FORSENSE
原极科技

Tactical MEMS 6 degrees of freedom inertial sensor

FSS-IMUP9 Product manual

Tactical grade MEMS gyroscope

- 0.2°/hr Bias instability
- 0.015 Angle random walk°/$\sqrt{\text{hr}}$
- 30/ hr temperature drift° (-40 ~ 85°C, <=1°C/ min@1σ)

Tactical grade MEMS accelerometer

- 10ug Bias instability
- 0.02 Speed random walkm/s/$\sqrt{\text{hr}}$
- 0.5mg temperature drift (-40~ 85°C, <=1°C/ min@1σ)

Large range of fine temperature compensation

- -40 °C to 85 °C temperature compensation
- Fine temperature calibration

Independent turntable calibration

- Independent calibration of each module: sensitivity, zero bias, non-orthogonal error

High strength condition tolerance

- Strong impact tolerance: 2000g (0.5ms, half sine, 3 axis)
- Strong vibration tolerance: 10g (10~2KHz, 3 axis)
- Full temperature environment stable operation: -40°C ~ 85°C
- 100% magnetic shielding

Real-time and flexible digital interface, small size

- Configurable output sampling rate up to 1KHz
- Support for serial 422
- 38.6*44.8*21.5mm, weighs about 48.5g

Product Overview

FSS-IMUP9 is a 6-DOF MEMS inertial sensor module built by FORSENSE Technology. It is equipped with three-axis gyroscope and acceleration information as standard.

High precision, high resolution, can capture subtle vibration and tilt. Large range output makes motion perception possible under large dynamics. All modules are equipped with ultra-wide temperature range of fine warming and independent calibration before delivery, so that each module can play stably in

various extreme conditions, while ensuring the performance of all products is highly consistent.

Application field

- Aerial mapping

On the basis of standard performance and output parameters, FORSENSE also provides customized software and LOGO customization services for your special needs, to help you in the product!

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FSS-IMUP9 Product Sheet

Contents

1. Performance parameters

1.1 Key performance parameters of gyroscope

Table 1 Key indicators of gyroscope

Parameters	Test conditions/Remarks	Typical values	Units
Measuring range		+ 300	°/s
Zero bias instability	@25℃, Allan Variance, 1σ	X/Y: 0.2Z : 0.15	°/hr
Zero bias stability	National military standard, 10S smooth	1.5	°/hr
Zero bias repeatability	National Army mark	7	°/hr
Non-orthogonal between axes		0.01	deg
Full temperature range zero deviation variation	-40 ~ 85℃ ≤1℃/min std@1σ	X/Y: 30Z : 10	°/h
Random Walk	@25℃, Allan Variance, 1σ	X/Y: 0.01Z : 0.015	°/√hr
scale coefficient error		X/Y: 1.5Z : 1	‰
scale factor nonlinear		100	ppm
Resolution		0.0003	°/s
Internal low-pass cutoff frequency		68	Hz
Sampling rate		1000	Hz
measured delay		10	ms

Note the zero deviation change of the total temperature at 1:1 ℃/ min is 1σ

Note 2: IEEE standard, Allan variance curve given at static 25℃ environment

1.2 Key performance indicators of accelerometers

Table 2 Accelerometer key performance indicators

Parameters	Test conditions/Remarks	Typical values	Units
Measuring range		Plus or minus 8	g
Zero bias instability	@25 ° C, ALLAN variance, 1σ	10	Mu g
Zero bias stability	National military standard, 10S smooth	25	Mu g
Zero bias repeatability	National Army mark	0.1	mg
Non-orthogonal between axes		0.01	deg
Full temperature range zero deviation variation	-40 ~ 85℃ ≤1℃/min std@1σ	0.5	mg
Random Walk	@25 ° C, ALLAN variance, 1σ	0.02	m/s/√hr
Calibration coefficient error		0.2	‰
Calibration coefficient nonlinearity		50	ppm
Resolution		1.5313	mg
Internal low-pass cutoff frequency		68	Hz
Sampling rate		1000	Hz
Measuring delay		10	ms

Note 1σ value of zero deviation change in total temperature at 1:1 ℃/ min

Note 2: IEEE standard, Allan variance curve given at static 25℃ environment

FIG. 1 ALLAN variance typical curve of gyroscope

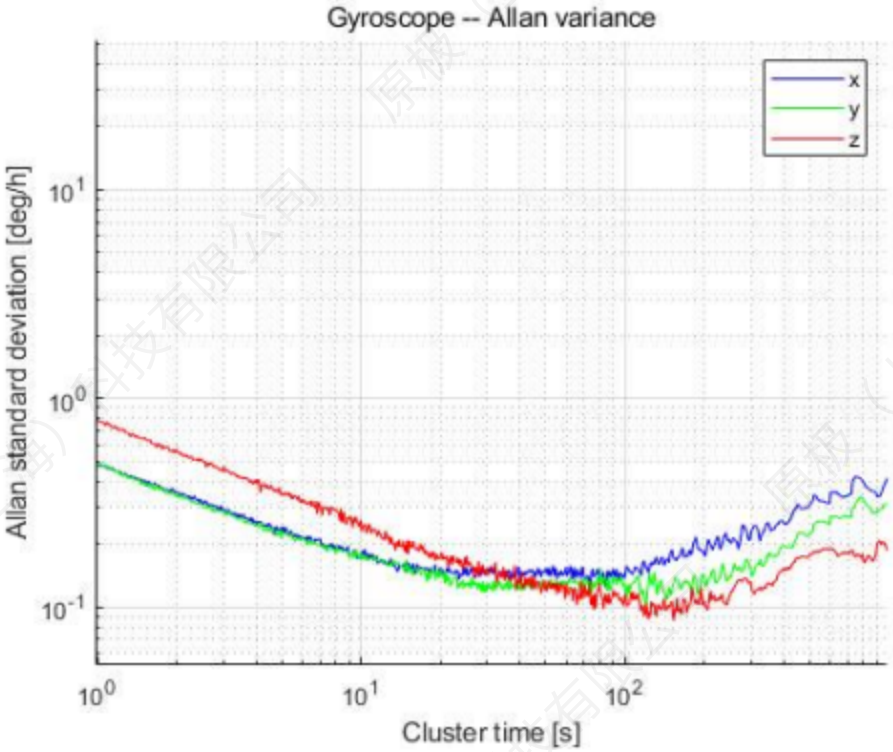
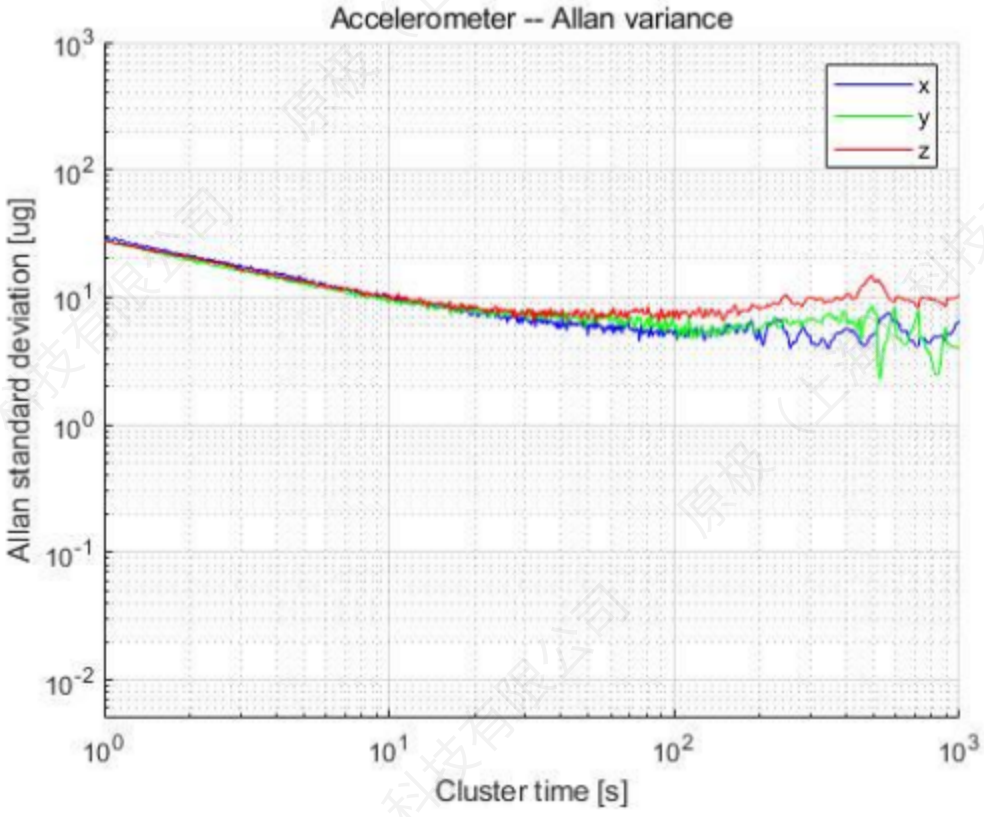


FIG. 2 Typical curve of ALLAN variance for accelerometer



2. External structure

Figure 3 Outline structure and size (unit: mm)

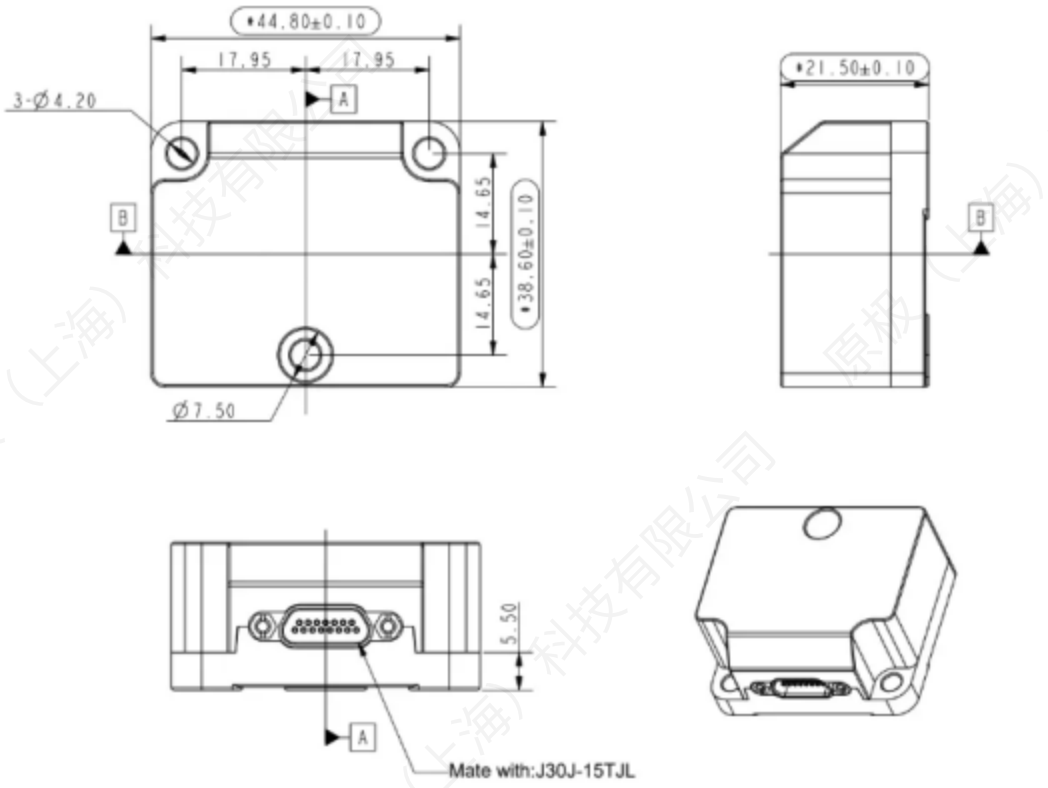


Figure 4 Location of IMU measurement center (unit: mm)

3. Specifications

3.1 Maximum absolute rated value

Table 3 Maximum absolute rated value

Parameters	Levels	Remarks
ESD	±2000V	
Storage temperature	And 55 ℃ ~ 90 ℃	
VSUP to GND	0.5 V to 6.5 V	
Use temperature	- 40 ℃ ~ + 85 ℃	
RXD+/RXD- to GND	- 0.3 V ~ + 7 V	Matching resistance =120Ω
RXD+ to RXD-	±6V	
TXD+/TXD- to GND	-8V~+8V	
ExtTrig to GND	- 0.3 V ~ + 7 V	
NRST to GND	- 0.3 V ~ + 7 V	
DATA READY to GND	- 0.3 V ~ + 7 V	

3.2 EMC

Table 4 EMC

Test Items	Test criteria
CE	Comply with EN55032 CISPR 16-2-1
CS	Complies with EN55035 EN(IEC)61000-4-6
EFT	Comply with EN55035 EN(IEC)61000-4-4
RE	Comply with EN55032 CISPR 16-2-3
RS	Meets EN55035 EN(IEC)61000-4-3
ESD	Complies with EN55035 EN(IEC)61000-4-2

3.3 ESD Rating

Table 5 ESD rating

V (ESD) Electrostatic discharge	Test mode	Test Criteria	Test grade
	Contact discharge	In accordance with EN(IEC)61000-4-2	±8 KV
	Air discharge		±15 KV

4 Electrical characteristics

Table 6 Electrical characteristics

Parameters	Conditions	Minimum	Typical	Max	Units
Power input		4.5	5	5.5	V
Power			1.08		W
Storage temperature		-55		90	℃
Use temperature		-40		85	℃
RS422 input resistor			120		Ω
RESET(NRST PIN)	High	2.3			V
	Low			0.6	V
NRST internal pull-up resistor			4.7		K Ω
Data Ready			3.3		V
ExtTrig	High	2.3			V
	Low			0.6	V

Note: When the supply voltage is higher than 6V, the internal voltage protection circuit will cut off the power supply and the device will enter the reset state until the voltage returns to the operating condition and resume work.

5. Pin definition

Figure 5 Pin diagram

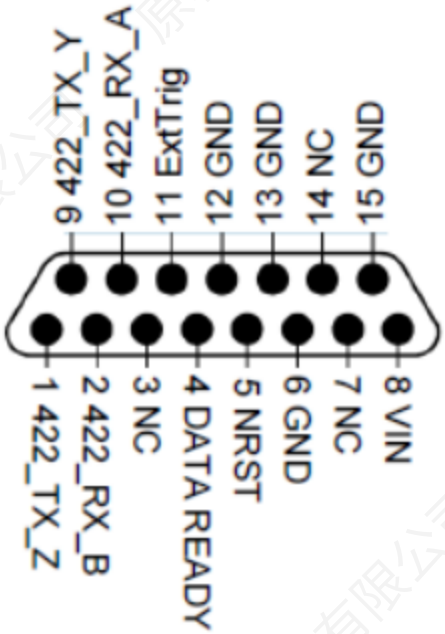


Table 7 Pin definitions

Pin serial number	Pin name	Pin description
1	422_TX_Z	RS-422,TXD-
2	422_RX_B	RS-422,RXD-
3	NC	Not pick up
4	DATA READY	Data Ready
5	NRST	External hardware reset input, internal pull-up
6	GND	Signalland
7	NC	Not pick up
8	VIN	Power input, +5V input
9	422_TX_Y	RS-422,TXD+
10	422_RX_A	RS-422,RXD+
11	ExtTrig	External trigger
12	GND	electrically
13	GND	Power ground
14	NC	Not pick up
15	GND	Power ground

6. Recommended connection method

Figure 6 Block diagram of normal acquisition mode

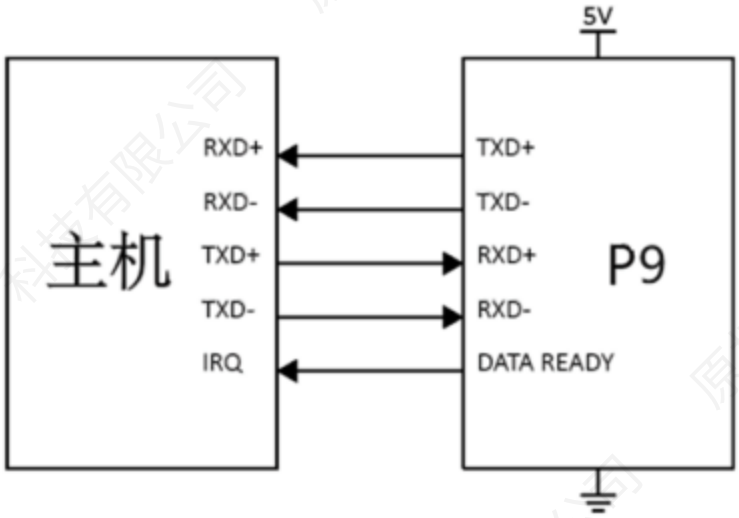
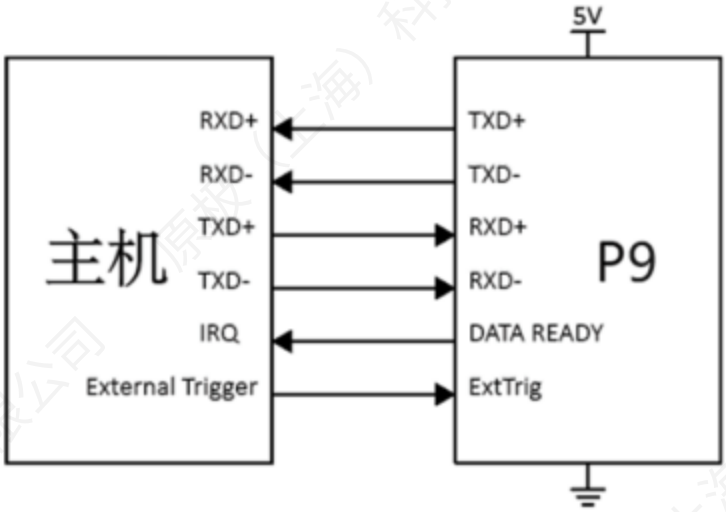


Figure 7 Block diagram of trigger acquisition mode



7. Serial communication protocol

Examples of serial port protocols based on QT, ROS, and STM32:

https://data.forsense-imu.com/page/download.html

The serial port communication supports two modes: Stream Mode and Command Mode. The IMU enters the corresponding mode according to the mode value configured by parameters after the initialization is complete.

Stream mode: Periodically output AHRS data at a fixed frequency;

Command mode: In this mode, the periodic output is stopped, the user communicates with the IMU by sending commands, and the sensor data, status, parameters, etc. can be obtained through the GET command, and the parameters of the IMU can also be configured.

7.1 COM Interface Parameters

Table 8 COM interface parameters

Transmission rate range	115200bps to 1.5Mbps
Default transfer rate	115200bps
Start bit	1 bit
Data bits	8 bits
Stop bits	1 bit
Parity check	There is no

7.2 Packet Format

The packet structure of IMU output and user input is composed as follows:

Table 9 IMU output and user input data structures

Offsets	Data type	Name	Description
0	uint8	Frame Header 1	IMU Output frame headers: 0xAA, 0x55 User input frame header: 0x55, 0xAA
1	uint8	Frame header 2	
2	uint16	ID low	The low bit of the frame ID for serial communication

3		ID high byte	The high byte of the serial port frame ID
4	uint16	Data length low	The lowest byte of the frame length of the COM communication. Length is the number of bytes occupied by the payload, that is, n
5		High data length	The upper byte of the frame length of the COM communication. Length is the number of bytes carried by the payload, that is, n
6	uint8	Payload (n bytes)	Data load
6+n	Uint32	CRC_CEHCK (32-bit data low byte)	CRC check
7+n		CRC_CEHCK (low byte in 32-bit data)	
8+n		CRC_CEHCK (high byte in 32-bit data)	
9+n		RC_CEHCK (32-bit data high byte)	

Note 1: Data is transmitted in small-endian format, with low bytes first and high bytes last

Note 2: The initial value of crc32 is 1. CRC calculation does not include all the data of this frame itself. See the end of the document for table lookup calculation

7.3 Data Flow frame — AHRS data

Table 10 Serial AHRS data format

	Frame Headers	Frame Headers	ID	length	payload	Frame tail
Data type	uint8	uint8	uint16	uint16	A1	uint32
Coding	0xAA	0x55	0x0002	0x002C		crc32

Table 11 COM A1 load data format

offset	Name	Data type	Units	Description
0	timer	uint32	Mu s	Time scale

4	/	/	/	/
8	/	/	/	/
12	/	/	/	/
16	ax	float	g	X-axis acceleration
20	ay	float	g	Y-axis acceleration
24	az	float	g	Z-axis acceleration
28	gx	float	°/s	X axis angular velocity
32	gy	float	°/s	Y-axis angular velocity
36	gz	float	°/s	Z axis angular velocity
40	temp	float	℃	IMU chip temperature

Example: Get AHRS data stream:

AA 55 02 00 2C 00 6D 89 16 05 8F C2 65 40 14 AE 07 BF 5C 0F B2 43 25 06 81 3D BC 74 13 3C 60 E5 80 BF EC 51 38 BD 0A D7 A3 BB CD CC CC BC D7 A3 EE 41 0C BF 84 80

The analysis is as follows:

Table 12 AHRS data flow obtained from serial port A1

Description	Raw Value	Analytic value	Description	Raw Value	Analytic value
ID	0200	02	Y-axis acceleration	BC74133C	0.009 g
Length	2C00	44	Z-axis acceleration	60E580BF	1.007 g
Time scale	6D891605	85363053	X axis angular velocity	EC5138BD	0.045 ° / s
Pitch Angle	8FC26540	3.59 °	Y-axis angular velocity	0AD7A3BB	0.005 ° / s
Roll Angle	14AE07BF	0.53 °	Z axis angular velocity	CDCCCCBC	0.025 ° / s

Heading Angle	5C0FB243	356.12 °	IMU chip temperature	D7A3EE41	29.83 ℃
X-axis acceleration	2506813D	0.063 g	crc32 Check	0CBF8480	2156183308

7.4 Command Mode GET Output — System status

Table 13 COM system status data format

	Frame Headers	Frame Headers	ID	length	payload	Frame tail
Data type	uint8	uint8	uint16	uint16	S1	uint32
Coding	0xAA	0x55	0x00FF	N		crc32

Note 1: The length of this frame varies according to the IMU model. All frames represent the length of S1 and need to be confirmed according to the IMU model.

Table 14 COM S1 load data format

offset	Name	Data type	Description
0	Software_ver	uint32	Software version number
4	Hardware_ver	uint32	Hardware version number
8	rev	uint16	Reserved bytes
10	sn0	uint32	First SN number
14	sn1	uint32	Second SN
18	sn2	uint32	Third SN
22	Board_version	uint32	Baseboard version number
26	Rev[16]	Uint8	All that follows is reserved bytes

Note 1: Reserved bytes vary based on the imu model. The IMU614E is 16 bytes.

For example, obtain the IMU status

Input data: 55 AA 01 00 18 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 BD DB 31 34

Response data: AA 55 FF 00 2A 00 1F 39 03 00 65 6F 01 00 50 83 30 33 35 55

34 50 15 FF 8F 5F FF FF 50 83 FF 1F 29 00 00 00 00 E0 00 07 10 17 08 50 D0 37 10 3B 7A C3 00 02

Based on the response data, the resolution yielded software version number 211231(1F 39 03 00) and hardware version number 94053(65 6F 01 00).

7.5 Command Mode GET output — Read parameters

Table 15 Data format of COM parameters

	Frame header	Frame header	ID	length	payload	Frame trailer
Data type	uint8	uint8	uint16	uint16	P1	uint32
Coding	0x55	0xAA	0x0006	0x0018		crc32

Table 16 Output data format of COM Parameter

	Frame headers	Frame Headers	ID	length	payload	Frame tail
Data type	uint8	uint8	uint16	uint16	P1	uint32
Coding	0xAA	0x55	0x7530	0x0018		crc32

Note 1: When reading Parameter, the IMU will disable the data stream. After the setting is complete, the data stream needs to be restarted.

Table 17 Load data format of COM P1

offset	Name	Data type	Description
0	Param1	float	Obtained Parameter (input data can be ignored)
4	Param2	float	Keep, default to 0
8	Param3	uint32	Set the Parameter index
12	Param4	uint32	Reserved, the default value is 0
16	Param5	Int32	Keep, default is 0
20	Param6	Int32	Keep, default is 0

Table 18 Index table of the Parameter of serial port P1 load

Param3	Param1	Units
3	Serial port output baud rate. The following baud rates are supported 115200, 230400, 460800, 921600, 1500000	bps
4	Coordinate system orientation (see Table 25 Coordinate System Orientation correspondence table)	
8	X-axis gyro zero bias calibration results, GYRO_X_OFF	°/s
9	Y-axis gyro zero bias calibration results, GYRO_Y_OFF	°/s
10	Z-axis gyro zero bias calibration results, GYRO_Z_OFF	°/s
21	AHRS output frequency, default 100Hz	Hz
31	Internal filter configuration, define the same SPI FILTER_CTRL table	

Example: Get AHRS output frequency

Input data: 55 AA 06 00 18 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 15 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 66 CB 46 AC

Response data: AA 55 30 75 18 00 00 00 00 48 42 00 00 00 00 00 00 00 00 15 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 31 2F A2 0A

According to the response data, the analysis results in an output frequency of 50hz (00 00 48 42).

7.6 Command mode SET instruction

Table 19 Serial port input command format

	Frame header	Frame Headers	ID	length	payload	Frame tail
Data type	uint8	uint8	uint16	uint16	R1	uint32
Coding	0x55	0xAA	CMD	0x0018		crc32

Note 1: For details about the relationship between CMD and R1, see the R1 load Parameter index table

Table 20 Load data format of COM R1

offset	Name	Data type	Description
0	Param1	float	Set Parameter
4	Param2	float	Keep, default to 0
8	Param3	uint32	Set the Parameter index
12	Param4	uint32	Reserved, the default value is 0
16	Param5	Int32	Keep, default is 0
20	Param6	Int32	Keep, default is 0

Table 21 Index of Parameter of the COM R1 load

CMD	Param1	Param3	Description
1	0	0	Trigger to get system status data once
2	0	0	Trigger to obtain AHRS data once
3	<mode>	0	Set output Mode: Mode=1, data stream output AHRS Mode=100 to disable data stream mode and enter COMMAD mode
5	0	0	Save the current Parameter to FLASH
6	0	<value>	Read Parameter, value is the index of the Parameter to be read, that is, P1.index, see the COM response output - Parameter read For example, to read AHRS output frequency (ODR), set value to 21 For example, to read the baud rate of the serial port,

			set value=3 For example, if you want to read the internal filter, set value=31 For example, if you want to read the coordinate system orientation, set value=4
9	0	0	Perform a software restart
14	<value>	3	Set the serial output baud rate, which is valid in bps value: 115200,230400,460800,921600,1500000 If value is other values, the default value is 115200bps After setting the baud rate parameter, you need to restart it for it to take effect. Procedure for setting the baud rate without power supply: Set the baud rate, save the parameter to the flash, and reset the software
14	<value>	21	Set the periodic AHRS data output frequency, common values in Hz value are: 1,10,50,100,200,500,1000 Recommended correspondence between the output frequency and the baud rate of the serial port 1000Hz: 921600bps 500Hz: 460800bps 200Hz: 460800bps 250Hz: 460800bps 100Hz: 115,200 BPS
14	<value>	31	Internal filter configuration, defined as SPI accelerometer and gyro filter configuration, default 0xBB, i.e. 47Hz
14	<value>	4	Set the orientation of the IMU coordinate system. The value ranges from 101 to 124. See Table 25 for the corresponding relation of the orientation of the coordinate system

Note 1: Please note that all values in this table are in decimal

Note 2: The host computer command generator function can be used to generate corresponding commands to send, see the use of the host computer section of this manual

For example, to enable AHRS output:

Enter 3 in CMD ID and 1 in parameter 1. The generated hexadecimal array can be filled into the COM assistant or program array and sent to the IMU.

7.7 Command Mode output — User command response

Table 22 Setting parameters COM response data format

	Frame header	Frame Headers	ID	length	ACK	Param3	Frame end
Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Coding	0xAA	0x55	0x753D	0x0004	0x7534	Parameter index	crc32

Table 23 Reserved Parameter COM response data format

	Frame header	Frame Headers	ID	length	ACK	result	Frame Tail
Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Coding	0xAA	0x55	0x753D	0x0004	0x0005	0x01	crc32

Table 24 Data format of COM user command response

	Frame Headers	Frame Headers	ID	length	command	result	Frame Tail
Data type	uint8	uint8	uint16	uint16	uint16	uint16	uint32
Coding	0xAA	0x55	0x0064	0x0004	Command ID	0x01	crc32

Example: Set the output baud rate of the COM to 115200

Data input: 55, AA, 0 e, 00,18,00,00,00, E1, 47,00,00,00,00,03,00,00,00,00,00,00,00,00,00,00,00,00,00,00,00,56,2 B, 4 d, 93

Response data: AA 55 3D 75 04 00 34 75 03 00 A7 98 2A 54

Set the periodic AHRS data output frequency to 100hz

Input data: 55 AA 0E 00 18 00 00 00 00 C8 42 00 00 00 00 00 00 00 15 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 0A 2B 2C 8D

Response data: AA 55 3D 75 04 00 34 75 15 00 70 2D B2 48

Save the current parameter to FLASH

Enter data: 55 AA 05 00 18 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 C9 2F E6 32

Response data: AA 55 3D 75 04 00 05 00 01 00 5A CF B1 7C

Set output mode to AHRS data stream

Input data: 55 AA 03 00 18 00 00 00 00 80 3F 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 52 D8 8E E8

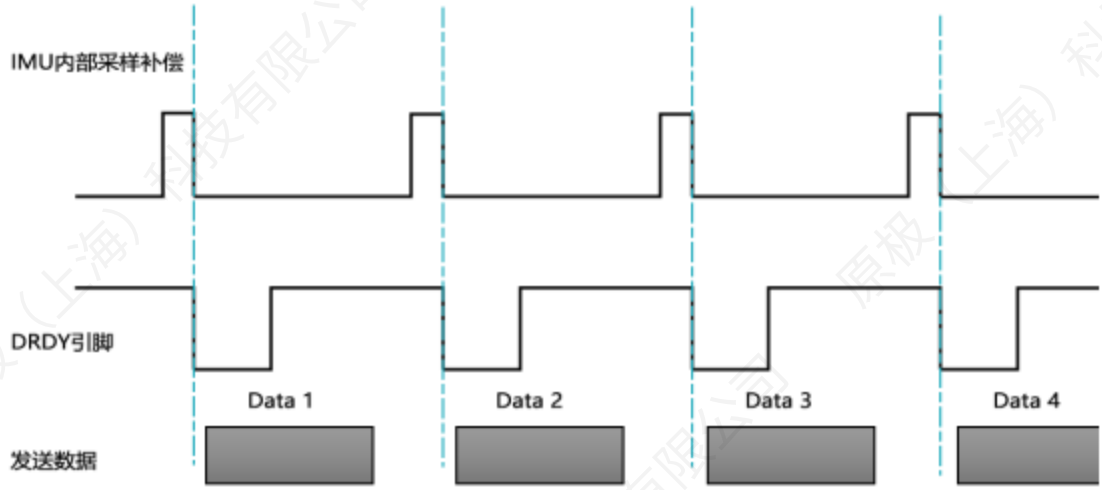
Response data: AA 55 64 00 04 00 03 00 01 00 E7 87 E3 AD

7.8 DRDY

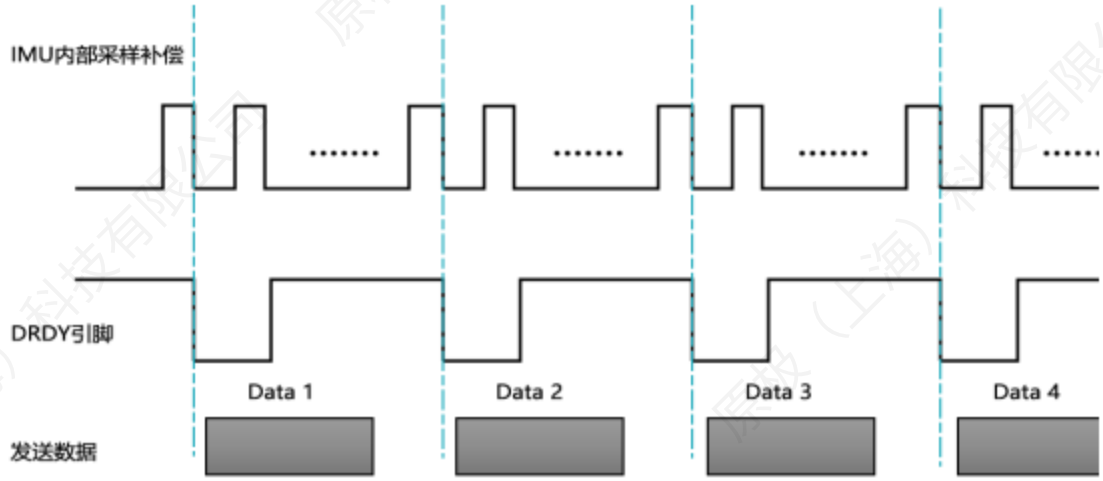
DRDY Pin output serves two purposes:

1. to provide a clock synchronization signal from inside the IMU;

2. Provide a signal to signal the start of transmitting data frames.



When the internal sampling frequency of the IMU (maximum ODR) is consistent with the serial output frequency (current ODR), the DRDY pin will be pulled down immediately after the completion of imu data sampling compensation, at which time the data frame will be sent from the serial port, and the DRDY internal sampling frequency will be pulled up again in the next cycle.



When the serial output frequency is less than the IMU internal sampling frequency, after the imu data sampling compensation is completed, it is determined whether DRDY pin cell is immediately pulled down according to the value youdaoplaceholder3 (maximum ODR/ current ODR). After the DRDY is pulled down,

the data frame will be sent from the COM, and the DRDY Pin will be pulled up again in the next IMU sampling period.

7.9 Time Synchronization

7.9.1 Input Requirements:

GPRMC 1HZ/10HZ

Disable inertial Navigation Assistant-related functions of the RTK board Turn off other statements, and the baud rate is consistent with the IMU baud rate.

PPS second pulse: 1s once, rising edge trigger, pulse width 5ms, aligned to UTC time. High level must not be higher than 5v.

7.10 Common AT instruction

7.10.1 Stop the current data stream output

Instruction: AT+SETNO\r\n

Answer: OK\r\n

You can stop the current data flow (without changing the Parameter of the data flow). If the response is OK, the next operation can be performed.

If there is no response, you can continue to send AT+SETNO\r\n command until the response is OK.

7.10.2 Querying the version number

Instruction: AT+VERSION\r\n

Answer: SW_VERSION Firmware version
HW_VERSION Hardware version
BOARD_VERSION Base Plate version

7.10.3 Querying User Parameter

Instruction: AT+CONFIG\r\n
Reply: BAUD_RATE Baud rate of the serial port
ORIENT current coordinate system
IMU_ODR Output frequency of the current IMU

STREAM_MODE1 Stream Mode of

COM 1 STREAM_MODE2 Stream Mode of

COM 2 STREAM_MODE3 Stream Mode of

COM 3 LP_CONFIG_REG Filtering of the current IMU

7.10.4 Setting and Querying the ODR

Example: Set the output frequency ODR to 50hz

Command: AT+SET_ODR=50

Answer: IMU_ODR:50

Query the ODR command of the IMU: AT+GET_ODR

Answer: IMU_ODR:

7.10.5 Setting and querying the coordinate system

Example: Set the IMU coordinate system to top right front

Instruction: AT+SET_ORIENT=101\r\n

Answer: orientation:101

Query the current IMU coordinate system

Instruction: AT+GET_ORIENT\r\n

Answer: orientation:

7.10.6 Set and query baud rate

For example, set the baud rate of the IMU to 115200

Instruction: AT+SET_BAUD=115200\r\n

Answer: OK

Query the current baud rate of IMU

Instruction: AT+GET_BAUD\r\n

Answer: BAUD_RATE:

7.10.7 Setting and querying filters

Example: Set the filter of the IMU to 20hz

Instruction: AT+SET_LPF=20\r\n

Answer: LP_CONFIG_REG:20

Query the IMU current filter

Instruction: AT+GET_LPF\r\n

Answer: LP_CONFIG_REG:

7.10.8 Save parameters

Instruction: AT+SAVE\r\n

Answer: OK

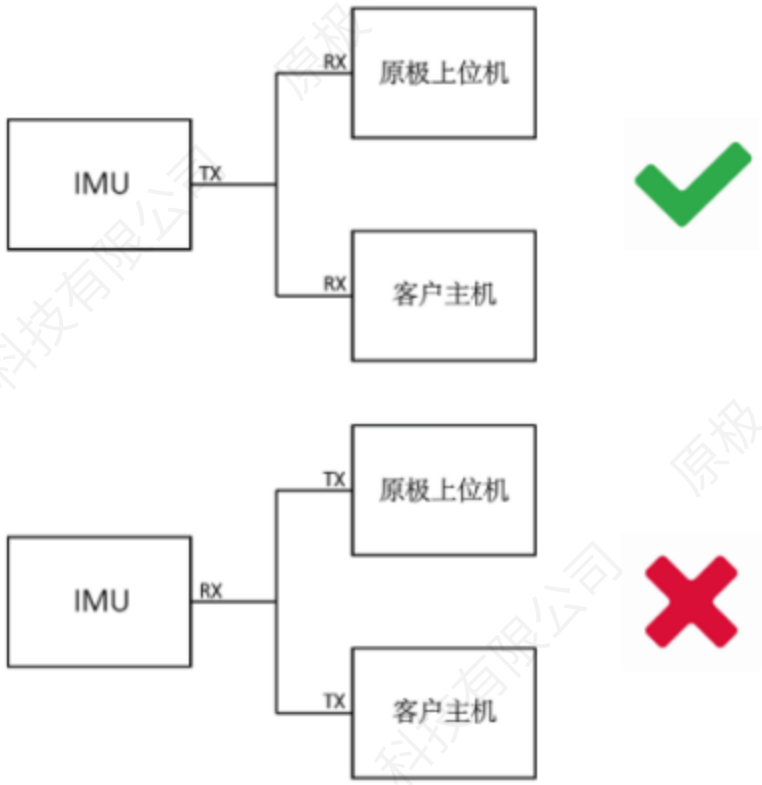
7.11 Common Faults of COM Connection

1) The RX of the IMU cannot connect to two Master TX

The RX of the COM cannot be connected to two TX at the same time. Therefore, if the Forsense upper machine needs to be connected, it needs to disconnect the communication with the COM of the user's host. Otherwise, the upper computer cell can only receive data and cannot send commands to the IMU.

As shown in the following picture:

Figure 8 Schematic diagram of COM connection



注：IMU TX 可接多路 RX，RX 不可接多路 TX；
IMU串口不可同时连接客户主机和原极上位机；
IMU可以预留另外一路串口专门连接原极上位机。

2) The version number cannot be obtained

You are advised to use the COM of the FT232 chip. CH340 and PL2303 data cables may lose packets when the baud rate is high (>115200bps)

It is recommended that COM be connected directly, and it is not recommended to be connected in series. If the interface of RS422 is connected to the computer, directly use RS422 to USB cable, and do not use RS422 to RS232+RS232Z to USB cable in series.

3) Upper computer software curve display lag

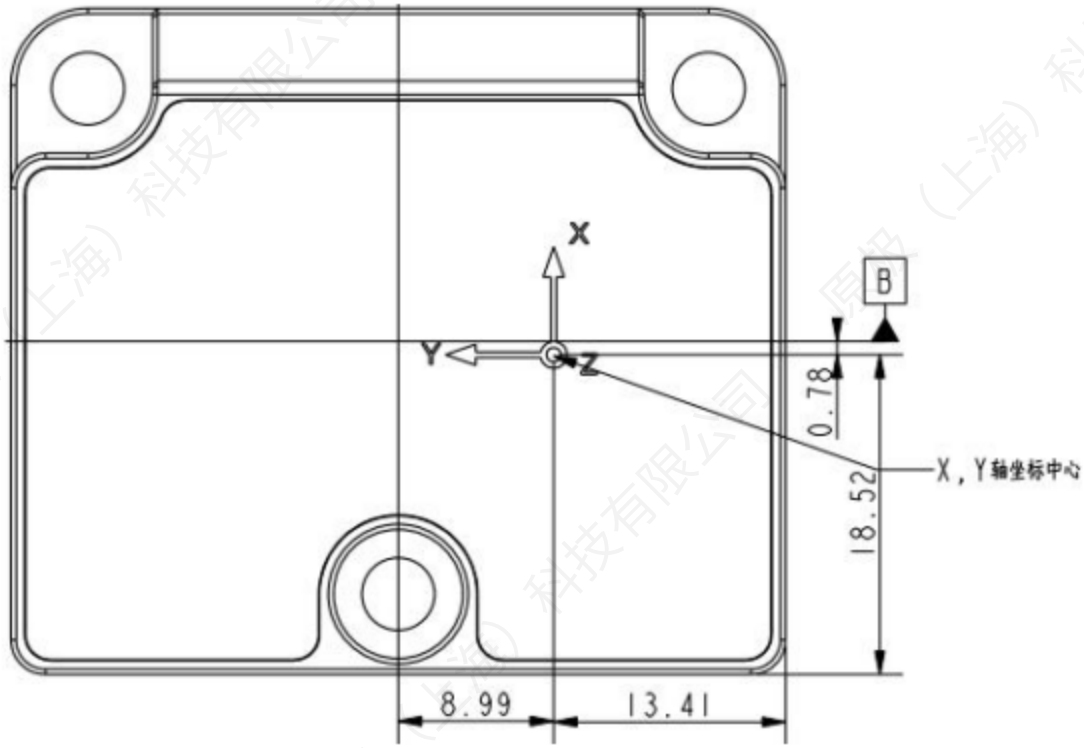
If it is an FT232 data line, use the system administrator to open the Upper computer software and automatically configure the COM delay

Manually configure COM delay in Device Manager.

8. Coordinate system definition

The coordinate system for P9 is defined as follows: right-front-top coordinate system.

Figure 9 Schematic diagram of the P9 coordinate system



9. CRC table lookup method calculation

It is recommended to refer directly to the example code.

Note 1: Data is transmitted in small-endian format, with low bytes first and high bytes last

Note 2: The initial value of crc32 is 1, and CRC calculations do not include all the data in this frame itself

```
Cstatic
    const  uint32_t  crc32_tab [ ]  =  {
  0x00000000, 0x77073096, 0xee0e612c, 0x990951ba, 0x076dc419, None 706Af48F
  ,0xe963a535, 0x9e6495a3, 0x0edb8832, 0x79dcb8a4, 0xe0d5e91e, 0x97d2d988
  ,0x09b64c2b, 0x7eb17cbd, 0xe7b82d07, 0x90bf1d91, 0x1db71064, 0x6ab020f2
  ,0xf3b97148, 0x84be41de, 0x1adad47d, 0x6ddde4eb, 0xf4d4b551, 0x83d385c7
  ,0x136c9856, 0x646ba8c0, 0xfd62f97a, 0x8a65c9ec, 0x14015c4f, 0x63066cd9
  ,0xfa0f3d63, 0x8d080df5, 0x3b6e20c8, 0x4c69105e, 0xd56041e4, 0xa2677172
  ,0x3c03e4d1, 0x4b04d447, 0xd20d85fd, 0xa50ab56b, 0x35b5a8fa, 0x42b2986c
  ,0xdbbbc9d6, 0xacbcf940, 0x32d86ce3, 0x45df5c75, 0xdcd60dcf, 0xabd13d59
  ,0x26d930ac, 0x51de003a, 0xc8d75180, 0xbfd06116, 0x21b4f4b5, 0x56b3c423
  ,0xcfba9599, 0xb8bda50f, 0x2802b89e, 0x5f058808, 0xc60cd9b2, 0xb10be924
  ,0x2f6f7c87, 0x58684c11, 0xc1611dab, 0xb6662d3d, 0x76dc4190, 0x01db7106
  ,0x98d220bc, 0xefd5102a, 0x71b18589, 0x06b6b51f, 0x9fbfe4a5, 0xe8b8d433
  ,0x7807c9a2, 0x0f00f934, 0x9609a88e, 0xe10e9818, 0x7f6a0dbb,  0x086d3d2d
  ,0x91646c97,  0xe6635c01,  0x6b6b51f4,  0x1c6c6162,  0x856530d8,
0xf262004e
  ,0x6c0695ed,  0x1b01a57b, 0x8208f4c1, 0xf50fc457, 0x65b0d9c6, 0x12b7e950
  ,0x8bbeb8ea, 0xfcb9887c, 0x62dd1ddf, 0x15da2d49, 0x8cd37cf3, 0xfbd44c65
  ,0x4db26158, 0x3ab551ce, 0xa3bc0074, 0xd4bb30e2, 0x4adfa541, 0x3dd895d7
  ,0xa4d1c46d, 0xd3d6f4fb, 0x4369e96a, 0x346ed9fc, 0xad678846, 0xda60b8d0
  ,0x44042d73, 0x33031de5, 0xaa0a4c5f, 0xdd0d7cc9, 0x5005713c,  0x270241aa
  ,0xbe0b1010,  0xc90c2086,  0x5768b525,  0x206f85b3,  0xb966d409,
0xce61e49f
  ,0x5edef90e,  0x29d9c998, 0xb0d09822, 0xc7d7a8b4, 0x59b33d17, 0x2eb40d81
  ,0xb7bd5c3b, 0xc0ba6cad, 0xedb88320, 0x9abfb3b6, 0x03b6e20c, 0x74b1d29a
  ,0xead54739, 0x9dd277af, 0x04db2615, 0x73dc1683, 0xe3630b12, 0x94643b84
  ,0x0d6d6a3e, 0x7a6a5aa8, 0xe40ecf0b, 0x9309ff9d, 0x0a00ae27, 0x7d079eb1
```

```
  ,0xf00f9344, 0x8708a3d2, 0x1e01f268, 0x6906c2fe, 0xf762575d,  0x806567cb
  ,0x196c3671,  0x6e6b06e7,  0xfed41b76,  0x89d32be0,  0x10da7a5a,
0x67dd4acc
  ,0xf9b9df6f,  0x8ebeeff9,  0x17b7be43,  0x60b08ed5,  0xd6d6a3e8,
0xa1d1937e
  ,0x38d8c2c4,  0x4fdff252,  0xd1bb67f1,  0xa6bc5767,  0x3fb506dd,
0x48b2364b
  ,0xd80d2bda, 0xaf0a1b4c, 0x36034af6, 0x41047a60, 0xdf60efc3, 0xa867df55
  ,0x316e8eef, 0x4669be79, 0xcb61b38c, 0xbc66831a, 0x256fd2a0, 0x5268e236
  ,0xcc0c7795, 0xbb0b4703, 0x220216b9, 0x5505262f, 0xc5ba3bbe, 0xb2bd0b28
  ,0x2bb45a92, 0x5cb36a04, 0xc2d7ffa7, 0xb5d0cf31, 0x2cd99e8b, 0x5bdeae1d
  ,0x9b64c2b0, 0xec63f226,  0x756aa39c,  0x026d930a,  0x9c0906a9,
0xeb0e363f
  ,0x72076785,  0x05005713,  0x95bf4a82,  0xe2b87a14,  0x7bb12bae,
0x0cb61b38,0x92d28e9b
  , 0xe5d5be0d, 0x7cdcefb7, 0x0bdbdf21, 0x86d3d2d4, 0xf1d4e242,0x68ddb3f8
  , 0x1fda836e, 0x81be16cd, 0xf6b9265b, 0x6fb077e1, 0x18b74777,0x88085ae6
  , 0xff0f6a70, 0x66063bca, 0x11010b5c, 0x8f659eff, 0xf862ae69,0x616bffd3
  , 0x166ccf45, 0xa00ae278, 0xd70dd2ee, 0x4e048354, 0x3903b3c2
  ,0xa7672661, 0xd06016f7,  0x4969474d,  0x3e6e77db,  0xaed16a4a,
0xd9d65adc,0x40df0b66
  ,  0x37d83bf0,  0xa9bcae53,  0xdebb9ec5,  0x47b2cf7f,
0x30b5ffe9,0xbdbdf21c
  , 0xcabac28a, 0x53b39330, 0x24b4a3a6, 0xbad03605, 0xcdd70693,0x54de5729
  , 0x23d967bf, 0xb3667a2e, 0xc4614ab8, 0x5d681b02, 0x2a6f2b94,0xb40bbe37
  , 0xc30c8ea1, 0x5a05df1b,  0x2d02ef8d
  ,}
  uint32_t  crc_crc32 (uint32_t  crc,  const  uint8_t  *buf,  uint32_t
size ) {for   (uint32_t
    i=0;  i<size ;  i++)  {crc
  =  crc32_tab [ (crc  ^  buf [i ] )  &  0xff]  ^   (crc  >>  8 ) ;
  }
  return crc;
  }
```

10 Match accessories

422 and P9 signal adapter cable

11 Update the record

Versions	Dates	Status/Comments
Version 1.0	20240813	First Release