Hardware Integration Manual

MTi 600-series

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Revisions

Revision	Date	By	Changes
A	9 sept 2019	RGI	Initial release

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1 General information

This document provides hardware design instructions for the MTi 600-series module (MTi-600). The MTi-600 is a fully functional, self-contained module that is easy to design-in with limited external hardware components to be added. The MTi-600 can be embedded in an application by mounting it directly on a PCB or as a standalone module by connecting it via a flat-ribbon cable. The MTi-600 can be connected to a host through RS232, CAN or UART interfaces.

The *MTi 600-series Datasheet*[1] provides information on the usage and technical details of the MTi 600-series modules. The MTi 600-series module (MTi-600) is a fully functional, self-contained module that is easy to design-in. The MTi-600 module can be connected to a host through RS232, CAN or UART interfaces, or through USB using the UART to USB converter (included in the MTi 600-series Development Kit).

The *MTi Family Reference Manual*[1] supplements this document. It reports generic information on the MTi 1-series and MTi 600-series, such as output definitions, algorithm details and installation tips.

For testing and prototyping, Xsens provides the MTi-630 and MTi-670 Development Kits (MTi-630-DK and MTi-670-DK). In addition to the RS232, CAN and UART pin connectors of the MTi 600-series module, the Development Kit offers a direct USB, RS232, RS422 and CAN interface. Technical details of the Development Kit and its usage can be found in the *MTi 600-series DK User Manual*[1].

The *MT Low Level Communication Protocol*[1] document provides a complete reference for the protocols used to communicate with Xsens Motion Trackers on low-level basis. The MT Low Level Communication Protocol document also describes the synchronization messages and settings in detail.

Table 1 summarizes all available official documents for the Xsens MTi product line.

Table 1: MTi product documentation overview

<table>
<tr><th>MTi 1-series</th><th>MTi 600-series</th><th>MTi 10/100-series</th></tr>
<tr><td colspan="2">MTi Family Reference Manual</td><td rowspan="5">MTi User Manual</td></tr>
<tr><td>MTi 1-series Datasheet</td><td>MTi 600-series Datasheet</td></tr>
<tr><td>MTi 1-series DK User Manual</td><td>MTi 600-series DK User Manual</td></tr>
<tr><td rowspan="2">MTi 1-series HW Integration Manual</td><td>MTi 600-series HW Integration Manual</td></tr>
<tr><td>MT CAN protocol Documentation</td></tr>
<tr><td colspan="3">MT Manager Manual</td></tr>
<tr><td colspan="3">Magnetic Calibration Manual</td></tr>
<tr><td colspan="3">MT Low Level Communication Protocol Documentation</td></tr>
<tr><td colspan="3">Firmware Updater User Manual</td></tr>
</table>

2 Interfaces

2.1 Pin Configuration

Figure 1 shows the pin configuration of the MTi-600.

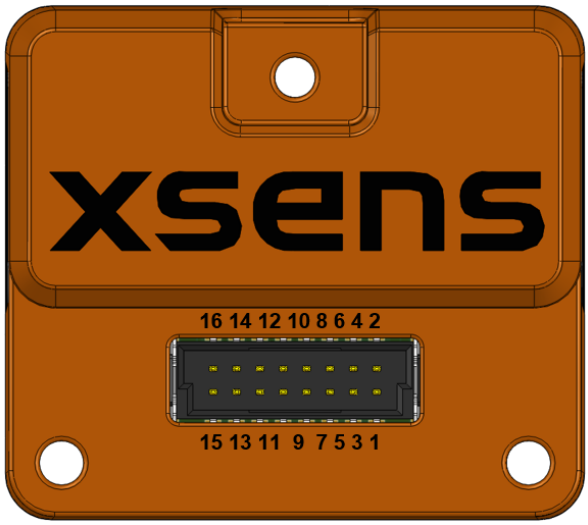


Figure 1: Pin configuration of the MTi-600

Table 2 shows the pin descriptions.

Table 2: Pin descriptions

Pin	Name	I/O type	Description
1	VIN	PWR	Power input
2	GND	PWR	Ground
3	CAN_H	I/O	CAN bus differential low side
4	CAN_L	I/O	CAN bus differential high side
5	RS232_TxD	O	RS232 transmitter output to host
6	RS232_RTS	O	RS232 Ready To Send output to host
7	RS232_RxD	I	RS232 receiver input from host
8	RS232_CTS	I	RS232 Clear To Send input from host
9	SYNC_IN1	I	Multifunctional synchronization input
10	SYNC_IN2	I	Multifunctional synchronization input
11	GNSS_TxD	O	RS232 transmitter output to GNSS module
12	GNSS_RxD	I	RS232 receiver input from GNSS module
13	SYNC_OUT	O	Configurable synchronization output
14	GND	PWR	Ground
15	UART_TxD	O	UART transmitter output
16	UART_RxD	I	UART receiver input

2.2 Communication to host

The MTi-600 is designed to be used as a peripheral device in embedded systems or as a standalone unit. The MTi-600 supports Controller Area Network (CAN), RS232 and Universal Asynchronous Receiver/Transmitter (UART) protocols for the communication between the MTi-600 and a host. See Table 3 for interface specifications. For the physical connection recommendations, see section 4.3.

Table 3: Host communication interfaces specifications

Interface	Symbol	Min	Typ	Max	Units	Description
CAN	f_{CAN}	10.0	250.0	1000	kbps	Host CAN Interface Baud Rate
RS232	f_{RS232}	4.8	115.2	1000	kbps	Host RS232 Interface Baud Rate
UART	f_{UART}	4.8	115.2	2000	kbps	Host UART Interface Baud Rate

A USB and RS422 interface is possible through a UART to USB/RS422 converter (see example in the MTi 600-series Development Kit).
At its core, the module uses the Xsens-proprietary Xbus protocol which is compatible with all Xsens Motion Tracker products. This protocol is available on all interfaces, UART, RS232 and CAN.
The *MT Low Level Communication Protocol Documentation* is a complete reference for the protocol[1].

2.2.1 CAN

The CAN interface of the MTi-600 does not include a termination resistor; it can be used in a CAN bus that already incorporates the required termination. If used in a single device connection, a 120 Ω termination resistor needs to be added between the CAN_H and CAN_L pins.

For more information please review the *MT CAN Protocol Documentation*[1].

2.2.2 RS232

The RS232 interface complies with the standard RS232 voltage levels. It includes hardware flow control through RTS and CTS lines.

The RTS signal is an output of the MTi-600. If the RTS line is low, the module is busy and unable to receive new data. Otherwise, the module's UART is idle and ready to receive. The CTS signal is an input for the MTi-600. The module checks the state of the CTS line at the start of every byte it transmits. If CTS is high, the module transmits the byte. Otherwise, it postpones transmission until CTS is raised. If flow control is not used the CTS input should be connected to a logic high to make sure that the MTi-600 can transmit data. A RS232 logic high voltage should be between +3 V and +25 V.

The CTS signal is an input for the module. The module checks the state of the CTS line at the start of every byte it transmits. If CTS is high, the module transmits the byte. Otherwise, it postpones transmission until CTS is raised. When during the transmission of a byte the user lowers the CTS signal, then the module completes transmission of that byte before postponing further output. The module will not retransmit this byte. Figure 2 shows the behaviour of the TX and CTS lines.

[1] Links to the latest available documentation can be found via the following link: Xsens MTi Documentation

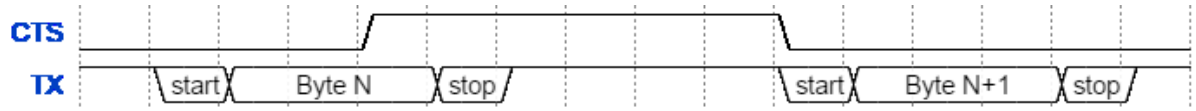


Figure 2: Data transmit behaviour under CTS

The RTS signal is an output of the module. If the RTS line is low, the module is busy and unable to receive new data. Otherwise, the module's UART is idle and ready to receive. After receiving a byte the direct memory access (DMA) controller of the module will transfer the byte to its receive first-in-first-out (FIFO) buffer. The module will pull down the RTS signal during this transfer. Therefore, with every byte received, the module lowers the RTS line shortly. Figure 3 shows this behaviour.

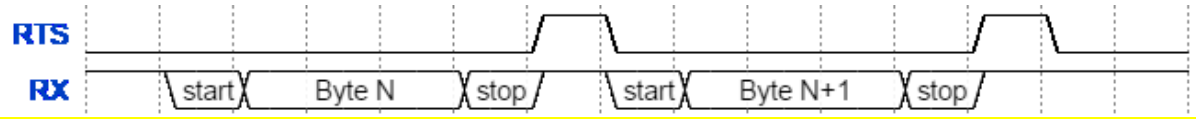


Figure 3: RTS behaviour during data reception

The user can use this communication mode without hardware flow control. In this case, the user must tie the CTS line high (e.g. VIN) to make the module transmit.

2.2.3 UART

The UART interface can be used to directly connect to an MCU with 3.3 V IO-levels. The user can configure the MTi 600-series module to communicate over UART. The UART frame configuration is 8 data bits, no parity and 1 stop bit (8N1). The UART protocol only has the TX and RX lines without any flow control.

2.3 GNSS receiver interface

The MTi-670 variant of the MTi 600-series module family supports external inputs from a GNSS receiver, such as the uBlox MAX-M8 GNSS receiver. For the GNSS receiver, the RS232 or UART communication pins of the receiver need to be connected to the GNSS_TxD and GNSS_RxD pins of the MTi-670 module. In case of a UART interface on the GNSS receiver an additional RS232 transceiver should be connected in-between the MTi-600 and the GNSS receiver. See Figure 4 for connection details and Table 4 for interface specifications.

The PPS/TIMEPULSE output of the GNSS receiver should be connected to either one of the SYNC inputs of the MTi-600. The used SYNC input needs to be configured in software accordingly. Under default configurations, the PPS/TIMEPULSE output should be connected to SYNC_IN1

Table 4: GNSS receiver interface specifications

Interface	Symbol	Typ	Max	Units	Description
RS232	f_{GNSS}	115.2	1000	kbps	GNSS Interface Baud Rate

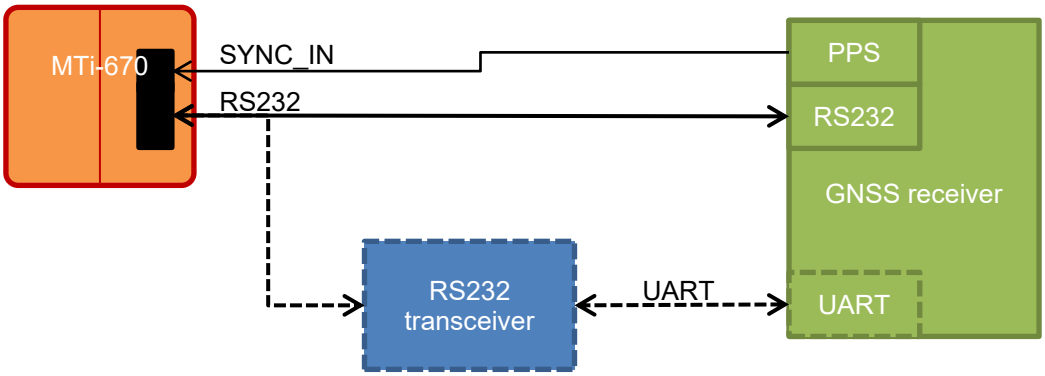


Figure 4: Connections for the GNSS interface

2.4 SYNC

The MTi-600 has two multifunctional synchronization inputs and one synchronization output. The electrical specifications can be seen in Table 7. Refer to the *MTi 600-series Datasheet*[2] for configuration details.

[2] Links to the latest available documentation can be found via the following link: Xsens MTi Documentation

3 Electrical Specifications

This section lists the recommended electrical operating conditions for the MTi-600 series module.

3.1 Supply voltage

The MTi-600 series module has a single supply pin that can be supplied with a voltage within the range specified in Table 5.

Table 5: Supply voltage specifications

Symbol	Min	Typ	Max	Unit	Description
V_{IN}	4.5	5	24	V	Power input voltage

3.2 Power consumption

The power consumption of an MTi 600-series module depends, among others, on the input voltage, sample rate and communication protocol. Table 6 shows some typical power consumption values for different MTi-600 types.

Table 6: Power consumption specifications

	Typ	Unit	Conditions
MTi-630	320	mW	5V, UART, measurement mode, 400Hz, 921.6 kbps
MTi-630	350	mW	5V, RS232, measurement mode, 400Hz, 921.6 kbps
MTi-630	495	mW	24V, UART, measurement mode, 400Hz, 921.6 kbps
MTi-630	525	mW	24V, RS232, measurement mode, 400Hz, 921.6 kbps
MTi-670	310	mW	5V, UART, measurement mode, 400Hz, 921.6 kbps
MTi-670	340	mW	5V, RS232, measurement mode, 400Hz, 921.6 kbps
MTi-670	495	mW	24V, UART, measurement mode, 400Hz, 921.6 kbps
MTi-670	530	mW	24V, RS232, measurement mode, 400Hz, 921.6 kbps

3.3 I/O pins

The I/O interface specifications are listed in Table 7.

Table 7: I/O interface specifications

I/O interface	Symbol	Min	Typ	Max	Unit	Description
CAN	$V_{I(DIFF)(R)}$	-4.0		0.5	V	Recessive differential input voltage -12V < $V_{(CANH, CANL)}$ < +12V
	$V_{I(DIFF)(D)}$	0.9		9.0	V	Dominant differential input voltage -12V < $V_{(CANH, CANL)}$ < +12V
	$V_{O(DIFF)(R)}$	-500	0	50	mV	Recessive differential output voltage
	$V_{O(DIFF)(D)}$	1.3	2.0	5.0	V	Dominant differential output voltage
	$V_{O(L)(D)}$	0.5	1.5	2.25	V	CAN_L dominant output voltage

	$V_{O(H)(D)}$	2.75	3.5	4.5	V	CAN_H dominant output voltage
RS232 (GNSS)	V_{IL}	-25		0.6	V	Low input voltage
	V_{IH}	2.4		+25	V	High input voltage
	V_{OT}	±5	±5.4		V	Driver Output Voltage swing
UART	V_{IL}	0		0.88	V	Low input voltage
	V_{IH}	2.29		3.6	V	High input voltage
	V_{OL}	0		0.44	V	Low output voltage
	V_{OH}	2.6		3.3	V	High output voltage
SYNC_IN1/ SYNC_IN2	V_{IL}	-25		0.6	V	Low input voltage
	V_{IH}	2.4		+25	V	High input voltage
SYNC_OUT	V_{OL}	0		0.44	V	Low output voltage
	V_{OH}	2.6		3.3	V	High output voltage

4 Design

This section describes the (mechanical) design and hardware integration considerations of the MTi 600-series module. 3D models of the module are available and can be downloaded online: https://base.xsens.com/hc/en-us/articles/360023863393

4.1 Sensor reference frames

The MTi 600-series module uses a right-handed coordinate system as the basis of the sensor frame. The default sensor coordinate system is printed on the side of the MTi and is shown in Figure 5. More details regarding (the modification of) the reference frames of the MTi can be found in the *MTi 600-series Datasheet*[3] and *MTi Family Reference Manual*[3].

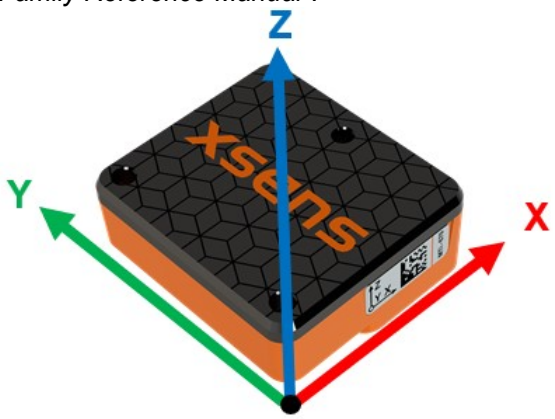


Figure 5: Default sensor coordinate system for the MTi 600-series module

4.2 Origin of accelerometer

The accelerometer determines the origin of measurements. The ⊕ in Figure 14 shows the location of the accelerometer of the MTi 600-series module.

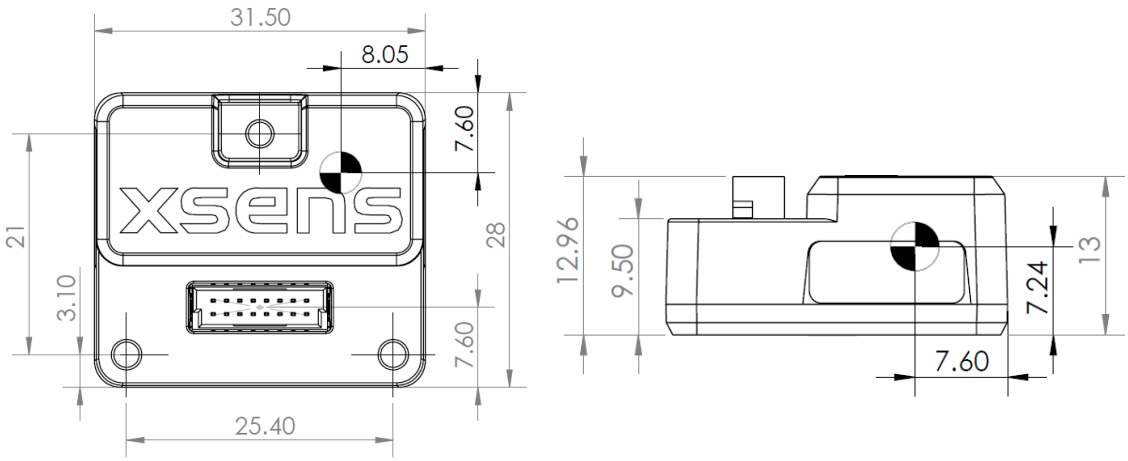


Figure 6: Location origin of measurements (dimensions in mm)

[3] Links to the latest available documentation can be found via the following link: Xsens MTi Documentation

4.3 Physical connections

The connector on the MTi-600 series module is a 16 pins, 1.27 mm pitch male connector of Phoenix Contact (FP 1,27/ 16-MV 1,75 – 1714936). This connector supports an SMD counterpart that can be soldered onto a PCB as well as a ribbon cable (IDC) counterpart. In order to mount the MTi-600 onto a PCB, the connector should be facing down and the MTi-600 housing should be supported with M2 spacers that can be soldered onto the PCB. When using a ribbon cable the MTi-600 can be mounted upside-down to create easy access to the connector.

Figure 7 shows both mounting options. In both cases, the MTi-600 is fixated with three M2 screws with a length of at least 12mm. It is recommend to use screws and spacers with weak magnetic properties to reduce the influence on the internal magnetometer.

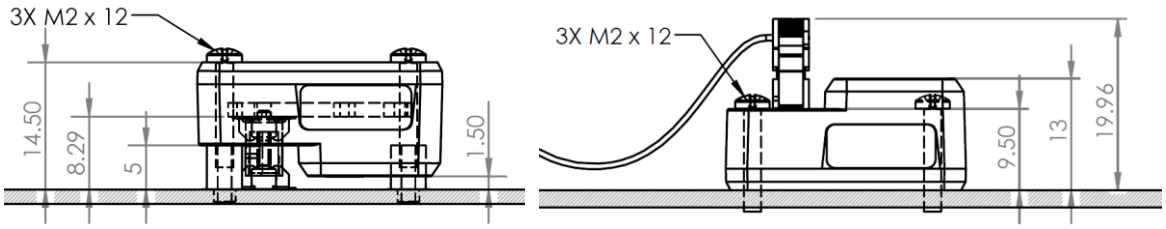


Figure 7: Connection options (left: PCB, right: standalone, dimensions in mm)

4.3.1 Footprint for PCB layout

Figure 8 shows the recommended footprint of the MTi-600 counterpart connector together with the three spacers. Table 8 shows the recommended parts for this mounting option.

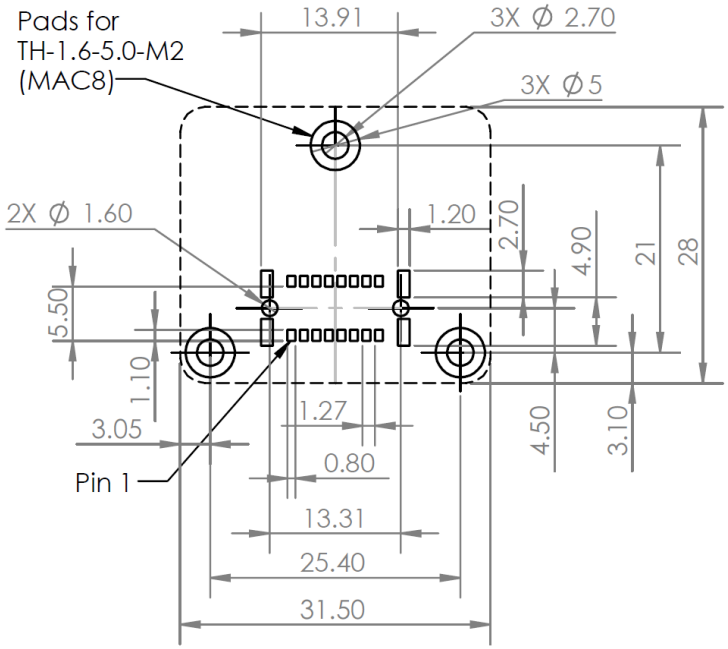


Figure 8: Layout footprint example (dimensions in mm)

Table 8: Recommended mating/mounting parts

Part	Manufacturer + part number	Description
SMD connector	Phoenix Contact: 1714892 (FP 1,27/ 16-FV 6,25)	To be used in combination with 5 mm spacers (shown in Figure 7)
	Phoenix Contact: 1715000 (FP 1,27/ 16-FV 9,05)	To be used in combination with 8 mm spacers
PCB spacers	MAC8: TH-1.6-5.0-M2	M2 x 5 mm, recommended
	Würth Elektronik: 9774050243R	M2 x 5 mm, not recommended (ferromagnetic)
Screws		Brass, M2 x 12 mm

4.3.2 Footprint for standalone mounting

Figure 9 shows the mounting hole positions for the MTi-600 when mounted upside-down for the IDC connection. Table 9 shows the recommended parts for this mounting option.

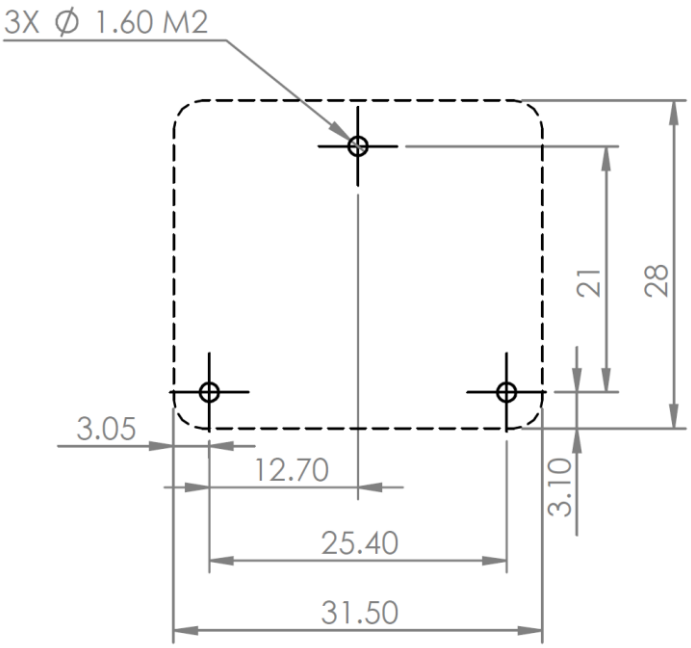


Figure 9: Standalone mounting hole positions (dimensions in mm)

Table 9: Recommended mating/mounting parts

Part	Manufacturer + part number	Description
IDC connector	Phoenix Contact: 1714903 (FP 1,27/ 16-FWL)	Single IDC connector
	Phoenix Contact: 1010258/P/xxx (FP 1,27/ 16-FWL-10/P/xxx)	Cable assembly with one IDC connector; replace xxx with cable length in m (0.05 – 0.95)
	Phoenix Contact: 1010251/P/xxx (FP 1,27/ 16-FWL-11/P/xxx)	Cable assembly with two IDC connectors; replace xxx with cable length in m (0.05 – 0.95)
Screws		Brass, M2 x 12 mm

4.4 Mechanical stress

In general, it is recommended to place the MTi 600-series module in an area on the PCB where mechanical stress is minimal. The following paragraphs describe possible causes of mechanical stress and ways to reduce it.

4.4.1 Torque

The connector of the MTi-600 is soldered onto the PCB board which also contains the sensing elements. Care should be taken to design the mounting such (see chapter 4.3) that there is no stress on the connector when mounted on the PCB or connected with a ribbon cable. As any stress on the connector could potentially result in torque on the PCB which can lead to unwanted biases and signal noise.

4.4.2 Vibrations

The MTi 600-series features an industry-leading signal processing pipeline (AttitudeEngine™) which rejects vibrations. For best results however, it is recommended that the MTi 600-series is mechanically isolated from vibrations as much as possible. Especially in applications where vibrations are likely to occur, the anchor points of the PCB that holds the MTi 600-series module should be dampened. The required type of dampening varies from application to application.

4.5 Magnetometer

The MTi 600-series uses a 3D magnetometer for measuring the geomagnetic field. This part is sensitive to magnetic disturbances. Magnetic disturbances can be calibrated for or identified and rejected by the MTi, however it is recommended to avoid their influence during hardware integration.

4.5.1 Ferromagnetic materials

Ferromagnetic materials can be magnetized and the magnetic behaviour can change during operation. This behaviour will influence the measurements of the 3D magnetometer of the MTi 600-series. Therefore, it is recommended to keep these ferromagnetic materials away from the MTi 600-series.

4.5.2 High currents

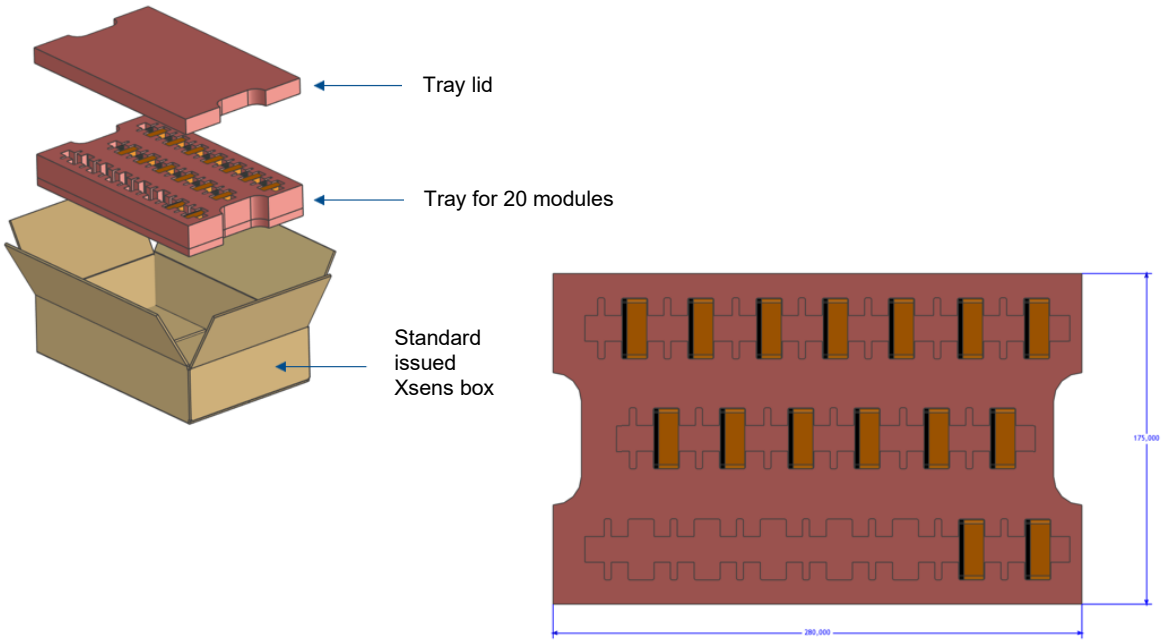
High current power lines on the PCB will introduce magnetic fields that may influence the measurements of the 3D magnetometer of the MTi 600-series. Place high current power lines away from the MTi 600-series. Example: a power line with a current of 100 mA at a distance of 10 mm from the magnetometer, will introduce an error of 2 µT.

More information on magnetic interference can be found in the *MTi Family Reference Manual*[4]. Static magnetic disturbances can be calibrated for, see the *Magnetic Calibration Manual*[4].

[4] Links to the latest available documentation can be found via the following link: Xsens MTi Documentation

5 Packaging information

The MTi 600-series packaging boxes contain from 5 up to 20 modules.



Box Dimensions (mm)			Box packaging information	
Length	**Width**	**Height**	**Qty/Tray MOQ 5**	**Qty/Box MOQ 5**
285	185	75	5-20 units	5-20 units

NOTES:

- All dimensions are in millimeters.
- Pictured tray and box representative only, actual tray may look different.

CONTENT:

- 5 to 20 modules per box.
- Calibration certificate.