G-Port HEQ Gimbal Communication Protocol

1、 Frame Structure Definition

Frame Header	Version	Length	Command	Frame Header Checksum	Data	Data Checksum

Frame structure field explanation

Field	Size (byte)	Data Type	Remarks
Frame Header	1	uint8_t	the starting value of 1 frame data is fixed to 0XAE
Version	1	uint8_t	protocol version, currently 0x01
Length	1	uint8_t	the length of the data segment content
Command	1	uint8_t	different commands correspond to different functions
Frame Header Checksum	1	uint8_t	Version, length, and command **checksum**
Data	N		Different meanings depending on different messages, see the **Protocol Details** section
Data Checksum	4	uint32_t	CRC32 value of data segment content, no data field means no CRC32 content. See **crc32.c** for CRC32 calculation code

Unless otherwise specified, the fields are all little-endian bytes. From the Assistant software/flight control/car to the gimbal is downlink, and vice versa is uplink.

2、 Protocol Details

2.1、Gimbal Function Reading

Command：0x13

Data field: None

Data flow: Downlink

Send example：AE 01 00 13 14

Example description: There is no data field, so there is no need to add CRC32 check. The same applies to the subsequent steps.

2.2、Gimbal Function Reading Return

command：0x14

Data field：Length: 15 bytes

Index	Type	Function Description	Remarks
0-10		Reserved	No practical use
11	uint8_t	Dead zone range	0-255
12	uint8_t	Following speed	When it is 0, it does not follow the aircraft head, other values follow the aircraft head
13	int8_t	Gimbal inversion	-1 means inverted, 1 means upright
14		Reserved	No practical use

Data flow：uplink

Return example：AE 01 0F 14 24 00 00 00 00 00 00 00 00 00 00 00 32 0A FF 00 26 37 1B BA

Example description: Dead zone range 32=50; follow speed 0A=10; FF=-1 inverted

2.3、Gimbal Function Setting

command：0x15

Data field：Length: 15 bytes

Index	Type	Function Description	Remarks

0-10		Reserved	No practical use
11	uint8_t	Dead zone range	0-255
12	uint8_t	Following speed	When it is 0, it does not follow the aircraft head, other values follow the aircraft head
13	int8_t	Gimbal inversion	-1 means inverted, 1 means upright
14		Reserved	No practical use

Data flow：downlink

Return example：AE 01 0F 15 25 00 00 00 00 00 00 00 00 00 00 00 32 0A FF 00 26 37 1B BA
Example description: Dead zone range 32=50; follow speed 0A=10; FF=-1 inverted

2.4、Gimbal Function Setting Return

Command：0x16

Data field：None

Data flow：uplink

Return example：AE 01 00 16 17

2.5、Gimbal Control Command

Command：0x85

Data field：Length: 13 bytes

Index	Type	Function Description	Remarks
0	int8_t	Control mode	1. Speed control 2. Angle control 3. gimbal return to center 4. Lock mode
1-2	int16 t	Roll angle control parameters	The angle unit is 0.01°
3-4	int16 t	Pitch angle control parameters	The angle unit is 0.01°
5-6	int16 t	Yaw angle control parameters	The angle unit is 0.01°

7-8	int16_t	Roll speed control parameters	The speed unit is 0.01°/s
9-10	int16_t	Pitch speed control parameters	The speed unit is 0.01°/s
11-12	int16_t	Yaw speed control parameters	The speed unit is 0.01°/s

Data flow：downlink

Send example：

Speed control Yaw 30°/sec: AE 01 0D 85 93 01 00 00 00 00 00 00 00 00 00 00 B8 0B CC F5 E1 63

Angle control: Rotate yaw to 30°: AE 01 0D 85 93 02 00 00 00 00 B8 0B 00 00 00 00 00 00 76 AB AF 70

Gimbal return to center: AE 01 0D 85 93 03 00 00 00 00 00 00 00 00 00 00 00 00 44 06 BE 68

Lock mode: AE 01 0D 85 93 04 00 00 00 00 00 00 00 00 00 00 00 00 9B 5B 72 2F

Note: Speed control is similar to joystick control. If only one piece of data is sent, the gimbal will move at that speed for 1 second and then stop. To achieve continuous control, it is recommended to send speed control to the gimbal at a frequency of 10HZ. If you want to stop immediately, you need to send a speed control command with a speed of 0. Otherwise, the gimbal will move at the speed sent by the last speed control command for 1 second and then stop.

2.6、Gimbal Angle Push(V1.0.0)

Command：0x87

Data field：Length: 12 bytes

Index	Type	Function Description	Remarks
0-1	int16 t	IMU_ROLL	IMU roll angle*100
2-3	int16 t	IMU_PICTH	IMU pitch angle*100
4-5	int16 t	IMU_YAW	IMU yaw angle*100
6-7	int16 t	Hall Angle_ROLL	Hall roll angle*100
8-9	int16 t	Hall Angle_PITCH	Hall pitch angle*100
10-11	int16 t	Hall Angle_YAW	Hall yaw angle*100

Data flow：uplink

Return example：AE 01 0C 87 94 00 00 00 00 A7 F0 7F F8 F0 FF D2 01 44 0D AD 53

Example description：

IMU roll angle 00 00 =0； IMU pitch angle 00 00 =0； IMU yaw angle A7 F0 =-3929=-39.29*100；

Hall roll angle 7F F8 =-1921=-19.21；Hall pitch angle F0 FF =-16=-0.16*100；Hall yaw angle D2 01 =466=4.66*100；

2.7、Gimbal Angle Push(V2.0.0)

command：0x87

Data field：Length: 24 bytes

Index	Type	Function Description	Remarks
0-1	int16_t	IMU_ROLL	IMU roll angle*100
2-3	int16_t	IMU_PICTH	IMU pitch angle*100
4-5	int16_t	IMU_YAW	IMU yaw angle*100
6-7	int16_t	Hall Angle_ROLL	Hall roll angle*100
8-9	int16_t	Hall Angle_PITCH	Hall pitch angle*100
10-11	int16_t	Hall Angle_YAW	Hall yaw angle*100
12-13	int16_t	Hall Angle ROLL_angular velocity	Hall roll angular velocity*100
14-15	int16_t	Hall Angle PICTH_angular velocity	Hall pitch angular velocity*100
16-17	int16_t	Hall Angle YAW_angular velocity	Hall yaw angular velocity*100
18-19	int16_t	IMU_X_angular velocity	IMU_X angular velocity*100
20-21	int16_t	IMU_Y_angular velocity	IMU_Y angular velocity*100
22-23	int16_t	IMU_Z_angular velocity	IMU_Z angular velocity*100

Data flow：uplink

Return example：AE 01 18 87 A0 00 00 00 00 AF 00 91 FF 03 00 00 00 F8 FF F1 FF 01 00 F8 FF F1 FF 01 00 E0 32 7E 13

Example description：

IMU roll angle 00 00 =0； IMU pitch angle 00 00 =0； IMU yaw angle AF 00 =175=1.75*100；

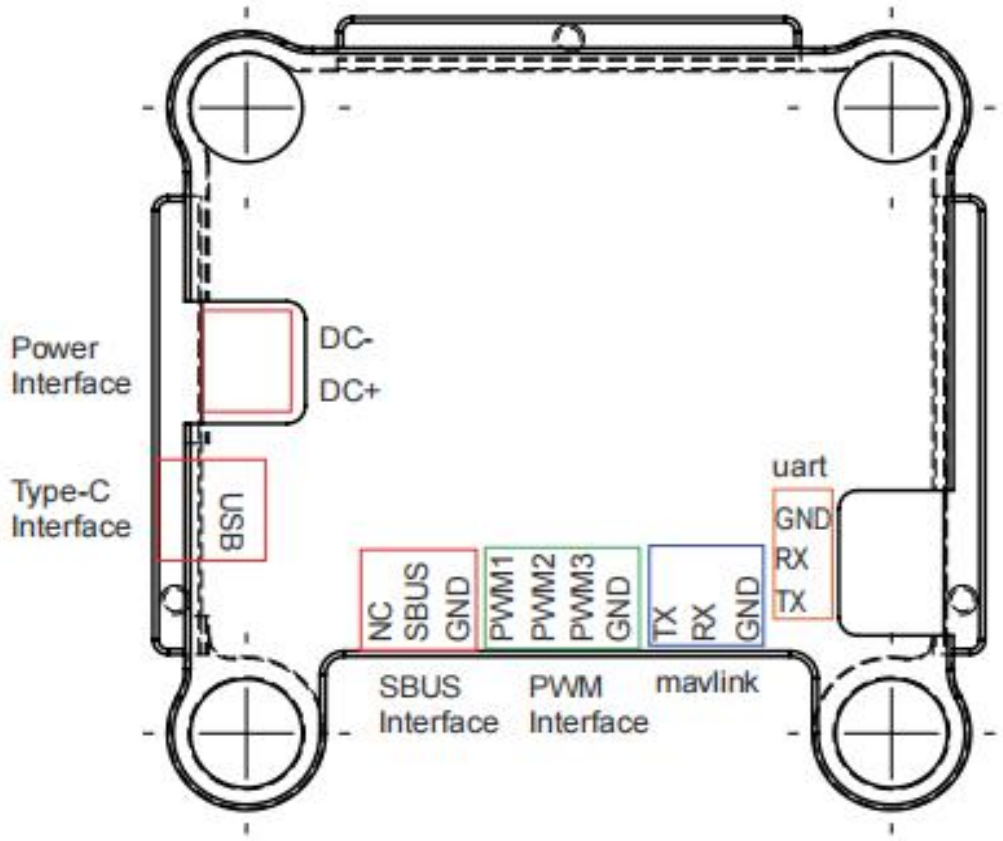
Hall roll angle 91 FF =-110=-1.10*100； Hall pitch angle 03 00 =3=0.03*100； Hall yaw angle 00 00 =0；

Hall roll angular velocity F8 FF =-7=-0.07*100; Hall pitch angular velocity F1 FF =-14=-0.14*100; Hall yaw angular velocity 01 00 =1=0.01*100;

IMU_X angular velocity F8 FF =-7=-0.07*100; IMU_Y angular velocity F1 FF =-14=-0.14*100; IMU_Z angular velocity 01 00 =1=0.01*100

3、 G-Port Serial Communication Precautions

The communication interface is as shown below: UART port; baud rate 115200; data bit 8bt, stop bit 1; no parity check; if the wiring and configuration are correct, the serial port will always receive the gimbal attitude report starting with AE.



Appendix, CRC32 calculation (C language version)

```
uint32 Crc32Table[ 256 ] =
{
  0x00000000, 0x04C11DB7, 0x09823B6E, 0x0D4326D9, 0x130476DC, 0x17C56B6B,
  0x1A864DB2, 0x1E475005, 0x2608EDB8, 0x22C9F00F, 0x2F8AD6D6, 0x2B4BCB61,
  0x350C9B64, 0x31CD86D3, 0x3C8EA00A, 0x384FBDBD, 0x4C11DB70, 0x48D0C6C7,
  0x4593E01E, 0x4152FDA9, 0x5F15ADAC, 0x5BD4B01B, 0x569796C2, 0x52568B75,
  0x6A1936C8, 0x6ED82B7F, 0x639B0DA6, 0x675A1011, 0x791D4014, 0x7DDC5DA3,
  0x709F7B7A, 0x745E66CD, 0x9823B6E0, 0x9CE2AB57, 0x91A18D8E, 0x95609039,
  0x8B27C03C, 0x8FE6DD8B, 0x82A5FB52, 0x8664E6E5, 0xBE2B5B58, 0xBAEA46EF,
  0xB7A96036, 0xB3687D81, 0xAD2F2D84, 0xA9EE3033, 0xA4AD16EA, 0xA06C0B5D,
  0xD4326D90, 0xD0F37027, 0xDDB056FE, 0xD9714B49, 0xC7361B4C, 0xC3F706FB,
  0xCEB42022, 0xCA753D95, 0xF23A8028, 0xF6FB9D9F, 0xFBB8BB46, 0xFF79A6F1,
  0xE13EF6F4, 0xE5FFEB43, 0xE8BCCD9A, 0xEC7DD02D, 0x34867077, 0x30476DC0,
  0x3D044B19, 0x39C556AE, 0x278206AB, 0x23431B1C, 0x2E003DC5, 0x2AC12072,
  0x128E9DCF, 0x164F8078, 0x1B0CA6A1, 0x1FCDBB16, 0x018AEB13, 0x054BF6A4,
  0x0808D07D, 0x0CC9CDCA, 0x7897AB07, 0x7C56B6B0, 0x71159069, 0x75D48DDE,
  0x6B93DDDB, 0x6F52C06C, 0x6211E6B5, 0x66D0FB02, 0x5E9F46BF, 0x5A5E5B08,
  0x571D7DD1, 0x53DC6066, 0x4D9B3063, 0x495A2DD4, 0x44190B0D, 0x40D816BA,
  0xACA5C697, 0xA864DB20, 0xA527FDF9, 0xA1E6E04E, 0xBFA1B04B, 0xBB60ADFC,
  0xB6238B25, 0xB2E29692, 0x8AAD2B2F, 0x8E6C3698, 0x832F1041, 0x87EE0DF6,
  0x99A95DF3, 0x9D684044, 0x902B669D, 0x94EA7B2A, 0xE0B41DE7, 0xE4750050,
  0xE9362689, 0xEDF73B3E, 0xF3B06B3B, 0xF771768C, 0xFA325055, 0xFEF34DE2,
  0xC6BCF05F, 0xC27DEDE8, 0xCF3ECB31, 0xCBFFD686, 0xD5B88683, 0xD1799B34,
  0xDC3ABDED, 0xD8FBA05A, 0x690CE0EE, 0x6DCDFD59, 0x608EDB80, 0x644FC637,
  0x7A089632, 0x7EC98B85, 0x738AAD5C, 0x774BB0EB, 0x4F040D56, 0x4BC510E1,
  0x46863638, 0x42472B8F, 0x5C007B8A, 0x58C1663D, 0x558240E4, 0x51435D53,
  0x251D3B9E, 0x21DC2629, 0x2C9F00F0, 0x285E1D47, 0x36194D42, 0x32D850F5,
  0x3F9B762C, 0x3B5A6B9B, 0x0315D626, 0x07D4CB91, 0x0A97ED48, 0x0E56F0FF,
  0x1011A0FA, 0x14D0BD4D, 0x19939B94, 0x1D528623, 0xF12F560E, 0xF5EE4BB9,
  0xF8AD6D60, 0xFC6C70D7, 0xE22B20D2, 0xE6EA3D65, 0xEBA91BBC, 0xEF68060B,
  0xD727BBB6, 0xD3E6A601, 0xDEA580D8, 0xDA649D6F, 0xC423CD6A, 0xC0E2D0DD,
  0xCDA1F604, 0xC960EBB3, 0xBD3E8D7E, 0xB9FF90C9, 0xB4BCB610, 0xB07DABA7,
  0xAE3AFBA2, 0xAAFBE615, 0xA7B8C0CC, 0xA379DD7B, 0x9B3660C6, 0x9FF77D71,
  0x92B45BA8, 0x9675461F, 0x8832161A, 0x8CF30BAD, 0x81B02D74, 0x857130C3,
  0x5D8A9099, 0x594B8D2E, 0x5408ABF7, 0x50C9B640, 0x4E8EE645, 0x4A4FFBF2,
  0x470CDD2B, 0x43CDC09C, 0x7B827D21, 0x7F436096, 0x7200464F, 0x76C15BF8,
  0x68860BFD, 0x6C47164A, 0x61043093, 0x65C52D24, 0x119B4BE9, 0x155A565E,
  0x18197087, 0x1CD86D30, 0x029F3D35, 0x065E2082, 0x0B1D065B, 0x0FDC1BEC,
  0x3793A651, 0x3352BBE6, 0x3E119D3F, 0x3AD08088, 0x2497D08D, 0x2056CD3A,
  0x2D15EBE3, 0x29D4F654, 0xC5A92679, 0xC1683BCE, 0xCC2B1D17, 0xC8EA00A0,
  0xD6AD50A5, 0xD26C4D12, 0xDF2F6BCB, 0xDBEE767C, 0xE3A1CBC1, 0xE760D676,
  0xEA23F0AF, 0xEEE2ED18, 0xF0A5BD1D, 0xF464A0AA, 0xF9278673, 0xFDE69BC4,
  0x89B8FD09, 0x8D79E0BE, 0x803AC667, 0x84FBDBD0, 0x9ABC8BD5, 0x9E7D9662,
  0x933EB0BB, 0x97FFAD0C, 0xAFB010B1, 0xAB710D06, 0xA6322BDF, 0xA2F33668,
  0xBCB4666D, 0xB8757BDA, 0xB5365D03, 0xB1F740B4 };
```

```
//Lookup table method
uint32 crc_32(uint8 *pData, uint16 Length)
{

  uint32nReg; //CRC Register
   uint32 nTemp = 0;
   uint16 i, n;

   nReg = 0xFFFFFFFF; //
   for ( n = 0; n < Length; n++ )
   {
     nReg ^= (uint32) pData [ n ];

     for ( i = 0; i < 4; i++ )
     {
       nTemp = Crc32Table [ ( uint8 )( ( nReg >> 24 ) & 0xff ) ]; //Take a byte and look up the table
       nReg <<= 8; //Discard the last calculated BYTE
       nReg ^= nTemp; //XOR with the calculation result of the previous BYTE
       }
   }
   return nReg;
}
```

G-Port 禾启云台通信协议-250224

一、 帧结构定义

帧头	版本	长度	指令	帧头校验	数据	数据校验

帧结构字段解释

字段	大小(byte)	数据类型	备注
帧头	1	uint8_t	—帧数据的起始值,固定为0XAE
版本	1	uint8_t	协议版本，目前为0x01
长度	1	uint8_t	数据段内容的长度
指令	1	uint8_t	不同的指令对应不同的功能
帧头校验	1	uint8_t	版本、长度、指令的校验和
数据	N		根据不同的消息有不同的含义 ,具体见协议详解 部分
数据校验	4	uint32_t	数据段内容的CRC32值,无数据域则无CRC32内容。 CRC32计算代码见crc32.c

无特别说明， 字段内都为小端字节。上位机/飞控/小车等到云台为下行，反之为上行。

二、 协议详解

2.1、云台功能读取

指令：0x13

数据域：无

数据流向：下行

发送示例：AE 01 00 13 14

示例说明：无数据域所以无需添加CRC32校验，后续同理。

2.2、云台功能读取返回

指令：0x14

数据域：长度15字节

Index	类型	功能描述	备注
0-10		预留	暂无实际用途
11	uint8_t	死区范围	0-255
12	uint8_t	跟随速度	为0的时候不跟机头，其他值跟机头
13	int8_t	云台倒置	-1表示倒置，1表示正放
14		预留	暂无实际用途

数据流向：上行

返回示例：AE 01 0F 14 24 00 00 00 00 00 00 00 00 00 00 00 32 0A FF 00 26 37 1B BA

示例说明：死区范围 32=50；跟随速度0A=10； FF=-1倒置

2.3、云台功能设置

指令：0x15

数据域：长度15字节

Index	类型	功能描述	备注

0-10		预留	暂无实际用途
11	uint8_t	死区范围	0-255
12	uint8_t	跟随速度	为0的时候不跟机头，其他值跟机头
13	int8_t	云台倒置	-1表示倒置，1表示正放
14		预留	暂无实际用途

数据流向：下行

返回示例：AE 01 0F 15 25 00 00 00 00 00 00 00 00 00 00 00 32 0A FF 00 26 37 1B BA

示例说明：死区范围 32=50；跟随速度0A=10； FF=-1倒置

2.4、云台功能设置返回

指令：0x16

数据域：无

数据流向：上行

返回示例：AE 01 00 16 17

2.5、云台控制指令

指令：0x85

数据域：长度13字节

Index	类型	功能描述	备注
0	int8_t	控制模式	1、速度控制 2、角度控制 3、云台回中 4、锁定模式
1-2	int16_t	roll角度控制参数	角度单位为0.01度
3-4	int16_t	pitch角度控制参数	角度单位为0.01度
5-6	int16_t	yaw角度控制参数	角度单位为0.01度

7-8	int16_t	roll速度控制参数	速度单位为0.01度/秒
9-10	int16_t	pitch速度控制参数	速度单位为0.01度/秒
11-12	int16_t	yaw速度控制参数	速度单位为0.01度/秒

数据流向：下行

发送示例：

速度控制 偏航30°/秒：AE 01 0D 85 93 01 00 00 00 00 00 00 00 00 00 00 B8 0B CC F5 E1 63

角度控制 转动偏航到30°：AE 01 0D 85 93 02 00 00 00 00 B8 0B 00 00 00 00 00 00 76 AB AF 70

云台回中：AE 01 0D 85 93 03 00 00 00 00 00 00 00 00 00 00 00 00 44 06 BE 68

锁定模式：AE 01 0D 85 93 04 00 00 00 00 00 00 00 00 00 00 00 00 9B 5B 72 2F

说明：速度控制类似摇杆控制，只发送一条数据则云台以该速度运动一秒后停止，实现连续控制建议以10HZ的频率向云台发送速度控制，且如果想立即停止需发送一条速度为0的速度控制指令。否则云台会以最后一条速度控制指令发送的速度运动一秒后再停止。

2.6、云台角度推送(V1.0.0)

指令：0x87

数据域：长度12字节

Index	类型	功能描述	备注
0-1	int16_t	IMU_ROLL	IMU横滚角*100
2-3	int16_t	IMU_PICTH	IMU俯仰角*100
4-5	int16_t	IMU_YAW	IMU偏航角*100
6-7	int16_t	霍尔角度_ROLL	霍尔横滚角*100
8-9	int16_t	霍尔角度_PITCH	霍尔俯仰角*100
10-11	int16_t	霍尔角度_YAW	霍尔偏航角*100

数据流向：上行

返回示例：AE 01 0C 87 94 00 00 00 00 A7 F0 7F F8 F0 FF D2 01 44 0D AD 53

示例说明：

IMU横滚角 00 00 =0；IMU俯仰角 00 00 =0；IMU偏航角 A7 F0 =-3929=-39.29*100；

霍尔横滚角 7F F8 =-1921=-19.21；霍尔俯仰角 F0 FF =-16=-0.16*100；霍尔偏航角 D2 01 =466=4.66*100；

2.7、云台角度推送(V2.0.0)

指令：0x87

数据域：长度24字节

Index	类型	功能描述	备注
0-1	int16_t	IMU_ROLL	IMU横滚角*100
2-3	int16_t	IMU_PICTH	IMU俯仰角*100
4-5	int16_t	IMU_YAW	IMU偏航角*100
6-7	int16_t	霍尔角度_ROLL	霍尔横滚角*100
8-9	int16_t	霍尔角度_PITCH	霍尔俯仰角*100
10-11	int16_t	霍尔角度_YAW	霍尔偏航角*100
12-13	int16_t	霍尔角度ROLL_角速度	霍尔横滚角速度*100
14-15	int16_t	霍尔角度PICTH_角速度	霍尔俯仰角速度*100
16-17	int16_t	霍尔角度YAW_角速度	霍尔偏航角速度*100
18-19	int16_t	IMU_X_角速度	IMU_X角速度*100
20-21	int16_t	IMU_Y_角速度	IMU_Y角速度*100
22-23	int16_t	IMU_Z_角速度	IMU_Z角速度*100

数据流向：上行

返回示例：AE 01 18 87 A0 00 00 00 00 AF 00 91 FF 03 00 00 00 F8 FF F1 FF 01 00 F8 FF F1 FF 01 00 E0 32 7E 13

示例说明：

IMU横滚角 00 00 =0；IMU俯仰角 00 00 =0；IMU偏航角 AF 00 =175=1.75*100；

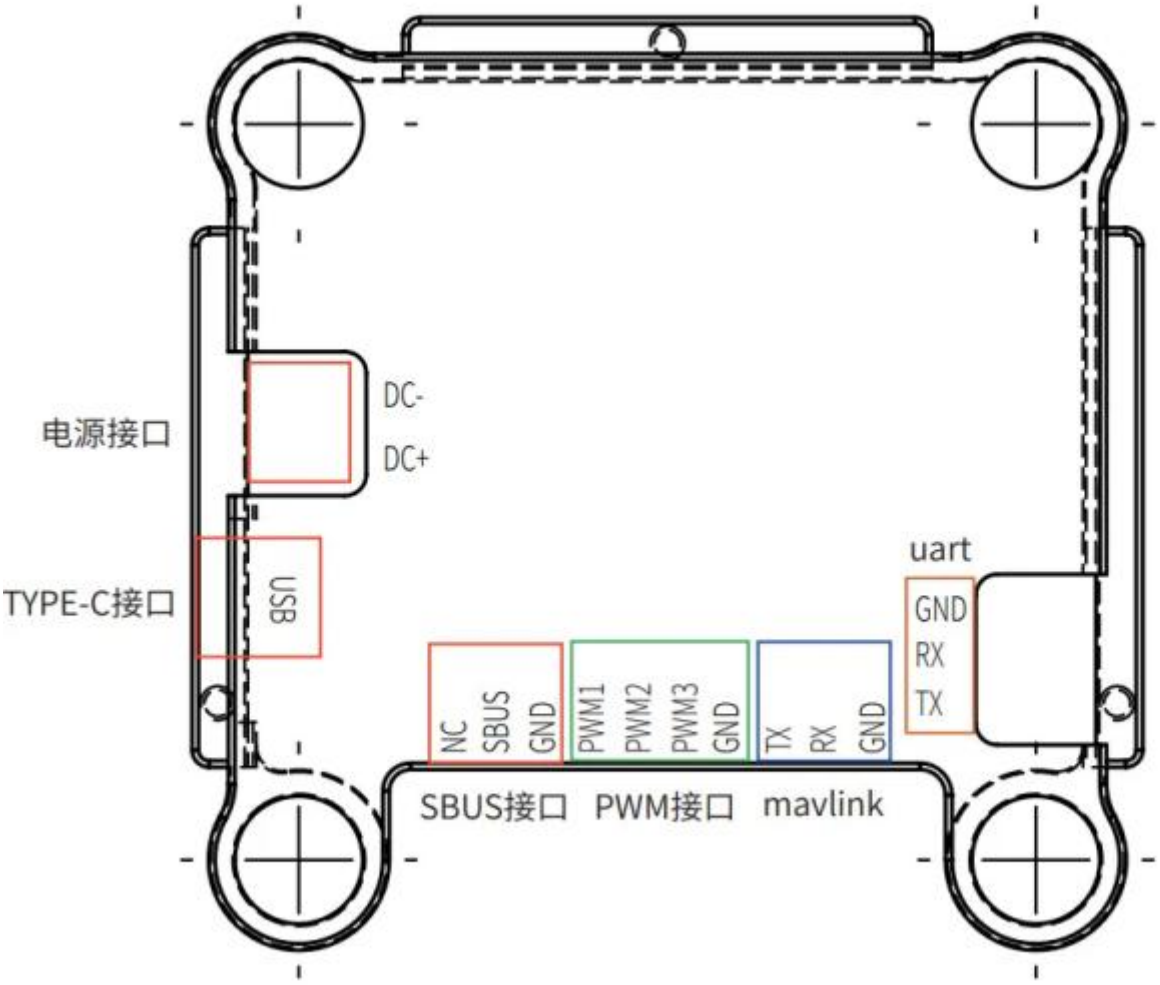
霍尔横滚角 91 FF =-110=-1.10*100；霍尔俯仰角 03 00 =3=0.03*100；霍尔偏航角 00 00 =0；

霍尔横滚角速度 F8 FF =-7=-0.07*100；霍尔俯仰角速度 F1 FF =-14=-0.14*100；霍尔偏航角速度 01 00 =1=0.01*100；

IMU_X角速度 F8 FF =-7=-0.07*100； IMU_Y角速度 F1 FF =-14=-0.14*100； IMU_Z角速度 01 00 =1=0.01*100

三、G-port串口通信注意事项

通信接口为下图UART口； 波特率 115200；数据位8bt，停止位1；无奇偶校验；接线和配置正确的情况下串口会一直收到AE开头的云台姿态上报。



附录、CRC32计算（C语言版本）

```
uint32 Crc32Table[ 256 ] =
{
  0x00000000, 0x04C11DB7, 0x09823B6E, 0x0D4326D9, 0x130476DC, 0x17C56B6B,
  0x1A864DB2, 0x1E475005, 0x2608EDB8, 0x22C9F00F, 0x2F8AD6D6, 0x2B4BCB61,
  0x350C9B64, 0x31CD86D3, 0x3C8EA00A, 0x384FBDBD, 0x4C11DB70, 0x48D0C6C7,
  0x4593E01E, 0x4152FDA9, 0x5F15ADAC, 0x5BD4B01B, 0x569796C2, 0x52568B75,
  0x6A1936C8, 0x6ED82B7F, 0x639B0DA6, 0x675A1011, 0x791D4014, 0x7DDC5DA3,
  0x709F7B7A, 0x745E66CD, 0x9823B6E0, 0x9CE2AB57, 0x91A18D8E, 0x95609039,
  0x8B27C03C, 0x8FE6DD8B, 0x82A5FB52, 0x8664E6E5, 0xBE2B5B58, 0xBAEA46EF,
  0xB7A96036, 0xB3687D81, 0xAD2F2D84, 0xA9EE3033, 0xA4AD16EA, 0xA06C0B5D,
  0xD4326D90, 0xD0F37027, 0xDDB056FE, 0xD9714B49, 0xC7361B4C, 0xC3F706FB,
  0xCEB42022, 0xCA753D95, 0xF23A8028, 0xF6FB9D9F, 0xFBB8BB46, 0xFF79A6F1,
  0xE13EF6F4, 0xE5FFEB43, 0xE8BCCD9A, 0xEC7DD02D, 0x34867077, 0x30476DC0,
  0x3D044B19, 0x39C556AE, 0x278206AB, 0x23431B1C, 0x2E003DC5, 0x2AC12072,
  0x128E9DCF, 0x164F8078, 0x1B0CA6A1, 0x1FCDBB16, 0x018AEB13, 0x054BF6A4,
  0x0808D07D, 0x0CC9CDCA, 0x7897AB07, 0x7C56B6B0, 0x71159069, 0x75D48DDE,
  0x6B93DDDB, 0x6F52C06C, 0x6211E6B5, 0x66D0FB02, 0x5E9F46BF, 0x5A5E5B08,
  0x571D7DD1, 0x53DC6066, 0x4D9B3063, 0x495A2DD4, 0x44190B0D, 0x40D816BA,
  0xACA5C697, 0xA864DB20, 0xA527FDF9, 0xA1E6E04E, 0xBFA1B04B, 0xBB60ADFC,
  0xB6238B25, 0xB2E29692, 0x8AAD2B2F, 0x8E6C3698, 0x832F1041, 0x87EE0DF6,
  0x99A95DF3, 0x9D684044, 0x902B669D, 0x94EA7B2A, 0xE0B41DE7, 0xE4750050,
  0xE9362689, 0xEDF73B3E, 0xF3B06B3B, 0xF771768C, 0xFA325055, 0xFEF34DE2,
  0xC6BCF05F, 0xC27DEDE8, 0xCF3ECB31, 0xCBFFD686, 0xD5B88683, 0xD1799B34,
  0xDC3ABDED, 0xD8FBA05A, 0x690CE0EE, 0x6DCDFD59, 0x608EDB80, 0x644FC637,
  0x7A089632, 0x7EC98B85, 0x738AAD5C, 0x774BB0EB, 0x4F040D56, 0x4BC510E1,
  0x46863638, 0x42472B8F, 0x5C007B8A, 0x58C1663D, 0x558240E4, 0x51435D53,
  0x251D3B9E, 0x21DC2629, 0x2C9F00F0, 0x285E1D47, 0x36194D42, 0x32D850F5,
  0x3F9B762C, 0x3B5A6B9B, 0x0315D626, 0x07D4CB91, 0x0A97ED48, 0x0E56F0FF,
  0x1011A0FA, 0x14D0BD4D, 0x19939B94, 0x1D528623, 0xF12F560E, 0xF5EE4BB9,
  0xF8AD6D60, 0xFC6C70D7, 0xE22B20D2, 0xE6EA3D65, 0xEBA91BBC, 0xEF68060B,
  0xD727BBB6, 0xD3E6A601, 0xDEA580D8, 0xDA649D6F, 0xC423CD6A, 0xC0E2D0DD,
  0xCDA1F604, 0xC960EBB3, 0xBD3E8D7E, 0xB9FF90C9, 0xB4BCB610, 0xB07DABA7,
  0xAE3AFBA2, 0xAAFBE615, 0xA7B8C0CC, 0xA379DD7B, 0x9B3660C6, 0x9FF77D71,
  0x92B45BA8, 0x9675461F, 0x8832161A, 0x8CF30BAD, 0x81B02D74, 0x857130C3,
  0x5D8A9099, 0x594B8D2E, 0x5408ABF7, 0x50C9B640, 0x4E8EE645, 0x4A4FFBF2,
  0x470CDD2B, 0x43CDC09C, 0x7B827D21, 0x7F436096, 0x7200464F, 0x76C15BF8,
  0x68860BFD, 0x6C47164A, 0x61043093, 0x65C52D24, 0x119B4BE9, 0x155A565E,
  0x18197087, 0x1CD86D30, 0x029F3D35, 0x065E2082, 0x0B1D065B, 0x0FDC1BEC,
  0x3793A651, 0x3352BBE6, 0x3E119D3F, 0x3AD08088, 0x2497D08D, 0x2056CD3A,
  0x2D15EBE3, 0x29D4F654, 0xC5A92679, 0xC1683BCE, 0xCC2B1D17, 0xC8EA00A0,
  0xD6AD50A5, 0xD26C4D12, 0xDF2F6BCB, 0xDBEE767C, 0xE3A1CBC1, 0xE760D676,
  0xEA23F0AF, 0xEEE2ED18, 0xF0A5BD1D, 0xF464A0AA, 0xF9278673, 0xFDE69BC4,
  0x89B8FD09, 0x8D79E0BE, 0x803AC667, 0x84FBDBD0, 0x9ABC8BD5, 0x9E7D9662,
  0x933EB0BB, 0x97FFAD0C, 0xAFB010B1, 0xAB710D06, 0xA6322BDF, 0xA2F33668,
  0xBCB4666D, 0xB8757BDA, 0xB5365D03, 0xB1F740B4 };
```

```
//查表法
uint32 crc_32(uint8 *pData, uint16 Length)
{


  uint32 nReg; //CRC寄存器
  uint32 nTemp = 0;
  uint16 i, n;

  nReg = 0xFFFFFFFF; //
  for ( n = 0; n < Length; n++ )
  {
    nReg ^= (uint32) pData[ n ];

    for ( i = 0; i < 4; i++ )
    {
      nTemp = Crc32Table[ ( uint8 )( ( nReg >> 24 ) & 0xff ) ]; //取一个字节，查表
      nReg <<= 8; //丢掉计算过的头一个BYTE
      nReg ^= nTemp; //与前一个BYTE的计算结果异或
    }
  }
  return nReg;
}
```