AIT

Integrated GNSS/INS Fusion Navigation System INS-3820-R11

Technical Manual

V1.0

Integrated GNSS/INS Fusion Navigation System

INS-3820-R11

FEATURES

- **Multi-Constellation RTK**: BDS/GPS/Galileo/GLONASS/QZSS | **0.8 cm H / 1.5 cm V accuracy**.
- **Dual-Antenna Heading**: **0.05° static** | EMI-hardened for harsh zones.
- **200 Hz IMU**: Seamless GNSS outage navigation via kinematic modeling.
- **Drift Control**: **<0.2% over 1 km** | Odometry fusion cuts drift **10x vs. GNSS-only**.
- **200 Hz + CAN FD/Ethernet**: Ultra-low latency for AVs/robotics.
- **Post-Process to mm**: Raw data logging; **Sub-meter PPP** without RTK.
- **300g Rugged (IP65)**: For drones, AGVs, harsh sites.

APPLICATIONS

- **Autonomous Vehicles**: Lane-level navigation for self-driving cars; obstacle detection in urban canyons.
- **Agriculture & Precision Farming**: Autonomous tractor guidance; crop health mapping via drone integration.
- **Construction & Heavy Machinery**: Grade control for excavators; crane/swing-arm anti-collision systems.
- **Marine & Offshore**: Offshore platform navigation; underwater ROV positioning.
- **Drones & Aerial Surveying**: Centimeter-accurate LiDAR/Photogrammetry for 3D mapping.
- **Geospatial & Infrastructure**: Bridge deformation monitoring; railway track alignment.

DESCRIPTION

The INS-3820-R11 is a next-generation **Integrated GNSS/INS Fusion Navigation System** engineered for industries demanding uncompromising precision. By fusing multi-constellation RTK signals, dual-antenna heading correction, and high-frequency inertial data, it delivers **continuous centimeter-level accuracy**—even in urban canyons, tunnels, or dense foliage.

Precision Engineered for Critical Applications:

- **RTK-Enhanced Positioning:** Leveraging full-frequency BDS, GPS, Galileo, GLONASS, and QZSS signals, the INS-3820-R11 performs real-time kinematic corrections to achieve **0.8 cm horizontal / 1.5 cm vertical accuracy**—ideal for autonomous vehicles, precision agriculture, and aerial surveying.
- **Dual-Antenna Heading Optimization:** Dual GNSS antennas provide **0.05° static heading accuracy**, eliminating reliance on magnetic sensors and ensuring reliability in electromagnetic interference (EMI)-heavy environments.
- **Seamless Inertial Navigation:** When GNSS signals degrade, the system transitions to **200 Hz IMU-driven navigation**, aided by vehicle kinematics and proprietary divergence suppression algorithms. With odometry fusion, positional drift is reduced to **<0.2% over 1 km**—10x tighter than conventional GNSS-only systems.
- **Tightly Coupled Fusion Architecture:** Deep integration of satellite, inertial, and odometry data through adaptive Kalman filtering ensures **sub-decimeter accuracy** during rapid acceleration, sharp turns, or signal outages.

Why Choose the INS-3820-R11?

- **Robust Redundancy:** Dual antennas and multi-source fusion guard against single-point failures.
- **High Dynamic Performance:** 500 Hz output frequency and CAN FD support meet the latency demands of autonomous driving and robotics.
- **Post-Processing Flexibility:** Raw data logging enables centimeter-accurate trajectory reconstruction for mapping and forensic analysis.

For drones, AGVs, or industrial machinery operating in GPS-hostile environments, the INS-3820-R11 sets the benchmark for **always-accurate navigation**.

TECHNICAL PARAMETER

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B3I/L5/E5a/B2a Pseudo-distance	10cm	10cm	10cm	10cm
B3I/L5/E5a/B2a Carrier phase	1mm	1mm	1mm	1mm
Measuring range of roll/pitch/yaw	Roll±180°, pitch±90°, Yaw 0~360°			
Heading accuracy (with GNSS signal)	0.05° static 0.1° dynamic			
Roll/Pitch（1σ）(with GNSS signal)	0.03° static 0.1° dynamic			
GPS Loss of Lock Accuracy (on-board CEP)	Position drift (1km or 2min)		0.2%, with odometer combination	
	Heading drift (1min)		0.15°	
Gyro range	±400°/s	Gyro Bias Stability	3 °/h （10s smooth） 0.3°/h（Allan variance）	
Accelerometer range	±8 g (default ±2g)	Accelerometer Bias Stability	50ug（10s smooth）	
Output frequency	200Hz			

COMMUNICATION INTERFACE

Interface Type

Interface	Connector Type	Description
16G-12 Core Square Flange (Male)	16G-10 Core Square Flange (Female)	Power interface /Communication port
16G-10 Core Square Flange (Male)	16G-10 Core Square Flange (Female)	Power interface /Communication port
TNC Female	TNC Male	GNSS Main Antenna Interface
TNC Female	TNC Male	GNSS Satellite Antenna Interface

Serial port settings

Baud rate	8000000/ 460800 / 230400 / 115200 / 19200 / 9600 / 2400
Data bits	8
Default configuration	115200 8 1Non-validated
Serial port optional	RS422(RS485) / RS232

Other interfaces

Two CAN FD interfaces
One Ethernet interface

PRODUCT LIST

Type	Name	Model	Quantity	Note
Factory standard	GNSS	INS-3820-R11	1	Net weight: 300g
Standard	Power interface /Communication port	16G-12-core - Square flange (female + 0.5m cable)	1	Net weight: 170g
Standard	Power interface /Communication port	16G-10-core - Square flange (female + 0.5m cable)	1	Net weight: 170g
Optional	GNSS Antenna	BT-300 antenna + large base stud +TNC coaxial feed line (5m)	2	Net weight: 360g
Optional	4GDTU module	MD-649R	1	

DIMENSIONS

Outline Dimensions

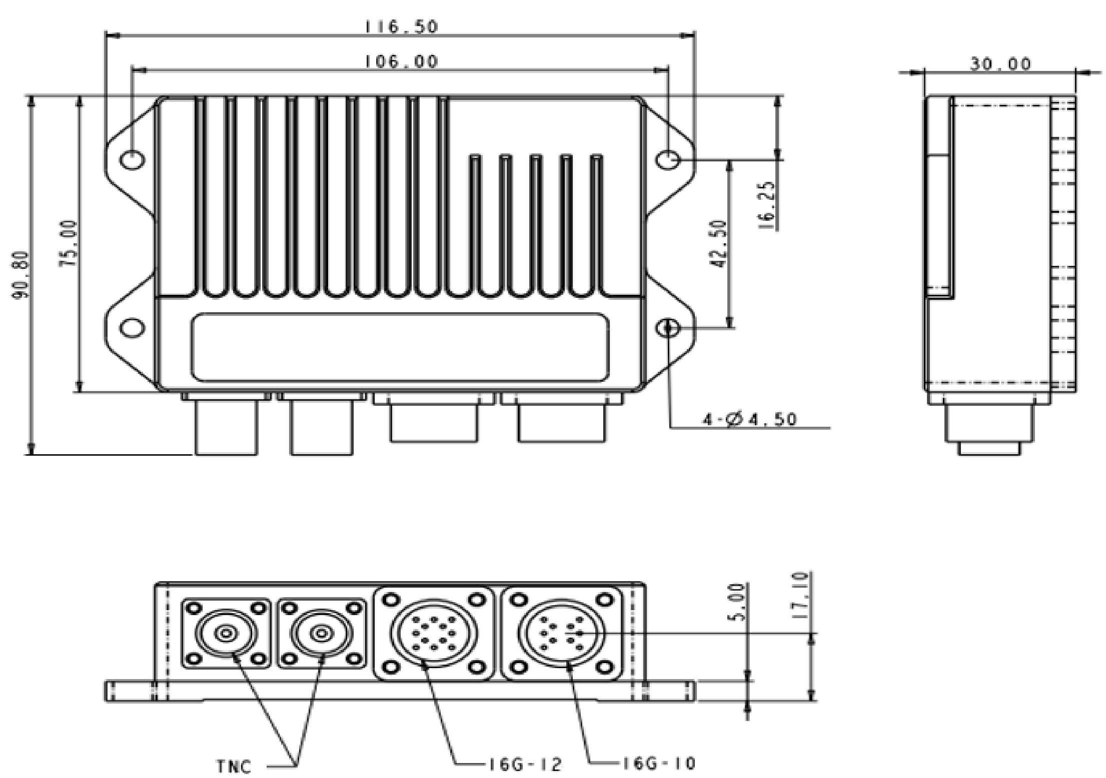

Figure 1. Outline Dimensions

INSTALLATION AND REQUIREMENTS

Basic Hardware Connection Diagram

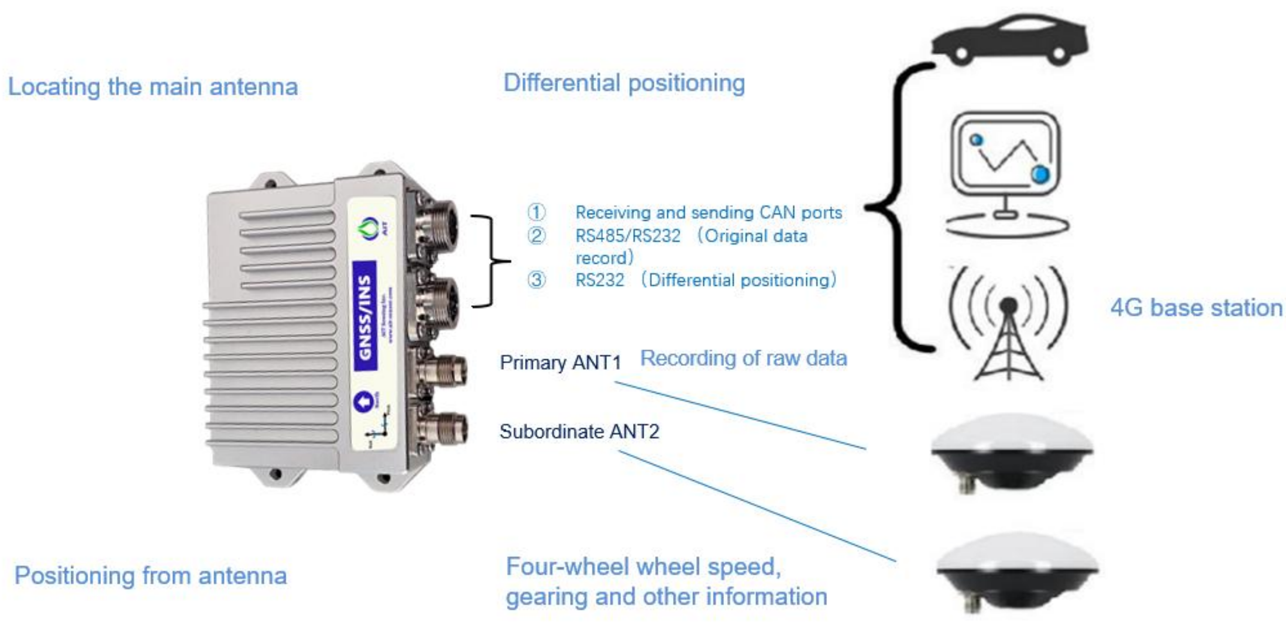

Figure 2. Connection Diagram

Pin Definitions

12-core (cable)			10-core (cable)		
Pin No.	**Signal Name(Color)**	**Function Description**	**Pin No.**	**Signal Name(Color)**	**Function Description**
A1	POWER_IN (Brown)	DC 9-36V (Power Input)	B1	PPS_3.3V (Brown)	Clock Synchronization Pulse (3.3V)
A2	AGND (White)	Analog Ground (Power Negative Pole)	B2	INT (White)	Event Interrupt Input
A3	WKUP (Blue)	External Wake-Up	B3	EVENT (Blue)	Event Interrupt Output
A4	CANH1 (Black)	CAN1 Signal Pin	B4	DGND (Black)	Digital Ground
A5	CANL1 (Gray)	CAN1 Signal Pin	B5	CANH2 (Gray)	CAN2 Signal Pin
A6	232RXD (Pink)	232 Communication Pin	B6	CANL2 (Pink)	CAN2 Signal Pin
A7	232TXD (Purple)	232 Communication Pin	B7	ETH_RX+ (Purple)	Ethernet Pin
A8	DGND (Orange)	Digital Ground	B8	ETH_RX- (Orange)	Ethernet Pin
A9	485_A/422_T+ (Gray-Pink)	485/422 Communication Pin	B9	ETH_TX+ (Gray-Pink)	Ethernet Pin
A10	485_B/422_T- (White-Blue)	485/422 Communication Pin	B10	ETH_TX- (White-Blue)	Ethernet Pin
A11	422_R+ (White-Gray)	422 Communication Pin			
A12	422_R- (Gray-Brown)	422 Communication Pin			

GNSS Antenna Specifications

The GNSS antenna used by the INS-3820-R11 needs to be an active antenna. The INS-3820-R11 provides a 5V DC antenna feed and supports a maximum of 200mA current. The recommended or required parameters are listed below:

1. Frequency points to be supported:

GNSS	frequency	GNSS	frequency
BDS	B1I/B2I/B3I	Galileo	E1/E5a/E5b
GPS	L1/L2/L5	QZSS	L1/L2/L5
GLONASS	G1/G2	-	L-band

2. Recommended gain: 40dB
3. Recommended noise figure: NF<1.5
4. Feed: 2.8~5V
5. Phase center error: ±2mm.

RF coaxial cable specifications

Master antenna RF coaxial cable should be matched with the impedance of the antenna and receiver, the characteristic impedance is 50Ω, and the recommended line attenuation is less than 10dB. RF coaxial cable connector is adapted to the GNSS antenna at one end, and FAKRA-C connector is adapted to the master antenna interface of INS-3820-R11 at the other end.

Slave antenna RF coaxial cable should be matched with the impedance of the antenna and receiver, the characteristic impedance is 50Ω, the recommended line attenuation is less than 10dB. RF coaxial cable connector at one end to adapt to the GNSS antenna, at the other end of the FAKRA-D connector to adapt to the INS-3820-R11 slave antenna interface.

Temperature and protection class

INS-3820-R11 has the following temperature requirements.

1.Working temperature -40°C~+85°C.

2.Storage Temperature -55°C~+95°C

Protection grade: IP54

Power supply specifications

INS-3820-R11 requires the following power supply specifications.

1. Voltage range +9V~+36V DC
2. At least 10W stable output power

Installation of GNSS antenna

The INS-3820-R11 is currently available in dual antenna as well as single antenna versions.

The following considerations apply when installing the GNSS antenna:

1. The GNSS antenna location is open and unobstructed above the carrier.
2. The GNSS antenna is rigidly connected to the carrier to ensure that the antenna will not shake when the carrier is moved.
3. Under dual-antenna mode, it is recommended that the antenna distance is more than 1 meter, and the farther apart the better.

In GNSS dual antenna mode, it is recommended that the baseline of the dual antennas is horizontal to the forward direction of the carrier, as shown in the figure below:

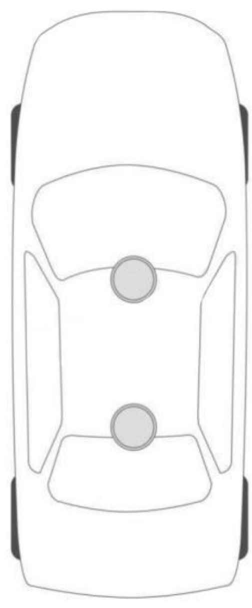

Figure 2. Installation Diagram

Installation of INS-3820-R11 complete machine

In order to improve the accuracy, the IMU should be installed horizontally as close as possible to the main GNSS antenna, and it must be ensured that the INS-3820-R11 is rigidly connected to the carrier to ensure that the relative positions of the INS-3820-R11 and the antenna on the carrier are fixed. And to ensure that the INS-3820-R11 installation is stable and reliable, in the carrier travelling process will not move or shake.

In order to simplify the system configuration, it is recommended that the combination of navigation system INS-3820-R11 installed in close proximity to the carrier rear axle position, attitude to maintain a horizontal (i.e., the Z-axis should be perpendicular to the ground pointing upward), the Y-axis of the INS-3820-R11 should be pointing in the direction of the forward direction of the carrier (as shown in the figure below).

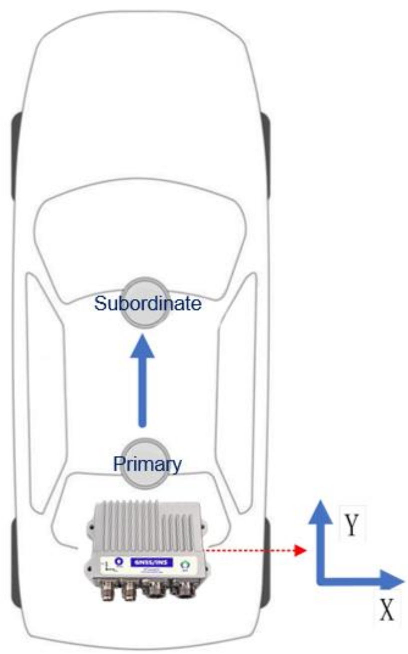

Figure 4. Installation Diagram

COMMUNICATION LINK

The INS-3820-R11 can use the serial port to communicate with external communication devices. Currently, commands and RTK data can only be sent through the 232 port.

Serial port

The Combined Navigation System INS-3820-R11 provides two serial ports as shown below:

Serial number	RS-232	RS-485	RS-422
COM1	Support	Not Supported	Not Supported
COM2	Not Supported	Support	Support

Power connection

Pin 1 POWER_IN and pin 3 KEY power enable pin in the connector are connected to the positive side of the power supply, and pin 2 GND is connected to the negative side of the power supply.

Check INS-3820-R11 status

After installing INS-3820-R11, turn on the power and send the command UNLOG, it should be noted that when using the serial assistant to send commands, you need to check the box to send a new line to confirm that the INS-3820-R11 is running normally, if so, the INS-3820-R11 will respond to the following content:
Command response: OK.

EQUIPMENT USE

Serial port communication

Ensure that the INS-3820-R11 has been installed as described in the previous section and is powered up and working before use.
The INS-3820-R11 can communicate with computers and other devices through the serial port. Before the two can establish communication, both INS-3820-R11 and computer need to configure the serial port parameters appropriately. The default serial port configuration of INS-3820-R11 is:

1.115200bps
2. No parity bit
3.8bit data bits
4.1bit stop bit
5.No parity bit
Only COM1 supports port configuration using the command CONFIG.

Command header	Serial device	Serial port parameter	Parameter Description
CONFIG	COM1 COM2	Baud rate	Setting the baud rate of the serial port
Command	Description		
config com1 115200	Set the baud rate of COM1 to 115200. You can set either COM1 or COM2 to any of the following baud rates: 2400, 9600, 19200, 115200, 230400, 460800, or 8000000.		

The command format is:
CONFIG [serial port device number] [serial port attribute parameter]
Simplified ASCII syntax:

GNGGA GNSS Multi-system Joint Positioning Data

This instruction is used to set the current serial port or the specified serial port to output the result of multi-system joint positioning, and the output information contains the time of the GNSS receiver and positioning related data. The statement starts with GNGGA. Depending on the satellite systems involved in positioning, the output may be GPGGA, BDGGA, GLGGA, GAGGA, GPGGA when only GPS satellite system is involved in positioning solution, BDGGA when only BDS satellite system is involved, GLGGA when only GLONASS satellite system is involved, GLGGA when only Galileo satellite system is involved, GLGGA when only Galileo satellite system is involved, GLGGA when only Galileo satellite system is involved. When only the Galileo satellite system is involved in the positioning solution, the output is in the form of GAGGA.
Output in the form of GAGGA. The output is in the form of GNGGA when only the GLONASS satellite system is

involved in the position solution, and in the form of GAGGA when only the Galileo satellite system is involved in the position solution.

Simplified ASCII format:

GNGGA 1 Outputs 1Hz GNGGA information from the current serial port.

GNGGA COM2 1 Outputs a 1Hz GNGGA message at com2.

Message output:

$GNGGA,025754.00,4004.74102107, N,11614.19532779, E,1,18,0.7,63.3224, M,-9.7848, m, 00,0000*58

GNGGA Data Structure

ID	field	Data Description	notation	typical example
1	$GNGGA	Log header		$GNGGA
2	utc	The UTC time to which the location corresponds.	hhmmss.ss	173568.00
3	lat	hh/mm/ss.ss	IIII.II	3251.2654
4	Lat dir	Latitude (DDmm.mm)	a	N
5	lon	Latitude direction (N = North, S = South)	yyyyy.yy	12033.3592
6	lon dir	Longitude (DDDmm.mm)	a	E
7	qual	Longitude direction (E = East, W = West)	x	1
8	# sats	GPS Quality Indicator	xx	10
9	hdop	0 = Positioning unavailable or invalid	x.x	1.0
10	alt	1 = Single point fix	x.x	1021.45
11	a-units	2 = Pseudorange Differential or SBAS positioning	M	M
12	undulation	4 = RTK fixed solution	x.x	-17.183
13	u-units	5 = RTK floating point solution	M	M
14	age	6 = Inertial guidance positioning	xx	(00 without differential data)
15	stn ID	7 = Fixed Position for User Setting	xxxx	(00 when no differential data)
16	*xx	Position)	*hh	*3F
17	[CR][LF]	Number of satellites in use. May not match the number seen		[CR][LF]

IMU Raw Data Information

This statement contains an indication of the IMU status and the measured values of the accelerometers and gyroscopes relative to the IMU housing coordinate system.

Command Format.

RAWIMUA COM1 1

ID	field	Data Description
1	$RAWIMUA	Log Header
2	Week	GNSS Week
3	Seconds Into Week	Seconds per week
4	Z Accel Output	Velocity varies along the Z-axis.
5	Y Accel Output	Velocity varies along the Y-axis.
6	X Accel Output	Velocity variation along the X-axis.
7	Z Gyro Output	The amount of angular change in the right-handed helix along the Z-axis.
8	Y Gyro Output	The amount of angular change in the right-handed helix along the Y-axis.
9	X Gyro Output	The amount of angular change in the right-handed helix along the X-axis.
10	*xx	Checksum
11	[CR][LF]	Statement terminator

INSPVA Combined Navigation Position, Speed and Attitude Information

Sets up the output of the combined navigation and positioning results, with ASCII statements beginning with "#INSPVA".

Recommended input.

INSPVAA com2 1

INSPVA Data Structure

ID	field	Data Description
1	$INSPVA	Log Header
2	Week	GNSS Week
3	Seconds	Seconds per week
4	Latitude	Latitude (WGS84) [degrees]
5	Longitude	Longitude (WGS84) [degrees]
6	Height	Ellipsoid height (WGS84) [m]
7	East Velocity	Eastward velocity (negative for southward) [m/s]
8	North Velocity	Northward velocity (negative for westward direction) [m/s]
9	Up Velocity	Velocity in the sky direction [m/s]
10	Roll	Cross-roll angle (right-handed spiral along Y-axis) [degrees]
11	Pitch	Pitch angle (right hand spiral along X-axis) [degrees]
12	Azimuth	Heading angle, counterclockwise from north (right-handed helix around the Z axis), which is the inertial azimuth calculated by the IMU gyro through a combined filter
13	Status	INS Status
14	xxxx	32-bit CRC
15	[CR][LF]	Statement terminator (ASCII only)

INSPVB Combined Navigation Position, Velocity and Attitude Information

Sets up the output of the combined navigation and positioning results in a binary statement that starts with "#INSPVB".

Recommended input.

INSPVAB com2 1

INSPVB Data Structure

ID	field		data description	typology	Byte Count Byte Offset	ID
1	Synchronization Segment		0x57	char	1	0
2	Frame Information		0x00	char	1	1
3	Length Segment		0x5B	char	1	2
4	Address Segment		0x00	char	1	3
5	Command Segment		0x03	char	1	4
6	data segment	Week	GNSS Week	Ulong	4	8
		Seconds	Seconds per week	Double	8	16
		Latitude	Latitude (WGS84) [degrees]	Double	8	24
		Longitude	Longitude (WGS84) [degrees].	Double	8	32
		Height	Ellipsoid Height (WGS84) [m]	Double	8	40
		East Velocity	Eastward velocity (negative for southward) [m/s]	Double	8	48
		North Velocity	Northward velocity (negative for westward direction) [m/s]	Double	8	56
		Up Velocity	Velocity in the sky direction [m/s]	Double	8	64
		Roll	Cross-roll angle (right-handed spiral along Y-axis) [degrees]	Double	8	72
		Pitch	Pitch angle (right hand spiral along X-axis) [degrees]	Double	8	80
		Azimuth	Heading angle, counterclockwise from north (right-handed helix around the Z axis), which is the inertial azimuth calculated by the IMU gyro through a combined filter	Double	8	88
		Status	INS Status	Enum	1	89
7		xxxx	32-bit CRC	Hex	4	93

Other commands

Unlog Stop Serial Port Output

This instruction is used to stop the serial port from outputting specific data messages. Configurable parameter [Statement] stops the output of corresponding data information;

Configurable parameter [Port] to stop port output. If no port is specified, the command defaults to the port currently receiving the command; if no message name is specified, the output of all messages will be stopped.

The command format is:

UNLOG [port] [message]

Simplified ASCII Syntax

UNLOG Stop outputting all messages for the current port.

UNLOG GNGGA Stop the output of GNGGA statement for the current serial port.

UNLOG COM1 Stop all messages from com1.

UNLOG COM2 GNGGA stops the GNGGA statement output from com2.

The parameters of the Unlog command are as follows：

Command header	port number	Description
UNLOG	COM1 COM2	Name of the message that will stop the output

saveconfig Save User Configuration

This command saves the current user configuration.

The command format is:

SAVECONFIG

Simplified ASCII syntax:

SAVECONFIG

The parameters of the saveconfig command are as follows

command header	command parameter	descriptive
SAVECONFIG	——	Save User Configuration

IMU to Main Antenna Lever Arm Parameter Configuration

Use this command to enter the offset between the IMU and the GNSS main antenna phase center, i.e. the inertial guidance to main antenna rod arm parameter. The rod arm parameters should be measured as accurately as possible, especially in RTK mode, and an error of 1 cm is desirable. any error in the rod arm parameters will be directly converted to an error in the inertial navigation system position. x, y, and z represent the vectors from the IMU to the main antenna phase center. To improve accuracy, the IMU should be mounted horizontally so that it is as close as possible to the main GNSS antenna. The IMU position is in the upper left corner of the INS-3820-R11.

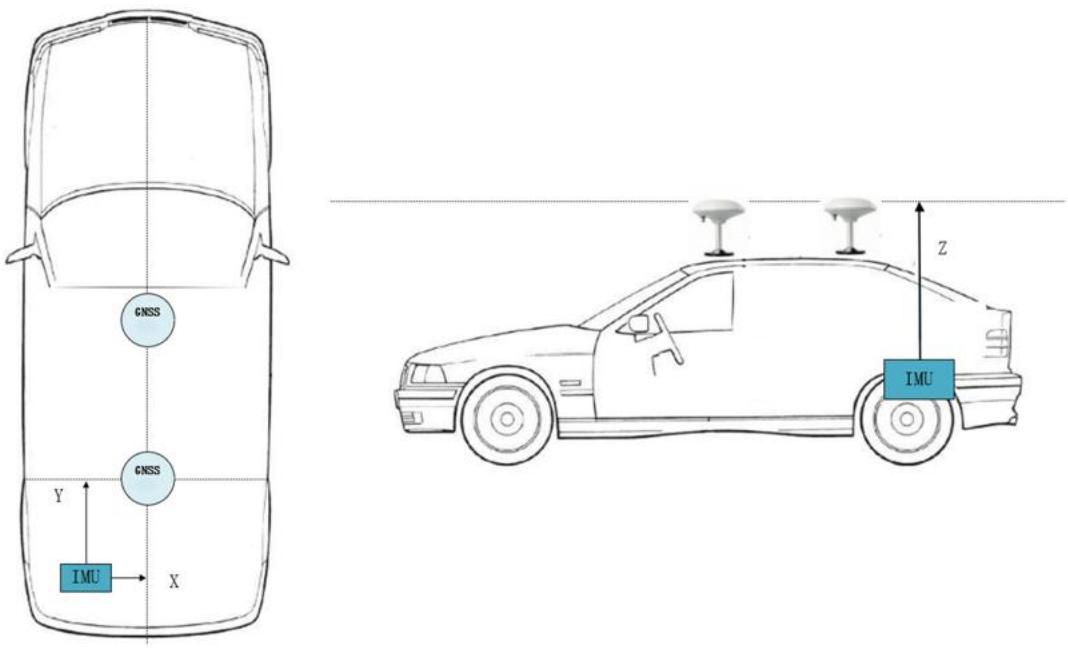

Figure 5.IMU Offset to Antenna Phase Center

Command Format.

CONFIG LEVER ARM x y z

Simplified ASCII syntax: CONFIG LEVER ARM 0.05 -1.05 0.03

CONFIG LEVER ARM 0.05 -1.05 0.03

IMU to main antenna arm parameter configuration

Command header	Parameters	Parameter Description
CONFIG LEVER ARM	X	X-direction offset, unit: meter, range -100~100, retain two decimal places
	Y	Y direction offset, unit: meter, range -100~100, retain two decimal places
	Z	Z direction offset, unit: meter, range -100~100, retain two decimal places

Appendix 2: Binary Protocol Format

synchronization segment 1 Byte	Frame Information 1 Byte	Length Segment 1/2/4 Byte	Address Segment 1/2/4 Byte	Command Segment 1/2/4 Byte	Command Segment 1/2/4 byte	Ending Paragraph 4 Byte

Data frame description

Name	Length	Description
Synchronized segments	1 Byte	Fixed to 0x57 for data frame synchronization
Frame information	1 Byte	Indicates the information of the data frame Bit 7 Frame information check, 0 when the number of 1's in Bit 6 to Bit 0 is even, 1 when the number of 1's is odd Bit 6 Reserved, constant 0 Bit 5:4 Data length of the length segment 00: 1 byte 01: 2 bytes 02: 4 bytes 03: Reserved Bit 3:2 Data length of the address segment 00: 1 byte 01: 2 bytes 02: 4 bytes 03: Reserved Bit 1:0 Data length of the command segment 00: 1 byte 01: 2 bytes 02: 4 bytes 03: Reserved
Length Segment	1/2/4 Byte	Number of bytes from the address segment (inclusive) to the end segment (inclusive), high byte first, number of bytes determined by Bit 5:4 of the frame information
Address segment	1/2/4 Byte	Address of the target sensor of the data frame, high byte first, number of bytes determined by Bit 3:2 of the frame message. The sensor will only respond if this address is equal to the sensor address or if it is equal to 0
Command segment	1/2/4 Byte	Command message of the data frame, high byte first, number of bytes determined by Bit 3:2 of the frame message. Determines the role of the data frame, the lowest bit is 0 for sending to the sensor and the lowest bit is 1 for returning from the sensor
Data segment	0~n Byte	Data information corresponding to the command segment, typically sensor readings or configuration parameters
Ending paragraph	4 Byte	Parity information of the data frame, CRC parity value from the frame information (included) to the data segment (included), high byte first The CRC information is as follows: Width: 32 bits Polynomial: 04C11DB7 Initial value: FFFFFFFF Resulting iso-or: 00000000 Input inverted: No Output inverted: No

Mechanical Characteristic

Connector	RS422(RS485) / RS232
Protection level	IP65
Shell material	Magnesium alloy sanding oxidation
Installation	Three M4 screws

EXECUTIVE STANDARD

- National Standard for Static Calibration of Biaxial Inclination Sensors (Draft)
- GB/T 191 SJ 20873-2003 General Specification for Tiltmeters and Levelling Devices