XM-B User Manual

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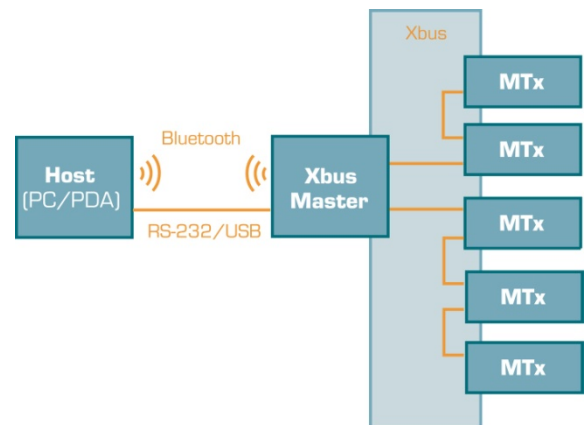
Revisions

Revision	Date	By	Changes
1.0	November 20, 2002	SSM	First release.
1.3	September 23, 2003	SSM	Update for XM-B version.
A	January 11, 2006	PSL	XM-B-XB2 changes included
B	February 7, 2006	RGI	Update pictures Updated XM settings in MT Software
C	March 2, 2006	SSM	Updated Xbus Master Settings dialog
D	February 7, 2007	SSM	Updates for XM-B-XB3 throughout whole document
E	October 18, 2007	MTI	Update additional WR-A
F	April 1, 2008	MMI	Update for latest MT Manager Added section on NiMH batteries
G	October 31, 2008	KVE MMI	Sync scenarios added Pictures updated Added FCC DoC and CE DoC for the USB converter
H	May 27, 2009	MHA	Pin definitions edited Added note on AnalogIn synchronization New corporate design
I	Oct 15, 2010	MHA	Minor editorial changes

Table of Contents

1 Introduction

The Xbus Master interconnects multiple MTx Motion Trackers (Xbus version) with an Xbus cable. It delivers power to the connected Motion Trackers and retrieves their data while they are sampled *exact synchronously*.

The collected data is transmitted by a (USB) serial cable or wireless Bluetooth link to PC/laptop/PDA.

The Xbus system is fully compatible with all Xsens software and software development tools.

The Xbus Master features:
- Multiple MTx Motion Trackers on two Xbus strings
- Synchronous sampling of multiple MTx's at adjustable sample frequencies up to 512 Hz.
- Compatible with PC via the XM USB-RS232 Cable or wireless Bluetooth link
  - Using Bluetooth connection can also easily be made to e.g. a PDA
- External synchronization with other devices possible
- Runs on batteries or external power supply
- Battery low detection
- Supplies power to Motion Trackers
- Ergonomic design with strap

The Xbus Master package contains the following items:
- Xbus Master
- Black strap/belt
- Four rechargeable batteries (AA style)
- Power adaptor
- XM USB-RS232 Cable data and power cable
- CD with MT SDK compatible with the Xbus Master

The Xbus Kit also contains:
- 5 Motion Trackers (MTx)
- 5 Xbus cables (1m)
- Wireless Receiver (WR-A)

The Xbus Master can only be used with Xbus compatible MTx's (MTx-**49**A##G##.).

NOTE: Do NOT connect the standalone RS-232/422/485 Motion Trackers to the Xbus Master.

The Xbus version of the Motion Tracker can be recognized by the two connectors at one side and by the product code which should have the following formatting: MTx-**49**A##G##. These Motion Trackers are shipped with an Xbus cable (1m) to be connected to the Xbus Master.

Together with a set of Motion Trackers, the Xbus Master enables ambulatory motion capturing of for example the human body. The system measures 3D angles, accelerations, angular velocity (rotation rate) of the body segments, of which real-time 3D body movements can be reconstructed.

2   Hardware overview

Xbus connectors

Belt eyelet

Battery compartment

Status LED

Push button

Sync connector[1]

Host connector

External power connector
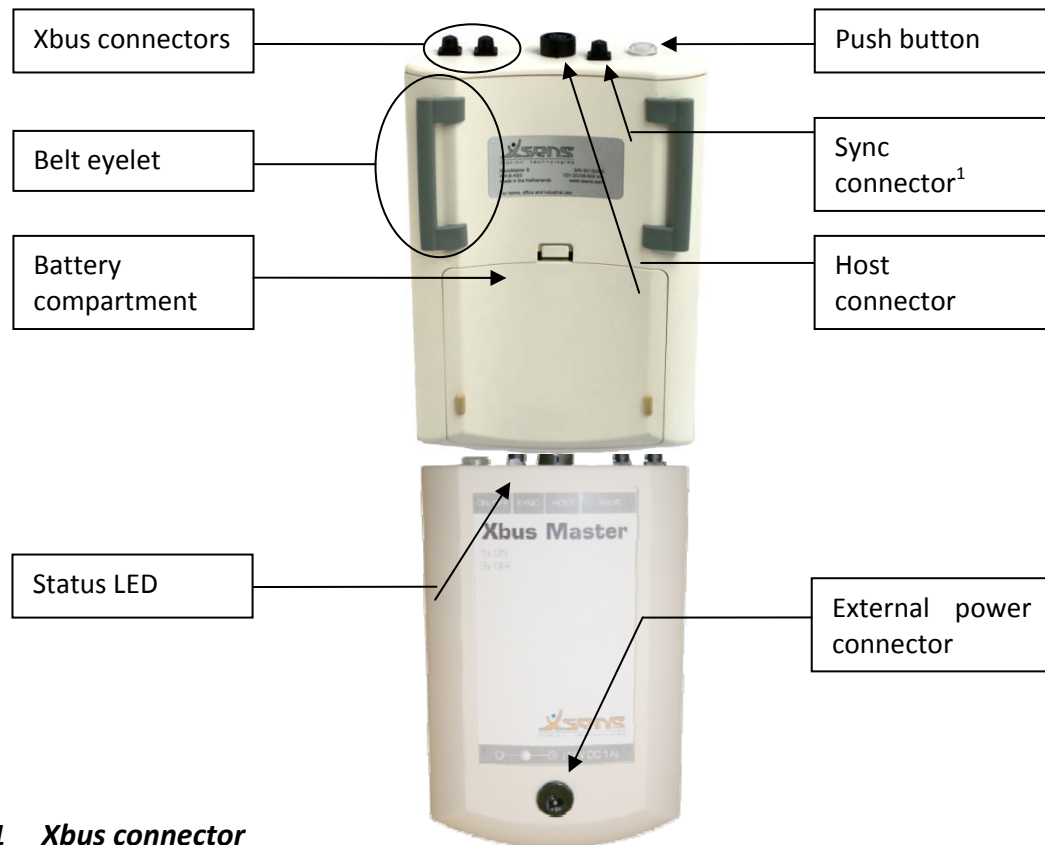
2.1   Xbus connector

The Xbus connector connects a string or chain of Motion Trackers with the Xbus Master. One or two Xbus connectors can be used to connect up to two strings of Motion Trackers to the Xbus Master. There is no difference between the two connectors and either one or both can be used. This connector supplies power to the Motion Trackers and interconnects the data transmission lines.

NOTE: Never connect more than 5 MTx on one Xbus connector!

2.2   Belt eyelet

The eyelets can be used to attach the Xbus Master to the belt supplied with the Xbus Master so it can be fasten around the waist.

2.3   Battery compartment

The battery compartment holds four AA type batteries used for Xbus power. You can either use rechargeable or non-rechargeable batteries. To open the compartment, pull the tab at the top of the compartment down and pull away from the housing.

NOTE: Xsens recommends the use of PowerEx NiMH rechargeables batteries 1.2 V AA NiMH 2700 mAh (or more) for a cost-efficient and prolonged operating time solution.

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[1] Sync connector is available since the introduction of Xbus Master with product code XM-B-XB3

2.4   Push Button

This push button controls the power state of the Xbus Master and it is also used to switch between Bluetooth and serial communication and to restore the factory defaults.

To power on the Xbus Master   →   press button **once**
                                                                    a beep sounds
To power off the Xbus Master   →   press button **three times**
                                                                    three beeps sound

To change the communication mode or restore the factory defaults first power down the Xbus Master and then perform one of the following actions.

Enable Bluetooth communication   →   **press and hold** button and release when the LED turns blue
Enable serial communication   →   **press and hold** button and release when the LED turns green
                                                                    for the second time
To restore factory defaults[2]   →   **press and hold** button for more than five seconds

2.5   Status LED

The Xbus Master visualizes its status using the status LED. It shows the current state (config or measurement state) and the current mode (Bluetooth, serial, low battery, etc). The current state is visualized using a specific flash sequence of the LED. The following table shows which flash sequence correspond to which Xbus Master state.

LED flash sequence	Xbus Master current state
Off	Power down
Solid	Config state
Two short flashes	Measurement state – waiting for trigger[3]
One flash	Measurement state – sending data

The status LED also visualizes the current mode of the Xbus Master using a specific color. The different Xbus Master modes and their corresponding color are listed in the next table.

LED color	Xbus Master active mode
Off	Power down
🟢 Green	Serial mode
🔵 Blue	Bluetooth mode
🟣 Purple	Bluetooth mode – host not found
🟡 Yellow	Low battery mode
🔴 Red	Fault mode

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[2] For explanation of factory defaults see chapter 5
[3] See section about synchronization section in chapter 6.7.

2.6   Host connector

This connector connects the Xbus Master with the supplied XM USB-RS232 Cable to a host (computer/laptop/PDA/handheld) using the standard USB communication port. Please, note that sometimes a connection through a USB hub can cause problems, try to connect directly to USB port on the PC.

Take care while fastening the connector to the Xbus Master. Before you insert the cable use the three white dots on the cable and on the Xbus Master for alignment. Twist to lock the connector.

2.7   External power connector

Use this connector to connect the power adapter for usage without batteries. The Xbus Master will use either the batteries or the external power depending on which power source has the highest voltage. It will switch instantaneous between the two power sources without short-circuiting the sources. If external power is applied it will not charge the batteries.

The specification of the power adapter is 12V DC 1A.

2.8   Sync connector

This connector can be used for synchronization with other devices or another Xbus Master. See section 6.7 for more information about synchronization and the use of this connector.

3 Using the Xbus Master

3.1 General setup

1. Insert supplied AA type batteries (4x rechargeable type NiMH) in the battery compartment. The drawings in the battery compartment show the polarity of the batteries.

   Or, connect the power adapter with mains and the external power connector of the Xbus Master. The batteries may still be inside but they will not be used to power the Xbus Master while the external power is supplied.

2. Make sure the Xbus Master is powered off. The LED must be off. If not, press the power button three times shortly.

3. If applicable, feed the belt through the belt eyelets and fasten the belt around the waist.

4. Fasten up to ten Motion Trackers (Xbus version) to the object to be measured and interconnect them with the supplied Xbus cables and connect at least one directly to the Xbus connector of Xbus Master to create a chain. These are two possible configurations for five Motion Trackers:

NOTE: Do not connect more than 5x Motion Trackers on a single chain.

3.2 Setup for serial cable connection

The following section describes how to setup the Xbus Master using the XM USB-RS232 Cable. If you prefer to setup the Xbus Master using Bluetooth, skip the following section.

1. Make sure you have correctly setup the Xbus Master (see General setup section)

2. Make sure the Xbus Master is configured in serial mode. To change the interface mode use the push button (see section 2.4) or the MT Manager (in the Device List, select the "Device Information" and then press the button on the right hand side to open the Xbus Master settings).

3. Use the XM USB-RS232 Cable to connect the Xbus Master (using the host connector) with a USB communication port of a PC or laptop. The next two pictures clarify how to connect the cable to the Xbus Master (align the three white dots and twist).

Make sure that all connectors are fastened to prevent data loss.

4. Connect one or more Motion Trackers to the Xbus Master if not done already

5. Turn the Xbus Master on by pressing the power button once. The green LED will light up. After a short time the LED will start flashing two short times or one time. This indicates that Motion Trackers are found and initialized and the Xbus Master is ready for measurement (see also the Status LED section in Chapter 2).

Please continue with section Using MT Manager.

3.3 Configure Bluetooth connection

To connect the Xbus Master for the first time with the host using Bluetooth, a special configuration procedure has to be followed.

By default the Xbus Master is configured for serial communication. Use the push button to switch to Bluetooth mode (power off, press and hold button until the LED turns blue). It is also possible to change the communication mode using the MT Manager (in the Device List, select the "Device Information" and then press the button on the right hand side to open the Xbus Master settings).

The Xbus Master is now configured for Bluetooth communication. Turn off the Xbus Master by pressing the push button three times shortly.

In Bluetooth mode, the Xbus Master will try to connect to a specific Bluetooth device (= host) when it is turned on. But first, it has to "learn" (also known as "pairing") which device to connect to. This is not necessary for your Xbus Master and wireless receiver, these are already paired with each other.

3.3.1 Setup for wireless receiver (WR-A)

1. Disable Bluetooth devices on your computer.

2. Connect the WR-A with the cable to a free PC USB port (USB 1.1 or higher).

3. After connecting the wireless receiver to your computer, you will see a notification 'Found New Hardware' in your System Tray Toolbar and the drivers will automatically be installed. Xsens drivers are WHQL certified and will be installed automatically.

4. Make sure that the Xbus Master operates in Bluetooth mode. See steps above or section 2.4.

5. Turn the Xbus Master on – the Xbus Master will connect to the wireless receiver. While searching for the Bluetooth host the LED will switch between purple and blue. Once it is connected the status LED will be blue only and start flashing (section 2.5). For trouble-shooting see chapter 7.

6. Also the WR-A uses LED colors to visualize its current mode. The different WR-A modes and their corresponding color are listed in the next table.

LED color	Wireless Receiver active mode
Off	Power down
🟢 Green	Powered – Searching
🔵 Blue	Connected
🔵 / ⚪ Blue flashing	Receiving data

3.3.2 Setup for other Bluetooth devices

1. Disable Bluetooth devices on your computer.

2. Install the latest driver software of your Bluetooth device on your PC/laptop (refer to Quick Setup sheet)

3. Turn Xbus Master on. The status LED should turn to blue and toggle between blue and purple. This means that Xbus Master is in Bluetooth mode and it will try to connect to the last used Bluetooth device (which can not be found).

4. Wait until the status LED will turn solid purple to indicate that the remote Bluetooth device could not be found.

5. At the host PC, start a Bluetooth search with your Bluetooth device from "My Bluetooth Places" that can be found on the desktop. The Xbus Master should appear. If not, search again for devices in range and minimize the distance between the host Bluetooth unit and the Xbus Master. If no Xbus Master can be found see the FAQ in chapter 7.

6. Connect your Bluetooth device with the Xbus Master using the **Serial Port Profile (SPP)** or Serial Port Service. See screenshot below.
   a. If the Bluetooth software asks for a PIN or PASSKEY of the Xbus Master enter **0000**.
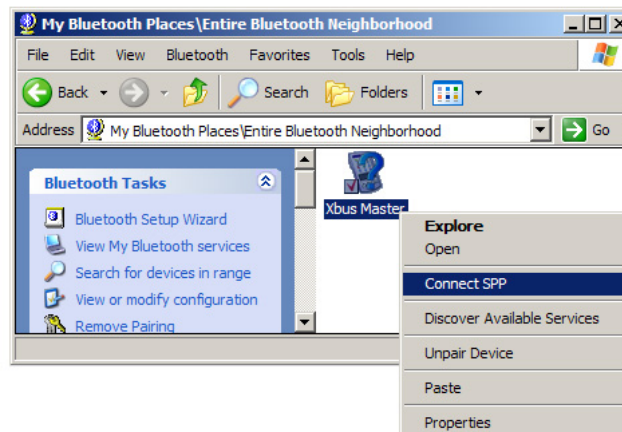
7. If the connection has been made, disconnect the Bluetooth link by turning off the Xbus Master (press the button three times shortly). The Xbus Master has stored the Bluetooth address of your remote Bluetooth device.

8. Make sure that the Xbus Master operates in Bluetooth mode. See steps above or section 2.4.

9. Check and enable your host Bluetooth device and software.

10. Turn the Xbus Master on – the Xbus Master will connect to the previously used Bluetooth device. While searching for the Bluetooth host the LED will switch between purple and blue. Once it is connected the status LED will be blue only and start flashing. For trouble-shooting see chapter 7.

To connect the Xbus Master to another Bluetooth device, turn the previously used Bluetooth device off and follow the actions described in the previous section.

3.4 Using MT Manager

1. Make sure the Xbus Master is correctly setup using either the XM USB-RS232 Cable or Bluetooth and is turned on. The status LED flashes (green = serial mode, blue = Bluetooth mode)

2. Install the MT Manager from the supplied CD if necessary.

3. Start the MT Manager.

4. If the Xbus Master is correctly set up the MT Manager will show the connected Motion Trackers in the Device List.

5. Start measurement by press the Record button in the toolbar of the MT Manager. Additional information about the MT Manager can be found in the MT Manager User Manual.

6. Stop measurement by toggling the Record button of the MT Manager

7. Before disconnecting the Motion Trackers, make sure that the Xbus Master is turned off (LED is off). To turn the Xbus Master off press the power button three times shortly. The LED will flash three times shortly for confirmation. It is now safe to disconnect the Motion Trackers.

For further, detailed instructions, please refer to the MT Manager User Manual.

4 Bluetooth remarks

4.1 Performance issues

When using the Xbus Master to wireless transmit data to another device, please keep the following remarks in mind:

- The maximum range is approximately 100 meters in open field but longer distances are possible. The Xbus Master uses a Bluetooth 2.0 module with a maximum of 20dBm output power.
- Maximum range and data throughput highly depends on whether or not objects are placed between Xbus Master and the receiving Bluetooth device. For best results, make sure that there is line-of-sight between Xbus Master and receiving Bluetooth device.
- Because Bluetooth transmissions use microwave frequencies, water has a high influence on the transmission signal. Amongst others, human bodies can negatively influence or even block the data transmission. For best results, make sure that no human bodies or water containers reside in the transmission path. An operating microwave oven will negatively influence the data rate throughput.
- If the Xbus Master is worn at the waist of a human body make sure that during the measurement the Xbus Master has line-of-sight with the receiving Bluetooth device. If this is not possible keep the amount of time in which no line-of-sight is possible to an absolute minimum by relocating the receiving device or locating the Xbus Master at a proper position around the waist.
- Interference due to other Bluetooth devices or WiFi devices can disrupt the wireless communication severely. They use the same RF spectrum and therefore the signals can collide. If possible, disable WiFi on your laptop/PDA for maximum performance.

4.2 Changing remote Bluetooth device

If a non-default Bluetooth device is to be used to collect the Xbus Master data, it first has to make a connection with the Xbus Master. The Xbus Master will store the Bluetooth address of the last connected device. This Bluetooth address is used for further connections. See also Configure Bluetooth connection in section 3.3.

4.3 Power consumption

Using a wireless connection to transfer data increases the power consumption of the Xbus Master. Depending on the number of connected Motion Trackers the additional power consumption is approximately 350mW. For more information about the operating time see chapter 6.

4.4 Interoperability

The Xbus Master equipped with a Bluetooth module has been successfully tested by Xsens with the following products:

- WR-A (installed software version 1.4.2.18), → shipped with Xbus Kit.
- TDK Bluetooth USB Adapter (installed software version 1.4.2.18)
- TDK Bluetooth PC Card (installed software version 1.3.2.19)
- MSI PC2PC Bluetooth Transceiver Key MS-6967 (installed software version 1.3.1)
- BELKIN USB dongle 100m (F8T001 Ver. 2) (installed software version 1.4.2.10)
- iPAQ PocketPC model 3870, 3970 and 5455

The following Bluetooth products should not have any interoperability problems with the Xbus Master but they are not tested by Xsens in house:

- Socket Bluetooth Card for Windows CE^{TM}

- Anycom PC-Card
- Anycom Blue Card for Windows CE^{TM}
- DLINK USB dongle for PC
- Palm Tungsten T
- BrainBoxes Compact Flash.

Please note that other Bluetooth products may not be fully compliant although they claim to support other Bluetooth units including the serial port profile. Problems that could occur are connection failures or loss of data.

The Xbus Master B features a **Bluetooth 2.0** compatible transceiver which supports the Serial Port Profile (SPP). The transceiver does not support EDR or enhanced data-rate.

5 Xbus Master settings

The Xbus Master has several settings that are stored in non-volatile memory, i.e. even if power is removed the settings will be saved. These settings are related to the sample frequency, serial port baudrate, connection mode and synchronization mode. They can be changed using the MT Manager or manually using messages (see XM Technical Documentation). In the following section these settings are explained. The procedure to restore the default settings is described in the last section of this chapter.

5.1 Changing settings using MT Manager

Using the MT Manager various settings of the Xbus Master can be viewed and/or changed. Follow the setup procedure described in chapter 3 and select "Device Information" in the Device List of the MT Manager and then press the button on the right hand side to open the dialog shown here.
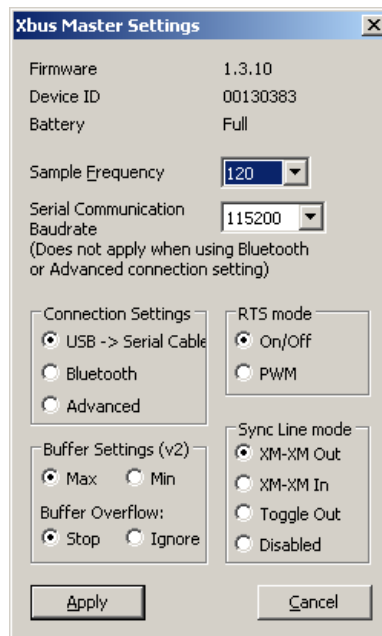
Firmware revision
The first line shows the version of the installed firmware of the Xbus Master.

Battery Level
The battery level gives a rough indication of the current battery status.
This can be one of the following: Full, Good, Low. The remaining operating time is very dependant on the configuration (How much and what type of Motion Trackers).
Only works for revision 2 and 3 of the Xbus Master (XM-B-XB2 and XM-B-XB3).

Serial port baudrate
The baudrate of the serial port can be changed to 9k6, 14k4, 19k2, 28k8, 38k4, 57k6, 76k8, 115k2, 230k4 or 460k8 bits per second. The factory default is 115k2 bps.

NOTE: Baudrates lower than 57k6 are not supported by the MT Manager.

If the Bluetooth connection mode is selected the serial baudrate setting will have no effect.

Sample frequency

Use this option to change the sample frequency during measurement. The sample frequency can be changed to 10, 25, 50, 64, 100, 120, 200, 256, 320, 400 or 512 Hz. The factory default is 100 Hz.

By changing the sample frequency and/or baudrate, keep in mind the following limiting factors for the maximum number of Motion Trackers which can be used.

- o OutputMode and OutputSettings of the MTx. These settings have an effect on the number of data bytes transmitted for every sample.
    - o Raw data has little calculation time, and 20 bytes to send
    - o Orientation data needs approx 6 msec for calculations and 16 (quaternion), 12 (euler) or 36 (cosine matrix) bytes of data to transmit
    - o Calibrated data has approx. 1 msec for calculations and 36 bytes of data to transmit.
- o Selected baudrate and connection mode. Remember that Bluetooth throughput is dependant on the environment and objects that weaken the signal power. To be on a safe side use an effective throughput of 20 kbytes per second.

For example:

5 MTx, quaternion output, Bluetooth mode:

5 * 16 bytes + 7 bytes (header incl. sample counter) = 87 bytes per sample

  → 200 Hz should be possible

NOTE:

Make sure you test the configuration before any measurement. If the sample frequency is too high to receive all Motion Tracker data within the one period the Xbus Master will enter the config state and send an error message. If the data throughput between the Xbus Master and the host is a bottleneck the internal buffer of the Xbus Master will overflow. Depending on the buffer overflow setting the Xbus Master will stay in the measurement state or send an error message and enter the config state. See the Buffer Overflow paragraph in this section. See the XM-B Technical Documentation for more information on how to interpret these errors.

Connection Settings

Select one of the connection mode options to either use the Xbus Master is serial mode or in Bluetooth mode. The advanced mode is reserved for future enhancements. Factory default is serial cable mode.

RTS mode

The RTS output pin (= CTS at the host) of the serial port of Xbus Master can be used to synchronize with other devices. These options are only available in serial mode. Currently, two RTS modes are defined On/Off and PWM. For more information on these modes and synchronization see section 6.7.

Buffer Size

The Xbus Master has a buffer for the data that is send to the host. If you are experiencing delays set the buffer to Min to minimize the delay. Data lost may occur more frequently in this case if the Bluetooth connection quality is poor.

- o Max: buffer size is set to 64256 bytes
- o Min: buffer size is set to 256 bytes

The buffer is implemented in revision 2 and 3 of the Xbus Master (XM-B-XB2 and XM-B-XB3).

Buffer Overflow

Action to take when the transmit buffer is full.

- o Ignore:
  Continue sending data and stay in measurement mode. There will be lost data.
- o Stop:
  At a buffer overflow the Xbus Master stops the measurement and it tries to send the buffer data to the host. I.e. all data logged thus far will be correct. After the data messages the Xbus Master sends an error message and enter the config state.

Only works for revision 2 and 3 of the Xbus Master (XM-B-XB2 and XM-B-XB3).

Sync line mode

With the introduction of revision 3 of the Xbus Master B a sync connector is available for multiple Xbus Master configurations. It can also be used for synchronization with other units that work with logic level trigger lines (0-5V). See section 6.7 for more information on synchronization using the Xbus Master.

5.2 Restoring the factory default settings

To restore the default settings (see previous section) use the following procedure:

1. Shutdown the Xbus Master – press push button three times shortly
2. Press and hold the button for at least five seconds – Xbus Master will automatically shutdown and power up again.
3. The default settings are now used:

serial port baudrate	**115k2 bps**
sample frequency	**100Hz**
connection mode	**serial**
RTS mode	**on/off**
sync line mode	**disabled**

6 Miscellaneous

6.1 Low-battery warning

If the Xbus Master is powered by batteries a low-battery warning will become active if the batteries are almost depleted. A visual warning is given by the status LED; it will change color to yellow. Also, an audible warning will sound by the internal buzzer every five minutes. The operating time during battery-low depends on the number of connected Motion Trackers and battery type. Generally, the maximum operating time at the first audible warning will be one hour if one Motion Tracker is connected and thirty minutes if ten Motion Trackers are used. This also depends on the type of batteries.

6.1.1 Batteries

The typical operating time (using the wireless connection) with the provided batteries (2700mAh) is approximately 2-3 hours (using 10 MTx). The Xbus Masters will beep when the battery voltage drops below 4.7V. **Usually in this case it is still possible to operate for some quite some time.**

Please take care of the following recharging tips to ensure maximum battery life. Please refer to the battery or charger user manual that you are using for details. The information below is common to NiMH battery technology.

Rapid Charge Mode (usually charger default – not recommended)
1. Shortest recharging time (approximately one hour).
2. Suitable for NiMH AA batteries with capacity greater than 2000mAh.

Soft Charging Mode
- Maximizes battery life and performance (recharging time approximately two hours).
- Suitable for most batteries.
- Recommended if recharging time is not critical.

Conditioning Mode
- A special mode which rejuvenates and cycles batteries. Applies a special initial charge, discharge and recharge cycle which restores battery performance (requires up to 14 hours to complete).
- Conditioning cycle can be used to rescue degraded batteries and exercise infrequently-used batteries.
- Recommended once every ten normal charges for NiMH batteries to ensure performance.

NOTE: Stored at 20° C (68°F) NiMH batteries will lose up to 40% of their charge within a month. If they are stored at a higher temperature, they will self discharge at an even higher rate. Stored at a lower temperature, they discharge at a lower rate. A typical daily spontaneous discharge rate is 1-5% a day.

6.2 Maximum operating time

The maximum operating time when using batteries depends on the number of Motion Trackers connected to the Xbus Master and the battery type. Xsens has carried out tests measuring the maximum operating time using maximum sample frequency possible. The test results are shown in the next table. These results are based on the rechargeable batteries of brand PowerEx AA NiMH 2700 mAh.

Number of MTx	Time - Serial	Time – Bluetooth
3	8h	6h
5	4.5h	3.5h
10	2h	2h

6.3 Number of Motion Trackers

Currently, up to ten Motion Trackers can be connected to the Xbus Master simultaneously and at most five at one Xbus string. With revision 3 of the Xbus Master it is possible to synchronize multiple Xbus Masters and have a system of up to 20 Motion Trackers.

6.4 Sampling at non-default frequencies

It is possible to sample the Motion Trackers at other frequencies than the default 100Hz. The Xbus Master can be configured to sample at frequencies between 10-512Hz when connected to one or more Motion Trackers. The maximum frequency depends on the number of connected Motion Trackers and it also limited by the speed of the host interface.

To configure the Xbus Master at non-default frequencies please check the XM Technical Documentation or see chapter 5.

6.5 Using custom devices

The Xbus Master can also connect to custom-designed devices. Please contact Xsens for more information about the interface requirements and Xbus information.

6.6 Using custom software

If you are building custom software to log the raw data of the Xbus Master, see XM Technical Documentation for more information about packet format and examples. Be advised that it is very important to create a fast event handler for reading incoming data bytes or else data will be lost. Please, refer to the MT SDK documentation. We recommend using the MT Communication C++ communication class. Source code of this class is supplied in the SDK.

6.7 Synchronization

The Xbus Master can synchronize with other devices as with another Xbus Master. The Xbus Master can either trigger or it can be triggered by an external device. There are two interfaces available for synchronization; using the RTS/CTS signals of the RS-232 interface or the sync signal which has 0-5V logic levels.

RTS/CTS signals
The RTS and CTS signals are defined in the RS-232 interface for handshaking between the two devices. The Xbus Master uses these signals for synchronization with external devices. The voltage values of signals are +3…+25V for a zero and -3…-25V for a one.

The CTS pin, which is an input for the Xbus Master, is used to trigger / enable the sampling of the Xbus sensors. If made active at the host the Xbus Master immediately issues the Xbus sensors to start the sampling procedure. If the CTS pin stays active the Xbus Master will continue to sample the Xbus sensors at the current defined sample frequency. Otherwise if the CTS pin is made inactive the Xbus Master will not send any data nor does it sample the Xbus sensors. If the Xbus Master is in measurement state it will wait for a trigger (CTS to go active). The status LED will flash two short times in measurement state. See also the state description of the status LED in section 2.5.

If an external high-precision master clock is available for synchronization, it can be used for indicate the sampling moment using the CTS pin. Note that the voltage values of this clock signal should match the RS-232 voltage specification.

The RTS pin (sample for the Xbus Master) gives an external device, e.g. the host PC, notification of the sampling moment. There are two modes, an On/Off mode and a pulse width modulated mode (PWM). Besides

the sample moment the modes give also information about the corresponding sample counter, the PWM mode more than the On/Off mode. See the following figure.
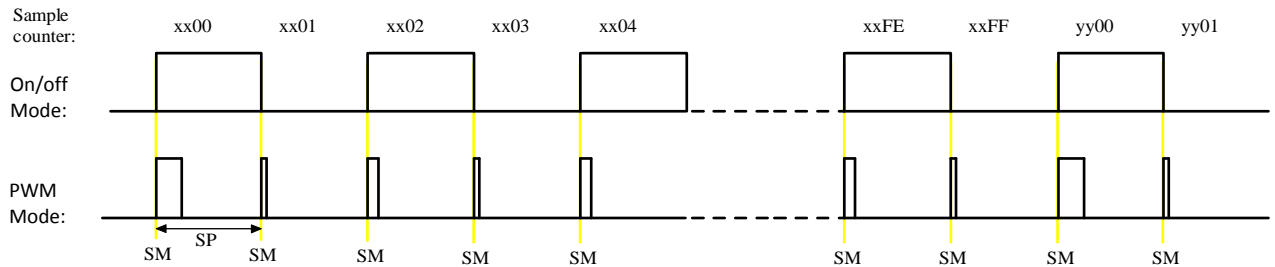
SM is the abbreviation for sample moment and SP is sample period. The PWM mode pulses at the SM with different pulse-widths. The pulse-widths are either 100us or 200us for the odd and even sample-counter values respectively. There is one exception; for a sample counter value of which the lower byte is equal to zero the pulse-width is 300us. The default RTS mode is On/off mode.

See section 5.1 to set the preferred RTS mode using the MT Manager.

In Bluetooth mode the RTS & CTS signals are not available. Use the sync pin instead, see section paragraph.

Sync line
Note: make sure that if the sync line is not used the mode is set to disabled. If there is no sync line, the performance of the MTx's will show erratic behavior. See the Xbus Master settings to check or change the sync line mode (section 5.1).

With the introduction of latest Xbus Master (XM-B-XB3) an additional sync signal is available for synchronization. This sync pin, which is available at the host and the sync connector, can be configured as an input or output. If configured as an output the pin will remain low (= 0V) until the Xbus Master is ready to instruct the Xbus devices to start sampling. At this moment the Xbus Master will make the sync pin high (= 5V) for at least 100 us. Thus the sync pin will pulse with the same frequency as the current sample frequency set in the Xbus Master.

The sync line can also be configured as a toggle output. The waveform is the same as the RTS pin in On/Off mode except that the voltage values are zero and five volts. See previous section.

If the trigger pin is configured as an input the Xbus Master will wait for a positive rising edge on this pin before it will trigger the sampling of the Xbus sensors and requesting data of all the Xbus sensors. After requesting all the data the Xbus Master will again wait for the next pulse before triggering the sampling again. Keep in mind that the voltage value on the trigger pin must NOT exceed the 0-5V range!

Using the Xsens sync cable two Xbus Master can be easily synchronized. First configure the sync line mode using the MT Manager (see section 5.1). Configure the sync line of one Xbus Master as output (XM-XM out) and the other Xbus Master as input (XM-XM in). Connect the cable and set the Xbus Master with the sync line configured as an input first in measurement mode. If the Xbus Master with the sync line configured as an output is set in measurement the two Xbus Master will start sampling at the same time. The two first data messages of the Xbus Masters contain the sensor data that are taken at the same time instance.

Syncing scenarios
The Xbus Master has two different hardware syncing possibilities as explained above. To determine which syncing option is best for your application, a few scenarios are given below.
Please read carefully the Hardware specification below before connecting any devices to the Xbus Master.
All the syncing possibilities SyncIn/SyncOut and RTS (XM) are available at the 7 pins binder *main serial* and 4 pins binder *sync* connecter on the Xbus Master.
It is not recommended to use the CTS (XM) for sync-in purposes.

Trigger scenario	SyncIn/SyncOut	RTS (XM)
1) Triggering another devices	Yes	Yes[4]
2) Other Xbus Master	Yes	No
3) Accurate clock device syncOut	Yes	No
4) Using long cable lengths for triggering	No	Yes
5) Triggering when using Bluetooth	Yes	Yes[5]
6) Using Xbus MTx AnalogIn for start/stop frame synchronization	Yes	No

1. Triggering another device.
   a. You can synchronize another device with the Xbus Master. For devices which accept standard logic levels between 0-5V use the SyncIn/SyncOut pin.
      • With MT manager → set the sync line mode to : XM-XM Out
   b. If your device only accepts RS232 level sync pulses, you can use the RTS pin either from the main serial or sync connector. If you want to use Bluetooth, you have to set the output option of the Xbus Master to Advanced.
      i. With MT manager → set the RTS mode to on/off or PWM.
      ii. With MT manager → set output mode to Advanced (if you want to use RTS and Bluetooth.).

1a) Syncing another device in Bluetooth mode

1b) Syncing another device with RTS, Xbus connected to a PC
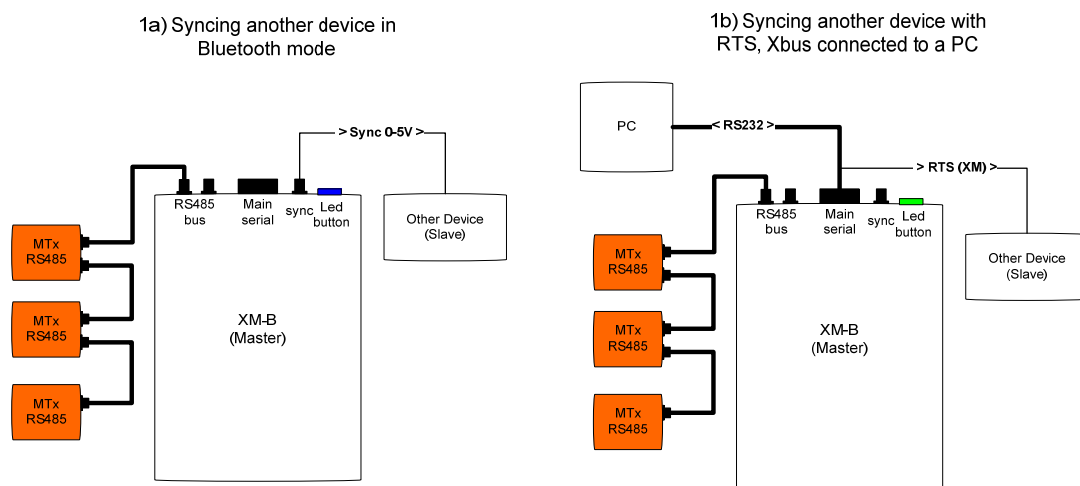
[4] Cannot be used when the Xbus Master is in Bluetooth mode.
[5] Only available in Advanced output mode

2. Syncing another Xbus Master

When syncing another Xbus Master, you have to set both Xbus Masters in a correct way with MT manager:

- Set the master in the settings menu sync line : XM-XM out

- Set the slave in the settings menu sync line : XM-XM in

1+5) Syncing 2 Xbus Masters in Bluetooth mode
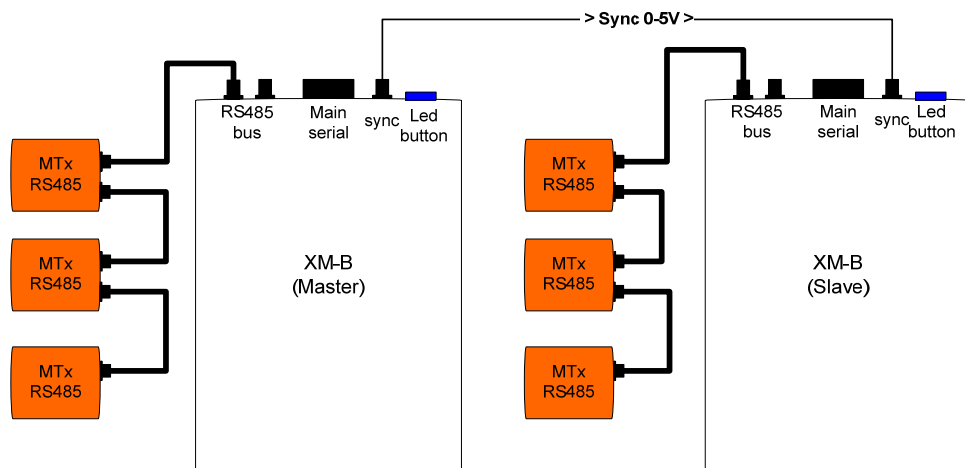
3. Using an accurate clock device to sync the Xbus Master

To sync the Xbus Master by an external device, we recommend using the SyncIn/syncOut pin. Note that the frequency of the external clock must be precisely known and be set in order to retrieve an accurate orientation calculation.

- Set in MT manager → sync line dialog : XM-XM in

4. Syncing devices using longer cables

It is recommended to use the RTS signal line when using longer (>5m) cables for synchronization. The RTS lines are RS232 levels compatible and less sensitive to interference.

- In MT manager → Serial Cable + RTS mode : On/Off or PWM

5. Syncing when using the Xbus Master in Bluetooth mode

Only the SyncIn/SyncOut pin is available and not the RTS pin for syncing purposes when using the Xbus Master in Bluetooth mode (indicated with a blue led).

Use the Advanced output mode to use Bluetooth in combination with RTS synchronization, described in point 1.b.ii .

6. Using Xbus MTx AnalogIn for start/stop frame synchronization

For many applications it is convenient to synchronize the start frame or sample of the Xbus Master with data from another device (e.g. an optical system). For this purpose you can use the AnalogIn of one Xbus MTx sensor. Connect the synchronization pulse or waveform to pin 3 (AnalogIn) and 4 (GND) of the binder connector (see also page 45, MTi and MTx User Manual). Set the corresponding Xbus Sensor to the following output mode:

- In MT manager → enable AnalogIn in configuration dialogue for the corresponding sensor MTx Xbus sensor. *Each data packet from the Xbus Master will now also include one AnalogIn signal from an Xbus MTx sensor.*

You can use this synchronization method in combination with the above mentioned synchronization options.

In the picture below an example is given of an optical system which generates a sync signal for phase synchronization and a toggle signal for frame synchronization. Of course with this method of frame synchronization, the accuracy depends on the sample frequency:

$$t_{error\_max} = 1/(fs).$$

If the sample frequency=120Hz, than the maximum deviation is t_{error_max} = 8.3ms.
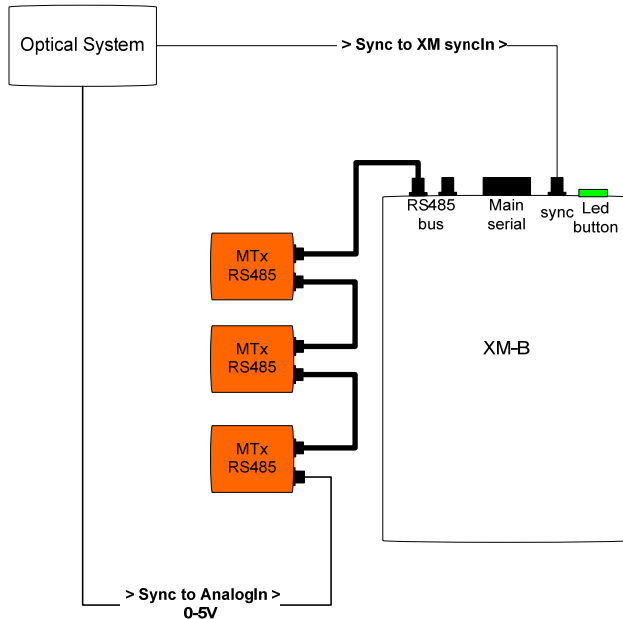
Timing diagram example; synchronization with an optical system as master device. Start and stop frame are indicated as a toggle signal at the AnalogIn of an Xbus sensor.
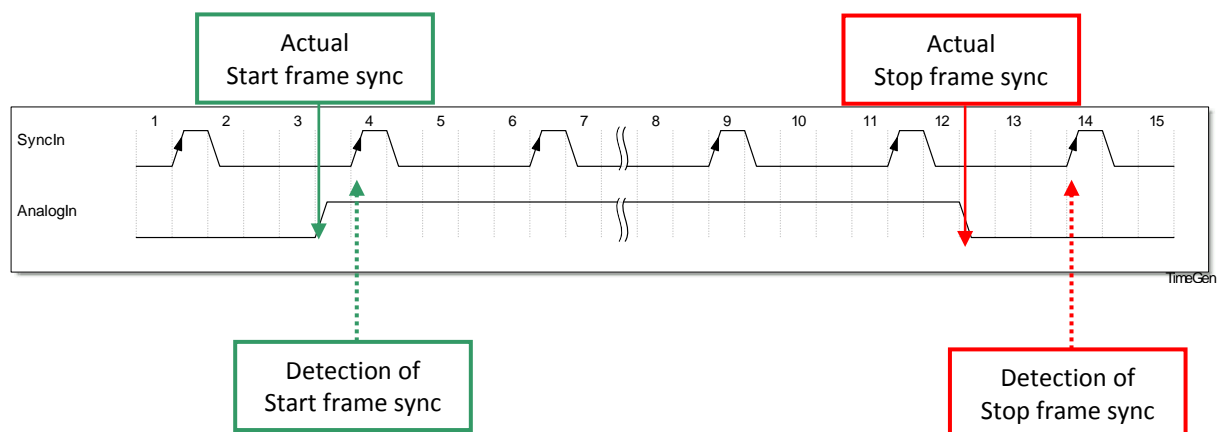

NOTE: AnalogIn is not available when using RAW data output mode.

If you have any problems with frame synchronization, please contact Xsens Technologies.

Sync hardware specification

Hardware electrical specifications	Sync line		Main serial
	SyncIn	SyncOut	RTS XM
Input threshold voltage high	3.0 V	NA	NA
Input threshold voltage low	1.0 V	NA	NA
Trigger edge	Rising	NA	NA
Trigger mode		pulse	Toggle/PWM
Pulse duration (pulse/PWM)	>200μs	215 μs	See 6.7 PWM mode
Jitter	NA	+/- 10μs	NA
Latency	<10μs	NA	NA
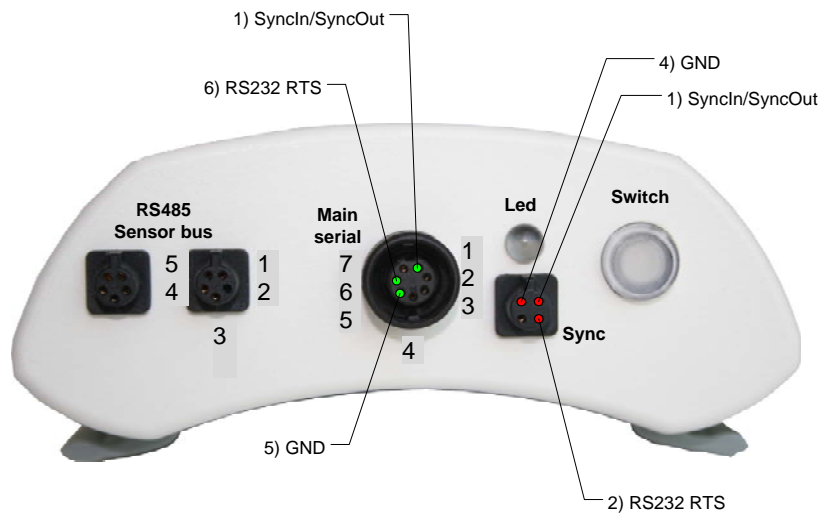
Pin definitions of the Main serial connector and the RS485 Sensor bus connectors are described in the XM-B Technical Documentation

Hardware mechanical specifications	Main serial connector	Sync connector
SYNC	1	1
GND	5	4
RTS (XM)	6	2

7 Frequently-asked questions

Q: *Why can't the MT Manager detect my Xbus Master using the serial cable?*
A: First check if the Xbus Master is turned on and is in serial mode (status LED should be green). If the LED is not green the Xbus Master may be in Bluetooth mode. Enable the serial mode using the MT Manager or the push button procedure. See section 2.4 or 5.1.
Check if the serial cable is correctly attached to the Xbus Master and the host. Use the twist-lock at the Xbus Master side to attach it properly. Make sure that the RS-232 (COM) port used by the Xbus Master is not used by other software installed on your computer, e.g. ActiveSync.

Q: *Why can't the MT Manager detect my Xbus Master using Bluetooth?*
A: First check if the Xbus Master is in Bluetooth mode; status LED should be blue or purple. If this is not the case, use the MT Manager to enable Bluetooth mode using the serial cable (see section 5.1) or use the push button procedure (section 2.4).
If the LED is purple the Xbus Master could not connect to the remote Bluetooth device. Try to minimise the distance between the Bluetooth devices and even ensure line-of-sight (see chapter 4). To retry, turn the Xbus Master off and on again.
If the LED still doesn't start flashing check the host Bluetooth device and its software. If it turns solid purple follow the instructions of section **Configure Bluetooth connection** in chapter 3.

Q: *Why can't the MT Manager detect my Xbus Master using the serial cable? I am using a USB<>RS-232 converter to connect to the host.*
A: Some converter drivers have an auto RTS/CTS flow control. Disable this option for proper communication with the Xbus Master.

Q: *Why shuts the Xbus Master itself down automatically after I turned it on?*
A: If the Xbus Master detects no connected MTx's, it automatically turns itself off.

Q: *My Xbus Master is set to Bluetooth mode but the previously connected Bluetooth device is unavailable. How can I use the MT Manager to reset the Xbus Master settings?*
A: Restore the factory default settings (Serial cable mode, 115k2 bps, 100Hz) and use the Xbus Master serial cable to connect to the host.

Q: *Why are the indication LED's of the XbusMaster and Wireless Receiver continuously blue.*
A: The Xbus Master and Wireless Receiver are connected, but there is no data transmission. Turn the Xbus Master OFF and ON again. The LED's will be flashing blue, this indicates data transmission.

Q: *I am using my own serial cable and software. Why can't I read any data?*
A: First of all check if the Xbus Master is in serial cable mode. If you use your own cable you must use a null-modem cable with at least five conductors. The following signals must be connected TX, RX, GND, RTS and CTS of which the first two and the last two are crossed! To log data from the Xbus Master the RTS line (host side) must be active. See section 6.7.

Q: *What is the Advanced option in the Xbus Master Settings?*
A: If this option is selected the serial port output signals will also be active during Bluetooth connection. NOTE: you can only read from the serial port (log data) and use the sampling moment notification signal. You can not use the serial port to communicate with Xbus Master. If the Advanced option is selected the serial baudrate will always be 921k6 bps for firmware revision 1.2.10 and higher. For older firmware revision it is 460k8 bps.

Q: *Why do I hear a beep in the middle of my measurement?*

A: This is either the low battery warning or an error beep. Check status LED for more information. If the LED is red an error occurred (error on the Xbus). This may also occur if the sampling frequency is set too high!

8   Specifications XM-B-XB3

Xbus	
Type	RS-485
Speed	460k8 bits/sec
Number of Xbus connectors	2 (enables 2 Xbus strings of max 2x 5 MTx)
Sample frequency	Adjustable from 10-512Hz
Maximum number of Motion Trackers	10x MTx (at 100Hz sampling frequency[6])
Host interface	
Cable type	RS-232 (configured as DTE)
Baudrate	115k2 bits/sec (default) configurable between 9k6 and 921k6 bits/sec
Wireless type	Bluetooth v2.0 (Serial Port Profile)
Radio output power	100mW or 20 dBm
Data rate	Up to 52 kB/sec
Xbus units	
Motion Trackers	MTx-49A##G##
User-defined sensors	Request Xbus specification if you would like to add your own sensor to the Xbus. Contact info@xsens.com
Software	
MT Manager	For MT configuration, logging and 3D orientation calculation and visualization
MT SDK	For utilisation and integration of the MT API in your own software application
Power	
Operating voltage	4-12V
Supply current @ 12V DC	30 mA (no MTxs, Bluetooth disabled) 210 mA (5 MTxs, Bluetooth disabled) 230 mA (5 MTxs, Bluetooth enabled) 440 mA (10 MTxs, Bluetooth enabled)
Batteries	4x AA type (included)
Minimum operating time-battery powered[7]	About 2-3 hr (10x MTx @ 50Hz, Bluetooth enabled)
Power adapter	12V DC 1A
Physical specifications	
Dimensions	10x15x4 cm (W x L x H)
Weight	330 g (200 g excl batteries)

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[6] Max sampling rate (update rate) depends on host connection type and throughput rate, please refer to XM-B Technical Documentation for details.
[7] Using the included rechargeable batteries

9 Important notices

9.1 Operating conditions

The recommended operating temperature of the Xbus Master is between -20°C and +55°C ambient temperature. If operated outside this temperature range performance may decrease or the device might be damaged. Fast transient temperature fluctuations may cause significant temperature gradients across the device.

The Wireless Receivers, Xbus Masters must be kept **dry** at all times. Condense and water may damage the internal electronics.

The Xbus Master should be protected from electro static discharges or sources of radiation, as exposure to such source will damage the internal electronics.

9.2 Absolute maximum ratings

Stresses above Absolute Maximum Ratings to the Xbus Master may cause permanent damage to the device.

Input Voltage:	-0.3 V … 30 V
Interface inputs:	-25 V … 25 V (RX, A and B inputs)
Sync IN:	-1 V … 5.5 V
Operating/Storage Temperature:	-20 °C - +70 °C

Stresses beyond those listed here may cause permanent damage to the device. These are stress ratings only, and functional operation of the Xbus Master at these or any other conditions beyond those indicated in the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

9.3 Maintenance

The Wireless Receivers, Xbus Masters will not require any maintenance if properly used.

9.4 Warranty and liability

Xsens Technologies B.V. warrants the products manufactured by it to be free from defects in material and workmanship for a period of 1 year from the date of delivery. Products not subjected to misuse will be repaired, replaced or credit issued at the sole option of Xsens Technologies B.V. Contact support@xsens.com for return material authorization (RMA) prior to returning any items for calibration, repair or exchange. The product **must be returned in its original packaging** to prevent damage during shipping.

The warranty shall not apply to products repaired or altered or removed from the original casing by others than Xsens Technologies B.V. so as, in Xsens Technologies B.V. opinion, to have adversely affected the product, products subjected to negligence, accidents or damaged by circumstances beyond Xsens Technologies B.V.'s control.

NOTE: Xsens reserves the right to make changes in its products in order to improve design, performance, or reliability.

Subject to the conditions and limitations on liability stated herein, Xsens warrants that the Product as so delivered shall materially conform to Xsens' then current specifications for the Product, for a period of one year from the date of delivery. ANY LIABILITY OF XSENS WITH RESPECT TO THE SYSTEM OR THE PERFORMANCE THEREOF UNDER ANY WARRANTY, NEGLIGENCE, STRICT LIABILITY OR OTHER THEORY WILL BE LIMITED EXCLUSIVELY TO PRODUCT REPAIR, REPLACEMENT OR, IF REPLACEMENT IS INADEQUATE AS A REMEDY OR, IN XSENS' OPINION IMPRACTICAL, TO REFUND THE PRICE PAID FOR THE PRODUCT. XSENS DOES NOT WARRANT, GUARANTEE, OR MAKE ANY REPRESENTATIONS REGARDING THE USE, OR THE RESULTS OF THE USE, OF THE PRODUCT OR WRITTEN MATERIALS IN TERMS OF CORRECTNESS, ACCURACY, RELIABILITY, OR OTHERWISE. Xsens shall have no liability for delays or failures beyond its reasonable control.

9.5 Customer Support

Xsens Technologies B.V. is glad to help you with any questions you may have about your product or about the use of the technology for your application. Please contact Xsens Customer Support:

➔ by e-mail: support@xsens.com
➔ telephone: +31 (0)88 9736700

To be able to help you, please mention your Xbus Master **Device ID** (on the back of the device) and **software license registration number** in your e-mail.

9.6 Bluetooth Qualification Information

This product contains a Bluetooth qualified product QD ID B010798.

The Bluetooth wireless link used in the Xbus Master conforms to the following product specifications.

R&TTE Directive 1999/5/EC
EN 300 328 V1.6.1 (2004-11)
EMC Directive: 89/336/EEC
EN 301 489-1 V1.4.1 (2002-08)
EN 301 489-17 V1.2.1 (2002-08)
EN 61000-6-2 (2001)
Safety Compliance
EN 60950-1:2001 and/or IEC 60950-1:2001 (1st Edition)
EN 60950-1/A11:2004 + Corrigendum:2004
Medical Electrical Equipment
IEC 60601-1-2 (2001)

9.7 Wireless use conformity for Japan

This product contains radio modules certified for use in Japan with certification number 005WWCA0163.

9.8 FCC Statement

> This device contains
> **FCC** ID: PVH090103L
> **IC**: 5325A-090103L

9.9 Radio Frequency Exposure and Emission

The Xbus Master system contains a small radio transmitter and receiver. During communication with other Bluetooth products system receives and transmits radio frequency (RF) electromagnetic fields (microwaves) in the frequency range 2400 of 2500 MHz. The output power of the radio transmitter is very low. When using the system, you will be exposed to some of the transmitted RF energy. This exposure is well below the prescribed limits in all national and international RF safety standards and regulations.

Most modern electronic equipment, for example, in hospitals and cars, is shielded from RF energy. However, certain electronic equipment is not. Therefore:

Note: This equipment emits RF energy in the ISM (Industrial, Scientific, Medical) band. Please insure that all medical devices used in proximity to this device meet appropriate susceptibility specifications for this type of RF energy.

Turn off this electronic device before entering an area with potentially explosive atmosphere. It is very rare, but any electronic device could generate sparks. Sparks in such areas could cause an explosion or fire resulting in bodily injury or even death. Areas with a potentially explosive atmosphere are often, but not always, clearly marked. They include fuelling areas, such as petrol station, below deck on boats, fuel or chemical transfer or storage facilities, and areas where the air contains chemicals or particles, such as grain, dust, or metal powders.

9.10 CE Declaration of Conformity for the USB converter

We, **Xsens Technologies BV**, of
Pantheon 6a
7521 PR Enschede
The Netherlands

declare under our sole responsibility that our product:

    CA-USBXM RS232

to which this declaration relates, is in conformity with the essential requirements of the EMC Directive: 89/336/EEC and the following Standards and other Normative Documents:

EMC Directive: 89/336/EEC
EN 61326-1 (2006)
EN 61000-3-2 (2006)
EN 61000-3-3 (1995) + A1 (2001) + A2 (2005)

Environment to be used is light industrial / laboratory

Class of emission is B and performance criterion B.

Test results are summarized in the Electromagnetic Compatibility Test Report with the following document number 08C00497RPT01

September 23 2008 Enschede, the Netherlands

Per Slycke
CTO
Xsens Technologies BV

9.11 FCC Declaration of Conformity for the USB converter

We, **Xsens Technologies BV**, of
Pantheon 6a
7521 PR Enschede
The Netherlands

declare under our sole responsibility that our product:

CA-USBXM RS232

to which this declaration relates, has been tested and found to comply with the limits for a Unintentional Radiator as described in 47 CFR 15 (2007 May, 04 Edition) Class B Digital Device, pursuant to Part 15 of the FCC Rules.

Operation is subject to the following two conditions:
1. This device may not cause harmful interference, and
2. This device must accept any interference received, including interference that may cause undesired operation.

Test results are summarized in the Electromagnetic Compatibility Test Report with the following document number 08C00497RPT01

September 23 2008 Enschede, the Netherlands

Per Slycke
CTO
Xsens Technologies BV