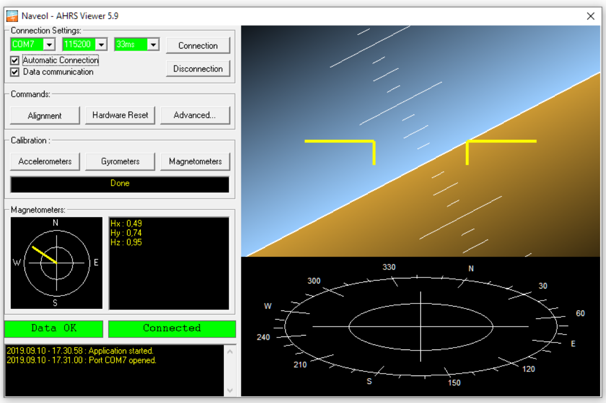
Orientation Sensor – IMU / AHRS

Description

NavH 2.0 is a miniature and low-cost Inertial Measurement Unit (IMU) with Attitude and Heading Reference System (AHRS) algorithms. It is fitted with high precision inertial sensors from ST (3-axes gyroscope, 3-axes accelerometer, 3-axes magnetometer) and a powerful 16 MIPS Digital Signal Processor. The module can be equipped with very standard 0.1” headers (6 pins) and is directly compatible with a 3.3V FTDI cable.

The board only requires 2.8V to 10V power supply to output data through serial stream (UART 3.3V) at 115200 bauds. The data packets are output when asked (character “F” has to be sent).

The sensors are sampled at 100Hz (10ms) and the virtual platform is also updated at 100Hz.



Free software available (www.naveol.com)

Features

Sensors

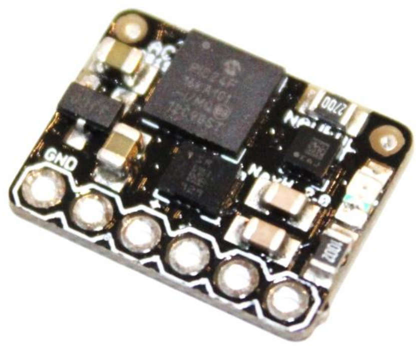
3 axes gyrometer (500°/s) – LSM6DSR (ST)
3 axes accelerometer (±4g) – LSM6DSR (ST)
3 axes magnetometer (±4Ga) – LIS3MDL (ST)

Inputs / Outputs

Full duplex UART (3.3V logic level) @ 115200bps
MCLR reset input (active low).

Hardware

16 MIPS DSP
16mA @ 2.8V to 10V
12.0mm * 16.0mm * 2.4mm
Weight: <1g



Software

IMU / AHRS

The implemented AHRS algorithm calculates attitude (Phi & Theta) and heading (Psi). The orientation quaternion (Q0, Q1, Q2, Q3) is also output, as well as the compensated sensor values.

The frequency of the basic task is 100Hz.

Calibration

The boards are individually calibrated in bias and scale factor. Auto-calibration routines are provided, especially for the magnetometers, to easily correct iron effects after installation in the final application.

LED indication

One green LED provides indications of the system state. At power up, the LED is switched ON, indicating the alignment of the AHRS (the board must remain stable during that time which lasts around 2s). Finally, the LED flashes each second indicating normal state of the AHRS.

Output Data

Output data is sent on a standard Universal Asynchronous Receiver Transmitter (UART). This serial transmission uses 3.3V logic levels and the baud rate is set to 115200bps, with 8 data bits, one stop bit and no parity bit.

The data packet starts with byte “F” and decimal byte 18 corresponding to the number of floats to be transmitted. Then, the 18 floats are transmitted. Each float is coded with 4 bytes:

F	18	Float 1	Float 2		Float 18

Float i	=	Byte 1	Byte 2	Byte 3	Byte 4

Data Packet

The following parameters are transmitted after reception of character “F”:

- “F”
- Number of floats (18)
- Phi (rad)
- Theta (rad)
- Psi (rad)
- Q0 (Quaternion parameter 0)
- Q1 (Quaternion parameter 1)
- Q2 (Quaternion parameter 2)
- Q3 (Quaternion parameter 3)
- P (rad/s)
- Q (rad/s)
- R (rad/s)
- Acceleration on X axis (m/s²)
- Acceleration on Y axis (m/s²)
- Acceleration on Z axis (m/s²)
- Earth Magnetic Field on X axis[1]
- Earth Magnetic Field on Y axis[1]
- Earth Magnetic Field on Z axis[1]
- Menu position (used during calibration)
- CPU load

[1] : The values are normalized to 1

Alignment

After power up, the AHRS needs 2 seconds to align. During that period, the board must be stable (no angular velocity and no acceleration). It is not necessary to put the board horizontally.

The alignment uses raw accelerometer and magnetometer data to compute rough attitude and heading. The gyrometer biases are also measured during that time and are used to initialise the real-time bias calculation.

Sending the command “R” at any time will force the AHRS alignment.

Calibration

An easy-to-use procedure has been implemented for the calibration of the sensors. The accelerometers can be re-calibrated in bias and scale factor by putting the board on the 6 faces of a cube. The gyrometers can be re-calibrated in scale factor by rotating exactly 1 turn on each axis. The magnetometers need to be calibrated after the installation in the user application or after any modification in the installation in order to compensate the iron effects (battery, screws...)

The parameters of each sensor calibration are stored into non-volatile Flash memory.

Accelerometers Calibration

The PC software gives indications to the user. When clicking on the “Accelerometer” button, the board outputs textual indications through UART that are displayed, such as “On the left (Phi=-90°)”, meaning the board should be positioned vertically, on the left side (Phi = -90°). The artificial horizon also helps by indicating the orientation the board should have. The 6 orientations (faces of a cube) have to be done.

Gyrometers Calibration

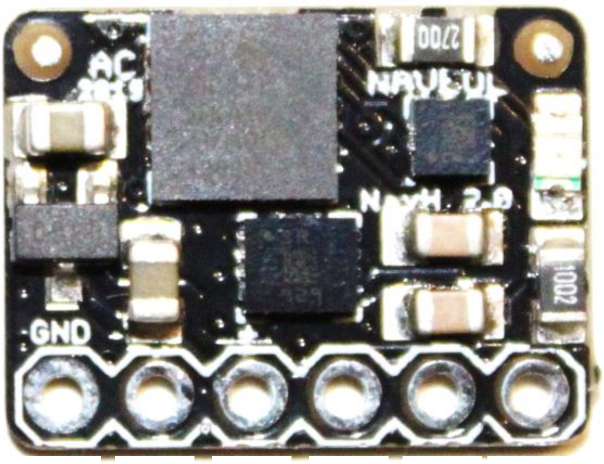
The calibration of the gyrometers starts by clicking on the “Gyrometers” button. The board must be rotated exactly 1 turn on each axis, in less than 5 seconds.

Magnetometers Calibration

The calibration of the magnetometers is needed after each installation modification. The principle is to align each axis of the board to the Earth magnetic vector. Be careful, this vector is not horizontal (except at the equator). In France for example, this vector is “down” by 60°. The 6 axes (positive and negative values) of the board must be manually aligned on the Earth vector during calibration. The idea is to sense the maximum value of the Earth magnetic field.

After the calibration, the user should verify that the magnetic vector measured by the AHRS (and displayed by the PC software) describes a circle when rotating the board horizontally along the Z axis. The radius of the described circle varies with latitude on Earth. It is around 0.5 (60°) in France (inner circle on PC software).

Board Connections



GND RB2 VDD RX TX MCLR