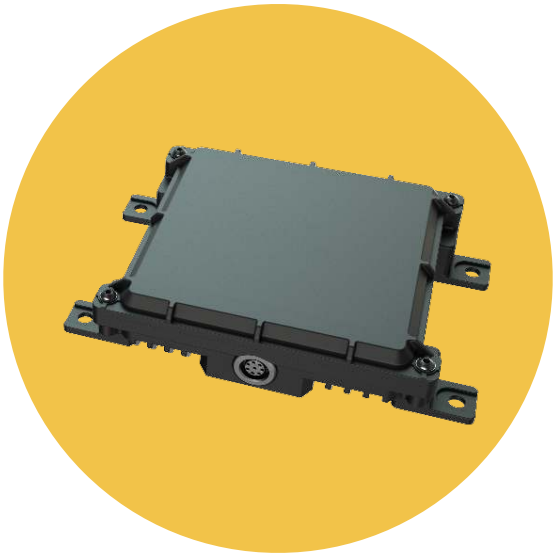
LR-D1 USER MANUAL



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Revision History:

Version Number	Date	Authors	Notes
D00.00.01	Sep 13, 2018	Hao Liu, Liqiang Ren, Zhenyu Hu	Initial Draft
D00.00.03	Oct 17, 2018	Zhenyu Hu	Add section 7 - Known Issues
D00.01.01	Nov 5, 2018	Andrew Megaris	Technical Revision
D00.01.02	Dec 6, 2018	Zhenyu Hu	Spec updates
D00.01.03	Jan 14, 2019	Zhenyu Hu	Data protocol update
D00.01.04	May 17, 2021	Zhenyu Hu	From original version of V2.2
P00.01.04	June 2, 2021	Ethan Perrins	Public Version
D00.01.05	June 18, 2021	Zhenyu Hu	From original version of V2.4

Technical Data:

Table 1: Specification

Starting Frequency	24 GHz
Bandwidth	250 MHz
Power Consumption	<11.00 W
Operating Voltage	10 - 30 V
Altitude Range	1.4m~500m (1)
Altitude Precision	±0.8m (2)
Update Rate	40Hz
Detection Angle Range	Azimuth 43° , Elevation 30° (3)
Maximum Velocity	up to 45m/s in elevation
Detection Velocity Range	<±45m/s
Temp. Range	-40°C~60°C
Dimensions	<112mm*102.5mm*29mm (mounting bracket is NOT included)
Weight	300g (exclude external connector cable)
IP Rating	Built to the requirements of IP67 (Test pending) (4)

Note:

1. Radar data may vary over different terrains when radar is out of its detection range. Please see Appendix 1 for more details.
2. Range detection might be limited by terrains, pitch and roll of aircraft, etc.. The range accuracy above only indicates the step size of data from radar itself.
3. Based on mm-wave radar specs, large angle of pitch and roll would bring error for detection.Under the same measurement circumstance, larger angle by aircraft bring more error.
4. IP rate here only focus on radar itself. This rating does not cover

any cabling interface.

RS-232 Data Protocol for LR-D1

- Protocol: RS-232
- I/O Standard: 3.3V LVTTL
- Baud Rate: 115200 b/s
- Data length: 8 bits, plus one start bit and one stop bit, and no parity bit

Table 2: Data Packet Definition

From	LR-D1	To	Receiver
Byte	Data	Note	
data1	0xEB	Packet Header MSB (Most Significant Bits)	
data2	0x90	Packet Header LSB (Least Significant Bits)	
data3	deviceID	Device ID Byte (0x00)	
data4	0x1C	Data packet length; Fixed as 28 Bytes	
data5	0x00: Normal Others: Malfunction (1)	Malfunction Alert	
data6	0x01	Objects Number; Fixed as 1	
data7	high1_h (2)	Object 1 Altitude MSB	
data8	high1_l (2)	Object 1 Altitude LSB	
data9	snr1	Object 1 SNR	
data10	speed1_h (3)	Object 1 Velocity MSB	
data11	speed1_l (3)	Object 1 Velocity LSB	
data12	high2_h	0xFF (4)	
data13	high2_l	0xFF	
data14	snr2	0xFF	
data15	speed2_h	0xFF	
data16	speed2_l	0xFF	

data17	high3_h	0xFF
data18	high3_l	0xFF
data19	snr3	0xFF
data20	speed3_h	0xFF
data21	speed3_l	0xFF
data22	high4_h	0xFF
data23	high4_l	0xFF
data24	snr4	0xFF
data25	speed4_h	0xFF
data26	speed4_l	0xFF
data27	high5_h	0xFF
data28	high_l	0xFF
data29	snr5	0xFF
data30	speed5_h	0xFF
data31	speed5_l	0xFF
data32	checksum	Checksum: (data4+data5+...+data29+data31) bitwise-AND with 0xFF

Note:

1. Please see Appendix 1 for details about malfunction information.
2. Altitude Data Parse: Altitude = (high_h * 256) + high_l; unit: **0.01 m (cm)**; Type: **Unsigned**
3. Velocity Data Parse: Velocity = (speed _h * 256) + speed _l; unit: **0.1m/s**; Type: **Signed**
4. V1.0 only detects ONE object, any data bytes of other objects are 0xFF.

Mechanical Drawing

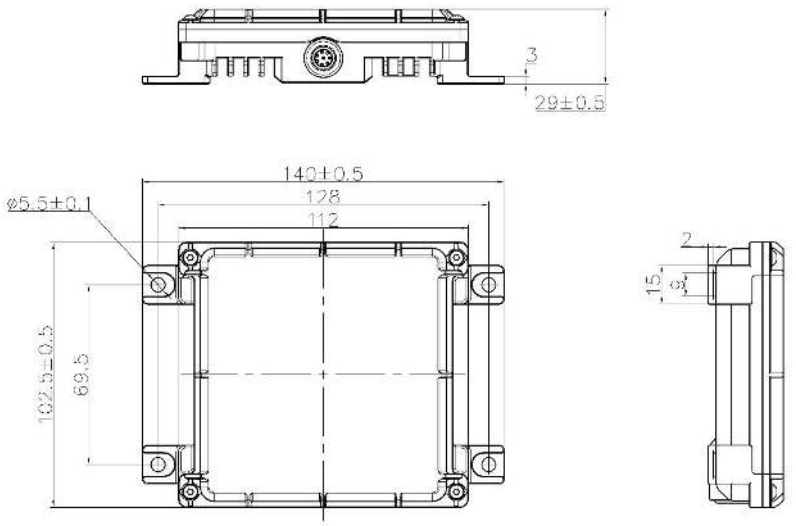

Figure 1: Dimensions of LR-D1 (Units: mm)

Hardware Interface

Table 3: Pin Out Definition

Pin	Wire Color	Pin Name	Function	Note
1	Red	VCC	Input Voltage	10 - 30 V Power < 11W
2	Red	VCC	Input Voltage	10 - 30 V Power < 11W
3	Blue	T+	RS422: TX+ RS232: TX	Default Setting: RS232
4	Brown	T-	RS422: TX- RS232: RX	Default Setting: RS232
5	White	R+	RS422: RX +	Leave unwired for RS232
6	Green	R-	RS422: RX -	Leave unwired for RS232
7	Black	GND	Ground	
8	Black	GND	Ground	

Note:

LR-D1's default hardware interface is RS-232. If the RS-422 interface is required, please contact Ainstein for assistance.

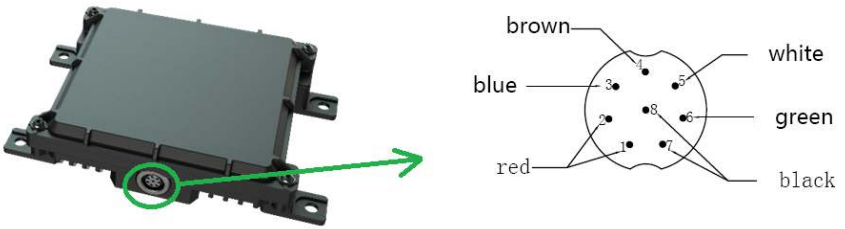

Figure 2: LR-D1 Pinout Diagram

Cabling Diagram

- **Connector Part Number: 99-0425-10-08**

Figure 3: Included Cable

From the User's end, there are two types of cable:

1. Bare header for all wires (See Figure 3)
2. Pre-crimped header for Power and Ground wires (See Figure 4)

Figure 4: Included Cable with Pre-crimped headed

Installation Instructions

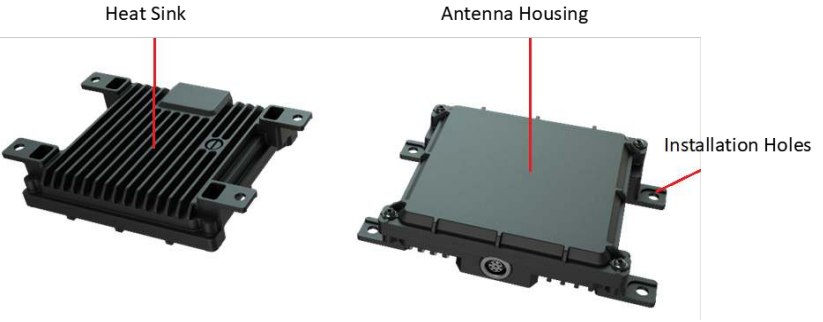

Figure 5: Radar Key Points

Mounting Requirements:

- Antenna should be perpendicular to the target that to be measured
- Keep antenna housing clean, and do not cover it.
- Keep any unexpected objects out of radar's FoV (Field of View), otherwise it might situate radar's signal
- No specific requirement for mount orientation

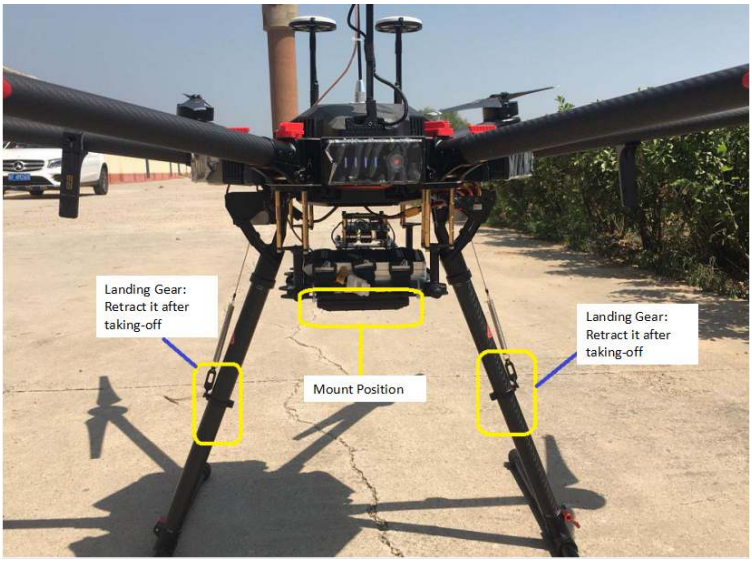

Figure 6: Proper Mounting Example

Appendix 1: Malfunction Alert Information List

Malfunction Alert Code	Malfunction Alert Info	Possible Reasons	Suggestion
0x 01	Temperature alert	Error in device or ambient temperature is out of LR-D1's operational temperature	Stop use and checking
0x02 ~ 0x08	Voltage alert	Error in device	Stop use and checking

About Ainstein

Our mission is to enable safer driving, flying, working and living through radar-based technology. We are in the business of improving safety and protecting valuable assets through innovations in radar technology.

Ainstein makes radar systems smarter, more affordable and easier to deploy. We offer complete solutions for autonomous drones, advanced driver-assistance systems (ADAS), autonomous vehicles and industrial sensing – incorporating a combination of millimeter wave (mmWave) radar, sensor fusion and artificial intelligence (AI).

For years, cost, weight and performance constraints have hindered the wider adoption of radar. Ainstein makes radar systems accessible to everyone by overcoming these constraints. One recent innovation: we've developed the world's first UAV collision avoidance radar with 4D detection.

Radar systems and sensor data processing intelligence are keys to our autonomous future. We offer deep scientific, mathematical and engineering expertise along with a full spectrum portfolio (24GHz, 60GHZ, 76-81GHz) of hardware and software to support our customers in developing highly customized solutions with unmatched precision in unpredictable environments.

Our core team has more than a combined 100 years of experience in radar research and development with deep knowledge gained through projects funded

by NASA, the U.S. National Science Foundation (NSF), the European Space Agency and others.

Other radar companies are at least two to three years behind Ainstein. Startups have been slow to market and are unable to produce at scale, while established companies are slow to adopt the newest technological innovations.

Ainstein products can be fully customized to specific application requirements, have unmatched precision in ALL weather conditions and surface types, and are a fraction of the price of competitive products.

Visit our website (www.ainstein.ai) for more information, or get in touch with Andrew Boushie, Vice President for Strategy and Partnerships, at andrew.boushie@ainstein.ai to arrange a phone call.