OriginGPS
mini+mighty

ORG1511-AG05 (Hornet)

GNSS Module With Integrated Antenna

DATASHEET

OriginGPS.com

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ABBREVIATIONS

Abbreviation	Description
A-GPS	Assisted GPS
AC	Alternating Current
ADC	Analog to Digital Converter
AGC	Automatic Gain Control
BPF	Band Pass Filter
C/N0	Carrier to Noise density ratio [dB-Hz]
CDM	Charged Device Model
CE	European Community conformity mark
CEP	Circular Error Probability
CMOS	Complementary Metal-Oxide Semiconductor
CPU	Central Processing Unit
CTS	Clear-To-Send
CW	Continuous Wave
DC	Direct Current
DOP	Dilution Of Precision
DR	Dead Reckoning
DSP	Digital Signal Processor
ECEF	Earth-Centered Earth-Fixed
ECHA	European Chemical Agency
EGNOS	European Geostationary Navigation Overlay Service
EIA	Electronic Industries Alliance
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
ENIG	Electroless Nickel Immersion Gold
ESD	Electro-Static Discharge
ESR	Equivalent Series Resistance
EU	European Union
EVB	Evaluation Board
EVK	Evaluation Kit
FCC	Federal Communications Commission
FSM	Finite State Machine
GAGAN	GPS Aided Geo-Augmented Navigation
GNSS	Global Navigation Satellite System
GPIO	General Purpose Input or Output
GPS	Global Positioning System
HBM	Human Body Model
HDOP	Horizontal Dilution Of Precision
I2C	Inter-Integrated Circuit
I/O	Input or Output
IC	Integrated Circuit

Abbreviation	Description
ICD	Interface Control Document
IF	Intermediate Frequency
ISO	International Organization for Standardization
JEDEC	Joint Electron Device Engineering Council KA (Keep Alive)
KF	Kalman Filter
LDO	Low Dropout regulator
LGA	Land Grid Array
LNA	Low Noise Amplifier
LP	Low Power
LS	Least Squares
LSB	Least Significant Bit
MID	Message Identifier
MM	Machine Model
MSAS	Multi-functional Satellite Augmentation System
MSB	Most Significant Bit
MSL	Moisture Sensitivity Level
NFZ™	Noise-Free Zones System
NMEA	National Marine Electronics Association
NVM	Non-Volatile Memory
PCB	Printed Circuit Board
PLL	Phase Lock Loop
PMU	Power Management Unit
POR	Power-On Reset
PPS	Pulse Per Second
PRN	Pseudo-Random Noise
PSRR	Power Supply Rejection Ratio
PTF™	Push-To-Fix
QZSS	Quasi-Zenith Satellite System
RAM	Random Access Memory
REACH	Registration, Evaluation, Authorization and Restriction of Chemical substances
RF	Radio Frequency
RHCP	Right-Hand Circular Polarized
RMS	Root Mean Square
RoHS	Restriction of Hazardous Substances directive
ROM	Read-Only Memory
RTC	Real-Time Clock
RTS	Ready-To-Send
SAW	Surface Acoustic Wave
SBAS	Satellite-Based Augmentation Systems
SID	Sub-Identifier
SIP	System In Package
SMD	Surface Mounted Device
SMPS	Switched Mode Power Supply

Abbreviation	Description
SMT	Surface-Mount Technology
SOC	System On Chip
SPI	Serial Peripheral Interface
SV	Satellite Vehicle
TCXO	Temperature-Compensated Crystal Oscillator
TTFF	Time To First Fix
TTL	Transistor-Transistor Logic
UART	Universal Asynchronous Receiver/Transmitter
VCCI	Voluntary Control Council for Interference by information technology equipment
VEP	Vertical Error Probability
VGA	Variable-Gain Amplifier
WAAS	Wide Area Augmentation System

Related Documentation

№	Document Name
1	ORG1511-AG05 Evaluation Kit Datasheet
2	AG-L1-GNSS SW Manual

Revision History

Revision	Date	Change Description	Author
1.0	4-September-2023	First release	Orel Nimni Igor Mindel

Scope

This document describes the features and specifications of the ORG1511-AG05 GNSS module.

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1. About the Hornet Family

The OriginGPS GNSS modules are specifically designed to cater to markets where compact size, lightweight, stand-alone functionality, high integration, low power consumption, and design versatility are of utmost importance.

Introducing the OriginGPS Hornet family, which surpasses size limitations by offering the industry's tiniest fully integrated, exceptionally sensitive GPS and GNSS modules with integrated antennas or on-board RF connectors.

Incorporating OriginGPS' exclusive NFZ technology, the Hornet family ensures exceptional sensitivity and noise resistance, even in challenging signal conditions like urban canyons, dense foliage, or situations where the receiver's spatial position changes rapidly.

With the Hornet family, you can achieve the shortest TTM (Time-to-Market) with minimal design risks, as all that is required is to connect the power supply to a single layer PCB.

2. About the ORG1511-AG05 Module

The ORG1511-AG05 module represents a fully integrated System-in-Package (SiP) with a compact LGA SMT footprint, purposefully designed to offer exceptional integration capabilities for applications requiring high volume and cost-effectiveness.

Tailored to support both compact and traditional applications like smart watches, wearable devices, and asset trackers, the ORG1511-AG05 module is a miniature, multi-channel receiver supporting GPS, GLONASS, Galileo, BeiDou, SBAS, and QZSS. It continuously tracks all available satellites, providing real-time positioning data in the widely used NMEA format.

With its impressive performance, the ORG1511-AG05 module boasts superior sensitivity and achieves a rapid Time-to-First-Fix (TTFF) in under one second. It ensures location accuracy of approximately two meters and exhibits a remarkable tracking sensitivity of -165dBm.

In a mere 10mm x 10mm package, the ORG1511-AG05 module sets a new standard as the industry's smallest module of its kind.

What sets this module apart is its groundbreaking energy efficiency per fix ratio, unparalleled accuracy, and rapid fixes even in challenging signal conditions, such as urban areas with dense buildings and foliage.

The module features an integrated GNSS System-on-a-Chip (SoC) equipped with a high-performance microprocessor and sophisticated firmware. This design ensures that the positioning payload remains offloaded from the host, enabling seamless integration into embedded solutions while keeping computing resource consumption low.

Utilizing an innovative architecture, the module can detect changes in context, temperature, and satellite signals. It achieves near-continuous availability by maintaining and opportunistically updating its internal fine time, frequency, and satellite ephemeris data, all while consuming mere microwatts of battery power.

3. ABOUT ORIGINGPS

OriginGPS is a renowned global leader in the design, manufacturing, and supply of miniature positioning modules, and cellular IoT systems and products. Our expertise lies in creating fully integrated, compact GPS/GNSS and IoT solutions to empower developers and facilitate their product development.

At the core of OriginGPS modules is our groundbreaking Noise-Free-Zone system (NFZ™) proprietary technology, which sets new benchmarks for sensitivity and noise immunity. This enables faster position fixing and ensures stable navigation even in challenging satellite signal conditions.

Established in 2006, OriginGPS has been at the forefront of developing cutting-edge technologies that miniaturize RF modules, catering to the increasing demand for smaller wireless solutions in the market. With over a decade of experience, our team of experts has been dedicated to producing ultra-sensitive, dependable, and high-performance modules with the smallest footprint available.

Our versatile range of products supports various sectors, including asset tracking, fleet management, industrial IoT, law enforcement, pet and people tracking, precise agriculture, smart cities, sports, and wearables. OriginGPS remains committed to innovation and delivering top-notch solutions for all our customers' positioning and IoT needs.

4. MODULE DESCRIPTION

The following section provides comprehensive details on the ORG1511-AG05, and includes the module's highlights, features and integrated parts, and provides a presentation of its architecture.

4.1. Module Highlights

The following subsection details the key features incorporated within the ORG1511-AG05 module.

- Autonomous operation
- OriginGPS Noise Free Zone System technology
- Fully integrated patch antenna, integrated dual-LNA, SAW filter, TCXO, RTC, GNSS SoC, RF shield, and PMU.
- Concurrent tracking of multiple constellations: GPS, Galileo and GLONASS, BeiDou, and QZSS.
    - Supports GPS & Galileo L1 1575.42 frequency, C/A code.
    - Supports GLONASS G1 FDMA 1598-1606MHz frequency band, SP signal.
    - Supports BeiDou B1I (1561.098MHz) and B1C (1575.42MHz) frequency bands.
    - DGPS capability supports SBAS (WAAS, EGNOS, MSAS, GAGAN).
- Sensitivity down to -165dBm
- TTFF of < 1s in 50% of trials under hot start conditions
- Power consumption of ≤ 54mW
- High accuracy of 2m@CEP
- Accuracy of 1.9m@CEP in open sky conditions over 24 hours
- AGPS support: Embedded Assist System (EASY) and Extended Prediction Orbit (EPO) and Hot Still
- Indoor and outdoor multi-path detection and compensation
- Jamming rejection – 12 multi-tone Active Interference Cancellation (AIC)
- 2MB built-in flash
- Power management modes: ALP, SW RTC, BackUp, and HW RTC
- NMEA, RTCM, and raw data with PAIR commands over UART and I2C
- Update message rate of 1-10Hz
- 1PPS output
- Voltage supply of 1.8V input and backup input
- LGA footprint of 10mm x 10mm
- Weight of 1.43g
- Operating from -40°C to +85°C
- Optimized for automatic assembly and reflow equipment.
- FCC, CE, VCCI, RoHS II/REACH compliant

4.2. Architecture

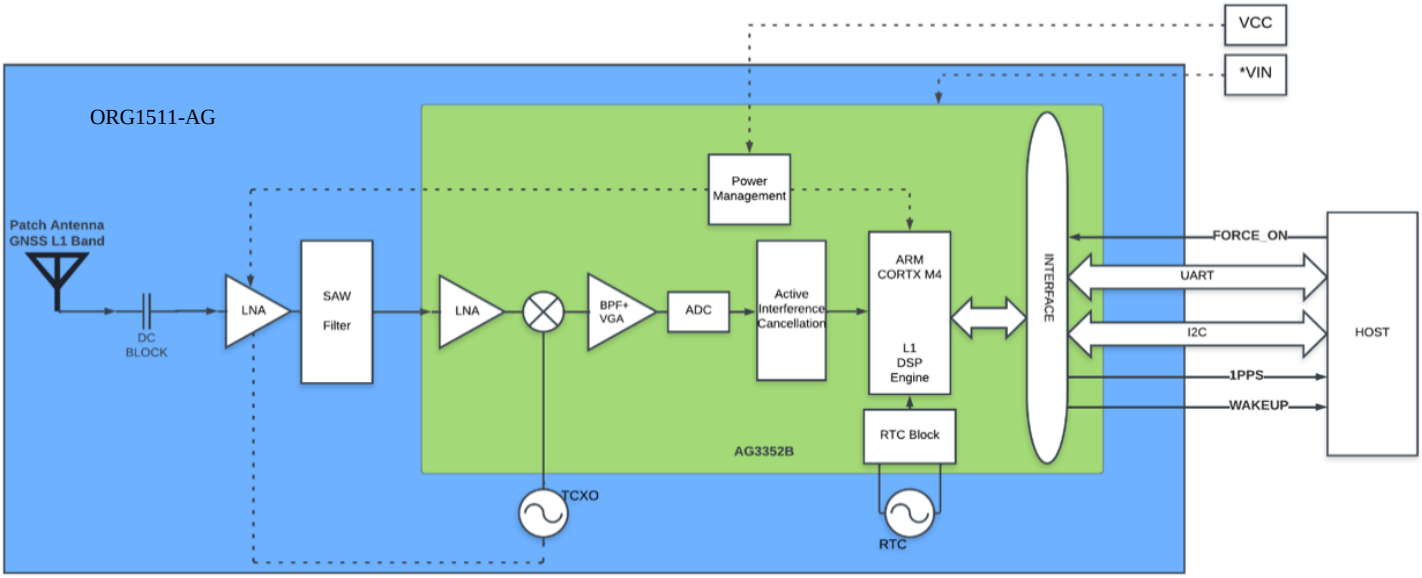

Figure 1. ORG1511-AG05 Architecture

The ORG1511-AG05 module includes the following main components:

- **GNSS SAW Filter**

  The band-pass SAW filter eliminates out-of-band signals that may interfere with GNSS reception. The GNSS SAW filter is optimized for low Insertion Loss in the GNSS band and low Return Loss outside of it.

- **GNSS LNA**

  The dual stage cascaded LNAs amplify GNSS signals to meet RF down converter input threshold.

  The noise figure (NF) optimized design provides maximum sensitivity.

- **TCXO**

  The 26MHz oscillator serves as the clock source for the down conversion process in the RF block. Its stability is of paramount importance because it directly affects the performance of the GNSS module in several ways; shortening the TTFF and improving the navigation stability.

- **RTC Crystal**

  The RTC (Real-Time Clock) in the GNSS SoC plays a crucial role in maintaining the Hot Start and Warm Start capabilities of the module. To achieve these capabilities, a high-precision 32.768 kHz quartz crystal is utilized as the timekeeping reference for the RTC. This crystal has very tight specifications, which means it exhibits highly accurate and stable frequency characteristics.

- **RF Shield**

  The RF enclosure serves two critical purposes in the operation of the GNSS module: protection from external interference and containment of internal emissions. The RF enclosure prevents external RF signals from entering the module and interfering with the GNSS receiver's operation.

- **Flash**

  The Flash has a capacity of 2MB (megabytes). During boot-up, the GNSS SoC reads the firmware from the Flash memory and loads it into its internal processing units. The firmware stored in the built-in Flash enables the GNSS module to operate independently. This is particularly useful in applications where the GNSS module must function in remote or resource-constrained environments.

- **AG3352B GNSS SoC**

  The AG3352B is a multi-GNSS System on Chip (SoC) designed by AIROHA. As a hybrid positioning processor, it combines signals from multiple GNSS constellations, including GPS, Galileo, GLONASS, BeiDou, and QZSS, to offer a high-performance navigation solution.

  Key features of the AG3352B SoC include:

  GNSS RF: This part of the chip handles the radio frequency functions required for receiving and processing signals from various GNSS satellites.

  GNSS baseband: The GNSS baseband component processes the received signals from the satellites to extract navigation data and calculate precise positioning information.

  Integrated navigation solution software: The SoC comes with built-in software that handles the complex algorithms necessary for processing data from multiple GNSS constellations and providing accurate positioning information.

  ARM Cortex-M4 with floating-point unit: This processor is responsible for executing general-purpose tasks and performing computations related to positioning and navigation.

  Low latency RAM: The RAM ensures quick and efficient data access during its operation.

  Chip power managing unit: The power management unit ensures efficient power usage and extending the device's battery life.

  Serial flash: The flash memory is used for storing firmware, configuration data and essential information for the chip's operation.

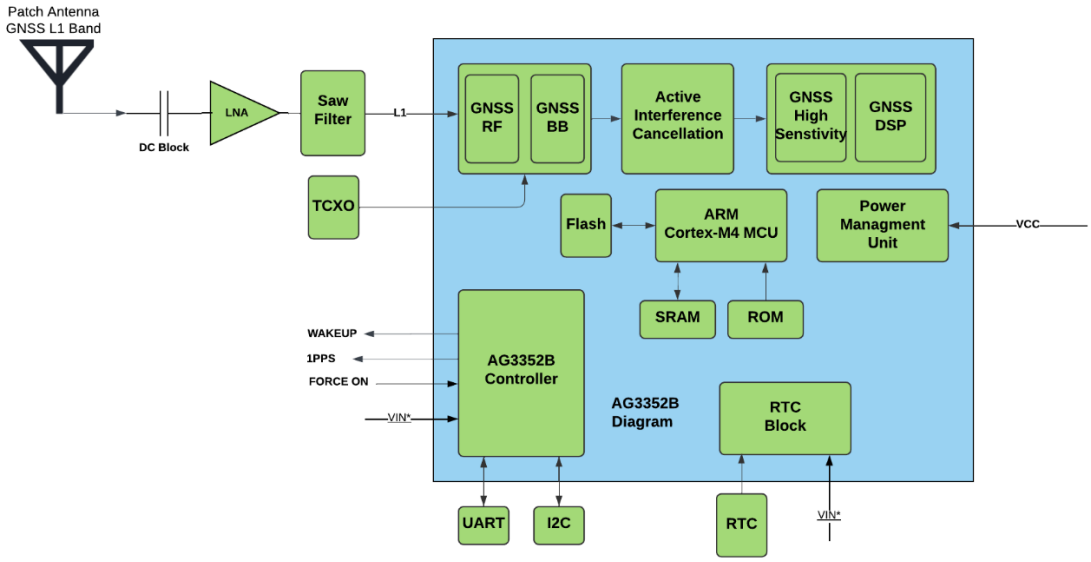

Figure 2. AG3352B System Block Diagram and Peripherical Components

AIROHA AG3352B is a feature-rich multi-GNSS SoC:

- **GNSS radio subsystem** enables concurrent multi-channel reception (GPS, Galileo, GLONASS, BeiDou, SBAS, QZSS) in L1/B1/E1, with mixer, current mode interface, fractional-N synthesizer, self-calibrating filters, IF VGA with AGC, and high-sample rate ADCs with adaptive dynamic range.
- **Measurement subsystem** includes DSP core for GNSS signal acquisition and tracking, interference scanner and detector, removers, multipath mitigation, dedicated DSP code ROM, and DSP cache SRAM, interfacing seamlessly with the GNSS radio subsystem.
- **Navigation subsystem** integrates an ARM Cortex-M4 microprocessor system for precise position, velocity, and time solutions, along with program ROM, data SRAM, and flash memory.
- **Peripheral Controller subsystem (a)** facilitates UART Host interface, I2C, RTC block, and wake-up signal option for efficient communication.
- **Peripheral Controller subsystem (b)** interfaces with navigation, PLL, and PMU subsystems, ensuring smooth data flow and control.
- **Navigation subsystem** efficiently communicates with the measurement subsystem, enhancing overall navigation performance.
- **PMU subsystem** features voltage regulators for RF and baseband domains, optimizing power management and performance.

4.3. ORG1511-AG05 Feature Description

4.3.1. Assisted GPS (AGPS)

Assisted GPS (A-GPS) is a technique that reduces Time To First Fix (TTFF) by using data from sources other than broadcast GPS signals. The receiver can calculate necessary ephemeris data locally (locally generated ephemeris) or obtain it from a server (server-generated ephemeris), storing it in the module. The ORG1511-AG05 incorporates EPO and HotStill technologies, enabling Hot Starts even in weak signal conditions and while on the move. EPO (Extended Prediction Orbit) is Airoha's proprietary off-line server based AGPS solution. By utilizing an application to store and load EPO files into the device, multi-constellation EPO enhances user experience with improved TTFF and better first fix accuracy.

4.3.1.1. Server-generated AGPS (Extended Prediction Orbit - EPO)

The AGPS (EPO™) feature provides predicted EPO (Extended Prediction Orbit) data to speed up Time To First Fix (TTFF). Users can download this data to the GNSS engine from an FTP server via the Internet or a wireless network. When satellite navigation information is limited or signal strength is weak, the GNSS engine utilizes the EPO data for position calculation. An application on the host device can be used to store and load EPO files. Multi-constellation EPO further enhances user experience by improving TTFF and first fix accuracy. The predicted ephemeris file is obtained from the AGPS server and injected into the module via UART interface. These predictions do not require local broadcast ephemeris collection and remain valid for up to 14 days.

4.3.2. Differential GNSS (DGNSS)

Differential GNSS applications leverage data from GNSS augmented systems or ground station networks to enhance the performance of primary GNSS constellations. By collecting correction information from the broadcast navigation messages of augmented systems or ground stations, the receiver integrates this data using estimation methodology to improve the accuracy of position-related information. The ORG1511-AG05 module fully supports differential GNSS applications, including Satellite Based Augmentation System (SBAS), Radio Technical Commission for Maritime Services (RTCM), and Sub-meter Level Augmentation Service (SLAS). The following sections provide detailed descriptions of the DGNSS (differential GNSS) applications implemented by the module.

4.3.2.1. QZSS (Quasi-Zenith Satellite System)

The Japanese SBAS (Satellite-Based Augmentation System) is comprised of three satellites positioned in a highly inclined elliptical orbit that is geosynchronous (not geostationary). These satellites follow analemma-like ground tracks, allowing them to provide continuous coverage over Japan with just three satellites. The main function of the Japanese SBAS is to augment the GPS system, enhancing its accuracy and reliability. However, the signals

from these satellites can also be utilized for ranging purposes. Users have the flexibility to enable or disable NMEA reporting for QZSS (Quasi-Zenith Satellite System) as per their requirements.

4.3.2.2. Satellite-Based Augmentation System (SBAS)

The ORG1511-AG05 module can effectively utilize Satellite-Based Augmentation System (SBAS) satellites for two purposes: obtaining differential corrections and satellite range measurements. Systems such as WAAS, EGNOS, MSAS, and GAGAN employ geostationary satellites to transmit regional differential corrections via GNSS-compatible signals. By integrating SBAS corrections, the module can greatly enhance position accuracy by compensating for significant error sources, such as the ionospheric delay and satellite time/clock errors. This enhancement ensures more precise and reliable GNSS-based positioning information for various applications.

4.3.3. Power Management Modes

The ORG1511-AG05 module offers different operational modes to cater to various requirements, allowing it to provide positioning information while minimizing overall current consumption. The choice of power management modes takes into account the availability of GNSS signals in the module's operating environment, allowing the designer to strike the right balance between performance and power consumption.

The power management modes available are described below and can be enabled using specific commands:

Full Power Continuous: This mode ensures optimal GNSS performance, providing accurate positioning information without compromising on the power consumption. It is suitable for scenarios where precise positioning is of utmost importance, and power efficiency is not a primary concern.

Power Save Mode (range of options): The module offers a range of power-saving modes designed to optimize power consumption while still providing positioning information. These modes are ideal for situations where power efficiency is crucial, and the level of positioning accuracy can be adjusted based on the specific application's needs.

By offering a variety of power management modes, the ORG1511-AG05 module enables designers to find the best trade-off between performance and power consumption.

4.3.3.1. Full Power Continuous Mode

The ORG1511-AG05 module initiates its operation in the full power continuous mode by default, as the FORCE_ON pin is internally set to HIGH. In this mode, the acquisition engine operates at its maximum performance, leading to the shortest Time To First Fix (TTFF) and highest sensitivity. The module actively searches for signals from all available satellites during this phase.

Upon meeting the following conditions, the module transitions from the acquisition engine to the tracking engine, which results in reduced power consumption:

Valid GPS/GNSS position obtained: Once the module successfully determines a valid position using the acquired satellite signals, it switches to the tracking engine to maintain the accuracy of the position information.

Valid ephemeris for each satellite in view: Ephemeris data contains essential information about the satellite's orbital parameters. When the module receives valid ephemeris data for all the satellites in view, it shifts to the tracking engine to optimize power consumption while continuously tracking the satellites' movements for consistent positioning updates.

By intelligently switching to the tracking engine when necessary, the module achieves a balance between performance and power consumption, ensuring accurate positioning while efficiently managing power resources.

4.3.3.2. RTC Mode

The RTC (Real-Time Clock) mode is an additional power-saving feature of the ORG1511-AG05 module. In this mode, all systems, including the GNSS engine and internal processing units, are shut down, except for a dedicated low-power RTC block. The GNSS engine no longer provides position-related information, and PAIR commands cannot be sent during this mode.

The navigation data, which includes critical information like ephemeris, almanac, location, and time, used to facilitate TTFF performance, is saved to RTCRAM for future use upon exiting RTC mode.

There are three ways to enter RTC mode:

1. Running a PAIR command (SW RTC Mode): A specific PAIR command, which can be time-specific, triggers the module to enter RTC mode.
2. Disconnecting the module from the main power while keeping VIN - "V_backup" at 1.8V (available in BOM option AG05): This method allows the module to enter RTC mode while maintaining a low-power state.
3. Setting the FORCE_ON pin to LOW state (HW RTC Mode): Configuring the FORCE_ON pin in this way causes the module to enter RTC mode.

To wake the module from RTC mode, there are two options:

1. Setting the RTC timer by a PAIR650 command: The RTC timer can be set to wake the module from RTC mode at a specific time.
2. Pulling the FORCE_ON pin HIGH: Changing the state of the FORCE_ON pin to HIGH will wake the module from RTC mode.

Upon exiting RTC mode, all system resources are re-initialized, allowing the module to resume normal operation. The RTC mode provides an effective means to save power when continuous GNSS operation is not required, ensuring efficient power management in various scenarios.

(*)- Note that VIN must be connected to a power source at all times to ensure the module’s functionality.

4.3.3.3. Periodic Mode

This mode enables autonomous power on/off with reduced fix rate to reduce average power consumption. In periodic mode, the main power supply VCC is still powered, but power distribution to internal circuits is controlled by the receiver. The periodic mode consists of the running and sleeping stages. In the running stage, the GNSS module provides the position-related information while staying in the lower power consumption status in the sleeping stage.

The periodic mode in the ORG1511-AG05 module enables autonomous power on/off with a reduced fix rate, effectively reducing average power consumption. In this mode, the main power supply VCC remains powered, but power distribution to internal circuits is controlled by the receiver.

The periodic mode operates in two stages:

1. Running Stage: During the running stage, the GNSS module provides position-related information. However, it does so while maintaining a lower power consumption status, optimizing energy usage.
2. Sleeping Stage: In the sleeping stage, the GNSS module goes into a low-power state, conserving energy and reducing overall power consumption. During this period, the module is not actively providing position-related information.

By cycling between the running and sleeping stages, the module achieves a balance between periodically providing position information and conserving power during intervals when positioning updates are not required frequently. This approach ensures efficient power management, making it suitable for applications where lower average power consumption is desired without compromising essential positioning functionality.

Figure 3. Periodic Mode - Power Consumption

The time span of the running stage can be changed dynamically and also strictly limited. To improve the TTFF performance after waking up from the sleeping stage, the module will change the time span of the running stage dynamically to obtain more navigation information.

In the periodic mode, the time span of the running stage can be dynamically adjusted and strictly limited. This flexibility allows the module to optimize the Time To First Fix performance after waking up from the sleeping stage.

Upon waking up from the sleeping stage, the module adopts a method to dynamically change the time span of the running stage. By extending the

duration of the running stage, the module can gather more navigation information, this additional information helps improve the TTFF performance as the module has a better chance of acquiring and processing sufficient data to determine an accurate position fix in a shorter time.

To activate the periodic mode, issue the following command:

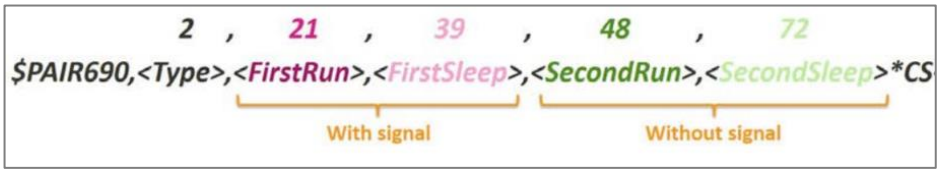

Figure 4. Periodic Mode Command Structure

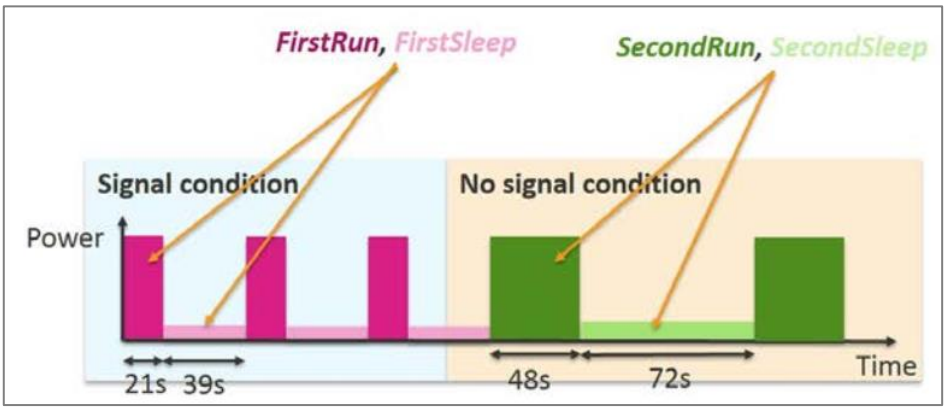

Figure 5. Periodic Mode - Time Parameters

To exit the periodic mode and return to Full Power Continuous Mode, send the Pair690,0-disable command immediately after the module wakes up from a sleep cycle. To return the module to its regular operating mode, a restart can be performed.

4.3.3.4. ALP Mode

The Adaptive Low Power mode (ALP) utilizes duty cycles to conserve power but may have an impact on GNSS performance. The receiver provides positioning solutions at each epoch during ALP operation. This mode is limited to the "Normal" and "Fitness" navigation modes and is not supported at high fixing rates (greater than 1 Hz). Additionally, certain module features, such as SBAS, SLAS, low power periodic mode, and GLP mode, will be automatically disabled while ALP is active.

4.3.4. Configuration Settings

When the power is turned off, the configuration settings in the ORG1511-AG05 module are erased and reset to their default values. However, to retain the desired configuration settings for future navigation sessions, users can save them to the internal flash memory using the PAIR513 command. By using this command, the configuration settings will be stored in the internal flash, ensuring that they are preserved and loaded for the next navigation session, even after a power cycle or system restart. Detailed instructions on how to use the PAIR513 command can be found in the *AG-L1-GNSS SW Manual*".

5. PAD ASSIGNMENTS

Table 1. Pin Out

Pad	Name	Function	Direction
1	FORCE_ON	Forced full-power mode signal	Input
2	1PPS	UTC Time Mark	Output
3	UART0_TX	UART0 Transmit (Serial Output)	Output
4	V_{CC}	System Power Input	Power
5	GND	System Ground	Power
6	WAKEUP	GNSS operating indicator	Output/Input
7	SDA	I2C Data	Bi-directional
8	VIN	Input for backup power or VIO input	Power
9	SCL	I2C Clock	Bi-directional
10	UART0_RX	UART0 Receive (Serial Input)	Input

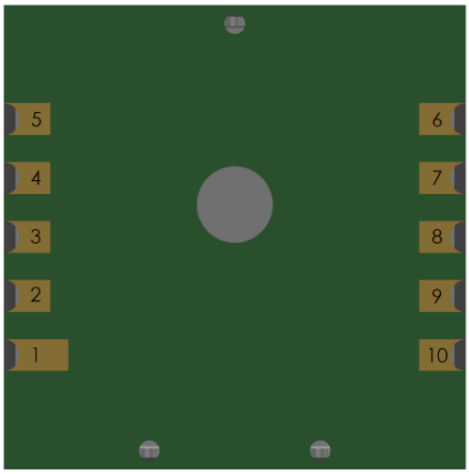

Figure 6. ORG1511-AG05 Module - Bottom View

6. MECHANICAL SPECIFICATIONS

The ORG1511-AG05 module features the following mechanical specifications:

- Packaging: The module comes in a miniature LGA (Land Grid Array) SMD (Surface Mount Device) package, measuring 10mm x 10mm in size.
- Enclosure: The module is built on a PCB (Printed Circuit Board) assembly enclosed within a metallic RF shield box. The Patch antenna element is positioned on top of this shield box.
- SMT Pads: On the bottom side of the module, there are 10 SMT (Surface Mount Technology) pads with a base and ENIG (Electroless Nickel Immersion Gold) plating. These pads facilitate the connection and mounting of the module on the PCB.
- Assembly Compatibility: The ORG1511-AG05 module supports automated pick and place assembly, enabling efficient mass production processes. It is also compatible with reflow soldering processes, ensuring reliable and consistent solder connections during production.

  These mechanical specifications make the ORG1511-AG05 module suitable for integration into various electronic devices and systems, providing reliable and precise GNSS positioning capabilities.

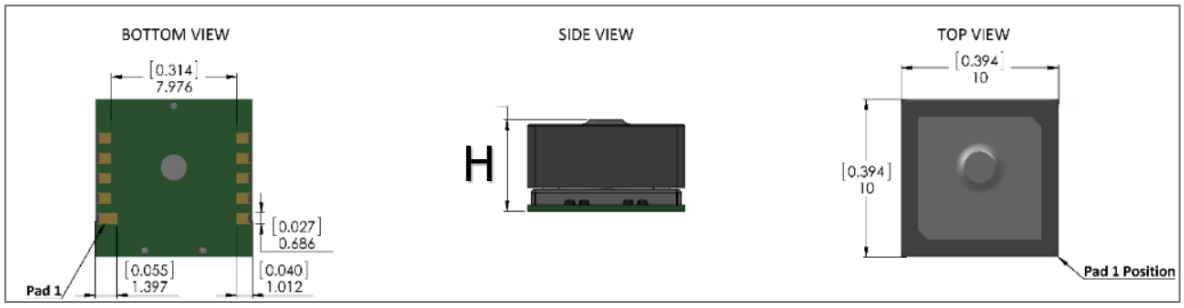

Figure 7. Mechanical Layout

Table 2. ORG1511-AG05 Module - Basic Dimensions

Dimensions	Length	Width	(H) Height	Weight	
mm	10.0 + 0.2 / -0.1	10.0 + 0.3 / -0.1	3.9 + 0.3 / -0.1	gr	1.43
inches	0.394 + 0.008 / -0.004	0.394 + 0.012 / -0.004	0.154 + 0.012 / -0.004	oz	0.05

7. ELECTRICAL SPECIFICATIONS

7.1. Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device.

Table 3. Absolute Maximum Ratings

Parameter		Symbol	Min	Max	Unit
Power Supply Voltage		V_{CC}	0	1.93	V
Backup Supply Voltage		V_{IN}	0	3.63	V
Power Supply Current[1]		I_{CC}		500	mA
Digital I/O Voltage		V_{IO}	-0.30	3.63	V
ESD Voltage		$V_{IO/RF}$, HBM [2]	-2000	2000	V
		$V_{IO/RF}$, MM[3]	-500	500	V
RF Power[4]	f_{IN} = 1560MHz÷1630MHz	P_{RF}		+10	dBm
	f_{IN} <1560MHz, >1630MHz			+30	
Operating Temperature[5]		T_{AMB}	-45	+85	°C

Notes:

1. Inrush current for ~20µs duration
2. Human Body Model (HBM) contact discharge per EIA/JEDEC JESD22-A114D. Step: 500V (+/-)
3. Machine Model (MM) contact discharge per EIA/JEDEC JESD22-A115C. Step: 50V (+/-)
4. Power delivered to antenna element.
5. Lead temperature at 1mm from case for a 10s duration.

7.2. Recommended Operating Conditions

Device reliability may be impacted by exposure to stresses beyond the Recommended Operating Conditions.

Table 4. Recommended Operating Conditions

Parameter	Symbol	Mode/Pad	Test Conditions	Min	Typical	Max	Unit
Power supply voltage	V_{CC}	V_{CC}		1.735	1.8	1.98	V
Backup supply voltage	V_{IN}	V_{IN}=Vbackup		1.62		3.63	V
Digital IO pin low level input voltage	Vil	Type 0 IO Level 1.8V		-0.3	0	+0.45	V
Digital IO pin high level input voltage	Vih			+1.35	+1.8	+2.1	V
Digital IO pin low level output voltage	Vol				0	0.27	V
Digital IO pin high level output voltage	Voh			+1.53	1.8		V
Power supply current[1]	I_{CC}	Acquisition			32		mA
		Tracking			30		mA
		Acquisition ALP Mode			28		mA
		Tracking ALP Mode			22		mA
		SW RTC	PAIR command		16		µA
		BackUp	Vcc = OFF; VIN = ON		33		µA
		HW RTC	FORCE_ON = Low		210		µA
Input impedance	Z_{IN}	RF Input	F_{in} = 1575.42MHz		50		Ω
Input return loss	R_{LIN}			-7			dB
Input power range	P_{IN}			-165		-110	dBm
Input frequency range	f_{IN}			1560		1620	MHz
Operating temperature	T_{AMB}			-40	+25	+85	°C

8. PERFORMANCE

8.1. Acquisition Time

TTFF (Time to First Fix) refers to the duration between the module's power-up and the acquisition of a valid position estimation.

8.1.1. Hot Start

Hot Start occurs when a module undergoes a software reset after a continuous navigation period or when it returns from a short idle period that followed continuous navigation. During a hot start, all essential data, such as position, velocity, time, and satellite ephemeris, are stored in RAM and remain relevant with the specified accuracy and availability.

8.1.2. Signal Reacquisition

Reacquisition is the process that follows a temporary interruption or blocking of GNSS signals. A common example of a reacquisition scenario is driving through a tunnel, where the GPS signals are temporarily lost due to the tunnel's obstruction.

8.1.3. Aided Start

Aided Start is a technique used to decrease TTFF by providing the receiver with valid satellite ephemeris data, which is crucial for precise positioning. This aiding process can be implemented using Extended Prediction Orbit (EPO) data.

8.1.4. Warm Start

Warm Start is a state that typically occurs when a user provides position and time initialization data or when a receiver maintains continuous Real-Time Clock (RTC) operation with an accurate last known position stored in RAM. In the warm start state, the position and time data are present and valid, but the satellite ephemeris data, which is essential for precise satellite tracking, is no longer valid.

8.1.5. Cold Start

Cold Start is a state that occurs when the satellite ephemeris data, as well as the position and time data, are unknown to the receiver. This typically happens during the initial power application or when the receiver has been off for an extended period, and it needs to start the satellite acquisition process from scratch. In a cold start scenario, the receiver has no prior information to rely on, so it needs to search and acquire satellite signals, determine its position, and establish accurate time information, which can take a longer time compared to warm or hot start scenarios.

Table 5. Acquisition Time

Operation[1]	Value	Unit
Hot Start	< 3	s
Aided Start[2]	< 5	s
Warm Start	< 23	s
Cold Start	< 28	s
Signal Reacquisition[3]	< 4	s

Notes:

I. It is static under signal conditions of -130dBm and ambient temperature of +25°C during 24 hours test.

II. Tested on the evaluation board in conducted conditions.

III. Outage duration ≤ 30s for reacquisition.

8.2. Sensitivity

8.2.1. Tracking

Tracking refers to the receiver's ability to maintain valid satellite ephemeris data and lock onto the signals from multiple satellites to calculate a position solution. During tracking, there may be instance when the receiver temporarily stops outputting valid position solutions, especially if there is a loss of signal or interference.

Tracking sensitivity is defined as the minimum GNSS signal power required for tracking.

8.2.2. Reacquisition

Reacquisition occurs after a temporary loss or blocking of GNSS signals. Reacquisition sensitivity refers to the minimum power level of GNSS signals required for the receiver to successfully reacquire and track the satellites after a temporary signal loss.

8.2.3. Navigation

During navigation, the receiver consistently outputs valid positioning information, allowing users to determine their accurate position, velocity, and time.

Navigation sensitivity refers to the minimum GNSS signal power required for the receiver to maintain reliable navigation.

8.2.4. Hot Start

Hot start sensitivity is defined as the minimum GNSS signal power required for a receiver to obtain a valid position solution under hot start conditions.

8.2.5. Aided Start

Aided start sensitivity is defined as the minimum GNSS signal power required for a receiver to obtain a valid position solution following the aiding process.

8.2.6. Cold Start

Cold start sensitivity is defined as the minimum GNSS signal power required for a receiver to obtain a valid position solution under cold start conditions.

The cold start sensitivity, also known as the ephemeris decode threshold, represents the receiver's ability to acquire and decode weak GNSS signals to determine the satellite positions and obtain a valid position solution.

8.3. Received Signal Strength

Table 6. Received Signal Strength

Parameter	Value	Unit
C/N_0	45	dB-Hz

8.4. Position Accuracy

Table 7. ORG1511-AG05 Position Accuracy

Parameter	CEP (m)
Horizontal Position Accuracy	2

8.5. Dynamic Constraints

Table 8. Dynamic Constraints

Parameter	Metric	Imperial
Velocity	514m/s	1000Knots
Altitude	18288m	60000 ft
Acceleration	4g	

Note: Standard dynamic constraints according to regulatory limitations.

9. CONTROL INTERFACE

9.1. Power Supply

For the fastest TTFF and optimal receiver performance, keep the power supply on at all times. This maintains the active RTC block and enables satellite data storage in RAM. Removing VCC resets settings to factory defaults, leading to a cold start on the next power-up, erasing stored data like ephemeris and time info.

9.1.1. Power Supply Design

Here are some key points to consider for the power supply design for the ORG1511-AG05 module:

1. **Voltage Requirement**: The module requires a regulated power supply providing 1.8V DC.
2. **Tracking and Processing Power Consumption**: During tracking, the processing is less intense compared to acquisition, resulting in lower power consumption.
3. **Filtering**: To manage high alternating current flows on the power input connection, an additional LC filter on the power input may be necessary. This filter helps reduce system noise.
4. **Input Current Rate of Change**: The ORG1511-AG05 module has a high rate of input current change. Therefore, low Equivalent Series Resistance (ESR) bypass capacitors are required to handle this.
5. **Output Capacitors**: Additional output capacitors with a higher ESR can provide input stability damping. The ESR and size of these output capacitors directly impact the output ripple voltage in relation to the selected inductor size. Large, low ESR output capacitors are beneficial for achieving low noise.

9.1.2. Ground

To ensure optimal performance and reduce potential interference, it is imperative to establish a direct connection between the ground pad of the ORG1511-AG05 module and the host PCB ground. This can be achieved either by utilizing the shortest possible trace or employing multiple VIAs.

9.1.3. VIN

In the ORG1511-AG05 module, the VIN line is specifically connected to the RTC (Real-Time Clock) domain. By connecting an external regulated power source of 1.8V to the VIN pin, the RTC block remains powered on. This enables the module to achieve a faster TTFF by storing satellite and navigation data in the RAM. The stored data can be used in case of a power cut or when the module is in RTC mode, ensuring a more efficient and quicker satellite signal acquisition process.

However, it's important to note that if the user does not intend to utilize this feature, the VIN pin should be connected to VCC instead. This would bypass the RTC domain and maintain a standard power configuration for the module.

9.2. Interfaces

9.2.1. UART- Host Interface

The ORG1511-AG05 module features standard UART ports with the following specifications:

Supported Baud Rates: The module supports various baud rates, including:

- 9600 bps (default)
- 19200 bps
- 38400 bps
- 57600 bps
- 115200 bps
- 230400 bps
- 460800 bps
- 921600 bps
- 3000000 bps

Users can select the desired baud rate based on their application requirements and communication needs. However, they should be aware that hardware flow control is not an option and should use alternative methods.

9.2.1.1. TX

In the ORG1511-AG05 module, the TX serial data line is used for sending GPS data reports. The data sent through the TX line can be in different formats, including NMEA, RTCM, raw data, and potentially other formats.

When the module is not actively transmitting data, the TX data line idles high.

9.2.1.2. RX

The RX (Receive) data line is utilized for receiver control and firmware upgrades. It is versatile, capable of receiving information in various formats like PAIR, RTCM, among others.

9.2.2. I2C – Host Interface

The ORG1511-AG05 module is equipped with a standard I2C host interface, offering the following features:

- I2C slave mode: In this mode, the host initiates the clock and data transmission.
- 7-bit I2C address support: The module supports 7-bit I2C address, allowing for communication and interaction with other I2C devices.

9.2.3. Data Interface

9.2.3.1. 1PPS

Pulse-per-Second (PPS) output provides a pulse signal for timing purposes.

The pulse may be configured for duration, frequency, and phase via a command.

The pulse varies 30ns (1σ). The relationship between the PPS signal and UTC is unspecified.

The proprietary PAIR command enables configuring or disabling this functionality.

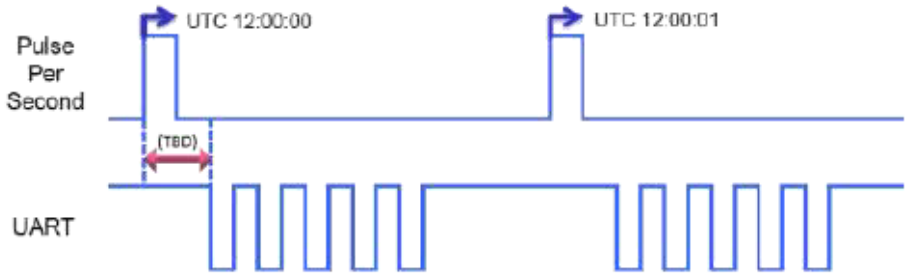

Figure 8. Mechanical Layout

To modify the 1PPS settings, refer to the SW manual called “AG-L1-GNSS SW Manual”.

9.2.3.2. FORCE-ON

The FORCE-ON is an input pin which controls the power state of the module. The FORCE-ON line is configured in a high-level state due to an internal 10KΩ pull-up resistor.

There are two possible states for this pin: LOW and HIGH.

Low State: The module enters low power mode (RTC).

High State: The module exits low power mode (RTC).

9.2.3.3. WAKEUP

When the ORG1511-AG05 module is on (full power), the output is high. In RTC or periodic mode, the output is low. Wakeup output is only for probing the module’s active/non-active state, with the probe type potentially affecting the high voltage level.

10. TYPICAL APPLICATION CIRCUIT

The following diagram depicts the schematics of the ORG1511-AG05 module.

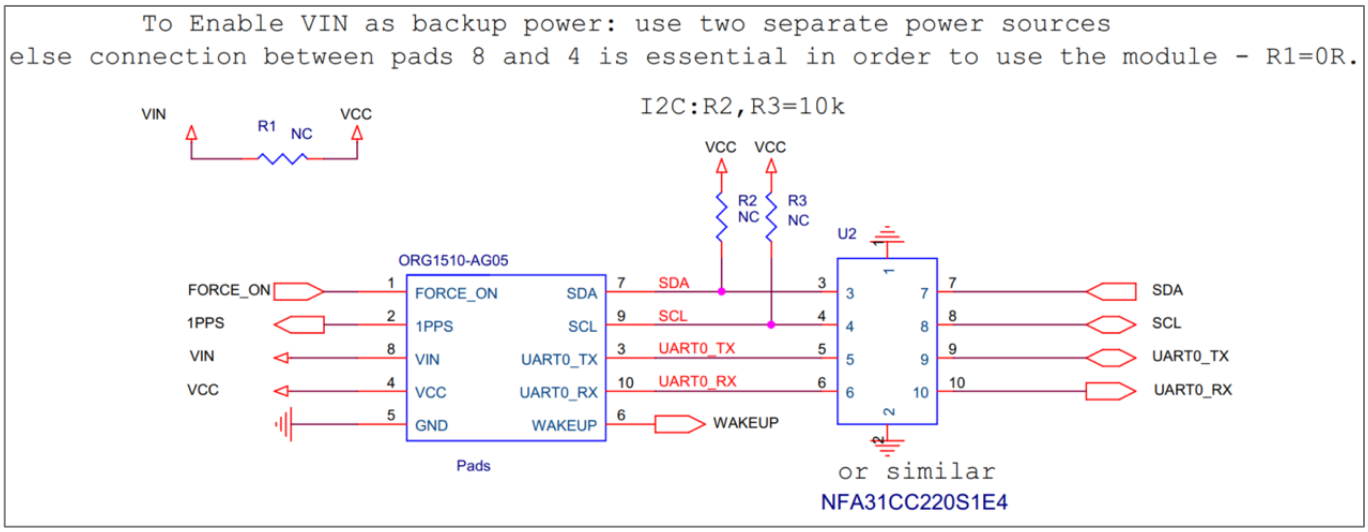

Figure 9. ORG1511-AG05 Module – Reference Schematic Diagram

11. RECOMMENDED PCB LAYOUT

You can access the full PCB layout of the ORG1511-AG05 module by visiting the link: https://origingps.com/gnss-modules/gnss-resources/. From there, scroll down and click on the 'Hornet Modules Layout Recommendations and Integration – Application Note' to access the detailed application note.

12. DESIGN CONSIDERATIONS

The ORG1511-AG05 module incorporates an on-board antenna element that boasts exceptional compatibility with the receiver front-end, precisely trimmed to the GPS band, and exhibits Right-Hand Circularly Polarized (RHCP) characteristics.

OriginGPS has designed the module with a proprietary structure, ensuring a stable antenna resonance within the GPS band. This resonance remains largely unaffected by variations in the host PCB size, conducting plane geometry, or stack-up, providing reliable performance.

To maintain the antenna resonance and avoid PCB-related issues, it's important to refrain from copper spillage on the side where the module is situated. Additionally, the orientation of the module must be carefully considered to minimize polarization losses in the on-board antenna. Consequently, it is advisable to steer clear of placing long and narrow copper planes beneath the module.

In its operation, the ORG1511-AG05 module can handle received signal levels down to -165dBm. However, it is susceptible to high absolute RF signal levels outside the GNSS band, moderate RF interference near the GNSS band, and low-level RF noise within the GNSS band.

When integrating the module into small products with design constraints, caution must be exercised due to potential RF interference from nearby electronic circuits or radio transmitters. Such interference may contain enough energy to desensitize the ORG1511-AG05, while energy levels outside the GNSS band might leak through RF filters, affecting its performance.

Hence, for small product designs with proximity to transmitters like Wi-Fi, Bluetooth, RFID, cellular, and other radios, EMI/jamming susceptibility tests for radiated and conducted noise should be conducted on prototypes. Additionally, risk assessments of other potential factors should be carried out to safeguard the optimal functioning of the ORG1511-AG05 module.

13. FIRMWARE UPDATES

Configuration details of the firmware are listed below:

- Normal mode is enabled.
- L1 full satellite is enabled.
- Constellations - GPS, Galileo, BeiDou, and GLONASS.
- Additional constellations - QZSS and SBAS.
- PPS is enabled
    - Always ON mode.
- The firmware is stored in the internal Flash memory and is upgradeable.

14. HANDLING INFORMATION

14.1. Moisture Sensitivity

The ORG1511-AG05 modules are classified as MSL (Moisture Sensitivity Level) 3 designated devices in accordance with the IPC/JEDEC J-STD-033B standard.

For modules that come in sample or bulk packaging, it is essential to perform a baking process before assembly. The recommended baking conditions involve subjecting the modules to a temperature of 125°C for a duration of 48 hours.

14.2. Assembly

The ORG1511-AG05 module is compatible with automatic pick-and-place assembly and reflow soldering processes.

To achieve reliable and consistent soldering results, it is recommended to use a solder paste stencil with a thickness of 5 mil.

14.3. Soldering

When reflow soldering the ORG1511-AG05 module, it should always be placed on the component side (top side) of the host PCB, following the guidelines specified in the standard IPC/JEDEC J-STD-020D for LGA SMD (Land Grid Array Surface Mount Devices).

It is crucial to avoid exposing the ORG1511-AG05 module to a face-down orientation during the reflow soldering process.

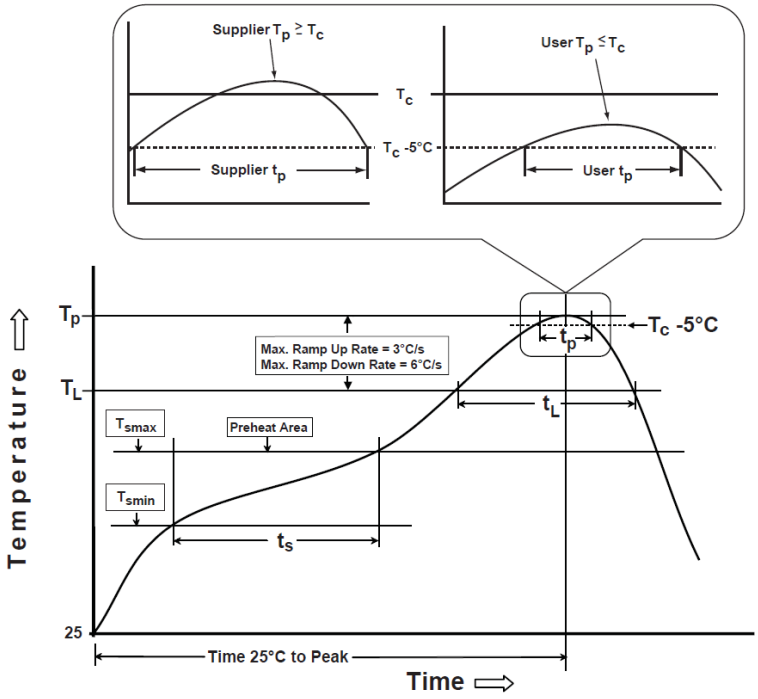

Figure 10. Recommended Soldering Profile

Throughout the soldering process, temperature measurement is conducted on the top surface of the ORG1511-AG05 module's package. To ensure proper soldering, the recommended peak reflow temperature is 250°C for 30 seconds when using Pb-free solder paste.

However, it's important to note that the actual board assembly reflow profile must be tailored individually based on the specific characteristics of the furnace utilized. This customization allows for optimal performance and adherence to quality standards.

Various factors influence the reflow furnace settings, including the number of heating and cooling zones, the type of solder paste and flux utilized, the board design, component density, and the types of packages used in the assembly.

Table 9. Soldering Profile Parameters

Symbol	Parameter	Min	Typical	Max	Unit
T_C	Classification Temperature		250		°C
T_P	Package Temperature			250	°C
T_L	Liquidous Temperature		217		°C
T_S	Soak/Preheat Temperature	150		200	°C
t_S	Soak/Preheat Time	60		120	s
t_L	Liquidous Time	60		150	s
t_P	Peak Time		30		s

14.4. Cleaning

In instances where flux cleaning is necessary, the ORG1511-AG05 module is designed to withstand a standard cleaning process using a vapor degreaser with Solvon® n-Propyl Bromide (NPB) solvent. Additionally, the module can be safely washed in DI (Deionized) water.

However, it is crucial to avoid using an ultrasonic degreaser for the cleaning process. The vibrations produced by the ultrasonic cleaning method may lead to performance degradation or, in extreme cases, damage the internal circuitry of the module.

14.5. Rework

Absolutely, when localized heating is needed for reworking or repairing the ORG1511-AG05 module, precautionary measures must be taken to prevent exposure to solder reflow temperatures that could cause irreversible damage to the device.

14.6. Safety Information

Improper handling and usage of the product can lead to permanent damage.

The ORG1511-AG05 module is an ESD (Electrostatic Discharge) sensitive device, making it vital to exercise caution during its handling.

14.7. Disposal Information

The ORG1511-AG05 module should never be treated as household waste.

Due to its electronic nature, it requires specialized disposal and recycling procedures to minimize environmental impact and recover valuable resources.

To properly dispose of or recycle electronic components like the ORG1511-AG05 module, contact your local waste management authority.

15. COMPLIANCE

The production of ORG1511-AG05 modules adheres to the following standards:

- IPC-6011/6012 Class2 for PCB manufacturing
- IPC-A-600 Class2 for PCB inspection
- IPC-A-610D Class2 for SMT acceptability

The production of ORG1511-AG05 modules takes place in facilities that have achieved accreditation in various internationally recognized management standards:

- ISO 9001:2008: The facilities where ORG1511-AG05 modules are manufactured have attained certification under ISO 9001:2008. This standard focuses on quality management systems and ensures that the manufacturing processes consistently meet customer requirements and deliver high-quality products.
- ISO 14001:2004: The facilities hold accreditation in ISO 14001:2004, which emphasizes environmental management systems. This standard ensures that the manufacturing practices consider environmental impacts and strive to minimize any negative effects, promoting sustainability and eco-friendly approaches.
- OHSAS 18001:2007: The facilities are accredited under OHSAS 18001:2007, which pertains to occupational health and safety management systems. This standard prioritizes the health and safety of employees and visitors within the manufacturing environment, fostering a safe working environment and risk reduction.

The ORG1511-AG05 modules are designed, manufactured, and handled in strict compliance with the following European Union directives and regulations:

- RoHS III (Directive 2015/65/EU): The modules adhere to RoHS III, which restricts the use of specific hazardous substances in electrical and electronic equipment to safeguard human health and the environment.
- REACH (Commission Regulation EU 2018/1881): The modules are manufactured and handled in accordance with the substance bans specified in Annex XVII of Commission Regulation EU 2018/1881 on Registration, Evaluation, Authorization, and Restriction of Chemicals. This includes adherence to all amendments and the candidate list issued by the European Chemicals Agency (ECHA).
- Radio Equipment Directive (Directive 2014/53/EU): The handling of ORG1511-AG05 modules complies with the EU directive 2014/53/EU, which concerns the placing of radio-electric equipment on the market. The compliance ensures that the modules meet the necessary requirements for radio equipment in the European market, as per the directive issued on 13 June 2017.

16. PACKAGING AND DELIVERY

16.1. Appearance

ORG1511-AG05 modules are delivered in reeled tapes for an automatic pick and place assembly process.

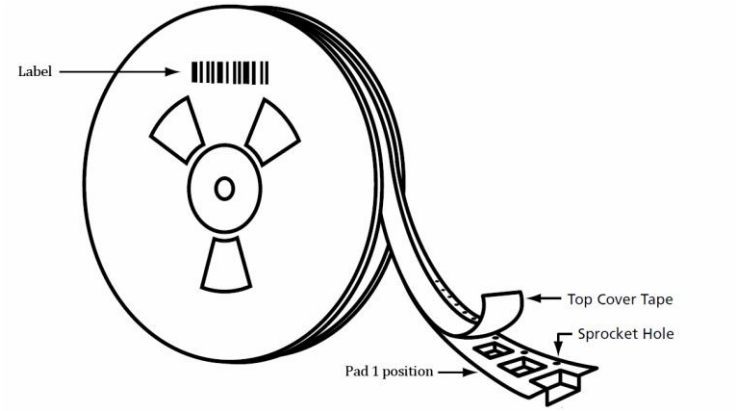

Figure 11. Module Position

ORG1511-AG05 modules are packed in two different tape reel quantities.

Table 10. Reel Quantity

Suffix	Tape Reel 1 (TR1)	Tape Reel 2 (TR2)
Quantity	150	500

Reels are dry-packed with a humidity indicator card and desiccant bag according to the IPC/JEDEC J-STD-033B standard for MSL 3 devices.

Reels are vacuum sealed inside anti-static moisture barrier bags.

Sealed reels are labeled with MSD stickers providing information about:

- MSL
- Shelf life
- Reflow soldering peak temperature.
- Seal date

  Sealed reels are packed inside cartons.

  Reels, reel packs, and cartons are labeled with sticker providing information about:

  - Product description
  - Part number
  - Lot number
  - Customer PO number
- Quantity
- Date code

16.2. Carrier Tape

The carrier tape is made of polystyrene with carbon (PS+C).

The cover tape is made of a polyester-based film with a heat-activated adhesive coating layer.

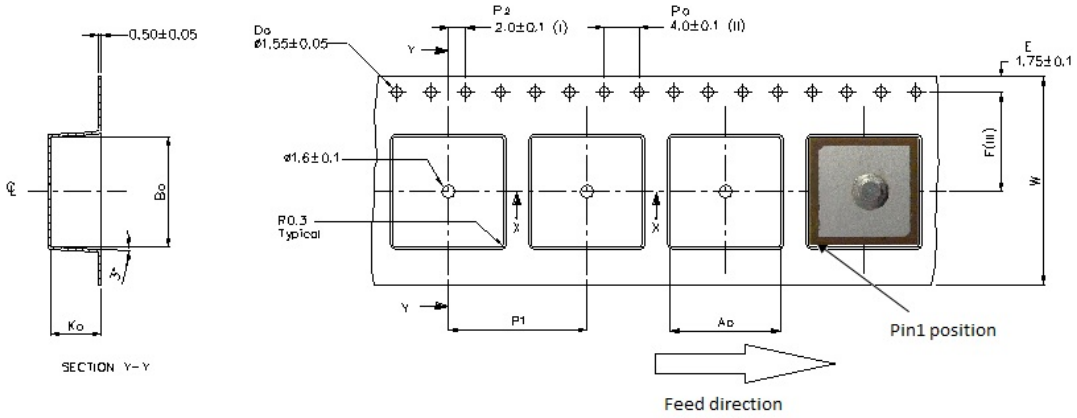

Figure 12. Carrier Tape

Table 11. Carrier Tape Dimensions

	MM	Inch
A_0	10.9 ± 0.1	0.429 ± 0.004
B_0	10.7 ± 0.1	0.421 ± 0.004
K_0	6.1 ± 0.1	0.240 ± 0.004
F	7.5 ± 0.1	0.295 ± 0.004
P1	12.0 ± 0.1	0.472 ± 0.004
W	16.0 ± 0.3	0.630 ± 0.012

16.3. Reel

The product reel is made of anti-static plastic.

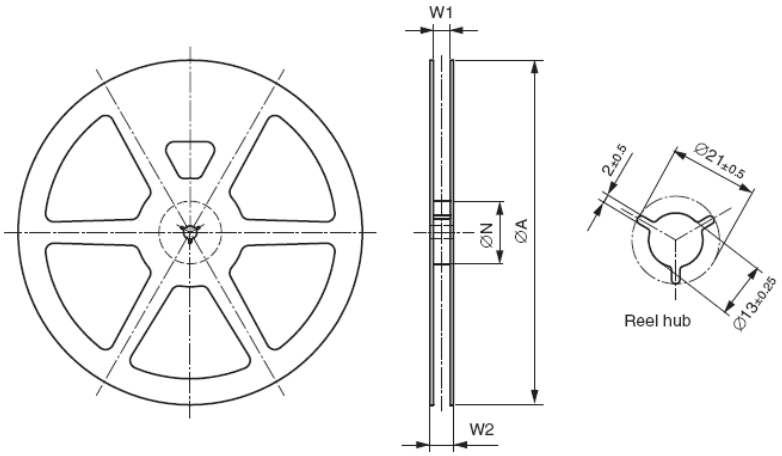

Figure 13. Product Reel

Table 12. Reel Dimensions

Suffix	TR1		TR2	
	mm	Inches	mm	Inches
ØA	178.0 ± 1.0	7.00 ± 0.04	330.0 ± 2.0	13.00 ± 0.08
ØN	60.0 ± 1.0	2.36 ± 0.04	102.0 ± 2.0	4.02 ± 0.08
W1	16.7 ± 0.5	0.66 ± 0.02	16.7 ± 0.5	0.66 ± 0.02
W2	19.8 ± 0.5	0.78 ± 0.02	22.2 ± 0.5	0.87 ± 0.02

17. ORDERING INFORMATION

The ORG1511-AG05 module may be ordered in accordance with the following methodology.

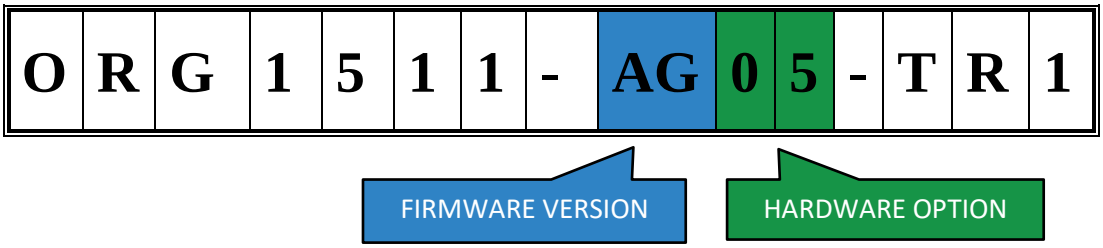

Figure 14. Ordering Options

Table 13. Orderable Devices

Part Number	FW Version	HW Option	VCC Range	Packaging	SPQ
ORG1511-AG05-TR1	AG	05	1.8V	Reeled tape	150
ORG1511-AG05-TR2	AG	05	1.8V	Reeled tape	500
ORG1511-AG05-UAR	AG	05	5V USB	Evaluation kit	1
ORG1511-AG04-USB	AG	04	5V USB	GNSS ON A STICK	1