Inertial navigation

GNSS+INS MODULE

PRODUCT DOCUMENTATION

INS7 | INS8 | INS Development kit

GABLE

MASTERING MOTION

GABLE TECHNOLOGIES BV
Lintelerweg 10
7556 PD Hengelo,The Netherlands

Document information

Name	Date	Revision	Source
Gable-IMU™ GNSS-INS Module Product Documentation	06-02-2026	A.02	www.gable-imu.nl

Revision History

Revision number	Date	By	Description
A.00	07-07-2025	HCV, JF	First release
A.01	11-07-2025	HCV	Added specifications, renamed document and changed formatting
A.02	06-02-2026	HCV, SMB	Updated Figure 6, updated cover

Table of Contents

List of Tables

List of Figures

1 General information

This document provides information on the technical details and usage of the Gable-IMU™ GNSS-INS Module Development Kit. The GNSS-INS Module Development Kit is a fully functional, easy to build-in combination of MTi-7/8 Inertial Measurement Units (IMUs) with GNSS Module and barometer, which can be easily used in prototype solutions including Arduino-compatible development boards. The GNSS-INS Module can also be easily integrated into an existing solution. Please consult Gable Technologies for advice and/or support on these topics.

Gable Technologies B.V.
www.gable-imu.nl

1.1 Remarks on the documentation

1.1.1 Target audience

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards. It is essential that the documentation and the following notes and explanations are followed when installing and commissioning GNSS-INS Module.
It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.
The responsible staff must ensure that the application or use of the devices described in this manual satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

1.1.2 Disclaimer

The documentation has been prepared with care. The devices described are, however, constantly under development.
Gable Technologies B.V. reserves the right to revise and change the documentation at any point in time and without prior announcement. No claims for the modification of products that have already been supplied may be made based on the data, diagrams and descriptions in this documentation.

1.1.3 Trademarks

Gable-IMU™ is a trademark of Gable Technologies B.V.

U-blox is a registered trademark of u-blox Holding AG.

XSENS® is a registered trademark of XSENS Technologies B.V. and/or its parent, subsidiaries and/or affiliates in The Netherlands, the USA and/or other countries.

1.1.4 Copyright

1.2 Safety instructions

1.2.1 Safety regulations

The following safety instructions should be read and noted! Specific safety instructions can be found in subsections throughout this document.

1.2.2 Exclusion of liability

All the components are supplied with specific hardware and software configurations appropriate for the application. Hardware or software configuration modifications other than those described in this document are not permitted, and nullify the liability of Gable Technologies B.V.

1.2.3 Personnel qualification

This description is only intended for trained specialists in control and automation familiar with the applicable national standards.

1.2.4 Description of symbols

In this documentation the following symbols are used with an accompanying safety instruction or note. Make sure to carefully read the instructions!

INFORMATION
This symbol indicates information that contributes to better understanding.

CAUTION
This symbol makes the user alert to actions that could cause equipment damage, resulting in the equipment becoming unsafe, or to actions or operations that could have undesirable consequences.

WARNING
This symbol makes the user aware of potentially hazardous events related to the GNSS-INS Module that may result in permanent damage to the device and/or interfaced equipment.

1.3 Ordering information

When ordering a Gable GNSS-INS Module, the order codes as specified in Table 1 are to be used. Our online product selector (www.gable-imu.nl) can also be used to find the product that fits your application best. Please consult our sales department about production quantities, pricing and custom solutions.

Table 1: Ordering code GNSS-INS Module

INS7	-	MOD
↓		↓
TYPE: INS7 INS8		**VARIANT:** MOD = GNSS/INS Module DEV = Development Kit

1.4 Packaging Information

Table 2: Packaging information Development Kit

Kit	Description	Content	Packing method
INS7-DEV		▪ GNSS-INS Module equipped with MTi-7[1] and ZED-F9P[2] ▪ Arduino Shield ▪ MHF-4-compatible to MHF-4-compatible RF connecting cable ▪ GNSS Antenna ▪ USB-A to USB-C cable	Single unit
INS8-DEV		▪ GNSS-INS Module equipped with MTi-8[3] and ZED-F9P[2] ▪ Arduino Shield ▪ MHF-4-compatible to MHF-4-compatible RF connecting cable ▪ GNSS Antenna ▪ USB-A to USB-C cable	Single unit

Table 3: Packaging information GNSS-INS Module

Module	Description	Package Content	Packing method
INS7-MOD	GNSS-INS Module equipped with the Xsens MTi-7 sensor and a U-blox ZED-F9P GNSS receiver	GNSS-INS Module MTi-7	Single unit or box of 20
INS8-MOD	GNSS-INS Module equipped with the Xsens MTi-8 sensor and a U-blox ZED-F9P GNSS receiver	GNSS-INS Module MTi-8	Single unit or box of 20

[1] https://www.movella.com/products/sensor-Modules/xsens-mti-7-gnss-ins
[2] https://www.u-blox.com/en/product/zed-f9p-Module
[3] https://www.movella.com/products/sensor-Modules/xsens-mti-8

2 Introduction

This section presents the Gable-IMU™ GNSS-INS Module Development Kit.

2.1 Development Kit contents and features

The GNSS-INS Module Development Kit contains (from left-to-right in Figure 1):

- GNSS-INS Module with Arduino Shield extension,
- Active antenna with SMA connector,
- USB-A to USB-C cable,
- USB A to 4-pin header cable.

Figure 1: GNSS-INS Module Development Kit with cables/extensions

The features of GNSS-INS Module Development Kit (see Figure 2) include:

- USB-C connector enabling access to the onboard MTi-7/8,
- GNSS RTK correction interface,
- Arduino-compatible headers,
- Peripheral interface selection switch (enables selection of SPI, I^{2}C or UART Half-Duplex and Full-Duplex),
- Optionally mountable RTK/GFC status connector,
- GNSS receiver USB-connection header,
- IPEX MHF-4-compatible extension connector,
- SMA active antenna connector.

Figure 2: GNSS-INS Module Development Kit

2.2 Absolute maximum ratings

Table 4: Absolute maximum ratings

	Min	Max	Unit	Comment
Supply voltage Vin	-0.3	6	V	With respect to GND (Ground)
Storage temperature	-40	+90	°C	
Operating temperature	-40	+85	°C	
Storage humidity		< 90%		Relative Humidity non-condensing
Acceleration[4]		10,000	g	Any axis, unpowered for 0.2ms
ESD protection[5]		±2000	V	Human body model

[4] This is a mechanical shock (g) sensitive device. Proper handling is required to prevent damage to the part.
[5] This is an ESD-sensitive device. Proper handling is required to prevent damage to the part.

3 GNSS-INS Module

3.1 Recommended operating conditions

Table 5: GNSS-INS Module recommended operating conditions

	Min	Typ.	Max	Unit	Comment
Supply voltage Vin	4	-	5.5	V	With respect to GND (Ground)
$V_{UART,PSEL,I2C,SPI,NRST,SYNC,TMP}$	-0.3	-	3.6	V	Voltage level of UART, PSEL, I^2C, SPI, NRST, SYNC, TMP with respect to GND (3.3V logic level)
V_{VCC_USB}	4	-	5.5	V	Voltage level for GNSS USB power with respect to GND
Power consumption	-	550	650	mW	Power consumption (without external components)
Output current range (3.3V output)	-	-	500	mA	Combined current that can be sourced from the 3.3V outputs on the fine pitch connectors

3.2 GNSS-INS Module performance specifications

In this section the position and orientation performance specifications of the GNSS-INS Module are presented.

Table 6: Orientation performance specifications

Parameter		INS-7	INS-8
Roll/Pitch [deg]	Static [RMS]	0.5	0.5
	Dynamic (car, 25m/s)[RMS]	0.5	0.5
Yaw [deg]	[RMS]	1.5	1.0[6]

Table 7: Position and velocity performance INS-7

Parameter		Specification
Position [m]	Horizontal (CEP)	1.0
	Vertical (CEP)	2.0
Velocity [m/s]	(1σ RMS)	0.05

Table 8: Position and velocity performance INS-8 (RTK enabled)

Parameter		Specification
Position [m]	Horizontal (CEP)	0.01 + 1 ppm[7]
	Vertical (CEP)	0.1 + 1 ppm[7]
Velocity [m/s]	(1σ RMS)	0.05

[6] With RTK/correction messages enabled

[7] 1 ppm = 1 part per million, e.g. an additional 1 mm of error for every kilometer distance from the RTK base station. Position accuracies are assuming proper GNSS reception/circumstances.

3.3 GNSS-INS Module data output rates

In this section the data output rates of the GNSS-INS Module are presented. A zero in the column with the 'Min' identifier means it can be turned off such that this data is not send. Different output rates up to the value in the 'Max' column can be configured through MT Manager (see section 5.1).

Table 9: Data output rates

Group	Min	Max	Unit	Comment
Temperature	0	1	Hz	IMU temperature [°C]
Orientation Data	0	100	Hz	Quaternion, Rotation Matrix and Euler Angles [deg]
Pressure	0	50	Hz	Baro pressure [Pa]
Acceleration	0	100	Hz	(Free) acceleration [m/s^2] and Delta V (Delta velocity value) [m/s]
Position	0	100	Hz	Altitude Ellipsoid [m], Position ECEF [m] and Latitude/Longitude [deg]
GNSS	0	4	Hz	GNSS PVT data and GNSS PVT pulse [s]
Angular Velocity	0	400	Hz	Rate of turn [rad/s] and Delta Q (Delta quaternion value)
Magnetic	0	100	Hz	Magnetic Field [a.u.]
Velocity	0	100	Hz	Velocity XYZ [m/s]

Besides the data outputs mentioned in Table 9, also the raw acceleration and gyroscope data can be obtained at ~1KHz. Please note that these outputs are not aligned with the other data. A unique timestamp is included for these outputs.

3.4 GNSS-INS Module pinout

The GNSS-INS Module is a ready-to-insert Low SWaP-C solution that aims at providing highly precise position and orientation data. In Figure 3, the 3D model of GNSS-INS Module is presented with marked connector designators.

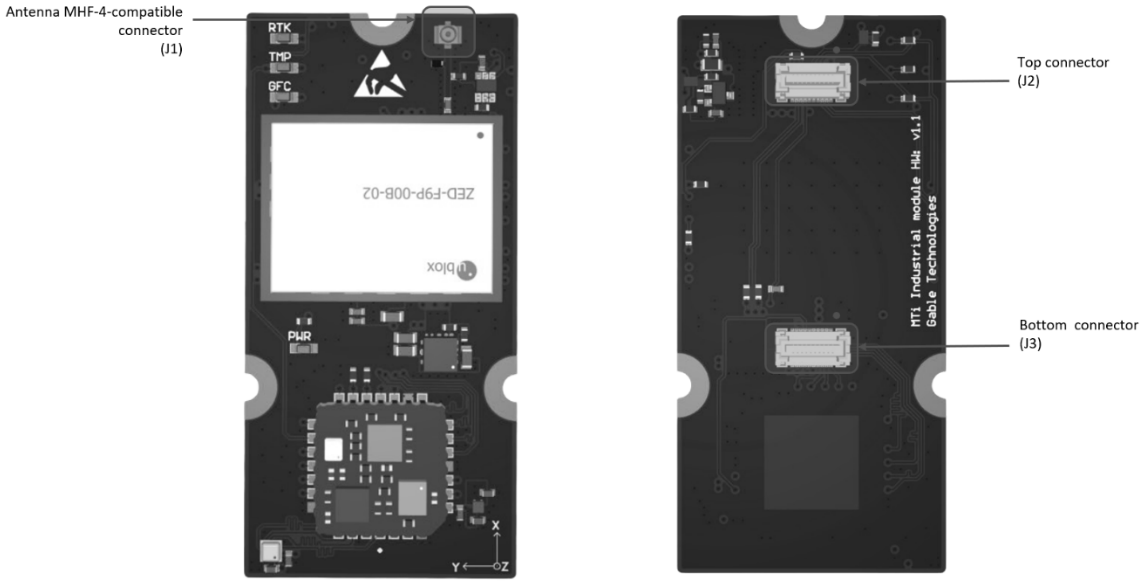

Figure 3: GNSS-INS Module connector designators

Pin 1 of each fine pitch connector, J2 and J3, is the top-left pin in GNSS-INS Module top view (top-right pin in the Module bottom view), marked with a blue dot in the bottom view (see Figure 3). The individual numbering of pins in the fine pitch connectors are shown in Figure 4.

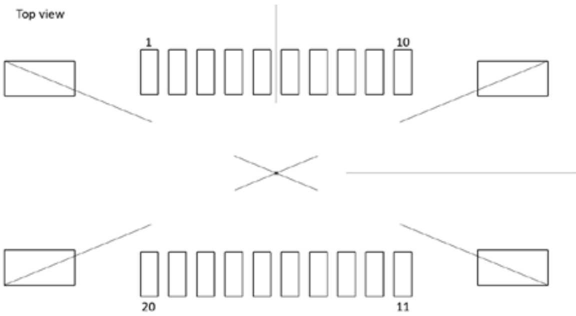

Figure 4: Pinout and footprint of the fine pitch connector (GNSS_INS Module top view)

The functionality of each individual connector pin is presented in Table 10 and Table 11.

Table 10: Pinout description Top connector (J2)

Pin	Name	Description
J2-1	3V3OUT	3.3V output voltage, for maximum ratings check Table 5
J2-2	GND	Ground
J2-3	GFC_STAT	Geofence status, user defined
J2-4	RTK_STAT	Real-time kinematic positioning (RTK) status 0 = RTK/PPP-RTK fixed Blinking = receiving and using corrections 1 = no corrections
J2-5	TMP (SYNC_PPS)	Time Pulse, Pulse Per Second output of GNSS Module
J2-6	GND	Ground
J2-7	GND	Ground
J2-8	$\overline{\mathrm{NRST\_GNSS}}$	Active low GNSS reset
J2-9	GND	Ground
J2-10	3V3OUT	3.3V output voltage, for max ratings check section Table 5
J2-11	GND	Ground
J2-12	DP	GNSS USB D+
J2-13	DN	GNSS USB D-
J2-14	VCC_USB	GNSS USB power (5V input)
J2-15	GND	Ground
J2-16	GND	Ground
J2-17	GND	Ground
J2-18	TX2	GNSS correction UART output
J2-19	RX2	GNSS correction UART input
J2-20	GND	Ground

Table 11: Pinout description Bottom connector (J3)

Pin	Name	Description
J3-1	GND	Ground
J3-2	TX/SCL	UART Transmitter data output / I^2C Serial Clock Line
J3-3	RX/SDA	UART Receiver data input / I^2C Serial Data Line
J3-4	CTS/nRE	UART Clear-to-Send
J3-5	RTS/DE	UART Ready-to-Send
J3-6	GND	Ground
J3-7	$\overline{\mathrm{NRST\_MTI}}$	Active low MTi-7/8 reset
J3-8	3V3OUT	3.3V output voltage (For output current limit refer to section 3.1)**Fout! Verwijzingsbron niet gevonden.**
J3-9	GND	Ground

J3-10	VIN	Voltage input (Refer to section 3.1 for input range)
J3-11	GND	Ground
J3-12	SPI_nCS	SPI active high Chip Select
J3-13	SPI_MISO	SPI Serial Data Input (Master Out Slave In)
J3-14	SPI_MOSI	SPI Serial Data Output (Master In Slave Out)
J3-15	SPI_SCK	SPI Serial Clock
J3-16	GND	Ground
J3-17	PSEL0	Peripheral interface selection pin 0
J3-18	PSEL1	Peripheral interface selection pin 1
J3-19	SYNC_IN	Sync Input, accepts a trigger input to request the latest available data message
J3-20	SYNC_OUT	Sync Output (reserved for future use, do not connect)

It is important to note that the GNSS-INS Module can only operate at **a 3.3V logic level**. Therefore, different logic levels require external level shifting in the customer's design.

3.5 Peripheral interface selection

The GNSS-INS Module supports three low level interfaces for host communication (I^2C, SPI and UART). They can be selected by the host through the peripheral interface selection pins PSEL0 and PSEL1. The state of the pins are read at the start-up of the Module, therefore, to change the interface, the host has to set the pin levels and then reset the MTi-7/8 (see Table 11). The MTi-7/8 has internal pull-ups on both pins, therefore the default selection is I^2C when left unconnected. In Table 12, the interfaces and corresponding combinations of PSEL1/0 are presented.

Table 12: Peripheral interface selection combinations

Interface	PSEL1	PSEL0
UART full duplex	0	0
UART half duplex	0	1
SPI	1	0
I^2C	1	1

3.6 Module dimensions

The general dimensions of the GNSS-INS Module are given in Figure 5 (in millimeters). The location of the origin of MTi-7/8 measurements is described with dimensions with respect to bottom right corner of the board (left image in Figure 5). For the GNSS position measurements, the origin of measurement is the antenna origin (Please refer to the lever arm settings in https://mtidocs.movella.com/messages → 'SetGnssLeverArm' to configure the lever arm between the MTi-7/8 origin and GNSS antenna origin).

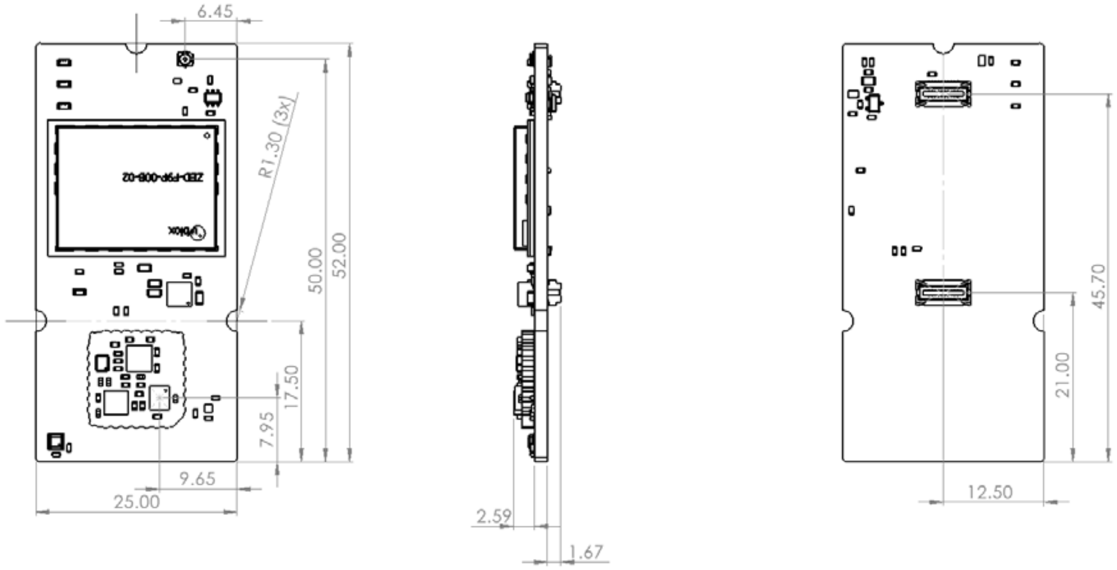

Figure 5: GNSS-INS Module dimensions

3.7 LED indicators for RTK/TMP/GFC

3.7.1 RTK LED indicator

After a connection between the GNSS-INS module and a RTK correction message source (refer to section 5.3) has been established, the LED indicator will show the current state of 3D fixing of the device (see Table 13). If the LED indicator is off, no (valid) RTK corrections are received by the device, and RTK_STAT pin is 1. If the LED indicator is blinking, then valid RTK corrections are received by the device. When the LED indicator is steady lit, an accurate 3D position fix is achieved. The RTK_STAT pin now is 0.

3.7.2 TMP LED indicator

After correct and accurate position data is being received, the GNSS receiver sends a continuous time pulse to the onboard MTi-7/8 and through the fine pitch connector (J2) to other connected devices. The time pulse is by default set to 1Hz. If the TMP LED indicator is blinking this means a time pulse signal is sent by the onboard GNSS receiver (see Table 13).

3.7.3 GFC LED indicator

After setting up geofence functionality on the GNSS-INS module (refer to section 5.4), the LED indicator will show GFC status. By default, when device is inside at least one geofence, GFC_STAT will be 0, causing the LED indicator on the GNSS-INS module to be steady lit. When the device is outside of the configured geofence(s), the GFC_STAT pin will be 1, and the LED is off (see Table 13).

Table 13: LED indicator states

LED	State	Description
RTK	Off	No (valid) RTK corrections
	Blinking	Valid RTK corrections received, float/fix
	Steady Lit	3D fix
TMP	Off	No time pulse
	Blinking	1 second time pulse
GFC	Off	Outside of configured Geofence(s)
	Steady lit	Inside configured Geofence(s)

4 Arduino Shield

4.1 Recommended operating conditions

Table 14: Arduino Shield recommended operating conditions

	Min	Typ.	Max	Unit	Comment
Supply voltage 5V	4.5	5	5.5	V	With respect to GND (Ground)
$V_{UART,PSEL,I2C,SPI,NRST,SYNC,TMP}$	-0.3	-	3.6	V	Voltage level of UART, PSEL, I^2C, SPI, NRST, SYNC, TMP with respect to GND (3.3V logic level)
$V_{MTI\ USBI}$	4.5	-	5.5	V	Voltage level for MTi USB power with respect to GND
V_{VCC_USB}	4.5	-	5.5	V	Voltage level for GNSS USB power with respect to GND
Power consumption	-	-	650	mW	With GNSS-INS Module installed

CAUTION | Risk of damage to the device!

Follow the mounting instructions and recommendations to prevent damage and undesirable effects.

4.2 Arduino Shield pinout

The Arduino Shield allows for two different connection types - either through the onboard USB connection to the a host computer or by installing the device onto an Arduino-compatible development board (for example Arduino Uno, STM32Nucleo etc.). The board provides access to all GNSS-INS Module functionalities through the connectors marked in Figure 6**Fout! Verwijzingsbron niet gevonden.**.

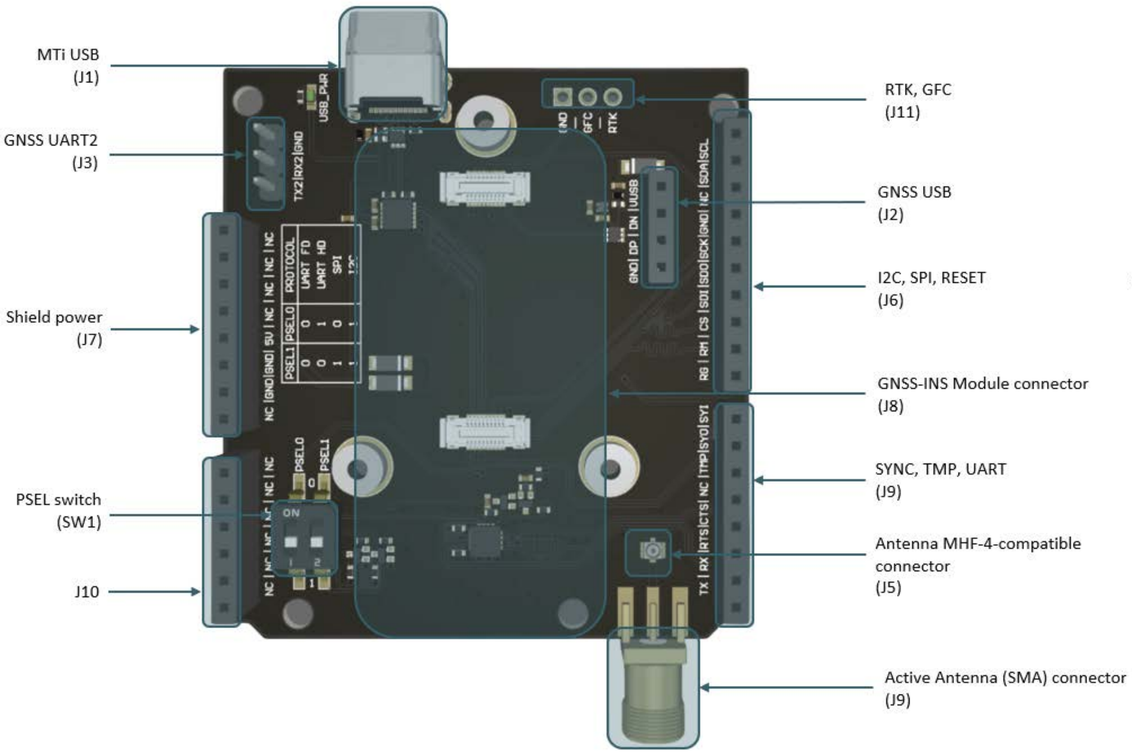

Figure 6: Arduino Shield connector designators

A detailed descriptions and connector pinout is presented in Table 15 till Table 20. The individual pins are numbered based on the left-to-right and top-to-bottom order. The pinout of connector J10 is not listed as it is fully disconnected (NC) and only used for mounting purposes. The pinout of the GNSS-INS Module connector was already described in the section 3.4.

Table 15: Pinout description GNSS UART2 connector (J3)

Pin	Name	Description
J3-1	GND	Ground
J3-2	RX2	GNSS correction UART input
J3-3	TX2	GNSS correction UART output

Table 16: Pinout description Shield power connector (J7)

Pin	Name	Description
J7-1	NC	Not connected
J7-2	NC	Not connected
J7-3	NC	Not connected
J7-4	NC	Not connected
J7-5	5V	5V input
J7-6	GND	Ground
J7-7	GND	Ground
J7-8	NC	Not connected

Table 17: Pinout description RTK, GFC connector (J11)

Pin	Name	Description
J11-1	GND	Ground
J11-2	GFC	Geofence status, user defined
J11-3	RTK	Real-time kinematic positioning (RTK) status 0 = RTK/PPP-RTK fixed Blinking = receiving and using corrections 1 = no (valid) corrections received

Table 18: Pinout description GNSS USB (J2)

Pin	Name	Description	USB wire colors
J2-1	VUSB	USB power (5V input)	Red
J2-2	DN	GNSS D-	White
J2-3	DP	GNSS D+	Green
J2-4	GND	Ground	Black

Table 19: Pinout description of I2C, SPI, RESET (J6)

Pin	Name	Description
J6-1	SCL	I^2C Serial Clock Line
J6-2	SDA	I^2C Serial Data Line
J6-3	NC	Not connected
J6-4	GND	Ground
J6-5	SCK	SPI Serial Clock
J6-6	SDO	SPI Serial Data Output (MISO)
J6-7	SDI	SPI Serial Data Input (MOSI)
J6-8	nCS	SPI active low Chip Select
J6-9	RM	Active low MTi-7/8 reset
J6-10	RG	Active low GNSS reset

Table 20: Pinout description SYNC, TMP, UART connector (J9)

Pin	Name	Description

J9-1	SYI	Sync Input (Accepts a trigger input to request the latest available data message)
J9-2	SYO	Sync Output (reserved for future use, do not connect)
J9-3	TMP (SYNC_PPS)	Time Pulse (Pulse Per Second output of GNSS Module)
J9-4	NC	Not connected
J9-5	CTS	UART Clear-to-Send
J9-6	RTS	UART Ready-to-Send
J9-7	RX	UART Receiver data input
J9-8	TX	UART Transmitter data output

It is important to note that Arduino Shield can only operate at **a 3.3V logic level**. Therefore, different logic levels require external adaptations/level shifters in the design.

4.3 Arduino Shield dimensions

The general dimensions of the Arduino Shield for the GNSS-INS Module are presented in Figure 7 (in millimeters). The Arduino connection headers J6, J7, J9, and J10 are placed according to the Arduino Shield design rules, which are available online. For the GNSS-INS Module footprint, only the origin point is shown. Exact dimensions can be calculated based on the GNSS-INS Module connector footprint given in section 3.4. All headers have a pitch of 2.54 mm, including J11 which is by default not populated.

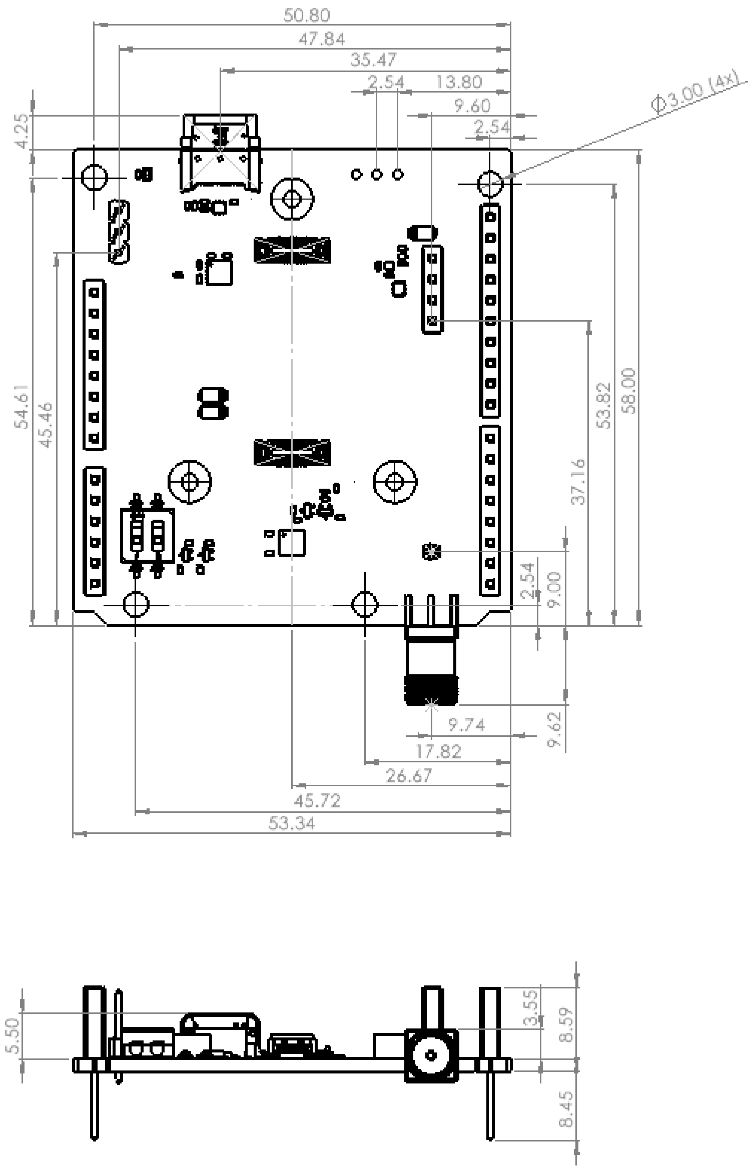

Figure 7: Arduino Shield dimensions

5 Getting started with GNSS-INS Module Development kit

This section describes how to get started with the GNSS-INS Module Development Kit.

WARNING
Make sure proper ESD precautions are taken to protect the GNSS-INS Module and any interfaced hardware. ESD unsafe handling can result in permanent damage to the device and/or any interfaced hardware.

5.1 Connecting to the MTi-7/8 sensor

Connect the device to a host computer through connector J1 (Figure 6) using the supplied USB-A to USB-C cable (shown in Figure 1), which is included in the Development Kit.

To be able to access the MTi-7/8 sensor data, first download MT Manager from the Movella website[8]. After installation of the software, click *Scanning Single Port* button in MT Manager to scan for the MTi-7/8 sensor, which should appear in *Device List* at the left side of the window. Both icons are marked in Figure 8.

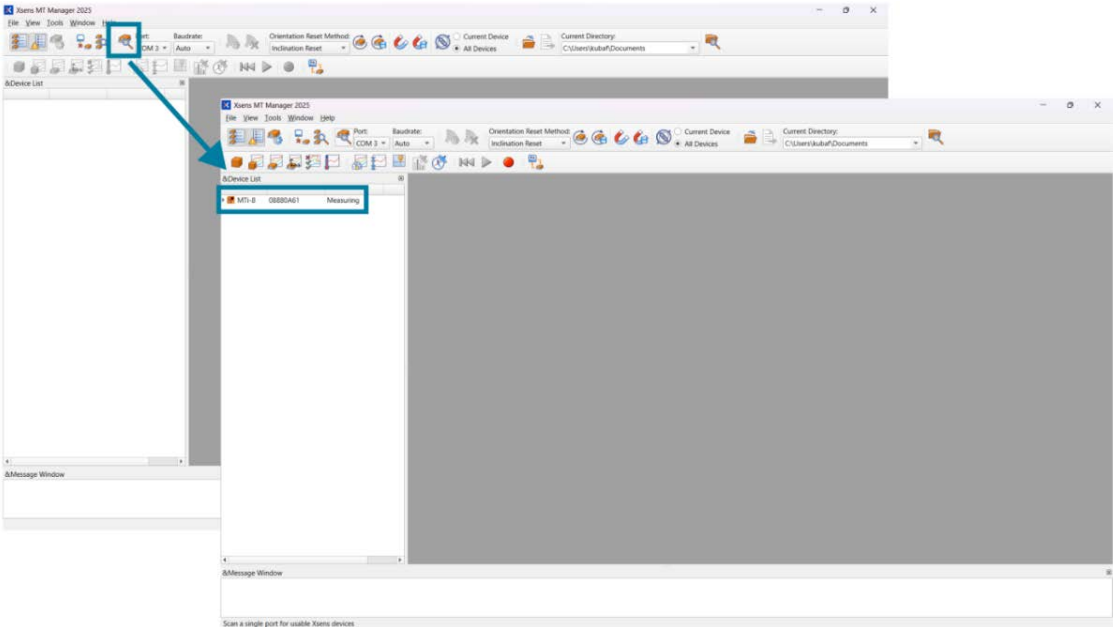

Figure 8: MT Manager: scanning for MTi sensor and device list

If the warning 'Data Overflow detected appears, the (configured) baudrate is too low. To solve this, increase the baud rate to 2000000 by going into *View->Device Settings->Device Settings->COM port baudrate*.
After this initial set-up, the data for Inertial Measurement Unit can be read. To get full readings, both from the MTi-7/8 sensor and the GNSS Module, connect the supplied GNSS antenna (shown in Figure 1) to connector J9 (Figure 6**Fout! Verwijzingsbron niet gevonden.**), and place the active antenna part outside (without any roof or other cover over it, which would suppress the signal). Once connected to the u-blox receiver (ZED-F9P), the MTi-7/8 will configure it on start-up, therefore, no prior configuration is required before first use.

[8] https://www.movella.com/support/software-documentation

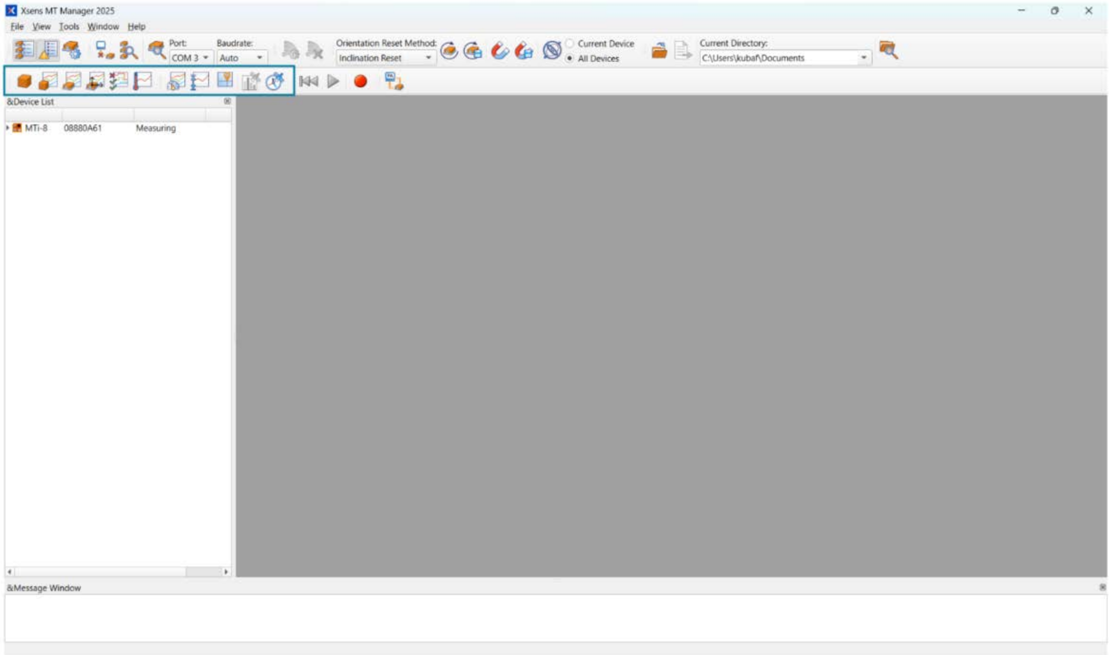

Figure 9: Graphs and GNSS view in MT Manager

In Figure 9, the Graphs and GNSS view toolbar is marked. These graphs display different data streams from the GNSS-INS Module. From the left to right these icons are

- 3D orientation – 3D display of device orientation,
- Orientation Data – graph displaying 3D orientation in Either Euler angles in degrees vs. time or Quaternions vs. time,
- Inertial Data – graphs displaying acceleration, angular velocity and magnetic field,
- Free Acceleration Data – graph displaying acceleration without gravity component, visualized by default in East-North-Up (ENU) format,
- Status Data – graph displaying status flags,
- Temperature Data – graph displaying internal temperature of the device in degrees Celsius,
- Velocity Data – graph displaying 3D velocity by default displayed in East-North-Up (ENU) format,
- Altitude Data – graph displaying altitude as height above WGS-84 ellipsoid in meters,
- Position – graph displaying 2D position of MTi in terms of longitude and altitude,
- Space Vehicle Data – display of satellites with their respective signal strength in dBHz (not available for the GNNS-INS module),
- UTC Date/Time – UTC time and date automatically retrieved by GNSS receiver.

For more information, refer to the MT Manager user manual[9].

5.2 Connecting to the GNSS receiver

The GNSS Module can be accessed directly to have full access and change settings of GNSS Module. For that, the host PC needs to be connected to the GNSS USB connector J2 (Figure 6**Fout! Verwijzingsbron niet gevonden.**) of the device using the USB-A to 4-pin adapter cable included in Development Kit. The right color order of connector is shown in Table 18. VCC_USB is not a power supply for the whole board; therefore, the Development kit needs to be powered either through USB C or through the 5V pin on the shield headers. Additionally, dedicated software, u-center or u-center2, is required, which can be downloaded from the u-blox website[10].

To access the device, first it needs to be detected by clicking *Data sources*, then *Add data source*, and then choose the correct device in the *COM port window* as shown in Figure 10.

[9] https://mtidocs.movella.com/mt-manager

[10] https://www.u-blox.com/en/product/u-center

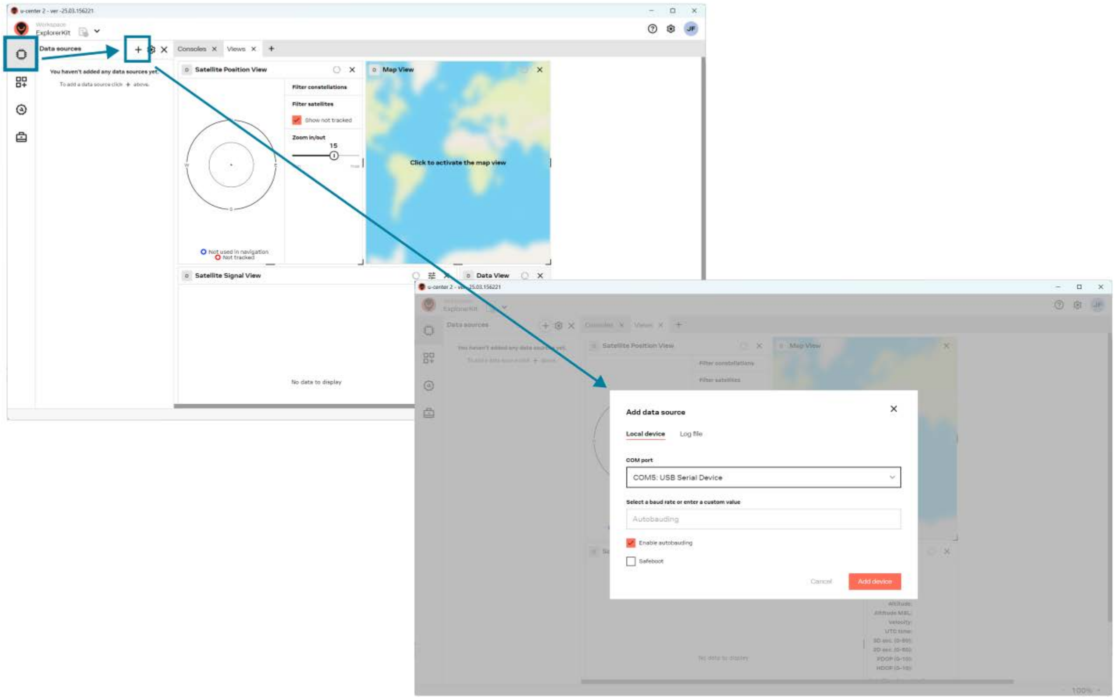

Figure 10: Connecting to GNSS Module in u-center

After correctly connecting to the device, the data/information should show as in Figure 11. If the speed of transmission in kbit/s shown in Data sources is marked yellow, the baud rate has to be increased.

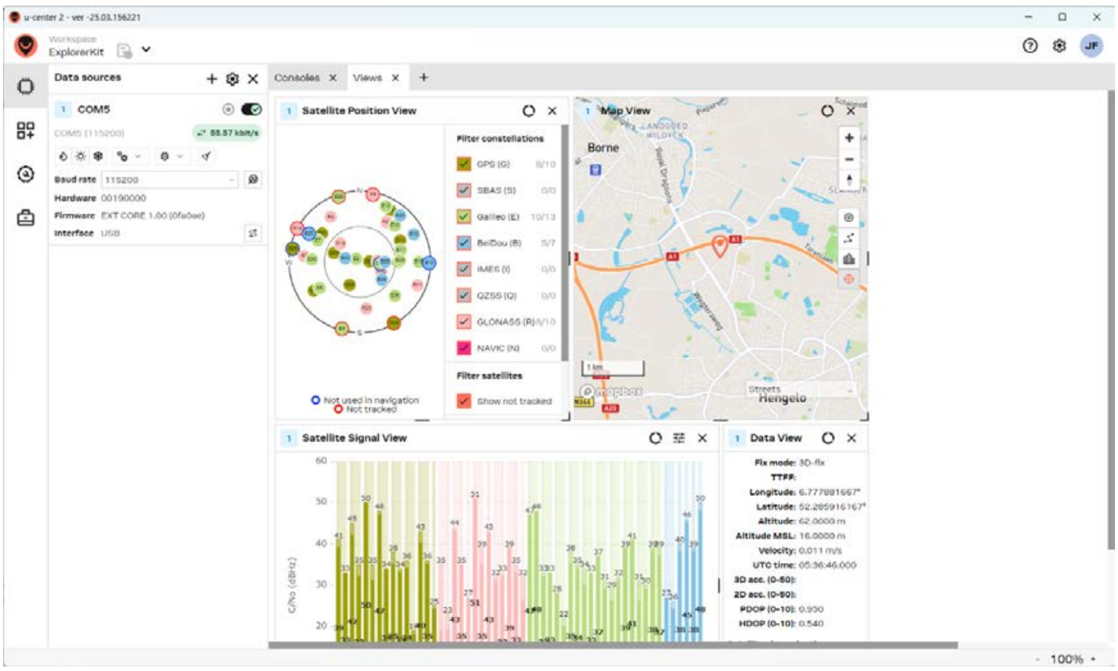

Figure 11: Exemplary view of u-center with correctly connected GNSS Module

5.3 RTK corrections

While standard GNSS positioning allows for sub-meter accuracy, the u-blox ZED-F9P GNSS Module allows for RTK (Real-Time Kinematic) corrections that can improve the accuracy up to sub-centimeter levels. The Arduino Shield includes a connector (J3, see Figure 6), which allows for sending RTK correction messages over UART. For information regarding adjusting RTK settings in ZED-F9P using u-center refer to the ZED-F9P Integration Manual[11].

5.4 Geofence set-up

Geofencing allows for configuration of circular regions (up to 4) by setting up the center of the area and its radius. The device will later determine if the antenna origin is inside at least one geofence or outside of the defined geofence area(s). For information regarding adjusting GFC settings in ZED-F9P using u-center refer to the ZED-F9P Integration Manual[12].

5.5 Programming examples

Movella, the MTi-7/8 manufacturer, provides several example libraries that can be used for initial testing and prototyping with the GNSS-INS Module Development Kit. These resources are available through this link[13].

---

[11] https://www.u-blox.com/en/product/zed-f9p-Module?legacy=Current#Documentation-&-resources
[12] https://www.u-blox.com/en/product/zed-f9p-Module?legacy=Current#Documentation-&-resources
[13] https://base.movella.com/s/article/Introduction-to-the-MT-SDK-programming-examples-for-MTi-devices?language=en_US

6 Hardware integration of the GNSS-INS Module

CAUTION | Risk of mechanical damage to the device!
Only handle the GNSS-INS Module in an ESD safe environment

CAUTION | Risk of mechanical damage to the device!

It is recommended to tighten the PCB fasteners hand tight (max. 0.2 Nm) to prevent damage to the PCB.

CAUTION | Risk of permanent damage to the device!

It is highly recommended to prevent hot swapping the GNSS-INS Module to a live mating board. First install the GNSS-INS Module before powering the system.

6.1 Mounting of the INS Module

The GNSS-INS Module has two fine pitch connectors for interfacing with mating boards. For proper support, the GNSS-INS Module should be mounted on three spacers. Both the spacers and mating connectors are listed in Table 21. The fine pitch connectors are of a floating type, allowing for stress-free mounting and vibration resistance. It is advised to use stainless steel or brass screws as PCB fasteners to create a stiff connection with the mating board.

Table 21: Mating connectors and spacers

Component	Manufacturer	Manufacturer order code	Amount needed
SlimStack Board-to-Board fine pitch connector 20 circuits	Molex	204928-0201	2
Spacer M2.5x3.0mm	Würth Elektronik	9774030151R	3

6.2 Footprint design

To integrate the GNSS-INS Module on another PCB, footprints and stencil guidelines of the mating parts need to be considered. In Figure 12, the location of both fine pitch connectors and the three spacers are outlined. Points of reference are defined for each component center.

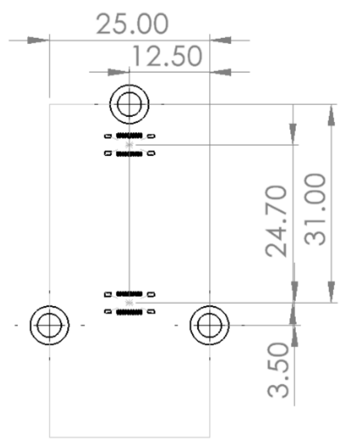

Figure 12: GNSS-INS Module connector footprint dimensions

6.3 Pin termination

While integrating the GNSS-INS Module into a hardware design, some functionalities might not be used. These unused pins need to be properly terminated. In Table 22 and Table 23, terminations are presented for all the pins of both fine pitch connectors (J2 and J3, see also Figure 3). An "*"means that the GNSS-INS Module cannot function properly without this connection.

Table 22: Pin termination for connector J2

Pin	Name	Terminations
J2-1	3V3OUT	Leave not connected (NC)
J2-2	GND	*
J2-3	GFC_STAT	Leave not connected (NC)
J2-4	RTK_STAT	Leave not connected (NC)
J2-5	TMP (SYNC_PPS)	Leave not connected (NC)
J2-6	GND	*
J2-7	GND	*
J2-8	NRST_GNSS	Leave not connected (NC)
J2-9	GND	*
J2-10	3V3OUT	Leave not connected (NC)
J2-11	GND	*
J2-12	DP	Leave not connected (NC)
J2-13	DN	Leave not connected (NC)
J2-14	VCC_USB	Connect to GND
J2-15	GND	*
J2-16	GND	*
J2-17	GND	*
J2-18	TX2	Leave not connected (NC)
J2-19	RX2	Leave not connected (NC)
J2-20	GND	*

Table 23: Pin termination for connector J3

Pin	Name	Description
J3-1	GND	*
J3-2	TX/SCL	Leave not connected (NC)
J3-3	RX/SDA	Leave not connected (NC)
J3-4	CTS/nRE	Leave not connected (NC)
J3-5	RTS/DE	Leave not connected (NC)
J3-6	GND	*
J3-7	NRST_MTI	Leave not connected (NC)
J3-8	3V3OUT	Leave not connected (NC)
J3-9	GND	*
J3-10	VIN	*
J3-11	GND	*
J3-12	SPI_nCS	Leave not connected (NC)
J3-13	SPI_MISO	Leave not connected (NC)
J3-14	SPI_MOSI	Leave not connected (NC)
J3-15	SPI_SCK	Leave not connected (NC)
J3-16	GND	*
J3-17	PSEL0	Leave not connected (NC)
J3-18	PSEL1	Leave not connected (NC)
J3-19	SYNC_IN	Leave not connected (NC)
J3-20	SYNC_OUT	Leave not connected (NC)

6.4 Logic level shifting

The GNSS-INS Module can only operate properly at a 3.3V logic level. Therefore, if the mating board is on different logic levels, level shifters are required. To facilitate this, each connector of the GNSS-INS Module has

3.3V output to supply the 3.3V side of the level shifter. A level shifter example application design for UART connection to a 1.8V external system is presented in Figure 13. The pull-up resistors are only required if the I2C protocol is used and their values are application dependent.
It is advised to use 3.3V output pins from the GNSS-INS Module only for powering level shifting logic, transceivers or other supporting components. Overloading of the buck converter on the GNSS-INS Module causes a rise in board temperature which can negatively affect the performance.

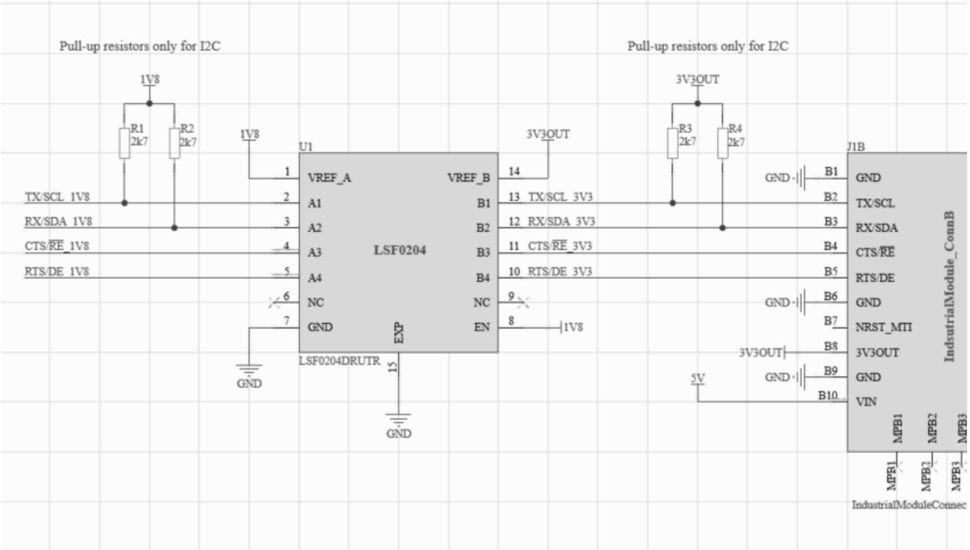

Figure 13: Example application with level shifter

6.5 GNSS USB connection

To configure the ZED-F9P using dedicated software, the hardware design of direct USB connection to this component is required. For best practices refer to the corresponding ZED-F9P application note[14].

6.6 MHF-4 connector

While the Development Kit has an SMA connector for the antenna, a custom design integrating the GNSS-INS module needs its own antenna connector implementation based on functional and technical requirements. The active antenna connector for the GNSS-INS Module (marked as J1 in Figure 3) is a MHF-4 connector from Taoglas[15] (part number RECE.20449.001E.01). For exact dimensions of the connector refer to component datasheet. Mating extension cables can be found on Taoglas[16] or GradConn[17], and are also shown in Figure 14.

Figure 14: MHF-4 to SMA adapter cables from Taoglas (left) and GradConn (right)

[14] https://www.u-blox.com/en/product/zed-f9p-Module
[15] https://www.taoglas.com/product/rece-20449-001e-01-receptacle-ipex-mhf4hsc-comp/
[16] https://www.taoglas.com/product/cab-s02-ipexmhf4hsc-comp-to-200mm-0-81mm-coax-cable-to-smafbk-jack-straight/
[17] https://www.gradconn.com/Products/CoaxialCableAssembly/All?cnt=I-PEX%20MHF%204%20Series%2CSMA#Type