



SDS661 Development Kit User Guide

April 9, 2024

© 2017-2024 Six Degrees Space Ltd.

Legal disclaimer: All hardware and software (including firmware) included in the product ("Product") is licensed to Customer pursuant to a nonexclusive, limited license, solely for its intended purpose. Customer may not copy, disclose, modify, translate or adapt the Product, and may not disassemble or reverse engineer the Product, or seek in any manner to discover, disclose or use any proprietary design (included but not limited to optics, algorithms and techniques) contained therein. SIXDOF AND ITS SUPPLIERS SHALL IN NO EVENT BE LIABLE TO CUSTOMER (OR ANY THIRD PARTY), WITH RESPECT TO ANY CLAIM RELATING TO THE PRODUCT, WHETHER BASED IN CONTRACT, TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY OR OTHERWISE (EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES OR IF SUCH DAMAGES ARE FORESEEABLE) FOR: LOST PROFITS OR INDIRECT, INCIDENTAL, SPECIAL, PUNITIVE OR CONSEQUENTIAL DAMAGES; OR ANY AMOUNTS EXCEEDING (IN THE AGGREGATE) THE PURCHASE PRICE FOR THE PRODUCT.

Abstract

Welcome to the SDS661 Development User Guide. This manual is designed to provide documentation for people who will use the SDS661 Sensor, beacons, and software. It contains instructions for effortlessly setting up the sensor and verifying its functionality, along with essential reference materials needed to operate the sensor.

For technical support, please contact Sixdof Space by email support@sixdofspace.com

Contents

1	Introduction	4
1.1	The Sixdof SDS661 Development Kit	4
1.2	Content Overview	4
1.3	What Sixdof Does	5
1.4	Safety Notes	6
1.4.1	IR Safety	6
1.4.2	Operation	6
1.5	Support	6
2	Quick Start	7
3	Sixdof Software Suite Overview	8
3.1	Sixdof Studio	8
3.2	Sixdof Drone SDK	8
4	Sixdof Technology Use Cases	9
4.1	Drone Landing	9
4.2	Warehouse Logistics	9
4.3	AR in Industry	9
4.4	AR/VR Accurate Head Positioning on a Moving Platform	9
4.5	Drone Cluster Positioning	9
4.6	Robotic Indoor Navigation	10
4.7	“Follow-Me”	10
4.8	Construction	10
A	Troubleshooting and Technical Support	11
A.1	Firewall	11
A.2	Network Issues	11
A.2.1	Ping Failed	11
A.2.2	Network Not Found	11
A.2.3	Algo Address Already in Use	11
A.2.4	ARP Entry Not Found	11
A.2.5	Invalid IP Address	11
A.3	Sending Data to Sixdof for Debugging	12
A.3.1	How to prepare the data file	12
A.3.2	Send the data to Sixdof Space	12
A.4	Contact Technical Support	13
B	Licensing Notes	14
B.1	Open Source Code	14

1 Introduction

1.1 The Sixdof SDS661 Development Kit

This development kit allows you to quickly create a test setup to demonstrate the operation of the SDS661 Sensor and help you plan the implementation of its use.

The Development Kit is a blend of software, optics, electronics and algorithms that together provide a comprehensive understanding of object movements. By using the SDS661 Sensor attached to an object, you can accurately track the position of that object during its motion. Additionally, the integration of multiple sensors across various objects enables simultaneous tracking of each object's movement. To get you started, this guide outlines a quick setup process to configure the sensor, enabling you to immediately visualize the real-time flow of 6dof positional data.

1.2 Content Overview

The SDS661 Development Kit contains the following components:

Sixdof Sensor: The heart of the system is the SDS661 Sensor device of three optical sensing units housed with a processing board.

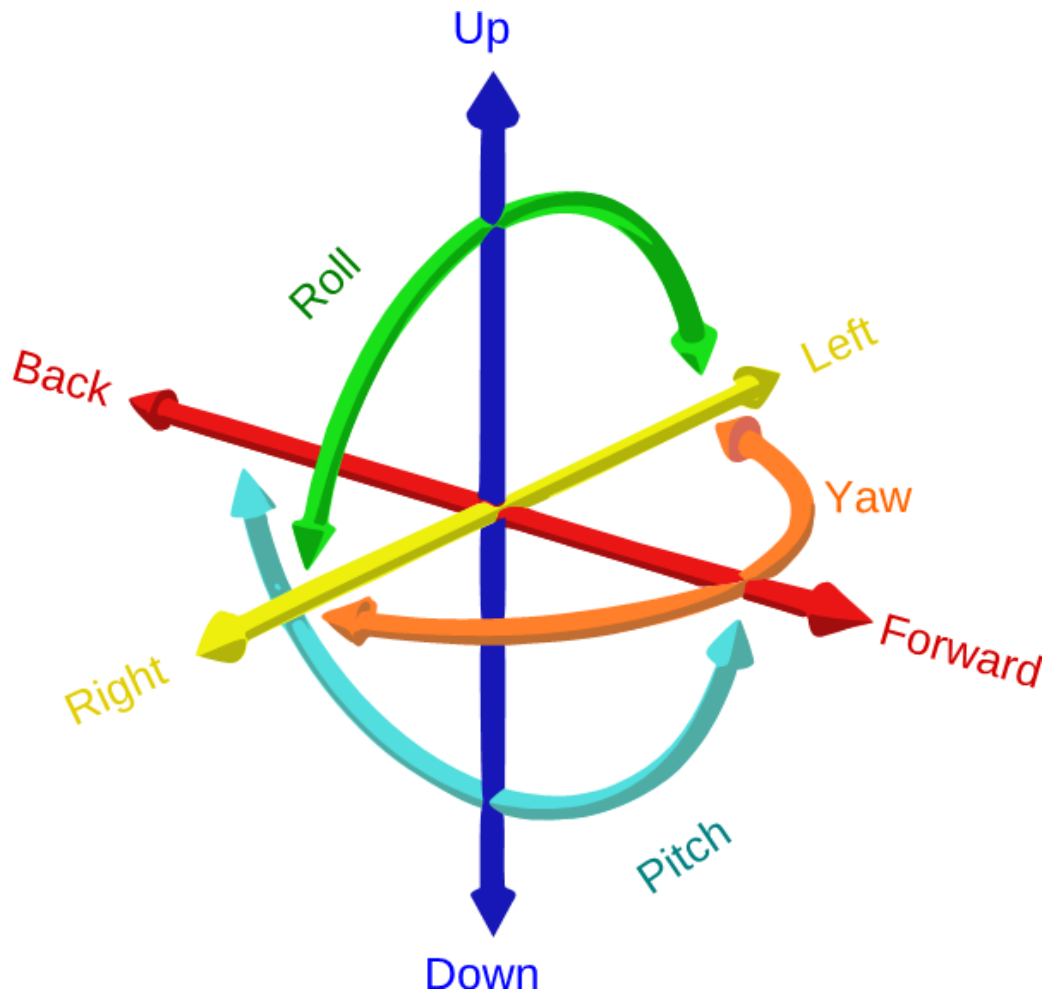
Sixdof BasaltD IR Beacons: Every kit contains 1 BasaltD to drive 4 or 6 lower powered LED's and 1 higher powered LED (the configuration is customized based on the use case).

Cabling, accessories: 90W - 20V power supply for the BasaltD Beacons, 3-meter RJ-45 Ethernet cable, USB to RJ-45 adapter and 3-meter USB power cable.

Software download link: To download the Sixdof Software Suite.

1.3 What Sixdof Does

When describing the position of a rigid body, six parameters represent the directions in which the body is free to move. This is known as “6DOF” (Six Degrees of Freedom) - the full position and orientation (pose) of an object (see image below). Many systems require live, precise measurements and ongoing reporting of these six parameters in order to function. We provide those parameters in real-time with low latency. This means that the object or user’s absolute position and orientation are tracked and rapidly communicated to the system that needs them.



Whether embedded in drones, VR/AR headsets, robots, warehouse vehicles, medical devices or dozens of other applications, the key ingredients for such a system to be successful are speed, accuracy and low latency. The approach of the Sixdof SDS661 Optical Sensor offers breakthroughs in all of these factors. The approach combines optics, algorithms and electronics in a single package for deployment in a variety of products, in multiple industries. The patented technology is used together with coded, infra-red LEDs that serve as location beacons. By embedding the SDS661 Sensor in your existing hardware, the system will independently report accurate position to your host system at very high speed. Communications with your host computer are provided by an Ethernet interface and the Sixdof software package that includes a suite of tools to control system operation, a host processing SDK and visualization tools. These tools may be customized to meet your exact requirements.

1.4 Safety Notes

1.4.1 IR Safety

WARNING: The beacons emit infrared light. When powered on, do not look directly at the beacon from very short distance with the naked eye.¹ **NOTE:** Many front-facing cameras on smart-phones are able to see infrared and will be able to see an emitting IR Beacon. If you have such a camera, you can use it to look at each beacon board to confirm that the IR emitters at the center of the board are lit up. It remains the responsibility of those installing infra-red emitters to check for themselves that the appropriate safety guidelines are followed.

1.4.2 Operation

- The hardware contents of the package are NOT waterproof and are not designed for operation in a wet environment.
- The system is currently evaluated for operation between 0°C and 45°C.
- The kit is for demonstration, development and training purposes.

1.5 Support

The SDS661 Development Kit allows testing, evaluation, and prototyping with Sixdof's high-speed optical 6dof sensor.

With every package, Sixdof also provides technical support to help you integrate the SDS661 Sensor's optical tracking with your specific applications. We are here to get your application up and running as quickly as possible and are ready to provide you with the expert advice to do just that.

To schedule a consultation with the Development Team to help you to determine the optimum integration of sensors with your application, contact Sixdof at support@sixdofspace.com.

¹The emitted radiation is a wide beam of 850nm IR light (non-laser, over $120^\circ \times 120^\circ$, with average optical power of around 400mW, and peak optical power of around 4.8 Watts.

2 Quick Start

To get started, we highly recommend launching Sixdof Studio, an intuitive tool designed to guide you through the setup process. Here's a simplified breakdown of the steps:

- **Launch Sixdof Studio:** Navigate to the `sixdof_studio` folder and run the Sixdof Studio application.
- **Connect the Sensor:** Follow the on-screen instructions to connect your sensor.
- **Tracking Mode Selection:** Choose between three distinct options:
 - **6DOF:** Position and orientation of the sensor relative to the map. Operating range 0-6m.
 - **Relative Beacon:** Position of a beacon relative to the sensor. Operating range 0-2m.
 - **Relative Angle:** Angle of a beacon relative to the sensor. Operating range 0-100m, depending on beacon availability.
- **Set Up Beacons (Optional):** If 6DOF mode is chosen, configure the beacons as per your requirements. The studio provides easy-to-follow steps for this process.
- **Visualize Tracking Data:** Once the sensor is connected and, if applicable, beacons are set up, you can visualize the sensor in action with real-time visualizations of data flow.

You are now ready to dive into the Sixdof Drone SDK code. To familiarize yourself with the SDK functions, we suggest exploring the provided build examples.

- **Examples Location:** The build examples can be found in the `examples` folder.
- **Review the Code:** Take a thorough look at the code. Remember to input your sensor's ID and network name in the appropriate locations.
- **Build and Run:** Work with one example at a time: build it and then execute it. You will find that each example yields distinct data outputs.
- **Further Details:** Refer to the `Build_Examples.pdf` in the `examples` folder for comprehensive instructions.

By following these steps, you will efficiently acquaint yourself with the system, paving the way for a smooth and productive exploration of its capabilities.

3 Sixdof Software Suite Overview

3.1 Sixdof Studio

Sixdof Studio is a user-friendly graphical interface designed to streamline the setup process and allow users to test and verify sensor functionality efficiently. It includes a step by step process for connecting the sensor and configuration, as well as various visualizations of the tracking data. The actions performed within Sixdof Studio seamlessly align with the SDK operations, transforming the Studio into a valuable tool for understanding SDK functionalities and ultimately facilitating smoother integration.

Sixdof Studio is available on the following platforms:

- Windows
- Linux Ubuntu

The files for running Sixdof Studio can be found in the `sixdof_studio` folder.

When initially launching Sixdof Studio, you will encounter a popup requesting administrator permissions, click "Allow". These permissions are necessary because the program conducts network discovery of the sensor by adding the sensor to the ARP table. It is how the sensor obtains its own IP Address.

3.2 Sixdof Drone SDK

SdsDroneSdk is a shared library that provides a C++ interface to the Sixdof tracking system. Drone guidance is the main application of this library, however other applications that require a programmatic interface to the Sixdof technology can use this library as well. The SDK comes with full documentation, stand alone examples, and is available on the following platforms:

- Windows
- Linux Ubuntu
- Linux Raspberry Pi OS (32 bit)
- Linux Raspberry Pi OS (64 bit)
- Nvidia Jetson

The SDK shared library can be found in the `bin` folder of this software release. Use the library from the folder that corresponds to your platform's name to ensure compatibility. The SDK header file can be found in the `include` folder. See the `examples` folder for build-able examples that can get you started. The full API documentation can be found in the `include` folder.

4 Sixdof Technology Use Cases

The sensor has a large field of view, low data bandwidth and gives minimal disruption to your work site as it delivers accurate 6dof data. It gives you the ability to flexibly integrate this positioning technology into your product. Below are some recurring use cases:

4.1 Drone Landing

Sixdof Space has created an optical tracking solution offering precision landing with cm level accuracy both indoors and outdoors in direct sunlight. Our patented technology leverages infrared lighting to serve as location beacons. Our sensor unit, connected to your drone, can see the beacons on the ground at up to 40 meters. Our algorithms will report the 6dof positional data to the drone, to direct an autonomous landing.

4.2 Warehouse Logistics

Warehouses and manufacturing plants rely on robots, forklifts and other indoor vehicles. The sensor offers an optimized solution for using infrared coded beacons for autonomous navigation or independent location tracking.

4.3 AR in Industry

AR/VR is being used today for maintenance, manufacturing and simulators. The problem: if the head is not tracked accurately and at a very fast speed, the experience is underwhelming and often adopted with resistance. The Sixdof technology is accurate and very fast – we are tracking at speeds of up to 1000 times per second.

4.4 AR/VR Accurate Head Positioning on a Moving Platform

Most camera-based trackers rely on an IMU – the device that in a smart-phone that lets it know that it is tilting or moving. Camera-based SLAM systems all rely on the IMU. But if you are using a headset in an active vehicle (a bus, a car, a tank or even an airplane) – the IMU cannot function properly because the vehicle is moving. The Sixdof Sensor does not rely on an IMU and is thus ideally suited for applications in moving vehicles.

4.5 Drone Cluster Positioning

Some use cases require drones to fly in fast-moving swarms. With little distance between the drones, GPS does not offer the precision that operators need to keep the drones traveling safely in formation. The Sixdof tracking solution provides more precise tracking information, mapping the position of drones with unmatched accuracy.

4.6 Robotic Indoor Navigation

In a large facility or tunnel, the mounted Sixdof tracking solution can navigate a tractor or robot using beacons built in to lights. Positional data is sent back to a host computer over local-area wireless communication, or even uploaded to the cloud using 5G cellular service. A unified map of the facility or tunnel can be shared by all tracking units.

4.7 “Follow-Me”

A vehicle can follow another vehicle in its group by the Sixdof Sensor and beacons on the front and back of the vehicle. This technology allows each moving vehicle to “see” the vehicle in front and behind, and to easily follow it.

4.8 Construction

By installing the Sixdof tracking unit as part of the helmet, workers can be tracked in a construction zone using installed infrared coded beacons. The Sixdof technology can significantly add to site safety, either for locating workers or to ensure that a worker does not accidentally go into a dangerous area. Sixdof Sensors mounted on equipment enables you to precisely track that equipment, for example, preventing it from exceeding operating boundary limits or colliding with other equipment or objects.

A Troubleshooting and Technical Support

A.1 Firewall

If a popup is displayed asking about the firewall permissions, click "Allow". Make sure to check off and allow for both private and public networks.

A.2 Network Issues

In this section, we will discuss how to diagnose and solve issues relating to computer networking that can arise in Sixdof Studio or from the SdsDroneSdk. When any of the following messages are displayed, the connection to the sensor was not established.

A.2.1 Ping Failed

The "Ping failed" message is displayed when incorrect sensor ID was entered. Check the sensor ID label on the sensor and make sure that the correct ID is entered.

A.2.2 Network Not Found

The "Network not found" message is displayed when an incorrect network name is selected. Use the "Discover" button in Sixdof Studio to ensure that the network that the sensor is attached to is selected.

A.2.3 Algo Address Already in Use

The "Algo address already in use" message is displayed when the connection to the sensor cannot be established. This is most likely due to rerunning the program immediately after previously closing it. Wait a few seconds and then reestablish the connection the sensor.

A.2.4 ARP Entry Not Found

The "ARP entry not found" message is displayed when an incorrect sensor ID or IP address is entered. Check the sensor ID label on the sensor and make sure that the correct ID is entered, and check that the IP address entered corresponds to the address that you have entered in the ARP table.

A.2.5 Invalid IP Address

The "Invalid IP address" message is displayed when an invalid IP address is entered. Check that the IP address entered corresponds to the address that you have entered in the ARP table, and that it is a valid IP address.

A.3 Sending Data to Sixdof for Debugging

Should you encounter an unresolvable scenario with the data flow, you may be asked to send data to Sixdof Space so that we can analyze and resolve the problem. Please follow this procedure to obtain the data for analysis.

A.3.1 How to prepare the data file

Generate a dump file as follows:

- Ensure that the system is connected, the IR Beacons are powered on, the sensor is connected to a USB power supply and also connected via the Ethernet cable to the computer running the Sixdof software.
- Open Sixdof Studio and follow the setup steps.
- In the mode configuration, open the "Additional Settings" tab. Next to "Dump Path" enter `C:\sixdof\data_from_companyname.bin`
Please replace "companyname" with the name of your company.
- After clicking "Initialize", click the "Start" button (from the "Control" widget).
- Once all the data is recorded, close Sixdof Studio.
- At this point, the data dump file **data_from_companyname.bin** will be automatically generated and will be located in the `sixdof` folder on your computer.

A.3.2 Send the data to Sixdof Space

Please e-mail the bin file to support@sixdofspace.com

Please include the following:

- The contact name and information for the person working with the SDS661 Sensor.
- The csv file you received with the kit.
- The serial numbers of the sensor and BasaltD boards.

A.4 Contact Technical Support

At Sixdof, we value your feedback and questions. Please report issues by sending an email to support@sixdofspace.com

The guidelines below may prove helpful:

- Please choose a subject line that clearly reflects the issue. For example "Feature Request: Would like to be able to see magic lights" or "Bug Report: Sensor won't lock when UFO is present."
- In the body of the mail:
 - If it is not clear from your email address (e.g. you are using a Gmail address), please include your name and the company you work for
 - Please list the SDS661 Sensor serial number you are using
 - Please describe the other equipment you are using (host computer, etc)
 - Please provide some details regarding the application or use case
 - For feature requests
 - * Please describe the additional features that you feel would be beneficial
 - For bug reports
 - * Please describe what you were doing at the time of the problem
 - * Please describe what happened when the problem occurred
 - * Please describe whether the problem happens all the time, occasionally, or rarely
 - * Please describe if you were able to work-around the problem (for example by using a previous version of software or changing your behavior)
 - Indicate how important this matter is to you (high/medium/low priority)
 - Feel free to leave more contact information such as phone numbers, colleagues' email addresses, etc.

You should receive an automated response to your email that notifies you that your request has been received. Please check your SPAM filters and if necessary, notify us by other means. Additional contact details can be found at www.sixdofspace.com/contact .

B Licensing Notes

B.1 Open Source Code

Many of the Sixdof applications use open source software. You can find the licensing information for each program in the **SixdofSoftwareLicense.pdf** file.