GPS low power receiver GNS601uLP

Datasheet

1 INTRODUCTION

GNS introduces a new series of complete GPS receivers that are optimized for very small battery budgets.
Thanks to advanced dynamic power management technology, the power consumption is reduced to a minimum below 7 mA (<20mW). Average power savings are 60%.

Unlike other concepts that use trickle operation modes with reduced update rates of the position, GNS601uLP works at full 1 per second position update rate.
Best power savings can be achieved in typical outdoor scenarios with wide view angles to the sky. GNS601uLP allows long term tracking in small applications like fitness wearables, pet tracking and camera applications.
Very low power requirements and internal voltage regulator makes it easy to run the receiver with various power supplies and allows direct connection to LiIon batteries.

GNS601uLP utilizes a patch antenna (15 by 15 mm) to realize high sensitivity and optimum radiation pattern.
If space is a main requirement, GNS also offers a chip antenna version (GNS302uLP).

The navigation performance and accuracy is improved by using correction data from SBAS (WAAS, EGNOS, GAGAN, MSAS), QZSS.

First Fixes after just a few seconds are achieved with the help of A-GPS using EPO™ (Extended Prediction Orbit) and the EASY™ self generated orbit prediction algorithm. EASY™ (Embedded Assist System) does not require any resources from the host and no data from the network.

AlwaysLocate™ power management feature can be activated to further lower the power requirements at lower update rates. It adaptively adjusts power consumption depending on the environment and motion conditions, in order to achieve a balance between fix rate, power consumption and position accuracy.

GPS low power receiver GNS601uLP

Datasheet

GNS601uLP offers the industry's highest level of navigation sensitivity up to -165dBm[1]. It has superior dynamic performance at high velocity and provides effective protection against interference signals using MTAIC™ (Multi-tone active interference canceller). Up to 12 independent channel interference continuous wave jammers <-80dBm can be eliminated or reduced.

The embedded logger function LOCUS with a 16-hrs (8000 samples) on chip memory makes this GPS module a complete track logger for many applications.

In professional timing applications the outstanding high accuracy PPS (pulse per second) hardware pin is used for synchronization to GPS second. Typical accuracy is 10ns RMS.

Features

- Ultra low power technology at full tracking output rate
- 66 acquisition-/ 22 tracking channels
- Ultra high tracking/navigation sensitivity: -165dBm[1]
- tuned ceramic patch antenna
- SBAS (WAAS,EGNOS,MSAS,GAGAN, QZSS) correction support
- A-GPS by EPO "Extended Prediction Orbit" ™ enables 7/14days prediction
- 12 Multitone Active Interference Canceller (MTAIC) for GPS-in-band jammer rejection
- EASY ™ : Self generated orbit prediction support
- AlwaysLocate ™ : Intelligent Algorithm for power saving
- High accuracy 1PPS output
- NMEA-0183 or binary protocol
- High update rate (up to 10/s)
- Embedded logger function with 16hrs internal memory
- GPS current consumption (@3.3V):
  Acquisition: 20mA typical
  Tracking: 6mA typical
- Low backup current consumption 7uA, typical
- SMD type , manual soldering also possible
- Small form factor: 16x16x6.7mm
- RohS certified

[1] Note: Measured navigation sensitivity at RF input of chipset

2 INDEX

3 FUNCTIONAL DESCRIPTION

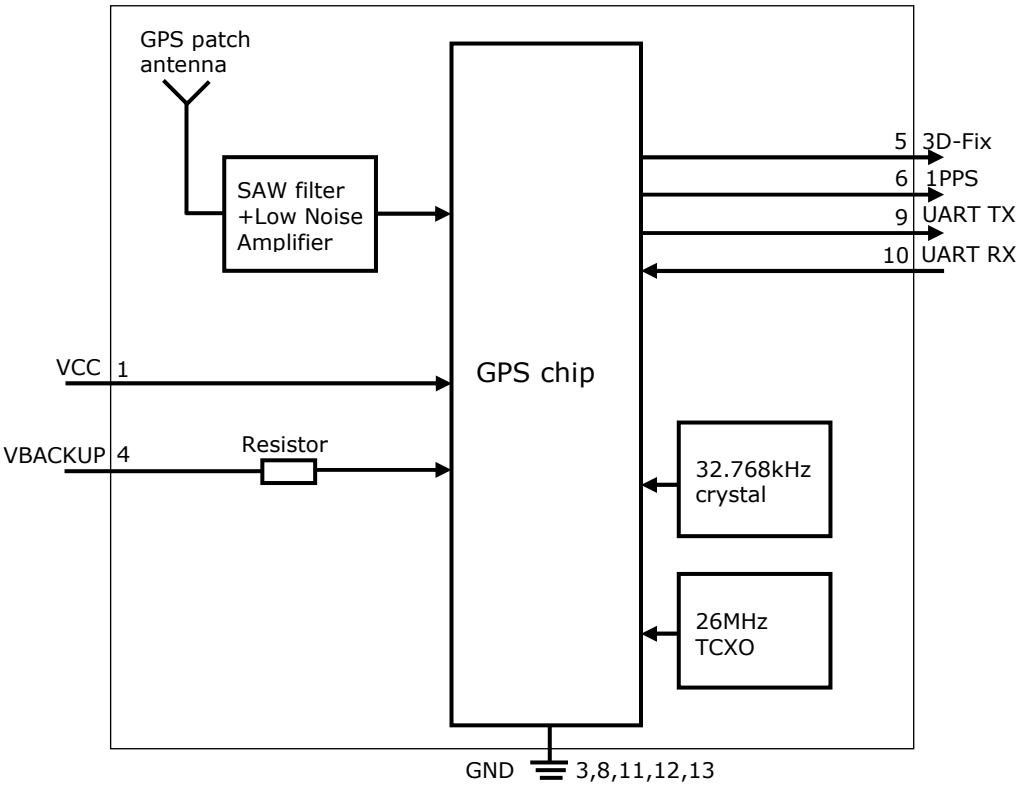
3.1 System description

The GNS601uLP is a high performance, low power GPS receiver that includes an integrated RF frontend (SAW Filter + LNA) and a finely tuned 15x15x4mm ceramic patch antenna.
Due to high input sensitivity and integrated low noise amplifier (LNA), it can work at very weak GPS signals.

GNS601uLP is a complete autonomous GPS receiver, including:

- Full GPS processing, without any host processing requirements
- Standard NMEA message output
- A powerful NMEA command and control interface
- All clock sources integrated
- RF frontend integrates a low noise amplifier (LNA) and a SAW filter
- Interface for UART, PPS output pin, Fix Status Indicator pin

3.2 Block diagram



3.3 AGPS with EPO data

AGPS (assisted GPS) allows to shorten TTFF (TimeToFirstFix) by injecting ephemeris data from an external source into the module's memory. With the help of these data, the module does not need to acquire satellite positions by receiving the data from the satellites.
Depending on time and position information, that is still available in the module memory, the TTFF can be reduced to just a few seconds.
The GNS AGPS service is based on a short term predicted data service. The predicted data will be fully processed by the GPS engine. The host must load the data from the web and transfer them over the UART into the module:

1. Check GNS601uLP module EPO (Extended Prediction Orbit) data for validity by comparing the time.
2. Connect to web server through network connection (GPRS, WLAN, LAN,..).
3. Download file. There are just two files, covering all GPS satellites. The first file (MTK7d.EPO) is for 7 days (53kB), the other is 106Kbytes for 14 days (MTK14d.EPO)
4. "Parse" file, using software example. This is quite easy, there must be added some header bytes and a checksum and a control counter. GNS offers software support on this.
5. Download to GNS601uLP receiver. Please refer to the *NMEAcommandInterface manual* for details.

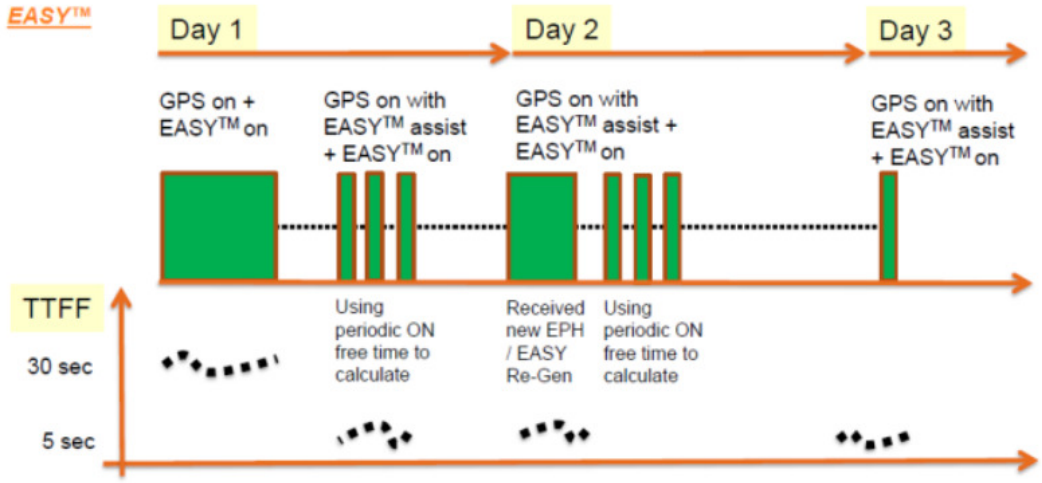
If the host has low memory available, there's no need to save the whole file. The steps 3..5 can be done frame by frame needing less than 2kBytes of buffer memory.

Code samples and support for several platforms are available from GNS (in preparation).
Thanks to the predicted system, download data stay valid for up to 14 days. Therefore, users can initiate the download everytime and benefit from using (W)LAN instead of using expensive GSM.
File size will be ~50kBytes for a one week prediction data set.

AGPS characteristics					
System					predicted data
File size for data download		53		kB	1 week prediction data
Maximum prediction time	7	14		days	
TTFF		1		sec	Time and last position available
TTFF		15		sec	Last position available

3.4 EASY™ self generated prediction data feature

GNS601uLP includes an internal prediction system, that allows to sample satellite orbit data during operation and use that data to speed up TTFF on later starts.The prediction time frame is up to three days forward.
Although this prediction feature does not provide the very short TTFF that is achieved using AGPS, it can help to find a fix solution faster and in weak signal condition scenario. Prediction data will be kept in memory as long as V_{BACKUP} is present. This option is activated by default.
Note: The EASY functionality is only supported, if "V_{BACKUP}" pin is conntected and the NMEA update rate is 1Hz.



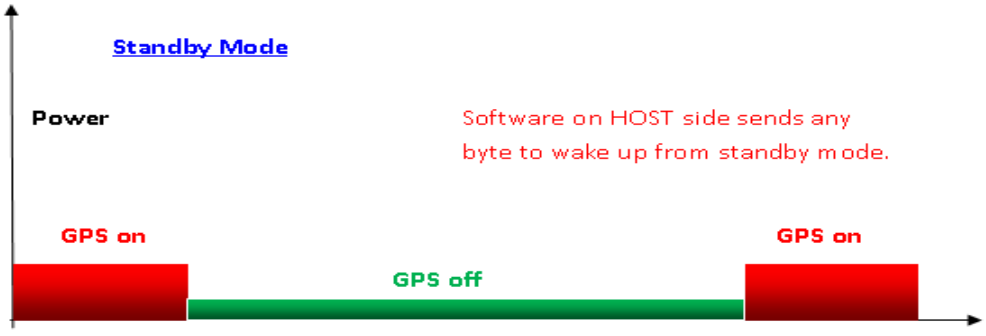
3.5 Power Management Features

GNS601uLP uses an advanced hardware / firmware architecture to minimize power consumption at full navigation update rate of 1position per second.
Best savings are possible with 6 SVs in track and good field strength.

- ***uLP feature*** is a dynamic power management system that allows to reduce the power consumption to ~40% in average. Thanks to advanced hardware and firmware architecture and unlike other power management features, uLP feature will calculate and output position data every second. uLP feature has been developed for fitness- and other wearable applications. The average accuracy will be slightly reduced (4m instead of 3m). For static or slow moving scenarios , the savings can be better than 70%. uLP feature is activated by default and can be deactivated through $PMTK262,0 command.

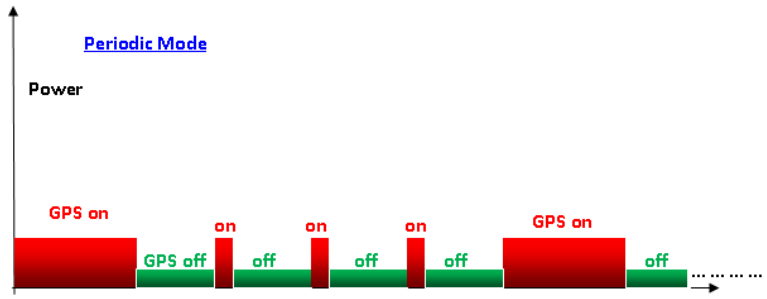
Besides the uLP power mode, the well-known power savings modes with reduced output rate and performance are also available when uLP is disabled.
Power management schemes implemented for any GPS system requires an optimally tuned performance for both accuracy of the position fixes and the average power consumed for best user experience. GNS601uLP architecture achieves these both aspects by providing flexibility and design choices for the system integration, based on wide range of use cases and by leveraging on the proven silicon methodologies. Also GNS601uLP provides position, velocity and time measurements without any host loading. This, coupled with the optional built-in power management options, reduces the overall system power budget.
Selectable Power management features:

- In ***Standby mode*** RF frontend and internal MPU are switched to deep sleep state. Power consumption is reduced.This state can be entered by sending the NMEA command: $PMTK161,0*28<CR><LF>.
  Leaving standby mode and resuming to normal operation will be managed by sending any byte to the module. Current consumption is ~500µA in standby

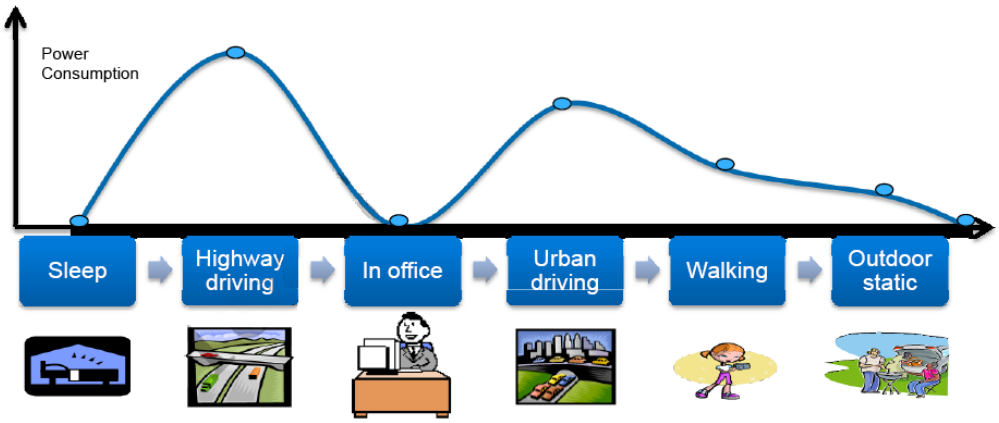


- ***Periodic mode*** describes a power mode, which will autonomously power on/off the module in programmable time slots with reduced fix rate. Periodic mode is useful during stationary operation or if position fixes are just needed from time to time. Since power consumption in GPS off times is nearly zero, the power consumption in periodic mode can be estimated by

$P_{tracking} * (t_{on}/(t_{on}+t_{off}))$.
Periodic mode is controlled with NMEA command $PTMK225. See document *NMEAcommandInterface manual* for programming details.

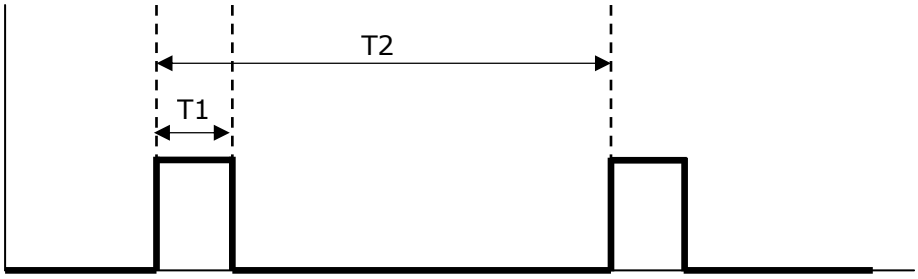


- ***AlwaysLocate***™ feature provides an optimized overall GPS system power consumption in tracking mode under open sky conditions. Always Locate is an intelligent control of periodic mode. Depending on the environment and motion conditions, GNS601uLP can adjust the on/off time to achieve balance of positioning accuracy and power consumption. The best power saving will be made under good reception in stationary mode. Critical reception conditions and dynamic movements will need full activity of the GPS engine which causes nominal power requirements (20mA typ in tracking mode).



3.6 Pulse Per Second (PPS)

GNS601uLP provides a Pulse Per Second (PPS) hardware output pin for timing purposes. After calculation of a 3D position fix (default setting), the PPS signal is accurately aligned to the GPS second boundaries. The pulse generated is approximately 100 milliseconds in duration and the repetition rate is 1 second. On request PPS output can activated on a 2D- fix or after power-up of the module, providing a time accuracy decreased PPS signal.



T1 = 100ms T2 = 1sec

GNS601uLP module provides an exceptionally low RMS jitter of typical 10 nanoseconds.

PPS characteristics based upon a 3D-fix					
1PPS pulse duration	-	100	-	msec	
1PPS time jitter	-	10		nsec RMS	Pulse rising edge deviation from expected pulse time, measured with full 3D fix
1PPS rise and fall time		5		nsec	10%..90%, load is 10k||5pF

3.7 Logger function

GNS601uLP provides an autonomous logger function that automatically stores position information in an internal 128kB flash memory. A complete tracking unit can be realized without any external CPU or memory.
The parameters for logging are programmable via the NMEA command interface. The following parameter can be set to optimize logging time:

- logger rate

The commands for logger include:

- start logging
- stop logging
- erase memory
- readout memory

please refer to the *NMEAcommandInterface manual* for details.

Internal Logger Function					
Logger data rate	1/15		1	1/s	
Logger data memory		128		kBytes	Flash memory
Logger trigger		programmable			Logger can be triggered on various events

3.8 Active interference cancellation (MTAIC)

Because different wireless technologies like Wi-Fi, GSM/GPRS, 3G/4G, Bluetooth are integrated into portable systems, the harmonic of RF signals may influence the GPS reception.
The multi-tone active interference canceller can reject external RF interference which come from other active components on the main board, thus improving the performance of GPS reception. GNS601uLP can cancel up to 12 independent continuous wave (CW) channels having signal levels of up to -80dBm. The functionality is enabled by default and increases power consumption by about 1mA.

3.9 SBAS (Satellite Based Augmentation) support

GNS601uLP supports Satellite Based Augmentation for improvement of the navigation precision. Correction data is sent from geostationary satellites to the GPS receiver. GNS601uLP supports European, US, and Asian augmentation systems (EGNOS, WAAS, GAGAN, MSAS, QZSS) to enable precision improvements in nearly every region of the world.
SBAS is active by default and will automatically track the available SBAS satellites. It can be disabled by NMEA command. See document NMEAcommandInterface manual for details.
Note: SBAS is deactivated in uLP mode. For SBAS activation, uLP mode must be disabled

3.10 GPS almanac and ephemeris data

For quick re-acquisition of the GPS after off-times, the GPS engine should have access to almanac and ephemeris data. This data is permanently stored inside GNS601uLP module, even if all power supplies have been removed. When the GPS is powered-up again, the data will be used to allow a quick re-acquisition, as soon as a coarse time information is available. Time will be available immediately, when RTC is kept running.

3.11 Real time clock (RTC)

GNS601uLP has a real time clock with 32,768Hz crystal onboard. As long as V_{BACKUP} is connected to a power source, the real time clock and the module memory can be kept alive at very low power consumption of just 7uA. The RTC will track the current time and enable the module to start from sleep states with very fast time to first Fix (TTFF).

3.12 UART interface

GNS601uLP core and I/O sections work at 3.3V nominal. Absolute Maximum Ratings should not be exceeded. Should the GNS601uLP be interfaced to a host with I/O at higher/lower levels, level shifters should be used. UART baud rate is 9600 baud by default. The baud rate can be modified to higher rates by a NMEA software command. See document *NMEAcommandInterface manual* for details.

GPS UART Default Settings	
Parameter	**Value**
Baud rate	9600
Data length	8 bits
Stop bit	1
Parity	None

3.13 Module default settings

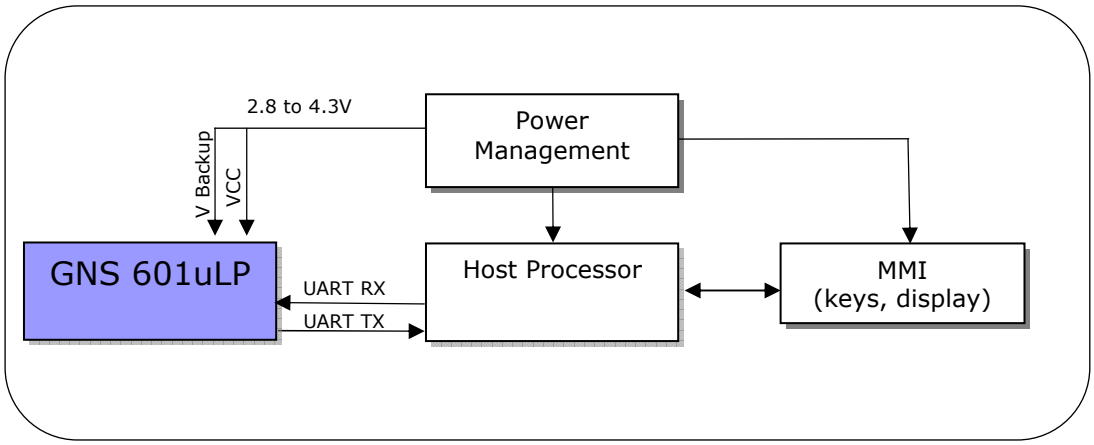
The GNS601ULP receiver comes with default settings, which are persistently programmed. Whenever power is removed from the module (both V_{CC} and V_{BACKUP}), the settings will be reset to the values shown in the following table.

NMEA output sentences	
Setting	**Default value**
UART setting	9600,8,N,1
Fix frequency (update rate)	1/sec
NMEA sentences	$GPRMC,$GPGSA,$GPGSV,$GPGGA
NMEA rate	Once a second
Self survey prediction mode: EASY™	enabled
Active interference cancellation:MTAIC	enabled
Datum	WGS 84
Logging parameters	Full&Stop / Content Basic / Interval 15 sec
Low Power Feature	Activated (disabled on request)

On request, other options can be selected as preprogrammed (persistent default) options. Please contact the GNS support for your project requirements.
Note : Customized options are solely available for fixed order lots.

4 TYPICAL APPLICATION BLOCK DIAGRAM

4.1 Typical System Overview



5 GPS characteristics

5.1 GPS characteristics

Parameter	Min	Typ	Max	Unit	Note
general					
Frequency		1575.42		MHz	GPS L1 C/A code
SBAS					WAAS,EGNOS,MSAS,GAGAN,QZSS Not available in uLP mode
Datum					WGS84
AGPS	7		14	days	Configurable
Output data frequency	1/10	1	10	1/sec	
Navigation&tracking sensitivity[1]		-165		dBm	autonomous
Acquisition sensitivity[1]		-148		dBm	Cold start
Reacquisition sensitivity[1]		-163		dBm	Hot start
TTFF hotstart		1		sec	6 SVs @-130dBm
TTFF autonomous warm start		34		sec	6 SVs @-130dBm
TTFF autonomous warm start		5..10		sec	6 SVs @-130dBm / with EASY on
TTFF autonomous cold start		35		sec	6 SVs @-130dBm
Reacquisition time		<1		sec	6 SVs @-130dBm
Number of channels tracking		22			
Number of acquisition channels		66			
Dimension		16x16x6.7		mm	Tolerance is 0.2 mm
Weight		6		g	
Power consumption					
GPS ACTIVE (acquisition)		21		mA	NMEA frequency = 1/sec, 3.3V; SBAS enabled;MTIAC enabled
GPS ACTIVE (tracking)		20		mA	NMEA frequency = 1/sec, 3.3V; SBAS enabled;MTIAC enabled
GPS ACTIVE (tracking in uLP mode)		6		mA	uLP mode activated, 6 SVs in solution

standby current		500		µA	By software command standby
Backup current		70		µA	By software command backup
Backup current @ 3V		7		µA	Vcc = 0

Accuracy					
Position error (50%CEP)	-	4	-	m	2D-RMS
Position error (50%CEP)	-	2.5	-	m	Using (SBAS) , uLP mode disabled
Velocity error	-	0.1	-	m/s	
velocity error	-	0.05	-	m/s	Using (SBAS) , uLP mode disabled

ITAR limits					
Operation altitude		-	18,000	m	
Operation velocity	-	-	515	m/s	
Operation acceleration	-	-	4	G	

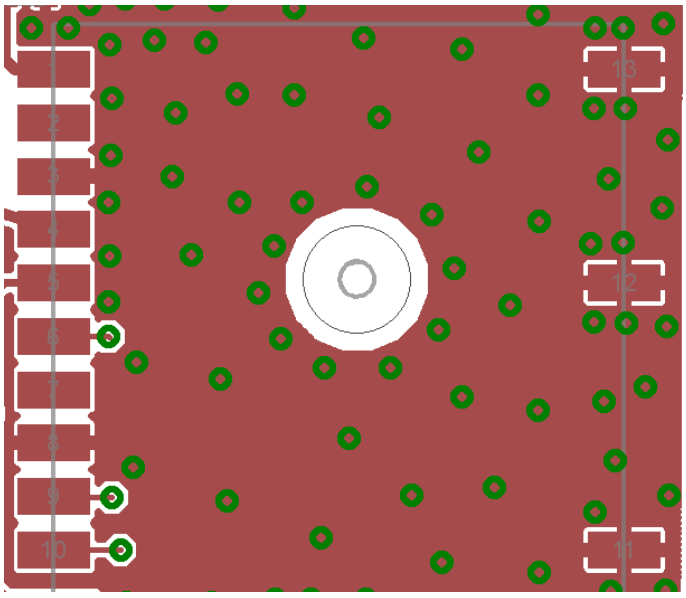
[1] note: based on chip specifications

6 DESIGN GUIDELINES

Although GNS601uLP GPS receiver provides best performance at low power consumption, special care should be taken to provide clean signal and clean power supplies. Power lines should be blocked near to the receiver with low ESR capacitors.
Radiated noise from neighbor components may also reduce the performance of the receiver. Plastic enclosures can have impact on the antenna center frequency. Avoid that the antenna is in touch with any enclosure parts. A space of ~2mm should be kept clear between antenna and enclosure. Product testing should be performed with the PCB already mounted in the final enclosure.

6.1 PCB LAYOUT GUIDELINES

GNS601uLP uses a high performance chip antenna design.
For optimum performance, a ground plane area is needed on the main board. This area should be at least 20 x 20mm, a larger ground is recommended.



The ground plane can be part of the main ground layer of the mainboard, some (small) components in the neighborhood are acceptable. Do not place any bulky or metallic components near the antenna (in a distance below 30mm) to avoid unwanted electromagnetic shielding effects.
It's recommended to place GNS601uLP near the rim of the main PCB, so that the antenna has a wide unobstructed working angle.

The marked clearance area around the antenna pin must be kept clear! It is recommended to place a 3mm hole to ensure proper mechanical flat placement of the module. See chapter 10 for hole location.
If possible, do not place any signal tracks below the module.
Place multiple vias from Top-GND layer to bottom (or other) GND layer(s) as shown in the example.
All ground pads of the module should be releliably soldered.

General rules for good and low noise design should be followed:

- ➔ Use a solid ground plane.
- ➔ Keep noisy components (µC, switch mode supplies) as far as possible away from sensitive antenna inputs
- ➔ Place decoupling capacitors near to the source of noise and provide a short and low induction connection to ground (use multi-vias if needed)
- ➔ EMC filters or noise filtering coils or beads can help to reduce the noise level further.
- ➔ Select system clocks in a way, that no harmonics will match the GPS frequency of 1575.42 MHz

7 ELECTRICAL SPECIFICATION

7.1 Absolute Maximum Ratings

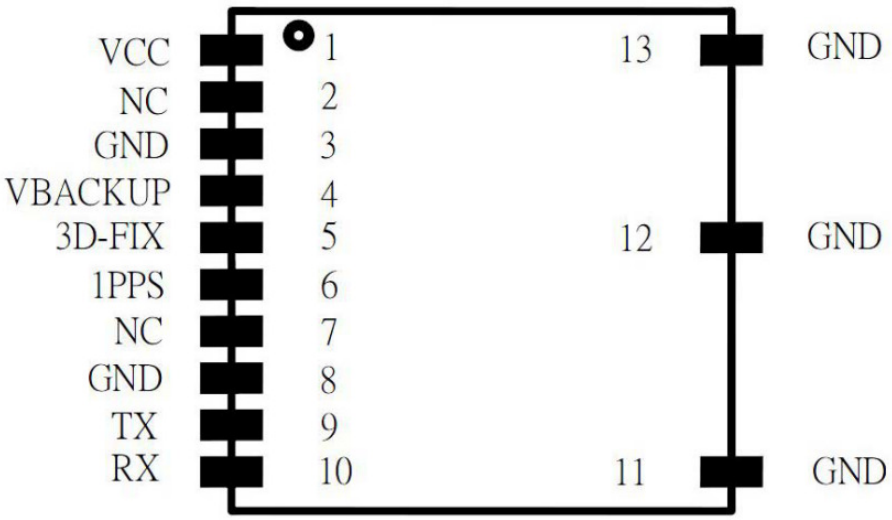
Parameter	Value	Unit
Supply voltage range: Vcc	2.8 to 4.3	V
Backup voltage: VBACKUP	2 to 4.3	V

7.2 Recommended Operating Conditions

Parameter	Min	Typ	Max	Unit	Note
V_{cc}	3.2	3.3	4.2	V	supply voltage
V_{cc} ripple voltage				50	mVpp
VBACKUP	2.2	3.0	4.2	V	Backup voltage for RTC and memory retention, must be available during normal operation
RX0 TTL H Level	2.0		V_{cc}	V	Condition: VCC=3.0V~4.3V
RX0 TTL L Level	0		0.8	V	Condition: VCC=3.0V~4.3V
TX0 TTL H Level	2.4		2.8	V	Condition: VCC=3.0V~4.3V
TX0 TTL L Level	0		0.4	V	Condition: VCC=3.0V~4.3V
Storage temperature	-50		90	°C	
Operating temperature	-40		85	°C	

8 PIN CONFIGURATION

Top View



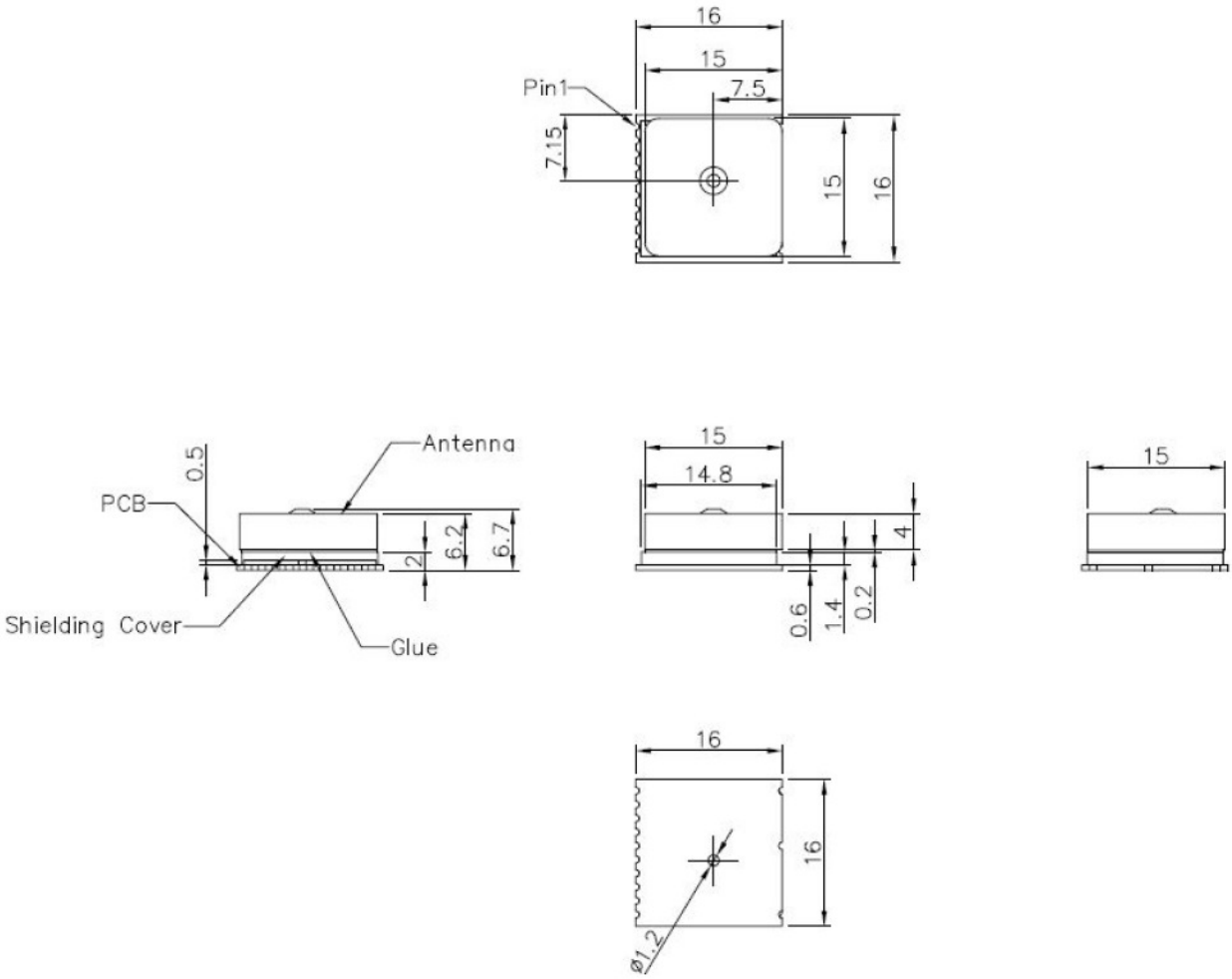
Pin	Name	I/O	Description & Note
1	VCC	P	Main DC power input The main DC power supply for the module. The voltage should be kept between from 3.2V to 5.0V. The ripple must be limited under 50mVpp (Typical: 3.3V).
2	NC		Not connected
3	GND	P	Ground .
4	V_{BACKUP}	P	Backup power input for RTC & navigation data keep This connects to the backup power of the GPS module. Power source (such as battery) connected to this pin will help the GPS chipset in keeping its internal RTC running when the main power source is turned off. The voltage should be kept between 2.0V~4.3V, Typical 3.0V. If VBACKUP power was not reserved, the GPS module will perform a lengthy cold start every time it is powered-on because previous satellite information is not retained and needs to be re-transmitted. **This pin must be connected for normal operation.**
5	3D_FIX	O	3D-Fix Indicator The 3D_FIX is assigned as a fix flag output. If not used, keep floating. Before 2D Fix The pin will continuously toggle with 1Hz. output one second high-level and one-second low-level signal After 2D or 3D Fix The pin will continuously output low-level signal. **This pin may not connected to high-level at power-on sequence.**
6	1PPS	O	1PPS Time Mark Output 2.8V CMOS Level This pin provides one pulse-per-second output from the module and synchronizes to GPS time. Keep floating if not used.
7	NC		Not connected
8	GND	P	Ground .
9	TX	O	Serial Data Output A for NMEA output (TTL) This is the UART transmitter of the module. It outputs GPS information for application.
10	RX	I	Serial Data Input A for Firmware update (TTL) This is the UART receiver of the module. It is used to receive commands from system.
11	GND	P	Ground .
12	GND	P	Ground .
13	GND	P	Ground .

(1) I = INPUT; O = OUTPUT; I/O = BIDIRECTIONAL; P = POWER PIN; ANA = ANALOG PIN.

9 PHYSICAL DIMENSIONS

TOP VIEW

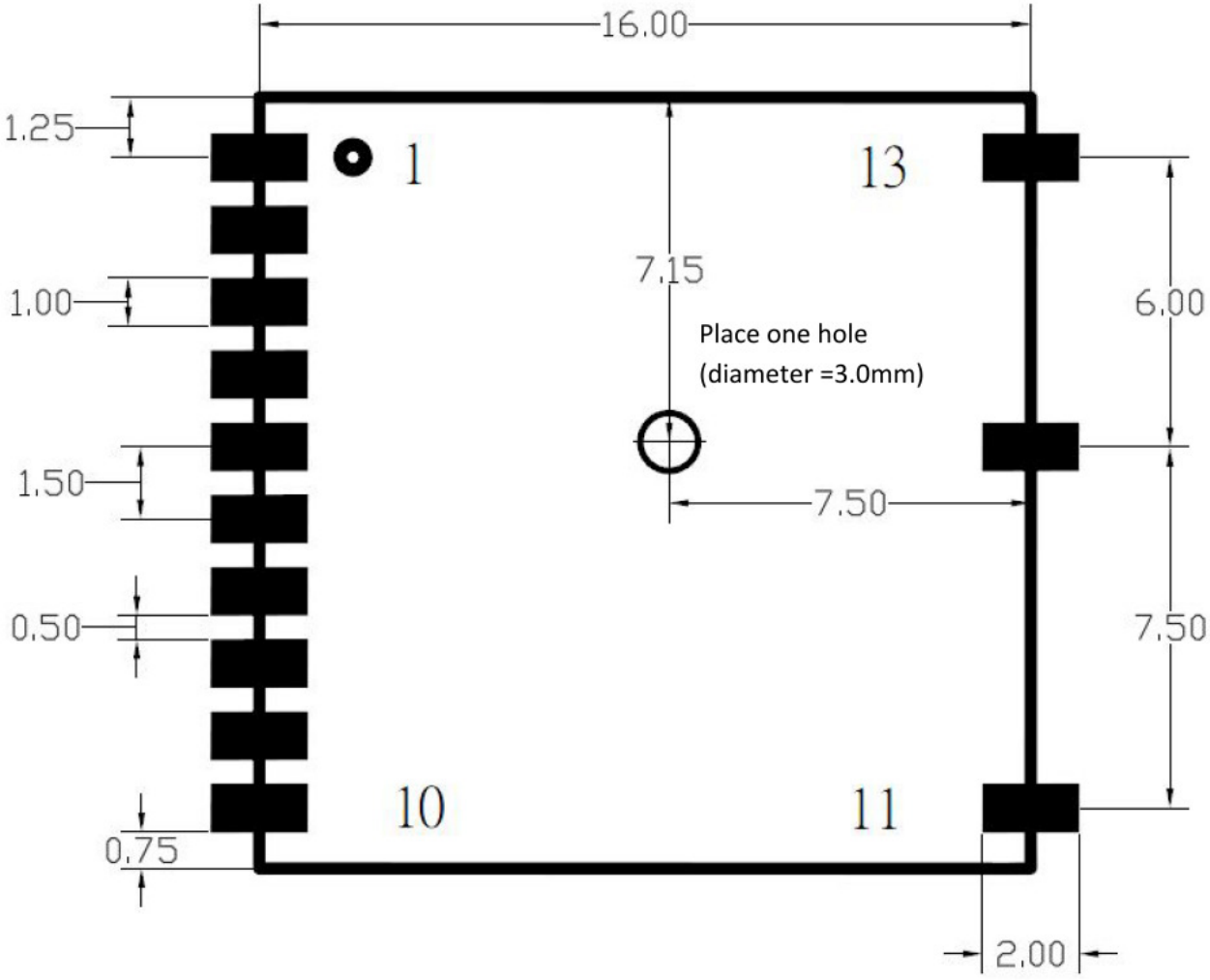
all units in mm, tolerance is ±0.2mm



10 RECOMMENDED PAD LAYOUT

all units in mm

Footprint Top View



11 NMEA DATA interface

GNS601uLP provides NMEA (National Marine Electronics Association) 0183 compatible data.
A set of proprietary NMEA commands are available to send control messages to the receiver.
These commands are described in a separate document: *NMEAcommandInterface manual*.
For standard operation, no commands are needed; the module will start outputting NMEA sentences after power supply has been attached
If nonstandard options are needed they can be programmed from host controller during runtime.
Important note : Options set by using NMEA command interface are not persistent! They will be lost when power is removed. A backup supply at V_{BACKUP} will be sufficient to keep them.

11.1 NMEA output sentences

NMEA output sentences	
Type	**content**
Common GPS sentences	
$GPRMC	Recommended Minimum Navigation Information
$GPGGA	Fix Data, Time, Position and fix related data for a GPS receiver
$GPGSA	DOP and active satellites
$GPGLL	Geographic Position - Latitude/Longitude
$GPGSV	GPS Satellites in view

11.2 NMEA command interface

The GNS601uLP NMEA command interface allows controlling settings and extended functions. The command interface specification is available as an extra document: *NMEAcommandInterface manual.*

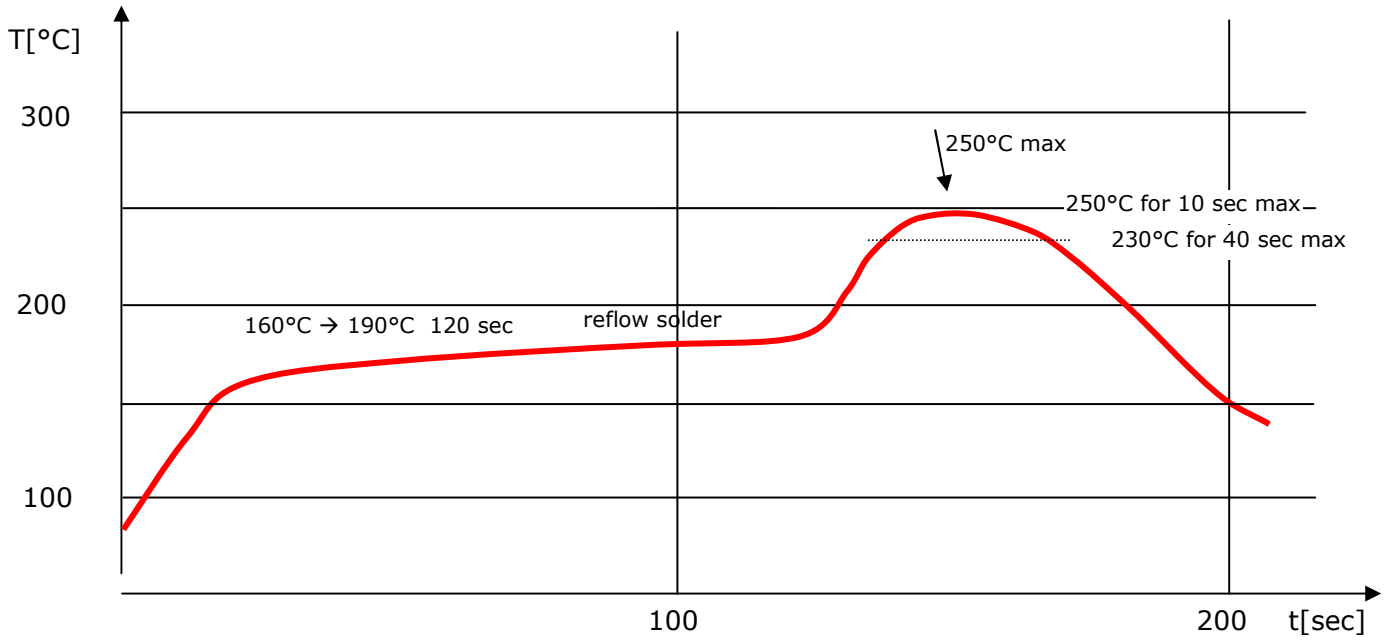
Two groups of commands are available:
Setting commands do modify the behavior of the module.
Note: Modified settings will be valid as long as the module is powered through VCC or VBACKUP. (e.g.: setting of a new baud rate). After removing VCC and VBACKUP, all settings are reset to their default values.
Action commands will perform the specified action one time after the command has been received. (e.g.: request for cold start)

Commands are always started with $PTMK, directly followed by the command number 000..999.
Each command must be terminated by *<chksum>and a <CR><LF>.
The checksum calculation is simple, just XOR all the bytes between the $ and the * (not including the delimiters themselves). Then use the hexadecimal ASCII format.

12 MATERIAL INFORMATION

Complies to ROHS standard
ROHS documentations are available on request
Contact surface: gold over nickel

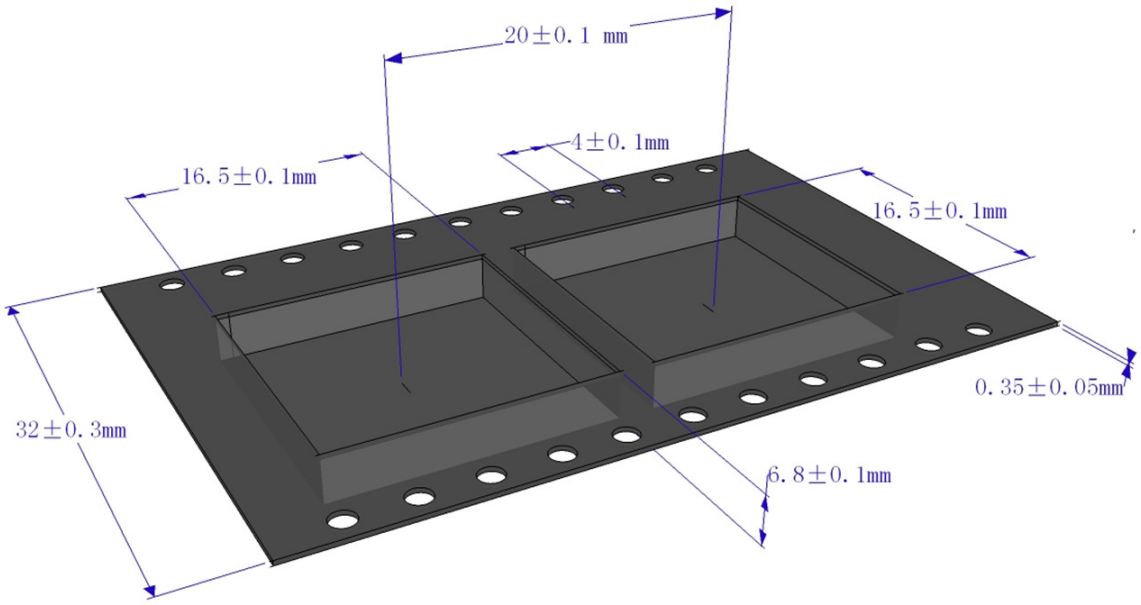
13 RECOMMENDED SOLDERING REFLOW PROFILE



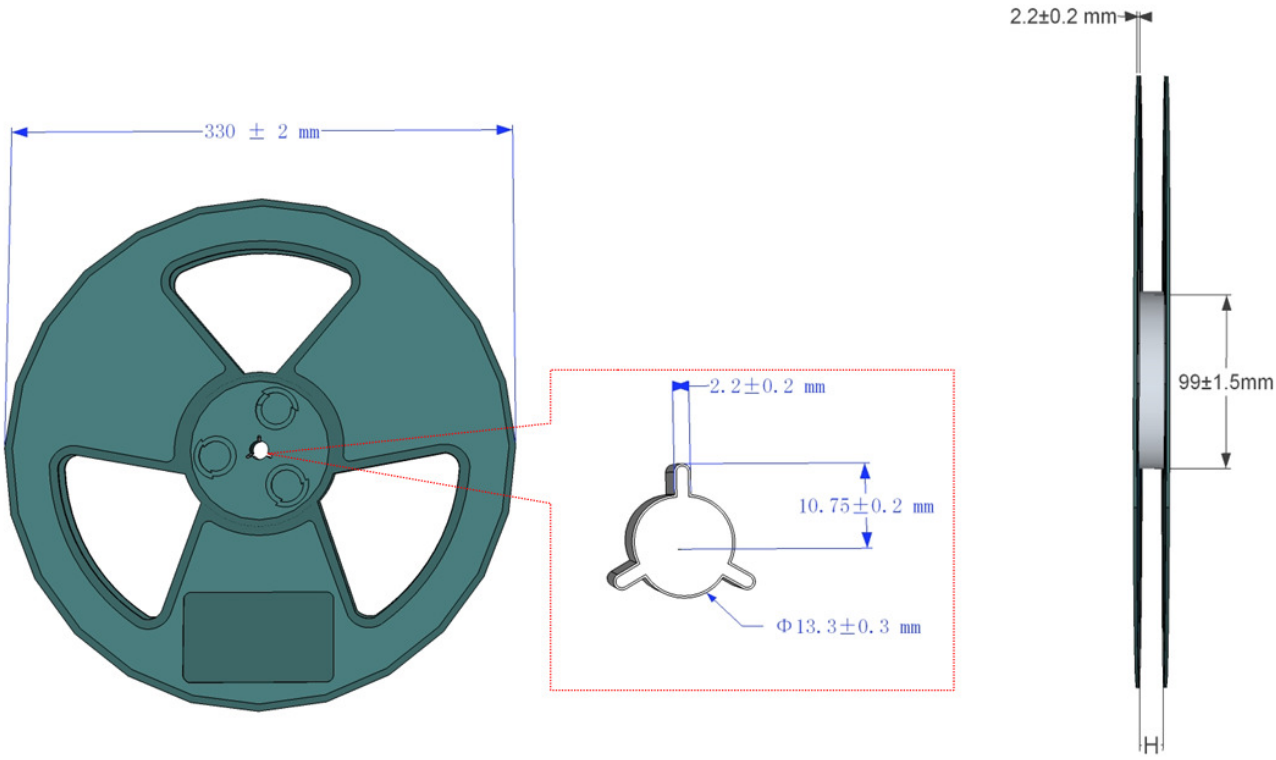
Notes:
1. GNS601uLP should be soldered in upright soldering position. In case of head-over soldering, please prevent shielding / GNS601uLP receiver from falling down.
2. Do never exceed maximum peak temperature
3. Reflow cycles allowed: 1 time
5. This device is not applicable for flow solder processing
6. This device is applicable for solder iron process. Use solder iron at or below 350°C, soldering time < 3 sec, pause between two solder points 3 sec.

14 TAPE&REEL INFORMATION

Tape information:



Reel information:



H= 32.5mm

Number of devices: 250pcs/reel

15 ORDERING INFORMATION

Ordering information			
Type	**Part#**	**marking**	**Description**
GNS601uLP	**4037735105386**	GNS601uLP	

16 ENVIRONMENTAL INFORMATION

This product is free of environmental hazardous substances and complies with 2002/95/EC. (RoHS directive).

17 MOISTURE SENSITIVITY

This device must be prebaked before being put to reflow solder process.
Disregarding may cause destructive effects like chip cracking, which leaves the device defective !

Shelf life	6 months , sealed
Possible prebake recommendations	12 hrs @ 60°C
Floor life (time from prebake to solder process)	<72 hrs

18 DOCUMENT REVISION HISTORY

V1.0	Jun 30 2015	P.Skaliks	initial document, preliminary
V1.3	Feb 17 2016	O.Diegel/ P.Skaliks	Corrected Part#, general review, baud rate, PCB design hints, pictures
V1.4	Aug 3 2016	P.Skaliks	removed backup command (incorrect !), moved EASY description
V1.5	Sep 4 2017	M.Heinzel	GNS Electronics – new company appearence
V1.6	Dec 4 2017	C.Diehl	Minor corrections, removed preliminary status
V1.7	Feb 8 2019	M.Heinzel	New company logo

19 RELATED DOCUMENTS

Title	**Description / file**		**Available from**
NMEA_Interface_manual_MTK_Vx	Detailed description of NMEA interface		www.gns-gmbh.com
GNS601uLP StarterKit user manual	User manual for the GNS601uLP receiver based evaluation kit		www.gns-gmbh.com