LC29H (EA) Moving Base Application Note

GNSS Module Series

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The following safety precautions must be observed during all phases of operation, such as usage, service, or repair of any terminal or mobile incorporating the module. Manufacturers of the terminal should notify users and operating personnel of the following safety information by incorporating these guidelines into all product manuals. Otherwise, Quectel assumes no liability for customers' failure to comply with these precautions.

	Ensure that the product may be used in the country and the required environment, as well as that it conforms to the local safety and environmental regulations.
	Keep away from explosive and flammable materials. The use of electronic products in extreme power supply conditions and locations with potentially explosive atmospheres may cause fire and explosion accidents.
	The product must be powered by a stable voltage source, and the wiring shall conform to security precautions and fire prevention regulations.
	Proper ESD handling procedures must be followed throughout the mounting, handling and operation of any devices and equipment that incorporate the module to avoid ESD damages.

About the Document

Document Information	
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Revision History

Version	Date	Description
-	2023-03-30	Creation of the document
1.0	2023-07-20	First official release
1.1	2024-05-11	1. Updated pin functions of LC29H (EA) (*Table 1*). 2. Added moving base operation guide (*Chapter 8*).

Contents

Table Index

Figure Index

1 Introduction

Quectel LC29H (EA) supports multi-band RTK technology, which can output high precision position, heading and attitude information. RTK technology includes **the rover** and **the base**. The base sends a continuous differential correction data stream to the rover via a communication link. In standard RTK mode, the base remains static in a known position, while the rover can move. However, in Moving Base mode, both the base and the rover can move, making it suitable for use in drones, mowers and vehicles.

Quectel LC29H (EA) module can be implemented in two configurations:

● Single unit configuration (one Quectel LC29H (EA) module for general applications).
● Dual unit configuration (two Quectel LC29H (EA) modules for Moving Base application). To enable the Moving Base function, both two LC29H (EA) modules must be installed on the same carrier platform.

This document presents the software and hardware designs of the two LC29H (EA) modules in the Moving Base application. The terms "base", "rover", "baseline", and "heading" are used to describe the Moving Base function.

● **Base:** Receiver that transmits the differential correction data stream.
● **Rover:** Receiver that receives the differential correction data stream.
● **Baseline:** Vector connecting the base antenna to the rover antenna. The LC29H (EA) Moving Base function supports baseline lengths varying from 0.2 m to 5 m.
● **Heading:** Angle from true north to baseline measured in a clockwise direction.

2 Hardware Design

In a dual unit configuration for the Moving Base application, one LC29H (EA) operates as the base and the other as the rover. The base and rover can be distinguished in the connection diagram. The base communicates with the MCU via its UART1, and the rover communicates with the UART2 on base via its UART1. *Figure 1: Schematic Diagram of Connection Between Base and Rover* illustrates the specific connection configuration.

The functions of pins 17–19 in a single unit configuration of LC29H (EA) are different from those in the dual unit configuration for the Moving Base application.

Table 1: Pin Function Differences for LC29H (EA) in Different Applications

Pin No.	Pin Function	
	General Applications (Single Unit)	**Moving Base Application (Dual Unit)**
17	RESERVED	RESET_CTL: Controls the RESET_N of the rover
18	RESERVED	TXD2: UART2 transmits data
19	RESERVED	RXD2: UART2 receives data
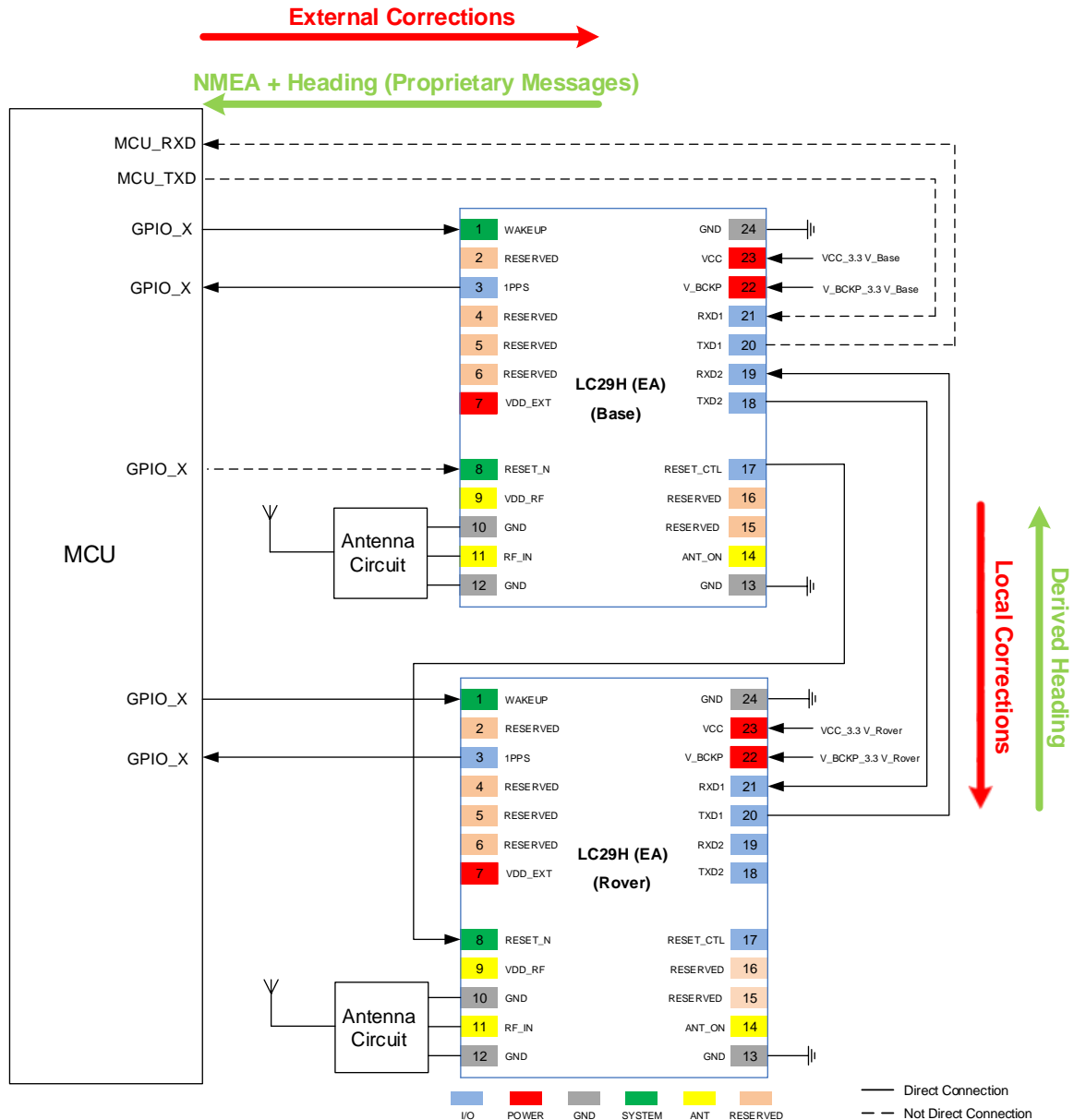
Figure 1: Schematic Diagram of Connection Between Base and Rover

- External Corrections: External corrections can be obtained from the VRS provider. The MCU sends the RTCM corrections from the VRS to the base, enabling it to perform the RTK positioning function.
- Local Corrections: Local corrections are provided by the base and transmitted via its UART2 interface to the rover to calculate heading information.
- Derived Heading: Heading information is calculated by the rover and sent back to the base, and finally output by the base.
- NMEA + Heading (Proprietary Messages): Positioning data (standard NMEA messages) and heading information (proprietary NMEA messages) are sent from the base to the MCU. The connection between the MCU and the base is required.
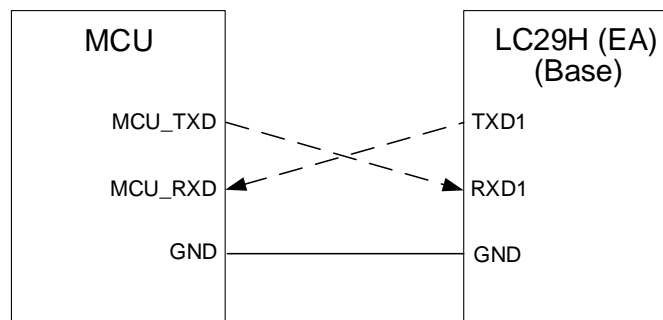
> **NOTE**
>
> 1. The modules operate at an I/O voltage of 2.8 V. If the I/O voltage of the MCU differs from this value, a level-shifting circuit must be used.
> 2. It is recommended to use an OC drive circuit for the RESET_N pin of base. For more information, see *Chapter 2.1.3 RESET_N*.
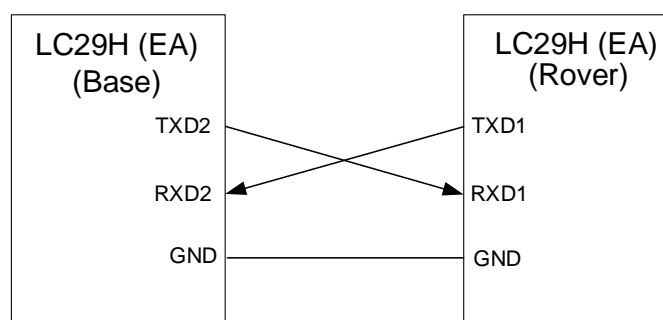
2.1. Application Interfaces

2.1.1. UART Interfaces

The UART1 on the base is connected to MCU, as shown below:

Figure 2: Reference Design of UART1 Interface on Base

The UART1 on the rover is connected to the UART2 on the base, as shown below:

Figure 3: Reference Design of UART1 Interface on Rover

2.1.2. WAKEUP

For power-sensitive applications, the module supports a Backup mode to reduce power consumption. Pull the WAKEUP pin high for at least 10 ms to wake up the module from the Backup mode. Keep this pin open or pulled low before entering the Backup mode. The WAKEUP pin is pulled down internally and it belongs to backup domain. If unused, leave the pin N/C.

The base can synchronously transmit the commands received from the MCU to the rover via UART interfaces. Thus, the MCU sends commands to the base via UART interfaces to enable the base and the rover enter the Backup mode at the same time.

- ● Enter the Backup mode:
1. Send **$PAIR650** to shut down internal main power supply in sequence. For more information about the relevant software command, see *document [1] protocol specification*.
2. Cut off the power supply to the VCC pin and keep the V_BCKP pin powered.

- ● Exit the Backup mode:
1. Restore VCC.
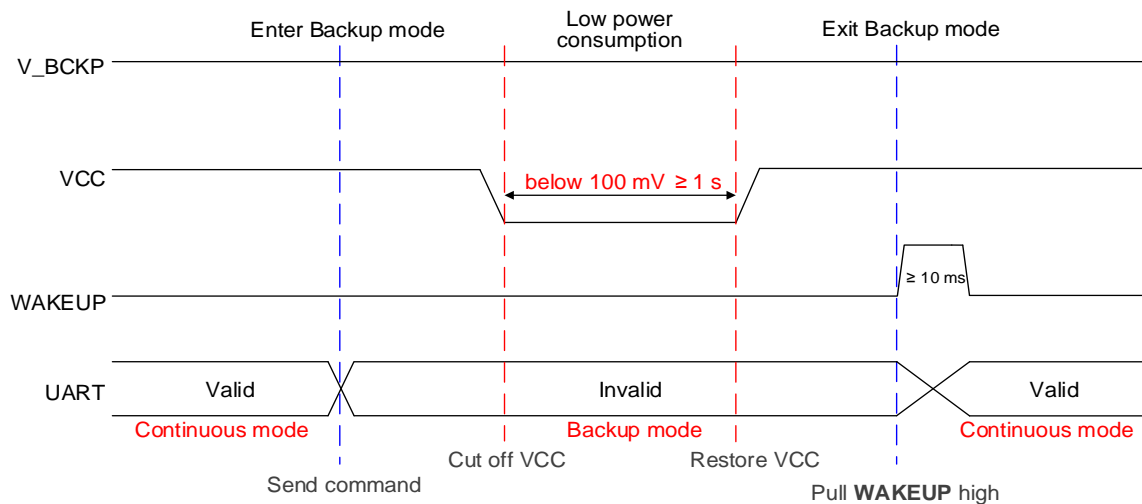2. Pull the WAKEUP pin high for at least 10 ms.


Figure 4: Enter/Exit Backup Mode Sequence

> **NOTE**
>
> The WAKEUP pin is pulled down internally with a 47 kΩ resistor, and the GPIO of MCU connected to the WAKEUP pin needs to support push-pull output.

2.1.3. RESET_N

RESET_N is an input pin. The module can be reset by driving the RESET_N pin low for at least 100 ms and then releasing it.

For the base, the RESET_N pin is connected to the GPIO control pin of the MCU. An OC driver circuit as shown below is recommended to control the RESET_N pin.
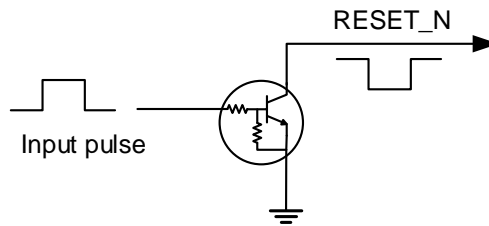
Figure 5: Reference OC Circuit for Base Reset

For the rover, the RESET_N pin is connected in series with the RESET_CTL pin of the base through a 0 Ω resistor for upgrading.

2.1.4. RESET_CTL

For the base, the RESET_CTL is used to control the RESET_N of the rover for upgrading. The RESET_N pin of the base is pulled down via the GPIO of the MCU to complete the base's upgrading, and then the RESET_CTL is pulled down automatically so that the RESET_N pin of the rover is also pulled down, allowing the rover's upgrading to be completed. The default state is 2.8 V high level, active low.

For the rover, leave the pin floating.

3 System Construction

This chapter provides system-level recommendations for using the base and rover to develop high-performance Moving Base solutions.

3.1. Precautions for GNSS Antenna Mounting

3.1.1. Antenna Mounting Method

In practical applications, it is important to fix GNSS antennas during mounting, as shown in the following figure. The vector from the base antenna to the rover antenna is called the baseline. Its minimum length is 0.2 m.
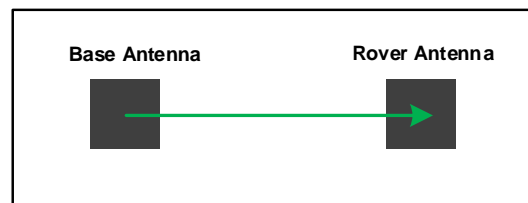
Figure 6: Antenna Mounting Top View

If the orientation test is carried out on the same device, ensure to use two identical GNSS antennas and place them on the same reference ground plane (with the same ground plane size, shape, angle of the horizontal plane). However, the use of a helix antenna does not require reference ground plane.
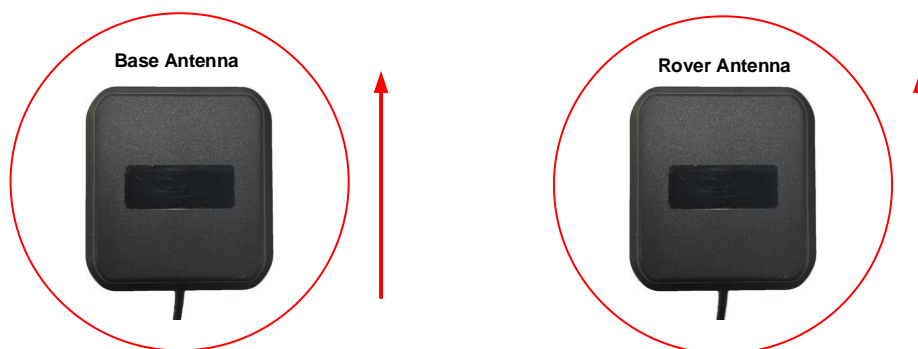
Figure 7: Antenna Mounting (Same Reference Ground Plane)

3.1.2. Recommended Mounting for GNSS Antennas

The recommended mounting for GNSS antennas depends on the application. For a drone, place the GNSS antennas on top of the drone to avoid interference from crowded structures and motors, as shown in the figure below:

Figure 8: Antenna Mounting – Drone

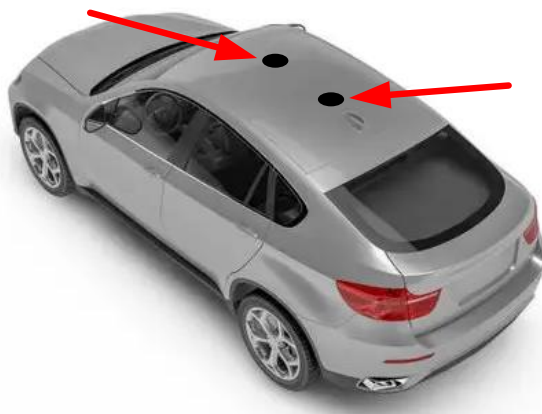For mowers, apply the GNSS antennas in an open, unstructured environment.

Figure 9: Antenna Mounting – Mower

For a vehicle, apply GNSS antennas in the same plane and unstructured environment.

Figure 10: Antenna Mounting – Vehicle

> **NOTE**
>
> For recommended antenna selection and design, see *document [2] GNSS antenna selection guidance* or contact Quectel Technical Support (support@quectel.com).

4 Reference Frame

4.1. Local Cartesian Coordinate System (ENU)

Local Cartesian coordinate system is a right-handed rectangular coordinate system where the coordinate origin is located at the station center. In the Moving Base application, the phase center of the base antenna is considered the station center, and the heading and pitch angle outputs of rover are referenced to this coordinate system.
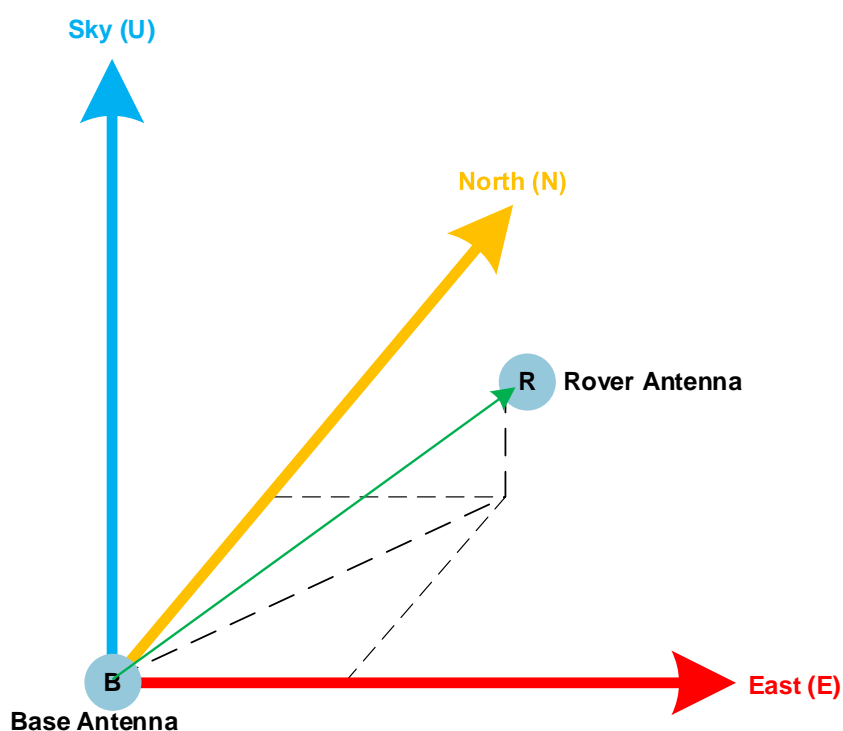

Figure 11: Local Cartesian Coordinate System

5 Angle Definition

This chapter provides the definitions of the heading and pitch angles in the LC29H (EA) Moving Base applications.
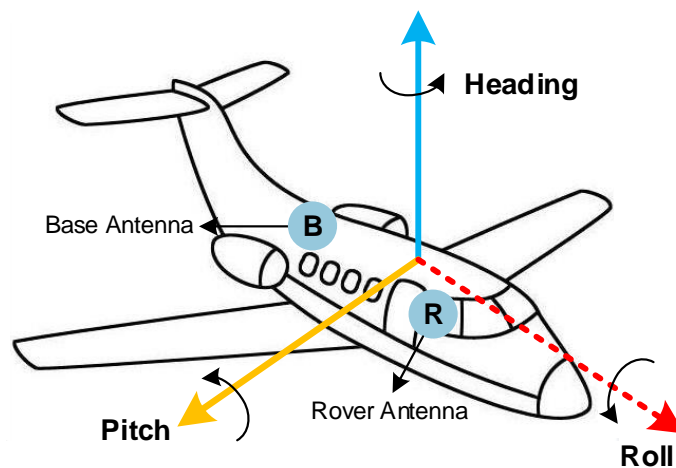
Figure 12: Heading and Pitch Angles

> **NOTE**
>
> Roll angle is not supported by the LC29H (EA) Moving Base applications.

5.1. Heading

The heading angle in the dual antenna setup is referenced to the local Cartesian coordinate system (ENU). It is defined as the angle between the projection of the baseline vector (i.e., the vector connecting the base antenna and rover antenna) on the horizontal plane and the true north (i.e., N-axis) with the effective range of [0,360). For details about the heading angle output, see *Chapter 7.2 PQTMTAR* .

The heading angle (with north and east directions as reference planes) is illustrated below:
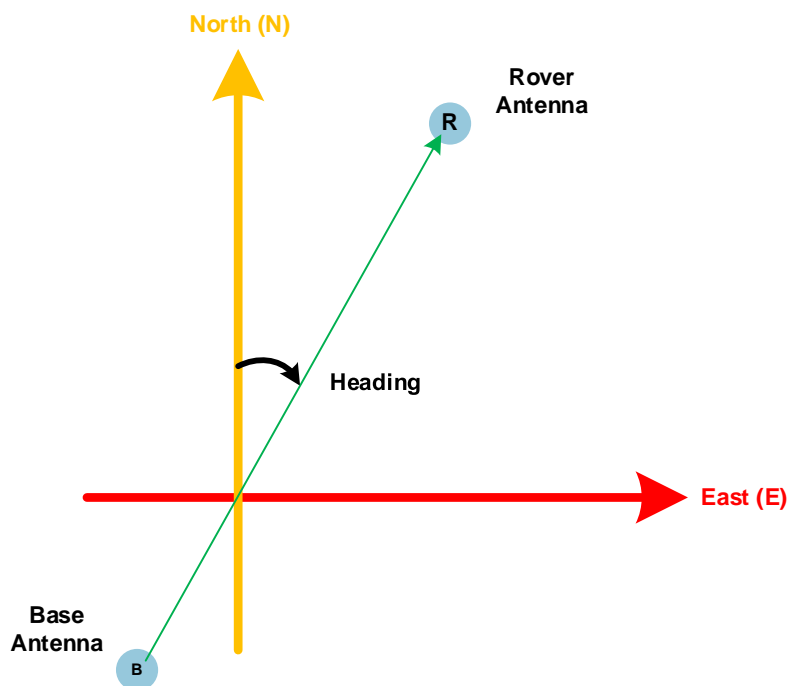
Figure 13: Heading Angle

> **NOTE**
>
> This heading angle is derived using dual antenna orientation, and it is different from the heading angle output in **RMC** message.

5.2. Pitch

The pitch angle references local Cartesian coordinate system (ENU). It is the angle between the baseline vector (base antenna to rover antenna) and the horizontal plane, with a range of [-90,+90]. Positive values correspond to upward pitch, while negative values correspond to downward pitch. For details about the pitch angle output, see *Chapter 7.2 PQTMTAR*.

The pitch angle is illustrated below:
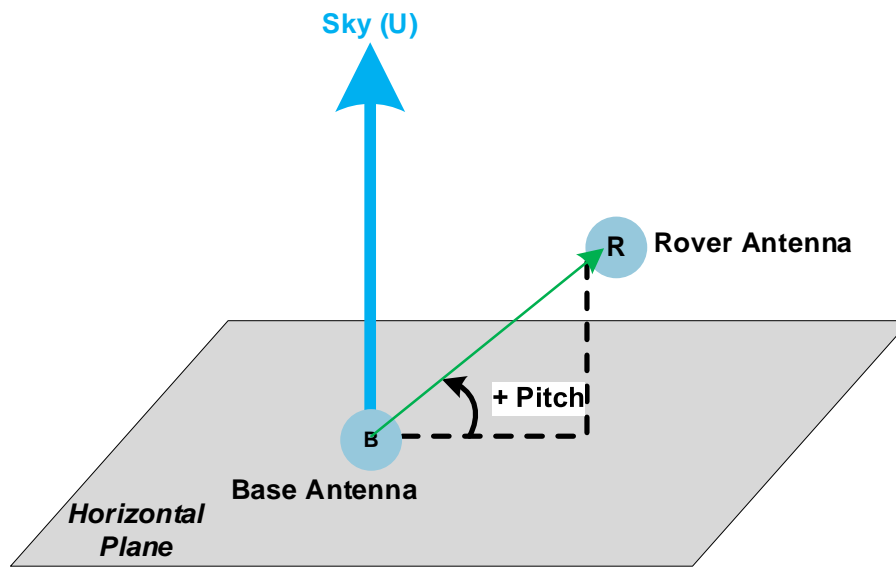
Figure 14: Pitch Angle

6 Configuration

As long as the two LC29H (EA) modules are properly connected as shown in *Figure 1: Schematic Diagram of Connection Between Base and Rover*, the system automatically identifies them as rover or base and no special configuration is required for the Moving Base application.

The heading and attitude information are provided by **$PQTMTAR** message on the rover. Use **$PQTMCFGMSGRATE** command (see *Chapter 7.1 PQTMCFGMSGRATE* for details) to enable the output of **$PQTMTAR** message (see *Chapter 7.2 PQTMTAR* for details).

Example:

//Enable **$PQTMTAR** message:
$PQTMCFGMSGRATE,W,PQTMTAR,1,1*09
$PQTMCFGMSGRATE,OK*29

7 Moving Base Related Messages

7.1. PQTMCFGMSGRATE

Sets/gets the message output rate on the current port.

Type:

Set/Get

Synopsis:

```
//Set:
$PQTMCFGMSGRATE,W,<MsgName>,<Rate>,<MsgVer>*<Checksum><CR><LF>
//Get:
$PQTMCFGMSGRATE,R,<MsgName>,<MsgVer>*<Checksum><CR><LF>
```

Parameter:

Field	Format	Unit	Description
<MsgName>	String	-	Configuration message name.
<Rate>	Numeric	-	Message output rate. 0 = Output disabled. 1 = Output once every position fix.
<MsgVer>	Numeric	-	Message version.

Result:

- If successful, the module returns:

```
//Response to Set command:
$PQTMCFGMSGRATE,OK*<Checksum><CR><LF>
//Response to Get command:
$PQTMCFGMSGRATE,OK,<MsgName>,<Rate>,<MsgVer>*<Checksum><CR><LF>
```

- If failed, the module returns:

$PQTMCFGMSGRATE,ERROR,<ErrCode>*<Checksum><CR><LF>

For details about **<ErrCode>**, see *Table 2: Error Codes*.

Table 2: Error Codes

Field	Format	Unit	Description
<ErrCode>	Numeric	-	Error code. 1 = Invaild parameters. 2 = Execution failed.

Example:

//Enable **$PQTMTAR** message:
$PQTMCFGMSGRATE,W,PQTMTAR,1,1*09
$PQTMCFGMSGRATE,OK*29

7.2. PQTMTAR

Outputs the UTC and attitude of the module (rover). This message can be enabled or disabled by **$PQTMCFGMSGRATE** command.

Type:

Output

Synopsis:

$PQTMTAR,<MsgVer>,<Time>,<Quality>,<Res1>,<Length>,<Pitch>,<Res2>,<Heading>,<Acc_Pitch>,<Res3>,<Acc_Heading>,<UsedSV>*<Checksum><CR><LF>

Parameter:

Field	Format	Unit	Description
<MsgVer>	Numeric	-	Message version. 1 = Version 1 (Always 1 for this message version.)
<Time>	hhmmss.sss	-	UTC time. hh: Hours (00–23) mm: Minutes (00–59) ss: Seconds (00–59)

Field	Format	Unit	Description
			sss: Decimal fraction of seconds
<Quality>	Numeric	-	GNSS quality indicator: 0 = Fix not available or invalid 1 = GPS SPS mode 2 = Differential GPS, SPS mode 4 = Real Time Kinematic (RTK) mode. System used in RTK mode with fixed integers. 5 = Float RTK mode. Satellite system used in RTK mode, floating integers.
<Res1>	-	-	Reserved. Always null.
<Length>	Numeric	Meter	Baseline length.
<Pitch>	Numeric	Degree	Pitch angle. Range: -90.000000 to 90.000000. Note that this field is null in case of an invalid value.
<Res2>	Numeric	Degree	Reserved. Always null.
<Heading>	Numeric	Degree	Heading angle. Range: 0.000000 to 359.999999. Note that this field is null in case of an invalid value.
<Acc_Pitch>	Numeric	Degree	Vehicle pitch accuracy. Note that this field is null in case of an invalid value.
<Res3>	Numeric	Degree	Reserved. Always null.
<Acc_Heading>	Numeric	Degree	Vehicle heading accuracy. Note that this field is null in case of an invalid value.
<UsedSV>	Numeric	-	Number of satellites used in heading solution.

Example:

$PQTMTAR,1,165034.000,4,,0.860,1.124780,,50.968541,0.254125,,0.012547,21*59

8 Moving Base Operation Guide

8.1. Antenna Installation

This chapter explains how to install the GNSS antennas for accurate Moving Base operation by using antenna installation on Quectel's test vehicle as an example.

Requirements:

● Two identical GNSS antennas compatible with LC29H (EA) which support the same GNSS constellations.

● Antennas must be firmly and stably mounted on the same reference plane. In the example of the Quectel's test vehicle illustrated below in *Figure 15: Antenna Installation on Test Vehicle*, two identical antennas are securely affixed to the same mounting bar to ensure that they are on the same reference plane. A rigid connection between the mounting bar and the vehicle is required for antenna stability.

Positioning:

● Place the base antenna at the rear of the vehicle and the rover antenna at the front. In this case, the baseline direction (vector connecting the base antenna to the rover antenna) is consistent with the direction of vehicle travel, ensuring the heading angle output by the module is the angle between the direction of the vehicle's front and true north.


Figure 15: Antenna Installation on Test Vehicle

8.2. How to Use the Module

This chapter explains how to use the Moving Base function of the module by using Quectel GNSS-MODULE-EVB as an example and view the output results through the QGNSS tool. For detailed information on the EVB and QGNSS, see *documents [3] EVB user guide* and *[4] QGNSS user guide*.

Step 1: Prepare the hardware, then power on the EVB.

 a. Short-circuit the pins of J101 and J103 respectively after mounting the modules.
 b. Connect the antennas to the module. For details about the connection, refer to *Figure 16: Moving Base Connection Diagram*.
 c. Connect the EVB's GNSS-USB interface (J0506) to the PC using a USB Type-C cable. Then toggle the power switch (S0503) to the "ON" position.
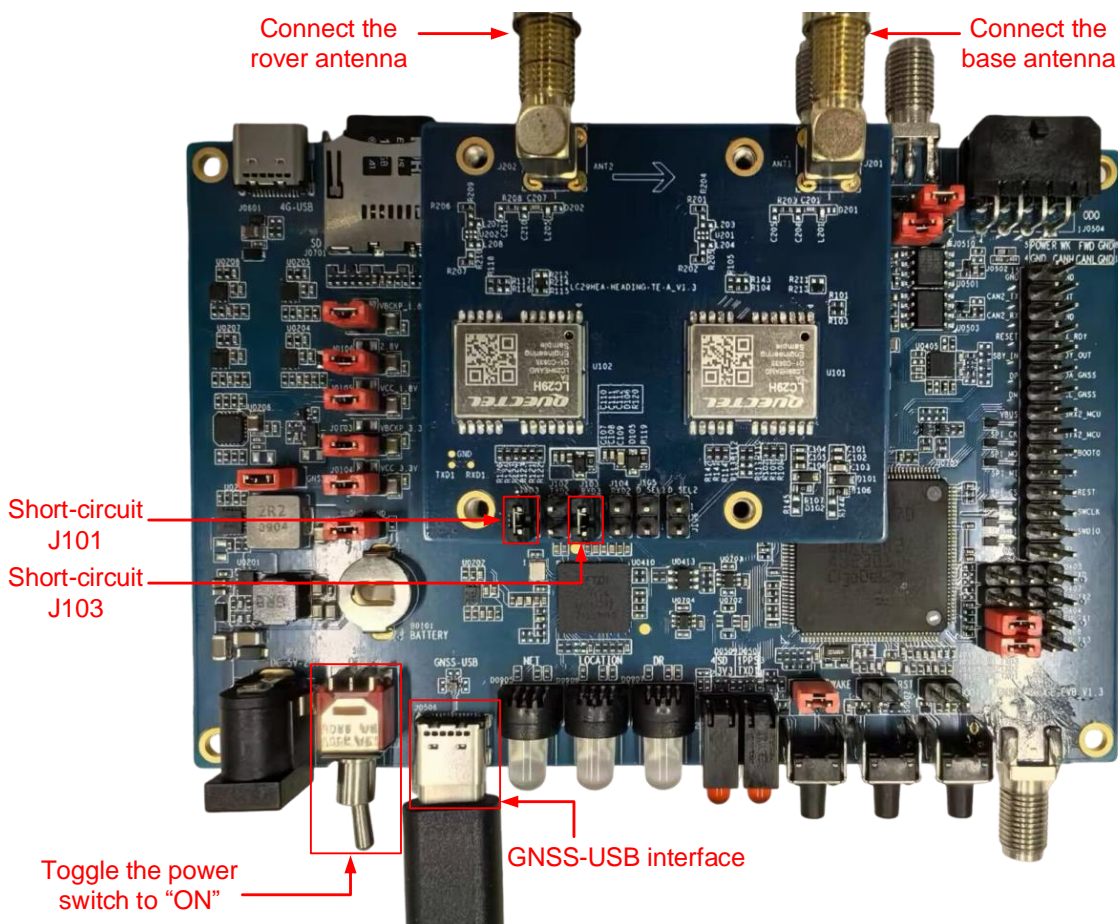
**Figure 16: Moving Base Connection Diagram**

Step 2: Check the connection. If the connection between the EVB and the PC is normal, four random but consecutive port numbers appear in the Device Manager, as shown in *Figure 17: Device Manager*.
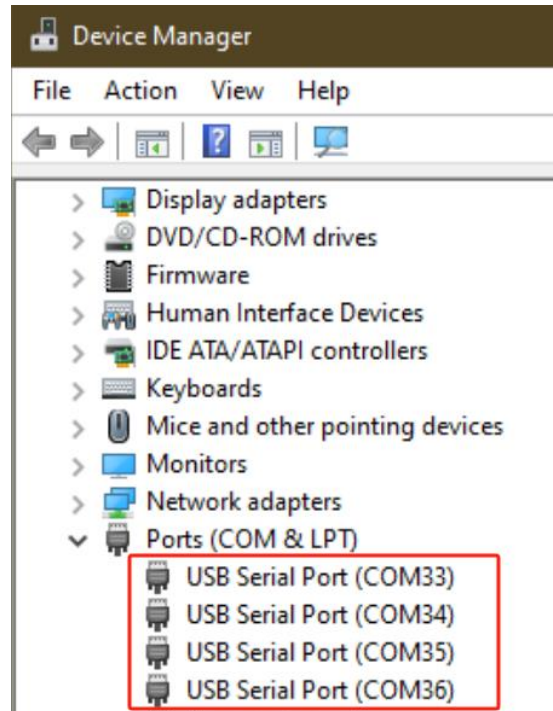
Figure 17: Device Manager

Step 3: Configure the QGNSS tool, as shown in *Figure 18: Device Information Window*.

    a.   Open the QGNSS tool and click   to enter the "**Device Information**" window.

    b.   Select the module model to be connected.

    c.   Select the COM port with the lowest number among the available four COM ports.

    d.   Select the baud rate corresponding to the module UART (that is, using the default baud rate 460800 bps).

    e.   Click "**OK**".
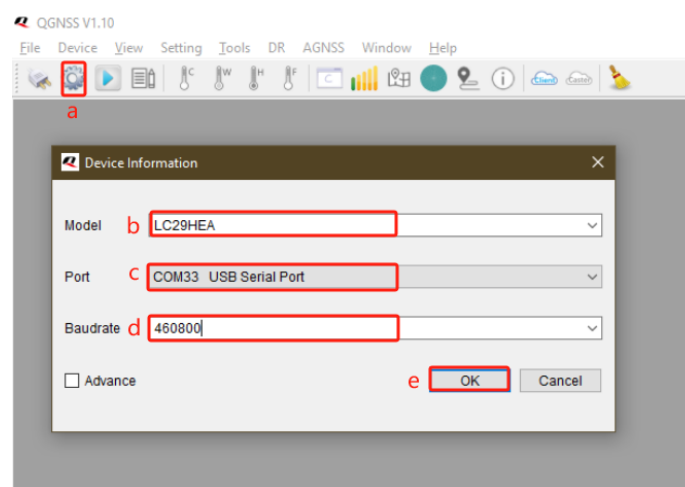
Figure 18: Device Information Window

Step 4: From the "**Tools**" drop-down menu, select the "**Command Console**" to open the "**Command console**" window, as shown in *Figure 19: Open Command Console Window*.
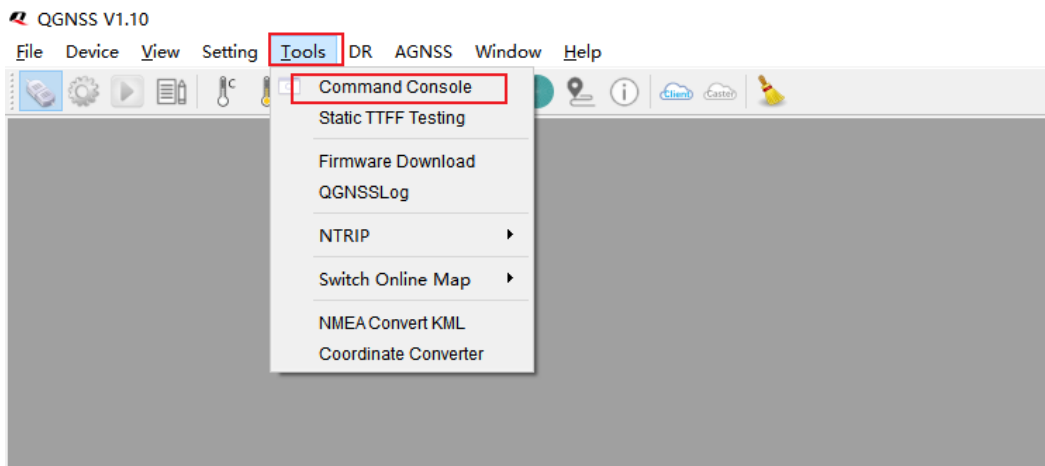
Figure 19: Open Command Console Window

Step 5: Enable Moving Base function. Enter the "**$PQTMCFGMSGRATE,W,PQTMTAR,1,1*09**" in the command field. After clicking "**Send**", the module returns "**$PQTMCFGMSGRATE,OK*29**" and starts to output the **$PQTMTAR** messages, indicating that the Moving Base functions normally, as shown in *Figure 20: Configure Output of $PQTMTAR Message*.
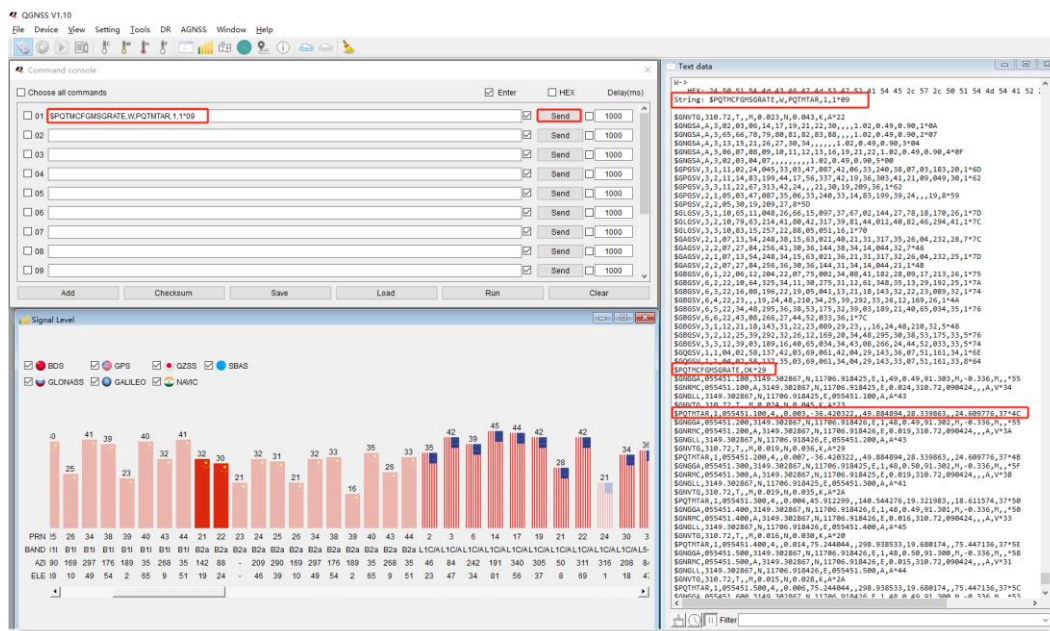
Figure 20: Configure Output of $PQTMTAR Message

9 Appendix A References

Table 3: Related Documents

Document Name
[1] Quectel_LC29H_Series&LC79H(AL)_GNSS_Proocol_Specification
[2] Quectel_GNSS_Antenna_Selection_Guidance
[3] Quectel_GNSS_Module_EVB_User_Guide
[4] Quectel_QGNSS_User_Guide

Table 4: Terms and Abbreviations

Abbreviation	Description
ENU	East North Up
EVB	Evaluation Board
GNSS	Global Navigation Satellite System
I/O	Input/Output
MCU	Microcontroller Unit/Microprogrammed Control Unit
PC	Personal Computer
RF	Radio Frequency
RMC	Recommended Minimum Specific GNSS Data
RTK	Real-Time Kinematic
RXD	Receive Data (Pin)
TXD	Transmit Data (Pin)
UART	Universal Asynchronous Receiver/Transmitter

Abbreviation	Description
UTC	Coordinated Universal Time
VRS	Virtual Reference Station

10 Appendix B Special Characters

Table 5: Special Characters

Special Character	Definition
<CR>	Carriage return character.
<LF>	Line feed character.
<...>	Parameter name. Angle brackets do not appear in the message.
[...]	Optional field of a message. Square brackets do not appear in the message.
{…}	Repeated field of a message. Curly brackets do not appear in the message.
Underline	Default setting of a parameter.