

TG SERIES DEVELOPMENT MANUAL



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1 WORKING MECHANISM

The YDLIDAR TG Series(including TG15,TG30,TG50 etc) system has 4 working modes: idle mode, scan mode, stop mode, Power-down protection mode.

- **Idle mode:** When TG Series is powered on, the default mode is idle mode. In idle mode, the TG Series's ranging unit does not work and the laser is not light.
- **Scan mode:** When TG Series is in scanning mode, the ranging unit turns on the laser. When the TG Series starts to work, it continuously samples the external environment and outputs it in real time after background processing.
- **Stop mode:** When TG Series runs with an error, such as turning on the scanner, the laser is off, the motor does not rotate, etc.TG Series will automatically turn off the distance measuring unit and feedback the error code.
- **Power-down protection mode:** In this mode, lidar needs to continuously receive the scan commands with a less than 3 second's transmission interval so that it will keep working. If the lidar does not receive a continuous scan command, the system will automatically stop. This mode is not enabled by default.

1.1 System Workflow

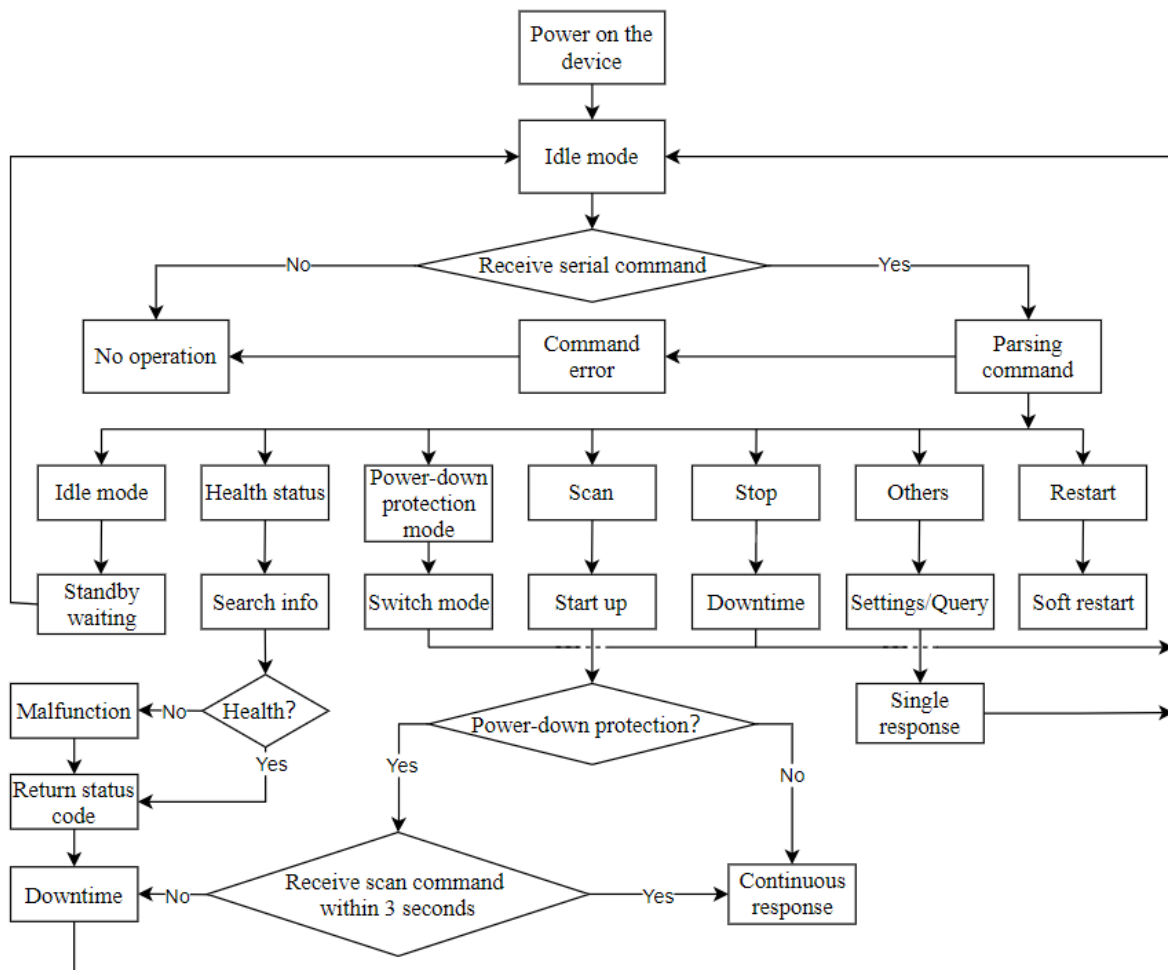


FIG 1 YDLIDAR TG SERIES WORKFLOW

2 SYSTEM COMMUNICATION

2.1 Communication Mechanism

TG Series communicates commands and data with external devices through the serial port. When an external device sends a system command to TG Series, TG Series resolves the system command and returns a corresponding reply message. According to the command content, TG Series switches the corresponding working status. According to the content of the message, the external system can parse the message and obtain the response data.

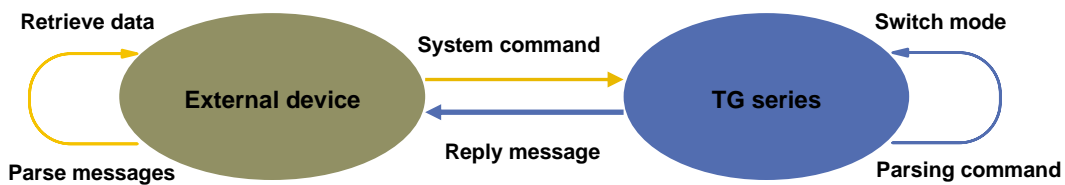


FIG 2 YDLIDAR TG SERIES SYSTEM COMMUNICATION

2.2 System Command

The external system can set the corresponding working status of TG Series and send corresponding data by sending related system commands. The TG Series system command is unified to 2 bytes, where the start byte is 0xA5 and the second byte is the command content. The system commands issued by TG Series are as follows:

CHART 1 YDLIDAR TG SERIES SYSTEM COMMAND

System command	Description	Mode Switching	Answer mode
0xA5 (Start)	0x60	Start scanning and export point cloud data	Scan mode Sustained response
	0x65	Stop and stop scanning	Stop mode No answer
	0x90	Get device information (model, firmware, hardware version)	No Single response
	0x91	Get device health statu	No Single response
	0x09	Increase the current scan frequency of 0.1Hz	No Single response
	0x0A	Reduce the current scan frequency of 0.1Hz	No Single response

0x0B	Increase the current scan frequency of 1Hz	No	Single response
0x0C	Reduce the current scan frequency of 1Hz	No	Single response
0x0D	Get the currently set scan frequency	No	Single response
0xD9	Power-down protection mode switch (off by default)	No	Single response
0x80	Soft restart	/	No response
0x93	Zero Angle deviation	No	Single response

2.3 System Messages

The system message is a response message that the system feeds back based on the received system command. According to different system commands, the reply mode and response content of the system message are also different. There are three kinds of response modes: no response, single response, continuous response.

No response means that the system does not return any messages. A single reply indicates that the system's message length is limited, and the response ends once. Sustained response means that the system's message length is infinite and needs to send data continuously, such as when entering the scan mode.

The one-time response and continuous response messages use the same data protocol. The contents of the protocol are: start sign, response length, response mode, type code and response content, and are output through the serial port hexadecimal system.

CHART 2 YDLIDAR TG SERIES SYSTEM MESSAGE DATA PROTOCOL

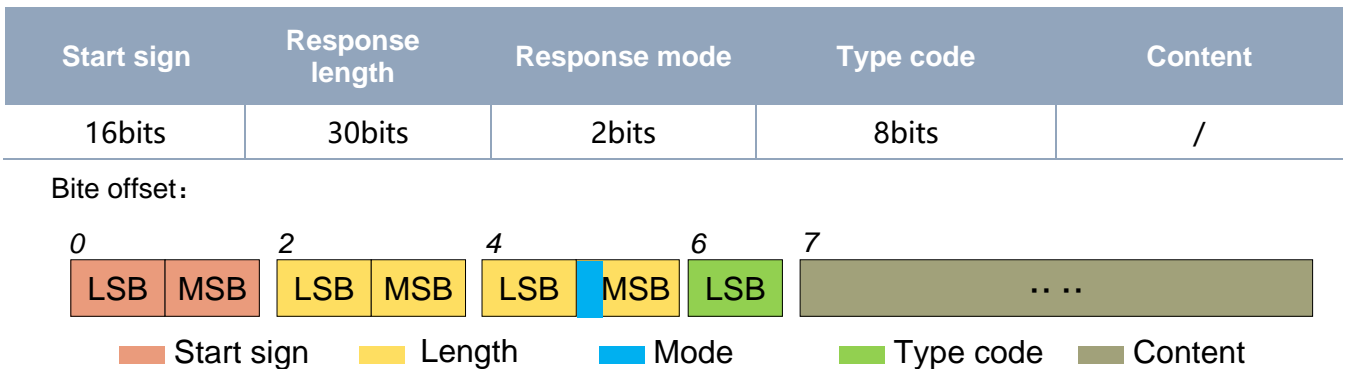


FIG 3 YDLIDAR TG SERIES SYSTEM MESSAGE DATA PROTOCOL

➤ **Start sign:** TG Series's message sign is unified as 0xA55A.

- **Response length:** Means the length of the response content, when the answer mode is continuous, the length should be infinite, so this value is invalid.
- **Response mode:** This bit is only 2 bits, which means this time it is a single response or continuous response. Its value and corresponding mode are as follows:

CHART 3 YDLIDAR TG SERIES RESPONSE VALUE AND CORRESPONDING RESPONSE MODE

Mode	0x0	0x1	0x2	0x3
Response mode	Single response	continuous response	Undefined	

- **Type code:** Different system commands correspond to different types codes.
- **Content:** Different system commands, feedback different data content, and their data protocols are also different.

Note 1: The TG Series data communication adopts the little-endian mode and the low-order mode.

Note 2: In the reply message, the lower 6 bits of the 6th byte belong to the response length and the upper 2 bits belong to the response mode.

3 DATA PROTOCOL

Different system commands have different packet contents. In the packets of different types of codes, the data protocol of the response content is also not the same. Therefore, users need to parse the data in the response content according to the corresponding data protocol, such as point cloud data, device information, etc.

3.1 Scan Command [A5 60]

When an external device sends a scan command to TG Series, TG Series goes into scan mode and feeds back point cloud data. The reply message is:

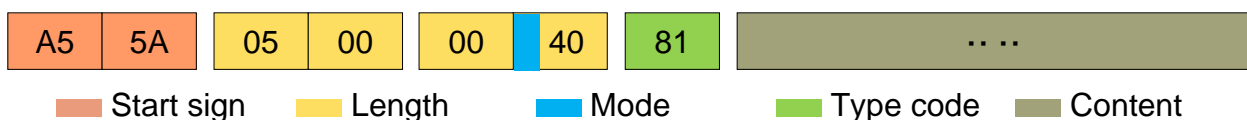


FIG 4 YDLIDAR TG SERIES SCAN COMMAND

The 6th byte high 2 is 01, so the response mode takes 0x1, which is a continuous response, ignoring the response length, and the type code is 0x81.

The response content is the point cloud data scanned by the system. According to the following data structure, the data is sent to the external device in hexadecimal to the serial port.

Byte offset:

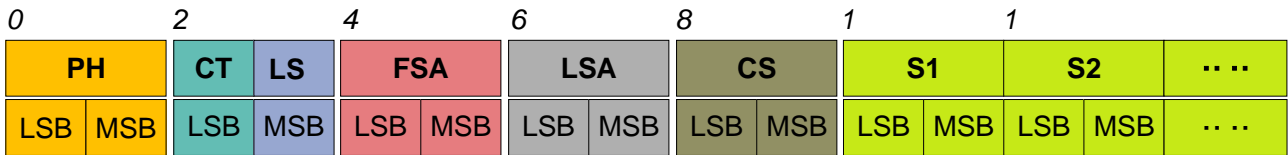


FIG 5 SCAN COMMAND RESPONSE CONTENT DATA STRUCTURE

CHART 4 SCAN COMMAND RESPONSE CONTENT DATA STRUCTURE DESCRIPTION

Content	Name	Description
PH(2B)	Packet header	2B in length, fixed at 0x55AA, low in front, high in back
CT(1B)	Package type	CT&0x01 is the type information of the point cloud: CT&0x01 = 0x00: Point Cloud Packet CT&0x01 = 0x01: Start Packet. CT&0xFE denotes other information: When CT&0x01 = 0x01, that is, the current data is zero packet data: CT&0xFE represents the frequency information calculated by radar, which can be 3.0Hz~15.7Hz The specific algorithm $Freq = ((CTt\&0xFE) >> 1) + 30) / 10$ Hz For example, CT= 0XB7, the current packet is the starting packet and the rotating speed is 12.1Hz
LSN(1B)	Sample quantity	Indicates the number of sampling points contained in the current packet. There is only one zero point of data in the zero packet. The value is 1.
FSA(2B)	Start angle	The angle data corresponding to the first sample point in the sampled data
LSA(2B)	End angle	The angle data corresponding to the last sample point in the sampled data
CS(2B)	Check code	The check code of the current data packet uses a two-byte exclusive OR to check the current data packet.
Si(2B)	Sample data	The system test sampling data is the distance data of the sampling point.

➤ **Start bit resolution:**

When CT&0x01 = 1 is detected, it indicates that the packet data is the initial packet, representing the beginning of a cycle of data. In this packet, LSN=1, that is, the number of Si is 1;

When CT&0x01 = 0 is detected, it indicates that the packet data is an intermediate packet in a data circle, not the starting point of a data circle.

See the following for the detailed value analysis of the distance and Angle.

➤ **Distance analysis:**

Distance solution formula:

$$Distance_i = Di[7:0] + Di[15:8] * 256 \quad \text{The unit is mm.}$$

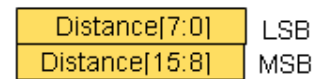


FIG 6 S node data

Among them, Di is the first and second byte data of the sampled data Si. Set the sampling data as E8 03. Since the system is in small-terminal mode, the sampling point D = 0x03E8 is substituted into the Distance solution formula to obtain the Distance=1000mm.

➤ **Angle analysis:**

Angle data is stored in FSA and LSA, and each Angle data has the following data structure, where C is the check bit and its value is fixed to 1. The specific process is as follows:

Starting angle solution formula: $Angle_{FSA} = \frac{Rshiftbit(FSA,1)}{64}$

End angle solution formula: $Angle_{LSA} = \frac{Rshiftbit(LSA,1)}{64}$

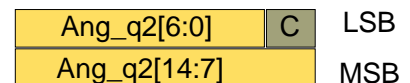


FIG 7 Angle data structure schematic

Intermediate angle solution formula:

$$Angle_i = \frac{diff(Angle)}{LSN-1} * (i - 1) + Angle_{FSA} \quad (i = 2,3, \dots, LSN - 1)$$

Rshiftbit (data,1) means shifting the data to the right by one bit. diff(Angle) means the clockwise angle difference from the starting angle (uncorrected value) to the ending angle (uncorrected value), and LSN represents the number of packet samples in this frame.

➤ **Check code parsing:**

The check code uses a two-byte exclusive OR to verify the current data packet. The check code itself does not participate in XOR operations, and the XOR order is not strictly in byte order. The XOR sequence is as shown in the figure. Therefore, the check code solution formula is:

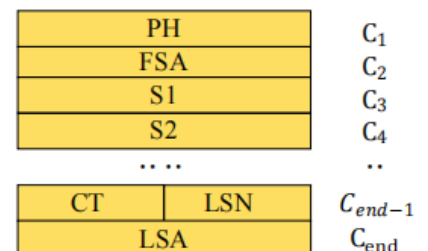


FIG 8 CS XOR SEQUENCE

$$CS = XOR_1^{en}(C_i) \quad i = 1, 2, \dots, end$$

XOR_1^{end} indicates the XOR of the element from subscript 1 to end. However, XOR satisfies the exchange law, and the actual solution may not need to follow the XOR sequence.

3.2 Stop Command [A5 65]

When the system is in the scanning state, TG Series always sends point cloud data to the outside. If you need to turn off scanning at this time, you can send this command to stop the system from scanning. After the stop command is sent, the system will be in the standby state. At this time, the ranging unit of the device is in the low power mode, and the laser is not lit.

The command is unresponsive, so the system will not respond to any messages after receiving the command.

3.3 Device Information [A5 90]

When an external device sends a Get Device Information command to (A5 90), TG Series will feedback the device's model, firmware version, and hardware version, and the device's factory serial number. The reply message is:

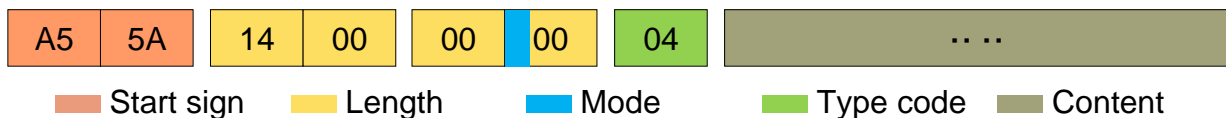


FIG 9 YDLIDAR TG SERIES DEVICE INFORMATION

According to the protocol resolution: response length = 0x00000014, answer mode = 0x0, type code = 0x04.

That is, the number of response content bytes is 20. The response is a single response and the type code is 04. This type of response content satisfies the following data structure:

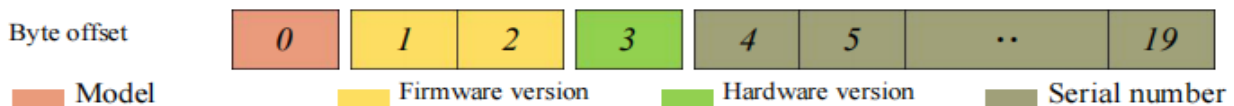


FIG 10 YDLIDAR TG SERIES DEVICE INFORMATION RESPONSE CONTENT DATA STRUCTURE

- **Model number:** One byte device model, such as the TG15 is 100, the TG30 is 101 and the TG50 is 102.
- **Firmware Version:** 2 bytes. The low byte is the major version number, and the high byte is the minor version number.
- **Hardware version:** 1 byte for hardware version.

- **Serial number:** 16 bytes, the only factory serial number.

3.4 Health Status [A5 91]

When an external device sends a health status command (A5 91) to TG Series, TG Series will give back the status code of the device. The reply message is:

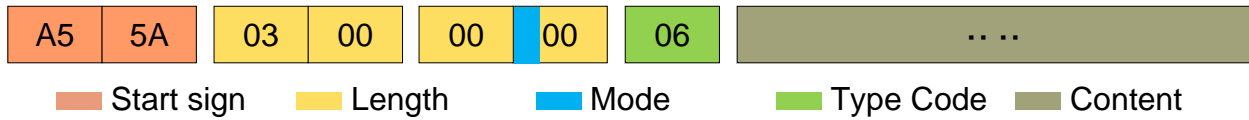


FIG 11 SCHEMATIC DIAGRAM OF YDLIDAR TG SERIES RADAR EQUIPMENT HEALTH STATUS MESSAGE

According to the protocol resolution: response length = 0x00000003, answer mode = 0x0, type code = 0x06.

That is, the number of response content bytes is 3. This response is a single response and the type code is 06. The type of reply content satisfies the following data structure:

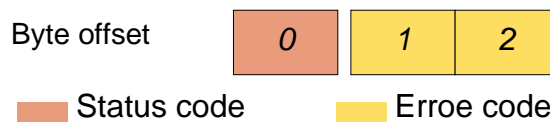


FIG 12 SCHEMATIC DIAGRAM OF DATA STRUCTURE OF HEALTH STATUS RESPONSE CONTENT OF YDLIDAR TG SERIES EQUIPMENT

- **Status code:** 1 byte, 0x0 means the device is running normally, 0x1 means the device is running warning, 0x2 means the device is running incorrectly.
- **Error code:** 2 bytes, when there is a warning or error state, the specific error code will be recorded in the field 0x00 means that the device runs without any error.

3.5 Zero Angle Deviation [A5 93]

When an external device sends the acquisition device zero Angle offset command (A5 93) to the TG Series, the TG Series will feedback the zero Angle offset value. The reply message is:

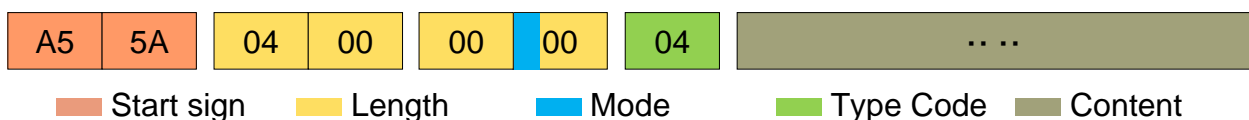


FIG 13 SCHEMATIC DIAGRAM OF YDLIDAR TG SERIES RADAR ZERO ANGLE OFFSET MESSAGE

According to the protocol resolution: response length = 0x00000004, answer mode = 0x0, type code = 0x04.

That is, the number of response content bytes is 4. This response is a single response and the type code is 04.

- **Zero Angle Offset:** 4 bytes of reply content divided by 4, in degrees.

3.6 Scan Frequency Setting [A5 09/0A/0B/0C]

TG Series provides multiple command interfaces for scanning frequency settings to increase or decrease the system scan frequency.

CHART 5 SCAN FREQUENCY SETTING COMMAND DESCRIPTION

Commands	Description
A509	Increase the current scan frequency of 0.1Hz
A50A	Reduce the current scan frequency of 0.1Hz
A50B	Increase the current scan frequency of 1Hz
A50C	Reduce the current scan frequency of 1Hz

The above commands are the same type of commands and have the same message structure. The scan frequency setting command has the following message structure:

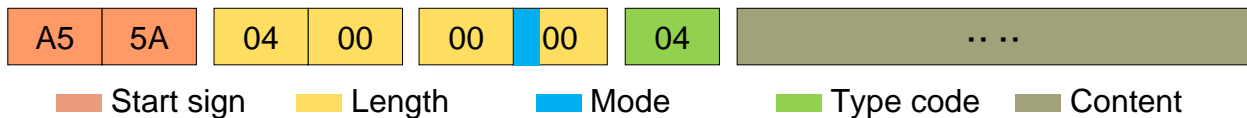


FIG 14 YDLIDAR TG SERIES SCAN FREQUENCY SETTING MESSAGE

According to the protocol resolution: response length = 0x00000004, answer mode = 0x0, type code = 0x04.

That is, the number of response content bytes is 4; this response is a single response, and the type code is 04. The response content represents the currently set scanning frequency (Unit: Hz), and its solution formula is:

$$F = \frac{\text{AnswerData}}{100}$$

Among them, AnswerData is converted to decimal data for response content (small-endian mode) in Hertz (Hz)

3.7 Scan Frequency Acquisition [A5 0D]

This command is used to get the scan frequency (note that it is not a real-time frequency). The message structure and response content are consistent with the scan frequency setting command. The user can refer to the scan frequency setting [A5 09/0A/0B/0C]. This section does not describe it.

3.8 Power-down Protection Switching [A5 D9]

If the lidar power supply and external equipment is not a shared power supply system, please turn on the power-down protection mode to protect the lidar.

Under this model, the scan command needs to be sent continuously and the transmission interval should be less than 3s. If the command is sent interrupted or the transmission interval is too long, the system will judge that the control terminal has been powered down, which will trigger the power failure protection and stop the lidar. This command is a switch command. The message of the command is as follows:

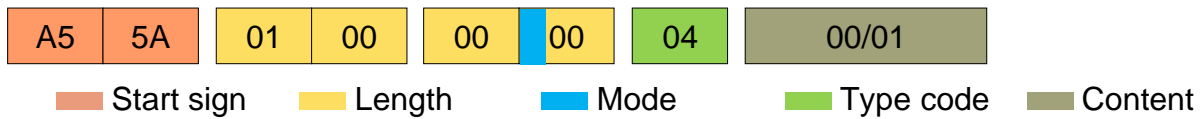


FIG 15 YDLIDARTGSERIESPOWER-DOWNPROTECTIONMESSAGE

According to the protocol resolution: response length = 0x00000001, answer mode = 0x0, type code = 0x04.

That is, the number of response content bytes is 1. This response is a single response and the type code is 04.

The response content of the command corresponds to the power-on protection mode being turned on and off, 00 means that the power-down protection is enabled, and 01 means that the power-down protection is turned off.

Note: In the power-down protection mode, the message structure of the scan command changes slightly. Only when the scan command is sent for the first time in the stop state, there will be a complete message structure. There is no start flag in the subsequent scan command. The response length, response mode, and type code are only the response content.

3.9 Restart Command [A5 80]

When an external device sends a Get Device command (A5 80) to TG Series, TG Series enters a soft reboot and the system restarts. This command does not answer.

3.10 Motor Speed Control

The TG Series integrates the system's speed control into the system's command interface, not the hardware interface. The user can change the speed of the motor by adjusting the scan frequency. See the section on Scan Frequency Setting [A5 09/0A/0B/0C] for details. This section does not elaborate.

4 ATTENTION

When interacting with the TG Series command, other than stopping the scan command (A5 65), other commands cannot be interacted in the scan mode. This can easily result in packet parsing errors.

5 REVISE

Date	Version	Content
2019-05-26	1.0	Compose a first draft
2020-01-15	1.1	Modify the distance solution formula as SI, the protocol and the page number information
2020-06-09	1.2	Add command of read zero Angle offset
2021-06-02	1.3	Delete motor rotation direction setting and constant frequency setting