Project	Moitessier AIS/GNSS Navigation HAT (PE77001Exx)			
Date	2020-01-12			
Revision	0.1	2017-11-21	TP	Creation
	0.2	2018-02-22	TP	Updated specification Added new information
	0.3	2018-02-24	TP	Revised features Updated part numbering scheme
	0.4	2018-06-11	TP	Changed logo Changed sensitivity specification
	0.5	2018-06-26	TP	Pinout of HAT headers added
	0.6	2018-08-31	TP	Updated part numbering scheme Updated pinout 40-pin header
	0.7	2019-05-13	TP	Pinout of 40 pin IO header corrected
	0.8	2020-01-12	TP	Updated information for Moitessier HAT 2

Foreword

This document states the most relevant technical specifications of the Moitessier navigation HAT (hardware attached on top), that is compatible with the Raspberry Pi.

The specification is for reference only and is subject to technical changes and printing errors. This document can be changed at any time and without prior notice by csoft - Web and IT Solutions. All figures are symbolic photos.

Features

- Standalone usage or in combination with Raspberry Pi (standalone usage requires 3.3V power supply)
- Fully compatible with Raspberry Pi models supporting 40-pin IO header
- High-sensitivity dual channel AIS receiver with SMA antenna connector (better than -112 dBm)
- High-performance GNSS receiver with integrated patch antenna. An external antenna is supported via BNC connector.
- 3 status LEDs (AIS status, GNSS status, error)
- Barometric pressure, compass, heel and trim. Optional humidity and temperature (only reasonable for standalone usage). Sensors are directly accessible via Raspberry Pi. In standalone mode the sensors are controlled by the HAT microcontroller.
- IO headers (optional) to interface with spare GPIOs of the Raspberry Pi
  software emulated I^2C)
- UART signals of Raspberry Pi available on header (optional)
- Data communication via SPI (AIS, GNSS and meta data) and via I^2C (sensor data). Data accessible via device driver and device file.
- Supports ID EEPROM and automatic device tree loading
- Shutdown button
- Firmware upgradeable via Raspberry Pi
- OpenPlotter compatible (http://sailoog.com/openplotter)

Part Numbering Scheme

The Moitessier HAT features some options, that extend the functionality of the basic model and need to be specified when ordering.

Since hardware revision 5 the device is named *Moitessier HAT 2*.

**Figure 1: Basic model (left, PE77001Exx),
fully equipped model (right, PE77001Exx-DBG/IO/IPEX/M55/UART/SENS/256K/5V/I2C)**

Figure 2: HAT mounted on a Raspberry Pi 4 Model B (3D model)

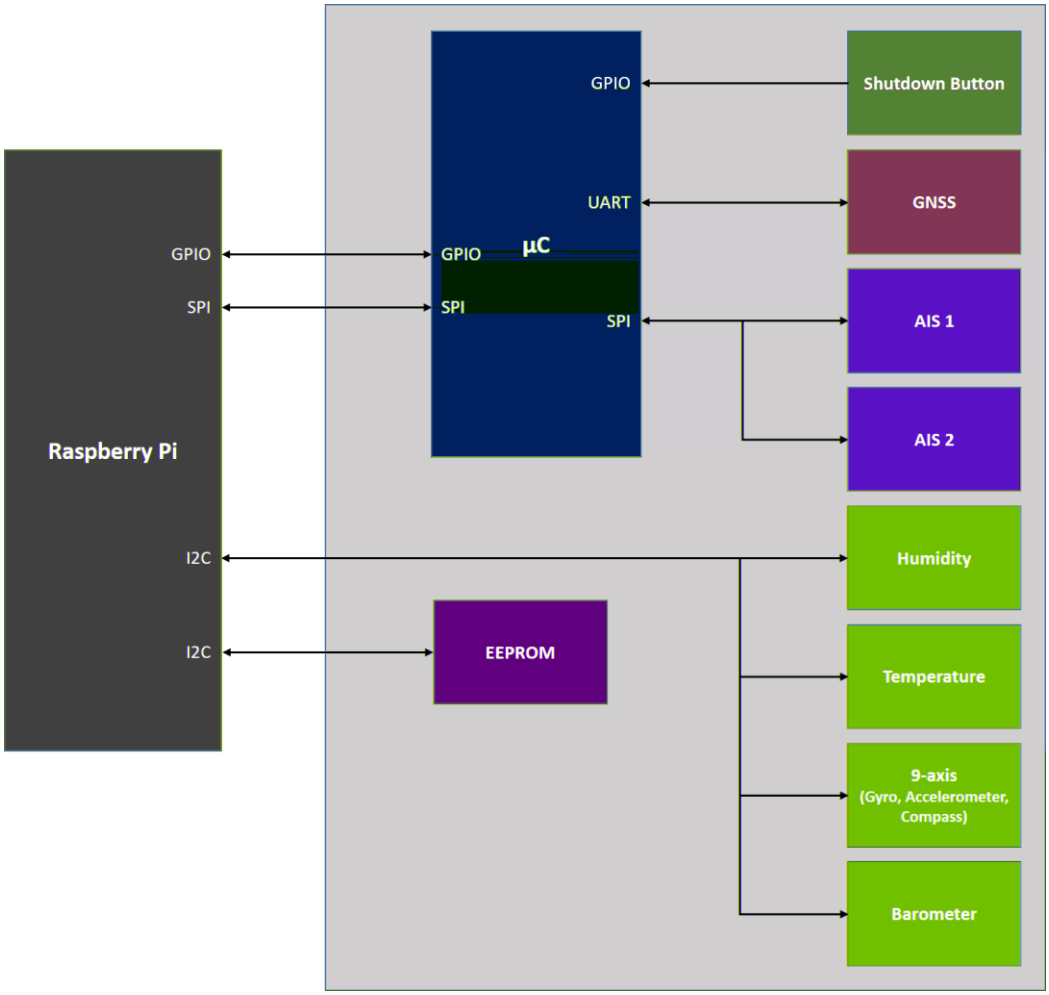

Figure 3: block diagram of the Moitessier HAT

Pinout 40 pin Raspberry Pi IO header

The HAT is controlled by the Raspberry Pi using several GPIOs. Green marked signals are not shareable with other hardware. Pins marked blue are not used by the HAT itself, but are accessible for extension purpose on optional headers on the HAT (see figure 5).

I²C and SPI bus can be shared with other hardware. Keep in mind that that this is not applicable for the chip select used with the SPI bus, which is exclusively used by the HAT.

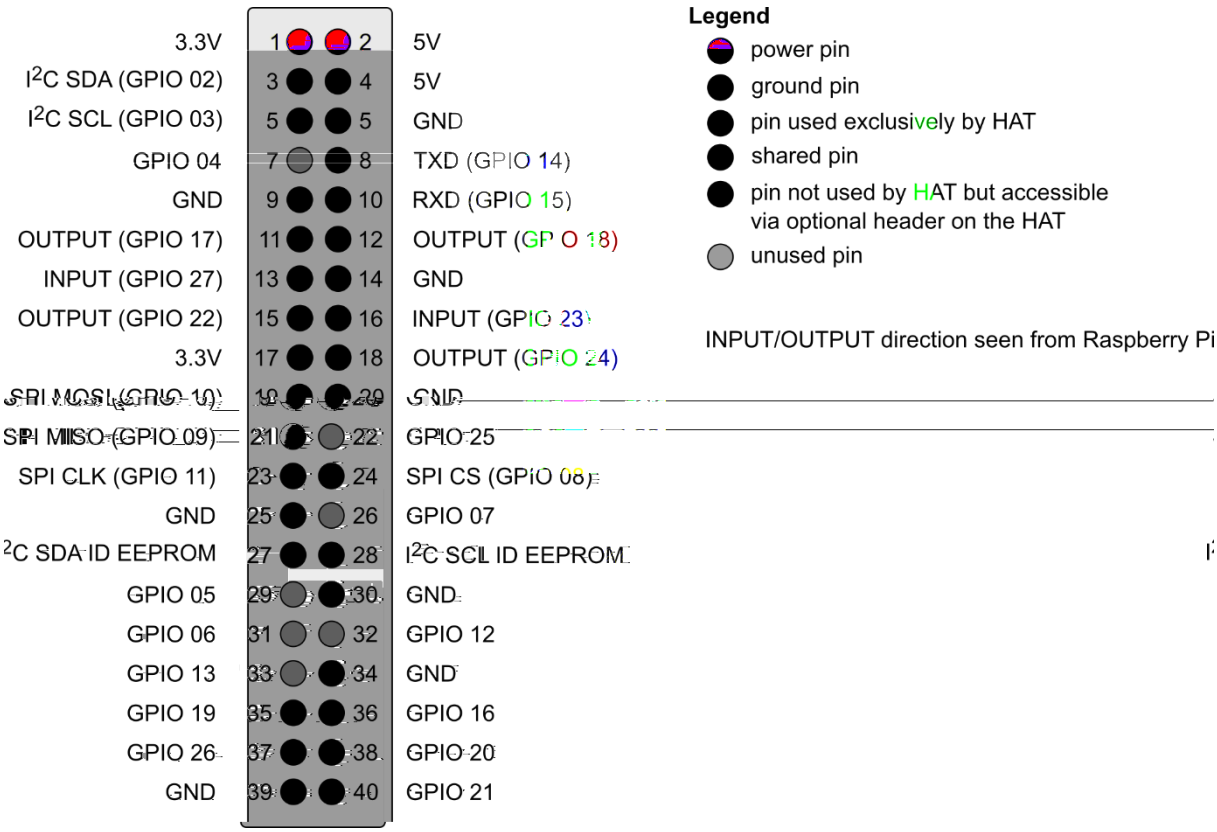

Figure 4: pinout of the Raspberry Pi 3 GPIO header

Pinout HAT headers

The Moitessier HAT features up to three optional headers, depending on the part number. Signals labeled with the prefix *DEBUG* are routed to the microcontroller of the HAT and are for debugging purpose only, mainly used for testing during production.

On header J503 the red marked signals shown in figure 4 are accessible. These signals are physically directly routed to the Raspberry Pi.

Header J702 is used for debugging and testing only and should not be used by the end customer.

The UART of the Raspberry Pi (GPIO15, GPIO14) can be accessed on J701. Be aware that this UART might be shared with the onboard Bluetooth module on the Raspberry Pi. You might need to change your boot configuration to use it.

Do not draw more than 15mA out of the 3.3V pins, the voltage regulator on the Raspberry Pi might reach its current limitation. This would result in a voltage drop and could cause a malfunction of the system.

Figure 5: pinout of the HAT headers

Technical Specification

Parameter	Meaning	Min.	Max.	Unit
General				
Supply voltage		3.135	3.465	V
Current consumption	Excl. HAT headers		185	mA
Operating temperature range		-20	65	°C
Dimensions	Excl. connectors		69x57	mm
Weight			39	g
AIS Receiver				
Interface	Seen from Raspberry Pi, receiver indirectly accessible through HAT microcontroller	SPI		
Input frequency	Channel spacing = 50 kHz	161.975	162.025	MHz
Input sensitivity	20 % PER, nominal input frequency	-112		dBm
Output data rate	Net data rate		9600	bits/s
	Packet interval *SPI communication interval between HAT and Raspberry Pi depends upon driver configuration*		37.5	Hz
BT			0.5	
GNSS Receiver				
Interface	Seen from Raspberry Pi, receiver indirectly accessible through HAT microcontroller	SPI		
Data rate	Net data rate		9600	bits/s
	Packet interval *SPI communication interval between HAT and Raspberry Pi depends upon driver configuration*		1	Hz
Channels	Acquisition		99	
	Tracking		33	
Supported satellite systems		GPS, GLONASS, QZSS		

Sensitivity	Acquisition		-148	dBm
	Tracking		-165	dBm
Dynamic performance	Altitude		18000	m
	Speed		515	m/s
	Acceleration		4	G
Cold start			35	s
Warm start			30	s
Horizontal position accuracy		2.5		m
Humidity and Temperature Sensor (Si7020-A20) - optional				
Interface	Directly accessible by Raspberry Pi	I^2C		
Slave address	7 bit	0x40		
Resolution	ADC, relative humidity		12	bits
	ADC, temperature		14	bits
Conversion time	12-bit relative humidity (RH)		12	ms
	14-bit temperature		10.8	ms
Operating range	Non-condensing	0	100	% RH
Accuracy	0-80% RH, T_A=30°C		±4	% RH
	> 80% RH, T_A=30°C		±6.5	% RH
	10°C < t_A < 85°C		±0.4	°C
	40°C < t_A < -10°C		±0.9	°C
	85°C < t_A < -125°C		±1.1	°C
Response time	RH sensor, $T_{63\%}$,1 m/s airflow, without cover		17	s
	Temperature sensor		7	s
Long term stability	RH sensor, typ. value			%RH/year
	Temperature sensor, typ. value			°C/year
Barometric Pressure Sensor (MS5607-02BA03)				
Interface	Directly accessible by Raspberry Pi	I^2C		
Slave address	7 bit	0x77		
Operating range		10	1200	mbar
Conversion time	Oversampling Ratio: 4096	7.4	9.04	ms
	Oversampling Ratio: 256	0.48	0.6	ms

Resolution	ADC		24	bits
	Oversampling Ratio: 256 / 512 / 1024 / 2048 / 4096	0.13/0.084/0.054/ 0.036/0.024		mbar
Accuracy	T_A=25°C, 750 mbar		±1.5	mbar
Response time	Oversampling Ratio: 256 / 512 / 1024 / 2048 / 4096	0.5/1.1/2.1/4.1/8.22		ms
Long term stability	Typ. value		±1.5	mbar/year
Motion Tracking Sensor (MPU-9250, gyroscope + accelerometer + magnetometer)				
Interface	Directly accessible by Raspberry Pi	I^2C		
Slave address	7 bit	0x68		
Gyroscope				
Full-scale range	FS_SEL=0, typ. value		±250	%s
	FS_SEL=1, typ. value		±500	%s
	FS_SEL=2, typ. value		±1000	%s
	FS_SEL=3, typ. value		±2000	%s
Sensitivity scale factor	FS_SEL=0, typ. value		131	LSB/(°/s)
	FS_SEL=1, typ. value		65.5	LSB/(°/s)
	FS_SEL=2, typ. value		32.8	LSB/(°/s)
	FS_SEL=3, typ. value		16.4	LSB/(°/s)
Resolution	ADC		16	bits
Nonlinearity	Best fit straight line, T_A=25°C, typ. value		±0.1	%
Output data rate		4	8000	Hz
Initial zero tolerance	T_A=25°C		±5	°/s
Accelerometer				
Full-scale range	AFS_SEL=0, typ. value		±2	g
	AFS_SEL=1, typ. value		±4	g
	AFS_SEL=2, typ. value		±8	g
	AFS_SEL=3, typ. value		±16	g
Sensitivity scale factor	AFS_SEL=0, typ. value		16384	LSB/g
	AFS_SEL=1, typ. value		8192	LSB/g
	AFS_SEL=2, typ. value		4096	LSB/g
	AFS_SEL=3, typ. value		2048	LSB/g
Resolution	ADC		16	bits
Initial tolerance	Typ. value		±3	%

Nonlinearity	Best fit straight line, T_A=25°C, typ. value		±0.5	%
Output data rate		0.24	4000	Hz
Magnetometer				
Full-scale range	Typ. value		±4800	µT
Resolution	ADC		14	bits
Sensitivity scale factor	Typ. value		0.6	µT/LSB
Initial calibration tolerance	Typ. value		±500	LSB