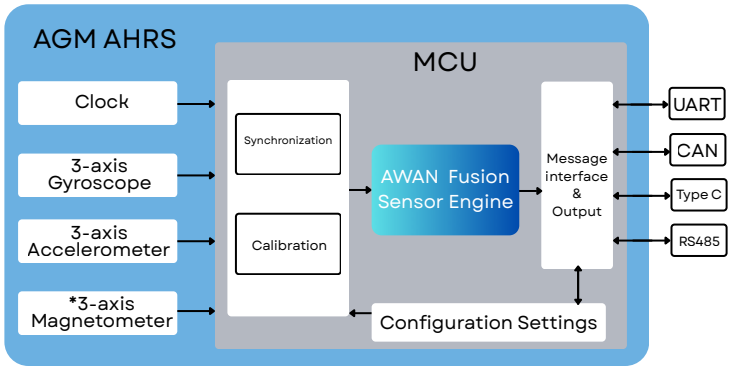
AGM AHRS Series Datasheet 產品規格書

1.PRODUCT OVERVIEW / 產品概述

AGM-510 /610 /720 (以下稱 AGM AHRS 系列模組)是工業級航姿參考系統 (AHRS) 模組。本系列結合了高精度 9 軸感測，包含三軸 MEMS 陀螺儀、三軸加速度計與三軸磁力計，並整合高頻率氣壓計。透過內建的高性能處理器與感測器融合演算法，能在複雜的動態與電磁環境下，即時輸出精準的 roll（橫滾）、pitch（俯仰）及 yaw（航向）姿態數據。本系列產品專為無人機、機器人、自動駕駛車輛及工業自動化設備等需要精確姿態控制的應用場景而設計。

- SYSTEM ARCHITECTURE/系統架構

圖 1.1 顯示了模組的簡化架構。AGM AHRS 系列模組包含了陀螺儀、加速度計、磁力計和 MCU。MCU 負責調節感測器的同步採樣，並運行 AWAN 專用的融合演算法，輸出高達 200 Hz 的高速姿態數據。透過彈性的通訊介面(如 UART, CAN, RS485 或 Type C），開發者能輕易將數據整合至系統中。



NOTE: Components marked with " * " may vary by model.

FIGURE 1.1 AGM AHRS SERIES ARCHITECTURE DIAGRAM

2.PERFORMANCE SPECIFICATIONS / 性能規格

2.1 System Accuracy/系統綜合精度

模組的精確度受演算法、量程、環境因素和感測器製造誤差的影響。以下的性能規格（見表2.1）為隨機取樣十個經過測試的感測器的平均值，這些數據僅供參考。而有必要的運動測試和校準均為工廠自動化生產過程的一部分，大幅縮短了系統整合時間，提高了系統的精確性和可靠性。

*Unless stated otherwise, all specifications are typical. Specifications subject to change without notice.

Parameter (項目)	AGM-510	AGM-610	AGM-720
Measurement Range (量程)	±180° (Roll)、±85° (Pitch)、±180° (Yaw)		
Dynamic Accuracy (動態精度)	< 0.5° (Roll / Pitch)	< 0.5° (Roll / Pitch)	< 0.4° (Roll / Pitch)
	< 2.0° (Yaw)	< 1.0° (Yaw)	< 0.8° (Yaw)
Resolution (解析度)	0.0055°		

TABLE 2.1 SYSTEM ACCURACY SPECIFICATIONS

2.2 SENSOR SPECIFICATIONS / 感測器規格

AGM AHRS 系列模組，各項感測器參數如下表：

Category (類別)	Parameter (技術項目)	Value (規格數值)	Unit (單位)
Gyroscope (陀螺儀)	Full Scale (標準全量程)	±2000	°/s (deg/s)
	Bandwidth (頻寬)	539	Hz
	Resolution (解析度)	0.07	deg/s
	In-run Bias Stability (零偏穩定性)	3	°/h (deg/h)
	Noise Density (噪聲密度)	0.005	°/s/√Hz
	Sensitivity Tolerance (靈敏度公差)	±5	%

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Category (類別)	Parameter (技術項目)	Value (規格數值)	Unit (單位)
Accelerometer (加速度計)	Full Scale (標準全量程)	±16	g
	Resolution (解析度)	0.488	mg/LSB
	Bandwidth (頻寬)	10~3000	Hz
	In-run Bias Stability (零偏穩定性)	0.03	mg
	Temperature Drift (溫度飄移)	±0.10	mg/ °C
	Noise Density (噪聲密度)	60	μg/√Hz
Magnetometer[1] (磁力計)	Dynamic Range (動態範圍)	4915.2	μT
	Resolution (解析度)	0.25	mG
	RMS Noise (RMS 噪聲)	3	mG

Note 1: AGM-510 is not equipped with a magnetometer.

TABLE 2.2 SENSOR SPECIFICATIONS

2.3 MECHANICAL DIMENSIONS / 機械尺寸

AGM AHRS 系列模組採用堅固的 ABS 外殼，總重量為 20 g，外觀尺寸為 49X42X13 mm。模組機械尺寸與外觀規格如下：

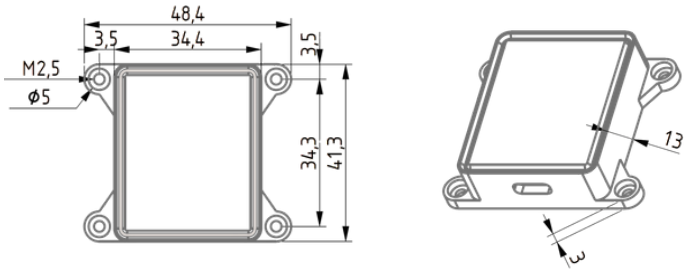

Figure 2.3 Mechanical Dimensions (Unit: mm)

2.4 ELECTRICAL & INTERFACE SPECIFICATIONS / 電氣與介面規格

AGM AHRS 系列模組的電氣特性與通訊介面功能說明，供系統整合參考。

Category(類別)	Parameter (技術項目)	Value (規格數值)	Description (說明)
Electrical (電氣特性)	Operating Voltage (工作電壓)	4.75 V ~ 5.25 V	DC Power Supply
	Power Consumption (功耗)	< 0.5 W	Typical operating power
Interfaces (介面與 I/O)	Hardware Interfaces (硬體介面)	UART, CAN, RS485, Type C	Supported communication interfaces
	Output Frequency (輸出頻率)	50 ~ 200 Hz	Configurable via software
	Protocols (支援協議)	AWAN Standard, MAVLink, NMEA, UBX	Standardized communication
	Clock Drift (時鐘漂移)	30 ppm	Precision timing reference

TABLE 2.4 ELECTRICAL AND INTERFACE SPECS

3. INTERFACE & PIN DEFINITIONS / 介面與接腳定義

AGM AHRS 系列模組提供高度靈活的通訊介面，支援 UART、CAN、RS485 及 Type C。

3.1 MAIN I/O CONNECTOR (10-PIN) / 主要輸入輸出連接器

Pin	Signal	Type	Description
1	GND	Power	System Ground (GND)
2	UART_RX	Input	UART Receive Data (RX)
3	UART_TX	Output	UART Transmit Data (TX)
4	DIO	I/O	Digital I/O (Function depends on firmware)
5	5.0 V DC	Power	Main Power Supply Input (5.0V DC)
6	RS485B	I/O	RS-485 Differential Line B (-)
7	RS485A	I/O	RS-485 Differential Line A (+)
8	CAN_L	I/O	CAN Bus Low (CAN_L)
9	CAN_H	I/O	CAN Bus High (CAN_H)
10	GND	Power	System Ground (GND)

TABLE 3.1.1 CONNECTOR PIN FUNCTION DESCRIPTION

- Standard Type: 1.27mm Pitch (Non-waterproof) / 標準型：1.27mm 間距 (不防水)

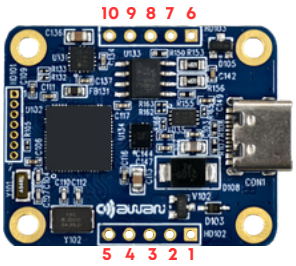

Figure 3.1.2 AGM-510/610/720 Pinout Layout

- Special Type: GH 9-Pin 1.25mm Pitch / 特殊型：GH 9-Pin 1.25mm 間距 (不防水)

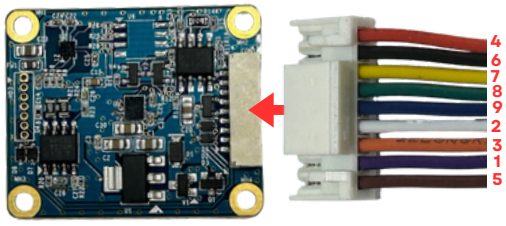

Figure 3.1.3 AGM-511/611 (Special Model) Pinout Layout

3.2 TYPE C INTERFACE DESCRIPTION / TYPE C 介面說明

AGM AHRS 系列模組的Type C 接口僅使用以下幾條線進行連接：

Signal	Description (說明)
Vbus	Power Supply Input (+5V DC)
GND	System Ground (GND)
D+	USB Differential Data Line Positive (D+)
D-	USB Differential Data Line Negative (D-)

Note: All other lines in the TYPE-C interface (e.g., CC1, CC2, SBU1, SBU2, VCONN, etc.) are not connected or used.

TABLE 3.2 TYPE C PINOUT DESCRIPTION

4. COMMUNICATION PROTOCOL / 傳輸協議

本產品數據傳輸採用 BIG-ENDIAN（大端序）格式，通訊架構分為六個核心部分。為確保 AGM AHRS 系列模組數據傳輸的準確性，系統會透過偵測固定起始位並進行校驗位驗證，以確保數據完整性。除 AWAN 標準協議外，本模組亦支援 MAVLINK 協議，可與開源飛控系統無縫對接。

4.1 FRAME STRUCTURE OVERVIEW / 數據幀結構總覽

下表定義了標準數據封包的組成結構：

Byte Index	Field Name	Length (Byte)	Value / Example	Description (數據定義說明)
Byte 0	Start Byte(起始位)	1	0xAA	Frame header
Byte 1	Device ID(裝置別)	1	0x51	Hardware ID for AGM-510
			0x61	Hardware ID for AGM-610
			0x72	Hardware ID for AGM-710
Byte 2	Length(長度)	1	L	Formula: Tag (1) + Payload (N)長度
Byte 3	Data Tag(資料標籤)	1	See Table 4.2	Identifier for data type
Byte 4~52	Payload(數據位)	53	Sensor Data	Actual measurement values
Byte N	Checksum(校驗位)	1	uint8_t	Sum of Byte[0] to Byte[N-1]

TABLE 4.1 FRAME STRUCTURE

4.2 DATA TAG AND IDENTIFIER MAPPING / 資料標籤與識別碼彙整

針對 AGM AHRS 支援的各種通訊介面，各項數據的識別碼與數據長度定義如下：

Category (數據類別)	UART Tag	CAN ID	長度 (Bytes)	Data Description (數據定義說明)
Reserved(保留位)	0xFF	-	1	Reserved for future use
Accelerometer(加速度計)	0xA0	050	7	3-axis acceleration
Gyroscope(陀螺儀)	0xB0	051	7	3-axis angular rate
Magnetometer(磁力計)	0xC0	052	7	3-axis magnetic field
Euler Angles(歐拉角)	0xD0	053	7	Roll / Pitch / Yaw orientation
Quaternions(四元數)	0xD1	054	9	Quaternion orientation
Temperature(溫度計)	0xE0	055	3	Module internal temperature
Timestamp(時間戳)	0xF1	-	9	Timestamp in μs

TABLE 4.2 DATA IDENTIFIER MAPPING

4.3 DATA PAYLOAD (EFFECTIVE PAYLOAD) / 數據位（有效負載）

本產品定義向前為 +X，向左為 +Y，向上為 +Z。旋轉方向遵循右手定則。角速度 [RX,RY,RZ]對應姿態 [ROLL,PITCH,YAW]。
NOTE：資料傳輸以先高 (BYTE) 後低 (BYTE) 方式傳輸。

Category (數據類別)	標籤(Tag)	欄位成員 (如 Ax, Ay, Az)	長度 (Byte)	Notes (備註)
Reserved (保留位)	0xFF	-	1	固定值，供協議擴展
Accel (加速度)	0xA0	Ax, Ay, Az (各 2-byte)	1+6	單位：m/s^2
Gyro (角速度)	0xB0	Rx, Ry, Rz (各 2-byte)	1+6	單位：deg/s
Mag (磁場強度)	0xC0	Mx, My, Mz (各 2-byte)	1+6	單位：μT
Euler (歐拉角)	0xD0	Roll, Pitch, Yaw (各 2-byte)	1+6	單位：度 (°)
Quaternion (四元數)	0xD1	i, j, k, w (各 2-byte)	1+8	Dimensionless (無單位)
Temperature (溫度)	0xE0	攝氏溫度 (2-byte)	1+2	單位：°C
Timestamp (時間戳)	0xF1	timestamp_us(8-byte)	1+8	單位: μs;模組內部時間基準，非UTC/GNSS絕對時間

TABLE 4.3.1 MAIN PAYLOAD STRUCTURE (0XFF FULL FUNCTION PACKET)

4.4 CHECKSUM CALCULATION / 校驗位 (校驗和)

CHECKSUM 是指從起始位加總至數據位末尾的所有位元組總和，並取其 低位元組 (LOW BYTE)。

```
uint8_t get_Checksum(uint8_t *payload, uint8_t payload_length)
{
  register unsigned int sum = 0;
  uint8_t CheckSum;

  // 只加總到倒數第二個字節，排除 checksum 本身
  for (uint8_t index = 0; index < payload_length - 1; index++)
  {
    sum += (uint8_t)payload[index];
  }

  CheckSum = (uint8_t)(sum & 0xff);
  return CheckSum;
}
```

FIGURE 4.4 CHECKSUM CALCULATION CODE

4.5 EXAMPLE PACKET WALKTHROUGH / 舉例說明

- Interface / 接口類型：CAN / UART
- Baud Rate / 傳輸速率： Default 921600 bps (9600 to 921600 configurable)
- Output Rate / 輸出頻率： Default 50 Hz (50 to 200Hz configurable)
- Byte Order / 字節順序： BIG-ENDIAN (MSB First)

Byte Offset	Field Name	Content / Tag	Data Type	Byte Length	Description / Receiver Action
0	Start Byte	0xAA	uint8_t	1	Start of Data Frame Marker
1	Device ID	(ex: 0x53)	uint8_t	1	Sender Device ID
2	Data Length	L	uint8_t	1	Number of Valid Data Bytes (from the next byte up to the checksum)
--- Start of Valid Data (Payload, Length = L) ---					
3	Reserved	0xFF	uint8_t	1	The current version is fixed at 0xFF. The receiver should read and ignore this byte. It is reserved for future protocol extension.

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Byte Offset	Field Name	Content / Tag	Data Type	Byte Length	Description / Receiver Action
4	Acceleration Tag	0xA0	uint8_t	1	
5	Acceleration X		int16_t	2	Acceleration X (m/s²) = Raw × 0.00488
7	Acceleration Y		int16_t	2	Acceleration Y (m/s²) = Raw × 0.00488
9	Acceleration Z		int16_t	2	Acceleration Z (m/s²) = Raw × 0.00488
11	Angular Rate Tag	0xB0	uint8_t	1	
12	Angular Rate X		int16_t	2	Angular rate X (°/s) = Raw × 0.0153
14	Angular Rate Y		int16_t	2	Angular rate Y (°/s) = Raw × 0.0153
16	Angular Rate Z		int16_t	2	Angular rate Z (°/s) = Raw × 0.0153
18	Magnetic Field Tag	0xC0	uint8_t	1	
19	Magnetic Field X		int16_t	2	Magnetic field X (μT) = Raw × 0.1
21	Magnetic Field Y		int16_t	2	Magnetic field Y (μT) = Raw × 0.1
23	Magnetic Field Z		int16_t	2	Magnetic field Z (μT) = Raw × 0.1
25	Euler Angles Tag	0xD0	uint8_t	1	
26	Roll		int16_t	2	Roll (°) = Raw × 0.0055
28	Pitch		int16_t	2	Pitch (°) = Raw × 0.0055
30	Yaw		int16_t	2	Yaw (°) = Raw × 0.0055
32	Quaternion Tag	0xD1	uint8_t	1	
33	Quaternion qx		int16_t	2	qx = Raw × 0.00006
35	Quaternion qy		int16_t	2	qy = Raw × 0.00006
37	Quaternion qz		int16_t	2	qz = Raw × 0.00006
39	Quaternion qw		int16_t	2	qw = Raw × 0.00006
41	Temperature Tag	0xE0	uint8_t	1	
42	Temperature		int16_t	2	* TEMP_SCALE_FACTOR_DIV (unit:°C)
44	Timestamp Tag	0xF1	uint8_t	1	Timestamp data identifier (時間戳資料標籤)
45	Timestamp		uint64_t	8	Timestamp (μs) = Raw
--- End of Valid Data (Payload) ---					
53 (i.e., 3 + L)	Checksum		uint8_t	1	Checksum: Sum of all bytes from 0xAA to the last data byte.

TABLE 4.5.1 MEMORY MAP & DATA OFFSET

- 輸出數據單位:下表彙整了將原始整數數據轉換為工程單位所需的解析度/縮放比例。

Category (數據類別)	Output Unit (輸出單位)	Scale Factor (比例係數)
Quaternions (四元數)	Dimensionless (無)	0.00006
Euler Angles (歐拉角)	度 (°)	0.0055
Angular Rate (角速率)	度每秒(deg/s)	0.0153
Acceleration (加速度)	米每秒平方 (m/s²)	0.00488
Magnetic Field (磁場強度)	微特斯拉(μT)	0.1
Temperature (溫度)	攝氏度 (℃)	0.01

TABLE 4.5.2 SCALE FACTOR

5. CONTROL COMMANDS / 控制命令

- Host端送出字串命令，命令要附加結束符號\r 或\n 或k，命令如下:

Category (功能分類)	Command (指令)	Description (設定說明)
USB	USB1 ~ USB8	Set USB CDC output (Baud rate matches UART serial number)
Baud Rate (波特率)	UART1 ~ UART8	Set UART baud rate: 9600 to 921600 (Default 921600)
	CAN9 ~ CAN16	Set CAN baud rate: 10 kbps to 1 Mbps
CAN ID 設定	CAN0x050	Set CAN Base ID (Default: 0x050)
	RCAN	Read current CAN Base ID and timestamp CAN ID
Output Rate(輸出頻率)	ODR2	Set output frequency to 25 Hz
	ODR3	Set output frequency to 50Hz
	ODR4	Set output frequency to 100Hz (Default)
Coordinate System (座標系)	FRM0	Set coordinate system to NWU
	FRM1	Set coordinate system to NED
	FRM2	Set coordinate system to ENU
	RFRM	Read current coordinate system
Output Format (輸出格式)	PRO1	Set output to AWAN binary (Default)
	PRO2	Set output to MAVLink AHRS (Fixed NED)
	PRO5	Set output to DroneCAN AHRS (Fixed NED
Relative Attitude (相對姿態)	ZRO	Set current roll/pitch as temporary relative zero
	SZRO	Save relative zero settings
	CZRO	Clear relative zero settings
	RZRO	Read current relative zero status
Fusion Control (感測融合控制)	FUSEON	Enable Magnetometer Fusion
	FUSEOFF	Disable Magnetometer Fusion
Lever Arm (模組安裝偏移)	LVRx,y,z	設定 vehicle reference / CoM 到 Module center 的距離，body frame，單位 m
	RLVR	讀取目前 Module offset
Mounting (安裝角補償)	MNT,r,p,y	Set mounting rotation compensation (Roll/Pitch/Yaw, unit: deg)
	MNTZ	Auto-level mounting roll/pitch
	MNTY,yaw	Set mounting yaw angle only (unit: deg)
	CMNT	Clear mounting rotation settings
	RMNT	Read current mounting rotation settings
System (系統操作)	RESET	System Restart
	UPFM	Enter Firmware Update Mode
	CONFIG	Read current version, interface, and status
	STOP	Stop packet stream output
	STRT	Resume packet stream output
	RPAR	Read full configuration settings

TABLE 5.1 CONTROL COMMAND SET

6. 解封包舉例說明 / DATA DECODING EXAMPLE

- Acceleration Z-Axis Data Decoding Example

The acceleration data is transmitted as a signed 16-bit two's-complement integer in big-endian byte order, with the most significant byte transmitted first.

The conversion formula is:

Acceleration Z (m/s^2) = Raw Acceleration Z × 0.00488

where 0.00488 m/s^2/LSB is the acceleration scale factor.

Example 1: Positive Acceleration

Assume that the two Accelerometer Z data bytes in the packet are:

07 D0

Because the data uses big-endian byte order:

Raw hexadecimal value = 0x07D0
Raw signed integer value = 2000

The physical acceleration is calculated as:

Acceleration Z = 2000 × 0.00488
= 9.76 m/s^2
≈ +0.995 g

Therefore:

07 D0 → +9.76 m/s^2 ≈ +0.995 g
Example 2: Negative Acceleration

Assume that the two Accelerometer Z data bytes in the packet are:

F8 30

Because the data uses big-endian byte order:

Raw hexadecimal value = 0xF830

The most significant bit is 1, indicating a negative value in signed 16-bit two's-complement format. The signed integer value is calculated as:

Raw signed integer value = 0xF830 − 0x10000
= 63536 − 65536
= −2000

The physical acceleration is calculated as:

Acceleration Z = −2000 × 0.00488
= −9.76 m/s^2
≈ −0.995 g

Therefore:

F8 30 → −9.76 m/s^2 ≈ −0.995 g

Note: The conversion between m/s^2 and g in the examples is based on 1 g = 9.80665 m/s^2.