# Inertial module IM 19 User Manual V 1.1

The IM 19 inertial module uses MEMS sensor and GNSS positioning data to achieve low cost and high precision attitude measurement and aerial position calculation (Dead-Reckoning).

## 1. Description of hardware usage

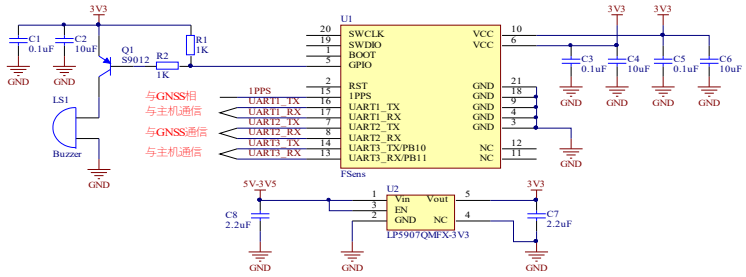
### .11. Module power supply parameters

| | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|
| supply voltage | 3.0 | 3.3 | 3.6 | V |
| supply current | 80 | 100 | 120 | mA |

### 1.2 Pin description

| pin | network | Function (all port logic voltage is 3.3V) |
|---|---|---|
| 1 | BOOT | Start mode select pin, set high B OOT mode, suspended or low normal start |
| 2 | RESET | Hardware reset pin, internal pull-up, pull down more than 10 mS reset module |
| 3 | GND | Power to |
| 4 | GND | Power to |
| 5 | GPIO | Output IO port, can be connected with the active buzzer |
| 6 | 3V3 | Processor power supply |
| 7 | UART2_TX | Serial port 2 is sent, connected to the GNSS card RX interface |
| 8 | UART2_RX | The serial port 2 is received and connected to the GNSS card TX interface |
| 9 | GND | Power to |
| 10 | 3V3 | Sensor power supply |
| 11 | NC | hang in the air |
| 12 | NC | hang in the air |
| 13 | UART3_RX | Serserial port 3 can be used for module configuration, message output, and firmware upgrade |
| 14 | UART3_TX | The serial port 3 is sent and can be used for module configuration, message output, and firmware upgrade |
| 15 | 1PPS | 1 PPS pin, connected to the GNSS board card 1 PPS |
| 16 | UART1_TX | The serial port 1 is sent and can be used for module configuration, message output, and firmware upgrade |
| 17 | UART1_RX | The serial port 1 receives, and can be used for module configuration, message output, and firmware upgrade |
| 18 | GND | Power to |
| 19 | SWDIO | Debug the interface, which is suspended |
| 20 | SWCLK | Debug the interface, which is suspended |
| 21 | GND | Power to |

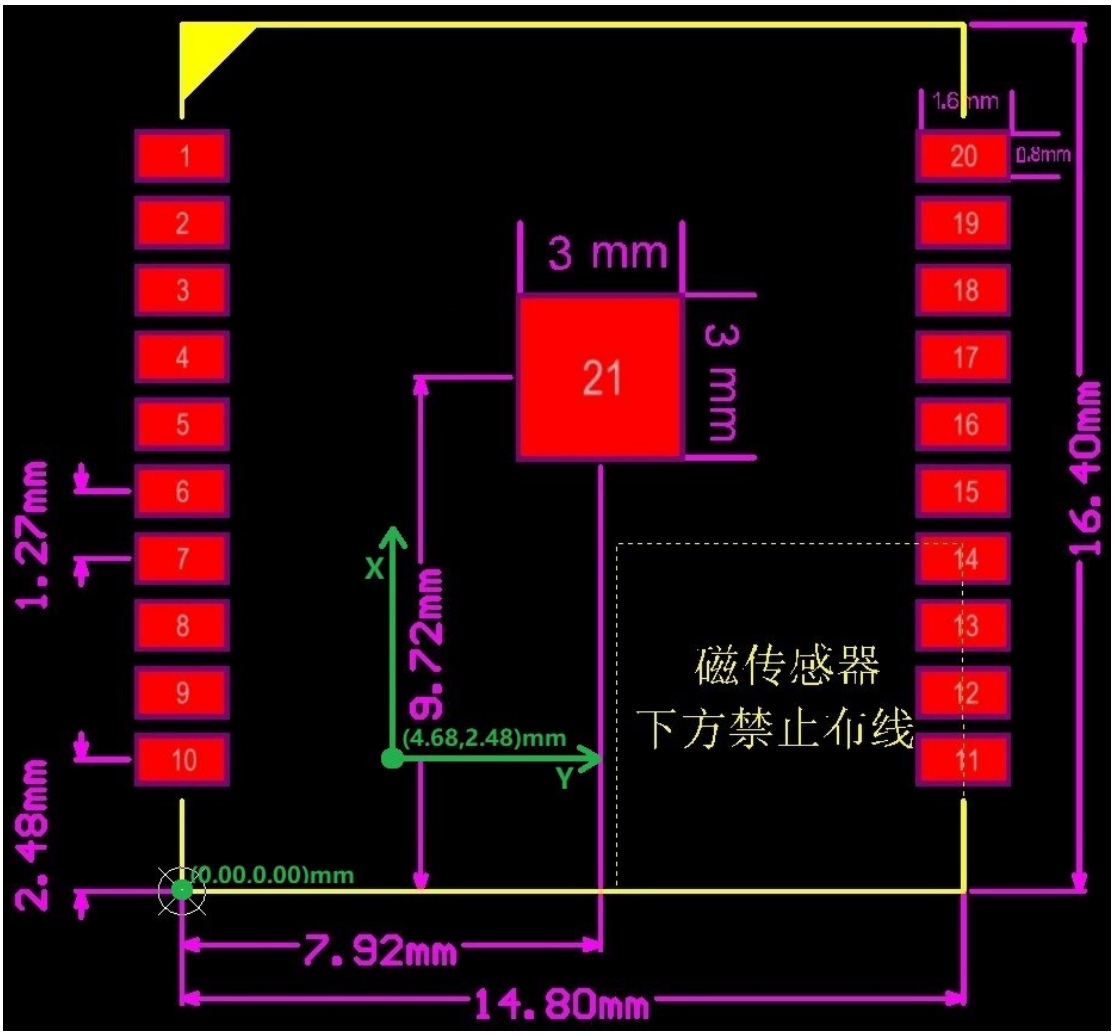
### 1.3 Reference design




Serial port 1 and 3 have the same functions, where one way can be connected to the main processor and the other way can serve as a debugging interface. In addition, the BOOT pin suggests a backup. The buzzer can be used for indications such as the power, the magnetic field parameters, and the installation angle.

### 1.4 Package dimensions

The edge pad size is 1mm-0.8mm, and the middle pad size is 3mm-3mm. No wiring is prohibited below the magnetic sensor to avoid the high current power supply or ground wire passing through the magnetic sensor. When the inertial module layout, it is recommended to place it in the temperature rise stability area to avoid convection with the external air. The coordinate system is defined, as shown in the figure. Use the right-handed system. It is recommended that the X-axis is consistent with the forward direction of the carrier.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
1.6mm
0.8mm
3 mm
3 mm
16.40mm
1.27mm
1.27mm
2.48mm
9.72mm
X
Y
(4.68,2.48)mm
(0.00,0.00)mm
磁传感器
下方禁止布线
7.92mm
14.80mm

# 2. Software Development Instructions

## 2.1 data communication protocol

### 2.1.1 MEMS raw data protocol

The IM 19 module can output M EMS raw data of 50Hz, the protocol adopts small end mode (low byte at low address, low byte first transmission during transmission), where the accelerometer unit is g, gyroscope data unit is rad / s, and magnetic field data unit is uT.

| project | content | type | relative position |
|---|---|---|---|
| data head | f | char | 1 |
| data head | m | char | 2 |
| data head | i | char | 3 |
| data type | m | char | 4 |
| Field 1 | hhmmss.ss | double | 5 |
| Field 2 | Acceleration X-axis data | float | 13 |
| Field 3 | Accelerated Y-axis data | float | 17 |
| Field 4 | Acceleration Z-axis data | float | 21 |
| Field 5 | Gyro X-axis data | float | 25 |
| Field 6 | GyyroY axis data | float | 29 |
| Field 7 | Gyro Z-axis data | float | 33 |
| Field 8 | Magnetometer X-axis data | float | 37 |
| Field 9 | Magnetometer, Y-axis data | float | 41 |
| Field 10 | Magnetometer Z-axis data | float | 45 |
| check sum | 1-84 Byte summed | uint16_t | 49 |
| Data tail | e | char | 51 |
| Data tail | d | char | 52 |

### 2.1.2 GNSS Raw data protocol

The original G NSS raw data output by the IM19 module comes from the output data of the G NSS receiver to the module. Its data frequency is consistent with the output frequency of the G NSS receiver, which is generally 5H z. The protocol adopts small end mode (storage time low bytes at low address, transmission time low bytes first transmission). Note: If the external G NSS raw data output by the module has low real-time performance and requires high real-time performance, please read the data directly from the GNSS receiver.

| project | content | type | relative position |
|---|---|---|---|
| data head | f | char | 1 |
| data head | m | char | 2 |
| data head | i | char | 3 |
| data type | g | char | 4 |
| Field 1 | hhmmss.ss | double | 5 |
| Field 2 | latitude (DEG) | double | 13 |
| Field 3 | longitude (DEG) | double | 21 |
| Field 4 | altitude | double | 29 |
| Field 5 | Northbound speed | float | 37 |
| Field 6 | East to speed | float | 41 |
| Field 7 | Downward speed | float | 45 |
| Field 8 | Northern position variance | float | 49 |
| Field 9 | East position variance | float | 53 |
| Field 10 | Variance of elevation position | float | 57 |
| Field 11 | continue to have | float | 61 |
| Field 12 | continue to have | float | 65 |
| Field 13 | Double antenna heading | float | 69 |
| Field 14 | HRMS | float | 73 |
| Field 15 | VRMS | float | 77 |
| Field 16 | HDOP | float | 81 |
| Field 17 | VDOP | float | 85 |
| Field 18 | The number of satellite | uint8_t | 89 |
| Field 19 | Solution state | uint8_t | 90 |
| Field 20 | Differential age | uint8_t | 91 |
| check sum | 1-79 Byte sums up | uint16_t | 92 |
| Data tail | e | char | 94 |
| Data tail | d | char | 95 |

### 2.1.3 NAVI inertial positioning data protocol

The NAVI inertial localization data output by the IM 19 module is the result of the fusion localization of the MEMS data and the GNSS data. The data include: longitude and longitude high, NED velocity (m / s), Euler angle (rad), gyroscope zero bias (rad/s), accelerometer zero bias (m / s ^ 2). Among them, the longitude and latitude height can be mapped according to the Euler angle

and the specified arm coordinates, completing similar functions such as tilt measurement. The protocol adopts small end mode (storage time low bytes at low address, transmission time low bytes first transmission).

| project | content | type | relative position |
|---|---|---|---|
| data head | f | char | 1 |
| data head | m | char | 2 |
| data head | i | char | 3 |
| data type | n | char | 4 |
| Field 1 | hhmmss.ss | double | 5 |
| Field 2 | latitude | double | 13 |
| Field 3 | longitude | double | 21 |
| Field 4 | altitude | double | 29 |
| Field 5 | Northbound speed | float | 37 |
| Field 6 | East to speed | float | 41 |
| Field 7 | Downward speed | float | 45 |
| Field 8 | roll angle | float | 49 |
| Field 9 | angle of pitch | float | 53 |
| Field 10 | path angle | float | 57 |
| Field 11 | steering angle | float | 61 |
| Field 12 | Accelerometer X-axis zero bias | float | 65 |
| Field 13 | Accelerometer Y-axis zero bias | float | 69 |
| Field 14 | Accelerometer X-axis zero bias | float | 73 |
| Field 15 | Gyro X-axis has zero bias | float | 77 |
| Field 16 | Gyro Y-axis has zero bias | float | 81 |
| Field 17 | Gyro Z-axis has zero bias | float | 85 |
| Field 18 | The steering angle Z-axis is of zero bias | float | 89 |
| Field 19 | **The status word is the STATUS** | uint32_t | 93 |
| check sum | 1 - 89 Byte sums up | uint16_t | 97 |
| Data tail | e | char | 99 |
| Data tail | d | char | 100 |

In the above table, the status word STATUS is defined as follows:

| The NAVI data STATUS status word | | | |
|---|---|---|---|
| order number | name | Character position | meaning |
| 1 | Finit | 0b 0000 0000 0001 | Filter initialization flag |
| 2 | Ready | 0b 0000 0000 0010 | Filter convergence completion flag |
| 3 | Inaccurate | 0b 0000 0000 0100 | In the filter convergence process |
| 4 | TiltReject | 0b 0000 0000 1000 | The inclination angle is too large for the sign position |
| 5 | GnssReject | 0b 0000 0001 0000 | The GNSS located the data difference marker bits |
| 9 | FReset | 0b 0000 0010 0000 | The filter will reset the flag bit |
| 12 | FixRlsStage1 | 0b 0000 0100 0000 | Tilt measurement mounting angle estimation phase 1 |
| 13 | FixRlsStage2 | 0b 0000 1000 0000 | Tilt measurement mounting angle estimation phase 2 |
| 14 | FixRlsStage3 | 0b 0001 0000 0000 | Tilt measurement mounting angle estimation phase 3 |
| 15 | FixRlsStage4 | 0b 0010 0000 0000 | Tilt measurement mounting angle estimation phase 4 |
| 16 | FixRlsOK | 0b 0100 0000 0000 | Tilt measurement mounting angle estimation is completed |

In Finit stage there is only attitude angle output, and after Finit stage there will be position, speed and attitude output.

**.1.4 The 2-character message output**

In addition to the message 2.1.1-2.2.3, the serial port will also actively output some string messages to indicate the running state of the current module, divided into three categories, starting with the "Warning:", "Error,": "and" Info: "strings, and ending with the" \ r \ n " string. Furthermore, some character messages of the module does not contain the above string header, such as the answer output for the instruction.

Warn ing Representative of some mistakes, but will not cause obvious impact on the system, can be ignored or give the user a warning.

Error represents some serious errors that are likely to affect the operation of the system, which should be analyzed in time. Error will not appear under normal circumstances.

Info represents some information from the active output of the system for status or message output.

## 2.2 Configuring instruction sets

The module can be configured by the serial port 1 or 3, and the instruction structure is:

A T+C OMMAND [=][PARA1],[PARA2],[PARA3]\r\n

All letters are capital, [] internal are optional parameters, any configuration except module activation instruction, if not saved, will be power reset. The default port rate is: 115,200 bps. The basic response to the instructions is:

\ r \ nOK \ r \ n \ r \ n or \ r \ nError \ r \ n \ r \ n

### .2.12 Module reset

Instructions: AT + SYSTEM_RESET \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.22 Firmware update

Within three seconds of the module start, the module is in IAP mode, when the IAP serial port prints "...". Enter the following instructions to the IAP serial port in IAP mode.

Instructions: AT + BOOT \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

After receiving the correct response from the module, the firmware is sent to the module through the IAP serial port. The interval between two adjacent packages cannot exceed 1 second, otherwise the module thinks the transmission is wrong and starts the transmission again. After the transmission completes and the verification pass, the module starts to guide the new firmware.

### .2.32 Parameter preservation

With the following instructions, you can save the configuration parameters used by the current module to Flash, Flash, wipe and write times is not less than 10K times, pay attention to the reasonable use of save instructions.

Instruction: AT + SAVE _ ALL \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.42 Set the G NSS board card type

With the following instructions, you can set the type of G NSS board card. There are mainly three types, mainly Hemisphere board card, N OVTEL board card and general type board card OEM. When set to the H EMI, you need to input the Bin 3 message to the module, and when set to the N OVTEL card, you need to input the B ESTPOS and B ESTVEL. When set to OEM board, you need to input G PGGA, G PRMC and G PGST into the module. When applied as dual antennas, it can only be set to OEM board, and requires a new message: G PHDT.

Instruction: AT + GNSS _ CARD = [HEMI | OEM | NOVTEL] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.52 to initialize the enabling magnetic field mode

The IM 19 module can be initialized using a magnetic field, and in this mode, magnetic field parameter correction may be required for initial use. In

general, when conducting tilt measurement applications, it is recommended to use the magnetic field initialization mode to speed up the initialization process.

Instruction: AT + AHRS = [ENABLE | DISABLE] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

**.2.62 Enable the dual-antenna mode**

IM 19 module can support dual antenna mode, dual antenna mode and magnetic field mode can not be opened at the same time. This instruction can be configured, refer to Section 5 for dual antenna installation requirements.

Instruction: AT + ANT 2 = [ENABLE | DISABLE] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

**.2.27 Read the module parameters**

The basic information of the module and the parameter configuration of the filter can be read through the following instructions.

When reading the S YSTEM parameter, the device number, port configuration, and activation time are output.

When reading the ALL parameter, the filter is output all parameters table + SYSTEM parameters.

Instruction: AT + READ _ PARA = [SYSTEM | ALL] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

**2.2.8 Load the default parameters**

The filter has a set of default parameters, which can be loaded when setting an error.

Instruction: AT + LOAD _ DEFAULT \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

**.2.29 Enable installation angle estimation**

This instruction is used to complete the mounting angle estimation in the tilt measurement application. Note that this instruction will only work when the filter is in the Ready state after convergence and stabilization. Return to the D ISABLE status automatically when the estimation is complete.

Instruction: AT + AUTO _ FIX = [ENABLE | DISABLE] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

**.2.210 Enabling magnetic field parameters are automatically saved**

.2.3With a MAG, when initialized, a magnetic sensor is used. The module will estimate the hard magnetic parameters of the magnetic field. If the magnetic field parameters are automatically saved, and when the magnetic field parameters are updated, the magnetic field parameters can be saved with the saving instruction of 2. At the next startup, preferentially check whether the previously estimated magnetic field parameters are correct, and if correct, use them directly to speed up the initialization. This configuration is recommended to turn on.

Instruction: AT + MAG _ AUTO _ SAVE = [ENABLE | DISABLE] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

**.2.211 The enabling gyro parameters are automatically saved**

.2.9Functionally similar to the 2's.

Instruction: AT + GYR _ AUTO _ SAVE = [ENABLE | DISABLE] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.122 Enable the addition of the table parameters to be automatically saved

.2.9Functionally similar to the 2's.

Instruction: AT + ACC _ AUTO _ SAVE = [ENABLE | DISABLE] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.123 Set the positional mapping vector

The IM 19 module supports mapping the G NSS antenna phase center position to any specified position according on the current attitude. When mapping, it is necessary to set the mapping vector. The origin of the vector coordinate system is located in the phase center of the antenna, and the coordinate axis direction defines the coordinate system direction for the IM 19 module (Section 1)..4

Instruction: AT + CLUB _ VECTOR = [VALUE1], [VALUE2], [VALUE3] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.124N AVI inertial positioning output

Set up the output port for the N AVI data.

Instruction: AT + NAVI _ OUTPUT = [UART1 | UART 3], [ON | OFF] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### 2.2.15 M EMS Raw data output

Sets the output port for the MEMS data.

Instruction: AT + MEMS _ OUTPUT = [UART1 | UART 3], [ON | OFF] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.126 The GNSS raw data output

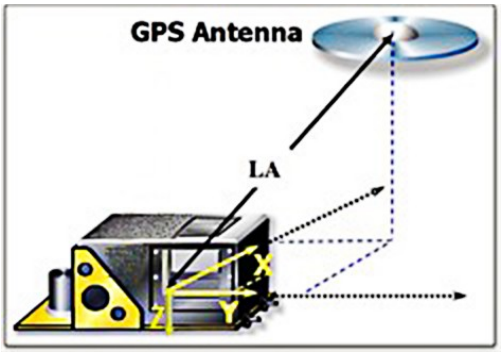
Sets the output port for the GNSS data.

Instruction: AT + GNSS _ OUTPUT = [UART1 | UART 3], [ON | OFF] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.127 Set the arm bar vector

Generally speaking, the central position of the G NSS antenna cannot coincide with the origin of the M EMS sensor coordinate system. When there is rotation, the position and speed measured by G NSS are not strictly the position and speed change perceived by the M EMS sensor. Therefore, a mapping is needed to solve this problem. The mapping vector coordinate system origin is MEMS, sensor, coordinate system origin, and coordinate axis direction is IM 19 module, which defines the coordinate system direction (Section 1)..4 As shown in the figure below, the antenna to the 3 D coordinates (X, Y, Z) of the origin of the IMU coordinate system should be set, which can be set through this instruction. Note: Z axis shown below, if the antenna is above IMU, Z value is negative, the antenna is below IMU, and Z value is positive.




Instruction: AT + LEVER _ ARM = X, Y, Z \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.218 Time-based synchronization test

Query whether the M EMS timestamp is synchronized with the G NSS. After sending this instruction, the serial port continues to output the message, enter any character again, and exit the query mode.

Instruction: AT + CHECK _ SYNC \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.219 High-rate mode

High speed mode is 50H z in the output of N AVI data, and it is real-time output, but the accuracy is relatively poor. It is suggested to set it to high speed mode in the application situation with high real-time requirements, and cancel the high speed output in the measurement application. At this time, the output data rate is consistent with the G NSS rate.

Instruction: AT + HIGH _ RATE = [ENABLE | DISABLE] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.220 Set up the all-round parameter table

The overall profile of IM 19 can be modified by this instruction. The profile can be written to the module through this command. Note If you want to update the parameter table, send the profile within 10S after sending the command.

Instruction: AT + SET _ ALL _ PARA \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.221 The module is activated

The modules provided during the test phase may have a test time limit. Once the limit date is reached, the modules cannot be used and need to be activated again. During activation, send command 2 (AT + READ _ PARA = SYSTEM) to obtain the module serial number and provide the serial number to Feeman Technology. After generating the activation code, it can be activated through this command..2.6

Instruction: AT + ACTIVATE _ KEY = [KEY] \ r \ n

Response: \ r \ nOK \ r \ n \ r \ n

### .2.222 Set the initial alignment speed

The I MU19 module starts running after the carrier reaches its initial alignment speed.

Instruction: AT + ALIGN _ VEL = 1.0 \ r \ n
Response: \ r \ nOK \ r \ n \ r \ n

## 3. Typical configuration table

### .13 The tilt measurement mode

When the module is in the tilt measurement mode, refer to the following configuration mode, please modify the specific configuration parameters according to the specific hardware implementation.

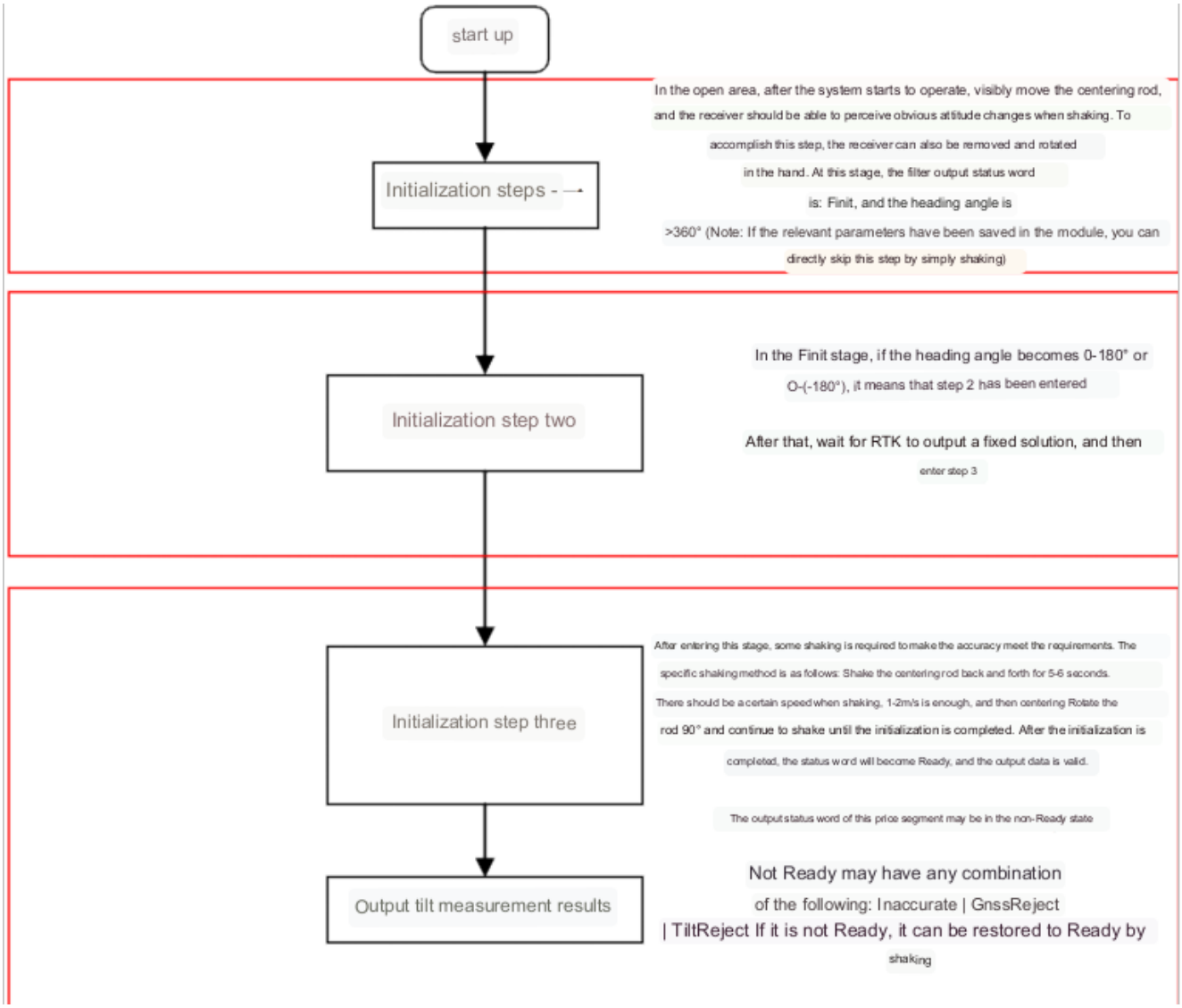
1. AT+MAG_AUTO_SAVE=ENABLE
2. AT+AHRS=ENABLE
3. AT+NAVI_OUTPUT=UART1,ON
4. AT+LEVER_ARM=0.007,-0.035,-0.025
5. AT+CLUB_VECTOR=0.00,0.00,1.855
6. AT+GNSS_CARD=HEMI
7. AT+HIGH_RATE=DISABLE
8. AT+SAVE_ALL

### 3.2 Combined navigation mode

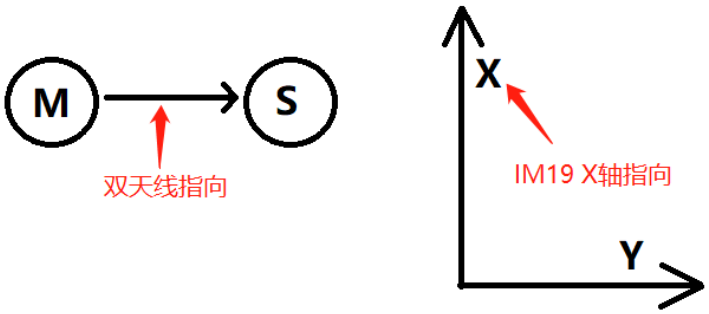
When the module is working in the combined navigation mode, refer to the following configuration mode. Please modify the specific configuration parameters according to the specific hardware implementation. If the real-time requirement are not high, you can choose to disable the high rate mode.

1. AT+MAG_AUTO_SAVE=DIS ABLE
2. AT+AHRS=DIS ABLE
3. AT+NAVI_OUTPUT=UART1,ON
4. AT+LEVER_ARM=0.007,-0.035,-0.025
5. AT+CLUB_VECTOR=0.00,0.00,0.00
6. AT+GNSS_CARD=HEMI
7. AT+HIGH_RATE=EN ABLE
8. AT+SAVE_ALL

## 4. Actual use process of tilt measurement mode




## 5. Dual-antenna installation requirements




Note: The heading given by IM 19 is the orientation of the X-axis