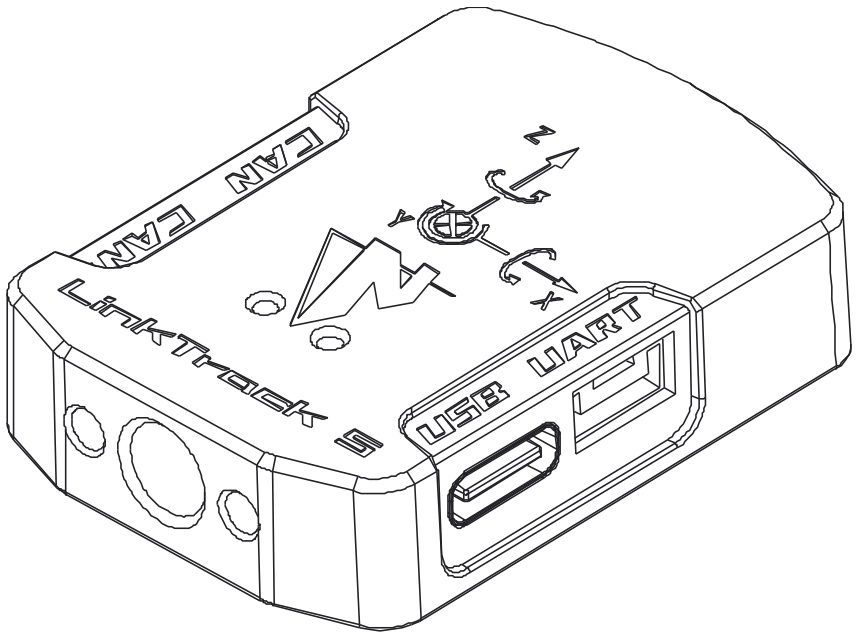
LinkTrack User Manual V2.1



Language: English
Firmware: V4.0.1
NLink: V1.3
NAssistant: V4.0.2
Product Series: LinkTrack S, LinkTrack P, LinkTrack SS, LinkTrack PS

Content

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1 Introduction

This document mainly describes how to use the LinkTrack system and what you need to pay attention to during use. You also need to read the following documents:

- LinkTrack Datasheet
- Nlink

Please download the relevant documents on the official website: www.nooploop.com

2 Basic Introduction

2.1 Power Supply

LinkTrack supports a variety of power supply methods, which are generally related to the scene, operation mode and role used. The common power supply devices are portable battery, adapter, lithium battery and so on. It should be noted that the length of the line directly supplying power to the LinkTrack is not recommended to exceed 3 meters to ensure that the power supply is clean and reliable, otherwise it is recommended to do power denoising processing.

Table 1: Description of power supply mode

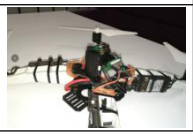
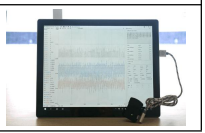
Power Supply Equipment	Power bank	Adapter	Battery	Charged Carrier	Terminal
Description	Mobile power supply, etc.	Mobile phone charging point (5V standard voltage) and so on.	Such as 1 S lithium battery (the standard voltage of general lithium battery is 3.7V, the full voltage is 4.2V).	Mobile devices that need to be located, such as drones, robots, main control boards and so on.	Notebooks, tablets, mobile phones and other devices.
Sample Picture					

Table 2: Role and power supply mode

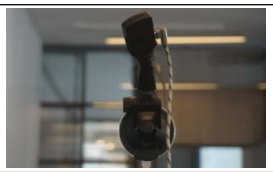
Role	**Recommended Power Supply Mode**
Tag	Charged carrier, battery
Anchor	Power bank, adapter, terminal
CONSOLE	Terminal
Note	Charged carrier, battery
Master, slave	Charged carrier, terminal

2.2 Node Installation

For LTS and LTP products with shell, you can refer to Table 3 to choose the installation method. For LTSS and LTPS hardware module products, generally choose to use M2 screw installation.

Table 3: Schematic diagram of node installation

Scene	**Description**	**Sample picture**
Tripod Installation	Use 1/4-20 screw holes to install on the tripod, tripod is generally placed on the horizontal ground. It is generally used for ANCHOR installation.	

Sucker Installation	Installed on the sucker by using 1/4-20 screw hole, and the sucker is generally adsorbed on glass, walls, automobiles and other relatively smooth surfaces. It is generally used for tag and anchor installation.	
Screw hole Installation	Installed on the carrier by using two M3 screw holes. Generally used for tag, node, master, slave installation.	
Free Connection	Connect directly through a communication interface such as a Type-C USB data line. It is generally used for CONSOLE, master and slave installation.	

2.3 About the Antenna

The orientation of the antenna mainly affects the ranging, positioning and communication distance. LP Mode is related to ranging, positioning and communication, so it has higher requirements for antenna orientation； DR Mode is related to ranging and communication, followed by the requirement of antenna orientation. DT Mode is only concerned with communication, and the requirement of antenna orientation is minimal. Optimizing the orientation of the antenna is an effective way to improve the distance of ranging, positioning and communication.

Although the standard antennas of LT series products are omni-directional antennas, it is difficult to have a completely ideal omni-directional antenna (the antenna pattern gain is consistent with each performance). Therefore, the antenna orientation is often optimized in the actual use process to further improve the use effect, .

For LT series antennas, the omni-directivity of XOY plane is better, the omni-directivity of Z-axis is worse, and the performance of Z-axis negative direction is the worst. Therefore, the principle of adjusting the antenna is to orient the area with the best performance of the node antenna to the direction that needs to communicate with other nodes as much as possible. In order to highlight the antenna, the node is simplified to a long strip antenna, and the end with a black block is in the positive direction of the Z axis of the node antenna. Table 4,Table 5 and

Table 6 show the diagrams of antenna orientation in common situations. Among them, five stars represent the best plan.

Table 4: Comparison of the orientation of the antenna between ANCHOR and TAG minimum component unit
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Table 5: Comparison of antenna orientation when the anchor and the tag are in the same plane

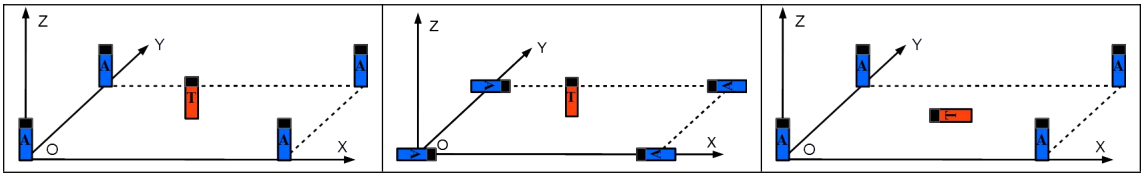

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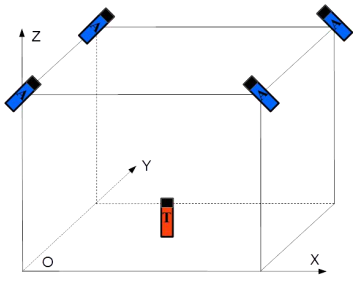
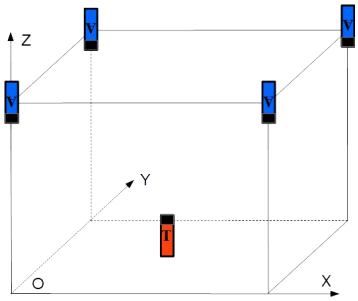
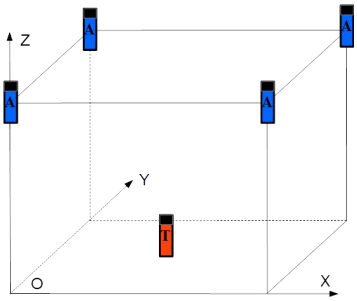
Table 6: Comparison of antenna orientation when the anchor and the tag are not in the same plane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For those occasions where the positioning effect needs to be further improved, the antenna direction of some products can be optimized according to the following operations. Generally, only products that use onboard antennas (LTS, LTSS, LTPS) do this optimization step when running under LP Mode. For LTP, the antenna is a rod antenna, so there is no need to do this optimization step.

Take LTS as an example, its antenna is a built-in board antenna, and the effect of the antenna on the front (negative Y-axis direction) is better than that on the back (positive Y-axis direction) and side (positive X-axis direction, negative X-axis direction). In Fig. 1, the left picture shows the recommended installation method for the anchor under LP Mode, and the figure on the right shows the non-recommended installation method.

Fig. 1: The physical picture of the installation direction of the LTS anchor antenna. Left: antenna facing inward； right: antenna facing outward

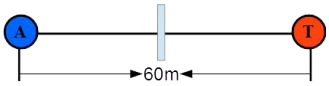
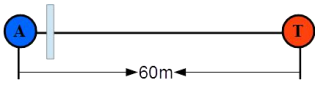
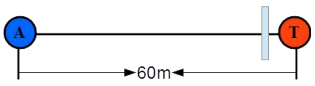
2. 4 About the Obstruction

In communication, occlusion will attenuate the signal strength and reduce the communication distance； in positioning, occlusion will also increase the positioning error. Therefore, occlusion has a great influence on LP and DR Mode, but relatively little effect on DT Mode. The influence of obstacle occlusion on positioning depends on the distance, size, material and other factors between the obstacle and the Node.

Long strip objects such as telephone poles, trees, human bodies, etc.： Take LP Mode as an example, the influence of these occlusion objects on positioning depends on the distance between the tag and the ANCHOR. For example, when the distance between the anchor and the tag is 60 meters, the occlusion object between the tag and the anchor has little influence on the positioning, and when the occlusion object is only 1 meter close to the anchor, the influence is great, as shown in Table 7.

Table 7: The influence of the distance from the occlusion object to the TAG and the ANCHOR on

positioning

Occasion	When the occlusion object is between the TAG and the ANCHOR	When the occlusion object is close to the ANCHOR	When the occlusion object is close to the TAG
Diagram			
Influence	Have less effect	Have a great effect	Have a great effect

Solid wall：Generally, LTS can pass through one solid wall, and LTP can pass through 2 or 3 solid walls. The communication distance will be shorter after passing through the wall, and the positioning error will increase about 30cm each time it passes through a wall, which is related to the thickness and material of the wall.

Glass wall：Generally, the glass which is not larger than the thickness of 3cm has little influence on the positioning accuracy and distance attenuation of UWB.

Steel plate, iron plate and other metals：The absorption of UWB electromagnetic wave is very serious, especially when it is close to the node, the electromagnetic wave can not be transmitted to the other end of the shield, resulting in the inability to locate.

Cardboard, wood, plastic, etc.：Generally, this kind of occlusion object of 10cm thickness has little influence on the positioning accuracy, and the signal strength will attenuate to some extent.

2.5 DOP

DOP is a concept introduced in the omni-directional positioning system (GPS). Because the quality of the observation results is related to and has a great influence on the geometry between the measured satellite and the receiver, the error caused by the above calculation is called the strength and weakness of the accuracy. The better the distribution of satellites in the sky, the higher the positioning accuracy (the smaller the value, the higher the accuracy).

Therefore, under LP Mode, the positioning accuracy of TAG is related to DOP. Generally, 4 ANCHOR are used as the minimum positioning unit, which has the following rules:

Situation 1：When the ANCHOR is in the same plane and the ANCHOR is installed as a square, the DOP of the X and Y coordinates is the smallest, the precision is the highest, and the accuracy is close to the original distance； The farther away the TAG is from the ANCHOR plane (not more than the length of the side of the square), the higher the precision of the Z coordinate is. The closer to the ANCHOR plane, the worse the accuracy. When the TAG is in the ANCHOR plane, the Z coordinate can not be solved.

Situation 2：When the ANCHOR is in the same plane and the ANCHOR is installed as a rectangle: Generally speaking, the coordinate accuracy of the long side is high and close to that of the original distance, while the coordinate accuracy of the short side is low, and its accuracy is roughly as follows: "original distance accuracy / (long side / short side)". The precision of Z coordinate will decrease accordingly.

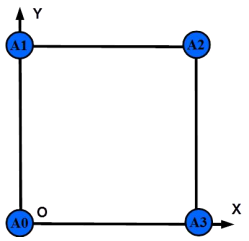
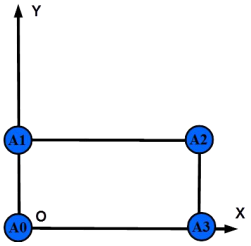
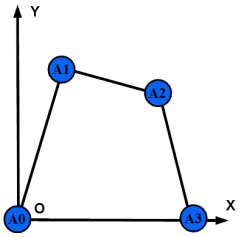
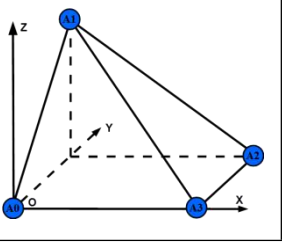
Situation 3：When the ANCHOR is in the same plane, but the quadrilateral surrounded by ANCHOR is irregular: the precision of the long side is high, the short side is low. And the closer to the square, the higher the accuracy of X, Y, Z coordinates.

Situation 4：When the ANCHOR is not in the same plane, the accuracy of X and Y will decrease,

while the accuracy of Z has little effect.

In general, it is recommended that the anchor be deployed in accordance with scenario 1. In practical use, the geometric aspect ratio of the ANCHOR is 2: 1, and the height difference of the anchor is about 0.5 meters, so there is no obvious location difference. Table 8 shows the corresponding diagrams of the above four situations.

Table 8: Schematic diagrams of different situations

Situation 1	Situation 2	Situation 3	Situation 4
			

3 LP Mode Quick Start

Under LP Mode, the positioning principle is similar to that of GPS, and the system running on LP Mode is the LPS system. The general occasions of, LP Mode applications are mainly divided into single-area positioning occasions, multi-area positioning occasions and other occasions.

LP Mode contains a variety of modes, the main difference is the capacity and update frequency of each role, so that it can adapt to the needs of different applications, and they are used in the same way. Specific indicators can be referred to [1].

In particular, in the system, when the coordinate value written to the anchor is -8388, it represents invalid coordinates.

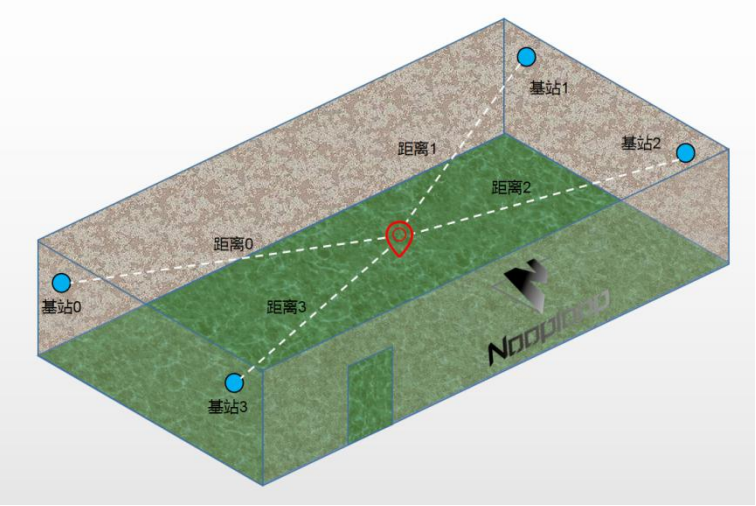


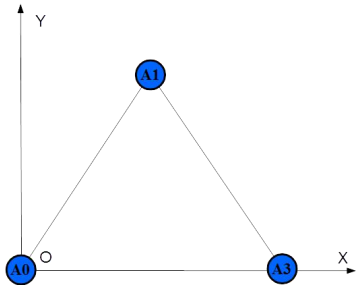
Fig. 2: LP Mode Typical application scenario

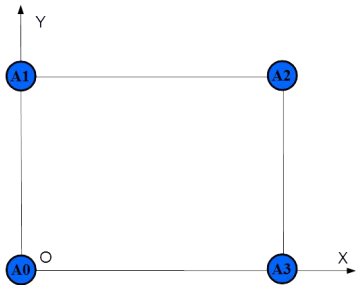
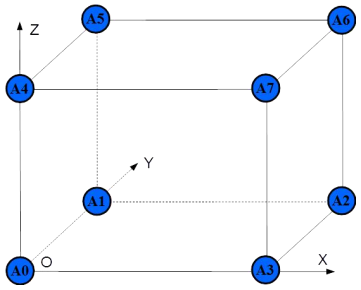
3.1 Single-regional Positioning Occasion

3.1.1 Introduction

The situation of single area mainly refers to the following three occasions, in order to easily describe and adapt to the related functions of the product (such as one-button calibration), it is agreed that A0 is the coordinate origin, the A0-A3 direction is the X-axis direction, and the installation sequence of the anchor is shown in Table 9.

Table 9: Description of single area location situation

Occasion	Description	Diagram
Occasion 1	The minimum positioning system, corresponding to MATH_MODEL1, 2. Given the distance between the tag and the three anchors, the positioning coordinates can be calculated through mathematical knowledge. It is impossible to distinguish whether the tag is above or below the anchor plane, and the system defaults to the solution that is lower than the Z axis of the anchor plane. In order to ensure the positioning effect, it is generally not recommended to use 3 anchors for positioning.	

Occasion 2	The most typical application, corresponding to MATH_MODEL2. The positioning effect of XY is slightly better than that of occasion 1 (about 2cm accuracy). The positioning effect of Z axis is similar to that of occasion 1. It is generally recommended that the ANCHOR be installed in the same plane to make higher accuracy of the two-dimensional positioning, and meet the condition of one-button calibration at the same time. A redundant ANCHOR is added to the minimum positioning system, which makes the positioning more reliable and the positioning performance is better. It is impossible to distinguish whether the tag is above or below the ANCHOR plane, and the system defaults to the solution that is lower than the Z axis of the ANCHOR plane. For example, when the Z coordinate of the A0~A3 is 0, the height of the tag output is "- 1" regardless of whether the tag is 1 meter above or below the ANCHOR plane.	
Occasion 3	Special 3D positioning situation, corresponding to MATH_MODEL1. It is suitable for situations where Z-axis coordinates need to be distinguished. The positioning effect of XY is similar to that of occasion 1. When near the plane of the ANCHOR, the effect of Z-axis is better than that of case 2. A0~A3 is required to be in the same plane (P0), A4~A7 in another plane (P1), and P1 is higher than P0.	

This document takes scenario 2 as an example, so it requires four ANCHOR. Assuming that there is one TAG to test, a total of five LinkTrack nodes are needed. The running mode is LP_MODE0, and the mathematical model is MATH_MODEL2.

3.1.2 Steps

1. **【Setting System】**If it is the first time to use the LinkTrack system or change the relevant Setting parameters, you need to make the relevant Setting. After the Setting is successful, the data are powered off and saved in each Node. Prepare 5 nodes (here, LTS is taken as an example), configure the Node as 4 anchors through NAssistant, which are denoted as A0, A1, A2, A3, and 1 TAG, denoted as T0. The A0~A3 is installed at four corners of a square with a side length of about 5m*5m according to the order of the anchor of the occasion.

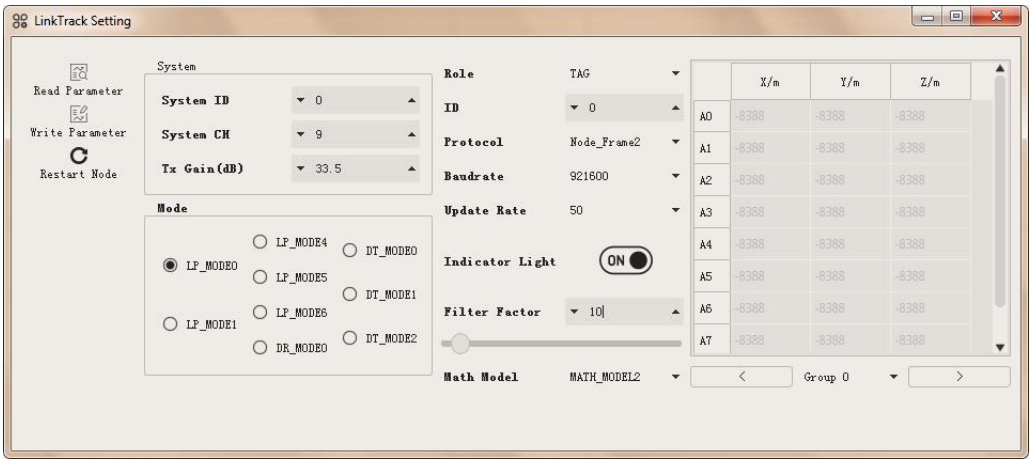


Fig. 3: T0 Setting diagram under LP_MODE0

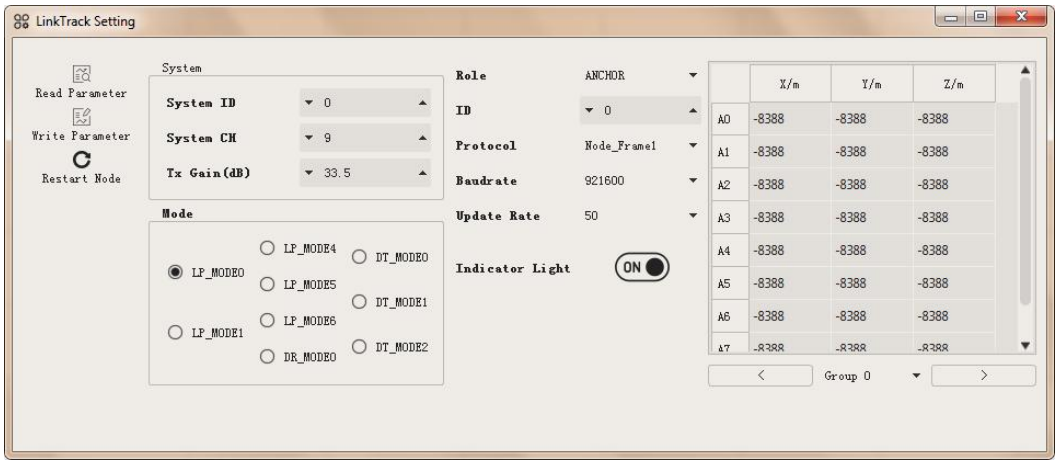


Fig. 4: A0 Setting diagram under LP_MODE0

System Parameter Setting： It is important to note that the System ID and CH must be guaranteed to be identical for all nodes in the same System. For example, in this example, the System ID is 0 and the system CH is 9. It should be noted that, System CH is related to the product model. The performance of LTS is better when System CH is 9, and the communication distance becomes very short at 7； LTP performs better when System CH is 2 and 3, and is poor at other values. For more information on the recommended Setting parameters for System CH, please see [1]. TX Gain is also generally configured to be consistent, and it is recommended that it be configured with a maximum of 33.5 when it is used for the first time to ensure a long enough communication distance.

Mode Setting： The example here is LP_MODE0, so the corresponding Setting is LP_MODE0. It is important to note that the Mode must be consistent for all nodes in the same system.

Role Setting： Select the corresponding options according to the Role you need to configure, such as ANCHOR, TAG, and so on.

ID Setting： Input the corresponding value according to the ID that needs to be configured, for example, the ID for A0 is 0, the ID for A3 is 3, and the ID for T0 is 0. It is important to note that the ID requirements are inconsistent for nodes of the same Role.

Protocol Setting： Select the corresponding Protocol option according to the user's needs. In this example, the Protocol for A0 is NLink_LinkTrack_Node_Frame1, the Protocol for T0 is NLink_LinkTrack_Node_Frame2. It is important to note that the Protocol only represents the format of the positioning frame output protocol frame, so the Protocol of each Node can be inconsistent. It is recommended to configure the consistent Protocol for the Node in the same Role, which is convenient

for users.

Baudrate Setting： Select the corresponding Baudrate option according to the user's needs. Here Baudrate refers to the speed of communication between UART and USB. In this example, the Baudrate for both A0 and T0 is 921600. It is important to note that Baudrate only represents the speed of Node communication, so the Baudrate of each Node can be inconsistent. It is recommended to configure the consistent Protocol for the Node in the same Role, which is convenient for users to use.

UpdateRate Setting： Select the corresponding UpdateRate option according to the user's needs. Under LP_MODE0, UpdateRate can reach up to 50Hz. In this example, the UpdateRate for both A0 and T0 is configured as 50Hz. It should be noted that the UpdateRate only represents the speed at which the Node outputs positioning data frames, so the UpdateRate of each Node can be inconsistent. It is recommended to configure the Node,UpdateRate of the same Role to be consistent, which is convenient for users to use. It is recommended to configure the consistent UpdateRate for the Node in the same Role, which is convenient for users to use.

Filter Factor Setting： Select the corresponding Filter Factor value according to the user's needs, and this Setting only exists in the TAG Setting. It should be noted that, Filter Factor only represents the effect of filtering the coordinates calculated by TAG, and only affects its own coordinates, so the Filter Factor of each TAG can be inconsistent. Table 10is the recommended numerical experience table for Filter Factor.

Table 10: Experience Table of Filter Factor recommended values and Application scenarios under LP_MODE0

Filter Factor Recommended Value	Application scenario
0	Users fuse scenes by themselves. For example, the coordinate data output by TAG and the IMU data on UAV / robot and other carriers are used for integrated navigation.
10	The occasion where the motion speed is less than 5m/s, such as trajectory monitoring, robot navigation and positioning, etc.
100	Low-speed sport occasion where the speed of movement does not exceed that of 0.5m/s.
255	The occasion where the moving speed is slow or the real-time requirement is not high, such as fixed assets monitoring.

Indicator Light Setting： When turned on, the indicator light will work properly； if you do not need to observe the LED status, you can choose to turn off the LED to save power consumption.

Anchor Coordinate Setting： The Setting of the Anchor Coordinate only exists in the Anchor and CONSOLE, and the Anchor Coordinate in the TAG is only for display, not for Setting. The specific writing parameters are related to the actual installation and deployment location of the ANCHOR. For more information, please see step 3. There is no need to write it in the current step. The default ANCHOR coordinate is an invalid value of -8388.

2. **【Installation Anchor】** For the installation of ANCHOR, please refer to Table 9. It should be noted that the order of the ANCHOR installation location is the same as that shown in occasion 1 (if it is different from the illustration, it may cause some functions not to be used properly or location calculation error), and power up the anchor.

3. 【**Calibrating Coordinates**】Calibrate the anchor coordinates. The LT system supports one-key calibration and manual calibration.

One-key Calibration： One-click calibration requires that all ANCHOR are in the same plane, otherwise it will bring additional calibration errors. Connect the terminal with NAssistant installed to any of the ANCHOR (if CONSOLE, is used, it is recommended to connect to CONSOLE), which is assumed to be A0. After clicking 【LinkTrack Setting】 in the NAssistant menu bar, and then clicking the 【One Key Calibration】 button in its interface, you can see the location icon of ANCHOR converge gradually in the 【2D】 interface of NAssistant (note that ANCHOR is in the field of view only when the interface scale is appropriate). At the same time, you can also see the change of the value of A0~A3 coordinates in the【LinkTrack Setting】interface. When the coordinates are calibrated successfully, the ANCHOR coordinates are automatically stored in A0. The system automatically exits the one-click calibration mode and enters the LP_MODE0 mode. If the tag has been connected to the system at this time, the changes of tag coordinates and related data can be seen on the NAssistant side. For more information about the principle and details of one-click calibration, please refer to Section 10.1.

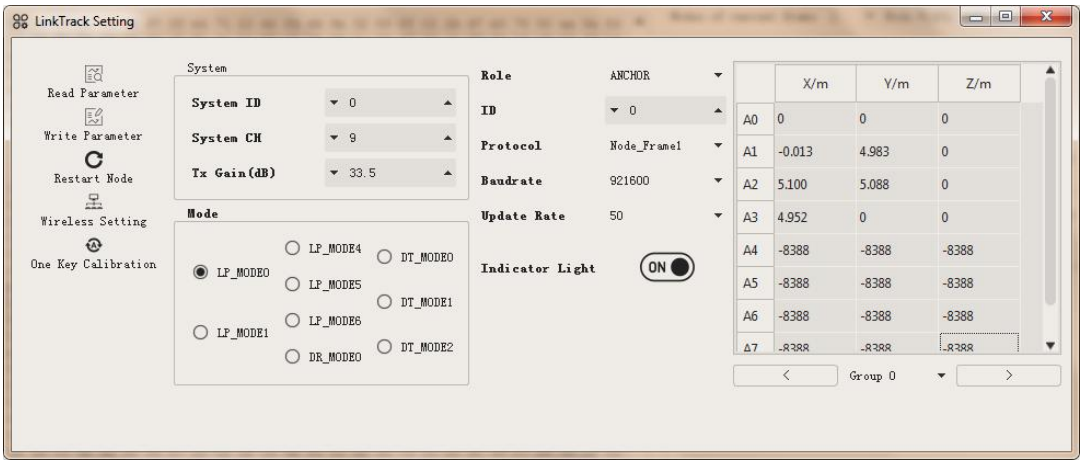


Fig. 5: Access to A0 and one-click to calibrate the ANCHOR coordinates successfully

Manual Calibration： Manual calibration of write coordinates can be done using either wired or wireless Settings. According to the written numerical content, it can be divided into two ways: the first is to write the A0~A3 coordinates directly to the ANCHOR of the connecting terminal, and the other ANCHOR only needs to confirm that the invalid data is written. The second way is to write their own coordinates to A0, A1, A2, and A3, respectively, and the coordinates of other ANCHOR can be kept as invalid data (or write actual values). As shown in Fig. 6, the A1 coordinates are only written in the second mode, and the other ANCHOR coordinates are invalid.

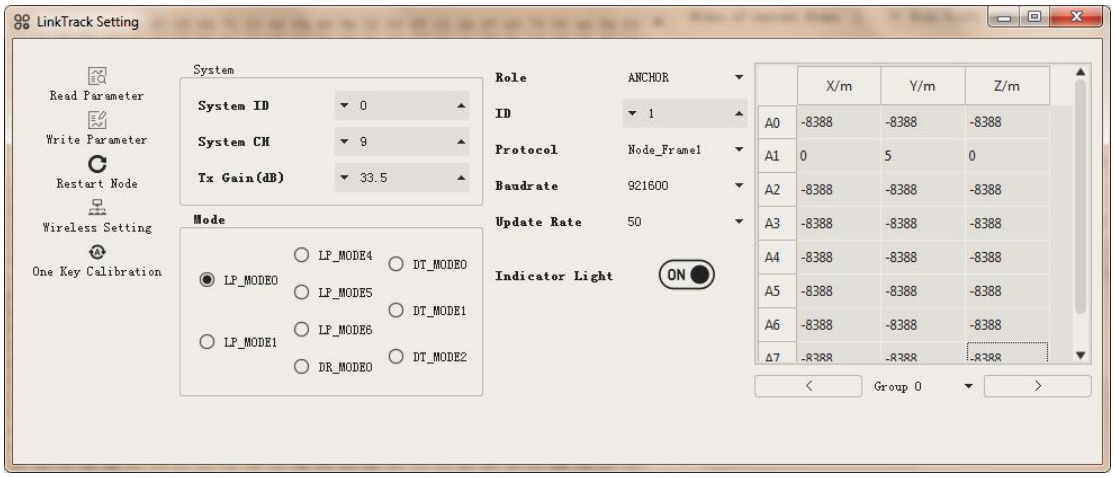


Fig. 6: Write its own coordinates to A1, other ANCHOR coordinates are invalid values

What is more convenient is that all nodes can start working normally without restarting the system after successful calibration coordinates, whether it is one-key calibration or manual calibration.

4. 【**Observational Data**】If the tag does not have a power supply, power the tag. At this time, T0-related data that can be viewed by any ANCHOR through NAssistant connection, if the system adds another tag, such as T2, the relevant data of T0 and T2 can be viewed through NAssistant； if T0 is connected through NAssistant, more detailed data such as T0 positioning coordinates and distance to the ANCHOR can be seen. If a CONSOLE C0 is added, the same data as the ANCHOR can be viewed on the NAssistant through the C0 connection terminal.

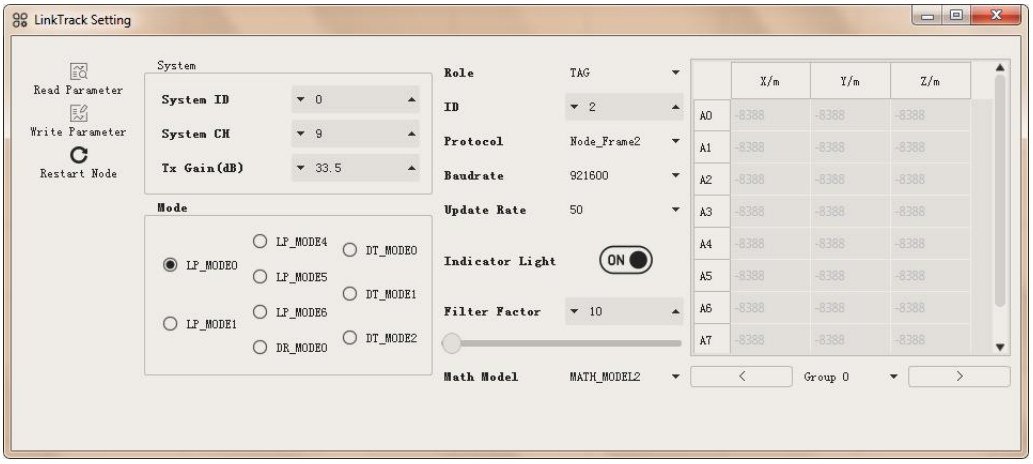


Fig. 7: T0 Setting diagram under LP_MODE0

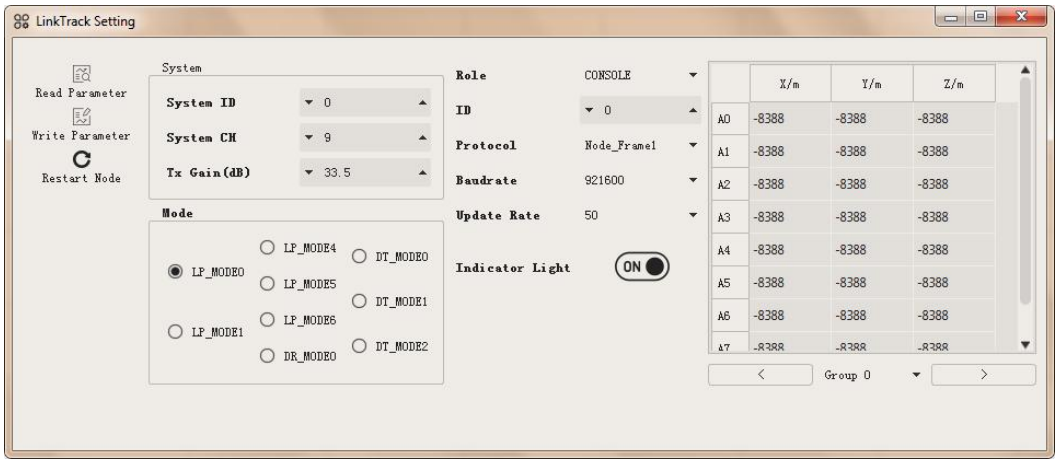


Fig. 8: C0 Setting diagram under LP_MODE0

5. 【**Data Transmission Test**】If the data transmission function is used, this step is performed. Send transparently transmitted data to T0 through the communication interface (transparent transmission, such as "20180803"), then a digital transmission frame NLink_LinkTrack_Node_Frame0 containing T0 transparently transmitted data will be output at any ANCHOR and CONSOLE. If the data that needs to be transmitted transparently is sent to A0 (or other ANCHOR or CONSOLE) through the communication interface (transparent transmission, such as "20190702"), the digital transmission frame NLink_LinkTrack_Node_Frame0 containing A0 (or other ANCHOR, CONSOLE) data will be output in T0. For more information on protocol analysis, please refer to Chapter 8.1.2.3.

3.1.3 Precautions

In order to improve the effect of use, users need to pay attention to the following points:

1. Avoid Occlusion

The nodes should be installed in a relatively open position as much as possible.

After positioning, the distance between TAG and ANCHOR should be as open as possible, avoiding obstacles that may cause errors. Otherwise, positioning accuracy will be reduced. However, the mutual occlusion between ANCHOR and TAG has no effect on positioning.

Under the one-click calibration, the ANCHOR is required to have no occlusion between each other, and other Role can have occlusion.

No matter what state it is in, there can be occlusion between CONSOLE and TAG, ANCHOR, which has no effect on the positioning accuracy.

For the effect of occlusion on positioning, please refer to 2.4.

2. Avoid Reflection

Generally speaking, the reflection has little effect on the positioning, but there are some special cases, such as the metal and other materials that may exist in the launch surface.

Ground: the distance between the ANCHOR/TAG and the ground is recommended to be more than 0.5m. For example, when the ANCHOR is placed on the ground, the positioning effect of the TAG can be obviously found to be worse.

Wall: for the scene where ANCHOR is installed near the wall, it can be installed directly against the wall. If the positioning effect is not good, it is recommended to install more than 10cm away from the wall.

3. Antenna Towards

Optimize the direction of the antenna as much as possible to improve the positioning effect. For suggestions on the orientation of the antenna, please refer to Section 2.3.

4. ANCHOR **Deployment**

Order: the solution position of the built-in mathematical model needs to comply with the requirements of the installation sequence of the ANCHOR, for example, under MATH_MODEL2, the installation order of the A0~A3 ANCHOR is clockwise. If it is in other order, it may result in abnormal positioning or worse positioning effect.

Height: under MATH_MODEL2, if conditions permit, it is recommended that the ANCHOR be on the same plane, at which time the positioning accuracy of X and Y is the highest. If you use the one-click calibration function to calibrate ANCHOR coordinates, the ANCHOR is required to maintain a high degree of consistency, otherwise it will bring additional calibration errors.

Range: the smaller the installation range of the ANCHOR (for example, the length and width are both 1m), the positioning error will be magnified. It is generally recommended that the length and width range of the ANCHOR installation is more than 1*1m.

Shape: the shape of the ANCHOR installation directly determines the size of the geometric precision factor. It is generally recommended to install as a square to maximize the geometric precision factor. It is generally recommended to install as a square to maximize the geometric precision factor. Four ANCHORs are used as the minimum positioning unit. When it is installed as a square with a length-width ratio of 1:1, the accuracy of X and Y coordinates corresponding to the length-width is consistent.

5. Setting

For the same set of systems, System CH, System ID, Mode need to be consistent, the ID of the same Role can not be repeated, otherwise the system can not work properly. System CH is related to the product, so you need to pay attention to choosing the appropriate System CH to ensure that it works properly.

6. Power Supply

Power supply needs to pay attention to the ripple size of the power supply. Please refer to section 2.1 for the power supply mode and matters needing attention.

7. I interference

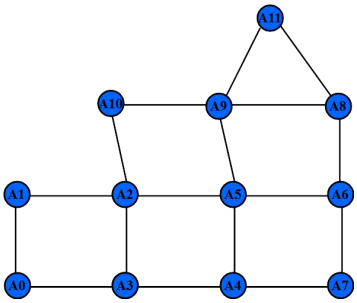
Node installation is generally recommended to stay away from high-power wireless transmitters to avoid interference.

3.2 Multi-regional Positioning Occasion

The current firmware of LT system does not support the function of automatically solving positioning coordinates for multi-area positioning occasions, but the positioning frame output by Tag contains the original distance information to each ANCHOR, and users can calculate the positioning coordinates based on this information.

Table 11: Description of multi-area location situation

Occasion	Description	Diagram

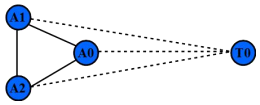
Occasion 1	By measuring the distance to each ANCHOR, the tag preferentially selects the ANCHOR within the minimum envelope surface for location solution, thus outputting location information.	

3.2.1 Steps

1. Prepare several LT nodes (here LTS is taken as an example), and configure the module as n ANCHORs and m tags through NAssistant.
2. Deploy the ANCHOR in each area and write its own coordinates.
3. After the power supply of the tag, the tag coordinates are calculated by reading the distance information from the tag to the ANCHOR and selecting the appropriate ANCHOR.

3.3 Other Occasion

Table 12: Description of other occasions

Occasion	Description	Diagram
Occasion 1	One-dimensional positioning occasion.	
Occasion 2	Follow the occasion. Several ANCHORs are installed on the car body, and the tag measures the distance to each ANCHOR, and calculates the distance between the opposite azimuth and the car (such as the geometric center of the envelope surface).	
other occasions	Due to the limited documentation, it is not possible to list all the scenarios one by one, just follow the working principle of LP Mode.	*

3.4 Fake-GPS

The steps to realize Fake-GPS are as follows: under LP Mode, change the positioning output frame in the tag parameter Setting to NMEA-0183, other Settings are consistent with the normal operation of LP Mode, so that the Fake-GPS positioning function can be realized. As shown in Fig. 9, only Protocol in the TAG Setting is deferent from the LP Mode routine operation, and other numeric variables are configured in the same way.

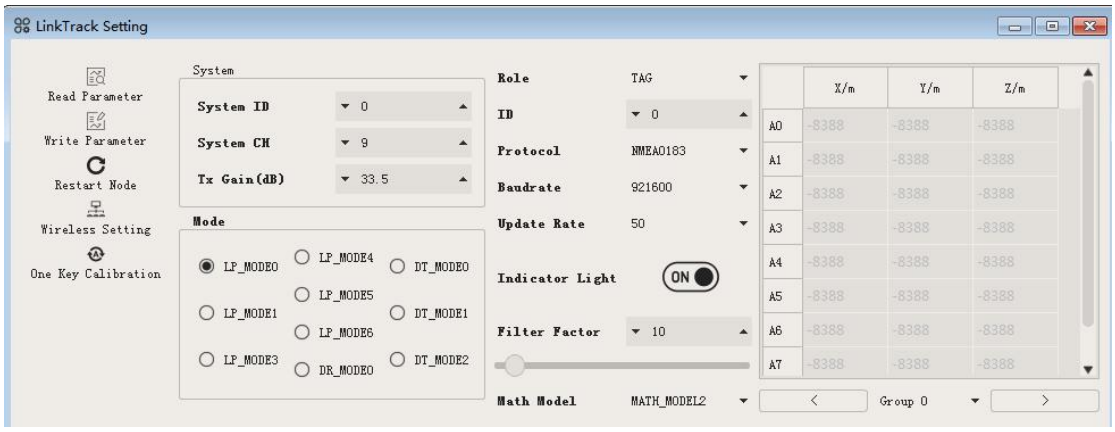


Fig. 9: TAG Setting in Fake-GPS application

The GPS NMEA-0183 output format uses the WGS84 coordinate system, which is the Earth coordinate system. The actual data output by TAG is based on the ANCHOR coordinate system, so there are the following conventions:

It is stipulated that the earth is a standard sphere, and the origin of the ANCHOR coordinate system is a fixed longitude and latitude (22.5180977 °N, 113.9007239 °E). The X axis of the ANCHOR coordinate system points to the east longitude, the Y axis to the north latitude, the Z axis to the sky. The specific formula code for the conversion from X and Y coordinates to longitude and latitude is as follows:

```
#define    LAT_START    22.5180977 //A0 latitude
#define    LONG_START    113.9007239 //A0 longitude
#define     LSB_M_TO_LAT_LONG     8.993216059e-6  // Unit coefficient of conversion from meters to latitudes and longitudes
lat = LAT_START + LSB_M_TO_LAT_LONG * pos.y;
lon = LONG_START + LSB_M_TO_LAT_LONG * pos.x;
```

Of which,

LSB_M_TO_LAT_LONG

= (2 * π * Radius of the earth) / 360

= (2 * π * 6371000) / 360

≈ 8.993216059e-6

Therefore, the coordinates output in the Fake-GPS application are simulated longitude and latitude, and do not have any direct relationship with the real longitude and latitude. If the user needs to align the Fake-GPS with the earth coordinate system, the projection transformation of the longitude and latitude output under the Fake-GPS needs to be done, the angle between the ANCHOR coordinate system and the WGS84 coordinate system needs to be measured manually, also the the deviation between the fictional starting point A0 and its real longitude and latitude.

Output the tag positioning coordinates and accuracy factors according to the NMEA-0183 communication format. Generally speaking, the GPS positioning function can be achieved by directly replacing the GPS receiver of the original carrier (such as UAV) without any underlying drive changes or minor changes (for example, the positioning accuracy is already quite high when the number of satellites simulated by LinkTrack is 4, but the accuracy of GPS is very poor when only 4 satellites are found. GPS applications often need more than 10 search stars to think that the data is valid). The specific communication protocol refers to the relevant contents of section 8.2.

Fig. 10: Satellite map of ANCHOR coordinate system origin corresponding to longitude and latitude

In particular, under Fake-GPS, only the location output protocol of TAG is changed, and its data transmission function and protocol are exactly the same as those of LP Mode. At the same time, part of TAG is configured for NMEA-0183 protocol output, and some TAG is configured for NLink_LinkTrack_Node_Frame2 and NLink_LinkTrack_Tag_Frame0 positioning protocol output. The Setting and use mode of ANCHOR and CONSOLE are exactly the same as that of LP Mode, which is not affected by the fact that the TAG positioning output frame protocol is configured as NMEA-0183.

4 DR Mode Quick Start

4.1 Introduction

In DR Mode, there is only one role of NODE, each NODE role is equivalent, and the roles such as TAG, ANCHOR and CONSOLE are no longer distinguished.

DR Mode requires that NODE running on the same system have the same configured capacity. Here the system is configured with 10 NODE capacities. Expand the description with the actual use of 5 LTS Node.

4.2 Steps

1. 【**Setting system**】Prepare 5 nodes and configure them with different ids through NAssistant, namely N0~N4. Fig. 11 shows the Setting of N0. For other node Settings, only the ID is generally different.

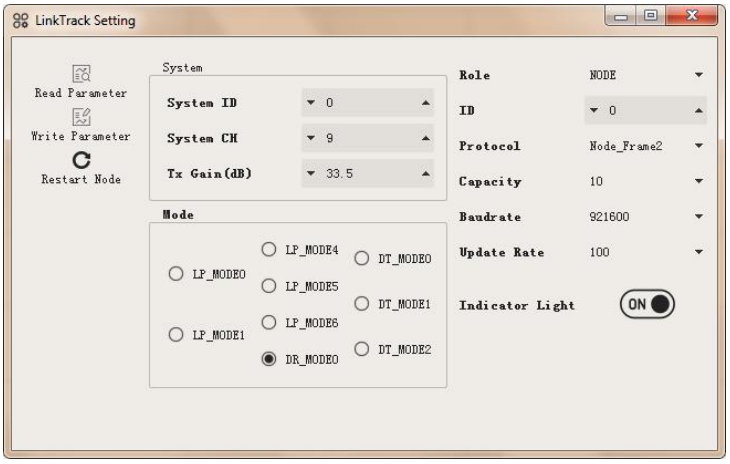


Fig. 11: N0 Setting diagram under DR_MODE0

System Parameter Setting： It is important to note that the System ID and CH must be guaranteed to be identical for all nodes in the same System. In this example, the System ID is 0 and the system CH is 9. It should be noted that System CH is related to the product model. The performance of LTS is better when System CH is 9, and the communication distance becomes very short at 7； LTP performs better when System CH is 2 and 3, and is poor at other values. For more information on the recommended Setting parameters for System CH, please see [1]. TX Gain is also generally configured to be consistent, and it is recommended that it be configured with a maximum of 33.5 when it is used for the first time to ensure a long enough communication distance.

Mode Setting：The example here is DR_MODE0, so the corresponding Setting is DR_MODE0. It is important to note that the Mode must be consistent for all Node in the same system, otherwise the system may not function properly.

Role Setting： Select the corresponding options according to the Role that needs to be configured. Under DR Mode, there is only one option for NODE.

ID Setting： Enter the corresponding value according to the ID that needs to be configured. For example, the ID corresponding to N0 is 0 and the ID corresponding to N3 is 3. It should be noted that in the same system, the ID of the same Role must be inconsistent, otherwise the system may not function properly.

Protocol Setting： Select the corresponding Protocol option according to the user's needs. In this

example, the protocol corresponding to N0 is NLink_LinkTrack_Node_Frame2. It is important to note that the Protocol only represents the format of the positioning frame output protocol frame, so the Protocol of each Node can be inconsistent. For the same Role node, Protocol is recommended to be consistent, which is convenient for users.

Baudrate Setting： Select the corresponding Baudrate option according to the user's needs. Here Baudrate refers to the speed of communication between UART and USB. In this example, the Baudrate for N0 is configured as 921600. It is important to note that Baudrate only represents the speed of Node communication, so the Baudrate of each Node can be inconsistent. For the same Role Node, Baudrate is recommended to be consistent, which is convenient for users.

Capacity Setting： Select the corresponding Capacity option according to the user's needs. Capacity means the maximum number of Node allowed to work at the same time on the same system, and the value of Capacity is related to the highest Update Rate. The Capacity selected in this example is 10, which allows a maximum of 10 Node to work at the same time (that is, a maximum of N0~N9 is allowed to work at the same time). In this example, only five Node,N0~N4 are actually used. It should be noted that the Capacity must be consistent in the same system, otherwise the system may not function properly.

Update Rate Setting： Select the corresponding Update Rate option according to the user's needs. Under DR_MODE0, Update Rate can reach up to 100Hz. In this example, the Update Rate of N0~N4 is configured as 50Hz. It should be noted that the, Update Rate only represents the speed at which the Node outputs positioning data frames, so the Update Rate of each Node can be inconsistent. For Nodes of the same Role, it is recommended to configure the Update Rate to be consistent, which is convenient for users.

2. **【Observation on Electricity】** It can be used after the Setting is complete. Supply power to each Node, and connect to one of the Node through NAssistant. If N0 is selected, the distance between N0 and N1~N3, signal strength and other data will be observed.

3. **【Data Transmission Test】** To use the data transfer feature, perform this step. Send DT data to the serial port of the node, and other nodes will automatically output the data transmission frame sent by that node.

5 DT Mode Quick Start

There are three modes in DT Mode, which are slightly different in use, so they are described separately.

5.1 DT_MODE0 Quick Start

5.1.1 Introduction

DT_MODE0 is a data transmission mode that integrates DT_MODE1 and DT_MODE2. It generally configures one Node for MASTER, and the other Node for SLAVE. The data that needs to be sent and the transmission mode are embedded into the NLink_LinkTrack_User_Frame1 protocol frame, and then sent to MASTER,MASTER through the communication interface (UART/USB), MASTER will transmit wireless messages to the corresponding SLAVE, to realize the function that MASTER broadcasts data to the slave or communicates with a slave in both directions.

Here, the case of "1 master + 4 slaves" is used as an example, and an LTS node is used for description.

5.1.2 Steps

1. 【**Configure the System**】Prepare 5 LT nodes, and configure one node as one MASTER through NAssistant, which is abbreviated as M； Configure another 4 nodes to be slaves with ids S0 to S3. Fig. 12 shows the Setting of M, Fig. 13 shows the Setting of S0, other SLAVE ID needs to correspond, and other parameters are generally the same as S0.

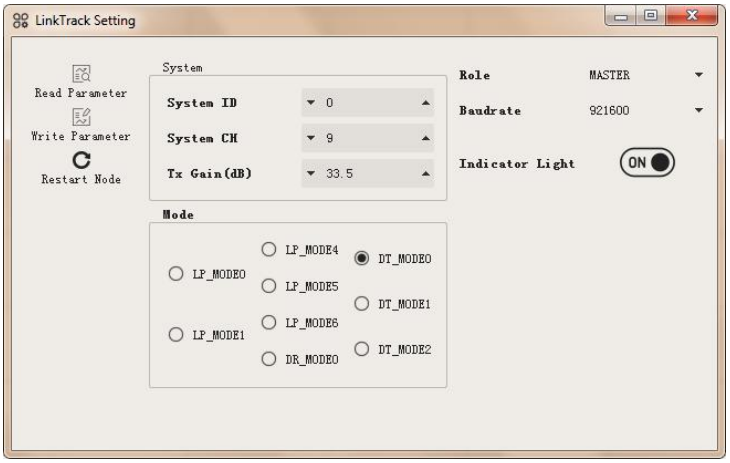


Fig. 12: M Setting diagram under DT_MODE0

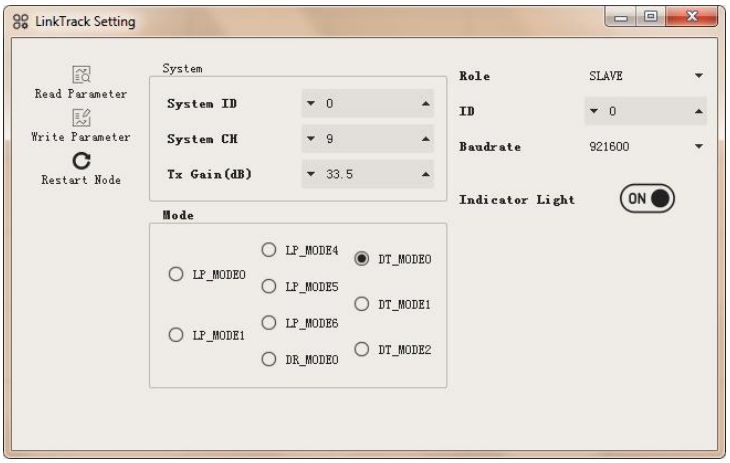


Fig. 13: S0 Setting diagram under DT_MODE0

System Parameter Setting： Note that the System ID and CH must be guaranteed to be identical for all NODE in the same System. In this example, System ID is 0 and the system CH is 9. It should be noted that, System CH is related to the product model, LTS has better performance when System CH is 9 and poor performance at 7； LTP has better performance when System CH is 2 and 3, and poor performance at other values. For more information on the recommended Setting parameters for System CH, please see [1]. TX Gain is also generally configured to be consistent, and it is recommended that it be configured with a maximum of 33.5 when it is used for the first time to ensure a long enough communication distance.

Mode Setting： The example here is DT_MODE0, so both MASTER and SLAVE are configured as DT_MODE0. It is important to note that the Mode must be consistent for all NODE in the same system, otherwise the system may not work properly.

Role Setting： Select the corresponding option according to the Role you need to configure. There are two kinds of Role under DT_MODE0: MASTER and SLAVE.

ID Setting： Enter the corresponding value according to the ID that needs to be configured. For example, the ID of S0 is 0 and the ID of S3 is 3. Master only allows 1 to exist, so there is no need to configure the ID, there is no ID Setting option. It should be noted that in the same system, the ID of the same Role must be inconsistent, otherwise the system may not function properly.

Baudrate Setting： Select the corresponding Baudrate option according to the user's needs. Here Baudrate refers to the speed of communication between UART and USB. In this example, the Baudrate Setting for both M and S0~S3 is 921600. It is important to note that Baudrate only represents the speed of the Node communication interface, so the Baudrate of each Node can be inconsistent. For the same Role Node, Baudrate is recommended to be consistent, which is convenient for users.

2. **【System Power Supply】** It can be used after the Setting is completed, and you can follow the next steps to test whether the relevant functions are normal. Connect M and S0 (if there are more computers, you can also connect S1~S3 to the corresponding computer) to the two computers installed with NAssistant through UART/USB interface, and open NAssistant's 【Serial Assistant】. It should be noted that you need to use a TTL to USB level conversion module to access it if you use a UART interface to connect a computer USB.
3. **【Data Transmission Test】** At the end of the computer connected to M, the broadcast data frame (data frame input) is sent through the serial port assistant, then S0~S3 will send the DT data from M (transparent output) through the communication interface. For example, if the data frame 5 in Table 13 is sent to M, then S0~S3 will output "AB CD EF". If send specified S0 two-way data

frames (input data frames), S0 sends data from M (transparent output) through the communication interface, and S1~S3 will not have data output, which means that M and S0 have established a two-way communication mechanism. If data is sent to S0 (transparent input), M will send data from S0 (transparent output) through the communication interface, such as sending Table 13 data frame 1 to M, then S0 outputs "11 11 01".

Table 13: DT_MODE0 MASTER Data transmission input frame

Data frame	Content (hexadecimal representation)	Description
1	54 F1 FF FF FF FF 05 00 03 00 11 11 01 6C	M sends 3-byte length DT data "11, 11, 01" to S0
2	54 F1 FF FF FF FF 05 00 05 00 12 34 56 78 90 EF	M sends 6-byte length DT data "12, 34, 56, 78, 90" to S0
3	54 F1 FF FF FF FF 05 00 00 00 46	M sends 0 bytes to S0. S0 has no data output, but the data of S0 can be transferred to M.
4	54 F1 FF FF FF FF 05 02 0A 00 12 34 56 78 90 12 34 56 78 90 9A	M sends 10-byte length DT data to S1 "12 34 56 78 90 12 34 56 78 90"
5	54 F1 FF FF FF FF 00 00 03 00 AB CD EF AB	M broadcasts 3-byte DT data "AB, CD, EF" to all S

5.2 DT_MODE1 Quick Start

5.2.1 Introduction

DT_MODE1 is a two-way data transmission mode, which supports two-way communication between a master and a slave.

Here, the “1 master + 1 slave” scenario is used as an example, and an LTS node is used for description.

5.2.2 Steps

1. 【**Configure the System**】Prepare 2 LT nodes, configure one node as 1 MASTER, abbreviated as M through NAssistant, and configure the other node as SLAVE, abbreviated as S. Fig. 14 shows the Setting of M and Fig. 15 shows the Setting of S.

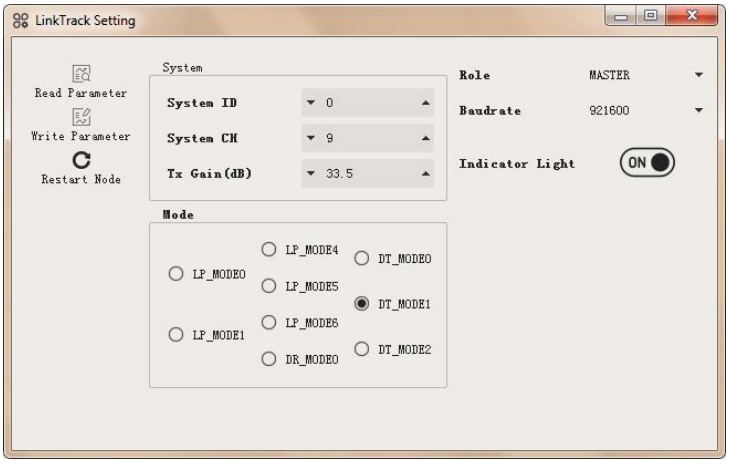


Fig. 14: M Setting diagram under DT_MODE1

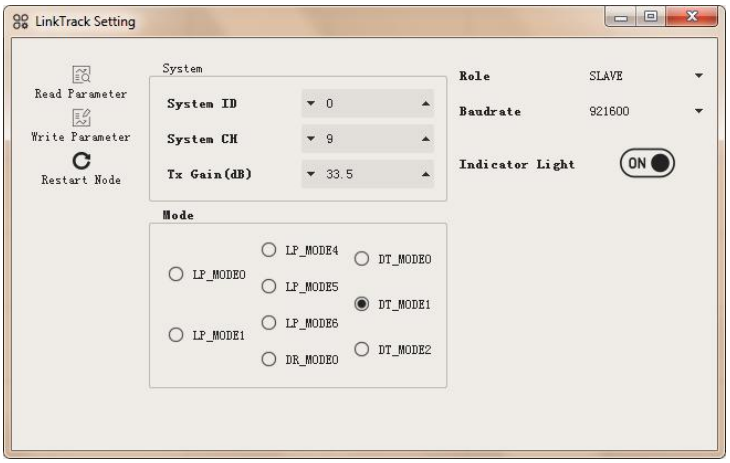


Fig. 15: S Setting diagram under DT_MODE1

The related Setting parameters of DT_MODE1 are basically the same as DT_MODE0, please refer to Fig. 12 and Fig. 13.

The differences that need to be noted are:

Mode is DT_MODE1. Only one SLAVE is allowed, so there is no need to configure the ID, there is no ID Setting option.

2. 【**System Power Supply**】It can be used after the Setting is completed, and you can follow the next steps to test whether the relevant functions are normal. Connect M and S to the two computers with NAssistant respectively through the UART/USB interface, and open the 【Serial Assistant】of NAssistant. It should be noted that you need to use the TTL to USB level conversion module access if you use the UART interface to connect the computer USB.

3. 【**Data Transmission Test**】At the end of the computer connected to M, the data is sent through the serial assistant (transparent input), and S will send the DT data from M (transparent output) through the communication interface. At the end of the computer connected to S, if the data is sent through the serial assistant (transparent input), M will send the DT data from S (transparent output) through the communication interface.

5.3 DT_MODE2 Quick Start

5.3.1 Introduction

DT_MODE2 is a broadcast mode that supports one master to broadcast data to an unlimited number of slaves.

Here, the case of "1 master + 2 slaves" is used as an example, and an LTS node is used for description.

5.3.2 Steps

1. 【**Configure the System**】Prepare 3 LT nodes, configure one Node as 1 MASTER through NAssistant, and abbreviate as M； configure 2 other nodes as SLAVE, and abbreviate as S. Fig. 16 shows the Setting of M, and Fig. 17 shows the Setting of S.

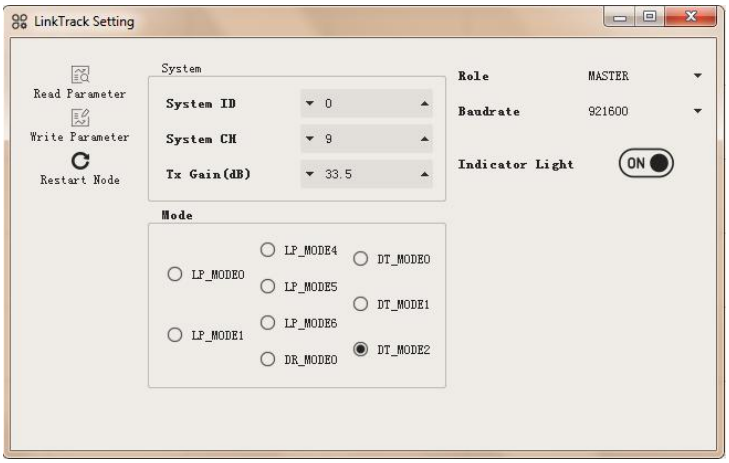


Fig. 16: M Setting diagram under DT_MODE2

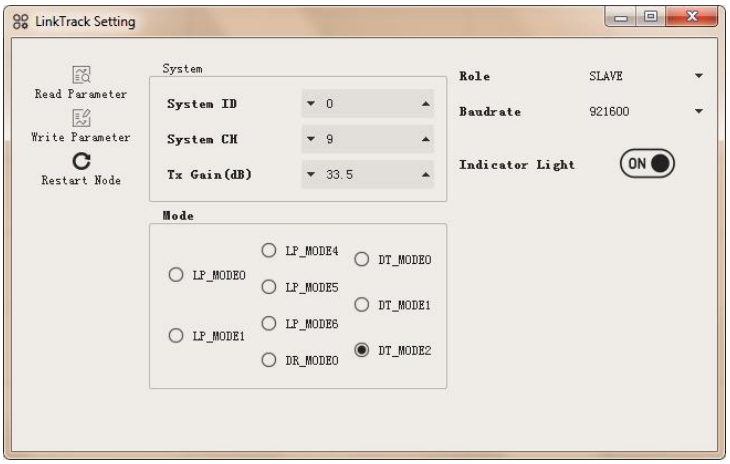


Fig. 17: S Setting diagram under DT_MODE2

The related Setting parameters of DT_MODE2 are basically the same as DT_MODE0, please refer to Fig. 12 and Fig. 13.

The differences that need to be noted are:

Mode is DT_MODE2. SLAVE allows countless existence,, so there is no need to configure the ID, and there is no ID Setting option, so the Setting of SLAVE is consistent.

2. **【System Power Supply】**It can be used after the Setting is completed, and you can follow the next steps to test whether the relevant functions are normal. M and one of the S are connected to two computers with NAssistant respectively through the UART/USB interface, and open the 【Serial Assistant】of NAssistant. It should be noted that if you use the UART interface to connect the computer USB, you need to use the TTL to USB level conversion module to access it.

3. **【Data Transmission Test】**At the end of the computer connected to M, the data is sent through the serial assistant (transparent input), and S will send the DT data from M (transparent output) through the communication interface.

6 NAssistant Operations

This chapter introduces the general operation of LinkTrack based on NAssistant.

6.1 Wireless Setting

When the system uses the following mode and the local directly connected node is the corresponding role, click [Wireless Setting] to enter the wireless setting mode.

1. The system is configured as LP_MODE, connect the CONSOLE or any ANCHOR.
2. The system is configured as DR_MODE and connects to any NODE.

After entering the wireless setting mode, you can see all the normal networking nodes in the network, and you can read, write and restart the parameters of a single node through the right mouse button menu on all nodes, and you can also modify the parameters of the same type of node with one click except Role and ID.

Next, take LP_MODE0 as an example, configure 1 CONSOLE + 4 ANCHOR + 2TAG, and connect the CONSOLE directly with the machine, and introduce related operations of wireless.

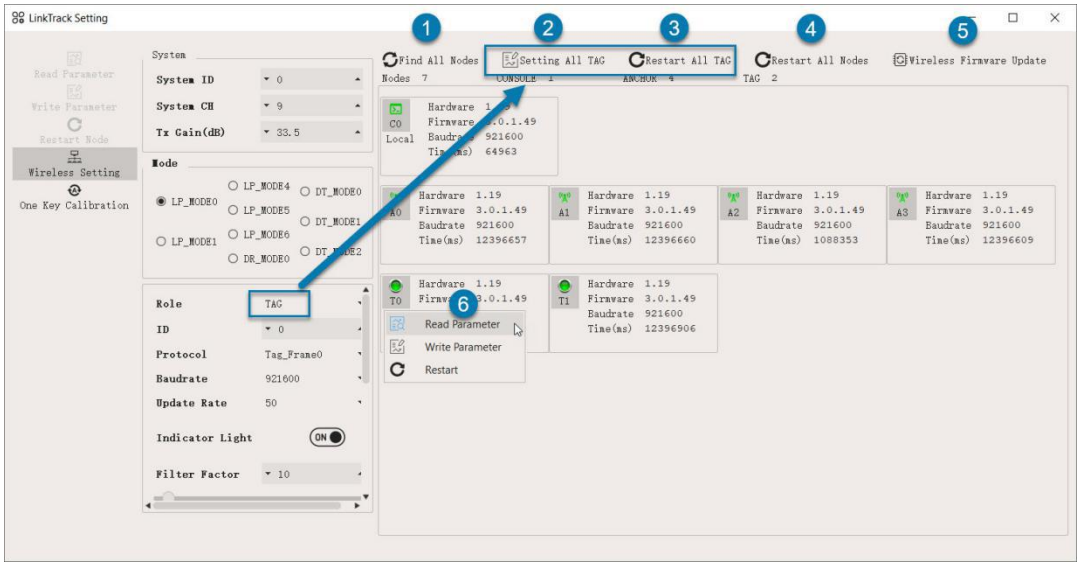


Fig. 18: Overview of Wireless Settings Operation

1. Find and update nodes in the network;
2. Set all node parameters under the currently selected type (the original Role and ID of the node remain unchanged);
3. Restart all nodes of the currently selected type (excluding nodes directly connected to the machine);
4. Restart all types of nodes (excluding nodes directly connected to the machine);
5. Open the wireless firmware update option and corresponding interface;
6. Right-click on a node to read, write, and restart parameters for a single node.

6.2 Firmware Update

The firmware update is divided into the following two steps:

1. Get firmware mode
    a. The software automatically acquires【Public Firmware】;
    b. If you get the test code, you can click【Beta Firmware】, enter the test code, and get the

test firmware.

c. If local firmware is available, click【Local Firmware】to load the local firmware.

2. If the firmware Version obtained in the previous step is higher than the firmware Version of the native-connected node, you can directly click 【Local Update】 to start the firmware Update (if the Wireless Update option is turned on in the Wireless Settings, 【Wireless Update】will be displayed here). If you need to force the Update or back the Version, you need to click【Ignore Version】 to continue the Update.

Fig. 19: Schematic diagram of firmware update interface

6.3 Record, Replay and Export

NAssistant provides convenient data recording, playback and export functions. Users can click the button to start real-time raw data recording at any time. After clicking the button again, the recording will be stopped and the * .dat file will be output. You can load the recorded historical data by clicking the button. It is also equipped with a playback control bar, which can easily adjust the playback rate, playback progress and so on.

Real-time status or playback status can be started by clicking the button to export text data to the local txt file. Clicking this button again will stop the export and open the folder where the file is located, which can be used for subsequent data analysis.

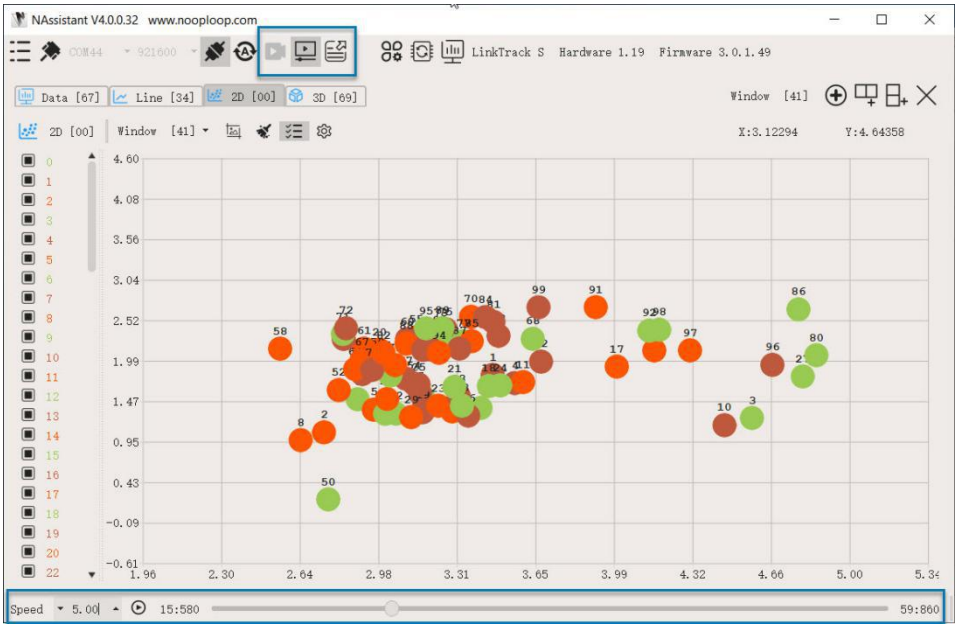


Fig 20: Data recording, playback and export

7 Variable

This chapter introduces the main variables in Protocol, excluding the introduction of variables in Setting_Frame0 and NMEA-0183 protocols.

7.1 Dis

Dis is short for Distance, which is expressed in the protocol as: dis.

Table 14: Table of relationship between Dis and Protocol

Mode	Role	Protocol	Description
LP Mode	TAG	TAG_FRAME0	Represents the distance of 8 ANCHOR from TAG to A0~A7 at the current time. TAG outputs up to 8 valid distances and cannot output ANCHOR distances where ID is greater than 7. The initial value of Dis is 0, and when the distance is invalid, the value of dis in the corresponding Block is the same as that of the previous time.
		NODE_FRAME2	Represents the effective distance from the TAG to all ANCHOR in the signal range at the current time, located in the Block of the variable length part. When the distance is invalid, the Block corresponding to that distance is not output.
		NODE_FRAME3	
	ANCHOR / CONSOLE	ANCHOR_FRAME0	Represents the distance of 8 ANCHOR from TAG to A0~A7 at the current time. TAG outputs up to 8 valid distances and cannot output ANCHOR distances where ID is greater than 7. The initial value of Dis is 0, and when the distance is invalid, the value of dis in the corresponding Block is the same as that of the previous time.
DR Mode	NODE	NODE_FRAME2	Represents the effective distance from the NODE to all NODE in the signal range at the current time, located in the Block of the variable length part. When the distance is invalid, the Block corresponding to that distance is not output.
		NODE_FRAME3	

7.2 RSSI

It is expressed in the protocol as: fp_rssi and rx_rssi.

The Node may output the received first path signal strength indication fp_rssi and the total received signal strength indication rx_rssi. It is usually output with distance (such as the distance output of the tag under LP Mode, the distance output of the node under DR Mode). In general, when "rx_rssi-fp_rssi" is less than 6dB, it is likely to be in the LOS state, and when greater than 10dB, it is likely to be in the NLOS or multipath state.

Table 15: Table of relationship between RSSI and Protocol

Mode	Role	Protocol	Description
LP Mode	TAG	NODE_FRAME2	Indicates the signal strength of the ANCHOR received by the TAG in the signal range at the current time, which is located in the Block of the variable length part. When the distance is invalid, the Block corresponding to the RSSI for that distance is not output.
		NODE_FRAME3	
DR Mode	NODE	NODE_FRAME2	Represents the signal strength of other NODE received by NODE in the signal range at the current time, which is located in the Block of the variable length part. When the distance is invalid, the Block corresponding to the RSSI for that distance is not output.
		NODE_FRAME3	

7.3 Pos

Pos is the abbreviation of Position and is expressed in the protocol as: pos.x, pos.y, pos.z.

Table 16: Table of relationship between Pos and Protocol

Mode	Role	Protocol	Description
LP Mode	TAG	TAG_FRAME0	Represents the position of the TAG at the current time. The initial value of Pos is 1, and when the position is invalid, its value is equal to the value of the previous time.
		NODE_FRAME2	
	ANCHOR / CONSOLE	ANCHOR_FRAME0	Indicates the total of 30 ANCHOR positions from A0 to A29 received by ANCHOR/CONSOLE at the current moment, and the maximum number of valid TAG positions is 30, and it cannot be output to the ANCHOR position whose ID is greater than 29. The initial value of Pos is 1, and when the position is invalid, the position in the corresponding Block is the same as the value at the previous time.
		NODE_FRAME1	Represents the position of all TAG within the range of signals received by ANCHOR/CONSOLE at the current time. The initial value of Pos is 1, and when the position is invalid, the position in the corresponding Block is the same as the value at the previous time.
DR Mode	NODE	NODE_FRAME2	Invalid data that exists in the protocol. DR Mode does not do location calculation.

7.4 Vel

Vel is the abbreviation of Velocity and is expressed in the protocol as: vel.x, vel.y, vel.z.

Vel is calculated through Pos. Currently, only vel.x and vle.y are calculated and output, and the vel.z output is always 0. When Filter Factor is equal to 0, that is, the filter is turned off, vel.x and vel.y

will be equivalent to the effect when Filter Factor is 10.

Table 17: Table of relationship between Vel and Protocol

Mode	Role	Protocol	Description
LP Mode	TAG	TAG_FRAME0	Indicates the speed of the TAG at the current moment. The initial value of Vel is 0. When the position is invalid, the Vel gradually becomes invalid.
		NODE_FRAME2	
DR Mode	NODE	NODE_FRAME2	Invalid data present in the protocol. DR Mode does not do speed estimation.

7.5 EOP

EOP is an acronym for Estimation of Precision and is expressed in the protocol as: eop.x, eop.y, eop.z.

EOP is calculated through the mathematical constraint relationship of multi-ANCHORs, which represents the estimation of the current positioning coordinate accuracy. EOP requires that the result is valid only when there are at least 4 ANCHOR participating in positioning in the system, otherwise the output of EOP cannot be estimated, and 2.55 is output at this time. EOP can only be used as a reference index of accuracy, and it is not completely reliable. Generally speaking, the smaller the EOP, the higher the accuracy； the larger the EOP, the worse the accuracy. For example, when the eop.x is 0.3m, the positioning accuracy of the X axis of the TAG may be 0.3m, that is, the coordinate deviation of the X axis may be ±0.3m (under the ideal condition of no deviation of the ANCHOR coordinates). When the EOP is 2.55, the positioning accuracy may be 2.55m or worse than 2.55m.

EOP can be used as a reference standard for users to evaluate the current tag positioning effect, such as in the process of multi-sensor fusion, it can be used as the weight of UWB positioning and integrated navigation with other sensors.

Table 18: Table of relationship between EOP and Protocol

Mode	Role	Protocol	Description
LP Mode	TAG	TAG_FRAME0	Represents the accuracy estimation factor of TAG at the current time, with an initial value of 2.55.
		NODE_FRAME2	
DR Mode	NODE	NODE_FRAME2	Invalid data that exists in the protocol. DR Mode does not estimate the accuracy estimation factor.

7.6 IMU Data

The data of IMU includes four variables: three-axis angular rate, three-axis acceleration, Euler angle and quaternion. The reference coordinate system is LT carrier coordinate system, and the product shell icon marks the coordinate system direction.

Triaxial Angular Velocity：It is expressed in the protocol as: g.x, g.y and g.z, which represent the angular rate of X, Y and Z axis respectively, and the direction accords with the right-handed helix law, which comes from the original data collected by LT built-in IMU.

Triaxial Acceleration： In the protocol, it is expressed as A.X, A.Y and A.Z, which represent the acceleration of X, Y and Z axes respectively, and come from the original acquisition data of LT built-in IMU.

Euler's Angle：It is expressed in the protocol that angle.x, angle.y and angle.z, represent the Euler angles of the X, Y and Z axes, respectively, and are obtained by attitude calculation based on angular velocity and acceleration. Euler's Angle is the total attitude solution, and there is no deadlock on the

universal axis.

Quaternion： In the protocol, it is expressed as: q0, q1, q2 and q3, which represent the real part and the imaginary part in the direction of X, Y and Z axis respectively. It is obtained by attitude calculation based on angular velocity and acceleration.

Table 19: Table of relationship between IMU Data and Protocol

Mode	Role	Protocol	Description
LP Mode	TAG	TAG_FRAME0	Represents the accuracy estimation factor of the TAG at the current time.
		NODE_FRAME2	
DR Mode	NODE	NODE_FRAME2	Invalid data that exists in the protocol. DR Mode does not do IMU data output and attitude calculation.

7.7 Valid Node Quantity

Expressed in the protocol as: valid_node_quantity。

Table 20: Table of relationship between Valid Node Quantity and Protocol

Mode	Role	Protocol	Description
LP Mode	TAG	NODE_FRAME0	Indicates the number of valid nodes received by the TAG at the current time, corresponding to the number of Block of the variable length part. Nodes can contain CONSOLE and ANCHOR.
		NODE_FRAME2	Indicates the number of valid nodes received by the TAG at the current time, corresponding to the number of Block of the variable length part. The node currently contains only ANCHOR.
		NODE_FRAME3	
	ANCHOR / CONSOLE	NODE_FRAME0	Represents the number of valid nodes received by ANCHOR or CONSOLE at the current time, corresponding to the number of Block in the variable length part. The node currently contains only TAG.
		NODE_FRAME1	
DR Mode	NODE	NODE_FRAME0	Indicates the number of valid nodes received by the NODE at the current time, corresponding to the number of Block of the variable length part. The node contains only other NODE.
		NODE_FRAME2	
		NODE_FRAME3	

7.8 Role & ID

Expressed in the protocol as: role、id。

If it occurs, the Role and ID of the frame protocol Node are output, and it occurs only once.

If it appears in a block, it represents the Role and ID corresponding to the block, and the number of occurrences corresponds to the number of blocks.

Table 21: Table of relationship between Role&ID and Protocol

Mode	Role	Protocol	Description
LP Mode	TAG	TAG_FRAME0	The Role is fixed as a TAG and the ID is the Setting value.
		NODE_FRAME0	In non-block, the Role is fixed as a TAG and the ID is the corresponding Setting value. In each block, it represents the Role and ID corresponding to the block.
		NODE_FRAME2	
		NODE_FRAME3	
	ANCHOR / CONSOLE	ANCHOR_FRAME0	Occurs once in a non-block, the Role is fixed as ANCHOR and the ID is the Setting value.
		NODE_FRAME0	In non-block, the Role is fixed as a ANCHOR and the ID is the corresponding Setting value.
		NODE_FRAME1	

			In each block, it represents the Role and ID corresponding to the block
DR Mode	NODE	NODE_FRAME0	Occurs once in a non-block, the Role is fixed as NODE and the ID is the Setting value. In each block, it represents the Role and ID corresponding to the block
		NODE_FRAME2	
		NODE_FRAME3	
DT Mode	MASTER	USER_FRAME1	It exists in the MASTER data transmission input frame of DT_MODE0.

7.9 Remote Role & Remote ID

Expressed in the protocol as: remote_role、remote_id。

Table 22: Table of relationship between Remote Role & Remote ID and Protocol

Mode	Role	Protocol	Description
DT Mode	MASTER	USER_FRAME1	It only exists in the MASTER data transmission input frame of DT_MODE0. When remote_role is NODE, remote_id must be 0xFF, which represents broadcasting data to all SLAVE； when remote_role is SLAVE, remote_id is the ID of the corresponding SLAVE for two-way communication.

7.10 Data Length & Data

Expressed in the protocol as: data_length、data。

Table 23: Table of relationship between Data Length & Data and Protocol

Mode	Role	Protocol	Description
LP Mode	TAG	NODE_FRAME0	Exists in each Block, representing the corresponding Data Length and Data.
	ANCHOR / CONSOLE		
DR Mode	NODE		
DT Mode	MASTER	USER_FRAME1	It only exists in the MASTER data transmission input frame of DT_MODE0.

7.11 Time

Time contains Local Time and System Time, expressed in the protocol as: local_time and system_time.

Local Time：Represents the local system time corresponding to the output frame Protocol node. When the node is powered on, the Local_time is 0.

System Time：Represents the synchronization time of the entire system. Corresponding to LP Mode, system_time takes A0 as the time benchmark. For DR_MODE, system_time takes the NODE that was the first to be powered as the time benchmark.

Table 24: System Time 与 Protocol 关系表

Mode	Role	Protocol	Description
LP Mode	TAG	TAG_FRAME0	Indicates that the Local Time and System Time corresponding to the Protocol node of the frame are output.
		NODE_FRAME0	
		NODE_FRAME3	
	ANCHOR / CONSOLE	NODE_FRAME0	

DR Mode	NODE	NODE_FRAME0	
		NODE_FRAME3	

7.12 Voltage

Expressed in the protocol as: voltage。

Table 25: Table of relationship between Voltage and Protocol

Mode	Role	Protocol	Description
LP Mode	TAG	TAG_FRAME0	Indicates that outputs the power supply voltage of the frame corresponding to the Protocol node.
		NODE_FRAME2	
		NODE_FRAME3	
	ANCHOR / CONSOLE	ANCHOR_FRAME0	
		NODE_FRAME1	
DR Mode	NODE	NODE_FRAME2	
		NODE_FRAME3	

8 Protocol Unpack

8.1 NLink Protocol

8.1.1 Introduction

In this chapter, the protocol parsing example is based on NLink protocol, and the NlinkUnpack sample parsing code based on C language is provided, which can effectively reduce the user development cycle. The C ++ code can refer to the supporting NLink ROS driver package.

According to the LinkTrack product data, in order to represent more data with as few bytes as possible, the floating point number is represented by shaping and transmitted through the protocol frame. Therefore, when unpacking, the shaping data with magnification is actually floating-point, which needs to be divided by the multiplying power of identification in NLink.

In particular, for type int24, we need to first convert it to type int32. To keep the sign the same, we divide by 256 after move it to the left. For example, for location data, we use int24 to express it, with a multiplier of 1000. The parsing code is as follows:

```
uint8_t byte[] = {0xe6,0x0e,0x00}；// represents a decimal value：3.814
int32_t temp = (int32_t)(byte[0] << 8 | byte[1] << 16 | byte[2] << 24) / 256；
float result = temp/1000.0f；
```

The same goes for uint24 type variables.

At present, there are two main types of protocol verification:

1. Fixed value check at the end of the protocol frame. Only the NLink_LinkTrack_Anchor_Frame0 protocol is a fixed value.
2. Single-byte sum check at the end of the protocol frame, sample code:

```
uint8_t verifyCheckSum(uint8_t *data, int32_t length){
    uint8_t sum = 0；
    for(int32_t i=0；i<length-1；++i){
        sum += data[i]；
    }
    return sum == data[length-1]；
}
```

Note: for the id item appearing in the protocol, a value of 255 indicates that the corresponding node data is invalid.

8.1.2 Example

This document takes "2 tags + 4 ANCHORs + 1 console" running in LP_MDOE0 as an example to introduce the principle of communication protocol analysis. In the course of the experiment, four ANCHOR were configured as A0~A3, two TAG were configured as T0, T1, and one CONSOLE was configured as C0.

8.1.2.1 NLink_LinkTrack_Anchor_Frame0

Data Source： The WINCC is connected to A0, and the Setting protocol is tNLink_LinkTrack_Anchor_Frame0, T0 and T2 work normally in the network.

Raw Data： 55 00 00 02 4f 0b 00 73 09 00 f9 fe ff 6c 01 4e 01 ea 01 ed 01 00 00 00 00 00 00 00

00 ff 0b 00 8e 09 00 4a fe ff c9 37 8a 34 06 ee 37 3f aa 02 02 7e 09 00 67 09 00 a3 02 02 83 09 00 5f 09 00 a3 fb ff 3e 01 2a 01 12 02 13 02 00 00 00 00 00 00 00 00 ff ab 91 ef ea 45 09 e1 18 5a 33 b4 f2 08 40 da ca c8 fd df f7 44 d7 3c 3a ff a2 ff f6 12 0c 05 4c 2b 7b 7d 6b 49 41 1d 48 44 fd bc 96 21 43 16 45 97 ef c6 71 e5 ff f4 83 77 fa 32 d3 01 19 29 bd fd fb 60 ff 00 04 1a 12 38 ba 26 b7 9b 6d 7d 3a ff 2f 5f da 82 64 40 42 86 fe df 72 08 1a 28 0b fb f7 77 f2 72 76 c4 38 79 2a 9d ff 24 24 20 25 4e b7 9f 99 4d 70 56 80 d3 9e e2 7d 12 3a 85 c6 8f bd c6 9f 81 8f ff f3 0c f4 c5 ce c9 91 51 d1 65 5f 30 3f 05 91 0c 86 b0 07 7e 39 d1 68 76 46 d3 ff 9f 6b 11 08 ce 06 b4 ac 59 e1 c4 33 ca 80 1f be 13 bc 6d e2 32 8d ea 75 a5 b1 ff 06 95 4d f7 12 d6 61 45 8c 89 84 36 64 96 e0 f0 02 a2 84 6c 37 fb fa ac 18 a4 ff 79 6a 78 76 78 60 ba 00 fb 7b d6 fb f8 00 8a f9 b5 63 cf eb d0 45 56 43 23 e9 ff bb 73 25 0a 0b cf b9 df cd aa 62 1f 54 eb 1d f7 b8 c0 02 d8 8a c3 af 34 97 03 ff e2 88 b6 c3 39 fa 89 5d 40 00 62 8b ce 4b c0 20 28 11 fd d6 ce bd 3c 60 7b 72 ff 42 e4 ed 90 61 70 40 28 df c1 be 11 00 15 55 cb 95 56 2d 50 a3 5d 28 32 ee bb ff 01 91 1d 67 35 f5 f8 bf 3c 10 01 1c 6d 1b f5 5e 89 1f 28 23 60 31 2f 75 44 02 ff 51 7b c7 af af f2 d0 0e ca bb 61 31 f6 ac e0 69 10 34 b3 73 7f 30 14 18 01 7a ff 76 ed 42 37 66 0a 2b 55 7f f5 04 43 f4 40 4e 3f 52 ee c4 4f 09 1e b9 8d f6 3d ff 51 f2 20 d6 4b d2 7d 87 0c a8 15 99 4b ee 2a 42 41 69 68 75 51 f3 bf 5d 4b 01 ff 8e 9e 1e 92 a8 a1 57 04 f4 c4 3f eb 43 18 ac 03 58 0d 5d d4 51 c8 81 64 7e 6d ff 71 c1 18 2b 4f b7 ef ec 7c 46 2a a4 8f 6c 94 cb 63 9e 6c 22 74 de 1f fc a3 62 ff 1f 01 f9 61 71 50 57 1a 83 b2 64 1e 3e 1c 85 22 2b 99 56 6d f9 bb b2 c1 a1 22 ff ef 5c af f7 4c f0 68 6d 4c 42 37 24 03 45 28 fd 1b a6 e2 04 7c a4 7c e5 33 9b ff 6b 1a 03 14 77 5f 23 3d a8 6c 44 80 17 64 f1 a2 10 06 38 24 06 d3 3c 3c 0c 68 ff 98 d2 ab 63 ca d0 f2 c6 2a 7e a3 57 dd 21 35 b1 60 14 ee de 36 15 d8 2b 08 b7 ff 17 6c 6b 21 ad da dc b3 31 dc ea 0c a6 cb 71 ff 4c e9 8e 08 66 58 e2 3e 6d e6 ff 00 d8 00 1c db db d1 05 ac ee 06 85 f6 de da 00 51 0c 2e ca ed 8b c7 16 7b 06 ff 17 ef f9 ef 7c 1e e0 d3 3f 6d 6c 6f eb 27 b9 65 53 c6 1f 2a 3e 11 3a 40 8f b1 ff 3e a2 12 20 c3 d5 b7 68 be 18 14 5c a4 a1 7f bb 9f fa c4 54 80 38 65 4e ff 51 ff 9a 1b d7 3f e7 96 20 3b 1c 08 82 9b 3f e2 04 ae 16 80 b7 ca e3 07 83 60 50 f5 ff 8a fd c1 24 2d 84 35 b7 fe 0c 6d 9b d6 e8 8c ee 79 21 ef e1 10 82 90 b7 92 c2 ff 57 04 da 00 0e bf 4e e7 c2 70 aa cc 95 85 ff 6b 30 03 83 41 8b df ad e3 8a 40 ff 02 ed cb 6f 7e 13 20 99 f1 f1 87 2a 21 82 00 00 0c c7 e9 7a 83 13 00 7d 00 00 00 03 ee

Table 26: NLink_LinkTrack_Anchor_Frame0 analytical table

Data	Type	Length (B)	Hex	Result
Frame Header	uint8	1	55	0x55
Function Mark	uint8	1	00	0x00
id	uint8	1	00	0
role	uint8	1	02	TAG
{pos.x, pos.y, pos.z} * 1000	int24	9	4f 0b 00	2.895 m
			73 09 00	2.419 m
			f9 fe ff	-0.263 m
{dis0, dis1, dis2, dis3, dis4, dis5, dis6, dis7} * 100	uint16	2	6c 01	3.64 m
			4e 01	3.34 m
			ea 0	4.9 m
			ed 01	4.93 m
			00 00	0 m
			00 00	0 m
			00 00	0 m

			00 00	0 m
Block1	*		...	*
id	uint8	1	02	2
role	uint8	1	02	TAG
{pos.x, pos.y, pos.z} * 1000	int24	9	83 09 00	2.435 m
			5f 09 00	2.399 m
			a3 fb ff	-1.117 m
{dis0, dis1, dis2, dis3, dis4, dis5, dis6, dis7} * 100	uint16	2	3e 01	3.18 m
			2a 01	2.98 m
			12 02	5.3 m
			13 02	5.31 m
			00 00	0 m
			00 00	0 m
			00 00	0 m
			00 00	0 m
Block3～Block29	*		...	*
reserved	*	67	...	*
local_time	uint32	4	21 82 00 00	33313
reserved		4	...	*
voltage	uint16	2	83 13	4.995 V
system_time	uint32	4	00 7d 00 00	32000 ms
id	uint8	1	00	0
role	uint8	1	03	CONSOLE
Sum Check	uint8	1	ee	0xee

8.1.2.2 NLink_LinkTrack_Tag_Frame0

Data Source： The WINCC is connected to T0, and the Setting protocol is NLink_LinkTrack_Tag_Frame0, A0, A1, A2 and A3 work normally in the network.

Raw Data： 55 01 01 02 8e 0a 00 a5 ff ff e8 03 00 da ff ff fa ff ff 00 00 00 35 0c 00 a3 15 00 cd 1a 00 4c 12 00 00 00 00 00 00 00 00 00 00 00 00 00 27 ac e2 3c a2 7d 0b 3c d2 70 3b bd cf a5 80 3e 3e fc 1b 41 1f a1 26 bd 26 5d 57 41 bd 80 57 41 3f 63 57 41 71 38 f5 25 44 fa 8a 22 28 bf 5a b7 00 be 20 4f 3d bf 1c 0b 52 3d f4 26 3d 40 0c ae 00 00 cb 17 01 00 f0 0b 10 ff 54 13 1d 48 00 00 bc fd

Table 27: NLink_LinkTrack_Tag_Frame0 analytical table

Data	Type	Length (B)	Hex	Result
Frame Header	uint8	1	55	0x55
Function Mark	uint8	1	01	0x01
id	uint8	1	00	0
role	uint8	1	02	TAG
{pos.x, pos.y, pos.z} * 1000	int24	9	8e 0a 00	2.702 m
			a5 ff ff	-0.091 m

			e8 03 00	1 m
{vel.x, vel.y, vel.z} * 10000	int24	9	da ff ff	-0.0038 m/s
			fa ff ff	-0.0006 m/s
			00 00 00	0 m/s
{dis0, dis1, dis2, dis3, dis4, dis5, dis6, dis7} * 1000	int24	24	35 0c 00	3.125 m
			a3 15 00	5.539 m
			cd 1a 00	6.861 m
			4c 12 00	4.684 m
			00 00 00	0 m
			00 00 00	0 m
			00 00 00	0 m
			00 00 00	0 m
{g.x, g.y, g.z}	float	12	27 ac e2 3c	0.02767 rad/s
			a2 7d 0b 3c	0.008514 rad/s
			d2 70 3b bd	-0.045762 rad/s
{acc.x, acc.y, acc.z}	float	12	cf a5 80 3e	0.251265 m/s^2
			3e fc 1b 41	9.74908 m/s^2
			1f a1 26 bd	-0.040681 m/s^2
reserved	float	12	...	*
{angle.x, angle.y, angle.z}*100	int16	6	71 38	144.49 °
			f5 25	97.17 °
			44 fa	-14.68 °
{q0, q1, q2, q3}	float	16	8a 22 28 bf	-0.656777
			5a b7 00 be	-0.125699
			20 4f 3d bf	-0.739489
			1c 0b 52 3d	0.0512801
reserved	*	4	...	*
local_time	uint32	4	0c ae 00 00	44556 ms
system_time	uint32	4	cb 17 01 00	71627 ms
reserved	*	1	...	*
{eop.x, eop.y, eop.z} * 100	uint8	3	0b	0.11 m
			10	0.16 m
			ff	2.55 m
supply_voltage * 1000	uint16	2	54 13	4.948 V
reserved	*	5	...	*
Sum Check	uint8	1	fd	0xfd

8.1.2.3 NLink_LinkTrack_Node_Frame0

Data Source： The WINCC is connected to A0, and the Setting protocol is NLink_LinkTrack_Node_Frame0, T0 and T2 work normally in the network. Among them, the data "11

22 33 44 55 66 77 88 99" and "11 12 23 22 32 44 34 54 55 65 67 76 67 87 77 99 aa a2 13 45 57 65 56 56 56 56 57 78 43 33 34 44 44 44 44 46 76" were continuously transmitted at 50Hz frequency through T0 and T2, respectively.

Raw Data： 55 02 42 00 01 00 d1 2c c3 88 02 02 00 09 00 11 22 33 44 55 66 77 88 99 02 02 25 00 11 12 23 22 32 44 34 54 55 65 67 76 67 87 77 99 aa a2 13 45 57 65 56 56 56 56 57 78 43 33 34 44 44 44 44 44 46 76 0d

Table 28: NLink_LinkTrack_Node_Frame0 analytical table

Data	Type	Length (B)	Hex	Result
Frame Header	uint8	1	55	0x55
Function Mark	uint8	1	02	0x02
Frame Length	uint16	2	42 00	66Bytes
role	uint8	1	01	ANCHOR
id	uint8	1	00	0
reserved	*	4	...	*
valid_node_quantity	uint8	1	02	2
role	uint8	1	02	TAG
id	uint8	1	00	0
data_length	uint16	2	09 00	9Bytes
data[length]	uint8	1*length	11 22 33 44 55 66 77 88 99	data
role	uint8	1	02	TAG
id	uint8	1	02	2
data length	uint16	2	25 00	37Bytes
data[length]	uint8	1*length	11 12 23 22 32 44 34 54 55 65 67 76 67 87 77 99 aa a2 13 45 57 65 56 56 56 56 57 78 43 33 34 44 44 44 44 46 76	data
Sum Check	uint8	1	0d	0x0d

8.1.2.4 NLink_LinkTrack_Node_Frame1

Data Source： The WINCC is connected to C0, and the Setting protocol is NLink_LinkTrack_Node_Frame1, T0 and T2 work normally in the network.

Raw Data： 55 03 44 00 03 00 e8 80 00 00 00 86 00 00 01 51 01 e8 01 f2 02 02 92 09 48 13 02 02 00 5f 0b 00 86 09 00 9b ff ff c9 37 8a 34 06 ee 37 3f aa 02 02 93 09 00 45 09 00 c4 fc ff 8d 09 00 66 09 00 c4 fc ff 8e

Table 29: NLink_LinkTrack_Node_Frame1 analytical table

Data	Type	Length (B)	Hex	Result
Frame Header	uint8	1	55	0x55
Function Mark	uint8	1	03	0x03
Frame Length	uint16	2	44 00	68 Bytes
role	uint8	1	03	CONSOLE
id	uint8	1	00	0
system_time	uint32	4	e8 80 00 00	33000 ms
local_time	uint32	4	00 86 00 00	34304 ms

reserved	*	10	...	*
voltage * 1000	uint16	2	48 13	4.936V
valid_node_quantity	uint8	1	02	2
role	uint8	1	02	TAG
id	uint8	1	00	0
{pos.x, pos.y, pos.z} * 1000	int24	9	5f 0b 00	2.911 m
			86 09 00	2.438 m
			9b ff ff	-0.101 m
reserved	*	9	...	*
role	uint8	1	02	TAG
id	uint8	1	02	2
{pos.x, pos.y, pos.z} * 1000	int24	9	93 09 00	2.451 m
			45 09 00	2.373 m
			c4 fc ff	-0.828 m
reserved	*	9	...	*
Sum Check	uint8	1	8e	0x8e

8.1.2.5 NLink_LinkTrack_Node_Frame2

Data Source： The WINCC is connected to T0, and the Setting protocol is NLink_LinkTrack_Node_Frame2, A0, A1, A2, and A3 work normally in the network.

Raw Data： 55 04 ac 00 02 01 ba 66 1d 00 06 09 ff de 0a 00 df ff ff e8 03 00 fa ff ff 1a 00 00 00 00 00 c0 12 00 00 00 00 00 00 00 27 ac e2 3c 56 ed 1c 3c d2 70 3b bd 32 57 66 3e 3b cb 1b 41 93 70 61 bd 25 b2 6b 41 a1 22 6c 41 da da 6b 41 6d 23 e9 23 70 dd db f7 30 3f 5f d6 31 3f ba 81 1e 3e 47 69 e2 bd 91 9b 40 40 c5 23 00 00 40 40 5c d5 1c 00 00 00 1d 00 6d 13 04 01 00 6b 0c 00 b1 9f a6 66 1d 00 16 45 01 01 ac 15 00 b4 a1 a6 66 1d 00 d3 01 01 02 48 1a 00 ca 9f a6 66 1d 00 38 ba 01 03 2b 12 00 c6 a0 a6 66 1d 00 64 40 25

Table 30: NLink_LinkTrack_Node_Frame2 analytical table

Data	Type	Length (B)	Hex	Result
Frame Header	uint8	1	55	0x55
Function Mark	uint8	1	04	0x04
Frame Length	uint16	2	ac 00	172 Bytes
role	uint8	1	02	TAG
id	uint8	1	00	0
system_time	uint32	4	ba 66 1d 00	1926842 ms
{eop.x, eop.y, eop.z} * 100	uint8	3	06	0.06 m
			09	0.09 m
			ff	2.55 m
{pos.x, pos.y, pos.z} * 1000	int24	9	de 0a 00	2.782 m
			df ff ff	-0.033 m
			e8 03 00	1 m

{vel.x, vel.y,vel.z} * 10000	int24	9	fa ff ff	-0.0006 m/s
			1a 00 00	0.0026 m/s
			00 00 00	0 m/s
reserved	int24	9	...	*
{g.x, g.y, g.z}	float	12	27 ac e2 3c	0.02767 rad/s
			56 ed 1c 3c	0.00958 rad/s
			d2 70 3b bd	-0.04576 rad/s
{acc.x, acc.y, acc.z}	float	12	32 57 66 3e	0.224942 m/s^2
			3b cb 1b 41	9.73712 m/s^2
			93 70 61 bd	-0.05504 m/s^2
reserved	*	12	...	*
{angle.x, angle.y, angle.z}*100	int16	6	6d 23	90.69 °
			e9 23	91.93 °
			70 dd	-88.48 °
{q0, q1, q2, q3}	float	16	db f7 30 3f	0.691282
			5f d6 31 3f	0.694677
			ba 81 1e 3e	0.154792
			47 69 e2 bd	-0.110552
reserved	*	4	...	*
local_time	uint32	4	c5 23 00 00	9157
reserved	*	10	...	*
voltage * 1000	uint16	2	6d 13	4.973 V
valid_node_quantity	uint8	1	04	4
role	uint8	1	01	ANCHOR
id	uint8	1	00	0
dis * 1000	int24	3	6b 0c 00	3.179 m
fp_rssi * (-2)	uint8	1	b1	-88.5 dB
rx_rssi * (-2)	uint8	1	9f	-79.5 dB
reserved	*	6	...	*
role	uint8	1	01	ANCHOR
id	uint8	1	01	1
dis * 1000	int24	3	ac 15 00	5.548 m
fp_rssi * (-2)	uint8	1	b4	-90 dB
rx_rssi * (-2)	uint8	1	a1	-80.5 dB
reserved	*	6	...	*
role	uint8	1	01	ANCHOR
id	uint8	1	02	2
dis * 1000	int24	3	48 1a 00	6.728 m

fp_rssi * (-2)	uint8	1	ca	-101 dB
rx_rssi * (-2)	uint8	1	9f	-79.5 dB
reserved	*	6	...	*
role	uint8	1	01	ANCHOR
id	uint8	1	03	3
dis * 1000	int24	3	2b 12 00	4.651 m
fp_rssi * (-2)	uint8	1	c6	-99 dB
rx_rssi * (-2)	uint8	1	a0	-80 dB
reserved	*	6	...	*
Sum Check	uint8	1	25	0x25

8.1.2.6 NLink_LinkTrack_Node_Frame3

Data Source： The WINCC is connected to T1, and the Setting protocol is NLink_LinkTrack_Node_Frame3, A0, A1, A2, and A3 work normally in the network.

Raw Data： 55 05 32 00 02 01 f8 11 07 00 6f d0 6e 00 00 00 01 02 5a 13 04 01 00 22 0b 00 b5 9f 01 01 a3 17 00 b6 a0 01 02 88 1c 00 aa 9f 01 03 e6 14 00 b8 a0 9a

Table 31: NLink_LinkTrack_Node_Frame3 analytical table

Data	Type	Length (B)	Hex	Result
Frame Header	uint8	1	55	0x55
Function Mark	uint8	1	05	0x05
Frame Length	uint16	2	32 00	50 Bytes
role	uint8	1	02	TAG
id	uint8	1	01	1
local_time	uint32	4	f8 11 07 00	463352 ms
system_time	uint32	4	6f d0 6e 00	7262319 ms
reserved	*	4	...	*
voltage * 1000	uint16	2	5a 13	4.954 V
valid_node_quantity	uint8	1	04	4
role	uint8	1	01	ANCHOR
id	uint8	1	00	0
dis * 1000	int24	3	22 0b 00	2.85 m
fp_rssi * (-2)	uint8	1	b5	-90.5 dB
rx_rssi * (-2)	uint8	1	9f	-79.5 dB
reserved	*	6	...	*
role	uint8	1	01	ANCHOR
id	uint8	1	01	1
dis * 1000	int24	3	a3 17 00	6.051 m
fp_rssi * (-2)	uint8	1	b6	-91 dB
rx_rssi * (-2)	uint8	1	a0	-80 dB
reserved	*	6	...	*

role	uint8	1	01	ANCHOR
id	uint8	1	02	2
dis * 1000	int24	3	88 1c 00	7.304 m
fp_rssi * (-2)	uint8	1	aa	-85 dB
rx_rssi * (-2)	uint8	1	9f	-79.5 dB
reserved	*	6	...	*
role	uint8	1	01	ANCHOR
id	uint8	1	03	3
dis * 1000	int24	3	e6 14 00	5.35 m
fp_rssi * (-2)	uint8	1	b8	-92 dB
rx_rssi * (-2)	uint8	1	a0	-80 dB
reserved	*	6	...	*
Sum Check	uint8	1	9a	0x9a

8. 1. 2. 7 NLink_LinkTrack_Setting_Frame0

Through the Setting_Frame0 protocol, the functions of reading the current node role, id, and ANCHOR coordinates and writing the ANCHOR coordinates can be implemented. It is important to note that, if perform a write operation, you need to embed part of the read data into the data frame to be written after the read operation. Examples are as follows:

【Read Operation】

Fill in the Mix in Setting_Frame0 with 0x01, other variables can be any value, in general, fill in 0xff. Fig. 21 is the C0 Setting diagram. The **read input frame** is sent to C0 through the communication interface, and the **read return frame** returned by C0 can be received.

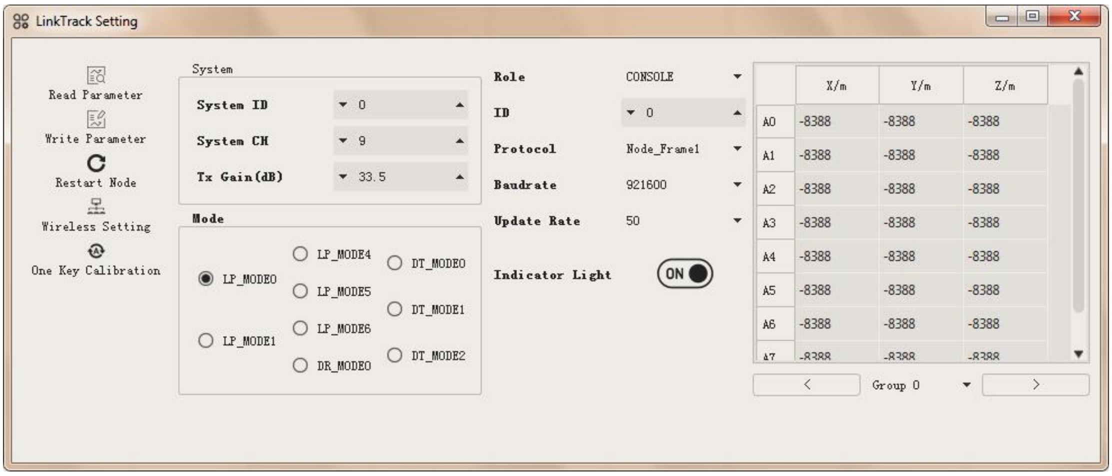


Fig. 21: Setting diagram when all C0 coordinates are invalid

Read Input Frame: 54 00 01 ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff d9

Read Return Frame: 54 00 00 03 02 00 10 0e 09 00 32 00 00 00 11 00 00 00 ff 03 43 00 00 00 14 00 00 6e 67 00 00 00 00 00 00 00 00 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02

80 60 02 80 6d

【Write Operation】

After reading the Setting of the node, if you want to write and modify the ANCHOR coordinates, on the basis of the frame returned by the above reading, you can update the final Checksum checksum after modifying the relevant variables in the group and ag regions, and pay attention to keeping other variables unchanged. It is assumed here that the coordinates of A0 ~ A3 ANCHORs are modified, then group is 0, a0 (or a00), a1 (or a01), a2 (or a02), and a3 (or a03) are the coordinates of corresponding values, all values of a4 ~ a9 (or a04 ~ a09) are all -8388 invalid values. The Setting interface corresponding to the **write input frame** in this example is shown in Fig. 22.

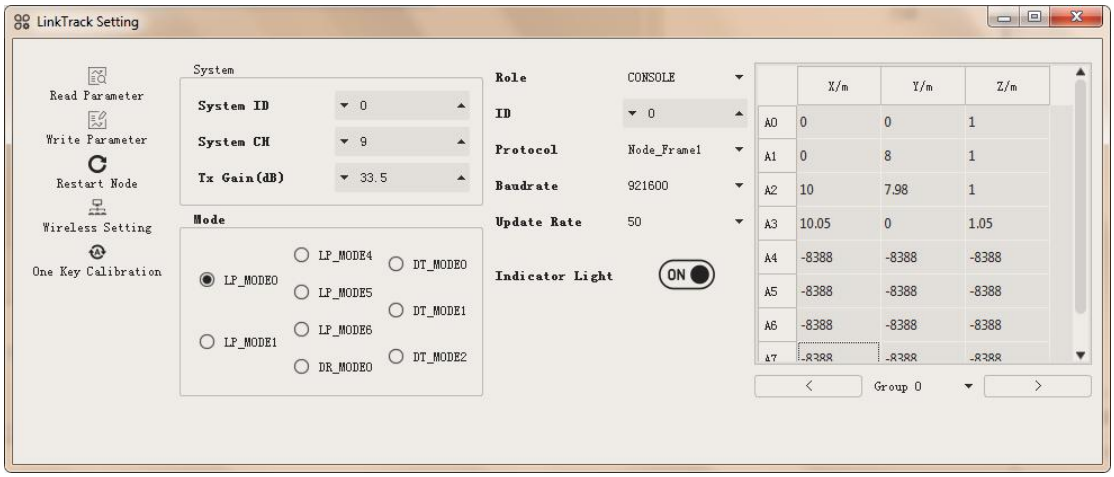


Fig. 22: Setting diagram when C0 partial coordinates are valid

Write Input Frame：54 00 00 03 02 00 10 0e 09 00 32 00 00 00 11 00 00 00 ff 03 43 00 00 00 14 00 00 f2 69 00 00 00 00 00 00 00 00 00 00 00 00 00 e8 03 00 00 00 00 40 1f 00 e8 03 00 10 27 00 2c 1f 00 e8 03 00 42 27 00 00 00 00 1a 04 00 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 60 02 80 84

The write return frame is consistent with the content of the write input frame data.

Table 32 is the parsing table corresponding to the content of the write input frame in the above example.

Table 32: Write input frame analytical table of NLink_LinkTrack_Setting_Frame0

Data	Type	Length (B)	Hex	Result
Frame Header	uint8	1	54	0x54
Function Mark	uint8	1	00	0x00
mix	uint8	1	00	Write
role	uint8	1	03	TAG
reserved	*	*	02 00 10 0e 09	*
id	uint8	1	00	0
reserved	*	4	32 00 00 00 11 00 00 00 ff 03 43 00 00 00 14 00 00 f2 69 00 00 00 00 00 00 00	*
group			00	group0

{ag0.x, ag0.y, ag0.z} * 1000	int24	12	00 00 00	a0.x = 0m
			00 00 00	a0.y = 0m
			e8 03 00	a0.z = 1m
{ag1.x, ag1.y, ag1.z} * 1000	int24	12	00 00 00	a1.x = 0m
			40 1f 00	a1.y = 8m
			e8 03 00	a1.z = 1m
{ag2.x, ag2.y, ag2.z} * 1000	int24	12	10 27 00	a2.x = 10m
			2c 1f 00	a2.y = 7.98m
			e8 03 00	a2.z = 1m
{ag3.x, ag3.y, ag3.z} * 1000	int24	12	42 27 00	a3.x = 10.05m
			00 00 00	a3.y = 0m
			1a 04 00	a3.z = 1.05m
{ag4.x, ag4y, ag4.z} * 1000	int24	12	60 02 80	a4.x = -8388m, invalid
			60 02 80	a4.y = -8388m, invalid
			60 02 80	a4.z = -8388m, invalid
{ag5.x, ag5.y, ag5.z} * 1000	int24	12	60 02 80	a5.x = -8388m, invalid
			60 02 80	a5.y = -8388m, invalid
			60 02 80	a5.z = -8388m, invalid
{ag6.x, ag6.y, ag6.z} * 1000	int24	12	60 02 80	a6.x = -8388m, invalid
			60 02 80	a6.y = -8388m, invalid
			60 02 80	a6.z = -8388m, invalid
{ag7.x, ag7.y, ag7.z} * 1000	int24	12	60 02 80	a7.x = -8388m, invalid
			60 02 80	a7.y = -8388m, invalid
			60 02 80	a7.z = -8388m, invalid
{ag8.x, ag8.y, ag8.z} * 1000	int24	12	60 02 80	a8.x = -8388m, invalid
			60 02 80	a8.y = -8388m, invalid
			60 02 80	a8.z = -8388m, invalid
{ag9.x, ag9.y, ag9.z} * 1000	int24	12	60 02 80	a9.x = -8388m, invalid
			60 02 80	a9.y = -8388m, invalid
			60 02 80	a9.z = -8388m, invalid
Sum Check	uint8	1	6d	0x6d

It should be noted that the ANCHOR coordinate writing is valid only when writing to ANCHOR or CONSOLE under LP Mode. TAG only supports reading of ANCHOR coordinates, but does not support writing. Default values of all ANCHOR coordinates on TAG are invalid and will not be updated until the corresponding valid ANCHOR coordinates are received. The specific value of the TAG receiving ANCHOR coordinates can be queried by the **read input frame**. The ANCHOR coordinates are not saved when TAG is powered off, and the initialization values of all ANCHOR coordinates are still invalid next time power goes on.

Gruop in the protocol represents the ANCHOR group. When gruop is 0, the corresponding ANCHOR coordinates are A0~A9. When gruop is 1, the corresponding ANCHOR coordinates are A11~A19. When gruop is 11, the corresponding ANCHOR coordinates are A110~A119.

8.2 NMEA-0183

8.2.1 Introduction

At present, the output protocol of the NMEA-0183 on the TAG end is GGA, GSA, and RMC data frames. Among them, the corresponding relationship between the meanings of each variable is as follows:

Table 33: GGA variable corresponding relationship

GGA Variable	Output Value
UTC	System time
Latitude	Latitude
Latitude Indicator	
Longitude	Longitude
Longitude Indicator	
GPS Quality Indicator	Invalid positioning output: 0； positioning valid output: 1
Viewable Satellites	Anchor Quantity，Number of effective Anchor
HDOP	eop.xy
Altitude	pos.z, corresponding tag Z axis coordinates
Altitude Unit	m
GEOID	Fixed output 0.000
GEOID Unit	m
RTCMSC	No output
DRSID	Fixed output “ 0000 ”

Table 34: GSA variable corresponding relationship

GSA Variable	Output Value
LocationMode	Fixed output：1
LocationType	Fixed output：3
PR0~PR11	ID of the ANCHOR participating in the positioning, not output if not participating
PDOP	eop.xyz, comprehensive position accuracy estimation factor
HDOP	eop.xy, level accuracy estimation factor
VDOP	eop.z, Vertical accuracy estimation factor

Table 35: variable corresponding relationship

GSA Variable	Output Value
UTC	network_system_time
NavigationStatus	A = Positioning is valid, V = Positioning is invalid
Latitude	Latitude
Latitude Indicator	

Longitude	Longitude
Longitude Indicator	
SpeedOverGrond	Ground speed
TrackAngle	Ground course
DataOfFix	UTC date
MagneticVariation	Magnetic variation
MagneticVariation Directin	Magnetic variation direction, E (East) or W (West)
ModeIndicator	Mode indicator

8.2.2 Example

This document takes "1 tag + 4 ANCHOR" as the scenario and runs on LP_MDOE0 as an example to introduce the principle of communication protocol analysis. In the course of the experiment, four ANCHOR were configured as A0~A3, and one TAG was configured as T0.

Data Source： The WINCC is connected to T0, and the Setting protocol is NMEA-0183, A0, A1, A2, and A3 work normally in the system. The following data is the corresponding data frame at a certain time, it should be noted that the NMEA-0183 protocol is represented by ASCII code, so ASCII code should be used instead of HEX when displaying data through serial port assistant.

Raw Data：

$GPGGA,000522.953,2231.08747980,N,11354.04484670,E,1,04,0.030,-0.681,M,0.000,M,,0000*43

$GPGSA,A,3,0,1,2,3,,,,,,,,,2.550,0.030,2.549*39

$GPRMC,000522.953,A,2231.08747980,N,11354.04484670,E,000.007,125.498,080318,,,A*62

The data analysis content is shown in Fig. 23

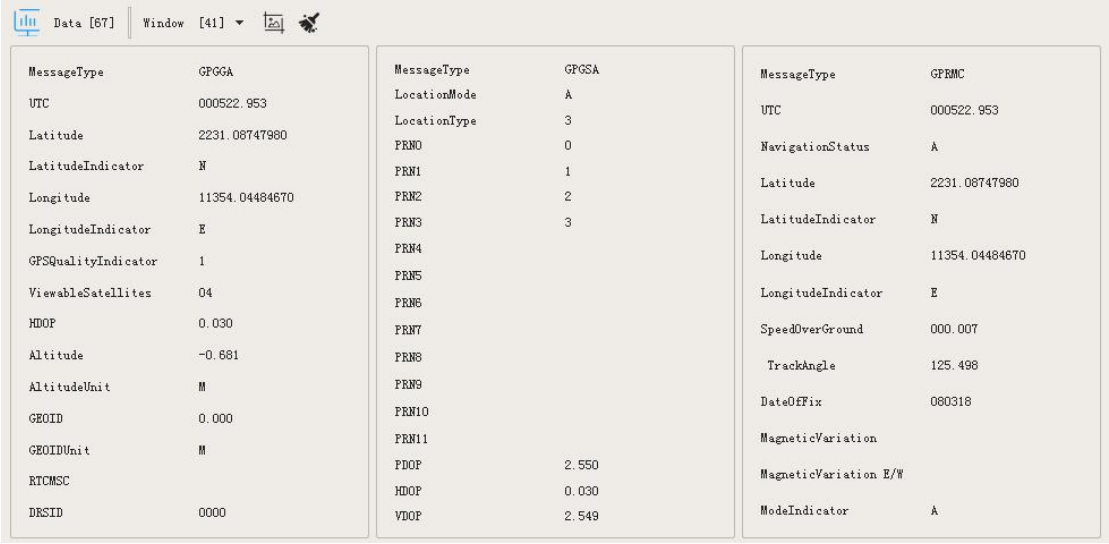


Fig. 23: NMEA-0183 data analysis diagram

9 How to Deal with

9.1 Read Manuals Carefully

Nooploop introduces the problems that users may encounter in the manual as much as possible, especially the data manual, user manual and NLink protocol manual. The data manual mainly introduces the product parameters, working principle, experimental data, etc.； the user manual mainly introduces how to use the product and the matters needing attention and frequently asked questions during the use of the product； the NLink protocol manual mainly introduces the communication protocol of the product.

9.2 Poor Performan and Abnormal Analysis

If the problem has not been solved after self-investigation through the manual, feedback the relevant problem to the official.

Table 36: Fault information feedback form

Name	Content
Firmware version number	The current node firmware version number, the general firmware version number requires the same, if inconsistent, please explain. Such as V4.0.0.
NAssistant version number	The current NAssistant version number. Such as V4.0.2.
Operation mode	The mode that is currently running (specific mode in LP, DR, DT). Such as LP_MODE0.
Role and quantity	The current roles at work and their number. Such as TAG:4, ANCHOR:4, CONSOLE:1.
Phenomenon description	Describe the specific problem phenomenon. Such as distance, positioning fluctuations are too large.
Node Setting	Please connect important roles through NAssistant (generally, each role is required to have at least one Setting parameter diagram), read the Setting parameters and provide the corresponding screenshot. Such as the Setting of T0, A0, C0.
Abnormal effect diagram	The diagrams of related abnormal phenomena are intercepted through the graphical interface of NAssistant. If the distance fluctuation is too large, intercept the distance waveform in the waveform interface.
Field scene diagram	Provides a field scenario diagram of node installation.
Recorded file	If the performance is poor, connect the corresponding node by using the NAssistant, then record the data that can reflect the problem through the recording function, and provide the recording file in .dat format.

9.3 Feasibility Analysis

For complex or unconventional scenarios, users may face problems such as product model, ANCHOR deployment location, quantity, and model, and can seek help through official channels.

10 Appendix

10. 1 One-key Calibration

One-click calibration means that after clicking the 【One-key Calibration】 button through NAssistant, the ANCHOR coordinates can be automatically measured and stored in the corresponding ANCHOR, and there is no need to rewrite it the next time it starts. At the time of positioning, the tag can obtain the coordinates of these stored ANCHORs and calculate the positioning coordinates by combining with the distance it measures to the ANCHOR.

Fig. 24 is a schematic diagram of one-click calibration ANCHOR installation, the basic principles of which are as follows:

1. The current firmware supports up to 4 ANCHORs to be calibrated, and the ANCHORs need to be in the same plane.
2. When calibrating, A0 and A3 are the ANCHORs that must work, and A0 is automatically set as the origin O (0, 0, 0) of LPS coordinate system, and the direction of A0A3 is the positive direction of X axis of LPS coordinate system.
3. A1 and A2 coordinates are considered to be in the positive direction of the Y axis. If four ANCHORs are needed for calibration, A1 and A2 are required to be on the same side of the X axis.

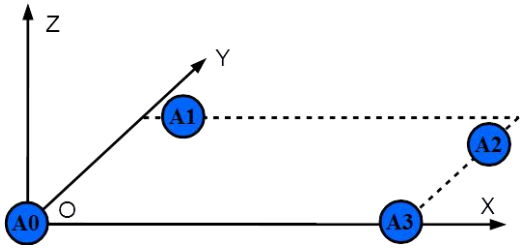


Fig. 24: One-key calibration of ANCHOR installation diagram

If the calibration of the ANCHOR is unsuccessful for a long time, please check as follows step:

1. Keep the ANCHORs unblocked and empty；
2. keep the ANCHOR in the same plane, the height error of each ANCHOR is generally not more than 20cm；
3. The ANCHOR layout range is generally recommended to be greater than 1 * 1m；
4. The length-width ratio of the ANCHOR is generally less than 3: 1；
5. If the above steps do not solve the problem, click "exit one-click calibration" through NAssistant, and the final calibration result will be stored in the ANCHOR or CONSOLE that initiated the one-click calibration.
6. If the calibration results are roughly consistent with the actual situation, the automatic calibration is completed； if there is a big difference from the actual situation, please determine the ANCHOR coordinates by other measurement methods, and write the parameters after entering the ANCHOR coordinates.

11 FAQ

Q1. Can it be used outdoors (can it be positioned outdoors)？ How is it different from indoor positioning？

It works. It is no different from the indoor use mode, effect and so on.

Q2. The location is carried out through UWB, is the communication also through UWB？

Yes.

Q3. Is there a sequence for powering on the nodes such as tags, ANCHORs, and CONSOLE？ Does it support dynamic addition and reduction？

There is no sequence for power-on. Supports dynamic addition and reduction.

Q4. Are LP Mode and DR Mode positioning and data transmission functions the same physical interface？ How to output positioning frame and data transmission frame？

Yes, through the UART or USB physical interface. When the node does not receive the DT data, it only outputs the positioning frame data. When the node receives the DT data, it first outputs the positioning frame data and waits for about 1ms time to output the digital transmission frame.

Q5. The product is not recognized by NAssistant？

- Please check if there is a serial port. If there is no serial port, there may be a problem with the data cable or the CP2102 driver is not installed.
- If there is a serial port, please check whether there are multiple serial ports and select the corresponding serial port of the product.
- ID repetition and Setting errors lead to interference. Cut off the other working nodes, power on the nodes to be identified again and identify them.

Q6. Can the ANCHOR be in a moving state？

Sure. Generally, the ANCHORs are required to be in a static state with each other. The entire ANCHOR coordinate system can be shifted relative to the geographic coordinate system, and the tag positioning coordinates are always relative to the ANCHOR coordinate system.

Q7. Can LTS, LTP, LTSS, and LTPS be mixed？ What should I pay attention to？

Sure. Note that System CH needs to be configured to support all channels to achieve the best performance, and the farthest communication distance is determined by the shorter nodes. Therefore, it is generally recommended to mix LTS with LTSS and LTP with LTPS. In special cases, if LTS/LTSS is mixed with LTP/LTPS, System CH is recommended to be set to 2 or 3.

Q8. Can different firmware versions be mixed？

It is generally recommended that all working nodes keep the same firmware version. The firmware version may cause the system to fail to function properly.

Q9. Does the NAssistant system have to be run on the terminal to work properly？

Don't need. All networking and positioning solutions are completed in the module, and NAssistant

is mainly responsible for monitoring, display, control and Setting functions.

Q10. In LP Mode, there are only ANCHORs and tags, can the console not be used?

Its not mandatory. The ANCHOR has all the functions of the console: data monitoring and data communication. Under some conditions, the ANCHOR can be used as a console directly. Consider adding the console role when the following occurs:

- Terminal platforms (such as computers, tablets, mobile phones) need to be mobile.
- The terminal platform is not within the scope of monitoring.
- The ANCHOR data transmission bandwidth can not meet the demand.

Q11. How is the ANCHOR coordinate system determined?

It is realized by constructing a ANCHOR coordinate system, specifically defining the origin of the ANCHOR coordinate system (generally taking the A0 ANCHOR as the origin), X, Y, Z axis, and the coordinates relative to the ANCHOR coordinate system are written to the ANCHOR.

Q12. Under what circumstances do the ANCHOR coordinates need to be recalibrated?

- The situation when the relative position of the ANCHOR changes. For example, the UAV automatic apron scenario, if the ANCHOR is permanently installed on the apron, there is no need to re-calibrate the ANCHOR coordinates when the apron needs to be moved to another place, because the relative position of the ANCHOR has not changed.
- The calibration accuracy of ANCHOR coordinates can not meet the requirements.

Q13. Can the refresh frequency of TAGs, ANCHORs, consoles and other nodes be different?

Sure. Under LP_MODE0, for example, the refresh rate of T0 can be 50Hz, T1 can be 10Hz, A0 can be 1Hz, A1 can be 20Hz, C0 can be 50Hz.

Q14. As the number of tags increases, will the refresh frequency and data transmission bandwidth decrease?

No. As long as the working MODE is selected, the refresh frequency and data transmission bandwidth are not affected by the dynamic increase and decrease of nodes. For example, in the case of "1 tag + 4 ANCHOR" and "40 tag + 8 ANCHOR" working under LP_MODE0, the refresh frequency and data transmission bandwidth of each node are the same.

Q15. Can the "1 tag + 3 ANCHORs" be located? Does it support one-click calibration? What is the difference in positioning accuracy between "1 TAG + 3 ANCHORs" and "1 TAG + 4 ANCHORs"?

It can be located. Support one-click calibration. The positioning accuracy of "1 tag + 3 ANCHOR" is about worse than that of "1 tag + 4 ANCHOR" 2cm, and the eop accuracy estimation factor in the information is invalid, there is no redundant ANCHOR, and the reliability is poor, so the scheme of "1 tag + 4 ANCHOR" is generally recommended.

Q16. Why does the tag have no positioning data output?

- First confirm whether the tag has its distance output to the ANCHOR through NAssistant.
- The system can output coordinate information only when it runs under LP Mode.

- Coordinates need to be written to the ANCHOR / console.
- Generally, coordinate information is output after at least three ANCHORs are powered on.

Q17. How to test the communication distance of the module?

Prepare two modules, one configured as a tag (assumed to be T0 here) and one configured as a ANCHOR (assumed to be A0 here) , under LP Mode (which is assumed to be configured as LP_MODE0). Connect the tag to NAssistant via Type-C USB / UART, and test the distance from near to far (the mobile terminal provides more convenient testing for the ANCHOR), and watch the change of the dis0 waveform curve, as shown in Fig. 25.

Fig. 25: Measured scene of module distance

Q18. Why is the communication distance so close that it is very different from the description in the data manual?

- The communication distance test is measured under the condition of first-level optimization System CH, please check whether the product is configured correctly.
- The communication distance test is measured under the condition that TX Gain is 33.5dB, please check whether TX Gain is set up large enough.
- The communication distance test is measured under open conditions, please check whether there is occlusion between nodes.
- In the communication distance test, the (LTP) of the node with external antenna is measured when there is an antenna, please check whether there is an antenna installed.

Q19. For the LTP module, can we communicate without an antenna? What's the impact?

Sure. The communication distance will be shorter.

Q20. The ANCHOR is too close to the ANCHOR, will there be interference if the tag is too close to the ANCHOR?

No, all modules can be close together without interference.

Q21. Does the occlusion between the ANCHOR and the ANCHOR affect the location?

There will be no influence in positioning, and the system has an automatic selection mechanism. However, the one-key calibration requires no shielding between the ANCHOR and the ANCHOR to ensure the reliability of the calibration, otherwise the one-key calibration function cannot be used.

Q22. Does vibration have any influence on ranging and positioning?

It doesn't matter. For example, the tag installed on the UAV will follow the UAV to produce

high-frequency vibration, but it has no effect on ranging and positioning.

Q23. What factors are related to the positioning accuracy?

- ANCHOR geometry. For example, the accuracy of the X and Y coordinates of a ANCHOR installed in a 10 * 10m square is 10cm, while the accuracy of a short side installed in 2 * 10m may only be 0.5m, and the accuracy of the long side is still 10cm.
- The location of the tag. For example, the accuracy within the envelope surface of the ANCHOR is about 10cm, and the accuracy outside the envelope surface decreases, and the farther away from the envelope surface, the lower the accuracy. As shown in Fig. 26, the accuracy of T0 is the highest, T1 is the second, and T2 is the worst.

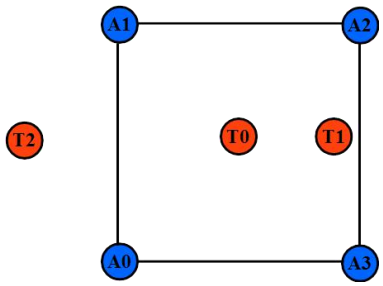


Fig. 26: Schematic of envelope surface positioning accuracy

Q24. Can the positioning function be realized out of the envelope surface of the ANCHOR? What will happen after getting out of the envelope of the ANCHOR?

It can be located. Generally speaking, the positioning accuracy of the tag outside the envelope surface is lower than that inside the envelope surface, and the farther away from the envelope surface, the lower the positioning accuracy.

Q25. Why does the positioning effect look bad?

- Please make sure that the ANCHOR coordinates are written correctly.
- Please confirm the fluctuation of the X and Y axis coordinates of the system under the open condition, and the fluctuation around the 10cm is a normal phenomenon.
- Please confirm whether there is an occlusion between the tag and the ANCHOR.
- Please confirm whether the ANCHOR is the same plane (for situations where the same plane is required);
- Whether the installation sequence of the ANCHOR is correct (for example, model1 is installed clockwise with A0A1A2A3);
- Whether the ANCHOR installation model is reasonable, otherwise the geometric accuracy factor is poor;
- Whether the tag is relatively far from the envelope surface of the ANCHOR;
- If there is no problem with all the above steps, please provide the Setting information of each node, the site installation photos and environment photos of the ANCHOR and tag, and record a data file (.dat format) that can reflect the unsatisfactory positioning effect by using NAssistant and feedback to the official.

Q26. Hope to develop new features in the future version, how to feedback to the R & D team?

Please send an email to "dev@nooploop.com".

12 Abbreviation and Acronyms

Table 37: Abbreviations and acronyms

Abbreviation	Full Title
UWB	Ultra Wideband
PNT	Positioning.Navigation. And Timing
PNTC	Positioning.Navigation.Timing.And Communication
LP	Local Positioning
CP	Centralized Positioning
DP	Distributed Positioning
DR	Distributed Ranging
DT	Data Transmission
LPS	Local Positioning System
GPS	Global Positioning System
BDS	BeiDou Navigation Satellite System
GNSS	Global Navigation Satellite System
LOS	Line of Sight
NLOS	Non-Line of Sight
RSSI	Received Signal Strength Indication
DOP	Dilution of Precision
PDOP	Position Dilution of Precision
HDOP	Horizontal Dilution of Precision
VDOP	Vertical Dilution of Precision
EOP	Esimation of Precision
PLR	Packet Loss Rate
IMU	Inertial Measurement Unit
WGS	World Geodetic System

13 Reference

[1] LinkTrack Datasheet

[2] NLink

14 Update Log

Table 38: Update Log

Version	Data	Description
1.0	20200324	● Release the first edition of the manual
1.1	20190731	● Fixed error details described in 4.1.1. ● Added RSSI description introduction. ● Added a detailed description of the use of NMEA-0183. ● Increased the number of FAQ.
2.0	20200323	● A comprehensive update of the manual
2.1	20200508	● Added introduction of LTSS and LTPS. ● Adapted the related content that the latitude and longitude resolution of NMEA-0183 is improved by 4 digits in V4.0.1 firmware.

15 Further Information

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