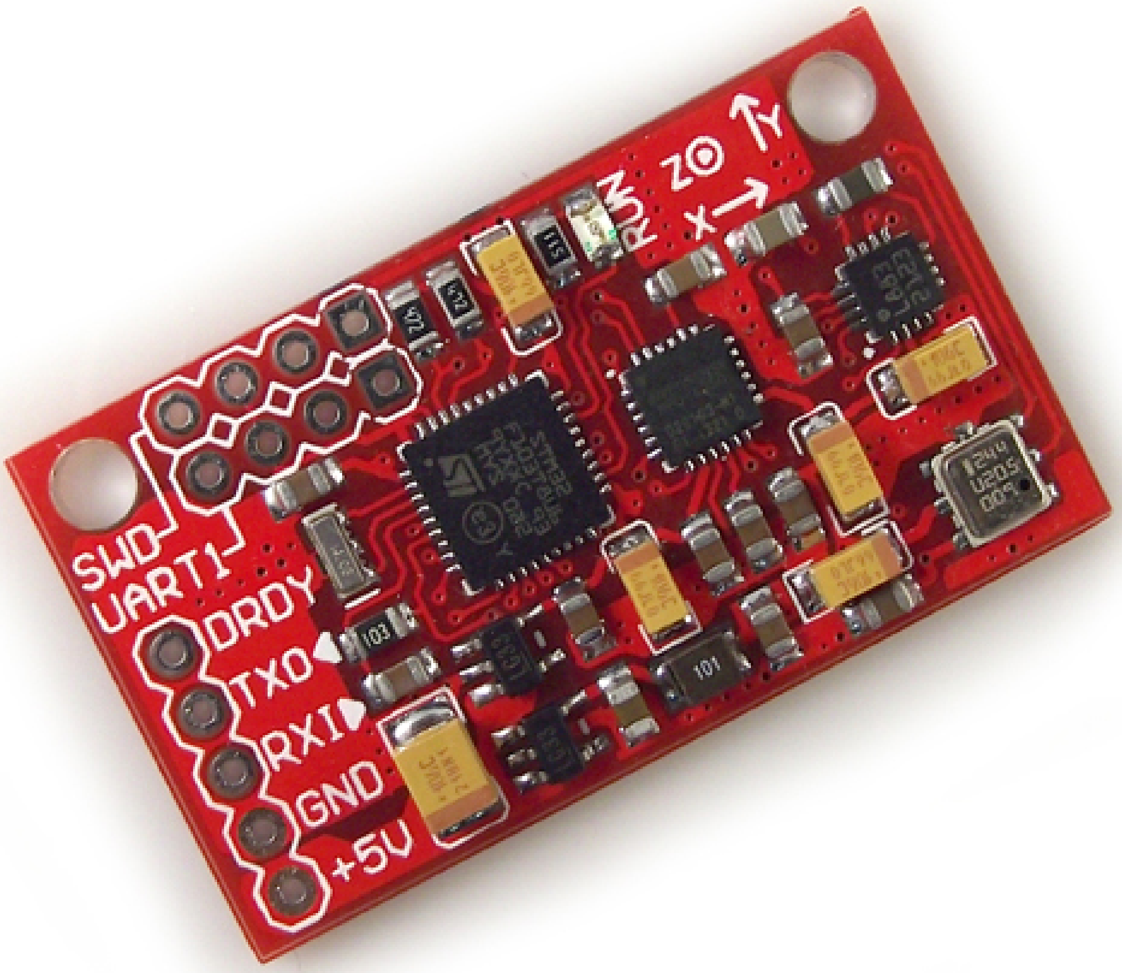
MiniIMU

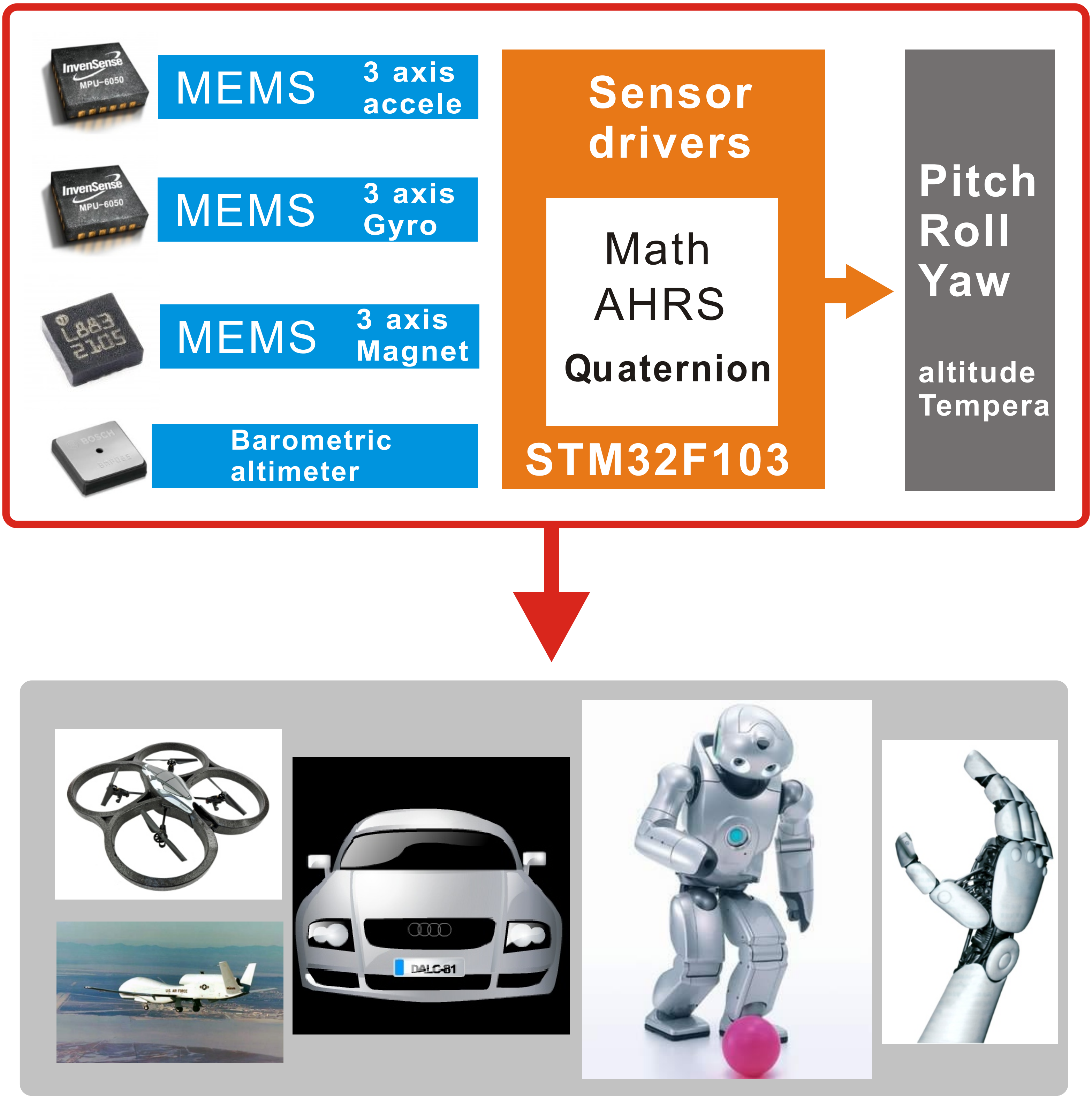
Mini IMU AHRS User manual

This chapter describes the functions and use of the MiniIMU :

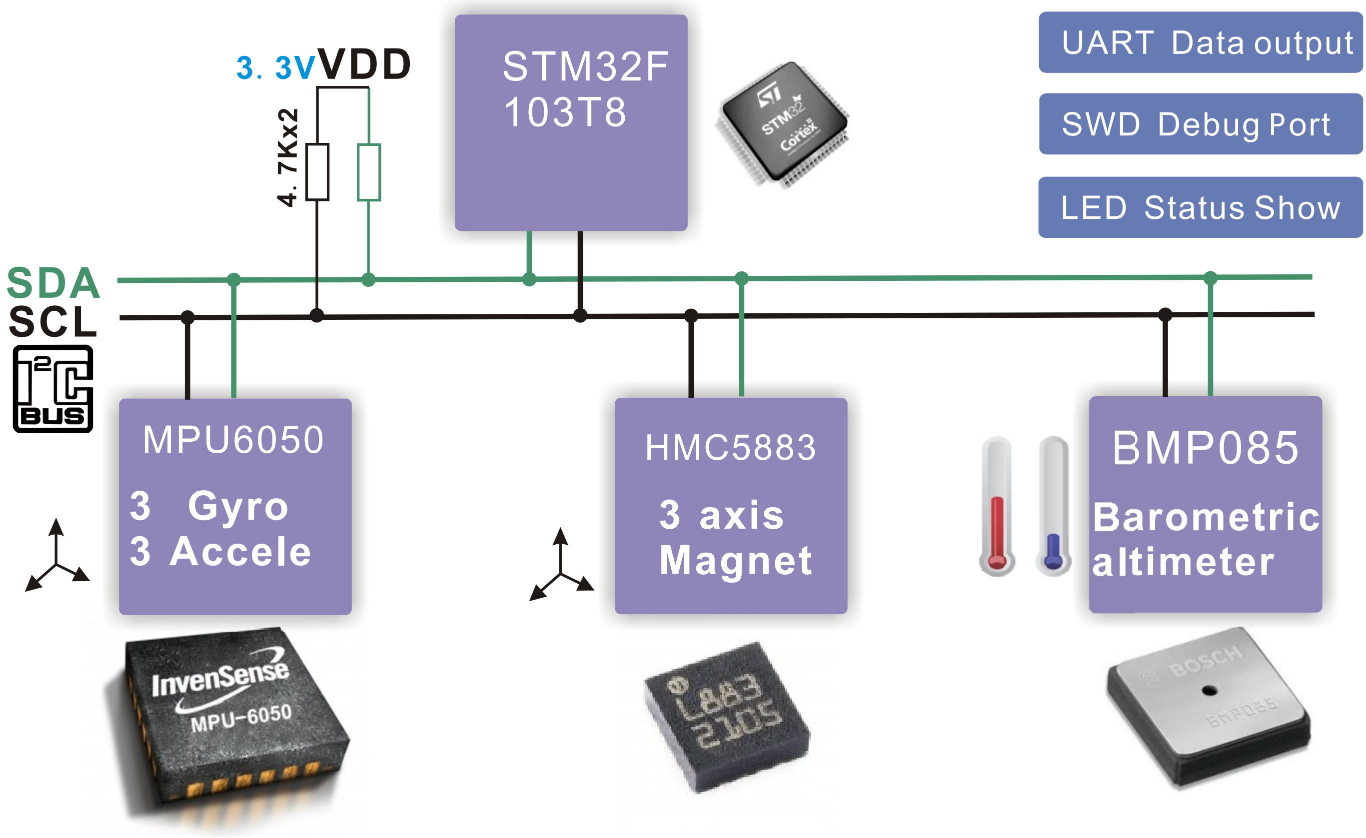
1. MiniIMU Hardware components and interfaces
2. MiniIMU Performance
3. How to use computer software to connect MiniIMU
4. Precautions for Use



Mini IMU AHRS Application diagram



Hardware



1 STM32F103

The main control chip in MiniIMU is STM32F103T8，ARM 32-bit Cortex™-M3 Kernel，It has 64KB of flash memory，and 20KB of memory to run. 7-channel DMA, 7 timers,8M crystal on the board and the STM32 internal PLL can make the controller run in the 72M clock speed, this requires a lot of mathematical programs that run for the attitude solution, faster processing speed can do more solver optimization.

The sensor on the MiniIMU use I2C interface to connect to STM32F, the sensor data interrupts connected to the IO pin STM32F. The sensor ADC rotation STM32F the first time to read the latest data, rapid response to changes in posture. This connection makes the controller has the largest initiative in the fastest access to the status of each sensor and the conversion results.

Communication capabilities:

MiniIMU have two serial communication port:

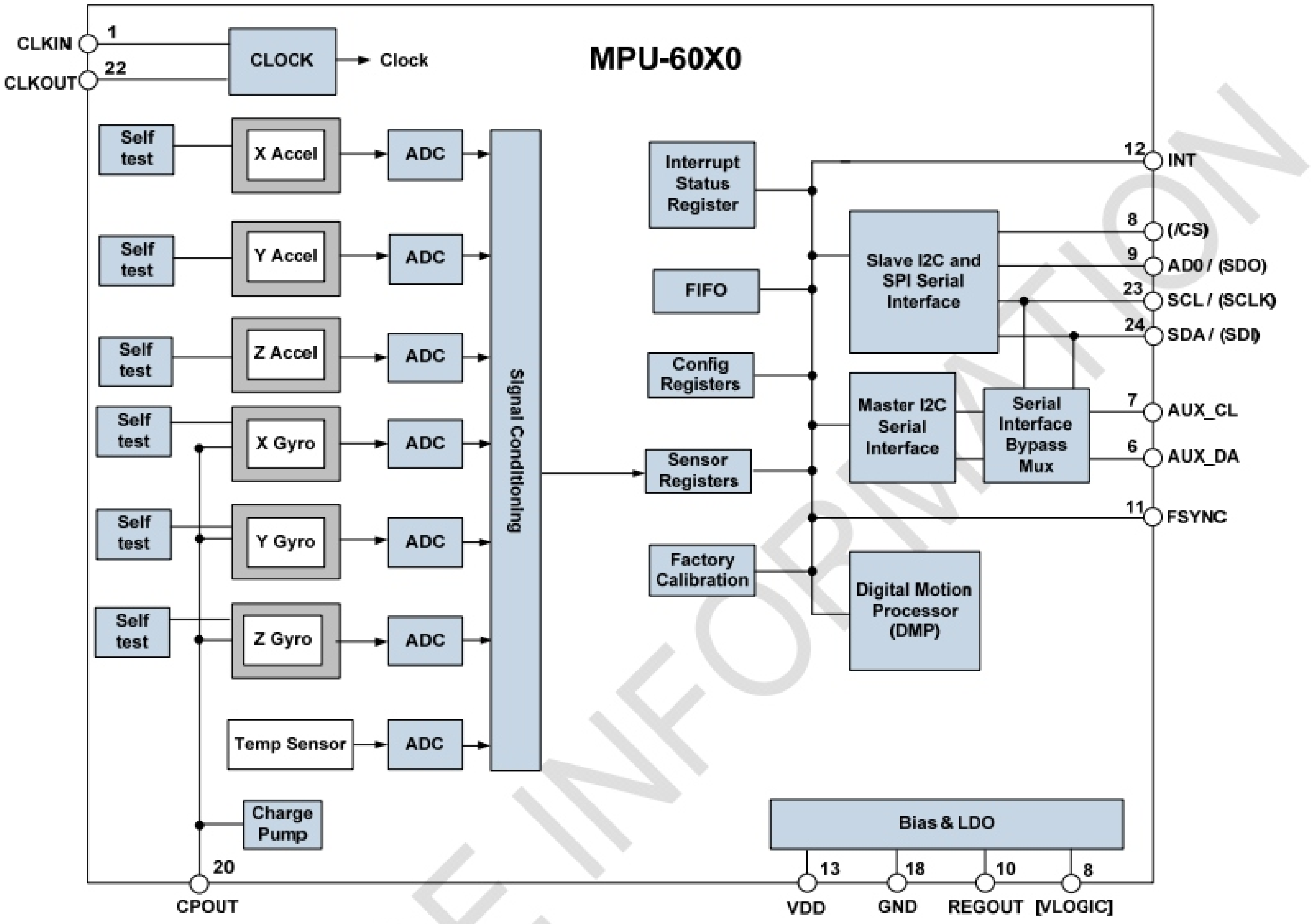
1. UART1 As the slave connection port
2. UART2 Do the main data output interface

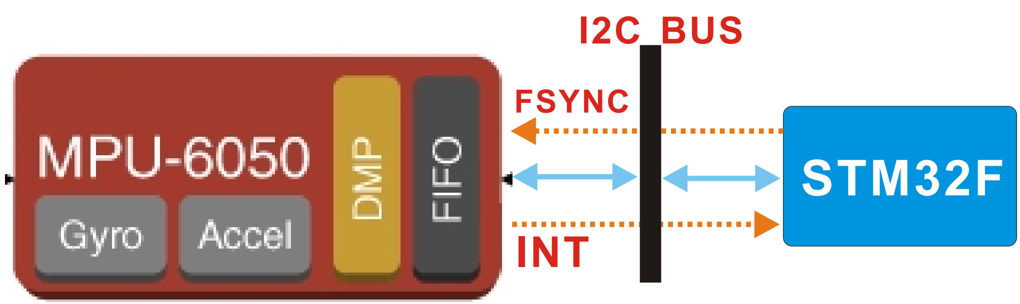
Two serial interface has a separate shared programmable baud rate to send and receive up to up to 4.5 Mbits / s. In the use of the DMA mode of the multi-buffer configuration, can achieve high-speed data communications.

UART1 can be used to connect an external GPS, to extend the function.
UART2 is used to send solver attitude data.

The emulator supports the SWD interface:
1. JLINK the V6 and above
2. ULINK2

2 MPU6050





Overview

MPU-6050 The world's first integrated 6-axis motion processing components, compared to the multi-component program, eliminating the difference between the issue in the axis of the combination of gyroscope and accelerator, reducing the amount of packaging space.

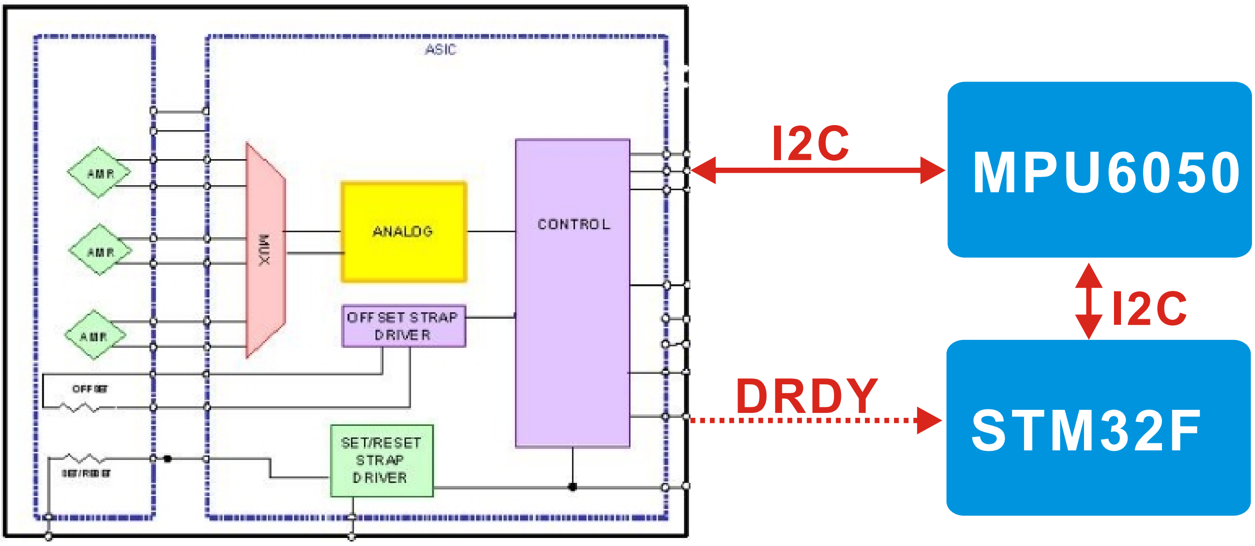
Features:

1. Tri-Axis angular rate sensor (gyro) with a sensitivity up to 131 LSBs/dps and a full-scale range of ±250, ±500, ±1000, and ±2000dps
2. Tri-Axis accelerometer with a programmable full scale range of ±2g, ±4g, ±8g and ±16g
3. Reduced settling effects and sensor drift by elimination of board-level cross-axis alignment errors between accelerometers and gyroscopes
4. Digital-output temperature sensor
5. Digital input on FSYNC pin to support video Electronic Image Stabilization and GPS
6. Programmable interrupt supports gesture recognition, panning, zooming, scrolling, free fall interrupt, high-G interrupt, zero-motion detection, tap detection, and shake detection
7. 400kHz Fast Mode I^2C
8. On-chip timing generator with ±1% frequency variation over full temperature range
9. 10,000g shock tolerant

Connection with the host controller

MPU6050 through the I2C interface connected to host controller STM32F. In the initialization phase, the STM32 will want to set the measurement sensitivity and sampling frequency of MPU6050 enable data update was interrupted. After the STM32 configuration pins as interrupt inputs. So that an interrupt is generated after the completion of a new sampling MPU6050 call STM32 read the new data.

3 HMC5883L



Overview

The Honeywell HMC5883L is an ultra-small sensor designed for low-field magnetic sensing with a digital interface for applications such as low-cost compassing and magnetometry.

The HMC5883L is a magnetic sensor in a 3.0x3.0x0.9 mm surface-mount 16-pin leadless chip carrier (LCC) that includes Honeywell's state-of-the-art, high-resolution magneto-resistive sensors with automatic degaussing (demagnetizing) strap drivers, offset cancellation and a 12-bit ADC for high resolution earth field sensing. Utilizing Honeywell's anisotropic magneto-resistive (AMR) technology, the solid-state HMC5883L features advanced precision in axis sensitivity and linearity and is designed to measure both the direction and the magnitude of Earth's magnetic fields. Applications for the HMC5883L include Mobile Phones, Netbooks, Consumer Electronics, Auto Navigation Systems and Personal Navigation Devices.

Key product features include:

1. 12-bit ADC coupled with low-noise AMR sensors achieves 2-milli gauss resolution in ±8 gauss fields
2. Allows for 1 to 2 degree compass heading accuracy
3. Built-in self-test – optional feature built into the internal ASIC
4. I2C digital interface
5. Fast 160 Hz Maximum Output Rate
6. Quickly verify sensor's full functionality without requiring expensive test equipment

Connection with the host controller

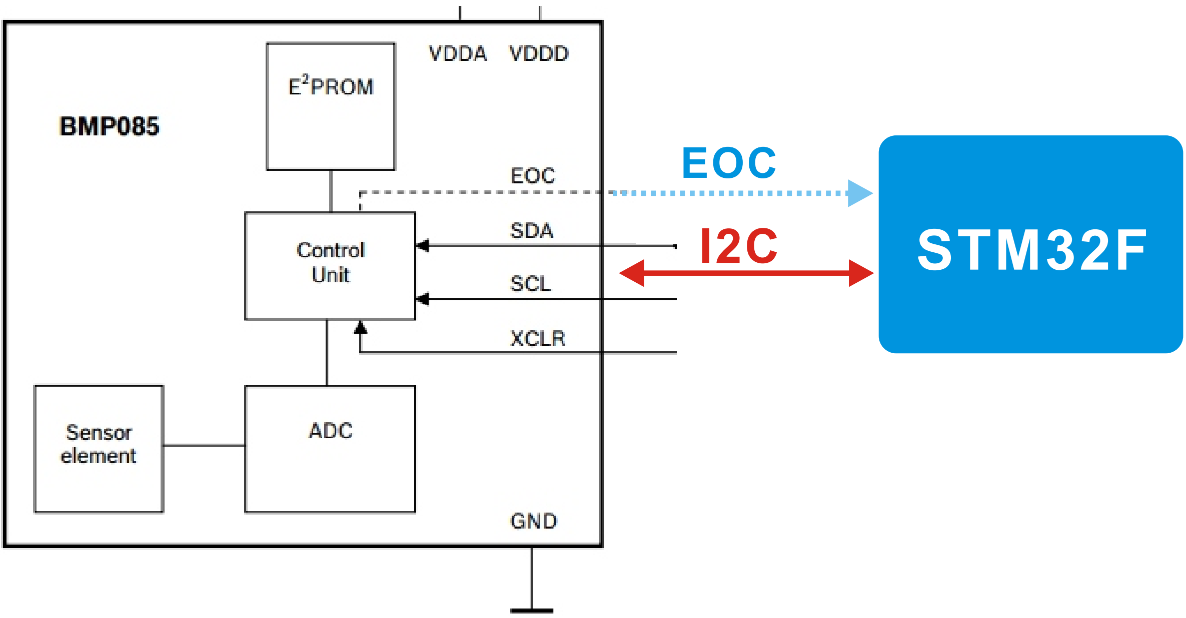
HMC5883L do not direct connected to host controller use I2C interface .But with MPU6050 AUXI2C interface connection, so that there are two ways to access the HMC5883L the data.

1. MPU6050 the AUX port is set to direct-attached STM32F direct access through the I2C HMC5883L
2. MPU6050 AUXI2C interface is responsible for collecting HMC5883L sampling results and the results stored in the FIFO register. STM32F by the access MPU6050 read the HMC5883 the conversion results.

The above two methods can be implemented in miniIMU no additional increase or modify the circuit, only to set MPU6050 corresponding control register.

HMC5883L data ready pin is connected to the STM32, check the pin level, determine whether there is a new conversion data.

4 BMP085



Overview

BMP085 is a high precision, ultra-low power consumption pressure sensors, can be applied to mobile devices. Its performance, the absolute accuracy of the minimum can reach 0.03hPa, and very low power consumption, only 3uA. BMP085 powerful 8-pin ceramic-lead chip carrier (LCC) ultra-thin package, through the I2C bus can be connected directly with a variety of microprocessor.

Key product features include:

Pressure range: 300 ... 1100hPa (Elevation 9000m...-500m)
Range: 300-1100mbar Accuracy: 0.03mbar
Interface: I2C Digital output
Supply voltage: 1.8V ... 3.6V (VDDA)
1.62V ... 3.6V (VDDD)
Low-power: 5μA In standard mode
High-precision: Low-power mode, Resolution 0.06hPa (0.5m)
High linear mode, Resolution 0.03hPa (0.25m)

- With temperature output
- I2C Interface
- Temperature compensation

Reaction time: 7.5ms
Standby current: 0.1μA

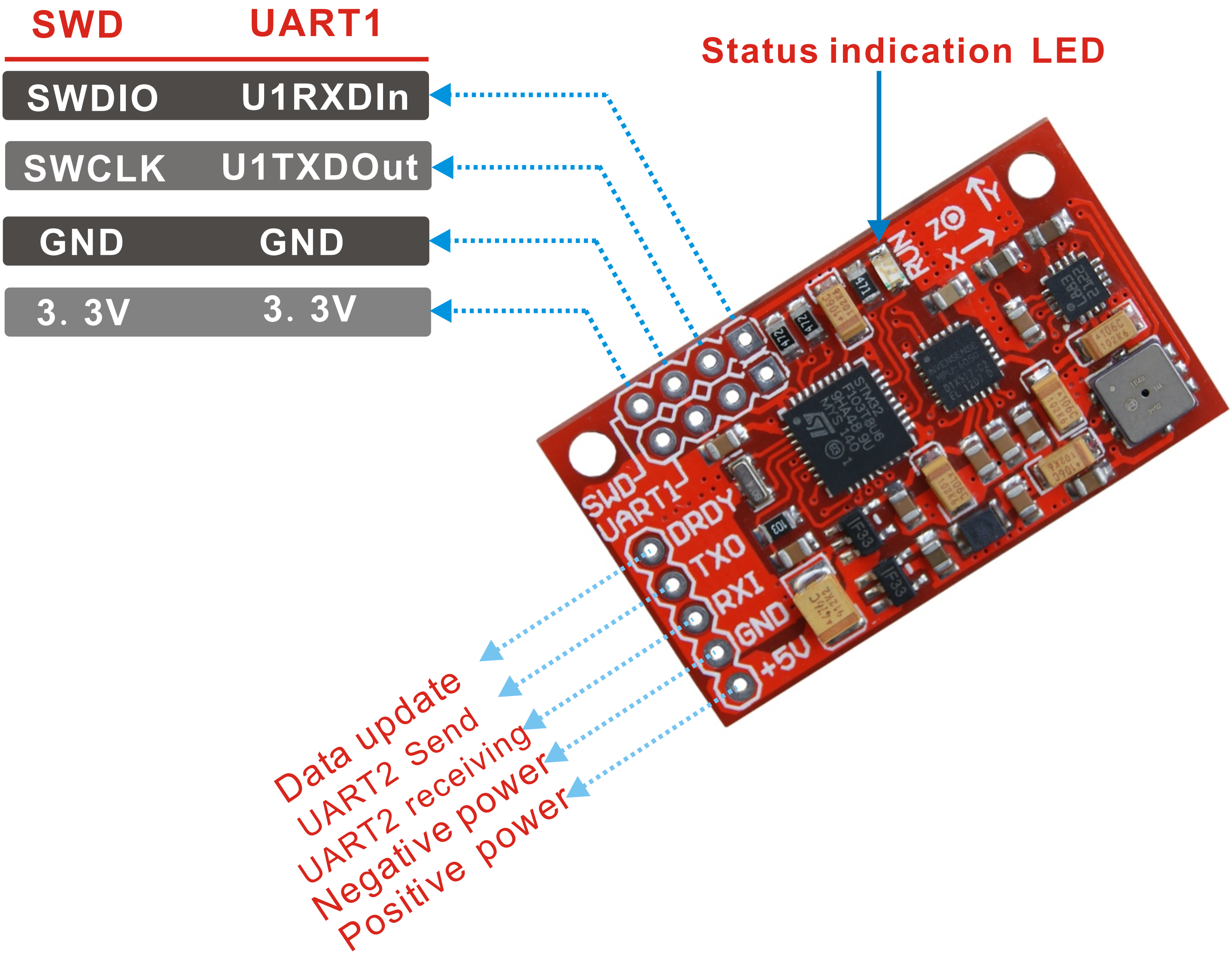
Connection with the host controller

BMP085 attached to the I2C bus, the STM32 can directly access to read the conversion data on BMP085.

Mode	Parameter *oversampling_setting*	Internal number of samples	Conversion time pressure max. [ms]	Avg. current @ 1 sample/s typ. [µA]	RMS noise typ. [hPa]	RMS noise typ. [m]
ultra low power	0	1	4.5	3	0.06	0.5
standard	1	2	7.5	5	0.05	0.4
high resolution	2	4	13.5	7	0.04	0.3
ultra high resolution	3	8	25.5	12	0.03	0.25

The maximum conversion time of 25.5ms, we do not want the program to wait for the conversion is complete, read the pressure. After the start of a conversion, how to use less CPU and learned conversion completed?
Then we need to read the level of the EOC to determine whether a conversion is completed. The open STM32F the port interrupt will be generated once the conversion is complete interruption.

5 MiniIMU Interface definition



6 MiniIMU Performance characteristics

Physical properties

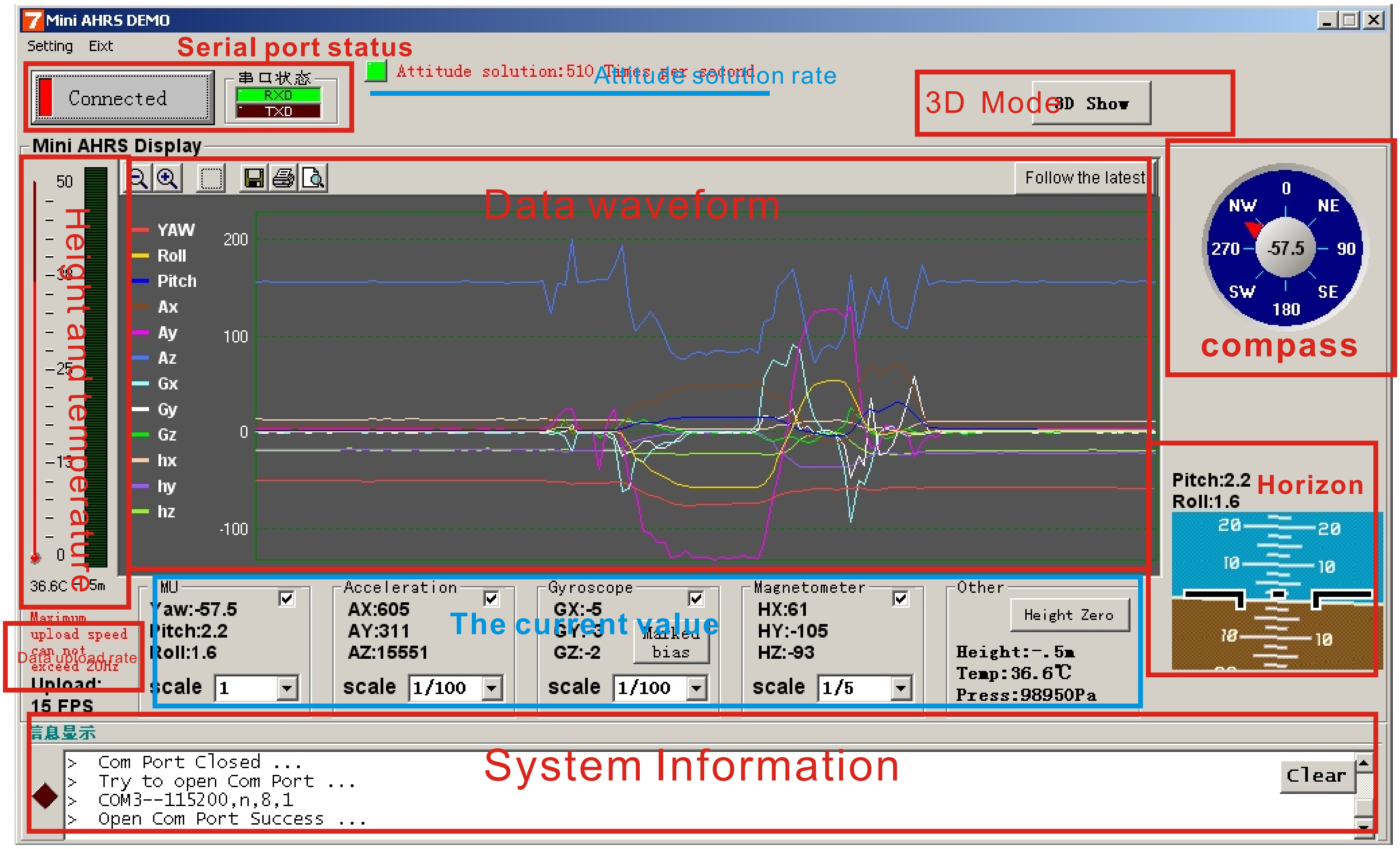
Module voltage:	4.0V-7.0V
Operating current:	50mA @5.0V
Dimensions:	37 x 22 x 5 mm
Weight (not including wire):	10g
Temperature range:	-10C - 60C
Digital interface:	**UARTA TTL Level**
Working hours power:	250**mW**

Sensor Characteristics

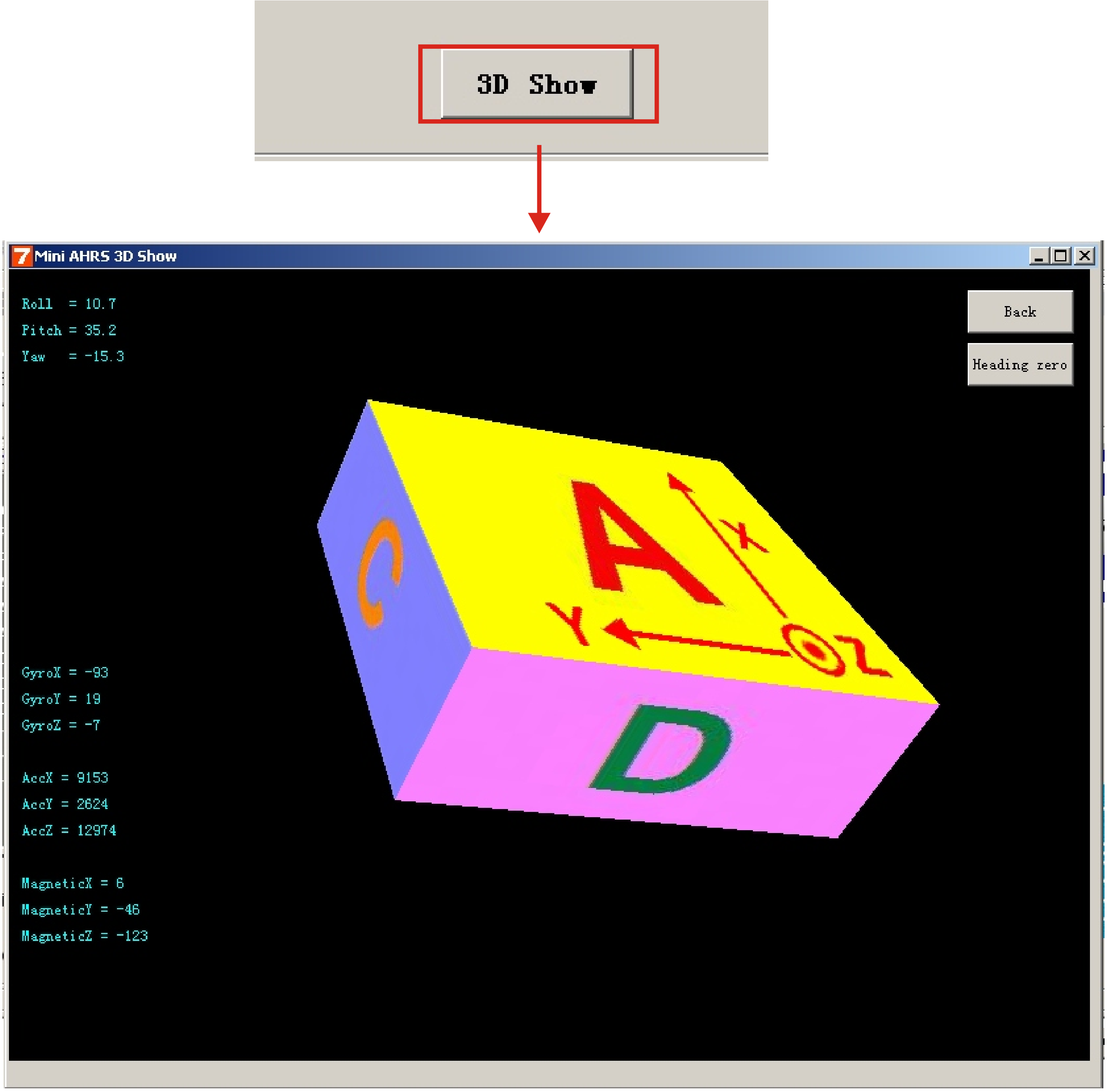
	Gyroscope	Accelerometer	magnetic	Pressure
Start-up	**100ms**	**100ms**	**50ms**	**10ms**
max range	±2,000d/s	**±16G**	**±8 Gaussian**	**300-1100hPa**
min range	**±250d/s**	**±2G**	**±1 Gaussian**	**300-1100hPa**
ADC	**16 Bit**	**16 Bit**	**12 Bit**	**16 Bit**
Resolution (**max range**)	**16.4 LSB/(°/s)**	**2,048 LSB/g**	**4.35 milli-gauss**	**0.01hPa**
Resolution (**min range**)	**131 LSB/(°/s)**	**16,384 LSB/g**	**0.73 milli-gauss**	**0.01hPa**
Update rate	4 - 8000 hz	**4 -1000 hz**	**0.75 - 75 hz**	**4.5 - 25.5 m**

7 MiniIMU With PC

Mini the IMU configuration of a host computer software used to display the output of each sensor, and attitude after the reconciliation count. Multiple display modes:
(1) waveform display data values written to the waveform in the form of the relationship between time
2, text displays the current value
3.3D shows that the attitude data after the solver can use 3D display various data.



Open the 3D gesture shows



Data communication protocol

To communicate with the host computer, you need the support of the communication protocol. A fixed frame format and the number of bytes specified. Host computer through an agreement known solution of the frame and update the corresponding data to the waveform, text and 3D display.

In the inside of this protocol, only two frames sent to the host computer:

1. Original sensors ADC data
2. Solving the attitude angle and pressure altitude

The original sensor ADC data is read out directly from the sensor measurement value, the ADC conversion results. No solver handling

Solver's attitude angle and pressure altitude will be the value of each sensor solver to get the current attitude of the target vector, pitch angle, roll angle, heading angle data

These two frames can be independently send. For example, only update the original ADC data, or update the data after the solver, which are allowed.

The original sensor ADC data frame format

Field	Description
Start 2bytes 0xA5 0x5A	Frame start byte, two bytes as a starting flag The first byte of a frame sent followed by 0xA5 0x5A
frame number of bytes 0x16	The frame contains the number of bytes, in addition to the starting byte (A5 5A) All the bytes (including itself and end bytes) the total number of
Frame Function 0xA2	Byte of the frame function is used to identify the frame type specified by the frame.
ACC X Axis H byte L byte	The first word of the data area is used to represent the X-axis of accelerometer ADC measured values□□.
⋮	
Mag Z Axis H byte L byte	The last word of the data area is used to represent the Z-axis magnetometer ADC measured values□□.
Frame Check 0xXX	protocol Checksum, all data (except for the two starting byte) be summated, the final result to take 8 as the calibration results.
End Byte 0xAA	The frame end byte

```
/*************************functions******************************************
*prototype:        void UART1_ReportMotion(int16_t ax,int16_t ay,int16_t az,int16_t gx,int16_t gy,int16_t gz,
                        int16_t hx,int16_t hy,int16_t hz)
*functions:          send the current sensor output value
Input:
     int16_t ax  Acceleration x Axis ADCoutput value
     int16_t ay  Acceleration y Axis ADCoutput value
     int16_t az  Acceleration z Axis ADCoutput value
     int16_t gx  Gyroscope X Axis ADCoutput value
     int16_t gy  Gyroscope y Axis ADCoutput value
     int16_t gz  Gyroscope z Axis ADCoutput value
     int16_t hx  Magnetic X Axis ADCoutput value
     int16_t hy  Magnetic y Axis ADCoutput value
     int16_t hz  Magnetic z Axis ADCoutput value
****************************************************************************/
void UART1_ReportMotion(int16_t ax,int16_t ay,int16_t az,int16_t gx,int16_t gy,int16_t gz,
                        int16_t hx,int16_t hy,int16_t hz)
{
     unsigned int temp=0xaF+9;
     char ctemp;
     UART1_Put_Char(0xa5);
     UART1_Put_Char(0x5a);
     UART1_Put_Char(14+8);
     UART1_Put_Char(0xA2);

     if(ax<0)ax=32768-ax;
     ctemp=ax>>8;
     UART1_Put_Char(ctemp);
     temp+=ctemp;
     ctemp=ax;
     UART1_Put_Char(ctemp);
     temp+=ctemp;

     if(ay<0)ay=32768-ay;
     ctemp=ay>>8;
     UART1_Put_Char(ctemp);
     temp+=ctemp;
     ctemp=ay;
     UART1_Put_Char(ctemp);
     Temp+=ctemp;

     if(az<0)az=32768-az;
     ctemp=az>>8;
     UART1_Put_Char(ctemp);
     Temp+=ctemp;
     ctemp=az;
     UART1_Put_Char(ctemp);
     temp+=ctemp;

     if(gx<0)gx=32768-gx;
     ctemp=gx>>8;
     UART1_Put_Char(ctemp);
     Temp+=ctemp;
     ctemp=gx;
     UART1_Put_Char(ctemp);
     temp+=ctemp;

     if(gy<0)gy=32768-gy;
     ctemp=gy>>8;
     UART1_Put_Char(ctemp);
     temp+=ctemp;
     Ctemp=gy;
     UART1_Put_Char(ctemp);
     temp+=ctemp;
//-------------------------
     if(gz<0)gz=32768-gz;
     ctemp=gz>>8;
     UART1_Put_Char(ctemp);
     temp+=ctemp;
     ctemp=gz;
     UART1_Put_Char(ctemp);
     temp+=ctemp;

     if(hx<0)hx=32768-hx;
     ctemp=hx>>8;
     UART1_Put_Char(ctemp);
     temp+=ctemp;
     ctemp=hx;
     UART1_Put_Char(ctemp);
     temp+=ctemp;

     if(hy<0)hy=32768-hy;
     ctemp=hy>>8;
     UART1_Put_Char(ctemp);
     temp+=ctemp;
     ctemp=hy;
     UART1_Put_Char(ctemp);
     temp+=ctemp;

     if(hz<0)hz=32768-hz;
     Ctemp=hz>>8;
     UART1_Put_Char(ctemp);
     temp+=ctemp;
     ctemp=hz;
     UART1_Put_Char(ctemp);
     Temp+=ctemp;

     UART1_Put_Char(temp%256);
     UART1_Put_Char(0xaa);
}
```

Solver attitude data frame format

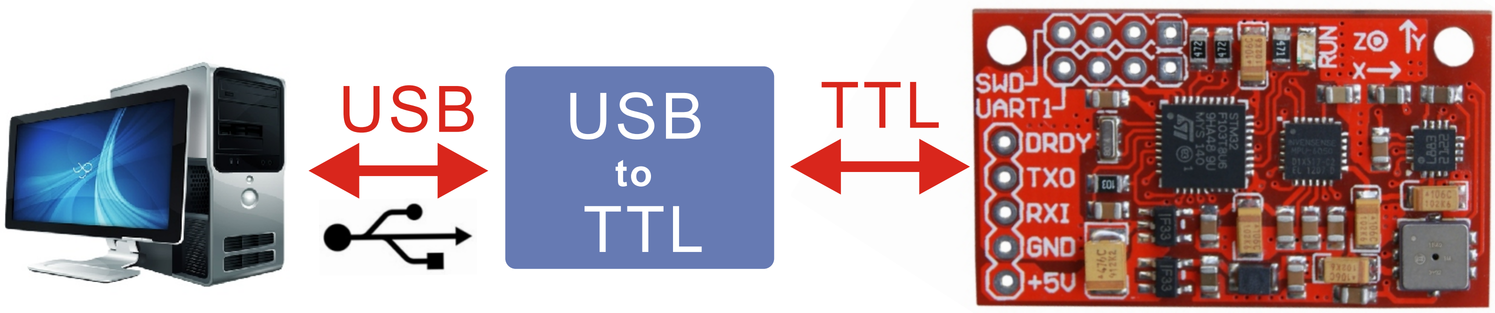
- **Start 2bytes 0xA5 0x5A** — Frame start byte, two bytes as a starting flag. The first byte of a frame sent followed by 0xA5 0x5A
- **frame number of bytes 0x10** — The frame contains the number of bytes, in addition to the starting byte (A5 5A) All the bytes (including itself and end bytes) the total number of
- **Frame Function 0xA1** — Byte of the frame function is used to identify the frame type specified by the frame.
- **heading angle H byte L byte** — The first word of the data area is used to represent the heading angle data after IMU solver This value is expressed in units of 0.1 degrees
- ⋮
- **Solving rate H byte L byte** — The last word in the data area, said the IMU operating frequency solver speed.This value should be a positive number
- **Frame Check 0xXX** — protocol Checksum, all data (except for the two starting byte) be summated, the final result to take 8 as the calibration results.
- **End Byte 0xAA** — The frame end byte

```
/*************************Functions****************************************
*Prototype:        void UART1_ReportIMU(int16_t yaw,int16_t pitch,int16_t roll
                   ,int16_t alt,int16_t tempr,int16_t press)
*Functions:        Solver attitude data sent to the PC
Input:
          int16_t yaw    Heading angle。Unit 0.1degree    0 -> 3600  Equal 0 -> 360.0度
          int16_t pitch Pitch angle，Unit 0.1degree   -900 - 900 Equal  -90.0 -> 90.0 度
          int16_t roll   Roll angle，Unit 0.1degree   -1800 -> 1800 Equal  -180.0  ->  180.0度
          int16_t alt    Pressure altitude。 Unit 0.1 m。
          int16_t tempr Temperature 。 Unit 0.1 c
          int16_t press Barometric pressure。Unit 10Pa
          int16_t IMUpersec   Attitude solution rate。Computing IMUpersec per second。
*****************************************************************************/
void UART1_ReportIMU(int16_t yaw,int16_t pitch,int16_t roll
,int16_t alt,int16_t tempr,int16_t press,int16_t IMUpersec)
{
    unsigned int temp=0xaF+2;
    char ctemp;
    UART1_Put_Char(0xa5);
    UART1_Put_Char(0x5a);
    UART1_Put_Char(14+2);
    UART1_Put_Char(0xA1);

    if(yaw<0)yaw=32768-yaw;
    ctemp=yaw>>8;
    UART1_Put_Char(ctemp);
    temp+=ctemp;
    ctemp=yaw;
    UART1_Put_Char(ctemp);
    temp+=ctemp;

    if(pitch<0)pitch=32768-pitch;
    ctemp=pitch>>8;
    UART1_Put_Char(ctemp);
    temp+=ctemp;
    ctemp=pitch;
    UART1_Put_Char(ctemp);
    temp+=ctemp;
    if(roll<0)roll=32768-roll;
    ctemp=roll>>8;
    UART1_Put_Char(ctemp);
    temp+=ctemp;
    ctemp=roll;
    UART1_Put_Char(ctemp);
    Temp+=ctemp;

    if(alt<0)alt=32768-alt;
    ctemp=alt>>8;
    UART1_Put_Char(ctemp);
    temp+=ctemp;
    ctemp=alt;
    UART1_Put_Char(ctemp);
    temp+=ctemp;

    if(tempr<0)tempr=32768-tempr;
    ctemp=tempr>>8;
    UART1_Put_Char(ctemp);
    temp+=ctemp;
    ctemp=tempr;
    UART1_Put_Char(ctemp);
    temp+=ctemp;

    if(press<0)press=32768-press;
    ctemp=press>>8;
    UART1_Put_Char(ctemp);
    temp+=ctemp;
    ctemp=press;
    UART1_Put_Char(ctemp);
    temp+=ctemp;

    UART1_Put_Char(temp%256);
    UART1_Put_Char(0xaa);
}
```

Mini IMU and PC hardware connection

Mini IMU interface is TTL level UART signals. Can not connect your computer directly. Converter is required. For a computer with a serial port, we can use an RS232 to TTL level of the module as a bridge.
Or a USB to serial TLL's module.

RS232 to TTL level adapter to connect



Adapter to connect USB to TTL level

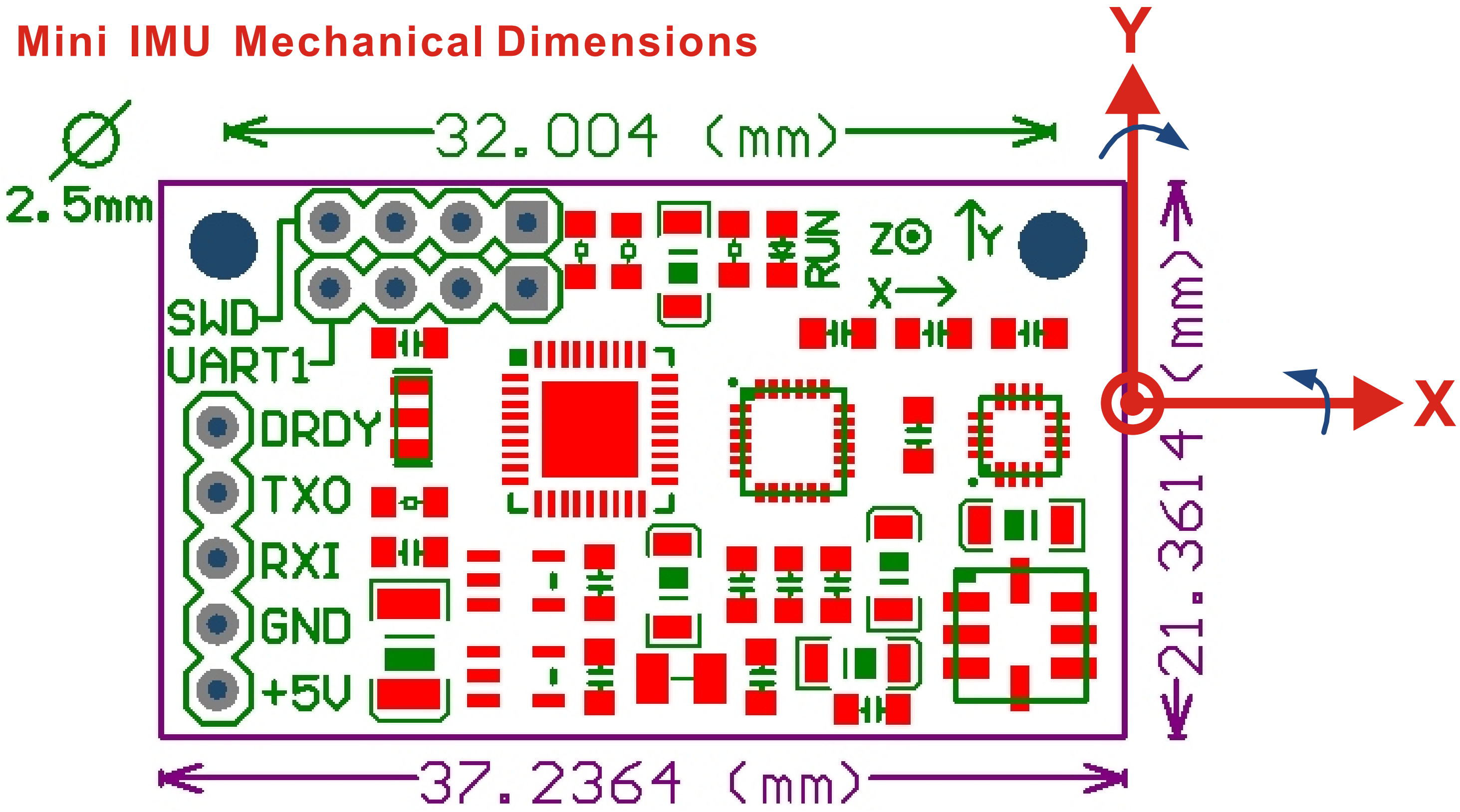
Special Note

TXO Send data interface module, signal direction is output
RXI Data receiving port of the module, signal direction for the input

In addition to communication devices to connect more than you need also to the module power supply to make it work. If you use a USB to TTL, you can take power from the computer's USB port.

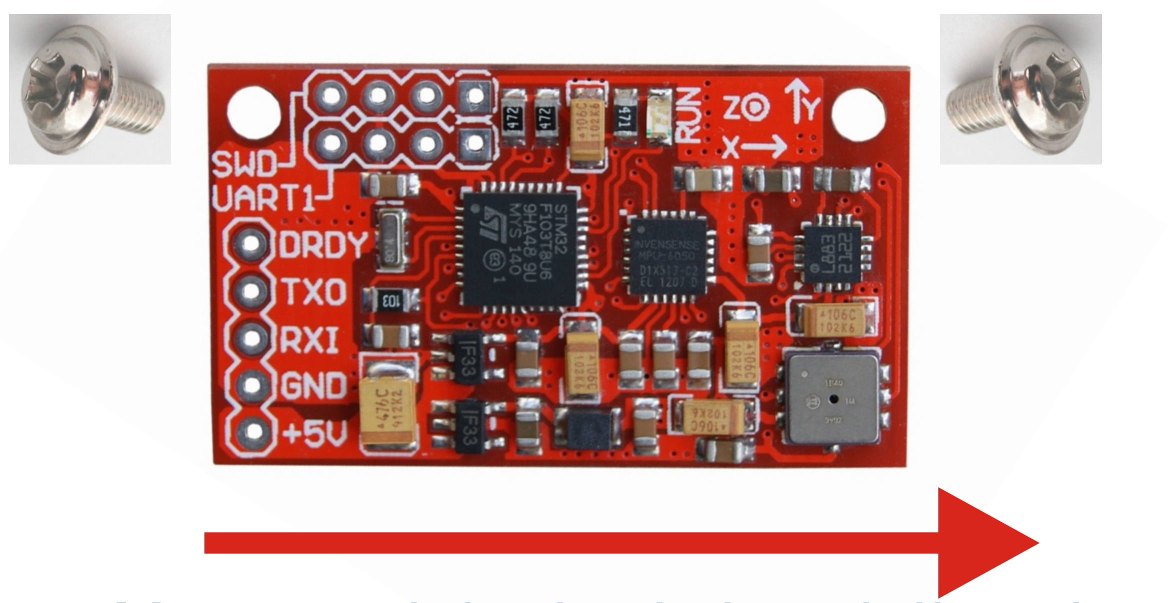
6 Installation Note

Mini IMU Mechanical Dimensions



Mini IMU Mounting

Mini the IMU has two screw holes for fixed module, the pore size of the screw holes is 2.7mm. Can be placed on a diameter of 2.5mm screws. Module must be horizontal, as far as possible be installed near the center of gravity of the measured carrier in the factory default X-axis direction of the arrow forward with the direction of the carrier head. We need to take appropriate damping measures, the best can install the module to the top of the shock mount, and then install the shock mount to the measured vector.



Measured the body head direction

Mini IMU Magnetic field effects

HMC5883L electronic compass is a detection device of the Earth's magnetic field, the geomagnetic field strength on the surface is not uniform, the intensity change due to their location in the venue change, the need for magnetic field calibration.

Earth's magnetic field strength ranging from 0.3-0.6 gauss, the intensity is very weak and susceptible to interference with metal objects, the current will cause interference. Should be used in the vehicle or ship away from the ferromagnetism of the engines and other large equipment.

There are two ways to reduce these disturbances:

A to install miniIMU must be kept away from metal objects, in particular, do not install a variable magnetic field generated in the motor of this place.

Once installation is complete, you need to HMC5883L magnetic field calibration operation. This operation can solve the fixed magnetic impact, such as the interference field generated by the nearby metal material, but can not lift the magnetic influence of the variable.

Thanks !

Thank you for your attention and choose

mini IMU