## LABORATORY GYRO

- Strapdown Inertial Navigation Systems (SINS) on MEMS and fiber-optic gyroscopes
- Drivers / Motors
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## APPROVED

(product code)
МИКГ. 402138.006 РЭ-ЛУ

Inertial Navigation System
GL150/2-M

Operating Manual
МИКГ. 402138.006 РЭ

## Introduction

The operating manual is intended to familiarize technical personnel with STRAPDOWN INERTIAL NAVIGATION SYSTEM (SINS).

Technical personnel who have studied the present operating manual МИКГ.402138.006 РЭ is admitted to operate the SINS product.

## 1 Purpose of product

The strapdown inertial navigation system (SINS) is intended for determination and delivery of orientation and navigation parameters with possibility of using data received from GPS/GLONASS satellite navigation systems and odometric sensors for mobile or stationary objects under the following operating conditions:
i) working ambient temperature from plus $55^{\circ} \mathrm{C}$ to minus $50^{\circ} \mathrm{C}$,
limit storage temperatures from plus $85^{\circ} \mathrm{C}$ to minus $50^{\circ} \mathrm{C}$,
air relative humidity from 5 to $98 \%$,
atmospheric pressure from 450 to 850 mm Hg ,
longitude range $\pm 180^{\circ}$,
latitude range $\pm 70^{\circ}$,
range of angular velocity $\pm 500 \%$.
range of angular accelerations $\pm 1000 \% \mathrm{~s}^{2}$,
single limit accelerations to $90 \mathrm{~g}(5 \mathrm{~ms})$.

## 2 Technical characteristics

The product technical characteristics are listed in Table 1.
Table 1

| Parameter | Value |
| :--- | :--- |
| 1 D.C. primary voltage supplied by on-board <br> electrical system, V | from 18 to 32 |
| 2 Pulsation coefficient of D.C. primary voltage at <br> Usup $=27 \mathrm{~V}, \%$, at most | 5 |
| 3 Readiness time on parking (from turn-on to stating <br> determination of heading, roll and pitch angles), s, at most | 5 |
| 4 Gyrocompassing and delivery time for measured heading <br> angle, minutes-seconds, at most | $6-00$ |
| 5 Root-mean-square error of heading angle determination, <br> deg., at most | $0.045 / \cos (\varphi)$ |
| 6 Root-mean-square error of roll angle <br> determination and delivery in measurement range <br> from minus 180 |  |
| 7 Root-mean-square error of pitch angle determination and <br> delivery in measurement range from minus $+60^{\circ}$ to plus <br> 180 |  |
| 8 Roog., at most <br> at most | 0.03 |
| 9 Roon-square error of directional angle storage, deg., <br> odometer correction, $\%$ of distance traveled, at most | 0.03 |
| 10 Power consumption in operating modes, W, at <br> most | 0.25 |
| 11 Continuous operation time, h, at least | 25 |
| 12 Mass, kg, at most | 24 |

$\varphi$ - site latitude

## 3 Product set

The set of SINS product is given in Table 2
Table 2

| Product <br> designatio <br> n | Product <br> name | Q-ty |
| :--- | :--- | :--- |
| БИНС GL150/2-M | МИКГ.402138.006 | 1 |
| Shock absorber SES-5А-5 |  | 4 |
|  |  |  |
| Operating manual <br> Passport | МИКГ.402138.006 | 1 |
|  | РЭ <br> МИКГ.402138.006 | 1 |
|  | ПС |  |

## 4 Design and functioning

### 4.1 Operation principle

Rigidly mounted in the sensing unit (SU) are three angular velocity sensors (AVS) and three accelerometers with sensitivity axes focused along $\mathrm{Ox}, \mathrm{Oy}, \mathrm{Oz}$ axes of rectangular coordinate system Oxyz associated with SU housing.

Reacting to angular velocities of rotation ( $\omega_{\mathrm{x}}, \omega_{\mathrm{y}}, \omega_{\mathrm{z}}$ ) and base accelerations ( $\mathrm{a}_{\mathrm{x}}, \mathrm{a}_{\mathrm{y}}, \mathrm{a}_{\mathrm{z}}$ ) representing vector projections $\omega_{\mathrm{a}}$ of absolute angular rotation velocity and apparent acceleration vector Aa over axes $\mathrm{Ox}, \mathrm{Oy}, \mathrm{Oz}$, these devices deliver signals primary for orientation problem solution.

Three accelerometers as part of the sensing unit form an orthogonal measuring system of object linear accelerations over two horizontal and one vertical channel ( $\mathrm{X}, \mathrm{Y}, \mathrm{Z}$ ).

Three sensors of angular velocity, constructed as per Sagnac ring interferometer scheme based on fiber-optical loop with servo feedback, form an orthogonal measuring system of object angular velocities.

The way of adding compass properties to SINS product is based on use of sensor indications of angular velocity and linear accelerations with their subsequent processing. The way of North direction determination is given in Figure 2.


Figure 2

Let's introduce geographical axes $0 \xi_{\Gamma}, 0 \eta_{\Gamma}$, axes $0 x^{\prime}, 0 y^{\prime}$ representing projections of object axes to the horizon plane and device axes
$0 \mathrm{xd}, 0 \mathrm{y}$ d (device N , device E).
True heading $K$ differs from device $K_{d}$ by value $\Delta K_{i}$ called heading correction.

$$
\begin{equation*}
\mathrm{K}=\mathrm{K}_{\mathrm{a}}+\Delta \mathrm{K}_{\mathrm{i}}, \tag{1}
\end{equation*}
$$

where $K_{d}$ - heading value determined by device, deg.
$\mathrm{Ki}-$ heading correction, deg.
Angular velocity vector components of Earth rotation $U_{\xi \mathbf{r}}$ and $U \eta_{\mathbf{r}}{ }_{\mathrm{s}}$ at zero object velocities are determined by formula:

$$
\begin{equation*}
\mathrm{U}_{\xi \mathbf{r}}=\mathrm{U} \cdot \cos \varphi \quad ; \quad \mathrm{U} \eta_{\mathbf{r}}=0 \tag{2}
\end{equation*}
$$

where U - angular rotation velocity vector of the Earth, deg/s, $\varphi$ - object latitude, deg.

Then $U$ vector projection to $\mathrm{Oy}_{\Pi}$ axis will be equal:
$U y_{\text {п }}=-U \cos \phi \sin \Delta K_{i}$
It follows that $\mathrm{Uy}_{\text {п }}$ with known latitude contains information on heading correction $\Delta \mathrm{K}_{\mathrm{i}}$.

- projection of the Earth angular rotation velocity to device axis $\mathrm{Oy}_{\text {п }}$ measured by sensor of angular velocity.

From the last ratio the heading correction value will be equal:

Substituting defined value of $\Delta \mathrm{K}_{\mathrm{i}}$ to formula (1), the calculation algorithm forms a value of "device" heading "converging" to value of true heading.

Possible change of correction sign of the heading $\left(\Delta \mathrm{K}_{\mathrm{i}+1}\right)$ is fixed by the algorithm and does not influence the process of "converging" $0 \times \Pi$ and ${ }^{0} \xi_{\mathbf{r}}$ axes in the calculation algorithm since the sign of the right part in formula (3) will change (see position of $0 x^{\prime} п р, 0 y^{\prime} п р$. axes in figure 2 ).

For correction of system indications on heading, roll and trim angles during the object movement, the on-board computer can accept signals on latitude $\varphi$ and longitude $\lambda$, velocity V , altitude h from the satellite navigation system and on distance traveled S from the wheel sensor mounted on the object.

The system delivers to the consumer the value of orientation angles $\psi, \gamma, \theta$ in analog form and in digital form as per coordinated protocol.

### 4.2 Design

The SINS system is built in a housing made of aluminum alloy and protected from moisture. The housing of SINS unit accommodates sensitive elements with necessary service electronics. The unit structure has four openings for fastening to object and two openings for fixing exact position of SINS sensitivity axes relative to object by means of pins.

The unit appearance is given in Figure 3

## 5 Marking

Each product unit should have the following marking:

- unit designation;
- number assigned to the unit in manufacturing.

Marking of the unit is made on the factory sign attached to the unit housing.

## 6 Use of product

### 6.1 Safety precautions

Technical personnel who have studied its operating instructions as per operating manual МИКГ.402138.006 РЭ is admitted to operate the product.

### 6.2 Orientation, preparation for operation, visual inspection of product, list of possible malfunctions

Device position installed on the basis at zero indications of scales is considered as initial. The system of axes associated with device housing is given in Figure 3.


Figure 3

At initial device position (zero heading, roll and pitch angles): X axis of device is directed to the North parallel to meridian, Y axis of the device is perpendicular to the horizon plane and is directed upwards. Z axis - supplements $\mathrm{X}, \mathrm{Y}$ axes to the right coordinate system.

Locate the SINS unit inside the object on the platform parallel to the measuring device "seat" plane of the object.

Install the measuring device on the mounting platform using pins (if provided), at the same time the axis of azimuth reference mark should be parallel to the object longitudinal geometrical axis (passing through the line of pins) and directed forward (in the main direction of object movement). Fix SINS on the object.

Prepare product for operation in a sequence given below.
Check fastening, appearance of product, condition of product units coatings, lack of cracks and damages in the housing.

Connect PC to SINS.

### 6.2.1 Operability check-up

### 6.2.1.1 Product turn-on

Turn on PC and start VerticalGyro program.
Apply power to the device
Attention: The pause from the previous turn-on should be at least 5 min.

On the monitor screen within five seconds look for data appearance in window in the VerticalGyro program, see Figure 4.

The device should deliver and receive information according to the document "Protocol of SINS data exchange. Main channel".


Figure 4
The state of the product according to Figure 5 is represented in NavyData window：

| 带譍 NavyData＞ |  |  |  |  | － | $\square \times$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| GParameters Table |  |  |  |  |  |  |
| No | Name | Current Value | Unit | Save | Show | Outpu |
| 1 | State | 1101100 | － | － | － | － |
| 2 | Ax | －0．00030419591348 | g | － | － | － |
| 3 | Ay | 1.00017976760864 | g | － | － | － |
| 4 | Az | 0.00073783478001 | g | － | － | － |
| 5 | W\％ | －0．0011049034073 | degree／s | － | － | － |
| 6 | Wy | 0.004347383044661 | degree／s | － | － | － |
| 7 | Wz | －0．0036011561751三 | degree／s | － | － | － |
| 8 | Roll | －0．0567568056285 | degree | － | － | － |
| 9 | Course | 161.926910400391 | degree | － | － | － |
| 10 | Pitch | －0．0283653978258 | degree | － | － | － |
| 11 | Latitude | 101229092 | rad＊e－8 | － | － | － |
| 12 | Longitude | 98157332 | rad＊e－8 | － | － | － |
| 13 | Height | 178.027053833008 |  | － | － | － |
|  |  |  |  |  |  |  |
| $\checkmark$ Show current values in table from capture file |  |  |  |  | 5 Cl | se |

Figure 5

- Valid values of roll and pitch angles are displayed in Roll, Pitch lines, right after power on.
- Device status is displayed in the State line according to Table 3.

Table 3

| State word |  |
| :---: | :---: |
| Bit 0 | INS malfunction: <br> 1 - INS is faulty; 0 - INS is operable |
| Bit 1 | SNS malfunction: <br> 1 - SNS is faulty; $0-$ SNS is operable |
| Bit 2 | Malfunction of magnetic compass (MC): $1-\mathrm{MC}$ is faulty; $0-\mathrm{MC}$ is operable |
| Bit 3 | Malfunction of barometric altimeter (BA): $1-$ BA is faulty; $0-\mathrm{BA}$ is operable |
| Bit 4 | Sign of reliable navigation data of SNS: <br> 1 - data are reliable; 0 - data are not reliable |
| Bit 5 | Sign of reliable data from the air velocity sensor (AVS): 1 - AVS is faulty; 0 - AVS is operable |
| Bit 6 | Sign - object movement: <br> 1 - fixed base; 0 - movement |
| Bit 7 | Correction of coordinates by Fixed Base sign - drift correction: <br> 1 - correction performed; 0 - correction not performed |
| Bit 8 | Correction of coordinates according to data from SNS: 1 - correction performed; 0 - correction not performed |
| Bit 9 | Alignment by known latitude: <br> 1 - performed; 0 - not performed |
| Bit 10 | Correction on the known heading and latitude: 1 - performed; 0 - not performed |
| Bit 11 | Reserve |
| Bit 12 | Reserve |
| Bit 13 | Double gyrocompassing: <br> 1 - performed; 0 - not performed |
| Bit 14 | Repeated setting for double gyrocompassing: 1 - expected; 0 - not expected |
| Bit 15 | Readiness of INS: <br> 1 - ready; 0 - not ready |
| Bit 16 | Reserve |
| Bit 17 | Accelerometer Correction mode 1 - performed; 0 - not performed |
| Bit 18 | Odometer Correction mode <br> 1 - performed; 0 - not performed |
| Bits 19-31 | Reserve |

Within several seconds check data availability from the device and absence of SINS Malfunction bit.
6.2.1.2 List of delivered data via the main exchange channel from the start-up

| Identifier | Pack name | Output frequency, Hz |
| :--- | :--- | :--- |
| 112 | Navigation and orientation data pack | 25 |
| 51 | SNS data pack | 1 |
| 52 | Pack of estimates | 1 |
| 53 | Wheel sensor parameter pack | 1 |
| 112 | Additional data pack | 1 |
| 164 | Pack of temporary parameters <br> (setting time) | 1 |

### 6.2.1.3 List of possible malfunctions

The list of possible malfunctions arising during preparation for operation, their cause and remedies are given in Table 4.

Table 4

| Malfunction | Cause | Remedies |
| :--- | :--- | :--- |
| No signals from the device | No supply voltage $\pm 27$ <br> V on the input connector <br> of the sigutal processing <br> unit | Check availability of <br> device supply voltage <br> $\pm 27 \mathrm{~V}$ |
| No link with PC | The cable is not connected to <br> PC | Check SINS <br> connection with PC |
| Odd value of device state is <br> displayed in the State line | Bit 0 sign set - sign of <br> device malfunction | Check SINS connections. <br> Restart the device. If the <br> malfunction sign is still <br> present - the device <br> should be send to the <br> manufacturer for repair |

After product operability check-up according to item 6.2 .1 of the present manual with positive check-up results the device is ready for operation.

### 6.3 Main modes of SINS

The product has three main modes:

- Standby;
- Fast Aligment;
-Navigation.
After power is on, the SINS performs loading, self-test and initialization of devices. Functioning in this state continues at most 5 s . In the absence of errors during self-test, SINS switches over to Standby mode.


### 6.3.1 Standby mode

In this mode, SINS has the following cyclogram:
$-0-10 \mathrm{~s}$ : rough horizontalizing.
$-10-\mathrm{N}$ s: rough alignment of heading angle.
SINS automatically starts Accelerated Setting No. 1 on coordinates from SNS in N seconds. Parameter N is set by user coefficient No. 1 USER_START_UP_TIME. If reliable coordinates from SNS are absent, the SINS is set on the saved coordinates.

### 6.3.2 Fast Alignment mode

The user can independently start Fast Alignment by known Latitude if the device is in Standby or Navigation modes (see para "3.3.2 Data input for management of operating modes 45 h " of the data exchange protocol).

For starting setting by means of technological panel: In Configurator tab enter actual values of latitude, longitude, altitude and command code, see Fig. 6.


Figure 6

On the panel it is necessary to enter values of latitude and longitude set in radians - as integers, for this purpose the initial fractional value is multiplied by $100,000,000$, the received value of latitude is entered in the Latitude line, the received value of longitude is entered in the Longitude line. Enter integer value of altitude, for this purpose reference fractional value is multiplied by 100,000.

When setting with assigned heading, enter integer value of heading, for this purpose reference fractional value is multiplied by 100,000 .

After input of coordinates, press the Send button to start independent fast setting of the product. Device switching over to Setting on latitude mode is checked, at the same time:

- in the status the Setting on latitude bit (bit No. 9) or Correction on known heading and latitude bit (bit No.10) should be set to 1 ;
- at the end of setting, the system will automatically clear bit No. 9 (or bit No.10) and will set Readiness of product bit (bit No. 15).

The system has several types of Fast Setting. The type of setting is assigned by means of command code (the fifth parameter):

| No. | Name | Command <br> cod | Requirements to immobility | $\begin{aligned} & \text { Kenned } \\ & \text { parameters } \end{aligned}$ | $\begin{aligned} & \text { Duration, } \\ & \mathbf{s} \\ & \hline \end{aligned}$ | Accepted parameters |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Alignment by known coordinates | 2, 4 | swinging base is <br> allowed | Heading, roll, pitch | 350 | 2 - coordinates are accepted from SNS, at their absence the device coordinates are not changed 4 - coordinates are accepted from the operator |
| 2 | Alignment by known coordinates and heading | 3, 5 | fixed base is required | Heading | 2 | 3 - coordinates are accepted from SNS, at their absence the device coordinates are not changed 5 - coordinates are accepted from the operator |
| 3 | Alignment by known coordinates | 8 | fixed base is required | Heading, roll, pitch | 350 | 8 - coordinates are accepted from the operator. Double gyrocompassing condition is possible |
| 4 | Alignment by known coordinates with turns | 17,18 | $\begin{aligned} & \text { swinging } \\ & \text { base is } \\ & \text { allowed } \end{aligned}$ | Heading, roll, pitch, tension of acceleromet ers, angular velocity sensor (AVS) drifts | 350 | 18 - coordinates are accepted from SNS, at their absence the device coordinates are not changed 17- coordinates are accepted from the operator |

### 6.3.2.1 Alignment No. 1 by known coordinates

Purpose: determination of heading angle with accuracy set as per specification on swinging base. The setting is started automatically at power on after termination of Standby mode.

### 6.3.2.2 Alignment No. 2 by known coordinates heading

Purpose: obtaining product readiness within 2 seconds.

### 6.3.2.3 Alignment No. 3 by known coordinates on fixed base, Double gyrocompassing condition is possible

Setting purpose: to exclude influence of accelerometer errors on its accuracy.

## Double gyrocompassing:

Purpose: Refining heading angle and AVS drifts.
For Double gyrocompassing the user should perform the following operations:
a) Execute Fast Setting No. 3 mode with command code 8. When performing this mode, the Expectation of repeated setting for Double gyrocompassing flag is set in the status (bit 14), the bit will automatically cleared after 180 s after the end of setting. At the end of setting the product sets Full readiness bit (bit 15).
b) Within three minutes, turn the product on heading angle from $70^{\circ}$ to $180^{\circ}$. It is recommended to turn the device by maximum possible angle, i. e. $\sim 180^{\circ}$.
c) Execute Fast Setting No. 3 mode with command code 8. At the same time, Double gyrocompassing bit will be set in the status (bit 13). At the end of setting, the product:

- will correct the heading angle and angular velocity sensor drifts, using data of two performed settings,
- will clear Double gyrocompassing bit 13.

Note: The Double gyrocompassing mode requires fixed base.

### 6.3.2.4 Alignment No. 4 by known coordinates with base turns.

Purpose: Refining heading angle and AVS drifts.
For this setting the following cyclogram is desirable:

- set product on (the necessary heading angle of $+\gamma$ deg),
- start setting, code $=18$,
- wait for 170-180 seconds. Turn the product on the necessary heading angle,
- wait for device readiness.
where $\gamma$ - turn on heading angle. It is recommended to turn the device to maximum possible angle, i. e. $\sim 180^{\circ}$.
During setting it is allowed to perform more number of turns.


### 6.3.2.5 Canceling execution of Fast Alignment mode

To cancel alignment being executed, the user should send Data input for management of operating modes 45 h command to the device. The command code should be 50 . After setting canceling, the device will be set with the heading:
a) equal to heading prior to gyrocompassing start, if from the moment of device turn-on the setting was completed;
b) equal to heading at the time of cancellation, if the alignment is made for the first time from the moment of device turn-on.

### 6.3.3 Navigation mode

After Fast Alignment mode termination, the SINS automatically switch over to Navigation mode, at the same time the Readiness of product bit appears in the status.

Duration of the mode is unlimited.
In this mode the system can refine parameters during data acquisition from SNS or odometric sensor.

Correction from odometric sensor is activated, if user coefficient No. 35 of "USE_DPP_IF_MORE100" is more than 100.

Correction from SNS is activated, if user coefficient No. 21 "GPS_CORRECTION_OFF_IF_MORE100" is less than 100.

### 6.4 Connection of odometric sensor

It is allowed to connect odometric sensor with amplitude of output signal from 9 to 24 V .
The conversion factor (MC) is set equal 0.1 m by default for each change of odometric sensor output signal status (on rising or falling edge).

The SINS will automatically perform SU adjustment in vehicle construction axes and odometric sensor MC, but previously it is recommended to set initial values:

- MC with accuracy of $30 \%$.
- $\quad$ SU setting angles (Psi, Tetta) with accuracy of $\pm 5$ degrees.

When making adjustments, SNS connection is not obligatory.

### 6.4.1 Versions of odometric sensor possible connections

Version 1: Frequency equivalent to motion speed arrives by "ODO_PHASE1" signal.

Discrete signal of back motion arrives by "ODO_PHASE2" signal. Frame ground means back motion. Open circuited signal means forward motion. For setting the mode, the user coefficient "DIRECTION_FOR_WHEEL_SENSOR" (No. 7) should be equal to 0 .

Version 2: Frequency equivalent to motion speed arrives by "ODO_PHASE1" and "ODO_PHASE1" signals. Signals should be shifted relative to each other in phase for accounting the motion direction.

For setting the mode, the coefficient "DIRECTION_FOR_WHEEL_SENSOR" should be equal to 150 .

Version 3: Frequency equivalent to motion speed arrives by "ODO_PHASE1", "ODO_PHASE1", "ODO_PHASE1" signals. Signals should be shifted relative to each other in phase for accounting the motion direction.

For setting the mode, the coefficient "DIRECTION_FOR_WHEEL_SENSOR"should be equal to 250 .

### 6.4.2 Automatic adjustment of SU in vehicle construction axes and odometric sensor MC

The SINS performs automatic adjustment of SU setting angles relative to vehicle construction axes and odometric sensor MC during vehicle movement.

The SINS displays current coefficients in the "Parameters of wheel sensor 35 h (53)" pack in fields:

No. 6 SF,
No. 7 Adj.angle Psi,
No. 8 Adj.angle Tetta.
For refining adjustment parameters, movement of vehicle within 8-10 minutes is sufficient.
For checking calculated parameters, it is required to execute Fast Setting mode and to repeat movement. If during repeated movement:

- amplitude of Psi and Tetta angle variations is less than 0.05 deg and,
- SFamplitude of variations is less than $0.1 \%$,
it is necessary to set user coefficient No. 28 "ODO_UST_READY_IF_MORE1" equal more than 1.
6.4.3 Manual adjustment of SU in vehicle construction axes and odometric sensor MC

Requirements to adjustment:

- distance of adjustment section, at least 50 m ,
- variation of heading angle during adjustment, at most 5 deg ,
- variation of pitch angle during adjustment, at most 3 deg,
- adjustment time, at most 180 seconds.

Sequence of adjustment procedures:

- Place the vehicle at the beginning of adjustment section;
- using panel, enter Initial Setting command with code 10, see Figure 7.

In State parameter, bit 18 "Correction of the Odometer mode" should be set to 1 ;

- right after setting bit 18 , begin rectilinear movement to the end of section;
- upon termination of movement, repeatedly issue Initial Setting command with code 10 ;
- the SINS will automatically calculate coefficients and will issue them in "Parameters of wheel sensor 35 h (53)" pack in fields:

Calculated angle Psi, grad,
Calculated angle Tetta, grad,
Calculated scale factor of odometer m/imp.;

- if necessary, procedure is repeated for determination of root-mean-square difference of coefficients and their average values;
- enter calculated coefficients by means of the panel, Configurator tab, OdometerCoef command, press the Send key, see Figure 8;
- Select WriteOdoCoefToFlash command in Configurator tab, press the Send key.


Figure 7


Figure 8

### 6.5 Connection of SNS

### 6.5.1 Checking SNS connection

- Built circuit according to electric circuit diagram МИКГ.402138.006 Э5.
- Apply power to the device.
- Select GPS Data group in parameters tab, check the Time parameter in the GPS Data window appeared. The SNS is connected if the Time parameter variates per second, see Figure 9.

Unidirectional serial interface RS-422 is used as data transmission line. The following COMport settings are necessary for operation:

- one starting bit;
- 8 data bits
- one stop bit;
- parity check is not made;
- data flow control is absent.

By default, transfer rate makes $115,200 \mathrm{bit} / \mathrm{s}$.
Additionally, PPS signal with amplitude from 3 to 44 V , duration from 2 to 10 ms , should be connected. (SINS from SNS uses NMEA packs: RMC, GSA, GGA).

SINS considers information from SNS to be reliable under condition:
HDOP $\leq 3.5$ in 2D coordinates
VDOP $\leq 4$ in 3D coordinates
Note: RMC, GSA, GGA packs should be transferred in no more than 0.6 s after PPS impulse.


Figure 9

### 6.5.2 Installation of SNS antenna

After antenna installation it is necessary to enter its location coordinates relative to SU center. Coordinates are defined in axes associated with SINS. Figure 10 shows an example of antenna arrangement. For arrangement specified, the following coordinates should be entered: $\mathrm{X}=+2 \mathrm{~m}$, $\mathrm{Y}=+3 \mathrm{~m}, \mathrm{Z}=+1 \mathrm{~m}$. These correspond to user coefficients "X_ANTENNA_DISPL" (No. 2), "Y_ANTENNA_DISPL" (No. 3), "Z_ANTENNA_DISPL" (No. 4).


Figure 10

For recording coordinates, in Configurator tab select GPS_Antenna_Displ command, set corresponding values in 1, 2, 3 lines and press Send key (see "3.3.11 SNS antenna displacement pack relative to SU 75 h center" for data exchange protocol). Use WriteUserCoefToFlash command for saving the entered data in FLASH.

### 6.6 Change of SINS measuring axes orientation.

The user can set orientation of SINS measuring axes by turning on heading, pitch and roll angles. These correspond to user coefficients "AXIS_HEAD_ADJ" (No. 25), "AXIS_PITCH_ADJ" (No. 27), "AXIS_ROLL_ADJ" (No. 26).

For recording angles in the Configurator tab select "INSAxisRotateAngles", set corresponding values in 1, 2, 3 lines and press the Send key

Use WriteUserCoefToFlash command for saving the entered data in FLASH.
The product will apply the entered coefficients only after power restart.

### 6.7 Reduction of SINS measurements to object construction axes

For reduction of SINS measurements to object construction axes, the user can enter two turns with specified sequence:

1) on heading, pitch and roll angles. These correspond the user coefficients:
"HEAD_ADJ" (No. 13), "PITCH_ADJ" (No. 14), "ROLL_ADJ" (No. 15);
2) on heading, pitch and roll angles. These correspond the user coefficients:
"HEAD_ADJ1" (No. 12), "PITCH_ADJ1" (No. 31), "ROLL_ADJ" (No. 24).
Turns are applied to product output parameters for correction of:

- heading, roll, and pitch angles,
- overloads on SINS measuring axes Ax, Ay, Az,
- angular velocities on SINS measuring axes Wx, Wy, WAz, transferred in "3.2.1 Navigation and orientation data pack 70 h " (of data exchange protocol).
- directional angle transferred in "3.2.3 Pack of additional data 72 h ".

For transfer of angles to the product, in the Configurator tab select command:
INSOutRotateAngles for input of the first turn,
INSOutRotateAngles 1 for input of the second turn.
Set corresponding values in 1, 2, 3 lines and press the Send key Use WriteUserCoefToFlash command for saving the entered data in FLASH.

### 6.8 Maintenance

The product is examined on absence of damages in housing and connectors, fastenings and appearance are checked. The product is wiped in the presence of dust.

## 7 Storage and packing

The product is packed and stored in container protecting it from shocks, pollution and corrosion.

The product orientation at storage is not regulated.
Storage conditions 4.1 as per GOST V 9.003 within three years.
Storage temperature from $+40^{\circ} \mathrm{C}$ to $+5^{\circ} \mathrm{C}$.

## 8 Transportation

The product is transported by motor transport with any reloads, and also by air, railway and water.

## Appendix 1 Description of main user coefficients

Coefficient No. 1 "USER_START_UP_TIME": Time of Fast setting on latitude automatic start-up after SINS turn-on, (s);

Coefficient No. 2 "X_ANTENNA_DISPL": SNS antenna displacement relative to SINS center along longitudinal axis, (m);

Coefficient No. 3 "Y_ANTENNA_DISPL": SNS antenna displacement relative to SINS center along vertical axis, (m);

Coefficient No. 4 "Z_ANTENNA_DISPL": SNS antenna displacement relative to SINS center along transverse axis, (m);

Coefficient No. 13 "HEAD_ADJ": Heading adjustment correction. Makes turn No. 1 of SINS device axes on heading, (deg.);

Coefficient No. 14 "ROLL_ADJ": Roll adjustment correction. Makes turn No. 1 of SINS device axes on roll, (deg.);

Coefficient No. 15 "PITCH_ADJ": Pitch adjustment correction. Makes turn No. 1 of SINS device axes on pitch, (deg.);

Coefficient No. 12 "HEAD_ADJ1": Heading adjustment correction. Makes turn No. 2 of SINS device axes on heading, (deg.);

Coefficient No. 24 "ROLL_ADJ1": Roll adjustment correction. Makes turn No. 2 of SINS device axes on roll, (deg.);

Coefficient No. 31 "PITCH_ADJ1": Pitch adjustment correction. Makes turn No. 2 of SINS device axes on pitch, (deg.);

Coefficient No. 21 "GPS_CORRECTION_OFF_IF_MORE100": If coefficient value exceeds 100, the system disconnects correction from SNS ( $\mathrm{n} / \mathrm{d}$ );

Coefficient No. 23 "GPS_FAULT_DETECTOR": Threshold of abnormal measurements determination from SNS, (m).

Coefficient No. 35 "USE_DPP_IF_MORE100": If coefficient value exceeds 100, the system enables correction from odometric sensor ( $\mathrm{n} / \mathrm{d}$ );

Note 1. Check current user coefficients in the UserCoef table (Parameters tab, VerticalGyro panel)
2. For recording user coefficients into the product, use OutUserCoef command (Configurator tab) for revision of all coefficients or ChangeUserCoefPar command for revision of one parameter.
3. For saving user coefficients in FLASH use WriteUserCoefToFlash command.

List of revisions


