MT Low Level Communication Documentation

MTi 10-series and MTi 100-series

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Revisions

Revision	Date	By	Changes
A	June 3, 2005	SSM	First version
…	…	…	…
O	25 Sep 2012	MHA	Added MTData2 and MTi configuration messages
P	18 Dec 2012	MHA	MT Software Suite 4.1, added MTi-G
Q	07 May 2013	MHA	Added Set/ReqUTCTime, Set/ReqExtOutputMode
R	28 October 2013	MHA	Added StartSampling, NMEA string mode, SetAlignmentRotation
S	17 January 2014	MHA	Added filter profiles for MTi-G-700, added 76k6 baud rate in table, removed some small errors
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

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
WR(-A)	Wireless Receiver
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
[MTi_MTx]	“MTi and MTx User Manual and Technical Documentation.pdf”, document id MT0100P
[MTi-G]	“MTi-G User Manual and Technical Documentation.pdf”, document id MT0137P
[XBM]	“XM-B User Manual.pdf”, document id XM0100P “XM-B Technical Documentation.pdf”, document id XM0101P
[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

2 Introduction

This document describes how to communicate with Xsens' range of miniature MEMS based inertial Motion Trackers; the MTi-G, the MTi/MTx, 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 RS-232, RS-485, RS-422 or USB interfaces. The MT communication protocol based message enables the user to change the configuration of the MT-G, MTi and MTx and retrieve the output data.

Note: not all products support the same functionality. There are 9 different products described in this document, in each message ID a table is depicted that shows the support for each product:

MTi	MTi-G	10	20	30	100	200	300	700	710

The meaning of these terms are:

- MTi: MTi and MTx legacy Motion Trackers (3rd generation)
- MTi-G: MTi-G legacy Motion Tracker with GPS (3rd generation)
- 10: MTi-10 IMU (4th generation)
- 20: MTi-20 VRU (4th generation)
- 30: MTi-30 AHRS (4th generation)
- 100: MTi-100 IMU (4th generation)
- 200: MTi-200 VRU (4th generation)
- 300: MTi-300 AHRS (4th generation)
- 700: MTi-G-700 GPS/INS (4th generation)
- 710: MTi-G-710 GNSS/INS (4th generation)

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`**. **`MTData`** messages are supported by all 9 products, **`MTData2`** messages only by the MTi-10 to MTi-G-710. Referencing to **`MTData`** and/or **`MTData2`** has been chosen with care and gives an indication whether a particular paragraph is applicable to 3rd generation products, all products or 4th generation products only.

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 3.

The messages used in **Config** and **Measurement** state are described in Section 4. 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 5 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 6. The last section gives a message reference overview of the MT messages with short descriptions, see section 7.

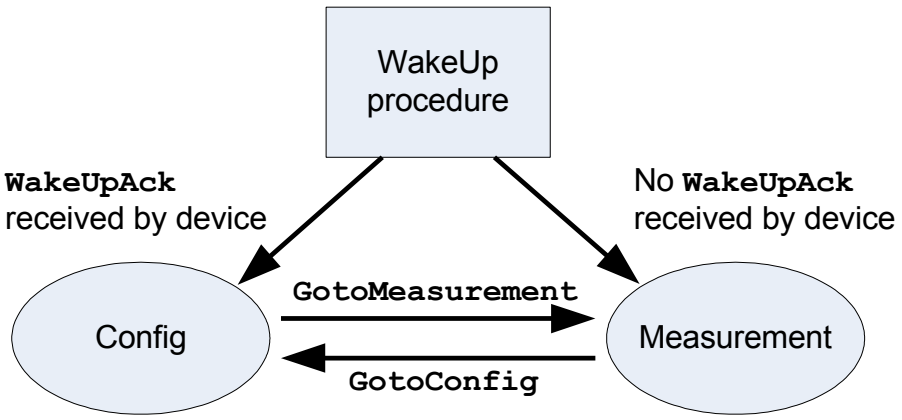
3 States

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 the device enters the Measurement State. But 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 Specification 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 mode and settings. Another way to enter the 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.



3.1 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 4 for more information about messages.

3.2 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	Value
Output mode	Orientation output
Setting profile	General
Output settings	Orientation in quaternion mode Sample counter enabled
Output frequency	100 Hz
Baud rate	115k2 bps
Output skip factor	0
SyncIn	Disabled
SyncOut	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.

See Section 4 for more information about messages.

4 Messages

4.1 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 (i.e. not connected on an Xbus Master) 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 4.3.

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.

4.2 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 output mode (`ReqOutputMode`) is the same as the message that sets the output mode (`SetOutputMode`). The difference between the two messages is that the Length field of `ReqOutputMode` is zero and non-zero for `SetOutputMode`.

Example
Request current output mode:
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 output mode:
Sending message:
`SetBaudrate =` 0xFA 0xFF 0x18 0x01 BR CS (hexadecimal values)
Receiving message (= Acknowledge):
`SetBaudrateAck =` 0xFA 0xFF 0x19 0x00 0xE8 (hexadecimal values)

4.3 Message listing

4.3.1 WakeUp + State messages

WakeUp

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

MTi	MTi-G	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

MTi	MTi-G	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

MTi	MTi-G	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

MTi	MTi-G	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.

4.3.2 Informational messages

ReqDID

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

MTi	MTi-G	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

MTi	MTi-G	10	20	30	100	200	300	700	710

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

InitMT / InitBus

MID	2 (0x02)
DATA	n/a
Direction	To MT
Valid in	Config State

MTi	MTi-G	10	20	30	100	200	300	700	710

This message is supported so the host can use the same message for MT as for the XbusMaster. The device will answer with the **InitMTResults** message. For the MT it has the same functionality as **ReqDID**.

InitMTResults / InitBusResults

MID	3 (0x03)
DATA	IDHH IDHL IDLH IDLL (4 bytes)
Direction	To host
Valid in	Config State

MTi	MTi-G	10	20	30	100	200	300	700	710

Acknowledge of **InitMT** message. Data field contains device ID / serial number and corresponds to the S/N number on the bottom of the device (hexadecimal values).

ReqProductCode

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

MTi	MTi-G	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

MTi	MTi-G	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

MTi	MTi-G	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 (3 bytes)
Direction	To host
Valid in	Config State

MTi	MTi-G	10	20	30	100	200	300	700	710

Acknowledge of **ReqFWRev** message. Data field contains firmware code (major, minor, revision part).

ReqDataLength

MID	10 (0x0A)
DATA	n/a
Direction	To MT
Valid in	Config State

MTi	MTi-G								

Request the length of the data field of the **MTData** message based on the current configuration. The device acknowledges with the **DataLength** message.

DataLength

MID	11 (0x0B)
DATA	DATALENGTH (2 bytes)
Direction	To host
Valid in	Config State

MTi	MTi-G								

Acknowledge of **ReqDataLength** message. The data field contains DATALENGTH, an unsigned 16 bits value that is equal to the data length of the **MTData** message send in Measurement State based on the current configuration.

RunSelftest

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

Runs the built-in self test.

MTi	MTi-G	10	20	30	100	200	300	700	710

SelftestAck

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

MTi	MTi-G	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

MTi	MTi-G	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 (Xsendeviceapi → HTML doc (index) → Modules → Global Enumerations → XsResultValue).

ReqGPSStatus

MID	166 (0xA6)
DATA	n/a
Direction	To MTi-G
Valid in	Config State

	MTi-G								

MTi-G requests status information from the GPS receiver at regular intervals. On request, this data is sent from cache. Also refer to the GPSStatus message below.

GPSStatus

MID	167 (0xA7)
DATA	GPSSTATUS
Direction	To host
Valid in	Config State

	MTi-G								

Acknowledge of the ReqGPSStatus message. The DATA field contains the GPS Satellite Status information of the GPS receiver. The MTi-G requests this information from the GPS receiver at regular intervals. On request, the latest data is sent from cache.

GPSSTATUS

DATA (B)	Description
0	Number of channels in range
Repeat the following block for all channels	
1 + NCH*5	Channel number, range 0..NCH-1 (NCH = number of channels)
2 + NCH*5	Satellite ID
3 + NCH*5	Bitmask, made up of the following values 0x01 = SV is used for navigation 0x02 = Differential correction data is available for this SV 0x04 = Orbit information is available for this SV (ephemeris or Almanach) 0x08 = Orbit information is Ephemeris 0x10 = SV is unhealthy / shall not be used
4 = NCH*5	Signal Quality indicator (range 0..7) 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
5 + NCH*5	Carrier to Nose Ratio (Signal Strength)

The bitmask is used for the GPS status and colours in the GPS info graph:

Legend	Description	Bit value of bitmask
Found	SV is found, and orbit information may be available	0x0 or 0x2
Found + D	SV is found, differential correction data is available, orbit information may be available	0x2 or 0x6
Found + E	SV is found, orbit information is Ephemeris, Almanach may also be available	0x8 or 0xC
Found + D + E	SV is found, orbit information is Ephemeris, Almanach may also be available, differential correction data is available	0xA or 0xE
Used	SV is used in the navigation solution; orbit information may be available	0x1, 0x5, 0x9 or 0xD
Used + D	SV is used in the navigation solution; orbit information may be available, differential correction data is available	0x3, 0x7, 0xB or 0xF
Unused	The SV is not used	0x10

4.3.3 Device-specific messages

ReqBaudrate

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

MTi	MTi-G	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

MTi	MTi-G	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 manuals ([MTi_MTx] and [MTi-G]) 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

MTi	MTi-G	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

MTi	MTi-G	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

ReqLocationID

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

MTi	MTi-G	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

MTi	MTi-G	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

MTi	MTi-G	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 6.1.

ReqTransmitDelay

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

MTi	MTi-G	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

MTi	MTi-G	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)

StoreFilterState

MID	138 (0x8A)
DATA	N/A
Direction	To MT
Valid in	Config State

MTi	MTi-G	10	20	30	100	200	300	700	710

Stores the estimated biases of the physical sensors in the non-volatile data of the MT.

4.3.4 Synchronization messages

ReqSyncSettings

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

		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

		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]. 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.

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 10s / MTi 100s	MTi-G-700/710
In1	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
Bi1Out	Bidirectional line 1 configured as output (SyncOut) Bidirectional line is NOT recommended for input.	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

ReqSyncInSettings

MID 214 (0xD6)
DATA PARAM (1 byte)
Direction To MT
Valid in Config State

MTi									

Request one of the current SyncIn settings of the device, i.e. mode, skip factor or offset. The requested setting is specified by the PARAM value. See **SetSyncInSettings** for description of the data field of the received acknowledge.

PARAM
PARAM defines which of the SyncIn settings should be returned by the acknowledge message. See following table.

PARAM value	Setting
0 (0x00)	SyncIn mode
1 (0x01)	Skip factor
2 (0x02)	Offset

SetSyncInSettings

MID	214 (0xD6)
DATA	PARAM VALUE (1+N bytes)
Direction	To MT
Valid in	Config State

MTi									

Set a SyncIn setting defined by the PARAM field with the value specified with the VALUE field. Use SyncIn to synchronize the MT with external hardware.

PARAM
The PARAM value (1 byte) indicates which SyncIn setting will be set. The VALUE field, which can be either two or four bytes long, defines the new value of the setting. See table for the different PARAM values.

PARAM value	Setting
0 (0x00)	SyncIn mode
1 (0x01)	Skip factor
2 (0x02)	Offset

VALUE - SyncIn mode

PARAM	VALUE	Description
0		SyncIn mode (2 bytes)
	Bit 1-0	Trigger mode
		00 = SyncIn mode disabled (default)
		01 = Rising Edge
		10 = Falling Edge
		11 = Reserved
	Bit 3-2	Trigger type
		00 = ADC sampling (incl sending of MTData)
		01 = Sending of latest output data
	Bit 15-4	Reserved

VALUE – Skip factor
An unsigned 16 bit value that defines how many times the trigger should be skipped before actually trigger the device.

PARAM	VALUE	Description
1		Skip factor (2 bytes)
	Bit 15-0	Skip factor value

VALUE – Offset
By default, the time between a valid trigger and actual sampling of the internal sensors is 20±2us. An additional offset can be set to increase this time. The offset value is an unsigned 32 bit value that defines the number of clock ticks to delay the sampling. One clock tick is equal to 1 / 29.4912 MHz = 33.9ns.

PARAM	VALUE	Description
2		Offset (4 bytes)
	Bit 31-0	Offset value
		Valid value is 0, 264 (0x00000108) and higher

ReqSyncOutSettings

MID	216 (0xD8)
DATA	PARAM (1 byte)
Direction	To MTi (not Mk4)
Valid in	Config State

MTi	MTi-G								

Request one of the current SyncOut settings of the MTi, i.e. SyncOut mode, skip factor, offset or pulse width. The requested setting is specified by the PARAM value. See **SetSyncOutSettings** for description of the data field of the received acknowledge.

PARAM
PARAM defines which of the SyncOut settings should be returned by the acknowledge message. See following table.

PARAM value	Setting
0 (0x00)	SyncOut mode
1 (0x01)	Skip factor
2 (0x02)	Offset
3 (0x03)	Pulse width

SetSyncOutSettings

MID	216 (0xD8)
DATA	PARAM VALUE (1+N bytes)
Direction	To MTi
Valid in	Config State

MTi	MTi-G								

Set a SyncOut setting defined by the PARAM field with the value specified with the VALUE field. Use SyncOut to synchronize other external hardware with the MTi or MTi-G[1]. Only the standard version of the MTi/MTi-G has an output pin that can be connected to other hardware which can be synchronized with the MTi/MTi-G. See **MTi and MTx User Manual** ([MTi_MTx]) or MTi-G User Manual ([MTi-G]) for more information about the SyncOut pin.

PARAM

The PARAM value (1 byte) indicates which SyncOut setting will be set. The VALUE field, which can be either two or four bytes long, defines the new value of the setting. See table for the different PARAM values.

PARAM value	Setting
0 (0x00)	SyncOut mode
1 (0x01)	Skip factor
2 (0x02)	Offset
3 (0x03)	Pulse width

VALUE - SyncOut mode

Toggle mode toggles the SyncOut output from a low voltage (0.0V) to a high voltage (3.0-3.3V) and vice versa (i.e. a block signal is generated). Pulse mode provides a pulse from a low voltage (0.0V) to either a positive or negative voltage, according to the set polarity. The pulse width can also be adjusted (see below).

See the next table for the description of the SyncOut mode bits.

PARAM	VALUE	Description
0		SyncOut mode (2 bytes)
	Bit 3-0	
		0000 = SyncOut mode disabled (default)
		0001 = Toggle mode
		0010 = Pulse mode
	Bit 4	Polarity

[1] Please note that the MTx does not support the SyncOut settings

		0 = Negative pulse
		1 = Positive pulse
	Bit 15-5	Reserved

VALUE – Skip factor
An unsigned 16 bit value that defines how many times the internal sampling instance should be skipped before changing the SyncOut pin state. The internal trigger instance is based on the sampling period set by **`SetPeriod`**.

PARAM	VALUE	Description
1		Skip factor (2 bytes)
	Bit 15-0	Skip factor value

VALUE – Offset
An unsigned 32 bit value that defines the number of clock ticks to delay the SyncOut state-change after the internal sampling instance. One clock tick is equal to 1 / 29.4912 MHz = 33.9ns.

PARAM	VALUE	Description
2		Offset (4 bytes)
	Bit 31-0	Offset value
		Valid value is 0, 513 (0x00000201) and higher

VALUE – Pulse width
An unsigned 32 bit value that defines the pulse width when SyncOut mode is set to Pulse mode. The pulse width is specified in ticks and one tick is equal to 1 / 29.4912 MHz = 33.9ns.

PARAM	VALUE	Description
3		Pulse width (4 bytes)
	Bit 31-0	Pulse width value
		Valid value is 0, 1700 (0x000006A4) and higher

4.3.5 Configuration messages

ReqConfiguration

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

MTi	MTi-G	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

MTi	MTi-G	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

		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

		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 4.3.6.

Group Name	Type Name	XDA type name	Hex Value	Valid for MTi product								Max frequency[2]
				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	●	●	●	●	●	●	●	●	
	GPS Age (legacy)	XDI_GpsAge	1040									
	Pressure Age (legacy)	XDI_PressureAge	1050									
	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		●	●		●	●	●	●	
Trigger Indication		**XDI_IndicationGroup**	4800	**MTw only; for MTi, see StatusWord**								
	TriggerIn1	XDI_TriggerIn	4810	MTw only; for MTi, see StatusWord								
	TriggerIn1	XDI_TriggerIn2	4820	MTw only; for MTi, see StatusWord								
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)

[2] 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.

	Rate of Turn	XDI_RateOfTurn	802y	•	•	•	•	•	•	•	•	
	Delta Q	XDI_DeltaQ	803y	•	•	•	•	•	•	•	•	
GPS		**XDI_GpsGroup**	**88x0**							•		4 Hz
	DOP	XDI_GpsDop	8830							•		
	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	•	•	•	•	•	•	•	•	
Analog In		**XDI_AnalogInGroup**	**B0x0**									2000 Hz
	Analog In 1	XDI_AnalogIn1	B010									
	Analog In 2	XDI_AnalogIn2	B020									
Magnetic		**XDI_MagneticGroup**	**C0xy**	•	•	•	•	•	•	•	•	50 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	•	•	•	•	•	•	•	•	
	RSSI	XDI_Rssi	E040									

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			
	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 10-15	Reserved	Reserved for future string types

ReqPeriod

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

MTi	MTi-G	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

MTi	MTi-G	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_MTx] and [MTi-G]) for further details.

ReqOutputSkipFactor

MID	212 (0xD4)
DATA	n/a
Direction	To MT
Valid in	Config State

MTi	MTi-G								

Request how many times the data output is skipped before sending the data in the **MTData** message to host. For information about data field of received acknowledge see **SetOutputSkipFactor**.

SetOutputSkipfactor

MID	212 (0xD4)
DATA	SKIPFACTOR (2 bytes)
Direction	To MT
Valid in	Config State

MTi	MTi-G								

Set the output skip factor.

SKIPFACTOR
The skip factor is an unsigned 16 bit value and is by default zero. The value represents how many times the data output is skipped (running at the current sampling frequency) before the next **MTData** message is sent. I.e. at sample period of 5.0ms (200Hz) and a skip factor of 4, the measurement is running at 200Hz but the data is sent at a rate of 40Hz (not 50Hz). See also **SetPeriod** for more information about the relationship between the sampling period and output skip factor.

If SKIPFACTOR is set to 65535 (0xFFFF), no data will be sent to the host and **ReqData** can be use to request an **MTData** message at an arbitrary time. This works also if SyncIn mode is enabled.

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_MTx] and [MTi-G]) for further details.

SKIPFACTOR	Description
≠ 65535 (0xFFFF)	Skipfactor value
65535 (0xFFFF)	Do not send MTData automatically

ReqObjectAlignment

MID	224 (0xE0)
DATA	n/a
Direction	To MT
Valid in	Config State

MTi	MTi-G								

Request the internally stored object alignment matrix which is set by the **`ResetOrientation`** message or **`SetObjectAlignment`** message. For information about data field of received acknowledge see **`SetObjectAlignment`**.

SetObjectAlignment

MID	224 (0xE0)
DATA	MATRIX (9x4 bytes)
Direction	To MT
Valid in	Config State

MTi	MTi-G								

Set the object alignment matrix.

MATRIX
Is equal to the object alignment matrix which is a 3x3 matrix of which all elements are specified in floats in the order first row then column. See the section about arbitrary alignment in the **MTi and MTx User Manual** ([MTi_MTx]) or MTi-G User Manual ([MTi-G]) for more information and an example for setting the object alignment to a known orientation.

Correspondence between the data fields and the alignment matrix is shown below.

a	b	c	d	e	f	g	h	i

$$R_{OS} = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}$$

ReqAlignmentRotation

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

		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

		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

ReqOutputMode

MID	208 (0xD0)
DATA	n/a
Direction	To MT
Valid in	Config State

MTi	MTi-G	10	20	30	100	200	300	700	710

Request the current output mode. See **SetOutputMode** for information about data field of the received acknowledge. Note that although this message does work for the MTi 10-series and MTi 100-series, it is recommended to use **SetOutputConfiguration** instead.

SetOutputMode

MID	208 (0xD0)
DATA	MODE (2 bytes)
Direction	To MT
Valid in	Config State

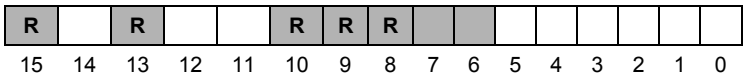
MTi	MTi-G	10	20	30	100	200	300	700	710

Sets the output mode of the MT. The settings here, combined with the **SetOutputSettings**, define the content of the DATA field in the **MTData** message. The

output mode can be set to various output modes of which most of them can be combined, like for example calibrated sensor data and orientation data. The un-calibrated RAW inertial data output however can not be used together with any of the other outputs, except GPS PVT data. The RAW inertial data and the GPS PVT data messages should often be used together. Note that although this message works for MTi 10-series and MTi 100-series, it is recommended to use `SetOutputConfiguration` instead.

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_MTx] and [MTi-G]) for further details.

MODE



MODE bits	Output mode
Bit 0	Temperature data
Bit 1	Calibrated data
Bit 2	Orientation data
Bit 3	Auxiliary data
Bit 4	Position data – MTi-G and 700/710 only
Bit 5	Velocity data – MTi-G and 700/710 only
Bit 11	Status data
Bit 12	GPS PVT data (Position, Velocity, Time and barometric pressure) – MTi-G and 700/710 only
Bit 14	RAW inertial data (16-bit ADC values) (Can only be combined with GPS PVT data)

ReqExtOutputMode

MID	134 (0x86)
DATA	MODE (2 bytes)
Direction	To MT
Valid in	Config State

		10	20	30	100	200	300	700	710

Request the current Extended Output Mode. See SetExtOutputMode for information about the data field of the received acknowledge message.

SetExtOutputMode

MID	134 (0x86)
DATA	MODE (2 bytes)
Direction	To MT
Valid in	Config State

		10	20	30	100	200	300	700	710

Sets the Extended Output Mode. This message can be used to set the hardware communication line to the alternative UART (see [MTi_10s_100s] for more information on this feature). [MTi_10s_100s]

Extended Output Mode	Description
Bit 3-1	Reserved
Bit 4	Alternative UART 0: Communication via serial connection and/or USB 1: Communication via alternative UART and/or USB
Bit 15-5	Reserved

ReqOutputSettings

MID 210 (0xD2)
DATA n/a
Direction To MT
Valid in Config State

MTi	MTi-G	10	20	30	100	200	300	700	710

Requests the current output settings. See **SetOutputSettings** for information about data field of received acknowledge. Note that although this message works for MTi 10-series and MTi 100-series, it is recommended to use **SetOutputConfiguration** instead.

SetOutputSettings

MID 210 (0xD2)
DATA SETTINGS (4 bytes)
Direction To MT
Valid in Config State

MTi	MTi-G	10	20	30	100	200	300	700	710

Sets the output settings of the MT. ***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 device manuals ([MTi_MTx] and [MTi-G]) for further details. Note that although this message works for MTi 10-series and MTi 100-series, it is recommended to use **SetOutputConfiguration** instead.

SETTINGS

	R	R	R	R	R	R	R	R	R	R	R	R						R	R				R							
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

SETTINGS bits	Settings
Bit 1-0	Timestamp output
	00 = No timestamp

	01 = Sample Counter
	10 = UTC Time
	11 = Sample Counter + UTC Time
Bit 3-2	Orientation Mode
	00 = Quaternion
	01 = Euler angles
	10 = Matrix
Bit 6-4	Calibration Mode
	Bit 4: 0 = Enable acceleration (xyz) output
	1 = Disable acceleration (xyz) output
	Bit 5: 0 = Enable rate of turn (xyz) output
	1 = Disable rate of turn (xyz) output
	Bit 6: 0 = Enable magnetometer (xyz) output
	1 = Disable magnetometer (xyz) output
Bit 7	Reserved
Bit 9-8	Output Format
	00 = Float output (default)
	01 = Fixed Point Signed 12.20 format
	10 = Fixed Point Signed 16.32 format (High precision mode, 6 bytes)
Bit 11-10	Auxiliary Mode
	Bit 10:
	Bit 11: 0 = Enable analog in #2 output
	1 = Disable analog in #2 output
Bit 13-12	Reserved
Bit 16-14	000 = LLA WGS84
Bit 18-17	00 = m/s XYZ
Bit 30-19	Reserved
Bit 31	0 = Use default co-ordinate system (X North, Z up)
	1 = Use X North, Z down “North East Down” (NED) convention for both LTP and MT body fixed coordinate system

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)

Output Format: Fixed point signed 12.20 format
This is a two’s complement fixed point format. It consists of 12 integer bits and 20 fractional bits.

There are several ways to convert a 12.20 format number to a double precision floating point number. The best way is to place the values into a 32-bit integer. The floating point value can then be computed by casting the value to double precision and dividing by 2^20.

Output Format: Fixed point signed 16.32 format (high precision)
This format consists of a signed 16-bit integer and an unsigned 32 bit integer. The short value is the integral part of the number, while the long value represents the fractional part. Concatenating the two values will effectively yield a 6-byte fixed point number with the radix point after the 16th bit, but note that the 32 fractional bits are sent before the 16 integer bits.

There are several ways to convert a 16.32 format number to a double precision floating point number. The best way is to place the values into a 64-bit integer, where the short value should be sign-extended (the highest bit should be copied into the upper 16 bits of the 64-bit integer), which can often be accomplished by casting to a long value. The floating point value can then be computed by casting the value to double precision and dividing by 2^32.

The high precision format is recommended to avoid quantization in position output (LLA) for the MTi-G when high precision is required for position.

4.3.6 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.

The MTi's factory settings (default settings) are in legacy MTData, see section 6.1.

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.

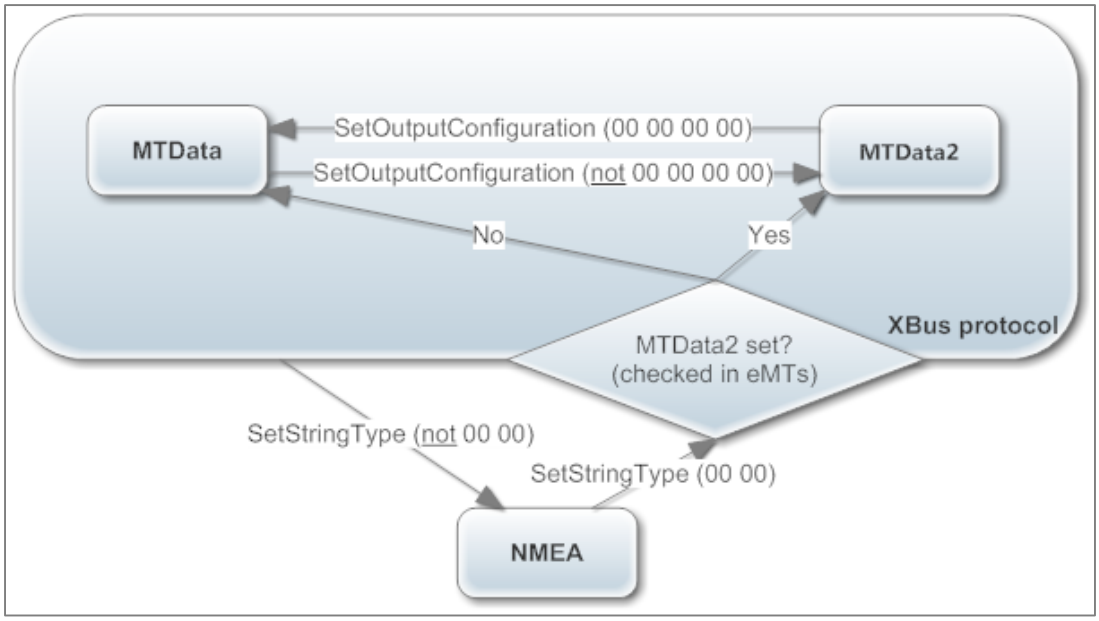


Figure 1: Flow chart for data format selection. Read the section above for more detailed explanation

ReqData

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

MTi	MTi-G	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. If however, the OutputSkipFactor is set to 65535 (0xFFFF) the the MT will not send the **MTData** or **MTData2** except if the user sends **ReqData**. For MkIV MTi's, use the synchronization settings (SetSyncSettings) to configure the MTi to send the latest data.

MTData

MID	50 (0x32)
DATA	DATA (length variable)
Direction	To host
Valid in	Measurement State

MTi	MTi-G	10	20	30	100	200	300	700	710

Note that although this message does work for the MTi 10-series and MTi 100-series, it is recommended to use **SetOutputConfiguration** and **MTData2** instead. Note that GPS PVT message is not supported for MTi 10-series and MTi 100-series.

This message contains the output data depending on the current OutputMode and OutputSettings. The data field can contain multiple data outputs but the order of outputs is always the same. The following order is used (disabled outputs must be omitted):

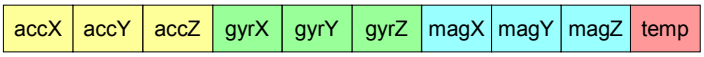
1. Temp
2. GPS PVT data
3. Calibrated data output
4. Orientation data output
5. Auxiliary data output
6. Position
7. Velocity
8. Status
9. Sample counter

RAW inertial data output cannot be used together with any of the other outputs, except GPS PVT data and AnalogIn (auxiliary data). The RAW inertial data and GPS PVT data should be used together. The following text explains the data values of each output.

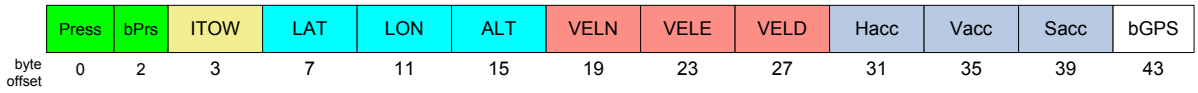
DATA
The data can contain multiple outputs. All the different outputs are described separately here. If not specified otherwise each data value is 4 bytes long and corresponds with the single-precision floating-point value as defined in the IEEE 754 standard (= float).

Un-calibrated RAW inertial data output mode (20 bytes)

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. The data values are NOT float values but 16 bit unsigned integer values.



GPS PVT data output mode (44 bytes)
When the MTi-G output mode is set to GPS PVT data, the following message structure will be output by the MTi-G. The data message contains pressure sensor and GPS data as described below. The description of each data field is given in the following table.



Description of MTi-G GPS PVT Sensor Data Message Structure

Name	Byte offset	Number format	Scaling	Unit	Purpose/Comment
Press	0	U2	2	Pa	Pressure value in Pascals.
bPrs	2	U1	-	-	Pressure sensor status. When the value decreases, new pressure data is available.
ITOW	3	U4	-	Ms	GPS Millisecond Time of Week
LAT	7	I4	$1e^{-7}$	Deg	Latitude
LON	11	I4	$1e^{-7}$	Deg	Longitude
ALT	15	I4	-	Mm	Altitude/Height above Ellipsoid
VEL_N	19	I4	-	cm/s	NED north velocity
VEL_E	23	I4	-	cm/s	NED east velocity
VEL_D	27	I4	-	cm/s	NED down velocity
Hacc	31	U4	-	Mm	Horizontal Accuracy Estimate. Expected error standard deviation.
Vacc	35	U4	-	Mm	Vertical Accuracy Estimate. Expected error standard deviation.
Sacc	39	U4	-	cm/s	Speed Accuracy Estimate. Expected error standard deviation.
bGPS	43	U1	-	-	GPS status byte or GPS data age. When the value decreases, new GPS data is available. The value is reset to zero upon receipt of GPS 1PPS pulse. The “data age” of GPS data can be calculated based on elapsed number of samples since the last 1PPS pulse.

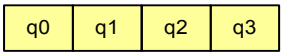
U1: Unsigned Char.
U2: Unsigned 16-bit integer
U4: Unsigned 32-bit integer
I2: Two’s complement 16-bit integer
I4: Two’s complement 32-bit integer

Temperature data output mode (4 bytes)

Contains the internal temperature of the sensor in degrees Celsius (float value).

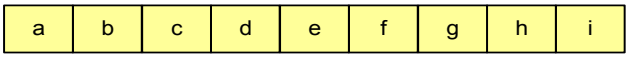
Calibrated data output mode (36 bytes)
Contains the calibrated data output of the accelerations, rate of turn and magnetic field in X, Y and Z axes in floats.

Orientation data output mode – quaternion (16 bytes)
Contains the q0, q1, q2 and q3 quaternions, in floats, that represent the orientation of the MT.

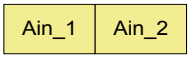


Orientation data output mode – Euler angles (12 bytes)
Contains the three Euler angles, in floats, that represent the orientation of the MT

Orientation data output mode – Matrix (36 bytes)
Contains the rotation matrix (DCM), in floats, that represents the orientation of the MT. See **MTi and MTx User Manual** ([MTi_MTx]) or MTi-G User Manual ([MTi-G]) for the interpretation of the data values.



Auxiliary data output mode (4 bytes)
Auxiliary data consists of both analogIN 1 and 2 data. This is the sampled value of the analog input #1 and #2. The data format is two 16 bit unsigned integer value and NOT a float value.

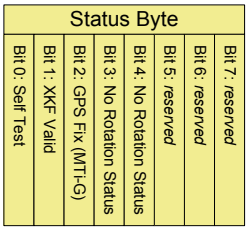


Position data output mode – LLA (12 bytes)
Contains the latitude, longitude and altitude, in floats, that represent the position of the MTi-G.

Velocity data output mode – VelXYZ (12 bytes)
Contains the velocity X, Y and Z, in, that represent the velocity of the MTi-G. Note that velocity in North East Down can be obtained by changing bit 31 in the **`SetOutputSettings`** DATA field.

Status (1 byte)

This byte contains flags that represent the status and estimated validity of the output of the MT. The currently defined flags are summarized below. A flag is set to 1 when the relevant condition is true.



Self Test: This flag indicates if the MT passed the latest self test (**`RunSelftest`**).
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
GPS Fix: This flag indicates if the GPS unit has a proper fix. The flag is only available in MTi-G units.
NoRotation 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: Error: Rotation detected, procedure not started (sticky)
01: Estimation complete, some samples rejected (sticky)
00: Estimation complete, no errors

Sample counter (2 bytes)
The (optional) sample counter is a 16 bit unsigned integer value that is increased for each transmission of the **`MTData`** message. If its maximum value is reached, i.e. 65535 (0xFFFF), it will wrap and start at zero again. See also **`SetErrorMode`** for the relation between the sample counter and the error mode.

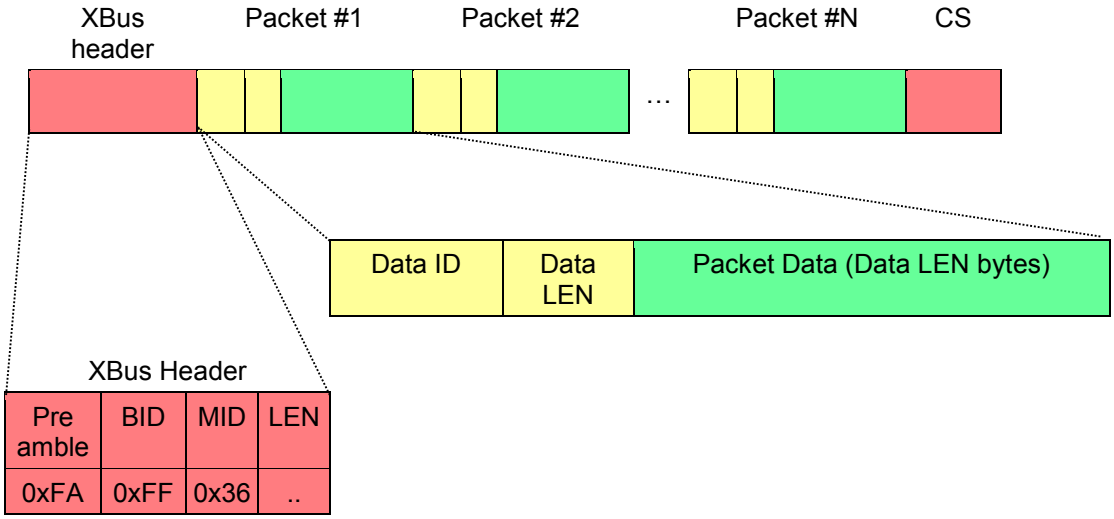
UTC Time (12 bytes)
Besides the sample counter, it is also possible to let the data be time stamped by UTC time. This data package is identical to the result of **`ReqUTCTime`**.

MTData2

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

		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:



The XBus header is explained in section 4.1. 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 4.3.5.

In the following, format descriptions for data values are defined as *[name : type]*. In cases where the type is $\mathbb{R}$ the data value is a real number and its format is defined by the *precision*

field of the data identifier (see Section 4.3.5). 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_RateOfTurn
Contains the calibrated rate of turn vector in x, y, and z axes

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: Error: Rotation detected, procedure not started (sticky) 01: Estimation complete, some samples rejected (sticky) 00: Estimation complete, no errors
5	Timestamp GNSS synced	
6	Timestamp clock synced	
7	On/Off	
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_Rssi
Contains the *received signal strength indicator (RSSI)* for data received over a wireless link

RSSI : I1

XDI_FrameRange
This packet applies only to recordings of an MTw device using XDA 4.0 and up, and contains the length of an SDI interval expressed in frames.

startFrame : U2	endFrame : U2

XDI_GpsAge
This packet applies only to recordings of a legacy MTi-G device using XDA 4.0 and up. It contains the GPS data age. When the value decreases, new GPS data is available. The value is reset to zero upon receipt of GPS 1PPS pulse. The “data age” of GPS data can be calculated based on elapsed number of samples since the last 1PPS pulse.

gpsAge : U1

XDI_PressureAge
This packet applies only to recordings of a legacy MTi-G device using XDA 4.0 and up. It contains the pressure sensor status or pressure age. When the value decreases, new pressure data is available.

pressureAge : U1

XDI_AnalogIn1
This packet contains the raw ADC result of measuring the first analog input (if connection available)

analogIn1 : U2

XDI_AnalogIn2
This packet contains the raw ADC result of measuring the second analog input (if connection available)

analogIn2 : U2

XDI_TriggerIn / XDI_TriggerIn2
Contains TriggerIndication of MTw (TriggerIndication of MTi is in Status Word)

Line number : U1	Polarity : U1	Time stamp: U4	Frame number: U2

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.ll,a,yyyyy.yy,a,x,xx,x.x,x.x,M,x.x,M,x.x,xxxx*hh hhmmss.ss → UTC time llll.ll → Latitude a → North or South yyyyy.yy → 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 SBAS station xxxx → SBAS station reference ID# *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
Reserved	Reserved for future string types

4.3.7 Filter messages

ReqHeading

MID	130 (0x82)
DATA	n/a
Direction	To MT
Valid in	Config State

MTi									

Request the current heading setting - see **SetHeading** for information about data field of received acknowledge.

SetHeading

MID	130 (0x82)
DATA	HEADING (4 bytes)
Direction	To MT
Valid in	Config State

MTi									

Sets the heading with the value specified in data field.

HEADING
HEADING is a single-precision floating-point number (4 bytes). The valid range is specified as [-π, +π]. Default value is zero.

ReqMagneticDeclination

MID	106 (0x6A)
DATA	n/a
Direction	To MT
Valid in	Config State

	MTi-G								

Request the current magnetic declination setting - see **SetMagneticDeclination** for information about data field of received acknowledge.

Magnetic declination is valid for MTi-G only. Note that Magnetic Declination in the MTi 10-series and MTi 100-series is calculated on board entering the last known position in the World Magnetic Model (this last known position can also be manually entered). In the MTi-G-700 GPS/INS and MTi-G-710 GNSS/INS last known position is updated using GNSS position.

SetMagneticDeclination

MID	106 (0x6A)
DATA	MAGNETICDECLINATION (4 bytes)
Direction	To MT
Valid in	Config State

	MTi-G								

Sets the magnetic declination with the value specified in data field.

MAGNETICDECLINATION
MAGNETICDECLINATION is a single-precision floating-point number (4 bytes). The valid range is specified as [-π, +π]. Default value is zero.

Magnetic declination is valid for MTi-G only. Note that Magnetic Declination in the MTi 10-series and MTi 100-series is calculated on board entering the last known position in the World Magnetic Model (this last known position can also be manually entered). In the MTi-G-700 GPS/INS and MTi-G-710 GNSS/INS last known position is updated using GNSS position.

ReqLatLonAlt

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

		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

		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

		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

		10	20	30	100	200	300	700	710

ReqAvailableScenarios

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

MTi	MTi-G	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.

AvailableScenarios

Contains information about available setting profiles (previously known as filter scenarios) 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 scenarios are available, the remaining scenarios are of type 0.

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

ReqCurrentScenario

Direction	To MT
MID	100 (0x64)

MTi	MTi-G	10	20	30	100	200	300	700	710

Requests the ID of the currently used setting profile or scenario.

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

SetCurrentScenario

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

MTi	MTi-G	10	20	30	100	200	300	700	710

Sets the setting profile or scenario to use. For more information about the various setting profiles and scenarios please refer to the filter profile sections in the device specific manuals ([MTi_MTx], [MTi-G] and [[MTi_10s_100s]).

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

SCENARIO	Hardware Type	Description
1	MTi-G	General
2	MTi-G	Automotive
3	MTi-G	Aerospace
4	MTi-MTx	Human
5	MTi-MTx	Human_large_accelerations
6	MTi-MTx	Machine
7	MTi-MTx	Machine_nomagfield
8	MTi-MTx	Marine
9	MTi-G	General_nobaro
10	MTi-G	Aerospace_nobaro
11	MTi-G	Automotive_nobaro
17	MTi-G	Marine
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
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	AutoUrbanCanyon

ReqCurrentScenarioAck

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

MTi	MTi-G	10	20	30	100	200	300	700	710

Contains the currently used setting profile or scenario.

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

DATA (B)	Description
VERSION (0)	Scenario version
SCENARIO (1)	Scenario type

ReqGravityMagnitude

Direction To MT
MID 102 (0x66)

MTi	MTi-G								

Requests the magnitude of the gravity that is used in the sensor fusion algorithm - see **SetGravityMagnitude** for information about data field of received acknowledge.

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

SetGravityMagnitude

Direction To MT
MID 102 (0x66)
DATA GRAVITY (float)

MTi	MTi-G	10	20	30	100	200	300	700	710

Sets the magnitude of the gravity that is used in the sensor fusion algorithm.

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

ReqProcessingFlags

Direction To MT
MID 32 (0x20)

MTi	MTi-G	10	20	30	100	200	300	700	710

Requests the processing flags that are used in the sensor fusion algorithm - see **SetProcessingFlags** for information about data field of received acknowledge.

NOTE: For MTi and MTi-G this is not supported in firmware version 2.2 and lower.

SetProcessingFlags

Direction To MT
MID 32 (0x20)
DATA PROCESSING FLAGS

MTi	MTi-G	10	20	30	100	200	300	700	710

Sets the processing flags that are used in the sensor fusion algorithm.

PROCESSING FLAGS bits	Processing Flag
Bit 0	Initialization Gyroscope Bias Estimation On/Off: Automatic 'No Rotation' assumption after filter reset and/or power on) to quickly estimate rate gyroscope bias. Refer to section 3.3 in User Manual. DEFAULT = off
Bit 1	Fixed Gravity On/Off: The filter can either calculate the local gravity from the GNSS LatLonAlt or use a fixed gravity set by the SetGravityMagnitude message DEFAULT = off

ReqLeverArmGps

Direction To MT
MID 104 (0x68)

	MTi-G								

Requests the lever arm of the GPS antenna with respect to the MTi-G in SENSOR coordinates.

SetLeverArmGps

Direction To MT
MID 104 (0x68)
DATA ARM (3x float)

	MTi-G								

Sets the lever arm of the GPS antenna with respect to the MTi-G in SENSOR coordinates.

ReqLeverArmGpsAck

Direction To host
MID 105 (0x69)
DATA ARM (3x float)

	MTi-G								

DATA Contains the lever arm of the GPS antenna with respect to the MTi-G in SENSOR coordinates.

ResetOrientation

MID 164 (0xA4)

DATA	CODE (2 bytes)
Direction	To MT
Valid in	Config State and Measurement State

MTi	MTi-G	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_MTx]), ([MTi-G] 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

MTi		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_MTx] and [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).

With the `SetProcessingFlags` message, an initial gyroscope bias estimation upon start-up of the MTi can be activated. Refer to the description of the `SetProcessingFlags` message for details.

DATA

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

ReqUTCTime

Direction	To MT
MID	96 (0x60)

	MTi-G	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)

	MTi-G	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)

	MTi-G	10	20	30	100	200	300	700	710

Contains UTC Time

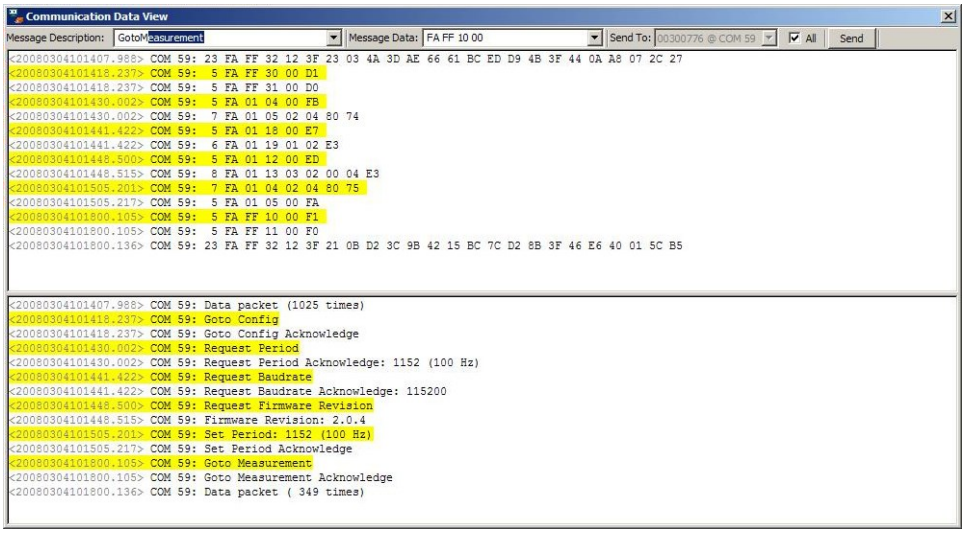
DATA (B)	Description
0	Nanoseconds of second, range 0 .. 1.000.000.000
4	Year, range 1999 .. 2099
6	Month, range 1..12
7	Day of Month, range 1..31
8	Hour of Day, range 0..23
9	Minute of Hour, range 0..59
10	Seconds of Minute, range 0..59
11	0x01 = Valid Time of Week 0x02 = Valid Week Number 0x04 = Valid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

5 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. Note that in MT Manager, this functionality is not available in release version 4.0.



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**

The following is legacy communication with **SetOutputMode** and **SetOutputSettings**. In upcoming versions of this document, this example will be updated to use **SetOutputConfiguration**.

Set the Output mode to calibration + orientation data:

TX: **FA FF D0 02 00 06 29**

The MT acknowledges with
RX: **FA FF D1 00 30**

Set the Output setting to matrix orientation output + sample counter:

TX: **FA FF D2 04 00 00 00 09 22**

The MT acknowledges with
RX: **FA FF D3 00 2E**

Goto measurement state to start logging data:

TX: **FA FF 10 00 F1**

The MT acknowledges with
RX: **FA FF 11 00 F0**

Start logging data:

The MT sends the **MTData** message which has the following format:
RX: **FA FF 32 4A AccData GyrData MagData MatrixData SC CS**

The **AccData, GyrData, MagData** fields contain 3x 4 bytes that are single-precision float values for the X,Y and Z-axis. **SC** stands for sample counter and is a 2 byte unsigned value and **CS** is the checksum.

6 Miscellaneous

6.1 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 setting of MTi 10-series and MTi 100-series has the same default setting as legacy MTi devices in order to be drop in replaceable when default settings are used.

The default settings and the messages to change the specific setting are listed in the following table.

Property	Default value	Message
Output mode	Orientation output	**SetOutputMode**
Output settings	Orientation in quaternion mode Sample counter	**SetOutputSettings**
Setting Profile	General	**SetCurrentScenario**
Sample frequency	100 Hz	**SetPeriod**
Baud rate	115k2 bps	**SetBaudrate**
Output skip factor	0	**SetOutputSkipfactor**
SyncIn	Disabled	**SetSyncInSettings**
SyncOut	Disabled	**SetSyncOutSettings**
Error mode	1	**SetErrorMode**

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

6.2 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 mode	Orientation output
Output settings	Orientation in quaternion mode; Sample counter
Sample frequency	100 Hz
Baud rate	115k2 bps
Output skip factor	0
SyncIn	Disabled
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 (the number of stop bits is different from the default settings).
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.

6.2.1 Default communication settings

Setting	Default Value
Bits/second (bps):	115200
Data bits:	8
Parity:	none
Stop bits:	2
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 1.

7 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 4.

WakeUp and State messages (Section 4.3.1)

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 4.3.2)

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
InitMT	2 (0x02)	To MT	Request device ID of the device (for compatibility of Xbus Master users)
InitMTResults	3 (0x03)	To host	Same as DeviceID message
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
ReqDataLength	10 (0x0A)	To MT	Request the number of data bytes in MTData message
DataLength	11 (0x0B)	To host	Contains the number of data bytes of the MTData message
Error	66 (0x42)	To host	Error message
ReqGPSStatus	166 (0xA6)	To MT	Request GPS Status
GPSStatus	167 (0xA7)	To host	Device returns GPS Status

Device-specific messages (Section 4.3.3)

Message	MID	Direction	Description
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
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
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
Message	MID	Direction	Description
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
ReqErrorMode	218 (0xDA)	To MT	Request error mode
ReqErrorModeAck	219 (0xDB)	To host	Device returns error mode

Synchronization messages (Section 4.3.4)

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
ReqSyncInSettings	214 (0xD6)	To MT	Request a SyncIn setting of the device, i.e. SyncIn mode, skip factor or offset
ReqSyncInSettingsAck	215 (0xD7)	To host	Device returns SyncIn setting

SetSyncInSettings	214 (0xD6)	To MT	Host sets a SyncIn setting
SetSyncInSettingsAck	215 (0xD7)	To host	Device acknowledges SetSyncInSettings message
ReqSyncOutSettings	216 (0xD8)	To MTi	Request a SyncOut setting of the device, i.e. SyncOut mode, skip factor, offset or pulse width
ReqSyncOutSettingsAck	217 (0xD9)	To host	Device returns SyncOut setting
SetSyncOutSettings	216 (0xD8)	To MTi	Host sets a SyncOut setting
SetSyncOutSettingsAck	217 (0xD9)	To host	Device acknowledges SetSyncOutSettings message

Configuration messages (Section 4.3.5)

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
ReqOutputConfiguration	192 (0xC0)	To MT	Request the current output configuration
ReqOutoutConfigurrationAck	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
ReqOutputSkipFactor	212 (0xD4)	To MT	Request how many times the data output is skipped before sending a MTData message
ReqOutputSkipFactorAck	213 (0xD5)	To host	Device returns OutputSkipFactor
SetOutputSkipFactor	212 (0xD4)	To MT	Host sets OutputSkipFactor
SetOutputSkipFactorAck	213 (0xD5)	To host	Device acknowledges SetOutputSkipfactor message

ReqObjectAlignment	224 (0xE0)	To MT	Request object alignment matrix
ReqObjectAlignmentAck	225 (0xE1)	To host	Device returns object alignment matrix
SetObjectAlignment	224 (0xE0)	To MT	To set the object alignment matrix
SetObjectAlignmentAck	225 (0xE1)	To host	Device acknowledges SetObjectAlignment message
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
ReqOutputModeAck	209 (0xD1)	To host	Device returns output mode
SetOutputMode	208 (0xD0)	To MT	Host sets output mode
SetOutputModeAck	209 (0xD1)	To host	Device acknowledges SetOutputMode message
ReqOutputSettings	210 (0xD2)	To MT	Request current output settings
ReqOutputSettingsAck	211 (0xD3)	To host	Device returns output settings
SetOutputSettings	210 (0xD2)	To MT	Host sets output settings
SetOutputSettingsAck	211 (0xD3)	To host	Device acknowledges SetOutputSettings message

Data-related messages (Section 4.3.6)

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 0)

Message	MID	Direction	Description
ReqHeading	130 (0x82)	To MT	Request heading settings
ReqHeadingAck	131 (0x83)	To host	Device returns heading
SetHeading	130 (0x82)	To MT	Host sets output mode
SetHeadingAck	131 (0x83)	To host	Device acknowledges SetHeading

			message
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
ReqAvailableScenarios	98 (0x62)	To MT	Request available scenarios
AvailableScenarios	99 (0x63)	To host	Device return available scenarios
ReqCurrentScenario	100 (0x64)	To MT	Request current used scenario
ReqCurrentScenarioAck	101 (0x65)	To host	Device return current scenario
SetCurrentScenario	100 (0x64)	To MT	Host set current scenario
SetCurrentScenarioAck	101 (0x65)	To host	Device acknowledges SetCurrentScenario
ReqGravityMagnitude	102 (0x66)	To MT	Request current used gravity magnitude
ReqGravityMagnitudeAck	103 (0x67)	To host	Device returns current gravity magnitude
SetGravityMagnitude	102 (0x66)	To MT	Host set gravity magnitude
SetGravityMagnitudeAck	103 (0x67)	To host	Device acknowledges SetGravityMagnitude
ReqleverArmGPS	104 (0x68)	To MT	Request current used lever arm GPS
ReqleverArmGPSAck	105 (0x69)	To host	Device returns current lever arm GPS
SetleverArmGPS	104 (0x68)	To MT	Host set current lever arm GPS
SetleverArmGPSAck	105 (0x69)	To host	Device acknowledges SetLeverArmGPS
ReqMagneticDeclination	106 (0x6A)	To MT	Request current used magnetic declination
ReqMagneticDeclinationAck	107 (0x6B)	To host	Device returns current magnetic declination
SetMagneticDeclination	106 (0x6A)	To MT	Host set current magnetic declination
SetMagneticDeclinationAck	107 (0x6B)	To host	Device acknowledges SetMagnetic Declination
ReqProcessingFlags	32 (0x20)	To MT	Request filter processing flags
ReqProcessingFlagsAck	33 (0x21)	To host	Device returns processing flags
SetProcessingFlags	32 (0x20)	To MT	Host sets processing flags
SetProcessingFlagsAck	33 (0x21)	To host	Device acknowledges SetProcessing Flags
SetNoRotation	34 (0x22)	To MT	Initiates ‘no rotation’ update procedure
SetNoRotationAck	35 (0x23)	To host	Device acknowledges SetNoRotation message