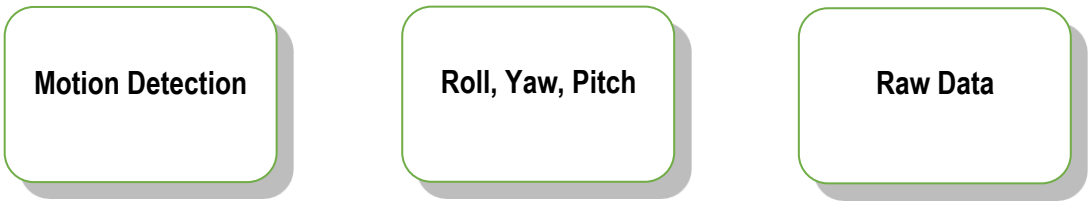
Application Note AN01
Inertial Sensors

RTLS Tags are equipped with so-called inertial sensors, that enable additional features. This document describes how the sensors can be utilized and what kind of information the user can get from them.

1 Sensor Utilization



The sensors can be used in three ways: for Motion Detection, to provide data in Roll, Yaw, Pitch format or to stream pure Raw Data. Only one of these options can be active at one time on the Tag.

2 Sensor Characteristics

The following table describes each Sensor's attributes:

	Accelerometer	Magnetometer	Gyroscope
Output	Acceleration	Magnetic field intensity	Angular Velocity
Data Output	Roll and Pitch	Yaw	Roll, Yaw, Pitch*
Power consumption	Low	Low	High
Limitations	Sensitive to vibrations, Cannot provide Yaw data	Sensitive to interference from nearby metallic objects	Slow Drifting, Zero offset
Availability	Available in default	Can be added	Can be added

*Slow drifting

The table indicates, that each sensor has a drawback. If the sensors are used together however, these weak spots can be easily compensated. To get the best combination of Roll, Yaw and Pitch data, all three sensors should be used in combination with each other.

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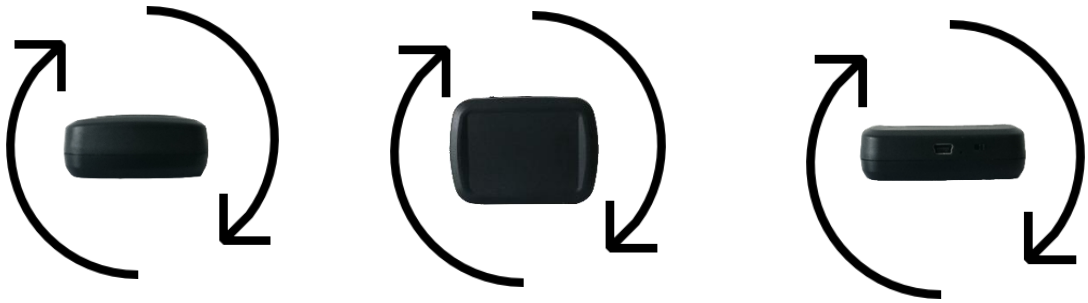
3 Roll Yaw and Pitch

Roll Yaw and Pitch are used to detect orientation in all three axes. See the infographics below:



Roll **Yaw** **Pitch**

When combined, the data can inform about the Tag's orientation in 3D space.

4 Sensor Types

The following chapters focus on detailed description of each inertial sensor. It also describes what kind of data can be retrieved with a combination of other sensors in the Tag as well. If all three sensors are combined, most precise inertial data can be received.

There are also different types of sensors in both versions of the Tag, the following table describes what kind of sensors can be mounted on each type of Tag, and what kind of data can be then obtained:

Tag	Sensor	Data
Li-ion	Accelerometer Magnetometer (Optional) Gyroscope (Optional)	Roll, Yaw, Pitch Raw data
Piccolino	Accelerometer	Roll, Pitch Raw Data

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4.1 Accelerometer

First sensor is the accelerometer, which is used for detecting the Tag's acceleration in all three axes. The basic functionalities of the Accelerometer are:

- **Motion detection**
- **Roll, Yaw, Pitch**
- **Raw Data**

Only one of these functionalities can be active per Tag at one time. The sensor itself also has a few limitations when used alone:

- Sensitive to vibrations
- Cannot detect Yaw
- Zero offset

4.1.1 Motion Detection

Motion detection utilizes the accelerometer's data to detect, whether the Tag is moving or not. This information enables the Tag to put the processor in Deep Sleep mode when the Tag is stationary, thus prolonging the battery lifetime.

4.1.2 Roll Yaw and Pitch

In combination with other sensors, Accelerometer can also provide Roll, Yaw and Pitch data. The following table describes what type of data can be gathered in combination with other sensors:

Sensor combination	Type of data	Limitations
Accelerometer only	Roll and Pitch	The Tag must be still to get reliable Roll and Pitch values
Accelerometer + Magnetometer	Roll, Yaw, Pitch	Magnetometer must be calibrated, The Tag must be still to get reliable Roll and Pitch values
Accelerometer + Gyroscope	Roll, Yaw, Pitch	Yaw value drifts and is inaccurate
All three sensors	Roll, Yaw, Pitch	No major limitations

4.1.3 Raw Data

The Accelerometer can be also used to stream pure raw acceleration data in all three axes. To receive data in the ms^{-2} format, you need to multiple the raw data by a constant of g/256.

4.2 Magnetometer

The role of the Magnetometer is to detect the intensity of the magnetic field. The Magnetometer is able to provide the following functionalities:

- **Roll, Yaw, Pitch**
- **Raw data**

Only one of these functionalities can be active per Tag at one time. The sensor itself also has a few limitations when used alone:

- Only able to detect Yaw
- Sensitive to magnetic interference (e.g. big metallic objects)
- To detect Yaw, Tag must be in horizontal position

4.2.1 Roll Yaw and Pitch

In combination with other sensors, Magnetometer can also provide Roll, Yaw and Pitch data. The following table describes what type of data can be gathered in combination with other sensors:

Sensor combination	Type of data	Limitations
Magnetometer only	Yaw	Must be calibrated, Tag must be oriented horizontally
Magnetometer + Accelerometer	Roll, Yaw, Pitch	Magnetometer must be calibrated, The Tag must be still to get reliable Roll and Pitch values
Magnetometer + Gyroscope	Roll, Yaw, Pitch	Reliable Yaw data, but Roll and Pitch will be drifting.
All three sensors	Roll, Yaw, Pitch	No major limitations

4.2.2 Raw Data

The Magnetometer can be also set to stream pure raw magnetic intensity data in real time. To receive data in the unit of Tesla, the data need to be multiplied by a constant of 0.1.

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4.3 Gyroscope

The role of the Gyroscope is to measure orientation and angular velocity for all three axes. The Gyroscope is able to provide the following functionalities:

- **Roll, Yaw, Pitch**
- **Raw Data**

Only one of these functionalities can be active per Tag at one time. The sensor itself also has a few limitations when used alone:

- If used alone, the values gradually drift
- Zero offset
- High power consumption

4.3.1 Roll Yaw and Pitch

In combination with other sensors, Gyroscope can also provide Roll, Yaw and Pitch data without drifting. The following table describes what type of data can be gathered in combination with other sensors:

Sensor combination	Type of data	Limitations
Gyroscope only	Roll, Yaw, Pitch	The values gradually drift, The values are reliable for short time
Gyroscope + Accelerometer	Roll, Yaw, Pitch	Yaw value drifts and is inaccurate
Gyroscope + Magnetometer	Roll, Yaw, Pitch	Reliable Yaw data, but Roll and Pitch will be drifting.
All three sensors	Roll, Yaw, Pitch	No major limitations

4.3.2 Raw Data

The Gyroscope can be also set to stream pure raw angular velocity data in real time. To receive data in the unit of rad/s, the data must be multiplied by a constant of:

$$\frac{1000 \cdot \pi}{32767 \cdot 180}$$

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5 Data Output Example

The inertial data can be streamed from the server from the corresponding Tag. Below is an example of a response from the server in JSON for both Raw Data and Roll, Yaw, Pitch format.

5.1 Roll Yaw Pitch

An example of data output for Roll Yaw Pitch in JSON format is shown below:

```
GET request on <STUDIO_IP_ADDRESS>/sensmapserver/api/tags/<TAG_ID>
{
        "id": "38",
            ……

        "datastreams": [
         {
          "id": "posX",
          "current_value": "2.25",
          "symbol": "",
          "label": ""
         },
         {
          "id": "posY",
          "current_value": "1.06",
          "symbol": "",
          "label": ""
         },
         {
          "id": "posZ",
          "current_value": "0",
          "symbol": "",
          "label": ""
         },
            ……
         {
          "id": "roll",
          "current_value": "0.00",
          "symbol": "",
          "label": ""
         },
         {
          "id": "pitch",
          "current_value": "0.00",
          "symbol": "",
          "label": ""
         },
         {
          "id": "yaw",
          "current_value": "301.50",
          "symbol": "",
          "label": ""
         },
            ……
        }
  },
```


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5.2 Raw Data

An example of data output for Raw Data in JSON format is shown below. The example shows data from Magnetometer and Accelerometer:

```
GET request on <STUDIO_IP_ADDRESS>/sensmapserver/api/tags/<TAG_ID>
{
        "id": "38",
            ……

        "datastreams": [
         {
          "id": "posX",
          "current_value": "2.25",
          "symbol": "",
          "label": ""
         },
         {
          "id": "posY",
          "current_value": "1.06",
          "symbol": "",
          "label": ""
         },
         {
          "id": "posZ",
          "current_value": "0",
          "symbol": "",
          "label": ""
         },
            ……
         {
          "id": "accX",
          "current_value": "88.00",
          "symbol": "",
          "label": ""
         },
         {
          "id": "accY",
          "current_value": "-17.00",
          "symbol": "",
          "label": ""
         },
         {
          "id": "accZ",
          "current_value": "231.00",
          "symbol": "",
          "label": ""
         },
         {
          "id": "magX",
          "current_value": "-12.00",
          "symbol": "",
          "label": ""
         },
```

```
                {
                  "id": "magY",
                  "current_value": "334.00",
                  "symbol": "",
                  "label": ""
                },
                {
                  "id": "magZ",
                  "current_value": "598.00",
                  "symbol": "",
                  "label": ""
                }
                      ......
               }
    },
```


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