6 km Laser Rangefinder Module

Model: LRF0609C

1. PRODUCT DESCRIPTION

The LRF0609C is a 6km 1535nm eye-safe laser rangefinder module that measures 20–6000m vehicle targets with ±2m accuracy and ≤0.5mrad divergence at 1–10Hz. Supplied from 4.5–16V with ≤1.5W average power in a 55×48×32mm, ≤62g housing and controlled via TTL UART with range-gate, first/last target and self-test functions, it is ideal for UAV payloads, vehicle EO/IR turrets and fixed security cameras.

2. MAIN TECHNICAL SPECIFICATIONS

2.1 Functions

The primary functions of the LRF0609C Mini Laser Rangefinder are:
a) Laser ranging;
b) First/last target ranging;
c) Range gating;
d) Built-in self-test (BIST);
e) Firmware update via serial port;
f) Power-on status and temperature acquisition;
g) Cumulative laser shot counter.

2.2 Performance

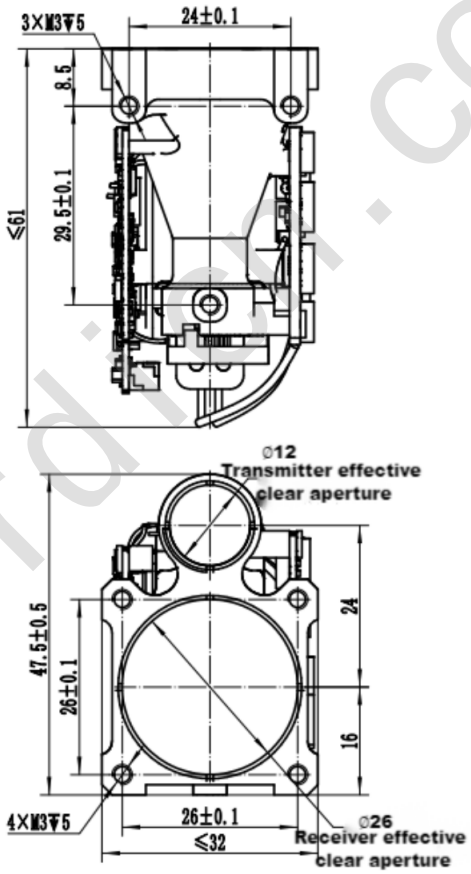
Key performance specifications:
a) Operating wavelength: 1535 nm ± 10 nm;
b) Maximum range:
Under visibility ≥ 12 km and relative humidity ≤ 60%, tested against a 0.3-reflectivity panel (or equivalent target):
Vehicle (2.3 m × 4.6 m): ≥ 6000 m;
c) Minimum range: ≤ 20 m;
d) Range accuracy: ≤ ±2 m;
e) Ranging rate: single shot, 1 Hz, 2 Hz, 3 Hz, 4 Hz, 5 Hz, 10 Hz;
f) Probability of range (valid return rate): ≥ 98%;
g) Range resolution: ≤ 38 m;
h) Beam divergence: ≤ 0.5 mrad.

2.3 Environmental Conditions

a) Operating temperature: −40 °C to +60 °C
b) Storage temperature: −50 °C to +70 °C (to be qualified at the system level)
c) Vibration: 5→50→5 Hz sweep, 1 octave/min, 2.5 g (system-level qualification)
d) Shock: 1200 g, 1 ms (system-level qualification)

3. PHYSICAL CHARACTERISTICS

a) Overall dimensions: ≤ 55 mm × 48 mm × 32 mm;
b) Mass: ≤ 62 g;
c) Mechanical and optical interfaces: see Figure 1.



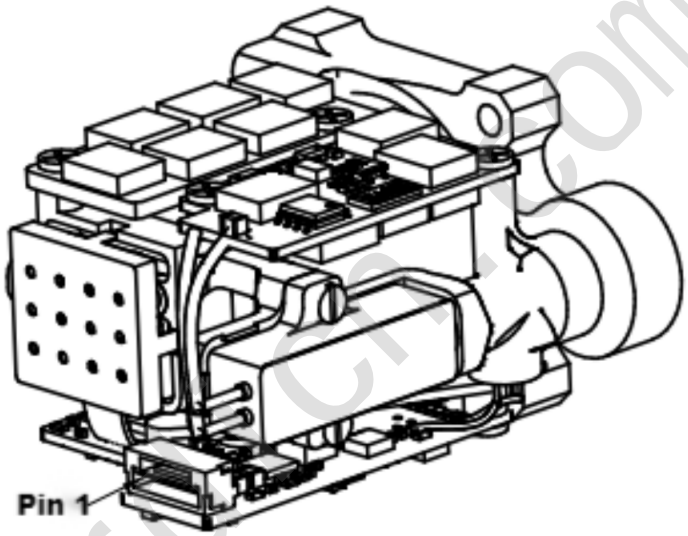
4. ELECTRICAL INTERFACE

a) Supply voltage: 4.5 V–16 V
b) Standby power consumption: ≤ 0.3 W; average power consumption: ≤ 1.5 W

c) The host computer connects to the rangefinder via a 6-pin connector for interface and testing. The pin assignment of the rangefinder's power and communication port is shown in Table 1.

Table 1 — Pin assignment of the rangefinder power and communication port

Pin #	Pin No.	Remarks
P-1	VIN+	Power input, 4.5–16 V
P-2	VIN-	Power ground (GND)
P-3	POWER_ON	Module power enable (TTL, 3.3 V logic level); Module ON (> 2.7 V), module OFF (< 0.3 V)
P-4	UART_TX	UART TXD (serial transmit), TTL, 3.3 V logic level
P-5	UART_RX	UART RXD (serial receive), TTL, 3.3 V logic level
P-6	GND	Serial ground (SGND)



5. SOFTWARE

5.1 Communication Protocol 1

5.1.1 Data

Data exchanged between the rangefinder and the host includes:

- Control commands: single-shot ranging, continuous ranging, query commands, etc.
- Returned data: distance information, ambient temperature, rangefinder status, etc.

The rangefinder and host communicate over TTL UART with the following characteristics:

- Baud rate: 115200 bps (default) / 57600 bps / 38400 bps / 9600 bps

- Byte format: 1 start bit, 8 data bits, no parity, 1 stop bit (8N1). Bits are transmitted least significant bit first, then most significant bit.

5.1.2 Messages

The format of control command messages is shown in Table 2.

Table 2 — Control command message format received by the rangefinder

Byte	Description	Byte data (command code, payload, checksum)	Remarks
1	Frame header	0x55	
2～5		Single-shot ranging: `0xF2 0x00 0x00 1 Hz ranging: `0xF3 0x01 0x00 0xF2` 2 Hz ranging: `0xF3 0x03 0x00 0xF0` 3 Hz ranging: `0xF3 0x04 0x00 0xF7` 4 Hz ranging: `0xF3 0x05 0x00 0xF6` 5 Hz ranging: `0xF3 0x02 0x00 0xF1` 10 Hz ranging: `0xF3 0x06 0x00 0xF5` Stop ranging: `0xF3 0x00 0x00 0xF3`	Returned data is shown in Table 3.
		aud rate setting: `0xF6 ___ ___ 0xXX`	"__ __" represents the configured baud rate divided by 100 (in hexadecimal). "0xXX" is the XOR
		Self-test command: `0xF0 0x00 0x00 Status query command: `0xF8 0x00 0x00	Returned data is shown in Table 5
		Range-gate setting: `0xF4 ___ ___ 0xXX`	"__ __" represents the configured range-gate value (in hexadecimal). "0xXX" is the XOR of bytes 2 through 4.
6	Frame terminator	0xAA	

The rangefinder's returned data are classified as routine data and query data.

- Routine data: includes number of targets, measured distance(s), rangefinder status, etc. See Tables 3 and 4 for details.
- Query and self-test data: includes ambient temperature, rangefinder status, etc. See Table 5 for details.

Table 3 — Routine data returned by the rangefinder

Byte	Description	Byte value (hexadecimal)
1	Frame header	0xAA
2	Number of targets	

3	First-target distance, high byte	
4	First-target distance, low byte	
5	First-target distance, fractional byte	Two decimal places
6	Last-target distance, high byte	
7	Last-target distance, low byte	
8	Last-target distance, fractional byte	Two decimal places
9	Ranging status byte	Status byte; see Table 4 for details.
10～13	Laser shot count	
14	Checksum byte	XOR of bytes 2 to 13
15	Frame terminator	0x55

Note: The correct measurement result will be displayed only when the rangefinder calculates the distance from the blind area to the maximum count. In other cases, 0xFF will be displayed, which means invalid status.

Table 4 — Status byte definitions

No.	Byte 9	Meaning
1	0xF2	Single-shot ranging
2	0xF3	1 Hz ranging
3	0xF6	2 Hz ranging
4	0xF7	3 Hz ranging
5	0xF8	4 Hz ranging
6	0xF4	5 Hz ranging
7	0xFA	10 Hz ranging
8	0xF5	Stop ranging

Table 5 — Query data returned by the rangefinder

Byte	Description	Byte value (hexadecimal)
1	Frame header	0xCC
2	Reserved	Reserved
3	Ambient temperature byte	8-bit signed value, unit: °C
4	Self-test information byte	0x00: Indicates default query value 0x03: Indicates self-test laser emission normal 0xFF: Indicates self-test laser emission abnormal

5	High-intensity operating status byte	0x01: Normal operation mode flag 0x00: High-intensity operation mode flag
6	Range-gate value, high byte	Hexadecimal representation
7	Range-gate value, low byte	
8	Baud rate, high byte	In hexadecimal, the baud rate is the return data × 100
9	Baud rate, low byte	
10	Laser shot count, high 8 bits	Hexadecimal representation
11		
12	Laser shot count, low 8 bits	
13		
14	Checksum byte	XOR of bytes 2 to 13
15	Frame terminator	0x55

5.2 Communication Protocol 2

5.2.1 Interface Overview

The system connects to the laser rangefinder via a TTL interface. Control commands are transmitted to the rangefinder through this serial port, and the system receives the rangefinder's status and self-test information in return.

5.2.2 Communication Interface

Data exchanged between the rangefinder and the host includes:

- **Control commands:** single-shot ranging, continuous ranging, query commands, etc.;
- **Returned data:** distance information, ambient temperature, rangefinder status, etc.

The rangefinder and host communicate via TTL serial communication with the following characteristics:

- **Baud rate:** 115200 bps (default) / 57600 bps / 38400 bps / 9600 bps
- **Byte format:** 1 start bit, 8 data bits, no parity, 1 stop bit (8N1). Data is transmitted with the least significant bit (LSB) first, followed by the most significant bit (MSB).

5.2.3 Data Packet Basic Format

Table 6 — Data Packet Format

Section description	Section length (in bytes)	Value range	Remarks
Frame header	2	0xEE	Fixed value

		0x16	
Data length	1	2~9	The data length is the total number of bytes in the device code, command code, and command parameter fields.
Device code	1	0x03	Fixed value
Command code	1	0~255	Indicates the control object of the current command.
Command parameter	0~4	0~255	Indicates the parameter of the control object for the current command.
Checksum	1	0~255	The checksum is calculated as the sum of all bytes in the device code, command code, and command parameter fields, taking the lower 8 bits of the result.

5.2.4 Control Commands

Table 7 — Control Command List

Command code	Description	Number of command parameter bytes
0x01	Device self-test	0
0x02	Single-shot ranging	0
0x03	Set first/last/multiple target mode	1
0x04	Continuous ranging	0
0x05	Stop ranging	0
0xA0	Set laser rangefinder module baud rate	4
0xA1	Set continuous ranging frequency	2
0xA2	Set minimum range-gate distance	2
0xA3	Query minimum range-gate distance	0
0xA4	Set maximum range-gate distance	2
0xA5	Query maximum range-gate distance	0
0x90	Query total laser emission count	0
0x91	Query laser emission count since last power-on	0

5.2.5 Response Data (Rangefinder Module → System)

Table 8 — Response Data Table

Command code	Description	Number of command parameter bytes
0x01	Device self-test	4
0x02	Single-shot ranging	7
0x03	Set first/last/multiple target mode	0
0x04	Continuous ranging	4
0x05	Stop ranging	0
0x06	Ranging error (This command is returned only when an error occurs during single-shot or continuous ranging, following the corresponding response message.)	4
0xA0	Set laser rangefinder module baud rate	4
0xA1	Set continuous ranging frequency	2
0xA2	Set minimum range-gate distance	2
0xA3	Query minimum range-gate distance	2
0xA4	Set maximum range-gate distance	2
0xA5	Query maximum range-gate distance	2
0x90	Query total laser emission count	3
0x91	Query laser emission count since last power-on	3

5.2.6 Communication Protocol

5.2.6.1 Device Self-Test

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5
Description	0xEE	0x16	0x02	0x03	0x01	0x04

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7	8	9
Description	0xEE	0x16	0x06	0x03	0x01	Status3	Status2	Status1	Status0	Check_sum

Status3:Reserved
Status2:Echo intensity, range 0x00–0xFF
Status1:
bit0 — MCU system status: 1 = normal, 0 = fault
bit1 — Laser emission status: 1 = emitting, 0 = not emitting
bit2 — Main pulse detection: 1 = detected, 0 = not detected
bit3 — Echo detection: 1 = detected, 0 = not detected
bit4 — Bias voltage switch: 1 = ON, 0 = OFF
bit5 — Bias voltage output: 1 = normal, 0 = abnormal
bit6 — Temperature status: 1 = normal, 0 = abnormal
bit7 — Laser shutoff control: 1 = active, 0 = inactive
Status0:
bit0 — 5V6 power supply status: 1 = normal, 0 = fault

5.2.6.2 Single-Shot Ranging

1）Command sent to the laser rangefinder module：

Byte	0	1	2	3	4	5
Description	0xEE	0x16	0x02	0x03	0x02	0x05

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7	8	9
Description	0xEE	0x16	0x06	0x03	0x02	Status	High 8 bits of the integer part of the measured distance	Low 8 bits of the integer part of the measured distance	Fractional part of the measured distance	Check_sum

When performing first/last target ranging:
Status = 0x00 — Single target detected
Status = 0x01 — Front (first) target detected
Status = 0x02 — Rear (last) target detected
Status = 0x03 — Reserved
Status = 0x04 — Out-of-range result
Status = 0x05 — Reserved
When performing multi-target ranging:
Status_bit3~0 = 0x00 — Single target detected
Status_bit3~0 = 0x01 — Front (first) target detected
Status_bit3~0 = 0x02 — Rear (last) target detected
Status_bit3~0 = 0x04 — Out-of-range result
Status_bit3~0 = 0x05 — Reserved

5.2.6.3 Set First/Last/Multiple Target Mode

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5	6
Description	0xEE	0x16	0x03 (data length)	0x03	0x03	Target	Check_sum

Target:
0x01 — Set to first-target ranging
0x02 — Set to last-target ranging
0x03 — Set to multi-target ranging

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5
Description	0xEE	0x16	0x02	0x03	0x03	0x06

5.2.6.4 Continuous Ranging

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5
Description	0xEE	0x16	0x02	0x03	0x04	0x07

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7	8	9
Description	0xEE	0x16	0x06	0x03	0x04	Status	High 8 bits of the integer part of the measured distance	Low 8 bits of the integer part of the measured distance	Fractional part of the measured distance	Check_sum

When performing first/last target ranging:
Status = 0x00 — The current ranging result indicates a single target.

5.2.6.5 Stop Ranging

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5
Description	0xEE	0x16	0x02	0x03	0x05	0x08

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5
Description	0xEE	0x16	0x02	0x03	0x05	0x08

5.2.6.6 Ranging Error

Response from the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7	8	9
Description	0xEE	0x16	0x06	0x03	0x06	Reserved	Reserved	Reserved	Status1	Check_sum

Status1:
bit0 — MCU system status: 1 = normal, 0 = fault
bit1 — Laser emission status: 1 = emitting, 0 = not emitting
bit2 — Main pulse detection: 1 = detected, 0 = not detected
bit3 — Echo detection: 1 = detected, 0 = not detected
bit4 — Bias voltage switch: 1 = ON, 0 = OFF
bit5 — Bias voltage output: 1 = normal, 0 = abnormal
bit6 — Temperature status: 1 = normal, 0 = abnormal
bit7 — Laser shutoff control: 1 = active, 0 = inactive
This command is returned **only when any of bits 0–7 in Status1 indicate an abnormal condition.**

5.2.6.7 Set Laser Rangefinder Module Baud Rate

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7	8	9
Description	0xEE	0x16	0x06	0x03	0xA0	BaudHigh24	BaudHigh16	BaudLow8	BaudLow0	Check_sum

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7	8	9
Description	0xEE	0x16	0x06	0x03	0xA0	BaudHigh24	BaudHigh16	BaudLow8	BaudLow0	Check_sum

5.2.6.8 Set Continuous Ranging Frequency

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7
Description	0xEE	0x16	0x04 (data length)	0x03	0xA1	Freq	Num	Check_sum3

Freq:
0x01 — 1 Hz ranging mode
0x02 — 2 Hz ranging mode
0x03 — 3 Hz ranging mode
0x04 — 4 Hz ranging mode
0x05 — 5 Hz ranging mode
0x0A — 10 Hz ranging mode
Num: 0x01

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5
Description	0xEE	0x16	0x02	0x03	0xA1	0xA4

5.2.6.9 Set Minimum Range-Gate Distance

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7
Description	0xEE	0x16	0x04 (data length)	0x03	0xA2	DIS_H	DIS_L	Check_sum

DIS_H: High 8 bits of distance
DIS_L: Low 8 bits of distance
DIS: 10–4000 (minimum range-gate distance range, in meters)

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7
Description	0xEE	0x16	0x04 (data length)	0x03	0xA2	DIS_H	DIS_L	Check_sum

DIS_H: High 8 bits of distance
DIS_L: Low 8 bits of distance
DIS: 10–4000 (minimum range-gate distance range, in meters)

5.2.6.10 Set Maximum Range-Gate Distance

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7
Description	0xEE	0x16	0x04 (data length)	0x03	0xA4	DIS_H	DIS_L	Check_sum

DIS_H: High 8 bits of the distance value
DIS_L: Low 8 bits of the distance value
DIS: 10–4000 (maximum range-gate distance range, in meters)

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7
Description	0xEE	0x16	0x04 (data length)	0x03	0xA4	DIS_H	DIS_L	Check_sum

DIS_H: High 8 bits of the distance value
DIS_L: Low 8 bits of the distance value
DIS: 10–4000 (maximum range-gate distance range, in meters)

5.2.6.11 Query Minimum Range-Gate Distance

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5
Description	0xEE	0x16	0x02	0x03	0xA3	0xA6

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7
Description	0xEE	0x16	0x04 (data length)	0x03	0xA3	DIS_H	DIS_L	Check_sum

DIS_H: High 8 bits of the distance value
DIS_L: Low 8 bits of the distance value
DIS: 10–4000 (maximum range-gate distance range, in meters)

5.2.6.12 Query Maximum Range-Gate Distance

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5
Description	0xEE	0x16	0x02	0x03	0xA5	0xA8

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7
Description	0xEE	0x16	0x04 (data length)	0x03	0xA5	DIS_H	DIS_L	Check_sum

DIS_H: High 8 bits of the distance value
DIS_L: Low 8 bits of the distance value
DIS: 10–4000 (maximum range-gate distance range, in meters)

5.2.6.13 Query Total Laser Emission Count

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5
Description	0xEE	0x16	0x02	0x03	0x90	0x93

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7	8
Description	0xEE	0x16	0x05	0x03	0x90	PNUM3	PNUM2	PNUM1	Check_sum

PNUM3: Total laser emission count, bits 23–16
PNUM2: Total laser emission count, bits 15–8
PNUM1: Total laser emission count, bits 7–0

5.2.6.14 Query Laser Emission Count Since Last Power-On

1）Command sent to the laser rangefinder module:

Byte	0	1	2	3	4	5
Description	0xEE	0x16	0x02	0x03	0x91	0x94

2）Response from the laser rangefinder module:

Byte	0	1	2	3	4	5	6	7	8
Description	0xEE	0x16	0x05	0x03	0x91	PNUM3	PNUM2	PNUM1	Check_sum

PNUM3: Laser emission count since last power-on, bits 23–16
PNUM2: Laser emission count since last power-on, bits 15–8
PNUM1: Laser emission count since last power-on, bits 7–0

6. Environmental Conditions

a) Operating temperature: −40 °C to +60 °C
b) Storage temperature: −50 °C to +70 °C (system-level qualification)
c) Vibration: 5 → 50 → 5 Hz sweep, 1 octave/min, 2.5 g (system-level qualification)
d) Shock: 1200 g, 1 ms (system-level qualification)

7. Optical Window Usage Recommendations

7.1 Material Selection

7.1.1 Optical Window Material

It is recommended to use optical glass **H-K9L** for the window material.
H-K9L is the most common colorless optical glass, suitable for the 300 nm–2100 nm laser wavelength range. It offers excellent cost performance and favorable physical properties.

7.1.2 Processing Requirements

- The wedge angle tolerance of the optical window should be as small as possible; recommended wedge tolerance ≤ 3′ (tolerance grade ≤ 7).
- The optical surface should be as smooth as possible; recommended surface roughness (Ra) ≤ 0.012 μm.

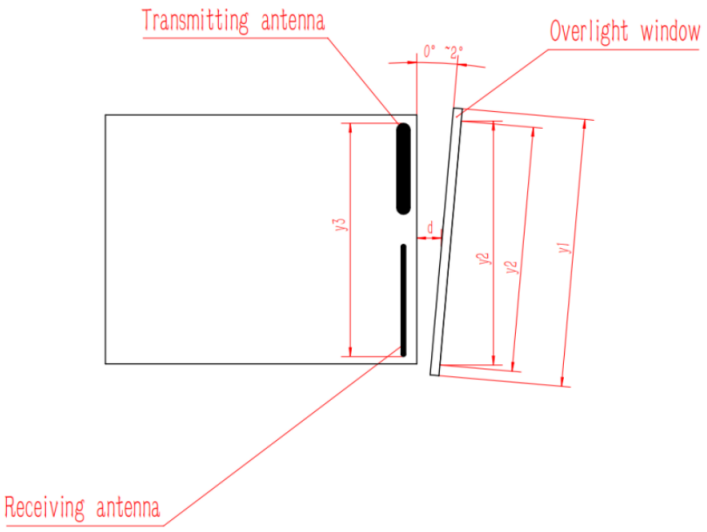
7.2 Usage Recommendations

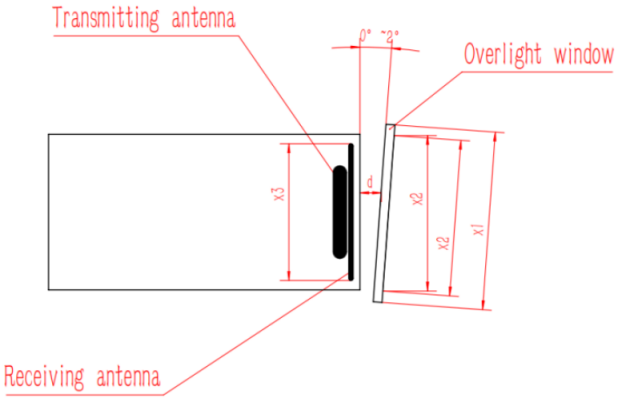
7.2.1 Optical Coating Recommendation

For 1535 nm laser rangefinders, it is recommended that the optical window be coated with an **anti-reflective (AR) coating** optimized for 1525 nm–1545 nm, with transmittance ≥ 99%.
Depending on the actual application environment, additional protective coatings such as **hydrophobic** or **hard coatings** can be applied to the external surface. Other performance criteria should comply with **MIL-STD-810G**, with overall transmittance ≥ 97%.

7.2.2 Optical Window Geometry and Installation Recommendations

- The **effective aperture** of the optical window should be determined according to the specific product design.
- The **outer diameter** of the window should ensure:
  - (Effective aperture – outer diameter) ≥ 2 mm
  - (Antenna outer diameter – projection of effective aperture) ≥ 1.5 mm
    (See schematic illustration below.)
- Since the optical window introduces some laser absorption, its **thickness** should be controlled within **2 – 4 mm**, depending on overall dimensions.
- Due to the high transmittance of the window, the **emission optical axis** should be aligned with the **window normal** within **2°–4°**.
  (See the schematic diagram showing the relative positions of the window and optical barrels.)
- The **air gap** between the optical window and the rangefinder should be minimized. Figure 3 illustrates two recommended configurations for optical window placement.





The effective aperture of the optical window y_2 - the outer diameter of the optical window y_1>2mm
The outer diameter of the rangefinder antennay$_3$-the projection size of the effective aperture of the optical window y_2，>1.5mm
The air gap d between the optical window and the rangefinder should be as small as possible

The effective aperture of the optical window x_2 - the outer diameter of the optical window x_1>2mm
The outer diameter of the rangefinder antenna x_3-the projection size of the effective aperture of the optical window x_2，>1.5mm
The air gap d between the optical window and the rangefinder should be as small as possible

Schematic diagrams of two ways of the external dimensions and placement of the optical window