2029 Becker Dr
Lawrence, KS 66047

Radar Altimeter

US-D1

User Manual

D00.02.04
11/04/2021

Revision History

Version Number	Date	Authors	Notes
D00.00.01	Mar 2, 2018	Jin Cheng, Sheen Xiao	Draft based on engineering spec and customer requirements
D00.00.02	April 10, 2018	Jin Cheng, Sheen Xiao	Put customer requirements in development phases
D00.00.03	September 10, 2018	Zhenyu Hu	Update specs and features. Add data format and communication protocol
D00.01.01	October 5, 2018	Andrew Megaris	Technical Revision
D00.02.00	June 24, 2019	Zhenyu Hu	Revision for FCC certificate
D00.02.01	October 23, 2019	Andrew Megaris	Final FCC Edit
D00.02.02	October 14, 2020	Zhenyu Hu	Add Firmware version information
D00.02.03	January 8, 2021	Zhenyu Hu	Update the Specs
D00.02.04	November 1, 2021	Camron Myers	Installation Instructions, Operational Requirements, Product Description

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Table of Contents

1. Product Description

1.1. US-D1

The US-D1 Radar Altimeter uses the principles of radio detection and ranging to determine the altitude of the aircraft. A microwave signal is transmitted out of the sensor, reflects off the target and is received by the sensor. Distance from the sensor to the terrain (altitude) is derived by the difference in time from when the signal is sent from the sensor to when the signal is received by the sensor

The US-D1 is enclosed in a black plastic case, the radome, which is conducive to radar telemetry. The US-D1 has a short cable terminated with a connector.

Custom units with different cable lengths and connector types may be configured for OEM customers. Contact Ainstein for more information.

1.2. Compliances

FCC ID: 2ATMB-USD1AZ

This device complies with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class B device (commercial or industrial use), pursuant to Part 15 of FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communication. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his/her own expense.

CE Compliance
This device complies with Directive 2014/53/EU of the EU declaration of conformity.

2. Installation Guidelines

Warning! Follow the manufacturer's regulations when mounting, modifying, repairing, and maintaining equipment. The manufacturer assumes no responsibility for any accidents caused by incorrectly mounted or incorrectly maintained equipment. The manufacturer assumes no responsibility for the system being incorrectly applied, or the system being programmed in a manner that jeopardizes safety.

The following instructions are critical to the proper operation of the US-D1 device. Failure to install the unit according to the given instructions can result in malfunction of the device.

2.1. Mounting Angle

When mounting the device, the front face of the US-D1 must be **perpendicular** to the ground below the aircraft. There should not be any angle of inclination in any direction while the device is fastened to the aircraft.

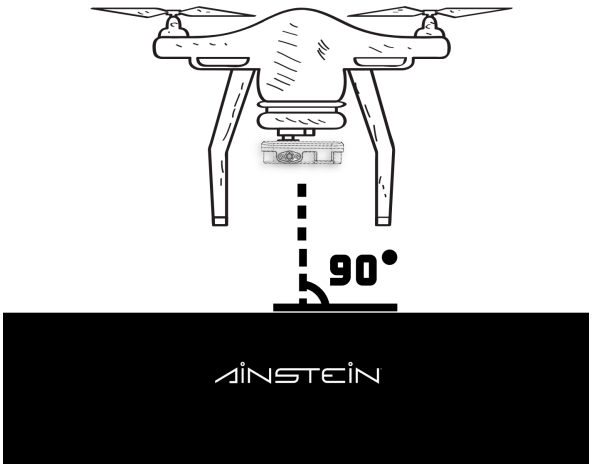


Figure 1

2.2 Mounting to an Aircraft

The device should be secured to the aircraft, where it is not free to move in any direction.

2.3. Line of Sight Clearance

Keep the face of the radar clean, and do not cover it with any additional materials. Any coatings, coverings, and modifications to the radome can degrade the performance of the radar device.
Additionally, keep any unexpected objects out of the radar's FoV (Field of View). Obstructions to the US-D1's field of view will cause a decrease in the performance of the radar. It is highly recommended that the US-D1 be mounted on the underside of the aircraft far away from the landing gear, other aircraft structures, or other equipment.

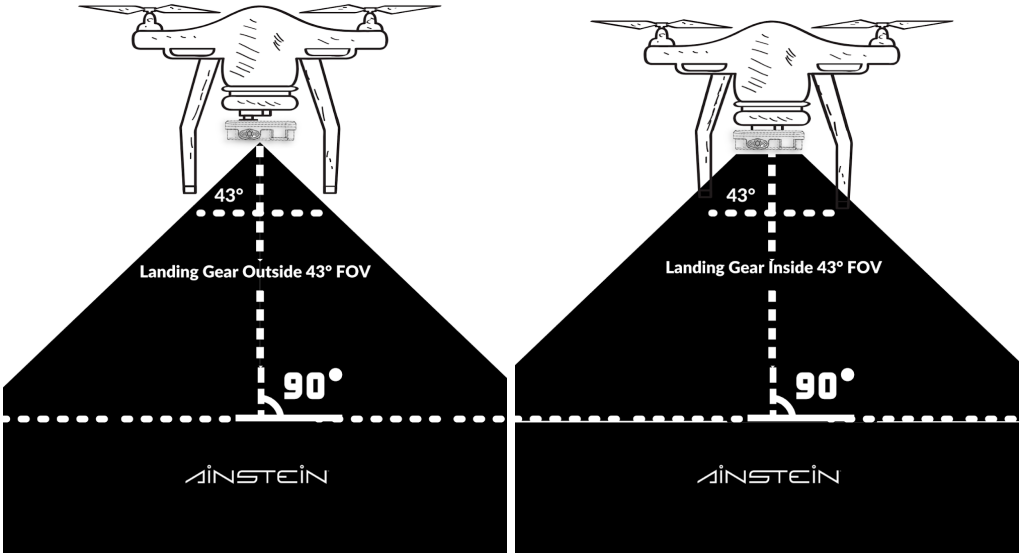


Figure 2

2.4. Integration Requirements

The US-D1 outputs altitude measurements and signal-to-noise ratio (SNR) measurements when operational. When integrating the US-D1 radar altimeter, it is necessary to use both altitude and SNR measurements to properly filter out erroneous altitude values.

Caution! Altitude measurements associated with a SNR value of 13dB or lower are considered erroneous.

The altitude measurements should not in any circumstances be used as true measurements independently of the corresponding SNR values.

A filtering algorithm should be used to estimate vehicle position, velocity and

angular orientation based on rate gyroscopes, accelerometer, compass, GPS, airspeed and barometric pressure measurements in addition to the recorded US-D1 measurements. Sensor redundancy is heavily advised for the US-D1.

3. Operational Requirements

The US-D1 will perform optimally if the operational requirements below are fully satisfied. Failure to meet the operational requirements may cause a decrease in performance, accuracy, or reliability of the US-D1 altimeter and is not advised.

3.1 Obstruction to the US-D1 Field of View

Objects or aircraft structures that are located within the US-D1's conical field of view which obstruct the radar's view of the ground may cause multipath reflections or other degrative phenomena to occur. The US-D1 should be mounted a safe distance away from the landing gear and any other components of the aircraft below it.

3.2 Excessive Pitch/Roll

Pitch and roll angles that exceed 21.5° and 15° respectively may also cause the performance of the US-D1 to worsen. This sensitivity increases with altitude.

3.3 Terrain

Terrain with poor reflectivity may cause the performance of the US-D1 to worsen. Flying at the limit of the US-D1's range over dry, loose soil, such as tilled farmland, or sand is not recommended.

3.4 Power Source

Any power source used to operate the US-D1 that does not provide the minimum power and voltage can worsen the performance of the device or cause it's operation to stop altogether.

3.5 Orientation of US-D1

The US-D1 must be mounted upon the aircraft in such a manner as to be fully horizontal, it's radome directly facing the ground. Any angle of inclination may degrade performance.

3.6 Minimum and Maximum Operating Altitude

Operating the US-D1 at altitudes below 0.5 meters and above 50 meters will result in a degradation of performance and potentially erroneous measurements.

4. Technical Specifications

Table 1: Specifications

Frequency Band	24 GHz
Bandwidth	190 MHz
Minimum Operating Altitude	0.5 meters
Maximum Operating Altitude	50 meters
Altitude Precision	6.0cm (< 1m), 4.0cm (> 1m)
Field of View	43 ° x 30 °
Interface	UART, CAN
Update Rate	100 Hz
Supply Voltage	5V~13V DC (5.5V recommended)
Power Consumption	2W(at 5 Volts DC input)
Operational Temperature Range	-20 °C ~ 65 °C*
Size	108 x 79 x 20 millimeters
Weight	110 grams
Environmental Conditions	IP67(with sealant)

Notes:

- All specs above are measured under the environment of 35 °C temperature, standard atmospheric pressure and humidity, without any Electromagnetic Interference (EMI).

- Operational Temperature Range indicates radar works properly in this range. If operating temperature goes beyond this range, radar might not be accurate and can suffer mechanical damage.
- The radar unit can be shipped with either CAN or UART for it's output data protocol.
- * Operational Temperature Range is based on the hardware's subcomponent specifications. Actual operational testing is still pending.

5. Data Protocol For US-D1

5.1 UART Data Protocol Specifications

- Baud Rate: 115200 b/s
- Data bit: 8
- Parity bit: N
- Stop bit: 1
- Voltage Level: 3.3V

A single data packet consists of six(6) bytes. Table 2 defines the packet structure.

Table 2: UART Data Packet Definition

From	**US-D1 Altimeter**	**To**	**Receiver**
Byte	**Data**	**Note**	
1	0xFE	Packet Head	
2	0x02	Version ID	
3	0x**	Altitude (Least Significant 8 Bits)	
4	0x**	Altitude (Most Significant 8 Bits)	
5	0x**	SNR	
6	0x**	Checksum (see formula below)	

Notes:

- '*' refers to a variable bit containing dynamic data.
- Altitude: The altitude bytes can be combined (total 16 bits) to represent the altitude information in centimeters. The structure would be: 0x[MSB][LSB], where MSB and LSB are each two hexadecimal numbers (8 bits).

- Checksum: The Checksum Byte could be used in the following:
    - checksum = (Version_ID + Altitude_H + Altitude_L + SNR) & 0xFF
    - If checksum = 1, check passed
    - if checksum = 0, check failed

5.2 CAN Data Protocol Specifications

- Baud Rate: 1 Mb/s
- Frame ID: customized (Standard Frame, Extended Frame)
- Standard: CAN Protocol 2.0 section A and B, ISO 11898-1:2015,-4

A single data packet uses four bytes of either a Standard or Extended CAN frame. The type of CAN frame used and CAN ID of the device can be customized. The CAN frame is defined in table 3.

Table 3: CAN Frame Data Packet Definition

From	**US-D1 Altimeter**	**To**	**Receiver**
Byte	**Data**	**Note**	
StdID	0x***	Standard ID frame	
EtdID	0x********	Extended ID frame (Default 0x00090002)	
1	0x**	Altitude (Most Significant 8 Bits)	
2	0x**	Altitude (Least Significant 8 Bits)	
3	0x**	SNR(Most Significant 8 Bits)	
4	0x**	SNR(Least Significant 8 Bits)	
5	0x00	(Reserved)	
6	0x00	(Reserved)	
7	0x00	(Reserved)	
8	0x00	(Reserved)	

6. Mechanical Specifications

Figure 3: Dimensions of US-D1 (Units: mm)

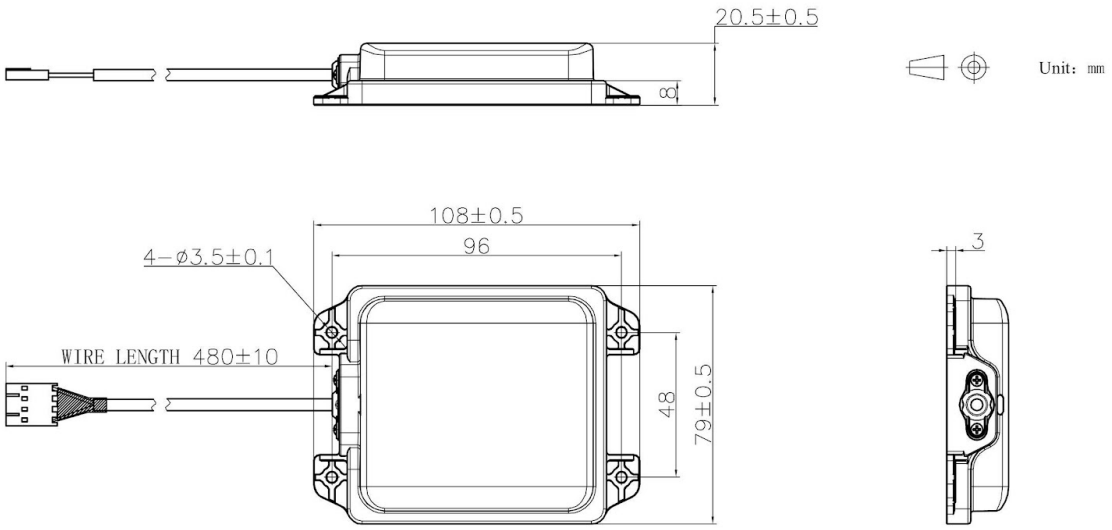
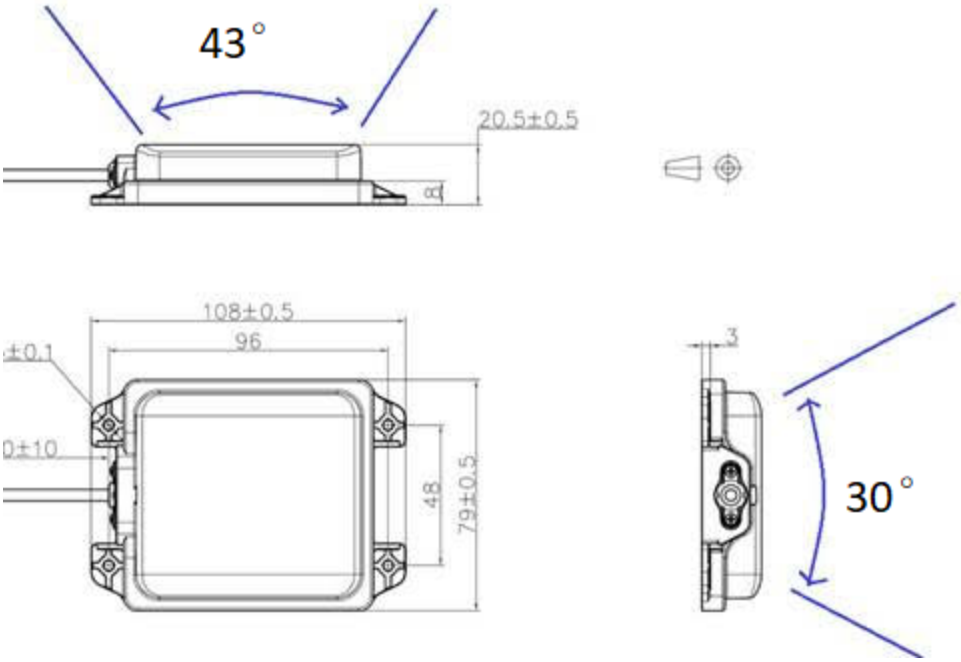


Figure 4: Field of View Orientation of US-D1



7. Radiated Emissions

The output field strength generated by the US-D1 is within the acceptable range set by the FCC and CE.

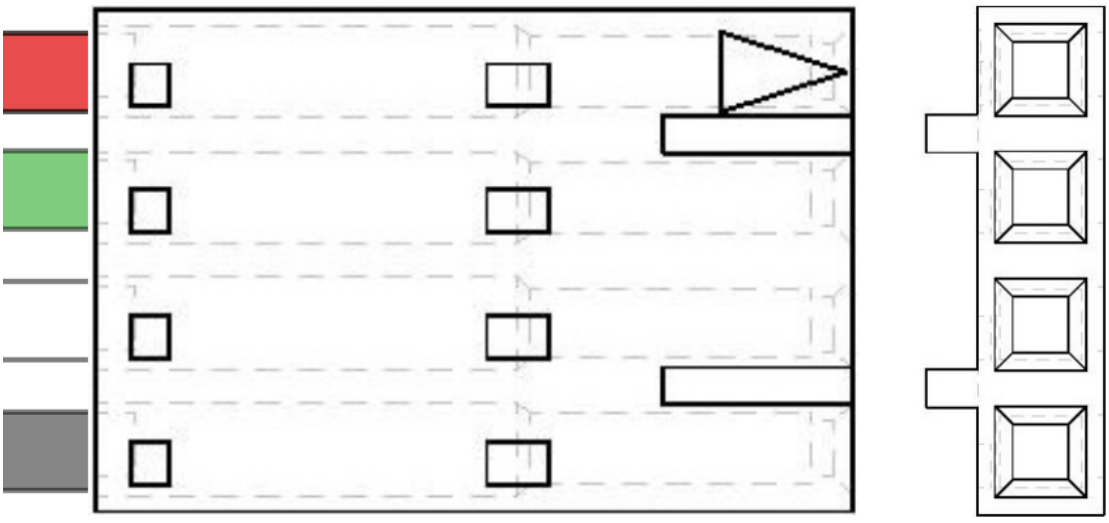
Maximum Transmit Power (EIRP)	25 dBm

8. Hardware Interface

Table 4: Data Packet Definition

Wire Color	UART	CAN
Black	Ground	Ground
White	RX(Radar)	CAN_LOW
Green	TX(Radar)	CAN_HI
Red	Voltage(5~13V)	Voltage(5~13V)

Figure 5: US-D1 Cabling Interface



9. Accessories & Peripherals

9.1. Firmware Update Kit

The US-D1 Firmware Update Kit is an external device that can update the firmware of the US-D1 radar altimeter. The Firmware Update Kit contains an update tool, a USB connector, and power cable. The Kit allows the US-D1 to connect to the Firmware Update Tool via USB port, which allows the user to load and flash new firmware versions onto the device. The Kit can be purchased directly from Ainstein.

9.2. Additional Customizations

The US-D1 Radar Altimeter has several hardware and firmware customization options. All customizations can be requested by contacting Ainstein directly.

Customizations

The following US-D1 hardware customizations can be requested prior to purchasing.

- US-D1 PCB (no enclosure)
- Interface Protocol (CAN, UART)
- Modified connector (JST, bare wire)
- Extended Cable (1 meter).
- BAUD Rate (38400, 57600, 115200, 250 Kbps, 500 Kbps, 1Mbps)

10. Application Notes

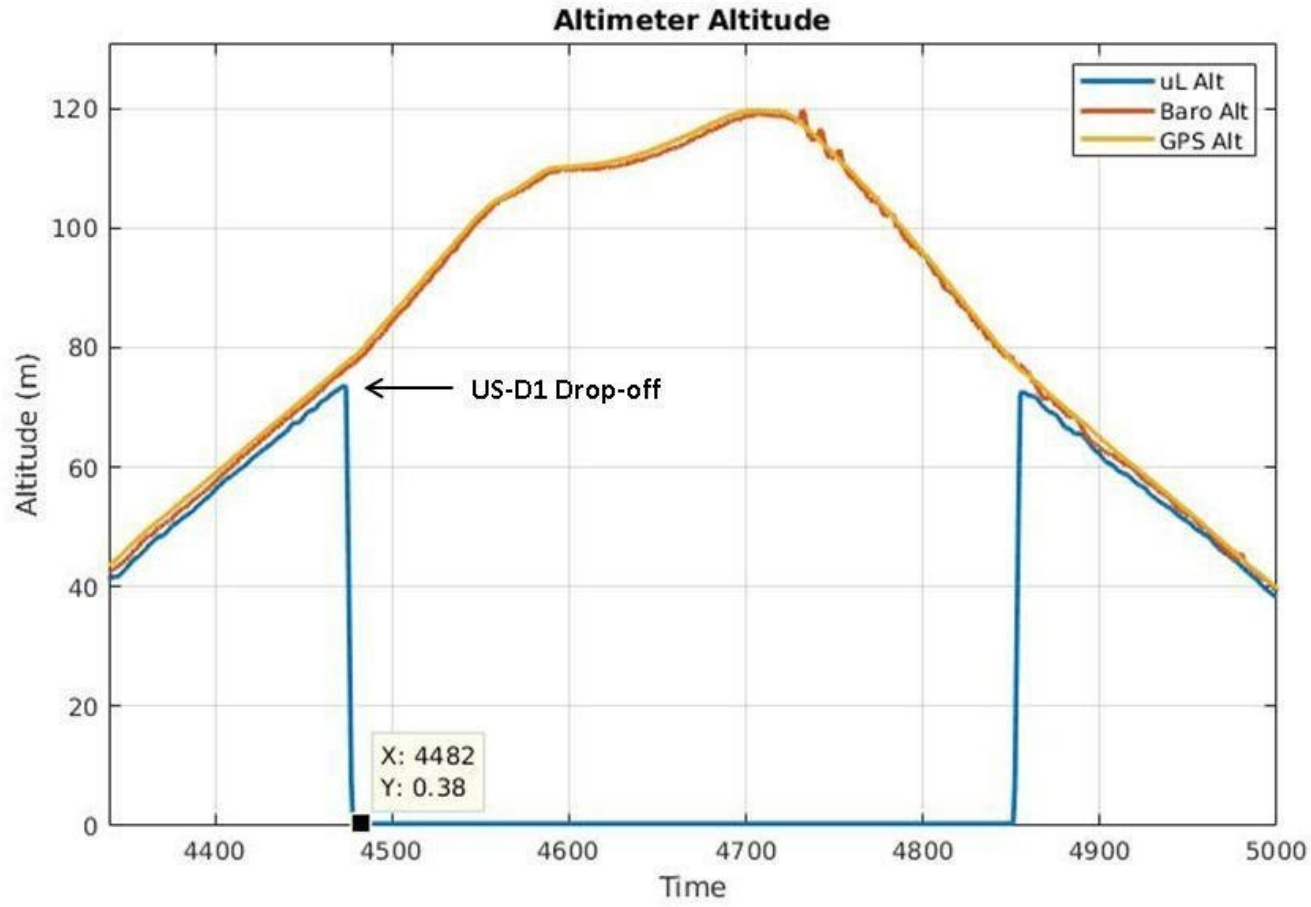
Table 5 lists the application notes that will be addressed in future revisions.

Table 5: US-D1 Application Note

Issue ID	Description	Notes
1	If US-D1 is used outside of its Maximum Operational Altitude (Table 1), Inconsistent small readings will be output(See Figure 4 below).	• For full confidence, only consider US-D1's data when used within its operating range
2	Altitude data from US-D1 may have various step-size, since a post-processing algorithm is implemented after radar processing, e.g. averaging, filtering.	• No action needed
3	Altitude data from US-D1 may give unexpected or incorrect measurements under operation in an indoor environment. Multipath reflections of the sensor's radio waves are complicated in enclosed environments and may introduce errors in the radar's processing.	• DO NOT rely on US-D1 in an indoor, tightly enclosed environment
4	When the US-D1 is operated at altitudes of ~1m, there may be rare unstable readings potentially due to multipath reflections of reflective surroundings or inaccuracies due to nearness to the radar's blind zone.	
5	When transitioning from normal detection to out-of-range detection, the US-D1 will report ~0.51m when out-of-range, because 0.51m is the edge of the US-D1's blind zone.	
6	When the US-D1 is close to the blind zone (<1m) and a highly reflective object is placed in between the US-D1 and the ground and then is removed, the US-D1 output may get stuck outputting erroneous values until another	

	object enters the FOV.	

Figure 6: US-D1 Altitude Drop-off Example



11. Hardware & Firmware Version

Firmware	V1.8.2/V1.8.3
Bootloader	V1.0.7
Hardware	V2.1.0

12. Firmware Changelog

US-D1 Generation 1 Firmware Changelog

Firmware Version	Change Reason	Date
v1.0.6	Initial released version	3/24/2019
v1.3.1	Update data format	7/17/2019
v1.4.0	Improve performance at low temperatures	12/20/2019
v1.4.1	New customized data format for US customers	2/26/2020
v1.4.2	Continued improvements to performance at low temperatures	3/15/2020
v1.4.3	Optimize FM bandwidth to comply with FCC certificate	4/9/2020
v1.43Y	Optimize calibration range coefficient to comply with FCC certificate	7/10/2020
v1.5.2	1. Optimize FM bandwidth to comply with FCC certificate 2. Fix for minor offset bug	11/20/2020

v1.5.2N	Fix for out of range aliasing	3/13/2021
v1.8.2	Optimize boot sequence to fix a altitude hang issue	8/16/2021

US-D1 Generation 2 Firmware Changelog

Firmware Version	**Change Reason**	**Date**
v1.5.3	Add support for new MCU model*	11/20/2020
v1.5.3N	1. Optimize FM bandwidth to comply with FCC certificate 2. Fix for minor offset bug	3/13/2021
v1.8.3	Optimize boot sequence to fix a altitude hang issue	8/16/2021
	*v.1.5.3 is the 1st firmware release of the 2nd generation US-D1. The performance and functionality is equivalent to v1.5.2	

13. Contact Us

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