FORSENSE
原极科技

# Automotive-grade MEMS 6-DOF Inertial Sensors

## FSS-IMU470-M Product Sheet

### Features

**Automotive-grade MEMS Gyroscope**

- Bias Instability: 2.0°/hr
- Angle Random Walk: 0.2°/√hr

**Automotive Grade MEMS Accelerometer**

- Bias Instability: 20μg
- Velocity Random Walk: 0.02m/s /√hr

**Independent Rotary Table Calibration**

- Independent Calibration for every module includes: sensitivity, bias instability, and misalignment
- Temperature compensation: -40°C to 105°C

**High-intensity Operating Condition Tolerance**

- Ultra Shock Resistance: 2000g（0.5ms，Half-sine shock pulse，3 axis）
- Superb Vibration Resistance: 10g（10~2KHz，3-axis）
- Full-temperature operating Range: -40°C to 105°C
- 100% Magnetic Shielding

**Real-time and Flexible Digital Interface with a Small Size**

- Configurable output sampling rate up to 1kHz
- uart serial port supported
- 17*17.5*3.7mm, about 1.6g


### Description

FSS-IMU470-M is a MEMS inertial measurement unit (IMU) module with 6 degrees of freedom (DOF) developed by Forsense (Shanghai) Technology Co., Ltd. It features three-axis gyroscopes and three-axis accelerometers. It is simple top apply without complex command and configuration.

High precision and resolution combined to help capture subtle vibration and tilt. All modules are calibrated independently on a rotary table and adjusted precisely include bias, scale factor and orthogonality before leaving the factory. In doing so, every module can deliver stable and consistent performance in most extreme conditions.

### Applications

- Advanced Driver Assistance System (ADAS)
- Autonomous Driving (AD)
- High-precision Integrated Navigation System
- Platform Stabilization and Control
- Lawn mower
- Pool Robot

Apart from standard performance and output parameters, Forsense also provides **customized** services, including software development and LOGO design, to better your products!

CONTENT

# 1. Performance Parameters

## 1.1 Gyroscope Key Metrics

Table 1 Gyroscope Key Metrics

| Parameter | Test Conditions/Remarks | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Measurement Range | | | ±300 | | °/s |
| Bias Instability[1] | @25°C,<br>ALLAN Variance, 1σ | | xy: 2.5<br>z: 2.0 | | °/hr |
| Bias Stability | GJB, 10s smoothing | | 10 | | °/hr |
| Bias Repeatability | GJB | | 30 | | °/hr |
| Resolution | | | 0.0071 | | °/s |
| Non-orthogonal between axes | | | 0.02 | | deg |
| Internal Low-pass Cutoff Frequency | Adjustable Software | | 50 | | Hz |
| ODR | | | 100 | 1000 | Hz |
| Measure Delay | | | 7 | | ms |
| Offset Error over Temperature[2] | -40°C ~ 105°C<br>≤1°C/min @1σ | | xy: 0.08<br>z: 0.05 | | °/s |
| Random Walk[1] | @25°C,<br>ALLAN Variance, 1σ | | xy: 0.25<br>z: 0.2 | | °/√hr |
| Scale Coefficient Error | | | xy: 2.0<br>z: 0.5 | | ‰ |
| Scale Factor Nonlinear | | | 50 | | ppm |

Note 1: IEEE standard values acquired from Allan Variance analysis in a static environment (25°C).

Note 2: 1σ variation of full-temperature bias at a heating rate of 1°C/min.

## 1.2 Accelerometer Key Metrics

Table 2 Accelerometer Key Metrics

| Parameter | Test Conditions/Remarks | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| Measurement Range | | | ±16 | | g |
| Bias Instability[1] | @25℃, ALLAN Variance, 1σ | | 25 | | μg |
| Bias Stability | GJB, 10s smoothing | | 75 | | μg |
| Bias Repeatability | GJB | | 0.3 | | mg |
| Resolution | | | 0.3536 | | mg |
| Non-orthogonal between axes | | | 0.02 | | deg |
| Internal Low-pass Cutoff Frequency | Adjustable Software | | 50 | | Hz |
| ODR | | | 100 | 1000 | Hz |
| Measure Delay | | | 7 | | ms |
| Offset Error over Temperature[2] | -40℃ ~ 105℃ ≤1℃/min @1σ | | 1 | | mg |
| Random Walk[1] | @25℃, ALLAN Variance, 1σ | | 0.02 | | m/s/√hr |
| Scale Coefficient Error | | | 0.5 | | ‰ |
| Scale Factor Nonlinear | @25℃ | | 30 | | ppm |

Note 1: IEEE standard values acquired from Allan Variance analysis in a static environment (25°C).

Note 2: 1σ variation of full-temperature bias at a heating rate of 1°C/min.

Fig. 1 Gyroscope - Typical Allan Variance Curve

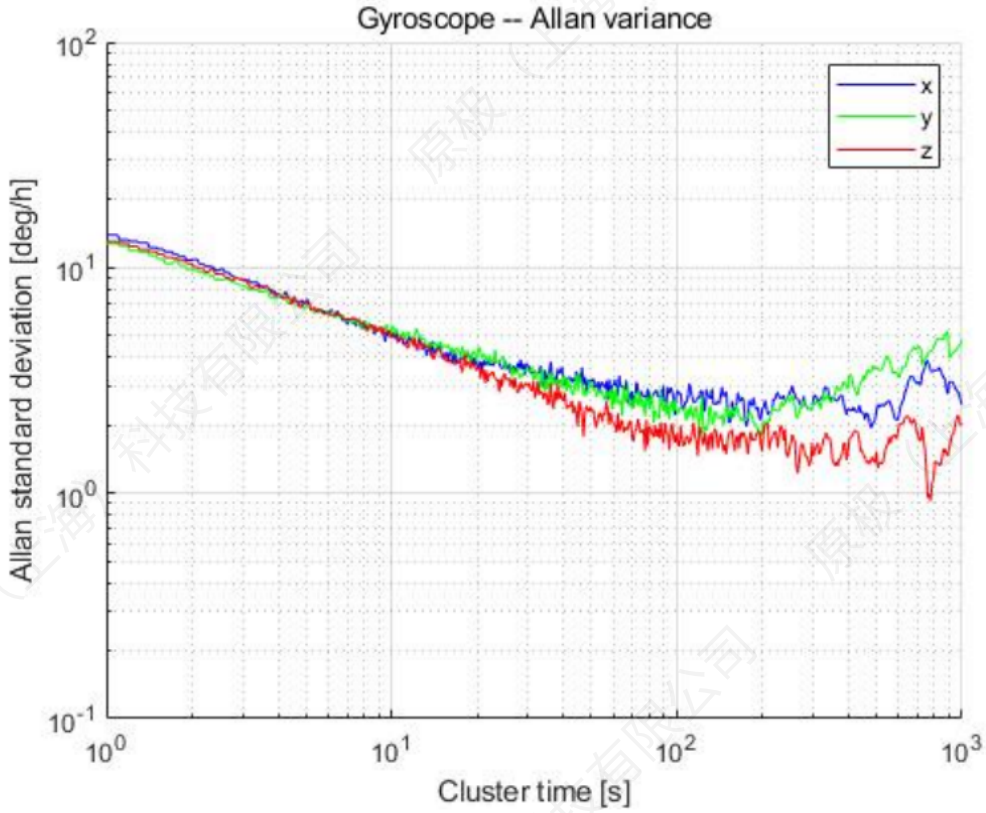
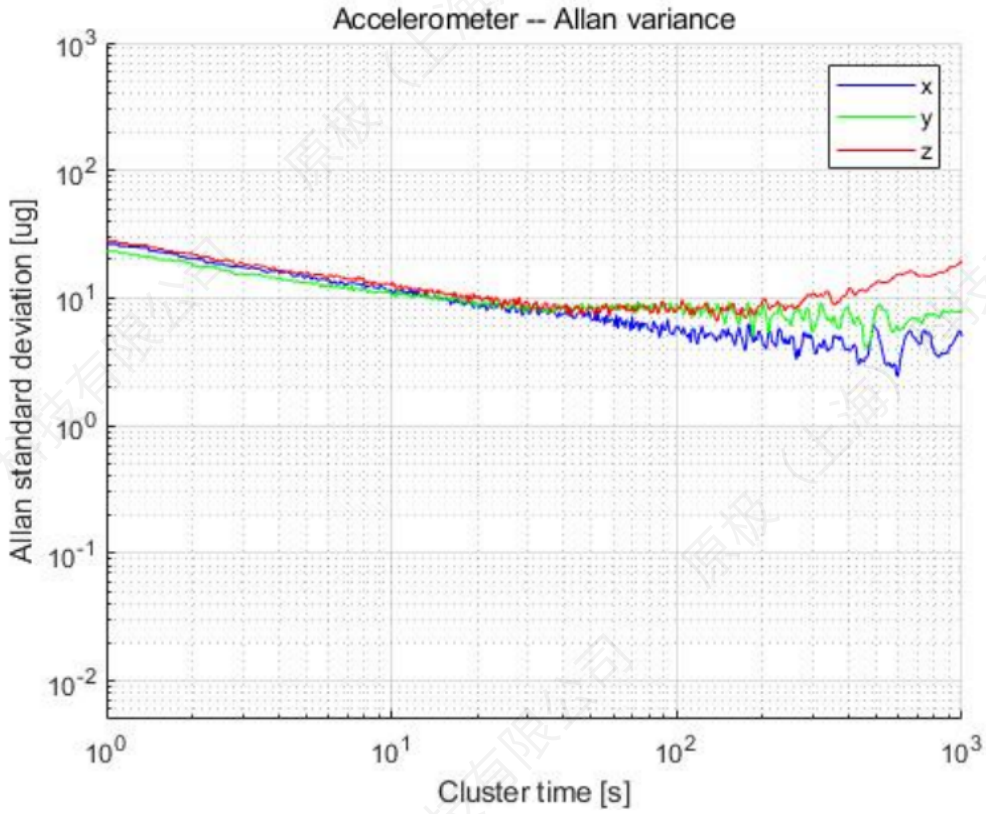



Fig. 2 Accelerometer - Typical Allan Variance Curve



# 2. External Structure

Fig. 3 Structure and Size (unit: mm)

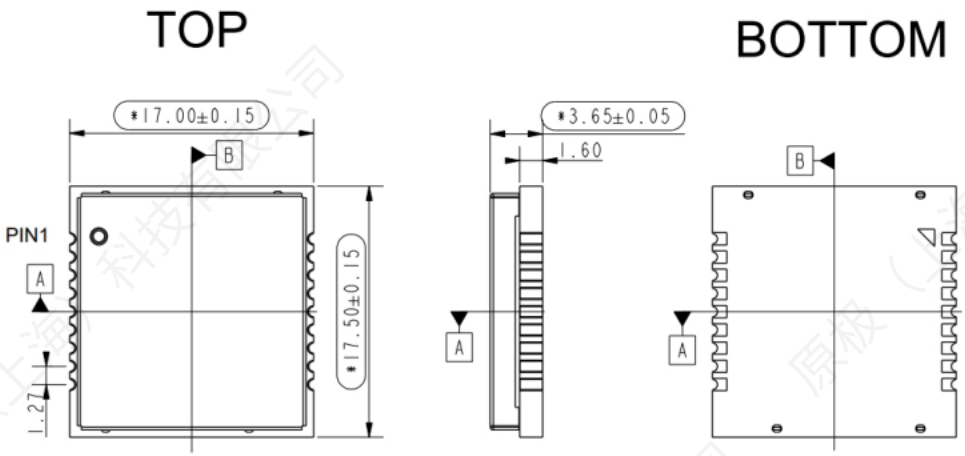
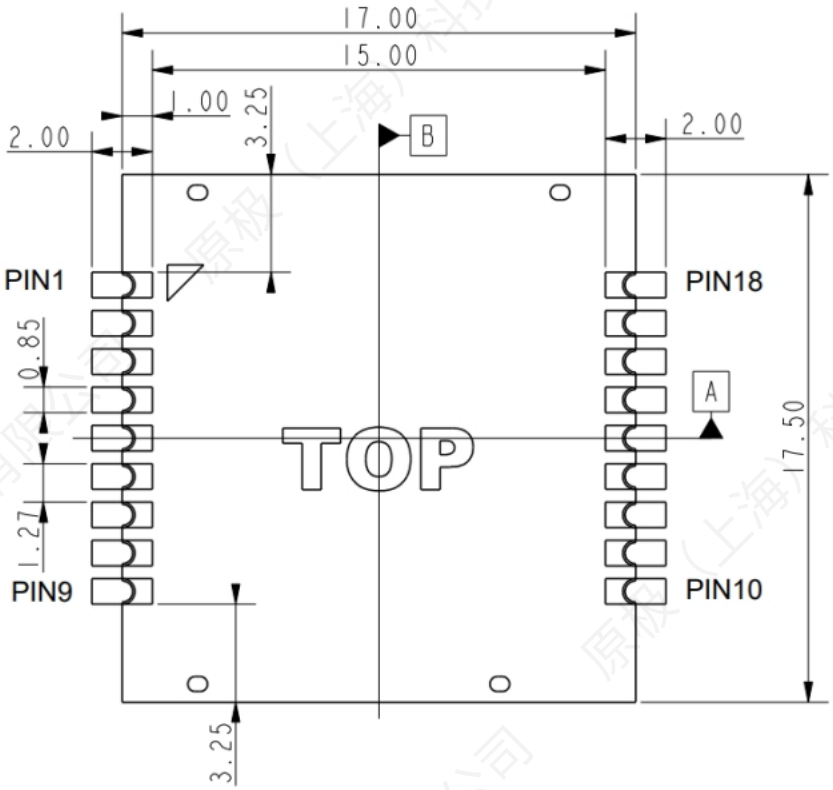



Fig. 4 Recommended Pad Size (unit:mm)



# 3. Electrical Properties

## 3.1 Absolute Maximum Ratings

Table 3 Absolute Maximum Ratings

| Parameter | Symbol | Range | Unit |
|---|---|---|---|
| Supply Voltage | VCC | -0.3 to 4 | V |
| Ground | GND | - | - |
| Input Pin Voltage | Vin | -0.3 to VCC+0.3 | V |
| Operating Temperature | Tot | -40 to 105 | ℃ |
| Storage Temperature | Tstg | -40 to 125 | ℃ |

## 3.2 Operating Conditions

Table 4 Operating Conditions

| **Parameter** | **Symbol** | **Min.** | **Typ.** | **Max.** | **Unit** |
|---|---|---|---|---|---|
| Supply Voltage | VCC | 3.13 | 3.3 | 3.47 | V |
| VCC Maximum Ripple | Vrpp | | ±40 | | mV |
| Power Consumption | P | | 0.1 | | W |
| Operating Temperature | T | -40 | | 105 | ℃ |
| Storage Temperature | T | -40 | | 125 | ℃ |

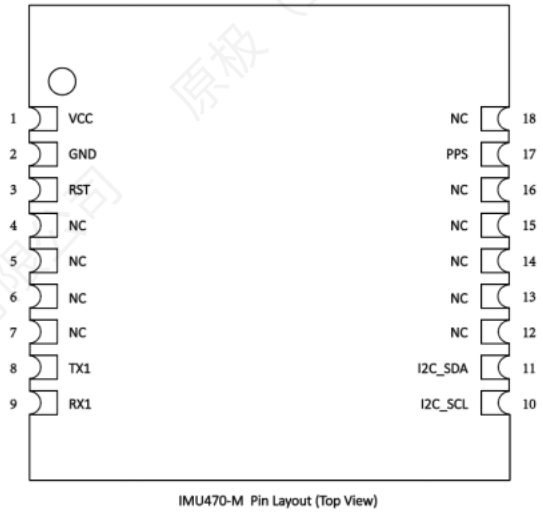
## 3.3 IO Threshold Characteristics

Table 5 IO Threshold Characteristics

| **Parameter** | **Symbol** | **Min.** | **Typ.** | **Max.** | **Unit** |
|---|---|---|---|---|---|
| Input Pin Low Voltage | Vin_low | 0 | | VCC*0.2 | V |
| Input Pin High Voltage | Vin_high | VCC*0.7 | | VCC+0.2 | V |
| Output Pin Low Voltage | Vout_low | 0 | | 0.45 | V |
| Output Pin High Voltage | Vout_high | VCC-0.45 | | VCC | V |

# 4. Pin Definitions

Fig. 5 Pin Diagram



IMU470-M Pin Layout (Top View)

Table 6 Pin Definitions

| Pin No. | Pin Name | Pin Description |
|---|---|---|
| 1 | VCC | Power Input, +3.3V, 40mA, with ripple not exceeding ±40mV |
| 2 | GND | Ground |
| 3 | RST | External hardware reset input, internal pull-up (for SPI mode) |
| 4 | NC | No connection |
| 5 | NC | No connection |
| 6 | NC | No connection |
| 7 | NC | No connection |
| 8 | TX1 | Receive asynchronous data output (Data communication interface (LVTTL)) |
| 9 | RX1 | Receive asynchronous data input (Data communication interface (LVTTL)) |
| 10 | I2C_SCL | I2C Serial Clock |
| 11 | I2C_SDA | I2C Serial Data |
| 12 | NC | No connection |
| 13 | NC | No connection |
| 14 | NC | No connection |
| 15 | NC | No connection |
| 16 | NC | No connection |
| 17 | PPS | Signal to trigger external synchronized sampling |
| 18 | NC | No connection |

# 5. Recommended Welding Furnace Temperature Profile

Fig. 6 Welding Furnace Temperature Profile

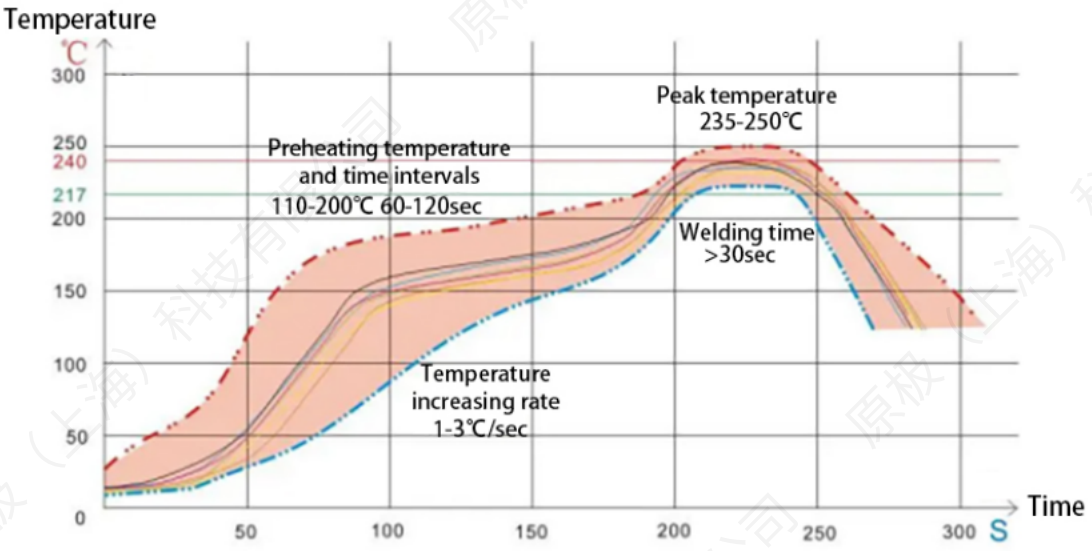



Table 7 Temperature Setting Modes

| Parameter | Min. | Max. | Unit |
|---|---|---|---|
| Maximum Temperature ramp-up rate (target = 0.8)<br>(Calculated time distance of the slope=60s)) | 1 | 3 | °/s |
| Maximum ramp-down rate<br>(Calculated time distance of the slope=60s)) | -3 | -1 | °/s |
| Preheating temperature and time intervals | 60 | 120 | s |
| Reflux time (period over 217°C) | 40 | 70 | s |
| Maximum temperature | 235 | 250 | °C |
| Maximum number of reflux | | 1 | Times |

For more information about SMT modules, please refer to the document Forsense - LCC Module SMT Application Guide.

**Notes:**

1. For modules, it is recommended to use reflux welding equipment with eight or higher temperature zones;

2. The module is a high-precision sensor sensitive to any deformation;

- If the thickness of the PCB board is less than 1.0 mm, it is recommended to use reflux fixtures to prevent the board from getting deformed under high temperature, thereby ensuring the coplanarity of pins.

- It is recommended that customers use high TG value boards as PCB main boards to avoid deformation during high temperature reflow, thus reducing the possibility of warping, extrusion, empty soldering, and solder bridging.

3. Due to the sensitive devices inside the module, the maximum temperature of the reflux soldering machine must not exceed 260°C (referring to the the top surface temperature of the package);

4. It is recommended to use lead-free solder paste, including the recommended product Alpha OM-338 SAC305 Sn96.5Ag3.0Cu0.5;

5. Given the sensitive devices in the module, the second reflux should be avoided to ensure proper performance of the module;

6. Cooling;

- Controlled cooling ramp rate can help reduce negative soldering effects (e.g. more brittle solder joints) and mechanical stresses within the product. Controlled cooling contributes to bright soldered surfaces with fine crystalline particles and low contact angles, avoiding the warping of the shielding cap caused by rapid cooling changes.

7. Exterior inspection:

- After the module is soldered, the X-ray and optical magnifying glass are used to test the welding quality. For details, please refer to the IPC-A-610F standards.

8. Using electric soldering iron requires the temperature to be controlled at 260 °C to 290 °C, the single welding time shall not exceed 3s, and the anti-static treatment shall be done.

# 6. ESD Protection


Static electricity may cause intermittent or permanent circuit damage, which is very harmful to electronic products. Most of them are identified as ESD damage.

Therefore, the electrostatic protection of modules is particularly important. The production and transportation process needs to be strictly subject to the following conditions:

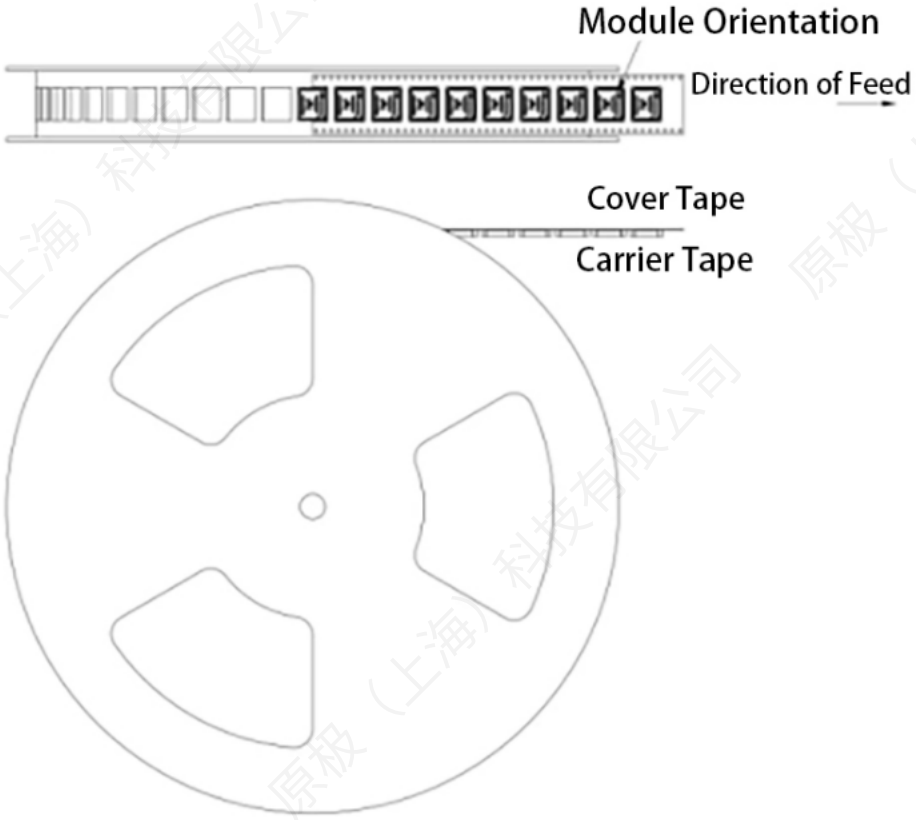
- It is prohibited to touch the module, especially the pin position, with bare hands;
- SMT patch machines, workstations, soldering irons and other equipment need to be grounded;
- Operators wear human anti-static bracelets with grounding wires (cordless static bracelets are not allowed and anti-static gloves are recommended);
- Packaging and PCBs must be made of qualified anti-static materials.

# 7. Packaging

The IMU470-M module is packaged in sealed tape and reel, which contributes to efficient production.

## 7.1 Tape and Reel Packaging

Fig. 7 Tape and Reel Packaging Diagram




Reel Size: 13inch (OD 330 x ID 100 x Thickness 37mm)

## 7.2 Carrier Tape

The IMU470-M module is placed on the carrier tape in the position and orientation shown below before leaving the factory:

Fig. 8 Module Position and Orientation on Carrier Tape

# 8. Revision History

| Version | Date | Status/Notes |
| --- | --- | --- |
| Version 1.0 | 09/29/2024 | First Edition |