



INS402 Interface Description

(Preliminary)

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Revision History

Revision	Date	Author	Change Description
1.0	03/28/2022	RJW/CEK	First version

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1 Introduction



The Aceinna INS402 high-precision navigation system integrates a multi-constellation, multi-frequency Global Navigation Satellite System (GNSS) (supports GPS, GALILEO, GLONASS, Beidou, QZSS, NAVIC and SBAS), an Aceinna MEMS Inertial Measurement Unit (IMU) module IMU330ZA, and a single Cypress multi-core Cortex-M7 micro-controller (MCU) CYT4BFBCHD as the main processor. The INS402 system includes built-in proprietary GNSS RTK positioning engine and a proprietary INS navigation engine.

The Aceinna IMU330ZA is a triple-redundant 6-axis (3-axis accelerometer and 3-axis gyro) IMU module that encloses three MEMS IMU sensor chips, and each of the three IMU sensor chips is calibrated individually. The combined IMU sensor data provides 6-DOF (Degrees of Freedom) inertial measurements.

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2 Scope

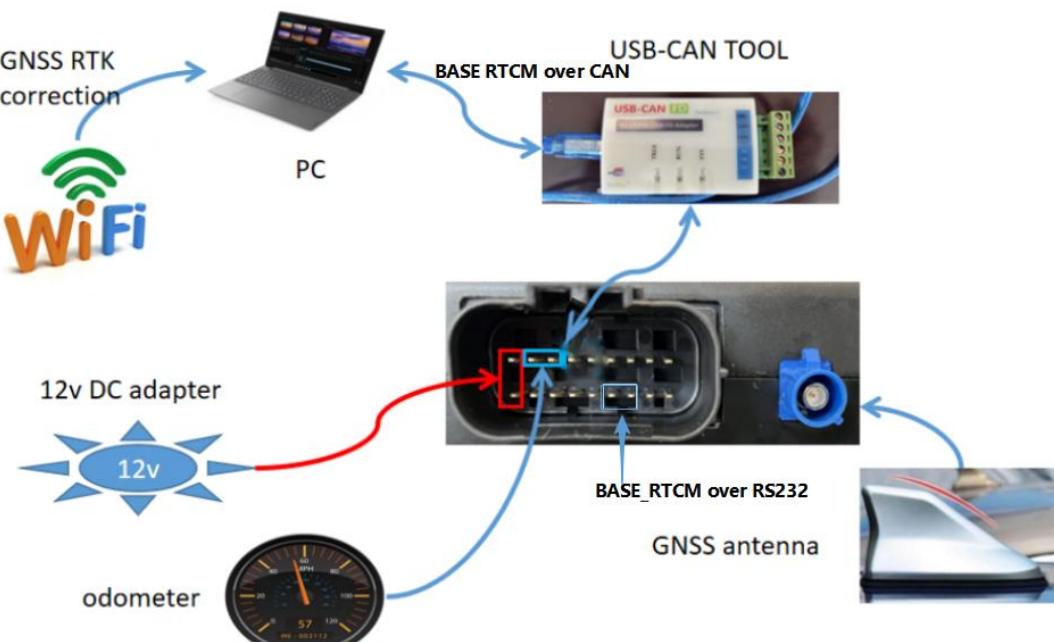
This document provides a description of the CAN and RS-232 interfaces on the INS402.

3 Interface Design

3.1 Hardware

The INS402 will ultimately support several interfaces including CAN, CANFD, Automotive Ethernet (100Mbps), and RS-232.

3.1.1 Connection



The overview of connections using CAN/RS232 interface with the vehicle is shown in the picture above. The primary interface is CAN J1939, while the RTCM data can be input to the INS401 via either CAN or RS-232 as shown.



DB9 connector is recommended to connect with odometer signal line.

3.1.2 Channels of CAN/CANFD ports

CAN1: CAN-J1939, 250 Kbps

CAN2: reserved(in future release, CAN2 will support either CANFD or standard CAN)

CAN3: reserved(not populated)

3.1.3 General settings of RS232

The serial port settings are RS232 with 1 start bit, 8 data bits, no parity bit, 1 stop bit, and no flow control. The serial port is used for RTCM input and ASCII NMEA messages.

Baud rate: 460800

3.1.4 RF Connector

An automotive grade FAKRA-J C type connector, manufactured by Molex, is used for the GNSS antenna connection. Its manufacturing part number is 734035112. The mating connector has part number 734036262. The center conductor carries the RF signal into the INS402 receiver and delivers 5 V DC from the INS402 to the external active antenna.

The master antenna should be connected with the RF connector which is near the main connector, the other RF connector for the slave antenna.

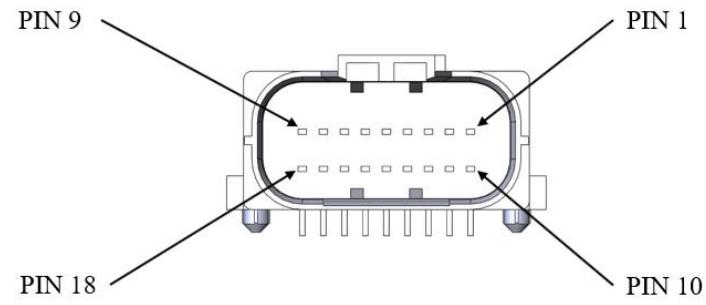
Installation: ensure that the 2 antennas have a clear view of the sky, and configure the lever arms based on accurate measurements of the antenna and INS locations (see detailed description of lever arm definition). For best performance the distance between master and slave antennas should be at least 1m.

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3.1.5 Main Connector and Pin Description

The main connector carries all the other power and I/O signals to and from the INS402 module. This connector is also of automotive grade and is manufactured by JAE Electronics. The male end which is installed in the INS402 housing has part number MX23A18NF1; the female end, which is attached to the external wiring harness, has part number MX23A18SF1. Figure below illustrates the location of the 18 pins in the male part, as seen facing the connector from outside the module.



Pin Diagram of the Male End

This table shows the functional description of the 18 pins in the main connector.

Pin #	INS402	Signal Description
1	CAN3_L	reserved
2	CAN3_H	reserved
3	ETH_TRX_N	Ethernet Negative
4	ETH_TRX_P	Ethernet Positive
5	CAN2_L	CANFD Low
6	CAN2_H	CANFD High
7	CAN1_L	CAN Low
8	CAN1_H	CAN High
9	VCC_IN	Power Supply Positive, range 9v to 32V
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

3.1.6 Mounting Instructions

Use four bolts of 1/4-20 UNC socket head cap screw (ASME B18.3) to fix the INS402 system on a flat rigid panel on the vehicle, using the mechanical dimension measures shown in Figure 1. The IMU navigation center

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and the IMU body frame default coordinate definition is shown in Figure 1. Align the INS402 system x-axis with the forward driving direction of the vehicle, Y is right, and Z is down.

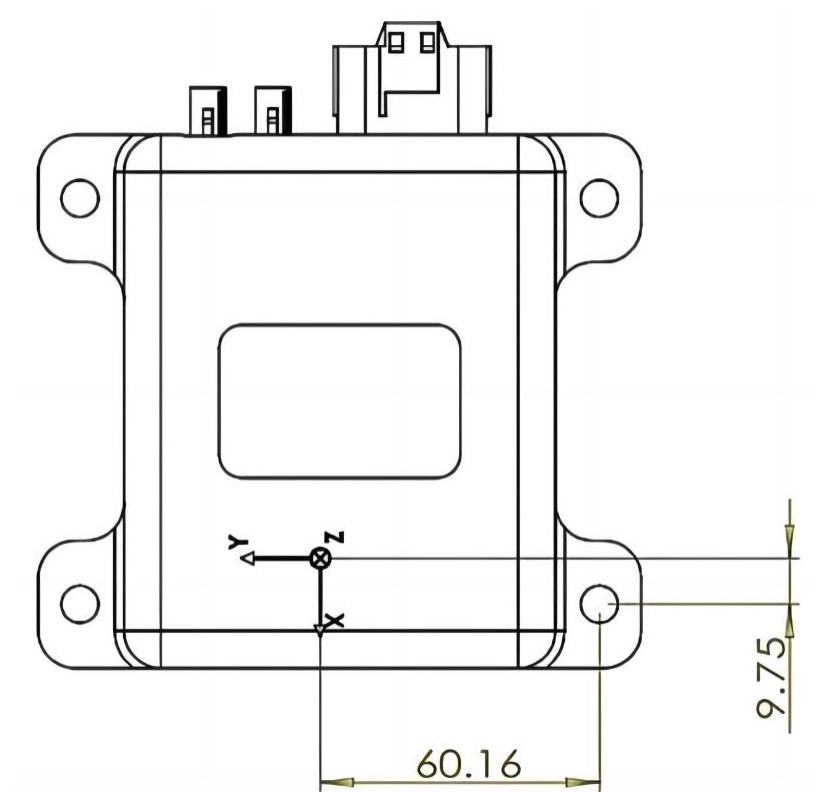


Figure 1 INS402 Hardware Dimensions (reference point sign)

By default, the IMU body frame orientation of INS402 is defined as in the figure above, with the X-axis pointing to the opposite direction of the connectors, Z-axis pointing down, and Y-axis completing a right-hand coordinate system. To align with the vehicle frame definition, the INS402 should be mounted on the vehicle with the connectors facing the tail of the vehicle, i.e., the X-axis of the IMU body frame points to the forward driving direction of the vehicle. If a different mounting orientation is used, the INS402 must be configured to re-align +X with the forward direction, +Y to the right, and +Z down. This is accomplished by the User Configuration Message (see Section 3.3.1).

For best performance, it is necessary to configure the lever arms, based on the mounting locations of the INS402 and the two antennas. Each lever arm specifies the translational 3D offset from the IMU navigation center (Figure 1) to the GNSS antenna phase center. For optimal performance, it is required to have the lever arm accuracy of less than 2 cm. For instance, a lever arm measurement of one antenna is shown in Figure 2. The translation offset is measured as 1 m in each direction of x, y, z. The IMU to the antenna lever arm is $[x, y, z] = [1.0, -1.0, -1.0]$ m.

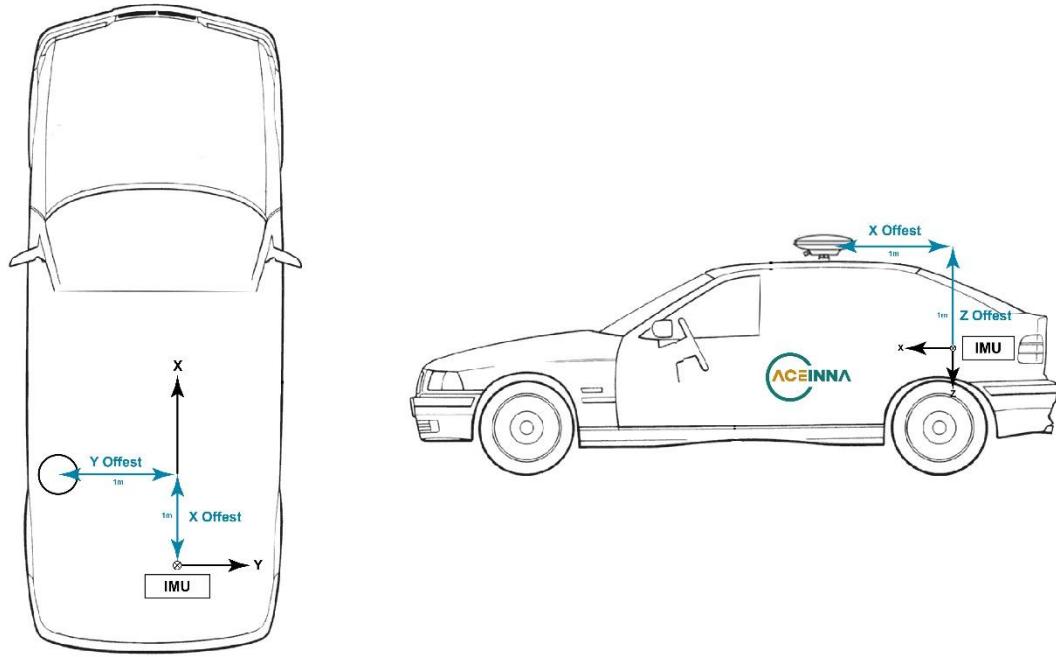


Figure 2 INS401 IMU to GNSS Antenna Lever Arm Definition and Measurement Demonstration

3.2 RS232 Messages Definition

ASCII packets are transited over RS232 interface.

3.2.1 ASCII Messages

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

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

3.2.1.1 EXAMPLE of GNGGA

\$GNGGA, 172814.10, 3723.46587704, N, 12202.26957864, W, 2, 6, 1.2, 18.893, M, -25.669, M, 2.0, 0031*4F

Field Sequence	Description
0	\$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

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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 *

3.2.1.2 EXAMPLE of GNZDA

\$GNZDA,172809.40,12,07,1996,00,00*45

Field Sequence	Description
0	\$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 *

3.2.2 BASE_RTCM Message Input Over RS232

For optimal performance, it is necessary to enable RTK corrections. The performance is related to the distance between the rover and the base station (ideally 20 km or less). The error increases according to the factor of 1 ppm times the baseline length.

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In order to perform GNSS RTK, the INS402 device needs RTK correction data (RTCM messages) input from user device (vehicle). The user device can send the RTCM messages over RS232 to the INS402, and refer to General settings of RS232.

Message	GNSS RTK correction RTCM data from base station, periodic input at 1 Hz
Protocol	RTCM 3.2
Length	Depending on the various RTCM message length
Payload	RTCM 3.2 protocol messages

Table 1 Base RTCM Data

Input GNSS RTK correction data is in RTCM format based on the version 3.x protocol, including a series of RTCM messages, e.g., GPS observation (type ID 1077), GLONASS observation (type ID 1087), GPS ephemeris (type ID 1019), and so on. The different type of RTCM messages can be accommodated in one Aceinna binary packet. If the length of a full epoch of RTCM messages is less than 1490 (1500-10) bytes, they can fit in one ethernet data frame. Note that the 10 bytes are the overhead of one Aceinna binary packet.

3.3 CAN1 port and Messages Definition

The CAN1 port of the INS402 supports standard CAN J1939 messages, including position, velocity, attitude, heading, and IMU data. RTCM data, odometer data, and lever arm configurations can also be input over the CAN1 port. INS402 source address: 0x64(manufacturer defined, can modify if need)

CAN ID	PGN	Priority	Cycle	Source to Destination	Description
0x0CFF0264	0xFF02	3	50hz	INS to other node	INS_Acc
0x0CFF0364	0xFF03	3	50hz	INS to other node	INS_GYRO
0x0CFF0464	0xFF04	3	50hz	INS to other node	INS_HeadingPitchRoll
0x0CFF0564	0xFF05	3	50hz	INS to other node	INS_HeightAndTime
0x0CFF0664	0xFF06	3	50hz	INS to other node	INS_LatitudeLongitude
0x0CFF0764	0xFF07	3	50hz	INS to other node	INS_Speed
0x0CFF0864	0xFF08	3	50hz	INS to other node	INS_DataInfo
0x0CFF0964	0xFF09	3	50hz	INS to other node	INS_Std
0x18FF50XX (XX is client address in this file)	0xFF50	6	event	other node to INS	Set user configuration
0x18EAFFXX	0xEA00	6	event	other node to INS	Request configuration
0x18FF5064	0xFF50	6	event	INS to other node	Configuration feedback
0x18FF51XX	0xFF51	6	event	other node to INS	Save configuration
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0x18FF4064	0xFF40	6	event	INS to other node	Product name
0x18FF4164	0xFF41	6	event	INS to other node	Serial No
0x18FF4264	0xFF42	6	event	INS to other node	App name
0x18FF4364	0xFF43	6	event	INS to other node	App version
0x18FF4464	0xFF44	6	event	INS to other node	Boot loader version
0x18FF4564	0xFF45	6	event	INS to other node	Hardware version
0x18FF4664	0xFF46	6	event	INS to other node	IMU name
0x18FF4764	0xFF47	6	event	INS to other node	IMU version
0x18FF4864	0xFF48	6	event	INS to other node	IMU serial No
0x18FF4964	0xFF49	6	event	INS to other node	RTK name
0x18FF4A64	0xFF4A	6	event	INS to other node	RTK version

Table 2 All CAN messages

Note: XX is client address in this file.

3.3.1 Output Binary Packets

The CAN messages include the input and output data packets, and the input packets are subject to user change. CAN1 output data frames are defined in the following table:

3.3.1.1 INS_Acc (ID: 0x0CFF0264, from CAN1, 50hz)

PGN: 0xFF02

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]	0.000122 0722	-4	g	E=N*0.0001220722-4	Accelerometer: X axis
ACC_Y	16	16	Unsigned	Intel	[-4,4]	0.000122 0722	-4	g	E=N*0.0001220722-4	Accelerometer: Y axis
ACC_Z	32	16	Unsigned	Intel	[-4,4]	0.000122 0722	-4	g	E=N*0.0001220722-4	Accelerometer: Z axis

3.3.1.2 INS_GYRO (0x0CFF0364, from CAN1, 50hz)

PGN: 0xFF03

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Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	paraphrase
GYRO_X	0	16	Unsigned	Intel	[-250,250]	0.007629 51	-250	deg/s	E=N*0.00762951-250	Gyro: Y axis
GYRO_Y	16	16	Unsigned	Intel	[-250,250]	0.007629 51	-250	deg/s	E=N*0.00762951-250	Gyro: X axis
GYRO_Z	32	16	Unsigned	Intel	[-250,250]	0.007629 51	-250	deg/s	E=N*0.00762951-250	Gyro: Z axis

3.3.1.3 INS_PitchRollHeading (0x0CFF0464, from CAN1, 50hz)

PGN: 0xFF04

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	paraphrase
INS_PitchAngle	0	16	Unsigned	Intel	[-360,360]	0.010986 5	-360	deg	E=N*0.0109865-360	Vehicle coordinate: pitch
INS_RollAngle	16	16	Unsigned	Intel	[-360,360]	0.010986 5	-360	deg	E=N*0.0109865-360	Vehicle coordinate: roll
INS_HeadingAngle	32	16	Unsigned	Intel	[-360,360]	0.010986 5	-360	deg	E=N*0.0109865-360	Vehicle coordinate: heading

3.3.1.4 INS_HeightAndTime (0x0CFF0564, from CAN1, 50hz)

PGN: 0xFF05

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	paraphrase
INS_Height	0	32	Unsigned	Intel	[-10000,10000]	0.001	-10000	m	E=N*0.001-10000	altitude

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INS_TimeOfWeek	32	32	Unsigned	Intel	[0,460800000]	1	0	ms	E=N	second in week
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3.3.1.5 INS LatitudeLongitude (0x0CFF0664, from CAN1, 50hz)

PGN: 0xFF06

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	paraphrase
INS_Latitude	0	32	Unsigned	Intel	[-180,180]	0.00000 01	-180	deg	E=N*1e-7-180	latitude
INS_Longitude	32	32	Unsigned	Intel	[-180,180]	0.00000 01	-180	deg	E=N*1e-7-180	longitude

3.3.1.6 INS Speed (0x0CFF0764, from CAN1, 50hz)

PGN: 0xFF07

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	Conversion	paraphrase
INS_NorthSpeed	0	16	Unsigned	Intel	[-100,100]	0.0030518	-100	m/s	E=N*0.0030518-100	north speed
INS_EastSpeed	16	16	Unsigned	Intel	[-100,100]	0.0030518	-100	m/s	E=N*0.0030518-100	east speed
INS_ToGroundSpeed	32	16	Unsigned	Intel	[-100,100]	0.0030518	-100	m/s	E=N*0.0030518-100	vertex speed

3.3.1.7 INS DataInfo (0x0CFF0864, from CAN1, 50hz)

PGN: 0xFF08

Direction: INS to other node

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Name	Start bit	Length Bit	Value Type	Byte Order	factor	offset	Conversion	paraphrase
INS_GpsFlag_Pos	0	8	Unsigned	Intel	1	0	E=N	gps 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)
INS_NumS_Used	8	8	Unsigned	Intel	1	0	E=N	GPS used satellites
INS_PosType	16	8	Unsigned	Intel	1	0	E=N	ins solution 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_Car_Status	32	8	Unsigned	Intel	1	0	E=N	car speed status 0: car speed used 1: car speed unused
INS_Status	40	8	Unsigned	Intel	1	0	E=N	Ins status (INS initialization need Base_RTCM data input) 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

3.3.1.8 INS_Std (0x0CFF0964, from CAN1, 50hz)

PGN: 0xFF09

Direction: INS to other node

Name	Start bit	Length Bit	Value Type	Byte Order	Range	factor	offset	Unit	paraphrase
INS_Latitude_Std	0	16	Unsigned	Intel	[0,65.535]	0.001	0	E=N*0.001	Standard deviation of latitude

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INS_Longitude_Std	16	16	Unsigned	Intel	[0,65.535]	0.001	0	E=N*0.001	Standard deviation of longitude
INS_LocatHeightStd	32	16	Unsigned	Intel	[0,65.535]	0.001	0	E=N*0.001	Standard deviation of height
INS_Heading_Std	48	16	Unsigned	Intel	[0,65.535]	0.001	0	E=N*0.001	Standard deviation of heading

3.3.2 Input Binary Packets

3.3.2.1 Set user configuration (0x18FF50XX, CAN1)

“Set user configuration” is used to configure data value based on configurations index, if you want to save it in flash, use “save configuration” command, refer to 3.3.2.6

PGN: 0xFF50

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 3 Index of Configurations

Example of ID and payload:

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

Index	Configuration	unit	Factor	Offset	Comments
1	Pri_lever_arm_x	m	0.001	-30(m)	Master Antenna position under NED coordinate system (forward-right-down vehicle frame), reference point of INS402 is origin point (0,0,0). Same coordinate system is used for below points.
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)	Vehicle reference point position. vrp is the position where odometer speed come from, which would be the center position of 2 rear wheels if your speed comes from 2 rear wheels.
5	vpr_lever_arm_y	m	0.001	-30(m)	
6	vpr_lever_arm_z	m	0.001	-30(m)	
7	user_lever_arm_x	m	0.001	-30(m)	Interesting point position, it could be the position of one antenna or any position you want. INS will send out the specified position in output packets.
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)	Rotation angles to align IMU body frame to vehicle frame, in order Z->Y->X
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)	Slave Antenna position under NED coordinate system(forward-right-down), reference point of INS402 is origin point (0,0,0).
14	Second_lever_arm_y	m	0.001	-30(m)	
15	Second_lever_arm_z	m	0.001	-30(m)	
22	Dual ant switch	-	1	0	0-Disable heading calibration 1-Default. Enable heading calibration
23	Baseline length	m	0.001	-30(m)	Distance between the 2 antennas (prefer > 1m)
24	Heading calibration	deg	0.01	-180(deg)	Compensate the small angle (from master to slave) bias caused by lever arm measurement accuracy. Take example: The calibration angle should be -0.5deg, when actual heading(89.5deg) different with calculated heading(90.0deg) based on current lever arms

Table 3 Index of Configurations

3.3.2.2 Get user configuration (0x18EAFFXX, CAN1)

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 required

Feedback:

Direction: INS to other node

CAN ID	Byte0	Byte1	Byte2	Byte3
0x18FF5064	0x64(INS address)	Index you required	unsigned Data-LSB	unsigned Data-MSB

*scale factor of Data, please refer to Table 3 Index of Configurations

3.3.2.3 Get Serial Number (0x18FF4164, CAN1)

Request:

PGN: 0xEA00

Direction: other node to INS

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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)

3.3.2.4 Get App version (0x18FF4364, CAN1)

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'	'.'	'0'	'3'

*example: v31.00.03

3.3.2.5 Wheel Speed Input (0x0CFF0145/46, to CAN1)

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

PGN: 0xFF01

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

3.3.2.6 Save configuration (0x0CF51XX, CAN1)

To save user configuration in flash. has no feedback

PGN: 0xFF51

Direction: other node to INS

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

3.4 DBC FILE

Pls download DBC from link: https://navview.blob.core.windows.net/forum/upload/ins402_can_20230327-lfqnksz1dbc

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