



NLE101-BA Hardware Design

GPS+Glonass Module

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Contents

| | | |
|------|--|----|
| 1 | Description..... | 4 |
| 1.1. | Key Features..... | 4 |
| 1.2. | Block Diagram..... | 5 |
| 2 | Application..... | 5 |
| 2.1. | Pin Assignment..... | 5 |
| 2.2. | Pin Definition..... | 6 |
| 2.3. | Power Supply..... | 8 |
| 2.4. | UART Interface..... | 10 |
| 2.5. | PPS VS. NMEA..... | 12 |
| 3 | Antenna Interfaces..... | 13 |
| 3.1. | PCB Design Guide..... | 13 |
| 3.2. | External Active Antenna..... | 13 |
| 4 | Electrical, Reliability and Radio Characteristics..... | 14 |
| 4.1. | Absolute Maximum Ratings..... | 14 |
| 4.2. | Operating Conditions..... | 15 |
| 4.3. | Current Consumption..... | 15 |
| 4.4. | Electrostatic Discharge..... | 16 |
| 5 | Mechanical Dimensions..... | 16 |
| 6 | Manufacturing, Packaging and Ordering Information..... | 17 |
| 6.1. | Assembly and Soldering..... | 17 |
| 6.2. | Moisture Sensitivity..... | 17 |
| 6.3. | ESD Protection..... | 18 |
| 6.4. | Tape and Reel Packaging..... | 18 |
| 7 | Appendix References..... | 19 |

General Description

The NLE101-BA is a complete GPS+Glonass engine module that features super sensitivity, ultra low power and small form factor. The GNSS signal is applied to the antenna input of module, and a complete serial data message with position, velocity and time information is presented at the serial interface with NMEA protocol or custom protocol. Its -162dBm tracking sensitivity extends positioning coverage into place like urban canyons and dense foliage environment where the GNSS was not possible before. The small form factor and low power consumption make the module easy to integrate into portable device like DVR, UVA, Car trackers applications

| | |
|-----------------------|--|
| Main chip | AT6558 |
| Track sensitivity | -162dBm |
| Time to First Fix | Extremely fast TTFFat low signal level |
| Built in high LNA | YES |
| Power consumption | Average 23mA@3.3V |
| Protocol | NMEA-0183 compliant protocol |
| Operating temperature | -40 to 85°C |
| Operating voltage | 3.0V to 3.6V |
| Module type | SMD |
| Size | 10.1x9.7x2.2mm |
| Certification | RoHS compliant(Lead-free) |

Table 1: General Description

1 Description

1.1. Key Features

| Parameter Specification | Specification |
|---|---|
| Power Supply | Supply voltage: 3.0V~3.6V Typical: 3.3V |
| Power Consumption | Acquisition: 23mA @VCC=VBAT=3.3V Tracking: 23mA @VCC=VBAT=3.3V Backup: 10uA @VBAT=3.3V |
| Receiver Type | 66 search channels, 22 synchronous GPS&QZSS L1 1575.42MHz C/A , GLONASS L1 1602MHz SBAS: WAAS, EGNOS, MSAS, GAGAN |
| Sensitivity | Tracking: -162dBm Re-acquisition: -160dBm Acquisition: -148dBm |
| TTF | Cold start: 32s typ @-130dBm Warm start: 30s typ @-130dBm Hot start: 1s typ @-130dBm |
| Horizontal Position Accuracy (Autonomous) | <2.5m CEP @-130 dBm |
| Update Rate | 1Hz |
| Accuracy of 1PPS Signal | Typical accuracy: ±30ns Time pulse width : 100ms |
| Acceleration Accuracy | Without aid: 0.1m/s ² |
| Dynamic Performance | Maximum altitude: 18,000m Maximum velocity: 515m/s Acceleration: 4G |
| UART Port | UART Port: TXD and RXD Supports baud rate from 4800bps to 115200bps, 9600bps By default UART port is used for NMEA output |
| Temperature Range | Normal operation: -40°C ~ +85°C Storage temperature: -45°C ~ +125°C |
| Physical Characteristics | Size: 10.1±0.15 x 9.7±0.15 x 2.2±0.1mm Weight: Approx. 0.41g |

Table 2: Key Features

1.2. Block Diagram

The following figure shows a block diagram of NLE101-BA module. It consists of a single chip GNSS IC which includes the RF part and Baseband part, a LNA, a SAW filter, a TCXO, a crystal oscillator.

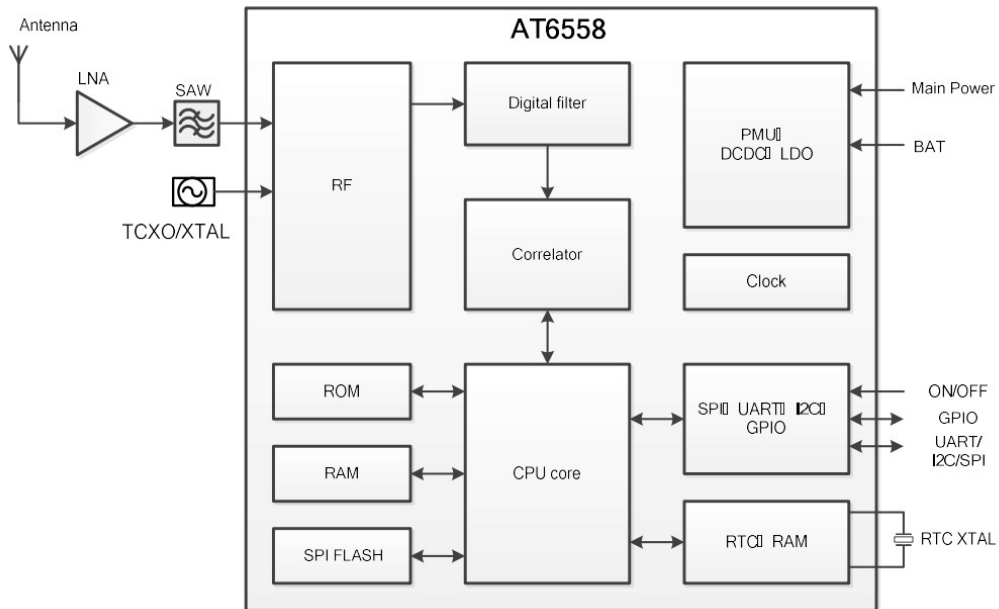


Figure 1: Block Diagram

2 Application

The module is equipped with a 18-pin SMT pad that connects to your application platform. Sub-interfaces included in the pad are described in details in the following chapters.

2.1. Pin Assignment



Figure 2: Pin Assignment

2.2. Pin Definition

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|-------------------------|---------|-----|----------------------|---|---|
| Power Supply | | | | | |
| VCC | 8 | I | Main power supply | V _{max} =3.6V V _{min} =2.8V V _{nom} =3.3V | Supply current not less than 100mA. |
| VBAT | 6 | I | Backup power supply | V _{max} =3.6V V _{min} =1.5V V _{nom} =3.3V | Supply power for RTC domain. The VBAT pin can be directly supplied power by battery or connect it to VCC. |
| GND | 1,10,12 | G | Ground | | Assure a good GND connection to all GND pins of the module, preferably with a large ground plane |
| Other Interfaces | | | | | |
| PPS | 4 | O | One pulse per second | V _{OLmin} =-0.3V V _{OLmax} =0.4V V _{OHmin} =2.4V V _{OHmax} =3.1V | Synchronized at rising edge, the pulse width is 100ms. If unused, keep this pin open. |
| RESET | 9 | I | System reset | V _{ILmin} =-0.3V V _{ILmax} =0.8V V _{IHmin} =2.0V V _{IHmax} =3.6V | Low level active. If unused, keep this pin open or connect it to VCC |
| UART Port | | | | | |
| RXDA | 3 | I | Receive data | V _{ILmin} =-0.3V V _{ILmax} =0.8V V _{IHmin} =2.0V V _{IHmax} =3.6V | |
| TXDA | 2 | O | Transmit data | V _{OLmin} =-0.3V V _{OLmax} =0.4V V _{OHmin} =2.4V V _{OHmax} =3.1V | |
| RXDB | 17 | I | Receive data | V _{ILmin} =-0.3V V _{ILmax} =0.8V V _{IHmin} =2.0V V _{IHmax} =3.6V | If not used, this pin is left vacant. |
| TXDB | 16 | O | Transmit data | V _{OLmin} =-0.3V V _{OLmax} =0.4V V _{OHmin} =2.4V V _{OHmax} =3.1V | If not used, this pin is left vacant. |

| Pin Name | Pin No. | I/O | Description | DC Characteristics | Comment |
|------------------------|---------|-----|----------------------------------|--------------------|--|
| GPIO Interfaces | | | | | |
| GPIO0 | 5 | I/O | Baud rate control | | See Figure 3 |
| GPIO1 | 18 | I/O | Baud rate control | | See Figure 3 |
| RF Interface | | | | | |
| RF_IN | 11 | I | External active antenna RF input | | Characteristic impedance of 50Ω |
| VCC_RF | 9 | O | Active antenna power output | Vnom=3.3V | Output Voltage RF section. VCC_RF can be selected according to the type of antenna |

Table 3: Pin Definition

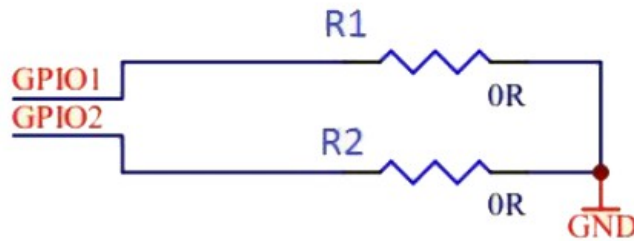


Figure 3: GPIO1/GPIO2 control circuit

| GPIO1 (R1) | GPIO2 (R2) | Baud rate state |
|------------|------------|-----------------|
| NC | NC | 9600bps |
| 0Ω | NC | 4800bps |
| NC | 0Ω | 115200bps |
| 0Ω | 0Ω | 38400bps |

Table 4: Module baud rate control

2.3. Power Supply

VCC pin supplies power for BB, RF, I/O, LNA, Antenna. The load current of VCC varies according to the VCC level, processor load, the number of tracked satellites and the rate of satellite re-acquisition. Using external active antenna will consume additional 11mA from our module. So it is important to supply sufficient current and make the power clean and stable. VCC supply ripple voltage should meet the requirement: 54mV (RMS) max @f=0...3MHz and 15mV (RMS) max@f>3MHz. You should choose the LDO without built-in output high-speed discharge function to keep long output voltage drop-down period. The decouple combination of 10uF and 100nF capacitor is recommended nearby VCC pin.

The VBAT pin supplies power for RTC domain. It should be valid when power on the module. The voltage of RTC domain ranges from 1.8V to 3.6V. In order to achieve a better TTFB, RTC domain should be valid all the time. It can supply power for SRAM memory in RTC domain which contains all the necessary GPS&Beidou information for quick start-up and a small amount of user configuration variables. The module's internal power construction is shown as below.

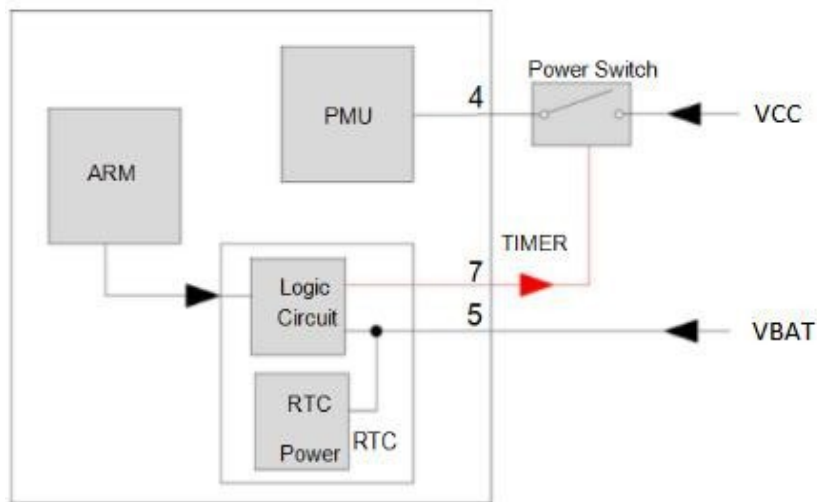


Figure 4: Internal Power Construction

VCC supplies power for PMU, and VBAT supplies power for RTC domain. TIMER signal highlighted in red in the following figure belongs to RTC domain and can be used to control the power switch on/off

The simplest power circuit for NLE101-BA module is 3.3V power source connected to VCC pin and VBAT pin of the module directly. In this case, once you powered on the module, the full cold start will be implemented.

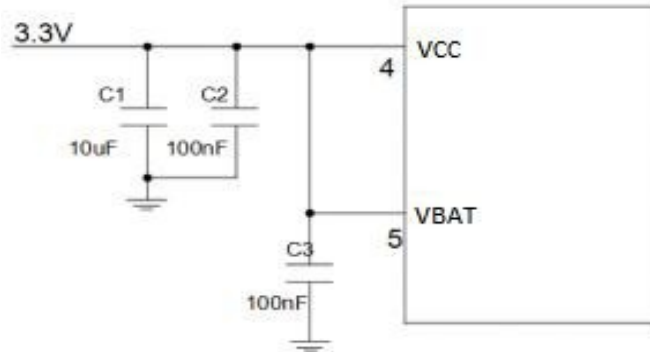


Figure 5: Reference Circuit for Power Supply

If your power supply circuit adopts the design mentioned above, NLE101-BA module does not support backup mode.

The other way is feeding VBAT through a backup battery directly. The module will enter into backup mode when power source (3.3V) is cut off. Furthermore, it is necessary to add an external charging circuit for rechargeable battery. The detailed schematic (mount R2 with 0R to replace Power switch) is shown as there is no charge source when power source (3.3V) is cut off. MS621FE FL11E from Seiko is recommended. The consumption of VBAT is as low as 7µA in backup mode.

The schematic with power supply circuit is shown as below. As power source (3.3V) is always valid and the battery is charged continuously, the capacity of the battery can be small. The detailed schematic for power switch circuit is shown in **Figure 6**.

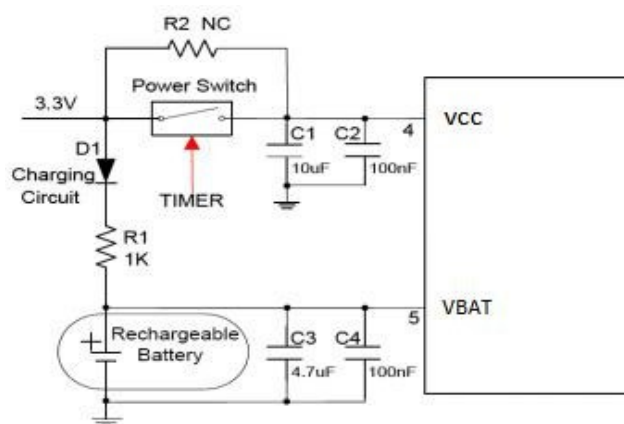


Figure 6: Reference Charging Circuit for Chargeable Battery

VCC does not supply power for RTC domain in NLE101-BA module, so the VBAT pin must be powered externally. Furthermore, it is strongly recommended to supply power to VBAT through a backup battery, which can ensure NLE101-BA module improves TTFF after next restart. For details about TTFF.

2.4. UART Interface

The module provides one universal asynchronous receiver& transmitter serial port. The module is designed as DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection. The module and the client (DTE) are connected through the signals shown in the following figure. It supports data baud-rate from 4800bps to 115200bps.

UART port:

TXD: Send data to the RXD1 signal line of DTE.

RXD Receive data from the TXD1 signal line of DTE

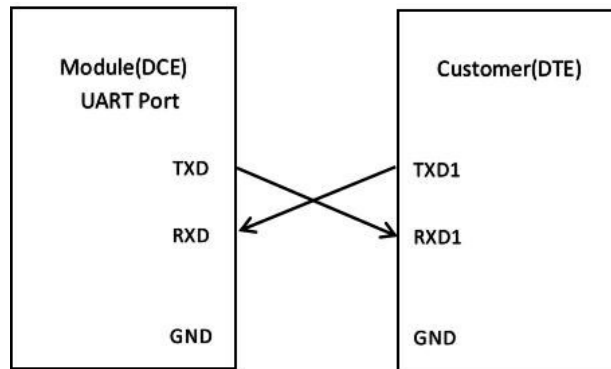


Figure 7: Connection of Serial Interfaces

This UART port has the following features:

- UART port can be used for NMEA output and proprietary commands input.
- The default output NMEA type setting is RMC, GGA, GSA, GSV, GLL, VTG
- UART port supports the following data rates:
- 4800, 9600, 14400, 19200, 38400, 57600, 115200bps.
- The default setting is 9600bps, 8 bits, no parity bit, 1 stop bit.
- Hardware flow control and synchronous operation are not supported.

The module supports the commonly used commands in configuration, The following table describes some of the parameters of the UART port configuration command, The Module power up initialization requires 300ms, Please send the sixteen system from CPU via serial port.

| Settings | Command NMEA |
|-------------------------------|----------------|
| Cold Start | \$PCAS10,2*1E |
| Warm start | \$PCAS10,1*1D |
| Hot start | \$PCAS10,0*1C |
| Factory Reset | \$PCAS10,3*1F |
| Standby mode (60 sec) | \$PCAS12,60*28 |
| Baud rate is 4800bps | \$PCAS01,0*1C |
| Baud rate is 9600bps | \$PCAS01,1*1D |
| Baud rate is 19200bps | \$PCAS01,2*1E |
| Baud rate is 38400bps | \$PCAS01,3*1F |
| Baud rate is 57600bps | \$PCAS01,4*18 |
| Baud rate is 115200bps | \$PCAS01,5*19 |

Table 5: Common instruction

The UART port does not support the RS-232 level but only CMOS level. If the module's UART port is connected to the UART port of a computer, it is necessary to add a level shift circuit between the module and the computer. Please refer to the following figure.

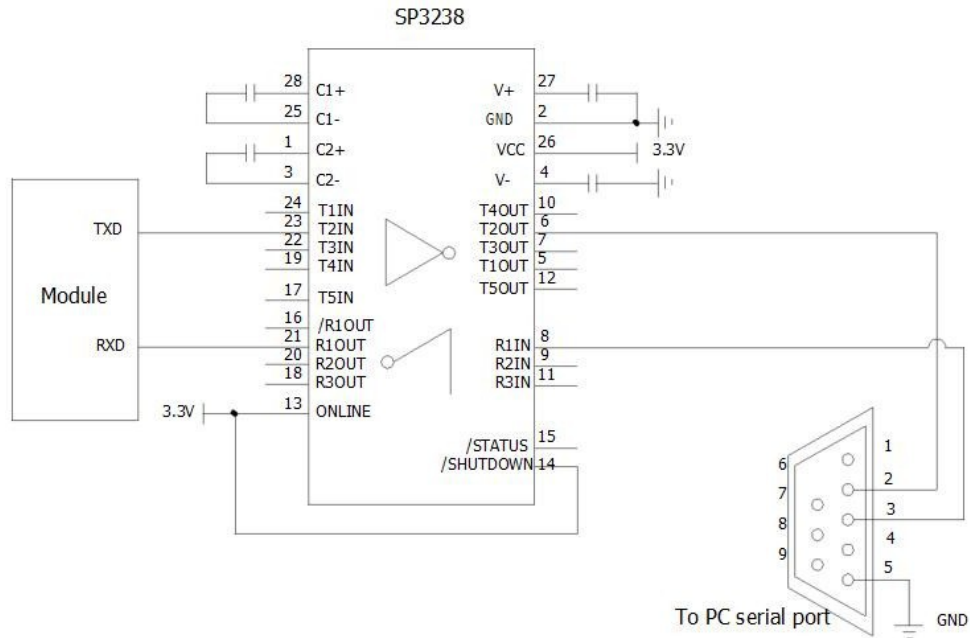


Figure 8: RS-232 Level Shift Circuit

2.5. PPS VS. NMEA

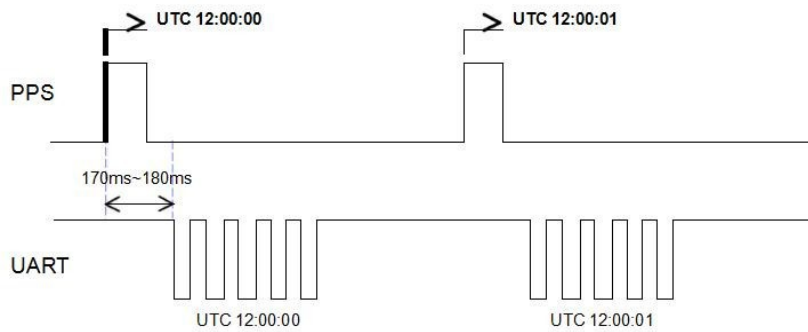


Figure 9: PPS VS. NMEA Timing

This feature only supports 1Hz NMEA output and baud rate at 14400~115200bps. At baud rate of 9600 and 4800bps, it only supports RMC NMEA sentence. Because at low baud rate, per second transmission may exceed one second if there are many NMEA sentences output.

3 Antenna Interfaces

3.1. PCB Design Guide

The NLE101-BA GPS&Beidou receiver is designed for supporting the active antenna or passive antenna connected with pin RF_IN. The gain of active antenna should be no less than 15dB. The maximum noise figure should be no more than 2.5dB and output impedance is at 50 Ohm.

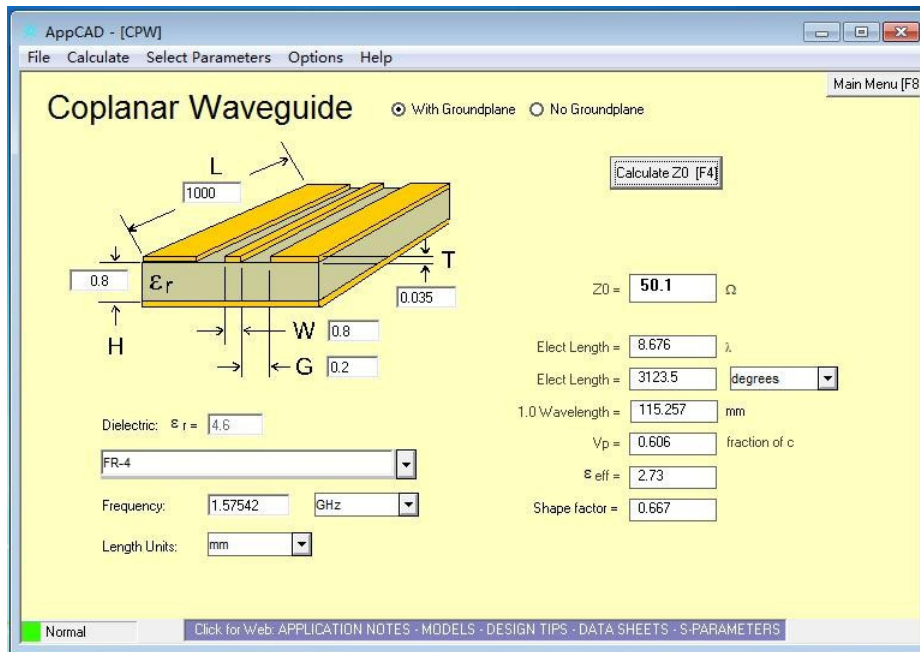


Figure 10: Antenna design requirements

3.2. External Active Antenna

The following figure is a typical reference design with active antenna. In this mode, DC on the VCC_RF pin is powered by VCC and supplies power to the external active antenna.

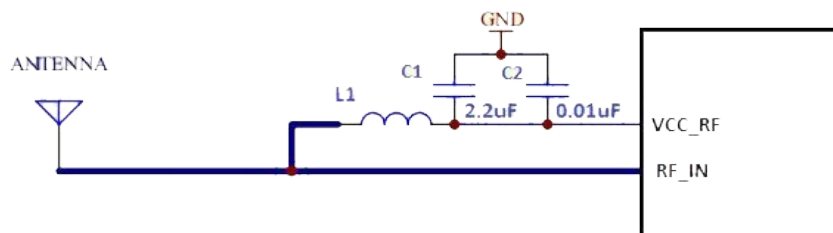


Figure 11: Reference Design for Active Antenna

C1, C2, L1 is used for power supply and filtering effect to the external active antenna, RF_IN antenna to a circuit part (BOLD line) for high frequency microstrip line, PCB in the design of this part of the line to calculate the characteristic impedance of the high-frequency line according to the principle of high frequency wiring.

Requirements: this section of the line in the 1575.42MHz frequency characteristic impedance requirement is 50ohm.

| Antenna Type | Specification |
|----------------|---|
| Active Antenna | Center frequency: 1575.42MHz Band width: >5MHZ VSWR: <2 (Typ.) Polarization: RHCP or Linear Noise figure: <1.5dB Gain (antenna): >-2dBi Gain (embedded LNA): 20dB (Typ.) Total gain: >18dBi(Typ.) |

Table 6: Recommended Active Antenna Specification

4 Electrical, Reliability and Radio Characteristics

4.1. Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital pins of the module are listed in the following table. values within the specified boundaries by using appropriate protection diodes.

| Parameter | Min. | Max. | Unit |
|-------------------------------|------|------|------|
| Power Supply Voltage (VCC) | -0.3 | 3.6 | V |
| Backup Battery Voltage (VBAT) | -0.3 | 3.6 | V |
| Input Voltage at Digital Pins | -0.3 | 3.6 | V |
| Input Power at RF_IN | | 15 | dBm |
| Storage Temperature | -45 | 125 | °C |

Table 7: Absolute Maximum Ratings

Stressing the device beyond the “Absolute Maximum Ratings” may cause permanent damage. These are stress ratings only. The product is not protected against over voltage or reversed voltage. If necessary, voltage spikes exceeding the power supply voltage specification, given in table above, must be limited to values within the specified boundaries by using appropriate protection diodes.

4.2. Operating Conditions

| Parameter | Description | Conditions | Min. | Typ. | Max. | Unit. |
|-----------|------------------------------|---|------|------|------|-------|
| VCC | Supply voltage | Voltage must stay within the min/max values, including voltage drop, ripple, and spikes | 3.0 | 3.3 | 3.6 | V |
| IVCCP | Peak supply current | VCC=3.3V | | | 100 | mA |
| VBAT | VBAT Backup voltage supply | | 1.5 | 3.3 | 3.6 | V |
| TOPR | Normal operating temperature | | -40 | 25 | 80 | °C |

Table 8: Power Supply Ratings

- The figure IVCCP can be used to determine the maximum current capability of power supply.
- Operation beyond the "Operating Conditions" is not recommended and extended exposure beyond the "Operating Conditions" may affect the device’s reliability.

4.3. Current Consumption

The values for current consumption are shown in the following table.

| Parameter | Conditions | Min. | Typ. | Max. | Unit |
|-------------------------------|---------------|------|------|------|------|
| I _{VCC @Acquisition} | VCC=VBAT=3.3V | | 23 | | mA |
| I _{VCC @Tracking} | VCC=VBAT=3.3V | | 23 | | mA |
| I _{BCKP @Backup} | VCC=VBAT=3.3V | | 10 | | uA |

Table 9: Current Consumption

The tracking current is tested in the following conditions:

- In Cold Start, 10 minutes after First Fix.
- In Hot Start, 15 seconds after First Fix.

4.4. Electrostatic Discharge

NLE101-BA module is an ESD sensitive device. ESD protection precautions should still be emphasized. Proper ESD handling and packaging procedures must be applied throughout the processing, handling and operation of any application.

The ESD bearing capability of the module is listed in the following table. Note that you should add ESD components to module pins in particular applications.

| Pin | Contact Discharge | Air Discharge |
|--------|-------------------|---------------|
| RF_IN | ±5KV | ±10KV |
| VCC | ±5KV | ±10KV |
| UART | ±3KV | ±6KV |
| Others | ±2KV | ±4KV |

Table 10: ESD Endurance Table (Temperature : 25°C, Humidity: 45%)

5 Mechanical Dimensions

This chapter describes the mechanical dimensions of the module.

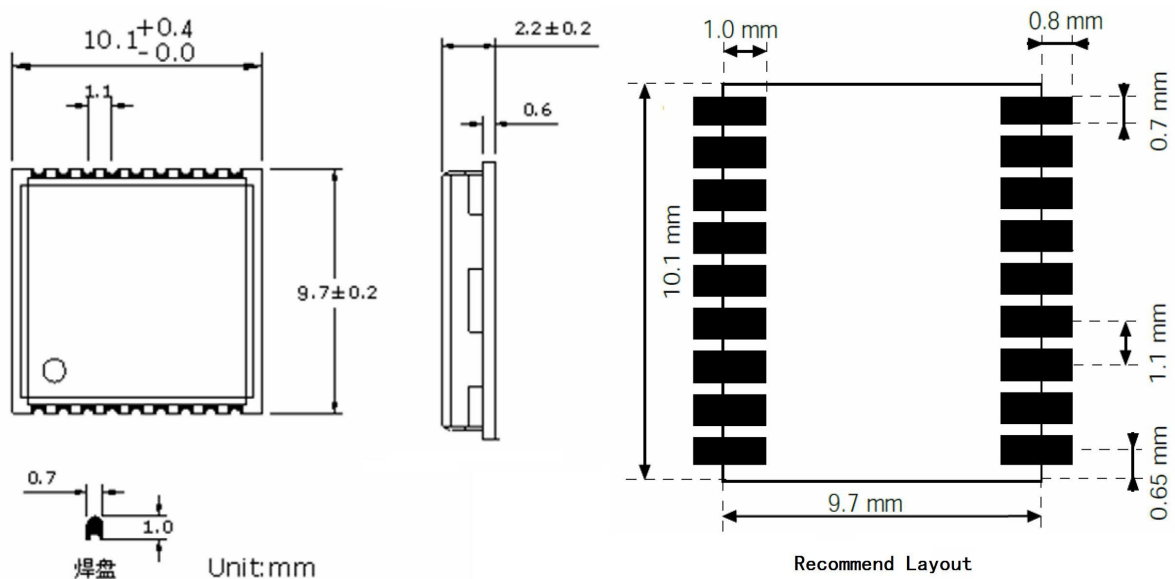


Figure 12: Bottom View Dimensions

6 Manufacturing, Packaging and Ordering Information

6.1. Assembly and Soldering

NLE101-BA module is intended for SMT assembly and soldering in a Pb-free reflow process on the top side of the PCB. It is suggested that the minimum height of solder paste stencil is 100um to ensure sufficient solder volume. Pad openings of paste mask can be increased to ensure proper soldering and solder wetting over pads. It is suggested that the peak reflow temperature is 235~245°C (for SnAg3.0Cu0.5 alloy). The absolute maximum reflow temperature is 260 °C. To avoid damage to the module when it is repeatedly heated, it is suggested that the module should be mounted after reflow soldering for the other side of PCB has been completed. Recommended reflow soldering thermal profile is shown below:

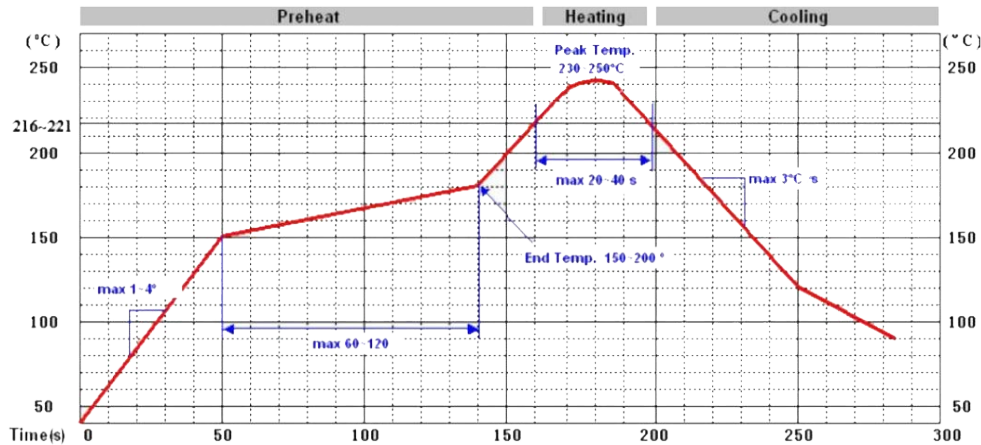


Figure 13: Recommended Reflow Soldering Thermal Profile

6.2. Moisture Sensitivity

NLE101-BA module is sensitive to moisture. To prevent NLE101-BA from permanent damage during reflow soldering, baking before reflow soldering is required in following cases:

- Humidity indicator card: One or more indicating spots are no longer blue.
- The seal is opened and the module is exposed to excessive humidity.

NLE101-BA should be baked for 192 hours at temperature 40°C+5°C/-0°C and <5% RH in low-temperature containers, or 24 hours at temperature 125°C±5°C in high-temperature containers. Care should be taken that the plastic tape is not heat resistant. NLE101-BA should be taken out from the tape before preheating; otherwise, the tape maybe damaged by high-temperature heating.

6.3. ESD Protection

NLE101-BA module is sensitive to ESD and requires special precautions when handling. Particular care must be exercised when handling patch antenna, duo to the risk of electrostatic charges.

6.4. Tape and Reel Packaging

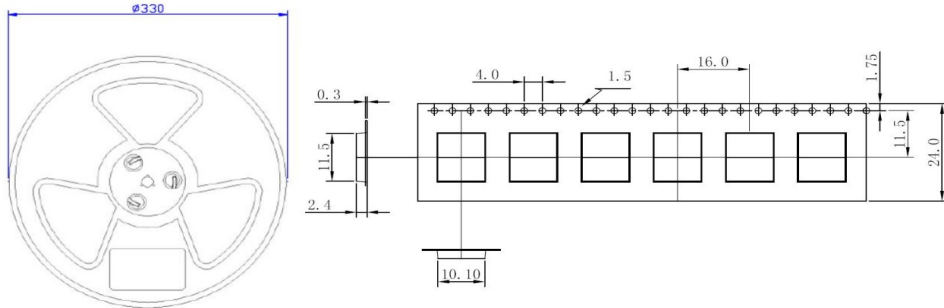


Figure 14: Tape and Reel Specifications

Unit: mm

Quantity per reel: 1500pcs

Length per reel: 16m



Figure 15: Tape and Reel Specifications

| Model Name | MOQ for MP | Minimum Package: 1000pcs |
|------------|------------|--|
| NLE101-BA | 1500pcs | Size: 365mm × 350mm × 53mm N.W: 1.3kg G.W: 1.5kg |

7 Appendix References

| Abbreviation | Description |
|--------------|--|
| AGNSS | Assisted Global navigation satellite system |
| DGPS | Differential GPS |
| ESD | Electrostatic Discharge |
| GPS | Global Positioning System |
| GNSS | Global Navigation Satellite System |
| GGA | GNSS Fix Data |
| GLL | Geographic Position – Latitude/Longitude |
| GLONASS | Global Navigation Satellite System |
| GSA | GNSS DOP and Active Satellites |
| GSV | GNSS Satellites in View |
| HDOP | Horizontal Dilution of Precision |
| I/O | Input/Output |
| Kbps | Kilo Bits Per Second |
| LNA | Low Noise Amplifier |
| MSAS | Multi-Functional Satellite Augmentation System |
| MOQ | Minimum Order Quantity |
| NMEA | National Marine Electronics Association |
| PDOP | Position Dilution of Precision |
| PPS | Pulse Per Second |
| PRN | Pseudo Random Noise Code |
| QZSS | Quasi-Zenith Satellite System |
| RHCP | Right Hand Circular Polarization |
| RMC | Recommended Minimum Specific GNSS Data |
| SBAS | Satellite-based Augmentation System |
| SAW | Surface Acoustic Wave |
| SPDT | Single-Pole Double-Throw |
| TTF | Time To First Fix |

| Description | Description |
|--------------------|--|
| UART | Universal Asynchronous Receiver & Transmitter |
| VDOP | Vertical Dilution of Precision |
| VTG | Course over Ground and Ground Speed, Horizontal Course and Horizontal Velocity |
| WAAS | Wide Area Augmentation System |
| I _{nom} | Nominal Current |
| I _{max} | Maximum Load Current |
| VOL _{min} | Minimum Output Low Level Voltage Value |
| V _{max} | Maximum Voltage Value |
| V _{nom} | Nominal Voltage Value |
| V _{min} | Minimum Voltage Value |
| VIH _{max} | Maximum Input High Level Voltage Value |
| VIH _{min} | Minimum Input High Level Voltage Value |
| VIL _{max} | Maximum Input Low Level Voltage Value |
| VIL _{min} | Minimum Input Low Level Voltage Value |
| VI _{max} | Absolute Maximum Input Voltage Value |
| VI _{min} | Absolute Minimum Input Voltage Value |
| VOH _{max} | Maximum Output High Level Voltage Value |
| VOH _{min} | Minimum Output High Level Voltage Value |
| VOL _{max} | Maximum Output Low Level Voltage Value |