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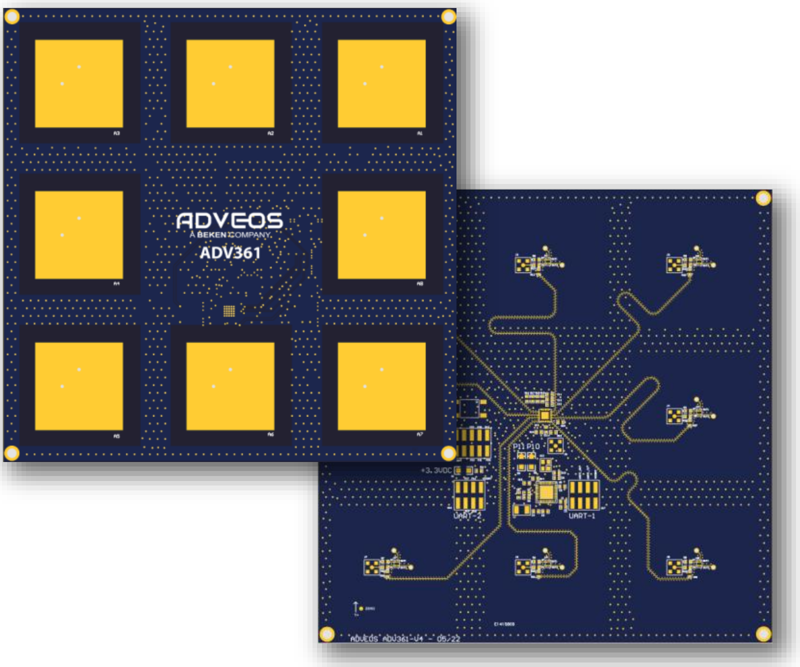
ADV361 - Datasheet

AoA / AoD Bluetooth Low Energy Locator

Rev. 3 – July 21, 2023



Abstract

This datasheet describes the technical specifications of ADV361, a locator device based on Bluetooth Low Energy Direction Finding technology. It supports operation in AoA and AoD mode and combines low power operation at a low cost. ADV361 enables best-in-class angle estimation accuracy, typically better than 5^0 in various environments and propagation conditions. It can be used as a standalone device for angle estimation, or it can be integrated into a complete positioning solution with exceptional estimation performance (30 – 50 cm accuracy).

Contents

Note: You can find the latest documentation and example code under:

https://github.com/Adveos/ADV361-public

1 Overview

ADV361 BLE locator uses Bluetooth Low Energy Direction Finding technology in a comprehensive package, incorporating 8 antenna elements, an RF switch, and a dual mode BT/BLE SoC (Beken BK3633), Figure 1.

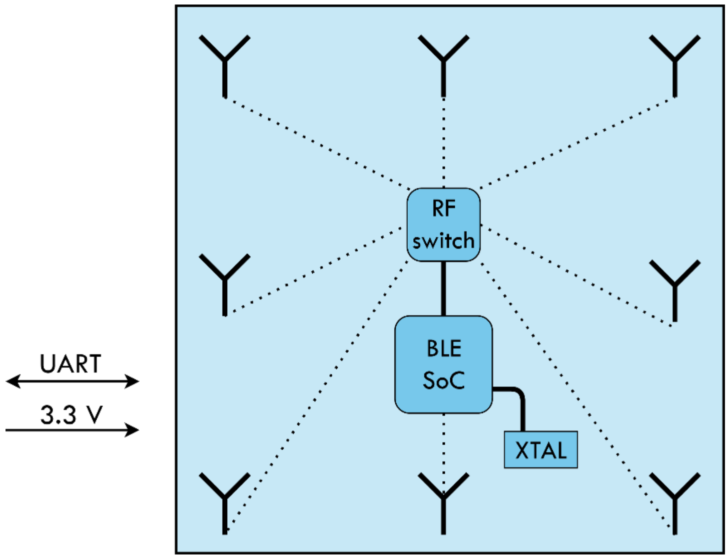


Figure 1 - ADV361 high-level block diagram

ADV361 uses best-in-class embedded angle estimation algorithms to support stand-alone operation or integration with an appropriate Indoor Positioning System (IPS). A reference positioning engine implementation is provided by ADVEOS and demonstrates industry-leading 3D positioning accuracy. An adaptive embedded firmware implementation allows customization of the internal algorithms to satisfy the performance targets of different applications (e.g., increased accuracy, detection speed, number of supported tags, etc.).

1.1 Features

The major features of the ADV361 are outlined in Table 1.

Technology	BLE 5.1 Direction Finding
System-on-Chip	Beken BK3633 - Dual mode Bluetooth
Antenna array	Proprietary design with excellent multipath suppression
Dual-axis operation	Supported (e.g., azimuth and elevation)
Estimation accuracy[1]	Mean absolute error < 5^0
Positioning support	Enables 2D/3D positioning with typical accuracy 30-50 cm
Applications	People/asset tracking, indoor navigation, geofencing, etc.

Table 1 - Major features of ADV361 locator

1.2 Operation modes

ADV361 is compatible with Angle-of-Arrival (AoA) and Angle-of-Departure (AoD) operation. In AoA mode, an ADV361 locator can detect the angle of an incoming signal from a compatible BLE tag. Similarly, in AoD mode the Angle-of-Departure from ADV361 towards a compatible BLE tag can be estimated. The two modes of operation are illustrated in Figure 2.

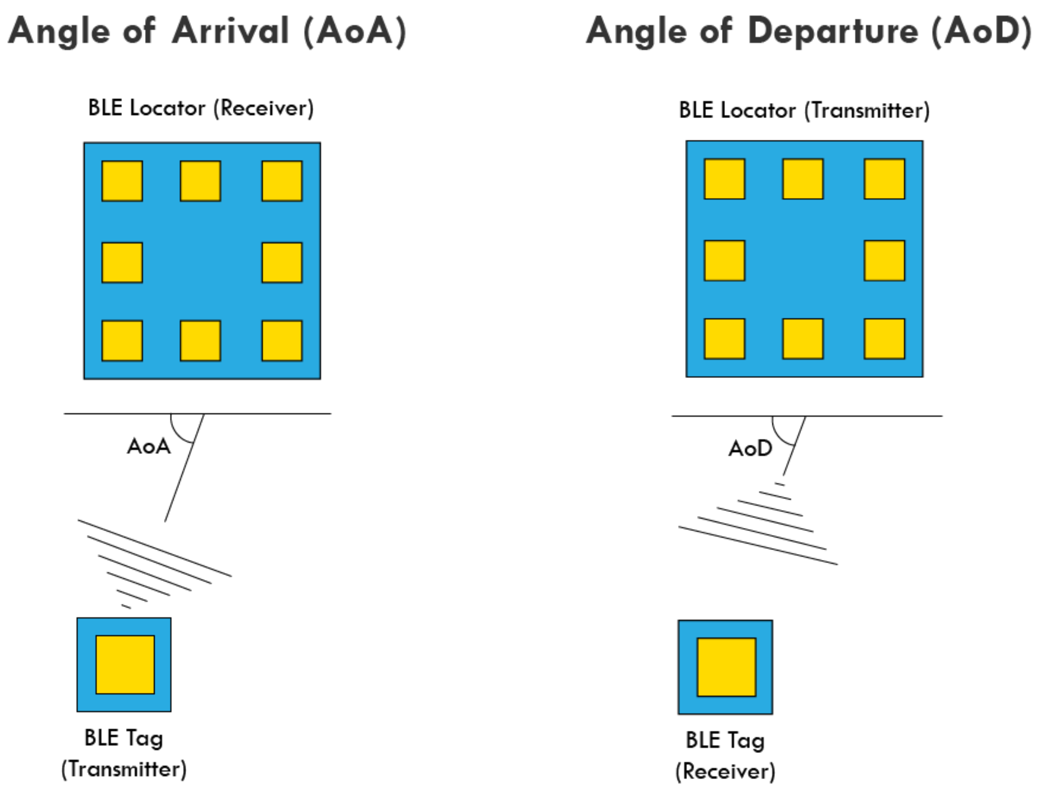


Figure 2 – Principles of AoA and AoD operation

[1] Please refer to Section 3.2 for indicative results of angle estimation accuracy in different environments.

2 Deployment guidelines

ADV361 uses proprietary technology to ensure optimal performance in a wide range of deployment scenarios. Some recommended deployment practices are outlined in the following sections to allow the system to demonstrate its full potential. Please note that for non-typical environments and use-cases, a dedicated survey may be required to identify an appropriate deployment scheme.

2.1 Angle estimation

Direction Finding technology relies on estimating the Line-of-Sight (LoS) signal between a locator and a tag device. Consequently, the useful range of this technology is not usually limited by the sensitivity of the receiving device, which can be in the order of 100 m, but on the existence of a LoS path between the two devices. Furthermore, the estimation performance depends on the relative strength of the LoS signal against signals arriving from reflected paths (multipath). ADV361 uses proprietary hardware and software methods to suppress the impact of multipath on the estimation performance.

Near-field obstacles

It is highly recommended to avoid installing ADV361 in close vicinity to metallic objects, especially in the Field-of-View of the locator antennas. Such objects can obscure the LoS visibility and result in strong reflected signals which will significantly reduce the AoA / AoD estimation performance.

LoS visibility

As mentioned previously, the operating range of Bluetooth Direction Finding technology is limited to areas with a LoS signal between the locator and tag devices. To maximize the coverage area of an ADV361 locator, installation points which maximize the area of LoS visibility should be preferred (Figure 3).

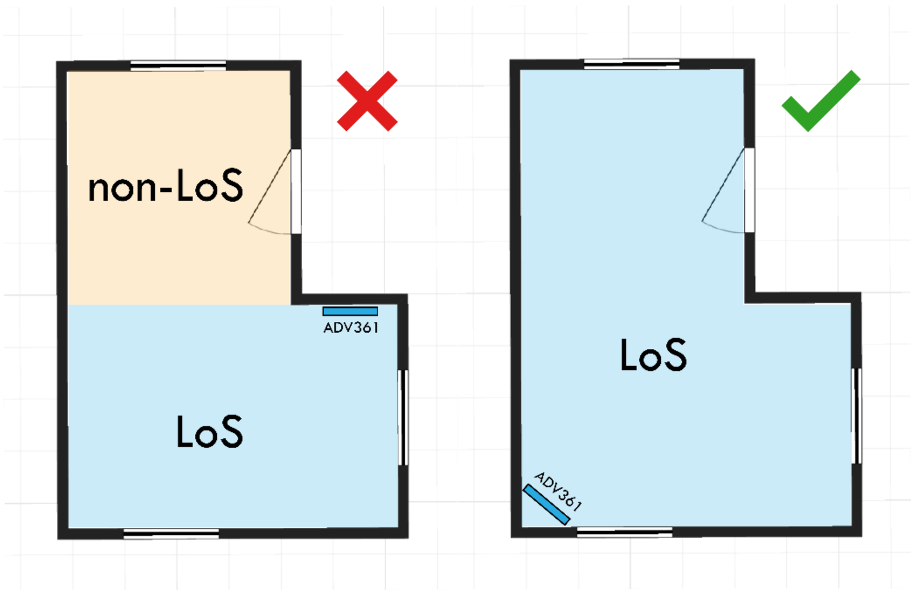


Figure 3 – Recommended deployment to maximize the LoS coverage area

Angle of incidence

The effect of antenna directivity and fundamental capabilities of Direction Finding technology offer the maximum estimation performance when the angle between the locator and tag devices (angle θ, Figure 4 - left) is below 90^0. Typical accuracy levels of ADV361 correspond to an error ε < 5^0 when θ is below 50^0, and ε < 10^0 for values of θ between 50^0 and 65^0, Figure 4 – right.

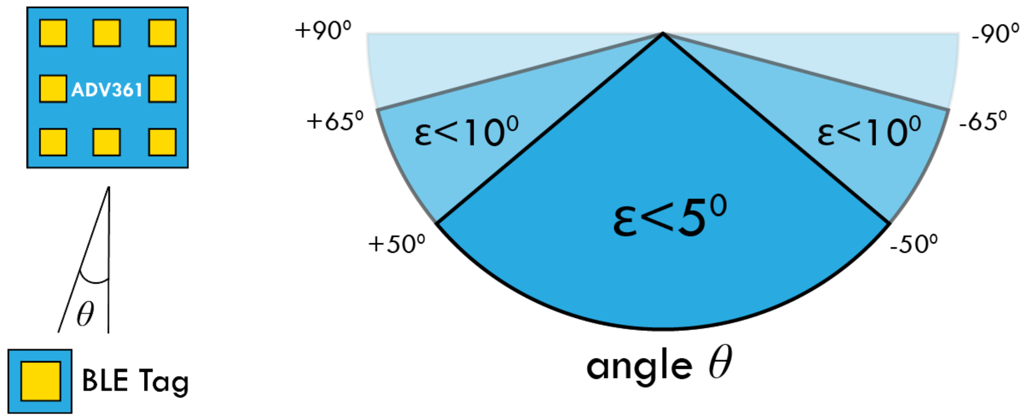


Figure 4 – Typical values of mean absolute estimation error

To maximize the area of optimal performance in a typical ADV361 deployment, it is recommended that locator devices are positioned and oriented in a way that restricts the expected values of AoA / AoD angles within ± 65^0 (Figure 5).

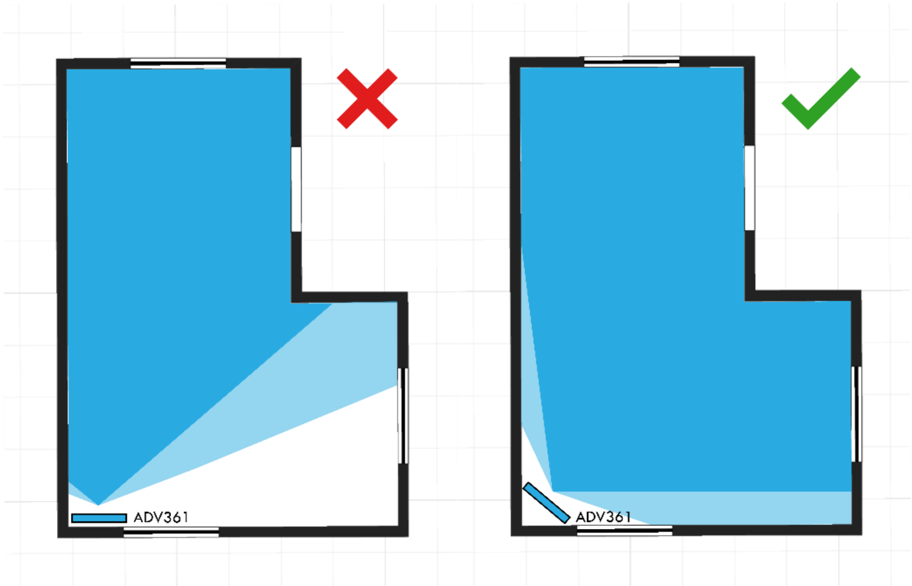


Figure 5 – Recommended deployment to optimize AoA / AoD estimation performance

2.2 Positioning

Previous recommended deployment practices refer to the use of ADV361 as a standalone device for AoA / AoD operation. When using multiple ADV361 locator devices as part of an IPS, there are a few additional considerations to maximize the system performance. These are outlined in the following paragraphs.

Horizontal positioning

Most conventional IPS, use angle or distance estimates from multiple sources to calculate the position of tag devices. To maximize the accuracy of these calculations, each locator should provide unique information to the positioning algorithm. Therefore, locators should not be placed in a straight line or be very close to each other. An example of such deployment is shown in Figure 6.

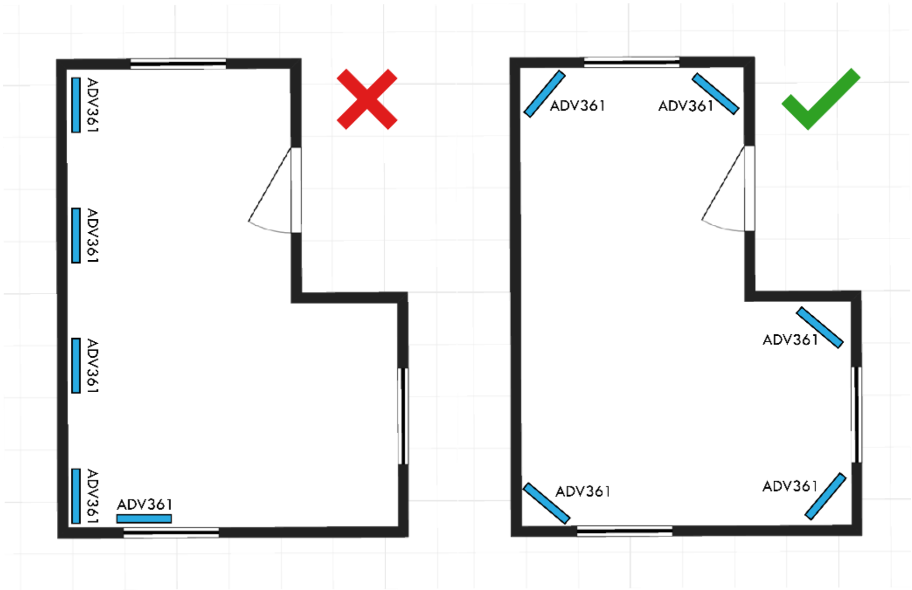


Figure 6 – Recommended deployment to optimize horizontal positioning accuracy

Vertical positioning

The same principle for the positioning of locator devices in the horizontal plane also applies to the vertical plane (height). Therefore, for deployment scenarios where height accuracy is of importance, the locator devices should not be positioned at the same height. It is recommended that at least 2 different height levels are used for each set of 4 locator devices.

3 Performance

The accuracy of BLE Direction Finding technology is highly dependent on the environment and, as shown previously, on the deployment of locator devices. This Section presents various measurement results from typical deployment scenarios, providing an indication of the expected angle estimation performance of ADV361.

3.1 Measurement setup

For all measurements described in this section, ADV361 is used in AoA mode, acting as a BLE Direction Finding receiver. At the other side of the communications link, a compatible BLE device (tag) is used as the transmitter. Measurement results are provided for two different types of tag antennas, one with Linear Polarization (LP) and another with Circular Polarization (CP). Please note that although ADV361 is designed for optimal operation with a CP antenna, existing tag devices with a more common LP antenna design can also be used. The difference in expected performance is demonstrated in this Section.

The measurement setup involves an ADV361 unit mounted on a tripod at a height of 1.5 m, near the edge of the room and a tag device located 4.5 m from the locator. During the measurements, ADV361 is rotated from -80^0 to $+80^0$ in the azimuth plane to demonstrate the dependency between estimation accuracy and angle of incidence, as indicated in Section 2.1. For each azimuth angle, a set of 100 measurements are taken for each tag polarization, and the results are expressed as the mean absolute error from the nominal azimuth angle between ADV361 and the tag.

3.2 Indoor office measurements

Open area

The first deployment scenario corresponds to an indoor office environment. More specifically, an open area without many obstructions to the LoS signal, and with most objects being more than 1m away from the ADV361 and tag devices (Figure 7). Results from this environment are provided as an example of a well-conditioned scenario with very low angle estimation errors.

Figure 7 – Open area environment used AoA estimation performance trial

The corresponding angle accuracy results for this scenario are shown in Figure 8.

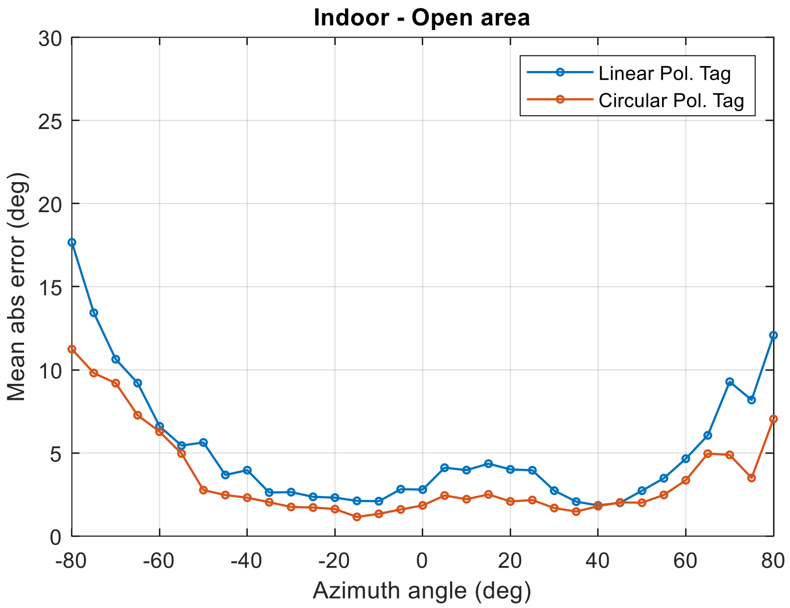


Figure 8 - Angle estimation performance in indoor open area environment

ADV361 demonstrates excellent performance, with the angular error being approximately 2^0 for a wide range of azimuth values. The use of a CP tag antenna results in a measurable performance gain, however, even an LP tag is demonstrating error levels below 5^0 at a wide range of azimuth values.

Office desk area

The next deployment scenario under consideration is that of a typical office environment, Figure 9. More specifically, the measurements are taken along a corridor between office desks and chairs. As in the previous scenario, ADV361 is located near the edge of the room at a height of 1.5 m, whereas the tag was located at a distance of 4.5 m, at the same height.

Figure 9 – Typical office environment used AoA estimation performance trial

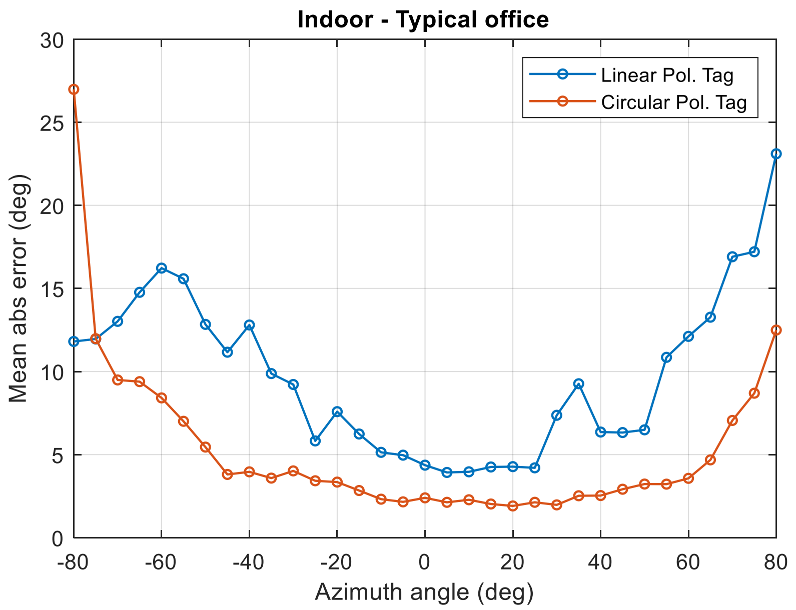


Figure 10 - Angle estimation performance in indoor office desk area

The indoor office results shown in Figure 10 have some similarities with the open environment shown previously, however the error in this scenario is higher, especially for the case of an LP tag. This is caused by additional multipath compared to the open environment of the first measurement. The difference in performance between the CP and LP tags can be attributed to the enhanced multipath suppression capabilities of the former.

3.3 Home measurements

The third environment under consideration is that of a typical home environment. The measurements are taken in a living room with typical furniture and electrical equipment. ADV361 and tag devices are positioned 4.5 m apart, at a height of 1.5 m.

Figure 11 - Typical home (living room) environment used AoA estimation performance trial (floorplan)

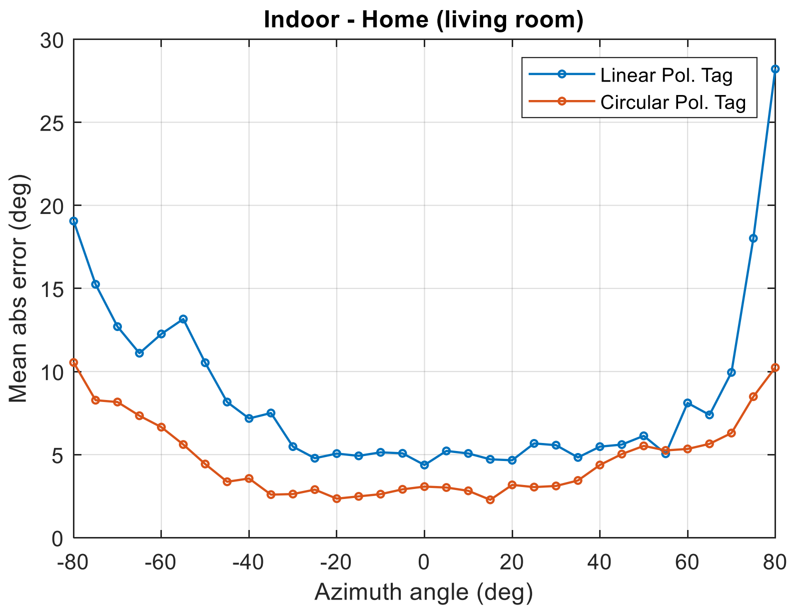


Figure 12 - Angle estimation performance in indoor home (living room) environment

The results from the home environment (Figure 12) demonstrate similar performance as in the case of the indoor office. Again, the performance of a CP tag is shown to be superior when compared to an LP tag. As mentioned previously, the performance difference can be attributed to the ability of the CP antenna design to suppress the effects of multipath.

4 Electrical characteristics

The major electrical characteristics of ADV361 are shown in Table 2.

Parameter	Min	Typical	Max	Unit
Power supply voltage	2.3	3.0	3.6	V
Temperature range	-40	+20	+105	^{0}C
Operating frequency	2402		2480	MHz
Output power	-20	9.5	+10	dBm

Table 2 – ADV361 electrical characteristics

5 UART interface

ADV361 provides a UART interface to enable its configuration and for displaying the detected angle information. The default configuration of this interface is the following:

Bitrate	1 Mbps
Data bits	8
Parity	None
Stop bits	1
Flow control	None

5.1 AT commands

A list of supported AT commands, along with the corresponding responses is shown in Table 3.

Command	Description	Response
AT+REBOOT	Performs system reboot	{"sys": {"state": "on"}}
AT+SCAN on	Initiates scanning to identify nearby devices ... Process stops automatically after 10 sec	{"ble": {"scan": "started"}} ... {"ble": {"scan": "stopped"}}
AT+SCAN off	Terminates scanning procedure	{"ble": {"scan": "stopped"}}
AT+SYNC on	Initiates synchronization procedure	{"ble": {"sync": "on"}}
AT+SYNC off	Terminates synchronization procedure	{"ble": {"sync": "off"}}

Table 3 – List of supported AT commands

5.2 Measurement data

In AoA mode, measurement data is displayed in the UART interface for each valid BLE AoA packet. This information has the following format:

```
{
  "aoa_rx":{
    "rx_dev":"loc_001",          # ADV361 locator ID
    "tx_dev":"tag_001",          # BLE tag ID

 "cfg":{
      "ch":25,                   # BLE channel
      "ant":"ADV361"             # ADV361 antenna type
    }
  },
  "n_dim":2,                     # Number of angle estimation axes
  "aoa_est":[37.4, -23.1]        # Angle estimates (deg) for two measurement axes
}
```

6 Mechanical specifications

ADV361 product dimensions and mounting hole specifications are shown in Figure 13.

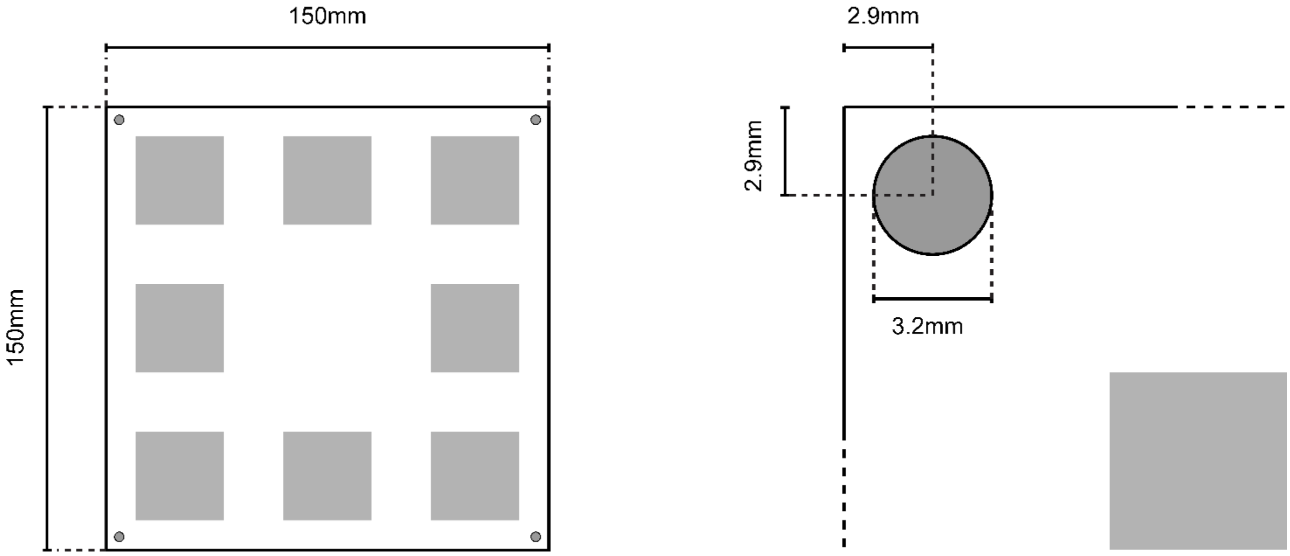


Figure 13 – ADV361 dimensions (left) and mounting hole specifications (right)

Appendix

Glossary

Abbreviation	Definition
AoA	Angle-of-Arrival
AoD	Angle-of-Departure
BLE	Bluetooth Low Energy
CP	Circular Polarization
IPS	Indoor Positioning System
LoS	Line-of-Sight
LP	Linear Polarization
RF	Radio Frequency
UART	Universal Asynchronous Receiver / Transmitter

Revision history

Rev.	Date	Description
1	June 1, 2022	Initial release
2	June 24, 2022	Updated with indoor measurements
3	July 21, 2023	Public release