OXTS

xRED

USER MANUAL

OXTS.COM

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Introduction

The purpose of this manual is to give users the information they need to evaluate and integrate the xRED from OXTS into their existing payloads.

For assistance with any of the content in this manual, contact support@oxts.com to contact your regional support.

We would love to hear any feedback you have on the xRED after having used it – please get in touch with your OXTS representative or email products@oxts.com to send us your feedback or arrange for a call.

Important information is highlighted throughout this manual in these boxes.

Intended use

The xRED inertial navigation systems are designed to precisely measure position, time, orientation, and dynamics for localisation, georeferencing, and validation applications. They are capable of logging navigation and localisation data as a passive measurement device, and/or outputting the data in real-time with low latency for use in active systems. If the outputs are used in any way as part of a control system, appropriate steps should be taken by the System Integrator to ensure that the control system as a whole meets the required functional safety standards, with additional independent and redundant sensors and modules.

The xRED is not IP rated so should not be exposed to dust or water ingress.

Related documents

This manual covers the installation and operation of the xRED, but it is beyond its scope to provide details on service or repair. Contact OXTS support or your local representative for customer service-related enquiries.

Additional manuals provide further information on some of the software and communication types mentioned in this manual. Table 1 lists related manuals and where to find them.

Document	Description
ROS2 driver	Allows an OXTS INS to interact with a wider ROS network. https://github.com/OxfordTechnicalSolutions/oxts_ros2_driver
NCOM Manual	Description of the OXTS NCOM format. NCOM_man.pdf [oxts.com]
NCOM C decoder	A collection of C functions to decode the binary protocol NCOM format. https://github.com/OxfordTechnicalSolutions/NCOMdecoder
NMEA 0183 Description	NMEA description manual for the NMEA outputs. NMEA_man.pdf [oxts.com]

Table 1:
Supplementary manuals

Scope of delivery

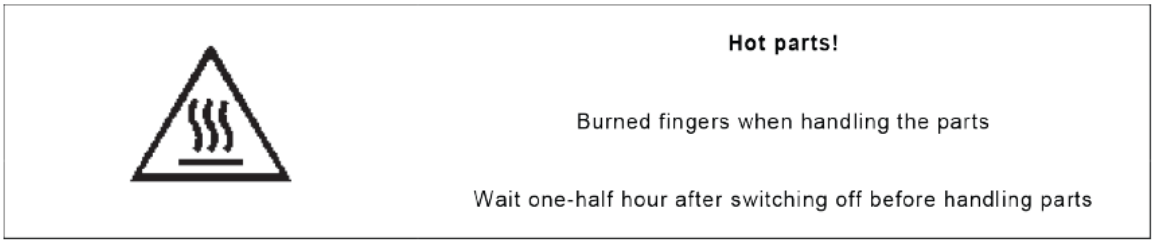
The xRED can be supplied in two kitting options: device-only or evaluation standard kit. The evaluation standard kit includes additional items that allow users to quickly and easily set up and evaluate the system.

Table 2 shows what is included in each kit variation.

Item	xRED – Device-Only	xRED (Evaluation) – Standard Kit
xRED inertial navigation system	✓	✓
xRED evaluation board		✓
Evaluation board mounting cradle		✓
Evaluation board mounting spacer		✓
Mains power cable		✓
Ethernet cable (RJ45)		✓
Evaluation board connector with leads		✓
MMCX to SMA cable (10 cm)		x2
Software USB		✓
Quick start guide		✓

Table 2:
xRED scope of delivery

Health and Safety



Hardware description

Overview

The xRED is a miniature GNSS-aided inertial navigation system. It combines dual multi-constellation, multi-frequency RTK GNSS receivers with an IMU array to provide a compact centimetre-level navigation solution. Additionally, the system includes 32 GB data storage and an on-board processor running the real-time strapdown navigator and Kalman filter.

The dual receiver integration allows greater heading accuracy with wider antenna baselines and ensures stable heading performance even when stationary and during low dynamics. The sensor fusion between the GNSS receivers and inertial sensors is done seamlessly in real-time for a continuous 100 Hz navigation output. Data is automatically logged to the 32 GB eMMC for added data protection.

Model variants

There are two main model variants of the xRED:

xRED AFP v1.1 – this model features ‘airflow protection’ caps on either side of the PCB to prevent sensitive components from large temperature variations and ensure best performance.

xRED v1 – this model is features the PCB only and must only be used in systems where the device will not be subject to significant airflow or temperature changes.

The PCB used in each model is identical; hence there are no changes interfacing capability between the two models. It is recommended that the xRED AFP v1.1 is used where the application allows to minimise risk of temperature changes impacting the performance of the device.

Design-in

Dimensions

xRED AFP v1.1

Figure 1 shows the outer dimensions of the xRED AFP v1.1, mounting points, antenna connectors, and the measurement origin point. When making measurements required in the configuration files, measurements should be made from the origin point.

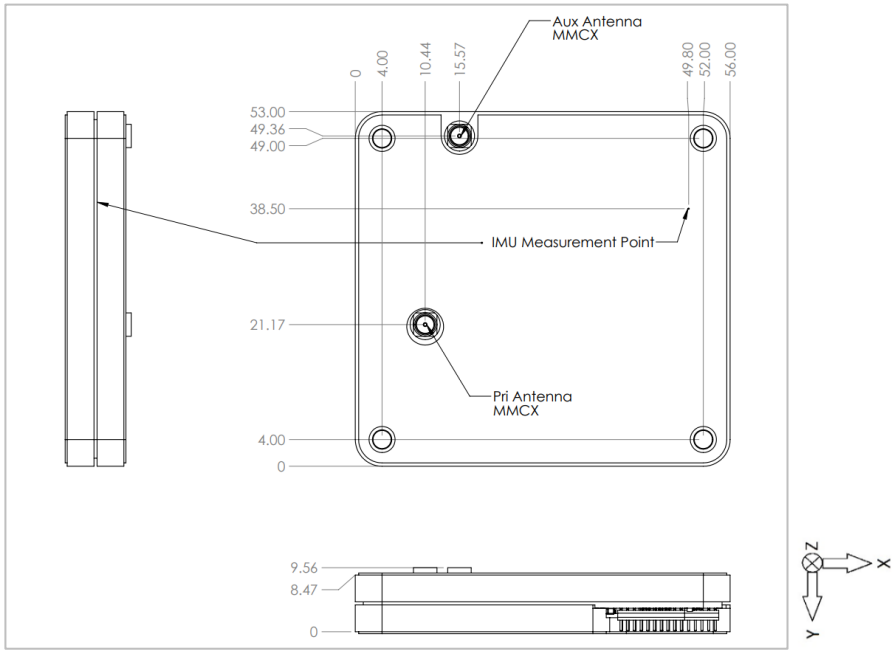


Figure 1:
Front view of xRED AFP v1.1

xRED v1

Figure 2 shows the outer dimensions of the xRED v1, mounting points, antenna connectors, and the measurement origin point. When making measurements required in the configuration files, measurements should be made from the origin point.

The PCB is 1.6mm thick and has a 2.5mm high keep out area on both sides to allow for the mounted components.

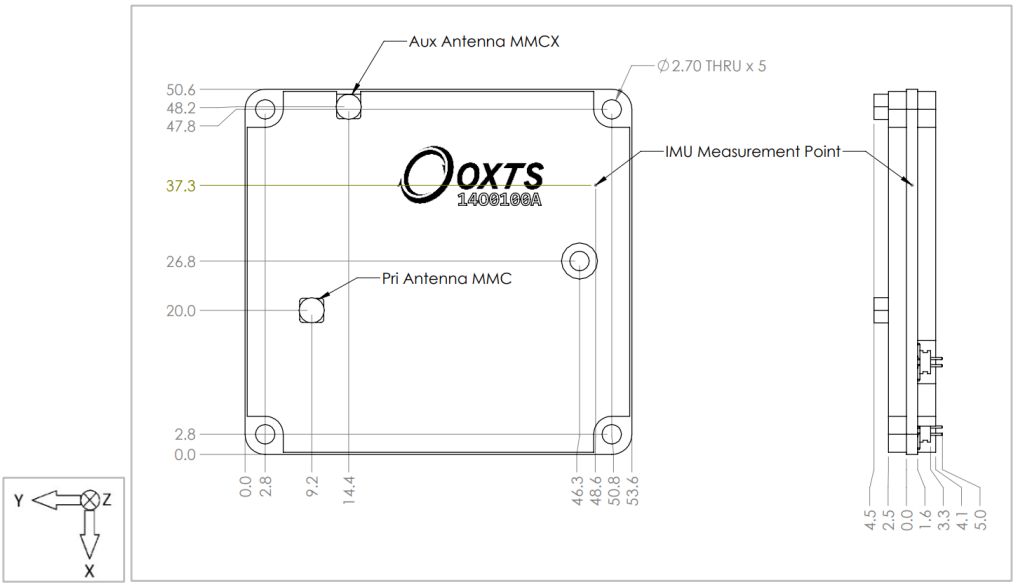


Figure 2:
Front view of xRED v1

Mounting

M2.5 screws should be used at all mounting points to secure the board in place. Care should be taken when mounting device to ensure it is not placed under undue strain as this will impact the performance of the IMU. For best performance, it is recommended that the xRED is mounted with the Z axis vertical.

The xRED (and any external sensors used for georeferencing applications) must be isolated from any significant vibration greater than 5Hz with damping isolators or shock mounts. Failure to do this will reduce the accuracy of navigation data.

Note: avoid physical contact with any of the electronic components when mounting the xRED

Temperature considerations

We advise that heat sinking is provided to the xRED to allow it to better dissipate its heat.

The inductor on the output of the power supply (PSU) is the component most at risk from overheating. In rare circumstances, there is a risk that the inductor will exceed its specified maximum operating temperature of 125°C and potentially become damaged without heat sinking.

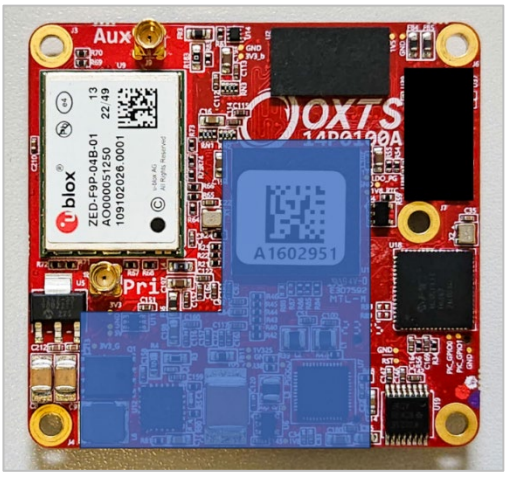


Figure 3:
xRED advised heat sinking locations

There are three main factors to consider when deciding how important heat sinking is for your application:

1. The ambient temperature - the higher the ambient temperature, the lower the acceptable temperature rise.
2. The input voltage used – the PSU becomes less efficient at higher voltages, resulting in more power being dissipated as heat.
3. The load connected to the 5V output line - the greater the load, the more heat is generated.

These factors can combine in different ways. To demonstrate, some examples from testing at room temperature with dual antennas connected include:

Ambient temperature	Input voltage	Load on 5V output	xRED inductor temperature	Max temperature exceeded?
20 °C	12V	4W	102 °C	No
20 °C	60V	0W	102 °C	No
20 °C	60V	4W	137 °C	Yes

Table 3:
Heat sinking considerations

NAVdisplay provides an IMU temperature output. Although please note this is a guide only and does not provide a definitive indication of the temperature of the inductor.

xRED v1 model-specific temperature considerations

If the selected model is an xRED v1, ensure the device is not placed near sources of heating or cooling. The GNSS receivers, located on the top and bottom of the PCB, are sensitive to sudden changes in ambient temperature and air flow, both of which can adversely impact signal tracking. For best performance avoid any flow of air directed straight at any part of the xRED.

Pin headers

The main pin header is reference J1 on the PCB and has all of the critical connections required to use the xRED. The auxiliary pin header is reference J2 on the PCB and contains optional connections for the xRED. Figure 4 shows the locations of the centre of both pin headers and the pin positions.

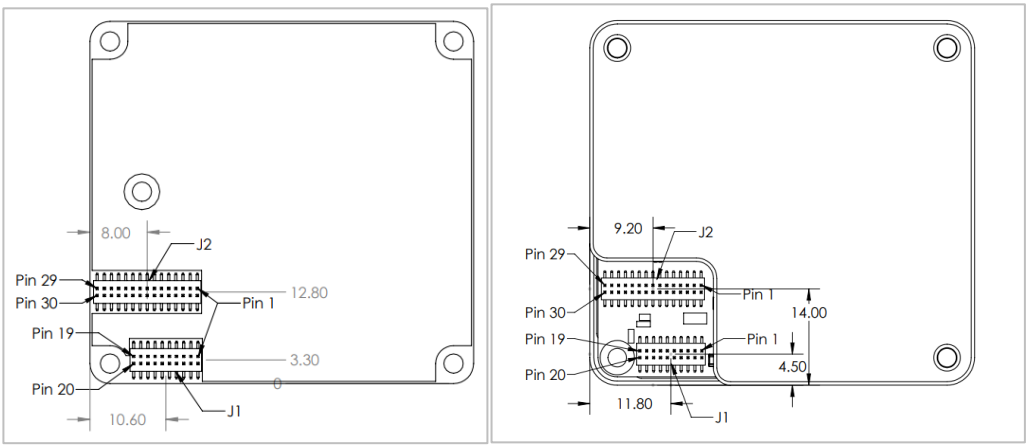


Figure 4:
xRED pin header locations for v1 (left) and AFP v1.1 (right)

J1 main pin header

The part number of the header used is Samtec FTMH-110-03-F-DV-A and the recommended part number of the mating header is Samtec CLM-110-02-F-D-P.

Pin No	Signal	Comments
1	Sig GND	
2	ETH_P1	Positive side of Ethernet pair 1
3	ETH_LED2	Ethernet link LED signal, active-low
4	ETH_N1	Negative side of Ethernet pair 1
5	Sig GND	
6	ETH_P0	Positive side of Ethernet pair 0
7	ETH_LED1	Ethernet activity LED signal, active-low
8	ETH_N0	Negative side of Ethernet pair 0
9	Sig GND	
10	Sig GND	
11	5V	Input power from 5V rail, or 5V, 0.8A output power for auxiliary circuitry. Note that if you use this as the power input you must connect VSS to Sig GND and leave VDD floating
12	VSS	Supply return signal. Connect this to Signal Ground if you're providing 5V as the input power source
13	UART1 Rx	3V3 TTL UART1 connection to receive data from other sensors in your payload
14	VDD	Supply positive signal, input voltage between 6 - 60 Volts. Leave floating if providing 5V as the input power source
15	UART1 Tx	3V3 TTL UART1 connection to transmit data to other sensors in your payload
16	UART2 Tx	RS232 UART2 connection to transmit data to other sensors in your payload
17	PPS	3V3 pulse per second from the primary GNSS card
18	Sig GND	
19	Trigger 1	Trigger configurable for a number of different functions
20	UART2 Rx	RS232 UART2 connection to receive data from other sensors on your payload

Table 4:
J1 main header pin allocations

J2 Auxiliary pin header

The part number of the header used is Samtec FTMH-115-03-F-DV-A and the recommended part number of the mating header is Samtec CLM-115-02-F-D-P.

Note: none of the signals on the aux pin header are vital to the operation of the xRED and can be left disconnected if your application does not require any of the signals on it.

Pin No	Signal	Comments
1	Reserved	Do not connect, for internal use only
2	Reserved	Do not connect, for internal use only
3	Sig GND	
4	Reserved	Do not connect, for internal use only
5	Reserved	Do not connect, for internal use only
6	Reserved	Do not connect, for internal use only
7	Reserved	Do not connect, for internal use only
8	Reserved	Do not connect, for internal use only
9	GPIO_7	Do not connect, general purpose IO pin for future use
10	Reserved	Do not connect, for internal use only
11	GPIO_6	Do not connect, general purpose IO pin for future use
12	LED4	GNSS LED, active-low
13	Sig GND	
14	LED3	GNSS LED, active-low
15	WS1	Wheelspeed sensor input, or signal A of quadrature wheelspeed input
16	LED2	Status LED, active-low
17	WS2	Signal B of quadrature wheelspeed input
18	LED1	Status LED, active-low
19	Sig GND	
20	Reset	The reset signal. Active-low, cycle to trigger a reset (for instance with a push button).
21	IMU_Sync	IMU sampling synchronisation signal. Output packets are synchronised with the falling edge
22	Spare 1	Do not connect, reserved for future functionality
23	Trigger 2	Trigger configurable for a number of different functions
24	Spare 2	Do not connect, reserved for future functionality
25	Sig GND	
26	Spare 3	Do not connect, reserved for future functionality
27	Reserved	Do not connect, for internal use only
28	Spare 4	Do not connect, reserved for future functionality
29	Reserved	Do not connect, for internal use only
30	Reserved	Do not connect, for internal use only

Table 5:
J2 aux header pin allocations

Voltage/power requirements

The main input supply accepts 6-60V between voltage drain (VDD) and voltage source (VSS). VSS is connected to signal ground on the xRED via some filtering; hence for best EMC performance it should be connected to the negative terminal of the power source only. This will keep the signal ground clean.

The 5V pin can be used to either supply 5V to peripheral circuitry (up to 0.8A) or as an input to supply power, bypassing the onboard PSU. If 5V is supplied on the 5V pin the VDD pin should be left disconnected and VSS connected to ground.

All signal ground pins should be joined to the ground plane of the mating board and be used as the reference for the interface signals.

The nominal power required by the xRED is approximately 4W. If the 5V pin is used to power auxiliary circuitry, then the power required will be higher.

The power consumption quoted on OXTS devices is using standard 5m antenna cables, using a shorter cable will reduce power consumption.

Note: to maximise power consumption efficiency, it is important to optimise the antenna setup. Poor-quality cables/connections and longer cabling can significantly increase the power consumption on the device.

Interface voltage levels

Most I/O signals on the xRED are 3V3 TTL and connect directly to 3V3 tolerant devices. These devices are normally connected directly to the main CPU without any on board protection. The exceptions to this are:

- UART2 (RS232 voltage levels)
- Ethernet (100BASE-T)

This means that anything connected that is not compatible with 3V3 must have level translation or clipping done on the mating board to avoid damaging the device. For example, if a 12V wheel speed device is connected, the voltage must be clipped before the signal is passed to the xRED.

Interface details

Ethernet

A 4-pin Ethernet interface is the primary interface for configuring and monitoring the xRED. The ethernet physical layer (PHY) used supports MDI, so it does not matter where each pair is connected on the socket, as long as the pairs +/- match.

Note that external ethernet transformers are required (e.g. Microchip part number KSZ9031RNX). Figure 5 shows how these should be wired to work with the PHY. It is important to note that RJ45 sockets regularly come with ethernet transformers integrated; if yours does, then you do not need to add additional ethernet transformers.

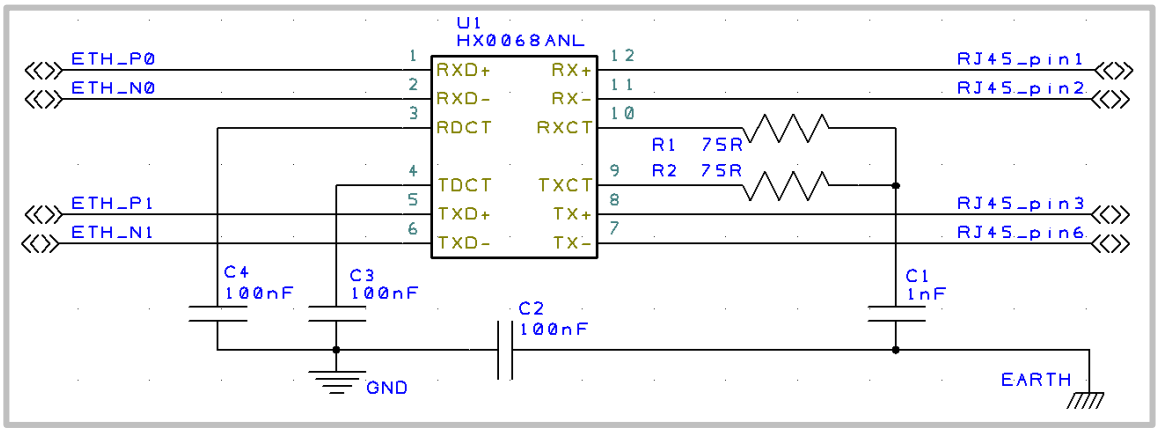


Figure 5:
Example ethernet transceiver wiring

Serial

The xRED has two serial ports whose inputs and outputs can be independently configured for several uses such as receiving corrections or outputting navigation data.

- The first serial port (UART1) is a 3V3 TTL interface connected directly to the CPU and can be used at rates up to 3MBd.
- The second serial port (UART2) operates at RS232 voltage levels and can be used at rates up to 1MBd.

We advise picking the port with the voltage level that suits your system requirements, with no need for external circuitry. However, if two identical serial connections are required (such as two RS232-level serial ports), an external transceiver must be used.

PPS (Pulse per second)

The PPS output is a pulse generated by the GNSS receiver. The falling edge of the pulse is the exact transition from one second to the next in GPS time. Note the output will **not** be active when the GNSS receiver has no valid position measurement.

The pulse is low for 1 ms, then high for 999 ms and repeats every second. The output is a low-voltage CMOS output, with 0.8 V or less representing a low and 2.4 V or more representing a high. No more than 10 mA should be drawn from this output.

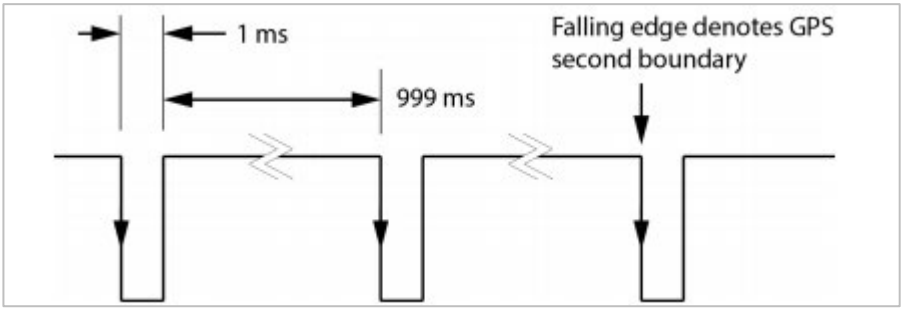


Figure 6:
PPS waveform

IMU synchronisation signal

The IMU sync signal is for synchronising with the IMU sampling, which is internally synchronised to the PPS. Each NCOM packet sent out by the xRED is synchronised to the falling edge of the IMU sync.

Triggers

The two triggers are configurable as inputs or outputs. Triggers can be configured using NAVconfig.

Wheel speed sensor input

The wheel speed sensor input works with either a single-ended device connected to just the WS1 pin, or a quadrature wheel speed device connected to both pins.

LEDs

There two LED outputs on the main pin header, and four on the auxiliary pin header. They work in pairs to show the status of various systems. As per the table above, all the LEDs on the xRED are active-low. The table below indicates what each LED is for.

Housed OXTS devices use red and green LEDs; providing red, green, and orange colours when used in combination. We recommend that using the same colours as OXTS to make support easier.

Some of the tables below give both the LED statuses (high, low, or toggling) and the OXTS housed device equivalent colours to help you understand what the LEDs mean when in use. We have not done this for the Ethernet LEDs, as these are unique to the xRED.

Ethernet LEDs

Ethernet LEDs are LEDs 1 and 2 on the main pin header.

Note: These LEDs are buffered. The buffer can source or sink 50mA per LED.

Pin State	Description
LED 1 (main) = high	No activity
LED 1 (main) = toggling	Activity (receiving or transmitting data)

Table 6:
LED 1 (main) behaviour

Pin State	Description
LED 2 (main) = high	Link off
LED 2 (main) = toggling	Link on (any speed)

Table 7:
LED 2 (main) behaviour

Status LEDs

Status LEDs are LEDs 1 and 2 on the auxiliary pin header.

Note: we recommend that you buffer these signals if they are being used to drive LEDs, as they are not buffered on the xRED board. If you do not use buffering, the current should be kept below 10mA per LED to avoid damaging the xRED board.

Pin State	Description	OXTS LED colour
LED 1 (aux) = high LED 2 (aux) = high	The operating system has not yet booted. This occurs at start-up.	LEDs off
LED 1 (aux) = toggling LED 2 (aux) = toggling	The system is asleep. Contact OXTS support for further information.	Red-green flash
LED 1 (aux) = high LED 2 (aux) = toggling	The operating system has booted but the GNSS receiver has not yet output a valid time, position, or velocity.	Red flash
LED 1 (aux) = high LED 2 (aux) = low	The GNSS receiver has locked on to satellites and has adjusted its clock to valid time (1PPS output now valid). The INS is ready to initialise.	Red
LED 1 (aux) = low LED 2 (aux) = low	The INS has initialised and data is being output, but the system is not yet real time (the Kalman filter delay is a few seconds). It takes around 10 seconds for the system to become real-time.	Orange
LED 1 (aux) = low LED 2 (aux) = high	The INS is running and the system is real-time.	Green

Table 8:
LED 1 and 2 (aux) behaviour

GNSS LEDs

GNSS LEDs are LEDs 3 and 4 on the auxiliary pin header.

Note: we recommend that you buffer these signals if they are being used to drive LEDs, as they are not buffered on the xRED board. If you do not use buffering, the current should be kept below 10mA per LED to avoid damaging the xRED board.

Pin State	Description	OXTS LED colour
LED 3 (aux) = high LED 4 (aux) = high	Before startup: the system is not online. After startup: GNSS receiver fault.	LEDs off
LED 3 (aux) = high LED 4 (aux) = toggling	The GNSS receiver is active but has not yet determined heading.	Red flash
LED 3 (aux) = high LED 4 (aux) = low	The GNSS receiver has a differential heading lock.	Red
LED 3 (aux) = low LED 4 (aux) = low	The GNSS receiver has a floating (poor) calibrated heading lock.	Orange
LED 3 (aux) = low LED 4 (aux) = high	The GNSS receiver has an integer (good) calibrated heading lock.	Green

Table 9:
LED 3 and 4 (aux) behaviour

Antennas

Antennas used with the xRED must at least be capable of tracking the GPS L1 signal for operation and additionally the GPS L2 signal for RTK performance. For optimal performance and improved reliability, the antennas used should be capable of tracking:

- GPS L1/L2
- GLONASS G1/G2
- Galileo E1/E5b
- BeiDou B1/B2b

Using an active antenna is recommended for best performance. The nominal antenna output voltage is 5V, dropping to 4.4V at 100mA draw which is the recommended maximum current draw from each RF connection.

The recommended minimum LNA gain for your antenna LNA gain is 17dB, while the maximum is 50dB.

For land applications OXTS recommends:

- Tallysman TW7972 (SMA) antennas
- VEXXIS GNSS 850 (TNC) antennas

For SWaP constrained UAV/UAS applications OXTS recommends:

- Tallysman 33-HC882-35 (SMA) antennas

The xRED has MMCX connectors for the primary and secondary GNSS antennas. If the antennas used are mounted outside of the housing containing the xRED, using SMA or TNC adapters is recommended to ensure a secure connection.

Antenna placement and orientation

For optimal performance it is essential for the GNSS antenna(s) to be mounted where they have a clear, uninterrupted view of the sky and on a suitable ground plane, such as the roof of a vehicle. They should be mounted away or shielded from any potential sources of electromagnetic interference (EMI), such as LiDAR systems.

For dual antenna systems, the secondary antenna should be mounted in the same orientation as the primary antenna, as shown in Figure 7. The antenna baseline should also be aligned with one of the vehicle axes where possible, either inline or perpendicular to the vehicle's forward axis.

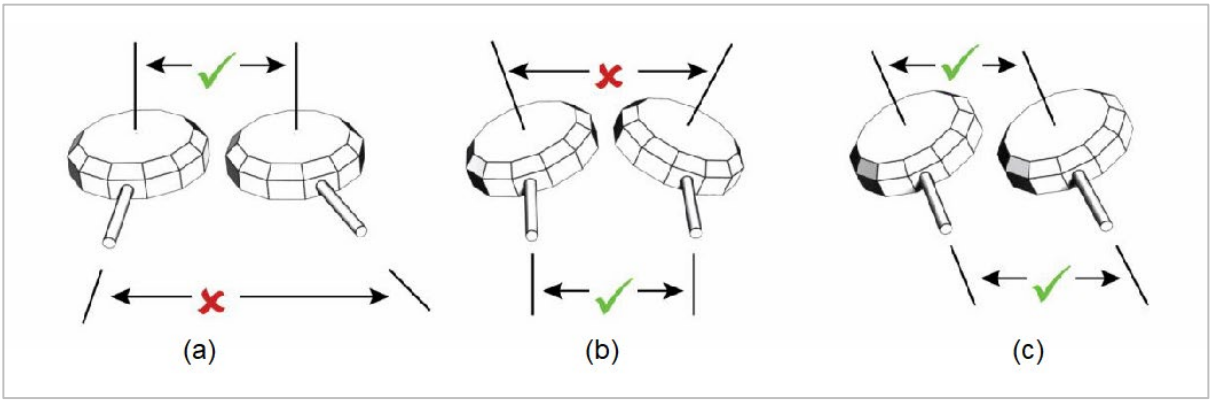


Figure 7:
Dual antenna orientation

a) The bases of the antennas are parallel, but the cables exit in different directions.
b) The cables exit in the same direction but the bases of the antennas are not parallel.
c) The bases of the antennas are parallel and the cables exit in the same direction. This configuration will achieve the best results.

Internal storage

The xRED uses a 32 GB eMMC for storage of hardware information, configuration files, and navigation data. Files can be sent to, or retrieved from the card via FTP, or with the software utilities provided (NAVconfig for configuration files and NAVsolve for data files).

The xRED starts logging data automatically on power-up. Each individual raw data file (*.rd) can be a maximum of 2 GB, equivalent to around one full day of logging at 100 Hz data rate with four GNSS constellations. Once the 2 GB file limit is reached, a new file is started automatically to continue logging. If the 32 GB storage limit is reached, the system will start overwriting existing RD files, starting from the oldest first.

Configuring

All OXTS devices need configuring before they can be used for the first time. To configure the xRED, follow these instructions:

1. Download and install the free NAVsuite range of applications from the OXTS website.
2. Connect your xRED to your computer via ethernet.
3. Launch NAVsuite, and from there launch NAVconfig.
4. Select ‘new configuration’, ‘connect to device’.
5. Either select the xRED from the default dropdown menu, or if your device is not connected to the computer click the “no connection” option and follow the steps to create a configuration for the device that will be sent to it when it is plugged in.
6. Follow the steps in the wizard to configure the device.

Please make sure that your ipv4 settings are correct – see this article for more information.

Evaluation board

The evaluation board is designed to make evaluation of the xRED more convenient. The evaluation board provides standard interfaces for the key connections, making it straightforward to set up and collect data.

Dimensions

The dimensions and mounting points of the evaluation board match that of the main device. An aluminium cradle and spacer allow the evaluation stack to sit stably on a desk or be mounted to a vehicle by screwing into the tapped corner holes.

Figure 8 shows xRED with the evaluation board attached. A CAD model is provided in the integrator pack.

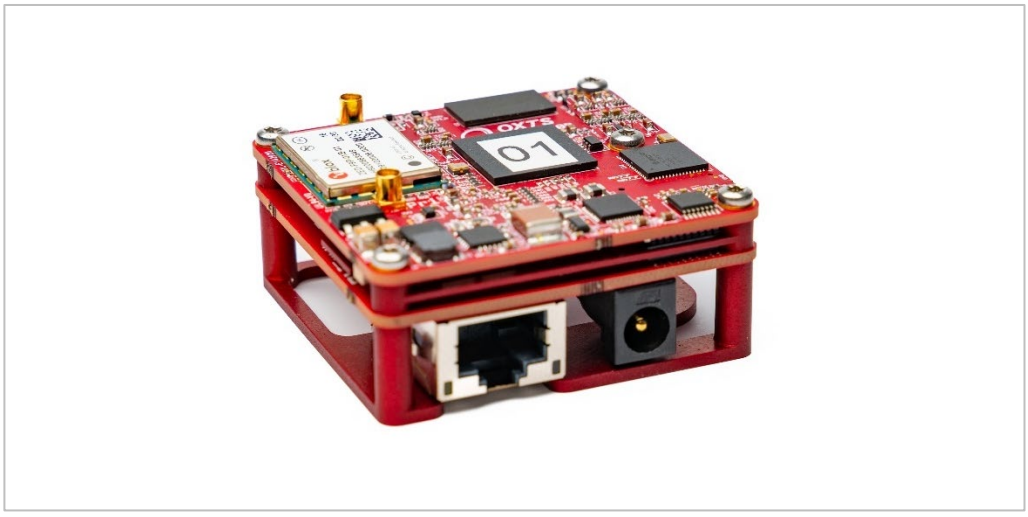


Figure 8:
xRED with evaluation board attached

Figure 9 shows the dimension of the xRED evaluation stack. A CAD model is provided in the integrator pack.

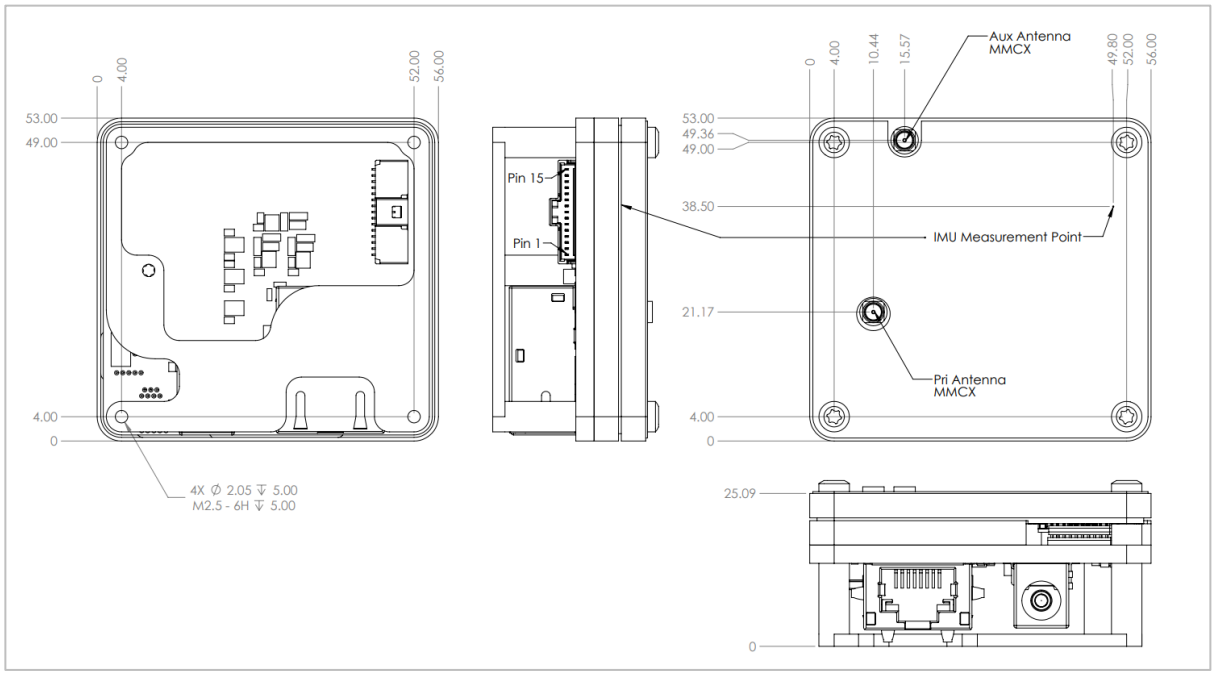


Figure 9:
xRED evaluation stack dimensions

Assembly

When attaching the xRED to the evaluation board, ensure that the correct spacer metalwork is used in the assembly, see **Figure 10**. All four attaching screws should be seated flush with the evaluation PCB.

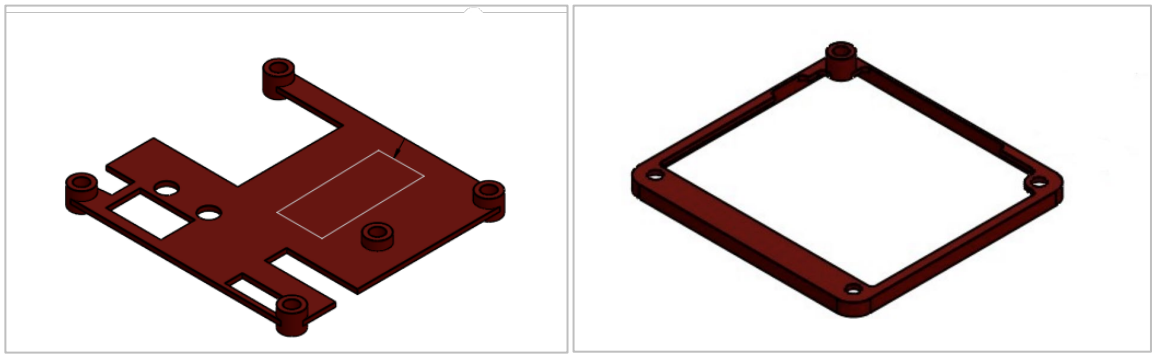


Figure 10:
xRED v1 spacer (left), xRED AFP v1.1 spacer (right)

Interfacing

The evaluation board provides the following connections:

- RJ45 connector for ethernet
- DC barrel connector for powering the device (part number 694106106102 from Würth Elektronik)
- Molex header connector for access to all other interfaces (mating part number 5013301500 and pre-crimped leads 797581019 (300mm) or 797581018 (150mm) from Molex).

The board also includes the same three standard LEDs we normally have on OXTS units, with the exception of the Ethernet LED. The Ethernet LED is built into the RJ45 connector, so the power LED on the evaluation board is solely for

power, either being low (green) when the unit is on, or high (off) when the unit is off. Additionally, the evaluation board includes a reset switch that will reset the system.

Evaluation board header pin allocation

Pin No	Signal	Comments
1	5V	5V input or 5V, 0.8A output. See section **Error! Reference source not found.** for more details
2	Reserved	Do not connect. This pin acts as a buffer between the power pin and other pins to avoid short-circuiting the unit.
3	Sig GND	
4	UART2 Tx	RS232 UART2 connection to transmit data to other sensors in your payload
5	UART2 Rx	RS232 UART2 connection to receive data from other sensors in your payload
6	Sig GND	
7	Trigger 1	Trigger configurable for a number of different functions
8	PPS	3V3 pulse per second from the primary GNSS card
9	Sig GND	
10	UART1 Tx	3V3 TTL UART1 connection to transmit data to other sensors in your payload
11	UART1 Rx	3V3 TTL UART1 connection to receive data from other sensors in your payload
12	Sig GND	
13	WS1	Signal A of quadrature wheel speed input, or input for a single-ended wheel speed sensor
14	WS2	Signal B of quadrature wheel speed input
15	Trigger 2	Trigger configurable for a number of different functions

Table 10:
Evaluation board header pin allocation

These signals are all routed directly from the main board set, so all interface specifications are as described earlier in the document, except for the triggers and wheel speed which have some voltage clipping on them to allow sensors such as a 12V wheel speed sensor to be used.

The pin allocation is indicated on the silk screen of the evaluation board for easy reference. Pin 1 is the pin closest to the RJ45.

Figure 11:
Pin allocation on evaluation board silk screen

Appendix A – Ensuring optimal operation

To maximise performance and ensure optimal operation, there are a number of areas to consider during installation and operation of the AV200 system.

Table 11 lists the topics to pay attention to.

Topic	Consideration
Installation	Antennas installed with same orientation
	Antennas installed clear of obstructions
	Antennas able to see same constellation of satellites
	Antennas and cables routed clear of sources of EMI
	Unit mounted rigidly in vehicle
	Unit and antennas unable to move independently
	Appropriate antivibration mounts used if necessary
	Unit has a stable, uninterrupted power supply
Configuration	Dual antenna set up as per OXTS guidelines
	Differential corrections enabled and configured (if applicable)
	Secondary antenna separation distance measured as accurately as possible (if appliable)
	Ethernet output enabled and monitored during vehicle operation
	Vibration levels are set to normal (higher levels will reduce confidence in IMU error models)
	GNSS environment set to Open skies (lower settings will reduce confidence in GNSS error models)
	A good warm up as been performed in RTK and an improved configuration committed to the unit (if applicable)
Pre-drive checks	Ensure all equipment is mounted securely
	Differential corrections are being received and the unit is in RTK position mode (if applicable)
	Position accuracy is being received over ethernet
	All cable connections are secure
Initialisation	Good GNSS conditions for dual antenna static initialisation (open skies, no multipath)
	Able to accelerate in a straight line and exceed speed threshold for dynamic initialisation
	Care not to exceed initialisation speed while reversing or turning
Vehicle operation	Device status is monitored – see Product Disclaimer for recommended status messages
	Avoid extended periods in blocked or obstructed GNSS environments without additional aiding sources such as a wheel speed

Table 11:
Optimal operation checks

Revision History

Revision	Changes
230315	First release.
231129	Additional health and safety section.
231211	Additional navigation recommendations and new warranty and liability section added.
240614	Added section 4.2.1 and updated front page.
241014	Clarification added that PPS will not output when no GNSS satellites are tracked.
241202	Manual rewritten for xRED AFP v1.1 models.
241219	Corrections to aux header LED behaviours.
250122	Additional information added about evaluation board spacers.
250430	Rebranding and xRED3000 changed to xRED.

Table 12:
Revision notes

Blank for user notes

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