Fully Integrated GPS Modules

Including Antenna

ORG-2000 Data Sheet

1. Introduction

The ORG-2000 receiver module with built-in antenna has been designed to address markets where performance, highest level of integration, power and flexibility are very important.
The ORG-2000 is OriginGPS smallest fully featured GPS receiver. The module provides a miniature multi-channel receiver that continuously tracks all satellites in view and provides accurate positioning data.
Featuring OriginGPS microstrip patch antenna and OriginGPS Noise-Free Zones technology the ORG-2000 offers the ultimate in high sensitivity GPS performance, capable of both autonomous and aided modes of operation.
The module can track down extremely weak signals and offers unparalleled accuracy and extremely fast fixes even under weak or noisy GPS signal conditions such as in built-up urban areas, dense foliage, indoors or while subject to challenging temperature profiles.
The ORG-2000 module is a complete SiP (System-in-Package) featuring advanced miniature packaging technology and an ultra small footprint designed to commit unique integration features for high volume, low cost and low power applications where tighter integration is required.
OriginGPS innovative material engineering approach resulted in microstrip patch antenna with outstanding narrow band performance.
OriginGPS case study of the specifications of key components through involvement in R&D effort of major vendors derived in highest performance in industry's smallest footprint parts available. These components placement using OriginGPS NFZ (Noise-Free Zones) technology created hard-to-achieve laboratory performance in heavy-duty environment.

2. Description

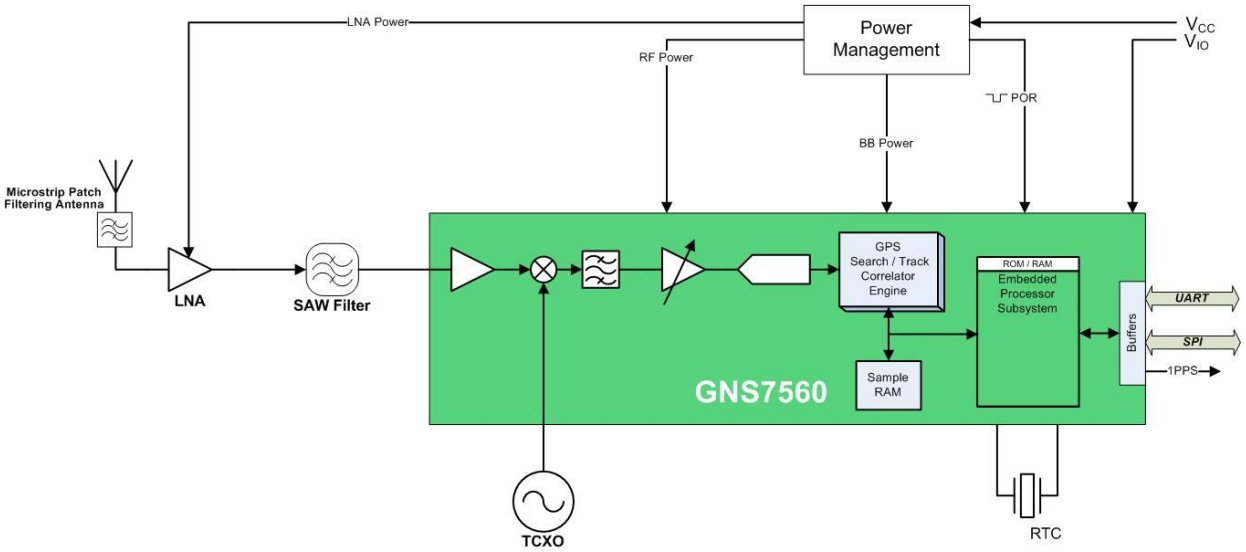
OriginGPS has revised and enhanced the architecture of classic GPS receivers.
In-house designed microstrip patch antenna with highest GPS-band performance and notch filtering for out-of band signals provides high selectivity.
Furthermore, combined with internal shielding and built-in ground plane the ORG-2000 shows good noise immunity and exceptional sensitivity.
Carefully selected key components including TCXO and LNA resulted in faster TTFF and operation stability under rapid environmental changes.
On-board Power Management comprising high temperature stability with high PSRR allows operation over a wide input voltage range down to 2.8 V with single voltage supply.

2.1. Features

- Fully integrated multi channel GPS receiver
- Microstrip patch antenna
- Acquisition sensitivity: -158dBm
- Tracking sensitivity: -160dBm
- Fast TTFF: <38s (typical) under cold start conditions
- Advanced proprietary tracking and multipath algorithms for robust, low-dropout tracking in indoor, very low-signal and rapid signal-transition environments.
- Hosted architecture optimized for cost and performance, with broad, high-level and real-time kernel OS support.
- Control plane and user plane A-GPS advanced aiding capability

- Automatic and user defined power saving scenarios
- Low power consumption: 125mW
- UART and SPI host communication
- Single operating voltage: 2.8V to 5.5V
- Small size: 14mm x 14mm x 2.5mm
- Industrial operating temperature range: -40^0 to 85^0C
- Pb-Free RoHS compliant

2.2. Architecture



- **Microstrip Patch Antenna**
  OriginGPS Microstrip Patch Antenna collects signals at 1575.42 MHz from the medium and blocks out of GPS L1 band frequencies.

- **LNA (Low Noise Amplifier)**
  The LNA amplifies the GPS signal to meet GNS4540 RF front-end signal chain input threshold. Noise figure optimizing design was implemented to provide maximum sensitivity.

- **Band-pass SAW Filter**
  Band-pass SAW filter eliminates inter-modulated out-of-band signals that may corrupt receiver performance.

- **TCXO (Temperature Compensated Crystal Oscillator):**
  This highly stable 16.368 MHz oscillator controls the down conversion process for the RFIC block. Highest characteristics of this component are key factors in fast TTFF.

- **Power Management:**
  This supplies a regulated voltage and power up sequence for the internal circuitry.
  The characteristics of this section of the circuit define the low power consumption and high PSRR performance.

- **GNS7560 IC**

  GNS7560 comprises RF and Baseband sections.

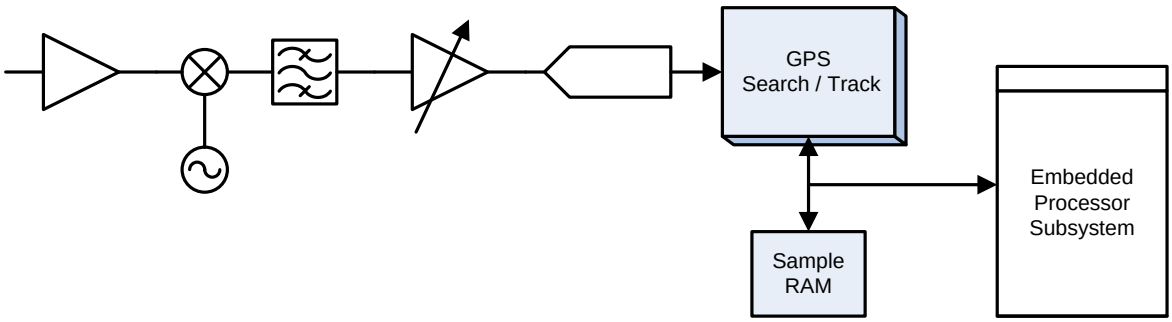


Figure 2-2: GNS7560 block diagram

GPS RF section includes the following features:

- Mixer
- IF band-pass filter
- VCO and high performance fractional-N PLL

GPS Baseband section includes the following features:

- Embedded DSP (Digital Signal Processing) block for GPS acquisition and tracking
- ROM for embedded DSP firmware
- Correlation engine
- GPS code generation.
- Coherent and incoherent summation block
- Doppler wipe off
- Magnitude calculation
- Compare & threshold signal detection
- Timing and control
- Power saving features
- Clocking architectures
- UART and SPI interfaces to host

2.3. Applications

The ORG-2000 was specially designed to meet wide range of OEM configurations and applications. The small size of the module and full integration feature makes it ideal for integration in:

- Cellular handsets - for navigation and location-based services.
- Handheld consumer navigation and multifunction devices.
- Precise timing devices.

The high sensitivity of the module makes it ideal for application in:

- Vehicle and people tracking devices – while weak GPS signal reception or indoor tracking.
- Asset tracking – while dense foliage impacts GPS signal reception.
- Automotive navigation systems – while module installation position and orientation limits satellites visibility.
- Marine navigation systems – while multipath reception degrades receiver performance.

3. Electrical Specifications

3.1. Absolute Maximum Ratings

Absolute Maximum Ratings are stress ratings only.
Stresses exceeding Absolute Maximum Ratings may damage the device.

Parameter	Symbol	Min	Max	Units
Power Supply Voltage	V_{CC}	0	6.0	V
Enable Voltage	V_{ENA}	0	V_{CC}	V
I/O Supply Voltage	$V_{CC(IO)}$	0	3.6	V
I/O Input Voltage	V_{IO}	0	$V_{CC(IO)}$ + 0.2	V
Storage Temperature	T_{ST}	-40	+125	^{0}C

Table 3-2: Absolute Maximum Ratings

3.2. Operating Conditions

Functional operation above the Recommended Operating Conditions is not implied.
Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Parameter	Symbol	Mode / Pin	Test Conditions		Min	Typ	Max	Units
Power supply voltage	V_{CC}				2.8	3.3	5.5	V
Power Supply Current	I_{CC}	Acquisition	V_{CC} = 3.3V			36		mA
		Sleep	$V_{CC(IO)}$ = 3.3V			4.5		mA
		Shutdown	T_{AMB} = 25^{0}C				1	µA
Input Voltage Low State	V_{IL}	Digital I/O	$V_{CC(IO)}$ = 3.3V		-0.3		+0.8	V
			$V_{CC(IO)}$ = 2.5V		-0.3		+0.7	V
			$V_{CC(IO)}$ = 1.8V		-0.3		+0.63	V
Input Voltage High State	V_{IH}	Digital I/O	$V_{CC(IO)}$ = 3.3V		2.0		3.63	V
			$V_{CC(IO)}$ = 2.5V		1.7		2.8	V
			$V_{CC(IO)}$ = 1.8V		1.17			V
Output Voltage Low State	V_{OL}	Digital I/O	$V_{CC(IO)}$ = 3.3V	I_{OL} = 2.4mA			0.4	V
			$V_{CC(IO)}$ = 2.5V				0.7	V
			$V_{CC(IO)}$ = 1.8V				0.45	V
Output Voltage High State	V_{OH}	Digital I/O	$V_{CC(IO)}$ = 3.3V	I_{OL} = 2.4mA	2.4			V
			$V_{CC(IO)}$ = 2.5V		1.7			V
			$V_{CC(IO)}$ = 1.8V		1.35			V
Operating Temperature	T_{AMB}				-40	+25	+85	^{0}C

Table 3-3: Operating Characteristics

4. Performance

4.1. Acquisition times

TTFF (Time To First Fix) – is the period of time from GPS power-up till position estimation.

Hot start

A hot start results from software reset after a period of continuous navigation or a return from a short idle period that was preceded by a period of continuous navigation. In this state, all of the critical data (position, velocity, time, and satellite ephemeris) is valid to the specified accuracy and available in SRAM.

Warm start

A warm start typically results from user-supplied position and time initialization data or continuous RTC operation with an accurate last known position available in memory. In this state, position and time data are present and valid but ephemeris data validity has expired.

Cold start

A cold start acquisition results when either position or time data is unknown.
Almanac information is used to identify previously healthy satellites.

Aided start

Aiding is a method of effectively reducing the TTFF by making every start Hot or Warm.

	TTFF	Signal Level	Test Conditions
Hot Start	< 1s	-130 dBm (Outdoor)	The receiver has estimates of time/date/position and valid Almanac and Ephemeris data
Warm Start	< 15s	-130 dBm (Outdoor)	The receiver has estimates of time/date/position and Almanac
Cold Start	< 38s	-130 dBm (Outdoor)	The receiver has no estimate of time/date/position and no recent Almanac
Aided Start	< 15s	-152 dBm (Indoor)	GSM (coarse) and WCDMA/3G Aiding - time known to <2 sec, location known to <3Km, oscillator known to 0.05ppm, known Ephemeris for available satellites
	< 10s	-152 dBm (Indoor)	CDMA Aiding – time known to <100us, location known to <3Km, Oscillator known to 0.05ppm, known Ephemeris for available satellites
Signal Reacquisition	< 1s	-130 dBm (Outdoor)	The receiver's calibrated clock is not stopped

Table 4-1: Acquisition times

4.2. Sensitivity

	Signal Level
Acquisition	-158 dBm (Deep Indoor)
Tracking	-160 dBm (Deep Indoor)
Cold Start	-145 dBm

Table 4-2: Sensitivity

4.3. Timing and Position Accuracy

	Method	Accuracy	Units	Test Conditions
Time	1 PPS	< 1	µs	-130 dBm (Outdoor)
Position	2dRMS	< 5	m	-130 dBm (Outdoor)
	2dRMS	< 20	m	-148 dBm (Indoor)
	2dRMS	< 50	m	-152 dBm (Indoor)

Table 4-4: Accuracy

4.4. Dynamic Constrains

Velocity	< 515m/s
Acceleration	< 2g
Altitude	< 18,000m

Table 4-5: Dynamic Constrains

5. Power Management

The ORG-2000 has four main operating modes, which are switched by internal state-machine and controlled by the High Level Software located on the host. These modes provide different levels of power and performance. Additional *Shutdown Mode* is hardware controlled.

5.1. Normal Mode

In Normal Mode the ORG-2000 is active as a GPS receiver.
The ORG-2000 will automatically acquire and track GPS satellites.
The GNS7560 IC will automatically enable or disable clocks to adapt power consumption for the operating environment parameters like satellite signal strength, user dynamics, Ephemeris validity etc.
When signal levels drop the receiver returns to full power so that message output rates remain constant. The adaptive mode can provide about 15% power saving.

5.2. Sleep Mode

The ORG-2000 is placed into *Sleep Mode* either by a command from the host based navigation software or after staying idle for 30 sec. and woken from this state by either communications from the host based navigation software or from an internal wake-up function.
In *Sleep Mode* the GNS7560 RF front-end is in low power mode, LNA and most baseband clocks are disabled. Local time is maintained using the RF clock.
On exit from *Sleep Mode* tracking of GPS satellites previously being tracked will continue.
Sleep Mode is supported for a maximum time of 60 sec. and after this the ORG-2000 will automatically transit to *Coma Mode*.

5.3. Coma Mode

The ORG-2000 is placed into *Coma Mode* by a command from the host based navigation software and woken from this state by either communications from the host or from an internal wake-up function. *Coma Mode* is supported for a maximum time of 19 hours (optionally 49 days).
In *Coma Mode* the GNS7560 has all clocks except RTC disabled, RF front-end is in low power mode and external LNA disabled. Local time is maintained using the RTC clock.
On exit from *Coma Mode* GPS satellites previously being tracked will be reacquired rapidly while the satellites Ephemeris are still valid.
If a RTC is not available the ORG-2000 will switch to *Deep Coma Mode*.

5.4. Deep Coma Mode

The ORG-2000 is placed into *Deep Coma Mode* by a command from the host based navigation software.
In *Deep Coma Mode* the GNS7560 has all clocks, RF front-end and external LNA disabled.
The only way to wake up from this mode is a via a Power On Reset.
This would be used while the system does not require any GPS functionality enabled.

5.5. Shutdown Mode

The ORG-2000 is placed into *Shutdown Mode* by a driving Enable input low.

Operation Mode		Power Consumption	Test Conditions
Normal	Acquisition	120 mW	V_{CC} = 3.3V $V_{CC(IO)}$ = 3.3V
	Tracking	100 mW	
	Power saving enabled	60 – 100 mW	
Sleep		15 mW	
Coma		5 mW	
Deep Coma		1 mW	
Shutdown		3 µW	

Table 5-1: Power Consumption

6. Interface

6.1. Pin Assignment

Pin Number	Pin Name	Pin Description	Direction	Default	Notes
1	RX/SCK	UART RX / SPI SCK	Input	High	1.8V/2.5V/3.3V compatible
2	TX/SDO	UART TX / SPI SDO	Output	Low	1.8V/2.5V/3.3V compatible
3	1PPS	1 Pulse Per Second	Output	Low	1.8V/2.5V/3.3V compatible
4	V_{IO}	I/O Power Input	Power		Connect to V_{CC} if powered 3.3V
5	GND	System Ground	Power		
6	GND	System Ground	Power		
7	GND	System Ground	Power		
8	nRESET	Asynchronous Reset	Input	High	
9	V_{CC}	System Power Input	Power		
10	GND	System Ground	Power		
11	EN	Enable	Input	High	Drive low to inhibit
12	GND	System Ground	Power		
13	nCS	SPI Chip Select	Input	High	
14	COMM_SEL	UART/SPI Select	Input	Low	
15	SDI	SPI Data In	Input	Low	
16	GND	System Ground	Power		
17	GND	System Ground	Power		
18	GND	System Ground	Power		

Table 6-1: ORG-2000 Module pin-out

6.2. Connectivity

Power supply

The ORG-2000 module requires only one power supply V_{CC}, which can be supplied directly from a battery since the module has internal regulators.
The ORG-2000 allows about 300mV_{PP} ripple voltage at the supply V_{CC} below 10kHz frequency. The ripple voltage should be reduced further at V_{CC} supply below 3mV_{P-P} at 100kHz frequency or higher.

Ground

All Ground pins should be connected to main Ground with shortest possible traces or vias.

Enable Input

The Enable control input can be used to inhibit the ORG-2000.
Enable signal is active low and has internal pull-up resistor.

nRESET Input

The Power-on-Reset (POR) is generated internally in the ORG-2000.
However, manual reset option is available through nRESET pin.
nRESET pin is active low and has internal pull-up resistor.
nRESET signal should be applied for at least 1µs.

COMM_SEL

The ORG-2000 is able to communicate via UART or SPI interface.
UART is default communication interface.
To select SPI communication 0Ω resistor to V_{IO} should be applied on this pin.
Do not connect if SPI communication is not used.

1PPS Output

The pulse-per-second (PPS) output provides a pulse signal for timing purposes.
Pulse length (high state) is about 1µs synchronized to full UTC second.
1PPS output level is CMOS 1.8V/2.5V/3.3V compatible.
1PPS output level is defined by applying appropriate voltage to $V_{CC(IO)}$ pin.

UART

The device supports full duplex 8-N-1 UART communication without flow control.
The baud rate is 115,200 bps. The protocol is NXP proprietary.
UART I/O levels are CMOS 1.8V/2.5V/3.3V compatible.
UART I/O levels are defined by applying appropriate voltage to $V_{CC(IO)}$ pin.
Do not connect if UART communication is not used.

SPI

The Host Interface SPI is a slave mode SPI that can be used as an alternative to the UART interface.
The four primary pins are SDI, SDO, nSE, SCK.
SPI I/O levels are CMOS 1.8V/2.5V/3.3V compatible.
SPI I/O levels are defined by applying appropriate voltage to $V_{CC(IO)}$ pin.
Do not connect if SPI communication is not used.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Clock input: pin SSI_SLV_CLKIN						
T_{clk}	clock period		40	-	-	ns
$t_{clk(H)}$	clock HIGH time		15	-	-	ns
$t_{clk(L)}$	clock LOW time		15	-	-	ns
Chip select input: pin SSI_SLV_CS						
$t_{su(CS)}$	CS set-up time		$0.5 \times T_{clk}$	-	$1 \times T_{clk}$	ns
$t_{su(clk)}$	clock set-up time		$0.5 \times T_{clk}$	-	$1 \times T_{clk}$	ns
$t_{CS(H)}$	HIGH CS time		$1 \times T_{clk}$	-	-	ns
$t_{CS(L)}$	LOW CS time		$9 \times T_{clk}$	-	-	ns
Serial data output: pin SSI_SLV_SO						
$t_{su(Q)}$	data output set-up time	10 pF load	-	-	15	ns
Serial data input: pin SSI_SLV_SI						
$t_{su(D)}$	data input set-up time		15	-	-	ns
$t_{h(D)}$	data input hold time		15	-	-	ns

Table 6-2: ORG-2000 SPI Timing

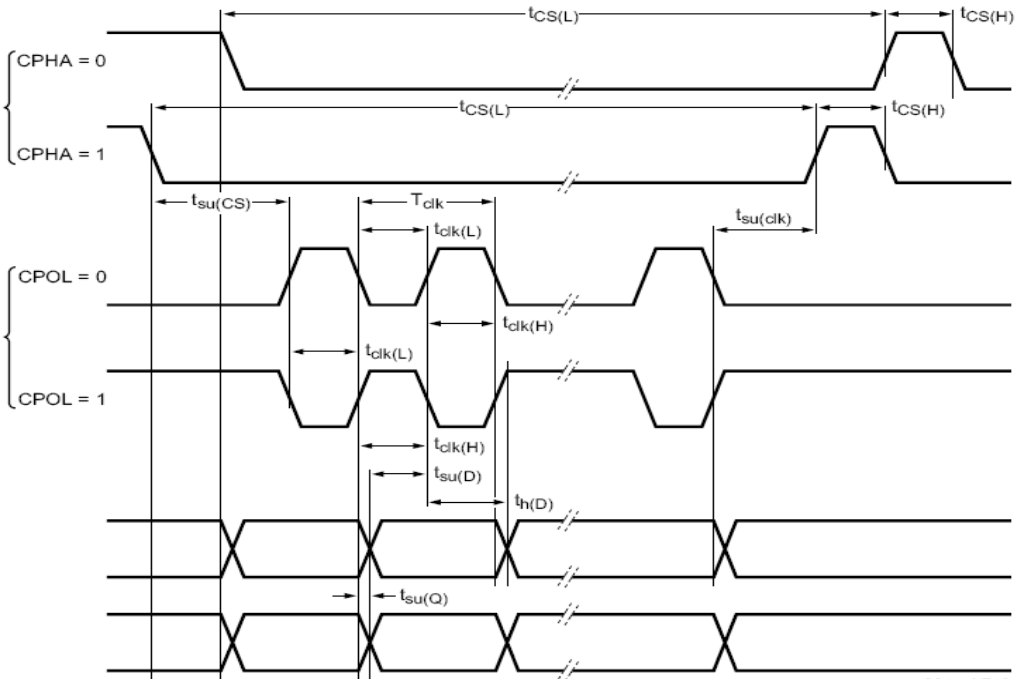


Figure 6-1: ORG-2000 SPI Timing

6.3. Typical Application Circuit

UART Communication

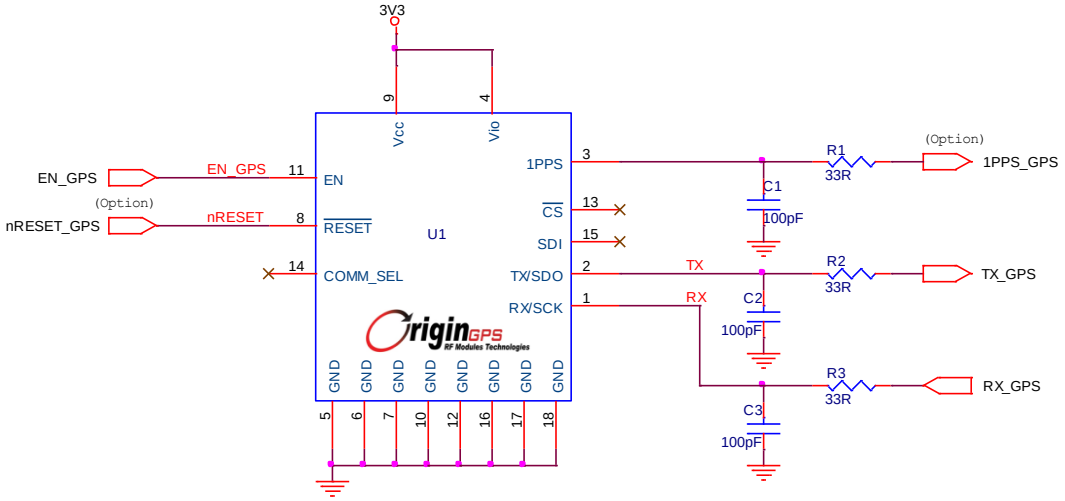


Figure 6-3: ORG-2000 UART Communication Circuit

SPI Communication

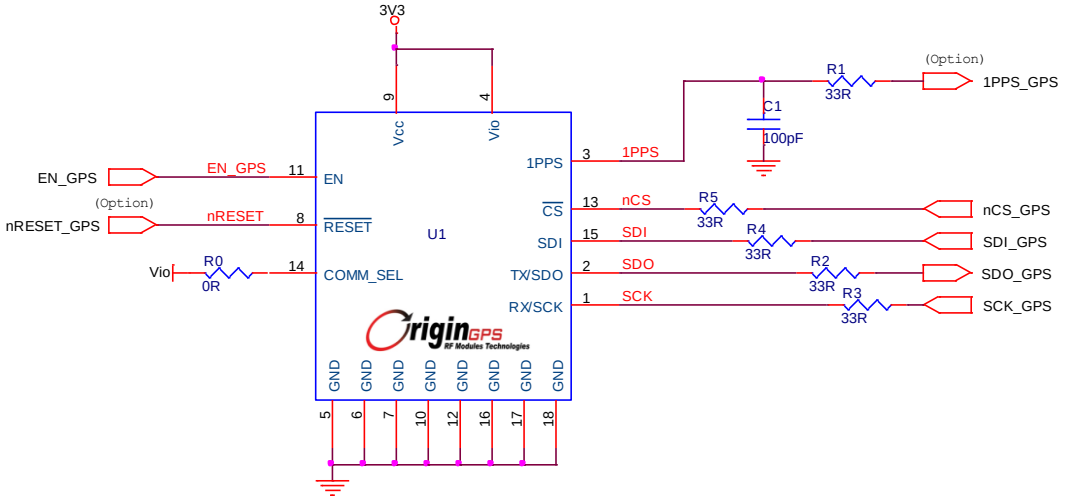


Figure 6-4: ORG-2000 SPI Communication Circuit

6.4. Recommended Land Pattern

TOP VIEW

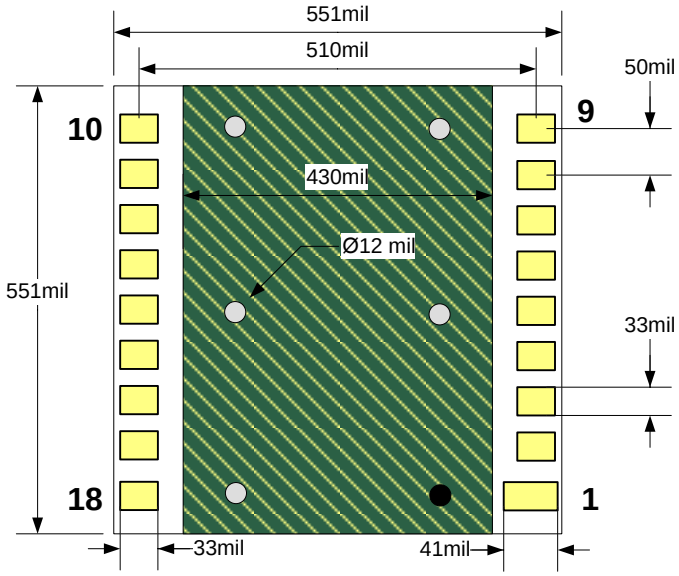


Figure 6-5: ORG-2000 Recommended PCB Layout

All Ground pins should be connected to main Ground with shortest possible traces or vias.
Ground pad at the middle should be connected to main Ground plane by multiple vias.
Ground pad at the middle should be solder masked.

7. Software Interface

7.1. Embedded Firmware

All real time critical or high interrupt rate functions are performed within the embedded DSP firmware.
The embedded DSP firmware performs the following functions:

- Interfaces to GPS baseband hardware:
- Searches for satellites either autonomously or commanded using acquisition data from host
- When a satellite has been acquired - transitions to track the satellite.
- Where possible - demodulates the satellite navigation message data.
- During satellite tracking - monitors the signals for validity and multipath.
- At the required update rate (typically 1Hz) sends the latest raw satellite measurements to the host based navigation software

7.2. Hardware Software Interface

The UART Interface typically uses an 115.2KBaud data rate, transferring about 4Kbytes of data per update.
The host based navigation software sends requests for when the next raw satellite measurements are required and also provides satellite acquisition aiding data and channel/satellite reset commands. The host based navigation software also sends commands for the ORG-2000 to go to *Sleep*, *Deep Sleep* or *Coma* modes.
The *Sleep* command also specifies a time-out for the automatic transition from *Sleep* to *Deep Sleep* mode. A wakeup command is also provided.
The ORG-2000 responds by sending raw satellite measurements to the host based navigation software at the requested time and also provides the parity checked raw sub frames of the satellite navigation messages (when available).

7.3. Host Based Navigation Software

The host based navigation software is provided separately and will run on a range of processors, notably ARM processors and a variety of high level and real-time OSs.
The purpose of this software is to provide the user application with GPS position information.
To do this, the GPS navigation software interfaces between the host processor software, the OS and the ORG-2000.
The Host based navigation software performs the following functions:

- Interface to the GNS7560
- API interface to host software
- Satellite navigation message data decode and state table generation
- Satellite measurement generation (pseudo range, Doppler, etc.)
- Navigation Kalman filter task: calculates frequency, position, velocity and time
- Satellite pre-positioning: predicts where to search for a satellite
- Navigation output generation, including NMEA-0183 stream

7.4. Software Functions

Feature	Description
Channels	Dynamic channel and dynamically configurable architecture management
Positioning Modes	Autonomous/Standalone, Mobile-Assisted, Mobile-Based, Simultaneous/Mixed Modes, Navigation (Kalman Filter)
Update Rate	User Selectable – event, position, command/request, periodic (10 per sec to 1 per hour)
Host SW Protocol Support	NMEA-0183, GLONAV API, Air Interface
Processor Requirements	No real-time processing requirements – only C compiler and floating point libraries

8. Handling Information

8.1. Product Packaging and Delivery

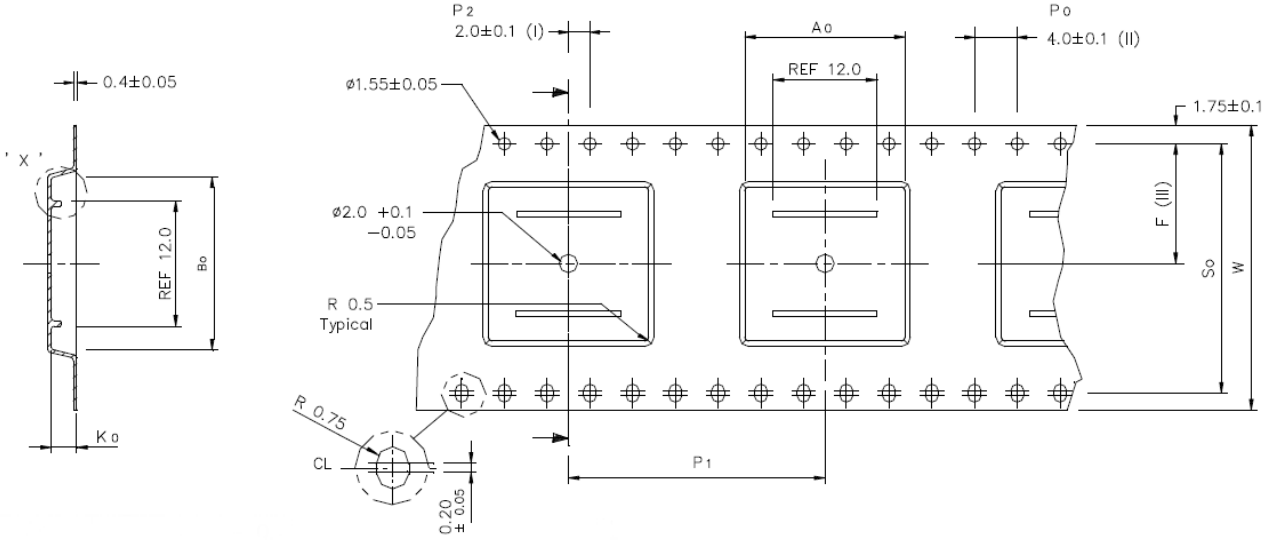
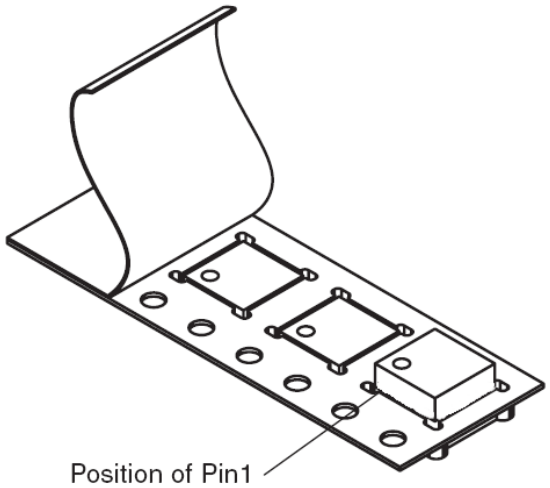


Figure 8-1: Carrier dimensions

	ORG-2000
A_0	14.40 ± 0.1
B_0	14.40 ± 0.1
K_0	03.70 ± 0.1
F	10.25 ± 0.1
P_1	20.00 ± 0.1
S_0	20.50 ± 0.1
W	24.00 ± 0.3

Carrier material: Conductive Polystyrene



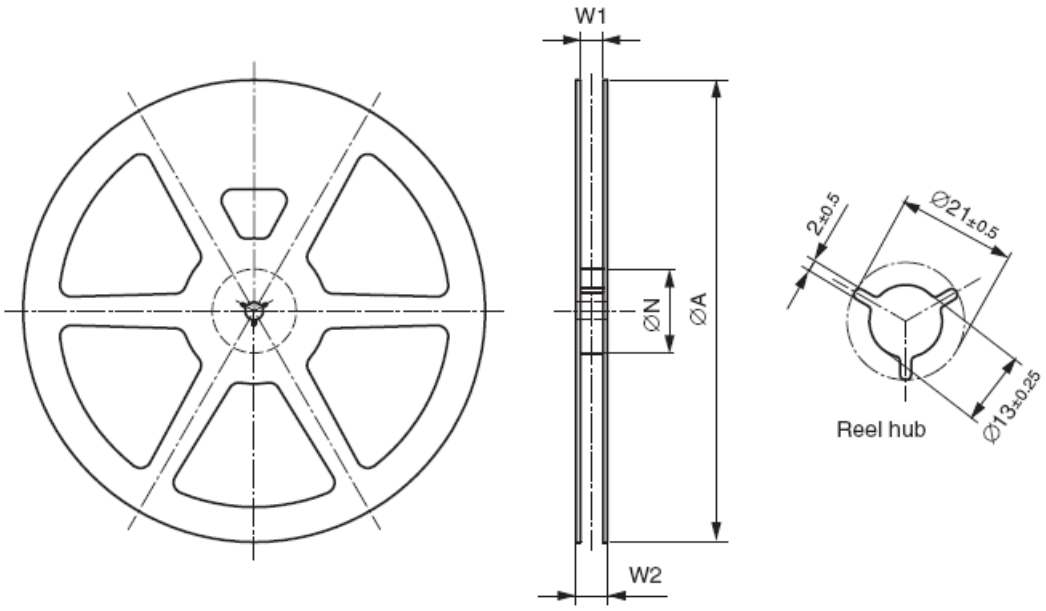


Figure 8-3: Reel dimensions

ØA	330.00 ± 0.85
ØN	60.00 ± 0.5
W_1	25.00 ± 0.5
W_2	31.00 ± 0.5

Reel material: Antistatic Plastic

Each reel contains 100 or 600 modules.

8.2. Moisture Sensitivity

The ORG-2000 module is moisture sensitive device at MSL 3 according to standard IPC/JEDEC J-STD-033B.

The recommended drying process for samples and bulk modules is to be done at 125°C for 48 hours.

8.3. Assembly

The ORG-2000 module support automatic assembly and reflow soldering processes on the component side of the motherboard PCB according to standard IPC/JEDEC J-STD-020D for LGA SMD. Suggested solder paste stencil is 5 mils to ensure sufficient solder volume.

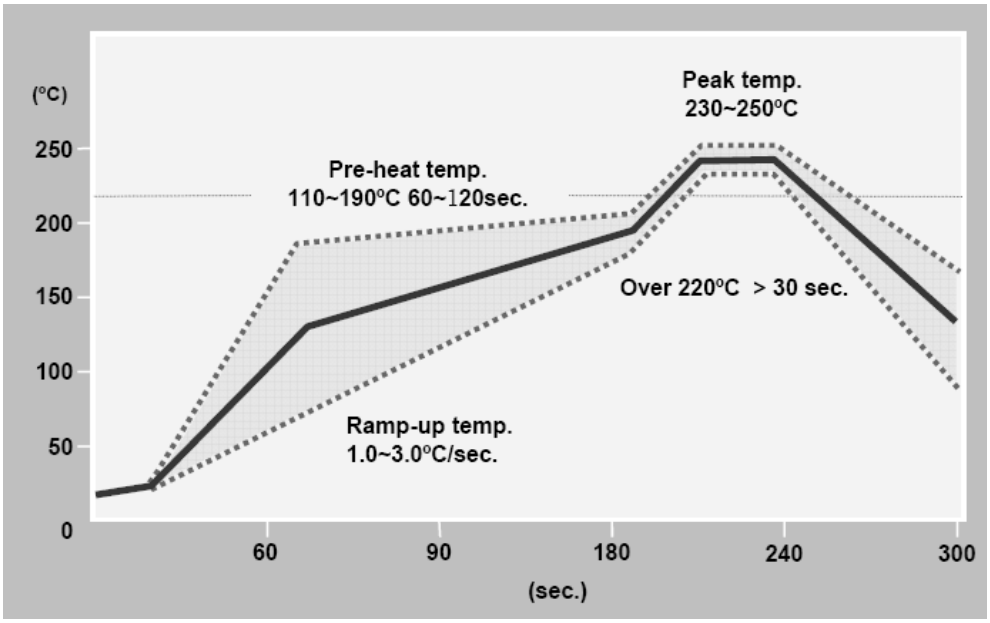


Figure 8-4: Recommended soldering profile

Suggested peak reflow temperature is 250°C for 10 sec. for Pb-Free solder paste.
Absolute Maximum reflow temperature is 260°C for 10 sec.

8.4. Rework

If localized heating is required to rework or repair the ORG-2000 module, precautionary methods are required to avoid exposure to solder reflow temperatures that can result in permanent damage to the device.

8.5. ESD Sensitivity

The ORG-2000 is ESD protected device according to +/- 2000KV HBM (JEDEC Human Body Model JESD22, Method A114D)

8.6. Compliances

The ORG-2000 modules comply with the following standards:

- Pb-Free/RoHS (Directive 2002/95/EC on the restriction of the use of certain hazardous substances in electrical and electronic equipment)
- ISO 9001:2000 accredited manufacturing facility

8.7. Safety Information

Improper handling and use can cause permanent damage to the device.
There is also the possible risk of personal injury from mechanical trauma or shocking hazard.

8.8. Disposal Information

We recommend that this product should not be treated as household waste.
For more detailed information about recycling this product, please contact your local waste management authority or the reseller from whom you purchased the product.

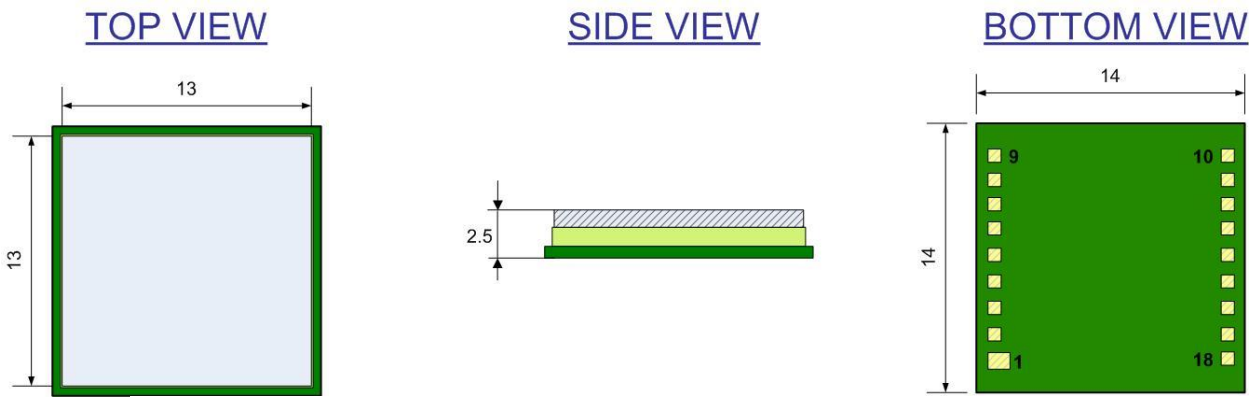
9. Mechanical Specifications

- The ORG-2000 module has advanced miniature packaging and a LGA footprint.
- The ORG-2000 module is a surface mount device packaged on a miniature printed circuit board with a metallic RF enclosure on one side and Microstrip Patch Antenna on top of the shield.
- There are 18 surface mount connection pads with a base metal of copper and an Electroless Nickel / Immersion Gold (ENIG) finish.
- The ORG-2000 module has been designed for automated pick and place assembly and reflow soldering processes.

Dimensions	Length	Width	Height
mm	14 ± 0.1	14 ± 0.1	2.5 ± 0.1
inch	0.55 ± 0.004	0.55 ± 0.004	0.1 ± 0.004

Weight	
gr	2
oz	0.1

Table 9-1: Mechanical Information



All dimensions are in millimeters

Figure 9-1: Mechanical Outline Drawing

10. Ordering Information

The part numbers of the ORG-2000 variants are shown in Table 10-1.

Part Number	Description
ORG-2000-TR	ORG-2000 (standard)
ORG-2000-UAR	ORG-2000 evaluation kit

Table 10-1: ORG-2000 Ordering Options