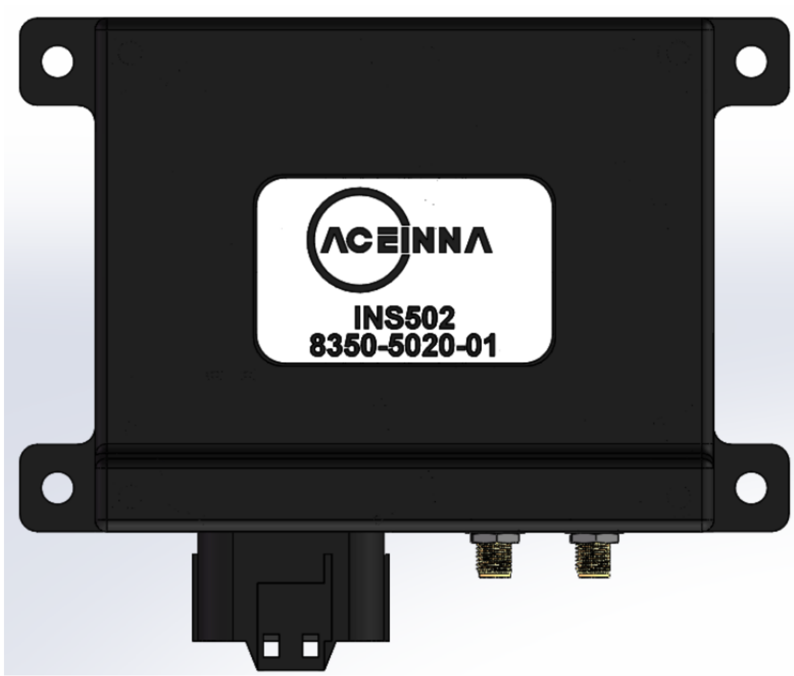
INS502 USER MANUAL

Document Part Number: 7430-5020-01



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Date	Document Revision	Firmware Applicability	Description	Author
Aug 31 2023	-D1	31.00.07/08/10	See Appendix B: for full revision details	CEK/WRJ
Dec 11 2023	-D2	31.00.11/12		WJT/CEK /WRJ
Feb 01 2024	-D3	31.00.13		WJT/CEK /WRJ
May 20 2024	-D4	31.00.14		WJT/CEK
Aug 15 2024	-D5	31.00.15		WJT/CEK

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Table of Contents

About this Manual

The following annotations have been used to provide additional information.

◀ NOTE

Note provides additional information about the topic.

☑ EXAMPLE

Examples are given throughout the manual to help the reader understand the terminology.

IMPORTANT

This symbol defines items that have significant meaning to the user

⚠ WARNING

The user should pay particular attention to this symbol. It means there is a chance that physical harm could happen to either the person or the equipment.

1 Introduction

1.1 INS502 Overview

The ACEINNA INS502 is a state-of-the-art, dual antenna Inertial Navigation System with 2 RTK-enabled GNSS receivers, triple-redundant inertial sensors, and Positioning Engine. It is designed for use in high-volume applications requiring precise position information, and accurate heading at static/dynamic conditions. The dead reckoning solution delivers strong performance in GNSS challenged environments. It is designed to work with odometer and RTK corrections for optimal performance. It is a lightweight and compact IP67 enclosure with RF connector, and a power/data connector.

The Aceinna INS502 high-precision navigation system integrates a multi-constellation, multi-frequency Global Navigation Satellite System (GNSS) (supporting GPS, GALILEO, GLONASS, Beidou, QZSS, NAVIC and SBAS), an Aceinna MEMS Inertial Measurement Unit (IMU) module, and a multi-core micro-controller (MCU). The INS502 system includes a built-in proprietary GNSS RTK positioning engine and a proprietary INS navigation engine

The internal IMU is a triple-redundant 6-axis (3-axis accelerometer and 3-axis gyro) IMU module that encloses three MEMS IMU sensor chips. Each of the three IMU sensor chips is calibrated individually. The combined IMU sensor data provides 6-DOF (Degrees of Freedom) inertial measurements.

Table 1 INS502 Frequency

Constellation	Satellite Signals
GPS	L1, L2, L5
GLONASS	G1, G2
BeiDou	B1I, B2I, B3I
Galileo	E1, E5a, E5b
QZSS	L1, L2, L5

The INS502 provides the following features:

1. Position, velocity, heading and attitude solutions at 100Hz
2. Multi-constellation and multi-frequency RTK algorithm support for centimeter accurate positioning
3. Integrated and calibrated triple-redundant MEMS IMU with range of ±8 g and ±200 °/s
4. Automotive ethernet interface
5. IP67 enclosure
6. 80 GNSS channel tracking and RTK algorithm support for centimeter level accuracy
7. Supported interfaces: ethernet, CAN/CAN FD, RS232
8. 1PPS output
9. Single and Dual antenna versions available

2 INS502 Hardware

As described in the overview, the INS502 is a dual-antenna Inertial Navigation System contained in a ruggedized aluminum housing, qualified for use in industrial and automotive applications. It contains a dual-band RTK-capable GNSS receiver, a triple redundant IMU which is fully calibrated for bias, scale factor, linearity, and misalignment and an Ethernet interface for external communication. The INS502 is powered directly from 12 V or 24 V battery systems (9 V ~ 32 V input range) and is designed and qualified to withstand the worst-case conditions in terms of overvoltage, reverse voltage and other fault conditions experienced in these vehicles.

2.1 Housing and Dimensions

The INS502 housing is cast aluminum for ruggedness and low manufacturing cost as shown in Figure 1. There are three connectors on the front panel, and they are permanently installed in the INS502 housing:

1. The 2 small circular connectors are the SMA-K type connectors for RF connection to the GNSS antennas. The primary antenna should be connected the primary RF connector which is the one furthest away from the main connector. The RF connector closest to the main connector is for the secondary antenna.
2. The large connector is the main electrical connector. It is an automotive grade MX23A connector that contains the power and communication interfaces to connect with the control unit of the application system.

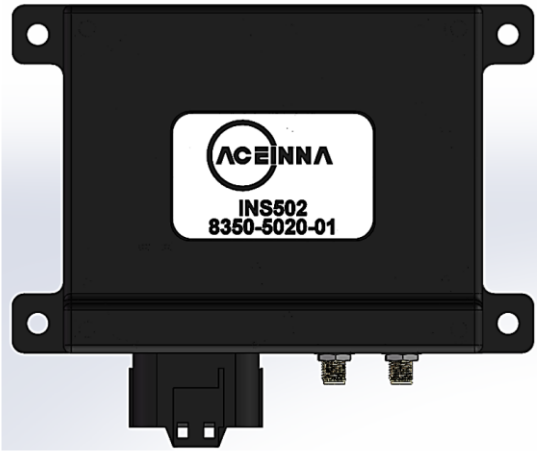

Figure 1 INS502 Housing

The overall dimensions are 132.5 x 112.4 x 34.5 mm, as shown in the 2D drawings in Figure 2. Refer to section 3.1 for details of the navigation center location.

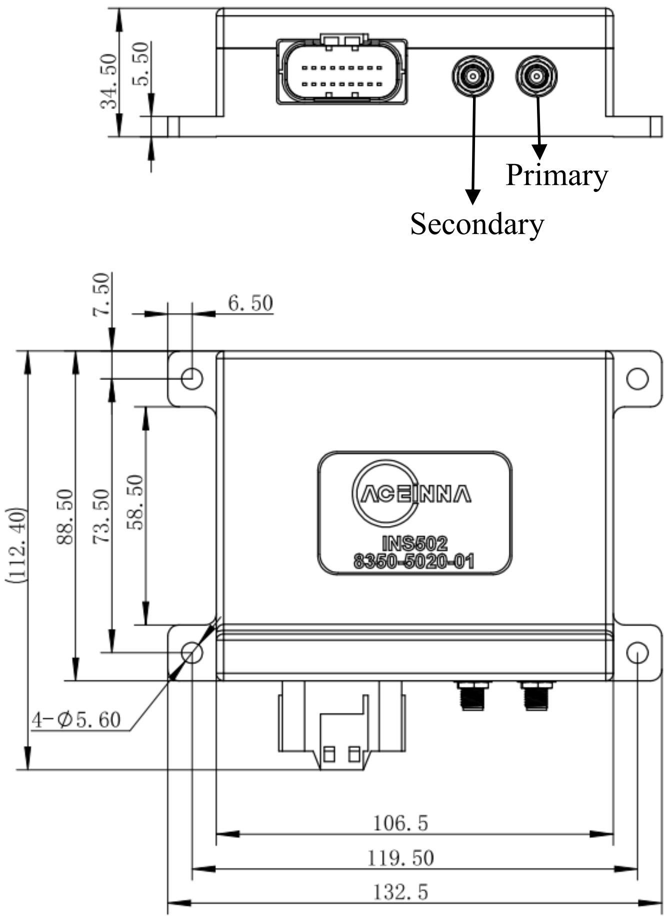

Figure 2 INS502 Hardware Dimensions

2.2 Mechanical Interface

2.2.1 RF Connector

The INS502 has two SMA-K type connectors (RFPC-SMA14-FN-A), manufactured by GradConn, for connection of the primary and secondary GNSS antennas. For antenna requirements please refer to section 3.2.

If building your own RF cable, please use SMA-J type.

2.2.2 Main Connector and Pin Description

The main connector carries all the other power and I/O signals to and from the INS502 module. This connector is of automotive grade and is manufactured by JAE Electronics (part number MX23A18NF1). When connecting a wiring harness to the INS502 it is recommended it has the corresponding female connector from JAE Electronics (part number MX23A18SF1). Figure 3 below illustrates the location of the 18 pins of the male part, as seen facing the connector from outside the module.

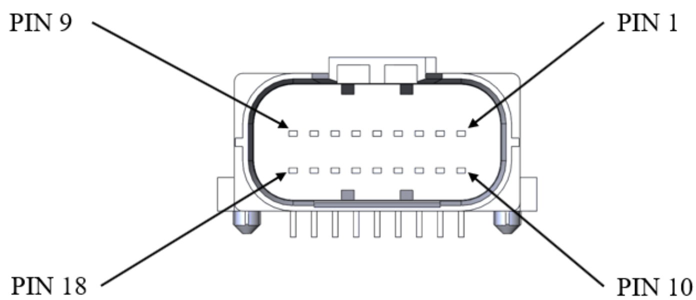

Figure 3 Pin Diagram of the Male End

Table 2 shows the functional description of the 18 pins of the main connector.

Table 2. Pin Description of the Main Connector

Pin #	INS502	Signal Description
1	Reserved	reserved
2	Reserved	reserved
3	ETH_TRX_N	Ethernet Negative
4	ETH_TRX_P	Ethernet Positive
5	CAN2_L	CAN Low
6	CAN2_H	CAN High
7	CAN1_L	CAN Low
8	CAN1_H	CAN High
9	VCC_IN	Power Supply Positive, range 9v to 32V, The INS502 consumes 4 W (typical value)
10	Reserved	Reserved
11	Reserved	Reserved
12	RXD	RS-232 RX Pin
13	TXD	RS-232 TX Pin
14	GND	Power Supply Negative
15	GND	Power Supply Negative
16	PPS	Synchronization Signal
17	GND	Power Supply Negative
18	GND	Power Supply Negative

3 INS502 Installation

3.1 Mounting Instructions

Use four bolts of 1/4-20 UNC socket head cap screw (ASME B18.3) to fix the INS502 system on a flat rigid panel on the vehicle, using the mechanical dimension measures shown in Figure 2. The IMU navigation center and the IMU body frame default coordinate definition is shown in Figure 4. Note that the IMU navigation center is located 17mm above the bottom of the unit. Align the INS502 system X-axis with the forward driving direction of the vehicle.

By default, the IMU body frame orientation of INS502 is defined as in the figure below, with the X-axis pointing in the opposite direction to the connectors, Z-axis pointing down, and Y-axis completing a right-hand coordinate system. To align with the vehicle frame definition, the INS502 should be mounted on the vehicle with the connectors facing the tail of the vehicle if the default orientation is used, i.e., the X-axis of the IMU body frame points to the forward driving direction of the vehicle. Please refer to Table 12 User configurations, then configure rotation angle on Z/Y/X when you use a new orientation.

The "Set User Configuration" command (see Table 14 and 5.3.1) should be used to re-align the coordinate system so that X is facing forward, Y is right, and Z is down if the INS502 is mounted in a different orientation.

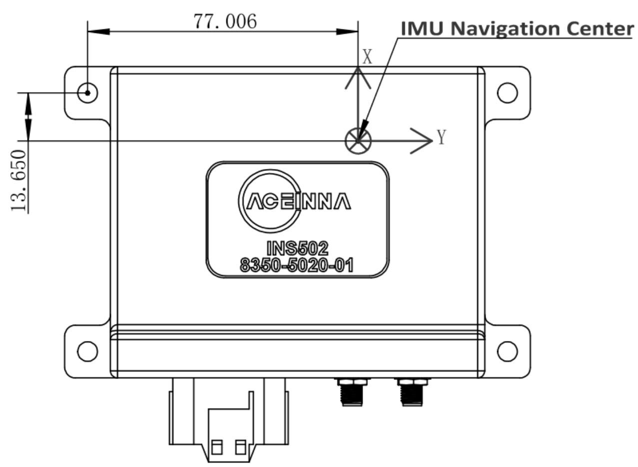

Figure 4 IMU Axis Definition and Navigation Center Location

After the INS502 is mounted to the vehicle, measure the IMU to the GNSS antennas lever arms (translational offset) from the IMU navigation center to the GNSS antenna phase center. The GNSS antenna is typically installed on top of the vehicle roof. For optimal performance, it is required to have the lever arm accuracy of less than 2 cm. An example lever arm measurement is shown in Figure 5. The translation offset is measured as 1 m in each direction of x, y, z. The IMU to the GNSS antenna lever arm is [x, y, z] = [1.0, -1.0, -1.0] m. The "Set User Configuration" command should be used to configure the INS502 with the correct lever arm configurations.

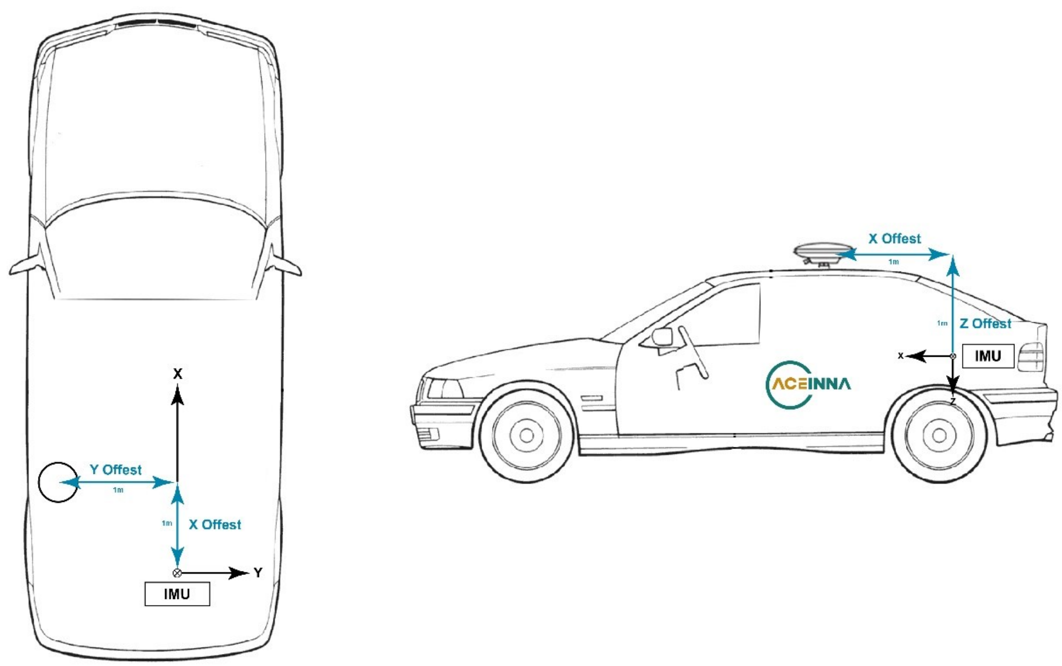

Figure 5 INS502 IMU to GNSS Antenna Lever Arm Definition and Measurement Demonstration

3.2 Antenna Selection and Connection

The INS502 works with a customized external wiring harness to connect to the antenna connector and the main connector.

1. Connect antenna cables to SMA-type RF terminals
2. Connect power supply, Ethernet, PPS signal to main connector MX23A18NF1
3. The INS502 will supply power (+5Vdc) to the antenna via the antenna cable

Based on your application, select an GNSS L1&L2&L5 active antenna. A antenna LNA gain should be between 18 dB and 36 dB is recommended, 30dB is typical.

When installing the GNSS antenna:

1. Choose an antenna location with a clear view of the sky so each satellite above the horizon can be tracked without obstruction
2. Mount the antenna on a secure, stable structure capable of safe operation in the specific environment
3. Ensure antenna is mounted to a rigid surface to minimize any movement due to vehicle dynamics.

Table 3 Recommended **GNSS Antenna Specification**

Item	SPEC
GNSS Frequency	L1 + L2 +L5
Impedance	50Ω
Polarization	RHCP
Axial Ratio	3dB (max)
Gain @ Zenith (90°)	3dBi (min)
LNA Gain	18-36dB
Operation Voltage	DC 3.3V ~ DC 3.6V

NOTE

GNSS Frequency request for slave antenna: L1+L2.

4 General Commination Definitions

4.1 Interfaces Overview

There are several combinations of interconnections supported, as shown in table below

Table 4 Interfaces Overview

	General setting			**Input Messages Supported**			**Output Messages Supported**					
Port	**ID**	**Protocol**	**Baud Rate**	**WSS**	**RTCM**	**Configuration**	**GNSS**	**INS**	**IMU**	**Diagnostic**	**NMEA-msg**	**RTCM**
RS-232	0	UART	230.4k default	yes	yes	yes	yes	yes	yes	yes	yes	yes
CAN-1	1	CAN J1939	250k	yes	no	yes	yes	yes	yes	yes	no	no
CAN-2	2	future										
Ethernet	3	100Base-T1	100M	yes	yes	yes	yes	yes	yes	yes	yes	yes

*Messages over RS-232 are disabled by default except NMEA, if needed please send set output commands to adjust the rate of desired packets over RS232.

4.2 Number Formats

Number Format Conventions include:

- 0x as a prefix to hexadecimal values
- No prefixes or delimiters to specify decimal values.

Table 5. Number Formats

Descriptor	**Description**	**Size (bytes)**	**Comment**	**Range**
U1	Unsigned Char	1		0 to 255
U2	Unsigned Short	2		0 to 65535
U4	Unsigned Int	4		0 to 2^32-1
U8	Unsigned Int64	8		0 to 2^64-1
I1	Signed Char	1		-128 to 127
I2	Signed Short	2	2's Complement	-2^15 to 2^15-1
I4	Signed Int	4	2's Complement	-2^31 to 2^31-1
F4	Single precision	4	IEEE754 Single Precision	-3.4E+38 ~ 3.4E+38

D8	Double precision	8		-1.79E+308 ~ 1.79E+308
SN	String	N	ASCII	

4.3 Bit status

4.3.1 The Master BIT Status Word

Table 6. Master BIT Status Word

Bit	Description	Value	Comment
0-2	Operating Mode	0 = Initialization, 1 = Normal 2 = Safe State	If the operating mode is "Safe State", at least one error flag in this Master BIT Status Word is set.
3	HW Error Status	0 = Normal 1 = HW error	Refer to Hardware BIT status (see **Table 7. Hardware BIT Status**) for further information of HW error.
4	SW Error Status	0 = Normal 1 = SW error	Refer to Software BIT is set (see **Table 11. SW Error**) for further information of SW error.
5	Application integrity Error	0 = Normal 1 = Application integrity error	Will be sent from Bootloader periodically with interval of 1 second if there is the application integrity error. This bit is always 0 after entering the application mode.
6-15	Reserved		

4.3.2 Hardware BIT status

Table 7. Hardware BIT Status

Bit (error_category)	Description	Value	Comment
0	MCU startup test error	0 = Normal 1 = MCU startup test error	MCU fails the startup test. Refer to **Table 8. HW Error** for HW error code.
1	IMU startup test error	0 = Normal 1 = IMU sensor startup test error	Any IMU sensor fails the startup test.
2	TPS3850 startup test error	0 = Normal 1 = External watch startup test error	The external watchdog fails the startup test.
3	MCU runtime error	0 = Normal 1 = MCU runtime test error	MCU fails the runtime test.

4	IMU runtime error	0 = Normal 1 = IMU sensor runtime test error	Any IMU sensor fails the runtime test. Over-range
5	External power supply status	0 = Normal 1 = External power supply voltage out of range warning	Power supply voltage out of range detected by TPS3850.
6	1PPS status	0 = Normal 1 = 1PPS warning	It is a Warning item
7	GNSS chip startup test error	0 = Normal 1 = GNSS chip startup test error	
8	GNSS chip runtime status	0 = Normal 1 = GNSS chip runtime warning	
9-15	Reserved		

Warnings don't set "HW Error" in the Master BIT Status Word

Table 8. HW Error

Error	Error Code	Description	Error Level	Comment
MCU startup test	0	No Error		
IMU startup test	0	No Error		
	1	IMU communication error	Error	There is no output from IMU when listening to IMU at startup
	2	IMU config error	Error	There is no response or error response from IMU when configuring IMU at startup.
	3	HW error	Error	Record the IMU Master BIT status (see **Table 9. IMU Master BIT status**) from S2 when IMU is normally working. If no S2 packets from IMU, and there is T0 packets output, record the error code in T0
	4	SW error	Error	
	5	Config error	Error	
	6	Calibration error	Error	
	7	Accel degradation	Warning	
	8	Gyro degradation	Warning	
	9	Forced restart	Error	
	10	CRC error	Error	
	11	Tx overflow error	Error	
TPS3850 startup test	0	No Error		
	1	power monitor self-test fail	Error	

	2	external watch self-test fail	Error	
MCU runtime	0	No Error		
	1	Temperature lower than min threshold	Error	
	2	Temperature higher than max threshold	Error	
	3	Power		
IMU runtime	0	No Error		
	1	IMU communication error	Error	INS has received S2 from IMU. But for 1 second, there is no packet received from IMU.
	2	HW error	Error	Record the IMU Master BIT status (see **Table 9. IMU Master BIT status**) from S2 when IMU is normally working. If no S2 packets from IMU, and there is T0 packets output, record the error code in T0
	3	SW error	Error	
	4	Config error	Error	
	5	Calibration error	Error	
	6	Accel degradation	Warning	
	7	Gyro degradation	Warning	
	8	Forced restart	Error	
	9	CRC error	Error	
	10	Tx overflow error	Error	
	11	Temperature lower than min threshold	Error	
	12	Temperature higher than max threshold	Error	
	13	timestamp non-continuity over threshold	Warning	The continuity duration is 10ms
	14	running number non-continuity over threshold	Warning	
	15	UTC timestamp delay over threshold	Warning	
External power supply status	0	No Error		
	1	External power supply voltage out of range warning	Warning	
1PPS status	0	No error		
	1	1PPS is not detected for 1 minute	Warning	
	2	1PPS is detected but not valid for 1 minute	Warning	The time interval between two adjacent will be compared with the interval timer to validate the 1PPS signal.

	3	No UTC time available	Warning	PPS is valid but UTC time is not received
GNSS chip startup test	0	No Error		
GNSS chip runtime	0	No Error		
	1	PPS not available	Warning	PPS is not detected for 60s: set to 1 PPS detected: set to 0
	2	GNSS NO data output	Warning	GNSS-chipset has NO data output for 5 sec
	3	GNSS NO valid data output	Warning	GNSS-chipset has data output, but no valid signal detected for 5 sec
	4	Primary antenna NOT connected	Warning	Antenna status
	5	Secondary antenna NOT connected	Warning	Antenna status
	6	Temperature lower than min threshold	Warning	
	7	Temperature higher than max threshold	Warning	

Info: normal state;

Warning: will set the corresponding bit in the SW/HW BIT status, but will not set the corresponding bit (HW Error bit and the SW Error bit) in the Master BIT status;

Error: will set the corresponding bit in the SW/HW BIT status, and will also set the corresponding bit (HW Error bit and the SW Error bit) in the Master BIT status.

Table 9. IMU Master BIT status

Bit	Description	Value
0	Master fail	0: Normal 1: Fatal error occurred
1	HW error	0: Normal 1: Hardware exception detected
2	SW error	0: Normal 1: Software exception detected
3	Config error	0: Normal 1: Config error detected by periodic self-test
4	Calibration error	0: Normal 1: Calibration data corrupted
5	Accel degradation	0: Normal

		1: Accel data degradation due to sensor exception
6	Gyro degradation	0: Normal 1: Gyro data degradation due to sensor exception
7	Forced restart	0: Normal 1: Forced restart
8	CRC error	0: Normal 1: CRC error detected
9	Tx overflow error	0: Normal 1: Tx Overflow occurred 10 consecutive cycles
10~15	Reserved	

4.3.3 Software BIT Status

Table 10. Software BIT status

Bit (error_category)	**Description**	**Value**	**Comment**
0	MCU overloaded error	0 = Normal 1 = MCU overloaded error	Data Processing Delay exceeded 5ms.
1	Stack overflow error	0 = Normal; 1 = stack overflow error	Stack overflow occurs.
2	Configuration error	0 = Normal, 1 = Configuration error	Incorrect configuration parameters or corrupted configuration partition.
3	Reserved		
4	Last Reset Status	0 = Normal 1 = abnormal reset error	Refer to **Table 11. SW Error** for SW error code.
5	INS algorithm error	0 = Normal 1 = INS algorithm error	INS algorithm error
6	Reserved		
7	Time sync master status	0 = Normal 1 = Time sync error	
8-15	Reserved		

Table 11. SW Error

Error	Error Code	Description	Error Level	Comment
MCU overloaded	0	No Error		
	1	CPU overloaded	Error	
Stack overflow	0	No Error		
	1	Stack overflow	Error	
Configuration	0	No Error		
	1	Configuration partition CRC error	Error	
Last Reset Status	0	Power-on reset	Info	Normal reset, and will not set the corresponding bit in the Software BIT status.
	1	User-command reset	Info	Normal reset, and will not set the corresponding bit in the Software BIT status.
	2	Watchdog self-test reset	Info	Intended reset, and will not set the corresponding bit in the Software BIT status.
	3	Watchdog reset	Error	
	4	Brown-out reset	Error	
INS algorithm	0	No Error	Error	
	1	Startup error	Error	Startup fail
	2	Transfer error	Error	Filter exchange failed
	3	Output overflow error	Error	Output buffers overflowed
	4	Apply state error	Error	Failure applying the states
	5	Process IMU failed	Error	Process IMU failed
	6	Process GNSS position failed	Error	Process GNSSPOS failed
	7	Process GNSS SAT or heading failed	Error	Process GNSSSATS or process heading failed
	8	Process odometer failed	Error	Process ODO failed
	9	Invalid use mode	Error	Engine is disabled or configured improperly
	10	Internal buffer overrun	Error	For delayed processing, IMU or odometer buffers overflowed (data gap will ensue)
	11	BUFRD process failure	Error	When catching or when whole epoch encountered up, one or more process functions failed

	12	Mechanized too long	Error	Low-latency engine has not had a filter exchange in (param.datalineup.maxMechanizationOnlyDT)
Time sync master status	0	No Error		

4.4 Available output packet rate

All output packets have their own output packet rate. The valid packet rate format is U1. And the available value is due to the output rate type. Output packet rate includes several types: Quiet, Periodicity and OnChange.

- Quiet

  No output. Only allow 0(0Hz). All output packets support.

- Periodicity

  Output data in a fixed period. The allowed values are 1(1Hz), 5(5Hz), 10(10Hz), 20 (20Hz), 25 (25Hz), 50 (50Hz), 100(100Hz). The IMU, INS output could be periodicity.

- OnChange

  Output when data generated. The value is only 255. Such as GNSS data.

4.5 User configuration

Table 12 User configurations

Index	Configuration	Format	Unit	Comments
1	pri_lever_arm_x	F4	m	Primary Antenna position under NED coordinate system (forward-right-down vehicle frame), reference point of INS502 is origin point (0,0,0). Same coordinate system is used for below points.
2	pri_lever_arm_y	F4	m	
3	pri_lever_arm_z	F4	m	
4	vrp_lever_arm_x	F4	m	Vehicle reference point position. vrp is the position where odometer speed originates, which would be the center position of 2 rear wheels if your speed comes from 2 rear wheels.
5	vrp_lever_arm_y	F4	m	
6	vrp_lever_arm_z	F4	m	
7	user_lever_arm_x	F4	m	Use this lever arm to set the desired position on the vehicle/machine that the INS solution will refer to. The primary antenna position or the center of the vehicle are commonly used.
8	user_lever_arm_y	F4	m	
9	user_lever_arm_z	F4	m	
10	rotation_rbv_x	F4	deg	Rotation angles to align IMU body frame to vehicle frame, in order Z->Y->X from vehicle frame to IMU body frame.
11	rotation_rbv_y	F4	deg	
12	rotation_rbv_z	F4	deg	
13	second_lever_arm_x	F4	m	Secondary Antenna position under NED coordinate system(forward-right-down), reference point of INS502 is origin point (0,0,0).
14	second_lever_arm_y	F4	m	
15	second_lever_arm_z	F4	m	
23	dual antenna length	F4	m	Distance between the 2 antennas (prefer > 1m) The length can either be input by the user via configuration parameter 23 or calculated automatically based upon the antenna lever arms set via user configuration parameters 1,2,3,13,14 and 15. If the lever arms are the parameters last modified, then heading boresight will be calculated from them. If parameter 23 is modified after the lever arms are configured, then its value will be used.
24	heading compensation	F4	deg	Compensates the small angle (from primary to secondary) bias caused by lever arm measurement accuracy. example:

				The calibration angle should be -0.5deg, when actual heading (89.5deg) differs from calculated heading (90.0deg) based on current lever arms **Generally, pls use 0 when 2 antennas position configured accurately.**
25	heading boresight	F4	deg	Angle from boresight line (from primary to secondary antenna) to heading direction, calculated by below formula: Angle = arctan(Δy/Δx) Δy: absolute distance between 2 antennas over y direction in vehicle body frame. Δx: absolute distance between 2 antennas over x direction in vehicle body frame. example: The calibration angle value should be -0.5deg, when boresight line is 0.5deg and vehicle forward direction is 0deg. The heading boresight can either be input by the user via configuration parameter 25 or calculated automatically based upon the antenna lever arms set via user configuration parameters 1,2,3,13,14 and 15. If the lever arms are the parameters last modified, then heading boresight will be calculated from them. If parameter 25 is modified after the lever arms are configured, then its value will be used.
29	user do zupt	U1	-	0: No 1: Yes (Default) Enable/disable ZUPT.
30	zupt interval	D8	s	Default 1. do zupt this often
200	baud rate of RS232	U2	-	Baud rate used in RS232: 0-230400(default); 1-115200; 2-460800;
210	baud rate of CAN1	U2	-	Bit0~3 of Byte0 Bitrate of CAN / Bitrate of arbitration field in CANFD (Dependents on the work mode in Byte1) 0: Auto 1: 100k 2: 125k 3: 250k (Default) 4: 500k 5: 800k 6: 1M Bit4~7 of Byte0 Bitrate of data field in CANFD (Not available when work under CAN mode) 0: Auto (Only the band rate above 500K is supported) 4: 500k 5: 800k 6: 1M 7: 2M

				Bit0 of Byte1 0: enable CAN 1: enable CANFD Bit1~7 of Byte1 Reserved In CANFD mode, below combinations are supported when configure baud rates: (100k, 100k), (125k, 125k), (250k, 250k), (500k, 500k), (800k, 800k), (1M, 1M), (500k, 1M), (500k, 2M), (1M, 2M) 1st number: Non-data segment bitrate 2nd number: data segment bitrate Pls note that CANFD is not implemented even though it can be configured
213	can1 id offset	U4	-	Message Id PS offset for CAN1, 4 bytes used. Byte0~1: id offset of packets output on CAN1. Default 0x0022 Byte2~3: id PS offset of input packets (0xFF40-4a, 0xFF50-53) on CAN1. Default 0x0040
216	bit timing of CAN1	U4	-	Bit Timing Configuration for CAN1, 250k as example Byte0: tq. Default 50(0x32) Byte1: seg1. Default 69(0x45) Byte2: seg2. Default 10(0x0A) Byte3: sjw. Default 1 By default, Sampling Point = (1+seg1)/(1+seg1+seg2) =87.5%
251	odometer protocol	U1	-	The protocol id for different customer to accept odometer information through CAN. 0: Wheel Speed Input (0x0CFF2145/46, to CAN1) 1: CAR Speed Input (0xF022D0, to CAN1)

NOTE

Reminder for new ID value configuration, after setting the new value INS algorithm related, a save command and a power cycle are required for it to take effect.

5 CAN Messages Definition

5.1 Message overview

The CAN1 port of the INS502 supports standard CAN J1939 messages, including position, velocity, attitude, heading, and IMU data. Odometer data, and lever arm configurations can also be input over the CAN1 port.

INS502 source address (SA): 0x64(manufacturer defined, can modify if need)

Table 13 All CAN messages

Index	CAN ID	Priority	Cycle	Direction	Description
1	0x0CFF2264	3	50hz	INS to other node	INS_Acc
2	0x0CFF2364	3	50hz	INS to other node	INS_Gyro
3	0x0CFF2464	3	50hz	INS to other node	INS_HeadingPitchRoll
4	0x0CFF2564	3	50hz	INS to other node	INS_HeightAndTime
5	0x0CFF2664	3	50hz	INS to other node	INS_LatitudeLongitude
6	0x0CFF2764	3	50hz	INS to other node	INS_Speed_and_BitStatus
7	0x0CFF2864	3	50hz	INS to other node	INS_Status_DataInfo
8	0x0CFF2964	3	50hz	INS to other node	INS_Std
9	0x0CFF2A64	3	1hz	INS to other node	GNSS Satellites
10	0x0CFF2B64	3	1hz	INS to other node	GNSS Solution Pos 1
11	0x0CFF2C64	3	1hz	INS to other node	GNSS Solution Pos 2
12	0x0CFF2D64	3	50hz	INS to other node	Position and Velocity Protection Level
13	0x0CFF2E64	3	50hz	INS to other node	Attitude Protection Level

-	0x18FF50XX (XX is client address in this file)	6	event	other node to INS	Set user configuration
-	0x18E8FF64	6	event	INS to other node	Set cmd feedback
-	0x18EAFFXX	6	event	other node to INS	Request configuration or device information
-	0x18FF5064	6	event	INS to other node	Configuration feedback
-	0x18FF51XX	6	event	other node to INS	Save configuration
-	0x18FF52XX	6	event	other node to INS	Software Reset
-	0x18FF53XX	6	event	other node to INS	Set GNSS to outage
-	0x18FF5464	6	event	INS to other node	Output rate of packets
-	0x0CFF2145/46	3	-	other node to INS	Wheel Speed Input
-	0x0CF022D0	3	-	other node to INS	CAR Speed Input
-	0x18FF4064	6	event	INS to other node	Product name
-	0x18FF4164	6	event	INS to other node	Serial No
-	0x18FF4264	6	event	INS to other node	App name
-	0x18FF4364	6	event	INS to other node	App version
-	0x18FF4464	6	event	INS to other node	Boot loader version
-	0x18FF4564	6	event	INS to other node	Hardware version
-	0x18FF4664	6	event	INS to other node	IMU name

-	0x18FF4764	6	event	INS to other node	IMU version
-	0x18FF4864	6	event	INS to other node	IMU serial No
-	0x18FF4964	6	event	INS to other node	RTK name
-	0x18FF4A64	6	event	INS to other node	RTK version

NOTE

XX is client address in this file.

5.2 Output Binary Packets

INS_HeightAndTime (0x0CFF2564) will be sent out as the first one of the group of packets for a new INS result updated.

CAN1 output data frames are defined in the following table:

5.2.1 INS_RawAcc And_IMU_BitStatus (0x0CFF2264, 50hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	Offset	Unit	Conversion	Description
acc_x	0	16	Unsigned	Intel	[-4,4]	0.0001220722	-4	g	E=N*0.0001220722-4	Accelerometer: X axis
acc_y	16	16	Unsigned	Intel	[-4,4]	0.0001220722	-4	g	E=N*0.0001220722-4	Accelerometer: Y axis
acc_z	32	16	Unsigned	Intel	[-4,4]	0.0001220722	-4	g	E=N*0.0001220722-4	Accelerometer: Z axis
bitstatus_imu_master_fail	48	1	Unsigned	Intel	[0,1]	1	0	-	E=N	Pls refer to 4.3
bitstatus_imu_hw_err	49	1	Unsigned	Intel	[0,1]	1	0	-	E=N	

bitstatus_imu_sw_err	50	1	Unsigned	Intel	[0,1]	1	0	-	E=N	
bitstatus_imu_config_err	51	1	Unsigned	Intel	[0,1]	1	0	-	E=N	
bitstatus_imu_calib_err	52	1	Unsigned	Intel	[0,1]	1	0	-	E=N	
bitstatus_imu_accel_degradation	53	1	Unsigned	Intel	[0,1]	1	0	-	E=N	
bitstatus_imu_gyro_degradation	54	1	Unsigned	Intel	[0,1]	1	0	-	E=N	
bitstatus_imu_foreced_restart	55	1	Unsigned	Intel	[0,1]	1	0	-	E=N	
bitstatus_imu_crc_err	56	1	Unsigned	Intel	[0,1]	1	0	-	E=N	
bitstatus_imu_tx_overflow_err	57	1	Unsigned	Intel	[0,1]	1	0	-	E=N	

5.2.2 INS_RawGyro (0x0CFF2364, 50hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	Description
gyro_x	0	16	Unsigned	Intel	[-250,250]	0.00762951	-250	deg/s	E=N*0.00762951-250	Gyro: Y axis
gyro_y	16	16	Unsigned	Intel	[-250,250]	0.00762951	-250	deg/s	E=N*0.00762951-250	Gyro: X axis

gyro_z	32	16	Unsigned	Intel	[-250,250]	0.00762951	-250	deg/s	E=N*0.00762951-250	Gyro: Z axis

5.2.3 INS_PitchRollHeading (0x0CFF2464, 50hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	Description
ins_pitchangle	0	16	Unsigned	Intel	[-360,360]	0.0109865	-360	deg	E=N*0.0109865-360	Vehicle coordinate: pitch
ins_rollangle	16	16	Unsigned	Intel	[-360,360]	0.0109865	-360	deg	E=N*0.0109865-360	Vehicle coordinate: roll
ins_headingangle	32	16	Unsigned	Intel	[-360,360]	0.0109865	-360	deg	E=N*0.0109865-360	Vehicle coordinate: heading

5.2.4 INS_HeightAndTime (0x0CFF2564, 50hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	Description
ins_height	0	32	Unsigned	Intel	[-10000,10000]	0.001	-10000	m	E=N*0.001-10000	altitude
ins_timeofweek	32	32	Unsigned	Intel	[0,460800000]	1	0	ms	E=N	second in week

5.2.5 INS_LatitudeLongitude (0x0CFF2664, 50hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	Description

ins_ latitude	0	32	Unsigned	Intel	[-180,180]	0.000 0001	-180	deg	E=N*1e-7-180	latitude
ins_longitude	32	32	Unsigned	Intel	[-180,180]	0.000 0001	-180	deg	E=N*1e-7-180	longitude

5.2.6 INS_Speed_And_BitStatus (0x0CFF2764, 50hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	Description
ins_northspeed	0	16	Unsigned	Intel	[-100,100]	0.0030518	-100	m/s	E=N*0.0030518-100	North velocity
ins_eastspeed	16	16	Unsigned	Intel	[-100,100]	0.0030518	-100	m/s	E=N*0.0030518-100	East velocity
ins_togroundspeed	32	16	Unsigned	Intel	[-100,100]	0.0030518	-100	m/s	E=N*0.0030518-100	Up velocity
bitstatus_pps_status	48	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	Pls refer to 4.3 Bit status
bitstatus_gnss_data_status	49	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	
bitstatus_gnss2_data_status	50	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	
bitstatus_gnss_signal_status	51	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	
bitstatus_power	52	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	
bitstatus_mcu_status	53	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	
bitstatus_temperature_under_mcu	54	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	

bitstatus_temperature_under_rtk	55	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	
bitstatus_temperature_under_imu	56	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	
bitstatus_temperature_over_mcu	57	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	
bitstatus_temperature_over_rtk	58	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	
bitstatus_temperature_over_imu	59	1	Unsigned	Intel	[0, 1]	1	0	-	E=N	

5.2.7 INS_Status_DataInfo (0x0CFF2864, 50hz)

Direction: INS to other node

Name	Start bit	Length	Value Type	Byte Order	factor	offset	Conversion	Description
gps_postype	0	3	Unsigned	Intel	1	0	E=N	The status of the main antenna GNSS solution: 0: INVALID 1: Single-point positioning (SPP) 2: Real time differential GNSS (RTD) 4: Real time kinematic (RTK), ambiguity fixed (RTK_FIXED) 5: RTK with ambiguity float (RTK_FLOAT)
primary_antenna_status_under_outage_simulation	3	1	Unsigned	Intel	1	0	E=N	0: primary antenna not disabled via oT command. 1: The primary antenna is disabled by oT command;
gps_heading_solution_type	4	3	Unsigned	Intel	1	0	E=N	The status of dual-antenna solution: 0: INVALID 1: Single-point positioning (SPP) 2: Real time differential GNSS (RTD)

								4: Real time kinematic (RTK), ambiguity fixed (RTK_FIXED) 5: RTK with ambiguity float (RTK_FLOAT)
secondary_antenna_status_under_outage_simulation	7	1	Unsigned	Intel	1	0	E=N	0: The antenna not disabled via oT command. 1: The secondary antenna is disabled by oT command;
ins_nums_used	8	8	Unsigned	Intel	1	0	E=N	Number of primary antenna GNSS satellites used
ins_postype	16	8	Unsigned	Intel	1	0	E=N	0: INVALID 1: SPP/INS 2: RTD/INS 3: INS_PROPAGATE 4: RTK_FIXED/INS 5: RTK_FLOAT/INS
ins_gps_age	24	8	Unsigned	Intel	1	0	E=N	age
ins_base_connect_status	32	1	Unsigned	Intel	1	0	E=N	0: base RTCM correction data not received (will be back to 0 3s after disconnection) 1: base RTCM correction data received (immediately after received over RS232/Ethernet)
reserve	33	7	Unsigned	Intel	-	-	-	-
ins_status	40	8	Unsigned	Intel	1	0	E=N	Ins status 0: INVALID 1: INS_ALIGNING 2:INS_HIGH_VARIANCE 3:INS_SOLUTION_GOOD 4:INS_SOLUTION_FREE 5:INS_ALIGNMENT_COMPLETE
ins_week	48	16	Unsigned	Intel	1	0	E=N	Gps week number

INS status definition:

- INVALID: INS not initialized
- INS_ALIGNING: System Initialization period waiting dual-antenna heading available
- INS_HIGH_VARIANCE: INS localization available but low accuracy
- INS_SOLUTION_GOOD: INS localization converged
- INS_SOLUTION_FREE: INS localization diverged or entry into dead reckoning
- INS_ALIGNMENT_COMPLETE: INS initialized

5.2.8 INS_Std (0x0CFF2964, 50hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	Paraphrase
ins_latitude_std	0	16	Unsigned	Intel	[0,65.535]	0.001	0	m	E=N*0.001	Standard deviation of latitude
ins_longitude_std	16	16	Unsigned	Intel	[0,65.535]	0.001	0	m	E=N*0.001	Standard deviation of longitude
ins_locatheightstd_	32	16	Unsigned	Intel	[0,65.535]	0.001	0	m	E=N*0.001	Standard deviation of height
ins_heading_std	48	16	Unsigned	Intel	[0,65.535]	0.001	0	deg	E=N*0.001	Standard deviation of heading

5.2.9 GNSS Satellites (0x0CFF2A64, 1hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	Paraphrase
satellitesnum_primary	0	8	Unsigned	Intel	[0,255]	1	0	-	E=N	Number of satellites in view from primary antenna
satellitesnum_secondary	8	8	Unsigned	Intel	[0,255]	1	0	-	E=N	Number of satellites in view from secondary antenna

primary_satellites_avg_cn0	16	8	Unsigned	Intel	[0,255]	1	0	-	E=N	Average CN0 value from satellites in view of primary antenna
secondary_satellites_avg_cn0	24	8	Unsigned	Intel	[0,255]	1	0	-	E=N	Average CN0 from satellites in view of secondary antenna. The value will be reserved if cannot get CN0 from secondary antenna.

5.2.10 GNSS Solution Pos 1 (0x0CFF2B64, 1hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	Paraphrase
latitude	0	32	Unsigned	Intel	[-180,180]	0.0000001	-180	deg	E=N*0.0000001-180	Latitude
longitude	32	32	Unsigned	Intel	[-180,180]	0.0000001	-180	deg	E=N*0.0000001-180	Longitude

5.2.11 GNSS Solution Pos 2 (0x0CFF2C64, 1hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	Paraphrase
height	0	32	Unsigned	Intel	[-10000, 4284967.295]	0.001	-10000	m	E=N*0.001-10000	Height above ellipsoid

5.2.12 INS Integrity: Position and Velocity Protection Level (0x0CFF2D64, 50hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	Paraphrase

horizon_position_pl	0	16	Unsigned	Intel	[0,655.35]	0.01	0	m	E=N*0.01	Horizontal position protection level
vertical_position_pl	16	16	Unsigned	Intel	[0,655.35]	0.01	0	m	E=N*0.01	Vertical position protection level
horizon_velocity_pl	32	16	Unsigned	Intel	[0,655.35]	0.01	0	m/s	E=N*0.01	Horizontal velocity protection level
vertical_velocity_pl	48	16	Unsigned	Intel	[0,655.35]	0.01	0	m/s	E=N*0.01	Vertical velocity protection level

5.2.13 INS Integrity: Attitude Protection Level (0x0CFF2E64, 50hz)

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	Paraphrase
roll_pl	0	16	Unsigned	Intel	[0,655.35]	0.01	0	deg	E=N*0.01	Roll protection level
pitch_pl	16	16	Unsigned	Intel	[0,655.35]	0.01	0	deg	E=N*0.01	Pitch protection level
heading_pl	32	16	Unsigned	Intel	[0,655.35]	0.01	0	deg	E=N*0.01	Heading protection level
reserved	-	-	-	-	-	-	-	-	-	-

5.3 Input Binary Packets

5.3.1 Set Commands

5.3.1.1 Set user configuration (0x18FF50XX)

To set a user configuration value, first determine the index number of that parameter from Table 14 Range, scaling and offset of configurations. Then issue a "Set user configuration" command with the appropriate index and data bytes. If you wish to save the updated configuration value in flash, so that it is maintained following reset or power cycle, then issue a "save configuration" command (refer to 5.3.1.2).

Direction: Other node to INS (set user configuration), or INS to Other node (feedback)

CAN ID	Byte0	Byte1	Byte2	Byte3
0x18FF50XX	Destination address	Index of configuration	Unsigned Data-LSB	Unsigned Data-MSB

*Scale factor of Data, pls refer to Table 14 Range, scaling and offset of configurations

Example of ID and payload:

0x18FF5000 payload: 64 01 44 7C: 0x7C44 = 31812 * 0.001 + (-30) = 1.812 m

Response Payload

Tx ID	0x18E8FF64, Intel		
Byte Offset	**Name**	**Format**	**Description**
0	Status		0: No error 1: Error
1	Reserved		
2	index_of_parameter	U1	
3 - 4	Error code	U2	3-main error code 4-sub error code
5 - 7	PGN	U3	The PGN number in request in LSB

Table 14 Range, scaling and offset of configurations

Index	Configuration	unit	Factor	Offset
1	pri_lever_arm_x	m	0.001	-30(m)
2	pri_lever_arm_y	m	0.001	-30(m)
3	pri_lever_arm_z	m	0.001	-30(m)
4	vrp_lever_arm_x	m	0.001	-30(m)

5	vrp_lever_arm_y	m	0.001	-30(m)
6	vrp_lever_arm_z	m	0.001	-30(m)
7	user_lever_arm_x	m	0.001	-30(m)
8	user_lever_arm_y	m	0.001	-30(m)
9	user_lever_arm_z	m	0.001	-30(m)
10	rotation_rbv_x	deg	0.01	-180(deg)
11	rotation_rbv_y	deg	0.01	-180(deg)
12	rotation_rbv_z	deg	0.01	-180(deg)
13	second_lever_arm_x	m	0.001	-30(m)
14	second_lever_arm_y	m	0.001	-30(m)
15	second_lever_arm_z	m	0.001	-30(m)
23	dual antenna length	m	0.001	-30(m)
24	heading compensation	deg	0.01	-180(deg)
25	heading boresight	deg	0.01	-180(deg)
29	user do zupt	-	1	0
30	zupt interval	s	1	0
200	baud rate of rs232	-	1	0
210	baud rate of can1	-	1	0
213	can1 id offset	-	1	0
216	bit timing of can1	-	1	0
251	odometer protocol	-	1	0

*for detailed definition, pls refer to Table 12 User configurations

5.3.1.2 Save configuration (0x18FF51XX)

To save user configuration in flash.

Direction: other node to INS

CAN ID	Byte0
0x18FF51XX	0x64(address of INS)

Response Payload

Tx ID	0x18E8FF64, Intel		
Byte Offset	**Name**	**Format**	**Description**
0	Status		0: No error 1: Error
1 – 4	Reserved		
5 – 7	PGN	U3	The PGN number in request

5.3.1.3 Software Reset (0x18FF52XX)

The command is intended to reset the MCU, not the GNSS chip. The function is the same as 3.5.12. It also follows Acknowledgement in J1939 for response.

Request Payload

Rx ID	0x18FF52XX, Intel		
Byte Offset	**Name**	**Format**	**Description**
0	ECU_ID	U1	INS50X's ECU ID. Default is 0x64

Response Payload

Tx ID	0x18E8FF64, Intel		
Byte Offset	**Name**	**Format**	**Description**
0	Status		0: No error 1: Error
1 – 4	Reserved		
5 – 7	PGN	U3	The PGN number in request

5.3.1.4 Set GNSS to outage (0x18FF53XX)

The command is to control GNSS solution if used in INS algorithm.
When GNSS is set outage, INS502 still outputs GNSS solutions, but will not transfer to INS algorithm. Both antenna status of INS_Status_DataInfo (0x0CFF2864, 50hz) message will be set as 1.

Request Payload

Rx ID	0x18FF53XX, Intel		
Byte Offset	**Name**	**Format**	**Description**
0	ecu_id	U1	INS50X's ECU ID. Default is 0x64
1	operation	U1	Use 2 bits to set outage of available antennas.

			Bits definitions, Bit0: Primary antenna Bit1: Secondary antenna Bit value definitions, 0: Disable. Unset the outage 1: Enable. Set to outage Allow values: 0, 1, 2, 3

Response Payload

Tx ID	0x18E8FF64, Intel		
Byte Offset	**Name**	**Format**	**Description**
0	status	U1	0: No error 1: Error
1	reserved		
2	operation	U1	The operation in request
3	error_code	U1	Set error code if the payload is not valid 1: Invalid ECU ID 9: Invalid operation
4	reserved		
5 – 7	PGN	U3	The PGN number in request

5.3.1.5 Set Output Rate of Specified Output Packet (0x18FF54XX)

The command is intended to set the frequency for a single output packet. The output rate of Height and time packet will be changed to the same value if there is a higher output rate configured for another packet. Because Height and time packet is the first one in every output period, it should be synced to the highest output rate packet. The configured output rate will be lost after power off, unless a Save Configuration command (sC) is issued.

Request Payload

Rx ID	0x18FF54XX, Intel		
Byte Offset	**Name**	**Format**	**Description**
0	destination address	U1	INS50X's ECU ID. Default is 0x64
1	output_packet_index	U1	The specified index of output packet refer to Table 14 Range, scaling and offset of configurations
2	output_rate	U1	Output rate of the output packet.

Response Payload

Tx ID	0x18E8FF64, Intel		
Byte Offset	**Name**	**Format**	**Description**
0	status		0: No error 1: Error
1	reserved		
2	output_packet_index	U1	
3	error_code	U1	error code: **error code list.**
4	reserved	U1	
5 - 7	PGN	U3	The PGN number in request in LSB

5.3.2 Get Commands

5.3.2.1 Get user configuration (0x18EAFFXX)

Request user configuration has feedback.

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2	Byte3
0x18EAFFXX	0x50	0xFF	0x00	Index you require

Feedback:

Direction: INS to other node

CAN ID	Byte0	Byte1	Byte2-7
0x18FF5064	0x64(INS address)	Index you required	bytes payload in little endian order.

*Scale factor of Data, please refer to Table 14 Range, scaling and offset of configurations

5.3.2.2 Get Product Name(0x18FF4064)

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2
0x18EAFFXX	0x40	0xFF	0x00

Feedback:

Direction: INS to other node

CAN ID	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5
0x18FF4064	'I'	'N'	'S'	'5'	'0'	'2'

*Example: INS502. ASCII code

5.3.2.3 Get Serial Number (0x18FF4164)

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2
0x18EAFFXX	0x41	0xFF	0x00

Feedback:

Direction: INS to other node

CAN ID	Byte0	Byte1	Byte2	Byte3(MSB)
0x18FF4164	0xDC(LSB)	0xD2	0xD5	0x8D(MSB)

*Example: 0x8DD5D2DC (decimal: 2379600604)

5.3.2.4 Get App Name (0x18FF4264)

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2
0x18EAFFXX	0x42	0xFF	0x00

Feedback:

Direction: INS to other node

CAN ID	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6
0x18FF4264	'R'	'T'	'K'	'_'	'I'	'N'	'S'

*Example: RTK_INS. ASCII code

5.3.2.5 Get App version (0x18FF4364)

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2
0x18EAFFXX	0x43	0xFF	0x00

Feedback:

Direction: INS to other node

CAN ID	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x18FF4364	'3'	'1'	'0'	'0'	'1'	'3'	'-'	'7'

*Example: 310013-7. ASCII code

5.3.2.6 Get Bootloader Version(0x18FF4464)

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2
0x18EAFFXX	0x44	0xFF	0x00

Feedback:

Direction: INS to other node

CAN ID	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5
0x18FF4464	'v'	'0'	'1'	'.'	'0'	'2'

*Example: v01.02. ASCII code

5.3.2.7 Get Hardware Version(0x18FF4564)

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2
0x18EAFFXX	0x45	0xFF	0x00

Feedback:

Direction: INS to other node

CAN ID	Byte0	Byte1	Byte2	Byte3
0x18FF4564	'v'	'4'	'.'	'0'

*Example: v4.0. ASCII code

5.3.2.8 Get IMU Name (0x18FF4664)

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2
0x18EAFFXX	0x46	0xFF	0x00

Feedback:

Direction: INS to other node

CAN ID	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x18FF4664	'I'	'M'	'U'	'3'	'3'	'0'	'N'	'L'

*Example: IMU330NL. ASCII code

5.3.2.9 Get IMU version (0x18FF4764)

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2
0x18EAFFXX	0x47	0xFF	0x00

Feedback:

Direction: INS to other node

CAN ID	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5
0x18FF4764	'v'	'2'	'7'	'.'	'0'	'4'

*Example: v27.04. ASCII code

5.3.2.10 Get IMU SN (0x18FF4864)

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2
0x18EAFFXX	0x48	0xFF	0x00

Feedback:

Direction: INS to other node

CAN ID	Byte0(LSB)	Byte1	Byte2	Byte3(MSB)
0x18FF4864	49	85	44	83

*Example: 0x83448549. Decimal: 2202305865)

5.3.2.11 Get RTK Name (0x18FF4964)

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2
0x18EAFFXX	0x49	0xFF	0x00

Feedback:

Direction: INS to other node

CAN ID	Byte0
0x18FF4964	'U'

*Example: U. ASCII code

5.3.2.12 Get RTK version (0x18FF4A64)

Request:

PGN: 0xEA00

Direction: other node to INS

CAN ID	Byte0	Byte1	Byte2
0x18EAFFXX	0x4A	0xFF	0x00

Feedback:

Direction: INS to other node

CAN ID	Byte0	Byte1	Byte2	Byte3	Byte4
0x18FF4A64	'V'	'7'	'6'	'5'	'0'

*Example: V7650. ASCII code

5.3.2.13 Get Output Rate of Packet(0x0x18FF5464)

The command can get output rate information for specified output binary packet witch matched PGN.

Request Payload

Rx ID	**0x18EAFFXX, Intel**		
Byte Offset	**Name**	**Format**	**Description**
0	odr_info_pgn	U2	0xFF54 in little endian.
2	pgn_end	U1	Always 0x00
3	output_packet_index	U1	The specified index of output packet. Please refer to Table 14 for a detailed index.

Response Payload

Tx ID	**0x0x18FF5464, Intel**		
Byte Offset	**Name**	**Format**	**Description**
0	destination address	U1	INS50X's ECU ID. Default is 0x64
1	output_packet_index	U1	The output packet index in request payload. Refer to Table 14 for the related output packet.
2	output_rate	U1	Output rate of the output packet. About the available value, please refer to 4.4.

5.3.3 Wheel Speed Input (0x0CFF2145/46, to CAN1)

There are two odometer formats currently supported, this section is the first one, for second pls refer to 5.3.4. Parameter 251 (see Table 14) determine which format speed is used. Aceinna can support additional formats based on customer requests, please contact factory for more information.

The speed of the left and right rear wheels needs to be input. 0x45(SA) is left and 0x46(SA) is right.

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	Offset	Unit	Conversion	Description
Speed	40	16	signed	Intel	[-21.53, 21.53]	0.000657203	0	m/s	E=N*0.000657203	TC_Motor_RPM

TC_Motor_RPM (bytes 5-6) is signed:

- Position value: moving forward.
- Negative value: move backward.

Examples:

Speed calculation based on TC_Motor_RPM:

- Moving forward 10m/s:
  - Right and left both: Byte5-0x70, byte6-0x3B
  - Rev/min = (TC_Motor_RPM_L+TC_Motor_RPM_R)/2 = 0x3B70 = 15216
  - Speed = 15216 * 0.000657203 = +10.0 m/s
- Moving backward -10m/s:
  - Right and left both: Byte-0x90, byte6-0xC4
  - Rev/min = (TC_Motor_RPM_L+TC_Motor_RPM_R)/2 = 0xC490= -15216 (complement of signed 16-bit value)
  - Speed = -15216 * 0.000657203 = -10.0 m/s

5.3.4 CAR Speed Input (0xF022D0, to CAN1)

There are two odometer formats currently supported, this is second one. For first one, pls refer to 5.3.3. Aceinna can support additional formats based on customer requests, please contact factory for more information.

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	Offset	Unit	Conversion	Description

speed	0	16	unsigned	Intel	[0-64.255]	0.001	0	m/s	E=N*0.001	The speed of car
direction	56	2	unsigned	Intel	[0-3]	1	0	-	E=N*1	The direction of car 0: Reverse 1: Forward

5.4 DBC FILE

The DBC file for the INS502 may be obtained either by downloading it from the INS502 product page on the Aceinna website or by contacting Aceinna.

6 UART/Ethernet Messages Definition

The INS50X supports a series of packet structures that include both command or input data packets (data sent to the INS50X) and measurement output or response packet formats (data sent out from the INS50X).

There are 3 types of packets transferred on INS50X, they are Aceinna Binary Packet, NMEA-0183 and RTCM.

6.1 Packet structures

6.1.1 Aceinna Binary Packet

This is a binary packet used in Aceinna proprietary message transfer protocol. Most of the messages will be wrapped as this packet, and it has different formats on each interface based on the payload length limitation.

6.1.1.1 Packet format under UART/Ethernet interface

Below is the structure of packet:

Packet Header	Packet Type (U2)	Payload Length (U2)	Counter (U2)	Payload	CRC (U2)

- Byte order

Values and numbers are transmitted to Little Endian (Least Significant Byte First).

- Packet Header

The packet header is always the bit pattern 0x5555 which is ASCII string "UU".

- Packet Type

The packet type is always two bytes long in unsigned short integer format. Most input and output packet types can be interpreted as a pair of ASCII characters.

- Payload Length

The payload length is always unsigned short integer format with a range of 0-65535. The payload length byte is the length (in bytes) of the payload portion of the packet only and does not include the CRC.

- Counter

The counter is a rolling number from 0 to 65535 in unsigned short integer format. For output packets, it helps to check if there is missing output. For input packets and commands, the counter in response is always the same as it is in request.

- Payload

The payload is of variable length based on the packet type.

- 16-bit CRC-CCITT

Packets end with a 16-bit CRC-CCITT calculated on the entire packet excluding the 0x5555 header and the CRC field itself. This 16-bit CRC standard is maintained by the International Telecommunication Union (ITU). The highlights are:

Width = 16 bits

Polynomial 0x1021

Initial value = 0x1D0F

No XOR performed on the final value.

See Appendix A: for sample code that implements the 16-bit CRC algorithm.

6.1.2 NMEA-0183

The output ASCII Messages are NMEA 0183 version 4.10 standard messages. Refer to http://www.nmea.org/ for more information.

Currently, the output packets are **GNGGA, GNZDA.**

6.1.3 RTCM

RTCM format will be used in position correction services, and RTCM format will also be used in outputting rover data.

6.2 Output Binary Packets

6.2.1 INS Solution Data IN

Result information from Inertial Navigation System, it includes position, velocity and attitude.

Interfaces	Packet Component	Value		Payload	Packet Rate	Description
UART/Ethernet	Packet Type	0x49	0x4e	IN	Quiet, Periodicity Default: **100Hz**	Please read the below payload definition.
	Length	0x3b	0x00			

IN payload						
Byte Offset	**Name**	**Range**	**Format**	**Scaling**	**Unit**	**Description**
0	gps_week	[0, 65535]	U2	-		GPS time: GPS week and seconds of the GPS reference week
2	gps_millisecs	[0, 604800000]	U4	-	ms	

6	ins_status	[0, 5]	U1	-		0: INACTIVE 1: INS_ALIGNING 2: INS_HIGH_VARIANCE 3: INS_SOLUTION_GOOD 4: INS_SOLUTION_FREE 5: INS_ALIGNMENT_COMPLETE
7	gnss_solution_type	[0, 5]	U1	-		It is GNSS solution type that integrated in INS algorithm. When the antenna is not normally working (such as outage), the value will be 0. In most of time, the value is the same as gnss_solution_type of GN packet. The available values list below, 0: INVALID 1: SPP 2: RTD 4: RTK_FIXED 5: RTK_FLOAT
8	latitude	[-90, 90]	I4	1e-7	deg	Latitude, scaled as double
12	longitude	[-180, 180]	I4	1e-7	deg	Longitude, scaled as double
16	height		F4	-	m	Height above ellipsoid
20	north_vel	[-100, 100]	I2	1/100	m/s	North velocity. Scaled as float
22	east_vel	[-100, 100]	I2	1/100	m/s	East velocity. Scaled as float
24	up_vel	[-100, 100]	I2	1/100	m/s	Up velocity. Scaled as float
26	roll	[-180, 180]	I2	1/100	deg	Vehicle roll
28	pitch	[-90, 90]	I2	1/100	deg	Vehicle pitch
30	heading	[0, 360]	U2	1/100	deg	Vehicle heading. Range is 0-360.
32	long_vel	[-100,100]	I2	1/100	m/s	Longitudinal velocity
34	lat_vel	[-100,100]	I2	1/100	m/s	Lateral velocity
36	latitude_std	[0, 65.535]	U2	1/1000	deg	Latitude standard deviation
38	longitude_std	[0, 65.535]	U2	1/1000	deg	Longitude standard deviation
40	height_std	[0, 65.535]	U2	1/1000	m	Ellipsoidal height standard deviation
42	north_vel_std	[0, 65.535]	U2	1/1000	m/s	North velocity standard deviation
44	east_vel_std	[0, 65.535]	U2	1/1000	m/s	East velocity standard deviation
46	up_vel_std	[0, 65.535]	U2	1/1000	m/s	Up velocity standard deviation
48	long_vel_std	[0, 65.535]	U2	1/1000	m/s	Longitudinal velocity standard deviation
50	lat_vel_std	[0, 65.535]	U2	1/1000	m/s	Lateral velocity standard deviation
52	roll_std	[0, 65.535]	U2	1/1000	deg	Roll standard deviation
54	pitch_std	[0, 65.535]	U2	1/1000	deg	Pitch standard deviation
56	heading_std	[0, 65.535]	U2	1/1000	deg	Heading standard deviation
58	reserved	[0, 255]	U1			

6.2.2 High Resolution IMU Data S2

This is the recommended data packet to be used in navigation and dead reckoning applications.

Interfaces	Packet Component	Value		Payload	Packet Rate	Description
UART/Ethernet	Packet Type	0x53	0x32	S2	Quiet, Periodicity Default: **100Hz**	Please read the below payload definition.
	Length	0x26	0x00			

This packet contains sensor data in floating point format, synchronized with GNSS unit timestamps and master status word. Below provided payload format of this message.

S2 payload					
Byte Offset	**Name**	**Range**	**Format**	**Unit**	**Description**
0	gps_week	[0, 65535]	U2		GPS time: GPS week and seconds of the GPS reference week
2	gps_millisecs	[0, 604800000]	U4	ms	
6	accel_x	[-78.4, 78.4]	F4	m/s^2	accel x axis measurement
10	accel_y	[-78.4, 78.4]	F4	m/s^2	accel y axis measurement
14	accel_z	[-78.4, 78.4]	F4	m/s^2	accel z axis measurement
18	gyro_x	[-250, 250]	F4	deg/s	gyro x axis measurement
22	gyro_y	[-250, 250]	F4	deg/s	gyro y axis measurement
26	gyro_z	[-250, 250]	F4	deg/s	gyro z axis measurement
30	temperature	[-200, 200]	F4	deg C	Unit temperature
34	masterstatus	[0, 65535]	U2	bitmask	Please refer to Table 9. IMU Master BIT status
36	reserved		U2		

6.2.3 GNSS Solution Data GN

Interfaces	Packet Component	Value		Payload	Packet Rate	Description
UART/Ethernet	Packet Type	0x47	0x4e	GN	Quiet, OnChange Default: **1Hz**	Please read the below payload definition.
	Length	0x32	0x00			

GN Payload						
Byte Offset	**Name**	**Range**	**Format**	**Scaling**	**Unit**	**Description**
0	gps_week	[0, 65535]	U2	-		GPS time: GPS week and seconds of the GPS reference week
2	gps_millisecs	[0, 604800000]	U4	-	ms	

6	gnss_solution_type	[0, 5]	U1	-		0: INVALID 1: SPP 2: RTD 4: RTK FIXED 5: RTK FLOAT
7	latitude	[-90, 90]	I4	1e-7	deg	Latitude, scaled as double
11	longitude	[-180, 180]	I4	1e-7	deg	Longitude, scaled as double
15	height		F4	-	m	Height above ellipsoid
19	satellite_count_in_view	[0, 255]	U1	-		Number of satellites in view
20	satellite_count_in_solution	[0, 255]	U1			Number of satellites in solution
21	rtcm_correction_status	[0, 255]	U1	-		The status of RTCM communications. RTCM data received Bit0: 0 - Exception, 1- Normal RTCM Validity Bit1: 0 – Exception, 1- Normal Bit2~7 reserved
22	hdop	[0, 100]	U2	1/100		Horizontal Dilution of Precision
24	vdop	[0, 100]	U2	1/100		Vertical Dilution of Precision
26	tdop	[0, 100]	U2	1/100		Time Dilution of Precision
28	diff_age	[0, 65535]	U2	-	s	Age of differential GNSS correction
30	north_vel	[-100, 100]	I2	1/100	m/s	North velocity. Scaled as float
32	east_vel	[-100, 100]	I2	1/100	m/s	East velocity. Scaled as float
34	up_vel	[-100, 100]	I2	1/100	m/s	Up velocity. Scaled as float
36	latitude_std	[0, 65.535]	U2	1/1000	deg	Latitude standard deviation
38	longitude_std	[0, 65.535]	U2	1/1000	deg	Longitude standard deviation
40	height_std	[0, 65.535]	U2	1/1000	m	Height standard deviation
42	north_vel_std	[0, 65.535]	U2	1/1000	m/s	North velocity standard deviation
44	east_vel_std	[0, 65.535]	U2	1/1000	m/s	East velocity standard deviation
46	up_vel_std	[0, 65.535]	U2	1/1000	m/s	Up velocity standard deviation
48	primary_cn0	[0, 255]	U1		db-Hz	Average cn0 value from satellites in view of primary antenna
49	secondary_cn0	[0, 255]	U1		db-Hz	Average cn0 value from satellites in view of secondary antenna. The value will be reserved if cannot get CN0 from secondary antenna.

6.2.4 Raw GNSS Data Log RR

This is a raw data packet which contains data from GNSS chip-set. It also includes RTCM rover data.

The output RTCM rover data includes message type with 1019, 1020, 1042, 1044, 1045, 1046, 1077, 1087, 1097, 1117, 1127. They are all standard format follow RTCM version 3. And it also includes Aceinna customized format 1200.

Interfaces	Packet Component	Value		Payload	Packet Rate
UART/Ethernet	Packet Type	0x52	0x52	RR payload	Quiet, OnChange Default: **OnChange**
	Length	N			

RR payload			
Offset	**Name**	**Format**	**Description**
0	piece_data	UN	Piece of RAW GNSS Data log payload

Below is the definition of RTCM Rover 1200, a customized format by Aceinna.

Name	Bit length	Scaling	Unit	Description
gps_week	16	1	week	GPS week
gps_millisecs	30	1/1000	second	Seconds of the GPS reference week
leap second	8	1	second	
satellite_count_in_view	8	1	-	Number of satellites in view
satellite_count_in_solution	8	1	-	Number of satellites in solution
gnss_solution_type	4	1	-	0: INVALID 1: SPP 2: RTD 4: RTK FIXED 5: RTK FLOAT
hdop	8	1/10	-	Horizontal Dilution of Precision
vdop	8	1/10	-	Vertical Dilution of Precision
pdop	8	1/10	-	Position Dilution of Precision
geoid undulation	16	1/100	m	
latitude	32	1e-9	rad	Latitude with radian measure
longitude	32	1e-9	rad	Longitude with radian measure
height	24	1/100	m	Height above ellipsoid
east_vel	20	1/100	m/s	North velocity
north_vel	20	1/100	m/s	East velocity
up_vel	20	1/100	m/s	Up velocity
horizon_position_pl	16	1/100	m	Horizontal position protection level
vertical_position_pl	16	1/100	m	Vertical position protection level

horizon_velocity_pl	16	1/100	m/s	Horizontal velocity protection level
vertical_velocity_pl	16	1/100	m/s	Vertical velocity protection level
clock bias	20	1/100	m	
clock drift	20	1/100	m/s	

6.2.5 Odometer Car Speed Data O1

This packet is converted odometer information, it contains gear and speed data.

Interfaces	Packet Component	Value		Payload	Packet Rate	Description
UART/Ethernet	Packet Type	0x4f	0x31	O1	Quiet, Periodicity Default: **100Hz**	Please read the below payload definition.
	Length	0x18	0x00			

O1 payload					
Offset	**Name**	**Range**	**Format**	**Unit**	**Description**
0	gps_week	[0, 65535]	U2		GPS time: GPS week and seconds of the GPS reference week
2	gps_millisecs	[0, 604800000]	U4	ms	
6	mode	[0,1]	U1		Vehicle speed source mode: 0: decoded from odometer message over CAN (default) 1: vehicle wheel tick number
7	speed	[-250, 250]	D8	m/s	Vehicle speed at the vehicle reference point
15	fwd	[-1,1]	I1		Vehicle driving mode: 0: parking 1: forward driving -1: reverse driving
16	wheel_tick		U8		Wheel tick number converted from wheel tick pulse (if in wheel tick speed mode)

6.2.6 INS Integrity II

Interfaces	Packet Component	Value		Payload	Packet Rate	Description
UART/Ethernet	Packet Type	0x49	0x49	II	Quiet, OnChange Default: **OnChange**	Please read the below payload definition.
	Length	0x15	0x00			

II payload						
Offset	**Name**	**Range**	**Format**	**Scaling**	**Unit**	**Description**
0	gps_week	[0,65535]	U2	-		

2	gps_millisecs	[0,604800000]	U4	-	ms	GPS time: GPS week and seconds of the GPS reference week
6	horizon_position_pl	[0,655.35]	U2	1/100	m	Horizontal position protection level
8	vertical_position_pl	[0,655.35]	U2	1/100	m	Vertical position protection level
10	horizon_velocity_pl	[0,655.35]	U2	1/100	m/s	Horizontal velocity protection level
12	vertical_velocity_pl	[0,655.35]	U2	1/100	m/s	Vertical velocity protection level
14	roll_pl	[0,655.35]	U2	1/100	deg	Roll protection level
16	pitch_pl	[0,655.35]	U2	1/100	deg	Pitch protection level
18	heading_pl	[0,655.35]	U2	1/100	deg	Heading protection level
20	status	[0,255]	U1	-		Bit value 0: Normal, 1: Error Bits definition bit0: Horizontal position protection level status bit1: Vertical position protection level status bit2: Horizontal velocity protection level status bit3: Vertical velocity protection level status bit4: Roll protection level status bit5: Pitch protection level status bit6: Heading protection level status

6.2.7 Heading Solution HS

Interfaces	**Packet Component**	**Value**		**Payload**	**Packet Rate**	**Description**
UART/Ethernet	Packet Type	0x48	0x53	HS	Quiet, OnChange Default: **OnChange**	Please read the below payload definition.
	Length	0x15	0x00			

Heading Solution payload						
Byte Offset	**Name**	**Range**	**Format**	**Scaling**	**Unit**	**Description**
0	gps_week	[0, 65535]	U2			GPS week
2	gps_millisecs	[0, 604800000]	U4		ms	GPS time of week
6	solution_type	[0, 5]	U1			Refer to gnss_solution_type in 6.2.3

7	length	[-100, 100]	U2	1/1000	m	
9	roll	[-180, 180]	I2	1/100	deg	
11	pitch	[-90, 90]	I2	1/100	deg	
13	heading	[0, 360]	U2	1/100	deg	Range is 0-360
15	heading_std	[0, 65.535]	U2	1/1000	deg	Heading accuracy
17	length_std	[0, 65.535]	U2	1/1000	m	Length accuracy
19	secondary_satellite_count_in_view	[0, 255]	U1			Number of satellites in view of secondary antenna
20	secondary_satellite_count_in_solution	[0, 255]	U1			Number of satellites in dual-antenna solution

6.2.8 Device diagnostic Packet DM

To be implemented in future.

6.3 Output ASCII Packet

The tables below describe the brief meaning of each field that is delimited by comma in the NMEA messages.

Table 15.GNGGA Packet

Field Sequence	Description
0	Message ID $GNGGA
1	UTC time of position fix
2	Latitude
3	Direction of latitude: N – North; S - South
4	Longitude
5	Direction of longitude: E - East; W - West
6	GNSS Positioning Quality indicator: 0: GNSS position Fix not valid 1: GNSS position fix (SPP) 2: Differential GNSS position fix (RTD) 4: Real-Time Kinematic, fixed integers 5: Real-Time Kinematic, float integers
7	Number of SVs in use, range from 00 through to 40
8	HDOP
9	Orthometric height (MSL reference)
10	M: unit of measure for orthometric height is meters
11	Geoid separation
12	M: geoid separation measured in meters

13	Age of differential GNSS correction data. Null field when differential GNSS is not used.
14	Reference station ID, range 0000-4095. A null field when no reference station ID is available, and no corrections are received.
15	The checksum data, always begins with *

Table 16.GNZDA

Field Sequence	Description
0	Message ID $GNZDA
1	UTC
2	Day, ranging between 01 and 31
3	Month, ranging between 01 and 12
4	Year
5	Local time zone offset from GMT, ranging from 00 through ±13 hours
6	Local time zone offset from GMT, ranging from 00 through 59 minutes
7	The checksum data, always begins with *

NOTE

The ASCII packet is only available on interface UART and Ethernet.

6.4 Input Binary Packets

6.4.1 Repacked RTCM Correction data iR

In order to perform GNSS RTK, the INS50X device needs RTK correction data (RTCM messages) input from user device (vehicle). For UART interface, it suggests user input raw correction data through RS232. But for Ethernet interface, it needs user to wrap the correction data as Aceinna Binary format. Below is the message format.

Interfaces	Packet Component	Value		Payload
UART	Raw RTCM correction data			
Ethernet	Packet Type	0x69	0x52	Raw RTCM correction data
	Length	N		

6.4.2 Vehicle Speed data cA

In addition, another user input of the INS50X is defined as below, to enhance the dead reckoning (DR) performance of the IMU based INS solution. The accurate vehicle speed from the vehicle reference point provides accurate speed constraint to the along-track direction. This speed is decoded from CAN odometer messages, and usually is the average of the two rear wheels' odometer speed. In such case, the vehicle reference point (VRP) is the middle point of the two rear wheels in the vehicle frame.

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x63	0x41	cA	Please read the below payload definition.
	Length	0x04	0x00		

cA payload				
Offset	**Name**	**Format**	**Unit**	**Description**
0	speed	F4	km/h	Positive if forward driving, negative if backward moving, zero if stationary.

6.5 User Commands

6.5.1 Get the Error Code gE

To be implemented in future.

6.5.2 Get the Hardware Version Number hV

The command responds the hardware version of the module. It includes product, model, part number and serial number.

Request

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x68	0x56	hV request payload	Please read below payload definition.
	Length	0x01	0x00		

hV request payload			
Byte Offset	**Name**	**Format**	**Description**
0	component	U1	0: INS50X 1: IMU 2: GNSS SoC

Response

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x68	0x56	hV response payload	Please read the below payload definition.
	Length	N			

hV response payload			
Byte Offset	**Name**	**Format**	**Description**
0	component	U1	The requested component
1	version	SN	The version value is based on component in request payload. Please refer to the mappings below.

Component	Version	Description
0	INS50X_HW	The value is combined as PRODUCT_NAME, PART_NUMBER, SERIAL_NUMBER, HW_VERSION For example, "INS50X 5020-4007-01 21790xxxxx Hardware v1.0"
1	IMU_HW	The value is combined as IMU_PRODUCT_NAME, IMU_PART_NUMBER, IMU_SERIAL_NUMBER For example, "IMU330NL 5020-4009-01 21790xxxxx"
2	GNSS_SoC_HW	The value is combined as SoC_NAME, SoC_PART_NUMBER, SoC_ SERIAL _NUMBER For example, "UM982 231041500001 LR23B131717371"
3~255		"Invalid component"

6.5.3 Get the Software Version Number sV

The command responds the software version of the module. It includes the software version of sub-system.

Request

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x73	0x56	sV request payload	Please read the below payload definition.
	Length	0x01	0x00		

sV request payload			
Byte Offset	**Name**	**Format**	**Description**
0	component	U1	0: INS50X App 1: INS50X Bootloader

			2: IMU 3: GNSS SoC

Response

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x73	0x56	sV response payload	Please read the below payload definition.
	Length	N			

sV response payload			
Byte Offset	**Name**	**Format**	**Description**
0	component	U1	The requested component
1	version	SN	The version value is based on component in request payload. Please refer to the mappings below.

Component	Version	Description
0	APP_VERSION	App version. Value could be "v31.00.01"
1	BOOT_VERSION	Bootloader version. Value could be "v01.00.09"
2	IMU_APP_VERSION	IMU app version. Value could be "v22.08.08"
3	GNSS_SOC_VERSION	SoC software version. The SoC could be UM982, AG335 or any other component.

6.5.4 Get the Algorithm Version Number aV

The command responds the algorithm version of the module.

Request

Interfaces	Packet Component	Value		Payload
UART/Ethernet	Packet Type	0x61	0x56	Empty
	Length	0x00	0x00	

Response

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x61	0x56	aV response payload	Please read the below payload definition.
	Length	N			

aV response payload			
Byte Offset	**Name**	**Format**	**Description**
0	algorithmVersion	SN	The value is combined as INSLIB_VERSION, RTKLIB_VERSION (if available), MVBLIB_VERSION (if available) and COMMA SPACE as split. For example, "INSLIB_1.0.0, RTKLIB_1.0.0, MVBLIB_1.0.0"

6.5.5 Get User Parameter in Batch gB

The command helps to get a continuous parameter in sequence at a time.

Request

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x67	0x42	gB request payload	Please read the below payload definition.
	Length	N			

gB request payload			
Byte Offset	**Name**	**Format**	**Description**
0	paramNums	U1	The count of parameters in the request
1	paramId1	U1	First parameter id
2	paramId2	U1	Second parameter id
...	...		
paramNums-1	paramIdN-1	U1	The last parameter id to read

Response

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x67	0x42	gB response payload	Please read the below payload definition.
	Length	N			

gB response payload			
Byte Offset	**Name**	**Format**	**Description**
0	paramNums	U1	The count of parameters in the response
1	paramId1	U1	The first parameter id
2	paramLen1	U1	The first parameter length
3	paramValue1	UN	The first parameter value

lastOffset+ lastParamSize	paramId2	U1	The second parameter id
lastOffset+1	paramLen1	U1	The second parameter length
lastOffset+2	paramValue2	UN	The second parameter value
…	…		More parameter

NOTE

For the actual parameter id and length, please refer to Table 12 User configurations.

6.5.6 Update Parameter in Batch uB

It allows to configure multiple parameters at a time with this command.

Request

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x75	0x42	uB request payload	Please read the below payload definition.
	Length	N			

uB request payload			
Byte Offset	**Name**	**Format**	**Description**
0	paramNums	U1	The count of parameters in the request
1	paramId1	U1	First parameter id
2	paramLen1	U1	First parameter length
3	paramValue1	UN	The first parameter value. Please make sure the size of parameter value, should be equal to parameter length
lastOffset+ lastParamSize	paramId2	U1	The second parameter id
lastOffset+1	paramLen2	U1	The second parameter length
lastOffset+2	paramValue2	UN	The second parameter value
...	...		More parameter

Response

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x75	0x42	uB response payload	Please read the below payload definition.
	Length	2*numsParamId+1			

uB response payload			
Byte Offset	**Name**	**Format**	**Description**

0	paramNums	U1	The count of parameters in the response
1	paramId1	U1	First parameter id
2	paramResult1	I1	First update Result. Parameter update result is an int8 format value. And have 4 types of value as defined below 0: Success Other: Error code
3	paramI2	U1	Second parameter id
4	paramResult2	I1	Second update result
…	…		More result

6.5.7 Save Configuration sC

The command performs to save the parameter changes. The value of parameters will not lose although the power off.

Request

Interfaces	Packet Component	Value		Payload
UART/Ethernet	Packet Type	0x73	0x43	Empty
	Length	0x00	0x00	

Response

Interfaces	Packet Component	Value		Payload
UART/Ethernet	Packet Type	0x73	0x43	Empty
	Length	0x00	0x00	

6.5.8 Restore to default parameter rD

This command performs parameters reset operation. All the parameters will be restored to factory settings. Most of user parameters will take effect when get the command feedback from INS502. But algorithm parameters will be applied after the next power-on.

Request

Interfaces	Packet Component	Value		Payload
UART/Ethernet	Packet Type	0x72	0x44	Empty
	Length	0x00	0x00	

Response

Interfaces	Packet Component	Value		Payload
UART/Ethernet	Packet Type	0x72	0x44	Empty

	Length	0x00	0x00	

6.5.9 Reset GNSS Command rG

This command performs a GNSS receiver reset.

Request

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x72	0x47	rG request payload	Please read the below payload definition.
	Length	0x04	0x00		

rG request payload				
Offset	**Name**	**Format**	**Unit**	**Description**
0	controlMode	U1		0x01 reset GNSS receiver

Response

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x72	0x47	rG response payload	Please read below payload definition.
	Length	0x02	0x00		

rG response payload				
Offset	**Name**	**Format**	**Unit**	**Description**
0	controlMode	U1		controlMode in rG request payload
1	result	U1		Result of operation 0: Success Other: Error Code

6.5.10 Software Reset Command sR

This command performs a core CPU reset, not reset GNSS chip. All default power-up field settings will apply. The unit will respond with a software reset response before the system goes down.

Request

Interfaces	Packet Component	Value		Payload
UART/Ethernet	Packet Type	0x73	0x52	Empty
	Length	0x00	0x00	

Response

Interfaces	Packet Component	Value		Payload
UART/Ethernet	Packet Type	0x73	0x52	Empty

	Length	0x00	0x00	

6.5.11 List output in COM Command IO

List the output packet setting on specified COM port. The response payload is increased with the new output packet configuration on UART port.

NOTE

About the detailed packet, please refer to the output packets in 6.2 Output Binary Packets

Request

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x6c	0x4f	lO request payload	Please read the below payload definition.
	Length	0x01	0x00		

lO request payload				
Offset	**Name**	**Format**	**Unit**	**Description**
0	interface_type	U1		0: UART 2: CAN-FD 3: ETHERNET 255: Current interface

Response

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x6c	0x4f	lO response payload	Please read the below payload definition.
	Length	packetNums*3+1			

lO response payload				
Offset	**Name**	**Format**	**Unit**	**Description**
0	packetNums	U1		Count of packet under request interface
1	packet1	U2		Output packet 1
3	dataOutputRate1	U1		0: Quiet 1: 1Hz 5: 5Hz 10: 10Hz 20: 20Hz 25: 25Hz 50: 50Hz

				100: 100Hz 255: On Change
4	packet2	U2		Output packet 2
6	dataOutputRate2	U1		
...	...			
packetNums*3-2	packetN	U2		Output packet N
packetNums*3	dataOutputRateN	U1		

6.5.12 Set output in COM Command sO

Assign the output packet to stream on specified COM port, it could also setup the data out rate. It allows to setup multiple output packets at the same time.

Request

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x73	0x4f	sO request payload	Please read the below payload definition.
	Length	packetNums*4+1			

sO request payload				
Offset	**Name**	**Format**	**Unit**	**Description**
0	packetNums	U1		Count of packets in this request
1	packet1	U2		Packet Type of Output packet 1
3	interface_type	U1		Interface type. Allows 0, 2, 3, 255
4	dataOutputRate	U1		Please refer to 4.4 Available output packet rate
5	packet2	U2		Packet Type of Output packet 2
7	interface_type	U1		
8	dataOutputRate	U1		
...	...			
packetNums*4-3	packetN	U2		Packet Type of Output packet N
packetNums*4-1	interface	U1		
packetNums*4	dataOutputRate	U1		

Response

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x73	0x4f	sO response payload	Please read the below payload definition.
	Length	packetNums*4+1			

sO response payload

Offset	Name	Format	Unit	Description
0	packetNums	U1		Count of packets in this request
1	packet1	U2		Packet Type of Output packet 1
3	Interface_type	U1		Interface type
4	set_result1	U1		Odr set result. 0: Success Other: Error code
5	packet2	U2		Packet Type of Output packet 2
7	interface_type	U1		Interface type
8	set_result2	U1		Odr set result.
...	...			
packetNums*4-3	packetN	U2		Packet Type of Output packet N
oacketNums*4-1	interface_type	U1		Interface type
packetNums*4	set_resultN	U1		Odr set result.

6.5.13 Clear output on COM Command cO

The command is intended for reset all the output packets rate configuration on specified COM port.

Request

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x63	0x4f	cO request payload	Please read the below payload definition.
	Length	0x01	0x00		

cO request payload				
Offset	Name	Format	Unit	Description
0	interface_type	U1		0: UART 2: CAN-FD 3: ETHERNET 255: Current port

Response

Interfaces	Packet Component	Value		Payload	Description
UART/Ethernet	Packet Type	0x63	0x4f	cO response payload	Please read the below payload definition.
	Length	0x01	0x00		

cO response payload				
Offset	Name	Format	Unit	Description
0	result	U1		0: success

				Other: Error Code

6.5.14 Set GNSS to Outage oT

The command is to control GNSS solution if used in INS algorithm. When GNSS is set outage, INS50X still outputs GNSS solution type in $GPGGA, but will not transfer to INS algorithm. And the highest significant bit of gnss_solution_type field in both GN and HS output packet will be set as 1.

Request

Interfaces	**Packet Component**	**Value**		**Payload**
UART/Ethernet	Packet Type	0x6f	0x54	oT request payload. Please read the below payload definition.
	Length	0x01	0x00	

oT request payload				
Byte Offset	**Name**	**Range**	**Format**	**Description**
0	operation	[0, 3]	U1	Use 2 bits to set outage of available antennas. Bits definitions, Bit0: Primary antenna Bit1: Secondary antenna Bit value definitions, 0: Disable. Unset the outage 1: Enable. Set to outage Allow values: 0, 1, 2, 3

Response

Interfaces	**Packet Component**	**Value**		**Payload**
UART/Ethernet	Packet Type	0x6f	0x54	oT response payload. Please read the below payload definition.
	Length	0x00	0x00	

oT response payload				
Byte Offset	**Name**	**Range**	**Format**	**Description**
0	operation	[0, 3]	U1	Operation in request
1	result	[0,255]	U1	0 = Success Other = Error Occurred

7 Firmware Upgrade

7.1 Firmware Upgrade over CAN

Boot loader over CAN to be added in future.

7.2 Firmware Upgrade over Ethernet

Boot loader over Ethernet is supported. Aceinna supplies a Windows utility to perform a FW upgrade via Ethernet. Please contact Aceinna, or follow the steps in the application note "INS502-Firmware Upgrade instructions over ethernet.pdf".

Appendix A: 16-bit CRC Implementation Sample Code

The following is the 16-bit CRC sample code used in most of the code development.

```
uint16_t CalculateCRC (uint8_t *buf, uint16_t length)
{
    uint16_t crc = 0x1D0F;

    for (int i=0; i < length; i++) {
        crc ^= buf[i] << 8;
        for (int j=0; j<8; j++) {
            if (crc & 0x8000) {
                crc = (crc << 1) ^ 0x1021;
            }
            else {
                crc = crc << 1;
            }
        }
    }
    return ((crc << 8) & 0xFF00) | ((crc >> 8) & 0xFF);
}
```

Appendix B: Detailed Revision History

Document Revision	Firmware Applicability	Description
-D1	31.00.07/08/10	Preliminary version
-D2	31.00.11/12	Add bit "INS_Base_Connect_Status" in INS_DataInfo CAN packet; In INS_DataInfo CAN packet, "INS_GpsFlag_Pos" is deleted and use bit0-2 instead, and heading solution status in bit4-6; Default baud rate of RS232 is updated to 230400 and can be configured over CAN/Ethernet by new ID; Add new ID for CAN PGN offset configuration; Update DBC file; Add description for each kind of INS status; Update figure of IMU Axis Definition and Navigation Center Location; Update RF connector to SMA type.
-D3	31.00.13	Add id-210/216 baud rate and sampling point configurations over CAN; Update feedback of get user configuration cmd over CAN; Add feedback for set/save cmd over CAN; Update DBC file; Add INS Integrity II packet over Ethernet;
-D4	31.00.14	Add software reset command over CAN; Support auto-rate in data field and add comments in configuration table; Support id offset in CAN messages; Support boresight & dual-antenna-length auto calculation and add comments in configuration table; Add oT command to simulate GNSS outage over CAN, antenna_disconnect bits in 5.2.7 to reflect GNSS outage simulation status; Add get app-name/app-version/bootloader-version/hw-version/imu-name/imu-version/imu-sn/rtk-name/rtk-version command over CAN; Support 0xF022D0 another format odometer input, add id-251 for Odometer protocol selection; Add Secondary_satellites_avg_cn0 in GNSS Satellites over CAN;
-D5	31.00.15	Update request of Antenna; Add Get/Set Output Rate of Packet over CAN; New Ethernet protocol implemented, update section 6, delete section 7; Add protection level and more GNSS packets over CAN; Update appendix A; Add section 1.4 Bit status; Add section 1.5 Available output packet rate; Add section 1.6 user configuration;