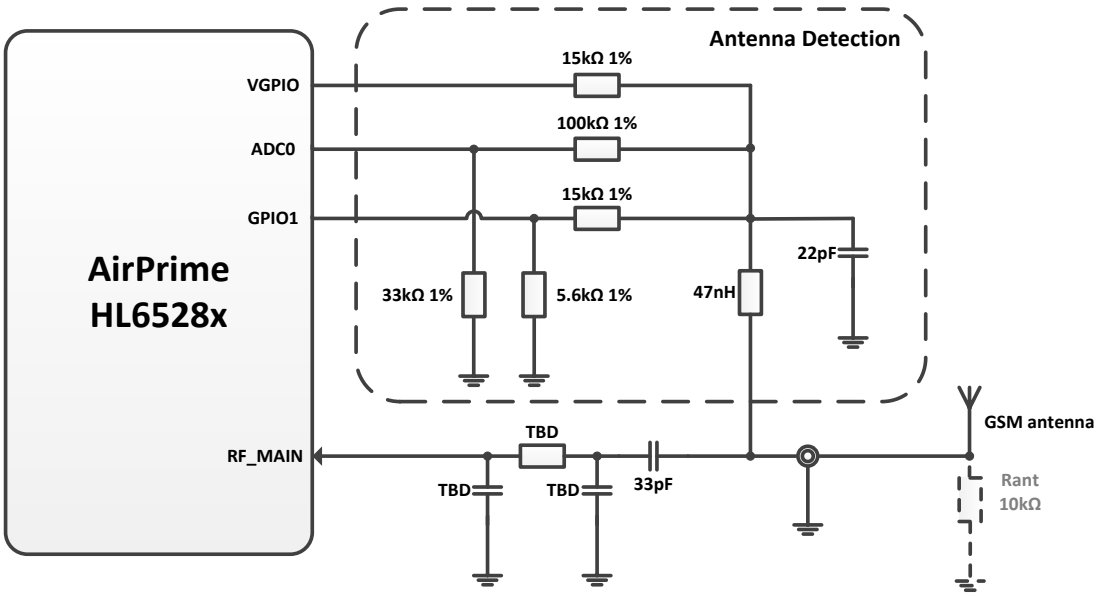


Figure 34. GSM Antenna Connection with Antenna Detection

Note: Antenna detection circuit is optional. Rant is the equivalent DC terminating resistor of the antenna. Rant should be close to 10KΩ.

5.8.2. GNSS Active Antenna Integration

The AirPrime HL6528-G and HL6528-G2.8V modules embed a GPS/GLONASS receiver inside. A possible implementation with an active GNSS antenna is defined below.

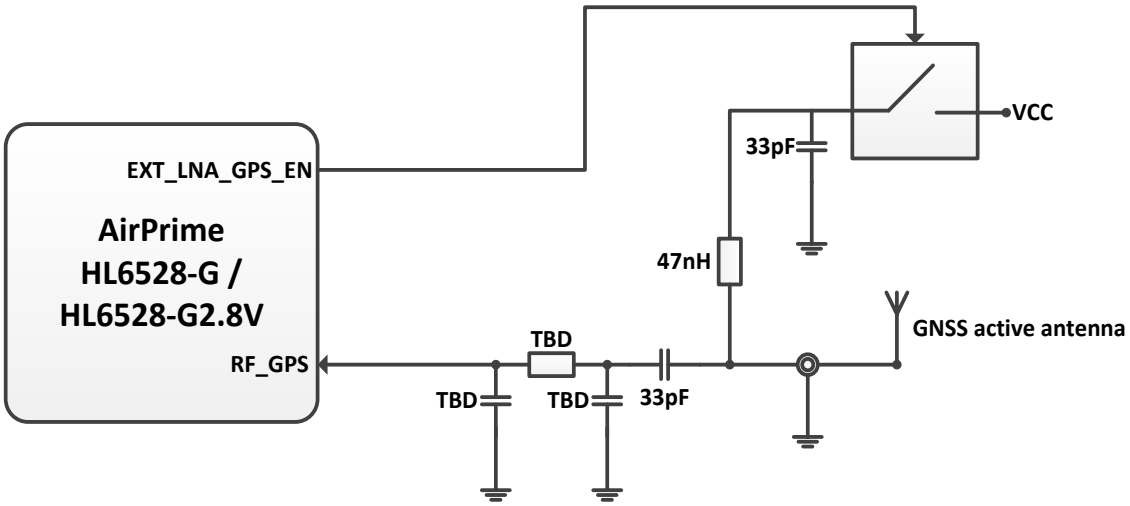


Figure 35. GNSS Application with Active Antenna

EXT_LNA_GPS_EN is a specific signal that automatically sets the AirPrime HL6528-G and HL6528-G2.8V modules' internal LNA to low gain when an external pull-down resistor is detected.

Note: When the application needs to monitor the active antenna current, current monitor devices can be connected to any of the module's GPIOs, and read with a dedicated AT command.

5.9. BUZZER

Pad 57 can be used as a buzzer output if UIM2 is not used. Refer to document [2] AirPrime HL6 and HL8 Series AT Commands Interface Guide for more information about configuring this pad as a buzzer output.

5.10. PWM

Pad 58 can be used as a PWM output if UIM2 is not used. Refer to document [2] AirPrime HL6 and HL8 Series AT Commands Interface Guide for more information about configuring this pad for use as a PWM output.

5.11. Temperature Monitor

The AirPrime HL6528x module is embedded with an internal temperature monitor that can be used to determine the module's internal temperature. Refer to document [2] AirPrime HL6 and HL8 Series AT Commands Interface Guide for more information about configuring the internal temperature monitor.

6. Flash Memory Endurance

As with other embedded devices, the AirPrime HL6528x uses flash (or non-volatile) memory which guarantees a limited number of program/erasing cycles per sector (100,000 cycles). Although a state-of-the-art mechanism has been implemented to limit the number of writing/erasing cycles, Sierra Wireless recommends using “write” AT commands appropriately and always with caution. AT commands used to write to and configure the embedded module’s flash memory are enumerated in document [2] AirPrime HL6 and HL8 Series AT Commands Interface Guide.

7. Reliability Specification

The AirPrime HL6528x module is tested against the Sierra Wireless Automotive Reliability Specification defined below.

7.1. Reliability Compliance

The AirPrime HL6528x module connected on a development kit board application is compliant with the following requirements.

Table 41. Standards Conformity

Abbreviation	Definition
IEC	International Electro technical Commission
ISO	International Organization for Standardization

7.2. Applicable Standards

The table below gives the basic list of standards applicable to the AirPrime HL6528x module. References to any features can be found from these standards.

Table 42. Applicable Standards and Requirements

Document	Current Version	Title
IEC6006826	7.0	Environmental testing - Part 2.6: Test FC: Sinusoidal Vibration.
IEC60068234	73	Basic environmental testing procedures part 2: Test FD: random vibration wide band - general requirements Cancelled and replaced by IEC60068-2-64. For reference only.
IEC60068264	2.0	Environmental testing - part 2-64: Test FH: vibration, broadband random and guidance.
IEC60068232	2.0	Basic environmental testing procedures - part 2: Test ED: (procedure 1) (withdrawn & replaced by IEC60068-2-31).
IEC60068231	2.0	Environmental testing part 2-31: Test EC: rough handling shocks, primarily for equipment-type specimens.
IEC60068229	2.0	Basic environmental testing procedures - part 2: Test EB and guidance: bump Withdrawn and replaced by IEC60068-2-27. For reference only.
IEC60068227	4.0	Environmental testing - part 2-27: Test EA and guidance: shock.
IEC60068214	6.0	Environmental testing - part 2-14: Test N: change of temperature.
IEC6006822	5.0	Environmental testing - part 2-2: Test B: dry heat.
IEC6006821	6.0	Environmental testing - part 2-1: Test A: cold.
IEC60068230	3.0	Environmental testing - part 2-30: Test DB: damp heat, cyclic (12 h + 12 h cycle).
IEC6006823	69 w/A1	Basic environmental testing procedures part 2: Test CA: damp heat, steady State Withdrawn and replaced by IEC60068-2-78. For reference only.
IEC60068278	1.0	Environmental testing part 2-78: Test CAB: damp heat, steady state.

Document	Current Version	Title
IEC60068238	2.0	Environmental testing - part 2-38: Test Z/AD: composite temperature/humidity cyclic test.
IEC60068240	1.0 w/A1	Basic environmental testing procedures - part 2: Test Z/AM combined cold/low air pressure tests.
ISO167501	2ND	Road vehicles - environmental conditions and testing for electrical and electronic equipment - part 1: general.
ISO167502	2ND	Road vehicles - environmental conditions and testing for electrical and electronic equipment - part 2: electrical loads.
ISO167503	2ND	Road vehicles - environmental conditions and testing for electrical and electronic equipment - part 3: mechanical loads.
ISO167504	2ND	Road vehicles - environmental conditions and testing for electrical and electronic equipment - part 4: climatic loads.
IEC60529	2.1 w/COR2	Degrees of protection provided by enclosures (IP code).
IEC60068217	4.0	Basic environmental testing procedures - part 2: Test Q: sealing.
IEC60068218	2.0	Environmental testing - part 2-18: Tests - R and guidance: water.
IEC60068270	1.0	Environmental testing - part 2: tests - test XB: abrasion of markings and letterings caused by rubbing of fingers and hands.
IEC60068268	1.0	Environmental testing - part 2: tests - test l: dust and sand.
IEC60068211	3.0	Basic environmental testing procedures, part 2: test KA: salt mist.
IEC60068260	2.0	Environmental testing - part 2: Test KE: flowing mixed gas corrosion test.
IEC60068252	2.0 w/COR	Environmental testing - part 2: Test KB: salt mist, cyclic (sodium chloride solution).

7.3. Reliability Prediction Model

7.3.1. Life Stress Test

The following tests the AirPrime HL6528x module product performances.

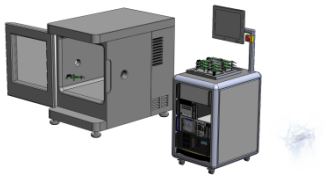
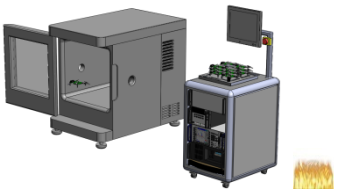
Table 43. Life Stress Test

Designation	Condition
Performance Test PT3T° & PT 	Standard: N/A
	Special conditions: • Temperature: ▪ Class A: -30°C to +70°C ▪ Class B: -40°C to +85°C ▪ Rate of temperature change: ± 3°C/min • Recovery time: 3 hours
	Operating conditions: Powered
	Duration: 14 days

7.3.2. Environmental Resistance Stress Tests

The following tests the AirPrime HL6528x module resistance to extreme temperature.

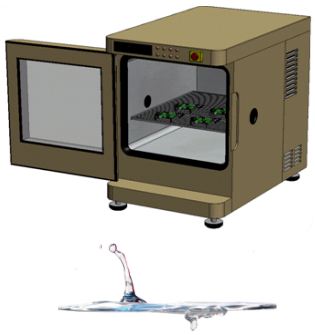
Table 44. Environmental Resistance Stress Tests

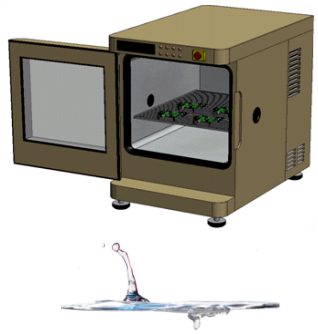
Designation	Condition
Cold Test Active **COTA** 	Standard: IEC 680068-2-1, Test Ad
	Special conditions: • Temperature: -40°C • Temperature variation: 1°C/min
	Operating conditions: Powered On a duty cycle, Idle 1hr/Tx full power 1hr
	Duration: 3 days
Resistance to Heat Test **RH** 	Standard: IEC 680068-2-2, Test Bb
	Special conditions: • Temperature: +90°C • Temperature variation: 1°C/min
	Operating conditions: Powered On a duty cycle, Idle 1hr/Tx full power 1hr
	Duration: 60 days

7.3.3. Corrosive Resistance Stress Tests

The following tests the AirPrime HL6528x module resistance to corrosive atmosphere.

Table 45. Corrosive Resistance Stress Tests

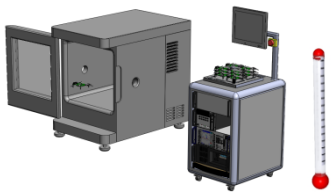
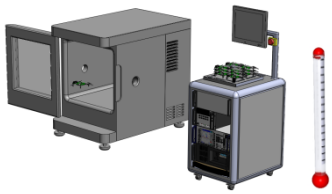
Designation	Condition
Humidity Test HUT 	Standard: IEC 60068-2-3
	Special conditions: • Temperature: +65°C • RH: 95% • Temperature variation: 3 ± 0.6°C/min
	Operating conditions: Powered on, DUT is powered up for 15 minutes and OFF for 15 minutes
	Duration: 10 days
Component Solder Wettability **CSW** 	Standard: JESD22 – B102, Method 1/Condition C, Solderability Test Method
	Special conditions: • Test method: Dip and Look Test with Steam preconditioning 8 h ±15min. dip for 5 +0/-0.5 seconds
	Operating conditions: Un-powered
	Duration: 1 days

Designation	Condition
Moist Heat Cyclic Test **MHCT** 	Standard: IEC 60068-2-30, Test Db
	Special conditions: • Upper temperature: +40 ± 2°C • Lower temperature: +25 ± 5°C • RH: ▪ Upper temperature: 93% ▪ Lower temperature: 95% • Number of cycles: 21 (1 cycle/24 hours) • Temperature Variation: 3 ± 0.6°C/min
	Operating conditions: Un-powered
	Duration: 21 days

7.3.4. Thermal Resistance Cycle Stress Tests

The following tests the AirPrime HL6528x module resistance to extreme temperature cycling.

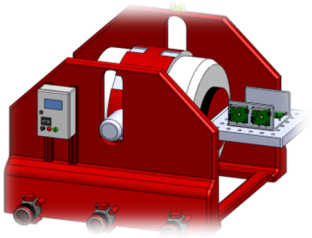
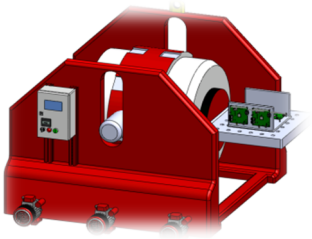
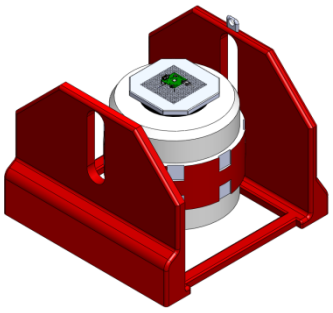
Table 46. Thermal Resistance Cycle Stress Tests

Designation	Condition
Thermal Shock Test **TSKT** 	Standard: IEC 60068-2-14, Test Na
	Special conditions: • Temperature: -40°C to +95°C • Temperature Variation: less than 30s • Number of cycles: 1000 • Dwell Time: 20 minutes
	Operating conditions: Un-powered
	Duration: 28 days
Temperature Change **TCH** 	Standard: IEC 60068-2-14, Test Nb
	Special conditions: • Temperature: -40°C to +95°C • Temperature Variation: 3 ± 0.6°C/min • Number of cycles: 400 • Dwell Time: 10 minutes
	Operating conditions: Un-powered
	Duration: 29 days

7.3.5. Mechanical Resistance Stress Tests

The following tests the AirPrime HL6528x module resistance to vibrations and mechanical shocks.

Table 47. Mechanical Resistance Stress Tests

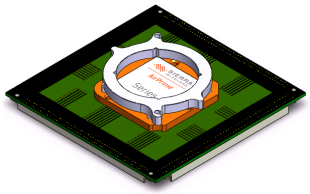
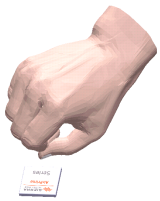
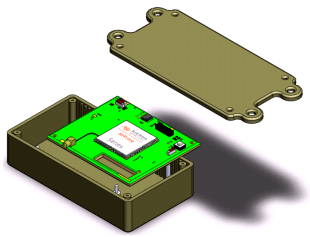
Designation	Condition
Sinusoidal Vibration Test SVT 	Standard: IEC 60068-2-6, Test Fc
	Special conditions: • Frequency range: 30 Hz to 500 Hz • Displacement: 0.35mm (peak-peak) • Acceleration: ▪ 5G from 30 to 62 Hz ▪ 3G from 62 to 200 Hz ▪ 1G from 200 to 500 Hz • Sweep rate: 15 minute / cycle • Number of Sweep: 36 sweeps/axis • Sweep direction: ±X, ±Y, ±Z
	Operating conditions: Un-powered
	Duration: 4 days
Random Vibration Test RVT 	Standard: IEC 60068-2-64
	Special conditions: • Frequency range: 10 Hz – 2000 Hz • Power Spectral Density in $[(m/s^2)^2/Hz]$ ▪ 0.1 g2/Hz at 10Hz ▪ 0.01 g2/Hz at 250Hz ▪ 0.005 g2/Hz at 1000Hz ▪ 0.005 g2/Hz at 2000Hz • Peak factor: 3 • Duration per Axis: 8hrs / axis
	Operating conditions: Un-powered
	Duration: 3 to 4 days
Mechanical Shock Test MST 	Standard: IEC 60068-2-27, Test Ea
	Special conditions: • Shock Test 1: ▪ Wave form: Half sine ▪ Peak acceleration: 30g ▪ Duration: 11ms ▪ Number of shocks: 8 ▪ Direction: ±X, ±Y, ±Z • Shock Test 2: ▪ Wave form: Half sine ▪ Peak acceleration: 100g ▪ Duration: 6ms ▪ Number of shocks: 3 ▪ Direction: ±X, ±Y, ±Z
	Operating conditions: Un-powered
	Duration: 72 hours

7.3.6. Handling Resistance Stress Tests

The following tests the AirPrime HL6528x module resistance to handling malfunctions and damage.

Caution: *Special conditions for ESDC and ESD tests are not met on the GPS pad (pad 38).*

Table 48. Handling Resistance Stress Tests

Designation	Condition
ESDC Test 	Standard: JESD22-A114, JESD22-A115, JEDEC JESD 22 – C101C
	Special conditions: • HBM (Human Body Model): 2KV (Class 2) • MM (Machine Model): 200V (Class B) • CDM (Charged Device Model): 500V (Class III)
	Operating conditions: Powered
	Duration: 3 days
ESD Test 	Standard: IEC 1000-4-2
	Special conditions: • Contact Voltage: ±2kV, ±4kV, ±8kV • Air Voltage: ±4kV, ±8kV, ±15kV
	Operating conditions: Powered
	Duration: 3 days
Free Fall Test **FFT 1** 	Standard: IEC 60068-2-32, Test Ed
	Special conditions: • Number of drops: 2 drops per unit and per axis (total 12 drops) • Height: 1m
	Operating conditions: Un-powered
	Duration: 6 hours
Free Fall Test **FFT 2** 	Standard: Standard Sierra Wireless Methodology
	Special conditions: • Number of drops: 2 drops per unit and per axis (total 12 drops) • Height: 1.5m
	Operating conditions: Un-powered
	Duration: 6 hours

8. FCC/IC Legal Information

8.1. Label

The AirPrime HL6528x module is labeled with its own FCC ID on the shield side. Each HL6528x variant has its own FCC ID as listed in the table below.

Table 49. FCC IDs

Model Name	FCC ID
HL6528	N7NHL6528
HL6528-G	N7NHL6528G
HL6528-2.8V	N7NHL652828V
HL6528-G2.8V	N7NHL6528G28V

When the module is installed in a customer's product, the FCC ID label on the module will not be visible. To avoid this case, an exterior label must be stuck on the surface of the customer's product to indicate the FCC ID of the enclosed module. This label can use wording such as the following: "Contains Transmitter module FCC ID: <FCC ID as listed in Table 49 FCC IDs>" or "Contains FCC ID: <FCC ID as listed in Table 49 FCC IDs>".

8.2. FCC Regulations

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

This device 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 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:

1. Reorient or relocate the receiving antenna
2. Increase the separation between the equipment and receiver.
3. Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
4. Consult the dealer or an experienced radio/TV technician for help.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

8.3. RF Exposure Information

This Modular Approval is limited to OEM installation for mobile and fixed applications only. The antenna installation and operating configurations of this transmitter, including any applicable source-based time-averaging duty factor, antenna gain and cable loss must satisfy MPE categorical Exclusion Requirements of §2.1091.

The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons, must not be collocated or operating in conjunction with any other antenna or transmitter, except in accordance with FCC multi-transmitter product procedures.

The end user has no manual instructions to remove or install the device and a separate approval is required for all other operating configurations, including portable configurations with respect to 2.1093 and different antenna configurations.

According to the MPE RF explore report, maximum antenna gain allowed for use with this device is TBDdBi for GSM 850 and TBDdBi for PCS 1900.

When the module is installed in the host device, the FCC ID label must be visible through a window on the final device or it must be visible when an access panel, door or cover is easily removed. Otherwise, a second label must be placed on the outside of the final device that contains the following text: Contains FCC ID: <FCC ID as listed in Table 49 FCC IDs>

8.4. IC Regulations

IC Radiation Exposure Statement:

> This equipment complies with IC RSS-102 radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 20cm between the radiator & your body.
>
> This device and its antenna(s) must not be co-located or operating in conjunction with any other antenna or transmitter.
>
> This Class B digital apparatus complies with Canadian ICES-003.
>
> Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p) is not more than necessary for successful communication.
>
> Labeling Requirements for the Host Device (from Section 3.2.1, RSS-Gen, Issue 3, December 2010): The host device shall be properly labeled to identify the module within the host device. The Industry Canada certification label of a module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labeled to display the Industry Canada certification number of the module, preceded by the words — Contains transmitter module, or the word — Contains, or similar wording expressing the same meaning, as follows: Contains transmitter module IC: <IC ID as listed below>.

Table 50. IC IDs

Model Name	IC ID
HL6528	2417C-HL6528
HL6528-G	2417C-HL6528G

Model Name	IC ID
HL6528-2.8V	2417C-HL652828V
HL6528-G2.8V	2417C-HL6528G28V

This device complies with Industry Canada license-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.

This radio transmitter (identify the device by certification number, or model number if Category II) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

9. Ordering Information

Model Name	Part Number	Designation
HL6528	1102044	HL6528, GENERIC 1.8V
HL6528-G	1102045	HL6528-G, GENERIC 1.8V
HL6528-2.8V	1102047	HL6528-2.8V, GENERIC 2.8V
HL6528-G2.8V	1102048	HL6528-G2.8V, GENERIC 2.8V
DEV-KIT	6000620	DEV-KIT, HL6 series

10. Terms and Abbreviations

Abbreviation	Definition
ADC	Analog to Digital Converter
AGC	Automatic Gain Control
AT	Attention (prefix for modem commands)
AVL	Automatic Vehicle Location
CCB	Customer Carrier Board
CDMA	Code Division Multiple Access
CF3	Common Flexible Form Factor
CLK	Clock
CODEC	Coder Decoder
CPU	Central Processing Unit
DAC	Digital to Analog Converter
DTR	Data Terminal Ready
EGNOS	European Geostationary Navigation Overlay Service
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EN	Enable
ESD	Electrostatic Discharges
ETSI	European Telecommunications Standards Institute
FDMA	Frequency-division multiple access
GAGAN	GPS aided geo augmented navigation
GLONASS	Global Navigation Satellite System
GND	Ground
GNSS	Global Navigation Satellite System
GPIO	General Purpose Input Output
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
Hi Z	High impedance (Z)
IC	Integrated Circuit
IMEI	International Mobile Equipment Identification
I/O	Input / Output
LED	Light Emitting Diode
LNA	Low Noise Amplifier
MAX	Maximum
MIN	Minimum
MSAS	Multi-functional Satellite Augmentation System
N/A	Not Applicable
PA	Power Amplifier
PC	Personal Computer
PCB	Printed Circuit Board
PCL	Power Control Level

Abbreviation	Definition
PLL	Phase Lock Loop
PWM	Pulse Width Modulation
QZSS	Quasi-Zenith Satellite System
RF	Radio Frequency
RFI	Radio Frequency Interference
RMS	Root Mean Square
RST	Reset
RTC	Real Time Clock
RX	Receive
SCL	Serial Clock
SDA	Serial Data
SIM	Subscriber Identification Module
SMD	Surface Mounted Device/Design
SPI	Serial Peripheral Interface
SV	Satellite Vehicle
SW	Software
PSRAM	Pseudo Static RAM
TBC	To Be Confirmed
TBD	To Be Defined
TP	Test Point
TTS	Text To Speech
TX	Transmit
TYP	Typical
UART	Universal Asynchronous Receiver-Transmitter
UICC	Universal Integrated Circuit Card
USB	Universal Serial Bus
UIM	User Identity Module
VBATT	Main Supply Voltage from Battery or DC adapter
VSWR	Voltage Standing Wave Ratio
WAAS	Wide Area Augmentation System