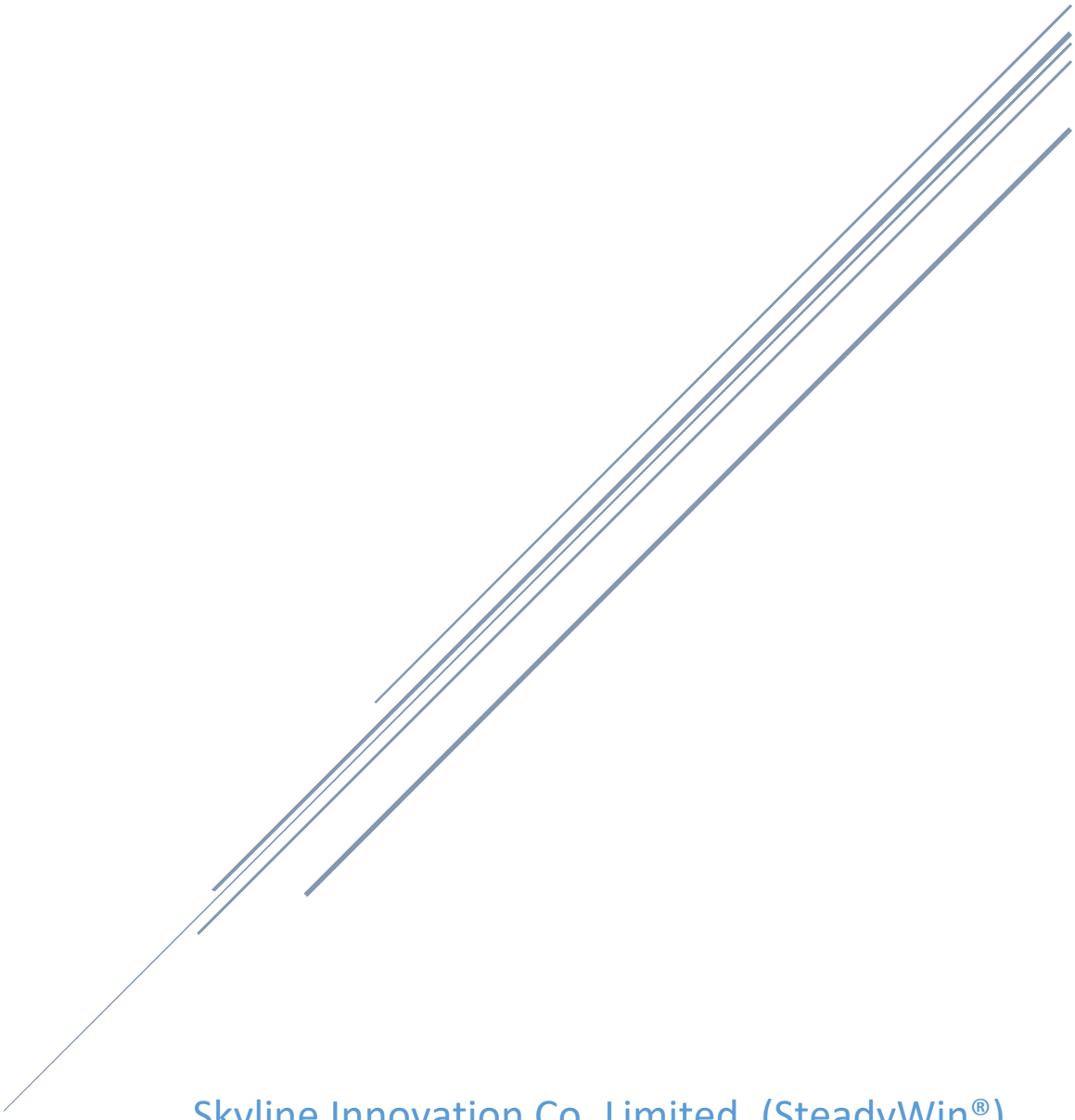
STEADYWIN® MOTOR DRIVER PROTOCOL SPECIFICATION



Skyline Innovation Co.,Limited. (SteadyWin®)

CONTENT

REVISION HISTORY

Version	Date	Revisions
1.0	2021.3.20	First version with CAN/RS485 protocols supported
1.1	2021.5.10	'Retrieve Indicator' command added to 'Status Commands' list to retrieve indicators in runtime
1.2	2021.5.20	Change float format from Q24 to IEEE
1.3	2021.7.15	"Refresh Configuration" command added
1.4	2021.9.2	'CAN Baud Rate', 'Flux Weakening Default KP' and 'Flux Weakening KI' added to 'Configuration List'
1.5	2022.3.2	✓ 'Encoder Direction' added to 'Configuration List' ✓ 'Mechanical Angle of Output Shaft' added to 'Indicator List'
1.6	2022.7.25	Change command values with each added with 0x70, i.e., 0x11 changed to 0x81, and so on.
1.7	2022.8.5	'CAN Protocol' added to 'Configuration List'
1.8	2022.8.9	'Zero Position'/'Power-off Position' meaning changed from multi-turn to angle in one revolution
	2022.9.23	'Over Temperature Threshold' added in configuration list
2.0	2022.11.10	✓ 'Update Firmware' command added ✓ 'Zero Position'/'Power-off Position' resolution changed from 14bit to 16bit ✓ 'Speed'/'Output Power' added to 'Indicator List' ✓ Return current temperature, position, speed and torque in the response of 'Torque Control'/'Speed Control'/'Position Control'
2.1	2022.12.20	✓ Parameter format in 'Modify Parameter' changed from IEEE float to 32-bit unsigned int ✓ 'Encoder Direction' removed from 'Configuration List'
2.2	2023.8.30	RS485 protocol support

1 SCOPE

Protocols specified in this document apply to:

1) SteadyWin® GIM series motor drivers
2) Hardware interfaces: CAN/RS485/RS232

2 BASICS

SteadyWin® GIM protocols basic functions:

1) Motor configurations
2) Motor control
3) Retrieve/Modify motor parameters
4) Retrieve motor runtime indicators

3 SPECIFICATION

3.1 BASICS

3.1.1 Hardware Specification

CAN	**RS485/RS232**
1. Baud Rate: < 1Mbps 2. ID：customized 3. Frame Format: Data 4. Frame Type: Standard **5.** DLC：8	1. Baud Rate: 921600 2. Stop Bits: 1bit 3. Data Bits: 8bit 4. Parity: No

Table 1 Hardware Specification

3.1.2 General Specification

3.1.2.1 CAN

Item	**Specification**	**Comment**
Frame Header	None	
Frame Payload	8 Bytes	
Byte Order	LSB	
Frame	Refers to 3.2	
Modulation	No (Base Band)	

Table 2 CAN Protocol

3.1.2.2 RS485

Item	Specification	Comment
Frame Header	4 bytes Byte0 | Byte1 | Byte2 | Byte3 ID | Type | Len | CRC	➢ ID: Identifier for the receiver on the bus ➢ Type: 0 for normal frame, and 1 for ACK frame. Note: ACK frame is only for fault situation like CRC fault, frame length error, etc. ➢ Len: Frame payload length ➢ CRC: XOR of the above three bytes
Frame Payload	8 Bytes	
Byte Order	LSB	
Frame	Refers to 3.2	
Modulation	No (Base Band)	

Table 3 RS485 Protocol

3.2 FRAME SPECIFICATION

The first byte of the frame is called COMMAND as listed in Table 4：

Frame Type	Command	Command Byte
Configuration	Reset Configuration	0x81
	Refresh Configuration	0x82
	Modify Configuration	0x83
	Retrieve Configuration	0x84
Control	Start Motor	0x91
	Stop Motor	0x92
	Torque Control	0x93
	Speed Control	0x94
	Position Control	0x95
	PTS (Position/Torque/Speed) Control	0x96
	Stop Control	0x97
Parameter	Modify Parameter	0xA1
	Retrieve Parameter	0xA2
Status	Get Version	0xB1
	Get Fault	0xB2
	Acknowledge Fault	0xB3
	Retrieve Indicator	0xB4
Update	Update Firmware	0xC1

Table 4 COMMAND list

3.2.1 Reset Configuration

Upon receiving this COMMAND, all configuration items should be reset to default values.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x81	NULL	NULL	NULL	NULL	NULL	NULL	NULL

NULL indicates any value, which does not affect result of the command execution.

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x81	RES	NULL	NULL	NULL	NULL	NULL	NULL

RES is the result code as listed:

RES	**Comment**
0x00	Success
0x01	Failure
0x02	Failure, Unknown Command
0x03	Failure, Unknown ID
0x04	Failure, Read-Only Register
0x05	Failure, Unknown Register
0x06	Failure, String Format
0x07	Failure, Data Format Error
0x0B	Failure, Write-Only Register

Table 5 Result Code list

3.2.2 Refresh Configuration

Upon receiving this COMMAND, all previously modified configurations should be applied.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x82	NULL	NULL	NULL	NULL	NULL	NULL	NULL

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x82	RES	NULL	NULL	NULL	NULL	NULL	NULL

3.2.3 Modify Configuration

Upon receiving this COMMAND, configuration item according to ConfType/ConfID should be modified and applied immediately or after reboot.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x83	ConfType	ConfID	NULL	DATA0	DATA1	DATA2	DATA3

Where ConfType indicates configuration item's value type as listed:

ConfType	Comment
0x00	32-bit signed integer
0x01	32-bit signed float

Table 6 Configuration Type

And ConfID indicates Configuration item ID as listed:

ConfType	ConfID	Comment	Permision	Effective
0x00 (32-bit signed integer)	0x00	Pole Pairs	R/W	Immediately
	0x01	Rated Current (A)	R/W	Immediately
	0x02	Max Speed (RPM)	R/W	Immediately
	0x06	Rated Voltage (V)	R/W	Immediately
	0x07	PWM Frequency (Hz)	R/W	After reboot
	0x08	Default KP of Current Loop	R/W	Immediately
	0x09	Default KI of Current Loop	R/W	Immediately
	0x0C	Default KP of Speed Loop	R/W	Immediately
	0x0D	Default KI of Speed Loop	R/W	Immediately
	0x0E	Default KP of Position Loop	R/W	Immediately
	0x0F	Default KI of Position Loop	R/W	Immediately
	0x10	Default KD of Position Loop	R/W	Immediately
	0x11	Gear Ratio	R/W	Immediately
	0x12	CAN ID	R/W	Immediately
	0x13	Host/Master CAN ID	R/W	Immediately
	0x14	Zero Position (Output Shaft)	R/W	Immediately
	0x15	Power-Off Position (Output Shaft)	R	Immediately
	0x16	Over Voltage Threshold (V)	R/W	Immediately
	0x17	Under Voltage Threshold (V)	R/W	Immediately
	0x18	CAN Baud Rate	R/W	Immediately
	0x19	Default KP of Flux Weakening	R/W	Immediately
	0x1A	Default KI of Flux Weakening	R/W	Immediately
	0x20	Over Temperature Threshold	R/W	Immediately
	0x1C	Protocol over CAN 0：SteadyWin GIM (Default) 1：MIT	R/W	Immediately
0x01 (32-bit signed float)	0x00	Rs (Ω)	R/W	Immediately
	0x01	Ls (H)	R/W	Immediately
	0x02	Back EMF Constant (Vrms/kRPM)	R/W	Immediately
	0x03	Torque Constant (N.m/A)	R/W	Immediately

	0x04	Sampling Resistor (Ω)	R/W	Immediately
	0x05	Amplification Gain	R/W	Immediately

Table 7 Configuration list

DATA0~DATA3 are value of configuration item with byte order of LSB. When ConfType=0x00 they can be converted into target value:

targetValue = ((int32_t)DATA3<<24) | ((int32_t)DATA2<<16) | ((int32_t)DATA2<<8) | DATA0

And when ConfType=0x01 they should be treated as IEEE float with byte order of LSB。

Zero Position and Power-Off Position are 16-bit integers, which are able to be used as parameters to control motor, and in this situation, they should be converted to RAD:

position(RAD) = position(int) * 2 π /65536

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x83	ConfType	ConfID	RES	NULL	NULL	NULL	NULL

3.2.4 Retrieve Configuration

Upon receiving this COMMAND, configuration item according to ConfType/ConfID should be returned to Host。

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x84	ConfType	ConfID	NULL	NULL	NULL	NULL	NULL

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x84	ConfType	ConfID	RES	DATA0	DATA1	DATA2	DATA3

Please refer to Table 6 for ConfType definitions and Table 7 for ConfID definitions. For DATA0~DATA3 please refer to 3.2.3.

3.2.5 Start Motor

Upon receiving this COMMAND, motor should be started and enter running state.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x91	NULL	NULL	NULL	NULL	NULL	NULL	NULL

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x91	RES	NULL	NULL	NULL	NULL	NULL	NULL

3.2.6 Stop Motor

Upon receiving this COMMAND, motor should be stopped and exit running state.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x92	NULL	NULL	NULL	NULL	NULL	NULL	NULL

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x92	RES	NULL	NULL	NULL	NULL	NULL	NULL

3.2.7 Torque Control

Upon receiving this COMMAND, motor should enter Torque Control mode and reach the torque target according to the command parameter.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x93	Torque0	Torque1	Torque2	Torque3	Duration0	Duration1	Duration2

Where Torque0~Torque3 are value of target torque with byte order of LSB and in unit of N.m. It is represented using IEEE format and can be converted into float value with correct byte order.

Duration0~Duration2 are 24-bit unsigned integer indicating torque control execution time in unit of ms.

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x93	RES	Temp	Pos0	Pos1	ST0	ST1	ST2

Where Temp is the current temperature of motor or driver board depending on which is available or which is higher if both are available.

Pos0~Pos1 are value of current position with byte order of LSB and in unit of RAD. The actual position value is float:

pos_float = pos_int * 25 / 65535 – 12.5

ST0~ST2 are the encoding result of current speed and torque. 12-bit speed is formed of ST0 as its higher 8 bits and ST1[7-4] as its lower 4 bits. The actual speed value is float in RAD/s:

speed_float = speed_int * 130 / 4095 – 65

12-bit torque is formed of ST2 as its lower 8 bits and ST1[3-0] as its higher 4 bits. The actual torque value is float in N.m:

torque_float = torque_int * (450 * torque_constant * gear_ratio) / 4095 – 225 * torque_constant * gear_ratio

3.2.8 Speed Control

Upon receiving this COMMAND, motor should enter Speed Control mode and reach the speed target according to the command parameter.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x94	Speed0	Speed 1	Speed 2	Speed 3	Duration0	Duration1	Duration2

Where Speed0~ Speed3 are value of target speed with byte order of LSB and in unit of RPM. It is represented using IEEE format and can be converted into float value with correct byte order.

Duration0~Duration2 are 24-bit unsigned integer indicating speed control execution time in unit of ms.

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x94	RES	Temp	Pos0	Pos1	ST0	ST1	ST2

Please refer to 3.2.7 for detailed explanation of Temp/Pos0~Pos1/ST0~ST2.

3.2.9 Position Control

Upon receiving this COMMAND, motor should enter Position Control mode and reach the position target according to the command parameter.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x95	Pos0	Pos 1	Pos 2	Pos 3	Duration0	Duration1	Duration2

Where Pos0~ Pos3 are value of target position with byte order of LSB and in unit of RAD. It is represented using IEEE format and can be converted into float value with correct byte order.

Duration0~Duration2 are 24-bit unsigned integer indicating position control execution time in unit of ms.

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x95	RES	Temp	Pos0	Pos1	ST0	ST1	ST2

Please refer to 3.2.7 for detailed explanation of Temp/Pos0~Pos1/ST0~ST2

3.2.10PTS Control

Not supported.

3.2.11Stop Control

Upon receiving this COMMAND, current ongoing control command should be stopped immediately, and if there is no ongoing control command it is just ignored.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x97	NULL	NULL	NULL	NULL	NULL	NULL	NULL

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0x97	RES	NULL	NULL	NULL	NULL	NULL	NULL

3.2.12Modify Parameter

Upon receiving this COMMAND, parameter corresponding to ParaID should be modified and applied immediately.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xA1	ParaID	NULL	NULL	DATA0	DATA1	DATA2	DATA3

Where ParaID indicates parameter ID as listed:

ParaID	Comment	Permission	Effective
0x00	Runtime KP of Current Loop	R/W	Immediately
0x01	Runtime KI of Current Loop	R/W	Immediately
0x02	Runtime KP of Speed Loop	R/W	Immediately
0x03	Runtime KI of Speed Loop	R/W	Immediately
0x04	Runtime KP of Position Loop	R/W	Immediately
0x05	Runtime KI of Position Loop	R/W	Immediately
0x06	Runtime KD of Position Loop	R/W	Immediately

0x07	Runtime KP of Flux Weakening	R/W	Immediately
0x08	Runtime KI of Flux Weakening	R/W	Immediately

Table 8 Parameter list

Where DATA0~DATA3 are parameter value in 32-bit unsigned int with byte order of LSB.

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xA1	ParaID	RES	NULL	NULL	NULL	NULL	NULL

3.2.13 Retrieve Parameter

Upon receiving this COMMAND, parameter corresponding to ParaID should be returned to host.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xA2	ParaID	NULL	NULL	NULL	NULL	NULL	NULL

For ParaID definitions please refer to Table 8.

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xA2	ParaID	RES	NULL	DATA0	DATA1	DATA2	DATA3

For DATA0~DATA3 please refer to 3.2.12.

3.2.14 Get Version

Current version of motor driver should be returned to host upon receiving this COMMAND.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xB1	NULL	NULL	NULL	NULL	NULL	NULL	NULL

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xB1	RES	NULL	NULL	DATA0	DATA1	DATA2	DATA3

Where DATA0~DATA3 32-bit unsigned integer indicating version number:

version = ((int32_t)DATA3<<24) | ((int32_t)DATA2<<16) | ((int32_t)DATA2<<8) | DATA0

3.2.15Get Fault

Fault may occur during motor running time, and host should get fault status periodically using this COMMAND.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xB2	NULL	NULL	NULL	NULL	NULL	NULL	NULL

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xB2	RES	FaultNo	NULL	NULL	NULL	NULL	NULL

Where FaultNo indicates fault number as listed:

FaultNo	Comment
0x00	No Fault
0x01	FoC Frequency Too High
0x02	Over Voltage
0x04	Under Voltage
0x08	Over Temperature
0x10	Start Failure
0x40	Over Current
0x80	Software Exception

Table 9 Fault List

3.2.16Acknowledge Fault

On any fault, motor would stop running and wait host command. If you want to continue running, this COMMAND should be sent to erase fault status and return to normal state. If fault is not acknowledged in runtime, motor driver will decline any COMMANDs from host.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xB3	NULL	NULL	NULL	NULL	NULL	NULL	NULL

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xB3	RES	NULL	NULL	NULL	NULL	NULL	NULL

3.2.17Retrieve Indicator

Upon receiving this COMMAND, indicator according to IndID should be returned to host.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xB4	IndID	NULL	NULL	NULL	NULL	NULL	NULL

Where IndID indicates indicator ID as listed:

IndID	Comment
0x00	Bus Voltage (V)
0x01	Driver Board Temperature
0x02	Motor Temperature
0x03	Power (W)
0x04	Ia (A)
0x05	Ib (A)
0x06	Ic (A)
0x07	Ialpha (A)
0x08	Ibeta(A)
0x09	Iq (A)
0x0A	Id (A)
0x0B	Target Iq (A)
0x0C	Target Id(A)
0x0D	Vq (V)
0x0E	Vd (V)
0x0F	Valpha (V)
0x10	Vbeta (V)
0x11	Electronical Angle of Rotor (RAD)
0x12	Mechanical Angle of Rotor (RAD)
0x13	Mechanical Angle of Output Shaft (RAD)
0x14	Speed (Output Shaft) (RPM)
0x15	Output Power (W)

Table 10 Indicator list

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xB4	IndID	RES	NULL	DATA0	DATA1	DATA2	DATA3

Where DATA0~DATA3 indicates indicator value with IEEE float format, and can be converted into float with byte order of LSB.

3.2.18Calibration

Upon receiving this COMMAND, driver enters calibration state and calibrates phase order or encoder.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xB5	CaliType	NULL	NULL	NULL	NULL	NULL	NULL

Where CaliType indicates the calibration type:

CaliType	Comment
0x00	phase order calibration
0x01	encoder calibration

Table 11 Calibration Type List

- Driver→Host

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xB4	CaliType	RES	NULL	NULL	NULL	NULL	NULL

3.2.19Update Firmware

Upon receiving this COMMAND, driver enters firmware updating mode. No response should be expected.

- Host→Driver

BYTE0	BYTE1	BYTE2	BYTE3	BYTE4	BYTE5	BYTE6	BYTE7
0xC1	IndID	NULL	NULL	NULL	NULL	NULL	NULL