

AHRS Protocol Specification

Protocol Key Features

The AHRS use proprietary protocol to transmit data to a host computer using asynchronous uart ports. This proprietary protocol has the following key features:

- Compact. 8 Bit Binary Data is used.
- Checksum Protected, using 16bit CRC16 checksum algorithm
- Modular, using a 2-stage Message Identifier (Class- and Message ID)

Packet Structure

A basic Packet looks as follows:

Sync1	Sync2	Class	ID	Length	Payload	Checksum
'T'	'M'	1Byte Message Class	1Byte Message ID	Length of the payload(2 Bytes) excluding sync,class,ID, length and Checksum fields	Payload,size depending on length and/or Class,ID	2Bytes CRC16 Checksum

Protocol Framing

- Every Message starts with 2 Bytes: 'T' 'M'
- A 1 Byte Class Field follows. The Class defines the basic subset of the message
- A 1 Byte ID Field defines the message that is to follow
- A 2 Byte Length Field is following. Length is defined as being the length of the payload, only. It does not include Sync Chars, Length Field, Class, ID or CRC fields. The number format of the length field is an unsigned 16-Bit integer in Little Endian Format.
- The Payload is a variable length field.
- Checksum is an unsigned 16-Bit integer in Little Endian Format whose calculation is defined below.

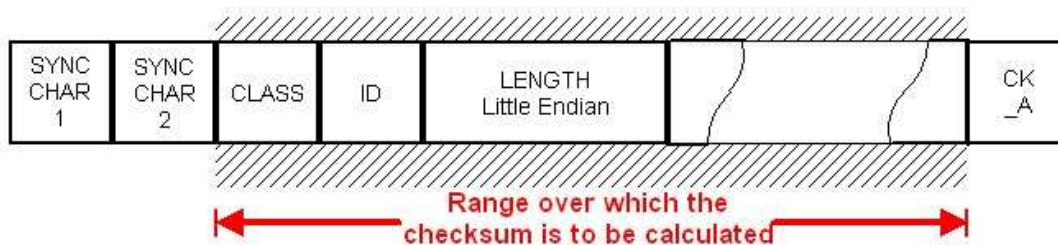
Number Formats

```
typedef unsigned char INT8U; // Unsigned 8 bit quantity
typedef signed char INT8S; // Signed 8 bit quantity
typedef unsigned short INT16U; // Unsigned 16 bit quantity
typedef signed short INT16S; // Signed 16 bit quantity
typedef unsigned int INT32U; // Unsigned 32 bit quantity
typedef signed int INT32S; // Signed 32 bit quantity
float FP32; // Single precision floating point
double FP64; // Double precision floating point
```

typedef

typedef
typedef

Checksum



The

checksum algorithm used is the 16-Bit CRC16 Algorithm .

```
INT16U const CRC16Table[256] = {
    0x0000, 0xC0C1, 0xC181, 0x0140, 0xC301, 0x03C0, 0x0280, 0xC241,
    0xC601, 0x06C0, 0x0780, 0xC741, 0x0500, 0xC5C1, 0xC481, 0x0440,
    0xCC01, 0x0CC0, 0x0D80, 0xCD41, 0x0F00, 0xCFC1, 0xCE81, 0x0E40,
    0x0A00, 0xCAC1, 0xCB81, 0x0B40, 0xC901, 0x09C0, 0x0880, 0xC841,
    0xD801, 0x18C0, 0x1980, 0xD941, 0x1B00, 0xDBC1, 0xDA81, 0x1A40,
    0x1E00, 0xDEC1, 0xDF81, 0x1F40, 0xDD01, 0x1DC0, 0x1C80, 0xDC41,
    0x1400, 0xD4C1, 0xD581, 0x1540, 0xD701, 0x17C0, 0x1680, 0xD641,
    0xD201, 0x12C0, 0x1380, 0xD341, 0x1100, 0xD1C1, 0xD081, 0x1040,
    0xF001, 0x30C0, 0x3180, 0xF141, 0x3300, 0xF3C1, 0xF281, 0x3240,
    0x3600, 0xF6C1, 0xF781, 0x3740, 0xF501, 0x35C0, 0x3480, 0xF441,
```

0x3C00, 0xFCC1, 0xFD81, 0x3D40, 0xFF01, 0x3FC0, 0x3E80, 0xFE41,
0xFA01, 0x3AC0, 0x3B80, 0xFB41, 0x3900, 0xF9C1, 0xF881, 0x3840,
0x2800, 0xE8C1, 0xE981, 0x2940, 0xEB01, 0x2BC0, 0x2A80, 0xEA41,
0xEE01, 0x2EC0, 0x2F80, 0xEF41, 0x2D00, 0xEDC1, 0xEC81, 0x2C40,
0xE401, 0x24C0, 0x2580, 0xE541, 0x2700, 0xE7C1, 0xE681, 0x2640,
0x2200, 0xE2C1, 0xE381, 0x2340, 0xE101, 0x21C0, 0x2080, 0xE041,
0xA001, 0x60C0, 0x6180, 0xA141, 0x6300, 0xA3C1, 0xA281, 0x6240,
0x6600, 0xA6C1, 0xA781, 0x6740, 0xA501, 0x65C0, 0x6480, 0xA441,
0x6C00, 0xACC1, 0xAD81, 0x6D40, 0xAF01, 0x6FC0, 0x6E80, 0xAE41,
0xAA01, 0x6AC0, 0x6B80, 0xAB41, 0x6900, 0xA9C1, 0xA881, 0x6840,
0x7800, 0xB8C1, 0xB981, 0x7940, 0xBB01, 0x7BC0, 0x7A80, 0xBA41,
0xBE01, 0x7EC0, 0x7F80, 0xBF41, 0x7D00, 0xBDC1, 0xBC81, 0x7C40,
0xB401, 0x74C0, 0x7580, 0xB541, 0x7700, 0xB7C1, 0xB681, 0x7640,
0x7200, 0xB2C1, 0xB381, 0x7340, 0xB101, 0x71C0, 0x7080, 0xB041,
0x5000, 0x90C1, 0x9181, 0x5140, 0x9301, 0x53C0, 0x5280, 0x9241,
0x9601, 0x56C0, 0x5780, 0x9741, 0x5500, 0x95C1, 0x9481, 0x5440,
0x9C01, 0x5CC0, 0x5D80, 0x9D41, 0x5F00, 0x9FC1, 0x9E81, 0x5E40,
0x5A00, 0x9AC1, 0x9B81, 0x5B40, 0x9901, 0x59C0, 0x5880, 0x9841,
0x8801, 0x48C0, 0x4980, 0x8941, 0x4B00, 0x8BC1, 0x8A81, 0x4A40,
0x4E00, 0x8EC1, 0x8F81, 0x4F40, 0x8D01, 0x4DC0, 0x4C80, 0x8C41,
0x4400, 0x84C1, 0x8581, 0x4540, 0x8701, 0x47C0, 0x4680, 0x8641,
0x8201, 0x42C0, 0x4380, 0x8341, 0x4100, 0x81C1, 0x8081, 0x4040

};

```

INT16U CRC16(INT8U *p, INT16U length)
{
    INT16U checksum = 0;

    for( ; length > 0; length-- )
    {
        checksum = ( checksum >> 8 ) ^ CRC16Table[ (checksum&0xFF) ^ *p ];

        p++;
    }

    return checksum;
}

```

AHRS Class IDs

A Class is a grouping of messages which are related to each other. The following table gives the short names, description and Class ID Definitions.

- Printf 0x01:姿态传感器返回的 printf 信息类,payload 中包含的是已格式化的 printf 字符串
- Communicate 0x0c:设置 uart bps 等
- Command 0x0f :对 AHRS 的基本操作及数据输出都归于此类, 校准, 配置 FIR 参数等

AHRS Message

Printf - Printf message (0x01 0x01)

Message	Printf message				
Description	格式化的一些 printf 信息, 多用于调试及一些内部状态观察, 协议中可把此类包直接丢弃				
传输方向	仅输出				
Message Structure	Header 'T' 'M'	Class , ID 0x01, 0x01	Length (根据不同的 printf)	Payload (Length)Bytes	Checksum
Payload Contents:	已格式化的字符串				

Communicate- Uart BPS (0x0c 0x02)

Message	Uart BPS				
Description	Uart BPS				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x15	Length (1)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Uart BPS	-	0: 1200 1: 2400 2: 4800 3: 9600 4: 14400 5: 19200 6: 28800 7: 38400 8: 56000 9: 57600 10:115200 11:128000 12:256000

Message	Uart BPS				
Description	Uart BPS				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0c, 0x02	Length (0)	Payload (Length)Bytes	Checksum

Command- ATTITUDE_AND_SENSORS (0x0f 0x01),此数据输出有四种输出数据结构，根据 **Data Output Mode** 设置不同而输出不同。

Message	ATTITUDE_AND_SENSORS (Attitude + Sensors)				
Description	标准姿态及传感器输出				
传输方向	仅输出				
Message Structure	Header 'T' 'M'	Class , ID 0x0f , 0x01	Length (49)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Flags	-	Reserved
1	FP32	-	Roll	degree	+ -180 Roll
5	FP32	-	Pitch	degree	+ -90 Pitch
9	FP32	-	Yaw	degree	+ -180 Heading
13	FP32	-	Gx	deg/s	Gyro x axis output
17	FP32	-	Gy	deg/s	Gyro y axis output
21	FP32	-	Gz	deg/s	Gyro z axis output
25	FP32	-	Ax	g	Acceleration x axis output
29	FP32	-	Ay	g	Acceleration y axis output
33	FP32	-	Az	g	Acceleration z axis output
37	FP32	-	Mx	-	Mag x axis output
41	FP32	-	My	-	Mag y axis output
45	FP32	-	Mz	-	Mag z axis output

Message	ATTITUDE_AND_SENSORS (Attitude + Sensors (body linear acc))				
Description	姿态及传感器输出，体加速度输出				
传输方向	仅输出				
Message Structure	Header 'T' 'M'	Class , ID 0x0f , 0x01	Length (49)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number	Scaling	Name	Unit	Purpose / Comment

	Format				
0	INT8U	-	Flags	-	Reserved
1	FP32	-	Roll	degree	+/-180 Roll
5	FP32	-	Pitch	degree	+/-90 Pitch
9	FP32	-	Yaw	degree	+/-180 Heading
13	FP32	-	Gx	deg/s	Gyro x axis output
17	FP32	-	Gy	deg/s	Gyro y axis output
21	FP32	-	Gz	deg/s	Gyro z axis output
25	FP32	-	Ax	g	Body linear acc x axis output
29	FP32	-	Ay	g	Body linear acc y axis output
33	FP32	-	Az	g	Body linear acc z axis output
37	FP32	-	Mx	-	Mag x axis output
41	FP32	-	My	-	Mag y axis output
45	FP32	-	Mz	-	Mag z axis output

Message	ATTITUDE_AND_SENSORS (Attitude Only)				
Description	仅姿态输出				
传输方向	仅输出				
Message Structure	Header 'T' 'M'	Class , ID 0x0f , 0x01	Length (13)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Flags	-	Reserved
1	FP32	-	Roll	degree	+/-180 Roll
5	FP32	-	Pitch	degree	+/-90 Pitch
9	FP32	-	Yaw	degree	+/-180 Heading

Message	ATTITUDE_AND_SENSORS (Air Mouse)				
Description	空中鼠标数据输出				
传输方向	仅输出				
Message Structure	Header 'T' 'M'	Class , ID 0x0f , 0x01	Length (13)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number	Scaling	Name	Unit	Purpose / Comment

	Format				
0	INT8U	-	Flags	-	Reserved
1	FP32	-	Airmouse X	-	-127 ~127(水平移动像素值)
5	FP32	-	Airmouse Y	-	-127 ~127(垂直移动像素值)
9	FP32	-	NC		Reserved

Command- Mag Start Factory calibrate (0x0f 0x0b)

Message	Mag Start Factory calibrate				
Description	开始指南针校准（获取最大最小值算 bias 和 scale）				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x0b	Length (0)	Payload (Length)Bytes	Checksum

Description					
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x0b	Length (0)	Payload (Length)Bytes	Checksum

Command- Mag Stop Factory calibrate (0x0f 0x0c)

Message	Mag Stop Factory calibrate				
Description	结束指南针校准，AHRS 将会计算指南针校准参数并写入 flash 中				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x0c	Length (0)	Payload (Length)Bytes	Checksum

Description					
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x0c	Length (0)	Payload (Length)Bytes	Checksum

Command- Mag Read 6 Faces Calibrate Data (0x0f 0x39)

Message	Mag Read 6 Faces Calibrate Data				
Description	读取指南针六面值				
传输方向	命令				

Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x39	Length (1)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Face	-	0~5:代表六个面，

Message	Mag Read 6 Faces Calibrate Data				
Description	输出 6 面校准中六个面的指南针 X, Y, Z 轴值				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x39	Length (73)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Sync	-	Reserved
1	FP32	-	Face 0 MagX	-	
5	FP32	-	Face 0 MagY	-	
9	FP32	-	Face 0 MagZ		
13	FP32	-	Face 1 MagX	-	
17	FP32	-	Face 1 MagY	-	
21	FP32	-	Face 1 MagZ		
25	FP32	-	Face 2 MagX	-	
29	FP32	-	Face 2 MagY	-	
33	FP32	-	Face 2 MagZ		
37	FP32	-	Face 3 MagX	-	
41	FP32	-	Face 3 MagY	-	
45	FP32	-	Face 3 MagZ		
49	FP32	-	Face 4 MagX	-	
53	FP32	-	Face 4 MagY	-	
57	FP32	-	Face 4 MagZ		
61	FP32	-	Face 5 MagX	-	
65	FP32	-	Face 5 MagY	-	
69	FP32	-	Face 5 MagZ		

Command- Mag 6 face Calibrate Calculate (0x0f 0x40)

Message	Mag 6 face Calibrate Calculate				
Description	使用读取的六面值用迭代法计算 bias 及 scale				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x40	Length (0)	Payload (Length)Bytes	Checksum

Message	Mag 6 face Calibrate Calculate				
Description	返回 6 面校准得到的标定参数值				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x40	Length (25)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Sync	-	Reserved
1	FP32	-	BiasX	-	
5	FP32	-	BiasY	-	
9	FP32	-	BiasZ	-	
13	FP32	-	ScaleX	-	
17	FP32	-	ScaleY	-	
21	FP32	-	ScaleZ	-	

Command- Default Mag 6 Faces Calibrate Cof(0x0f 0x42)

Message	Default Mag 6 Faces Calibrate Cof				
Description	默认指南针 6 面校准参数,将 6 面校准 bias 置 0,Scale 置 1				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x42	Length (0)	Payload (Length)Bytes	Checksum

Description					
Respond	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x42	Length (0)	Payload (Length)Bytes	Checksum

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Command- Read QR Parameter (0x0f 0x20)

Message	Read QR Parameter				
Description	读取噪音参数				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x20	Length (0)	Payload (Length)Bytes	Checksum

Message	Read QR parameter				
Description	Read QR parameter				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x20	Length (25)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Sync	-	Reserved
1	FP64	-	Q_Gyro	-	
9	FP64	-	R_Acc	-	
17	FP64	-	R_Mag		

Command- Write QR Parameter (0x0f 0x21)

Message	Write QR Parameter				
Description	Write QR Parameter				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x21	Length (25)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Sync	-	Reserved
1	FP64	-	Q_Gyro	-	
9	FP64	-	R_Acc	-	

17	FP64	-	R_Mag		
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Message	Write QR Parameter				
Description	设置噪音参数				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x21	Length (0)	Payload (Length)Bytes	Checksum

Command- QR Default (0x0f 0x22)

Message	QR Default				
Description	默认				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x22	Length (0)	Payload (Length)Bytes	Checksum

Description					
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x22	Length (0)	Payload (Length)Bytes	Checksum

Command- Install Direction(0x0f 0x23)

Message	Install Direction				
Description	支持 8 种安装方向				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f,	Length (1)	Payload (Length)Bytes	Checksum

		0x23			
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Direction	-	0:X_Forward 1:X_Right 2:X_Backward 3:X_Left 4:INV_X_Forward 5:INV_X_Right 6:INV_X_Backward 7:INV_X_Left

Message	Install Direction				
Description	Install Direction				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x23	Length (0)	Payload (Length)Bytes	Checksum

Command- Running mode (0x0f 0x24)

Message	Running mode				
Description	Running mode				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x24	Length (1)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Running mode	-	0:Predict only 1:IMU(without Compass) 2:AHRS(with Compass) 3:Inclinometer (Use Acc only)

Message	Running mode				
Description	Running mode				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x24	Length (0)	Payload (Length)Bytes	Checksum

Command- Data output mode (0x0f 0x25)

Message	Data output mode				
Description	Data output mode				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x25	Length (1)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Data output mode	-	0:Attitude+Sensors 1: Attitude+Sensors(body linear acc) 2:Attitude only 3:Airmouse

Message	Data output mode				
Description	Data output mode				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x25	Length (0)	Payload (Length)Bytes	Checksum

Command- Data Output Rate (0x0f 0x15)

Message	Data Output Rate				
Description	Data Output Rate				
传输方向	命令				
Message	Header	Class , ID	Length	Payload	Checksum

Structure	'T' 'M'	0x0f, 0x15	(1)	(Length)Bytes	
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Data Output Rate	-	0: 1HZ 1: 5HZ 2: 10HZ 3: 25HZ 4: 50HZ 5: 100HZ

Message	Data Output Rate				
Description	Data Output Rate				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x15	Length (0)	Payload (Length)Bytes	Checksum

Command- Write Gyro FIR parameter (0x0f 0x26)

Message	Write Gyro FIR parameter				
Description	Write Gyro FIR parameter				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x26	Length (66)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment

0	INT8U	-	Sync	-	Reserved
1	INT8U	-	Tags	-	0:Disable FIR 1~32:Tags
2	INT16U	-	FIR Cof[0]	-	FIR 参数
4	INT16U	-	FIR Cof[1]	-	FIR 参数
...
64			FIR Cof[31]	-	FIR 参数

Message	Write Gyro FIR parameter				
Description	设置 FIR 参数				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x26	Length (0)	Payload (Length)Bytes	Checksum

Command- Read Gyro FIRparameter (0x0f 0x27)

Message	Read Gyro FIR parameter				
Description	读取陀螺 FIR 参数				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x27	Length (0)	Payload (Length)Bytes	Checksum

Message	Read Gyro FIR parameter				
Description	Read Gyro FIR parameter				
传输方向	响应				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x27	Length (66)	Payload (Length)Bytes	Checksum
Payload Contents:					
Byte Offset	Number Format	Scaling	Name	Unit	Purpose / Comment
0	INT8U	-	Sync	-	Reserved
1	INT8U	-	Tags	-	0:Disable FIR 1~32:Tags

2	INT16U	-	FIR Cof[0]	-	FIR 参数
4	INT16U	-	FIR Cof[1]	-	FIR 参数
...
64			FIR Cof[31]	-	FIR 参数

Command- Default Gyro FIR Parameter (0x0f 0x28)

Message	Default Gyro FIR Parameter				
Description	Default Gyro FIR Parameter				
传输方向	命令				
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x28	Length (0)	Payload (Length)Bytes	Checksum

Description					
Respond					
Message Structure	Header 'T' 'M'	Class , ID 0x0f, 0x28	Length (0)	Payload (Length)Bytes	Checksum

加速度与指南针 FIR 滤波参数设置读取及默认结构与陀螺一致,不同这处只在 ID 号不一样, 相应 ID 号如下:

加速度设置 ID: 0x29,读取 ID: 0x30,默认参数 0x31

指南针设置 ID: 0x32,读取 ID: 0x33,默认参数 0x34