Benewake

TFA300 Series User Manual

Preface

This user manual contains the introduction, use and maintenance of TFA300 series LiDAR. Please read this manual carefully before formal use, and strictly follow the steps described in the manual during use to avoid product damage, property loss, personal injury or/and violation of product warranty terms.

If you encounter problems that cannot be solved during use, please contact Benewake staff for assistance.

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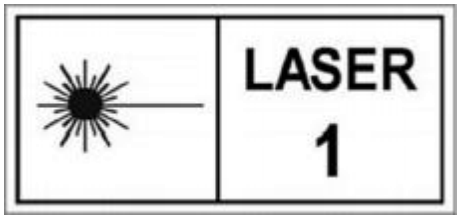
Disclaimer

The TFA300 series product is constantly being improved, and its specifications and parameters will undergo iterative changes. Please refer to the official website for latest version.

Contents

1. Laser Safety Information

The LiDAR contains IR and invisible laser spots. IR laser: Wavelength 905nm;
Class 1 according to IEC 60825-1:2014, EN 60825-1:2014+A11:2021.



CAUTION!

Use of controls, adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

2. Installation and Maintenance

CAUTION!

This laser product is classified as Class 1 during operational procedures. When the ranging feature is activated, the laser emitter of the LiDAR module may emit laser radiation, therefore, the LiDAR should NOT be aimed at humans and animals to ensure safety.

This product is designed and calibrated for installation with exposed lenses. If a protective window needs to be added in front of the lens, it is necessary to ensure the use of materials with high transmission at 905nm wavelength and anti-reflective coating.
Avoid the presence of smoke and fog in the detection field.
Avoid condensation.
Avoid direct exposure to moisture and water.
Do not use rough fabric or dirty towels or aggressive products to clean the laser lenses.
Do not use a supply voltage higher than the maximum required in the specifications to power the product.
Clean the laser lenses with compressed air. When needed, wipe the laser lenses only with a soft, clean microfiber cloth.
Make sure the sensor is securely mounted to prevent false readings or damage.
Only trained and qualified personnel may install, setup and repair the LiDAR.

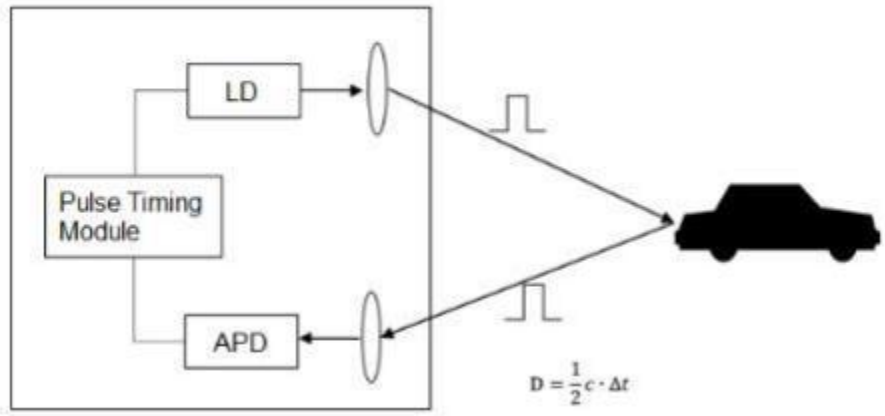
3. Product Overview

This chapter mainly introduces the measuring principle, technical specifications, structural description, equipment coordinates and field of view distribution of the TFA300 series LiDAR.

Measuring principle

TFA300 series is a typical Pulse Time of Flight (PToF) sensor. TFA300 series emits a narrow pulse laser, which is collimated by the transmitting lens, which enters the receiving system after being reflected by the measured target and is focused on the APD detector by the receiving lens. The time between the transmitted signal and the received signal is calculated through the circuit amplification and filtering, and the distance between TFA300 series and the measured target can be calculated through the speed

of light.



Pulsed time of flight

Technical Specifications

Performance Parameters		
Model	TFA300	TFA300-L
Detection range ①	270 m @ 90% ref. 100 KLux 150 m @ 30% ref. 100 KLux 90 m @ 10% ref. 100 KLux	290 m @ 90% ref. 100 KLux 170 m @ 30% ref. 100 KLux 100 m @ 10% ref. 100 KLux
Blind zone	≤ 0.1 m	
Accuracy ②	± 10 cm (< 10 m), 1% (≥ 10 m)	
Repeatability ②	< 3 cm @ 1。	
Distance resolution	1 cm	
Default frame rate	Up to 10,000 Hz (1 ~ 10,000 Hz configurable, default 50 Hz)	
Ambient light resistance	100 KLux	
Optical Parameters		
Light source	EEL	
Central wavelength	905 nm	
FoV	< 0.5°	
Eye safety	Class1 (IEC 60825-1:2014; EN 60825-1:2014+A11:2021)	
Mechanical and Electrical Parameters		
Average power consumption③	≤ 0.45 W	
Peak current③	< 0.75 A	
Power supply	DC 5 V ± 10%	
Logical voltage	3.3 V TTL	
Connector	JST GH 1.25 mm 6 PIN	
Operating temperature	- 20 ℃ ~ + 60 ℃	

Storage temperature	- 40 ℃ ~ + 80 ℃	
Protection level	IP67	NA
Typ. Dimensions④	49.4 mm x 37.0 mm x 28.6 mm	32.0 mm x 30.2 mm x 20.2 mm
Typ. Weight④	34.5 g (excluding cables)	10.5 g
Communication Protocol		
Communication Interface	UART / CAN (Can be switched by command)	
Baud rate	Default 115200 (Configurable)	
Data bit	8	
Stop bit	1	
Parity	None	

Notes:

1. Measured when the whole light spot falls on the target;
2. 100 KLux, 90% reflectivity target, measured when all light spots fall on the target object;
3. Measured at a temperature of 25 ℃, 50 Hz;
4. The weight and size are typical values for reference only. For detailed tolerance parameters, please consult the technical personnel of Benewake.

Structural Appearance

The overall appearance of the LiDAR is as shown in the figure below:

TFA300 series Appearance

Field of view

The FoV (field of view) is the angle covered by the LiDAR sensor. The horizontal FoV is 0.3° and the vertical FoV is 0.1°.

FoV of TFA300 series

0.1 ° and 0.3 ° are theoretical values. Due to production, processing, and installation errors, there may be some deviation between the actual field of view and this theoretical value. If strict requirements are placed on the spot position, it is recommended to use an infrared camera to confirm the actual spot position before installing and fixing the LiDAR.

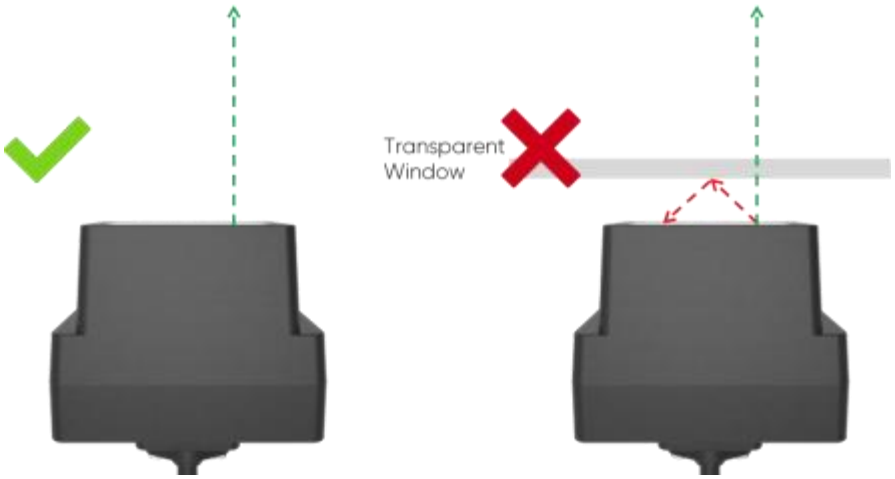
4. Device Installation

This section introduces the mechanical installation and connection information of TFA300 series LiDAR.

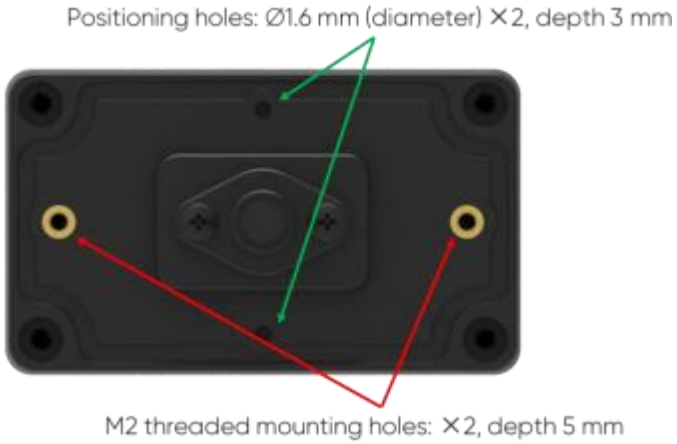
Mechanical installation

TFA300

The TFA300 has an IP67 waterproof housing. It is recommended to directly expose the front window of the TFA300 to the air for use. Do not add an additional transparent housing to cover the window, as this may cause crosstalk due to multiple reflections and affect the distance measurement performance.



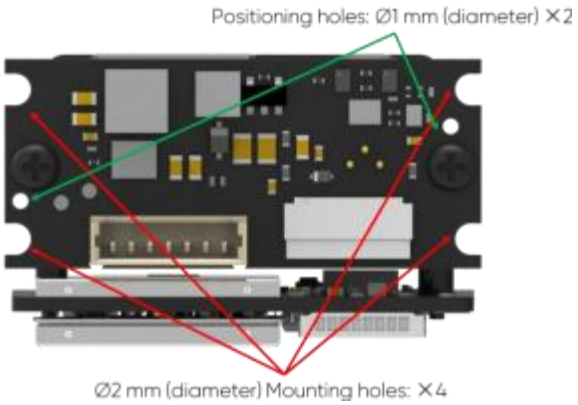
On the back of the product, there are two positioning holes and two embedded-thread M2 mounting holes. Be mindful of the depth restrictions to prevent casing damage.

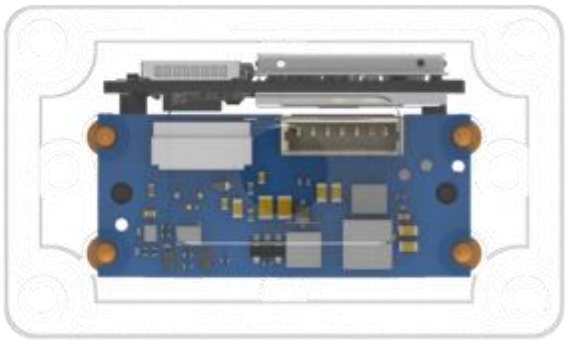


TFA300-L

TFA300-L is an unprotected product without an enclosure. Avoid exposing it directly to environments such as rain, snow, condensation, moisture, or dust, which may adversely affect the LiDAR's photoelectric components. The customer is obligated to implement necessary protective measures based on the application scenario.

The product features 4 mounting holes and 2 positioning holes for installation. For reference, the recommended installation method is illustrated below:





TFA300-L is not equipped with a protective enclosure or front window. Its transceiver lenses are directly exposed to the air and lack waterproof or dustproof capabilities. Do not expose the product directly to rain, snow, humidity, or environments with excessive dust. To better protect the device, customers are advised to design and install custom protective structures.

When designing a front window lens, ensure it tightly adheres to the LiDAR's front housing to avoid large gaps. Excessive spacing may cause optical crosstalk, which could compromise ranging performance.

The TFA300 series utilizes a laser source with a central wavelength of 905 nm. It is recommended to use materials with a transmittance greater than 90% at 905 nm to minimize the impact of laser energy loss on ranging performance.

Connector

The TFA300 series products are equipped by default with a JST GH GHR-06V-S wire-to-board connector featuring a locking mechanism, which can be inserted into the 6-pin UART interface of a flight controller. If replacement with other connector types or connection methods is required, please refer to the following pinout for custom design and development.

TFA300

Cable color	Definition
Blue	UART_Rx
Brown	UART_Tx
White	CAN_L
Green	CAN_H
Red	VCC
Black	GND

TFA300-L

The connector model is 1.25 mm-7P, as shown in the following figure:

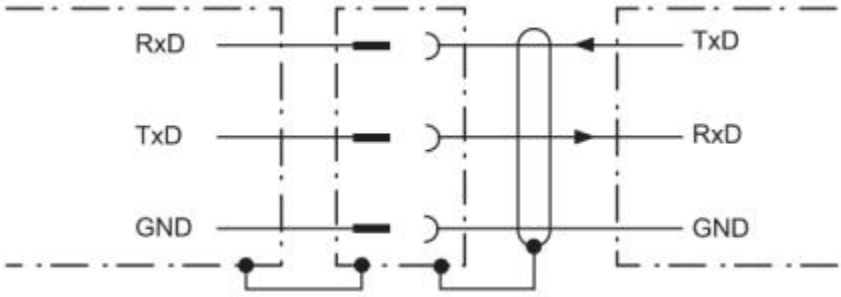
Pin No.	Definition
1	Rx
2	Tx
3	CAN_L
4	CAN_H
5	VCC
6	GND
7	Not used

5. Communication Protocol

The TFA300 series supports dual UART and CAN communication interfaces. Users can connect the corresponding cables and connectors based on their needs, then activate the desired protocol output via command. By default, the device operates using the UART protocol.

UART Communication

Communication protocol



UART Interface Wiring Diagram

To establish UART communication between two devices, connect the transmitter's TxD to the receiver's RxD, and the receiver's TxD to the transmitter's RxD.
The TFA300 series employs a UART-LVTTL interface with an output level of LVTTL (3.3 V). The communication protocol specifications are detailed in the table below:

UART Communication protocol details

Character	Value
Baud rate	115200
Data bit	8
Stop bit	1
Parity	None

Baud rate can be set to 9600, 14400, 19200, 38400, 56000, 57600, 115200, 128000, 230400, 256000, 460800, 500000, 512000, 600000, 750000, and 921600. If other value were set, TFA300 series will set it to 115200.

Data Frame

Each data frame under the UART interface contains distance and signal strength and consists of 9 bytes of hexadecimal values. Both distance and signal strength are represented by 2 bytes each, arranged in little-endian format. For details, refer to the table below:

Standard Data Frame Format

Data Byte	0	1	2	3	4	5	6	7	8
Description	Header	Header	Distance		Signal Strength		Reserved		Checksum
Typical Value	0x59	0x59	Low byte	High byte	Low byte	High byte	0x00	0x00	Sum

Notes on Signal Strength:
Signal Strength indicates the intensity of the reflected light signal received by the LiDAR.

- The value depends on the reflectivity of the target and distance:
- Lower reflectivity or longer distance typically results in a lower signal strength value.
- Excessively low signal strength may degrade ranging accuracy or even trigger an "out-of-range"

output if the signal-to-noise ratio (SNR) falls below the required threshold.

Recommendation:

- When signal strength is below 40, the reliability of ranging data is significantly reduced.
- Set an appropriate signal strength threshold based on your application to assist in validating measurement validity.

High Frame Rate Data Frame Format

Data Byte	0	1	2	3	4	5
Description	Header	Header	Distance		Signal Strength	
Typical Value	0x20	0x20	Low byte	High byte	Low byte	High byte

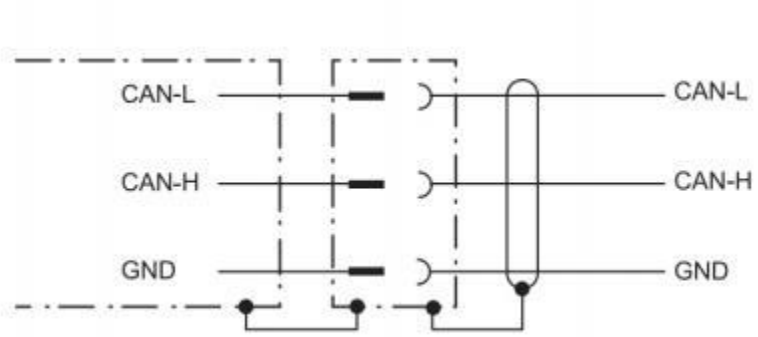
Important:

To achieve a frame rate exceeding 6000 Hz via UART:

- Use the command to switch to the 6-byte High Frame Rate Data Frame Format.
- Set the baud rate to 921600 to ensure data transmission integrity.

CAN Communication

The TFA300 series CAN interface supports the DroneCAN protocol. If needed, please enable it using custom configuration commands.



CAN Interface Wiring Diagram

Communication protocol

The CAN communication protocol of the TFA300 series can be customized according to customer needs, with adjustable CAN baud rate, ID, and frame format. The content of the agreement is as follows:

TFA300 Series CAN Interface Communication Protocol

Parameter	Value
Baud Rate	1 Mbps
Receive ID	- Standard Frame: 0x3 - Extended Frame: 0x3
Transmit ID	0x3
Frame Format	- Transmitted Frames: Standard Frame (default) - Received Frames: Supports both Standard and Extended Frames

The CAN interface baud rate setting only supports commonly used baud rates: 1000kps, 500kps, 250kps, 125kps, 100kps, 50kps, 20kps. If other values are set, the TFA300 series will set it to 1000kps.

Data Frame

Data frames under the CAN interface consist of 6 bytes of hexadecimal values, containing measured distance and signal strength, with the remaining bytes reserved.

TFA300 CAN Communication Data Frame Format

Data Byte	0	1	2	3	4	5
Description	Distance (Low)	Distance (High)	Signal Strength (Low)	Signal Strength (High)	Reserved	Reserved
Typical Value	DIST_L	DIST_H	Strength_L	Strength_H	_	_

Notes on Signal Strength:
Signal Strength indicates the intensity of the reflected light signal received by the LiDAR.

- The value depends on the reflectivity of the target and distance:
- Lower reflectivity or longer distance typically results in a lower signal strength value.
- Excessively low signal strength may degrade ranging accuracy or even trigger an "out-of-range" output if the signal-to-noise ratio (SNR) falls below the required threshold.

Recommendation:

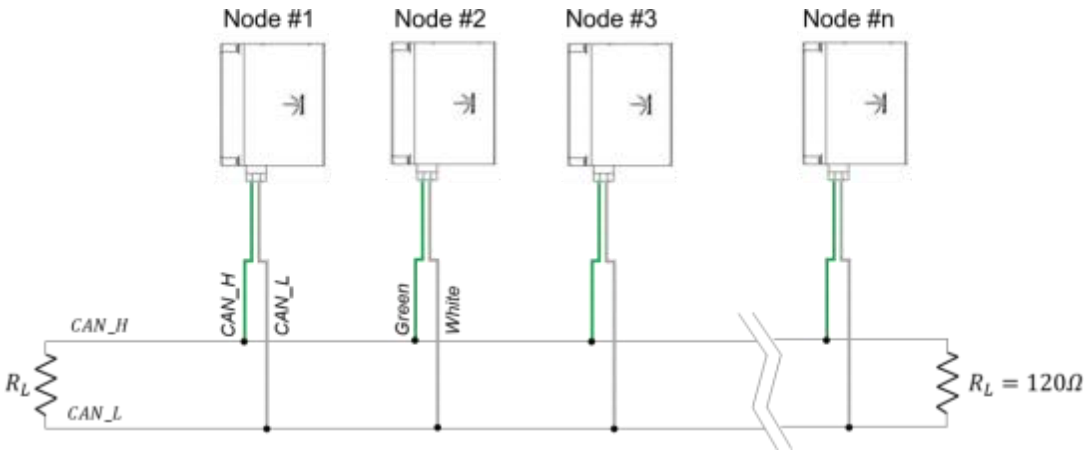
- When signal strength is below 40, the reliability of ranging data is significantly reduced.
- Set an appropriate signal strength threshold based on your application to assist in validating measurement validity.

Important:

- To achieve a frame rate exceeding 6000 Hz via CAN, set the baud rate to 1 Mbps to ensure data transmission stability.

CAN networking

The CAN bus network operates via the CAN_H and CAN_L lines, enabling serial differential signal transmission between nodes. To minimize signal reflection and electrical interference, a 120-ohm termination resistor must be connected between CAN_H and CAN_L.
The TFA300 series includes a built-in 120-ohm termination resistor, disabled by default. To simplify network setup, you can enable the built-in resistor via command only on devices located at the two ends of the CAN network. This eliminates the need for additional external termination resistors.



TFA300 series CAN networking

Custom configuration instructions

Protocol description

To accommodate diverse customer requirements, the TFA300 series allows users to configure operational parameters such as data format, frame rate, and more via command settings. Always strictly follow the instructions in this manual for product configuration and avoid sending undeclared commands.

TFA300 Series Command Protocol Format

Data Byte	Definition	Description
Byte 0	Header	Fixed value: 0x5A (hexadecimal).

Byte 1	Len	Total length of the command frame in bytes
Byte 2	ID	Command identifier (unique for each function).
Byte 3~N-2	Payload	Command-specific parameters (variable length and interpretation).
Byte N-1	Check Sum	Lower 8 bits of the sum of the first Len-1 bytes

Common configuration instructions

Description	Command	Response	Remarks	Default settings
Set Operating Frequency	5A 06 03 LL HH SU	Same as command	LL: lower 8 bits HH: higher 8 bits	50 Hz
Configure Transmission Protocol Type	UART: 5A 05 45 01 A5 CAN: 5A 05 45 02 A6	5A 05 45 00 A4	Save Configuration, changes take effect after reboot	UART
Set UART Baud Rate	5A 08 06 H1 H2 H3 H4 SU	Same as command		115200
Set 6-Byte Output Format	5A 05 05 20 84	5A 05 05 20 84		
Set 9-Byte Output Format	5A 05 05 01 65	5A 05 05 01 65		
Configure CAN Transmit ID	5A 08 50 H1 H2 H3 H4 SU	5A 05 50 00 AF	ID= (H4<<24)+(H3<<16)+(H2<<8)+H1 Takes effect under CAN	0x03
Configure CAN Receive ID	5A 08 51 H1 H2 H3 H4 SU	5A 05 51 00 B0	ID= (H4<<24)+(H3<<16)+(H2<<8)+H1 Takes effect under CAN	0x03
Set CAN Baud Rate	5A 08 52 H1 H2 H3 H4 SU	5A 05 52 00 B1	Baud rate= (H4<<24)+(H3<<16)+(H2<<8)+H1	1M
Set CAN Frame Type (Standard/Extended)	Standard: 5A 05 5D 00 BC Extended: 5A 05 5D 01 BD	5A 05 5D 00 BC		Standard
Configure Extended CAN Transmit ID	5A 08 93 H1 H2 H3 H4 SU	5A 05 93 00 F2	ID=(H4<<24)+(H3<<16)+(H2<<8)+H1 Takes effect under CAN	0x03
Configure Extended CAN Receive ID	5A 08 94 H1 H2 H3 H4 SU	5A 05 94 00 F3	ID=(H4<<24)+(H3<<16)+(H2<<8)+H1 Takes effect under CAN	0x03
Set CAN Termination Resistor (Enable/Disable)	ON: 5A 05 91 01 F1 OFF: 5A 05 91 00 F0	5A 05 91 00 F0		OFF
Enable/Disable DroneCAN Mode	ON: 5A 05 84 00 E3 OFF: 5A 05 84 01 E4	5A 05 84 00 E3		OFF
Configure DroneCAN Node ID	5A 05 95 NUM SU	5A 05 95 00 F4	Range: 1 ~ 127 (0x01 ~ 0x7F)	0x0D
Set Out-of-Range Output Value	5A 06 4F LL HH SU	5A 05 4F 00 AE	Out-of-Range Output Value = (HH << 8) + LL, unit: cm	30000
Set Offset Calibration	5A 06 69 LL HH SU	5A 05 69 00 C8	offset = (HH<<8) + LL, unit: cm	0
Enable/Disable Data Output	ON: 5A 05 07 01 67 OFF: 5A 05 07 00 66	Same as command		ON
Single Trigger Command	5A 04 04 62	No response	Only takes effect when "Disable Data Output"	
Save Current Configuration	5A 04 11 6F	5A 05 11 00 70		
Restore Factory Defaults	5A 04 10 6E	5A 05 10 01 70		

Important: After modifying one or more parameters via configuration commands, always send the "Save Current Configuration" command to write the changes to the device. Otherwise, parameters will revert to the last saved values upon re-powering.

Command editing

This section describes the Command Channel of TFA300 which is used to read and set TFA300's working parameters. The command channel is available via all the interfaces.
A standard TFA300 command consists of frame header, command length, command ID, parameters and checksum. Follow these steps to generate a command:

1. Choose the right command ID and confirm its length
2. Convert parameter from the decimal value to hexadecimal value
3. Fill the hexadecimal parameter into the command
4. Calculate the checksum and fill its low 8-bits into the command

Example: Setting Baud Rate to 460800

1. Identify Command ID and Length
   Assume the command ID is 0x06 and total length is 8 bytes (including header and checksum).

2. Convert 460800 to Hexadecimal
   460800 → 0x00 07 08 00 (hex, little-endian).

3. Construct the Command Frame

Header	Len	ID	Param 1	Param 2	Param 3	Param 4	Checksum
0x5A	0x08	0x06	0x00	0x08	0x07	0x00	

4. Calculate Checksum
   Sum: 0x5A + 0x08 + 0x06 + 0x00 + 0x08 + 0x07 + 0x00 = 0x77 (lower 8 bits).
   Final Command: 0x5A 0x08 0x06 0x00 0x08 0x07 0x00 0x77