MT Low Level Communication Documentation

MTi 1-series/10-series/100-series

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Revisions

Revision	Date	By	Changes
A	June 3, 2005	SSM	First version
…	…	…	…
T	27 February 2015	MHA	Added NWU to format bits in Output configuration Corrected GPS UTC Time spec (Fractional nanosecs) Corrected frequency choice for NMEA output mode Remark about ECEF representation in fixed point Added MTi-G-710
U	29 Jun 2015	MHA	Corrected magnetometer maximum frequency Checked entire protocol, some minor changes Added MTi 1-series Changed number of stopbits
V	12 January 2016	MHA	Corrected support on ProcessingFlags Updated Default configuration Removed legacy products (MTi, MTi-G, MTx, MTw) and corresponding messages Added SetOptionFlags
W	12 Jul 2016	MHA	Corrected that ENU/NWU/NED mask is available for orientation only Corrected GPGGA documentation SetOptionFlags (added AHS and GPS options; corrected LEN) Corrected ReqFWRev message
X	29 Nov 2016	MHA	Updated “scenarios” to new term “filter profiles” Updated filter profiles for 1-series Typo in low level communication example Added IccCommand Added NMEA strings (GPZDA and XSVEL) Corrected UTC Time for 1-series (not available) Removed Legacy Mode
X1	21 Dec 2016	MHA	Removed Legacy messages from message listing
X2	13 Mar 2017	MHA	Corrected ICCRESULTS table

Table of Contents

1 Terms, abbreviations and references

Term	Description
Quaternion	A non-commutative extension of complex numbers

Abbreviation	Description
DOF	Degrees Of Freedom
DSP	Digital Signal Processor
GPS	Global Positioning System
IMU	Inertial Measurement Unit
LLA	Latitude Longitude Altitude
MT	Motion Tracker
MTB	MT Binary Communication Protocol
MTM	MT Manager
PVT	Position, Velocity, Time
SDK	Software Development Kit
UTC	Coordinated Universal Time
Xbus	Xsens digital data bus system
XKF-3	Xsens Kalman Filter 3 DOF
XKF-6	Xsens Kalman Filter 6 DOF
XML	eXtended Markup Language

Abbreviation	Description
[LLCP]	"MT Low-Level Communication Protocol Documentation.pdf", document id MT0101P
[MFM]	"Magnetic Field Mapper Documentation.pdf", document id MT0202P
[MTM]	"MT Manager User Manual.pdf", document id MT0216P
[SDK]	"MT Software Development Kit Documentation.pdf", document id MT0200P
[MTi_10s_100s]	"MTi User Manual, MTi 10-series and MTi 100-series", document ID MT0605P
[MTi_1s]	"Data sheet MTi 1-series", document ID MT0512P

2 Xsens Help Center and User Community

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The knowledge base and user community are searchable simultaneously. A search query thus shows results irrespective of the source.

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3 Introduction

This document describes how to communicate with Xsens' range of miniature MEMS based inertial Motion Trackers; MTi 1-series, MTi 10-series and MTi 100-series (including MTi-G-700 GPS/INS and MTi-G-710 GNSS/INS). These Motion Trackers (or MTs) all use a common binary communication protocol called the "XBus Protocol". Knowledge of this protocol is important if you wish to directly communicate to an MT on low-level basis using the I^{2}C, SPI, UART, RS-232, RS-485, RS-422 or USB interfaces. The MT communication protocol based message enables the user to change the configuration of the MTi's and retrieve the output data. For I^{2}C and SPI interfaces, refer to [MTi_1s] for more information on the MTSSP protocol.

Note: not all products support the same functionality. There are 11 different products described in this document, in each message ID a table is depicted that shows the support for each product:

1	2	3	10	20	30	100	200	300	700	710

The meaning of these terms are:

- 1: MTi-1 IMU (4th generation or MTi MkIV)
- 2: MTi-2 VRU (4th generation or MTi MkIV)
- 3: MTi-3 AHRS (4th generation or MTi MkIV)
- 10: MTi-10 IMU (4th generation or MTi MkIV)
- 20: MTi-20 VRU (4th generation or MTi MkIV)
- 30: MTi-30 AHRS (4th generation or MTi MkIV)
- 100: MTi-100 IMU (4th generation or MTi MkIV)
- 200: MTi-200 VRU (4th generation or MTi MkIV)
- 300: MTi-300 AHRS (4th generation or MTi MkIV)
- 700: MTi-G-700 GPS/INS (4th generation or MTi MkIV)
- 710: MTi-G-710 GNSS/INS (4th generation or MTi MkIV)

An empty field indicates that the message is not supported by that particular device. In the document, there are two references to data messages: **MTData** and **MTData2**. **MTData2** messages are supported by all products, **MTData** messages by the MTi-10 to MTi-G-710. Referencing to **MTData** and/or **MTData2** has been chosen with care.

The configuration settings are all user-settable using the communication protocol. Examples are output frequency, in- and output synchronization, baud rate and output configuration. The different output modes enable the user to change the output data to the one that is preferred.

Configuration changes are executed in the so-called "**Config State**". In this state the MT accepts messages that set the output mode or other settings. Whenever the preferred configuration is set the user can set the MT into the "**Measurement State**". In this state the MT starts outputting the data based the current configuration settings. The MT states are discussed in the Section 4.

The messages used in **Config** and **Measurement** state are described in Section 5. In this section the generic format of a message is first explained, next is described how to use the message in general and finally all the messages are described grouped by functionality.

Section 6 lists some examples of how to use the MT binary data communication protocol. Additional information about the MT such as a list of factory default values and table of maximum sample frequencies can be found in section 7. The last section gives a message reference overview of the MT messages with short descriptions, see section 8.

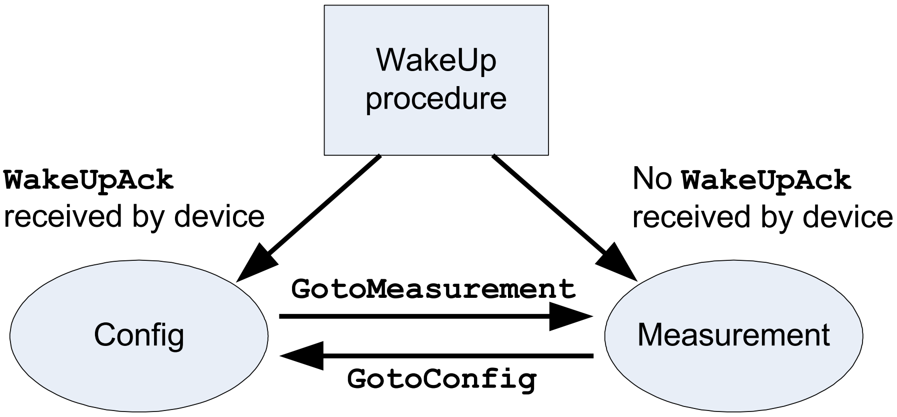
4 States

The MT has two states, i.e. **Config** and **Measurement** state. In the **Config** State various settings can be read and written and in the **Measurement** state the MT will output its data message which contains data dependent on the current configuration.

There are two different ways to enter the Config State or the Measurement State. At power-up the MT starts the WakeUp procedure and it will send the **`WakeUp`** message. If no action is taken and the OptionFlag is not set to **`DisableAutoMeasurement`**, the device enters the Measurement State. If the **`WakeUpAck`** message is sent within 500ms after reception of the **`WakeUp`** message the MT enters the Config State.

Prior to entering the Measurement State, the **`Configuration`** and eMTS (extended Motion Tracker Settings messages are always sent to the host. Configuration data is the configuration that is read from the internal non-volatile memory and will be used in the Measurement State. The data in the **`Configuration`** message can always be used to determine the output configuration. Another way to enter Config State or Measurement State is to use the **`GoToConfig`** or **`GoToMeasurement`** messages. The encrypted eMTS data is required to be able to later process the data by Xsens software to calculate calibrated inertial data values as well as estimating orientation etc.

Another way to enter the Config or Measurement State is to use the **`GoToConfig`** or **`GoToMeasurement`** messages while the other state is active.



4.1 Config State

Config State is used to get and/or set various settings of the MT. Most of the settings will change the configuration which defines the device functionality in Measurement State. Settings that change the configuration are for example the communication baud rate, sample period, output mode, output settings or synchronization properties.

At power-up all settings are read from non-volatile memory. All settings are stored in a format developed by Xsens known as the eMTS (extended Motion Tracker Specification), along with other device specific data such as calibration parameters. The format is proprietary, but all settings can be manipulated by using the appropriate Set messages.

Settings changed in Config State are immediately stored in the memory and will retain their latest values even if the device is disconnected from power. Some messages have an additional parameter that requires the user to **expressly** specify whether or not the new values should be stored in non-volatile memory. Either way, the setting changes are immediate.

NOTE: There is one exception, namely the baud rate setting. The new setting will **not** be used immediately, it will be used at the next power-cycle or after a soft-reset.

See Section 5 for more information about messages.

4.2 Measurement State

In Measurement State the MT will output its data to the host in a way depending on the configuration settings defined in Config State. A single message, **`MTData2`**, is used for all different data outputs. It is therefore important that the host knows how the device is configured. The current configuration will determine how the message data must be interpreted. A special message, **`Configuration`**, contains the relevant information which with the data received by the host in Measurement State can be unambiguously interpreted. When logging **`MTData2`** messages it is advisable to include the **`Configuration`** message in the data header for future analysis or post-processing.

If the host does not respond to the **`WakeUp`** message at power-up (or after issuing a **`Reset`** message) the MT will automatically enter the Measurement State. Just before entering the state it will send the **`Configuration`** message. The configuration settings are all read from the non-volatile memory and are used during the measurement. The default configuration of the MT is shown in the next table.

Property	**MTi-1/10/100 IMU**	**MTi-2/20/200 VRU** **MTi-3/30/300 AHRS**	**MTi-G-700/710 GNSS/INS**
Output Configuration		Quaternion: float	Quaternion: float
	Delta_q: float		
	Delta_v: float		
	Mag Field: Float		
	Packet counter	Packet counter	Packet counter
	Sample Time Fine	Sample Time Fine	Sample Time Fine
	Status Word	Status Word	Status Word
			AltitudeEllipsoid:FP1632
			LatLon: FP1632
			VelocityXYZ: FP1632
Setting profile	N/A	• VRU_General (VRU) • General (AHRS)	General
Output frequency	100 Hz	100 Hz	100 Hz
Baud rate	115k2 bps	115k2 bps	115k2 bps
Output skip factor	0	0	0
SyncIn	Disabled	Disabled	GPS_Clock_Sync
SyncOut	Disabled	Disabled	Disabled

Measurement State is normally not used to change any settings. To change settings the device must enter the Config State for which the user must first send the **`GoToConfig`** message.

5 Messages

5.1 *Message structure*

The communication with the MT is done by messages which are built according to a standard structure. The message has two basic structures; one with a standard length and one with extended length. The standard length message has a maximum of 254 data bytes and is used most frequently. In some cases the extended length message needs to be used if the number of data bytes exceeds 254 bytes.

The Awinda Station can send indications, which fit in the categories above, but use their own Indication Id to further specify the type of indication.

An MT message (standard length) contains the following fields:

Xbus header					
Preamble	BID	MID	LEN	DATA	CHECKSUM

An MT message (extended length) contains these fields:

Preamble	BID	MID	LEN^{ext}	LEN	DATA	CHECKSUM

An Awinda Station indication message contains these fields:

Preamble	BID	MID (0x46)	LEN	IND ID	DATA	CHECKSUM

Field	Field width	Description
Preamble	1 byte	Indicator of start of packet → 250 (0xFA)
BID	1 byte	Bus identifier or Address → 255 (0xFF)
MID	1 byte	Message identifier
LEN	1 byte	For standard length message: Value equals number of bytes in DATA field. Maximum value is 254 (0xFE) For extended length message: Field value is always 255 (0xFF)
EXT LEN	2 bytes	16 bit value representing the number of data bytes for extended length messages. Maximum value is 2048 (0x0800)
IND ID	1 byte	The type of indication received
DATA (standard length)	0 – 254 bytes	Data bytes (optional)
DATA (extended length)	255 – 2048 bytes	Data bytes
Checksum	1 byte	Checksum of message

Preamble
Every message starts with the preamble. This field always contains the value 250 (=0xFA).

BID or Address
The BID (bus ID address) field is included in the message format to be compatible with the Xbus Master which connects to multiple Motion Trackers**.**

A stand-alone MT has a BID value of 1 (0x01) indicating “first device”. A stand-alone MT device is however also a “master device” on its own bus and it can therefore also be addressed using the BID value 255 (0xFF) indicating a “master device”.

An MT will only acknowledge a message (reply) if it is addressed with a valid BID. An MT will always acknowledge a message with the same BID that has been used to address it. For example, this means that the same device can be addressed using a BID of 255 (0xFF) as well as 1 (0x01), and it will reply appropriately with the corresponding BID. Note however, that messages generated by the MT itself (i.e. not in acknowledge on a request) will always have a BID of 255 (0xFF). In practice, the only message for which this occurs is the **`MTData2`** and **`MTData`** messages.

Message Identifier (MID)
This message field identifies the kind of message. For a complete listing of all possible messages see section 5.3.

Length (LEN)
Specifies the number of data bytes in the DATA field for standard length message. If value 255 (=0xFF) is specified the message will be interpreted as an extended message length and the next two bytes are used for the number of bytes in the DATA field. If zero, no DATA field exists.

Extended Length (EXT LEN)
This field is a 16 bit value representing the number of data bytes in the DATA field of an extended length message.

Indication Identifier (IND ID)
This field is an 8-bit value that contains the ID of the indication that was received. Indication Identifiers are similar to Message Identifiers.

Data (DATA)
This field contains the data bytes and it has a variable length which is specified in the Length or Extended Length field. The interpretation of the data bytes is message specific, i.e. depending on the MID value the meaning of the data bytes is different. The data is always transmitted in big-endian format. See the description of the specific message for more details about the data bytes.

Checksum
This field is used for communication error-detection. If all message bytes excluding the preamble are summed and the lower byte value of the result equals zero, the message is valid and it may be processed. The checksum value of the message should be included in the summation.

5.2 *Message usage*

Generally, a message with a certain MID value will be replied with a message with a MID value that is increased by one, i.e. the acknowledge message. Depending on the message type the acknowledge message can have a data field (no fixed length) or not. If nothing is specified the data field does not exist. In some cases an error message will be returned (MID = 66 (0x42)). This occurs in case the previous message has invalid parameters, is not valid, or could not be successfully executed. An error message contains an error code in its data field.

Example
Requesting the device ID of an MT:

Sending message:
    `ReqDID =`   0xFA 0xFF 0x00 0x00 0x01 (hexadecimal values)
Receiving message (= Acknowledge):
    `DeviceID =`   0xFA 0xFF 0x01 0x04 HH HL LH LL CS (hexadecimal values)

The requested Device ID is given in the acknowledge message **`DeviceID`** (here shown as: HH HL LH LL, the checksum is CS). As you can see the MID (Message ID) of the acknowledge message is increased by one in comparison with the sending message **`ReqDID`**.

Some messages have the same MID and depending on whether or not the message contains the data field the meaning differs. This is the case with all the messages that refer to changeable settings. For example, the MID of message requesting the baud rate (**`ReqBaudrate`**) is the same as the message that sets the baud rate (**`SetBaudrate`**). The difference between the two messages is that the Length field of **`ReqBaudrate`** is zero and non-zero for **`SetBaudrate`**.

Example
Request current baud rate:
Sending message:
    `ReqBaudrate =`   0xFA 0xFF 0x18 0x00 0xE9 (hexadecimal values)
Receiving message (= Acknowledge):
    `ReqBaudrateAck =`   0xFA 0xFF 0x19 0x01 BR CS (hexadecimal values)

`ReqBaudrateAck` contains data which represents the current mode (= BR). CS stands for the checksum value. To change the baud rate you must add the baud rate in the data field of the sending message:

Set the baud rate:
Sending message:
    `SetBaudrate =`   0xFA 0xFF 0x18 0x01 BR CS (hexadecimal values)
Receiving message (= Acknowledge):
    `SetBaudrateAck =`   0xFA 0xFF 0x19 0x00 0xE8 (hexadecimal values)

5.3 *Message listing*

5.3.1 WakeUp + State messages

WakeUp

MID	62 (0x3E)
DATA	n/a
Direction	To host
Valid in	WakeUp procedure

1	2	3	10	20	30	100	200	300	700	710

At power-up or after issuing a reset this message is sent to the host. If the host sends **WakeUpAck** (MID 63 (0x3F)) within 500ms after reception of this message, the MT enters the Config State else Measurement State.

GoToConfig

MID	48 (0x30)
DATA	n/a
Direction	To MT
Valid in	Measurement State and Config State

1	2	3	10	20	30	100	200	300	700	710

Switch the active state of the device from Measurement State to Config State. This message can also be used in Config State to confirm that Config State is currently the active state.

GoToMeasurement

MID	16 (0x10)
DATA	n/a
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Switch the active state of the device from Config State to Measurement State. The current configuration settings are used to start the measurement.

Reset

MID	64 (0x40)
DATA	n/a
Direction	To MT
Valid in	Config State and Measurement State

1	2	3	10	20	30	100	200	300	700	710

Sending this message will cause the MT to reset and to activate the WakeUp procedure. An acknowledge message will be sent to confirm reception of the **Reset** message.

5.3.2 Informational messages

ReqDID

MID	0 (0x00)
DATA	n/a
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Request to send the device identifier (or serial number). MT acknowledges by sending the **`DeviceID`** message.

DeviceID

MID	1 (0x01)
DATA	IDHH IDHL IDLH IDLL (4 bytes)
Direction	To host
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Acknowledge of **`ReqDID`** message. Data field contains device ID / serial number.

ReqProductCode

MID	28 (0x1c)
DATA	n/a
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Request to send the product code. MT acknowledges by sending the **`ProductCode`** message.

ProductCode

MID	29 (0x1d)
DATA	PRODUCT CODE (max 20 bytes)
Direction	To host
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Acknowledge of **`ReqProductCode`** message. Data field contains the product code string in ASCII format, e.g. MTi-28A33G85.

ReqFWRev

MID	18 (0x12)
DATA	n/a
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Request to send the firmware revision of the device. MT acknowledges by sending **`FirmwareRev`** message.

FirmwareRev

MID	19 (0x13)
DATA	MAJOR MINOR REV BUILDNR SVNREV (11 bytes)
Direction	To host
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Acknowledge of **`ReqFWRev`** message. Data field contains the firmware code (major, minor, revision, build number, subversion revision).

RunSelftest

MID	36 (0x24)
DATA	n/a
Direction	To MT
Valid in	Config State

Runs the built-in self test.

1	2	3	10	20	30	100	200	300	700	710

SelftestAck

MID	37 (0x25)
DATA	SELFTEST RESULTS (2 bytes)
Direction	To host
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Acknowledge of **`RunSelftest`** message. The data field contains SELFTEST RESULTS, an unsigned 16 bits value that represents the result of the self test for each individual sensor (bit value of 1 indicates a passed self test):

	R	R	R	R	R	R	R	magZ	magY	magX	gyrZ	gyrY	gyrX	accZ	accY	accX
Bit#	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

The self test results will be stored in the eMTS.

Error

MID	66 (0x42)
DATA	ERRORCODE (1 byte)
Direction	To host
Valid in	Config and Measurement State

1	2	3	10	20	30	100	200	300	700	710

Indicate that an error has occurred. Error type is specified in the ERROR field. The error code can be followed by more bytes.

ERRORCODE
A one-byte value indicating the type of error. See table.

ERRORCODE	Error description
3 (0x03)	Period sent is not within valid range
4 (0x04)	Message sent is invalid
30 (0x1E)	Timer overflow, this can be caused to high output frequency or sending too much data to MT during measurement
32 (0x20)	Baud rate sent is not within valid range
33 (0x21)	Parameter sent is invalid or not within range
40 (0x28)	Device Error - try updating the firmware; extra device error contains 5 bytes

A full list can be found in the doxygen documentation (Xsensdeviceapi → HTML doc (index) → Modules → Global Enumerations → XsResultValue).

5.3.3 Device-specific messages

ReqBaudrate

MID	24 (0x18)
DATA	n/a
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Request the baud rate of the device. See **SetBaudrate** for data field description of the received acknowledge.

SetBaudrate

MID	24 (0x18)
DATA	BAUDRATE (1 byte)
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

This message changes the baud rate of the communication interface (RS-232 or RS-422). The new baudrate will be stored in non-volatile memory and will become active after issuing the **Reset** message or power cycle.

BAUDRATE

See table for the different baud rates and the corresponding value of BAUDRATE.

NOTE: The baud rate may limit the output frequency that can be used for a specific output mode and output setting due to the amount of data that must be transmitted (throughput); refer to the device manual ([MTi_10s_100s]) for further details.

Baud rate (bps)	BAUDRATE
921k6	128 (0x80) or 10 (0x0A)
460k8	0 (0x00)
230k4	1 (0x01)
115k2 (default setting in serial mode)	2 (0x02)
76k6	3 (0x03)
57k6	4 (0x04)
38k4	5 (0x05)
28k8	6 (0x06)
19k2	7 (0x07)
14k4	8 (0x08)
9k6	9 (0x09)
4k8	11 (0x0B)

ReqErrorMode

MID	218 (0xDA)
DATA	n/a
Direction	To MT
Valid in	Config State

			10	20	30	100	200	300	700	710

Request the current error mode - see **SetErrorMode** for information about data field of received acknowledge.

SetErrorMode

MID	218 (0xDA)
DATA	ERRORMODE (2 bytes)
Direction	To MT
Valid in	Config State

			10	20	30	100	200	300	700	710

Set the error mode to a specific ERRORMODE.

ERRORMODE
The ERRORMODE is an unsigned 16 bit value that defines how the device should deal with errors that are not message-related. The default error mode is that in case the sampling instance is missed the sample counter is increase and no further action is taken (ERRORMODE = 1).

ERRORMODE	Description
0 (0x0000)	Ignore any errors except message handling errors
1 (0x0001)	In case of missing sampling instance: increase sample counter and do NOT send error message
2 (0x0002)	In case of missing sampling instance: increase sample counter and DO send error message
3 (0x0003)	In case of non-message handling error an error message is sent and the device will enter the Config State

ReqOptionFlags

MID	72 (0x48)
DATA	n/a
Direction	To MT
Valid in	Config State

1	2	3								

Requests Options Flags from the eMTS - see **SetOptionFlags** for information about data field OPTIONFLAGS of received acknowledge message.

SetOptionFlags

MID	72 (0x48)
DATA	SetFlags and ClearFlags (8 bytes)
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Changes the state of the option flags in the eMTS field “OptionFlags”.

DATA
DATA contains two parts: SetFlags and ClearFlags (LSB of ClearFlags is LSB of DATA). When setting a flag use SetFlags, for clearing a flag use ClearFlags. Values of 0 in the SetFlags and ClearFlags data fields will leave the OptionFlags field in the eMTS untouched.

OPTIONFLAGS	NAME	Product	Description
0x00000001	DisableAutoStore	MTi 1-series	When set to 1, automatic writing of configuration will be disabled. Changes will only be saved in the volatile memory. Changes will be lost after reset. Use this flag to reduce wear on the flash memory. When set to 0 (i.e. cleared) in the same SetOptionFlags message, setting DisableAutoStore to 1 has precedence.
0x00000002	DisableAutoMeasurement	MTi 1-series	When set to 1, the MT will stay in Config Mode upon start up. This allows full control on when the MT may start sending data. When set to 0 (i.e. cleared) in the same SetOptionFlags message, setting DisableAutoMeasurement to 1 has precedence.
0x00000004	EnableBeidou	MTi-G-710	Enables Beidou, disables GLONASS (MTi-G-710)
0x00000008	Reserved		
0x00000010	EnableAHS	All products	When set to 1, the MTi will have Active Heading Stabilization (AHS) enabled. AHS overrides magnetic reference, so heading output will be heading tracking instead of referenced heading.
0x00000080	EnableInRunCompassCalibration	All products	When set to, the MTi will have In-run Compass Calibration (ICC) enabled. ICC compensates for magnetic disturbances that move with the object.

Examples:
Setting the following message will set DisableAutoStore and will clear the DisableAutoMeasurement flag:

Preamble, BusId MID, LEN	SetFlags (4 bytes)	ClearFlags (4 bytes)	Checksum
FA FF 48 08	00 00 00 01	00 00 00 02	CS

The result will be that changes made will not be written to the flash memory and that the MT will go to Measurement Mode upon wake up.
Example → message for enabling AHS: FA FF 48 08 00 00 00 10 00 00 00 00 A1

ReqLocationID

MID	132 (0x84)
DATA	n/a
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Request location ID - see `SetLocationID` for information about data field of received acknowledge message.

SetLocationID

MID	132 (0x84)
DATA	LOCID (2 bytes)
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Set a user-defined value. This value can be used to give the device a location dependant identifier or any arbitrary user value.

LOCID
A 16 bit value having an arbitrary value set by the user. Default value is zero.

RestoreFactoryDef

MID	14 (0x0E)
DATA	n/a
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

If this message is sent to the MT the factory defaults are restored. All settings that have changed will be discarded including object alignments, filter settings, etc. For more information about the default settings values see section 7.1.

ReqTransmitDelay

MID	220 (0xDC)
DATA	n/a
Direction	To MT
Valid in	Config State

			10	20	30	100	200	300	700	710

Requests the delay value which equals the minimum time between last byte reception and transmission start of acknowledge in RS485 mode.

SetTransmitDelay

MID	220 (0xDC)
DATA	SETTING (2 bytes)
Direction	To MT
Valid in	Config State

			10	20	30	100	200	300	700	710

An unsigned 16 bit value that defines the number of clock ticks to delay the transmission start after last byte reception. One clock tick is equal to 1 / 29.4912 MHz = 33.9ns. This setting has no effect on RS-232 type MTs.

SETTING	Description
Bit 16-0	Delay value
	Valid value is 590 (20 usec) to 65535 (2.2 msec)

5.3.4 Synchronization messages

ReqSyncSettings

MID	44 (0x2C)
DATA	None (0 bytes)
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Request the synchronization settings of the device. This will return a full list of all configured synchronization options. See **SetSyncSettings** for a description of the fields in the message. The data size of the result will be N*12 bytes, where N=[0..10].

SetSyncSettings

MID	44 (0x2C)
DATA	Setting List (N*12 bytes)
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Set the synchronization settings of the device. This will replace the current synchronization options with the supplied list.

The size of the message data part is used to compute the size of the list. Each entry in the list is 12 bytes. To clear the list of sync settings, send a message with a single entry with a polarity set to 0.

Settings
For information on the functionality, refer to [MTi_10s_100s] and [MTi_1s]. Each setting describes either a system event that should trigger a sync out action or a sync in event that should trigger a system action. The layout of the fields is similar for both sync-in and sync-out settings, but the values are interpreted slightly differently.
“Trigger Once” means that the device will perform the action only once. If the device is reset or receives new sync settings it will again perform the action once.

Sync-in setting

Offset (bytes)	Setting	Size (bytes)	Description
0	Function	1	The action to take when activated (see table below)
1	Line	1	The sync line to use (see table below)
2	Polarity	1	Which line transition to respond to. One of: Rising Edge (1), Falling Edge (2) or Both (3)
3	Trigger Once	1	Trigger only once (1) or multiple times (0).
4	Skip First	2	The number of initial events to skip before taking action.
6	Skip Factor	2	The number of events to skip after taking the action before taking action again. Ignored for

			ReqData.
8	Pulse Width	2	Ignored for sync in.
10	Delay or Clock period	2	Delay after receiving a sync pulse to taking action (100µs units, range [0..60000]) or Reference clock period (in ms) for ClockBiasEstimation

Sync-out setting

Offset (bytes)	Setting	Size (bytes)	Description
0	Function	1	The system event to respond to (see table below)
1	Line	1	The sync line to use (see table below)
2	Polarity	1	The polarity of the sync pulse. One of: Positive Pulse (1), Negative Pulse (2), Both/Toggle (3)
3	Trigger Once	1	Trigger only once (1) or multiple times (0)
4	Skip First	2	The number of initial events to skip before taking action.
6	Skip Factor	2	The number of events to skip after taking the action before taking action again.
8	Pulse Width	2	The width of the generated pulse in 100µs units. Ignored for Toggle pulses.
10	Offset	2	Offset from event to pulse generation (100µs units, range [-30000..+30000]).

Function table

ID	Name	Description
3	TriggerIndication	A sync event item is added to the MTData2 output (StatusWord) when the trigger is detected.
4	Interval Transition Measurement	Sends an pulse (3V3) on the SyncOut line
8	SendLatest	Send the latest available sample.
9	ClockBiasEstimation	Do a clock bias estimation on trigger.
11	StartSampling	Starts the digital part of the signal processing pipeline, so that data output at 2kHz to 100 Hz can be timed to 0.1 ms

Sync Line table

This table describes the different synchronization line identifiers used by the Xsens devices. Since not all devices support the same synchronization features, each device can have a different ID for the same line.

Name	Description	MTi 1s / MTi 10s / MTi 100s	MTi-G-700/710
In 1	Input line 1	2	2
ClockIn	Reference clock input for clock bias estimation	0	0
GpsClockIn	GPS reference clock input for clock bias estimation, internal connection	-	1
ExtTimepulseIn	External GPS time pulse input. This is used to notify the device when an external GPS device samples its data.	-	5
SyncOut	SyncOut line	4	4
Software	Software line, where triggers can be sent or received via the communication protocol. Only available for SendLatest with ReqData message.	6	6

5.3.5 Configuration messages

ReqConfiguration

MID	12 (0x0C)
DATA	n/a
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Requests the configuration settings of the device. Can be used for logging purposes - include the `Configuration` message in the log file to store settings for offline data processing.

Configuration

MID	13 (0x0D)
DATA	CONFIGURATION (118 bytes)
Direction	To host
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Acknowledge of `ReqConfiguration`. Data field contains the current MTi configuration.

CONFIGURATION

The CONFIGURATION data contains the following information. For more information about the different fields check the corresponding message description.

offset (B)	length (B)	Description
0	4	Master device ID
4	2	Sampling period
6	2	Output skip factor
8	2	Syncin settings - Mode
10	2	Syncin settings - Skip Factor
12	4	Syncin settings - Offset
16	8	Date, format YYYYMMDD (can be set by host)
24	8	Time, format HHMMSSHH (can be set by host)
32	32	Reserved (host)
64	32	Reserved (client)
96	2	Number of devices (= 1 (0x0001))
98	4	Device ID (same as master device ID)
102	2	Data length of MTData or MTData2 message
104	2	Output mode
106	4	Output settings
110	8	Reserved

ReqOutputConfiguration

MID	192 (0xC0)
DATA	None (0 bytes)
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Request the output configuration of the device. The response is the same as for **SetOutputConfiguration**.

SetOutputConfiguration

MID	192 (0xC0)
DATA	OutputConfig (N*4 bytes)
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Set the output configuration of the device. This supersedes SetPeriod, SetOutputSkipFactor, SetOutputMode and SetOutputSettings.
The data is a list of maximum 32 data identifiers combined with a desired output frequency. The response message contains a list with the same format, but with the values actually used by the device.
Each entry in the list contains:

Offset	Value
0	Data Identifier (2 bytes)
2	Output Frequency (2 bytes)

Each Data Identifier is constructed in this way:

	Group					Reserved			Type				Format			
Bit#	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Group defines the category of the data, such as timestamps, orientations, angular velocities, etc.
Type combined with *Group* defines the actual type of the data.
Format defines how the data is formatted (fixed point, floating point, which coordinate system to use)
Reserved is currently unused, but reserved for adding new options to *Group* and *Type*.

All current identifiers are listed in the MT SDK 4 in xsdataidentifiers.h and are listed in the table below. For a description of their contents, refer to the MTData2 message description in section 5.3.6.

Group Name	Type Name	XDA type name	Hex Value	Valid for MTi product											Max frequency[1]
				1	2	3	10	20	30	100	200	300	700	710	
Temperature		**XDI_TemperatureGroup**	**08x0**	●	●	●	●	●	●	●	●	●	●	●	1 Hz
	Temperature	XDI_Temperature	081y	●	●	●	●	●	●	●	●	●	●	●	
Timestamp		**XDI_TimestampGroup**	**10x0**	●	●	●	●	●	●	●	●	●	●	●	2000 Hz
	UTC Time	XDI_UtcTime	1010				●	●	●	●	●	●	●	●	
	Packet Counter	XDI_PacketCounter	1020	●	●	●	●	●	●	●	●	●	●	●	
	Integer Time of Week (ITOW)	XDI_Itow	1030				●	●	●	●	●	●	●	●	
	Sample Time Fine	XDI_SampleTimeFine	1060	●	●	●	●	●	●	●	●	●	●	●	
	Sample Time Coarse	XDI_SampleTimeCoarse	1070	●	●	●	●	●	●	●	●	●	●	●	
	Frame Range	XDI_FrameRange	1080												
Orientation Data		**XDI_OrientationGroup**	**20xy**		●	●		●	●		●	●	●	●	400 Hz
	Quaternion	XDI_Quaternion	201y		●	●		●	●		●	●	●	●	
	Rotation Matrix	XDI_RotationMatrix	202y		●	●		●	●		●	●	●	●	
	Euler Angles	XDI_EulerAngles	203y		●	●		●	●		●	●	●	●	
Pressure		**XDI_PressureGroup**	**30xy**							●	●	●	●	●	50 Hz
	Baro Pressure	XDI_BaroPressure	301y							●	●	●	●	●	
Acceleration		**XDI_AccelerationGroup**	**40xy**	●	●	●	●	●	●	●	●	●	●	●	2000 Hz (see note)
	Delta V	XDI_DeltaV	401y	●	●	●	●	●	●	●	●	●	●	●	
	Acceleration	XDI_Acceleration	402y	●	●	●	●	●	●	●	●	●	●	●	
	Free Acceleration	XDI_FreeAcceleration	403y		●	●		●	●		●	●	●	●	
	AccelerationHR	XDI_AccelerationHR	404y	●	●	●									1000 Hz
Position		**XDI_PositionGroup**	**50xy**										●	●	400 Hz
	Altitude Ellipsoid	XDI_AltitudeEllipsoid	502y										●	●	
	Position ECEF	XDI_PositionEcef	503y										●	●	
	LatLon	XDI_LatLon	504y										●	●	
GNSS		**XDI_GnssGroup**	**70x0**										●	●	4 Hz
	GNSS PVT data	XDI_GnssPvtData	7010										●	●	
	GNSS satellites info	XDI_GnssSatInfo	7020										●	●	
Angular Velocity		**XDI_AngularVelocityGroup**	**80xy**	●	●	●	●	●	●	●	●	●	●	●	2000 Hz (see note)
	Rate of Turn	XDI_RateOfTurn	802y	●	●	●	●	●	●	●	●	●	●	●	
	Delta Q	XDI_DeltaQ	803y	●	●	●	●	●	●	●	●	●	●	●	
	RateOfTurnHR	XDI_RateOfTurnHR	804y	●	●	●									1000 Hz
GPS		**XDI_GpsGroup**	**88x0**										●		4 Hz
	DOP	XDI_GpsDop	8830										●		

[1] Maximum frequencies may differ on the chosen combination of outputs. Availability and frequency of outputs may differ between onboard processing and processing in XDA, as SCR or delta_q/delta_v is needed for processing data. 2000 Hz acceleration and angular velocity only available in XDA processing.

	SOL	XDI_GpsSol	8840										●		
	Time UTC	XDI_GpsTimeUtc	8880										●		
	SV Info	XDI_GpsSvInfo	88A0										●		
Sensor Component Readout (SCR)		**XDI_RawSensorGroup**	**A0x0**				●	●	●	●	●	●	●	●	2000 Hz
	ACC, GYR, MAG, temperature	XDI_RawAccGyrMagTemp	A010				●	●	●	●	●	●	●	●	
	Gyro temperatures	XDI_RawGyroTemp	A020				●	●	●	●	●	●	●	●	
Magnetic		**XDI_MagneticGroup**	**C0xy**	●	●	●	●	●	●	●	●	●	●	●	100 Hz
	Magnetic Field	XDI_MagneticField	C02y	●	●	●	●	●	●	●	●	●	●	●	
Velocity		**XDI_VelocityGroup**	**D0xy**										●	●	400 Hz
	Velocity XYZ	XDI_VelocityXYZ	D01y										●	●	
Status		**XDI_StatusGroup**	**E0x0**	●	●	●	●	●	●	●	●	●	●	●	2000 Hz
	Status Byte	XDI_StatusByte	E010	●	●	●	●	●	●	●	●	●	●	●	
	Status Word	XDI_StatusWord	E020	●	●	●	●	●	●	●	●	●	●	●	

Where:
‘x’ = The hex value of the Type bits
‘y’ = The hex value of the Format bits (see table below). The value is formed by doing a bitwise OR of the available fields. For example:
Quaternion orientation output (201y) expressed in the NED coordinate system with fixed point 16.32 numbers:

- Fp16.32 = 0x2
- NED = 0x4
- Fp16.32 and NED = 0x6

The resulting hex value for the identifier will be 0x2016

Field	Format	Description	Short name
Precision			
	0x0	Single precision IEEE 32-bit floating point number	Float32
	0x1	Fixed point 12.20 32-bit number	Fp1220
	0x2	Fixed point 16.32 48-bit number	Fp1632
	0x3	Double precision IEEE 64-bit floating point number	Float64
Coordinate system (only available for orientation group)			
	0x0	East-North-Up coordinate system	ENU
	0x4	North-East-Down coordinate system	NED
	0x8	North-West-Up	NWU

ReqStringOutputType

MID	142 (0x8E)
DATA	n/a
Direction	To MT
Valid in	Config State

			10	20	30	100	200	300	700	710

Request the configuration of the NMEA data output. The frequency can be retrieved with **`ReqPeriod`**.

SetStringOutputType

MID	142 (0x8E)
DATA	NMEA strings
Direction	To MT
Valid in	Config State

			10	20	30	100	200	300	700	710

Configures the NMEA data output. The frequency must be set with **`SetPeriod.`**

Bit	String Type	Description
Bit 0	$HCHDM	Magnetic Heading
Bit 1	$HCHDG	Heading with HeadingOffset
Bit 2	TSS2	Heading, Heave (0), Status, Roll, Pitch, Heading Status flag (F)
Bit 3	$PHTRO	Pitch, Roll
Bit 4	$PRDID	Pitch, Roll, Heading
Bit 5	EM1000	Roll, Pitch, Heave (0), Heading
Bit 6	$PSONCMS	Quaternion, Acceleration, Rate of Turn, Magnetic Field, Temp.
Bit 7	$HCMTW	Temperature
Bit 8	$HEHDT	True Heading
Bit 9	$HEROT	Rate of Turn
Bit 10	$GPGGA	UTC time, Latitude, Longitude, Fix quality, # of satellites, HDOP, Altitude
Bit 11	$PTCF	Heading, Roll, Pitch, Roll rate, Pitch rate
Bit 12	$XSVEL	Velocity X, Y, Z
Bit 13	$GPZDA	Hours, minutes, seconds, day, month, year
Bit 14-15	Reserved	Reserved for future string types

ReqPeriod

MID	4 (0x04)
DATA	n/a
Direction	To MT
Valid in	Config State

			10	20	30	100	200	300	700

Request the current sample period. The MT replies with **ReqPeriodAck**. The data field of this message contains the sample period. For the description of the data field see **SetPeriod**. Note: **ReqPeriod** for MTi MkIV (MTi 10-710) is only available for NMEA output mode (**SetStringOutputType**).

SetPeriod

MID	4 (0x04)
DATA	PERIOD (2 bytes)
Direction	To MT
Valid in	Config State

			10	20	30	100	200	300	700	710

Sets the sampling period of the device used in Measurement State. Note: **SetPeriod** for MTi MkIV (MTi 10-710) is only available for NMEA output mode (**SetStringOutputType**).

PERIOD

PERIOD is an unsigned 16-bit value indicating the length of the period. Resolution is in (1/115200) seconds, i.e. 8.68 us. The following table shows the default, minimum and maximum values.

PERIOD	Value	Sampling period (freq)
Default	1152 (0x0480)	10.0ms (100Hz)
Minimum	225 (0x00E1)	1.95ms (512Hz)
Maximum	1152 (0x0480)	10.0ms (100Hz)

The MT outputs the **MTData** at a rate that is not only depending on the sampling frequency but also on the OutputSkipfactor (see **SetOutputSkipfactor**). Normally this factor is zero and the **MTData** message is sent (1 / sampling period) times per second. A value higher than zero corresponds to how many times the **MTData** message is NOT sent to the host. To calculate how often the **MTData** is sent to the host, use the following formula.

MTData frequency (Hz) = 115200 / (PERIOD * (OutputSkipfactor + 1))

The MT output frequencies lower than 100Hz are not settable directly. By default, the device uses 100Hz as lowest sampling frequency. However in combination with the OutputSkipfactor (see **SetOutputSkipfactor** message) lower frequencies can be set. For example, if **SetPeriod** is sent with a sampling period of 20ms (50Hz), the device will automatically set the sampling period to 10ms (100Hz) and the OutputSkipfactor to 1. The resulting sampling period is 10ms * (OutputSkipfactor + 1) = 20ms (50Hz). If the sampling period can not be made (OutputSkipfactor is not an integer), an error message will be returned. In this case, choose a lower sampling period with an integer OutputSkipfactor to generate the requested frequency. For example, to have a resulting sampling period of 13.33ms (75Hz) set the sampling period to 6.67ms (150Hz) and the OutputSkipfactor to 1.

NOTE: The baud rate may limit the output frequency that can be used for a specific output mode and output setting due to the amount of data that must be transmitted (throughput); please refer to the device specific manuals ([MTi_1s]**Error! Reference source not found.** nd [MTi_10s_100s]) for further details.

ReqAlignmentRotation

MID	236 (0xEC)
DATA	PARAMETER (1 byte)
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Request the internally stored object alignments (RotSensor and RotLocal in quaternions) which are set by the **`ResetOrientation`** message or **`SetAlignmentRotation`** message. For information about data field of received acknowledge see **`SetAlignmentRotation`**.

SetAlignmentRotation

MID	236 (0xEC)
DATA	PARAMETER + QUATERNION (4x4 bytes)
Direction	To MT
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Set the object alignment.

PARAMETER
The parameter indicates which alignment rotation will be set.

PARAMETER value	Description
0	Sensor alignment (RotSensor)
1	Local alignment (RotLocal)

QUATERNION
Corresponds to the alignment matrices RotSensor and RotLocal. The quaternion (to be entered in floats) can be found by applying the matrix-to-quaternion transformations as described in [MTi_10s_100s] or by using the functions in XDA.

Values 1-4 of the Quaternion field are displayed below.

q0	q1	q2	q3

Output Format: Float (DEFAULT)
The default format used by the MT is FLOAT. FLOAT is 4 bytes long and corresponds with the single-precision floating-point value as defined in the IEEE 754 standard (= float)

5.3.6 Data-related messages

The MTi MkIV supports 3 different data message structures: 2 in XBus Protocol (MTData2 (recommended) and MTData (legacy)) and 1 in NMEA. This section describes how to switch between MTData, MTData2 and NMEA. Note that MTData (legacy) is deprecated. It is advised to use MTData2 (or NMEA).

Switching from MTData to MTData2
In order to switch from MTData to MTData2, just select an output with `SetOutputConfiguration`. `SetOutputConfiguration` overrules `SetOutputMode`

Switching from MTData2 to MTData
In order to switch from MTData2 to MTData, send a `SetOutputConfiguration` message to the MTi with an empty data identifier (i.e. 4 empty bytes: 0x FA FF C0 04 00 00 00 00 3D). Use `SetOutputMode` and `SetOutputSettings` to configure settings for MTData (legacy mode)

Switching from MTData2 or MTData to NMEA
In order to switch from MTData or MTData2 to NMEA, send a `SetStringOutputType` message to the MTi with at least one NMEA string configured. `SetStringOutputType` overrules `SetOutputConfiguration` and `SetOutputMode`

Switching from NMEA to MTData or MTData2
In order to switch from NMEA to MTData or MTData2, send a `SetStringOutputType` message to the MTi with an empty data field (i.e.: 0x FA FF 8E 02 00 00 71). After this message, the data settings stored in the eMTS in the XBus protocol will be retrieved; this will determine whether the MTi uses MTData or MTData2 .

The below chart shows what messages to use to switch protocols or data message structure.

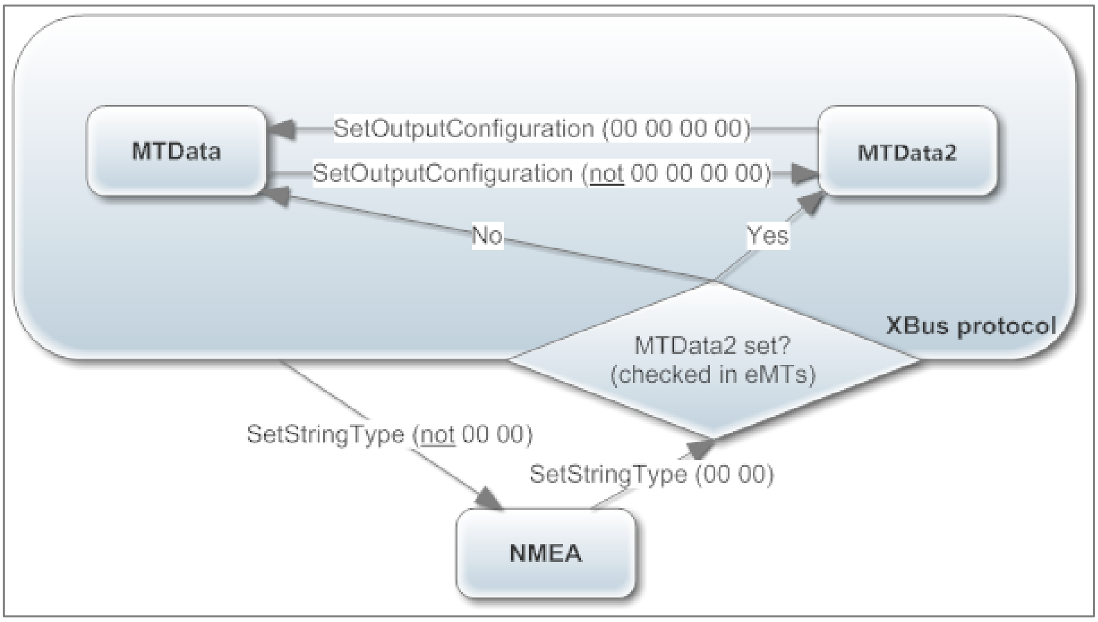

MTData
SetOutputConfiguration (00 00 00 00)
SetOutputConfiguration (not 00 00 00 00)
MTData2
No
Yes
XBus protocol
MTData2 set?
(checked in eMTs)
SetStringType (not 00 00)
SetStringType (00 00)
NMEA

Figure 1: Flow chart for data format selection. Read the section above for more detailed explanation

ReqData

MID	52 (0x34)
DATA	n/a
Direction	To MT
Valid in	Measurement State

1	2	3	10	20	30	100	200	300	700	710

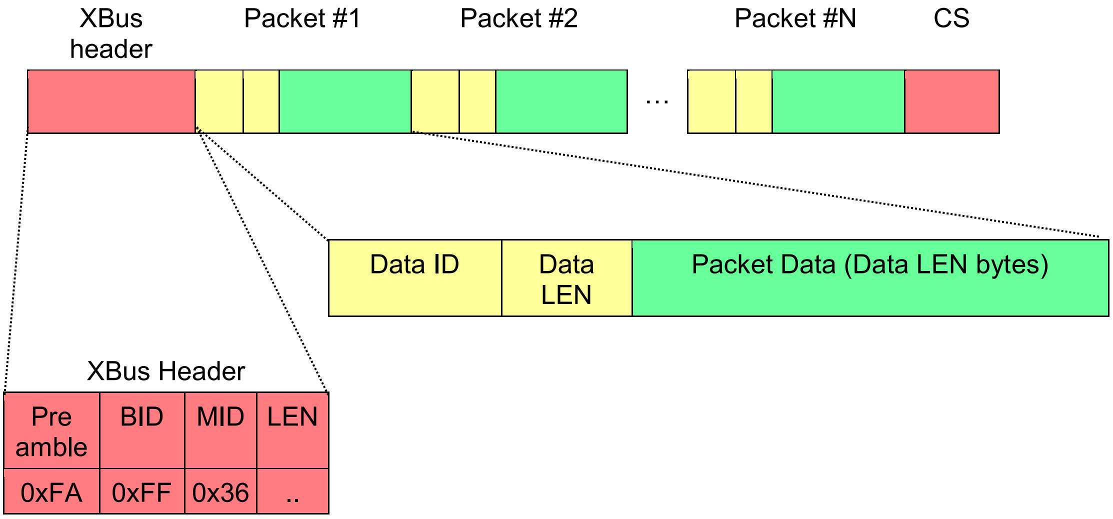
This message can be used to ask the MT to send data to the host. Normally, the MT will send the **MTData** or **MTData2** message automatically according to the sampling period and output skip factor settings. Use the synchronization settings (SetSyncSettings) to configure the MTi to send the latest data with **ReqData**.

MTData2

MID	54 (0x36)
DATA	DATA (length variable)
Direction	To host
Valid in	Measurement State

1	2	3	10	20	30	100	200	300	700	710

The MTData2 message contains output data according the current OutputConfiguration. Unlike the legacy MTData message an MTData2 message does not have to contain all configured output all the time. Instead of a single fixed output format for a particular configuration an MTData2 message consists of one or more packets, each containing a specific output. The layout of an MTData2 message is shown below:



Pre amble	BID	MID	LEN
0xFA	0xFF	0x36	..

The XBus header is explained in section 5.1. The variable LEN is the length of all bytes between LEN and CS, including Data ID's, Data LEN and Packet Data itself.

The payload of the message consists of multiple (N) packets. Each packet starts with a two byte *Data Identifier* followed by a one byte *Size* field. After that follows the *Packet Data* that is *Size* bytes long. The Data Identifier determines the format of the Packet Data.

This packet scheme makes the output data format very flexible. If a particular output data is not available the packet is omitted from the message. Also if during parsing of the message an unknown Data Identifier is encountered the packet can be skipped using its Size field. It allows for more optimal bandwidth usage and simplifies keeping future devices and/or software backwards compatible

DATA

The data can contain multiple outputs each in a separate packet identified by its Data Identifier. The output format of all the different Data Identifiers are described here. The output formats described here are identified using their Data Identifier names as defined by the XDA. For the numerical value of these identifiers refer to Section 5.3.5.

In the following, format descriptions for data values are defined as *[name : type]*. In cases where the type is ℝ the data value is a real number and its format is defined by the *precision* field of the data identifier (see Section 5.3.5). Most common is to set the precision to 0x0 (Float32) which corresponds to the 4 bytes long single-precision floating point value as defined in the IEEE 754 standard

Other defined types are:
U1: Unsigned Char.
U2: Unsigned 16-bit integer
U4: Unsigned 32-bit integer
I1: Two's complement 8-bit integer.
I2: Two's complement 16-bit integer.
I4: Two's complement 32-bit integer.

Note: Not all outputs are available for all products. Refer to `SetOutputConfiguration` for supported outputs per product.

XDI_Temperature

Contains the internal temperature of the sensor in degrees Celsius

Temp : ℝ

XDI_UtcTime

Contains the timestamp expressed as the UTC time

ns : U4	Year : U2	Month : U1	Day : U1	Hour : U1	Minute : U1	Second : U1	Flags : U1

XDI_Itow

Contains the timestamp expressed as the GPS time of week. The number is the number of milliseconds since the start of the week

TimeOfWeek : U4

XDI_PacketCounter

This packet contains the packet counter. This counter is incremented with every generated MTData2 message

PacketCounter : U2

XDI_SampleTimeFine

Contains the sample time of an output expressed in 10kHz ticks. When there is no GNSS-fix in the MTi-G-700/MTi-G-710, this value is arbitrary for GNSS messages.

SampleTimeFine : U4

XDI_SampleTimeCoarse
Contains the sample time of an output expressed in seconds. When there is no GNSS-fix in the MTi-G-700/MTi-G-710, this value is arbitrary for GNSS messages.

SampleTimeCoarse : U4

Combining XDI_SampleTimeCoarse and XDI_SampleTimeFine allows for creating a big range timestamp (expressed as a real number) using:

BigTimestamp = [SampleTimeCoarse + (SampleTimeFine mod 10000) / 10000] *(seconds)*

XDI_Quaternion
Contains orientation output expressed as a quaternion

Q0 : ℝ	Q1 : ℝ	Q2 : ℝ	Q3 : ℝ

XDI_EulerAngles
Contains the three Euler angles that represent the orientation of the MT

Roll : ℝ	Pitch : ℝ	Yaw : ℝ

XDI_RotationMatrix
This packet contains the rotation matrix (DCM) that represents the orientation of the MT.

a : ℝ	b : ℝ	c : ℝ	d : ℝ	e : ℝ	f : ℝ	g : ℝ	h : ℝ	i : ℝ

XDI_BaroPressure
Contains the pressure as measured by the internal barometer expressed in Pascal

Pressure : U4

XDI_DeltaV
Contains the delta velocity value of the SDI output

Δv.x : ℝ	Δv.y : ℝ	Δv.z : ℝ

XDI_DeltaQ
Contains the delta quaternion value of the SDI output

Δq0 : ℝ	Δq1 : ℝ	Δq2 : ℝ	Δq3 : ℝ

XDI_Acceleration
Contains the calibrated acceleration vector in x, y, and z axes

accX : ℝ	accY : ℝ	accZ : ℝ

XDI_FreeAcceleration

Contains the free acceleration vector in x, y, and z axes

freeAccX : ℝ	freeAccY : ℝ	freeAccZ : ℝ

XDI_AccelerationHR

Contains the calibrated acceleration vector in x, y, and z axes. Output data rate is 1000 Hz, direct output from the digital inertial sensors.

accX : ℝ	accY : ℝ	accZ : ℝ

XDI_RateOfTurn

Contains the calibrated rate of turn vector in x, y, and z axes

gyrX : ℝ	gyrY : ℝ	gyrZ : ℝ

XDI_RateOfTurnHR

Contains the calibrated rate of turn vector in x, y, and z axes. Output data rate is 1000 Hz, direct output from the digital inertial sensors.

gyrX : ℝ	gyrY : ℝ	gyrZ : ℝ

XDI_GpsDop

This packet contains the *dilution of precision (DOP)* values for the most recent GPS position. This data comes directly from the on-board GPS module.

Description of XDI_GpsDop Packet Structure

Name	Byte offset	Number format	Scaling	Unit	Purpose/Comment
iTOW	0	U4	-	ms	GPS Millisecond Time of Week
gDOP	4	U2	0.01	-	Geometric DOP
pDOP	6	U2	0.01	-	Position DOP
tDOP	8	U2	0.01	-	Time DOP
vDOP	10	U2	0.01	-	Vertical DOP
hDOP	12	U2	0.01	-	Horizontal DOP
nDOP	14	U2	0.01	-	Northing DOP
eDOP	16	U2	0.01	-	Easting DOP

Note:

- DOP values are dimensionless
- All DOP values are scaled by a factor of 100. For example if a value is 213 the DOP value is 2.13

XDI_GpsSol
This packet contains the Navigation Solution Information of the on-board GPS. This data comes directly from the on-board GPS module
Description of XDI_GpsSol Packet Structure

Name	Byte offset	Number format	Scaling	Unit	Purpose/Comment
iTOW	0	U4	-	ms	GPS Millisecond Time of Week
fTOW	4	I4	-	ns	Nanoseconds remainder of rounded ms above, range -500000 .. 500000
Week	8	I2	-	-	GPS week (GPS time)
gpsFix	10	U1	-	-	GPSfix Type, range 0..4 0x00 = No Fix 0x01 = Dead Reckoning only 0x02 = 2D-Fix 0x03 = 3D-Fix 0x04 = GPS + dead reckoning combined 0x05..0xFF: reserved
Flags	11	U1	-	-	Fix Status flags: bit (0) = valid fix (within DOP and accuracy masks) bit (1) = DGPS is used bit (2) = Week Number is valid bit (3) = Time of Week is valid)
ecefX	12	I4	-	cm	ECEF X coordinate
ecefY	16	I4	-	cm	ECEF Y coordinate
ecefZ	20	I4	-	cm	ECEF Z coordinate
pAcc	24	U4	-	cm	3D Position Accuracy Estimate
ecefVX	28	I4	-	cm/s	ECEF X velocity
ecefVY	32	I4	-	cm/s	ECEF Y velocity
ecefVZ	36	I4	-	cm/s	ECEF Z velocity
sAcc	40	U4	-	cm/s	Speed Accuracy Estimate
pDOP	44	U2	0.01	-	Position DOP
reserved1	46	U1	-	-	Reserved
numSV	47	U1	-	-	Number of SVs used in navigation solution
reserved2	48	U1	-	-	Reserved

XDI_GpsTimeUtc
Contains the *UTC Time Solution* coming directly from the on-board GPS module
Description of XDI_GpsTimeUtc Packet Structure

Name	Byte offset	Number format	unit	Purpose/Comment
iTOW	0	U4	ms	GPS Millisecond Time of Week

tAcc	4	U4	ns	Time Accuracy Estimate
nano	8	I4	ns	Fractional nanoseconds, remainder of rounded ms above [-500000 .. 5000000] (UTC)
year	12	U2	y	Year, range [1999.2099] (UTC)
month	14	U1	month	Month, range [1.. 12] (UTC)
day	15	U1	d	Day of Month, range [1..31] (UTC)
hour	16	U1	h	Hour of Day, range [0..23] (UTC)
min	17	U1	min	Minute of Hour, range [0..59] (UTC)
sec	18	U1	s	Seconds of Minute, range [0..59] (UTC)
valid	19	U1	-	Validity flags: bit (0) = UTC Date is valid bit (1) = UTC Time of Day is valid bit (2) = UTC Time of Day has been fully resolved (i.e. no seconds uncertainty)

XDI_GpsSvInfo
Contains the *Space Vehicle Information* as reported directly by the on-board GPS module
Description of XDI_GpsSvInfo Packet Structure

Name	Byte offset	Number format	unit	Purpose/Comment
iTOW	0	U4	ms	GPS Millisecond Time of Week
numCh	4	U1	-	Number of channels
reserved1	5	U1	-	Reserved
reserved2	6	U2	-	Reserved
Start of repeated block (numCh times)				
chn	8 + 12*N	U1	-	Channel number, 255 for SVs not assigned to a channel
svid	9 + 12*N	U1	-	Satellite ID
flags	10 + 12*N	U1	-	Bitmask, made up of the following bit values bit (0) = SV is used for navigation bit (1) = Diff correction data is available for SV bit (2) = Orbit information is available for SV bit (3) = Orbit information is Ephemeris bit (4) = SV is unhealthy / shall not be used
quality	11 + 12*N	U1	-	Signal Quality indicator (range 0..7). The following list shows the meaning of the different QI values: 0 : This channel is idle 1, 2 : Channel is searching 3 : Signal detected but unusable 4 : Code Lock on Signal 5, 6 : Code and Carrier locked 7 : Code and Carrier locked, receiving 50bps data

cno	12 + 12*N	U1	dbHz	Carrier to Noise Ratio (Signal Strength)
elev	13 + 12*N	I1	deg	Elevation in integer
azim	14 + 12*N	I2	deg	Azimuth in integer
prRes	16 + 12*N	I4	cm	Pseudo range residual
End of repeated block				

XDI_GnssPvtData

Name	Byte offset	Number format	Scaling	Unit	Purpose/Comment
itow	0	U4	-	ms	GPS time of week
year	4	U2	-	y	Year (UTC)
month	6	U1	-	m	Month (UTC)
day	7	U1	-	d	Day of the month (UTC)
hour	8	U1	-	h	Hour of the day 0..23 (UTC)
min	9	U1	-	min	Minute of hour 0..59 (UTC)
sec	10	U1	-	s	Seconds of minute 0..60 (UTC)
valid	11	U1	-	-	Validity flags: bit (0) = UTC Date is valid bit (1) = UTC Time of Day is valid bit (2) = UTC Time of Day has been fully resolved (i.e. no seconds uncertainty)
tAcc	12	U4	-	ns	Time accuracy estimate (UTC)
nano	16	I4	-	ns	Fraction of second $-1e^{-9}$ .. $1e^{-9}$
fixtype	20	U1	-	-	GNSS fix type (range 0..5): 0x00 = No Fix 0x01 = Dead Reckoning only 0x02 = 2D-Fix 0x03 = 3D-Fix 0x04 = GNSS + dead reckoning combined 0x05 = Time only fix 0x06..0xFF: reserved
flags	21	U1	-	-	Fix Status Flags: bit (0) = valid fix (within DOP and accuracy masks) bit (1) = differential corrections are applied bit (2..4) = reserved (ignore) bit (5) = heading of vehicle is valid
numSV	22	U1	-	-	Number of satellites used in navigation solution
Reserved1	23	U1	-	-	-
lon	24	I4	$1e^{-7}$	deg	Longitude
lat	28	I4	$1e^{-7}$	deg	Latitude
height	32	I4	-	mm	Height above ellipsoid

hMSL	36	I4	-	mm	Height above mean sea level
hAcc	40	U4	-	mm	Horizontal accuracy estimate
vAcc	44	U4	-	mm	Vertical accuracy estimate
velN	48	I4	-	mm/s	NED north velocity
velE	56	I4	-	mm/s	NED east velocity
velD	56	I4	-	mm/s	NED down velocity
gSpeed	60	I4	-	mm/s	2D ground speed
headMot	64	I4	$1e^{-5}$	deg	2D heading of motion
sAcc	68	U4	-	mm/s	Speed accuracy estimate
headAcc	72	U4	-	deg	Heading accuracy estimate (both motion and vehicle)
headVeh	76	I4	$1e^{-5}$	deg	2D heading of vehicle
gdop	80	U2	0.01	-	Geometric DOP
pdop	82	U2	0.01	-	Position DOP
tdop	84	U2	0.01	-	Time DOP
vdop	86	U2	0.01	-	Vertical DOP
hdop	88	U2	0.01	-	Horizontal DOP
ndop	90	U2	0.01	-	Northing DOP
edop	92	U2	0.01	-	Easting DOP

XDI_GnssSatInfo

Name	Byte offset	Number format	Scaling	Unit	Purpose/Comment
itow	0	U4	-	ms	GPS time of week
numSvs	4	U1	-	-	Number of satellites
res1	5	U1	-	-	Reserved for future use (1)
res2	6	U1	-	-	Reserved for future use (2)
res3	7	U1	-	-	Reserved for future use (3)
Start of repeated block (numCh times)					
gnssId	8+4*N	U1	-	-	GNSS identifier 0 = GPS 1 = SBAS 2 = Galileo 3 = BeiDou 4 = IMES 5 = QZSS 6 = GLONASS
svId	9+4*N	U1	-	-	Satellite identifier
cno	10+4*N	U1	-	dBHz	Carrier to noise ratio (signal strength)
flags	11+4*N	U1	-	-	Flags: bit (0..2) = signal quality indicator 0 = no signal 1 = searching signal 2 = signal acquired 3 = signal detected but unusable 4 = code locked and time synchronised 5, 6, 7 = code & carrier locked; time synchronised bit (3) = SV is being used for navigation bit (4..5) = SV health flag 0 = unknown 1 = healthy 2 = unhealthy bit (6) = differential correction data is available bit (7) = reserved

XDI_RawAccGyrMagTemp

Contains the un-calibrated raw data output of the accelerations, rate of turn and magnetic field in x, y and z axes. These values are equal to the analog-digital converter readings of the internal sensors. Message also include the value of the internal temperature sensor expressed in 1/256th degrees Celsius

accX : U2	accY : U2	accZ : U2	gyrX : U2	gyrX : U2	gyrZ : U2	magX : U2	magY : U2	magZ : U2	Temp : I2

XDI_RawGyroTemp

Contains the values of the gyroscope temperature sensors expressed in 1/256th deg Celsius

tempGyrX : I2	tempGyrY : I2	tempGyrZ : I2

XDI_MagneticField

Contains the calibrated magnetic field value in x, y, and z axes

magX : ℝ	magY : ℝ	magZ : ℝ

XDI_StatusByte

Contains the 8bit status byte which is equal to bits 0:7 of the XDI_StatusWord Packet

StatusByte : U1

XDI_StatusWord

Contains the 32bit status word

StatusWord : U4

The bits in StatusWord are defined in the following table

Bits	Field	Description
0	Selftest	This flag indicates if the MT passed the latest self-test (`RunSelftest`).
1	Filter Valid	This flag indicates if input into the orientation filter is reliable and / or complete. If for example the measurement range of internal sensors is exceeded, orientation output cannot be reliably estimated and the filter flag will drop to 0. For the MTi-G, the filter flag will also become invalid if the GPS status remains invalid for an extended period
2	GNSS fix	This flag indicates if the GNSS unit has a proper fix. The flag is only available in MTi-G units.
3:4	NoRotationUpdate Status	This flag indicates the status of the no rotation update procedure in the filter after the SetNoRotation message has been sent. 11: Running with no rotation assumption 10: Rotation detected, no gyro bias estimation (sticky) 00: Estimation complete, no errors
5	Representative Motion (RepMo)	Indicates if the MTi is in In-run Compass Calibration Representative Mode
6-7	Reserved	Reserved for future use
8	Clipflag Acc X	If set an out of range acceleration on the X axis is detected

9	Clipflag Acc Y	If set an out of range acceleration on the Y axis is detected
10	Clipflag Acc Z	If set an out of range acceleration on the Z axis is detected
11	Clipflag Gyr X	If set an out of range angular velocity on the X axis is detected
12	Clipflag Gyr Y	If set an out of range angular velocity on the Y axis is detected
13	Clipflag Gyr Z	If set an out of range angular velocity on the Z axis is detected
14	Clipflag Mag X	If set an out of range magnetic field on the X axis is detected
15	Clipflag Mag Y	If set an out of range magnetic field on the Y axis is detected
16	Clipflag Mag Z	If set an out of range magnetic field on the Z axis is detected
17:18	Reserved	Reserved for future use
19	Clipping Indication	This flag indicates going out of range of one of the sensors (is set when one or more bits from 8:16 are set)
20	Reserved	Reserved for future use
21	SyncIn Marker	When a SyncIn is detected, this bit will rise to 1
22	SyncOut Marker	When SyncOut is active this bit will rise to 1
23:25	Filter Mode	Indicates Filter Mode, currently only available for MTi-G-700/710: 000: Without GNSS (filter profile is in VRU mode) 001: Coasting mode (GNSS has been lost <60 sec ago) 011: With GNSS (default mode of MTi-G-700/MTi-G-710)
26:31	Reserved	Reserved for future use

XDI_PositionEcef
Contains the position of the MTi-G in the *Earth-Centered, Earth-Fixed (ECEF)* coordinate system. Note that position in ECEF cannot be represented in Fixed Point values because of the limited range of fixed point representations. Use double or float representation instead.

ecefX : ℝ	ecefY : ℝ	ecefZ : ℝ

XDI_LatLon
Contains the latitude and longitude of the MTi-G position

lat : ℝ	lon : ℝ

XDI_AltitudeEllipsoid
Contains the altitude of the MTi-G in meters above the WGS-84 Ellipsoid

altEllipsoid : ℝ

XDI_VelocityXYZ
Contains the X, Y and Z components of the MTi-G velocity

velX : ℝ	velY : ℝ	velZ : ℝ

NMEA (not part of the XBus protocol)
The following strings are available in the NMEA data output mode. NMEA strings are not part of the XBus protocol, and do not have the message structure of the XBus protocol.

The following strings are available:

String Type	Summary Format Description
$HCHDM	Magnetic Heading $HCHDM,xxx.xx,M*hh xxx.xx → heading with decimal fraction M → Magnetic *hh → checksum
$HCHDG	Heading with HeadingOffset $HCHDG,x.x,y.y,a,z.z,a*hr x.x → magnetic sensor heading y.y → magnetic deviation a → positive/negative deviation/variation z.z → magnetic variation in degrees a → positive/negative deviation/variation *hr → checksum
TSS2	Heading, Heave (0), Status, Roll, Pitch, Heading Status flag (F) :DDDDDSMHHHHQMRRRRSMPPPPE DDDDD → Heading * 100 degrees S → space M → space if positive, minus if negative HHHH → Heave in centimetres (fixed to 0) Q → Status flag (fixed to H, Heading) M → space if positive, minus if negative RRRR → Roll * 100 degrees S → Space M → space of positive, minus if negative PPPP → Pitch * 100 degrees E → Heading status flag, fixed to F
$PHTRO	Pitch, Roll $PHTRO,x.xx,a,y.yy,b*hh x.xx → pitch in degrees a → ‘M’ for bow up, ‘P’ for bow down y.yy → roll in degrees b→ port down *hh → terminator and checksum
$PRDID	Pitch, Roll, Heading $PRDID,PPP.PP,RRR.RR,hhh.hh PPP.PP → Pitch in degrees

	RRR.RR → Roll in degrees hhh.hh →True Heading in degrees
EM1000	Roll, Pitch, Heave (0), Heading ABRRPPAAHH AB → header 0x 00 90 RR → Roll in 0.01 degrees PP → Pitch in 0.01 degrees AA → Heave in cm (fixed to 0) HH → Heading in 0.01 degrees
$PSONCMS	Quaternion, Acceleration, Rate of Turn, Magnetic Field, Temperature $PSONCMS,Q.QQQQ,P.PPPP,R.RRRR,S.SSSS,XX.XXXX,YY.YYYY,ZZ.ZZZZ, FF.FFFF,GG.GGGG,HH.HHHH,NN.NNNN,MM,MMMM,PP.PPPP,TT.T*hh Q.QQQQ → q0 from quaternions P.PPPP → q1 from quaternions R.RRRR → q2 from quaternions S.SSSS → q3 from quaternions XX.XXXX → acceleration X in m/s^2 YY.YYYY → acceleration Y in m/s^2 ZZ.ZZZZ → acceleration Z in m/s^2 FF.FFFF → rate of turn X in rad/s GG.GGGG → rate of turn Y in rad/s HH.HHHH → rate of turn Z in rad/s NN.NNNN → magnetic field X in a.u. MM.MMMM → magnetic field Y in a.u. PP.PPPP → magnetic field Z in a.u. TT.T → Sensor temperature in degrees Celsius *hh → checksum
$HCMTW	Temperature $HCMTW,TT.T,C*hh TT.T → Sensor temperature in degrees Celsius C → indicates degrees Celsius *hh → checksum
$HEHDT	True Heading $HEHDT,xxx.xx,T*hh xxx.xx → Heading in degrees T → heading type (**T**rue, **G**rid, **M**agnetic)
$HEROT	Rate of Turn $HEROT,-xxx.x,A*hh -xxx.x → rate of turn Z in deg/min (- means bow turns to port) A → data valid *hh → checksum
$GPGGA	$GPGGA,hhmmss.ss,llll.llll,a,yyyyy.yyyy,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx*hh hhmmss.ss → UTC time llll.llll → Latitude

	a → North or South yyyyy.yyyy → Longitude a → East or West x → GPS quality indicator (0=invalid; 1=GPS fix; 2=Diff. GPS fix) xx → number of satellites in view x.x → HDOP x.x → Height above sea level (MSL) M → meters x.x → Geoidal separation between height above MSL and geoid (WGS84) M → meters x.x → age in seconds since last update from DGPS station (not used, blank) xxxx → DGPS station reference ID# (not used, blank) *hh → checksum
$PTCF	$PTCF,hhh.h,T,+RRR.R,+PPP.P,+rrr.r,+ppp.p,*cs hhh.h → heading T → True North +RRR.R → roll +PPP.P → pitch +rrr.r → roll rate +ppp.p → pitch rate *cs → checksum
$XSVEL	$XSVEL,+xxx.xxxx,+yyy.yyyy,+zzz.zzzz,*cs xxx.xxxx → Velocity X yyy.yyyy → Velocity Y zzz.zzzz → Velocity Z
$GPZDA	$GPZDA,hhmmss.ss,dd,mm,yyyy,xx,yy*CC hhmmss → Hours Minutes Seconds (UTC) dd,mm,yyy → Day,Month,Year xx → 00 yy → 00 *CC checksum
Reserved	Reserved for future string types

5.3.7 Filter messages

ReqLatLonAlt

Direction	To MT
MID	110 (0x6E)
DATA	N/A
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Requests the Latitude, Longitude and Altitude that is stored in the device. Latitude Longitude and Altitude are used for local magnetic declination and local gravity.

ReqLatLonAltAck

Direction	To host
MID	111 (0x6F)
DATA	LAT LON ALT (24 bytes)
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Returns the Latitude, Longitude and Altitude that is stored in the device. Latitude Longitude and Altitude are used for local magnetic declination and local gravity.

Data (byte offset)	Description
LAT (0)	Latitude in double floating point, big-endian
LON (8)	Longitude in double floating point, big-endian
ALT (16)	Altitude in double floating point, big-endian

SetLatLonAlt

Direction	To MT
MID	110 (0x6E)
DATA	LAT LON ALT (24 bytes)
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

Sets the Latitude, Longitude and Altitude that is stored in the device. Latitude, Longitude and Altitude are used for local magnetic declination and local gravity. See **`ReqLatLonAltAck`** for description of DATA.

SetLatLonAltAck

Direction	To host
MID	111 (0x6F)
DATA	N/A
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

ReqAvailableFilterProfiles

Direction	To MT
MID	98 (0x62)
Valid in	Config State

1	2	3	10	20	30	100	200	300	700	710

NOTE: For MTi and MTi-G this is not supported in firmware version 2.0 and lower.

Requests the available setting profiles from the on board memory of the Motion Tracker.

AvailableFilterProfiles

Contains information about available setting profiles that are stored on the non-volatile memory of the Motion Tracker.
Data contains the following for all 5 available setting profiles. When less than 5 filter profiles are available, the remaining filter profiles are of type 0.

DATA (B)	Description
TYPE (0 + 22*index)	Filter profile type
VERSION (1 + 22*index)	Filter profile version
LABEL (2 + 22*index)	Filter profile label. The label is NOT 0-terminated and it is padded to 20 bytes with spaces.

ReqFilterProfile

Direction	To MT
MID	100 (0x64)

1	2	3	10	20	30	100	200	300	700	710	

Requests the ID of the currently used filter profile.

SetFilterProfile

Direction To MT
MID 100 (0x64)
DATA FILTERPROFILE (2 bytes)

1	2	3	10	20	30	100	200	300	700	710

Sets the filter profile to use. For more information about the various setting profiles please refer to the filter profile sections in the device specific manuals ([MTi_10s_100s]).

FILTERPROFILE	Hardware Type	Description
39	MTi 10-series/MTi 100-series	General
40	MTi 10-series/MTi 100-series	High_mag_dep
41	MTi 10-series/MTi 100-series	Dynamic
42	MTi 10-series/MTi 100-series	Low_mag_dep
43	MTi 10-series/MTi 100-series	VRU_general
50	MTi 1-series	General
51	MTi 1-series	High_mag_dep
52	MTi 1-series	Dynamic
53	MTi 1-series	North_reference
54	MTi 1-series	VRU_general
01	MTi-G-700/710	General
02	MTi-G-700/710	GeneralNoBaro
03	MTi-G-700/710	GeneralMag
04	MTi-G-700/710	Automotive
05	MTi-G-700/710	HighPerformanceEDR

ReqFilterProfileAck

Direction To host
MID 101 (0x65)
DATA VERSION FILTERPROFILE

1	2	3	10	20	30	100	200	300	700	710

Contains the currently used setting profile.

NOTE: For MTi and MTi-G this is not supported in firmware version 2.0 and lower.

DATA (B)	Description
VERSION (0)	Filter profile version
FILTERPROFILE (1)	Filter profile type

ResetOrientation

MID	164 (0xA4)
DATA	CODE (2 bytes)
Direction	To MT
Valid in	Config State and Measurement State

1	2	3	10	20	30	100	200	300	700	710

Reset the orientation. Different resets are supported; see next table. For more information about the different resets see User Manuals ([MTi_1s] or [MTi_10s_100s]). To store the new orientation goto Config state and send the **ResetOrientation** message again but now with CODE = 0x0000. If the orientation is not stored the next time, the Measurement State becomes active the reset orientation results are discarded.

CODE

A two-byte value indicating which reset to perform during Measurement State. To store the present settings, enter the Config State and send the same message again with RESET equal to zero.

CODE	Description
0 (0x0000)	Store current settings (only in config mode)
1 (0x0001)	Heading reset (NOT supported by MTi-G)
2 (0x0002)	RESERVED
3 (0x0003)	Object reset

SetNoRotation

MID	34 (0x22)
DATA	Duration (seconds) (2 bytes)
Direction	To MT
Valid in	Measurement State

1	2	3	10	20	30	100	200	300	700	710

Initiates the ‘no rotation’ update procedure. For more information about the no rotation update procedure see [MTi_10s_100s]). Note that the acknowledge does not reflect the result of the `SetNoRotation` message. The result of the SetNoRotation message are represented in bits 3 and 4 of the status byte (see `MTdata` / 0x32).

DATA

PARAM	DATA	Description
0	Duration (seconds)	Duration of the 'no rotation' update.

ReqUTCTime

Direction To MT
MID 96 (0x60)

			10	20	30	100	200	300	700	710

Request UTC Time from sensor

SetUTCTime

Direction To MT
MID 96 (0x60)
DATA UTCTime (12 bytes)

			10	20	30	100	200	300	700	710

Set UTC Time in sensor

AdjustUTCTime

Direction To MT
MID 168 (0xA8)
DATA Correction ticks (4 bytes)

			10	20	30	100	200	300	700	710

Sends correction ticks for the UTC Time to the sensor (1 tick is 0.1 ms).
Value must be provided in two's complement 32-bit integer:

Value	Correction ticks (time in seconds)
0x00000001	1 (+0.0001 secs)
0x00002710	10000 (+1 sec)
0xFFFFD8EF0	-10000 (-1 sec)

UTCTime

Direction To host
MID 97 (0x61)
DATA UTCTime (12 bytes)

			10	20	30	100	200	300	700	710

Contains UTC Time

DATA (B)	Description
0	Nanoseconds of second, range 0 .. 1.000.000.000
4	Year, range 1999 .. 2099
6	Month, range 1..12
7	Day of Month, range 1..31
8	Hour of Day, range 0..23
9	Minute of Hour, range 0..59
10	Seconds of Minute, range 0..59
11	0x01 = Valid Time of Week 0x02 = Valid Week Number 0x04 = Valid UTC

NOTE: Time till UTC flag (0x04) goes to valid takes 12.5 minutes. This time is needed to correct for the clock bias of the receiver. It is advised to start synchronization using UTC only when the UTC flag is valid.

IccCommand

MID	116 (0x74)
DATA	COMMAND (1 byte)
Direction	To MT
Valid in	Measurement State, Config state

1	2	3	10	20	30	100	200	300	700	710

Handles request and actions with respect to In-run Compass Calibration (ICC) and Representative Motion.

COMMAND

VALUE	Action	State
00	Start Representative Motion	Measurement State
01	Stop Representative Motion	Measurement State
02	Store ICC parameters	Config State
03	Get Representative Motion State	Measurement State

IccCommandAck

MID	117 (0x75)
DATA	RESULT (0-7 bytes, depending on the command)
Direction	To host
Valid in	Measurement State

1	2	3	10	20	30	100	200	300	700	710

Acknowledges IccCommand and may return a result based on the command. Store ICC Paramaters is only valid in Config State.

RESULT

Payload offset (bytes)	Type	Length (bytes)	State
00	Uint8	1	IccCommand, see table COMMAND (0x74)
01	Command-specific	N	Command-specific additional payload (see table PAYLOAD)

PAYLOAD

ICC Command	Extra Payload for IccCommandAck (0x75)
Start Representative Motion (0x00)	None
Stop Representative Motion (0x01)	ICC results (see Table ICCRESULTS for complete message payload)
Store ICC results (0x02)	None
Representative Motion state (0x03)	State: - 0x00: representative motion inactive - 0x01: representative motion active

ICCRESULTS

Payload offset (bytes)	Type	Field
0	Uint8	Command = 0x01 = Stop Representative Motion
1	Float	ddt value (Ratio of disturbance with respect to noise)
5	Uint8	Dimension of estimate (2D/3D)
6	Uint8	Status byte: - 0x00 OK - 0x01 Too much disturbance - 0x02 Not enough data - 0x03 Too much disturbance and not enough data

Example: After Representative Motion is stopped, the MTi may return for example the next message:

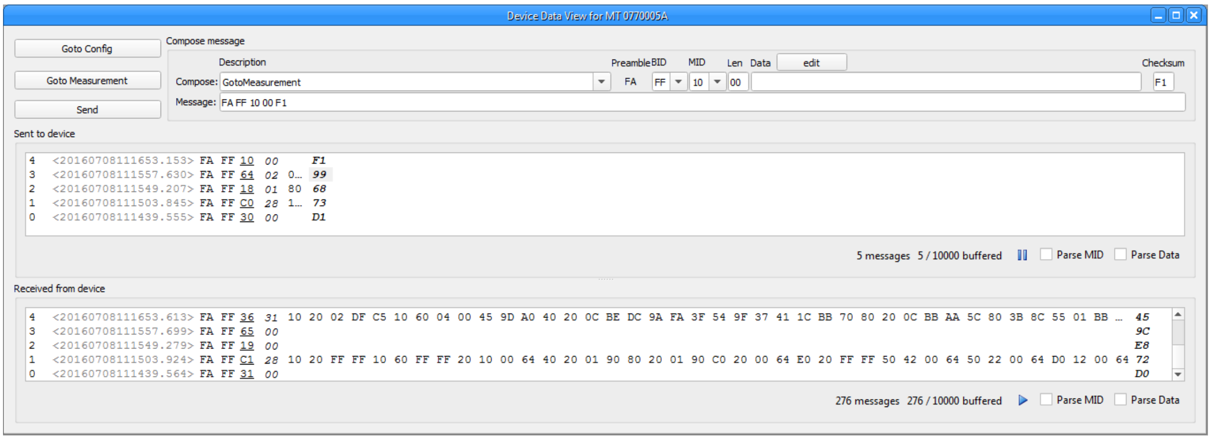
FA FF 75 07 01 40 80 3A 85 02 01

FA FF	: Preamble and BusId
75	: Message ID (IccCommandAck)
01	: Stop Representative Motion
40 80 3A 85	: ddt value (4.0071435)
02	: Dimension (2D)
00	: No warnings

6 MT low level communication protocol example

This section shows the communication between the host and MT as data bytes.

The byte values of the following examples are shown in hexadecimal. Make sure your application has the ability to communicate in hexadecimal format. In MT Manager, use the Device Data Viewer to see the low level communication. This example is for the MTi-G-700/710, so not all commands can be used on other MTi products.



Compose message

Description / Preamble / BID / MID / Len / Data / Checksum

Compose: GotoMeasurement | FA | FF | 10 | 00 | | F1

Message: FA FF 10 00 F1

Sent to device

```
4   <20160708111653.153> FA FF 10  00       F1
3   <20160708111557.630> FA FF 64  02  0... 99
2   <20160708111549.207> FA FF 18  01  80   68
1   <20160708111503.845> FA FF C0  28  1... 73
0   <20160708111439.555> FA FF 30  00       D1
```

5 messages 5 / 10000 buffered ☐ Parse MID ☐ Parse Data

Received from device

```
4   <20160708111653.613> FA FF 36  31  10 20 02 DF C5 10 60 04 00 45 9D A0 40 20 0C BE DC 9A FA 3F 54 9F 37 41 1C BB 70 80 20 0C BB AA 5C 80 3B 8C 55 01 BB ...  45
3   <20160708111557.699> FA FF 65  00                                                                                                                             9C
2   <20160708111549.279> FA FF 19  00                                                                                                                             E8
1   <20160708111503.924> FA FF C1  28  10 20 FF FF 10 60 FF FF 20 10 00 64 40 20 01 90 80 20 01 90 C0 20 00 64 E0 20 FF FF 50 42 00 64 50 22 00 64 D0 12 00 64 72
0   <20160708111439.564> FA FF 31  00                                                                                                                             D0
```

276 messages 276 / 10000 buffered ☐ Parse MID ☐ Parse Data

Before you can change any settings, make sure Config is active:

TX: **FA FF** 30 00 D1

Continue receiving data until the following bytes are received:

RX: **FA FF** 31 00 D0

Set the configuration

TX: **FA FF** C0 28 10 20 FF FF 10 60 FF FF 20 10 00 64 40 20 01 90 80 20 01 90 C0 20 00 64 E0 20 FF FF 50 42 00 64 50 22 00 64 D0 12 00 64 73

The list of settings is:

- PacketCounter 0x1020
- SampleTimeFine 0x1060
- Quaternion 0x2010 @ 100 Hz (0x0064)
- Acceleration 0x4020 @ 400 Hz (0x0190)
- Rate of Turn 0x8020 @ 400 Hz (0x0190)
- Magnetic Field 0xC020 @ 100 Hz (0x0064)
- Statusword 0xE020
- LatLon 0x5042 @ 100 Hz (0x0064)
- Altitude 0x5022 @ 100 Hz (0x0064)
- Velocity XYZ 0xD012 @ 100 Hz (0x0064)

Note the mask: e.g. LatLon, in the example fixed point 16.32, is also available with fixed point 12.20. That part would then have been “50 41 00 64”.

The MT acknowledges with

RX: **FA FF** C1 28 10 20 **FF FF** 10 60 **FF FF** 20 10 00 64 40 20 01 90 80 20 01 90 C0 20 00 64 E0 20 **FF FF** 50 42 00 64 50 22 00 64 D0 12 00 64 72

Set the baud rate (serial communication only)

TX: **FA FF** 18 01 80 68

The MT acknowledges with

RX: **FA FF** 19 00 E8

Set the filter profile (in this case GeneralNoBaro for an MTi-G-710)

TX: **FA FF** 64 02 00 02 99

The MT acknowledges with

RX: **FA FF** 65 00 9C

Goto measurement state to start logging data:

TX: **FA FF** 10 00 F1

Start logging data:

The MT sends the **MTData** message which has the following format:
RX: **FA FF** 36 31 10 20 02 **DF** C5 10 60 04 00 45 9D A0 40 20 0C **BE DC** 9A **FA** 3F 54 9F 37 41 1C **BB** 70 80 20 0C **BB AA** 5C 80 3B 8C 55 01 **BB** 81 33 00 E0 20 04 00 00 00 81 45

The message is built up as following:

FA FF 36	Preamble, Bus ID and Message ID (0x36 is MTDATA2)
31	Length of all data
10 20 02 DF C5	In this case the highlighted part is the Packet counter (0x1020) with length 0x02 and these 2 bytes are DF C5 (decimal: 57285). Double-clicking a message in the data viewer will show the decimal value in a pop-up screen.
…	All data messages are following with total 0x31 bytes (49 bytes). Last data packet is “E0 20 04 00 00 00 81”
45	Checksum for this Xbus message

7 Miscellaneous

7.1 Default factory settings

The default settings of the MT will set the device in a configuration that calculates and outputs the orientation 100 times per second in quaternions. The **MTData** and **MTData2** messages will also include a sample counter which can be used to detect missing samples. The data is transmitted at a baud rate of 115k2 bits per second and the synchronization in- and outputs are disabled.

The default settings are listed in the table of section 4.2.

There are two ways to set the MT in this default setting. You can **RestoreFactoryDef** or you can use the individual messages shown in the table to (re)set the settings. Keep in mind that if you use the **RestoreFactoryDef** message the filter / device settings shown in the next table are also reset.

Property	Default value	Message (section nr)
Location	0	**SetLocationID**
Object alignment	Unity matrix	**ResetOrientation**
Heading	0	**SetHeading**
Magnetic calibration (MFM)	Factory calibration	N/A

7.2 Restore communication

If the MT has been programmed with a baud rate setting that is not compatible with software or is unknown to the user, a 'restore communication' procedure can be applied. This procedure will set a number of settings to its default values including the baud rate. Note that this only is valid for legacy devices (regardless of the interface) and the MTi 10-series/MTi 100-series with RS422 devices. For devices with both USB and serial interfaces, you can easily restore communication by disconnecting and reconnecting USB. The following settings will be reset.

Property	Default value
Output configuration	Depending on product, see section 4.2
Output frequency	100 Hz
Baud rate	115k2 bps
Output skip factor	0
SyncIn	Disabled (MTi-G-700/710: GPS Clock SyncIn)
SyncOut	Disabled
Error mode	1

You can either use the MT Manager (see Tools menu) or perform the procedure manually. To restore the settings manually follow the following procedure:

1. Disconnect the MT from the USB-serial converter cable
2. Insert the USB-serial converter cable into a free USB port and open the respective virtual COM port with the following settings: baud rate 115k2, 8 databits, no parity and 1 stop bit.
3. Start sending the byte value 222 (0xDE) repeatedly but make sure there is a gap of 0.1 to 0.5 ms between the words (no back-to-back transfer)
4. While sending connect the MT to the USB converter
5. Stop sending when the **`WakeUp`** message is received

This procedure during MT device WakeUp ensures that communication can always be restored with the device, even if erroneous settings have been programmed by accident.

7.2.1 Default communication settings

Setting	Default Value
Bits/second (bps):	115200
Data bits:	8
Parity:	none
Stop bits:	1
Flow control:	none

These settings are the same for the RS-232 as the RS-422/RS485 versions. The baud rate (bps) setting can be changed by the user. The maximum is 921600 bps and the minimum 4800 bps. Should the communication fail, it can be helpful to change the number of stop bits to 2.

8 Message Reference Listing

This section gives a quick reference of all the valid messages. For more information about the use of the messages see Section 5.

WakeUp and State messages (Section 5.3.1)

Message	MID	Direction
WakeUp	62 (0x3E)	To host
WakeUpAck	63 (0x3F)	To MT
GoToConfig	48 (0x30)	To MT
GoToConfigAck	49 (0x31)	To host
GoToMeasurement	16 (0x10)	To MT
GoToMeasurementAck	17 (0x11)	To host
Reset	64 (0x40)	To MT
ResetAck	65 (0x41)	To host

Informational messages (Section 5.3.2)

Message	MID	Direction	
ReqDID	0 (0x00)	To MT	Host request device ID of the device
DeviceID	1 (0x01)	To host	Device acknowledges request by sending its ID
	2 (0x02)	To MT	Reserved
	3 (0x03)	To host	Reserved
ReqProductCode	28 (0x1c)	To MT	Host request product code of the device
ProductCode	29 (0x1d)	To host	Device acknowledges request by sending its product code
ReqFWRev	18 (0x12)	To MT	Host requests firmware revision of device
FirmwareRev	19 (0x13)	To host	Device acknowledges request by sending its firmware revision
	10 (0x0A)	To MT	Reserved
	11 (0x0B)	To host	Reserved
Error	66 (0x42)	To host	Error message
	166 (0xA6)	To MT	Reserved
	167 (0xA7)	To host	Reserved

Device-specific messages (Section 5.3.3)

Message	MID	Direction	Description
RestoreFactoryDef	14 (0xE)	To MT	Restores all settings in MT to factory defaults
ReqBaudrate	24 (0x18)	To MT	Requests current baud rate of the serial communication
ReqBaudrateAck	25 (0x19)	To host	Device returns baud rate of serial communication
SetBaudrate	24 (0x18)	To MT	Host sets baud rate of serial communication
SetBaudrateAck	25 (0x19)	To host	Device acknowledges SetBaudrate message
RunSelftest	36 (0x24)	To MT	Runs the built-in self test
SelftestAck	37 (0x25)	To host	Returns the self test results
ReqErrorMode	218 (0xDA)	To MT	Request error mode
ReqErrorModeAck	219 (0xDB)	To host	Device returns error mode
SetErrorMode	218 (0xDA)	To MT	Host sets error mode
SetErrorModeAck	219 (0xDB)	To host	Device acknowledges SetErrorMode message
ReqTransmitDelay	220 (0xDC)	To MT	Request the transmit delay in RS485 MT's
ReqTransmitDelayAck	221 (0xDD)	To host	Device returns the transmit delay in RS485 MT's
SetTransmitDelay	220 (0xDC)	To MT	Host sets transmit delay in RS485 MT's
SetTransmitDelayAck	221 (0xDD)	To host	Device acknowledges SetTransmitDelay message
ReqOptionFlags	72 (0x48)	To MT	Requests state of OptionFlags
ReqOptionFlagsAck	73 (0x49)	To host	Device returns OptionFlags
SetOptionFlags	72 (0x48)	To MT	Sets state of OptionFlags
SetOptionFlagsAck	73 (0x49)	To host	Device acknowledges SetOptionFlags message
ReqLocationID	132 (0x84)	To MT	Request location ID
ReqLocationIDAck	133 (0x85)	To host	Device returns location ID
SetLocationID	132 (0x84)	To MT	Host sets location ID
SetLocationIDAck	133 (0x85)	To host	Device acknowledges SetLocationID message

Synchronization messages (Section 5.3.4)

Message	MID	Direction	Description
ReqSyncSettings	44 (0x2C)	To MT	Request the synchronization settings of the device
ReqSyncSettingsAck	45 (0x2D)	To host	Device returns synchronization settings
SetSyncSettings	44 (0x2C)	To MT	Set the synchronization settings of the device
SetSyncSettingsAck	45 (0x2D)	To host	Device acknowledges SetSyncSettings message

	214 (0xD6)	To MT	Reserved
	215 (0xD7)	To host	Reserved
	216 (0xD8)	To MTi	Reserved
	217 (0xD9)	To host	Reserved

Configuration messages (Section 5.3.5)

Message	MID	Direction	Description
ReqConfiguration	12 (0x0C)	To MT	Request the configuration of device. For logging/quick setup purposes
Configuration	13 (0x0D)	To host	Contains the configuration of device
ReqPeriod	4 (0x04)	To MT	Request current sampling period
ReqPeriodAck	5 (0x05)	To host	Device returns sampling period
SetPeriod	4 (0x04)	To MT	Host sets sampling period (10-500Hz)
SetPeriodAck	5 (0x05)	To host	Device acknowledges SetPeriod message
ReqExtOutputMode	134 (0x86)	To MT	Requests the current extended output mode (deprecated, see rev W of this document)
ExtOutputMode	135 (0x87)	To host	Device returns the current extended output mode (deprecated, see rev W of this document)
SetExtOutputMode	134 (0x86)	To MT	Sets the extended output mode (deprecated, see rev W of this document)
SetExtOutputModeAck	135 (0x87)	To host	Device acknowledges SetExtOutputMode (deprecated, see rev W of this document)
ReqOutputConfiguration	192 (0xC0)	To MT	Request the current output configuration
ReqOutputConfigurationAck	193 (0xC1)	To Host	Device returns the output configuration
SetOutputConfiguration	192 (0xC0)	To MT	Sets the output configuration
SetOutputConfigurationAck	193 (0xC1)	To Host	Device acknowledges SetOutputconfiguration message
ReqStringOutputTypes	142 (0x8E)	To MT	Request the configuration of the NMEA data output
ReqStringOutputTypesAck	143 (0x8F)	To host	Device returns the NMEA output configuration
SetStringOutputTypes	142 (0x8E)	To MT	Configures the NMEA data output
SetStringOutputTypesAck	143 (0x8F)	To host	Device acknowledges SetStringOutputTypes message
	212 (0xD4)	To MT	Reserved
	213 (0xD5)	To host	Reserved
	224 (0xE0)	To MT	Reserved

	225 (0xE1)	To host	Reserved
ReqAlignmentRotation	236 (0xEC)	To MT	Requests the sensor alignment or local alignment
ReqRotationQuaternionAck	237 (0xED)	To host	Device acknowledges ReqRotationQuaternion
SetAlignmentRotation	236 (0xEC)	To MT	Sets the sensor alignment or local alignment
SetRotationQuaternionAck	237 (0xED)	To host	Device acknowledges SetRotationQuaternion
ReqOutputMode	208 (0xD0)	To MT	Request current output mode (deprecated, see rev W of this document)
ReqOutputModeAck	209 (0xD1)	To host	Device returns output mode (deprecated, see rev W of this document)
SetOutputMode	208 (0xD0)	To MT	Host sets output mode (deprecated, see rev W of this document)
SetOutputModeAck	209 (0xD1)	To host	Device acknowledges SetOutputMode message (deprecated, see rev W of this document)
ReqOutputSettings	210 (0xD2)	To MT	Request current output settings (deprecated, see rev W of this document)
ReqOutputSettingsAck	211 (0xD3)	To host	Device returns output settings (deprecated, see rev W of this document)
SetOutputSettings	210 (0xD2)	To MT	Host sets output settings (deprecated, see rev W of this document)
SetOutputSettingsAck	211 (0xD3)	To host	Device acknowledges SetOutputSettings message (deprecated, see rev W of this document)

Data-related messages (Section 5.3.6)

Message	MID	Direction	Description
ReqData	52 (0x34)	To MT	Host requests device to send MTData message
MTData	50 (0x32)	To host	Message with un-calibrated raw data, calibrated data,orientation data or GPS PVT data
MTData2	54 (0x36)	To host	Message with one or more output data packets

Filter messages (Section 5.3.7)

Message	MID	Direction	Description
	130 (0x82)	To MT	Reserved
	131 (0x83)	To host	Reserved
	130 (0x82)	To MT	Reserved
	131 (0x83)	To host	Reserved

ResetOrientation	164 (0xA4)	To MT	Resets the orientation
ResetOrientationAck	165 (0xA5)	To host	Device acknowledges ResetOrientation message
ReqUTCTime	96 (0x60)	To MT	Request UTC Time
SetUTCTime	96 (0x60)	To MT	Sets time in UTC format
AdjustUTCTime	168 (0xA8)	To MT	Sets correction ticks to UTC time
UTCTime	97 (0x61)	To host	Device return UTC Time
ReqAvailableFilterProfiles	98 (0x62)	To MT	Request available filter profiles
AvailableFilterProfiles	99 (0x63)	To host	Device return available filter profiles
ReqFilterProfile	100 (0x64)	To MT	Request current used filter profile
ReqFilterProfileAck	101 (0x65)	To host	Device return current filter profile
SetFilterProfile	100 (0x64)	To MT	Host set current filter profile
SetFilterProfileAck	101 (0x65)	To host	Device acknowledges SetFilterProfile
	102 (0x66)	To MT	Reserved
	103 (0x67)	To host	Reserved
	102 (0x66)	To MT	Reserved
	103 (0x67)	To host	Reserved
	104 (0x68)	To MT	Reserved
	105 (0x69)	To host	Reserved
	106 (0x6A)	To MT	Reserved
	107 (0x6B)	To host	Reserved
	106 (0x6A)	To MT	Reserved
	107 (0x6B)	To host	Reserved
ReqLatLonAlt	110 (0x6E)	To MT	Requests the latitude, longitude and altitude that is stored in the device
ReqLatLonAltAck	111 (0x6F)	To host	Returns the latitude, longitude and altitude that is stored in the device
SetLatLonAlt	110 (0x6E)	To host	Sets latitude, longitude and altitude in the device
SetLatLonAltAck	111 (0x6F)	To MT	Device acknowledges SetLatLonAlt
	32 (0x20)	To MT	Reserved
	33 (0x21)	To host	Reserved
SetNoRotation	34 (0x22)	To MT	Initiates ‘no rotation’ update procedure
SetNoRotationAck	35 (0x23)	To host	Device acknowledges SetNoRotation message
IccCommand	116 (0x74)	To MT	
IccCommandAck	117 (0x75)	To host	