



X4M200 Datasheet

Respiration Sensor

XeThru Datasheet **by Novelda AS**

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Summary

The XeThru X4M200 Respiration Sensor is an industrialized sensor that complies with worldwide regulations ready for product integration. Based on Novelda's proprietary, highly integrated X4 system-on-chip (SoC), the sensor provides highly accurate measurement of a person's breathing frequency, together with distance and movement information.



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1 List of Features

- Non-contact vital signs monitoring up to 5 meters
 - Measures distance from sensor to person
 - Measures respiration rate of person when person is still
- Radar sensor
 - Baseband data output
 - Pulse Doppler output
- Novelda Ultra Wide Band (UWB) Impulse Radar X4 system on a chip (SoC)
- Built-in TX and RX antennas
- Multiple interface options
 - Serial interface, UART and USRT
 - On-board USB interface
- On-board multi-color LED
- Certifications
 - FCC for USA
 - CE for Europe
 - IC for Canada
 - KCC (pending) for Korea
 - MIC (pending) for Japan



X4M200 Respiration Sensor



1.1 Order information

Order Code	Item Description	MOQ	MPQ	Packaging
X4M200	X4M200 Respiration Sensor FCC and CE/ETSI version	1	1	1 unit in anti-static bag
X4M200-TR100	X4M200 Respiration Sensor FCC and CE/ETSI version	100	100	100 units in anti-static tray
X4M201	X4M200 Respiration Sensor KCC and MIC version	1	1	1 unit in anti-static bag
X4M201-TR100	X4M200 Respiration Sensor KCC and MIC version	100	100	100 units in anti-static tray

MOQ: Minimum Order Quantity

MPQ: Minimum Package Quantity

Whenever this datasheet states X4M200 the description is valid for all the above order codes. Regulatory approval information for FCC, IC and CE/ETSI is valid only for X4M200 and X4M200-TR100 order codes. Regulatory approval information for KCC and MIC is valid only for X4M201 and X4M201-TR100 order codes.

X4M200 and X4M200-TR100 are available now. X4M201 and X4M201-TR100 are expected available second half of 2018.

2 XeThru X4M200 Respiration Sensor

X4M200 senses vital signs data such as respiration rate, breathing pattern and movements on people that are still, typically lying in a bed or sitting still.

X4M200 is able to sense human presence by detecting any motion such as a person walking, hand movements and even a person with no other movements than respiration. The unique ability to sense respiration movement enables products that do not lose track of a person's presence if he /she sits still for a longer time period. Its extreme sensitivity enables it to detect presence up to a distance of 5.0 meters. It is also able to measure the distance between the sensor and the person with centimeter accuracy, and is not susceptible to "dead spots" within the detection zone.

With the XeThru technology's ability to see through light materials it also enables products that detect a person's presence and collects vitals signs data while sleeping with a blanket, duvet or clothes covering the person's body.

2.1 Supported Profiles

A Profile is defined as a specific configuration of the sensor for a specific use case. New Profiles might be included based on market demand.

The following Profiles are included in X4M200:

- Adult Respiration Profile (default)



- Baby Respiration Profile

Adult Respiration Profile is identified as Respiraton_2 in the SW API. Baby Respiration Profile is identified as Respiraton_3 in the SW API.

3 Sensor Operation

3.1 Power-up and Reset

3.1.1 First Power-Up

At first power-up of the sensor, the default Profile will be loaded and started with it's default User Settings. Each Profile has a default message that the sensor will start sending over the serial communication link.

3.1.2 Configuration

Profiles and User Settings can be modified and loaded as described in the Module Connector documentation found on www.xethru.com.

User Settings vary between different Profiles and each Profile has its own default settings. See the Profile description chapters for details.

User Settings can only be changed when the Profile is not running. To change any setting, follow these steps:

1. Stop running Profile (if any Profile is running)
2. Load desired Profile (if not already loaded)
3. Send settings commands
 - a. User Settings such as Detection Zone, Sensitivity etc.
 - b. Output Control settings that determine which messages will be sent over the serial communication link on X4M200
4. Start running Profile

Switching Profile will load the last used User Settings for the new Profile. If the new Profile has not been run earlier, default User Settings for that Profile are used.

3.1.3 Running Sensor Directly from Power-up or Reset

At power-up or reset, the sensor will start with its last used settings.

3.2 IO-pins

Various Profiles may have different uses of IO-pins. Do not connect IO-pins that are not in use. The sensor module will pull up these IO-pins internally. Future FW upgrades of the sensor and any existing or future pin compatible products may use these unused IO-pins for other functionality.

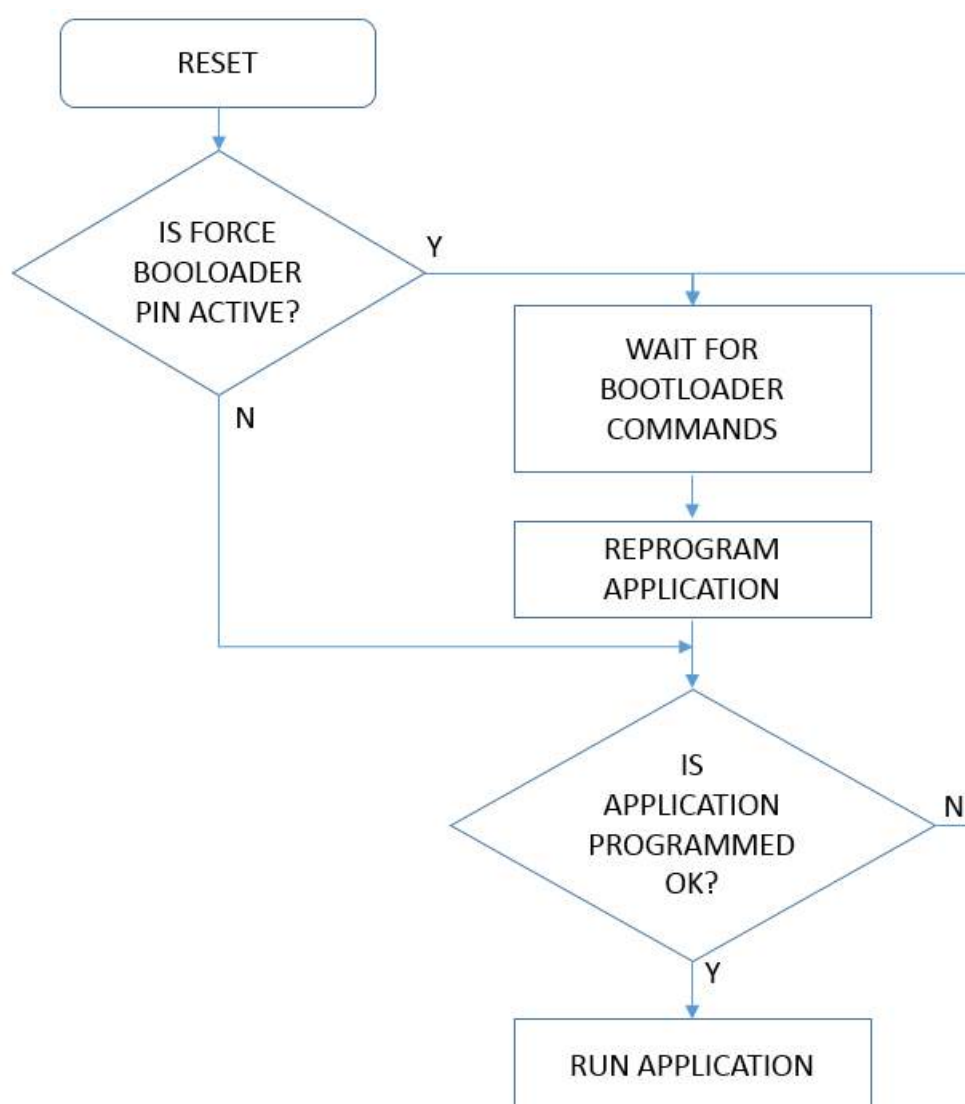


3.3 Firmware Versions

The datasheet may describe features not yet implemented in the current firmware version of the module. The datasheet chapter Firmware Versions explains what features are implemented in which firmware versions.

3.4 Bootloader

The module has a bootloader to allow field firmware upgrades. The bootloader is locked and cannot be reprogrammed, thus it can never be erased, altered or removed from the module over the serial protocol. The bootloader can be entered through the serial protocol, and it is also possible to force the module into bootloader mode using the pin header interface. See datasheet chapter Interface Options for details.



Bootloader flowchart

If a firmware upgrade fails (e.g. power loss) the host providing the firmware upgrade must reinitiate the entire firmware upgrade process. The previous version of the firmware may be lost, but the bootloader will still operate as described even after a failed firmware upgrade attempt.

If the Flash on the microcontroller is erased using an external programmer or debugger, the unit cannot be reprogrammed to default functionality by the user.



3.5 Fail Safe Mode

To contain possible issues that could unintentionally block communication and new firmware upgrades of X4M200 a Fail Safe Mode is implemented.

X4M200 will count the number of resets caused by issues in the firmware and enter Fail Safe Mode after ten such consecutive resets. In Fail Safe Mode, the LED of X4M200 will be white. In Fail Safe Mode, X4M200 will only respond to commands from the XEP interface, and a module reset or firmware upgrade command can be issued.. A reset command or power toggle will make X4M200 resume normal operation.

4 XeThru Adult Respiration Profile

4.1 Overview

The XeThru Adult Respiration Profile works by measuring the minute periodic movements of the human body while breathing. This Profile can be used to measure respiration both for a sleeping person in a bed with the sensor placed on a night stand, on the wall or in the ceiling, and for an awake person sitting still with the sensor placed at the height of the chest or abdomen pointing towards the chest or abdomen.

This Profile is intended for measuring respiration frequency of adult human beings and will enter Breathing state when the measured respiration frequency is between 8 and 30 Respirations per Minute (RPM).

The body part generating the best signal will vary from person to person. Some breathe shallowly, drawing air into the chest area and thus the largest movement will come from the chest. Others breathe deeper, expanding the abdomen rather than the chest. In this case, the abdomen will give the largest movement.

4.2 User Settings

4.2.1 Set Detection Zone

The Detection Zone is set by specifying the start and end of the Detection Zone. The end of the detection zone sets the maximum distance for presence and respiration detection, while the start of the detection zone sets the minimum distance.

Detection zone limits	
Minimum start of detection zone	0.40m
Maximum end of detection zone	5.00m
Minimum size of detection zone	0.20m
Maximum size of detection zone	4.60m



Step size between possible range settings is 5.14 cm. The desired detection zone can be set with 1 cm resolution. The actual detection zone will be set at the closest possible range setting before the lower range desired and the closest possible range setting after the upper range desired. The actual lower and upper range to be used by the sensor can be read back after setting the detection zone.

Movements closer to the sensor than the Detection Zone may trigger detection because of indirect reflection paths. Movements beyond the end of the detection zone will never trigger detection.

4.2.2 Sensitivity

Sensitivity settings	
Minimum sensitivity	0
Maximum sensitivity	9
Sensitivity step size	1

Higher sensitivity setting gives better sensing of small targets. Lower sensitivity makes the sensor more robust against false detections.

4.2.3 LED

The module has 1 multi-color RGB LED. The module LED can be configured between "Full" state indication, a "Simple" indication or "Off", which is convenient for sleep monitoring use.

Full

Initializing: Green (0.2sec) -> Orange (0.2sec) -> Red (0.3sec) -> Orange (0.2sec) -> Green (0.2sec) -> Off (0.3sec)

Breathing: Blue On/Off flashing 50% duty cycle. Period = RPM (not breathing pattern, RPM =15 means LED flashes 15 times/minute)

Movement tracking: Green (0.5sec) -> Blue (0.5sec)

Movement: Green (0.5sec) -> Orange (0.5sec)

No movement: Red (0.3sec) -> Off (4.7sec)

Simple

Initializing: Green (0.2sec) -> Orange (0.2sec) -> Red (0.3sec) -> Orange (0.2sec) -> Green (0.2sec) -> Off (0.3sec)

Breathing: Blue On

Movement tracking: Green On

Movement: Orange On

No movement: Red (0.3sec)-Off (4.7sec)

Off

Always: Off



4.2.4 Frequency Band

Low

In the low frequency band, X4M200 will operate in the 6.0 - 8.5 GHz band.

High

In the high frequency band, X4M200 will operate in the 7.25 - 10.20 GHz band.

4.2.5 Enable Noise Map

On

Enables noise map.

Off

Disables noise map. Detailed description of noise map in Firmware Algorithms section below.

4.2.6 Adaptive Noise Map

On

Enables Noise Map adaptation. Noise Map will still not adapt in certain conditions as described in Firmware Algorithms section below.

Off

Disables Noise Map adaptation.

4.2.7 Initialize Noise Map at Reset

On

A new Noise Map will always be created at reset or when the Profile is started. Sensor will be in Initialization state during Noise Map creation. A previously Stored Noise Map in the sensor will be ignored, but not overwritten, when the Profile starts.

Off

If a valid Stored Noise Map exists this will be used at reset or when the Profile is started. If no valid Stored Noise Map exists a new Noise Map will be created during Initialization state. The newly created Noise Map will be stored in the sensor when Initialization is done. A noise map created with a different Detection Zone is not valid.

4.2.8 Default User Settings

User Setting	Default value
Detection zone	0.40 - 5.00 m
Sensitivity	5



User Setting	Default value
LED	Full
Frequency band	Low
Enable Noise Map	On
Adaptive Noise Map	On
Initialize Noise Map at reset	On

4.3 Sensor Operation in Adult Respiration Profile

4.3.1 Detect Presence and Breathing

The X4M200 sensor detects presence within its detection zone by detecting movement and processing the data. Once the module detects movement, it will attempt to identify a breathing movement. The target person needs to be still in order to identify breathing movement properly.

If more than one person is present in the detection zone, the X4M200 sensor will measure the one who is closest to the sensor. If the intention is to not measure the closest person, the detection zone should be set to a minimum distance that excludes the closest person, but care should be taken since indirect reflection paths could lead to a closer person being read at a longer distance.

There are six states in the Respiration Profile:

- **No Movement** No presence detected
- **Movement:** Presence, but no identifiable breathing movement
- **Movement Tracking:** Presence and possible breathing movement detected
- **Breathing:** Valid breathing movement detected
- **Initializing:** The sensor initializes after the Respiration Profile is executed
- **Error:** The sensor is in an error state and requires a Profile and User Settings to be loaded

4.3.2 Measure Respiration Data

When running, the following data is reported:

- **State**

In all states except Initializing and Error states, the following data is measured:

- **MovementSlow:** Movements for the previous 20 seconds
- **MovementFast:** Movements for the previous 6 seconds

The movement metrics (MovementSlow and MovementFast) show the degree of movement as a relative number from 0 to 100 both for 5.14 cm intervals in the Detection Zone and for the entire Detection Zone. 0 means no Doppler cells above the detection threshold, while 100 means that all Doppler cells in the range interval are above the detection threshold.

When in Movement, Movement Tracking, or Breathing states, the following additional data is measured:



- **Distance to closest target:** Distance in meters to target closest to the sensor
- **RCS of closest target:** Radar Cross Section in dB(m²) as seen from X4M200
- **Signal Quality:** A relative number from 0 to 10 where 10 is best

When in Breathing state, the following additional data is measured:

- **RPM of closest breathing target:** Respirations per Minute
- **Distance to breathing target:** Distance in meters to target RPM is measured from
- **Breathing pattern of closest breathing target:** Detected respiratory movement in mm perpendicular to the X4M200

Distance to closest target and breathing target may be different even when only one target person is present in the Detection Zone. Distance to closest target measures the distance to the closest movements the sensor can see. Distance to breathing target measures the distance to where the respiration motion is seen. As an example, if the target person's hands are closer to the sensor than the chest or abdomen and have some minimal movement, distance to closest target will measure the distance to the hands and distance to breathing target will measure the distance to the chest or abdomen where the respiration motion is.

With two or more targets in the Detection Zone, different distance to closest target and distance to breathing target can also be experienced. As an example, if a still person is still at a longer distance than a second moving person closer to the sensor, the sensor may lock on the breathing of the person further away. In this case distance to closest target will be to the person moving closer to the sensor and distance to breathing target will be on the still person further away. Achieving breathing lock on a still person may be difficult if a moving person is closer to the sensor due to multiple direct path and multi path reflections from the closest moving person.

4.3.3 IO-pin Functionality

All units are shipped with IO-pin functionality off (inputs with pull-up).

When enabling IO-pins, the default functionality is:

Default IO-pin functions when enabled

IO-pin	Name	Direction	Functionality
IO1	MOVEMENT	Output	Low: Movement, Movement Tracking and Breathing states High: No Movement, Initializing and Unknown states
IO2	BREATHING	Output	Low: Breathing state High: All other states than Breathing
IO3		Input	Not in use. Do not connect
IO4		Input	Not in use. Do not connect
IO5		Input	Not in use. Do not connect
IO6		Input	Not in use. Do not connect

Each IO-pin has the following Pin Setup options:



- Input or output
- Open drain or push-pull
- Active high or active low
- Pull-up enable or disable

Each IO-pin can have one of these Pin Features:

- Disable all IO-pins. Using this feature overrides Pin Setup. Disabling all IO-pins means all IO-pins are input with pull-up.
- According to default functionality shown above. Using this feature overrides Pin Setup. Default IO-pin functionality also specifies which pins are inputs and outputs.
- Passive. Set and get IO-pin level over communication interface
- Movement. Function as described in table above, but can be set to any pin
- Breathing. Function as described in table above, but can be set to any pin

4.4 Detection Range

Detection range varies with the size of the target person and the angle between the sensor and the target person. The detection range varies with the size of the target person, the movement type of the target person and the angle between the sensor and the target person.

Detection range should not be confused with the user setting Detection Zone. Detection Zone defines at what range X4M200 is doing measurements. Detection range describes what can be detected inside the Detection Zone.

Characterization of Detection Range for various targets will be included here when available.

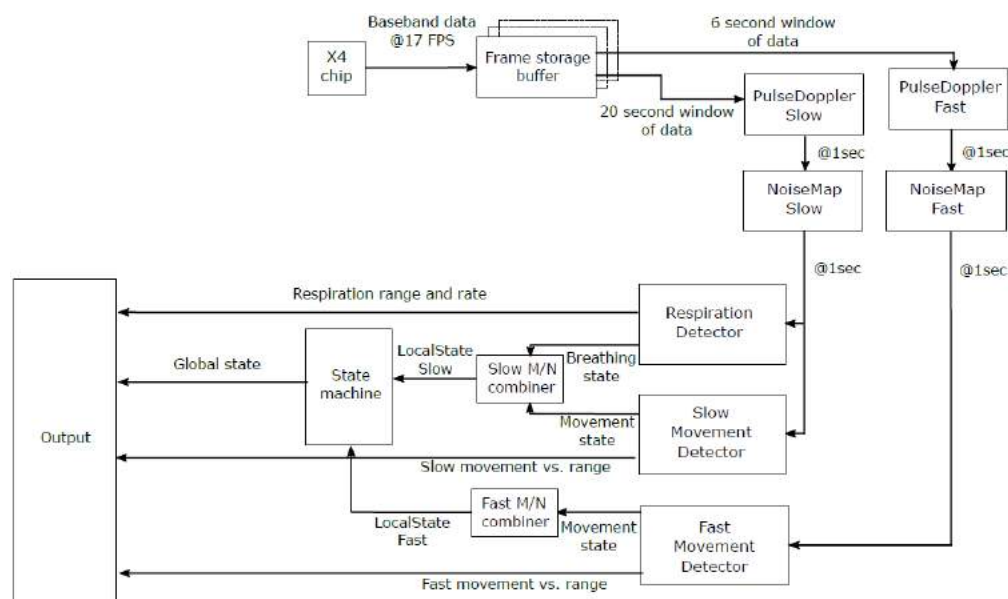
4.5 Detection Time

Typical detection time for this Profile is:

- From No Movement to Movement state: 3.5 - 9 seconds
- From Movement to No Movement state: 25 seconds
- From Movement to Breathing state: 25 seconds



4.6 Firmware Algorithms



Adult Respiration Profile signal processing block diagram

All firmware algorithms for movement detection and respiration measurements are running in the X4M200. The X4 UWB radar SoC is set up to provide 17 baseband data frames per second. The radar data frames are stored in a buffer. Two Range-Doppler matrices are running in parallel. The Slow Range-Doppler matrix is using the last 20 seconds of radar frames and the Fast Range-Doppler matrix is using the last 6 second of radar frames.

Both Range-Doppler matrices have individual Noise Maps to determine if a reflection at a certain distance and frequency is above a threshold. Creating and enabling a Noise Map will give different threshold values at different distances and frequencies and is recommended to achieve the best performance. If the Noise Maps are disabled a fixed threshold value will be used for all distances and frequencies, which in most cases will result in less sensitivity to small movements and higher risk of false detections.

The Noise Maps will adapt to changes in the environment unless Noise Map Adaptation is disabled. Noise Map adaptation works continuously and will over time remove presence detection of reflectors that are stationary. The Noise Map will not adapt if a still person with breathing frequency between 8 and 30 Respirations Per Minute (RPM) is detected.

The Fast Range-Doppler matrix with its Fast Movement Detector will detect presence quickly, typically when a person enters the Detection Zone. The Fast Movement Detector has two states, Movement or No Movement. The Fast M/N Combiner uses these states to determine the LocalStateFast. An M/N Combiner determines that M out of N detections need to be a certain value for the output to change.

Logic for Fast M/N Combiner

LocalStateFast	M/N
No Movement -> Movement	3/3
Movement -> No Movement	5/5



The Slow Range-Doppler matrix with its Slow Movement Detector and Respiration Detector will detect presence of stationary people and measure respiration rate and distance to the breathing target when the target person is still. The Slow Movement Detector and Respiration Detector have three states, Breathing, Movement and No Movement. The Slow M/N Combiner uses these states to determine the LocalStateSlow. An M/N Combiner determines that M out of N detections need to be a certain value for the output to change.

Logic for Slow M/N Combiner

LocalStateSlow	M/N
No Movement -> Movement	3/3
No Movement -> Breathing	3/3
Movement -> No Movement	5/5
Movement -> Breathing	6/7
Breathing -> No Movement	5/5
Breathing -> Movement	4/4

The State Machine determines the (global) State using the following logic.

Global state machine logic

LocalState Fast	LocalState Slow	Global state
Movement	Breathing	Breathing
No Movement	Breathing	Breathing
Movement	Movement	Movement
No Movement	Movement	Movement
Movement	No Movement	Movement
No Movement	No Movement	No Movement

4.6.1 Stored Noise Map

The Noise Map in use can be stored locally in the sensor. If a Stored Noise Map exists and User Setting Initialize Noise Map at Reset is off, the Stored Noise Map will be used.

If no valid Stored Noise Map exists, and User Setting Initialize Noise Map at Reset is off, a new Noise Map will be created during Initialization. This new Noise Map will also be stored locally in the sensor as the new Stored Noise Map.

The active Noise Map can become different than the Stored Noise Map due to Noise Map adaptation. The Stored Noise Map can be loaded as the active Noise Map during operation of the sensor without stopping the Profile or disrupting operation of the sensor.

The Stored Noise Map can be deleted without disrupting operation of the sensor. To initialize a new Noise Map, delete the Stored Noise Map, and then stop and start the Profile with User Setting Initialize Noise Map at Reset off. A new Noise Map will then be created during Initialization.

Only one Noise Map can be stored in the sensor.



The Stored Noise Map can be read and stored by the host and a new Stored Noise Map can be loaded over the serial interface.

4.6.2 Start-up Time

The Range-Doppler matrices are filled with radar data during Initialization state. This takes 20 seconds for the Slow Range-Doppler matrix. Creating a Noise Map takes 100 seconds. Total start-up time is 120 seconds when Noise Map is created and 20 seconds if a valid Stored Noise Map exists and User Setting Initialize Noise Map at Reset is off.

4.7 Baseband Data Output

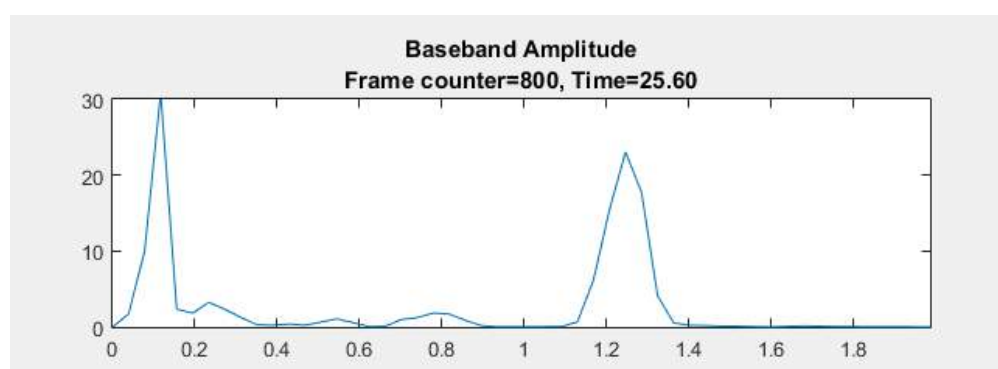
Baseband data is generated approximately 17 times per second and shows reflection at all distances in the Radar Frames used in 5.14 cm intervals.

The length and position of Radar Frames is controlled by the actual lower and upper range determined by the Detection Zone User Setting. The Radar Frame starts 5.14 cm before the actual lower range and ends 5.14 cm after the actual upper range.

Baseband data is available as an option on the communication port.

Baseband data outputs either amplitude and phase information of reflections, or the same data represented with I and Q values.

A Frame Counter is supplied with the Baseband Data. The Frame Counter increases by 1 for each radar frame that is output from the X4 UWB radar SoC. Stopping and starting a Profile does not reset the frame counter. Size of frame counter is 2^{32} . The frame counter wraps to 0 when it reaches the maximum. With 17 frames per second, the max value is reached in approximately 8 years. A reset of the X4 UWB radar SoC or a power toggle of the sensor module will reset the frame counter.



Example of baseband data output

The example above shows the amplitude of reflections plotted for a 2 meter Radar Frame. This particular measurement shows two reflections; the first reflection is about 0.1 meter into the Radar Frame, and the second reflection is about 1.2 meter into the Radar Frame.

Refer to application notes on www.xethru.com for more detailed descriptions on how to use baseband data output.

4.8 Pulse-Doppler Processing and Range-Doppler Data Output

X4M200 uses Pulse-Doppler processing as described in more detail here: https://en.wikipedia.org/wiki/Pulse-Doppler_signal_processing.



Pulse-Doppler processing results in Range-Doppler data, which can be output from X4M200. The data is represented as Range-Doppler matrices that show all reflections at different distances and frequencies over the last time period as specified in the Firmware Algorithm section for each Profile. All reflections with Doppler frequency 0 (static reflectors) are removed before the Pulse-Doppler processing.

5 XeThru Baby Respiration Profile

5.1 Overview

The XeThru Baby Respiration Profile works by measuring the minute periodic movements of the human body while breathing. This Profile can be used to measure respiration both for a sleeping person in a bed with the sensor placed on a night stand, on the wall or in the ceiling, and for an awake person sitting still with the sensor placed at the height of the chest or abdomen pointing towards the chest or abdomen.

This Profile is intended for measuring respiration frequency of babies and small children and will enter Breathing state when the measured respiration frequency is between 15 and 65 Respirations per Minute (RPM).

The body part generating the best signal will vary from person to person. Some breathe shallowly, drawing air into the chest area and thus the largest movement will come from the chest. Others breathe deeper, expanding the abdomen rather than the chest. In this case, the abdomen will give the largest movement.

5.2 User Settings

5.2.1 Set Detection Zone

The Detection Zone is set by specifying the start and end of the Detection Zone. The end of the detection zone sets the maximum distance for presence and respiration detection, while the start of the detection zone sets the minimum distance.

Detection zone limits	
Minimum start of detection zone	0.40 m
Maximum end of detection zone	5.00 m
Minimum size of detection zone	0.20 m
Maximum size of detection zone	4.60 m

Step size between possible range settings is 5.14 cm. The desired detection zone can be set with 1 cm resolution. The actual detection zone will be set at the closest possible range setting before the lower range desired and the closest possible range setting after the upper range desired. The actual lower and upper range to be used by the sensor can be read back after setting the detection zone.



Movements closer to the sensor than the Detection Zone may trigger detection because of indirect reflection paths. Movements beyond the end of the detection zone will never trigger detection.

5.2.2 Sensitivity

Sensitivity settings	
Minimum sensitivity	0
Maximum sensitivity	9
Sensitivity step size	1

Higher sensitivity setting gives better sensing of small targets. Lower sensitivity makes the sensor more robust against false detections.

5.2.3 LED

The module has 1 multi-color RGB LED. The module LED can be configured between "Full" state indication, a "Simple" indication or "Off", which is convenient for sleep monitoring use.

Full

Initializing: Green (0.2sec) -> Orange (0.2sec) -> Red (0.3sec) -> Orange (0.2sec) -> Green (0.2 sec) -> Off (0.3sec)

Breathing: Blue On/Off flashing 50% duty cycle. Period = RPM (not breathing pattern, RPM =15 means LED flashes 15 times/minute)

Movement tracking: Green (0.5sec) -> Blue (0.5sec)

Movement: Green (0.5sec) -> Orange (0.5sec)

No movement: Red (0.3sec) -> Off (4.7sec)

Simple

Initializing: Green (0.2sec) -> Orange (0.2sec) -> Red (0.3sec) -> Orange (0.2sec) -> Green (0.2 sec) -> Off (0.3sec)

Breathing: Blue On

Movement tracking: Green On

Movement: Orange On

No movement: Red (0.3sec)-Off (4.7sec)

Off

Always: Off

5.2.4 Frequency Band

Low

In the low frequency band, X4M200 will operate in the 6.0 - 8.5 GHz band.

High



In the high frequency band, X4M200 will operate in the 7.25 - 10.20 GHz band.

5.2.5 Enable Noise Map

On

Enables noise map.

Off

Disables noise map. Detailed description of noise map in Firmware Algorithms section below.

5.2.6 Adaptive Noise Map

On

Enables Noise Map adaptation. Noise Map will still not adapt in certain conditions as described in Firmware Algorithms section below.

Off

Disables Noise Map adaptation.

5.2.7 Initialize Noise Map at Reset

On

A new Noise Map will always be created at reset or when the Profile is started. Sensor will be in Initialization state during Noise Map creation. A previously Stored Noise Map in the sensor will be ignored, but not overwritten, when the Profile starts.

Off

If a valid Stored Noise Map exists this will be used at reset or when the Profile is started. If no valid Stored Noise Map exists a new Noise Map will be created during Initialization state. The newly created Noise Map will be stored in the sensor when Initialization is done. A noise map created with a different Detection Zone is not valid.

5.2.8 Default User Settings

User Setting	Default value
Detection zone	0.40 - 5.00 m
Sensitivity	5
LED	Full
Frequency band	Low
Enable Noise Map	On
Adaptive Noise Map	On



User Setting	Default value
Initialize Noise Map at reset	On

5.3 Sensor Operation in Baby Respiration Profile

5.3.1 Detect Presence and Breathing

The X4M200 sensor detects presence within its detection zone by detecting movement and processing the data. Once the module detects movement, it will attempt to identify a breathing movement. The target person needs to be still in order to identify breathing movement properly.

If more than one person is present in the detection zone, the X4M200 sensor will measure the one who is closest to the sensor. If the intention is to not measure the closest person, the detection zone should be set to a minimum distance that excludes the closest person, but care should be taken since indirect reflection paths could lead to a closer person being read at a longer distance.

There are six states in the Respiration Profile:

- **No Movement** No presence detected
- **Movement:** Presence, but no identifiable breathing movement
- **Movement Tracking:** Presence and possible breathing movement detected
- **Breathing:** Valid breathing movement detected
- **Initializing:** The sensor initializes after the Respiration Profile is executed
- **Error:** The sensor is in an error state and requires a Profile and User Settings to be loaded

5.3.2 Measure Respiration Data

When running, the following data is reported:

- **State**

In all states except Initializing and Error states, the following data is measured:

- **MovementSlow:** Movements for the previous 15 seconds
- **MovementFast:** Movements for the previous 6 seconds

The movement metrics (MovementSlow and MovementFast) show the degree of movement as a relative number from 0 to 100 both for 5.14 cm intervals in the Detection Zone and for the entire Detection Zone. 0 means no Doppler cells above the detection threshold, while 100 means that all Doppler cells in the range interval are above the detection threshold.

When in Movement, Movement Tracking, or Breathing states, the following additional data is measured:

- **Distance to closest target:** Distance in meters to target closest to the sensor
- **RCS of closest target:** Radar Cross Section in $\text{dB}(\text{m}^2)$ as seen from X4M200
- **Signal Quality:** A relative number from 0 to 10 where 10 is best

When in Breathing state, the following additional data is measured:

- **RPM of closest breathing target:** Respirations per Minute



- **Distance to breathing target:** Distance in meters to target RPM is measured from
- **Breathing pattern of closest breathing target:** Detected respiratory movement in mm perpendicular to the X4M200

Distance to closest target and breathing target may be different even when only one target person is present in the Detection Zone. Distance to closest target measures the distance to the closest movements the sensor can see. Distance to breathing target measures the distance to where the respiration motion is seen. As an example, if the target person's hands are closer to the sensor than the chest or abdomen and have some minimal movement, distance to closest target will measure the distance to the hands and distance to breathing target will measure the distance to the chest or abdomen where the respiration motion is.

With two or more targets in the Detection Zone, different distance to closest target and distance to breathing target can also be experienced. As an example, if a still person is still at a longer distance than a second moving person closer to the sensor, the sensor may lock on the breathing of the person further away. In this case distance to closest target will be to the person moving closer to the sensor and distance to breathing target will be on the still person further away. Achieving breathing lock on a still person may be difficult if a moving person is closer to the sensor due to multiple direct path and multi path reflections from the closest moving person.

5.3.3 IO-pin Functionality

All units are shipped with IO-pin functionality off (inputs with pull-up).

When enabling IO-pins, the default functionality is:

Default IO-pin functions when enabled

IO-pin	Name	Direction	Functionality
IO1	MOVEMENT	Output	Low: Movement, Movement Tracking and Breathing states High: No Movement, Initializing and Unknown states
IO2	BREATHING	Output	Low: Breathing state High: All other states than Breathing
IO3		Input	Not in use. Do not connect
IO4		Input	Not in use. Do not connect
IO5		Input	Not in use. Do not connect
IO6		Input	Not in use. Do not connect

Each IO-pin has the following Pin Setup options:

- Input or output
- Open drain or push-pull
- Active high or active low
- Pull-up enable or disable

Each IO-pin can have one of these Pin Features:



- Disable all IO-pins. Using this feature overrides Pin Setup. Disabling all IO-pins means all IO-pins are input with pull-up.
- According to default functionality shown above. Using this feature overrides Pin Setup. Default IO-pin functionality also specifies which pins are inputs and outputs.
- Passive. Set and get IO-pin level over communication interface
- Movement. Function as described in table above, but can be set to any pin
- Breathing. Function as described in table above, but can be set to any pin

5.4 Detection Range

Detection range varies with the size of the target person and the angle between the sensor and the target person. The detection range varies with the size of the target person, the movement type of the target person and the angle between the sensor and the target person.

Detection range should not be confused with the user setting Detection Zone. Detection Zone defines at what range X4M200 is doing measurements. Detection range describes what can be detected inside the Detection Zone.

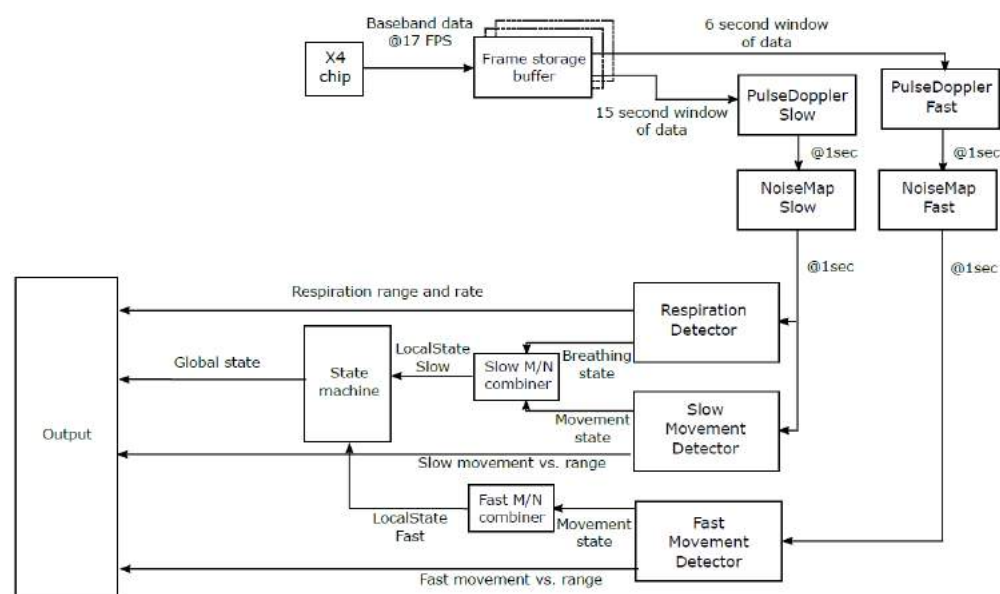
Characterization of Detection Range for various targets will be included here when available.

5.5 Detection Time

Typical detection time for this Profile is:

- From No Movement to Movement state: 3.5 - 9 seconds
- From Movement to No Movement state: 20 seconds
- From Movement to Breathing state: 20 seconds

5.6 Firmware Algorithms



Baby Respiration Profile signal processing block diagram

All firmware algorithms for movement detection and respiration measurements are running in the X4M200. The X4 UWB radar SoC is set up to provide 17 baseband data frames per second. The radar data frames are stored in a buffer. Two Range-Doppler matrices are running in parallel. The Slow Range-Doppler matrix is using the last 15 seconds of radar frames and the Fast Range-Doppler matrix is using the last 6 second of radar frames.



Both Range-Doppler matrices have individual Noise Maps to determine if a reflection at a certain distance and frequency is above a threshold. Creating and enabling a Noise Map will give different threshold values at different distances and frequencies and is recommended to achieve the best performance. If the Noise Maps are disabled a fixed threshold value will be used for all distances and frequencies, which in most cases will result in less sensitivity to small movements and higher risk of false detections.

The Noise Maps will adapt to changes in the environment unless Noise Map Adaptation is disabled. Noise Map adaptation works continuously and will over time remove presence detection of reflectors that are stationary. The Noise Map will not adapt if a still person with breathing frequency between 15 and 65 Respirations Per Minute (RPM) is detected.

The Fast Range-Doppler matrix with its Fast Movement Detector will detect presence quickly, typically when a person enters the Detection Zone. The Fast Movement Detector has two states, Movement or No Movement. The Fast M/N Combiner uses these states to determine the LocalStateFast. An M/N Combiner determines that M out of N detections need to be a certain value for the output to change.

Logic for Fast M/N Combiner

LocalStateFast	M/N
No Movement -> Movement	3/3
Movement -> No Movement	5/5

The Slow Range-Doppler matrix with its Slow Movement Detector and Respiration Detector will detect presence of stationary people and measure respiration rate and distance to the breathing target when the target person is still. The Slow Movement Detector and Respiration Detector have three states, Breathing, Movement and No Movement. The Slow M/N Combiner uses these states to determine the LocalStateSlow. An M/N Combiner determines that M out of N detections need to be a certain value for the output to change.

Logic for Slow M/N Combiner

LocalStateSlow	M/N
No Movement -> Movement	3/3
No Movement -> Breathing	3/3
Movement -> No Movement	5/5
Movement -> Breathing	6/7
Breathing -> No Movement	5/5
Breathing -> Movement	4/4

The State Machine determines the (global) State using the following logic.

Global state machine logic

LocalState Fast	LocalState Slow	Global state
Movement	Breathing	Breathing
No Movement	Breathing	Breathing



LocalState Fast	LocalState Slow	Global state
Movement	Movement	Movement
No Movement	Movement	Movement
Movement	No Movement	Movement
No Movement	No Movement	No Movement

5.6.1 Stored Noise Map

The Noise Map in use can be stored locally in the sensor. If a Stored Noise Map exists and User Setting Initialize Noise Map at Reset is off, the Stored Noise Map will be used.

If no valid Stored Noise Map exists, and User Setting Initialize Noise Map at Reset is off, a new Noise Map will be created during Initialization. This new Noise Map will also be stored locally in the sensor as the new Stored Noise Map.

The active Noise Map can become different than the Stored Noise Map due to Noise Map adaptation. The Stored Noise Map can be loaded as the active Noise Map during operation of the sensor without stopping the Profile or disrupting operation of the sensor.

The Stored Noise Map can be deleted without disrupting operation of the sensor. To initialize a new Noise Map, delete the Stored Noise Map, and then stop and start the Profile with User Setting Initialize Noise Map at Reset off. A new Noise Map will then be created during Initialization.

Only one Noise Map can be stored in the sensor.

The Stored Noise Map can be read and stored by the host and a new Stored Noise Map can be loaded over the serial interface.

5.6.2 Start-up Time

The Range-Doppler matrices are filled with radar data during Initialization state. This takes 15 seconds for the Slow Range-Doppler matrix. Creating a Noise Map takes 105 seconds. Total start-up time is 120 seconds when Noise Map is created and 15 seconds if a valid Stored Noise Map exists and User Setting Initialize Noise Map at Reset is off.

5.7 Baseband Data Output

Baseband data is generated approximately 17 times per second and shows reflection at all distances in the Radar Frames used in 5.14 cm intervals.

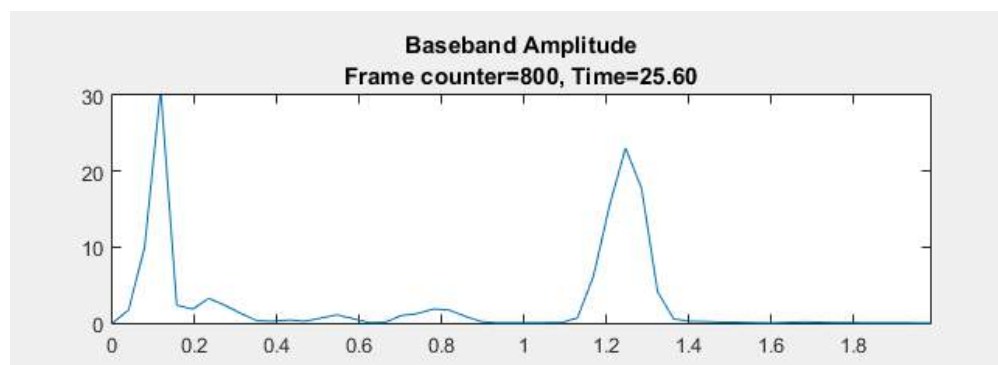
The length and position of Radar Frames is controlled by the actual lower and upper range determined by the Detection Zone User Setting. The Radar Frame starts 5.14 cm before the actual lower range and ends 5.14 cm after the actual upper range.

Baseband data is available as an option on the communication port.

Baseband data outputs either amplitude and phase information of reflections, or the same data represented with I and Q values.



A Frame Counter is supplied with the Baseband Data. The Frame Counter increases by 1 for each radar frame that is output from the X4 UWB radar SoC. Stopping and starting a Profile does not reset the frame counter. Size of frame counter is 2^{32} . The frame counter wraps to 0 when it reaches the maximum. With 17 frames per second, the max value is reached in approximately 8 years. A reset of the X4 UWB radar SoC or a power toggle of the sensor module will reset the frame counter.



Example of baseband data output

The example above shows the amplitude of reflections plotted for a 2 meter Radar Frame. This particular measurement shows two reflections; the first reflection is about 0.1 meter into the Radar Frame, and the second reflection is about 1.2 meter into the Radar Frame.

Refer to application notes on www.xethru.com for more detailed descriptions on how to use baseband data output.

5.8 Pulse-Doppler Processing and Range-Doppler Data Output

X4M200 uses Pulse-Doppler processing as described in more detail here: https://en.wikipedia.org/wiki/Pulse-Doppler_signal_processing.

Pulse-Doppler processing results in Range-Doppler data, which can be output from X4M200. The data is represented as Range-Doppler matrices that show all reflections at different distances and frequencies over the last time period as specified in the Firmware Algorithm section for each Profile. All reflections with Doppler frequency 0 (static reflectors) are removed before the Pulse-Doppler processing.

6 Certification Mode

6.1 Overview

X4M200 can be set in Certification Mode to test compliance with regulations.

6.2 Certification Modes

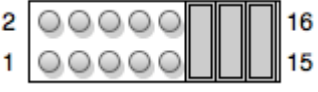

Various certification modes can be set either using the communication interface or by using jumpers or similar to short pins on the 16-pin XeThru Interface Connector.

Certification Mode	Jumper Setting	Description
--------------------	----------------	-------------



Certification Mode	Jumper Setting	Description
Tx Only		<p>Enables continuous UWB transmission, with all other activities disabled. Meaning that only the digital circuitry needed for operating the UWB transmitter, and the UWB transmitter is enabled. This mode is used to demonstrate the isolated emissions from the UWB transmitter, and the emissions generated by the digital circuitry needed to enable UWB transmission. The UWB transmitter must be set to continuous worst case transmission, i.e. that a pulse is sent at every PRI interval for the given chip setting, to maximize the average energy emitted from the module. LED is off in this mode to minimize noise.</p>
Tx Only Digital		<p>Enables only the digital part used for continuous UWB transmitting, with all other activities disabled. The exact same settings as Tx only mode is used, but with the UWB transmitter disabled. This mode demonstrates radiated emissions from digital circuitry used to enable operation of the UWB transmitter. These emissions should comply with FCC 15.521, § 15.209. LED is off in this mode to minimize noise.</p>
Stream Tx Off		<p>Disables continuous UWB transmitting, while associated digital devices used to control additional functions or capabilities on module is operating. This mode is used to demonstrate emissions from unintentional radiators not needed for, or generated by, UWB transmission. LED is orange in this mode.</p>
Stream		<p>Normal operation of the module with both UWB transmitter and associated digital devices, used to control additional functions or capabilities on module, activated. This mode is used to demonstrate typical emissions from a module during normal operation. LED is orange in this mode.</p>



Certification Mode	Jumper Setting	Description
Rx Fail Detection		<p>In normal operation, the FW monitors the sampler outputs to ensure acknowledgement of reception. If no such acknowledgement is received, the EUT will shut down the transmitter within 10 seconds.</p> <p>During certification test, this situation can be provoked / emulated by forcing the receiver to not provide an acknowledgement of reception. The procedure is as follows: 1. Power off the device. 2. Set the EUT in Stream mode by the appropriate jumpers (11/12 and 15/16). 3. Power up the device by connecting the USB cable. The EUT should now emulate normal operation. 4. Set RX Fail emulation jumper (13/14), this will emulate a missing acknowledgement within 3 seconds. 5. TX should now be shut down by the standard FW.</p> <p>Alternatively, all three jumpers may be set in step 2 and then power up and omit step 4. The EUT will start transmitting and within maximum 10 seconds shut down. LED is orange in this mode.</p>
End Certification Test		<p>Setting this jumper setting while the device is powered will return the module to normal operation after the execution of a power cycle. The module will then respond to the normal API over USB. Note that the EUT may be brought back to any other test mode by the appropriate jumper setting. LED is orange in this mode.</p>

7 Firmware versions

The firmware version can be read over the serial interface. All firmware versions support upgrading to a different firmware version.

In addition to the firmware versions described in this section, additional firmware versions with potential error corrections and stability improvements should be expected.

7.1 X4M200 Version 1.2.1

The following functions are supported:

- Baseband data
- Distance to closest target
- Distance to breathing target
- RPM for closest target
- RCS for closest target
- MovementFast and MovementSlow data
- Store Noise Map to sensor



- Delete Stored Noise Map in sensor
- Choice between using stored Noise Map or initializing new Noise Map at reset
- Noise Map always enabled
- Noise Map always adapts
- Only the low frequency band can be used

Baby Respiration Profile has limited testing on real babies and children. This Profile should be used for evaluation only with this FW version.

7.2 X4M200 Version 1.3.1

All functions from previous firmware version.

Added features from previous version:

- Breathing pattern of closest breathing target
- Pulse-Doppler data output

Baby Respiration Profile has limited testing on real babies and children. This Profile should be used for evaluation only with this FW version.

7.3 X4M200 Version 1.4.7

Added features from previous version:

- GPIO functions
- USRT communication mode

See errata section for bug fixes. Baby Respiration Profile has limited testing on real babies and children. This Profile should be used for evaluation only with this FW version.

7.4 X4M200 Version 1.x

All functions from previous firmware version with exception of noise map that will not initiate at reset if this is not selected in User Settings.

The additional functions are also supported:

- Enable / disable Noise Map (Previous versions always enable Noise Map)
- Enable / disable Noise Map adaption (Previous versions always enable Noise Map adaption)
- Load a Stored Noise Map into active Noise Map in sensor
- Load and Store Noise Map to host

7.5 Future versions of X4M200

Some of these features may be introduced as a new Profile not yet documented in this datasheet.

- Detection list for all moving targets in detection zone
- RPM for multiple targets in detection zone
- Radar Cross Section for all moving targets in detection zone
- Selection between low and high frequency band

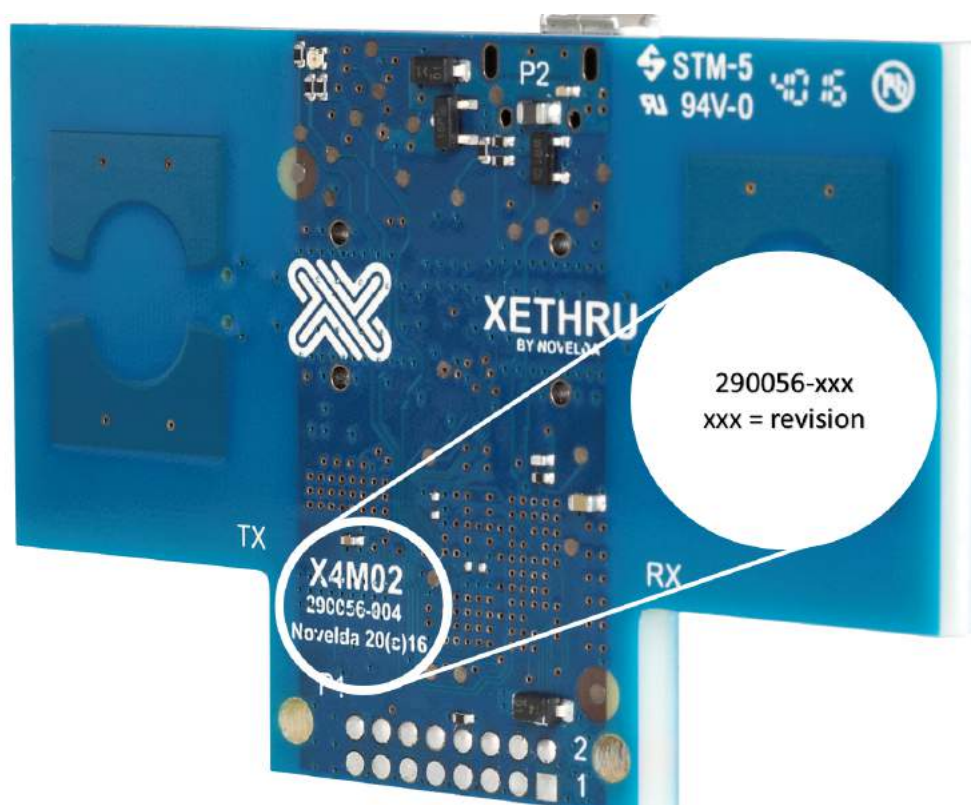


8 X4M200 HW Revisions

X4M200 uses the X4M02 hardware. This section describes all HW revisions of X4M02 that has been used in production, the difference between them and how to identify what HW revision your X4M200 is.

Some FW versions may require a specific HW revision. If applicable, this will be described in the FW version section of this datasheet.

8.1 Identifying HW revision



How to identify HW revision of X4M02

8.2 X4M02 Revision 4

Initial HW revision used for production of X4M300.

8.3 X4M02 Revision 5

- Added WiFi filter on Tx antenna.

Functionality is identical with previous HW revisions.

8.4 X4M02 Revision 6

Initial HW revision used for production of X4M200.



- MCU change from 1MB to 2MB version.

Functionality is identical with previous HW revisions.

8.5 X4M02 Revision 10

This HW revisions is required to meet the requirements for FCC and ETSI regulation.

- Added metal shield box on X4 UWB radar SoC.
- Replaced 12 MHz crystal with 12 MHz oscillator.
- Added components for EMI suppression.
- Added additional decoupling for MCU and SDRAM.
- Added filter on VDDPLLUSB domain.
- Improved MCU power delivery routing.
- Increased thickness of inner copper layers from 17 to 35 μm .

Functionality is identical with previous HW revisions.

9 Software Resources

9.1 XeThru Explorer

The XeThru Explorer application is a visual presentation of the protocol and data output from the sensor. It also allows for storing the measured data into a log file.

Firmware upgrades of X4M200 are deployed with new versions of XeThru Explorer.

XeThru Explorer can be downloaded from www.xethru.com.

9.2 XeThru Module Connector

The XeThru Module Connector is a software used to communicate with all XeThru radar sensor modules from a host computer through a serial interface. XeThru Module Connector makes a complete API of the modules available in host environments such as MATLAB, Python, C++ and C. This makes it easy to start streaming and analyzing radar data on multiple levels (raw radar data, baseband data, pulse doppler data, detection lists, respiration and presence) and directly to an environment ideally suited for development of new algorithms.

XeThru Module Connector includes a SW API that implements the serial protocol of X4M200 .

XeThru Module Connector can be downloaded from www.xethru.com.

9.3 Module Communication Protocol Wrapper (MCP Wrapper)

Module Communication Protocol (MCP) is the lowest level communication protocol implementation for the XeThru modules, used on the module FW and XeThru host components, e. g. Module Connector. The MCP Wrapper goes one step further for embedded host implementation adding a wrapper with convenience methods around the MCP. Compared to Module Connector, which is a more feature rich component with logging and buffering capabilities, MCP Wrapper offers a similar interface with only the basic transport methods wrapped in a more easy-to-use interface.



Typical use for the MCP Wrapper is when implementing a host application communicating with a XeThru module on an embedded target that does not need or have the Module Connector available .

MCP Wrapper is implemented in C. Example code is available in C and C++.

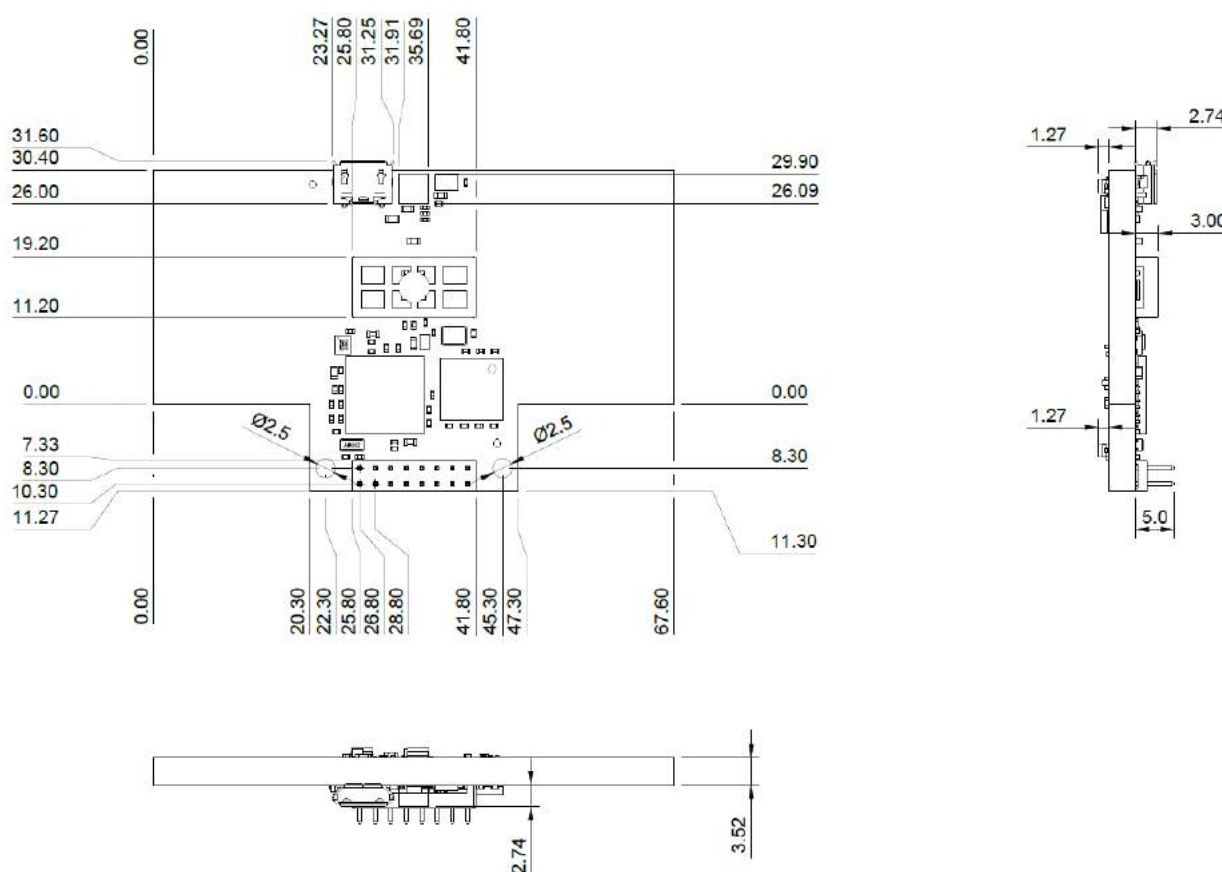
MCP Wrapper can be downloaded from www.xethru.com.

9.4 X4M200 Firmware Binary

Firmware upgrades of X4M200 can be done by using Module Connector, MCP Wrapper or any other custom implementation of the serial protocol in a scenario where the modules are deployed. In this case, the module firmware file that is used during firmware upgrade is needed.

X4M200 firmware binary (Annapurna) can be downloaded from www.xethru.com.

10 Mechanical Data



Mechanical drawing of the sensor module (in mm)

11 Electrical Specification

Parameter	Value	Comment
Supply Voltage VDD_EXT	3.3 - 5.5V	



Parameter	Value	Comment
Supply Voltage USB	4.5 - 5.5V	
IO-voltage range, nominal	-0.3 - 3.3V	
V _{IH} min	2.0V	Minimum input high threshold voltage
V _{IL} max	0.8V	Maximum input low threshold voltage
Typical power consumption	TBD mW	Expected around 600 mW
Operating Temperature range	0°C to +85°C	

12 X4M200 Interface Options

12.1 16-pin XeThru Interface Connector

The X4M200 has a 16-pin connector intended for interfacing a host board.

12.1.1 Pin Descriptions

Pin descriptions

Pin no	Description	Name	Type	Usage
1	Power, 3.3-5.5V	VDD_EXT	Power	Module power input
2	Power, GND	GND	Power	Module power input
3	USART RX / Force Bootloader	RX / BOOT	Input	USART receive / Holding pin 3 low during reset or power-up will force the unit into bootloader mode
4	USART TX	TX	Output	USART transmit
5	MODE SELECT 1 / USART SCK	MODESEL1	Input with pull-up	Mode select pin 1, ref table below for details / USART serial clock (USRT mode only)
6	MODE SELECT 2	MODESEL2	Input with pull-up	Mode select pin 2, ref table below for details
7	Reset	nRESET	Input with pull-up	Active low module MCU reset
8	No Connect	N.C	N/A	Leave unconnected



Pin no	Description	Name	Type	Usage
9	No Connect	N.C	N/A	Leave unconnected
10	No Connect	N.C	N/A	Leave unconnected
11	IO1	IO1	I/O	Functionality is Profile specific
12	IO2	IO2	I/O	Functionality is Profile specific
13	IO3	IO3	I/O	Functionality is Profile specific
14	IO4	IO4	I/O	Functionality is Profile specific
15	IO5	IO5	I/O	Functionality is Profile specific
16	IO6	IO6	I/O	Functionality is Profile specific

The connector is a 2x8 2.00mm pitch male pin header.

12.2 USB Connector

The X4M200 is fitted with a USB micro type B connector type supporting USB 2.0 High Speed.

12.3 Communication Modes

The sensor module will always use USB communication if USB power is present.

Additional communication modes can be selected at power-up or reset. The procedure is as follows seen from the host system outside the sensor:

1. Assert nRESET (set low for at least 1ms)
2. Set communication mode according to table below on pin 5 and 6.
3. Release nRESET (set high)
4. Hold communication mode level for minimum 2 seconds.
5. Set IO configuration of pins 3, 4, 5 and 6 to comply with the selected communication mode.
6. Selected communication is now activated on the sensor module

When USB is used this takes precedence over the table below. The use of USB is detected by the presence of power at the USB 5V power wire at startup. To change communication mode X4M200 need to be reset.

Mode	MODESEL1 (Pin 5)	MODESEL2 (Pin 6)	Comments
Reserved	Low	Low	Not supported
Reserved	Low	High	Not supported
USRT	High	Low	X4M200 is USRT slave



Mode	MODESEL1 (Pin 5)	MODESEL2 (Pin 6)	Comments
UART	High/Open (*)	High/Open (*)	Default UART settings are 115200 baud rate, 8 data bits, 1 stop bit , no parity This is the default mode. Enabled when pin 5 and pin 6 are left open.

(*) MODESEL1 and MODESEL2 has pull-up resistors and can be left open if a "High" is required.

Not supported modes should not be selected. Future firmware versions may use these modes.

12.4 Power System

There are 2 possible ways to power the sensor: Through pins 1 and 2 on the 16-pin interface connector or via USB. Both power sources may be connected at the same time. When powering via the USB connector this will always take precedence over the 16-pin connector.

13 Schematics and Bill of Material

Schematics and Bill of Material for X4M200 is available from www.xethru.com.

14 Module User Guide

14.1 Placing the Sensor Module

The sensor module should be protected from environmental surroundings such as moisture. Most firmware algorithms assumes the sensor to be still with no movement or vibrations during operation.

When placing the sensor, pay attention to the following:

- Point the sensor in the direction of the object or zone to monitor
- Be aware of indirect reflections. An object 1 meter away may also give additional reflections via the floor, the ceiling or walls at longer distances
- Nearby metallic objects should be avoided, especially in the signal path to the sensor's observation area
- The sensor can be placed on static (non-moving) surfaces such as:
 - On a desk
 - On a wall
 - Behind a wall (*)
 - In the ceiling
 - Behind the ceiling (*)

Firmware algorithms in the sensor module are sensitive to vibrations. If vibrations occur, the sensor may report movement in an empty detection zone.

If a sensor casing is required, the material should be of a kind that does not attenuate the high frequency signals in the sensor's main direction. Recommended materials are ABS and other types of non-conductive plastics (*).



(*): Different materials will attenuate the signal. Application note regarding this topic is found at www.xethru.com.

14.2 Connecting the X4M200 to a host system

The X4M200 can be connected to a host system in several ways:

1. Via USB
2. Via the interface connector using the UART interface
3. Via the interface connector using the USRT interface. X4M200 will be a USRT slave.

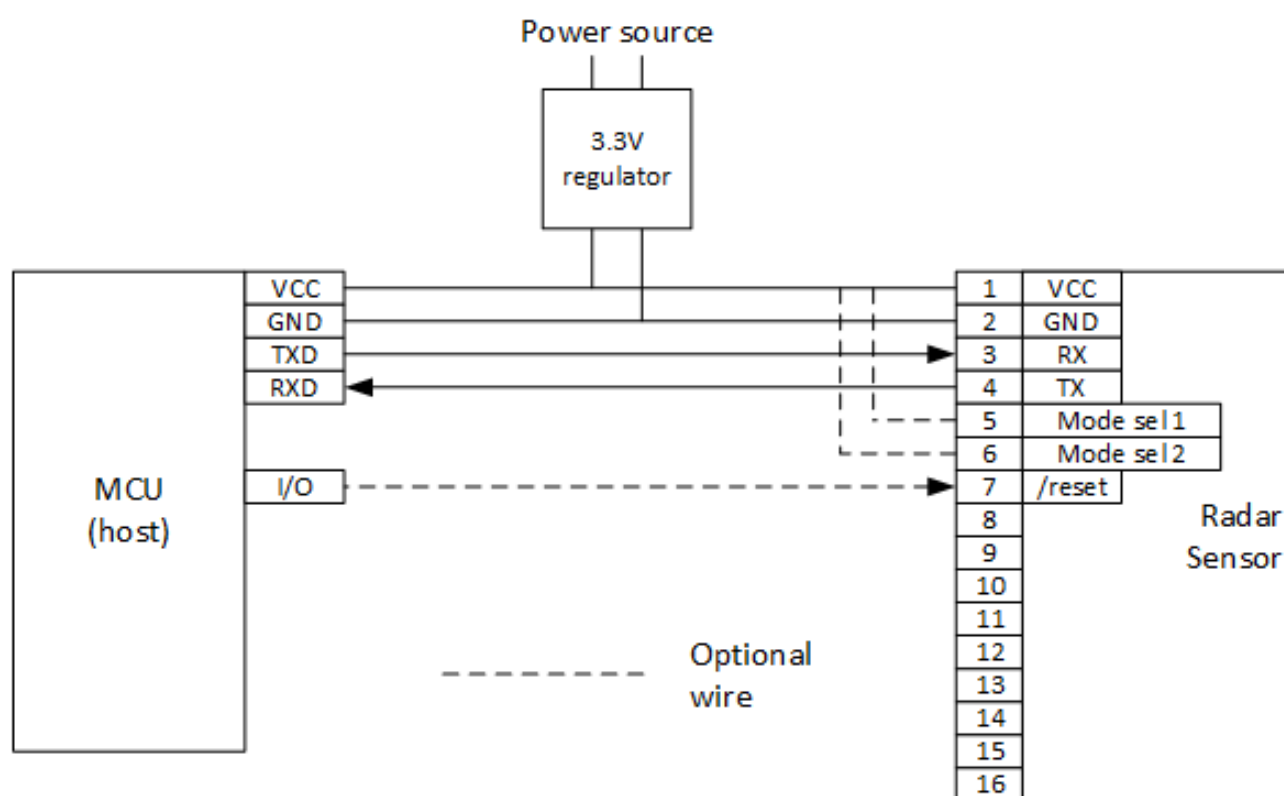
Some Profiles have GPIO interface that can be enabled and operate as the only control interface for a sensor module. The GPIO interface is described in the Profile chapters of this datasheet.

Bootloader for firmware updates only supports USB and UART.

14.2.1 Interfacing via USB

When interfacing via USB this interface will take presence over other interfaces.

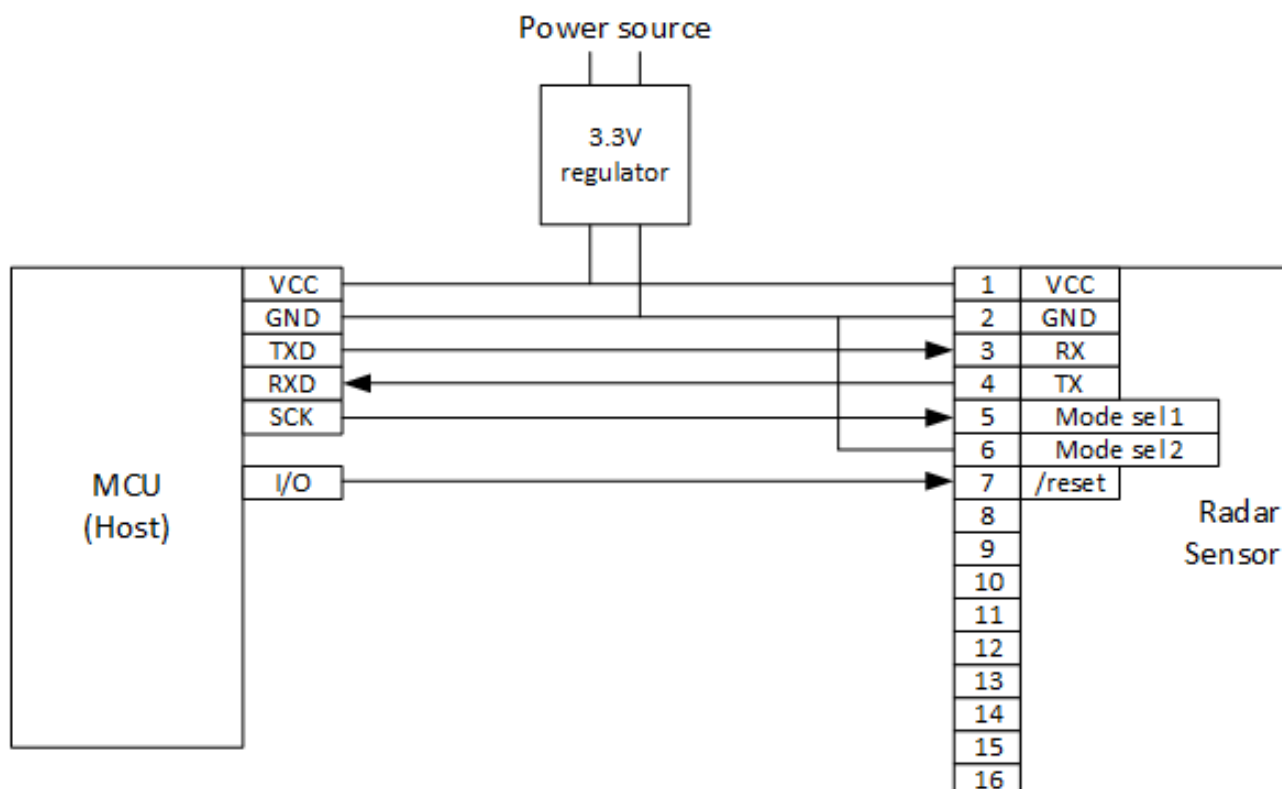
14.2.2 Interfacing via UART



Simplified schematics of host MCU using UART mode

14.2.3 Interfacing via USRT

The USRT mode is using a clock line in addition to RX and TX lines.



Simplified schematics of host MCU using USRT mode

14.2.4 Reset control of X4M200

Reset control from host is required for:

- Force bootloader function
- Exit from certain certification modes
- Selecting communication mode. UART is used if communication mode is not selected.

14.3 Upgrading the Firmware Using the Bootloader

The module's firmware may be updated over USB or UART.

LED will be purple during firmware upgrades.

15 Regulatory Approval

X4M200 is designed to meet UWB RF specifications of ETSI (Europe), FCC (USA), IC (Canada) KCC (Korea) and MIC (Japan).

This datasheet may describe several variants of X4M200 with different ordering codes. Not all ordering codes will meet all regulatory specifications.

Some regulatory specifications also specify how the sensor is used. Users of X4M200 must check regulatory requirements for their own use case and determine whether the regulatory approvals obtained from Novelda are sufficient for their product.



15.1 CE / ETSI Approval

English:

Hereby, **Novelda AS** declares that the radio equipment type X4M200 is in compliance with Directive 2014/53/EU. The full text of the EU declaration of conformity is available below.

Suomi:

Novelda AS vakuuttaa, että radiolaitetyyppi X4M200 on direktiivin 2014/53/EU mukainen. EU-vaatimustenmukaisuusvakuutuksen koko teksti on saatavilla alla.

Nederlands:

Hierbij verklaar ik, **Novelda AS**, dat het type radioapparatuur X4M200 conform is met Richtlijn 2014/53/EU. De volledige tekst van de EU-conformiteitsverklaring is hieronder beschikbaar.

Français:

Le soussigné, **Novelda AS**, déclare que l'équipement radioélectrique du type X4M200 est conforme à la directive 2014/53/UE. Le texte intégral de la déclaration de conformité de l'UE est disponible ci-dessous.

Svenska:

Härmed försäkrar **Novelda AS** att denna typ av radioutrustning X4M200 överensstämmer med direktiv 2014/53/EU. Den fullständiga texten till EU-försäkran om överensstämmelse finns nedan.

Dansk:

Hermed erklærer **Novelda AS**, at radioudstyrstypen X4M200 er i overensstemmelse med direktiv 2014/53/EU. EU-overensstemmelseserklæringens fulde tekst kan findes nedenfor.

Deutsch:

Hiermit erklart **Novelda AS**, dass der Funkanlagentyp X4M200 der Richtlinie 2014/53/EU entspricht. Der vollständige Text der EU-Konformitätserklärung finden Sie weiter unten.

Ελληνικά:

Με την παρούσα ο/η **Novelda AS**, δηλώνει ότι ο ραδιοεξοπλισμός X4M200 πληροί την οδηγία 2014/53/ΕΕ. Το πλήρες κείμενο της δήλωσης συμμόρφωσης της ΕΕ είναι διαθέσιμο παρακάτω.

Italiano:

Il fabbricante, **Novelda AS**, dichiara che il tipo di apparecchiatura radio X4M200 è conforme alla direttiva 2014/53/UE. Il testo integrale della dichiarazione di conformità dell'UE è disponibile sotto.

Espanol:

Por la presente, **Novelda AS** declara que el tipo de equipo radioeléctrico X4M200 es conforme con la Directiva 2014/53/UE. El texto completo de la declaración de conformidad de la UE está disponible a continuación.

Portugues:

O(a) abaixo assinado(a) **Novelda AS** declara que o presente tipo de equipamento de radio X4M200 esta em conformidade com a Diretiva 2014/53/UE. O texto completo da declaração de conformidade da UE está disponível abaixo.

Čeština:

Tímto **Novelda AS** prohlašuje, že typ radiového zařízení X4M200 je v souladu se směrnicí 2014/53/EU. Úplné znění prohlášení o shodě EU je k dispozici níže.

Eesti:

Kaesolevaga deklareerib **Novelda AS**, et kaesolev raadioseadme tüüp X4M200 vastab direktiivi 2014/53/EL nouetele. ELi vastavusdeklaratsiooni täielik tekst on allpool.

**Magyar:**

Novelda AS igazolja, hogy a X4M200 típusu radioberendezés megfelel a 2014/53/EU irányelvnek. Az EU-megfelelőségi nyilatkozat teljes szövege az alábbiakban található.

Latviešu valoda:

Ar šo **Novelda AS** deklarē, ka radioiekārta X4M200 atbilst Direktīvai 2014/53/ES. ES atbilstības deklarācijas pilns teksts ir pieejams zemāk.

Lietuvių kalba:

Aš, **Novelda AS**, patvirtinu, kad radijo įrenginių tipas X4M200 atitinka Direktyvą 2014/53/ES. Visas ES atitikties deklaracijos tekstas pateikiamas toliau.

Malti:

B'dan, **Novelda AS**, niddikjara li dan it-tip ta' tagħmir tar-radju X4M200 huwa konformi mad-Direttiva 2014/53/UE. It-test sħiħ tad-dikjarazzjoni ta 'konformità tal-UE huwa disponibbli hawn taħt.

Slovenčina:

Novelda AS týmto vyhlasuje, že rádiové zariadenie typu X4M200 je v súlade so smernicou 2014/53/EÚ. Úplné znenie vyhlásenia o zhode EÚ je k dispozícii nižšie.

Slovenščina:

Novelda AS potrjuje, da je tip radijske opreme X4M200 skladen z Direktivo 2014/53/EU. Celotno besedilo izjave EU o skladnosti je na voljo spodaj.

Romană:

Prin prezenta, **Novelda AS** declară că tipul de echipamente radio X4M200 este în conformitate cu Directiva 2014/53/UE. Textul integral al declarației UE de conformitate este disponibil mai jos.

Български:

С настоящото **Novelda AS** декларира, че този тип радиосъоръжение X4M200 е в съответствие с Директива 2014/53/ЕС. Пълният текст на декларацията за съответствие на ЕС е на разположение по-долу.

Polski:

Novelda AS niniejszym oświadcza, że typ urządzenia radiowego X4M200 jest zgodny z dyrektywą 2014/53/UE. Pełny tekst deklaracji zgodności UE jest dostępny poniżej.

Norsk:

Novelda AS erklærer herved at radioutstyr type X4M200 er i samsvar med direktiv 2014/53/EU. Den fullstendige teksten i EU-samsvarserklæringen er tilgjengelig nedenfor.

Islenska:

Hér með **Novelda AS** lýsir yfir að tegund þráðlausan búnað X4M200 er í samræmi við tilskipun 2014/53/ESB. Fullkominn texti ESB samræmisýfirlýsing er að finna hér að neðan.

Hrvatski:

Novelda AS ovime izjavljuje da je radijska oprema tipa X4M200 u skladu s Direktivom 2014/53/EU. Cijeli tekst izjave o sukladnosti EU-a nalazi se u nastavku.

Türk:

Burada, **Novelda AS** radyo ekipmanı türünün X4M200 2014/53/EU direktiflerine uyumlu olduğunu beyan eder. AB uyumu beyanının tam metni aşağıda verilmektedir.



15.1.1 EU Declaration of Conformity



EU DECLARATION OF CONFORMITY

- 1 XeThru X4M200 (product name)
- 2 Novelda AS, Garverivegen 2, NO-3850 Kviteseid, Norway (manufacturer, address)
- 3 This declaration of conformity is issued under the sole responsibility of the manufacturer
- 4 X4M200 Radar Sensor, HW version: 000164-010 (object of the declaration)
- 5 The object of the declaration described above is in conformity with the relevant Community harmonisation: European Directive 2014/53/EU (RED) and European Directive 2011/65/EU
- 6 The conformity with the essential requirements of the 2014/53/EU has been demonstrated against the following standards:

Standard reference	Article of Directive 2014/53/EU
EN 62479:2010 EN 60950-1:2006	3.1 (a): Health and Safety of the User
EN 301 489-1 (V2.1.1) EN 301 489-33 (V2.1.1)	3.1 (b): Electromagnetic Compatibility
EN 302 065-1 (V2.1.1)	3.2 : Effective use of spectrum allocated

In addition the requirements in **Directive (2011/65/EU)** on the restriction of use of certain hazardous substances in electrical and electronic equipment is satisfied by application of EN 50581:2012

Thus,  is placed on the product

- 7 The Technical Documentation (TD) relevant to the product described above and which supports this Declaration of Conformity, is held at: Novelda AS, Garverivegen 2, NO-3850 Kviteseid, Norway

Signed for and on behalf of Novelda AS

Kviteseid, 20.09.2017


Dag Arne Brænd, COO

Oslo
Novelda AS
Gjerdrumsvei 8
0484 Oslo
Norway

Kviteseid
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3850 Kviteseid
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Trondheim
Novelda AS
Rotvoll alle 2
7053 Trondheim
Norway



X4M200 EU Declaration of Conformity



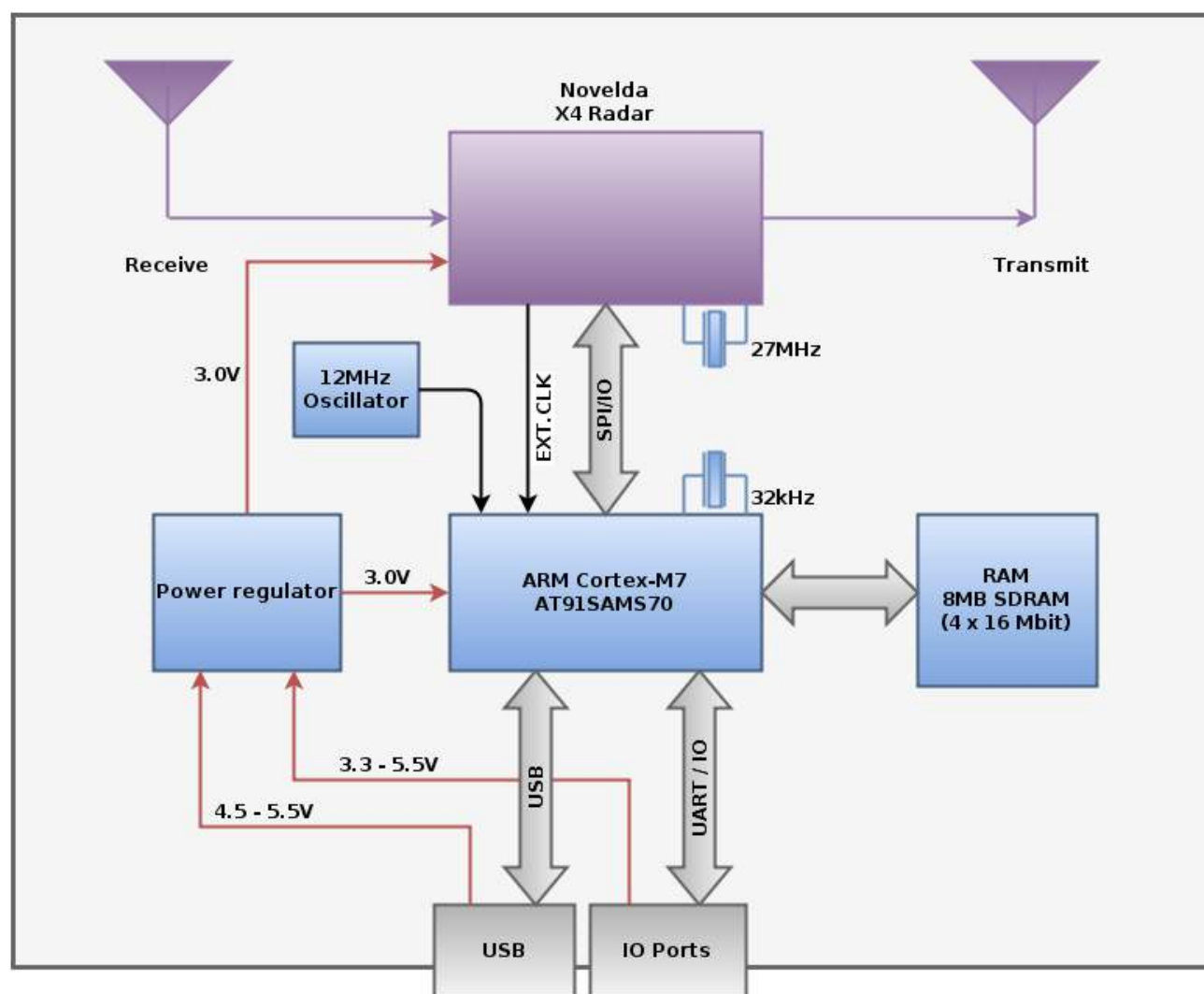
15.2 FCC Approval

X4M200 has Modular FCC approval, which means it can be used in an end product without obtaining new authorization for the end product with regard to use of UWB radar.

The X4M200 module meets FCC Part 15 requirements for UWB transmission equipment intended for unlicensed indoor use or outdoor use when not permanently installed as specified in FCC Part 15.519, 15.521 and 15.209.

FCC ID: 2AD9QX4M02.

15.2.1 X4M200 Block Diagram



Module clock and power system

Clocks:

The systems clocks are derived from a 12 MHz crystal oscillator connected to the main microcontroller, and a 27 MHz oscillator connected to the Novelda X4 UWB impulse radar chip. The communication between the microcontroller and the X4 radar chip uses SPI protocol. The SPI communication clock is set up to run at 50 MHz.



Mean output power of X4M200 depends on the Pulse Repetition Frequency (PRF) and tx_power settings in the X4 radar chip. PRF is set to 15.875 MHz and tx_power is set to Medium (2) in X4M200. Both the PRF and tx_power can be changed by the microcontroller but cannot be changed to comply with FCC regulations. For further description of the radar chip, please refer to the X4 datasheet.

Power:

The module is powered externally from either the USB port or an external power supply. If both power sources are connected, the USB takes precedence over the external power.

Antennas:

The antennas are embedded onto the PCB and cannot be changed by users. Please refer to the Antenna chapter in the X4M02 datasheet for details on the antennas.

15.2.2 Radar Functional Description

The module uses the Novelda X4 impulse radar chip. Please refer to the X4 datasheet for a detailed description.

15.2.3 FCC Regulatory Notices

Modification Statement

Novelda AS has not approved any changes or modifications to this device by the user. Any changes or modifications could void the user's authority to operate the equipment.

Interference Statement

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

RF Exposure Safety

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

The X4M02 is a radio transmitter and receiver.

It is designed not to exceed the emission limits for exposure to radio frequency (RF) energy set by the Federal Communications Commission.

FCC Class B Digital Device Notice

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:



- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Labelling Requirements for the Host Device

The host device shall be properly labelled to identify the modules within the host device. The certification label of the module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labelled to display the FCC ID of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows:

Contains FCC ID: 2AD9QX4M02

UWB devices may not be employed for the operation of toys. Operation on-board an aircraft, a ship or a satellite is prohibited.

15.3 Industry Canada Approval

X4M200 is approved by Industry Canada (IC)

IC Certification Number: 22782-X4M02

15.3.1 Regulatory Information Canada

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Les changements ou modifications non expressément approuvés par la partie responsable de la conformité pourraient annuler l'autorisation de l'utilisateur d'utiliser l'équipement.

This device complies with Industry Canada's licence-exempt RSSs. Operation is subject to the following two conditions: (1) This device may not cause interference; and (2) This device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

15.3.2 RF Exposure Safety

The X4M02 is a radio transmitter and receiver.

It is designed not to exceed the emission limits for exposure to radio frequency (RF) energy set by the ISED.

Le X4M02 est un émetteur et un récepteur radio.

Il est conçu pour ne pas dépasser les limites d'émission pour l'exposition à l'énergie radiofréquence (RF) établie par l'ISDE.



15.3.3 Labelling Requirements for the Host Device

The host device shall be properly labelled to identify the modules within the host device. The certification label of the module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labelled to display the IC of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows:

Contains IC: 22782-X4M02

Le'équipement hôte doit être correctement étiqueté pour identifier les modules dans l'équipement. L'étiquette de certification du module doit être clairement visible en tout temps lorsqu'il est installé dans l'hôte, l'équipement hôte doit être étiqueté pour afficher l'IC du module, précédé des mots "Contient le module émetteur", ou le mot "Contient", ou un libellé similaire exprimant la même signification, comme suit:

Contains IC: 22782-X4M02

CAN ICES-3 (B)/NMB-3(B)

15.4 KCC Approval

This chapter will cover the KCC approval of the X4M200.

15.5 MIC Approval

This chapter covers the MIC approval of the X4M200, which is for Japan: Ministry of internal affairs and communication (MIC)

16 Errata

16.1 Errata in Firmware Version 1.2.1

- RPM may lock on second harmonic frequency of the respiration frequency. Future FW upgrades are planned to improve this.
- RPM frequencies higher than maximum for a Profile (30 for Adult Respiration Profile and 65 for Baby Respiration Profile) may report as a frequency below the maximum value. Future FW upgrades are planned to improve this.
- RPM frequencies lower than minimum for a Profile (8 for Adult Respiration Profile and 15 for Baby Respiration Profile) may report as a frequency above the minimum value. Future FW upgrades are planned to improve this.
- Distance to breathing target may occasionally report a longer distance due to lock on multi path reflections. Future FW upgrades are planned to improve this.
- Memory leak in firmware may cause X4M200 to enter Fail Safe Mode. Workaround: Upgrade to FW ver.1.3.1 or newer. Workaround for this FW version: Toggle power or send a module reset command.
- Any reset, including intentional reset commands from a host, will cause the reset counter to increase. Fail Safe Mode may trigger after first reset caused by issues in the firmware if nine or more reset from any source has been experienced since last power-up. Workaround: Leave Fail Safe Mode by toggling power or send a module reset command.



16.2 Errata in Firmware Version 1.3.1

- RPM may lock on second harmonic frequency of the respiration frequency. Future FW upgrades are planned to improve this.
- RPM frequencies higher than maximum for a Profile (30 for Adult Respiration Profile and 65 for Baby Respiration Profile) may report as a frequency below the maximum value. Future FW upgrades are planned to improve this.
- RPM frequencies lower than minimum for a Profile (8 for Adult Respiration Profile and 15 for Baby Respiration Profile) may report as a frequency above the minimum value. Future FW upgrades are planned to improve this.
- Distance to breathing target may occasionally report a longer distance due to lock on multi path reflections. Future FW upgrades are planned to improve this.
- Any reset, including intentional reset commands from a host, will cause the reset counter to increase. Fail Safe Mode may trigger after first reset caused by issues in the firmware if nine or more reset from any source has been experienced since last power-up. Workaround: Leave Fail Safe Mode by toggling power or send a module reset command.

16.3 Errata in Firmware Version 1.4.7

- RPM may lock on second harmonic frequency of the respiration frequency. Future FW upgrades are planned to improve this.
- RPM frequencies higher than maximum for a Profile (30 for Adult Respiration Profile and 65 for Baby Respiration Profile) may report as a frequency below the maximum value. Future FW upgrades are planned to improve this.
- RPM frequencies lower than minimum for a Profile (8 for Adult Respiration Profile and 15 for Baby Respiration Profile) may report as a frequency above the minimum value. Future FW upgrades are planned to improve this.
- Distance to breathing target may occasionally report a longer distance due to lock on multi path reflections. Future FW upgrades are planned to improve this.

16.4 Errata in X4M02 Revision 6 and lower

USB communication can be unstable. The issue is more frequently observed with Win7, and less observed with Win10, Raspberry Pi, MacOS and Unix.

17 Support and Resources

Development support, resources, links to development partners and resellers can be found on Novelda's web site www.xethru.com.

18 Disclaimer

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